

US11316371B1 SYSTEM AND METHOD FOR INDUCTIVE CHARGING OF PORTABLE DEVICES

I. Samsung Infringement

1. An apparatus comprising: a system for providing power inductively to a portable device comprising a battery and an inductive receiver unit including a receiver coil and a receiver circuit, the system comprising:

The 371 Accused Smartphones and the 371 Accused Wireless Chargers are accused under this claim (collectively the “371 Claim 1 Accused Products”). As detailed below by representative products, the 371 Claim 1 Accused Products 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.

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.

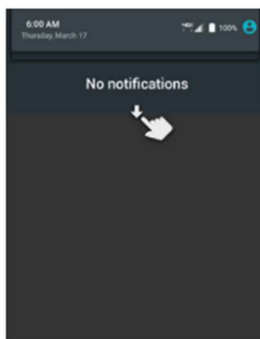
<https://www.verizon.com/support/knowledge-base-300922/>

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 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 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/>



Galaxy Watch Active Wireless Charger

EP-OR825BBEGWW

★★★★★ 2.1 (46) [Write a review](#)

- Compact, portable design
- Compact, portable design
- Wireless charging on the go

Choose your

Color: Black



Galaxy Watch Active Wireless Charger

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

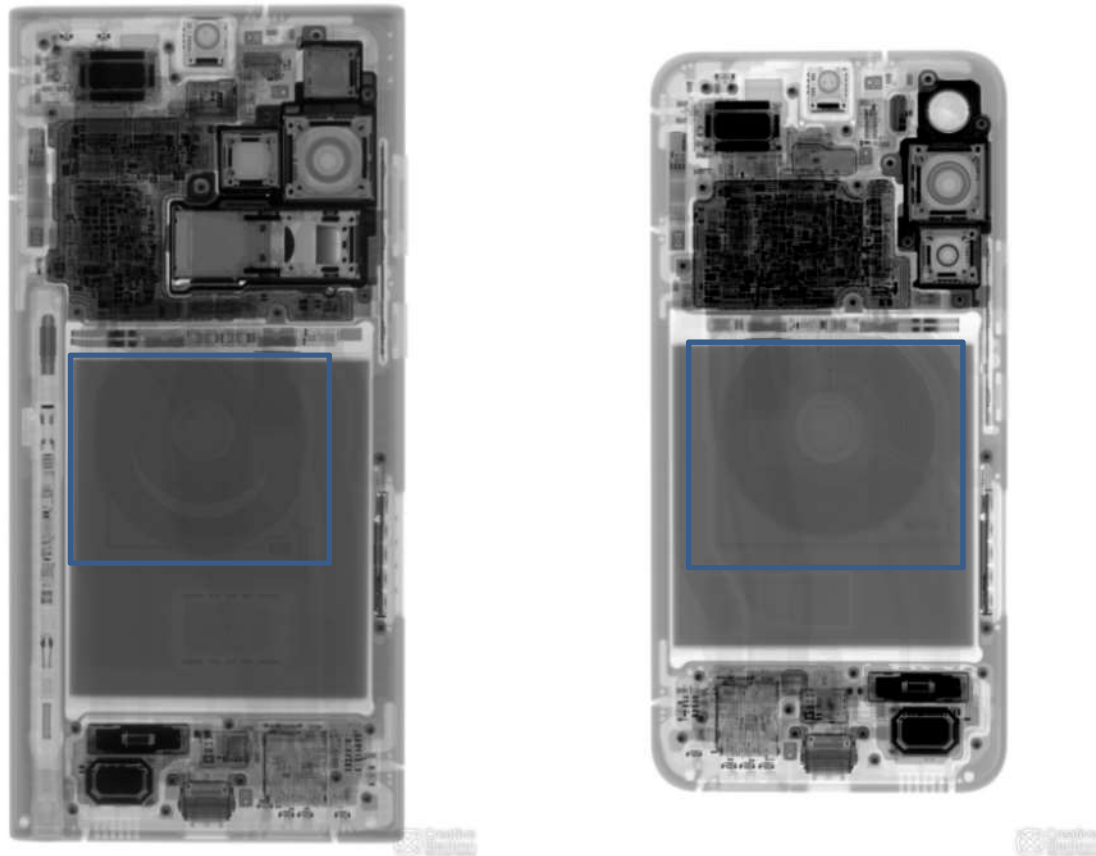
The 371 Claim 1 Accused Products each include a coil as specified by this part of the claim, as illustrated below for the representative products.

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.

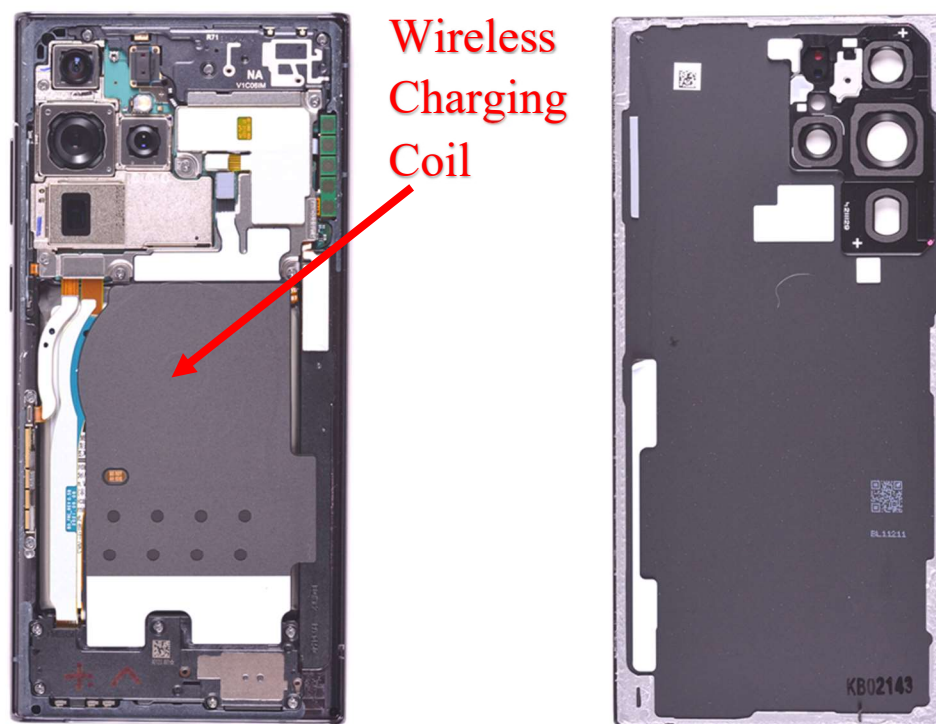
<https://www.ifixit.com/News/57567/galaxy-s22-teardowns-apple-is-making-samsung-sweat>

X-ray examination



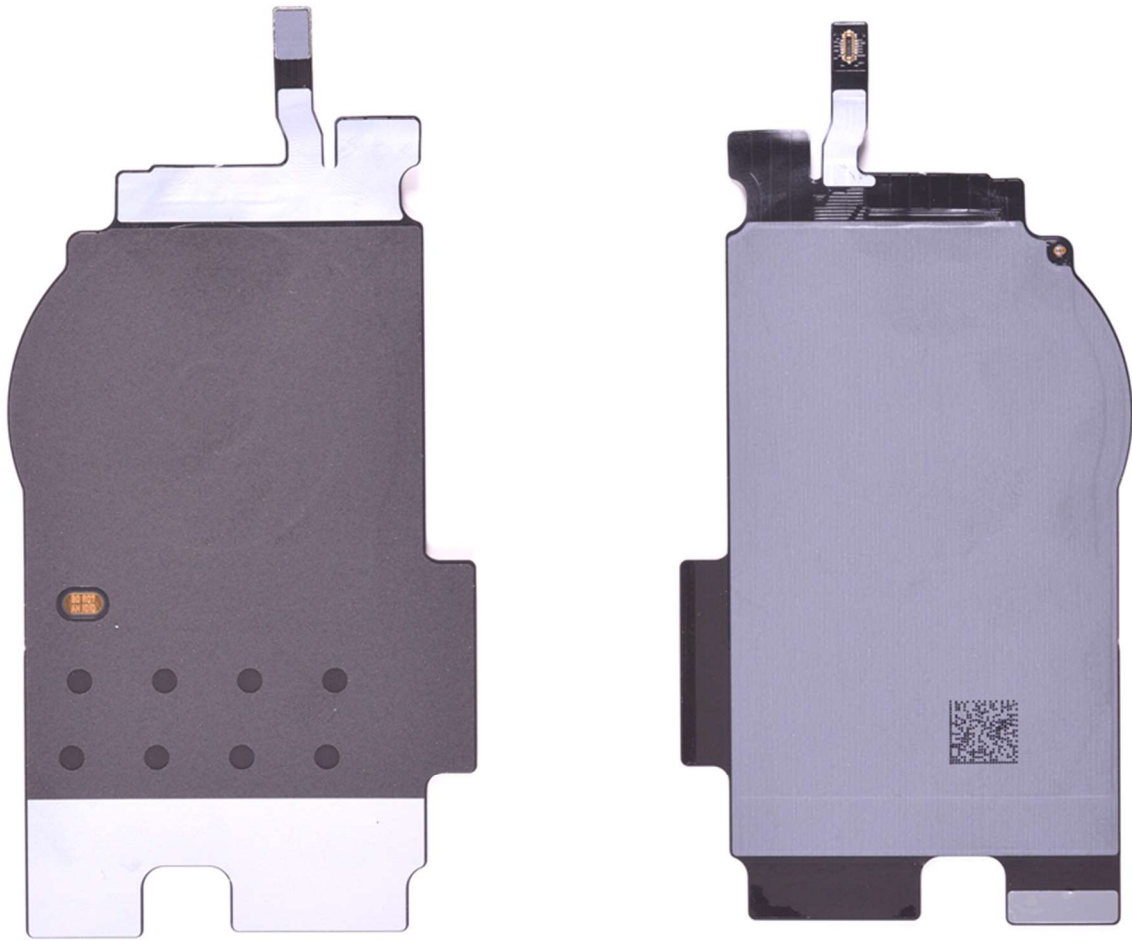
On the left is the Note-succeeding Samsung Galaxy S22 Ultra, with the "vanilla" S22 on the right.

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.

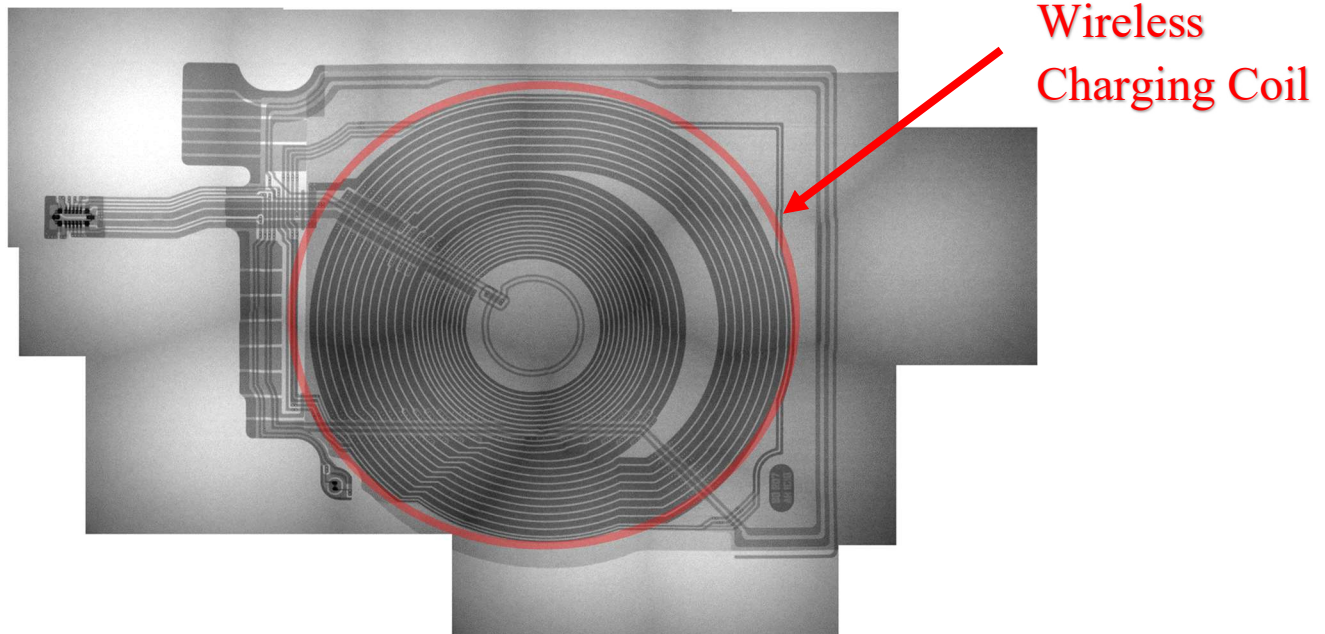


Samsung S22 Ultra – Back cover removed

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.



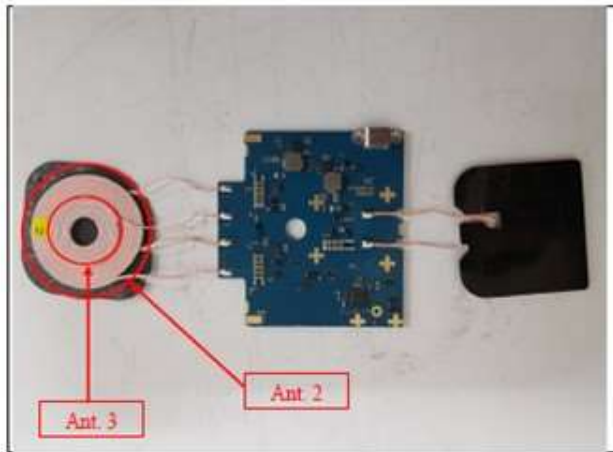
Wireless Chargers

The 5200 Duo Pad 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.

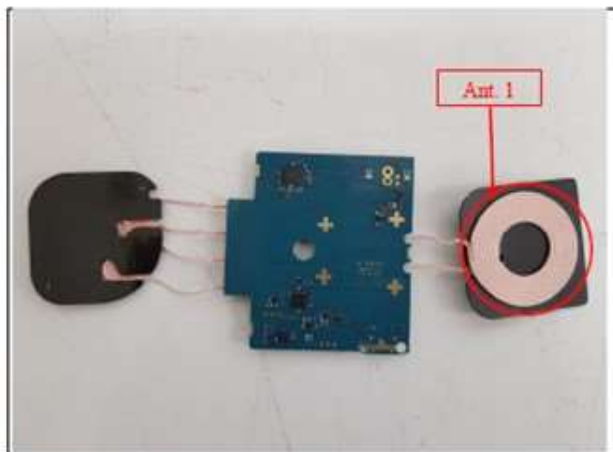
The 5200 Duo Pad contains three planar coils (identified as antennas [Ant. 1-3] in the images below) for transferring inductive power as recited by this part of the claim. The two coils on the product right side (Ant. 2 and 3) are concentric for charging a watch (Ant. 3) or another smartphone or earbud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

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.

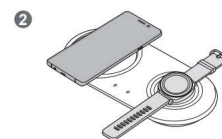
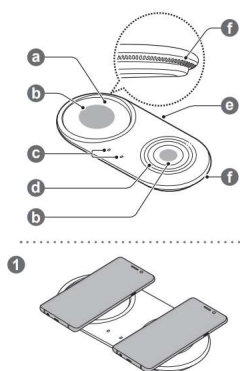
<https://fcc.report/FCC-ID/A3LEPP5200/4144766.pdf>



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 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 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 371 Claim 1 Accused Products each include a drive circuit 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

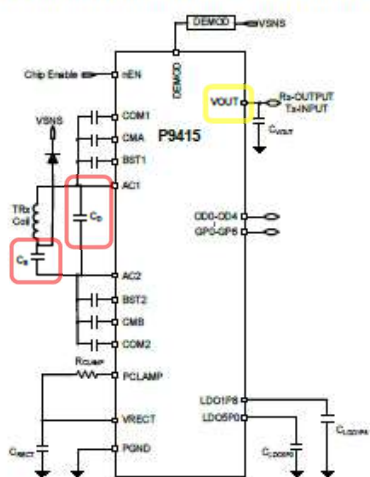


The Renesas P9415-R ASIC (15 W Receiver / Transmitter (Rx/Tx) IC for WPC 1.2)¹ [herein the “9415”], for which a datasheet is publicly available, is believed to be representative of the wireless power transceiver ASIC (such as the 9320S) included in the S22 Ultra for the purposes of infringement of this 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

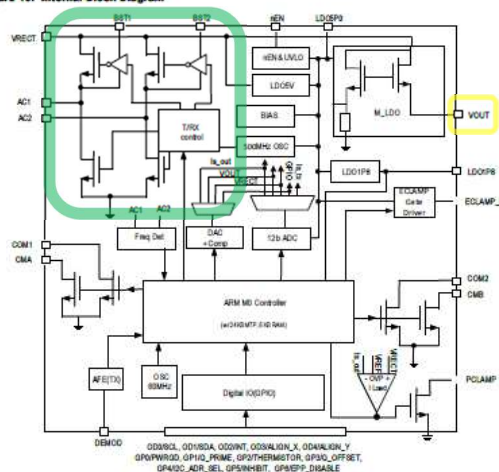
RENESAS

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 190 kHz from the transmitter.

Figure 15. Internal Block Diagram



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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 (yellow 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 receiver of the portable device to activate and power the receiver unit and charge the portable device wirelessly. This is illustrated below in the exemplary 9415 ASIC datasheet.



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.



P9415-R Datasheet

8.4.3 Demodulator

In TRx Mode, the Rx sends WPC protocol packets to the P9415-R. Using the demodulation (DEM0D) 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.

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 range 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,
Yeonjong-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.

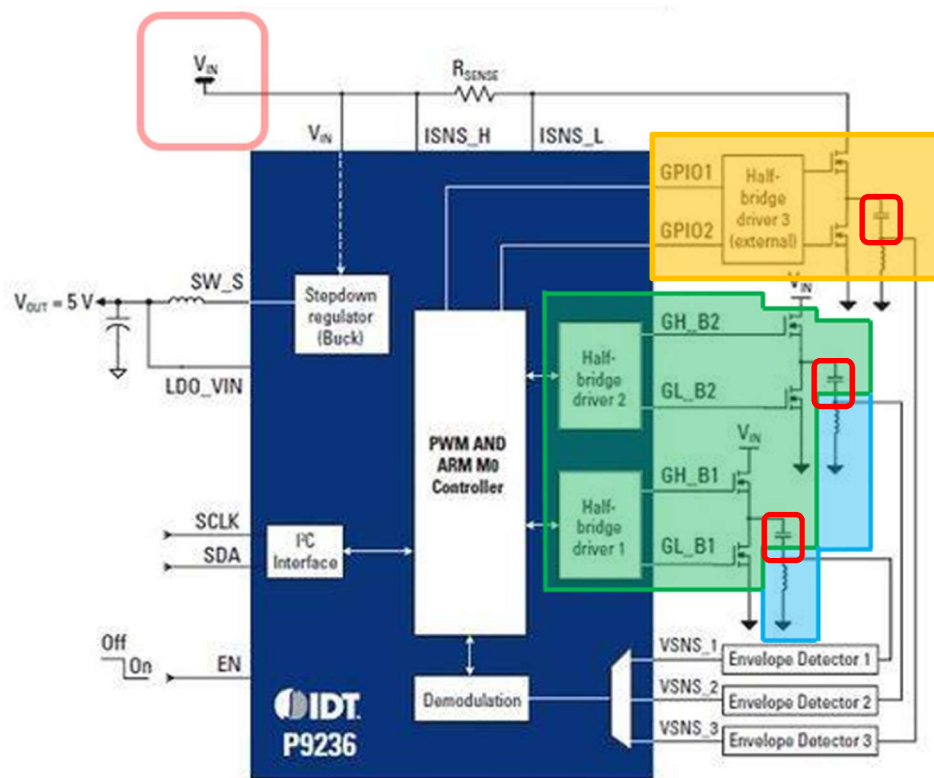
Wireless Chargers

A drive circuit as specified by this part of the claim is included in the 371 Accused Wireless Chargers.

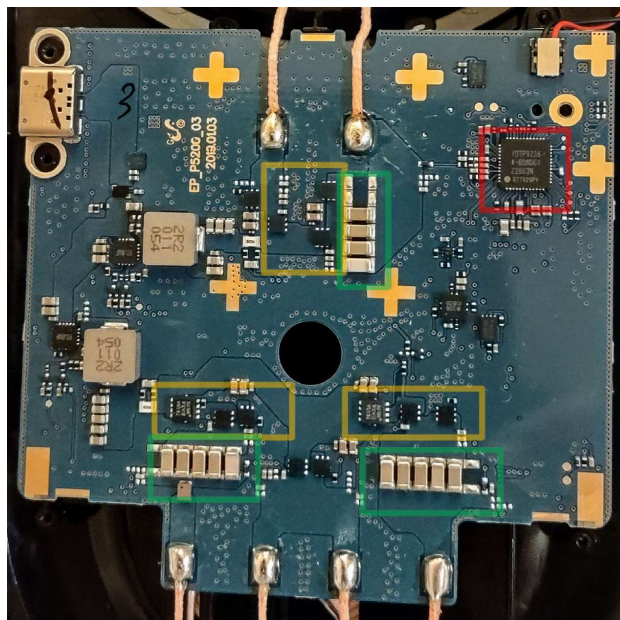
The 5200 Duo Pad includes a drive circuit that is structured and operates as specified by this part of the claim. They each include a wireless charging transmitter ASIC (e.g., the IDT/Renesas P9236 ASIC) (herein the "9236" ASIC) with associated external capacitors and field effect transistors (FETs).

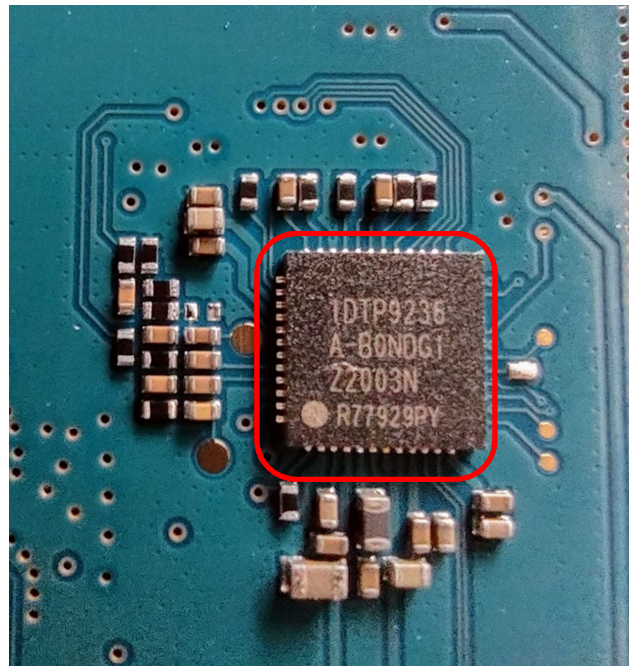
The representative 9236 ASIC includes two internal FET drivers used with external FETs and capacitors (green area below), and a third external driver can be used with additional external FETs and capacitors (orange rectangle), as shown in the datasheet below for the 9236 ASIC. Further, the V_{IN} shown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

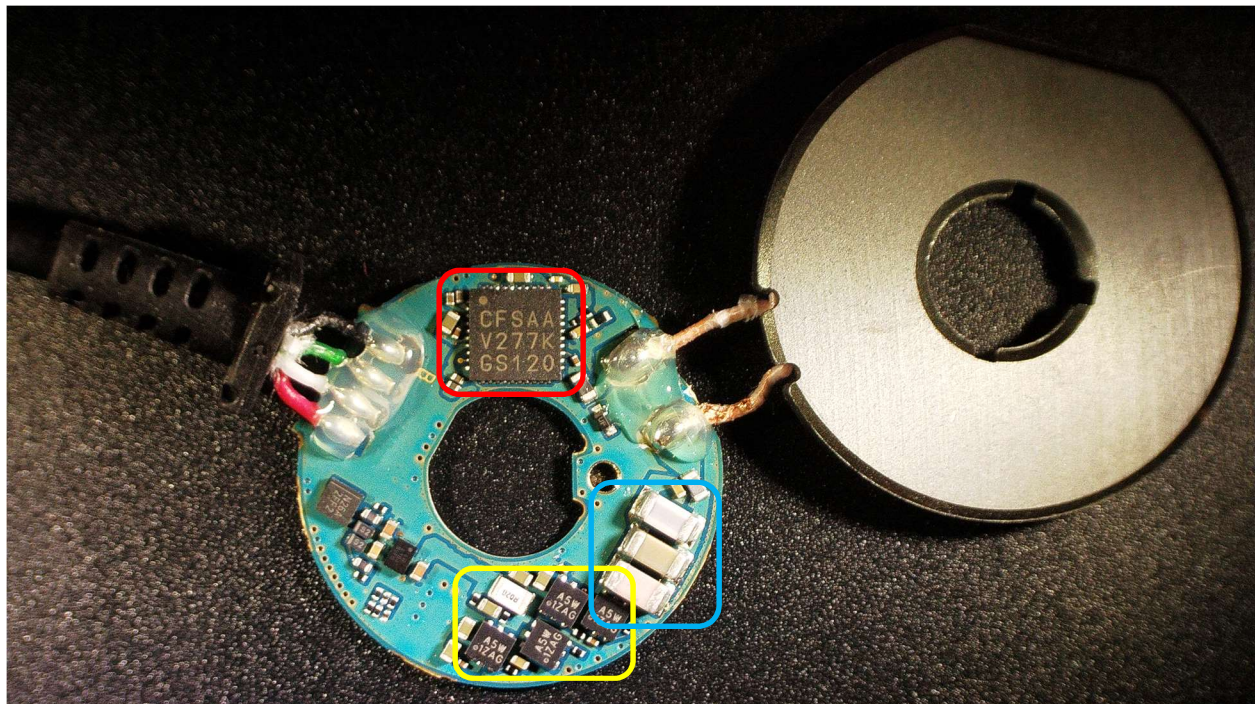


The 5200 Duo Pad includes wireless charging transmitter ASICs (e.g., the 9236) (red rectangles), FETs and FET drivers (yellow rectangles), and capacitors (green rectangles) as illustrated below.





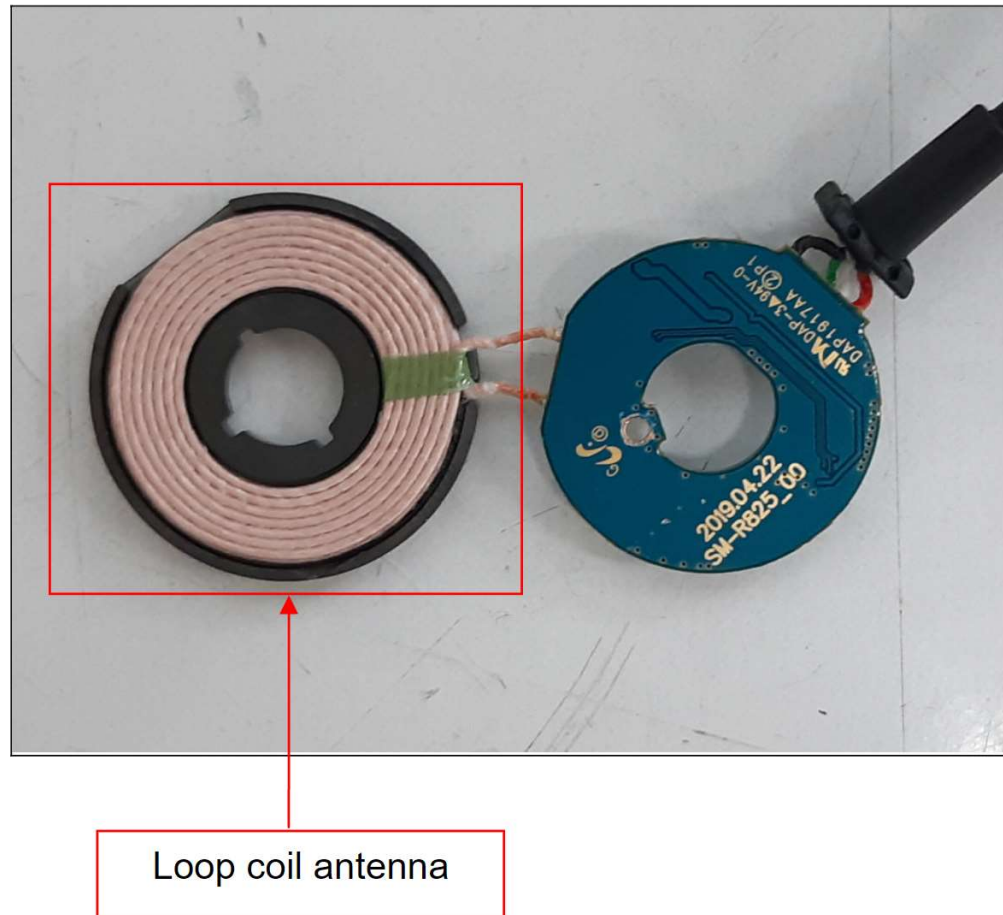
The 825 Watch Dock includes a drive circuit that is structured and operates as specified by this part of the claim is included in the representative 825 Watch Dock. It includes a wireless charging transmitter ASIC (e.g., the CFSAA V277K ASIC; red rectangle) (herein the “V277K”) with associated external capacitors (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 the external FET and capacitor. On Information and belief, a DC voltage from an external USB Power Supply is coupled to the DC Voltage Input which is coupled to the FET and the first primary coil for the 825 Watch dock as specified by this part of the claim.

825 Watch Dock: <https://fcc.report/FCC-ID/A3LEPOR825/4320461>

Bottom view of board



Loop coil antenna

The frequency ranges of operation of the 5200 Duo Pad 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.

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		

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

The 5200 Duo Pad is a WPC compatible charger, and the 825 Watch Dock follows the WPC Specification. These infringing products operate similarly to the S22 Ultra in PowerShare mode with respect to the claim sections relating to operating frequency range as described above for S22 Ultra. The WPC Specification relating to operating frequency range is shown below.

WPC Standard

The 371 Claim 1 Accused Products follow the WPC/Qi Standard (herein “WPC Standard”), as illustrated below by the representative products.

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

WPC Standard Citations

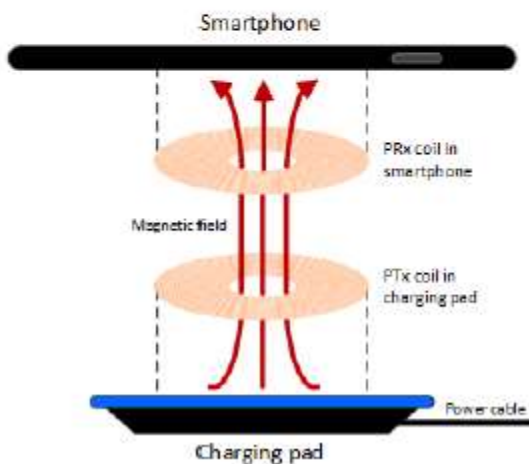
Following the WPC Standard, the drive circuits of the 371 Claim 1 Accused Products, during operation as a charger, apply an alternating electrical current to their associated primary coil at an operating frequency and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular 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.

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 371 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).



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

Version 1.2.4

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

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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

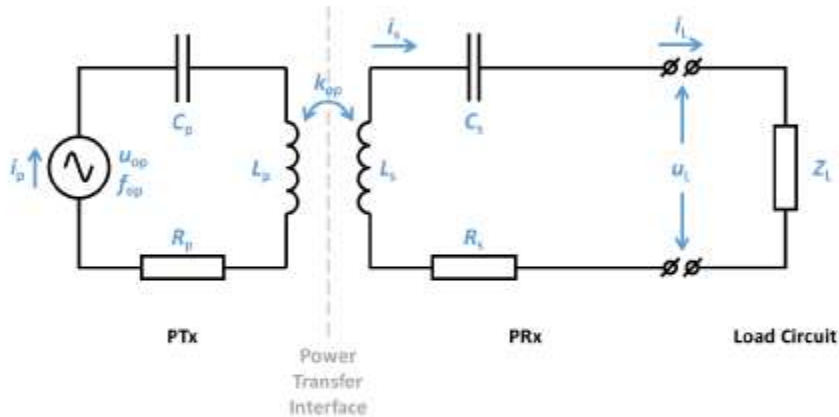
47

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 371 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 ($u_{\text{op}}, f_{\text{op}}$), 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_s 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_{op}	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 371 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).



The Qi Wireless Power Transfer System
 Power Class 0 Specification

Parts 1 and 2: Interface Definitions

Version 1.2.4

Power interface

- 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 to monitor current flow through the first primary coil during operation of the first drive circuit, wherein the first sense circuit includes a low pass filter and an amplifier to assist in detecting and amplifying a signal corresponding to a current modulation in the first primary coil induced by modulation of current in the receiver coil; and

The 371 Claim 1 Accused Products each include a sense circuit as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

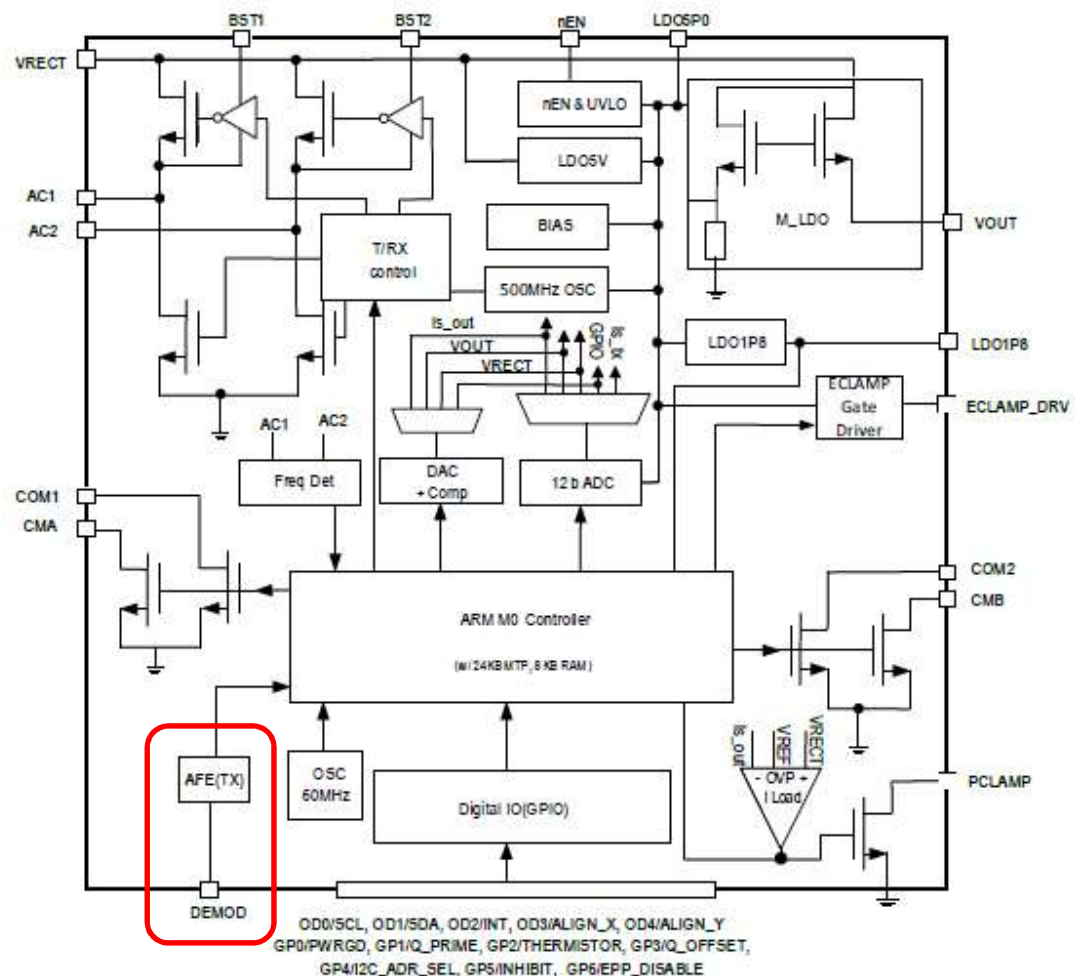
The S22 Ultra includes a sense circuit that is structured and operates as specified by this part of the claim. As shown below, the representative 9415 ASIC includes an Analog Front End (AFE)

(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

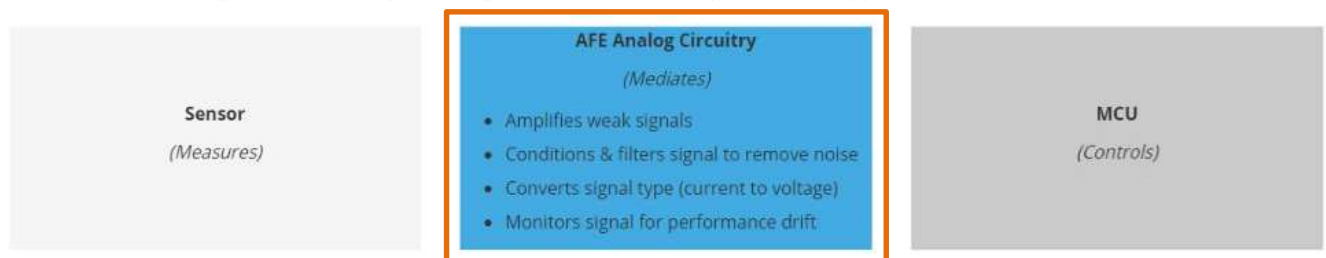


The AFE function includes a low pass filter (to distinguish the communication signal at ~ 2 kHz from the power transfer operating frequency of 100-200 kHz) and an amplifier.

[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.

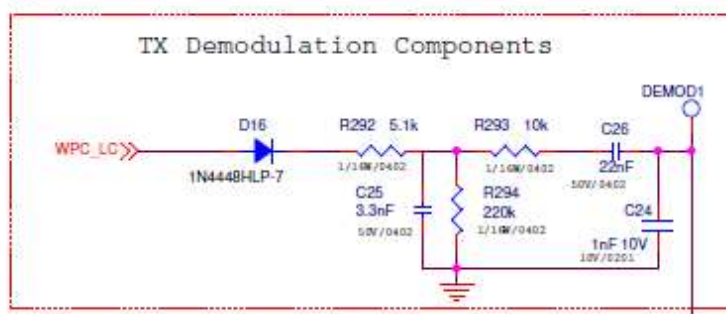


P9415-R Datasheet

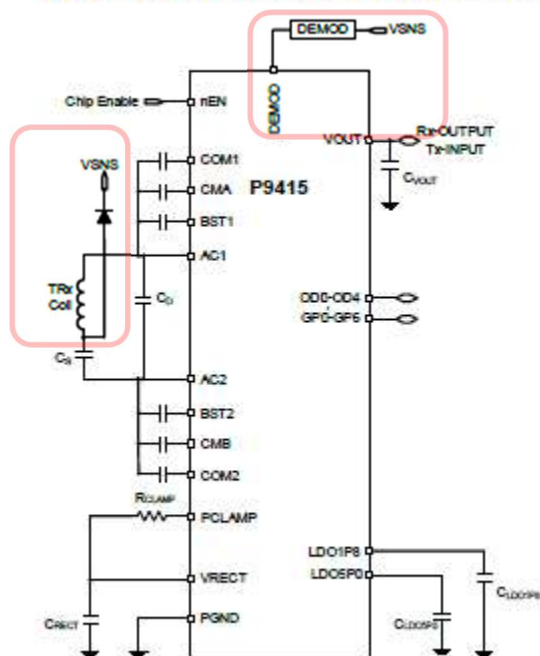
8.4.3 Demodulator

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



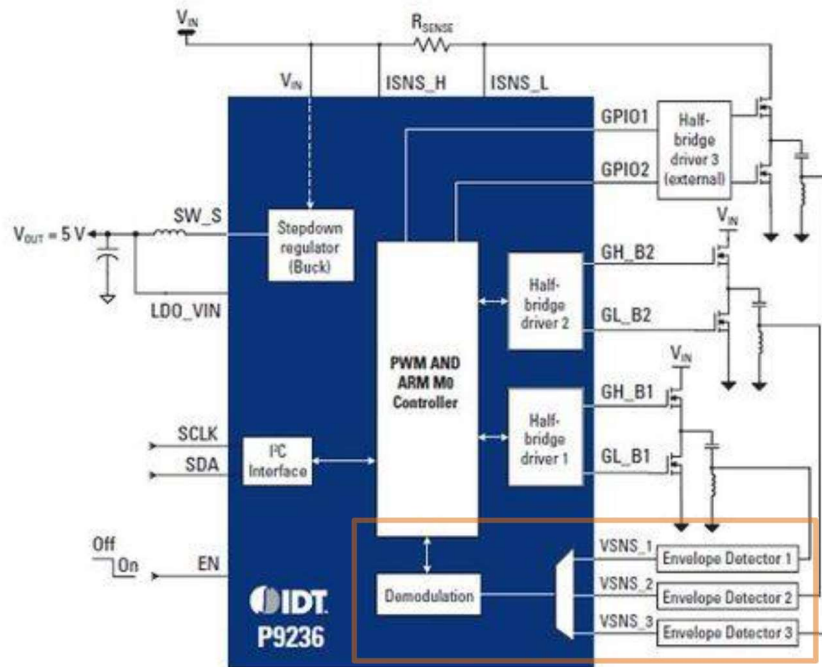
Typical Applications Schematic



Wireless chargers

The 5200 Duo Pad meets this part of the claim, as it includes 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 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 825 Watch Dock includes a wireless charging transmitter ASIC (e.g., the V277K). Upon information and belief, the 9415 ASIC discussion immediately above for the S22 Ultra applies similarly to the wireless charger ASICs included in the 825 Watch Dock.

WPC Standard

The WPC Standard reflects detection of communications by way of current modulation, as in the 371 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

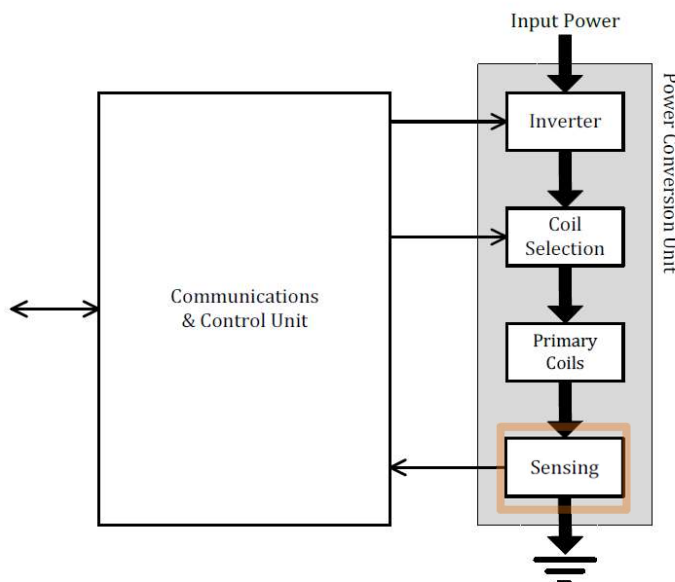
The Power Receiver communicates to the Power Transmitter using backscatter modulation. For this purpose, the Power Receiver modulates the amount of power that it draws from the Power Signal. The Power Transmitter detects this as a modulation of the current through and/or voltage across the Primary Cell. 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 to detect the signal corresponding to a current modulation, as in the 371 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.

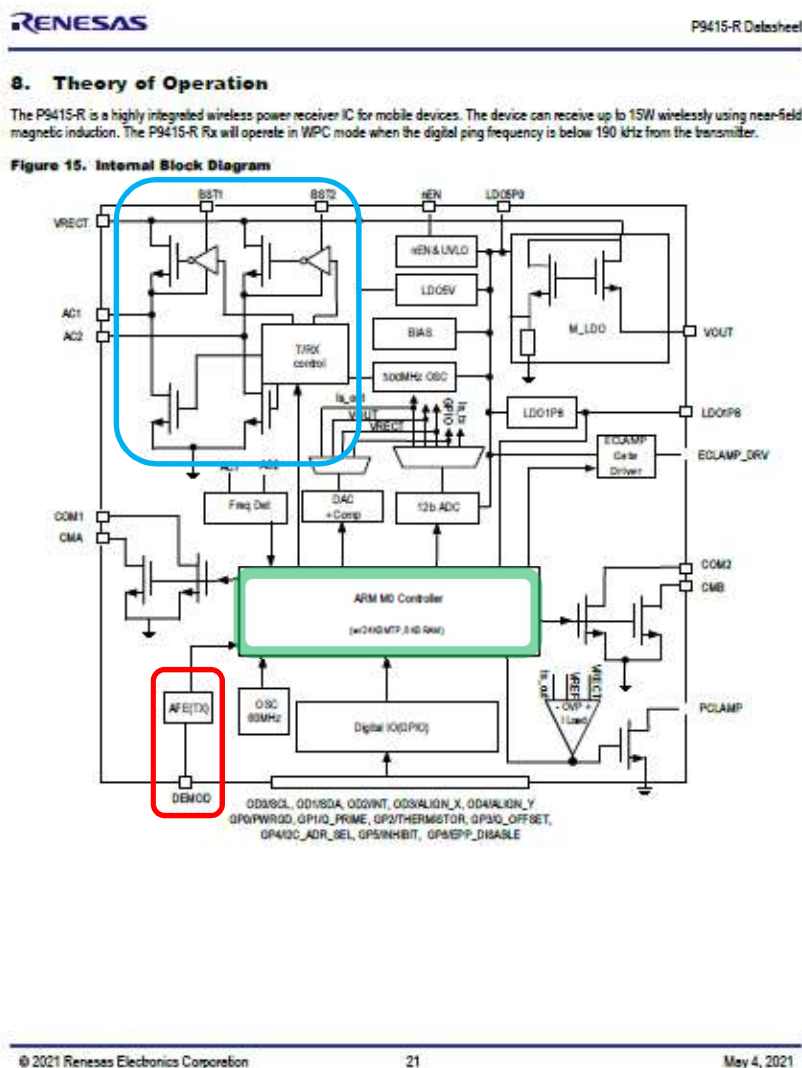
The Communications and Control Unit on the left-hand side of Figure 10 comprises the digital logic part of the design. The Communications and Control Unit receives and decodes messages from the Power Receiver, configures the Coil Selection block to connect the appropriate Primary Coil, executes the relevant 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.

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

The 371 Claim 1 Accused Products each include a communication and control circuit, including a microcontroller, as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

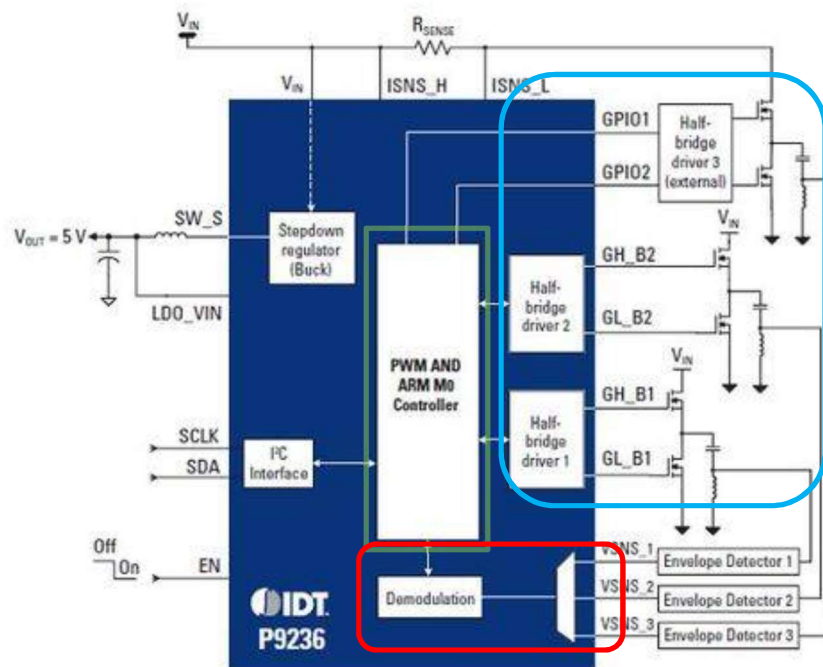
The S22 Ultra includes a communication and control circuit, including a microcontroller coupled to the first drive circuit and the first sense circuit, as specified by this part of the claim. The S22 Ultra includes a wireless transceiver ASIC. For example, as illustrated by the representative 9415 datasheet, the wireless transceiver ASIC in the S22 Ultra has a microcontroller (green rectangle) coupled to the first drive circuit (blue rectangle) and the first sense circuit (red rectangle).



Wireless chargers

The 5200 Duo Pad meets this part of the claim, as it includes 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 coupled to the first drive circuit (blue rectangle) and the first sense circuit (red rectangle) 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 825 Watch Dock include a wireless charging transmitter ASIC (e.g., the V277K). Upon information and belief, the 9415 ASIC and 9236 ASIC discussion immediately above applies similarly to the wireless charger ASIC included in the 825 Watch Dock.

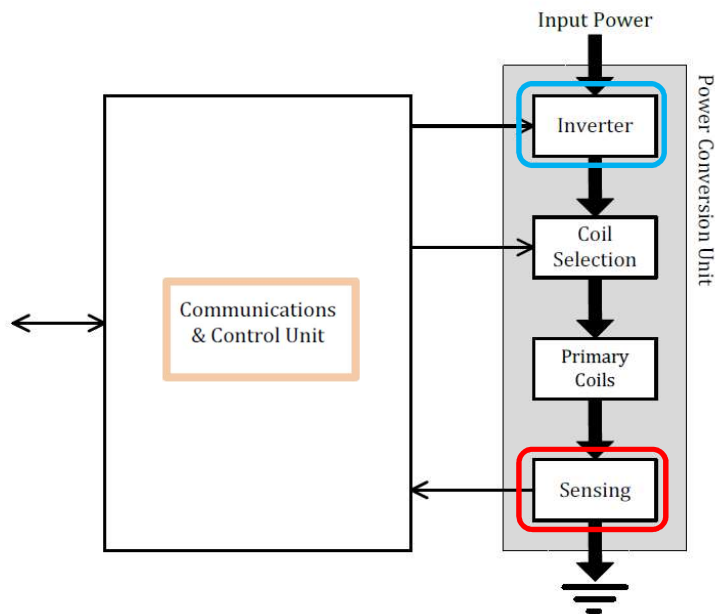
WPC Standard

That the 371 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). As per the WPC Standard, the communication and control circuit (which includes a microcontroller) is coupled to the first drive circuit (blue rectangle) and the first sense circuit (red rectangle) as shown below and relevant to this part of the claim.

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.

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

The 371 Claim 1 Accused Products are each configured to detect information in current modulation as specified by this part of the claim, as shown above with respect to the “first sense circuit” part of claim 1 and as further illustrated below.

WPC Standard

That 371 Claim 1 Accused Products meet this part of the claim is also indicated by 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.

operate the first drive circuit to inductively transfer power from the first primary coil to the receiver coil to activate and power the receiver unit to enable the receiver circuit to communicate the information detected in the current modulation in the first primary coil, wherein the communication of information includes information to enable the communication and control circuit to configure the inductive transfer of power to the portable device, wherein the received communication of information includes: information corresponding to a voltage or current induced by the first primary coil at the output of the receiver circuit; a unique identification code; a manufacturer code; a charge algorithm profile; and a power requirement; and

The 371 Claim 1 Accused Products are each configured to operate their drive circuits as specified by this part of the claim, as illustrated below.

WPC Standard

That the 371 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard.

Following the WPC Standard, the 371 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 by receiving wireless power from a wireless charger, the charger begins receiving 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 to the charger 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.

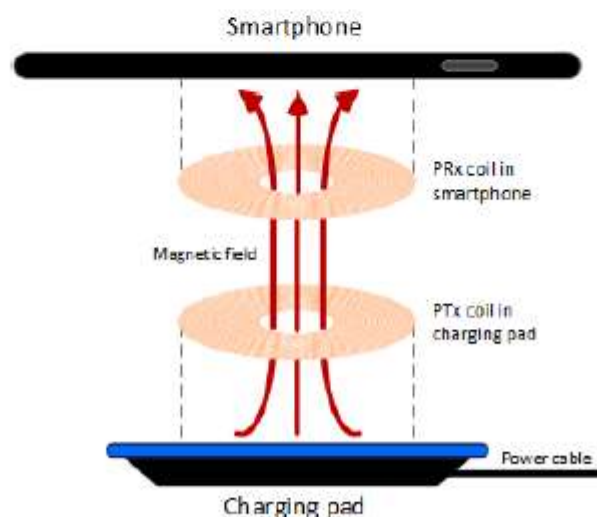
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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

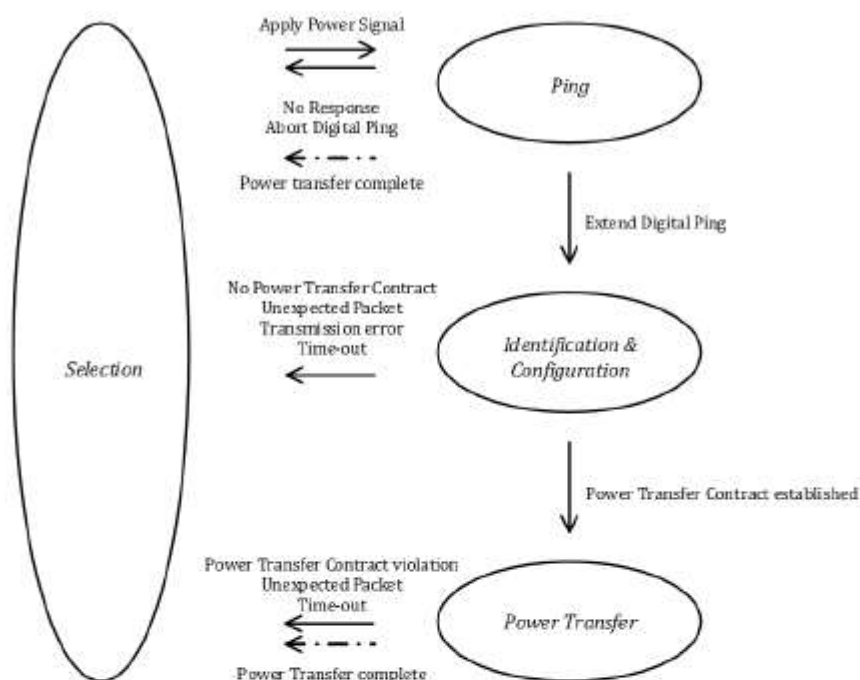
A critical feature of the magnetic field is that it can transfer through any non-metallic, non-ferrous materials, such as plastics, glass, water, wood, and air. In other words, wires and connectors are not needed between the power transmitter and power receiver.

Figure 6. Qi wireless power transfer using magnetic induction



From the Power Transmitter/Charger perspective, the WPC Baseline Power Profile (< 5 Watts) 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 (i.e. charger) 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

$$\text{Signal Strength Value} = \frac{U}{U_{\max}} \cdot 256,$$

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 phase communication received by the transmitter is described below and includes a unique identification code, a manufacturer code, 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 and charge algorithm profile to provide the power from the first primary coil to the receiver coil to power the receiver unit and charge the battery of the portable device, wherein to charge the battery of the portable device the communication and control circuit is further configured to:

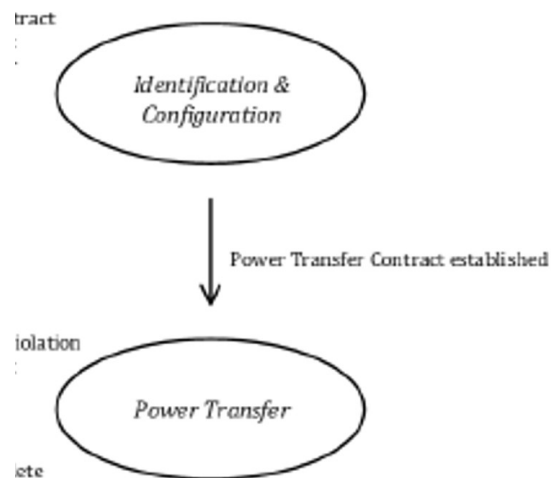
The 371 Claim 1 Accused Products are each configured to further operate their drive circuits as specified by this part of the claim, as illustrated below.

WPC Standard

That the 371 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard. After receiving the Identification and Configuration packets, the transmitter uses this information to create a power transfer contract and proceed to provide power (in the Power

Transfer phase) to the receiver accordingly to power the receiver unit and charge the battery of the portable device.

E.g., 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).



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.

- **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.

receive additional information in the current modulation in the first primary coil from the modulation of the current in the receiver coil corresponding to the voltage or current at the output of the receiver circuit while charging the battery of the portable device; regulate in a closed loop

feedback manner the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency and the duty cycle of the first drive circuit while charging the battery of the portable device;

The 371 Claim 1 Accused Products are each configured to receive additional information and regulate in a closed loop manner as specified by this part of the claim, as illustrated below for the representative products. They do so following the WPC Standard, including adjusting their operating frequency and/or duty cycle.

WPC Standard

That the 371 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard.

Per the WPC standard, the 371 Claim 1 Accused Products, perform the Power Transfer phase, as follows. *E.g.*, 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.

Wireless Power Consortium



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, as seen in the illustrative representative 9415 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.

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 and 825 Watch Dock performs closed loop control as specified by this part of the claim. Upon information and belief, the 9415 ASIC discussion immediately above applies similarly to the wireless charger ASICs included in the 5200 Duo Pad and 825 Watch Dock 825 Watch Dock.

monitor for continued presence of the portable device and completion of the charging of the battery of the portable device based on the communication from the receiver circuit and detected by the communication and control circuit through the first sense circuit; and if the portable device is no longer present or charging is complete, stop operation of the first drive circuit for the provision of power inductively to the portable device.

The 371 Claim 1 Accused Products are each configured to monitor for continued presence of the portable device and completion of the charging and stop the inductive power transfer as specified by this part of the claim, as illustrated below for the representative products. They do so following the WPC Standard.

WPC Standard

That the 371 Claim 1 Accused Products meet this part of the claim is indicated by the WPC Standard.

Following the WPC Standard, the 371 Claim 1 Accused Products terminate power transfer when the portable device is no longer present 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).



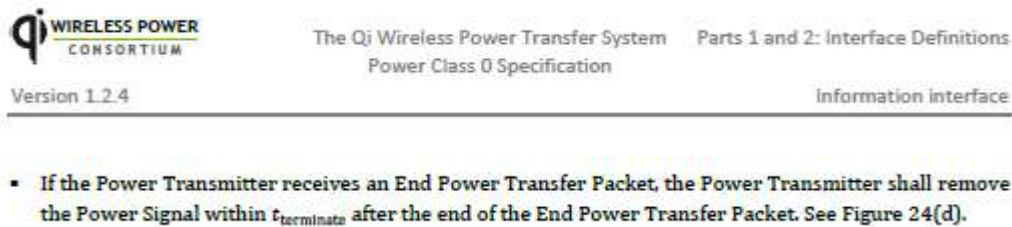
The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
Power Class 0 Specification

Version 1.2.4

Information interface

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.

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).



WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 94 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 92-93).



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.

Smartphones

The S22 Ultra 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.



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

8.2.15 End of Power Transfer (EPT)

In the event of EPT, the device turns off the LDO only after the AP instructs the P9415-R to continuously send End of Power (EPT) packets until the transmitter removes the power and the rectifier voltage on the receiver side drops below the UVLO threshold.

Wireless Chargers

The 5200 Duo Pad operates per WPC and 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.

The 825 Watch Dock 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. Upon information and belief, the 9415 ASIC and 9236 ASIC discussion immediately above applies similarly to the wireless charger ASICs included in the 825 Watch Dock.

Dependent claims (off claim 1)

2. The apparatus of claim 1, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit.

The 371 Claim 1 Accused Products additionally infringe this dependent claim, as the closed loop feedback manner they employ comprises a Proportional-Integral-Derivative (PID) control technique, per the WPC Standard.

E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 64.

5.1.2.6.1 Power transfer control

This version of the Specification, defines a specific method, which the Power Transmitter shall use to control its Primary Cell current towards the new Primary Cell current (see Section 5.1.1, Overview (informative)). This method is based on a discrete proportional-integral-differential (PID) algorithm as illustrated in Figure 26.

3. The apparatus of claim 1, wherein the DC voltage input is configured to receive a DC voltage and the system further comprises: a voltage regulator circuit coupled to the DC voltage input and to the microcontroller, wherein the microcontroller is configured to control the voltage regulator circuit to switch a level of the DC voltage between multiple discrete values based on the received communication of information and the additional information received by the communication and control circuit from the portable device.

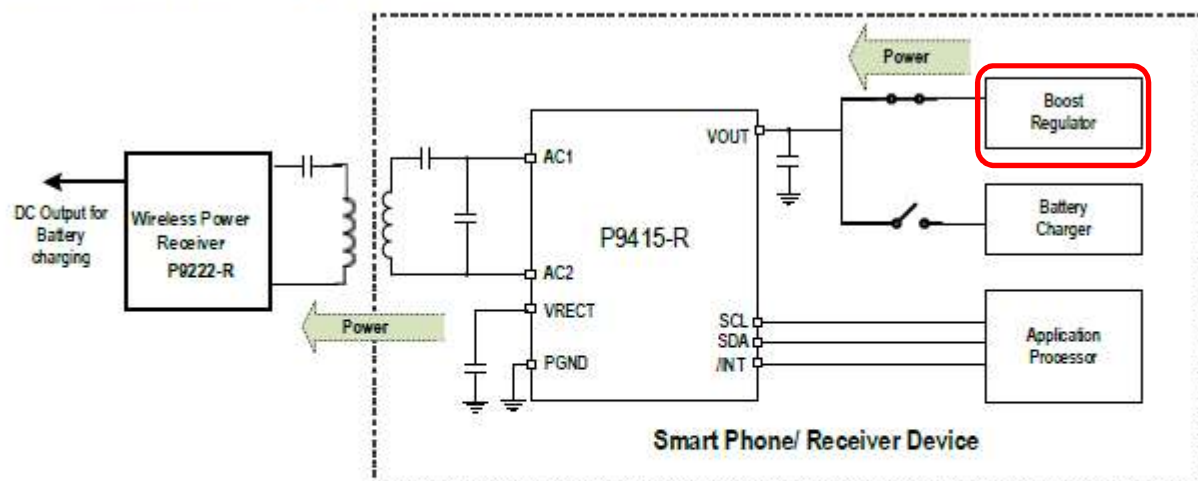
The 371 Claim 1 Accused Products additionally infringe this dependent claim, as they include a voltage regulator that switches the DC voltage, as specified by this claim.

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, 6, or 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

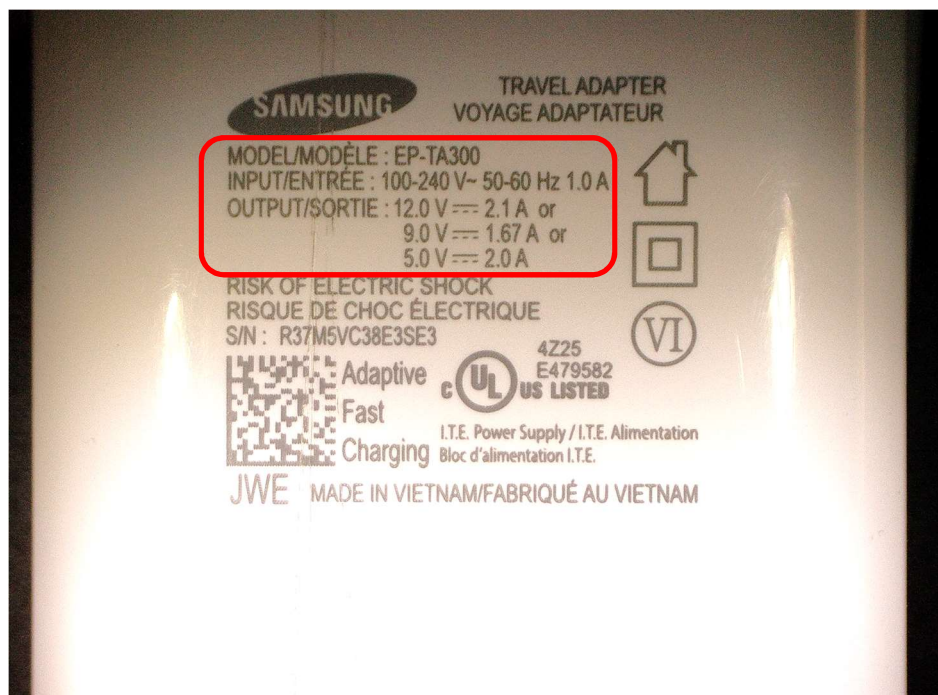
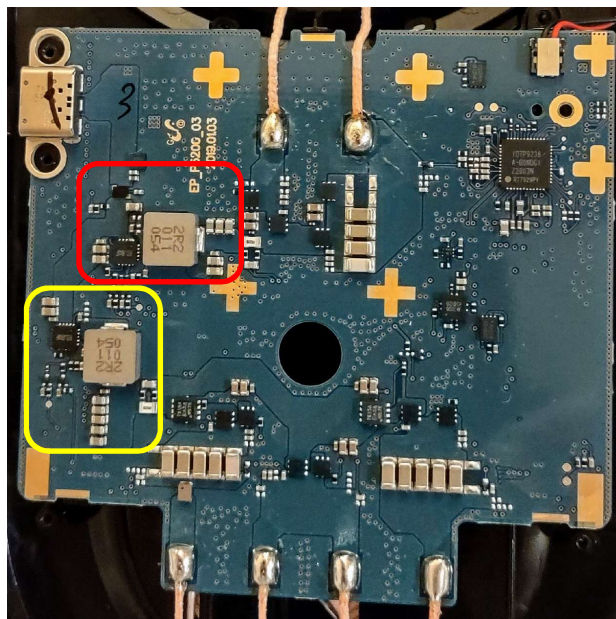


8.4.2 WattShare™ Mode Input Voltage

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 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. 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 takes 12 V from its USB adapter (Samsung EP-TA300, also shown below) and steps the voltage down to provide input voltage to the two ASICs (controlling the right and left side of the charger).



The 5200 Duo has two distinct voltage regulators as shown below. The one shown in red rectangle above 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 microcontroller in the ASIC communicates with the voltage regulator to provide e.g. 6 V.

The voltage regulator in the yellow rectangle above supplies the different discrete voltage values to the Input Voltage of the apparatus 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.

4. The apparatus of claim 1 wherein: the DC voltage input is configured to connect to and receive a DC voltage from a DC power supply via a universal serial bus (USB); and the communication and control circuit is further configured to communicate with the DC power supply via the USB.

The 371 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 (when operating in the PowerShare mode) and wireless chargers (such as the representative wireless power ASICs pointed out above with respect to claim 1).

Smartphones

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) communicates 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 Travel Adapter (TA; the Samsung name for their Power Adapters) to optimize power delivery depending on the power needs (as dictated by the communication and control circuit and power requirements during wireless charging).



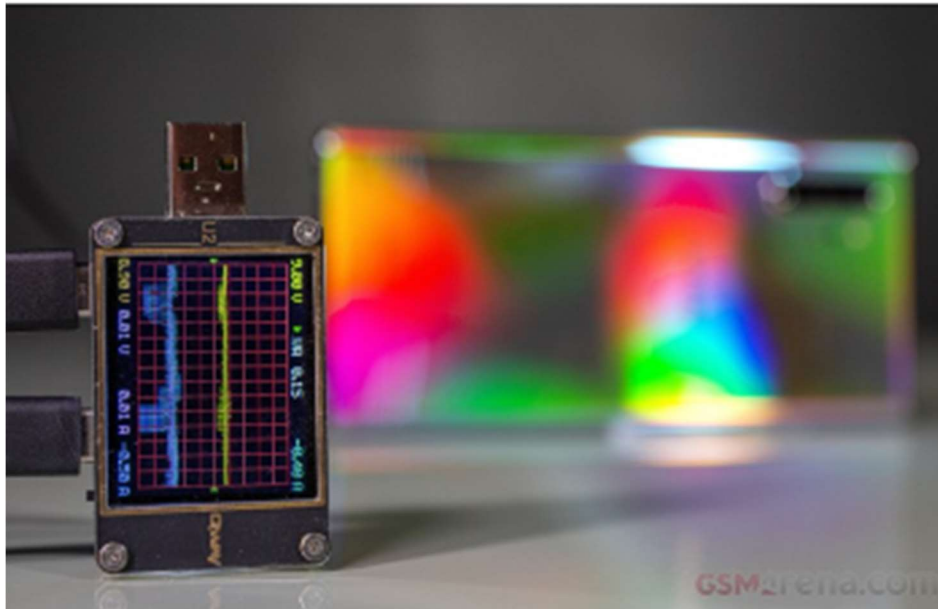
<https://www.samsung.com/levant/mobile-accessories/wall-charger-for-super-fast-charging-25w-ep-ta800xwegww/>

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

The screenshot shows the Belkin website's support section. At the top is the Belkin logo and navigation links: PRODUCTS, SOLUTIONS, BUSINESS, RESOURCES, and SUPPORT. A search bar on the right contains the text 'I'm looking for'. Below the navigation is a breadcrumb trail: support / what is programmable power supply (pps) fast charging?. The main heading is 'What is Programmable Power Supply (PPS) Fast Charging?'. To the right of the heading are social media share icons for Facebook, Twitter, LinkedIn, Email, and Print. The content is divided into three sections, each highlighted with a red border in the image:

- What is PPS Fast Charging?**

Programmable Power Supply (PPS) is a standard that refers to the advanced charging technology for USB-C® devices. It can modify in real time the voltage and current by feeding maximum power based on a device's charging status.

The USB Implementers Forum (USB-IF), a nonprofit group that supports the marketing and promotion of the Universal Serial Bus (USB), added PPS Fast Charging to the USB PD 3.0 standard in 2017. This allows data to be exchanged every 10 seconds, making a dynamic adjustment to the output voltage and current based on the condition of the receiving device's specifications.
- Differences between PPS, PD and QC**

PPS' main advantage over other standards is its capability to lower conversion loss during charging. This means that less heat is generated, which lengthens the device battery's lifespan.
- Some of the devices that support PPS include the following:**
 - Samsung Galaxy® 20
 - Samsung Galaxy Note® 10
 - Samsung S20® Ultra
 - Samsung S21®
 - Other laptops that support PPS

Wireless chargers

The 5200 Duo Pad and the 825 Watch Dock each receive power from a wired USB power adapter. 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 in claim 3) with the Samsung Fast Wireless Charging 2.0 protocol.

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

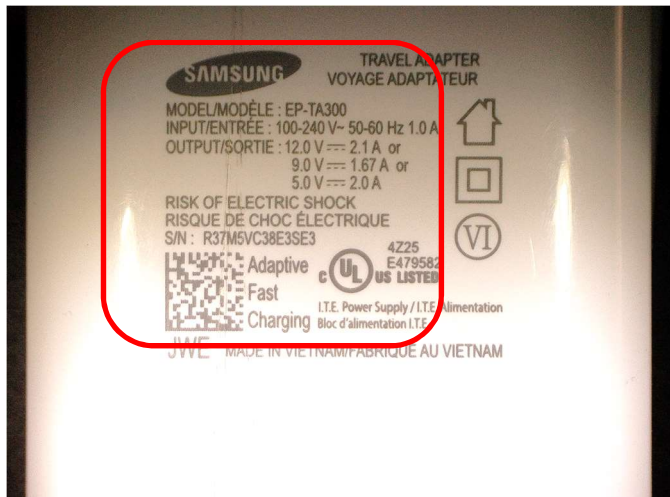
https://www.samsung.com/hk_en/mobile-accessories/wireless-charger-duo-pad-p5200-ep-p5200twegww/

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 (Galaxy S10e, S10, and S10+). Only available with Wireless Charger Duo Pad. Sold Separately. Actual Charging speed may also vary depending on the actual 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.



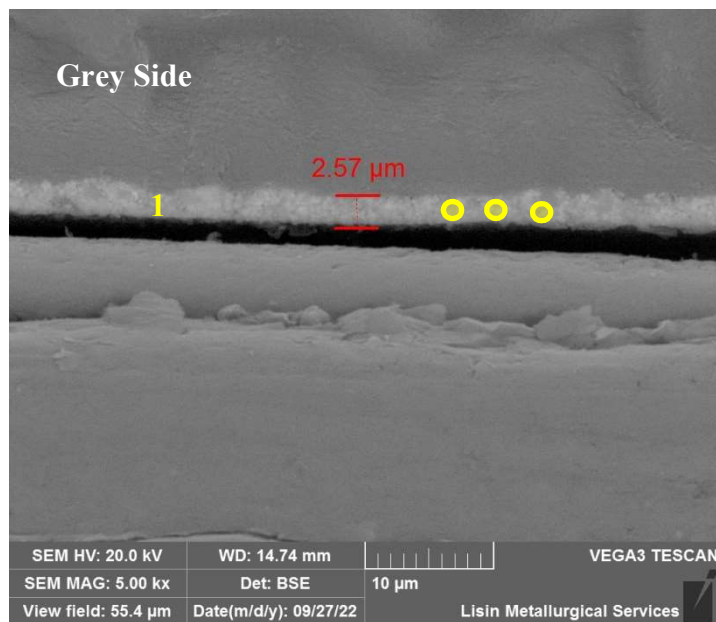
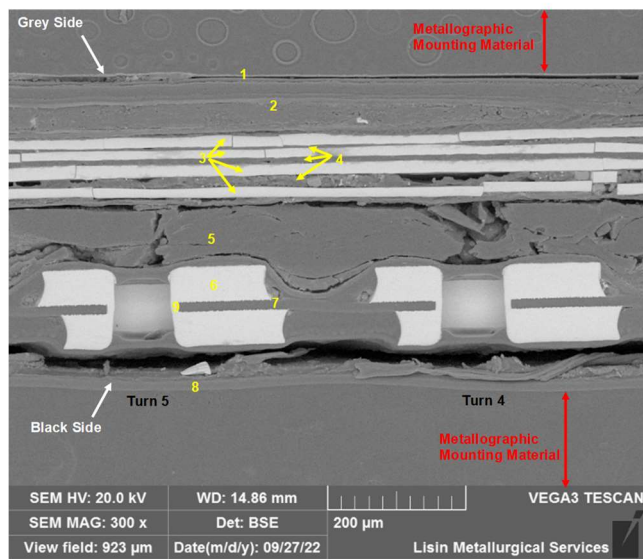
The 825 Watch Dock operates with the EP-TA300 USB power supply / adapter to negotiate an appropriate power level and speed of charging as described above.

8. The apparatus of claim 1, wherein the system further comprises a high heat conductivity layer positioned proximate to the first primary coil and at least covering an area surrounding the first primary coil to disperse any heat generated during provision of power inductively.

The 371 Claim 1 Accused Products which are smartphones additionally infringe this dependent claim, as the system includes a high heat conductivity layer that is structured and operates as specified by this claim.

Smartphones

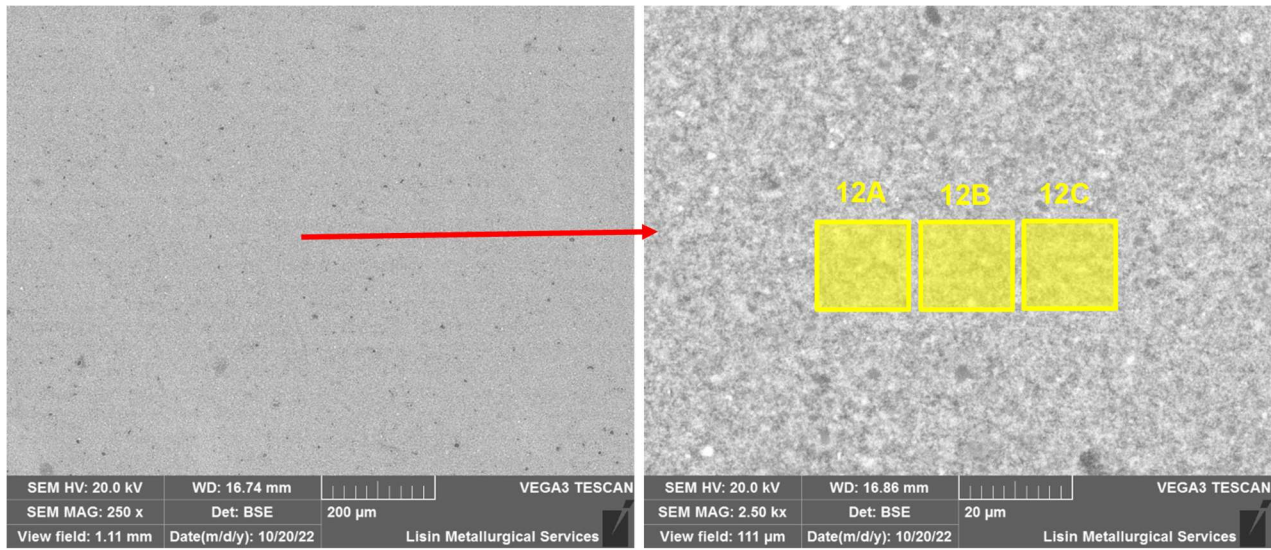
The S22 Ultra, representative product, has a coil structure that includes at least one high heat conductivity layer for heat dispersal proximate to the first primary coil (which is layer 6 below), as shown below in a cross-section SEM image of the coil structure. As an example, 3 points in layer 1 were analyzed as shown below. This high heat conductivity layer is located towards the inner side (towards inside of the phone) of the coil structure proximate to the first primary coil.



Normalized mass concentration [%]

Spectrum	Carbon	Oxygen	Aluminium	Silicon	Titanium	Iron
1A	50.7	24.3	1.0	0.3	23.2	0.5
1B	53.3	21.0	1.1	0.3	23.8	0.5
1C	53.2	21.1	1.2	0.4	23.8	0.4

Due to this layer being thin, in the analysis above, the Carbon concentration may be exaggerated due to pick up of Carbon from the adjacent Carbon rich layer adjacent (lower in above figure). This layer 1 (grey side of the coil structure facing the inside of the phone) was further also analyzed with an EDX beam perpendicular to the surface of the grey layer 1 to sample this layer with less signature from adjacent layers. The results are below. The results below show ~29% Titanium, ~1% Al, 1% Si and ~36% Carbon consistent with a high thermal conductivity layer.

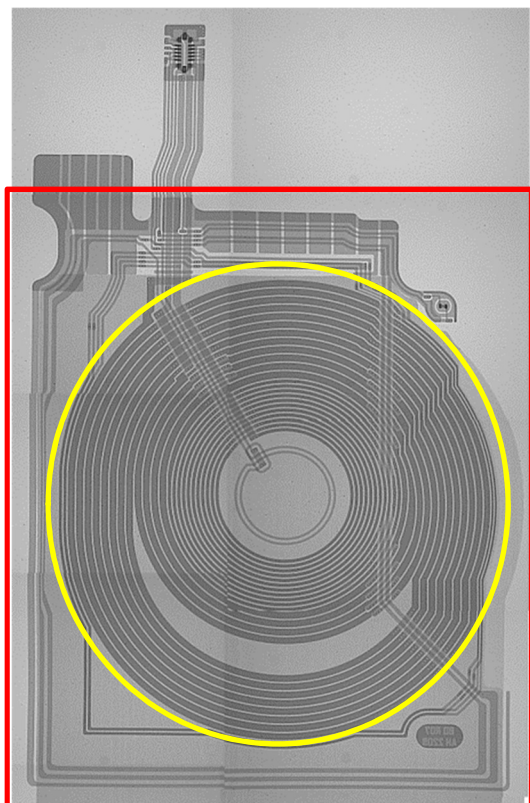


Images at 20kV, spectra at 10kV (interaction depth of 1.3 µm)

Normalized mass concentration [%]

Spectrum	Carbon	Oxygen	Aluminium	Silicon	Titanium
12a	33.0	34.6	0.8	0.6	30.9
12b	34.6	34.7	0.7	1.1	28.9
12c	39.0	33.1	0.7	1.1	26.2

The high heat conductivity layer (red rectangle) extends beyond the first primary coil (yellow area) and in addition to being under the coil, surrounds the coil as shown below.



Samsung discusses use of one or more heat conductive layers to disperse heat at around 25 minutes and 26 minutes into the below video introducing the Galaxy 22 Ultra phone.

https://www.youtube.com/watch?v=KpTBm_fg-Wk&ab_channel=Samsung



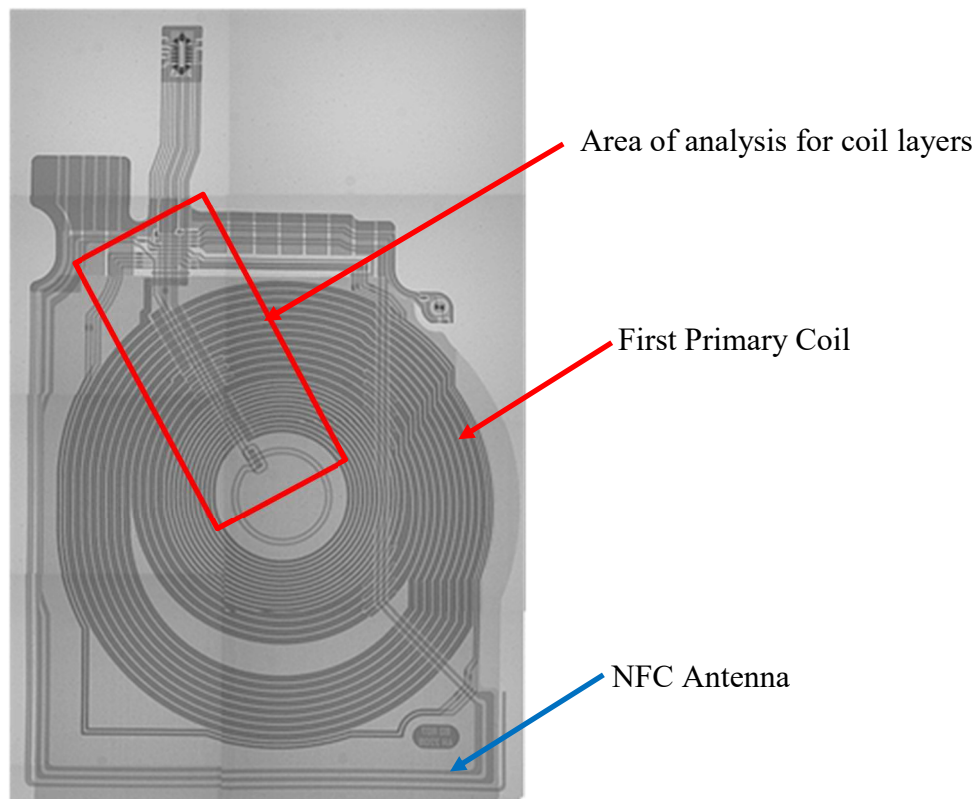
9. The apparatus of claim 1, further comprising a near field communication (NFC) antenna for communication of data, and further wherein: the first primary coil comprises a Printed Circuit Board (PCB) coil; the PCB coil comprises multiple layers of substantially similar copper thickness

and substantially similar spiral-shaped coil patterns connected by vias wherein each layer comprises 1 to 4 ounce (oz) copper thickness material; and the operating frequency is within a range of 100 kHz to 1 MHz.

The 371 Claim 1 Accused Products which are smartphones additionally infringe this dependent claim, as they include an NFC antenna and PCB coil as specified by this claim.

Smartphones

The S22 Ultra, representative product 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 first primary coil (Wireless Charging Coil) and the NFC Antenna are also shown in the FCC filing by Samsung for the S22 Ultra below.

<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

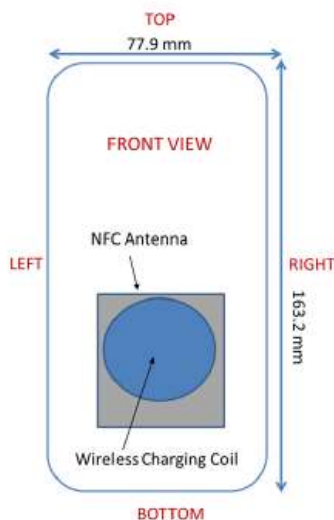
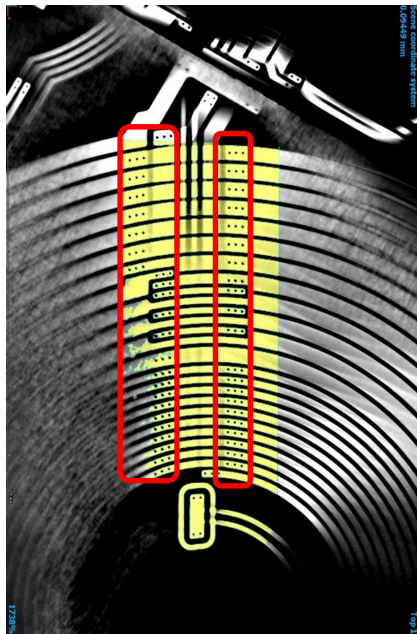


Figure F-2
NFC Antenna Locations

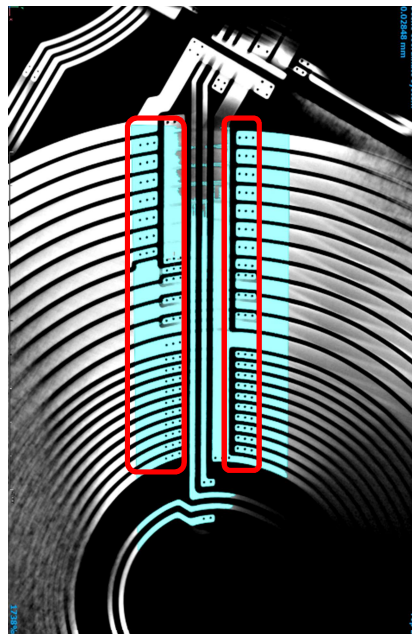
FCC ID A3LSMS908U	 PCTEST Pulse Test & Test Solutions	SAR EVALUATION REPORT		Approved by: Quality Manager
Test Dates: 10/31/21 – 11/15/21	DUT Type: Portable Handset			APPENDIX F: Page 2 of 8

© 2022 PCTEST

The two images below with 3D x-ray imagery distinguish between the two PCB coil layers (stacked vertically with one on top of the other) 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.

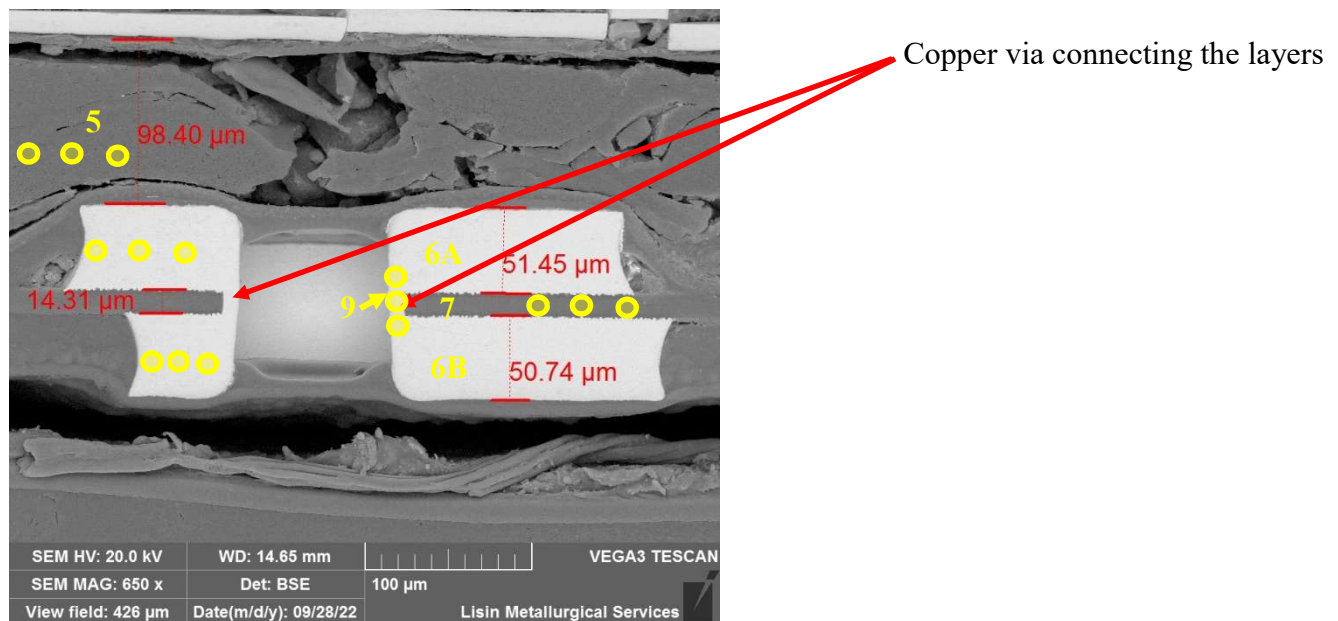


Coil Layer 1



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 thickness) 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. EDX 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 [%] Normalized mass concentration [%]

Spectrum	Aluminium	Iron	Copper	Spectrum	Aluminium	Iron	Copper
6A1	0.4	0.4	99.3	6B1	0.2	0.1	99.7
6A2	0.3	0.2	99.4	6B2	0.3	0.1	99.7
6A3	0.3	0.2	99.5	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

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 9.

<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

10. The apparatus of claim 1, wherein: the system further comprises a near field communication (NFC) antenna for communication of data; the first primary coil comprises a copper PCB coil structure; the PCB coil structure includes a substantially spiral-shaped pattern of multiple coil layers; each of the multiple coil layers comprises a PCB coil having an inner port and an outer port; the inner ports of each of the coil layers are coupled together by vias and form a first common pad; the outer ports of the coil layers are coupled together by vias and form a second common pad; and the two common contact pads provide electrical coupling of the first primary coil for applying the alternating electrical current to the first primary coil.

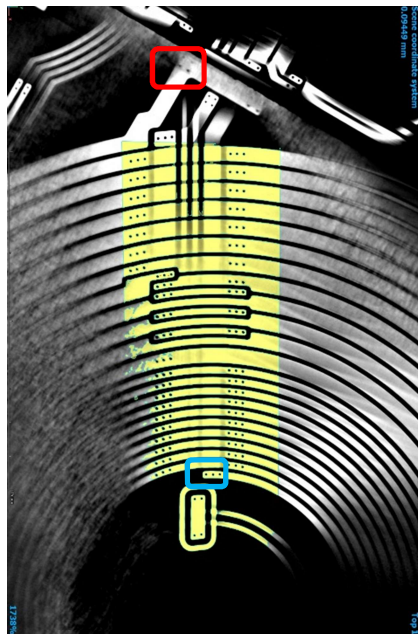
The 371 Claim 1 Accused Products which are smartphones additionally infringe this dependent claim as they include a NFC antenna and PCB coil as specified by this claim.

Smartphones

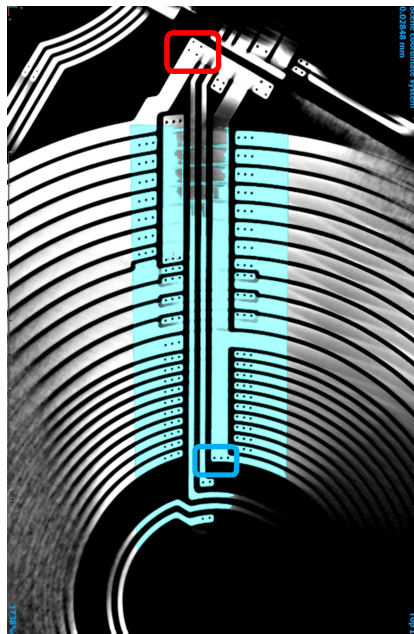
The S22 Ultra, representative product, includes an NFC Antenna and a first primary coil of a copper PC coil structure, as shown above with respect to dependent claim 9.

The two images below with 3D x-ray imagery show the substantially spiral-shaped coil patterns in each layer. The four vias connecting the two layers at a first outer port common pad (red

rectangles) and three vias at a second inner port common pad (blue rectangles) are shown below, as specified in the claim.

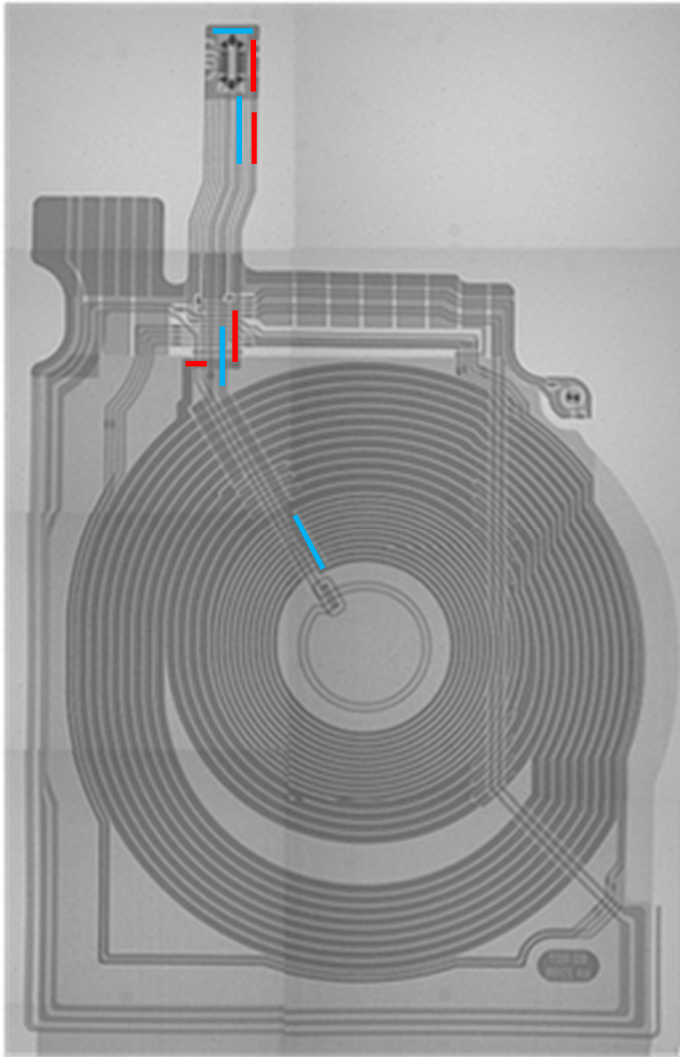


Coil Layer 1



Coil Layer 2

As shown below, Common Pad 1 shown above (with a red conductor trace to the connector) and Common Pad 2 (with a blue conductor trace to the connector) are coupled on the PCB to a connector on the top that plugs into a complementary connector in the phone to provide electrical coupling of the first primary coil for applying a current to the first primary coil as specified by the claim.



11. The apparatus of claim 1, wherein the closed loop feedback manner comprises a Proportional-Integral-Derivative (PID) control technique for regulating the voltage or current at the output of the receiver circuit, the portable device is a first portable device, and the receiver unit of the first portable device is a first receiver unit, the apparatus further comprises: a second portable device; the system is incorporated into the second portable device; and the second portable device further comprises: an internal, rechargeable battery and a DC-to-DC voltage converter to provide power to the system to inductively power the first receiver unit of the first portable device and charge the battery of the first portable device; a second receiver unit coupled to the first primary coil to enable the internal, rechargeable battery to be recharged inductively through the first primary coil; and the communication and control circuit is further configured to control whether the second portable device is receiving power inductively or charging the first portable device inductively.

The 371 Claim 1 Accused Products which are smartphones additionally infringe this dependent claim, as specified by this claim.

Smartphones

The S22 Ultra, representative product, meets this claim as reflected in the above mapping for claims 1 and 2 and the below mapping for claim 20 with respect to the S22 Ultra.

12. The apparatus of claim 1 wherein the first primary coil includes a magnetic core of ferromagnetic material within a central area of the first primary coil and the apparatus further comprises a Near Field Communication (NFC) antenna and circuitry for communication of data.

The 371 Claim 1 Accused Products, which are smartphones, additionally infringe this dependent claim, as the included primary coil is structured and operates as specified by this claim.

Smartphones

The S22 Ultra, representative product, includes a primary coil that operates as an NFC Antenna as 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

Figure 7 below shows 3 images. 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 by EDX. Layer 11 as shown below comprises ferromagnetic material as required by the claim.

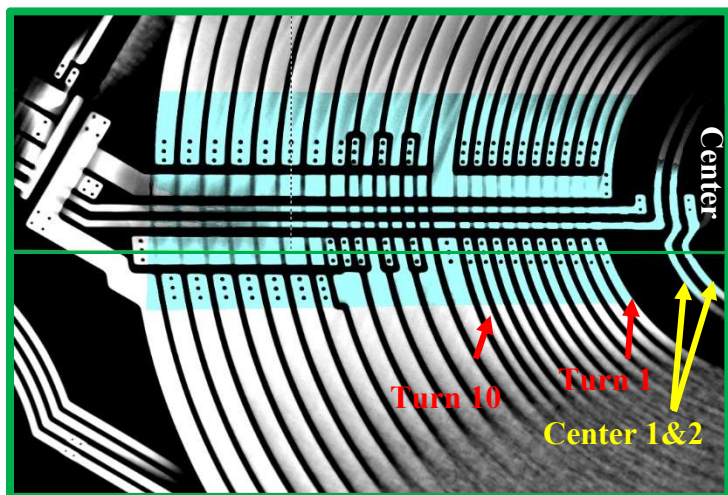
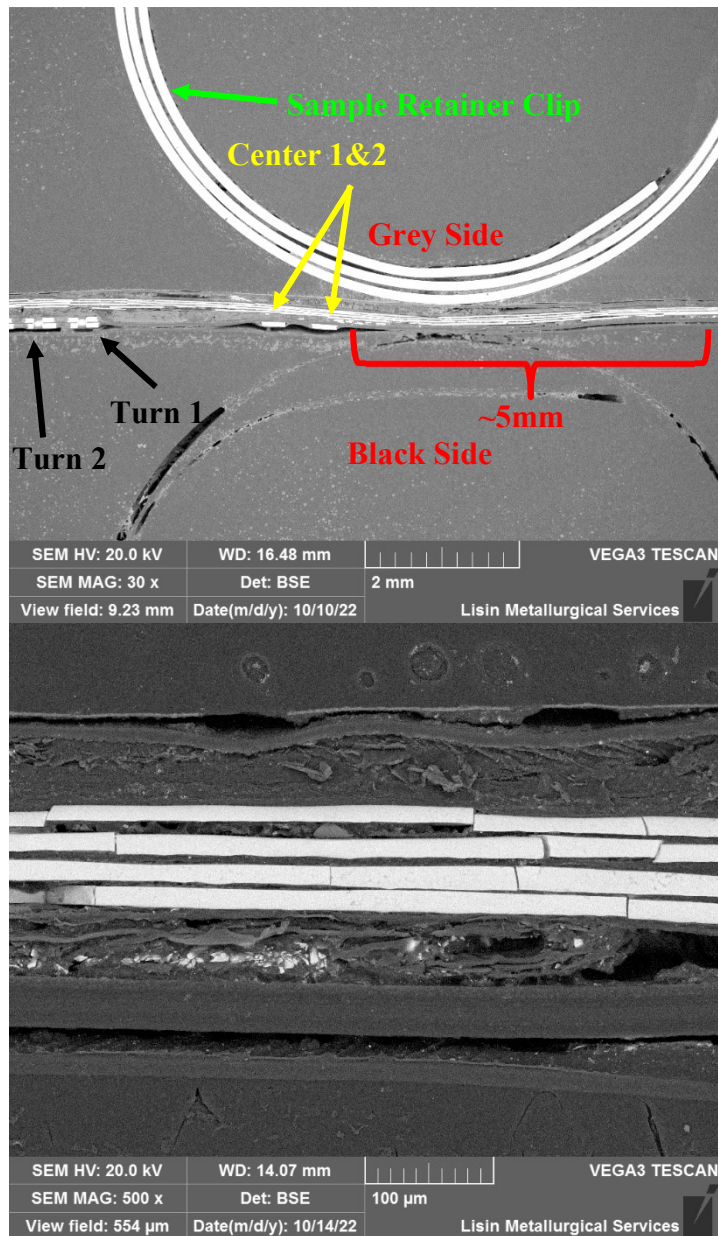
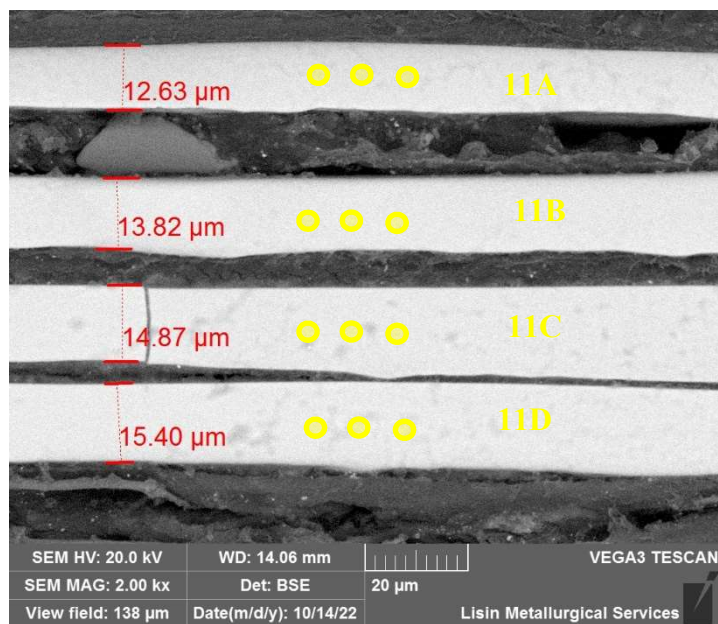
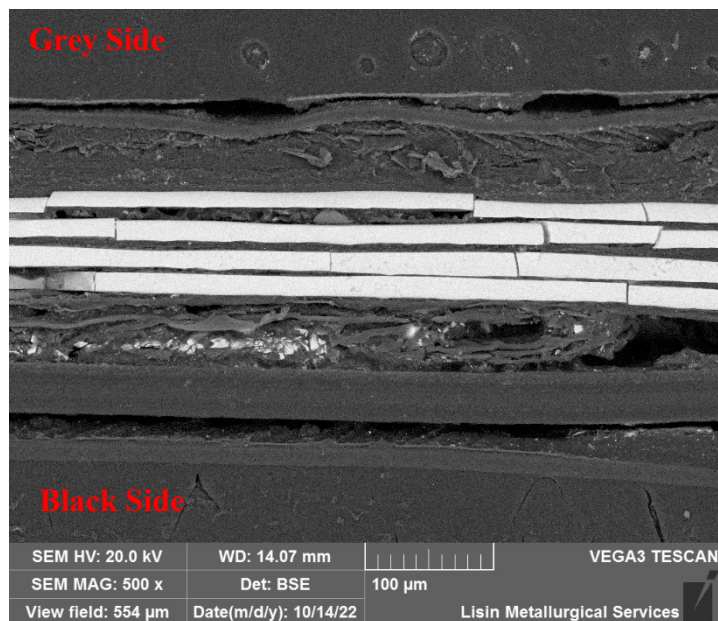


Figure 7

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

16. The apparatus of claim 1 wherein: the first primary coil includes multiple layers of copper PCB of similar spiral-shaped coil pattern interconnected by vias; and the first primary coil includes an outer surface to face a surface of the receiver coil and an inner surface to face away from the surface of the receiver coil; and the system further comprises: a ferromagnetic core located in a central area of the first primary coil; a planar ferromagnetic layer located proximate to the inner surface of the first primary coil; and a metallic layer located proximate to the planar ferromagnetic layer, wherein the ferromagnetic layer is located between the first primary coil and the metallic layer.

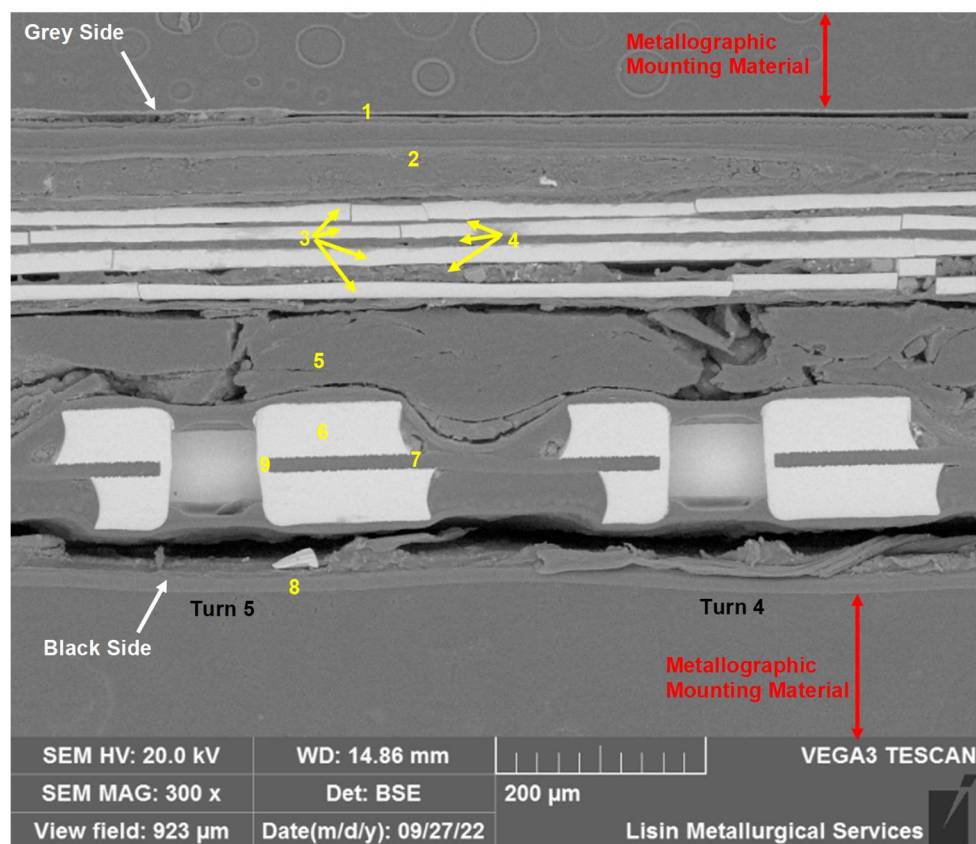
The 371 Claim 1 Accused Products which are smartphones additionally infringe this dependent claim, as the system is structured and operates as specified by this claim.

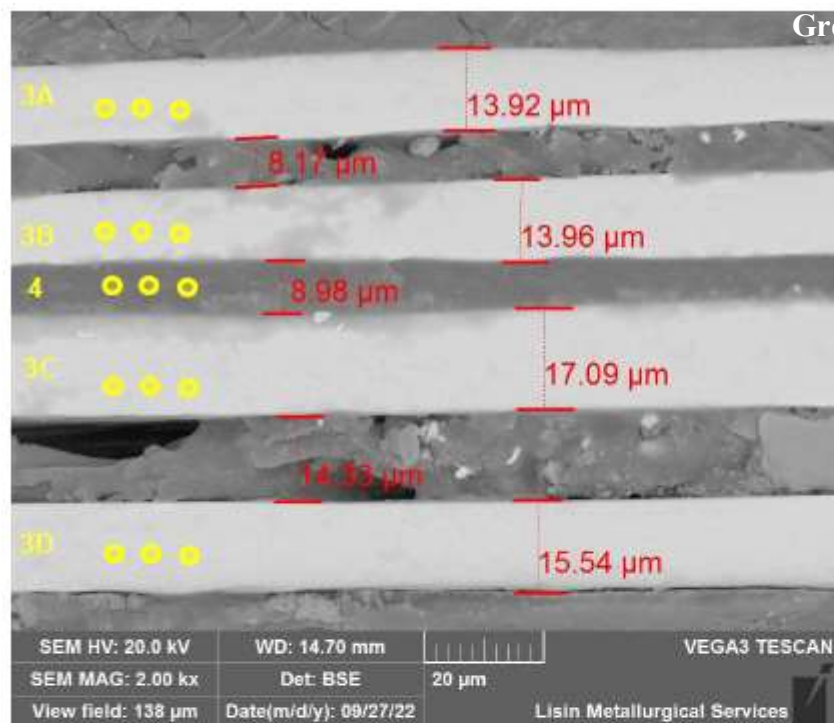
Smartphones

The S22 Ultra, representative product, includes multiple layers of similar spiral-shaped coil pattern interconnected by vias as shown above with respect to claims 9 and 10.

The ferromagnetic core is shown in claim 12 above.

The SEM cross-section image of the first primary coil structure below shows the various layers in this structure. In this image, the Black side at the bottom is the outer surface as described in the claim and the grey side is the inner surface as described in the claim. The two layers shown as 6 are the two first primary coil Copper layers as shown in claim 10 above. Layers shown as 3 are ferromagnetic (Iron / Silicon / Al) layers as shown further below and Layer 1 is a Ti / Al layer as shown in claim 8 above. As specified by the claim, the Ferromagnetic layer 3 is located between the first primary coil 6 and the metallic layer 1 (also as shown in claim 8 above).





Normalized mass concentration [%]

Spectrum	Aluminium	Silicon	Iron	Copper
3A1	0.1	7.4	91.0	1.5
3A2	0.1	7.4	91.0	1.5
3A3	0.0	7.3	91.2	1.5

Normalized mass concentration [%]

Spectrum	Aluminium	Silicon	Iron	Copper
3B1	0.2	7.3	91.0	1.5
3B2	0.4	6.9	90.9	1.8
3B3	0.3	6.8	91.5	1.4

Normalized mass concentration [%]

Spectrum	Aluminium	Silicon	Iron	Copper
3C1	0.1	7.0	91.2	1.7
3C2	0.2	7.3	90.7	1.9
3C3	0.3	7.3	90.7	1.7

Normalized mass concentration [%]

Spectrum	Aluminium	Silicon	Iron	Copper
3D1	0.8	6.5	90.3	2.4
3D2	0.8	5.2	91.6	2.5
3D3	2.2	5.4	90.0	2.4

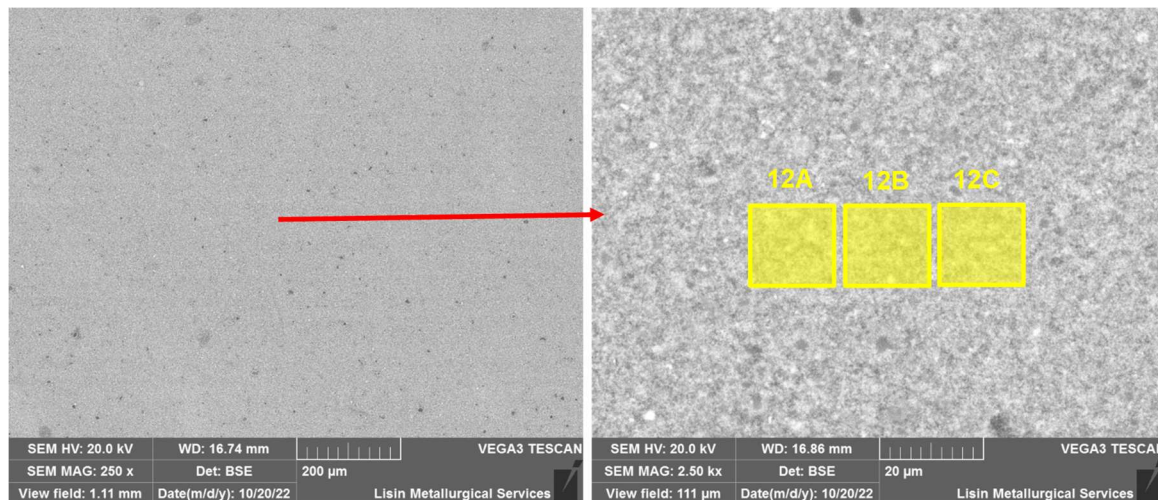
Normalized mass concentration [%]

Spectrum	Carbon	Oxygen	Magnesium	Aluminium	Silicon	Iron
4A	74.0	19.0	0.1	2.9	0.2	3.8
4B	76.9	16.4	0.1	3.5	0.2	3.0
4C	77.8	14.4	0.1	5.0	0.2	2.4

Normalized mass concentration [%]

Spectrum	Carbon	Oxygen	Aluminium	Silicon	Titanium	Iron
1A	50.7	24.3	1.0	0.3	23.2	0.5
1B	53.3	21.0	1.1	0.3	23.8	0.5
1C	53.2	21.1	1.2	0.4	23.8	0.4

As discussed above in claim 8 above, layer 1 (grey side of the coil structure facing the inside of the phone) was also analyzed with an EDX beam perpendicular to the surface of the grey layer 1 to sample this layer with less signature from adjacent layers. The results are below. The results below show ~29% Titanium, ~1% Al, 1% Si and ~36% Carbon for this metallic layer.



Images at 20kV, spectra at 10kV (interaction depth of 1.3 µm)

Normalized mass concentration [%]

Spectrum	Carbon	Oxygen	Aluminium	Silicon	Titanium
12a	33.0	34.6	0.8	0.6	30.9
12b	34.6	34.7	0.7	1.1	28.9
12c	39.0	33.1	0.7	1.1	26.2

20. A portable device comprising:

The 371 Accused Smartphones, the 371 Accused Earbud, and the 371 Accused Wearables, Products are accused under this claim (collectively the “371 Claim 20 Accused Products”). As detailed below by representative products, the 371 Claim 20 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.

Smartphones

The S22 Ultra is representative of how the 371 Accused Smartphones meet this introductory part of claim 1, as the S22 Ultra is a portable device, 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-

https://www.samsung.com/us/mobile-audio/galaxy-buds2/?ds_k=s22+ultra&gclid=ff35fb3f57bd152c75499907a5b4d433&gclsrc=3p.ds&mseclid=ff35fb3f57bd152c75499907a5b4d433



Earbuds

The Buds2 is representative of how the 371 Accused Earbud Products infringe claim 20. The Buds2 product meets this introductory part of claim 1 as it is a portable device.

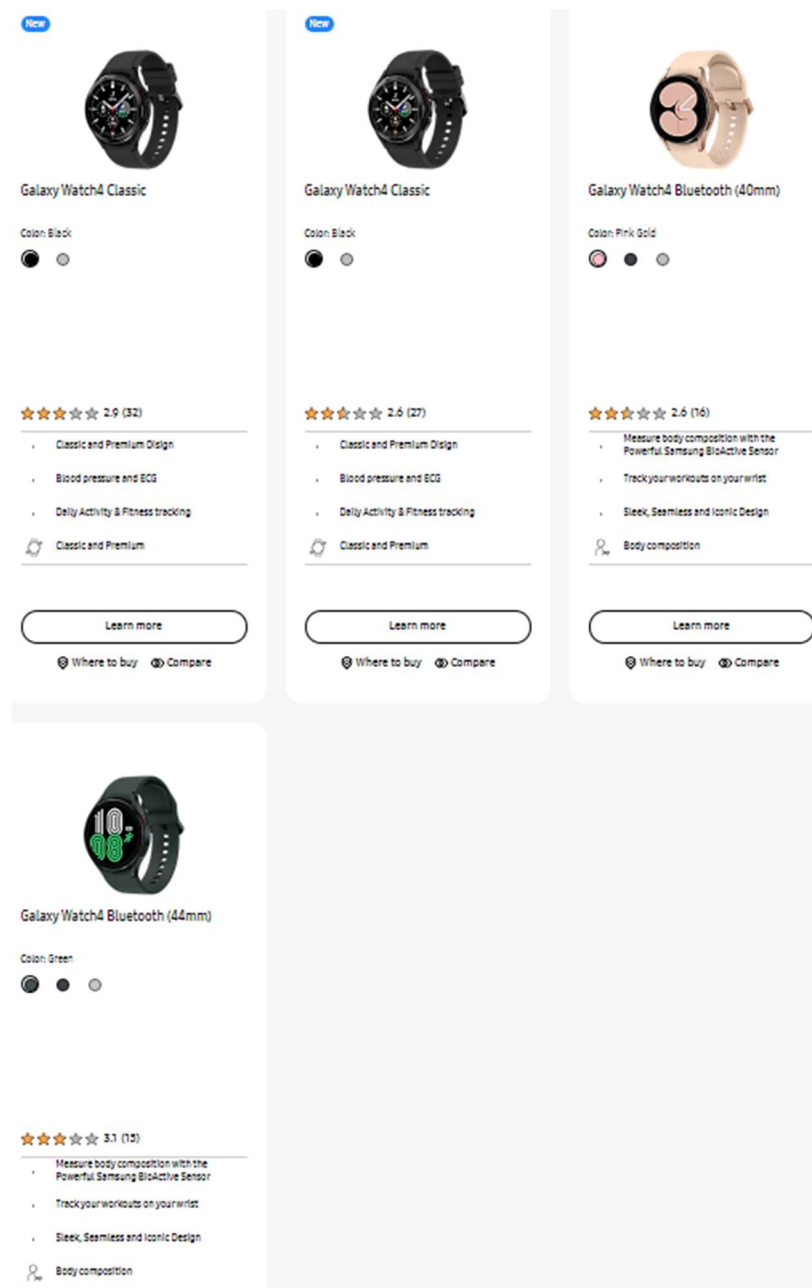
<https://www.samsung.com/us/mobile-audio/galaxy-buds2/>



Wearables

The Watch4 is representative of how the 371 Accused Wearables satisfy this introductory part of claim 1. The Watch4 is a portable device as specified by this introductory part of claim 1.

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



a battery; and

The 371 Claim 20 Accused Products meet this part of 371 claim 20 as they each include a battery, as illustrated below for the representative products.

Smartphones

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

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



Earbuds

The Buds2 case includes a battery as specified by this part of the claim.

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



Wearables

The Watch4 includes a battery, as recited by this part of the claim.

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

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



- 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.

a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:

The 371 Claim 20 Accused Products meet as represented by S22 Ultra, the Buds2 case, and the Watch4 meet this part of 371 claim 20 as they each include a receiver unit for receiving inductive power as specified by this part of the claim.

Smartphones

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

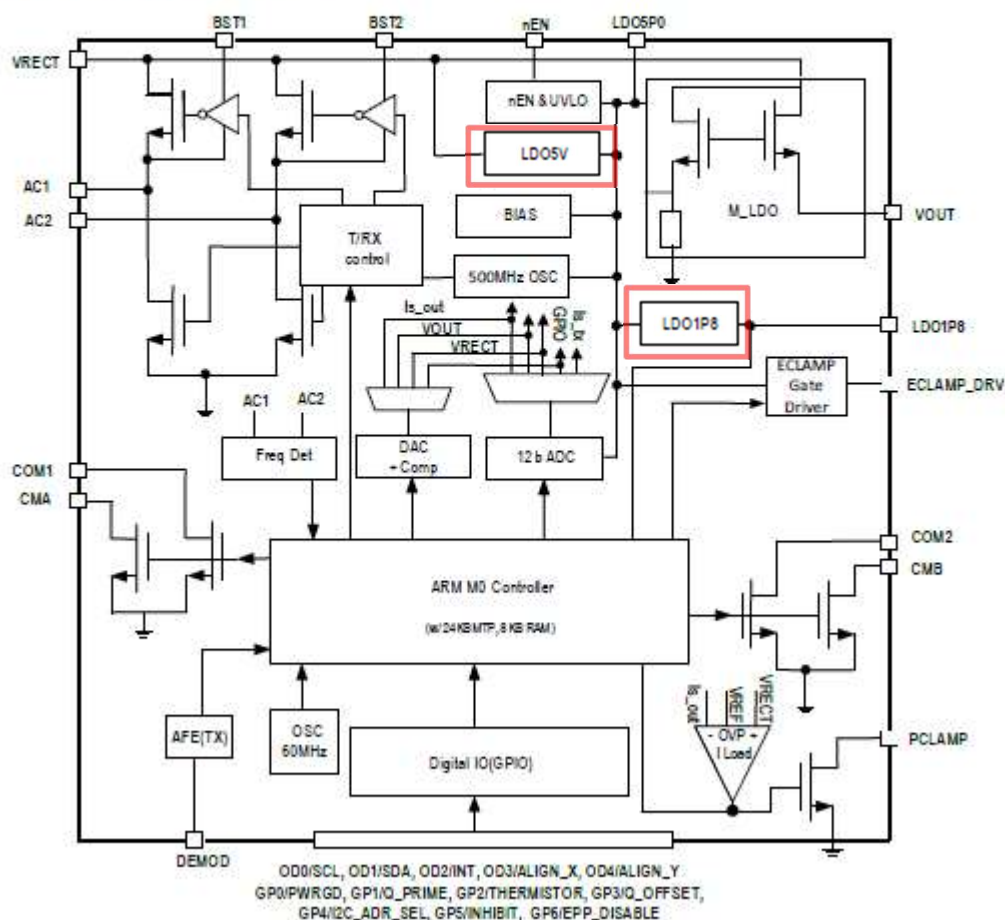
The receiver circuit in the S22 Ultra includes a wireless power transceiver ASIC (e.g., the 9320S ASIC) in combination with external capacitors and other external circuitry, as shown above with respect to claim 1.

The representative 9415 ASIC and external capacitors form a receiver circuit coupled to the battery 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 receive 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.

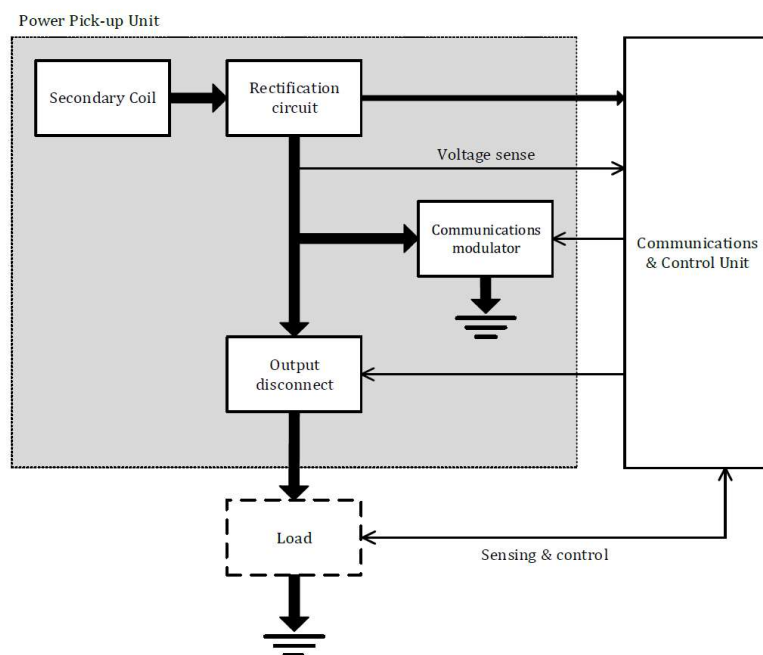
That the receiver circuit is powered inductively is further indicated by the WPC standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 23-24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 24-25).

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

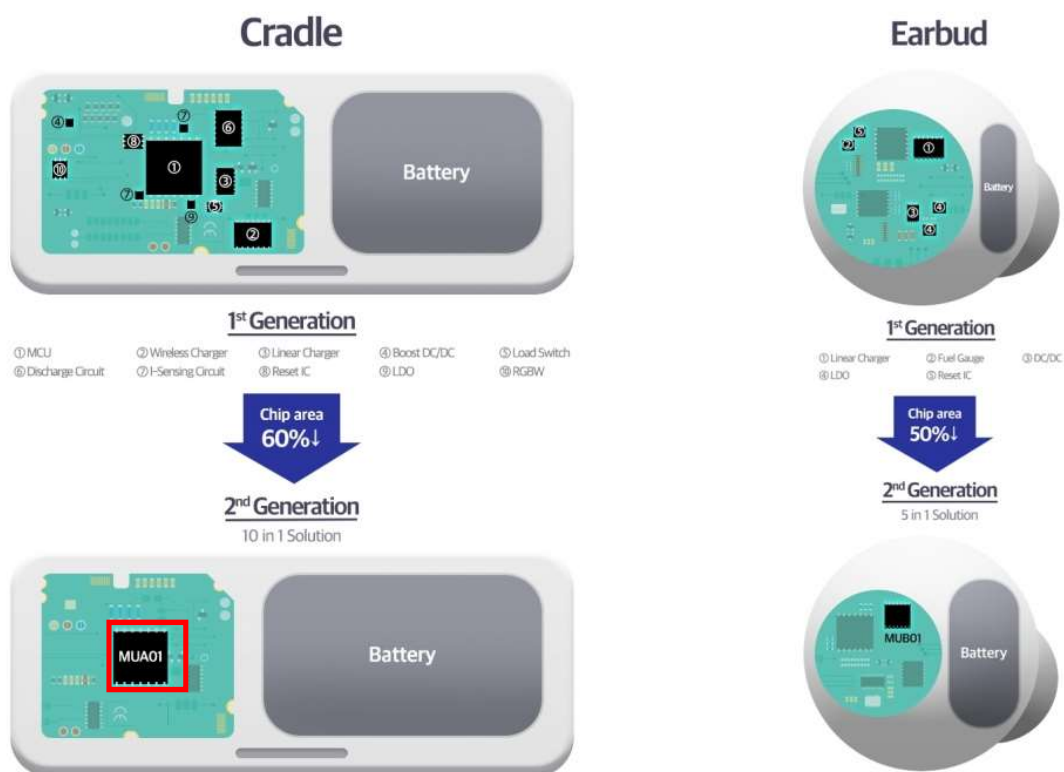
The Buds2 case includes a receiver circuit (as specified by later parts of this claim) that is coupled to the battery and receives power from the inductive charging system. For example, the Buds2 case includes a power management integrated circuit (PMIC) that comprises in part a receiver circuit that 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 is 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	
ADDITIONAL DETAILS	
Qi Registration id	11427
Version	1.2.4
Currently licensed	Yes
Power profile	Basic Power Profile
Maximum received power	2 watts

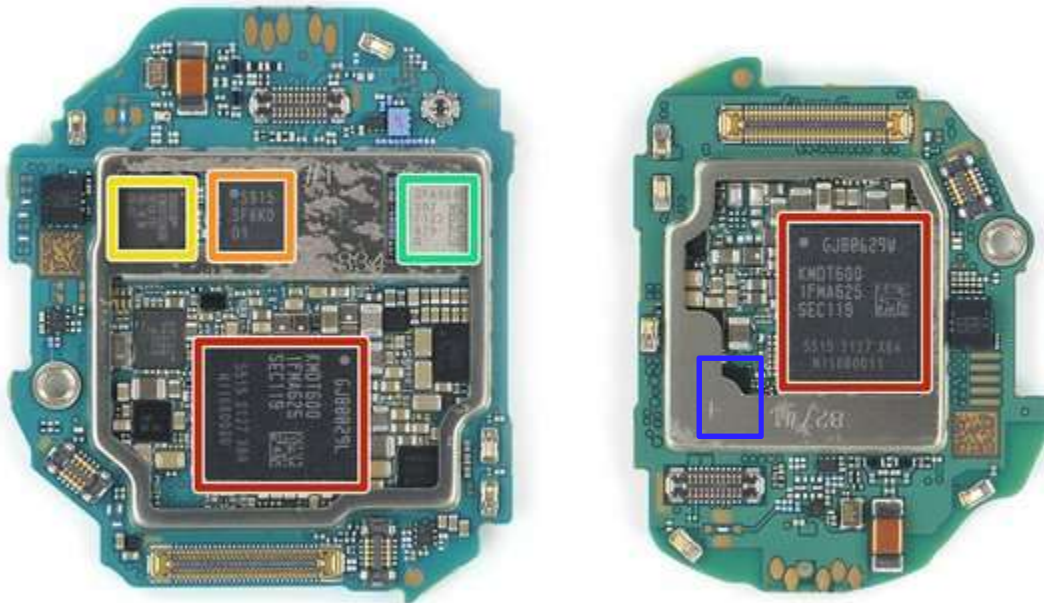


Per the WPC Standard, the receiver circuit of the Buds2 case is powered by the received inductive power from the inductive charging system and is coupled to the battery, as shown above with respect to the S22 Ultra with respect to this claim element.

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 receives power from the inductive charging system and is coupled to the battery. 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-rn-datasheet>

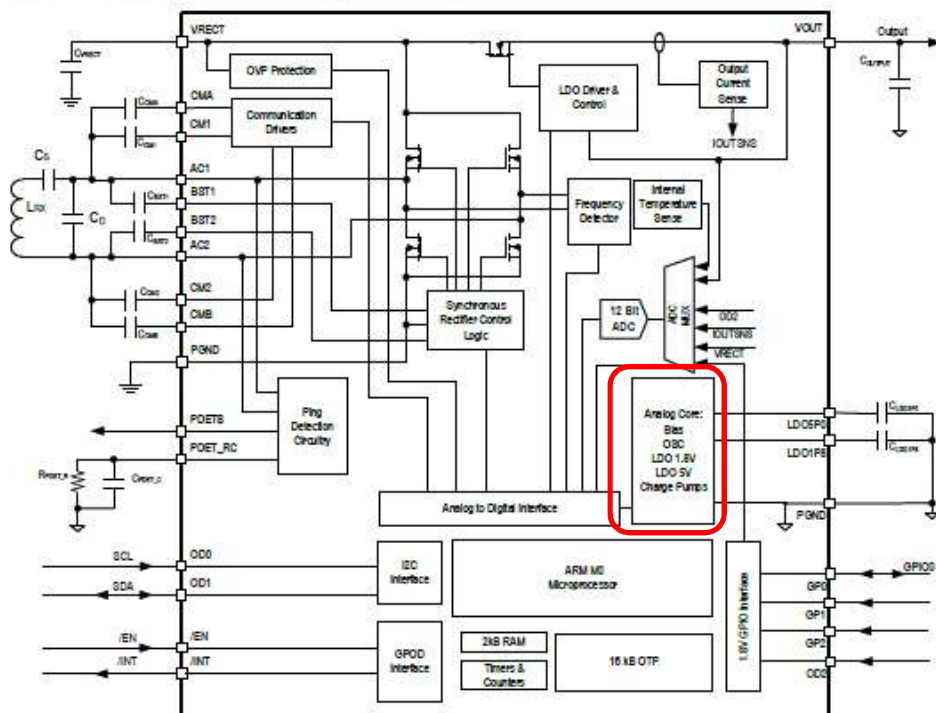
RENESAS

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

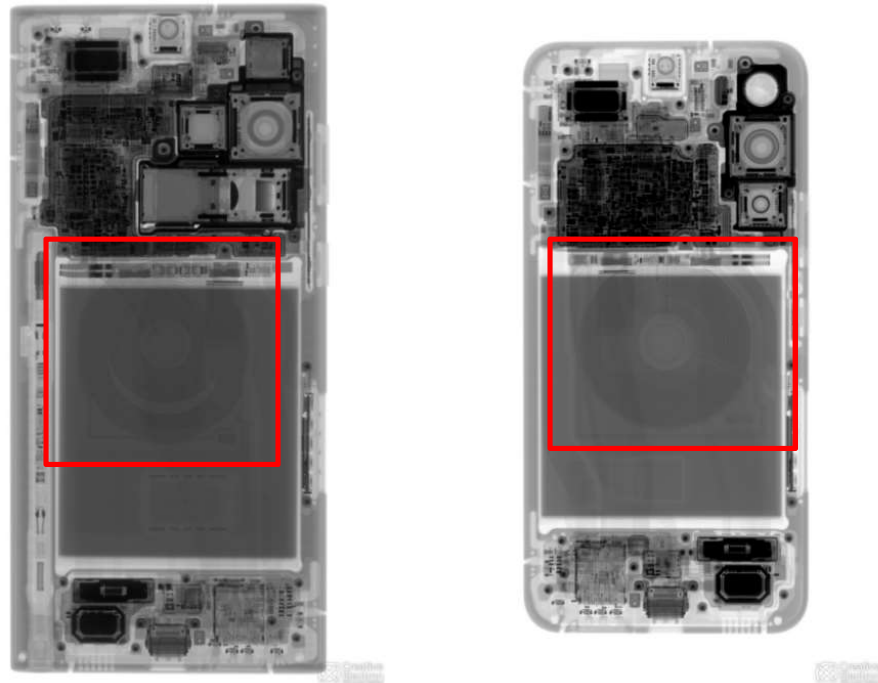
The 371 Claim 20 Accused Products meet this part of 371 claim 20 as they each include a receiver coil as specified by this part of the claim, as illustrated below for the representative products.

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.

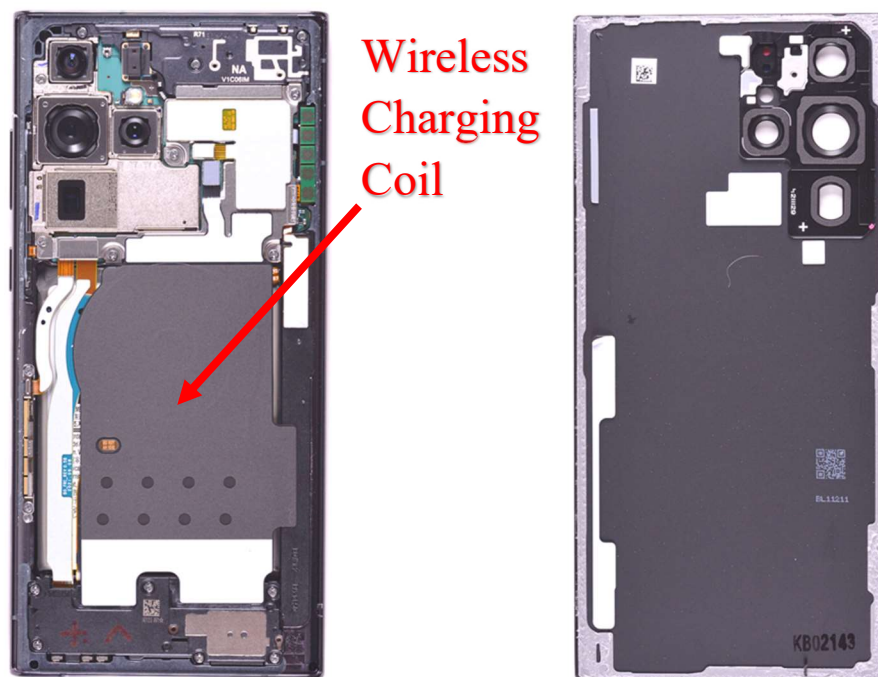
<https://www.ifixit.com/News/57567/galaxy-s22-teardowns-apple-is-making-samsung-sweat>

X-ray examination



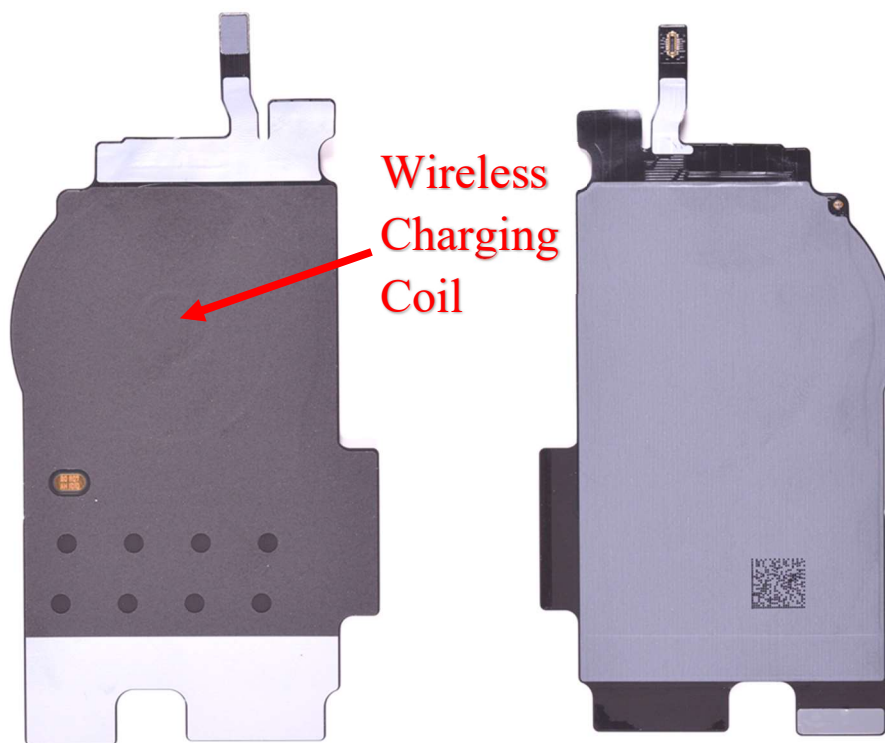
On the left is the Note-succeeding Samsung Galaxy S22 Ultra, with the "vanilla" S22 on the right.

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.

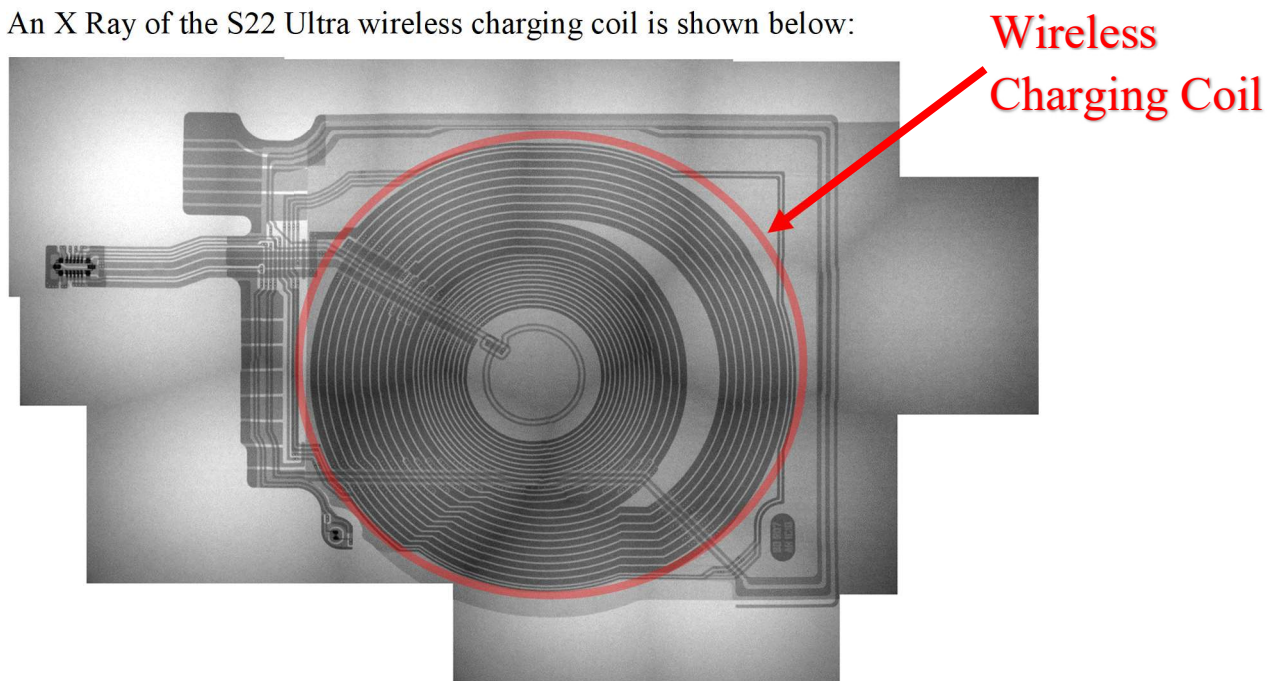


Samsung S22 Ultra – Back cover removed

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.



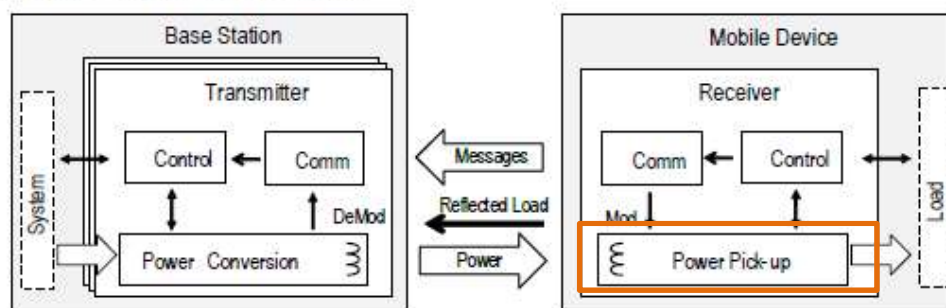
P9415-R Datasheet

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

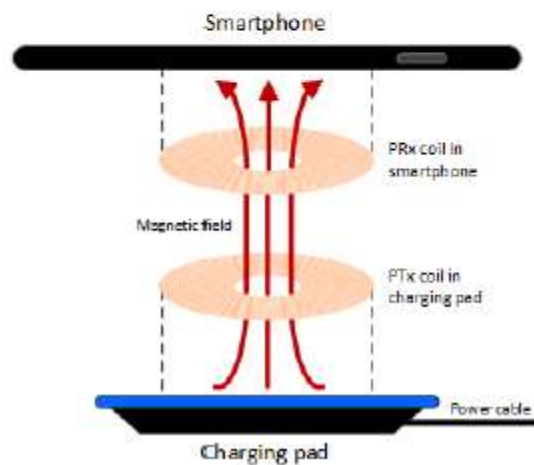


When placed on a WPC compliant charger, the S22 Ultra receives an alternating magnetic field substantially perpendicular to the plane of the planar receiver coil that generates a current for inductive power transfer as recited by this part of the claim. *E.g.*, WPC 1.2.4 Standard, Introduction, page 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

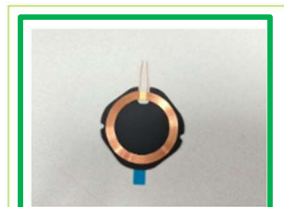
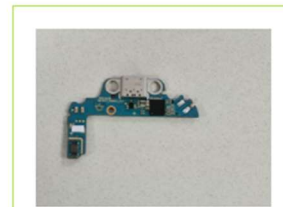
August 19, 2021

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

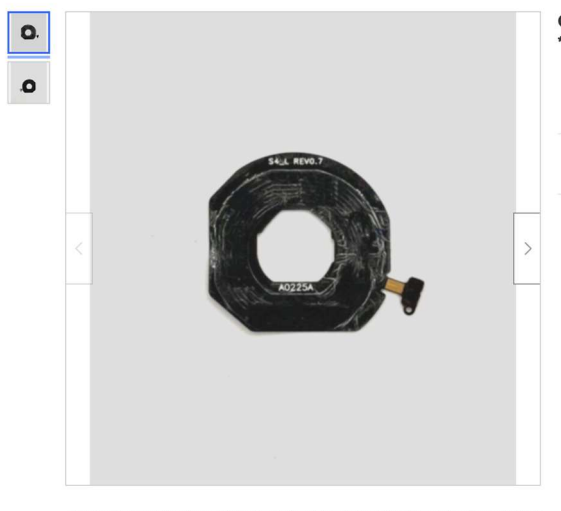


The Buds2 case is WPC compliant, as shown above. When placed on a WPC compliant charger, the Buds2 case receives an alternating magnetic field substantially perpendicular to the plane of the planar receiver coil that generates a current for inductive power transfer as recited by this part of the claim. *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-rrn-datasheet>

RENESAS

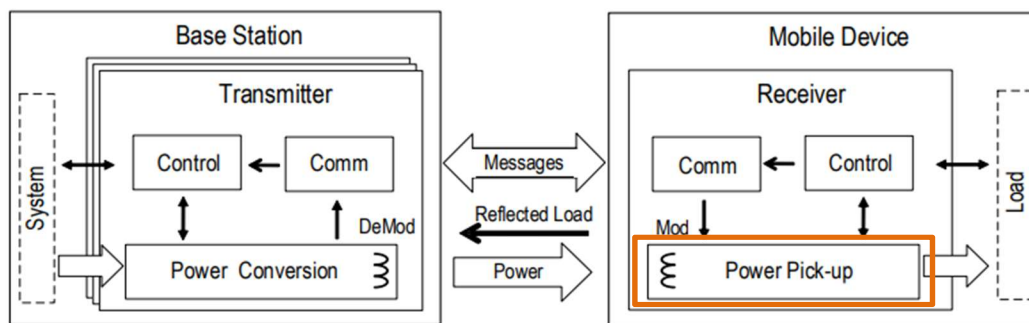
P9222-R/RN Datasheet

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 ferromagnetic layer placed under the receiver coil on a side of the receiver coil away from the surface of the portable device; and

The 371 Claim 20 Accused Products meet this part of 371 claim 20 as they each include a ferromagnetic layer placed in accordance with this part of the claim, as illustrated below for the representative products.

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 receiver coil (towards the inside of the phone as shown below on the gray backing side of the charging coil). See claim 16 above for evidence of the ferromagnetic layer.



Earbuds

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

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



Wearables

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

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

The 371 Claim 20 Accused Products meet this part of the claim as they each include 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, as illustrated below for the representative products.

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.

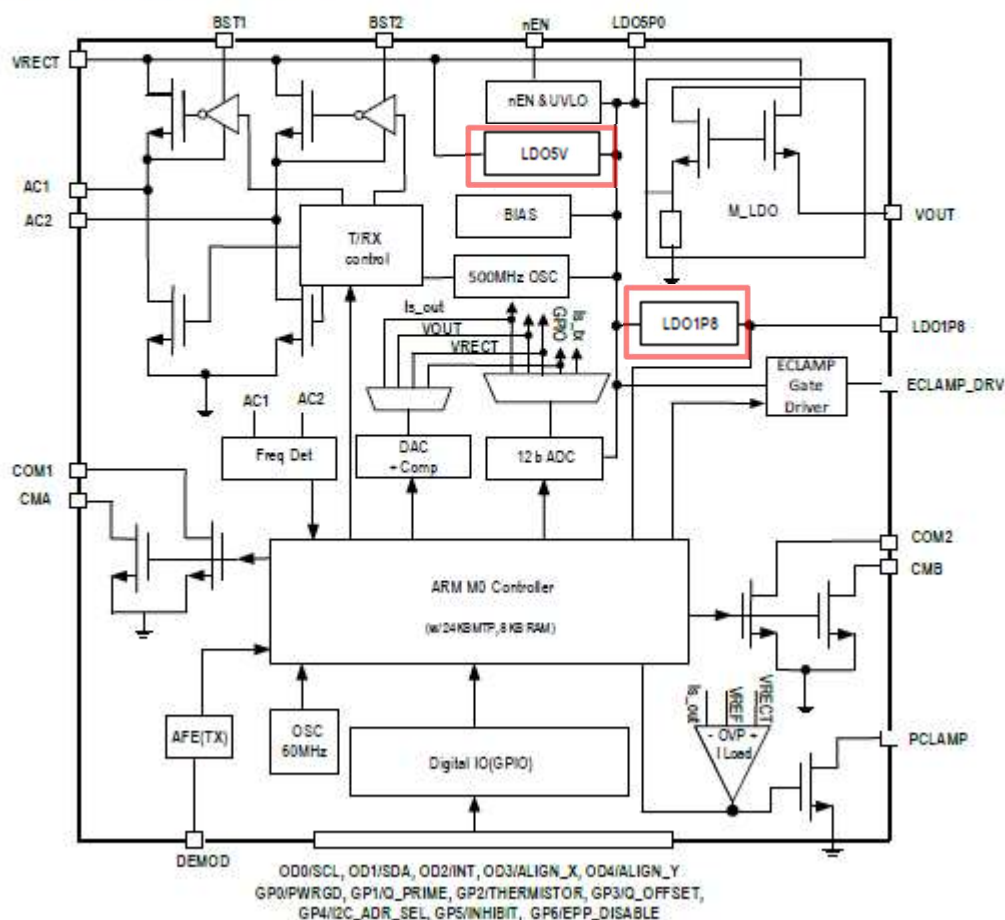
The receiver circuit in the S22 Ultra includes a wireless power transceiver ASIC (e.g., the 9320S ASIC) in combination with external capacitors and other external circuitry, as shown above with respect to claim 1.

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 9320S 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.

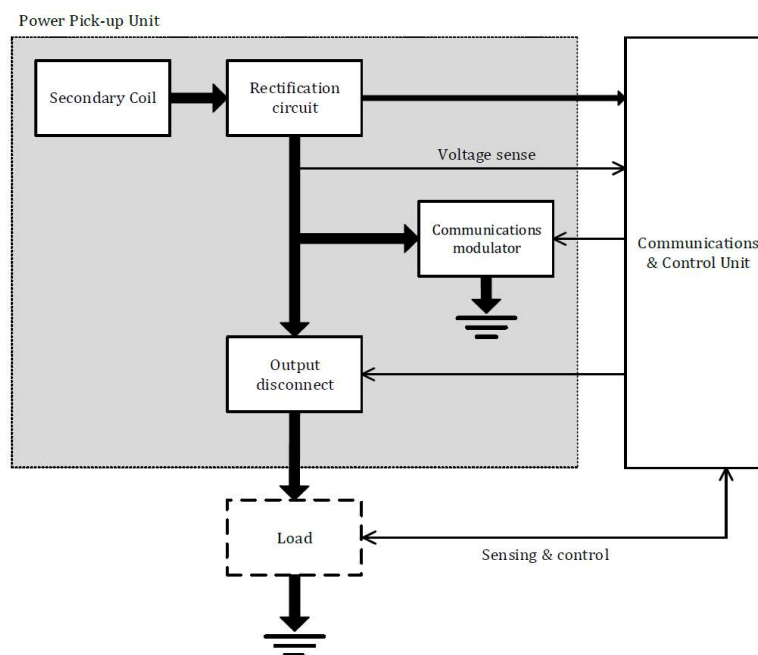
That the receiver circuit is powered inductively is further indicated by the WPC standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 23-24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 24-25).

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

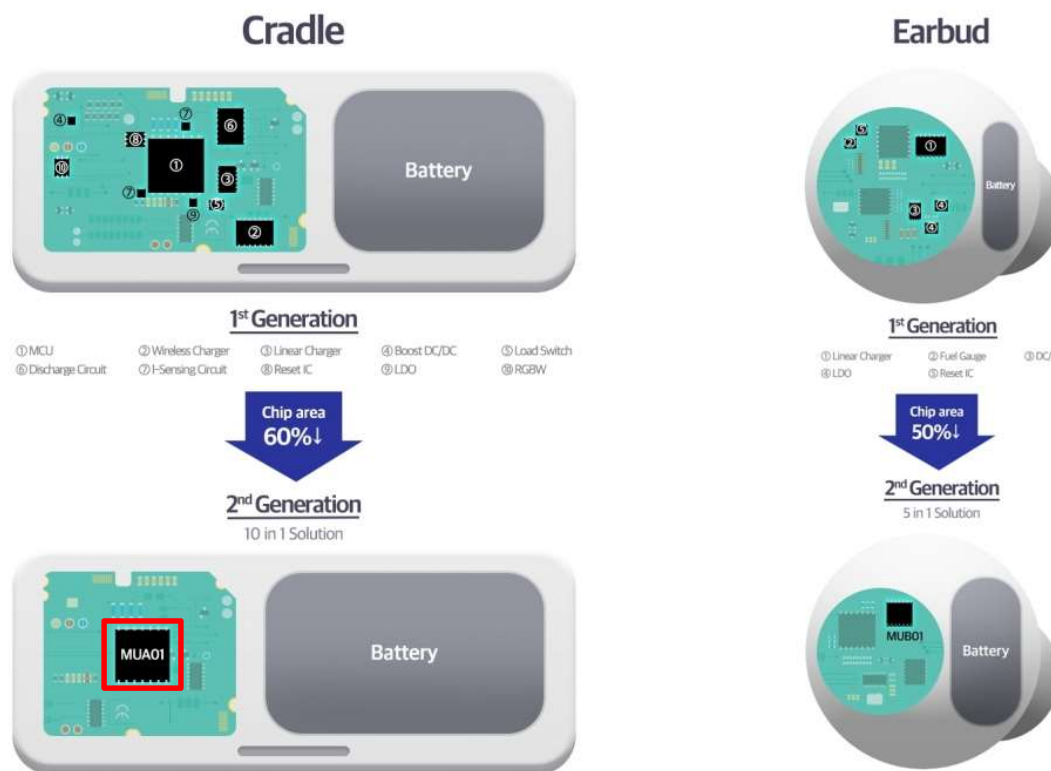
integrated circuit (PMIC) such as the MUA01 ASIC that comprises in part a receiver circuit that is powered inductively as claimed.

<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 371 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

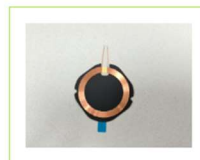
Power Class 0 Receiver

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

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.

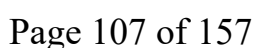
<https://www.renesas.com/us/en/document/dst/p9222-rn-datasheet>

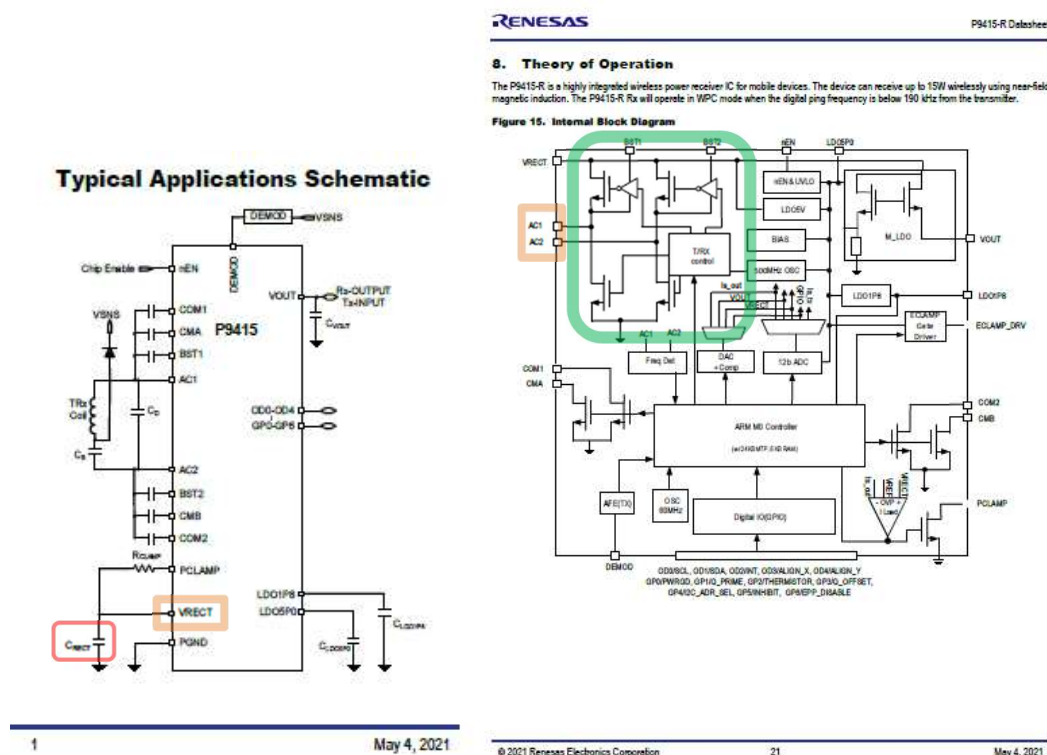


P9222-R/RN Datasheet

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.





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

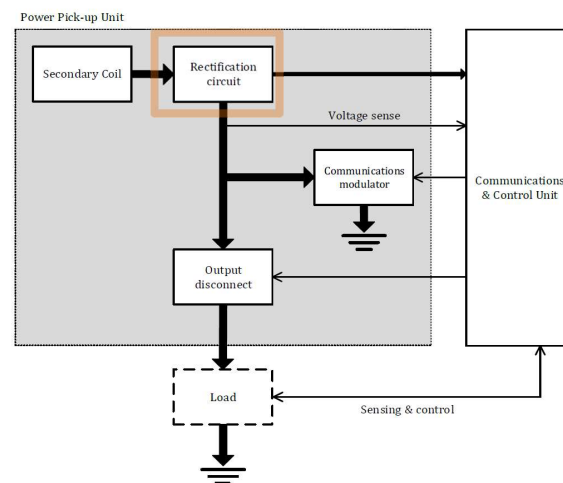
The WPC Standard shows a receiver rectifier circuit as claimed. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 23-24, 42, and 136 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 24-25, 42, 134) (in Figure 47 below, the red rectangle on right shows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

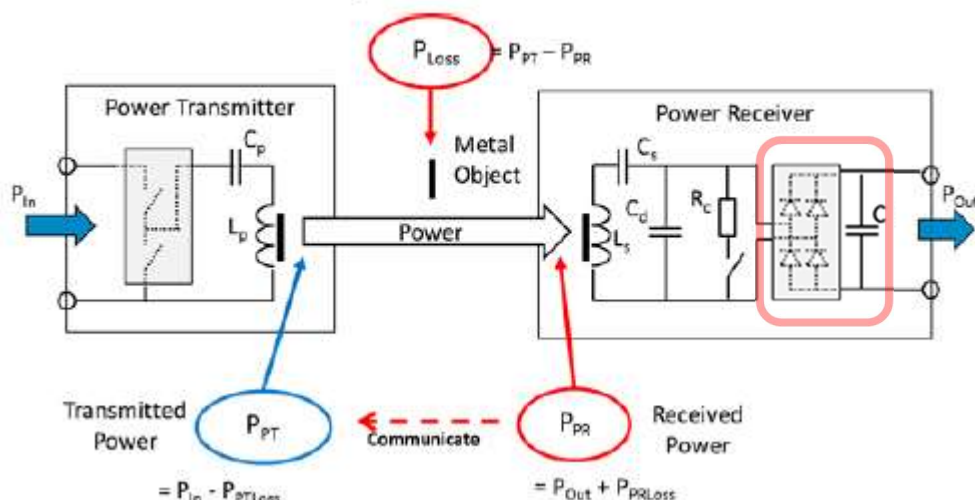
Figure 4. Functional block diagram for a Baseline Power Profile Power Receiver



- 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-rrn-datasheet>

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

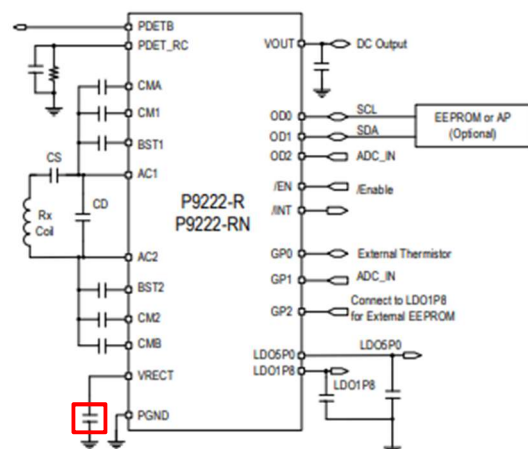
The P9222-R/RN is an integrated single-chip wireless power receiver IC (Rx) for up to 5W applications implementing in-band, bi-directional data communication with no additional circuitry. The device receives an AC power signal from a wireless power transmitter, such as the P9235A-RB WPC Qi BPP Wireless 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

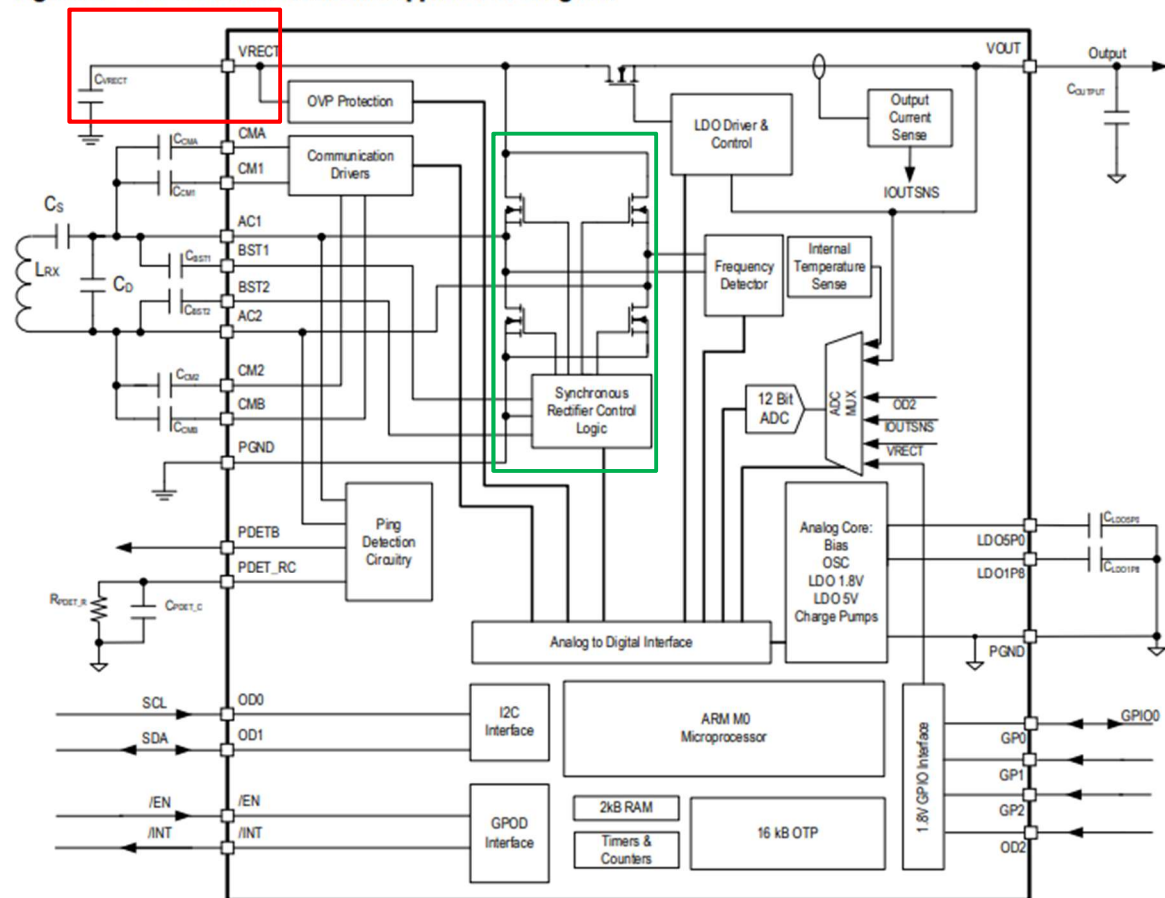
Figure 1. Simplified Block Diagram



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.

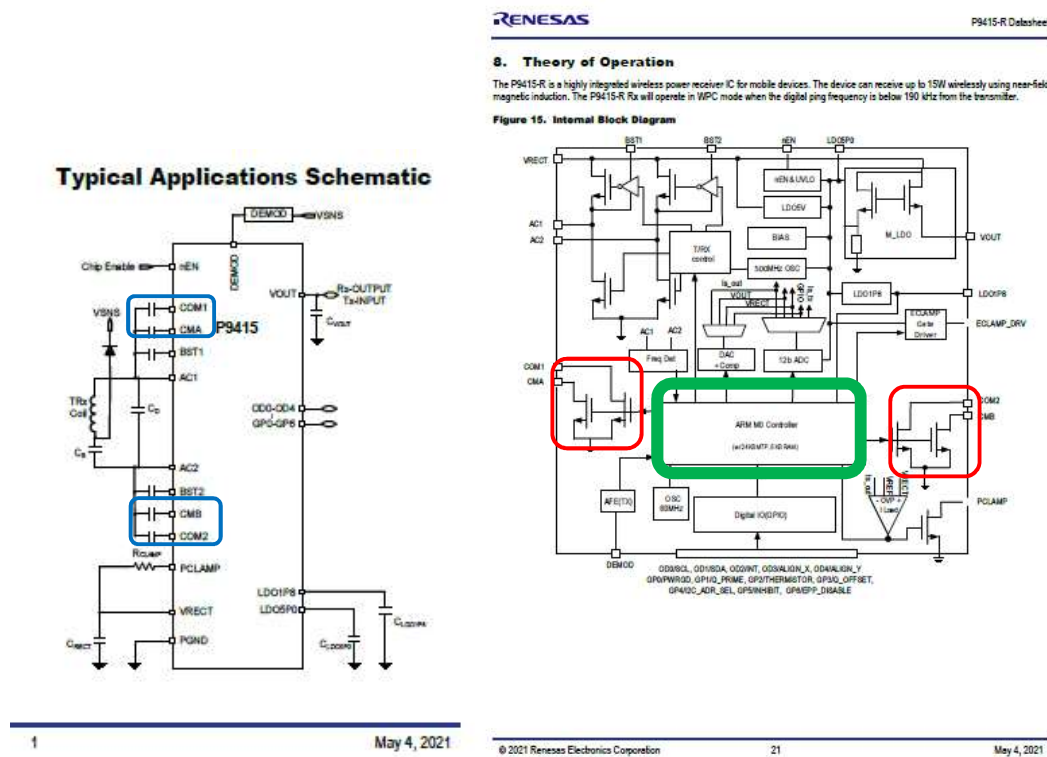
a receiver communication and control circuit including a microcontroller to modulate the current in the receiver coil to communicate with the base unit while the receiver circuit is being powered by the inductive charging system;

The 371 Claim 20 Accused Products meet this part of 371 claim 20 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. Using the FETs, the receiver communicates with the charger by modulating the impedance at the receiver coil by connecting and disconnecting the external capacitors shown in blue rectangles below. These circuits are powered by the inductive charging system.



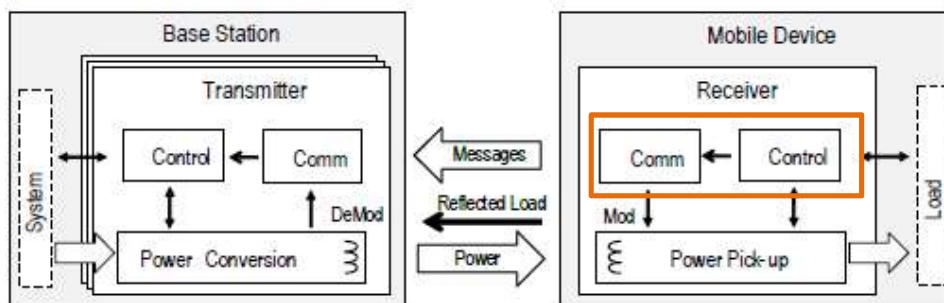
Current modulation is used for communication with the charger base unit, as explained further in the representative 9415 datasheet.

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



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.

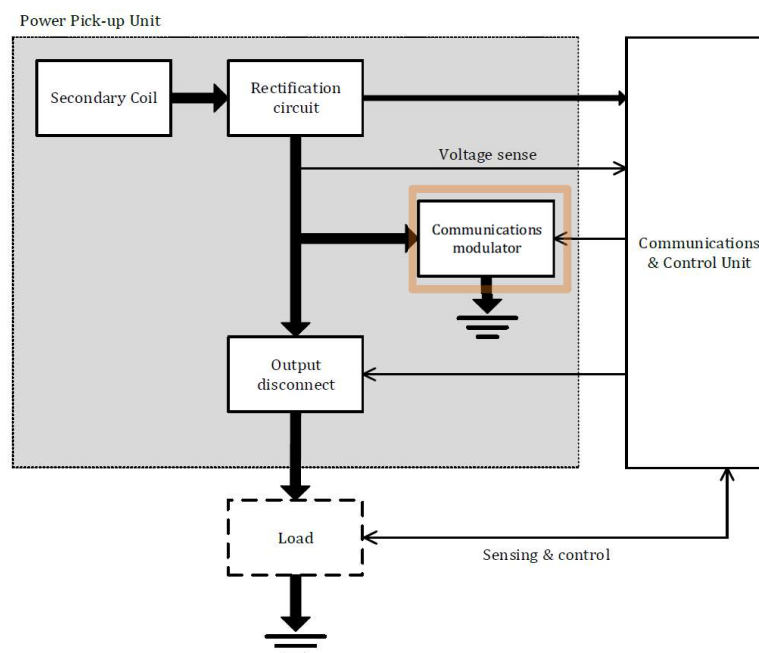
Furthermore, the communication and control circuit is powered inductively per the WPC Standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 23-24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 24-25).

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 section (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

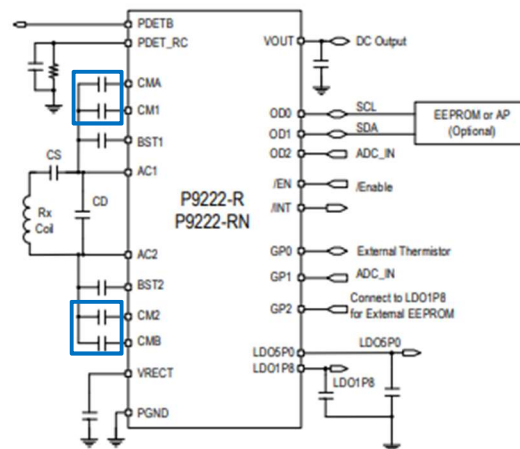
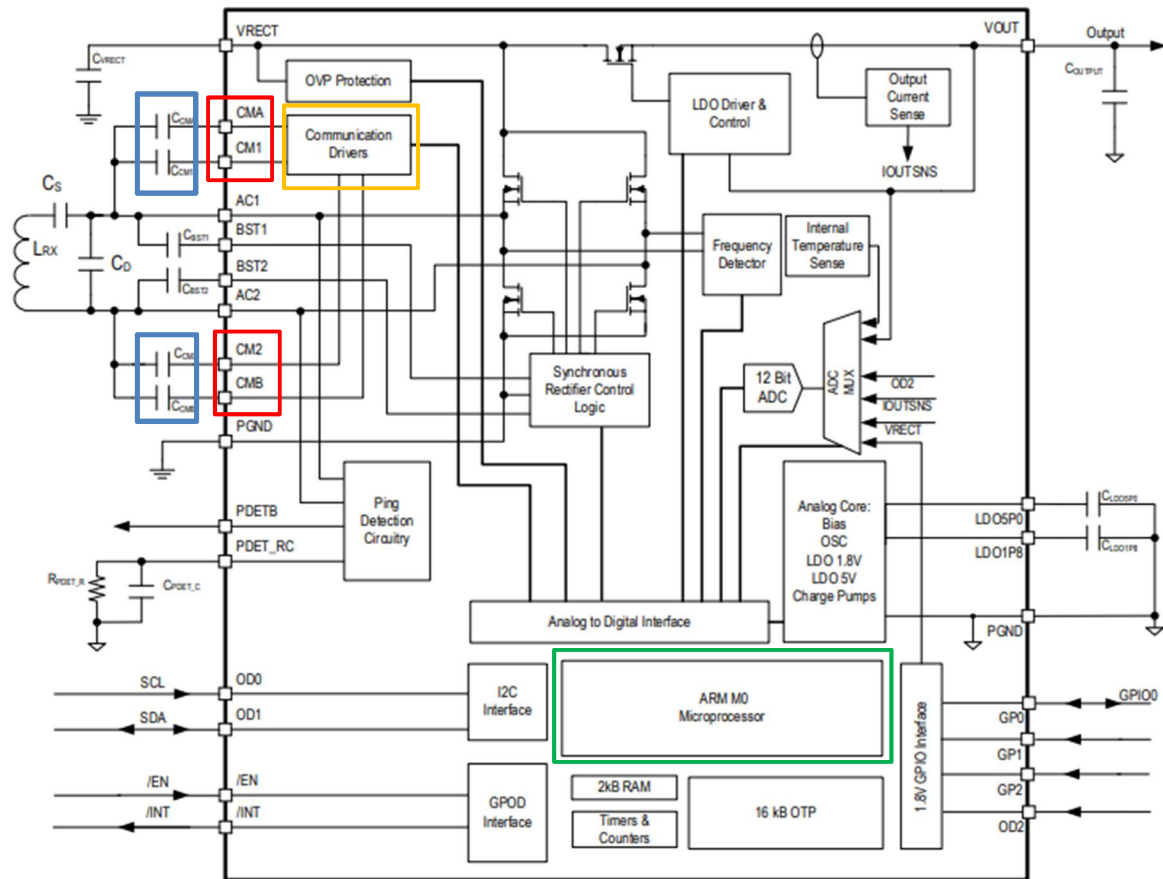


Figure 2. P9222-R/RN Block and Application Diagram

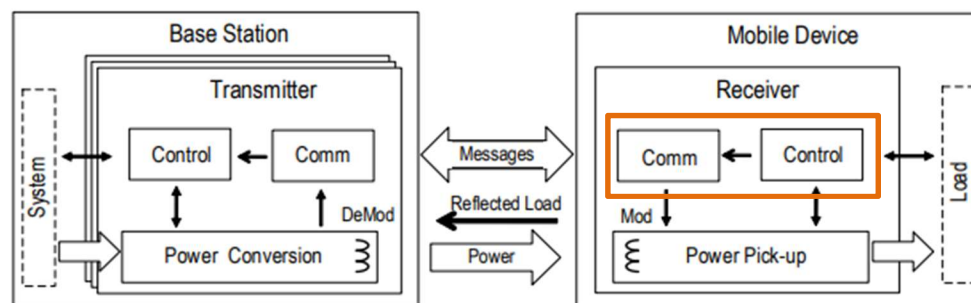


3. Description of the Wireless Power Charging System

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 to provide a regulated voltage to power the microcontroller from the received inductive power; and

The 371 Claim 20 Accused Products meet this part of 371 claim 20 as they each include a voltage regulator as specified by this part of the claim, as illustrated below for the representative products.

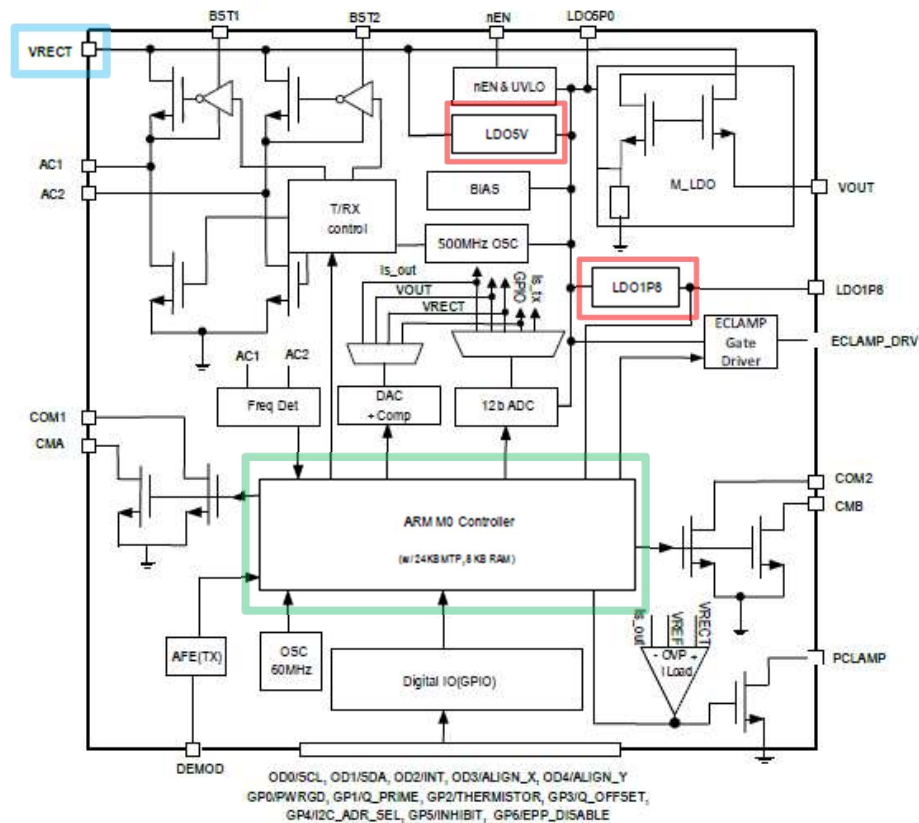
Smartphones

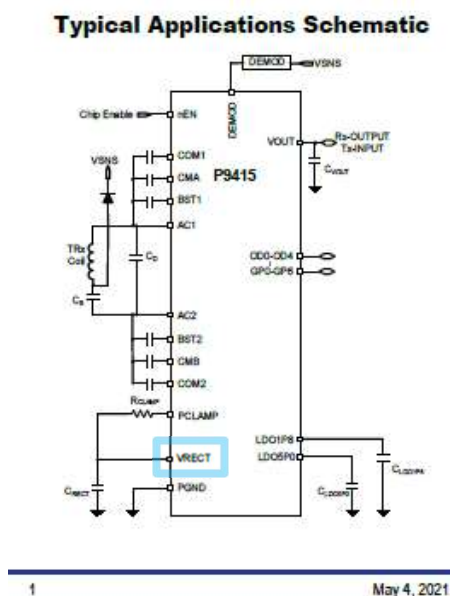
The S22 Ultra includes a voltage regulator as specified by this part of the claim. For example, in the representative 9415 ASIC receiver circuit, there are two Low Drop Out (LDO) regulators, LDO5V and LDO1P8 (red rectangles), which provide power to the microcontroller (green rectangle) as seen in the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





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 and smoothed DC voltage generated in the ASIC by the inductive charging system.

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

[illegible]

The diagram illustrates the pin configuration for the P9222-R and P9222-RN components. It shows the internal circuitry and the connection of various pins. Key pins and their functions are:

- PDET_B** and **PDET_RC**: Input pins for the PDET_B and PDET_RC signals.
- CS**: Chip Select pin, connected to a capacitor and a coil (Rx Coil).
- VRECT**: Rectified Voltage pin, connected to a capacitor and a coil (Rx Coil).
- PGND**: Power Ground pin, connected to ground.
- VOUT**: DC Output pin, connected to ground.
- OD0**: SCL (Serial Clock Line) pin, connected to an EEPROM or AP (Optional).
- OD1**: SDA (Serial Data Line) pin, connected to an EEPROM or AP (Optional).
- OD2**: ADC_IN pin, connected to an EEPROM or AP (Optional).
- /EN**: Enable pin, connected to ground.
- /INT**: Interrupt pin, connected to ground.
- GP0**: External Thermistor pin, connected to ground.
- GP1**: ADC_IN pin, connected to ground.
- GP2**: Connect to LD01P8 for External EEPROM pin, connected to ground.
- LD05P0**: LDO5P0 pin, connected to ground.
- LD01P8**: LDO1P8 pin, connected to ground.

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 to charge the battery, wherein the battery charging circuit is coupled to the output of the receiver rectifier circuit and coupled to the battery and begins drawing current only when the output of the receiver rectifier circuit reaches a set minimum voltage value;

The 371 Claim 20 Accused Products meet this part of 371 claim 20 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) coupled to the output of the rectifier circuit that meets this part of the claim.

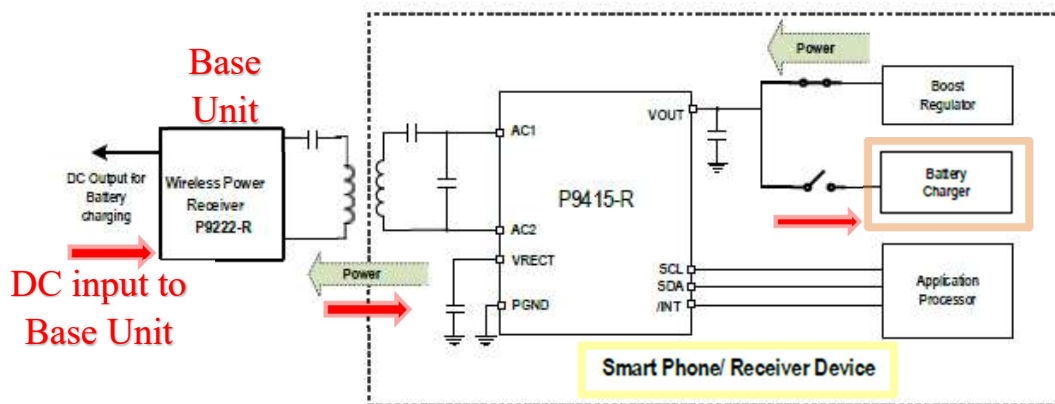
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Figure 8. Initial Startup Waveform



In addition, the S22 Ultra also may include a “Battery Charger” 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



Such an external Battery Charger will likely 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. 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

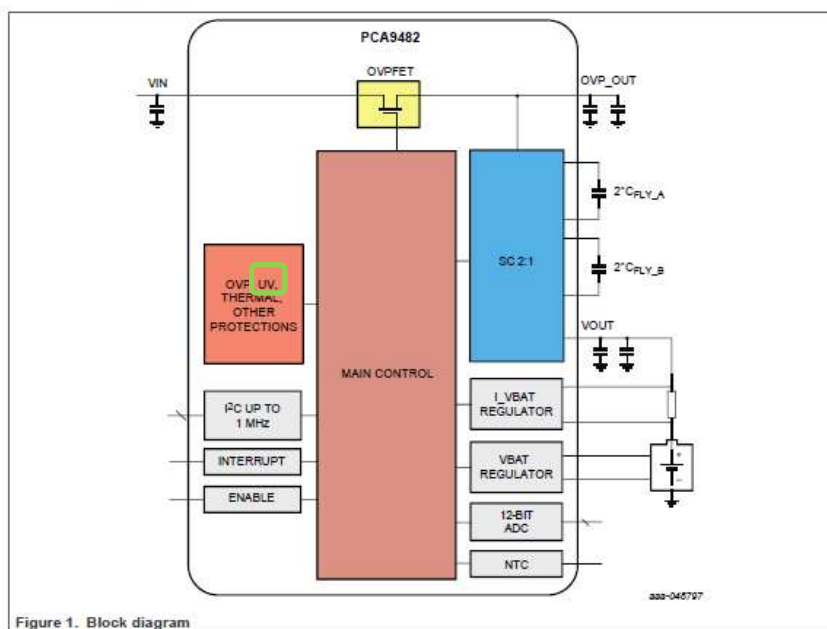
The PCA9482UK is a highly-integrated switched-capacitor converter with an embedded OVPFET, targeted to provide two times the output current for fast charging applications with a 1-cell battery. The device works in 2:1 switching operation with very high efficiency (>96.5 %, at $V_{OUT} = 4 \text{ V}$,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

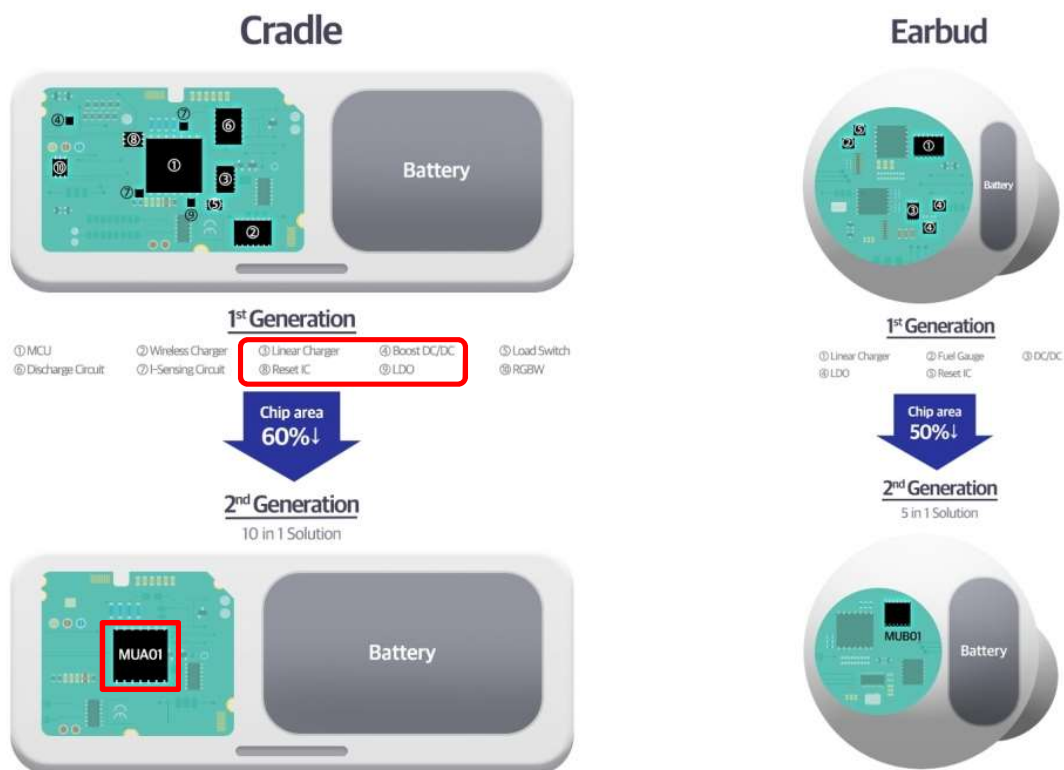
Undervoltage Lockout (UVLO)

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 battery charging circuit as specified by this part of the claim, with a minimum voltage lockout similar to that in the S22 Ultra (shown 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.

On information and belief, similarly to S22 Ultra, the Watch4 includes a charger IC that begins drawing current only when the output of the receiver rectifier circuit reaches a set minimum voltage value to charge the battery as per this claim.

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the receiver rectifier circuit and is used by the voltage regulator to power and activate the microcontroller and used by the battery charging circuit to charge the battery of the portable device; and

The 371 Claim 20 Accused Products meet this part of 371 claim 20 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 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 in the base unit, the receiver circuit is configured to:

The 371 Claim 20 Accused Products meet this part of 371 claim 20 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 371 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 base unit 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, a manufacturer code, a charge algorithm profile, and a power requirement; and

The 371 Claim 20 Accused Products meet this part of 371 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

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.

The representative 9415 datasheet below reflects that this part of the claim is met.



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 WPC Standard, with which the S22 Ultra is interoperable, also reflects that the S22 Ultra meets this part of the claim. Per the WPC Standard, after the receiver is activated, it proceeds to communicate with the base unit 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).

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.

A high-level description of the information communicated by the receiver to a base unit 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.

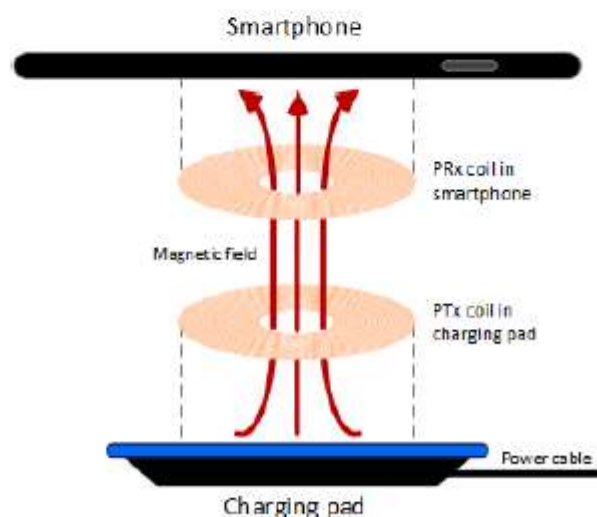
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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

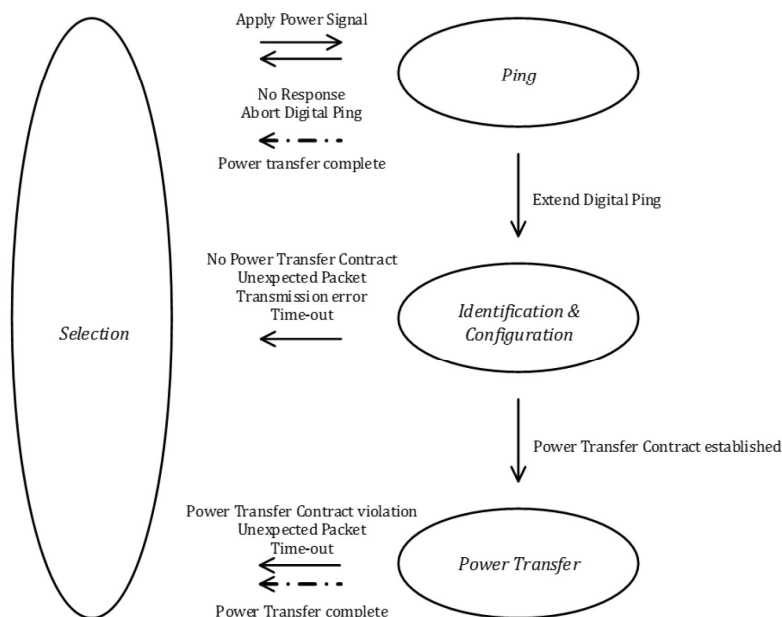
Figure 6. Qi wireless power transfer using magnetic induction



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,

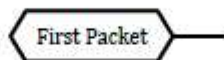
- the start of a Packet is defined as the instant that the Power Receiver transmits the first edge of the start bit of the Packet's header byte;
- the end of a Packet is defined as the instant that the Power Receiver transmits the second edge of the stop bit of the Packet's checksum byte; and
- the start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

$$\text{Signal Strength Value} = \frac{U}{U_{\max}} \cdot 256,$$

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 $U \geq U_{\max}$.

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.



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 base unit additional information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the portable device.

The 371 Claim 20 Accused Products meet this part of 371 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.



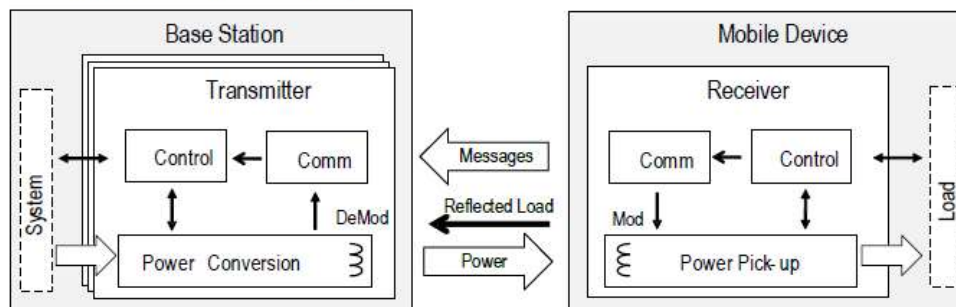
P9415-R Datasheet

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



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 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.

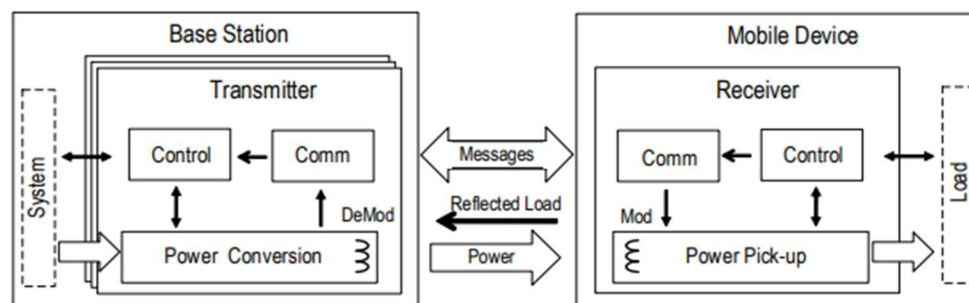
That the representative Watch4 periodically communicates with the base unit as claimed is also reflected by the representative 9222 datasheet.

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)

Dependent claims (off claim 20)

21. The portable device of claim 20 further comprising a magnetic core of ferromagnetic material within a central area of the receiver coil and a near field communication (NFC) antenna and circuitry for communication of data with other devices.

The 371 Claim 20 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 9 above. The S22 Ultra further includes circuitry for NFC functionality for communication with other devices, as shown in claim 12 above and repeated 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

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 receiver coil, as shown in claim 12 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.

22. The portable device of claim 20, 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 371 Claim 20 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 case 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 20. 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.

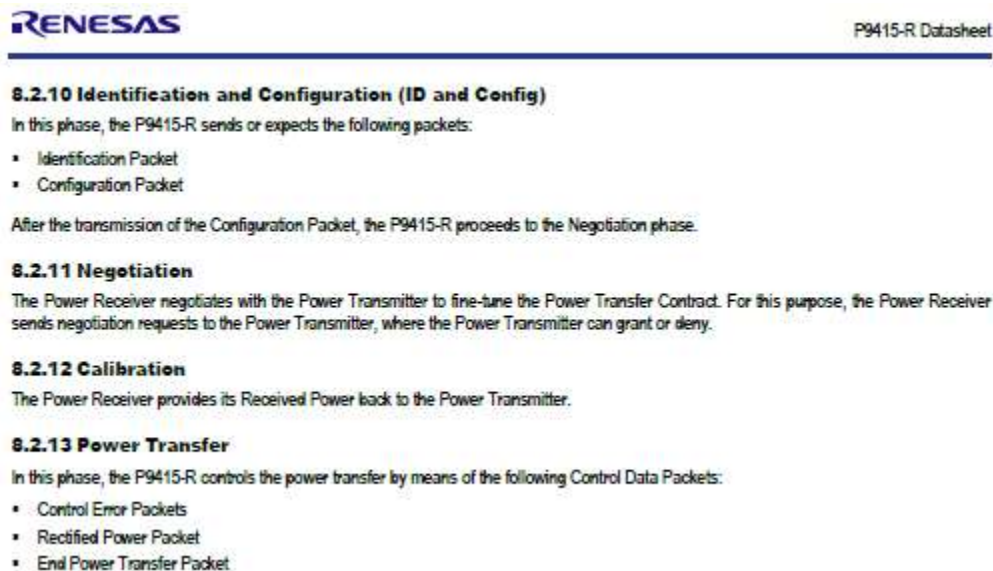
23. The portable device of claim 20, further comprising an output disconnect switch configured to connect and disconnect an output power from the receiver circuit to the battery, wherein: the communication and control unit is further configured to control the output disconnect switch to

disconnect the battery from the output power from the receiver circuit during at least some of the communication with the base unit.

The 371 Claim 20 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.

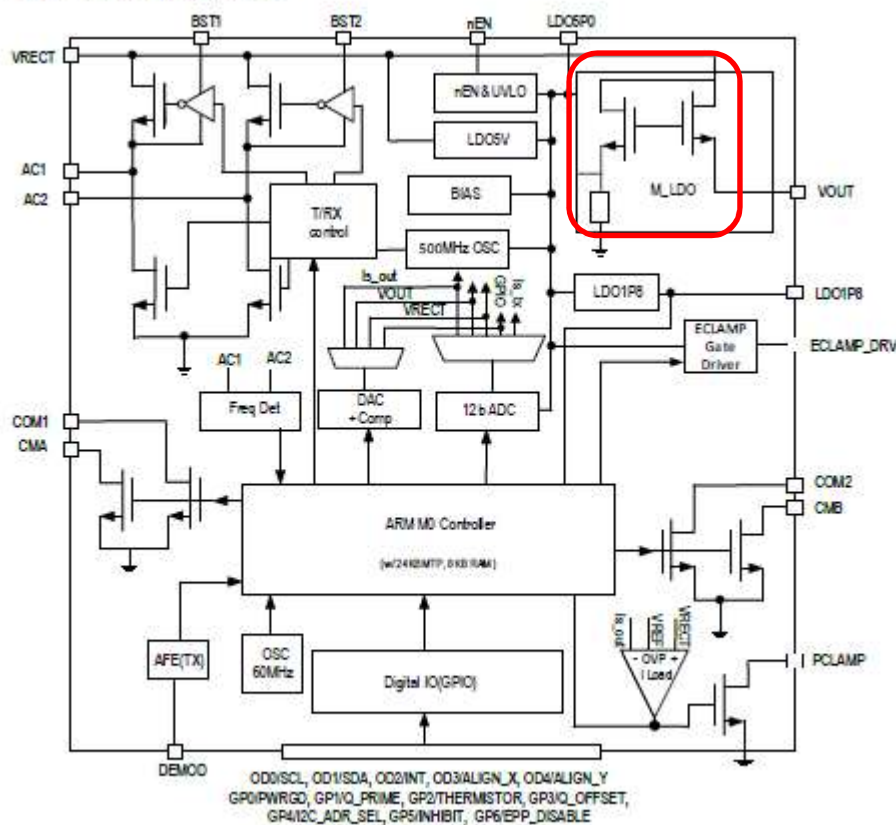
Smartphones

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.



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 $V_{OUT} + \text{headroom}$, 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_R) 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.

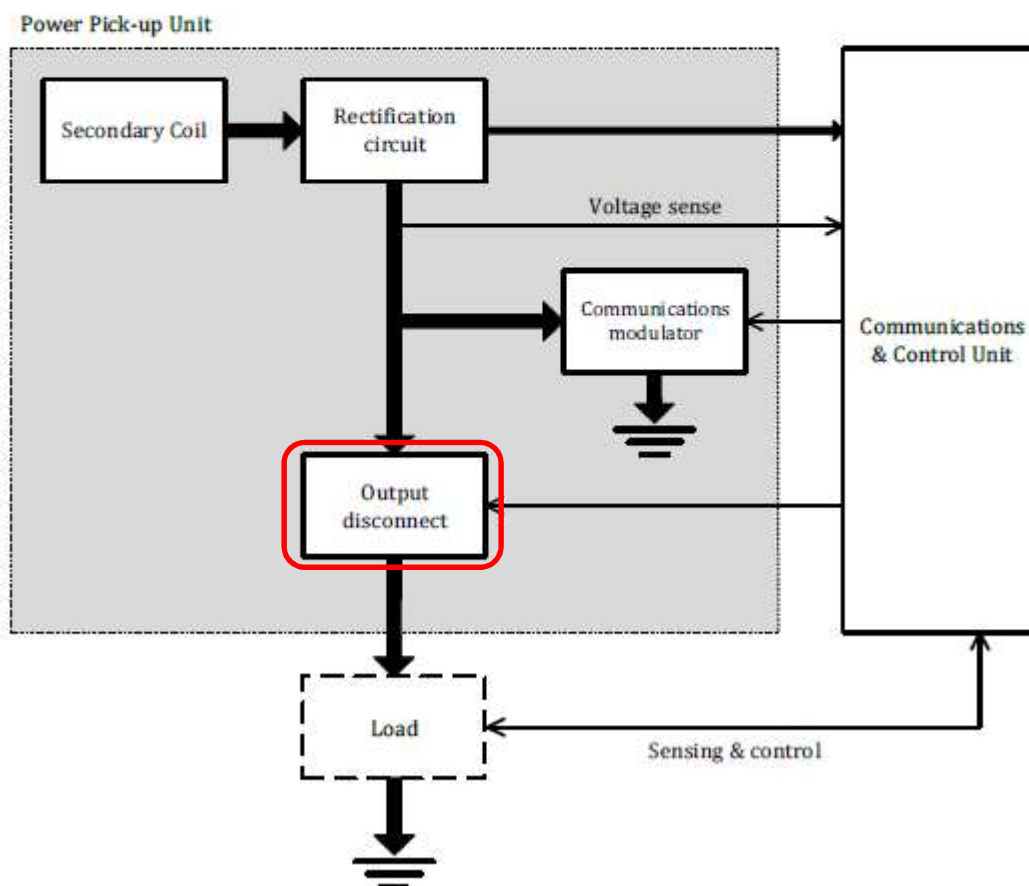
WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 23-24, 28.

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 20 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.

28. 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:

The 371 Accused Smartphones are accused under this claim. As detailed below by the S22 Ultra, the 371 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.

Smartphones

The S22 meets this introductory part of claim 28, as shown above with respect to the introductory part of claim 1.

a primary coil that is substantially planar and parallel to a surface of the system for providing power inductively to the portable device, wherein the primary coil comprises a flexible Printed Circuit Board (PCB), multi-turn coil having multiple layers of substantially similar patterns of substantially spiral-shaped conductors of 1 to 4 ounce copper thickness for each layer and having coil patterns electrically connected with vias between the layers;

Smartphones

The S22 Ultra meets this part of claim 28, as shown above with respect to the “first primary coil” part of claim 1 and with respect to the “PCB coil” part of claim 9. Furthermore, the primary coil has less than 1 mm thickness and is flexible. As can be seen in the image in claim 9, the dielectric PCB layer between the substantially similar copper coil layers on each side of the PCB is only ~14.3 micrometers thick and highly flexible qualifying it as a flexible PCB (FPCB) as described by the claim.

a drive circuit, including a FET driver, a capacitor and a FET switch, coupled to a DC voltage input and coupled to the primary coil, wherein during operation the drive circuit is configured to apply an alternating electrical current to the primary coil at an operating frequency within a range of 100 kHz to 1 MHz and duty cycle to generate an alternating magnetic field in a direction substantially perpendicular to the surface of the primary coil to provide power inductively to the portable device;

Smartphones

The S22 Ultra meets this part of claim 28, 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 to monitor current flow through the primary coil during operation of the drive circuit to sense a current modulation in the primary coil from a modulation of a current in the receiver coil; and

Smartphones

The S22 Ultra meets this part of claim 28, 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:

Smartphones

The S22 Ultra meets this part of claim 28, 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 current modulation in the primary coil;

Smartphones

The S22 Ultra meets this part of claim 28, as shown above with respect to the “detect” part of claim 1.

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

Smartphones

The S22 Ultra meets these parts of claim 28, 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,

Smartphones

The S22 Ultra meets these parts of claim 28, as shown above with respect to the “operate the first drive circuit according to the power requirement” part of claim 1.

wherein to charge the battery of the portable device the communication and control circuit is further configured to: receive additional information in the current modulation in the primary coil from modulation of the current in the receiver coil corresponding to a voltage or current at an output of the receiver circuit while charging the battery of the portable device; and regulate in a closed loop feedback manner, the voltage or current at the output of the receiver circuit in accordance with the received additional information corresponding to the voltage or current at the output of the receiver circuit by adjusting at least one of the operating frequency, the duty cycle, and the DC voltage input to the drive circuit during charging of the battery of the portable device.

Smartphones

The S22 Ultra meets these parts of claim 28, as shown above with respect to the “receive additional information” and “regulate in a closed loop feedback manner” parts of claim 1.

Dependent claims (off claim 28)

29. The system of claim 28, 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 371 Claim 28 Accused Products which are smartphones additionally infringe this dependent claim, as shown above with respect to claim 2.

30. A portable device comprising:

The 371 Accused Smartphones, the 371 Accused Wearables, and the 371 Accused Earbud Products are accused under this claim (collectively the “371 Claim 30 Accused Products”). The 371 Claim 30 Accused Products fit the description in this introductory part of claim 30, as seen above with respect to claim 20.

a battery; and

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “battery” part of claim 20.

a receiver unit, coupled to the battery, configured to receive inductive power from an inductive charging system including a base unit with a primary coil and associated circuit, the receiver unit comprising:

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “receiver unit” part of claim 20.

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

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “receiver coil” part of claim 20.

a ferrite material layer placed under the receiver coil on a side of the receiver coil opposite to the surface of the portable device;

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “ferromagnetic layer” part of claim 20.

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

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “receiver circuit” part of claim 20.

a receiver rectifier circuit including a rectifier and a capacitor; and

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “receiver rectifier circuit” part of claim 20.

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

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “receiver communication and control circuit” part of claim 20.

an output disconnect switch to interrupt a flow of current from an output of the receiver unit to the battery;

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to claim 23.

wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified and smoothed by the rectifier circuit and is used to power and activate the microcontroller and to charge the battery of the portable device;

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “wherein when a current is generated in the receiver coil” part of claim 20.

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

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “wherein upon powering and activation of the microcontroller” part of claim 20.

communicate to the base unit a power parameter and a voltage or current value at an output of the receiver rectifier circuit induced by the primary coil; and

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “communicate to the base unit information” part of claim 20.

periodically communicate to the base unit information corresponding to a presently induced output voltage or current of the receiver rectifier circuit to enable the base unit to regulate in a closed loop manner the output voltage or current of the receiver rectifier circuit during the charging of the battery of the portable device; and

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to the “periodically communicate to the base unit additional information” part of claim 20.

wherein the communication and control unit is configured to control the disconnect switch to disconnect the flow of current from the output of the receiver unit to the battery during at least some of the communication with the base unit.

The 371 Claim 30 Accused Products fit the description in this part of claim 30, as seen above with respect to claim 23.