

US11462942 EFFICIENCIES AND METHOD FLEXIBILITIES IN INDUCTIVE (WIRELESS) CHARGING

I. Samsung Infringement

1. 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:

As described below by representative products, the 942 Accused Products are capable of providing power inductively as specified by 942 claim 1 are accused under this claim; this includes the 942 Accused Smartphones and the 942 Accused Wireless Chargers (collectively the “942 Claim 1 Accused Products”).

Smartphones

The S22 Ultra meets this introductory part of claim 1, as it includes the “Wireless PowerShare” feature with a system to transfer power inductively to another device as described in this part of the claim.

<https://www.samsung.com/us/support/answer/ANS00082564/>

Compatible Samsung devices

Most Qi-Compatible Samsung devices can be charged with Wireless PowerShare, but check out the full list of compatible devices just in case. The speed and power of the charge will vary by device.

Phones that can use and also be charged with Wireless PowerShare:

- Galaxy S22, S22+, and S22 Ultra
- Galaxy S21, S21+, and S21 Ultra
- Note20 5G and Note20 Ultra 5G
- Galaxy Note10, Note10+, and Note10+ 5G
- Galaxy Fold, Z Fold2, and Z Fold3
- Galaxy Z Flip, Z Flip 5G, and Z Flip3
- Galaxy S20 5G, S20+ 5G, S20 Ultra 5G, and S20 FE
- Galaxy S10e, S10, S10+, and S10 5G

Other devices that can be charged by Wireless PowerShare:

- Galaxy Buds, Galaxy Buds2, Galaxy Buds+, Galaxy Buds Live, and Galaxy Buds Pro
- Galaxy Watch, Galaxy Watch3, Galaxy Watch4, Galaxy Watch4 Classic, Gear Sport, and Gear S3
- Galaxy S7/S7 Edge, S8/S8+, S9/S9+, Note8, and Note9
- Galaxy Watch Active and Galaxy Watch Active2

<https://screenrant.com/does-samsung-galaxy-s22-have-wireless-charging-support/>

On top of that, all three models of the Galaxy S22 also support Wireless PowerShare. This is the feature that allows S22 owners to use their phone as a wireless charger to charge accessories and other phones. To enable Wireless PowerShare, open the Settings app on the Galaxy S22 and tap 'Battery and device care.' Tap 'Battery,' tap 'Wireless power sharing,' and tap the toggle to turn it on. Now, placing another device on the back of the S22 will allow it to refuel like it would on any other wireless charging pad. This works best with smaller gadgets like earbuds and **Samsung** smartwatches, but it can also be used to charge another smartphone if you're in a pinch.

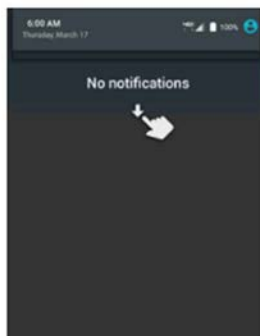
<https://www.verizon.com/support/knowledge-base-300922/>

Samsung Galaxy S22 / Galaxy S22 Ultra - Use Wireless PowerShare

NOTE

- Wireless PowerShare works with most wireless charging capable devices. Different devices may charge at different speeds.
- If unable to connect a device or charging is slow, remove any cover from each device.
→ For additional troubleshooting, refer to Wireless PowerShare Issues.
- Using Wireless PowerShare may affect call reception or data services, depending on network environment.

1. Swipe down on the **Status bar** (at the top) twice to expand the 'quick settings' menu.
→ The image below is an example.



2. Tap **Wireless power sharing**.
→ If unavailable, swipe left to view additional quick settings.
3. Place the center of your phone back to back with another PowerShare-capable device.

Wireless Chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, 3300 Wireless Charger Battery, SmartThings Station, 5300 Car Mount Charger, and 825 Watch Dock satisfy this introductory part of claim 1, as they can wirelessly charge various mobile devices as specified.

The 5200 Duo Pad can wirelessly charge various mobile devices.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/wireless-charger-duo-pad-black-ep-p5200tbegus/>



Qi certified

The Wireless Charger Duo Pad is Qi certified meaning any Qi compatible products can charge on it, including the Samsung Galaxy S10, Galaxy Note9, Apple iPhone 8, iPhone X, and Google Pixel 3.

The 5400 Duo Pad can wirelessly charge various mobile devices.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-cable-dark-gray-ep-p5400cbegus/>

One charger, two devices

Simultaneously power up your favorite pair of devices to enjoy together — whether that's your phone and Galaxy Watch or your Galaxy Watch and earbuds.

*The secondary part of this charger cannot charge a mobile phone and is only compatible with all Galaxy Buds and Galaxy Watch Active 1 and later watch models.



https://www.amazon.com/gp/product/B09MV3BRHC/ref=ask_ql_qh_dp_hza?th=1



This item Samsung 15W Wireless Charger Duo (w/TA), Black

Add to Cart

Customer Rating	★★★★☆ (40)
Price	\$78 ²⁸
Shipping	FREE Shipping. Details
Sold By	Amazon.com
Color	Black
Compatible Phone Models	Samsung Galaxy S10, Apple iPhone X, Samsung Galaxy Note 10

The 6300 Trio Pad can wirelessly charge various mobile devices.

https://www.samsung.com/us/mobile/mobile-accessories/phones/wireless-charger-pad-trio-white-ep-p6300twegus/?AID=11497444&PID=100357191&SID=oc5A05L8E%2FcFroF6SHThI8f8ZnfPNw%2BZwF9PQrmDBeIEeYcE9zsc4Yit4FMR1Nx&CID=afl-ecomm-cjn-cha-092118-54828&cjevent=ef703a2ec58011ec8256006e0a1c0e11&utm_source=Microsoft+Shopping+%28

The incredible 3-in-1 charger

With room to hold three devices at once — a smartwatch and two phones, or a smartwatch, earbuds, and phone — you can power up your ecosystem all at once. So when you're done for the day, just put your devices down in one place to be ready for tomorrow.



Compatible Models

Fast Charge compatible with Galaxy Note20, Note20 ultra, S20, S20+, S20 ultra, Z Fold2, Z Flip, Note 10+, Note 10, S10e, S10, S10+, S10 5G, Note9, S9, S9+, Note8, S8, S8+, S7, S7 Edge, Note 5, S6 Edge+ & Apple iPhone 11 pro, 11, SE, XS Max, XS, XR, 8, 8 Plus / Qi compatible with Galaxy S6, S6 Edge and Qi certified devices (Galaxy Buds live, Buds+) / Galaxy Watch3, Watch Active2, Watch Active

The 3300 Wireless Charger Battery can wirelessly charge various mobile devices as specified.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/25w-wireless-portable-battery--silver-eb-u3300xjegus/>

Fast charging, no cord required

In addition to its Super Fast Charging via cable, you can rest your phone on the pack to get a wireless recharge. Powering up to 7.5W, it can wirelessly charge a range of devices, so you can share with a friend, even if they don't have Galaxy.



Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
The 5300 Car Mount Charger can wirelessly charge various mobile devices as specified.
<https://www.samsung.com/us/mobile/mobile-accessories/phones/wireless-car-charger-black-ep-h5300cbegus/>

Wireless Car Charger, Black

BENEFITS SPECS REVIEWS SUPPORT



Great for most types of mobile phones that support wireless charging - even foldables!

The Wireless Car Charger holds mobiles of various sizes, even mobiles covered in up to 3mm thick cases. The Wireless Car Charger is compatible with both Android and iOS devices that support wireless charging. So just place your phone in and let it charge!

*Adapter not included.

**USB-C to USB-A cable included.

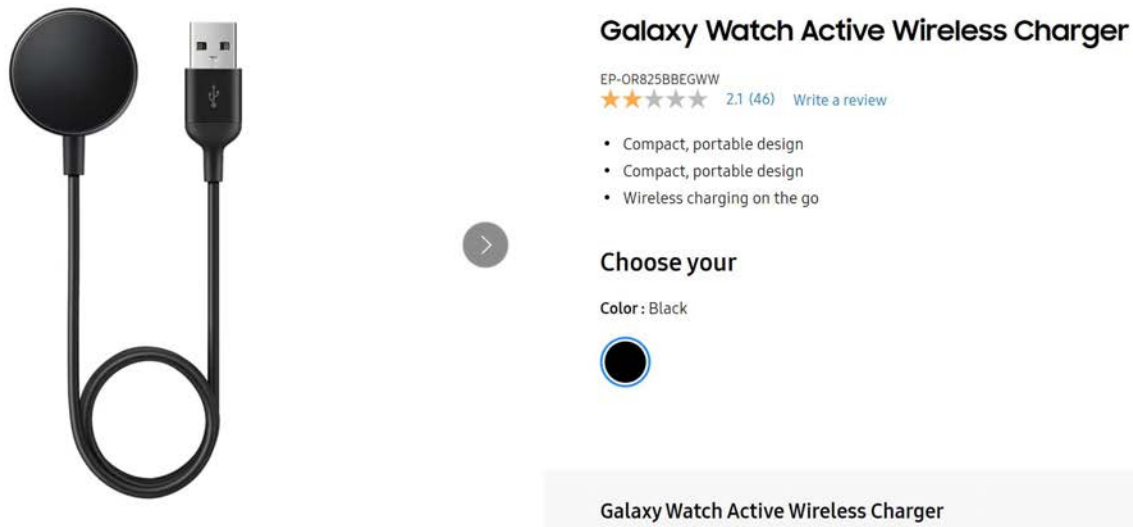
***Based on internal testing. Charging tests were conducted with Samsung cases only.

****Charge time may vary depending on charging conditions, case material, device type and other factors.

*****Image simulated for illustrative purposes only.

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
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The 825 Watch Dock can wirelessly charge Samsung Watches, e.g., the Watch4.

<https://www.samsung.com/levant/mobile-accessories/galaxy-watch-active2-charger-or825-ep-or825bbegww/>



a first primary coil that is substantially planar and substantially parallel to a charging surface of the system for providing power inductively to the portable device;

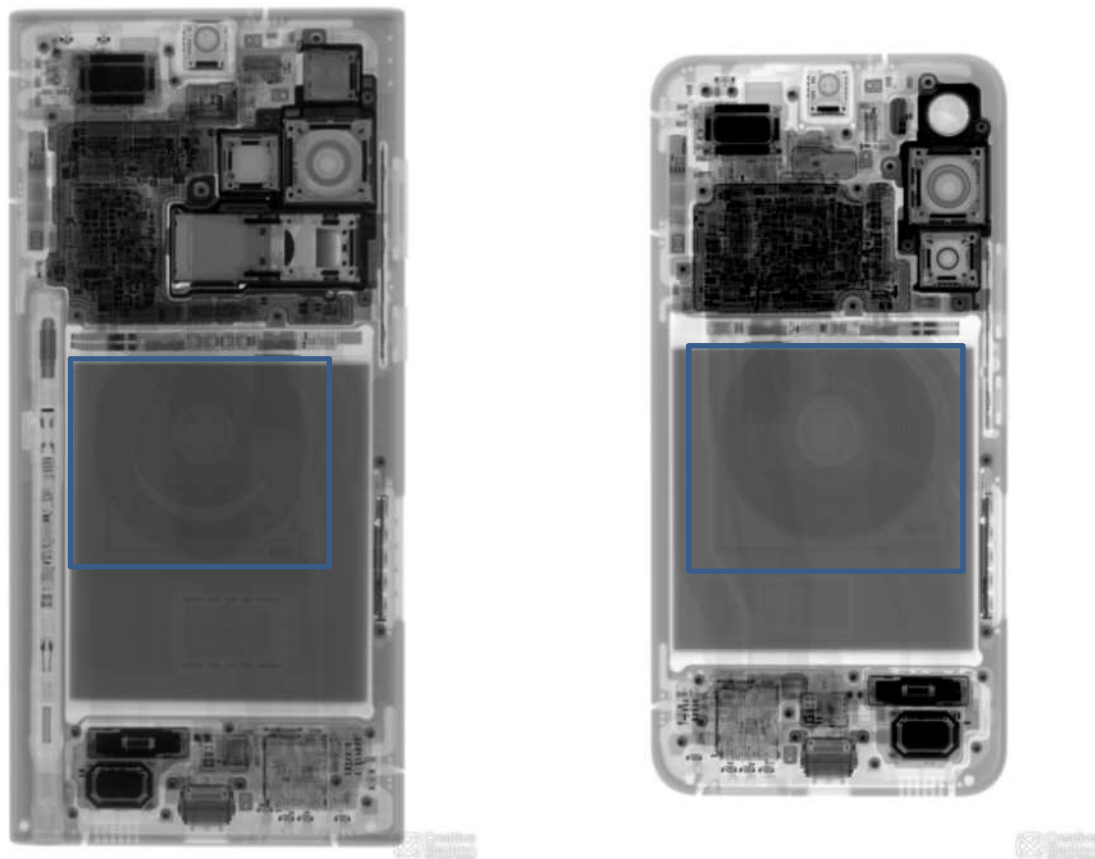
The 942 Claim 1 Accused Products include one or more coils as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

The S22 Ultra (shown on the left in the X-Ray image below; the similarly infringing S22 is shown on the right) includes a planar coil for transferring inductive power as recited by this part of the claim.

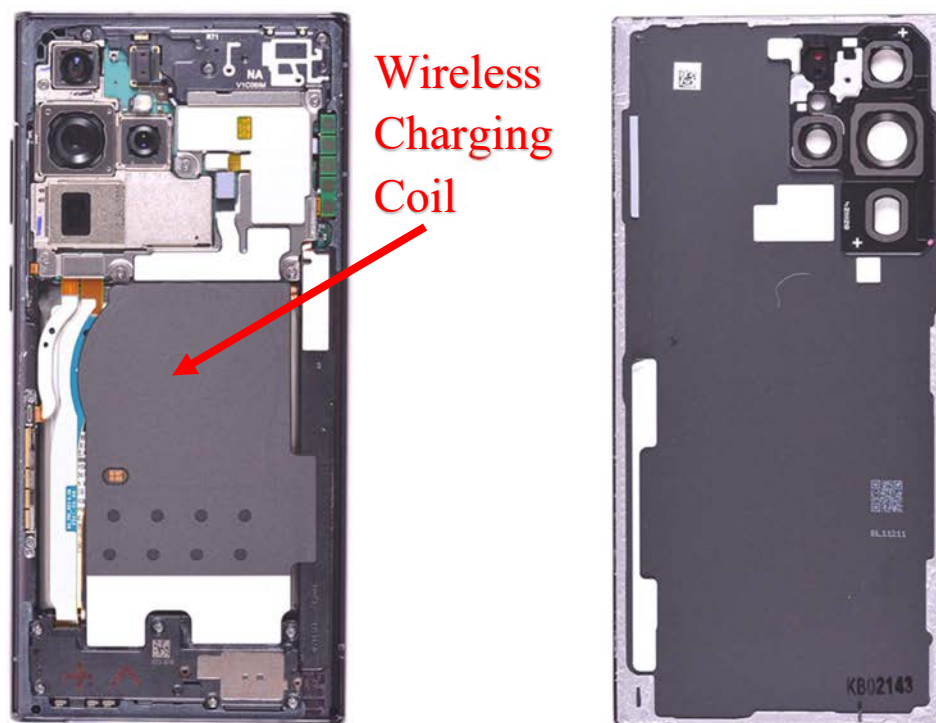
<https://www.ifixit.com/News/57567/galaxy-s22-teardowns-apple-is-making-samsung-sweat>

X-ray examination



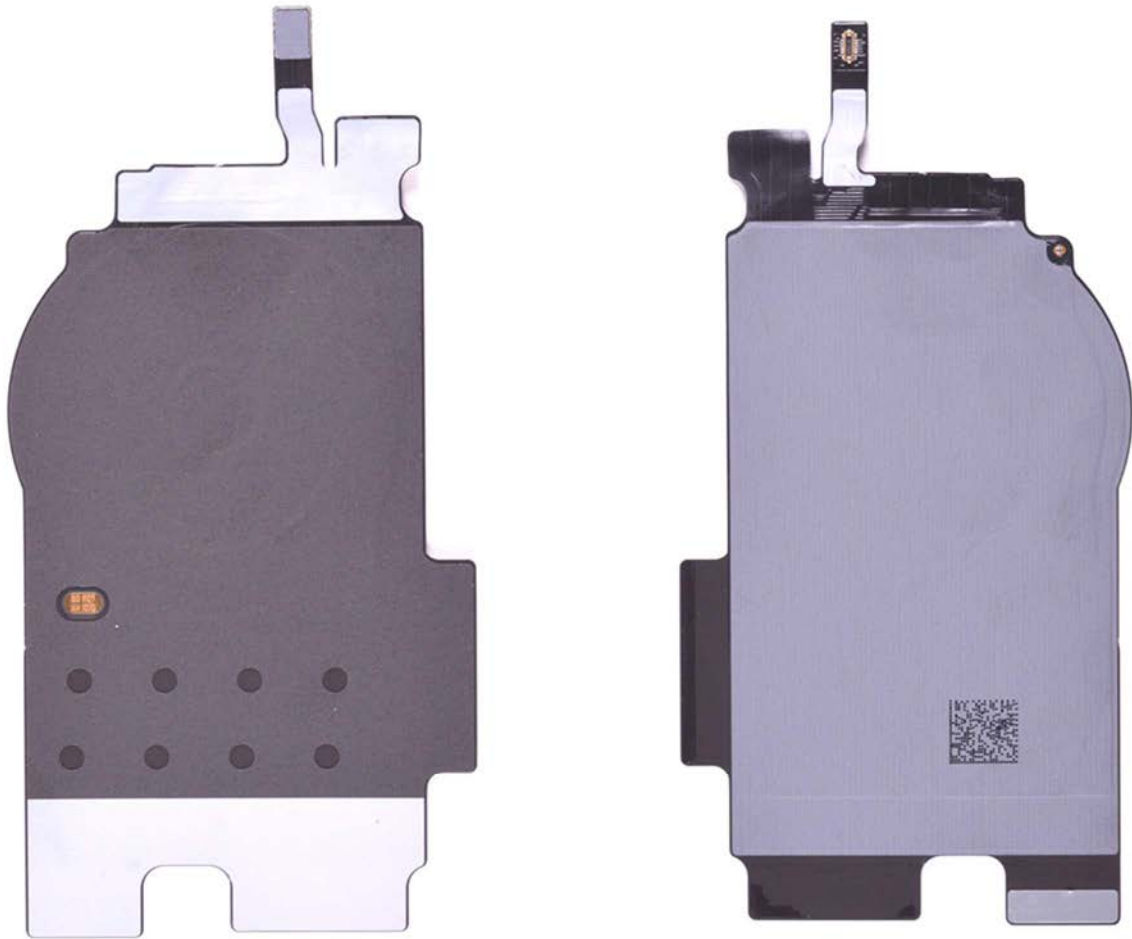
On the left is the Note-succeeding Samsung Galaxy S22 Ultra, with the "vanilla" S22 on the right.

The Samsung Galaxy S22 Ultra interior is shown below (left) after removal of the back cover. The back cover is shown on the right turned over, revealing the inside of the back cover. The wireless charging coil is substantially planar and substantially parallel to the back cover.

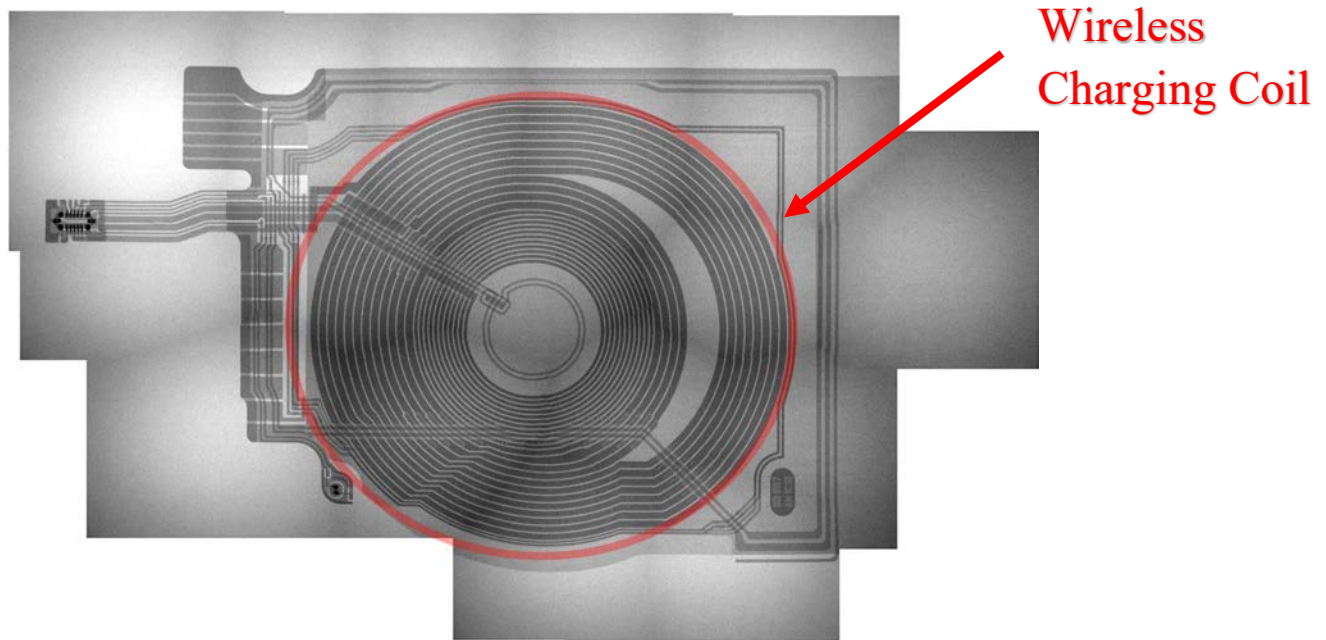


Samsung S22 Ultra – Back cover removed

The wireless charging coil structure after removal from the phone is shown below, with the outward facing side shown on the left and the inner facing side shown on the right.



An X-Ray of the wireless charging coil in the S22 Ultra is shown below.



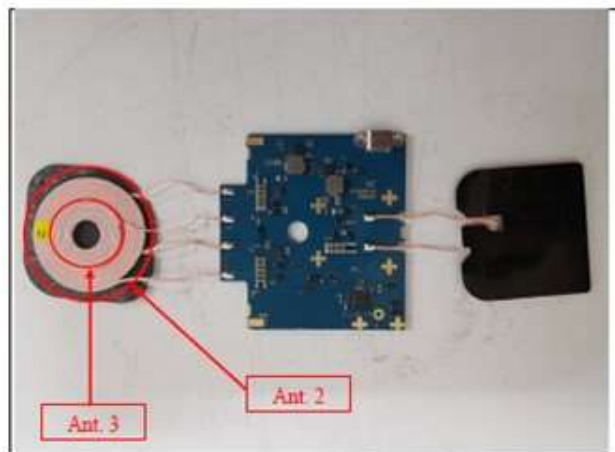
Wireless Chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, 3300 Wireless Charger Battery, 5300 Car Mount Charger, and 825 Watch Dock satisfy this part of claim 1, as they each include a substantially planar charging coil that is substantially parallel to the top surface of the system for providing power inductively to various portable devices.

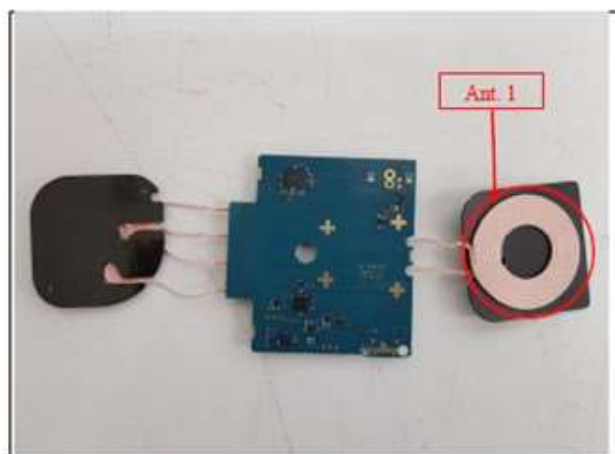
The 5200 Duo Pad contains three planar coils (identified as antennas [Ant. 1-3] in the images below) for transferring inductive power as recited by this part of the claim. The two coils on the product right side (Ant. 2 and 3) (Ant. 2 and 3 are shown on the left side of the FCC pictures below, which have inverted the coil sides of the product) are concentric for charging a watch (Ant. 3) or another smartphone or earbud case (Ant. 2). Antenna 1, on the product left side (right side of the FCC pictures), is for the charging of a smartphone. Each of the three coils is substantially planar to the top surface of the 5200 Duo Pad.

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The FCC pictures below show the three charging coils in the 5200 Duo Pad (Ant. 1-3) (with the product right and left sides reversed). <https://fcc.report/FCC-ID/A3LEPP5200/4144771>

SGS
Top view of PCB



Bottom view of PCB



The following is a Samsung webpage describing the 5200 Duo Pad.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/wireless-charger-Duo Pad-pad-black-ep-p5200tbegus/>



Charge a phone and a smartwatch

The Wireless Charger Duo Pad can charge your Samsung smartwatch too. Gear S3, Gear Sport, and Galaxy Watch can charge in the same location as your phone by simply placing your watch on the charging pad.

Charge two phones

Charge up to two smartphones by simply setting them down. Advanced Qi wireless charging technology enables you to charge your device without plugging in a cable.²



The following is a Samsung Quick Start Guide describing the 5200 Duo Pad.

<https://fcc.report/FCC-ID/A3LEPP5200/4144766.pdf>

English

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 Other marks are the property of their respective owners.

- Please read this guide before using the device to ensure safe and proper use.
- Images may differ in appearance from the actual product. Content is subject to change without prior notice. Visit www.samsung.com to view device information, the latest guide, and more.
- Before using the wireless charger, make sure it is compatible with your mobile device or Galaxy Watch.
- Your consumer rights are governed by the law of the country in which you purchased the product. Please contact your service provider for more information.

Device layout

a	Wireless charging surface (left)	d	Wireless charging surface (right)
b	Charging coil	e	Charger port (Type-C)
c	Indicator light	f	Fan vent

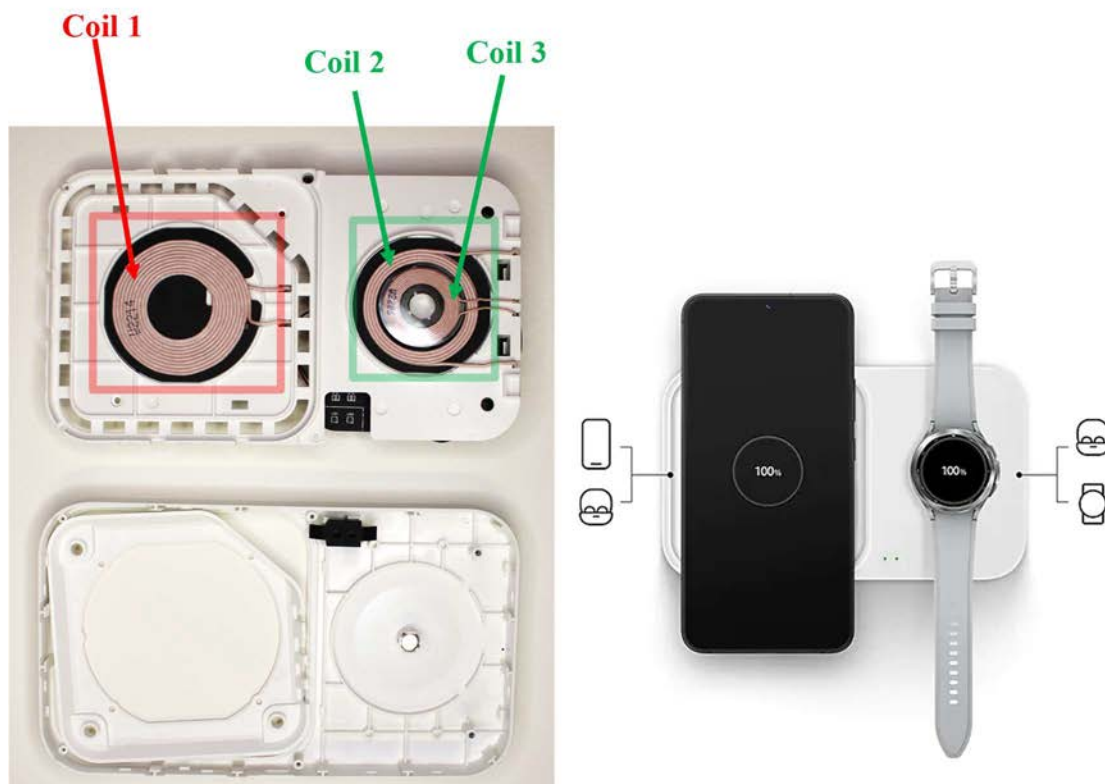
Using the wireless charger

1. Connect the charger to the wireless charger. When the charger is correctly connected to the wireless charger, the indicator light (c) flashes red, green, and orange, and then turns off.

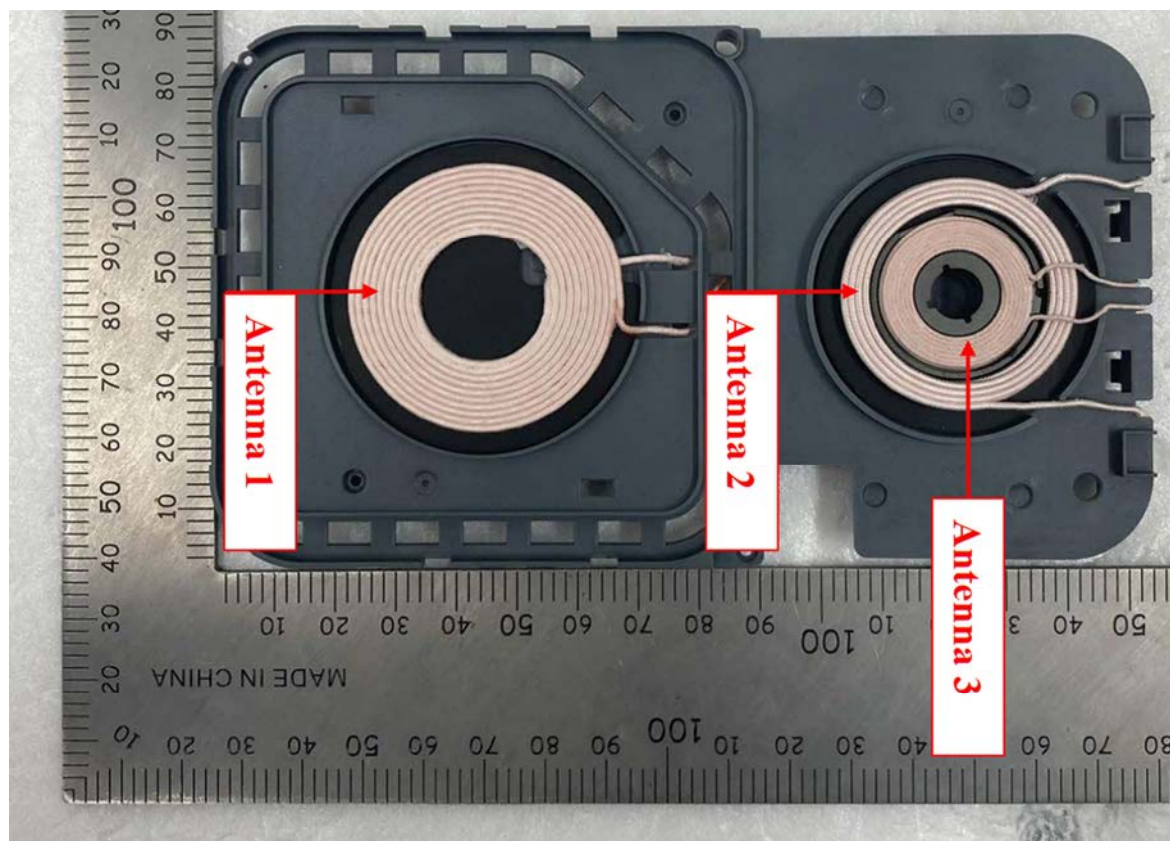
The 5400 Duo Pad contains three planar coils (Coils 1-3 in picture below) for transferring inductive power as recited by this part of the claim. The two coils on the product right side (Coils 2 and 3) are concentric for charging a watch (Coil 3) or another smartphone or earbud case (Coil 2). Coil

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1, on the product left side, is for the charging of a smartphone. Each of the three coils is substantially planar to the top surface of the 5400 Duo Pad.

The picture below shows the 5400 Duo Pad with the top cover removed (left) and the device in use (right).



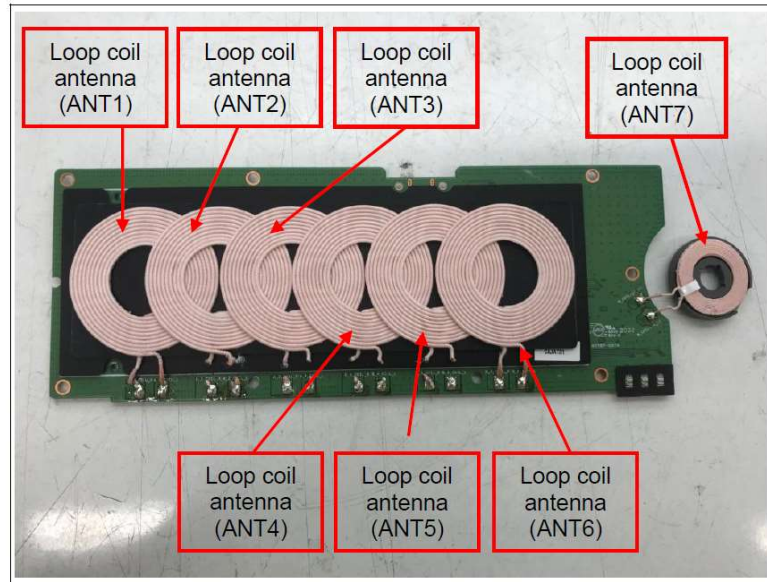
<https://fcc.report/FCC-ID/A3LEPP5200/4144771>



The 6300 Trio Pad includes seven charging coils (Ant. 1-7), of which the six on the left side of the pad are overlapping, as shown below. The coils on the left are for charging multiple smartphones and earbud cases, and the right-side smaller single coil is for charging a Samsung watch.

<https://fcc.report/FCC-ID/A3LEPP6300/4940796.pdf>

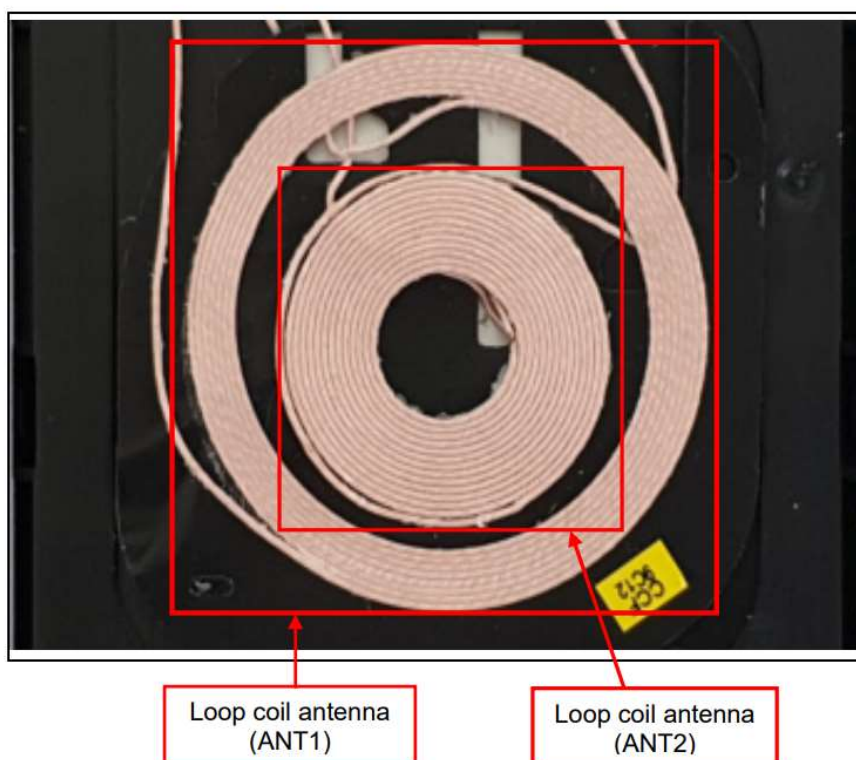
View of Antenna



The 3300 Wireless Charger Battery includes a charging coil as specified by this part of the claim, as shown below. The 3300 Wireless Charger Battery includes two substantially planar charging coils [ANT 1-2] that are substantially parallel to the top surface of the system for providing power inductively to various portable devices. The larger outer coil is for charging smartphones and

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earbud cases and the inner smaller coil is for charging a Samsung watch. The FCC pictures below
show the two charging coils [ANT 1-2] inside the 3300 Wireless Charger Battery.

<https://fcc.report/FCC-ID/A3LEBU3300/4624577>



The 5300 Car Mount Charger includes a charging coil as specified by this part of the claim, as shown below. The 5300 Car Mount Charger includes two substantially planar charging coils [ANT 1-2] that are substantially parallel to the top surface of the system for providing power inductively to various portable devices. The FCC pictures below show the two charging coils [ANT 1-2] inside the EP-H5300.

<https://fcc.report/FCC-ID/ZCAEPH5300/5517329>

EUT Constructional Details (EUT Photos)



The 825 Watch Dock includes a charging coil as specified by this part of the claim, as shown below. <https://fcc.report/FCC-ID/A3LEPOR825/4320461>



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 charging 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;

The 942 Claim 1 Accused Products include one or more drive circuits as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

The S22 Ultra includes a wireless power transceiver ASIC (such as the Renesas P9320S [herein the “9320S”] or similar) which forms in part a drive circuit with an internal FET driver and FET switch and accompanying external capacitor.

<https://www.ifixit.com/Guide/Samsung+Galaxy+S22+Ultra+Chip+ID/148073>

Step 1 Main Board Side 1

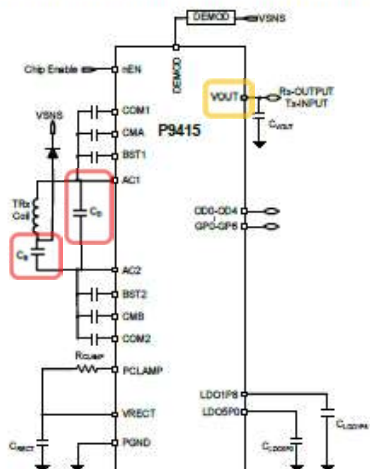


The Renesas P9415-R ASIC (15 W Receiver / Transmitter (Rx/Tx) IC for WPC 1.2)¹ [herein the “9415”], for which a datasheet is publicly available, is believed to be representative of the wireless power transceiver ASIC (such as the 9320) included in the S22 Ultra for the purposes of infringement of this patent. <https://www.renesas.com/us/en/document/dst/p9415-datasheet>

As shown below, the representative 9415 ASIC has a drive circuit with internal FET drivers and FET switches (green rectangle, with four FET switches [FETs] and associated FET drivers [the two triangles and the T/RX control rectangle]) and is externally connected to capacitors (red rectangles).

¹ This chart refers to versions of the WPC Standard, including exemplary versions 1.1.2 and 1.2.4, as part of its evidence of infringement. However, this should not be interpreted to limit Plaintiff’s infringement contentions to products complying with any particular version of the WPC standard (or products complying with the standard at all).

Typical Applications Schematic



1

May 4, 2021

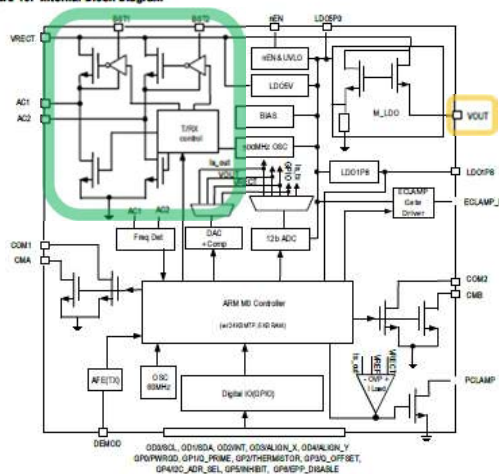
RENESAS

P9415-R Datasheet

8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 150 kHz from the transmitter.

Figure 15. Internal Block Diagram



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21

May 4, 2021

In the Wireless PowerShare mode, the drive circuit of the S22 Ultra is coupled to both a DC voltage input and to the primary coil. As a non-limiting example, the S22 Ultra has a DC voltage input coupled to a DC power source (e.g., an internal battery and/or an external DC power adapter/supply/charging-block) and coupled by the drive circuit to the primary coil for passing a current through the coil. When not plugged in to a power supply, the S22 Ultra, operating in PowerShare mode, uses its internal battery for inductive charging of another device. When the S22 Ultra is plugged in to a power supply, the DC voltage from the battery and/or external charger power supply is used. When in the Wireless PowerShare mode, the exemplary 9415 ASIC receives the DC voltage at its VOUT pin (gold rectangle shown above in the 9415 datasheet) (the VOUT pin functions as a VIN pin when the ASIC is in transmitter mode, whereas it provides an output voltage and acts as a VOUT pin when the ASIC is in receiver mode).

During operation of the S22 Ultra in the Wireless PowerShare mode, the drive circuit applies an alternating current to the 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 primary coil and the surface of the system to provide power inductively to the portable device to be wirelessly charged. This is illustrated below in the exemplary 9415 ASIC datasheet.

RENESAS

P9415-R Datasheet

8.4 WattShare™ (TRx) Mode Functions

The P9415-R can be configured as a wireless power transmitter. The device uses an on-chip full/half-bridge inverter, a PWM generator, a modulator/demodulator for communication, and a microcontroller to produce an AC power signal to drive external L-C tank to operate as a wireless power transmitter (TRx). The P9415-R uses the same L-C tank in both Rx mode and TRx mode.

The frequency range of operation for the S22 Ultra operating as a wireless charger in the Wireless PowerShare mode is specified in an FCC filing by Samsung below, showing the frequency of operation as 110-148 kHz, which is near the resonance frequency of a charging circuit including the primary coil and drive circuit capacitor shown above.

<https://fcc.report/FCC-ID/A3LSMS908U/5574740>

MEASUREMENT REPORT	
FCC Part 15C Wireless Power Transfer	
Applicant Name: Samsung Electronics Co., Ltd. 129, Samsung-ro, Yeongtong-gu, Suwon-si Gyeonggi-do, 16677, Korea	Date of Testing: 9/22/2021 – 12/7/2021 Test Report Issue Date: 12/7/2021 Test Site/Location: PCTEST Lab. Columbia, MD, USA Test Report Serial No.: 1M2109090102-20-R2.A3L
FCC ID:	A3LSMS908U
APPLICANT:	Samsung Electronics Co., Ltd.
Application Type:	Certification
Model:	SM-S908U
Additional Model(s):	SM-S908U1
EUT Type:	Portable Handset
Frequency Range:	110 – 148kHz, 0.53 – 0.60MHz
FCC Classification:	Part 15 Low Power Transmitter Below 1705kHz (DCD)
FCC Rule Part(s):	Part 15 Subpart C
Test Procedure(s):	ANSI C63.10-2013

The S22 Ultra's satisfaction of this part of the claim is further indicated in the representative 9415 datasheet.

The voltage at VRECT and the current through the rectifier are sampled periodically and digitized by the ADC. The digital equivalents of the voltage and current are supplied to the internal control logic, which decides whether the loading conditions on VRECT indicate that a change in the operating point is required. If the load is heavy enough to bring the voltage at VRECT below its target, the transmitter is instructed to move its frequency lower, closer to resonance. If the voltage at VRECT is higher than its target, the transmitter is instructed to increase its frequency. To maximize efficiency, the voltage at VRECT is programmed to decrease as the LDO's load current increases.

Wireless Chargers

A drive circuit as specified by this part of the claim is included in the 942 Accused Wireless Chargers.

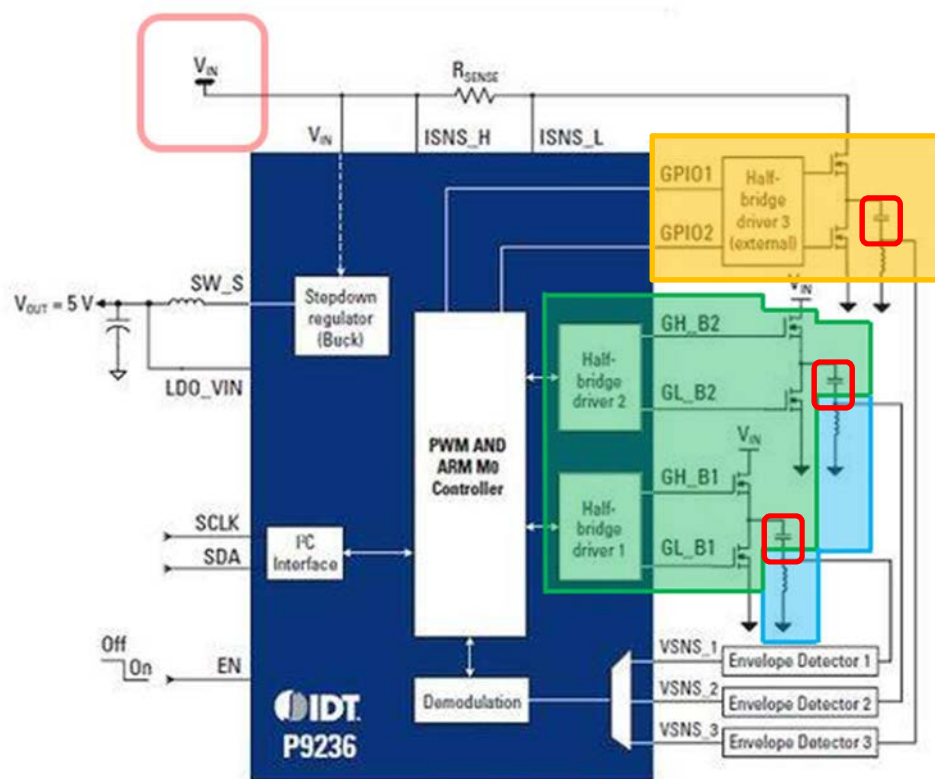
The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, and 3300 Wireless Charger Battery each include a drive circuit that is structured and operates as specified by this part of the claim. They each include a wireless charging transmitter ASIC (e.g., the IDT/Renesas P9236 ASIC) (herein the "9236" ASIC) with associated external capacitors and field effect transistors (FETs).

The representative 9236 ASIC includes two internal FET drivers used with external FETs and capacitors (green area below), and a third external driver can be used with additional external FETs and capacitors (orange rectangle), as shown in the datasheet below for the 9236 ASIC. Further, the

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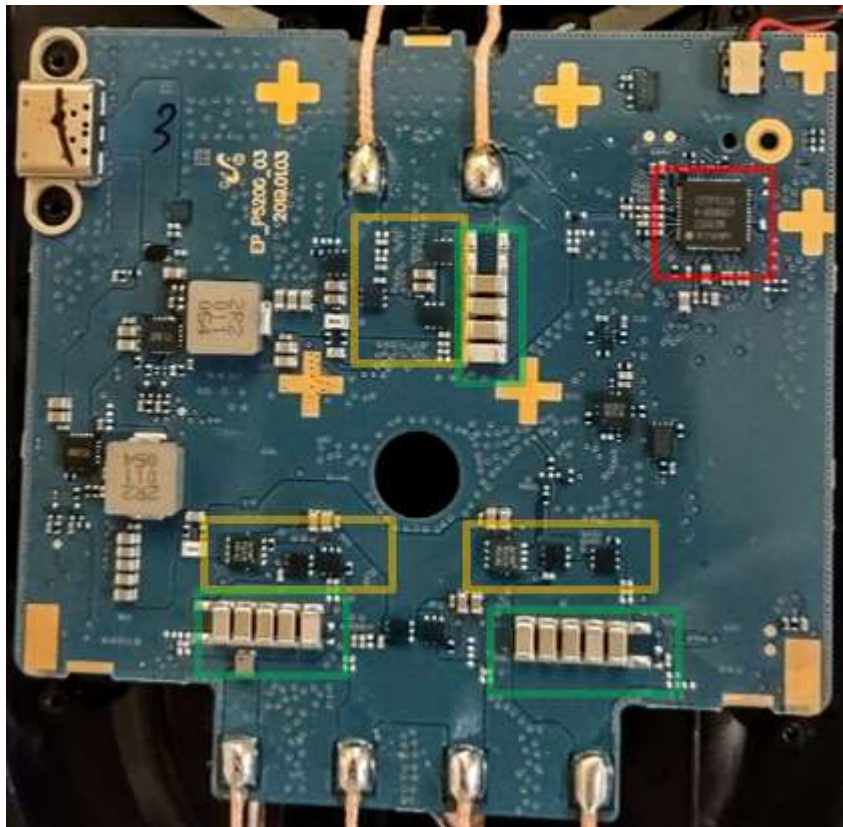
V_{IN} shown is a DC voltage input as specified by this part of the claim. The capacitors are shown in the red rectangles below.

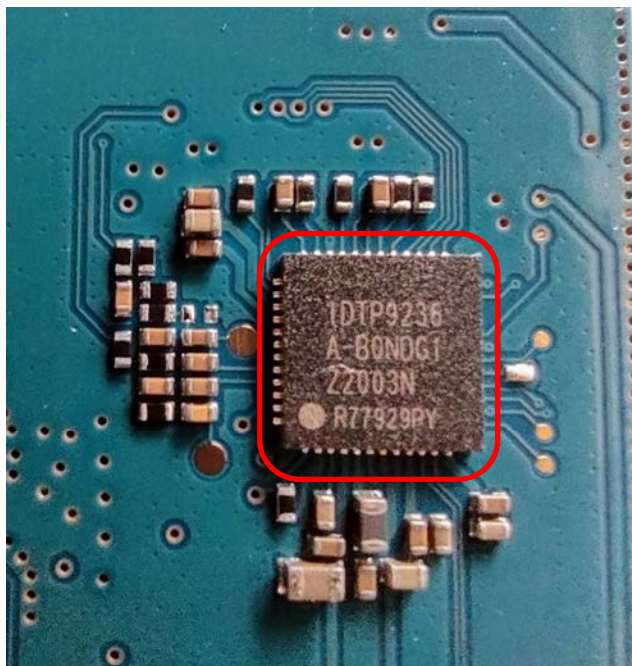
https://archive.eetindia.co.in/www.eetindia.co.in/ART_8800706913_1800008_NP_7a10c6fc.HTM



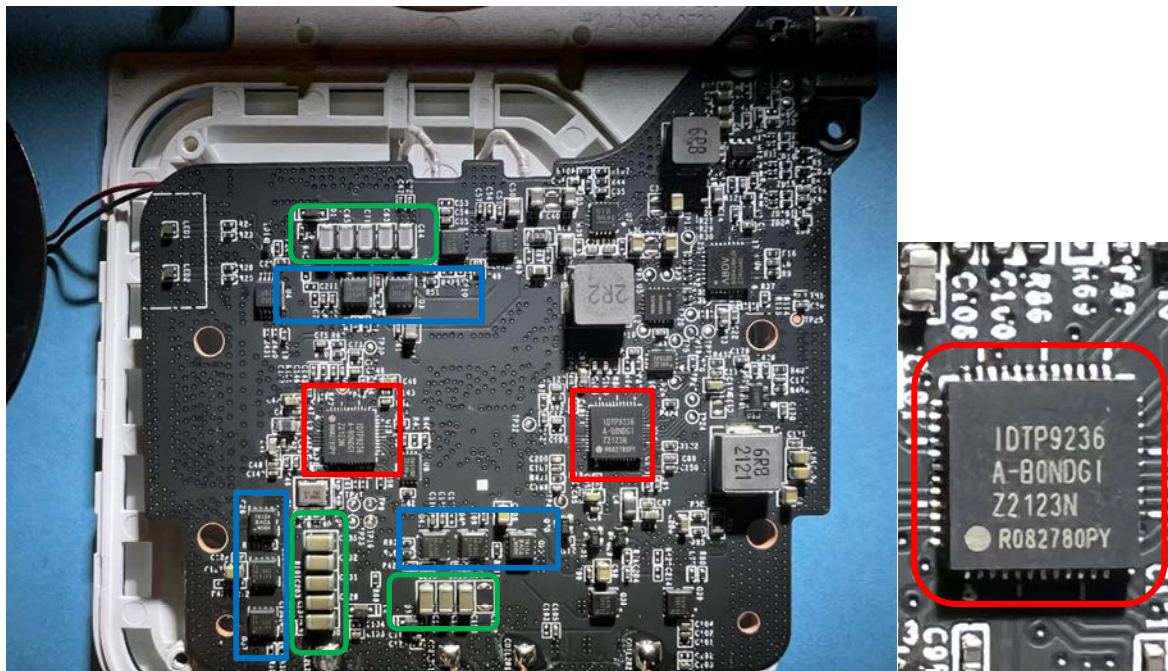
Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
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The 5200 Duo Pad includes wireless charging transmitter ASICs (e.g., the 9236) (red rectangles), FETs and FET drivers (yellow rectangles) and capacitors (green rectangles), as illustrated below.

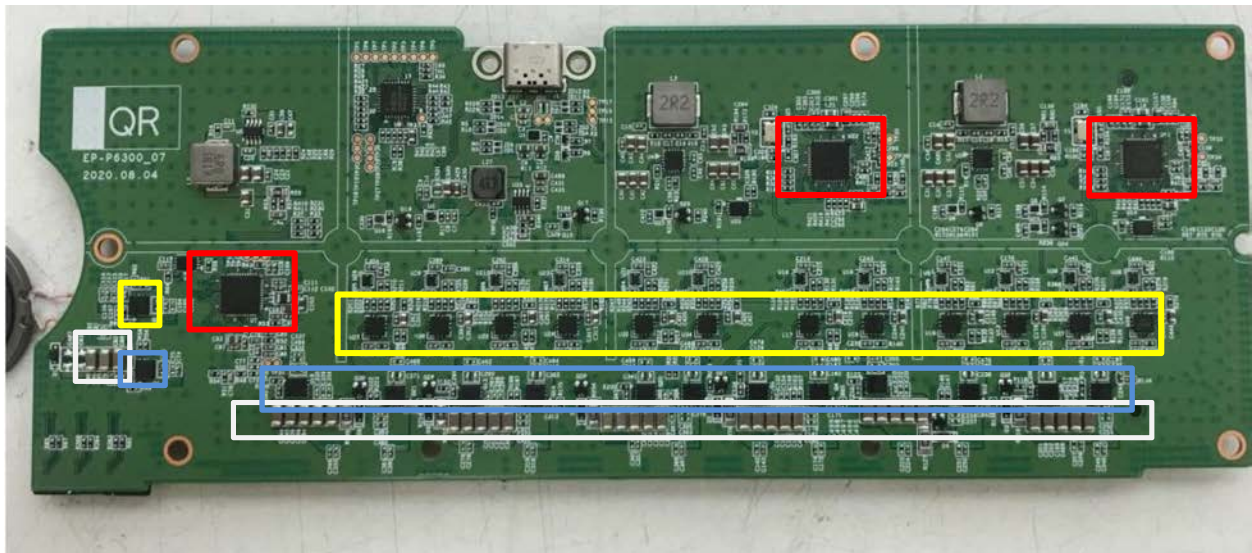




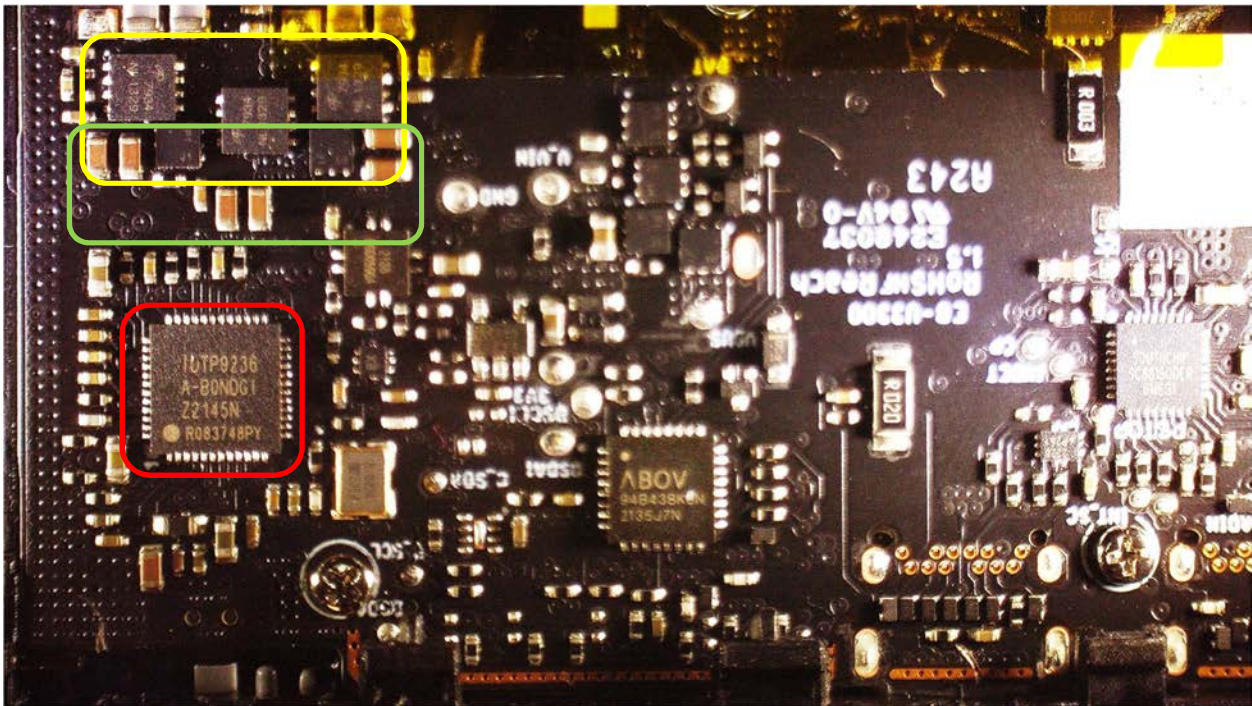
The 5400 Duo Pad includes wireless charging transmitter ASICs (e.g., 9236) (red rectangles), FETs and FET drivers (blue rectangles) and capacitors (green rectangles), as illustrated below.



The 6300 Trio Pad includes switching circuits associated with its coils which include wireless charging ASICs (e.g., 9236 ASICs) (red rectangles), separate FET drivers (yellow rectangles), separate FETs (blue rectangles) and capacitors (white rectangles) as seen below.

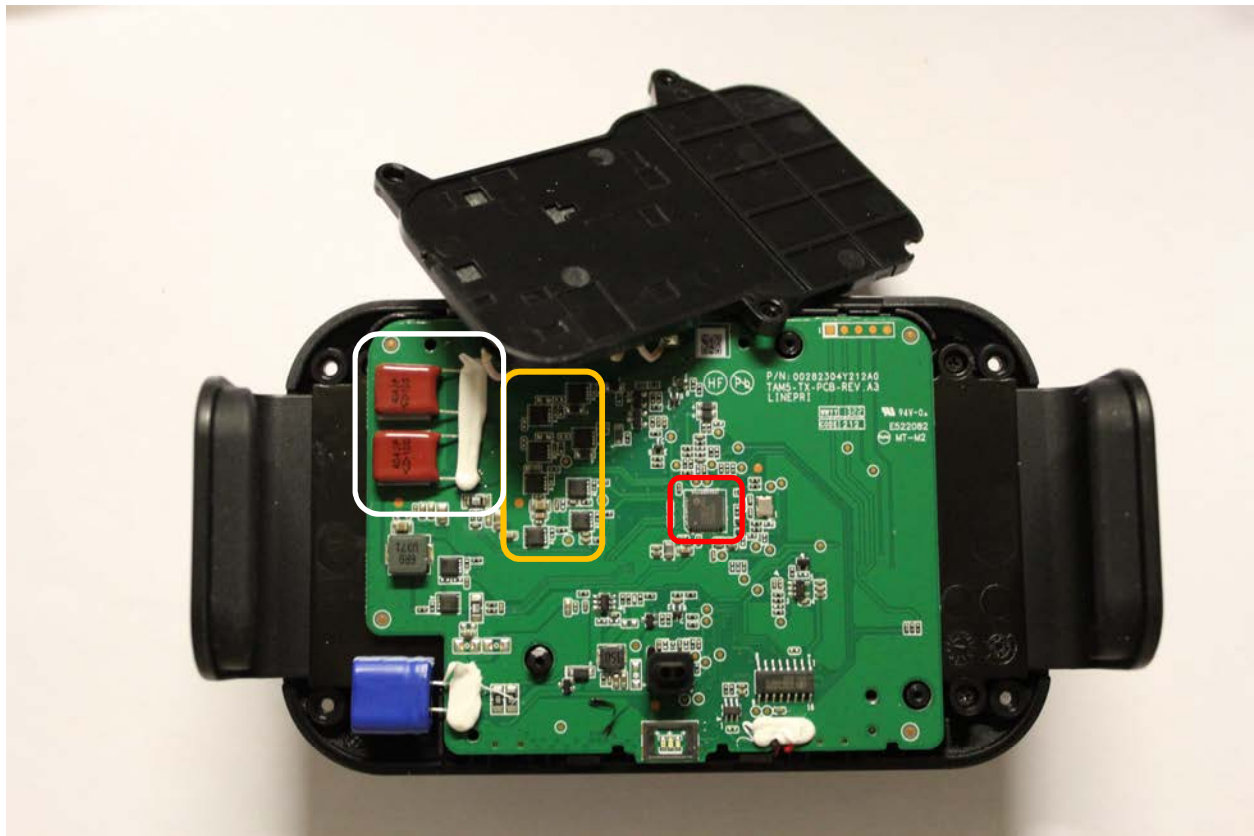


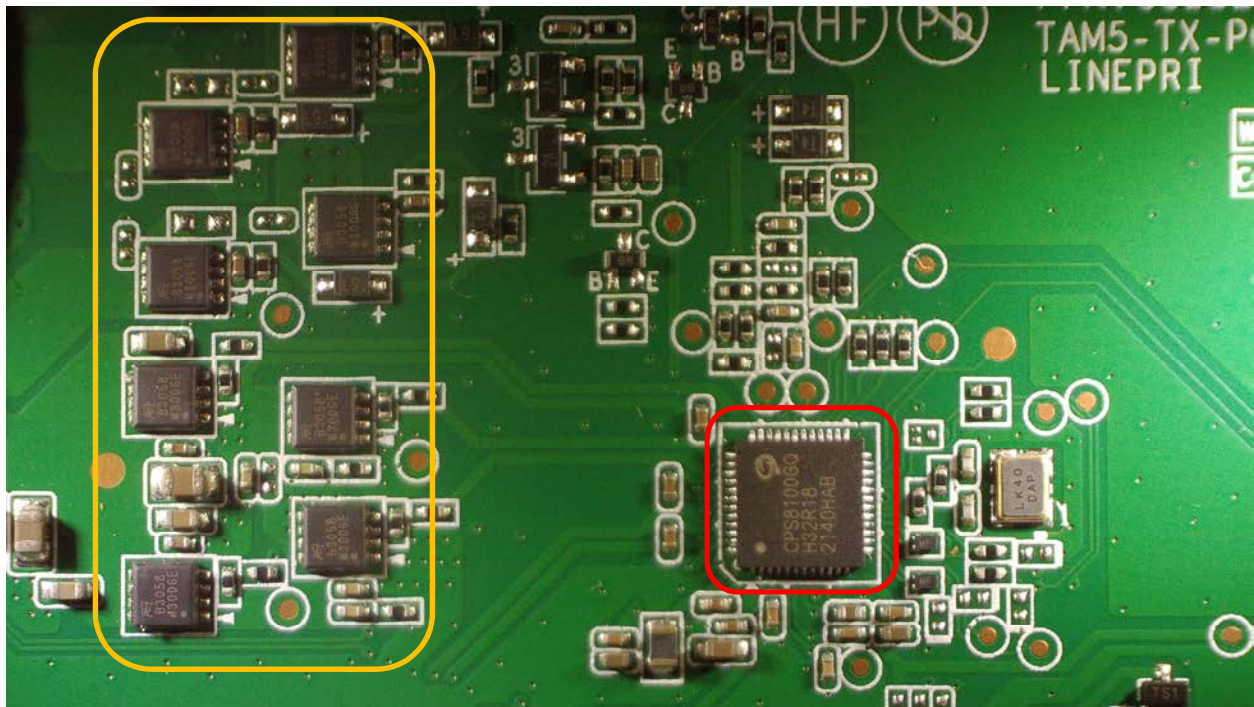
The 3300 Wireless Charger Battery includes wireless charging transmitter ASICs (e.g., the 9236) (red rectangles), FETs and FET drivers (yellow rectangles) and capacitors (green rectangles) as illustrated below.



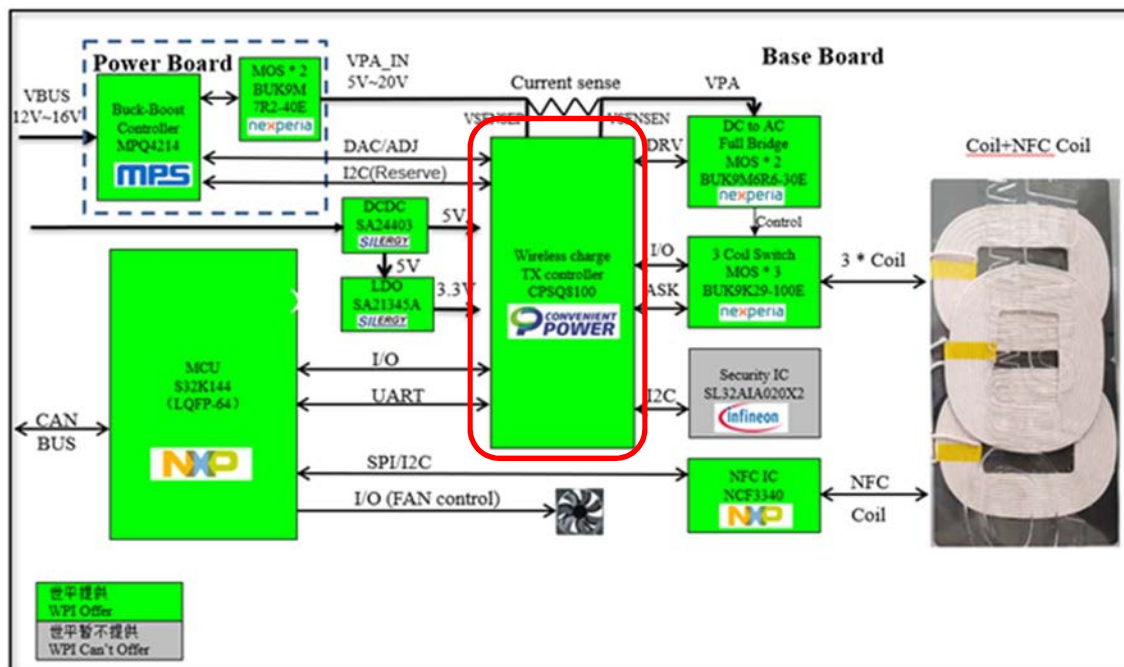
The 5300 Car Mount Charger includes a drive circuit that is structured and operates as specified by this part of the claim. The 5300 Car Mount Charger includes a wireless charging transmitter

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
ASIC (e.g., the CPS8100 from Convenient Power [the “CPS8100”]; red rectangles) (which has an
internal FET driver) and external FETs (orange rectangles) and capacitors (white rectangles) as
illustrated below.





The datasheet below describes the CPS8100 ASIC:
<https://www.wpgdatong.com/tw/blog/detail/45476>



The CPS8100 is a WPC 1.2.4 Transmitter with integrated FET drivers (Red rectangle below) and external capacitors (green rectangles below): <https://m.eefocus.com/consumer-electronics/525801>



CPS8100
Datasheet

Highly Integrated Wireless Transmitter

Descriptions

CPS8100 is a highly efficient, Qi-compliant, magnetic inductive wireless power transmitter IC with wide input voltage range of 3.9V to 26V. It supports secure bi-directional communication with wireless power receiver (ASK/FSK), flexible communication interface ports, as well as reliable over-voltage/current/temperature protection schemes.

It includes buck converter, low dropout linear regulator, DC-DC controller, full bridge drivers, communication modulator/demodulator, foreign object detection (FOD), a multi-channel 12-bit ADC, and ARM processor core and on-chip MTP for maximize software flexibility while consuming extremely low standby power.

The CPS8100 is available in a Pb-free, small QFN 6mmx6mm, 48 pin package. This product is rated over an operating temperature range of -40 to 105°C.

Features

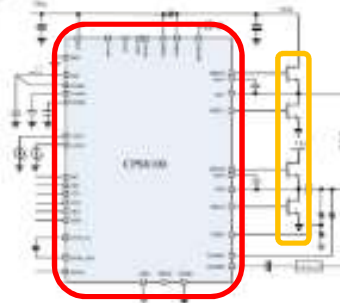
- WPC 1.2.4 compliant wireless power transmitter
- Integrated ARM core, 34KB MTP, 32KB ROM, 8KB SRAM
- Read-Protected/Write-Protected for MTP
- Support update MTP through CQ or DP/DN line
- Support I2C interface
- Integrated 2x UART interface
- Flexible adaptor support: QC2.0/QC3.0/PP3.0/SCP/AFG
- Flexible output power with external MOSFET
- Integrated 3 pairs half bridge driver
- Integrated Buck or Boost controller
- Support double Rx charging application
- Integrated external crystal driver
- Low Power Mode
- Over voltage/current/temperature protection
- RoHS, Halogen-Free and Lead-Free Compliant

Applications

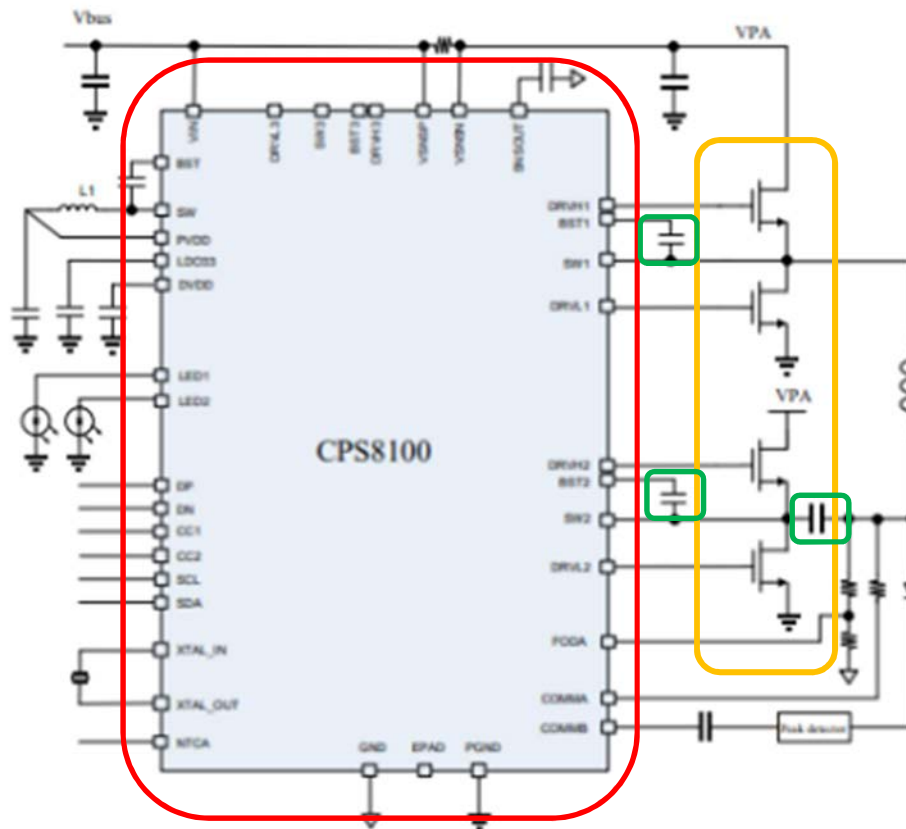
Wireless Fast Charge Transmitter for:

- Charging Pad
- Smart Phone
- MP3 Player
- Blue Tooth
- Tablets
- Accessories

Typical Application

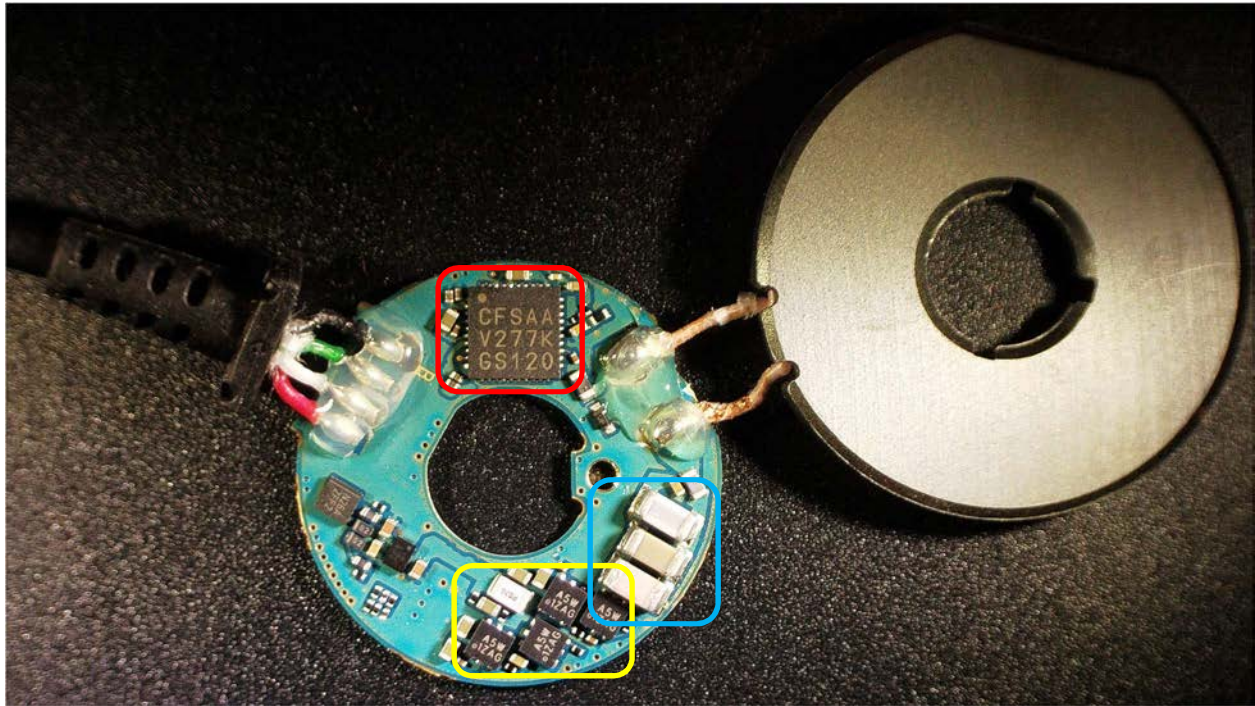


Typical Application



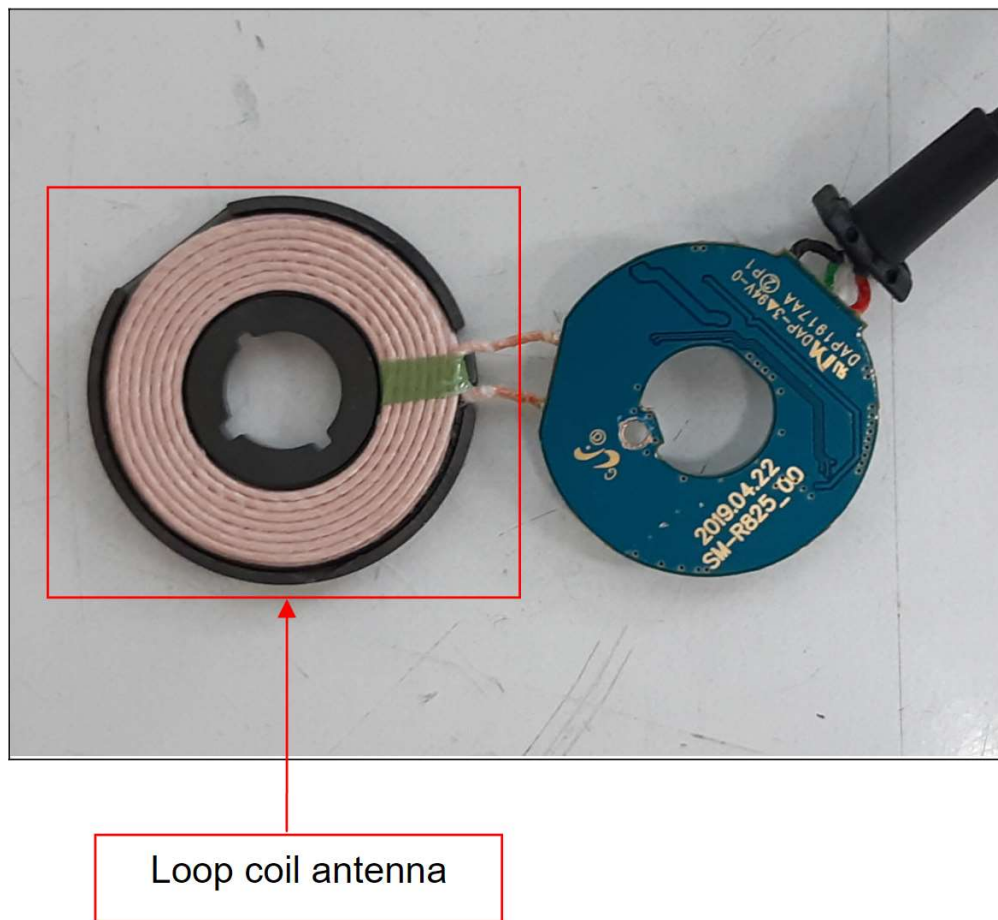
The 825 Watch Dock includes a drive circuit that is structured and operates as specified by this part of the claim is included in the representative 825 Watch Dock. It includes a wireless charging

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung transmitter ASIC (e.g., the CFSAA V277K ASIC; red rectangle) (herein the “V277K”) with associated external capacitor (blue rectangle) and FETs (yellow rectangle), as shown in the below.



On information and belief, the representative V277K ASIC includes an internal FET driver used with an external FET and capacitor. The Voltage Input (Vin) or the Vbus shown in the green rectangle above in the datasheet is a DC voltage input coupled to the FETs for the 825 Watch dock as specified by this part of the claim.

Bottom view of board



The frequency ranges of operation of the 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, 3300 Wireless Charger Battery, 5300 Car Mount Charger, and the 825 Watch Dock are seen in Samsung's FCC filings shown below. The frequency ranges are near the resonance frequency of a charging circuit including the primary coil and drive circuit capacitor of the product.

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
 Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
 5200 Duo Charger: <https://fcc.report/FCC-ID/A3LEPP5200/4144776>

1.4. Description of EUT

Kind of Product	WIRELESS CHARGER		
Model Name	EP-P5200		
Power Supply	DC 12.0 V		
Frequency Range	Normal charging (DC 5.0 V)	Fast charging (DC 9.0 V)	Fast charging 2.0 (DC 12.0 V)
	Ant. 1: 110 kHz ~ 148 kHz	Ant. 1: 110 kHz ~ 148 kHz	Ant. 1: 110 kHz ~ 148 kHz
	Ant. 2: 110 kHz ~ 148 kHz	Ant. 2: 110 kHz ~ 148 kHz	-
	Ant. 3: 125 kHz ~ 148 kHz	-	-
Antenna Type	Internal Type		

5400 Duo Charger: <https://fcc.report/FCC-ID/A3LEPP5400/5582928>

3.1 Product Description

The Samsung Electronics Co., Ltd., Model: EP-P5400 (referred to as the EUT in this report) is an WIRELESS CHARGER DUO. Product specification information described herein was obtained from product data sheet or user's manual.

DEVICE TYPE	WIRELESS CHARGER DUO
OPERATING FREQUENCY	Antenna 1 : 119 kHz ~ 122 kHz, 126.2 kHz ~ 129.2 kHz Antenna 2 : 126.2 kHz ~ 129.2 kHz Antenna 3 : 144.5 kHz ~ 147.5 kHz
RATED RF OUTPUT POWER	76.7 dBμV/m
ANTENNA TYPE	Antenna 1 (Single Coil) Antenna 2 (Alpha Coil) Antenna 3 (Gear Coil)
MODULATION	ASK
RATED SUPPLY VOLTAGE	DC 9.0 V

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
 Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
 6300 Trio Charger: <https://fcc.report/FCC-ID/A3LEPP6300/6088478>

3.1 Product Description

The Samsung Electronics Co., Ltd., Model: EP-P6300 (referred to as the EUT in this report) is an WIRELESS CHARGER.

Product specification information described herein was obtained from product data sheet or user's manual.

DEVICE TYPE	WIRELESS CHARGER
OPERATING FREQUENCY	119.0 kHz ~ 122 kHz (Antenna 1, Antenna 2, Antenna 3, Antenna 4, Antenna 5, Antenna 6), 126.2 kHz ~ 129.2 kHz (Antenna 1, Antenna 2, Antenna 3, Antenna 4, Antenna 5, Antenna 6), 136.5 kHz ~ 139.5 kHz (Antenna 1, Antenna 2, Antenna 3), 144.5 kHz ~ 147.5 kHz (Antenna 4, Antenna 5, Antenna 6, Antenna 7)
RATED RF OUTPUT POWER	95.6 dBμV/m
OPERATION MODE	2 W, 4.5 W, 7.5 W, 9 W
ANTENNA TYPE	Loop Coil Antenna
MODULATION	ASK
RATED SUPPLY VOLTAGE	DC 9.0 V

3300 Wireless Charger Battery: <https://fcc.report/FCC-ID/A3LEBU3300/4624568>

Kind of Product	WIRELESS battery pack	
Model Name	EB-U3300	
Power Supply	DC 12.0 V	
Operation Mode	5 W, 7.5 W	
Frequency Range	5 W	Ant. 1: 125.7 kHz ~ 129.7 kHz Ant. 2: 146 kHz
	7.5 W	Ant. 1: 125.7 kHz ~ 129.7 kHz
Antenna Type	Loop Coil Antenna	

4 General Information

4.1 Details of E.U.T.

Power supply: DC 5V, 2A/9V, 1.67 A powered by car charger as below:
 Model: EP-L5300
 Input: DC 12V-24V
 Output:
 (PDO) DC 5.0 V, 3.0A/DC 9.0 V, 3.0 A/DC 15.0 V/DC 20.0 V, 2.25A
 (PPS) DC 3.3-20.0 V, 2.25A
 (USBA) DC 5.0 V, 2.0A/DC 9.0 V, 1.67 A

Cable(s): Type C input ports

Test Voltage: AC 120 V, 60 Hz powered by DC power adapter to section 4.2

Operation Frequency: 120kHz to 130 kHz

Modulation Type: Load modulation

Antenna Type: Loop antenna

Number of Antenna: 2 but only 1 antenna is enabling during charging

Software Version: SV01

Hardware Version: TAM5-TX-PCB-REV.A2

Sample NO.: A1

Power Setting: Default can not changed by user

Function: Wireless Car Charger for vehicle use

825 Watch Dock: <https://fcc.report/FCC-ID/A3LEPOR825/4320468>

Kind of Product	WIRELESS CHARGER
Model Name	EP-OR825
Power Supply	DC 5.0 V
Frequency Range	110 kHz ~ 148 kHz
Antenna Type	Inductive loop coil antenna

WPC Standard

The 942 Claim 1 Accused Smartphones and Wireless Chargers (but for the Watch Charger) are each interoperable with the WPC/Qi Standard (herein “WPC Standard”), as illustrated below by the representative products. The Watch Charger largely follows WPC standard with regards to signaling and communication.

Smartphones

The S22 Ultra is interoperable with the WPC Standard as a charger in its Wireless PowerShare mode.

<https://www.samsung.com/us/support/answer/ANS00082564/>

Compatible Samsung devices

Most Qi-Compatible Samsung devices can be charged with Wireless PowerShare, but check out the full list of compatible devices just in case. The speed and power of the charge will vary by device.

Phones that can use and also be charged with Wireless PowerShare:

- Galaxy S22, S22+, and S22 Ultra
- Galaxy S21, S21+, and S21 Ultra
- Note20 5G and Note20 Ultra 5G
- Galaxy Note10, Note10+, and Note10+ 5G
- Galaxy Fold, Z Fold2, and Z Fold3
- Galaxy Z Flip, Z Flip 5G, and Z Flip3
- Galaxy S20 5G, S20+ 5G, S20 Ultra 5G, and S20 FE
- Galaxy S10e, S10, S10+, and S10 5G

Other devices that can be charged by Wireless PowerShare:

- Galaxy Buds, Galaxy Buds2, Galaxy Buds+, Galaxy Buds Live, and Galaxy Buds Pro
- Galaxy Watch, Galaxy Watch3, Galaxy Watch4, Galaxy Watch4 Classic, Gear Sport, and Gear S3
- Galaxy S7/S7 Edge, S8/S8+, S9/S9+, Note8, and Note9
- Galaxy Watch Active and Galaxy Watch Active2

Wireless Chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, 3300 Wireless Charger Battery, and 5300 Car Mount Charger are each interoperable with the WPC Standard. The 825 Watch Dock largely follows the WPC Standard.

The 5200 Duo Pad is interoperable with the WPC Standard.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/wireless-charger-duo-pad-black-ep-p5200tbegus/>



Qi certified

The Wireless Charger Duo Pad is Qi certified meaning any Qi compatible products can charge on it, including the Samsung Galaxy S10, Galaxy Note9, Apple iPhone 8, iPhone X, and Google Pixel 3.

https://www.amazon.com/gp/product/B09MV3BRHC/ref=ask_ql_qh_dp_hza?th=1



This item Samsung 15W Wireless Charger Duo (w/TA), Black

Add to Cart

Customer Rating	★★★★★ (40)
Price	\$78 ²⁸
Shipping	FREE Shipping. Details
Sold By	Amazon.com
Color	Black
Compatible Phone Models	Samsung Galaxy S10, Apple iPhone X, Samsung Galaxy Note 10

The 5400 Duo Pad is interoperable with the WPC Standard.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-cable-dark-gray-ep-p5400cbegus/#specs>



Charge fast with Super Fast Wireless Charging

Get the charge you need quickly, thanks to up to 15W of Fast Wireless Charging support. This charger boost is compatible with USB PD and Super Fast Charging travel adapters for an easy pick-me-up.

*Super Fast Wireless Charging speed requires included 25W power adapter and only available with Galaxy Note10, Note10+, S20, S20+, S20 Ultra, Note20, Note20 Ultra, S21, S21+, S21 Ultra, Z Fold2, Z Fold3, Z Flip3, Z Flip3, Rainbows.
**Compatible with all Galaxy devices that support wireless charging. Charging speeds may vary by device. Actual charging speed may vary depending on usage, charging conditions and other factors. 25W power adapter and above required for Super Fast Wireless Charging. 15W power adapter and above required for normal charging.
***Compatible with Apple smartphone models iPhone X and later, that support up to 7.5W fast charging.
****Galaxy Watch charging feature supports up to 4.5W.

The 6300 Trio Pad is interoperable with the WPC Standard.

[Wireless Charger Trio Pad, White Mobile Accessories - EP-P6300TWEGUS | Samsung US](#)

The incredible 3-in-1 charger

With room to hold three devices at once — a smartwatch and two phones, or a smartwatch, earbuds, and phone — you can power up your ecosystem all at once. So when you're done for the day, just put your devices down in one place to be ready for tomorrow.



Compatible Models

Fast Charge compatible with Galaxy Note20, Note20 ultra, S20, S20+, S20 ultra, Z Fold2, Z Flip, Note 10+, Note 10, S10e, S10, S10+, S10 5G, Note9, S9, S9+, Note8, S8, S8+, S7, S7 Edge, Note 5, S6 Edge+ & Apple iPhone 11 pro, 11, SE, XS Max, XS, XR, 8, 8 Plus / Qi compatible with Galaxy S6, S6 Edge and Qi certified devices (Galaxy Buds live, Buds+) / Galaxy Watch3, Watch Active2, Watch Active

The 3300 Wireless Charger Battery is interoperable with the WPC Standard.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/25w-wireless-portable-battery--silver-eb-u3300xjegus/>

Power up your devices all at once

With both a wireless pad and two wired charging ports, you can charge up to three devices in one go. It supports a variety of protocols to be able to charge your Qi-certified phone, Galaxy Watch, and earbuds.

The 5300 Car Mount Charger is interoperable with the WPC Standard.

<https://www.wirelesspowerconsortium.com/products/11748>

SAMSUNG WIRELESS CAR CHARGER (EP-H5300)



BRAND
Samsung

PRODUCT NAME
Wireless Car Charger

MANUFACTURER PART NUMBER
EP-H5300

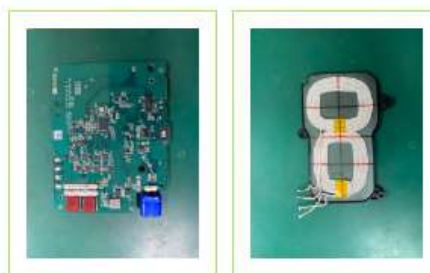
PRODUCT TYPE
Power Class 0 Transmitter

REGISTRATION DATE
October 12, 2021



ADDITIONAL DETAILS

Qi Registration id	11748
Version	1.2.4
Currently licensed	Yes
Power profile	Basic Power Profile
Transmitter design	A36
Automotive Charger for inline assembly	No
Compliant Automotive Guidelines	No
Evaluation module	No
Potential power level	5 watts
Subsystem for integration in other products	No
Samsung Proprietary Extension	Yes



The 825 Watch Dock largely follows the WPC Standard, including the portions shown herein.

WPC Standard Citations

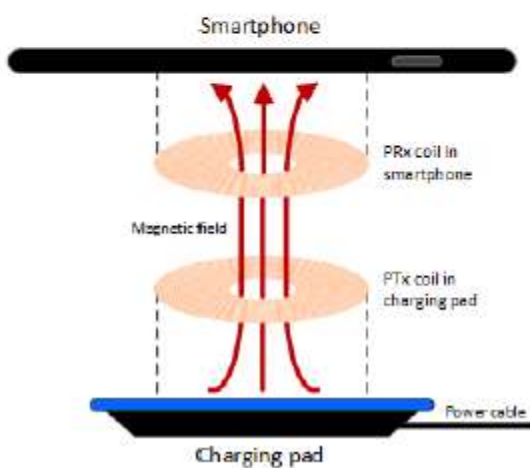
Following the WPC Standard, the drive circuits of the 942 Claim 1 Accused Products, during operation as a charger, apply an alternating electrical current to their associated primary coil at an operating frequency and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the plane of the primary coil and the surface of the system to provide power inductively to the portable device to be wirelessly charged.

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
E.g., WPC 1.2.4 Standard, Introduction, page 9 (see also WPC 1.2.3 Standard, Introduction, page 9).

When charging begins, the power transmitter runs an alternating electrical current through its coil(s), which generates an alternating magnetic field in accordance with Faraday's law. This magnetic field is in turn picked up by the coil inside the power receiver and transformed by a power converter back into an alternating electrical current that can be used to charge the battery.

A critical feature of the magnetic field is that it can transfer through any non-metallic, non-ferrous materials, such as plastics, glass, water, wood, and air. In other words, wires and connectors are not needed between the power transmitter and power receiver.

Figure 6. Qi wireless power transfer using magnetic induction



Following the WPC Standard, the 942 Claim 1 Accused Products meet the frequency range and resonant aspects of this part of the claim.

E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 12, 47 (see also WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 12, 47).



Version 1.2.4

The Qi Wireless Power Transfer System
Power Class 0 Specification

Parts 1 and 2: Interface Definitions

General

Operating Point	The combination of the frequency, duty cycle, and amplitude of the voltage that is applied to the Primary Cell.
Packet	A data structure for communicating a message from a Power Receiver to a Power Transmitter or vice versa. A Packet consists of a preamble, a header byte, a message, and a checksum. A Packet is named after the kind of message that it contains.

Wireless Power Consortium

12



The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
 Power Class 0 Specification

Version 1.2.4

Information interface

The Power Transmitter uses the Control Error Value and the actual Primary Cell current to determine a new Primary Cell current. After the system stabilizes from the communications of the Control Error Packet, the Power Transmitter has a short time window to control its actual Primary Cell current towards the new Primary Cell current. Within this window, the Power Transmitter reaches a new Operating Point: the amplitude, frequency, and duty cycle of the AC voltage that is applied to the Primary Cell. Subsequently, the Power Transmitter keeps its Operating Point fixed in order to enable the Power Receiver to communicate additional control and status information. For details, see Section 5.1.2.6.1, *Power transfer control*.

Wireless Power Consortium

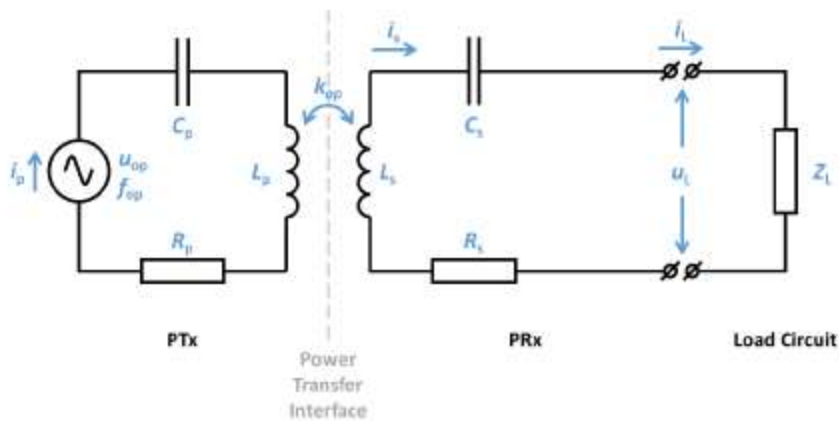
47

The WPC Standard, as seen below, specifies an operating frequency f_{op} of 100-200 kHz and a primary resonant frequency f_p of 100 kHz. The WPC Standard similarly specifies a secondary (receiver) resonance frequency f_s of 100 kHz. The WPC Standard further specifies that the transmitter use the part of the operating frequency wherein increasing the operating frequency results in lower primary (transmitter) current and thus lower current or voltage in the receiver. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 37 and 38. Thus, per the WPC Standard, the 942 Claim 1 Accused Products operate their drive circuits at frequencies near the resonant frequency of a wireless power transfer circuit including the primary coil and associated capacitor.

The Power Transmitter controls the amount of power it transfers by adjusting the amplitude of its voltage and frequency in the ranges given in Table 7. At start-up, it uses the ping voltage u_{ping} and ping frequency f_{ping} . To control the power up, it decreases its frequency while keeping its voltage constant at the maximum value. To control the power down, it increases the frequency at constant voltage, and after reaching the maximum frequency value decreases the voltage while keeping the frequency constant at that maximum.

Figure 10 illustrates a simplified model of the system comprising a Power Transmitter on the left and a Power Receiver on the right. For clarity, the load circuit is drawn separately from the Power Receiver. The Power Transmitter consists of a power source (u_{op} , f_{op}), a capacitance C_p , an inductance L_p , and a resistance R_p . The power source supplies a sinusoidal voltage u_{op} at a frequency f_{op} . The Power Receiver consists of a capacitance C_s , an inductance L_s , and a resistance R_s . A load having an impedance Z_L is connected to the output terminals of the Power Receiver. The symbols u_L , i_L , i_p , and k_{op} represent the load voltage, load current, Primary Coil current, and coupling factor.

Figure 10. Simplified system model



For simplicity the Power Receiver in the model includes neither a rectifier nor a resonance at a frequency f_d as defined in Sections 3.1.2 and 3.1.1. The absence of the additional resonance does not significantly affect the results discussed below. The effect of the rectifier is described at the end of this section.

Table 7 lists the parameters associated with the system model in Figure 10. Instead of the resonant capacitances C_p and C_s , and the resistances R_p and R_s , the resonant frequencies f_p and f_s , and quality factors Q_p and Q_s are provided. The relations between these parameters are as follows:

$$f_p = \frac{1}{2\pi\sqrt{L_p C_p}}, \quad f_s = \frac{1}{2\pi\sqrt{L_s C_s}}, \quad Q_p = \frac{2\pi f_p L_p}{R_p}, \quad Q_s = \frac{2\pi f_s L_s}{R_s}$$

Table 7. Parameters of the simplified model

Power Transmitter			Power Receiver		
L_p	25	μH	L_s	35	μH
f_p	100	kHz	f_s	100	kHz
Q_p	100		Q_s	40	
u_{op}	2...24	V (pk)	u_L	12	V (rms)
f_{os}	100...200	kHz	i_L	1.5	A (rms)
u_{plng}	24	V (pk)	Z_L	0.1...1000	Ω
f_{plng}	175	kHz	Z_{plng}	800	Ω

Power Transmitter operation is subject to these constraints:

- The PTx only uses the part of its Operating Frequency range where the Primary Coil current decreases while the Operating Frequency increases. This constraint ensures that the Control Error Packets from the Power Receiver have a consistent effect: a positive Control Error Value causes the Primary Coil current to increase, and a negative Control Error Value causes the Primary Coil current to decrease.

Following the WPC Standard, the 942 Claim 1 Accused Products inductively power the wireless charging receiver in the mobile device to be charged and charge the battery of the portable device. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 25).



- A rectification circuit that provides full-wave rectification of the AC waveform using, for example, four diodes in a full-bridge configuration or a suitable configuration of active components (see Section 3.1.2, *Rectification circuit*). The rectification circuit may perform output smoothing as well. In this example, the rectification circuit provides power to both the Communications and Control Unit of the Power Receiver and the output of the Power Receiver

a first sense circuit, including a low pass filter and an amplifier, coupled to the first primary coil to detect communication of information induced in the first primary coil by the receiver coil; and

The 942 Claim 1 Accused Products include one or more sense circuits as specified by this part of the claim, as illustrated below for the representative products.

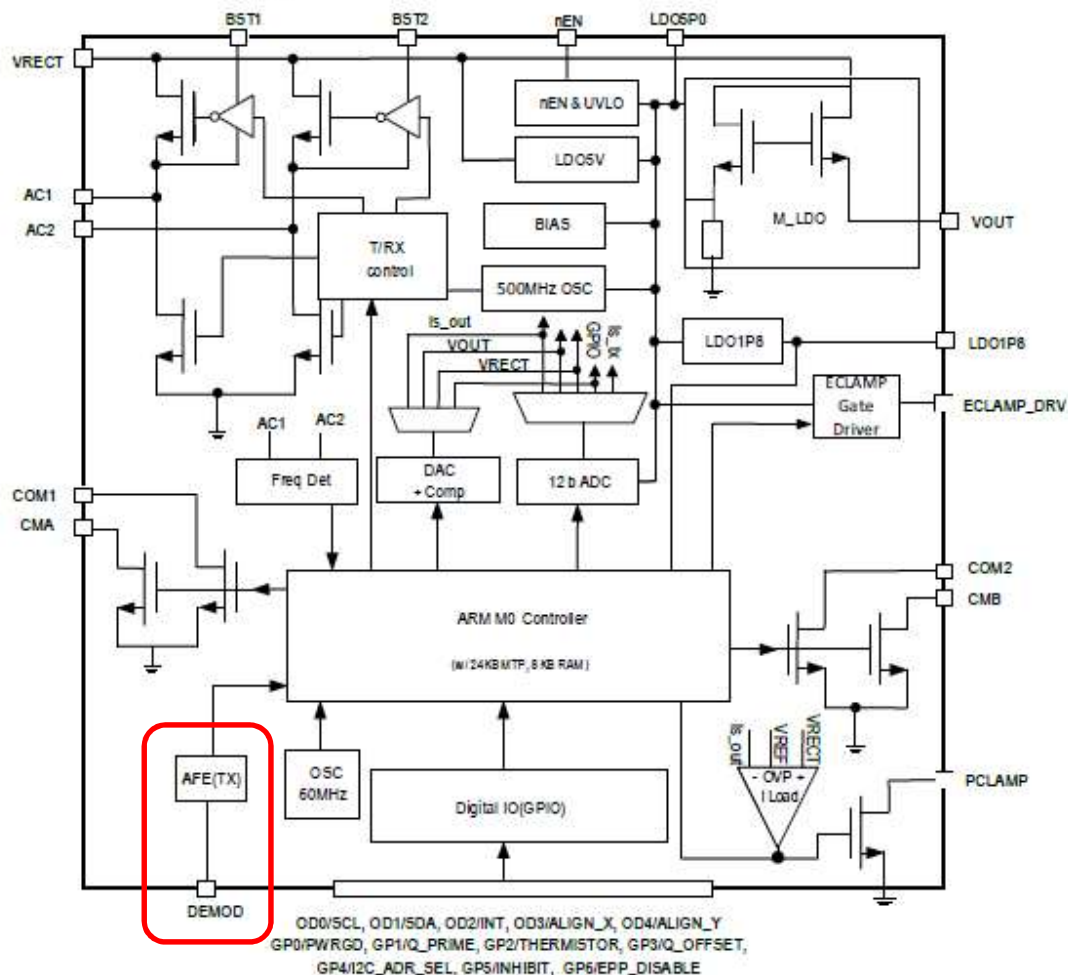
Smartphones

The S22 Ultra includes a sense circuit that is structured and operates as specified by this part of the claim. As shown below, the representative 9415 ASIC includes an Analog Front End (AFE) (red rectangle) and associated external demodulation circuitry (connected to the DEMOD pin). The AFE receives a demodulated signal from the charging coil via the DEMOD pin.

8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

Figure 15. Internal Block Diagram

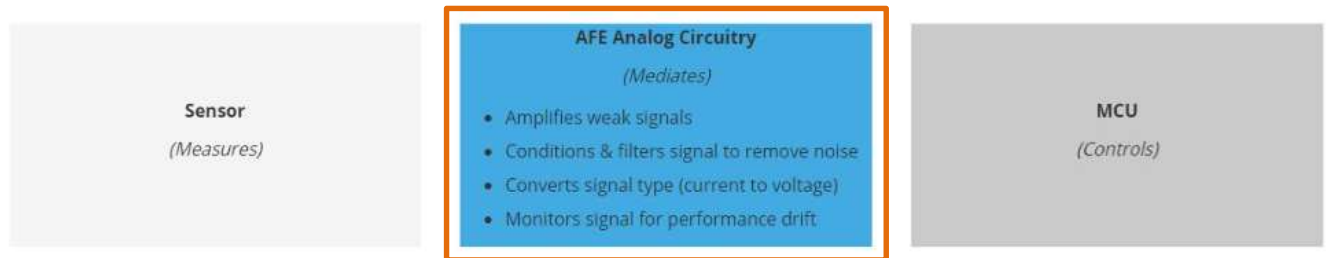


The AFE function includes a low pass filter (to pass the low frequency communication signal and remove the high frequency power signal at the higher operating frequency) and an amplifier.

[https://www.renesas.com/us/en/products/analog-products/smart-analog#:~:text=The%20analog%20front%20end%20\(AFE,configurations%20to%20support%20different%20MCUs](https://www.renesas.com/us/en/products/analog-products/smart-analog#:~:text=The%20analog%20front%20end%20(AFE,configurations%20to%20support%20different%20MCUs)

Analog Front End Brings Sensor and Microcontroller Together

The analog front end (AFE) is an essential system building block to a sensor circuit that amplifies and/or filters sensor signals that are often weak and may have complex electrical configurations to support different MCUs. In addition, the AFE that performs this vital bridging function is often difficult to simulate and must be adjusted because of specific component behavior, board layout, and nearby noise sources.



The 9415 datasheet describes a demodulation filter that includes a low pass filter as specified by this part of the claim.

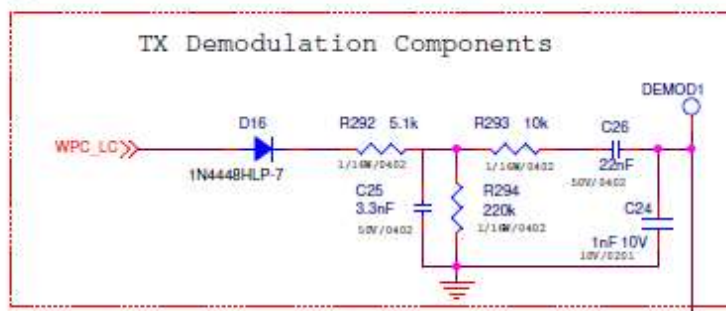


P9415-R Datasheet

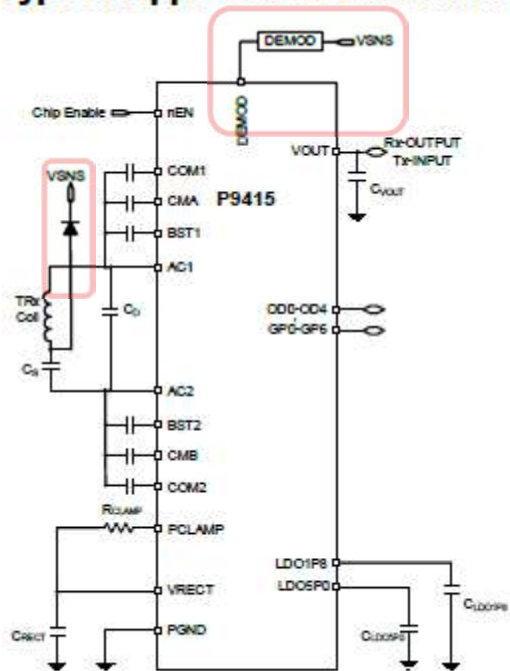
8.4.3 Demodulator

In TRx Mode, the Rx sends WPC protocol packets to the P9415-R. Using the demodulation (DEMOD) filter shown in Figure 22 and the internal demodulator circuitry, the P9415-R decodes the ASK modulation packets Rx sent. Based on the packet information, the P9415-R modulates the transmitted power by adjusting the operating frequency or duty cycle and detects a foreign object between Tx and Rx.

Figure 22. WattShare™ Mode Demodulation Filter



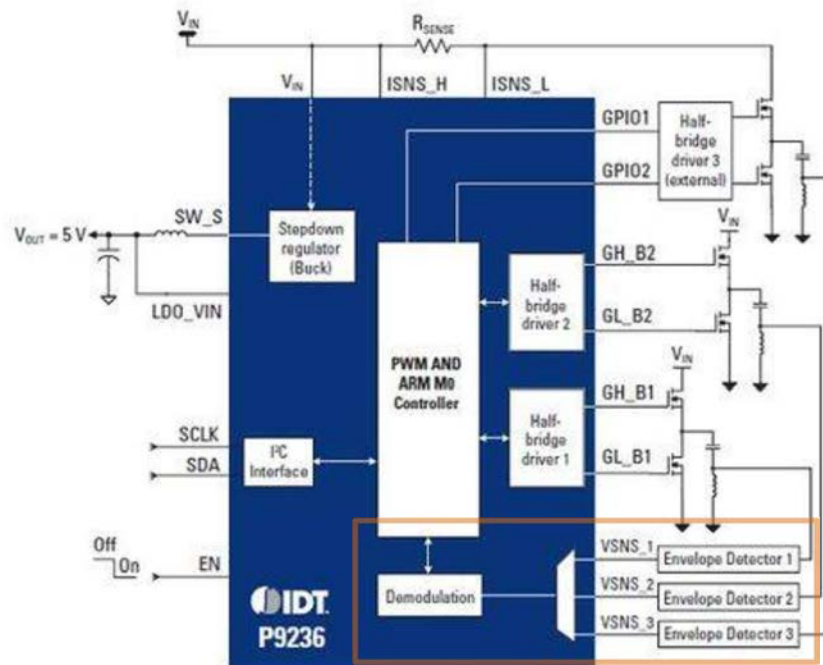
Typical Applications Schematic



Wireless chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, and 3300 Wireless Charger Battery each meet this part of the claim, as they include a sense circuit that is structured and operates as specified by this part of the claim. They include a wireless charger ASIC such as the 9236 ASIC that includes a demodulator as relevant to this part of the claim. The demodulator senses current modulation in the charger coil to detect a communication from the receiver being charged and to sense the presence or absence of the receiver, as shown in the datasheet below.

https://archive.eetindia.co.in/www.eetindia.co.in/ART_8800706913_1800008_NP_7a10c6fc.HTM



See also the 9415 ASIC discussion immediately above for the S22 Ultra, which on information and belief, applies similarly to the wireless chargers for this claim that use a wireless charger ASIC such as the 9236 ASIC.

The 5300 Car Mount Charger and 825 Watch Dock include a wireless charging transmitter ASIC (e.g., the CPS8100 and the V277K, respectively). Upon information and belief, the 9415 ASIC discussion immediately above for the S22 Ultra applies similarly to the wireless charger ASICs included in the 5300 Car Mount Charger and the 825 Watch Dock.

WPC Standard

The WPC Standard describes detection of communications by way of current modulation, as in the 942 Claim 1 Accused Products. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 87 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 86).



5.2 Power Receiver to Power Transmitter communications interface

5.2.1 Introduction

The Power Receiver communicates to the Power Transmitter using backscatter modulation. For this purpose, the Power Receiver modulates the amount of power that it draws from the Power Signal. The Power Transmitter detects this as a modulation of the current through and/or voltage across the Primary Cell. In other words, the Power Receiver and Power Transmitter use an amplitude modulated Power Signal to provide a Power Receiver to Power Transmitter communications channel.

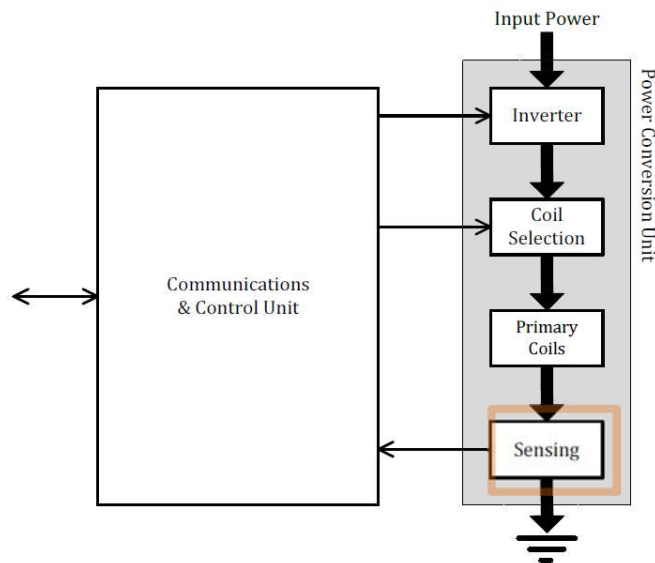
The WPC Standard also shows a sense circuit, as in the 942 Claim 1 Accused Products. *E.g.*, WPC 1.2.4 Standard, Part 4, Reference Designs, page 31 (*see also* WPC 1.2.3 Standard, Part 4, Reference Designs, page 31).



2.2.4 Power Transmitter design A4

Power Transmitter design A4 enables Free Positioning. Figure 10 illustrates the functional block diagram of this design, which consists of two major functional units, namely a Power Conversion Unit and a Communications and Control Unit.

Figure 10. Functional block diagram of Power Transmitter design A4



The Power Conversion Unit on the right-hand side of Figure 10 and the Detection Unit of the bottom of Figure 10 comprise the analog parts of the design. The inverter converts the DC input to an AC waveform that drives a resonant circuit, which consists of the selected Primary Coil plus a series capacitor. The selected Primary Coil is one from two partially overlapping Primary Coils, as appropriate for the position of the Power Receiver relative to the two Primary Coils. Selection of the Primary Coil proceeds by the Power Transmitter attempting to establish communication with a Power Receiver using either Primary Coil. Finally, the voltage sense monitors the Primary Coil voltage and current.

The Communications and Control Unit on the left-hand side of Figure 10 comprises the digital logic part of the design. The Communications and Control Unit receives and decodes messages from the Power Receiver, configures the Coil Selection block to connect the appropriate Primary Coil, executes the relevant power control algorithms and protocols, and drives the input voltage of the AC waveform to control the power transfer. The Communications and Control Unit also interfaces with other subsystems of the Base Station, *e.g.* for user interface purposes.

Smartphones

8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

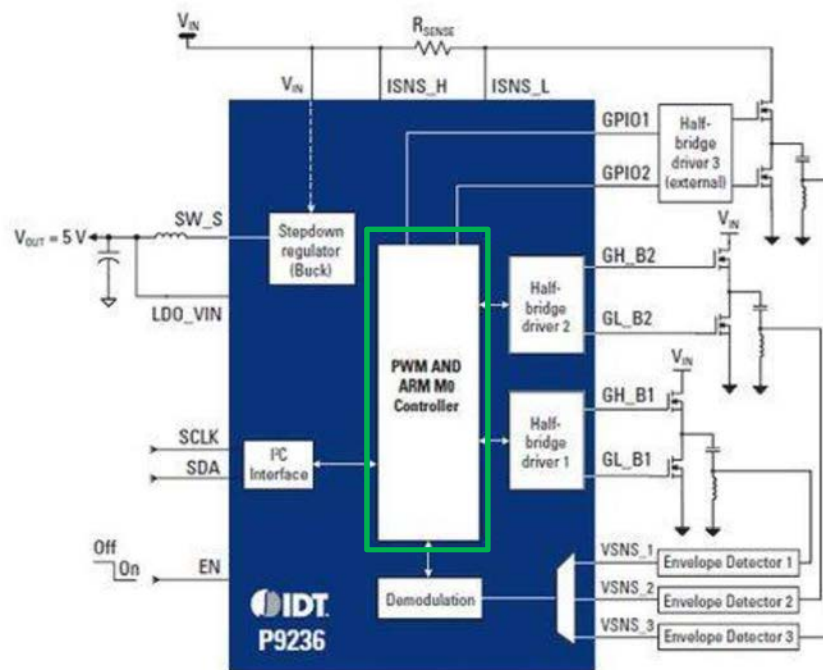
Figure 15. Internal Block Diagram

The internal block diagram of the P9415-R shows a central AFM MD Controller (w/2x16MTP & 45 Slew) block. This controller is connected to various peripheral blocks and components. At the top, there are BIST1, BIST2, hEN, LDOPB, and LDOPF blocks. Below these are VREG1, AC1, AC2, COM1, and CMA blocks. The controller is also connected to AFET(T), OSC 80MHz, and Digital I/O(PIC) blocks. On the right side, there are T/RX control, BIAS, 300MHz OSC, LDOEV, M_LDO, LDO1P6, ECLAMP, ECLAMP_DRV, COM2, CMB, and PClamp blocks. At the bottom, there are DENOC, QD3/CL, QD1/SDA, QD2/INT, QD3/VALIGN_X, QD4/VALIGN_Y, QD0/PWRGD, QD10/PRIME, QD2/THERMISTOR, QD3/Q_OFFSET, QD4/QC_ADDR_SEL, QD5/INHIBIT, and QD6/EEP_DISABLE blocks. The diagram illustrates the complex internal architecture of the P9415-R, showing the integration of various functional blocks and their interconnections.

Wireless chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, and 3300 Wireless Charger Battery each meet this part of the claim, as they each include a communication and control circuit that is structured and operates as specified by this part of the claim. They each include a wireless charger ASIC such as the 9236 ASIC that includes a microcontroller as relevant to this part of the claim. The microcontroller is programmed to operate as specified by this part of the claim. The microcontroller in the ASIC coordinates and controls the communications and the operation of the charger as specified by this part of the claim.

https://archive.eetindia.co.in/www.eetindia.co.in/ART_8800706913_1800008_NP_7a10c6fc.HTM



The 5300 Car Mount Charger and 825 Watch Dock include a wireless charging transmitter ASIC (e.g., the CPS8100 and the V277K, respectively). Upon information and belief, the 9415 ASIC and 9236 ASIC discussion immediately above applies similarly to the wireless charger ASICs included in the 5300 Car Mount Charger and the 825 Watch Dock.

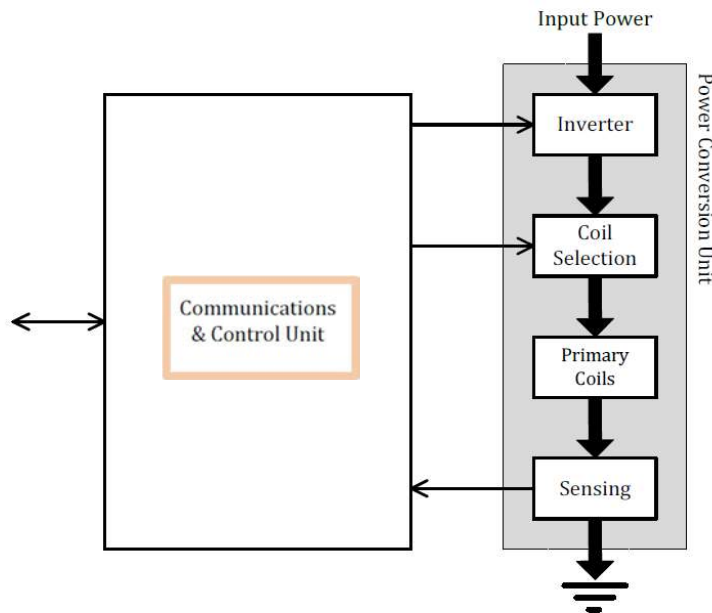
WPC Standard

That the 942 Accused Products meet this part of the claim is further indicated by the WPC Standard Reference Designs. *E.g.*, WPC 1.2.4 Standard, Part 4, Reference Designs, page 31 (*see also* WPC 1.2.3 Standard, Part 4, Reference Designs, page 31).

2.2.4 Power Transmitter design A4

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The Communications and Control Unit on the left-hand side of Figure 10 comprises the digital logic part of the design. The Communications and Control Unit receives and decodes messages from the Power Receiver, configures the Coil Selection block to connect the appropriate Primary Coil, executes the relevant power control algorithms and protocols, and drives the input voltage of the AC waveform to control the power transfer. The Communications and Control Unit also interfaces with other subsystems of the Base Station, e.g. for user interface purposes.

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 first primary coil via the first sense circuit, wherein the received 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; and a power requirement; and

The one or more communication and control circuits included in the 942 Claim 1 Accused Products are configured to operate their one or more drive circuits in this manner, as shown below for the representative products.

WPC Standard

That the 942 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard.

Following the WPC Standard, the 942 Claim 1 Accused Products inductively power the wireless charging receiver in the mobile device to be charged. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 25).



- A rectification circuit that provides full-wave rectification of the AC waveform using, for example, four diodes in a full-bridge configuration or a suitable configuration of active components (see Section 3.1.2, *Rectification circuit*). The rectification circuit may perform output smoothing as well. In this example, the rectification circuit provides power to both the Communications and Control Unit of the Power Receiver and the output of the Power Receiver

Once a wireless power receiver is activated, the charger receives communication from the receiver through load modulation. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 87 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 86) (shown with respect to the “detect” part of claim 1 immediately above).

A high-level description of the information communicated by the receiver is shown below. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9.



the electronics of an appropriate load to which it is connected. Conventional transformers use the same effect to achieve inductive power transfer between a primary and a secondary coil that are strongly coupled by means of a magnetic core.

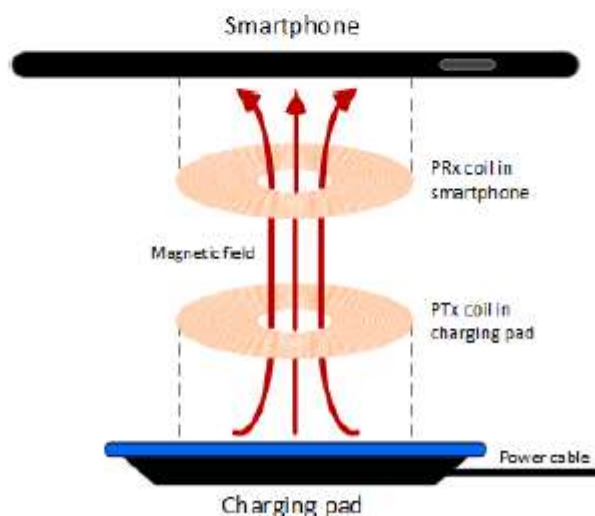
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close to one, whereas a Qi-based system typically has a magnetic coupling coefficient in the range of 0.5 or below.

In the Qi-based system illustrated in Figure 4, power is transferred from the PTx contained in the Qi charging pad to a PRx contained in the Qi smartphone. Before charging begins, the PRx and PTx communicate with each other to establish that the mobile device is indeed capable of being charged, whether it needs to be charged, how much power is required, etc. In short, the communication ensures an appropriate power transfer from the power transmitter to the power receiver. The communication channel can also be used to trigger location based services by providing an SSID, a Bluetooth link, or a unique ID.

When charging begins, the power transmitter runs an alternating electrical current through its coil(s), which generates an alternating magnetic field in accordance with Faraday's law. This magnetic field is in turn picked up by the coil inside the power receiver and transformed by a power converter back into an alternating electrical current that can be used to charge the battery.

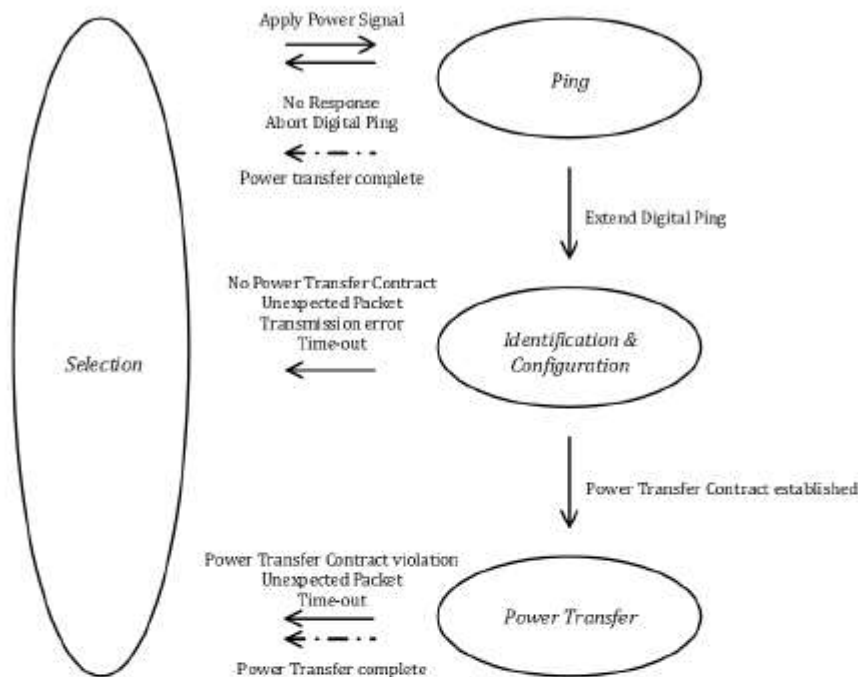
A critical feature of the magnetic field is that it can transfer through any non-metallic, non-ferrous materials, such as plastics, glass, water, wood, and air. In other words, wires and connectors are not needed between the power transmitter and power receiver.

Figure 6. Qi wireless power transfer using magnetic induction



From the Power Transmitter/Charger perspective, the WPC phases are as shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 45, 46, and 50 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 45, 46, 49, and 50).

Figure 16. Power transfer phases—Baseline Power Profile



The main activity in each of these phases is the following:

- **selection** In this phase, the Power Transmitter typically monitors the Interface Surface for the placement and removal of objects. The Power Transmitter may use a variety of methods for this purpose. See Section 10, *Object Detection (Informative)* for some examples. If the Power Transmitter discovers one or more objects, it should attempt to locate those objects—in particular if it supports Free Positioning. In addition, the Power Transmitter may attempt to differentiate between Power Receivers and Foreign Objects, such as keys, coins, etc. Moreover, the Power Transmitter should attempt to select a Power Receiver for power transfer. If the Power Transmitter does not initially have sufficient information for these purposes, the Power Transmitter may repeatedly proceed to the *ping* and subsequently to the *identification & configuration* phases—each time selecting a different Primary Cell—and revert to the *selection* phase after collecting relevant information. See Annex B, *Power Receiver Localization (Informative)* for examples. Finally, if the Power Transmitter selects a Primary Cell, which it intends to use for power transfer to a Power Receiver, the Power Transmitter proceeds to the *ping* phase and eventually to the *power transfer* phase. On the other hand, if the Power Transmitter does not select a Power Receiver for power transfer and is not actively providing power to a Power Receiver for an extended amount of time, the Power Transmitter should enter a stand-by mode of operation.⁴ See Section 9 for performance requirements on such a mode of operation.

⁴ Note that it is up to the Power Transmitter implementation to determine whether this stand-by mode of operation is part of the *selection* phase or is separate from the *selection* phase.



- *ping* In this phase, the Power Transmitter executes a Digital Ping, and listens for a Response. If the Power Transmitter discovers a Power Receiver, the Power Transmitter may extend the Digital Ping, i.e. maintain the Power Signal at the level of the Digital Ping. This causes the system to proceed to the *identification & configuration* phase. If the Power Transmitter does not extend the Digital Ping, the system shall revert to the *selection* phase.
- *identification & configuration* In this phase, the Power Transmitter identifies the selected Power Receiver, and obtains configuration information such as the maximum amount of power that the Power Receiver intends to provide at its output. [The Power Transmitter uses this information to create a Power Transfer Contract. This Power Transfer Contract contains limits for several parameters that characterize the power transfer in the *power transfer* phase. At any time before proceeding to the *power transfer* phase, the Power Transmitter may decide to terminate the extended Digital Ping (for example, to discover additional Power Receivers). This reverts the system to the *selection* phase.
- *power transfer* In this phase, the Power Transmitter continues to provide power to the Power Receiver, adjusting its Primary Cell current in response to control data that it receives from the Power Receiver. Throughout this phase, the Power Transmitter monitors the parameters that are contained in the Power Transfer Contract. A violation of any of the stated limits on any of those parameters causes the Power Transmitter to abort the power transfer, and returns the system to the *selection* phase. Finally, the system may also leave the *power transfer* phase on request of the Power Receiver. Section 5.1.2 defines the system control protocols in the *ping*, *identification & configuration*, and *power transfer* phases from a Power Transmitter perspective. Section 5.1.3 defines the system control protocols in these four phases from a Power Receiver perspective.

NOTE This version of the Specification does not define the system control protocol in the *selection* phase.

NOTE From a power transfer point of view, the Power Receiver remains passive throughout most of the *selection* phase.

At any time, a user can remove a Mobile Device that is receiving power. The Power Transmitter can recognize such an event from a time-out in the communications from the Power Receiver, or from a violation of the Power Transfer Contract. As a result, the Power Transmitter aborts the power transfer and the system reverts to the *selection* phase.

Throughout the *power transfer* phase, the Power Transmitter and Power Receiver control the amount of power that is transferred. Figure 17 illustrates a schematic diagram of the power transfer control loop, which basically operates as follows: the Power Receiver selects a desired Control Point: a desired output current and/or voltage, a temperature measured somewhere in the Mobile Device, etc. In addition, the Power Receiver determines its actual Control Point. The Power Receiver may use any approach to determine a Control Point. Moreover, the Power Receiver may change this approach at any time during the *power transfer* phase. Using the desired Control Point and actual Control Point, the Power Receiver calculates a Control Error Value—for example, by simply taking the (relative) difference of the two output voltages or currents. The result is negative if the Power Receiver requires less power in order to reach its desired Control Point and positive if the Power Receiver requires more power in order to reach its desired Control Point. Subsequently, the Power Receiver transmits this Control Error Value to the Power Transmitter.



5.1.2 Power Transmitter (PTx) perspective

This section defines a protocol that the Power Transmitter shall execute to transfer power to a Power Receiver. Note that three of the seven phases are applicable only to the Extended Power Profile if the Power Transmitter supports the Extended Power Profile.

1. **Selection phase.** Section 5.1.2.1 defines the protocol to select a Power Receiver for the power transfer.
2. **Ping phase.** Section 5.1.2.2 defines the Digital Ping.
3. **Identification & configuration phase.** Section 5.1.2.3 defines the part of the protocol that the Power Transmitter shall execute in order to identify the Power Receiver and establish a default Power Transfer Contract. This protocol extends the Digital Ping in order to enable the Power Receiver to communicate the relevant information.
4. **Negotiation phase (Extended Power Profile only).** Section 5.1.2.4 defines the part of the protocol that the Power Transmitter shall execute if the Power Receiver requests to negotiate changes to the default Power Transfer Contract.
5. **Calibration phase (Extended Power profile only).** Section 5.1.2.5 defines the part of the protocol that the Power Transmitter shall execute in the *calibration* phase. The Power Transmitter can use the information obtained from the Power Receiver in this phase to improve its ability to detect Foreign Objects during power transfer.
6. **Power transfer phase.** Section 5.1.2.6 defines the part of the protocol that the Power Transmitter shall execute during power transfer. In this part of the protocol, the Power Transmitter controls its Primary Cell current in response to control data received from the Power Receiver.
7. **Renegotiation phase (Extended Power Profile only).** Section 5.1.2.7 defines the part of the protocol that the Power Transmitter executes to update the Power Transfer Contract during power transfer.

Many provisions in Section 5.1.2 refer to the start and/or the end of a Packet, or to the start of a Packet's preamble. In the case of a Packet that is sent from the Power Receiver to the Power Transmitter:

- The start of the Packet is defined as the instant that the Power Transmitter receives the first edge of the start bit of the Packet's header byte.
- The end of the Packet is defined as the instant that the Power Transmitter receives the second edge of the stop bit of the Packet's checksum byte.
- The start of the Packet's preamble is defined as the instant that the Power Transmitter receives the first edge of the first preamble bit.

Initially, the transmitter applies power periodically for a period of time (ping) sufficiently long to wake up the receiver and receive some communication from it, including information corresponding to a voltage at the output of the receiver circuit (i.e., the Signal Strength Packet). *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 52 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 51).



5.1.2.2 Ping phase (PTx perspective)

In the *ping* phase, the Power Transmitter shall execute a Digital Ping. This Digital Ping shall proceed as follows, with conditions appearing earlier in this list taking precedence over conditions appearing later.

- The Power Transmitter shall apply a Power Signal at the Operating Point defined for the particular Power Transmitter design (*see Part 4: Reference Designs*).
- If the Power Transmitter does not detect the start of a Packet in the time window t_{ping} after the Primary Cell current amplitude reaches 50% of the stable level, the Power Transmitter shall remove the Power Signal (i.e. reduce the Primary Cell current to zero) within $t_{\text{terminate}}$. See Figure 19(a).
- If the Power Transmitter correctly receives a Signal Strength Packet, the Power Transmitter may proceed to the *identification & configuration* phase of the power transfer, maintaining the Power Signal at the Operating Point as defined for the particular Power Transmitter design. See Figure 19(b). If the Power Transmitter does not proceed to the *identification & configuration* phase, the Power Transmitter shall remove the Power Signal within t_{expire} after the start of the Signal Strength Packet. See Figure 19(c).

5.2.3.1 Signal Strength Packet (0x01)

Table 27 defines the format of the message contained in a Signal Strength Packet.

Table 27. Signal strength

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Signal Strength Value							

Signal Strength Value. The unsigned integer value in this field indicates the degree of coupling between the Primary Cell and Secondary Coil, with the purpose to enable Power Transmitters that use Free Positioning to determine the Primary Cell that provides optimum power transfer (see also Annex B, *Power Receiver Localization (Informative)*). To determine the degree of coupling, the Power Receiver shall monitor the value of a suitable variable during a Digital Ping. Examples of such variables are:

- The rectified voltage.
- The open circuit voltage (as measured at the output disconnect switch).
- The received Power (if the rectified voltage is actively or passively clamped during a Digital Ping).

The variable that is chosen shall result in a Signal Strength Value that increases monotonically with an increasing degree of coupling. The Signal Strength Value is reported as

$$\text{Signal Strength Value} = \frac{U}{U_{\max}} \cdot 255,$$

where U is the monitored variable and $U_{\max}$ is the maximum value that the Power Receiver expects during a Digital Ping.

NOTE The Power Receiver shall set the Signal Strength Value to 255 in the case that $U \geq U_{\max}$.

Following this phase, the system enters the Identification and Configuration phases with the receiver as described below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 54 (see also WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 53).



5.1.2.3 Identification & configuration phase (PTx perspective)

In the *identification & configuration* phase, the Power Transmitter shall identify the Power Receiver and collect configuration information. For this purpose, the Power Transmitter shall correctly receive the following sequence of Packets in the order shown and without changing its Operating Point.

1. If the Power Transmitter enters the *identification & configuration* phase from the *ping* phase, an Identification Packet.
2. If the Ext bit of the preceding Identification Packet is set to ONE, an Extended Identification Packet.
3. Up to 7 optional configuration Packets from the following set (the order in which the Power Transmitter receives these Packets, if any, is not relevant):
 - A Power Control Hold-off Packet. If the Power Transmitter receives multiple Power Control Hold-off Packets, the Power Transmitter shall retain the Power Control Hold-off Time t_{delay} contained in the last Power Control Hold-off Packet received (see below).
 - Any Proprietary Packet (as listed in Table 26). If the Power Transmitter does not know how to handle the message contained in the Proprietary Packet, the Power Transmitter shall ignore that message.
 - Any reserved Packet (as indicated in Table 26). The Power Transmitter shall ignore the message contained in the reserved Packet.
4. A Configuration Packet. If the number of optional configuration Packets, which the Power Transmitter has received, is not equal to the value contained in the Count field of the Configuration Packet, the Power Transmitter shall remove the Power Signal within $t_{\text{terminate}}$ ms after receiving the stop bit of the Configuration Packet's checksum byte, and return to the *selection* phase.

The Identification communication received by the transmitter is described below and includes a unique identification code, a manufacturer code, and a charge algorithm profile. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 100-101 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 98-99).



5.2.3.8 Identification Packet (0x71)

Table 35 defines the format of the message contained in an Identification Packet.

Table 35. Identification

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Major Version				Minor Version			
B ₁	(MSB)							
B ₂	Manufacturer Code (LSB)							
B ₃	Ext	(MSB)						
⋮	Basic Device Identifier							
B ₆	(LSB)							

Major Version. The combination of this field and the Minor Version field identifies to which revision of this Specification the Power Receiver complies. The Major Version field shall contain the binary coded digit value 0x1.

Minor Version. The combination of this field and the Major Version field identifies to which minor revision of this Specification the Power Receiver complies. The Minor Version field shall be set according to the power profile of the Power Receiver.

Table 36. Minor Version field settings

PRx Power Profile	Minor Version Setting	Neg Bit
Baseline Power Profile	0x1 or 0x2	ZERO
Extended Power Profile	0x2	ONE

Manufacturer Code. The bit string contained in this field identifies the manufacturer of the Power Receiver, as specified in the Power Receiver Manufacturer Codes, Wireless Power Consortium.



Basic Device Identifier. The bit string contained in this field contributes to the identification of the Power Receiver. A Power Receiver manufacturer should ensure that the combination of Basic Device Identifier and Manufacturer ID is sufficiently unique. Embedding a serial number of at least 20 bits in the Basic Device Identifier is sufficient. Alternatively, using a (pseudo) random number generator to dynamically generate part of the Basic Device Identifier is sufficient as well, provided that the generated part complies with the following requirements.

The configuration packet received by the transmitter also includes the receiver power requirement information. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 98 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 96).



5.2.3.7 Configuration Packet (0x51)

Table 34 defines the format of the message contained in a Configuration Packet.

Table 34. Message in a Configuration Packet

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Power Class		Maximum Power Value					
B ₁	Reserved							
B ₂	Prop	Reserved			ZERO		Count	
B ₃	Window Size					Window Offset		
B ₄	Neg	Polarity*	Depth*		Reserved			

* In the Baseline Power Profile, these bits are Reserved.

Power Class This field shall be set to '00'.

Maximum Power Value

(Baseline Power Profile) Apart from a scaling factor, the unsigned integer value contained in this field indicates the maximum amount of power that the Power Receiver expects to provide at the output of the rectifier. This maximum amount of power is calculated as follows:

$$P_{\max} = \left(\frac{\text{Maximum Power Value}}{2} \right) \times 10^{\text{Power Class W.}}$$

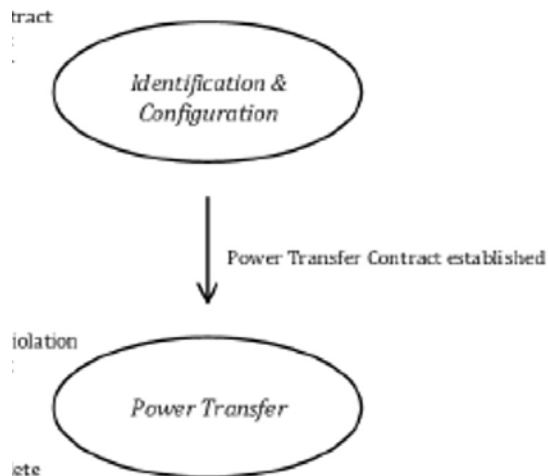
operate the first drive circuit according to the power requirement to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to: receive additional information in the first primary 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, the duty cycle, and a DC voltage at the DC voltage input of the first drive circuit while charging the battery of the portable device;

The one or more communication and control circuits included in the 942 Claim 1 Accused Products are configured to operate with their one or more drive circuits and sense circuits in this manner, as illustrated below for the representative products.

WPC Standard

That the 942 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard.

Per the WPC standard, the 942 Claim 1 Accused Products, operate as described in this portion of the claim. For example, *see*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 45 and 50 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 45 and 50). Following the Identification and Configuration phases, based on the information received, a power transfer contract is established and the system moves to the Power Transfer phase.



6. **Power transfer phase.** Section 5.1.2.6 defines the part of the protocol that the Power Transmitter shall execute during power transfer. In this part of the protocol, the Power Transmitter controls its Primary Cell current in response to control data received from the Power Receiver.

During the Power Transfer phase, power is transferred to the portable device as specified by this part of the claim and as shown below. *See also*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 46-47 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 46-47).



The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
Power Class 0 Specification

Version 1.2.4

Information interface

Throughout the *power transfer* phase, the Power Transmitter and Power Receiver control the amount of power that is transferred. Figure 17 illustrates a schematic diagram of the power transfer control loop, which basically operates as follows: the Power Receiver selects a desired Control Point: a desired output current and/or voltage, a temperature measured somewhere in the Mobile Device, etc. In addition, the Power Receiver determines its actual Control Point. The Power Receiver may use any approach to determine a Control Point. Moreover, the Power Receiver may change this approach at any time during the *power transfer* phase. Using the desired Control Point and actual Control Point, the Power Receiver calculates a Control Error Value—for example, by simply taking the (relative) difference of the two output voltages or currents. The result is negative if the Power Receiver requires less power in order to reach its desired Control Point and positive if the Power Receiver requires more power in order to reach its desired Control Point. Subsequently, the Power Receiver transmits this Control Error Value to the Power Transmitter.

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The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
Power Class 0 Specification

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Information interface

The Power Transmitter uses the Control Error Value and the actual Primary Cell current to determine a new Primary Cell current. After the system stabilizes from the communications of the Control Error Packet, the Power Transmitter has a short time window to control its actual Primary Cell current towards the new Primary Cell current. Within this window, the Power Transmitter reaches a new Operating Point: the amplitude, frequency, and duty cycle of the AC voltage that is applied to the Primary Cell. Subsequently, the Power Transmitter keeps its Operating Point fixed in order to enable the Power Receiver to communicate additional control and status information. For details, see Section 5.1.2.6.1, *Power transfer control*.

Figure 17. Power transfer control loop

Smartphone

The S22 Ultra in Wireless PowerShare mode performs closed loop control as specified by this part of the claim. For example, as seen in the illustrative representative 9415 datasheet below² the 9415 ASIC in a S22 Ultra operating as a receiver (as a portable device being charged) is instructed to perform as shown below. Similarly, the operation of a S22 Ultra in Wireless PowerShare mode following the WPC Standard is described below.



P9415-R Datasheet

8.1 Overview

The simplified internal block diagram of the P9415-R is shown in Figure 15. External Rx coil(s) and CS capacitor(s) as shown in Figure 1 transfer energy wirelessly using the P9415-R AC1 and AC2 pins to be full-wave-rectified (AC-to-DC).

The wireless power is stored on a capacitor(s) connected to VRECT. Until the voltage across the VRECT capacitor exceeds the UVLO threshold, the rectification is performed by the body diodes of the Synchronous Full Bridge Rectifier FETs. After the internal biasing circuit is enabled, the Driver and Control block operate the MOSFET switches of the rectifier in various modes to maintain reliable connections at optimal efficiency. An internal ADC monitors the voltage at VRECT and the load current, the P9415-R sends instructions to the wireless power transmitter to increase or decrease the amount of power transferred or to terminate power transmission based on these readings. The voltage at the output of the P9415-R Main Low-Drop-Out (LDO) regulator is programmed up to 20V using I2C commands. The internal temperature is continuously monitored to ensure proper operation.

The voltage at VRECT and the current through the rectifier are sampled periodically and digitized by the ADC. The digital equivalents of the voltage and current are supplied to the internal control logic, which decides whether the loading conditions on VRECT indicate that a change in the operating point is required. If the load is heavy enough to bring the voltage at VRECT below its target, the transmitter is instructed to move its frequency lower, closer to resonance. If the voltage at VRECT is higher than its target, the transmitter is instructed to increase its frequency. To maximize efficiency, the voltage at VRECT is programmed to decrease as the LDO's load current increases.

8.2.2 Power Transfer

Once the "identification and configuration" phase is completed and successful "negotiation and calibration" is made, then the transmitter initiates power transfer mode. The P9415-R control circuit measures the rectifier voltage and sends error packets to the transmitter to adjust the rectifier voltage to the level required to maximize the efficiency of the main LDO linear regulator and to notify the Tx of the current Rectified Power Packet for Foreign Object Detection (FOD) to guarantee safe efficient power transfer. The P9415-R is compatible with the WPC 1.2.4 Specification, and can use compatible Rx coils. Each receiver coil type has a unique inductance value. As such, a unique resonant capacitor (Cs) is used for a given type of receiver coil.

Wireless Chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, 3300 Wireless Charger Battery, the 5300 car mount charger and 825 Watch Dock, upon information and belief, with their included wireless charger ASICs operate per the WPC Standard as required by this part of the claim, similar to the 9415 ASIC discussion immediately above.

monitor for continued presence of the portable device and completion of the charging of the battery of the portable device detected by the communication and control circuit through the first sense circuit; and

² While this data sheet is showing the Rx mode it provides support for what is expected of the 9415 in Tx mode.

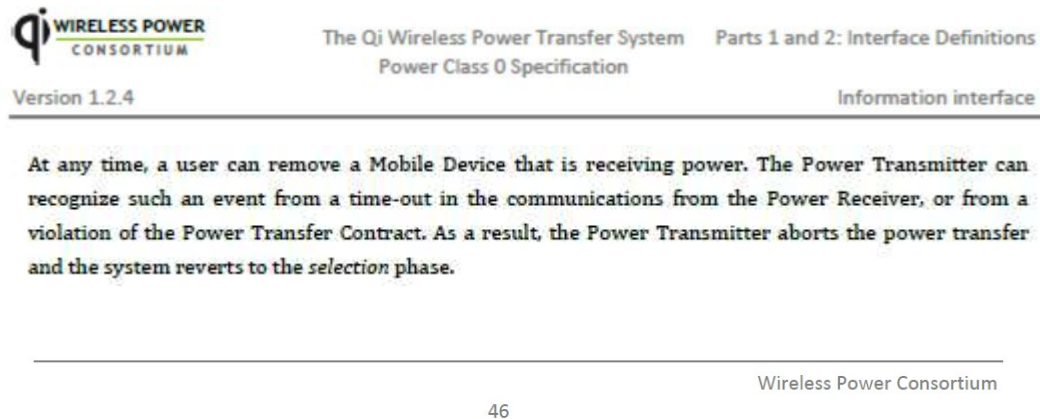
The one or more communication and control circuits included in the 942 Claim 1 Accused Products are configured to operate with their one or more drive circuits and sense circuits in this manner, as illustrated below for the representative products.

WPC Standard

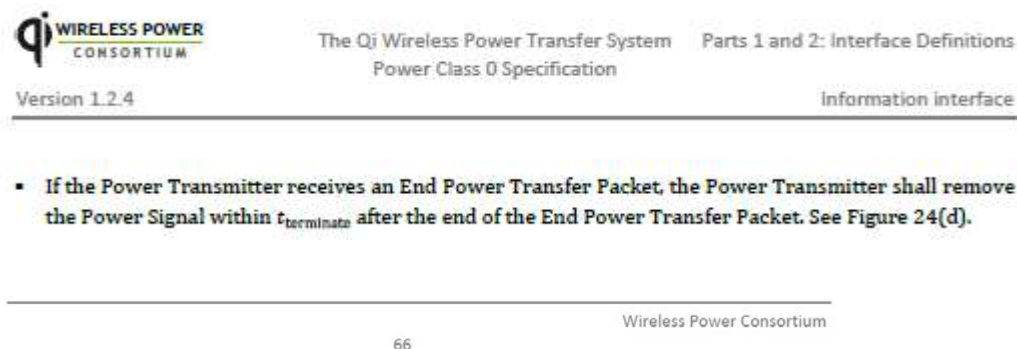
That the 942 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard.

Following the WPC Standard, the 942 Claim 1 Accused Products terminate power transfer as specified by this part of the claim.

E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 46 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 46).



At any time if the system receives an End Power Transfer communication (as may be used when charging is complete) or it does not receive any communication for a period of time (shown above), it shall end provision of power to the receiver. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 66 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 65).





5.2.3.2 End Power Transfer Packet (0x02)

Table 28 defines the format of the message contained in an End Power Transfer Packet.

Table 28. End Power Transfer

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	End Power Transfer Code							

End Power Transfer Code. This field identifies the reason for the End Power Transfer request, as listed in Table 29. The Power Receiver shall not transmit End Power Transfer Packets that contain any of the values that Table 29 lists as reserved.

Table 29. End Power Transfer values

Reason	Value	Recommended usage of the values (Informative)
Unknown	0x00	The Receiver may use this value if it does not have a specific reason for terminating the power transfer or if none of the other values listed in this table is appropriate.
Charge Complete	0x01	The Receiver should use this value if it determines that the battery of the Mobile Device is fully charged. On receipt of an End Power Transfer Packet containing this value, the Transmitter should set any "charged" indication on its user interface that is associated with the Receiver.

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.

The one or more communication and control circuits included in the 942 Claim 1 Accused Products are configured to operate with their one or more drive circuits and sense circuits in this manner, as illustrated below for the representative products.

Per the WPC Standard, at any time that the system receives an End Power Transfer communication (as may be used when charging is complete) or it does not receive any communication for a period of time (shown above), it shall end provision of power to the receiver. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 66 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 65).



- If the Power Transmitter receives an End Power Transfer Packet, the Power Transmitter shall remove the Power Signal within $t_{\text{terminate}}$ after the end of the End Power Transfer Packet. See Figure 24(d).

Smartphones

The S22 Ultra, for example, in Wireless PowerShare mode monitors the status of the wireless charging, and stops the wireless charging if the receiving device is no longer present or charging is complete, as specified by this part of the claim, as seen in the illustrative representative 9415 datasheet.



P9415-R Datasheet

8.2.13 Power Transfer

In this phase, the P9415-R controls the power transfer by means of the following Control Data Packets:

- Control Error Packets
- Rectified Power Packet
- End Power Transfer Packet

Wireless Chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, 3300 Wireless Charger Battery, the 5300 car mount charger and 825 Watch Dock are configured to operate per the WPC Standard discussed above.

Dependent off claim 1

5. The system of claim 1, wherein 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 vary the DC voltage at the DC voltage input based on at least one of the received communication of information and the additional information received by the communication and control circuit from the portable device.

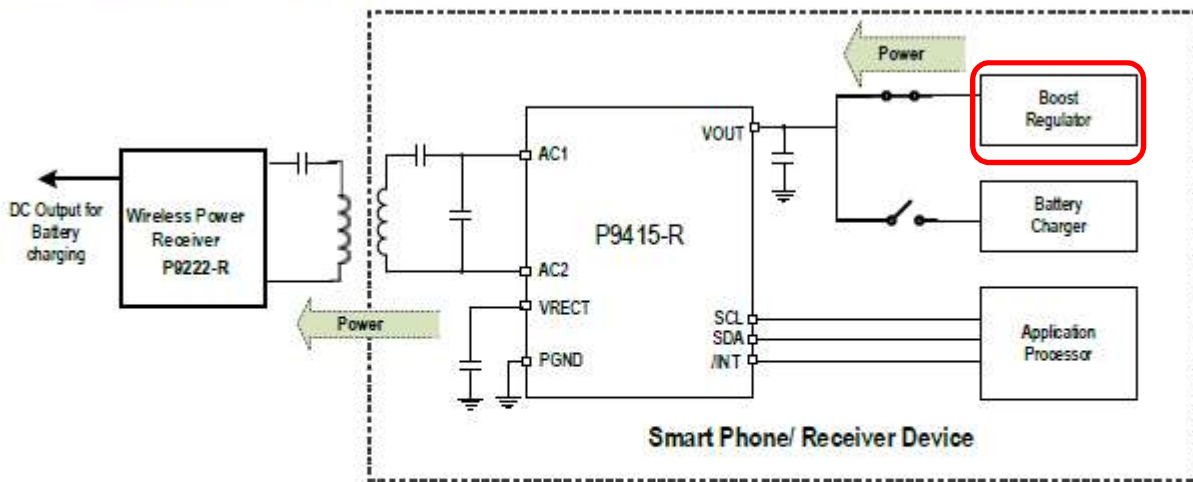
The 942 Claim 1 Accused Products additionally infringe this dependent claim, as they include a voltage regulator that switches the DC voltage, as specified by this claim.

Smartphones

The S22 Ultra includes a voltage regulator circuit as specified by this dependent claim, which is structured to switch the DC voltage input as specified by this dependent claim. In the representative 9415 datasheet as seen below, the boost regulator (red rectangle) boosts the input voltage from the battery of the S22 Ultra (typically ~ 3.7 V) to a higher level for operation of the ASIC, based on communication from the microcontroller in the ASIC. For example, the S22 Ultra, when plugged in to an external power supply / adapter, can operate in the PowerShare mode applying, e.g., 5, 6,

7.5, or 9 Volts supplied by the voltage regulator controlled by the microcontroller to the DC voltage input, and when using its internal battery power when not plugged in, switching, e.g., between 5 and 7.5 V, depending on the power needs of the portable device being charged as communicated by the portable device to the microcontroller to control the voltage regulator. As shown in the datasheet below, the input voltage to the ASIC must be around 7 to 9 V to provide 5W of output power but can be lower if charging a lower power device (such as a watch or earbud case) based on received or additional communication of information.

Figure 21. Enabling WattShare™ (TRx) Mode



8.4.2 WattShare™ Mode Input Voltage

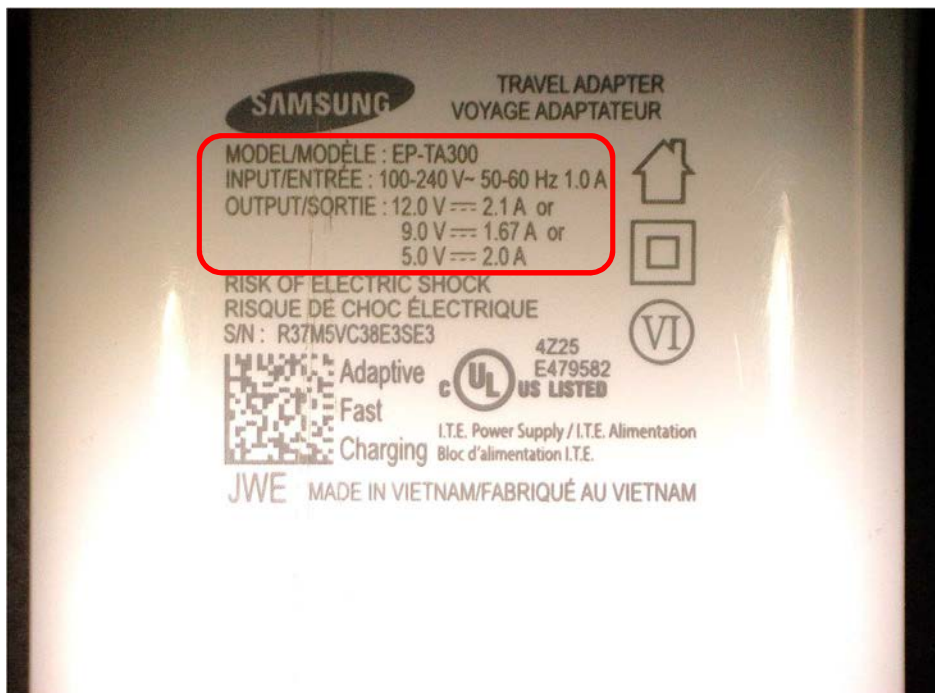
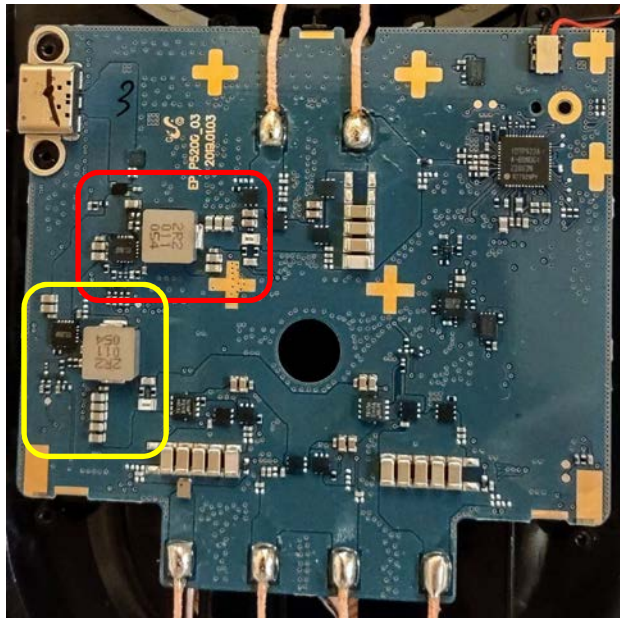
The P9415-R can transfer up to 5W of power in TRx mode. It follows the WPC 1.2.4 BPP protocol to transfer the power to other Qi-certified receivers such as Mobile devices and Earbud charging cases. The maximum power delivered in TRx mode is dependent on the input voltage on VOUT pin, coil characteristics such as AC resistance, and the friendly metal around the coil. Because the coil used for power transfer in TRx mode has high AC resistance compared to transmitter coil used in a charging pad, the input voltage on the VOUT pin in TRx mode must be around 7 to 9V to deliver 5W of power to the receiver.

Wireless Chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, and 3300 Wireless Charger Battery each meet this part of the claim, as they each include a communication and control circuit that is structured and operates as specified by this part of the claim. They each include a wireless charger ASIC such as the 9236 ASIC that includes a microcontroller as relevant to this part of the claim. The microcontroller is programmed to operate as specified by this part of the claim. The microcontroller in the ASIC coordinates and controls the communications and the operation of the charger as specified by this part of the claim.

The 5200 Duo Pad as a representative of the wireless chargers and the Wireless Charger Battery includes a voltage regulator circuit as specified by this dependent claim, which is structured to switch the DC voltage input as specified by this dependent claim. Further, as an example of the infringing chargers, the 5200 includes two wireless charging transmitter ASICs (e.g., the 9236 ASIC) with associated external voltage regulator circuits coupled to the DC voltage input. The voltage regulator components for the 5200 Duo are shown below (red and yellow rectangles) that

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Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
take 12 V from the USB adapter (Samsung EP-TA300, also shown below) and step the voltage
down to provide input voltages to the two ASICs (controlling the right and left side of the charger).



The 5200 Duo has two distinct regulators as shown above. The one shown in red rectangle provides discrete values (such as, for example, 5, 6, 9 and 10 V) to the Input Voltage of the system

for operating the larger single coil for charging the phone (left side of charger; shown with connections on the top of board in below image). For example, when charging a lower power receiver like an earbud case, the ASIC communicates with the regulator to provide e.g. 6 V.

The yellow rectangle above is showing the microcontroller in the ASIC which communicates with the voltage regulator to supply the different discrete voltage values to the Input Voltage of the system for operating the large coil and the small coil on the right side of the charger (double coil side – shown with 4 connections at the bottom of the above picture) for charging another phone. For operating the small coil on the right side for charging a watch requiring lower power levels, the microcontroller in the ASIC communicates with the regulator to supply e.g. 5 V. For charging an earbud on the right side (larger coil), the microcontroller instructs the regulator to supply e.g. 6 V.

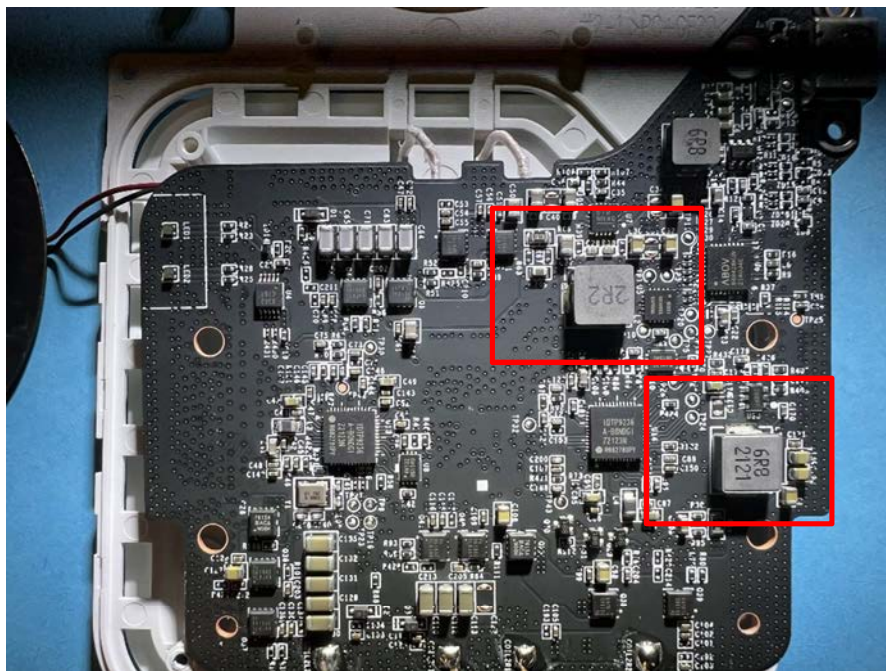
Consistent with this, the FCC document for the 5200 Duo describes the operation of the internal voltage regulator circuit to provide discrete input voltage values to the DC voltage input depending on the received communication of information and additional information from the portable device.

<https://fcc.report/FCC-ID/A3LEPP5200/4144776>

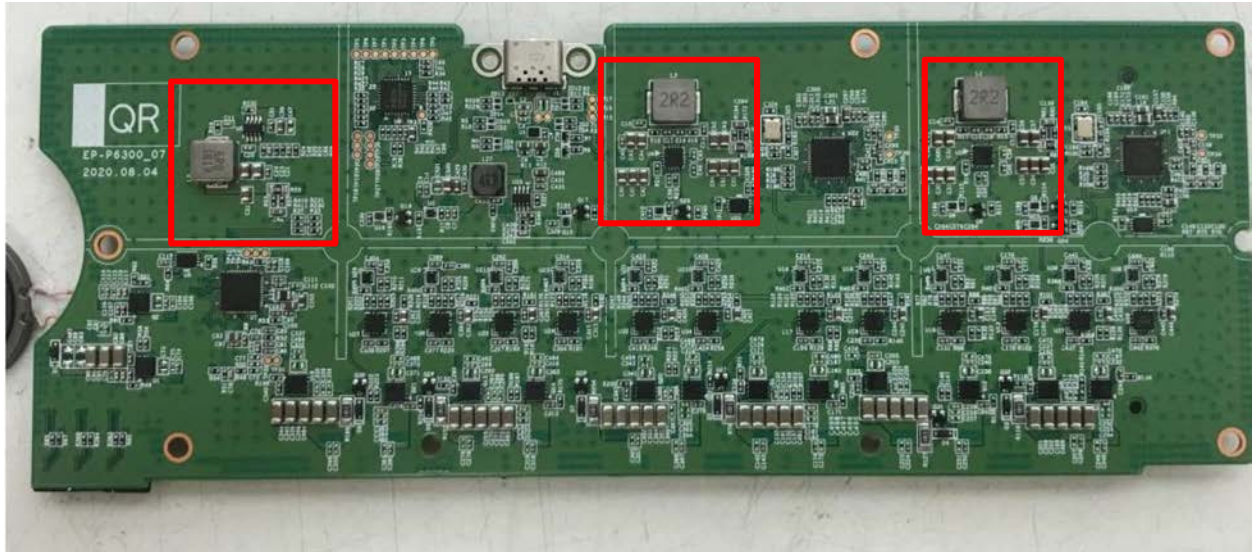
1.5. Declaration by the manufacturer

- The EUT has 3 inductive loop coil antennas and can be operating maximum 2 antennas simultaneously.
(For the details, please refer to Test setup photo)
- EUT is operated with input DC 12.0 V but internal circuit of EUT can divide DC 5.0 V, DC 9.0 V and DC 12.0 V depend on client devices.

The 5400 Duo includes voltage regulator circuits (red rectangles) as specified by this dependent claim, which are structured to switch the DC voltage input as specified by this dependent claim. On information and belief, the circuits operate in a substantially similar manner as discussed with the 5200 above.



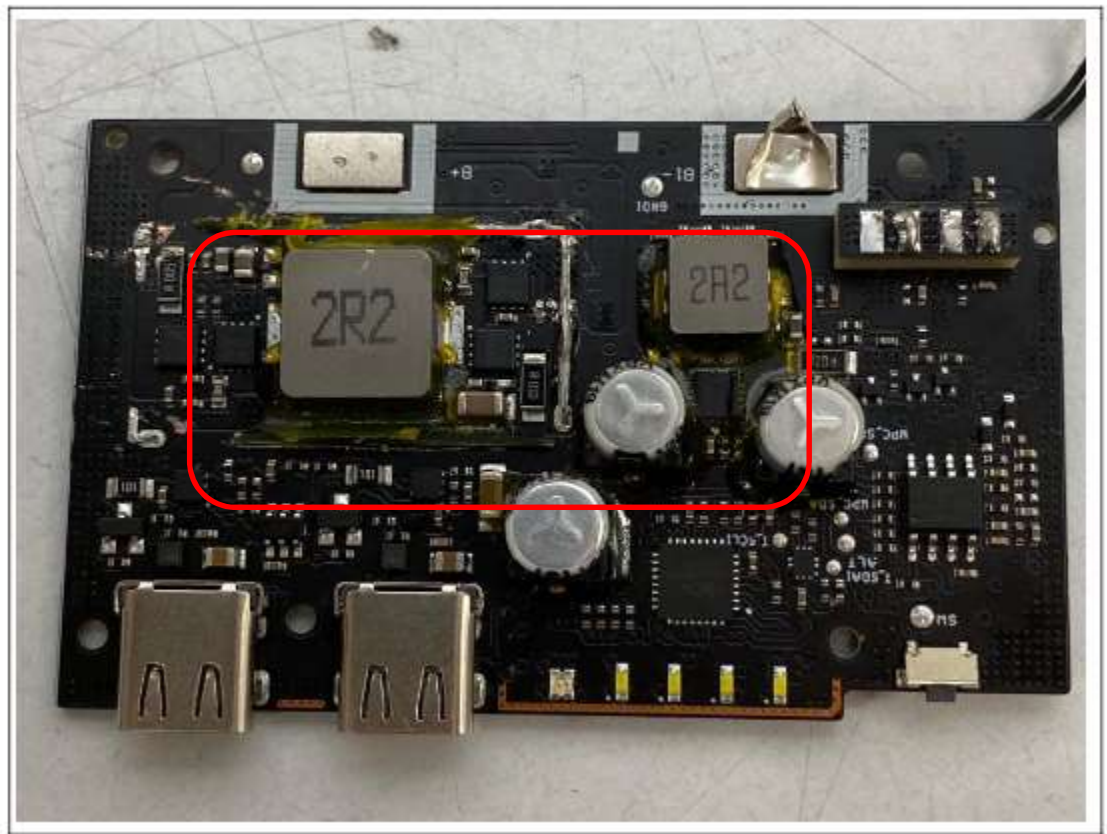
The 6300 Trio Pad includes voltage regulator circuits (red rectangles) as specified by this dependent claim, which are structured to switch the DC voltage input as specified by this dependent claim. On information and belief, the circuits operate in a substantially similar manner as discussed with the 5200 above.



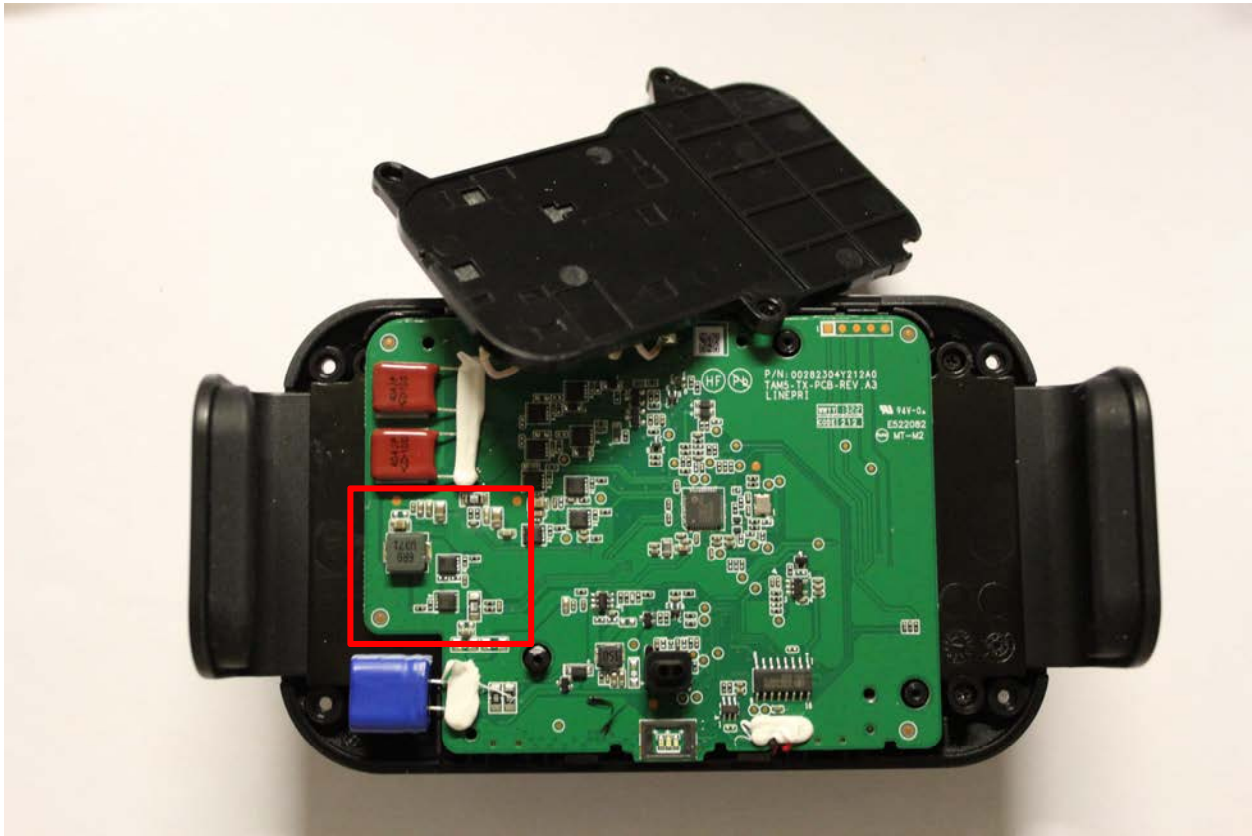
The 3300 Wireless Charger includes a voltage regulator circuit (red rectangle) as specified by this dependent claim, which is structured to switch the DC voltage input as specified by this dependent claim. On information and belief, the circuit operates in a substantially similar manner as the discussed with the 5200 above.

<https://fcc.report/FCC-ID/A3LEBU3300/4624577>

Bottom view of Main PCB



The 5300 Car Mount Charger includes a voltage regulator circuit (red rectangle) as specified by this dependent claim, which is structured to switch the DC voltage input as specified by this dependent claim. On information and belief, the circuit operates in a substantially similar way as discussed with the 5200 above.



6. The system of claim 1 wherein: the DC voltage input is configured to couple to and receive a DC voltage from a DC power supply via a universal serial bus (USB) power supply; and the system is further configured to communicate with the DC power supply via the USB.

The 942 Claim 1 Accused Products additionally infringe this dependent claim, as the DC voltage input and the communication and control circuit are structured and operate as specified by this claim. The smartphones and wireless chargers sold by Samsung are designed to be charged by a USB power supply / adapter and their communication and control circuits are in communication with the USB power supply / adapter to negotiate an appropriate power level and speed of charging. This communication is done at least in part by the wireless power ASIC in the smartphones and wireless chargers (such as the representative wireless power ASICs pointed out above with respect to claim 1).

Smartphones

As an example, the S22 Ultra can operate in the PowerShare mode with the phone plugged in and receiving power from a wired USB-C charger. During receiving power from this source, the smartphone is in communication with the USB power supply to establish the appropriate charge rate depending on the capability of the USB power supply.

<https://www.samsung.com/levant/support/mobile-devices/how-to-fast-charge-the-galaxy-s22-series-wired-or-wirelessly/>

Charge your phone with Fast and Super fast wired charging or Fast wireless charging

The Galaxy S22 Series allows **Fast charging** and **Fast wireless charging** when you really need your phone to be up and running quickly. When you plug in a Samsung fast charger, a pop-up message prompting you to turn on the **Fast charging** feature will appear on your phone screen the first three times it is connected. **Super fast charging** is only available on select phones, and you need to use the charger as well as a 25W or 45W Samsung-approved adapter.

- **Fast charging:** To use the fast charging feature, use a battery charger that supports Adaptive fast charging. 'Adaptive Fast Charging' text along with the charging icon is marked on the charger.
- **Fast wireless charging:** To use this feature, use a charger and components that support the fast wireless charging feature.
- **Super fast charging:** To use the super fast charging feature, use a USB PD (Power Delivery) charger that supports Super fast charging. 'Super Fast Charging' text along with the charging icon is marked on the charger.



Fast charger



Fast wireless charger



Super fast charger

These different charging rates have different current / voltage specifications and the power delivered by the USB supply is communicated and negotiated between the phone and the USB supply.

<https://www.digitaltrends.com/mobile/how-does-fast-charging-work/>

	Voltage	Current	Max power
Samsung Adaptive Fast Charging	5V/9V	2A	18W
Samsung Super Fast Charging 1.0	11V	2.25A	25W
Samsung Super Fast Charging 2.0	10V	4.5A	45W

The USB-C Power Delivery Protocol and its variants such as PPS used by Samsung are based on communication and control between the device being charged and the power supply:

<https://www.usb.org/usb-charger-pd>

The USB Power Delivery (USB PD) Specification enables the maximum functionality of USB by providing more flexible power delivery along with data over a single cable. Its aim is to operate with and build on the existing USB ecosystem.

USB Power Delivery offers the following features:

- **Increased power levels from existing USB standards** up to 240W.
 - New 28V, 36V, and 48V fixed voltages enable up to **140W, 180W and 240W** power levels, respectively.
 - An **adjustable voltage supply mode** allows the device being powered an ability to request intermediate voltages between 15V and up to the maximum available fixed voltage of the charger.
- **Power direction is no longer fixed.** This enables the product with the power (Host or Peripheral) to provide the power.

Samsung Fast Charge and Fast Charge 2.0 power adapters (currently EP-TA800 for 25 W output) for use with the S22 Ultra for the Samsung Fast Charging protocols use the Power Data Object (PDO) or Programmable Power Supply (PPS version of the USB 3.0 Standard) communication standards. Using PPS, the S22 Ultra (acting as a wireless charger in PowerShare mode) communicate with the USB Power Adapter (at up to every 10 seconds in PPS mode) to optimize the USB Power Adapter's output voltage and current based on the dynamic requirements during the S22 providing wireless power in the PowerShare mode.

The EP-TA 800 for the S22 Ultra shown below is capable of PDO or PPS operation. In either mode, the S22 Ultra communicates with the TA to optimize power delivery depending on the power needs (as dictated by the communication and control circuit and power requirements during wireless charging).



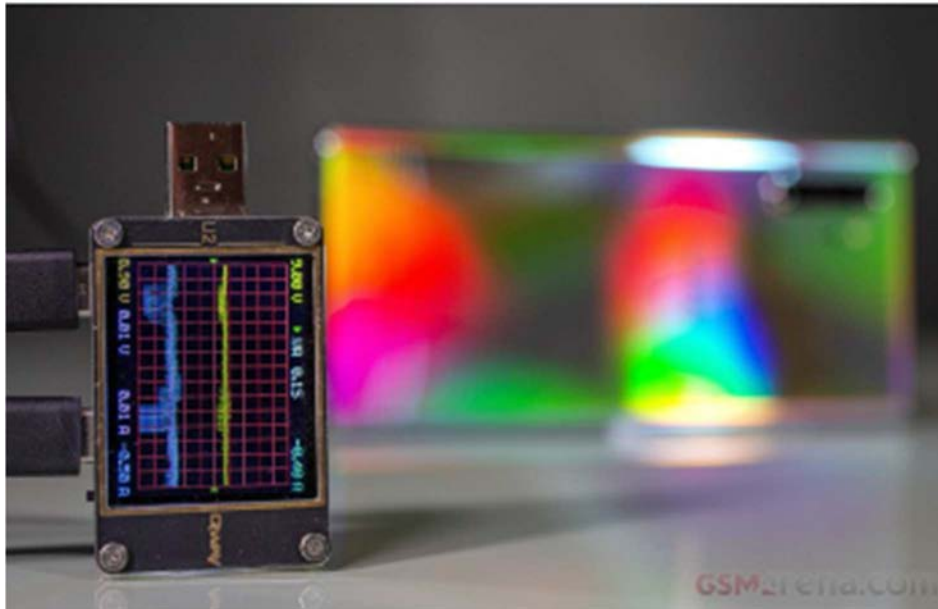
<https://www.samsung.com/levant/mobile-accessories/wall-charger-for-super-fast-charging-25w-ep-ta800xwegww/>

Power	Input Voltage	Output Voltage (Max, Normal Charge)
	100-240 V	5 V
	Output Voltage (Max, Fast Charge) PDO : 9V / PPS : 3.3-5.9V or 3.3-11.0V	Output Current (Max, Normal Charge) 3 A
	Output Current (Max, Fast Charge) PDO : 2.77A(9V) / PPS : 3.0A(3.3-5.9V) or 2.25A(3.3-11.0V)	

https://www.gsmarena.com/dont_just_buy_any_45w_pd_charger_for_the_samsung_galaxy_note_10-news-38837.php

Power Data Objects (PDO)

The basic form of a charger and host negotiating charging speed is PDO. It involves objects get tossed back and forth between the two parties until one of a few profiles get selected. Besides the typical 5V, USB PD adds support for **9V, 15V and 20V**.



However, a client can also try to request a **non-standard voltage** - in the case of Galaxy Note10+ that's 10V. The charger generally has no obligation to provide said voltage so it will normally provide the nearest lower voltage it can. So, when the Note10+ requests **10V at 4.5A** from a charger that is incapable of providing that, it would start giving out 9V@3A. That is a rather standard 27W PD charging rate, but far from the desired 45W. Still, nothing is going to explode in the process and the Note10+ will be charging.

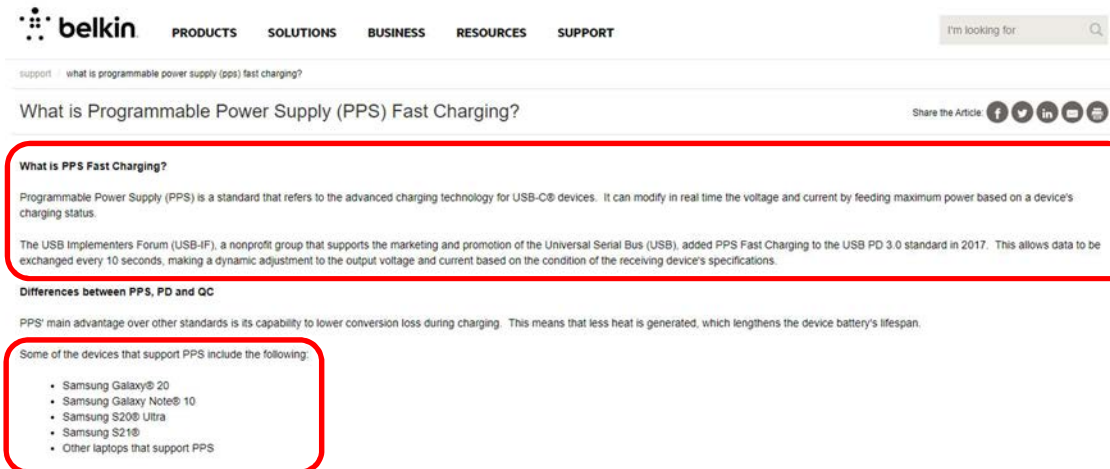
The majority of 45W+ chargers would only be able to provide 45W of power if the client requests 15V@3A - that kind of high voltage will generate a lot of heat when converted back to the 3.8V that a smartphone battery uses, so that's why it's not the way Samsung chose.

Programmable Power Supply (PPS)

This is where PPS steps in. It is one of the new additions to the PD3.0 standard and it allows for dynamic re-negotiation of non-standard voltages and currents between the charger and the client. It is a bit similar in principal to how Qualcomm's Quick Charge works, if you are familiar with that.

What happens is that the Note10+ asks the power supply for 10V, just like before. But instead of turning down the request and cautiously falling back to 9V, a PPS-enabled charger is fine and starts pumping out the 10V Samsung needs.

<https://www.belkin.com/us/support-article?articleNum=318878>



Wireless chargers

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, and 3300 Wireless Charger Battery each meet this part of the claim, as they each include a communication and control circuit that is structured and operates as specified by this part of the claim. They each include a wireless charger ASIC such as the 9236 ASIC that includes a microcontroller as relevant to this part of the claim. The microcontroller is programmed to operate as specified by this part of the claim. The microcontroller in the ASIC coordinates and controls the communications and the operation of the charger as specified by this part of the claim.

The 5200 Duo Pad, 5400 Duo Pad, 6300 Trio Pad, and 3300 Wireless Charger Battery, 5300 Car Mount Charger, and the 825 Watch Dock each receive power from a wired USB power adaptor. During receiving power from this source, the Samsung wireless charger is in communication with the USB power supply to establish the appropriate charge rate depending on the capability of the USB power supply.

The 5200 Duo Pad is designed to operate at up to 15 W with the Samsung USB travel adapter (e.g., EP-TA300 shown above) with the Samsung Fast Wireless Charging 2.0 protocol. Operation of the

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wireless charger with Fast Wireless Charging 2.0 uses communication between the charger and
the EP-TA300.

https://www.samsung.com/hk_en/mobile-accessories/wireless-charger-duo-pad-p5200-ep-p5200twegww/

Gives new meaning to fast

Power up your Galaxy S10e, S10, or S10+ with serious speed. The Wireless Charger Duo Pad has the improved Fast Wireless Charging 2.0 capabilities. It charges your phone faster than previous Samsung wireless chargers so you can get back to 100%, faster.



*Fast Wireless Charging 2.0 feature only available for Galaxy S10e, S10, and S10+. Based on results from Samsung lab tests, Galaxy S10 series may be charged up to 27-36% faster wirelessly than Galaxy S9. Charging time varies depending on the specific model, battery level, and ambient temperature. **Fast Wireless Charging 2.0 is only available with the Wireless Charger Duo Pad. Actual charging speed may also vary depending on the usage, charging conditions, and other factors.

*Fast Wireless Charging 2.0 only available with Samsung devices that support 10W+ wireless charging, such as the left pad on the Wireless Charger Duo Pad. Wireless charger requires power connection; please use the included original Samsung brand power cord and Travel Adapter. Use of third party items may cause damage to the Wireless Charger Duo Pad or a decrease in charging speed.



The 6300 Trio Pad is designed to operate at up to 9 W with USB travel adapter (e.g., PD 25W travel adaptor). On information and belief, the 6300 Trio communicates with the USB power supply in a substantially similar manner to the 5400 discussed above.

Get a fast battery boost with the Fast Charging capability. You and your friends with compatible devices can get back to 100% even faster by harnessing extra watts of power.



*Charging speeds may vary by device. Actual charging speed also may depend on usage, charging conditions and other factors.
 *Compatible Apple devices with wireless charging feature support up to 12W fast charging.
 *PD 25W Travel Adapter included in box.

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung

The 3300 Wireless Charger is designed to operate at up to 7.5 W with a USB power supply. On information and belief, the 3300 Wireless Charger communicates with the USB power supply in a substantially similar manner to the 5400 discussed above.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/25w-wireless-portable-battery--silver-eb-u3300xjegus/>



The 5300 Car Mount is designed to operate at up to 9 W with USB power supply (e.g., PD 25W travel adaptor). On information and belief, the 5300 Car Mount communicates with the USB power supply in a substantially similar manner to the 5400 discussed above.

<https://www.samsung.com/us/mobile/mobile-accessories/phones/wireless-car-charger-black-ep-h5300cbegus/>

Power up with a quickness

Charge your mobile device wirelessly in your car with ease. The 9W Wireless Car Charger supports Samsung Galaxy Devices, and up to 7.5W for iPhones. It even powers Qi-enabled devices up to 5W.

*Adapter not included.
**USB-C to USB-A cable included.
***Charge time may vary depending on charging conditions, case material, device type and other factors.
****Requires adapter with output of 12W or higher for up to 9W fast wireless charging (fast charging not available when using the vehicle's USB ports).
*****Compatible with Apple iPhone 8 and later models that are Qi-enabled (supports up to 7.5W charging).



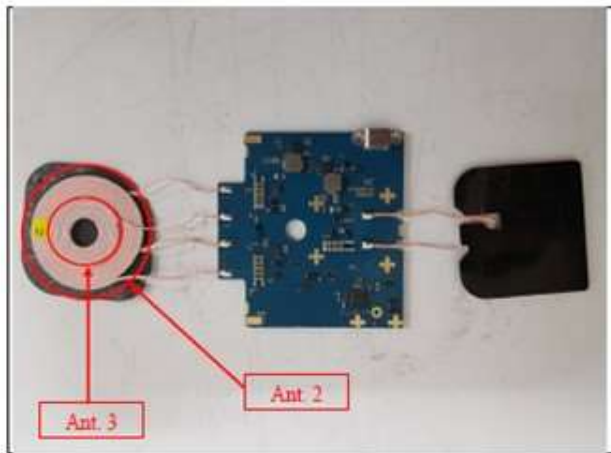
The 825 Watch Dock, an example of the infringing Watch Docks, operates with the EP-TA300 USB power supply / adapter to negotiate an appropriate power level and speed of charging as described above.

8. The system 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 a selection of the multiple primary coils most magnetically aligned with the receiver coil to charge the portable device.

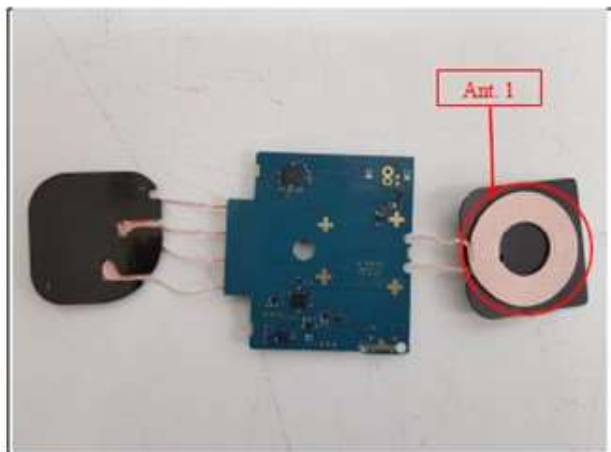
The 942 Claim 1 Accused Products with multiple wireless charging coils and drive circuits additionally infringe this dependent claim. This includes the 5200 Duo, 5400 Duo, 6300 Trio, 5300 Car Mount, and 3300 Wireless Charger Battery as representative products, as detailed below.

For example, the 5400 Duo Pad contains three planar coils and multiple drive circuits for selecting which of the primary coils is most aligned with the receiver coil in the portable device to charge the portable device. The FCC pictures below show the three charging coils in the 5200 Duo Pad (Ant. 1-3) (with the product right and left sides reversed). <https://fcc.report/FCC-ID/A3LEPP5200/4144771>

SGS
Top view of PCB

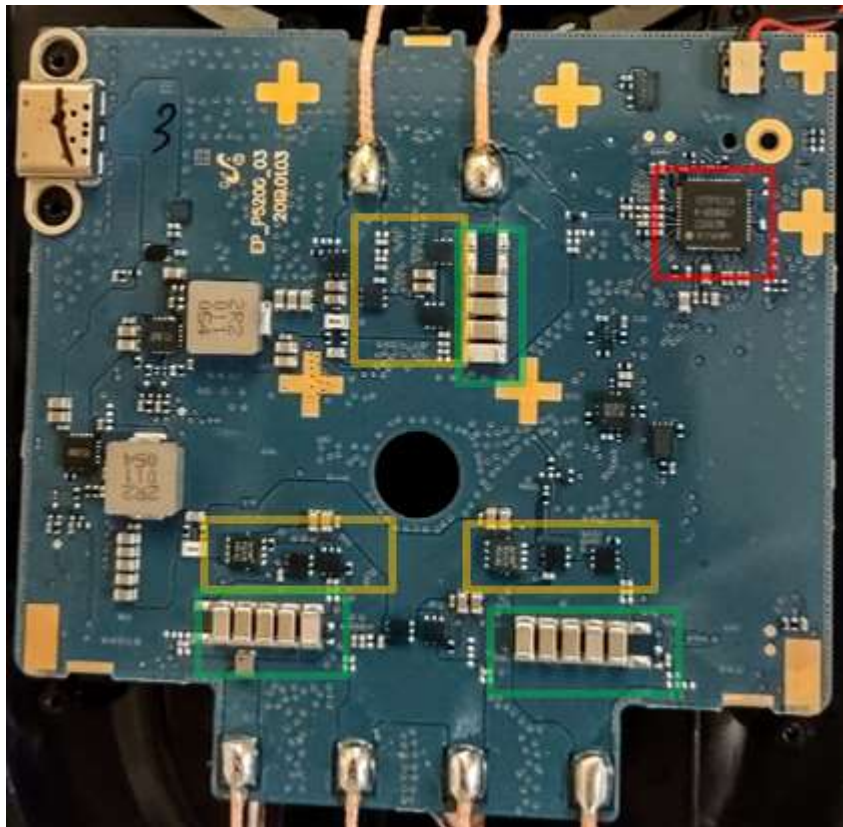


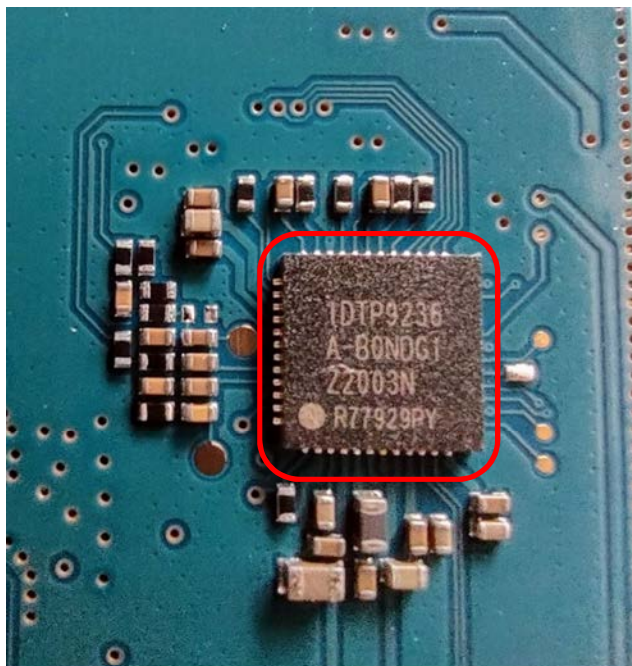
Bottom view of PCB



Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung

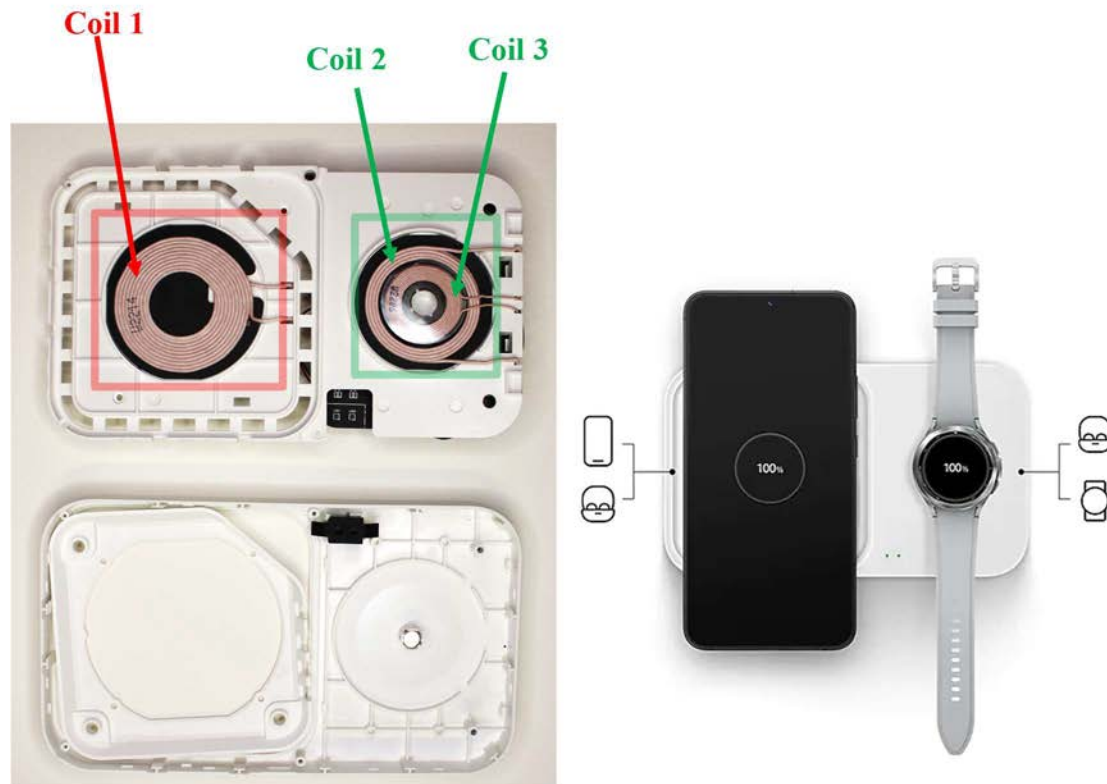
The 5200 Duo Pad includes wireless charging transmitter ASICs (e.g., the 9236) (red rectangles), FETs and FET drivers (yellow rectangles), as illustrated below.

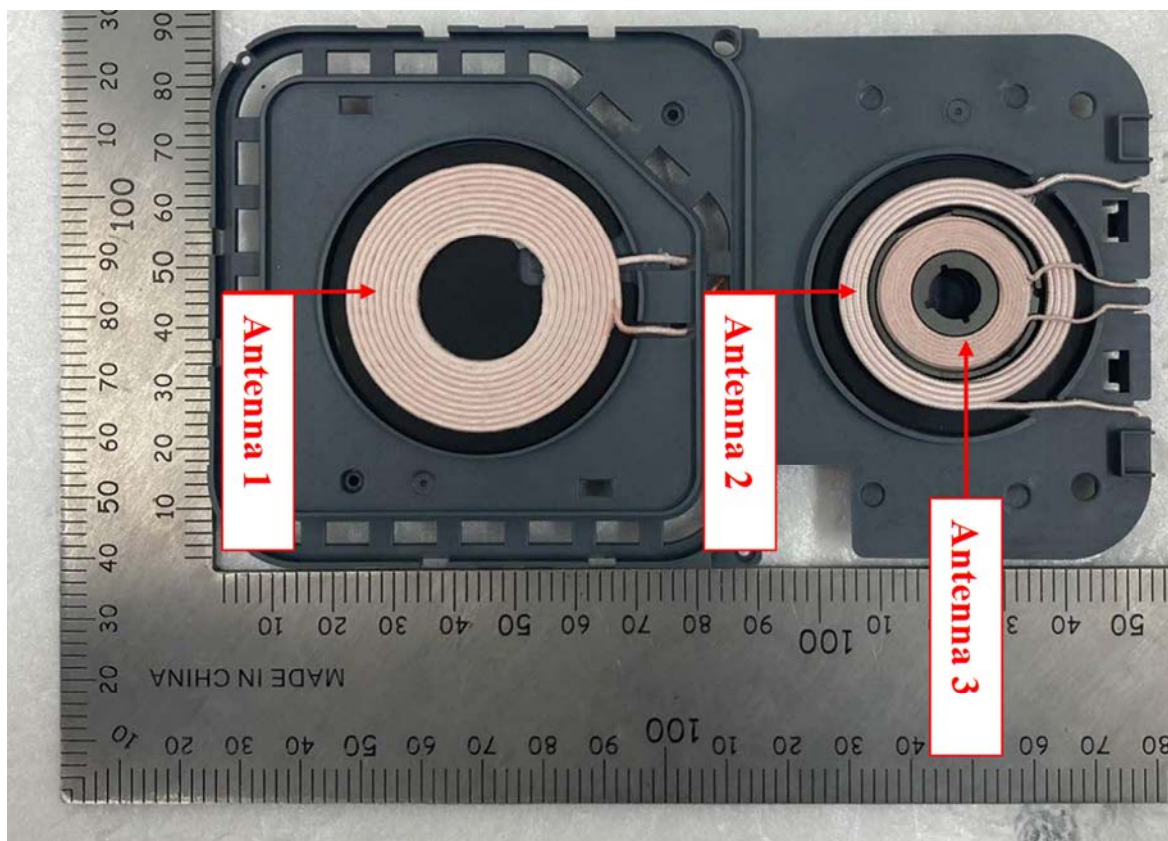




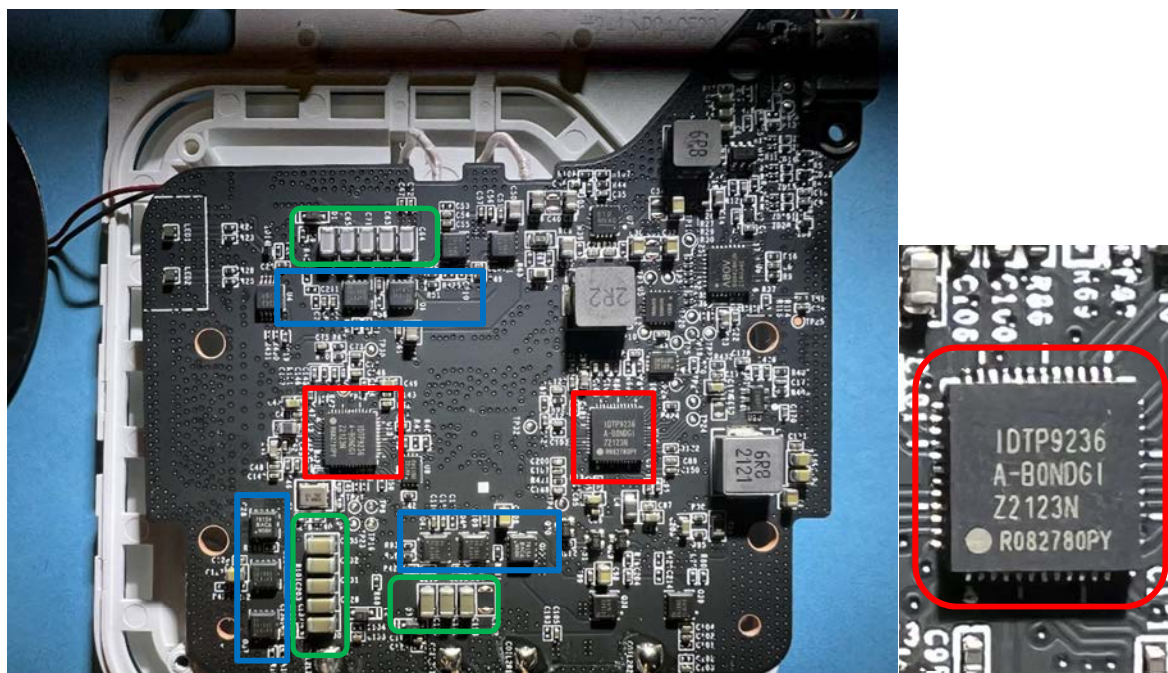
The 5400 Duo Pad contains three planar coils (Coils 1-3 in picture below) for transferring inductive power to a receiver magnetically aligned to them as recited by this part of the claim. The two coils on the product right side (Coils 2 and 3) are concentric for charging a watch (Coil 3) or another smartphone or earbud case (Coil 2). Coil 1, on the product left side, is for the charging of a smartphone.

The picture below shows the 5400 Duo Pad with the top cover removed (left) and the device in use (right).





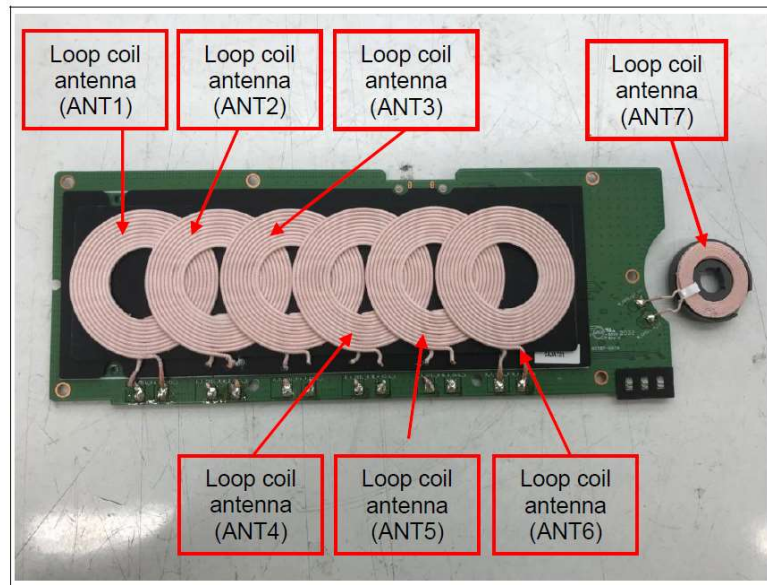
The 5400 Duo Pad includes wireless charging transmitter ASICs (e.g., 9236) (red rectangles), FETs and FET drivers (blue rectangles), as illustrated below.



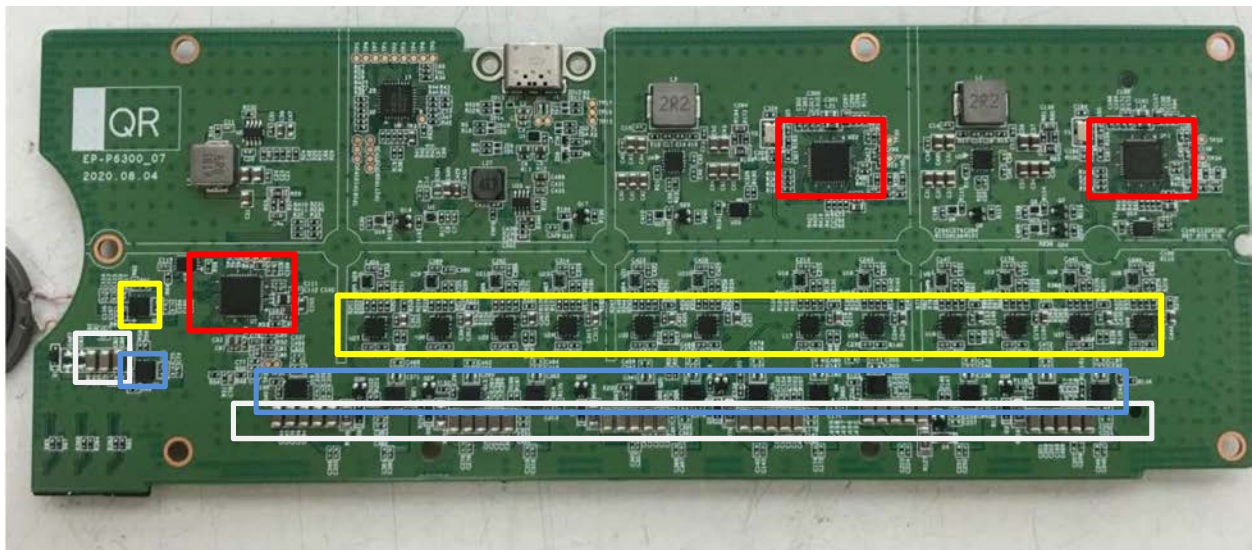
The 6300 Trio Pad includes seven charging coils (Ant. 1-7), of which the six on the left side of the pad are overlapping, as shown below. The coils on the left are for charging multiple smartphones and earbud cases, and the right-side smaller single coil is for charging a Samsung watch.

<https://fcc.report/FCC-ID/A3LEPP6300/4940796.pdf>

View of Antenna



The 6300 Trio Pad includes switching circuits associated with its coils which include capacitors (white rectangles), wireless charging ASICs (e.g., 9236 ASICs) (red rectangles), separate FET drivers (yellow rectangles), and separate FETs (blue rectangles), as seen below.



The 3300 Wireless Charger Battery includes a charging coil as specified by this part of the claim, as shown below. The 3300 Wireless Charger Battery includes two substantially planar charging coils [ANT 1-2] that are substantially parallel to the top surface of the system for providing power inductively to various portable devices. The larger outer coil is for charging smartphones and earbud cases and the inner smaller coil is for charging a Samsung watch. The FCC pictures below show the two charging coils [ANT 1-2] inside the 3300 Wireless Charger Battery.

<https://fcc.report/FCC-ID/A3LEBU3300/4624577>



The 5300 Car Mount Charger includes a charging coil as specified by this part of the claim, as shown below. The 5300 Car Mount Charger includes two substantially planar charging coils [ANT 1-2] for providing power inductively to various portable devices. The FCC pictures below show the two charging coils [ANT 1-2] inside the EP-H5300.

<https://fcc.report/FCC-ID/ZCAEPH5300/5517329>

EUT Constructional Details (EUT Photos)



The 5300 Car Mount Charger includes a drive circuit that is structured and operates as specified by this part of the claim. The 5300 Car Mount Charger includes a wireless charging transmitter

The system determines the degree of magnetic alignment (coupling) between the primary and secondary coils when it receives the first communication (signal strength packet) from a receiver. The process for selecting the most aligned primary coils with the receiver coil is described below. E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 93, 152 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 91, 150).



5.2.3 Logical layer (PRx to PTx)

This section defines the format of the messages used by the Power Receiver to Power Transmitter communications interface.

5.2.3.1 Signal Strength Packet (0x01)

Table 27 defines the format of the message contained in a Signal Strength Packet.

Table 27. Signal strength

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Signal Strength Value							

Signal Strength Value. The unsigned integer value in this field indicates the degree of coupling between the Primary Cell and Secondary Coil, with the purpose to enable Power Transmitters that use Free Positioning to determine the Primary Cell that provides optimum power transfer (*see also* Annex B, *Power Receiver Localization (Informative)*). To determine the degree of coupling, the Power Receiver shall monitor the value of a suitable variable during a Digital Ping. Examples of such variables are:

B.2 Primary Coil array based Free Positioning

In the case of Free Positioning, discovery and localization of a Power Receiver is less straightforward. This Annex B.2 discusses one sample approach, which is particularly suited to a Primary Coil array-based Power Transmitter. In this approach, the Power Transmitter first discovers and locates the objects that are present on its Interface Surface (e.g. using any of the methods discussed in Section 10, *Object Detection (Informative)*). This results in a set of Primary Cells, which represents the locations of potential Power Receivers. For each of the Primary Cells in this set, the Power Transmitter executes a Digital Ping (*see* Section 5.1.2.2), removing the Power Signal after receipt of a Signal Strength Packet (or an End Power Transfer Packet, or after a time out).¹⁴ This yields a new set of Primary Cells, namely those that report a Signal Strength Value above a certain threshold—which the Power Transmitter chooses. Finally, the Power Transmitter executes an extended Digital Ping (*see* Sections 5.1.2.2 and 5.1.2.3) for each of the Primary Cells in this new set in order to identify the discovered Power Receivers. The Power Transmitter should take the situations discussed in Annex B.2.1, B.2.2, and B.2.3 into account in order to select the most appropriate Primary Cells from the set for power transfer.

9. The system of claim 1, wherein the communication and control circuit is further configured to detect presence of the portable device by periodically operating the first drive circuit for a period of time, wherein the period of time is sufficient to activate and power the receiver unit in the portable device and to receive at least part of the received communication of information.

The 942 Claim 1 Accused Products additionally infringe this dependent claim, as the communication and control circuit is further configured to detect presence of the portable device by periodically operating the first drive circuit for a period of time, wherein the period of time is sufficient to activate and power the receiver unit in the portable device and to receive at least part of the received communication of information.

WPC Standard

Following the WPC Standard, the 942 Claim 1 Accused Products inductively power the wireless charging receiver in the mobile device to be charged. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 25).

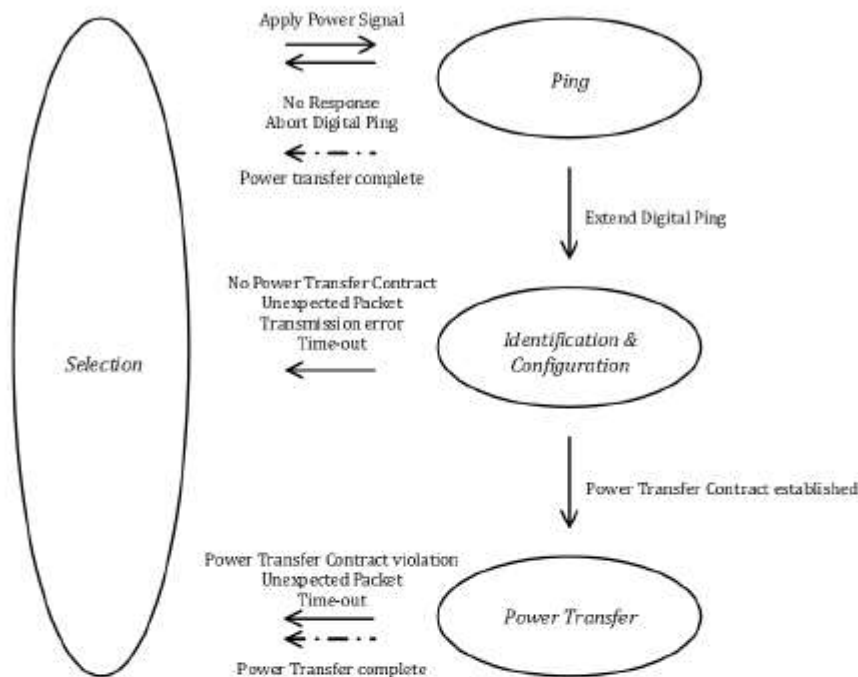


- A rectification circuit that provides full-wave rectification of the AC waveform using, for example, four diodes in a full-bridge configuration or a suitable configuration of active components (see Section 3.1.2, *Rectification circuit*). The rectification circuit may perform output smoothing as well. In this example, the rectification circuit provides power to both the Communications and Control Unit of the Power Receiver and the output of the Power Receiver

Once a wireless power receiver is activated, the charger receives communication from the receiver through load modulation.

From the Power Transmitter/Charger perspective, the WPC phases are as shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 45, 46, and 50 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 45, 46, 49, and 50).

Figure 16. Power transfer phases—Baseline Power Profile



The main activity in each of these phases is the following:

- **selection** In this phase, the Power Transmitter typically monitors the Interface Surface for the placement and removal of objects. The Power Transmitter may use a variety of methods for this purpose. See Section 10, *Object Detection (Informative)* for some examples. If the Power Transmitter discovers one or more objects, it should attempt to locate those objects—in particular if it supports Free Positioning. In addition, the Power Transmitter may attempt to differentiate between Power Receivers and Foreign Objects, such as keys, coins, etc. Moreover, the Power Transmitter should attempt to select a Power Receiver for power transfer. If the Power Transmitter does not initially have sufficient information for these purposes, the Power Transmitter may repeatedly proceed to the *ping* and subsequently to the *identification & configuration* phases—each time selecting a different Primary Cell—and revert to the *selection* phase after collecting relevant information. See Annex B, *Power Receiver Localization (Informative)* for examples. Finally, if the Power Transmitter selects a Primary Cell, which it intends to use for power transfer to a Power Receiver, the Power Transmitter proceeds to the *ping* phase and eventually to the *power transfer* phase. On the other hand, if the Power Transmitter does not select a Power Receiver for power transfer and is not actively providing power to a Power Receiver for an extended amount of time, the Power Transmitter should enter a stand-by mode of operation.⁴ See Section 9 for performance requirements on such a mode of operation.

⁴ Note that it is up to the Power Transmitter implementation to determine whether this stand-by mode of operation is part of the *selection* phase or is separate from the *selection* phase.



- *ping* In this phase, the Power Transmitter executes a Digital Ping, and listens for a Response. If the Power Transmitter discovers a Power Receiver, the Power Transmitter may extend the Digital Ping, i.e. maintain the Power Signal at the level of the Digital Ping. This causes the system to proceed to the *identification & configuration* phase. If the Power Transmitter does not extend the Digital Ping, the system shall revert to the *selection* phase.
- *identification & configuration* In this phase, the Power Transmitter identifies the selected Power Receiver, and obtains configuration information such as the maximum amount of power that the Power Receiver intends to provide at its output. [The Power Transmitter uses this information to create a Power Transfer Contract. This Power Transfer Contract contains limits for several parameters that characterize the power transfer in the *power transfer* phase. At any time before proceeding to the *power transfer* phase, the Power Transmitter may decide to terminate the extended Digital Ping (for example, to discover additional Power Receivers). This reverts the system to the *selection* phase.

Initially, the transmitter applies power periodically for a period of time (ping) sufficiently long to wake up the receiver and receive some communication from it, including information corresponding to a voltage at the output of the receiver circuit (i.e., the Signal Strength Packet). E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 52 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 51). As shown below, the power transmitter operates the first drive circuit for a sufficient amount of time to detect the start of a communication from the receiver. If no such response is received the transmitter stops applying power and returns to pinging periodically until a receiver is found.



5.1.2.2 Ping phase (PTx perspective)

In the *ping* phase, the Power Transmitter shall execute a Digital Ping. This Digital Ping shall proceed as follows, with conditions appearing earlier in this list taking precedence over conditions appearing later.

- The Power Transmitter shall apply a Power Signal at the Operating Point defined for the particular Power Transmitter design (*see Part 4: Reference Designs*).
- If the Power Transmitter does not detect the start of a Packet in the time window t_{ping} after the Primary Cell current amplitude reaches 50% of the stable level, the Power Transmitter shall remove the Power Signal (i.e. reduce the Primary Cell current to zero) within $t_{\text{terminate}}$. See Figure 19(a).
- If the Power Transmitter correctly receives a Signal Strength Packet, the Power Transmitter may proceed to the *identification & configuration* phase of the power transfer, maintaining the Power Signal at the Operating Point as defined for the particular Power Transmitter design. See Figure 19(b). If the Power Transmitter does not proceed to the *identification & configuration* phase, the Power Transmitter shall remove the Power Signal within t_{expire} after the start of the Signal Strength Packet. See Figure 19(c).

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The Identification communication received by the transmitter is described. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 98-101 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 96-99).



5.2.3.8 Identification Packet (0x71)

Table 35 defines the format of the message contained in an Identification Packet.

Table 35. Identification

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Major Version				Minor Version			
B ₁	(MSB) Manufacturer Code (LSB)							
B ₂								
B ₃	Ext	(MSB) Basic Device Identifier (LSB)						
⋮								
B ₆								

The configuration packet received by the transmitter also includes additional receiver information.



5.2.3.7 Configuration Packet (0x51)

Table 34 defines the format of the message contained in a Configuration Packet.

Table 34. Message in a Configuration Packet

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Power Class		Maximum Power Value					
B ₁	Reserved							
B ₂	Prop	Reserved			ZERO		Count	
B ₃	Window Size					Window Offset		
B ₄	Neg	Polarity*	Depth*		Reserved			

* In the Baseline Power Profile, these bits are Reserved.

Power Class This field shall be set to '00'.

Maximum Power Value

(Baseline Power Profile) Apart from a scaling factor, the unsigned integer value contained in this field indicates the maximum amount of power that the Power Receiver expects to provide at the output of the rectifier. This maximum amount of power is calculated as follows:

$$P_{\max} = \left(\frac{\text{Maximum Power Value}}{2} \right) \times 10^{\text{Power Class } W}.$$

10. The system of claim 1, further comprising a near field communication (NFC) antenna for communication of data, and further wherein: the first primary coil is formed in a flexible Printed Circuit Board (PCB) and has an inductance in a range of 1 microhenry to 100 microhenries; the PCB coil comprises multiple metallic layers of substantially spiral-shaped patterns comprising copper 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.

The 942 Accused Smartphones additionally infringe this dependent claim as they include an NFC antenna and PCB coil as specified by this claim.

Smartphones

For the S22 Ultra the first primary coil (Wireless Charging Coil) and the NFC Antenna are shown below in the FCC filing by Samsung.

<https://fcc.report/FCC-ID/A3LSMS908U/5963293>

Note: Exact antenna dimensions and separation distances are shown in the Technical Descriptions in the FCC Filing.

Figure F-1
DUT Antenna Locations

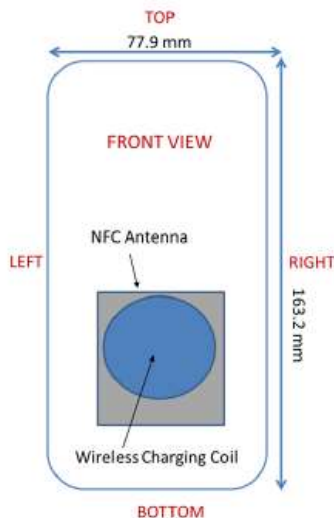
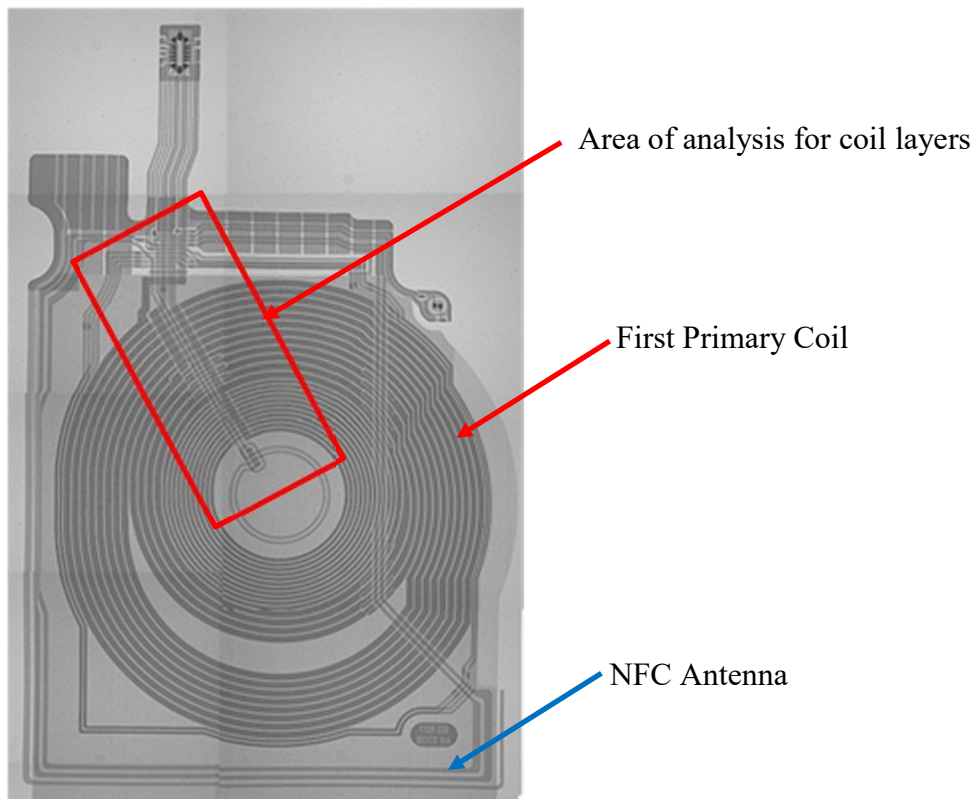


Figure F-2
NFC Antenna Locations

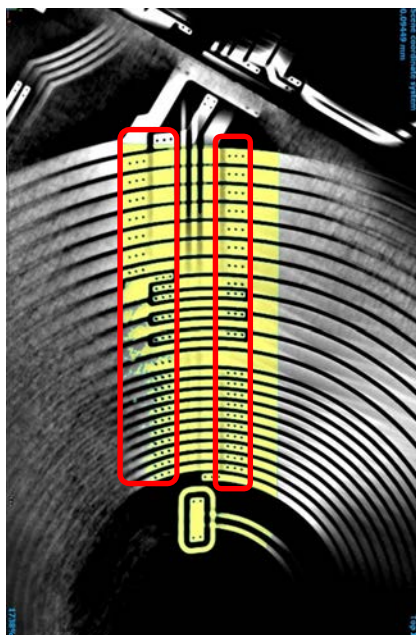
FCC ID: A3LSMS908U	PCTEST Measuring the past, defining the future	SAR EVALUATION REPORT	SAMSUNG	Approved by: Quality Manager
Test Dates: 10/31/21 – 11/15/21	DUT Type: Portable Handset			APPENDIX F: Page 2 of 8

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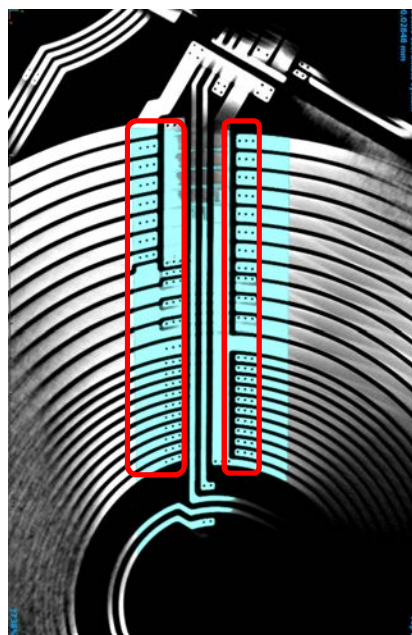
The representative S22 Ultra comprises an NFC Antenna as shown below in the top-view x-ray. Moreover, the first primary coil comprises a PCB coil. The area shown in Red Rectangle is further analyzed with 3D x-ray imagery.



The two images below with 3D x-ray imagery distinguish between the two coil layers present. The images show the substantially similar spiral-shaped coil patterns in each layer. The vias connecting the two layers (black dots) are shown in the 2 below images in the red rectangles.

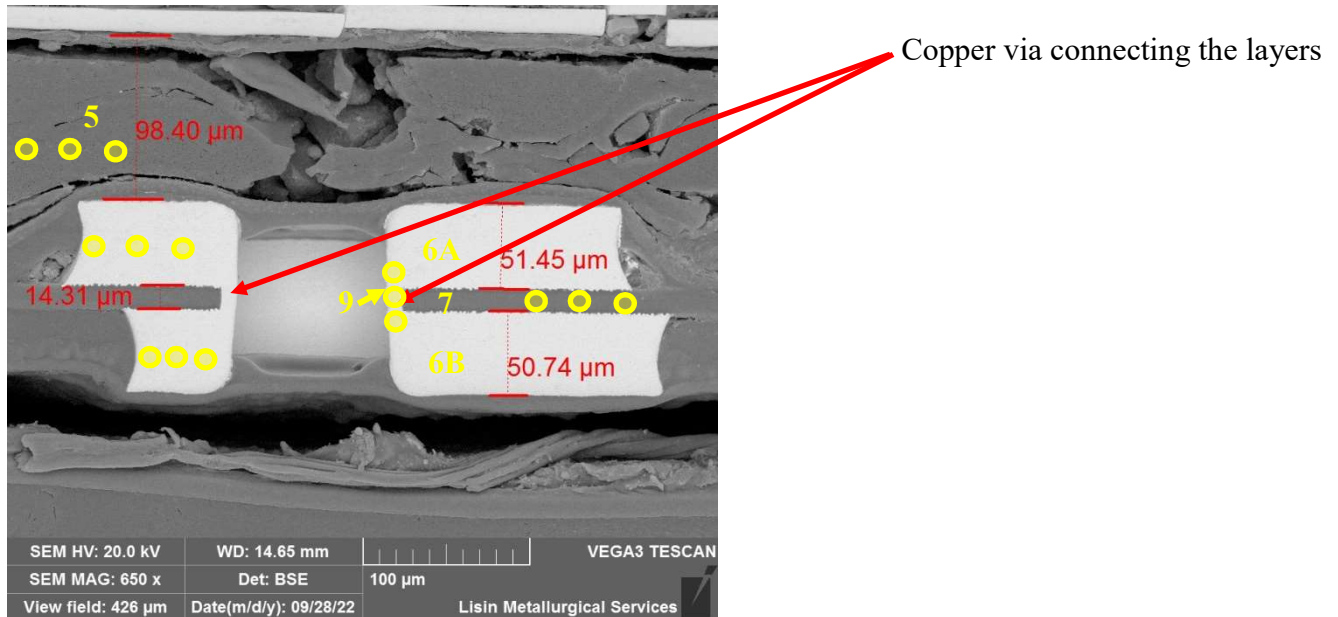


Coil Layer 1



Coil Layer 2

The primary coil comprises two layers (6A and 6B) of >99% copper with each layer being about 51 micrometer thick (~1.46 ounce copper) as shown below separated by a thin (~14.3 micrometer thick) dielectric flexible PCB (layer 7). A typical copper via connecting the two layers is shown below as section 9. Analysis of this via shows it is composed of copper as shown below.



Normalized mass concentration [%]

Spectrum	Carbon	Oxygen	Aluminium	Silicon	Iron	Copper
5A	85.7	13.6	0.1	0.0	0.2	0.4
5B	81.4	17.7	0.1	0.1	0.3	0.5
5C	80.6	18.5	0.3	0.0	0.2	0.4

Normalized mass concentration [%]

Spectrum	Aluminium	Iron	Copper
6A1	0.4	0.4	99.3
6A2	0.3	0.2	99.4
6A3	0.3	0.2	99.5

Normalized mass concentration [%]

Spectrum	Aluminium	Iron	Copper
6B1	0.2	0.1	99.7
6B2	0.3	0.1	99.7
6B3	0.4	0.1	99.6

Normalized mass concentration [%]

Spectrum	Carbon	Nitrogen	Oxygen	Copper
7A	71.8	8.0	17.9	2.3
7B	72.3	8.1	17.3	2.2
7C	72.9	7.8	16.7	2.6

Normalized mass concentration [%]

Spectrum	Aluminium	Iron	Copper
9a	0.0	0.2	99.7
9b	0.2	0.3	99.5
9c	0.4	0.2	99.4

On information and belief, the inductance of the wireless charging coil of the representative S22 Ultra is ~ 8 to 10 microhenries, which is within the range specified in the claim.

The operating frequency reported to FCC for the system for providing power inductively is shown below in a red rectangle to be within the range specified in dependent claim 10.

<https://fcc.report/FCC-ID/A3LSMS908U/5574740>



PCTEST
 7185 Oakland Mills Road, Columbia, MD 21046 USA
 Tel. 410.290.6652 / Fax 410.290.6654
<http://www.pctest.com>



MEASUREMENT REPORT
FCC Part 15C Wireless Power Transfer

Applicant Name:
 Samsung Electronics Co., Ltd.
 129, Samsung-ro,
 Yeongtong-gu, Suwon-si
 Gyeonggi-do, 16677, Korea

Date of Testing:
 9/22/2021 – 12/7/2021
Test Report Issue Date:
 12/7/2021
Test Site/Location:
 PCTEST Lab. Columbia, MD, USA
Test Report Serial No.:
 1M2109090102-20-R2.A3L

FCC ID:	A3LSMS908U
APPLICANT:	Samsung Electronics Co., Ltd.

Application Type: Certification
Model: SM-S908U
Additional Model(s): SM-S908U1
EUT Type: Portable Handset
Frequency Range: 110 – 148kHz 0.53 – 0.60MHz
FCC Classification: Part 15 Low Power Transmitter Below 1705kHz (DCD)
FCC Rule Part(s): Part 15 Subpart C
Test Procedure(s): ANSI C63.10-2013

12. The system of claim 1, wherein the system is incorporated into a second portable device, the second portable device further comprising: an internal, rechargeable battery; a DC-to-DC voltage regulator coupled to the DC voltage input to provide

power to operate the system; and a second receiver circuit coupled to the primary coil; wherein the second portable device is configured to operate in a first mode in which the second portable device is powering the system at the DC voltage input by the DC-to-DC voltage regulator to provide power inductively through the first primary coil and in a second mode in which the second portable device is receiving power inductively through the first primary coil to power the second receiver circuit and charge the internal, rechargeable battery; and wherein in the first mode, 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.

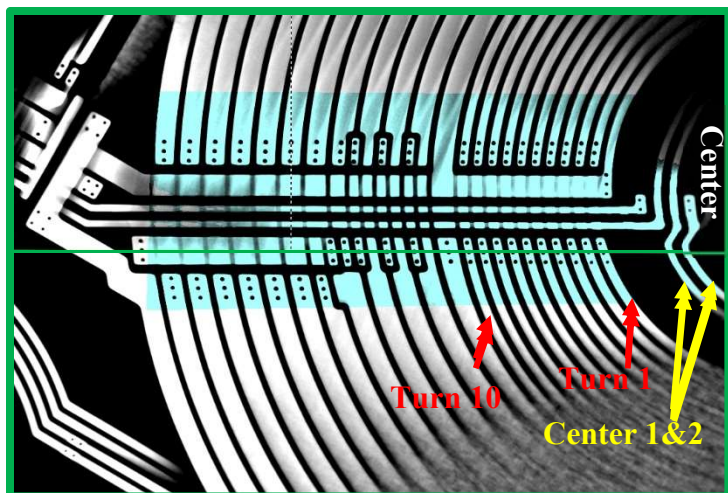
The 942 Accused Smartphones additionally infringe this dependent claim as, for example, the S22 Ultra can both provide wireless power as set forth above with respect to claim 1 and receive wireless power as set forth below with respect to claim 21. The representative S22 Ultra has an internal rechargeable battery and a DC-to-DC regulator to operate as an inductive charger as set forth with respect to claim 1. The S22 Ultra also includes a receiver circuit coupled to the primary coil to receive power according to the WPC Standard as set forth below with respect to claim 21. As discussed above with respect to claims 1 and 2, the S22 Ultra operates in a closed loop feedback manner comprising a PID control technique for providing inductive power. Moreover, as shown for claim 5 above, the S22 Ultra includes a DC-to-DC regulator as specified by this claim. As discussed below with respect to claim 21, S22 Ultra is a portable device with an internal rechargeable battery.

13. The system 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 system further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

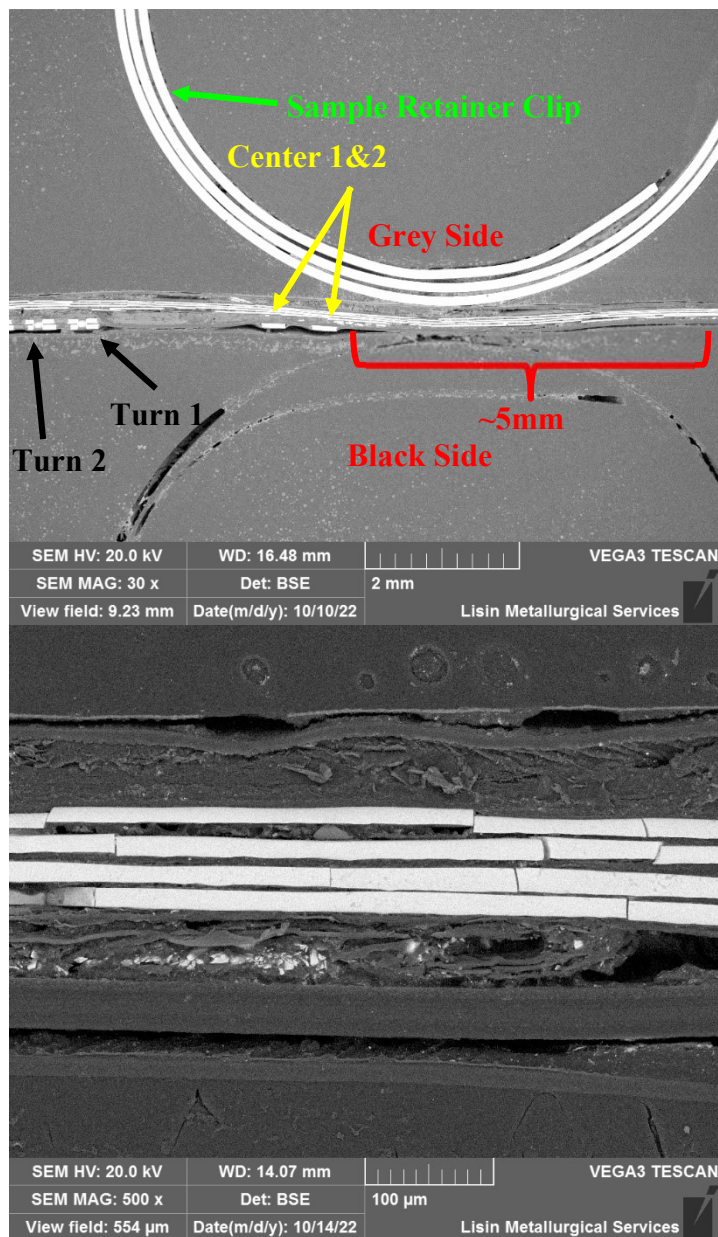
The 942 Accused Smartphones additionally infringe this dependent claim as shown below for the representative S22 Ultra.

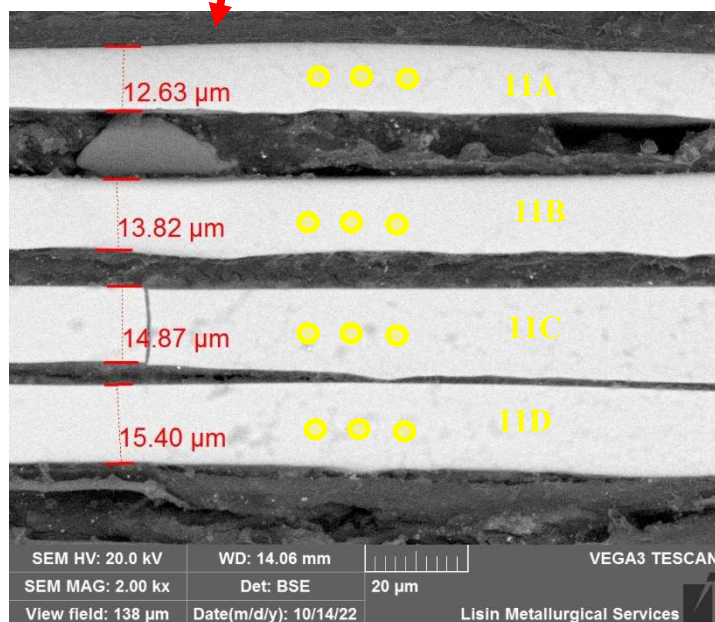
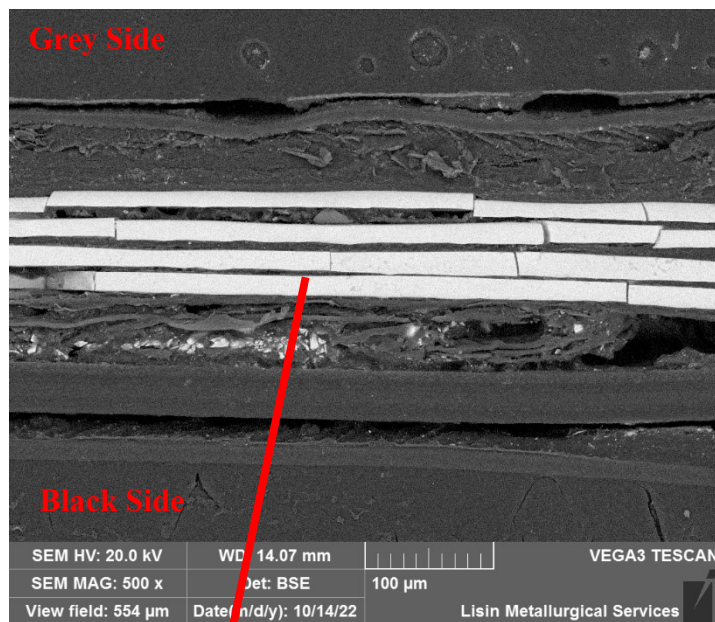
Smartphones

In the representative S22 Ultra, as an example, the images below show a magnetic core of ferromagnetic material within the primary coil as claimed. The top and lower left image show the top and side view of the location of analysis. In lower right image, a section within the 5 mm part shown in the central area of the first primary coil was analyzed. Layer 11 comprises ferromagnetic material as reflected by the spectral analysis as shown by the concentration of iron and other metals.



Scanned image (left) and backscattered electron images (lower right and left) acquired from a metallographic section through the center of the coil.





Normalized mass concentration [%]

Spectrum	Aluminium	Silicon	Iron	Copper
11A1	0.1	7.7	90.1	2.1
11A2	0.0	7.6	90.6	1.8
11A3	0.0	7.1	91.3	1.7
11B1	0.3	7.4	90.7	1.5
11B2	0.1	7.9	90.0	2.0
11B3	0.1	7.1	91.9	0.9
11C1	0.1	7.7	90.9	1.4
11C2	0.1	7.9	90.9	1.2
11C3	0.1	7.1	91.7	1.1
11D1	0.0	8.8	89.1	2.1
11D2	0.2	7.2	91.7	0.9
11D3	0.0	8.0	90.5	1.5

The NFC Antenna is shown in claim 10 above. Furthermore, the S22 Ultra comprises electronics for NFC communication of data.

<https://www.techinsights.com/blog/samsung-galaxy-s22-ultra-teardown>



Figure 1. Samsung Galaxy S22 board shot

21. A portable device configured to receive inductive power from an inductive charging system comprising a primary coil and associated circuit, the portable device comprising:

a battery;

The 942 Accused Products capable of receiving power inductively as specified by this claim are accused under this claim; this includes the 942 Accused Smartphones, the 942 Accused Wearables, and the 942 Accused Earbud Products (collectively the “942 Claim 21 Accused Products”). The 942 Claim 21 Accused Products fit the description in this introductory part of the claim, as each is a portable device as specified by this introductory part of the claim. The S22 Ultra, Watch4, and Buds2 are representative thereof.

Smartphones

The S22 Ultra is representative of how the 942 Accused Smartphones meet this introductory part of claim 21, as the S22 Ultra is a portable device that includes a battery, as specified by this claim.

https://www.samsung.com/us/smartphones/galaxy-s22-ultra/buy/galaxy-s22-ultra-256gb-unlocked-sm-s908uzwexaa/?cid=sem-mktg-pfs-mob-us-bing-na-02232022-141299-&ds_e=MICROSOFT-cr:%25ecid!-pl:%25epid!-&ds_c=FF~Device+Ultra+-+Core CN~s22_PH~laun_MK~usnat_BS~im_PR~smart_SB~sse_PK~ROAS_FS~lo_CA~kew_KS~ba_MT~phrase-&ds_ag=AG~S22_MK~usnat_AT~ta_MD~h_PK~roah_PB~bing_AI~no_TG~mas_SA~mass-&ds_k=s22+ultra&gclid=ff35fb3f57bd152c75499907a5b4d433&gclsrc=3p.ds&mclid=ff35fb3f57bd152c75499907a5b4d433

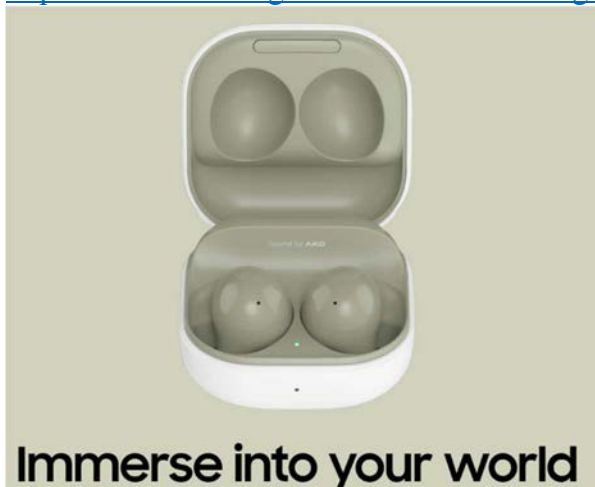




Earbuds

The Buds2 is representative of how the 942 Accused Earbud Products infringe claim 21. The Buds2 product meets this introductory part of claim 21 as the Buds2 case is a portable device that is configured to receive inductive power and includes a battery.

<https://www.samsung.com/us/mobile-audio/galaxy-buds2/>



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<https://www.ifixit.com/News/52635/galaxy-buds2-teardown-great-buds-with-one-big-flaw>
(Galaxy Buds2)



Wearables

The Watch4 is representative of how the 942 Accused Wearables satisfy this introductory part of claim 21. The Watch4 is a portable device that includes a battery, as specified by this introductory part of claim 21.

<https://www.samsung.com/levant/watches/galaxy-watch/>

New



Galaxy Watch4 Classic

Color: Black

★ ★ ★ ★ ☆ 2.9 (32)

- Classic and Premium Design
- Blood pressure and ECG
- Daily Activity & Fitness tracking

Classic and Premium

Learn more

Where to buy Compare

New



Galaxy Watch4 Classic

Color: Black

★ ★ ★ ★ ☆ 2.6 (27)

- Classic and Premium Design
- Blood pressure and ECG
- Daily Activity & Fitness tracking

Classic and Premium

Learn more

Where to buy Compare



Galaxy Watch4 Bluetooth (40mm)

Color: Pink Gold

★ ★ ★ ★ ☆ 2.6 (16)

- Measure body composition with the Powerful Samsung BioActive Sensor
- Track your workouts on your wrist
- Sleek, Seamless and Iconic Design

Body composition

Learn more

Where to buy Compare



Galaxy Watch4 Bluetooth (44mm)

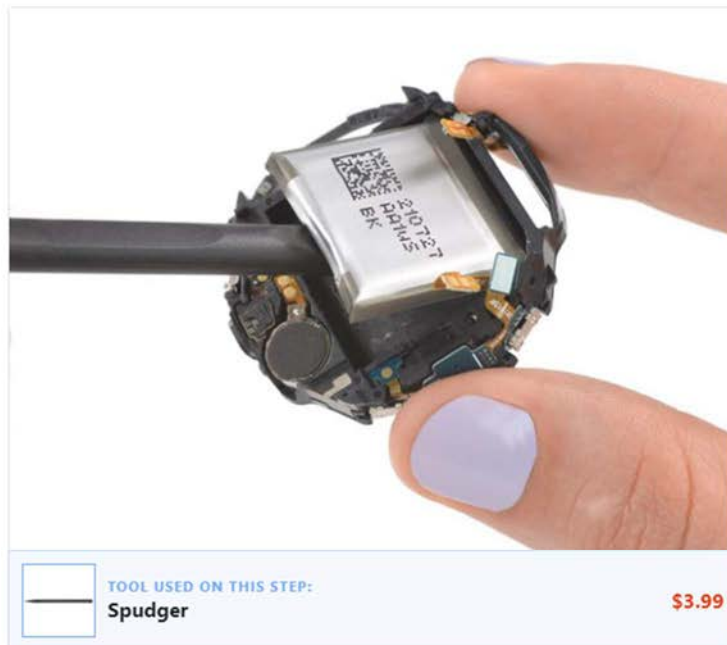
Color: Green

★ ★ ★ ★ ☆ 3.1 (13)

- Measure body composition with the Powerful Samsung BioActive Sensor
- Track your workouts on your wrist
- Sleek, Seamless and Iconic Design

Body composition

Step 7



TOOL USED ON THIS STEP:
Spudger

\$3.99



- The watches' fuel tanks are hidden under the motherboards and nestled within plastic midframes.
- ① Thankfully, both can be removed without any heat—so long as you have a sturdy [spudger](#) on hand. (Just don't poke too hard—the usual li-ion battery cautions apply here.)
- The Watch4 Classic 46 mm accommodates a 1.40 Wh (361 mAh @ 3.88 V) battery—while its 40 mm little sister, the Watch4, houses a 0.95 Wh (247 mAh @ 3.88 V) battery.
- ① Compared to the Watch3 with 1.3 Wh (340 mAh @ 3.85 V), this represents a modest upgrade. With 1.62 Wh, the [2021 Mi Watch](#) still packs a bit more power—and the [Apple Watch Series 6 \(44 mm\)](#) twiddles its thumbs at the bottom of the stack with 1.17 Wh.

Step 7



TOOL USED ON THIS STEP:
Spudger

\$3.99



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a coil substantially planar in shape and located parallel to a charging surface of the portable device so that an alternating magnetic field, when received through the charging surface of the portable device from the primary coil of the inductive charging system in a direction substantially perpendicular to the plane of the coil, inductively generates a current in the coil to provide power inductively to the portable device when the portable device is placed on the inductive charging system for charging the battery of the portable device;

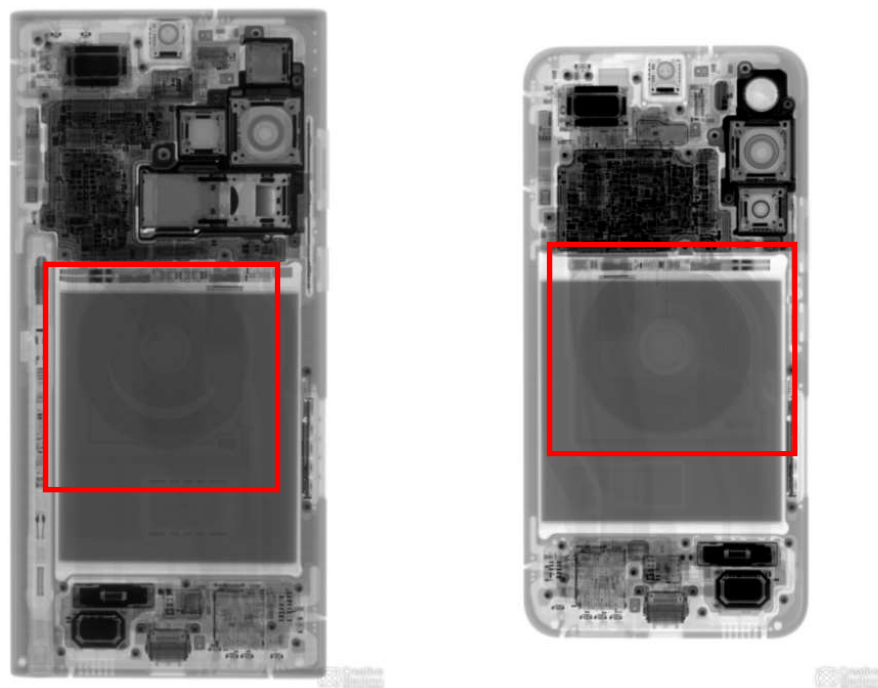
The 942 Claim 21 Accused Products include a receiver coil as specified by this part of the claim.

Smartphones

The S22 Ultra includes a receiver coil, as specified by this part of the claim. In the below X-rays, the S22 Ultra is shown on the left, and the S22, which similarly infringes, is shown on the right.

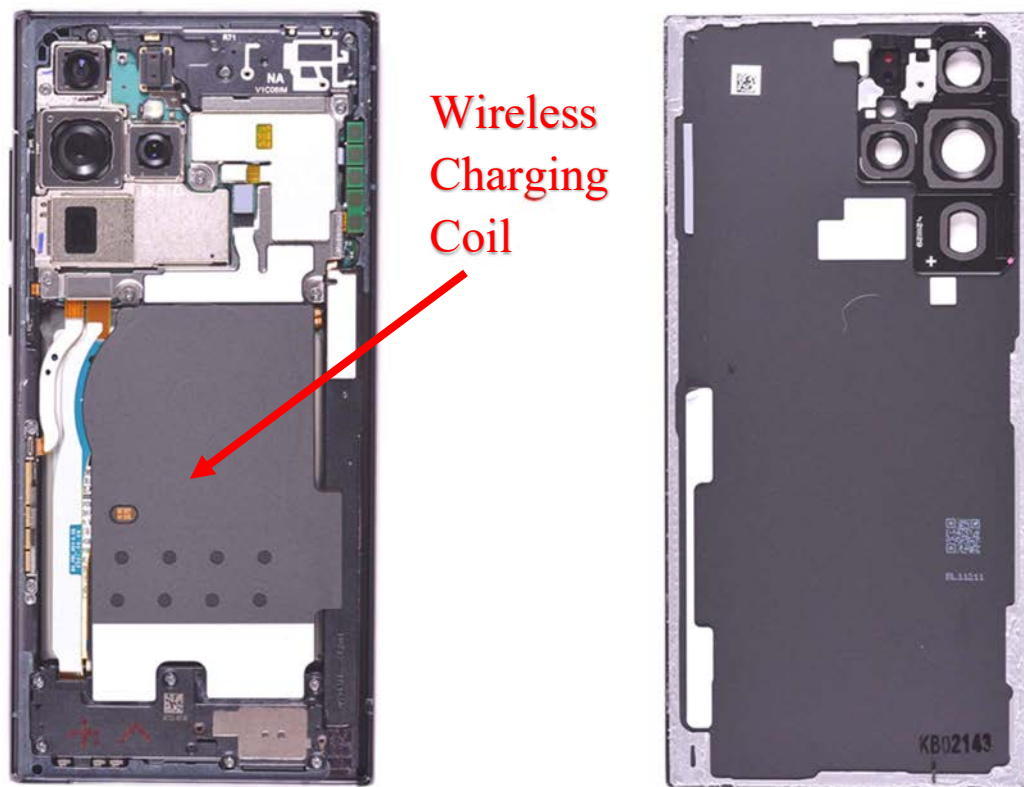
<https://www.ifixit.com/News/57567/galaxy-s22-teardowns-apple-is-making-samsung-sweat>

X-ray examination



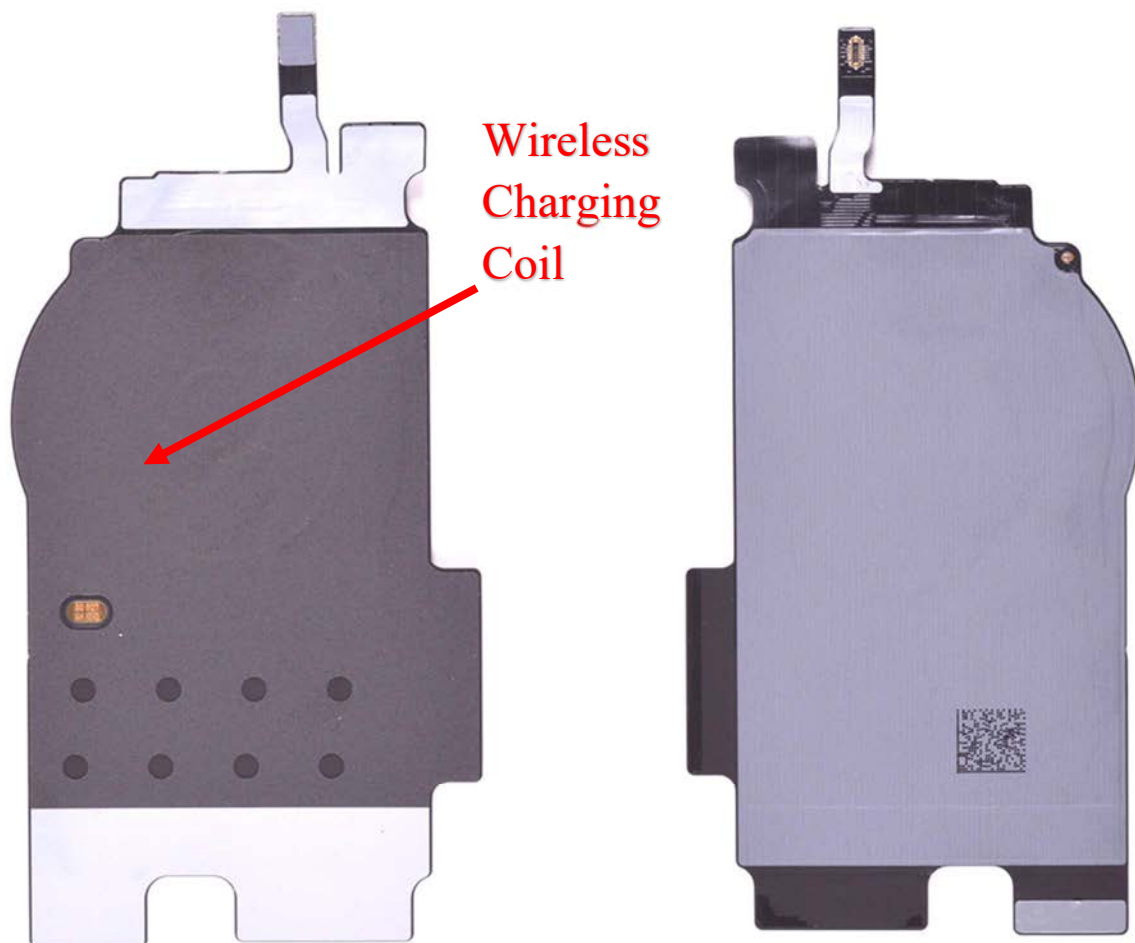
On the left is the Note-succeeding Samsung Galaxy S22 Ultra, with the "vanilla" S22 on the right.

The S22 Ultra interior is shown below (on the left) after removal of the back cover (shown on the right, turned over to reveal the inside of the back cover). The substantially planar wireless charging coil can be seen, used as a receiver coil to receive wireless power when in the receive mode.

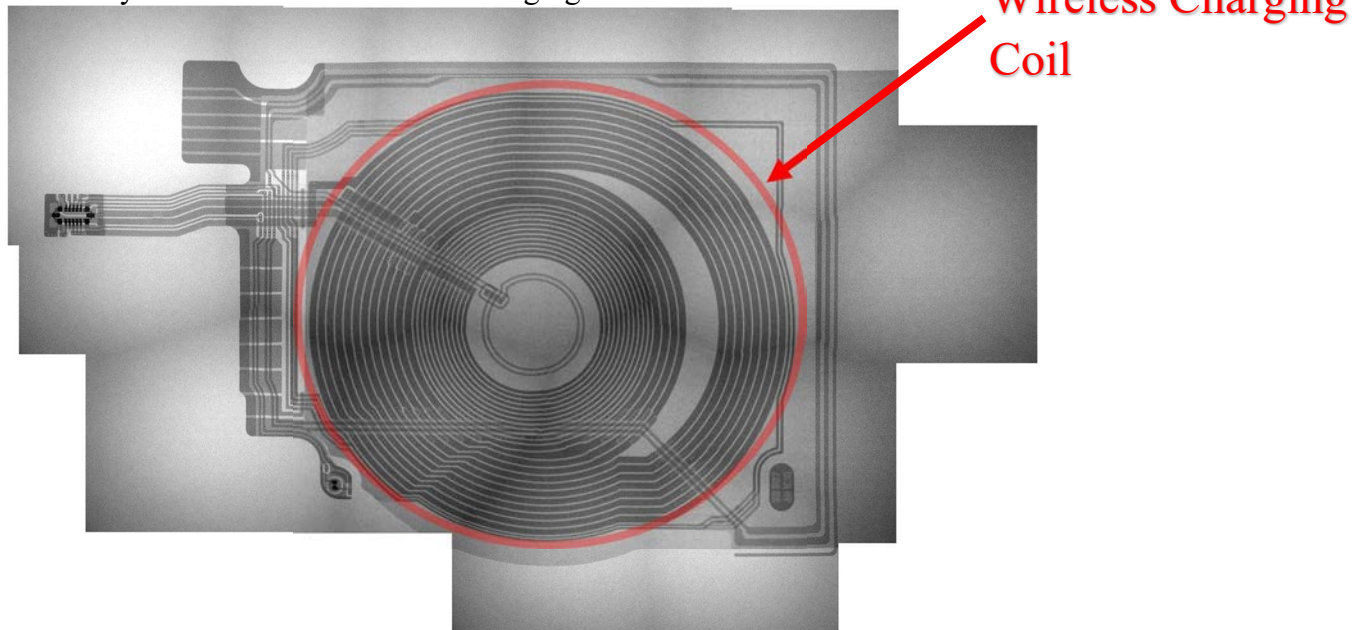


Samsung S22 Ultra – Back cover removed

The wireless charging coil after removal from the phone are shown below, with the outer side shown on the left and the inner side shown on the right.



An X Ray of the S22 Ultra wireless charging coil is shown below:



The receiver coil can be seen in block diagram form in the 9415 ASIC datasheet below, which as note above, is believed to be representative of the wireless power transceiver ASIC in the S22 Ultra.

RENESAS

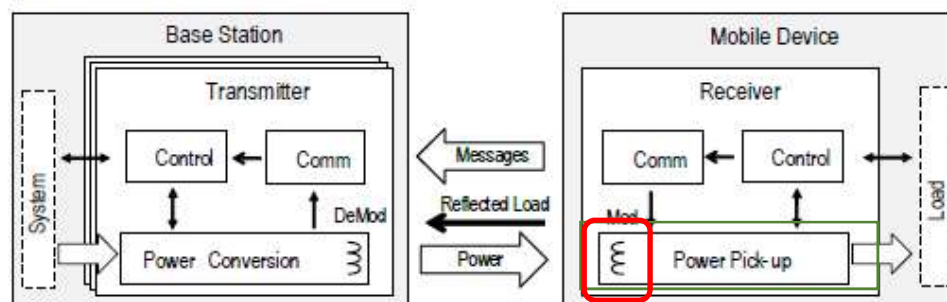
P9415-R Datasheet

6. Wireless Power Charging System

A wireless power charging system has a base station with one or more transmitters that make power available via DC-to-AC inverter(s), and transmit the power over a strongly-coupled inductor pair (magnetic induction) or over a loosely-coupled inductor pair (magnetic resonance) to a receiver in a mobile device. A WPC¹ system uses near field magnetic induction between coils and can be a free-positioning or magnetically-guided type of system.

In WPC systems, the amount of power transferred to the mobile device is controlled by the receiver. The receiver sends communication packets to the transmitter to increase power, decrease power, or maintain the power level. The bit rate for Rx-to-Tx communication link is 2kbps for WPC receivers and is amplitude modulated (ASK) on top of the power link that exists.

Figure 2. Block Diagram of WPC System



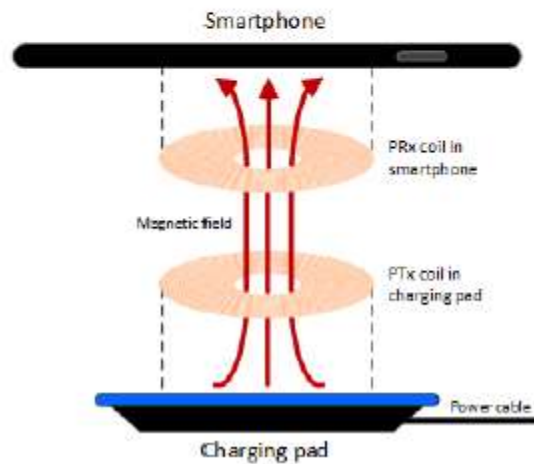
When placed on a WPC compliant charger, the S22 Ultra receives an alternating magnetic field substantially perpendicular to the plane of the planar receiver coil that generates a current for

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex.)
Ex. 5 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,462,942 by Samsung
inductive power transfer as recited by this part of the claim. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9 (*see also* WPC 1.2.3 Standard, Introduction, page 9).

When charging begins, the power transmitter runs an alternating electrical current through its coil(s), which generates an alternating magnetic field in accordance with Faraday's law. This magnetic field is in turn picked up by the coil inside the power receiver and transformed by a power converter back into an alternating electrical current that can be used to charge the battery.

A critical feature of the magnetic field is that it can transfer through any non-metallic, non-ferrous materials, such as plastics, glass, water, wood, and air. In other words, wires and connectors are not needed between the power transmitter and power receiver.

Figure 6. Qi wireless power transfer using magnetic induction



Earbuds

The Buds2 case includes a generally planar receiver coil, as specified by this part of the claim.

<https://www.wirelesspowerconsortium.com/products/11427>

SAMSUNG ELECTRONICS GALAXY BUDS2 (SM-R177)



BRAND

Samsung Electronics

PRODUCT NAME

Galaxy Buds2

MANUFACTURER PART NUMBER

SM-R177

PRODUCT TYPE

Power Class 0 Receiver

REGISTRATION DATE

August 19, 2021

DESCRIPTION

GALAXY BUDS 2

ADDITIONAL DETAILS

Qi Registration id	11427
Version	1.2.4
Currently licensed	Yes
Power profile	Basic Power Profile
Maximum received power	2 watts



The Buds2 case is WPC compliant, as shown above. When placed on a WPC compliant charger, the Buds2 case receives an alternating magnetic field substantially perpendicular to the plane of the planar receiver coil that generates a current for inductive power transfer as recited by this part of the claim. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9 (shown above for this claim element with respect to Smartphones).

Wearables

The Watch4, representative product, includes a planar receiver coil, (the ring shapes photo below) as shown in the listing below.

https://www.ebay.com/itm/225173935598?nma=true&si=ziHGdlkwhvLsE97LpXFj7979J8g%253D&orig_cvip=true&nordt=true&rt=nc&_trksid=p2047675.l2557



The receiver coil can be seen also in block diagram form in the 9222 datasheet below, which is believed to be representative of the wireless power receiver ASIC included in the Galaxy Watches.
<https://www.renesas.com/us/en/document/dst/p9222-rn-datasheet>

RENESAS

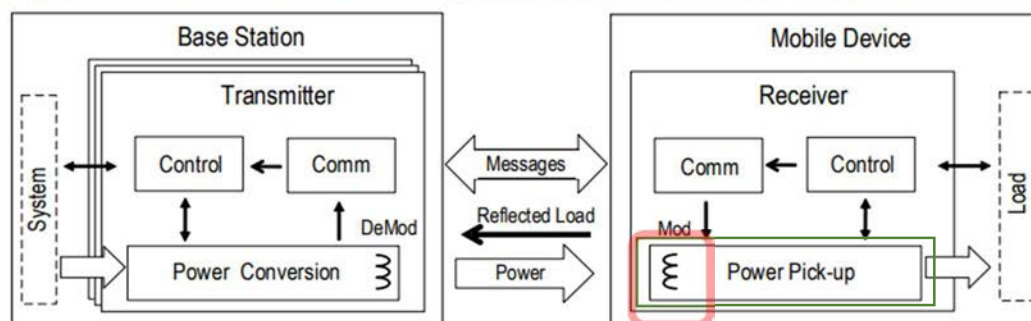
P9222-R/RN Datasheet

3. Description of the Wireless Power Charging System

A wireless power charging system has a base station with one or more transmitter coils that make power available via DC-to-AC inverter(s) and transmit the power over a strongly-coupled inductor pair (magnetic induction), or over a loosely-coupled inductor pair (magnetic resonance) to a receiver in a mobile device. A WPC (see Figure 4) uses near-field magnetic induction between coils and can be a free-positioning or magnetically-guided type of system.

In WPC Inductive systems, the amount of power transferred to the mobile device is controlled by the receiver. The receiver sends communication packets to the transmitter to increase power, decrease power, or maintain the power level. The bit rate for the Rx-to-Tx communication link is 2kbps for WPC receivers. It is modulated on top of the power link that exists.

Figure 4. Block Diagram of WPC Compliant Wireless Power Transfer System



The Watch4 receives an alternating magnetic field that is substantially perpendicular to the plane of the planar receiver coil that generates a current for inductive power transfer when placed on a compatible charger. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9 (shown above for this claim element with respect to Smartphones).

a ferrite layer positioned under the coil on a side of the coil opposite to the charging surface of the portable device; and

The 942 Claim 21 Accused Products include a ferrite material layer as specified by this part of the claim.

Smartphones

The S22 Ultra includes a ferromagnetic layer, as specified by this part of the claim. In particular, the wireless charging coil assembly includes a ferromagnetic layer on the back side of the charging coil (towards the inside of the phone as shown below towards the gray backing side of the charging coil).



Earbuds

The Buds2 case includes a ferromagnetic layer in the black backing seen below, as specified by this part of the claim.



Wearables

On information and belief, the Watch4 includes a ferromagnetic layer, as specified by this part of the claim.

a receiver circuit powered by the received inductive power from the inductive charging system, wherein the receiver circuit comprises:

The 942 Claim 21 Accused Products include a receiver circuit as specified by this part of the claim.

Smartphones

The S22 Ultra includes a receiver circuit (as specified by later parts of this claim) that is powered by the inductive charging system as specified by this part of the claim.

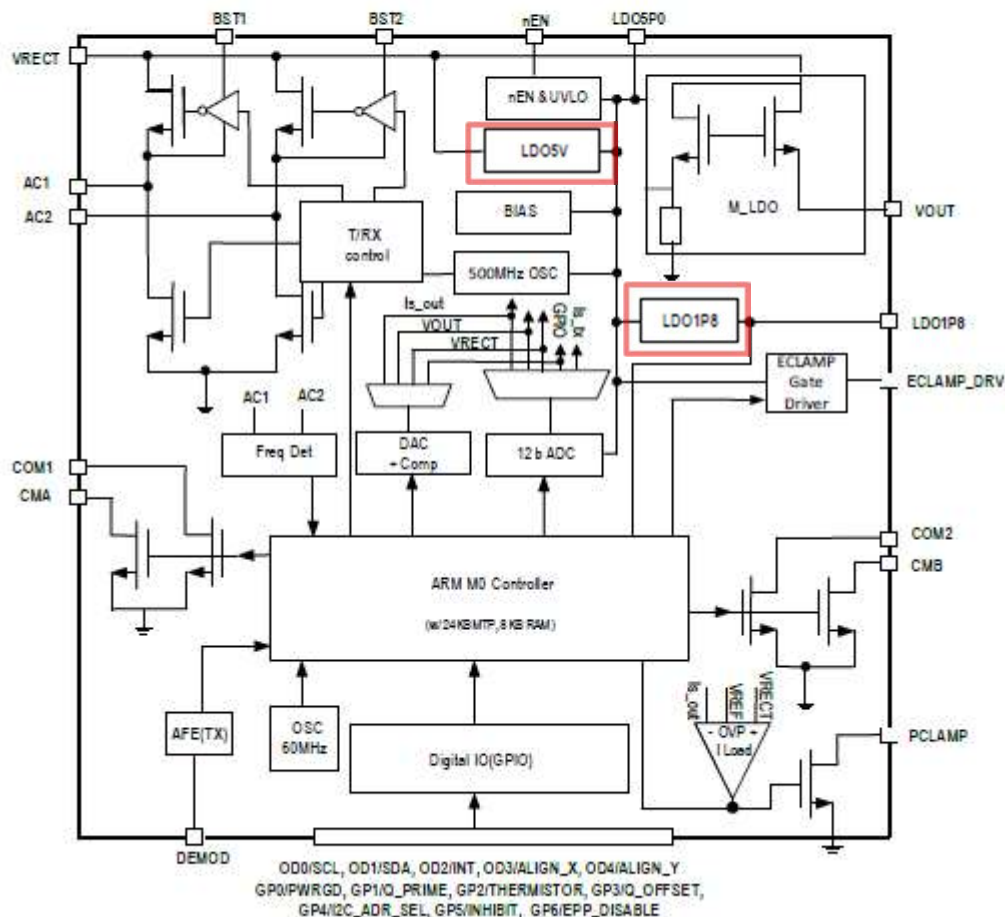
The receiver circuit in the S22 Ultra includes a wireless power transceiver ASIC (e.g., the 9320S ASIC) in combination with external capacitors and other external circuitry, as shown above with respect to claim 1.

The representative 9415 ASIC and external capacitors form a receiver circuit as specified by this part of the claim as shown below (again, believed to be representative of the 9320 ASIC). As seen in the 9415 datasheet, the internal blocks of the receiver circuit are powered by the received inductive power from the inductive charging system through two internal Low Drop Out (LDO) regulators.

8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

Figure 15. Internal Block Diagram



8.3.6 LDO Regulators

The P9415-R has three LDOs. The Main LDO (VOUT pin) is programmable from 5V to 20V and LDO5P0 is powered by VRECT. LDO1P8 is powered by LDO5P0. Both LDO5P0 and LDO1P8 are used for supplying power to internal low voltage blocks. The LDOs must have local ceramic bypass capacitors placed near the P9415-R.

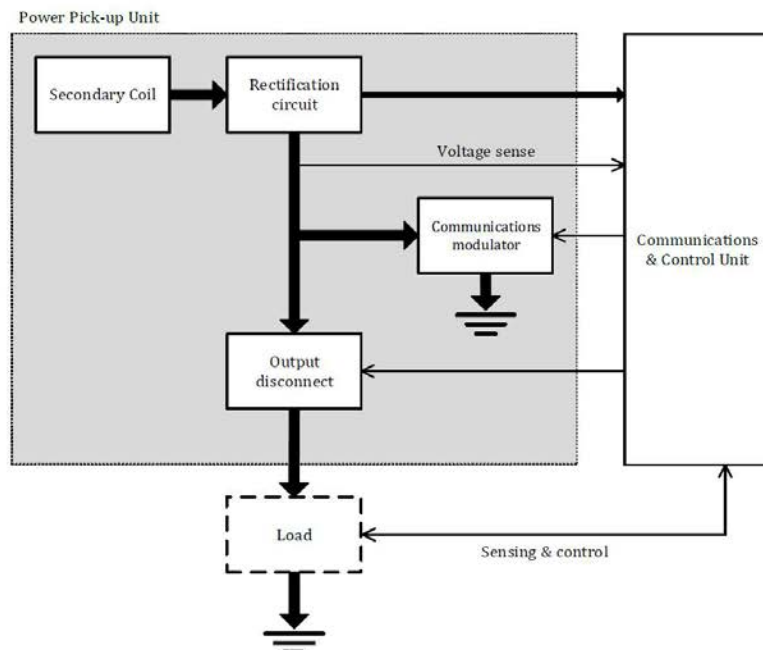
That the receiver circuit is powered inductively is further indicated by the WPC standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 23-24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 24-25).

3 Power interface

3.1 Power Receiver design requirements (PRx)

Figure 4 illustrates an example of a functional block diagram for a Baseline Power Profile Power Receiver.

Figure 4. Functional block diagram for a Baseline Power Profile Power Receiver



- A rectification circuit that provides full-wave rectification of the AC waveform using, for example, four diodes in a full-bridge configuration or a suitable configuration of active components (see Section 3.1.2, *Rectification circuit*). The rectification circuit may perform output smoothing as well. In this example, the rectification circuit provides power to both the Communications and Control Unit of the Power Receiver and the output of the Power Receiver

Earbuds

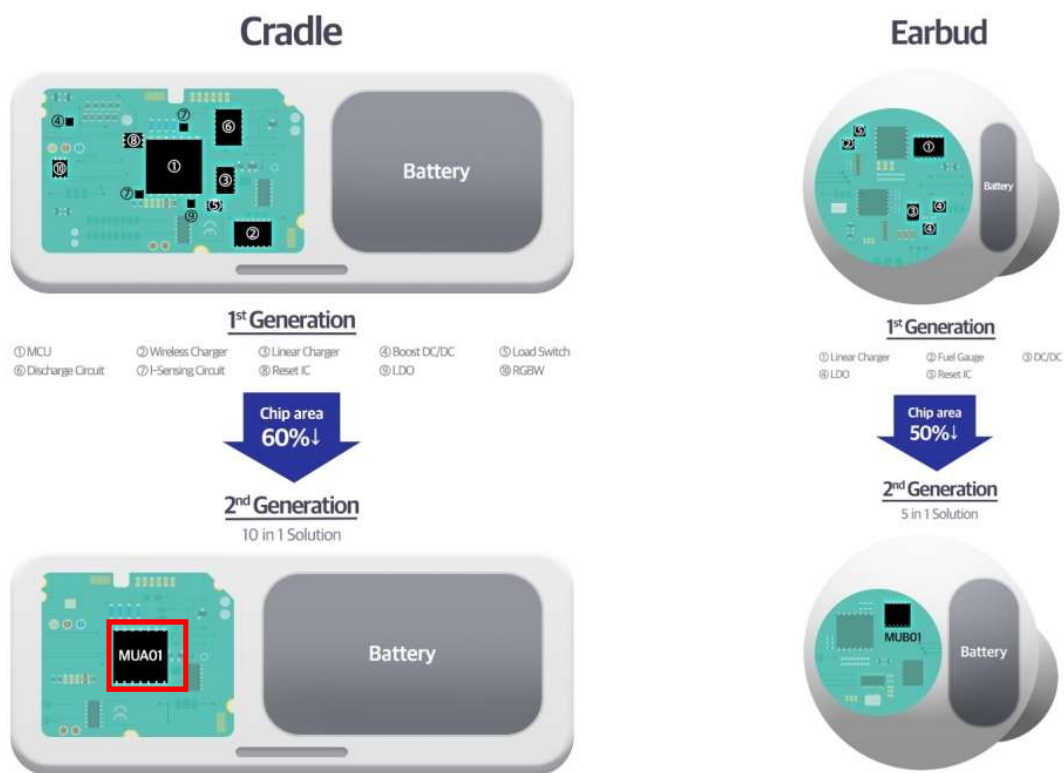
The Buds2 case includes a receiver circuit (as specified by later parts of this claim) that is powered by the inductive charging system. For example, the Buds2 case includes a power management integrated circuit (PMIC) that comprises in part a receiver circuit that is powered inductively as claimed.

<https://news.samsung.com/global/samsung-introduces-industrys-first-all-in-one-power-ics-optimized-for-wireless-earbuds>

The MUA01 is also the industry's first solution to support both wireless and wired charging in a single chip. For wireless charging, it supports the Wireless Power Consortium's (WPC) Qi 1.2.4, the consortium's latest wireless power transfer interface standard. To provide efficient power management, the MUA01 integrates a highly effective switching charger. In addition, MUA01 comes with a microcontroller unit (MCU) and embedded Flash (eFlash), offering the option of modifying its firmware to support other applications.

The MUA01 and MUB01 are currently in mass production and are featured in Samsung's recently-announced Galaxy Buds+ TWS earbuds.

<https://www.sammobile.com/news/samsung-launches-industry-first-power-chipsets-true-wireless-earbuds/>



On information and belief, the wireless charging receiver section of the representative MUA01 PMIC included in the Buds2 case with respect to the 942 patent is similar to the representative 9415 ASIC and/or the representative 9222 ASIC shown above.

The MUA01 or similar PMIC in the Buds2 case is WPC 1.2.4 certified.

<https://www.wirelesspowerconsortium.com/products/11427>

SAMSUNG ELECTRONICS GALAXY BUDS2 (SM-R177)



BRAND

Samsung Electronics

PRODUCT NAME

Galaxy Buds2

MANUFACTURER PART NUMBER

SM-R177

PRODUCT TYPE

Power Class 0 Receiver

REGISTRATION DATE

August 19, 2021

DESCRIPTION

GALAXY BUDS 2



ADDITIONAL DETAILS

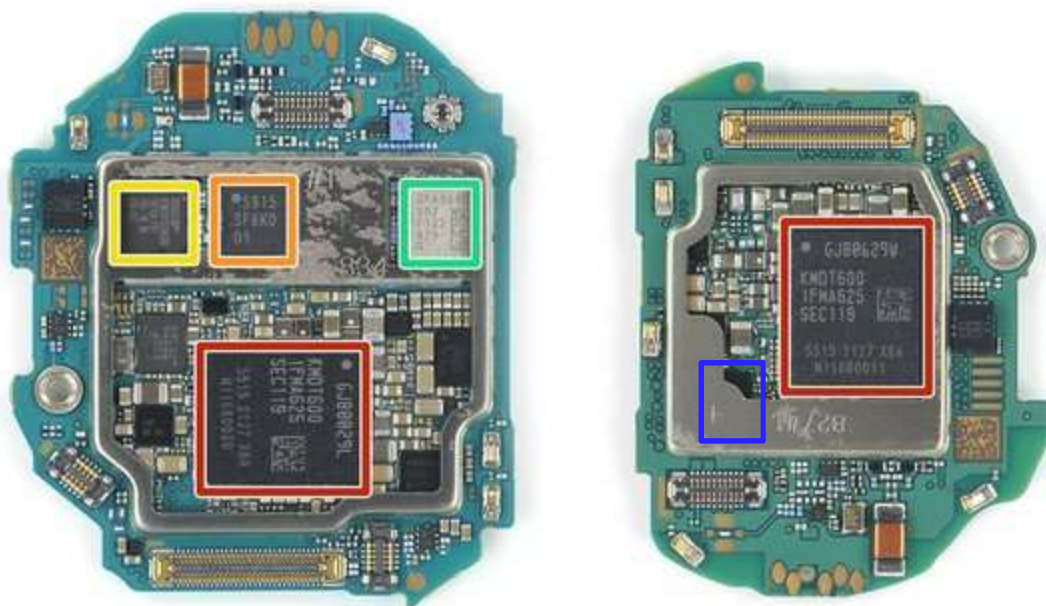
Qi Registration id	11427
Version	1.2.4
Currently licensed	Yes
Power profile	Basic Power Profile
Maximum received power	2 watts

Per the WPC Standard, the receiver circuit of the Buds2 case is powered by the received inductive power from the inductive charging system, as shown above with respect to the S22 Ultra with respect to this claim element.

Wearables

On information and belief, the Watch4 includes a receiver ASIC (Renesas/IDT P9222S) shown in the blue rectangle in the representative Watch4 below:

<https://www.ifixit.com/Teardown/Samsung+Galaxy+Watch4+and+Watch4+Classic+Teardown/144595>



The Watch4 includes a receiver circuit (as specified by later parts of this claim) that is powered by the inductive charging system. The 9222 ASIC (or equivalent) included in the Watch4 is powered by the received inductive power from the charger. In the representative 9222 ASIC, Two Low Drop Out (LDO) Regulators LDO5P0 and LDO1P8 power the internal low voltage blocks of the receiver circuit from the received inductive power, such as seen below in the 9222 datasheet.

<https://www.renesas.com/us/en/document/dst/p9222-rrn-datasheet>

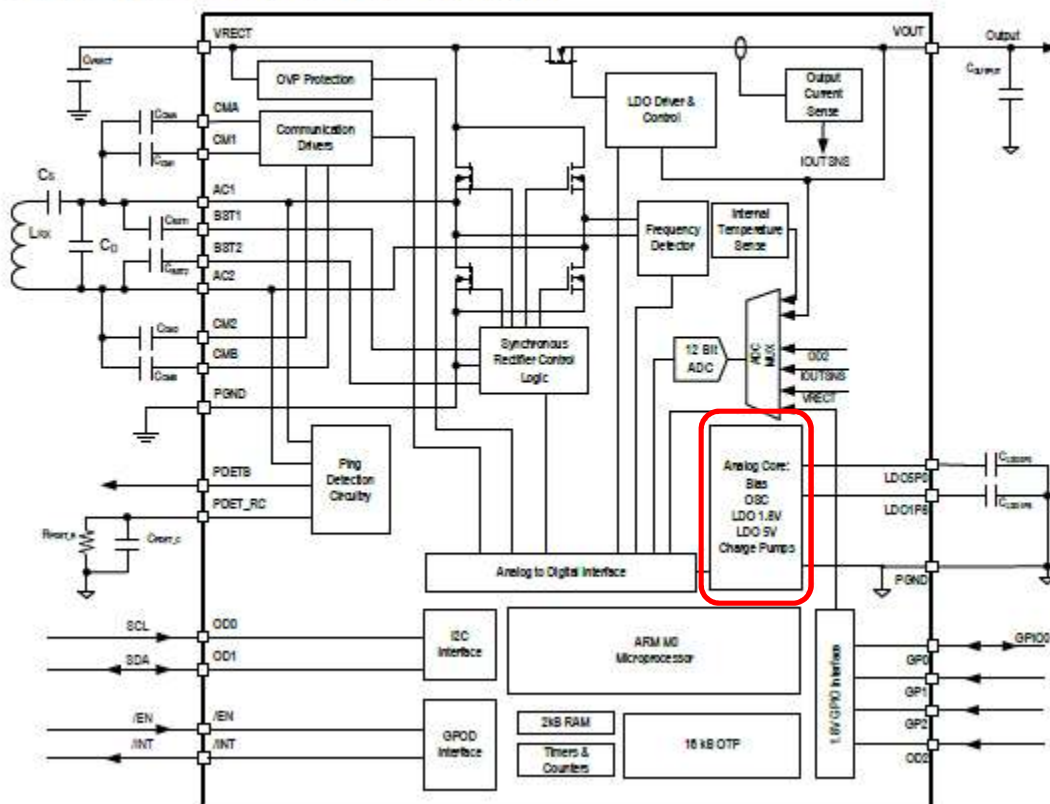


P9222-R/RN Datasheet

5.11 Low Drop-Out (LDO) Regulators

The P9222-R/RN has three LDO regulators. The primary VOUT LDO is powered by VRECT. The VOUT LDO can be programmed to any voltage between 3.5V and 10V; however, the output voltage setting should be compatible with the wireless Tx capability and coil type. The LDO5P0 is powered directly from VRECT, and LDO1P8 is powered from LDO5P0. Both are used for supplying power to internal low-voltage blocks. The LDOs must have local ceramic bypass capacitors placed near the P9222-R/RN. For recommended values, follow the application schematic in Figure 36.

Figure 2. P9222-R/RN Block and Application Diagram



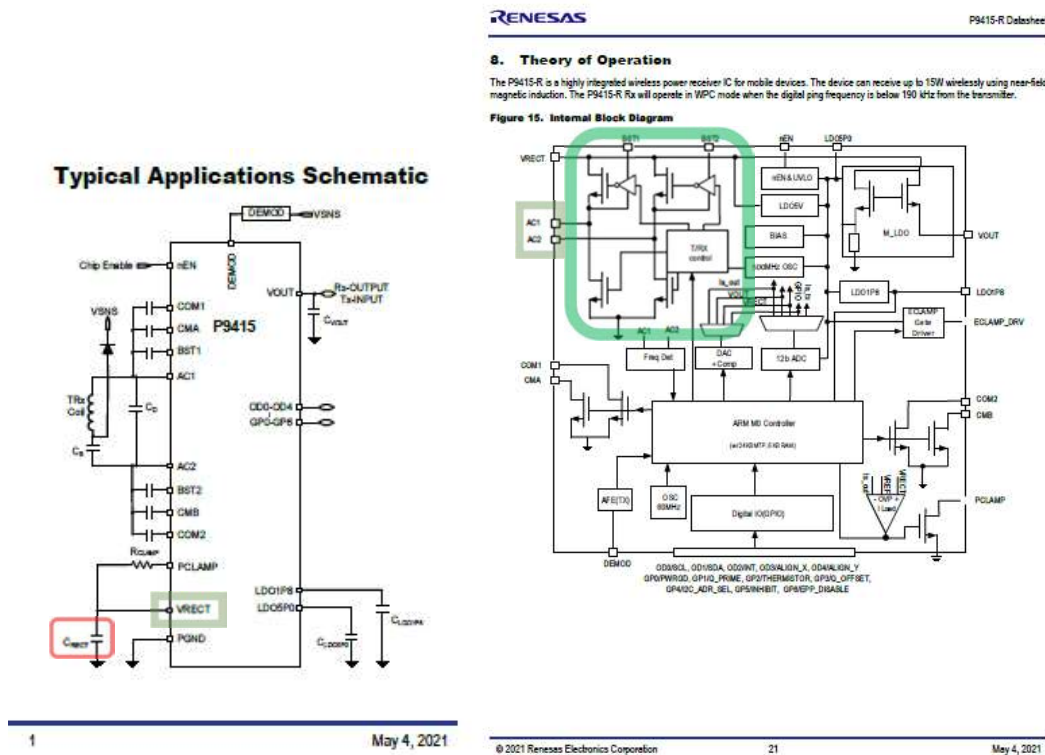
a receiver rectifier circuit including a rectifier and a capacitor;

The 942 Claim 21 Accused Products include a receiver rectifier circuit as specified by this part of the claim.

Smartphones

The S22 Ultra includes a receiver rectifier circuit including a rectifier and a capacitor (as specified by this part of the claim) in the included wireless power transceiver ASIC with associated external capacitor.

For example, the representative 9415 ASIC has a rectifier (formed by way of a synchronous rectifier circuit shown in the green rectangle below) which rectifies the AC voltage induced by the base unit at the AC1 and AC2 inputs (connected to the receiver coil) when the 9415 ASIC is in the receiver mode. This rectified voltage (VRECT) is smoothed by the external capacitor, C_{VRECT} (shown in red rectangle), connected to the VRECT pin.



8.3 Rx Mode Functions

8.3.1 Synchronous Rectifier

The efficiency of the full-bridge rectifier in the P9415-R is increased by implementing it as a synchronous rectifier. The rectifier comprises four internally-driven switches that work in a full synchronous mode of operation when the load applied to VOUT is higher than the programmed threshold value. Below that threshold, the rectifier works in half-synchronous rectification mode. In half-synchronous rectification mode, only the low-side N-MOSFETs are driven and the high-side N-MOSFETs are forced into diode mode. At power-up, when the voltage is below the UVLO threshold, the rectifier works by using the body diodes associated with the NMOS transistors. The BST capacitors are used to provide power to drive the gates of high-side NMOS switches.

9.4 Input Capacitor (VRECT Capacitors)

The LDO input capacitors (VRECT capacitors) should be located as close as possible to the VRECT pins and ground (PGND). Ceramic capacitors are recommended for their low ESR and small profile.

This is consistent with the WPC standard, with which the S22 Ultra is interoperable. In particular, the S22 Ultra is a WPC Baseline Power Profile (BPP or <5 W) receiver and registered with WPC as certified and tested to meet the WPC specification as a Power Class 0 Receiver. <https://www.wirelesspowerconsortium.com/products/12711>

SAMSUNG ELECTRONICS GALAXY S22 ULTRA (SM-S908U)

BRAND
Samsung Electronics

PRODUCT NAME
Galaxy S22 Ultra

MANUFACTURER PART NUMBER
SM-S908U

PRODUCT TYPE
Power Class 0 Receiver

REGISTRATION DATE
February 9, 2022



ADDITIONAL DETAILS

Qi Registration Id	12184
Version	1.2.4
Currently licensed	Yes
Power profile	Basic Power Profile
Maximum received power	4.4 watts

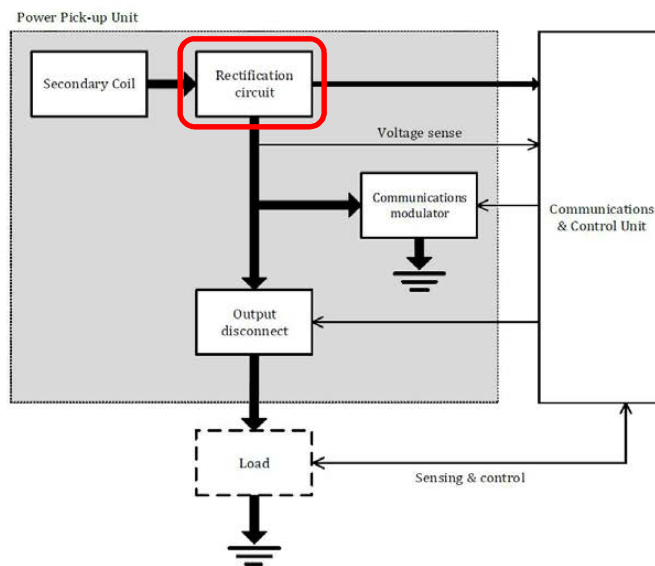
The WPC Standard shows a receiver rectifier circuit as claimed. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 23-24, 42, and 136 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 24-25, 42, 134) (in Figure 47 below, the red rectangle on right shows the rectifier circuit and the capacitor).

3 Power interface

3.1 Power Receiver design requirements (PRx)

Figure 4 illustrates an example of a functional block diagram for a Baseline Power Profile Power Receiver.

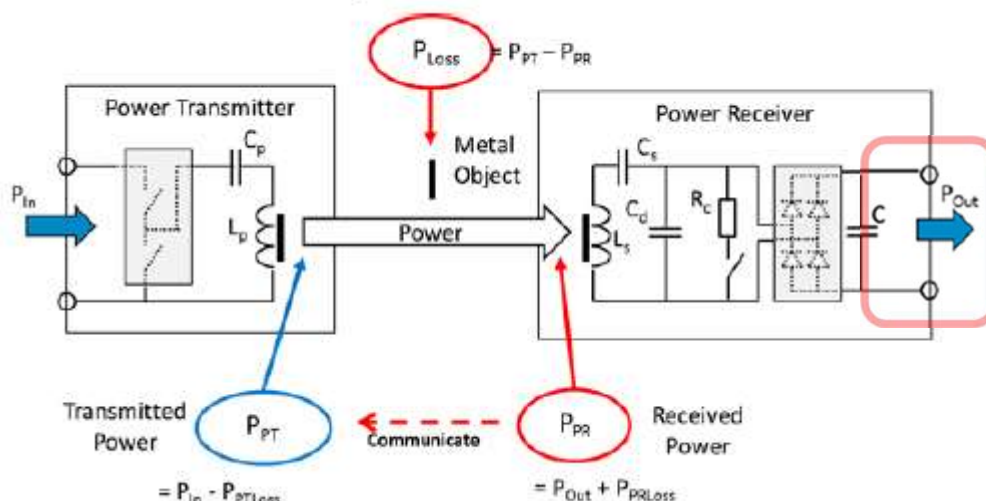
Figure 4. Functional block diagram for a Baseline Power Profile Power Receiver



- A rectification circuit that provides full-wave rectification of the AC waveform using, for example, four diodes in a full-bridge configuration or a suitable configuration of active components (see Section 3.1.2, *Rectification circuit*). The rectification circuit may perform output smoothing as well. In this example, the rectification circuit provides power to both the Communications and Control Unit of the Power Receiver and the output of the Power Receiver

All practical Power Receiver implementations use a rectifier as part of the load circuit shown in Figure 10 (see also Section 3.1.2). Moreover, most Power Receiver implementations include a capacitor directly after this rectifier to smoothen the ripple on the rectified voltage. In combination with a high load

Figure 47. Power losses illustrated



Earbuds

The Buds2 case includes a receiver rectifier circuit including a rectifier circuit and a capacitor as specified by this part of the claim in part by way of an included PMIC (such as the MUA01) with associated external capacitor(s), which on information and belief, is similar to that included in the S22 Ultra (discussed above) and/or the Watch4 (described below) with respect to this part of the claim. See also the WPC Standard references cited above with respect to the smartphones for this part of the claim.

Wearables

The Watch4 includes a receiver circuit comprising a rectifier and a capacitor as claimed, namely, in a wireless power receiver ASIC (such as the 9222 ASIC) in combination with external capacitor(s). As indicated by the representative 9222 datasheet, the 9222 ASIC includes an internal rectifier and an accompanying external capacitor, as shown below.

<https://www.renesas.com/us/en/document/dst/p9222-rn-datasheet>

RENESAS **Wireless Power Receiver for Low Power Applications** **P9222-R/RN Datasheet**

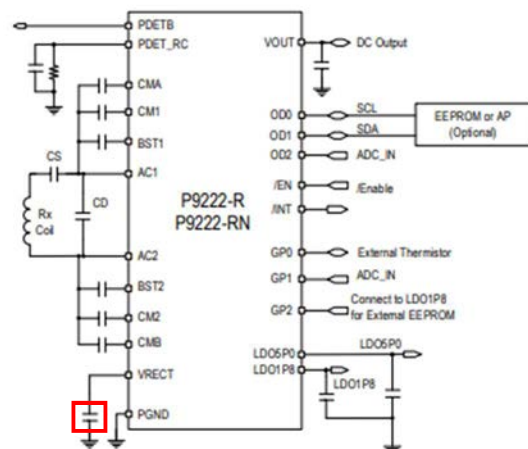
The P9222-R/RN is an integrated single-chip wireless power receiver IC (Rx) for up to 5W applications implementing in-band, bi-directional data communication with no additional circuitry. The device receives an AC power signal from a wireless power transmitter, such as the P9235A-RB WPC Qi BPP Wireless Transmitter IC, and converts it to a rectified output voltage, which can be used to power devices or supply the battery charger input in a wide range of wireless power applications. The receiver (Rx) integrates a high-efficiency synchronous full bridge rectifier (SFBR) and control circuits that enable bi-directional communication from and to the transmitter (Tx) for optimized power delivery.

Features

- Ultra-compact, efficient wireless power receiver for up to 5W applications
- P9222-R default firmware is WPC 1.2.4 Qi Baseline Power Profile (BPP) compatible
- P9222-RN default firmware is WPC 1.3 Qi Baseline Power Profile (BPP) compatible
- Ping detection for reduced power consumption at end of charging

Block Diagram

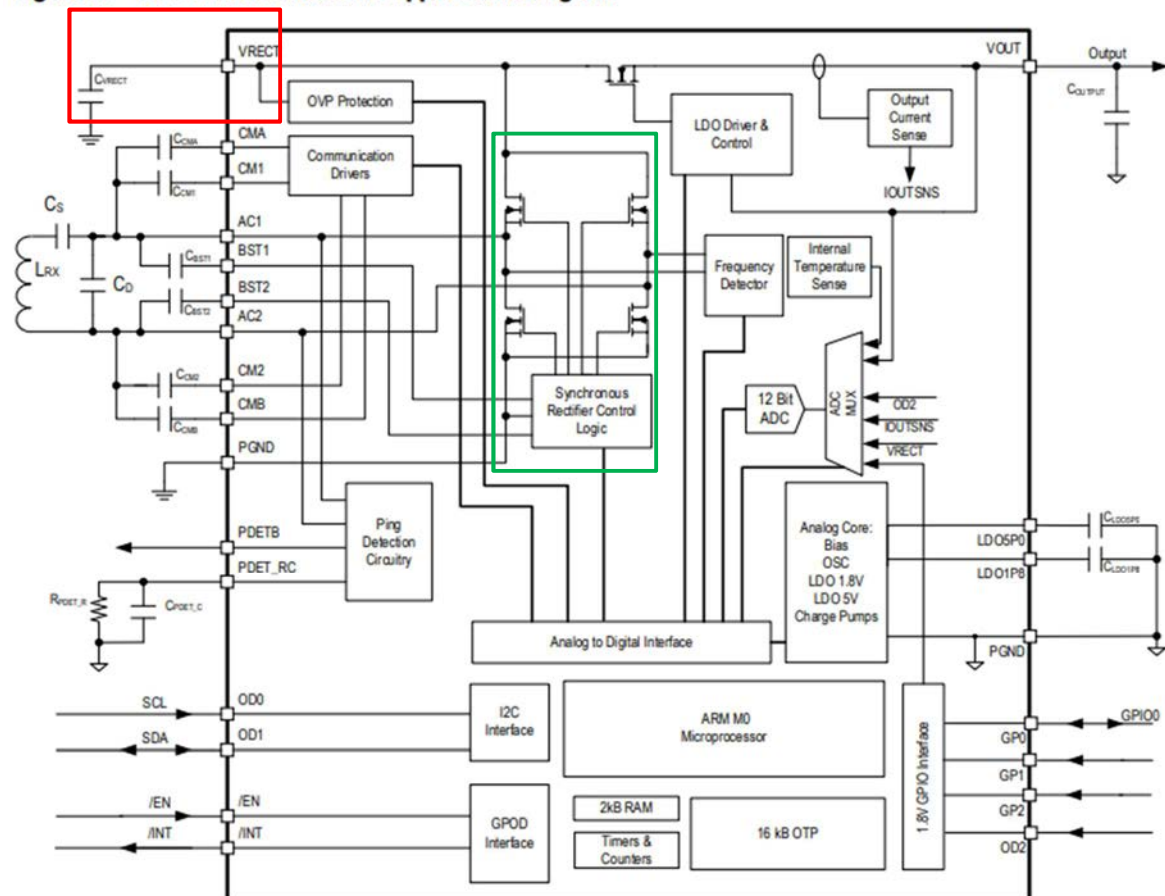
Figure 1. Simplified Block Diagram



RENESAS

P9222-R/RN Datasheet

Figure 2. P9222-R/RN Block and Application Diagram



5.1.2 Rx Operation

The wireless power is stored on a capacitor(s) connected to the VRECT pin in Rx mode. Until the voltage across the VRECT capacitor exceeds the under-voltage lock-out (UVLO) threshold, the rectification is performed by the body diodes of the synchronous full bridge rectifier FETs. After the internal biasing circuit is enabled, the driver and control blocks operate the MOSFET switches of the rectifier in various modes to maintain reliable connections and optimal efficiency. An internal ADC monitors the voltage at VRECT and the load current. The P9222-R/RN sends instructions to the wireless power transmitter to increase or decrease the amount of power transferred or to terminate power transmission based on these readings. The LDO VOUT pin can be pre-programmed from 3.5V up to 12V or changed after startup using I²C commands. The headroom and target VRECT value will automatically adjust based on the latest VOUT set-point programmed value. The internal temperature is continuously monitored to ensure proper operation.

5.5 Synchronous Rectifier

The efficiency of the full-bridge rectifier in the P9222-R/RN is increased by operating in full synchronous rectifier mode. The rectifier is comprised of four self-driven switches that work in a full synchronous mode of operation when the load is higher than a programmable level (typically 150mA for BPP operation). Below that threshold, the rectifier works in half-synchronous rectification mode. At power-up, when the voltage is below the UVLO threshold, the rectifier functions by using the body diodes associated with the NMOS transistors. The BST capacitors are used to provide power to drive the gates of the high-side NMOS switches.

That this part of the claim is met by the Watch4 is also indicated by the WPC Standard, as shown above for the S22 Ultra with respect to this part of the claim.

a receiver communication and control circuit including a microcontroller, wherein the receiver communication and control circuit is configured to modulate the current in the coil to communicate with the inductive charging system while the receiver circuit is being powered by the inductive charging system;

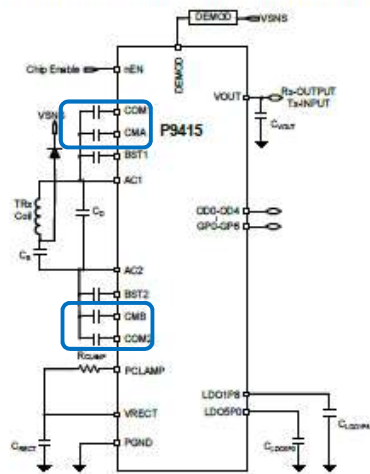
The 942 Claim 21 Accused Products meet this part of the claim as they each include a receiver communication and control circuit as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

The S22 Ultra includes a receiver communication and control circuit as specified by this part of the claim.

The S22 Ultra includes a receiver communication and control circuit with a microcontroller by way of the included wireless power transceiver ASIC. As seen in the representative 9415 datasheet, the Communication and Control circuit includes the Microcontroller (green rectangle below) and the two communication FETs for modulating COM1 and CMA and two additional FETs for modulating COM2 and CMB (shown in red rectangles) along with associated external capacitors. The FETs communicate by modulating the impedance at the receiver coil by connecting and disconnecting external capacitors shown in blue rectangles below. These circuits are powered by the inductive charging system.

Typical Applications Schematic



1

May 4, 2021

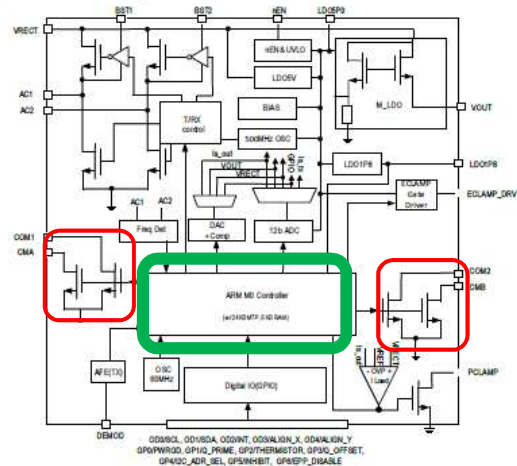
RENESAS

P9415-R Datasheet

8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 150 kHz from the transmitter.

Figure 15. Internal Block Diagram



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21

May 4, 2021

Current modulation is used for communication with the charger base unit, as explained further in the representative 9415 datasheet.

6. Wireless Power Charging System

A wireless power charging system has a base station with one or more transmitters that make power available via DC-to-AC inverter(s), and transmit the power over a strongly-coupled inductor pair (magnetic induction) or over a loosely-coupled inductor pair (magnetic resonance) to a receiver in a mobile device. A WPC¹ system uses near field magnetic induction between coils and can be a free-positioning or magnetically-guided type of system.

In WPC systems, the amount of power transferred to the mobile device is controlled by the receiver. The receiver sends communication packets to the transmitter to increase power, decrease power, or maintain the power level. The bit rate for Rx-to-Tx communication link is 2kbps for WPC receivers and is amplitude modulated (ASK) on top of the power link that exists.

Figure 2. Block Diagram of WPC System

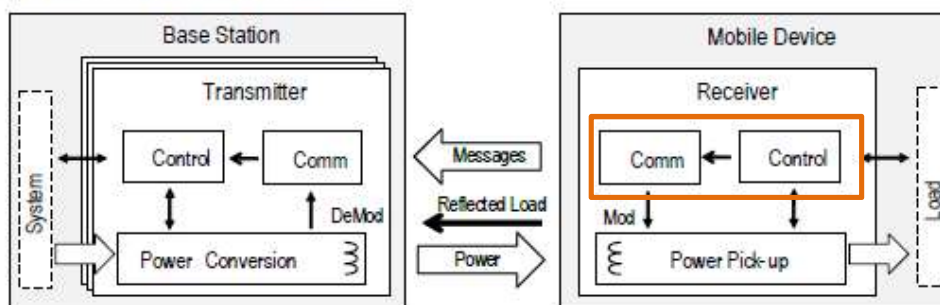
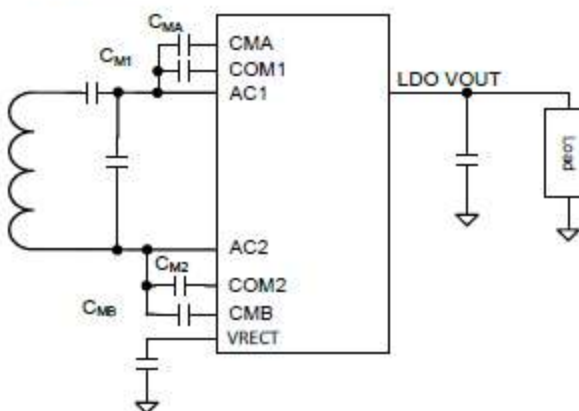


Figure 16. Rx Modulation Components



Receiver-to-transmitter communication is completed by modulating the load applied to the receiver's inductor. To the transmitter, this appears as an impedance change, which results in measurable variations of the transmitter's output waveform. Modulation is done with AC Modulation, using internal switches to connect external capacitors from AC1 and AC2 to ground.

The P9415-R communicates with the base via communication packets or decodes messages sent by WPC Rx's. Each communication packet has the following structure:

Figure 17. Communication Packet Structure



According to the WPC specification, the power receiver communicates with the power transmitter using backscatter modulation. The load seen by the power transmitter's inductor is modulated on the receiver side to send packets. The power transmitter demodulates these signals as a modulation of coil current/voltage to decode and receive packets.

Furthermore, the current modulation used by the S22 Ultra for communication with the charger follows per the WPC Standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 87 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 86).



5.2 Power Receiver to Power Transmitter communications interface

5.2.1 Introduction

The Power Receiver communicates to the Power Transmitter using backscatter modulation. For this purpose, the Power Receiver modulates the amount of power that it draws from the Power Signal. The Power Transmitter detects this as a modulation of the current through and/or voltage across the Primary Cell. In other words, the Power Receiver and Power Transmitter use an amplitude modulated Power Signal to provide a Power Receiver to Power Transmitter communications channel.

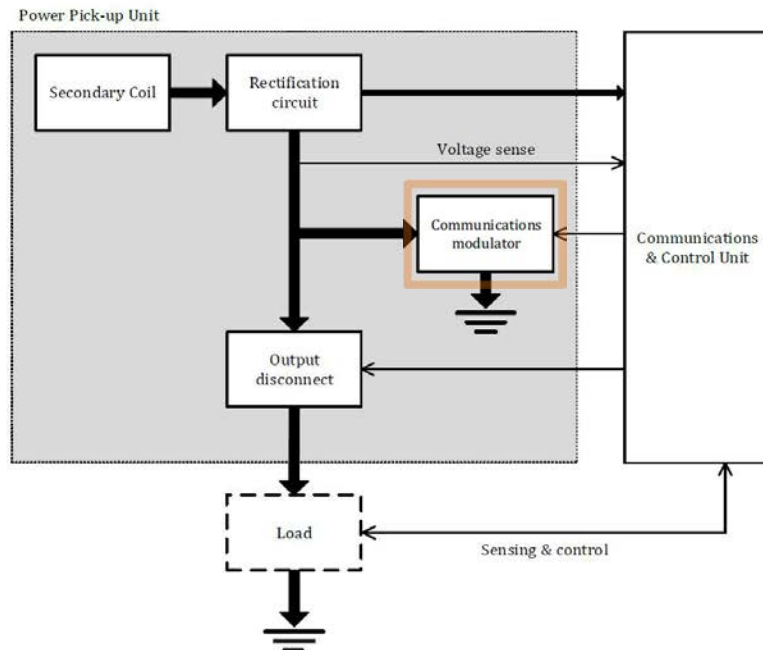
Furthermore, the communication and control circuit is powered inductively per the WPC Standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 23-24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 24-25).

3 Power interface

3.1 Power Receiver design requirements (PRx)

Figure 4 illustrates an example of a functional block diagram for a Baseline Power Profile Power Receiver.

Figure 4. Functional block diagram for a Baseline Power Profile Power Receiver



Earbuds

The wireless power ASIC (such as the MUA01) included in the Buds2 case is WPC certified and includes a receiver communication and control circuit as recited by this part of the claim, similar to the representative 9415 ASIC of the S22 Ultra (above) and/or the representative 9222 ASIC of the Watch4 (below).

That this part of the claim is met is also indicated by the WPC Standard, as shown above for the S22 Ultra with respect to this part of the claim.

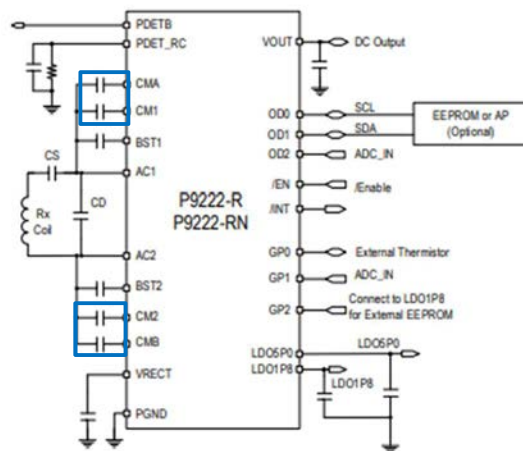
Wearables

The Watch4 includes a receiver communication and control circuit as specified by this part of the claim, e.g., by way of an included wireless power receiver ASIC such as seen in the representative 9222 datasheet. The communication and control circuit includes a microcontroller (green rectangle) and two communication FETs for modulating COM1 and CMA and two additional FETs for modulating COM2 and COMB (red rectangles). The four FETs are located in the Communications Drive rectangle (golden rectangle) along with associated external capacitors (blue rectangles). The FETs communicate by modulating the impedance at the receiver coil by connecting and disconnecting external capacitors shown in the blue rectangles. These circuits are powered by the inductive charging system.

<https://www.renesas.com/us/en/document/dst/p9222-rrn-datasheet>

Block Diagram

Figure 1. Simplified Block Diagram

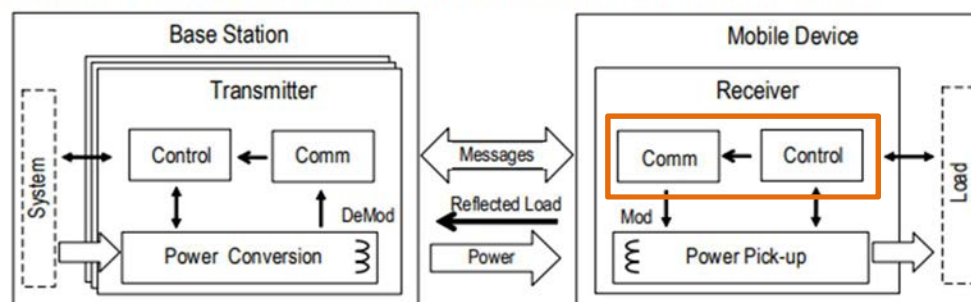


3. Description of the Wireless Power Charging System

A wireless power charging system has a base station with one or more transmitter coils that make power available via DC-to-AC inverter(s) and transmit the power over a strongly-coupled inductor pair (magnetic induction), or over a loosely-coupled inductor pair (magnetic resonance) to a receiver in a mobile device. A WPC (see Figure 4) uses near-field magnetic induction between coils and can be a free-positioning or magnetically-guided type of system.

In WPC Inductive systems, the amount of power transferred to the mobile device is controlled by the receiver. The receiver sends communication packets to the transmitter to increase power, decrease power, or maintain the power level. The bit rate for the Rx-to-Tx communication link is 2kbps for WPC receivers. It is modulated on top of the power link that exists.

Figure 4. Block Diagram of WPC Compliant Wireless Power Transfer System



That this part of the claim is met is also indicated by the WPC Standard, as shown above for the S22 Ultra with respect to this part of the claim.

a voltage regulator coupled to an output of the receiver rectifier circuit and coupled to the microcontroller, wherein the voltage regulator is configured to provide a regulated voltage to power the microcontroller from the received inductive power; and

The 942 Claim 21 Accused Products meet this part the claim as they each include a voltage regulator as specified by this part of the claim, as illustrated below for the representative products.

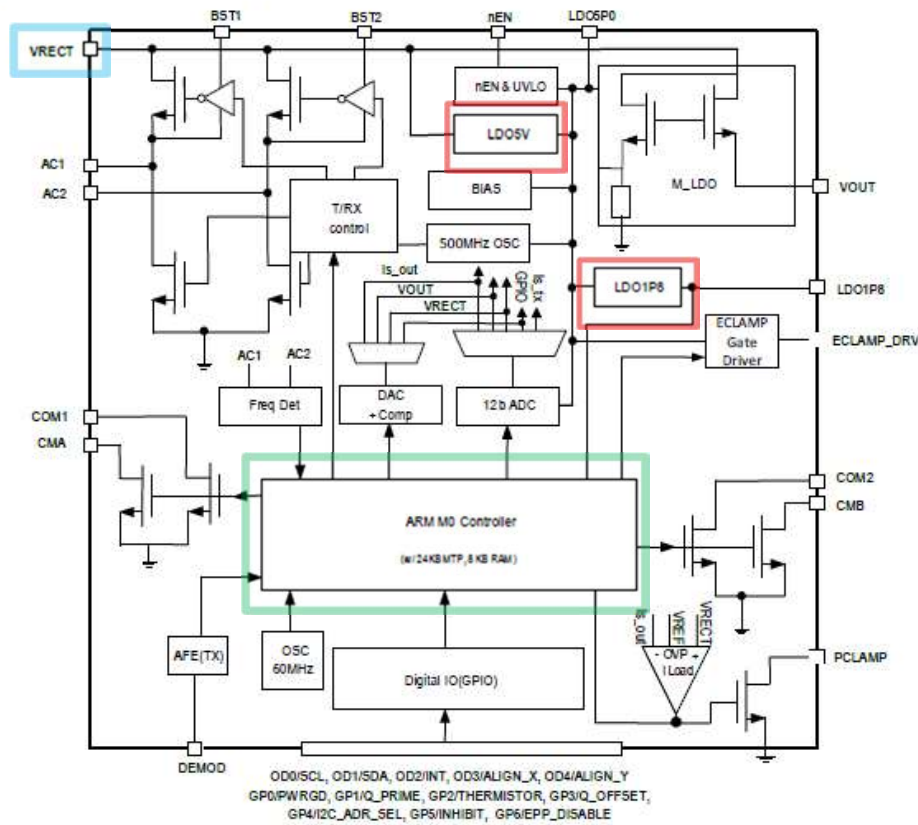
Smartphones

The S22 Ultra includes a voltage regulator as specified by this part of the claim. For example, in the representative 9415 ASIC receiver circuit, there are two Low Drop Out (LDO) regulators, LDO5V and LDO1P8 (red rectangles), which provide power to the microcontroller (green rectangle) as seen in the 9415 ASIC datasheet below. These LDOs are powered by VRECT (blue rectangle), which is the rectified DC voltage generated in the ASIC by the inductive charging system.

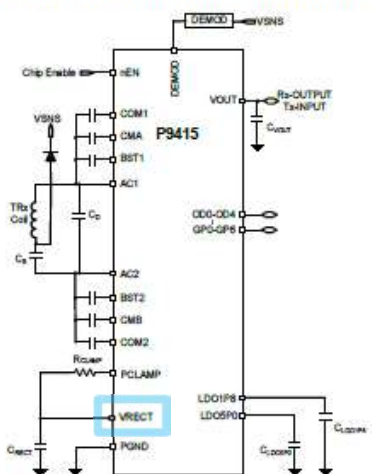
8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

Figure 15. Internal Block Diagram



Typical Applications Schematic



1

May 4, 2021

8.3.6 LDO Regulators

The P9415-R has three LDOs. The Main LDO (VOUT pin) is programmable from 5V to 20V and LDO5P0 is powered by VRECT. LDO1P8 is powered by LDO5P0. Both LDO5P0 and LDO1P8 are used for supplying power to internal low voltage blocks. The LDOs must have local ceramic bypass capacitors placed near the P9415-R.

8.2 WPC Mode Characteristics

8.2.1 Startup

When a mobile device containing the P9415-R is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "Ping" phase, once the rectifier voltage at the VRECT pin goes above the UVLO threshold, the digital section of the P9415-R enables communication. The control loop of the P9415-R adjusts the rectifier voltage by sending error packets to the transmitter before and after it enables the VOUT LDO.

Earbuds

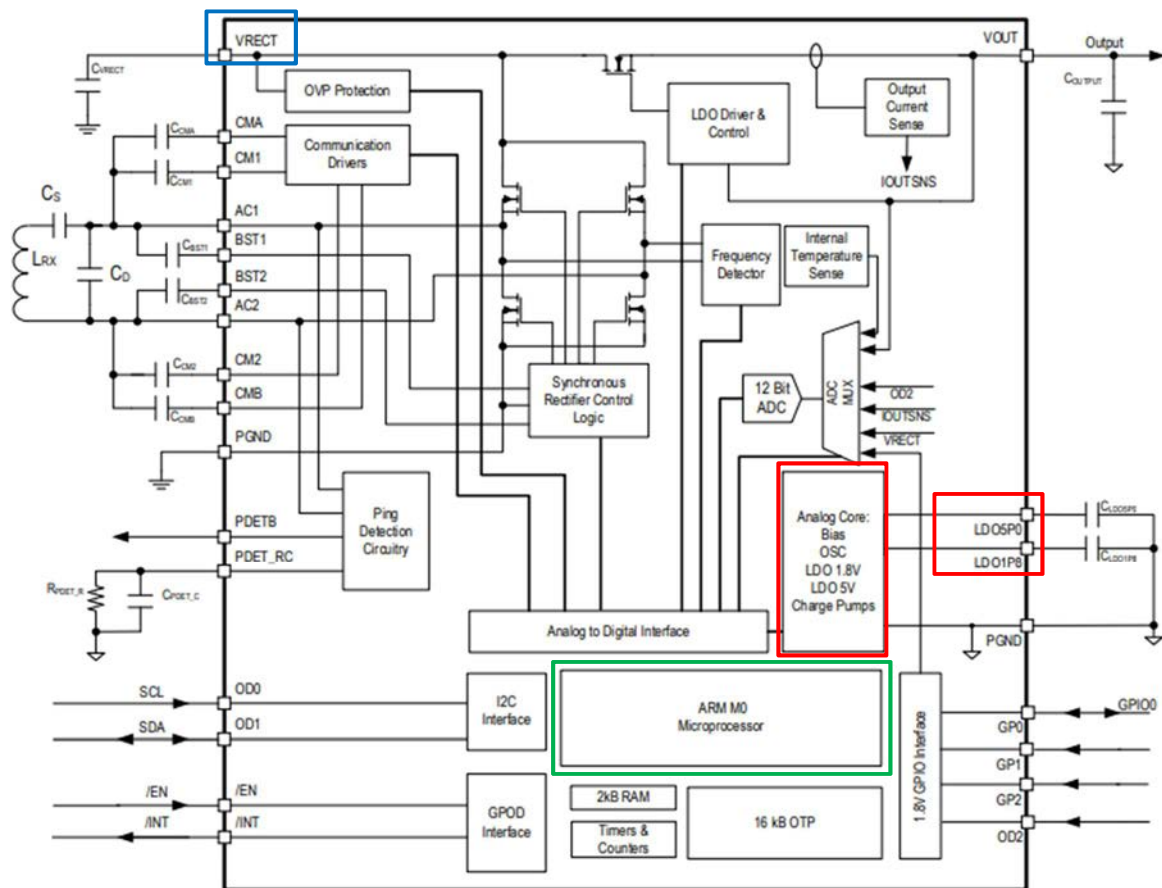
In the Buds2 case, on information and belief, the wireless power ASIC such as the MUA01 includes a voltage regulator as specified by this part of the claim to power its internal microcontroller, similar to the voltage regulator included in the representative 9415 ASIC of the S22 Ultra (above) and/or the representative 9222 ASIC of the Watch4 (below).

Wearables

The Watch4 includes a voltage regulator as specified by this part of the claim. For instance, in the representative 9222 ASIC receiver circuit, there are two Low Drop Out (LDO) regulators, LDO 5V and LDO 1.8V (red rectangles), which provide power to the microcontroller (green rectangle) as seen in the 9222 datasheet below. These LDOs are powered by VRECT (blue rectangle), which is the rectified DC voltage generated in the ASIC by the inductive charging system.

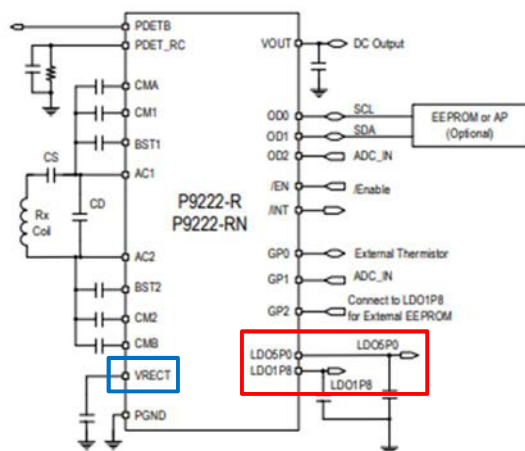
<https://www.renesas.com/us/en/document/dst/p9222-rrn-datasheet>

Figure 2. P9222-R/RN Block and Application Diagram



Block Diagram

Figure 1. Simplified Block Diagram



5.11 Low Drop-Out (LDO) Regulators

The P9222-R/RN has three LDO regulators. The primary VOUT LDO is powered by VRECT. The VOUT LDO can be programmed to any voltage between 3.5V and 10V; however, the output voltage setting should be compatible with the wireless Tx capability and coil type. The LDO5P0 is powered directly from VRECT, and LDO1P8 is powered from LDO5P0. Both are used for supplying power to internal low-voltage blocks. The LDOs must have local ceramic bypass capacitors placed near the P9222-R/RN. For recommended values, follow the application schematic in Figure 36.

5.3 Startup

When a mobile device containing the P9222-R/RN is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "ping" phase, once the rectifier provides a voltage at the VRECT pin above the UVLO threshold, the digital section of the P9222-R/RN enables communication. The control loop of the P9222-R/RN adjusts the rectifier voltage by sending Control Error Packets (CEPs) to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer phase is initiated and the voltage at VRECT (i.e., the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage). For example, if the VOUT voltage target is 5V, the target VRECT voltage is VOUT plus headroom. If the VRECT target voltage is not reached within 1 second after entering the power transfer phase, the VOUT LDO will be enabled automatically.

a battery charging circuit configured 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 is configured to begin drawing current when the output of the receiver rectifier circuit reaches a set minimum voltage value;

The 942 Claim 21 Accused Products meet this part of 942 claim 21 as they each include a battery charging circuit as claimed, as illustrated below for the representative products.

Smartphones

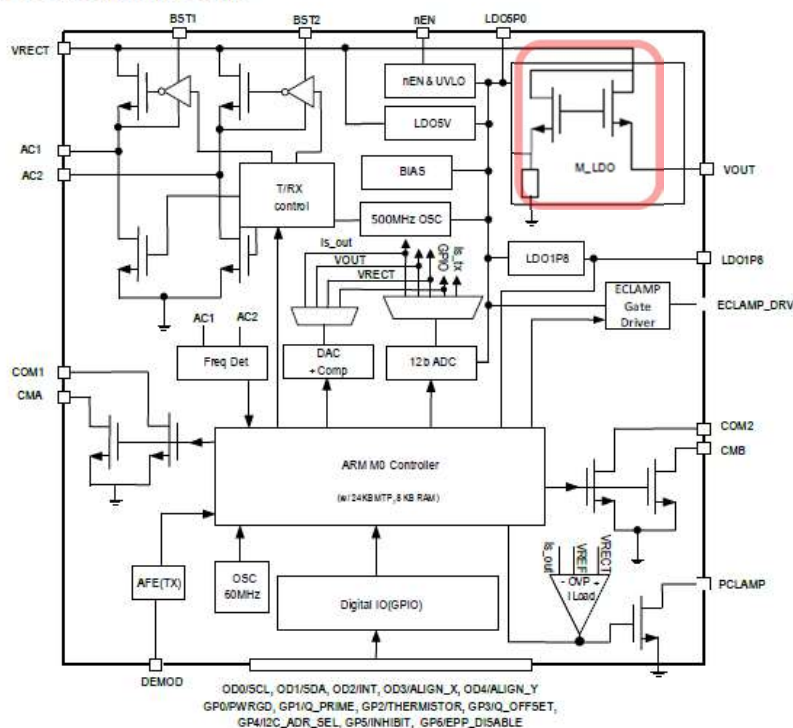
The S22 Ultra includes a battery charging circuit as specified by this part of the claim.

For example, the representative 9415 ASIC includes an MLDO (red rectangle below) that meets this part of the claim.

8. Theory of Operation

The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

Figure 15. Internal Block Diagram



The MLDO is a Low Drop Out (LDO) regulator. The MLDO acts as an output LDO regulator and switch for charging the battery, as described below with respect to the MLDO. The MLDO enables an output at the VOUT pin (which is coupled to the battery for charging the battery) when VRECT reaches a set minimum voltage value, as described below.

8.2 WPC Mode Characteristics

8.2.1 Startup

When a mobile device containing the P9415-R is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "Ping" phase, once the rectifier voltage at the VRECT pin goes above the UVLO threshold, the digital section of the P9415-R enables communication. The control loop of the P9415-R adjusts the rectifier voltage by sending error packets to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer mode is initiated and the voltage at VRECT, the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage. For example, if the VOUT voltage target is 12V, the target VRECT voltage is VOUT + headroom, where the headroom is a function of the output current.

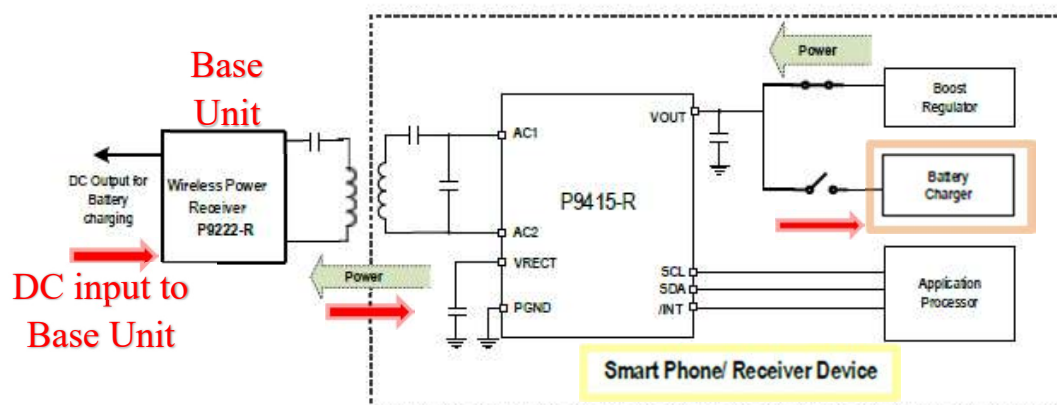
The 9415 datasheet includes an oscilloscope image of the startup for receiving power. The output of the ASIC (Vout in blue below) is enabled when the Vrect (Rectifier output voltage) shown in Yellow below reaches a set minimum voltage value.

Figure 8. Initial Startup Waveform



In addition, the S22 Ultra also may include a “Battery Charger” or Power Management IC (PMIC) (shown on the right in the orange rectangle) external to the wireless power ASIC for further controlling and regulating power for charging the battery as specified by this part of the claim, as seen below in the example application in the representative 9415 datasheet (with the power path to the battery charger circuit in the smartphone labelled).

Figure 21. Enabling WattShare™ (TRx) Mode



An example of such a Battery Charger IC in the S22 Ultra is shown below.

<https://www.techinsights.com/blog/samsung-galaxy-s22-ultra-teardown>



Figure 1. Samsung Galaxy S22 board shot

On information and belief, such an external Battery Charger will have an input voltage minimum lockout so that the Battery Charger operates when a minimum threshold is reached, as specified by this part of the claim. As an example of such a feature in battery chargers, see datasheet for a similar NXP battery charger below:

<https://www.nxp.com/docs/en/data-sheet/PCA9481AUK-SDS.pdf>

PCA9482UK

7 A 2:1, 1:2, and 1:1 mode switched capacitor direct charger
 Rev. 1.0 — 8 November 2022 Short data sheet

1 General description

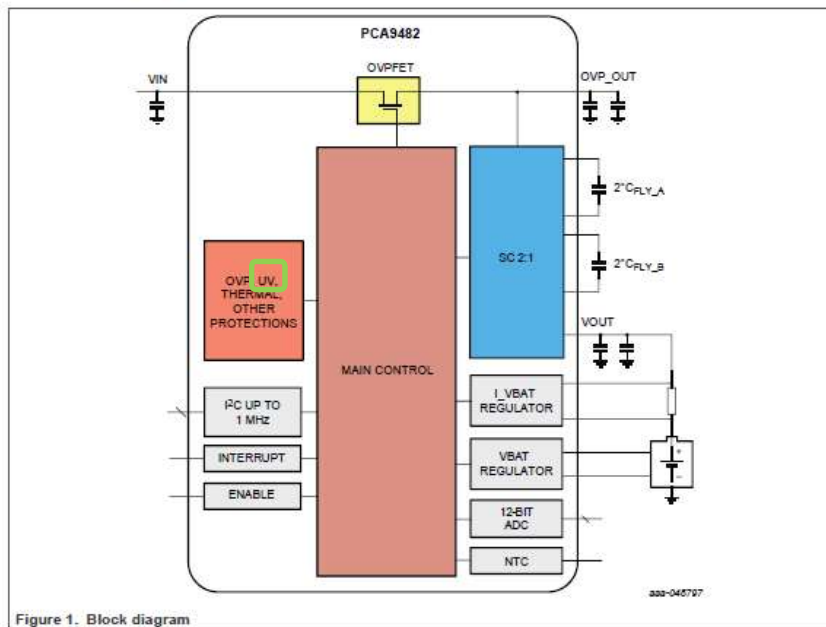
The PCA9482UK is a highly-integrated switched-capacitor converter with an embedded OVPFET, targeted to provide two times the output current for fast charging applications with a 1-cell battery. The device works in 2:1 switching operation with very high efficiency (>96.5 %, at $V_{OUT} = 4\text{ V}$, $I_{OUT} = 5\text{ A}$), in 1:2 switching operation or in 1:1 mode with forward and reverse direction.

As absolute maximum voltage for each VIN and VOUT, VIN input is designed to support up to 16.5 V with no pre-biased scheme and 20 V with the pre-bias enabled for USB VBUS, and VOUT input is designed to support up to 7 V with the pre-bias enabled for a 1-cell battery application.

The device provides multiple safety schemes such as OV (Overvoltage), UV (Undervoltage), switching pin short, thermal shutdown and others.

The device features all the functions with I²C-bus interface, with up to 1 MHz.

5 Block diagram



An NXP battery charger describes the start-up sequence when input voltage to the battery charger exceeds the UnderVoltage LockOut (UVLO) voltage:

<https://www.nxp.com/docs/en/data-sheet/PCA9420DS.pdf>

8.11.3 Power-up/down sequence and on-the-fly voltage change

Power-up sequence

The device initiates the default power-up sequence in three different conditions.

Condition 1) The device is off with no any power supply (No valid VIN and No battery with 2.7 V or above attached). In this condition, two signals below are able to start the default power-up sequence.

- A valid VIN supply on VIN pin
- A voltage on ASYS higher than ASYS_UVLO, a 2.8 V typical

Other suppliers also describe implementation of such a UVLO in their battery chargers.

<https://www.analog.com/media/en/technical-documentation/data-sheets/4002f.pdf>

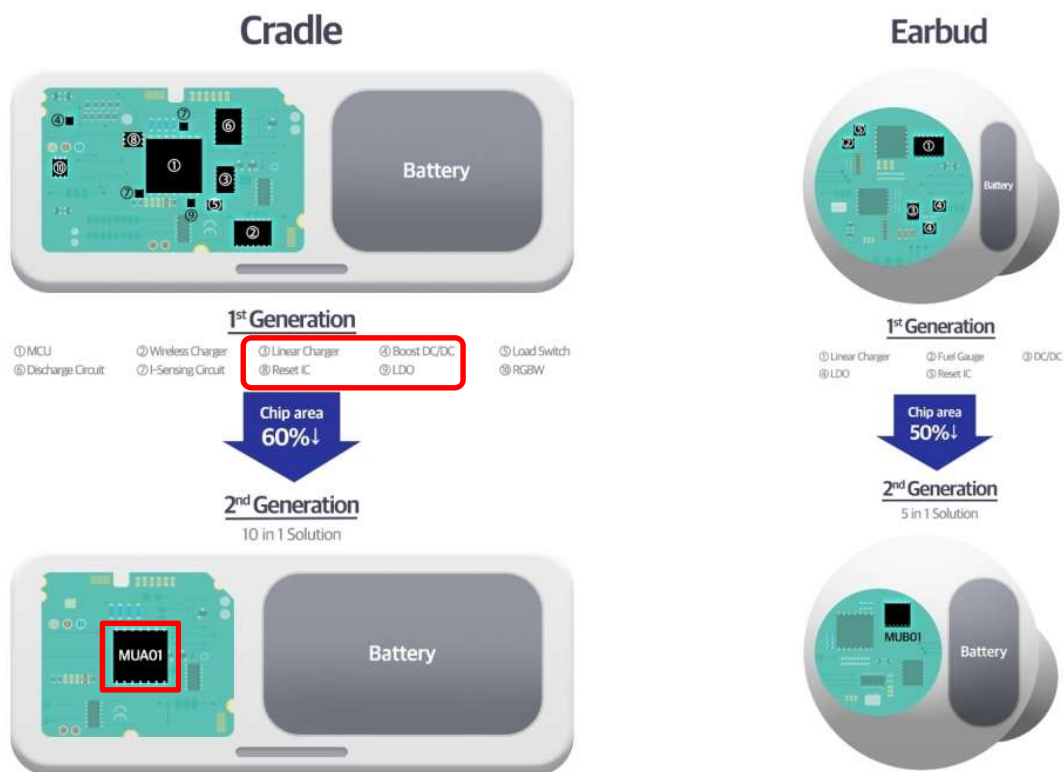
Undervoltage Lockout (UVLO)

An undervoltage lockout circuit monitors the input voltage and keeps the charger off until V_{CC} rises above the UVLO threshold (4.2V for the 4.2 version, 7.5V for the 8.4 version) and at least 250mV above the battery voltage. To

Earbuds

The Buds2 case includes a PMIC, such as the MUA01, which, on information and belief includes a regulator and a battery charging circuit as specified by this part of the claim, with a minimum voltage lockout similar to that in the S22 Ultra (show above with respect to this claim element).

<https://www.sammobile.com/news/samsung-launches-industry-first-power-chipsets-true-wireless-earbuds/>



Wearables

In the Watch4, a battery charging circuit is also present, as specified by this part of the claim, in the wireless power ASIC such as that indicated in the 9222 datasheet, as seen below describing the VOUT LDO with Lock Out that is used to charge the battery.

5.3 Startup

When a mobile device containing the P9222-R/RN is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "ping" phase, once the rectifier provides a voltage at the VRECT pin above the UVLO threshold, the digital section of the P9222-R/RN enables communication. The control loop of the P9222-R/RN adjusts the rectifier voltage by sending Control Error Packets (CEPs) to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer phase is initiated and the voltage at VRECT (i.e., the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage). For example, if the VOUT voltage target is 5V, the target VRECT voltage is VOUT plus headroom. If the VRECT target voltage is not reached within 1 second after entering the power transfer phase, the VOUT LDO will be enabled automatically.

Similarly to the S22 Ultra described above, the Watch4 PMIC / battery charger on information and belief includes additional UnderVoltage LockOut (UVLO) features.

wherein when a current is generated in the coil inductively by the primary coil: the receiver rectifier circuit is configured to rectify and smooth the current, the voltage regulator is configured to use the current to power and activate the microcontroller, and the battery charging circuit is configured to use the current to charge the battery of the portable device; and

The 942 Claim 21 Accused Products meet this part of 942 claim 21 as they each are configured to operate as specified by this part of the claim, namely, the voltage regulator and battery charging circuit identified above are powered inductively and used to power the microcontroller and charge the battery, as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

In the S22 Ultra, inductive power from the base unit during wireless charging powers the voltage regulator (such as LDO5V and LDO1P8 in the representative 9415 ASIC) powering the 9415 ASIC microcontroller and powers the battery charging circuit (such as the MLDO in the 9415 ASIC) as claimed, as seen above with respect to the voltage regulator and battery charging circuit parts of the claim, which are both powered inductively.

Earbuds

The Buds2 case is configured to operate as specified by this part of the claim, as seen above with respect to the voltage regulator and battery charging circuit parts of the claim, which are both powered inductively.

Wearables

The Watch4 is configured to operate is configured to operate as specified by this part of the claim, as seen above with respect to the voltage regulator and battery charging circuit parts of the claim, which are both powered inductively.

wherein upon powering and activation of the receiver circuit by the primary coil, the receiver circuit is configured to:

The 942 Claim 21 Accused Products meet this part of 942 claim 21 as they each include a receiver circuit configured to operate as specified in the remaining parts of the claim, as illustrated below for the representative products with respect to the following subparts of the claim. Upon powering and activation by inductive power, the receiver circuits in the 942 Claim 20 Accused Products are configured to communicate to negotiate and receive wireless power as specified in the remaining parts of the claim.

communicate to the inductive charging system information corresponding to a voltage or current value at the output of the receiver rectifier circuit induced by the primary coil, a unique identifier code, and a power requirement; and

The 942 Claim 21 Accused Products meet this part of 942 claim 21 as they each communicate to the base unit as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

In the S22 Ultra, after its receiver circuit is activated by inductive power, the S22 Ultra proceeds to communicate with the charger through load modulation the information recited by this part of the claim, namely, the initial information specified by this part of the claim, per the WPC Standard so that the base unit can charge the battery of the S22 Ultra.

A high-level description of the information communicated by the receiver to the inductive charging system is shown below. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9.



the electronics of an appropriate load to which it is connected. Conventional transformers use the same effect to achieve inductive power transfer between a primary and a secondary coil that are strongly coupled by means of a magnetic core.

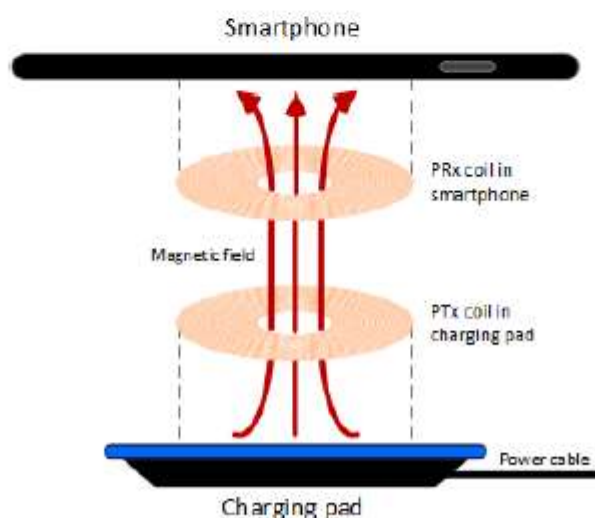
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close to one, whereas a Qi-based system typically has a magnetic coupling coefficient in the range of 0.5 or below.

In the Qi-based system illustrated in Figure 4, power is transferred from the PTx contained in the Qi charging pad to a PRx contained in the Qi smartphone. Before charging begins, the PRx and PTx communicate with each other to establish that the mobile device is indeed capable of being charged, whether it needs to be charged, how much power is required, etc. In short, the communication ensures an appropriate power transfer from the power transmitter to the power receiver. The communication channel can also be used to trigger location based services by providing an SSID, a Bluetooth link, or a unique ID.

When charging begins, the power transmitter runs an alternating electrical current through its coil(s), which generates an alternating magnetic field in accordance with Faraday's law. This magnetic field is in turn picked up by the coil inside the power receiver and transformed by a power converter back into an alternating electrical current that can be used to charge the battery.

A critical feature of the magnetic field is that it can transfer through any non-metallic, non-ferrous materials, such as plastics, glass, water, wood, and air. In other words, wires and connectors are not needed between the power transmitter and power receiver.

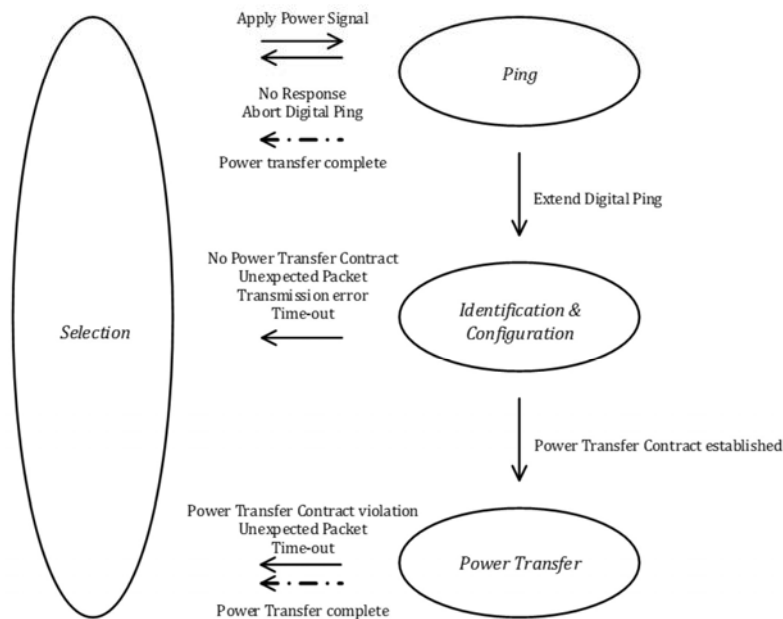
Figure 6. Qi wireless power transfer using magnetic induction



The main phases of WPC Standard in Baseline Power Profile (BPP operating at < 5W) are shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 45 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 45).



Figure 16. Power transfer phases—Baseline Power Profile



From the receiver perspective, the WPC Standard phases are shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 71 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 70).



5.1.3 Power Receiver (PRx) perspective

This section defines the protocol that a Power Receiver shall execute to receive power from a Power Transmitter. Each of the seven phases is defined in a separate subsection of this section:

- **Selection phase.** Section 5.1.3.1 defines the initial Response of the Power Receiver to the application of a Power Signal. As part of this initial Response, the Power Receiver wakes up its Communications and Control Unit—if that is not already up and running.
- **Ping phase.** Section 5.1.3.2 defines the Response of a Power Receiver to a Digital Ping. This Response ensures the Power Transmitter that it is dealing with a Power Receiver rather than some unknown object.
- **Identification & configuration phase.** Section 5.1.3.3 defines the Response of a Power Receiver to an extended Digital Ping. In this phase, the Power Receiver identifies itself and provides information for a default Power Transfer Contract.
- **Negotiation phase (Extended Power profile only).** Section 5.1.3.4 defines the part of the protocol in which the Power Receiver negotiates changes to the default Power Transfer Contract. In addition, the Power Receiver verifies that the Power Transmitter has not detected a Foreign Object (so far).
- **Calibration phase (Extended Power Profile only).** Section 5.1.3.5 defines the part of the Protocol that the Power Receiver shall execute during the *calibration* phase. In this phase, the Power Receiver provides information that the Power Transmitter can use to improve its ability to detect Foreign Objects during power transfer.
- **Power transfer phase.** Section 5.1.3.6 defines the part of the protocol that the Power Receiver shall execute during power transfer.
- **Renegotiation phase (Extended Power Profile only).** Section 5.1.3.7 defines the part of the protocol that the Power Receiver can execute to request modification of the Power Contract.

Many provisions in this section refer to the start and/or the end of a Packet, or the start of a Packet's preamble. In the case that a Packet is sent from the Power Receiver to the Power Transmitter,

- the start of a Packet is defined as the instant that the Power Receiver transmits the first edge of the start bit of the Packet's header byte;
- the end of a Packet is defined as the instant that the Power Receiver transmits the second edge of the stop bit of the Packet's checksum byte; and
- the start of a Packet's preamble is defined as the instant that the Power Receiver transmits the first edge of the first preamble bit.

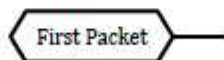
Initially, the receiver circuit in the S22 Ultra receives inductive power from the base unit (ping) for a period of time sufficiently long to wake up the receiver circuit and so that the receiver circuit can communicate with the base unit. The receiver circuit upon being activated, initially sends information corresponding to a voltage at the output of the receiver circuit (i.e. Signal Strength Packet) followed by Identification and Configuration Packets. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 74 and 93 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 73, 91).



5.1.3.2 Ping phase (PRx perspective)

If the Power Receiver responds to the Digital Ping, the Power Receiver shall transmit either a Signal Strength Packet or an End Power Transfer Packet as its first Packet. The Power Receiver shall transmit this first Packet immediately upon entering the *ping* phase.

Figure 28. Power Receiver timing in the ping phase



After the Power Receiver has transmitted a Signal Strength Packet, the Power Receiver shall proceed to the *identification & configuration* phase. After the Power Receiver has transmitted an End Power Transfer Packet, it shall remain in the *ping* phase. In that case, the Power Receiver should transmit additional End Power Transfer Packets.⁶

5.1.3.3 Identification & configuration phase (PRx perspective)

In the *identification & configuration* phase, the Power Receiver shall transmit the following sequence of Packets:

- If the Power Receiver enters the *identification & configuration* phase from the *ping* phase, an Identification Packet.
- If the Ext bit of the preceding Identification Packet is set to ONE, an Extended Identification Packet.
- Up to 7 optional configuration Packets from the following set (the order in which the Power Receiver transmits these Packets, if any, is not relevant):
 - A Power Control Hold-off Packet. The Power Control Hold-off Time t_{delay} contained in this Packet shall satisfy the relation $t_{\text{delay}}^{(\text{min})} \leq t_{\text{delay}} \leq t_{\text{delay}}^{(\text{max})}$. See Table 10.
 - Any Proprietary Packet (as listed in Table 26).
- A Configuration Packet.

5.2.3.1 Signal Strength Packet (0x01)

Table 27 defines the format of the message contained in a Signal Strength Packet.

Table 27. Signal strength

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Signal Strength Value							

Signal Strength Value. The unsigned integer value in this field indicates the degree of coupling between the Primary Cell and Secondary Coil, with the purpose to enable Power Transmitters that use Free Positioning to determine the Primary Cell that provides optimum power transfer (see also Annex B, *Power Receiver Localization (Informative)*). To determine the degree of coupling, the Power Receiver shall monitor the value of a suitable variable during a Digital Ping. Examples of such variables are:

- The rectified voltage.
- The open circuit voltage (as measured at the output disconnect switch).
- The received Power (if the rectified voltage is actively or passively clamped during a Digital Ping).

The variable that is chosen shall result in a Signal Strength Value that increases monotonically with an increasing degree of coupling. The Signal Strength Value is reported as

$$\text{Signal Strength Value} = \frac{U}{U_{\max}} \cdot 255,$$

where U is the monitored variable and $U_{\max}$ is the maximum value that the Power Receiver expects during a Digital Ping.

NOTE The Power Receiver shall set the Signal Strength Value to 255 in the case that $U \geq U_{\max}$.

Following the Ping phase, the receiver moves to the Identification and Configuration phase:



P9415-R Datasheet

8.2.10 Identification and Configuration (ID and Config)

In this phase, the P9415-R sends or expects the following packets:

- Identification Packet
- Configuration Packet

After the transmission of the Configuration Packet, the P9415-R proceeds to the Negotiation phase.

The identifying information communicated by the receiver circuit includes the following. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 71, 74, and 101 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 70, 73, 99).

- **Identification & configuration phase.** Section 5.1.3.3 defines the Response of a Power Receiver to an extended Digital Ping. In this phase, the Power Receiver identifies itself and provides information for a default Power Transfer Contract.

5.1.3.3 Identification & configuration phase (PRx perspective)

In the *identification & configuration* phase, the Power Receiver shall transmit the following sequence of Packets:

- If the Power Receiver enters the *identification & configuration* phase from the *ping* phase, an Identification Packet.



The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
Power Class 0 Specification

Version 1.2.3

Information interface

Basic Device Identifier. The bit string contained in this field contributes to the identification of the Power Receiver. A Power Receiver manufacturer should ensure that the combination of Basic Device Identifier and Manufacturer ID is sufficiently unique. Embedding a serial number of at least 20 bits in the Basic Device Identifier is sufficient. Alternatively, using a (pseudo) random number generator to dynamically generate part of the Basic Device Identifier is sufficient as well, provided that the generated part complies with the following requirements.

- The generated part shall comprise at least 20 bits.
- All possible values shall occur with equal probability.
- The Power Receiver shall not change the generated part while the Power Signal is applied.
- The Power Receiver shall retain the generated part for at least 2 seconds if the Power Signal is interrupted or removed.

NOTE These requirements ensure that the scanning procedure of a type B1 Power Transmitter proceeds correctly. See Annex B.2, *Primary Coil array based Free Positioning*.

5.2.3.9 Wireless Power ID Packets (0x54 and 0x55)

Table 37 shows the format of the message payload contained in the Wireless Power Identification Packets.

Table 37. WP Identification Packets

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	(MSB) WPID (LSB)							
B ₁								
B ₂								
B ₃	(MSB) CRC (LSB)							
B ₄								

The fields of these data Packets have the following purpose:

- **CRC**—unsigned integer. This field shall contain the Cyclic Redundancy Check (CRC) of the WPID field in this Packet. The CRC-16 value shall be calculated as defined in Section 5.2.3.9.1.
- **WPID**—bit string. This field shall contain the 24 most significant bits (Packet 0x54) or the 24 least significant bits (Packet 0x55) of the identifier that uniquely identifies the Power Receiver. For more information, see Section 5.1.3.4.2.4.

The Identification communication is further described below and includes a unique identification code, a manufacturer code, and a charge algorithm profile. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 100-101 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 98-99).



5.2.3.8 Identification Packet (0x71)

Table 35 defines the format of the message contained in an Identification Packet.

Table 35. Identification

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Major Version				Minor Version			
B ₁	(MSB)							
B ₂	Manufacturer Code							(LSB)
B ₃	Ext	(MSB)						
⋮	Basic Device Identifier							
B ₆	(LSB)							

Major Version. The combination of this field and the Minor Version field identifies to which revision of this Specification the Power Receiver complies. The Major Version field shall contain the binary coded digit value 0x1.

Minor Version. The combination of this field and the Major Version field identifies to which minor revision of this Specification the Power Receiver complies. The Minor Version field shall be set according to the power profile of the Power Receiver.

Table 36. Minor Version field settings

PRx Power Profile	Minor Version Setting	Neg Bit
Baseline Power Profile	0x1 or 0x2	ZERO
Extended Power Profile	0x2	ONE

Manufacturer Code. The bit string contained in this field identifies the manufacturer of the Power Receiver, as specified in the Power Receiver Manufacturer Codes, Wireless Power Consortium.



Basic Device Identifier. The bit string contained in this field contributes to the identification of the Power Receiver. A Power Receiver manufacturer should ensure that the combination of Basic Device Identifier and Manufacturer ID is sufficiently unique. Embedding a serial number of at least 20 bits in the Basic Device Identifier is sufficient. Alternatively, using a (pseudo) random number generator to dynamically generate part of the Basic Device Identifier is sufficient as well, provided that the generated part complies with the following requirements.

The configuration packet includes the receiver power requirement information transmitted to the base unit. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 98 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 96).



5.2.3.7 Configuration Packet (0x51)

Table 34 defines the format of the message contained in a Configuration Packet.

Table 34. Message in a Configuration Packet

	b ₇	b ₆	b ₅	b ₄	b ₃	b ₂	b ₁	b ₀
B ₀	Power Class		Maximum Power Value					
B ₁	Reserved							
B ₂	Prop	Reserved			ZERO		Count	
B ₃	Window Size					Window Offset		
B ₄	Neg	Polarity*	Depth*		Reserved			

* In the Baseline Power Profile, these bits are Reserved.

Power Class This field shall be set to '00'.

Maximum Power Value

(Baseline Power Profile) Apart from a scaling factor, the unsigned integer value contained in this field indicates the maximum amount of power that the Power Receiver expects to provide at the output of the rectifier. This maximum amount of power is calculated as follows:

$$P_{\max} = \left(\frac{\text{Maximum Power Value}}{2} \right) \times 10^{\text{Power Class } W}.$$

Earbuds

The Buds2 case is configured to communicate as specified by this part of the claim, per the WPC Standard, as seen above with respect to the S22 Ultra.

Wearables

The Watch4 is configured to communicate as specified by this part of the claim, as set forth in the WPC Standard, as seen above with respect to the S22 Ultra, which the Watch4 follows in relevant respects.

That the representative Watch4 communicates with the base unit as claimed is also reflected by the representative 9222 datasheet, e.g.:

7.5 System Feedback Control

The P9222-R/RN is fully compatible with WPC (Baseline Power Profile) and has all the necessary circuitry to communicate with the base station via WPC communication packets. The overall WPC system behavior between the transmitter and the receiver follows the state machine shown in Figure 25.

The P9222-R/RN goes through four phases:

1. Selection
2. Ping
3. Identification and Configuration
4. Power Transfer

periodically communicate to the inductive charging system additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the inductive charging system to regulate in a closed loop feedback manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device.

The 942 Claim 20 Accused Products meet this part of 942 claim 20 as they each communicate to the base unit as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

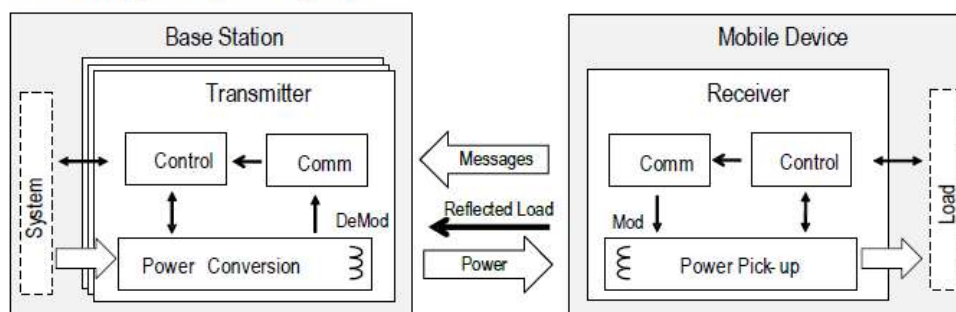
The S22 Ultra periodically communicates to the base unit as claimed. This is reflected by the representative 9415 datasheet and the WPC Standard, as shown below.

6. Wireless Power Charging System

A wireless power charging system has a base station with one or more transmitters that make power available via DC-to-AC inverter(s), and transmit the power over a strongly-coupled inductor pair (magnetic induction) or over a loosely-coupled inductor pair (magnetic resonance) to a receiver in a mobile device. A WPC¹ system uses near field magnetic induction between coils and can be a free-positioning or magnetically-guided type of system.

In WPC systems, the amount of power transferred to the mobile device is controlled by the receiver. The receiver sends communication packets to the transmitter to increase power, decrease power, or maintain the power level. The bit rate for Rx-to-Tx communication link is 2kbps for WPC receivers and is amplitude modulated (ASK) on top of the power link that exists.

Figure 2. Block Diagram of WPC System



8.1 Overview

The simplified internal block diagram of the P9415-R is shown in Figure 15. External Rx coil(s) and CS capacitor(s) as shown in Figure 1 transfer energy wirelessly using the P9415-R AC1 and AC2 pins to be full-wave-rectified (AC-to-DC).

The wireless power is stored on a capacitor(s) connected to VRECT. Until the voltage across the VRECT capacitor exceeds the UVLO threshold, the rectification is performed by the body diodes of the Synchronous Full Bridge Rectifier FETs. After the internal biasing circuit is enabled, the Driver and Control block operate the MOSFET switches of the rectifier in various modes to maintain reliable connections at optimal efficiency. An internal ADC monitors the voltage at VRECT and the load current, the P9415-R sends instructions to the wireless power transmitter to increase or decrease the amount of power transferred or to terminate power transmission based on these readings. The voltage at the output of the P9415-R Main Low-Drop-Out (LDO) regulator is programmed up to 20V using I2C commands. The internal temperature is continuously monitored to ensure proper operation.

The voltage at VRECT and the current through the rectifier are sampled periodically and digitized by the ADC. The digital equivalents of the voltage and current are supplied to the internal control logic, which decides whether the loading conditions on VRECT indicate that a change in the operating point is required. If the load is heavy enough to bring the voltage at VRECT below its target, the transmitter is instructed to move its frequency lower, closer to resonance. If the voltage at VRECT is higher than its target, the transmitter is instructed to increase its frequency. To maximize efficiency, the voltage at VRECT is programmed to decrease as the LDO's load current increases.

8.2 WPC Mode Characteristics

8.2.1 Startup

When a mobile device containing the P9415-R is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "Ping" phase, once the rectifier voltage at the VRECT pin goes above the UVLO threshold, the digital section of the P9415-R enables communication. The control loop of the P9415-R adjusts the rectifier voltage by sending error packets to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer mode is initiated and the voltage at VRECT, the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage. For example, if the VOUT voltage target is 12V, the target VRECT voltage is VOUT + headroom, where the headroom is a function of the output current.

8.2.2 Power Transfer

Once the "identification and configuration" phase is completed and successful "negotiation and calibration" is made, then the transmitter initiates power transfer mode. The P9415-R control circuit measures the rectifier voltage and sends error packets to the transmitter to adjust the rectifier voltage to the level required to maximize the efficiency of the main LDO linear regulator and to notify the Tx of the current Rectified Power Packet for Foreign Object Detection (FOD) to guarantee safe efficient power transfer. The P9415-R is compatible with the WPC 1.2.4 Specification, and can use compatible Rx coils. Each receiver coil type has a unique inductance value. As such, a unique resonant capacitor (Cs) is used for a given type of receiver coil.

8.2.7 System Feedback Control

The P9415-R is fully compatible with WPC (latest specification) and has all necessary circuitry to communicate with the base station or with a receiver via WPC communication packets. The overall WPC system behavior between the transmitter and the receiver follows the state machine in Figure 20.

8.2.13 Power Transfer

In this phase, the P9415-R controls the power transfer by means of the following Control Data Packets:

- Control Error Packets
- Rectified Power Packet
- End Power Transfer Packet

This is also reflected in the WPC Standard.

Per the WPC standard, the S22 Ultra communicates this information to the base unit so that the base unit can use the information to control the inductive charging in a closed loop feedback manner. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 46-47, 12 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 46-47, 12).



Throughout the *power transfer* phase, the Power Transmitter and Power Receiver control the amount of power that is transferred. Figure 17 illustrates a schematic diagram of the power transfer control loop, which basically operates as follows: the Power Receiver selects a desired Control Point: a desired output current and/or voltage, a temperature measured somewhere in the Mobile Device, etc. In addition, the Power Receiver determines its actual Control Point. The Power Receiver may use any approach to determine a Control Point. Moreover, the Power Receiver may change this approach at any time during the *power transfer* phase. Using the desired Control Point and actual Control Point, the Power Receiver calculates a Control Error Value—for example, by simply taking the (relative) difference of the two output voltages or currents. The result is negative if the Power Receiver requires less power in order to reach its desired Control Point and positive if the Power Receiver requires more power in order to reach its desired Control Point. Subsequently, the Power Receiver transmits this Control Error Value to the Power Transmitter.



The Power Transmitter uses the Control Error Value and the actual Primary Cell current to determine a new Primary Cell current. After the system stabilizes from the communications of the Control Error Packet, the Power Transmitter has a short time window to control its actual Primary Cell current towards the new Primary Cell current. Within this window, the Power Transmitter reaches a new Operating Point: the amplitude, frequency, and duty cycle of the AC voltage that is applied to the Primary Cell. Subsequently, the Power Transmitter keeps its Operating Point fixed in order to enable the Power Receiver to communicate additional control and status information. For details, see Section 5.1.2.6.1, *Power transfer control*.

Figure 17. Power transfer control loop

Operating Point The combination of the frequency, duty cycle, and amplitude of the voltage that is
f applied to the Primary Cell.



The Power Transmitter uses the Control Error Value and the actual Primary Cell current to determine a new Primary Cell current. After the system stabilizes from the communications of the Control Error Packet, the Power Transmitter has a short time window to control its actual Primary Cell current towards the new Primary Cell current. Within this window, the Power Transmitter reaches a new Operating Point: the amplitude, frequency, and duty cycle of the AC voltage that is applied to the Primary Cell. Subsequently, the Power Transmitter keeps its Operating Point fixed in order to enable the Power Receiver to communicate additional control and status information. For details, see Section 5.1.2.6.1, *Power transfer control*.

Earbuds

The Buds2 case is configured to communicate as specified by this part of the claim, per the WPC Standard, as seen above with respect to the S22 Ultra.

Wearables

The Watch4 is configured to communicate as specified by this part of the claim, as set forth in the WPC Standard, as seen above with respect to the S22 Ultra, which the Watch4 follows in relevant respects.

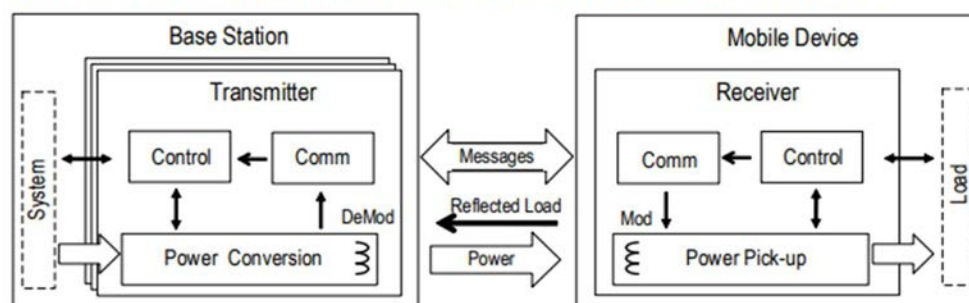
That the representative Watch4 periodically communicates with the base unit as claimed is also reflected by the representative 9222 datasheet.

3. Description of the Wireless Power Charging System

A wireless power charging system has a base station with one or more transmitter coils that make power available via DC-to-AC inverter(s) and transmit the power over a strongly-coupled inductor pair (magnetic induction), or over a loosely-coupled inductor pair (magnetic resonance) to a receiver in a mobile device. A WPC (see Figure 4) uses near-field magnetic induction between coils and can be a free-positioning or magnetically-guided type of system.

In WPC Inductive systems, the amount of power transferred to the mobile device is controlled by the receiver. The receiver sends communication packets to the transmitter to increase power, decrease power, or maintain the power level. The bit rate for the Rx-to-Tx communication link is 2kbps for WPC receivers. It is modulated on top of the power link that exists.

Figure 4. Block Diagram of WPC Compliant Wireless Power Transfer System



5.1 Overview

The simplified internal block diagram of the P9222-R/RN is shown in Figure 2. Energy is transferred wirelessly from the transmitter to the P9222-R/RN via an external Rx coil and C_S capacitor(s). The external LC is connected to the AC1 and AC2 pins to be full-wave-rectified (AC-to-DC).

5.1.1 Low-Power Ping Detection

Once charging has completed, the wireless power connection to the Tx can be programmed to terminate to save power. In order to inform the system that the P9222-R/RN is still on the charger, the PDET pin will be held LOW as long as Tx ping pulses are detected. The resistor and capacitor (RC) connected to the PDET_RC pin should be selected such that the time constant of the RC maintains an adequate charge between Tx ping events to prevent PDET from changing states until the device is removed from the Tx. The values of the RC circuit should be selected based on the expected ping time interval of the Tx. For more information, see "Low-Power Ping Detection Operation".

5.1.2 Rx Operation

The wireless power is stored on a capacitor(s) connected to the VRECT pin in Rx mode. Until the voltage across the VRECT capacitor exceeds the under-voltage lock-out (UVLO) threshold, the rectification is performed by the body diodes of the synchronous full bridge rectifier FETs. After the internal biasing circuit is enabled, the driver and control blocks operate the MOSFET switches of the rectifier in various modes to maintain reliable connections and optimal efficiency. An internal ADC monitors the voltage at VRECT and the load current. The P9222-R/RN sends instructions to the wireless power transmitter to increase or decrease the amount of power transferred or to terminate power transmission based on these readings. The LDO VOUT pin can be pre-programmed from 3.5V up to 12V or changed after startup using I²C commands. The headroom and target VRECT value will automatically adjust based on the latest VOUT set-point programmed value. The internal temperature is continuously monitored to ensure proper operation.

5.2 Wireless Power Control

The voltage at VRECT and the current through the rectifier are sampled periodically and digitized by the ADC. The digital equivalents of the voltage and current are supplied to the internal control logic, which decides whether the loading conditions on VRECT indicate that a change in the operating point is required. If the load is heavy enough to bring the voltage at VRECT below its target, the transmitter is instructed to move its frequency lower, closer to resonance. If the voltage at VRECT is higher than its target, the transmitter is instructed to increase its frequency. To maximize efficiency, the voltage at VRECT is programmed to decrease as the LDO's load current increases.

5.3 Startup

When a mobile device containing the P9222-R/RN is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "ping" phase, once the rectifier provides a voltage at the VRECT pin above the UVLO threshold, the digital section of the P9222-R/RN enables communication. The control loop of the P9222-R/RN adjusts the rectifier voltage by sending Control Error Packets (CEPs) to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer phase is initiated and the voltage at VRECT (i.e., the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage). For example, if the VOUT voltage target is 5V, the target VRECT voltage is VOUT plus headroom. If the VRECT target voltage is not reached within 1 second after entering the power transfer phase, the VOUT LDO will be enabled automatically.

5.4 Power Transfer

Once the "identification and configuration" phase is completed then the transmitter initiates the power transfer mode. The P9222-R/RN control circuit measures the rectifier voltage, sends CEPs to the transmitter to adjust the rectifier voltage to the level required to maximize the efficiency of the linear regulator, and sends Received Power Packets (RPPs) to notify the Tx of the current for foreign object detection (FOD) to guarantee safe, efficient power transfer. For more information about WPC-compliant power transfer, see "WPC-Compliant Power Transfer."

7.5 System Feedback Control

The P9222-R/RN is fully compatible with WPC (Baseline Power Profile) and has all the necessary circuitry to communicate with the base station via WPC communication packets. The overall WPC system behavior between the transmitter and the receiver follows the state machine shown in Figure 25.

The P9222-R/RN goes through four phases:

1. Selection
2. Ping
3. Identification and Configuration
4. Power Transfer

7.5.4 Power Transfer

In the "Power Transfer" phase, the P9222-R/RN controls the power transfer by means of the following control data packets:

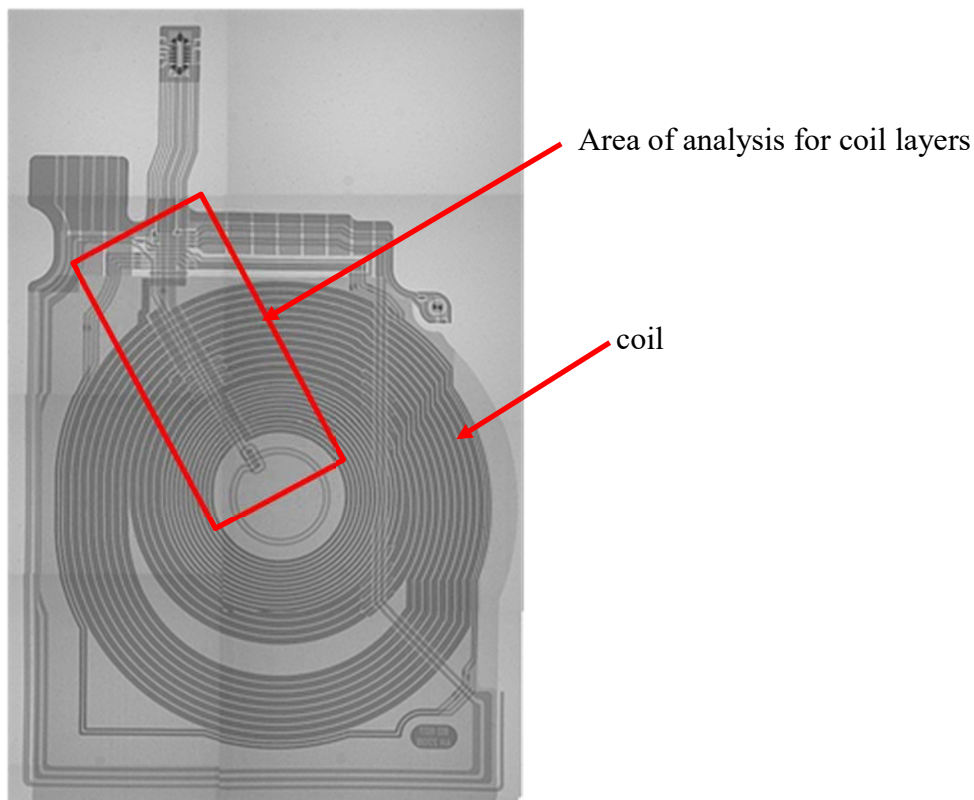
- Control Error Packets (CEP)
- Rectified Power Packet (RPP)
- End Power Transfer Packet (EPT)

22. The portable device of claim 21, wherein the coil is formed in a flexible Printed Circuit Board (PCB) of multiple layers of substantially spiral-shaped conductor coil patterns electrically connected with vias.

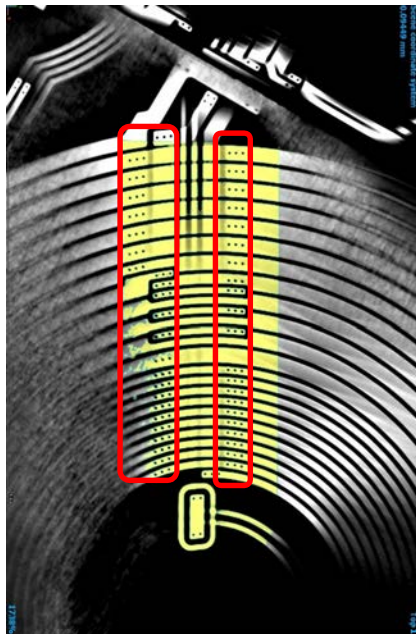
The 942 Claim 21 Accused Products additionally infringe this dependent claim, as they include coils and PCBs and specified by this claim.

Smartphones

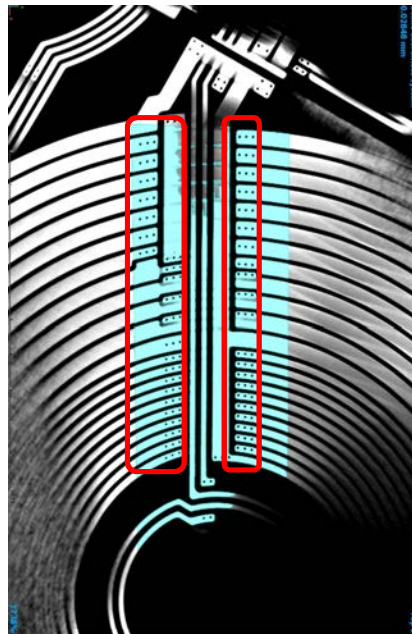
The representative S22 Ultra comprises a coil as shown below in the top-view x-ray. The area shown in Red Rectangle is further analyzed with 3D x-ray imagery.



The two images below with 3D x-ray imagery distinguish between the two coil layers present. The images show the substantially spiral-shaped coil patterns in each layer. The vias connecting the two layers (black dots) are shown in the 2 below images in the red rectangles.



Coil Layer 1



Coil Layer 2

23. The portable device of claim 21, further comprising a magnetic core of ferromagnetic material within a central area of the coil and a near field communication (NFC) antenna and circuitry for communication of data with other devices.

The 942 Claim 21 Accused Products which are smartphones and watches additionally infringe this dependent claim, as they include a magnetic core and NFC antenna and circuitry as specified by this claim, as illustrated below for the representative products.

Smartphones

The S22 Ultra includes an NFC Antenna as shown in claim 10 above. The S22 Ultra further includes circuitry for NFC functionality for communication with other devices, as shown below.

https://www.samsung.com/hk_en/nfc-support/



Using the NFC feature

Use the NFC feature to send images or contacts to other devices, and read product information from NFC tags. If you insert a SIM or USIM card that has a payment feature, you can use the device to make payments conveniently.

On the Apps screen, tap **Settings** → **NFC** and then drag the **NFC** switch to the right. Place the NFC antenna area on the back of your device near an NFC tag. The information from the tag will appear.

Making a purchase with the NFC feature

Before you can use the NFC feature to make payments, you must register for the mobile payment service. To register or get details about the service, contact your service provider.

On the Apps screen, tap **Settings** → **NFC**, and then drag the **NFC** switch to the right. Touch the NFC antenna area on the back of your device to the NFC card reader. To set the default payment app, tap **Tap and pay** and select an app. The Payment services list may not be included in payment apps.

 The Payment services list may not be included in payment apps.

NFC detection area

 NFC detection area[#]

Galaxy S22 Ultra



Samsung Galaxy S22 Ultra

Furthermore, the S22 Ultra comprises circuitry for NFC communication of data.

<https://www.techinsights.com/blog/samsung-galaxy-s22-ultra-teardown>



Figure 1. Samsung Galaxy S22 board shot

The S22 Ultra also includes a magnetic core of ferromagnetic material within a central area of the coil, as shown in claim 13 above.

Wearables

The Watch4 includes an NFC Antenna and circuitry for communication with other devices.

<https://www.samsung.com/global/galaxy/galaxy-watch4/specs/>

Connectivity

LTE, Bluetooth® 5.0, Wi-Fi 802.11 a/b/g/n 2.4+5GHz,
 NFC, A-GPS/GLONASS/Beidou/Galileo

*Beidou may not be available in certain regions.
 *LTE connectivity only available in LTE models.

[VIEW MORE CARRIERS](#)

On information and belief, the Watch4 also includes a magnetic core of ferromagnetic material within a central area of the receiver coil.

24. The portable device of claim 21, 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.

The 942 Claim 21 Accused Products additionally infringe this dependent claim, as the included receiver circuit includes a limiter that is structured and operates as specified by this claim, as illustrated below for the representative products.

Smartphones

The S22 Ultra includes a limiter as specified by this dependent claim. For example, the representative 9415 ASIC datasheet shows multiple built-in and optional external features limiting the output voltage of the receiver rectifier circuit as shown below.



P9415-R Datasheet

8.3.3 Over-Voltage Protection

If VRECT voltage increases above 90% of the OVP voltage set point, the P9415-R turns on the internal clamp to bring the rectifier voltage back to a safe operating level. If the Vrect voltage increases above the OVP voltage set point, the P9415-R sends an interrupt to the AP to notify Over-voltage condition. The internal clamp is released when the VRECT voltage falls below 90% of the OVP voltage set point. The default OVP voltage setpoint is 18.04V for EPP and 14.66V for BPP mode and both are programmable.

9.8 PCLAMP Connection

The P9415-R has an internal automatic DC clamping feature to protect the device from events that cause high voltages to occur on the AC or DC side of the rectifier. The clamping engages by the VRECT connection to the PCLAMP pin. The VRECT node must be connected to the PCLAMP pin at all times during Rx mode operation. For greater than 5W operation, the VRECT node is connected to the PCLAMP pin using a 50Ω to 100Ω resistor with greater than 1/4W rating with 2.5x or greater over-power surge capability. For space-constrained designs, the PCLAMP pin can be directly connected to the VRECT node for 5W or lower power operation.

Also, there is an option for external FET and resistor clamping by the use of the ECLAMP_DRV pin which can output 5V to drive the gate of external MOSFET. This output is synchronized with the internal PCLAMP signal. ECLAMP_DRV can provide additional clamping capability as needed and there is no thermal increase in the IC side because clamping energy is consumed in external components.

9.9 Transient Voltage Suppressors

The Transient Voltage Suppressor (TVS) is an active device that will direct high voltages from the input to ground, thus protecting the wireless power device or other downstream ICs from being exposed to high voltages.

Transient Voltage Suppressor diodes should be added to the design from the AC1 and AC2 nodes to GND or from AC1 to AC2. These components are useful to rapidly limit incoming ESD surges or situations when the TX incoming power exceeds the expected power and VRECT voltage rises above target and Over-voltage protection threshold in less than 10μs to aid in voltage limiting the incoming AC waveforms in conjunction with the PCLAMP power limiting circuitry.

A balance in Reverse Standoff Voltage (VRWM), Clamping Voltage (VCL), Break-down Voltage (VBR) relative to the expected Vrect operating voltage Vrect (be sure minimum VBR is less than maximum operating Vrect value and that VCL is less than Vrect Absolute maximum voltage) should be reached.

Table 6. Transient Voltage Suppressors (TVS) Recommendations

V_{MLDO} = 12V D24V0L1B2LP
VRWM = 24V maximum
VBR = 26V minimum at 1mA
VCL = 42V maximum at 1A pp

Over-voltage Protection						
V _{OVP}	Over-voltage Protection	OVP interrupt rising voltage on VRECT (Default setting)		14.7 (BPP) 18 (EPP)		V
V _{OVP-HYS}	Over-voltage Hysteresis			1.5		V
V _{PCLAMP}	Pclamp Over-voltage Protection	Pre-clamp OVP, rising voltage on VRECT		13.2 (BPP) 16.2 (EPP)		V

Power Receiver Mode

P9415-R Datasheet

Features

- Delivers up to 15W as a receiver
- WattShare™ (TRx) mode with up to 5W Tx capability
- 24kB Multiple-time programmable (MTP) non-volatile memory
- WPC 1.3 Specification hardware ready
- 2.5V Under-Voltage Lockout (UVLO) threshold for expanding the charging area
- Internal reverse current sense for WattShare™ mode
- **Reliable VRECT over-voltage clamping**
- Internal IOUT filtering to remove the battery charger current ripple
- Supports Bi-Directional communications
- Supports X-Y alignment coils
- The device is capable of delivering 30W using a custom firmware
- Embedded 32-bit ARM® Cortex®-M0 processor
- Supports I2C 400kHz standard interface and GPIOs
- Package: 6 × 9 ball array, 2.82 × 4.22 × 0.50 mm, 53-WLCSP with 0.40mm ball pitch

Earbuds

The Buds2 includes an MUA01 ASIC as described in claim 20 above. On information and belief, the wireless charging receiver section of the representative MUA01 PMIC included in the Buds2 case includes an overvoltage protection circuit for the rectifier output as required by this claim similar to that seen for the representative 9415 ASIC with respect to the S22 Ultra and/or the representative 9222 ASIC with respect to the Watch4.

Wearables

The Watch4 includes a 9222 ASIC as shown above in claim 21. On information and belief, this ASIC has an overvoltage protection circuit for the VRECT output as shown below in its datasheet.

5.6 Over-Voltage Protection

In the event that the input voltage increases above 15V (default setting), the Rx sends control error packets to the transmitter in an attempt to bring the rectifier voltage back to a safe operating voltage level while simultaneously clamping the incoming energy using the internal high voltage OVP FET for VRECT over-voltage clamping control. The clamp is released when the VRECT voltage falls below the V_{OVP} hysteresis falling level. The P9222-R/RN also sends interrupts to the application processor (AP) when the over-voltage event occurs.

25. The portable device of claim 21, 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 inductive charging system.

The 942 Claim 21 Accused Product additionally infringe this dependent claim, as they each include an output disconnect switch that is structured and operates as specified by this claim, as illustrated below for the representative products.

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With respect to the S22 Ultra, the representative 9415 datasheet describes the ASIC as operating in the “Ping,” “Identification and Configuration,” and “Negotiation and Calibration” phases, communicating with the Base Unit before proceeding to the “Power Transfer” phase.



P9415-R Datasheet

8.2.10 Identification and Configuration (ID and Config)

In this phase, the P9415-R sends or expects the following packets:

- Identification Packet
- Configuration Packet

After the transmission of the Configuration Packet, the P9415-R proceeds to the Negotiation phase.

8.2.11 Negotiation

The Power Receiver negotiates with the Power Transmitter to fine-tune the Power Transfer Contract. For this purpose, the Power Receiver sends negotiation requests to the Power Transmitter, where the Power Transmitter can grant or deny.

8.2.12 Calibration

The Power Receiver provides its Received Power back to the Power Transmitter.

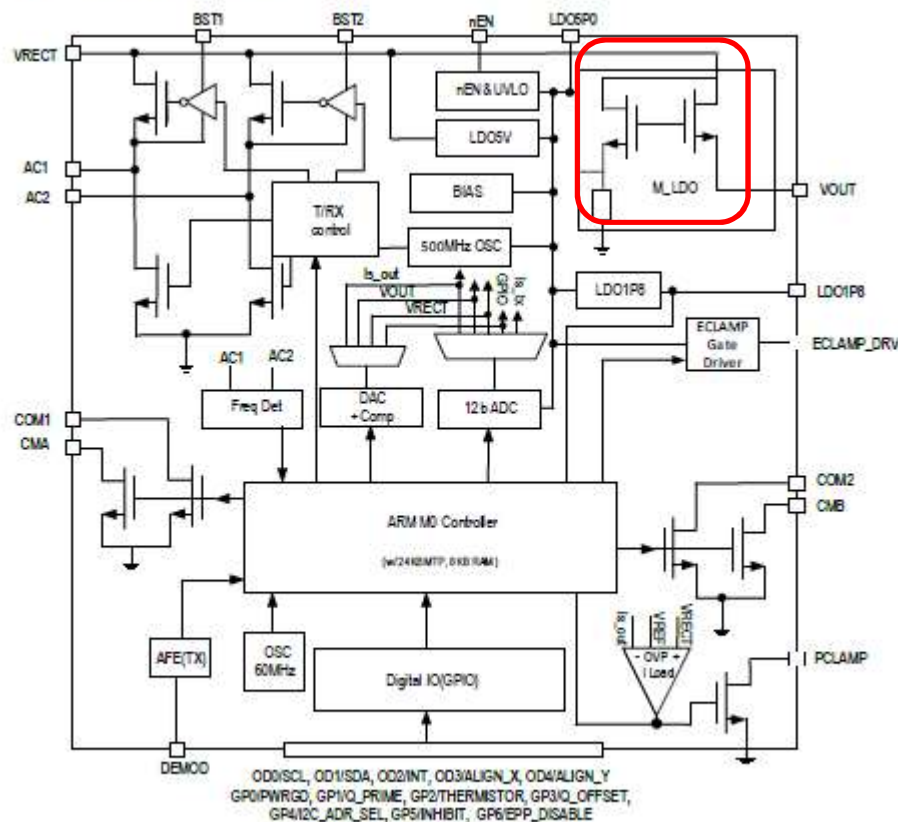
8.2.13 Power Transfer

In this phase, the P9415-R controls the power transfer by means of the following Control Data Packets:

- Control Error Packets
- Rectified Power Packet
- End Power Transfer Packet

During the “Power Transfer” phase, after some further communication, when the output of the VRECT reaches a target voltage, the VOUT LDO (M_LDO) shown in the red rectangle below acting an output disconnect switch (see 8.2.4 below) is enabled as described per this claim.

Figure 15. Internal Block Diagram



8.2.1 Startup

When a mobile device containing the P9415-R is placed on a WPC "Qi" charging pad, it responds to the transmitter's "ping" signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the "Ping" phase, once the rectifier voltage at the VRECT pin goes above the UVLO threshold, the digital section of the P9415-R enables communication. The control loop of the P9415-R adjusts the rectifier voltage by sending error packets to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer mode is initiated and the voltage at VRECT, the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage. For example, if the VOUT voltage target is 12V, the target VRECT voltage is VOUT + headroom, where the headroom is a function of the output current.

8.2.2 Power Transfer

Once the "identification and configuration" phase is completed and successful "negotiation and calibration" is made, then the transmitter initiates power transfer mode. The P9415-R control circuit measures the rectifier voltage and sends error packets to the transmitter to adjust the rectifier voltage to the level required to maximize the efficiency of the main LDO linear regulator and to notify the Tx of the current Rectified Power Packet for Foreign Object Detection (FOD) to guarantee safe efficient power transfer. The P9415-R is compatible with the WPC 1.2.4 Specification, and can use compatible Rx coils. Each receiver coil type has a unique inductance value. As such, a unique resonant capacitor (C_s) is used for a given type of receiver coil.

8.2.4 Status/Interrupt Output

When the power transfer connection is established and stable, the VOUT LDO is enabled. GPOD and GPIO pins can be connected to the AP to perform status and interrupt commands.

Furthermore, the Output Disconnect Switch (red rectangle) is shown in the WPC Standard.

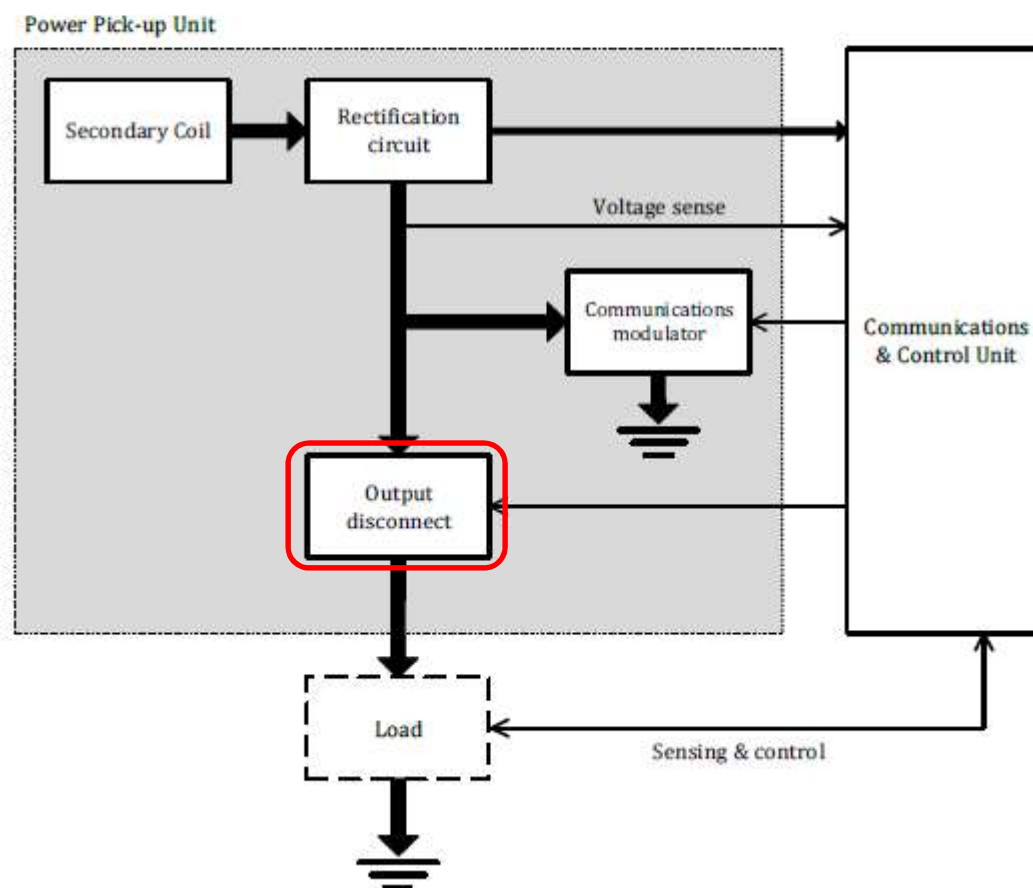
WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 23-24, 28.

3 Power interface

3.1 Power Receiver design requirements (PRx)

Figure 4 illustrates an example of a functional block diagram for a Baseline Power Profile Power Receiver.

Figure 4. Functional block diagram for a Baseline Power Profile Power Receiver



- An output disconnect switch, which prevents current from flowing to the output when the Power Receiver does not provide power at its output. In addition, the output disconnect switch prevents current backflow into the Power Receiver when the Power Receiver does not provide power at its output. Moreover, the output disconnect switch minimizes the power that the Power Receiver draws from the Power Transmitter when a Power Signal is first applied to the Secondary Coil.
- A rectified voltage sense.

The Communications and Control Unit on the right-hand side of Figure 4 comprises the digital logic part of the Power Receiver. This unit executes the relevant power control algorithms and protocols, drives the communications modulator, controls the output disconnect switch, and monitors several sensing circuits in both the Power Pick-up Unit and the load. (A good example of a sensing circuit in the load is a circuit that measures the temperature of a rechargeable battery.)

3.1.6 Output disconnect

The Power Receiver shall have the means to disconnect its output from the subsystems connected thereto. If the Power Receiver has disconnected its output, it shall ensure that it still draws a sufficient amount of power from the Power Transmitter, such that Power Receiver to Power Transmitter communications remain possible (see Section 5.2.2.1, *Modulation scheme*).

The Power Receiver shall keep its output disconnected until it reaches the power transfer phase for the first time after a Digital Ping (see Section 5.1, *System Control*). Subsequently, the Power Receiver may operate the output disconnect switch any time while the Power Transmitter applies a Power Signal.

Earbuds

The Buds2 case includes an MUA01 ASIC as described in claim 21 above. On information and belief, the wireless charging receiver section of the MUA01 ASIC includes an output disconnect as described in this claim similar to the representative 9415 ASIC and/or the representative 9222 ASIC shown above and below with respect to the S22 Ultra and the Watch4.

Wearables

The Watch4 includes a 9222 ASIC receiver. The representative 9222 datasheet describes the Startup process to be similar to that for the representative 9415 datasheet with respect to the S22 Ultra. An output MLDO is enabled and the output is connected to the battery after initial communication and control phases are accomplished and after the “Power Transfer Phase” has proceeded for some time.

5.3 Startup

When a mobile device containing the P9222-R/RN is placed on a WPC “Qi” charging pad, it responds to the transmitter’s “ping” signal by rectifying the AC power from the transmitter and storing it on a capacitor connected to VRECT. During the “ping” phase, once the rectifier provides a voltage at the VRECT pin above the UVLO threshold, the digital section of the P9222-R/RN enables communication. The control loop of the P9222-R/RN adjusts the rectifier voltage by sending Control Error Packets (CEPs) to the transmitter before and after it enables the VOUT LDO.

The VOUT LDO is enabled when the power transfer phase is initiated and the voltage at VRECT (i.e., the output of the full-wave synchronous rectifier reaches the target voltage that includes headroom in addition to the LDO VOUT target voltage). For example, if the VOUT voltage target is 5V, the target VRECT voltage is VOUT plus headroom. If the VRECT target voltage is not reached within 1 second after entering the power transfer phase, the VOUT LDO will be enabled automatically.

5.12 MLDO Output Enable Conditions

After the P9222-R/RN is energized wirelessly by a valid Tx and reaches the power transfer state, there are two criteria that must be met prior to the VOUT MLDO regulator being automatically enabled after start-up. Upon connection to a Tx, the P9222-R/RN sends CEP +55 in order to drive VRECT up to 6.5V and also starts a 1-second timer to allow VRECT to reach the target. After this timer expires, one of two conditions must be met before the VOUT output is enabled: CEP values are less than +4 (indicates VRECT has reached the target), or 5 seconds pass. Either of these events will trigger the P9222-R/RN to enable VOUT. In cases where VRECT is still below the target voltage (5 seconds pass and $VRECT < Vrect_Target$), VOUT is enabled in order to allow charging to start. When VRECT is below $Vrect_Target$, full power charging may not be possible because the Tx is not providing adequate energy for full power to be transferred.

26. The portable device of claim 21, wherein: the portable device further comprises a FET driver and a FET switch coupled to the coil and 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 coil to charge the battery of the portable device, and in the inductive power transfer mode, the portable device is configured to operate the FET driver to drive the FET switch to apply an alternating current to the coil for providing power inductively to a second portable device.

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The 942 Accused Smartphones, as illustrated by the representative S22 Ultra, meet this claim as reflected in the analysis with respect to claims 1, 12, and 21 regarding like claim elements.

29. A system for providing power inductively to a portable device comprising a battery, a receiver coil, and a receiver circuit, the system comprising:

The 942 Accused Smartphones are accused under this claim. As detailed below by the S22 Ultra, the 942 Accused Smartphones fit the description in this introductory part of the claim, as each includes a system for providing power inductively as specified by this introductory part of the claim.

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The S22 Ultra meets this introductory part of claim 29, as shown above with respect to the introductory part of claim 1.

a primary coil that is substantially planar and parallel to a charging 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 spiral-shaped conductor patterns of 1 to 4 ounce copper thickness for each layer with vias interconnecting at least some of the layers of conductor patterns;

Smartphones

The S22 Ultra meets this part of claim 29, as shown above with respect to the “first primary coil” part of claim 1 and with respect to the “PCB coil” part of claims 10 and 22.

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 charging surface of the primary coil to provide power inductively to the portable device;

Smartphones

The S22 Ultra meets this part of claim 29, as shown in large part above with respect to the “first drive circuit” part of claim 1. As shown above, the frequency range of operation for the S22 Ultra operating as a wireless charger in the Wireless PowerShare mode is specified in an FCC filing by Samsung, showing the frequency of operation as 110-148 kHz. <https://fcc.report/FCC-ID/A3LSMS908U/5574740> (shown above)

a sense circuit configured to sense communication of information in the primary coil induced by the receiver coil and the receiver circuit; and

Smartphones

The S22 Ultra meets this part of claim 29, as shown above with respect to the “first sense circuit” part of claim 1.

a communication and control circuit, including a microcontroller coupled to the drive circuit and the sense circuit, configured to:

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The S22 Ultra meets this part of claim 29, as shown above with respect to the “communication and control circuit” part of claim 1.

detect, through the sense circuit, a received communication of information in the primary coil;

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The S22 Ultra meets this part of claim 29, as shown above with respect to the “detect” part of claim 1

operate the drive circuit to inductively transfer sufficient power to the receiver circuit to activate and power the receiver circuit to enable the receiver circuit to communicate the information received in the primary coil; determine a power parameter from the received information communicated by the receiver circuit; and

Smartphones

The S22 Ultra meets these parts of claim 29, as shown above with respect to the “operate the first drive circuit to inductively transfer power” part of claim 1.

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 primary coil induced by 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 a DC voltage at the DC voltage input to the drive circuit during charging of the battery of the portable device.

Smartphones

The S22 Ultra meets these parts of claim 29, as shown above with respect to the “receive additional information” and “regulate in a closed loop feedback manner” parts of claim 1.

30. The system of claim 29, 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.

The 942 Accused Smartphones additionally infringe this dependent claim, as shown above with respect to claims 1, 2, and 12 as to like claim elements.

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The S22 Ultra meets these parts of claim 30, as shown above with respect to claims 1 and 2 as to like claim elements.