Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 06/30/2020. OMB 0651-0035
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Application Number	Unassigned
Filing Date	October 21, 2021
First Named Inventor	Afshin Partovi
Title	System and Method for Inductive Charging of Portable Devices
Art Unit	Unassigned
Examiner Name	Unassigned
Attorney Docket Number	AFPA-01013US7

SIGNATURE of Applicant or Patent Practitioner

Signature	/Kent B. Chambers/	Date	October 21, 2021
Name	Kent B. Chambers	Telephone	512-338-9100
Registration Number	38,839		

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Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Afshin Partovi	Nonprovisional Application Number (if known):	
Title of Invention:	System and Method for Inductive Charging of Portable Devices		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Kent B. Chambers/	Date October 21, 2021
Name (Print/Typed) Kent B. Chambers	Practitioner Registration Number 38,839

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SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES

Inventors: Afshin Partovi, Michael Sears

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Claim of Priority:

[0001] This application is a continuation-in-part of U.S. patent application 11/669,113, filed 1/30/2007, titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM", which application claims the benefit of U.S. provisional patent application 60/763,816, filed 1/31/2006, titled "PORTABLE INDUCTIVE POWER SOURCE"; U.S. provisional patent application 60/810,262, filed 6/1/2006, titled "MOBILE DEVICE, CHARGER, AND POWER SUPPLY"; U.S. provisional patent application 60/810,298, filed 6/1/2006, titled "MOBILE DEVICE, BATTERY, CHARGING SYSTEM, AND POWER SUPPLY"; and U.S. provisional patent application 60/868,674, filed 12/5/2006, titled "SYSTEM FOR PROVIDING A PORTABLE INDUCTIVE POWER SOURCE"; this application also claims the benefit of U.S. provisional patent application 60/916,748, filed 5/8/2007, titled "CHARGING AND POWERING MOBILE DEVICES, BATTERIES"; U.S. provisional patent application 60/952,835, filed 7/30/2007, titled "INDUCTIVE CHARGING OF PORTABLE DEVICES"; U.S. provisional patent application 61/012,922, filed 12/12/2007, titled "WIRELESS CHARGER WITH POSITION INSENSITIVITY"; U.S. provisional patent application 61/012,924, filed 12/12/2007, titled "CONTROL, REGULATION, AND COMMUNICATION IN CHARGERS"; U.S. provisional patent application 61/015,606, filed 12/20/2007, titled "PORTABLE INDUCTIVE POWER SOURCE"; and U.S. provisional patent application 61/043,027, filed 4/7/2008, titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; this application is also related to copending U.S. patent application 11/757,067 filed 6/1/2007, titled "POWER SOURCE, CHARGING SYSTEM, AND INDUCTIVE RECEIVER FOR MOBILE DEVICES", each of which above applications are herein incorporated by reference.

Field of Invention:

[0002] The invention is related generally to power supplies, power sources, and particularly to a system and method for inductive charging of portable devices.

Background:

[0003] There is currently a need for powering portable or mobile devices for use in commercial, business, personal, consumer, and other applications. Examples of such devices include cellular telephones, personal digital assistants (PDAs), notebook computers, mobile email devices, Blackberry devices, Bluetooth headsets, hearing aids, music players (for example, MP3 players), radios, compact disk players, video game consoles, digital cameras, walkie-talkie or other communication devices, GPS devices, laptop computers, electric shavers, and electric toothbrushes. Most of these devices include a rechargeable internal battery that must be first charged by an external power supply or charger, before the device itself can be used. The power supply typically provides direct current (DC) voltage through a special connector to the device. The power supply can then be disconnected, and the device will continue to run for a short period of time until the battery is depleted. The voltage and power requirements of the different devices vary, and to date there is currently no standardized connector for the devices. As a result of this, each mobile device is invariably sold or distributed bundled with its own charger. The costs associated with these multiple different types and numbers of charger are paid by the consumer indirectly by being incorporated into the prices being charged for the mobile device.

[0004] The rapid increase in the total number and variety of mobile products has meant that most people have several of the above-mentioned devices. In a typical day, that user would have to separately connect their multiple devices to each of their appropriate chargers for charging of each device. In addition, many people find it necessary to charge their devices in different locations such as their offices and cars. Thus, many users have purchased additional chargers for their offices and cars, for use in charging their mobile phones, notebook computers, and music players in those locations.

[0005] It will be evident that the above situation has caused typical users to have a multitude of incompatible devices (i.e. power supplies and chargers) that essentially provide the same function of charging a mobile device, but because of the number and variety that must be kept by the user are inconvenient to use. In many situations, users

simply forget to charge their devices, or else find they need to recharge their device in situations where no appropriate charger is available. This leads to loss of ability to use the device when desired or needed.

[0006] In addition, when traveling way from home, mobile users have a particular problem in that they need to pack and carry the multiple chargers for their devices. In many situations, these chargers are bulkier and heavier than the devices themselves, and use of these devices in foreign countries requires clumsy adaptors, and sometimes voltage converters. This leads to a high degree of inconvenience for the ever-more-mobile consumer.

[0007] In addition, the power connector for the mobile devices is often cheaply manufactured, and a source of mechanical and electrical failure. In many applications, such as toothbrushes or applications where the device is exposed to water and needs to be hermetically sealed, such a physical connection can not be used. Thus an alternative means of powering those types of devices must be used.

[0008] Several products have tried to address this situation. Some companies propose the use of a universal charger that consists of a power supply base unit, and interchangeable tips that both fit into the base unit and in turn fit different devices. The tip includes a customized regulator that sets the voltage required by the particular device. However, a user must carry the multiple tips he or she needs for each of the various devices they have, and then charge each device serially by connecting the device to the power supply. While this product reduces the overall weight of the charging tools the user must carry, the user still needs to carry and exchange the tips to connect to different devices. In addition, the charging of multiple devices simultaneously is often not possible.

[0009] Realizing that a power supply typically contains a transformer for voltage conversion, another approach is to split the transformer into two parts: a first part can contain the first winding and the electronics to drive this winding at the appropriate operating frequency, while the second part consists of a winding where power is received and then rectified to obtain DC voltage. If the two parts are brought into physical proximity to each other, power is transformed from the first part to the second inductively, i.e. by induction, without any physical electrical connection. This is the approach that is used in many electrical toothbrushes, shavers, and other products that are expected to be used in wet environments. However, a common problem with such inductive units is that the windings are bulky, which restricts their use in lightweight portable devices. Furthermore,

to achieve adequate power transfer, the parts must be designed to fit together suitably so that their windings are closely aligned. This is typically done by molding the device casing (for example, an electric toothbrush) and its charger/holder so that they fit together in only one suitable way. However, the molded base and shape of the portable device means they cannot be used in a universal fashion to power other devices.

[0010] Some companies have proposed pad-like charging devices based on inductive concepts, but that also ostensibly allow for different types of devices to be charged. These pads typically include grids of wires in an x and y direction, that carry an electrical current, and that generate a uniform magnetic field parallel to the surface of the pad. A receiver coil wound around a magnetic core lies on the surface of the pad and picks up the magnetic field parallel to the surface, and in this manner energy can be transferred. However, each of these methods suffer from poor power transfer, in that most of the power in the primary is not picked up in the receiver, and thus the overall power efficiency of the charger is very low. In addition, the magnetic cores used for the primary and receiver are often bulky and add to the total cost and size of the system, and limit incorporation into many devices.

[0011] Another point to note is that, while all of the above devices allow a user to charge a device, they also require the charging device or base unit to be electrically connected to a power source, such as a power outlet or a DC source. In many cases, the user may not have access to such a power source such as when traveling, camping, or working in an area without access to power. However, to date, no device has been provided that is portable, and that allows for inductive charging of multiple devices with differing power requirements, and which itself can be intermittently or occasionally charged either by an external power source, or by other means, or that is self-powered or includes its own power source.

Summary:

[0012] A portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices or rechargeable batteries is disclosed herein. In accordance with an embodiment the system comprises 2 parts: The first part is a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. The second part of the system is a

receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device or rechargeable battery. The receiver may comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device.

[0013] In some embodiments the receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device or the charging circuit in the device, or to communicate information to the pad. In additional embodiments, the charging or power system can provide for additional functionality such as communication of data stored in the electronic device or to be transferred to the device. Some embodiments may also incorporate efficiency measures that improve the efficiency of power transfer between the charger and receiver, and ultimately to the mobile device or battery. In accordance with an embodiment the charger or power supply includes an internal battery for self-powered operation. In accordance with other embodiments the charger or power supply can include a solar cell power source, hand crank, or other means of power supply for occasional self powered operation. Other embodiments can be incorporated into charging kiosks, automobiles, trains, airplanes, or other transport and other applications.

[0014] In accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or secondary side; and additional circuits and components that perform specialized tasks, such as mobile device identification, and automatic voltage or power-setting for different devices.

Brief Description of the Figures:

[0015] **Figure 1** shows a pad using multiple transmitter or charger coils in accordance with an embodiment.

[0016] **Figure 2** shows a figure of a circuit diagram in accordance with an embodiment.

[0017] **Figure 3** shows a charging pad using multiple coils in accordance with an embodiment.

[0018] **Figure 4** shows a charging pad using multiple overlapping coil layers in accordance with an embodiment.

[0019] **Figure 5** shows the use of multiple coil types and sizes in overlapping pad layers in accordance with an embodiment.

[0020] **Figure 6** shows a receiver with an integrated battery in accordance with an embodiment.

[0021] **Figure 7** shows a coupling of receiver with a device to be charged or powered in accordance with an embodiment.

[0022] **Figure 8** shows a pad allowing modular or multiple connectivity in accordance with an embodiment.

[0023] **Figure 9** shows a figure of a circuit diagram in accordance with an embodiment.

[0024] **Figure 10** shows a figure of a circuit diagram in accordance with an embodiment.

[0025] **Figure 11** shows a figure of a circuit diagram in accordance with an embodiment.

[0026] **Figure 12** shows a figure of power transfer chart in accordance with an embodiment.

[0027] **Figure 13** shows a figure of a coil layout in accordance with an embodiment.

[0028] **Figure 14** shows a figure of a coil layout in accordance with an embodiment.

[0029] **Figure 15** shows a figure of a charging pad with multiple coils in accordance with an embodiment.

[0030] **Figure 16** shows a figure of a charging pad with movable coils and two devices receiving power or charge in accordance with an embodiment.

[0031] **Figure 17** shows a figure of a circuit diagram in accordance with an embodiment.

[0032] **Figure 18** shows an illustration of a means of stacking coils, in accordance with an embodiment.

[0033] **Figure 19** shows a figure of a circuit diagram for identification verification in accordance with an embodiment.

[0034] **Figure 20** shows a figure of a circuit diagram for bidirectional communication in accordance with an embodiment.

[0035] **Figure 21** shows a figure of a circuit diagram for output controller in accordance with an embodiment.

[0036] **Figure 22** shows a figure of a circuit diagram for the receiver with regulator in accordance with an embodiment.

[0037] **Figure 23** shows a figure of a circuit diagram for MCU regulation in accordance with an embodiment.

[0038] **Figure 24** shows a figure of a circuit diagram for unidirectional communication in accordance with an embodiment.

[0039] **Figure 25** shows a figure of a circuit diagram for time-based regulation in accordance with an embodiment.

[0040] **Figure 26** shows a high level view of a flyback power supply geometry in accordance with an embodiment.

[0041] **Figure 27** shows an embodiment in which the output voltage to a load is monitored and with changes in the load condition, a chip or a Micro Controller Unit (MCU) varies the frequency or the duty cycle of the FET driver to achieve optimum operation.

[0042] **Figure 28** shows an implementation of a charger in accordance with an embodiment, wherein the primary stage and the receiver stage communicate wirelessly.

[0043] **Figure 29** shows an embodiment that includes Zero Voltage Setting (ZVS).

[0044] **Figure 30** shows an embodiment in which, instead of a digital feedback circuit, an analog circuit based on coupling between a light emitting diode (LED) and a light detector can be used.

[0045] **Figure 31** shows an embodiment in which the opto-coupler is replaced by a Voltage Controlled Oscillator (VCO) and FET and in the primary, the signal is sent to adjust a frequency controller to provide optimum output voltage.

[0046] **Figure 32** shows an embodiment in which the wireless link can be analog or digital or can be integrated into the device to take advantage of existing wireless links in the device.

[0047] **Figure 33** shows a basic schematic for an inductive single coil charging system in accordance with an embodiment.

[0048] **Figure 34** shows the main components of a wireless power/charging system in accordance with an embodiment.

[0049] **Figure 35** shows a typical experimental curve for power transferred and Power Transfer in accordance with an embodiment.

[0050] **Figure 36** shows an embodiment in which a coil mosaic is used to cover the surface area of a pad.

[0051] **Figure 37** shows an embodiment in which the number of drive (and sensing) circuits may be reduced by using electrical or electronic switches.

[0052] **Figure 38** shows an embodiment in which three coil layer printed circuit board (PCB) is arranged to provide a cluster for uniform power in an area using only one coil powered at any given time.

[0053] **Figure 39** shows an embodiment in which the coils are arranged such that by powering only one of the coils in the cluster, any receiver coil placed with a center within any location in the effective area can receive the specified power if the appropriate charger coil is activated.

[0054] **Figure 40** shows an embodiment in which the number of switches required is reduced.

[0055] **Figure 41** shows an embodiment of a multi-charger pad that incorporates a plurality of charging clusters.

[0056] **Figure 42** shows an embodiment that uses a cluster of two layers of three coils and a central coil to create an effective area.

[0057] **Figure 43** shows a mosaic of hexagonal coils with the central port to each coil shown as circles.

[0058] **Figure 44** shows an embodiment of a MEMS pad including the top view.

[0059] **Figure 45** shows an embodiment of a MEMS pad including a segmented MEMS charger pad.

[0060] **Figure 46** shows an embodiment in which one or more regulated power supplies are connected to the charger pad.

[0061] **Figure 47** shows an array of contacts on the surface of a pad in accordance with an embodiment.

[0062] **Figure 48** shows the side view of a MEMS conductive charger pad in accordance with an embodiment.

[0063] **Figure 49** shows an embodiment wherein several regulated power supplies provide power to the pad, to allows charging of several devices simultaneously.

[0064] **Figure 50** shows an alternative embodiment of a pad using a segmented surface.

[0065] **Figure 51** shows an industry standard means that is used for measuring emissions from a product.

[0066] **Figure 52** shows an embodiment which illustrates absorption through a copper layer.

[0067] **Figure 53** shows attenuation values for Copper and Aluminum layers for several thicknesses.

[0068] **Figure 54** shows transmitted power through Copper and Aluminum layers of varying thickness for an incident field at 1 MHz.

[0069] **Figure 55** shows an embodiment which allows for obtaining local alignment independence between coils in the charger and the receiver.

[0070] **Figure 56** show an embodiment in which coil magnets can divided into sections.

[0071] **Figure 57** shows an embodiment in which one or more alignment magnets can be used behind each coil.

[0072] **Figure 58** shows an illustration of a device for inductive power charging that includes an internal battery for self-powered operation, in accordance with an embodiment.

[0073] **Figure 59** shows an illustration of an inductive charger unit with a solar cell power source for self powered operation, in accordance with an embodiment.

[0074] **Figure 60** shows an illustration of an inductive charger unit with an incorporated communications and/or storage unit, in accordance with an embodiment.

[0075] **Figure 61** shows an illustration of a kiosk that incorporates an inductive charger unit in accordance with an embodiment.

[0076] **Figure 62** illustrates some common regular (non-charger) mobile phone holders types, in accordance with an embodiment.

[0077] **Figure 63** illustrates various products for a music player, that includes an external rechargeable battery pack, in accordance with an embodiment.

[0078] **Figure 64** illustrates a multi-function device that includes a hard drive, rechargeable battery, and wireless connectivity, in accordance with an embodiment.

[0079] **Figure 65** illustrates a system for use with a charger case to inductively power or charge a mobile device, in accordance with an embodiment.

[0080] **Figure 66** shows a pad using multiple receiver/energizer coils in accordance with an embodiment.

[0081] **Figure 67** shows, in a multi-charger or power supply where multiple coils are used, such a high heat conductivity layer may be repeated around each coil or cover all areas between the multiple coils, in accordance with an embodiment.

[0082] **Figure 68** shows a similar method that may be used for heat removal from wound coils of other shape and type.

[0083] **Figure 69** shows an embodiment in which the layer can be patterned to provide heat conductivity channels rather than a continuous layer.

[0084] **Figure 70** shows an illustration of the electronics for the PCB coil inductive charger and/or power supply or the inductive receiver as fabricated on the same PCB as the coil, in accordance with an embodiment.

[0085] **Figure 71** shows an embodiment in which magnets placed at the center of a stationary coil or a moving, floating charger and/or power supply coil and the receiver coil can provide a method for alignment of the coils and to achieve this result.

[0086] **Figure 72** shows an embodiment in which two or more magnets that do not cross the center of the coil are used.

[0087] **Figure 73** is an illustration that shows how the magnets may be placed outside the PCB coil area, in accordance with an embodiment.

[0088] **Figure 74** shows an embodiment in which magnetic arc-shaped parts around a circular coil are used.

[0089] **Figure 75** illustrates the use of bar magnets on or around the coil, in accordance with an embodiment.

Detailed Description:

[0090] A portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, rechargeable batteries, and other devices is disclosed herein. In accordance with an embodiment the system comprises two parts: The first part is a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. In some embodiments the pad can also contain various signaling, and switching or communication circuitry, or means of identifying the presence of devices or batteries to be charged or powered. In some embodiments the pad can also contain multiple coils or sections to charge or power various devices or to allow charging or powering of devices or batteries placed anywhere on the pad. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile battery, or other device. The receiver can comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device or battery.

[0091] In some embodiments the receiver can also comprise electronic components or logic to set the voltage and current to the appropriate levels required by the mobile device or battery. In some embodiments, the receiver can also contain circuitry to sense and determine the status of the electronic device or battery to be charged, the battery inside a device, or a variety of other parameters and to communicate this information to the pad. In additional embodiments, the system can provide for additional functionality such as communication of data stored in the electronic device (for example, digital images stored in cameras, telephone numbers in cell phones, songs in MP3 players) or data into the device.

[0092] Embodiments can also incorporate efficiency measures that improve the efficiency of power transfer between the charger or power supply and the receiver, and ultimately to the mobile device or battery. In accordance with an embodiment, the charger or power supply comprises a switch, (for example, a MOSFET device or another switching mechanism), that is switched at an appropriate frequency to generate an alternative current (AC) voltage across a primary coil, and generates an AC magnetic field. This field in turn generates a voltage in the coil in the receiver that is rectified and then smoothed by a capacitor to provide power to a load, with the result being greater efficiency.

[0093] In accordance with other embodiments the coils are mounted such that they can move laterally within the pad and within an area of their segments, while continuing to be connected to their driver electronics placed on the edges of the area. The floating coils and the drive circuit are sandwiched in between thin upper and lower cover layers that act to allow the coils lateral movement while limiting vertical movement. When a receiver is placed on the pad, the pad senses the position of the receiver coil and moves the coils to the right position to optimize power transfer. Magnets can be used to better orient the coils and improve greater power transfer efficiency.

[0094] Additional embodiments are also described herein. For example, in accordance with an embodiment the charging/power supply device includes an internal battery for self-powered operation. In accordance with other embodiments the charging/power supply device can include a solar cell power source, hand crank, or other means of power supply for occasional self powered operation. Other embodiments can be incorporated into charging kiosks, automobiles, computer cases, and other electronic devices and applications.

Inductive Charging System

[0095] While the above mentioned technologies describe various aspects of inductive charging, they do not address the basic requirements that a consumer and manufacturer desire in such a product. These include the following desired features:

- The pad should be able to charge or power a number of devices or batteries with various power requirements efficiently. A typical number may be one to six or even 12 or moredevices or batteries, including four or more low power (up to 5 W) devices or batteries simultaneously. When multiple devices or batteries are being charged, a method for energizing only those coils near a device or battery is preferable.
- The same pad should be able to power low-power devices (mobile phones, PDAs, cameras, game consoles, etc.) or batteries with power requirements of 5 W or less, and higher-power devices such as notebook computers (which often have a power requirement of 60 W or higher) or high power batteries.
- The power transfer efficiency between the primary coil and the receiver should be maximized. Lack of efficiency in the power transfer would necessitate larger and heavier AC to DC power supplies. This would add cost and decrease product attractiveness to customers. Thus methods where the entire pad is energized are not as attractive.

- A simple method for verification of the manufacturer of the receiver, and possibly information for power requirements, should be supported as necessary to ensure product compatibility and to provide means of product registration and licensing.
- The EMI radiation from the system should be minimized, and ideally, the system should radiate little or no EMI with no device present. A charger should preferably not emit any power until an appropriate device or battery is brought close to the charger or power supply itself. In this way, electric power is not wasted, and electromagnetic power is not emitted needlessly. In addition, accidental effects on magnetically sensitive devices such as credit cards, disk drives and such are minimized.
- The pad and the receiver should be reasonably simple to construct, and cost effective. Since both parts can be integrated into mobile devices or batteries, the overall size, weight, and form factor should be minimized.

[0096] As used herein, the term "charger" can refer to a device for supplying power to a mobile or stationary device for the purpose of either charging its battery, operating the device at that moment in time, or both. For example, as is common in portable computers, the power supply can operate the portable computer, or charge its battery, or accomplish both tasks simultaneously. The charger may include circuitry for driving a coil appropriately to generate an AC magnetic field, power or current sense or regulation circuitry, microcontrollers, and means of communication with a receiver, battery, or device. It may also be able to communicate data with a device or battery or perform other functions. As used herein, the term 'receiver' means an inductive coil or coils and the circuitry for rectification and smoothing of received current, any possible control or communication circuitry for communication with the charger and regulation of power and any possible circuit for managing charging or measurement of status of a battery or a device to be charged or powered such as a charge management circuit, fuel gauge, current, voltage, or temperature sensor, etc. The receiver can also incorporate appropriate circuitry for data transfer between a device or battery and the charger. In accordance with an embodiment, the mobile device charger and/or power supply can have any suitable configuration, such as the configuration of a flat pad. The power received by the mobile device from the mobile device charger/power supply (such as the primary in the mobile device charger) can be rectified in the receiver and smoothed by a capacitor before being connected to the rechargeable battery which is represented by the load in the figures. To ensure proper charging of the battery, a regulator or charge

management circuit can be placed between the output of the output of the rectifier/capacitor stage and the battery. This regulator or charge management circuit can sense the appropriate parameters of the battery (voltage, current, capacity), and regulate the current drawn from the receiver appropriately. The battery can contain a chip with information regarding its characteristics that can be read out by the regulator or charge management circuit. Alternatively, such information can be stored in the regulator or charge management circuit for the mobile device to be charged, and an appropriate charging profile can also be programmed into the regulator or charge management circuit.

[0097] **Figure 1** shows a pad using multiple receiver/energizer coils in accordance with an embodiment. In its simplest format, the mobile device or battery charger or power supply preferably has a substantially flat configuration, such as the configuration of a pad 100, and comprises multiple coils or sets of wires 104. These coils or wires can be the same size as or larger than the coils or wires in the mobile devices, or battery and can have similar or different shapes, including for example a spiral shape. For example, for a mobile device charger or power supply designed to charge or provide power to up to four mobile devices of similar power (up to 10 W each) such as mobile phones, MP3 players, batteries, etc., four or more of the coils or wires will ideally be present in the mobile device or battery charger. The charger or power supply pad can be powered by plugging into a power source such as a wall socket or itself be powered or charged inductively. The pad can also be powered by another electronic device, such as the pad being powered through the USB outlet of a laptop or by the connector that laptops have at the bottom for interfacing with docking stations, or powering other devices. The pad can also be incorporated into a docking station, such as may be used by notebook computers or built into a table or other surface.

[0098] In accordance with an embodiment, a mobile device can include a receiver that includes one or more coils or wires to receive the power from the mobile device charger or power supply. As described in further detail below, the receiver can be made part of the battery in the mobile device or of the shell of the mobile device. When it is part of the mobile device shell, the receiver can be part of the inside surface of the mobile device shell or of the outside surface of the mobile device shell. The receiver can be connected to the power input jack of the mobile device or can bypass the input jack and be directly connected to the battery or charge management circuit inside the mobile device. In any of these configurations, the receiver includes one or more appropriate coil

or wire geometries that can receive power from the mobile device charger or power supply when it is placed adjacent to the mobile device charger or power supply. In accordance with an embodiment, the coils in the mobile device charger or power supply and/or the coils in the mobile devices or battery can be printed circuit board (PCB) coils, and the PCB coils can be placed in one or more layers of PCB.

[0099] In some embodiments, the charger or power supply can also itself be built into a mobile device or battery. For example, a laptop computer or other portable or mobile device can incorporate a charger or power supply section so that other mobile devices can be charged or powered as described above. Alternatively, using the same set of coils or wires, or a separate set of coils or wires, any mobile device or battery can itself be used as an inductive charger or power supply to power or charge other mobile devices or batteries.

[00100] In accordance with an embodiment, the mobile device charger/power supply or pad, and the various mobile devices or batteries, can communicate with each other to transfer data. In one embodiment, the coils in the mobile device charger/ power supply that are used for powering or charging the mobile device, or another set of coils in the same PCB layer or in a separate layer, can be used for data transfer between the mobile device charger/power supply and the mobile device to be charged or powered or the battery directly. Techniques employed in radio and network communication, such as radio frequency identification (RFID), Bluetooth, WiFi, Wireless USB, or others can be used. In one embodiment a chip connected to an antenna (for example, the receiver coil or separate data antenna) or another means of transfer of information can be used to provide information about, for example, the presence of the mobile device or battery, its authenticity (for example its manufacturer code) and the devices' charging/power requirements (such as its required voltage, battery capacity, and charge algorithm profile).

[00101] In accordance with an embodiment, a typical sequence for charger/power supply operation is as follows:

- The mobile device charger or power supply can be in a low power status normally, thus minimizing power usage.
- Periodically, each of the coils (or a separate data coil in another PCB layer) is powered up in rotation with a short signal such as a short radiofrequency (RF) signal that can activate a signal receiver in the receiver such as an RF ID tag or a circuitry connected to the receiver coil.

- The mobile device charger/power supply then tries to identify a return signal from any mobile device, battery (or any receiver) that may be nearby.
- Once a mobile device, or battery (or a receiver) is detected, the mobile device charger or power supply and the mobile device or battery to proceed to exchange information.
- This information can include a unique ID code that can verify the authenticity and manufacturer of the charger or power supply and mobile device or battery, the voltage requirements of the battery or the mobile device, and the capacity of the battery. For security purposes or to avoid counterfeit device or pad manufacture, such information can be encrypted, as is common in some RFID tags or other verification systems.

[00102] In accordance with various embodiments, other protocols such as Near Field Communications (NFC) or Felica can be used, wherein the circuitry containing the ID and the necessary information is powered either by the mobile device or battery or remotely by the mobile device charger or power supply. Depending on the particular implementation needs, Bluetooth, WiFi, Wireless USB, and other information transfer processes can be used. Additional information regarding the charging profile for the battery can also be exchanged and can include parameters that are used in a pre-programmed charge profile stored in the mobile device or battery charger. However, the information exchanged can be as simple as an acknowledge signal that shows the mobile device charger that a mobile device or rechargeable battery is present. The charger or power supply can also contain means for detection and comparison of the strength of the signal over different locations on the charger or power supply. In this way, it can determine the location of the mobile device or battery on the charger or power supply, and then proceed to activate the appropriate region for charging or powering.

[00103] In some embodiments that require greater simplicity, no communication need take place between the mobile device charger or power supply and the mobile device or battery. In some embodiments the mobile device charger or power supply can sense the mobile device or battery by detecting a change in the conditions of a resonant circuit in the mobile device charger or power supply when the mobile device or battery is brought nearby. In other embodiments the mobile device or battery can be sensed by means of a number of proximity sensors such as capacitance, weight, magnetic, optical, or other sensors that determine the presence of a mobile device or battery near a coil in the mobile device or battery charger or power supply. Once a mobile device or battery is

sensed near a primary coil or section of the mobile device or battery charger or power supply, the mobile device charger or power supply can then activate that primary coil or section to provide power to the receiver coil in the mobile device's battery, shell, receiver module, battery, or the device itself.

Inductive Charging Circuit

[00104] Each mobile device and its battery has particular characteristics (voltage, capacity, etc.). In order to facilitate these different devices or batteries with a single universal mobile device charger or power supply, several circuit architectures are possible, some of which are described in further detail below.

[00105] **Figure 2** shows the main components of a typical inductive power transfer system 110. The circuit illustrated is used to illustrate the principle of inductive power transfer and is not meant to be limiting to an embodiment. In accordance with an embodiment, the charger 112 comprises a power source 118, and a switch T 126 (which can be a MOSFET or other switching mechanism) that is switched at an appropriate frequency to generate an AC voltage across the primary coil Lp 116 and generate an AC magnetic field. This field in turn generates a voltage in the coil 120 in the receiver 114 that is rectified and then smoothed by a capacitor to provide power 122 to a load Rl 124. For ease of use, a receiver can be integrated with a mobile device, such as integrated inside the mobile device or attached to the surface of the mobile device during manufacture, to enable the device to receive power inductively from a mobile device charger or integrated into, or on its battery.

[00106] In accordance with an embodiment, the circuit shown in **Figure 2** can receive energy fed to it from a power source, store the energy alternately in the inductor and the timing capacitor (much like a tank stores liquid), and subsequently produce an output as a continuous alternating current (AC) wave. As the voltage is applied to the primary side, the tank circuit supplies the energy to the receiver. One of the benefits of such a design is that the timing capacitor in the circuit can be easily replaced. For example, if a relatively higher value for capacitance (referred to in some instances as a timing capacitance) is used, then the frequency of operation is lowered. This increases the on-time for the circuit, and provides longer power transfer and current through the transformer, and thus more power. As such a higher value of capacitance can be used for high power applications. Conversely, if a relatively lower value for capacitance is used,

then the frequency of operation is increased. This reduces the on-time and provides less power transfer and current through the transformer, and thus less power. Thus, a lower value of capacitance can be used for low power applications. Replacing the timing capacitance can be easily handled during manufacturing to tune the power requirement on a macro level, i.e. to get the output into an appropriate range for the chosen application. Additional techniques can then be used to set the voltage output on a more accurate basis.

[00107] The mobile device or its battery typically can include additional rectifier(s) and capacitor(s) to change the AC induced voltage to a DC voltage. This is then fed to a regulator/charge management chip which includes the appropriate information for the battery and/ or the mobile device. The mobile device charger provides power and the regulation is provided by the mobile device. The mobile device or battery charger or power supply, after exchanging information with the mobile device or battery, determines the appropriate charging/powering conditions to the mobile device. It then proceeds to power the mobile device with the appropriate parameters required. For example, to set the mobile device voltage to the right value required, the value of the voltage to the mobile device charger can be set. Alternatively, the duty cycle of the charger switching circuit or its frequency can be changed to modify the voltage in the mobile device or battery. Alternatively, a combination of the above two approaches can be followed, wherein regulation is partially provided by the charger or power supply, and partially by the circuitry in the receiver.

Inductive Charger Pad

[00108] To allow the operation of the mobile device or battery charger or power supply regardless of position of the mobile device or battery, the total area of the mobile device or battery charger or power supply can be covered by coils or by another wire geometry that creates magnetic field.

[00109] **Figure 3** shows a charging pad using multiple coils in accordance with an embodiment. As shown in **Figure 3**, in accordance with an embodiment the pad 140 is largely covered with individual receiver coils 144.

[00110] **Figure 4** shows a charging pad using multiple overlapping coil layers in accordance with an embodiment. This embodiment addresses the problem of voids between the multiple coils. As shown in **Figure 4**, any areas of the pad 150 with minimal

magnetic field between a first set of coils 152 can be filled by a second set of coils 154, so that the coils are tiled such that the centers of this coil array fill the voids in the primary set. This second set can be at a different layer of the same PCB, or in a different PCB. In each of these geometries, the sensing circuitry can probe each location of a coil in a raster, predetermined, or random fashion. Once a mobile device or battery on or near a coil is detected, that coil is activated to provide power to the receiving unit receiver of the appropriate device.

[00111] It can be seen from the above example that by providing more layers of the PCB with coils, or by providing coils of different geometry or size, one can obtain as much resolution or coverage as desired.

[00112] In accordance with an embodiment, to power mobile devices or batteries with power requirements that exceed maximum powers attainable by typical coils in a surface, the mobile device or battery, during its hand shake and verification process can indicate its power/voltage requirements to the mobile device or battery charger or power supply. Several geometries for achieving power/voltage levels otherwise not attainable from a single primary coil of the mobile device or battery charger or power supply are possible.

[00113] In accordance with one embodiment of the system geometry, the power receiving unit of the mobile device or battery has several coils or receiving units that are connected such that the power from several primary coils or sets of wires of the mobile device or battery charger or power supply can add to produce a higher total power. For example, if each primary coil is capable of outputting a maximum of 10 Watts, by using six primary coils and six receiver coils, a total output power of 60 Watts can be achieved. The number of primary and receiver coils need not be the same, and a large receiver coil (receiving unit) that is able to capture the majority of magnetic flux produced by 6 or other number of primary coils or a large primary coil powering six or another number of receiver coils can achieve the same effect. The size and shape of the multiple primary coils and receiver coils also do not need to be the same. Furthermore, neither set of primary and receiver coils need to be in the same plane or PCB layer. For example, the primary coils in the examples shown above can be dispersed such that some lay on one PCB plane and the others in another plane.

[00114] In accordance with another geometry, the PCB of the mobile device or battery charger or power supply has multiple layers, wherein coils or wire patterns of

certain size and power range can be printed on one or more layers and other layers can contain coils or wire patterns of larger or smaller size and power capability. In this way, for example, for low power devices, a primary from one of the layers will provide power to the mobile device or battery. If a device or battery with higher power requirements is placed on the pad, the mobile device or battery charger or power supply can detect its power requirements and activate a larger coil or wire pattern with higher power capabilities or a coil or wire pattern that is connected to higher power circuitry. One may also achieve similar results by using a combination of the different processes and geometries described above.

[00115] **Figure 5** shows the use of multiple coil types and sizes in overlapping pad layers in accordance with an embodiment. As shown in **Figure 5**, the mobile device or battery charger or power supply or pad 160 can comprise two overlapping layers with a first layer 162 containing low power coils, and a second layer 164 containing high power coils.

Inductive Charging Receiver

[00116] As described above, the inductive charging or power supply pad is used to power a receiver, which in turn is used to power or to charge a portable or mobile device or battery. In accordance with one embodiment of the receiver, the power from the mobile device or battery charger or power supply is emitted at a magnitude that is sufficient to power any foreseeable mobile device or battery (such as 5 W or 10 W for small mobile devices or batteries). The receiver that is appropriate for each mobile device or battery has a power receiving part that when matched to the mobile device or battery charger or power supply is able to receive sufficient power for the mobile device or battery. For example a receiver for a mobile phone requiring 2.5 W can be a coil with certain diameter, number of turns, wire width, etc. to allow receipt of the appropriate power. The power is rectified, filtered, and then fed into the battery or power jack of the device. As discussed above, a regulator or charge management circuit can be used before the power is provided to the battery or the mobile device.

[00117] To save energy, the power emitted by the mobile device or battery charger or power supply can be regulated. It is desirable to regulate the power emitted by the charger or power supply because if the charger or power supply is emitting 10 W of power and the receiver is designed to receive 5 W, the rest of the emitted power is wasted. In

one embodiment, the receiver or the mobile device can, through an electrical (such as RF), mechanical, or optical method, inform the charger or power supply about the voltage/current characteristics of the device or battery. The primary of the charger or power supply in the circuit diagrams shown above then can be driven to create the appropriate voltage/current in the receiver. For example, the duty cycle of the switch in that circuit can be programmed with a microprocessor to be changed to provide the appropriate levels in the receiver.

[00118] In accordance with an embodiment, the programming can be performed by a look up table in a memory location connected to a microprocessor or by using an algorithm pre-programmed into the microprocessor. Alternatively, the frequency of the switch can be changed to move the circuit into, and out of, resonance to create the appropriate voltage in the receiver. In an alternate geometry, the voltage into the circuitry in the primary can be changed to vary the voltage output from the receiver. Furthermore, the induced voltage/current in the mobile device can be sensed and communicated to the charger to form a closed-loop, and the duty cycle, frequency, and/or voltage of the switch can be adjusted to achieve the desired voltage/current in the mobile device.

[00119] In accordance with an embodiment, the receiver is built onto or into the battery for the mobile device. The receiver can include one or more coils or wires shaped to receive power from the charger or power supply. The one or more coils or wires can be either printed on one or more PCBs, or formed from regular wires. As described above, the receiver can also contain rectifier(s) and capacitor(s) to produce a cleaner DC voltage. This output can be directly, or through a current limiting resistor, connected to one of the contacts on the battery. To avoid overcharging the battery, a battery regulator or charge management chip can also be used. This circuit then measures the various parameters of the battery (voltage, degree of charging, temperature, etc.) and uses an internal program to regulate the power drawn from the circuit to ensure over-charging does not occur. The circuit can also include LEDs to show the receiver being in the presence of a magnetic field from the charger, complete charge LEDs and/or audible signals.

[00120] In typical commercial and end-user applications, such as in cell phones, PDAs, and MP3 players, the battery can be incorporated into the battery pack or the device by the original equipment manufacturer (OEM), or as an after-market size and shape compatible battery pack that can replace the original battery pack. The battery compartment in these applications is typically at the bottom of the device. The user can

open the battery compartment, take out the conventional battery, replace it with a modified battery in accordance with an embodiment, and then replace the battery lid. The battery can then be charged inductively when the mobile device is placed adjacent a mobile device charger.

[00121] To enhance the ability of the receiver to receive power, it may be desirable to minimize the distance between the charger's primary coil and the receiver's coil or wire. In order to achieve this, in accordance with an embodiment the receiver's coil or wire can be put on the outside of the battery pack.

[00122] **Figure 6** shows a battery with an integrated receiver in accordance with an embodiment. As shown in **Figure 6**, the receiver 170 comprises the battery 182, together with the receiver coil 172, and any rectifiers 174, capacitors 176, regulators or charge management chips 180 necessary for proper operation of the charging receiver. If the battery compartment lid of the device prevents a power receiving light emitting diode (LED) to be seen, the lid can itself be replaced with a see-through lid or a lid with a light pipe that will allow the user to see the charging indicator LED when the mobile device is placed adjacent to the charger.

[00123] In an alternative embodiment, the receiver battery can include a mechanical, magnetic, or optical method of alignment of the coils or wires of the charger and mobile device for optimum power transfer. In accordance with an embodiment, the center of the primary in the charger contains a magnet such as a cylinder or disk or ring with the poles parallel to the charger surface and the magnetic field perpendicular to the charger surface. The receiver also contains a magnet or magnetic metal part of a similar or different shape behind or in front of the coil or wire receivers. When the mobile device or battery is placed on or adjacent to the charger or power supply, the magnets attract and pull the two parts into alignment with the centers of the two coils or wires aligned. The magnets do not need to be especially strong to actively do this. Weaker magnets can provide guidance to the user's hand and largely achieve the intended results. Alternatively, audible, or visual signs (for example an LED that gets brighter as the parts are closer aligned), or mechanical means (dimples, protrusions, etc.) can be used for alignment.

[00124] In accordance with another embodiment, the coil or wires and the magnet in the charger or power supply are mechanically attached to the body of the charger or power supply such that the coil can move to align itself appropriately with the mobile

device or battery when it is brought into close proximity to the charger or power supply. In this way, an automatic alignment of coils or wire patterns can be achieved.

[00125] In another embodiment, the receiver electronics described above are preferably made from flexible PCB which can be formed into a curved shape. Such a PCB can be placed on the surface of a battery pack, including one that is not flat, or that has a curved shape. The curve on the battery or back of a mobile device battery lid can be matched to a curved primary in the mobile device or battery charger or power supply and be used for alignment. One example of usage of this embodiment can be for example flashlights that have circular handles: the batteries can be charged with coils on the side of circular batteries, or circling the cylindrical battery. Similarly, the mobile device or battery charger or power supply can have a curved shape. For example, the charger or power supply surface can be in the shape of a bowl or some similar object. A mobile device or battery that may have a flat or curved back can be placed into the bowl. The shape of the bowl can be made to ensure that the coil of the mobile device or battery is aligned with a primary coil to receive power.

[00126] In another embodiment, the primary can be incorporated into a shape such as a cup. A mobile device can be placed into the cup standing on end and the receiver can be built-in to the end of the mobile device (such as a mobile phone) or battery or on the back or circumference of the device or battery. The receiver can receive power from the bottom or wall of the cup.

[00127] In another embodiment, the primary of the charger can have a flat shape and the mobile devices or battery can be stood up to receive power. The receiver is built into the end of the device or battery in this case and a stand or some mechanical means can be incorporated to hold the device or battery while being charged.

[00128] In another embodiment, the charger or power supply can be made to be mounted on a wall or a similar surface, vertically or at an angle (such as on a surface in a car), so as to save space. The charger or power supply can incorporate physical features, magnets, fasteners or the like to enable attachment or holding of mobile devices to be charged. The devices or batteries to be charged or powered can also incorporate a retainer, magnet, or physical shape to enable them to stay on the charger or power supply in a vertical, slanted, or some other position. In this way, the device or battery can be charged or powered by the primary while it is near or on it.

[00129] For those applications where the lid of the battery compartment or the bottom part of the mobile device is made from a metal, a replacement non-metallic lid or backing can be used. Alternatively, the coil can be attached to the outside of the metal surface. This allows electromagnetic (EM) fields to arrive at the power receiver coil or wires. The rest of the receiver (i.e. circuitry) can be placed behind a metal for the receiver to work. In some other applications where the battery has metal parts, these parts may interfere with the EM field and the operation of the coil in the receiver. In these cases, it may be desirable to provide a distance between the metal in the battery and the coils. This can be done with a thicker PCB or battery top surface. Alternatively, to provide additional immunity, ferrite material (such as those provided by Ferrishield Inc.) can be used between the receiver and the battery to shield the battery or device from the EM fields. These materials can be made so as to be thin, and then used during the construction of the integrated battery/receiver.

[00130] In accordance with another embodiment, the receiver in the battery or mobile device also includes a means for providing information regarding battery manufacturer, required voltage, capacity; current, charge status, serial number, temperature, etc. to the charger. In a simplified embodiment, only the manufacturer, required voltage, and/or serial number is transmitted. This information is used by the charger or power supply to adjust the primary to provide the correct charge or power conditions. The regulator or charge management chip in the receiver can then regulate the current and the load to charge the battery correctly and can end charge at the end. In another embodiment, the receiver can control the charging process fully depending on the time dependent information on battery status provided to it. Alternatively, the charging process can be controlled by the charger in a similar manner. As described above, the information exchange between the charger and the receiver can be through an RF link or an optical transmitter/ detector, RFID techniques, Near-Field Communication (NFC), Felica, Bluetooth, WiFi, or some other method of information transfer. Similarly, the receiver can send signals that can be used by the charger to determine the location of the receiver to determine which coil or section of the charger or power supply to activate. The communication link can also use the same coil or wires as antenna for data transfer or use a separate antenna. In some embodiments the received can use the actual capabilities of the mobile device (for example, the built-in Bluetooth or NFC capabilities of mobile phones) to communicated with the charging or power supply pad.

[00131] As described above, in accordance with some embodiments the receiver can be integrated into the body of the device or battery itself at a location that may be appropriate and can be exposed to EM radiation from outside. The output of the receiver can be routed to the electrodes of the battery internally inside the device and appropriate circuitry inside the device can sense and regulate the power. The device can include LEDs, messages, etc. or audible signs that indicate to the user that charging is occurring or complete or indicate the strength of the received power (i.e. alignment with a primary in the charger) or the degree of battery charge. In other embodiments, the receiver is built into an inner or outer surface of a component that is a part of the mobile device or battery's outer surface where it is closest to the charger. This can be done as original equipment or as an after-market item. The component can be the lid of the battery pack or the bottom cover of the mobile device. In yet other embodiments, the receiver can be integrated into the back or front of the battery compartment or an interchangeable shell for the mobile device for use in after-market applications. For example, in a mobile phone application, the back battery cover or shell can be removed and replaced with the new shell or battery cover with the receiver built in.

[00132] **Figure 7** shows a coupling of receiver with a device to be charged or powered in accordance with an embodiment. As shown in **Figure 7**, the original mobile phone setup 190 includes a device 192 with shell 194 and power jack 196. The after-market modification 200 replaces the original shell with a combination shell 210 that includes the necessary receiver coils and battery couplings. The contacts from this circuitry can then make direct contact to the battery electrodes inside the mobile device or to some contact points inside the mobile device if such contacts exist or become provisioned by the device manufacturer during manufacture. Alternatively, the receiver may be a component (such as a shell) that has a connector that plugs into the input power jack of the mobile phone or electrodes of a battery. The receiver can be fixed to, or detachable from, the mobile device or battery. This can be achieved by having a plug that is attached either rigidly or by a wire to the receiver (shell). Alternatively, the replacement receiver (shell) can be larger than the original shell and extend back further than the original shell and contain the plug so that when the receiver (shell) is attached, simultaneously, contact to the input power jack is made. Alternatively, the receiver (shell) can have a pass-through plug so that while contact is made to this input power connector, the connector allows for an external regular power supply plug to be also used as an

alternative. Alternatively, instead of a pass-through, this part can include a power jack in another location in the back so that a regular power supply can be used to charge the battery. In cases where the connector to the device performs other functions such as communication to the device, a pass-through connector can allow communication/ connectivity to the device.

[00133] In accordance with another embodiment, the replacement receiver (i.e. the replacement shell) or the plug in unit, in addition to the power receiver components and circuitry, can include additional circuitry that can provide further functionalities to the mobile device. These can include, for example, the ability to exchange data through Bluetooth, WiFi, NFC, Felica, WiMax, RFID, or another wireless or optical mechanism. It can also provide extended functionalities such as Global Positioning System (GPS) location information, flashing lights, flashlight, or other decorative or electronic functions. As described above, various methods for improving coil alignment, or location, battery manufacturer, or battery condition information transfer can also be integrated into the receiver or replacement shell.

[00134] In another embodiment, the receiver is supplied in the form of a separate unit that is attached to the input jack of the mobile device or battery or integrated into a receiver protective skin for the mobile device. Many leather or plastic covers for mobile phones, cameras, and MP3 players already exist. The primary purpose of these covers is to protect the device from mechanical scratches, shocks, and impact during daily use. However, they typically have a mere decorative or advertising application. In accordance with one embodiment, the receiver is formed of a thin PCB with the electronics formed thereon, and the receiver coil or wire that is attached to the back of the device and plugs into the input jack similar to the shell described above. Alternatively, it can be connected through a flexible wire or flexible circuit board that is routed to a plug for the input power jack.

[00135] In accordance with another embodiment, the receiver can be a separate part that gets plugged into the input jack during charging and is placed on the charger and can then be unplugged after charging is finished.

[00136] In another embodiment, the receiver is built in the inside or outside surface or in between two layers of a plastic, leather, silicone, or cloth cover for the mobile device and plugs in or makes contact to the contact points on the device.

[00137] It will be noted that certain devices such as notebooks and some music players have metal bottom surfaces. The methods described above for changing the back surface or use of a plug in the mobile device or a secondary skin with an integrated receiver is particularly useful for these applications. As described previously, the effect of the metal surface can also be minimized, if necessary, by increasing the distance between the wires of the receiver and the metal surface or by placing a ferrite layer in between the receiver and the metal bottom.

[00128] It is also noted that the use of methods such as curving the receiver or integrating magnets, LEDs, audio signals or messages, etc. for alignment, or methods for location, manufacturer or charging condition identification, as described above are possible with all embodiments of an embodiment described above. In any of the above cases, the charger or power supply can contain lights, LEDs, displays, or audio signals or messages to help guide the user to place the mobile device or battery on a primary coil for maximum reception, to show charging is occurring, and to show the device is fully charged. Displays to show how full the battery is or other information can also be incorporated.

Flexible/Modular Charging Pad

[00129] In accordance with an embodiment a flexible mobile device charger or power supply is provided in the shape of a pad that can be folded or rolled up for carrying. In one implementation of an embodiment, the electronics of the charger or power supply are placed on a thin flexible PCB or the coils are made of wires that can be rolled up or shaped. The electronics components made of silicon chips, capacitors, resistors and the like may not be flexible but take up very little space. These rigid components can be mounted on a flexible or rigid circuit board, while the main section of the pad containing the coils or wires for energy transfer can be made to be flexible to allow conformity to a surface or to be rolled up. Thus the pad resembles a thin mouse pad or the like.

[00130] In some cases, it may be advantageous to the user to have a mobile device charger or power supply that is extendible in functionalities. The cases include but are not limited to:

- A user may purchase a mobile device or battery charger or power supply for charging or powering a single low power device or battery but, at a later stage, may want to extend the capability to charge or power more devices or batteries

simultaneously.

- A user may purchase a mobile device or battery charger or power supply for charging or supplying power to one or more low power devices or batteries but may want to charge or supply power to more low power or high power devices or batteries.
- A user may buy a mobile device or battery charger or power supply that can charge or supply power to one or more low-power or high-power devices or batteries and later wish to have the communication or local storage, or a rechargeable battery, or means of power generation such as solar panels or some other capability, added to the charger or power supply.

[00131] In all of the cases above and others, it can be useful to have a modular approach to expand the capabilities of the mobile device or battery charger or power supply.

[00132] **Figure 8** shows a pad 220 in accordance with an embodiment that allows for modular or multiple connectivity. In this case, the user can purchase a first unit 222 that is powered by an electric outlet 224. However, interconnects 226 for power and data are provided so that additional units 228, 230 can simply fit or plug into this first one directly or indirectly and expand the capabilities as the customer's needs grow. Data communications and storage units 234 can also be attached in a modular fashion. This approach would enable the customer to use the technology at a low cost entry point and grow his/her capabilities over time.

[00133] Some of the electronics devices that can benefit from these methods include: mobile phones, cordless phones, personal data assistants (PDAs), pagers, walkie-talkies, other mobile communication devices, mobile electronic mail devices, Blackberry's, MP3 players, CD players, DVD players, game consoles, headsets, Bluetooth headsets, hearing aids, head-mounted displays, GPS units, flashlights, watches, cassette players, laptops, electronic address books, handheld scanning devices, toys, electronic books, still cameras, video cameras, film cameras, portable printers, portable projection systems, IR viewers, underwater cameras or any waterproof device, toothbrushes, shavers, medical equipment, scientific equipment, dental equipment, military equipment, coffee mugs, kitchen appliances, cooking pots and pans, lamps or any battery, DC, or AC operated device.

[00134] In addition, inductive power transfer can provide power to devices that are not so far battery operated. For example, a mobile device charger or power supply in the shape of a pad placed on a desk or a kitchen table can be used to power lamps or kitchen appliances. In one embodiment for the use in a kitchen, a flat charger, or power supply such as a pad, placed on or built into a counter can allow the chef to place devices on the charger or power supply to be inductively charged or powered during use and simply place them away after use. The devices can be, for example, a blender, mixer, can opener, or even pot, pan, or heater. This can eliminate the need for a separate cooking and work area. It will be noted that placement of a metal pan close to the inductive pad can directly heat the pan and the contents while keeping the charger or power supply surface cool. Due to this reason, inductive kitchen ranges have been commercialized and shown to be more efficient than the electric ranges that work by resistive heating of a coil.

[00135] In another embodiment, rather than direct heating of metal pans by nearby inductive fields, cooking pans may include a receiver and heating or even cooling elements. Once placed on a charger, the pan will heat up or cool down as desired by a dial or the like on the pan allowing precise temperature control of the pan and the contents.

[00136] Similarly, in an office or work area setting, if a charger or power supply is readily available for charging or powering mobile devices or batteries, it can also be used to power up lamps for illumination of the desk or used to power or charge office appliances, such as fax machines, staplers, copiers, scanners, telephones, and computers. In one embodiment, the receiver can be built into the bottom of a table lamp and the received power is used to power the incandescent or LED lamp.

[00137] In another embodiment, a mug, cup, glass, or other eating appliance such as a plate can be fitted with a receiver at its bottom. The received power can be used to heat the mug, etc. with a heating coil thus keeping beverages or food warm to any degree desired. Furthermore, in accordance with an embodiment, by use of devices such as thermoelectric coolers the contents can be cooled or heated as desired.

[00138] Similarly, many children's toys often run out of battery power due to extended use or simple forgetfulness to turn the device off. Often these batteries are included inside a battery compartment that for safety reasons can only be opened by a screwdriver. Inclusion of the receiver into toys or batteries inside can reduce the need to change the device batteries and allow recharging with a much simpler method.

[00139] In another implementation, the receiver can be built into medical devices or their batteries that are implanted or inserted in the body. Since batteries in these devices such as pace makers, cochlear implants, hearing aids, or other monitoring devices may need periodic charging, inductive power transfer can provide an ideal non-contact method for charging and testing the performance of the devices (i.e. check up) or downloading data that the devices have logged.

[00140] In another implementation, some active RFID tags include batteries that can send out information about the status or location of a package or shipment. An inexpensive method for charging these tags is to include a receiver with each tag. Thus, a charger can be used to power or charge these RFID tags.

[00141] It will be noted that the effective working distance of the inductive charger is dependent on the power and the frequency of the source and the size and geometry of the coil. By increasing the frequency to several or tens of MHz, one can obtain a working distance of several inches or feet depending on the application for the technology. It will also be noted that any of the above embodiments that eliminate the input power jack are especially important because they add to product reliability by removing a source of mechanical or environmental failure. In addition, elimination of the jack is imperative for water proof applications and for extra safety.

Efficiency Enhancements through Coil Circuit

[00142] In accordance with an embodiment, in order for the power efficiency to be maximized and to minimize losses in the coil, the coils should be manufactured to have as low a resistance as possible. This can be achieved by use of more conductive material such as gold, silver, etc. However the costs of these materials are sometimes prohibitive. In practice, reduced resistivity can be obtained by using thicker copper-clad PCBs or wider tracks. Most common PCBs use 1-2 oz copper PCBs. In accordance with some embodiments the coil PCB used for the wireless charger can be made from PCBs clad with between 2 and 4, or even 6 oz copper. The process of manufacture of the PCB can also be optimized to achieve higher conductivity. For example, sputtered copper has a higher conductivity than rolled copper and is typically better for this application. In operation, the coil and the circuitry demonstrate a resonance at a frequency determined by the parameters of the design of the coil (for example, the number of windings, coil thickness, width, etc.). Previous work has concentrated on circuits driven by square

waves with a MOSFET. This approach has the disadvantage that since a square wave is not a pure sinusoid, it produces harmonics. These harmonics are undesirable because:

- The PCB coil produces optimum power transfer efficiency at a particular frequency. The harmonics in the primary signal are not transferred as efficiently and decrease the overall system efficiency.
- The rapid voltage change in the leading and falling edge of the square wave creates oscillations that create further harmonics resulting further EMI.
- The harmonics radiated by the primary create higher frequency components that contribute to the EMI that is more radiative (due to higher frequency). It is desirable to limit the frequency range of the operation of the overall system to as low a frequency as possible while maintaining the other requirements of the system (such as sufficient working distance, etc.), so these harmonics must be avoided.
- At the instance of switch turn-on and turn-off, the change in the in-rush current to the coil causes huge voltage swings across the coil for a short period of time. All the power is transferred to the receiver during these times that are short.

[00143] Previous attempts to achieve 90% transfer efficiency with PCB coil primary and receiver have used a laboratory power supply to drive their circuit. While this approach has demonstrated the higher efficiency that can be achieved with a sinusoidal voltage on the coil, such power supplies are complex, costly, and too large to be able to be used for any practical charger application. In accordance with an embodiment, a capacitor is added in parallel to the drain/source contacts of the MOSFET.

[00144] **Figure 9** shows a figure of a circuit diagram 240 in accordance with an embodiment. The coil in the wireless charger system is driven by switching the FET at the resonance frequency of the circuit when the receiver is present. Without the receiver nearby, the circuit is detuned from resonance and radiates minimal EMI. The capacitor 244 acts as a reservoir of energy that discharges during switch off time and enhances energy transfer. As with the examples described above, changing the value of the capacitance allows for tuning the power and efficiency levels on a lower-power/ high-power basis, and additional features and techniques can be used to fine tune the power output for particular devices.

[00145] The circuit designs illustrated in **Figure 2** and **Figure 9** use a zero-crossing power supply. Briefly, in a zero-crossing power supply, when the transistor in the primary coil is first turned on, electrical current passes through the primary coil and the transistor

to ground. When the transistor is then turned off, the voltage level at the transistor swings high (for example, if the input voltage is 5V, then the voltage level may swing to 10V, or even 100V). A non-zero-crossing circuit allows the current to drop to zero, before the cycle is restarted. A forward mode circuit can then use an inductor in series with the load to revive the current and charge up the inductor, while a diode allows charging in both directions (when full phase AC is used).

[00146] In a traditional transformer design, zero-crossing is not used, since it invariably results in lower efficiency compared to non-zero designs, at least with higher power or ferrite cores. This is primarily because the traditional ferrite cores act as capacitors and store energy, which in turn reduces the circuit efficiency. As described above, in accordance with an embodiment, when a non ferrite coil there is no magnetic flux, so the efficiency is not affected to the same extent.

[00147] Furthermore, since the system does not use a ferrite or ferromagnetic core, the overall size and weight of the device can be reduced. In accordance with some embodiments the coil can be formed on a printed circuit board (PCB), with no heavy ferrite coils, no soldering and no wiring to the coils. In accordance with some embodiments there is no need for a magnetic core in the secondary in the receiver. Since magnetic cores are usually large and heavy this results in considerable size savings.

[00148] By way of example, in accordance with an embodiment that uses an IRFR0220 chip as a FET and use 4 oz copper coils with 9 turns and 1.25" diameter, the circuit in **Figure 2** above, can be loaded with RL of 10 Ohm and tuned to operate at 1.3 MHz. With matching coils in the primary and secondary in the receiver, without capacitor C, total circuit efficiency of the circuit including the clock and FET driver circuit approaches 48%. Addition of a 1600 pF capacitor in parallel to the FET increases the total circuit efficiency to 75% (a better than 50% increase in efficiency), while simultaneously decreasing the voltage across the FET and also the harmonics in the circuit. The coil to coil transfer efficiency with the capacitor placed in parallel with the FET is estimated to be approximately 90%. The advantages of this approach include:

- High efficiency (~90% coil to coil).
- Low ringing oscillation and EMI.
- Simplicity and low cost.
- Lower FET source-drain voltage swing allowing use of a larger selection of FETs.

[00149] In many applications, it is also desired that the pad and the receiver are arranged so that the pad does not emit power unless the receiver is nearby.

[00150] **Figure 10** and **Figure 11** show circuit diagrams in accordance with an embodiment. In addition to high efficiency, one method that is required for minimizing EMI and maintaining high overall efficiency is the ability to recognize the presence of a receiver nearby, and then turning on the pad only when appropriate. Two methods for this are described below.

[00151] As shown in **Figure 10**, in accordance with one embodiment, the pad circuit 260 incorporates a micro control unit (MCU1) 266 that can enable or disable the FET driver 268. The MCU1 receives input from another sensor mechanism that will provide information that it can then use to decide whether a device is nearby, what voltage the device requires, and/or to authenticate the device to be charged or powered.

[00152] One of the sensor mechanisms for this information are through the use of an RFID reader 280 that can detect an RFID tag of circuit and antenna in the receiver (i.e. device or battery to be charged or powered). The information on the tag can be detected to identify the voltage in the receiver required and to authenticate the circuit to be genuine or under license. The information on the tag can be encrypted to provide further security. Once a device or battery containing the tag is nearby the pad, the RFID reader can be activated, can read the information on the tag memory, and compare with a table to determine authenticity/voltage required or other info. This information table can also reside on the MCU1 memory. Once the information is read and verified, the MCU1 can enable the FET driver to start driving the coil on the pad and to energize the receiver.

[00153] In another embodiment the MCU1 relies on a clock 270 to periodically start the FET driver. The current through the FET driver is monitored through a current sensor 264. Several methods can be implemented with this implementation, including for example:

- A small resistor can be placed in series with the FET to ground contact. The voltage across this resistor can be measured by a current sensor chip, such as a Linear Technology Current Sense Amplifier part number LT1787.
- A Hall sensor, such as a Sentron CSA-1A, that measures the current from a wire running under it, can be placed on top of the PCB line from the FET to the ground to measure the current without any electrical connection to the circuit.

The advantage of this approach is that no extra resistor in series with this portion of the circuit is necessary reducing the impedance.

- Other techniques may be used to measure the current.
- A Hall sensor or a Reed switch can sense a magnetic field. If a small magnet is placed inside the receiver unit of the system, a Hall sensor or Reed switch can be used to sense presence of the magnet and can be used as a signal to start the FET.
- Other capacitance, optical, magnetic, or weight, etc. sensors can be incorporated to sense the presence of a secondary or receiver and to begin the energy transfer process.

[00154] **Figure 11** shows a figure of a circuit diagram 290 in accordance with an embodiment. In accordance with an embodiment, the MCU1 can periodically start the FET driver. If there is a receiver nearby, it can power the circuit. The regulator 296, or another memory chip in the circuit can be programmed so that on power-up, it draws current in a pre-programmed manner. An example is the integration of an RFID transponder chip in the path, such as ATMEL e5530 or another inexpensive microcontroller (shown here as MCU2 294), that upon power-up modulates the current in the receiver that can then be detected as current modulation in the primary. As with the previous example, other sensors, such as an RFID antenna 292 can also be used to provide positional and other information.

[00155] **Figure 12** shows a figure of a power transfer chart 300 in accordance with an embodiment, illustrating transferred power as a function of offset between coils.

Efficiency Enhancements in Coil Layout

[00156] An important aspect of power transfer efficiency relates to the alignment of coils with respect to each other.

[00157] **Figure 13** and **Figure 14** show figures of a coil layout in accordance with an embodiment. If position independence is required, the pad PCB can be patterned with a coil pattern to cover the full area. **Figure 13** shows a pad type charger or power supply 310 including a layer of coils 312 with minimal spacing 314 between the coils. Each coil has a center 316 associated with it. In accordance with an embodiment, the power transfer for a 1.25" diameter coil as the center of the receiver is offset from the center of

primary. The power drops off to 25% of the maximum value when the two coils are offset by a coil radius. As described above, in order to better keep the coils aligned, use of magnets centered on the primary and the receiver coil can provide an automatic method of bringing the two parts into alignment.

[00158] In order to produce uniform fields, a number of coils around the receiver coil will typically need to be turned on to produce a field. However, with such a pattern, if a receiver coil is placed in between two primary coils, the voltage is still not optimized. Research has shown that to obtain uniform fields, three layers of coil patterns offset with respect to each other are required.

[00159] **Figure 14** shows a pad-type charger 320 with two of the three layers 322, 324 required to achieve position independent magnetic field pattern. For a receiver placed at the center of the circle, all the coils nearby (in and around the circle 328) will need to be turned on to achieve a uniform field in the desired location 326. While this approach solves the offset issue and can be used to provide position independence, it does not produce high transfer efficiency. The reason is that ten or more coils have to be turned on near the receiver center to create the uniform field in that area, which in turn leads to inefficient power transfer.

Efficiency Enhancements through Independent Coil Movement

[00160] In accordance with some embodiments, techniques are included to provide high transfer efficiency while maintaining position independence.

[00161] **Figure 15** shows a figure of a charging pad with multiple coils in accordance with an embodiment. The area of the pad 330 is divided into a plurality of, or multiple segments 332, that are bounded 336 by a wall or physical barrier, or simply some tethering means with no physical walls but that otherwise restrict movement to within the segment. The coils 334 are mounted such that they can move laterally, or float, within the area of their segments while continuing to be connected to the drive electronics placed on the edges of the area. In accordance with an embodiment, the floating coils and the drive circuit are sandwiched between thin upper and lower cover layers that act to allow the coils lateral movement while limiting vertical movement. When a receiver coil is placed on the pad, the pad senses the position of the receiver coil and moves the coils to the right position to optimize power transfer.

[00162] **Figure 16** shows a figure of a charging pad with movable coils in accordance with an embodiment. When the mobile device, for example a cell phone 340, or a battery is placed on the pad 330, the nearest coil moves 342 within its segment to better orient itself with the mobile device or battery. In accordance with one embodiment, the method used for achieving this is by attaching a magnet to the bottom center of each coil in the pad. A matching magnet at the center of the receiver coil attracts the primary magnet nearby and centers it automatically with respect to the receiver coil.

[00163] In accordance with an embodiment, each coil in this configuration can be suspended by the wires carrying power to the coil or by a separate wire/spring or by another mechanism so that each coil can move freely in the plane of the pad while it can receive power from an individual or shared driving circuit. In order to facilitate movement, the surface of the coils or the bottom surface of the top layer for the base unit (the area where the coils move against) or both layers can be made smooth by use of a low friction material, attachment of a low friction material, or lubrication. The wire/spring or current carrying mechanism described above can also be used to center each coil in an area at the center of desired movement sector for each coil. In this way, without a receiver coil in the vicinity, each coil in the base unit stays at the central location of its sector and responds and moves to match a receiver coil when a device or battery is brought nearby. Overlap of movement between adjacent charger or power supply coils can be controlled by means of limiting movement through limiting length of current carrying wires to the coil, arrangement of the suspension, or spring, or placement of dividing sectors, pillars or by any other mechanism.

[00164] In another embodiment, the pad will include a method for detecting the presence of the mobile device, battery/receiver and taking appropriate action to turn on the coil and/or to drive the coil with the appropriate pattern to generate the required voltage in the receiver. This can be achieved through incorporation of RFID, proximity sensor, current sensor, etc. A sequence of events to enable position independence and automatic pad turn-on can be:

- Multiple movable coils are used to cover the pad surface area.
- The coils in the pad are normally off and periodically powered up sequentially to sense whether the receiver is nearby by measuring the current through the primary coil. Alternatively, proximity sensors under each section can sense the presence of a magnet or change in capacitance or other parameter to know

where a device is placed. RFID techniques with localized antennas under each section or such can also be used.

- Once a device is identified as placed in a section, the pad can interrogate the device through one of the processes described earlier to authenticate and to understand its voltage/power, etc. requirements.
- The MCU1 unit uses the information received above to set the PWM pattern which it will use to drive the FET drive to produce the appropriate voltage in the receiver.
- The board continues to 'search' for other devices on the pad by scanning coils or using the RFID system, etc. and then turn on other coils as appropriate.
- The pad also uses monitoring to find out when and if the first mobile device is removed from the pad, or when the end of charge is reached.

Efficiency Enhancements in Coil Registration and Switching

[00165] In accordance with an embodiment, a global RFID system that can identify the approach of a mobile device to the pad can be used to 'wake up' the board. This can be followed by sequential polling of individual coils to recognize where the device is placed in a manner similar to described above. Other embodiments can be used to provide safeguards against false charging of objects placed on the base unit. It is known that a metal object placed on coils such as the ones in the base of the charger or power supply system will cause current to flow in the primary and transfer power dissipated as heat to the metal object. In practical situations, this will cause placement of keys and other metal objects on the base unit to trigger a start and to needlessly draw current from the base unit coil and possibly lead to failure due to over-heating. To avoid this situation, in embodiments such as described above, the switching of voltage to the coil will not start unless an electronic device with a verifiable RFID tag is nearby thereby triggering the sequence of events for recognizing the appropriate coil to turn on and operate. In an alternate geometry, the total system current or individual coil current is monitored, and, if a sudden unexpected drawn current is noticed, measures to investigate further or to shut down the appropriate coil indefinitely or for a period of time or to indicate an alarm is taken.

[00166] In another embodiment, the regulators or battery charging circuit in mobile devices or batteries, or the regulator in a receiver electronics, typically has a start voltage

(such as 5 V) that is required to start the charging process. Once the battery charge circuit detects the presence of this voltage, it switches on and then proceeds to draw current at a preset rate from the input to feed the battery for charging. The battery charger circuits operate such that an under or over voltage at the start will prevent startup. Once the startup occurs, the voltage at the battery charger output is typically the voltage of the battery and depends on the state of charge, but is for example 4.4 V to 3.7 V, or lower for Lithium-Ion batteries. With a wireless charge system such as described here, the voltage on the receiver is highly dependent on relative position of the primary and receiver coil as shown in **Figure 5**. Since typically the start voltage of the battery charger is within a narrow range of the specified voltage, under-voltage and over-voltage in the receiver coil due to misalignment or other variation will result in shutdown of the battery charger circuit.

Efficiency Enhancements through Coil Voltage Clamping

[00167] **Figure 17** shows a figure of a circuit diagram 350 in accordance with an embodiment. In accordance with one embodiment, a Zener diode 352 is incorporated to clamp the maximum voltage at the output of the receiver prior to the regulator or battery charger circuit, as shown in **Figure 17**. Using a Zener allows more insensitivity to placement between the primary and receiver coil while maintaining the ability to charge or power the device. For example, the drive pattern on the primary can be set so that when the primary and receiver coil are aligned, the voltage on the receiver is above the nominal voltage for the battery charger startup. For example, for a 5 V startup, the voltage at center can be set for 6 or 7 volts. In this way, the Zener can be chosen to have an appropriate value (5 V) and clamp the voltage at this value at the input to the battery charger unit while the coils are centered or mis-aligned. Once the battery charger starts operation after detection of the appropriate voltage at the input, the battery charger circuitry will pull the voltage at this point to the pre-programmed voltage or voltage of the battery. In this way, the use of Zener diode enables less sensitivity to position and other operational parameters in wireless chargers or power supplies and is extremely useful.

Efficiency Enhancements through Coil Stacking

[00168] **Figure 18** shows an illustration of a means of stacking coils, in accordance with an embodiment. In accordance with an embodiment, to achieve higher flux densities,

a coil is constructed with two or more layers, for example by using two or more layers of printed circuit board. Multiple layer boards can be used to allow compact fabrication of high flux density coils. By altering the dimensions of the coil in each layer (including the thickness, width, and number of turns) and by stacking multiple layers, the resistance, inductance, flux density, and coupling efficiency for the coils can be adjusted so as to be optimized for a particular application.

[00169] In accordance with an embodiment, a transformer comprising two PCB coils separated by a distance has many parameters that are defined by the design of the coil, including:

R1 is the primary winding resistance,

R'2 is the secondary (in the receiver) winding resistance referred to the primary,

RL is the resistive load,

Llk1 is the primary leakage inductance,

L'lk2 is the secondary leakage inductance referred to the primary,

LM1 is the primary mutual inductance,

C1 is the primary winding capacitance,

C'2 is the capacitance in the secondary winding referred to the primary,

C12 is the capacitance between primary and secondary windings, and

n is the turns ratio.

[00170] In accordance with the embodiment shown in **Figure 18**, a multi-layer PCB coil 356 is created in separate PCB layers 357, which are then connected 358, and manufactured together via common techniques used in PCB fabrication, for example by use of a via or contacts. The resulting overall stack is a thin multi-layer PCB that contains many turns of the coil. In this way, wide coils (low resistance) can be used, while the overall width of the coil is not increased. This technique can be particularly useful for cases where small x-y coil dimensions are desired, and can be used to create higher flux densities and more efficient power transfer.

Efficiency Enhancements through Coil Shape and Materials

[00171] In accordance with an embodiment, the system can use a non-ferrite material for both the primary and the secondary (receiver) coils. For example, the coils can be made of copper material that is sputtered, deposited, or formed onto a printed circuit board (PCB), as described above. As also described above the coils can be

formed in any number of different shapes, including, for example, flat or planar hexagonal shapes, or spirals. The coils can also be distributed in layers of coils, spirals, and other various shapes.

[00172] One of the advantages of using a non-ferrite or non ferromagnetic material for the primary and secondary (receiver) is that the coils can be made much flatter and thinner than a ferrite coil. Additionally, non-ferrite coils can be made to have a lower inductance than a comparable coil made from a ferrite material (the inductance is on the order of 1 micro Henry, although the actual value will vary depending on the frequency of the voltage applied to the coil). The non-ferrite nature effectively eliminates hysteresis in the coil, and allows the system to be switched on and off more rapidly, and with less energy storage artifacts.

Variations in Coil Circuitry

[00173] In accordance with some embodiments, an inductance-capacitance (often referred to as an LC or "tank capacitor") circuit can be used to provide a range of power outputs to approximately suit the intended application. For example, the circuit can be optimized to suit either low-power applications, or high-power applications.

[00174] Depending on the particular intended application, the original capacitor (referred to herein as a "timing capacitor") in the circuit design can be removed and/or replaced with a different value of capacitor to obtain a different overall level of power output. From a manufacturing perspective this is a relatively simple and inexpensive procedure. This technique can also be used to easily manufacture different charger or pad embodiments for different end-user applications, in that the majority of the pad components can be designed to be common to each pad design, with the primary difference being the value for a single capacitor. This single capacitor can then be specified or changed during the manufacturing process. Although the timing capacitor can be used to adjust the system for, e.g. high-power or low-power applications, the final power output as it is received at the mobile device can be fine-tuned using additional techniques and features such as those described in further detail below.

Coil Waveform Generation

[00175] In accordance with an embodiment, a half-phase electrical waveform is used to charge the tank circuit, and to subsequently provide inductive power to the

receiver coil in the mobile device. Unlike a full-phase waveform, the half-phase waveform can be used with a zero-crossing power supply. In accordance with this embodiment, when the transistor in the primary coil is first turned on, electrical current passes through the primary coil and the transistor to ground. When the transistor is turned off, the voltage level at the transistor swings high (anywhere from twice, to many times the value of the input voltage). This is the standard oscillation behavior of an inductor. When the current falls to zero the transistor is turned on again, and the process is repeated.

[00176] Many traditional transformer designs do not use half-phase waveforms, and instead use a non-zero-crossing design, since their ferrite core acts like a capacitor and stores energy during the off phase, which results in large losses in power efficiency if zero-crossing was used. However, in accordance with an embodiment, the use of non-ferrite coils, coupled with lower power (on the order of 2 Watts) allows for suitable efficiency with a half-phase and a zero-crossing circuit.

[00177] Furthermore, in accordance with some embodiments the half-phase waveform can be designed to have an exponential or curved shape, rather than an abrupt shape, so that higher frequency emissions are reduced. These higher frequency emissions might otherwise cause problems with portable and other devices, or conflict with federal communications regulations that prohibit high frequency emissions in consumer electrical devices.

Automatic Voltage Setting

[00178] In accordance with some embodiments, the system can include additional circuits, components, features, and techniques, which perform specialized tasks, such as mobile device identification, and automatic voltage or power-setting for different devices. As described above, although the timing capacitor can be replaced to modify the circuit frequency and the resulting output voltage of the system, this is not a practical solution for allowing a consumer to modify the voltage, or to modify the voltage to suit the particular requirements of individual mobile devices. In practice the timing capacitor can be used to provide a particular range of output power (i.e. high power applications; or low power applications). Additional techniques are then used to adjust the power for a particular device. This is particularly important when the charger or the pad is designed to power or charge multiple different devices simultaneously, since each of those different devices

may have different power and voltage requirements. In accordance with various embodiments, different features can be used to support this, including:

- Hardwiring the receiver coil to take the voltage requirements of its device into account, and to use the appropriate dimensions to receive the correct voltage for that device. However, while this approach works to adjust the voltage for that device, it is by its nature hard-wired and does not provide much flexibility to adjust the voltage for interoperability between different devices and different chargers or power supplies.
- Use of dynamic programming to obtain a different voltage. In accordance with this embodiment, if the timing capacitance is known, then the frequency of the circuit can be adjusted to produce the required output voltage.
- In a zero-switching circuit, clipping can be used to tune the voltage. This can include turning the circuit on, then allowing it to turn off but clipping the waveform earlier, and then turning it on again. The process is then repeated. The clipping may be less efficient than unclipped switching, but can be used to tune the voltage.

[00179] When used with the above capacitor-based techniques, the choice of timing capacitor can be used to determine the overall range of the charger, power supply, or pad (for example, whether it is best suited for low power, or for high power applications). The additional features can then be used to fine-tune the frequency and the output voltage. In accordance with some embodiments, additional features can be used to improve efficiency and to add functionality.

[00180] As described above, in accordance with one embodiment, the pad circuit 260 incorporates a micro control unit (MCU) 266 that can enable or disable the FET driver 268. The MCU receives input from another sensor mechanism that will provide information that it can then use to decide whether a device is nearby, what voltage the device requires, and/or to authenticate the device to be charged. The communicated feedback from the receiver to primary can be used by the primary to, for example, adjust the frequency, or to otherwise alter the output voltage to that receiver, using the frequency/output characteristics described above. Some traditional transformer designs use a third coil to provide a measure of feedback. However the use of an MCU as described herein eliminates the need for such extra coil feedback devices.

[00181] Also as described above, in accordance with one embodiment, a Zener diode 352 is incorporated to clamp the maximum voltage at the output of the receiver prior

to the regulator or battery charger circuit. In each of the feedback designs described above, the actual communication between the receiver and the primary as to voltage requirements can be of open loop design, or of closed loop design. In an open loop design, the charging device, pad or power source provides the power to the primary, which is then inductively transferred to the receiver and the mobile device or battery other device to be charged. The primary itself determines how much power should be received at the receiver. In a closed loop design, such as in a switching mode power supply, the device/receiver communicates information back to the primary, and then the primary determines how much power should be sent to the receiver.

Device Identification and Verification

[00182] **Figure 19** shows a figure of a circuit diagram 400 for identification verification in accordance with an embodiment. In accordance with an embodiment, the circuit design can be used to ensure a device is valid, i.e. authorized to be used with the charger, power supply or pad. The information can also be used as part of an open-loop or closed-loop design to set the voltage for the device. In operation, the primary circuit is first turned on. An initial signal is generated as the circuit induces power in the receiver. This information is quickly compared with a number or value stored in the MCU, and is used to determine whether the mobile device (or the receiver associated with that mobile device or battery) is valid for operation with the base unit, charger, power supply, or charging pad. In addition to validation the information can similarly be used to set the charging voltage for the receiver, battery, or mobile device.

[00183] **Figure 20** shows a figure of a circuit diagram 420 for bidirectional communication in accordance with an embodiment. As shown in **Figure 20**, in accordance with an embodiment the charger or power supply or primary can include means for communication with the receiver, battery, or mobile device, including for example radio frequency (RF) or other means of communication.

[00184] **Figure 21** shows a figure of a circuit diagram 440 for output controller in accordance with an embodiment. As shown in **Figure 21**, in accordance with an embodiment the output controller in the receiver waits until power is sufficient, and then turns the power on to the mobile device or battery.

[00185] **Figure 22** shows a figure of a circuit diagram 480 for receiver with regulator or charge management circuit in accordance with an embodiment. As shown in

Figure 22, in accordance with an embodiment the receiver includes a regulator for regulating the voltage.

[00186] **Figure 23** shows a figure of a circuit diagram 500 for MCU regulation in accordance with an embodiment. As shown in **Figure 23**, in accordance with an embodiment the MCU can provide the voltage regulation.

[00187] **Figure 24** shows a figure of a circuit diagram 540 for unidirectional communication and data transfer in accordance with an embodiment. As shown in **Figure 24**, in accordance with an embodiment the receiver can include a means of transferring data to the mobile device to which it is coupled.

[00188] **Figure 25** shows a figure of a circuit diagram 560 for time-based regulation in accordance with an embodiment.

Zero Voltage Setting

[00189] In accordance with some embodiments, the system can use a technique such as Zero Voltage Switching (ZVS) to provide more efficient power transfer and power supply control. These techniques can also be used to provide more efficient regulation for power transfer between coils of small induction value, such as those created by spiral patterns in PCBs, stamped metal coils, and low number of turns wound wire coils. In switching mode power supplies used today, the common geometries used are boost buck, flyback, boost, or a variation of these types. In most of these geometries, the input voltage is switched rapidly by a transistor such as a FET and the energy is transferred across a transformer to a load. In accordance with an embodiment, by adjusting the duty cycle of the switching circuit, regulation of transferred power is achieved.

[00190] **Figure 26** shows a high level view of a flyback power supply geometry 580 in accordance with an embodiment. During the time that the FET is closed, the current through the primary coil stores energy in this coil and during the period that the FET is open, this energy is transferred to the secondary (receiver) coil and into the load. The energy stored in the coil is directly proportional to the inductance of the coil and values of several hundred Henry are typical for 10's or 100's of Watts of power supply power.

[00191] In contrast, Printed Circuit Board Coils (PCBC's) are typically spiral circular, rectangular, or other shape coils that are printed on rigid or flexible PCB material or stamped out of sheets of copper or by other methods where the coil or transformer in a

power supply is primarily flat and takes very little space. Two of these coils placed with a distance between them (such as on both sides of a PCB material) or with an air or material gap (such as in wireless power applications where a charger transmits power to a receiver in an electronic or electric device that can be separated or removed from the charger) can be used to form a transformer such as the one shown in **Figure 26**. Switching of these coils at high frequency (~1 MHz depending on the coil geometry and size) can transfer power across an air or material gap and an efficient power supply with a very small transformer can be developed. Uses of such compact coils for wireless powering of mobile devices such as mobile phones and MP3 players have been demonstrated. However, many prior techniques used a laboratory power supply to provide a sinusoidal or similar voltage to the primary coil and study the transferred power, rather than a compact efficient circuit for a power supply.

[00192] In accordance with a ZVS geometry embodiment, a capacitor is added to the circuit so that in the switch OFF position, the capacitor and the coil inductor create a resonant circuit. During the switch ON time, current passes through the inductor while the voltage across the capacitor is zero. During the period where the switch is turned off, the voltage across the capacitor rises to a maximum value of twice the input voltage and then resonates back to zero. A characteristic of this geometry is that the switch is closed exactly when this voltage arrives back to zero (hence the name Zero Voltage Switching), thereby minimizing power usage and achieving high efficiencies. Some of the benefits of this geometry include: High efficiency and 'Loss-less' transitions; Reduced EMI/EMC due to soft switching and use of sinusoids rather than square waves; Peak current is not higher than square wave switching; and Relatively simple control and regulation. In addition, this geometry can work very efficiently with low inductance values and is therefore better suited for the PCBC applications. In accordance with various embodiments the geometry can be configured to operate in various topologies, for example buck, boost, buck-boost, and flyback.

[00193] Some embodiments provide more efficient power transfer and power supply control and regulation for power transfer between coils of small induction value such as created by spiral patterns in PCBs, stamped metal coils, low number of turns wound wire coils, etc. In addition, typically, magnetic cores are not used if the coils are driven at high frequency. For a spiral coil, the inductance of a coil is given by:

$$L = \frac{r^2 N^2}{(2r + 2.8d) \times 10^5}$$

Where

L = inductance (H)

r = mean radius of coil (m)

N = number of turns

d = depth of coil (outer radius minus inner radius) (m)

[00194] For example, for a coil of 10 turns, an outer radius of 15 mm, and inner radius of zero, then L=1 H. While larger values can be obtained by increasing the number of turns or stacking a number of coils vertically and connecting them in series, this larger induction comes at the price of increased resistance and therefore loss in the inductor.

[00195] Spiral coils printed on PCBs without use of any magnetic core can provide high power transmission efficiency if operated at high frequency. An analogous method to the above technique is one referred to as Zero Current Switching (ZCS). ZCS operates by similar principles; however switching is done during zero current passing through the switch thereby achieving low switching losses. In the following discussion, ZVS switching is generally discussed; however, the ZCS geometry can equally be applied to the following. In accordance with some embodiments, methods are described for achieving and optimizing high power transfer with such small and/or thin coils with low induction values and describe several techniques for control and regulation of this power in real world power applications. While this technology is generally described for any type of power supply using such inductors, in accordance with a particular embodiment the two coils in the transformer are separated, with the primary being in an inductive charger and the receiver embedded in a device, battery, casing, skin, or other part of an electronic or electric device. In this case, a wireless charger or power supply can be created which is especially useful for charging or powering mobile electronic or electric devices or batteries.

[00196] The advantages of use of ZVS geometry in general, and in particular for coils with small inductance and no magnetic cores, has been described above. However,

another important aspect of power supply design is the Control and Regulation Circuitry that is implemented. Regulation of the power to a load can be achieved by a linear or switching regulator at the output stage. However, if the regulation of the power is achieved in this way and constant power is supplied from the primary coil, under light load conditions (such as when a battery is fully charged or a device is on stand-by, then the power generated and transmitted by the primary is mostly wasted leading to a low efficiency power supply. A better solution is achieved by adjusting the power into the primary coil under different load conditions, to maintain high efficiency during different load conditions or battery charging stages.

[00197] In accordance with an embodiment, such control of output power in a ZVS power supply can be achieved by changing the frequency of the operation. In this embodiment, the output power is inversely proportional to the operating frequency and control can be achieved by an appropriate control circuit.

[00198] **Figure 27** shows how the output voltage to the load is monitored and with changes in the load condition, a chip or a Micro Controller Unit (MCU) varies the frequency or the duty cycle of the FET driver to achieve optimum operation and controlled output voltage with a changing load. As shown in **Figure 27**, a digital control 600 for operation is shown. However, analog operation can also be achieved and may be simpler and faster in response time to load changes and preferable in some applications. In the implementation shown, the primary (Control Circuit, Clock, FET Driver, FET, primary coil, etc.) and the receiver (secondary coil, rectifier, capacitor, other circuitry, etc.) are able to communicate through a wired connection.

Switching Mode Power Supply with Wireless Communication

[00199] In accordance with an embodiment that includes a charger or power supply wherein the charger or power supply and the receiver are separable from each other (wireless or inductive charging or supply of power to devices), the charger or power supply can contain the basic control and switching functions while the receiver contains the rectifier diode and capacitor for smoothing of the output voltage and additional circuitry. In this embodiment the two parts need to communicate with each other wirelessly.

[00200] **Figure 28** shows an implementation of a more sophisticated charger or power supply. According to this embodiment, where the primary stage and the

secondary (receiver) stage communicate wirelessly. In the geometry shown in **Figure 28**, a digital control scheme is implemented. The primary (charger or power supply) 620 is controlled by a Micro Control Unit (MCU1) that receives signals from a Current Sensor in series with the coil. The communication between the charger and the receiver 630 is achieved through the same coil as the power transfer. However, these functions can be separated.

[00201] In the geometry shown, the secondary (receiver) contains circuitry that enables this part to modulate the load as seen by the primary. In accordance with an embodiment this is achieved through modulation of switch Q2 by an MCU2 in the receiver. This can be a very small Programmable IC (PIC) and can easily fit into very small form factors. As the primary charger or power supply sends power to the secondary receiver, the circuit in the receiver turns on. The power received is rectified and filtered by rectifier D1 and Capacitor C2 respectively. Since MCU2 requires constant voltage input at all times, a small, low current regulator (Voltage Regulator) for powering MCU2 only is incorporated. This can be a linear or switching regulator. Since the power usage of MCU2 is very small and the unit can also be put into hibernation between tasks, use of this regulator does not affect the overall efficiency much. The output of the rectified stage is input to a device or Charge Management IC for the case of a battery charger configuration. This Charge Management IC is integrated into most Original Equipment Manufacturer (OEM) mobile devices that operate by rechargeable batteries or can be integrated into or on a rechargeable battery to directly charge the battery when the battery is in proximity to the charger. The Charge Management IC typically, for a fully drained battery, will pass on the maximum input current to the battery to enable rapid charging when the battery is at low voltage. This presents a low impedance load to the power supply circuit and requires the power supply to sustain the voltage at the required value while supplying the current. The Charge Management IC is in communication with the MCU2 which also monitors the output voltage (Vout) and tries to maintain this Vout within a pre-programmed range. This is achieved by MCU2 sending a digital signal to Q2 to modulate the switch. This modulation is prior to the rectifier stage and is at high frequency so the rectified and smoothed Vout is not affected. However, this modulation of the impedance of the secondary stage affects the current through the primary coil stage and can be easily detected by the Current Sense circuit in the primary.

[00202] In accordance with an embodiment the Current Sense circuit can comprise a small resistor in parallel to a voltage amplifier, a Hall sensor, etc. The output of the Current Sensor is connected to MCU1 and the digital sequence is detected by an A/D converter. The firmware in MCU1 determines whether the output voltage is too high or too low and then executes the appropriate step to adjust accordingly by sending a signal to a clock to adjust the frequency of the FET drive to bring the output of the power supply to within acceptable range. Higher drive frequency corresponds to lower output power by shortening the time for integration of power in the resonant ZVS cycle and lower frequency corresponds to higher output power.

[00203] In accordance with an embodiment, one method for implementing the variable frequency is to use a variable frequency source whose output frequency changes with change in the voltage to its input. Using a programmable resistor and changing this resistor value by varying a voltage signal from MCU1, the frequency for driving FET 1 can be changed. Other methods for achieving this change are also possible.

[00204] As an example of the method for control, in a typical application, the operating frequency of the circuit can be 1-2 MHz and the data transmission for control is at 14.4 kbits/sec. If the full output power range is achieved by moving the frequency in the 1.2-1.4 MHz, this range is broken into 256 steps. In one implementation, the receiver sends a digital code corresponding to the output voltage and MCU1 compares this to the earlier output voltage value and makes a determination about which direction and by how many steps to move the frequency. The frequency is then changed accordingly. In another implementation, MCU2 sends one of 2 values corresponding to a voltage high or low condition. If the voltage is within range, MCU2 does not communicate with the primary. When a voltage high signal is received, MCU1, takes a pre-determined step towards higher frequency to lower the output power and the process is repeated until output voltage is within required range. A voltage low signal has the opposite effect. Many variations of these basic methods are possible to allow rapid, efficient locking of the output voltage. Proportional-Integral-Derivative (PID) techniques, etc. can also be used. Depending on the geometry, the circuit may also use a switch Q3 in series with the load. This optional switch may be opened during communication to create a better signal to noise ratio. Since communication occurs in several msec, opening and closing Q3 rapidly does not have a large impact on charging time of a load battery that can be in many hours.

[00205] In accordance with an embodiment, as the battery charges and its terminal voltage rises, the Charge Management IC throttles the incoming current back, and switches to a mode where the voltage across the battery terminal is maintained at or near its final value. The supply will sense a higher output impedance and MCU2 and MCU1 work in concert to keep the output within range throughout the charging cycle. At the end of the charge cycle, the Charge Management IC can signal end of charge cycle to MCU2 which sends a pre-determined code to MCU1 to shut down the charger, move to hibernation mode or take some other pre-determined step.

[00206] It is important to note that, in the embodiment, the voltage regulator in the receiver does not regulate the output voltage to the load itself. If the regulator was performing this function, then the control and regulation described here would not be necessary. However, the overall system efficiency is much lower and, with a constant power going into the receiver, some fraction of this power is wasted as the battery reached a full charge or as the load became lighter and less power was required. This wasted energy can heat up the receiver, the load, or the device battery depending on the geometry. All of these cases are undesirable. In the geometry described here, the primary can in these cases adjust to send less power to the receiver, thereby maintaining high efficiency regardless of load condition.

Verification and Data Transmission

[00207] In accordance with an embodiment, the digital transmission process described here is bi-directional, and can be used for verification process at start of charge or power transfer to ensure that the right kind of device is present and about to be charged, or to inform the charger or power supply about the voltage/power requirements of the device or battery to be charged or powered. In accordance with an embodiment, this bi-directional data transfer can also be used for actual data communication between a device and a charger or power supply. For example, the charger or power supply can be powered by the USB outlet of a laptop and simultaneously receive data from the laptop to be transferred to a mobile device. When a mobile device or battery is on the charger or power supply, it can be charged or powered, and its data can also be synchronized simultaneously through this channel.

Extension to Other Geometries

[00208] While the above discussion has focused on one implementation of the control with a Zero Voltage Switching power supply, the basic concepts for the control, verification, and data transmission are applicable to other geometries and topologies, and can be implemented in a similar manner. In accordance with some embodiments, the Charge Management Circuit is optional and is only used when a battery is present at the load. For example, as shown in **Figure 28**, If Vout is used to directly operate a load, the Charge Management Circuit is not used and Vout is directly connected to the load.

Fully Regulated Switching Mode Supply with Wireless Communication

[00209] **Figure 28**, described above, shows the basic building blocks for a digitally controlled wireless control circuit for a Zero Voltage Switching (ZVS) circuit were described. The geometry shown in **Figure 28** can regulate the output power through a wide range. However, as a battery charges or the load condition changes to require very low output powers, the accuracy required for control of the Vout may require many finer steps or not be possible with the geometry of **Figure 28** alone.

[00210] **Figure 29** shows an embodiment that includes an enhancement that can be used to address the ZVS issue.

[00211] In the fully regulated power supply shown in **Figure 29**, a voltage regulator (Voltage Regulator 1) that can switch the input voltage between 2 values or more is used. In normal operation, Q2 is closed and the Voltage Regulator 1 is shut down though its enable pin. Therefore, the input voltage is directly available for the Coil L1 and is regulated as described earlier. However, if the output requires extremely low powers (such as end of charge stage for batteries), and the charger determines that a switch to a different range is required, Q2 is opened, and Voltage Regulator 1 is switched on to change the input to Coil 1 to a lower voltage value. Regulation is maintained at this range by shifting to the appropriate frequency to achieve required output power. For example, if Vin is 5 V, this lower voltage level may be 3 V. Multiple voltage levels are also possible.

[00212] Since for most cases, and in high power conditions, Q2 is open and Voltage Regulator 1 is turned off, high overall system efficiency can be achieved. Only during the lowest current conditions, the input voltage is changed by switching this Voltage Regulator 1 on and regulating at this level. Depending on the type of regulator used, some efficiency loss can be expected in this regime. However, this occurs at very low output power levels only. Voltage Regulator 1 can be a high efficiency Switching DC-

DC supply or a lower frequency, less complicated and less costly linear regulator depending on efficiency/cost trade-offs.

Regulated Switching Mode Power Supply with Opto-Coupler Feedback

[00213] The geometries described above use a digital method for transmission of information between a primary and receiver circuit. However, in some cases, the load changes instantaneously. Examples are when in a laptop computer, the screen or the hard drive start or shut down, etc. To handle these cases, the feedback loop has to be extremely fast to avoid having severe and rapid voltage overshoots and undershoots. This becomes especially important for high power applications.

[00214] **Figure 30** shows an embodiment in which instead of a digital feedback circuit, an analog circuit based on coupling between an LED and a light detector can be used.

[00215] In this case, the output voltage, Vout is continuously compared to a reference voltage and the intensity of light from a diode changes rapidly in proportion to the voltage value. A detector in the charger stage provides a voltage value to a frequency controller that controls the FET drive. An MCU in the charger, MCU1 also monitors the process and can switch on an optional lower voltage input to the primary coil (through Q2 and Voltage Regulator) if necessary. It can also sense the end of charge or perform verification or other tasks.

[00216] In some embodiments a high power completely wireless inductive charger for a laptop requiring up to 90 W continuously can be implemented with this scheme. In accordance with an embodiment the transformer coils are PCB spiral coils that have 4" or more diameters and comprise 7 turns with a total inductance of 1 micro Henry. The rapid response time of the analog circuit allows maintaining of the output voltage with rapid swings in the load. The charger or power supply comprises a pad where the charger or power supply circuitry and a flat spiral PCB coil are integrated into and the receiver comprises circuitry and a similar coil integrated into the bottom of a laptop. The optical components are mounted such that the light from the transmitter is detected by the receiver in the charger or power supply.

[00217] Digital communication through the optical parts is also possible to achieve this result, but requires a higher bandwidth and high speed processing.

[00218] It will be evident that these features, or any other geometry described here, can be combined to achieve the desired results. For example, while the control process for regulation may be through the opto-coupler feedback described here, a separate digital data link through the coil can be established for data transmission or verification of the charger, power supply, or vice versa.

Regulated Switching Mode Power Supply with Isolated Transformer Feedback

[00219] In accordance with an embodiment, another geometry for the regulation uses a similar analog feedback technique with the feedback information being transferred through a separate isolated transformer.

[00220] **Figure 31** shows an embodiment in which the opto-coupler is replaced by a Voltage Controlled Oscillator (VCO) and FET and in the primary, the signal is sent to adjust a frequency controller to provide optimum output voltage. An optional voltage regulator and switch Q2 can also be used to provide precise control at low output powers. Similarly, this communication can be implemented digitally, and also requires a high bandwidth to allow for rapid response. Since the circuit in **Figure 31** is completely wireless and does not require optical components, it may be preferable in cases where an optically transmissive window in the charger or power supply or the receiver may not be possible.

Regulated Switching Mode Power Supply with RF Feedback Regulation

[00221] In accordance with another embodiment, the information between the charger and the receiver can be exchanged through a wireless link in the two parts. The advantage with this embodiment compared to the optical case is that the two parts do not need to be optically transmissive. In addition, compared to the earlier-described versions (optical and through a transformer), the relative alignment is not as important. However, in most practical application, the charger or power supply and the receiver coil will be aligned for power transfer, so an alignment of some degree will occur and with the right geometry, can enable transformer or optical feedback alignment and regulation to be implemented.

[00222] **Figure 32** shows an embodiment in which the wireless link can be analog or digital (requires higher bandwidth and complexity) or can be integrated into the device

to take advantage of existing wireless links in the device (Bluetooth, WiFi, Wireless USB, WiMax, etc.).

[00223] **Figure 33** shows a basic schematic for an inductive single coil charging system in accordance with an embodiment. As shown therein, the coil inductor in the charger pad is switched by Switch T which is typically a FET transistor. A capacitor in parallel with the FET may be used to improve performance. The receiver in the right hand side comprises a similar coil, rectifying diode, and a capacitor to provide DC output to a load R_L.

[00224] **Figure 34** shows the main components of a more advanced wireless power/charging system. Charge Management IC in the receiver also controls the charging of the battery to ensure appropriate charging. The MCU1 and current sense chips in the charger and MCU2 can provide bi-directional communication between the charger or power supply and the receiver for optimum charging or supply of power. The optional voltage regulator in the receiver is used to provide a constant low current voltage to MCU2 and is not regulating the power into the battery. The Receiver is integrated into or on a mobile or electronic device or a rechargeable battery. Points A, B and C are described later and can be used for placement of switching circuits. Q3 is a switch that can disconnect the battery during communication for higher signal to noise ratio and is optional.

[00225] An embodiment of the system incorporates a MicroControl Unit (MCU1) that can enable or disable the FET driver. This system also uses a Charge Management IC in the receiver which controls the charging of the battery to ensure appropriate charging profile is followed and the battery is not overcharged. Most mobile devices today already include a Charge Management IC in their power circuit between the input power jack and the rechargeable battery of the device to control charging of their internal battery. This chip can be incorporated into the receiver circuitry to enable a battery to directly receive power from an inductive source as shown in **Figure 34**.

[00226] **Figure 34** also shows a Zener diode (Z1) incorporated at the receiver. This Zener is used to ensure that the output voltage from the rectifier does not exceed a pre-determined value. In some instances this may be important, since the output of the receiver is fed into a Charge Management IC that may have a finite turn-on time. At the beginning of charging (when a device is placed on a pad first), the Charge Management IC may seem like a high impedance load. Without the Zener diode, such a load may

cause the voltage the input to the Charge Management Circuit to increase to high values, potentially exceeding its safe operating conditions. A fast Zener diode can clamp the voltage under this or other unusual conditions and may be incorporated into the receiver. Depending on the architecture, other methods for avoiding such conditions may be incorporated. Incorporating a Zener Diode is an effective, and inexpensive method for dealing with these potential issues.

[00227] In accordance with an embodiment, the receiver may also incorporate a voltage regulator just to provide a constant voltage (or voltage in the acceptable range for operation) to MCU2. This voltage regulator just provides the low power necessary for this and is not in the path of the main power going into the battery. Any power loss due to this regulator is small, because it is very low power and does not affect the overall system efficiency much. It is mainly used to keep the MCU active during startup or other changes so the communication with charger or power supply is maintained.

[00228] The MCU1 receives input from another sensor mechanism that provides information that it can use to decide whether a device or battery is nearby, what voltage the device or battery requires, and/or to authenticate the device or battery to be charged or powered. Several examples of the mechanisms for providing this information are:

[00229] The MCU1 periodically starts the FET driver. The current through the FET is monitored through a current sensing method. The inductance of L1 is highly dependent on the presence of objects nearby that affect its magnetic field. These objects include metallic objects or another nearby coil such as L2. Switching L1 at high frequency (100 kHz to several MHz) through a Field Effect Transistor (FET) such as Q1, the value of current being drawn is highly dependent on the L1 Value. This property can be used to sense the presence of nearby devices or batteries capable of drawing power and also to enable bi-directional communication if desired. Several methods for this are possible:

- A small resistor can be placed in series with the FET to ground contact. The voltage across this resistor can be measured by a current sensor chip such as Linear Technology Current Sense Amplifier part number LT1787.
- A Hall sensor such as Sentron CSA-1A that measures the current from a wire running under it can be placed on top of the PCB line from the FET to the ground to measure the current without any electrical connection to the circuit. The advantage of this approach is that no extra resistor in series with this portion of the circuit is necessary reducing the impedance.

- Other techniques can be used to measure the current.
- By monitoring the current and comparing it to a baseline measurement taken at power up, and periodically with no devices nearby, MCU1 can determine whether a device or battery is near the coil and drawing power. This provides a first level verification of an object capable of drawing power being nearby. However, there may be a possibility of false starts with metallic objects or wires in any electronic device or battery drawing power. A second level of verification may be desirable.

[00230] To enable a more secure verification, in accordance with an embodiment the MCU1 can periodically start the FET driver. If current is being drawn, MCU1 may activate the Q1 in a predetermined state (for example, this may be a low power state). This can provide a first level indication that a receiver may be nearby. If there is a genuine receiver nearby (versus, say, a metallic object, electronic device, or a non-approved receiver), the emitted power from L1 will power the receiver circuit. The charge control circuit in the figure or another chip in the Receiver circuit can be pre-programmed so that on power-up, it draws current in a pre-programmed manner. An example of this is the integration of the MCU2 and chip model number 10F220 Programmable IC by Microchip Inc. or another inexpensive microcontroller that upon power-up, executes a predetermined program that modulates the current being drawn in the receiver in a predetermined code (which can be encrypted). This receiver modulation can be detected as a current modulation in the current through the L1 by the charger or power supply current sensor in **Figure 34**.

[00231] After the initial handshake and verification, the MCU1 and current sense chips in the charger or power supply and MCU2 can provide bi-directional communication between the charger or power supply and the receiver for optimum charging or supply of power. The system can also regulate the power and voltage received at the Charge Control Circuit to insure overvoltage conditions do not occur. As shown in **Figure 34**, switch Q3 is a switch that can disconnect the battery during communication for higher signal to noise ratio and is optional.

[00232] If the handshake and verification between the charger or power supply and the receiver is not successful, the MCU1 will assume that the device drawing power is not an appropriate receiver and will terminate powering it. This process invalidates false starts due to objects being accidentally placed on the pad, and also provides protection

against counterfeit or non approved receivers. An RFID, Near-Field Communication (NFC) or other wireless data transmission method reader that can detect an RFID, NFC, or other tag included with the receiver circuit and antenna (i.e. device or battery to be charged). The information on the tag can be detected to identify the voltage for the receiver required, and to authenticate the circuit to be genuine or under license.

[00233] The information on the tag can be encrypted to provide further security. Once a device containing the tag is near the charger or power supply pad, the tag reader is activated, the system reads the information on the tag memory, and compares it with a table to determine authenticity/voltage required or other info. In some embodiments, this information table can also reside on the MCU1 memory. Once the information is read and verified, the MCU1 can enable the FET driver to start driving the coil on the pad and to energize the receiver.

A Hall sensor or a Reed switch can sense a magnetic field. If a small magnet is placed inside the receiver unit of the system, a Hall sensor or Reed switch can be used to sense presence of the magnet and can be used as a signal to start the FET.

Other capacitance, optical, magnetic, or weight, etc. sensors can be incorporated to sense the presence of a receiver and to begin the energy transfer process.

[00234] The methods for verification and communication between the charger or power supply and the receiver are provided above by way of example, and in accordance with various embodiments. In practice a combination or a variation on the above methods may be used. It will also be evident that different embodiments can use different verification techniques, in addition to or instead of those described above, and various combinations of such.

Efficiency Enhancements through Lateral Offset Between Coils

[00235] **Figure 35** shows a typical experimental curve for power transferred and Power Transfer Efficiency through a pair of circular spiral coils as a function of lateral offset between the center of the coils. The power transferred is shown at the receiver after rectification and other electronics, and is the DC power available for charging/powering a device. Power Transfer Efficiency is defined as the DC Power out from the receiver divided by DC power into the charger or power supply circuit; so it includes any power consumed by the FET driver, the FET, rectifier diode, and other electronics. This efficiency includes all losses (electronics, coil to coil losses, rectifier,

etc.) and is a more practical number for efficiency than the ratio of AC power out of a receiver coil to AC power into a charger or power supply coil commonly used. It can be seen that very efficient power transfer efficiency can be obtained with inductive methods. In accordance with the example shown, the coils can be identical and 1.25" in diameter and comprise 10 turns.

[00236] As can be seen from **Figure 35**, for the coil geometries used here, at an offset between the center of coils of half the radius, the power transferred can be 75% of the maximum value. Improvements in flatness of the curve may be possible with changing the design of the coil to overlap more of the field on the outer areas of the coil or by using hybrid coils.

[00237] However, it is important to note that while the transferred power decreases with offset between the coil centers due to reduced overlap of the coil areas, the power transfer efficiency (ratio of DC power out from receiver to DC power into charger or power supply) remains relatively constant in the range of offset < 3r/4. This is a more critical factor in design of an efficient system. If one assumes that a system can be designed such that the coil offset is never larger than r/2, then in a wireless charging or power transfer system, then, one can design the system such that the power transferred at this maximum possible offset is equal or greater than the maximum transferred power necessary.

[00238] For example, if **Figure 35** represents the maximum power transfer possible given the particular coil type, size, and geometry and the switching circuit (FET) and circuit design, then 3 W or more power can be transferred depending on the offset between the coils assuming that the coil offset is always smaller or equal to r/2. For a power supply application where regulated, constant power to a device is necessary, using regulation of the output power or a feedback to the charger or power supply to change the frequency or duty cycle, etc. to keep the power constant can insure that the received power to a device is independent of the offset between the coils. For example in this case, using regulation, one can ensure that up to a maximum power of 3 W can be provided to a load independent of coil offset (up to the maximum allowable offset – assumed to be r/2 here). In this case, the 3 W is sufficient for most mobile devices (mobile phones, cameras, Bluetooth headsets, etc.). Again, it is noted that the overall efficiency of the system remains high in all cases, since the offset (within the range of

possible offset values) and regulation of the power (if it is performed at the charger or power supply by changing duty cycle, etc.) do not have a large impact on efficiency.

Position Independence using Layers

[00239] From the discussion above, one can achieve the goals of high efficiency and position independence if a method is found wherein the offset between the charger or power supply and receiver coils is always kept equal or less than r/2. In the case of hexagonal spirals with side = r, the maximal diameter is 2r (similar to a circle with radius r). So for a given hexagon with side = r, the same relation holds. As described herein, several methods of achieving this are proposed.

[00240] **Figure 36** shows an embodiment in which a coil mosaic is used to cover the surface area of the pad. The circuitry can include means of sensing the presence of a receiver coil to start the appropriate driver to provide power. The drive and sense circuits and other electronics are shown here as components in the perimeter of the coil area but can be located anywhere. The approximate Effective Area is also shown. If the center of a receiver coil is placed anywhere within the effective area, the receiver will receive the specified power with only one appropriate coil in the charger or power supply activated.

[00241] In the geometry described here, each coil is driven by its own drive circuit. A sensing mechanism senses the presence of a receiver coil on top or close to a charger or power supply coil and starts the drive circuit to power the appropriate coil. The sensing mechanism can be a current sense mechanism. Each coil drive circuit can periodically start driving the coil at an appropriate frequency and a current sense circuit can monitor the drawn current to sense when a receiver is nearby thereby affecting the inductance of the charger or power supply coil. Driving the charger or power supply coil circuit at an appropriate frequency determined by the inductances of the charger or power supply and receiver coils and the capacitance of the load, can provide very high sensitivity to this change in the inductance.

[00242] Additional verification can be obtained by exchanging a verification code through the coils or by exchange of information through a second wireless data communication link (such as RFID, NFC, WiFi, etc.) between the pad and the device(s) to be charged. The code exchange can also provide information to the charger or power supply coil regarding the necessary voltage, power, temperature, or other diagnostic information for achieving reliable charging.

[00243] The approximate Effective Area is shown in **Figure 36**. Any point within the Effective Area shown has the property that a receiver coil placed with its center within this area is always within half a width or less of the center of at least one charger or power supply coil. If the system is designed such that moving the receiver coil within half the width of the center of any given activated coil provides at minimum the maximum output required (i.e. 3 W in the earlier example), the Effective Area has the property that a receiver coil with its center anywhere within this area can receive the necessary maximum output power or more with only one appropriate charger or power supply coil activated.

[00244] For the geometry shown in **Figure 36** comprising 75 hexagonal coils with side = r in 3 layers, the effective area is approximately 12 r wide and 6 mr high where mr is the minimal radius of the hexagon = $\sqrt{3}$ r. The total area is approximately 62r. In accordance with an embodiment, the Coverage Efficiency (CE) is defined as the Effective Area in units of coil radius (for circular coils) or length of side (for Hexagonal coils) divided by the number of Coils used. CE ~ 0.83 in this example.

[00245] To consider an example, one can take the maximum offset between the receiver and charger or power supply coil to achieve sufficient output power to be half the width of a coil (assuming symmetrical coils). Using coils with different width or radii (in the case of circular coils) or other geometries would change this value. It can be shown that a hybrid coil with a PCB coil and a wound wire coil are placed on top of each other is shown to have a more flat power transfer efficiency curve as a function of offset between the charger or power supply and receiver coil offsets. The general results and the operating principles for the embodiments discussed herein are valid regardless of what type of coil, geometry, or regulation is used to allow larger (or smaller) insensitivity to charger or power supply/receiver coil offset.

[00246] For the remaining portions of this document, embodiments are generally described which use half the width of the charger or power supply coil as the maximum allowable offset between the charger or power supply and receiver coil before the transferred power becomes lower than the desired maximum transferred power value.

[00247] The sense and control mechanism in the Configuration shown in **Figure 36** may be shared between a number of drive circuits to reduce parts count or may be integrated with each drive section. A number of other sense mechanism such as magnetic, optical, or capacitance sensors may also be used.

[00248] **Figure 37** shows an alternative embodiment in which the number of drive (and sensing) circuits may be reduced by using 1XN electrical or electronic switches. In this embodiment, a number (N) of coils are connected to a 1XN switch that is on the other side connected to a coil drive and sense circuitry. The switch periodically switches each of the coils in rotation to the coil drive and sense circuitry. Once an appropriate receiver coil in the vicinity of a charger or power supply coil is detected, that coil may be interrogated further to verify a chargeable device is nearby and then charging or powering of the device begins.

[00249] One drawback of this scheme is that since each drive electronics module can at most only be connected to 1 coil out of N coils in each segment, 2 devices placed on 2 different coils in that segment may not be powered or charged simultaneously. In practice, since each device to be charged will cover a certain amount of area on the surface, by appropriately segmenting the pad and choosing the size of charger or power supply and receiver coils, one can minimize the impact of this effect.

[00250] For an extreme case that N= NC (i.e. the number of coils in the pad), one can use a single drive and sense electronics module to monitor and power any coil in the pad thus greatly simplifying the architecture and potentially the cost of the charger or power supply. However, only one receiver coil, and hence only one device may be powered up or charged at any given time. The desirable characteristics of the 1XN switch are:

- Low ON resistance: This would reduce wasted power in the form of heat at the switch.
- High current capability: For power charging applications, depending on application and device to be charged, 0.5 A and higher, up to several Amps of current may be carried in ON state.
- High reliability: Failure of a switch would render the related segment dysfunctional.

Fortunately, the switching speed of the 1 X N switch is not critical for this application. For example, if it is desired for the pad to have a 1 second response time (time it takes for the pad to sense a device and begin charging), the switch must be able to disconnect and establish a new connection in under 1/N seconds (ignoring the time it takes for the sense and control circuitry to work which can be extremely fast). As an example, for N=10, this switch disconnect and connect time is under 100 msec, which is

quite achievable. Even lower switching speeds are acceptable for longer response times.

[00251] In accordance with an embodiment, the 1 X N switches may be implemented by electronics circuits or SPDT or DPDT IC switches, relays, MOSFETs, or Micro-Electro-Mechanical Systems (MEMS) switches. Other methods for switching may also be employed.

[00252] As an example of a an IC switch for this application, a series of Single Pole Double Throw (SPDT) switches with relatively low R_{ds} of 80 mΩ that can be used in this application. An example of the SPDT is available in a Quad (four switches) pack and is capable of carrying 500 mA which is sufficient for most low power applications. If larger current carrying capability is desired, two or more of the switches may be used in parallel. This particular IC also incorporates over current, short circuit, and temperature sense circuitry which provides additional safety features for a system. A 1XN switch can be created by connecting several of such switches.

[00253] In accordance with one embodiment, the surface of a charging pad is divided into segments where within each segment, a significant Effective Area wherein the center of a receiving coil can be placed to receive power is created.

[00254] **Figure 38** shows a case where a three-coil layer PCB is arranged to provide a cluster for uniform power in an area using only one coil powered at any given time. In this case, layer 1 comprises six coils arranged around a central coil for a total of seven coils. The second and third layers comprise six coils total. In total, nineteen coils exist in the three layers of the PCB.

[00255] **Figure 39** shows the coils are arranged such that by powering only one of the coils in the cluster, any receiver coil (for the receiver) placed with a center within any location in the effective area receive the specified power if the appropriate charger or power supply coil is activated. When the three layers are stacked together, seen from above, the structure is as shown in **Figure 39**. As described above, any point within the Effective Area shown has the property that a receiver coil placed with its center within this area is always within half a width of the center of at least one charger or power supply coil. Therefore, it can receive the necessary minimum power or more with only one appropriate charger or power supply coil activated.

[00256] For the case shown in **Figure 38** with nineteen distinct coils, five of the quad SPDT chips mentioned above can provide the necessary Switching capability to

allow a single drive and sense circuit to sense the presence or absence of a receiver coil near each coil. In accordance with an embodiment, the sequence can be:

- The switches are set so that the coil 1 in Layer 1 shown as (1,1) in **Figure 38** is connected to a switching and sense circuitry similar to the left side of **Figure 34** (i.e. the charger or power supply in **Figure 34**).
- MCU1 gives a command to the FET driver to begin switching the coil. The duty cycle may be set very low to generate a low voltage in any potential nearby receiver coil.
- If a receiver coil is nearby, it begins drawing power from the charger or power supply coil. This can be sensed as a higher than normal current draw in the current sense circuit of the charger or power supply.
- Additionally, the charger or power supply and receiver coil can exchange a code to confirm that a valid device or battery with appropriate circuitry is nearby and verified.
- At this point, the amount of current through the sense circuit is digitized by MCU1 and saved in its memory.
- Alternately, the receiver circuit can note the amount of voltage or power being received and report back to the charger or power supply. This information can be encoded by modulating the input impedance of the receiver circuit by MCU2. This information is then sensed by the charger or power supply sense circuitry, digitized by MCU1 and saved.
- The FET driver and therefore the FET are disabled.
- The switches are configured to connect the drive and sense circuitry to the next coil (Coil (1,2) in this example).
- Commands 2 through 8 are executed until all coils have been activated and tested.
- MCU1 compares the values received for sense currents and determines which coil has the highest sense current when turned on. This is the closest charger or power supply coil to the receiver coil. If additional circuitry for confirmation of valid receiver through exchange of code is implemented, the closest coil has to also pass this test.
- The appropriate coil is turned on and charging starts. An additional verification can be performed prior to start of charge.
- The charging continues in open or closed loop depending on the system architecture until end of charge is achieved. This is either indicated to the charger or

power supply by the MCU2 or sensed in the charger or power supply sense circuit by a change in the amount of current being drawn.

[00257] Depending on the characteristics desired and cost/performance tradeoffs, it may be decided that for each cluster, 2 or more drive and sense circuits and a smaller number of switches are used.

[00258] **Figure 40** shows one configuration wherein the number of switches required is reduced to three to switch to any of the 20 coils in **Figure 39**. The first switch connects the Vc to one of the ports (outside or inside contact point of the spiral coil) on every coil in one of the three layers. The other ports of groups of three of coils from different layers are connected together and input into the switches 2 & 3 as shown in the figure. The outputs of Switch 2 & 3 are connected together, and connect to the FET for switching. The center coil (1,7) is connected to the poles of the switches by itself. This coil is often the most likely coil for the receiver coil to be adjacent to since it is central. Comparing **Figure 40** with **Figure 34** shows that using this scheme, any one of the coils in the system can be connected by the switches to be driven by the FET.

[00259] Depending on cost/performance trade-offs involved, it may be advantageous to cut the number of switches by schemes such as shown in **Figure 40**. Such a scheme can also be used to cut down the number of switches in a larger array. For example, the array in **Figure 36** comprising 75 coils would require 19 Quad SPDT ICs to implement. However, by using one Switch to choose one of the 3 layers and 7 switches to choose one of the 25 coils in each layer, one can achieve the same results with 8 total switches.

[00260] With further cascading of switching layers, it is possible to further reduce this number. However, it must be noted that cascading of switching layers increases the Series Resistance along the current path of the charger or power supply coil which is undesirable.

[00261] In the examples given above, the switching is shown for Point A in **Figure 34** prior to the coils. However, Point B can also be used for this purpose.

[00262] The associated electronics are shown on the perimeter of the coils but can be placed in other locations too.

[00263] **Figure 41** shows a multi-charger or power supply pad that incorporates four of the clusters shown in **Figure 39**. A device to be charged or powered would have

to be placed such that the center of the receiver coil is within one of the effective areas in one of the clusters or segments. As an example, if the cluster is made of hexagons with side lengths r, a hexagonal Effective Area in the center of the cluster with a maximal diameter of 5 r is created. The Effective Area ~ 19r achieved with 19 coils giving a Coverage Efficiency = Effective Area (in coil radius or side length Units)/Number of Coils = 1.

[00264] For a typical coil of r =0.625" side, this leads to a maximal diameter of 3.125". Such an almost circular Effective Area with a diameter of over 3" can be marked on the surface of the charger or power supply pad and allows the user to easily place the receiver coil inside (or on) a mobile device such as camera, mobile phone, batteries, game players, etc. in the right location for charging without much alignment and effort. Each of the clusters in the configuration shown in Figure 41 can have their own coil drive and sense circuits or may share this circuitry through multiplexing with switches.

[00265] In this way, a practical system for providing a large Effective Area in each charging area (i.e. segment) while maintaining high power transfer efficiency is developed. A significant advantage is also that simultaneous charging of multiple devices can be achieved.

[00266] It should be noted that the charger or power supply coils can be designed to be larger than the receiver coils. By doing so, one can obtain an even larger effective area and insensitivity to placement of the receiver coil. The Effective Area has a maximal diameter of 3r. Other combination of coil patterns to achieve local position independence with a number of coils can be constructed.

[00267] **Figure 42** shows a cluster of 2 layers of 3 coils and a central coil (total 7 coils) that can create an effective area of 3r. In practice, such an area may be sufficient for many applications. It will be noted that while Hexagonal coils are shown in many of these figures, a combination of Hexagons and/or circles, or other shapes can be combined to provide the best efficiency/position independence performance. Similarly, the size and shape of the receiver can be non-Hexagonal.

[00268] For example, in Figure 42, the central and the receiver coil can instead be circular (spiral coil) and the central charger or power supply coil is the most likely charger or power supply coil for the receiver coil to be on top of. If the receiver coil is placed on any other position, a hexagonal coil is the closest coil and be powered. In accordance with other embodiments, the central coil in Figure 16 can be larger than the receiver coil

and cover most of the likely central area. The remainder of the coils would only be used if the receiver is placed in extreme outside locations.

[00269] It must be noted that the foregoing description describes the situation wherein the transmitted power drops to acceptable levels when the coil centers are offset by half the radius. In practice, this value can be different and by using a combination of coil patterns and sizes and regulation of the transmitted power, uniform power transmission across an area can be maintained.

[00270] While the use of IC switching elements has been discussed above, other switching mechanisms such as MEMS, relays, etc. can be used to achieve the results. In accordance with other embodiments, the switching may be implemented by creating a deformable layer under the coil layers to act as the switch. Each spiral coil discussed here has 2 ports with one at the outside diameter wherein the coil starts and one at the center wherein the coil terminates.

[00271] **Figure 43** shows a mosaic of hexagonal coils with the central port to each coil shown as circles. In accordance with an embodiment, one of the ports of all of the coils in the 3 layers (in this case, the outside port) is connected to a common point, called here P1. The other port of each coil (shown as the central one here) in the mosaic pattern of Figure 42 is brought down through vias to a common layer at the bottom of the multi-layer PCB and connected to a copper pad with a certain surface area. Such a pattern seen from above (the same side as Figure 43) is shown in Figure 44.

[00272] **Figure 44** shows the top view seen from the same side. The side view of the pad has integrated MEMS switch for contacting individual coil contact pads.

[00273] In an earlier US patent application 11/669,113, the use of attracting magnets placed at the centers of an inductive charger or power supply's PCB coil and the center of the receive coil to align and center the 2 parts conveniently has been described. Such techniques were used in the charger or power supply for mobile device or battery alignment.

[00274] In accordance with a present embodiment, a planar conductive layer or conductive traces patterned with conductive pads similar to the coil port pattern shown in Top part of Figure 44 and all connected to a common point (called P2 here) is created on a flexible material film. Examples of the material for the flexible film are mylar, polyimide, flexible PCB material such as Kapton, etc. or plastic. At the center of each of the pads, a

small magnet or ferromagnetic material is attached to the other side of the film. Alternatively, a layer of ferromagnetic material is deposited and patterned to have a pattern similar to Figure 45 top so that only material with a pattern similar to the PCB port pad remains. The flexible film is attached to the bottom of the PCB such that a small gap between the top layer of the film and the bottom of the PCB is created by a spacer. The side view of the MEMS charger or power supply pad is shown in Figure 44.

[00275] The entire package shown in the bottom of Figure 44 has 2 electrical connection points. One from the PCB, called P1 that is connected to one of the ports of all of the coils in the 3 layers of the PCB (in this case the edge port). The other connection is to the common pads on the flexible film. This is called P2. Looking at Figure 34, the entire package can be treated as L1, and connect P1 to point A in this circuit and P2 to point C.

[00276] Ordinarily, none of the coil center ports are connected to the contact pads on the flexible film and therefore the circuit is not completed. If a receiver coil with a magnet attached to the back of its PCB coil and the magnet oriented with correct polarity is brought close to the pad, it attracts the magnet or patterned ferromagnetic layer at the center of the nearest charger or power supply coil and at the bottom of the flexible film towards itself. This causes the top conductive layer on the flexible film to make contact with the center port of the appropriate coil and close the circuit. In this way, current can flow only through the appropriate coil and then activate it.

[00277] In accordance with an embodiment, to avoid oxidation of the contact pads at the bottom of the PCB and the flexible film contacts, these surfaces can be protected by deposition of additional layers such as gold or other material on top of the copper. Such processes are often used in PCB manufacture to protect exposed contacts. In addition, the PCB pad package can be hermetically sealed to avoid dust contamination on the contacts. Additionally, the volume inside can be filled with an inert gas such as nitrogen.

[00278] By optimizing the surface area of the contact pad and the flexible film contact areas and material composition, low contact resistance can be obtained. Other parameters to optimize are the area of the magnet or magnetic material and the type of material used.

[00279] The configuration above is provided by way of example. In accordance with other embodiments, it is possible to connect the components in a different manner, or to place in an external drive circuit in a different configuration to achieve the desired

result. A 3 layer board has also been used to demonstrate this approach. Simpler constructions with 1 or 2 layers or configurations wherein the coils in the different layers have different functions or sizes and provide different power levels can also be implemented. The advantages of this approach are:

1- High efficiency: Only the appropriate coil for high coil overlap is activated.

2- Position Independence: The receiver coil can be placed anywhere with its center in the Effective Area and achieve specified power transfer.

3- Low cost: The pad does not use any IC switching elements for connecting to the appropriate coil.

As described above, in accordance with an embodiment the entire package in Figure 44 is connected between points A and C in the circuit of Figure 34. One example of the operation of the system is described in more detail here:

- MCU1 gives a command to the FET driver periodically to begin switching the coil. The duty cycle may be set very low to generate a low voltage in any potential nearby receiver coil.
- Ordinarily, none of the coils is connected to point C in Figure 34. Therefore, no current is sensed in the current sense circuit.
- If a receiver coil is placed on the pad, it will cause the appropriate charger or power supply coil center port to contact the pad on the flexible film and therefore the appropriate coil is contacted to points A and C in Figure 34.
- The receiver coil begins drawing power from the charger or power supply coil. This can be sensed as a higher than normal current draw in the current sense circuit of the charger or power supply.
- Additionally, the charger or power supply and receiver coil can exchange a code to confirm that a valid device or battery with appropriate circuitry is nearby and verified.
- Once MCU1 determines that an appropriate receiver coil is on the pad and ready to draw power, the FET is turned on and charging starts. An additional verification can be performed.
- The charging continues in open or closed loop depending on the system architecture until end of charge is achieved. This is either indicated to the charger or power supply by the MCU2 or sensed in the charger or power supply sense circuit by a change in the amount of current being drawn.

[00280] The description provided above describes what happens when the activation of the MEMS switch occurs through magnetic attraction. In accordance with some embodiments, the switch can be designed such that it closes at the appropriate location due to static attraction, pressure, temperature change, or other mechanism.

[00281] In the MEMS system described above, a disk or other magnet in the receiver coil attracts a magnet or patterned ferromagnetic layer attached or deposited under the flexible film to close the contact beneath the appropriate charger or power supply coil to the FET. However, in other embodiments a ferromagnetic layer can also be used in the middle of the receiver coil (on the front of the PCB, its back or separate layer from the coil layer) and use either permanent magnets or deposit or sputter, etc. a patterned ferromagnetic layer that is permanently magnetized behind the flexible layer film. In this way, the charger or power supply pad would contain multiple magnetic points corresponding to the centers of the coils. When a ferromagnetic material is brought close to the pad, the appropriate coil is activated. To avoid false starts with metallic objects placed on the pad, secondary verification techniques, as described above, can be used, including in some embodiments an exchange of code between the charger or power supply and receiver coil.

[00282] Examples of metals that can be used are Ni, Fe, Co, or various commonly used alloys. These can be deposited on a flexible film in a variety of ways such as sputtering, evaporation, e-beam, plating, etc.

[00283] The system shown in Figure 44 is mostly designed to operate with a single FET and allow charging of a single device somewhere on the pad. If 2 devices are placed on the pad and 2 coils are connected to the pad, the power transferred may not reach the full specified power and it may not be clear which device is sending or receiving the control signals during charging.

[00284] In accordance with an embodiment, to overcome these issues, a segmented pad where clusters of charger or power supply coils are attached to individual drive and sense circuits and are independent of each other can be used.

[00285] The X-Y area is divided into segments (in this case 4 shown). One coil in each section can be driven by an appropriate FET and sense Circuit for that segment. Top: The pattern for contact pads at the bottom layer of the PCB. Each pad is connected to the central port of a coil in one of the 3 layers above. The top view is shown here.

Bottom: The side view of the pad with integrated MEMS switch for contacting individual coil contact pads. Spacers at the edges and the walls of the segment areas keep the flexible film at a pre-determined distance from the bottom layer of the PCB.

[00286] **Figure 45** shows the architecture of the segmented MEMS charger or power supply pad in accordance with an embodiment. Each segment comprising a number of coils is connected to points A and C of a different driver and sense circuit. Thus, devices placed inside each segment can be driven with their own driver and are independent. In this way, several (in this case 4) devices can be charged or powered simultaneously.

[00287] In Figure 45, additional spacers are placed at the boundaries of the segments. These spacers may help with keeping the flexible film/PCB gap constant and operation of the flexible film uniform along the X and Y direction. Such spacers interspersed in the X-Y plane between the PCB and flexible film layer may be used regardless of whether the pad is segmented electrically or not.

[00288] In accordance with some embodiments, the MEMS switching method described here can also be applied to the cluster geometry shown in Figure 41 or any other geometry.

Conductive Multi-Charger or Power Supply Surface

[00289] As discussed above, in accordance with some embodiments, another method for charging or powering multiple devices on a common charger or power supply surface is to incorporate a number of connector points or strips into the pad. The user can place a device with an appropriate connector on a pad or similar object and receive power through matching contacts on the pad. **Figure 46** shows a general diagram for this approach is shown in. In this approach, one or more regulated power supplies are connected to the charger or power supply pad. The pad comprises an array of contacts or strips of exposed connector.

[00290] **Figure 47** shows an array of contacts on the surface of a pad. In Figure 47, each position comprises a Voltage and Ground contact. In this picture, the connector is shown as a recessed circle similar to a washer where one contact is in the middle and the other contact is in the body or outside of the circle. Other connector geometries are possible.

[00291] A device with an appropriate mating connector at its bottom or in a plug-in unit for after-market applications can be placed on the pad and the connectors on the device make appropriate contacts to the pad contacts if placed on one of the contact points. In accordance with an embodiment, the connectors on the surface of the charger or power supply pad are connected to a number of switches which are connected to regulated power supplies and sense circuits as shown through switch arrays as shown in Figure 46. MCU1 periodically turns ON one of the regulated power supplies. The switches are set such that a connection is made to the 2 contacts of a contact point in the pad. The sense circuit detects any possible flow of current. If a current flow is detected, the system may verify the presence of a valid receiver through exchange of information through the contact with a MCU2 in the receiver. If no current is being drawn or the verification process fails, the MCU1 reconnects the supply to the next contact position. By rastering the entire pad periodically, contact to several devices on the pad for charging or power can be established. A diode D1 can be used for protection against reverse voltage, a Capacitor (C1) to filter any potential noise on the regulated power supply output, and MCU2 to enable communication between the Charger or power supply and the Receiver are shown. The receiver may also incorporate a voltage regulator to provide a constant voltage (or voltage in the acceptable range for operation) to MCU2. This voltage regulator just provides the low power necessary for this, and is not in the path of the main power going into the battery. Any power loss due to this regulator is small because it is very low power and does not affect the overall system efficiency much. It is mainly used to keep the MCU active during startup or other changes so the communication with charger or power supply is maintained. However, these components are optional and may not be present depending on the architecture used. The description provided herein does not depend on use of these components for operation.

[00292] If the ground (through a sense circuit) contact for all positions is connected together, then Switch Array 2 can be eliminated. Care must be taken to interpret the received signals in interpreting the current sense values since it is the sum of currents from all devices being charged.

[00293] The switching arrangements discussed above for the Inductive cases can be modified and used for this type of conductive switching as well. In addition, the MEMS based approach shown above are applicable to this application.

[00294] An embodiment for a universal charging pad using conduction is shown in **Figure 48**. In this case, one of the contact points for each position (e.g. Ground contact) is connected together throughout the pad and connected to the appropriate location (Ground through the sense circuit in this case). The other contacts are brought through the charger or power supply surface to the bottom of the surface and contact pads are formed.

[00295] Top: The pattern for contact pads at the layer below the connectors. One of the contact points for each position (e.g. Ground contact) is connected together throughout the pad and connected to the appropriate location (through Sense circuit to Ground in this case). Bottom: Side view of the pad with integrated MEMS switch for contacting individual contacts to the power supply. Spacers at the edges keep the flexible film at a pre-determined distance from the bottom layer of the PCB.

[00296] In accordance with an embodiment, a planar conductive layer or conductive traces patterned with conductive pads similar to the charger or power supply surface contact pattern shown in Top part of Figure 48 and all connected to a common point (called P2 here) is created on a flexible material film. Examples of the material for the flexible film are mylar, polyimide, flexible PCB material such as Kapton, etc. or plastic. At the center of each of the pads, a small magnet or ferromagnetic material is attached to the other side of the film. Alternatively, a layer of ferromagnetic material is deposited and patterned to have a pattern similar to the Top in Figure 47 so that it only material with a pattern similar to the charger or power supply surface pad pattern remains. The flexible film is attached to the bottom of the charger or power supply surface such that a small gap between the top layer of the film and the bottom of the charger or power supply surface is created by a spacer.

[00297] **Figure 48** shows the side view of the MEMS conductive charger or power supply pad. Using the MEMS conductive charger or power supply pad eliminates the need for switching arrays.

[00298] In accordance with an embodiment, the entire package shown in the bottom of Figure 48 has two electrical connection points. One from the top surface, called P1 that is connected to one of the connector points of all of the connector positions on the charger or power supply surface (Ground in this case). The other connection is to the common pads on the flexible film. This is called P2, and is connected to the other position in the circuit. For example, for the geometry discussed here, P1 can be connected to

Point B in Figure 49 and P2 connected to Point A. Figure 49 is a generalized block diagram of a charger or power supply pad with multiple regulated power supplies.

[00299] The case discussed here and the pad in Figure 48 enable connection of one regulated supply to one or more devices placed on the pad. However in the case of multiple devices on the pad, the voltage characteristics of the device would have to be identical to the first one and the sum of powers being drawn from the supply not exceed the maximum rating of the power supply. A more generalized approach wherein different voltages/power can be supplied to different devices is discussed in further detail below.

[00300] Ordinarily, none of the connectors are connected to the contact pads on the flexible film and therefore the circuit is not completed. In accordance with an embodiment, if a receiver with a magnet attached to the back or perimeter of the connector and the magnet oriented with correct polarity is brought close to the charging surface, it attracts the magnet or patterned ferromagnetic layer at the center of the nearest contact pad and at the bottom of the flexible film towards itself. This causes the top conductive layer on the flexible film to make contact with the contact pad for the appropriate connector at the bottom of the charger or power supply surface and close the circuit. In this way, current can flow only through the appropriate connector into the receiver circuit and the device to be charged.

[00301] As described above, to avoid oxidation of the contact pads at the bottom of the charger or power supply surface and the flexible film contacts, these surfaces can be protected by deposition of additional layers such as gold on top of the Copper. Such processes are common to protect exposed contacts. In addition, the pad package can be hermetically sealed to avoid dust contamination on the contacts. Additionally, the volume inside can be filled with an inert gas such as nitrogen.

[00302] By optimizing the surface area of the contact pad and the flexible film contact areas and material composition, low contact resistance can be obtained. Other parameters to optimize are the area of the magnet or magnetic material and the type of material used.

[00303] Top: The pattern for contact pads at the layer below the connectors. One of the contact points for each position (e.g. Ground contact) is connected together throughout the pad to form contact point P1. Bottom: Side view of the pad with integrated MEMS switch for contacting individual contacts to the power supply. Spacers at the edges and the walls of the segment areas keep the flexible film at a pre-determined

distance from the bottom layer of the PCB. The contact pads in each segment of the flexible film are connected together to form contact P2 for each segment.

[00304] **Figure 49** shows another embodiment where several regulated power supplies provide power to the pad. This allows charging of several devices simultaneously.

[00305] **Figure 50** shows an alternative embodiment using a segmented surface. The operation of this is similar to previously described except that the top and bottom contact points for each segment P1 and P2 are connected to the appropriate positions in B and A in Figure 49 so that each regulated power supply is connected to one of the segments in the charger or power supply surface when the circuit is closed. In this way, a device placed on each of the segments can be powered by the regulated power supply at its required voltage and power level.

Electromagnetic Shielding

[00306] Electromagnetic Interference (EMI) is an important aspect of performance of any electronic device. Any device to be sold commercially requires adherence to regulation in different countries or regions in terms of radiated power from it.

[00307] For an inductive charger or power supply comprising a number of coils and electronics switches and control circuitry, the main sources of noise include:

- Any potential radiated noise from switching FETS, drivers, etc. or sense and control circuitry. This noise can be at higher frequency than the fundamental drive frequency of the coils and can be emitted away from the charger or power supply because of the frequency. This noise can be minimized by optimizing the drive circuit to avoid sharp edges in the drive waveform and associated noise.
- Noise from copper traces with ac signals. This noise can also be at higher frequency and emit away from the charger or power supply. The length of these paths must be minimized.
- EM emission from the switched coil. For coils described here and driven in the 100's of kHz up to several MHz, the wavelength of the Electromagnetic (EM) field generated can be in the hundreds of meters. Given the small length of the coils windings (often 1 m or less), the coils used are not efficient far-field transmitters of the EM field and the generated EM field is in general highly contained near the coil surface. The magnetic

flux pattern from a PCB coil is highly contained in the area of a coil and does not emit efficiently away from the coil.

[00308] Care must be taken when designing the current paths, and in some embodiments shielding of the FETs or other ICs or electronics components may be necessary. In addition, switching the coils with waveforms that have higher frequency components, gives rise to noise at higher frequencies. In any of the above geometries described, incorporation of conductive layers and/or ferromagnetic layers in the system can shield the outside environment from any potential radiative fields. The conductive layers may be incorporated in the PCB to eliminate the need for additional separate shielding layers.

[00309] In the examples provided above, while the 3 coil layers can be incorporated into PCB layers, the electronics components can be placed on the lower most surface of the PCB to allow a flat surface on the top and allow receiver coils to get as close as possible to the charger or power supply coils. One possible arrangement for the location of the electronics components at the bottom surface of the total PCB stack is shown. In this case, in some or all of the layers above, the PCB layers can incorporate Copper sections in the areas shown in black in this figure. By appropriately grounding these sections and providing additional conductive and/or magnetic layers below the electronics components, the EMI can be significantly reduced.

[00310] In accordance with an embodiment, another method for minimizing the effect of the copper traces in the PCB is to sandwich them between layers of conductors in the PCB. In a multi-layer PCB, the copper trances and connections to all the components and coils can be for example, be in a middle layer and the necessary connections to the ICs or other layers be made through vias. Given that the magnetic flux is highly contained within the coil area, the layer containing the coil or another layer below or above can contain a substantially continuous layer of copper covering everything except the area of the flux generated by the PCB (very close to the outside ring of the coil). By having two or more conductive PCB layers for shielding sandwiching the signal and current paths, most of the noise generated can be shielded very close to the source. Since the noise from the PCB is minimal and does not radiate, the remaining source of noise, the electronics, FETS, etc. can be shielded by covering the section with these devices with a metallic cover or shield.

[00311] Similar types of judicious incorporation of grounded Copper layers in the PCB layers in any of the designs above can significantly reduce any potential EMI issues without requiring additional shielding layers.

[00312] **Figure 51** shows a standard used within the European Union for measuring emissions from a product. In this case, the emissions from a product are measured at 10 m distance. This test (EN 55022) looks for emissions from 30 MHz to 1 GHz. Limits for Class A and Class B certification are shown in the Figure.

[00313] Figure 51 shows a typical scan of emissions from an inductive multi-charger or power supply pad. As discussed above, the radiation at the fundamental operating frequency (100's of kHz to several MHz), can be self-contained within the coil area. However, noise at higher frequencies (such as the test range of 30 MHz to 1 GHz) must be reduced to avoid interference with other nearby electronic devices.

[00314] Metallic and/or Ferromagnetic layers are often included in electronic devices to reduce their EM emission. An example of such layers is described in U.S. Patent Nos. 6,888,438, and 6,501,364. In these instances, PCB coils are formed on two sides of a PCB, and ferromagnetic and copper layers are placed on each side of the PCB to limit emissions from a package containing such a transformer.

Frequency Selective Electromagnetic Shielding

[00315] In accordance with some embodiments of the inductive universal charger or power supply pad described herein, the inclusion of metallic and/or Ferromagnetic layers at areas that are potential sources of emission such as FETs, etc. may be beneficial. However, a method that would wholly cover the charger or power supply pad package to eliminate potential for escaping EM fields may provide benefits.

[00316] Given that the inductive charger or power supply pad operates by generating an oscillating magnetic field, such an approach does not seem feasible as it would block such a field from being sensed by the receiver coil.

[00317] In accordance with an embodiment, a method is described herein that allows the inductive pad to emit EM waves efficiently for operation while simultaneously providing shielding to high frequency EM fields. Such operation is achieved by taking advantage of the skin effect in conductors.

[00318] The skin effect is the tendency of an alternating electric current (AC) to distribute itself within a conductor so that the current density near the surface of the conductor is greater than inside the material. That is, the electric current tends to flow at the "skin" of the conductor.

[00319] The skin effect causes the effective resistance of a conductor to increase with the frequency of the current and has practical consequences in the design of radio-frequency and microwave circuits.

[00320] The current density J in an infinitely thick plane conductor decreases exponentially with depth δ from the surface, as shown below:

$$J = J_S e^{-\delta/d}$$

where d is a constant called the “skin depth”. This is defined as the depth below the surface of the conductor at which the current density decays to 1/e (about 0.37) of the current density at the surface. It is given by:

$$d = \sqrt{\frac{2\rho}{\omega\mu}}$$

Where:

ρ = resistivity of conductor

ω = angular frequency of current = 2π × frequency

μ = absolute magnetic permeability of conductor $= \mu_0 \cdot \mu_r$, where μ_0 is the permeability of free space and μ_r is the relative permeability of the conductor.

It is important to note that d decreases rapidly with frequency. The magnetic and electric field similarly get attenuated traveling through a sheet of a conductor. Using the values for conductivity of copper (5.8×10^7 Siemens/m), the absorption going through a single layer of copper with various thickness can be calculated.

[00321] **Figure 52** shows the absorption through a copper layer of 70 μm and 7 μm. While the 70 μm layer provides very high attenuation in the region of interest (30

MHz to 1 GHz), the attenuation is excessive in most cases and is only needed in extraordinarily noisy circumstances.

[00322] As described herein, the transmitted power is considered through a very thin conductive layer.

[00323] **Figure 53** shows how the attenuation values are shown for Copper and Aluminum (conductivity of 3.76×10^7 for 99.99% Al) layers for several thicknesses.

[00324] For these calculations, the placement of the layer with respect to the source of the EM field needs to be included. In these calculations, the source is assumed to be 0.5 mm under the layer. This is similar to placing the layer essentially directly on the source of the field.

[00325] It will be noted that, for very thin layers of Copper and Aluminum, down to 1 micron thickness, very high attenuation values at frequencies over 1 MHz are obtained. The attenuation of 1 μm layers of Copper and Aluminum at 10^9 Hz are respectively 32 dB and 28 dB and are comparable. However, at 1 MHz or below, the attenuation in either material for such a thin layer is minimal. In accordance with some embodiments, this behavior or characteristic can be exploited.

[00326] **Figure 54** shows Transmitted EM Power through Copper and Aluminum layers of varying thickness for an incident EM field at 1 MHz which is a typical operating frequency for the type of inductive universal charger or power supply described herein. Below 5 □μm thickness, the transmitted power exceeds 95%. Aluminum in particular (due to its lower conductivity), has a wide range of thicknesses that allows a 1 MHz radiation to transmit through without much attenuation.

[00327] As discussed above, in some embodiments of the inductive charger or power supply device described herein, the generated EM field at the operating frequency of the charger or power supply (typically ~ 1 MHz), is generated by an inefficient PCB coil antenna and is mostly confined to the area immediately near the coil (to be picked up by the receiver coil). However, any noise generated by driving the coil at this fundamental frequency (due to nonlinearities at the components, non-sinusoidal signal, or at the FET or the FET driver) or any noise generated at any other location in the charger or power supply device current paths or components or the receiver (including noise generated at the receiver rectifier), can have components that are much higher in frequency. It is desirable to suppress such noise to the extent possible.

[00328] In accordance with an embodiment, a very thin layer of a conductor (such as Copper or Al, organic conductors, nanotech materials, nanotubes, or other material), covering all or part of the charger or power supply and/or receiver circuit can be used to allow the desired low frequency components (Several MHz or below) to travel through without attenuation while severely reducing the higher frequency noise. In accordance with some embodiments, the entire inside or outside surface of the charger or power supply and/or receiver package circuitry or part of it is covered to achieve this frequency selective shielding without dramatically affecting the fundamental operation of the device.

[00329] In one embodiment, the entire inside or outside of the package for the inductive charger or power supply and /or the receiver for such a charger or power supply is covered by a thin layer of a conductor (15 μm thick or less or preferably less than 5 μm thick). The conductor can be metallic as discussed above, metal alloys, organic, nanotech materials, nanotubes, etc. At high frequencies, such a layer reduces the emitted EM power considerably (greater than 20 dB or even 30 dB) while allowing most (>90%) of the fundamental operating frequency power to transmit through the layer. The conductive layer can be directly deposited on the parts. To avoid shorting of any electronics or connectors, contacts, a dielectric layer, paint or other material must be first deposited. Alternatively, the conductive parts can be masked off so as not to contact the EM shielding conductive layer.

[00330] The deposition of the conductive material can be done in a variety of manners (sputtering, evaporation, electroplating, coating through dipping, Langmuir Blodgett, painting, etc.) for different materials. Recently, an inexpensive method (Ecoplate) for conformally coating any material with metallic or metal alloy layers at room temperature has been developed. In this process, a spray of molten metal at controlled temperature and velocity instantaneously cools on incidence with a substrate and forms a conformal layer covering the entire or part of a part.

The EM conductive shield can also be deposited onto a substrate such as a polymer (e.g. mylar, polyimide, polyurethane, plastics, etc.), rubber, etc. and the conductive layer coated polymer be applied to the inside or outside of the part. Anti-static bags are an example of a metalized polymer material. Aluminum is commonly used for this application.

[00331] In another embodiment, the PCB boards, electronics components, and the coils in the charger or power supply and/or the receiver are covered by a nonconductive layer (such as a dielectric, paint, etc.) and then covered completely or locally by a

conductive layer of appropriate thickness either directly deposited on the board and the electronics or indirectly with a polymer or similar backing (as described above).

[00332] The optimum thickness of the conductive material is highly dependent on its conductivity. By choosing the material composition and thickness, one can obtain the desired combination of EM noise suppression and transmission of fundamental frequency.

[00333] It is also possible to combine conductive layer materials and thicknesses to construct a more tailored frequency response. Such an approach is commonly taken in the optical domain to fabricate wavelength dependent filters.

[00334] In those embodiments wherein the conductive layer covers the charger or power supply and/or receiver coil, it may be desirable to generate an EM field with a charger or power supply coil and then, after passing the emitted field through such a conductive layer, turn it back to DC power through the receiver coil and rectification. Since the conductive layer is a frequency dependent filter, in this process, this removes or weaken any higher frequency signals and enables the receiver to receive a cleaner, and depending on the design, more sinusoidal signal. Such high frequency noise is often related to not-only EMI disturbance and lack of signal to noise ratio in the electronic device to be charged. In addition, the higher frequency noise causes non-optimum operation of the receiver and possibly heating of the receiver or other components. By removing the generated noise, electrical and thermal/environmental performance of the charger or power supply and receiver system may be improved.

[00335] Such a physical filtering of an electrical system is analogous to an optical signal being filtered in the wavelength domain (by an optical filter, grating, etc.) before reaching a receiver. The SNR and efficiency of the system is improved in this way.

Use of Magnets for Alignment of the Coils

[00336] **Figure 55** shows a method for obtaining local alignment independence between the coils in the charger or power supply and the receiver are shown therein. In accordance with an embodiment, by using small magnets behind (on the side opposite to the side facing the surface of the charger or power supply) the center of each coil in the charger or power supply, and behind (on the side opposite to the side facing the surface of the charger or power supply) the coil in the receiver, such that the magnets attract each other, a charger or power supply system can be provided wherein the user can easily find the location where the charger or power supply coil is located, without providing any

physical features and/or marking on the surface of the charger or power supply. This may be advantageous in enabling charger or power supplies which can be used with any device to be charged without need for special alignment or size features. This allows charging of any size and shape device and/or battery. In this geometry, shown in Figure 55, the magnets can be thin flat or other shape magnets placed at the center of the coil and allow the device or battery to be charged to be rotated around the charger or power supply coil with no effect.

[00337] As described above, by enabling the coil in the charger or power supply to move laterally (and somewhat vertically) in the plane of the charger or power supply surface, automatic alignment of the charger or power supply and device and/or battery coil can be achieved when a device and/or battery is laterally brought close to the center of the charger or power supply coil.

[00338] If magnets used for this application are electrically conductive, then some of the field generated by the coil will generate currents in the magnet and heat the magnet, decreasing the efficiency of the system and generating unwanted heat. This effect especially becomes important as the field strength of the coil is increased for higher powers.

[00339] In accordance with some embodiments, methods for dealing with this problem can be included, such as:

- Since the currents are created by eddy currents generated in the magnets, use of non-conductive and/or low conductivity magnetic material can improve this condition.
- The magnet can be constructed of thin flat magnet material with laminate in between the layers to decrease the current flow and loss of power.

[00340] **Figure 56** show an embodiment in which the magnets can be broken or divided into sections, such as semi-circles with a gap or non-conductive material in-between to avoid current circulation. By having each set of magnets behind a coil to be made of two or more sections, the electrons are disrupted from circulating and generating strong eddy currents leading to heating and power loss. In this figure, each set of magnets behind a coil are made of semi-circular magnets. The poles of the magnet are aligned with the South or North pole facing the surface of the charger or power supply. The magnet in the device or battery have the opposite polarity so that the magnets of the charger or power supply and the device and/or battery attract. By having each set of

magnets behind a coil to be made of two or more sections, the electrons are disrupted from circulating and generating strong eddy currents leading to heating and power loss. In Figure 56, each set of magnets behind a coil are made of two semi-circular magnets.

[00341] **Figure 57** shows an embodiment in which one or more alignment magnets can be used behind each coil. However, in accordance with an embodiment the magnets are placed such that each magnet does not cover an area extending beyond the center of the coil. In other words, the surface of the magnet does not cover the center of the coil and thereby does not allow circular currents to be set up in the magnet as effectively. In this way, the eddy currents set up are much weaker and much smaller power dissipation in the magnets occurs. Alignment magnets at center of charger or power supply and device and/or battery coils for alignment of the two coils are attached to the back of the coils in such a way that the area of the magnet does not extend beyond the center of the coil. In this way, the eddy currents created are much weaker and much less power is lost to the magnets. In this figure, two magnets are shown per back of each coil (four total for a pair of charger or power supply and receiver magnets). However, any number of magnets from one to many can be used.

Additional Applications - Charger/Power Supply with Self-Powered Operation

[00342] **Figure 58** shows an illustration of a device for inductive power charging that includes an internal battery for self-powered operation, in accordance with an embodiment. As shown in Figure 58, an inductive charging unit such as an inductive pad 360 includes a rechargeable battery 364. The unit is normally operated with, or is occasionally coupled to, power input from an electrical outlet, or from a dc source such as a standard automobile 12 volt dc outlet, or from an outlet in an airplane or an external dc source, or from another power source such as the USB outlet from a computer or other device. Alternatively, the power can come from a mechanical source such as a windmill, or a human-powered crank handle. The unit can include coils 362 that are energized to transfer power to receiver coils in mobile electronics devices such as mobile phones, MP3 players, radios, cd players, PDAs, and notebook computers. At the same time, the input power charges the rechargeable battery inside the unit itself. When the external power source to the unit is disconnected, or when no input power is provided, the unit automatically switches its operation from its charged internal battery. Alternatively, the unit's operation can be switch-operated by user. In this way, users can continue to charge

their devices by placement on the unit without any outside power source. This use can continue until the external power is restored or until the internal battery is completely discharged.

[00343] The ability of the unit to continue charging depends on the capacity of the battery included. Thus, for example, with a 1500 mAH internal battery, the unit is able to charge a mobile phone with a 1000 mAH battery completely if the losses due to conversion efficiency, operation of the circuitry in the unit, and other losses are up to 500 mAH.

[00344] In other embodiments of an embodiment, the unit can be powered by other power sources such as a fuel cell that generates power from methanol or other sources. The unit can also be connected to the electric grid through an outlet or to an external DC power source such as power from an outlet in a car or airplane or be itself charged or powered inductively by another unit. However, when not connected to outside power, the unit can be powered by its internal power generator from the fuel cell and can charge devices placed on it inductively.

[00345] **Figure 59** shows an illustration of an alternate embodiment of an inductive charger or power supply unit or pad 370 with a solar cell power source for self powered operation, in accordance with an embodiment. As shown in Figure 20, the surface of the unit can be covered by a solar panel or solar cell 376. In normal operation, the unit can be powered-up or charged by connection to an electric outlet or external DC source. But without external electric power, the panel generates electric power that is used to power the charger or power supply which in turn can charge devices placed on it through the inductors in the unit. In some embodiments the unit can also include a rechargeable battery 374 that can be charged when the unit is either connected to external electric power or charged by the solar cells on the surface of the unit. This battery can then operate the unit when the unit is either not connected to external electric power or the solar cell is not generating enough power to run the unit such as during operation at night.

[00346] **Figure 60** shows an illustration of an inductive charger or power supply unit with an incorporated communications and/or storage unit, in accordance with an embodiment. As shown in Figure 21, in accordance with some embodiments the charger or power supply, including for example the regular charger or power supply 380, and the solar-cell powered charger or power supply 382, can further comprise an optional communications and/or storage unit, for storage of data and transmission of data to and from a mobile device being charged. Examples of components that can be incorporated include Bluetooth, Near-field Communications (NFC), WiFi, WiMax, wireless USB, and proprietary communications capabilities, including means of connecting to the Internet.

Additional Applications - Inductive Charger Applications and Kiosk

[00347] The technology described herein may also be used for other applications. In some applications, it may be desirable to build the inductive (as described above) or wire free charger or power supply into a case for an electronic device, a briefcase, or other carrier such as a box, holder, or container in a car or other wise. An example can be a brief case, hand bag, or back pack where the bottom part or the outside surface has an integrated charger or power supply. Any device enabled to receive power from such a charger or power supply (device containing coils and the appropriate electronics to receive power or with appropriate contacts for wire free charging) can be placed on or inside such a briefcase and be charged. The charging circuitry can be powered by plugging the briefcase, handbag, or back pack into an outlet power or having internal

batteries that can be charged through power from a wall plug or by themselves being inductively charged when the briefcase, handbag, or backpack is placed on an another inductive or wire free charger or power supply. Uses can be applied to any bag, container, or object that can be used to essentially charge or power another device. This first object can itself be charged or powered through an outlet directly by wires or wirelessly through an inductive or wire free charging system. As an alternative, the first object (the charger or power supply) can be powered by solar cells, Fuel cells, mechanical methods (hand cranks, pendulums, etc.).

[00348] In all of the above case, it is possible for the functions of the inductor or wire free charger or power supply and the power source for the charger or power supply (battery, fuel cell, solar cell, etc.) to be separated. Furthermore, in some cases, the charger or power supply part can be separated from a portable power source to operate it (such as a rechargeable battery) which is in turn powered or charged by another source (power outlet, fuel cell, solar cell, mechanical source, etc.). The three parts can be in the same enclosure or area or separate from each other.

[00349] An additional example may be an after market inductive or wire free charger or power supply for a car where the inductive or wire free charger or power supply or pad including a solar cell on the pad or in another area and connected to the pad by wires is used to charge mobile devices. Such a device placed on the dashboard or tray between seats or a special compartment can be used to charge a number of devices such as phones, MP3 players, cameras, etc. Devices such as GPS navigation systems, radar detectors, etc. can also be powered from such a device. In another application, mugs, cups, or other containers with a receiver circuitry and means of heating or cooling the contents can be used in combination with the inductive charger or power supply to keep the contents hot or cold. A dial or buttons on the cup or container can set the temperature. The charging device or pad can also contain rechargeable batteries that allow the device or pad to store energy and operate in the absence of any external power if necessary.

[00350] Other applications of this technology include clothing, jackets, vests, etc. that have an integrated inductive charger or power supply such that a user can power or charge a device by simply placing it on or near a pocket or an area where wireless inductive power is available. The jacket or clothing can in turn be powered by solar cells, Fuel cells, batteries, or other forms of energy. It can also be powered by batteries that are

recharged through solar cells sown onto the clothing or be recharged by placing or hanging the clothing item on a rack or location where it is recharged wirelessly or inductively. By using inductive charging, the user does not have to plug in devices into individual wires and connectors at the appropriate jacket pocket.

[00351] In some cases, it may be desirable to build the charger or power supply or the secondary part (receiver for a charger or power supply) into the protective case of another device. For example, many products exist today that are after-market or optional items such as a skin or case for a music player, phone, PDA, or notebook computer. In one implementation, the case or skin can contain the electronics and the coil necessary to allow the device to be charged or charge other devices or both. The charger or power supply can be powered by the device it is attached to or can receive power from a separate source such as a solar cell, fuel cell, etc. that is integrated with the charger or power supply or in another location and electrically connected to the charger or power supply. For example, in a briefcase, while the charger or power supply is inside the briefcase and can charge devices inside, the surface of the briefcase can have solar cells that power the charger or power supply inside. The briefcase can also contain rechargeable batteries that store power generated by the solar cells and use them when necessary to charge devices inside. Similarly, the charger or power supply can be built on the outside or inside surface of the case and charge devices placed on or near the surface.

[00352] It is also possible to provide a charger or power supply with modular components that allow other capabilities to be added later or simultaneously as an option. In one embodiment, an inductive charging pad that contains a rechargeable battery can have a separate top surface module or all around cover or skin that contains a solar cell array and simultaneously electrically connect to the charger or power supply pad to enable the battery internal to the unit to be charged without any external power input. It is also possible to have the cover or the outside skin to provide other capabilities such as communications, or simply provide a different look or texture so that the pad fits in with the user's taste or décor.

[00353] **Figure 61** shows an illustration of a kiosk that incorporates an inductive charger or power supply unit in accordance with an embodiment. As shown in Figure 61, the kiosk 390 includes a control screen 392 and an inductive charging pad 394, to allow individuals to walk-up and purchase an occasional charge for their mobile device.

Currently, the usage model of typical mobile user consists of charging their most essential device (phone, MP3 player, Bluetooth headset, etc.) during the night or at the office or car. In cases where the user is outside their environment for a long time such as traveling, this may not be possible. A variety of public mobile device charging stations have appeared that allow the user to charge their device in a public setting by paying a fee. An inductive or wire free public charging station or kiosk would allow the user to place their mobile device that is 'enabled' (i.e. has the appropriate receiver or components to allow it to receive power from the charger or power supply) on or in the wire free or inductive charger or power supply station and charge the device. The customer can pay for the service or receive the service for free depending on the service providers' approach. The payment can be cash, credit card, debit card, or other methods.

[00354] In accordance with an embodiment, a single pad with multiple stations can charge multiplicity of devices simultaneously. The user may be asked to pay for the service before charging a device or the service may be for free. Alternatively, each charging station can be in a compartment and the device is secured by a door that can only be opened through a code given to the device owner when charging starts or payment occurs. The door can also be secured by a combination lock or physical key.

[00355] Alternatively, the charging station or kiosk can be open and not physically secure but when the user pays for the service, a code is issued. The user proceeds to place their device to be charged but when the charging ends or the user wants to pick up the device, the code must be entered first. If no code is entered, an alarm is sounded or the device is deactivated or some other warning occurs. In this way, a thief or the wrong user can not remove the device without attracting attention that may act as a deterrent. A combination of the above techniques may be used in implementing a public charging kiosk.

[00356] Since a typical charging process can take up to 30 minutes or more, it is possible to also synchronize data, download songs, movies, etc. into the device during this time. Many of current mobile devices have Bluetooth or WiFi capability. Other communication protocols such as WiMax can increase the data rate further. By combining the charging and information transfer process, the service provider can charge for additional services. In addition, if a camera is being charged and has wireless capability, it can download the pictures or movies to a designated website or online storage area or be emailed to a designated email address while charging. In this way, a

traveler can simultaneously charge a camera while downloading the contents of its memory to a location with larger memory. This would enable the traveler to free up limited memory space in their camera or other mobile device. Such a service would enable devices that have limited or short range wireless communication capabilities (such as mobile phones, MP3 players, cameras, etc.) to be able to connect to the internet and send or receive data indirectly. It is important to recognize that without the charging capability, a device conducting such downloading or synchronization through an intermediate device (Bluetooth to internet gateway for example) often run out of power due to the length of time this takes. In this manner the charging capability of the kiosk enables a more effective operation.

Additional Applications - Inductive Charger Applications and Kiosk

[00357] With increased functionality in mobile devices, there is an ever-increasing focus on maximizing the battery life. Currently, the rate of increase of power usage continues to outpace new and improved battery technologies. Given the desire to minimize mobile device size, the battery power limitation has required some mobile device manufacturers to begin shipping mobile devices with several batteries and a desktop charger to keep all of those batteries regularly charged. The user is sometimes expected to change the batteries for the device during the day while using the device. Such a situation is not ideal and puts the burden on the user to carry multiple batteries, and to keep those batteries charged.

[00358] Methods for extending the battery life in mobile devices, but which do not greatly increase the size and weight of the mobile device, are extremely useful for new power hungry enhanced multi-media mobile devices. By way of example, one solution that has been proposed is described in U.S. Patent No. 6,184,654. However, such a technique and geometry is incompatible with the variety of mobile devices and connectors in use today, and requires the user to plug the device into a connector inside the holster while fastening it to hold it securely.

[00359] Described herein is a system and method for extending the battery life of mobile devices by integrating a wireless charger into the case, carrier, or holster for the device. The system and method has the advantage of keeping the size and weight of the mobile device low while enabling the user to automatically recharge the device when placed in the case thereby dramatically increasing the device run time.

[00360] In one embodiment, the case recharges the mobile device inductively, and can itself be recharged by an inductive base charger. Various embodiments including additional integrated functionality such as data storage and communication in the case are also described herein.

[00361] **Figure 62** illustrates some common regular (non-charger) mobile phone holders types, including a belt holder 1000 and case 1002.

Powering Mobile Devices and Inductive Charging Case

[00362] Mobile devices continue to converge and to combine multiple functions and protocols into ever-smaller packages. While mobile TV, radio, high resolution cameras, GPS, etc. are becoming standard in many mobile phones, the power usage of the devices continues to rise. One solution that has been applied to several devices is the use of external battery packs.

[00363] **Figure 63** illustrates various products for a music player, (e.g. an iPod or MP3 player) that include an external rechargeable battery pack.

[00364] As shown in, the external battery pack provides extra running power for the device when it is plugged into the music device and clipped to its back, by providing power through the battery pack's internal higher capacity batteries. However, this battery pack is expected to remain connected to the device at all times and increases the size and weight of the device considerably. This is very undesirable from the customer perspective and inhibits mobility/use and adoption.

[00365] In accordance with embodiments of an embodiment, the battery power of the mobile device is extended by providing a holster, case, pouch, bag, wallet, or an equivalent holding, carrying, or storage device (which for convenience are herein referred to as a "case") for the mobile device (e.g. mobile phone, Bluetooth headset, camera, laptop, PDA, MP3 player, game player, etc.). The case can incorporate one or more rechargeable batteries, and one or more inductive charger or power supplies. A mobile device can be 'enabled' to receive power inductively by providing a receiver (such as a coil, etc.), and circuitry integrated by the manufacturer, or by a battery with a built-in receiver, or by a plug-in unit to receive power, etc. A suitably enabled device can thus receive power when placed in the case. In accordance with some embodiments, the case can also include means of recognition of the device automatically by, for example, RFID,

Felica, detection of coil from change in the case's coil's induction, or by verification using proprietary techniques, etc. In some embodiments, the system or coil can be enabled to turn on automatically as necessary and to begin charging the device. Alternatively, the case and/or coils can turn on when a device is placed in it by sensing the presence of a device through a magnetic, mechanical, or other form of switch. Alternatively, the case can include a mechanical or sensory switch that must be manually activated by a user to begin charging the device.

[00366] In accordance with some embodiments, the case can accommodate more than one device. For example, the case can include a location for a Bluetooth headset and a mobile phone. Either or both of these devices can be inductively charged by the case when placed inside the case. This enables the user to have a simple way to carry both parts or devices together, and to extend the battery capacity of both without needing them to be any larger, thus providing great advantages for the consumer.

[00367] In accordance with an embodiment, the batteries inside the inductive charger case can themselves be charged by either a regular charger/power supply, or through another inductive charger or power supply. For example, a desktop inductive charger can charge the inductive charger case, and simultaneously charge the mobile devices (mobile phone, Bluetooth headset, camera, etc.) or battery. Alternatively, the desktop charger or power supply or base can be designed so that it can also charge the mobile device directly when the device is placed on it (without any case present). As described above, the inductive case can also be designed so that it will charge its internal batteries, and the devices inside, when it is connected to a regular power supply/charger.

[00368] Some embodiments of the case can include data storage, communication or other capabilities (for example, GPS, WiFi, etc.).

[00369] **Figure 64** illustrates a multi-function device that includes a hard drive, rechargeable battery, Bluetooth, and WiFi connectivity.

[00370] Typical multi-function devices such as that shown in Figure 64 are of the size of a credit card and about 10mm in thickness. The multifunction device allows a mobile phone user to store the majority of their digital data (pictures, movies, music, etc.), and to have that data available wirelessly on their mobile devices. The mobile phone and multifunction device can also connect wirelessly to a computer or laptop, for download or upload of information.

[00371] In accordance with an embodiment, a multifunction device such as that shown in Figure 3 can be integrated into the case, and can have a wireless charger or power supply built into it. Once a mobile device is placed into the case or on the modified multifunction device, it can establish communication, and/or can be charged simultaneously. Since a typical multifunction device already has internal rechargeable batteries, the same batteries can be used to power the charger for the mobile device. The multifunction device case can also be charged wirelessly (using an inductive charger or power supply pad or similar device), or through conventional means.

[00372] In other embodiments, the wireless charger or power supply case can be integrated into a compartment in a briefcase, handbag, backpack, carrier, clothing, automobile, airplane, or other transport vehicle, etc. Some of these are applications are described in further detail in copending U.S. Patent Application titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; Application No. 11/669,113, incorporated herein by reference.

[00373] **Figure 65** illustrates a system for use with a charger or power supply case to inductively power or charge a mobile device. As shown therein, an inductive charger or power supply base or pad charges a case, holster, or other small, portable charger that in turn can charge or power a mobile device or battery placed in proximity to it. The second part (charger case) can be a stand-alone device or be integrated into another device, as in the case of the multifunction device example described above. In other embodiments, the charger or power supply case can be charged or powered through a conventional, wired charger or power supply. In accordance with an embodiment, the system comprises:

[00374] Inductive Charger or Power Supply Base: In accordance with an embodiment, this part can be a stand-alone charger or power supply or desktop charger or power supply that comprises a Field Effect Transistor (FET) that periodically turns the current through a coil on and off. In one embodiment, for a typical 9 turn PCB coil with 1" diameter, a drive frequency of 1-2 MHz is ideal, and the power transfer efficiency is increased when a capacitor of appropriate value is placed in parallel with the FET. When the circuit is driven at a resonant frequency, the amount of current through the FET can vary greatly by proximity of another coil (L2) to L1. To allow the system to operate automatically, a current sensing system can be used to sense the secondary (L2) being in close proximity to the primary (L1). In other embodiments, a separate circuit for positive identification of a device to be charged being in proximity can be integrated. These can

include wireless identification systems such as RFID, Felica, Bluetooth, WiFi, WiMax, etc. In another embodiment, the system of the charger or power supply case can be designed so that a chip in the charger or power supply case (near L2) senses an input voltage and modulates the current through L2 in a pre-programmed manner. This results in a modulation in the current in L1 that can be sensed with the current sensor and positively identifies the charger or power supply case and initiates power transfer and operation if the pattern matches a pre-stored pattern for verification. In some embodiments, the inductive charger or power supply base can have the shape of a formed piece that the inductive case would fit into, or a pad for placement of the inductive case and/or mobile devices or both.

[00375] Inductive case: In accordance with an embodiment, the case has means for receipt of power inductively (from the charger or power supply base) and charging another device (or number of devices) inductively. Alternatively, it may be possible for the case to be designed so that it operates by being charged or powered directly by a wired power supply/charger. The case has a receiver part that is connected to a battery charger circuit that charges one or more internal batteries and simultaneously, can also operate the circuitry in the charger or power supply case to charge a nearby mobile device or battery. The case has charger or power supply circuitry similar to the charger or power supply base that can be powered by its internal battery or the power from the charger or power supply base. The case can in turn recognize a nearby mobile device automatically or through mechanical or other means as described earlier and commence charging when a mobile device is placed in or near the case/holster. In another embodiment, the charger or power supply case may contain two or more charger or power supply sections so that several devices in the case (e.g. mobile phone and a headset) can be charged simultaneously. As described earlier, the circuitry/functions described here can be integrated into a device that also extends the functionality to storage, WiFi or Bluetooth connectivity, etc. In one embodiment, the batteries in the charger or power supply case are identical to the batteries used in the mobile device and are removable. In this case, the user may exchange the batteries between the charger or power supply case and the mobile device (such as a mobile phone) in an emergency to allow quick use of the mobile device without waiting for the charging of the mobile device to occur. This can provide an additional desirable feature for the user.

[00376] Mobile Device Receiver: In accordance with an embodiment, the mobile receiver part comprises a coil and circuitry that can be either integrated into a mobile device by the manufacturer (i.e. an OEM), integrated into a battery that can be swapped with the original battery to enable a mobile device to receive power inductively, or provided as a plug in unit that plugs into the existing power jack of a device and has the coil and the circuitry to enable the device to receive power inductively. Alternatively, the receiver can be built into a jacket or skin for a device that plugs into the device and allows the device to become 'enabled'. Variations of these are described in further detail in copending U.S. Patent Application titled "INDUCTIVE POWER SOURCE AND CHARGING SYSTEM"; Application No. 11/669,113. The above-referenced patent application also describes the use of attracting magnets placed at the center of an inductive charger or power supply's PCB coil, and the center of the receive coil, to align and center the two parts conveniently. Such techniques can be used in the base to case coil alignment, or the case to mobile device alignment or both. In addition, the alignment can be achieved through visual or mechanical marks, indentation, or mechanical design of the parts to enable easy alignment.

Heat Reduction and Dissipation

[00377] In order to generate the magnetic field for an inductive charger and/or power supply, a coil made of wires or printed on PCB is typically used. Such a coil can be in a simple way, modeled by an inductive and resistive element in series. The resistance of the coil can be estimated by using the dimensions of the wire or PCB trace, its length, and the resistivity of the material used (such as copper). At higher frequencies, the resistance increases due to the skin effect whereby the electrical current travels near the surface of the wire or trace rather than throughout its cross section, thereby decreasing the wire's or trace's effective cross section. In order to obtain reasonable inductive values, several turns of wire or PCB trace are necessary.

[00378] For example, in a PCB spiral coil of 1.25"diameter, about 10 turns are necessary for a 1 micro Henry inductance value. To design a high efficiency inductive power transfer coil, the resistivity of the coil must be minimized while the resulting induction is kept at desired levels. It must be noted that any heat generated at the coil will increase the resistivity of the coil material in turn leading to higher heat generation and temperature increase. To avoid this positive feedback for heat generation, the main

methods for reduction of temperature at the inductive coil include reduction of heat generated and dispersal of heat away from the coil.

[00379] In addition, electronic devices generally need to satisfy regulatory and safety requirements which include the requirement not to interfere with the operation of nearby devices. For an inductive charger and/or power supply that creates a time varying magnetic field to transfer energy to a receiver, care must be taken to keep the level of interference to below allowed limits.

[00380] In general, the magnetic created by a small coil (~1"diameter) of several turns when it is driven by an electrical voltage at around 1 MHz, does not radiate more than several mm beyond the coil and is confined to the near field. To reduce the effect of such radiation (for example, as provided in Near Field Power™ radiation devices) at higher frequencies, which are of bigger concern for most devices, the driving voltage of the circuit must be made to have weaker higher harmonics.

[00381] Another concern for generation of Electromagnetic Interference (EMI) is the electronic circuitry and switching Field Effect Transistor (FET) incorporated in the circuit. Such components can be additional noise sources. Described herein are some ways of reducing the effect of above EMI sources.

[00382] Another important factor in efficient operation of an inductive charger/ power supply is the alignment of the charger/power supply coil and the receiver coil in the device to be charged/powered. Various methods of alignment of the coils using magnets have been described in prior applications. In addition, also described are the use of moving coils and other methods by which several coils or clusters of coils can be used to provide position tolerance between the coils for efficient power transfer.

[00383] In accordance with an embodiment, to reduce the temperature increase at the inductive coil, several methods can be used.

[00384] In accordance with an embodiment, the coil can be optimized by using the minimum number of turns necessary thereby decreasing the length and resistance of the coil. The diameter, thickness, or width of the wire or PCB trace can be optimized to provide optimum resistance.

[00385] For coils such as PCB coils discussed above, the magnetic field created is strong inside the coil, and drops very rapidly as the radial distance to the center of the coil exceeds the radius of the coil. This dependence can be verified using electromagnetic

modeling (such as described in Xun Liu; Hui, S.Y., Optimal Design of a Hybrid Winding Structure for Planar Contactless Battery Charging Platform, IEEE Transactions on Power Electronics, Volume 23, Issue 1, Jan. 2008 Page(s):455 - 463), and also by experimental means. The heat generated at the coil can be dispersed away from the coil by use of high heat conductivity PCB substrates or material for the coils. Since the magnetic field is minimal in the area outside the coil, use of high conductivity metal layers will not have a large effect on the field and will not create undesirable eddy currents. Therefore, the surface of the area surrounding the coil can be designed to have metal or other material that have high heat conductivity and remove the generated heat rapidly.

[00386] **Figure 66** is an illustration that shows a geometry for an arrangement 1030 in which the area surrounding a PCB coil is designed to have metal on the top, bottom or another layer of the PCB. As shown in Figure 66, the area surrounding a PCB coil is designed to have metal on the top, bottom or another layer of the PCB. The metal pattern can be incorporated at the same layer as the coil or a separate PCB layer. This metal layer can be continuous or have a gap in one area to avoid generation of eddy currents due to circulating electrons due to magnetic fields generated by the coil. In a typical PCB, the coil and the metal layer are made of copper. In this manner, any heat generated at the coil is dispersed laterally rapidly and thus does not result in large temperature increase. In accordance with an embodiment, such a PCB can be itself the top layer of an inductive charger in which case, any heat carried away by the metal layer can be additionally evaporated to the surrounding environment. Alternatively, the heat can be further dispersed by removal to another area or surface or use of elements such as fins or slits. Similarly, the receiver coil and the circuitry for receiving power that is integrated into a device, battery, outside carrier of an electronics device, etc. can have a similar geometry to enable dispersal of heat generated.

[00387] In accordance with an embodiment, for typical applications with a PCB, the metal layer can be made from copper material similar to that of the PCB coil itself, and it is desired to have sufficient thickness to provide a low thermal conductivity path for the heat. For example, a copper layer of several microns or even 10s of micrometers can be used.

[00388] Any such high thermal conductivity or metal layer may begin at the edge of the PCB coil or with a gap to the PCB coil. Since the layer is not covering the PCB coil, it may not cause eddy current loss in the layer. In those instances that eddy currents are generated, a gap in the metal layer as shown in Figure 66 can be used to reduce the

effect of circulating currents, and reduce the resultant heating and power draw. In accordance with an embodiment a metal layer can be used on top of the coil (with a thin non-conducting layer or dielectric in between) if its thickness is small. For example, in previous applications as referenced above, the use of a thin layer of metal (several micrometers) on top of a PCB coil was described to act as an EMI shield for high frequencies while transmitting low (around 1 MHz and below) frequencies of the inductive charger. Such a layer may also be used in addition to the metal layer surrounding the coil to facilitate heat dispersal.

[00389] **Figure 67** is an illustration that shows, in a multi-charger or power supply where multiple coils are used, such a high heat conductivity layer 1040 may be repeated around each coil or cover all areas between the multiple coils.

[00390] **Figure 68** is an illustration that shows a similar method may be used for heat removal from wound coils of other shape and type 1050, 1056. In accordance with the geometry of this embodiment, to facilitate heat removal from a coil that may be a wound coil around a core, the coil may be attached to a high heat conductivity layer or a metal layer. In the case of a metal layer, such a layer can be designed to be in the area surrounding the outside of the coil to avoid interference with the field generated inside the coil. Similarly, to avoid eddy currents, the metal layer or the core of the wound coil or both can have a gap or discontinuous portion to reduce circulating currents.

[00391] In above examples, a metal or high heat conductivity layer has been shown. **Figure 69** shows an illustration of an embodiment 1060 in which the layer can be patterned to provide heat conductivity channels rather than a continuous layer if needed.

[00392] In accordance with any of the above geometries, additional means of heat removal such as use of fins, fans, additional surfaces, heat pipes, thermal grease, thermally conductive epoxies, etc. can be incorporated to facilitate heat removal. In addition, it is possible to incorporate heat conducting layers, such as ceramics or polymers can be incorporated below or above the main PCB to help in heat removal.

[00393] In the above discussion, round shape coils are generally shown. It will be evident that the techniques described herein are applicable to coils of other shape or multiple coils in a cluster or separated to power or charge separate devices. In many instances, the increase of the temperature at the center of a PCB coil is largest. To remove this heat, in accordance with an embodiment the surface of the charger or a layer behind the coil that contains high heat conductivity material can be used to disperse the

generated heat laterally. An example of such a layer is ceramic material. High alumina ceramics can provide high heat conductivity and low electrical conductivity, which characteristics are important for this application.

Reduction of EMI from Inductive Charger and/or Power Supply

[00394] An advantage of the metal layers discussed above is that any EMI generated inside the inductive charger or power supply will be greatly shielded from the outside and will be attenuated outside the charger or power supply device by the metal layer.

[00395] Additionally, in the above geometries, the metal layer on the top layer can be made to contact electrically to other metal layers on the side and/or bottom of the charger and/or power supply, thereby forming a box or other enclosed shape where only the coil is not covered by metal. Such an enclosure will greatly attenuate EMI from the switching electronics or other parts in the charger. To reduce the effect of the potential eddy currents generated in the metal box due to the magnetic field, in some embodiments it is useful to eliminate use of metal directly below the coil area where magnetic fields may exist. In addition, to avoid generation of eddy currents in the walls of the metal box or similar outside surface, the wall can be cut in one or more location so that a continuous metal circuit or ring is not formed, and does not allow the electrons to circle unimpeded. This gap can be filled with a non-conductive material to provide rigidity.

[00396] In the geometries shown above, it is possible to use a PCB whereby the coil is formed in one area and the electronics is on the same PCB. In accordance with an embodiment, to provide shielding and heat dissipation discussed above, the metal layer around the coil may be in a layer on top (closer to the outside surface) of the PCB. For example, the coil may be formed on the top layer of the PCB along with the heat dissipation and/or EMI shield layer and the PCB electronic components may be on the bottom layer of the PCB. Alternatively, the metal layer can be in a separate layer in the middle or even the bottom layer with the PCB electronic components. However, the EMI shielding effects from the electronics components will be reduced if the metal layer surrounds the electronics area and does not provide an electrical barrier directly above it.

[00397] **Figure 70** shows an illustration of the electronics for the PCB coil inductive charger and/or power supply or the inductive receiver as fabricated on the same PCB as the coil in accordance with various embodiments 1070, 1076. The electronics in this case

may be at the bottom layer, while the coil and the metal layer surrounding the coil are on the top layer and shield any electronic noise generated by the electronics from the outside.

[00398] Any of the shapes and geometries discussed above are equally appropriate for incorporation into the charger and/or power supply coil or the receiver coil and for dispersal of heat and reduction of EMI from a device to be charged/powered inductively as well as the coil in the charger/power supply itself.

Magnetic Alignment of Coils

[00399] In accordance with an embodiment, to enable efficient power transfer in an inductive charger and/or power supply, the coils in the charger and/or power supply and the receiver must generally be aligned with on another.

[00400] **Figure 71** shows an embodiment 1080 in which magnets placed at the center of a stationary coil or a moving, floating charger and/or power supply coil and the receiver coil can provide a method for alignment of the coils and to achieve this result.

[00401] A problem with this method is that, since the magnetic material is composed of electrically conductive material, eddy currents can be generated when the coils are operated to generate a time-varying magnetic field. This can cause lost power, and can also cause heating in the magnets which is not beneficial.

[00402] To address this problem, **Figure 72** illustrates an embodiment 1090 in which two or more magnets that do not cross the center of the coil are used. This geometry reduces the eddy currents created greatly. In accordance with an embodiment, the system can use an alternative magnet geometry that provides a simple and inexpensive method for alignment of coils. In addition, this method provides for a considerable amount of alignment tolerance when placing a device on the charger and/or power supply.

[00403] To provide alignment magnets that will not draw current due to eddy currents created in them when a magnetic field is applied, in accordance with an embodiment the magnets are placed outside the PCB coil area.

[00404] **Figure 73** is an illustration of two embodiments 1094, 1098 that shows how the magnets may be placed outside the PCB coil area. The magnet shown in Figure 73 comprises a ring that surrounds the coil or overlaps each coil such that little effect on eddy

current generation or loss is created. If any eddy current effects are observed, then in accordance with an embodiment gaps can be inserted in the magnet ring by cutting after manufacture or by inserting this separation during manufacture. In this manner the eddy currents can be significantly reduced or eliminated. The magnet in the case shown is magnetized perpendicular to the surface of the ring. By attaching one magnet to around the charger and/or power supply coil and another magnet with opposing polarity to the receiver coil, the two coils can easily be aligned with minimal effort by the user.

[00405] In addition, the use of a ring has the advantage of allowing circularly symmetric operation so that the two coils can be rotated with respect to each other with no effect on charger/power supply operation or efficiency.

[00406] A typical geometry for the charger/power supply can comprise the PCB shown in Figure 8 such that the coil can be fabricated on the top surface of the PCB, and the magnetic ring is attached to the bottom side of the PCB where the electronics may be located. A similar receiver can have a magnet attached with opposing polarity so that when the receiver is brought close to the charger/power supply, the two magnets can attract and pull the coils into alignment. With this geometry, the magnetic field of the coils create attraction and alignment as long as the coils have any overlap.

[00407] For example for coils of 1.25" outside diameter and using ring magnets of 1.25" inner diameter, as long as the centers of the coils are less than 1.25" away laterally, the coils can be brought into alignment when the two magnets are vertically (distance in the axis perpendicular to the plane of the coil) brought close enough to allow the magnetic fields to sense each other. Thus in this case, if the user brings the center of the receiver coil to be within a circle of 1.25" radius of the center of the charger/power supply coil, the coils can attract and provide automatic alignment of the parts.

[00408] For most applications, this amount of alignment tolerance is sufficient. By using marks to outline the location for the coil on the surface, this degree of tolerance allows the user to place a device or battery incorporating the receiver coil very easily into the right location.

[00409] Examples of magnets that can be used include those manufactured from various magnetic material such as Neodymium Iron Boron, Samarium Cobalt, AlNiCo, ceramics, bonded magnetic material, etc. The magnetic strength can be designed to provide alignment or secure attachment without being too strong or difficult for separation.

[00410] Alternatively, the coils can be manufactured on the lower surface close to the magnet and the electronics or can be manufactured on another layer in between. Various geometries are possible. In any case, the magnets can be used to align the two coils for optimum operation.

[00411] In above description, ring shaped magnets are described. However, in many cases, size and spacing requirements may require use of a different geometry.

[00412] **Figure 74** shows an embodiment 1100 in which magnetic arc shaped parts around a circular coil are used. This case may be combined with the matching magnet on the other coil having the same shape or a ring shape similar to Figure 73. For example, in a mobile battery application where the battery with an integrated inductive receiver is charged by placement on an inductive charger pad, the size of the coil determines the received power and may require the width of the battery to be equal or similar to the receiver coil. To allow attachment of alignment magnets, two arcs as shown in Figure 9 can be attached to the coil. In this case, the magnets can be placed in between the battery and the coil PCB to allow the coil to be on the top surface and therefore closest to the charger coil. The matching magnet in the charger can be a ring or a similar set of arcs or another shape or size to facilitate alignment. If a ring is used behind the charger coil, then central symmetry between the two parts is retained and the parts can be rotated with respect to each other while keeping alignment for optimum operation.

[00413] Other geometries are possible. For example, **Figure 75** illustrates embodiments 1120, 1126 in which the use of bar magnets on or around the coil is shown. Such a geometry does not have the symmetry offered by a ring magnet. However, this may be useful if only one dimension of alignment insensitivity is desired.

[00414] In any of the above geometries, use of two magnets with opposing polarity to attract each other is described. However, in accordance with some embodiments it is preferable for one of the parts to be non-magnetized. This may be advantageous in cases where it is not desirable for the mobile device to attract metallic parts when not being charged or powered by the inductive charger/power supply. An example may be a mobile phone where it is not desirable for the phone to attract metallic objects during normal use. In this case, the charger and/or power supply can contain a magnetized part and the other matching part in the mobile device/battery, can be made of appropriate magnetic material but not magnetized. For example, the charger/power supply may contain a magnetized

ring as described above and a mobile phone can have a matching ring or arc made of magnetic material but not magnetized.

[00415] In addition, it is possible for the charger and/or power supply magnet to be activated electrically and be normally non-magnetized. For example, a wire winding or PCB trace is placed around the perimeter of the power transfer coil and powered to create a DC magnetic field for alignment of the two coils for power transfer/charging. In this way, neither of the two alignment parts need to be normally magnetized and therefore eliminate any concerns regarding unintended attraction of metallic objects or effects on magnetically sensitive parts such as credit cards, etc. The generated magnetic field can be further strengthened by using a non-magnetized magnetic material on or near the alignment trace area.

[00416] As an example, a circular path around the main charger/power supply PCB coil can be powered by a DC current periodically or when a user desires to charge or power a mobile device. This can be done by the user or can also be activated automatically by a sensor that senses the approach of an appropriate device to be charged or powered through RF, optical, magnetic, or other methods. Once the magnetic field (such as a ring pattern as described above), is generated it will attract and align a magnetic metal part or magnet of appropriate shape in the mobile device or battery into the correct alignment and placement and help the user place the mobile device in the correct position. Once the device is placed in the right location, the DC magnetic field may no longer be necessary and can be shut down or reduced to save power. Thus only for a very brief period this alignment magnet may be needed. During other times, neither the charger and/or power supply or the mobile device can be designed to have any magnetic field around them or contain weaker magnets.

[00417] The use of magnets as described above is especially useful for cases where movement between the power supply and/or charger and the device or battery to be charged or powered may occur. As an example, in an automobile environment, it is desirable to keep a mobile device such as a phone from moving during charging. Thus the use of the magnets described above, in addition to the above benefits, can enable use in moving environments. In addition, in some cases, it may be beneficial to have the charger and/or power supply in a position that is not horizontal. For example, a charger can be installed vertically. In this case, the magnets can be designed to be strong enough

to hold the mobile device or battery in place vertically during the charging or powering process.

[00418] In any of the above geometries, if any additional eddy currents are generated as a result of the presence of the magnets, the effect can be minimized by fabricating the coil from low electrical conductivity materials or ceramics, layering the magnet into thin sheets to increase resistivity, using bonded material in an epoxy matrix, roughing the surface, cutting gaps in the material to reduce circular motion of electrons, or other common techniques to increase the resistivity. The magnet can also be manufactured from segments that are not electrically connected to prevent electrons to be able to travel around a circular path. For example, the ring magnet can be manufactured, formed or attached to the coils from two or four ring arcs that are not electrically in contact or attached to each other, using a non-conducting epoxy to form a full ring, or parts of a ring.

[00419] In addition, the coils shown above are generally circular. However, the methods and discussion above can be applied to coils of any shape and size as well as an array or cluster of coils and can provide in performance of any size and type of coil.

[00420] The foregoing description of an embodiment has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit an embodiment to the precise forms disclosed. The embodiments were chosen and described in order to best explain the principles of an embodiment and its practical application, thereby enabling others skilled in the art to understand an embodiment for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of an embodiment be defined by the following claims and their equivalence.

[00421] Some aspects of an embodiment may be conveniently implemented using a conventional general purpose or a specialized digital computer, microprocessor, or electronic circuitry programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers and circuit designers based on the teachings of the present disclosure, as will be apparent to those skilled in the art.

[00422] In some embodiments, an embodiment includes a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a computer to perform any of the processes of an embodiment.

The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, DVD, CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[00423] The foregoing description of an embodiment has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit an embodiment to the precise forms disclosed. Many modifications and variations will be apparent to the practitioner skilled in the art. Particularly, while the embodiments of the systems and methods described above are described in the context of charging pads, it will be evident that the system and methods may be used with other types of charger or power supplies. Similarly, while the embodiments described above are described in the context of charging mobile devices, other types of devices can be used. The embodiments were chosen and described in order to best explain the principles of an embodiment and its practical application, thereby enabling others skilled in the art to understand an embodiment for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of an embodiment be defined by the following claims and their equivalence.

Claims:

What is claimed is:

1. A system for inductive powering and charging of portable devices or batteries, comprising:

a base unit, including one or more primary coils composed of a non-ferrite material and shaped as planar spiral coils, which are capable of generating an inductive energy for use in powering or charging multiple devices or batteries simultaneously;

a receiver unit, including a receiver coil also composed of a non-ferrite material and shaped as a planar spiral coil, which is coupled to or incorporated into a portable device or battery, wherein the secondary coil receives energy inductively from the primary coil and uses it to charge or power the portable device or battery;

means within the base unit for allowing a degree of position independence of the devices or batteries on the base unit and selectively activating the one or more primary coils; and

wherein the base unit can simultaneously charge or power additional portable devices or batteries with additional secondary coils.

2. The system of claim 1, wherein the charger or power supply includes a plurality of coils, and wherein the means for selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery.

3. The system of claim 1, wherein the charger and a receiver in the device or battery both include microcontroller units, wherein the microcontroller unit in the charger monitors current flow, and wherein the microcontroller unit in the portable device or battery provides communication between the charger and the receiver for use in controlling charging.

4. The system of claim 1, wherein the charger or power supply includes an additional verification step prior to activating charging, to verify the identity or permissions of a device or battery.

5. The system of claim 1, wherein a plurality of coils are integrated into a pad-like

charger or power supply and wherein the coils are used to form a coil mosaic and an effective area of charging or power that does not cover more than appromximately 90% of pad surface.

6. The system of claim 1, wherein each of the plurality of coils are driven by an individual drive circuit to provide power to each coil and to selectively activate one or more coils.

7. The system of claim 1, wherein one or more coils includes a switch component, and wherein the microcontroller unit periodically starts the switch components, monitors the current therein, and uses the current to sense the proximity of a receiver and device or battery to that coil, and activate charging in that coil, or a selection of coils in that region.

8. The system of claim 1, wherein a plurality of layers of coils are layered upon one another to create an effective area, and so that powering any one or a selection of the coils allows a receiver whose center is within the effective area to be charged.

9. A mobile device capable of being inductively powered or charged comprising:

a battery; and

a receiver for one of inductively powering the device or charging the battery in the mobile device, and wherein the receiver is one of attached to or incorporated into the battery or the mobile device.

10. The mobile device charger or power supply of claim 9, wherein the coils or wires are formed within a printed circuit board PCB layer of at least two different sizes or shapes.

11. The mobile device charger or power supply of claim 9, wherein the charger or the power supply, and the mobile device, communicate with each other to transfer data.

12. The mobile device charger or power supply of claim 9, wherein the data transfer includes information about the presence of the mobile device adjacent to the charger or power supply and/or wherein the charger or power supply stores charging or power

requirements for mobile devices which can be charged or powered by the charger or power supply.

13. A system for use with a mobile device or battery for charging or powering the mobile device or battery inductively, comprising:

a base unit including one or more primary coils therein, the primary coil having a generally planar shape so that when a current is passed through the primary coil a magnetic field is generated in a direction substantially perpendicular to the plane of the primary coil; and

wherein the perpendicular magnetic field inductively generates a current in a matching receiver coil or coils within a mobile device or battery placed close to and aligned with the base unit, to charge or power the mobile device or battery.

14. The system of claim 13 wherein one or more of the coils are manufactured on printed circuit boards and are manufactured to have a low resistance.

15. The system of claim 13 further comprising a battery coupled to and powering the base unit, and wherein the battery can be occasionally charged by an external power supply to maintain a charge sufficient to power the inductive charger or power supply device for a period of time.

16. The system of claim 13 further comprising one of a solar cell coupled to a battery in the base unit, for charging the battery in the base unit; a data storage component for storage of data, for subsequent transmission of data to or from the mobile device; or a cover surface of the base unit or pad includes a decorative or non-slip surface.

17. The system of claim 13, wherein a plurality of modular chargers or power supplies can be interconnected to form a single unit.

18. The system of claim 13, wherein the mobile device to be charged or powered includes a charging circuit having a Zener diode, wherein the Zener diode clamps the voltage to the mobile device or battery to a predetermined maximum voltage, and a switch means that includes a MOSFET and the circuit includes a capacitor connected in parallel

to the source to drain terminals of the MOSFET, and wherein the alternating switching in the primary coil is automatically started by the MOSFET when the base unit detects a mobile device or battery placed close to or aligned with the primary coil.

19. The system of claim 13, further comprising means within the base unit for providing control regulation, and/or verification of the power charging and/or powering, including a switch means for adjusting and/or controlling the power into the coils under different load conditions, to maintain high efficiency during different load conditions or charging stages.

20. The system of claim 19, wherein the switch means is a zero voltage crossing or zero current crossing switch geometry, and wherein the controlling of output power is be achieved by changing the frequency of the operation.

Abstract:

A system and method for variable power transfer in an inductive charging or power system. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile device, battery, or other device. In accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or receiver side; and additional circuits and components that perform specialized tasks, such as mobile device or battery identification, and automatic voltage or power-setting for different devices or batteries.

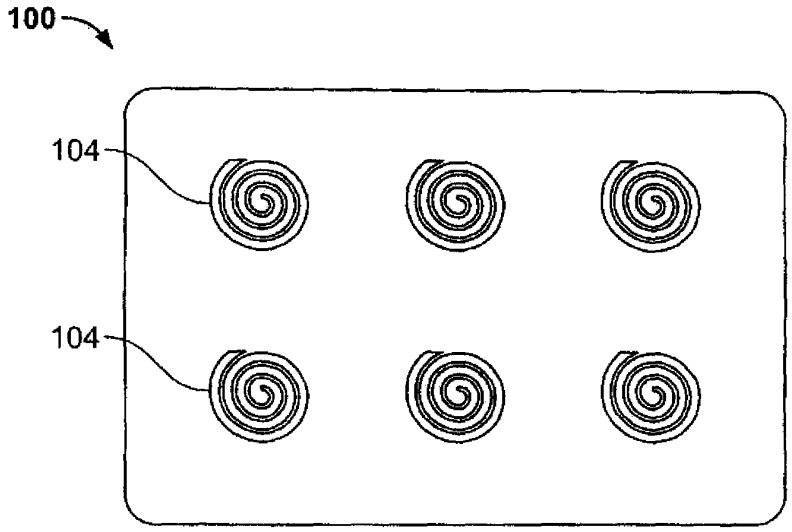

100
104
104

FIG. 1

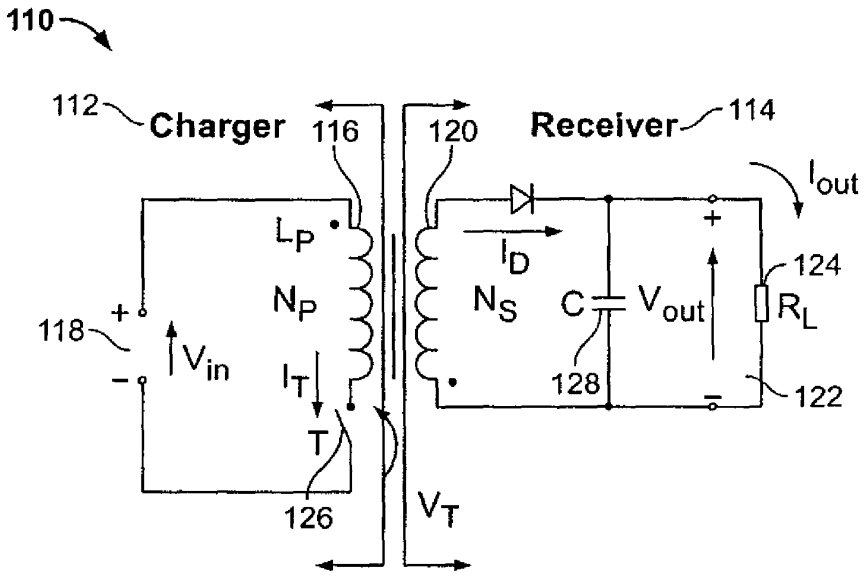

110
112
Charger
116
120
Receiver
114
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
124
R_L
118
+
V_{in}
−
I_T
T
126
128
122
V_T

FIG. 2

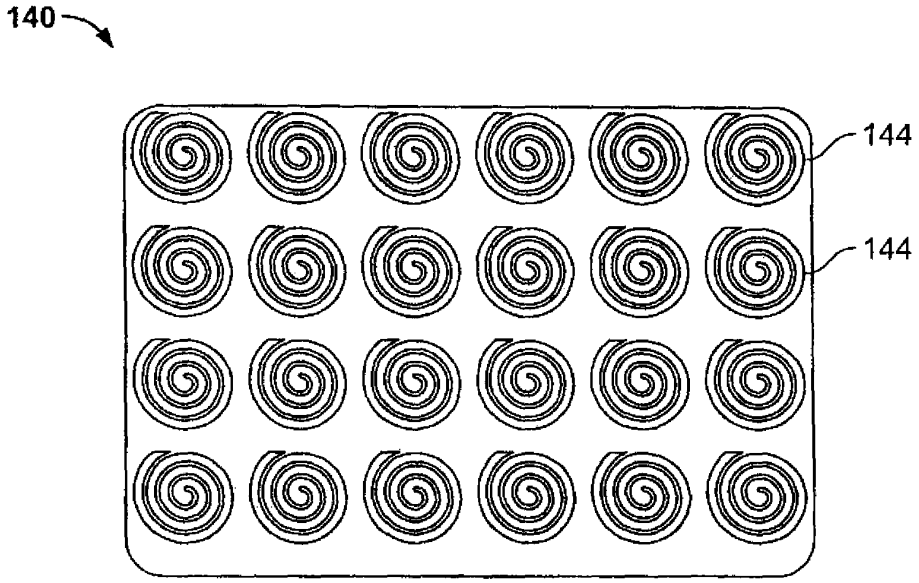


FIG. 3

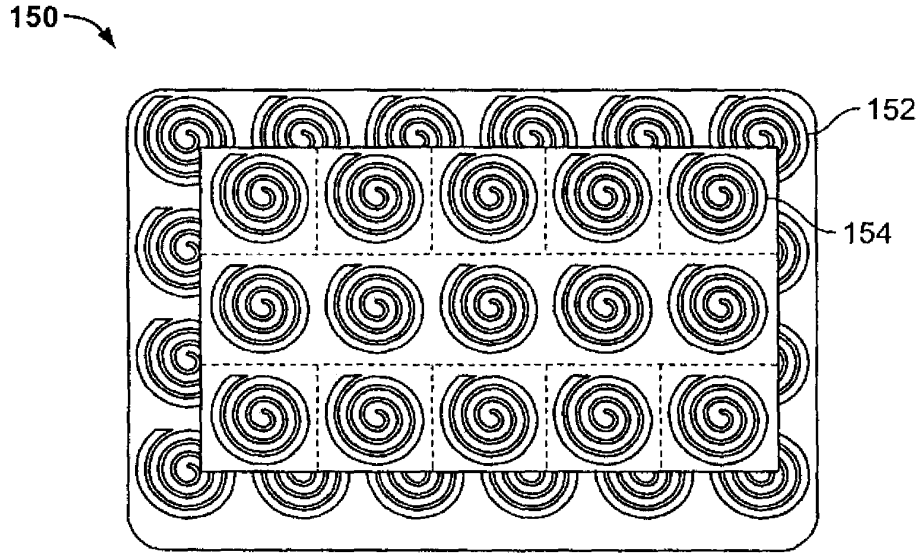


FIG. 4

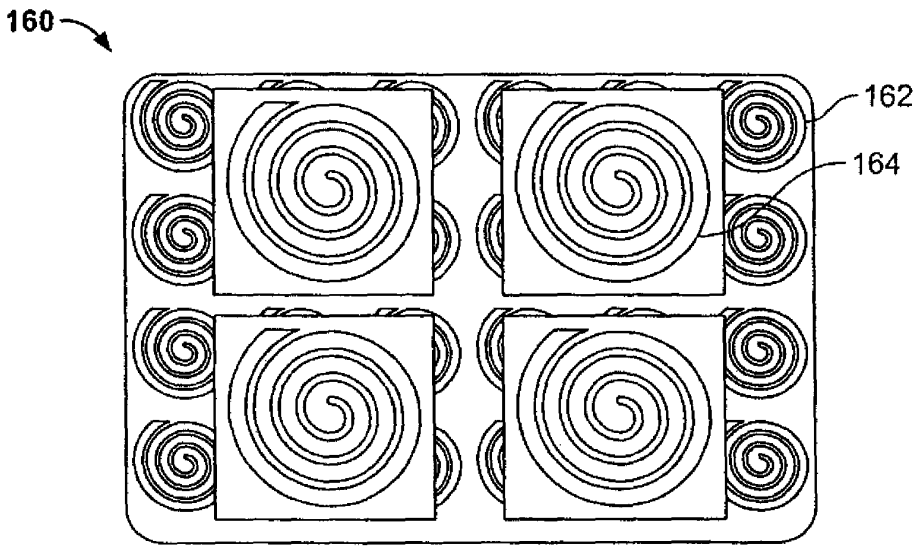

160
162
164

FIG. 5

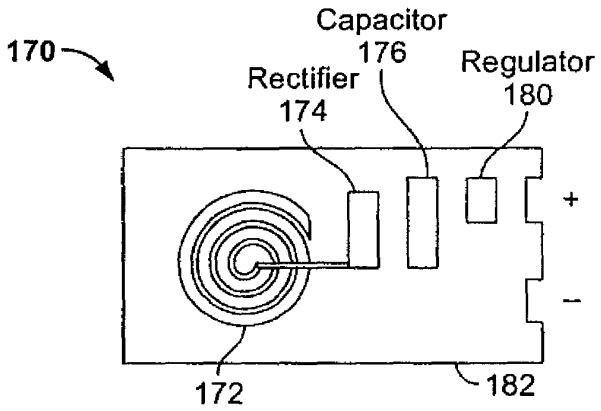

170
Capacitor
176
Rectifier
174
Regulator
180
+
–
172
182

FIG. 6

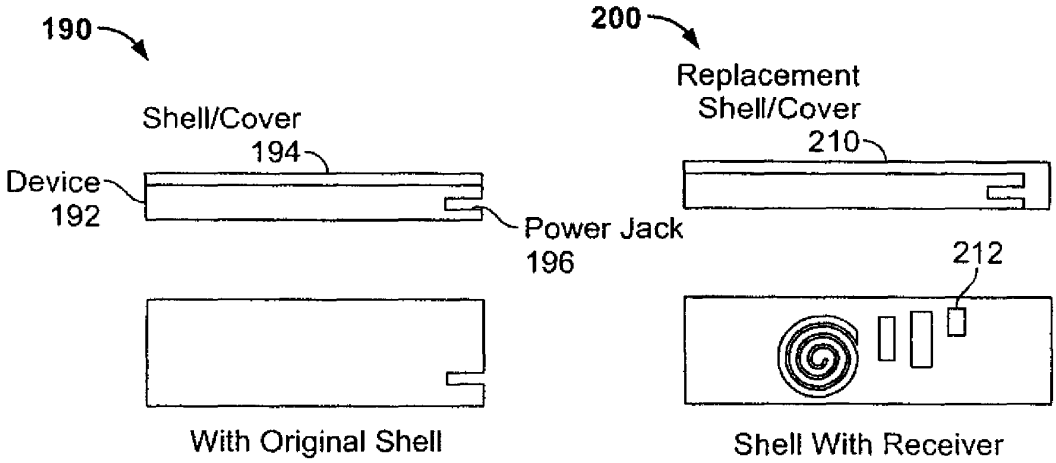

190
200
Shell/Cover
194
Device
192
Power Jack
196
Replacement
Shell/Cover
210
212
With Original Shell
Shell With Receiver

FIG. 7

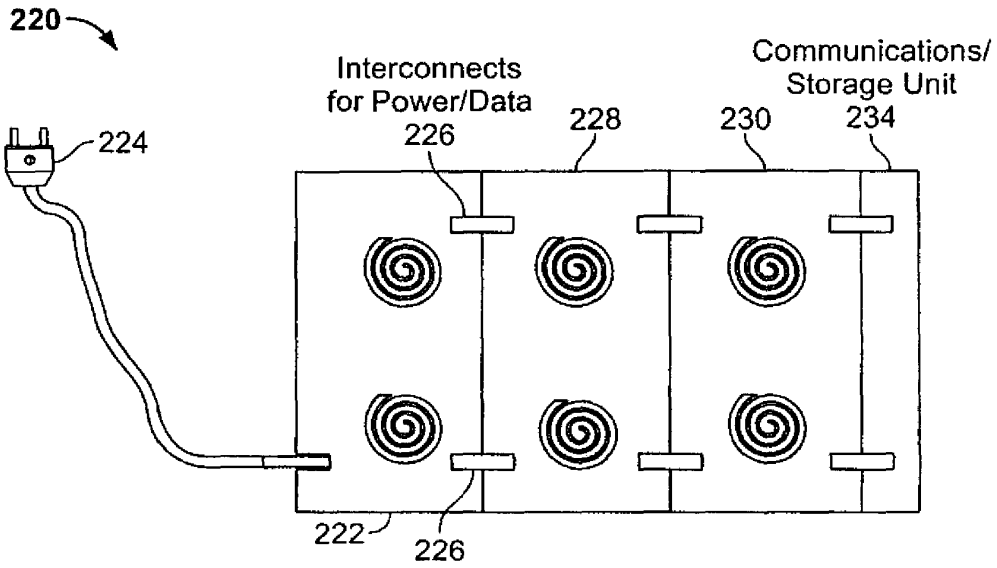

220
224
Interconnects
for Power/Data
226
228
230
Communications/
Storage Unit
234
222
226

FIG. 8

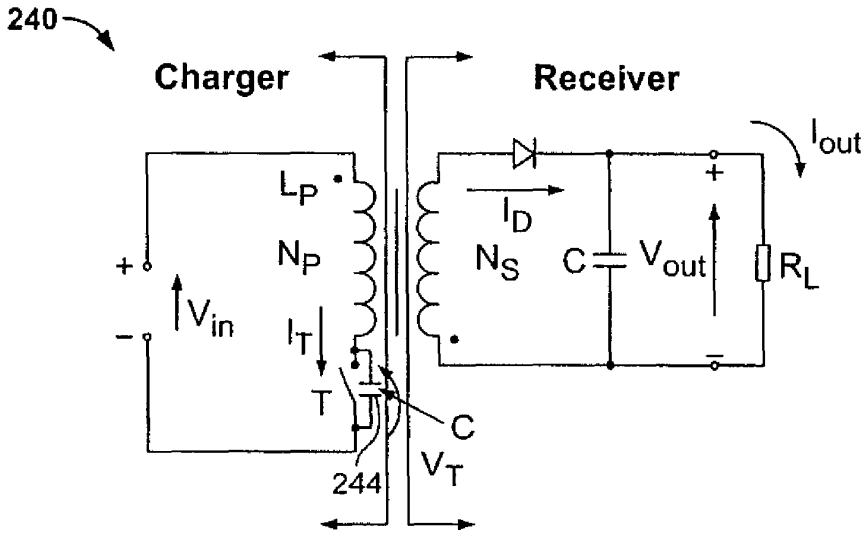

240
Charger
Receiver
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
R_L
+
V_{in}
−
I_T
T
C
V_T
244

FIG. 9

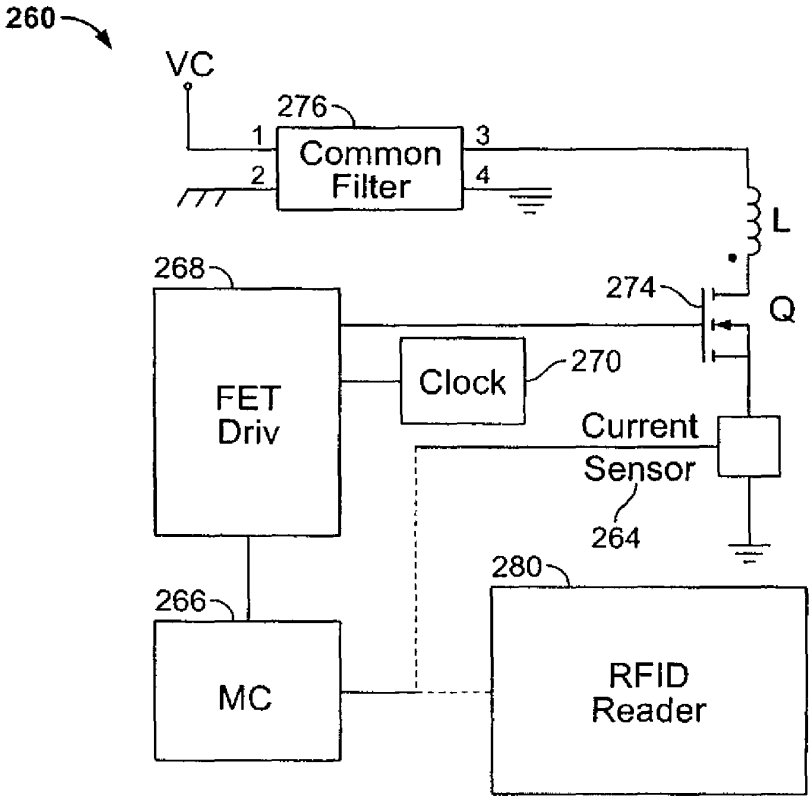

260
VC
276
1
2
Common Filter
3
4
L
268
274
Q
FET Driv
Clock
270
Current Sensor
264
280
266
MC
RFID Reader

FIG. 10

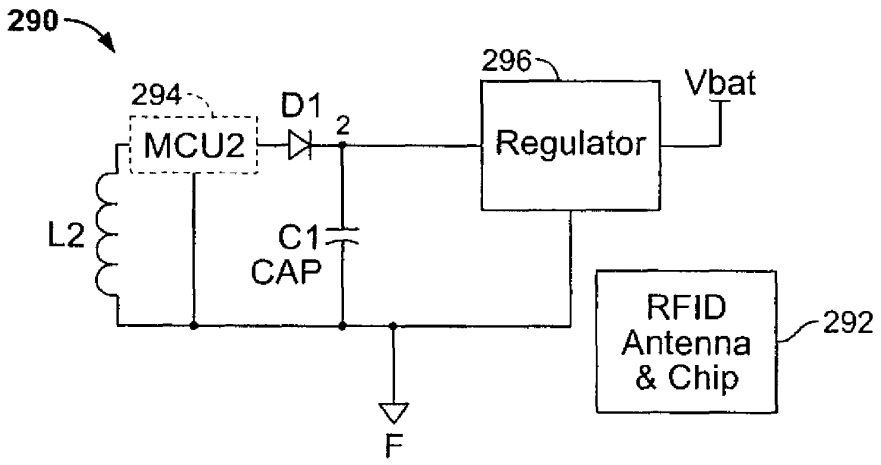

290
294
MCU2
D1
2
296
Regulator
Vbat
L2
C1
CAP
RFID
Antenna
& Chip
292
F

FIG. 11

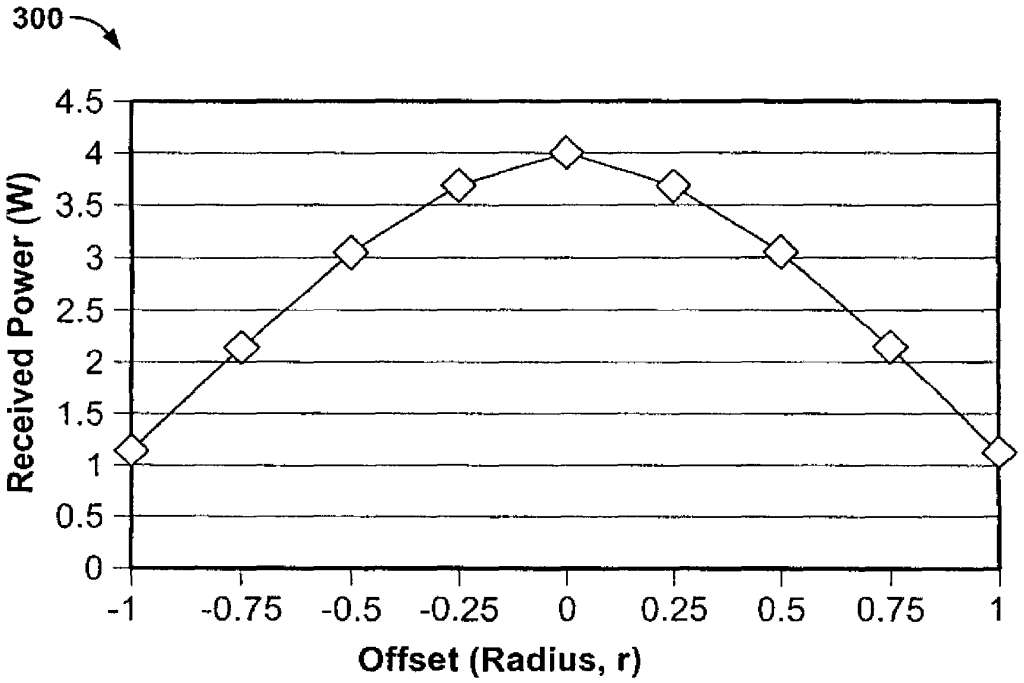

300
Received Power (W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Offset (Radius, r)

FIG. 12

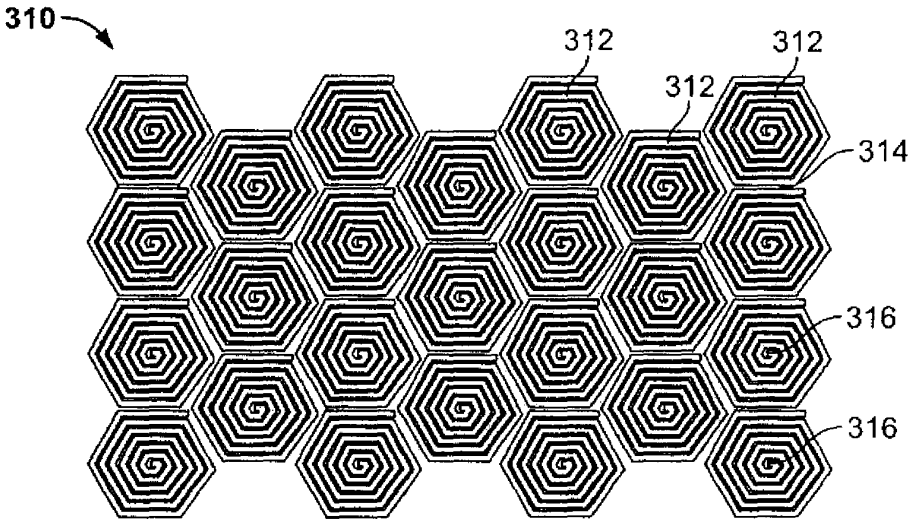


FIG. 13

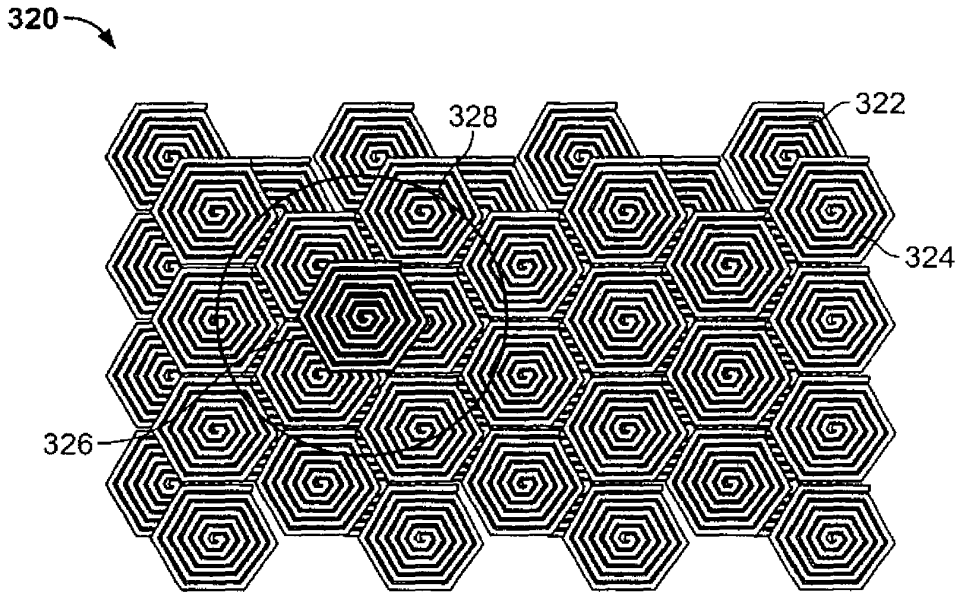


FIG. 14

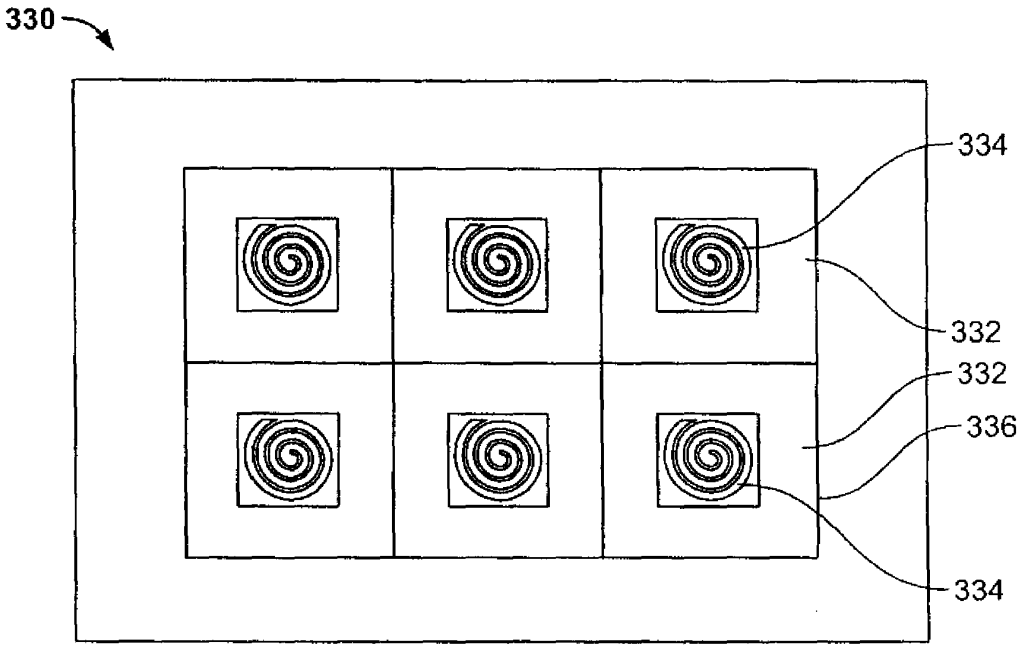


FIG. 15

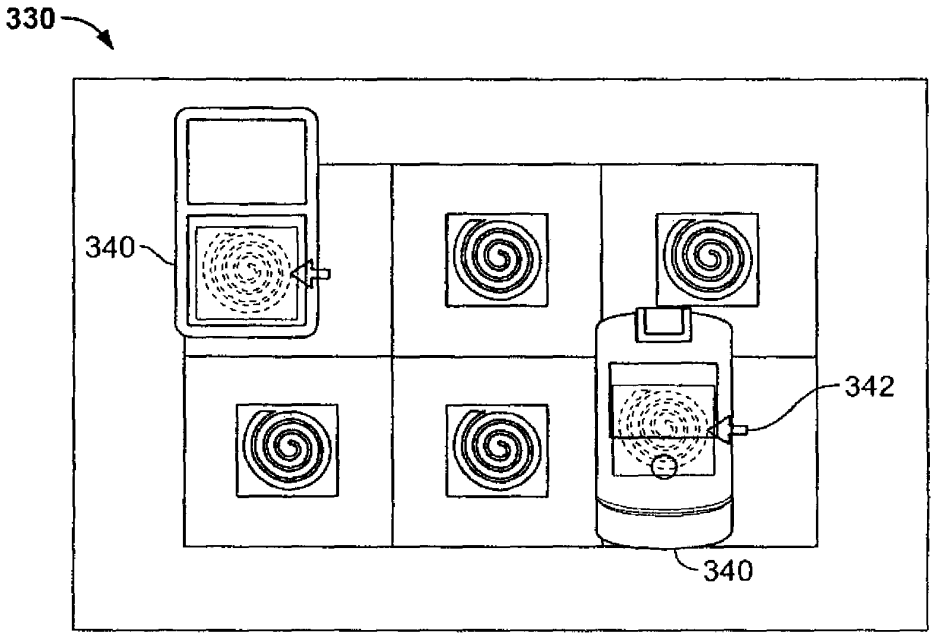


FIG. 16

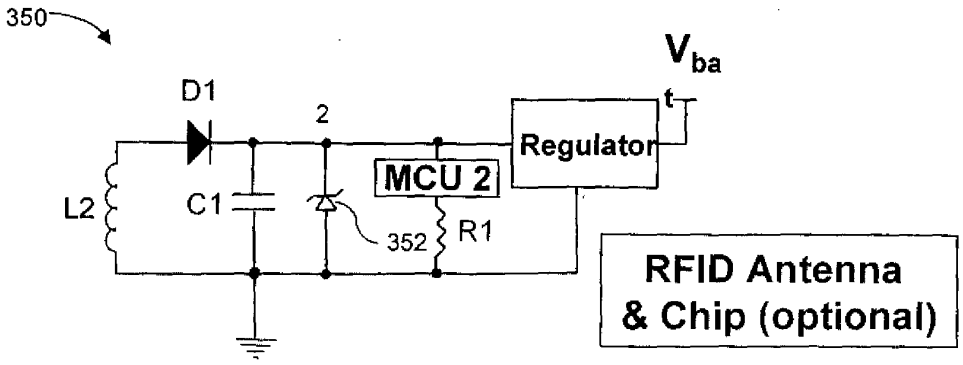

350
V_{ba}
D1
2
t
Regulator
MCU 2
L2
C1
352
R1
RFID Antenna
& Chip (optional)

FIG. 17

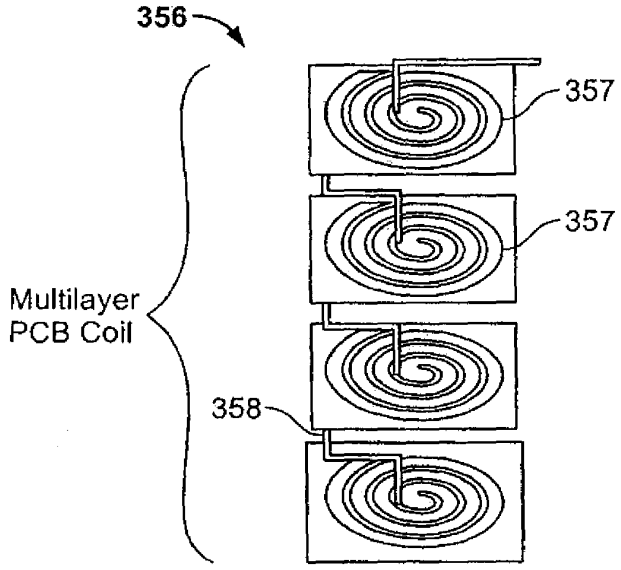

356
357
357
Multilayer
PCB Coil
358

FIG.18

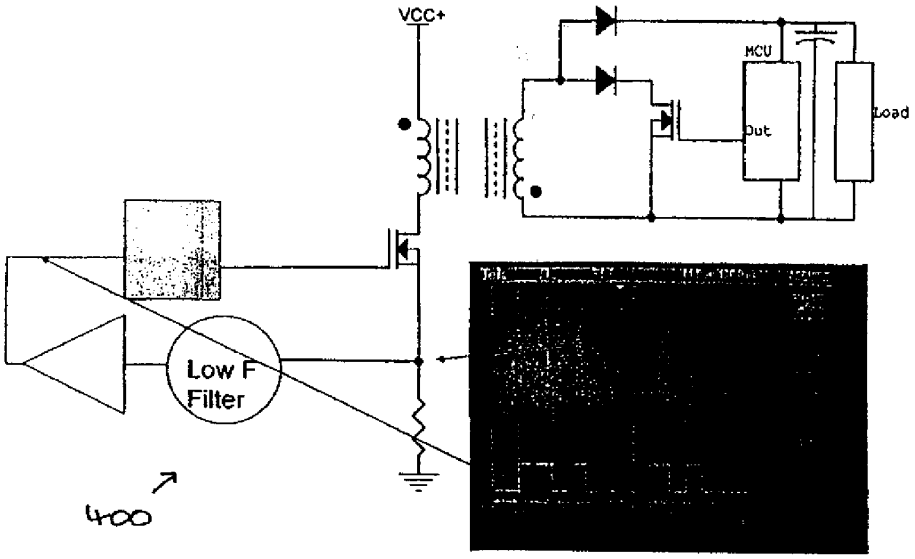


FIG. 19

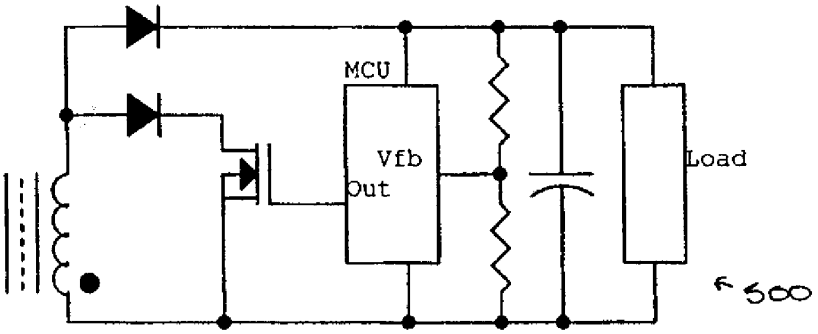


FIG. 23

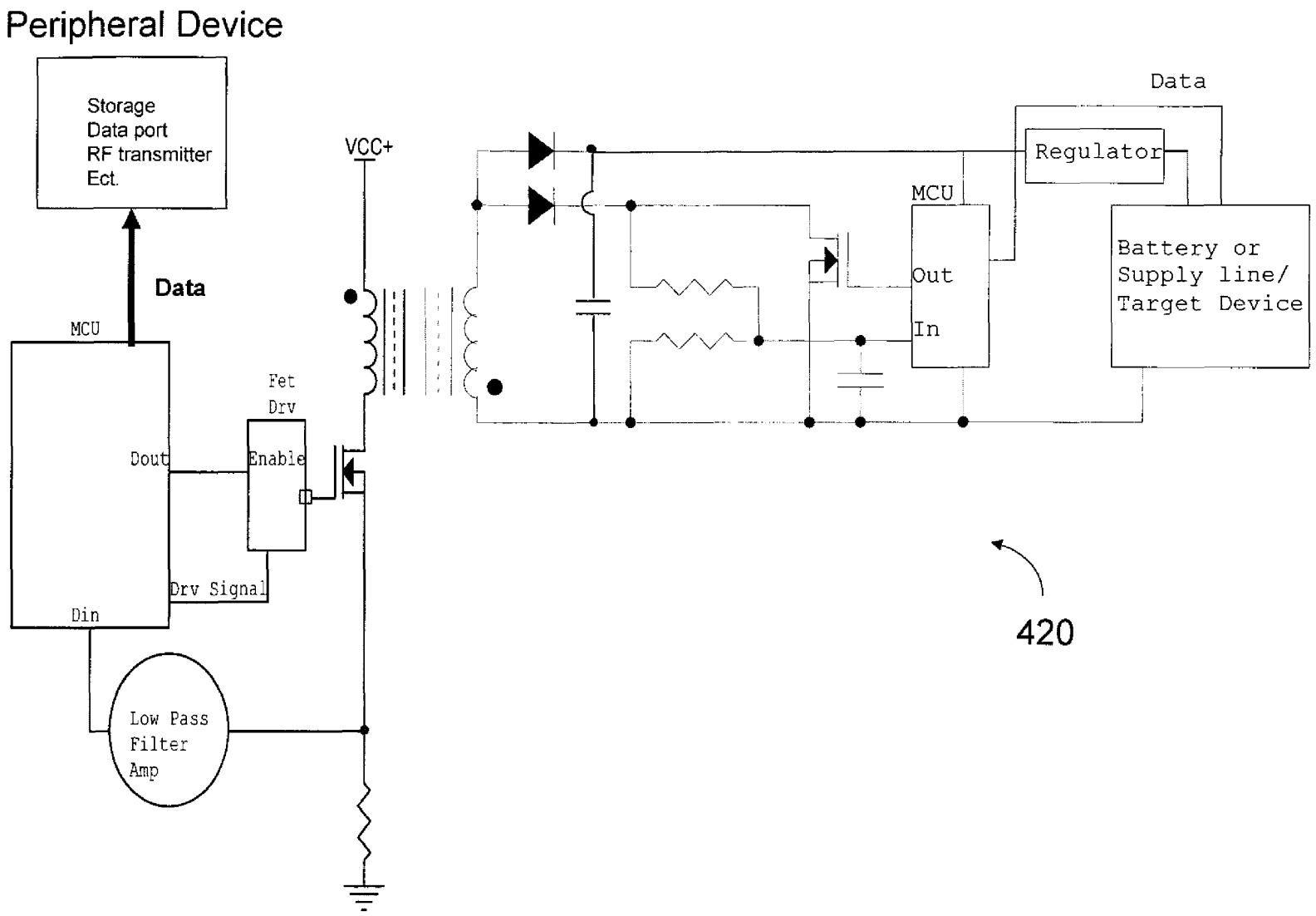

Peripheral Device
Storage
Data port
RF transmitter
Ect.
Data
MCU
Dout
Din
Fet
Drv
Enable
Drv Signal
Low Pass
Filter
Amp
VCC+
Data
Regulator
MCU
Out
In
Battery or
Supply line/
Target Device
420

Figure 20

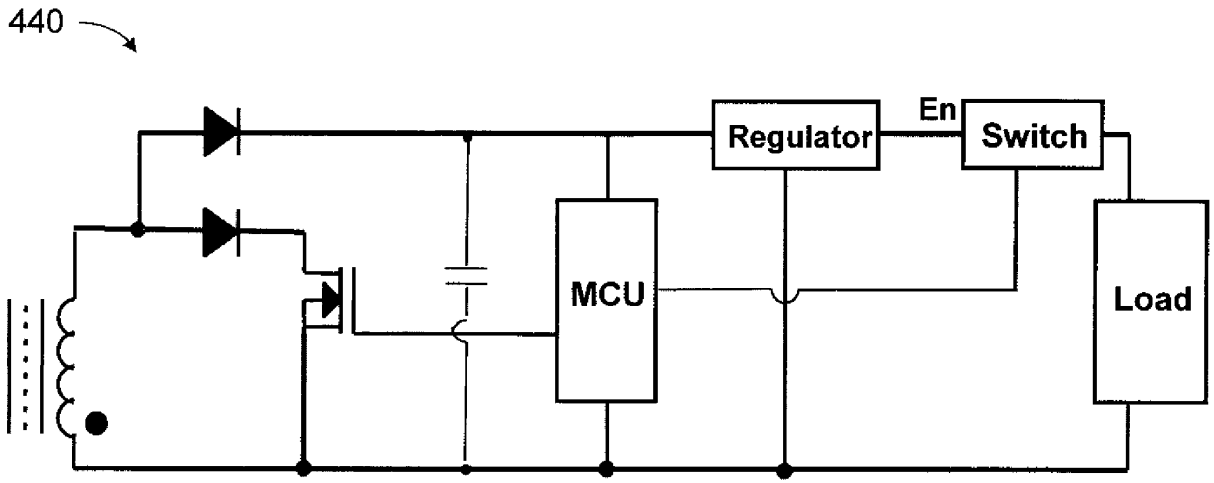


Figure 21

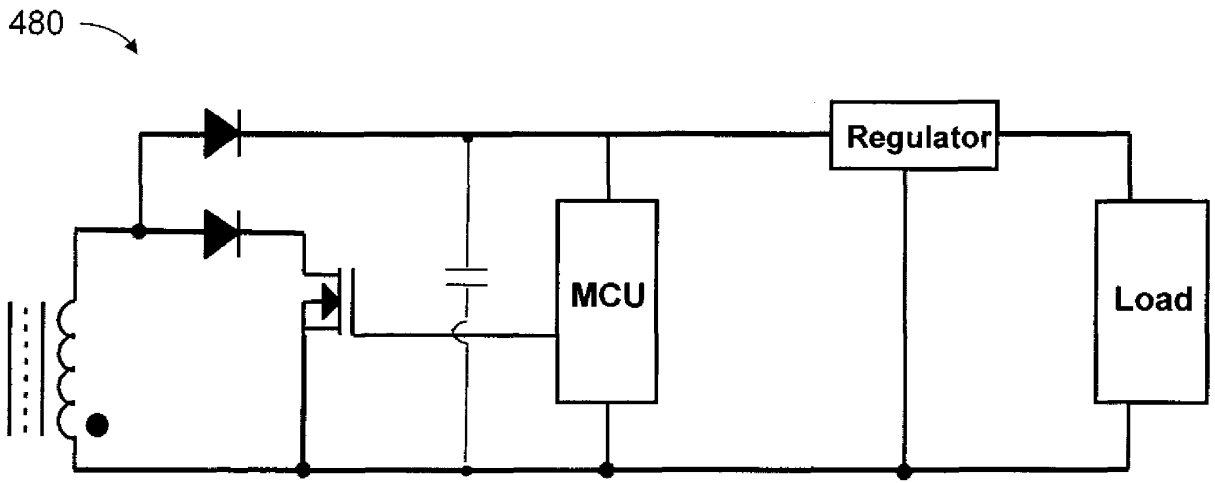


Figure 22

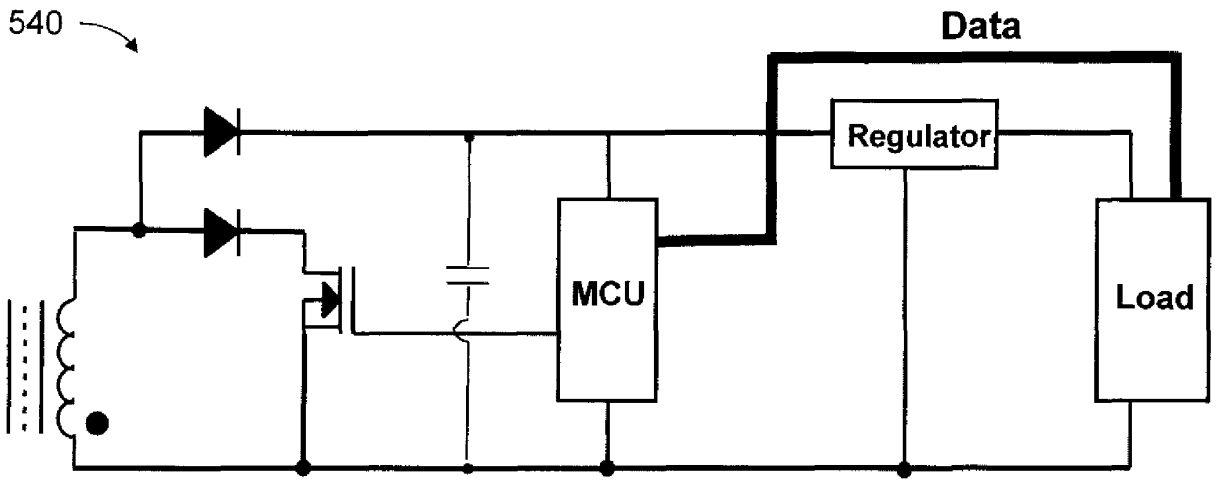


Figure 24

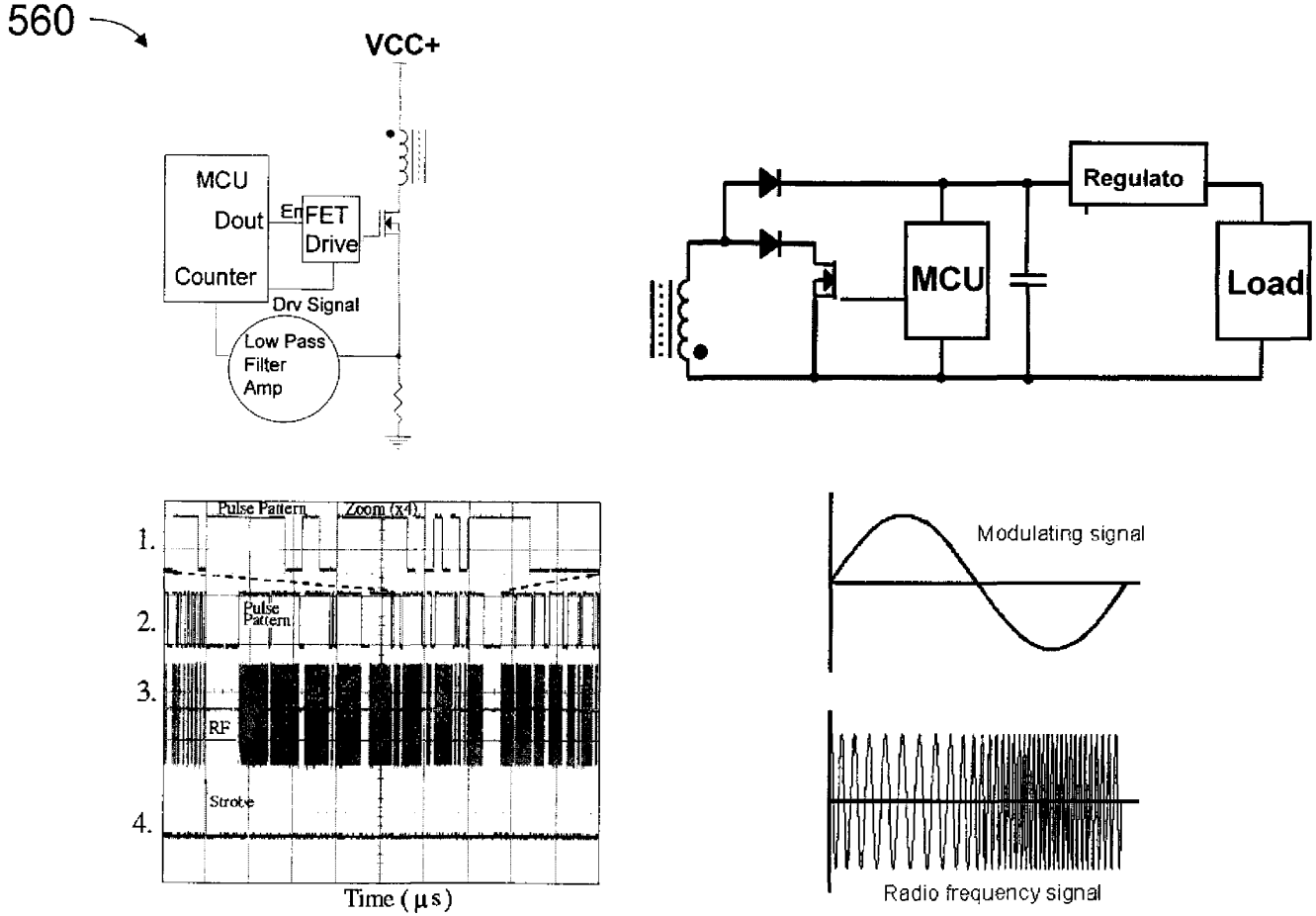

560
VCC+
MCU
Dout
Counter
En
FET
Drive
Drv Signal
Low Pass
Filter
Amp
Regulato
MCU
Load
Pulse Pattern
Zoom (x4)
1.
2.
Pulse
Pattern
3.
RF
Strobe
4.
Time (µs)
Modulating signal
Radio frequency signal

Figure 25

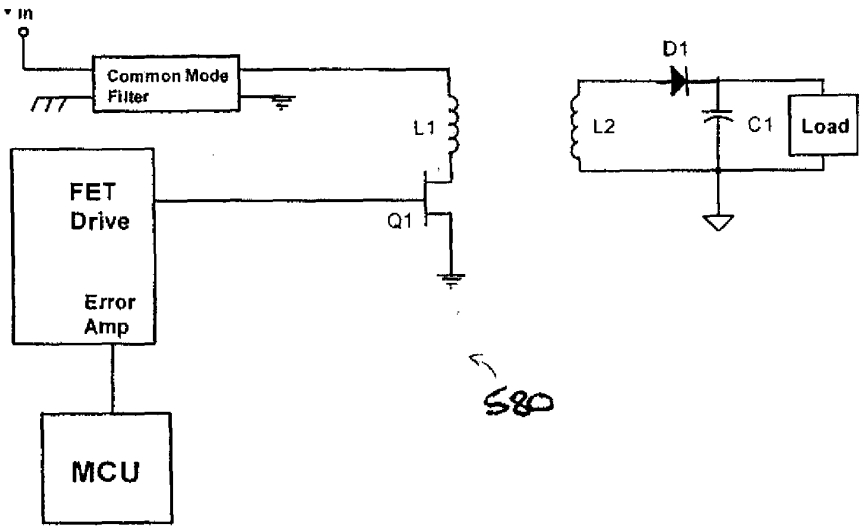

In
Common Mode Filter
L1
FET Drive
Error Amp
Q1
MCU
580
D1
L2
C1
Load

FIG. 26

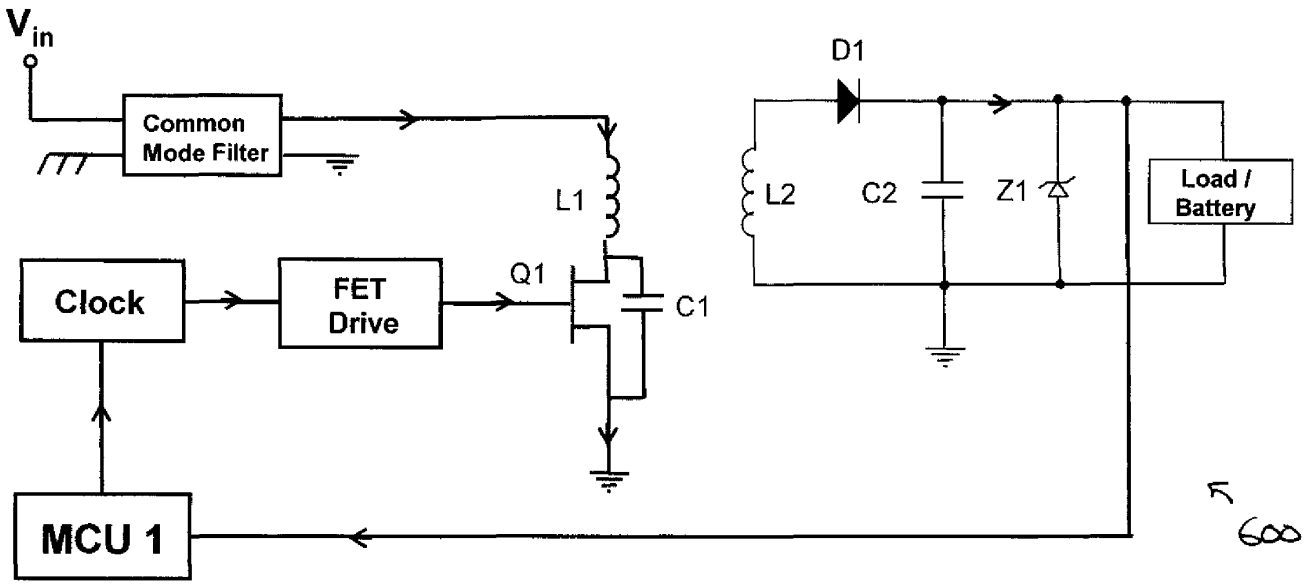

V_{in}
Common Mode Filter
L1
D1
L2
C2
Z1
Load / Battery
Clock
FET Drive
Q1
C1
MCU 1
68

Figure 27

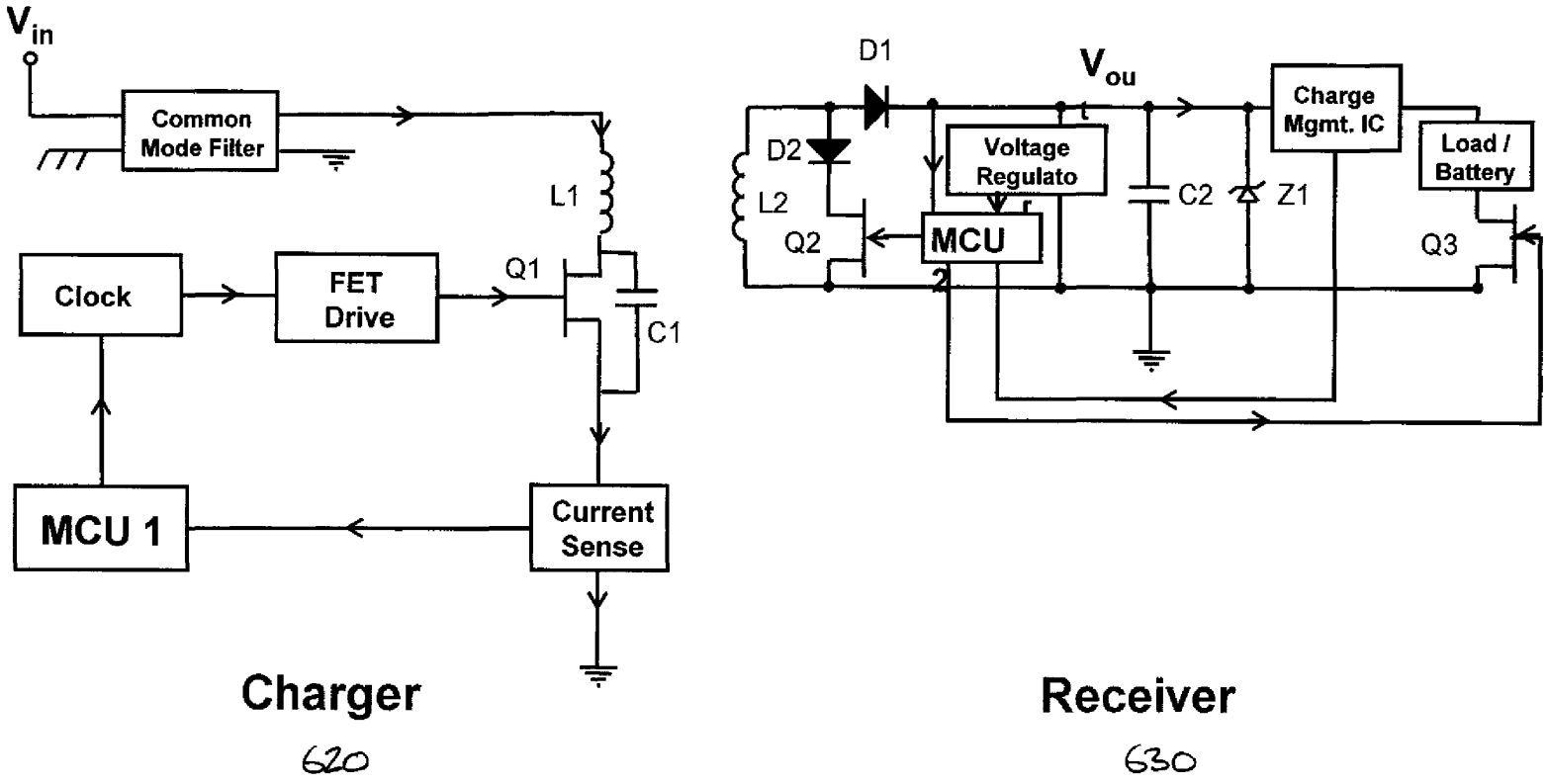

V in
Common Mode Filter
L1
Clock
FET Drive
Q1
C1
MCU 1
Current Sense
Charger
620
D1
V ou
Charge Mgmt. IC
Load / Battery
D2
Voltage Regulato
L2
Q2
MCU
C2
Z1
Q3
Receiver
630

Figure 28

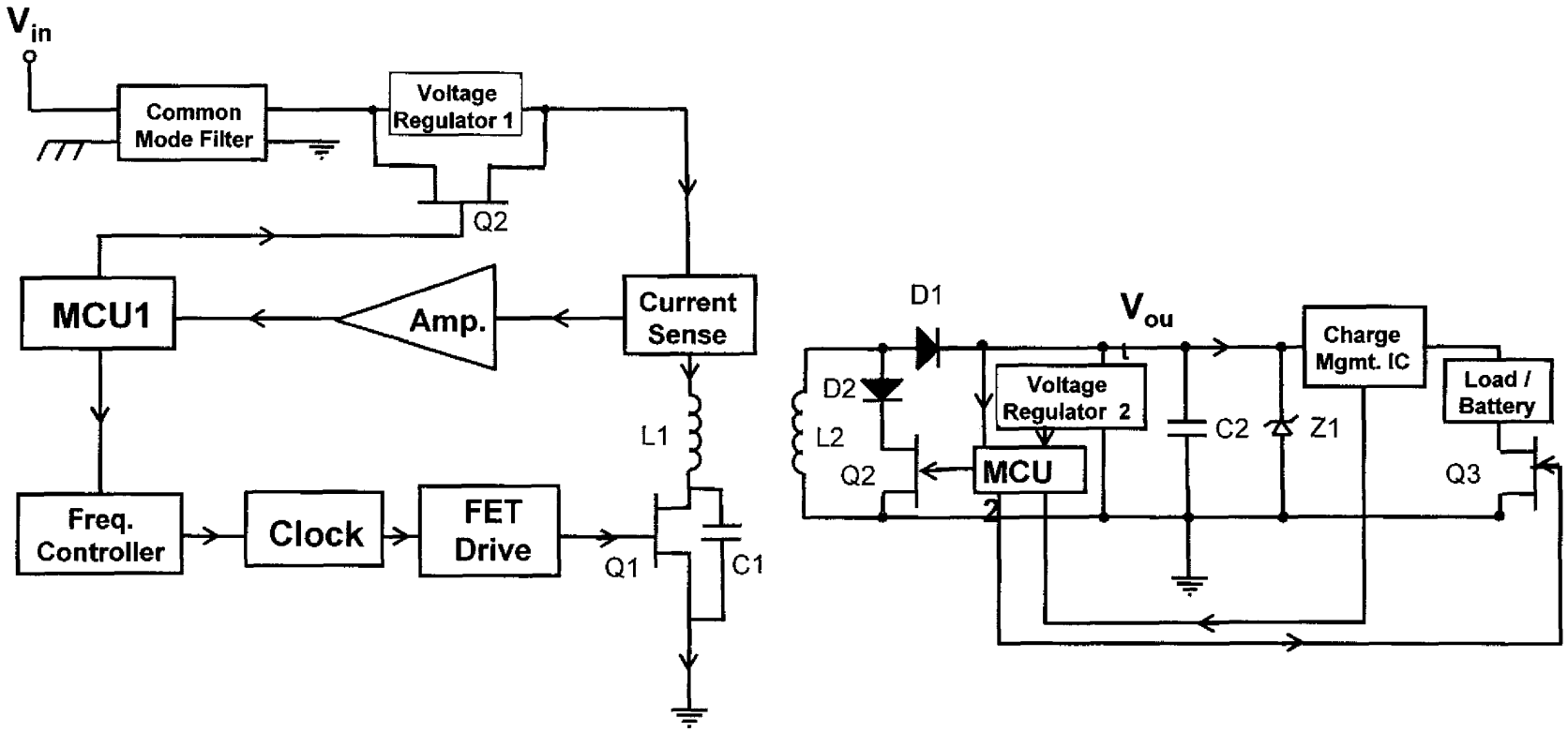

V_{in}
Common Mode Filter
Voltage Regulator 1
Q2
MCU1
Amp.
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D1
V_{ou}
D2
L2
Q2
Voltage Regulator 2
MCU
C2
Z1
Charge Mgmt. IC
Load / Battery
Q3
Charger
Receiver
640

Figure 29

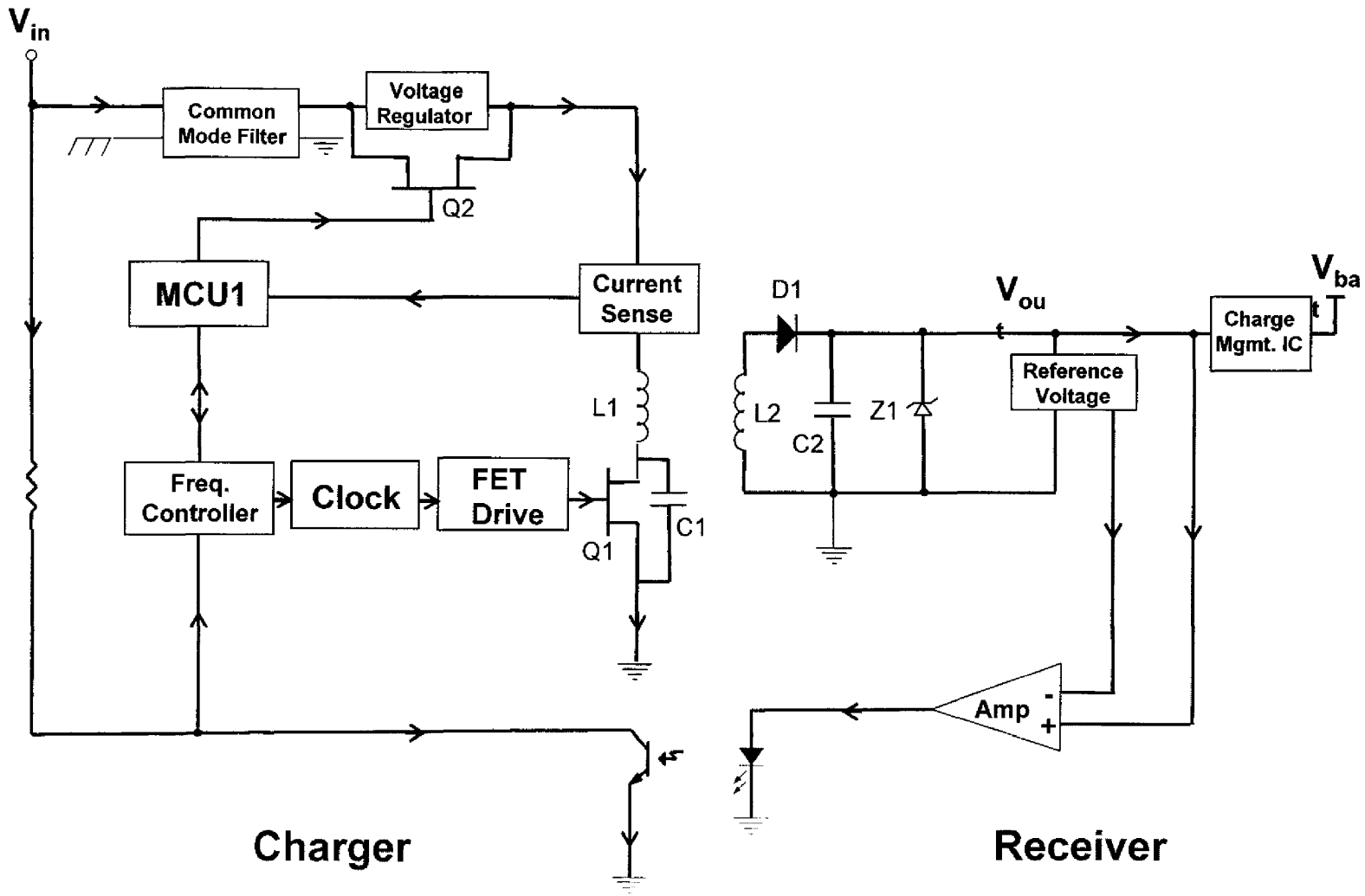

V_in
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D1
V_ou
L2
C2
Z1
Reference Voltage
Charge Mgmt. IC
V_ba
Amp
Charger
Receiver
650

Figure 30

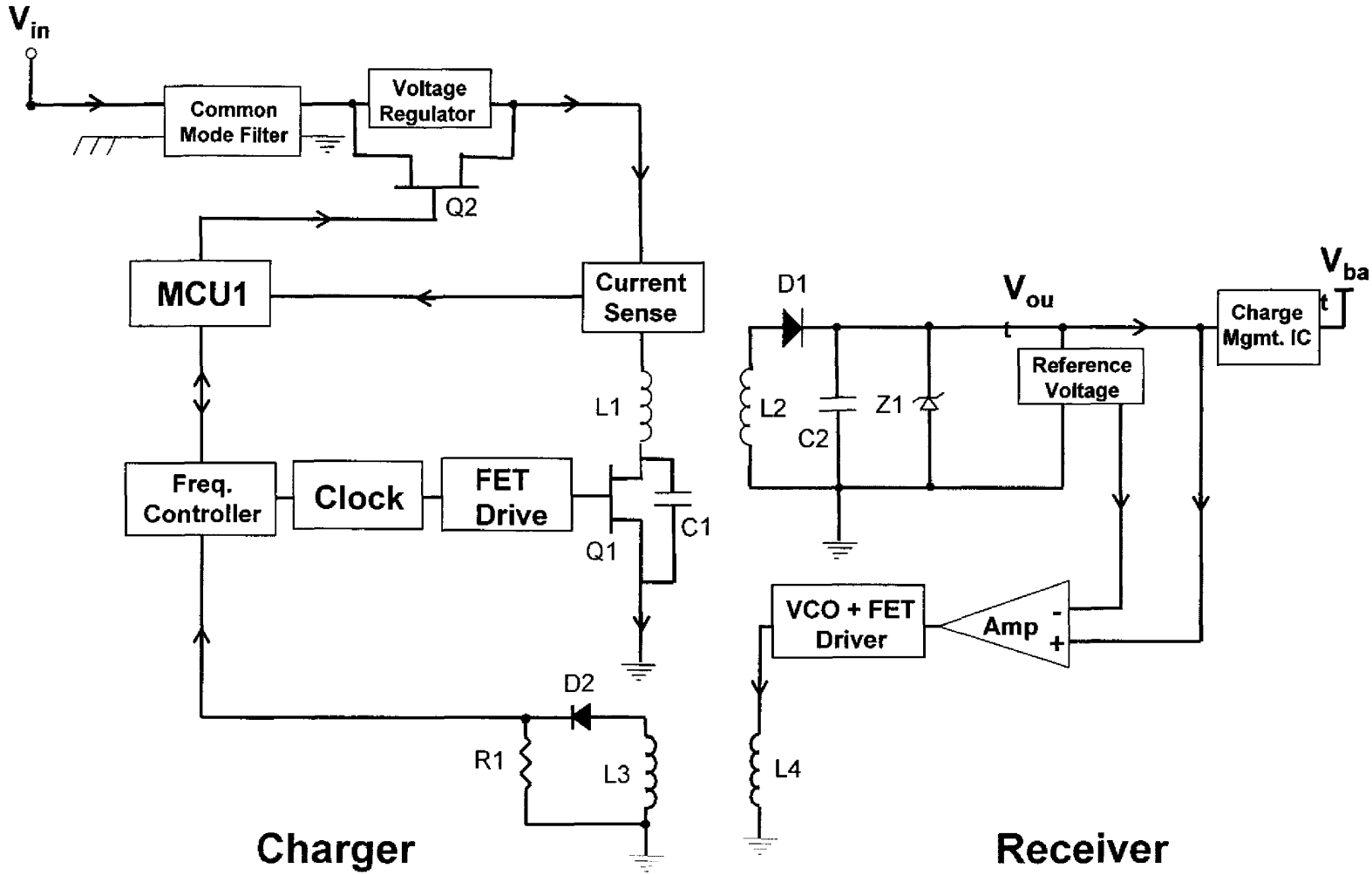

V_{in}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D2
R1
L3
Charger
D1
V_{ou}
Charge Mgmt. IC
V_{ba}
Reference Voltage
L2
C2
Z1
VCO + FET Driver
Amp
L4
Receiver
660

Figure 31

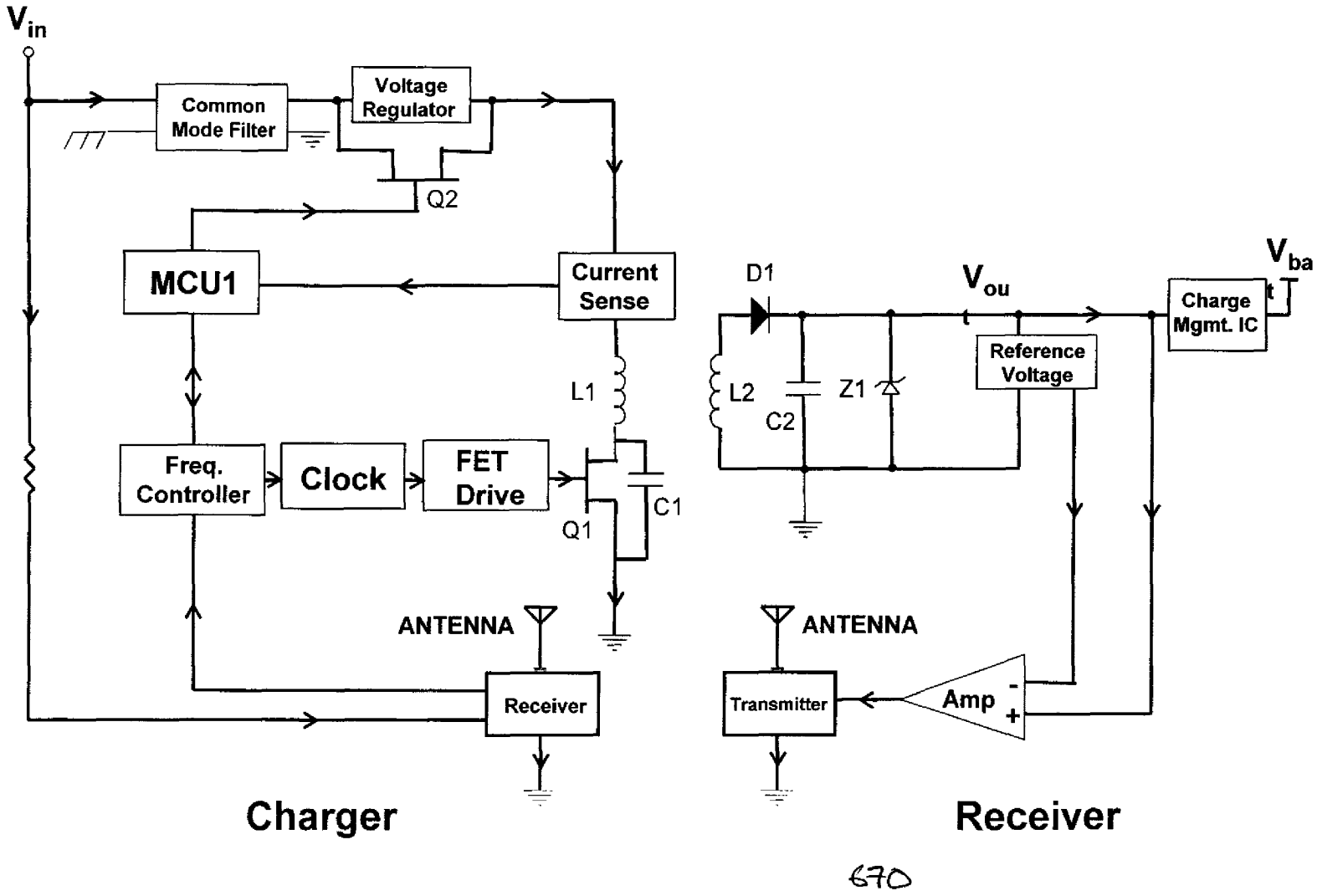

V in
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
ANTENNA
Receiver
Charger
D1
V ou
V ba
Charge Mgmt. IC
Reference Voltage
L2
C2
Z1
ANTENNA
Transmitter
Amp
-
+
Receiver
670

Figure 32

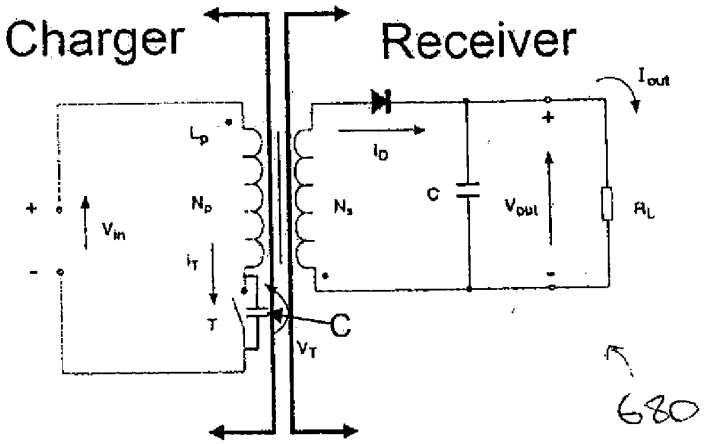


FIG. 33

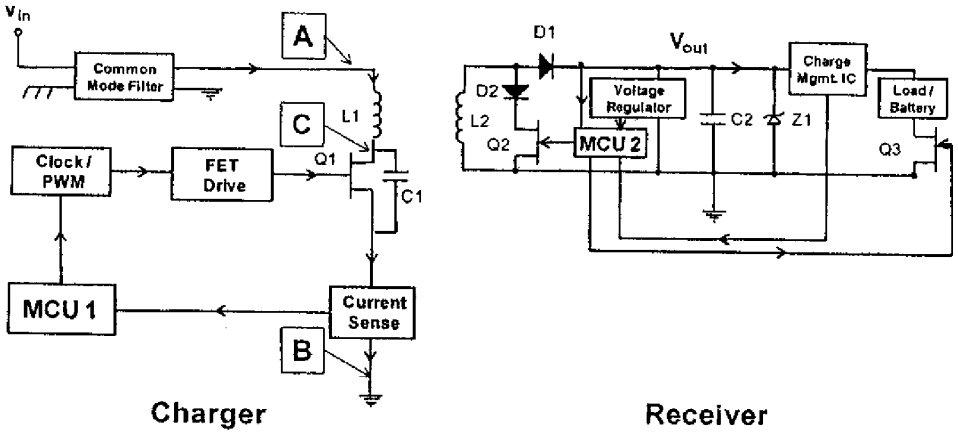


FIG. 34

700

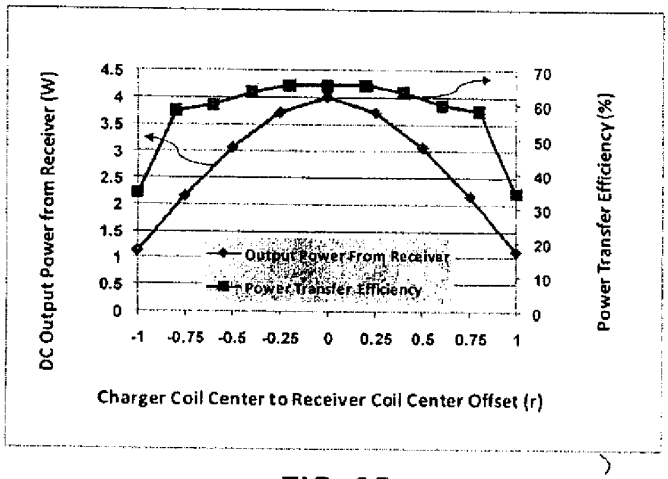


FIG. 35

720

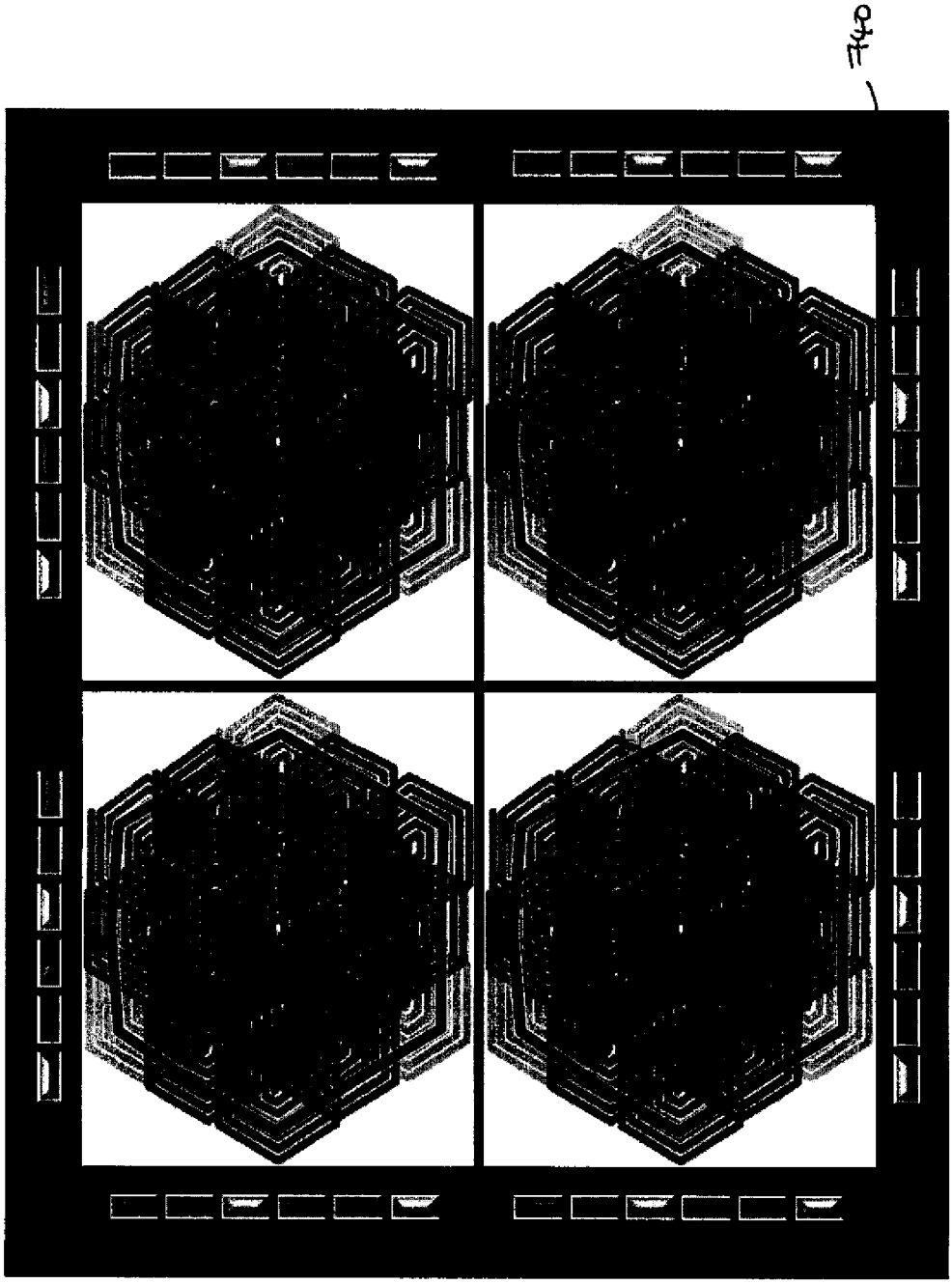


Figure 36

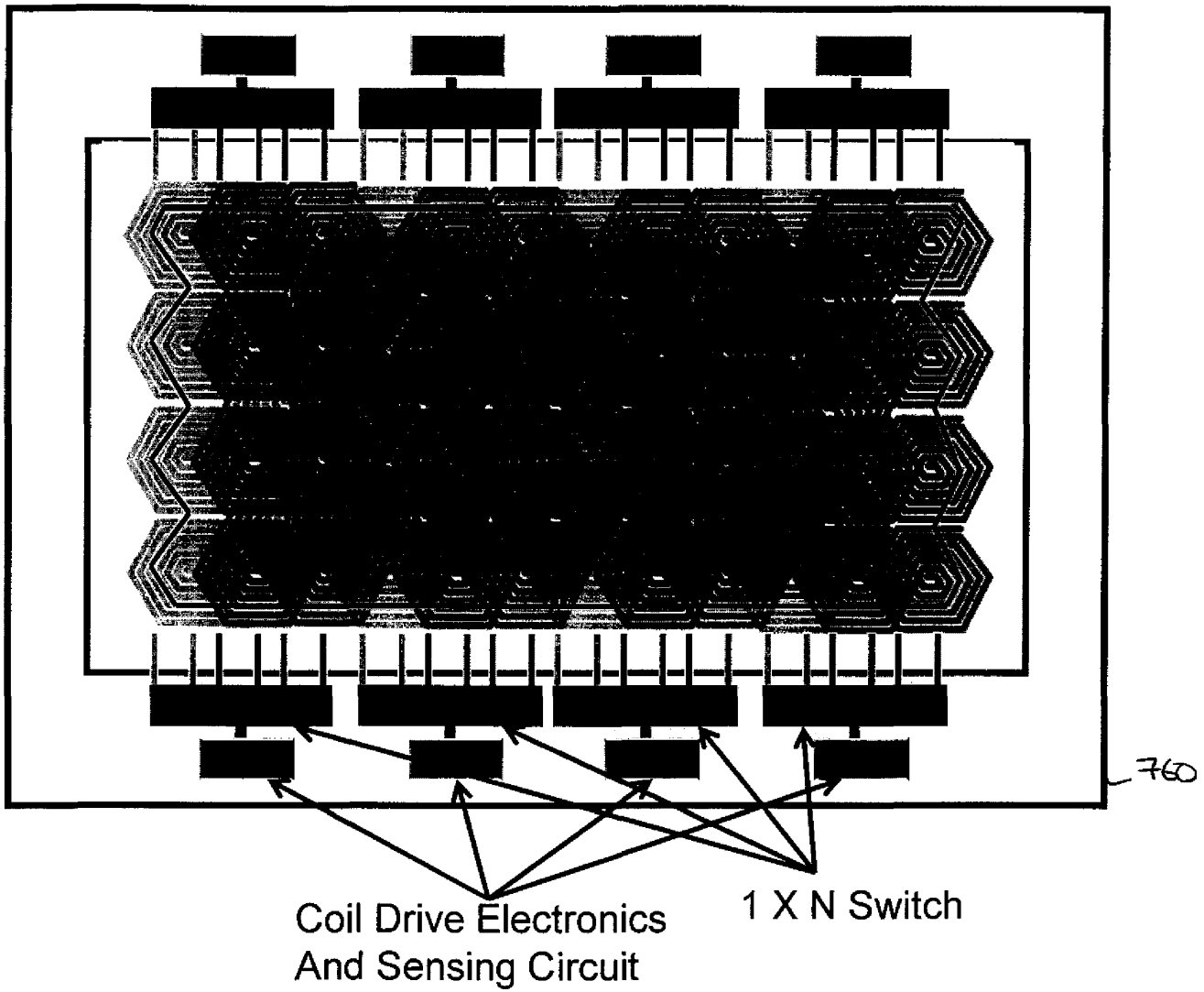


Figure 37

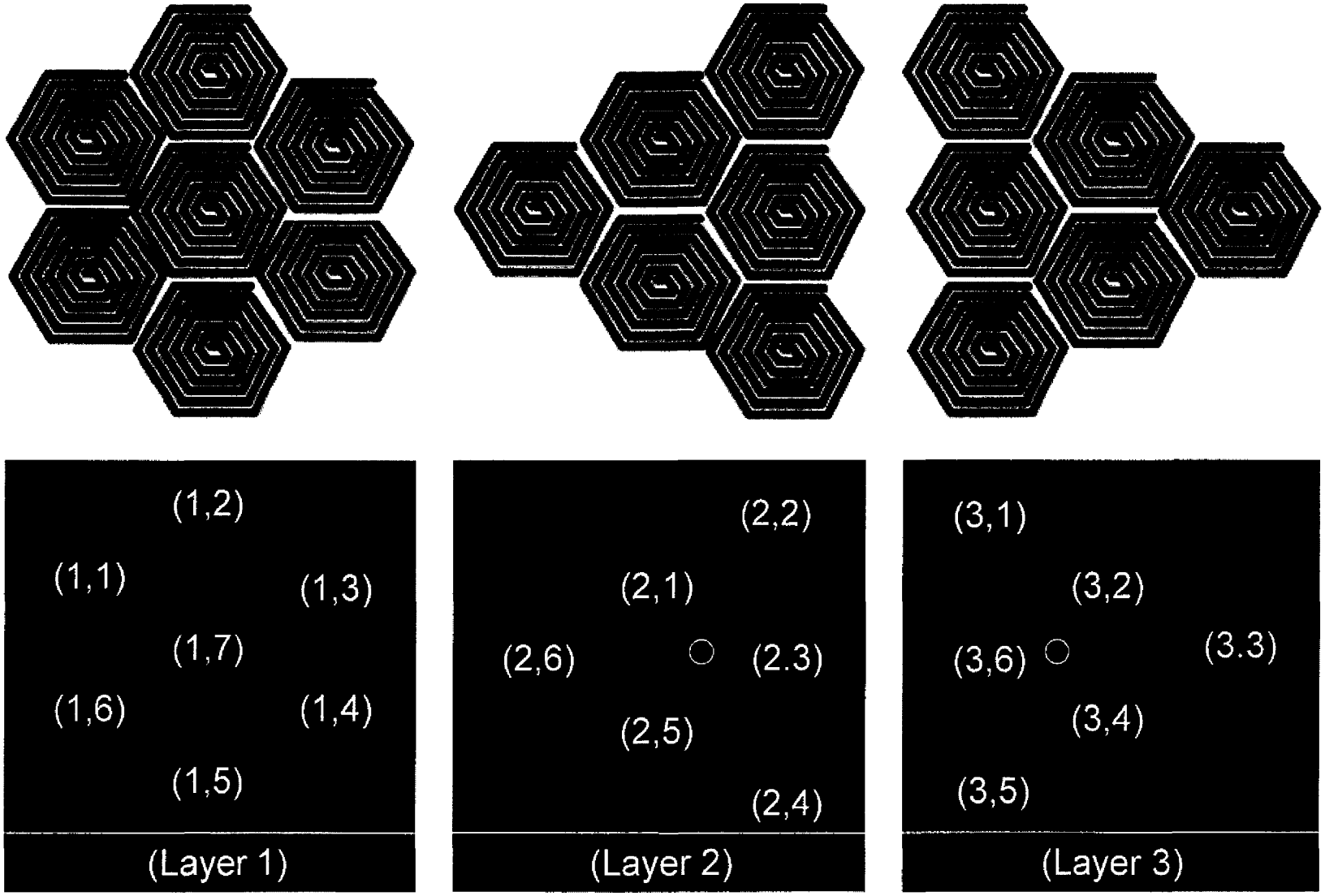

(1,2)
(1,1)
(1,3)
(1,7)
(1,6)
(1,4)
(1,5)
(Layer 1)
(2,2)
(2,1)
(2,6)
(2.3)
(2,5)
(2,4)
(Layer 2)
(3,1)
(3,2)
(3,6)
(3.3)
(3,4)
(3,5)
(Layer 3)
780

Figure 38

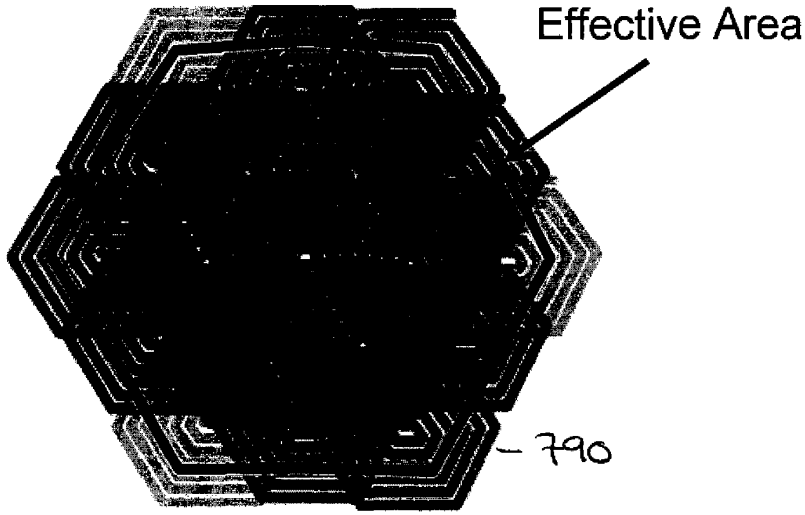


Figure 39

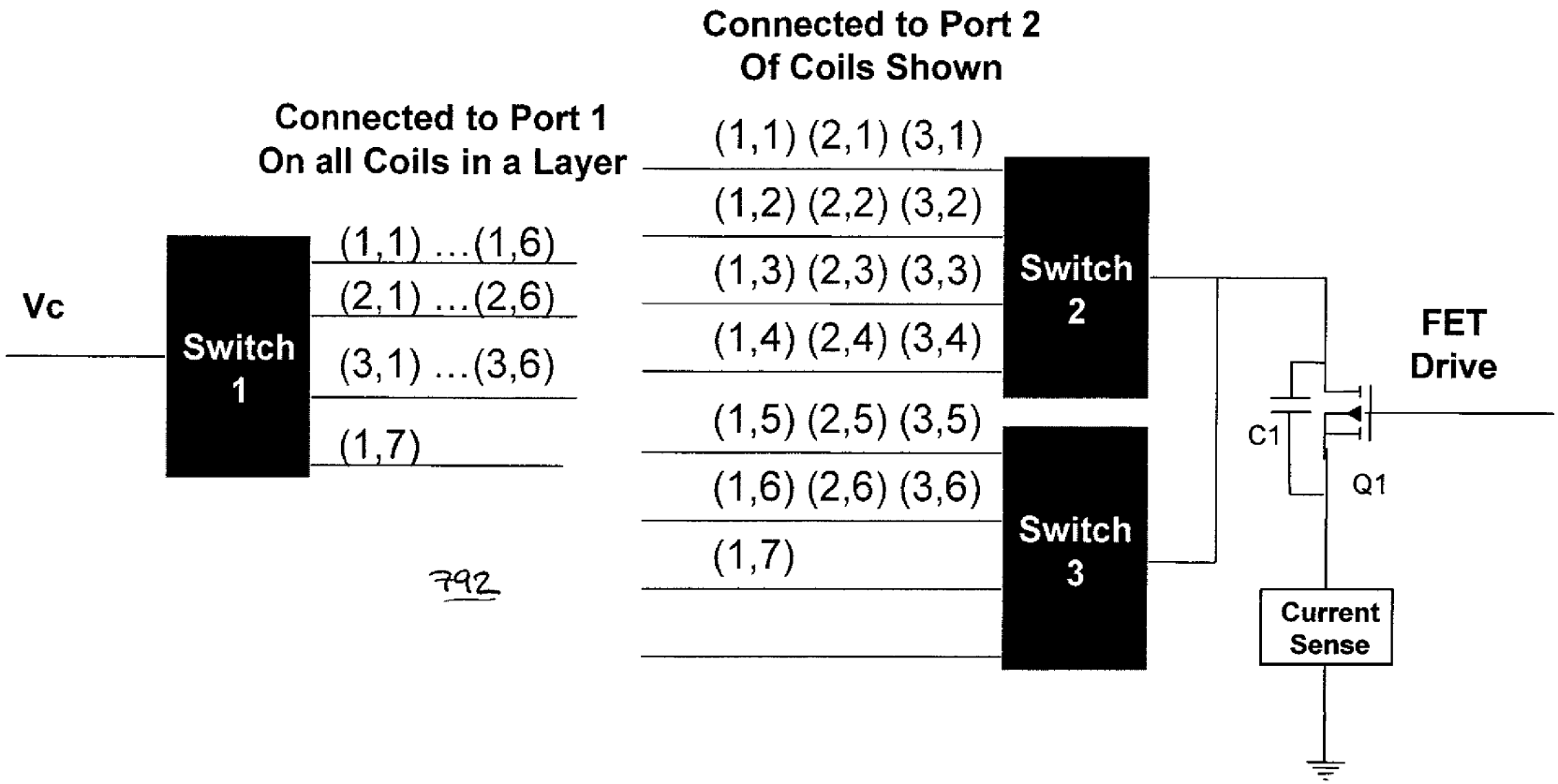

Connected to Port 2
Of Coils Shown
Connected to Port 1
On all Coils in a Layer
(1,1) (2,1) (3,1)
(1,2) (2,2) (3,2)
(1,3) (2,3) (3,3)
(1,4) (2,4) (3,4)
(1,5) (2,5) (3,5)
(1,6) (2,6) (3,6)
(1,7)
Vc
Switch 1
(1,1) ...(1,6)
(2,1) ...(2,6)
(3,1) ...(3,6)
(1,7)
Switch 2
Switch 3
FET Drive
C1
Q1
Current Sense
792

Figure 40

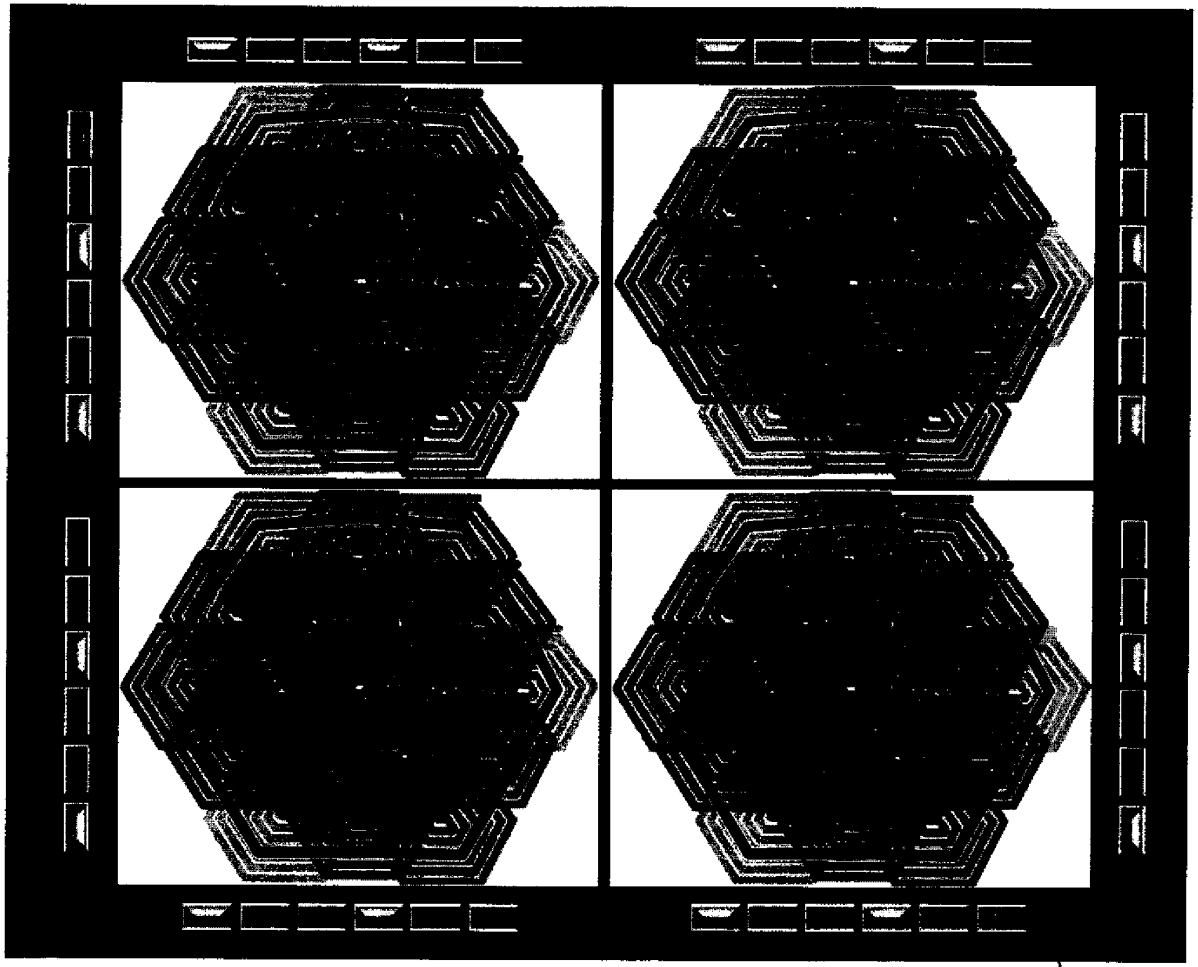


Figure 41

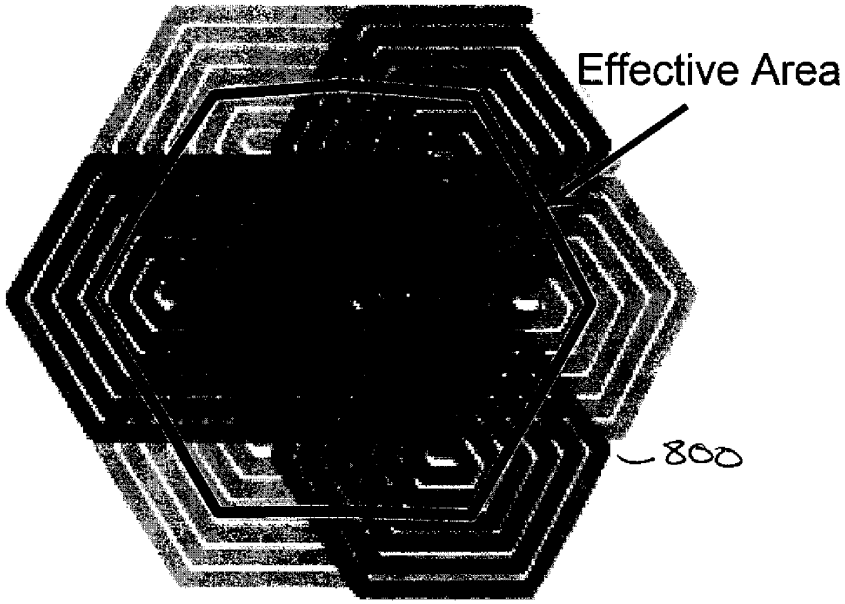


Figure 42

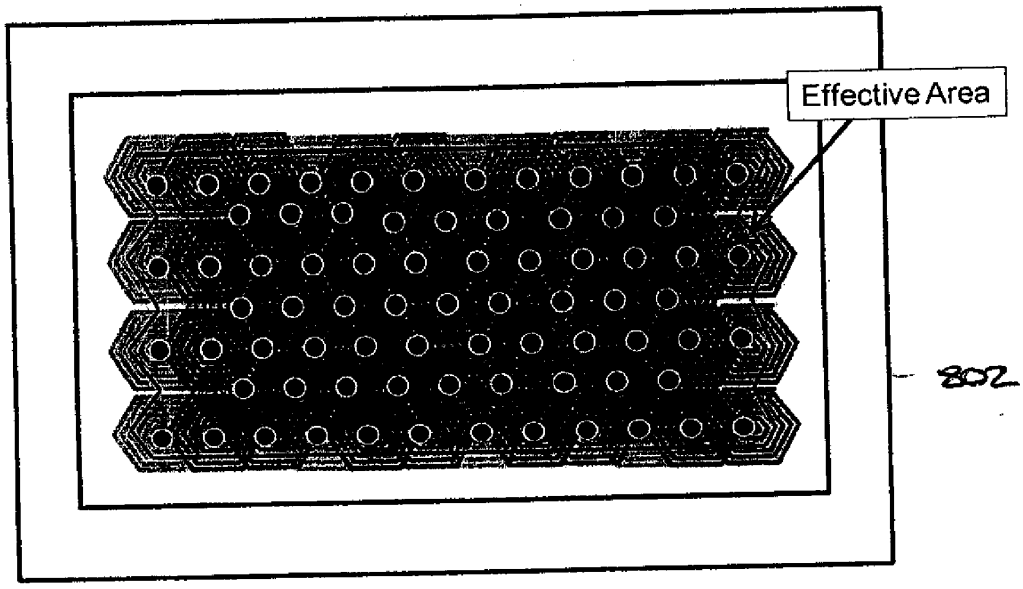

Effective Area
802

FIG. 43

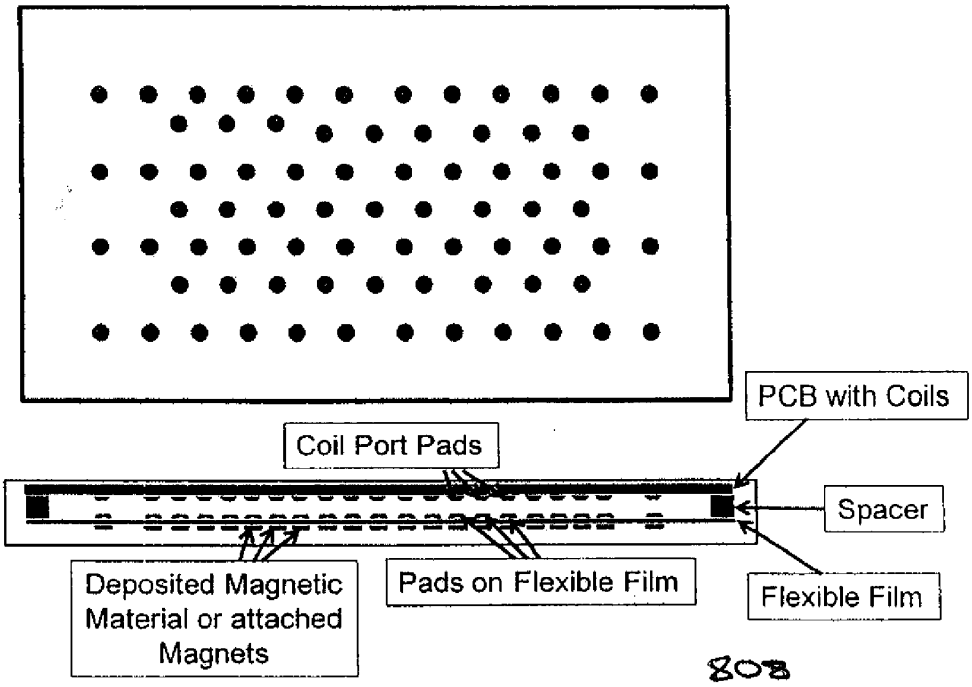

PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film
808

FIG. 44

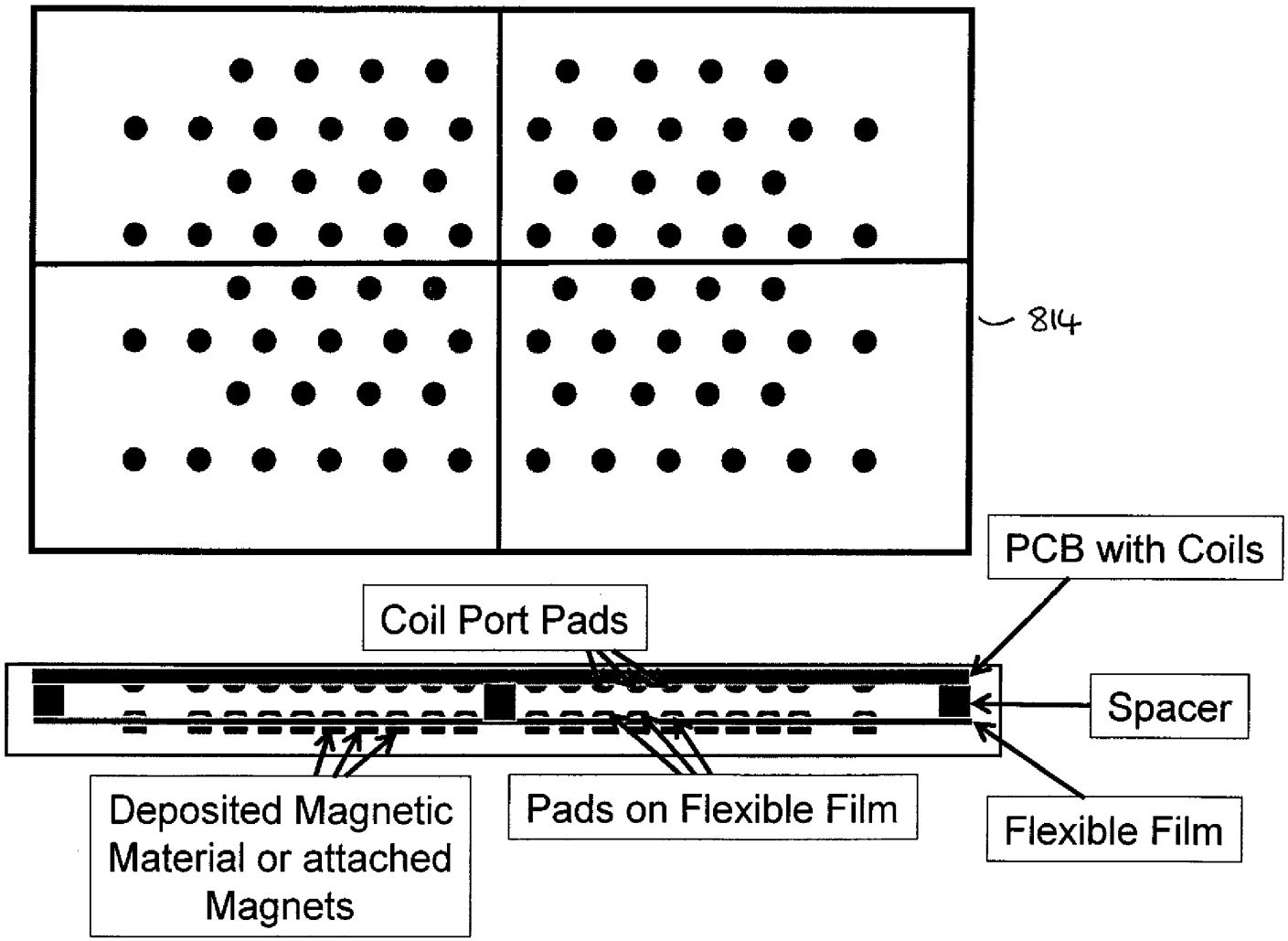

814
PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Figure 45

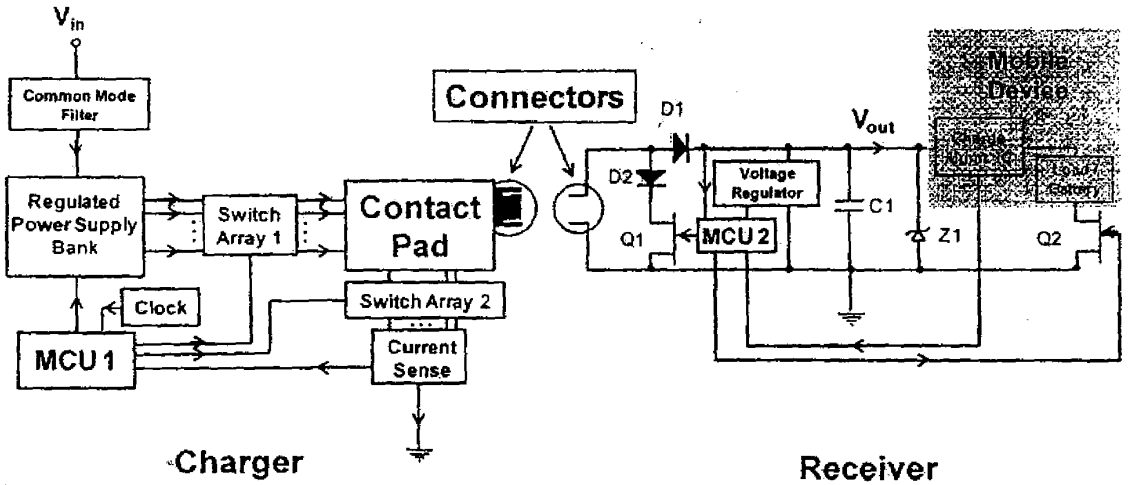
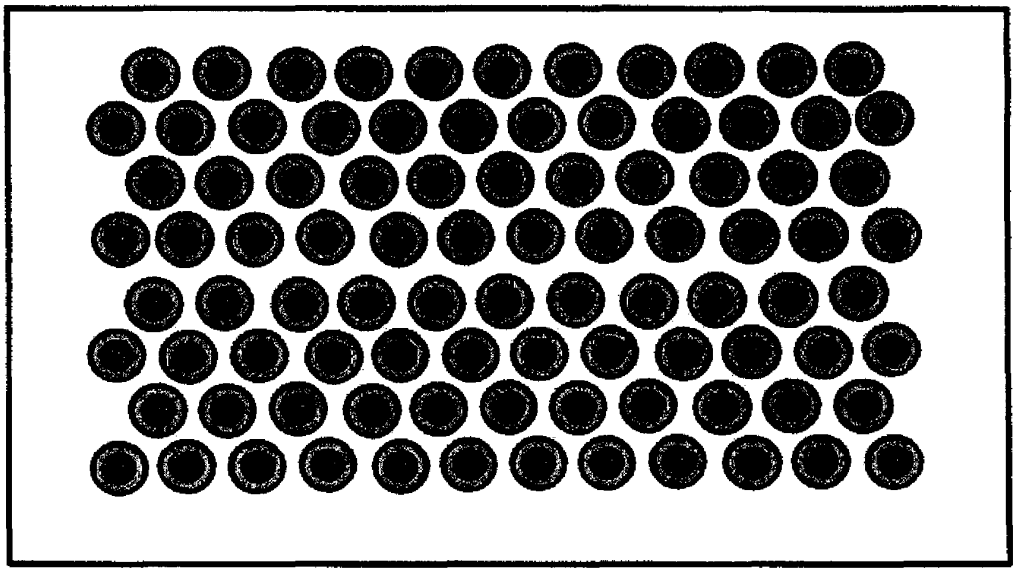

V_{in}
Common Mode Filter
Regulated Power Supply Bank
Switch Array 1
Contact Pad
Connectors
Clock
MCU 1
Switch Array 2
Current Sense
Charger
D1
D2
Q1
Voltage Regulator
MCU 2
V_{out}
C1
Z1
Q2
Receiver

FIG. 46

820



824

FIG. 47

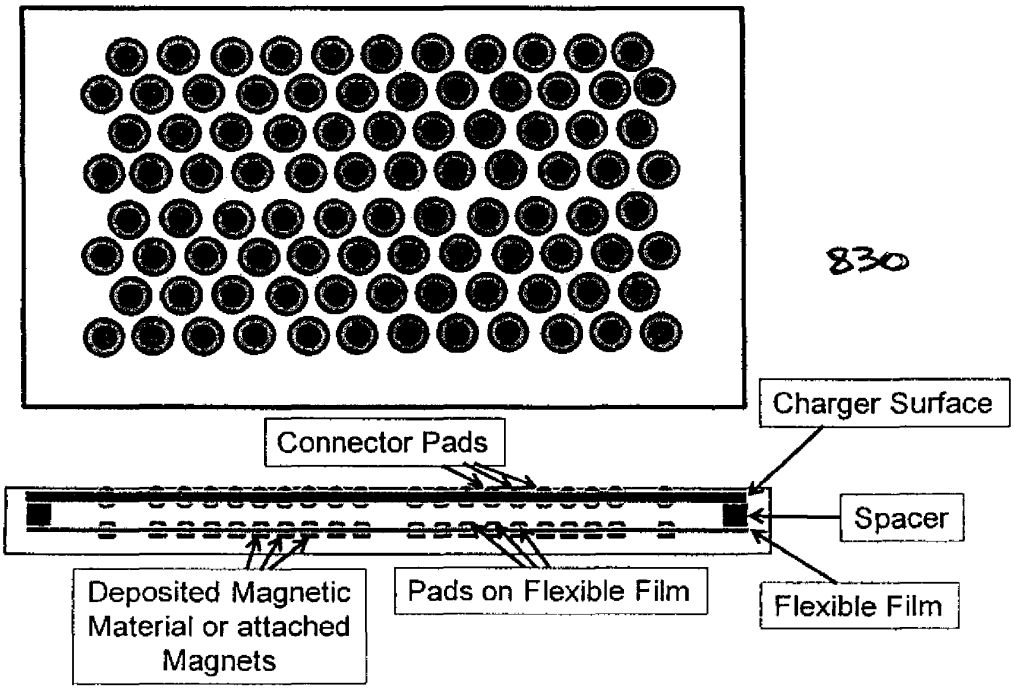


FIG. 48

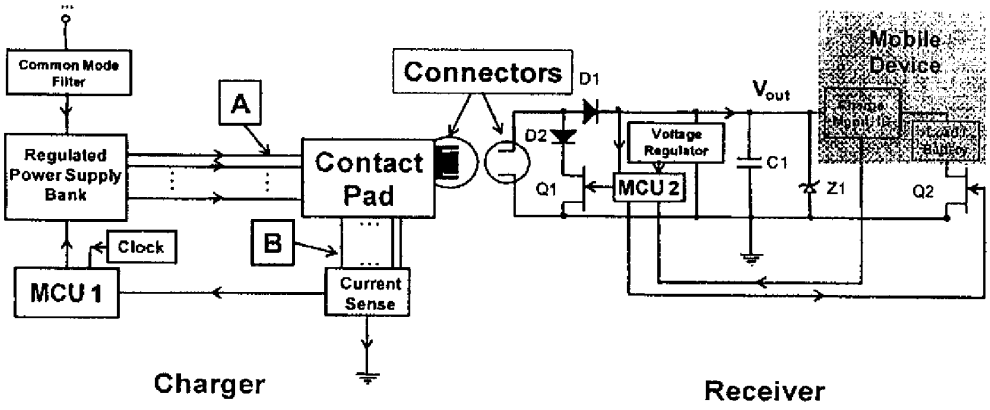
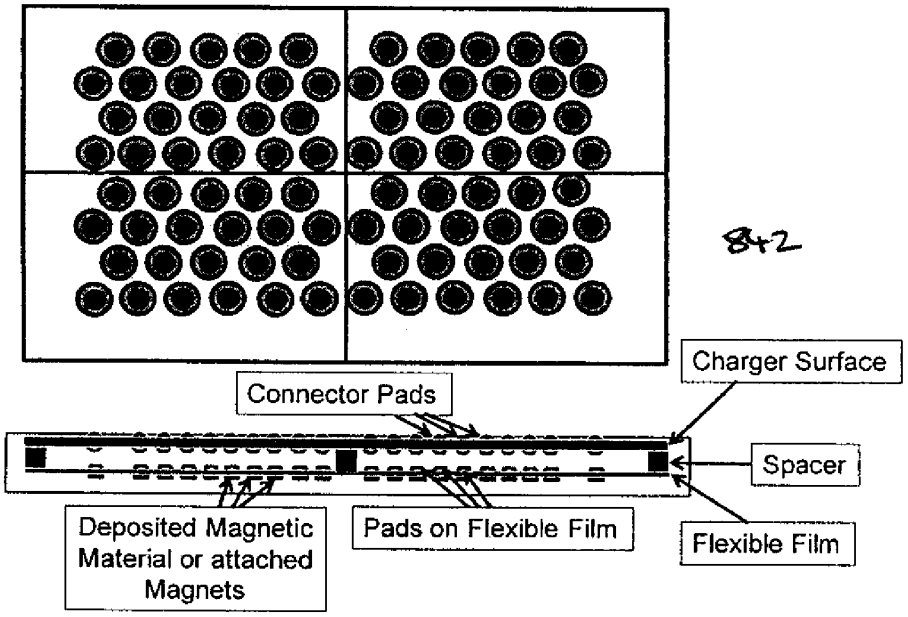


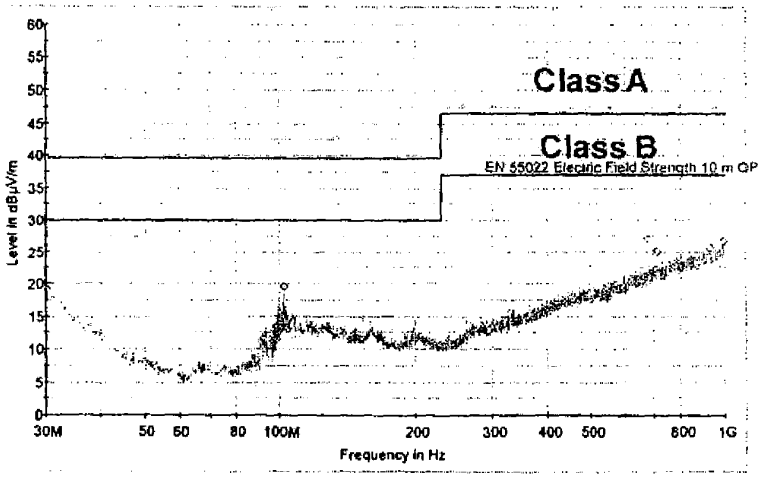
FIG. 49

836



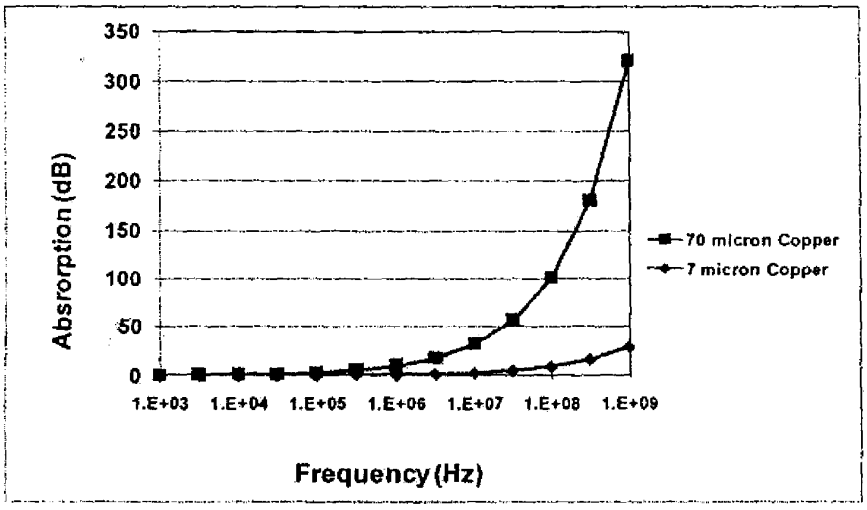
842

FIG. 50



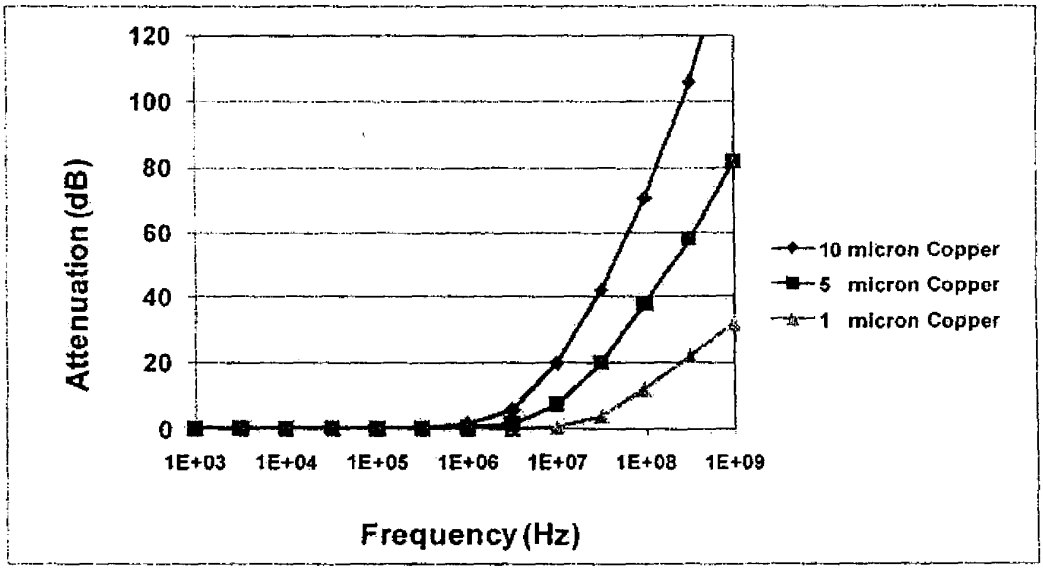
846

FIG. 51

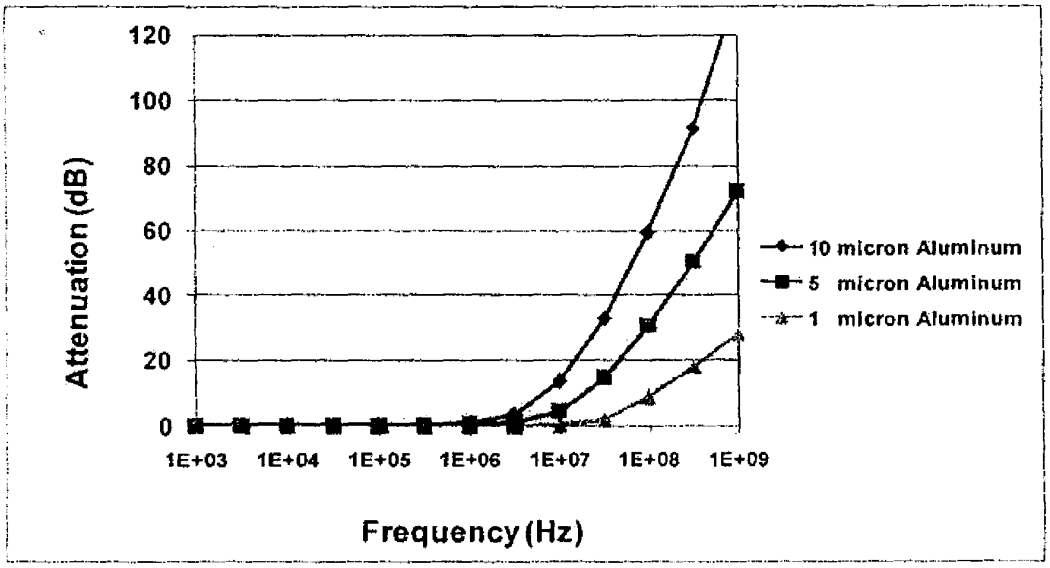


850

FIG. 52



854



856

FIG. 53

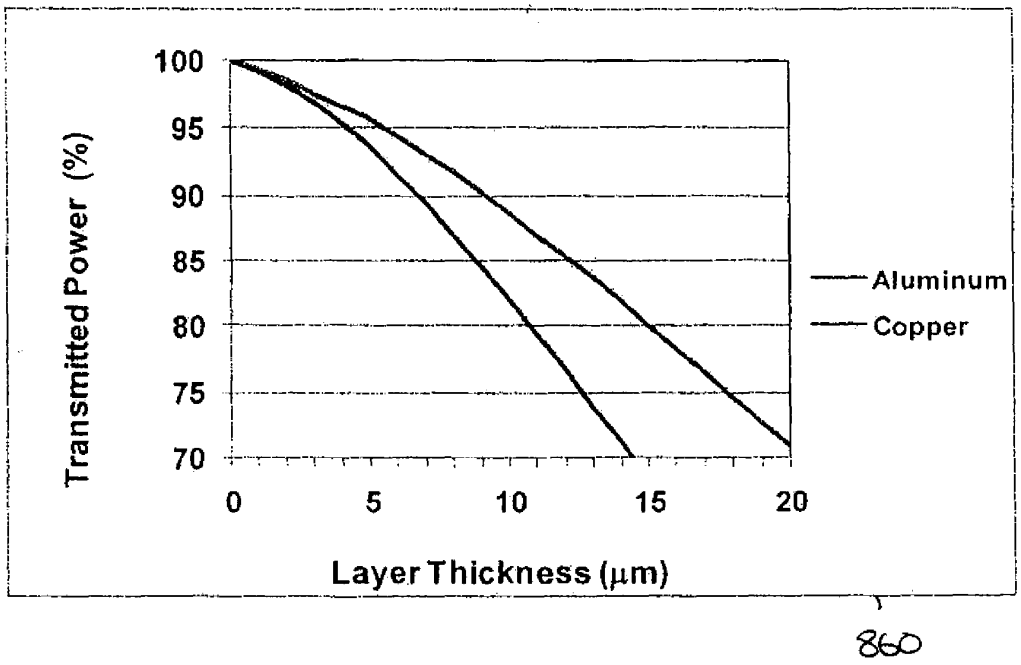

100
95
90
85
80
75
70
Transmitted Power (%)
0
5
10
15
20
Layer Thickness (μm)
Aluminum
Copper
860

FIG. 54

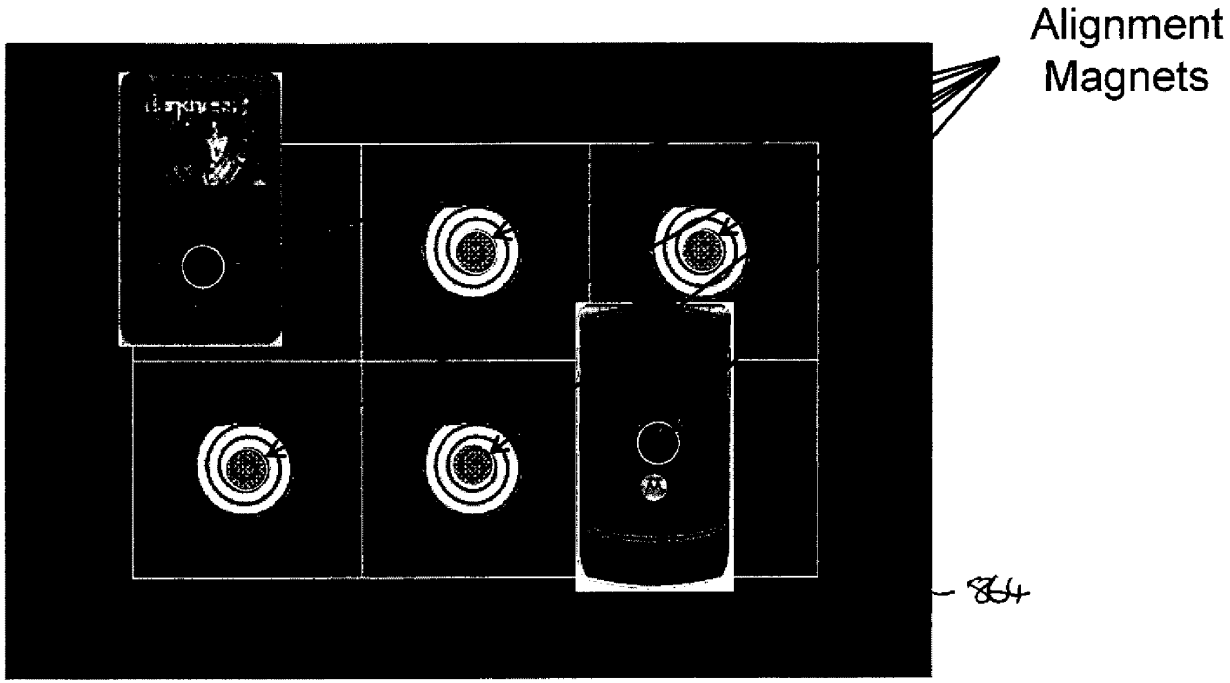


Figure 55

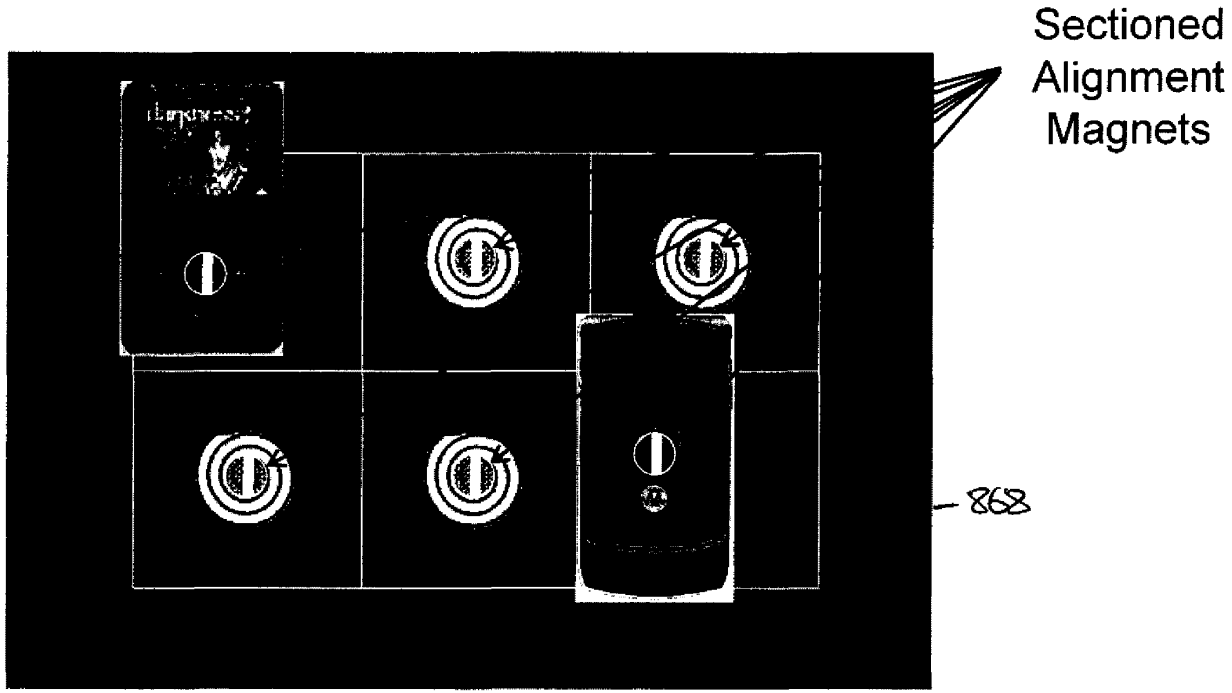


Figure 56

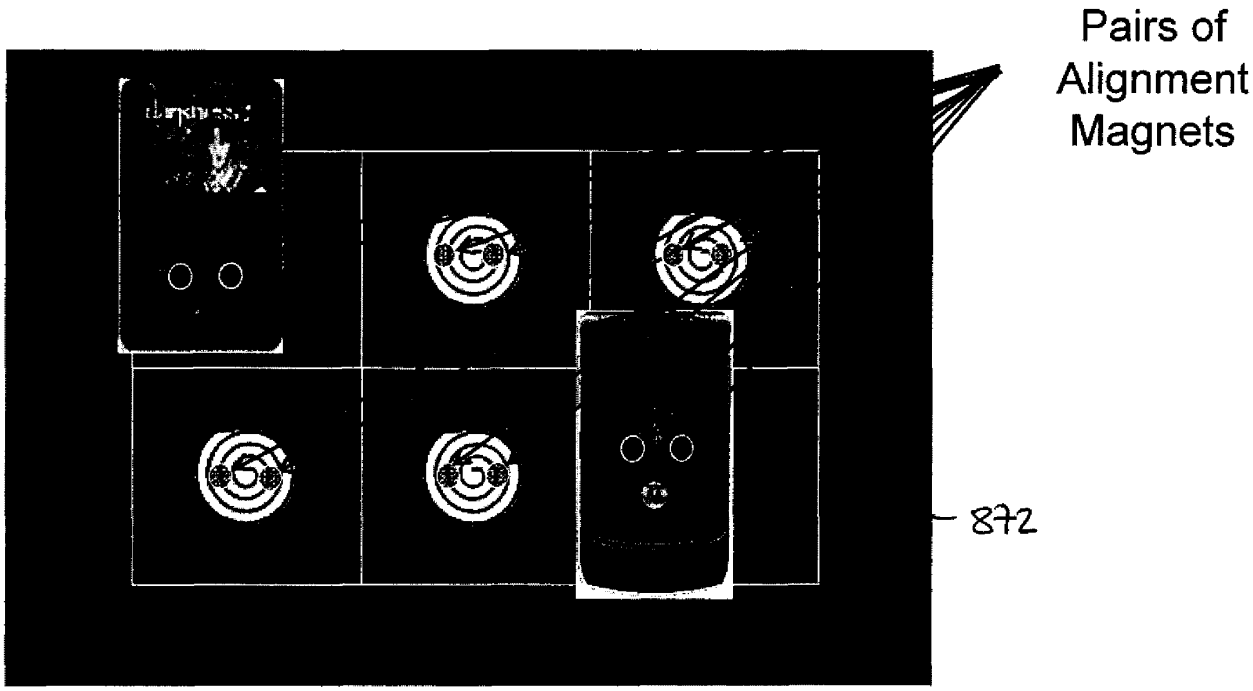


Figure 57

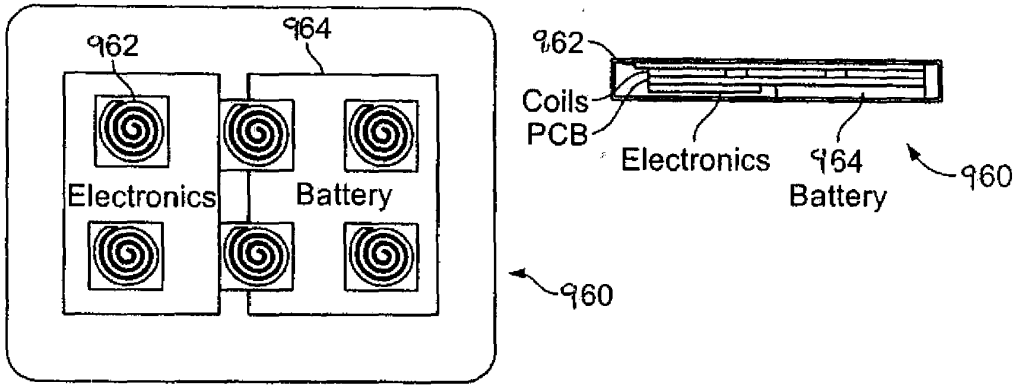

962
964
Electronics
Battery
960
962
Coils
PCB
Electronics
964
Battery
960

FIG. 58

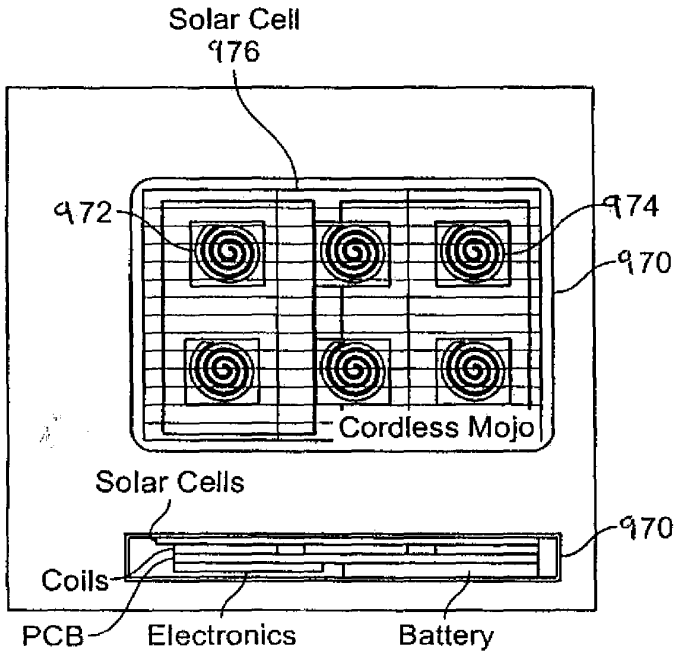

Solar Cell
976
972
974
970
Cordless Mojo
Solar Cells
970
Coils
PCB
Electronics
Battery

FIG. 59

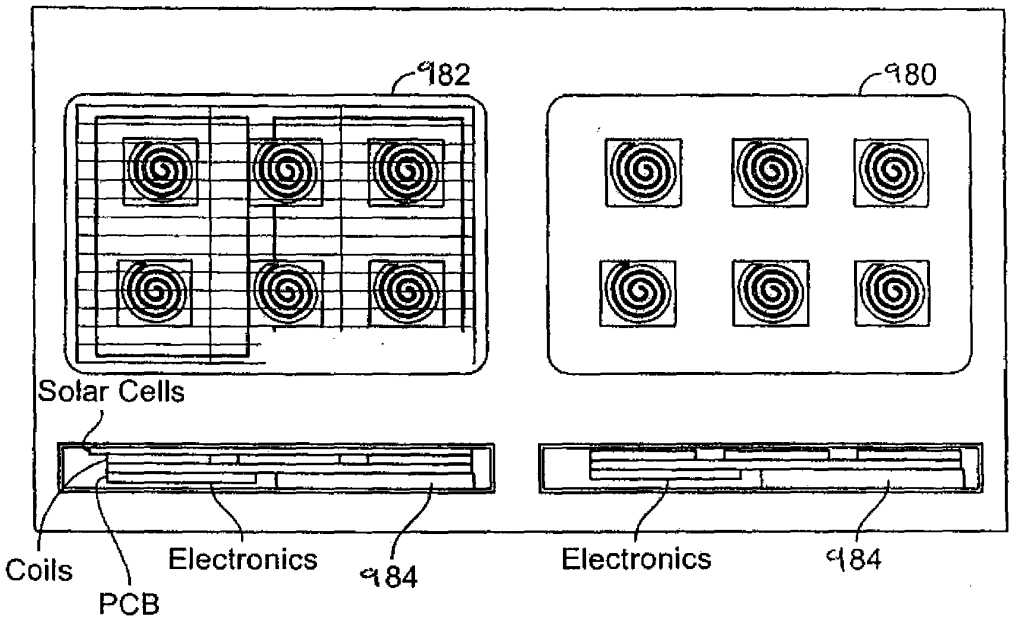

982
980
Solar Cells
Coils
PCB
Electronics
984
Electronics
984

FIG. 60

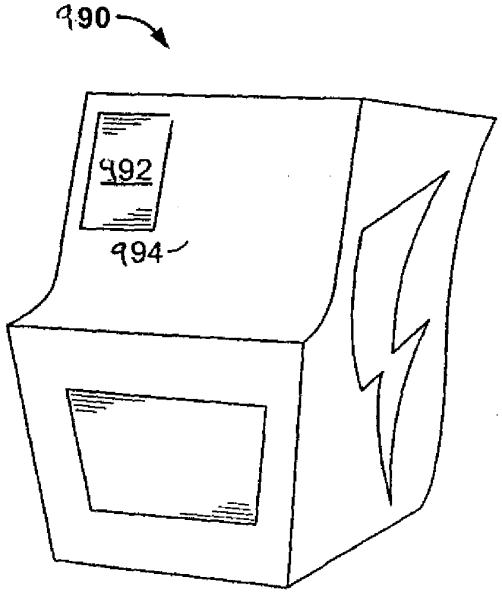

990
992
994

FIG. 61



FIG. 62

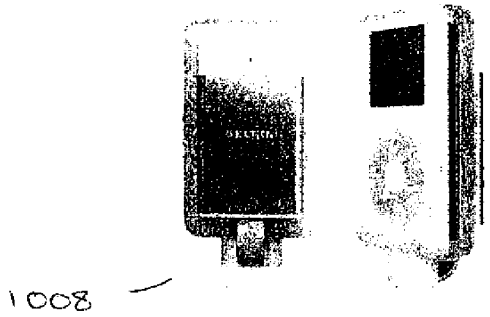


FIG. 63

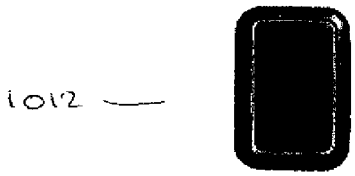


FIG. 64

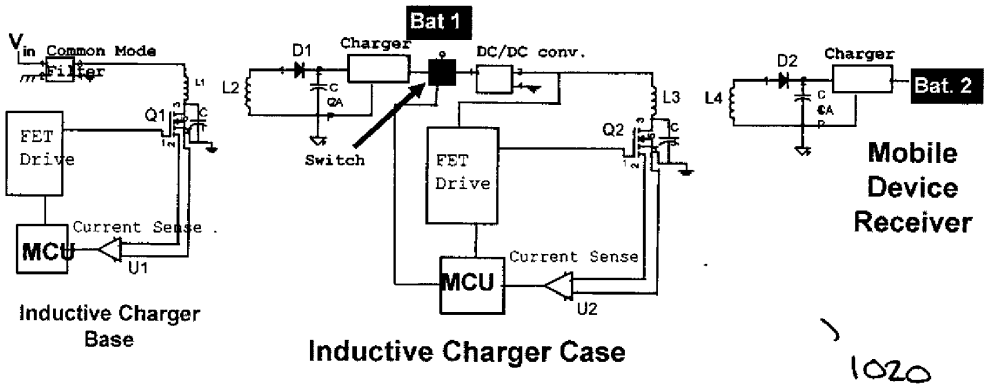

Vin
Common Mode
Filter
L1
Q1
FET
Drive
Current Sense
MCU
U1
Inductive Charger
Base
Bat 1
D1
Charger
DC/DC conv.
L2
C
CA
Switch
FET
Drive
Q2
L3
Current Sense
MCU
U2
Inductive Charger Case
D2
Charger
Bat. 2
L4
Mobile
Device
Receiver
1020

Figure 65

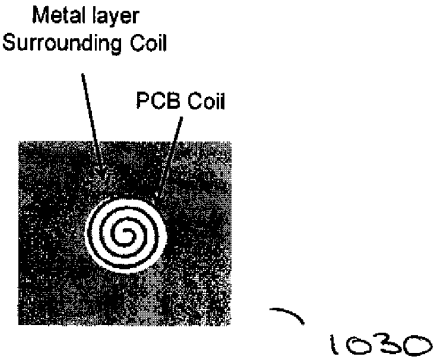


Figure 66

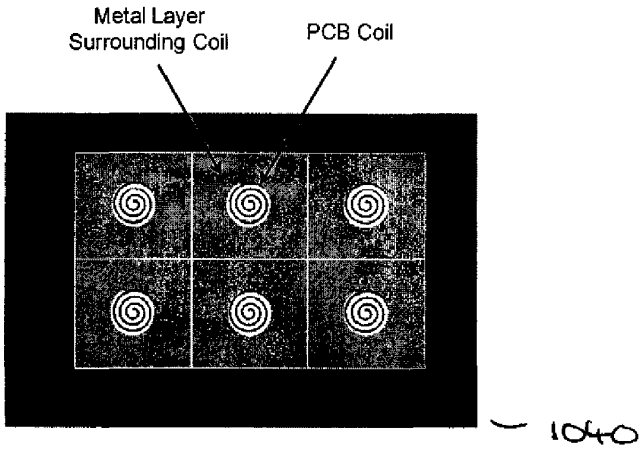


Figure 67

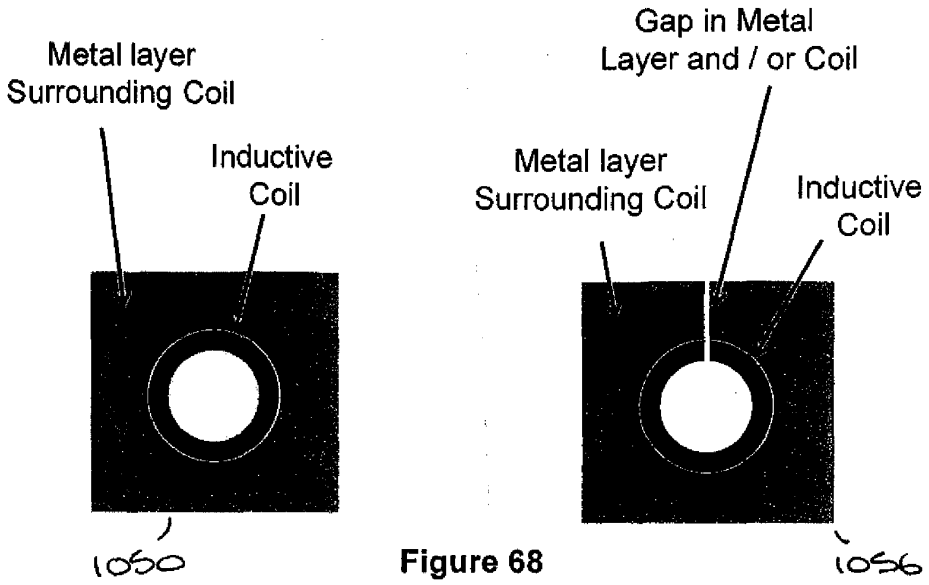


Figure 68

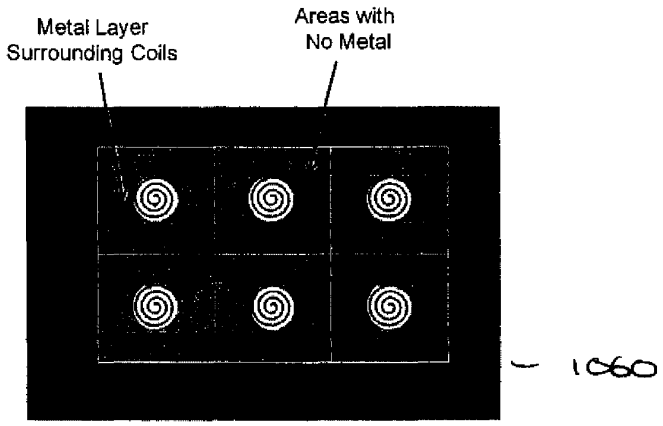


Figure 69

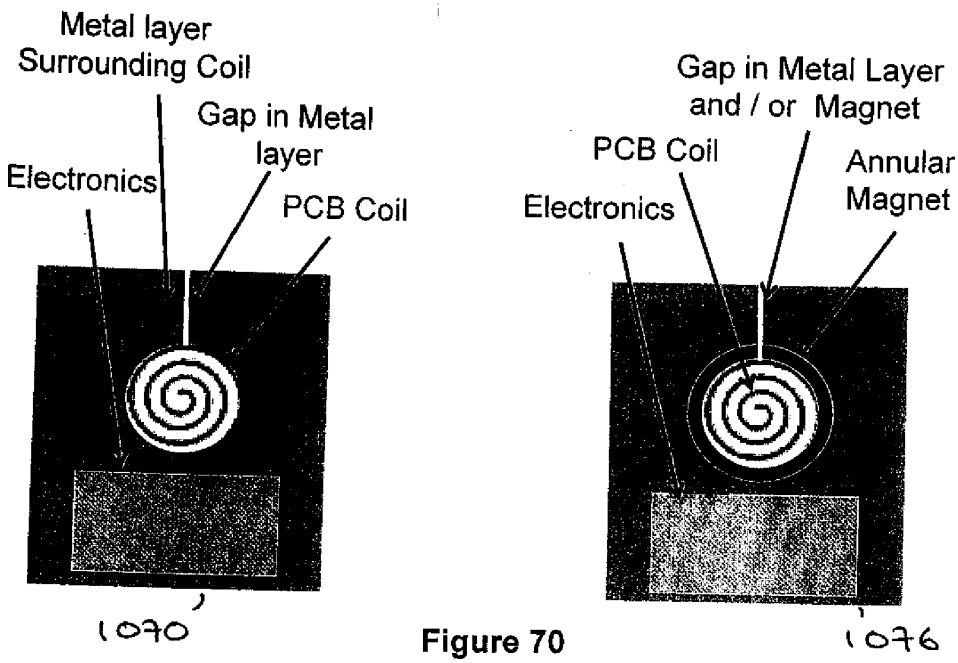


Figure 70

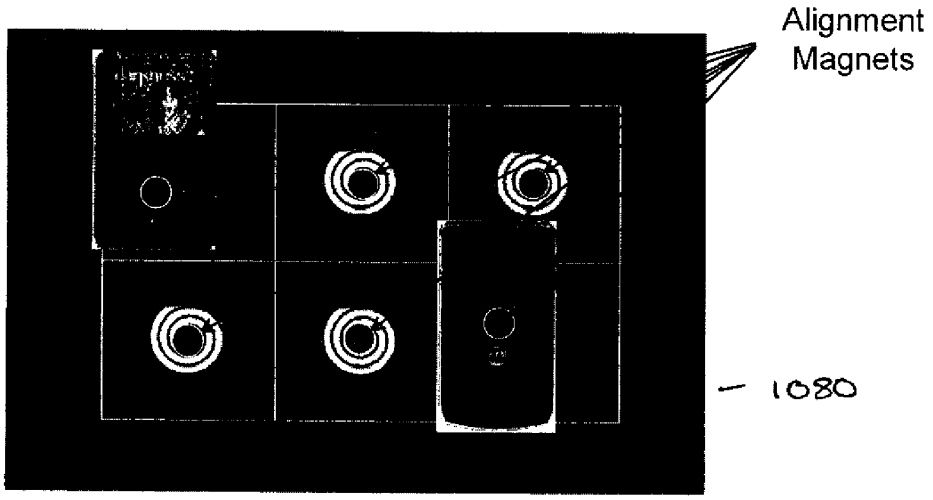


Figure 71

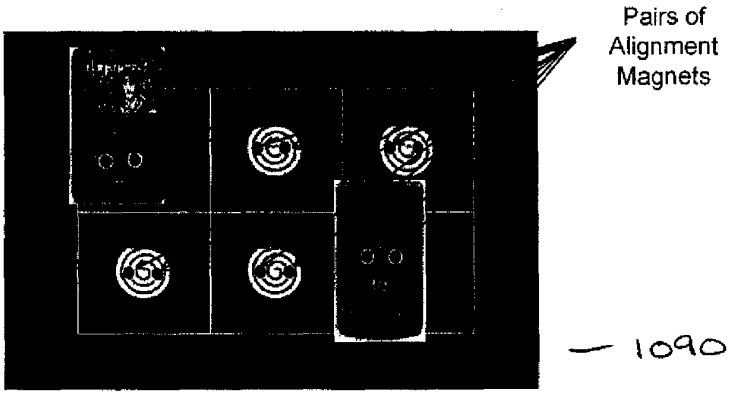


Figure 72

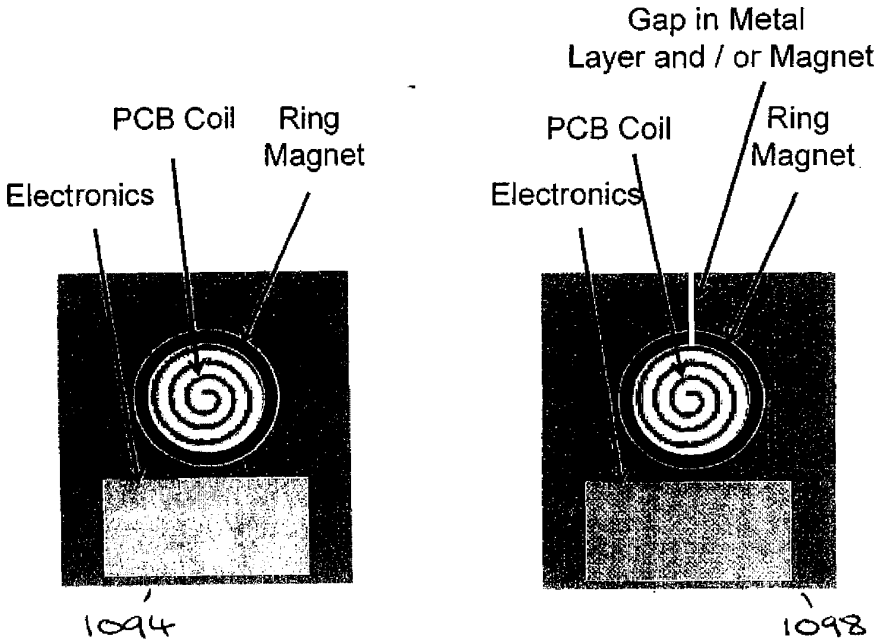


Figure 73

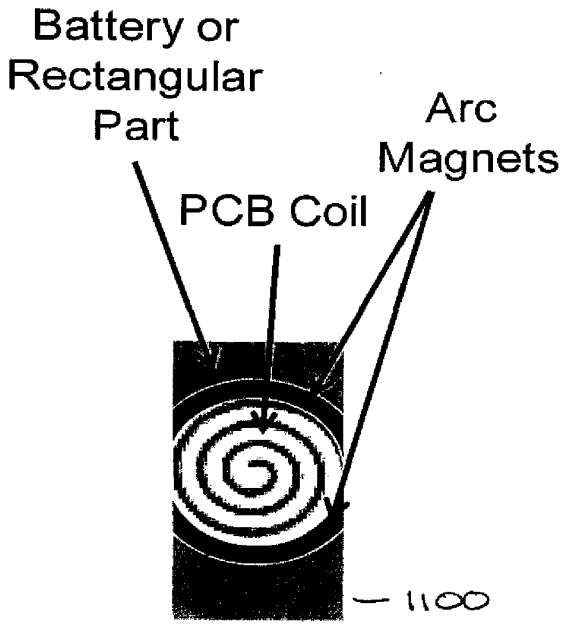


Figure 74

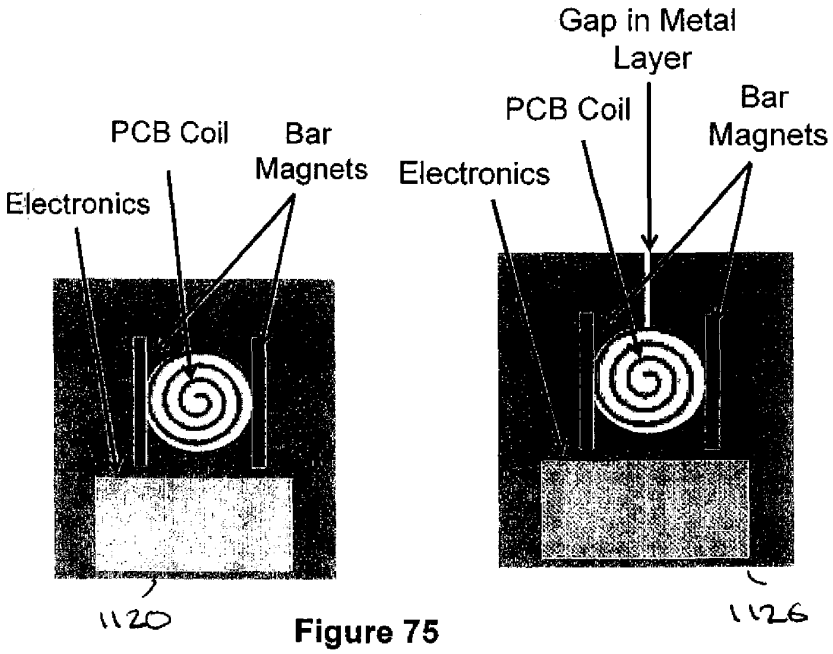


Figure 75

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Kent Bryan Chambers/Celeste Scarborough
Attorney Docket Number:	AFPA-01013US7

Filed as Small Entity

Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	80	80
UTILITY SEARCH FEE	2111	1	350	350
UTILITY EXAMINATION FEE	2311	1	400	400
REQUEST FOR PRIORITIZED EXAMINATION	2817	1	2100	2100
Pages:				
Claims:				
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	2830	1	70	70
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**3000**

Electronic Acknowledgement Receipt	
EFS ID:	44089858
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Celeste Scarborough
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	21-OCT-2021
Filing Date:	
Time Stamp:	16:15:53
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$3000
RAM confirmation Number	E20210KG16401913
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	AFPA-01013US7_ADS.pdf	1257014 9373e01a4c4d4278284724ffc772843a8ea1d13	no	10
Warnings:					
Information:					
2	Oath or Declaration filed	AFPA-01013US7_Declaration_Partovi-signed_.pdf	689457 c45eb0521d19ed73aa447ad88dd922a603eb604e	no	3
Warnings:					
Information:					
3	Oath or Declaration filed	AFPA-01013US7_Declaration_Sears-signed_.pdf	989143 e2a01c8d8ecab140ed872b23a1a9ceae11d4c21e	no	3
Warnings:					
Information:					
4	Power of Attorney	AFPA-01013US7_POA_Transmittal_82A.pdf	227345 4cfb6c149f2340ebe91425fa17b51dc86b62c7be	no	1
Warnings:					
Information:					
5	Power of Attorney	Mojo-Mobility_POA-82B.pdf	492120 f90671cf3259f18cdf7d285a9db2fca479d77538	no	1
Warnings:					
Information:					
6	TrackOne Request	AFPA-01013US7_Track1.pdf	150374 ca53116116e136dab3dfe8b7a72c32d41366dc68	no	2
Warnings:					
Information:					

7		AFPA-01013US0_EarliestRegPriorityAppl.pdf	6530028 37873a13f31c0ce9400f723257172 7f50de1c22f	yes	159

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	103
	Claims	104	107
	Abstract	108	108
	Drawings-only black and white line drawings	109	159

Warnings:

Information:

8	Fee Worksheet (SB06)	fee-info.pdf	50944 2d35e073cac9debca8dd1ec3a4f1c45721c6f46c	no	2

Warnings:

Information:

Total Files Size (in bytes):	10386425

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Afshin		Partovi	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	Palo Alto	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	3707 Heron Way		
Address 2			
City	Palo Alto	State/Province	CA
Postal Code	94303	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Michael		Sears	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	Ben Lomond	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	140 Middle Road		
Address 2			
City	Ben Lomond	State/Province	CA
Postal Code	95005	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	33438		
Email Address	kchambers@tcciplaw.com	Add Email	Remove Email
Email Address	celeste@tcciplaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	System and Method for Inductive Charging of Portable Devices		
Attorney Docket Number	AFPA-01013US7	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	50	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	33438		

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove

Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16055109	2018-08-05

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16055109	Continuation of	15463252	2017-03-20	10044229	2018-08-07

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15463252	Continuation of	15056689	2016-02-29	9601943	2017-03-21

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15056689	Continuation of	14608052	2015-01-28	9276437	2016-03-01

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14608052	Continuation of	13708548	2012-12-07	8947047	2015-02-03

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13708548	Continuation of	13442698	2012-04-09	8629654	2014-01-14

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13442698	Continuation of	12116876	2008-05-07	8169185	2012-05-01

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12116876	Continuation in part of	11669113	2007-01-30	7952322	2011-05-31

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
11669113	Claims benefit of provisional	60868674	2006-12-05
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
11669113	Claims benefit of provisional	60810298	2006-06-01
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
11669113	Claims benefit of provisional	60810262	2006-06-01
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
11669113	Claims benefit of provisional	60763816	2006-01-31
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12116876	Claims benefit of provisional	61043027	2008-04-07
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12116876	Claims benefit of provisional	61015606	2007-12-20
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12116876	Claims benefit of provisional	61012924	2007-12-12
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12116876	Claims benefit of provisional	61012922	2007-12-12
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12116876	Claims benefit of provisional	60952835	2007-07-30

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
12116876	Claims benefit of provisional	60916748	2007-05-08
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.			Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.			Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Mojo Mobility, Inc.		
Mailing Address Information For Applicant:			
Address 1	3707 Heron Way		
Address 2			
City	Palo Alto	**State/Province**	CA
Country	US	Postal Code	94303
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	Mojo Mobility, Inc.

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	3707 Heron Way		
Address 2			
City	Palo Alto	**State/Province**	CA
Country i	US	Postal Code	94303
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Kent B. Chambers/			Date (YYYY-MM-DD)	2021-10-21
First Name	Kent	Last Name	Chambers	Registration Number	38,839

Additional Signature may be generated within this form by selecting the Add button. Add

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	AFPA-01013US7
	Application Number	
Title of Invention	System and Method for Inductive Charging of Portable Devices	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	System and Method for Inductive Charging of Portable Devices

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [x] The attached application, or
- [ ] United States application or PCT international application number _____ filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Afshin Partovi Date (Optional): Oct 20, 2021

Signature: Afshin Partovi

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

AFPA-01013US7_Declaration_Partovi

Final Audit Report 2021-10-21

Created:	2021-10-20
By:	Kent Chambers (kchambers@tcciplaw.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAmUPN7tix5oWPHf9kqeoBsEGEOgh9WDVT

"AFPA-01013US7_Declaration_Partovi" History

Document created by Kent Chambers (kchambers@tcciplaw.com)
2021-10-20 - 11:19:29 PM GMT- IP address: 24.227.235.50

Document emailed to Afshin Partovi (afshin.partovi@mojomobility.com) for signature
2021-10-20 - 11:20:22 PM GMT

Email viewed by Afshin Partovi (afshin.partovi@mojomobility.com)
2021-10-21 - 0:58:23 AM GMT- IP address: 104.28.123.184

Document e-signed by Afshin Partovi (afshin.partovi@mojomobility.com)
Signature Date: 2021-10-21 - 1:08:45 AM GMT - Time Source: server- IP address: 73.162.56.249

Agreement completed.
2021-10-21 - 1:08:45 AM GMT

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PTO/AIA/01 (06-12)
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LEGAL NAME OF INVENTOR

Inventor: Michael Sears Date (Optional): Oct 20, 2021

Signature: Michael Sears

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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AFPA-01013US7_Declaration_Sears

Final Audit Report 2021-10-21

Created:	2021-10-20
By:	Kent Chambers (kchambers@tcciplaw.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAT1tCsLxzGmeQ5XJZXUT059q6VM-8grjQ

"AFPA-01013US7_Declaration_Sears" History

Document created by Kent Chambers (kchambers@tcciplaw.com)
2021-10-20 - 11:15:53 PM GMT- IP address: 24.227.235.50

Document emailed to Michael Sears (michael.sears.bl@gmail.com) for signature
2021-10-20 - 11:17:29 PM GMT

Email viewed by Michael Sears (michael.sears.bl@gmail.com)
2021-10-21 - 1:15:12 AM GMT- IP address: 74.125.212.73

Document e-signed by Michael Sears (michael.sears.bl@gmail.com)
Signature Date: 2021-10-21 - 1:17:34 AM GMT - Time Source: server- IP address: 73.223.233.23

Agreement completed.
2021-10-21 - 1:17:34 AM GMT

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7

CONFIRMATION NO. 9345

33438
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

FORMALITIES LETTER

OC000000129462007

Date Mailed: 11/02/2021

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

SUMMARY OF FEES DUE:

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **210** for **18** electronically equivalent pages in excess of **100** application size fee.
- $(**0**) previous unapplied payment amount.
- $ **210** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/hnguyen/

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/507,323

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			210			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	1040		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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United States Patent and Trademark Office
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/507,323	10/21/2021	2859	830	AFPA-01013US7	20	3

CONFIRMATION NO. 9345

33438
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

FILING RECEIPT

OC000000129462008

Date Mailed: 11/02/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Afshin Partovi, Palo Alto, CA;
Michael Sears, Ben Lomond, CA;

Applicant(s)

Mojo Mobility, Inc., Palo Alto, CA;

Assignment For Published Patent Application

Mojo Mobility, Inc., Palo Alto, CA

Power of Attorney: The patent practitioners associated with Customer Number 33438

Domestic Priority data as claimed by applicant

This application is a CON of 16/055,109 08/05/2018
which is a CON of 15/463,252 03/20/2017 PAT 10044229
which is a CON of 15/056,689 02/29/2016 PAT 9601943
which is a CON of 14/608,052 01/28/2015 PAT 9276437
which is a CON of 13/708,548 12/07/2012 PAT 8947047
which is a CON of 13/442,698 04/09/2012 PAT 8629654
which is a CON of 12/116,876 05/07/2008 PAT 8169185
which is a CIP of 11/669,113 01/30/2007 PAT 7952322
which claims benefit of 60/868,674 12/05/2006
and claims benefit of 60/810,298 06/01/2006
and claims benefit of 60/810,262 06/01/2006
and claims benefit of 60/763,816 01/31/2006
and said 12/116,876 05/07/2008

claims benefit of 61/043,027 04/07/2008
and claims benefit of 61/015,606 12/20/2007
and claims benefit of 61/012,924 12/12/2007
and claims benefit of 61/012,922 12/12/2007
and claims benefit of 60/952,835 07/30/2007
and claims benefit of 60/916,748 05/08/2007

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 10/29/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/507,323**

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

System and Method for Inductive Charging of Portable Devices

Preliminary Class

320

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ

in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Undetermined
Attorney Docket Number	AFPA 01013US7

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(11) EP 2 396 901 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
25.12.2019 Bulletin 2019/52

(21) Application number: **10707151.6**

(22) Date of filing: **12.02.2010**

(51) Int Cl.:
H04B 5/00 *(2006.01)*

(86) International application number:
PCT/US2010/024161

(87) International publication number:
WO 2010/093973 (19.08.2010 Gazette 2010/33)

(54) **WIRELESS POWER FOR CHARGEABLE AND CHARGING DEVICES**

DRAHTLOSE STROMVERSORGUNG FÜR AUFLADBARE UND LADEEINRICHTUNGEN

ALIMENTATION SANS FIL POUR DISPOSITIFS RECHARGEABLES ET DE CHARGEMENT

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: **28.01.2010 US 695911**
13.02.2009 US 152359 P

(43) Date of publication of application:
21.12.2011 Bulletin 2011/51

(73) Proprietor: **QUALCOMM Incorporated**
San Diego, CA 92121 (US)

(72) Inventors:
- **KIRBY, Miles, A.**
San Diego
CA 92121 (US)
- **GROB, Matthew, S.**
San Diego
CA 92121 (US)

(74) Representative: **Tomkins & Co**
5 Dartmouth Road
Dublin 6 (IE)

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EP 2 396 901 B1

Description

BACKGROUND

Field

[0001] The present invention relates generally to wireless electronic devices, and more specifically to electronic devices configured for wireless communication, wireless charging, and enabling for an optimal charging scenario.

Background

[0002] Typically, each battery powered device requires its own charger and power source, which is usually an AC power outlet. This becomes unwieldy when many devices need charging.

[0003] Approaches are being developed that use over the air power transmission between a transmitter and the device to be charged. These generally fall into two categories. One is based on the coupling of plane wave radiation (also called far-field radiation) between a transmit antenna and receive antenna on the device to be charged which collects the radiated power and rectifies it for charging the battery. Antennas may be of resonant length in order to improve the coupling efficiency. This approach suffers from the fact that the power coupling falls off quickly with distance between the antennas. So charging over reasonable distances (e.g., >1-2m) becomes difficult. Additionally, since the system radiates plane waves, unintentional radiation can interfere with other systems if not properly controlled through filtering.

[0004] Other approaches are based on inductive coupling between a transmit antenna embedded, for example, in a "charging" mat or surface and a receive antenna plus rectifying circuit embedded in the host device to be charged. This approach has the disadvantage that the spacing between transmit and receive antennas must be very close (e.g. mms). Though this approach may have the capability to simultaneously charge multiple devices in the same area, this area is typically small, hence the user must locate the devices to a specific area.

[0005] WO2008125072 (A1) discloses a data transmission system comprises a plurality of noncontacting mobile radio participants, the mobile radio participants each comprising an electromagnetic radio wave-based (FW) HF transmitter/receiver unit at least for transmitting an individual identification code (IDT). The data transmission system comprises a plurality of inductive charging stations, each having a magnetic charging station antenna for emitting an alternating magnetic field (MAG). The mobile radio participants are each provided with a magnetic radio participant antenna for decoupling electrical energy from the alternating magnetic field (MAG) of each charging station at least for supplying the HF transmitter/receiver unit of the mobile radio participant,

[0006] US 2009/0039828 A1 discloses a wireless charger wherein a user can select different charging protocols.

[0007] A need exists for wireless power devices configured for detecting other wireless power devices and determining optimal charging solutions. More specifically, a need exists for a chargeable device configured to detect one or more wireless chargers and, thereafter, determine an optimal charging solution for receiving a charge. Further, a need exists for a wireless charger configured to detect one or more chargeable devices and, thereafter, determine an optimal charging solution for charging at least one of the one or more detected chargeable devices.

Summary of the invention

[0008] The invention is defined by the independent claims. Preferred embodiments of the invention are described in the dependent claims. While several embodiments and/or examples have been disclosed in this description, the subject matter for which protection is sought is strictly and solely limited to those embodiments and/or examples encompassed by the scope of the appended claims. Embodiments and/ or examples mentioned in the description that do not fall under the scope of the claims are useful for understanding the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 shows a simplified block diagram of a wireless power transfer system.

FIG. 2 shows a simplified schematic diagram of a wireless power transfer system.

FIG. 3 shows a schematic diagram of a loop antenna for use in exemplary embodiments of the present invention.

FIG. 4 is a simplified block diagram of a transmitter, in accordance with an exemplary embodiment of the present invention.

FIG. 5 is a simplified block diagram of a receiver, in accordance with an exemplary embodiment of the present invention.

FIG. 6 shows a simplified schematic of a portion of transmit circuitry for carrying out messaging between a transmitter and a receiver.

FIG. 7 illustrates a chargeable device, in accordance with an exemplary embodiment of the present invention.

FIG. 8 illustrates another chargeable device, according to an exemplary embodiment of the present invention.

FIG. 9 illustrates a system including a wireless charger and a chargeable device, according to an exemplary embodiment of the present invention.

FIG. 10 illustrates a system including a plurality of wireless chargers and a chargeable device, in ac-

cordance with an exemplary embodiment of the present invention.

FIG. 11 illustrates a chargeable device having a plurality of receive antennas, according to an exemplary embodiment of the present invention.

FIG. 12 illustrates a system including a plurality of wireless chargers and a chargeable device having a plurality of receive antennas, according to an exemplary embodiment of the present invention.

FIG. 13 is a flowchart illustrating a method, according to an exemplary embodiment of the present invention.

FIG. 14 illustrates a wireless charger, according to an exemplary embodiment of the present invention.

FIG. 15 illustrates a system including a wireless charger and a plurality of chargeable devices, according to an exemplary embodiment of the present invention.

FIG. 16 illustrates another system including a wireless charger and a plurality of chargeable devices, in accordance with an exemplary embodiment of the present invention.

FIG. 17 is a flowchart illustrating another method, according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0010] The word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[0011] The detailed description set forth below in connection with the appended drawings is intended as a description of exemplary embodiments of the present invention and is not intended to represent the only embodiments in which the present invention can be practiced. The term "exemplary" used throughout this description means "serving as an example, instance, or illustration," and should not necessarily be construed as preferred or advantageous over other exemplary embodiments. The detailed description includes specific details for the purpose of providing a thorough understanding of the exemplary embodiments of the invention. It will be apparent to those skilled in the art that the exemplary embodiments of the invention may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the novelty of the exemplary embodiments presented herein.

[0012] The words "wireless power" is used herein to mean any form of energy associated with electric fields, magnetic fields, electromagnetic fields, or otherwise that is transmitted between from a transmitter to a receiver without the use of physical electromagnetic conductors.

[0013] FIG. 1 illustrates a wireless transmission or charging system 100, in accordance with various exemplary embodiments of the present invention. Input power 102 is provided to a transmitter 104 for generating a radiated field 106 for providing energy transfer. A receiver 108 couples to the radiated field 106 and generates an output power 110 for storing or consumption by a device (not shown) coupled to the output power 110. Both the transmitter 104 and the receiver 108 are separated by a distance 112. In one exemplary embodiment, transmitter 104 and receiver 108 are configured according to a mutual resonant relationship and when the resonant frequency of receiver 108 and the resonant frequency of transmitter 104 are very close, transmission losses between the transmitter 104 and the receiver 108 are minimal when the receiver 108 is located in the "near-field" of the radiated field 106.

[0014] Transmitter 104 further includes a transmit antenna 114 for providing a means for energy transmission and receiver 108 further includes a receive antenna 118 for providing a means for energy reception. The transmit and receive antennas are sized according to applications and devices to be associated therewith. As stated, an efficient energy transfer occurs by coupling a large portion of the energy in the near-field of the transmitting antenna to a receiving antenna rather than propagating most of the energy in an electromagnetic wave to the far field. When in this near-field a coupling mode may be developed between the transmit antenna 114 and the receive antenna 118. The area around the antennas 114 and 118 where this near-field coupling may occur is referred to herein as a coupling-mode region.

[0015] FIG. 2 shows a simplified schematic diagram of a wireless power transfer system. The transmitter 104 includes an oscillator 122, a power amplifier 124 and a filter and matching circuit 126. The oscillator is configured to generate a signal at a desired frequency, which may be adjusted in response to adjustment signal 123. The oscillator signal may be amplified by the power amplifier 124 with an amplification amount responsive to control signal 125. The filter and matching circuit 126 may be included to filter out harmonics or other unwanted frequencies and match the impedance of the transmitter 104 to the transmit antenna 114.

[0016] The receiver 108 may include a matching circuit 132 and a rectifier and switching circuit 134 to generate a DC power output to charge a battery 136 as shown in FIG. 2 or power a device coupled to the receiver (not shown). The matching circuit 132 may be included to match the impedance of the receiver 108 to the receive antenna 118. The receiver 108 and transmitter 104 may communicate on a separate communication channel 119 *(e.g.,* Bluetooth, zigbee, cellular, *etc*).

[0017] As illustrated in FIG. 3, antennas used in exemplary embodiments may be configured as a "loop" antenna 150, which may also be referred to herein as a "magnetic" antenna. Loop antennas may be configured to include an air core or a physical core such as a ferrite core. Air core loop antennas may be more tolerable to extraneous physical devices placed in the vicinity of the core.

Furthermore, an air core loop antenna allows the placement of other components within the core area. In addition, an air core loop may more readily enable placement of the receive antenna 118 (FIG. 2) within a plane of the transmit antenna 114 (FIG. 2) where the coupled-mode region of the transmit antenna 114 (FIG. 2) may be more powerful.

[0018] As stated, efficient transfer of energy between the transmitter 104 and receiver 108 occurs during matched or nearly matched resonance between the transmitter 104 and the receiver 108. However, even when resonance between the transmitter 104 and receiver 108 are not matched, energy may be transferred at a lower efficiency. Transfer of energy occurs by coupling energy from the near-field of the transmitting antenna to the receiving antenna residing in the neighborhood where this near-field is established rather than propagating the energy from the transmitting antenna into free space.

[0019] The resonant frequency of the loop or magnetic antennas is based on the inductance and capacitance. Inductance in a loop antenna is generally simply the inductance created by the loop, whereas, capacitance is generally added to the loop antenna's inductance to create a resonant structure at a desired resonant frequency. As a non-limiting example, capacitor 152 and capacitor 154 may be added to the antenna to create a resonant circuit that generates resonant signal 156. Accordingly, for larger diameter loop antennas, the size of capacitance needed to induce resonance decreases as the diameter or inductance of the loop increases. Furthermore, as the diameter of the loop or magnetic antenna increases, the efficient energy transfer area of the near-field increases. Of course, other resonant circuits are possible. As another non-limiting example, a capacitor may be placed in parallel between the two terminals of the loop antenna. In addition, those of ordinary skill in the art will recognize that for transmit antennas the resonant signal 156 may be an input to the loop antenna 150.

[0020] Exemplary embodiments of the invention include coupling power between two antennas that are in the near-fields of each other. As stated, the near-field is an area around the antenna in which electromagnetic fields exist but may not propagate or radiate away from the antenna. They are typically confined to a volume that is near the physical volume of the antenna. In the exemplary embodiments of the invention, magnetic type antennas such as single and multi-turn loop antennas are used for both transmit (Tx) and receive (Rx) antenna systems since magnetic near-field amplitudes tend to be higher for magnetic type antennas in comparison to the electric near-fields of an electric-type antenna (*e.g.*, a small dipole). This allows for potentially higher coupling between the pair. Furthermore, "electric" antennas (*e.g.*, dipoles and monopoles) or a combination of magnetic and electric antennas is also contemplated.

[0021] The Tx antenna can be operated at a frequency that is low enough and with an antenna size that is large enough to achieve good coupling (*e.g.*, >-4 dB) to a small Rx antenna at significantly larger distances than allowed by far field and inductive approaches mentioned earlier. If the Tx antenna is sized correctly, high coupling levels (*e.g.*, -2 to -4 dB) can be achieved when the Rx antenna on a host device is placed within a coupling-mode region (*i.e.*, in the near-field) of the driven Tx loop antenna.

[0022] FIG. 4 is a simplified block diagram of a transmitter 200, in accordance with an exemplary embodiment of the present invention. The transmitter 200 includes transmit circuitry 202 and a transmit antenna 204. Generally, transmit circuitry 202 provides RF power to the transmit antenna 204 by providing an oscillating signal resulting in generation of near-field energy about the transmit antenna 204. By way of example, transmitter 200 may operate at the 13.56 MHz ISM band.

[0023] Exemplary transmit circuitry 202 includes a fixed impedance matching circuit 206 for matching the impedance of the transmit circuitry 202 (*e.g.*, 50 ohms) to the transmit antenna 204 and a low pass filter (LPF) 208 configured to reduce harmonic emissions to levels to prevent self-jamming of devices coupled to receivers 108 (FIG. 1). Other exemplary embodiments may include different filter topologies, including but not limited to, notch filters that attenuate specific frequencies while passing others and may include an adaptive impedance match, that can be varied based on measurable transmit metrics, such as output power to the antenna or DC current draw by the power amplifier. Transmit circuitry 202 further includes a power amplifier 210 configured to drive an RF signal as determined by an oscillator 212. The transmit circuitry may be comprised of discrete devices or circuits, or alternately, may be comprised of an integrated assembly. An exemplary RF power output from transmit antenna 204 may be on the order of 2.5 Watts.

[0024] Transmit circuitry 202 further includes a controller 214 for enabling the oscillator 212 during transmit phases (or duty cycles) for specific receivers, for adjusting the frequency of the oscillator, and for adjusting the output power level for implementing a communication protocol for interacting with neighboring devices through their attached receivers.

[0025] The transmit circuitry 202 may further include a load sensing circuit 216 for detecting the presence or absence of active receivers in the vicinity of the near-field generated by transmit antenna 204. By way of example, a load sensing circuit 216 monitors the current flowing to the power amplifier 210, which is affected by the presence or absence of active receivers in the vicinity of the near-field generated by transmit antenna 204. Detection of changes to the loading on the power amplifier 210 are monitored by controller 214 for use in determining whether to enable the oscillator 212 for transmitting energy to communicate with an active receiver.

[0026] Transmit antenna 204 may be implemented as an antenna strip with the thickness, width and metal type selected to keep resistive losses low. In a conventional implementation, the transmit antenna 204 can generally

be configured for association with a larger structure such as a table, mat, lamp or other less portable configuration. Accordingly, the transmit antenna 204 generally will not need "turns" in order to be of a practical dimension. An exemplary implementation of a transmit antenna 204 may be "electrically small" *(i.e.,* fraction of the wavelength) and tuned to resonate at lower usable frequencies by using capacitors to define the resonant frequency. In an exemplary application where the transmit antenna 204 may be larger in diameter, or length of side if a square loop, *(e.g.,* 0.50 meters) relative to the receive antenna, the transmit antenna 204 will not necessarily need a large number of turns to obtain a reasonable capacitance.

[0027] The transmitter 200 may gather and track information about the whereabouts and status of receiver devices that may be associated with the transmitter 200. Thus, the transmitter circuitry 202 may include a presence detector 280, an enclosed detector 290, or a combination thereof, connected to the controller 214 (also referred to as a processor herein). The controller 214 may adjust an amount of power delivered by the amplifier 210 in response to presence signals from the presence detector 280 and the enclosed detector 290. The transmitter may receive power through a number of power sources, such as, for example, an AC-DC converter (not shown) to convert conventional AC power present in a building, a DC-DC converter (not shown) to convert a conventional DC power source to a voltage suitable for the transmitter 200, or directly from a conventional DC power source (not shown).

[0028] As a non-limiting example, the presence detector 280 may be a motion detector utilized to sense the initial presence of a device to be charged that is inserted into the coverage area of the transmitter. After detection, the transmitter may be turned on and the RF power received by the device may be used to toggle a switch on the Rx device in a pre-determined manner, which in turn results in changes to the driving point impedance of the transmitter.

[0029] As another non-limiting example, the presence detector 280 may be a detector capable of detecting a human, for example, by infrared detection, motion detection, or other suitable means. In some exemplary embodiments, there may be regulations limiting the amount of power that a transmit antenna may transmit at a specific frequency. In some cases, these regulations are meant to protect humans from electromagnetic radiation. However, there may be environments where transmit antennas are placed in areas not occupied by humans, or occupied infrequently by humans, such as, for example, garages, factory floors, shops, and the like. If these environments are free from humans, it may be permissible to increase the power output of the transmit antennas above the normal power restrictions regulations. In other words, the controller 214 may adjust the power output of the transmit antenna 204 to a regulatory level or lower in response to human presence and adjust the power output of the transmit antenna 204 to a level above the regulatory level when a human is outside a regulatory distance from the electromagnetic field of the transmit antenna 204.

[0030] As a non-limiting example, the enclosed detector 290 (may also be referred to herein as an enclosed compartment detector or an enclosed space detector) may be a device such as a sense switch for determining when an enclosure is in a closed or open state. When a transmitter is in an enclosure that is in an enclosed state, a power level of the transmitter may be increased.

[0031] In exemplary embodiments, a method by which the transmitter 200 does not remain on indefinitely may be used. In this case, the transmitter 200 may be programmed to shut off after a user-determined amount of time. This feature prevents the transmitter 200, notably the power amplifier 210, from running long after the wireless devices in its perimeter are fully charged. This event may be due to the failure of the circuit to detect the signal sent from either the repeater or the receive coil that a device is fully charged. To prevent the transmitter 200 from automatically shutting down if another device is placed in its perimeter, the transmitter 200 automatic shut off feature may be activated only after a set period of lack of motion detected in its perimeter. The user may be able to determine the inactivity time interval, and change it as desired. As a non-limiting example, the time interval may be longer than that needed to fully charge a specific type of wireless device under the assumption of the device being initially fully discharged.

[0032] FIG. 5 is a simplified block diagram of a receiver 300, in accordance with an exemplary embodiment of the present invention. The receiver 300 includes receive circuitry 302 and a receive antenna 304. Receiver 300 further couples to device 350 for providing received power thereto. It should be noted that receiver 300 is illustrated as being external to device 350 but may be integrated into device 350. Generally, energy is propagated wirelessly to receive antenna 304 and then coupled through receive circuitry 302 to device 350.

[0033] Receive antenna 304 is tuned to resonate at the same frequency, or near the same frequency, as transmit antenna 204 (FIG. 4). Receive antenna 304 may be similarly dimensioned with transmit antenna 204 or may be differently sized based upon the dimensions of the associated device 350. By way of example, device 350 may be a portable electronic device having diametric or length dimension smaller that the diameter of length of transmit antenna 204. In such an example, receive antenna 304 may be implemented as a multi-turn antenna in order to reduce the capacitance value of a tuning capacitor (not shown) and increase the receive antenna's impedance. By way of example, receive antenna 304 may be placed around the substantial circumference of device 350 in order to maximize the antenna diameter and reduce the number of loop turns (*i.e.*, windings) of the receive antenna and the inter-winding capacitance.

[0034] Receive circuitry 302 provides an impedance match to the receive antenna 304. Receive circuitry 302

includes power conversion circuitry 306 for converting a received RF energy source into charging power for use by device 350. Power conversion circuitry 306 includes an RF-to-DC converter 308 and may also in include a DC-to-DC converter 310. RF-to-DC converter 308 rectifies the RF energy signal received at receive antenna 304 into a non-alternating power while DC-to-DC converter 310 converts the rectified RF energy signal into an energy potential (*e.g.*, voltage) that is compatible with device 350. Various RF-to-DC converters are contemplated, including partial and full rectifiers, regulators, bridges, doublers, as well as linear and switching converters.

[0035] Receive circuitry 302 may further include switching circuitry 312 for connecting receive antenna 304 to the power conversion circuitry 306 or alternatively for disconnecting the power conversion circuitry 306. Disconnecting receive antenna 304 from power conversion circuitry 306 not only suspends charging of device 350, but also changes the "load" as "seen" by the transmitter 200 (FIG. 2).

[0036] As disclosed above, transmitter 200 includes load sensing circuit 216 which detects fluctuations in the bias current provided to transmitter power amplifier 210. Accordingly, transmitter 200 has a mechanism for determining when receivers are present in the transmitter's near-field.

[0037] When multiple receivers 300 are present in a transmitter's near-field, it may be desirable to time-multiplex the loading and unloading of one or more receivers to enable other receivers to more efficiently couple to the transmitter. This "unloading" of a receiver is also known herein as a "cloaking." A receiver may also be cloaked in order to eliminate coupling to other nearby receivers or to reduce loading on nearby transmitters. Furthermore, this switching between unloading and loading as controlled by receiver 300 and detected by transmitter 200 provides a communication mechanism from receiver 300 to transmitter 200 as is explained more fully below. Additionally, a protocol can be associated with the switching which enables the sending of a message from receiver 300 to transmitter 200. By way of example, a switching speed may be on the order of 100 μsec.

[0038] In an exemplary embodiment, communication between the transmitter and the receiver refers to a device sensing and charging control mechanism, rather than conventional two-way communication. In other words, the transmitter uses, for example, on/off keying of the transmitted signal to adjust whether energy is available in the near-filed. The receivers interpret these changes in energy as a message from the transmitter. From the receiver side, the receiver uses tuning and detuning of the receive antenna to adjust how much power is being accepted from the near-field. The transmitter can detect this difference in power used from the near-field and interpret these changes as signal forming a message from the receiver.

[0039] Receive circuitry 302 may further include signaling detector and beacon circuitry 314 used to identify received energy fluctuations, which may correspond to informational signaling from the transmitter to the receiver. Furthermore, signaling and beacon circuitry 314 may also be used to detect the transmission of a reduced RF signal energy (*i.e.*, a beacon signal) and to rectify the reduced RF signal energy into a nominal power for awakening either un-powered or power-depleted circuits within receive circuitry 302 in order to configure receive circuitry 302 for wireless charging.

[0040] Receive circuitry 302 further includes processor 316 for coordinating the processes of receiver 300 described herein including the control of switching circuitry 312 described herein. Cloaking of receiver 300 may also occur upon the occurrence of other events including detection of an external wired charging source (*e.g.*, wall/USB power) providing charging power to device 350. Processor 316, in addition to controlling the cloaking of the receiver, may also monitor beacon circuitry 314 to determine a beacon state and extract messages sent from the transmitter. Processor 316 may also adjust DC-to-DC converter 310 for improved performance.

[0041] FIG. 6 shows a simplified schematic of a portion of transmit circuitry for carrying out messaging between a transmitter and a receiver. In some exemplary embodiments of the present invention, a means for communication may be enabled between the transmitter and the receiver. In FIG. 6 a power amplifier 210 drives the transmit antenna 204 to generate the radiated field. The power amplifier is driven by a carrier signal 220 that is oscillating at a desired frequency for the transmit antenna 204. A transmit modulation signal 224 is used to control the output of the power amplifier 210.

[0042] The transmit circuitry can send signals to receivers by using an ON/OFF keying process on the power amplifier 210. In other words, when the transmit modulation signal 224 is asserted, the power amplifier 210 will drive the frequency of the carrier signal 220 out on the transmit antenna 204. When the transmit modulation signal 224 is deactivated, the power amplifier will not drive any signal on the transmit antenna 204.

[0043] The transmit circuitry of FIG. 6 also includes a load sensing circuit 216 that supplies power to the power amplifier 210 and generates a receive signal 235. In the load sensing circuit 216, a voltage drop across resistor R_s develops between the power in signal 226 and the power supply 228 to the power amplifier 210. Any change in the power consumed by the power amplifier 210 will cause a change in the voltage drop that will be amplified by differential amplifier 230. When the transmit antenna is in coupled mode with a receive antenna in a receiver (not shown in FIG. 6) the amount of current drawn by the power amplifier 210 will change. In other words, if no coupled mode resonance exist for the transmit antenna 204, the power required to drive the radiated field will be a first amount. If a coupled mode resonance exists, the amount of power consumed by the power amplifier 210 will go up because much of the power is being coupled

into the receive antenna. Thus, the receive signal 235 can indicate the presence of a receive antenna coupled to the transmit antenna 235 and can also detect signals sent from the receive antenna. Additionally, a change in receiver current draw will be observable in the transmitter's power amplifier current draw, and this change can be used to detect signals from the receive antennas.

[0044] Details of some exemplary embodiments for cloaking signals, beacon signals, and circuits for generating these signals can be seen in U.S. Utility Patent Application 12/249,873, entitled "REVERSE LINK SIGNALING VIA RECEIVE ANTENNA IMPEDANCE MODULATION" filed on October 10, 2008; and in U.S. Utility Patent Application 12/249,861, entitled "TRANSMIT POWER CONTROL FOR A WIRELESS CHARGING SYSTEM" filed on October 10, 2008.

[0045] Details of exemplary communication mechanisms and protocols can be seen in U.S. Utility Patent Application 12/249,866 entitled "SIGNALING CHARGING IN WIRELESS POWER ENVIRONMENT" filed on October 10, 2008.

[0046] FIG. 7 depicts a chargeable device 700 that may comprise any known and suitable chargeable device. As non-limiting examples, chargeable device 700 may comprise a cellular telephone, a portable media player, a camera, a gaming device, a navigation device, a headset (*e.g.*, a Bluetooth headset), a tool, a toy, or any combination thereof. Chargeable device 700 may include at least one receive antenna 702, at least one coil 705, or any combination thereof. Each of receive antenna 702 and coil 705 may be configured to receive power wirelessly transmitted from a suitable wireless power source. More specifically, according to one exemplary embodiment, antenna 702 and an associated receiver, such as receiver 108 of FIG. 2, may be configured to receive wireless power transmitted from a wireless power source within an associated near-field region. Further, according to another exemplary embodiment, coil 705 and an associated receiver, such as receiver 108 of FIG. 2, may be configured to receive wireless power transmitted from a wireless power source via inductive coupling. Additionally, chargeable device 700 may be configured to store received power within a battery (*e.g.*, battery 136 of FIG. 2) of chargeable device 700. It is noted that the terms "receive antenna" and "coil" may each be referred to herein as a "receive element."

[0047] Furthermore, in accordance with various exemplary embodiments, chargeable device 700 may be configured to detect one or more wireless chargers, which are positioned within a charging region of chargeable device 700 and include one or more wireless transmit elements (*e.g.*, a wireless transmit antenna or a coil). More specifically, chargeable device 700 may be configured to detect one or more wireless chargers according to one or more specific protocols and/or one or more specific frequencies. For example only, chargeable device 700 may be configured to detect one or more wireless chargers by sampling for wireless chargers operating with one or more specific wireless charging protocols, sampling for wireless chargers resonating at one more specific frequencies, or both. As described more fully below, upon detection of a wireless charger, chargeable device 700 may be configured to determine an amount of power received from the detected wireless charger, including at each frequency and with each protocol that the detected wireless charger is configured to transmit.

[0048] According to one exemplary embodiment, chargeable device 700 may be configured to detect a wireless charger, which is positioned within a near-field region of chargeable device 700 and is configured to wirelessly transmit power at one or more suitable frequencies (*e.g.*, unlicensed ISM bands) via a near-field resonance protocol. It is noted that various frequencies may be suitable for wireless power transmission in one location (*e.g.*, a first country) but not suitable in another location (*e.g.*, a second country). As such, according to one exemplary embodiment, chargeable device 700 may be configured to determine its location via a location device 701, and, thereafter, determine which one or more frequencies are suitable for wireless power transmission. For example only, location device 701 may comprise a Global Positioning System (GPS) device. By way of example only, chargeable device 700 may be configured to detect a wireless charger positioned within an associated near-field region and configured to transmit wireless power, via near-field resonance, at one or more of 6.78 MHz, 13.56 MHz, 27.12, and 40.68 MHz. Further, according to one exemplary embodiment, chargeable device 700 may be configured to detect a wireless charger positioned within an associated charging region and configured to convey wireless power via an inductive coupling protocol.

[0049] Moreover, chargeable device 700 may be configured to establish a communication link with a detected wireless charger and, upon establishing the communication link, may wirelessly receive data (*e.g.*, audio files, data files, or video files) from the detected wireless charger, wirelessly transmit data to the detected wireless charger, or both. It is noted that chargeable device 700 may be configured to detect and receive wireless power from multiple versions of wireless chargers. It is noted further that chargeable device 700 may be configured to identify a version of a detected wireless charger and, as a result, may receive wireless power from and communicate with the detected wireless charger accordingly. Additionally, upon establishing the communication link, chargeable device 700 may be configured to control an operation of a detected wireless charger (*e.g.*, transmission of power, synchronization of data, displaying media, or any user-interface functionality).

[0050] Upon detection of one or more wireless chargers, chargeable device 700 may be further configured to select at least one of the detected one or more wireless charging to receive power therefrom for optimizing an amount of power received by chargeable device 700. A method of optimizing an amount of power received by

chargeable device 700 may be based on at least one of one or more charging protocols of each detected wireless charger, one or more charging frequencies of each detected wireless charger, a position of each detected wireless charger relative to chargeable device 700, and a version of each detected wireless charger. It is noted that relatively small chargeable devices *(e.g.,* a Bluetooth headset) may charge more efficiently at a higher frequency *(e.g.,* 40.68 MHz) in comparison to a lower frequency (6.78 MHz). On the other hand, relatively large chargeable devices (*e.g.*, a camera) may charge more efficiently at a lower frequency (*e.g.*, 6.78 MHz) in comparison to a higher frequency (40.68 MHz).

[0051] FIG. 8 illustrates a chargeable device 700A, which is similar to chargeable device 700 of FIG. 7 and, therefore, will not be explained again. However, in FIG. 8, chargeable device 700A does not include a coil and only includes one receive antenna 702. It is noted that in an embodiment wherein chargeable device 700A includes a single receive element *(i.e.,* receive antenna 702), chargeable device 700A may be configured to receive wireless power from only one wireless transmit element at any one time. Accordingly, in this exemplary embodiment, chargeable device 700A may be configured to determine which detected wireless charger may enable for optimal charging. Stated another way, chargeable device 700A may be configured to determine which detected wireless charger and, more specifically, which transmit element of the one or more detected wireless chargers may enable for maximum efficiency, maximum charging rate, minimum interference, or any combination thereof. Further, according to another exemplary embodiment, chargeable device 700A may be configured to determine which plurality of transmit elements of the one or more detected wireless chargers, utilizing a time domain multiplexing method based upon allocated activation time slots for each selected transmit element, may enable for maximum efficiency, maximum charging rate, minimum interference, or any combination thereof.

[0052] FIG. 9 illustrates a system 730 including chargeable device 700A and a wireless charger 732. Wireless charger 732 includes a first transmit antenna 734 configured to transmit wireless power at a frequency of, for example only, 13.56 MHz. Further, wireless charger 732 includes a second transmit antenna 736 configured to transmit wireless power at a frequency of, for example only, 6.78 MHz. According to one contemplated operation of system 730, chargeable device 700 may detect wireless charger 732, which is positioned within an associated charging region and operating with one or more specific protocols (*e.g.*, near-field resonance) and/or resonating at one or more specific frequencies (*e.g.*, 6.78 MHz and 13.56 MHz). Further, upon detection of wireless charger 732, a communication link 733 between chargeable device 700A and wireless charger 732 may be established. Moreover, after wireless charger 732 has been detected, an optimal scenario for charging chargeable device 700A with wireless charger 732 may be determined.

[0053] According to one exemplary embodiment, determining an optimal charging scenario may include determining which single protocol *(i.e.,* either near-field resonance via transmit antenna 734 or near-field resonance via transmit antenna 736) enables for optimal charging (*e.g.*, maximum efficiency, maximum charging rate, minimum interference, or any combination thereof) of chargeable device 700A. As an example, chargeable device 700A, wireless charger 732, or a combination thereof, may determine that transmit antenna 736 enables for optimal charging of chargeable device 700A. As a more specific example, chargeable device 700A may receive wireless power from transmit antenna 734 at a first frequency (*e.g.*, 13.56 MHz.), determine an amount of power received from transmit antenna 734 and, thereafter, provide this information to wireless charger 732. Further, chargeable device 700A may receive wireless power from transmit antenna 736 at a second frequency (*e.g.*, 6.78 MHz.), determine an amount of power received from transmit antenna 736 and, thereafter, provide this information to wireless charger 732. Wireless charger 732 may then inform chargeable device 700A, via communication link 733, which protocol *(i.e.,* either near-field resonance via transmit antenna 734 or near-field resonance via transmit antenna 736) facilitates optimal charging by wireless charger 732. After determining which transmit element facilitates optimal charging, chargeable device 700A, wireless charger 732, or a combination thereof, may select the transmit element, and wireless power may be transmitted to chargeable device 700A.

[0054] It is noted that upon receiving information from chargeable device 700A relating to an amount of power received from a specific transmit element (*e.g.*, transmit antenna 734 or transmit antenna 736), wireless charger 732 may be configured to increase or decrease an amount of power transmitted from the specific transmit element. It is further noted that depending on the type of device *(i.e.,* whether chargeable device 700A is, for example only, a mobile telephone, a media player, or a Bluetooth headset) and/or a type of battery within chargeable device 700A, wireless charger 732 may be configured to increase or decrease an amount of power transmitted from a specific transmit element.

[0055] According to another exemplary embodiment, determining an optimal charging scenario may include determining which plurality of transmit elements, utilizing a time domain multiplexing method, may provide for optimal charging. As an example, chargeable device 700A, wireless charger 732, or a combination thereof, may determine that transmit antenna 734 may be time multiplexed with transmit antenna 736 to enable for optimized charging of chargeable device 700A.

[0056] FIG. 10 illustrates another system 750 including chargeable device 700. System 750 further includes a first wireless charger 752, a second wireless charger 754, and a third wireless charger 756, each of which is positioned within an associated charging region of chargea-

ble device 700. As illustrated in FIG. 10, first wireless charger 752 includes a transmit antenna 760 and may be configured to transmit wireless power at a frequency of, for example only, 40.68 MHz. Further, second wireless charger 754 includes a first transmit antenna 762 configured to transmit wireless power at a frequency of, for example only, 27.12 MHz., and a second transmit antenna 764 configured to transmit wireless power at a frequency of, for example only, 6.78 MHz. Moreover, third wireless charger 756 includes a transmit antenna 766 configured to transmit wireless power at a frequency of, for example only, 13.56 MHz. Third wireless charger 756 further includes a coil 768 configured to transmit power, via inductive coupling, to a coil *(e.g.,* coil 705) adequately aligned therewith.

[0057] According to one contemplated operation of system 750, chargeable device 700 may detect one or more wireless chargers positioned within an associated charging region and operating with one or more specific protocols (*e.g.*, near-field resonance and/or inductive coupling) and/or resonating at one or more specific frequencies (*e.g.*, unlicensed ISM bands). Accordingly, chargeable device 700 may detect each of first wireless charger 752, second wireless charger 754, and third wireless charger 756. Moreover, upon detection, respective communication links 735, 737, and 739 may be established between chargeable device 700 and first wireless charger 752, second wireless charger 754, and third wireless charger 756.

[0058] Furthermore, upon detection of first wireless charger 752, second wireless charger 754, and third wireless charger 756, an optimal charging scenario for charging chargeable device 700 may be determined. Determining an optimal charging scenario may include, as noted above, determining an optimal charging scenario for one or more detected wireless chargers that may include one or more protocols and/or are configured to transmit wireless power at one or more frequencies. Furthermore, determining an optimal charging scenario may include determining which plurality of transmit elements within one or more detected wireless chargers, utilizing a time domain multiplexing method, may provide for optimal charging. For example, according to one exemplary embodiment, chargeable device 700 may be configured to sequentially receive wireless power from each individual transmit element within system 750. Further, after receiving wireless power from each individual transmit element within system 750, chargeable device 700 may be configured to determine which one or more transmit elements enable for optimal charging.

[0059] More specifically, for example, receive antenna 702 may be configured to receive wireless power from transmit antenna 760, via near-field resonance, at a frequency (*e.g.*, 40.68 MHz.), and an amount of power received from transmit antenna 760 may be determined by chargeable device 700. In addition, receive antenna 702 may be configured to receive wireless power from transmit antenna 762, via near-field resonance, at a frequency (*e.g.*, 27.12 MHz.), and chargeable device 700 may determine an amount of power received from transmit antenna 762. Further, receive antenna 702 may be configured to receive wireless from power transmit antenna 764, via near-field resonance, at a frequency (*e.g.*, 6.78 MHz.), and an amount of power received from transmit antenna 764 may be determined by chargeable device 700. Moreover, transmit antenna 700 may be configured to receive wireless power from transmit antenna 766, via near-field resonance, at a frequency (*e.g.*, 6.78 MHz.), and an amount of power received from transmit antenna 766 may be determined by chargeable device 700. Furthermore, coil 705 may be configured to receive wireless power, via inductive coupling, from coil 768 of wireless charger 756 and chargeable device 700 may determine an amount of received from coil 768. Thereafter, chargeable device 700 may determine which one or more transmit elements enable for maximum efficiency, maximum charging rate, minimum interference, or any combination thereof. Accordingly, as an example, chargeable device 700 may determine that wireless charger transmit antenna 762 of wireless charger 754 and coil 768 of wireless charger 756 enable for optimal charging. After determining which one or more transmit elements enable for an optimal charging scenario, chargeable device 700 may select the one or more transmit elements and wireless power may be transmitted to chargeable device 700A accordingly.

[0060] Furthermore, as noted above, a time domain multiplexing method may be utilized to provide for optimal charging. As such, chargeable device 700 may be configured to determine an optimal charging scenario by utilizing a time domain multiplexing method based upon allocated activation time slots for two or more transmit elements. Accordingly, as an example, chargeable device 700 may determine that, in addition to receiving wireless power from coil 768, transmit antenna 760 of wireless charger 752 may be time multiplexed with transmit antenna 766 of wireless charger 756 to enable for optimized charging.

[0061] FIG. 11 depicts a chargeable device 700B, which is similar to chargeable device 700 of FIG. 7 and, therefore, will not be explained again. However, in FIG. 11, chargeable device 700B includes a plurality of receive antennas 702. Although chargeable device 700B is depicted as having only two receive antennas 702, chargeable device 700B may include any number of receive antennas 702. Similarly to chargeable device 700, chargeable device 700B may be configured to detect one or more wireless chargers positioned within an associated charging region and including one or more transmit elements. Furthermore, upon detection of one or more wireless chargers, chargeable device 700B may be configured to optimize an amount of power received from the one or more wireless chargers and, more specifically, the one or more transmit elements. It is noted that in an embodiment wherein chargeable device 700B includes multiple receive antennas, chargeable device 700B may

be configured to receive wireless power from multiple transmit antennas associated with one or more wireless chargers at any one time.

[0062] Determining an optimal charging scenario may include determining an optimal charging scenario for one or more detected wireless chargers that may include one or more protocols and/or may be configured to transmit wireless power at one or more frequencies. More specifically, determining an optimal charging scenario may include determining which plurality of transmit elements associated with one or more detected wireless chargers enables for optimal charging of chargeable device 700B. It is noted that in an embodiment wherein chargeable device 700B includes multiple antennas, a time domain multiplexing method, as mentioned above, may still be used.

[0063] FIG. 12 illustrates a system 780 including chargeable device 700B. System 780 further includes first wireless charger 752, second wireless charger 754, and third wireless charger 756, each of which is positioned within an associated charging region of chargeable device 700B. First wireless charger 752, second wireless charger 754, and third wireless charger 756 have been described above and, therefore, will not be explained again. However, it is noted that first wireless charger 752 includes a coil 763. According to one contemplated operation of system 780, chargeable device 700B may detect one or more wireless chargers within an associated charging region and operating with one or more specific protocols (*e.g.*, near-field resonance and/or inductive coupling) and/or resonating at one or more specific frequencies *(i.e.,* unlicensed ISM bands). Accordingly, chargeable device 700B may detect each of first wireless charger 752, second wireless charger 754, and third wireless charger 756.

[0064] Moreover, upon detection thereof, respective communication links 765, 767, and 769 may be established between chargeable device 700B and first wireless charger 752, second wireless charger 754, and third wireless charger 756. As noted above with respect to chargeable device 700, upon establishing a communication link with a detected wireless charger, chargeable device 700B may be configured to control an operation of a detected wireless charger (*e.g.*, transmission of power, synchronization of data, displaying media, or any user-interface functionality). Further, upon detection of first wireless charger 752, second wireless charger 754, and third wireless charger 756, chargeable device 700B may be configured to determine an optimal charging scenario.

[0065] For example, with reference to FIG. 12, chargeable device 700B may be configured to sequentially receive wireless power from each individual transmit element *(i.e.,* transmit antenna 760, transmit antenna 762, transmit antenna 764, transmit antenna 766, coil 763, and coil 768). Furthermore, chargeable device 700B may be configured to sequentially receive wireless power from every possible and suitable combination of two or more transmit elements. It is noted that chargeable device 700B may only simultaneously receive power from a number of transmit antennas equal to a number of receive antennas 702. For example, if chargeable device 700B comprises two receive antennas 702, chargeable device 700B may be configured to simultaneously receive wireless power from every possible combination of two transmit antennas. However, it is noted that coil 705 may simultaneously receive wireless power from both coil 763 and 768, so long as coil 763 and 768 are each in phase with coil 705.

[0066] After determining an amount of power received from each suitable combination of transmit elements, and optionally each transmit element individually, chargeable device 700B may be configured to identify one or more transmit elements for optimal charging. By way of example, in an embodiment wherein chargeable device 700B includes two antennas 702, charging device 700B may identify transmit antenna 764, transmit antenna 766, and coil 763 as transmit elements for enabling an optimal charging scenario. As another example, charging device 700B may identify transmit antenna 766, transmit antenna 762, and coil 768 as transmit elements for enabling an optimal charging scenario. Further, chargeable device 700B may be configured to determine an optimal charging scenario by utilizing a time domain multiplexing method based upon allocated activation time slots for two or more transmit antennas.

[0067] FIG. 13 is a flowchart illustrating a method 680, in accordance with one or more exemplary embodiments. Method 680 may include detecting one or more transmit elements positioned within an associated charging region (depicted by numeral 682). Method 680 may further include selecting at least one transmit element of the detected one or more transmit elements to receive wireless power therefrom to enable optimal charging of the chargeable device (depicted by numeral 684).

[0068] FIG. 14 depicts a charger 900 that may comprise any known and suitable charger configured to transmit wireless power. Charger 900 may include at least one transmit antenna 704 configured to wirelessly transmit power to at least one chargeable device (*e.g.*, chargeable device 700). More specifically, transmit antenna 704 and an associated transmitter, such as transmitter 104 of FIG. 2, may be configured to transmit wireless power at a frequency (*e.g.*, an unlicensed ISM band) to a receiver within an associated near-field region. Further, charger 900 may include at least one coil 902 configured to transmit wireless power to a chargeable device (*e.g.*, chargeable device 700) via inductive coupling.

[0069] Furthermore, in accordance with various exemplary embodiments of the present invention, charger 900 may be configured to detect one or more chargeable devices, which are positioned within a charging region of charger 900 and are configured to receive wireless power via a suitable protocol. More specifically, charger 900 may be configured to detect one or more chargeable devices according to one or more specific protocols, one or more specific frequencies, or both. For example only,

charger 900 may be configured to detect chargeable devices within a charging region by sampling for chargeable devices operating with specific wireless charging protocols, sampling for chargeable devices resonating at specific wireless charging frequencies, or both.

[0070] According to one exemplary embodiment, charger 900 may be configured to detect one or more chargeable devices positioned within an associated near-field region and configured to receive wireless power at one or more frequencies via near-field resonance. For example only, charger 900 may be configured to detect one or more chargeable devices positioned within an associated near-field region and configured to receive wireless power, via near-field resonance, at a suitable frequency, such as an unlicensed ISM band *(e.g.,* 13.56 MHz). It is noted that various frequencies may be suitable for wireless power transmission in one location (*e.g.*, a first country) but not suitable in another location (*e.g.,* a second country). As such, according to one exemplary embodiment, charger 900 may be configured to determine its location via a location device 901 and, thereafter, determine which one or more frequencies are suitable for wireless power transmission. For example only, location device 901 may comprise a Global Positioning System (GPS) device. Further, according to one exemplary embodiment, charger 900 may be configured to detect one or more chargeable devices positioned within an associated charging region and configured to receive wireless power via an inductive coupling protocol.

[0071] Moreover, charger 900 may be configured to establish a communication link with a detected chargeable device and, upon establishing the communication link, may wirelessly receive data (*e.g.*, audio files, data files, or video files) from the chargeable device, wirelessly transmit data to the chargeable device, or both. Additionally, it is noted that charger 900 may be configured to perform various operations (*e.g.*, synchronizing data and/or displaying media) while transmitting power to one or more chargeable devices. Furthermore, charger 900 may be configured to detect and transmit wireless to multiple versions of chargeable devices. Accordingly, charger 900 may be configured to identify a version of a detected chargeable device and transmit power to and communicate with the detected chargeable device in a suitable manner. It is further noted that charger 900 may attempt to communicate with each detected chargeable device according to a common version protocol. However, in the event that a detected chargeable device is not compatible with the common version protocol, charger 900 may be configured to communicate with the chargeable device in a suitable manner using a suitable version protocol.

[0072] Additionally, upon detection of one or more chargeable devices, charger 900 may be configured to determine an optimal charging solution which may maximize efficiency, maximize charging rates, minimize interference, or any combination thereof, for charging the one or more detected chargeable devices. More specifically, for example, charger 900 may be configured to determine an optimal solution for providing wireless power to one or more of the detected chargeable devices for a given set of conditions (*e.g.*, the number of available transmit elements within charger 900 compared to the number of detected chargeable devices, the charging levels of each of the detected chargeable devices, or the amount of power received by each detected chargeable devices (*i.e.,* the charging efficiency between charger 900 and each of the detected chargeable devices)).

[0073] FIG. 15 illustrates a system 910 including a charger 900A, a first chargeable device 902, and a second chargeable device 903. As illustrated, each of first chargeable device 902 and second chargeable device 903 include a receive antenna 702 and each are configured to receive wireless power transmitted at a specific frequency via near-filed resonance. It is noted that charger 900A is similar to charger 900 of FIG. 13 and, therefore, will not be described in detail. However, it is noted that charger 900A does not include a coil and only includes a single transmit antenna 704.

[0074] According to one contemplated operation of system 910, charger 900A may detect each of first chargeable device 902 and second chargeable device 903 via any suitable manner. According to one contemplated operation of system 910, charger 900A may detect each of first chargeable device 902 and second chargeable device 903, each of which being positioned within an associated charging region and operating with one or more wireless power protocols (*e.g.*, near-field resonance) and/or resonating at one or more wireless power frequencies (*e.g.*, unlicensed ISM bands). Moreover, upon detection thereof, respective communication links 905 and 907 may be established between charger 900A and each of first chargeable device 902 and second chargeable device 903. Furthermore, upon detection of first chargeable device 902 and second chargeable device 903, charger 900A may determine an optimal charging solution for system 910. It is noted that in an embodiment wherein charger 900A includes a single transmit element *(i.e.,* transmit antenna 704), charger 900A may be configured to transmit wireless power to only one chargeable device at any one time.

[0075] As such, according to one exemplary embodiment, charger 900A may be configured to determine which single detected chargeable device *(i.e.,* either first chargeable device 902 or second chargeable device 903) should be charged to enable for an optimal charging solution. As one example, charger 900A may be configured to determine charging efficiencies between charger 900A and each of first chargeable device 902 and second chargeable device 903. Thereafter, to reduce power loss, charger 900A may be configured to convey wireless power to the device that has the highest charging efficiency. More specifically, for example, charger 900A may be configured to sequentially transmit wireless power to each of first chargeable device 902 and second chargeable device 903. Further, charger 900A may be configured to

request and receive a signal from each of first chargeable device 902 and second chargeable device 903 identifying an amount of power received by each of first chargeable device 902 and second chargeable device 903. Thereafter, charger 900A may determine which chargeable device has a higher charging efficiency and, thereafter, convey power thereto. By way of example, charger 900A may determine that a charging efficiency with first chargeable device 902 is greater than a charging efficiency with second chargeable device 903 and, therefore, charger 900A may select first chargeable device 902 and convey power thereto.

[0076] As another example, charger 900A may be configured to charge a device having the greatest need for a charge. More specifically, for example, charger 900A may be configured to determine, via communication means, a charging level of each of first chargeable device 902 and second chargeable device 903 and, thereafter, select and convey wireless power to the device that has the least charged battery. By way of example, charger 900A may determine that a battery of second chargeable device 903 has a lower charging level than a battery of first chargeable device 902 and, as a result, charger 900A may select and convey wireless power to second chargeable device 903. Furthermore, after a charging level of the battery of second chargeable device 903 has reached an acceptable status, charger 900A may convey wireless power to first chargeable device 902. Further, according to another exemplary embodiment, charger 900A may be configured to determine whether a time domain multiplexing method, based upon allocated activation time slots for each of first chargeable device 902 and second chargeable device 903, may enable for an optimal charging solution.

[0077] FIG. 16 illustrates a system 950 including charger 900B, a first chargeable device 911, a second chargeable device 912, a third chargeable device 913, and a forth chargeable device 914. As illustrated, each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 include an antenna 702 configured to receive wireless power transmitted at a specific frequency via nearfiled resonance. Furthermore, each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 include a coil 909 configured to receive wireless power via inductive coupling. It is noted that charger 900B is similar to charger 900 of FIG. 13 and, therefore, will not be described in detail. However, it is noted that charger 900B includes two transmit antennas 704. According to one contemplated operation of system 950, charger 900B may detect each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 via any suitable means. According to one contemplated operation of system 950, charger 900B may detect each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914, each of which being positioned within an associated charging region and operating with one or more wireless power protocols (e.g., near-field resonance) and/or resonating at one or more wireless power frequencies (*e.g.*, unlicensed ISM bands).

[0078] Moreover, upon detection thereof, respective communication links 970, 971, 972, and 973 may be established between charger 900 and each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and a forth chargeable device 914. Furthermore, upon detection of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914, charger 900B may determine an optimal charging solution for system 950.

[0079] It is noted that charger 900B may simultaneously transmit power to a number of receive antennas *(i.e.,* receive antenna 702) equal to a number of transmit antennas (*i.e.*, transmit antennas 704). For example, in the embodiment illustrated in FIG. 15, charger 900B may be configured to simultaneously transmit wireless power to two transmit antennas 704. Furthermore, it is noted that coil 902 may simultaneously transmit wireless power to multiple coils 909, so long as the coils 909 are in phase with coil 902

[0080] According to one exemplary embodiment, charger 900B may be configured to determine which one or more detected chargeable devices should be charged to enable for an optimal charging solution. As one example, charger 900B may be configured to determine a charging efficiency between charger 900B and each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914. Thereafter, to reduce power loss, charger 900B may be configured to convey wireless power to one or more chargeable devices that have the highest charging efficiency. More specifically, for example, charger 900B may be configured to sequentially transmit wireless power to each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 according to various protocols and frequencies. Further, charger 900B may be configured to request and receive a signal from each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 identifying an amount of power received by each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 according to each suitable protocol and frequency. Thereafter, charger 900B may determine which one or more chargeable devices should be charged with which protocols and frequencies to enable for an optimal charging scenario of system 950.

[0081] As another example, charger 900B may be configured to convey power to one or more chargeable devices that have the greatest need for a charge. More specifically, for example, charger 900B may be configured to determine, via communication means, a charging level

of each of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914 and, thereafter, convey wireless power to the one or more chargeable devices having the least charged batteries. Further, according to another exemplary embodiment, charger 900B may be configured to determine whether a time domain multiplexing method, based upon allocated activation time slots for two or more of first chargeable device 911, second chargeable device 912, third chargeable device 913, and forth chargeable device 914, may enable for an optimal charging solution.

[0082] It is noted that charger 900 and, more specifically, at least one antenna 704 of charger 900 may include additional functionality. As one example, antenna 704 may be configured to transmit radio frequencies. Furthermore, for example, antenna 704 may be configured to operate as a RF repeater, a femtocell, a WiFi access point (AP), or any combination thereof. Additionally, antenna 704 may positioned remotely from and connected to charger 900 via a coax, an RF conductor, an IP connection, or any other suitable connector. In this example, antenna704 may configured to operate as a remote antenna for an RF repeater, a femtocell, a WiFi access point (AP), or any combination thereof.

[0083] FIG. 17 is a flowchart illustrating a method 690, in accordance with one or more exemplary embodiments. Method 690 may include detecting one or more receive elements positioned within an associated charging region (depicted by numeral 692). Method 690 may further include selecting at least one receive element of the detected one or more receive elements to transmit wireless power thereto to enable for an optimal charging solution of one or more chargeable devices associated with the one or more receive elements (depicted by numeral 694).

[0084] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[0085] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the exemplary embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the exemplary embodiments of the invention.

[0086] The various illustrative logical blocks, modules, and circuits described in connection with the exemplary embodiments disclosed herein may be implemented or performed with a general purpose processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, *e.g.*, a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[0087] The steps of a method or algorithm described in connection with the exemplary embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in Random Access Memory (RAM), flash memory, Read Only Memory (ROM), Electrically Programmable ROM (EPROM), Electrically Erasable Programmable ROM (EEPROM), registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such that the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[0088] In one or more exemplary embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Computer-readable media includes both computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote

source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of medium. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and blu-ray disc where *disks* usually reproduce data magnetically, while *discs* reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

[0089] The previous description of the disclosed exemplary embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these exemplary embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the scope of the invention as defined by the appended claims.

Claims

1. A wireless charger for transmitting power, via a wireless field, to a chargeable device (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), the wireless charger comprising:

   means for detecting one or more chargeable devices positioned within an associated charging region;
   means for transmitting power to the one or more chargeable devices, via the wireless field, in accordance with a plurality of charging protocols, the means configured to transmit power to one of said chargeable devices in accordance with a first protocol of the plurality of charging protocols and to transmit power to the one of said chargeable devices in accordance with a second protocol of the plurality of charging protocols;
   means (214) for determining an optimal charging protocol from the first and second charging protocols for the one of said chargeable devices, and for selecting the determined optimal charging protocol for transmitting power to the one of said chargeable devices.

2. The wireless charger of claim 1, further comprising:

   means for detecting (280) a plurality of receive elements of a chargeable device positioned within an associated charging region; and
   means for selecting (214) at least one receive element of the detected plurality of receive elements to transmit power thereto.

3. The wireless charger of claim 1, wherein the means for transmitting power via the wireless field comprises an antenna (204, 704, 714, 734, 736, 760, 762, 764, 766) or a coil (768, 763, 902).

4. The wireless charger of claim 1, further comprising means for detecting the one or more chargeable devices according to at least one of a plurality charging protocols and a plurality of charging frequencies.

5. The wireless charger of claim 4, wherein the means for detecting is configured to detect the one or more chargeable devices by sampling for chargeable devices operating with at least one of the plurality of charging protocols, and wherein the plurality of charging protocols include a near-field resonance protocol and an inductive coupling protocol.

6. The wireless charger of claim 4, wherein the means for detecting is configured to detect the one or more chargeable devices by sampling for chargeable devices resonating at one of the plurality of charging frequencies.

7. A method of transmitting power, via a wireless field, to a chargeable device (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) from a transmitter adapted to transmit power in accordance with a plurality of charging protocols, the method comprising:

   detecting one or more chargeable devices positioned within an associated charging region;
   transmitting power to one of said chargeable devices in accordance with a first protocol of the plurality of charging protocols and transmitting power to the one of said chargeable devices in a accordance with a second protocol of the plurality of charging protocols;
   determining an optimal charging protocol from the first and second protocols for the one of said chargeable devices; and
   selecting the determined optimal charging protocol; and
   transmitting power to the one of said chargeable devices, via the wireless field, in accordance with the selected optimal charging protocol.

8. The method of claim 7, wherein the protocol comprises at least one of a near-field resonance protocol and an inductive coupling protocol.

9. The method of claim 7, wherein the chargeable device includes a plurality of receive elements, the method further comprising selecting the plurality of receive elements to transmit power thereto in a time-domain multiplexing method.

10. The method of claim 7, wherein the chargeable de-

vice includes a plurality of receive elements, the method further comprising receiving a signal from the chargeable device indicative of an amount of power received at each of the plurality of receive elements; and selecting a receive element of the plurality of receive elements having the highest charging efficiency with the transmitter.

11. The method of claim 7, wherein the transmitter includes a plurality of transmit elements and the chargeable device includes a plurality of receive elements, the method further comprising:

detecting at least one of a plurality of receive elements positioned within an associated charging region; and
selecting at least one transmit element to transmit power to one of the detected plurality of receive elements.

12. A device for receiving power according to a plurality of charging protocols, via a wireless field, from a transmitter (114, 202, 732, 752, 754, 756, 900, 900A, 900B), the device comprising:

means for receiving power in accordance with a first protocol of the plurality of charging protocols and for receiving power in accordance with a second protocol of the plurality of charging protocols;
means for selecting (316) an optimal charging protocol from the first and second charging protocols; and
means for receiving power (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), from the transmitter (114, 202, 732, 752, 754, 756, 900, 900A, 900B), in accordance with the selected optimal charging protocol.

13. A method of receiving power with a receiver (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) configured to receive power, via a wireless field, according to a plurality of charging protocols from a transmitter (114, 202, 732, 752, 754, 756, 900, 900A, 900B), the method comprising:

receiving power in accordance with a first protocol of the plurality of charging protocols;
receiving power in accordance with a second protocol of the plurality of charging protocols;
selecting an optimal charging protocol from the first and second charging protocols; and
receiving power, via the wireless field, from the transmitter in accordance with the selected optimal charging protocol.

14. A computer program product for processing data for a program configured to operate a receiver (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) to receive power, via wireless field, from a transmitter(114, 202, 732, 752, 754, 756, 900, 900A, 900B), the computer program product comprising:
a non-transitory computer-readable medium having stored thereon code for causing processing circuitry to perform the method of claim 13.

Patentansprüche

1. Ein drahtloses Ladegerät zum Übertragen von Leistung über ein drahtloses Feld zu einem aufladbaren Gerät (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), wobei das drahtlose Ladegerät aufweist:

Mittel zum Erfassen eines oder mehrerer aufladbarer Geräte, die in einem assoziierten Ladebereich positioniert sind,
Mittel zum Übertragen von Leistung zu dem einen oder den mehreren aufladbaren Geräten über das drahtlose Feld gemäß einer Vielzahl von Ladeprotokollen, wobei die Mittel konfiguriert sind zum Übertragen von Leistung zu einem der aufladbaren Geräte gemäß einem ersten Protokoll aus der Vielzahl von Ladeprotokollen und zum Übertragen von Leistung zu dem einen der aufladbaren Geräte gemäß einem zweiten Protokoll aus der Vielzahl von Ladeprotokollen,
Mittel (214) zum Bestimmen eines optimalen Ladeprotokolls aus den ersten und zweiten Ladeprotokollen für das eine der aufladbaren Geräte und zum Auswählen des bestimmten optimalen Ladeprotokolls für das Übertragen von Leistung zu dem einen der aufladbaren Geräte.

2. Drahtloses Ladegerät nach Anspruch 1, das weiterhin aufweist:

Mittel zum Erfassen (280) einer Vielzahl von Empfangselementen eines aufladbaren Geräts, das in einem assoziierten Ladebereich positioniert ist, und
Mittel zum Auswählen (214) wenigstens eines Empfangselements aus der erfassten Vielzahl von Empfangselementen für das Übertragen von Leistung zu diesem.

3. Drahtloses Ladegerät nach Anspruch 1, wobei die Mittel zum Übertragen von Leistung über das drahtlose Feld eine Antenne (204, 704, 714, 734, 736, 760, 762, 764, 766) oder eine Spule (768, 763, 902) umfassen.

4. Drahtloses Ladegerät nach Anspruch 1, das weiterhin Mittel zum Erfassen des einen oder der mehreren aufladbaren Geräte gemäß einer Vielzahl von Lade-

protokollen und/oder einer Vielzahl von Ladefrequenzen aufweist.

5. Drahtloses Ladegerät nach Anspruch 4, wobei die Mittel zum Erfassen konfiguriert sind zum Erfassen des einen oder der mehreren aufladbaren Geräte durch das Suchen nach aufladbaren Geräten, die mit dem wenigstens einen aus der Vielzahl von Ladeprotokollen betrieben werden, und wobei die Vielzahl von Ladeprotokollen ein Nahfeldresonanzprotokoll und ein Induktivkopplungsprotokoll umfassen.

6. Drahtloses Ladegerät nach Anspruch 4, wobei die Mittel zum Erfassen konfiguriert sind zum Erfassen des einen oder der mehreren aufladbaren Geräte durch das Suchen nach aufladbaren Geräten, die bei einer aus der Vielzahl von Ladefrequenzen resonieren.

7. Ein Verfahren zum Übertragen von Leistung über ein drahtloses Feld zu einem aufladbaren Gerät (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) von einem Sender, der ausgebildet ist zum Übertragen von Leistung gemäß einem aus einer Vielzahl von Ladeprotokollen, wobei das Verfahren aufweist:

   Erfassen eines oder mehrerer aufladbarer Geräte, die in einem assoziierten Ladebereich positioniert sind,
   Übertragen von Leistung zu einem der aufladbaren Geräte gemäß einem ersten Protokoll aus der Vielzahl von Ladeprotokollen, und Übertragen von Leistung zu dem einen der aufladbaren Geräte gemäß einem zweiten Protokoll aus der Vielzahl von Ladeprotokollen,
   Bestimmen eines optimalen Ladeprotokolls aus den ersten und zweiten Ladeprotokollen für das eine der aufladbaren Geräte, und Auswählen des bestimmten optimalen Ladeprotokolls, und Übertragen von Leistung zu dem einen der aufladbaren Geräte über das drahtlose Feld gemäß dem ausgewählten optimalen Ladeprotokoll.

8. Verfahren nach Anspruch 7, wobei das Protokoll ein NahfeldResonanzprotokoll und/oder ein Induktionskopplungsprotokoll ist.

9. Verfahren nach Anspruch 7, wobei das aufladbare Gerät eine Vielzahl von Empfangselementen enthält, wobei das Verfahren weiterhin das Auswählen der Vielzahl von Empfangselementen für das Übertragen von Leistung zu diesen in einem Zeitmultiplexverfahren aufweist.

10. Verfahren nach Anspruch 7, wobei das aufladbare Gerät eine Vielzahl von Empfangselementen enthält, wobei das Verfahren weiterhin das Empfangen eines Signals von dem aufladbaren Gerät, das eine an jedem aus der Vielzahl von Empfangselementen empfangene Leistungsmenge angibt, und das Auswählen eines Empfangselements aus der Vielzahl von Empfangselementen mit der höchsten Ladeeffizienz mit dem Sender aufweist.

11. Verfahren nach Anspruch 7, wobei der Sender eine Vielzahl von Sendeelementen enthält und das aufladbare Gerät eine Vielzahl von Empfangselementen enthält, wobei das Verfahren weiterhin aufweist:

   Erfassen wenigstens eines aus einer Vielzahl von Empfangselementen, die in einem assoziierten Ladebereich positioniert sind, und
   Auswählen wenigstens eines Sendeelements für das Übertragen von Leistung zu einem aus der erfassten Vielzahl von Empfangselementen.

12. Ein Gerät zum Empfangen von Leistung gemäß einem aus einer Vielzahl von Ladeprotokollen über ein drahtloses Feld von einem Sender (114, 202, 732, 752, 754, 756, 900, 900A, 900B), wobei das Gerät aufweist:

   Mittel zum Empfangen von Leistung gemäß einem ersten Protokoll aus der Vielzahl von Ladeprotokollen und zum Empfangen von Leistung gemäß einem zweiten Protokoll aus der Vielzahl von Ladeprotokollen,
   Mittel zum Auswählen (316) eines optimalen Ladeprotokolls aus den ersten und zweiten Ladeprotokollen, und
   Mittel zum Empfangen von Leistung (118, 302, 700, 700a, 700B, 902, 903, 911, 912, 913, 914) von dem Sender (114, 202, 732, 752, 754, 756, 900, 900A, 900B) gemäß dem ausgewählten optimalen Ladeprotokoll.

13. Ein Verfahren zum Empfangen von Leistung mit einem Empfänger (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), der konfiguriert ist zum Empfangen von Leistung über ein drahtloses Feld gemäß einer Vielzahl von Ladeprotokollen von einem Sender (114, 202, 732, 752, 754, 756, 900, 900A, 900B), wobei das Verfahren aufweist:

   Empfangen von Leistung gemäß einem ersten Protokoll aus der Vielzahl von Ladeprotokollen,
   Empfangen von Leistung gemäß einem zweiten Protokoll aus der Vielzahl von Ladeprotokollen,
   Auswählen eines optimalen Ladeprotokolls aus den ersten und zweiten Ladeprotokollen, und
   Empfangen von Leistung über das drahtlose Feld von dem Sender gemäß dem ausgewählten optimalen Ladeprotokoll.

14. Ein Computerprogrammprodukt für das Verarbeiten von Daten für ein Programm, das konfiguriert ist zum Betreiben eines Empfängers (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) für das Empfangen von Leistung über ein drahtloses Feld von einem Sender (114, 202, 732, 752, 754, 756, 900, 900A, 900B), wobei das Computerprogrammprodukt aufweist:
ein nicht-transitorisches, computerlesbares Medium mit einem darauf gespeicherten Code, der einen Verarbeitungsschaltungsaufbau veranlasst zum Durchführen des Verfahrens von Anspruch 13.

Revendications

1. Chargeur sans fil destiné à transmettre de l'énergie, par l'intermédiaire d'un champ sans fil, à un dispositif rechargeable (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), le chargeur sans fil comprenant :

   un moyen pour détecter un ou plusieurs dispositifs rechargeables positionnés dans une zone de charge associée ;
   un moyen pour transmettre de l'énergie audit un ou auxdits plusieurs dispositifs rechargeables, par l'intermédiaire du champ sans fil, conformément à une pluralité de protocoles de charge, le moyen étant configuré de manière à transmettre de l'énergie à l'un desdits dispositifs rechargeables conformément à un premier protocole de la pluralité de protocoles de charge, et à transmettre de l'énergie audit un desdits dispositifs rechargeables conformément à un second protocole de la pluralité de protocoles de charge ;
   un moyen (214) pour déterminer un protocole de charge optimal parmi les premier et second protocoles de charge pour ledit un desdits dispositifs rechargeables ; et
   un moyen pour sélectionner le protocole de charge optimal déterminé en vue de transmettre de l'énergie audit un desdits dispositifs rechargeables.

2. Chargeur sans fil selon la revendication 1, comprenant en outre :

   un moyen pour détecter (280) une pluralité d'éléments de réception d'un dispositif rechargeable positionné dans une zone de charge associée ; et
   un moyen pour sélectionner (214) au moins un élément de réception parmi la pluralité détectée d'éléments de réception, en vue de lui transmettre de l'énergie.

3. Chargeur sans fil selon la revendication 1, dans lequel le moyen de transmission d'énergie par l'intermédiaire du champ sans fil comprend une antenne (204, 704, 714, 734, 736, 760, 762, 764, 766) ou une bobine (768, 763, 902).

4. Chargeur sans fil selon la revendication 1, comprenant en outre un moyen pour détecter ledit un ou lesdits plusieurs dispositifs rechargeables selon au moins l'un parmi une pluralité de protocoles de charge et une pluralité de fréquences de charge.

5. Chargeur sans fil selon la revendication 4, dans lequel le moyen de détection est configuré de manière à détecter ledit un ou lesdits plusieurs dispositifs rechargeables, par le biais d'un échantillonnage, pour des dispositifs rechargeables fonctionnant avec au moins un protocole de la pluralité de protocoles de charge, et dans lequel la pluralité de protocoles de charge inclut un protocole de résonance en champ proche et un protocole de couplage inductif.

6. Chargeur sans fil selon la revendication 4, dans lequel le moyen de détection est configuré de manière à détecter ledit un ou lesdits plusieurs dispositifs rechargeables, par le biais d'un échantillonnage, pour des dispositifs rechargeables résonnant à l'une de la pluralité de fréquences de charge.

7. Procédé de transmission d'énergie, par l'intermédiaire d'un champ sans fil, à un dispositif rechargeable (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), à partir d'un émetteur apte à transmettre de l'énergie selon une pluralité de protocoles de charge, le procédé comprenant les étapes ci-dessous consistant à :

   détecter un ou plusieurs dispositifs rechargeables positionnés dans une zone de charge associée ;
   transmettre de l'énergie à l'un desdits dispositifs rechargeables conformément à un premier protocole de la pluralité de protocoles de charge, et transmettre de l'énergie audit un desdits dispositifs rechargeables conformément à un second protocole de la pluralité de protocoles de charge ;
   déterminer un protocole de charge optimal parmi les premier et second protocoles de charge pour ledit un desdits dispositifs rechargeables ; et
   sélectionner le protocole de charge optimal déterminé ; et
   transmettre de l'énergie audit un desdits dispositifs rechargeables, par l'intermédiaire du champ sans fil, conformément au protocole de charge optimal sélectionné.

8. Procédé selon la revendication 7, dans lequel le pro-

tocole comprend au moins un protocole parmi un protocole de résonance en champ proche et un protocole de couplage inductif.

9. Procédé selon la revendication 7, dans lequel le dispositif rechargeable inclut une pluralité d'éléments de réception, le procédé comprenant en outre l'étape consistant à sélectionner la pluralité d'éléments de réception en vue de leur transmettre de l'énergie dans le cadre d'un procédé de multiplexage de domaine temporel.

10. Procédé selon la revendication 7, dans lequel le dispositif rechargeable inclut une pluralité d'éléments de réception, le procédé comprenant en outre l'étape consistant à recevoir un signal en provenance du dispositif rechargeable, indicatif d'une quantité d'énergie reçue au niveau de chaque élément de la pluralité d'éléments de réception ; et l'étape consistant à sélectionner un élément de réception, parmi la pluralité d'éléments de réception, présentant l'efficacité de charge le plus élevée avec l'émetteur.

11. Procédé selon la revendication 7, dans lequel l'émetteur inclut une pluralité d'éléments de transmission et le dispositif rechargeable inclut une pluralité d'éléments de réception, le procédé comprenant en outre les étapes ci-dessous consistant à :

détecter au moins un élément parmi une pluralité d'éléments de réception positionnés dans une zone de charge associée ; et
sélectionner au moins un élément de transmission en vue de transmettre de l'énergie à un élément de la pluralité sélectionnée d'éléments de réception.

12. Dispositif destiné à recevoir de l'énergie selon une pluralité de protocoles de charge, par l'intermédiaire d'un champ sans fil, en provenance d'un émetteur (114, 202, 732, 752, 754, 756, 900, 900A, 900B), le dispositif comprenant :

un moyen pour recevoir de l'énergie conformément à un premier protocole de la pluralité de protocoles de charge, et pour recevoir de l'énergie conformément à un second protocole de la pluralité de protocoles de charge ;
un moyen pour sélectionner (316) un protocole de charge optimal parmi les premier et second protocoles de charge ; et
un moyen pour recevoir de l'énergie (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914), en provenance de l'émetteur (114, 202, 732, 752, 754, 756, 900, 900A, 900B), conformément au protocole de charge optimal sélectionné.

13. Procédé de réception d'énergie au moyen d'un récepteur (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) configuré de manière à recevoir de l'énergie, par l'intermédiaire d'un champ sans fil, selon une pluralité de protocoles de charge, en provenance d'un émetteur (114, 202, 732, 752, 754, 756, 900, 900A, 900B), le procédé comprenant les étapes ci-dessous consistant à :

recevoir de l'énergie conformément à un premier protocole de la pluralité de protocoles de charge ;
recevoir de l'énergie conformément à un second protocole de la pluralité de protocoles de charge ;
sélectionner un protocole de charge optimal parmi les premier et second protocoles de charge ; et
recevoir de l'énergie, par l'intermédiaire du champ sans fil, en provenance de l'émetteur, conformément au protocole de charge optimal sélectionné.

14. Produit formant un programme informatique destiné à traiter des données pour un programme configuré de manière à faire fonctionner un récepteur (118, 302, 700, 700A, 700B, 902, 903, 911, 912, 913, 914) destiné à recevoir de l'énergie, par l'intermédiaire d'un champ sans fil, en provenance d'un émetteur (114, 202, 732, 752, 754, 756, 900, 900A, 900B), le produit formant un programme informatique comprenant :
un support non transitoire lisible par ordinateur sur lequel est stocké un code pour amener un montage de circuits de traitement à mettre en œuvre le procédé selon la revendication 13.

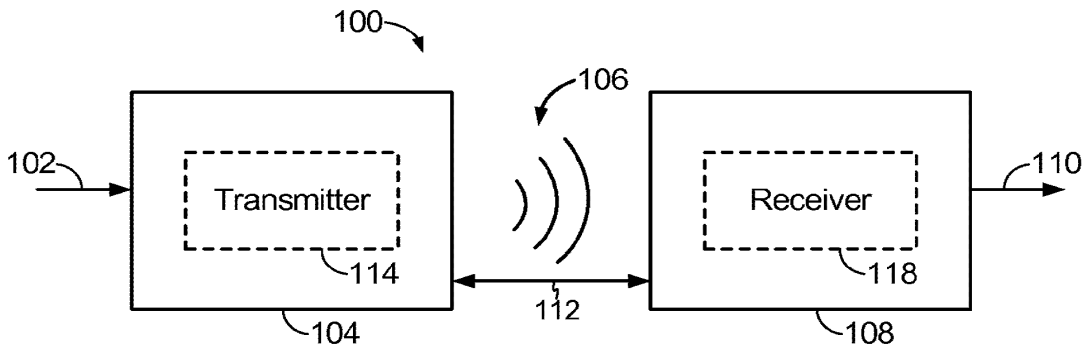


FIG. 1

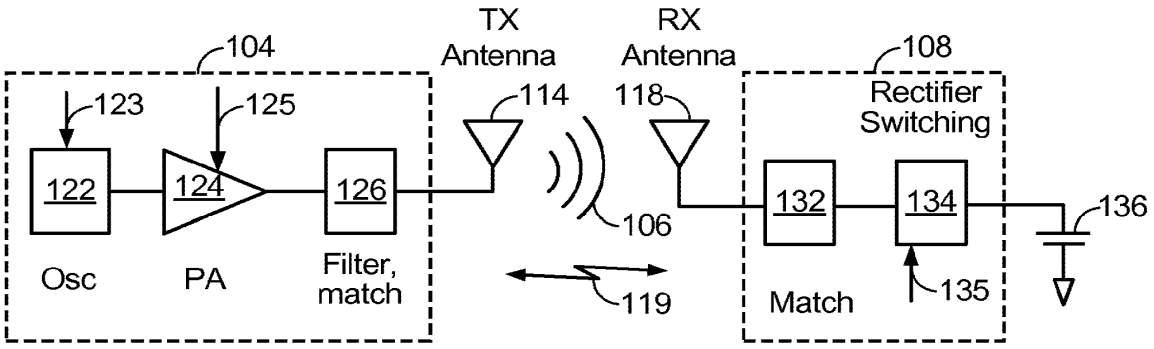


FIG. 2

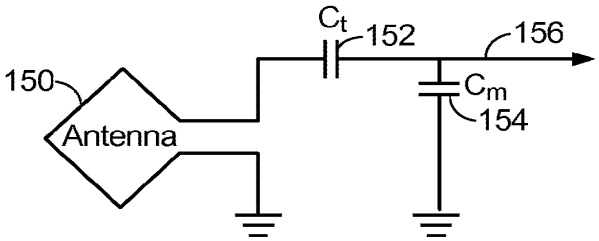


FIG. 3

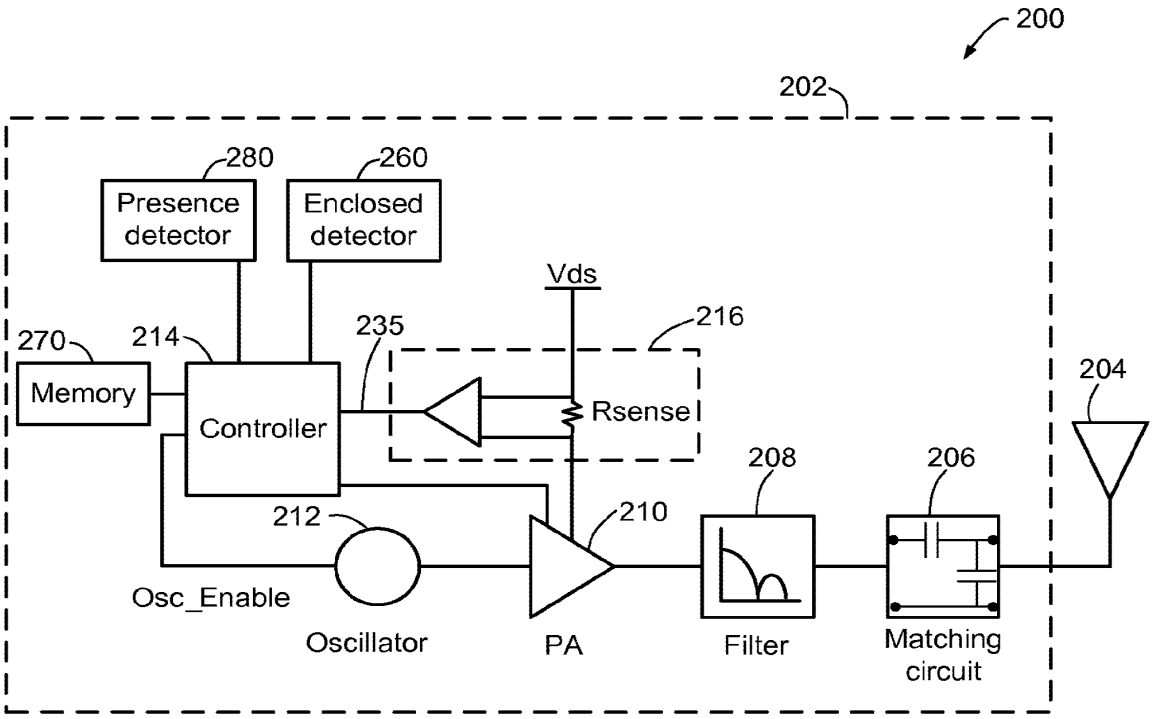

200
202
280
260
Presence detector
Enclosed detector
Vds
216
235
214
270
Memory
Controller
Rsense
204
208
206
212
210
Osc_Enable
Oscillator
PA
Filter
Matching circuit

FIG. 4

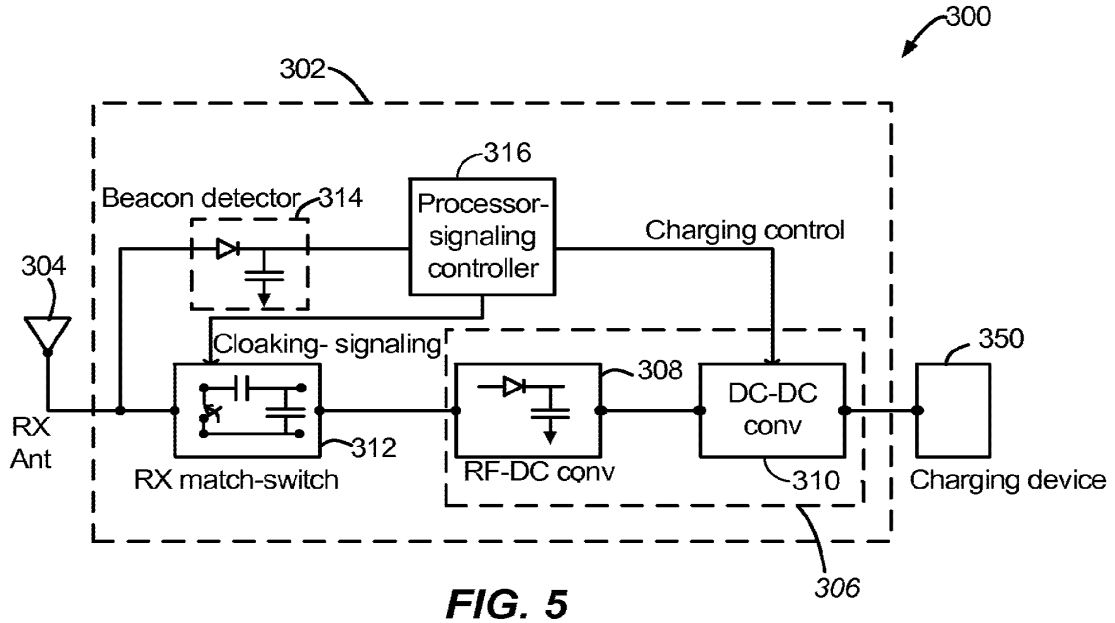

300
302
316
Beacon detector
314
Processor-signaling controller
Charging control
304
Cloaking- signaling
350
308
DC-DC conv
RX Ant
312
RX match-switch
RF-DC conv
310
Charging device
306

FIG. 5

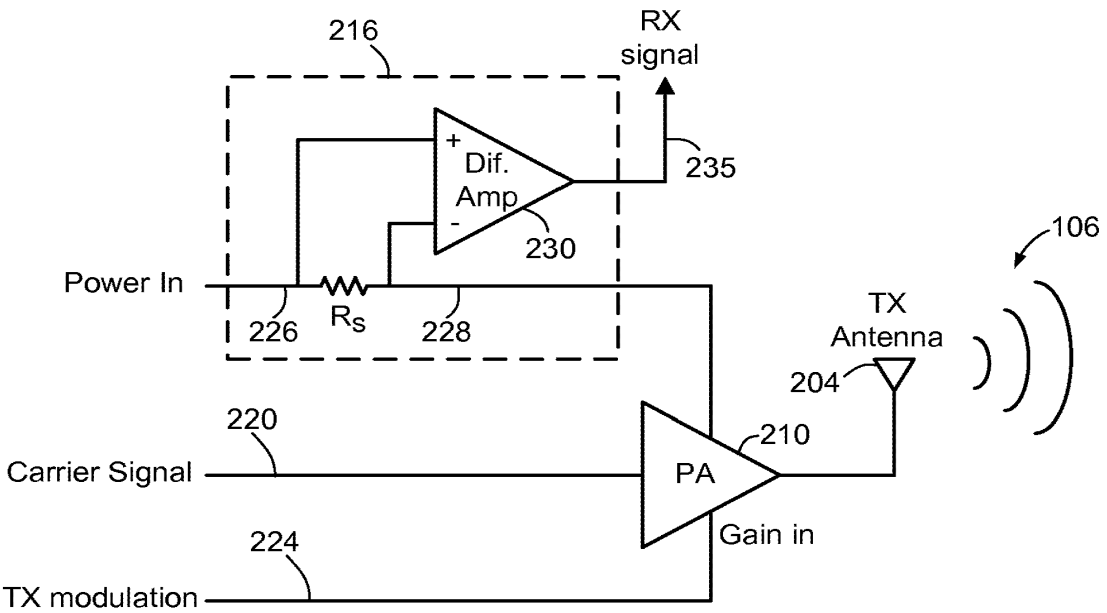

216
RX
signal
+
Dif.
Amp
-
235
230
106
Power In
226
Rs
228
TX
Antenna
204
220
210
Carrier Signal
PA
Gain in
224
TX modulation

FIG. 6

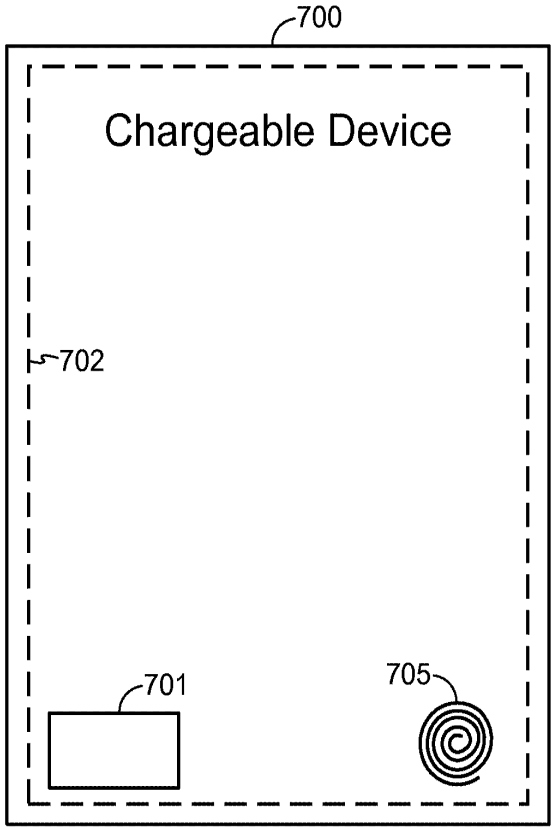

700
Chargeable Device
702
701
705

FIG. 7

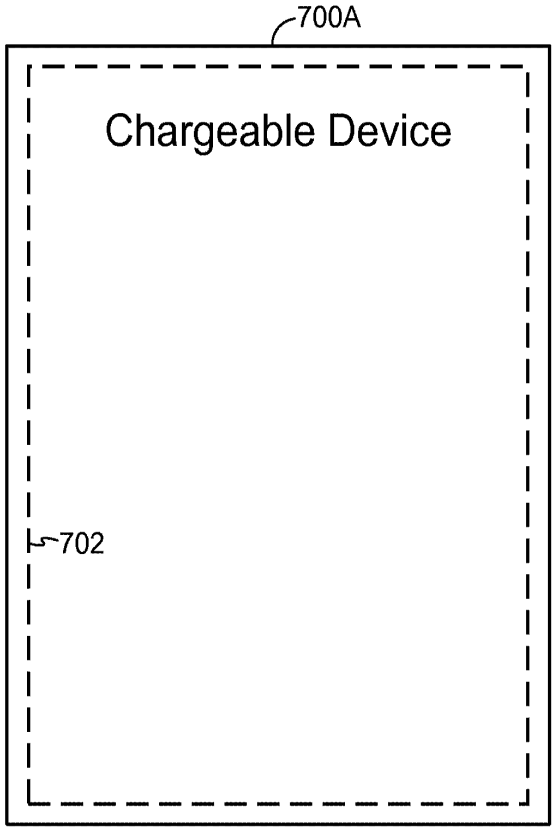

700A
Chargeable Device
702

FIG. 8

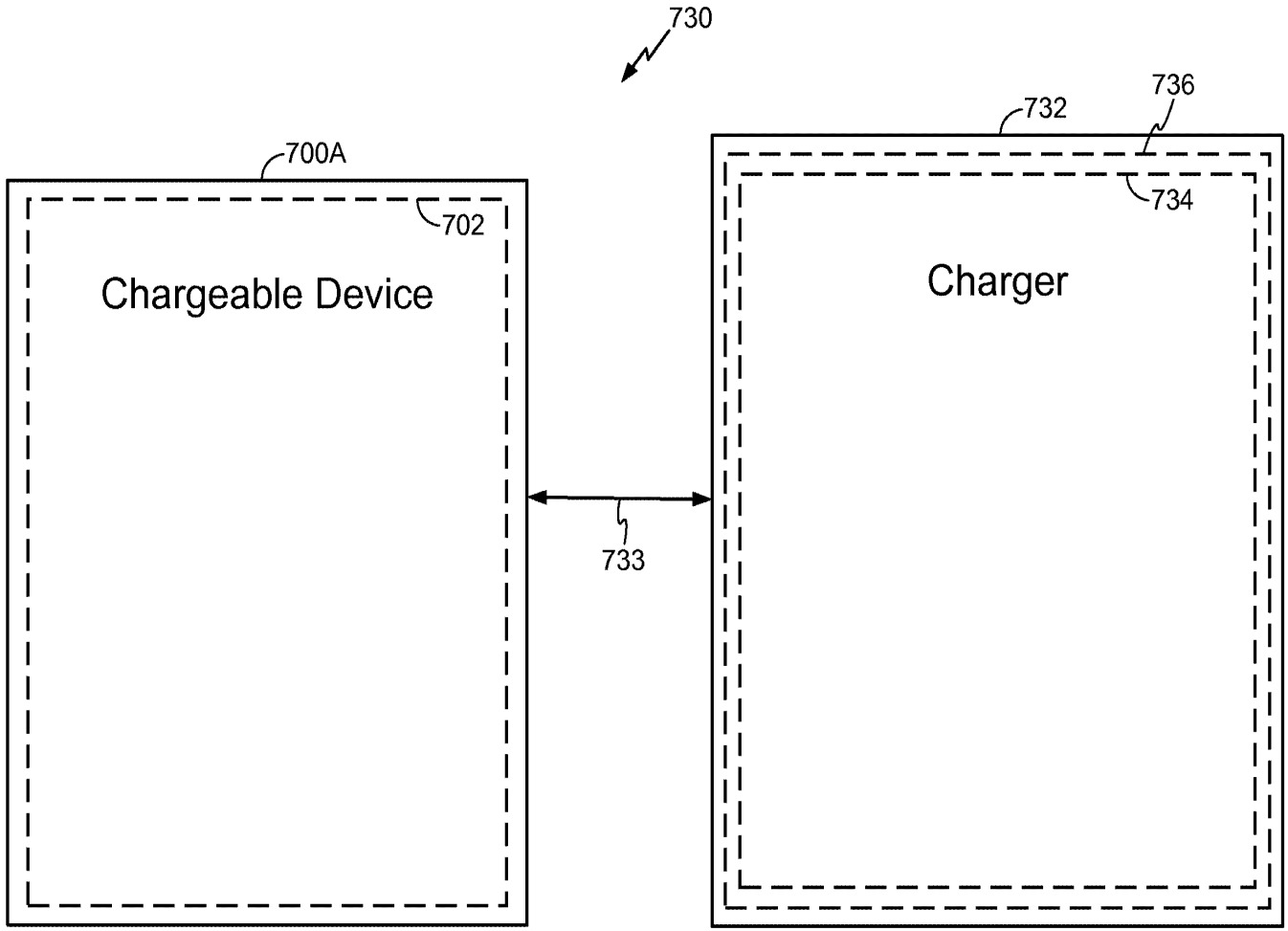


FIG. 9

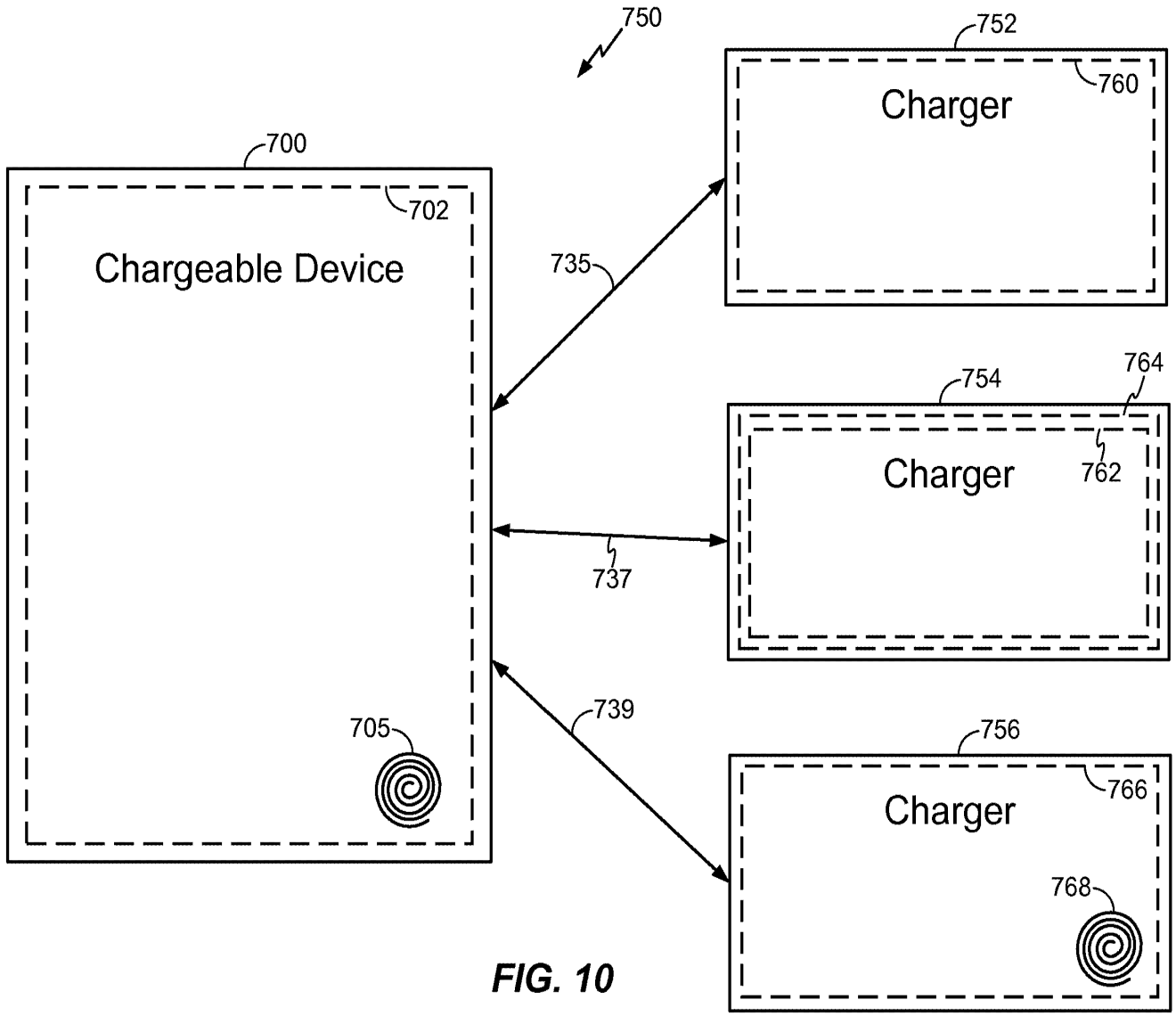

750
752
Charger
760
700
702
Chargeable Device
735
754
764
Charger
762
737
739
705
756
Charger
766
768

FIG. 10

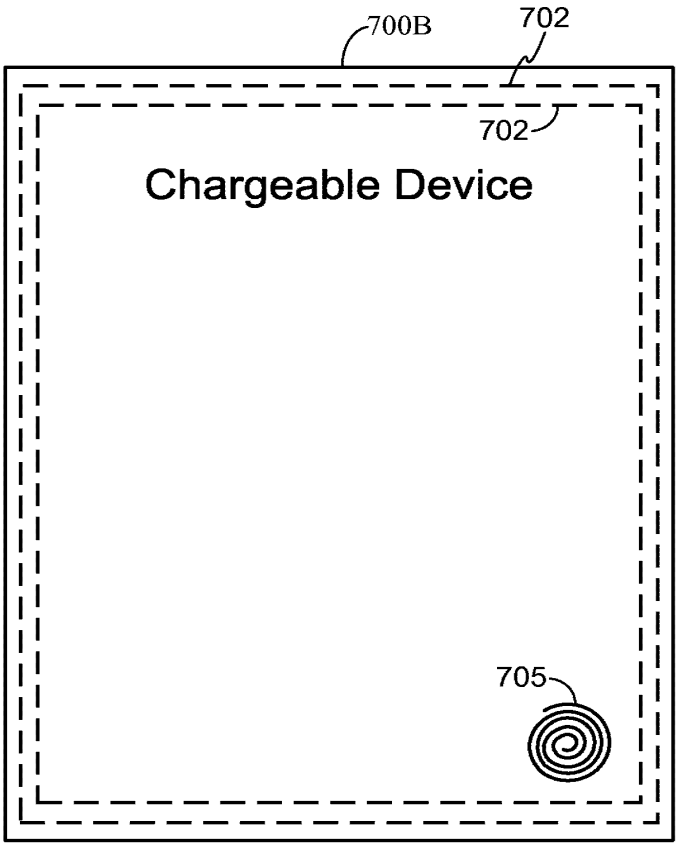


FIG. 11

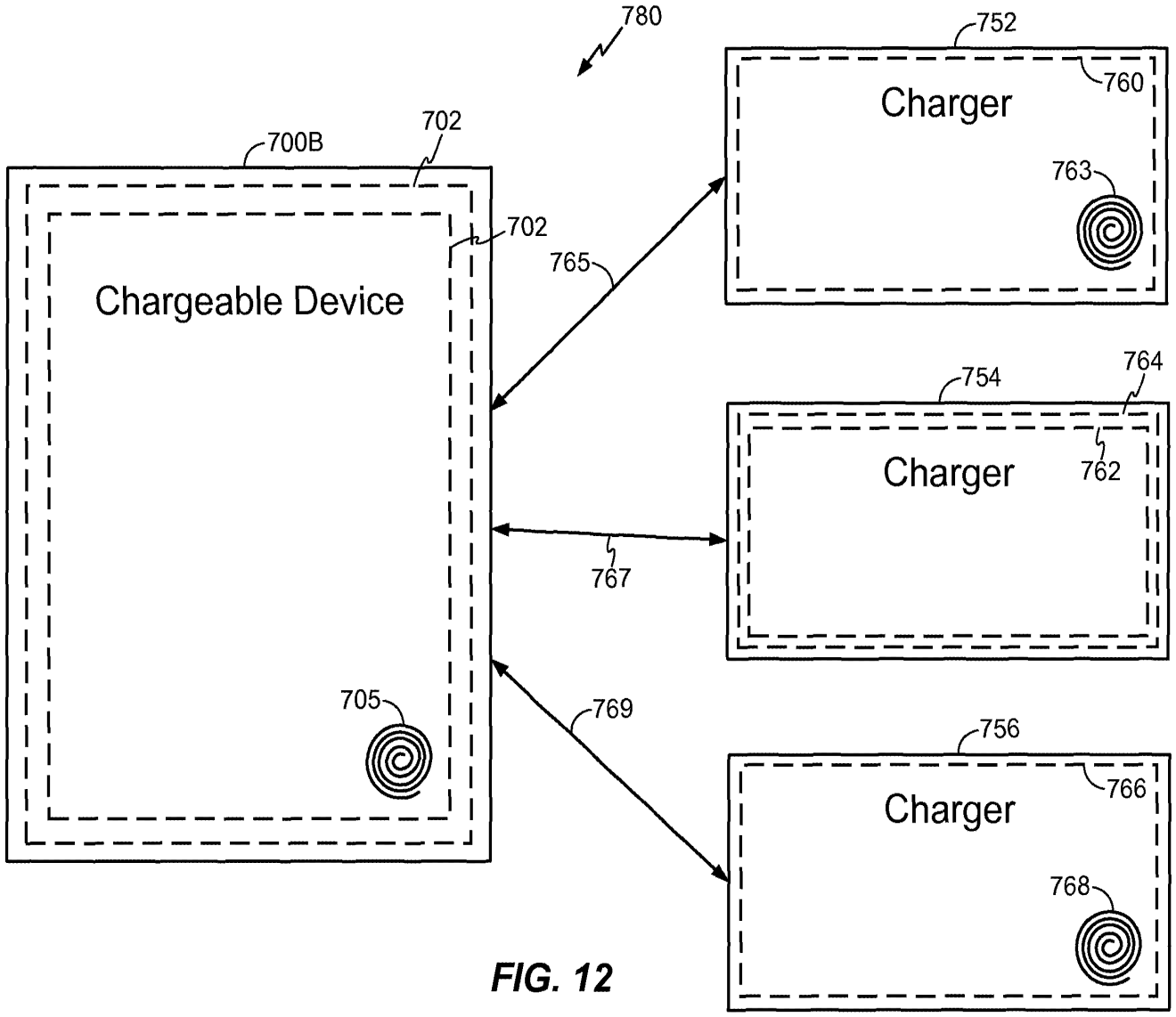

780
752
760
Charger
763
700B
702
702
765
Chargeable Device
754
764
762
Charger
767
705
769
756
766
Charger
768

FIG. 12

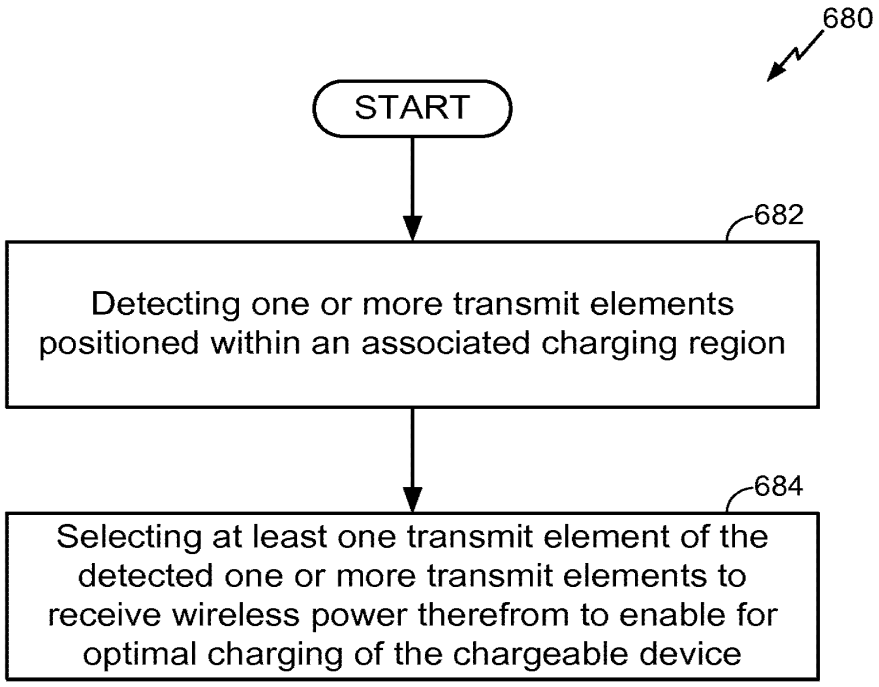

680
START
682
Detecting one or more transmit elements positioned within an associated charging region
684
Selecting at least one transmit element of the detected one or more transmit elements to receive wireless power therefrom to enable for optimal charging of the chargeable device

FIG. 13

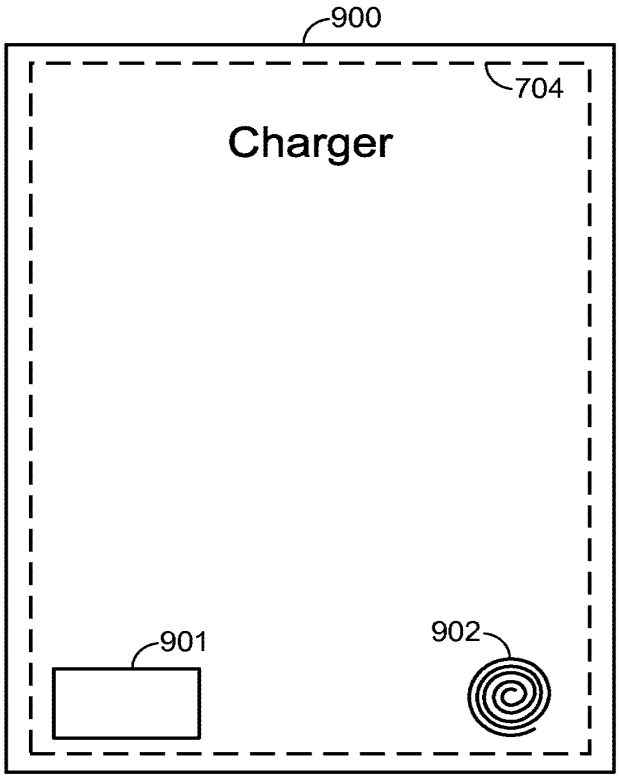


FIG. 14

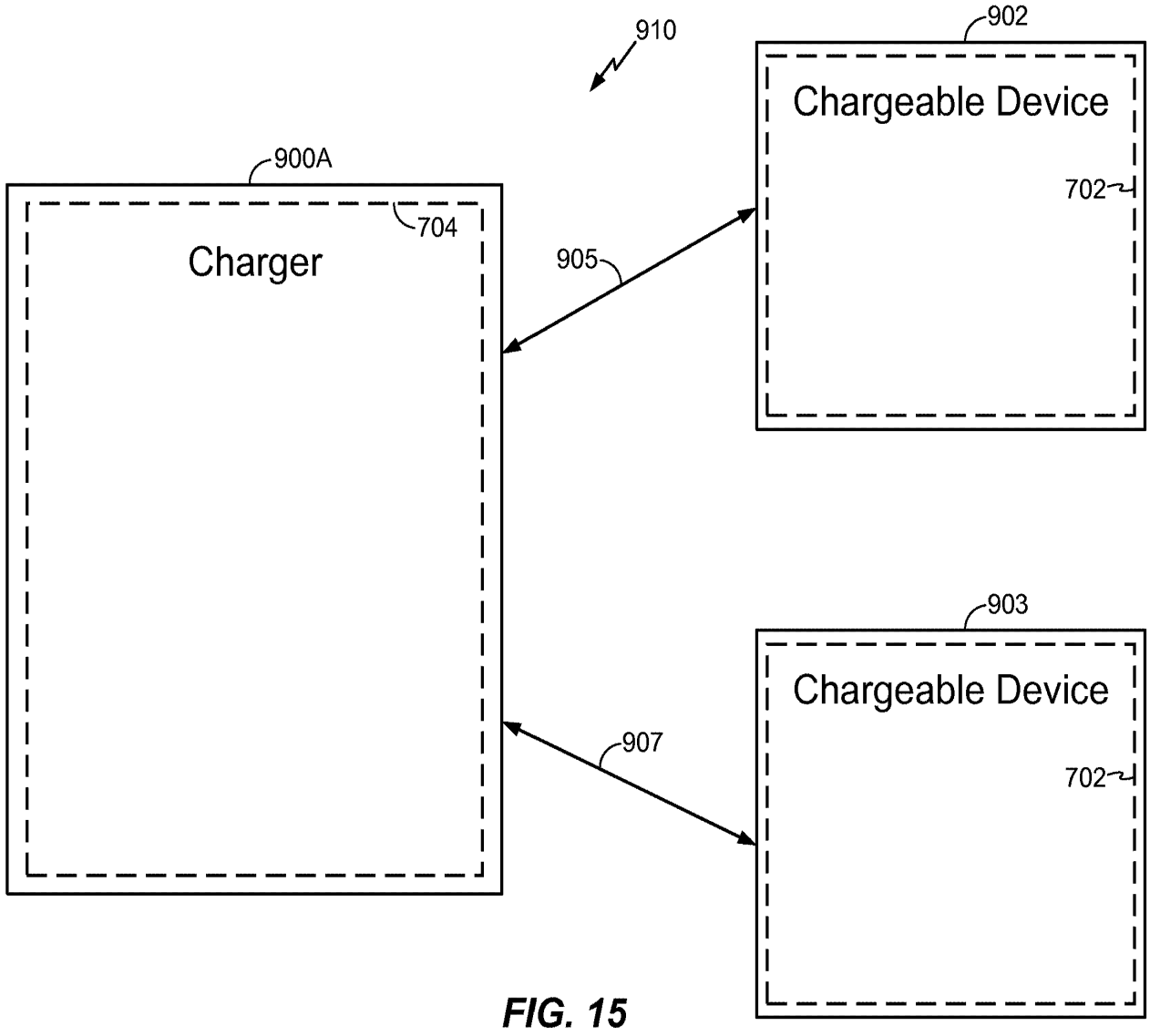

910
902
Chargeable Device
702
900A
704
Charger
905
903
Chargeable Device
907
702

FIG. 15

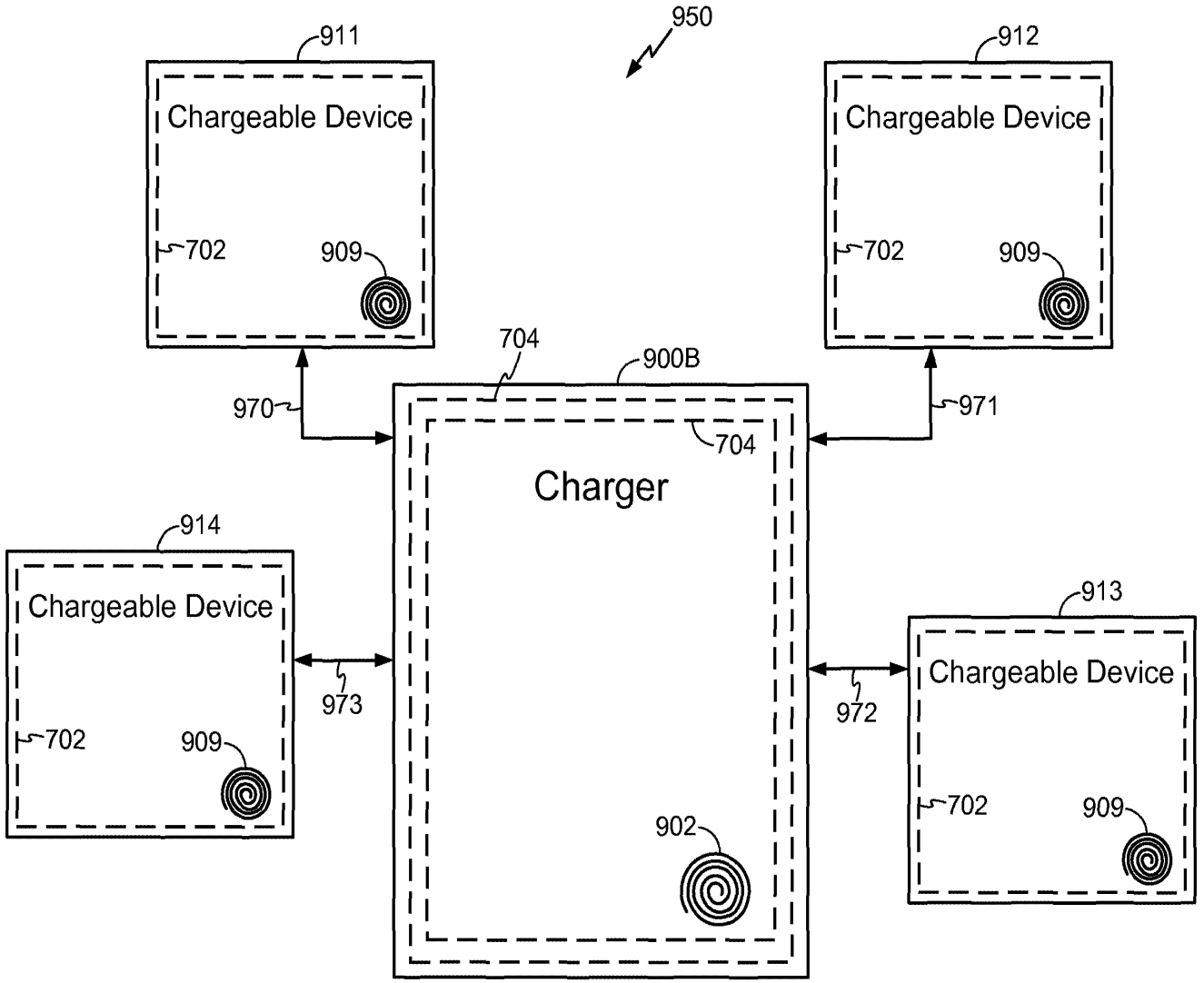

950
911
Chargeable Device
702
909
912
Chargeable Device
702
909
704
900B
970
971
704
Charger
914
Chargeable Device
702
909
973
913
Chargeable Device
702
909
972
902

FIG. 16

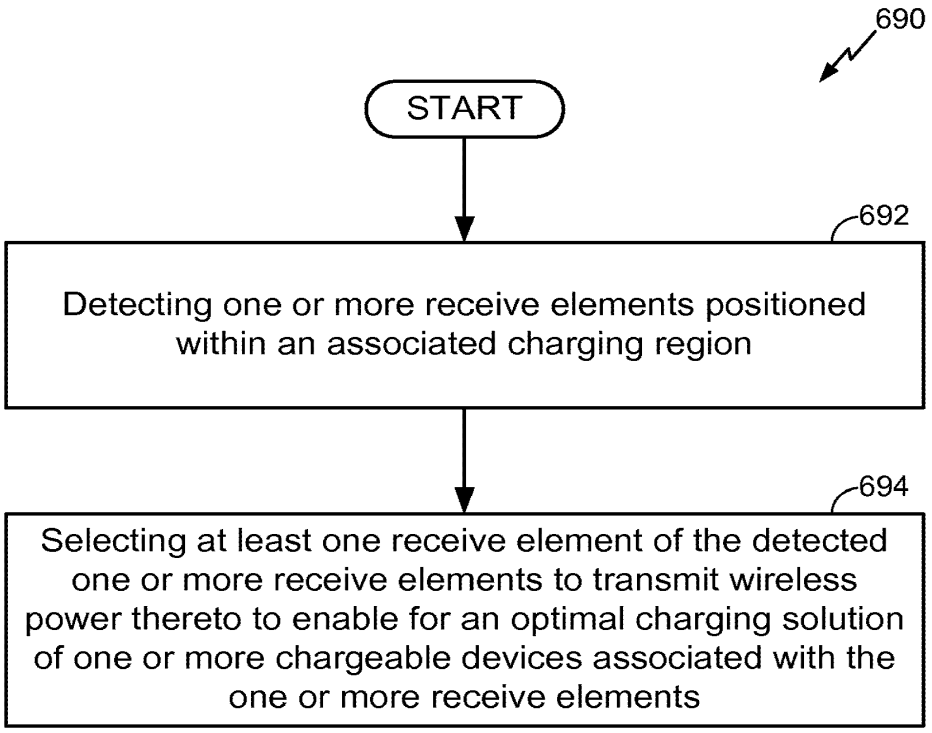

690
START
692
Detecting one or more receive elements positioned within an associated charging region
694
Selecting at least one receive element of the detected one or more receive elements to transmit wireless power thereto to enable for an optimal charging solution of one or more chargeable devices associated with the one or more receive elements

FIG. 17

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 20090039828 A1 **[0006]**
- US 24987308 **[0044]**
- US 24986108 **[0044]**
- US 24986608 **[0045]**

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 January 2006 (05.01.2006)

PCT

(10) International Publication Number
WO 2006/001557 A1

(51) International Patent Classification[7]: H02J 7/02

(21) International Application Number:
PCT/KR2004/002263

(22) International Filing Date:
7 September 2004 (07.09.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10-2004-0048286 25 June 2004 (25.06.2004) KR

(71) Applicant *(for all designated States except US)*: **HANRIM POSTECH CO., LTD.** [KR/KR]; 626-1 Pajang-dong, Jangan-gu, Suwan-si, Gyeonggi-do 440-290 (KR).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **JUNG, Chun-Kil** [KR/KR]; 77-9 Nonhyeong-dong, Gangnam-gu, Seoul 135-010 (KR). **KOOK, Yoon-Sang** [KR/KR]; 123-102 Jugong Apartment, 37 Jungang-dong, Gwacheon-si, Gyeonggi-do 427-010 (KR).

(74) Agent: **KIM, Sung-Gyu**; 4th FL. Jangan Bldg., 827-3 Yoksam-dong, Kangnam-gu, Seoul 135-080 (KR).

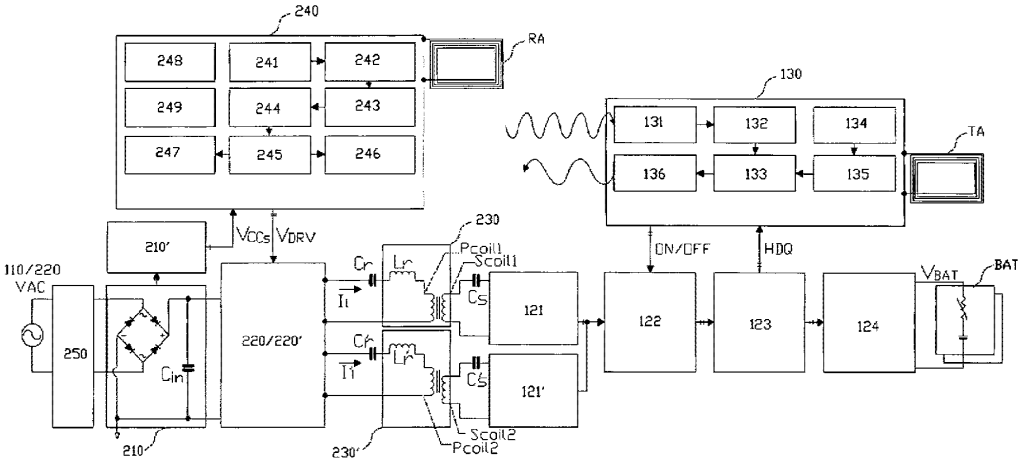
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

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(54) Title: WIRELESS CHARGING PAD AND BATTERY PACK USING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY



(57) Abstract: The present invention relates to a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad. Thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

WO 2006/001557 A1

DESCRIPTION

WIRELESS CHARGING PAD AND BATTERY PACK USING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY

Technical Field

The present invention relates, in general, to a wireless charging pad and a battery pack to which a radio frequency identification technology is applied and, more particularly, to a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Background Art

Recently, with the development of communication and information processing technologies, the use of portable devices that are convenient to carry, such as a mobile phone, is increasing, and with the development of technologies, new model terminals having improved efficiency are continuously popularized. To charge such portable devices, a contact type charging method is used,

or a non-contact type charging method in which a battery is charged using magnetic coupling without electrical contact is used so as to overcome the problem of the contact type charging method that is attributable to the exposure of contact terminals to an outside.

As for technology corresponding to a non-contact charger, a method of charging a battery through wireless communication between a battery pack and a charging device using magnetic cores is disclosed in Korean Unexamined Pat. Pub. No. 2002-0035242 entitled "Non-contact Charging Device for Battery of Portable Device using Inductive Coupling," and a method of solving a problem of a magnetic core using a transformer formed in such a way that coils are wound on a Printed Circuit Board (PCB) is disclosed in Korean Unexamined Pat. Pub. No. 2002-0057469 entitled "Thin PCB Transformer without Core and Non-contact Battery Charger using PCB Transformer."

The present applicant proposed the technology in which a wireless charging pad for functioning as a wireless charger was constructed and the battery pack of a portable device was charged in a non-contact manner by placing the battery pack on the wireless charging pad through "Non-contact Battery Charging System capable of Multi-Charging and Method of Designing Core Block" (Korean Pat. application No. 2004-21335).

However, in the prior art, the wireless charging pad

could not detect the charged status of the battery pack in real time and a means for detecting devices placed on the wireless charging pad was not implemented, so that a problem arises in that the prior art is difficult to cope with the case where a plurality of battery packs, or an object that cannot be charged, is placed on a wireless charging pad.

Description of Drawings

FIG. 1 is a view showing the construction of a battery pack charged by a wireless charging pad in a non-contact manner, according to the present invention;

FIG. 2 is a view showing the entire construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention;

FIGS. 3 to 5 are views illustrating the components of the wireless charging pad or battery pack, according to the present invention;

FIG. 6 is a view showing a method of generating a magnetic field based on the switching patterns of the wireless charging pad, according to the present invention;

FIG. 7 is a view showing the size expansion of the wireless charging pad according to the number of charging devices, according to the present invention;

FIG. 8 is a view showing the detailed construction of

the non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention;

FIG. 9 is a flowchart showing a method of charging a battery using the wireless charging pad of FIG. 8;

FIGS. 10 and 11 are views showing the equivalent circuits of series and parallel resonant converters, respectively, provided to the wireless charging pad of the present invention;

FIGS. 12 to 17 are views showing the operation of a half-bridge series resonant converter provided to the wireless charging pad of the present invention, according to modes;

FIG. 18 is a view showing the voltage and current waveforms of a transformer according to the gate signal of the half-bridge series resonant converter provided to the wireless charging pad of the present invention;

FIG. 19 is a view showing the rotating directions of a magnetic field according to the operation of the half-bridge series resonant converter provided to the wireless charging pad of the present invention, according to modes;

FIGS. 20 to 23 are views showing the rectifying circuits of a charging receiver module according to the present invention;

FIG. 24 is a view showing the construction of a controller provided to the wireless charging pad of the

present invention; and

FIG. 25 is a view showing the flow of an RF signal between the wireless charging pad and the battery pack according to the present invention.

Disclosure

Technical Problem

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Technical Solution

In order to accomplish the above objects, the present invention provides a wireless charging pad (200) for charging a battery pack (100) mounted on a portable device in a non-contact manner, to which a radio frequency identification technology is applied, including a controller (240) for switching to an active mode and

controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack (100) is detected, for transmitting a Radio Frequency (RF) carrier signal to the battery pack (100) in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information of the battery pack (100), through a reader antenna (RA) in response to the RF carrier signal, and indicating the charged status of the battery pack (100), and for switching to the energy saving mode again when charging of the battery pack (100) is completed; the drive circuits (220 and 220') for switching two primary coils (Pcoil1 and Pcoil2) under control of the controller (240); and a primary-side transformer formed by constructing a pad core, which is adapted to generate induced electromotive force through switching of the drive circuits (220 and 220') and charge the battery pack (100), and which is formed by connecting a plurality of small cobalt-based amorphous metallic or ferrite planar cores in a square or rectangular shape, and winding two primary coils (Pcoil1 and Pcoil2) on the pad core in directions perpendicular to each other.

Preferably, the controller (240) may read wireless identification information and charged status information of each of battery packs (100) in order in which the battery packs (100) are placed, indicate charged status of

each battery pack (100), and switch to the energy saving mode when charging of all the battery packs (100) are completed, and therefore, fully charged status may be established.

Preferably, the controller (240) may include an oscillator (241) for generating an oscillation signal of a certain frequency; an antenna driver (242) for using the oscillation signal of the oscillator (241) as a clock, monitoring the access of the battery pack (100) by transmitting the RF carrier signal to an outside through the reader antenna (RA) and monitoring whether a return signal exists, and wirelessly receiving RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack (100), in response to the RF carrier signal when the battery pack (100) makes access; a demodulator (243) for demodulating the RF data received by the antenna driver (242); a filter and amplification unit (244) for filtering the wireless identification information and charged status information from the demodulated data and amplifying the filtered information; a data decoder (245) for decoding the wireless identification information and the charged status information received by the filter and amplification unit (244); and a display unit (247) for displaying the data decoded by the data decoder (245).

Preferably, the drive circuits (220 and 220') may

include two half-bridge series-parallel resonant converters to control the primary coils (Pcoil1 and Pcoil2) perpendicular to each other, and switch the primary coils (Pcoil1 and Pcoil2) at a frequency higher than a resonant point so that switching patterns of the primary coils (Pcoil1 and Pcoil2) have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating in a sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

Preferably, the wireless charging pad may further include an electromagnetic wave filter (250) combined with a power input terminal to block electromagnetic waves from Alternating Current (AC) power input; an AC/Direct Current (DC) conversion circuit (210) for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter (250) and rectifying the AC power into DC power; and a flyback converter (210') connected to the AC/DC conversion circuit (210) and the controller (240) to accumulate power while a transistor is turned on and transmit the accumulated power to the controller (240) when the transistor is turned off so as to drive the drive circuits (220 and 220').

Preferably, the wireless charging pad (200) may include input ports that are combined with at least one of an AC adapter, a Universal Serial Bus (USB) port and a

cigar lighter jack for a vehicle.

The present invention provides a battery pack (B) mounted on a portable device to be charged by a wireless charging pad (A) in a non-contact manner, to which a radio frequency identification technology is applied, including a charging receiver module (110) formed of an amorphous metallic planar core and two secondary coils (Scoil1 and Scoil2), which are wound on the planar core in vertical and horizontal directions, to induce power through magnetic coupling with the wireless charging pad (200); a charging protection circuit module (120) combined with the charging receiver module (110) and the battery (BAT) to record charged status information generated by periodically monitoring charged status of the battery (BAT) in an Radio Frequency Identification (RFID) tag (130), and to control whether to charge or discharge the battery (BAT) by selectively supplying or blocking the power induced to the charging receiver module (110) to the battery (BAT); the RFID tag (130) combined with the charging protection circuit module (120) to store wireless identification information of the battery (BAT), to periodically record the charged status information, and to generate and modulate RF data including the wireless identification information and charged status information of the battery (BAT) and transmit the modulated RF data to the wireless charging pad (200) when an RF carrier signal is transmitted

from the wireless charging pad (200) through a tag antenna (TA); and the battery (BAT) to be charged under control of the protection circuit (124).

Preferably, the wireless charging pad may further include an amorphous metallic electromagnetic protector (140) for minimizing a rise in temperature of the battery (BAT) attributable to frequency interference, which is caused by radio signals or induced electromotive force in a magnetic field, or attributable to inductive heating, by magnetically blocking a gap between the battery (BAT) and the charging receiver module (110).

Preferably, the wireless charging pad may further include a battery casing (150) manufactured using a cool polymer to perform an operation of emitting heat generated due to charging while admitting the induced electromotive force, and to entirely surround a structure that is formed by assembling the components.

Preferably, the charging protection circuit module (120) may include rectifying circuits 121 and 121' for rectifying the power induced to the charging receiver module (110) and supplying the rectified power to a charging control circuit (122); the charging control circuit (122) combined with the rectifying circuits (121 and 121') to supply the power rectified by the rectifying circuits (121 and 121') to a fuel gauge (123) under On/Off control of the RFID tag (130); the fuel gauge (123) for

supplying the power supplied from the charging control circuit (122) to the battery (BAT) through a protection circuit (124), and generating the charged status information while monitoring the charged status of the battery (BAT), and periodically recording the charged status information in the RFID tag (130); and the protection circuit (124) combined with the fuel gauge (123) and the battery (BAT) to protect the battery (BAT) by controlling whether to charge or discharge according to the charged status of the battery (BAT).

Preferably, the rectifying circuits (121 and 121') may be series-parallel resonant center tap half-bridge rectifying circuits using an output of a single center tap rectifying diode and an output filter capacitor, or series-parallel resonant full-bridge rectifying circuits using an output of a full-bridge rectifying diode and an output filter capacitor.

Preferably, the RFID tag (130) may include a clock extraction unit (131) for extracting a clock from the RF carrier signal wirelessly received from the wireless charging pad (200); a sequencer (132) for inspecting an sequence of arranged data extracted from the clock extraction unit (131) and transmitting a control signal to a data encoder (133); the data encoder (133) for receiving the wireless identification information and charged status information of the battery (BAT) from a tag (135) when the

control signal is transmitted from the sequencer (132), and transmitting the wireless identification information and charged status information to a data modulator (136) after coding the wireless identification information and charged status information; the data modulator (136) for generating RF data generated by modulating the data received from the data encoder (133), and wirelessly transmitting the RF data to the wireless charging pad (200); Read Only Memory (ROM) (134) for recording the wireless identification information and charged status information therein; and the tag (135) for reading the wireless identification information and charged status information of the battery (BAT) stored in the ROM (134), and transmitting the wireless identification information and charged status information to the data encoder (133).

Preferably, the wireless identification information may correspond to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in the RFID tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

Preferably, the RF carrier signal may be a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in High Frequency (HF) (3 to 30 MHz) or Ultra High Frequency (UHF) (300 to 3000 MHz)

bands.

Advantageous Effects

As described above, the present invention is advantageous in that there is provided a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Best Mode

Preferred embodiments of the present invention are described in detail with reference to the attached drawings below, but detailed descriptions of related well-known functions and construction may be omitted if the detailed descriptions are determined to make the gist of the present invention unclear.

FIG. 1 is a view showing the entire construction of a battery pack charged by a wireless charging pad in a non-contact manner, according to the present invention.

Referring to FIG. 1, a battery pack 100 includes a charging receiver module 110 provided with secondary coils Scoil1 and Scoil2 to receive induced electromotive force

from a primary-side wireless charging pad 200 (refer to FIG. 2), a charging protection circuit module 120 and a battery BAT having fuel gauge and charging functions, an RFID tag 130 (refer to FIG. 2) and a tag antenna TA adapted to transmit and receive radio signals, and an electromagnetic protector 140 that is an amorphous metal-based electromagnetic interference shield for magnetically isolating the battery BAT and the charging receiver module 110 so that the battery BAT does not affect the inductive coupling between the receiver module 110 and the wireless charging pad 200 (refer to FIG. 2).

The electromagnetic protector 140 is made of an amorphous metal-based magnetic material to remove frequency interference in a magnetic field attributable to radio signals and induced electromotive force, and generally functions to minimize a rise in temperature of the battery BAT in a magnetic field attributable to inductive heating caused by a metallic battery casing, so that the electromagnetic protector 140 must be inserted.

The battery pack 100 may further include the battery casing 150 for surrounding all the components, such as the charging receiver module 110, the charging protection circuit module 120, the battery BAT and the electromagnetic protector 140, combined into a single structure. In this case, the battery casing 150 is manufactured using a cool polymer material, such as cobalt or nickel, so that the

battery casing 150 functions to pass the induced electromotive force or electromagnetic waves, and emit heat generated inside the battery casing 150 due to charging.

FIG. 2 is a view showing the construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention.

Referring to FIG. 2, the non-contact battery charging system composed of the wireless charging pad and the battery pack separately comprises the wireless charging pad 200 adapted to function as a non-contact charger and the battery pack 100 charged with power provided by the wireless charging pad 200. A separative transformer is provided between the wireless charging pad 200 and the battery pack 100 so that a primary side of the transformer is provided in the wireless charging pad 200 and a secondary side of the transformer is provided in the battery pack 100.

The battery pack 100 includes the charging receiver module 110, the charging protection circuit module 120, the RFID tag 130, the tag antenna TA and the battery BAT that constitute the secondary side of the transformer.

The charging receiver module 110 receives the power induced from the wireless charging pad 200 and supplies the power to the charging protection circuit module 120.

The charging protection circuit module 120 having

fuel gauge and charging functions includes rectifying circuits 121 and 121′ for rectifying the power supplied from the charging receiver module 110 by performing AC/DC conversion, a switch mode charging control circuit 122 for charging the battery BAT made of lithium ion or lithium polymer at Constant Voltage (CV) and Constant Current (CC), and a protection circuit 124 for detecting the charged status of the battery BAT and determining whether to supply or block the power supplied to the battery BAT from the charging control circuit 122 so as to protect the battery BAT. The charging protection circuit module 120 is constructed in such a way that the output of the charging receiver module 110 is the input of the rectifying circuits 121 and 121′ and the output of the rectifying circuits 121 and 121′ is connected to the input of the switch mode charging control circuit 122. Furthermore, the output of the charging control circuit 122 is connected to a fuel gauge 123, and the fuel gauge 123 is connected to the protection circuit 124 that protects the battery BAT from excessive charging and excessive current. Such components are mounted in the battery pack 100 of a portable device, and can be applied to a hard pack or an inner pack according to the type of the battery pack 100.

The wireless charging pad 200 functioning as a non-contact charger has various input ports having DC inputs, so that the wireless charging pad 200 can be used in

connection with various types of external power sources (e.g., the output of an AC adapter, a USB port of a computer, cigar lighter jack of a vehicle, etc.). In the wireless charging pad 200, the primary side of the transformer is provided, switching loss is reduced through zero voltage and zero current soft switching by switching at a frequency higher than a resonant point using a half-bridge resonant converter, and linkage flux is induced to the battery pack 100 of a portable device that constitutes a secondary side. Furthermore, the wireless charging pad 200 has a function of detecting the wireless identification information of the battery BAT and indicating charged status information on the wireless charging pad 200 through radio communication when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200, and a function of entering a shutdown mode and an energy saving mode when an object other than a battery pack 100 is placed on the wireless charging pad 200. Furthermore, when a plurality of portable devices is placed on the wireless charging pad 200, the wireless charging pad 200 reads the wireless identification information (e.g., personal phone numbers, etc.) stored in the RFID tag 130, indicates the wireless identification information on the wireless charging pad 200, indicates charged status, and indicates charging completion status on the wireless charging pad 200 after receiving information

on the completion of charging from the battery pack 100.

The RFID tag 130 and the tag antenna TA function to interface with the fuel gauge 123 that controls the charged status information of the battery BAT and transmit the charged status information of the battery BAT to the wireless charging pad 200 in a radio data form using a radio frequency in HF (13.56MHz) or UHF (900MHz) bands. The RFID tag 130 includes a memory block and a logic block, and stores the wireless identification information, such as a product name, a serial number and a user identification number (e.g., personal telephone number), therein. In this case, the user identification number is stored in the memory block of the RFID tag 130 through the communication between the terminal body of the portable device and the battery pack 100.

FIGS. 3 and 4 are views illustrating the components of the wireless charging pad and the battery pack according to the present invention, respectively.

Referring to FIG. 3, the wireless charging pad 200 according to the present invention includes a controller 240 for reading the RFID tag and controlling charging, drive circuits 220 and 220', and primary coils Pcoil1 and Pcoil2.

The wireless charging pad 200 may include various input ports having DC inputs, and generates the switching patterns of the primary coils Pcoil1 and Pcoil2 through the

drive circuits 220 and 220', respectively, and performs a control function of detecting portable devices placed on the wireless charging pad 200 and indicating the energy saving mode and the charged status of each of the portable devices. The drive circuits 220 and 220' are On/Off switching devices for switching the primary coils Pcoil1 and Pcoil2, respectively, each of which is composed of an upper switch and a lower switch. The drive circuits 220 and 220' are each constructed using a half-bridge or full-bridge resonant converter (serial, parallel or serial-parallel resonant converter).

Referring to FIG. 4, in the wireless charging pad 200 according to the present invention, the primary side of the transformer is constructed in such way that the two primary coils Pcoil1 and Pcoil2 are wound on a planar core, which is formed by combining small cobalt-based amorphous metallic cores, such as Co, Fe, Ni, B and Si, or ferrite cores in various shapes, in directions perpendicular to each other as shown in FIG. 4. In this case, the switching patterns perform switching so that a phase difference of 90 degrees occurs between the two primary coils Pcoil1 and Pcoil2. Accordingly, induced energy can be received regardless of the location of the portable device that is placed on the wireless charging pad 200 and has the battery pack 100 equipped with the charging receiver module 100.

The input form of the wireless charging pad 200 is

described below.

A control power source supplies the driving power of the controller 240 and the drive circuits 220 and 220' using a flyback converter in a 110/220 V direct drive fashion. In the resonant converter, DC power obtained by rectifying AC power in a 110/220 V switching fashion is always set to a 110 V input condition. DC power (12, 24, 48 V) is generated using the flyback converter for free voltages ranging from 86 to 265 V and is used as the input power of the resonant converter, and forms the driving power of the controller 240 and the drive circuits 220 and 220' using a regulator.

The controller 240 performs both a function of reading an RFID tag and a function of controlling charging. The construction of the controller 240 is described below.

First, a controller 240 is provided to detect the battery pack 100 equipped with the charging receiver module 110 and control charging. Wireless identification information, such as the product code and serial number of the battery BAT, and charged status information are read from the RFID tag 130 of the battery pack 100 through the controller 240. Furthermore, when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200 while the controller 240 in a sleep mode is maintained in a standby mode (energy saving mode: below 1 W) and monitors the battery pack 100, the

controller 240 wakes up and switches to an active mode to generate induced electromotive force by controlling the drive circuits 220 and 220', starts to charge the battery pack 100, and indicates the charged status of the battery pack 100. When the charging of the battery pack 100 is completed, the wireless charging pad 200 switches from the active mode to the energy saving mode again to save energy.

Second, when a plurality of battery packs 100 each equipped with a charging receiver modules 110 is placed on the wireless charging pad 200, wireless identification information stored in the RFID tags 130 of the battery packs 100 is read in order in which the battery packs 100 are placed. Furthermore, a fully charged battery pack 100 is indicated by a green Light Emitting Diode (LED) and a discharged battery pack 100 is indicated by a red LED. When the battery pack 100 is fully charged, the LED switches from red to green by receiving the wireless identification information of the RFID tag 130 so that the charged status is indicated by the wireless charging pad 200.

The construction of the drive circuits 220 and 220' is described below.

Two resonant converters control perpendicularly arranged primary coils Pcoil1 and Pcoil2, respectively, and the primary coils Pcoil1 and Pcoil2 are switched at a frequency higher than a resonant point so that the switching patterns of the primary coils have a phase

difference of 90 degrees. Accordingly, linkage flux rotates by 360 degrees in eight steps, thus enabling the battery pack 100 to be charged regardless of the location of the battery pack 100.

The construction of the primary side of the transformer is described below.

A single square or rectangular pad core is formed by connecting a plurality of small planar cores, is surrounded by an insulation tape, is provided with a coil wound thereon in a vertical direction, and is insulated by an insulation tape. Furthermore, the pad core is provided with a coil wound thereon in a horizontal direction and is insulated by an insulation tape, thus manufacturing the primary side of a planar transformer. In this case, the coil may be formed into a bobbinless type and be inserted into the pad core in vertical and horizontal directions. The charging receiver module 110 is operated as the secondary side of the transformer.

FIG. 5 is a view showing the charging receiver module 110. The charging receiver module 110 is manufactured in such a way that a plurality of cobalt-based amorphous metallic cores is stacked to form a single planar core, and secondary coils Scoil1 and Scoil2 are wound on the single planar core in vertical and horizontal directions, respectively. In this case, the planar core is made of an amorphous metal-based material that has high magnetic

permeability (>80,000) and a non-breakable characteristic. In the charging receiver module 110, the magnitude of induced electromotive force varies according to a function of the number of stacked cores forming the planar core, the sectional area of the planar core and the number of windings of the coils. The charging receiver module 110 has a load curve in which voltage is inversely proportional to current.

FIG. 6 is a view showing a method of generating a magnetic field depending on the switching patterns of the wireless charging pad according to the present invention.

In the wireless charging pad 200, a magnetic field rotates by 360 degrees in the case where current is applied by successively switching regions in the sequence of a first region→ a second region→ a third region→ a fourth region→ a fifth region→ a sixth region→ a seventh region→ an eighth region at a predetermined frequency, thus enabling a portable device equipped with the charging receiver module 110 to be charged regardless of the location and direction of the portable device when the portable device is placed on the wireless charging pad 200 (the magnetic field is rotated by 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°). In this case, the drive circuits 220 and 220' include two half-bridge series-parallel resonant converters to control the perpendicularly arranged primary coils Pcoil1 and Pcoil2, respectively, and switch

the primary coils Pcoil1 and Pcoil2 at a frequency higher than a resonant point so that the switching patterns of the primary coils Pcoil1 and Pcoil2 have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating by 360 degrees in the sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

FIG. 7 is a view showing the size expansion of the wireless charging pad according to the number of charging devices, according to the present invention.

In a process of forming a pad core constituting the wireless charging pad 200, a wireless charging pad 200 having a desired size and shape can be formed by combining a plurality of small cobalt-based metallic or ferrite planar cores. For example, a pad core is formed by combining m cores in a longitudinal direction and n cores in a transverse direction according to the number of portable devices desired to be charged.

FIG. 8 is a view showing the detailed construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack according to the present invention.

As shown in FIG. 8, a primary-side wireless charging pad 200 and a secondary-side battery pack 100 equipped with the charging receiver module 110 are magnetically combined with each other.

The primary-side wireless charging pad 200 includes a power input terminal, an AC/DC conversion circuit 210, a controller 240 for detecting wireless identification information transmitted from the secondary side, two half-bridge serial-parallel resonant converters, drive circuits 220 and 220′ for generating a magnetic field by generating control signals for controlling the two primary coils Pcoil1 and Pcoil2, respectively, a primary-side transformer constructed by winding the two primary coils Pcoil1 and Pcoil2 on the pad core in vertical and horizontal directions, respectively, and inductive couplers 230 and 230′ formed by providing L_r and L_r' to the corresponding primary-side transformer.

Furthermore, the primary-side wireless charging pad 200 may further include an electromagnetic wave filter 250 connected to the power input terminal for the purpose of blocking the electromagnetic waves of input AC power, and a flyback converter 210′ connected to the AC/DC conversion circuit 210 for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter 250 and rectifying the AC power into DC power and the controller 240 for the purpose of accumulating power while an equipped transistor is turned on and transmitting the accumulated power to the controller 240 when the equipped transistor is turned off so as to enable the drive circuits 220 and 220′ to be driven.

The secondary-side battery pack 100 includes a receiver module 110 composed of an amorphous metallic planar core and two secondary coils Scoil1 and Scoil2 that are wound on the planar core in vertical and horizontal directions, respectively, to be magnetically combined with the wireless charging pad 100, thus inducing induced electromotive force; a charging protection circuit module 120 for generating charged status information by periodically monitoring the charged status of a battery BAT, recording the generated charged status information in an RFID tag 130 and controlling whether to charge or discharge the battery BAT by selectively supplying or blocking the power, which is induced to the charging receiver module 110, to the battery BAT under the On/Off control of the RFID tag 130; the RFID tag 130 combined with the charging protection circuit module 120 to store the wireless identification information of the battery BAT and periodically record the charged status information therein, generate and modulate RFID data including the wireless identification information and charged status information of the battery BAT and transmit the modulated RFID data to the wireless charging pad 200 in response to an RFID carrier signal transmitted from the wireless charging pad 200 through a tag antenna TA; and the battery BAT to be charged under the control of the protection circuit 124.

The charging protection circuit module 120 may

include rectifying circuits 121 and 121' adapted to rectify the power induced to the charging receiver module 110 and supply the rectified power to a charging control circuit 122, the charging control circuit 122 combined with the rectifying circuits 121 and 121' to supply the power, rectified by the rectifying circuits 121 and 121' under the On/Off control of the RFID tag 130, to a fuel gauge 123, the fuel gauge 123 adapted to supply the power supplied from the charging control circuit 122 to the battery BAT through the protection circuit 124, and generate the charged status information by monitoring the charged status of the battery BAT and periodically record the charged status information in the RFID tag 130, and the protection circuit 124 combined with the fuel gauge 123 and the battery BAT to protect the battery BAT by controlling whether to charge or discharge in accordance with the charged status of the battery BAT.

When the RFID carrier signal is transmitted from the wireless charging pad 200 through the tag antenna TA, the RFID tag 130 generates and modulates RFID data that includes previously stored wireless identification information of the battery BAT and charged status information, which is periodically recorded through the fuel gauge 123, in response to the RFID carrier signal, and transmits the modulated RFID data to the wireless charging pad 200. In this case, the RFID tag 130 is composed of a

memory block and a logic block. The memory block can be implemented using ROM 134 in which the wireless identification information and the charged status information are recorded. It is preferable to use Electrically Erasable and Programmable Read Only Memory (EEPROM) as the ROM 134. The logic block can be implemented using a clock extraction unit 131 for extracting a clock from the RFID carrier signal that is wirelessly received from the wireless charging pad 200, a sequencer 132 for inspecting the sequence of arranged data extracted from the clock extraction unit 131 and transmitting a control signal to a data encoder 133, the data encoder 133 for receiving the wireless identification information and charged status information of the battery BAT from a tag 135 when the control signal is transmitted from the sequencer 132, encoding the received information and transmitting the encoded information to a data modulator 136, the data modulator 136 for generating the modulated RFID data by modulating the data received from the data encoder 133 and wirelessly transmitting the modulated RFID data to the wireless charging pad 200, and the tag 135 for reading the wireless identification information and charged status information of the battery BAT stored in the ROM 134 and transmitting the wireless identification information and charged status information to the data encoder 133.

FIG. 9 is a flowchart showing a method of charging a

battery through the wireless charging pad of FIG. 8. The method of charging a battery using the wireless charging pad 200 according to the present invention is described with reference to FIG. 9 below.

Step S100) First, when the secondary-side battery pack 100 is placed on the primary-side wireless charging pad 200, the primary-side wireless charging pad 200 generates an RFID carrier signal and inspects an object placed on the wireless charging pad 200.

Step S110) If, as a result of the inspection, the object does not contain information indicating that the object is a battery pack 100 equipped with a charging receiver module 110, the primary-side wireless charging pad 200 always enters an energy saving mode.

Step S120) If, as a result of the inspection, the object contains information indicating that the object is a battery pack 100 equipped with a charging receiver module 110, the wireless charging pad 200 wakes up to detect wireless identification information and starts charging control.

Step S130) Wireless identification information about the battery pack 100 of each of various portable devices is displayed, and whether the battery pack 100 is in charging status or fully charged status is indicated after receiving charged status information. The battery 100 in fully charged status that indicates charging is completed is

indicated by a green LED, and the battery 100 being charged is indicated by a red LED.

Step S140) When the fully charged status in which the charging of all the battery packs 100 are completed is established, the wireless charging pad 200 collects the wireless identification information and enters a standby mode, that is, the energy saving mode.

FIGS. 10 and 11 are views showing the equivalent circuits of series and parallel resonant converters provided to the wireless charging pad according to the present invention.

FIGS. 10 and 11 are views showing the equivalent circuits of a separative transformer that has a gap between the wireless charging pad 200 and the battery pack 100. In a non-contact type charging method in which energy is transmitted using the magnetic coupling of the transformer, the primary side of the transformer is included in the wireless charging pad 200 functioning as a non-contact charger and the secondary side of the transformer is included in the battery pack 100, so that a gap exists between the primary and secondary sides, thus causing inefficiency in energy transmission because a coupling coefficient and magnetizing inductance are reduced and leakage inductance is increased. Besides, it is problematic in that it is difficult to electrically transmit output information to a primary-side controller at the time of

controlling feedback. In the present invention, in order to overcome the disadvantages of the separative transformer and effectively transmit energy, a half-bridge serial resonant converter is applied to the primary side of the transformer. The serial resonant converter applied to the primary side of the transformer reduces the influence of leakage inductance on the primary side of the separative transformer, thus enabling effective energy transmission.

The self-inductance L_1 and L_2 are measured in such a way that a secondary-side module is opened and primary-side inductance is measured, and the leakage inductance L_{l1} and L_{l2} are measured in such a way that a secondary-side module is shorted and primary-side inductance is measured.

Mutual inductance L_M is calculated in such a way that impedance L_P is measured by connecting the primary and secondary sides in parallel, impedance L_S is measured by connecting the primary and secondary sides in series, and the measured impedance L_P and L_S are substituted for L_P and L_s of Equation 1,

$$L_M = \frac{L_P - L_S}{4} \quad (1)$$

The magnetizing inductance L_m is measured using Equations 2 to 4,

$$L_m = L_M(\frac{N_1}{N_2}), \quad N = \frac{N_2}{N_1} \tag{2}$$

(N_1: number of primary windings, N_2: number of secondary windings)

$$k = \frac{L_M}{\sqrt{L_1 L_2}} \tag{3}$$

$$L_{l1} = L_1 - L_m, \quad L_{l2} = L_2 - NL_M \tag{4}$$

Voltage imposed in the primary side of the transformer is applied to the primary side of the transformer through the voltage distribution of L_{l1} and L_{l2}, and is transmitted to the secondary side based on a winding ratio. The secondary-side voltage is transmitted to the actual secondary side of the transformer through the voltage distribution of L_{l2} and secondary-side load, so that the voltage gain is lower than that of an ideal transformer.

Furthermore, if the coupling coefficient is low, the magnetizing inductance L_m of the transformer is low, so that current flowing to the primary side of the transformer is not transmitted to the secondary side of the transformer through L_{l2}, but is circulated and transmitted to the first side of the transformer again through the magnetizing inductance L_m that has lower impedance. That is, in order to supply current required by the load, input current must be large. If the primary-side current increases, continuity loss in a switch increases, thus causing the efficiency of

a system to decrease. Accordingly, in order to increase the efficiency of the system by reducing the primary-side current, the coupling coefficient of the transformer must be increased. In the non-contact charger, the primary- and secondary-side cores are separated by a gap, and winding areas are also separated. Furthermore, the gap is located in a path through which magnetic flux passes, so that magnetic resistance is increased, thus lowering the magnetic flux density inside the cores.

When a large gap exists between the primary- and secondary-side cores, magnetic flux density is expressed by Equation 5,

$$B_f = \frac{NI}{\frac{l_f}{\mu_f} + \frac{l_g}{\mu_o}} \approx \frac{\mu_o NI}{l_g} (\mu_f >> \mu_o) \quad (5)$$

(B: magnetic flux density, N: number of windings, I: current flowing through transformer, l_f: length of magnetic path of core, l_g: length of magnetic path in gap, μ_f: magnetic permeability of core, μ_o: magnetic permeability of gap)

The magnetic flux density, when the gap does not exist, is expressed by Equation 6,

$$B_f = \frac{\mu_f NI}{l_f} >> B_f \quad (6)$$

The magnetic permeability of the core is considerably larger than that of air, and the size of the gap is relatively larger than that of the core, so that the magnetic flux density in the case where the gap does not exist has a value considerably higher than that in the case where the gap is large. As a result, in the case of a transformer having a large gap, it is difficult for saturation status to occur inside the core, and also local saturation status is not generated easily. Accordingly, with respect to the shape of a core, a narrow section or protrusion is allowed. Furthermore, the magnetic flux density in the core is low, so that core loss due to hysteresis is also low.

Since the gap is large, the magnetic resistance is increased, so that the inductance of the core is decreased. Accordingly, in order to obtain required magnetizing inductance, the number of windings is increased and a wider winding area is required as a result.

The magnetizing inductance L_m may be expressed by Equation 7,

$$L_m = L_M(\frac{N_1}{N_2}) = \frac{N_1}{N_2}(\frac{N_1 N_2}{R_m}) = \frac{N_1^2}{R_m} \quad (7)$$

(R_m: magnetic resistance, N_1: number of primary windings, N_2: number of secondary windings, L_M: mutual inductance)

That is, since the magnetic resistance R_m is large, the number of windings is increased to obtain the required magnetizing inductance L_M. Generally, the difference between the primary- and secondary-side voltages of a non-contact charger is large, so that a difference in the winding ratio is also large. As a result, since the winding areas of the primary and secondary sides are different and the difference between the winding ratios is large, the shapes of the primary- and secondary-side cores are generally asymmetric.

Most leakage magnetic flux is generated in the gap existing between the primary- and secondary-side cores, so that a section area of the cores opposite to each other must be large to increase the coupling coefficient in the transformer. However, in the case of a transformer used in the non-contact charger, the volume and weight of the secondary-side core are limited because the secondary-side core is located inside the battery pack, so that the section area of the cores opposite to each other is also limited. However, in the present invention, a planar pad core, the section area of which is large in considerations of limited volume and weight, is used.

FIGS. 12 to 17 are views showing the operation of the half-bridge serial resonant converter provided to the wireless charging pad of the present invention, according

to modes.

FIGS. 12 to 17 are views showing the operation of the half-bridge serial resonant converter (upper converter), according to modes.

In FIG. 12, when Q_1 is turned on, current i_1 flows to a transformer through the switch Q_1. In FIG. 13, when the switch Q_1 is turned off, the current i_1 flows while discharging the parallel capacitor of a switch Q_2 and charging the parallel capacitor of the switch Q_1. In FIG. 14, when the voltage of the switch Q_2 is zero (the voltage of the switch Q_1 is input voltage), the current i_1 flows through the parallel diode of the switch Q_2, and the voltage of the switch Q_2 remains at zero. Furthermore, if the switch Q^2 is turned on before the direction of the current i_1 is reversed, Zero Voltage Switching (ZVS) is achieved in the switch Q_2. In FIG. 15, when the direction of the current i_1 is reversed, the current i_1 flows through the switch Q^2. In FIG. 16, when the switch Q^2 is turned off, the current i_1 flows while discharging the parallel capacitor of the switch Q^1 and charging the parallel capacitor of the switch Q^2. In FIG. 17, when the voltage of the switch Q^2 is zero (the voltage of the switch Q^2 is the input voltage), the current i_1 flows through the parallel diode of the switch Q^1, and the voltage of the switch Q^1 remains at zero. Furthermore, when the switch Q^1 is turned on before the direction of the current is restored, the ZVS is achieved

in the switch Q^1.

In order to achieve the ZVS of the switch Q^2, the magnitude of the current i_1 at the time of being changed from FIG. 12 to FIG. 13 must be large enough so that the energy of a magnetic circuit depending on the current i_1 can charge or discharge the parallel capacitor, and the gate signal of the switch Q^2 must be provided before the direction of the current i_1 is reversed. The switch Q^1 can achieve the ZVS using the same principle.

In this case, a resonant frequency considerably affects efficiency. The switching frequency is operated at a frequency close to the resonant frequency, so that the core loss and gap loss of the transformer are reduced if the resonant frequency is low. However, the loss may be increased because magnetic current, that is, the primary-side current of the transformer, is increased. Accordingly, the switching loss attributable to the ZVS is reduced by selecting a switching frequency higher than the resonant frequency.

FIG. 18 is a view showing the voltage and current waveforms of the transformer according to the gate signal of the half-bridge series resonant converter provided in the wireless charging pad of the present invention.

Referring to FIG. 18, square wave voltage identical to the input voltage is applied to the transformer by the gate signals of the switches Q^1 and Q^2, and sine wave current

identical to the current i_1 flows to the transformer through the resonant circuit.

FIG. 19 is a view showing the rotating directions of the magnetic field according to the operation of the half-bridge series resonant converter provided in the wireless charging pad of the present invention, according to modes.

FIG. 20 is a view showing the rotating directions of the magnetic field generated according to the operation of the half-bridge series resonant converter according to modes. Accordingly, since the magnetic field rotates by 360 degrees, induced electromotive force can be transmitted to the secondary side regardless of the location and direction of the battery pack 100 when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200.

FIGS. 20 to 23 are views showing the rectifying circuits of the charging receiver module according to the present invention.

Referring to FIGS. 20 to 23, the secondary-side charging receiver module 110 transmits power through a series-parallel resonant center tap half-bridge rectifying circuit that uses the output of a single center tap rectifying diode and an output filter capacitor, or through a series-parallel resonant full-bridge rectifying circuit that uses the output of a full-bridge rectifying diode and an output filter capacitor.

FIG. 24 is a view showing the construction of a controller provided in the wireless charging pad of the present invention.

The controller 240 provided in the wireless charging pad 200 of the present invention determines whether a battery pack 100 is placed on the wireless charging pad 200, reads wireless identification information, which is stored in the RFID tag 130, from the battery pack 100 if the battery pack 100 is placed, determines whether the battery pack 100 needs to be charged or how many battery packs 100 are placed, and generates a drive control signal and indicates the charged status of each of the battery packs at the same time.

Referring to FIG. 24, the controller 240 provided in the wireless charging pad 200 of the present invention may include an oscillator 241 for generating an oscillation signal of a certain frequency, an antenna driver 242, a demodulator 243 for demodulating RF data received by the antenna driver 242, a filter and amplification unit 244 for filtering wireless identification information and charged status information from the demodulated data and amplifying the filtered information, a data decoder 245 for decoding the wireless identification information and charged status information received by the filter and amplification unit 244, a driver control unit 246 for performing mode conversion according to the charged status based on the

decoded data, a display unit 247 for displaying the data decoded by the data decoder 245, a timer 248, and a reset unit 249.

The antenna driver 242 uses the oscillation signal of the oscillator 241 as a clock, monitors the access of the battery pack 100, and wirelessly receives RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack 100, in response to an RF carrier signal through the reader antenna RA when the battery pack 100 makes access. In this case, a polling method of periodically transmitting the RF carrier signal to the outside through the reader antenna RA and monitoring whether a return signal exists can be applied as a method of the antenna driver 242 monitoring the access of the battery pack 100.

Furthermore, in the case where a plurality of battery packs 100 is placed, the controller 240 reads the wireless identification information and charged status information of each of the battery packs 100 in order in which the battery packs 100 are placed, indicates the charged status of each of the battery packs 100, and switches from an active mode to an energy saving mode when all the battery packs 100 are completely charged, and thereby, the fully charged status is established.

FIG. 25 is a view showing the flow of the RF signal between the wireless charging pad and the battery pack

according to the present invention.

Referring to FIG. 25, when the controller 240 accesses the RFID tag 130 in the battery pack 100 equipped with the charging receiver module 110 to access information on the battery BAT using a carrier frequency in HF (3 to 30 MHz) or UHF (300 to 3000 MHz) bands, the battery information stored in the memory block of the RFID tag 130 is transmitted to the wireless charging pad 200 in a modulated RF signal form.

The present invention may be modified in various forms without departing from the basic concept of the invention according to the demands of those skilled in the art.

CLAIMS

1. A wireless charging pad (200) for charging a battery pack (100) mounted on a portable device in a non-contact manner, to which a radio frequency identification technology is applied, comprising:

a controller (240) for switching to an active mode and controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack (100) is detected, for transmitting a Radio Frequency (RF) carrier signal to the battery pack (100) in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information of the battery pack (100), through a reader antenna (RA) in response to the RF carrier signal, and indicating the charged status of the battery pack (100), and for switching to the energy saving mode again when charging of the battery pack (100) is completed;

the drive circuits (220 and 220') for switching two primary coils (Pcoil1 and Pcoil2) under control of the controller (240); and

a primary-side transformer formed by constructing a pad core, which is adapted to generate induced electromotive force through switching of the drive circuits (220 and 220') and charge the battery pack (100), and which is formed by connecting a plurality of small cobalt-based

amorphous metallic or ferrite planar cores in a square or rectangular shape, and winding two primary coils (Pcoil1 and Pcoil2) on the pad core in directions perpendicular to each other.

2. The wireless charging pad according to claim 1, wherein the controller (240) reads wireless identification information and charged status information of each of battery packs (100) in order in which battery packs (100) are placed, indicates charged status of each battery pack (100), and switches to the energy saving mode when charging of all the battery packs (100) are completed, and therefore, fully charged status is established.

3. The wireless charging pad according to claim 1 or 2, wherein the controller (240) comprises an oscillator (241) for generating an oscillation signal of a certain frequency; an antenna driver (242) for using the oscillation signal of the oscillator (241) as a clock, monitoring the access of the battery pack (100) by transmitting the RF carrier signal to an outside through the reader antenna (RA) and monitoring whether a return signal exists, and wirelessly receiving RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack (100), in response to the RF carrier signal when the

battery pack (100) makes access; a demodulator (243) for demodulating the RF data received by the antenna driver (242); a filter and amplification unit (244) for filtering the wireless identification information and charged status information from the demodulated data and amplifying the filtered information; a data decoder (245) for decoding the wireless identification information and the charged status information received by the filter and amplification unit (244); and a display unit (247) for displaying the data decoded by the data decoder (245).

4. The wireless charging pad according to claim 1, wherein the drive circuits (220 and 220') include two half-bridge series-parallel resonant converters to control the primary coils (Pcoil1 and Pcoil2) perpendicular to each other, and switch the primary coils (Pcoil1 and Pcoil2) at a frequency higher than a resonant point so that switching patterns of the primary coils (Pcoil1 and Pcoil2) have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating in a sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

5. The wireless charging pad according to claim 1, further comprising:

an electromagnetic wave filter (250) combined with a

power input terminal to block electromagnetic waves from Alternating Current (AC) power input; an AC/Direct Current (DC) conversion circuit (210) for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter (250) and rectifying the AC power into DC power; and a flyback converter (210') connected to the AC/DC conversion circuit (210) and the controller (240) to accumulate power while a transistor is turned on and transmit the accumulated power to the controller (240) when the transistor is turned off so as to drive the drive circuits (220 and 220').

6. The wireless charging pad according to claim 1, wherein the wireless charging pad (200) includes input ports that are combined with at least one of an AC adapter, a Universal Serial Bus (USB) port and a cigar lighter jack for a vehicle.

7. The wireless charging pad according to claim 1, wherein the wireless identification information corresponds to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in an Radio Frequency Identification (RFID) tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

8. The wireless charging pad according to claim 1, wherein the RF carrier signal is a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in High Frequency (HF) (3 to 30 MHz) or Ultra High Frequency (UHF) (300 to 3000 MHz) bands.

9. A battery pack (B) mounted on a portable device to be charged by a wireless charging pad (A) in a non-contact manner, to which a radio frequency identification technology is applied, comprising:

a charging receiver module (110) formed of an amorphous metallic planar core and two secondary coils (Scoil1 and Scoil2), which are wound on the planar core in vertical and horizontal directions, to induce power through magnetic coupling with the wireless charging pad (200);

a charging protection circuit module (120) combined with the charging receiver module (110) and the battery (BAT) to record charged status information generated by periodically monitoring charged status of the battery (BAT) in an RFID tag (130), and to control whether to charge or discharge the battery (BAT) by selectively supplying or blocking the power induced to the charging receiver module (110) to the battery (BAT);

the RFID tag (130) combined with the charging protection circuit module (120) to store wireless

identification information of the battery (BAT), to periodically record the charged status information, and to generate and modulate RF data including the wireless identification information and charged status information of the battery (BAT) and transmit the modulated RF data to the wireless charging pad (200) when an RF carrier signal is transmitted from the wireless charging pad (200) through a tag antenna (TA); and

the battery (BAT) to be charged under control of the protection circuit (124).

10. The wireless charging pad according to claim 9, further comprising an amorphous metallic electromagnetic protector (140) for minimizing a rise in temperature of the battery (BAT) attributable to frequency interference, which is caused by radio signals or induced electromotive force in a magnetic field, or attributable to inductive heating, by magnetically blocking a gap between the battery (BAT) and the charging receiver module (110).

11. The wireless charging pad according to claim 9 or 10, further comprising a battery casing (150) manufactured using a cool polymer to perform an operation of emitting heat generated due to charging while admitting the induced electromotive force, and to entirely surround a structure that is formed by assembling the components.

12. The wireless charging pad according to claim 9, wherein the charging protection circuit module (120) comprises:

rectifying circuits 121 and 121' for rectifying the power induced to the charging receiver module (110) and supplying the rectified power to a charging control circuit (122); the charging control circuit (122) combined with the rectifying circuits (121 and 121') to supply the power rectified by the rectifying circuits (121 and 121') to a fuel gauge (123) under On/Off control of the RFID tag (130); the fuel gauge (123) for supplying the power supplied from the charging control circuit (122) to the battery (BAT) through a protection circuit (124), and generating the charged status information while monitoring the charged status of the battery (BAT), and periodically recording the charged status information in the RFID tag (130); and the protection circuit (124) combined with the fuel gauge (123) and the battery (BAT) to protect the battery (BAT) by controlling whether to charge or discharge according to the charged status of the battery (BAT).

13. The wireless charging pad according to claim 12, wherein the rectifying circuits (121 and 121') are series-parallel resonant center tap half-bridge rectifying circuits using an output of a single center tap rectifying

diode and an output filter capacitor, or series-parallel resonant full-bridge rectifying circuits using an output of a full-bridge rectifying diode and an output filter capacitor.

14. The wireless charging pad according to claim 9, wherein the RFID tag (130) comprises:

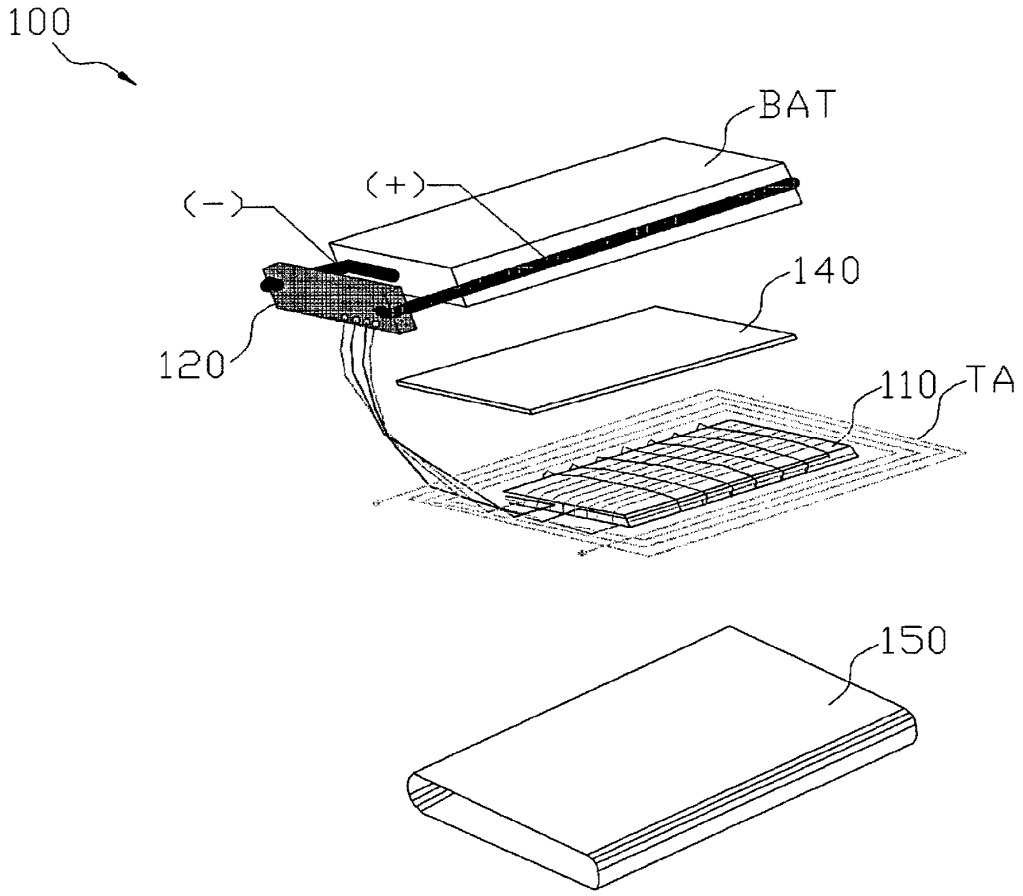
a clock extraction unit (131) for extracting a clock from the RF carrier signal wirelessly received from the wireless charging pad (200); a sequencer (132) for inspecting an sequence of arranged data extracted from the clock extraction unit (131) and transmitting a control signal to a data encoder (133); the data encoder (133) for receiving the wireless identification information and charged status information of the battery (BAT) from a tag (135) when the control signal is transmitted from the sequencer (132), and transmitting the wireless identification information and charged status information to a data modulator (136) after coding the wireless identification information and charged status information; the data modulator (136) for generating RF data generated by modulating the data received from the data encoder (133), and wirelessly transmitting the RF data to the wireless charging pad (200); Read Only Memory (ROM) (134) for recording the wireless identification information and charged status information therein; and the tag (135) for

reading the wireless identification information and charged status information of the battery (BAT) stored in the ROM (134), and transmitting the wireless identification information and charged status information to the data encoder (133).

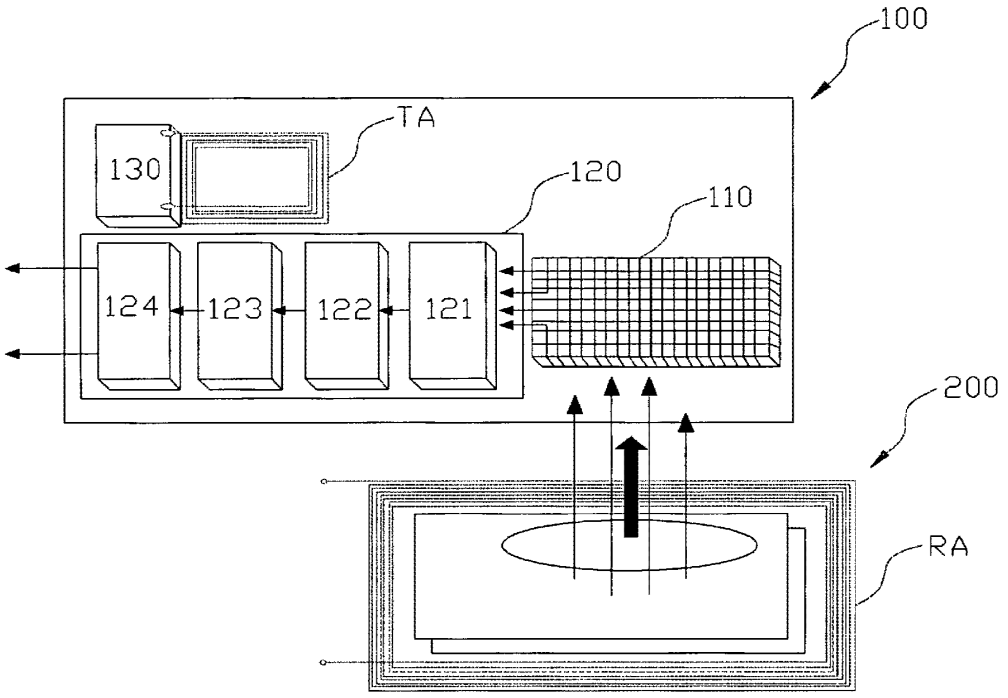
15. The wireless charging pad according to claim 9, wherein the wireless identification information corresponds to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in the RFID tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

16. The wireless charging pad according to claim 9, wherein the RF carrier signal is a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in HF (3 to 30 MHz) or UHF (300 to 3000 MHz) bands.

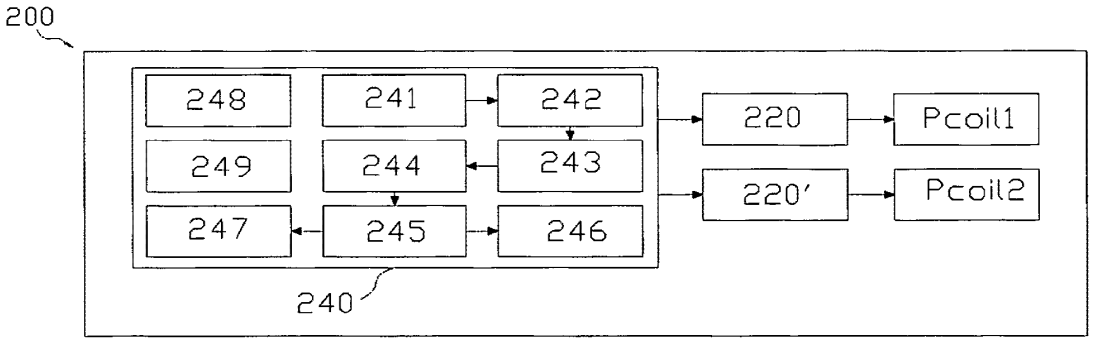
【FIG. 1】



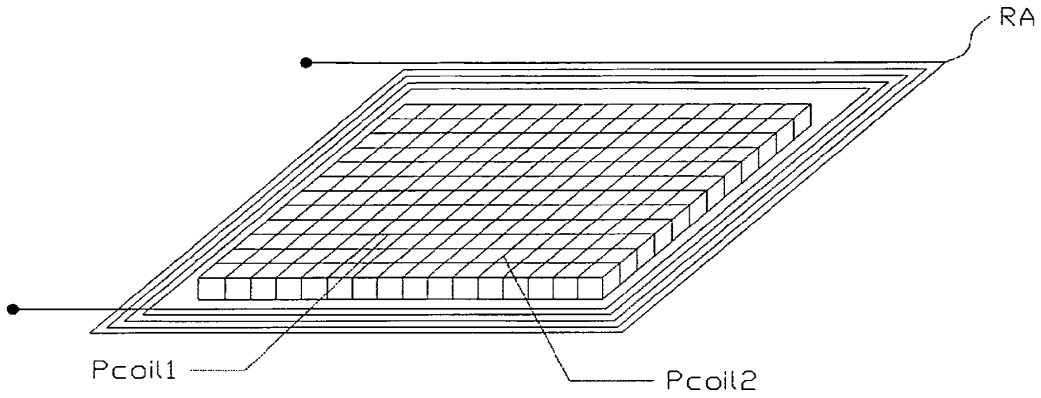
【FIG. 2】


100
TA
130
120
110
124
123
122
121
200
RA

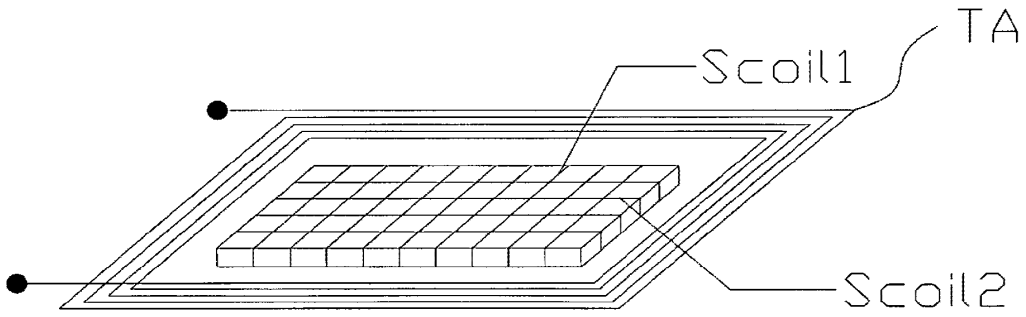
【FIG. 3】


200
248
241
242
249
244
243
247
245
246
240
220
Pcoil1
220'
Pcoil2

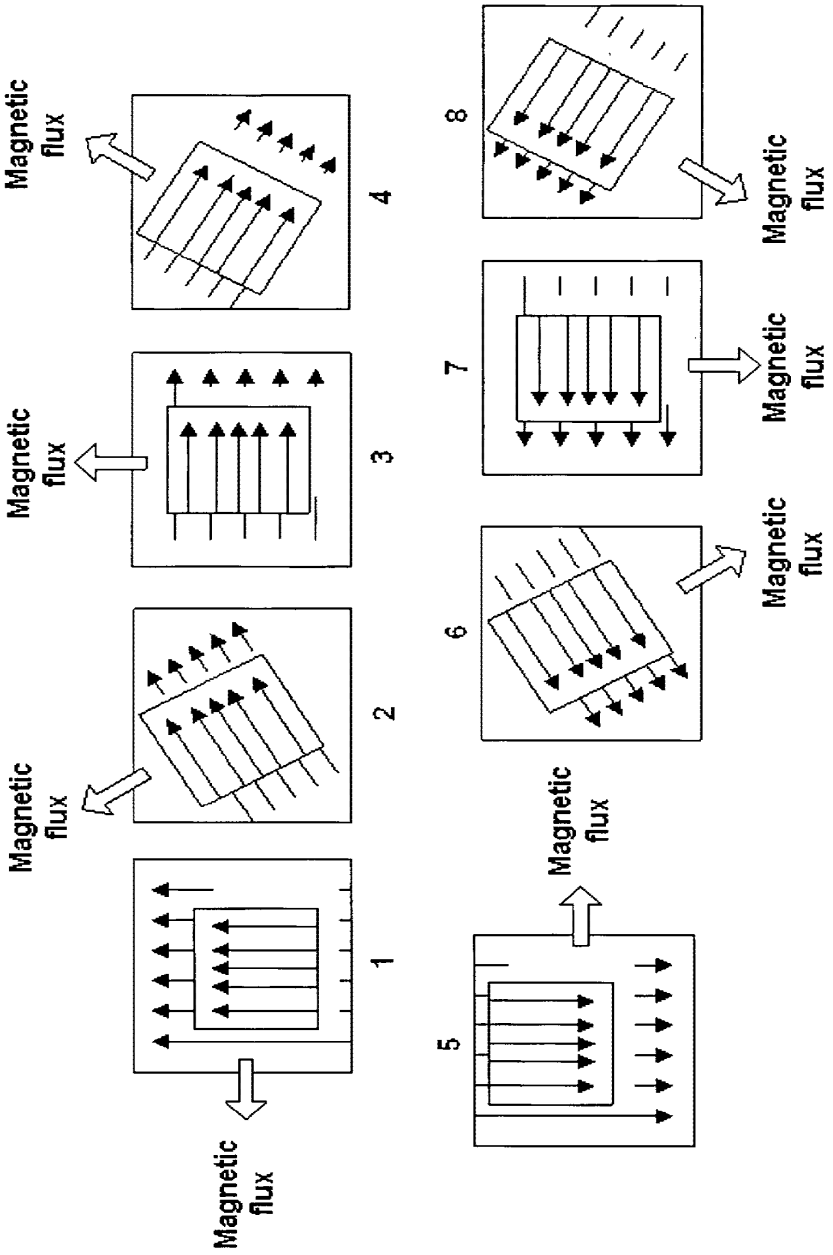
【FIG. 4】



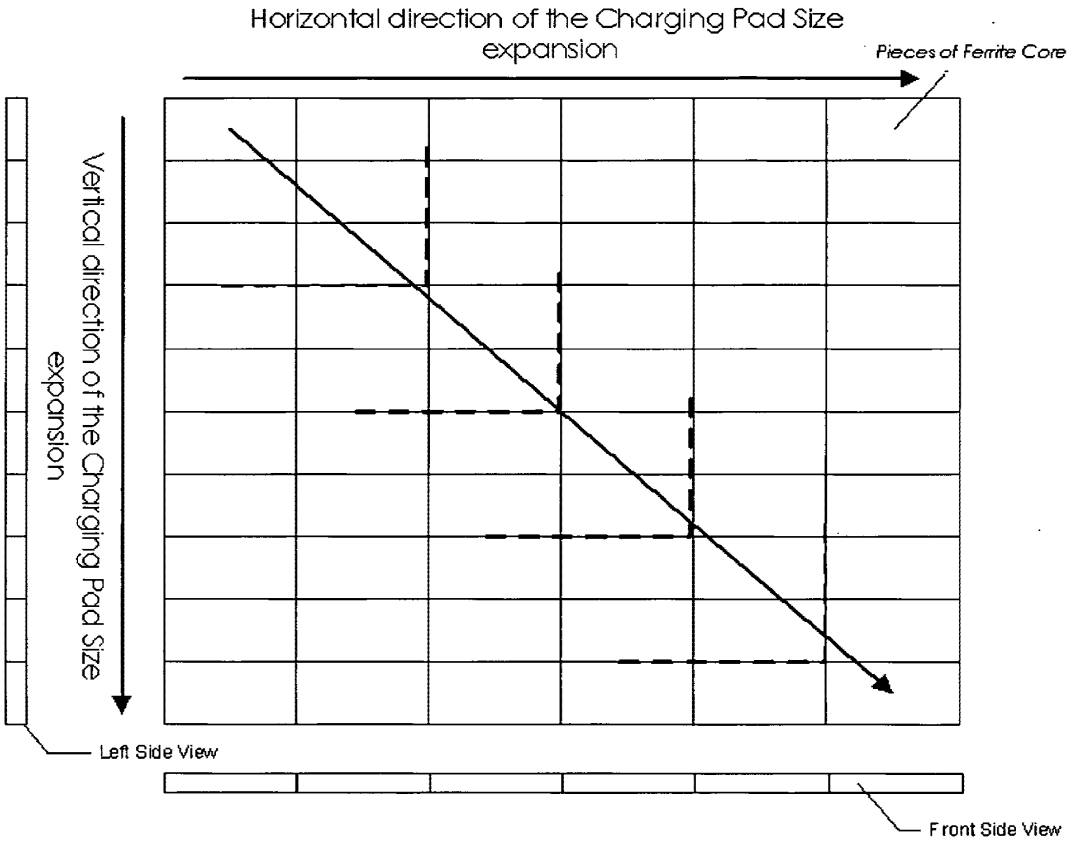
【FIG. 5】



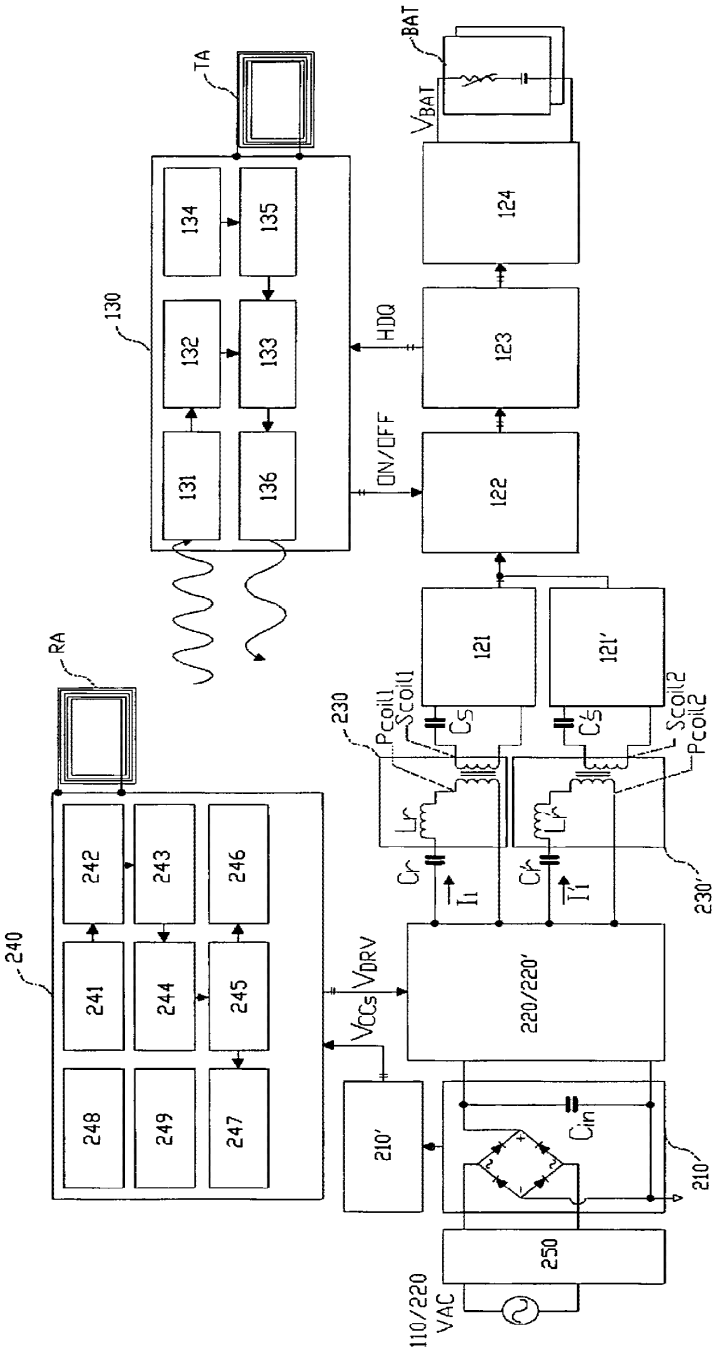
【FIG. 6】


Magnetic flux
1
Magnetic flux
2
Magnetic flux
3
Magnetic flux
4
Magnetic flux
5
Magnetic flux
6
Magnetic flux
7
Magnetic flux
8

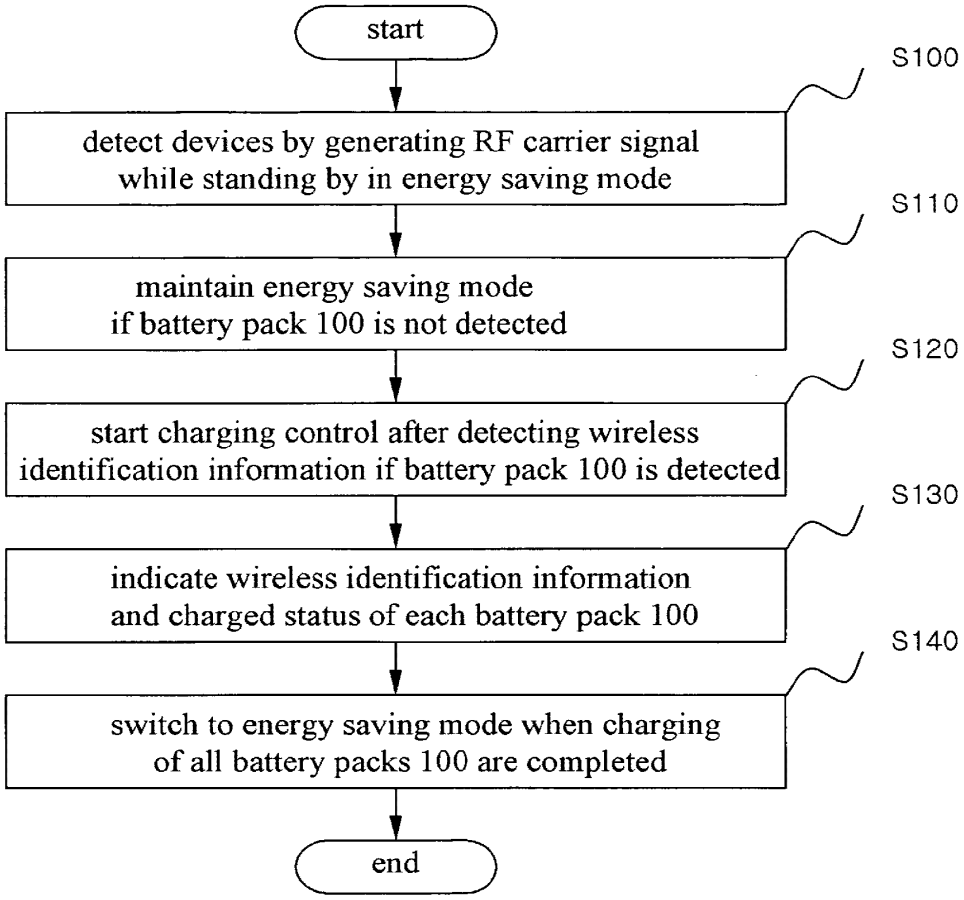
【FIG. 7】


Horizontal direction of the Charging Pad Size expansion
Pieces of Ferrite Core
Vertical direction of the Charging Pad Size expansion
Left Side View
Front Side View

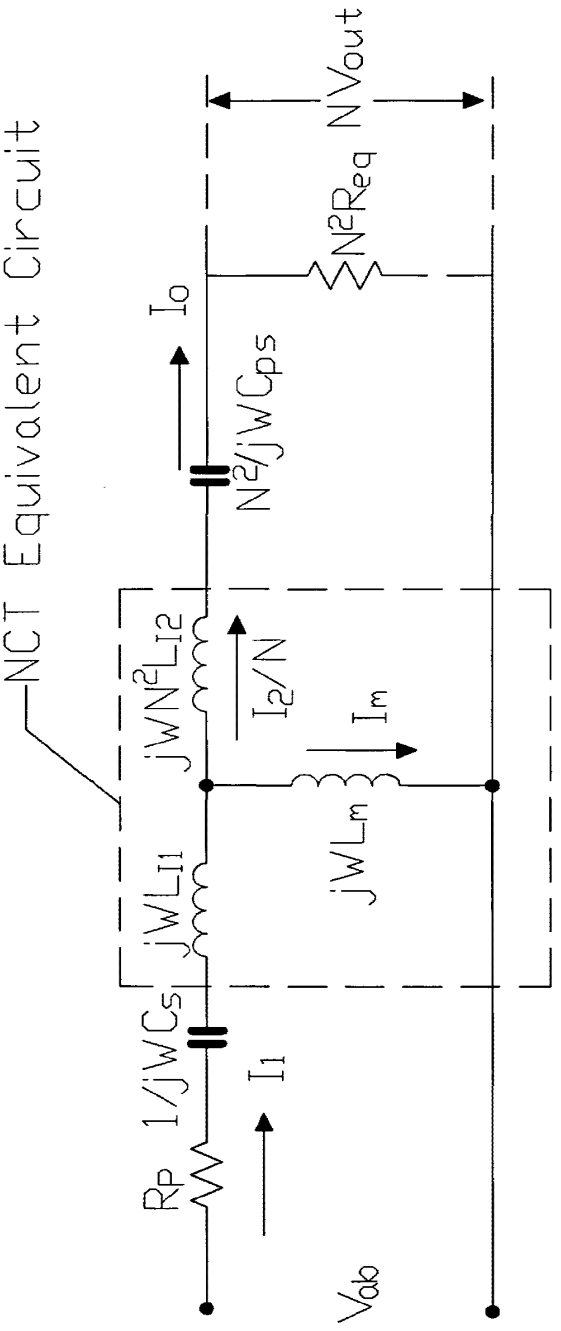
【FIG. 8】


TA
BAT
V_{BAT}
124
123
122
130
134
135
132
133
131
136
HDQ
ON/OFF
121
121'
RA
230
Pcoil1
Scoil1
Scoil2
Pcoil2
Cs
Cs
Lp
Lp
Cp
Cp
I1
I1'
230'
240
242
243
246
241
244
245
248
249
247
V_{DRV}
V_{CCS}
220/220'
210'
C_{in}
210'
250
110/220
VAC

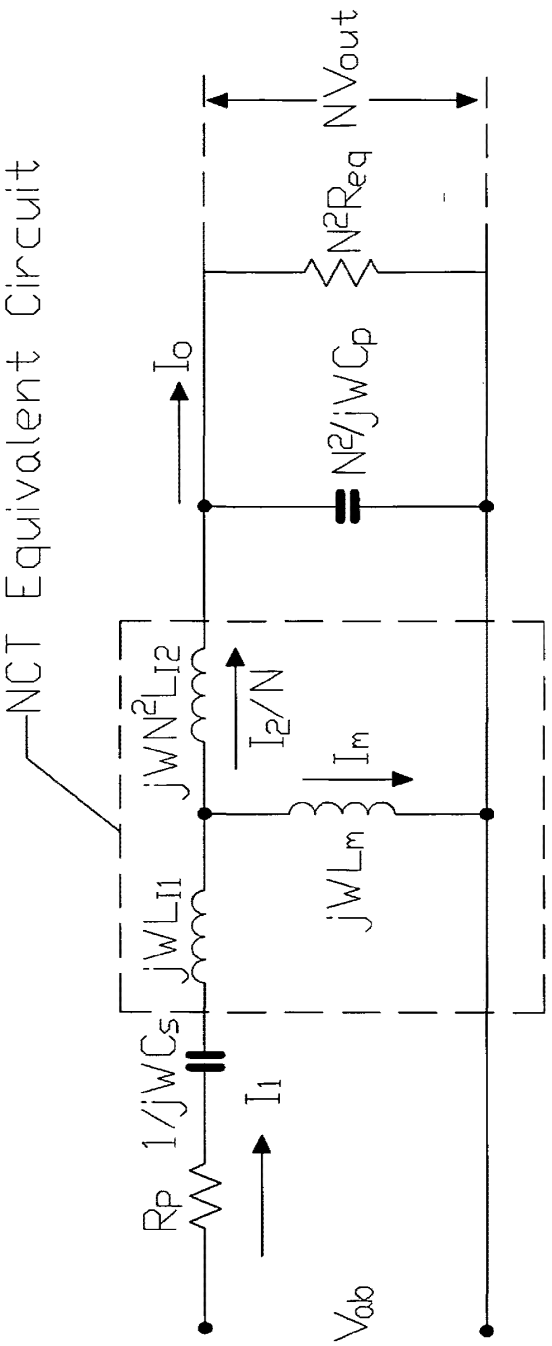
【FIG. 9】


start
S100
detect devices by generating RF carrier signal while standing by in energy saving mode
S110
maintain energy saving mode if battery pack 100 is not detected
S120
start charging control after detecting wireless identification information if battery pack 100 is detected
S130
indicate wireless identification information and charged status of each battery pack 100
S140
switch to energy saving mode when charging of all battery packs 100 are completed
end

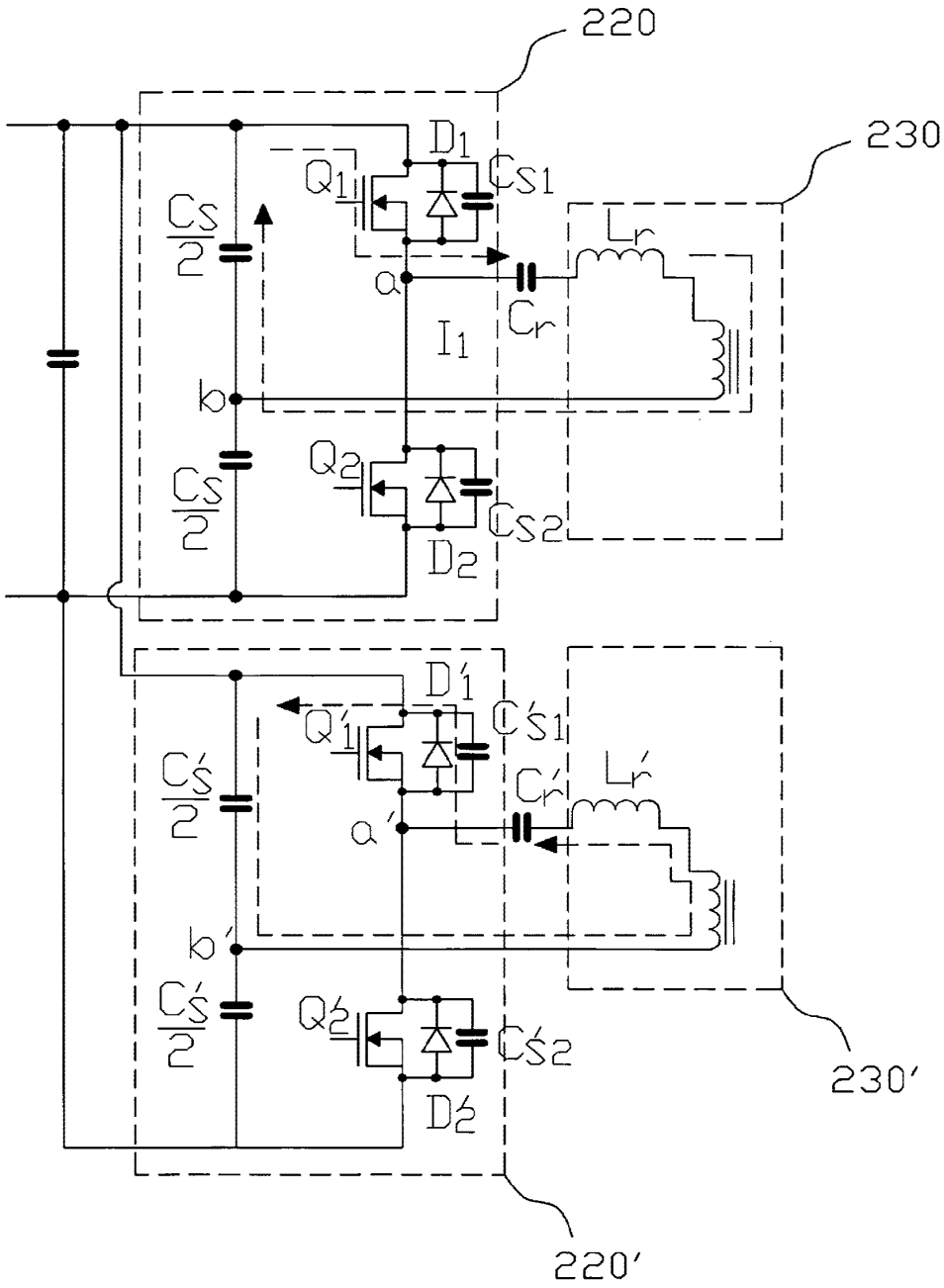
【FIG. 10】


NCT Equivalent Circuit
NVout
N²Req
Io
N²/jwCps
I2/N
Im
jwN²LI2
jwLm
jwLI1
1/jwCs
Rp
I1
Vab

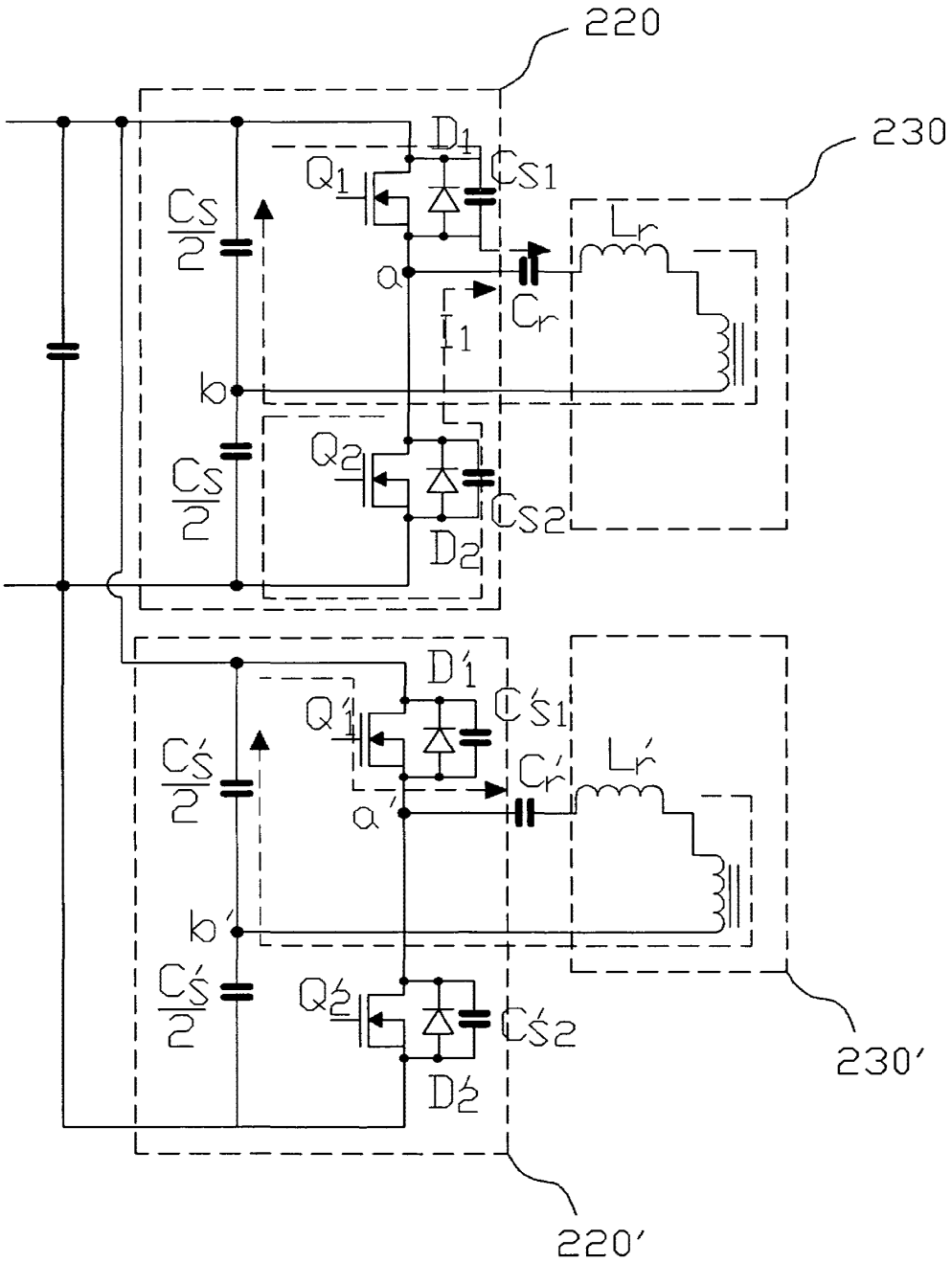
【FIG. 11】


NCT Equivalent Circuit
NVout
N²Req
Io
N²/jWCp
I2/N
Im
jWN²LI2
jWLm
jWLI1
1/jWCs
RP
I1
Vab

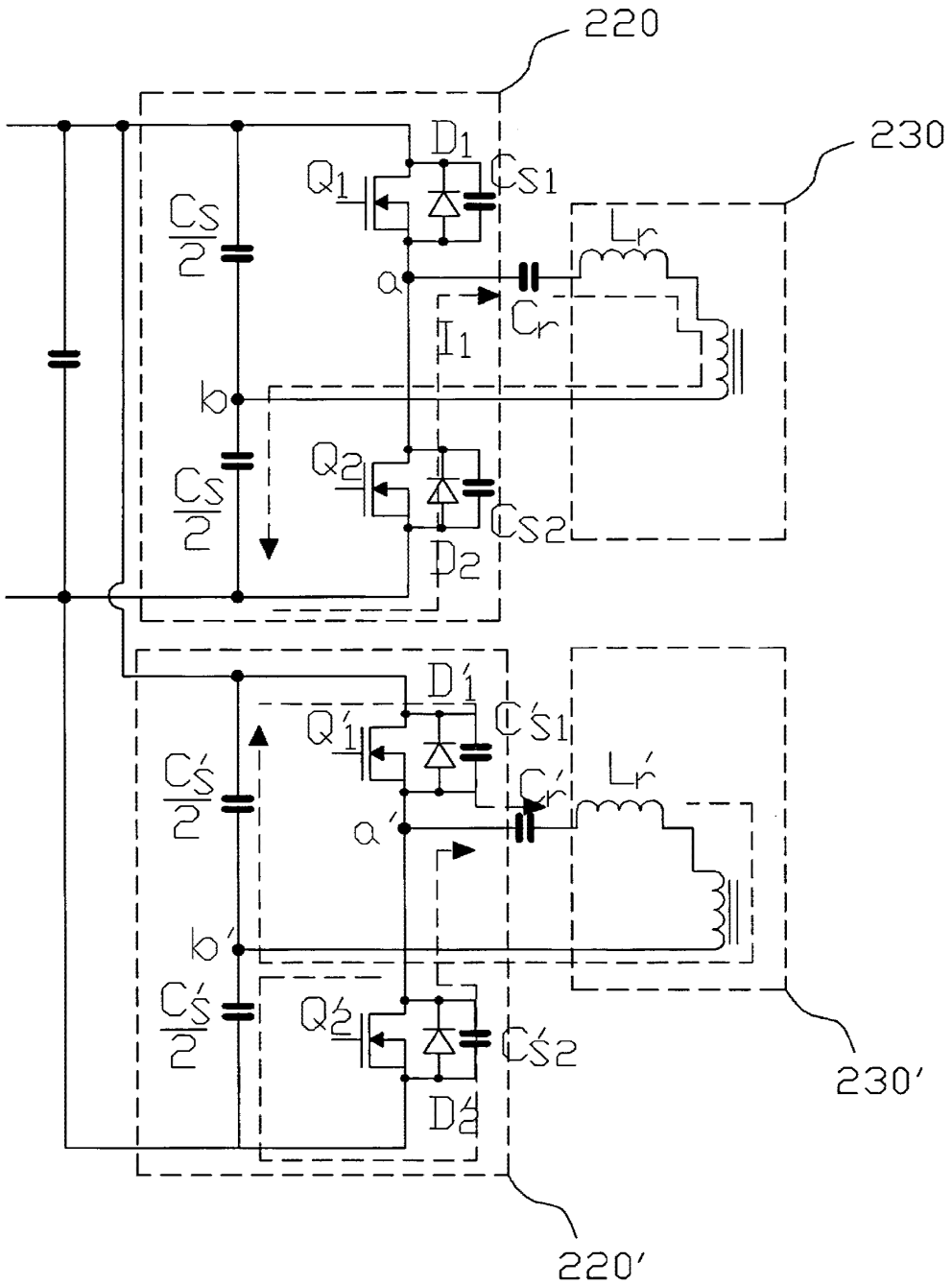
【FIG. 12】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

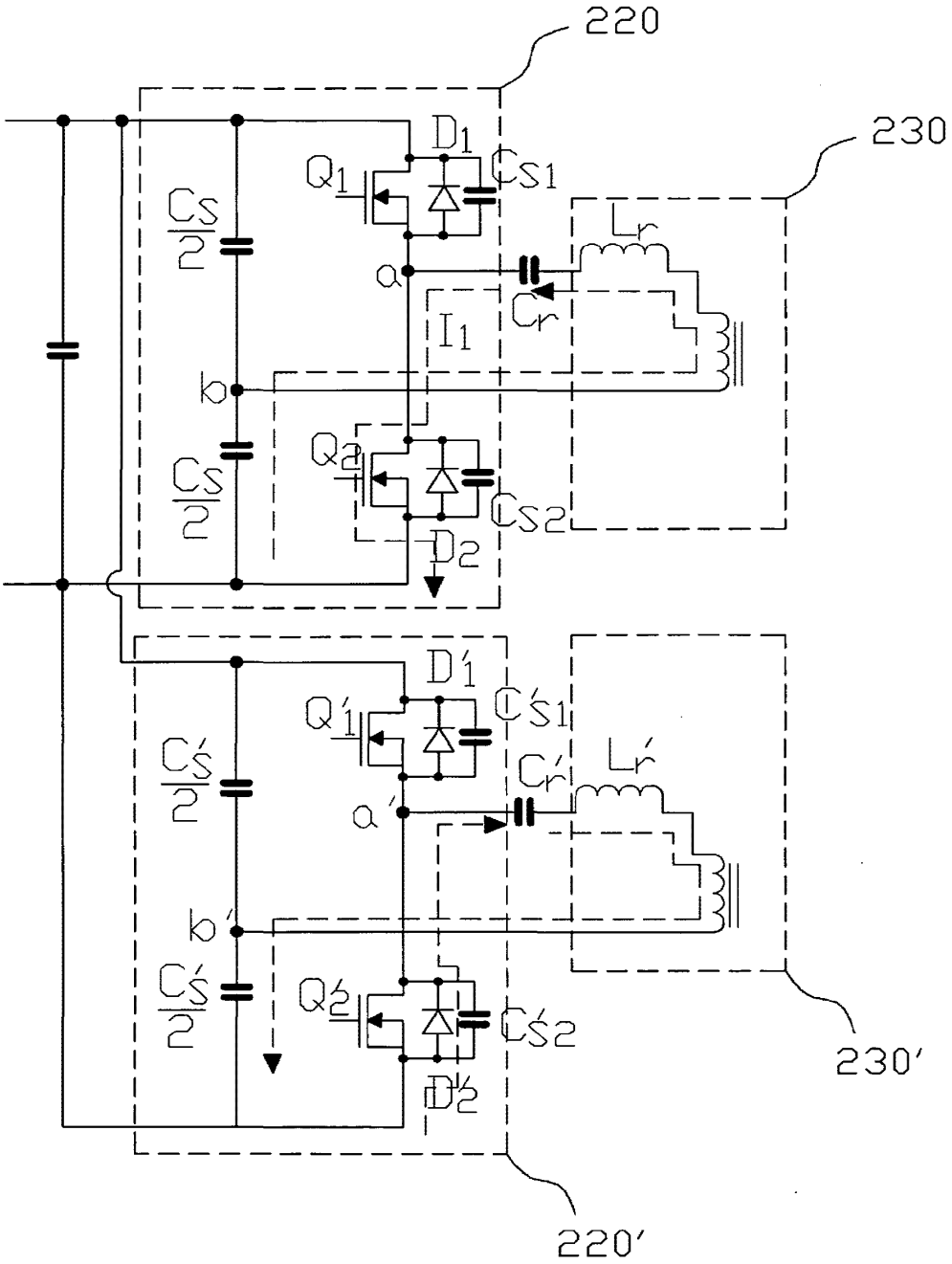
【FIG. 13】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

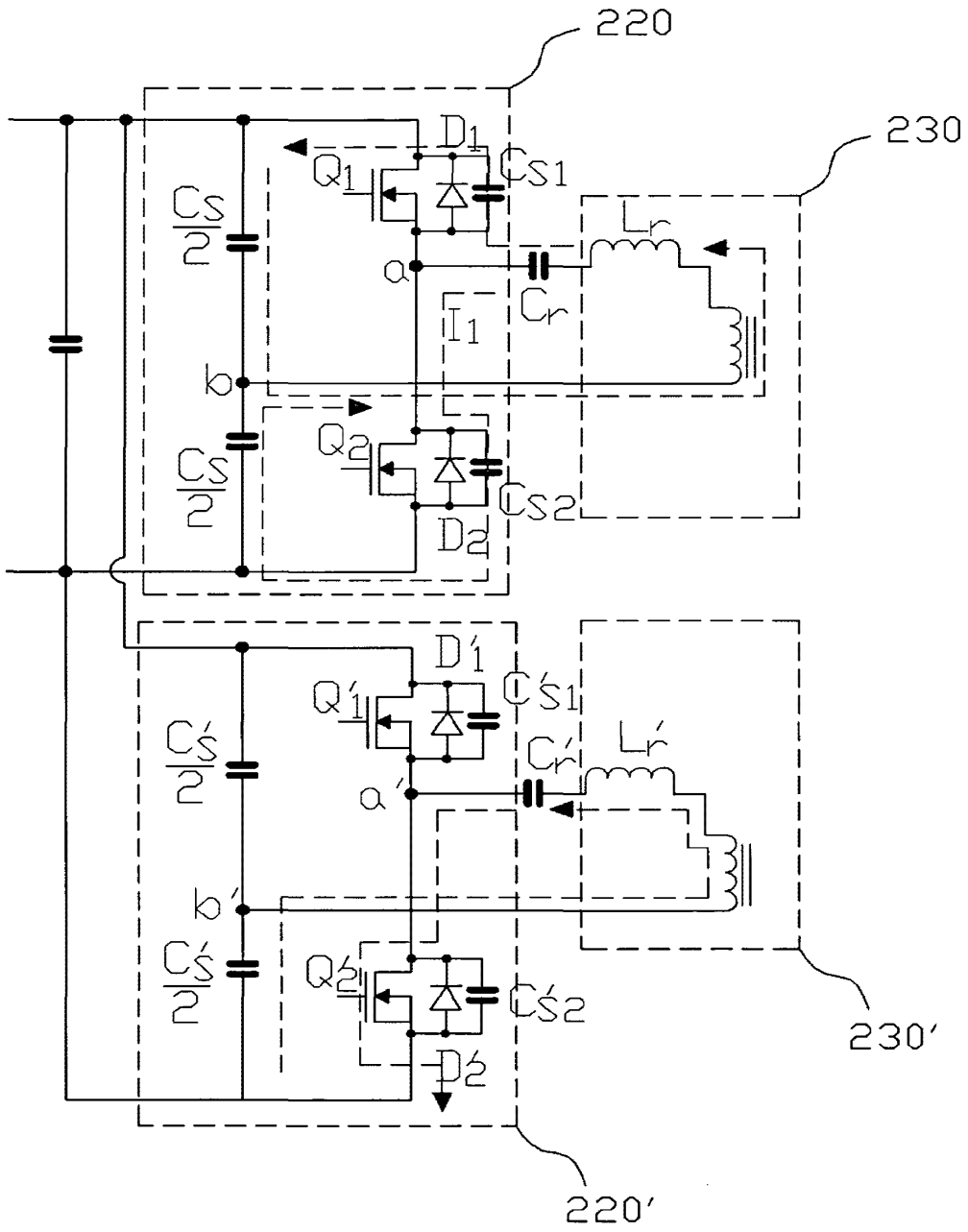
【FIG. 14】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

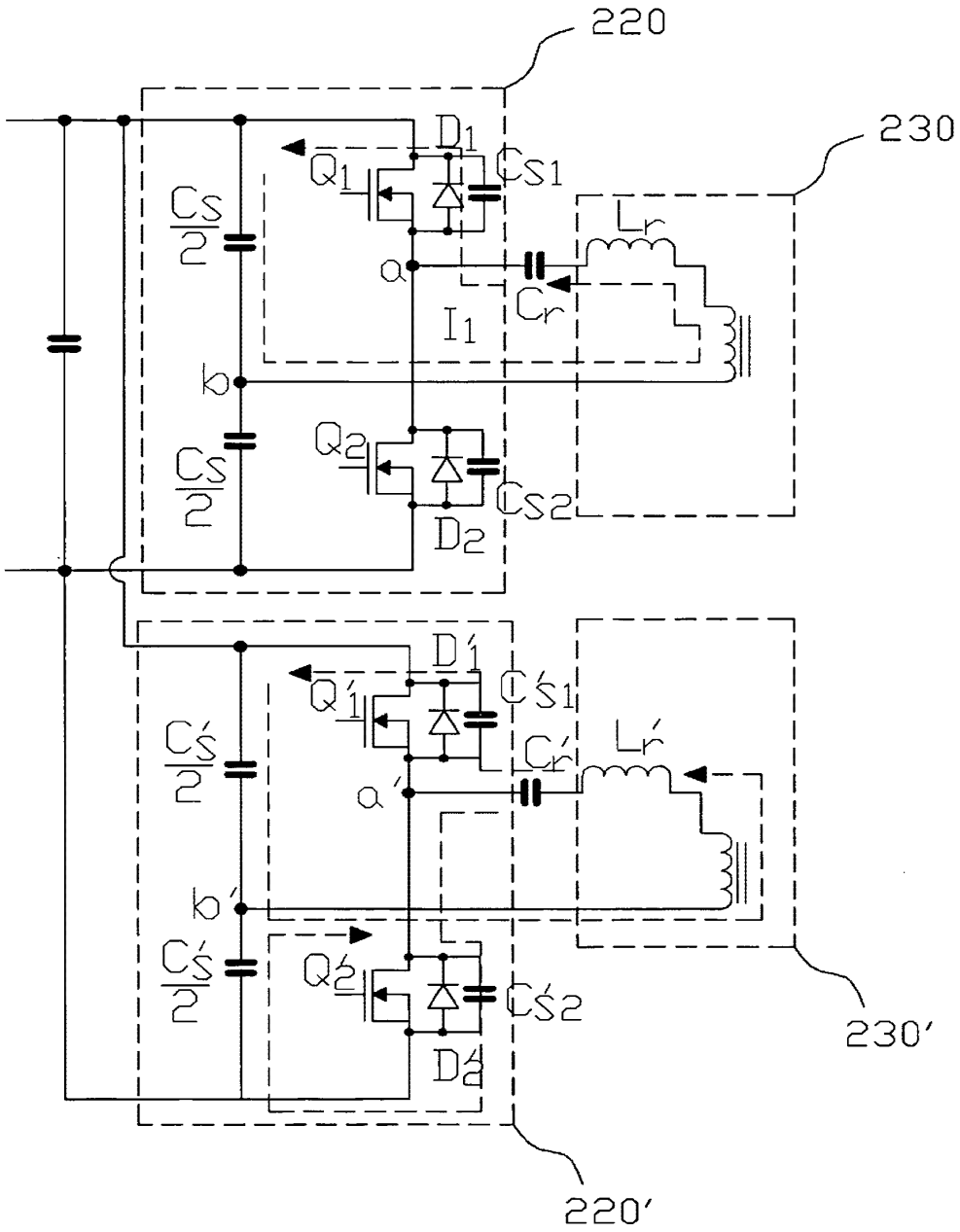
【FIG. 15】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

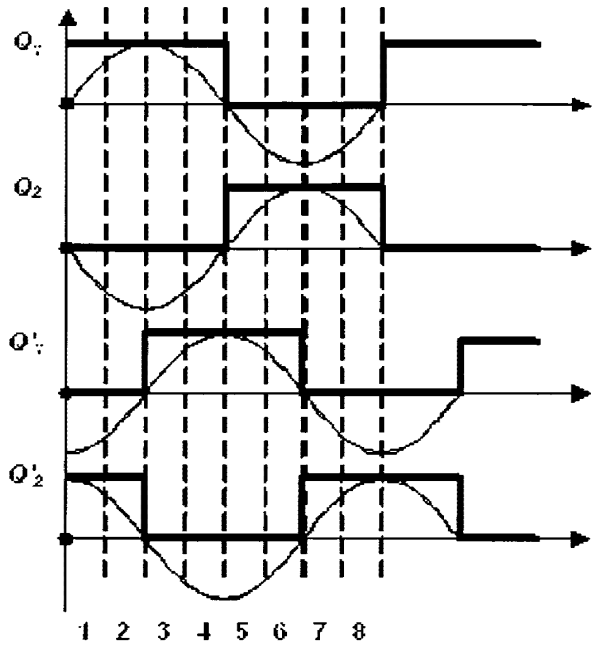
【FIG. 16】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

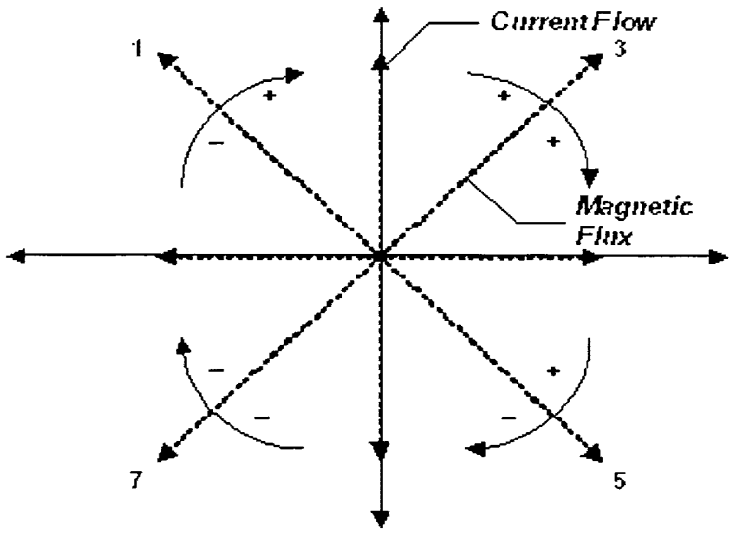
【FIG. 17】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
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C'S/2
C'r
L'r
a'
b'
Q'2
C'S2
D'2
230'
220'

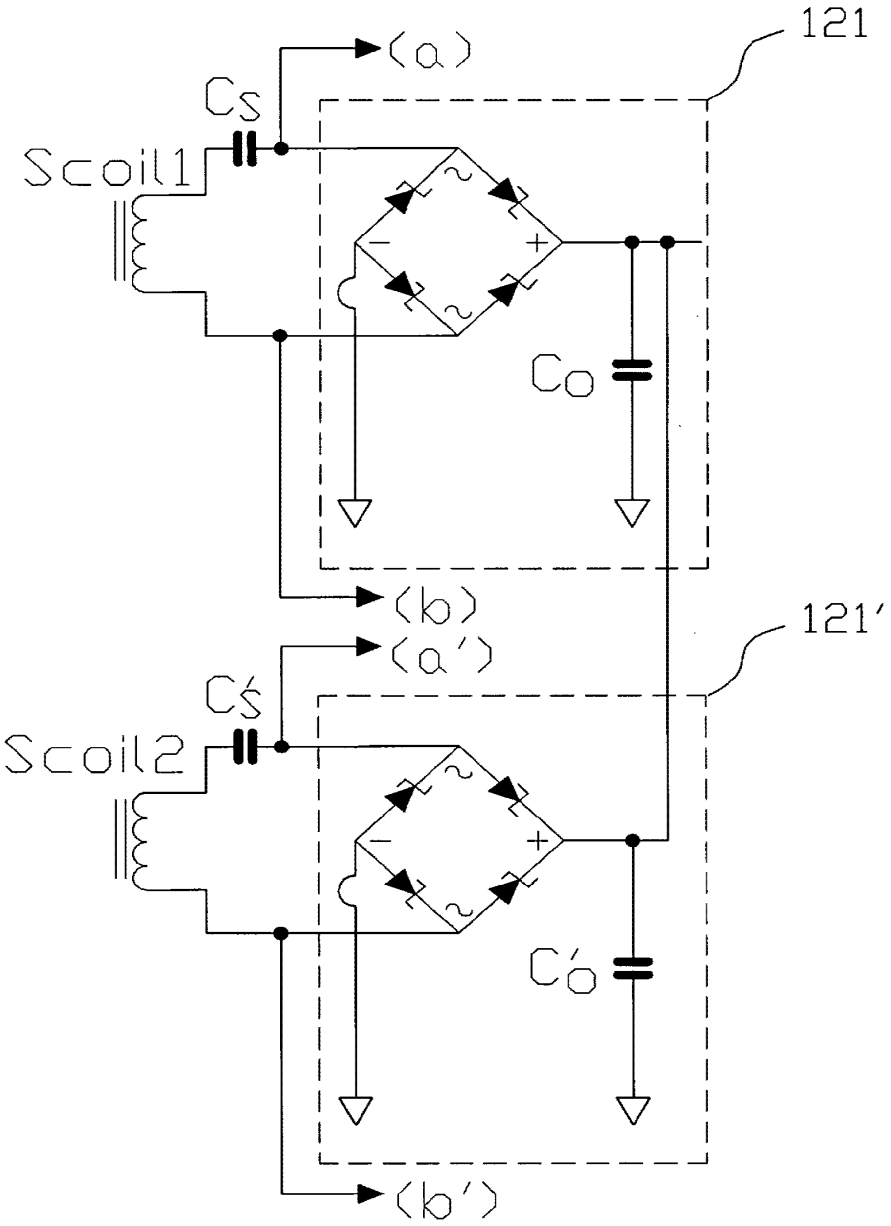
【FIG. 18】



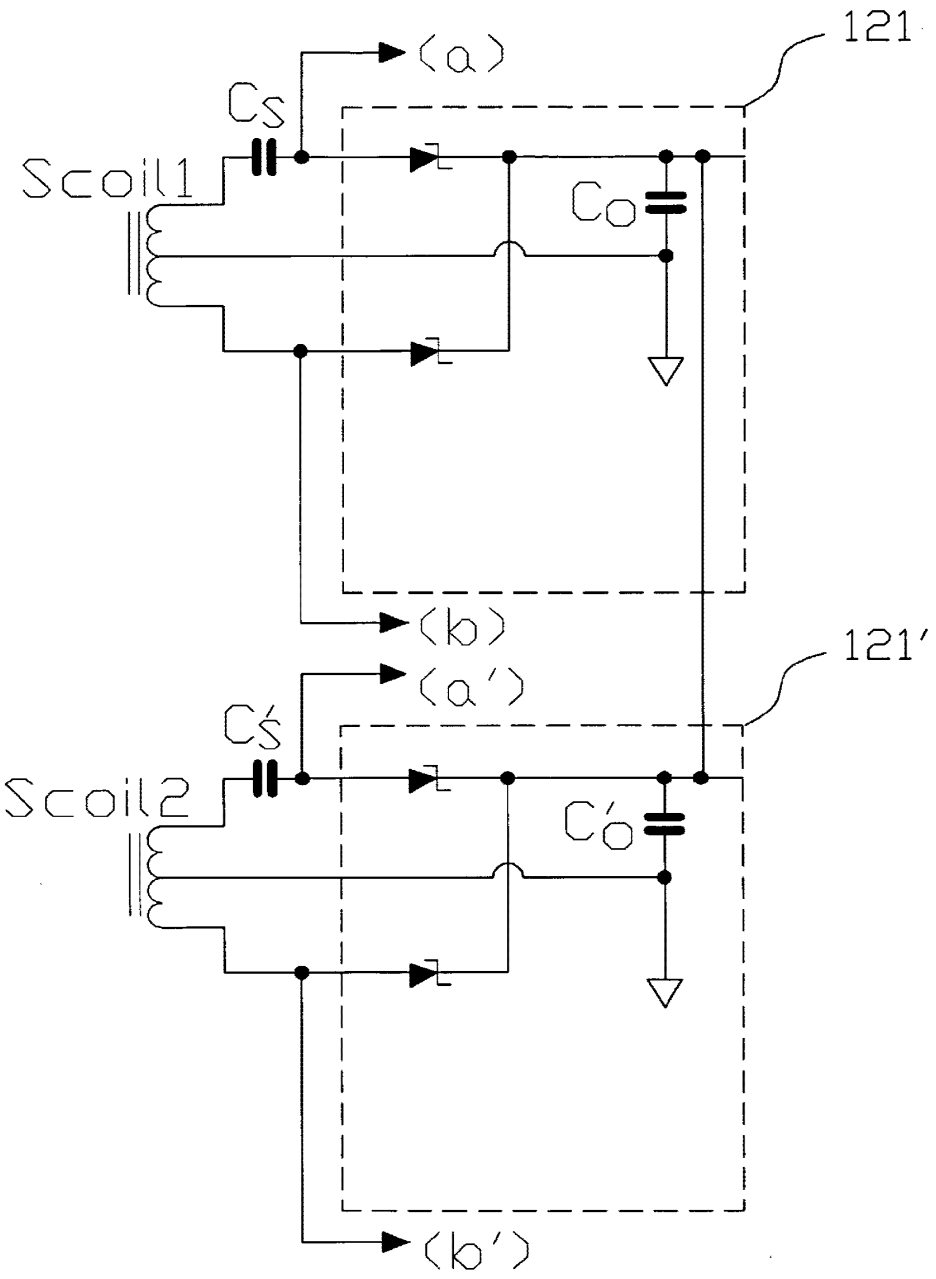
【FIG. 19】



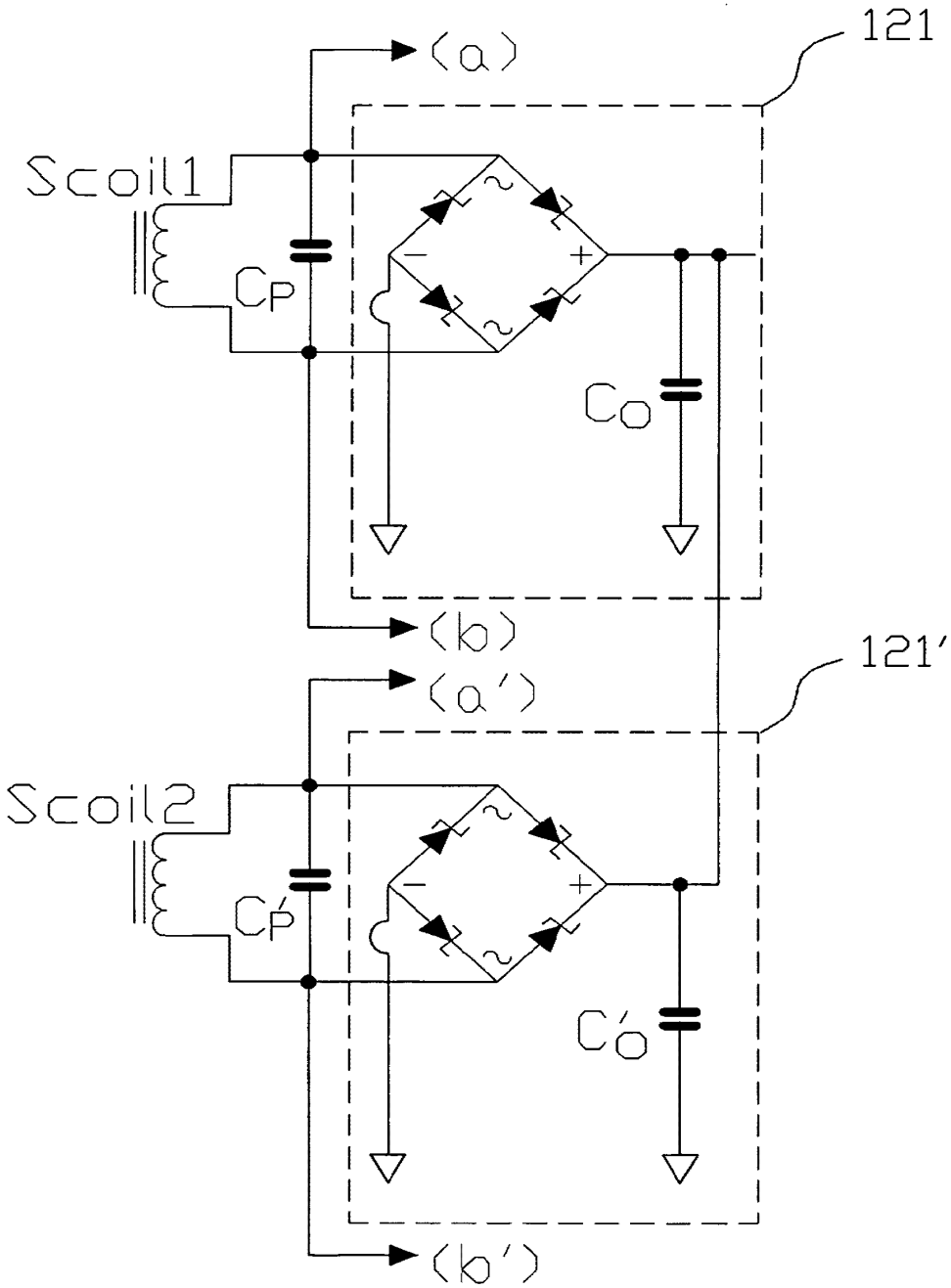
【FIG. 20】



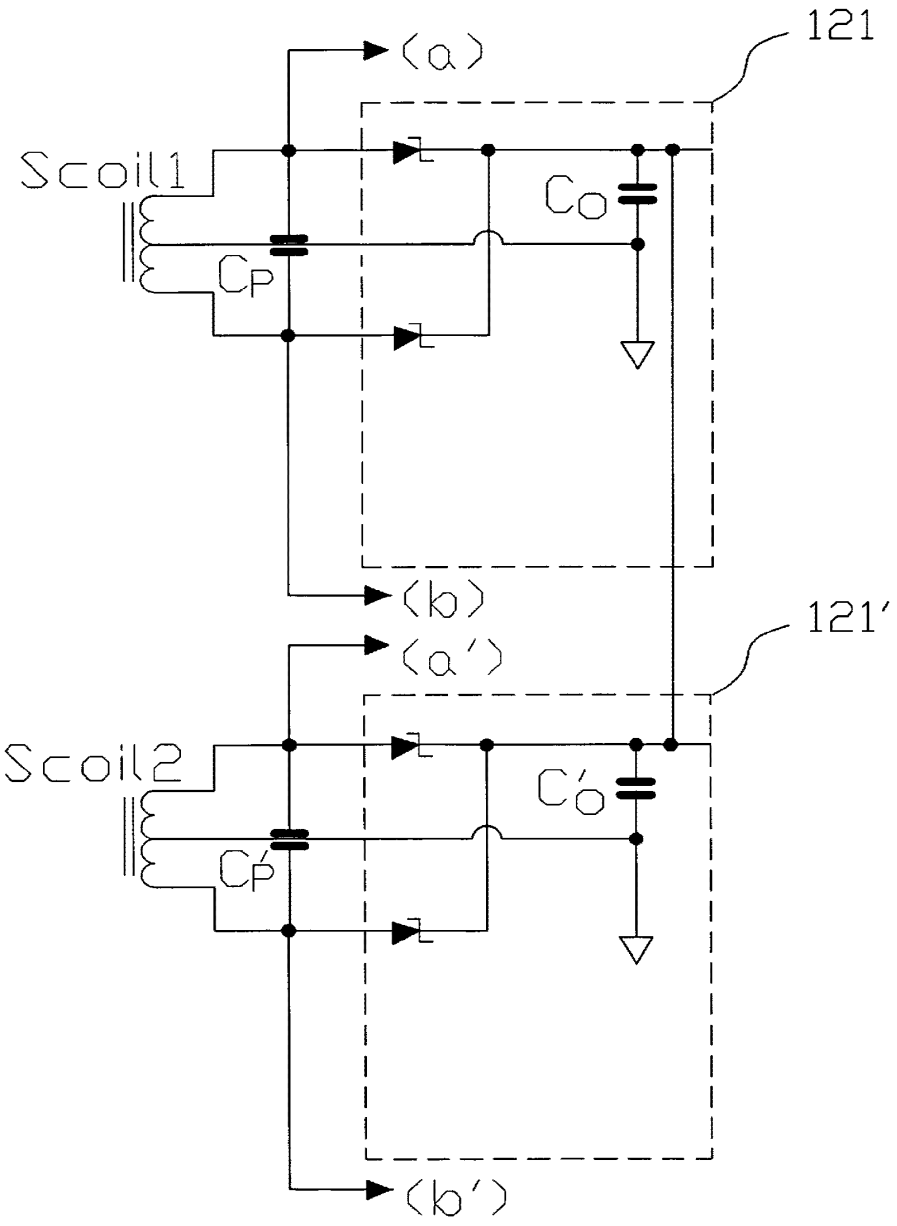
【FIG. 21】



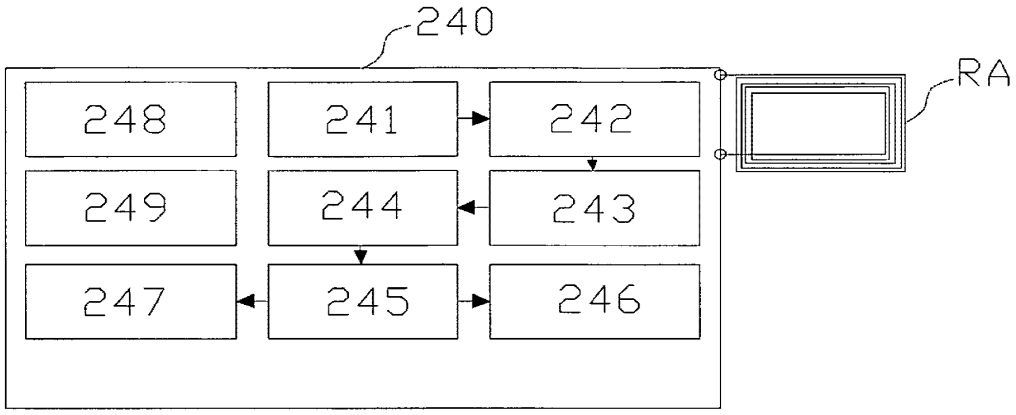
【FIG. 22】



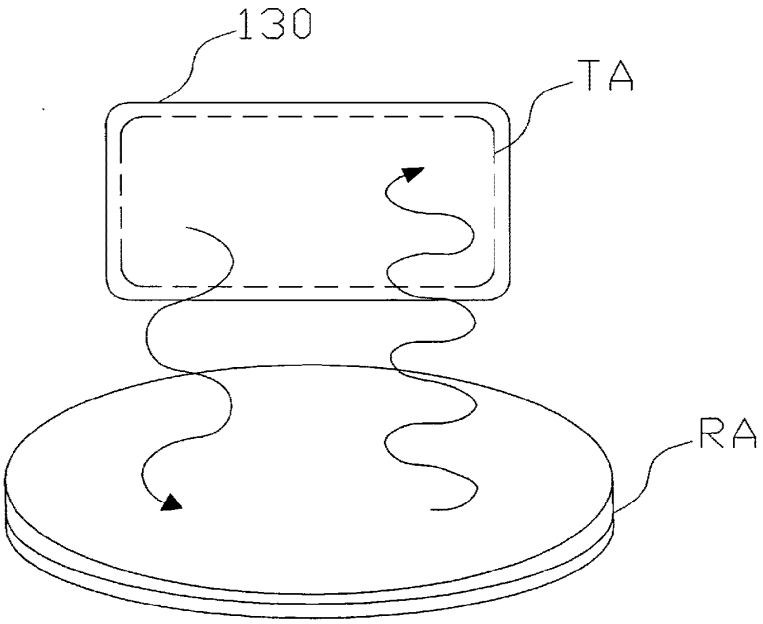
【FIG. 23】



【FIG. 24】



【FIG. 25】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2004/002263

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H02J 7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7: H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and application for inventions since 1975
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Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5600225 A (NEC CO., LTD.) 4 FEB. 1997 Abstract, fig. 2, Claims 1-3	1, 9
A	JP 2003-047178 A (SONY CO., LTD.) 14 FEB. 2003 Abstract, fig. 1, Claims 1-3	1, 9
A	JP 11-178232 A (CANON INC.) 2 JUL. 1999 Fig. 1, Claims 1-3	1, 9
A	JP 2002-272020 A (SONY CO., LTD.) 20 SEP 2002 Abstract, fig. 1, Claims 1-4	1, 9
A	JP 09-233706 A (HITACHI CO., LTD) 5 SEP. 1997 Abstract, fig. 1, Claim 1	1, 9
A	JP 11-68837 A (CASIO COMPUTER CO., LTD) 22 JUN. 1999 See the whole document	1, 9
A	JP 10-201113 A (OKI ELECTRIC INDUSTRIAL CO., LTD.) 31 JUL. 1998 See the whole document	1, 9

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Electronic Acknowledgement Receipt	
EFS ID:	44212667
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Anita Chambers
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	05-NOV-2021
Filing Date:	21-OCT-2021
Time Stamp:	11:04:30
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	AFPA-01013US7_IDS1_2021-11-05.pdf	1035418 6b9d764e25d0f3d44a762062364313ee6ede395e	no	6

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2	Foreign Reference	EP2396901B1.pdf	488937 0618297a4df59ee4d7f4e9aac6319eec7219c2e7	no	32
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(Not for submission under 37 CFR 1.99)

Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Undetermined
Attorney Docket Number	AFPA-01013US7

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	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	1	PCT International Search Report in connection with PCT application No. PCT/US2007/61406, 8 pages, dated February 14, 2008.	
	2	PCT International Search Report in connection with PCT application No. PCT/US2008/63084, 8 pages, dated August 8, 2008.	
	3	Office Action in connection with Application No. 13/442,698 dated September 13, 2012, 6 pages.	
	4	Office Action in connection with Application No. 12/116,876 dated May 2, 2011, 5 pages.	
	5	Office Action in connection with Application No. 11/669,113 dated May 13, 2010, 20 pages.	
	6	Office Action in connection with Application No. 11/669,113 dated August 25, 2009, 17 pages.	
	7	Office Action in connection with Application No. 11/669,113 dated October 29, 2008, 11 pages.	
	8	Office Action in connection with Application No. 13/113,977 dated November 9, 2012, 9 pages.	
	9	International Search Report and Written Opinion of the International Searching Authority, Korean Intellectual Property Office, in re International Application No. PCT/US2010/032845 dated December 13, 2010, 10 pages.	
	10	WildCharge Life unplugged!. http://www.wildcharg.com/4/17/2009, 2 pages	
	11	Powermat "the Future of Wireless Power has Arrived", http://www.pwrmal.com,4/15/2009, 2 pages	

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	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	12	eCoupled Wireless Power Technology Fulton Innovation, http://www.ecoupled.com, 4/15/2009, 5 pages	
	13	Qualcomm Products and Services -Wirelss Airlink Technologies, http://www.qualcomm.com/products_services/airlinks, 4/15/2009, 4 pages	
	14	Office Action in connection with Application No. 11/757,067 dated January 26, 2009, 14 pages.	
	15	Office Action in connection with Application No. 11/757,067 dated October 19, 2009, 14 pages.	
	16	Office Action in connection with Application No. 11/757,067 dated May 10, 2010, 15 pages.	

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	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

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OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kent B. Chambers/	Date (YYYY-MM-DD)	2021-11-05
Name/Print	Kent B. Chambers	Registration Number	38839

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EFS ID:	44212702
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Anita Chambers
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	05-NOV-2021
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Application Type:	Utility under 35 USC 111(a)

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	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

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	4	Witricity. Wireless Electricity Delivered Over Distance, http://www.witricity.com, 11/18/2011, 1 page	
	5	ConvenientPower, ConvenientPower HK Limited, http://www.convenientpower.com/1/about.php, 11/18/2011, 1 page	
	6	Nigel Power LLC: Private Company Information - Business Week, http://investing.businessweek.com/research/stocks/private/snapshot.asp? p ... , 11/18/2011, 2 pages	
	7	SAKAMOTO, et al., "A Novel Circuit for Non-Contact Charging Through Electro-Magnetic Coupling", 1992, IEEE, pp. 165-17 4.	
	8	ABE, et al., "A Non-Contact Charger Using a Resonant Converter with Parallel Capacitor of the Secondary Coil", April 2000, IEEE, Vo.l. 36, No. 2, pp. 444-451.	
	9	SAKAMOTO, et al. "Large Air-Gap Coupler for Inductive Charger", September 1999, IEEE, Vol. 35, No. 5, pp. 3526-3528.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	10	SAKAMOTO, et al. "A Novel Converter for Non-Contact Charging with Electromagnetic Coupling", November 1993, IEEE, Vol. 29, No. 6, pp. 3228-3230	
	11	KIM, et al. "Design of a Contactless Battery Charger for Cellular Phone", December 2001, IEEE, Vol. 48, No. 6, pp. 1238-1247.	
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Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Anita Chambers
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	05-NOV-2021
Filing Date:	21-OCT-2021
Time Stamp:	11:09:09
Application Type:	Utility under 35 USC 111(a)

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U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	35	LIU, et al., "Optimal Design of a Hybrid Winding Structure for Planar Contactless Battery Charging Platform", IEEE, Department of Electronic Engineering, City University of Hong Kong, 2006, pp. 2568-2575, 8 pages.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

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	39	HUI, et al., "Some Electromagnetic Aspects of Careless PCB Transformers", IEEE Transactions on Power Electronics, Vol. 15, No. 4, July 2000, pp. 805-810, 6 pages.	
	40	WAFFENSCHMIDT, et al., "Limitation of Inductive Power Transfer for Consumer Applications", 13th European Conference on Power Electronics and Applications, Barcelona, 2009. EPE '09. pp. 1 - 10, 10 pages.	
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	42	SULLIVAN, Visteon to Sell Wireless Gadget Charger, "Wire-Free Technology will Lets Consumers Dump Cords and Chargers", Red Herring, December 29, 2006, 2 pages.	
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	45	Fulton Innovation LLC, "The Big Story for CES 2007: The Public Debut of eCoupled Intelligent Wireless Power", ecoupled, December 27, 2006, 2 pages.	
	46	MILLER, "Palm May Make Pre Scarce", The San Jose Mercury News, April 29, 2009, 1 page.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	47	MURAKAMI et al., "Consideration on Cordless Power Station Contactless Power Transmission System", IEEE Transactions on Magnets, Vol. 32, No. 5, September 1996, 3 pages.
	48	Epson Air Trans "Wireless Power Transfer", http://www.2k1.co.uk/components/epson_airtrans.asp, 12/8/2008, 2 pages.
	49	CHOI, et al., "A New Contactless Battery Charger for Portable Telecommunication/Compuing Electronics", IEEE, School of Electronic and Electrical Engineering, Kyungpook National University, Taegu, Korea, 2001, pp. 58-59 2 pages.
	50	PCT International Preliminary Report on Patentability dated 10 November 2011 in re International Application No. PCT, US2010/032845, 7 pages.

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kent B. Chambers/	Date (YYYY-MM-DD)	2021-11-05
Name/Print	Kent B. Chambers	Registration Number	38839

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	44212787
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Anita Chambers
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	05-NOV-2021
Filing Date:	21-OCT-2021
Time Stamp:	11:11:03
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	AFPA-01013US7_IDS5_2021-11-05.pdf	1044904 be04f17422b4fda924d40399e328a72d23c35ad2	no	37

Warnings:

Information:	
Total Files Size (in bytes):	1044904

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Patent Application Fee Transmittal

Application Number:	17507323
Filing Date:	21-Oct-2021
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
UTILITY APPL SIZE FEE PER 50 SHEETS >100	2081	1	210	210
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**210**

Electronic Acknowledgement Receipt	
EFS ID:	44649305
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers
Filer Authorized By:	
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	01-JAN-2022
Filing Date:	21-OCT-2021
Time Stamp:	13:12:42
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$210
RAM confirmation Number	E202211D13211333
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	AFPA-01013US7_RNtFMP_2022-01-01.pdf	75697 eae6af7e63c1f9c84c5610c693520a5be29515e4	no	2
Warnings:					
Information:					
2	Applicant Response to Pre-Exam Formalities Notice	AFPA-01013US7_NtFMP_2021-11-02.pdf	57944 9907969f9753b5edec42591cd5d415f38ed08310	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	37848 5e0ba21003e3b61d494529ff97b119e78b9c6d61	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	171489		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Afshin Partovi, Michael Sears		
Applicant:	Mojo Mobility, Inc.		
Title:	Efficiencies and Flexibilities in Inductive (Wireless) Charging		
Application No.:	17/507,323	Filing Date:	October 21, 2021
Examiner:	Unassigned	Group Art Unit:	Unassigned
Docket No.:	AFPA-01013US7	Customer No.:	33438

ELECTRONICALLY FILED

Austin, Texas
January 1, 2022

RESPONSE TO NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

This paper is a response to the November 2, 2021 Notice to File Missing Parts of Nonprovisional Application ("Notice") having a shortened statutory period for reply of January 3, 2021 (January 2, 2021 being a Sunday).

The Notice requires payment of $210 for 18 electronic equivalent pages in excess of 100 pages. Concurrently with the filing of this response, Applicant has paid the $210 fee.

Accompanying this response is a copy of the Notice.

Applicant respectfully submits that this Response including a copy of the Notice and payment of the $210 fee is a complete response to the Notice.

CERTIFICATE OF TRANSMISSION

I hereby certify that on January 1, 2022 this correspondence is being transmitted via the U.S. Patent & Trademark Office's electronic filing system.

/Kent B. Chambers/

Respectfully submitted,

/Kent B. Chambers/

Kent B. Chambers
Attorney for Applicant(s)
Reg. No. 38,839

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7

CONFIRMATION NO. 9345

33438
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

FORMALITIES LETTER

OC000000129462007

Date Mailed: 11/02/2021

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

SUMMARY OF FEES DUE:

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **210** for **18** electronically equivalent pages in excess of **100** application size fee.
- $(**0**) previous unapplied payment amount.
- $ **210** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/hnguyen/

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/507,323

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			210			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	1040		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/507,323	10/21/2021	2859	1040	AFPA-01013US7	20	3

CONFIRMATION NO. 9345

UPDATED FILING RECEIPT

33438
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

OC000000130847372

Date Mailed: 01/04/2022

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Afshin Partovi, Palo Alto, CA;
Michael Sears, Ben Lomond, CA;

Applicant(s)

Mojo Mobility, Inc., Palo Alto, CA;

Assignment For Published Patent Application

Mojo Mobility, Inc., Palo Alto, CA

Power of Attorney: The patent practitioners associated with Customer Number 33438

Domestic Priority data as claimed by applicant

This application is a CON of 16/055,109 08/05/2018 PAT 11201500
which is a CON of 15/463,252 03/20/2017 PAT 10044229
which is a CON of 15/056,689 02/29/2016 PAT 9601943
which is a CON of 14/608,052 01/28/2015 PAT 9276437
which is a CON of 13/708,548 12/07/2012 PAT 8947047
which is a CON of 13/442,698 04/09/2012 PAT 8629654
which is a CON of 12/116,876 05/07/2008 PAT 8169185
which is a CIP of 11/669,113 01/30/2007 PAT 7952322
which claims benefit of 60/868,674 12/05/2006
and claims benefit of 60/810,298 06/01/2006
and claims benefit of 60/810,262 06/01/2006
and claims benefit of 60/763,816 01/31/2006
and said 12/116,876 05/07/2008

claims benefit of 61/043,027 04/07/2008
and claims benefit of 61/015,606 12/20/2007
and claims benefit of 61/012,924 12/12/2007
and claims benefit of 61/012,922 12/12/2007
and claims benefit of 60/952,835 07/30/2007
and claims benefit of 60/916,748 05/08/2007

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 10/29/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/507,323**

Projected Publication Date: 04/14/2022

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

System and Method for Inductive Charging of Portable Devices

Preliminary Class

320

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ

in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

33438 7590 01/10/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
CENTRAL, DOCKET	

ART UNIT	PAPER NUMBER
OPAP	

NOTIFICATION DATE	DELIVERY MODE
01/10/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

USPTO@dockettrak.com
celeste@tcciplaw.com
tmunoz@tcciplaw.com

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 17/507,323	**Applicant(s)** Partovi et al.	
	Examiner CHERYL P GIBSON BAYLOR	**Art Unit** OPET	**AIA (FITF) Status** No

1. THE REQUEST FILED 21 October 2021 IS **GRANTED** .

   The above-identified application has met the requirements for prioritized examination
   - A. ☑ for an original nonprovisional application (Track I).
   - B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:
   - A. filing a **petition for extension of time** to extend the time period for filing a reply;
   - B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;
   - C. filing a **request for continued examination** ;
   - D. filing a notice of appeal;
   - E. filing a request for suspension of action;
   - F. mailing of a notice of allowance;
   - G. mailing of a final Office action;
   - H. completion of examination as defined in 37 CFR 41.102; or
   - I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to CHERYL GIBSON BAYLOR at (571)272-3213. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/CHERYL GIBSON BAYLOR/ Paralegal Specialist, OPET	

U.S. Patent and Trademark Office
PTO-2298 (Rev. 02-2012)

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Zixuan Zhou
Attorney Docket Number	AFPA-01013US7

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6527971	B1	2003-03-04	Nakamura et al.	
	2	6803744	B1	2004-10-12	Sabo	
	3	7311526	B2	2017-12-25	Rohrbach et al.	
	4	7331793	B2	2008-02-19	Hernandez et al.	
	5	7352567	B2	2008-04-01	Hotelling et al.	
	6	8766484	B2	2014-07-01	Baarman et al.	
	7	6869019	B1	2005-03-22	Nagi et al.	
	8	7514765	B2	2009-04-07	Huang et al.	

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	Filing Date	2021-10-21
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	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

	9	6756656	B2	2004-06-29	Lowther	

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U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050062567	A1	2005-03-24	Zimmerling et al.	
	2	20060061324	A1	2006-03-23	Oglesbee	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		

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	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kent B. Chambers/	Date (YYYY-MM-DD)	2022-01-19
Name/Print	Kent B. Chambers	Registration Number	38839

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Zixuan Zhou
Attorney Docket Number	AFPA-01013US7

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4720667	A	1988-01-19	Lee et al.	
	2	6057668	A	2000-05-02	Chao	
	3	6028413	A	2000-02-22	Brockmann	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20070103110	A1	2007-05-10	Sagoo	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							

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	Attorney Docket Number	AFPA-01013US7

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Examiner Signature		Date Considered	

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Name/Print	Kent B. Chambers	Registration Number	38839

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	44785316
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Anita Chambers
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	19-JAN-2022
Filing Date:	21-OCT-2021
Time Stamp:	21:12:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	AFPA-01013US7_IDS6_2022-01-14.pdf	1034870 b0ce79de84556570a8d96687dec07f7fa0db6e32	no	5

Warnings:

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	AFPA-01013US7_IDS7_2022-01-19.pdf	1034381 2b191fdf1c352a9faf4bd01e2a9665479be93c96	no	4
Warnings:					
Information:					
			Total Files Size (in bytes):	2069251	

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

33438 7590 01/27/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
ZHOU, ZIXUAN	

ART UNIT	PAPER NUMBER
2859	

NOTIFICATION DATE	DELIVERY MODE
01/27/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

USPTO@dockettrak.com
celeste@tcciplaw.com
tmunoz@tcciplaw.com

Office Action Summary	Application No. 17/507,323	Applicant(s) Partovi et al.	
	Examiner ZIXUAN ZHOU	Art Unit 2859	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 10/21/2021.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 10/21/2021 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date See Continuation Sheet.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

Continuation of Attachment(s) 2) Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date: 11/05/2021, 11/05/2021, 11/05/2021, 11/05/2021, 01/19/2022 and 01/19/2022

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Priority

This application discloses and claims only subject matter disclosed in prior application no 12/116,876, filed 05/07/2008, and names the inventor or at least one joint inventor named in the prior application. Accordingly, this application may constitute a continuation or division. Should applicant desire to claim the benefit of the filing date of the prior application, attention is directed to 35 U.S.C. 120, 37 CFR 1.78, and MPEP § 211 *et seq.*

Information Disclosure Statement

The information disclosure statement (IDS) submitted on 11/05/2021, 11/05/2021, 11/05/2021, 11/05/2021, 01/19/2022 and 01/19/2022 are in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112(a):

> (a) IN GENERAL.—The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor or joint inventor of carrying out the invention.

The following is a quotation of the first paragraph of pre-AIA 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claim 6 is rejected under 35 U.S.C. 112(a) or 35 U.S.C. 112 (pre-AIA), first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor or a joint inventor, or for applications subject to pre-AIA 35 U.S.C. 112, the inventor(s), at the time the application was filed, had possession of the claimed invention.

Claim 6 recites limitations of "…to selectively activate one or more coils". However, the instant application and the parent application (12/116,876) do not provide disclosure for "selectively activating one or more coils". Thus the claim contains subject matter which was not described in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

> The following is a quotation of 35 U.S.C. 112(b):
> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

> The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:
> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 2-4, 10-12 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor (or for applications subject to pre-AIA 35 U.S.C. 112, the applicant), regards as the invention.

Claim 2 recites the limitation "the charger or power supply" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 3 recites the limitation "the charger" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 4 recites the limitation "the charger or power supply" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 10 recites the limitation "the coils or wires" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 11 recites the limitation "the charger or the power supply" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 12 recites the limitation "the data transfer" in lines 1-2. There is insufficient antecedent basis for this limitation in the claim.

Claim 12 recites the limitation "the charger or the power supply" in lines 2-3. There is insufficient antecedent basis for this limitation in the claim.

Regarding claims 10-12, the phrase "The mobile device charger or power supply" renders the claim indefinite because the limitations of claim 9 refer to a mobile device (a wireless power receiver). The preamble of claims 10-12 are directed to a mobile device charger power supply (a wireless power transmitter). Therefore, the Examiner cannot determine the metes and bounds of claims 10-12. Appropriate correction is required.

Claim Interpretation

The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the

corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The claims in this application are given their broadest reasonable interpretation using the plain meaning of the claim language in light of the specification as it would be understood by one of ordinary skill in the art. The broadest reasonable interpretation of a claim element (also commonly referred to as a claim limitation) is limited by the description in the specification when 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is invoked.

As explained in MPEP § 2181, subsection I, claim limitations that meet the following three-prong test will be interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph:

(A) the claim limitation uses the term “means” or “step” or a term used as a substitute for “means” that is a generic placeholder (also called a nonce term or a non-structural term having no specific structural meaning) for performing the claimed function;

(B) the term “means” or “step” or the generic placeholder is modified by functional language, typically, but not always linked by the transition word “for” (e.g., “means for”) or another linking word or phrase, such as “configured to” or “so that”; and

(C) the term "means" or "step" or the generic placeholder is not modified by sufficient structure, material, or acts for performing the claimed function.

Use of the word "means" (or "step") in a claim with functional language creates a rebuttable presumption that the claim limitation is to be treated in accordance with 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph. The presumption that the claim limitation is interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is rebutted when the claim limitation recites sufficient structure, material, or acts to entirely perform the recited function.

Absence of the word "means" (or "step") in a claim creates a rebuttable presumption that the claim limitation is not to be treated in accordance with 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph. The presumption that the claim limitation is not interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is rebutted when the claim limitation recites function without reciting sufficient structure, material or acts to entirely perform the recited function.

Claim limitations in this application that use the word "means" (or "step") are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, except as otherwise indicated in an Office action. Conversely, claim limitations in this application that do not use the word "means" (or "step") are not being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, except as otherwise indicated in an Office action.

Double Patenting

A rejection based on double patenting of the "same invention" type finds its support in the language of 35 U.S.C. 101 which states that "whoever invents or

discovers any new and useful process... may obtain a patent therefor..." (Emphasis added). Thus, the term "same invention," in this context, means an invention drawn to identical subject matter. See *Miller v. Eagle Mfg. Co.*, 151 U.S. 186 (1894); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Ockert*, 245 F.2d 467, 114 USPQ 330 (CCPA 1957).

A statutory type (35 U.S.C. 101) double patenting rejection can be overcome by canceling or amending the claims that are directed to the same invention so they are no longer coextensive in scope. The filing of a terminal disclaimer cannot overcome a double patenting rejection based upon 35 U.S.C. 101.

Claims 1-20 are provisionally rejected under 35 U.S.C. 101 as claiming the same invention as that of claims 1-20 of copending Application No. 17/507,351 (reference application). This is a provisional statutory double patenting rejection since the claims directed to the same invention have not in fact been patented.

Claim Rejections - 35 USC § 102

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claim(s) 9-10, 13-14, 17 is/are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Hui (US Pub 2005/0189910).

Regarding claim 9, Hui teaches a mobile device capable of being inductively powered or charged (¶ 0070; an inductive charger system) comprising:

a battery (¶ 0072; charging the battery inside the portable equipment); and

a receiver for one of inductively powering the device or charging the battery in the mobile device, and wherein the receiver is one of attached to or incorporated into the battery or the mobile device (**¶ 0072; the secondary winding…for charging the battery inside the portable equipment**).

Regarding claim 10, Hui teaches the mobile device charger or power supply wherein the coils or wires are formed within a printed circuit board PCB layer of at least two different sizes or shapes (¶ 0071 and fig. 17).

Regarding claim 13, Hui teaches a system for use with a mobile device or battery for charging or powering the mobile device or battery inductively (¶ 0069), comprising:

a base unit including one or more primary coils therein (see fig. 4c, 5a, 5b, 8, 9a), the primary coil having a generally planar shape (¶ 0009) so that when a current is passed through the primary coil a magnetic field (magnetic flux) is generated in a direction substantially (interprets as "mostly") perpendicular (according to the "right-hand rule") to the plane of the primary coil (¶ 0004); and

wherein the perpendicular magnetic field inductively generates a current in a matching receiver coil or coils within a mobile device or battery placed close to and aligned with the base unit, to charge or power the mobile device or battery (**¶ 0011, 0070; the device includes a planar secondary winding for receiving electrical energy from a battery charger**).

Regarding claim 14, Hui discloses wherein one or more of the coils are manufactured on printed circuit boards (¶ 0071) and are manufactured to have a low resistance (metal-based material).

Regarding claim 17, Hui discloses wherein a plurality of modular chargers or power supplies can be (interprets as "can be" or "cannot be") interconnected to form a single unit (see fig. 41 and 42).

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claim 1- 2, 5-6, 8 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hui (US Pub 2005/0189910) in view of Karalis et al. US Pub 2008/0278264 (hereinafter Karalis).

Regarding claim 1, Hui discloses a system for inductive powering and charging of portable devices or batteries (see abstract), comprising:

a base unit, including one or more primary coils shaped as planar spiral coils (**see fig. 4(c), 5(a), 5(b); ¶ 0014**), which are capable of generating an inductive energy for use in powering or charging multiple devices or batteries simultaneously (**see fig. 4(a) to 4(c); ¶ 0009: the primary charging circuit is adapted to charge two or more devices simultaneously**);

a receiver unit, including a receiver coil also shaped as a planar spiral coil (¶ 0011), which is coupled to or incorporated into a portable device or battery (a battery powered portable electronic device),

wherein the secondary coil receives energy inductively from the primary coil and uses it to charge or power the portable device or battery (¶ 0009-0011);

means within the base unit for allowing a degree of position independence of the devices or batteries on the base unit and selectively activating the one or more primary coils (**claim 16 and ¶ 0070: when a device is placed on the charging surface charging energy is transferred to the device from only those primary windings closely adjacent to said device**); and

wherein the base unit can simultaneously charge or power additional portable devices or batteries with additional secondary coils (¶ 0009).

Hui does not disclose the primary coils and secondary coils composed of a non-ferrite material.

Karalis discloses a wireless energy transfer system includes a source coil and a device coil. The two identical coils are both made of copper in ¶ 0188. The specification of the instant application states "...the coils can be made of copper material..." in ¶ 00171. Therefore, the prior art reads on the claimed limitations.

It would have been obvious to one skilled in the art at the time was made to modify Hui to incorporate with the teaching of Karalis by including copper coils in the wireless transfer system, because it would be advantageous to increase wireless transfer efficiency and further reduce the charging time.

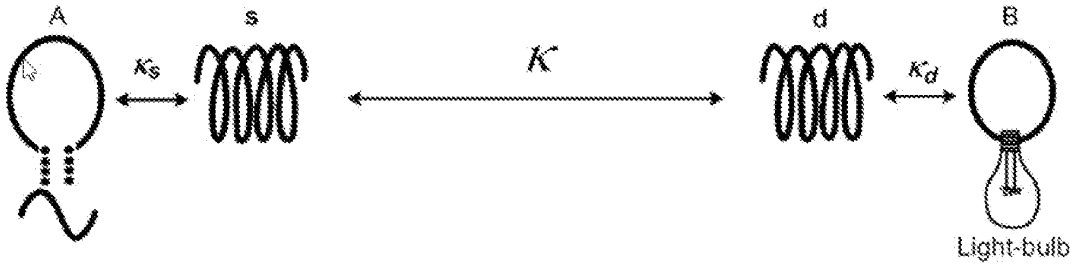


FIG. 14

Regarding claim 2, Hui discloses wherein the charger or power supply includes a plurality of coils (¶ 0009 and fig. 4(c)), and wherein the **means for** selective charging or powering is used to control the on off operation of the coils in the vicinity of the portable device or battery (**claim 16 and ¶ 0014, 0070: when a device is placed on**

the charging surface charging energy is transferred to the device from only those primary windings closely adjacent to said device).

Regarding claim 5, Hui discloses wherein a plurality of coils are integrated into a pad-like charger or power supply (fig. 4a to 4c and ¶ 0079; such as a mouse pad) and wherein the coils are used to form a coil mosaic and an effective area of charging or power that does not cover more than approximately (interpret as "can be more or less") 90% of pad surface (¶ 0079 and see fig. 15-17; the effective area can be more or less than 90%).

Regarding claim 6, Hui discloses wherein each of the plurality of coils are driven by an individual drive circuit to provide power to each coil and to selectively activate one or more coils.

Regarding claim 8, Hui discloses wherein a plurality of layers of coils are layered upon one another to create an effective area, and so that powering any one or a selection of the coils allows a receiver whose center is within the effective area to be charged (¶ 0087).

Claims 3-4 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hui in view of Karalis as applied to claim 1 above, and further in view of Kook et al. WO2006/001557A1 (hereinafter Kook).

Regarding claim 3, Hui in view of Karalis does not disclose wherein the charger and a receiver in the device or battery both include microcontroller units, wherein the microcontroller unit in the charger monitors current flow, and wherein the microcontroller

unit in the portable device or battery provides communication between the charger and the receiver for use in controlling charging.

Kook discloses a wireless charging pad is able to charge a battery pack mounted on a portable device in a non-contact manner. The wireless charging pad includes a controller (or MCU), and the controller 240 for switching to an active mode and controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack is detected, for transmitting a RF carrier signal to the battery pack in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information…and for switching to the energy saving mode again when charging of the battery pack is completed on page 5, line 19 to page 6, line 11. Further, the controller is able to monitor/control the operation of the half-bridge serial resonant converter provided to the wireless charging pad according to the different modes. The operation of the half-bridge serial resonant converter controls the direction of current flowing to the transformer through the switches on page 36, line 5 to page 37, line 9.

Further, the battery pack of Kook includes a microcontroller unit (a RFID tag 130). When the controller 240 access the RFID tag 130 in the battery pack 100 equipped with the charging receiver module 110 to access information on the battery BAT using a carrier frequency, the battery information stored in the memory block of the RFID tag 130 is transmitted to the wireless charging pad 200 in a modulated RF signal form on page 41, line 2-9.

It would have been obvious to one skilled in the art at the time was made to modify Hui in view of Karalis to incorporate a MCU in the charger and a different MCU in

the battery pack as suggested by Kook, because it would be advantageous to improve charging efficiency and reduce the core loss and gap loss of the transformer.

Regarding claim 4, Hui in combination of Karalis and Kook discloses wherein the charger or power supply includes an additional verification step prior to activating charging, to verify the identity or permissions of a device or battery (Kook, fig. 9, step 120).

Claims 11-12, 16, 19-20 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hui in view of Kook et al. WO2006/001557A1 (hereinafter Kook).

Regarding claim 11, Hui fails to disclose wherein the charger or the power supply, and the mobile device, communicate with each other to transfer data.

Kook discloses a system of charging a battery through wireless communication between a battery pack and a charging device. Further, the wireless identification information is stored in the RFID tag 130 through communication between a body of a portable device on which the battery pack 100 is mounted, and the battery pack. The data encoder 133 is able to receive the wireless identification information and charged status information of the battery from the tag when the control signal is transmitted from the sequencer, and transmitting the wireless identification information and charged status information to a data modulator 136 on pages 11-12.

It would have been obvious to one skilled in the art at the time was made to modify Hui to incorporate with the teaching of Kook by transmitting wireless identification information and charged status information to the wireless charger before

charging process, because it would be advantageous to avoid overcharging the battery pack and further prolong the service life of the battery pack.

Regarding claim 12, Hui in view of Kook discloses wherein the data transfer includes information about the presence of the mobile device adjacent to the charger or power supply **and/or** wherein the charger or power supply stores charging or power requirements for mobile devices which can be charged or powered by the charger or power supply (Kook, pages 11-12; charged status information).

Regarding claim 16, Hui does not disclose the system further comprising one of a solar cell coupled to a battery in the base unit, for charging the battery in the base unit; a data storage component for storage of data, for subsequent transmission of data to or from the mobile device; or a cover surface of the base unit or pad includes a decorative or non-slip surface.

Kook discloses a system of charging a battery through wireless communication between a battery pack and a charging device. Further, the wireless identification information is stored in the RFID tag 130 through communication between a body of a portable device on which the battery pack 100 is mounted, and the battery pack. The data encoder 133 is able to receive the wireless identification information and charged status information of the battery from the tag when the control signal is transmitted from the sequencer, and transmitting the wireless identification information and charged status information to a data modulator 136 on pages 11-12.

It would have been obvious to one skilled in the art at the time was made to modify Hui to incorporate with the teaching of Kook by transmitting wireless identification information and charged status information to the wireless charger before

charging process, because it would be advantageous to avoid overcharging the battery pack and further prolong the service life of the battery pack.

Regarding claim 19, Hui does not disclose the system includes means within the base unit for providing control regulation, and/or verification of the power charging and/or powering, including a switch means for adjusting and/or controlling the power into the coils under different load conditions, to maintain high efficiency during different load conditions or charging stages.

However, Kook further discloses the system of Kook includes means within the base unit for providing control regulation, and/or verification of the power charging and/or powering, including a switch means for adjusting and/or controlling the power (switching from active mode to saving mode) into the coils under different load conditions (charged status), to maintain high efficiency during different load conditions or charging stages (pages 6-7; and switch to the energy saving mode when charging of all the battery packs are completed).

It would have been obvious to one skilled in the art at the time was made to modify Hui to incorporate with the teaching of Kook by monitoring the charged status of each battery pack, because it would be advantageous to avoid overcharging the battery packs and further reduce energy usage.

Regarding claim 20, Hui does not disclose wherein the switch means is a zero voltage crossing or zero current crossing switch geometry, and wherein the controlling of output power is be achieved by changing the frequency of the operation.

Kook further discloses wherein the switch means is a zero voltage crossing or zero current crossing switch geometry, and wherein the controlling of output power is be achieved by changing the frequency of the operation (pages 36-37).

It would have been obvious to one skilled in the art at the time was made to modify Hui to incorporate with the teaching of Kook by tuning the switching frequency close to the resonant frequency, because it would be advantageous to increase the charge efficiency and lower the core loss and gap loss of the transformer.

Claim 15 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hui in view of Toya (US Pub 2008/0061733).

Regarding claim 15, Hui fails to disclose the system comprising: a battery coupled to and powering the base unit, and wherein the battery can be occasionally charged by an external power supply to maintain a charge sufficient to power the inductive charger or power supply device for a period of time.

However, Toya discloses a wireless battery charger includes a battery (Toya, fig. 4 and 5, element 12) coupled to and powering the base unit (fig. 4, element 11), and wherein the battery can be occasionally charged by an external power supply (¶ 0008) to maintain a charge sufficient to power the inductive charger or power supply device for a period of time (¶ 0008).

It would have been obvious to one skilled in the art at the time was made to modify Hui to incorporate with the teaching of Kook by further including an internal battery in the wireless charger, because it would be advantageous to charge the portable device when no external power inputs to the battery charger.

Allowable Subject Matter

Claims 7, 18 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ZIXUAN ZHOU whose telephone number is (571)272-6739. The examiner can normally be reached 9:00 am to 5:00 pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Drew A Dunn can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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/ZIXUAN ZHOU/
Primary Examiner, Art Unit 2859
01/22/2022

Notice of References Cited	Application/Control No. 17/507,323	Applicant(s)/Patent Under Reexamination Partovi et al.	
	Examiner ZIXUAN ZHOU	Art Unit 2859	Page 1 of 1

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*	B	US-20080278264-A1	11-2008	Karalis; Aristeidis	H02J50/80	333/219
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NON-PATENT DOCUMENTS

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	V	
	W	
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	Art Unit
	ZIXUAN ZHOU	2859

CPC - Searched*		
Symbol	Date	Examiner
H02J50/10, G06F1/1683, H02J7/025, H02J50/402	01/22/2022	ZZ

CPC Combination Sets - Searched*		
Symbol	Date	Examiner
H02J7/342 AND H02J50/10	01/22/2022	ZZ

US Classification - Searched*			
Class	Subclass	Date	Examiner
320	108	01/22/2022	ZZ
307	104	01/22/2022	ZZ

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
IP.com search	01/22/2022	ZZ
inventor and assignee search	01/22/2022	ZZ
EAST text search was conducted -- see printout	01/22/2022	ZZ
CPC and USPC search was conducted with text base	01/22/2022	ZZ

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	**Art Unit**
	ZIXUAN ZHOU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
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CLAIMS										
☐ Claims renumbered in the same order as presented by applicant			☐ CPA		☐ T.D.		☐ R.1.47			
CLAIM		**DATE**								
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	18	✓								
	19	✓								
	20	✓								

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 January 2006 (05.01.2006)

PCT

(10) International Publication Number
WO 2006/001557 A1

(51) International Patent Classification[7]: H02J 7/02

(21) International Application Number:
PCT/KR2004/002263

(22) International Filing Date:
7 September 2004 (07.09.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10-2004-0048286 25 June 2004 (25.06.2004) KR

(71) Applicant *(for all designated States except US)*: **HANRIM POSTECH CO., LTD.** [KR/KR]; 626-1 Pajang-dong, Jangan-gu, Suwan-si, Gyeonggi-do 440-290 (KR).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **JUNG, Chun-Kil** [KR/KR]; 77-9 Nonhyeong-dong, Gangnam-gu, Seoul 135-010 (KR). **KOOK, Yoon-Sang** [KR/KR]; 123-102 Jugong Apartment, 37 Jungang-dong, Gwacheon-si, Gyeonggi-do 427-010 (KR).

(74) Agent: **KIM, Sung-Gyu**; 4th FL. Jangan Bldg., 827-3 Yoksam-dong, Kangnam-gu, Seoul 135-080 (KR).

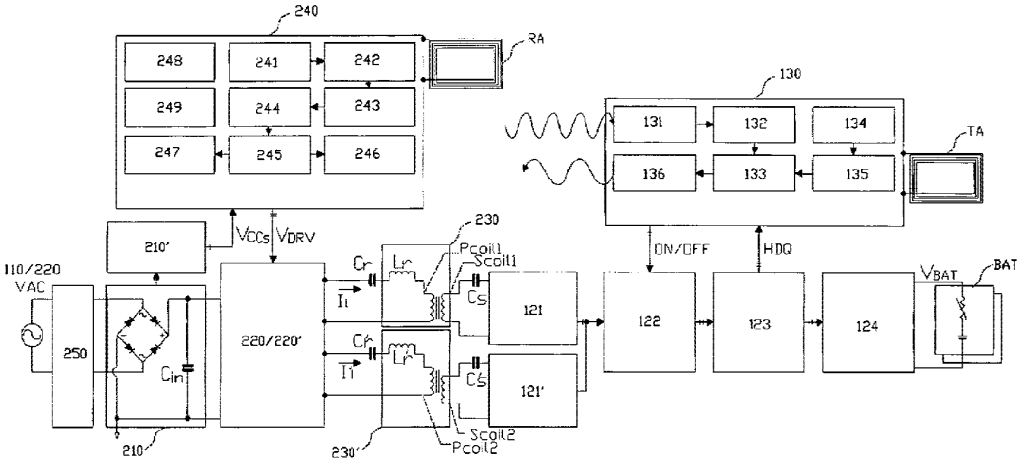
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: WIRELESS CHARGING PAD AND BATTERY PACK USING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY



(57) Abstract: The present invention relates to a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad. Thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

WO 2006/001557 A1

DESCRIPTION

WIRELESS CHARGING PAD AND BATTERY PACK USING RADIO FREQUENCY IDENTIFICATION TECHNOLOGY

Technical Field

The present invention relates, in general, to a wireless charging pad and a battery pack to which a radio frequency identification technology is applied and, more particularly, to a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Background Art

Recently, with the development of communication and information processing technologies, the use of portable devices that are convenient to carry, such as a mobile phone, is increasing, and with the development of technologies, new model terminals having improved efficiency are continuously popularized. To charge such portable devices, a contact type charging method is used,

or a non-contact type charging method in which a battery is charged using magnetic coupling without electrical contact is used so as to overcome the problem of the contact type charging method that is attributable to the exposure of contact terminals to an outside.

As for technology corresponding to a non-contact charger, a method of charging a battery through wireless communication between a battery pack and a charging device using magnetic cores is disclosed in Korean Unexamined Pat. Pub. No. 2002-0035242 entitled "Non-contact Charging Device for Battery of Portable Device using Inductive Coupling," and a method of solving a problem of a magnetic core using a transformer formed in such a way that coils are wound on a Printed Circuit Board (PCB) is disclosed in Korean Unexamined Pat. Pub. No. 2002-0057469 entitled "Thin PCB Transformer without Core and Non-contact Battery Charger using PCB Transformer."

The present applicant proposed the technology in which a wireless charging pad for functioning as a wireless charger was constructed and the battery pack of a portable device was charged in a non-contact manner by placing the battery pack on the wireless charging pad through "Non-contact Battery Charging System capable of Multi-Charging and Method of Designing Core Block" (Korean Pat. application No. 2004-21335).

However, in the prior art, the wireless charging pad

could not detect the charged status of the battery pack in real time and a means for detecting devices placed on the wireless charging pad was not implemented, so that a problem arises in that the prior art is difficult to cope with the case where a plurality of battery packs, or an object that cannot be charged, is placed on a wireless charging pad.

Description of Drawings

FIG. 1 is a view showing the construction of a battery pack charged by a wireless charging pad in a non-contact manner, according to the present invention;

FIG. 2 is a view showing the entire construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention;

FIGS. 3 to 5 are views illustrating the components of the wireless charging pad or battery pack, according to the present invention;

FIG. 6 is a view showing a method of generating a magnetic field based on the switching patterns of the wireless charging pad, according to the present invention;

FIG. 7 is a view showing the size expansion of the wireless charging pad according to the number of charging devices, according to the present invention;

FIG. 8 is a view showing the detailed construction of

the non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention;

FIG. 9 is a flowchart showing a method of charging a battery using the wireless charging pad of FIG. 8;

FIGS. 10 and 11 are views showing the equivalent circuits of series and parallel resonant converters, respectively, provided to the wireless charging pad of the present invention;

FIGS. 12 to 17 are views showing the operation of a half-bridge series resonant converter provided to the wireless charging pad of the present invention, according to modes;

FIG. 18 is a view showing the voltage and current waveforms of a transformer according to the gate signal of the half-bridge series resonant converter provided to the wireless charging pad of the present invention;

FIG. 19 is a view showing the rotating directions of a magnetic field according to the operation of the half-bridge series resonant converter provided to the wireless charging pad of the present invention, according to modes;

FIGS. 20 to 23 are views showing the rectifying circuits of a charging receiver module according to the present invention;

FIG. 24 is a view showing the construction of a controller provided to the wireless charging pad of the

present invention; and

FIG. 25 is a view showing the flow of an RF signal between the wireless charging pad and the battery pack according to the present invention.

Disclosure

Technical Problem

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Technical Solution

In order to accomplish the above objects, the present invention provides a wireless charging pad (200) for charging a battery pack (100) mounted on a portable device in a non-contact manner, to which a radio frequency identification technology is applied, including a controller (240) for switching to an active mode and

controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack (100) is detected, for transmitting a Radio Frequency (RF) carrier signal to the battery pack (100) in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information of the battery pack (100), through a reader antenna (RA) in response to the RF carrier signal, and indicating the charged status of the battery pack (100), and for switching to the energy saving mode again when charging of the battery pack (100) is completed; the drive circuits (220 and 220') for switching two primary coils (Pcoil1 and Pcoil2) under control of the controller (240); and a primary-side transformer formed by constructing a pad core, which is adapted to generate induced electromotive force through switching of the drive circuits (220 and 220') and charge the battery pack (100), and which is formed by connecting a plurality of small cobalt-based amorphous metallic or ferrite planar cores in a square or rectangular shape, and winding two primary coils (Pcoil1 and Pcoil2) on the pad core in directions perpendicular to each other.

Preferably, the controller (240) may read wireless identification information and charged status information of each of battery packs (100) in order in which the battery packs (100) are placed, indicate charged status of

each battery pack (100), and switch to the energy saving mode when charging of all the battery packs (100) are completed, and therefore, fully charged status may be established.

Preferably, the controller (240) may include an oscillator (241) for generating an oscillation signal of a certain frequency; an antenna driver (242) for using the oscillation signal of the oscillator (241) as a clock, monitoring the access of the battery pack (100) by transmitting the RF carrier signal to an outside through the reader antenna (RA) and monitoring whether a return signal exists, and wirelessly receiving RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack (100), in response to the RF carrier signal when the battery pack (100) makes access; a demodulator (243) for demodulating the RF data received by the antenna driver (242); a filter and amplification unit (244) for filtering the wireless identification information and charged status information from the demodulated data and amplifying the filtered information; a data decoder (245) for decoding the wireless identification information and the charged status information received by the filter and amplification unit (244); and a display unit (247) for displaying the data decoded by the data decoder (245).

Preferably, the drive circuits (220 and 220') may

include two half-bridge series-parallel resonant converters to control the primary coils (Pcoil1 and Pcoil2) perpendicular to each other, and switch the primary coils (Pcoil1 and Pcoil2) at a frequency higher than a resonant point so that switching patterns of the primary coils (Pcoil1 and Pcoil2) have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating in a sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

Preferably, the wireless charging pad may further include an electromagnetic wave filter (250) combined with a power input terminal to block electromagnetic waves from Alternating Current (AC) power input; an AC/Direct Current (DC) conversion circuit (210) for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter (250) and rectifying the AC power into DC power; and a flyback converter (210') connected to the AC/DC conversion circuit (210) and the controller (240) to accumulate power while a transistor is turned on and transmit the accumulated power to the controller (240) when the transistor is turned off so as to drive the drive circuits (220 and 220').

Preferably, the wireless charging pad (200) may include input ports that are combined with at least one of an AC adapter, a Universal Serial Bus (USB) port and a

cigar lighter jack for a vehicle.

The present invention provides a battery pack (B) mounted on a portable device to be charged by a wireless charging pad (A) in a non-contact manner, to which a radio frequency identification technology is applied, including a charging receiver module (110) formed of an amorphous metallic planar core and two secondary coils (Scoil1 and Scoil2), which are wound on the planar core in vertical and horizontal directions, to induce power through magnetic coupling with the wireless charging pad (200); a charging protection circuit module (120) combined with the charging receiver module (110) and the battery (BAT) to record charged status information generated by periodically monitoring charged status of the battery (BAT) in an Radio Frequency Identification (RFID) tag (130), and to control whether to charge or discharge the battery (BAT) by selectively supplying or blocking the power induced to the charging receiver module (110) to the battery (BAT); the RFID tag (130) combined with the charging protection circuit module (120) to store wireless identification information of the battery (BAT), to periodically record the charged status information, and to generate and modulate RF data including the wireless identification information and charged status information of the battery (BAT) and transmit the modulated RF data to the wireless charging pad (200) when an RF carrier signal is transmitted

from the wireless charging pad (200) through a tag antenna (TA); and the battery (BAT) to be charged under control of the protection circuit (124).

Preferably, the wireless charging pad may further include an amorphous metallic electromagnetic protector (140) for minimizing a rise in temperature of the battery (BAT) attributable to frequency interference, which is caused by radio signals or induced electromotive force in a magnetic field, or attributable to inductive heating, by magnetically blocking a gap between the battery (BAT) and the charging receiver module (110).

Preferably, the wireless charging pad may further include a battery casing (150) manufactured using a cool polymer to perform an operation of emitting heat generated due to charging while admitting the induced electromotive force, and to entirely surround a structure that is formed by assembling the components.

Preferably, the charging protection circuit module (120) may include rectifying circuits 121 and 121' for rectifying the power induced to the charging receiver module (110) and supplying the rectified power to a charging control circuit (122); the charging control circuit (122) combined with the rectifying circuits (121 and 121') to supply the power rectified by the rectifying circuits (121 and 121') to a fuel gauge (123) under On/Off control of the RFID tag (130); the fuel gauge (123) for

supplying the power supplied from the charging control circuit (122) to the battery (BAT) through a protection circuit (124), and generating the charged status information while monitoring the charged status of the battery (BAT), and periodically recording the charged status information in the RFID tag (130); and the protection circuit (124) combined with the fuel gauge (123) and the battery (BAT) to protect the battery (BAT) by controlling whether to charge or discharge according to the charged status of the battery (BAT).

Preferably, the rectifying circuits (121 and 121') may be series-parallel resonant center tap half-bridge rectifying circuits using an output of a single center tap rectifying diode and an output filter capacitor, or series-parallel resonant full-bridge rectifying circuits using an output of a full-bridge rectifying diode and an output filter capacitor.

Preferably, the RFID tag (130) may include a clock extraction unit (131) for extracting a clock from the RF carrier signal wirelessly received from the wireless charging pad (200); a sequencer (132) for inspecting an sequence of arranged data extracted from the clock extraction unit (131) and transmitting a control signal to a data encoder (133); the data encoder (133) for receiving the wireless identification information and charged status information of the battery (BAT) from a tag (135) when the

control signal is transmitted from the sequencer (132), and transmitting the wireless identification information and charged status information to a data modulator (136) after coding the wireless identification information and charged status information; the data modulator (136) for generating RF data generated by modulating the data received from the data encoder (133), and wirelessly transmitting the RF data to the wireless charging pad (200); Read Only Memory (ROM) (134) for recording the wireless identification information and charged status information therein; and the tag (135) for reading the wireless identification information and charged status information of the battery (BAT) stored in the ROM (134), and transmitting the wireless identification information and charged status information to the data encoder (133).

Preferably, the wireless identification information may correspond to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in the RFID tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

Preferably, the RF carrier signal may be a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in High Frequency (HF) (3 to 30 MHz) or Ultra High Frequency (UHF) (300 to 3000 MHz)

bands.

Advantageous Effects

As described above, the present invention is advantageous in that there is provided a wireless charging pad and a battery pack, to which a radio frequency identification technology is applied, which can detect the charged status of the battery pack in real time, and which includes a means for detecting devices placed on the wireless charging pad, thus effectively coping with the case where a plurality of battery packs, or an object that cannot be charged, is placed on the wireless charging pad.

Best Mode

Preferred embodiments of the present invention are described in detail with reference to the attached drawings below, but detailed descriptions of related well-known functions and construction may be omitted if the detailed descriptions are determined to make the gist of the present invention unclear.

FIG. 1 is a view showing the entire construction of a battery pack charged by a wireless charging pad in a non-contact manner, according to the present invention.

Referring to FIG. 1, a battery pack 100 includes a charging receiver module 110 provided with secondary coils Scoil1 and Scoil2 to receive induced electromotive force

from a primary-side wireless charging pad 200 (refer to FIG. 2), a charging protection circuit module 120 and a battery BAT having fuel gauge and charging functions, an RFID tag 130 (refer to FIG. 2) and a tag antenna TA adapted to transmit and receive radio signals, and an electromagnetic protector 140 that is an amorphous metal-based electromagnetic interference shield for magnetically isolating the battery BAT and the charging receiver module 110 so that the battery BAT does not affect the inductive coupling between the receiver module 110 and the wireless charging pad 200 (refer to FIG. 2).

The electromagnetic protector 140 is made of an amorphous metal-based magnetic material to remove frequency interference in a magnetic field attributable to radio signals and induced electromotive force, and generally functions to minimize a rise in temperature of the battery BAT in a magnetic field attributable to inductive heating caused by a metallic battery casing, so that the electromagnetic protector 140 must be inserted.

The battery pack 100 may further include the battery casing 150 for surrounding all the components, such as the charging receiver module 110, the charging protection circuit module 120, the battery BAT and the electromagnetic protector 140, combined into a single structure. In this case, the battery casing 150 is manufactured using a cool polymer material, such as cobalt or nickel, so that the

battery casing 150 functions to pass the induced electromotive force or electromagnetic waves, and emit heat generated inside the battery casing 150 due to charging.

FIG. 2 is a view showing the construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack, according to the present invention.

Referring to FIG. 2, the non-contact battery charging system composed of the wireless charging pad and the battery pack separately comprises the wireless charging pad 200 adapted to function as a non-contact charger and the battery pack 100 charged with power provided by the wireless charging pad 200. A separative transformer is provided between the wireless charging pad 200 and the battery pack 100 so that a primary side of the transformer is provided in the wireless charging pad 200 and a secondary side of the transformer is provided in the battery pack 100.

The battery pack 100 includes the charging receiver module 110, the charging protection circuit module 120, the RFID tag 130, the tag antenna TA and the battery BAT that constitute the secondary side of the transformer.

The charging receiver module 110 receives the power induced from the wireless charging pad 200 and supplies the power to the charging protection circuit module 120.

The charging protection circuit module 120 having

fuel gauge and charging functions includes rectifying circuits 121 and 121' for rectifying the power supplied from the charging receiver module 110 by performing AC/DC conversion, a switch mode charging control circuit 122 for charging the battery BAT made of lithium ion or lithium polymer at Constant Voltage (CV) and Constant Current (CC), and a protection circuit 124 for detecting the charged status of the battery BAT and determining whether to supply or block the power supplied to the battery BAT from the charging control circuit 122 so as to protect the battery BAT. The charging protection circuit module 120 is constructed in such a way that the output of the charging receiver module 110 is the input of the rectifying circuits 121 and 121' and the output of the rectifying circuits 121 and 121' is connected to the input of the switch mode charging control circuit 122. Furthermore, the output of the charging control circuit 122 is connected to a fuel gauge 123, and the fuel gauge 123 is connected to the protection circuit 124 that protects the battery BAT from excessive charging and excessive current. Such components are mounted in the battery pack 100 of a portable device, and can be applied to a hard pack or an inner pack according to the type of the battery pack 100.

The wireless charging pad 200 functioning as a non-contact charger has various input ports having DC inputs, so that the wireless charging pad 200 can be used in

connection with various types of external power sources (e.g., the output of an AC adapter, a USB port of a computer, cigar lighter jack of a vehicle, etc.). In the wireless charging pad 200, the primary side of the transformer is provided, switching loss is reduced through zero voltage and zero current soft switching by switching at a frequency higher than a resonant point using a half-bridge resonant converter, and linkage flux is induced to the battery pack 100 of a portable device that constitutes a secondary side. Furthermore, the wireless charging pad 200 has a function of detecting the wireless identification information of the battery BAT and indicating charged status information on the wireless charging pad 200 through radio communication when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200, and a function of entering a shutdown mode and an energy saving mode when an object other than a battery pack 100 is placed on the wireless charging pad 200. Furthermore, when a plurality of portable devices is placed on the wireless charging pad 200, the wireless charging pad 200 reads the wireless identification information (e.g., personal phone numbers, etc.) stored in the RFID tag 130, indicates the wireless identification information on the wireless charging pad 200, indicates charged status, and indicates charging completion status on the wireless charging pad 200 after receiving information

on the completion of charging from the battery pack 100.

The RFID tag 130 and the tag antenna TA function to interface with the fuel gauge 123 that controls the charged status information of the battery BAT and transmit the charged status information of the battery BAT to the wireless charging pad 200 in a radio data form using a radio frequency in HF (13.56MHz) or UHF (900MHz) bands. The RFID tag 130 includes a memory block and a logic block, and stores the wireless identification information, such as a product name, a serial number and a user identification number (e.g., personal telephone number), therein. In this case, the user identification number is stored in the memory block of the RFID tag 130 through the communication between the terminal body of the portable device and the battery pack 100.

FIGS. 3 and 4 are views illustrating the components of the wireless charging pad and the battery pack according to the present invention, respectively.

Referring to FIG. 3, the wireless charging pad 200 according to the present invention includes a controller 240 for reading the RFID tag and controlling charging, drive circuits 220 and 220', and primary coils Pcoil1 and Pcoil2.

The wireless charging pad 200 may include various input ports having DC inputs, and generates the switching patterns of the primary coils Pcoil1 and Pcoil2 through the

drive circuits 220 and 220', respectively, and performs a control function of detecting portable devices placed on the wireless charging pad 200 and indicating the energy saving mode and the charged status of each of the portable devices. The drive circuits 220 and 220' are On/Off switching devices for switching the primary coils Pcoil1 and Pcoil2, respectively, each of which is composed of an upper switch and a lower switch. The drive circuits 220 and 220' are each constructed using a half-bridge or full-bridge resonant converter (serial, parallel or serial-parallel resonant converter).

Referring to FIG. 4, in the wireless charging pad 200 according to the present invention, the primary side of the transformer is constructed in such way that the two primary coils Pcoil1 and Pcoil2 are wound on a planar core, which is formed by combining small cobalt-based amorphous metallic cores, such as Co, Fe, Ni, B and Si, or ferrite cores in various shapes, in directions perpendicular to each other as shown in FIG. 4. In this case, the switching patterns perform switching so that a phase difference of 90 degrees occurs between the two primary coils Pcoil1 and Pcoil2. Accordingly, induced energy can be received regardless of the location of the portable device that is placed on the wireless charging pad 200 and has the battery pack 100 equipped with the charging receiver module 100.

The input form of the wireless charging pad 200 is

described below.

A control power source supplies the driving power of the controller 240 and the drive circuits 220 and 220' using a flyback converter in a 110/220 V direct drive fashion. In the resonant converter, DC power obtained by rectifying AC power in a 110/220 V switching fashion is always set to a 110 V input condition. DC power (12, 24, 48 V) is generated using the flyback converter for free voltages ranging from 86 to 265 V and is used as the input power of the resonant converter, and forms the driving power of the controller 240 and the drive circuits 220 and 220' using a regulator.

The controller 240 performs both a function of reading an RFID tag and a function of controlling charging. The construction of the controller 240 is described below.

First, a controller 240 is provided to detect the battery pack 100 equipped with the charging receiver module 110 and control charging. Wireless identification information, such as the product code and serial number of the battery BAT, and charged status information are read from the RFID tag 130 of the battery pack 100 through the controller 240. Furthermore, when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200 while the controller 240 in a sleep mode is maintained in a standby mode (energy saving mode: below 1 W) and monitors the battery pack 100, the

controller 240 wakes up and switches to an active mode to generate induced electromotive force by controlling the drive circuits 220 and 220', starts to charge the battery pack 100, and indicates the charged status of the battery pack 100. When the charging of the battery pack 100 is completed, the wireless charging pad 200 switches from the active mode to the energy saving mode again to save energy.

Second, when a plurality of battery packs 100 each equipped with a charging receiver modules 110 is placed on the wireless charging pad 200, wireless identification information stored in the RFID tags 130 of the battery packs 100 is read in order in which the battery packs 100 are placed. Furthermore, a fully charged battery pack 100 is indicated by a green Light Emitting Diode (LED) and a discharged battery pack 100 is indicated by a red LED. When the battery pack 100 is fully charged, the LED switches from red to green by receiving the wireless identification information of the RFID tag 130 so that the charged status is indicated by the wireless charging pad 200.

The construction of the drive circuits 220 and 220' is described below.

Two resonant converters control perpendicularly arranged primary coils Pcoil1 and Pcoil2, respectively, and the primary coils Pcoil1 and Pcoil2 are switched at a frequency higher than a resonant point so that the switching patterns of the primary coils have a phase

difference of 90 degrees. Accordingly, linkage flux rotates by 360 degrees in eight steps, thus enabling the battery pack 100 to be charged regardless of the location of the battery pack 100.

The construction of the primary side of the transformer is described below.

A single square or rectangular pad core is formed by connecting a plurality of small planar cores, is surrounded by an insulation tape, is provided with a coil wound thereon in a vertical direction, and is insulated by an insulation tape. Furthermore, the pad core is provided with a coil wound thereon in a horizontal direction and is insulated by an insulation tape, thus manufacturing the primary side of a planar transformer. In this case, the coil may be formed into a bobbinless type and be inserted into the pad core in vertical and horizontal directions. The charging receiver module 110 is operated as the secondary side of the transformer.

FIG. 5 is a view showing the charging receiver module 110. The charging receiver module 110 is manufactured in such a way that a plurality of cobalt-based amorphous metallic cores is stacked to form a single planar core, and secondary coils Scoil1 and Scoil2 are wound on the single planar core in vertical and horizontal directions, respectively. In this case, the planar core is made of an amorphous metal-based material that has high magnetic

permeability (>80,000) and a non-breakable characteristic. In the charging receiver module 110, the magnitude of induced electromotive force varies according to a function of the number of stacked cores forming the planar core, the sectional area of the planar core and the number of windings of the coils. The charging receiver module 110 has a load curve in which voltage is inversely proportional to current.

FIG. 6 is a view showing a method of generating a magnetic field depending on the switching patterns of the wireless charging pad according to the present invention.

In the wireless charging pad 200, a magnetic field rotates by 360 degrees in the case where current is applied by successively switching regions in the sequence of a first region→ a second region→ a third region→ a fourth region→ a fifth region→ a sixth region→ a seventh region→ an eighth region at a predetermined frequency, thus enabling a portable device equipped with the charging receiver module 110 to be charged regardless of the location and direction of the portable device when the portable device is placed on the wireless charging pad 200 (the magnetic field is rotated by 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°). In this case, the drive circuits 220 and 220′ include two half-bridge series-parallel resonant converters to control the perpendicularly arranged primary coils Pcoil1 and Pcoil2, respectively, and switch

the primary coils Pcoil1 and Pcoil2 at a frequency higher than a resonant point so that the switching patterns of the primary coils Pcoil1 and Pcoil2 have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating by 360 degrees in the sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

FIG. 7 is a view showing the size expansion of the wireless charging pad according to the number of charging devices, according to the present invention.

In a process of forming a pad core constituting the wireless charging pad 200, a wireless charging pad 200 having a desired size and shape can be formed by combining a plurality of small cobalt-based metallic or ferrite planar cores. For example, a pad core is formed by combining m cores in a longitudinal direction and n cores in a transverse direction according to the number of portable devices desired to be charged.

FIG. 8 is a view showing the detailed construction of a non-contact battery charging system composed of the wireless charging pad and the battery pack according to the present invention.

As shown in FIG. 8, a primary-side wireless charging pad 200 and a secondary-side battery pack 100 equipped with the charging receiver module 110 are magnetically combined with each other.

The primary-side wireless charging pad 200 includes a power input terminal, an AC/DC conversion circuit 210, a controller 240 for detecting wireless identification information transmitted from the secondary side, two half-bridge serial-parallel resonant converters, drive circuits 220 and 220′ for generating a magnetic field by generating control signals for controlling the two primary coils Pcoil1 and Pcoil2, respectively, a primary-side transformer constructed by winding the two primary coils Pcoil1 and Pcoil2 on the pad core in vertical and horizontal directions, respectively, and inductive couplers 230 and 230′ formed by providing L_r and L_r' to the corresponding primary-side transformer.

Furthermore, the primary-side wireless charging pad 200 may further include an electromagnetic wave filter 250 connected to the power input terminal for the purpose of blocking the electromagnetic waves of input AC power, and a flyback converter 210′ connected to the AC/DC conversion circuit 210 for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter 250 and rectifying the AC power into DC power and the controller 240 for the purpose of accumulating power while an equipped transistor is turned on and transmitting the accumulated power to the controller 240 when the equipped transistor is turned off so as to enable the drive circuits 220 and 220′ to be driven.

The secondary-side battery pack 100 includes a receiver module 110 composed of an amorphous metallic planar core and two secondary coils Scoil1 and Scoil2 that are wound on the planar core in vertical and horizontal directions, respectively, to be magnetically combined with the wireless charging pad 100, thus inducing induced electromotive force; a charging protection circuit module 120 for generating charged status information by periodically monitoring the charged status of a battery BAT, recording the generated charged status information in an RFID tag 130 and controlling whether to charge or discharge the battery BAT by selectively supplying or blocking the power, which is induced to the charging receiver module 110, to the battery BAT under the On/Off control of the RFID tag 130; the RFID tag 130 combined with the charging protection circuit module 120 to store the wireless identification information of the battery BAT and periodically record the charged status information therein, generate and modulate RFID data including the wireless identification information and charged status information of the battery BAT and transmit the modulated RFID data to the wireless charging pad 200 in response to an RFID carrier signal transmitted from the wireless charging pad 200 through a tag antenna TA; and the battery BAT to be charged under the control of the protection circuit 124.

The charging protection circuit module 120 may

include rectifying circuits 121 and 121' adapted to rectify the power induced to the charging receiver module 110 and supply the rectified power to a charging control circuit 122, the charging control circuit 122 combined with the rectifying circuits 121 and 121' to supply the power, rectified by the rectifying circuits 121 and 121' under the On/Off control of the RFID tag 130, to a fuel gauge 123, the fuel gauge 123 adapted to supply the power supplied from the charging control circuit 122 to the battery BAT through the protection circuit 124, and generate the charged status information by monitoring the charged status of the battery BAT and periodically record the charged status information in the RFID tag 130, and the protection circuit 124 combined with the fuel gauge 123 and the battery BAT to protect the battery BAT by controlling whether to charge or discharge in accordance with the charged status of the battery BAT.

When the RFID carrier signal is transmitted from the wireless charging pad 200 through the tag antenna TA, the RFID tag 130 generates and modulates RFID data that includes previously stored wireless identification information of the battery BAT and charged status information, which is periodically recorded through the fuel gauge 123, in response to the RFID carrier signal, and transmits the modulated RFID data to the wireless charging pad 200. In this case, the RFID tag 130 is composed of a

memory block and a logic block. The memory block can be implemented using ROM 134 in which the wireless identification information and the charged status information are recorded. It is preferable to use Electrically Erasable and Programmable Read Only Memory (EEPROM) as the ROM 134. The logic block can be implemented using a clock extraction unit 131 for extracting a clock from the RFID carrier signal that is wirelessly received from the wireless charging pad 200, a sequencer 132 for inspecting the sequence of arranged data extracted from the clock extraction unit 131 and transmitting a control signal to a data encoder 133, the data encoder 133 for receiving the wireless identification information and charged status information of the battery BAT from a tag 135 when the control signal is transmitted from the sequencer 132, encoding the received information and transmitting the encoded information to a data modulator 136, the data modulator 136 for generating the modulated RFID data by modulating the data received from the data encoder 133 and wirelessly transmitting the modulated RFID data to the wireless charging pad 200, and the tag 135 for reading the wireless identification information and charged status information of the battery BAT stored in the ROM 134 and transmitting the wireless identification information and charged status information to the data encoder 133.

FIG. 9 is a flowchart showing a method of charging a

battery through the wireless charging pad of FIG. 8. The method of charging a battery using the wireless charging pad 200 according to the present invention is described with reference to FIG. 9 below.

Step S100) First, when the secondary-side battery pack 100 is placed on the primary-side wireless charging pad 200, the primary-side wireless charging pad 200 generates an RFID carrier signal and inspects an object placed on the wireless charging pad 200.

Step S110) If, as a result of the inspection, the object does not contain information indicating that the object is a battery pack 100 equipped with a charging receiver module 110, the primary-side wireless charging pad 200 always enters an energy saving mode.

Step S120) If, as a result of the inspection, the object contains information indicating that the object is a battery pack 100 equipped with a charging receiver module 110, the wireless charging pad 200 wakes up to detect wireless identification information and starts charging control.

Step S130) Wireless identification information about the battery pack 100 of each of various portable devices is displayed, and whether the battery pack 100 is in charging status or fully charged status is indicated after receiving charged status information. The battery 100 in fully charged status that indicates charging is completed is

indicated by a green LED, and the battery 100 being charged is indicated by a red LED.

Step S140) When the fully charged status in which the charging of all the battery packs 100 are completed is established, the wireless charging pad 200 collects the wireless identification information and enters a standby mode, that is, the energy saving mode.

FIGS. 10 and 11 are views showing the equivalent circuits of series and parallel resonant converters provided to the wireless charging pad according to the present invention.

FIGS. 10 and 11 are views showing the equivalent circuits of a separative transformer that has a gap between the wireless charging pad 200 and the battery pack 100. In a non-contact type charging method in which energy is transmitted using the magnetic coupling of the transformer, the primary side of the transformer is included in the wireless charging pad 200 functioning as a non-contact charger and the secondary side of the transformer is included in the battery pack 100, so that a gap exists between the primary and secondary sides, thus causing inefficiency in energy transmission because a coupling coefficient and magnetizing inductance are reduced and leakage inductance is increased. Besides, it is problematic in that it is difficult to electrically transmit output information to a primary-side controller at the time of

controlling feedback. In the present invention, in order to overcome the disadvantages of the separative transformer and effectively transmit energy, a half-bridge serial resonant converter is applied to the primary side of the transformer. The serial resonant converter applied to the primary side of the transformer reduces the influence of leakage inductance on the primary side of the separative transformer, thus enabling effective energy transmission.

The self-inductance L_1 and L_2 are measured in such a way that a secondary-side module is opened and primary-side inductance is measured, and the leakage inductance L_{l1} and L_{l2} are measured in such a way that a secondary-side module is shorted and primary-side inductance is measured.

Mutual inductance L_M is calculated in such a way that impedance L_P is measured by connecting the primary and secondary sides in parallel, impedance L_S is measured by connecting the primary and secondary sides in series, and the measured impedance L_P and L_S are substituted for L_P and L_s of Equation 1,

$$L_M = \frac{L_P - L_S}{4} \quad (1)$$

The magnetizing inductance L_m is measured using Equations 2 to 4,

$$L_m = L_M(\frac{N_1}{N_2}), \quad N = \frac{N_2}{N_1} \tag{2}$$

(N_1: number of primary windings, N_2: number of secondary windings)

$$k = \frac{L_M}{\sqrt{L_1 L_2}} \tag{3}$$

$$L_{l1} = L_1 - L_m, \quad L_{l2} = L_2 - NL_M \tag{4}$$

Voltage imposed in the primary side of the transformer is applied to the primary side of the transformer through the voltage distribution of L_{l1} and L_{l2}, and is transmitted to the secondary side based on a winding ratio. The secondary-side voltage is transmitted to the actual secondary side of the transformer through the voltage distribution of L_{l2} and secondary-side load, so that the voltage gain is lower than that of an ideal transformer.

Furthermore, if the coupling coefficient is low, the magnetizing inductance L_m of the transformer is low, so that current flowing to the primary side of the transformer is not transmitted to the secondary side of the transformer through L_{l2}, but is circulated and transmitted to the first side of the transformer again through the magnetizing inductance L_m that has lower impedance. That is, in order to supply current required by the load, input current must be large. If the primary-side current increases, continuity loss in a switch increases, thus causing the efficiency of

a system to decrease. Accordingly, in order to increase the efficiency of the system by reducing the primary-side current, the coupling coefficient of the transformer must be increased. In the non-contact charger, the primary- and secondary-side cores are separated by a gap, and winding areas are also separated. Furthermore, the gap is located in a path through which magnetic flux passes, so that magnetic resistance is increased, thus lowering the magnetic flux density inside the cores.

When a large gap exists between the primary- and secondary-side cores, magnetic flux density is expressed by Equation 5,

$$B_f = \frac{NI}{\frac{l_f}{\mu_f} + \frac{l_g}{\mu_o}} \approx \frac{\mu_o NI}{l_g} (\mu_f >> \mu_o) \quad (5)$$

(B: magnetic flux density, N: number of windings, I: current flowing through transformer, l_f: length of magnetic path of core, l_g: length of magnetic path in gap, μ_f: magnetic permeability of core, μ_o: magnetic permeability of gap)

The magnetic flux density, when the gap does not exist, is expressed by Equation 6,

$$B_f = \frac{\mu_f NI}{l_f} >> B_f \quad (6)$$

The magnetic permeability of the core is considerably larger than that of air, and the size of the gap is relatively larger than that of the core, so that the magnetic flux density in the case where the gap does not exist has a value considerably higher than that in the case where the gap is large. As a result, in the case of a transformer having a large gap, it is difficult for saturation status to occur inside the core, and also local saturation status is not generated easily. Accordingly, with respect to the shape of a core, a narrow section or protrusion is allowed. Furthermore, the magnetic flux density in the core is low, so that core loss due to hysteresis is also low.

Since the gap is large, the magnetic resistance is increased, so that the inductance of the core is decreased. Accordingly, in order to obtain required magnetizing inductance, the number of windings is increased and a wider winding area is required as a result.

The magnetizing inductance L_m may be expressed by Equation 7,

$$L_m = L_M(\frac{N_1}{N_2}) = \frac{N_1}{N_2}(\frac{N_1 N_2}{R_m}) = \frac{N_1^2}{R_m} \quad (7)$$

(R_m: magnetic resistance, N_1: number of primary windings, N_2: number of secondary windings, L_M: mutual inductance)

That is, since the magnetic resistance R_m is large, the number of windings is increased to obtain the required magnetizing inductance L_M. Generally, the difference between the primary- and secondary-side voltages of a non-contact charger is large, so that a difference in the winding ratio is also large. As a result, since the winding areas of the primary and secondary sides are different and the difference between the winding ratios is large, the shapes of the primary- and secondary-side cores are generally asymmetric.

Most leakage magnetic flux is generated in the gap existing between the primary- and secondary-side cores, so that a section area of the cores opposite to each other must be large to increase the coupling coefficient in the transformer. However, in the case of a transformer used in the non-contact charger, the volume and weight of the secondary-side core are limited because the secondary-side core is located inside the battery pack, so that the section area of the cores opposite to each other is also limited. However, in the present invention, a planar pad core, the section area of which is large in considerations of limited volume and weight, is used.

FIGS. 12 to 17 are views showing the operation of the half-bridge serial resonant converter provided to the wireless charging pad of the present invention, according

to modes.

FIGS. 12 to 17 are views showing the operation of the half-bridge serial resonant converter (upper converter), according to modes.

In FIG. 12, when Q_1 is turned on, current i_1 flows to a transformer through the switch Q_1. In FIG. 13, when the switch Q_1 is turned off, the current i_1 flows while discharging the parallel capacitor of a switch Q_2 and charging the parallel capacitor of the switch Q_1. In FIG. 14, when the voltage of the switch Q_2 is zero (the voltage of the switch Q_1 is input voltage), the current i_1 flows through the parallel diode of the switch Q_2, and the voltage of the switch Q_2 remains at zero. Furthermore, if the switch Q^2 is turned on before the direction of the current i_1 is reversed, Zero Voltage Switching (ZVS) is achieved in the switch Q_2. In FIG. 15, when the direction of the current i_1 is reversed, the current i_1 flows through the switch Q^2. In FIG. 16, when the switch Q^2 is turned off, the current i_1 flows while discharging the parallel capacitor of the switch Q^1 and charging the parallel capacitor of the switch Q^2. In FIG. 17, when the voltage of the switch Q^2 is zero (the voltage of the switch Q^2 is the input voltage), the current i_1 flows through the parallel diode of the switch Q^1, and the voltage of the switch Q^1 remains at zero. Furthermore, when the switch Q^1 is turned on before the direction of the current is restored, the ZVS is achieved

in the switch Q^1.

In order to achieve the ZVS of the switch Q^2, the magnitude of the current i_1 at the time of being changed from FIG. 12 to FIG. 13 must be large enough so that the energy of a magnetic circuit depending on the current i_1 can charge or discharge the parallel capacitor, and the gate signal of the switch Q^2 must be provided before the direction of the current i_1 is reversed. The switch Q^1 can achieve the ZVS using the same principle.

In this case, a resonant frequency considerably affects efficiency. The switching frequency is operated at a frequency close to the resonant frequency, so that the core loss and gap loss of the transformer are reduced if the resonant frequency is low. However, the loss may be increased because magnetic current, that is, the primary-side current of the transformer, is increased. Accordingly, the switching loss attributable to the ZVS is reduced by selecting a switching frequency higher than the resonant frequency.

FIG. 18 is a view showing the voltage and current waveforms of the transformer according to the gate signal of the half-bridge series resonant converter provided in the wireless charging pad of the present invention.

Referring to FIG. 18, square wave voltage identical to the input voltage is applied to the transformer by the gate signals of the switches Q^1 and Q^2, and sine wave current

identical to the current i_1 flows to the transformer through the resonant circuit.

FIG. 19 is a view showing the rotating directions of the magnetic field according to the operation of the half-bridge series resonant converter provided in the wireless charging pad of the present invention, according to modes.

FIG. 20 is a view showing the rotating directions of the magnetic field generated according to the operation of the half-bridge series resonant converter according to modes. Accordingly, since the magnetic field rotates by 360 degrees, induced electromotive force can be transmitted to the secondary side regardless of the location and direction of the battery pack 100 when the battery pack 100 equipped with the charging receiver module 110 is placed on the wireless charging pad 200.

FIGS. 20 to 23 are views showing the rectifying circuits of the charging receiver module according to the present invention.

Referring to FIGS. 20 to 23, the secondary-side charging receiver module 110 transmits power through a series-parallel resonant center tap half-bridge rectifying circuit that uses the output of a single center tap rectifying diode and an output filter capacitor, or through a series-parallel resonant full-bridge rectifying circuit that uses the output of a full-bridge rectifying diode and an output filter capacitor.

FIG. 24 is a view showing the construction of a controller provided in the wireless charging pad of the present invention.

The controller 240 provided in the wireless charging pad 200 of the present invention determines whether a battery pack 100 is placed on the wireless charging pad 200, reads wireless identification information, which is stored in the RFID tag 130, from the battery pack 100 if the battery pack 100 is placed, determines whether the battery pack 100 needs to be charged or how many battery packs 100 are placed, and generates a drive control signal and indicates the charged status of each of the battery packs at the same time.

Referring to FIG. 24, the controller 240 provided in the wireless charging pad 200 of the present invention may include an oscillator 241 for generating an oscillation signal of a certain frequency, an antenna driver 242, a demodulator 243 for demodulating RF data received by the antenna driver 242, a filter and amplification unit 244 for filtering wireless identification information and charged status information from the demodulated data and amplifying the filtered information, a data decoder 245 for decoding the wireless identification information and charged status information received by the filter and amplification unit 244, a driver control unit 246 for performing mode conversion according to the charged status based on the

decoded data, a display unit 247 for displaying the data decoded by the data decoder 245, a timer 248, and a reset unit 249.

The antenna driver 242 uses the oscillation signal of the oscillator 241 as a clock, monitors the access of the battery pack 100, and wirelessly receives RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack 100, in response to an RF carrier signal through the reader antenna RA when the battery pack 100 makes access. In this case, a polling method of periodically transmitting the RF carrier signal to the outside through the reader antenna RA and monitoring whether a return signal exists can be applied as a method of the antenna driver 242 monitoring the access of the battery pack 100.

Furthermore, in the case where a plurality of battery packs 100 is placed, the controller 240 reads the wireless identification information and charged status information of each of the battery packs 100 in order in which the battery packs 100 are placed, indicates the charged status of each of the battery packs 100, and switches from an active mode to an energy saving mode when all the battery packs 100 are completely charged, and thereby, the fully charged status is established.

FIG. 25 is a view showing the flow of the RF signal between the wireless charging pad and the battery pack

according to the present invention.

Referring to FIG. 25, when the controller 240 accesses the RFID tag 130 in the battery pack 100 equipped with the charging receiver module 110 to access information on the battery BAT using a carrier frequency in HF (3 to 30 MHz) or UHF (300 to 3000 MHz) bands, the battery information stored in the memory block of the RFID tag 130 is transmitted to the wireless charging pad 200 in a modulated RF signal form.

The present invention may be modified in various forms without departing from the basic concept of the invention according to the demands of those skilled in the art.

CLAIMS

1. A wireless charging pad (200) for charging a battery pack (100) mounted on a portable device in a non-contact manner, to which a radio frequency identification technology is applied, comprising:

a controller (240) for switching to an active mode and controlling drive circuits (220 and 220') while standing by in an energy saving mode when access of the battery pack (100) is detected, for transmitting a Radio Frequency (RF) carrier signal to the battery pack (100) in the active mode, receiving RF data, which is modulated and includes wireless identification information and charged status information of the battery pack (100), through a reader antenna (RA) in response to the RF carrier signal, and indicating the charged status of the battery pack (100), and for switching to the energy saving mode again when charging of the battery pack (100) is completed;

the drive circuits (220 and 220') for switching two primary coils (Pcoil1 and Pcoil2) under control of the controller (240); and

a primary-side transformer formed by constructing a pad core, which is adapted to generate induced electromotive force through switching of the drive circuits (220 and 220') and charge the battery pack (100), and which is formed by connecting a plurality of small cobalt-based

amorphous metallic or ferrite planar cores in a square or rectangular shape, and winding two primary coils (Pcoil1 and Pcoil2) on the pad core in directions perpendicular to each other.

2. The wireless charging pad according to claim 1, wherein the controller (240) reads wireless identification information and charged status information of each of battery packs (100) in order in which battery packs (100) are placed, indicates charged status of each battery pack (100), and switches to the energy saving mode when charging of all the battery packs (100) are completed, and therefore, fully charged status is established.

3. The wireless charging pad according to claim 1 or 2, wherein the controller (240) comprises an oscillator (241) for generating an oscillation signal of a certain frequency; an antenna driver (242) for using the oscillation signal of the oscillator (241) as a clock, monitoring the access of the battery pack (100) by transmitting the RF carrier signal to an outside through the reader antenna (RA) and monitoring whether a return signal exists, and wirelessly receiving RF data, which is modulated and includes the wireless identification information and charged status information of the battery pack (100), in response to the RF carrier signal when the

battery pack (100) makes access; a demodulator (243) for demodulating the RF data received by the antenna driver (242); a filter and amplification unit (244) for filtering the wireless identification information and charged status information from the demodulated data and amplifying the filtered information; a data decoder (245) for decoding the wireless identification information and the charged status information received by the filter and amplification unit (244); and a display unit (247) for displaying the data decoded by the data decoder (245).

4. The wireless charging pad according to claim 1, wherein the drive circuits (220 and 220') include two half-bridge series-parallel resonant converters to control the primary coils (Pcoil1 and Pcoil2) perpendicular to each other, and switch the primary coils (Pcoil1 and Pcoil2) at a frequency higher than a resonant point so that switching patterns of the primary coils (Pcoil1 and Pcoil2) have a phase difference of 90 degrees, thus allowing linkage flux to vary while rotating in a sequence of 180°→ 135°→ 90°→ 45°→ 0°→ -45°→ -90°→ -135°, and thereby, generating a magnetic field that rotates by 360 degrees.

5. The wireless charging pad according to claim 1, further comprising:

an electromagnetic wave filter (250) combined with a

power input terminal to block electromagnetic waves from Alternating Current (AC) power input; an AC/Direct Current (DC) conversion circuit (210) for receiving the AC power, the electromagnetic waves of which are blocked, from the electromagnetic wave filter (250) and rectifying the AC power into DC power; and a flyback converter (210') connected to the AC/DC conversion circuit (210) and the controller (240) to accumulate power while a transistor is turned on and transmit the accumulated power to the controller (240) when the transistor is turned off so as to drive the drive circuits (220 and 220').

6. The wireless charging pad according to claim 1, wherein the wireless charging pad (200) includes input ports that are combined with at least one of an AC adapter, a Universal Serial Bus (USB) port and a cigar lighter jack for a vehicle.

7. The wireless charging pad according to claim 1, wherein the wireless identification information corresponds to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in an Radio Frequency Identification (RFID) tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

8. The wireless charging pad according to claim 1, wherein the RF carrier signal is a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in High Frequency (HF) (3 to 30 MHz) or Ultra High Frequency (UHF) (300 to 3000 MHz) bands.

9. A battery pack (B) mounted on a portable device to be charged by a wireless charging pad (A) in a non-contact manner, to which a radio frequency identification technology is applied, comprising:

a charging receiver module (110) formed of an amorphous metallic planar core and two secondary coils (Scoil1 and Scoil2), which are wound on the planar core in vertical and horizontal directions, to induce power through magnetic coupling with the wireless charging pad (200);

a charging protection circuit module (120) combined with the charging receiver module (110) and the battery (BAT) to record charged status information generated by periodically monitoring charged status of the battery (BAT) in an RFID tag (130), and to control whether to charge or discharge the battery (BAT) by selectively supplying or blocking the power induced to the charging receiver module (110) to the battery (BAT);

the RFID tag (130) combined with the charging protection circuit module (120) to store wireless

identification information of the battery (BAT), to periodically record the charged status information, and to generate and modulate RF data including the wireless identification information and charged status information of the battery (BAT) and transmit the modulated RF data to the wireless charging pad (200) when an RF carrier signal is transmitted from the wireless charging pad (200) through a tag antenna (TA); and

the battery (BAT) to be charged under control of the protection circuit (124).

10. The wireless charging pad according to claim 9, further comprising an amorphous metallic electromagnetic protector (140) for minimizing a rise in temperature of the battery (BAT) attributable to frequency interference, which is caused by radio signals or induced electromotive force in a magnetic field, or attributable to inductive heating, by magnetically blocking a gap between the battery (BAT) and the charging receiver module (110).

11. The wireless charging pad according to claim 9 or 10, further comprising a battery casing (150) manufactured using a cool polymer to perform an operation of emitting heat generated due to charging while admitting the induced electromotive force, and to entirely surround a structure that is formed by assembling the components.

12. The wireless charging pad according to claim 9, wherein the charging protection circuit module (120) comprises:

rectifying circuits 121 and 121' for rectifying the power induced to the charging receiver module (110) and supplying the rectified power to a charging control circuit (122); the charging control circuit (122) combined with the rectifying circuits (121 and 121') to supply the power rectified by the rectifying circuits (121 and 121') to a fuel gauge (123) under On/Off control of the RFID tag (130); the fuel gauge (123) for supplying the power supplied from the charging control circuit (122) to the battery (BAT) through a protection circuit (124), and generating the charged status information while monitoring the charged status of the battery (BAT), and periodically recording the charged status information in the RFID tag (130); and the protection circuit (124) combined with the fuel gauge (123) and the battery (BAT) to protect the battery (BAT) by controlling whether to charge or discharge according to the charged status of the battery (BAT).

13. The wireless charging pad according to claim 12, wherein the rectifying circuits (121 and 121') are series-parallel resonant center tap half-bridge rectifying circuits using an output of a single center tap rectifying

diode and an output filter capacitor, or series-parallel resonant full-bridge rectifying circuits using an output of a full-bridge rectifying diode and an output filter capacitor.

14. The wireless charging pad according to claim 9, wherein the RFID tag (130) comprises:

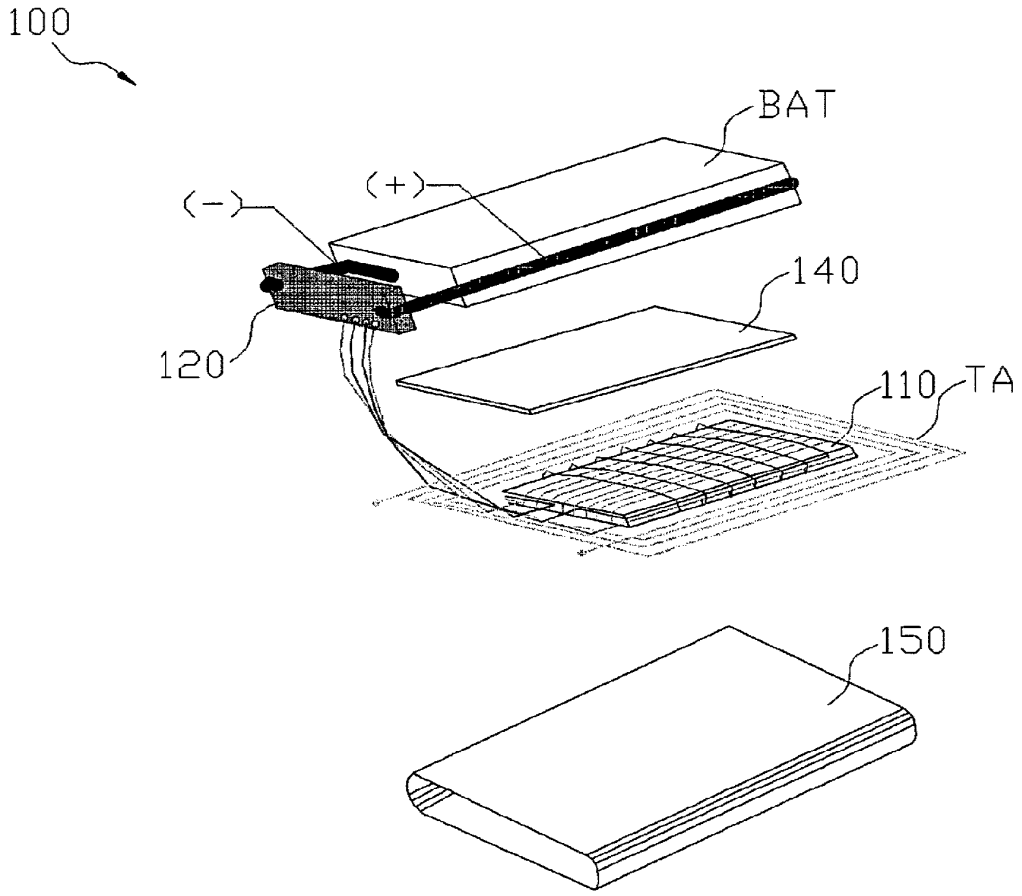
a clock extraction unit (131) for extracting a clock from the RF carrier signal wirelessly received from the wireless charging pad (200); a sequencer (132) for inspecting an sequence of arranged data extracted from the clock extraction unit (131) and transmitting a control signal to a data encoder (133); the data encoder (133) for receiving the wireless identification information and charged status information of the battery (BAT) from a tag (135) when the control signal is transmitted from the sequencer (132), and transmitting the wireless identification information and charged status information to a data modulator (136) after coding the wireless identification information and charged status information; the data modulator (136) for generating RF data generated by modulating the data received from the data encoder (133), and wirelessly transmitting the RF data to the wireless charging pad (200); Read Only Memory (ROM) (134) for recording the wireless identification information and charged status information therein; and the tag (135) for

reading the wireless identification information and charged status information of the battery (BAT) stored in the ROM (134), and transmitting the wireless identification information and charged status information to the data encoder (133).

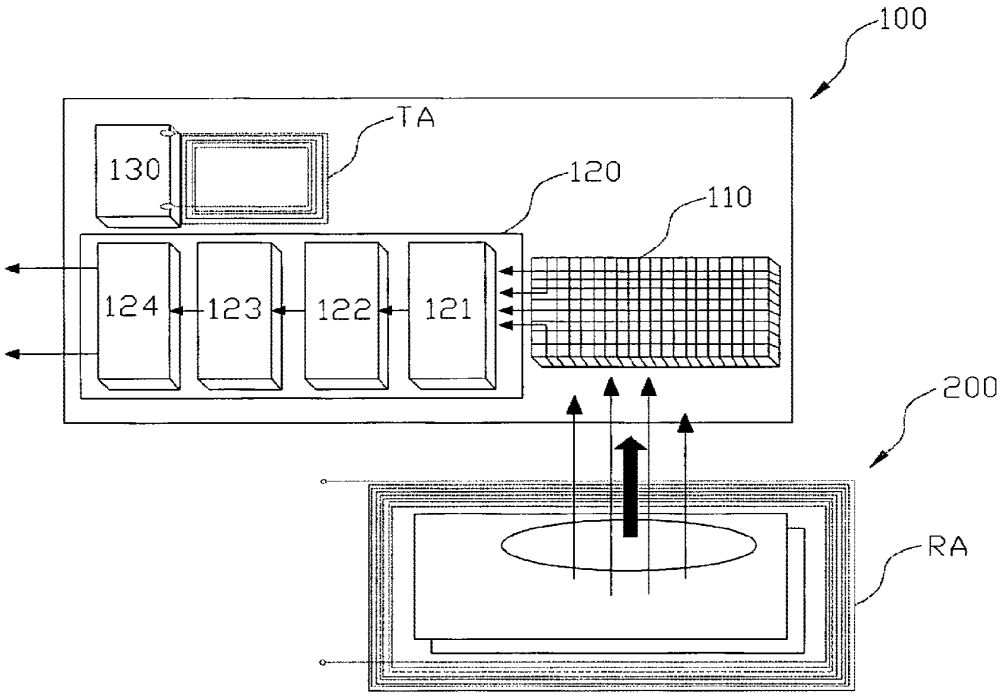
15. The wireless charging pad according to claim 9, wherein the wireless identification information corresponds to one of a product name of the battery (BAT), a serial number of the battery (BAT) and a user identification number that is stored in the RFID tag (130) through communication between a body of a portable device, on which the battery pack (100) is mounted, and the battery pack (100).

16. The wireless charging pad according to claim 9, wherein the RF carrier signal is a signal that accesses an RFID signal stored in the battery pack (100) using a carrier signal in HF (3 to 30 MHz) or UHF (300 to 3000 MHz) bands.

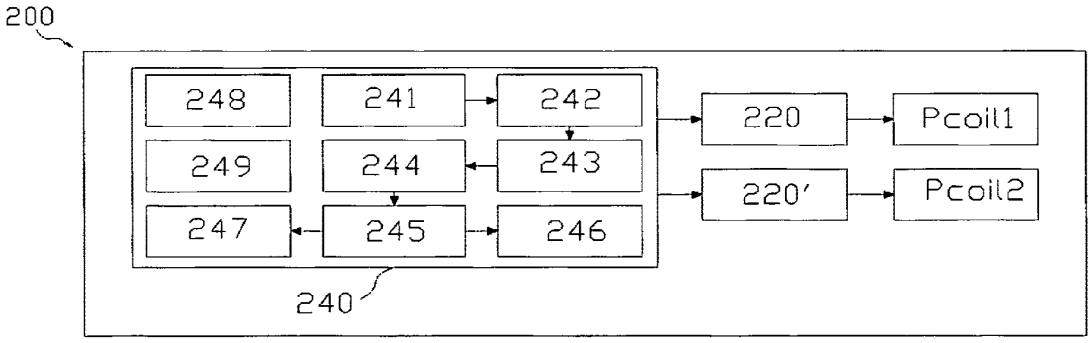
【FIG. 1】



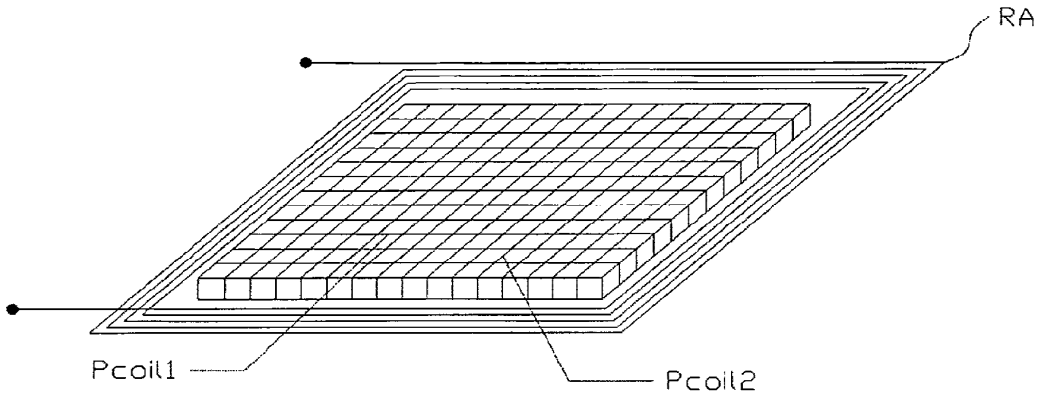
【FIG. 2】


100
TA
130
120
110
124
123
122
121
200
RA

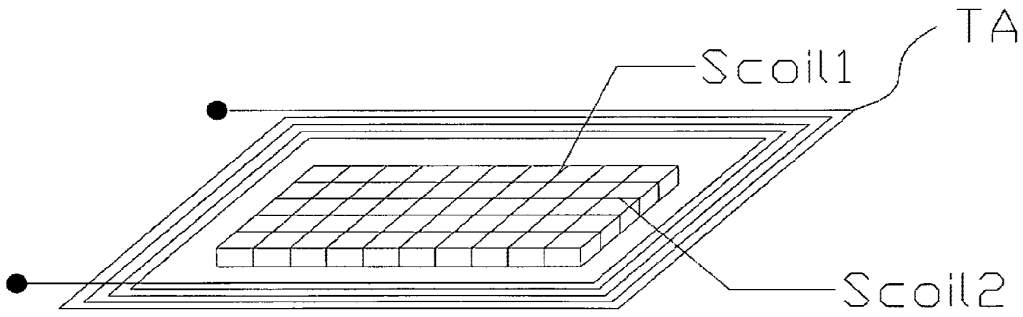
【FIG. 3】


200
248
241
242
249
244
243
247
245
246
240
220
Pcoil1
220'
Pcoil2

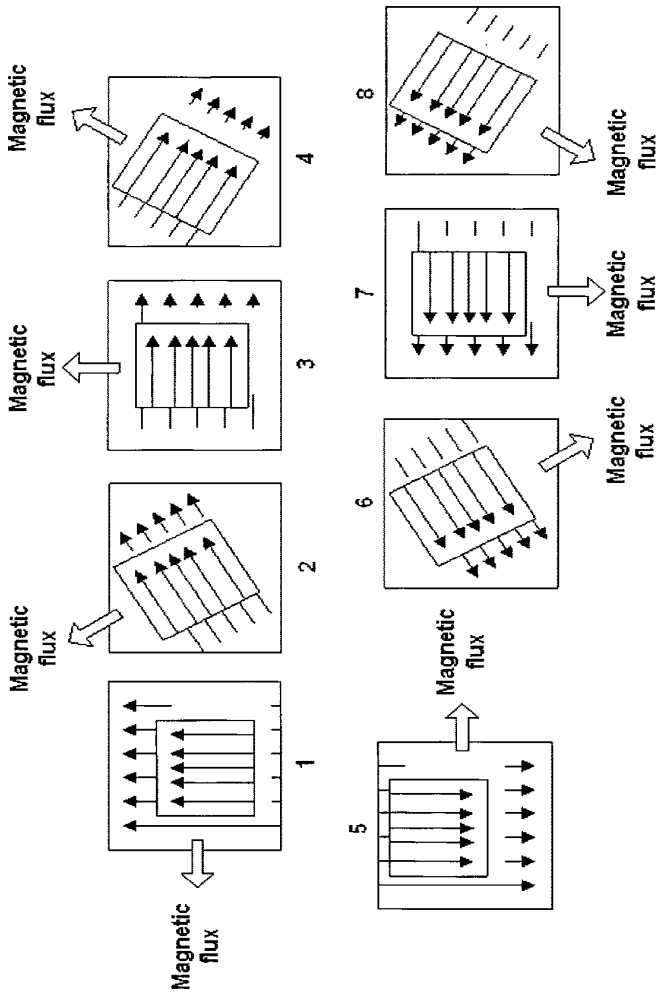
【FIG. 4】



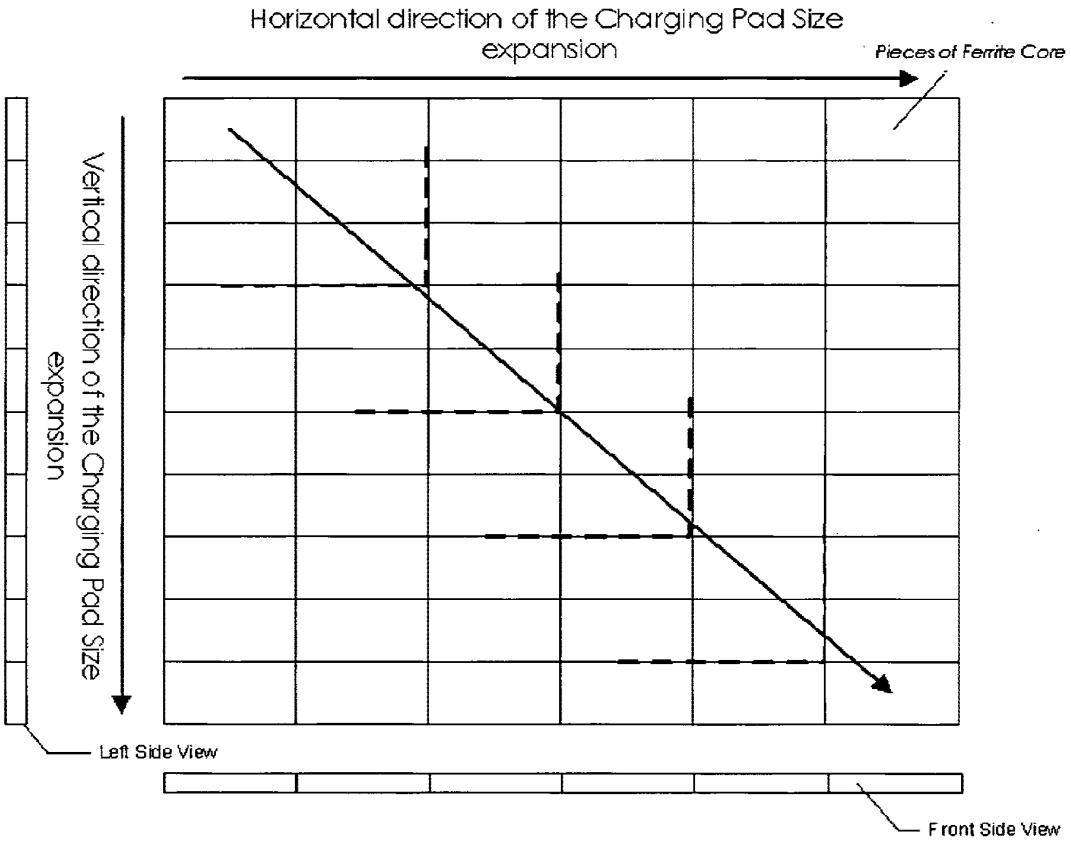
【FIG. 5】



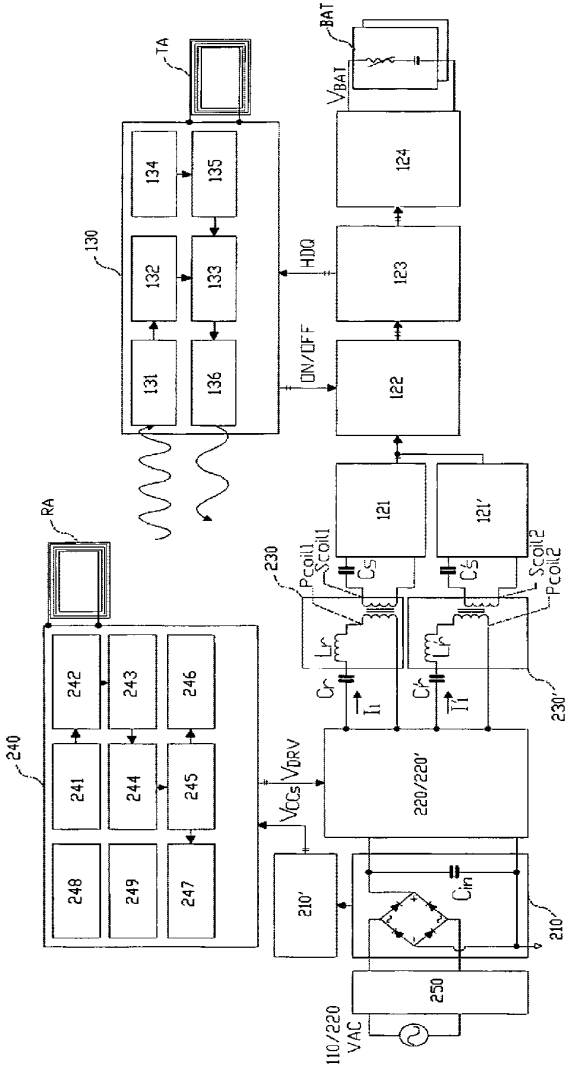
【FIG. 6】



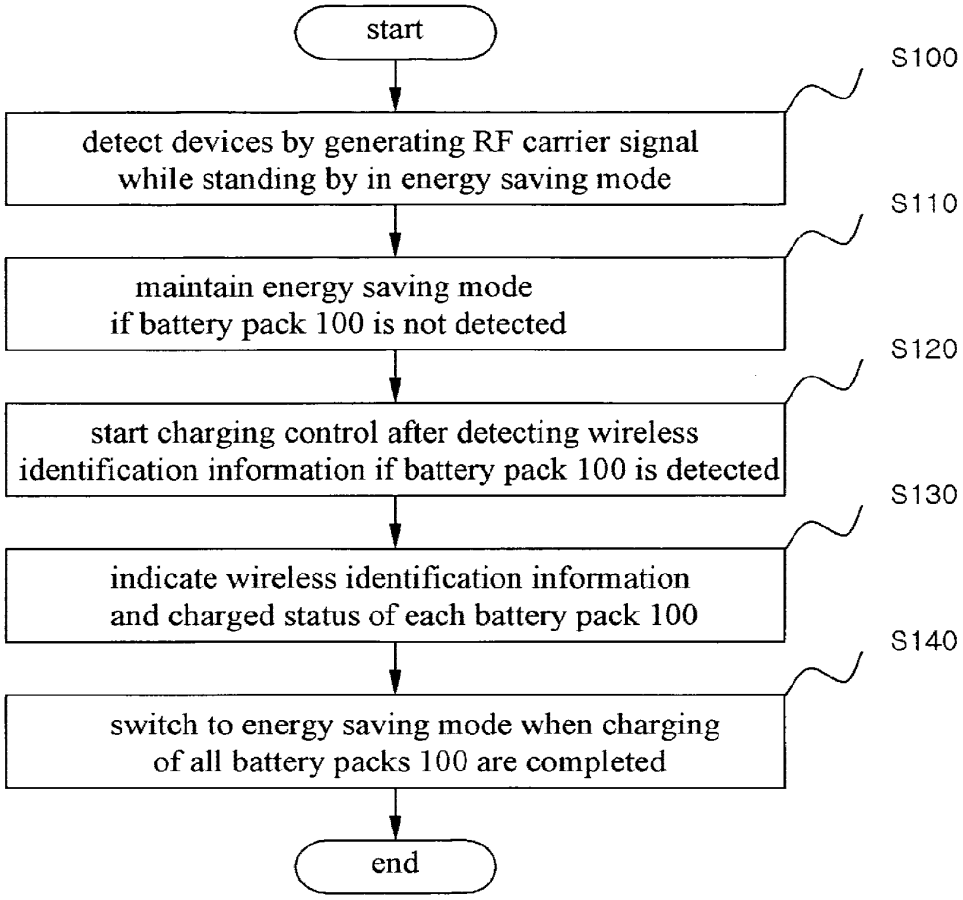
【FIG. 7】


Horizontal direction of the Charging Pad Size expansion
Pieces of Ferrite Core
Vertical direction of the Charging Pad Size expansion
Left Side View
Front Side View

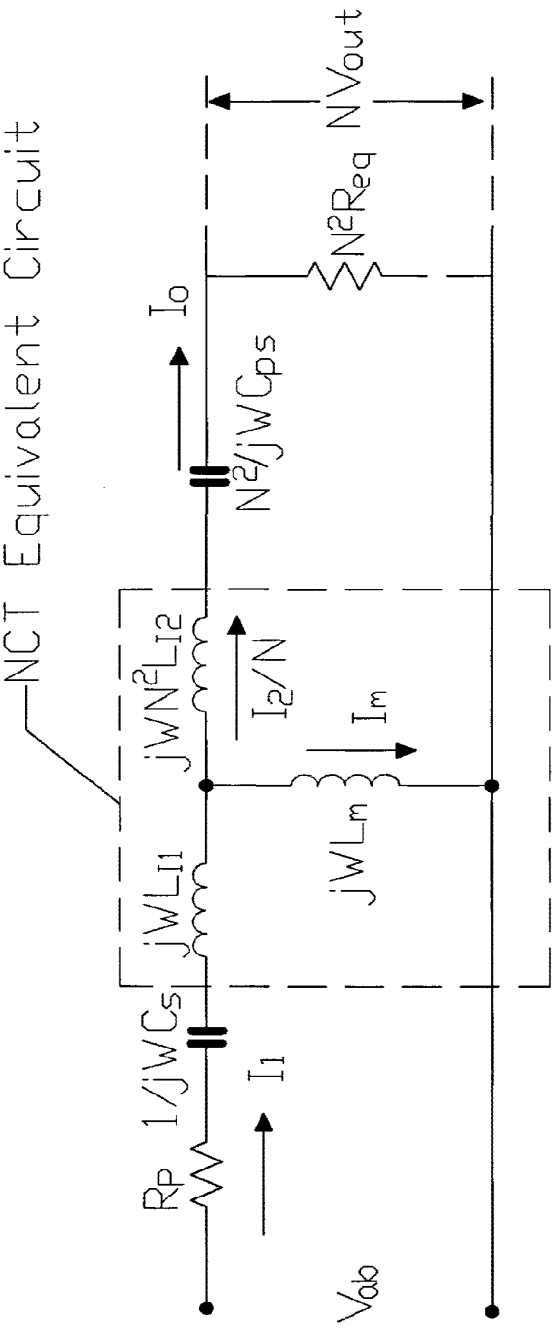
【FIG. 8】


TA
BAT
VBAT
124
123
122
HDQ
ON/OFF
130
131
132
133
134
135
136
RA
121
121'
230
Pcoil1
Scoil1
Cs
Scoil2
Pcoil2
Lr
Cr
I1
230'
240
241
242
243
244
245
246
247
248
249
VCCs
VDRV
220/220'
210'
Cinf
210
250
110/220
VAC

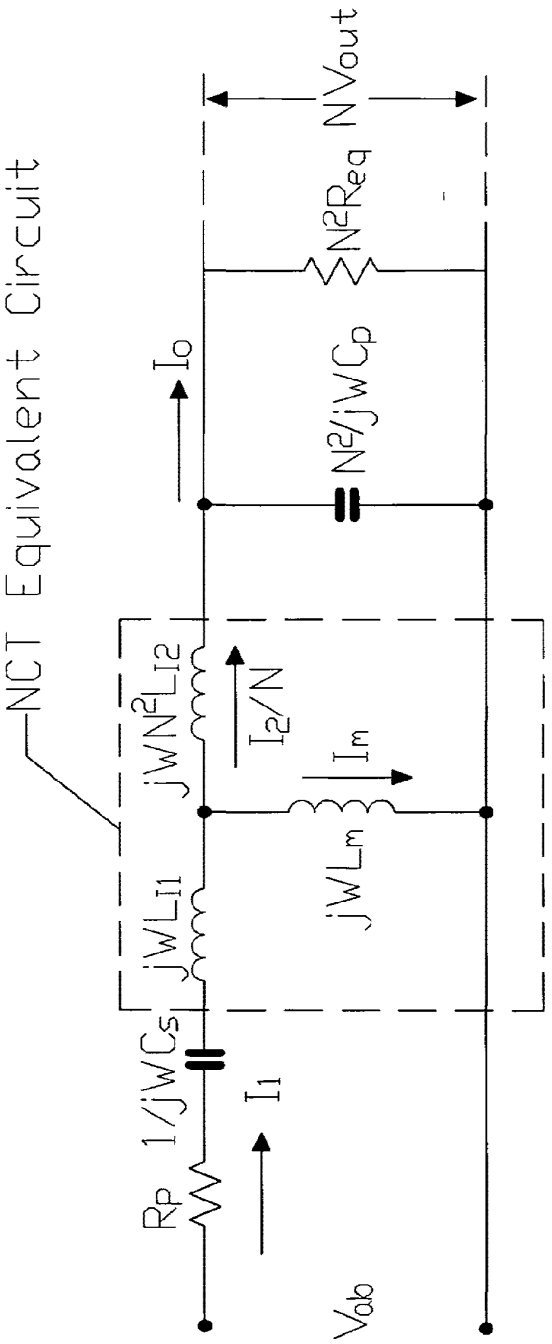
【FIG. 9】


start
S100
detect devices by generating RF carrier signal while standing by in energy saving mode
S110
maintain energy saving mode if battery pack 100 is not detected
S120
start charging control after detecting wireless identification information if battery pack 100 is detected
S130
indicate wireless identification information and charged status of each battery pack 100
S140
switch to energy saving mode when charging of all battery packs 100 are completed
end

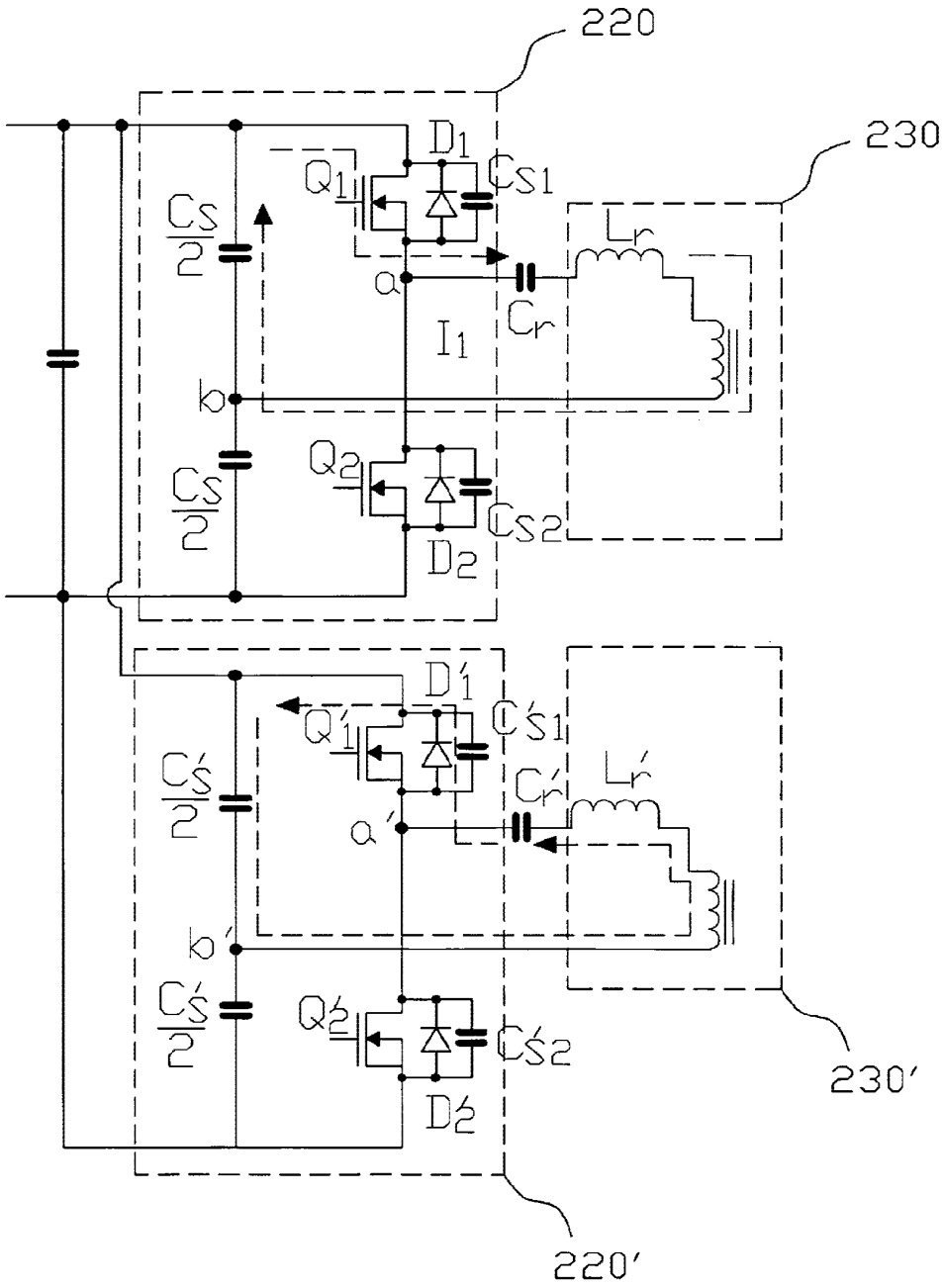
【FIG. 10】


NCT Equivalent Circuit
NVout
N²Req
Io
N²/jWCps
jWN²LI2
I2/N
Im
jWLm
jWLI1
1/jWCs
Rp
I1
Vab

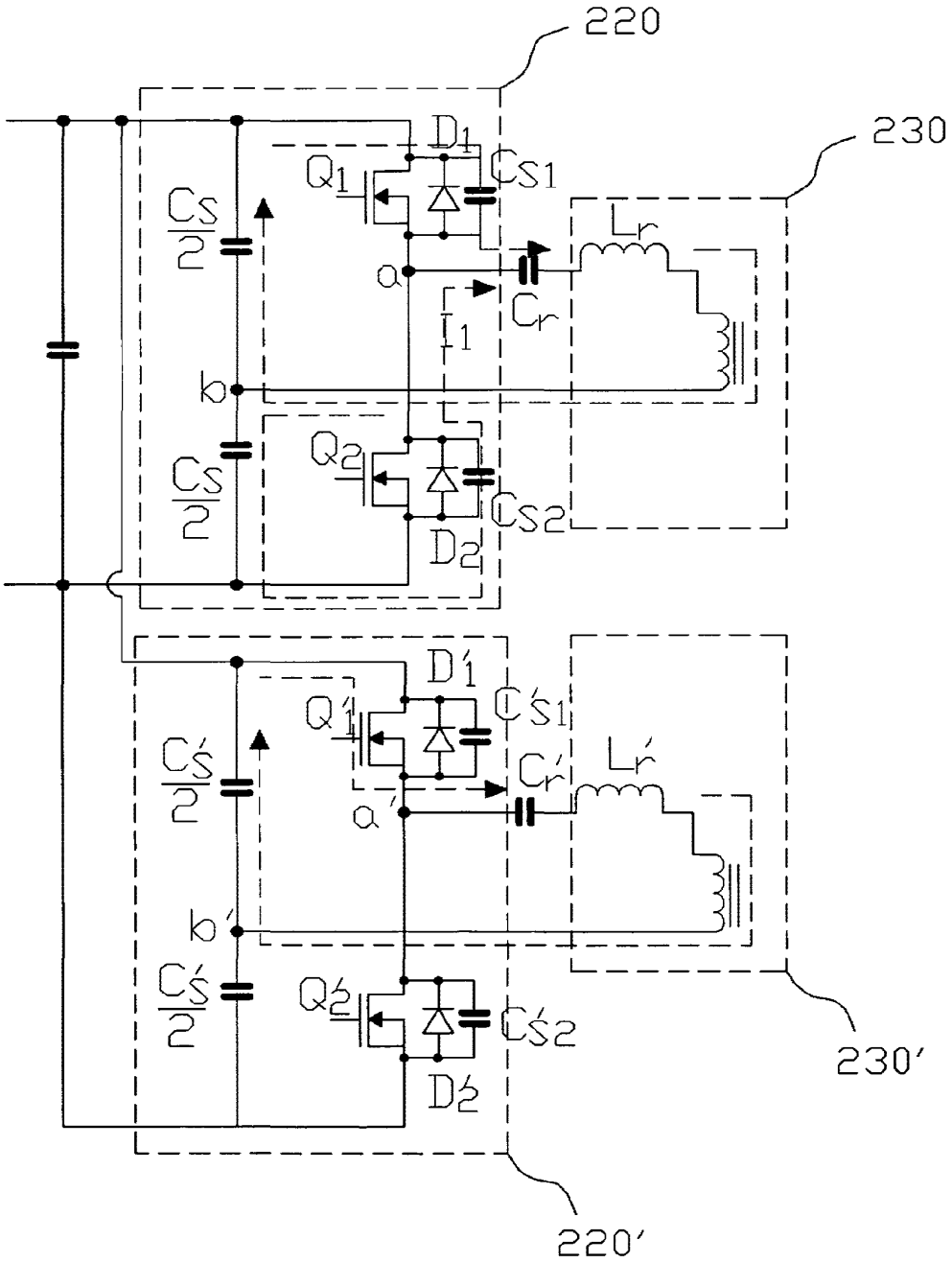
【FIG. 11】


NCT Equivalent Circuit
NVout
N²Req
Io
N²/jwCp
I2/N
Im
jwN²LI2
jwLm
jwLI1
1/jwCs
Rp
I1
Vab

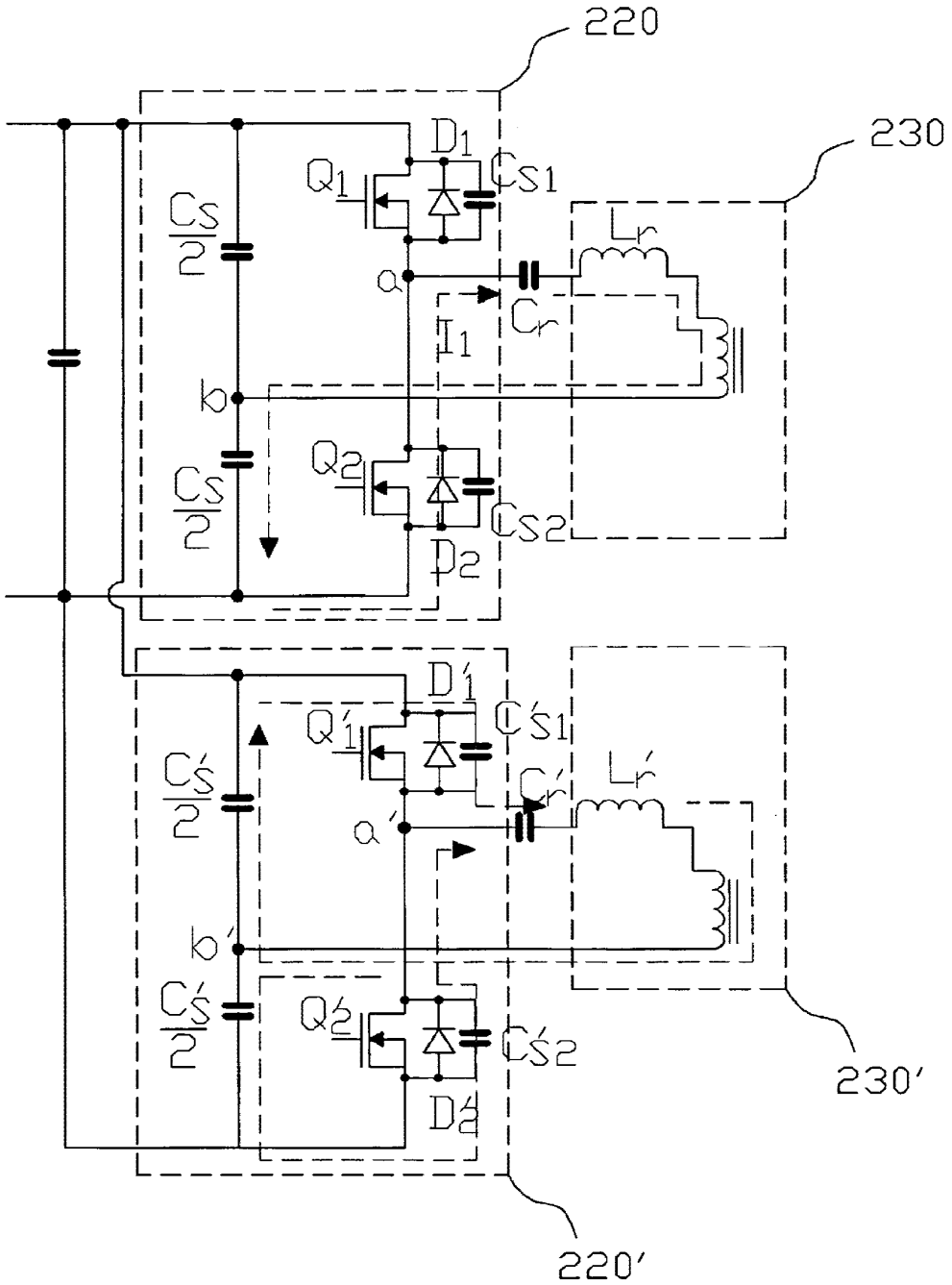
【FIG. 12】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

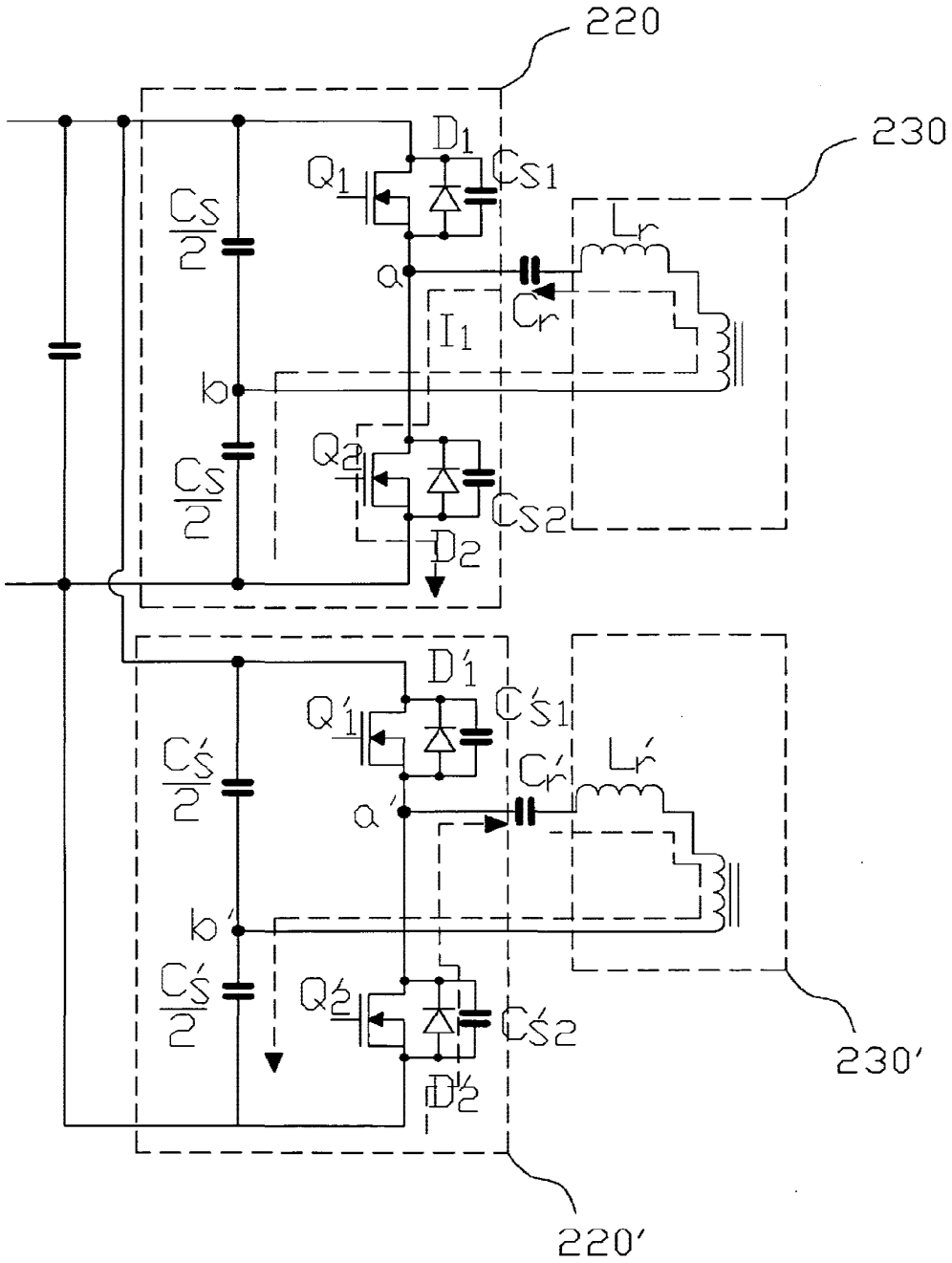
【FIG. 13】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
C'r
L'r
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

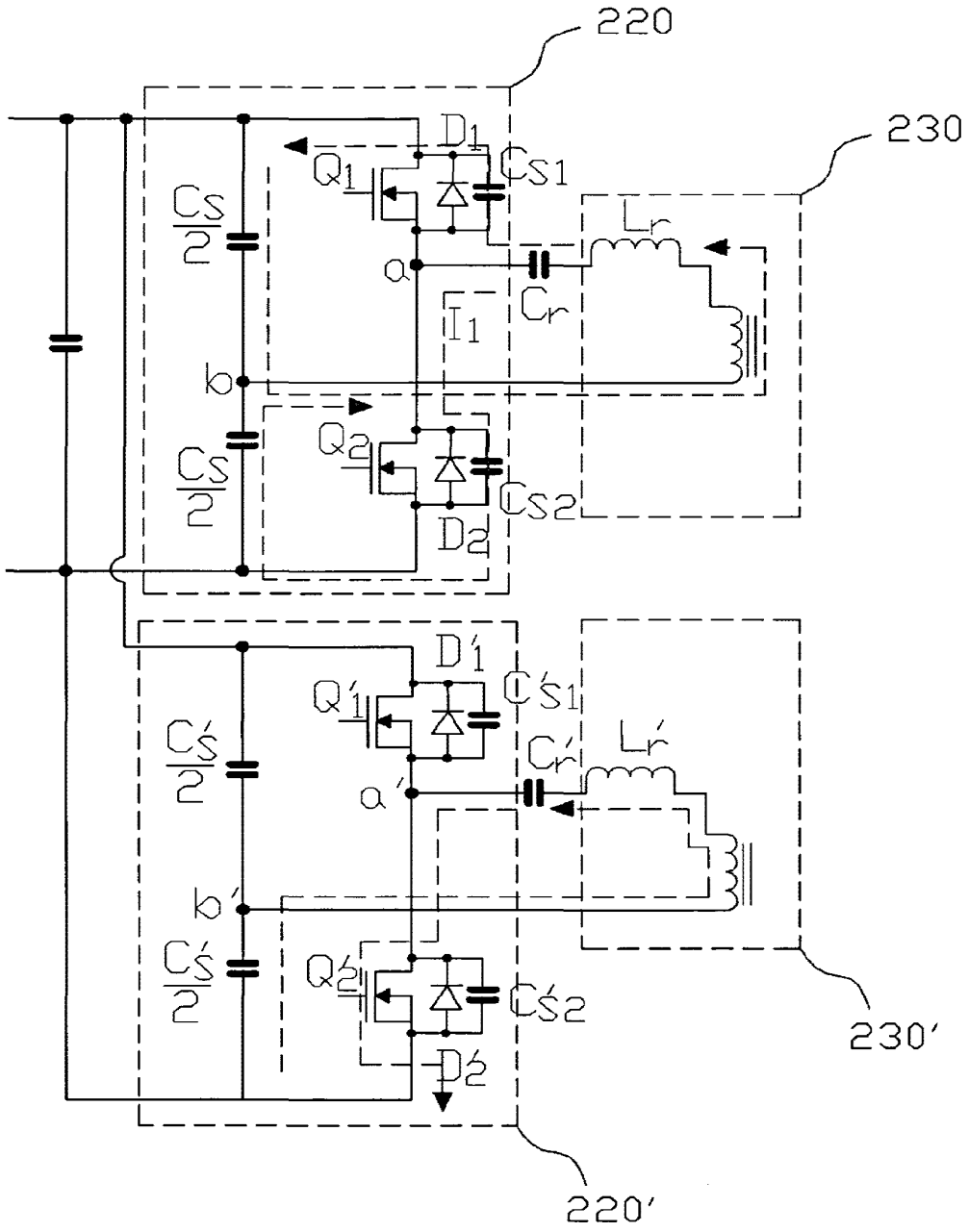
【FIG. 14】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

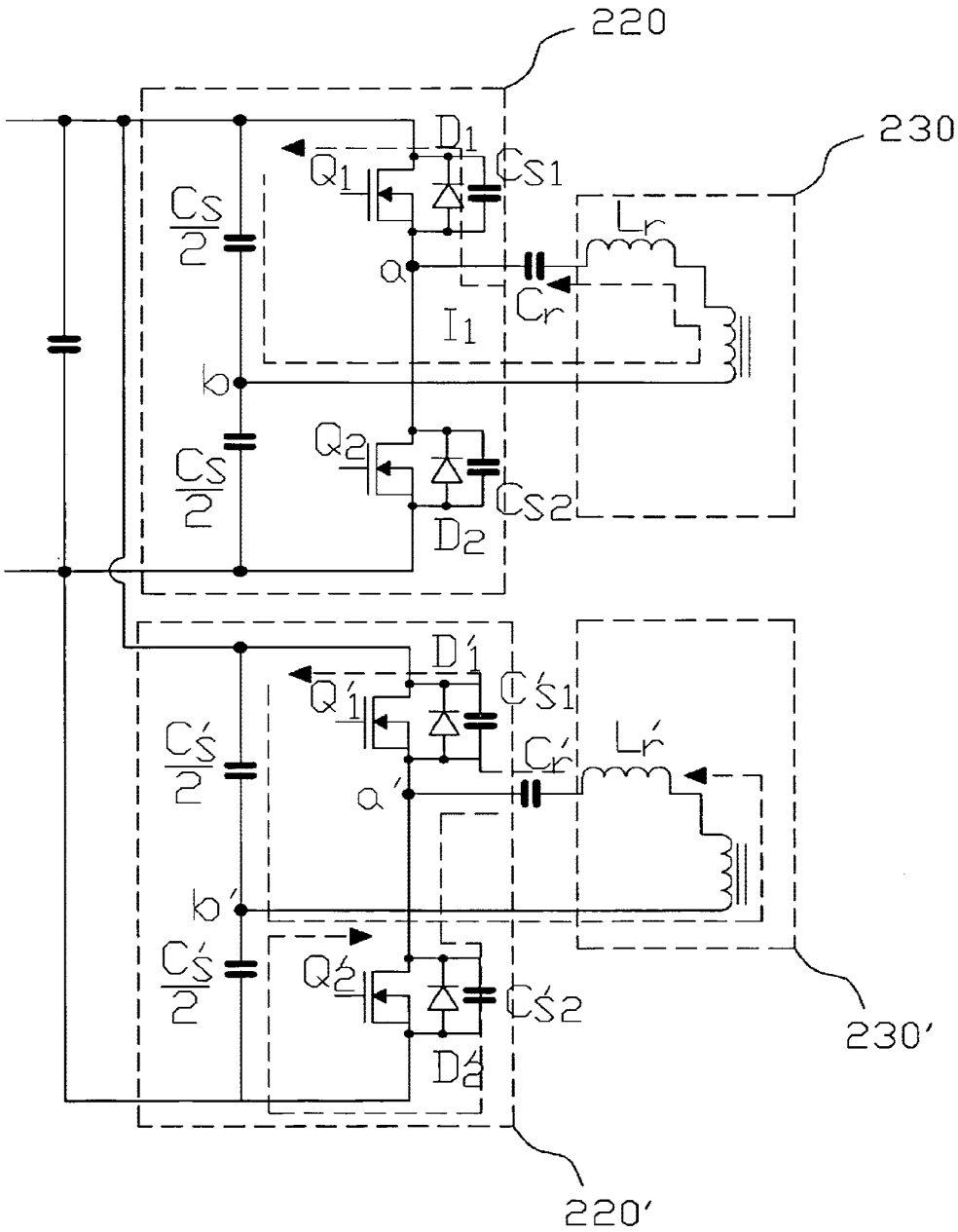
【FIG. 15】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

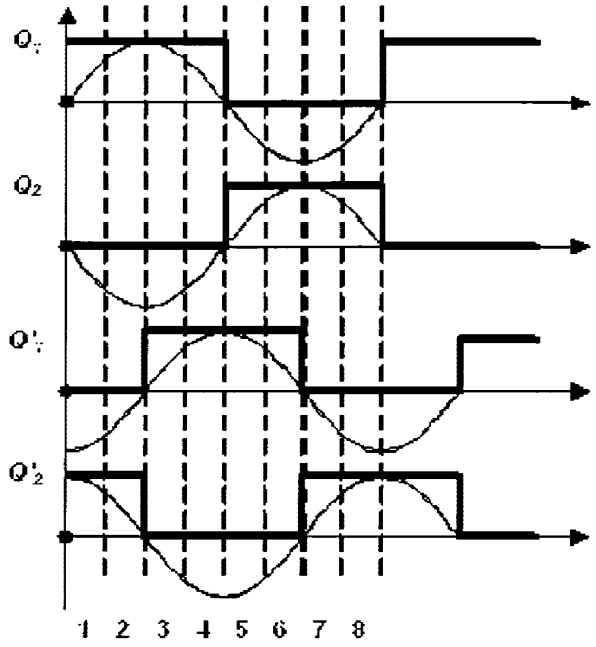
【FIG. 16】


220
230
D1
Q1
Cs1
Cs/2
Lr
a
Cr
I1
b
Q2
Cs/2
Cs2
D2
D'1
Q'1
C's1
C's/2
Cr'
Lr'
a'
b'
C's/2
Q'2
C's2
D'2
230'
220'

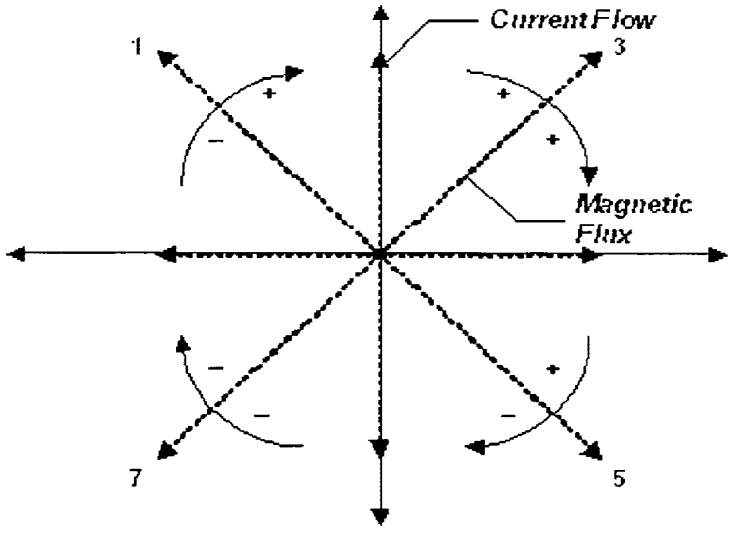
【FIG. 17】


220
230
D1
Q1
CS1
CS/2
Lr
a
Cr
I1
b
Q2
CS/2
CS2
D2
D'1
Q'1
C'S1
C'S/2
C'r
L'r
a'
b'
C'S/2
Q'2
C'S2
D'2
230'
220'

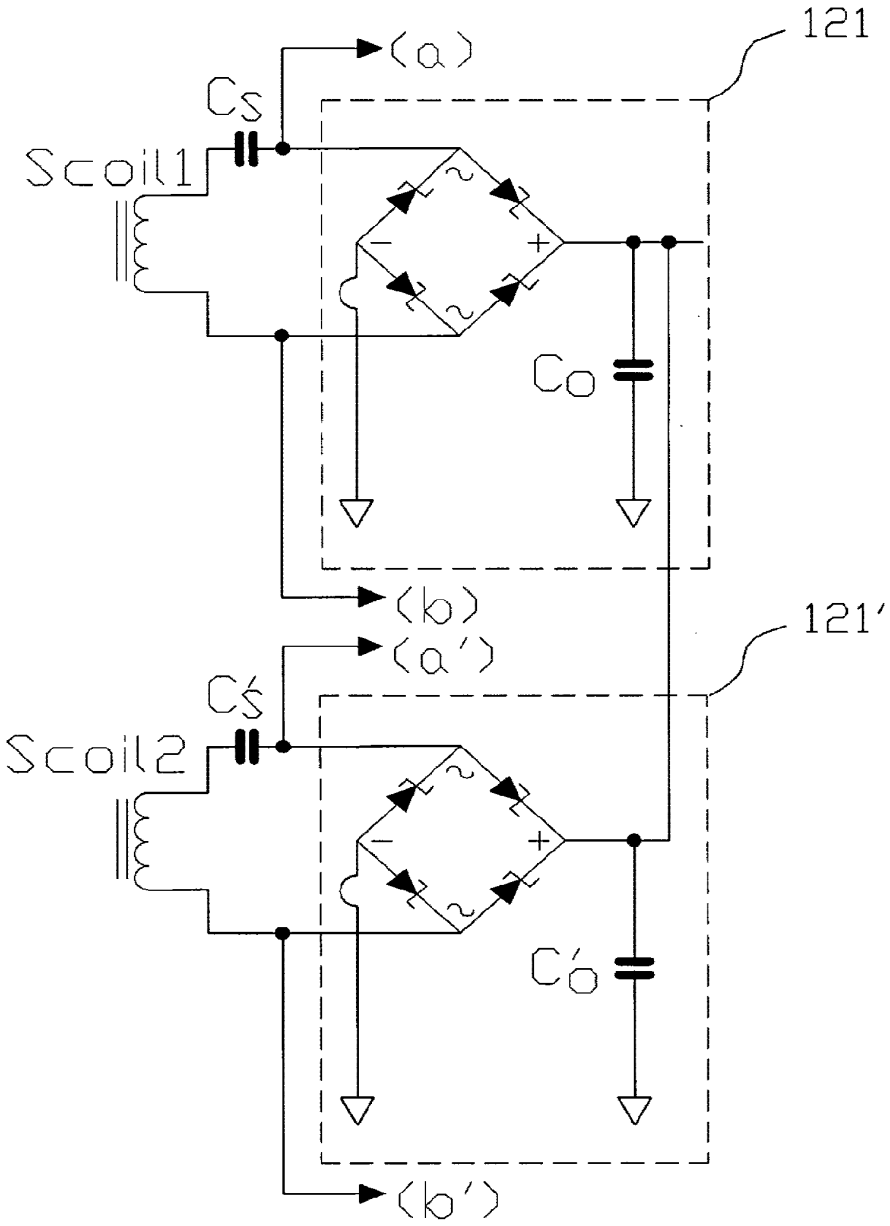
【FIG. 18】



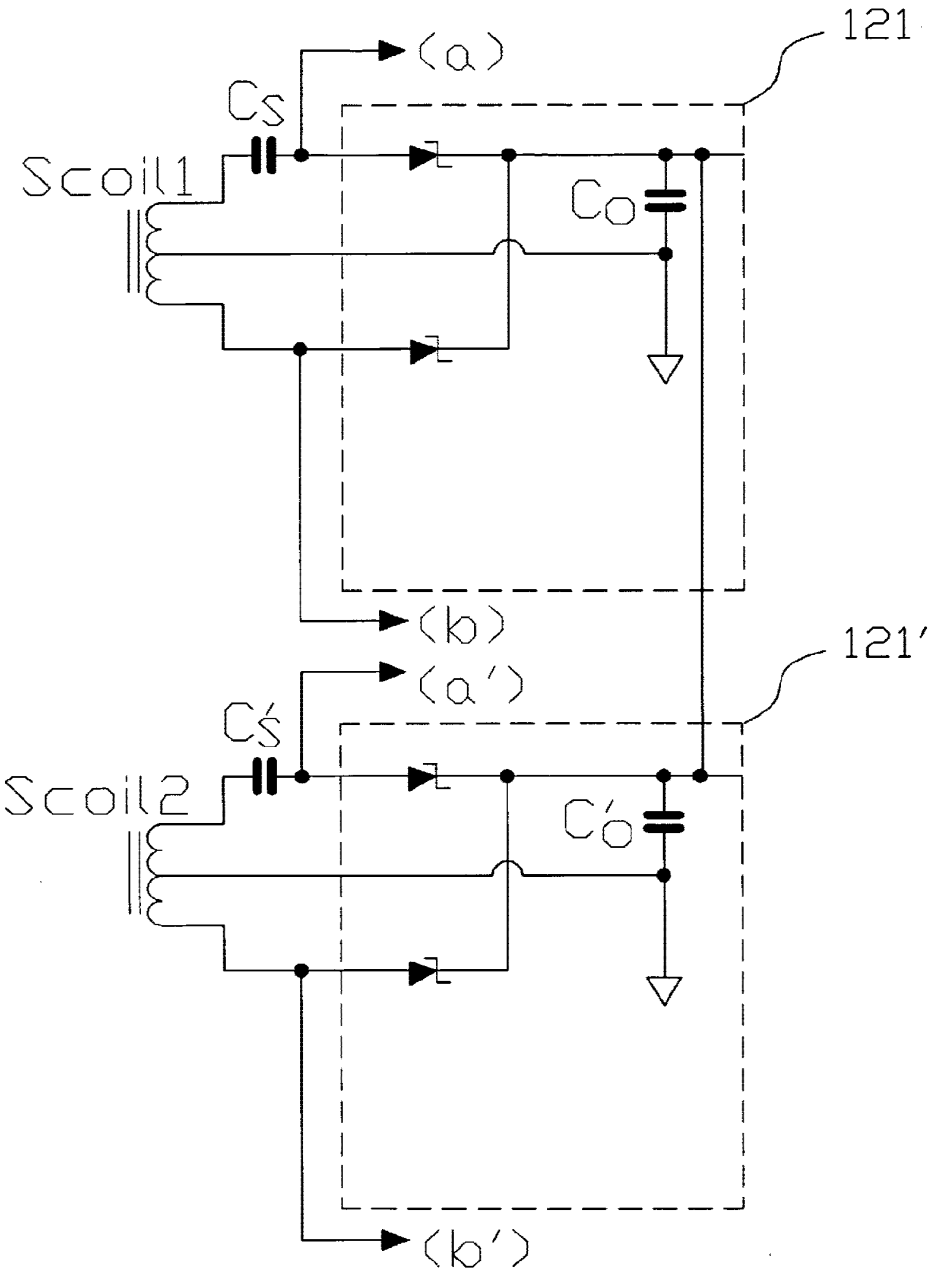
【FIG. 19】



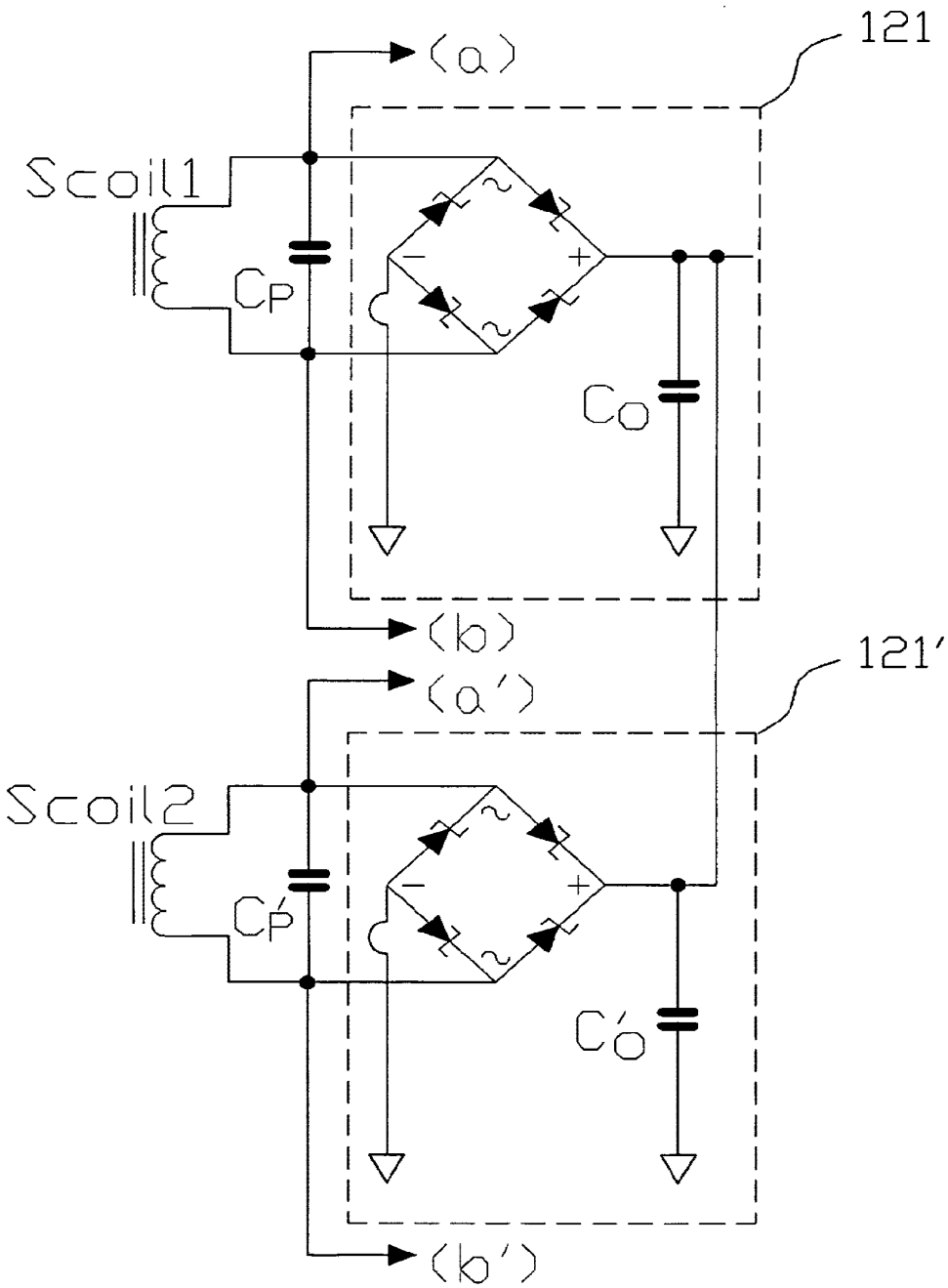
【FIG. 20】



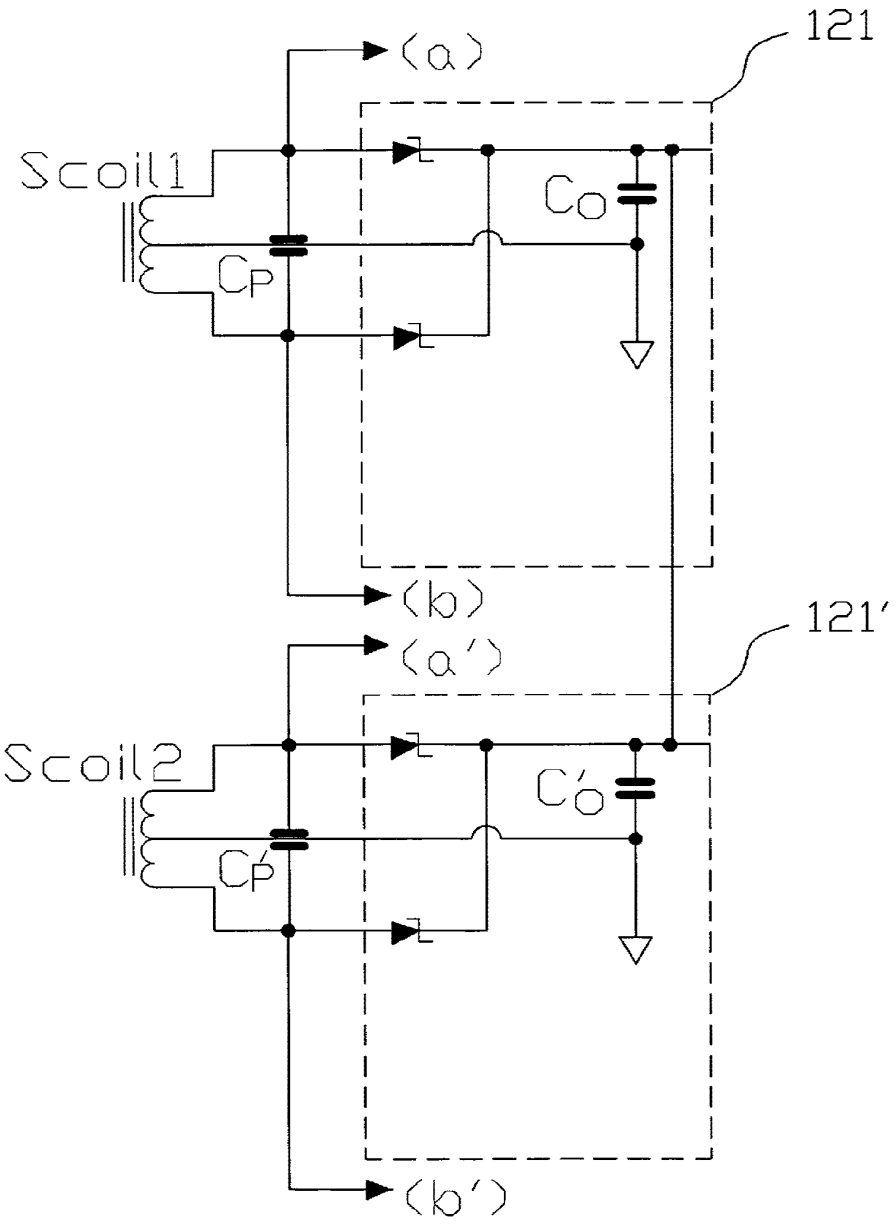
【FIG. 21】



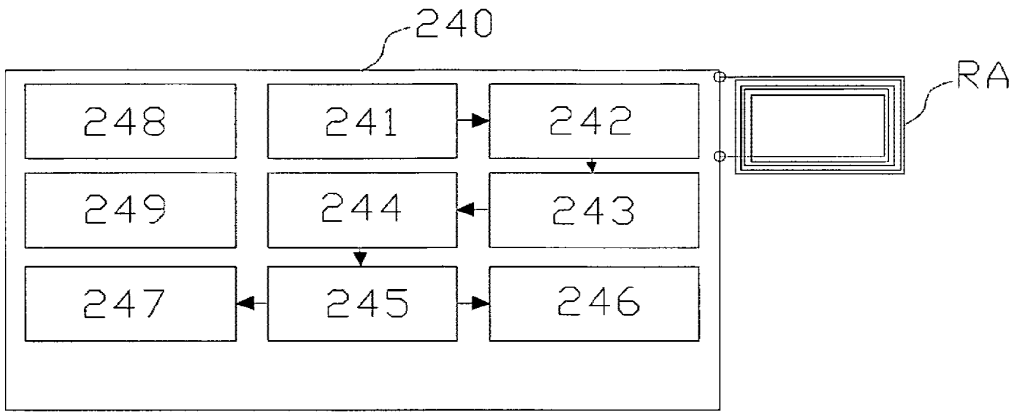
【FIG. 22】



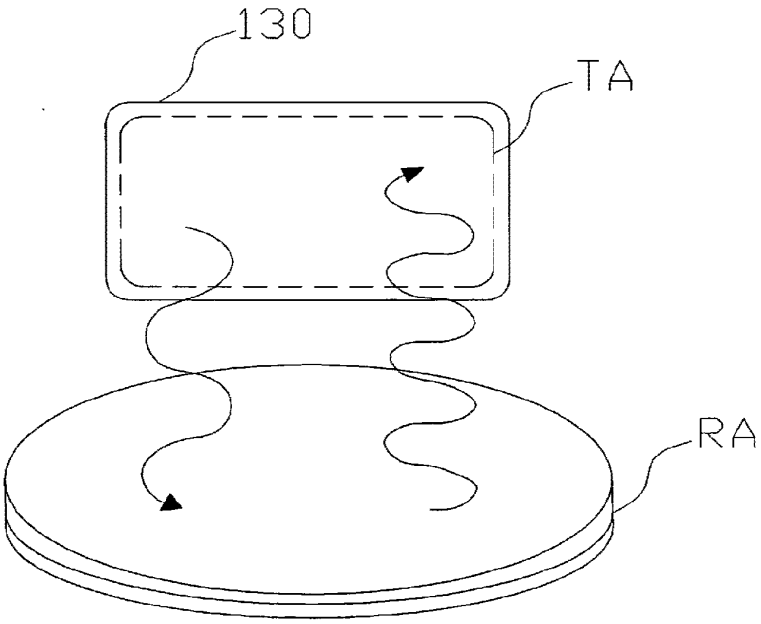
【FIG. 23】



【FIG. 24】



【FIG. 25】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2004/002263

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H02J 7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7: H02J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
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Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5600225 A (NEC CO., LTD.) 4 FEB. 1997 Abstract, fig. 2, Claims 1-3	1, 9
A	JP 2003-047178 A (SONY CO., LTD.) 14 FEB. 2003 Abstract, fig. 1, Claims 1-3	1, 9
A	JP 11-178232 A (CANON INC.) 2 JUL. 1999 Fig. 1, Claims 1-3	1, 9
A	JP 2002-272020 A (SONY CO., LTD.) 20 SEP 2002 Abstract, fig. 1, Claims 1-4	1, 9
A	JP 09-233706 A (HITACHI CO., LTD) 5 SEP. 1997 Abstract, fig. 1, Claim 1	1, 9
A	JP 11-68837 A (CASIO COMPUTER CO., LTD) 22 JUN. 1999 See the whole document	1, 9
A	JP 10-201113 A (OKI ELECTRIC INDUSTRIAL CO., LTD.) 31 JUL. 1998 See the whole document	1, 9

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Date of the actual completion of the international search	Date of mailing of the international search report
25 MARCH 2005 (25.03.2005)	**26 MARCH 2005 (26.03.2005)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	JEON, Yong Hai Telephone No. 82-42-481-5657

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Doc code: IDS
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Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Undetermined
Attorney Docket Number	AFPA-01013US7

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	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	1	PCT International Search Report in connection with PCT application No. PCT/US2007/61406, 8 pages, dated February 14, 2008.	
	2	PCT International Search Report in connection with PCT application No. PCT/US2008/63084, 8 pages, dated August 8, 2008.	
	3	Office Action in connection with Application No. 13/442,698 dated September 13, 2012, 6 pages.	
	4	Office Action in connection with Application No. 12/116,876 dated May 2, 2011, 5 pages.	
	5	Office Action in connection with Application No. 11/669,113 dated May 13, 2010, 20 pages.	
	6	Office Action in connection with Application No. 11/669,113 dated August 25, 2009, 17 pages.	
	7	Office Action in connection with Application No. 11/669,113 dated October 29, 2008, 11 pages.	
	8	Office Action in connection with Application No. 13/113,977 dated November 9, 2012, 9 pages.	
	9	International Search Report and Written Opinion of the International Searching Authority, Korean Intellectual Property Office, in re International Application No. PCT/US2010/032845 dated December 13, 2010, 10 pages.	
	10	WildCharge Life unplugged!. http://www.wildcharg.com/4/17/2009, 2 pages	
	11	Powermat "the Future of Wireless Power has Arrived", http://www.pwrmal.com,4/15/2009, 2 pages	

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	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	12	eCoupled Wireless Power Technology Fulton Innovation, http://www.ecoupled.com, 4/15/2009, 5 pages	
	13	Qualcomm Products and Services -Wirelss Airlink Technologies, http://www.qualcomm.com/products_services/airlinks, 4/15/2009, 4 pages	
	14	Office Action in connection with Application No. 11/757,067 dated January 26, 2009, 14 pages.	
	15	Office Action in connection with Application No. 11/757,067 dated October 19, 2009, 14 pages.	
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Doc description: Information Disclosure Statement (IDS) Filed

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Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Zixuan Zhou
Attorney Docket Number	AFPA-01013US7

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	1	6527971	B1	2003-03-04	Nakamura et al.	
	2	6803744	B1	2004-10-12	Sabo	
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	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

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	First Named Inventor	Afshin Partovi
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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

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Bibliographic Data

Application No: 17/507,323

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /ZIXUAN ZHOU/ Examiner's Signature | Initials

Title: System and Method for Inductive Charging of Portable Devices

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/21/2021	320	2859	AFPA-01013US7
RULE			

APPLICANTS

Mojo Mobility, Inc., Palo Alto, CA,

INVENTORS

Afshin Partovi, Palo Alto, CA, UNITED STATES

Michael Sears, Ben Lomond, CA, UNITED STATES

CONTINUING DATA

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Attorney Docket Number	AFPA 01013US7

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	Attorney Docket Number	AFPA 01013US7

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	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

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	Examiner Name	Undetermined
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		"6906495" OR "6913477" OR "6917163" OR "6917182" OR "6943733" OR "6972543" OR "6975198" OR "7026789").pn.					
L7	75	("7031662" OR "7042196" OR "7116200" OR "7118240" OR "7126450" OR "7132918" OR "7151357" OR "7162264" OR "7164245" OR "7164255" OR "7183870" OR "7184706" OR "7209084" OR "7211986" OR "7221919" OR "7239110" OR "7248017" OR "7305258" OR "7311526" OR "7324051" OR "7336054" OR "7342539" OR "7352567" OR "7355150" OR "7375493" OR "7376408" OR "7378817" OR "7382636" OR "7385357" OR "7388543" OR "7399202" OR "7415248" OR "7443135" OR "7462951" OR "7477195" OR "7487921" OR "7495414" OR "7498871" OR "7525283" OR "7554316" OR "7576514" OR "7605496" OR "7645143" OR "7733215" OR "7741734" OR "7781916" OR "7804054" OR "7825543" OR "7855529" OR "7872445" OR	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/20 11:07 AM

		"7906936" OR "7915858" OR "7948208" OR "7952322" OR "8035255" OR "8040103" OR "8049370" OR "8050068" OR "8069100" OR "8115448" OR "8169185" OR "8234189" OR "8234509" OR "8290463" OR "8554165" OR "9407327" OR "9793738" OR "D603603" OR "D607879" OR "D611407" OR "D611408" OR "D624316" OR "D625721" OR "D636333" OR "D639734").pn.					
L8	201	("7031662" OR "7042196" OR "7116200" OR "7118240" OR "7126450" OR "7132918" OR "7151357" OR "7162264" OR "7164245" OR "7164255" OR "7183870" OR "7184706" OR "7209084" OR "7211986" OR "7221919" OR "7239110" OR "7248017" OR "7305258" OR "7311526" OR "7324051" OR "7336054" OR "7342539" OR "7352567" OR "7355150" OR "7375493" OR "7376408" OR "7378817" OR "7382636" OR "7385357" OR "7388543" OR "7399202" OR "7415248" OR "7443135" OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 AM

		"7462951" OR "7477195" OR "7487921" OR "7495414" OR "7498871" OR "7525283" OR "7554316" OR "7576514" OR "7605496" OR "7645143" OR "7733215" OR "7741734" OR "7781916" OR "7804054" OR "7825543" OR "7855529" OR "7872445" OR "7906936" OR "7915858" OR "7948208" OR "7952322" OR "8035255" OR "8040103" OR "8049370" OR "8050068" OR "8069100" OR "8115448" OR "8169185" OR "8234189" OR "8234509" OR "8290463" OR "8554165" OR "9407327" OR "9793738" OR "D603603" OR "D607879" OR "D611407" OR "D611408" OR "D624316" OR "D625721" OR "D636333" OR "D639734").pn.					
L9	868	("20020004167" OR "20020067238" OR "20020089305" OR "20020093309" OR "20030094921" OR "20030103039" OR "20030210106" OR "20030214255" OR "20040113589" OR "20040130915" OR "20040130916" OR "20040145342" OR "20040145343" OR "20040150934" OR "20040222751" OR "20040232845" OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 AM

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		"6975198" OR "7026789").pn.					
L10	1050	L8 OR L9	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 AM
L11	202	L10 AND (copper OR aluminum OR nickel OR gold OR silver OR non$ferrite)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 AM
L13	85	L10 AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR antenna))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:13 AM
L14	89	L10 AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR antenna OR wind$3))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:19 AM
L15	126333	(H02J50/10 OR G06F1/1683 OR H02J7/025 OR H02J50/402).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO;	OR	ON	ON	2022/01/20 11:59 AM

			DERWENT)				
L16	12242	320/108.ccls. OR 307/104.ccls.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:59 AM
L17	9728	(L15 OR L16) AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR antenna OR wind$3))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 12:02 PM
L18	9125	(L15 OR L16) AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR wind$3))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 12:10 PM
L19	3	"20050189910"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 03:20 PM
L21	1801	(H02J7/342 AND H02J50/10).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 PM

L22	56	320/108.ccls. AND 320/103.ccls.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:55 PM
L23	91994	(switch$3 OR transistor OR mosfet OR relay OR fet OR bjt OR switchable OR on$1off OR contactor) WITH (coil) WITH (estimat$3 OR metrolog$4 OR evaluat$3 OR measur$6 OR determin$3 OR monitor$3 OR detect$3 OR sens$3 OR acquisition OR calculat$3 OR comput$3 OR test$3 OR evaluat$3 OR ascertain$3 OR obtain$3 OR determination OR computation OR meter OR gauge OR predict$3 OR acquir$3 OR collect$3 OR retriev$3 OR infer$4) WITH (proximity OR presence OR position)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/21 04:23 PM
L24	1540	(L15 OR L16) AND L23	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/21 04:23 PM
L25	5	(320/108.ccls. AND 320/103.ccls.) AND solar	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO);	OR	ON	ON	2022/01/22 12:45 AM

			FPRS; EPO; JPO; DERWENT)				

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

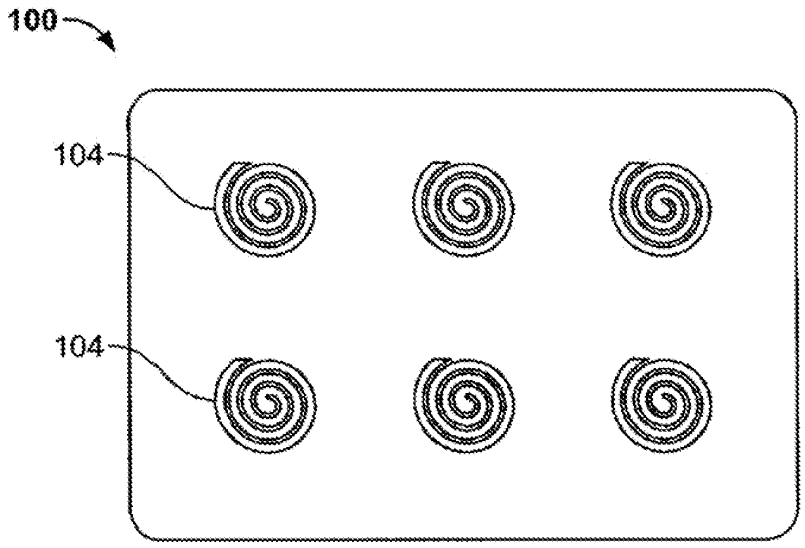

100
104
104

FIG. 1

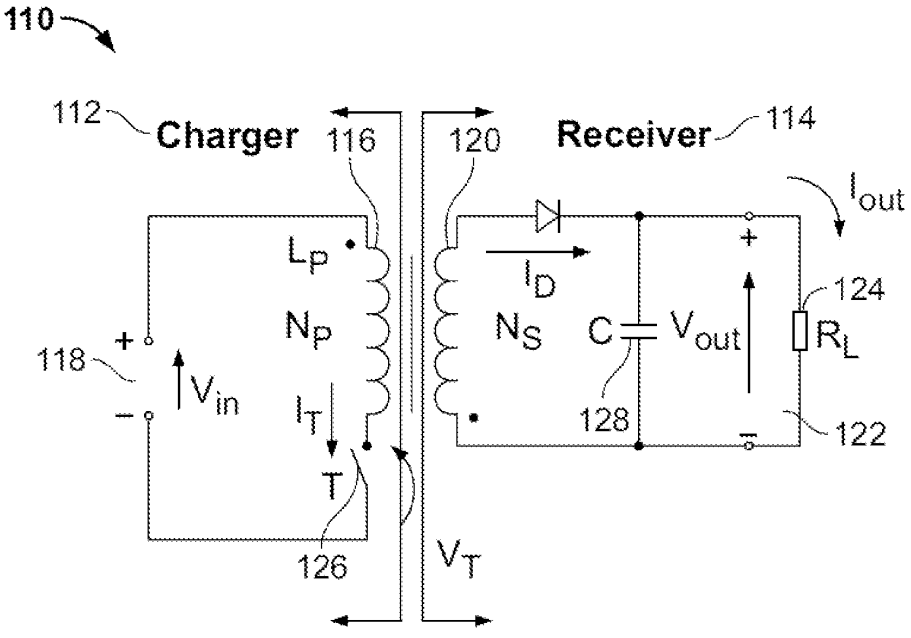

110
112
Charger
116
120
Receiver
114
Iout
LP
NP
ID
NS
C
Vout
RL
124
118
+
Vin
−
IT
128
122
T
126
VT

FIG. 2

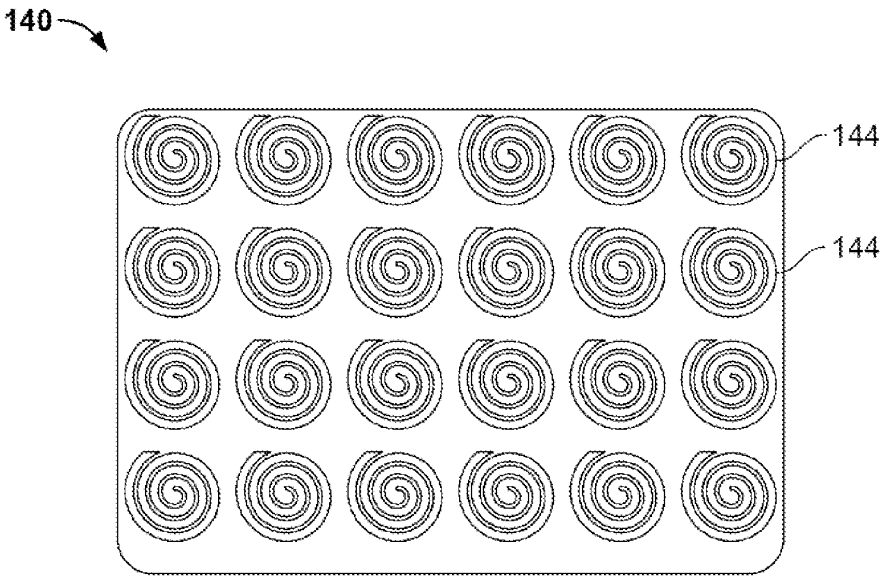


FIG. 3

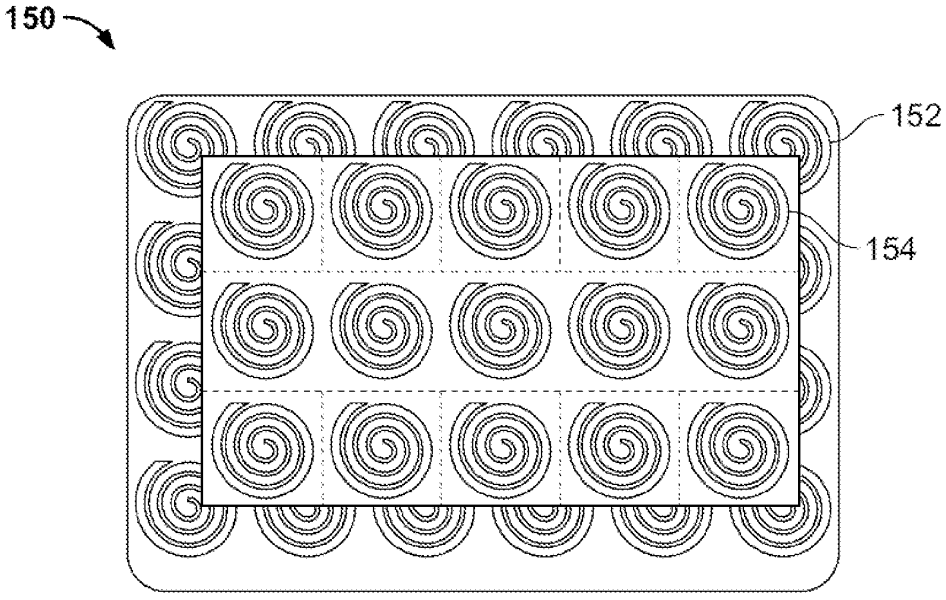


FIG. 4

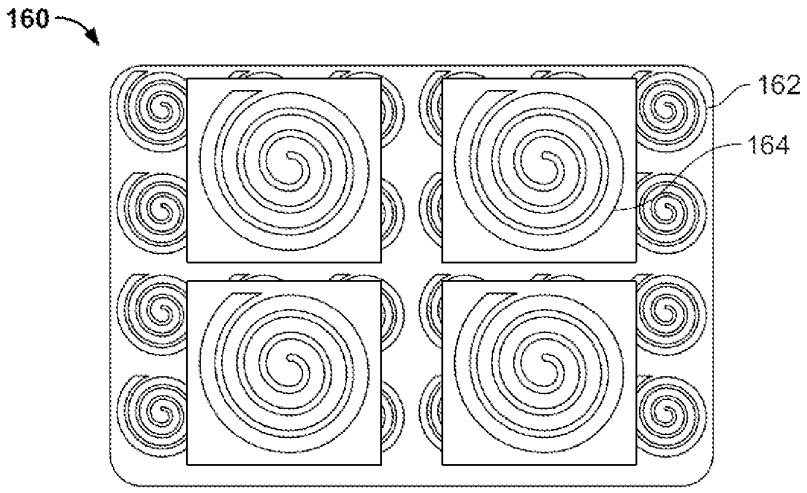

160
162
164

FIG. 5

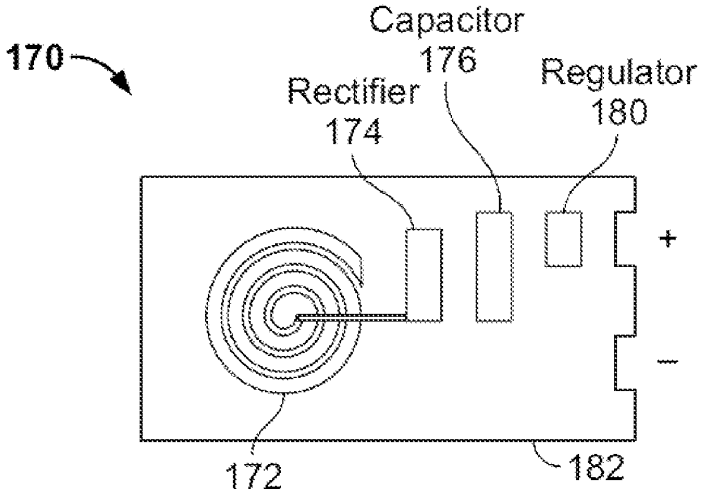

170
Capacitor
176
Rectifier
174
Regulator
180
+
–
172
182

Fig. 6

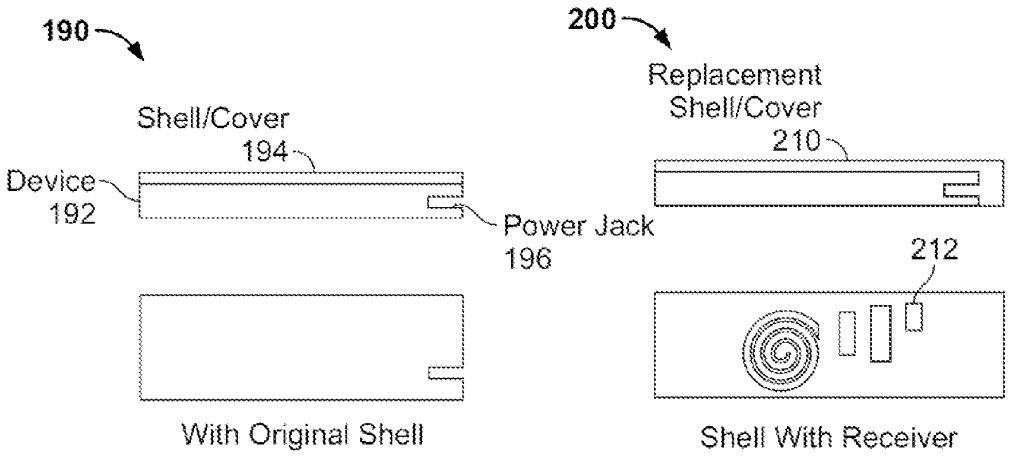

190
200
Replacement
Shell/Cover
210
Shell/Cover
194
Device
192
Power Jack
196
212
With Original Shell
Shell With Receiver

Fig. 7

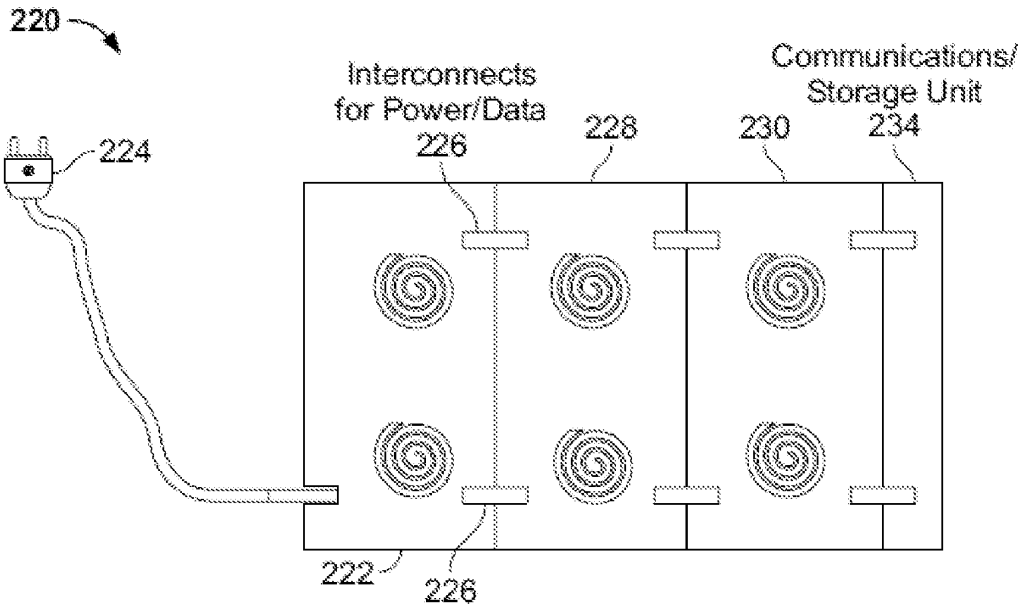

220
Interconnects
for Power/Data
226
228
230
Communications/
Storage Unit
234
224
222
226

Fig. 8

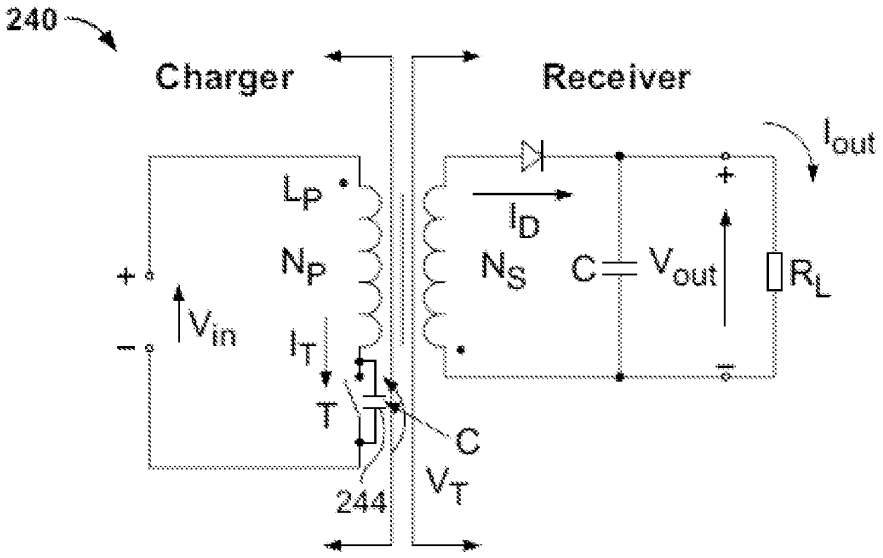

240
Charger
Receiver
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
R_L
+
V_{in}
−
I_T
T
C
V_T
244

Fig. 9

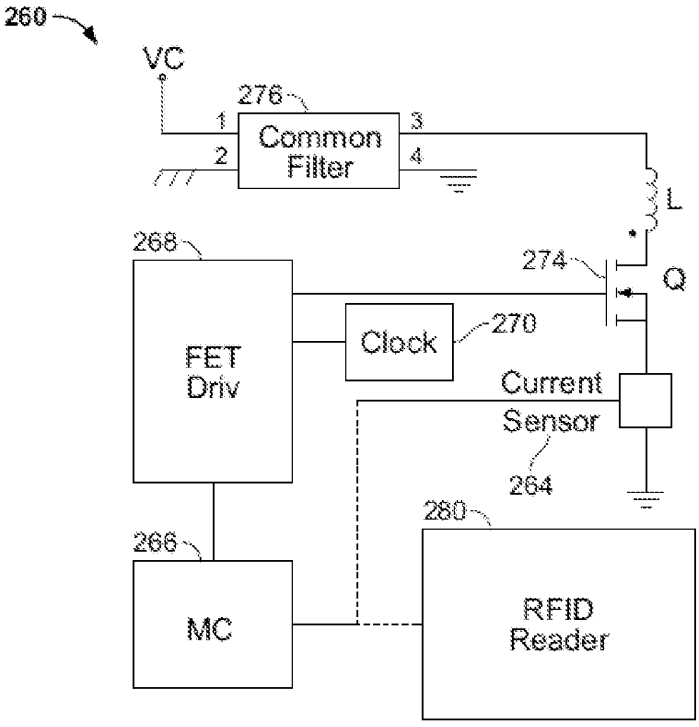

260
VC
276
1
2
Common Filter
3
4
L
268
274
Q
FET Driv
Clock
270
Current Sensor
264
280
266
MC
RFID Reader

Fig. 10

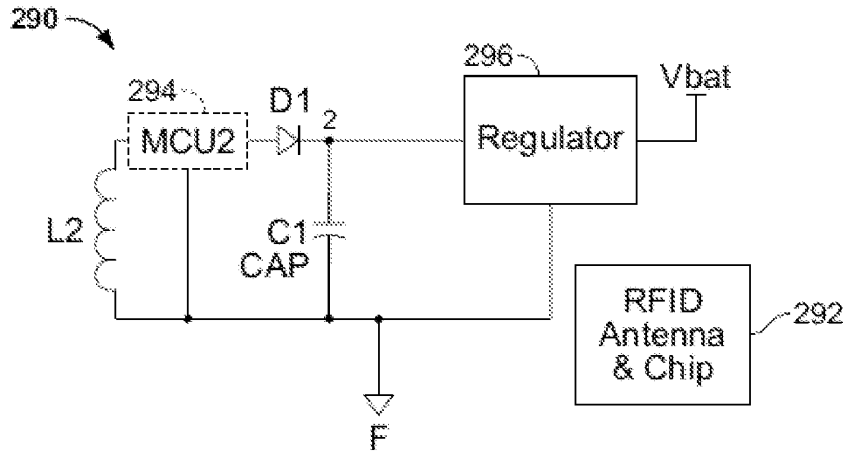

290
294
MCU2
D1
2
296
Regulator
Vbat
L2
C1
CAP
RFID
Antenna
& Chip
292
F

Fig. 11

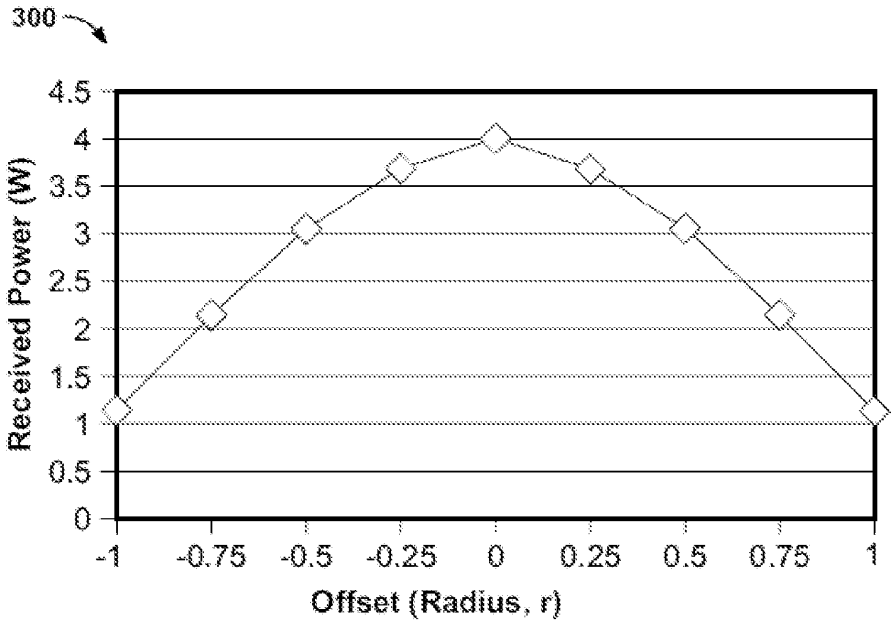

300
Received Power (W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Offset (Radius, r)

Fig. 12

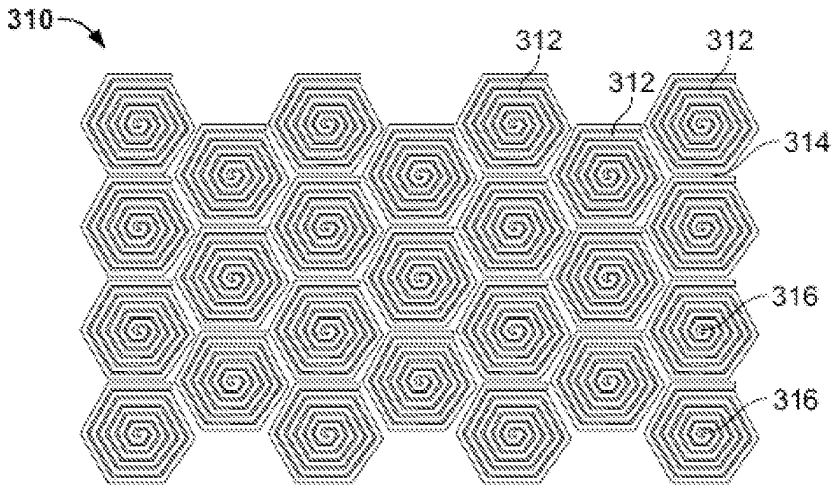


Fig. 13

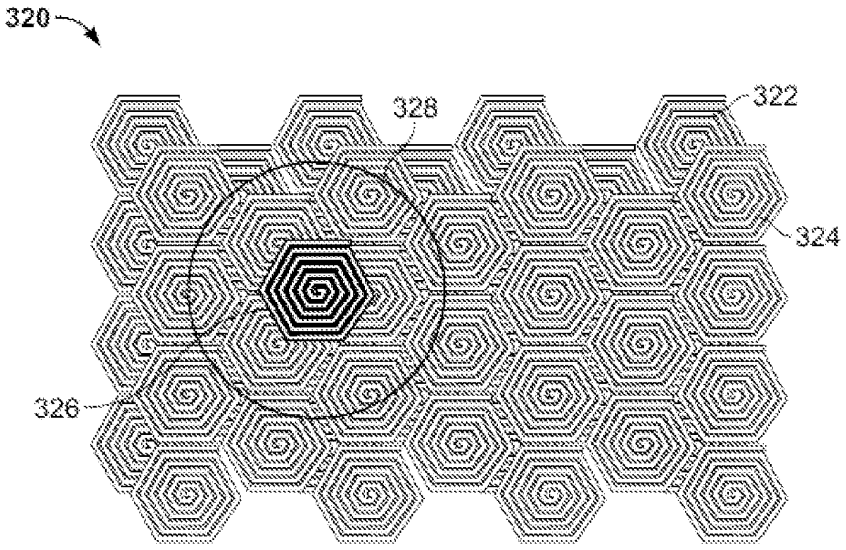


Fig. 14

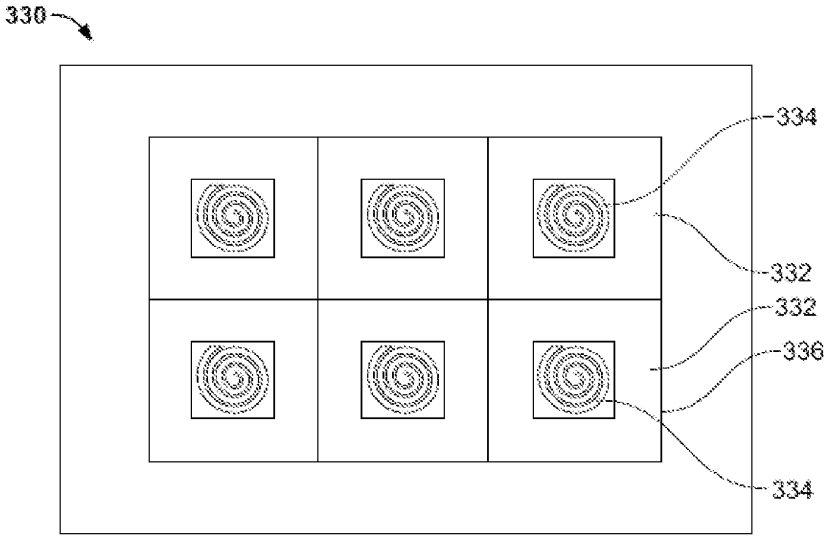


Fig. 15

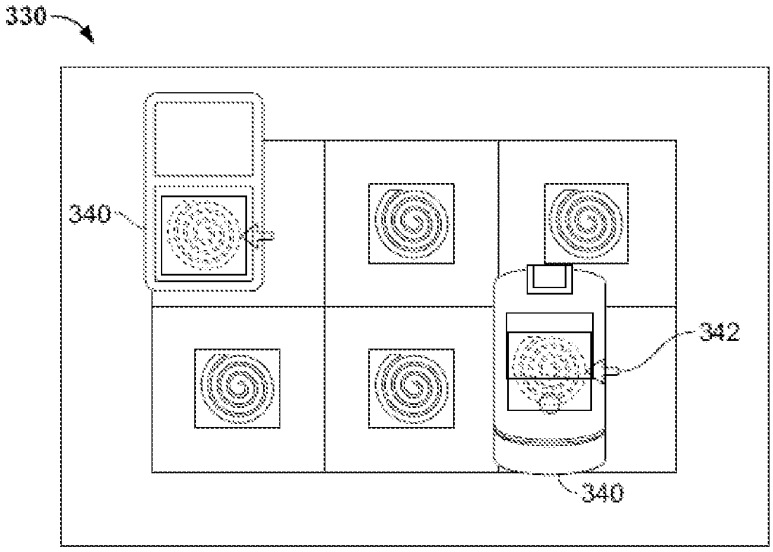


Fig. 16

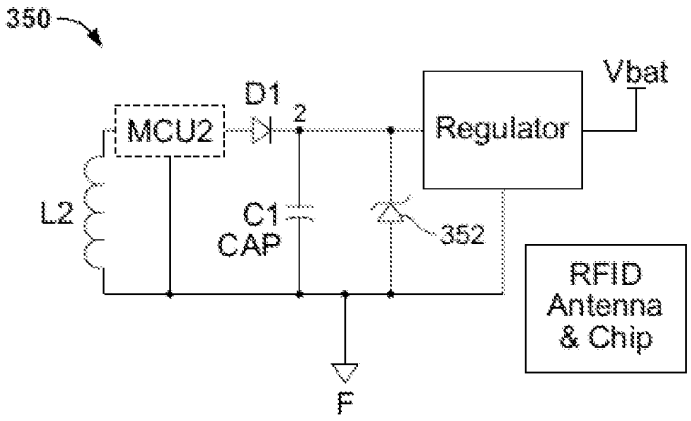

350
D1
2
MCU2
Regulator
Vbat
L2
C1
CAP
352
RFID
Antenna
& Chip
F

Fig. 17

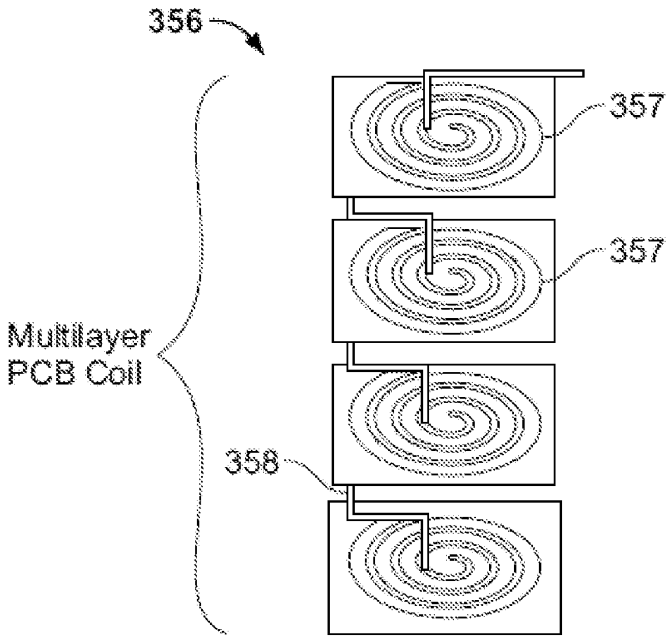

356
357
357
Multilayer
PCB Coil
358

Fig. 18

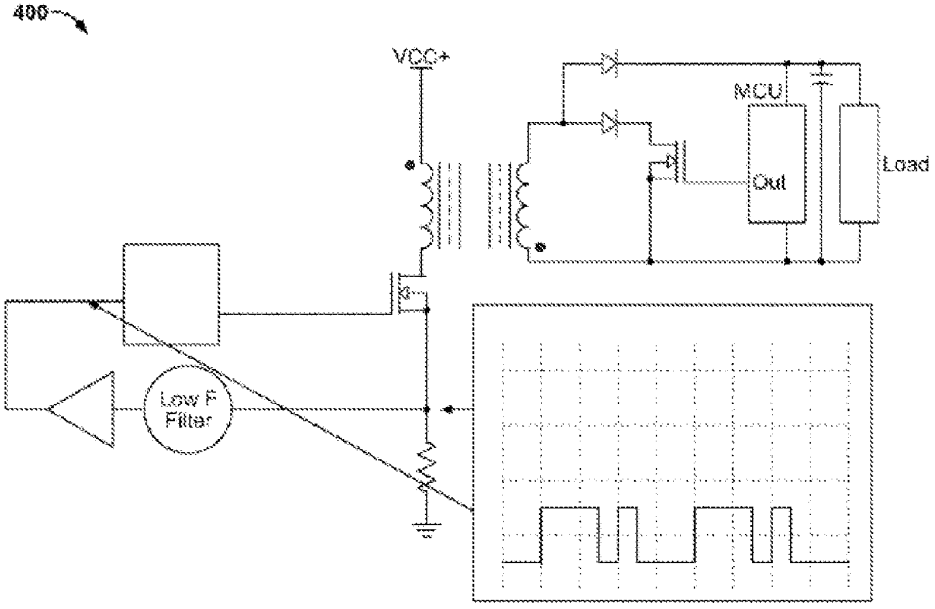

400
VCC+
MCU
Out
Load
Low F
Filter

Fig. 19

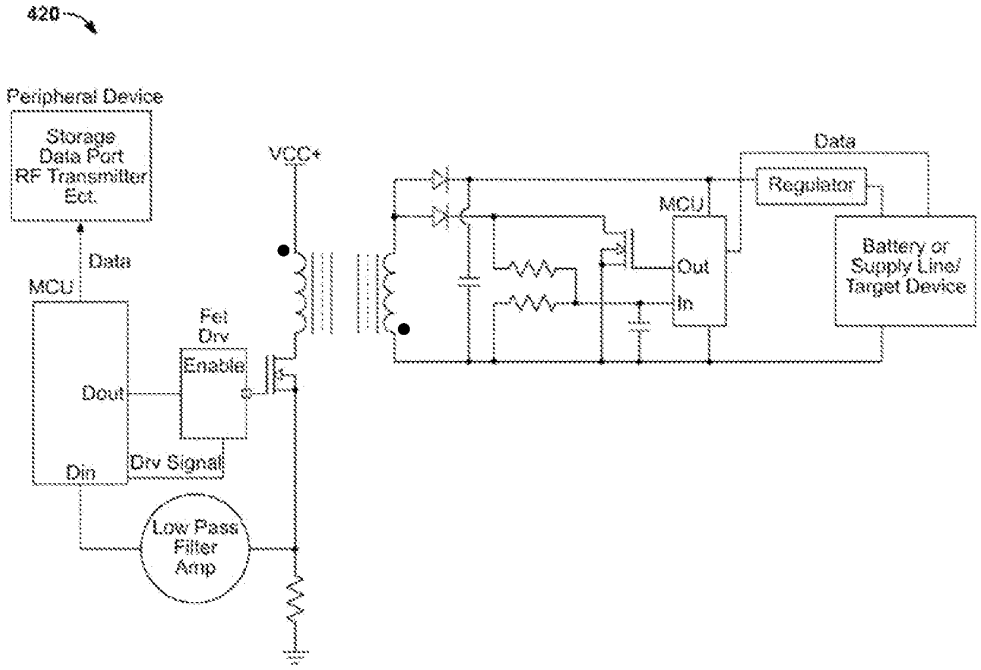

420
Peripheral Device
Storage
Data Port
RF Transmitter
Ect.
Data
MCU
Dout
Din
Fet
Drv
Enable
Drv Signal
Low Pass
Filter
Amp
VCC+
Data
Regulator
MCU
Out
In
Battery or
Supply Line/
Target Device

Fig. 20

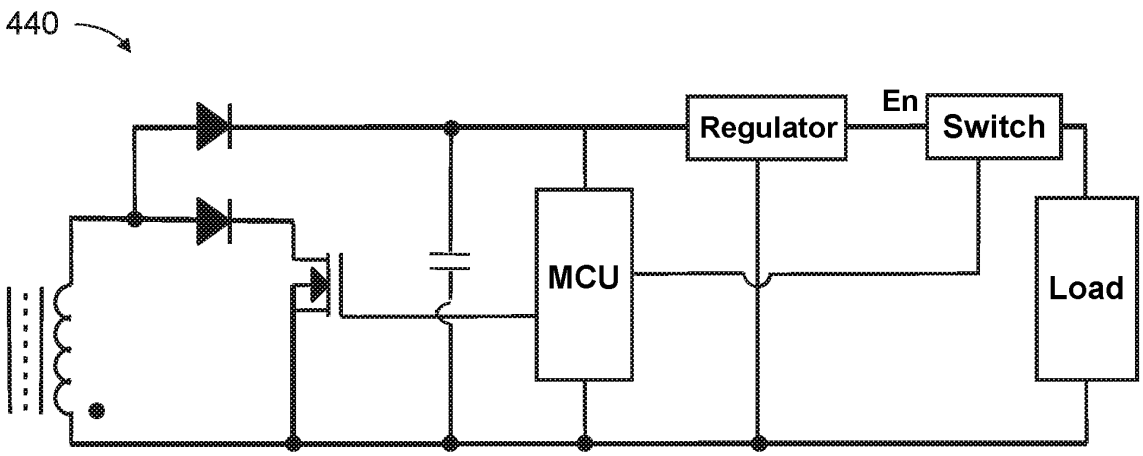


Fig. 21

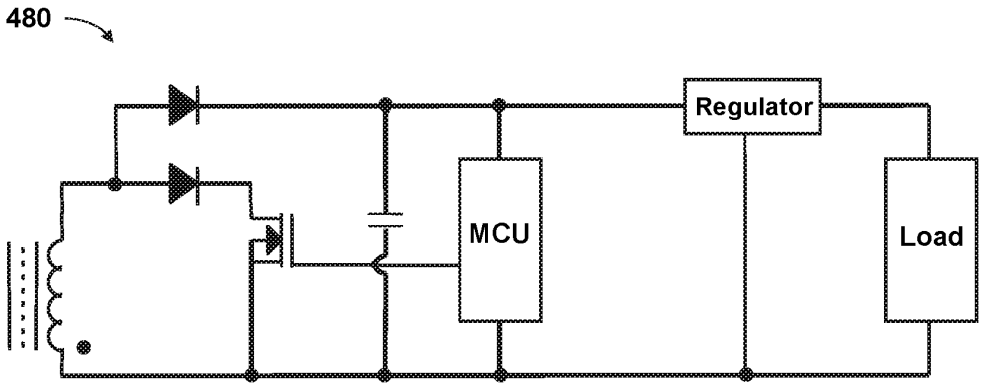


Fig. 22

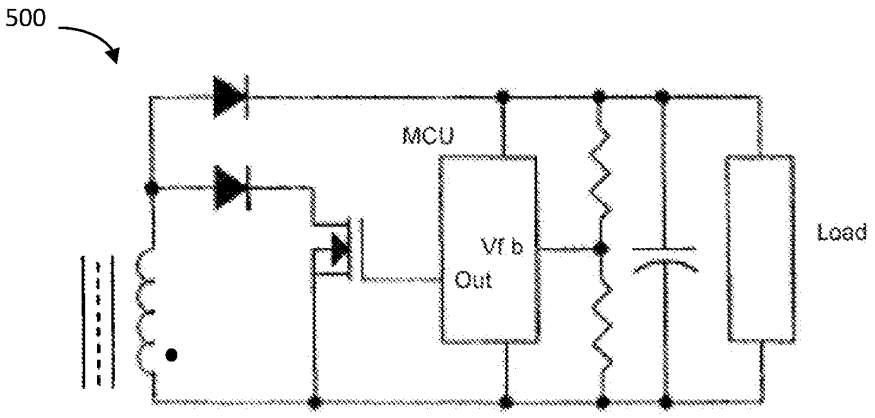


Fig. 23

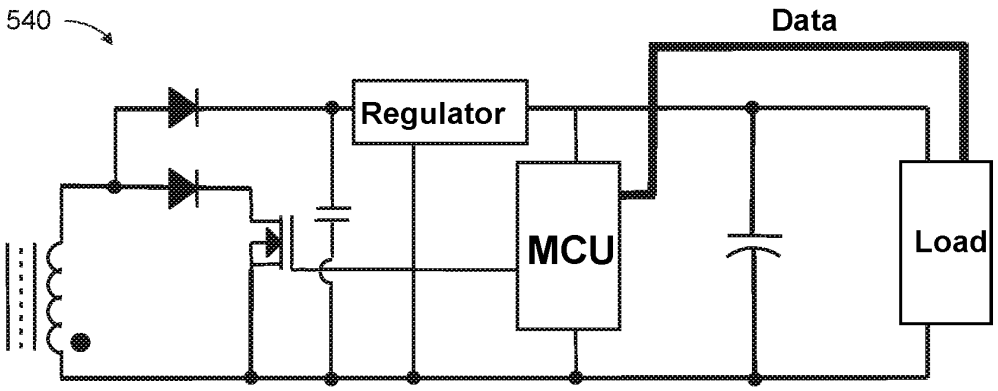


Fig. 24

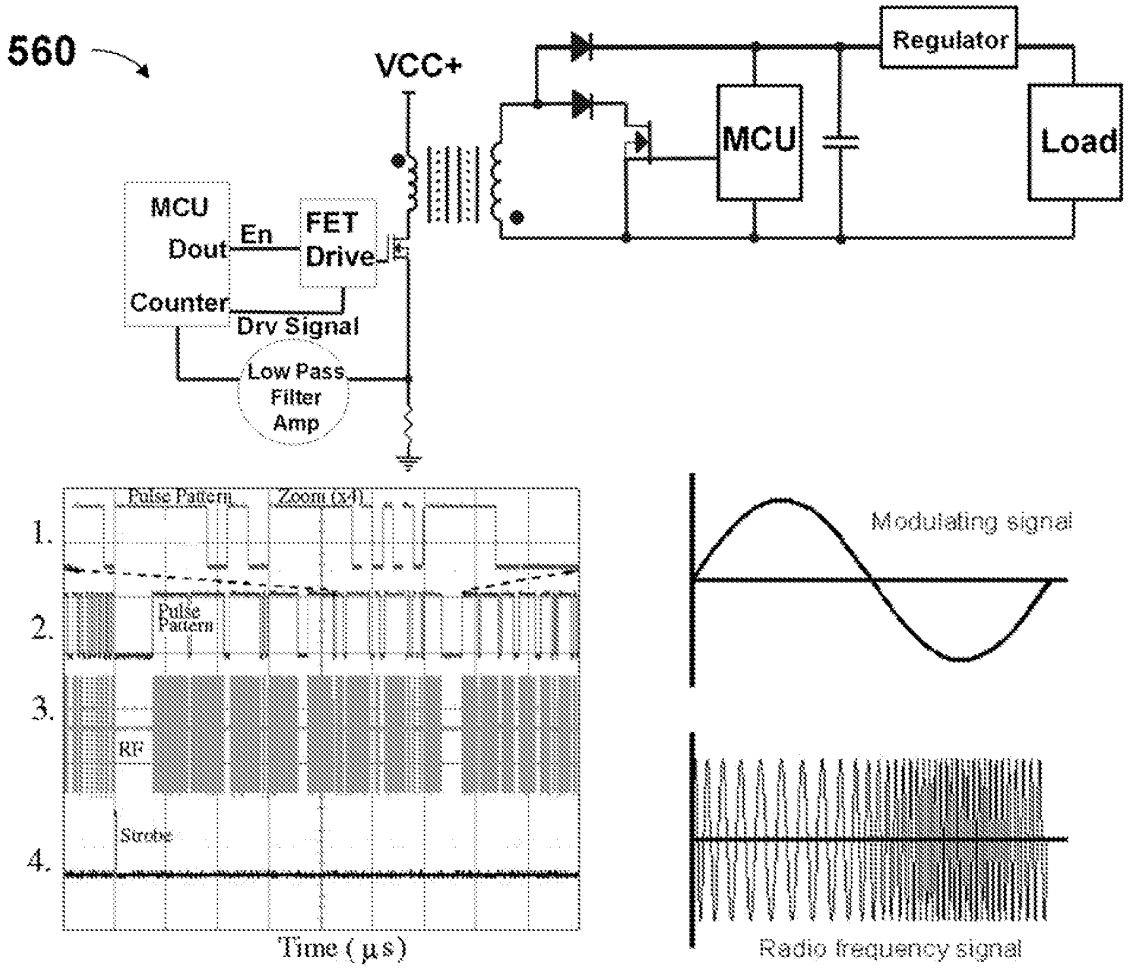

560
VCC+
Regulator
MCU
Load
MCU
Dout
En
FET
Drive
Counter
Drv Signal
Low Pass
Filter
Amp
Pulse Pattern
Zoom (x4)
1.
2.
3.
4.
Pulse Pattern
RF
Strobe
Time (µs)
Modulating signal
Radio frequency signal

Fig. 25

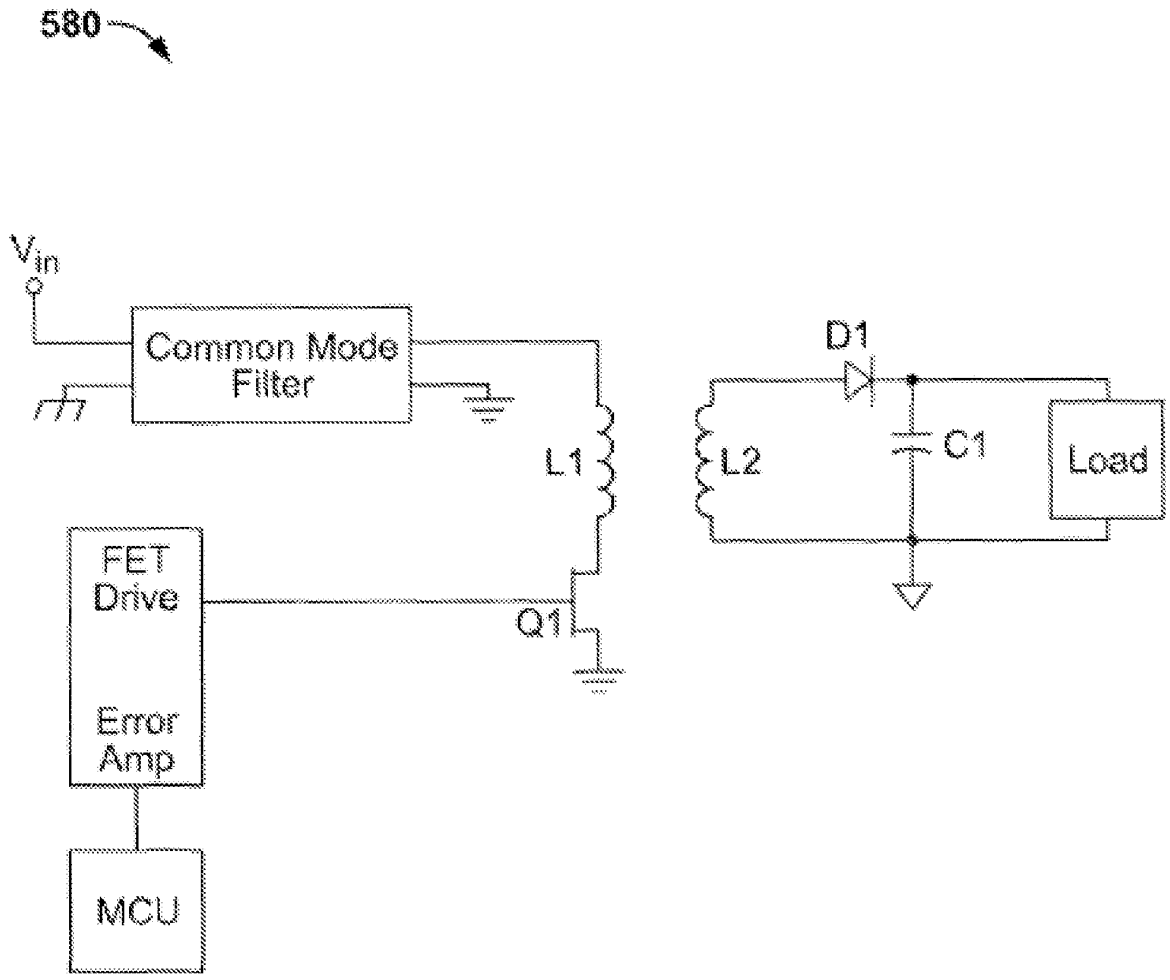

580
V_{in}
Common Mode Filter
L1
FET Drive
Error Amp
MCU
Q1
D1
L2
C1
Load

Fig. 26

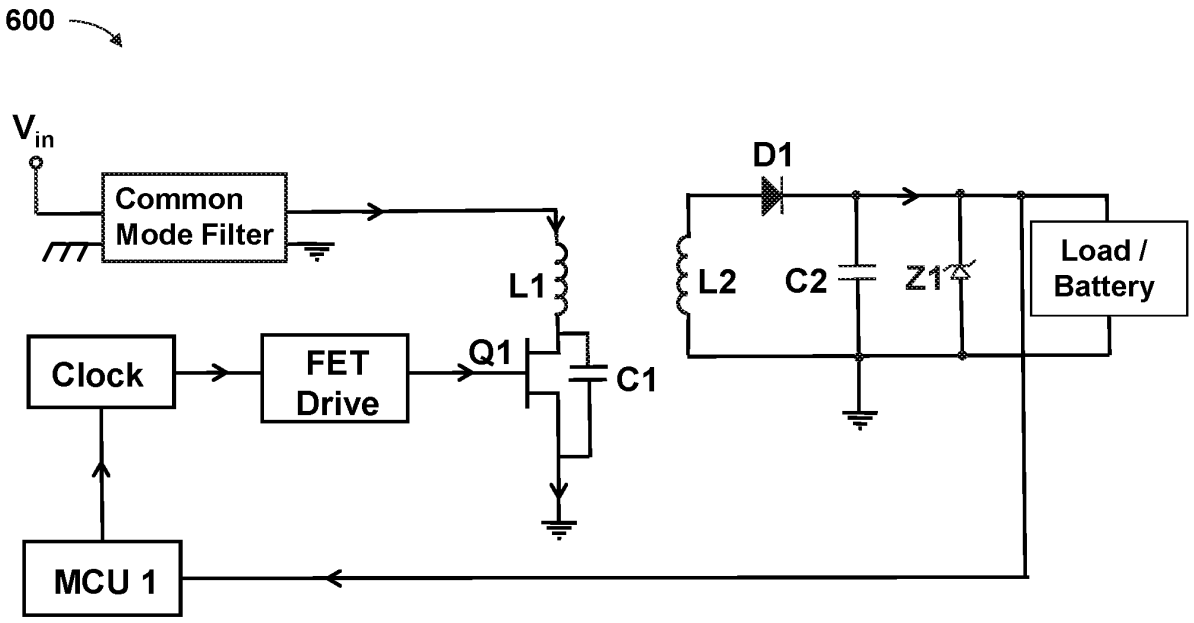

600
V_{in}
Common Mode Filter
L1
D1
L2
C2
Z1
Load / Battery
Clock
FET Drive
Q1
C1
MCU 1

Fig. 27

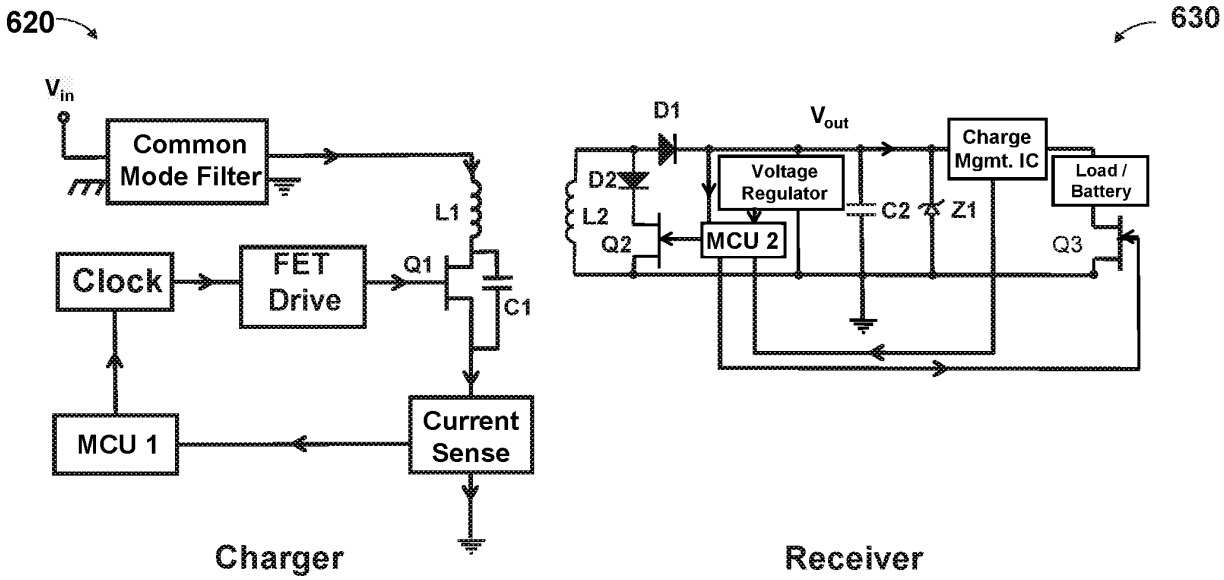

620
630
V_{in}
Common Mode Filter
L1
D1
V_{out}
Charge Mgmt. IC
Load / Battery
D2
Voltage Regulator
L2
Q2
MCU 2
C2
Z1
Q3
Clock
FET Drive
Q1
C1
MCU 1
Current Sense
Charger
Receiver

Fig. 28

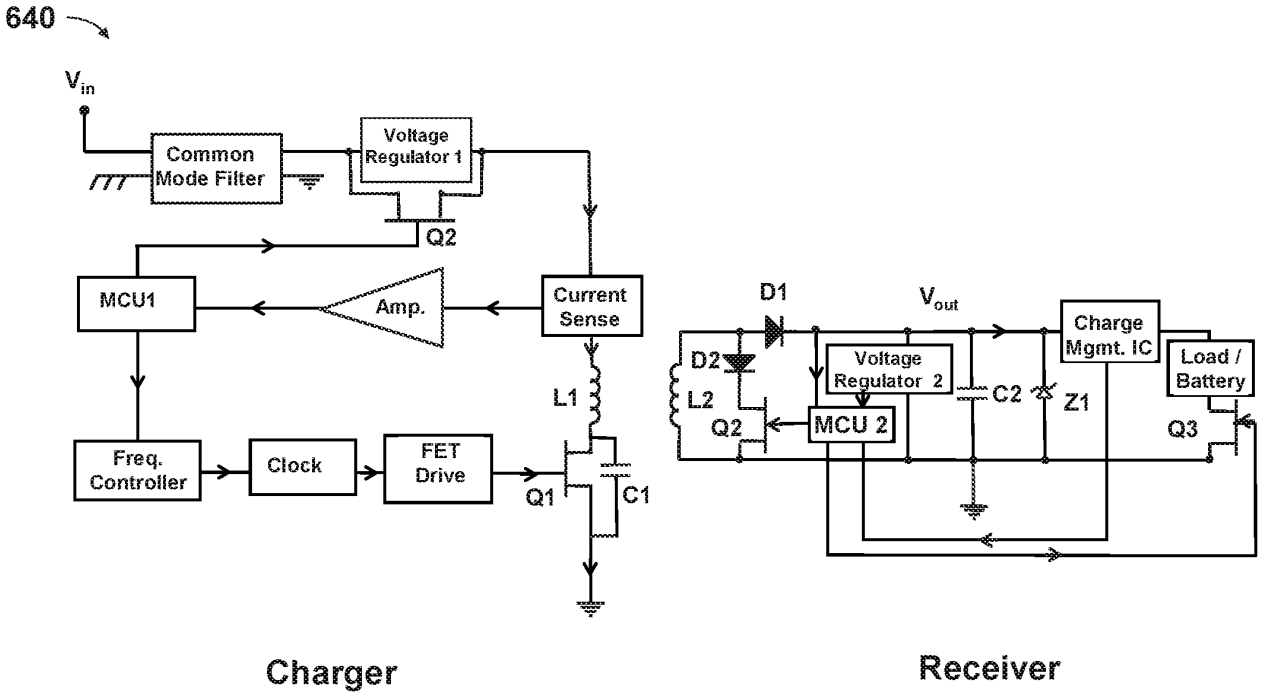

640
V_{in}
Common Mode Filter
Voltage Regulator 1
Q2
MCU1
Amp.
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D1
V_{out}
D2
L2
Q2
Voltage Regulator 2
MCU 2
C2
Z1
Charge Mgmt. IC
Load / Battery
Q3
Charger
Receiver

Fig. 29

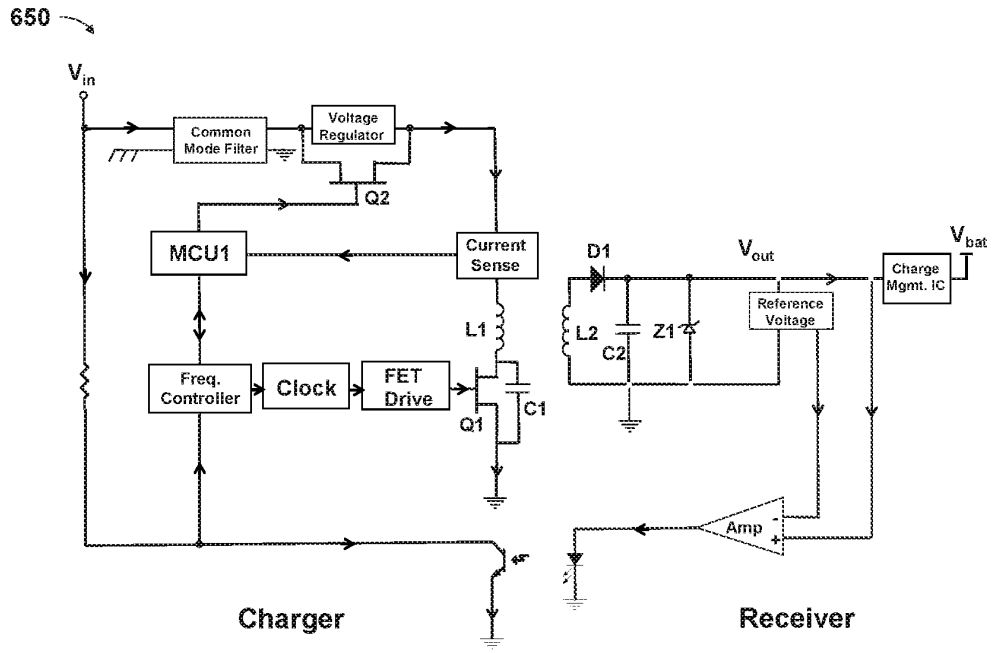

650
V_{in}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D1
V_{out}
V_{bat}
Charge Mgmt. IC
Reference Voltage
L2
C2
Z1
Amp
Charger
Receiver

Fig. 30

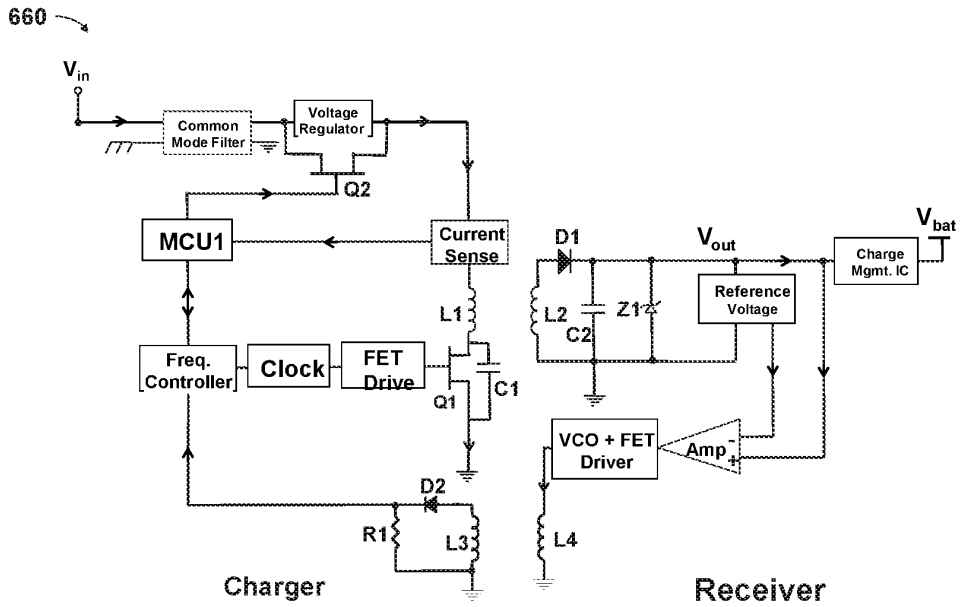

660
V_{in}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D2
R1
L3
Charger
D1
V_{out}
V_{bat}
Charge Mgmt. IC
Reference Voltage
L2
C2
Z1
VCO + FET Driver
Amp
L4
Receiver

Fig. 31

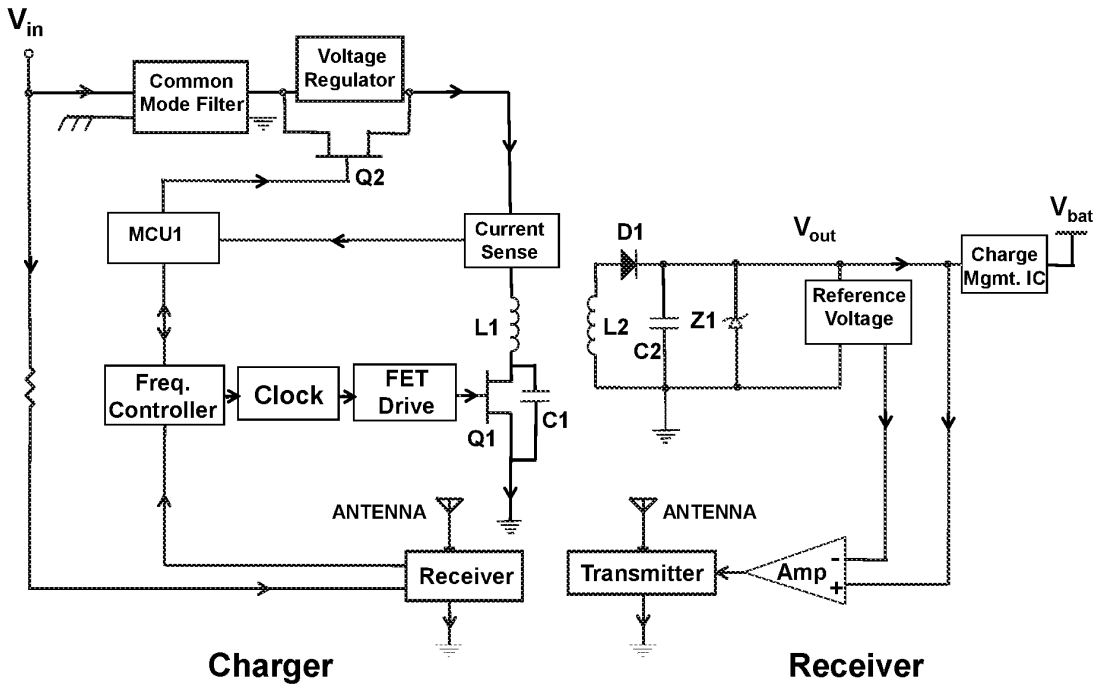

V_{in}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
ANTENNA
Receiver
Charger
D1
V_{out}
V_{bat}
Charge Mgmt. IC
Reference Voltage
L2
C2
Z1
ANTENNA
Transmitter
Amp
Receiver

Fig. 32

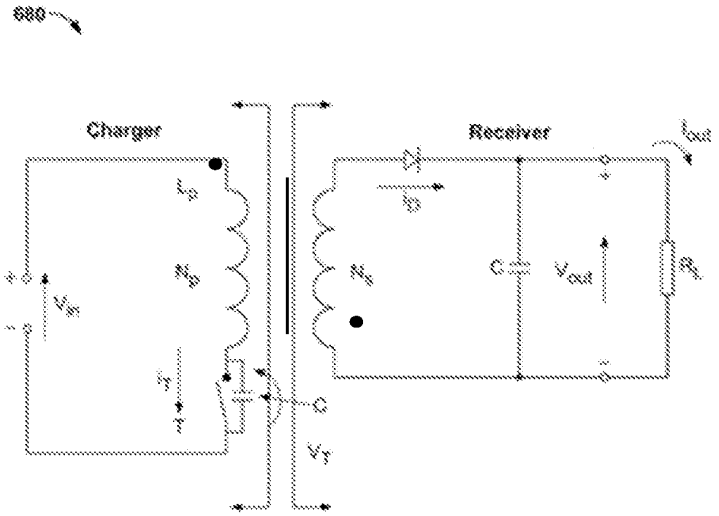

Charger
Receiver

Fig. 33

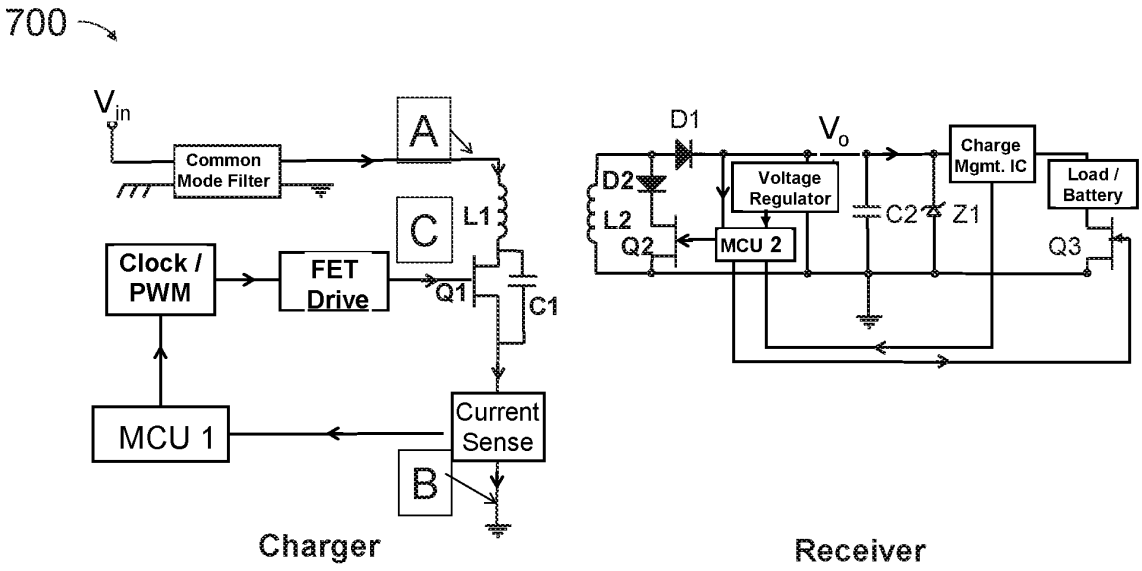

700
Vin
Common Mode Filter
A
C
L1
Clock / PWM
FET Drive
Q1
C1
MCU 1
Current Sense
B
Charger
D1
Vo
D2
L2
Q2
Voltage Regulator
MCU 2
C2
Z1
Charge Mgmt. IC
Load / Battery
Q3
Receiver

Fig. 34

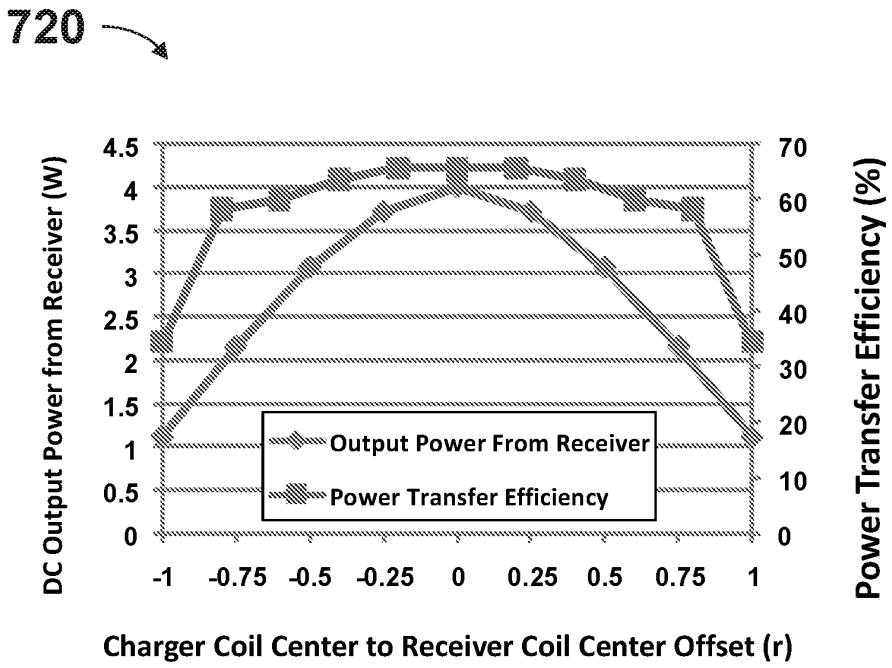

720
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
DC Output Power from Receiver (W)
70
60
50
40
30
20
10
0
Power Transfer Efficiency (%)
Output Power From Receiver
Power Transfer Efficiency
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Charger Coil Center to Receiver Coil Center Offset (r)

Fig. 35

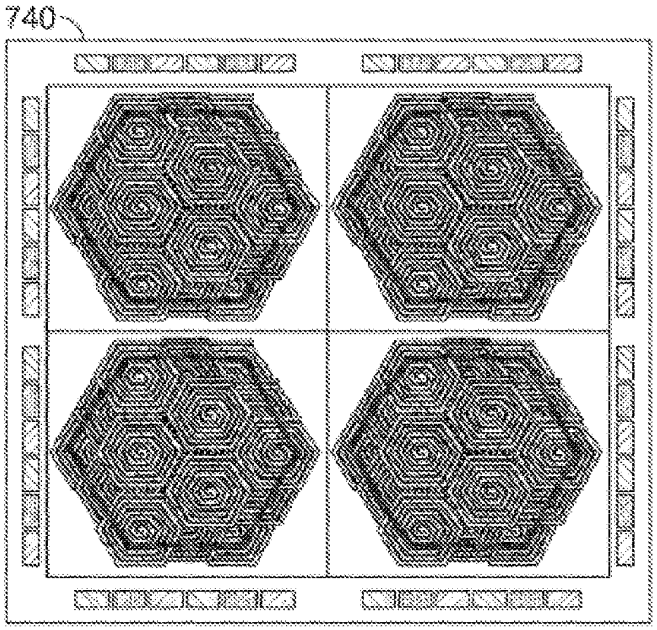

740

Fig. 36

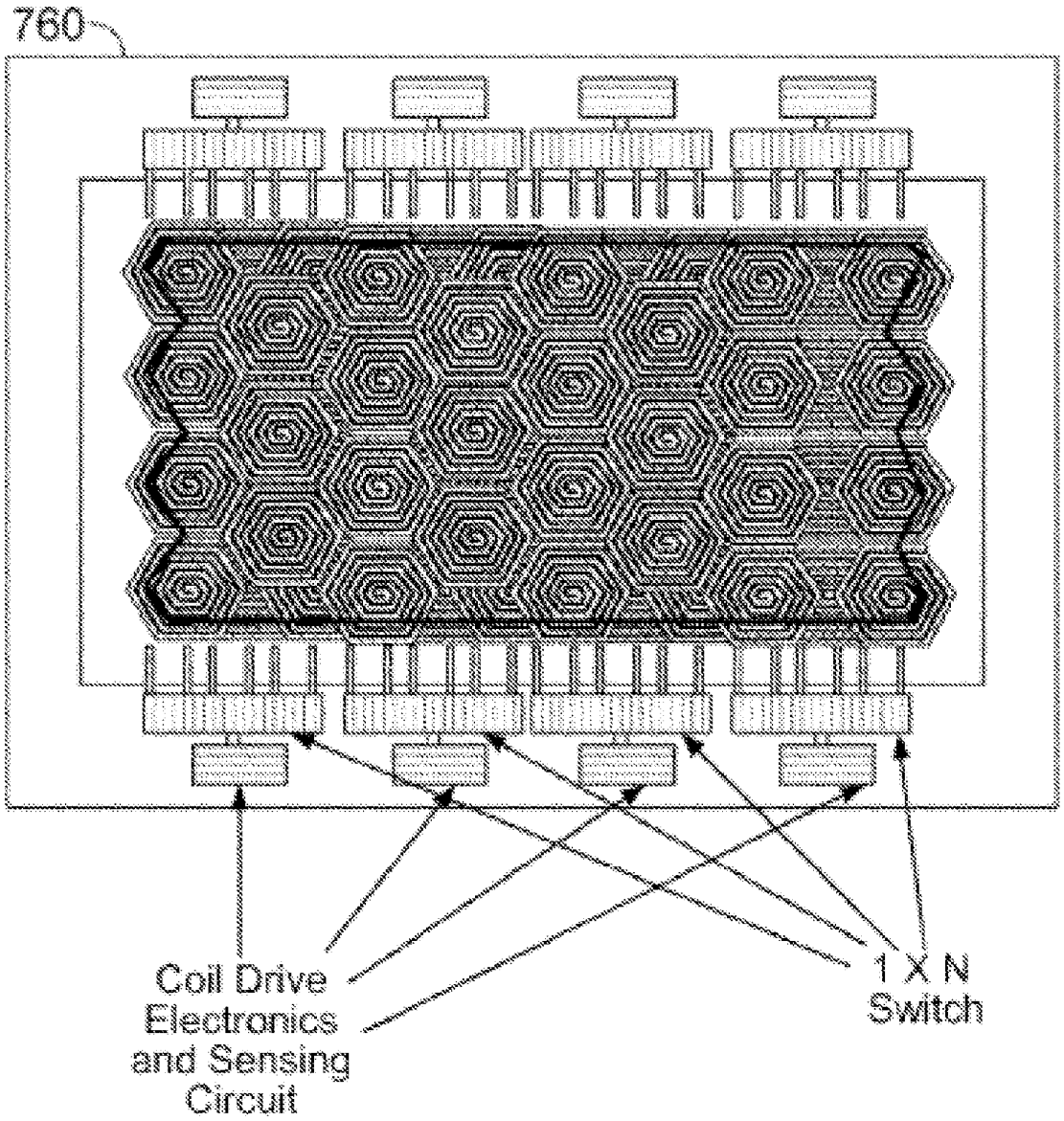


Fig. 37

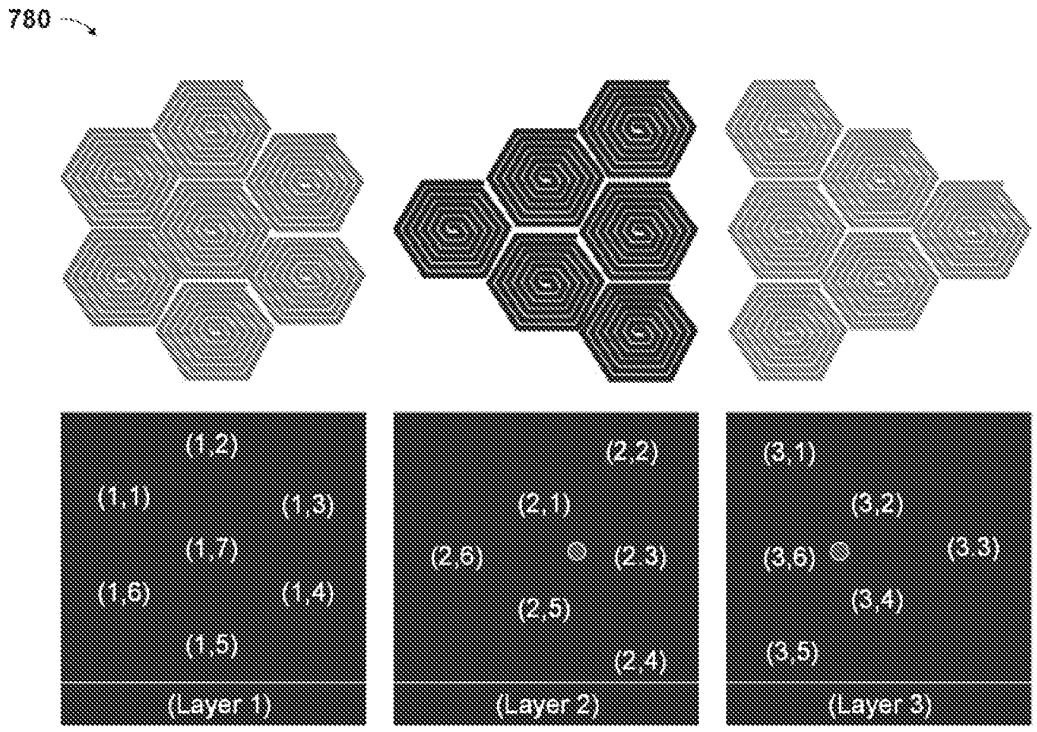

780
(1,2)
(1,1)
(1,3)
(1,7)
(1,6)
(1,4)
(1,5)
(Layer 1)
(2,2)
(2,1)
(2,6)
(2,3)
(2,5)
(2,4)
(Layer 2)
(3,1)
(3,2)
(3,6)
(3,3)
(3,4)
(3,5)
(Layer 3)

Fig. 38

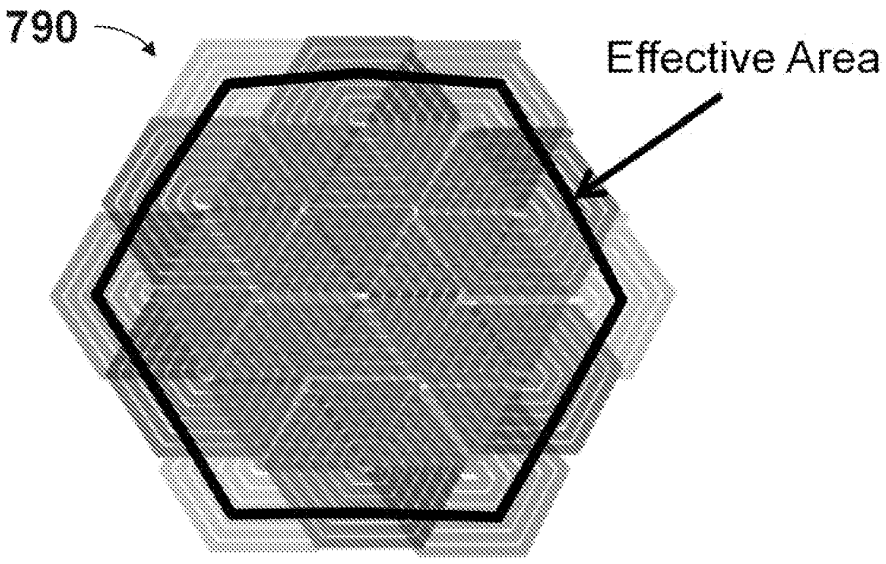

790
Effective Area

Fig. 39

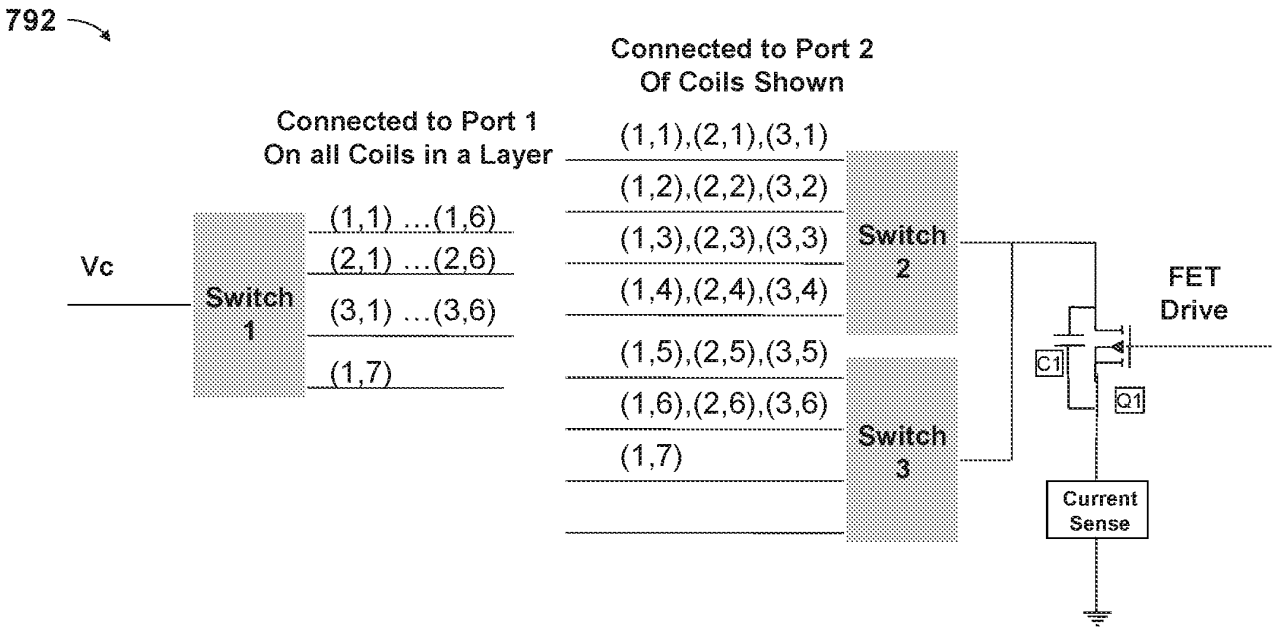

792
Connected to Port 2
Of Coils Shown
Connected to Port 1
On all Coils in a Layer
(1,1),(2,1),(3,1)
(1,2),(2,2),(3,2)
(1,3),(2,3),(3,3)
(1,4),(2,4),(3,4)
(1,5),(2,5),(3,5)
(1,6),(2,6),(3,6)
(1,7)
Vc
Switch 1
(1,1) …(1,6)
(2,1) …(2,6)
(3,1) …(3,6)
(1,7)
Switch 2
Switch 3
FET Drive
C1
Q1
Current Sense

Fig. 40

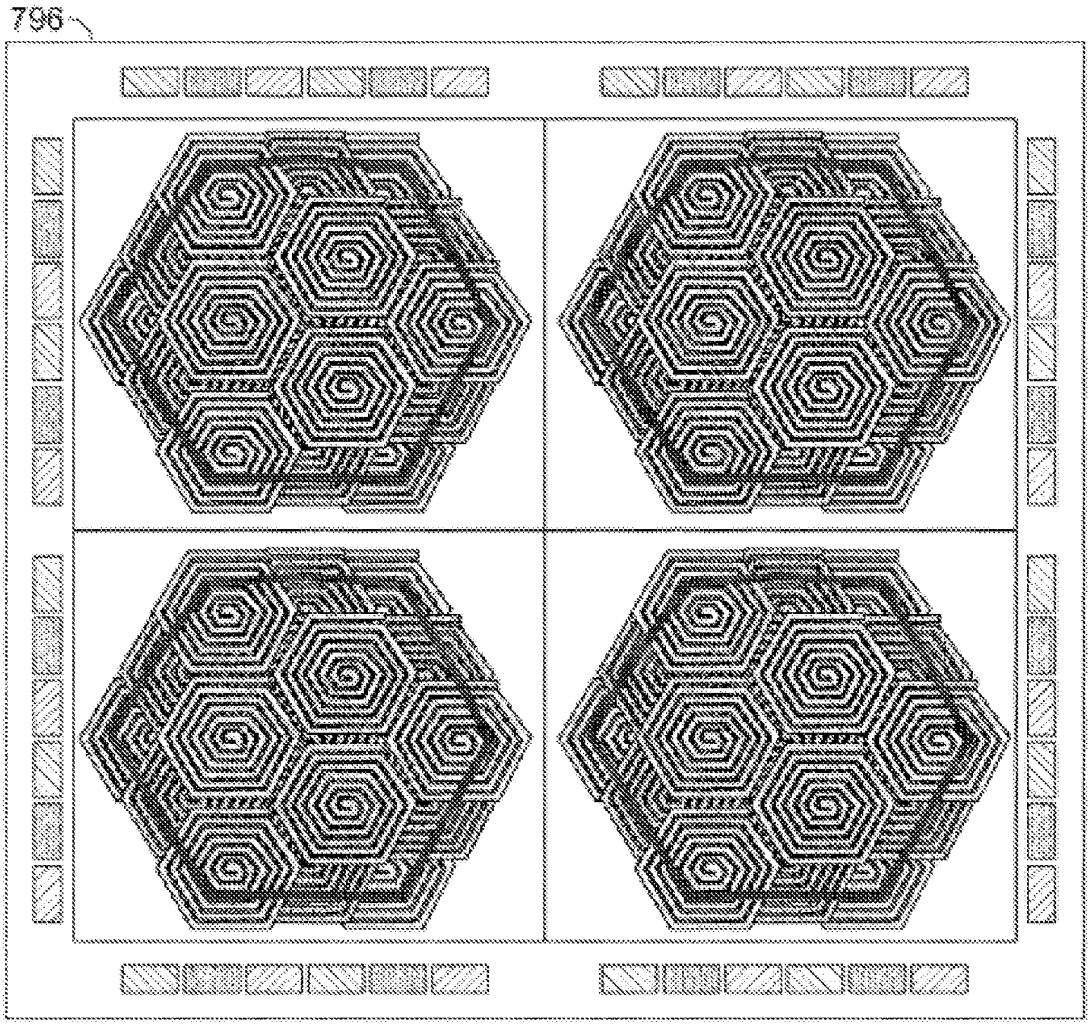


Fig. 41

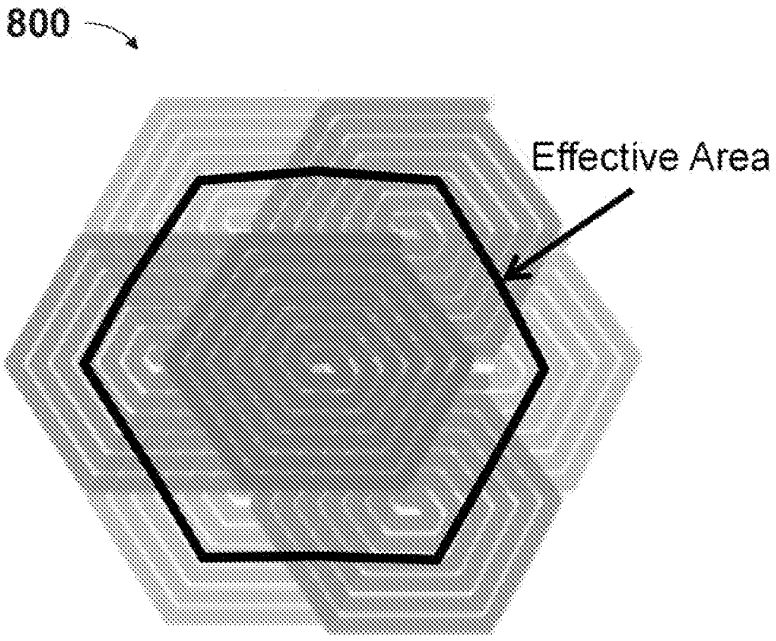


Fig. 42

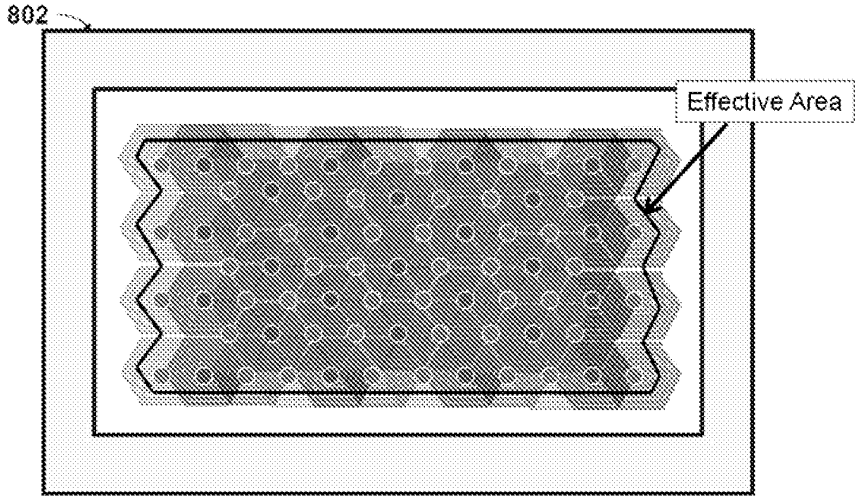


Fig. 43

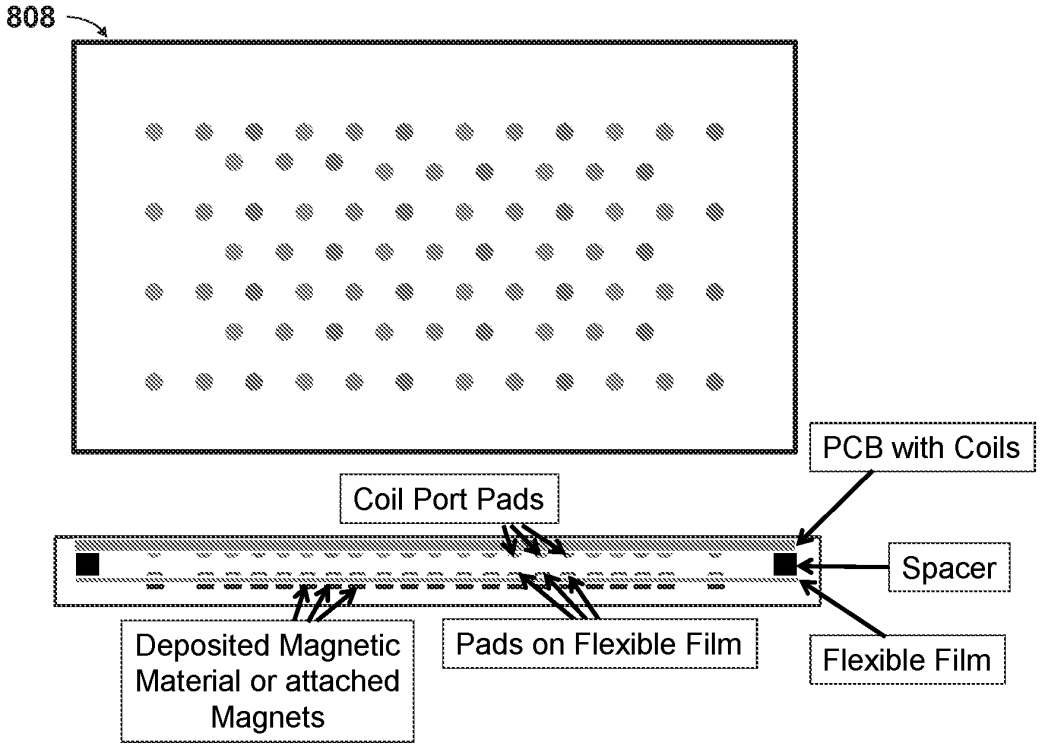

808
PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 44

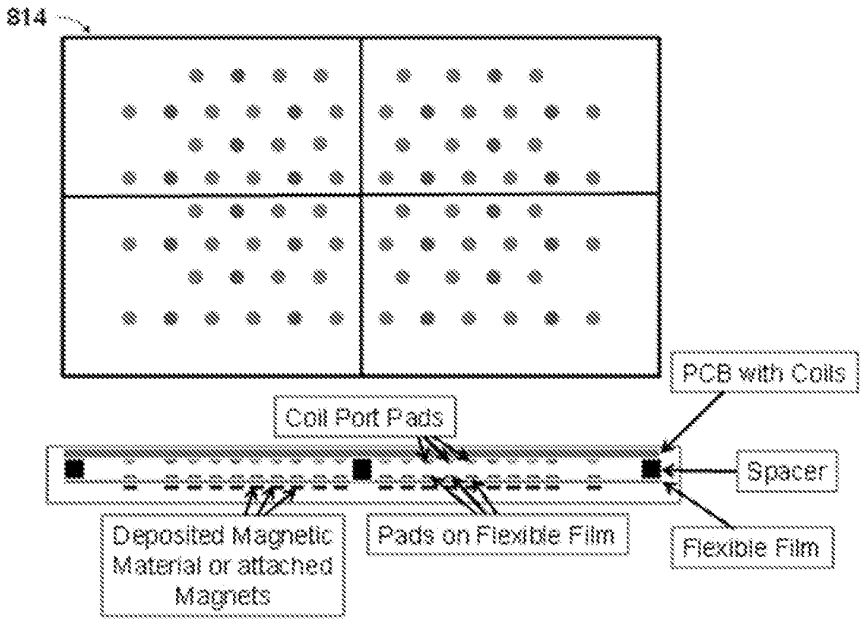

814
PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 45

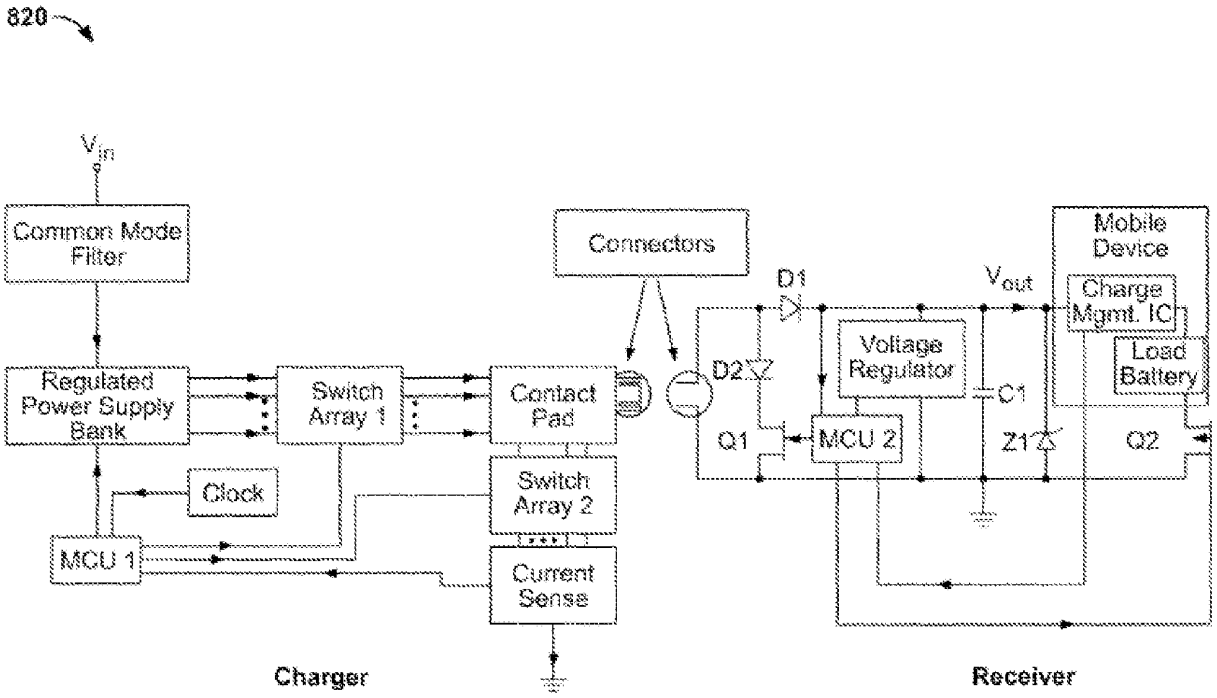

820
V_{in}
Common Mode Filter
Regulated Power Supply Bank
Switch Array 1
Contact Pad
Connectors
D1
D2
Q1
MCU 2
Voltage Regulator
V_{out}
C1
Z1
Mobile Device
Charge Mgmt. IC
Load Battery
Q2
Clock
Switch Array 2
MCU 1
Current Sense
Charger
Receiver

Fig. 46

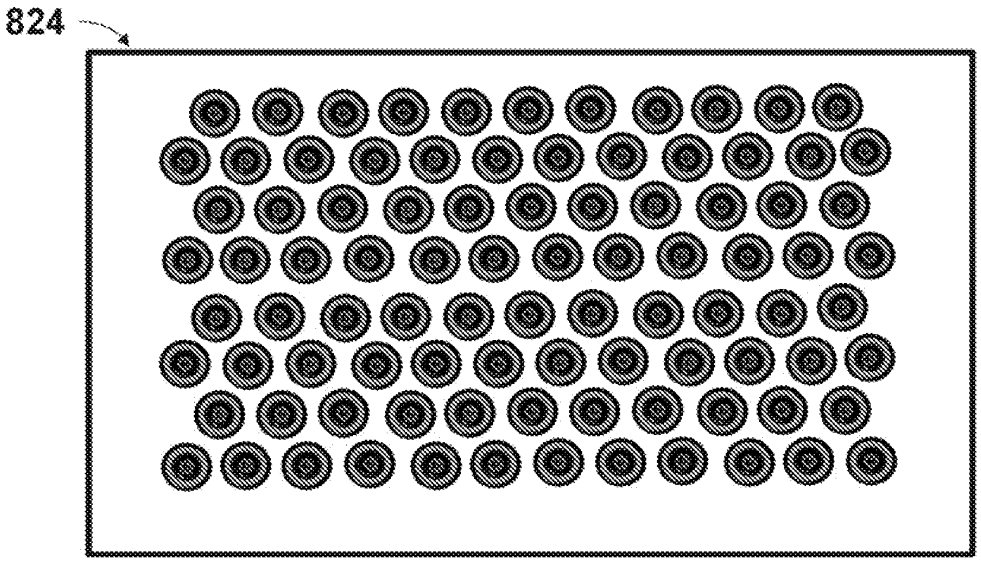

824

Fig. 47

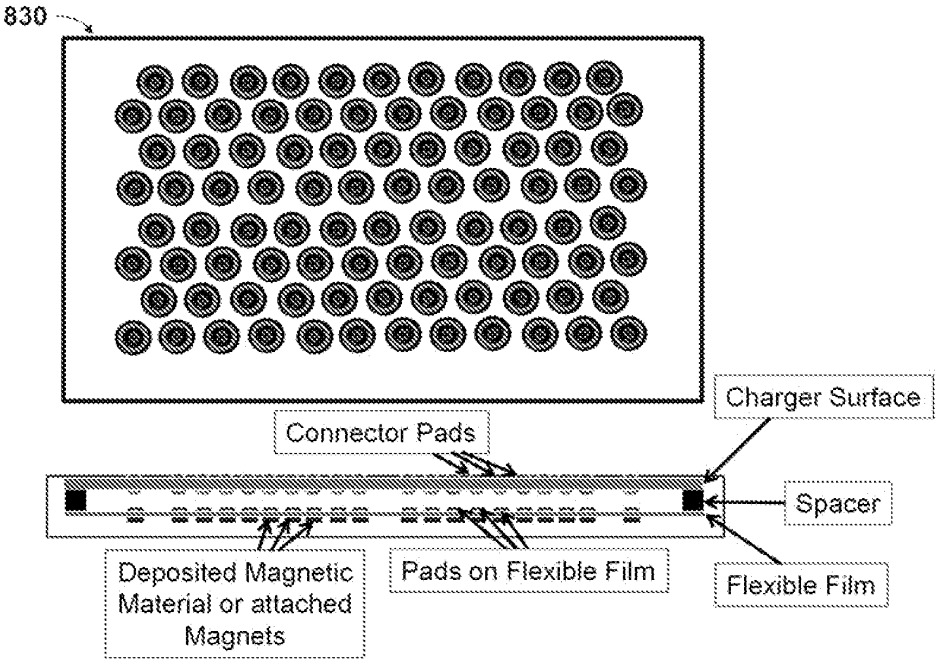

830
Charger Surface
Connector Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 48

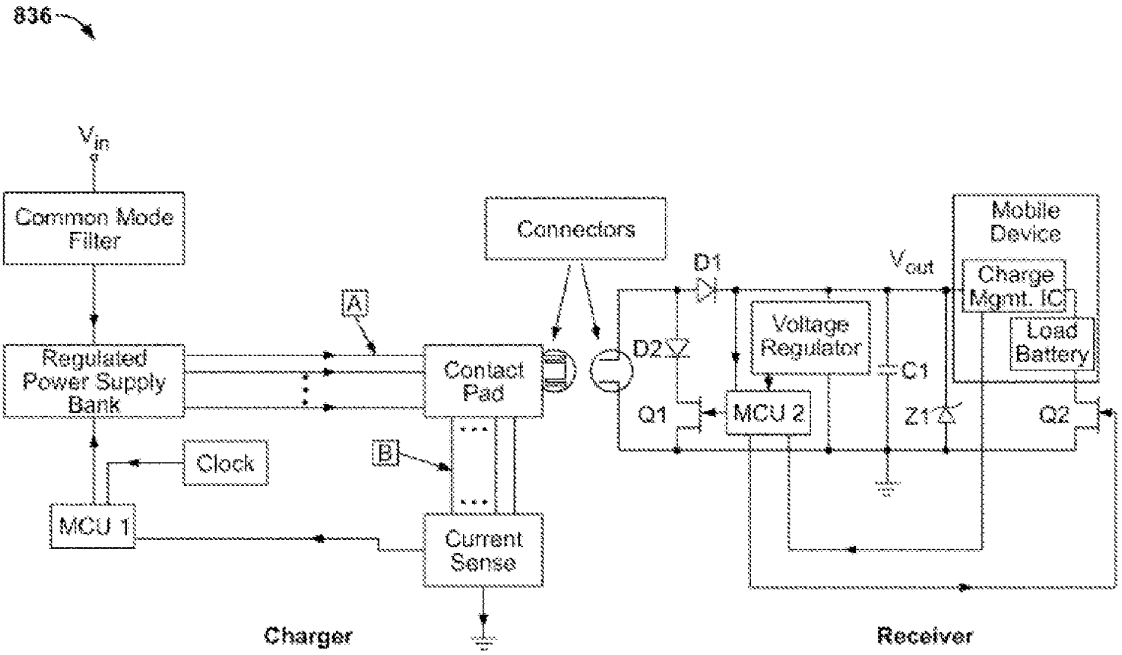

836
V_{in}
Common Mode Filter
Regulated Power Supply Bank
Clock
MCU 1
A
B
Contact Pad
Current Sense
Connectors
D1
D2
Q1
MCU 2
Voltage Regulator
V_{out}
C1
Z1
Q2
Mobile Device
Charge Mgmt. IC
Load Battery
Charger
Receiver

Fig. 49

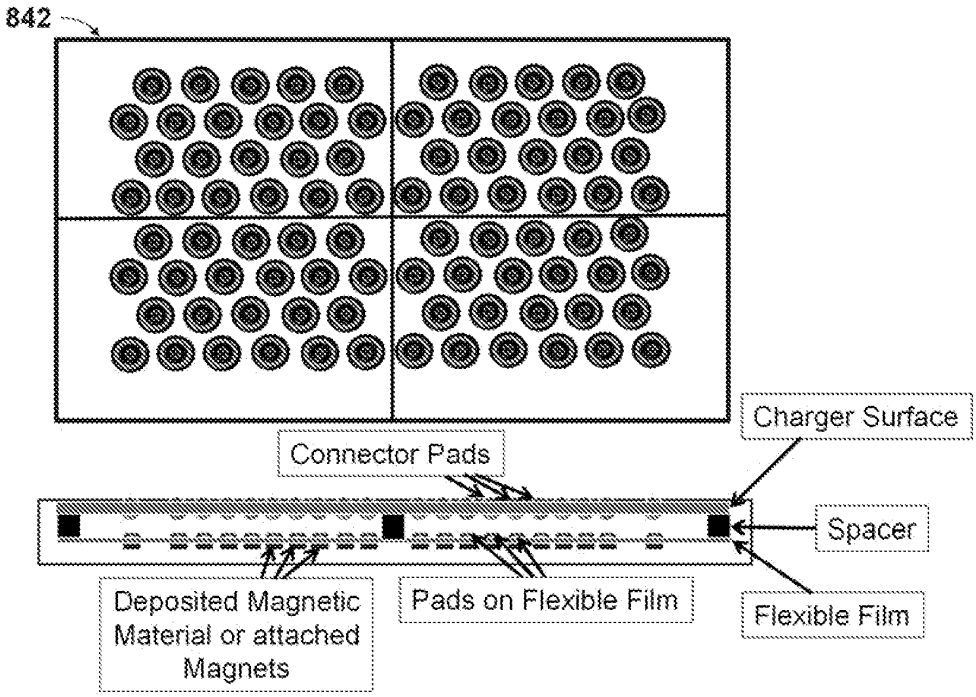

842
Charger Surface
Connector Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 50

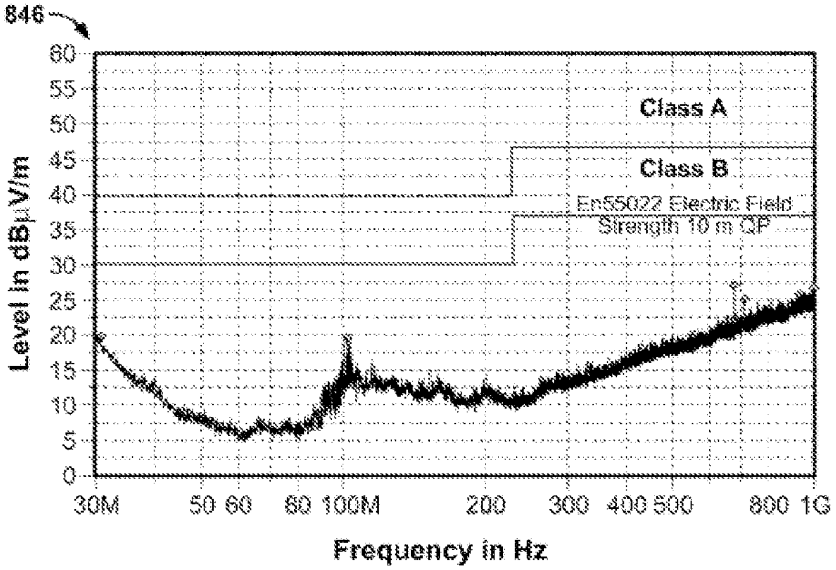

846
Class A
Class B
En55022 Electric Field Strength 10 m QP
Level in dBµV/m
Frequency in Hz
30M
50
60
80
100M
200
300
400
500
800
1G

Fig. 51

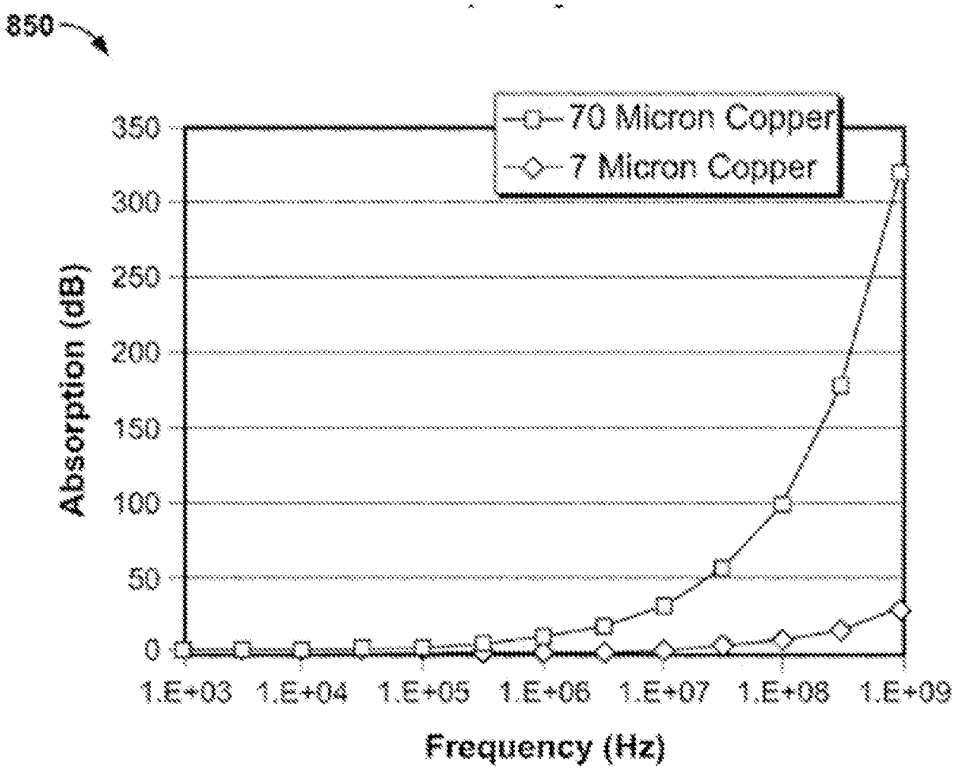

850
70 Micron Copper
7 Micron Copper
350
300
250
200
150
100
50
0
Absorption (dB)
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07
1.E+08
1.E+09
Frequency (Hz)

Fig. 52

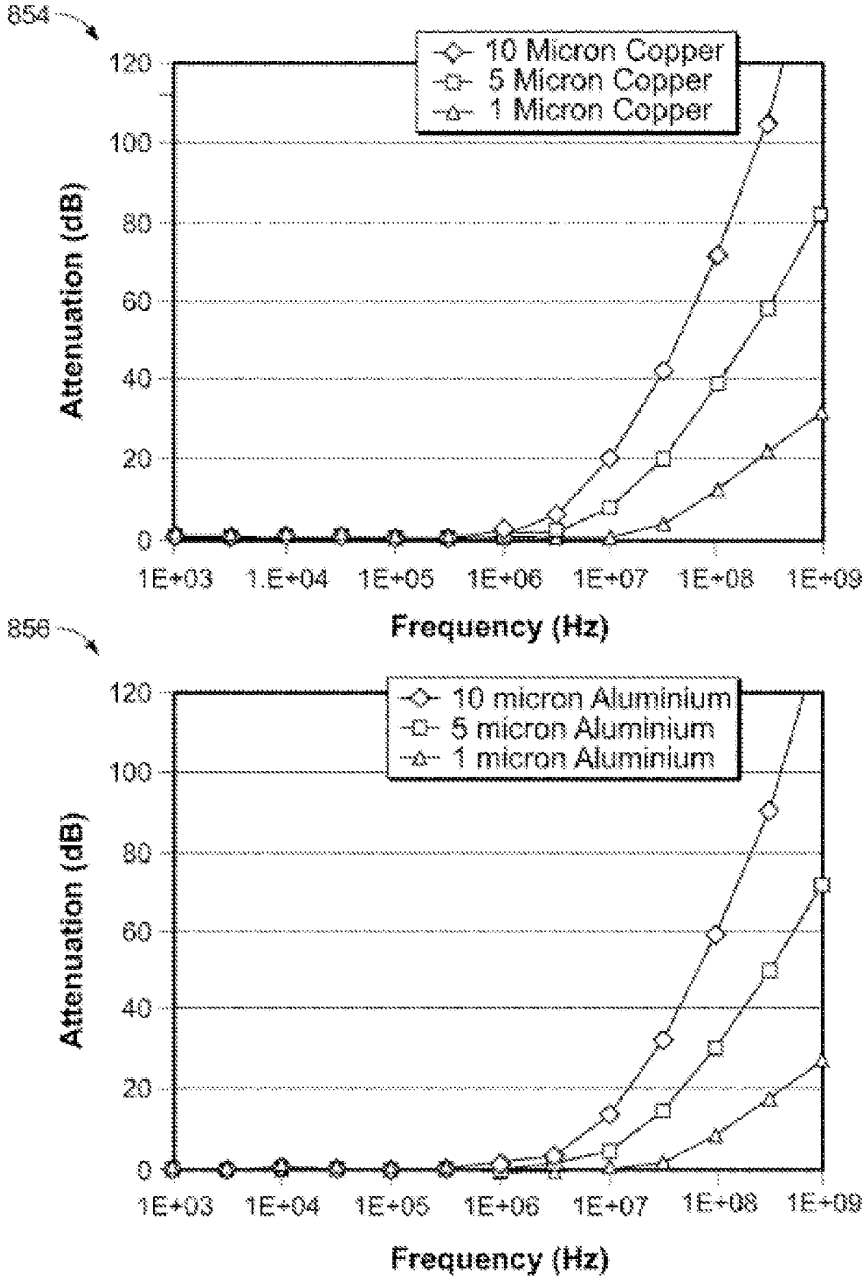

854
10 Micron Copper
5 Micron Copper
1 Micron Copper
Attenuation (dB)
120
100
80
60
40
20
0
1E+03
1.E+04
1E+05
1E+06
1E+07
1E+08
1E+09
Frequency (Hz)
856
10 micron Aluminium
5 micron Aluminium
1 micron Aluminium
Attenuation (dB)
120
100
80
60
40
20
0
1E+03
1E+04
1E+05
1E+06
1E+07
1E+08
1E+09
Frequency (Hz)

Fig. 53

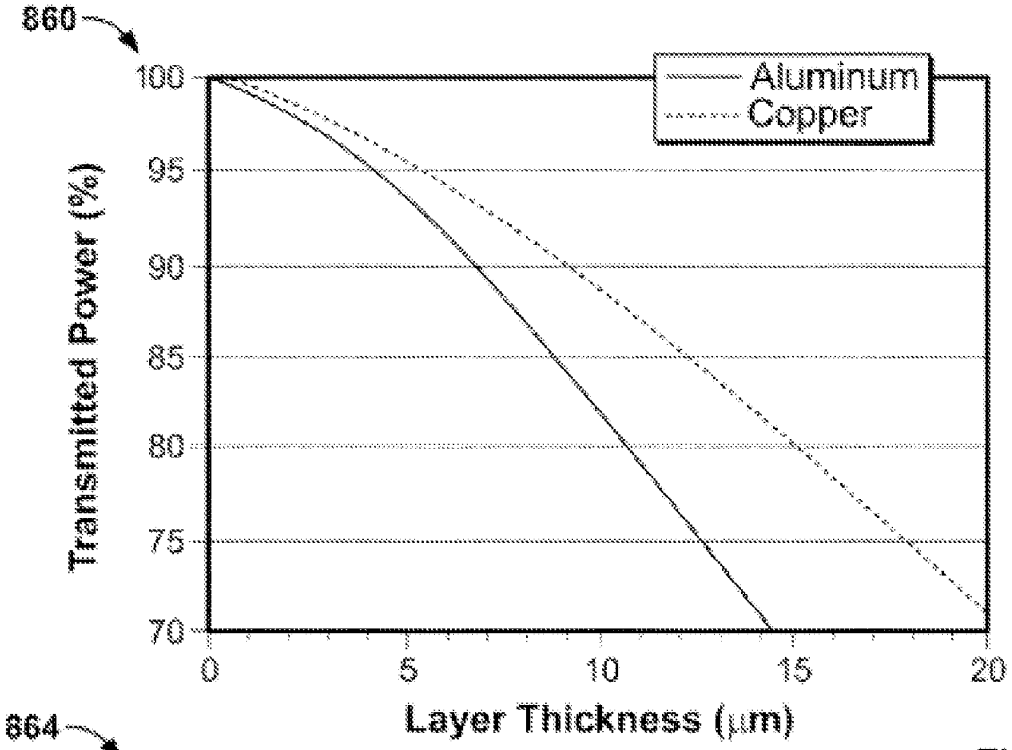

860
100
95
90
85
80
75
70
Transmitted Power (%)
0
5
10
15
20
Layer Thickness (μm)
Aluminum
Copper

FIG. 54

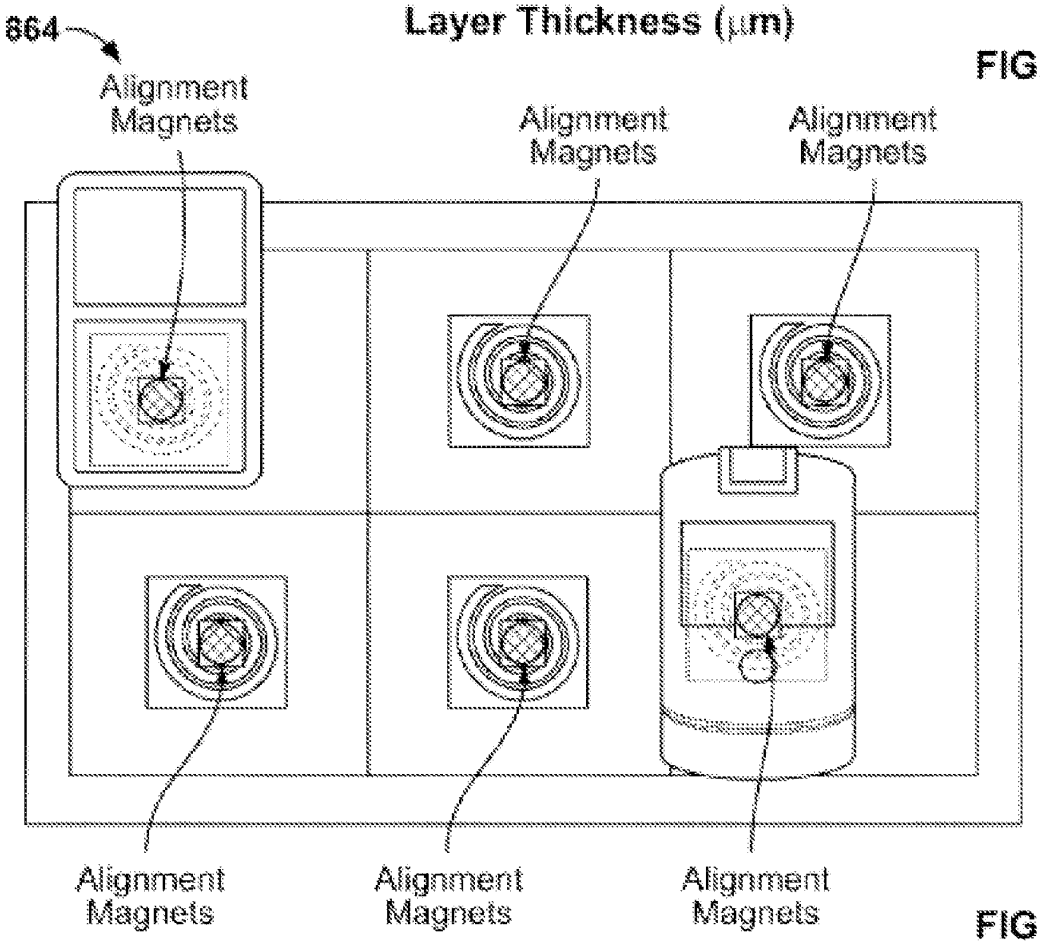

864
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets

FIG. 55

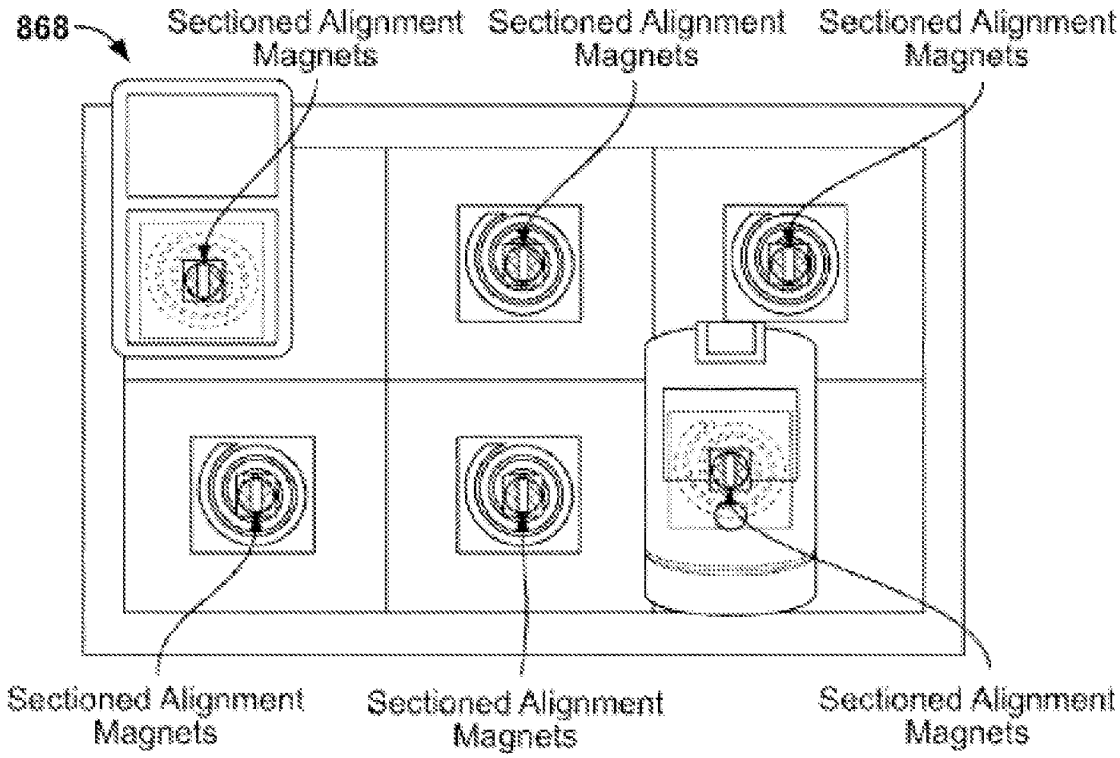

868
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets

FIG. 56

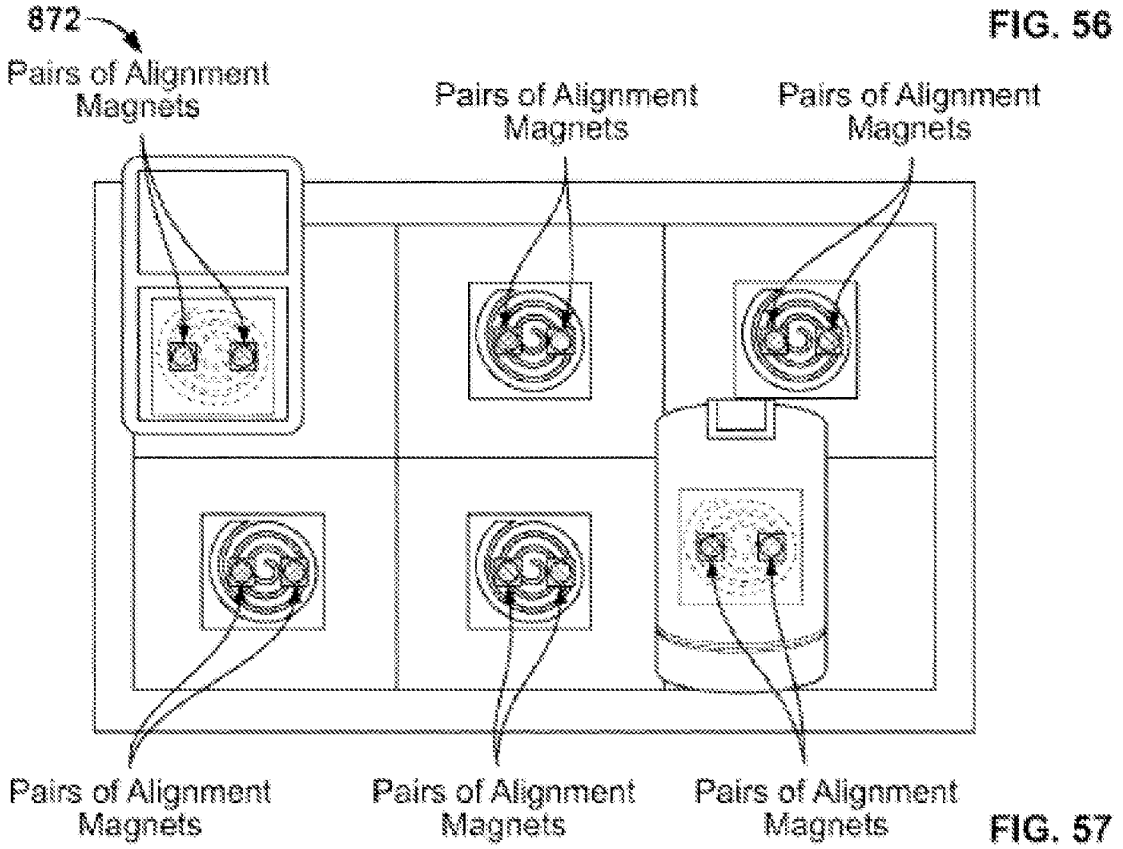

872
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets

FIG. 57

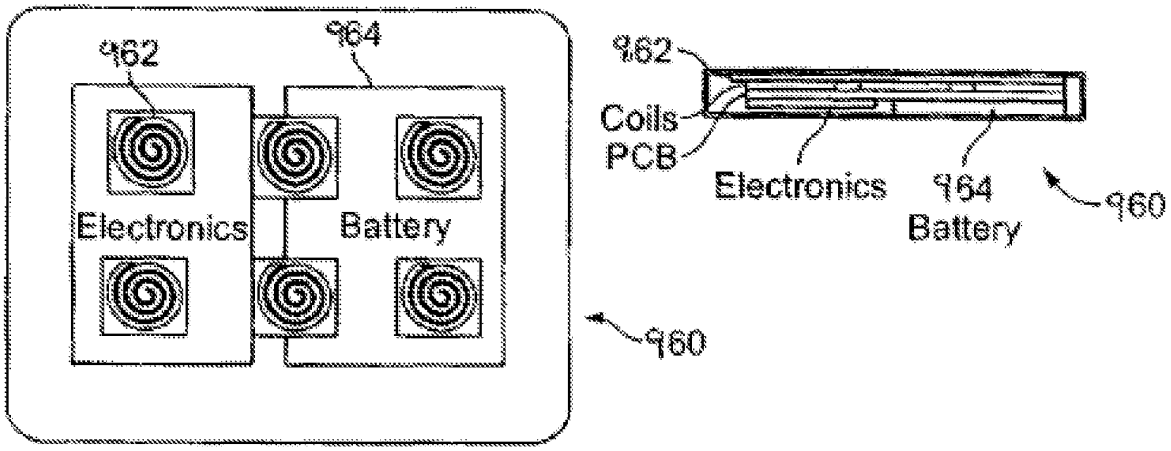

962
964
Electronics
Battery
960
962
Coils
PCB
Electronics
964
Battery
960

Fig. 58

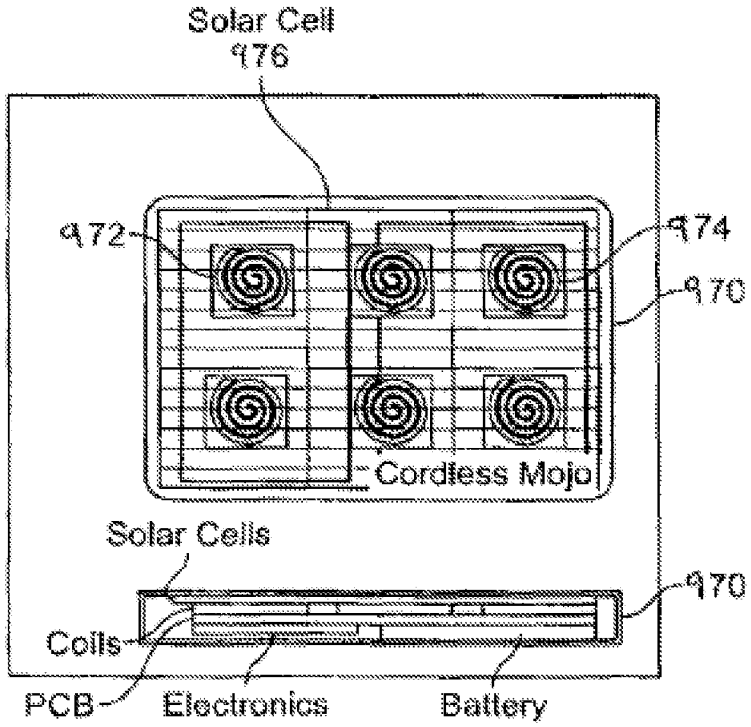

Solar Cell
976
972
974
970
Cordless Mojo
Solar Cells
970
Coils
PCB
Electronics
Battery

Fig. 59

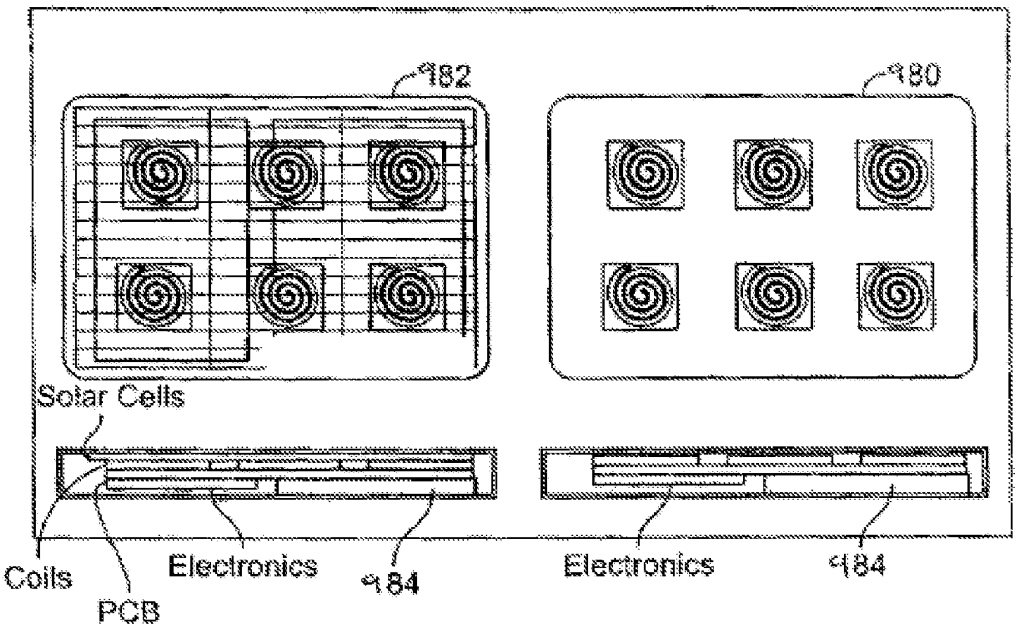

982
980
Solar Cells
Coils
PCB
Electronics
984
Electronics
984

Fig. 60

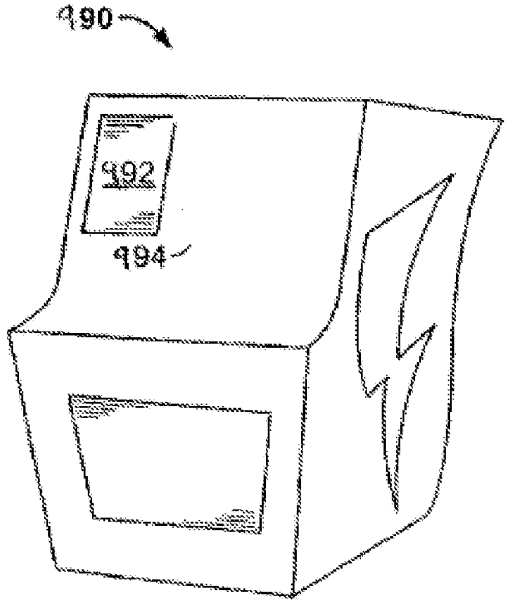

990
992
994

Fig. 61

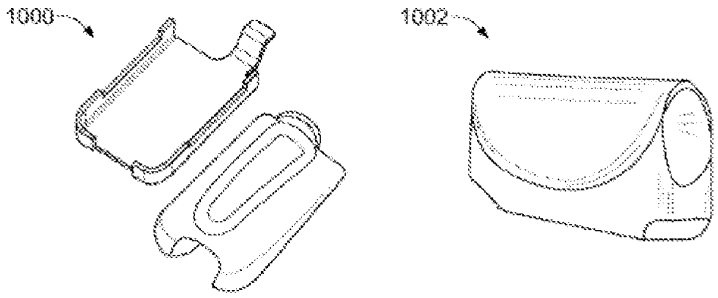


Fig. 62

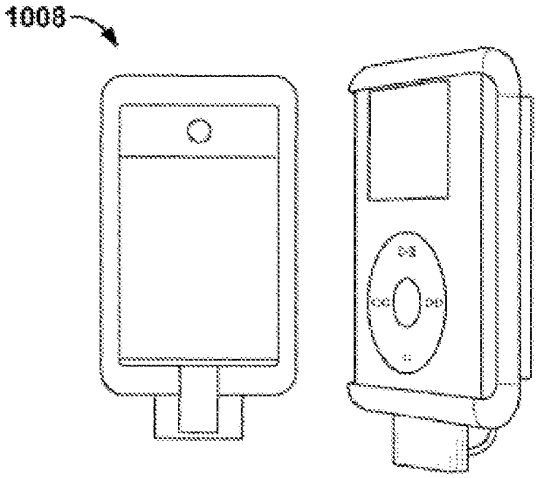


Fig. 63

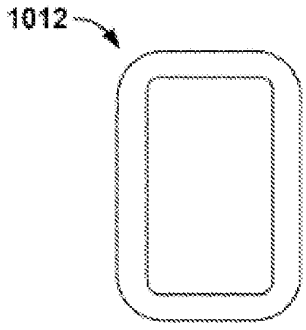


Fig. 64

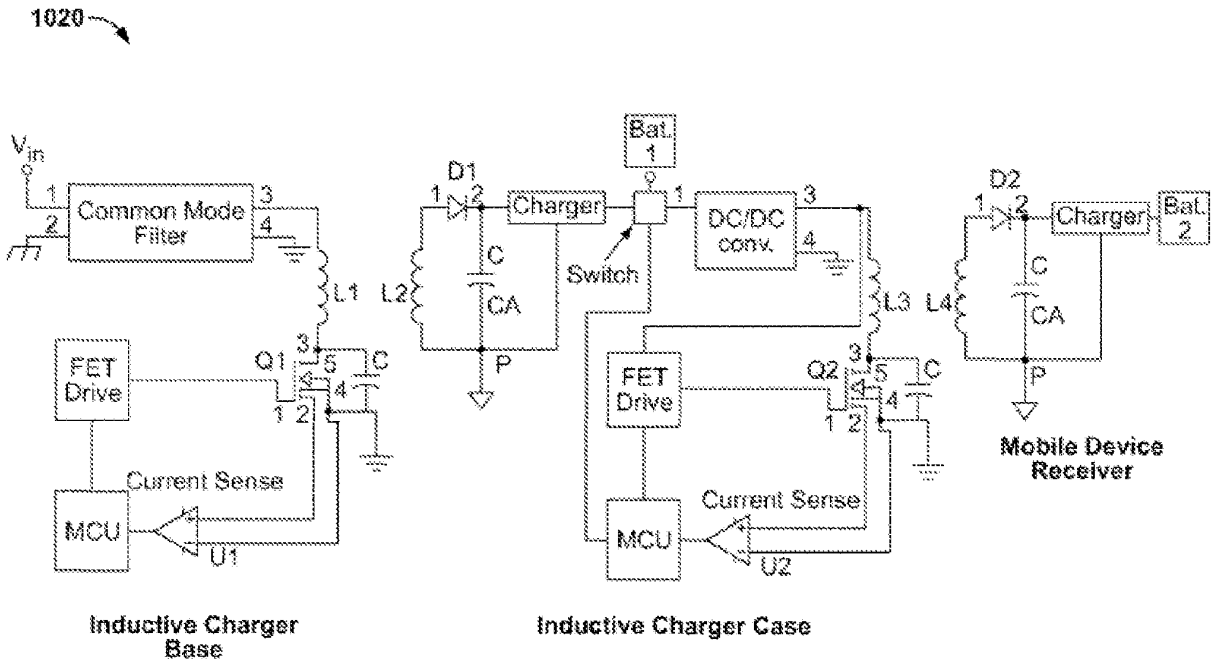

1020
V_{in}
Common Mode Filter
L1
L2
FET Drive
Q1
C
Current Sense
MCU
U1
Inductive Charger Base
D1
Charger
Bat. 1
DC/DC conv.
Switch
C
CA
P
FET Drive
Q2
C
Current Sense
MCU
U2
Inductive Charger Case
L3
L4
D2
Charger
Bat. 2
C
CA
P
Mobile Device Receiver

Fig. 65

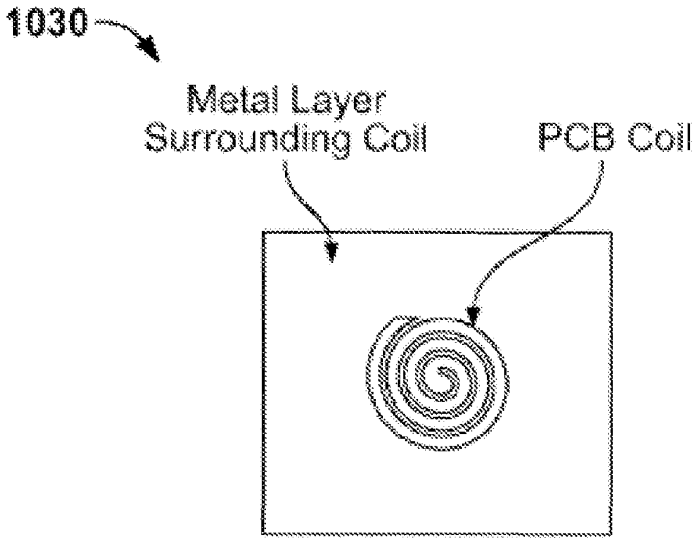

1030
Metal Layer Surrounding Coil
PCB Coil

Fig. 66

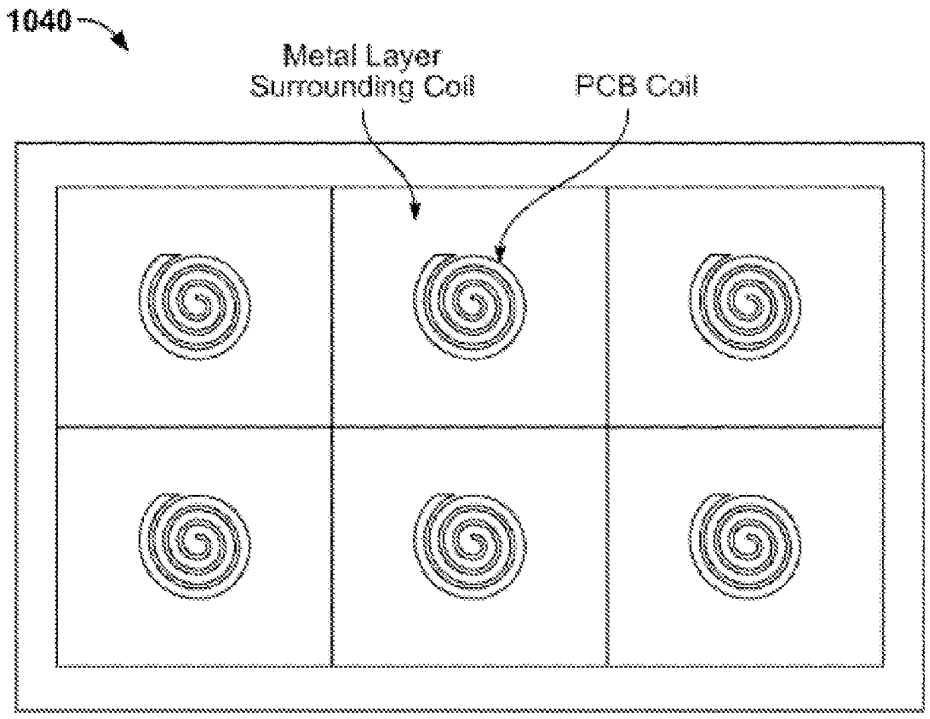

1040
Metal Layer Surrounding Coil
PCB Coil

Fig. 67

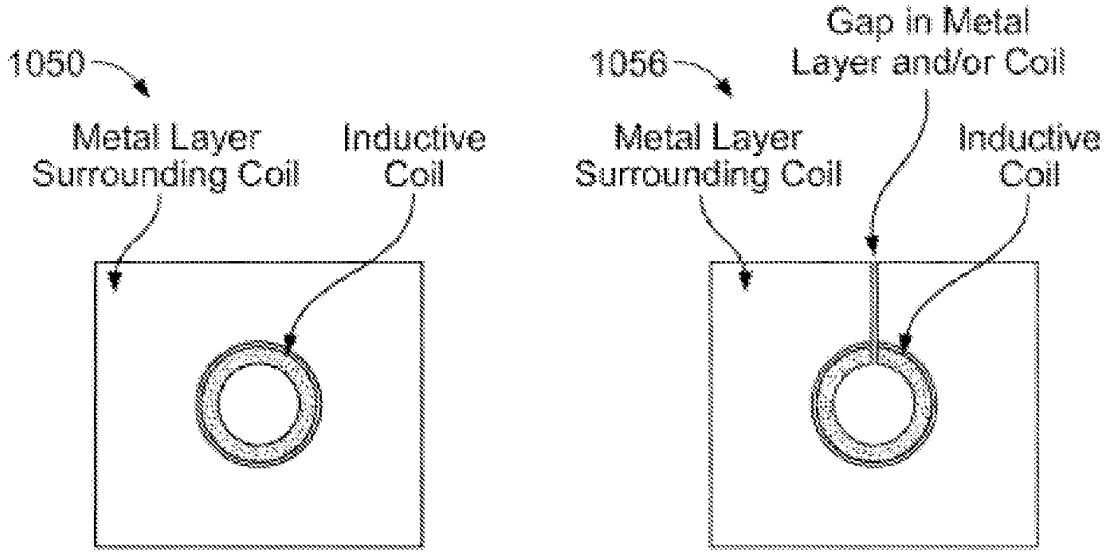

1050
Metal Layer Surrounding Coil
Inductive Coil
1056
Gap in Metal Layer and/or Coil
Metal Layer Surrounding Coil
Inductive Coil

Fig. 68

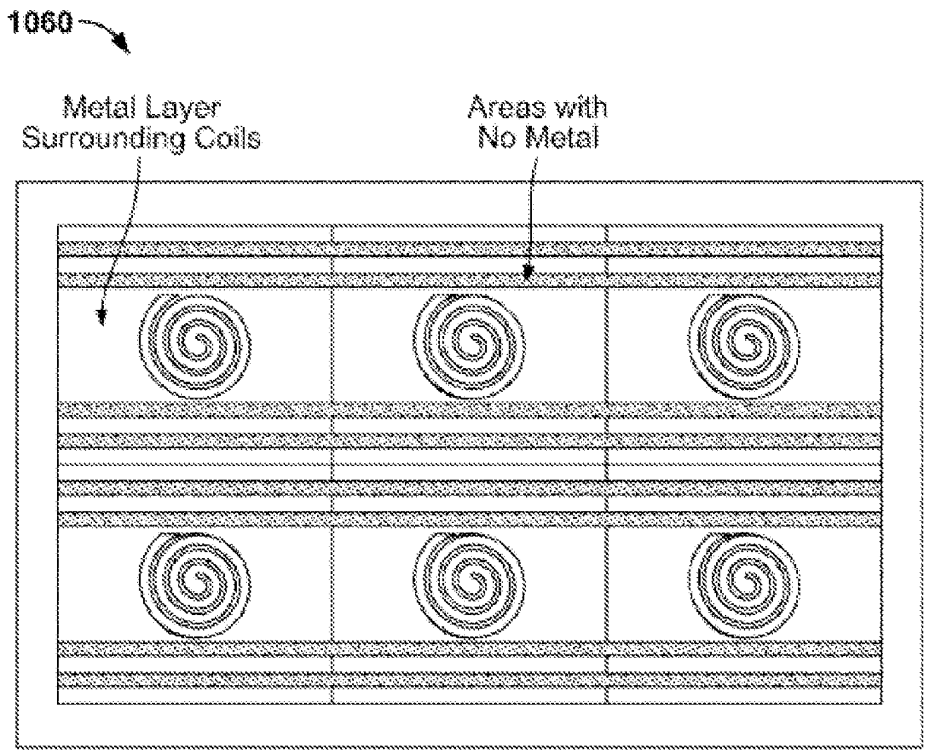

1060
Metal Layer Surrounding Coils
Areas with No Metal

Fig. 69

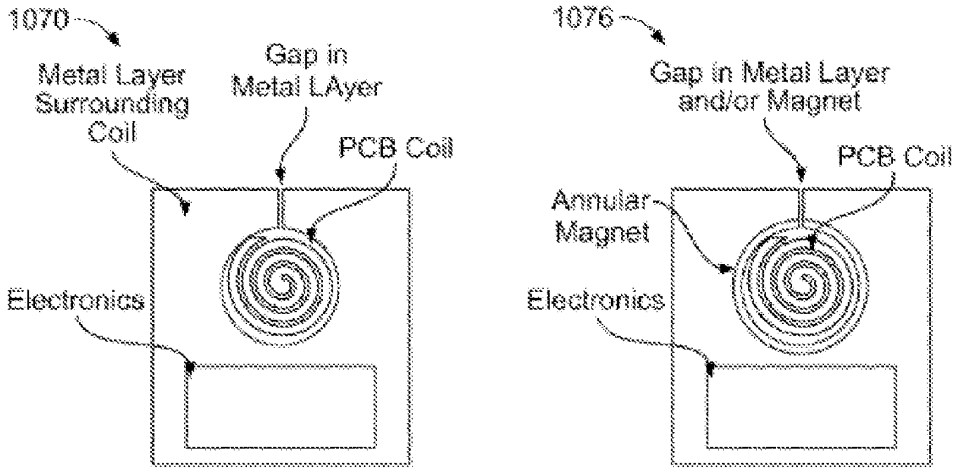

1070
Metal Layer Surrounding Coil
Gap in Metal LAyer
PCB Coil
Electronics
1076
Gap in Metal Layer and/or Magnet
PCB Coil
Annular Magnet
Electronics

Fig. 70

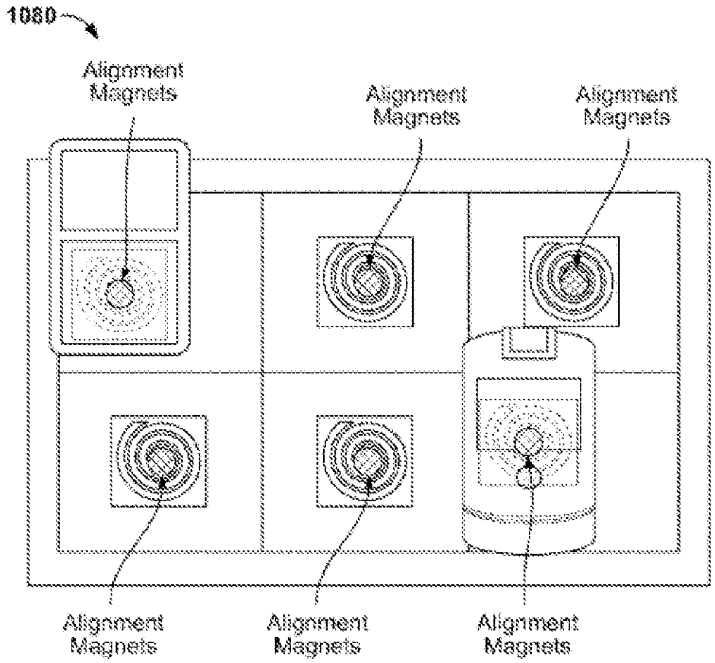

1080
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets

Fig. 71

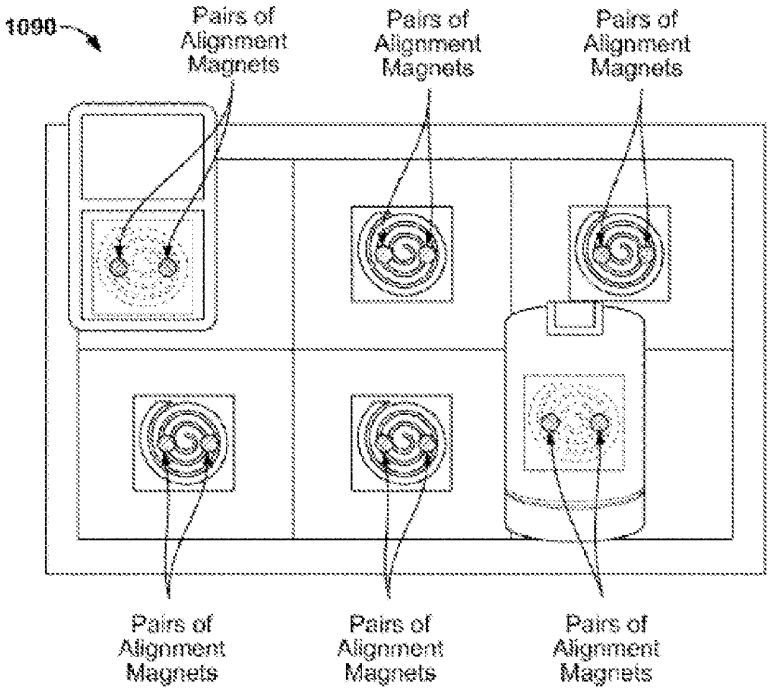

1090
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets

Fig. 72

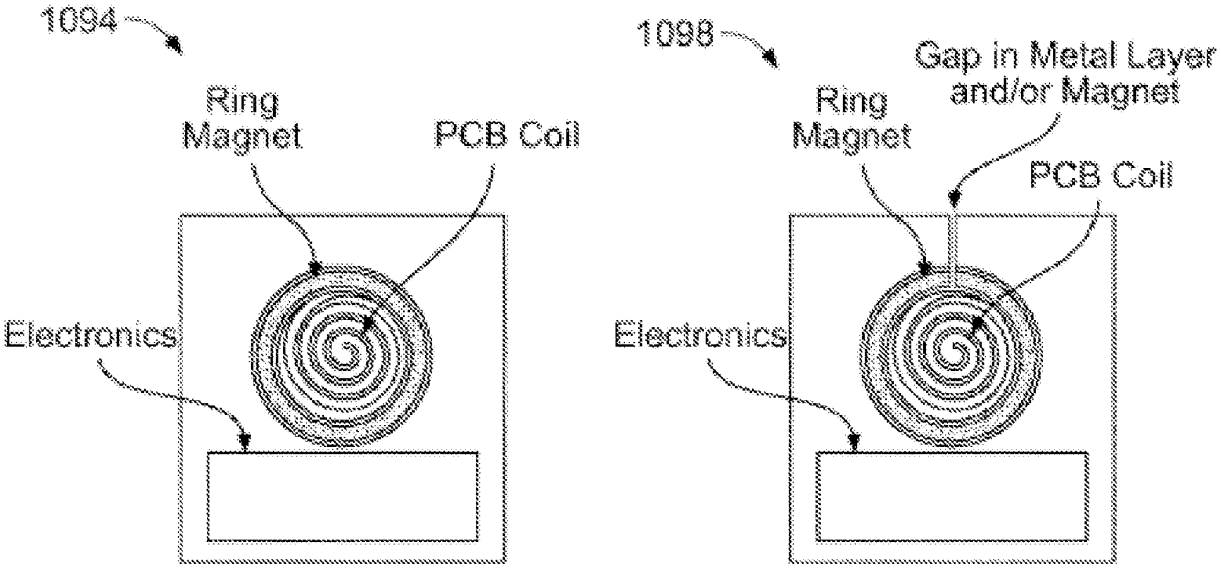

1094
Ring Magnet
PCB Coil
Electronics
1098
Ring Magnet
Gap in Metal Layer and/or Magnet
PCB Coil
Electronics

Fig. 73

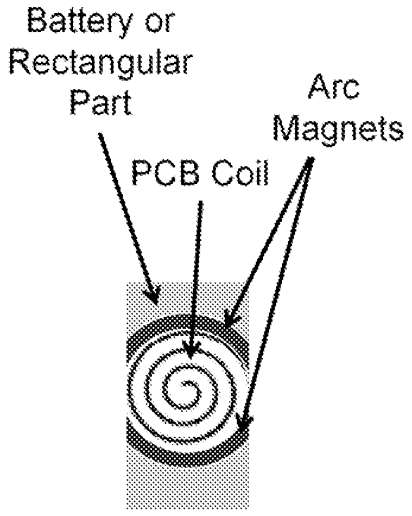

Battery or Rectangular Part
Arc Magnets
PCB Coil

Fig. 74

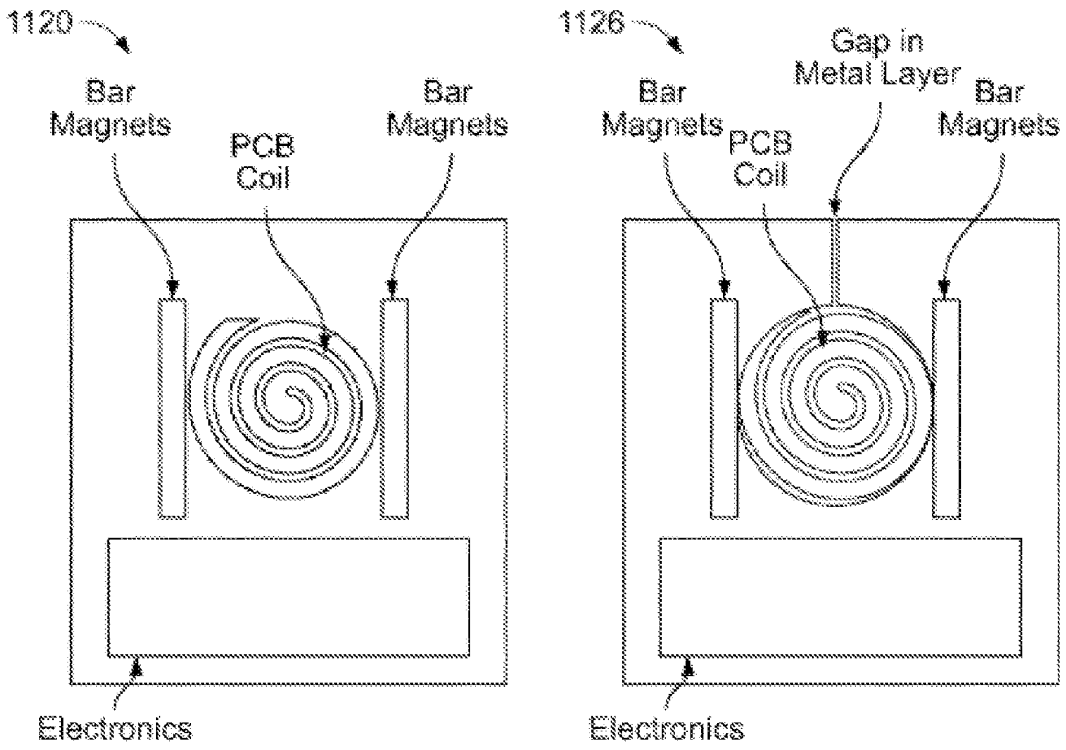

1120
Bar Magnets
PCB Coil
Bar Magnets
Electronics
1126
Bar Magnets
Gap in Metal Layer
PCB Coil
Bar Magnets
Electronics

Fig. 75

Electronic Patent Application Fee Transmittal

Application Number:	17507323
Filing Date:	21-Oct-2021
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	1202	10	100	1000
INDEPENDENT CLAIMS IN EXCESS OF 3	1201	1	480	480
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1480**

Electronic Acknowledgement Receipt	
EFS ID:	44960953
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers
Filer Authorized By:	
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	10-FEB-2022
Filing Date:	21-OCT-2021
Time Stamp:	02:21:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1480
RAM confirmation Number	E202220322231722
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Req. Reconsideration-After Non-Final Reject	AFPA-01013US7_RNFOA_2022-01-27.pdf	169157 72a00600d2322902d1b15734f51a32214497104b	no	29
Warnings:					
Information:					
2	Drawings-only black and white line drawings	AFPA-01013US7_Figures_Replacement-Sheets.pdf	1919452 915020279111ffe50a3a4af5c7407b9597344841b	no	41
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	40047 b7cbf3d5d9f4ad6ecf02bbb4d78c23207acabeb2	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2128656		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Afshin Partovi, Michael Sears		
Applicant:	Mojo Mobility, Inc.		
Title:	Efficiencies and Flexibilities in Inductive (Wireless) Charging		
Application No.:	17/507,323	Filing Date:	February 10, 2022
Examiner:	Zixuan Zhou	Group Art Unit:	2859
Docket No.:	AFPA-01013US7	Customer No.:	33438

ELECTRONICALLY FILED

Austin, Texas
February 10, 2022

RESPONSE TO NON-FINAL OFFICE ACTION

This paper is responsive to the Office action dated January 27, 2022, having a shortened statutory period expiring April 27, 2022. Further examination and reconsideration are respectfully requested.

The USPTO is also authorized to charge any underpayment of fees to Deposit Account No. 502264.

AMENDMENTS TO THE SPECIFICATION

Please amend paragraph 0043 as follows:

[0043] Figure 29 shows an embodiment that includes Zero Voltage ~~Setting~~ Switching (ZVS).

Please amend paragraph 00130 as follows:

[00130] In accordance with another embodiment, the receiver in the battery or mobile device also includes a means for providing information regarding battery manufacturer, required voltage, capacity; current, charge status, serial number, temperature, etc. to the charger. In a simplified embodiment, only the manufacturer, required voltage, and/or serial number is transmitted. This information is used by the charger or power supply to adjust the primary to provide the correct charge or power conditions. The regulator or charge management chip in the receiver can then regulate the current and the load to charge the battery correctly and can end charge at the end. In another embodiment, the receiver can control the charging process fully depending on the time dependent information on battery status provided to it. Alternatively, the charging process can be controlled by the charger in a similar manner. As described above, the information exchange between the charger and the receiver can be through an RF link or an optical transmitter/ detector, RFID techniques, Near-Field Communication (NFC), Felica, Bluetooth, WiFi, or some other method of information transfer. Similarly, the receiver can send signals that can be used by the charger to determine the location of the receiver to determine which coil or section of the charger or power supply to activate. The communication link can also use the same coil or wires as antenna for data transfer or use a separate antenna. In some embodiments the ~~received~~ receiver can use the actual capabilities of the mobile device (for example, the built-in Bluetooth or NFC capabilities of mobile phones) to ~~communicated~~ communicate with the charging or power supply pad.

Please amend paragraph 00188 as follows:

[00188] Figure 25 shows a figure of a circuit diagram 560 for time-based regulation in accordance with an embodiment.

Zero Voltage ~~Setting~~ Switching

Please amend paragraph 00190 as follows:

[00190] FIG. 26 shows a high-level view of a flyback power supply geometry 580 in accordance with an embodiment. During the time that the FET is closed, the current through the primary coil stores energy in this coil and during the period that the FET is open, this energy is transferred to the secondary (receiver) coil and into the load. The energy stored in the coil is directly proportional to the inductance of the coil and values of several hundred μHenry are typical for 10's or 100's of Watts of power supply power.

Please amend paragraph 00194 as follows:

[00194] For example, for a coil of 10 turns, an outer radius of 15 mm, and inner radius of zero, then L= l μH. While larger values can be obtained by increasing the number of turns or stacking a number of coils vertically and connecting them in series, this larger induction comes at the price of increased resistance and therefore loss in the inductor.

Please amend paragraph 00412 as follows:

[00412] FIG. 74 shows an embodiment 1100 in which magnetic arc shaped parts around a circular coil are used. This case may be combined with the matching magnet on the other coil having the same shape or a ring shape similar to FIG. 73. For example, in a mobile battery application where the battery with an integrated inductive receiver is charged by placement on an inductive charger pad, the size of the coil determines the received power and may require the width of the battery to be equal or similar to the receiver coil. To allow attachment of alignment magnets, two arcs as shown in FIG. [[9]] 74 can be attached to the coil. In this case, the magnets can be placed in between the battery and the coil PCB to allow the coil to be on the top surface and therefore closest to the charger coil. The matching magnet in the charger can be a ring or a similar set of arcs or another shape or size to facilitate alignment. If a ring is used behind the charger coil, then central symmetry between the two parts is retained and the parts can be rotated with respect to each other while keeping alignment for optimum operation.

Please amend paragraph 00418 as follows:

[00418] In any of the above geometries, if any additional eddy currents are generated as a result of the presence of the magnets, the effect can be minimized by fabricating the [[coil]] magnet from low electrical conductivity materials or ceramics, layering the magnet into thin sheets to increase resistivity, using bonded material in an epoxy matrix, roughing the surface, cutting gaps in the material to reduce circular motion of electrons, or other common techniques to increase the resistivity. The magnet can also be manufactured from segments that are not electrically connected to prevent electrons to be able to travel around a circular path. For example, the ring magnet can be manufactured, formed or attached to the coils from two or four ring arcs that are not electrically in contact or attached to each other, using a non-conducting epoxy to form a full ring, or parts of a ring.

AMENDMENTS TO THE FIGURES

Please replace Figures 1-75 with the attached REPLACMENT SHEETS.

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) An apparatus comprising:

a system for providing ~~A charger or power supply~~ for providing ~~substantially continuous charging or for supplying wireless~~ power inductively to [[one,]] a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system ~~plurality, or a combination of electrical, electronic or mobile devices and/or batteries, on a surface of the charger or power supply,~~ comprising:

a first primary coil ~~plurality of coils arrayed in one or multiple layers to provide~~ that is substantially planar and substantially parallel to a surface of the system for providing power inductively to the portable device; ~~continuous charging or to supply wireless power over an effective charging area of the surface of the charger or power supply, wherein the effective charging area is larger than a single coil surface area, and the coils are arrayed such that any location on the effective charging area is at a distance equal to or less than a radius or a side-to-center length of at least one coil; and~~

a first drive circuit, including a FET driver, a capacitor, and a FET switch, coupled to a DC voltage input and coupled to the first primary coil, wherein during operation the first drive circuit is configured to apply an alternating electrical current to the first primary coil at an operating frequency and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the plane of the first primary coil and the surface of the system to provide power inductively to the portable device, wherein the operating frequency is within a range of frequencies (i) that are near a resonance frequency of a circuit comprising the first primary coil and the capacitor and (ii) such that increasing values of the operating frequency within the range of frequencies would correspond to a lower voltage or current induced in the output of the receiver circuit and (iii) that allow activation and powering of the receiver unit and charging the battery of the portable device.

a first sense circuit to monitor current flow through the first primary coil during operation of the first drive circuit, wherein the first sense circuit includes a low pass filter and an amplifier to assist in detecting and amplifying a signal corresponding to a current modulation in the first primary coil induced by modulation of current in the receiver coil; and

a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit, configured to:

detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil;

operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate the information detected in the current modulation in the first primary coil, wherein the communication of information includes information to enable the communication and control circuit to configure the inductive transfer of power to the portable device, wherein the received communication of information includes:

information corresponding to a voltage or current induced by the first primary coil at an output of the receiver circuit;

a unique identification code;

a manufacturer code;

a charge algorithm profile; and

a power requirement;

operate the first drive circuit according to the power requirement and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

receive additional information in the current modulation in the first primary coil from the modulation of the current in the receiver coil corresponding to the voltage or current at the output of the receiver circuit while charging the battery of the portable device;

regulate in a closed loop feedback manner the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the first drive circuit while charging the battery of the portable device;

monitor for continued presence of the portable device and completion of the charging of the battery of the portable device based on the communication from the receiver circuit and detected by the communication and control circuit through the first sense circuit; and

if the portable device is no longer present or charging is complete, stop operation of the first drive circuit for the provision of power inductively to the portable device.

~~ferromagnetic and/or electrically conductive layers or structures positioned within the charger or power supply to shield components within the charger or power supply or to shield nearby environment.~~

2-20. (Canceled)

21. (New) The apparatus of claim 1, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

22. (New) The apparatus of claim 1, wherein the DC voltage input is configured to receive a DC voltage and the system further comprises:

a voltage regulator circuit coupled to the DC voltage input and to the microcontroller, wherein the microcontroller is configured to control the voltage regulator circuit to switch a level of the DC voltage between multiple discrete values based on the received communication of information and the additional information received by the communication and control circuit from the portable device.

23. (New) The apparatus of claim 1 wherein:
the DC voltage input is configured to connect to and receive a DC voltage from a DC power supply via a universal serial bus (USB); and
the communication and control circuit is further configured to communicate with the DC power supply via the USB.

24. (New) The apparatus of claim 1 wherein:
the first primary coil is one of multiple primary coils in the system and the first drive circuit is one of multiple drive circuits in the system; and
the system further comprises means for operating the multiple drive circuits to drive the multiple primary coils to separately control simultaneously induced charging voltages and/or currents in receiver units of multiple portable devices coupled to the multiple primary coils.

25. (New) The apparatus of claim 1 wherein:
the first primary coil is a substantially spiral-shaped coil and is fabricated from a copper conductor with a thickness optimized for lower resistance due to skin effect at an operating frequency range of 100 kHz to 1 MHz relative to resistance at an operating frequency outside the range of 100 kHz to 1 MHz, and
a number of turns of the first primary coil, an inner radius of the first primary coil, and an outer radius of the first primary coil are selected for an inductance in a range of 1 microhenry to 100 microhenries, and
the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

26. (New) The apparatus of claim 1, wherein the communication and control circuit is further configured to operate the first drive circuit for a short period of time to detect a current

draw through the first primary coil indicating a possible presence of the portable device for charging, wherein the short period of time is less than that needed to activate and power a receiver unit in the portable device.

27. (New) The apparatus of claim 1, further wherein the system includes N primary coils including the first primary coil and a 1xN switch, wherein the 1xN switch is configured to connect the first drive circuit to each of the N primary coils, wherein N is an integer greater than or equal to 2.

28. (New) The apparatus of claim 1, further comprising a near field communication (NFC) antenna for communication of data, and further wherein:

the first primary coil comprises a Printed Circuit Board (PCB) coil;

the PCB coil comprises multiple layers of substantially similar copper thickness and substantially similar spiral-shaped coil patterns connected by vias wherein each layer comprises 1 to 4 ounce (oz) copper thickness material; and

the operating frequency is within a range of 100 kHz to 1 MHz.

29. (New) The apparatus of claim 1, wherein:

the system further comprises a near field communication (NFC) antenna for communication of data;

the first primary coil comprises a copper PCB coil structure;

the PCB coil structure includes a substantially spiral-shaped pattern of multiple coil layers;

each of the multiple coil layers comprises a PCB coil having an inner port and an outer port;

the inner ports of each of the coil layers are coupled together by vias and form a first common pad;

the outer ports of the coil layers are coupled together by vias and form a second common pad; and

the two common contact pads provide electrical coupling of the first primary coil for applying the alternating electrical current to the first primary coil.

30. (New) The apparatus of claim 1, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit, the portable device is a first portable device, and the receiver unit of the first portable device is a first receiver unit, the apparatus further comprises:

a second portable device;

the system is incorporated into the second portable device; and

the second portable device further comprises:

an internal, rechargeable battery and a DC-to-DC voltage converter to provide power to the system to inductively power the first receiver unit of the first portable device and charge the battery of the first portable device;

a second receiver unit coupled to the first primary coil to enable the internal, rechargeable battery to be recharged inductively through the first primary coil; and

the communication and control circuit is further configured to control whether the second portable device is receiving power inductively or charging the first portable device inductively.

31. (New) The apparatus of claim 1 wherein the first primary coil includes a magnetic core of ferromagnetic material within a central area of the first primary coil and the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

32. (New) The apparatus of claim 1 wherein:

the system comprises a permanent magnet within a central area of the first primary coil;

the permanent magnet includes a substantially flat surface;

the permanent magnet is magnetized in a direction perpendicular to the substantially flat surface of the magnet; and

the permanent magnet is a ceramic permanent magnet, wherein the permanent magnet impedes eddy current generation and heating of the permanent magnet by the alternating magnetic field during inductive power transfer.

33. (New) The apparatus of claim 1 wherein:

the system comprises a permanent magnet within a central area of the first primary coil; and

the permanent magnet comprises magnetic material bonded using a polymer matrix configured to form a bonded permanent magnet in a substantially flat shape and magnetized with a magnetization direction substantially perpendicular to the substantially flat surface of the magnet, wherein the permanent magnet impedes eddy current generation and heating of the permanent magnet by the alternating magnetic field during inductive power transfer.

34. (New) The apparatus of claim 1 further comprising a common mode electrical noise filter circuit coupled to the DC voltage input to shield the DC voltage input from Electromagnetic Interference (EMI) during the provision of power inductively to the portable device.

35. (New) The apparatus of claim 1 wherein:

the first primary coil includes multiple layers of copper PCB of similar spiral-shaped coil pattern interconnected by vias; and

the first primary coil includes an outer surface to face a surface of the receiver coil and an inner surface to face away from the surface of the receiver coil; and

the system further comprises:

a ferromagnetic core located in a central area of the first primary coil;

a planar ferromagnetic layer located proximate to the inner surface of the first primary coil; and

a metallic layer located proximate to the planar ferromagnetic layer, wherein the ferromagnetic layer is located between the first primary coil and the metallic layer.

36. (New) The apparatus of claim 1 further comprising multiple, arc-shaped, permanent magnet components arranged in a circular pattern surrounding a perimeter of the first primary coil to assist in alignment of the receiver coil with the first primary coil, wherein:

the magnet components are disposed concentric with the first primary coil; and

adjacent magnet components are separated by gaps to prevent an electrical connection between the magnet components.

37. (New) The apparatus of claim 1, further wherein:
the first primary coil comprises a substantially planar, metallic spiral-shaped conductor;
the first primary coil includes:
substantially planar first side closest to the surface of the system for providing inductive power to the inductive receiver unit; and
a second side opposite the first side;
the system further comprises a metallic first shield layer positioned proximate the first side of the first primary coil and opposite the second side of the first primary coil such that the first shield layer covers the metallic spiral-shaped conductor of the first side of the first primary coil that faces the surface of the system, and
the first shield layer has a metal thickness in a range of 1 micrometer to 70 micrometers.

38. (New) The apparatus of claim 1, wherein:
the first primary coil, first drive circuit, first sense circuit, and the communication and control circuit comprise a first inductive charger module;
the first module further includes mechanical components and electrical components for interconnecting mechanically and electrically with a second inductive charger module to form a modular system; and
the electrical components are configured to allow the first inductive charger module and the second inductive charger module to share electrical power.

39. (New) A portable device comprising:
a battery; and
a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:
a receiver coil which has a substantially planar shape and is located parallel to a surface of the portable device so that an alternating magnetic field, when received through the surface of the portable device from the primary coil

in the base unit in a direction substantially perpendicular to the plane of the receiver coil, inductively generates a current in the receiver coil to provide power inductively to the portable device when the portable device is placed on the base unit for charging the battery of the portable device;

a ferromagnetic layer placed under the receiver coil on a side of the receiver coil away from the surface of the portable device; and

a receiver circuit powered by the inductive charging system, wherein the receiver circuit comprises:

a receiver rectifier circuit including a rectifier and a capacitor;

a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system;

a voltage regulator coupled to an output of the receiver rectifier circuit and coupled to the microcontroller to provide a regulated voltage to power the microcontroller from the received inductive power; and

a battery charging circuit to charge the battery, wherein the battery charging circuit is coupled to the output of the receiver rectifier circuit and coupled to the battery and begins drawing current only when an output of the receiver rectifier circuit reaches a set minimum voltage value;

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the receiver rectifier circuit and is used by the voltage regulator to power and activate the microcontroller and used by the battery charging circuit to charge the battery of the portable device; and

wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to:

communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced

by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement; and

periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device.

40. (New) The portable device of claim 39 further comprising a magnetic core of ferromagnetic material within a central area of the receiver coil and a near field communication (NFC) antenna and circuitry for communication of data with other devices.

41. (New) The portable device of claim 39, wherein the receiver circuit further comprises a limiter to limit the output voltage of the receiver rectifier circuit to a maximum value within a safe operating range of the battery charging circuit.

42. (New) The portable device of claim 39, further comprising an output disconnect switch configured to connect and disconnect an output power from the receiver circuit to the battery, wherein:

the communication and control unit is further configured to control the output disconnect switch to disconnect the battery from the output power from the receiver circuit during at least some of the communication with the base unit.

43. (New) The portable device of claim 39, wherein:

the receiver coil includes a substantially planar, metallic, spiral-shaped conductor;

the spiral-shaped conductor includes:

a substantially planar first side for receiving inductive charging power from the primary coil; and

a second side opposite the first side, wherein the first side is closer than the second side to the surface of the portable device through which inductive charging power from the primary coil is received;

the portable device further includes a metallic first shield layer positioned proximate the first side of the receiver coil opposite the second side of the receiver coil such that the first shield layer covers the first side of the spiral-shaped conductor and is located between the surface and the spiral-shaped conductor, and

wherein the first shield layer has a metal thickness in a range of 1 micrometer to 70 micrometers.

44. (New) The portable device of claim 39, wherein:

the portable device is configured to operate in an inductive power receiving mode and in an inductive power transfer mode,

in the inductive power receiving mode, the portable device is configured to receive power inductively via the receiver coil to charge the battery of the portable device, and

in the inductive power transfer mode, the portable device is configured to operate an internal inductive charging system included in the portable device for providing power inductively to a second portable device comprising a second battery and a second receiver unit including a second receiver coil and a second receiver circuit, the internal inductive charging system comprising:

a drive circuit, including a FET driver, a second capacitor, and a FET switch, coupled to a DC voltage input and coupled to the receiver coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the receiver coil at an operating frequency and duty cycle to provide power inductively to the second portable device, wherein the operating frequency is within a range of frequencies (i) that are near a resonance frequency of a circuit comprising the receiver coil and the second capacitor and (ii) such that increasing values of the operating frequency within the range of frequencies would correspond to a lower voltage or current induced in the output of the second receiver circuit and (iii) that allow activation and powering of the second receiver unit and charging the second battery of the second portable device.

a sense circuit to monitor current flow through the receiver coil during operation of the drive circuit, wherein the sense circuit includes a filter and an amplifier to detect and amplify a signal corresponding to a current modulation in the receiver coil induced by modulation of current in the second receiver coil; and

wherein the communication and control circuit is coupled to the drive circuit and the sense circuit and is further configured to:

detect, through the sense circuit, a received communication of information in the current modulation in the receiver coil;

operate the drive circuit to inductively transfer sufficient power to the second receiver unit to activate and power the second receiver circuit to enable the second receiver circuit to communicate the received communication of information in the current modulation in the receiver coil, wherein the received communication of information includes information to enable the communication and control circuit to configure the provision of power inductively to the second portable device, wherein the received communication of information includes:

information corresponding to a voltage or current induced by the receiver coil at an output of the second receiver circuit;

a unique second identification code;

a second manufacturer code;

a second charge algorithm profile; and

a second power requirement; and

operate the drive circuit according to the second power requirement and second charge algorithm profile to provide the power from the receiver coil to the second receiver coil to power the second receiver unit and charge the second battery of the second portable device, wherein to charge the second battery of the second portable

device the communication and control circuit is further configured to:

receive additional received information in the current modulation in the receiver coil from the modulation of the current in the second receiver coil corresponding to the voltage or current at the output of the second receiver circuit while charging the second battery of the second portable device; and regulate in a closed loop feedback manner the voltage or current at the output of the second receiver circuit in accordance with the additional received information corresponding to the voltage or current at the output of the second receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the drive circuit while charging the second battery of the second portable device.

45. (New) The portable device of claim 39 wherein the portable device is a case for holding and charging a Bluetooth headset, and the battery is configured to charge the Bluetooth headset when placed in the case.

46. (New) The portable device of claim 39, comprising multiple, arc-shaped, permanent magnet components arranged in a circular pattern surrounding a perimeter of the receiver coil to assist in alignment of the receiver coil with the primary coil, wherein:

the magnet components are disposed concentric with the first receiver coil; and

adjacent magnet components are separated by gaps to prevent an electrical connection between the magnet components.

47. (New) A system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system comprising:

a primary coil that is substantially planar and parallel to a surface of the system for providing power inductively to the portable device, wherein the primary coil

comprises a flexible Printed Circuit Board (PCB), multi-turn coil having multiple layers of substantially similar patterns of substantially spiral-shaped conductors of 1 to 4 ounce copper thickness for each layer and having coil patterns electrically connected with vias between the layers;

a drive circuit, including a FET driver, a capacitor and a FET switch, coupled to a DC voltage input and coupled to the primary coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the primary coil at an operating frequency within a range of 100 kHz to 1 MHz and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the surface of the primary coil to provide power inductively to the portable device;

a sense circuit to monitor current flow through the primary coil during operation of the drive circuit to sense a current modulation in the primary coil from a modulation of a current in the receiver coil; and

a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to:

detect, through the sense circuit, a received communication of information in the current modulation in the primary coil;

operate the drive circuit to inductively transfer sufficient power to the inductive receiver unit to activate and power the receiver circuit to enable the receiver circuit to communicate the information in the current modulation in the primary coil;

from the information communicated by the receiver circuit, determine a power parameter; and

operate the drive circuit according to the power parameter to provide power inductively from the primary coil to the receiver coil to power the microcontroller and to charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

receive additional information in the current modulation in the primary coil from modulation of the current in the receiver coil

corresponding to a voltage or current at an output of the receiver circuit while charging the battery of the portable device; and

regulate in a closed loop feedback manner, the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency, the duty cycle, and the DC voltage input to the drive circuit during charging of the battery of the portable device.

48. (New) The system of claim 47, wherein:

the sense circuit includes a low pass filter and an amplifier; and

the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

49. (New) A portable device comprising:

a battery; and

a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:

a receiver coil having a substantially planar shape and located parallel to a surface of the portable device so that an alternating magnetic field, when received through the surface of the portable device from the primary coil in the base unit in a direction substantially perpendicular to the plane of the receiver coil, inductively generates a current in the receiver coil to provide power inductively to the portable device when the portable device is placed on the base unit for charging the battery of the portable device;

a ferrite material layer placed under the receiver coil on a side of the receiver coil opposite to the surface of the portable device;

a receiver circuit powered by the inductive charging system, wherein the receiver circuit comprises:

a receiver rectifier circuit including a rectifier and a capacitor; and

a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system;

an output disconnect switch to interrupt a flow of current from the output of the receiver unit to the battery;

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the rectifier circuit and is used to power and activate the microcontroller and to charge the battery of the portable device;

wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to:

communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil; and

periodically communicate to the base unit information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device; and

wherein the communication and control unit is configured to control the disconnect switch to disconnect the flow of current from the output of the receiver unit to the battery during at least some of the communication with the base unit.

REMARKS

Claim 1 is pending.

Claims 2-20 have been canceled without prejudice or disclaimer of the subject matter recited therein.

Claim 1 has been amended.

Claims 21-49 have been added.

AMENDMENTS TO THE FIGURES

Applicant has submitted replacement sheets for all the Figures to provide better clarity to the Figures. The Replacement Sheets are identical to the Figures as filed with the exception of correction of minor errors as described below:

- **Figure 25.** Figure 25 has been amended to show for clarity the alignment of the coils in the circuit diagram 560, which is consistent with standard transformer depictions and consistent with the other depicted transformer circuits in the *Present Application*.

- **Figures 30-32.** In original Figures 30-32, "Vbat" was truncated to produce "Vba" on one line and "t" directly below "Vba." Amended Figures 30-32 correct the original figures by replacing "Vba" with "Vbat" and deleting the separated letter "t."

- **Figure 74.** Figure 74 has been amended to conform with Figure 9 of US Provisional Patent Application No. 61/043,027 (the ´027 Provisional). The *Present Application* incorporates the ´027 Provisional application by reference in as set forth in paragraph 0001 of the *Present Application*. (See the last 6 lines of the *Present Application*, ¶0001. The descriptions of Figure 74 in the *Present Application*, ¶¶0088 and 0412 are identical to the descriptions of Figure 9 in the ´027 Provisional, ¶¶0015 and 0055. Paragraph 0412 of the originally filed *Present Application* actually retains a reference to "Figure 9" in the description of Figure 74. Thus, Figure 74 of the *Present Application* has been amended to reflect the actual priority Figure 9 of the ´027 Provisional.

No new matter has been added.

AMENDMENTS TO THE SPECIFICATION

The Specification has amended as follows:

- Paragraph **0043** has been amended to replace "Zero Voltage Setting (ZVS)" with "Zero Voltage Switching (ZVS)." Support for the amendment is in ¶00189, first sentence, which states, "In accordance with some embodiments, the system can use a technique such as Zero Voltage Switching (ZVS) to provide more efficient power transfer and power supply control."

- Paragraph **00130**, last sentence has been amended to correct two typographical errors to replace "embodiments of the received" with "embodiments of the receiver" and replace "to communicated" with "to communicate."

- Paragraph **00188** has also been amended to replace "**Zero Voltage Setting**" with "**Zero Voltage Switching**." Support for the amendment is in ¶00189, first sentence, which states, "In accordance with some embodiments, the system can use a technique such as Zero Voltage Switching (ZVS) to provide more efficient power transfer and power supply control."

- Paragraph **00190** has been amended to replace "Henry" with "μH." Support for the amendment is on page 4, second paragraph, line 5, of U.S. Provisional Patent Application No. 61/012,924 (the "′924 Provisional"), which is incorporated by reference by the *Present Application* as indicated in ¶0001, line 15. Page 4 of the ′924 Provisional references Figure 1, and paragraph 00190 of the *Present Application* references Figure 26. Figure 1 of the ′924 Provisional is identical to Figure 26 of the *Present Application*. The description of the ′924 Provisional Figure 1, which corresponds to Figure 26 of the *Present Application* is relevantly identical as shown below:

  > Figure 1 shows a high level view of a Flyback power supply geometry wherein, during the time that the FET is closed, the current through the primary coil stores energy in this coil and during the period that the FET is open, this energy is

transferred to the secondary coil and into the load. The energy stored in the coil is directly proportional to the inductance of the coil and values of several hundred **µHenry** are typical for 10 's or 100 's of Watts of power supply power. ´924 Provisional, p. 4, ¶2 (emphasis added).

- Paragraph **00194** has been amended to correct an error in the unit of inductance from L=1 H to L=1 µH. Support for the amendment is on page 6 of the ´924 Provisional, which is incorporated by reference by the *Present Application* as indicated in ¶0001, line 15. Page 6 of the ´924 Provisional provides the exact same formula as set forth in ¶00193 of the *Present* Application and the same sample problem as ¶00194 of the *Present Application*. The inductance for the example problem in the ´924 Provisional is L=1 µH. The relevant portion of the ´924 Provisional, page 6, ¶5 is copied below for convenient reference:

  For a spiral coil, the inductance of a coil is given by:

  $$L = \frac{r^2 N^2}{(2r + 2.8d)\ x\ 10^5)}$$

  Where

  L = inductance (H)

  r = mean radius of coil (m)

  N = number of turns

  d – depth of coil (outer radius minus inner radius) (m)

  For example, for a coil of 10 turns, and outer radius of 15 mm and inner radius of zero, **L= l µH**. While larger values can be obtained by increasing the number of turns or stacking a number of coils vertically and connecting them in series, this larger induction comes at the price of increased resistance and therefore loss in the inductor. ´924 Provisional, p. 6, ¶5 (emphasis added).

- Paragraph **00412**, line 7 has been amended to correct a Figure reference error from "Fig. 9" to "Fig. 74."

- Paragraph **00418**, line 2 has been amended to correct a clerical error to replace "coil" with "magnet." Support for the amendment is in at least paragraphs 00403, 00404, and 00418. Paragraph 00418 discusses the construction of a magnet not a coil. For example, "The magnet can also be manufactured from segments that are not electrically connected to prevent electrons …" and "For example, the ring magnet can

be manufactured, formed or attached … .” Thus, in line 2 of ¶00418, “fabricating” refers to the “magnet” and not the coil. Furthermore, the first sentence of ¶00418 refers to the generation of eddy currents, specifically, “In any of the above geometries, if any additional eddy currents are generated as a result of the presence of the magnets, the effect can be minimized by fabricating … .” The referenced “above geometries” all refer to “magnets” as set forth in, for example, the immediately preceding paragraphs ¶¶00403-00417. Additionally, the reference to “additional eddy currents” references the eddy currents associated with magnets. For example, preceding ¶¶00403 and 00404 discuss eddy currents and magnets:

> To provide alignment magnets that will not draw current due to eddy currents created in them … .” ¶00403.
>
> If any eddy current effects are observed, then in accordance with an embodiment gaps can be inserted in the magnet ring by cutting after manufacture or by inserting this separation during manufacture. In this manner the eddy currents can be significantly reduced or eliminated. ¶00404.

No new matter has been added.

Claim Rejections - 35 USC § 112

Claim 6 is rejected under 35 USC § 112(a). Claims 2-4 and 10-12 are rejected under 35 USC § 112(b).

Claims 2-4, 6, and 10-12 have been canceled.

Accordingly, Applicant respectfully requests withdrawal of the rejection.

Double Patenting

Claims 1-20 have been provisionally rejected as claiming the same invention has claims 1-20 of copending Application No. 17/507,351.

Applicant notes the provisional rejection. Claim 1 of the *Present Application* and claim 1 of copending Application No. 17/507,351 have been amended. If after reviewing the amended claims of the *Present Application* and the amended claims of copending Application No.

17/507,351 the Examiner maintains the double patenting rejection, Applicant will provide a substantive response.

Claims 2-20 have been canceled.

Claim Rejections - 35 USC § 102

Claim(s) 9-10, 13-14, and 17 is/are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Hui (US Pub 2005/0189910).

Claims 9-10, 13-14, and 17 have been canceled.

Applicant respectfully requests withdrawal of the rejection.

Claim Rejections - 35 USC § 103

Claim 1, 2, 5, 6, and 8 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hui (US Pub 2005/0189910) (hereinafter *Hui*) in view of Karalis et al. US Pub 2008/0278264 (hereinafter *Karalis*). Applicant respectfully traverses the rejection.

Hui relates to providing a "planar inductive battery charging system designed to enable electronic devices to be recharged," and the "system includes a planar charging module having a charging surface on which a device to be recharged is placed." *Hui*, Abstract. "Within the charging module and parallel to the charging surface is at least one and preferably an array of primary windings that coupled energy inductively to a secondary winding formed in the device to be recharged." *Id.* "Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface." *Id.*, ¶0007. "In this way the precise position and orientation of the electronic device on the charging surface is not critical." *Id.* "To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array." *Id.*

"In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said

device." *Id*., ¶0011. "An important aspect of the present invention is that it provides a battery charging system that employs a localised (sic) charging concept." *Id*., ¶0014. "In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged." *Id*. "As shown in FIG. 4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings." *Id*., ¶0072. "The secondary winding is also planar and is located in the portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment either directly or via a charging circuit." *Id*.

Karilis states that, "The inventors have realized that resonant objects with coupled resonant modes having localized evanescent field patterns may be used for non-radiative wireless energy transfer." *Karilis,* ¶0005. *Karilis* further states that, "efficient wireless energy-exchange can be achieved between the reso-nant objects, while suffering only modest transfer and dissi-pation of energy into other off-resonant objects." *Id*. *Karilis* discloses, "Referring to FIG. 1, energy is transferred, over a distance D, between a resonant source object having a characteristic size L1 and a resonant device object of characteristic size L2." *Id*., ¶0099. "The source object is connected to a power supply (not shown), and the device object is connected to a power consuming device (e.g., a load resistor, not shown)." *Id*. "Energy is provided by the power supply to the source object, transferred wirelessly and non-radiatively from the source object to the device object, and consumed by the power consuming device." *Id*. "Referring between to two FIG. 3, in self-resonant some embodiments, energy is transferred between two self-resonant conducting-wire coils." *Id*., ¶0113. *Karilis* also discusses in context copper conductors.

Thus, *Hui* discloses in some detail a charging system that transfers energy from one or more primary windings in the charging system to a secondary winding in a device to be recharged, and *Karilis* discloses specific details of coupling and transferring energy between a source object and a device object. Thus, the combination of *Hui* and *Karilis* discloses transferring energy between a primary winding and a secondary winding including self-resonant embodiments, and the copper can be used as a conductor.

Amended claim 1 distinguishes over the combination of *Hui* in view of *Karilis*. For example, although *Hui* in view of *Karilis* transfers energy from a primary winding of a battery charging system to a secondary winding of a device being charged, *Hui* in view of *Karilis* does not teach or suggest the communication and control circuit and its configuration as set forth in claim 1. Applicant respectfully submits that *Hui* in view of *Karilis* does not teach or suggest a "a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit." Claim 1. The communication and control circuit of claim 1 is configured to, *inter alia*, "detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil" and "wherein the received communication of information includes: … a charge algorithm profile and a power requirement." *Id*. "The communication and control circuit is also configured to, *inter alia*, "operate the first drive circuit according to the power requirement and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device." *Id*.

Accordingly, Applicant respectfully requests withdrawal of the rejection of claim 1.

Independent claim 39 also distinguishes over the combination of *Hui* in view of *Karilis*. For example, *Hui* in view of *Karilis* does not teach or suggest "a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system," and "wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement" and "periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device" as required by claim 1.

Independent claim 47 also distinguishes over the combination of *Hui* in view of *Karilis*. For example, *Hui* in view of *Karilis* does not teach or suggest "a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to: detect, through the sense circuit, a received communication of information in the current modulation in the primary coil," "from the information communicated by the receiver circuit, determine a power parameter," and "operate the drive circuit according to the power parameter to provide power inductively from the primary coil to the receiver coil to power the microcontroller and to charge the battery of the portable device" as required by claim 47.

Independent claim 49 also distinguishes over the combination of *Hui* in view of *Karilis*. For example, *Hui* in view of *Karilis* does not teach or suggest "a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system," "wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil" as required by claim 49.

CONCLUSION

Applicant respectfully submits that all pending claims are in condition for allowance. Accordingly, Applicant requests that a Notice of Allowance be issued. Nonetheless, should any issues remain that might be subject to resolution through a telephone interview, the Examiner is requested to telephone the undersigned at 512-338-9100.

CERTIFICATE OF TRANSMISSION

I hereby certify that on February 10, 2022 this correspondence is being transmitted via the U.S. Patent & Trademark Office's electronic filing system.

/Kent B. Chambers/

Respectfully submitted,

/Kent B. Chambers/

Kent B. Chambers
Attorney for Applicant(s)
Reg. No. 38,839

DocCode – SCORE

SCORE Placeholder Sheet for IFW Content

Application Number: 17507323 Document Date: 02/10/2022

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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/507,323	Filing Date 10/21/2021	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	02/10/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 20	= 10		x $50 =	500
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 3	= 1		x $240 =	240
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	740

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/RENEE D HAWKINS/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

33438 7590 02/22/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
ZHOU, ZIXUAN	

ART UNIT	PAPER NUMBER
2859	

NOTIFICATION DATE	DELIVERY MODE
02/22/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

USPTO@dockettrak.com
celeste@tcciplaw.com
tmunoz@tcciplaw.com

Office Action Summary	Application No. 17/507,323	Applicant(s) Partovi et al.	
	Examiner ZIXUAN ZHOU	Art Unit 2859	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 02/10/2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1 and 21-49 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☐ Claim(s) _____ is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☑ Claim(s) 1 and 21-49 are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 02/10/2022 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☑ Other: See Continuation Sheet.

Continuation of Attachment(s) 4) Other: The amended specification and drawings have been attached

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Status of claims

Claims 2-20 have been cancelled. Claims 21-49 have been newly added. The newly amended specification on 02/10/022 has been entered. The replacement sheets for all the drawings have been approved.

Election/Restrictions

The amendment filed on 02/10/2022 canceling all claims drawn to the elected invention and presenting only claims drawn to a non-elected invention is non-responsive (MPEP § 821.03) and has not been entered. The remaining claims are not readable on the elected invention because the claims now include, inter alia, the system includes a first drive circuit, including a FET driver, a capacitor, and a FET switch, coupled to a DC voltage input and coupled to the first primary coil, wherein during operation the first drive circuit is configured to apply an alternating electrical current to the first primary coil at an operating frequency and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the plane of the first primary coil and the surface of the system to provide power inductively to the portable device; a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit, configured to: detect, through the first sense circuit, a received communication of information in the current modulation in the first primary

coil; operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate the information detected in the current modulation in the first primary coil. The aforementioned aspects cause the new claims to have a materially different design and mode of operation compared to the claims originally filed. For further clarification, see the claims originally filed on 10/21/2021.

Since the above-mentioned amendment appears to be a bona fide attempt to reply, applicant is given a shortened statutory period of TWO (2) MONTHS from the mailing date of this notice within which to supply the omission or correction in order to avoid abandonment. EXTENSIONS OF THIS TIME PERIOD UNDER 37 CFR 1.136(a) ARE AVAILABLE but in no case can any extension carry the date for reply to this letter beyond the maximum period of SIX MONTHS set by statute (35 U.S.C. 133).

Claim Objections

Claims 1, 21-38 are objected to because of the following informalities:

In claim 1, the claim is not amended based on the original claim 1 as filed on 10/21/2021.

The dependent claims are objected for the reasons as the independent claim from which they depend.

Appropriate correction is required.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ZIXUAN ZHOU whose telephone number is (571)272-6739. The examiner can normally be reached 9:00 am to 5:00 pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Drew A Dunn can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/ZIXUAN ZHOU/
Primary Examiner, Art Unit 2859
02/15/2021

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	Art Unit
	ZIXUAN ZHOU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/22/2022	02/15/2022							
	1	✓	÷							
	2	✓	-							
	3	✓	-							
	4	✓	-							
	5	✓	-							
	6	✓	-							
	7	✓	-							
	8	✓	-							
	9	✓	-							
	10	✓	-							
	11	✓	-							
	12	✓	-							
	13	✓	-							
	14	✓	-							
	15	✓	-							
	16	✓	-							
	17	✓	-							
	18	✓	-							
	19	✓	-							
	20	✓	-							
	21		÷							
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	31		÷							
	32		÷							
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	34		÷							
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	36		÷							
	37		÷							
	38		÷							
	39		÷							
	40		÷							
	41		÷							
	42		÷							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	**Art Unit**
	ZIXUAN ZHOU	2859

CLAIM		DATE								
Final	Original	01/22/2022	02/15/2022							
	43		÷							
	44		÷							
	45		÷							
	46		÷							
	47		÷							
	48		÷							
	49		÷							

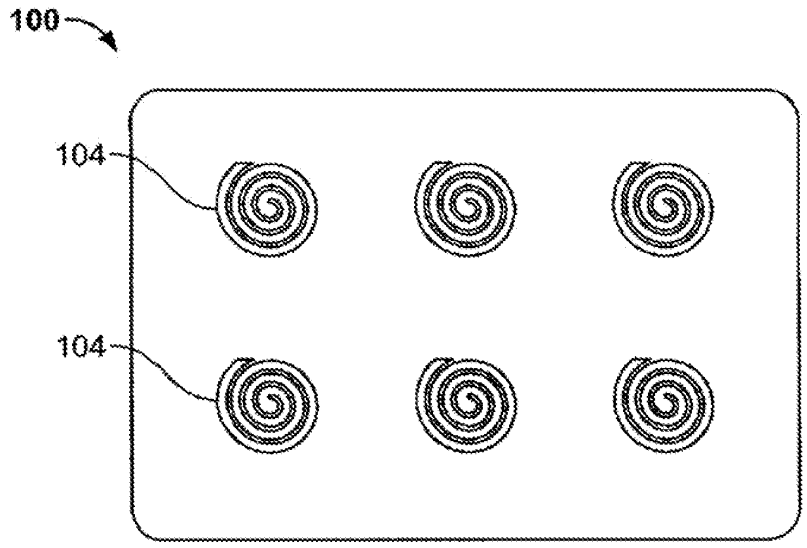

100
104
104

FIG. 1

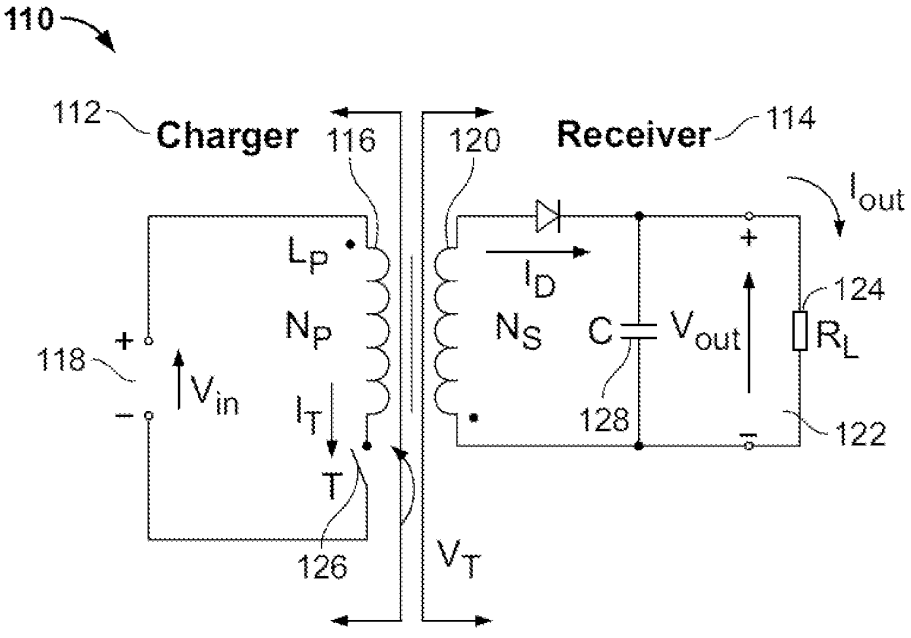

110
112
Charger
116
120
Receiver
114
I_{out}
L_P
I_D
124
N_P
N_S
C
V_{out}
R_L
118
V_{in}
I_T
128
122
T
126
V_T

FIG. 2

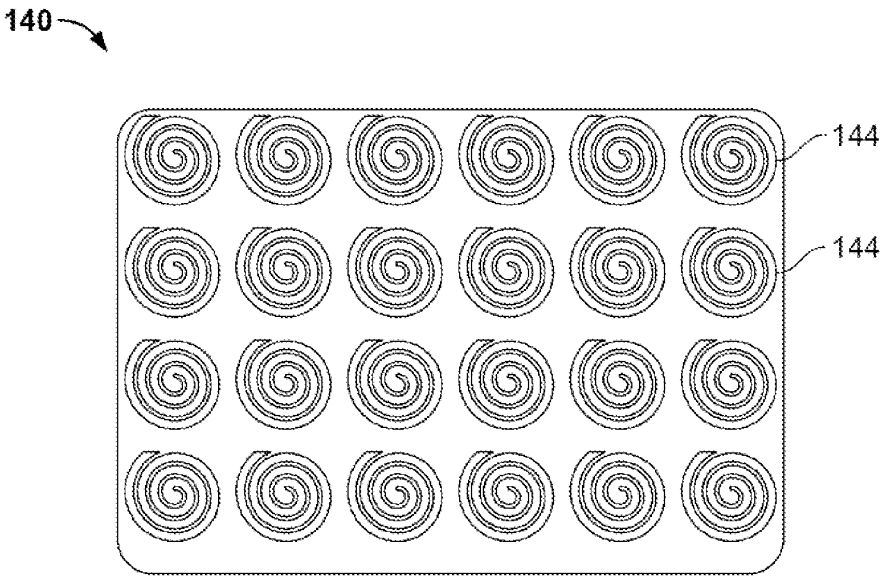


FIG. 3

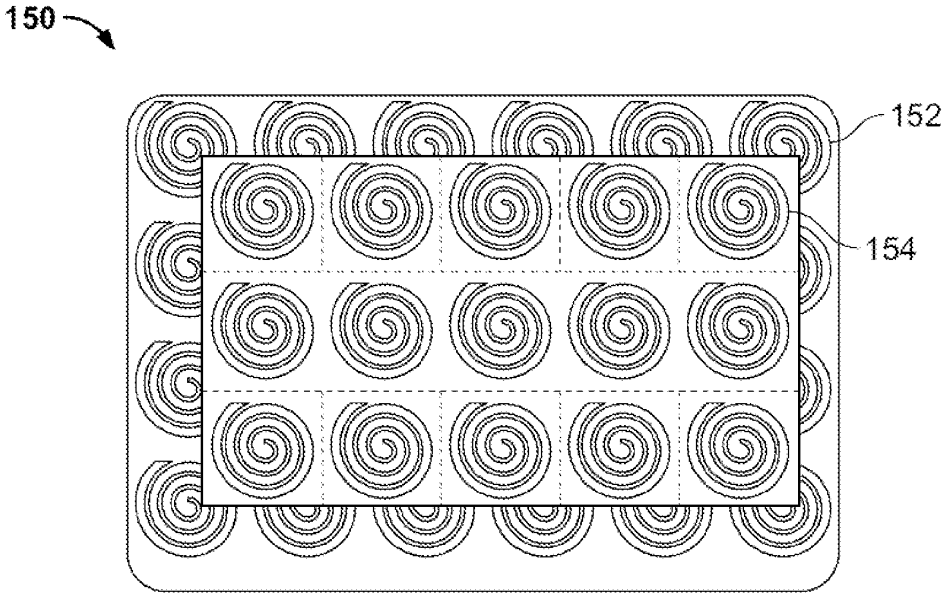


FIG. 4

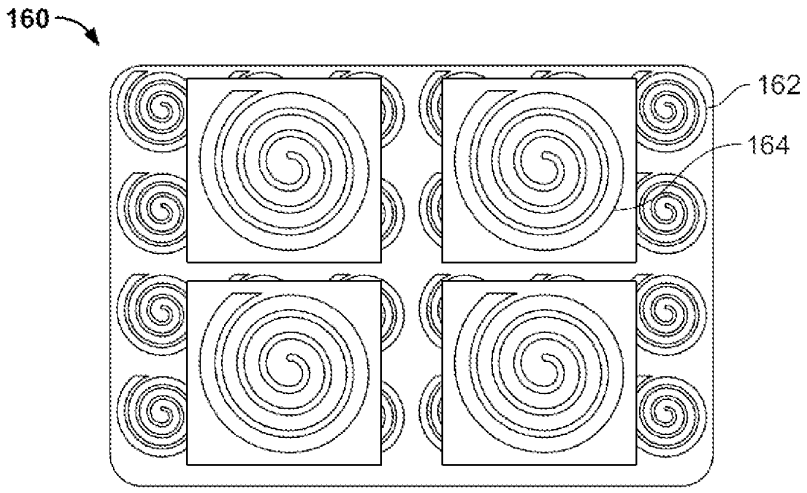

160
162
164

FIG. 5

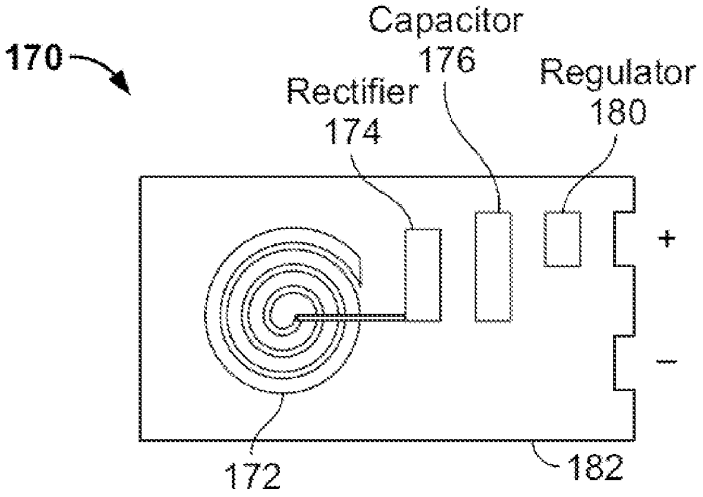

170
Capacitor
176
Rectifier
174
Regulator
180
+
–
172
182

Fig. 6

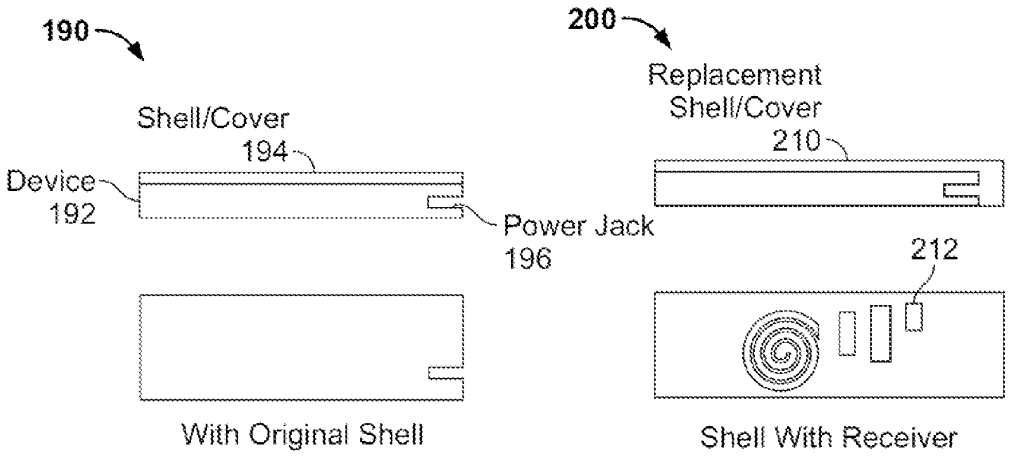

190
200
Replacement
Shell/Cover
210
Shell/Cover
194
Device
192
Power Jack
196
212
With Original Shell
Shell With Receiver

Fig. 7

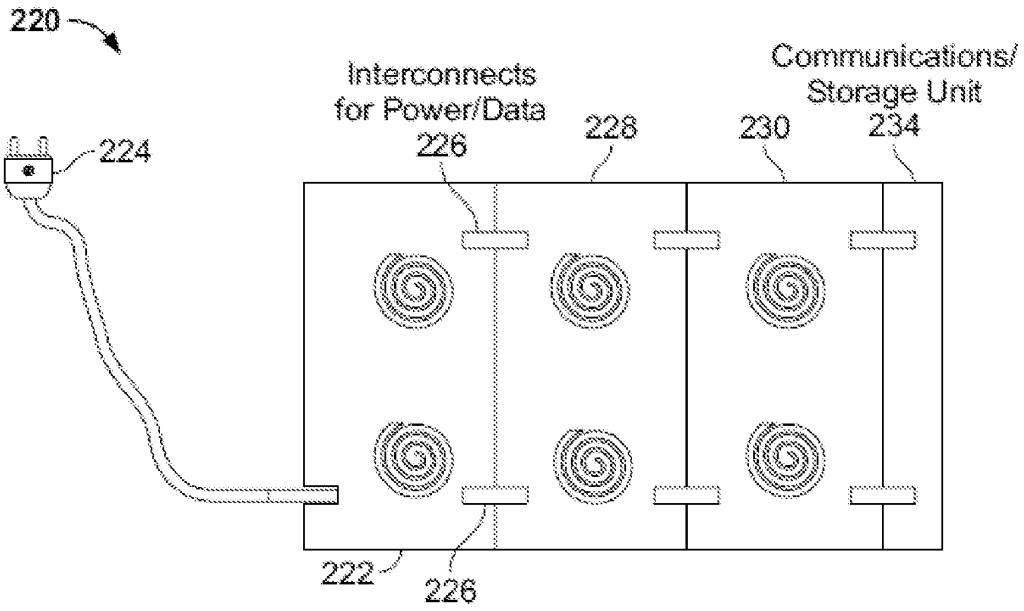

220
Interconnects
for Power/Data
226
228
230
Communications/
Storage Unit
234
224
222
226

Fig. 8

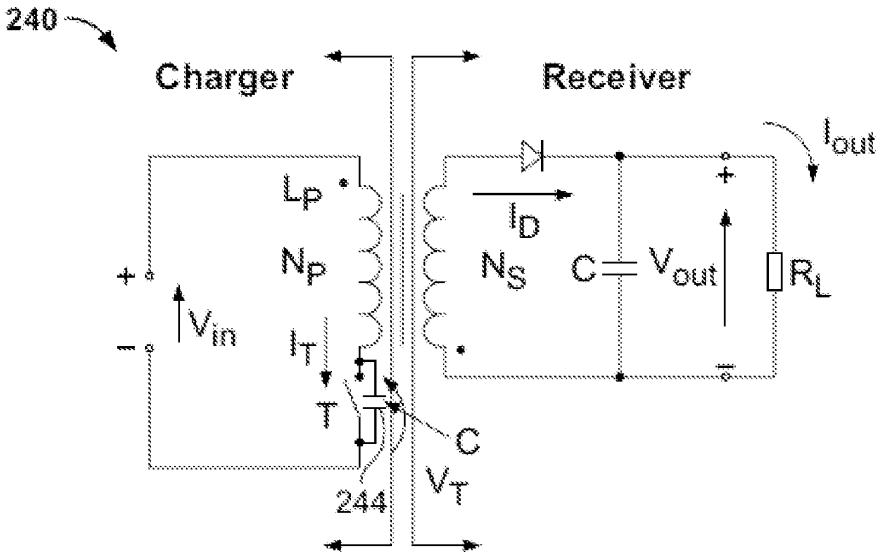

240
Charger
Receiver
I_{out}
L_P
N_P
I_D
N_S
C
V_{out}
R_L
+
V_{in}
−
I_T
T
C
V_T
244

Fig. 9

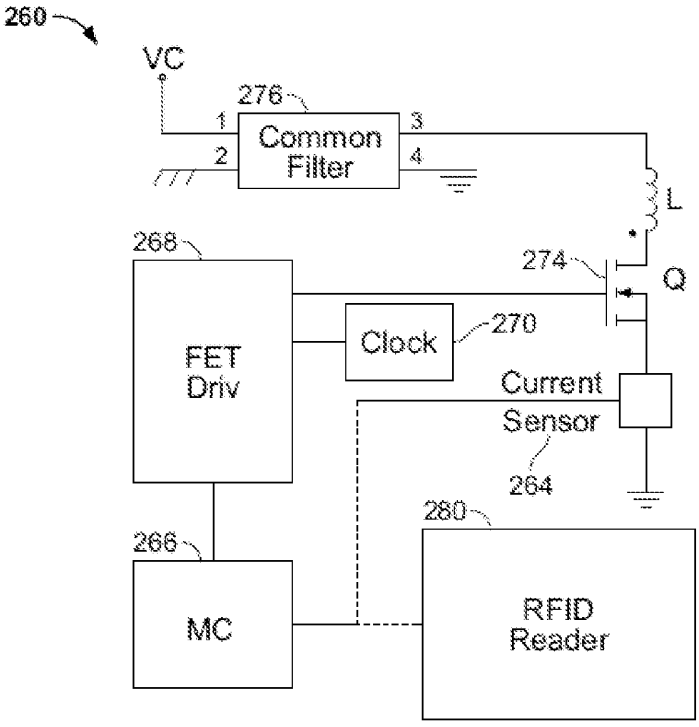

260
VC
276
1
2
Common Filter
3
4
L
268
274
Q
FET Driv
Clock
270
Current Sensor
264
280
266
MC
RFID Reader

Fig. 10

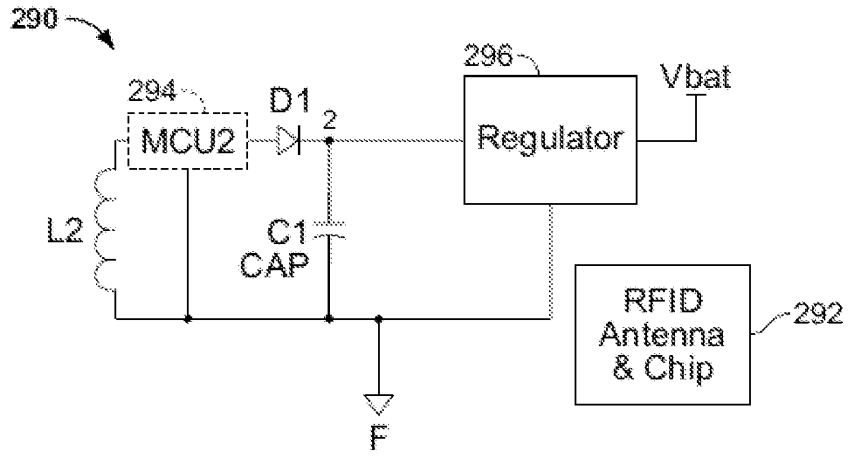

290
294
MCU2
D1
2
296
Regulator
Vbat
L2
C1
CAP
RFID
Antenna
& Chip
292
F

Fig. 11

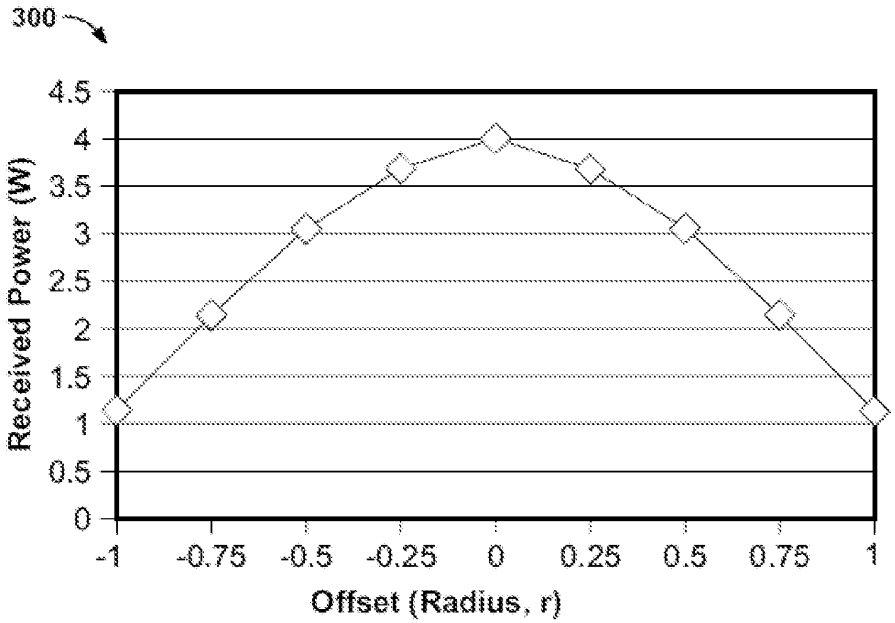

300
Received Power (W)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Offset (Radius, r)

Fig. 12

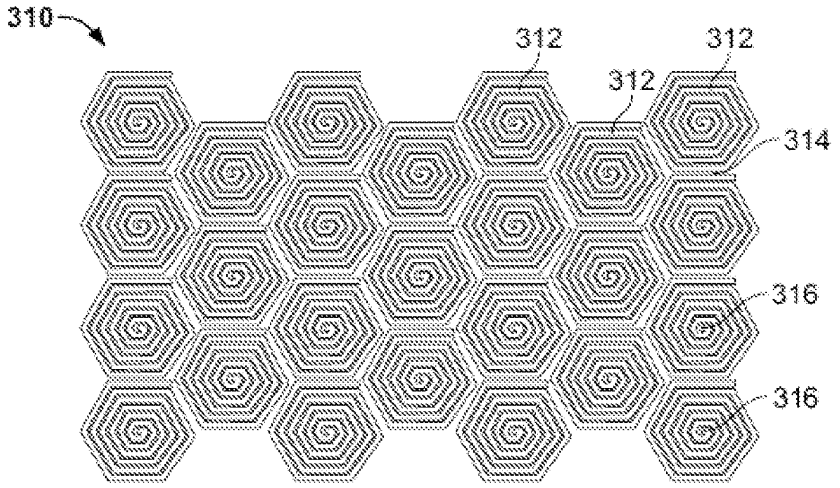


Fig. 13

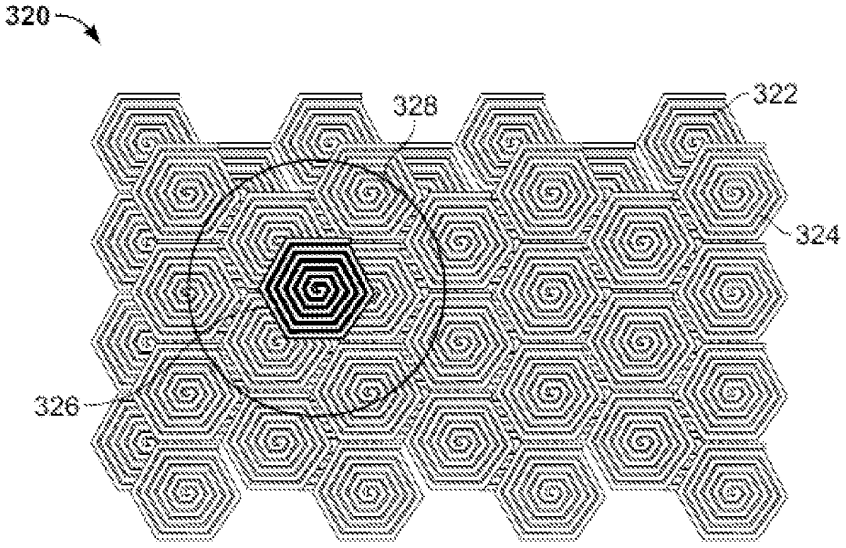


Fig. 14

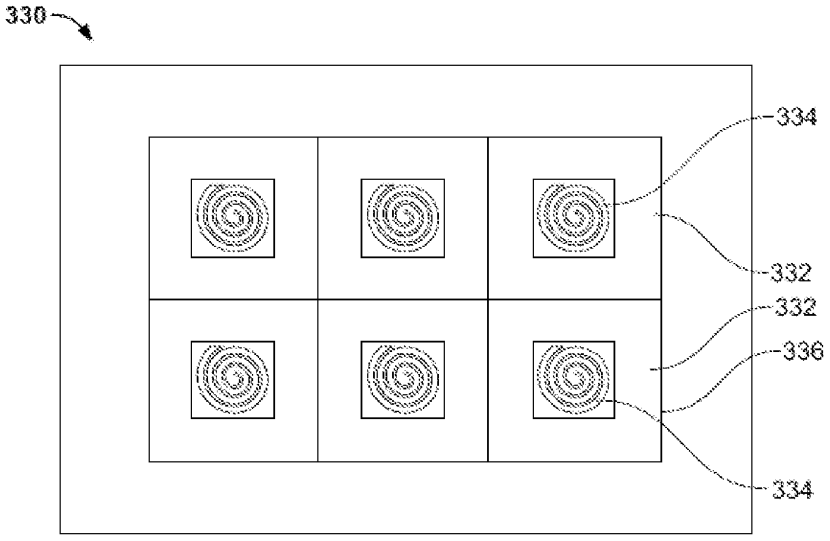


Fig. 15

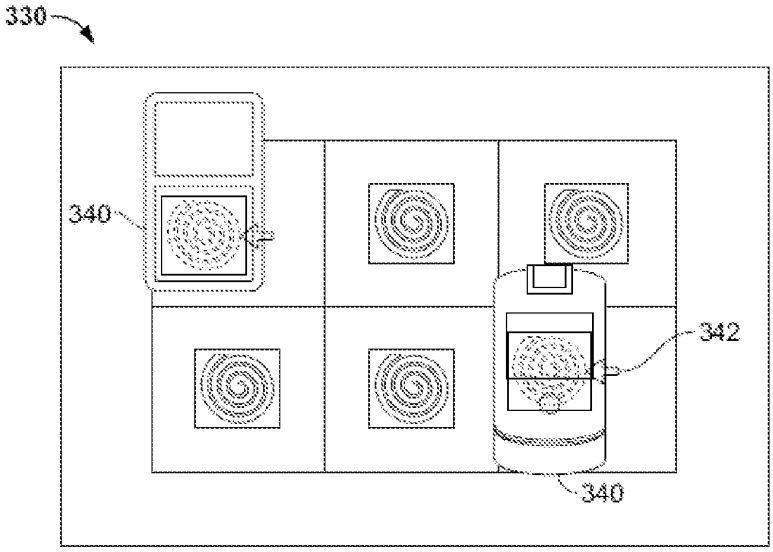


Fig. 16

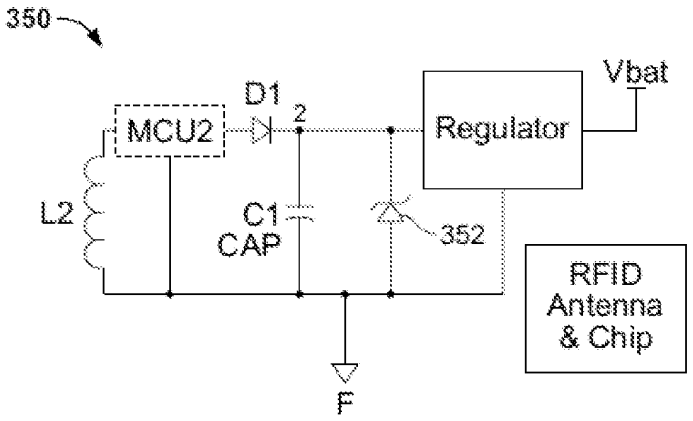

350
D1
2
MCU2
Regulator
Vbat
L2
C1
CAP
352
RFID
Antenna
& Chip
F

Fig. 17

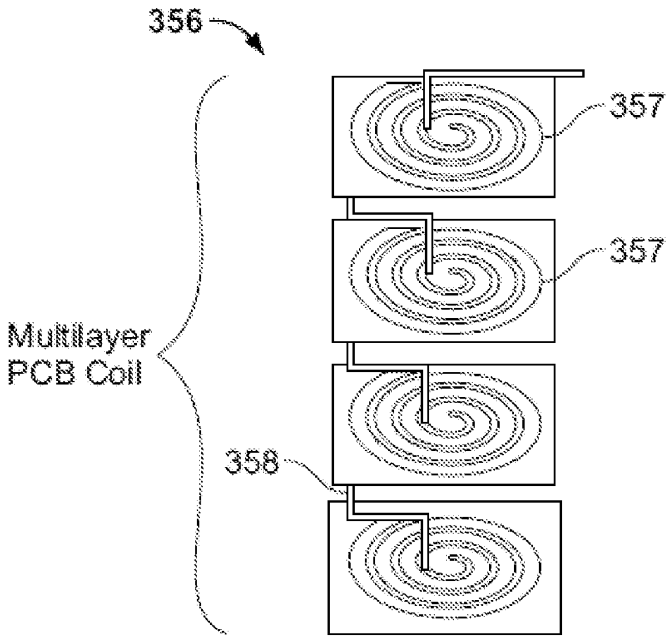

356
357
357
Multilayer
PCB Coil
358

Fig. 18

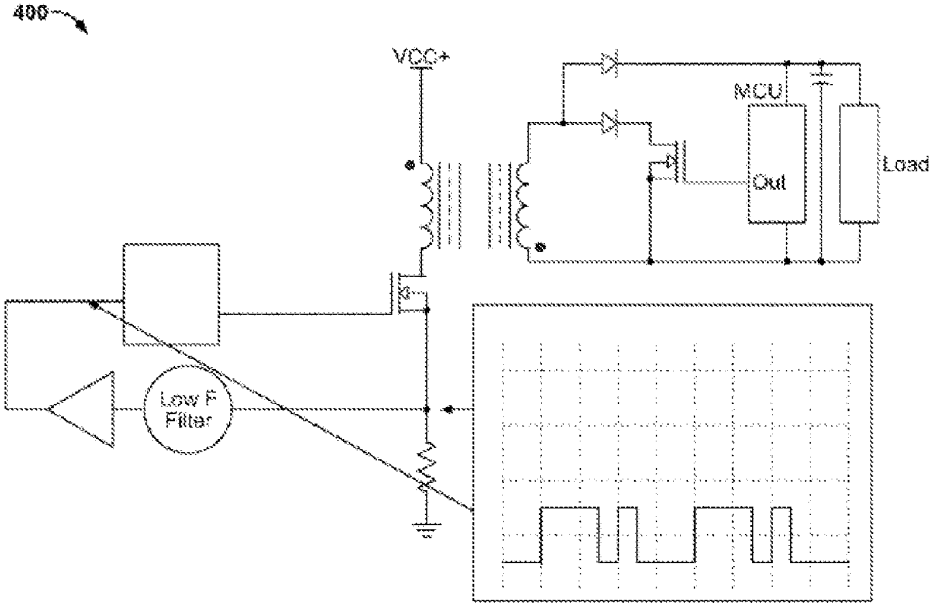

400
VCC+
MCU
Out
Load
Low F
Filter

Fig. 19

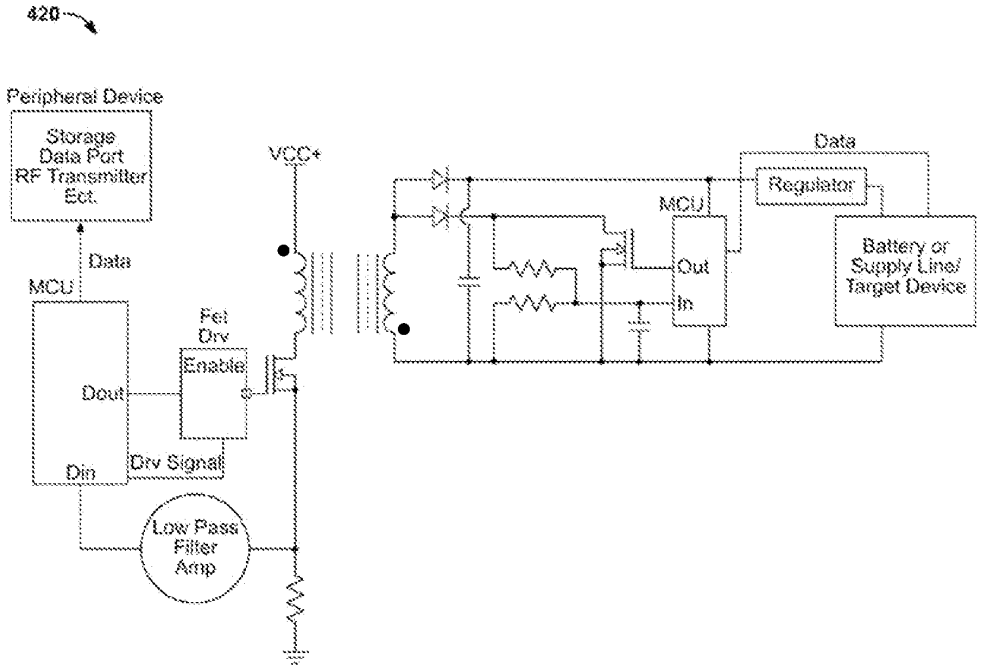

420
Peripheral Device
Storage
Data Port
RF Transmitter
Ect.
Data
MCU
Dout
Din
Fet
Drv
Enable
Drv Signal
Low Pass
Filter
Amp
VCC+
Data
Regulator
MCU
Out
In
Battery or
Supply Line/
Target Device

Fig. 20

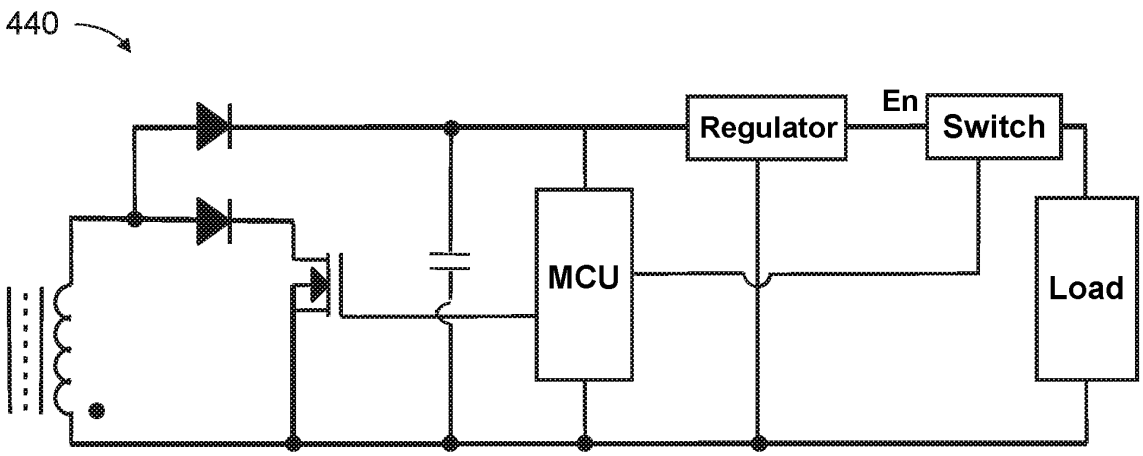


Fig. 21

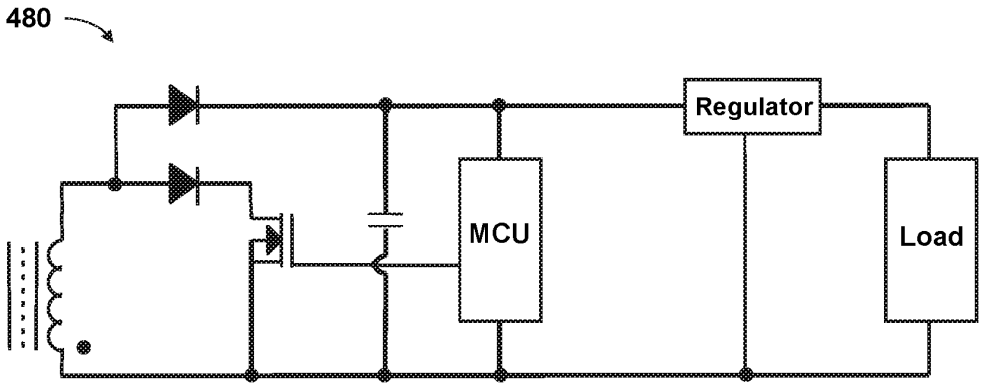


Fig. 22

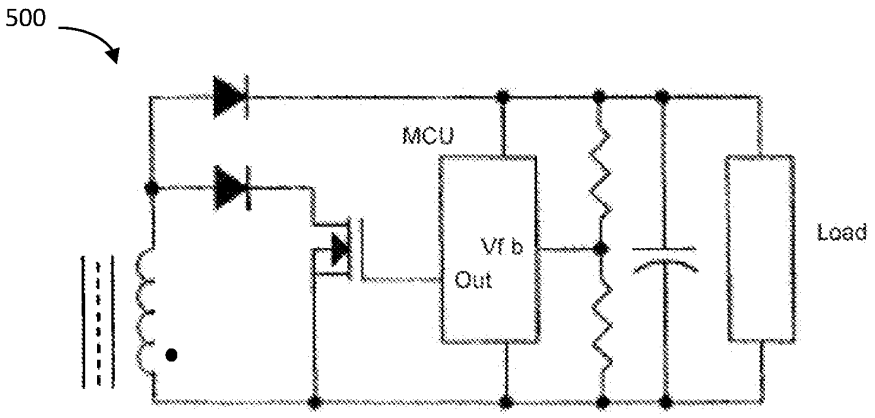


Fig. 23

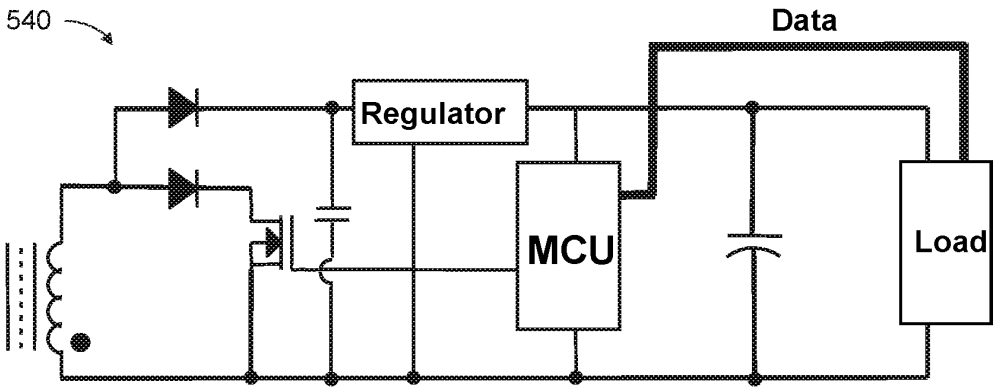


Fig. 24

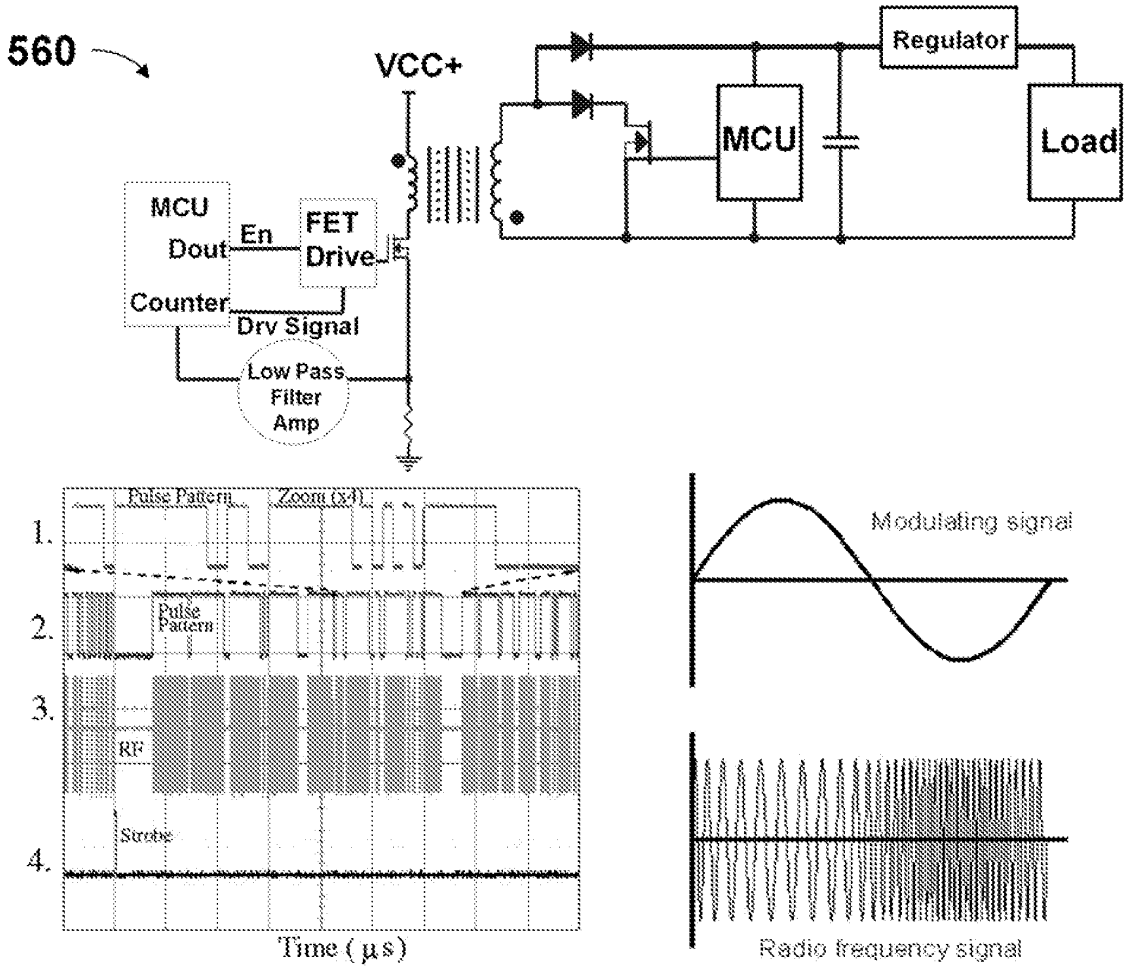

560
VCC+
Regulator
MCU
Load
MCU
Dout
En
FET
Drive
Counter
Drv Signal
Low Pass
Filter
Amp
Pulse Pattern
Zoom (x4)
1.
2.
3.
4.
Pulse Pattern
RF
Strobe
Time (μs)
Modulating signal
Radio frequency signal

Fig. 25

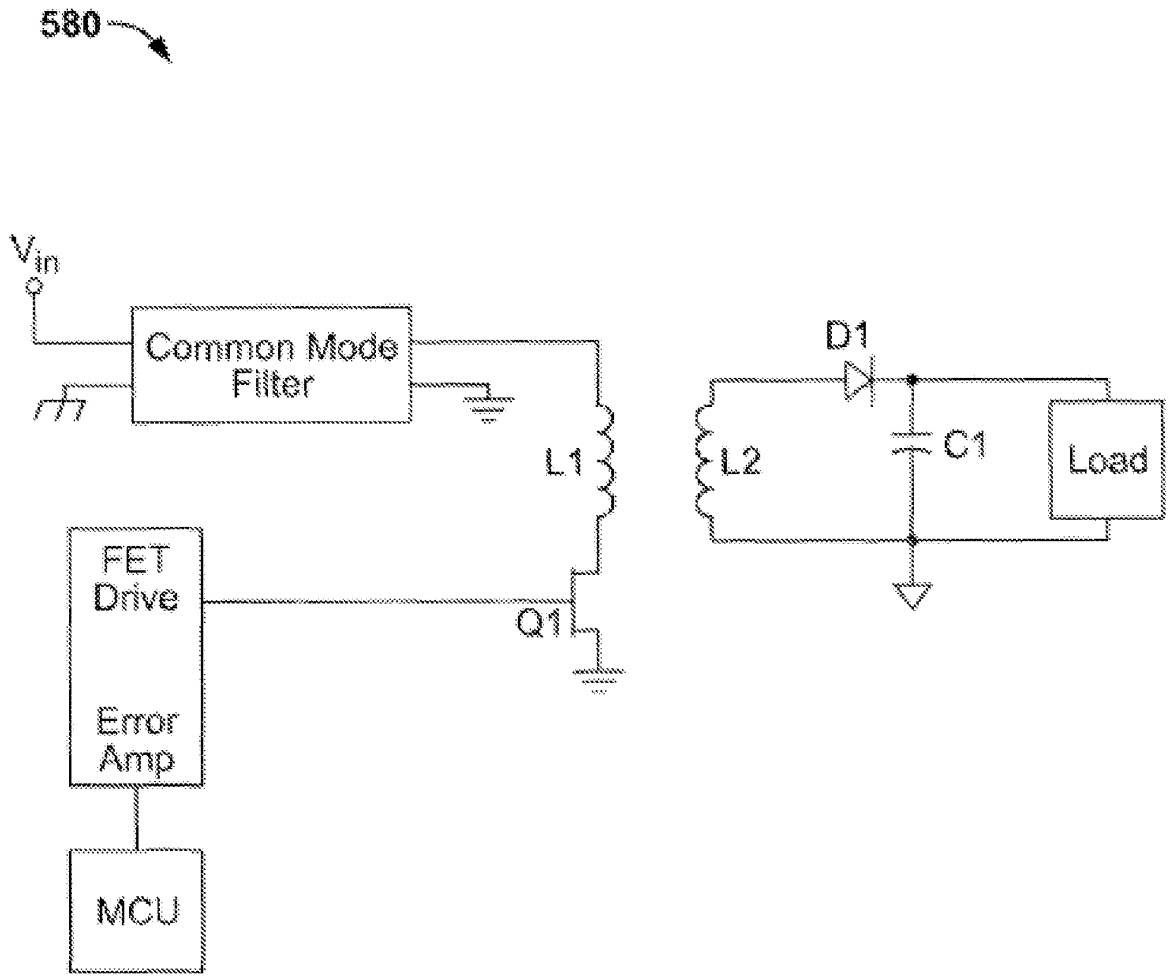

580
V_{in}
Common Mode Filter
L1
FET Drive
Q1
Error Amp
MCU
D1
L2
C1
Load

Fig. 26

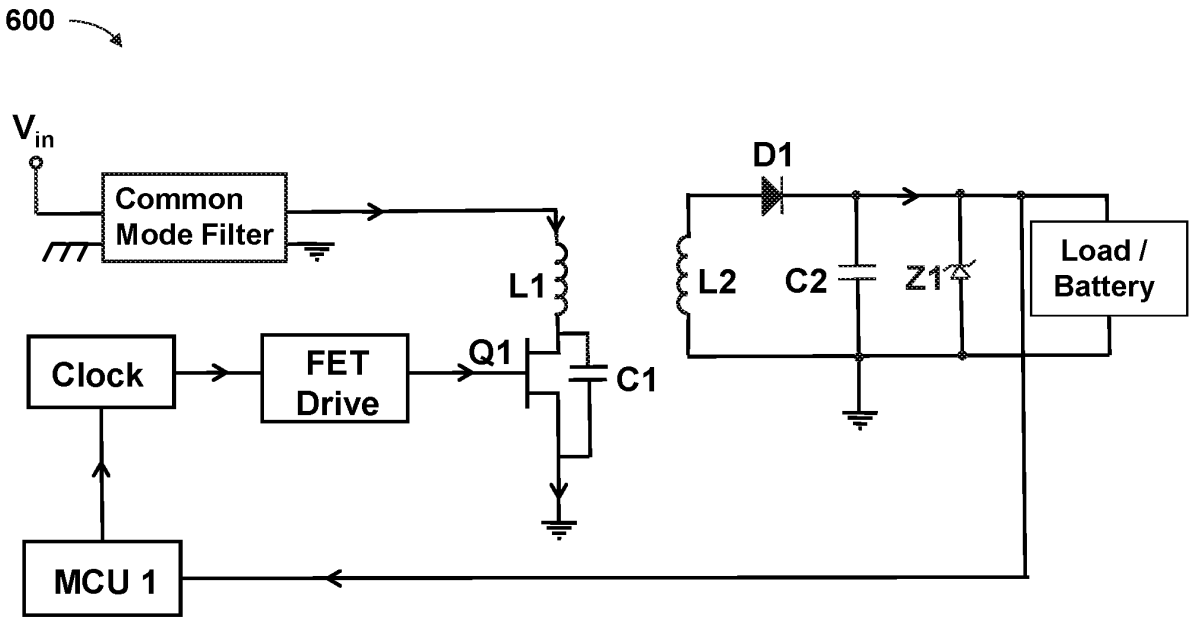

600
V_{in}
Common Mode Filter
L1
D1
L2
C2
Z1
Load / Battery
Clock
FET Drive
Q1
C1
MCU 1

Fig. 27

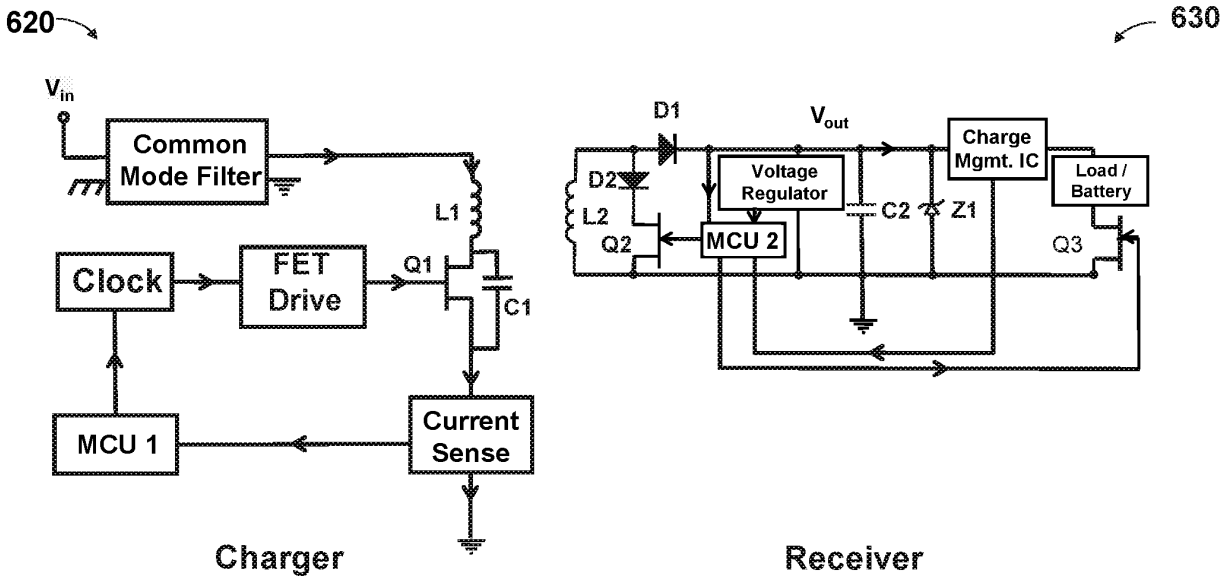

620
630
V_{in}
Common Mode Filter
L1
D1
V_{out}
Charge Mgmt. IC
Load / Battery
D2
Voltage Regulator
L2
Q2
MCU 2
C2
Z1
Q3
Clock
FET Drive
Q1
C1
MCU 1
Current Sense
Charger
Receiver

Fig. 28

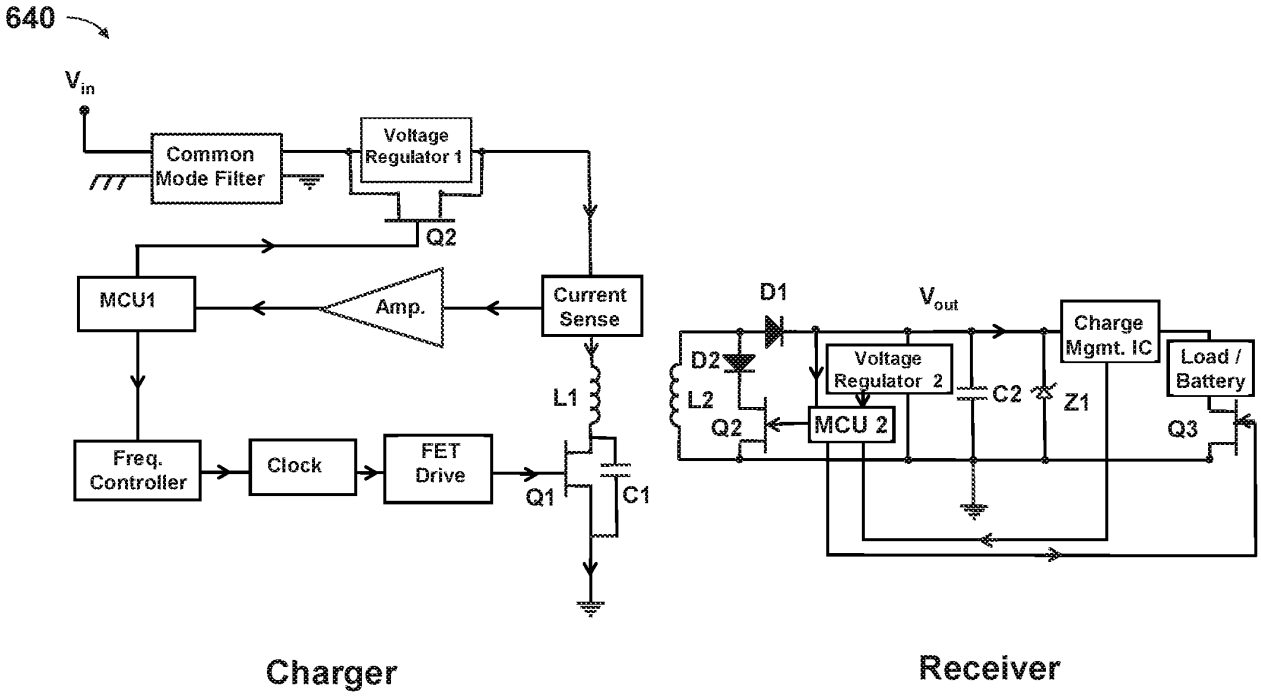


Fig. 29

APPROVED: /Z.Z/

02/15/2022

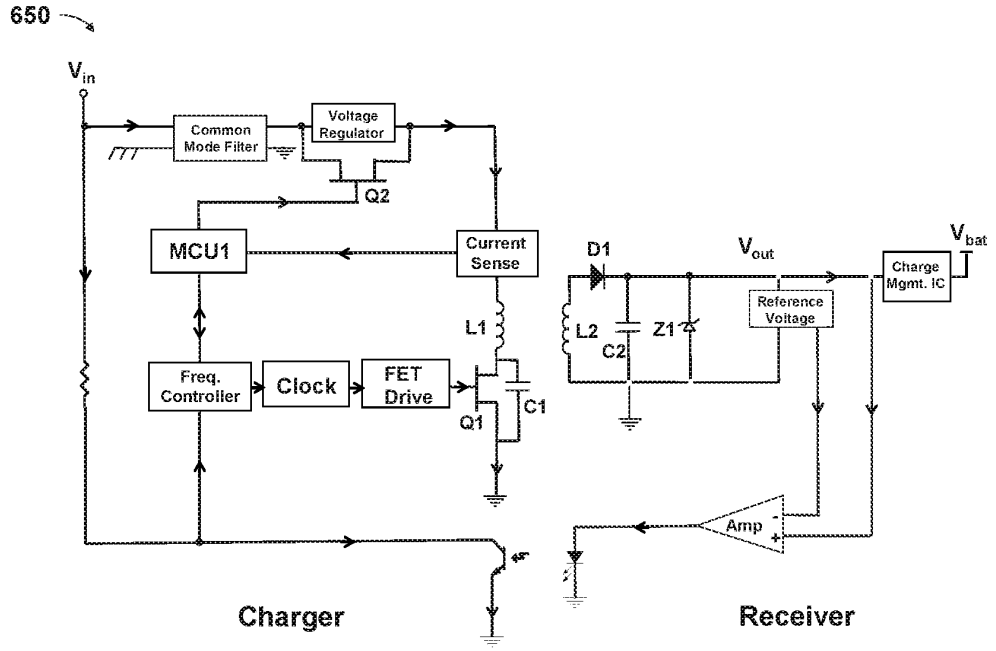


Fig. 30

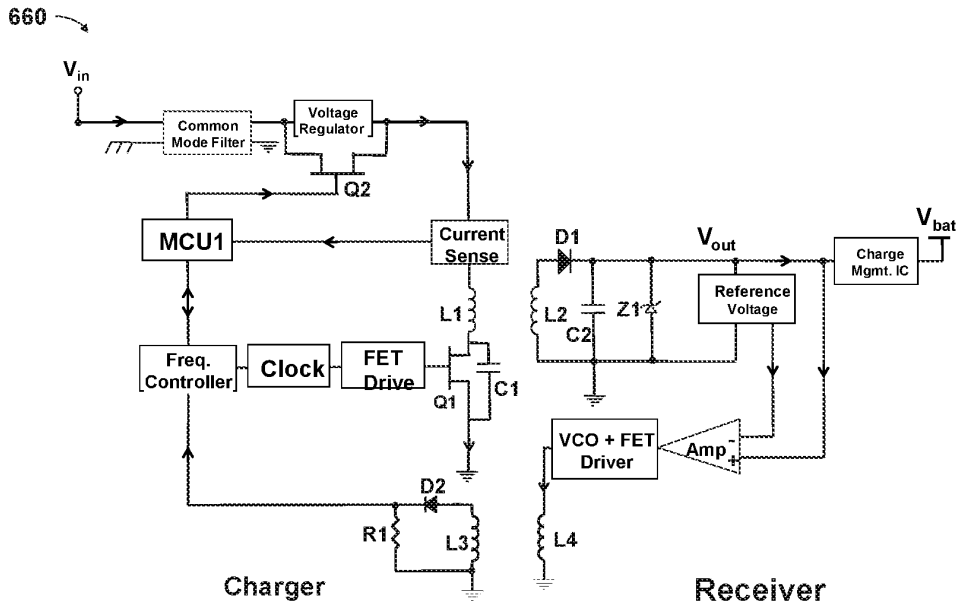

660
V_{in}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
D2
R1
L3
Charger
D1
V_{out}
V_{bat}
Charge Mgmt. IC
Reference Voltage
L2
C2
Z1
VCO + FET Driver
Amp
L4
Receiver

Fig. 31

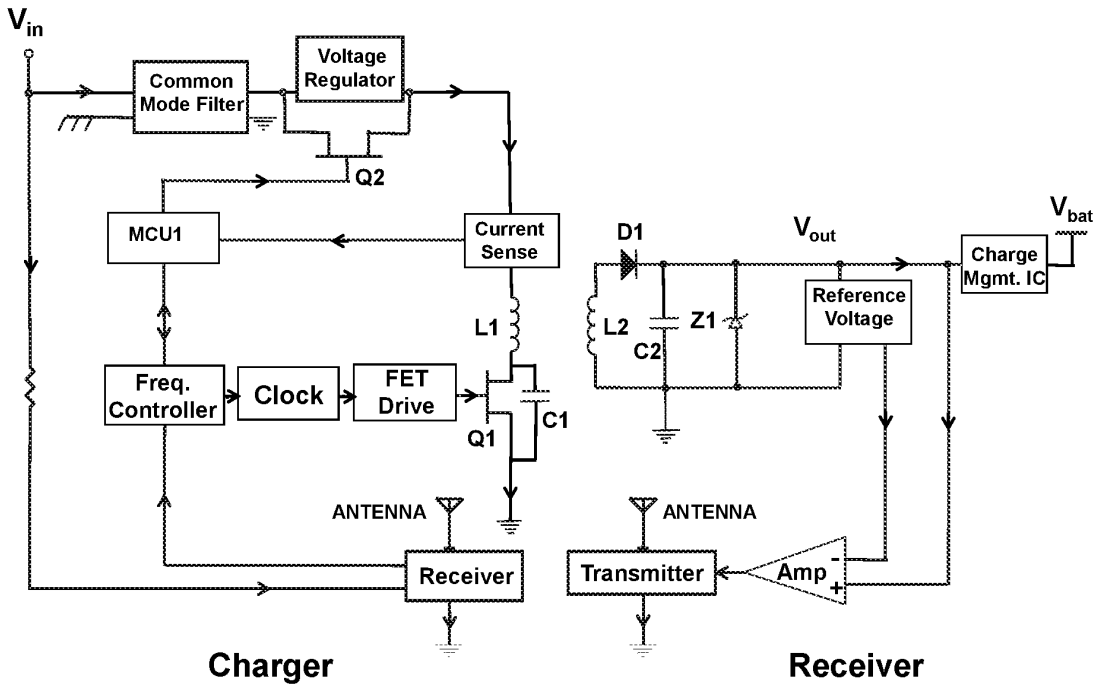

V_{in}
Common Mode Filter
Voltage Regulator
Q2
MCU1
Current Sense
L1
Freq. Controller
Clock
FET Drive
Q1
C1
ANTENNA
Receiver
Charger
D1
V_{out}
V_{bat}
Charge Mgmt. IC
Reference Voltage
L2
C2
Z1
ANTENNA
Transmitter
Amp
Receiver

Fig. 32

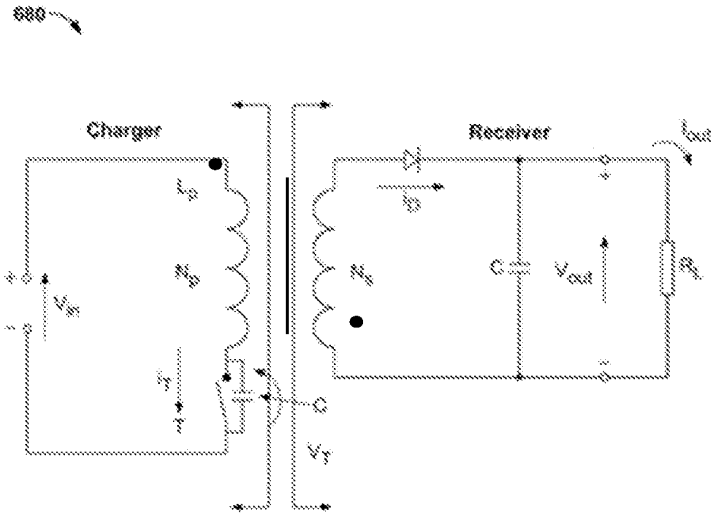

Charger
Receiver

Fig. 33

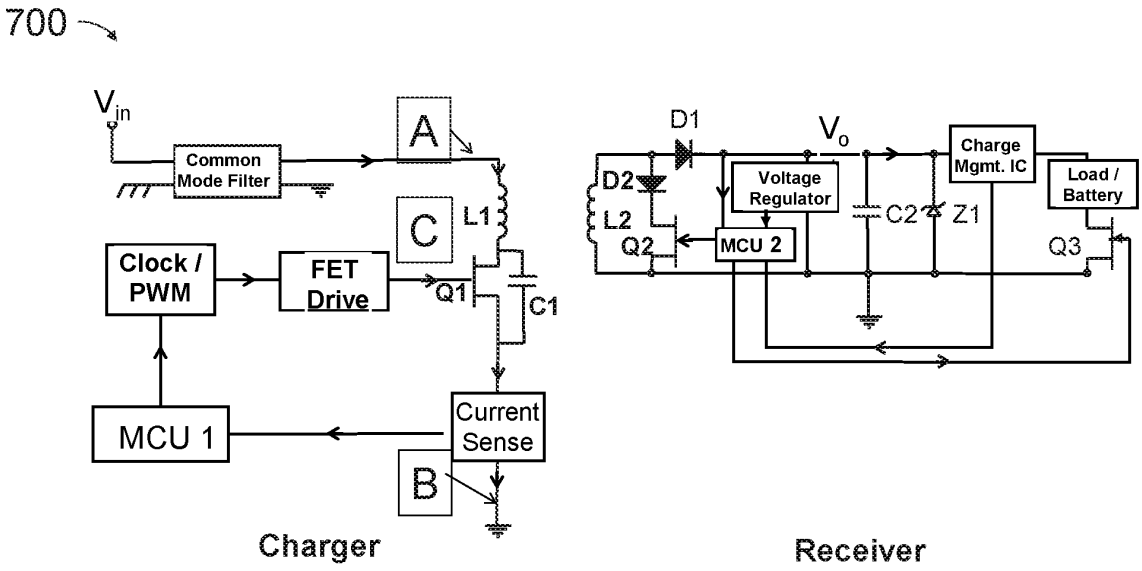

700
Vin
Common Mode Filter
A
C
L1
Clock / PWM
FET Drive
Q1
C1
MCU 1
Current Sense
B
Charger
D1
Vo
D2
L2
Q2
Voltage Regulator
MCU 2
C2
Z1
Charge Mgmt. IC
Load / Battery
Q3
Receiver

Fig. 34

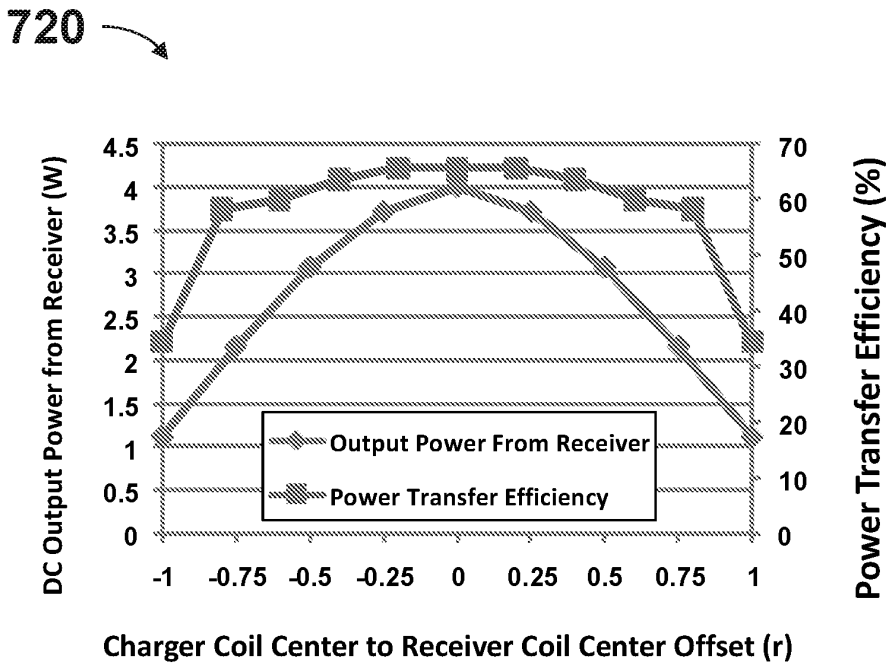

720
DC Output Power from Receiver (W)
Power Transfer Efficiency (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
70
60
50
40
30
20
10
0
-1
-0.75
-0.5
-0.25
0
0.25
0.5
0.75
1
Output Power From Receiver
Power Transfer Efficiency
Charger Coil Center to Receiver Coil Center Offset (r)

Fig. 35

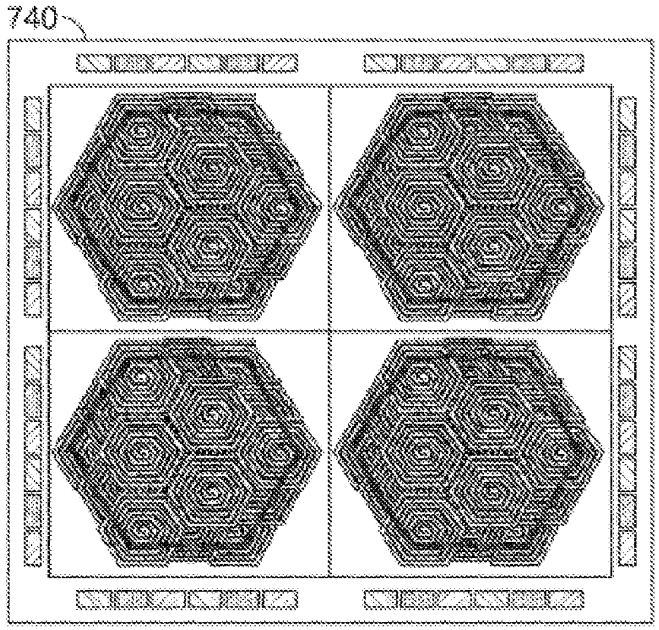

740

Fig. 36

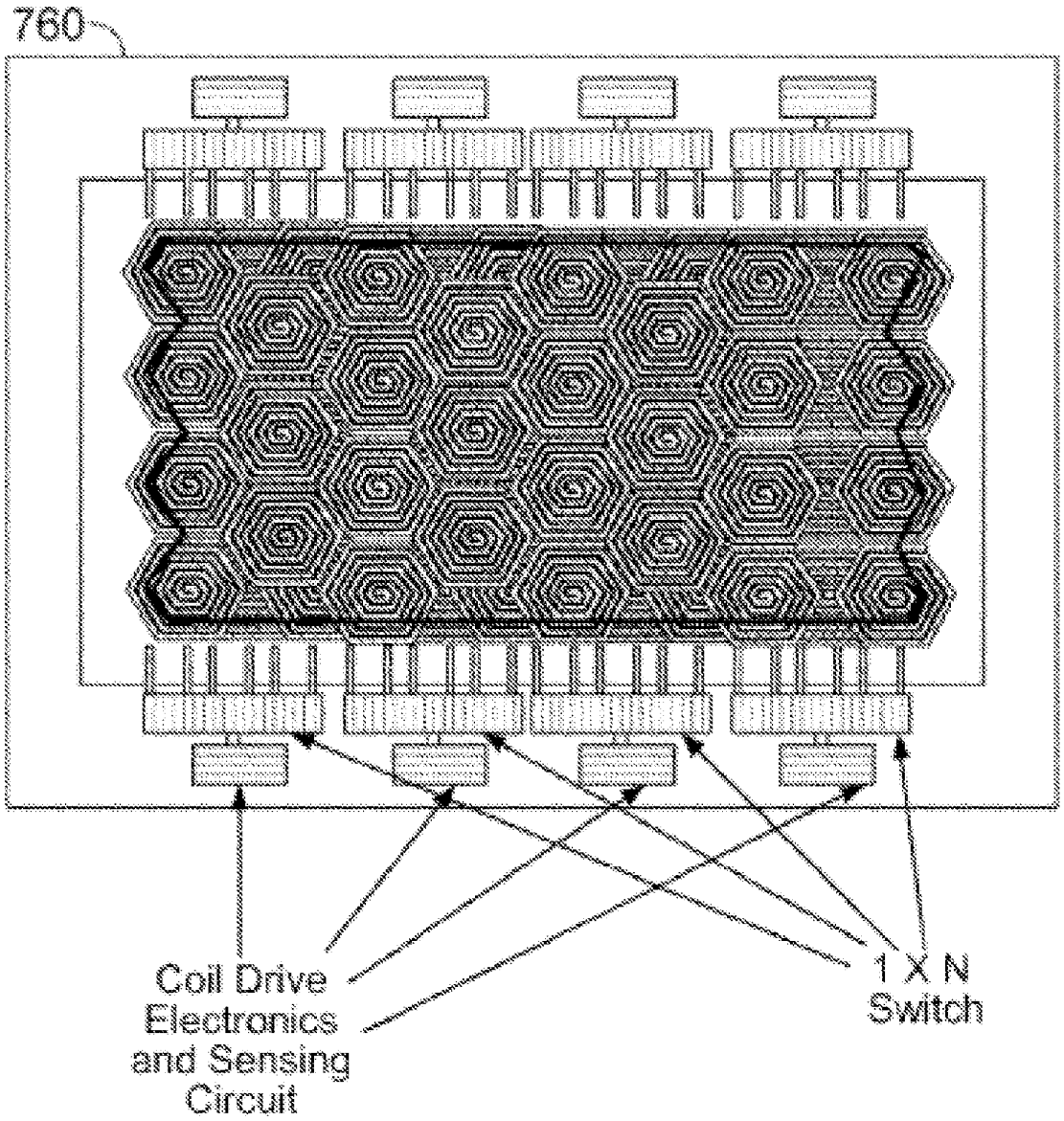


Fig. 37

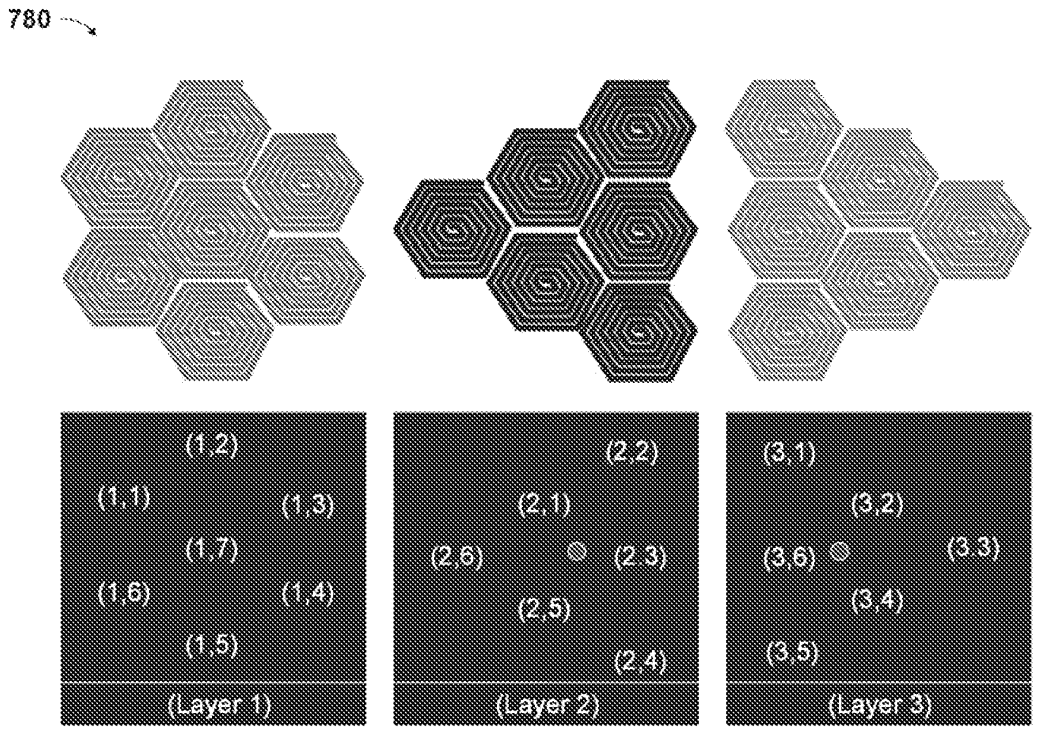

780
(1,2)
(1,1)
(1,3)
(1,7)
(1,6)
(1,4)
(1,5)
(Layer 1)
(2,2)
(2,1)
(2,6)
(2,3)
(2,5)
(2,4)
(Layer 2)
(3,1)
(3,2)
(3,6)
(3,3)
(3,4)
(3,5)
(Layer 3)

Fig. 38

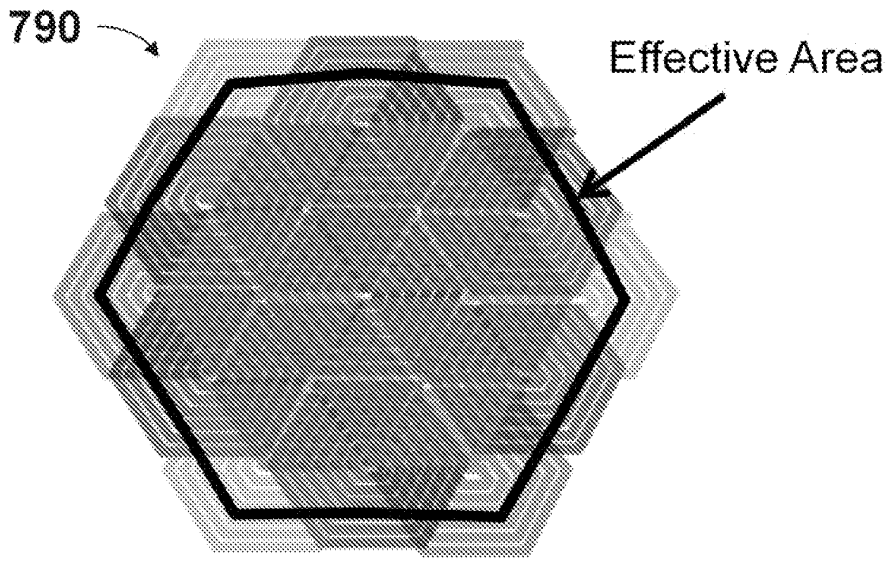

790
Effective Area

Fig. 39

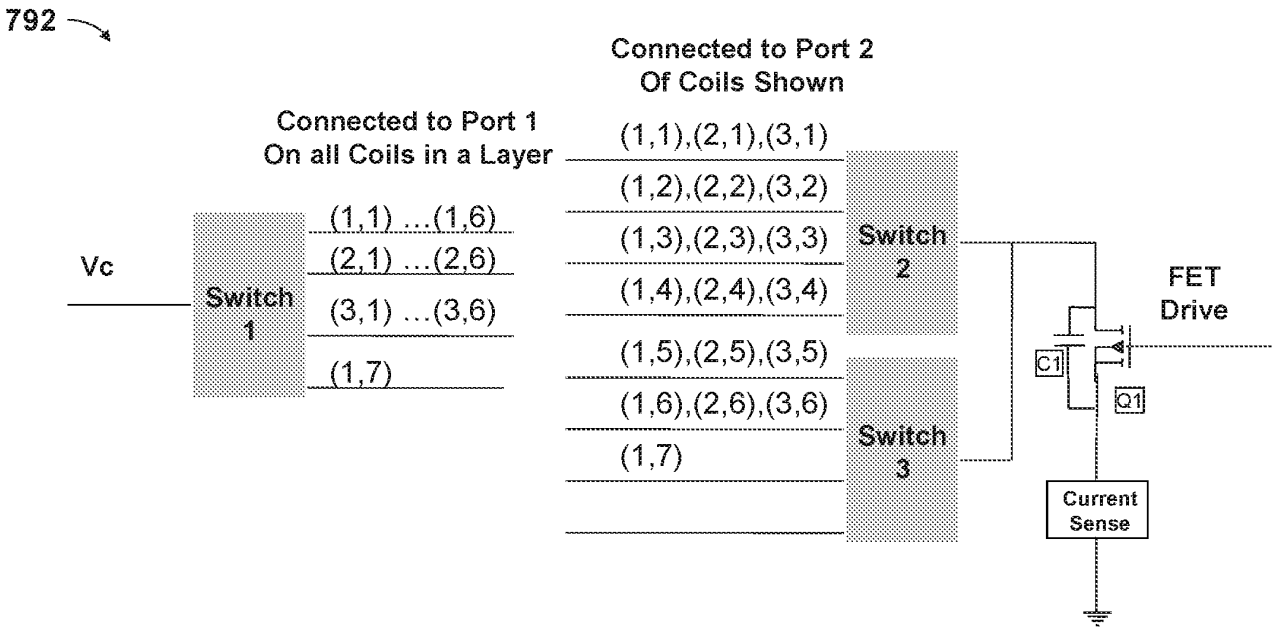

792
Connected to Port 2
Of Coils Shown
Connected to Port 1
On all Coils in a Layer
(1,1),(2,1),(3,1)
(1,2),(2,2),(3,2)
(1,3),(2,3),(3,3)
(1,4),(2,4),(3,4)
(1,5),(2,5),(3,5)
(1,6),(2,6),(3,6)
(1,7)
(1,1) …(1,6)
(2,1) …(2,6)
(3,1) …(3,6)
(1,7)
Vc
Switch 1
Switch 2
Switch 3
FET Drive
C1
Q1
Current Sense

Fig. 40

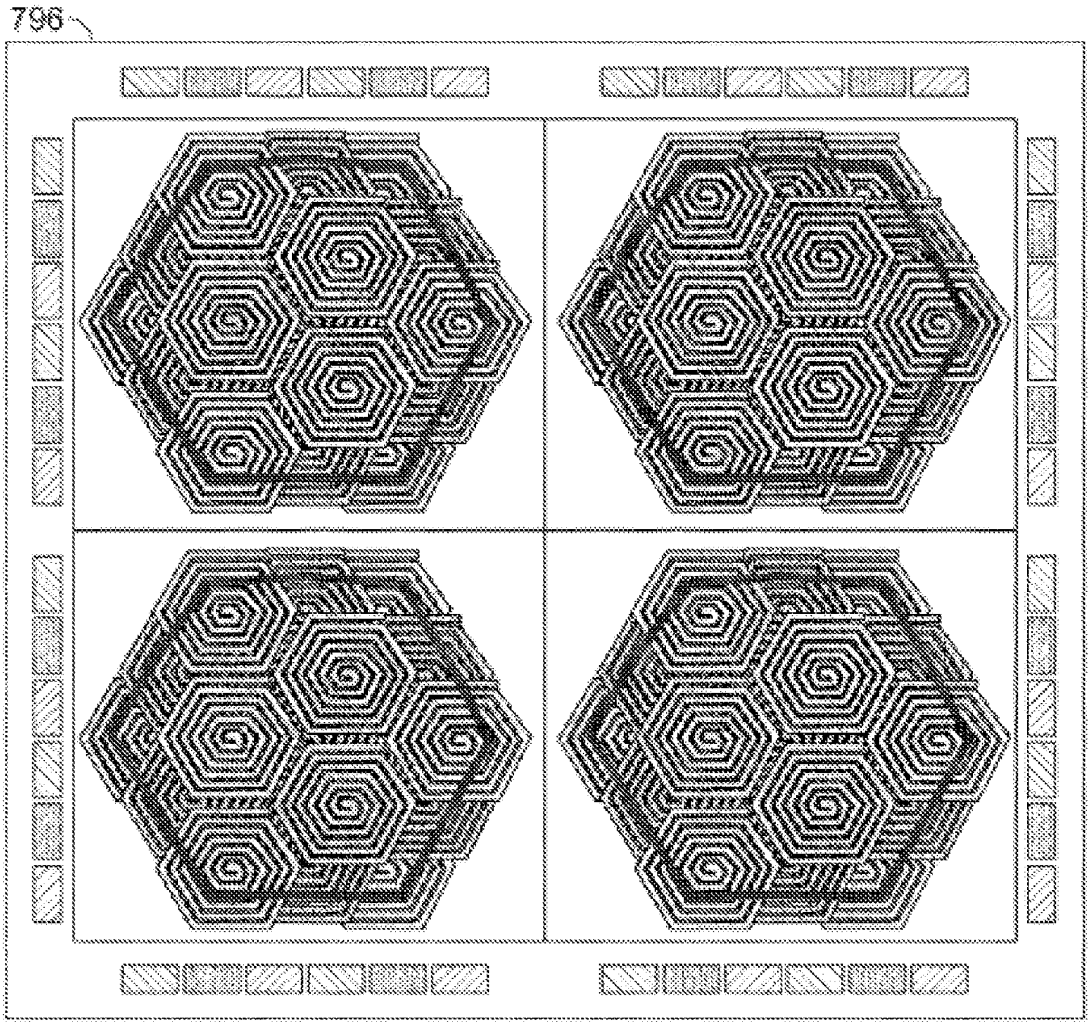


Fig. 41

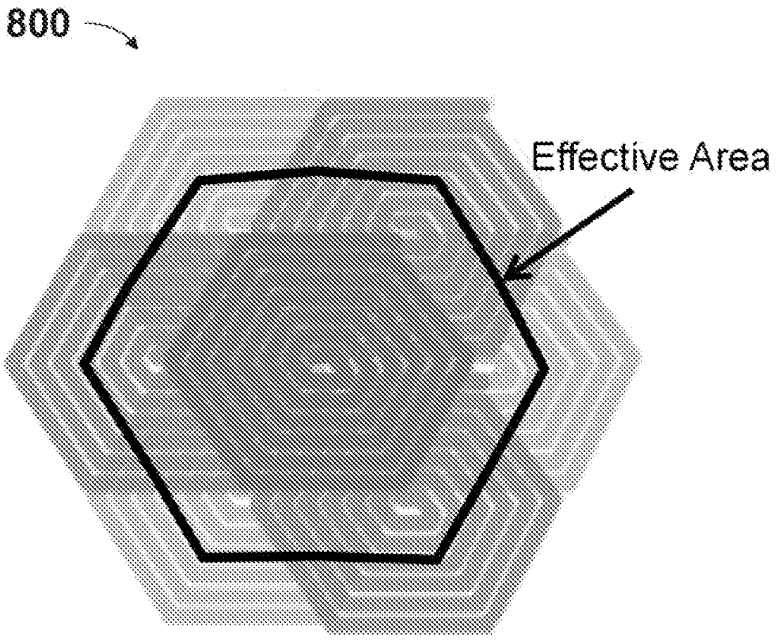


Fig. 42

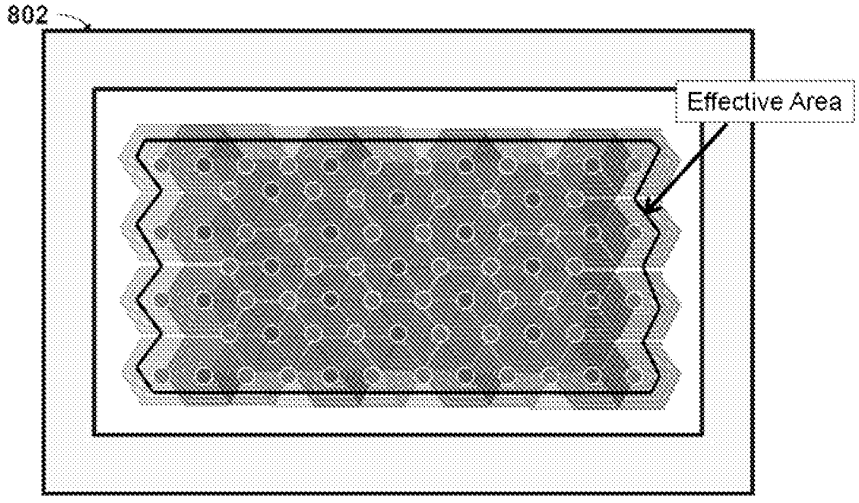


Fig. 43

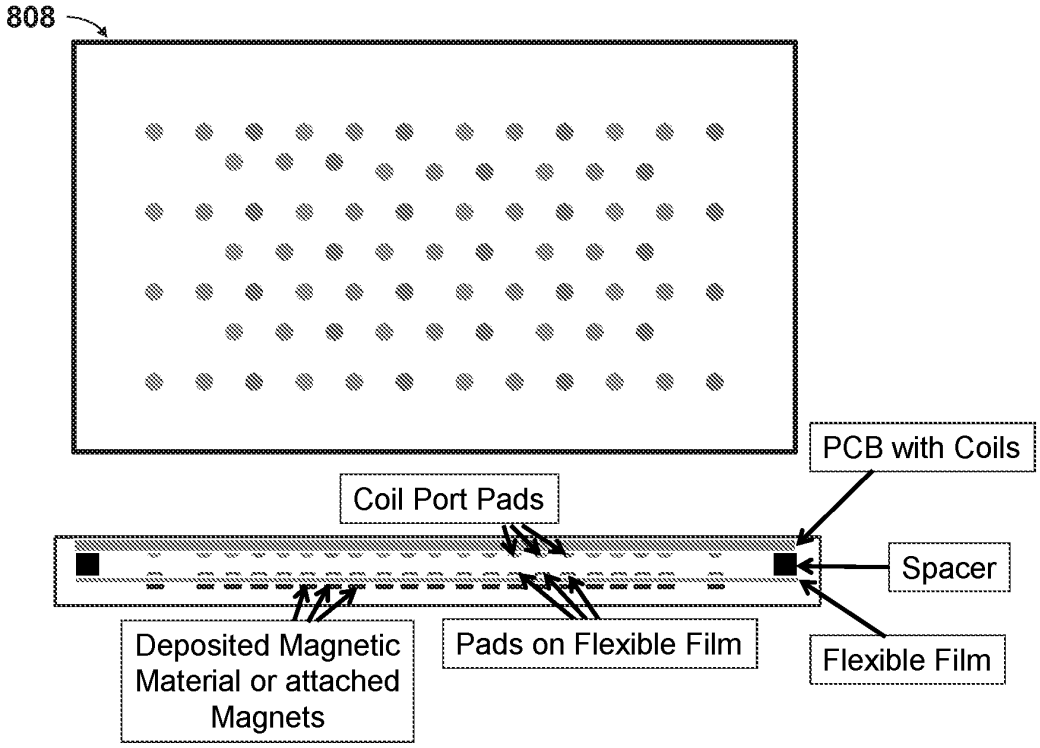

808
PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 44

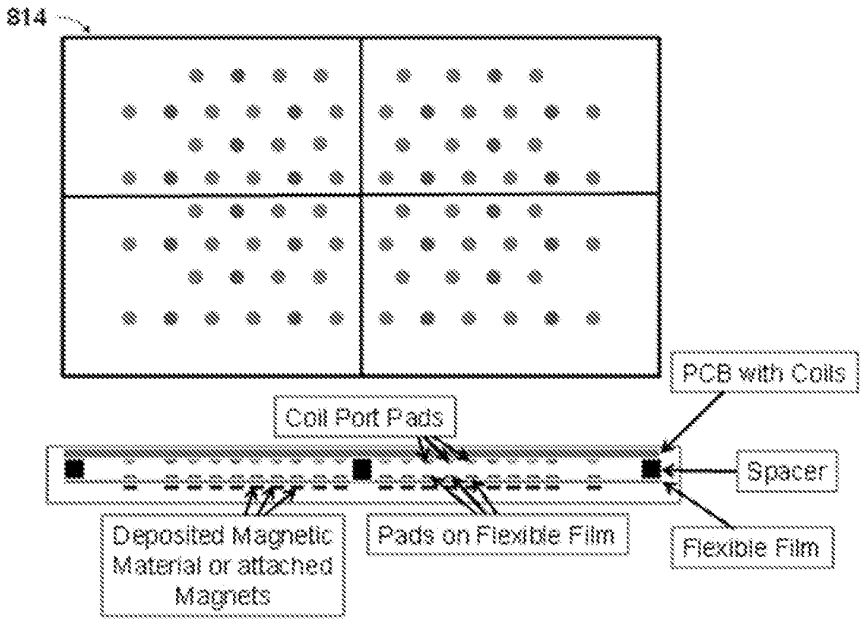

814
PCB with Coils
Coil Port Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 45

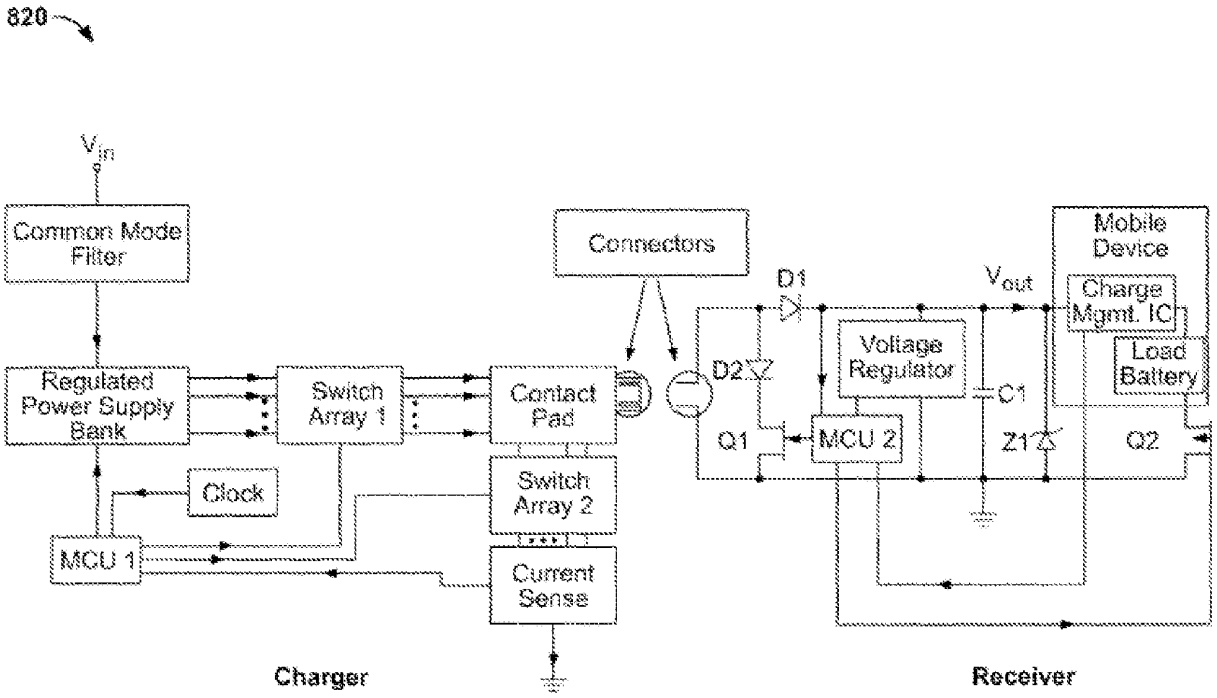

820
V_{in}
Common Mode Filter
Regulated Power Supply Bank
Switch Array 1
Contact Pad
Clock
MCU 1
Switch Array 2
Current Sense
Charger
Connectors
D1
D2
Q1
MCU 2
Voltage Regulator
V_{out}
C1
Z1
Q2
Mobile Device
Charge Mgmt. IC
Load Battery
Receiver

Fig. 46

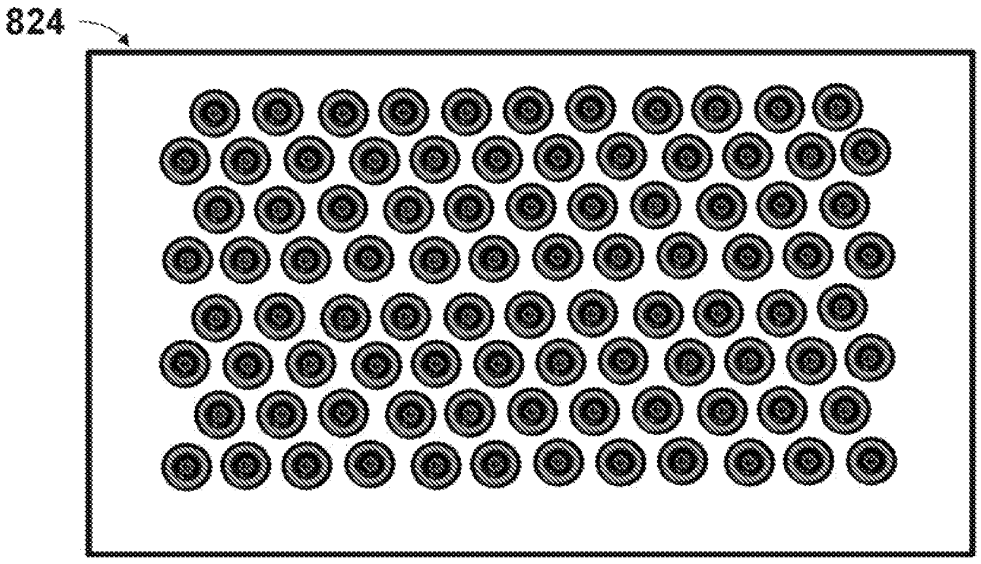

824

Fig. 47

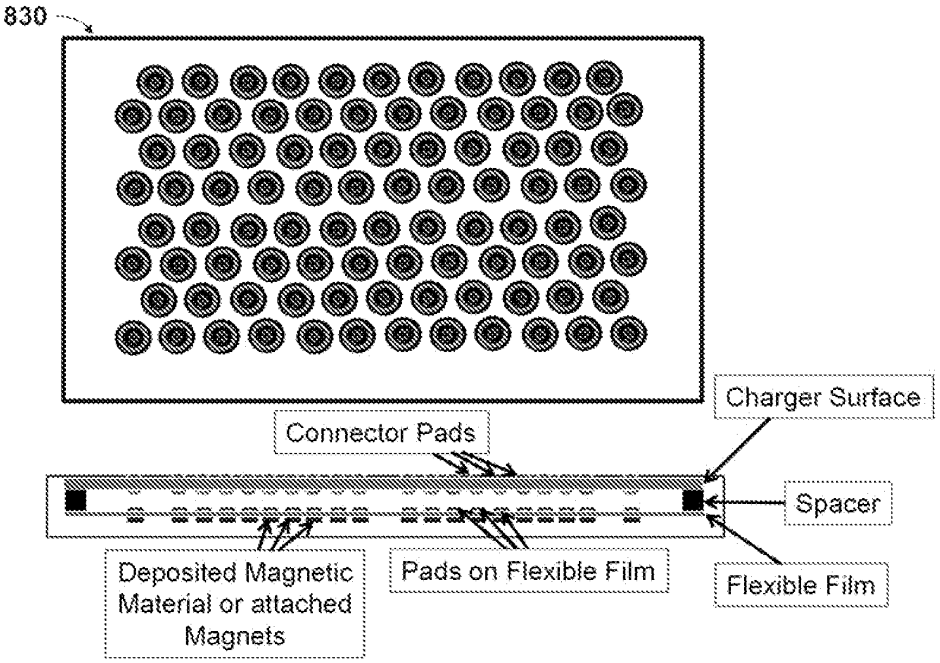

830
Charger Surface
Connector Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 48

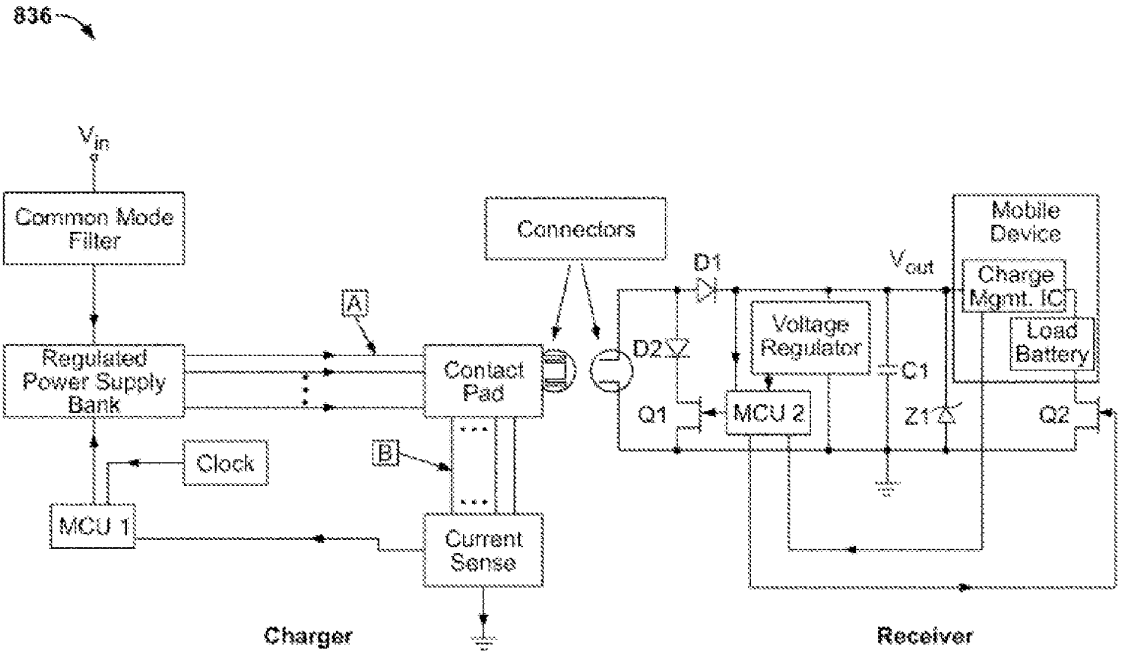

836
V_{in}
Common Mode Filter
Regulated Power Supply Bank
Clock
MCU 1
A
B
Contact Pad
Current Sense
Connectors
D1
D2
Q1
MCU 2
Voltage Regulator
V_{out}
C1
Z1
Q2
Mobile Device
Charge Mgmt. IC
Load Battery
Charger
Receiver

Fig. 49

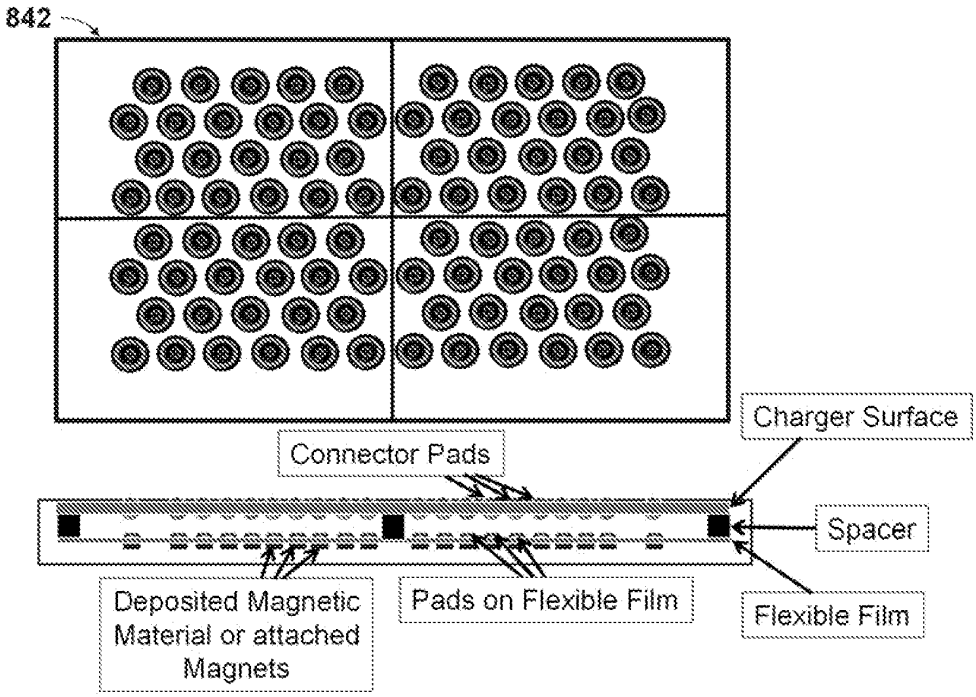

842
Charger Surface
Connector Pads
Spacer
Deposited Magnetic Material or attached Magnets
Pads on Flexible Film
Flexible Film

Fig. 50

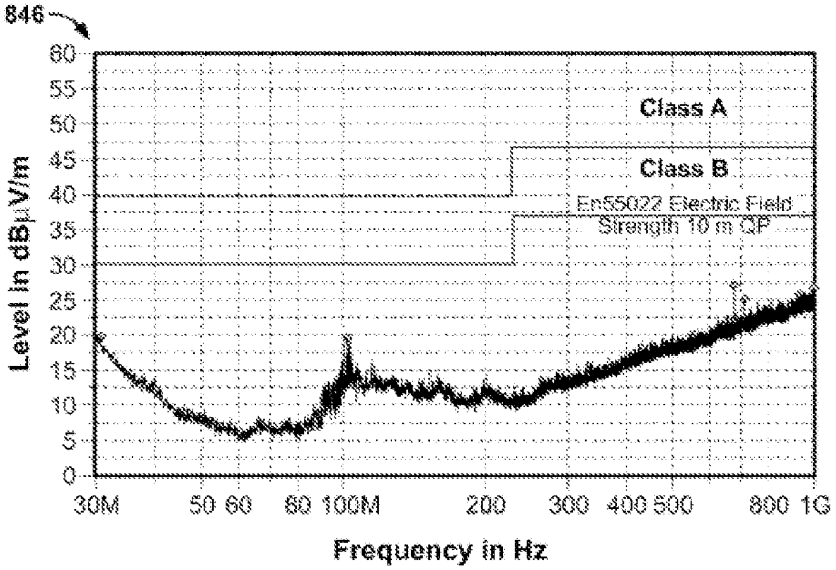

846
Class A
Class B
En55022 Electric Field Strength 10 m QP
Level in dBµV/m
Frequency in Hz
30M
50
60
80
100M
200
300
400
500
800
1G

Fig. 51

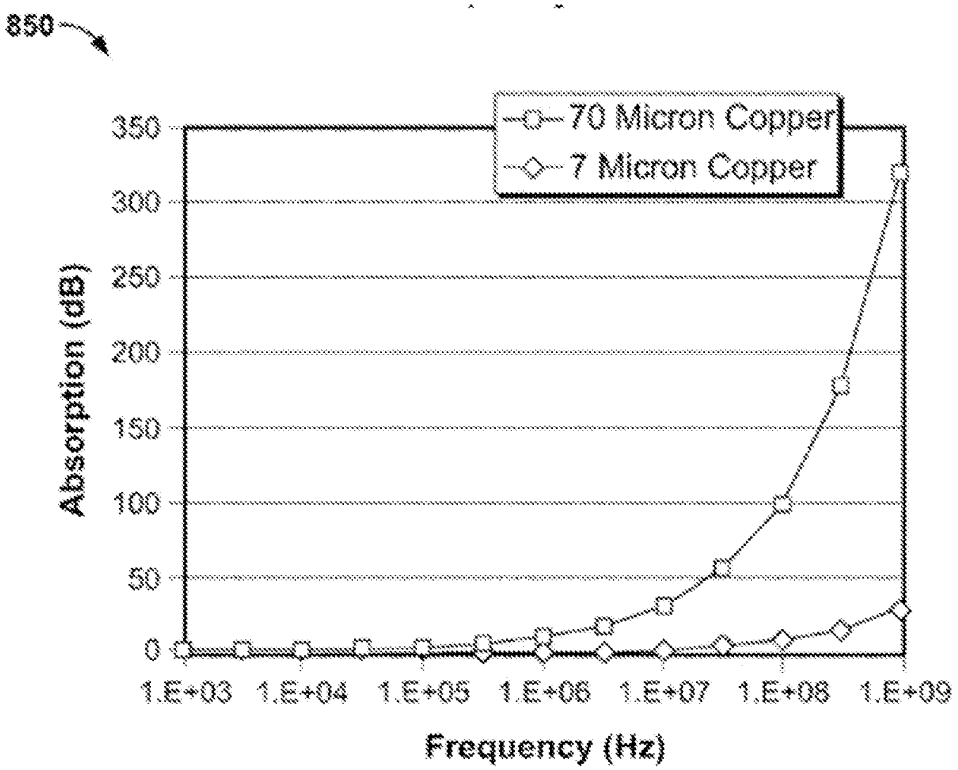

850
70 Micron Copper
7 Micron Copper
350
300
250
200
150
100
50
0
Absorption (dB)
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07
1.E+08
1.E+09
Frequency (Hz)

Fig. 52

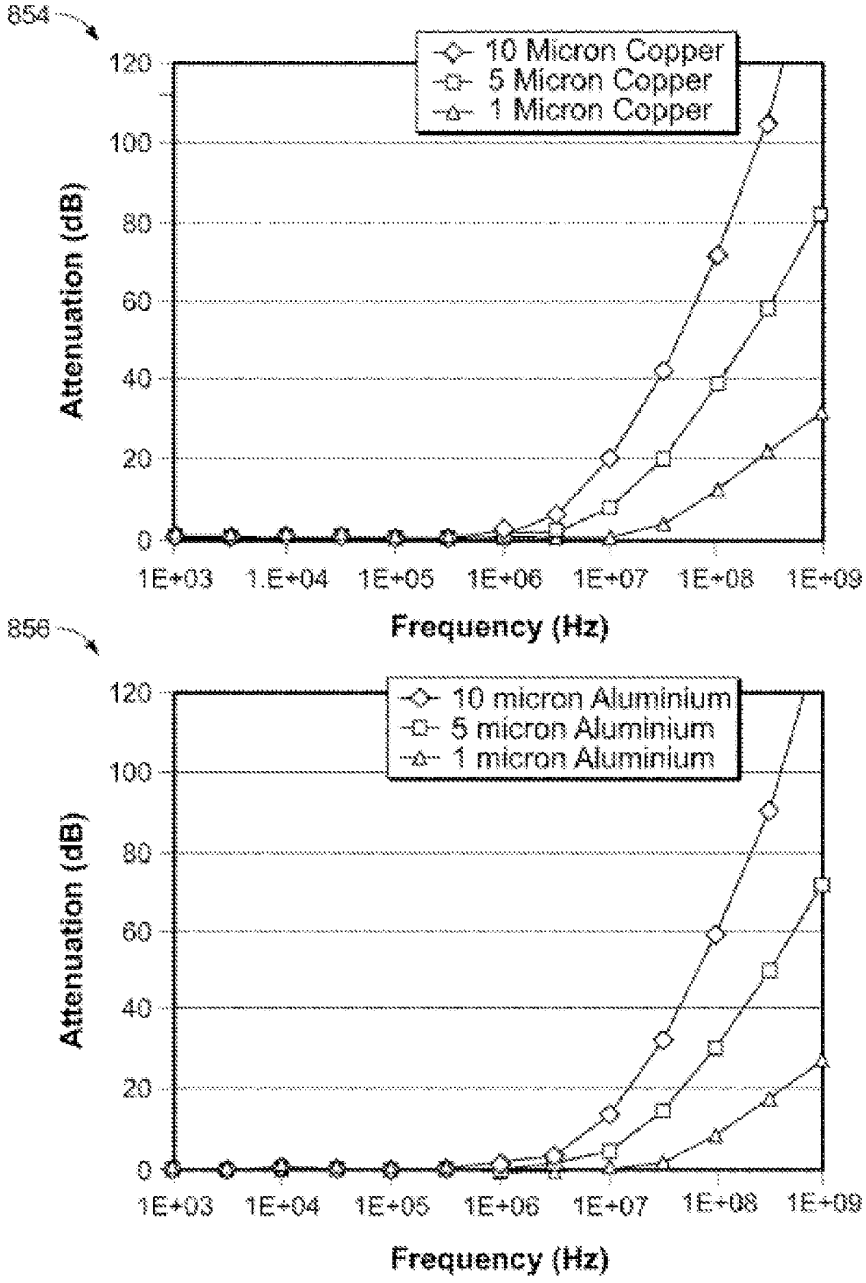

854
10 Micron Copper
5 Micron Copper
1 Micron Copper
Attenuation (dB)
120
100
80
60
40
20
0
1E+03
1.E+04
1E+05
1E+06
1E+07
1E+08
1E+09
Frequency (Hz)
856
10 micron Aluminium
5 micron Aluminium
1 micron Aluminium
Attenuation (dB)
120
100
80
60
40
20
0
1E+03
1E+04
1E+05
1E+06
1E+07
1E+08
1E+09
Frequency (Hz)

Fig. 53

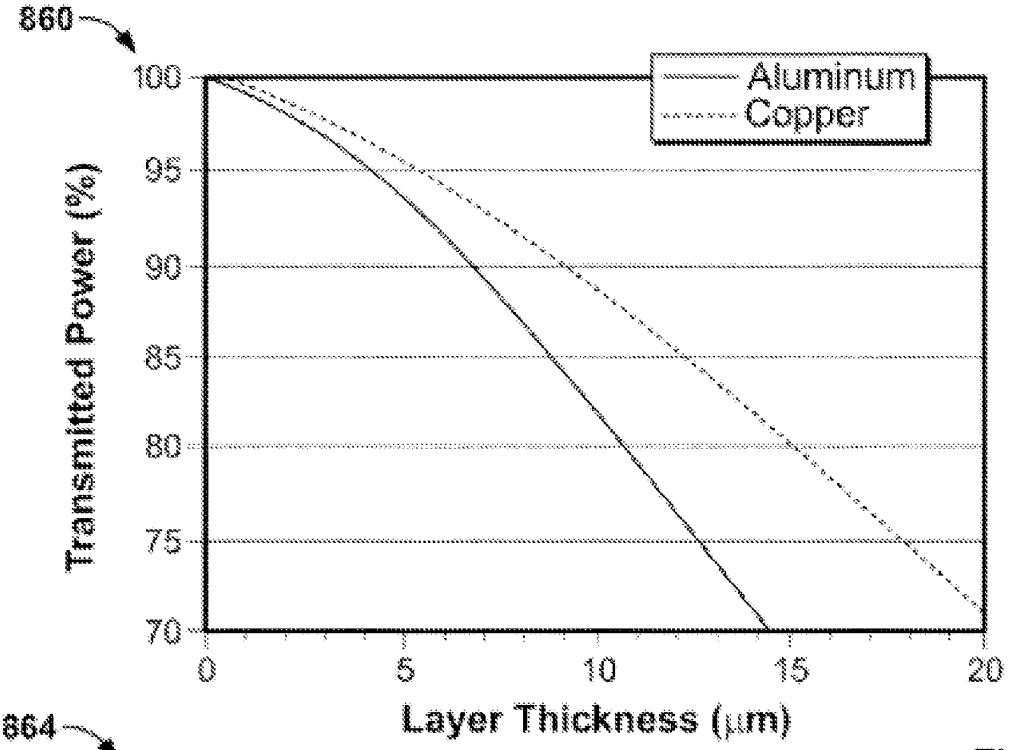

860
100
95
90
85
80
75
70
Transmitted Power (%)
0
5
10
15
20
Layer Thickness (μm)
Aluminum
Copper

FIG. 54

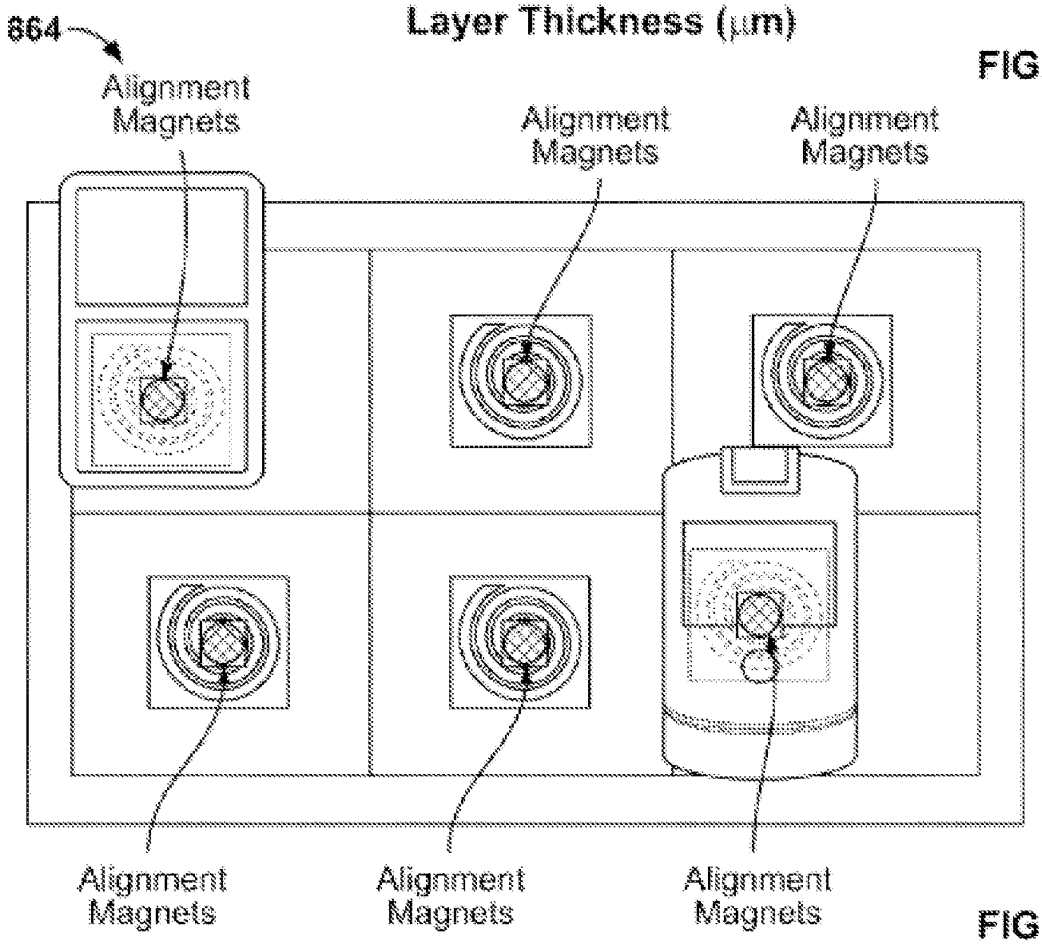

864
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets

FIG. 55

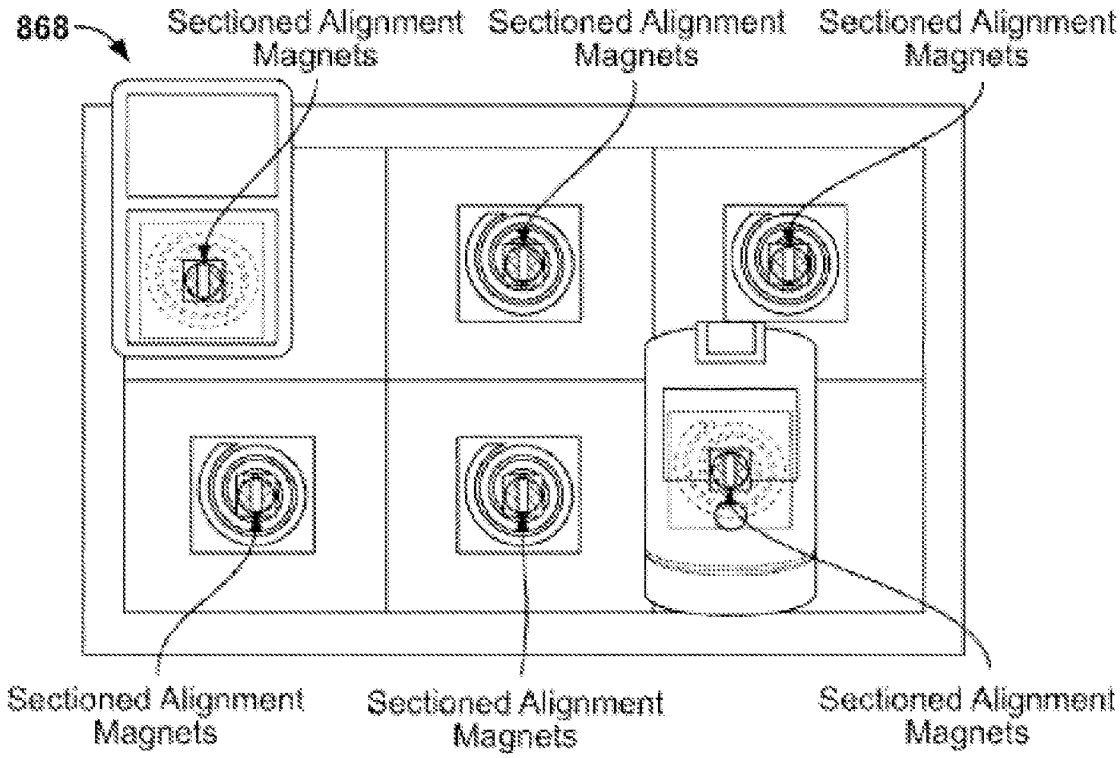

868
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets
Sectioned Alignment Magnets

FIG. 56

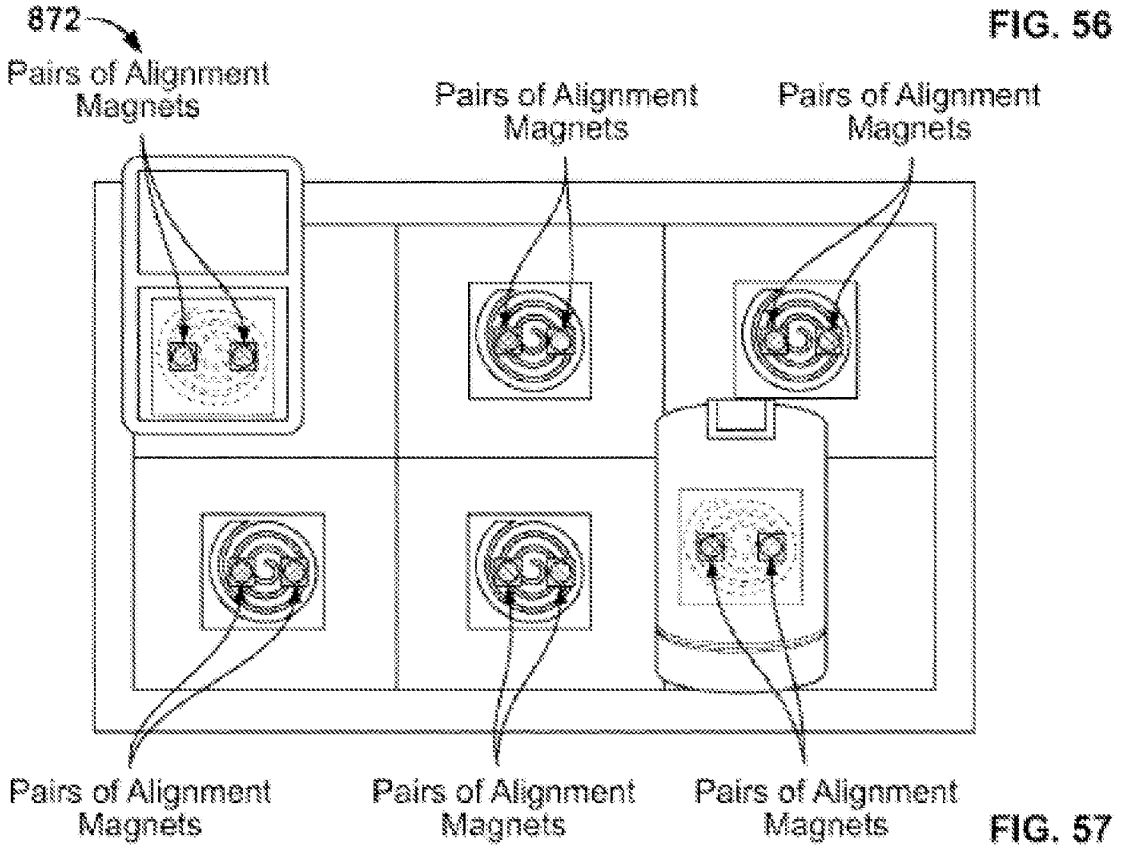

872
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets

FIG. 57

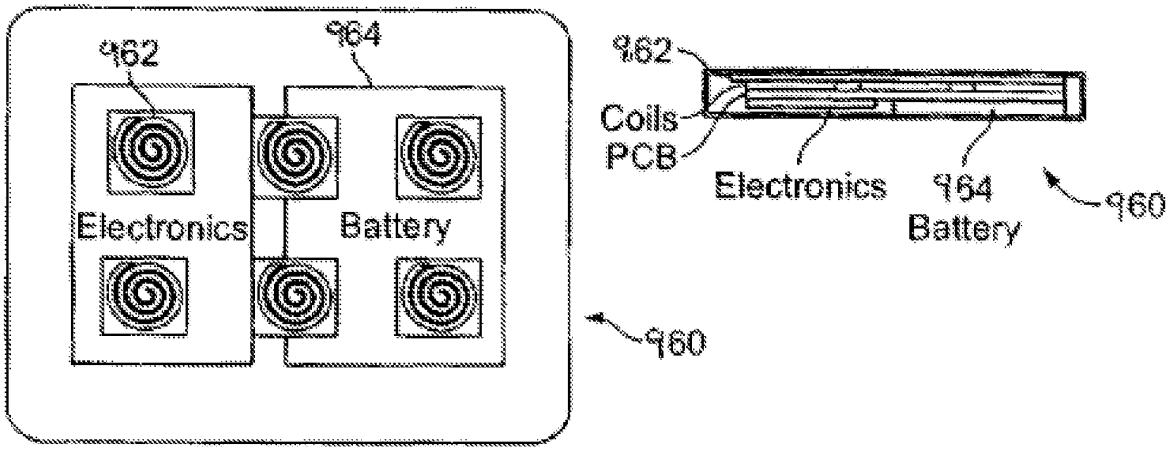

962
964
Electronics
Battery
960
962
Coils
PCB
Electronics
964
Battery
960

Fig. 58

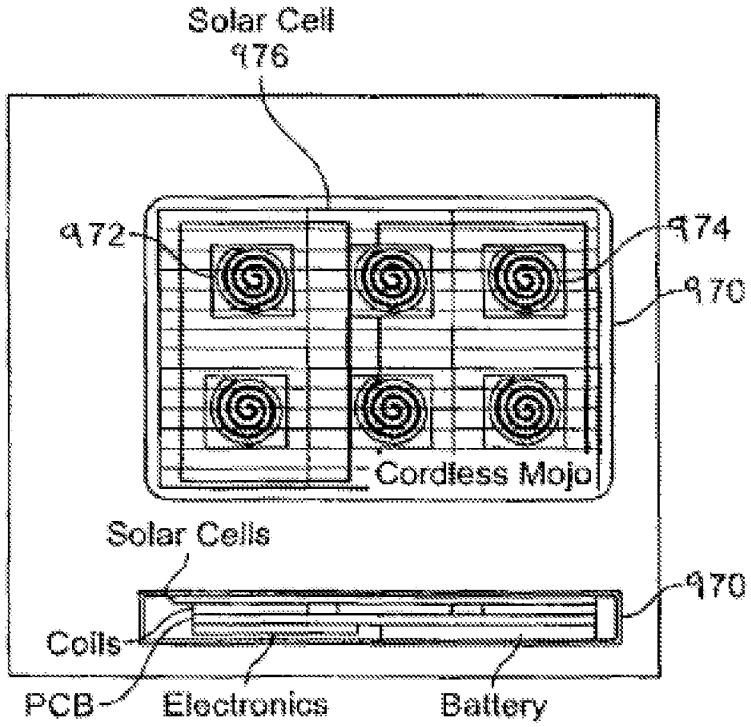

Solar Cell
976
972
974
970
Cordless Mojo
Solar Cells
970
Coils
PCB
Electronics
Battery

Fig. 59

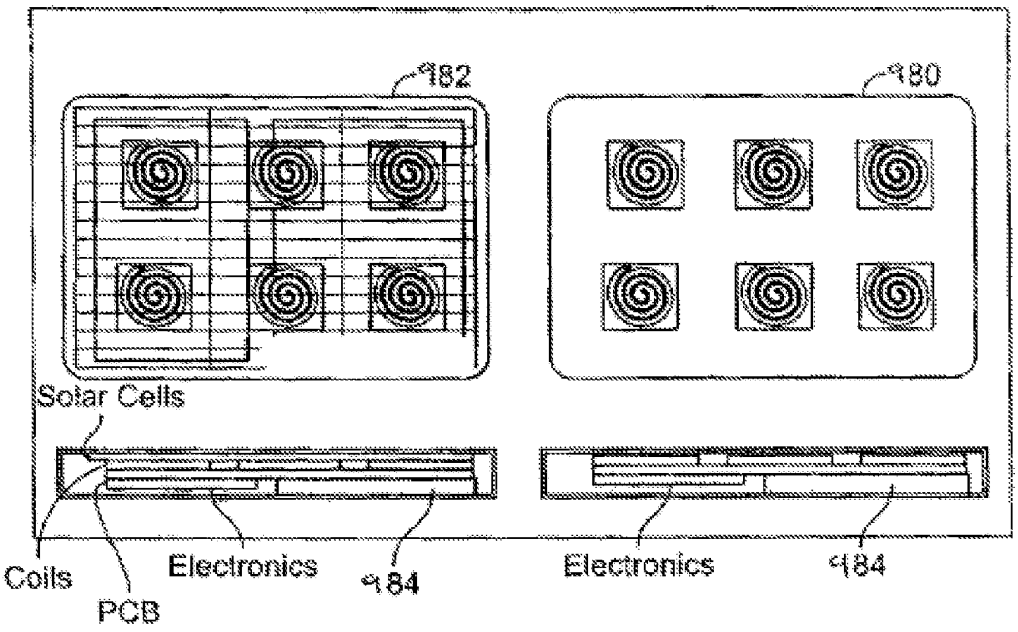

982
980
Solar Cells
Coils
PCB
Electronics
984
Electronics
984

Fig. 60

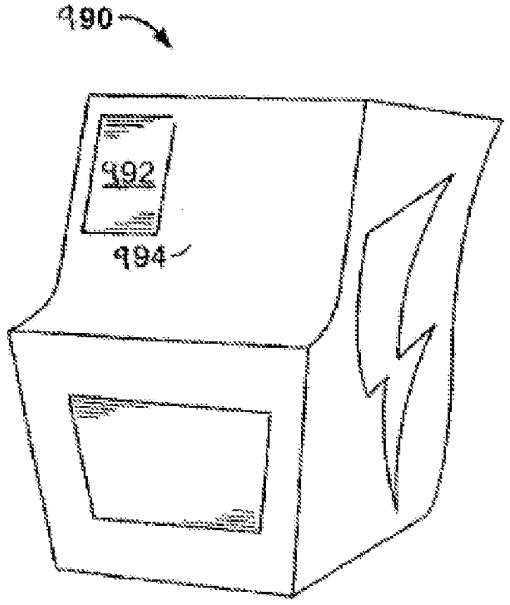

990
992
994

Fig. 61

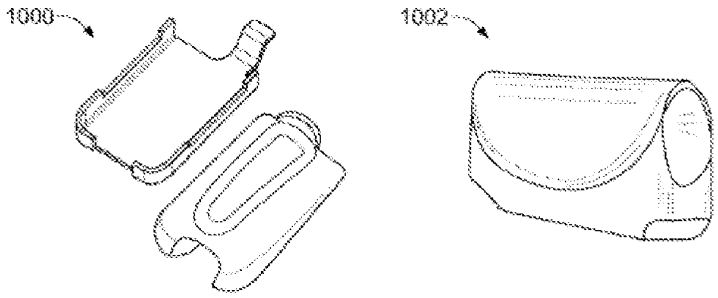


Fig. 62

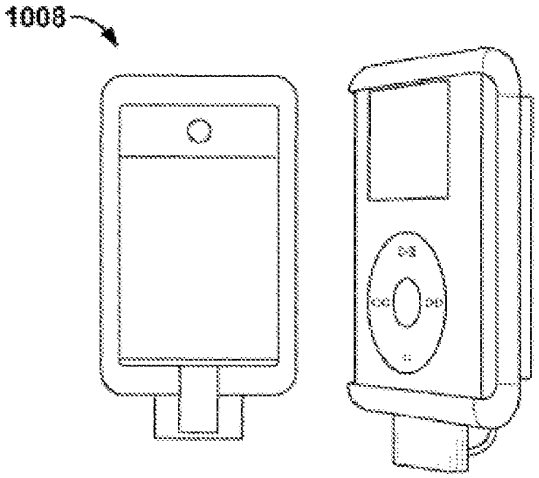


Fig. 63

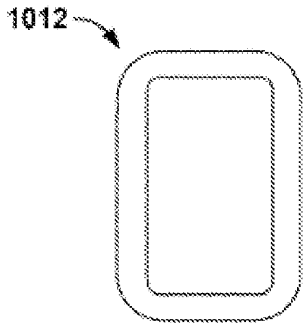


Fig. 64

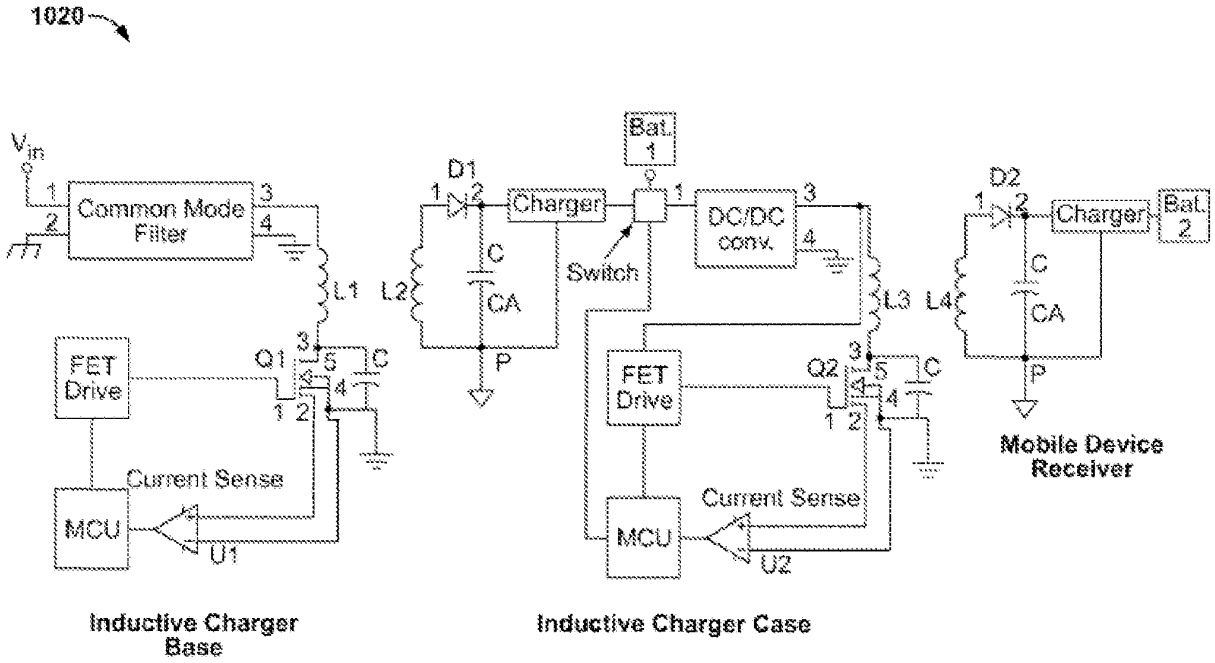

1020
V_{in}
Common Mode Filter
L1
L2
FET Drive
Q1
C
Current Sense
MCU
U1
Inductive Charger Base
D1
Charger
Bat. 1
DC/DC conv.
Switch
C
CA
P
FET Drive
Q2
C
Current Sense
MCU
U2
L3
L4
Inductive Charger Case
D2
Charger
Bat. 2
C
CA
P
Mobile Device Receiver

Fig. 65

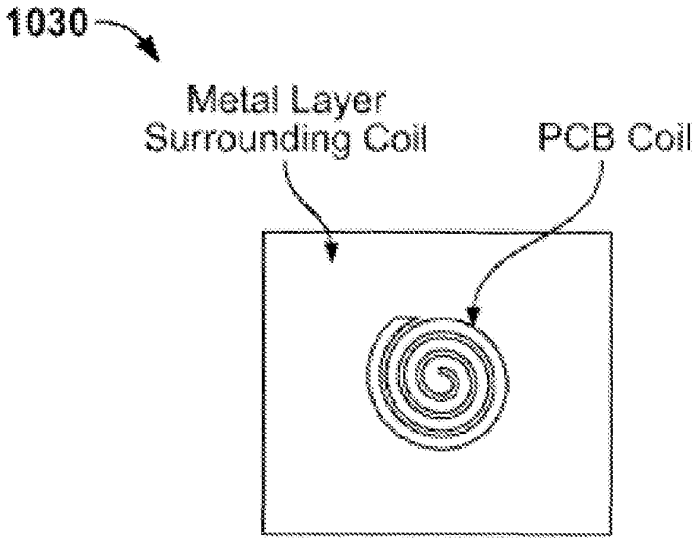

1030
Metal Layer Surrounding Coil
PCB Coil

Fig. 66

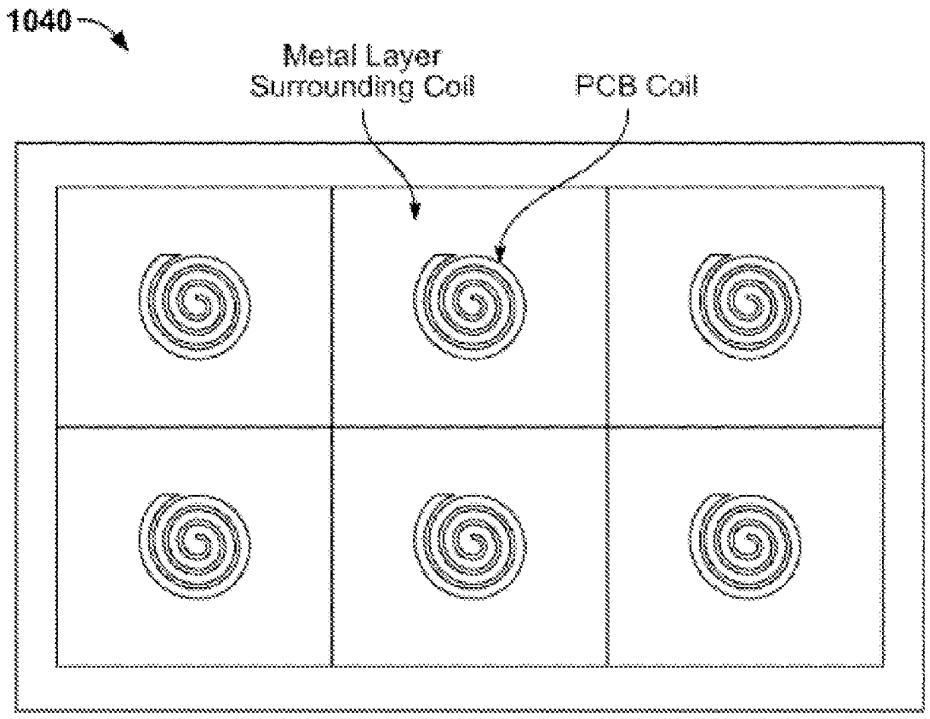

1040
Metal Layer Surrounding Coil
PCB Coil

Fig. 67

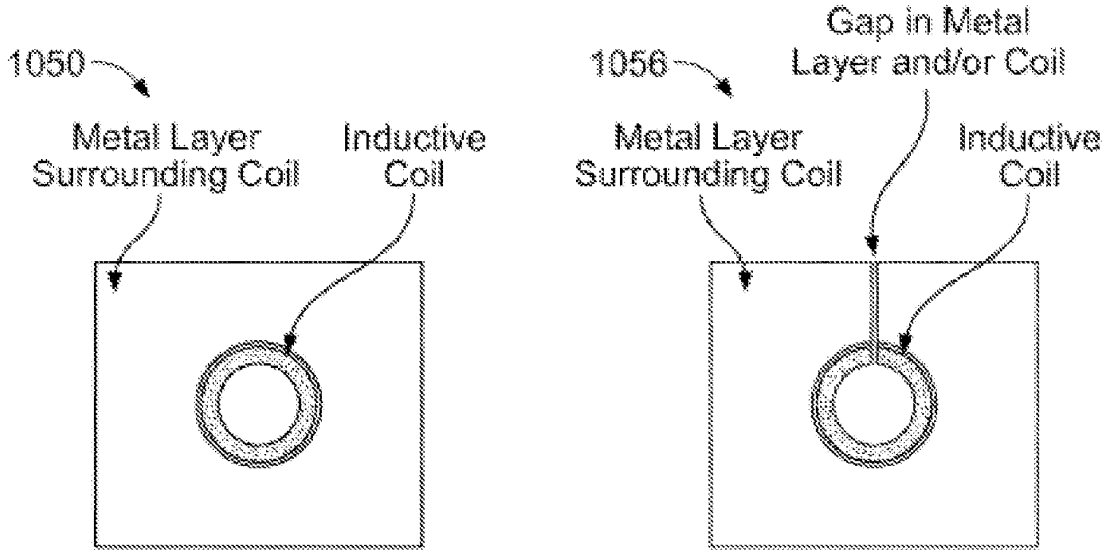

1050
Metal Layer Surrounding Coil
Inductive Coil
1056
Gap in Metal Layer and/or Coil
Metal Layer Surrounding Coil
Inductive Coil

Fig. 68

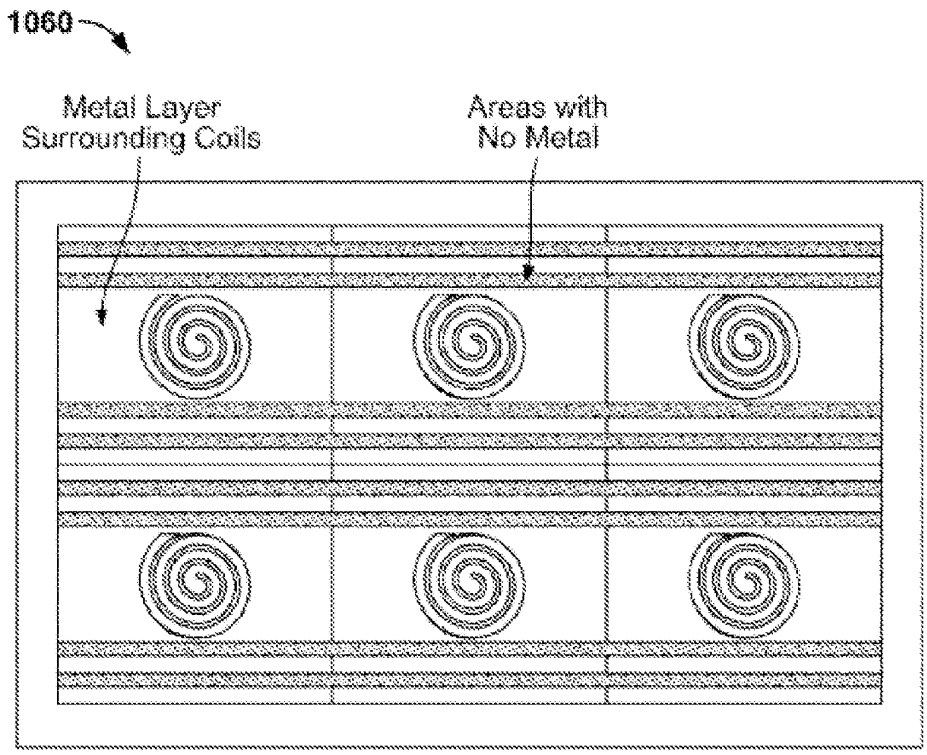

1060
Metal Layer Surrounding Coils
Areas with No Metal

Fig. 69

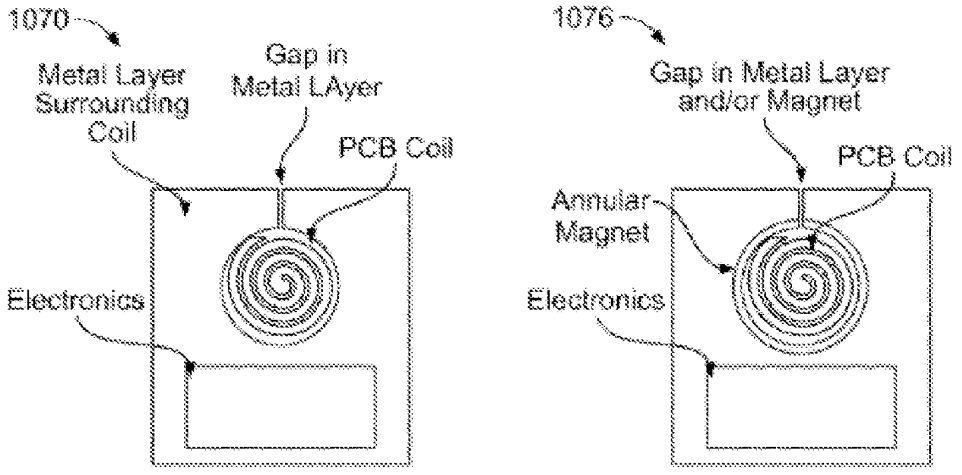

1070
Metal Layer Surrounding Coil
Gap in Metal LAyer
PCB Coil
Electronics
1076
Gap in Metal Layer and/or Magnet
PCB Coil
Annular Magnet
Electronics

Fig. 70

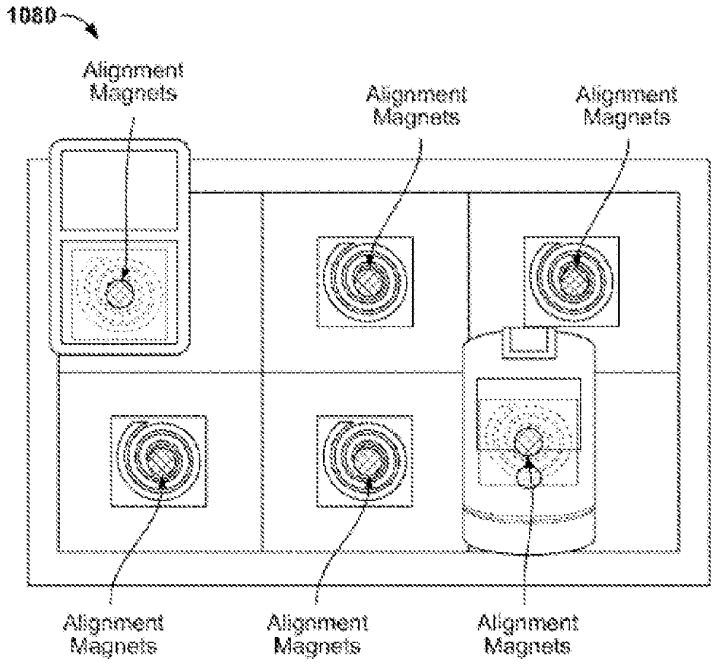

1080
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets
Alignment Magnets

Fig. 71

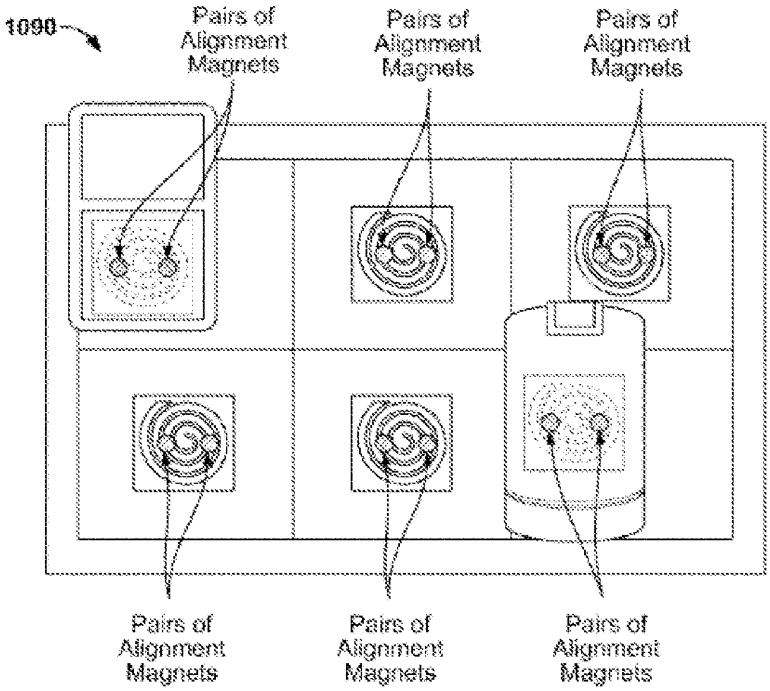

1090
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets
Pairs of Alignment Magnets

Fig. 72

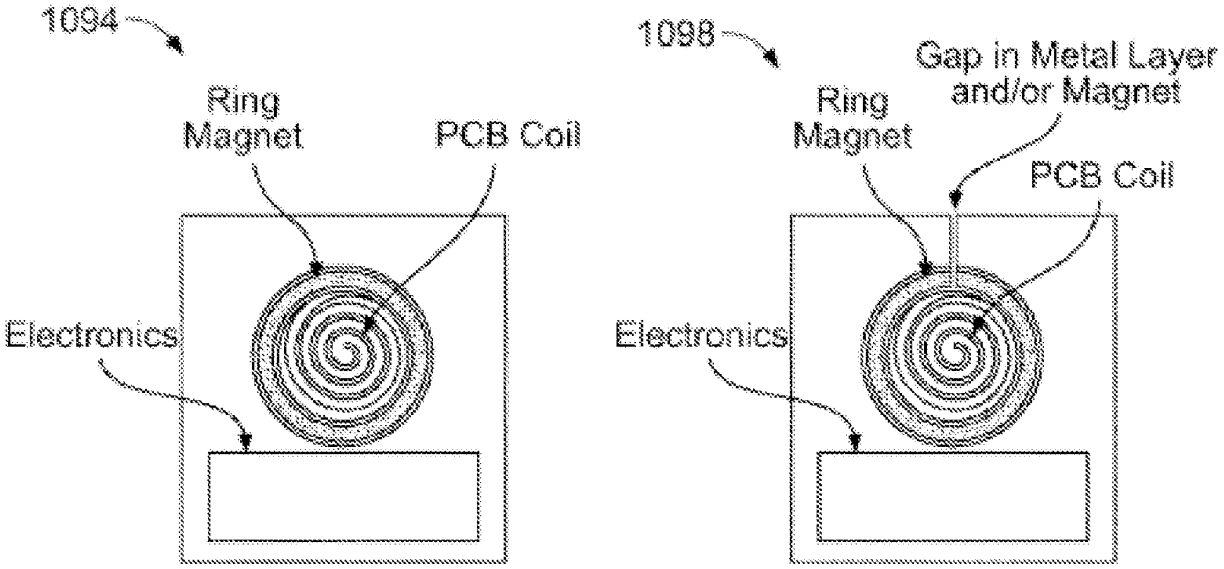


Fig. 73

APPROVED: /Z.Z/

02/15/2022

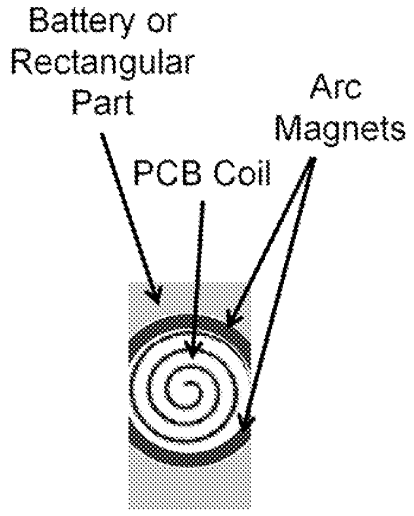


Fig. 74

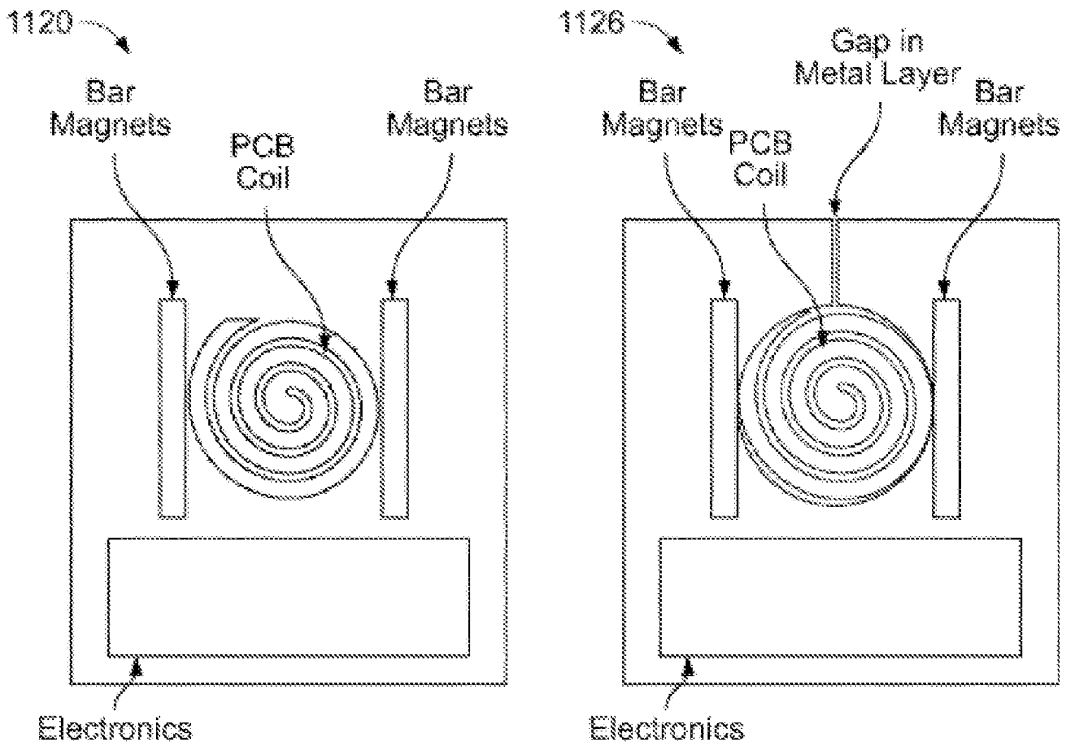

1120
Bar Magnets
PCB Coil
Bar Magnets
Electronics
1126
Bar Magnets
Gap in Metal Layer
PCB Coil
Bar Magnets
Electronics

Fig. 75

AMENDMENTS TO THE SPECIFICATION

Please amend paragraph 0043 as follows:

[0043] Figure 29 shows an embodiment that includes Zero Voltage ~~Setting~~ Switching (ZVS).

Please amend paragraph 00130 as follows:

[00130] In accordance with another embodiment, the receiver in the battery or mobile device also includes a means for providing information regarding battery manufacturer, required voltage, capacity; current, charge status, serial number, temperature, etc. to the charger. In a simplified embodiment, only the manufacturer, required voltage, and/or serial number is transmitted. This information is used by the charger or power supply to adjust the primary to provide the correct charge or power conditions. The regulator or charge management chip in the receiver can then regulate the current and the load to charge the battery correctly and can end charge at the end. In another embodiment, the receiver can control the charging process fully depending on the time dependent information on battery status provided to it. Alternatively, the charging process can be controlled by the charger in a similar manner. As described above, the information exchange between the charger and the receiver can be through an RF link or an optical transmitter/ detector, RFID techniques, Near-Field Communication (NFC), Felica, Bluetooth, WiFi, or some other method of information transfer. Similarly, the receiver can send signals that can be used by the charger to determine the location of the receiver to determine which coil or section of the charger or power supply to activate. The communication link can also use the same coil or wires as antenna for data transfer or use a separate antenna. In some embodiments the ~~received~~ receiver can use the actual capabilities of the mobile device (for example, the built-in Bluetooth or NFC capabilities of mobile phones) to ~~communicated~~ communicate with the charging or power supply pad.

Please amend paragraph 00188 as follows:

[00188] Figure 25 shows a figure of a circuit diagram 560 for time-based regulation in accordance with an embodiment.

Zero Voltage ~~Setting~~ Switching

Please amend paragraph 00190 as follows:

[00190] FIG. 26 shows a high-level view of a flyback power supply geometry 580 in accordance with an embodiment. During the time that the FET is closed, the current through the primary coil stores energy in this coil and during the period that the FET is open, this energy is transferred to the secondary (receiver) coil and into the load. The energy stored in the coil is directly proportional to the inductance of the coil and values of several hundred μHenry are typical for 10's or 100's of Watts of power supply power.

Please amend paragraph 00194 as follows:

[00194] For example, for a coil of 10 turns, an outer radius of 15 mm, and inner radius of zero, then L= l μH. While larger values can be obtained by increasing the number of turns or stacking a number of coils vertically and connecting them in series, this larger induction comes at the price of increased resistance and therefore loss in the inductor.

Please amend paragraph 00412 as follows:

[00412] FIG. 74 shows an embodiment 1100 in which magnetic arc shaped parts around a circular coil are used. This case may be combined with the matching magnet on the other coil having the same shape or a ring shape similar to FIG. 73. For example, in a mobile battery application where the battery with an integrated inductive receiver is charged by placement on an inductive charger pad, the size of the coil determines the received power and may require the width of the battery to be equal or similar to the receiver coil. To allow attachment of alignment magnets, two arcs as shown in FIG. [[9]] 74 can be attached to the coil. In this case, the magnets can be placed in between the battery and the coil PCB to allow the coil to be on the top surface and therefore closest to the charger coil. The matching magnet in the charger can be a ring or a similar set of arcs or another shape or size to facilitate alignment. If a ring is used behind the charger coil, then central symmetry between the two parts is retained and the parts can be rotated with respect to each other while keeping alignment for optimum operation.

Please amend paragraph 00418 as follows:

[00418] In any of the above geometries, if any additional eddy currents are generated as a result of the presence of the magnets, the effect can be minimized by fabricating the [[coil]] magnet from low electrical conductivity materials or ceramics, layering the magnet into thin sheets to increase resistivity, using bonded material in an epoxy matrix, roughing the surface, cutting gaps in the material to reduce circular motion of electrons, or other common techniques to increase the resistivity. The magnet can also be manufactured from segments that are not electrically connected to prevent electrons to be able to travel around a circular path. For example, the ring magnet can be manufactured, formed or attached to the coils from two or four ring arcs that are not electrically in contact or attached to each other, using a non-conducting epoxy to form a full ring, or parts of a ring.

PTO/SB/08a (02-18)
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(Not for submission under 37 CFR 1.99)

Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Zixuan Zhou
Attorney Docket Number	AFPA-01013US7

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	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5
	1	Notice of Allowance mailed on February 16, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-2.	
	2	Amendment after Notice of Allowance dated February 3, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-6.	
	3	Notice of Allowance mailed January 31, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-2.	
	4	Amendment after Notice of Allowance dated January 28, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-14.	
	5	Notice of Allowance mailed January 18 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-7.	
	6	Preliminary Amendment dated January 5, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-14.	
	7	Preliminary Amendment dated December 16, 2021, filed in U.S. Patent Application No. 17/472,351, pages 1-11.	
	8	Preliminary Amendment dated December 12, 2021, filed in U.S. Patent Application No. 17/472,351, pages 1-12.	

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	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

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	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

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OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Kent B. Chambers/	Date (YYYY-MM-DD)	2022-03-01
Name/Print	Kent B. Chambers	Registration Number	38839

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal	
Application Number:	17507323
Filing Date:	21-Oct-2021
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Kent Bryan Chambers/Anita Chambers
Attorney Docket Number:	AFPA-01013US7
Filed as Large Entity	
Filing Fees for Utility under 35 USC 111(a)	

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	260	260
		Total in USD ($)		**260**

Electronic Acknowledgement Receipt	
EFS ID:	45121036
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers/Anita Chambers
Filer Authorized By:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	01-MAR-2022
Filing Date:	21-OCT-2021
Time Stamp:	20:53:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$260
RAM confirmation Number	E202231K54273728
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	AFPA-01013US7_IDS10.pdf	1034742 231d325d22619b279097c25e28c6c017d96c2aa5	no	5
Warnings:					
Information:					
2		AFPA-01001US5_PH_thru_2022-03-01.pdf	2486531 8924b14821584f5b3efc53a3f6aabea07ea9030d	yes	68

Multipart Description/PDF files in .zip description

Document Description	Start	End
Non Patent Literature	1	2
Non Patent Literature	3	8
Non Patent Literature	9	10
Non Patent Literature	11	24
Non Patent Literature	25	31
Non Patent Literature	32	45
Non Patent Literature	46	56
Non Patent Literature	57	68

Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	37986 6a5550e84e7214889711f3e2954c612b64dd6b30	no	2
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Total Files Size (in bytes):	3559259

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

33438 7590 03/02/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
ZHOU, ZIXUAN	

ART UNIT	PAPER NUMBER
2859	

NOTIFICATION DATE	DELIVERY MODE
03/02/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

USPTO@dockettrak.com
anita@tcciplaw.com
tmunoz@tcciplaw.com

Applicant-Initiated Interview Summary	**Application No.** 17/507,323	**Applicant(s)** Partovi et al.		
	Examiner ZIXUAN ZHOU	**Art Unit** 2859	**AIA (First Inventor to File) Status** No	**Page** 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
ZIXUAN ZHOU	Primary Examiner	Telephonic
Kent Chambers (Reg. No. 38,839)	Attorney of Record	

Date of Interview: 25 February 2022

Issues Discussed:

Election/Restriction

Discussed the interview summary agenda, it appears all of the amended claims are drawn to the invention of the originally examined claims. Therefore, agreement has been reached.

/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

Electronic Acknowledgement Receipt

EFS ID:	45148892
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers
Filer Authorized By:	
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	04-MAR-2022
Filing Date:	21-OCT-2021
Time Stamp:	14:53:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment/Request for Reconsideration-After Non-Final Rejection	AFPA-01013US7_RNFOA-2_2022-02-22.pdf	159927 c22a8dec2b717818908c3aedbebc85dd1c6d04d2	no	31

Warnings:

Information:	
Total Files Size (in bytes):	159927

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Afshin Partovi, Michael Sears		
Applicant:	Mojo Mobility, Inc.		
Title:	Efficiencies and Flexibilities in Inductive (Wireless) Charging		
Application No.:	17/507,323	Filing Date:	March 3, 2022
Examiner:	Zixuan Zhou	Group Art Unit:	2859
Docket No.:	AFPA-01013US7	Customer No.:	33438

ELECTRONICALLY FILED

Austin, Texas
March 3, 2022

RESPONSE TO NON-FINAL OFFICE ACTIONS AND INTERVIEW SUMMARY RECORD

This paper is responsive to the Office actions dated January 27, 2022 and February 22, 2022, having a shortened statutory period expiring April 22, 2022. This paper also includes an Interview Summary Record. Further examination and reconsideration are respectfully requested.

The USPTO is also authorized to charge any underpayment of fees to Deposit Account No. 502264.

INTERVIEW SUMMARY RECORD

On February 25, 2022, Examiner Zhou and Kent Chambers, attorney of record, conducted a telephonic interview to discuss the February 22, 2022 Election/Restrictions Office Action of the amended claim 1 and new claims 21-49. The Examiner and Mr. Chambers agreed that all of the claims are drawn to the invention of the originally examined claims. Accordingly, the Examiner and Mr. Chambers agreed that restriction is not required, and Applicant will refile the claims for examination in the present application.

AMENDMENTS TO THE SPECIFICATION

Please amend the Summary section in paragraph 0012 as follows:

[0012] In one embodiment, a portable device includes a battery and a receiver unit coupled to the battery. The receiver unit is configured to receive inductive power from an inductive charging system. The receiver unit includes a receiver coil, a ferromagnetic layer, and a receiver circuit powered by the inductive charging system. The receiver circuit includes a receiver rectifier circuit, a receiver communication and control circuit, a voltage regulator, and a battery charging circuit. When a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the receiver rectifier circuit and is used by the voltage regulator to power and activate the microcontroller and used by the battery charging circuit to charge the battery of the portable device. Upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement and periodically communicate to the base unit additional information. In other embodiments, [[A]] a portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices or rechargeable batteries is disclosed herein. In accordance with an embodiment the system comprises 2 parts: The first part is a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device or rechargeable battery. The receiver may comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device.

Please amend the Summary section in paragraph 0014 as follows:

[0014] In another embodiment, an apparatus includes a system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil

and a receiver circuit. The system includes a first primary coil, a first drive circuit, a first sense circuit, and a communication and control circuit. The communication and control circuit is configured to detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil. The communication and control circuit is also configured to operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate information detected in the current modulation in the first primary coil. The communication and control circuit is further configured to operate the first drive circuit according to a power requirement and charge algorithm profile to provide power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device. To charge the battery of the portable device the communication and control circuit is further configured to receive additional information, regulate in a closed loop feedback manner the voltage or current at the output of the receiver circuit, monitor for continued presence of the portable device and completion of the charging of the battery, and if the portable device is no longer present or charging is complete, stop operation of the first drive circuit for the provision of power inductively to the portable device. Additionally, in [[In]] accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or secondary side; and additional circuits and components that perform specialized tasks, such as mobile device identification, and automatic voltage or power-setting for different devices.

Please amend the Abstract on p. 108 as follows:

A system for providing power inductively to a portable device. The system includes a primary coil, a drive circuit, a sense circuit, and a communication and control circuit. The communication and control circuit is configured to perform operations, including detection of communication and drive circuit operations. A portable device that includes a receiver unit coupled to a battery and configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit The receiver unit includes a receiver coil, a ferromagnetic layer, and a receiver circuit. The receiver circuit includes a

receiver communication and control circuit to modulate current in the receiver coil to communicate with a base unit while the receiver circuit is being powered by the inductive charging system. ~~A system and method for variable power transfer in an inductive charging or power system. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile device, battery, or other device. In accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or receiver side; and additional circuits and components that perform specialized tasks, such as mobile device or battery identification, and automatic voltage or power-setting for different devices or batteries.~~

AMENDMENTS TO THE CLAIMS

1-20. Canceled.

21. (New) An apparatus comprising:

a system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system comprising:

a first primary coil that is substantially planar and substantially parallel to a surface of the system for providing power inductively to the portable device;

a first drive circuit, including a FET driver, a capacitor, and a FET switch, coupled to a DC voltage input and coupled to the first primary coil, wherein during operation the first drive circuit is configured to apply an alternating electrical current to the first primary coil at an operating frequency and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the plane of the first primary coil and the surface of the system to provide power inductively to the portable device, wherein the operating frequency is within a range of frequencies (i) that are near a resonance frequency of a circuit comprising the first primary coil and the capacitor, (ii) such that increasing values of the operating frequency within the range of frequencies would correspond to a lower voltage or current induced in an output of the receiver circuit and (iii) that allow activation and powering of the receiver unit and charging the battery of the portable device.

a first sense circuit to monitor current flow through the first primary coil during operation of the first drive circuit, wherein the first sense circuit includes a low pass filter and an amplifier to assist in detecting and amplifying a signal corresponding to a current modulation in the first primary coil induced by modulation of current in the receiver coil; and

a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit, configured to:

detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil;

operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate the information detected in the current modulation in the first primary coil, wherein the communication of information includes information to enable the communication and control circuit to configure the inductive transfer of power to the portable device, wherein the received communication of information includes:

information corresponding to a voltage or current induced by the first primary coil at the output of the receiver circuit;

a unique identification code;

a manufacturer code;

a charge algorithm profile; and

a power requirement;

operate the first drive circuit according to the power requirement and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

receive additional information in the current modulation in the first primary coil from the modulation of the current in the receiver coil corresponding to the voltage or current at the output of the receiver circuit while charging the battery of the portable device;

regulate in a closed loop feedback manner the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the first drive circuit while charging the battery of the portable device;

monitor for continued presence of the portable device and completion of the charging of the battery of the portable device based on the communication from the receiver circuit and detected by the communication and control circuit through the first sense circuit; and

if the portable device is no longer present or charging is complete, stop operation of the first drive circuit for the provision of power inductively to the portable device.

22. (New) The apparatus of claim 21, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

23. (New) The apparatus of claim 21, wherein the DC voltage input is configured to receive a DC voltage and the system further comprises:

a voltage regulator circuit coupled to the DC voltage input and to the microcontroller, wherein the microcontroller is configured to control the voltage regulator circuit to switch a level of the DC voltage between multiple discrete values based on the received communication of information and the additional information received by the communication and control circuit from the portable device.

24. (New) The apparatus of claim 21 wherein:

the DC voltage input is configured to connect to and receive a DC voltage from a DC power supply via a universal serial bus (USB); and

the communication and control circuit is further configured to communicate with the DC power supply via the USB.

25. (New) The apparatus of claim 21 wherein:

the first primary coil is one of multiple primary coils in the system and the first drive circuit is one of multiple drive circuits in the system; and

the system further comprises means for operating the multiple drive circuits to drive the multiple primary coils to separately control simultaneously induced charging voltages and/or currents in receiver units of multiple portable devices coupled to the multiple primary coils.

26. (New) The apparatus of claim 21 wherein:

the first primary coil is a substantially spiral-shaped coil and is fabricated from a copper conductor with a thickness optimized for lower resistance due to skin effect at an operating frequency range of 100 kHz to 1 MHz relative to resistance at an operating frequency outside the range of 100 kHz to 1 MHz;

a number of turns of the first primary coil, an inner radius of the first primary coil, and an outer radius of the first primary coil are selected for an inductance in a range of 1 microhenry to 100 microhenries; and

the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

27. (New) The apparatus of claim 21, wherein the communication and control circuit is further configured to operate the first drive circuit for a short period of time to detect a current draw through the first primary coil indicating a possible presence of the portable device for charging, wherein the short period of time is less than that needed to activate and power a receiver unit in the portable device.

28. (New) The apparatus of claim 21, wherein the system further comprises a high heat conductivity layer positioned proximate to the first primary coil and at least covering an area surrounding the first primary coil to disperse any heat generated during provision of power inductively.

29. (New) The apparatus of claim 21, further comprising a near field communication (NFC) antenna for communication of data, and further wherein:

the first primary coil comprises a Printed Circuit Board (PCB) coil;

the PCB coil comprises multiple layers of substantially similar copper thickness and substantially similar spiral-shaped coil patterns connected by vias wherein each layer comprises 1 to 4 ounce (oz) copper thickness material; and

the operating frequency is within a range of 100 kHz to 1 MHz.

30. (New) The apparatus of claim 21, wherein:

the system further comprises a near field communication (NFC) antenna for communication of data;

the first primary coil comprises a copper PCB coil structure;

the PCB coil structure includes a substantially spiral-shaped pattern of multiple coil layers;

each of the multiple coil layers comprises a PCB coil having an inner port and an outer port;

the inner ports of each of the coil layers are coupled together by vias and form a first common pad;

the outer ports of the coil layers are coupled together by vias and form a second common pad; and

the two common contact pads provide electrical coupling of the first primary coil for applying the alternating electrical current to the first primary coil.

31. (New) The apparatus of claim 21, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit, the portable device is a first portable device, and the receiver unit of the first portable device is a first receiver unit, the apparatus further comprises:

a second portable device;

the system is incorporated into the second portable device; and

the second portable device further comprises:

an internal, rechargeable battery and a DC-to-DC voltage converter to provide power to the system to inductively power the first receiver unit of the first portable device and charge the battery of the first portable device;

a second receiver unit coupled to the first primary coil to enable the internal, rechargeable battery to be recharged inductively through the first primary coil; and

the communication and control circuit is further configured to control whether the second portable device is receiving power inductively or charging the first portable device inductively.

32. (New) The apparatus of claim 21 wherein the first primary coil includes a magnetic core of ferromagnetic material within a central area of the first primary coil and the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

33. (New) The apparatus of claim 21 wherein:

the system comprises a permanent magnet within a central area of the first primary coil;

the permanent magnet includes a substantially flat surface;

the permanent magnet is magnetized in a direction perpendicular to the substantially flat surface of the magnet; and

the permanent magnet is a ceramic permanent magnet, wherein the permanent magnet impedes eddy current generation and heating of the permanent magnet by the alternating magnetic field during inductive power transfer.

34. (New) The apparatus of claim 21 wherein:

the system comprises a permanent magnet within a central area of the first primary coil; and

the permanent magnet comprises magnetic material bonded using a polymer matrix configured to form a bonded permanent magnet in a substantially flat shape and magnetized with a magnetization direction substantially perpendicular to the substantially flat surface of the magnet, wherein the permanent magnet impedes

eddy current generation and heating of the permanent magnet by the alternating magnetic field during inductive power transfer.

35. (New) The apparatus of claim 21 further comprising a common mode electrical noise filter circuit coupled to the DC voltage input to shield the DC voltage input from Electromagnetic Interference (EMI) during the provision of power inductively to the portable device.

36. (New) The apparatus of claim 21 wherein:

the first primary coil includes multiple layers of copper PCB of similar spiral-shaped coil pattern interconnected by vias; and

the first primary coil includes an outer surface to face a surface of the receiver coil and an inner surface to face away from the surface of the receiver coil; and

the system further comprises:

a ferromagnetic core located in a central area of the first primary coil;

a planar ferromagnetic layer located proximate to the inner surface of the first primary coil; and

a metallic layer located proximate to the planar ferromagnetic layer, wherein the ferromagnetic layer is located between the first primary coil and the metallic layer.

37. (New) The apparatus of claim 21 further comprising multiple, arc-shaped, permanent magnet components arranged in a full or partial circular pattern surrounding a perimeter of the first primary coil to assist in alignment of the receiver coil with the first primary coil, wherein:

the magnet components are disposed concentric with the first primary coil; and

adjacent magnet components are separated by gaps to prevent an electrical connection between the magnet components.

38. (New) The apparatus of claim 21, further wherein:

the first primary coil comprises a substantially planar, metallic spiral-shaped conductor;

the first primary coil includes:

substantially planar first side closest to the surface of the system for providing inductive power to the inductive receiver unit; and

a second side opposite the first side;

the system further comprises a metallic first shield layer positioned proximate the first side of the first primary coil and opposite the second side of the first primary coil such that the first shield layer covers the metallic spiral-shaped conductor of the first side of the first primary coil that faces the surface of the system; and

the first shield layer has a metal thickness in a range of 1 micrometer to 70 micrometers.

39. (New) The apparatus of claim 21, wherein:

the first primary coil, first drive circuit, first sense circuit, and the communication and control circuit comprise a first inductive charger module;

the first module further includes mechanical components and electrical components for interconnecting mechanically and electrically with a second inductive charger module to form a modular system; and

the electrical components are configured to allow the first inductive charger module and the second inductive charger module to share electrical power.

40. (New) A portable device comprising:

a battery; and

a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:

a receiver coil which has a substantially planar shape and is located parallel to a surface of the portable device so that an alternating magnetic field, when received through the surface of the portable device from the primary coil in the base unit in a direction substantially perpendicular to the plane of the receiver coil, inductively generates a current in the receiver coil to provide power inductively to the portable device when the portable device is placed on the base unit for charging the battery of the portable device;

a ferromagnetic layer placed under the receiver coil on a side of the receiver coil away from the surface of the portable device; and

a receiver circuit powered by the inductive charging system, wherein the receiver circuit comprises:

a receiver rectifier circuit including a rectifier and a capacitor;

a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system;

a voltage regulator coupled to an output of the receiver rectifier circuit and coupled to the microcontroller to provide a regulated voltage to power the microcontroller from the received inductive power; and

a battery charging circuit to charge the battery, wherein the battery charging circuit is coupled to the output of the receiver rectifier circuit and coupled to the battery and begins drawing current only when an output of the receiver rectifier circuit reaches a set minimum voltage value;

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the receiver rectifier circuit and is used by the voltage regulator to power and activate the microcontroller and used by the battery charging circuit to charge the battery of the portable device; and

wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to:

communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement; and

periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device.

41. (New) The portable device of claim 40 further comprising a magnetic core of ferromagnetic material within a central area of the receiver coil and a near field communication (NFC) antenna and circuitry for communication of data with other devices.

42. (New) The portable device of claim 40, wherein the receiver circuit further comprises a limiter to limit the output voltage of the receiver rectifier circuit to a maximum value within a safe operating range of the battery charging circuit.

43. (New) The portable device of claim 40, further comprising an output disconnect switch configured to connect and disconnect an output power from the receiver circuit to the battery, wherein:

the communication and control unit is further configured to control the output disconnect switch to disconnect the battery from the output power from the receiver circuit during at least some of the communication with the base unit.

44. (New) The portable device of claim 40, wherein:

the receiver coil includes a substantially planar, metallic, spiral-shaped conductor;

the spiral-shaped conductor includes:

a substantially planar first side for receiving inductive charging power from the primary coil; and

a second side opposite the first side, wherein the first side is closer than the second side to the surface of the portable device through which inductive charging power from the primary coil is received;

the portable device further includes a metallic first shield layer positioned proximate the first side of the receiver coil opposite the second side of the receiver coil such that the first shield layer covers the first side of the spiral-shaped conductor and is located between the surface and the spiral-shaped conductor; and

the first shield layer has a metal thickness in a range of 1 micrometer to 70 micrometers.

45. (New) The portable device of claim 40, wherein:

the portable device is configured to operate in an inductive power receiving mode and in an inductive power transfer mode,

in the inductive power receiving mode, the portable device is configured to receive power inductively via the receiver coil to charge the battery of the portable device, and

in the inductive power transfer mode, the portable device is configured to operate an internal inductive charging system included in the portable device for providing power inductively to a second portable device comprising a second battery and a second receiver unit including a second receiver coil and a second receiver circuit, the internal inductive charging system comprising:

a drive circuit, including a FET driver, a second capacitor, and a FET switch, coupled to a DC voltage input and coupled to the receiver coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the receiver coil at an operating frequency and duty cycle to provide power inductively to the second portable device, wherein the operating frequency is within a range of frequencies (i) that are near a resonance frequency of a circuit comprising the receiver coil and the second capacitor, (ii) such that increasing values of the operating frequency within the range of frequencies would correspond to a lower voltage or current induced in an output of the second receiver circuit and (iii) that allow activation and powering of the second receiver unit and charging the second battery of the second portable device; and

a sense circuit to monitor current flow through the receiver coil during operation of the drive circuit, wherein the sense circuit includes a filter and an amplifier to detect and amplify a signal corresponding to a current modulation in the receiver coil induced by modulation of current in the second receiver coil; and

wherein the communication and control circuit is coupled to the drive circuit and the sense circuit and is further configured to:

detect, through the sense circuit, a received communication of information in the current modulation in the receiver coil;

operate the drive circuit to inductively transfer sufficient power to the second receiver unit to activate and power the second receiver circuit to enable the second receiver circuit to communicate the received communication of information in the current modulation in the receiver coil, wherein the received communication of information includes information to enable the communication and control circuit to configure the provision of power inductively to the second portable device, wherein the received communication of information includes:

information corresponding to a voltage or current induced by the receiver coil at the output of the second receiver circuit;

a unique second identification code;

a second manufacturer code;

a second charge algorithm profile; and

a second power requirement; and

operate the drive circuit according to the second power requirement and second charge algorithm profile to provide the power from the receiver coil to the second receiver coil to power the second receiver unit and charge the second battery of the second portable device, wherein to charge the second battery of the second portable device the communication and control circuit is further configured to:

receive additional received information in the current modulation in the receiver coil from the modulation of the current in the second receiver coil corresponding to the voltage or current at the output of the second receiver circuit while charging the second battery of the second portable device; and

regulate in a closed loop feedback manner the voltage or current at the output of the second receiver circuit in accordance with the additional received information corresponding to the voltage or current at the output of the second receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the drive circuit while charging the second battery of the second portable device.

46. (New) The portable device of claim 40 wherein the portable device is a case for holding and charging a Bluetooth headset, and the battery is configured to charge the Bluetooth headset when placed in the case.

47. (New) The portable device of claim 40, further comprising multiple, arc-shaped, permanent magnet components arranged in a full or partial circular pattern surrounding a perimeter of the receiver coil to assist in alignment of the receiver coil with the primary coil, wherein:

the magnet components are disposed concentric with the first receiver coil; and

adjacent magnet components are separated by gaps to prevent an electrical connection between the magnet components.

48. (New) A system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system comprising:

a primary coil that is substantially planar and parallel to a surface of the system for providing power inductively to the portable device, wherein the primary coil comprises a flexible Printed Circuit Board (PCB), multi-turn coil having multiple layers of substantially similar patterns of substantially spiral-shaped conductors of 1 to 4 ounce copper thickness for each layer and having coil patterns electrically connected with vias between the layers;

a drive circuit, including a FET driver, a capacitor and a FET switch, coupled to a DC voltage input and coupled to the primary coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the primary coil at

an operating frequency within a range of 100 kHz to 1 MHz and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the surface of the primary coil to provide power inductively to the portable device;

a sense circuit to monitor current flow through the primary coil during operation of the drive circuit to sense a current modulation in the primary coil from a modulation of a current in the receiver coil; and

a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to:

detect, through the sense circuit, a received communication of information in the current modulation in the primary coil;

operate the drive circuit to inductively transfer sufficient power to the inductive receiver unit to activate and power the receiver circuit to enable the receiver circuit to communicate the information in the current modulation in the primary coil;

from the information communicated by the receiver circuit, determine a power parameter; and

operate the drive circuit according to the power parameter to provide power inductively from the primary coil to the receiver coil to power the microcontroller and to charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

receive additional information in the current modulation in the primary coil from modulation of the current in the receiver coil corresponding to a voltage or current at an output of the receiver circuit while charging the battery of the portable device; and

regulate in a closed loop feedback manner, the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency, the duty cycle, and the DC voltage input to

the drive circuit during charging of the battery of the portable device.

49. (New) The system of claim 48, wherein:

the sense circuit includes a low pass filter and an amplifier; and

the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

50. (New) A portable device comprising:

a battery; and

a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:

a receiver coil having a substantially planar shape and located parallel to a surface of the portable device so that an alternating magnetic field, when received through the surface of the portable device from the primary coil in the base unit in a direction substantially perpendicular to the plane of the receiver coil, inductively generates a current in the receiver coil to provide power inductively to the portable device when the portable device is placed on the base unit for charging the battery of the portable device;

a ferrite material layer placed under the receiver coil on a side of the receiver coil opposite to the surface of the portable device;

a receiver circuit powered by the inductive charging system, wherein the receiver circuit comprises:

a receiver rectifier circuit including a rectifier and a capacitor; and

a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system;

an output disconnect switch to interrupt a flow of current from an output of the receiver unit to the battery;

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the rectifier circuit and is used to power and activate the microcontroller and to charge the battery of the portable device;

wherein upon powering and activation of the microcontroller by the primary coil in the base unit, the receiver circuit is configured to:

communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil; and

periodically communicate to the base unit information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the battery of the portable device; and

wherein the communication and control unit is configured to control the disconnect switch to disconnect the flow of current from the output of the receiver unit to the battery during at least some of the communication with the base unit.

REMARKS

Applicant has received two Office Actions: an initial January 27, 2022 Non-Final Office Action, and a February 22, 2022 Election/Restriction Office Action.

On February 10, 2022, Applicant filed a Response to the January 27, 2022 Office Action. In the February 22, 2022 Office Action the Examiner stated, "The amendment filed on 02/10/2022 canceling all claims drawn to the elected invention and presenting only claims drawn to a non-elected invention is non-responsive (MPEP § 821.03) and has not been entered." Accordingly, originally filed claims 1-20 are pending.

The Examiner and Kent Chambers, attorney of record conducted a telephonic interview on February 25, 2022. During the February 25, 2022, telephonic interview the Examiner agreed that the claims as filed by Applicant on February 10, 2022 in response to the January 27, 2022 Office Action are drawn to the same invention as the originally filed claims 1-20.

Because the claims as filed on February 10, 2022 in response to the January 27, 2022 Office Action were not entered, in the present Response Applicant has refiled the same independent claims discussed in the interview as new claims 21, 40, 48, and 50. New, refiled claims 21-50 are the same claims discussed in the February 25, 2022 interview that the Examiner agreed to enter with the only difference being (1) corrections of minor, typographical errors and changes to dependent claims 28, 37, and 47 (claims 27, 36, and 46, respectively in the February 10, 2022 Response). The independent claims discussed on February 25, 2022 are identical to new independent claims 21, 40, 48, and 50 with correction of minor, typographical errors.

Rather than amending the originally filed claims, for clarity and convenience to the Examiner, Applicant has refiled claims 21-50 as clean versions of the claims submitted in the January 27, 2022 Office Action and considered during the February 25, 2022 interview. Accordingly, Applicant's Response herein is consistent with the February 25, 2022 agreement with the Examiner, and Applicant respectfully requests entry of the claims as filed herein.

Claims Status

Claims 1-20 have been canceled without prejudice or disclaimer of the subject matter recited therein.

Claims 21-49 have been added.

February 10, 2022 Amendments to the Specification and Figures

In accordance with the February 22, 2022 Office Action:

- The amended specification on February 10, 2022 was entered.
- The replacement sheets for all the drawings submitted on February 10, 2022 was approved.

PRESENT AMENDMENTS TO THE SPECIFICATION

The Specification has amended as follows:

- The Summary section in paragraphs 0012 and 0014 has been updated to reflect the current state of claims 40 and 21, respectively.
- The Abstract has been amended to reflect an abstract of the claims.

No new matter has been added.

February 22, 2022 Election/Restrictions Office Action

In response to the February 22, 2022 Election/Restrictions Office Action, the Examiner and Applicant's representative Kent Chambers conducted a telephonic interview to discuss the Election/Restrictions. As indicated in the Examiner's March 2, 2022 *Applicant-Initiated Interview Summary*, the Examiner and the Applicant agreed that the claims as submitted on February 10, 2022 in response to the January 27, 2022 Office Action are drawn to the invention of the originally examined claims. As previously stated, Applicant has refiled the same claims as discussed in the February 10, 2022 as new claims 21-50 with correction of minor typographical errors and dependent claim 28.

Accordingly, Applicant respectfully submits that Applicant has fully responded to the February 22, 2022 Election/Restrictions Office Action.

January 27, 2022 Non-Final Office Action

Applicant below addresses all matters raised in the January 27, 2022 Non-Final Office Action with reference to the claims filed in this present Response.

Claim Rejections - 35 USC § 112

Claim 6 is rejected under 35 USC § 112(a). Claims 2-4 and 10-12 are rejected under 35 USC § 112(b).

Claims 2-4, 6, and 10-12 have been canceled.

Accordingly, Applicant respectfully requests withdrawal of the rejection.

Double Patenting

Claims 1-20 have been provisionally rejected as claiming the same invention has claims 1-20 of copending Application No. 17/507,351.

Claims 1-20 have been canceled.

If after reviewing the claims submitted herein the Examiner maintains the double patenting rejection, Applicant will provide a substantive response.

Claim Rejections - 35 USC § 102

Claim(s) 9-10, 13-14, and 17 is/are rejected under pre-AIA 35 U.S.C. 102(b) as being anticipated by Hui (US Pub 2005/0189910).

Since, claims 9-10, 14, and 17 have been canceled, Applicant addresses the rejection with reference to refiled claims 21-50.

Hui relates to providing a "planar inductive battery charging system designed to enable electronic devices to be recharged," and the "system includes a planar charging module having a

charging surface on which a device to be recharged is placed." *Hui*, Abstract. "Within the charging module and parallel to the charging surface is at least one and preferably an array of primary windings that coupled energy inductively to a secondary winding formed in the device to be recharged." *Id.* "Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface." *Id.*, ¶0007. "In this way the precise position and orientation of the electronic device on the charging surface is not critical." *Id.* "To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array." *Id.*

"In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said device." *Id.*, ¶0011. "An important aspect of the present invention is that it provides a battery charging system that employs a localised (sic) charging concept." *Id.*, ¶0014. "In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged." *Id.* "As shown in FIG. 4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings." *Id.*, ¶0072. "The secondary winding is also planar and is located in the portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment either directly or via a charging circuit." *Id.*

Thus, *Hui* discloses in some detail a charging system that transfers energy from one or more primary windings in the charging system to a secondary winding in a device to be recharged.

Independent claim 21 distinguishes over *Hui*. For example, although *Hui* transfers energy from a primary winding to a secondary winding of a device being charged, *Hui* does not teach or suggest, for example, the communication and control circuit and its configuration as set forth in claim 21. Applicant respectfully submits that *Hui* does not teach or suggest a "a

communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit." Claim 21. The communication and control circuit of claim 21 is configured to, *inter alia*, "detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil" and "wherein the received communication of information includes: … a charge algorithm profile and a power requirement." *Id.* "The communication and control circuit is also configured to, *inter alia*, "operate the first drive circuit according to the power requirement and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device." *Id.*

Independent claim 40 also distinguishes over *Hui*. For example, as stated above, although *Hui* transfers energy from a primary winding to a secondary winding of a device being charged, *Hui* does not teach or suggest the communication and control circuit and its configuration as set forth in claim 40. For example, *Hui* does not teach or suggest, for example, "a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system," and "wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement" and "periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device" as required by amended claim 40.

Likewise, *Hui* does not teach or suggest, for example, "a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to: detect, through the sense circuit, a received communication of information in the current modulation in the primary coil," "from the information communicated by the receiver circuit, determine a power parameter," and "operate the drive circuit according to the power parameter to provide power inductively from the primary coil to the receiver coil to power the

microcontroller and to charge the battery of the portable device" as required by independent claim 48.

Independent claim 50 also distinguishes over the combination of *Hui* in view of *Karilis*. For example, *Hui* in view of *Karilis* does not teach or suggest, for example, "a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system," "wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil" as required by claim 50.

Accordingly, Applicant respectfully submits that independent claims 21, 40, 48, and 50, and claims dependent thereon are allowable over *Hui*.

Claim Rejections - 35 USC § 103

Claim 1, 2, 5, 6, and 8 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hui (US Pub 2005/0189910) (hereinafter *Hui*) in view of Karalis et al. US Pub 2008/0278264 (hereinafter *Karalis*). Applicant respectfully traverses the rejection.

Since claims 1, 2, 5, 6, and 8 have been canceled, Applicant addresses the following remarks to refiled independent claims 21, 40, 48, and 50.

As previously stated, *Hui* relates to providing a "planar inductive battery charging system designed to enable electronic devices to be recharged," and the "system includes a planar charging module having a charging surface on which a device to be recharged is placed." *Hui*, Abstract. "Within the charging module and parallel to the charging surface is at least one and preferably an array of primary windings that coupled energy inductively to a secondary winding formed in the device to be recharged." *Id.* "Preferably the magnetic flux generated by the primary winding is substantially uniform over at least a major part of the planar charging surface." *Id.*, ¶0007. "In this way the precise position and orientation of the electronic device on the charging surface is not critical." *Id.* "To achieve this the charging module may comprise a plurality of primary windings, which may preferably be disposed in a regular array." *Id.*

"In addition to the battery charging system, the invention also extends to a battery powered portable electronic device comprising a rechargeable battery, and wherein the device includes a planar secondary winding for receiving electrical energy from a battery charger, and electromagnetic shielding between the winding and the major electronic components of said device." *Id.*, ¶0011. "An important aspect of the present invention is that it provides a battery charging system that employs a localised (sic) charging concept." *Id.*, ¶0014. "In particular, when there is an array of primary coils, it will be understood that energy is only transferred from those primary coils that are adjacent the secondary coil located in the device being charged." *Id.* "As shown in FIG. 4, the primary transformer circuit module transmits electrical energy at high frequency through a flat charging surface that contains the primary transformer windings." *Id.*, ¶0072. "The secondary winding is also planar and is located in the portable electronic equipment and couples this energy, and a rectifier within the portable equipment rectifies the high-frequency secondary AC voltage into a DC voltage for charging the battery inside the portable equipment either directly or via a charging circuit." *Id.*

Karilis states that, "The inventors have realized that resonant objects with coupled resonant modes having localized evanescent field patterns may be used for non-radiative wireless energy transfer." *Karilis,* ¶0005. *Karilis* further states that, "efficient wireless energy-exchange can be achieved between the reso-nant objects, while suffering only modest transfer and dissi-pation of energy into other off-resonant objects." *Id.* *Karilis* discloses, "Referring to FIG. 1, energy is transferred, over a distance D, between a resonant source object having a characteristic size L1 and a resonant device object of characteristic size L2." *Id.*, ¶0099. "The source object is connected to a power supply (not shown), and the device object is connected to a power consuming device (e.g., a load resistor, not shown)." *Id.* "Energy is provided by the power supply to the source object, transferred wirelessly and non-radiatively from the source object to the device object, and consumed by the power consuming device." *Id.* "Referring between to two FIG. 3, in self-resonant some embodiments, energy is transferred between two self-resonant conducting-wire coils." *Id.*, ¶0113. *Karilis* also discusses in context copper conductors.

Thus, *Hui* discloses in some detail a charging system that transfers energy from one or more primary windings in the charging system to a secondary winding in a device to be

recharged, and *Karilis* discloses specific details of coupling and transferring energy between a source object and a device object. Thus, the combination of *Hui* and *Karilis* discloses transferring energy between a primary winding and a secondary winding including self-resonant embodiments, and the copper can be used as a conductor.

Independent claim 21 distinguishes over the combination of *Hui* in view of *Karilis*. For example, as previously stated, although *Hui* in view of *Karilis* transfers energy from a primary winding of a battery charging system to a secondary winding of a device being charged, *Hui* in view of *Karilis* does not teach or suggest the communication and control circuit and its configuration as set forth in claim 21. Applicant respectfully submits that *Hui* in view of *Karilis* does not teach or suggest at least "a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit." Claim 21. The communication and control circuit of claim 21 is configured to, *inter alia*, "detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil" and "wherein the received communication of information includes: … a charge algorithm profile and a power requirement." *Id.* "The communication and control circuit is also configured to, *inter alia*, "operate the first drive circuit according to the power requirement and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device." *Id.*

Independent claim 40 also distinguishes over the combination of *Hui* in view of *Karilis*. For example, although *Hui* in view of *Karilis* transfers energy from a primary winding of a battery charging system to a secondary winding of a device being charged, *Hui* in view of *Karilis* does not teach or suggest at least "a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system," and "wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement" and "periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to

enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device" as required by claim 40.

Independent claim 48 also distinguishes over the combination of *Hui* in view of *Karilis*. For example, *Hui* in view of *Karilis* does not teach or suggest "a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to: detect, through the sense circuit, a received communication of information in the current modulation in the primary coil," "from the information communicated by the receiver circuit, determine a power parameter," and "operate the drive circuit according to the power parameter to provide power inductively from the primary coil to the receiver coil to power the microcontroller and to charge the battery of the portable device" as required by claim 48.

Additionally, independent claim 50 distinguishes over the combination of *Hui* in view of *Karilis*. For example, *Hui* in view of *Karilis* does not teach or suggest "a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system," "wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil" as required by claim 50.

Accordingly, Applicant respectfully submits that independent claims 21, 40, 48, and 50, and claims dependent thereon are allowable over *Hui* in view of *Karilis*.

CONCLUSION

Applicant respectfully submits that all pending claims are in condition for allowance. Accordingly, Applicant requests that a Notice of Allowance be issued. Nonetheless, should any issues remain that might be subject to resolution through a telephone interview, the Examiner is requested to telephone the undersigned at 512-338-9100.

CERTIFICATE OF TRANSMISSION

I hereby certify that on March 3, 2022 this correspondence is being transmitted via the U.S. Patent & Trademark Office's electronic filing system.

/Kent B. Chambers/

Respectfully submitted,

/Kent B. Chambers/

Kent B. Chambers
Attorney for Applicant(s)
Reg. No. 38,839

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ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $240 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	03/04/2022	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 30	= 0		x $50 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0		x $240 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ANTJUAN M RIVERA/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

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TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
ZHOU, ZIXUAN	
ART UNIT	PAPER NUMBER
2859	

DATE MAILED: 03/21/2022

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

TITLE OF INVENTION: System and Method for Inductive Charging of Portable Devices

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	06/21/2022

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

33438 7590 03/21/2022
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

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nonprovisional	SMALL	$600	$0.00	$0.00	$600	06/21/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
ZHOU, ZIXUAN	2859	320-108000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

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17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

33438 7590 03/21/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
ZHOU, ZIXUAN	
ART UNIT	PAPER NUMBER
2859	

DATE MAILED: 03/21/2022

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 17/507,323	Applicant(s) Partovi et al.	
	Examiner ZIXUAN ZHOU	Art Unit 2859	AIA (FITF) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 03/04/2022.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 21-50 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 03/01/2022.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/ZIXUAN ZHOU/
Primary Examiner, Art Unit 2859

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Priority

This application discloses and claims only subject matter disclosed in prior application no 12/116,876, filed 05/07/2008, and names the inventor or at least one joint inventor named in the prior application. Accordingly, this application may constitute a continuation or division. Should applicant desire to claim the benefit of the filing date of the prior application, attention is directed to 35 U.S.C. 120, 37 CFR 1.78, and MPEP § 211 *et seq.*

Information Disclosure Statement

The information disclosure statement (IDS) submitted on 03/01/2022 is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Allowable Subject Matter

Claims 21-50 are allowed.

The following is an examiner's statement of reasons for allowance:

Regarding claim 21, the prior art fails to teach or suggest further inclusion of an apparatus comprising: a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit, configured to: detect, through

the first sense circuit, a received communication of information in the current modulation in the first primary coil; operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate the information detected in the current modulation in the first primary coil; regulate in a closed loop feedback manner the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the first drive circuit while charging the battery of the portable device.

Regarding claim 40, the prior art fails to teach or suggest further inclusion of a portable device comprising: a receiver rectifier circuit including a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system; and wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to: periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver 45 rectifier circuit during the charging of the portable device.

Regarding claim 48, the prior art fails to teach or suggest further inclusion of a system for providing power inductively to a portable device comprising: a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to: operate the drive circuit according to the power

parameter to provide power inductively from the primary coil to the receiver coil to power the microcontroller and to charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to: regulate in a closed loop feedback manner, the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency, the duty cycle, and the DC voltage input to the drive circuit during charging of the battery of the portable device.

Regarding claim 50, the prior art fails to teach or suggest further inclusion of a portable device comprising: a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system; wherein upon powering and activation of the microcontroller by the primary coil in the base unit, the receiver circuit is configured to: periodically communicate to the base unit information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the battery of the portable device.

The dependent claims are allowable for the reasons as the independent claims from which they depend.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably

accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ZIXUAN ZHOU whose telephone number is (571)272-6739. The examiner can normally be reached 9:00 am to 5:00 pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Drew A Dunn can be reached on 571-272-2312. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/ZIXUAN ZHOU/
Primary Examiner, Art Unit 2859
03/10/2022

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	**Art Unit**
	ZIXUAN ZHOU	2859

CPC						
Symbol					**Type**	**Version**
H02J	/	50	/	10	F	2016-02-01
G06F	/	1	/	1683	I	2013-01-01
H02J	/	7	/	025	I	2013-01-01
H02J	/	50	/	05	I	2016-02-01
H02J	/	50	/	402	I	2020-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
H02J	/	7	/	342	I	1	1	2020-01-01
H02J	/	50	/	10	I	1	2	2016-02-01

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	30	
/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	10 March 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	20

U.S. Patent and Trademark Office — Part of Paper No.: 20220310

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	Art Unit
	ZIXUAN ZHOU	2859

INTERNATIONAL CLASSIFICATION					
CLAIMED					
H02J	/	7	/	00	
NON-CLAIMED					
	/		/		

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
320	108

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					
307	104					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	30	
/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	10 March 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	20

U.S. Patent and Trademark Office — Part of Paper No.: 20220310

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
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	Examiner	**Art Unit**
	ZIXUAN ZHOU	2859

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
-	1	-	10	-	19	8	28	17	37	26	46				
-	2	-	11	-	20	9	29	18	38	27	47				
-	3	-	12	1	21	10	30	19	39	28	48				
-	4	-	13	2	22	11	31	20	40	29	49				
-	5	-	14	3	23	12	32	21	41	30	50				
-	6	-	15	4	24	13	33	22	42						
-	7	-	16	5	25	14	34	23	43						
-	8	-	17	6	26	15	35	24	44						
-	9	-	18	7	27	16	36	25	45						

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	30	
/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	10 March 2022	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	20

U.S. Patent and Trademark Office Part of Paper No.: 20220310

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	Art Unit
	ZIXUAN ZHOU	2859

CPC - Searched*		
Symbol	Date	Examiner
H02J50/10, G06F1/1683, H02J7/025, H02J50/402	01/22/2022	ZZ

CPC Combination Sets - Searched*		
Symbol	Date	Examiner
H02J7/342 AND H02J50/10	01/22/2022	ZZ

US Classification - Searched*			
Class	Subclass	Date	Examiner
320	108	01/22/2022	ZZ
307	104	01/22/2022	ZZ

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
IP.com search	01/22/2022	ZZ
inventor and assignee search	01/22/2022	ZZ
EAST text search was conducted -- see printout	01/22/2022	ZZ
CPC and USPC search was conducted with text base	01/22/2022	ZZ
Updated EAST text search was conducted -- see printout	03/10/2022	ZZ

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	US PG Pub interference search was conducted - - see printout	03/10/2022	ZZ

/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
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	Examiner	Art Unit
	ZIXUAN ZHOU	2859

/ZIXUAN ZHOU/ Primary Examiner, Art Unit 2859	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
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	Examiner	Art Unit
	ZIXUAN ZHOU	2859

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	01/22/2022	02/15/2022	03/10/2022						
-	1	✓	÷	-						
-	2	✓	-	-						
-	3	✓	-	-						
-	4	✓	-	-						
-	5	✓	-	-						
-	6	✓	-	-						
-	7	✓	-	-						
-	8	✓	-	-						
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/507,323	Partovi et al.
	Examiner	**Art Unit**
	ZIXUAN ZHOU	2859

CLAIM		DATE								
Final	Original	01/22/2022	02/15/2022	03/10/2022						
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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17507323
Filing Date	2021-10-21
First Named Inventor	Afshin Partovi
Art Unit	2859
Examiner Name	Zixuan Zhou
Attorney Docket Number	AFPA-01013US7

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20090212637	A1	2009-08-29	Baarman et al.	
	2	20090230777	A1	2009-09-17	Baarman et al.	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Zixuan Zhou
	Attorney Docket Number	AFPA-01013US7

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5
	1	Notice of Allowance mailed on February 16, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-2.	
	2	Amendment after Notice of Allowance dated February 3, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-6.	
	3	Notice of Allowance mailed January 31, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-2.	
	4	Amendment after Notice of Allowance dated January 28, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-14.	
	5	Notice of Allowance mailed January 18 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-7.	
	6	Preliminary Amendment dated January 5, 2022, filed in U.S. Patent Application No. 17/472,351, pages 1-14.	
	7	Preliminary Amendment dated December 16, 2021, filed in U.S. Patent Application No. 17/472,351, pages 1-11.	
	8	Preliminary Amendment dated December 12, 2021, filed in U.S. Patent Application No. 17/472,351, pages 1-12.	

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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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AMENDMENTS TO THE SPECIFICATION

Please amend the Summary section in paragraph 0012 as follows:

[0012] In one embodiment, a portable device includes a battery and a receiver unit coupled to the battery. The receiver unit is configured to receive inductive power from an inductive charging system. The receiver unit includes a receiver coil, a ferromagnetic layer, and a receiver circuit powered by the inductive charging system. The receiver circuit includes a receiver rectifier circuit, a receiver communication and control circuit, a voltage regulator, and a battery charging circuit. When a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the receiver rectifier circuit and is used by the voltage regulator to power and activate the microcontroller and used by the battery charging circuit to charge the battery of the portable device. Upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to communicate to the base unit information corresponding to a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement and periodically communicate to the base unit additional information. In other embodiments, [[A]] a portable inductive power source, power device, or unit, for use in powering or charging electrical, electronic, battery-operated, mobile, and other devices or rechargeable batteries is disclosed herein. In accordance with an embodiment the system comprises 2 parts: The first part is a pad or similar base unit that contains a primary, which creates an alternating magnetic field by means of applying an alternating current to a winding, coil, or any type of current carrying wire. The second part of the system is a receiver that comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile or other device or rechargeable battery. The receiver may comprise coils, windings, or any wire that can sense a changing magnetic field, and rectify it to produce a direct current (DC) voltage, which is then used to charge or power the device.

Please amend the Summary section in paragraph 0014 as follows:

[0014] In another embodiment, an apparatus includes a system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil

and a receiver circuit. The system includes a first primary coil, a first drive circuit, a first sense circuit, and a communication and control circuit. The communication and control circuit is configured to detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil. The communication and control circuit is also configured to operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate information detected in the current modulation in the first primary coil. The communication and control circuit is further configured to operate the first drive circuit according to a power requirement and charge algorithm profile to provide power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device. To charge the battery of the portable device the communication and control circuit is further configured to receive additional information, regulate in a closed loop feedback manner the voltage or current at the output of the receiver circuit, monitor for continued presence of the portable device and completion of the charging of the battery, and if the portable device is no longer present or charging is complete, stop operation of the first drive circuit for the provision of power inductively to the portable device. Additionally, in [[In]] accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or secondary side; and additional circuits and components that perform specialized tasks, such as mobile device identification, and automatic voltage or power-setting for different devices.

Please amend the Abstract on p. 108 as follows:

A system for providing power inductively to a portable device. The system includes a primary coil, a drive circuit, a sense circuit, and a communication and control circuit. The communication and control circuit is configured to perform operations, including detection of communication and drive circuit operations. A portable device that includes a receiver unit coupled to a battery and configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit The receiver unit includes a receiver coil, a ferromagnetic layer, and a receiver circuit. The receiver circuit includes a

receiver communication and control circuit to modulate current in the receiver coil to communicate with a base unit while the receiver circuit is being powered by the inductive charging system. ~~A system and method for variable power transfer in an inductive charging or power system. In accordance with an embodiment the system comprises a pad or similar base unit that contains a primary, which creates an alternating magnetic field. A receiver comprises a means for receiving the energy from the alternating magnetic field from the pad and transferring it to a mobile device, battery, or other device. In accordance with various embodiments, additional features can be incorporated into the system to provide greater power transfer efficiency, and to allow the system to be easily modified for applications that have different power requirements. These include variations in the material used to manufacture the primary and/or the receiver coils; modified circuit designs to be used on the primary and/or receiver side; and additional circuits and components that perform specialized tasks, such as mobile device or battery identification, and automatic voltage or power-setting for different devices or batteries.~~

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	90	((("Partovi") near3 ("Afshin"))).INV.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/01/18 03:43 PM
L2	89	((("Sears") near3 ("Michael"))).INV.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2022/01/18 03:44 PM
L3	15	("20050062567" OR "20060061324" OR "20070103110" OR "4720667" OR "6028413" OR "6057668" OR "6527971" OR "6756656" OR "6803744" OR "6869019" OR "7311526" OR "7331793" OR "7352567" OR "7514765" OR "8766484").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/01/20 10:56 AM
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L5	5	L3 AND (copper OR aluminum OR nickel OR gold OR silver OR non$ferrite)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:00 AM
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		"5550452" OR "5600225" OR "5642087" OR "5656917" OR "5696433" OR "5734254" OR "5744933" OR "5803744" OR "5889384" OR "5925814" OR "5952814" OR "5959433" OR "5963012" OR "5991170" OR "5991665" OR "6008622" OR "6016046" OR "6040680" OR "6094119" OR "6118249" OR "6184651" OR "6184654" OR "6208115" OR "6301128" OR "6310465" OR "6331744" OR "6436299" OR "6462509" OR "6489745" OR "6498455" OR "6501364" OR "6573817" OR "6586909" OR "6625477" OR "6636017" OR "6650088" OR "6673250" OR "6697272" OR "6731071" OR "6741064" OR "6756765" OR "6798716" OR "6803744" OR "6803774" OR "6806649" OR "6812645" OR "6825620" OR "6831417" OR "6831544" OR "6844702" OR "6870089" OR "6888438" OR "6906495" OR "6913477" OR "6917163" OR "6917182" OR "6943733" OR "6972543" OR					

		"6975198" OR "7026789").pn.					
L10	1050	L8 OR L9	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 AM
L11	202	L10 AND (copper OR aluminum OR nickel OR gold OR silver OR non$ferrite)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 AM
L13	85	L10 AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR antenna))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:13 AM
L14	89	L10 AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR antenna OR wind$3))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:19 AM
L15	126333	(H02J50/10 OR G06F1/1683 OR H02J7/025 OR H02J50/402).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO;	OR	ON	ON	2022/01/20 11:59 AM

			DERWENT)				
L16	12242	320/108.ccls. OR 307/104.ccls.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:59 AM
L17	9728	(L15 OR L16) AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR antenna OR wind$3))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 12:02 PM
L18	9125	(L15 OR L16) AND ((copper OR aluminum OR nickel OR gold OR silver OR non$ferrite) WITH (coil OR transmit$4 OR receiv$3 OR wind$3))	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 12:10 PM
L19	3	"20050189910"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 03:20 PM
L21	1801	(H02J7/342 AND H02J50/10).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:08 PM

L22	56	320/108.ccls. AND 320/103.ccls.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/20 11:55 PM
L23	91994	(switch$3 OR transistor OR mosfet OR relay OR fet OR bjt OR switchable OR on$1off OR contactor) WITH (coil) WITH (estimat$3 OR metrolog$4 OR evaluat$3 OR measur$6 OR determin$3 OR monitor$3 OR detect$3 OR sens$3 OR acquisition OR calculat$3 OR comput$3 OR test$3 OR evaluat$3 OR ascertain$3 OR obtain$3 OR determination OR computation OR meter OR gauge OR predict$3 OR acquir$3 OR collect$3 OR retriev$3 OR infer$4) WITH (proximity OR presence OR position)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/21 04:23 PM
L24	1540	(L15 OR L16) AND L23	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/01/21 04:23 PM
L25	5	(320/108.ccls. AND 320/103.ccls.) AND solar	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO);	OR	ON	ON	2022/01/22 12:45 AM

			FPRS; EPO; JPO; DERWENT)				
L26	3	"16055109"	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 09:27 AM
L27	32	(Artificial Intelligence) More Like: US-20210044147-A9 Text: (US-8169185-B2 OR US-11201500-B2 OR US-20200099260-A1 OR US-11114886-B2 OR US-8629654-B2 OR US-11121580-B2 OR US-10115520-B2 OR US-11139687-B2 OR US-20180358834-A1 OR US-20160181860-A1 OR US-9496732-B2 OR US-20130285604-A1 OR US-20130300204-A1 OR US-9601943-B2 OR US-20220021247-A1 OR US-20200215925-A1 OR CN-113785470-A OR US-9722447-B2 OR US-9837846-B2 OR US-8947047-B2).did.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2022/03/10 09:44 AM
L28	2	("20090212637" OR "20090230777").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2022/03/10 09:47 AM
L29	170721	(H02J50/$3 OR G06F1/1683 OR H02J7/025 OR H02J50/402).cpc.	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 11:04 AM
L30	12228	320/108.ccls. OR 307/104.ccls.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA,	OR	ON	ON	2022/03/10 11:04 AM

			EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)				
L31	402589	(plane OR planar OR pad OR flat) WITH (charg$3 OR re$charg$3 OR power$3 OR transmission OR transmit$4 OR suppl$4) WITH (induct$3 OR magnetic OR electromagnetic OR wireless$2 OR non$contact$3 OR wire$free$2)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 11:27 AM
L32	134309	(receiv$3 OR secondary) WITH (rectification OR rectifier OR AC$DC OR AC$to$DC OR (AC adj3 DC)) WITH (capacitor OR accumulator OR capacitance)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 11:55 AM
L33	397994	(receiv$3 OR secondary) WITH (layer$3 OR foil$3 OR shield$3 OR plat$3 OR cover$3) WITH (magnetic$3 OR electro$1magnetic$3 OR ferrite)	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 12:01 PM
L34	1351	L31 AND L32 AND L33	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 12:01 PM
L35	174273	L29 OR L30	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU,	OR	ON	ON	2022/03/10 12:07 PM

			CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)				
L36	757	L34 AND L35	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 12:07 PM
L37	1750481	(current OR voltage OR power OR energy) near7 (modulat$3 OR PWM)	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 02:16 PM
L38	21858	L35 AND L37	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 02:16 PM
L39	462	L31 AND L32 AND L33 AND L37	(US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT)	OR	ON	ON	2022/03/10 02:17 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp

N1	10787	((receiv$3 OR secondary) WITH (layer$3 OR foil$3 OR shield$3 OR plat$3 OR cover$3) WITH (magnetic$3 OR electro$1magnetic$3 OR ferrite)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/03/10 12:08 PM
N2	3507	((receiv$3 OR secondary) WITH (rectification OR rectifier OR AC$DC OR AC$to$DC OR (AC adj3 DC)) WITH (capacitor OR accumulator OR capacitance)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2022/03/10 12:08 PM
N3	29	N1 AND N2	(US-PGPUB; USPAT)	OR	ON	ON	2022/03/10 12:08 PM

Electronic Acknowledgement Receipt	
EFS ID:	45293130
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Customer Number:	33438
Filer:	Kent Bryan Chambers
Filer Authorized By:	
Attorney Docket Number:	AFPA-01013US7
Receipt Date:	22-MAR-2022
Filing Date:	21-OCT-2021
Time Stamp:	20:19:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Amendment after Notice of Allowance (Rule 312)	AFPA-01013US7_312-Amendment_2022-03-22.pdf	125580 be7dff35fb78fc97cb50630e96cd08e52d4ece4e	no	19
Warnings:					

Information:	
Total Files Size (in bytes):	125580

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Afshin Partovi, Michael Sears		
Applicant:	Mojo Mobility, Inc.		
Title:	Efficiencies and Flexibilities in Inductive (Wireless) Charging		
Application No.:	17/507,323	Filing Date:	March 3, 2022
Examiner:	Zixuan Zhou	Group Art Unit:	2859
Docket No.:	AFPA-01013US7	Customer No.:	33438

ELECTRONICALLY FILED

Austin, Texas
March 3, 2022

AMENDMENT UNDER 37 C.F.R. § 1.312

This paper is submitted under and in compliance with 37 C.F.R. § 1.312. As explained in more detail below, Applicant respectfully submits that this amendment complies with 37 C.F.R. § 1.312 and MPEP §714.16. Entry of the amendment is respectfully requested.

The USPTO is also authorized to charge any underpayment of fees to Deposit Account No. 502264.

AMENDMENTS TO THE CLAIMS

1-20. Canceled.

21. (Currently Amended) An apparatus comprising:

a system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system comprising:

a first primary coil that is substantially planar and substantially parallel to a surface of the system for providing power inductively to the portable device;

a first drive circuit, including a FET driver, a capacitor, and a FET switch, coupled to a DC voltage input and coupled to the first primary coil, wherein during operation the first drive circuit is configured to apply an alternating electrical current to the first primary coil at an operating frequency and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the plane of the first primary coil and the surface of the system to provide power inductively to the portable device, wherein the operating frequency is within a range of frequencies (i) that are near a resonance frequency of a circuit comprising the first primary coil and the capacitor, (ii) such that increasing values of the operating frequency within the range of frequencies would correspond to a lower voltage or current induced in an output of the receiver circuit and (iii) that allow activation and powering of the receiver unit and charging the battery of the portable device[[.]];

a first sense circuit to monitor current flow through the first primary coil during operation of the first drive circuit, wherein the first sense circuit includes a low pass filter and an amplifier to assist in detecting and amplifying a signal corresponding to a current modulation in the first primary coil induced by modulation of current in the receiver coil; and

a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit, configured to:

detect, through the first sense circuit, a received communication of information in the current modulation in the first primary coil;

operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate the information detected in the current modulation in the first primary coil, wherein the communication of information includes information to enable the communication and control circuit to configure the inductive transfer of power to the portable device, wherein the received communication of information includes:

information corresponding to a voltage or current induced by the first primary coil at the output of the receiver circuit;

a unique identification code;

a manufacturer code;

a charge algorithm profile; and

a power requirement; and

operate the first drive circuit according to the power requirement and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

receive additional information in the current modulation in the first primary coil from the modulation of the current in the receiver coil corresponding to the voltage or current at the output of the receiver circuit while charging the battery of the portable device;

regulate in a closed loop feedback manner the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the first drive circuit while charging the battery of the portable device;

monitor for continued presence of the portable device and completion of the charging of the battery of the portable device based on the communication from the receiver circuit and detected by the communication and control circuit through the first sense circuit; and

if the portable device is no longer present or charging is complete, stop operation of the first drive circuit for the provision of power inductively to the portable device.

22. (Previously Presented) The apparatus of claim 21, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

23. (Previously Presented) The apparatus of claim 21, wherein the DC voltage input is configured to receive a DC voltage and the system further comprises:

a voltage regulator circuit coupled to the DC voltage input and to the microcontroller, wherein the microcontroller is configured to control the voltage regulator circuit to switch a level of the DC voltage between multiple discrete values based on the received communication of information and the additional information received by the communication and control circuit from the portable device.

24. (Previously Presented) The apparatus of claim 21 wherein:

the DC voltage input is configured to connect to and receive a DC voltage from a DC power supply via a universal serial bus (USB); and

the communication and control circuit is further configured to communicate with the DC power supply via the USB.

25. (Previously Presented) The apparatus of claim 21 wherein:

the first primary coil is one of multiple primary coils in the system and the first drive circuit is one of multiple drive circuits in the system; and

the system further comprises means for operating the multiple drive circuits to drive the multiple primary coils to separately control simultaneously induced charging voltages and/or currents in receiver units of multiple portable devices coupled to the multiple primary coils.

26. (Previously Presented) The apparatus of claim 21 wherein:

the first primary coil is a substantially spiral-shaped coil and is fabricated from a copper conductor with a thickness optimized for lower resistance due to skin effect at an operating frequency range of 100 kHz to 1 MHz relative to resistance at an operating frequency outside the range of 100 kHz to 1 MHz;

a number of turns of the first primary coil, an inner radius of the first primary coil, and an outer radius of the first primary coil are selected for an inductance in a range of 1 microhenry to 100 microhenries; and

the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

27. (Previously Presented) The apparatus of claim 21, wherein the communication and control circuit is further configured to operate the first drive circuit for a short period of time to detect a current draw through the first primary coil indicating a possible presence of the portable device for charging, wherein the short period of time is less than that needed to activate and power a receiver unit in the portable device.

28. (Previously Presented) The apparatus of claim 21, wherein the system further comprises a high heat conductivity layer positioned proximate to the first primary coil and at least covering an area surrounding the first primary coil to disperse any heat generated during provision of power inductively.

29. (Previously Presented) The apparatus of claim 21, further comprising a near field communication (NFC) antenna for communication of data, and further wherein:

the first primary coil comprises a Printed Circuit Board (PCB) coil;

the PCB coil comprises multiple layers of substantially similar copper thickness and substantially similar spiral-shaped coil patterns connected by vias wherein each layer comprises 1 to 4 ounce (oz) copper thickness material; and

the operating frequency is within a range of 100 kHz to 1 MHz.

30. (Previously Presented) The apparatus of claim 21, wherein:

the system further comprises a near field communication (NFC) antenna for communication of data;

the first primary coil comprises a copper PCB coil structure;

the PCB coil structure includes a substantially spiral-shaped pattern of multiple coil layers;

each of the multiple coil layers comprises a PCB coil having an inner port and an outer port;

the inner ports of each of the coil layers are coupled together by vias and form a first common pad;

the outer ports of the coil layers are coupled together by vias and form a second common pad; and

the two common contact pads provide electrical coupling of the first primary coil for applying the alternating electrical current to the first primary coil.

31. (Previously Presented) The apparatus of claim 21, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit, the portable device is a first portable device, and the receiver unit of the first portable device is a first receiver unit, the apparatus further comprises:

a second portable device;

the system is incorporated into the second portable device; and

the second portable device further comprises:

an internal, rechargeable battery and a DC-to-DC voltage converter to provide power to the system to inductively power the first receiver unit of the first portable device and charge the battery of the first portable device;

a second receiver unit coupled to the first primary coil to enable the internal, rechargeable battery to be recharged inductively through the first primary coil; and

the communication and control circuit is further configured to control whether the second portable device is receiving power inductively or charging the first portable device inductively.

32. (Previously Presented) The apparatus of claim 21 wherein the first primary coil includes a magnetic core of ferromagnetic material within a central area of the first primary coil and the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

33. (Previously Presented) The apparatus of claim 21 wherein:

the system comprises a permanent magnet within a central area of the first primary coil;

the permanent magnet includes a substantially flat surface;

the permanent magnet is magnetized in a direction perpendicular to the substantially flat surface of the magnet; and

the permanent magnet is a ceramic permanent magnet, wherein the permanent magnet impedes eddy current generation and heating of the permanent magnet by the alternating magnetic field during inductive power transfer.

34. (Previously Presented) The apparatus of claim 21 wherein:

the system comprises a permanent magnet within a central area of the first primary coil; and

the permanent magnet comprises magnetic material bonded using a polymer matrix configured to form a bonded permanent magnet in a substantially flat shape and magnetized with a magnetization direction substantially perpendicular to the substantially flat surface of the magnet, wherein the permanent magnet impedes

eddy current generation and heating of the permanent magnet by the alternating magnetic field during inductive power transfer.

35. (Previously Presented) The apparatus of claim 21 further comprising a common mode electrical noise filter circuit coupled to the DC voltage input to shield the DC voltage input from Electromagnetic Interference (EMI) during the provision of power inductively to the portable device.

36. (Previously Presented) The apparatus of claim 21 wherein:

the first primary coil includes multiple layers of copper PCB of similar spiral-shaped coil pattern interconnected by vias; and

the first primary coil includes an outer surface to face a surface of the receiver coil and an inner surface to face away from the surface of the receiver coil; and

the system further comprises:

a ferromagnetic core located in a central area of the first primary coil;

a planar ferromagnetic layer located proximate to the inner surface of the first primary coil; and

a metallic layer located proximate to the planar ferromagnetic layer, wherein the ferromagnetic layer is located between the first primary coil and the metallic layer.

37. (Previously Presented) The apparatus of claim 21 further comprising multiple, arc-shaped, permanent magnet components arranged in a full or partial circular pattern surrounding a perimeter of the first primary coil to assist in alignment of the receiver coil with the first primary coil, wherein:

the magnet components are disposed concentric with the first primary coil; and

adjacent magnet components are separated by gaps to prevent an electrical connection between the magnet components.

38. (Previously Presented) The apparatus of claim 21, further wherein:

the first primary coil comprises a substantially planar, metallic spiral-shaped conductor;

the first primary coil includes:

substantially planar first side closest to the surface of the system for providing inductive power to the inductive receiver unit; and

a second side opposite the first side;

the system further comprises a metallic first shield layer positioned proximate the first side of the first primary coil and opposite the second side of the first primary coil such that the first shield layer covers the metallic spiral-shaped conductor of the first side of the first primary coil that faces the surface of the system; and

the first shield layer has a metal thickness in a range of 1 micrometer to 70 micrometers.

39. (Previously Presented) The apparatus of claim 21, wherein:

the first primary coil, first drive circuit, first sense circuit, and the communication and control circuit comprise a first inductive charger module;

the first module further includes mechanical components and electrical components for interconnecting mechanically and electrically with a second inductive charger module to form a modular system; and

the electrical components are configured to allow the first inductive charger module and the second inductive charger module to share electrical power.

40. (Currently Amended) A portable device comprising:

a battery; and

a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:

a receiver coil which has a substantially planar shape and is located parallel to a surface of the portable device so that an alternating magnetic field, when received through the surface of the portable device from the primary coil in the base unit in a direction substantially perpendicular to the plane of the receiver coil, inductively generates a current in the receiver coil to provide power inductively to the portable device when the portable device is placed on the base unit for charging the battery of the portable device;

a ferromagnetic layer placed under the receiver coil on a side of the receiver coil away from the surface of the portable device; and

a receiver circuit powered by the inductive charging system, wherein the receiver circuit comprises:

a receiver rectifier circuit including a rectifier and a capacitor;

a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system;

a voltage regulator coupled to an output of the receiver rectifier circuit and coupled to the microcontroller to provide a regulated voltage to power the microcontroller from the received inductive power; and

a battery charging circuit to charge the battery, wherein the battery charging circuit is coupled to the output of the receiver rectifier circuit and coupled to the battery and begins drawing current only when [[an]] the output of the receiver rectifier circuit reaches a set minimum voltage value;

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the receiver rectifier circuit and is used by the voltage regulator to power and activate the microcontroller and used by the battery charging circuit to charge the battery of the portable device; and

wherein upon powering and activation of the receiver circuit by the primary coil in the base unit, the receiver circuit is configured to:

communicate to the base unit information corresponding to a voltage or current value at [[an]] the output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, a manufacturer code, a charge algorithm profile, and a power requirement; and

periodically communicate to the base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a

closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device.

41. (Previously Presented) The portable device of claim 40 further comprising a magnetic core of ferromagnetic material within a central area of the receiver coil and a near field communication (NFC) antenna and circuitry for communication of data with other devices.

42. (Previously Presented) The portable device of claim 40, wherein the receiver circuit further comprises a limiter to limit the output voltage of the receiver rectifier circuit to a maximum value within a safe operating range of the battery charging circuit.

43. (Previously Presented) The portable device of claim 40, further comprising an output disconnect switch configured to connect and disconnect an output power from the receiver circuit to the battery, wherein:

the communication and control unit is further configured to control the output disconnect switch to disconnect the battery from the output power from the receiver circuit during at least some of the communication with the base unit.

44. (Currently Amended) The portable device of claim 40, wherein:

the receiver coil includes a substantially planar, metallic, spiral-shaped conductor;

the spiral-shaped conductor includes:

a substantially planar first side for receiving inductive ~~charging~~ power from the primary coil; and

a second side opposite the first side, wherein the first side is closer than the second side to the surface of the portable device through which inductive ~~charging~~ power from the primary coil is received;

the portable device further includes a metallic first shield layer positioned proximate the first side of the receiver coil opposite the second side of the receiver coil such that the first shield layer covers the first side of the spiral-shaped conductor and is located between the surface and the spiral-shaped conductor; and

the first shield layer has a metal thickness in a range of 1 micrometer to 70 micrometers.

45. (Previously Presented) The portable device of claim 40, wherein:

the portable device is configured to operate in an inductive power receiving mode and in an inductive power transfer mode,

in the inductive power receiving mode, the portable device is configured to receive power inductively via the receiver coil to charge the battery of the portable device, and

in the inductive power transfer mode, the portable device is configured to operate an internal inductive charging system included in the portable device for providing power inductively to a second portable device comprising a second battery and a second receiver unit including a second receiver coil and a second receiver circuit, the internal inductive charging system comprising:

a drive circuit, including a FET driver, a second capacitor, and a FET switch, coupled to a DC voltage input and coupled to the receiver coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the receiver coil at an operating frequency and duty cycle to provide power inductively to the second portable device, wherein the operating frequency is within a range of frequencies (i) that are near a resonance frequency of a circuit comprising the receiver coil and the second capacitor, (ii) such that increasing values of the operating frequency within the range of frequencies would correspond to a lower voltage or current induced in an output of the second receiver circuit and (iii) that allow activation and powering of the second receiver unit and charging the second battery of the second portable device; and

a sense circuit to monitor current flow through the receiver coil during operation of the drive circuit, wherein the sense circuit includes a filter and an amplifier to detect and amplify a signal corresponding to a current modulation in the receiver coil induced by modulation of current in the second receiver coil; and

wherein the communication and control circuit is coupled to the drive circuit and the sense circuit and is further configured to:

detect, through the sense circuit, a received communication of information in the current modulation in the receiver coil;

operate the drive circuit to inductively transfer sufficient power to the second receiver unit to activate and power the second receiver circuit to enable the second receiver circuit to communicate the received communication of information in the current modulation in the receiver coil, wherein the received communication of information includes information to enable the communication and control circuit to configure the provision of power inductively to the second portable device, wherein the received communication of information includes:

information corresponding to a voltage or current induced by the receiver coil at the output of the second receiver circuit;

a unique second identification code;

a second manufacturer code;

a second charge algorithm profile; and

a second power requirement; and

operate the drive circuit according to the second power requirement and second charge algorithm profile to provide the power from the receiver coil to the second receiver coil to power the second receiver unit and charge the second battery of the second portable device, wherein to charge the second battery of the second portable device the communication and control circuit is further configured to:

receive additional received information in the current modulation in the receiver coil from the modulation of the current in the second receiver coil corresponding to the voltage or current at the output of the second receiver circuit while

charging the second battery of the second portable device; and

regulate in a closed loop feedback manner the voltage or current at the output of the second receiver circuit in accordance with the additional received information corresponding to the voltage or current at the output of the second receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the drive circuit while charging the second battery of the second portable device.

46. (Previously Presented) The portable device of claim 40 wherein the portable device is a case for holding and charging a Bluetooth headset, and the battery is configured to charge the Bluetooth headset when placed in the case.

47. (Previously Presented) The portable device of claim 40, further comprising multiple, arc-shaped, permanent magnet components arranged in a full or partial circular pattern surrounding a perimeter of the receiver coil to assist in alignment of the receiver coil with the primary coil, wherein:

the magnet components are disposed concentric with the first receiver coil; and

adjacent magnet components are separated by gaps to prevent an electrical connection between the magnet components.

48. (Previously Presented) A system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system comprising:

a primary coil that is substantially planar and parallel to a surface of the system for providing power inductively to the portable device, wherein the primary coil comprises a flexible Printed Circuit Board (PCB), multi-turn coil having multiple layers of substantially similar patterns of substantially spiral-shaped conductors of 1 to 4 ounce copper thickness for each layer and having coil patterns electrically connected with vias between the layers;

a drive circuit, including a FET driver, a capacitor and a FET switch, coupled to a DC voltage input and coupled to the primary coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the primary coil at an operating frequency within a range of 100 kHz to 1 MHz and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the surface of the primary coil to provide power inductively to the portable device;

a sense circuit to monitor current flow through the primary coil during operation of the drive circuit to sense a current modulation in the primary coil from a modulation of a current in the receiver coil; and

a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to:

detect, through the sense circuit, a received communication of information in the current modulation in the primary coil;

operate the drive circuit to inductively transfer sufficient power to the inductive receiver unit to activate and power the receiver circuit to enable the receiver circuit to communicate the information in the current modulation in the primary coil;

from the information communicated by the receiver circuit, determine a power parameter; and

operate the drive circuit according to the power parameter to provide power inductively from the primary coil to the receiver coil to power the microcontroller and to charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

receive additional information in the current modulation in the primary coil from modulation of the current in the receiver coil corresponding to a voltage or current at an output of the receiver circuit while charging the battery of the portable device; and

regulate in a closed loop feedback manner, the voltage or current at the output of the receiver circuit in accordance with the received

additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency, the duty cycle, and the DC voltage input to the drive circuit during charging of the battery of the portable device.

49. (Previously Presented) The system of claim 48, wherein:
the sense circuit includes a low pass filter and an amplifier; and
the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

50. (Currently Amended) A portable device comprising:
a battery; and
a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:
a receiver coil having a substantially planar shape and located parallel to a surface of the portable device so that an alternating magnetic field, when received through the surface of the portable device from the primary coil in the base unit in a direction substantially perpendicular to the plane of the receiver coil, inductively generates a current in the receiver coil to provide power inductively to the portable device when the portable device is placed on the base unit for charging the battery of the portable device;
a ferrite material layer placed under the receiver coil on a side of the receiver coil opposite to the surface of the portable device;
a receiver circuit powered by the inductive charging system, wherein the receiver circuit comprises:
a receiver rectifier circuit including a rectifier and a capacitor; and
a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with

the base unit while the receiver circuit is being powered by the inductive charging system; and

an output disconnect switch to interrupt a flow of current from an output of the receiver unit to the battery;

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the rectifier circuit and is used to power and activate the microcontroller and to charge the battery of the portable device;

wherein upon powering and activation of the microcontroller by the primary coil in the base unit, the receiver circuit is configured to:

communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil; and

periodically communicate to the base unit information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the battery of the portable device; and

wherein the communication and control unit is configured to control the disconnect switch to disconnect the flow of current from the output of the receiver unit to the battery during at least some of the communication with the base unit.

REMARKS

Claims 21-49 have been allowed.

Claims 21, 40, 44, and 50 have been amended.

The issue fee has not been paid.

37 C.F.R. § 1.312 and MPEP §714.16 permit an applicant to amend an application after allowance and before payment of the issue fee. The MPEP §714.16 states that "where amendments of the type noted [below] are shown (A) to be needed for proper disclosure or protection of the invention, and (B) to require no substantial amount of additional work on the part of the Office, they may be considered and, if proper, entry may be recommended by the primary examiner." Types of amendments permitted under 37 C.F.R. § 1.312 include:

- (C) an amendment to the claims.

The amendments requested herein are of the type (C) and are shown (A) to be needed for proper disclosure or protection of the invention, and (B) to require no substantial amount of additional work on the part of the Office.

- Claim 21:
    - Line 21 has been amended to correct a minor grammatical error by replacing the period with a semi-colon.
    - Line 45 has been amended to correct a minor grammatical error by adding the conjunction "and" at the end of the penultimate clause.
- Claim 40:
    - Lines 28 and 38 have been amended to replace "an output of the receiver circuit" to "the output of the receiver circuit" for proper antecedent basis to the first instance of "output of the receiver circuit" on line 22.

- Claim 44:
    - Lines 4 and 8 have been amended to replace “inductive charging power” with “inductive power” for consistency with independent claim 40, which uses the term “inductive power” on lines 3 and 24.
- Claim 50:
    - Line 21 has been amended to correct a minor grammatical error by adding “and” to the penultimate element preceding the “wherein” clauses.

All of the amendments are for clarity and apparent from within claim 40 itself and, thus, comply with the requirements of 37 C.F.R. § 1.312 and MPEP §714.16.

Accordingly, Applicant respectfully requests entry of the amendments.

CERTIFICATE OF TRANSMISSION

I hereby certify that on March 3, 2022 this correspondence is being transmitted via the U.S. Patent & Trademark Office’s electronic filing system.

/Kent B. Chambers/

Respectfully submitted,

/Kent B. Chambers/

Kent B. Chambers
Attorney for Applicant(s)
Reg. No. 38,839

PART B - FEE(S) TRANSMITTAL

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Kent B. Chambers	(Typed or printed name)
/Kent B. Chambers/	(Signature)
March 23, 2022	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

TITLE OF INVENTION: System and Method for Inductive Charging of Portable Devices

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	06/21/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
ZHOU, ZIXUAN	2859	320-108000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

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(A) NAME OF ASSIGNEE: Mojo Mobility, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Palo Alto, California

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❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

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PTOL-85 Part B (08-18) Approved for use through 01/31/2020 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Electronic Patent Application Fee Transmittal

Application Number:	17507323
Filing Date:	21-Oct-2021
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
Filer:	Kent Bryan Chambers
Attorney Docket Number:	AFPA-01013US7

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	600	600

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**600**

Electronic Acknowledgement Receipt	
EFS ID:	45301931
Application Number:	17507323
International Application Number:	
Confirmation Number:	9345
Title of Invention:	System and Method for Inductive Charging of Portable Devices
First Named Inventor/Applicant Name:	Afshin Partovi
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Filer:	Kent Bryan Chambers
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Attorney Docket Number:	AFPA-01013US7
Receipt Date:	23-MAR-2022
Filing Date:	21-OCT-2021
Time Stamp:	16:41:41
Application Type:	Utility under 35 USC 111(a)

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Payment Type	CARD
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2	Fee Worksheet (SB06)	fee-info.pdf	37624 a9f39e170d8bf8b717517a7d8fa25f1c9a4d89fb	no	2
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7	9345

33438 7590 03/31/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

EXAMINER	
ZHOU, ZIXUAN	

ART UNIT	PAPER NUMBER
2859	

NOTIFICATION DATE	DELIVERY MODE
03/31/2022	ELECTRONIC

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Response to Rule 312 Communication	Application No.	Applicant(s)	
	17/507,323	Partovi et al.	
	Examiner	Art Unit	AIA (FITF) Status
	ZIXUAN ZHOU	2859	No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

1. ☑ The amendment filed on 22 March 2022 under 37 CFR 1.312 has been considered, and has been:

a) ☐ entered.

b) ☑ entered as directed to matters of form not affecting the scope of the invention.

c) ☐ disapproved because the amendment was filed after the payment of the issue fee.

Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

d) ☐ disapproved. See explanation below.

e) ☐ entered in part. See explanation below.

f) ☐ not entered because the supplemental or corrected Application Data sheet (ADS)

☐ was not accompanied by a petition to accept an unintentionally delayed claim under 37 CFR 1.55 or 27 CFR 1.78;

☐ did not identify the information being changed in accordance with 37 CFR 1.76(c)(2);

☐ was not properly signed in accordance with 37 CFR 1.76(e) (or 37 CFR 1.33(b) for applications filed prior to September 16, 2012).

/ZIXUAN ZHOU/
Primary Examiner, Art Unit 2859

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventors:	Afshin Partovi, Michael Sears		
Applicant:	Mojo Mobility, Inc.		
Title:	Efficiencies and Flexibilities in Inductive (Wireless) Charging		
Application No.:	17/507,323	Filing Date:	March 3, 2022
Examiner:	Zixuan Zhou	Group Art Unit:	2859
Docket No.:	AFPA-01013US7	Customer No.:	33438

ELECTRONICALLY FILED

Austin, Texas
March 3, 2022

AMENDMENT UNDER 37 C.F.R. § 1.312

This paper is submitted under and in compliance with 37 C.F.R. § 1.312. As explained in more detail below, Applicant respectfully submits that this amendment complies with 37 C.F.R. § 1.312 and MPEP §714.16. Entry of the amendment is respectfully requested.

The USPTO is also authorized to charge any underpayment of fees to Deposit Account No. 502264.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	76	20090267709		2009-10-29	Joannopoulos	
	77	20090224856		2009-09-10	Karalis	
	78	20090195333		2009-08-06	Joannopoulos	
	79	20090195332		2009-08-06	Joannopoulos	
	80	20080278264		2008-11-13	Karalis	
Change(s) applied to document, /S.D./ 3/25/2022	81	20110266878		~~2008-11-13~~ 11/2011	Cook	
	82	20100038970		2010-02-18	Cook	
	83	20090243397		2009-10-01	Cook	
	84	20090224609		2009-09-10	Cook	
	85	20090224608		2009-09-10	Cook	
	86	20090213028		2009-08-27	Cook	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Z.Z/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA-01013US7

	53	6489745		2002-12-03	Koreis	
	54	6331744		2001-12-18	Chen	
Change(s) applied to document, /S.D./ 3/25/2022	55	7336054		~~2005-03-89~~ 02/2008	Crisp	
	56	5803744	B1	~~2014-10-12~~ 09/1998	~~Anthony Sabo~~ Yen	
	57	6636017		2003-10-21	Zink et al	
	58	6586909		2003-07-01	Trepka	
	59	6462509		2002-10-08	Abe	
	60	6844702		2005-01-28	Giannopoulos	
	61	4311953		1982-01-19	Fukuda	
	62	6016046		2000-01-18	Kaile et al.	
	63	7164255	B2	2007-01-16	Shu-Yuen Ron Hui	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Z.Z/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17507323
	Filing Date	2021-10-21
	First Named Inventor	Afshin Partovi
	Art Unit	2859
	Examiner Name	Undetermined
	Attorney Docket Number	AFPA 01013US7

	20	9793738	B2	2017-10-17	Jacobs et al	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
Change(s) applied to document, /S.D./ 3/25/2022	1	20040145342	A1	2004-07-29	~~Hewlett-Packard Company~~ Lyon	
	2	20040150934	A1	2004-08-05	Baarman et al	
	3	20050068019	A1	2005-03-31	Nakamura et al	
	4	20050189910	A1	2005-09-01	Shu-yuen, Ron Hui	
	5	20080272889	A1	2008-11-06	Symons, Peter Robert	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2396901	EP	B1	2019-12-25	Kirby et al		

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Z.Z/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/507,323	04/26/2022	11316371	AFPA-01013US7	9345

33438 7590 04/06/2022

TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site http://pair.uspto.gov for additional inventors):

Afshin Partovi, Palo Alto, CA;
Michael Sears, Ben Lomond, CA;

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Mojo Mobility, Inc., Palo Alto, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

IR103 (Rev. 10/09)

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7

CONFIRMATION NO. 9345

33438
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

PUBLICATION NOTICE



Title: System and Method for Inductive Charging of Portable Devices

Publication No.US-2022-0115908-A1
Publication Date:04/14/2022

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:22-cv-00433	10/7/2022	Eastern District of Texas

PLAINTIFF	DEFENDANT
Mojo Mobility Inc.	Samsung Electronics Co., Ltd and Samsung Electronics America, Inc.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 7,948,208	5/24/2011	Mojo Mobility Inc.
2	US 9,577,440	2/21/2017	Mojo Mobility Inc.
3	US 11,292,349	4/5/2022	Mojo Mobility Inc.
4	US 11,201,500	12/14/2021	Mojo Mobility Inc.
5	US 11,316,371	4/26/2022	Mojo Mobility Inc.

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

ATTACHMENT TO FORM AO-120
REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
(Mojo Mobility Inc. v. Samsung Electronics Co., Ltd and Samsung Electronics America, Inc.)

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
6 US 11,342,777	5/24/2022	Mojo Mobility Inc.
7 US 11,462,942	10/4/2022	Mojo Mobility Inc.

PTO/AIA/81A (02-15)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it displays a valid OMB control number

PATENT - POWER OF ATTORNEY OR REVOCATION OF POWER OF ATTORNEY WITH A NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS

Patent Number	11,316,371
Issue Date	2022-04-26
First Named Inventor	Afshin Partovi
Title	System and Method for Inductive Charging of Portable Devices
Attorney Docket No.	1343/5/8 UTIL

I hereby revoke all previous powers of attorney given in the above-identified patent.

☐ A Power of Attorney is submitted herewith.

OR

☉ I hereby appoint Practitioner(s) associated with the Customer Number identified in the box at right as my/our attorney(s) or agent(s) with respect to the patent identified above, and to transact all business in the United States Patent and Trademark Office connected therewith: 115007

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s) with respect to the patent identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

Practitioner(s) Name	Registration Number

Please recognize or change the correspondence address for the above-identified patent to:

☒ The address associated with the above-identified Customer Number.

OR

☐ The address associated with the Customer Number identified in the box at right:

OR

☐ Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☉ Applicant.

OR

☐ Patent owner.

Statement under 37 CFR 3.73(c) (Form PTO/AIA/96) submitted herewith or filed on _____.

SIGNATURE of Applicant or Patent Owner

Signature		Date	2023-03-10
Name	Afshin Partovi	Telephone	650-892-5001
Title and Company	CEO, Mojo, Mobility Inc.		

NOTE: Signatures of all the applicants or patent owners of the entire interest or their representative(s) are required. If more than one signature is required, submit multiple forms, check the box below, and identify the total number of forms submitted in the blank below.

☑ A total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public, which is to update (and by the USPTO to process) the file of a patent or reexamination proceeding. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES
PATENT AND TRADEMARK OFFICE

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/507,323	**03/13/2023 03:52:14 PM ET**	**AFPA-01013US7**

Title of Invention

System and Method for Inductive Charging of Portable Devices

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	11316371
CONFIRMATION #	9345	FILED BY	Jana Passe
PATENT CENTER #	61731850	FILING DATE	10/21/2021
CUSTOMER #	33438	FIRST NAMED INVENTOR	Afshin Partovi
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Douglas Meier

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
1343-5-8UTIL-20230310-POA-signed.pdf	2	Power of Attorney	1794 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
1343-5-8UTIL-20230310-POA-signed.pdf	1ABFD7A2EE520A831476EABF546FCEF85FEC8A0A10D1EFC98F61DAD9AA3BDAAB5A155B454771D7DF1D62049BCA4B40E4D11C3D5D5D47648DD06E1C5A06F648C2

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized

by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/507,323	10/21/2021	Afshin Partovi	AFPA-01013US7

CONFIRMATION NO. 9345

33438
TERRILE, CANNATTI & CHAMBERS, LLP
P.O. BOX 203518
AUSTIN, TX 78720

POWER OF ATTORNEY NOTICE

OC000000137657472

Date Mailed: 04/05/2023

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/13/2023.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/rnegga/

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UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/507,323	10/21/2021	Afshin Partovi	1343/5/8 UTIL

CONFIRMATION NO. 9345

115007
NK Patent Law
4101 Lake Boone Trail
Suite 218
Raleigh, NC 27607

POA ACCEPTANCE LETTER

OC000000137657475

Date Mailed: 04/05/2023

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 03/13/2023.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/rnegga/