



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	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
61/129,859	07/24/2008		105	1052-44		

CONFIRMATION NO. 6672

Yossi Azancot
11, Amal Street
Rosh HaAyin, 48092
ISRAEL

FILING RECEIPT



OC000000031416282

Date Mailed: 08/07/2008

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, 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 Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections 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**

Applicant(s)

Yossi Azancot, Jerusalem, ISRAEL;
Amir Ben Shalom, Modiin, ISRAEL;
Arik Rofe, Jerusalem, ISRAEL;
Oola Greenwald, Jerusalem, ISRAEL;
Alfred Leibovitz, Petach Tikva, ISRAEL;

Power of Attorney: None

If Required, Foreign Filing License Granted: 08/06/2008

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/129,859**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

Inductive feedback

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

page 1 of 3

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 (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with

respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. _____

INVENTOR(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Yossi	Azancot	Jerusalem, Israel
Amir	Ben Shalom	Modi'in, Israel
Arik	Rofe	Jerusalem, Israel
Oola	Greenwald	Jerusalem, Israel
Alfred	Leibovitz	Petach Tikva, Israel

Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max):

Inductive Feedback

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☐ The address corresponding to Customer Number: _____

OR

☒ Firm or Individual Name

Address 11, Amal Street

City Rosh HaAyin	State Israel	Zip 48092
Country Israel	Telephone +972 3 902 1057	Email morris@ipfactor.co.il

ENCLOSED APPLICATION PARTS (check all that apply)

☐ Application Data Sheet. See 37 CFR 1.76

☒ Drawing(s) Number of Sheets 4

☒ Specification (e.g. description of the invention) Number of Pages 14

☐ CD(s), Number of CDs _____

☐ Other (specify) _____

Fees Due: Filing Fee of \$200 (\$100 for small entity). If the specification and drawings exceed 100 sheets of paper, an application size fee is also due, which is \$250 (\$125 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).

METHOD OF PAYMENT OF THE FILING FEE AND APPLICATION SIZE FEE FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fee and application size fee (if applicable).

☒ Payment by credit card. Form PTO-2038 is attached

☐ The Director is hereby authorized to charge the filing fee and application size fee (if applicable) or credit any overpayment to Deposit

TOTAL FEE AMOUNT (\$) 105

Account Number: _____ A duplicative copy of this form is enclosed for fee processing.

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. 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 8 hours 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.

PROVISIONAL APPLICATION COVER SHEET
Page 2 of 2

PTO/SB/16 (07-07)

Approved for use through 06/30/2010. OMB 0651-0032

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.

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.	
☒	No.
☐	Yes, the name of the U.S. Government agency and the Government contract number are: _____

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.

SIGNATURE /Yossi Azancot/ /Amir Ben Shalom/ /Arik Rofe/ /Oola Greenwald/ /Alfred Leibovitz/

Date 24th July 2008

TYPED or PRINTED NAME Yossi Azancot Amir Ben Shalom Arik Rofe Oola Greenwald **Alfred Leibovitz**
(if appropriate)

TELEPHONE +972 3 902 1057

Docket Number 1052-44

Inductive Feedback

Field of the Invention

The present invention is directed to providing a communications channel for the transfer of feedback signals in inductive power transfer systems. More specifically, the present invention relates to coil-to-coil signal transfer in inductive power couplings.

Background

When providing power to electric devices it may be desirable to provide a channel for signal transfer. This may be useful for power regulation or load authentication for example. Thus a communication channel is often provided alongside the power input channel. Known methods for providing such a communication channel include wired connections to the device, which may be packaged within the same cable as the power lines.

Devices such as transformers and induction connectors transfer energy between primary and secondary coils by induction. In such systems, feedback from the device to the power source is necessary, in order to regulate the power provided to a load via the secondary coil. However in applications where the primary coil and secondary coil must remain galvanically isolated from one another, a wired connection is inherently unsuitable.

Systems for the transfer of signals between galvanically isolated elements of a circuit are known. For example, an optical signal may be transmitted from an optical transmitter, such as a light emitting diode, over a short optical path to a galvanically isolated receiver, such as a photo-transistor which may convert the optical signal into an electrical signal. Such system require an optical line-of-sight between transmitter and receiver which may be inappropriate.

United States Patent No. 5,455,466 titled, "Inductive coupling system for power and data transfer" to Terry J. Parks and David S. Register describes a system for inductively coupling power and data to a portable electronic device. The portable device, such as a personal digital assistant (PDA), is powered or recharged via an inductive link between the device and a support unit. The same inductive link is also used to transfer data signals between the device and a second electronic device, such as a conventional desktop computer. The support unit includes a primary winding of a

transformer, a power amplifier and a modulator. The portable device includes a secondary winding connected in parallel with the input of a rectifier, the output of which is connected to a battery charging circuit, and to a modem, which is further connected to the device microprocessor. Placement of the device on the support unit
5 effects the inductive coupling when the primary and secondary windings are in proximity to one another. Parks' system is thus directed to providing a data channel for synchronizing two data storage devices for example a PDA and a computer.

In Parks' system data transfer from the primary winding to the secondary winding may be provided by modulating the power signal. This requires a separate
10 data signal to be transmitted by the secondary winding which is induced in the primary winding. Power transmission must therefore be interrupted in order to transmit data signals from the secondary winding to the primary winding. As a result, Parks' system does not offer any solution to providing a feedback signal for the regulation of uninterrupted inductive power transfer to an electric load.

15 The need remains for a signal transfer system for transferring feedback signals between an electric load and an inductive power outlet, which does not require alignment of the signal transmitter and the signal receiver, and the present invention addresses this need.

20

Summary of the Invention

It is an aim of the invention to provide a signal transfer system for an inductive power transfer system, the inductive power transfer system comprising at least one primary inductive coil for forming an inductive couple with at least one secondary inductive coil wired to an electric load. The primary inductive coil is wired to a power supply via a driver configured to provide a driving voltage across the primary inductive coil. The driving voltage oscillates at a transmission frequency higher than the resonant frequency of the inductive couple. The primary inductive coil is further wired to a reception circuit comprising a voltage monitor for monitoring the amplitude of a primary voltage across the primary coil. The secondary inductive coil is further wired to a transmission circuit for connecting at least one electric element to the secondary inductive coil thereby increasing the resonant frequency.

In preferred embodiments the secondary inductive coil is wired to two inputs of a bridge rectifier, the electric load is wired to two outputs of said bridge rectifier and the transmission circuit is wired to one input of said bridge rectifier and one output of said bridge rectifier.

The transmission circuit may further comprise a modulator for modulating a bit-rate signal with an input signal to create a modulated signal and a switch for intermittently connecting said electrical element to said secondary inductive coil according to said modulated signal.

Optionally, the voltage monitor further comprises a correlator for cross-correlating the amplitude of said primary voltage with said bit-rate signal for producing an output signal.

Variously, the signal transfer system may transfer data pertaining to at least one of the group comprising:

- presence of said electric load;
- location of said secondary inductive coil;
- required operating voltage for said electric load;
- required operating current for said electric load;
- required operating temperature for said electric load;

- required operating power for said electric load;
- measured operating voltage for said electric load;
- measured operating current for said electric load;
- measured operating temperature for said electric load;
- 5 ▪ measured operating power for said electric load;
- power delivered to said primary inductive coil;
- power received by said secondary inductive coil, and
- a user identification code.

10 Typically, the signal transfer system transfers a feedback signal from said secondary inductive coil to said primary inductive coil for regulating power transfer across an inductive power coupling. In some embodiments, the driver being configured to adjust said transmission frequency in response to said feedback signals.

Preferably, the system is adapted to transfer a first signal and a second signal, and said driver is configured to:

- 15 ▪ increase said transmission frequency when said first signal is received by the receiver, and
- decrease said transmission frequency when said second signal is received by the receiver.

20 Optionally, the system comprises a power converter selected from the group comprising: a transformer, a DC-to-DC converter, an AC-to-DC converter, an AC-to-AC converter, a flyback transformer, a flyback converter, a full-bridge converter, a half-bridge converter and a forward converter.

25 It is another aim of the invention to provide a method for transferring a signal, in an inductive power transfer system, from a secondary inductive coil wired to an electric load, to a primary inductive coil, wired to a power supply via a driver, said method comprising the following steps:

- Step (a) - providing a voltage monitor for monitoring the amplitude of a primary voltage across said primary coil;

- Step (b) - providing a transmission circuit for connecting an electric element to said secondary inductive coil thereby increasing the resonant frequency of said inductive power transfer system;
- 5 Step (c) - providing an oscillating voltage to said primary inductive coil at an initial transmission frequency higher than said resonant frequency thereby inducing a voltage in said secondary inductive coil;
- 10 Step (d) - said transmission circuit modulating a bit-rate signal with the input signal to create a modulated signal and connecting said electrical element to said secondary inductive coil intermittently according to said modulated signal;
- Step (e) - said voltage monitor cross-correlating the amplitude of said primary voltage with said bit-rate signal for producing an output signal.

It is still a further aim of the invention to provide a signal transfer system for transferring feedback signals for regulating power transfer in an inductive power transfer system, said inductive power transfer system comprising at least one primary inductive coil for forming an inductive couple with at least one secondary inductive coil wired to an electric load, wherein said feedback signals are transferred from said secondary inductive coil to said primary inductive coil concurrently with uninterrupted inductive power transfer from said primary inductive coil to said secondary inductive coil.

15

20

Brief Description of the Figures

For a better understanding of the invention and to show how it may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings.

5 With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no
10 attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention; the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice. In the accompanying drawings:

 Fig. 1 is a block diagram showing the main elements of an inductive power transfer system with an inductive feedback channel according to a first embodiment of
15 the present invention.

 Fig. 2 is a graph showing how the amplitude of operational voltage of an inductive power transfer system varies according to the voltage transmission frequency and the resonant frequency of the system;

20 Fig. 3 is a circuit diagram of an inductive power transfer system including an inductive feedback channel for providing coil-to-coil signal transfer concurrently with uninterrupted inductive power transfer between the coils in accordance with another embodiment of the invention; and

 Fig. 4 is a flowchart showing a method for transferring a signal from the
25 secondary inductive coil to a primary inductive coil of an inductive power transfer system according to still a further embodiment of the invention.

Description of the Preferred Embodiments

 Reference is now made to Fig. 1 showing a block diagram of the main
30 elements of an inductive power transfer system 100 consisting of an inductive power outlet 200 configured to provide power to a remote secondary unit 300. The inductive power transfer system 100 includes an inductive communication channel 120 according to a first embodiment of the present invention. The communication

channel 120 is configured to produce an output signal S_{out} in the power outlet 200 when an input signal S_{in} is provided by the secondary unit 300.

5 The inductive power outlet 200 includes a primary inductive coil 220 wired to a power source 240 via a driver 230. The driver 230 is configured to provide an oscillating driving voltage to the primary inductive coil 220, typically at a voltage transmission frequency f_t which is higher than the resonant frequency f_R of the system.

10 The secondary unit 300 includes a secondary inductive coil 320, wired to an electric load 340, which is inductively coupled to the primary inductive coil 220. The electric load 340 draws power from the power source 240. Where the electric load 340 requires a direct current supply, for example a charging device for an electrochemical cell or the like, a rectifier 330 may be provided to rectify the alternating current signal induced in the secondary coil 320.

15 An inductive communication channel 120 is provided for transferring signals from the secondary inductive coil 320 to the primary inductive coil 220 concurrently with uninterrupted inductive power transfer from the primary inductive coil 220 to the secondary inductive coil 320. The communication channel 120 may provide feedback signals to the driver 230.

20 The inductive communication channel 120 includes a transmission circuit 122 and a receiving circuit 124. The transmission circuit 122 is wired to the secondary coil 320, optionally via a rectifier 330, and the receiving circuit 124 is wired to the primary coil 220.

25 The signal transmission circuit 122 includes at least one electrical element 126, selected such that when it is connected to the secondary coil 320, the resonant frequency f_R of the system increases. The transmission circuit 122 is configured to selectively connect the electrical element 126 to the secondary coil 320.

As known, the resonant frequency f_R of an inductive couple is given by the formula $f_R = \frac{1}{2\pi\sqrt{LC}}$, where L is the inductance of the system and C is the capacitance of the system. Thus any decrease in either the inductance L or the capacitance C increases the resonant frequency of the system. The electrical element 126 may be a low resistance for example, typically the resistance of the electrical element 126 is under 50 ohms and preferably about 1 ohm.

30

The signal receiving circuit 124 may include a voltage peak detector 128 configured to detect large increases in the transmission voltage. In systems where the voltage transmission frequency f_t is higher than the resonant frequency f_R of the system, such large increases in transmission voltage may be caused by an increase in the resonant frequency f_R thereby indicating that the electrical element 126 has been connected to the secondary coil 320. Thus the transmission circuit 122 may be used to send a signal pulse to the receiving circuit 124 and a coded signal may be constructed from such pulses.

According to some embodiments, the transmission circuit 122 may also include a modulator (not shown) for modulating a bit-rate signal with the input signal S_{in} . The electrical element 126 may then be connected to the secondary inductive coil 320 according to the modulated signal. The receiving circuit 124 may include a demodulator (not shown) for demodulating the modulated signal. For example the voltage peak detector 128 may be connected to a correlator for cross-correlating the amplitude of the primary voltage with the bit-rate signal thereby producing the output signal S_{out} .

In other embodiments, a plurality of electrical elements 126 may be provided which may be selectively connected to induce a plurality of voltage peaks of varying sizes in the amplitude of the primary voltage. The size of the voltage peak detected by the peak detector 128 may be used to transfer multiple signals.

Fig. 2 is a graph showing how the amplitude of the operational voltage varies according to the transmission frequency. It is noted that the voltage is at its highest when the transmission frequency is equal to the resonant frequency f_R of the system, this maximum amplitude is known as the resonance peak 2. If the resonant frequency f_R of the system increases, a new resonance peak 2' is produced.

According to an exemplary embodiment of the invention, an inductive power transfer system 100 operates at a given transmission frequency f_t which is higher than the resonant frequency f_R of the system. The normal operating voltage V_t is monitored by the voltage peak detector 128. When the electric element 126 is connected to the secondary inductive coil 320 the resonant frequency of the system increases. Therefore, the operating voltage increases to a higher value V_t' . This increase is detected by the voltage peak detector 128.

The present invention allows data signals to be transferred from the secondary coil 320 to the primary coil 220 concurrently with inductive transfer of power from

the primary coil 220 to the secondary coil 320. Consequently, the signal transfer system may be used to provide feedback signals for real time power regulation. This is in contradistinction to prior art inductive signal transfer systems, such as the system described in the abovementioned United States Patent No. 5,455,466 titled, "Inductive
5 coupling system for power and data transfer" to Terry J. Parks and David S. Register as referred to hereabove, in which a separate data signal is supplied to the secondary inductive coil such that a voltage is induced in the primary coil.

Fig. 3 shows an exemplary circuit diagram of an inductive power outlet 2200 and a secondary unit 2300, according to another embodiment of the invention. An
10 inductive feedback channel 2120 is provided for transferring signals between the coils concurrently with uninterrupted inductive power transfer.

The inductive power outlet 2200 comprises a primary coil 2220 driven by a half-bridge converter 2230 connected to a power source 2240. The half-bridge converter 2230 is configured to drive the primary coil 2220 at a frequency higher than
15 the resonant frequency of the system. The secondary unit 2300 comprises a secondary coil 2320 wired to the input terminals T_1 , T_2 of a rectifier 2330, and an electric load 2340 wired to the output terminals T_3 , T_4 of the rectifier 2330.

Although only a half-bridge converter 2230 is represented in the inductive power outlet 2200 of Fig. 3, it is noted that other driving circuits could be used. These
20 include: a DC-to-DC converter, an AC-to-DC converter, an AC-to-AC converter, a flyback transformer, a full-bridge converter, a flyback converter or a forward converter for example.

The inductive feedback channel 2120 comprises a transmission circuit 2122, in the secondary unit 2300 and a receiving circuit 2124 in the inductive power outlet
25 2200. The transmission circuit 2122 comprises an electrical resistor 2126 connected to the rectifier 2330 via a power MOSFET switch 2125. A modulator 2123 may provide an input signal S_{in} to the power MOSFET 2125.

It is noted that in this embodiment the transmission circuit 2122 is wired to one input terminal T_1 and one output terminal T_3 of the rectifier 2330. This
30 configuration is particularly advantageous as, even when the transmission circuit 2122 is connected, the resistor 2126 only draws power from the system during one half of the AC cycle, thereby significantly reducing power loss.

The receiving circuit 2124 includes a voltage peak detector 2128 that is configured to detect increases in the transmission voltage, and a demodulator 2129 for producing an output signal S_{out} .

5 With reference now to Fig. 4, a flowchart is presented showing the main steps in a method for transferring a signal from the secondary inductive coil to a primary inductive coil of an inductive power transfer system. The method includes the following steps:

Step (a) – connecting the primary inductive coil to a voltage monitor for monitoring the amplitude of a primary voltage across the primary coil;

10 Step (b) – connecting the secondary inductive coil to a transmission circuit for connecting an electric element to the secondary inductive coil thereby increasing the resonant frequency of the inductive power transfer system;

Step (c) – providing an oscillating voltage to the primary inductive coil at an initial transmission frequency higher than the resonant frequency thereby inducing a voltage in the secondary inductive coil;

Step (d) – using the transmission circuit to modulate a bit-rate signal with the input signal to create a modulated signal and connecting the electrical element to the secondary inductive coil intermittently according to the modulated signal;

20 Step (e) – using the voltage monitor to cross-correlate the amplitude of the primary voltage with the bit-rate signal for producing an output signal.

The inductive feedback channel 2120 may be used for transferring data, such as data pertaining to any or all of the following:

- the required operating voltage, current, temperature or power for the electric load 240
- 25 ▪ the measured voltage, current, temperature or power supplied to the electric load 240 during operation
- the measured voltage, current, temperature or power received by the electric load 240 during operation and the like
- identification data for the user, electronic device and such like

30 Therefore, the inductive communication channel may be used to transfer a feedback signal from the secondary inductive coil to the primary inductive coil for regulating power transfer across an inductive power coupling.

For example the system may be configured to transfer two signals with the driver being configured to decrease the transmission power when a first signal is received, and to increase the transmission power when a second signal is received.

Power may be regulated by altering the duty cycle of the transmission voltage
5 provided by the driver. Furthermore, when the transmission frequency is not equal to the resonance frequency of the system, the driver 230 may also be configured to adjust the transmission frequency in order to regulate the power transfer, as described in the inventors' copending application United States Serial No. 61/129,526. Accordingly, the driver may be configured to adjust the transmission frequency in
10 response to feedback signals. The transmission frequency may be increased when the first signal is received thereby decreasing the operating voltage, and the transmission frequency may be decreased when the second signal is received, thereby increasing the operating voltage.

Thus the present invention provides a communication channel which may be
15 used for regulating power transfer and/or for transmitting data signals from the secondary coil to the primary coil of an inductive couple while power is being transferred. The scope of the present invention is defined by the appended claims and includes both combinations and sub combinations of the various features described hereinabove as well as variations and modifications thereof, which would occur to
20 persons skilled in the art upon reading the foregoing description.

In the claims, the word "comprise", and variations thereof such as "comprises", "comprising" and the like indicate that the components listed are included, but not generally to the exclusion of other components.

Claims

1. A signal transfer system for an inductive power transfer system, said inductive power transfer system comprising at least one primary inductive coil for forming an inductive couple with at least one secondary inductive coil wired to an electric load,
5 said primary inductive coil being wired to a power supply via a driver; said driver being configured to provide a driving voltage across said primary inductive coil, said driving voltage oscillating at a transmission frequency higher than the resonant frequency of said inductive couple; wherein
 - 10 a. said primary inductive coil is further wired to a reception circuit comprising a voltage monitor for monitoring the amplitude of a primary voltage across said primary coil, and
 - b. said secondary inductive coil is further wired to a transmission circuit for connecting at least one electric element to said secondary inductive coil
15 thereby increasing said resonant frequency.
2. The signal transfer system of claim 1 said secondary inductive coil being wired to two inputs of a bridge rectifier and said electric load being wired to two outputs of said bridge rectifier wherein said transmission circuit is wired to one input of said bridge rectifier and one output of said bridge rectifier.
- 20 3. The signal transfer system of claim 1 wherein said transmission circuit further comprises a modulator for modulating a bit-rate signal with an input signal to create a modulated signal and a switch for intermittently connecting said electrical element to said secondary inductive coil according to said modulated signal.
4. The signal transfer system of claim 3 wherein said voltage monitor further
25 comprises a correlator for cross-correlating the amplitude of said primary voltage with said bit-rate signal for producing an output signal.
5. The signal transfer system of claim 1 for transferring data pertaining to at least one of the group comprising:
 - a. presence of said electric load;
 - 30 b. location of said secondary inductive coil;

- c. required operating voltage for said electric load;
 - d. required operating current for said electric load;
 - e. required operating temperature for said electric load;
 - f. required operating power for said electric load;
 - 5 g. measured operating voltage for said electric load;
 - h. measured operating current for said electric load;
 - i. measured operating temperature for said electric load;
 - j. measured operating power for said electric load;
 - k. power delivered to said primary inductive coil;
 - 10 l. power received by said secondary inductive coil, and
 - m. a user identification code.
6. The signal transfer system of claim 1 for transferring a feedback signal from said secondary inductive coil to said primary inductive coil for regulating power transfer across an inductive power coupling.
- 15 7. The system of claim 6 said driver being configured to adjust said transmission frequency in response to said feedback signals.
8. The system of claim 6 adapted to transfer a first signal and a second signal, and said driver being configured to:
- i. increase said transmission frequency when said first signal is
 - 20 received by the receiver, and
 - ii. decrease said transmission frequency when said second signal is received by the receiver.
9. The system of claim 1 comprising a power converter selected from the group comprising: a transformer, a DC-to-DC converter, an AC-to-DC converter, an
- 25 AC-to-AC converter, a flyback transformer, a flyback converter, a full-bridge converter, a half-bridge converter and a forward converter.
10. A method for transferring a signal, in an inductive power transfer system, from a secondary inductive coil wired to an electric load, to a primary inductive coil, wired to a power supply via a driver, said method comprising the following steps:

- a. providing a voltage monitor for monitoring the amplitude of a primary voltage across said primary coil;
 - b. providing a transmission circuit for connecting an electric element to said secondary inductive coil thereby increasing the resonant frequency of said inductive power transfer system;
 - c. providing an oscillating voltage to said primary inductive coil at an initial transmission frequency higher than said resonant frequency thereby inducing a voltage in said secondary inductive coil;
 - d. said transmission circuit modulating a bit-rate signal with the input signal to create a modulated signal and connecting said electrical element to said secondary inductive coil intermittently according to said modulated signal;
 - e. said voltage monitor cross-correlating the amplitude of said primary voltage with said bit-rate signal for producing an output signal.
11. A signal transfer system for transferring feedback signals for regulating power transfer in an inductive power transfer system, said inductive power transfer system comprising at least one primary inductive coil for forming an inductive couple with at least one secondary inductive coil wired to an electric load, wherein said feedback signals are transferred from said secondary inductive coil to said primary inductive coil concurrently with uninterrupted inductive power transfer from said primary inductive coil to said secondary inductive coil.

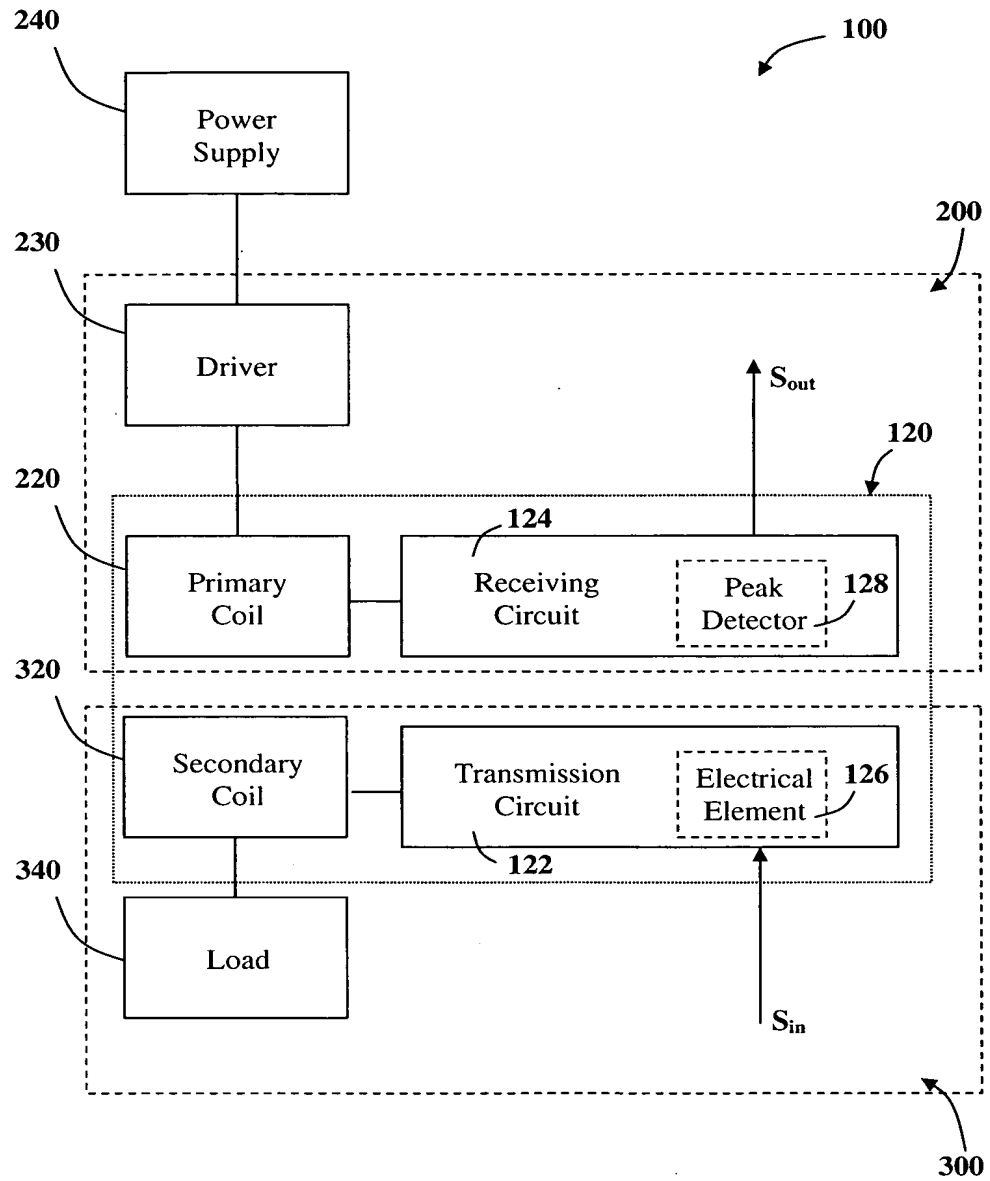


Fig. 1

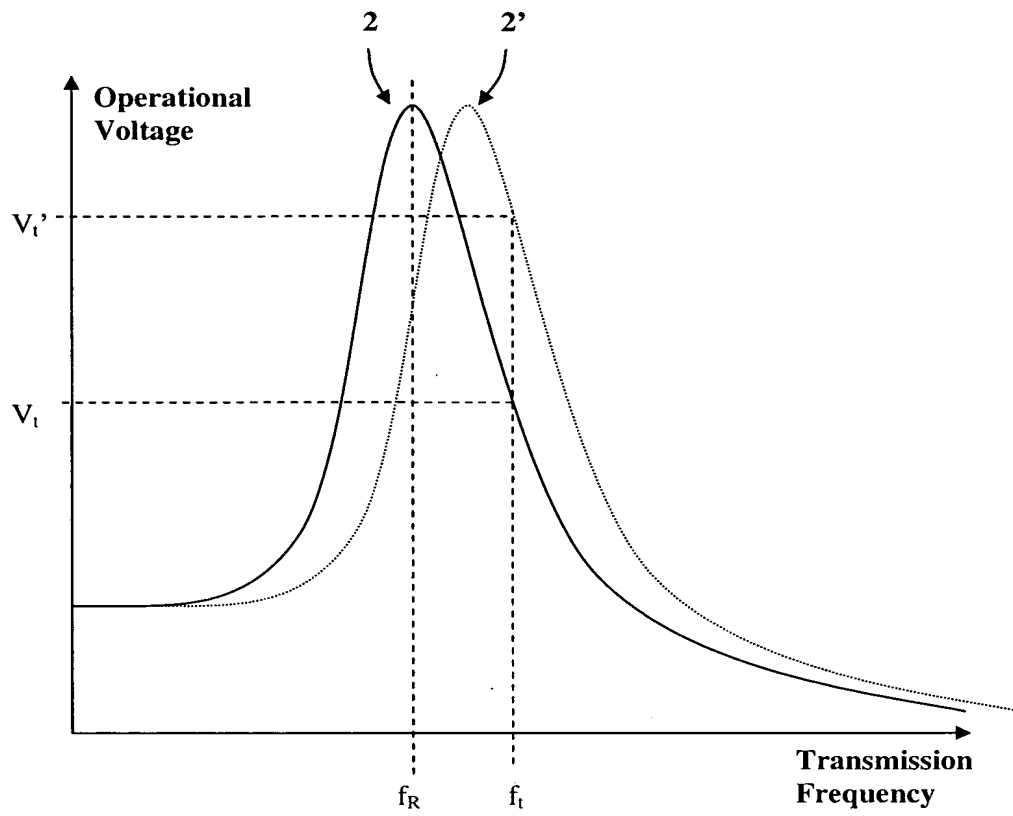


Fig. 2

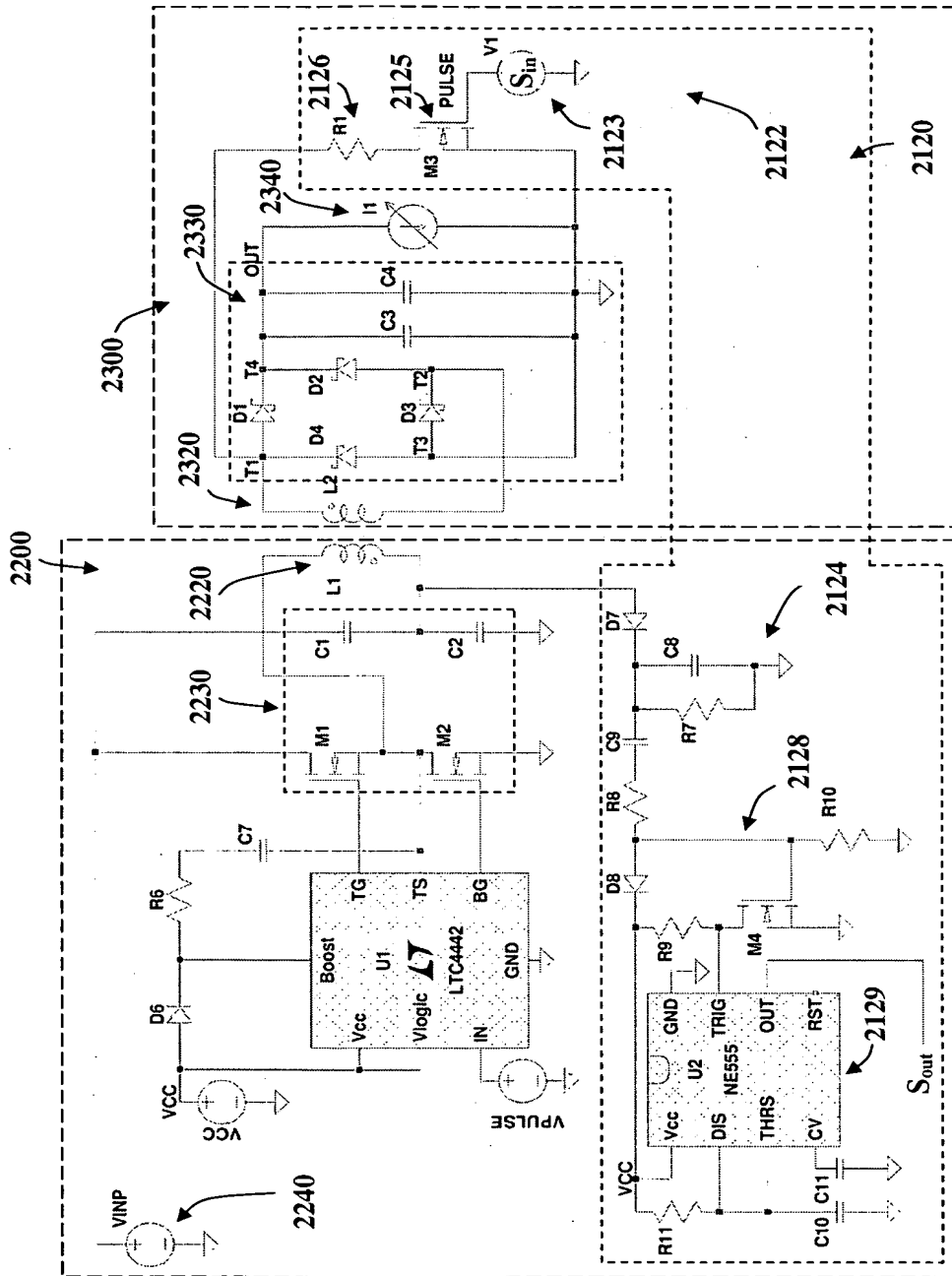
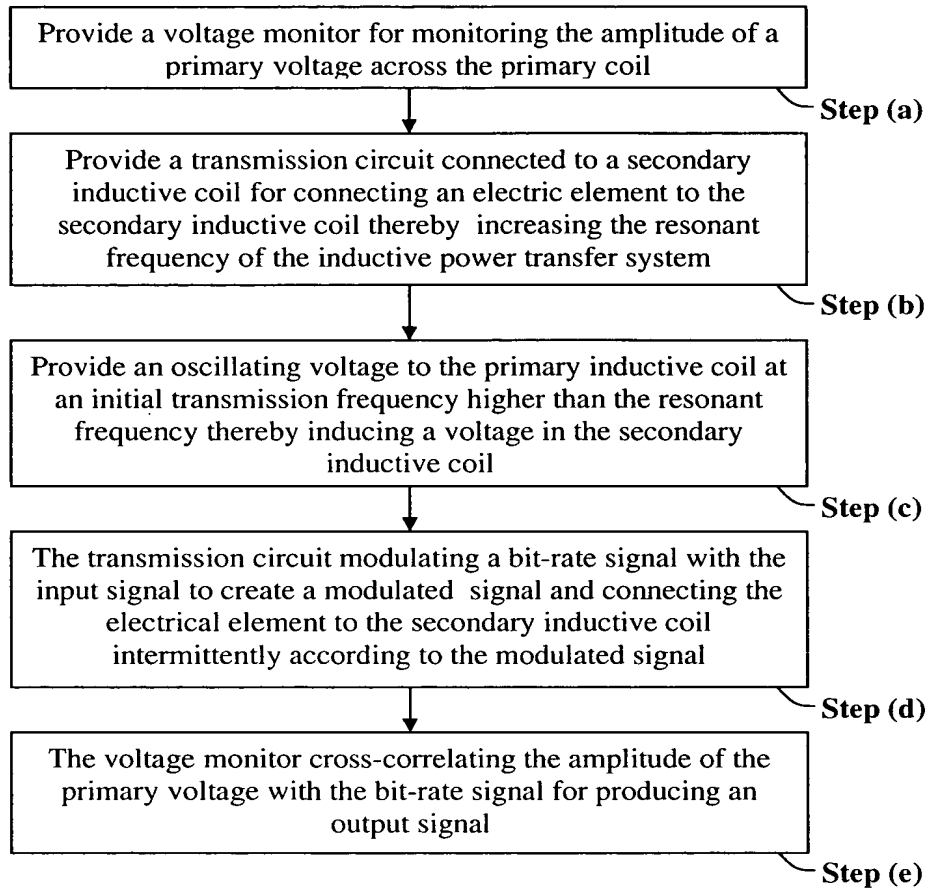


Fig. 3

**Fig. 4**

PATENT APPLICATION SERIAL NO. _____

**U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET**

07/25/2008 LTRUONG 00000040 61129859

01 FC:2005

105.00 OP

PTO-1556
(5/87)