

US11201500B2 EFFICIENCIES AND FLEXIBILITIES IN INDUCTIVE (WIRELESS) CHARGING

I. Infringement

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

As described below by representative products, the 500 Accused Products are capable of providing power inductively as specified by 500 claim 1 are accused under this claim; this includes the 500 Accused Wireless Chargers and 500 Accused Smartphones (collectively the “500 Claim 1 Accused Products”).

Smartphones

The S22 Ultra meets this introductory part of claim 1, as when it is in the Wireless PowerShare mode, it is a wireless charging system capable of transferring power inductively to another device as described in this part of the claim.

<https://www.samsung.com/au/support/mobile-devices/how-to-use-powershare-on-your-galaxy-phone/>

Using Wireless PowerShare on my Samsung Phone

Last Update date : Feb 13, 2023

What if you could charge all your devices on the fly, even if you forgot their chargers? It's not too good to be true. With the new Wireless PowerShare feature, your phone can reverse wireless charge another phone, watch, or Galaxy Buds. All you need to do is place the two devices together.

Note: Wireless PowerShare works with most Qi-Compatible devices. This feature may not work with some cases, accessories, or other manufacturers' devices.

Please Note: This guide is designed for Australian variant devices, if you have an international device and require further support [click here](#) to get in touch with your Samsung subsidiary.

Device-to-Device Charging

If the battery on your device is getting low, automatically transfer power from your compatible Galaxy phone. Simply activate "Wireless PowerShare" on your notification panel, then place the other device on the centre of your Galaxy phone with their backs facing. Separate the devices when enough power has been transferred, or wait until the other device is fully charged.

Supports WPC Qi certified smartphone products and Samsung wearable devices

- **Phones:** Samsung or other brand smartphones that support wireless charging(WPC Qi-certified devices.). Different devices may charge at different speeds. ※ Other company devices can vary depending on the device setting or design, even for WPC Qi certified devices
- **In case of Wearables,** limited to Samsung wearable devices (Gear S3/Sport, Galaxy Watch, Galaxy Watch Active, Galaxy Watch Active2, Galaxy Buds)

<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.

Wireless Chargers

The 5200 Duo meets this introductory part of claim 1, as it is a wireless charging system capable of transferring power inductively to another device as described in this part of the claim.

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.

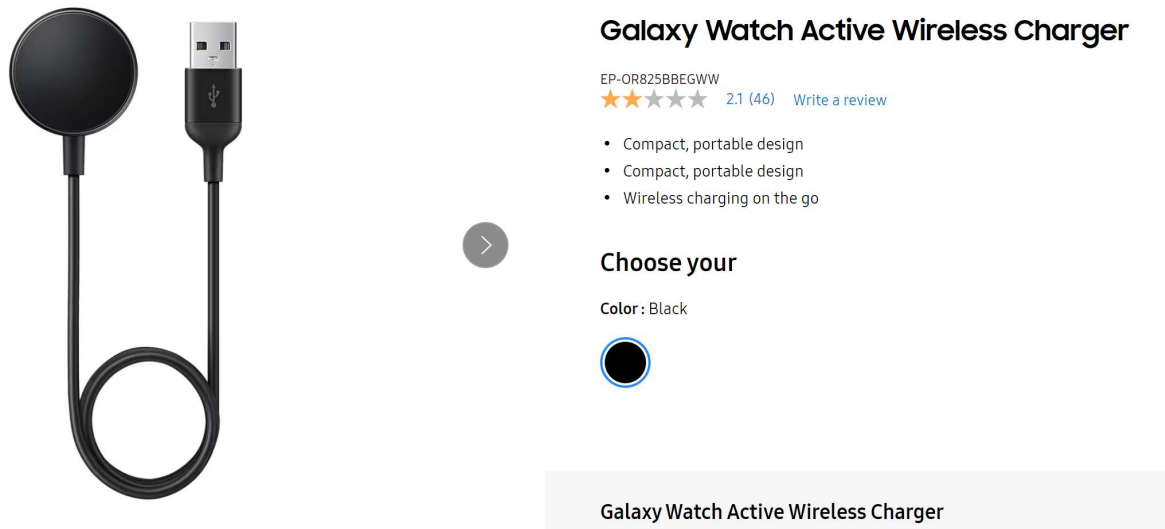
Charge two phones

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 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/>



one or more primary coils that are substantially planar and parallel to a surface of the system for powering or charging one or more compatible portable devices including batteries and receiver units, each receiver unit including a receiver coil and a receiver circuit including a receiver rectifier circuit;

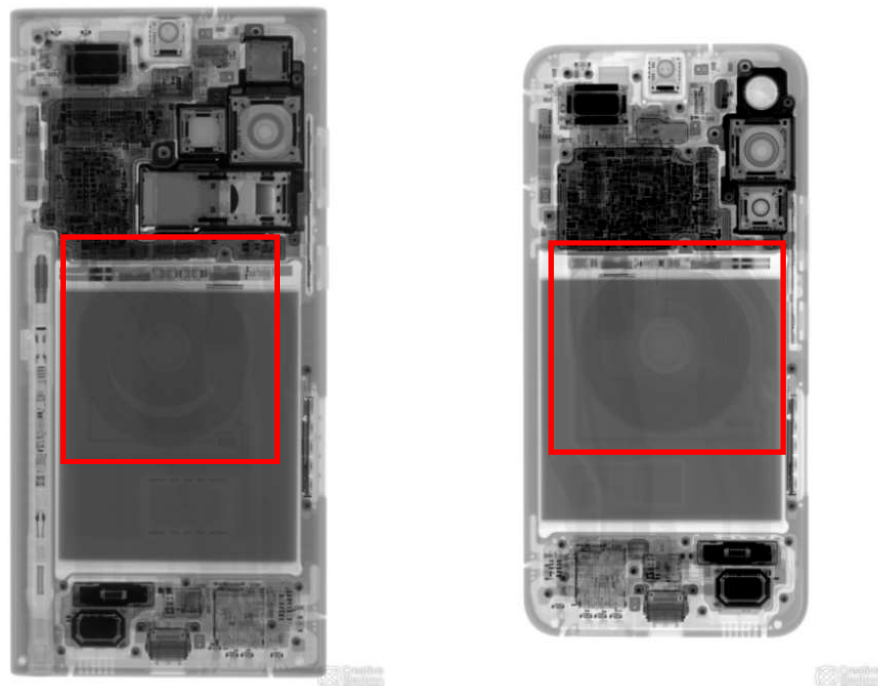
The 500 Claim 1 Accused Products include one or more coils as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

The S22 Ultra satisfies 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 planar charging coil is shown in the red rectangles of the X-Ray of the S22 Ultra (left) and the S22 (right) below.

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

X-ray examination



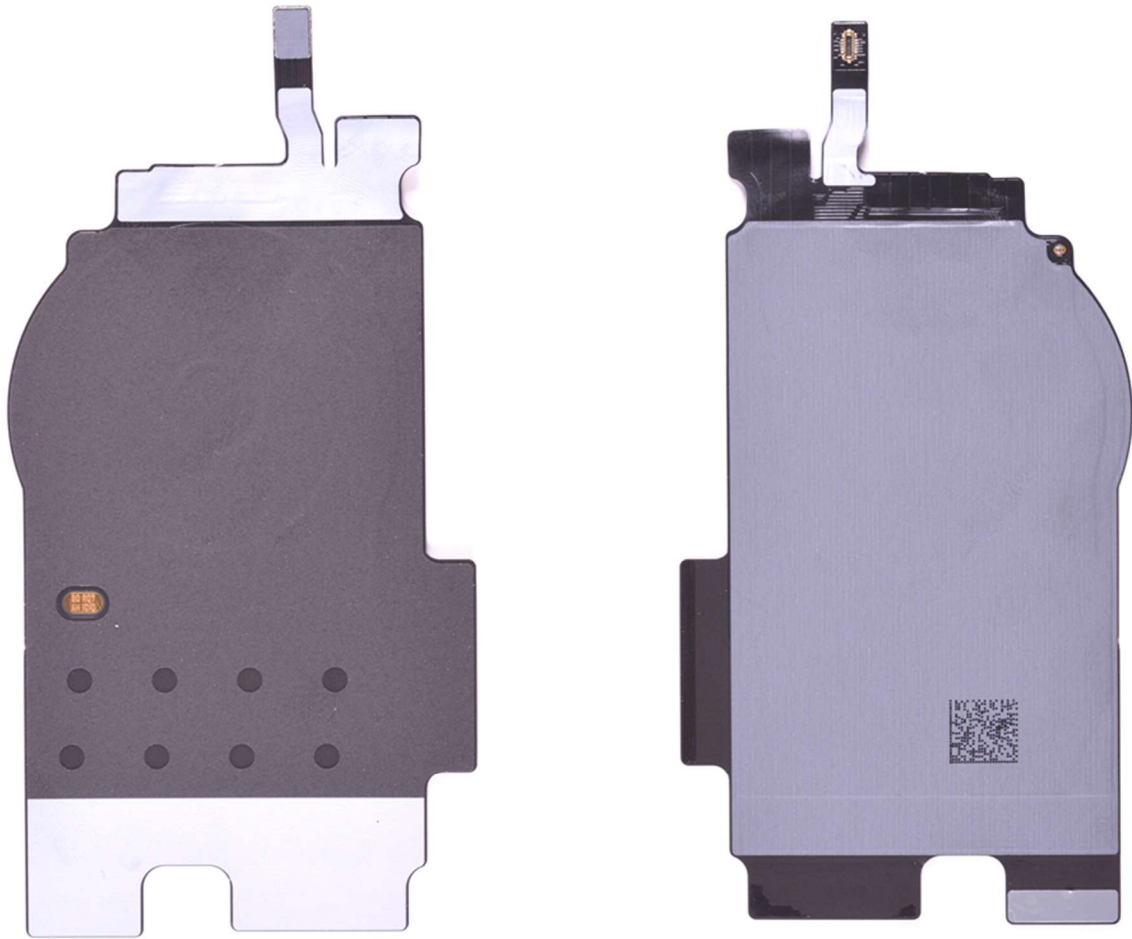
On the left is the Note-succeeding Samsung Galaxy S22 Ultra, with the "vanilla" S22 on the right.

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.

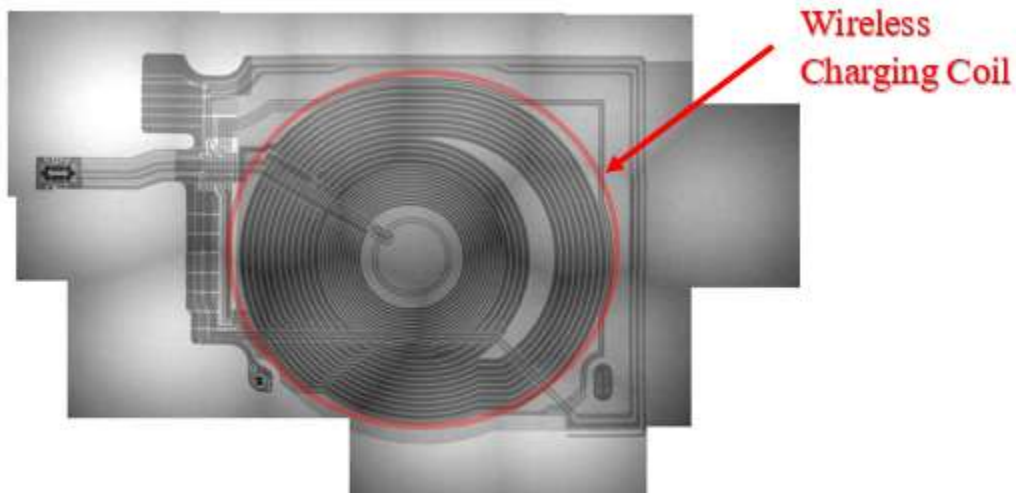


Samsung S22 Ultra – Back cover removed

The wireless charging coil structure after removal from the phone is shown below, with the outward facing (away from the inside of the phone) 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 satisfies 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 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.

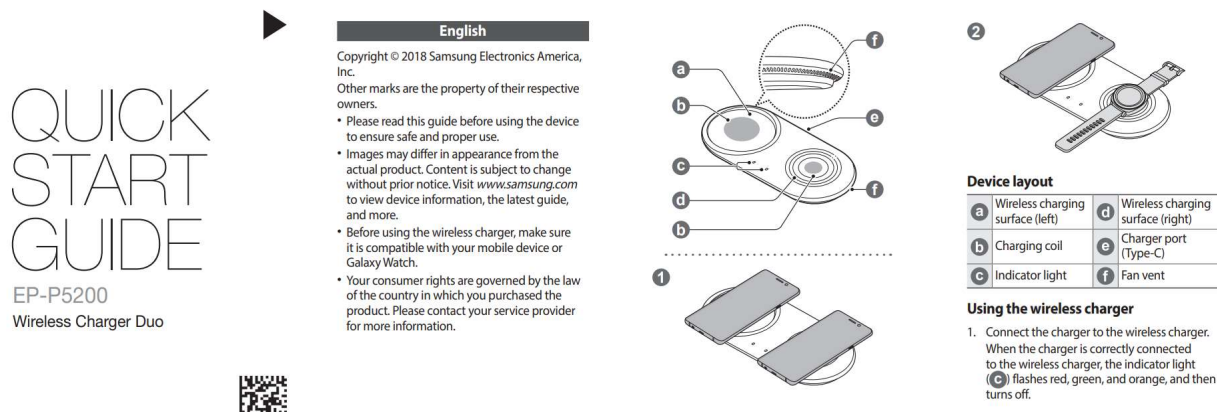
Charge two phones

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.

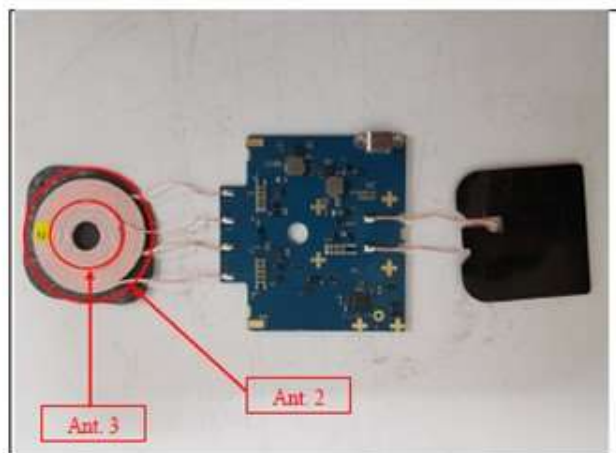
<https://fcc.report/FCC-ID/A3LEPP5200/4144766.pdf>



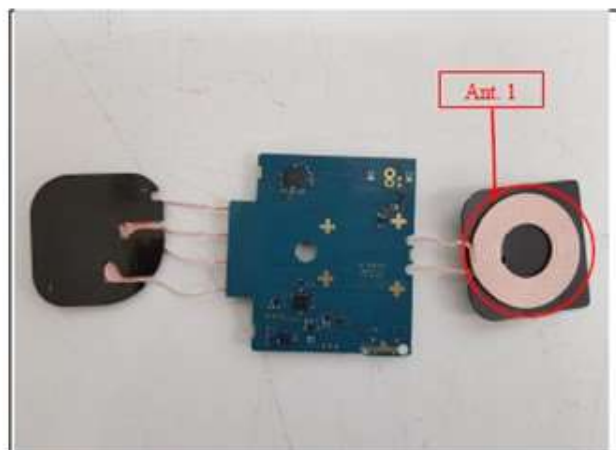
The 5200 Duo Pad shown above contains three planar coils (identified as antennas [Ant. 1-3] in the FCC images below) for transferring inductive power as recited by this part of the claim. The two coils on the product right side (Ant. 2 and 3 below) are concentric for charging a watch (Ant. 3) or another 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 825 Watch Dock includes a substantially planar charging coil that is substantially parallel to the top surface of the system for providing power inductively to various portable devices, as shown below. <https://fcc.report/FCC-ID/A3LEPOR825/4320461>



one or more drive circuits including one or more FET drivers, FET switches, and capacitors coupled to the one or more primary coils that when operated apply an alternating electrical current to the one or more primary coils to generate a magnetic field in a direction substantially perpendicular to the plane of the one or more primary coils and the surface of the system to provide power to the one or more portable devices capable of being powered or charged by the system when present and near the one or more primary coils;

The 500 Claim 1 Accused Products include one or more drive circuits as specified by this part of the claim, as illustrated below for the representative products.

Smartphones

A drive circuit as specified by this part of the claim is included in the 500 Accused 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(s).

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

Step 1 Main Board Side 1

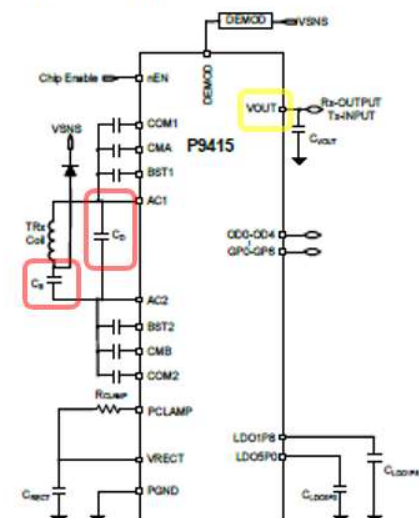


The Renesas P9415-R ASIC (15 W Receiver / Transmitter (Rx/Tx) IC for WPC 1.2)¹ [herein the “9415”], for which a datasheet is publicly available, is believed to be representative of the wireless power transceiver ASIC (such as the 9320S) included in the S22 Ultra for the purposes of infringement of this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

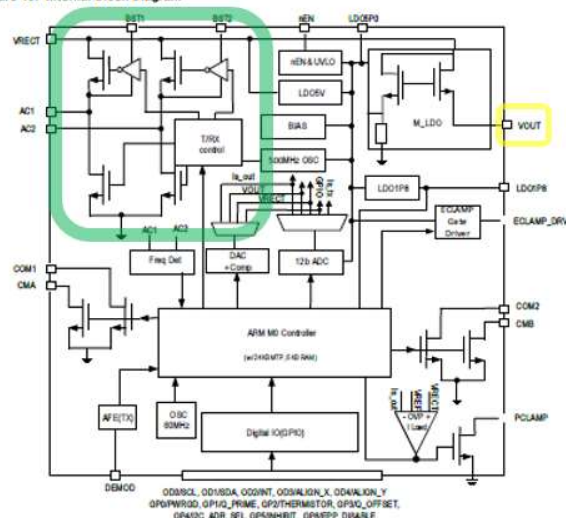
RENESAS

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 150 kHz from the transmitter.

Figure 15. Internal Block Diagram



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May 4, 2021

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

RENESAS

P9415-R Datasheet

8.4 WattShare™ (TRx) Mode Functions

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

Wireless Chargers

A drive circuit as specified by this part of the claim is included in the 500 Accused Wireless Chargers.

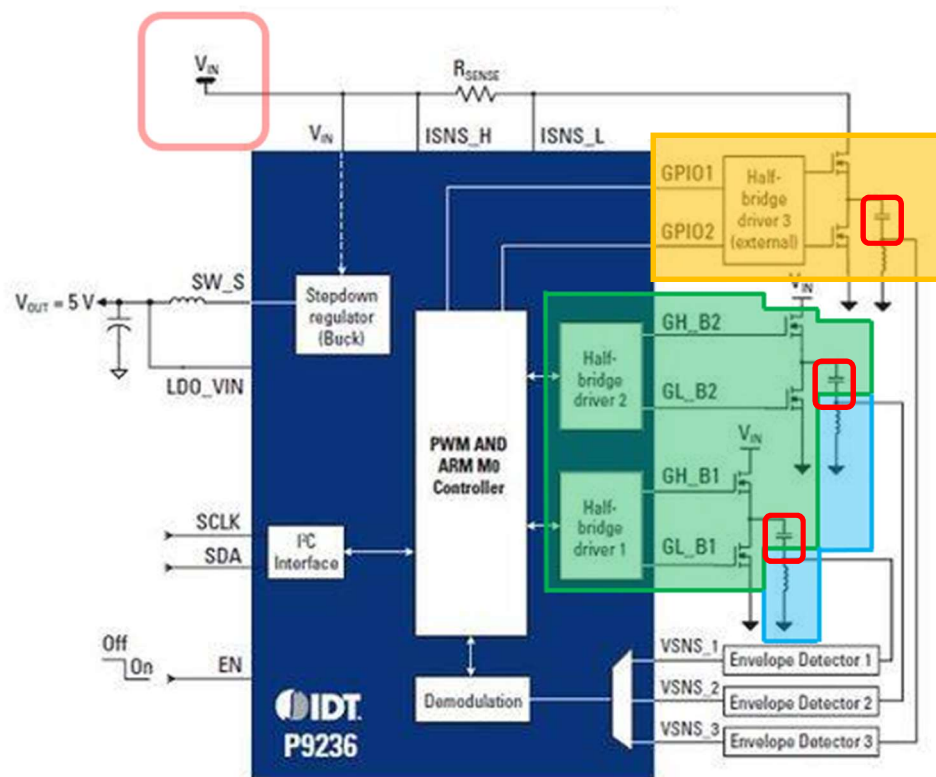
The 5200 Duo Pad includes a drive circuit that is structured and operates as specified by this part of the claim. They each include a wireless charging transmitter ASIC (e.g., the IDT/Renesas P9236

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
 Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung 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 areas below), and a third external driver can be used with additional external FETs and capacitors (orange rectangle below), as shown in the datasheet below for the 9236 ASIC. The capacitors are shown in the red rectangles below.

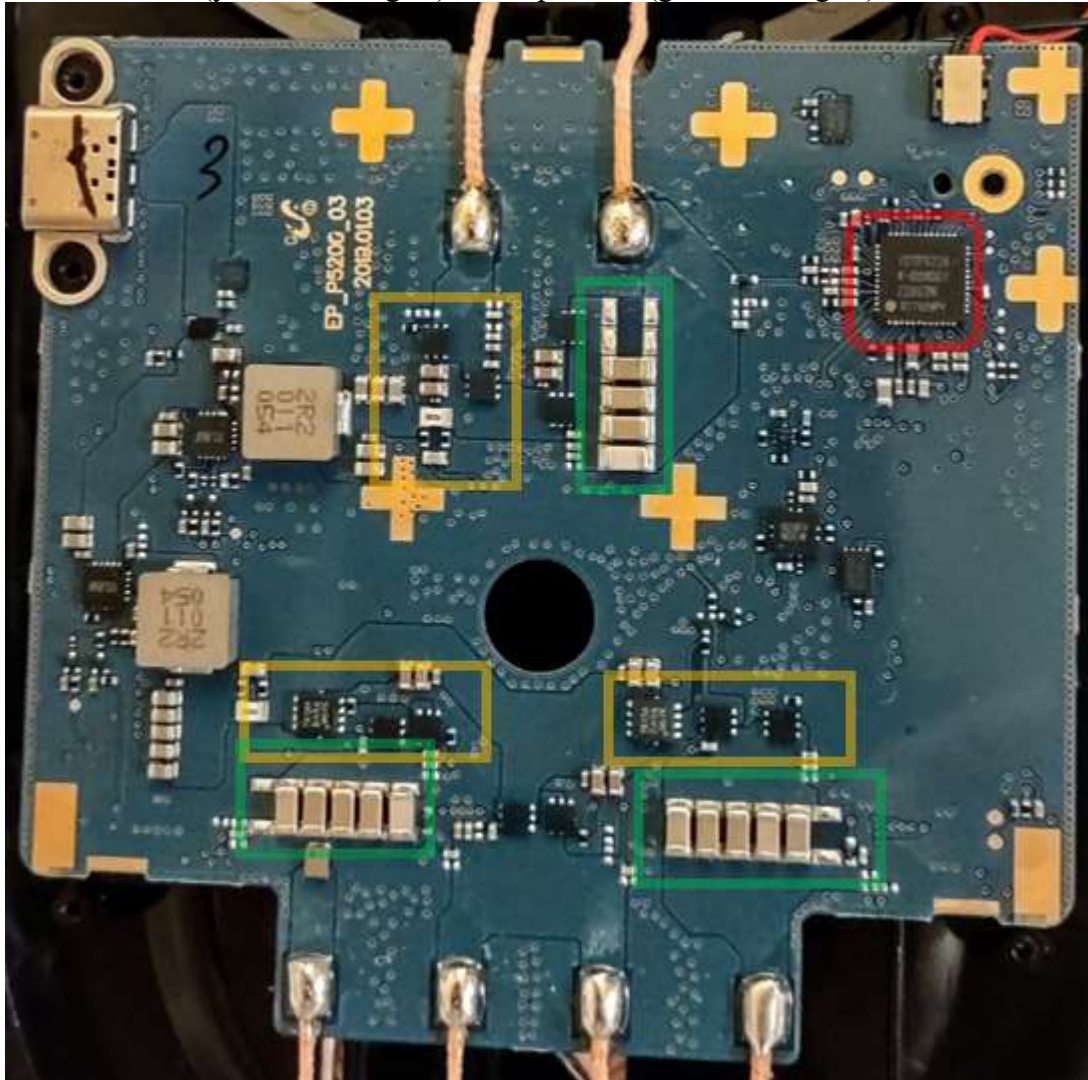
The drive circuit is operated by applying an electrical current to the one or more primary coils (shown below) to generate a magnetic field to provide power to the one or more portable devices as required by this part of the claim.

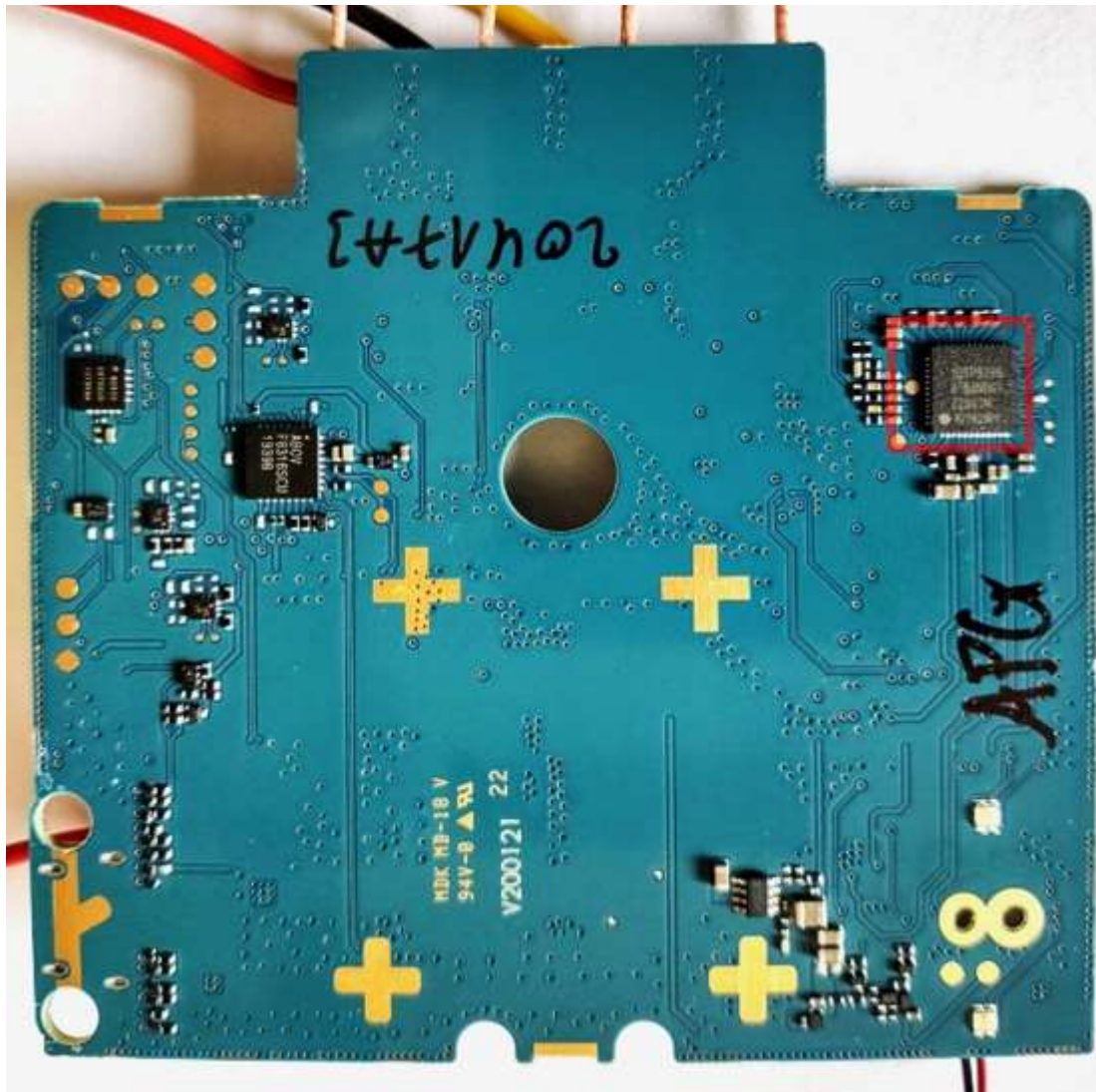
https://archive.eetindia.co.in/www.eetindia.co.in/ART_8800706913_1800008_NP_7a10c6fc.HTM

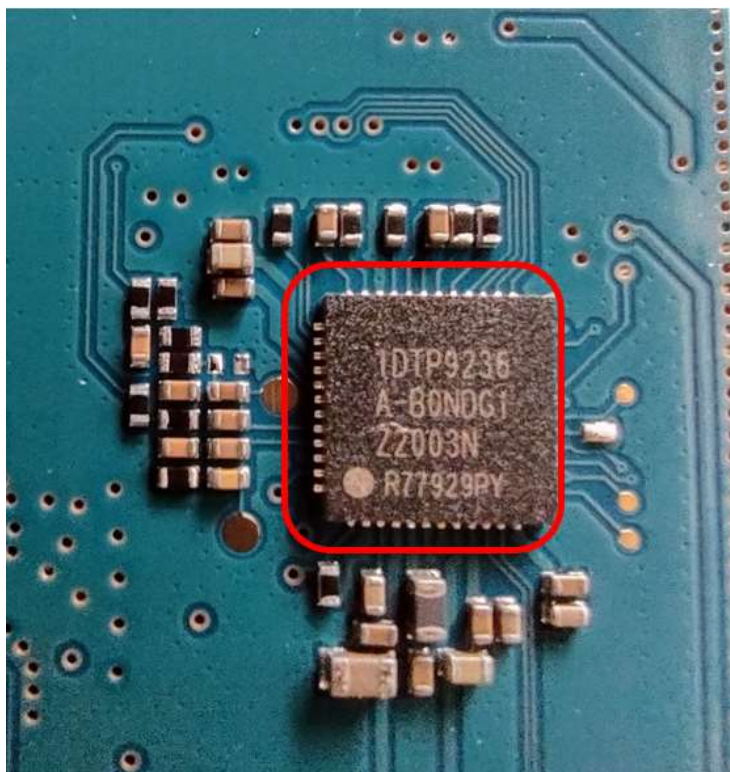


Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung

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.

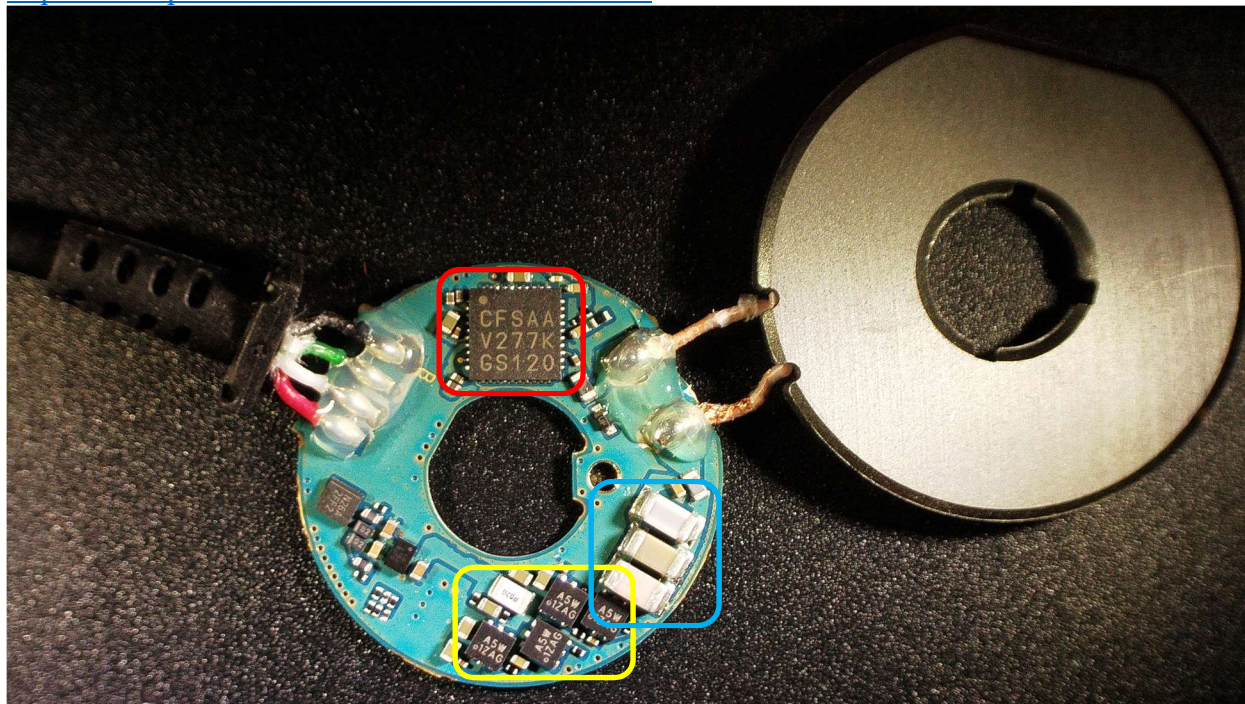




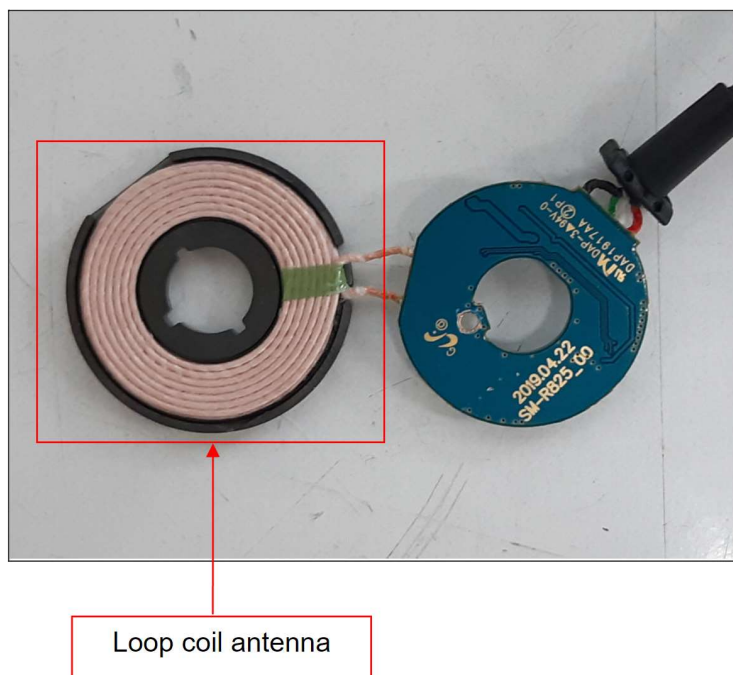


The 825 Watch Dock includes a drive circuit that is structured and operates as specified by this part of the claim. It includes a wireless charging transmitter ASIC (e.g., the CFSAA V277K ASIC;

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
red rectangle) (herein the “V277K”) with associated external capacitors (blue rectangle) and FETs
(yellow rectangle), as shown in the below.
<https://fcc.report/FCC-ID/A3LEPOR825/4320461>



Bottom view of board



WPC Standard

The 500 Claim 1 Accused Products are each interoperable with 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/au/support/mobile-devices/how-to-use-powershare-on-your-galaxy-phone/>

Using Wireless PowerShare on my Samsung Phone

Last Update date : Feb 13, 2023

What if you could charge all your devices on the fly, even if you forgot their chargers? It's not too good to be true. With the new Wireless PowerShare feature, your phone can reverse wireless charge another phone, watch, or Galaxy Buds. All you need to do is place the two devices together.

Note: Wireless PowerShare works with most Qi-Compatible devices. This feature may not work with some cases, accessories, or other manufacturers' devices.

Please Note: This guide is designed for Australian variant devices, if you have an international device and require further support [click here](#) to get in touch with your Samsung subsidiary.

Device-to-Device Charging

If the battery on your device is getting low, automatically transfer power from your compatible Galaxy phone. Simply activate "Wireless PowerShare" on your notification panel, then place the other device on the centre of your Galaxy phone with their backs facing. Separate the devices when enough power has been transferred, or wait until the other device is fully charged.

Supports WPC Qi certified smartphone products and Samsung wearable devices

- **Phones:** Samsung or other brand smartphones that support wireless charging(WPC Qi-certified devices.). Different devices may charge at different speeds. ※ Other company devices can vary depending on the device setting or design, even for WPC Qi certified devices
- In case of **Wearables**, limited to Samsung wearable devices (Gear S3/Sport, Galaxy Watch, Galaxy Watch Active, Galaxy Watch Active2, Galaxy Buds)

<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-p5200tbeginus/>



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 largely follows the WPC Standard, including the portions shown herein.

WPC Standard Citations

Following the WPC Standard, the drive circuits of the 500 Claim 1 Accused Products, during operation as a charger, apply an alternating electrical current to their associated primary coil to generate an alternating magnetic field in a direction substantially perpendicular to the plane of the

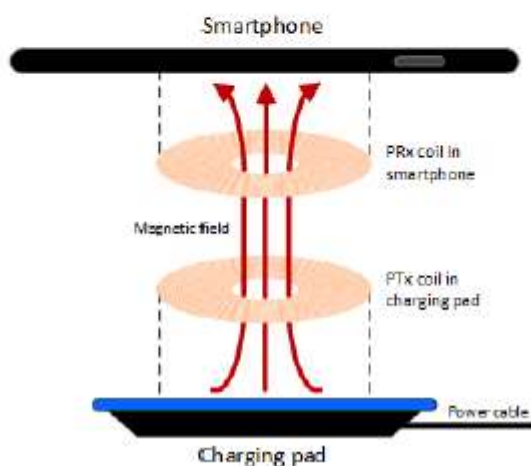
Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
primary coil and the surface of the system to provide power inductively to the portable device to
be wirelessly charged.

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



one or more sense circuits to monitor the current through the one or more primary coils to sense communications from the one or more receiver coils; and

The 500 Claim 1 Accused Products include one or more sense circuits as specified by this part of the claim, as illustrated below for the representative products.

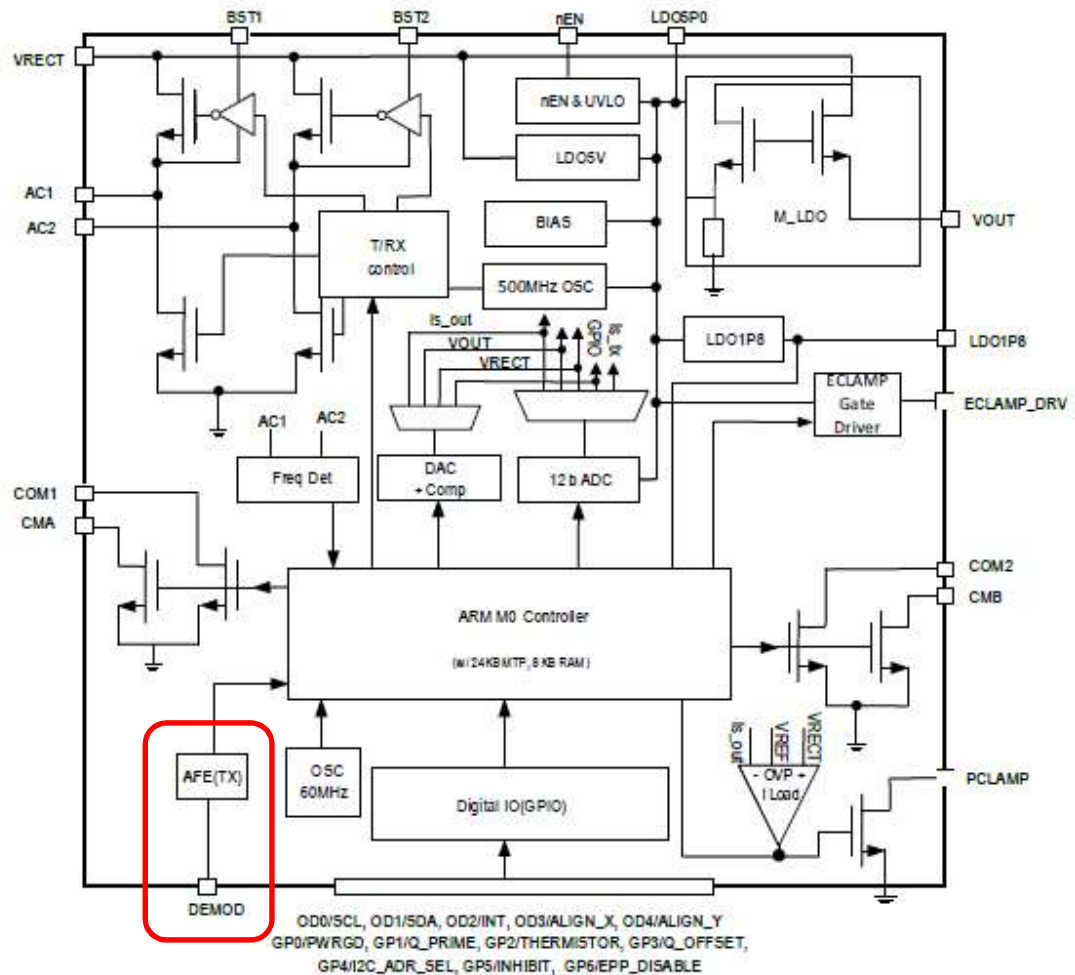
Smartphones

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

8. Theory of Operation

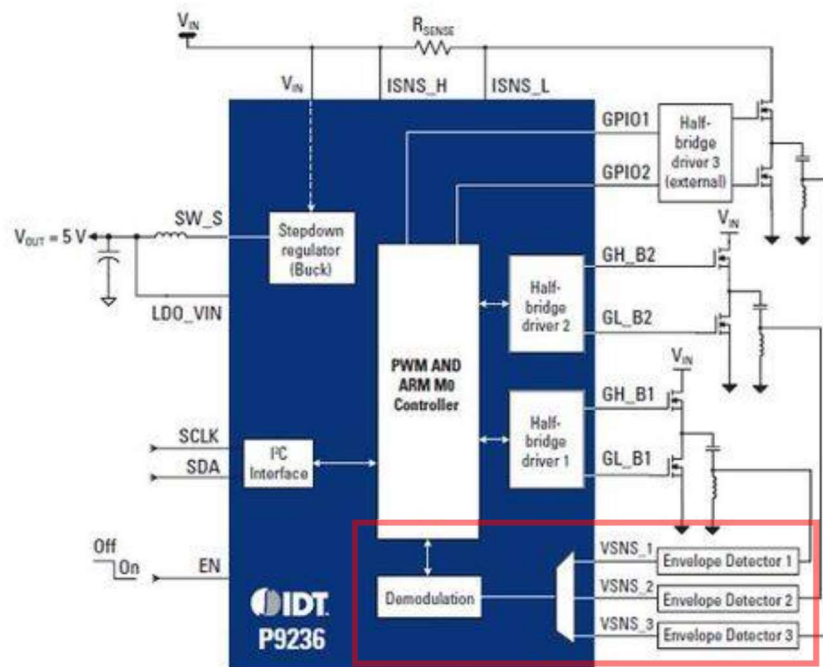
The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

Figure 15. Internal Block Diagram



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. The 5200 Duo Pad includes a wireless charger ASIC such as the 9236 ASIC that includes a demodulator as relevant to this part of the claim. The demodulator senses current modulation in the charger coil to detect a communication from the receiver being charged and to sense the presence or absence of the receiver, as shown in the datasheet below.



The 825 Watch Dock includes a wireless charging transmitter ASIC (V277K). Upon information and belief, the 9415 ASIC discussion immediately above for the S22 Ultra applies similarly to the wireless charger ASIC included the 825 Watch Dock.

WPC Standard

The WPC Standard describes detection of communications by the transmitter by way of current modulation, as in the 500 Claim 1 Accused Products. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 87 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 86).



5.2 Power Receiver to Power Transmitter communications interface

5.2.1 Introduction

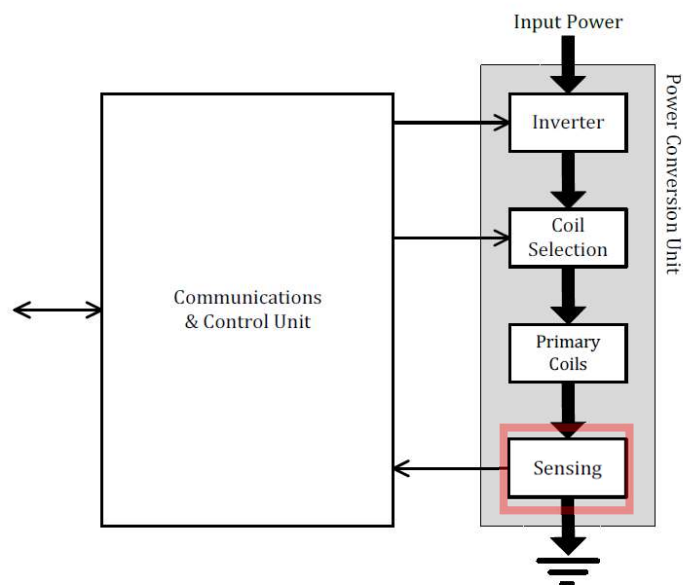
The Power Receiver communicates to the Power Transmitter using backscatter modulation. For this purpose, the Power Receiver modulates the amount of power that it draws from the Power Signal. The Power Transmitter detects this as a modulation of the current through and/or voltage across the Primary Cell.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

The WPC Standard also shows a sense circuit, as in the 500 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.

one or more communication and control circuits including one or more microcontrollers coupled to the one or more drive circuits and the one or more sense circuits that detect communications through the one or more sense circuits via the one or more primary coils and control the one or more drive circuits to control the powering or charging of the one or more compatible portable devices; wherein the one or more communication and control circuits:

The 500 Claim 1 Accused Products include one or more communication and control circuits as specified by this part of the claim, as illustrated below for the representative products.

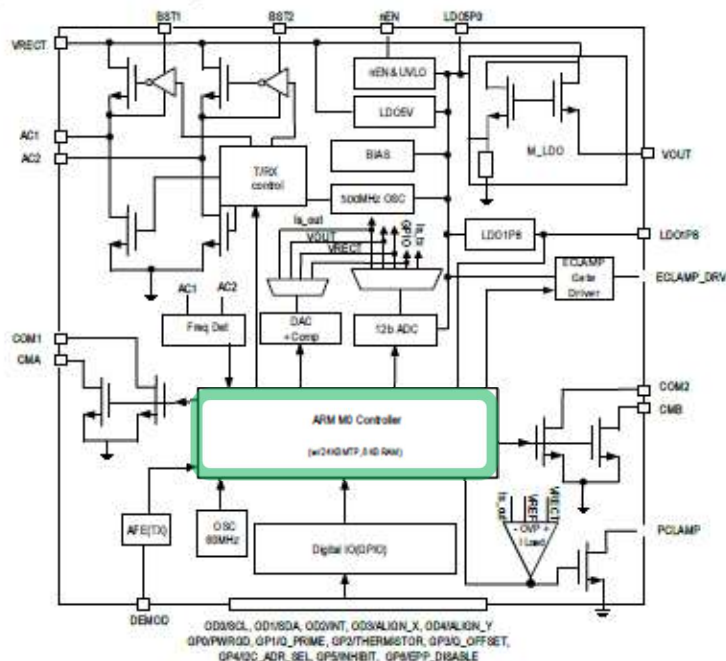
Smartphones

The S22 Ultra includes a communication and control circuit, including a microcontroller, 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) 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 is coupled to the drive circuit and the sense circuit as shown above and coordinates and controls the communications and the operation of the S22 Ultra operating as a charger in the Wireless PowerShare mode as specified by this part of the claim.

8. Theory of Operation

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

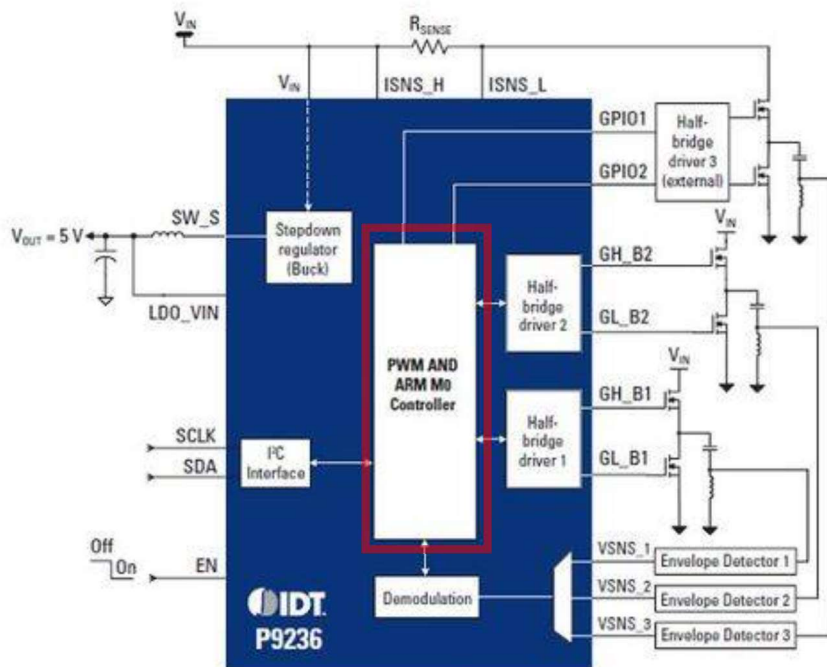
Figure 15. Internal Block Diagram



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. The 5200 Duo Pad includes a wireless charger ASIC such as the 9236 ASIC that includes a microcontroller as relevant to this part of the claim. The microcontroller is coupled to the drive circuit and the sense circuit as shown above and 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



825 Watch Dock includes a wireless charging transmitter ASIC (V277K). Upon information and belief, the 9415 and 9236 ASIC discussions immediately above for the S22 Ultra and the 5200 Duo Pad apply similarly to the wireless charger ASIC included the 825 Watch Dock.

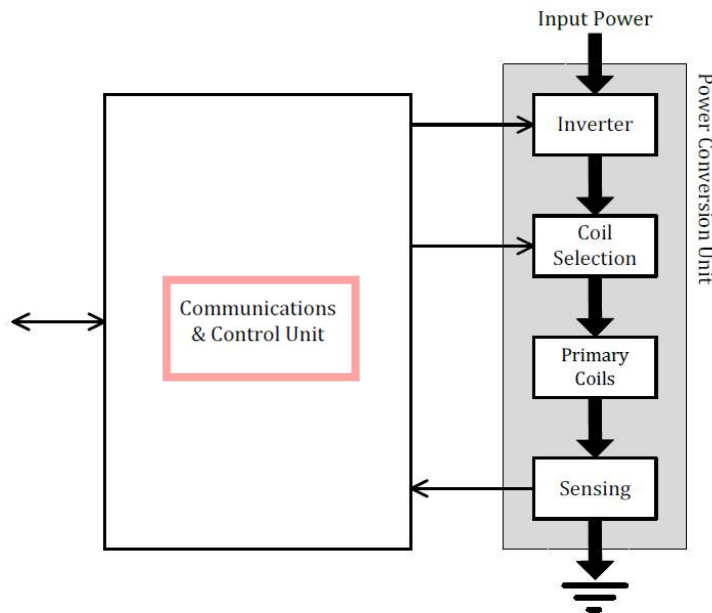
WPC Standard

That the 500 Accused Products meet this part of the claim is further indicated by the WPC Standard Reference Designs. *E.g.*, WPC 1.2.4 Standard, Part 4, Reference Designs, page 31 (*see also* WPC 1.2.3 Standard, Part 4, Reference Designs, page 31).

2.2.4 Power Transmitter design A4

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.

operate the one or more drive circuits near a first resonant frequency of a circuit formed by a primary coil and a drive circuit and a receiver coil and a receiver circuit of a compatible portable device when nearby;

The one or more communication and control circuits included in the 500 Claim 1 Accused Products are configured to operate their one or more drive circuits in this manner.

Smartphones

For the S22 Ultra, the frequency range of operation when operating as a wireless charger in the Wireless PowerShare mode is specified in an FCC filing by Samsung below, showing the frequency of operation as 110-148 kHz, which is near the resonance frequency of a charging circuit including the primary coil and drive circuit capacitor of the S22 Ultra and a nearby receiver coil and a receiver circuit of a compatible device when nearby as required by the claim.

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

MEASUREMENT REPORT **FCC Part 15C Wireless Power Transfer**

Applicant Name: Samsung Electronics Co., Ltd. 129, Samsung-ro, Yeongtong-gu, Suwon-si Gyeonggi-do, 16677, Korea	Date of Testing: 9/22/2021 – 12/7/2021 Test Report Issue Date: 12/7/2021 Test Site/Location: PCTEST Lab. Columbia, MD, USA Test Report Serial No.: 1M2109090102-20-R2.A3L
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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

Wireless Chargers

The 5200 Duo frequency range of operation is seen in Samsung's FCC filings shown below. The wireless charging ASIC operates the one or more drive circuits near a first resonant frequency of a circuit formed by a primary coil and a drive circuit and a receiver coil and a receiver circuit of a compatible portable device when nearby. <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		

The 825 Watch Dock frequency range of operation is seen in Samsung's FCC filings shown below. Its wireless charging ASIC operates the one or more drive circuits near a first resonant frequency of a circuit formed by a primary coil and a drive circuit and a receiver coil and a receiver circuit of a compatible Watch when nearby.

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

1.4. Description of EUT

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

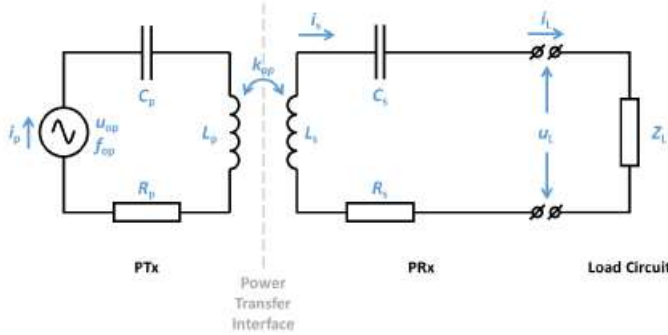
WPC Standard Citations

The WPC Standard, as seen below, specifies a typical operating frequency f_{op} of 100-200 kHz and a primary resonant frequency f_p 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, as shown below, the 500 Claim 1 Accused Products operate their drive circuits at frequencies near the resonant frequency of a wireless power transfer circuit formed by a primary coil and a drive circuit (including the transmitter resonant capacitor) and a receiver coil and a receiver circuit (including the receiver resonant capacitor) of a compatible portable device when nearby. The relationship between the primary coil and the receiver coil when nearby is shown by the coupling factor (coupling coefficient) k_{op} between the coils in the section below.

Whereas a Power Transmitter can hold its Primary Coil current to a sufficiently low level, placing a hard limit on the Primary Coil current can prevent a Power Receiver from reaching its target power level when it has connected its load. A better solution is to define more than one limit according to the amount of power that is transmitted: the Power Transmitter should use a low current limit if the Transmitted Power is low to prevent an over-voltage from occurring in the Power Receiver, and it should use a high current limit if the Transmitted Power is high to enable the Power Receiver to reach its target Operating Point without creating an over-voltage in the Power Receiver. The system model and analysis below explain this approach in more detail.

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

Figure 10. Simplified system model



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

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

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

Table 7. Parameters of the simplified model

Power Transmitter			Power Receiver		
L_p	25	μH	L_s	35	μH
f_p	100	kHz	f_s	100	kHz
Q_p	100		Q_s	40	
u_{op}	2...24	V (pk)	u_L	12	V (rms)
f_{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.

The coupling coefficient (k_{op} above) between the primary coil and receiver coil is described below *E.g.*, WPC 1.2.4 Standard, Introduction, page 9 and page 12.



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.

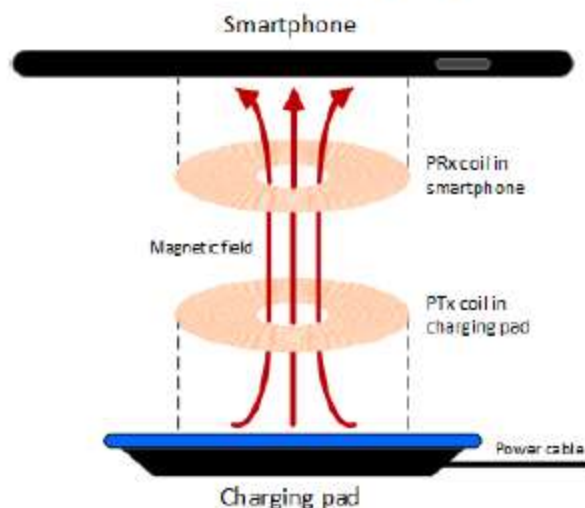
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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



4.4 Coupling requirements

Coupling occurs when current changes in one coil creates a voltage in the other coil via magnetic induction.

Coupling is highest—with the most efficient power transfer—when:

- the PTx and PRx use exactly the same coil
- the PTx and PRx are perfectly aligned
- the distance between the coils is small (less than the diameter of the coils)
- the coils are externally shielded by ferrite

Conditions that decrease coupling (and power transfer efficiency) include different power transmitter/power receiver coil sizes and shapes, coil misalignment, excessive distance between coils, and the presence of foreign objects on the power transmitter.

switch the one or more primary coils at a frequency and power level sufficient to transfer power to one or more of the receiver units when near the one or more primary coils for a sufficiently long period of time to activate the one or more receiver circuits and to receive a response from the one or more receiver circuits via the one or more receiver coils which the one or more primary coils sense via the one or more sense circuits as a modulation of one or more primary coil currents;

The 500 Claim 1 Accused Products with their one or more communication and control circuits are configured to operate with their one or more drive circuits and sense circuits in this manner with respect to the WPC Standard.

WPC Standard

The charger switches the one or more primary coils at a frequency and sufficient power level for a period of time (ping) to activate a receiver and seek a response from a nearby receiver. See as an example, WPC 1.2.3 Standard, Part 1&2: Reference Designs, page 46:

- *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.

Following the WPC Standard, the 500 Claim 1 Accused Products inductively power and activate the wireless charging receiver in the portable 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).



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

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

Once a wireless power receiver is activated, the charger receives communication from the receiver through load modulation. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 87 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 86)

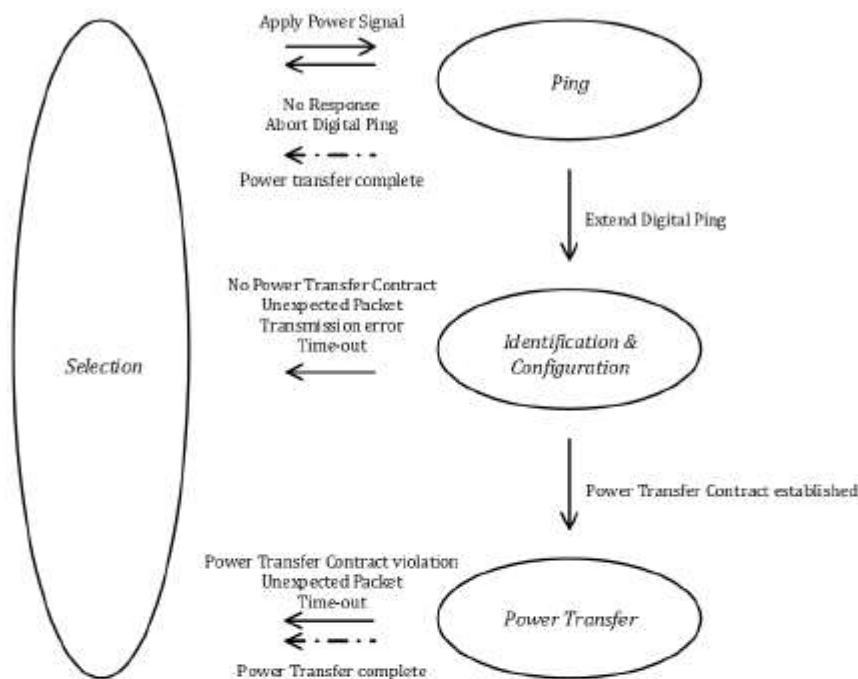
5.2 Power Receiver to Power Transmitter communications interface

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.

From the Power Transmitter/Charger perspective, the WPC phases in the Baseline Power Profile (< 5W power transferred) 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.

From the Receiver perspective, the receiver is powered by the received inductive power from the charger and if the charger applies a power signal at a frequency and of sufficient power level for a sufficiently long period of time to generate a sufficiently high rectified voltage in the receiver as shown below, the receiver proceeds to the ping phase and begins to transmit communication to the charger. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 73 and 74 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 72 and 73).



5.1.3.1 Selection phase (PRx perspective)

As soon as the Power Transmitter applies a Power Signal, the Power Receiver shall enter the *selection* phase if the Power Receiver is not in the *selection* phase already.⁵

NOTE This Specification does not define how the Power Receiver should detect that the Power Transmitter applies a Power Signal.

If the Power Receiver considers the rectified voltage V_r to be sufficiently high, the Power Receiver shall proceed to the *ping* phase, such that the first Packet (see Section 5.1.3.2, *Ping phase (PRx perspective)*) starts at t_{wake} . Here, the time t_{wake} starts from the instant that the Primary Cell current amplitude crosses 50% of the stable level. See Figure 27 and Table 16.

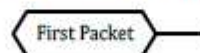
If the Power Receiver does not proceed to the *ping* phase, the Power Receiver shall not transmit any Packet.



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

detect, through the one or more sense circuits, communications from the one or more receiver units through the one or more receiver coils including information corresponding to one or more voltages at one or more outputs of the receiver rectifier circuits induced by the one or more primary coils and the one or more receiver coils and information associated with the one or more portable devices and/or receiver units to enable the one or more communication and control circuits to

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
 Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
 identify the one or more portable devices and/or receiver units and to determine any one or more
 appropriate charging or powering algorithm profiles therefor;

The 500 Claim 1 Accused Products with their included one or more communication and control
 circuits are configured to operate with their one or more drive circuits and sense circuits in this
 manner as seen in the WPC Standard.

WPC Standard

As per below (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 93 (*see also* WPC
 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 91) the one or more sense circuits detect
 communication from the one or more receiver coils including information corresponding to one or
 more voltages at one or more outputs of the receiver rectifier circuits induced by the one or more
 primary coils.

5.2.3.1 Signal Strength Packet (0x01)

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

Table 27. Signal strength

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

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

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

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

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

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

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

Additional information received by the transmitter is described at a high level 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.

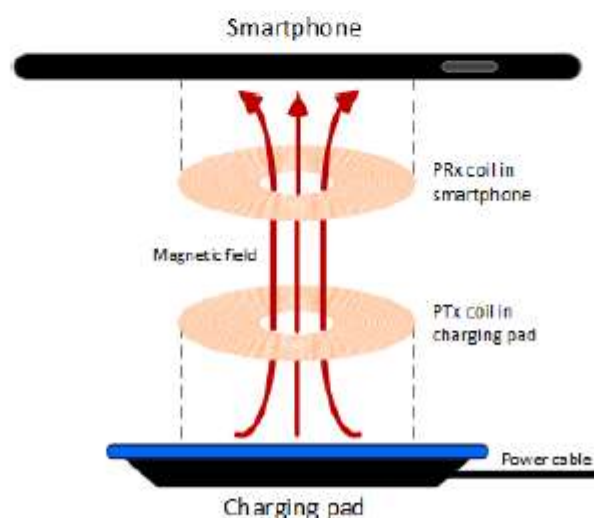
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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



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



5.2.3.8 Identification Packet (0x71)

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

Table 35. Identification

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

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

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

Table 36. Minor Version field settings

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

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



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

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



5.2.3.7 Configuration Packet (0x51)

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

Table 34. Message in a Configuration Packet

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

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

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

Maximum Power Value

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

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

for each portable device, determine the primary coil electromagnetically most aligned with the receiver coil of the portable device;

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
The 500 Claim 1 Accused Products with their included one or more communication and control circuits are configured to operate in this manner, as outlined in the WPC Standard below.

WPC standard

The 500 Claim 1 Accused Products adhere to WPC Standard, pursuant to which for single and multi-coil chargers, specifies that the charger applies power to any and each coil sequentially for a period of time to see if it detects a message from a potential nearby and aligned receiver through the activated coil. This information is used to determine whether a coil is aligned and the most aligned coil(s) in the charger to one or more receiver coils present. The following description is from the WPC standard for multi-coil chargers.

See as an example, WPC 1.2.3 Standard, Part 1&2: Reference Designs, page 46:

- *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.

As shown above, the first message transmitted by a receiver and received by the transmitter during a ping process is a Signal Strength Packet. Per below (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 93 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 91) the purpose of transmission of the Signal Strength Packet by the receiver and receipt of this message by the transmitter is to enable the transmitter to determine the degree of coupling (i.e. alignment and gap) between the activated transmitter coil and the receiver coil and make a determination to proceed to the next phase if sufficient alignment exists.

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
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 effect of alignment and coupling between the transmitter coil and receiver coil is discussed below *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Introduction, page 9 and page 12.



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.

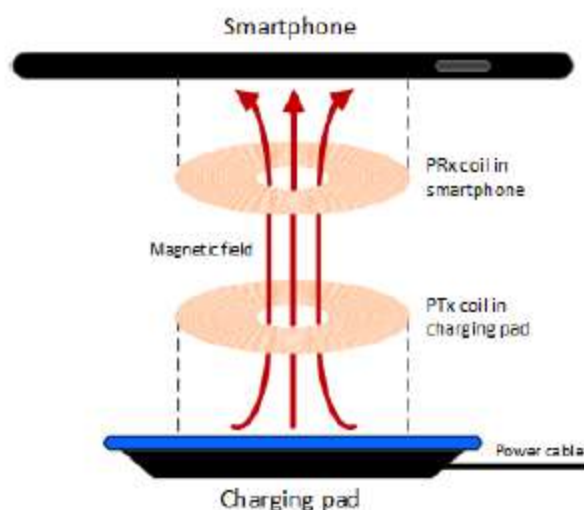
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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



4.4 Coupling requirements

Coupling occurs when current changes in one coil creates a voltage in the other coil via magnetic induction.

Coupling is highest—with the most efficient power transfer—when:

- the PTx and PRx use exactly the same coil
- the PTx and PRx are perfectly aligned
- the distance between the coils is small (less than the diameter of the coils)
- the coils are externally shielded by ferrite

Conditions that decrease coupling (and power transfer efficiency) include different power transmitter/power receiver coil sizes and shapes, coil misalignment, excessive distance between coils, and the presence of foreign objects on the power transmitter.

Pursuant to the WPC standard, the Samsung charger applies power to the activated coil for a period of time to see if it detects a message from a potential nearby and aligned receiver coil. This information is used to determine the most aligned primary coil(s) in the charger to the receiver coil of the portable device.

See as an example, WPC 1.2.3 Standard, Part 1&2: Reference Designs; P. 150:

Power Receivers. For each of the Primary Cells in this set, the Power Transmitter executes a Digital Ping (see Section 5.1.2.2), removing the Power Signal after receipt of a Signal Strength Packet (or an End Power Transfer Packet, or after a time out).¹⁵ This yields a new set of Primary Cells, namely those that report a Signal Strength Value above a certain threshold—which the Power Transmitter chooses. Finally, the Power Transmitter executes an extended Digital Ping (see Sections 5.1.2.2 and 5.1.2.3) for each of the Primary Cells in this new set in order to identify the discovered Power Receivers. The Power Transmitter should take the situations discussed in Annex B.2.1, B.2.2, and B.2.3 into account in order to select the most appropriate Primary Cells from the set for power transfer.

drive the one or more FET switches associated with the most aligned one or more primary coils; periodically receive information corresponding to one or more output voltages or currents of the one or more receiver rectifier circuits via the one or more primary coils and the one or more sense circuits; and regulate in a closed loop feedback manner the one or more output voltages or currents of the one or more receiver rectifier circuits by adjusting the frequency or duty cycle of the one or more drive circuits during the charging or powering of the one or more portable devices.

The 500 Claim 1 Accused Products with their included one or more communication and control circuits are configured to operate in this manner, as seen in the WPC Standard.

WPC Standard

Following the Identification and Configuration phase, the transmitter enters the Power Transfer phase. This phase is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 82 (see also WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 49).



5.1.3.6 Power transfer phase (PRx perspective)

In the *power transfer* phase, the Power Receiver controls the power transfer from the Power Transmitter, by means of control data that it transmits to the latter. For this purpose, the Power Receiver shall transmit zero or more of the following Packets:

- Control Error Packet. The Power Receiver shall set the Control Error Value to zero if the actual Control Point is equal to the desired Control Point. The Power Receiver shall set the Control Error Value to a negative value to request a decrease of the Primary Cell current. The Power Receiver shall set the Control Error Value to a positive value to request an increase of the Primary Cell current. See Sections 5.1.1, *Overview (informative)*, and 5.1.2.6.1, *Power transfer control*.
- Received Power Packet.
- Charge Status Packet.
- End Power Transfer Packet.
- Any Proprietary Packet (as listed in Table 26).

During the Power Transfer phase the transmitter regulates in a closed loop feedback manner the amount of output voltage or current as follows as specified by this section of the claim. *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).



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

Smartphones

That the S22 Ultra controls the duty cycle and/or frequency as claimed is also seen in the representative 9415 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.

Wireless chargers

The 5200 Duo Pad and 825 Watch Dock similarly control the duty cycle and/or frequency for regulation as claimed, as seen in the WPC Standard.

Dependent Claims (off of claim 1)

2. The system of claim 1, further comprising one or more voltage regulator circuits that can change input voltages to the one or more drive circuits between two or more levels to accommodate different powers required by the portable devices.

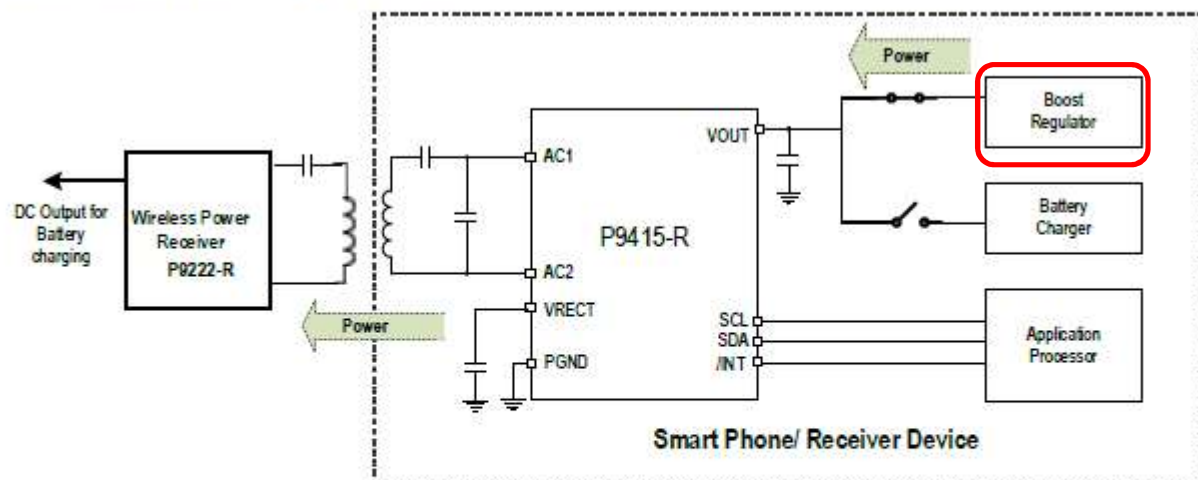
The 500 Claim 1 Accused Products each include one or more voltage regulator circuits as specified by this part of the claim.

Smartphones

The S22 Ultra includes a voltage regulator circuit as specified by this dependent claim, which is structured to switch the DC voltage input (Vout pin below) as specified by this dependent claim. In the representative 9415 datasheet as seen below, the boost voltage regulator (red rectangle) boosts the input voltage from the battery of the S22 Ultra (typically ~ 3.7 V) to a higher level for the drive circuit of the system, 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 boost voltage regulator controlled by the microcontroller to the DC voltage input, and when using its internal battery power when not plugged in, supplies voltages between 5 and 7.5 V, depending on the power needs of the portable device being charged as communicated by the portable device to the microcontroller to control the boost 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

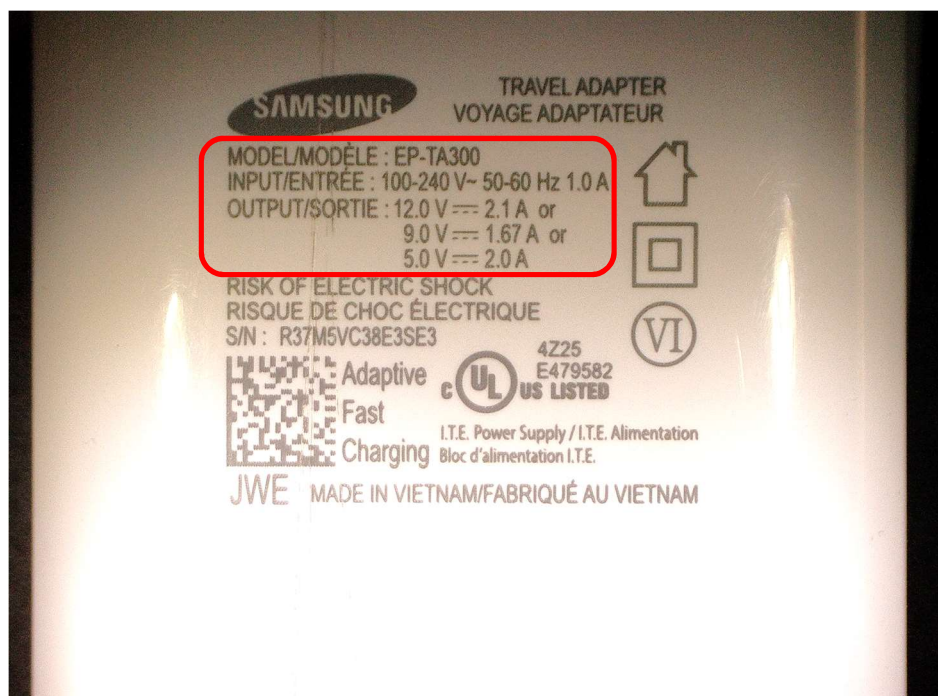
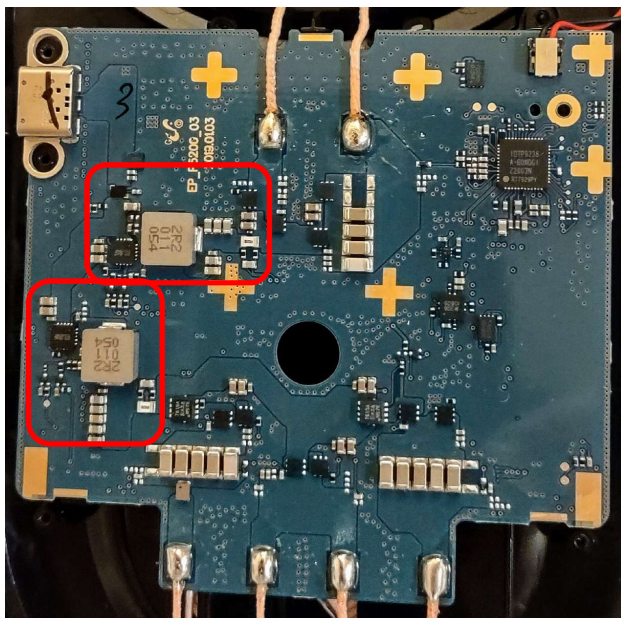


8.4.2 WattShare™ Mode Input Voltage

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 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 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).



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.

3. The system of claim 1, wherein the one or more drive circuits, primary coils and associated capacitors are designed to be driven in a Zero Voltage Switching or Zero Current Switching mode during inductive power transfer to a portable device.

In the 500 Claim 1 Accused Products, on information and belief, the one or more drive circuits, primary coils and associated capacitors identified above with respect to claim 1 are designed to be driven in a Zero Voltage Switching or Zero Current Switching mode.

4. The system of claim 1, wherein the one or more communication and control circuits are designed to receive from a receiver unit of a portable device identification information including one or more codes identifying the manufacturer of the portable device and/or receiver unit, a unique portable device and/or receiver ID code, a charge algorithm profile, and a power requirement of the portable device and/or receiver unit.

The 500 Claim 1 Accused Products infringe this dependent claim. The one or more communication and control circuits included in the 500 Claim 1 Accused Products are configured to receive the information specified in this dependent claim.

WPC Standard

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



5.2.3.8 Identification Packet (0x71)

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

Table 35. Identification

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

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

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

Table 36. Minor Version field settings

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

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



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

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



5.2.3.7 Configuration Packet (0x51)

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

Table 34. Message in a Configuration Packet

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

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

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

Maximum Power Value

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

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

9. The system of claim 1, wherein the one or more communication and control circuits can provide bi-directional digital communication between the one or more primary coils and the receiver coils for a verification process to ensure that a receiver unit that can be charged or powered by the system is present and to determine the voltage or power requirements of the receiver unit.

The 500 Accused Wireless Chargers which are Samsung fast chargers (e.g., the 5200 Duo and the Watch5 Charging Dock [EP-OR900]) additionally infringe this dependent claim, as their one or more communication and control circuits can provide bi-directional digital communication between the one or more primary coils and the receiver coils for a verification process to ensure that a receiver unit that can be charged or powered by the system is present and to determine the voltage or power requirements of the receiver unit, per the WPC Standard.

Samsung Wireless Fast Charge transmitters operating in the Samsung Wireless Fast Charge mode (following the WPC EPP communication protocol) for power levels over 5 W (for smartphones; up to 5 W for Watch5), in addition to receiving amplitude modulated communication from receivers as shown in claim 1, transmit communication to the receivers using frequency modulation. As shown in the WPC standard, packets can be sent bi-directionally (from the receiver to the transmitter or from the transmitter to the receiver) in the Extended Power Profile (EPP)

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
mode in the Samsung Wireless Fast Charge mode, which is a Samsung variation on WPC EPP
using the EPP bi-directional communication. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface
Definitions, page 108 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page
106).



5.3 Power Transmitter to Power Receiver communications interface

5.3.1 Introduction

The Power Transmitter communicates to the Power Receiver using Frequency Shift Keying, in which the Power Transmitter **modulates the Operating Frequency of the Power Signal**.

5.3.2 Physical and data link layers (PTx to PRx)

This section defines both the physical layer and the data link layer of the Power Transmitter to Power Receiver communications interface. The data link layer supports both Packets and Responses. The format of a Packet is defined in Section 5.3.2.3. The format of a Response is defined in Section 5.3.2.4.

5.3.2.1 Modulation scheme

The Power Transmitter shall switch its Operating Frequency between the Operating Frequency f_{op} in the unmodulated state and the Operating Frequency f_{mod} in the modulated state. The difference between these two frequencies is characterized by two parameters:

Further, as shown in the WPC standard (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 59-61; *see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 59-60), the bidirectional communication during the Negotiation phase can include a verification process to ensure that a receiver unit that can be charged or powered by the system is present to be charged at the EPP / Samsung Wireless Fast Charge power levels (over 5 W for smartphones; up to 5 W for Watch5) and to determine the voltage or power requirements of the receiver unit.

5.1.2.4.2.1 Power Transmitter Responses

The Power Transmitter shall send a Response as defined in Table 13. In addition, if the case of a Specific Request Packet, the Power Transmitter shall send an ND Response if

- the Request field contains a value listed as reserved in Table 43; or
- one or more of the reserved bits in the Request Value are set to ONE (see Section 5.2.3.13, *Specific Request Packet—EPP only* [0x20]).

Table 13. Power Transmitter Responses in the *negotiation* phase

Packet type	Power Transmitter Response
Specific Request Packet	Guaranteed Power. If the Power Transmitter supports the requested Guaranteed Power Value, it shall update the Guaranteed Power in the temporary Power Transfer Contract and shall send an ACK Response. Otherwise, it shall send a NAK Response.
	Received Power Packet type. If the Received Power Packet Header is 0x31 (24-bit Received Power Packet), the Power Transmitter shall update the Received Power Packet Format in the temporary Power Transfer Contract and shall send an ACK Response. Otherwise, the Power Transmitter shall send a NAK Response.
	FSK parameters. The Power Transmitter shall update the requested FSK Polarity and Modulation Depth parameters in the temporary Power Transfer Contract and shall send an ACK Response.
	Maximum Power. The Power Transmitter shall update the Maximum Power in the temporary Power Transfer Contract and shall send an ACK Response.



Packet type	Power Transmitter Response
	<p>Proprietary. If the Power Transmitter does not have a defined Proprietary Response, it shall send a Not-Defined (ND) Response. Otherwise, it shall send its defined Proprietary Response, which may be an ACK Response, a NAK Response, or an ND Response.</p> <p>End Negotiation. The Power Transmitter shall return to the <i>selection</i> phase if the Power Transmitter has not sent an ACK Response earlier in the <i>negotiation</i> phase to both</p> <ul style="list-style-type: none"> a Specific Request Packet with Request = 0x02 (Received Power Packet Type), and an FOD Status Packet. <p>Otherwise, the Power Transmitter shall verify that the Count Value matches the number of parameters that differ between the active Power Transfer Contract and the temporary Power Transfer Contract.</p> <ul style="list-style-type: none"> In the case of a match, the Power Transmitter shall send an ACK Response. Subsequently it shall copy the temporary Power Transfer Contract to the active Power Transfer Contract, and proceed to the <i>calibration</i> phase. Otherwise, the Power Transmitter shall copy the active Power Transfer Contract to the temporary Power Transfer Contract, send a NAK Response, and remain in the <i>negotiation</i> phase. <p>NOTE This action effectively discards all negotiated changes to the Power Transfer Contract.</p>
General Request Packet	<p>The Power Transmitter shall send a Packet containing the information that is requested by the Power Receiver. If the Request is a reserved value, or a proprietary value for which the Power Transmitter does not have a defined Response (see Table 54 in Section 5.3.2.3.2, <i>Header</i>), the Power Transmitter shall send a Power Transmitter Data Not Available Packet (see Section 5.3.3.1, <i>Power Transmitter data not available Packet (0x00)</i>).</p> <p>NOTE Whereas General Request Packets enable a Power Receiver to obtain information from a Power Transmitter, they do not enable the Power Transmitter to modify the Power Transfer Contract.</p>
FOD Status Packet	<p>If the Mode field is set to a reserved value, or if the any one of the reserved bits is set to ONE, the Power Transmitter shall send an ND Response and ignore the content of the Packet. Otherwise, the Power Transmitter shall send</p> <ul style="list-style-type: none"> an ACK Response if it did not detect a Foreign Object; or a NAK Response if it did detect a Foreign Object. In this case, the Power Transmitter shall return to the <i>selection</i> phase within 5 seconds irrespective of further communications from the Power Receiver. <p>It is recommended that the Power Transmitter uses the Reference Quality Factor contained in the FOD Status Packet to determine its Response. For this purpose, the Power Transmitter should</p> <ul style="list-style-type: none"> adjust its quality-factor threshold based on the Reference Quality Factor Value; compare its measured quality factor to its adjusted threshold; and send an ACK or a NAK Response based on the comparison. <p>See Section 11.3, <i>FOD based on quality factor change</i> for details.</p>

The Watch5 Wireless Charging Dock (EP-OR900) is a fast charger capable of 5W of power for charging a Samsung Galaxy 5 watch.

<https://fcc.report/FCC-ID/A3LEPOR900/5892919>

1.3. Details of Manufacturer

Company : Samsung Electronics Co., Ltd.
Address : Yen Phong 1 Industrial park, Yen Phong District Bac Ninh Province, VIETNAM

1.4. Description of EUT

Kind of Product	WIRELESS CHARGER
Model Name	EP-OR900
Serial Number	R37T4DA00T1RTA
Power Supply	DC 5 V
Operation Mode	5 W
Frequency Range	143.5 ~ 146.5 MHz
Antenna Type	Loop Coil Antenna
Antenna Serial Number	W2401
PCB Version	EP-OR900 REV0.5, EP-OR900 REV0.6
H/W Version	01
S/W Version	V3.2

<https://www.samsung.com/us/mobile/mobile-accessories/smartwatches/galaxy-watch-charger-ep-or900bbeguj/#specs>

On your marks. Get set. Charge.

Your watch is your all-day, all-night companion. And now, it never has to be off your wrist for long. Get to 45% in just 30 minutes with the fast-charging infrastructure that supports 5V/2A higher and PD.



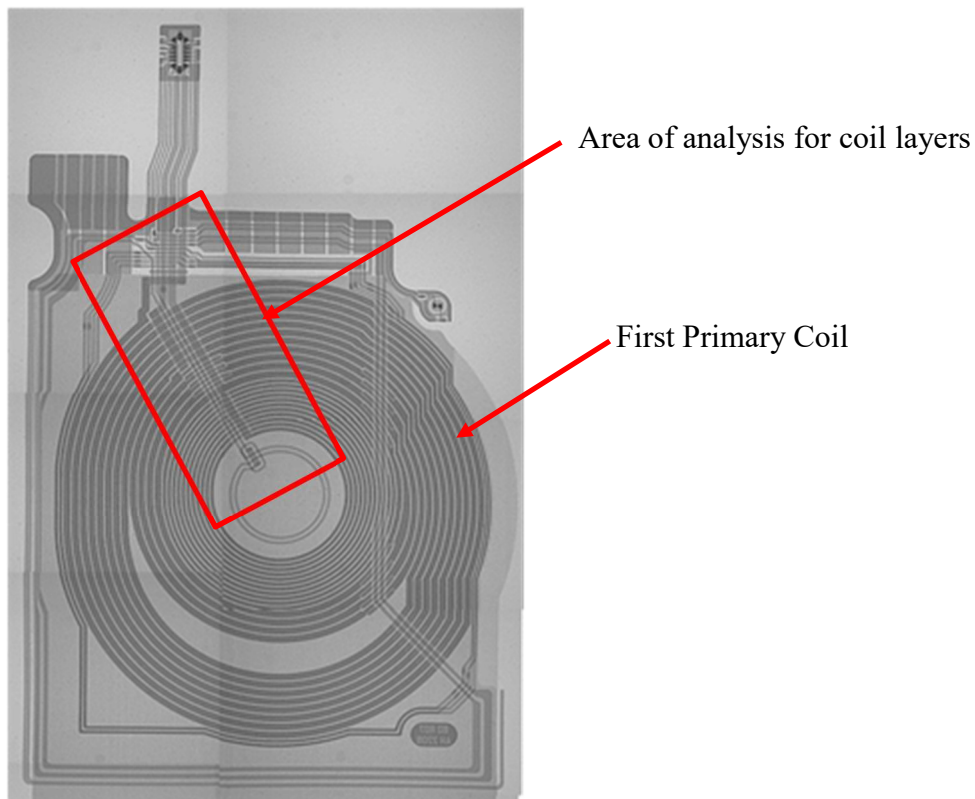
The Watch 5 charger (EP-OR900) similar to other Samsung Fast Chargers includes one or more communication and control circuits that can provide bi-directional digital communication between the one or more primary coils and the receiver coils to ensure that a receiver unit that can be charged or powered by the system is present and to determine the voltage or power requirements of the receiver unit as required by the claim.

11. The system of claim 1, wherein the one or more primary coils are constructed of a Printed Circuit Board comprising multiple layers connected by vias.

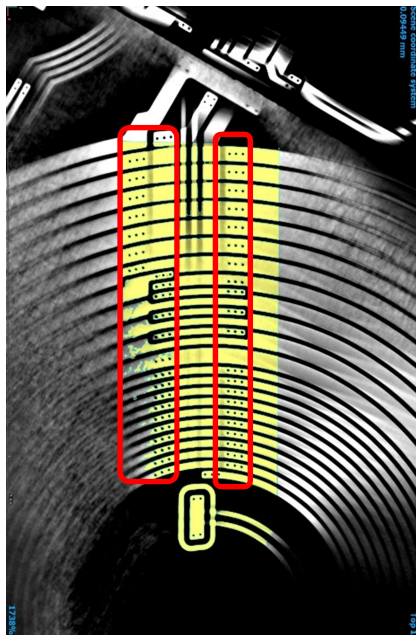
The 500 Accused Smartphones additionally infringe this dependent claim.

Smartphones

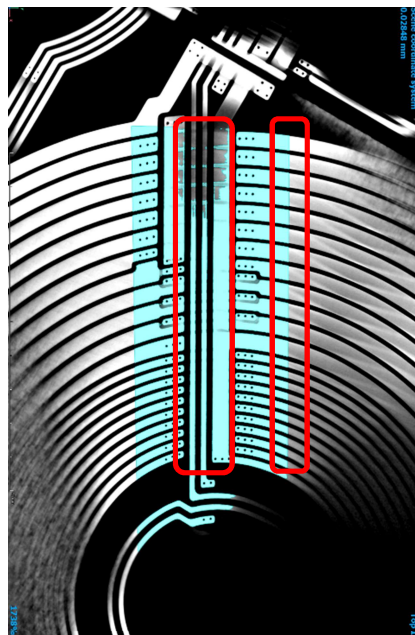
For example, the representative S22 Ultra includes one or more primary coils comprises a PCB coil with multiple layers connected by vias. The area shown in Red Rectangle below is further analyzed with 3D x-ray imagery.



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



Coil Layer 1



Coil Layer 2

12. The system of claim 1, wherein the system is incorporated into a portable device or battery pack comprising an internal rechargeable battery that can be periodically recharged and can operate the system for inductive charging or powering for a period of time.

The 500 Accused Smartphones additionally infringe this dependent claim.

Smartphones

The representative S22 Ultra comprises a portable device with an internal rechargeable battery that can be periodically recharged and can operate the system for inductive charging or powering for a period of time. (See also claim 1 above and claim 23 below with respect to the S22 Ultra.)

13. The system of claim 12, further comprising one or more receiver unit circuits coupled to one or more of the one or more primary coils to enable the system and its internal battery to be charged or powered inductively.

The 500 Accused Smartphones additionally infringe this dependent claim.

Smartphones

For example, the representative S22 Ultra is a portable device further comprising one or more receiver unit circuits coupled to one or more of the one or more primary coils to enable the system and its internal battery to be charged or powered inductively. The detail for this limitation can be found in Claim 23 below. The S22 Ultra uses the same primary coil for receiving inductive power.

18. The system of claim 1, further wherein the one or more communication and control circuits use a Proportional-Integral-Derivative control technique to regulate one or more outputs of the one or more receiver rectifier circuits.

The 500 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

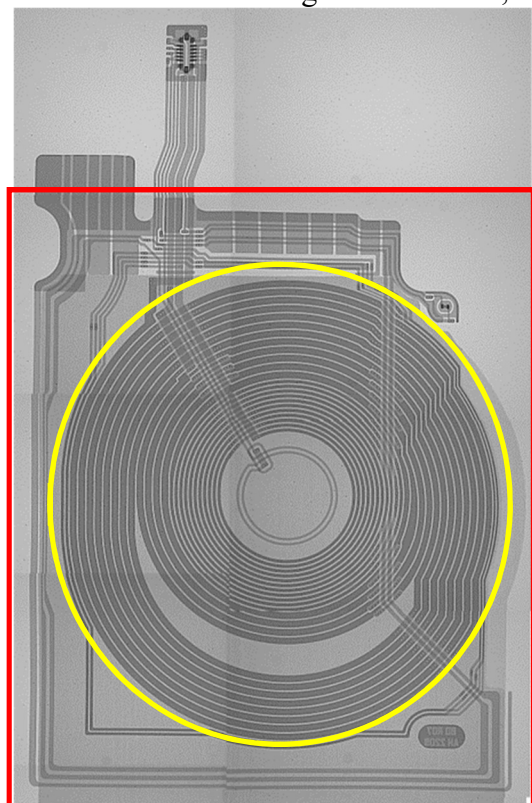
This version of the Specification, defines a specific method, which the Power Transmitter shall use to control its Primary Cell current towards the new Primary Cell current (see Section 5.1.1, Overview (informative)). This method is based on a discrete proportional-integral-differential (PID) algorithm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

20. The system of claim 1, further comprising a metallic layer designed to remove heat from the one or more primary coils during power transfer.

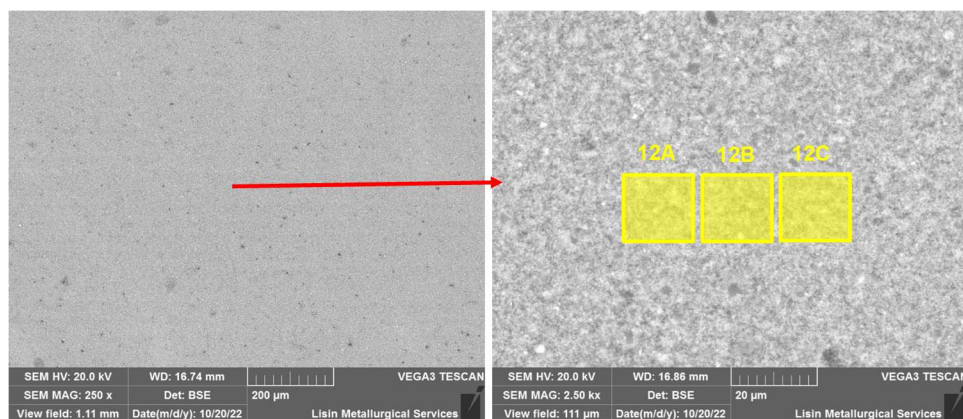
The 500 Accused Smartphones additionally infringe this dependent claim.

The representative S22 Ultra, for example, includes a metallic layer to remove heat from the coil during power transfer.

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.



This layer was 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 below show ~29% Titanium, ~1% Al, 1% Si and ~36% Carbon for this metallic layer.



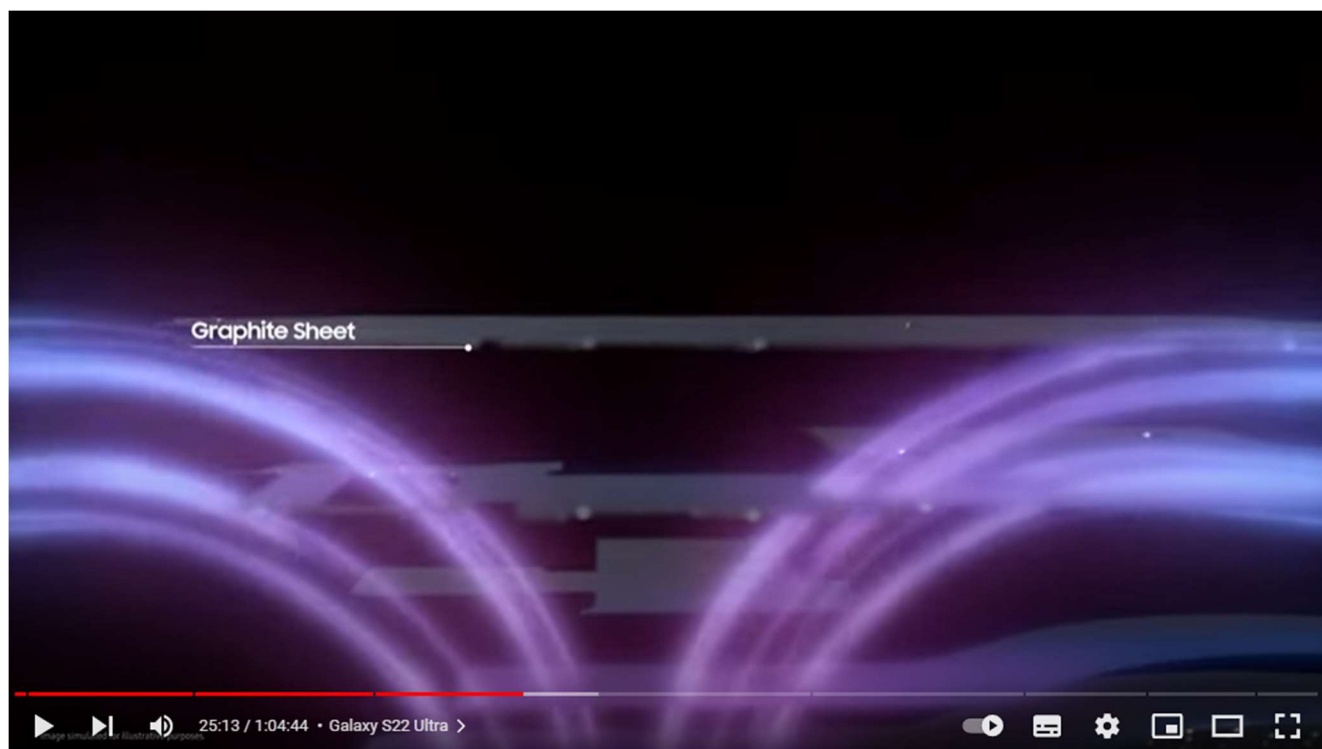
Images at 20kV, spectra at 10kV (interaction depth of 1.3 μ m)

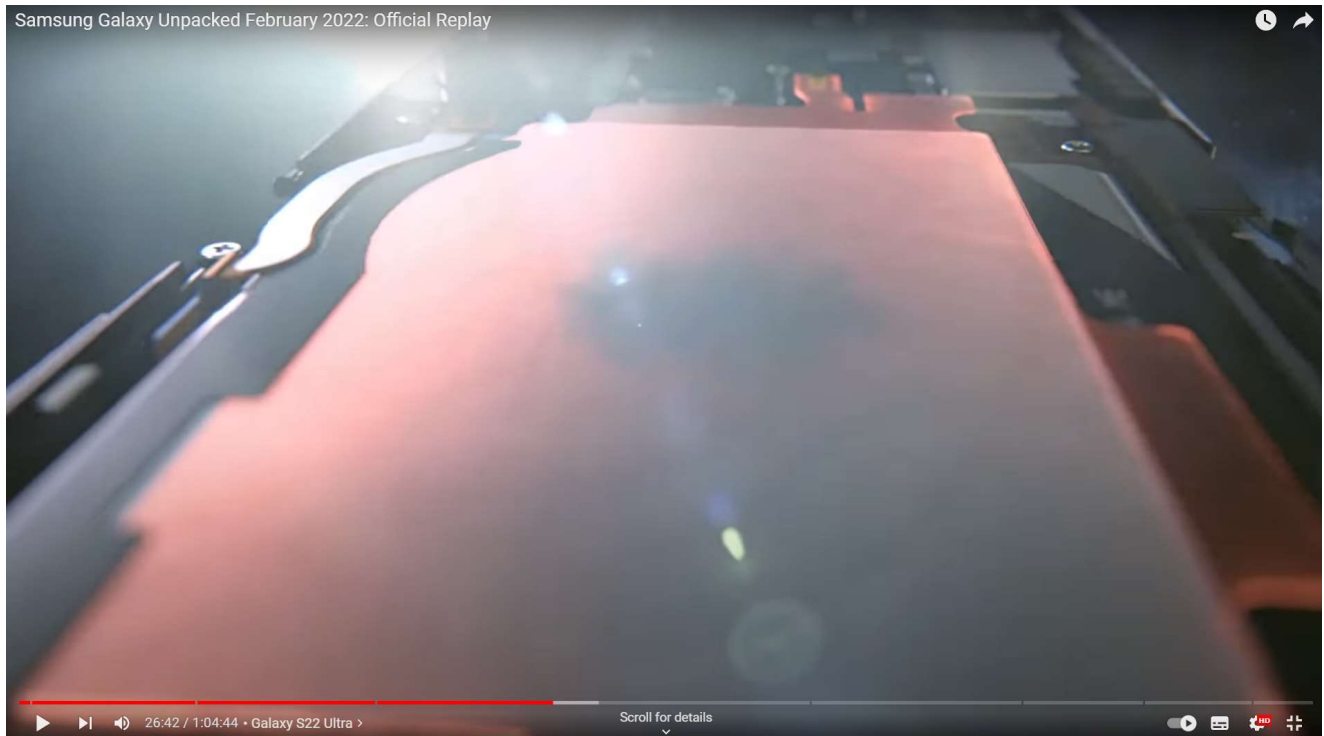
Normalized mass concentration [%]

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

Further, 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





23. A portable device including a battery capable of receiving inductive power from an inductive charging system including a base unit with one or more primary coils and associated circuits, the portable device comprising:

The 500 Accused Products capable of receiving power inductively as specified by this claim are accused under this claim; this includes the 500 Accused Smartphones, the 500 Accused Wearables, and the 500 Accused Earbud Products (collectively the “500 Claim 23 Accused Products”). The 500 Claim 23 Accused Products fit the description in this introductory part of the claim, as each is a portable device as specified by this introductory part of the claim. The S22 Ultra, Watch4, and Buds2 are representative thereof.

Smartphones

The S22 Ultra is representative of how the 500 Accused Smartphones meet this introductory part of claim 1, as the S22 Ultra is a portable device that includes a battery, as specified by this claim.

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

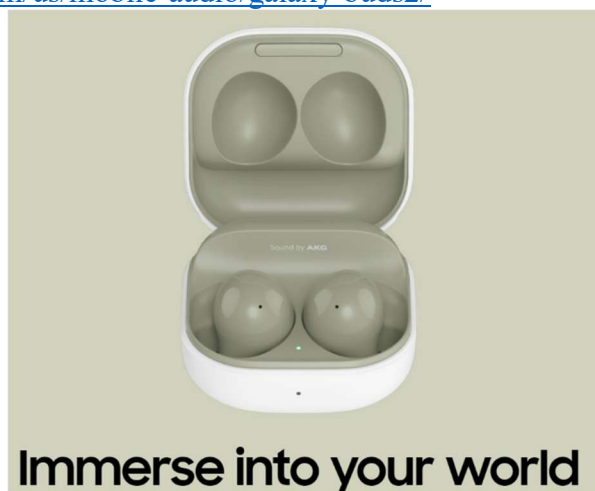




Earbuds

The Buds2 is representative of how the 500 Accused Earbud Products infringe claim 23. The Buds2 product meets this introductory part of claim 23 as the Buds2 case is a portable device that includes a battery and is capable of receiving inductive power.

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



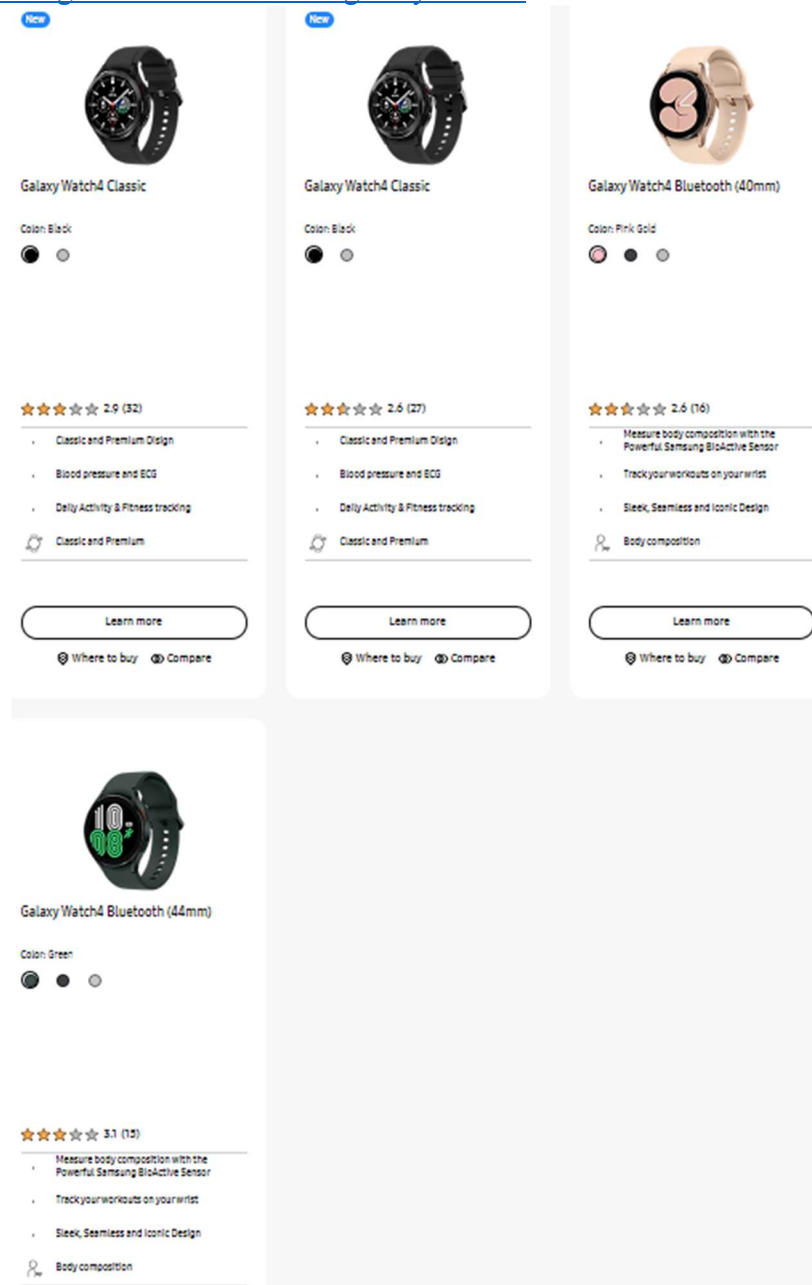
Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
<https://www.ifixit.com/News/52635/galaxy-buds2-teardown-great-buds-with-one-big-flaw>
(Galaxy Buds2)



Wearables

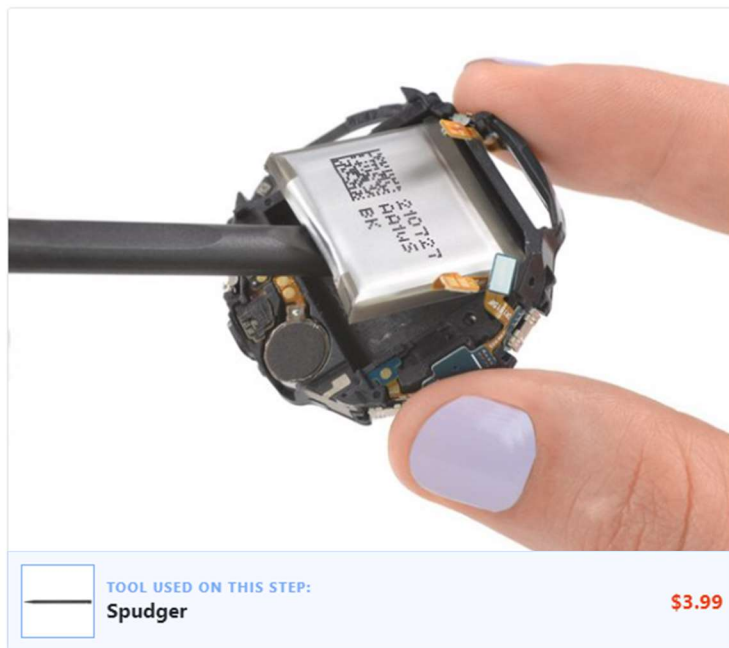
The Watch4 is representative of how the 500 Accused Wearables satisfy this introductory part of claim 23. The Watch4 is a portable device that includes a battery, as specified by this introductory part of claim 23.

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



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

Step 7



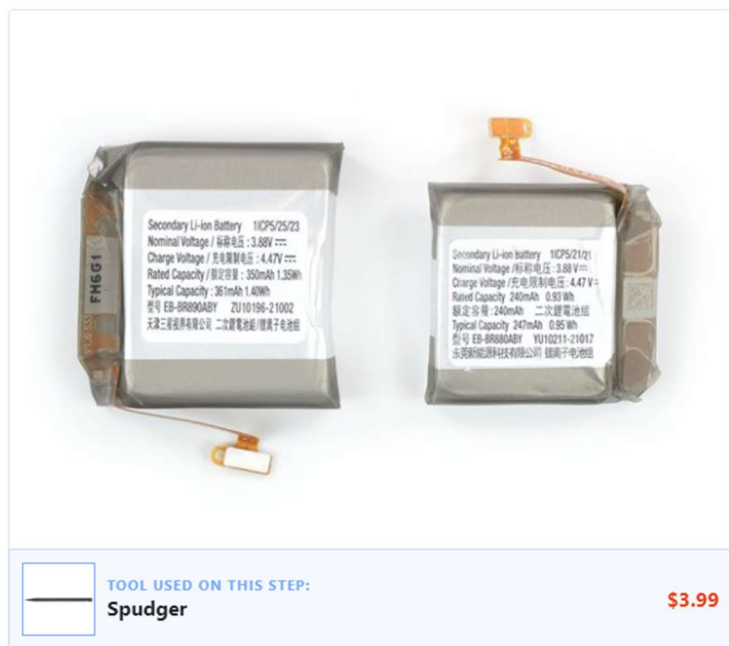
TOOL USED ON THIS STEP:
Spudger

\$3.99



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

Step 7



TOOL USED ON THIS STEP:
Spudger

\$3.99



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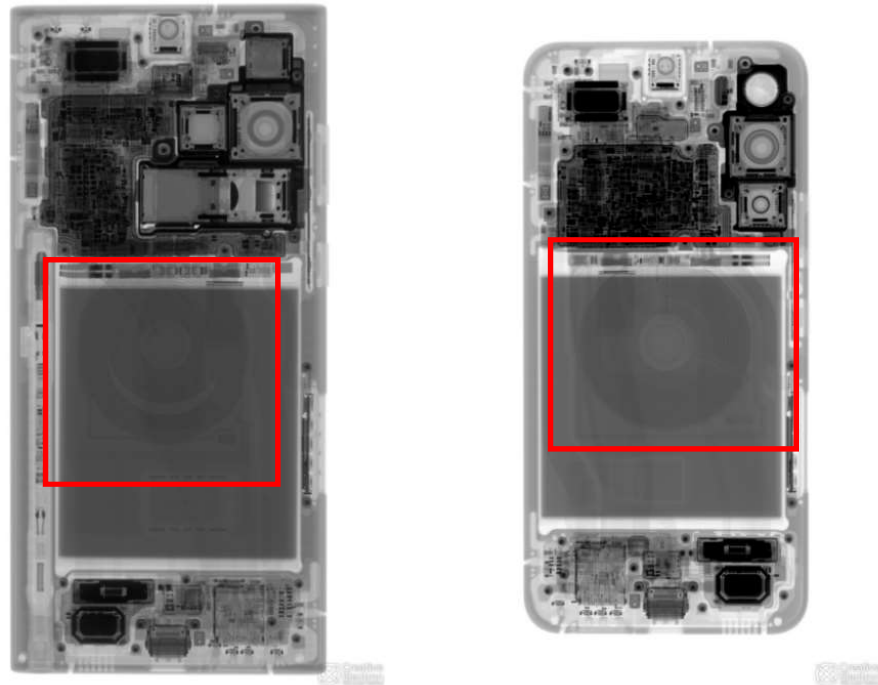
a receiver coil which has a substantially planar shape and located parallel to a surface of the portable device so that a magnetic field received from a primary coil in a base unit of an inductive charging system in a direction substantially perpendicular to the plane of the receiver coil is used to inductively generate a current in the receiver coil to power or charge the portable device;

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
The 500 Claim 23 Accused Products include a receiver coil as specified by this part of the claim.

Smartphones

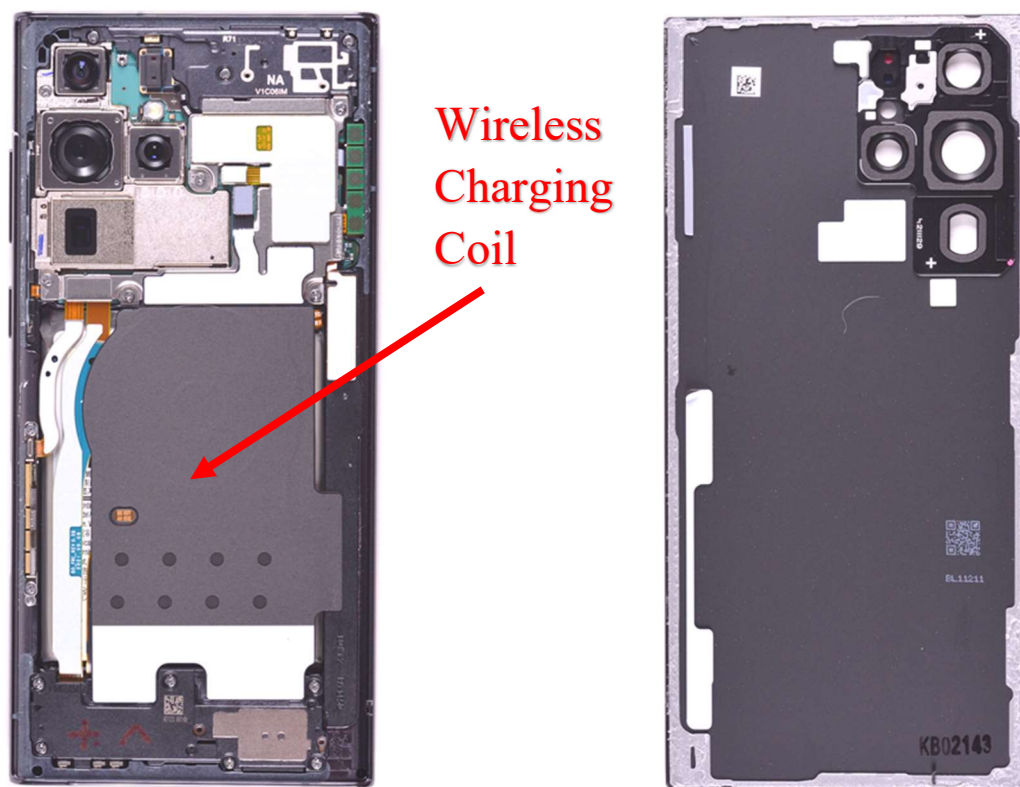
The S22 Ultra includes a receiver coil, as specified by this part of the claim. In the below X-rays, the S22 Ultra is shown on the left, and the S22, which similarly infringes, is shown on the right.
<https://www.ifixit.com/News/57567/galaxy-s22-teardowns-apple-is-making-samsung-sweat>

X-ray examination



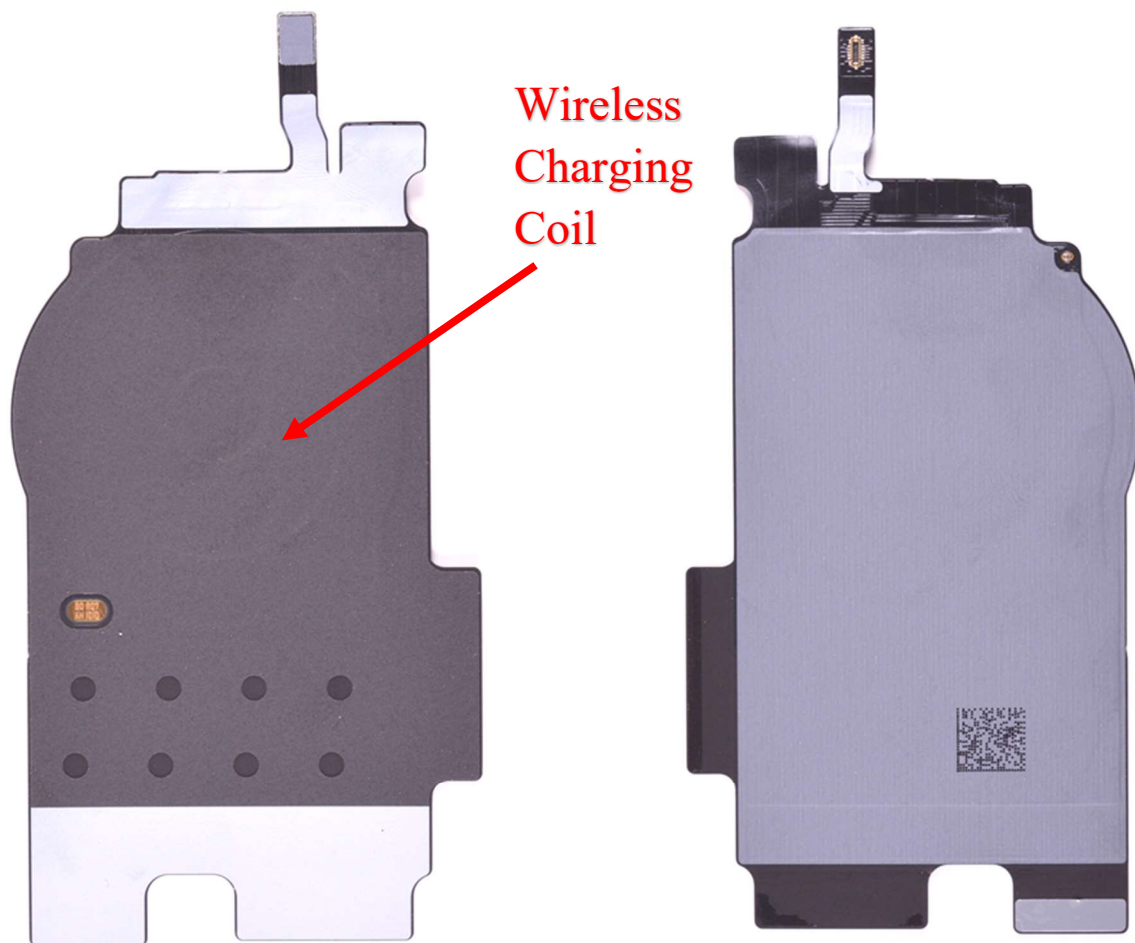
On the left is the Note-succeeding Samsung Galaxy S22 Ultra, with the "vanilla" S22 on the right.

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

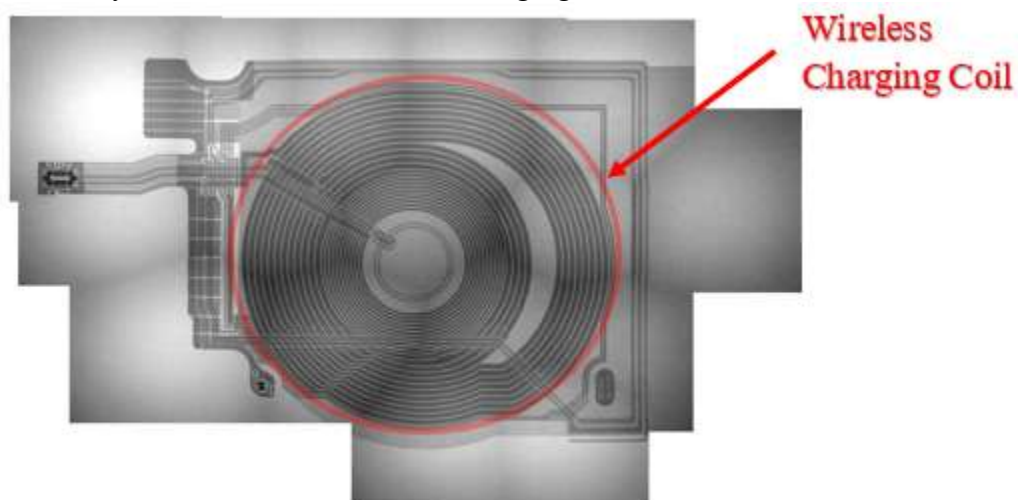


Samsung S22 Ultra – Back cover removed

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



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



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



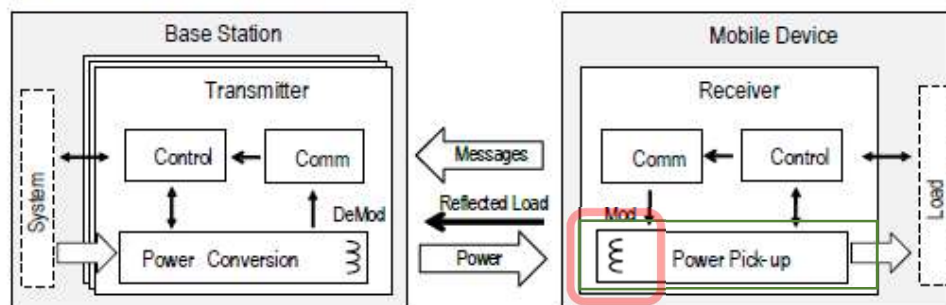
P9415-R Datasheet

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

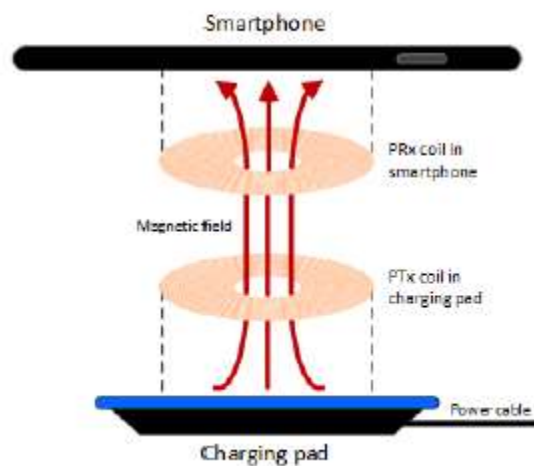


When placed on a WPC compliant transmitter, the S22 Ultra receives an alternating magnetic field substantially perpendicular to the plane of the planar receiver coil that generates a current for inductive power transfer as recited by this part of the claim. *E.g.*, WPC 1.2.4 Standard, Introduction, page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

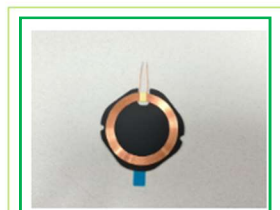
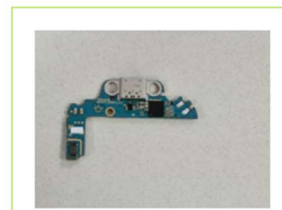
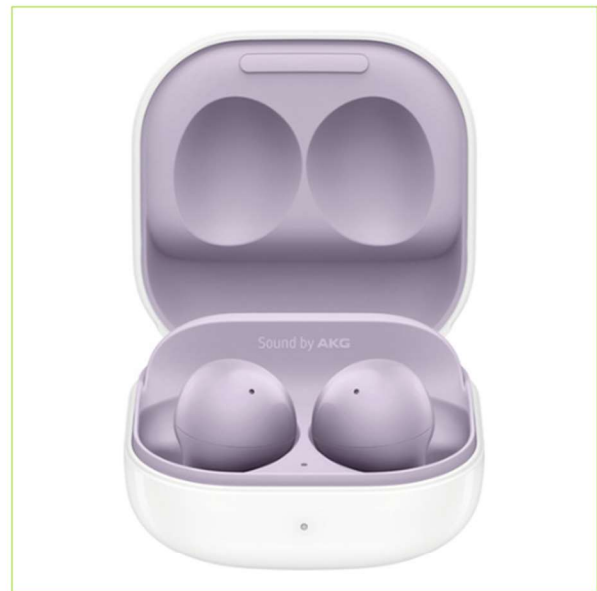
August 19, 2021

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 transmitter, 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

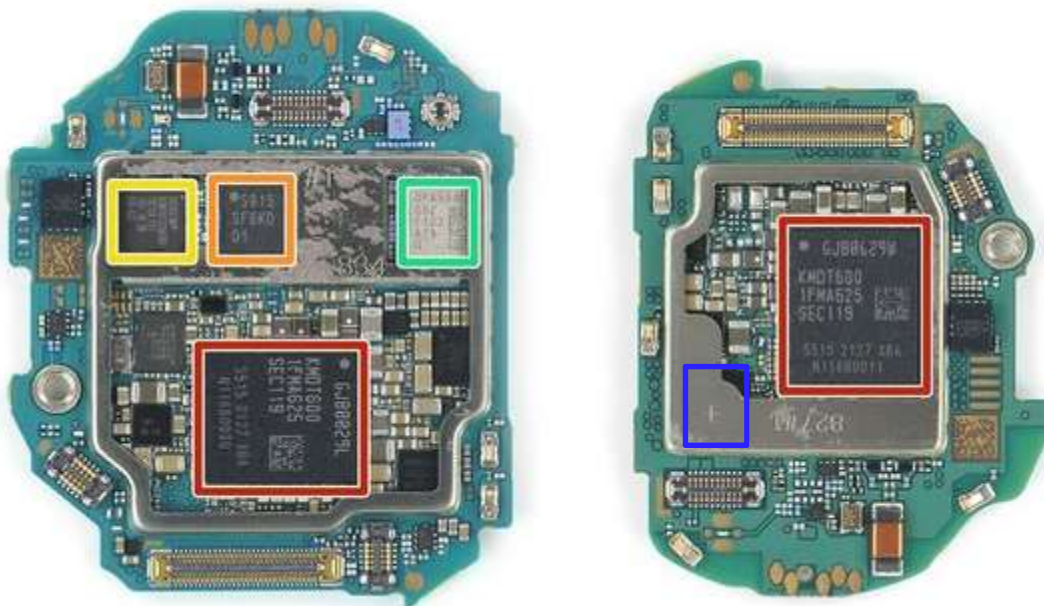
The representative Watch4 includes a planar receiver coil, (the ring shaped photo below) as shown in the listing below.

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



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>



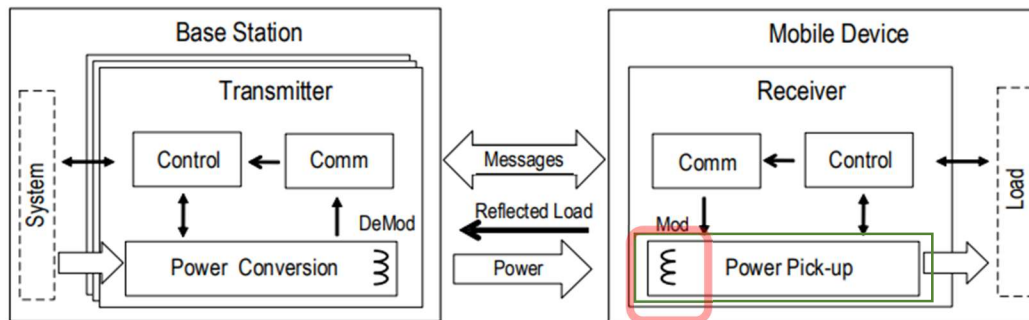
The receiver coil can be seen also in block diagram form in the 9222 datasheet below, which is believed to be representative of the wireless power receiver ASIC included in the Galaxy Watches.
<https://www.renesas.com/us/en/document/dst/p9222-rrn-datasheet>

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 transmitter. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9 (shown above for this claim element with respect to Smartphones).

a ferrite material layer placed behind the receiver coil and opposite to the surface of the portable device to provide shielding in the portable device from electromagnetic fields;

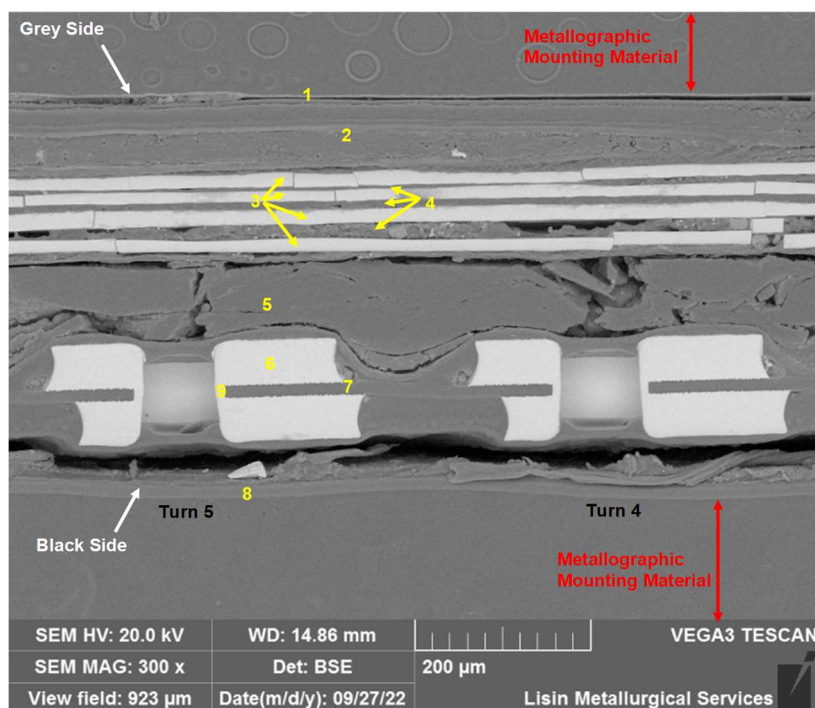
The 500 Claim 23 Accused Products include a ferrite material layer as specified by this part of the claim.

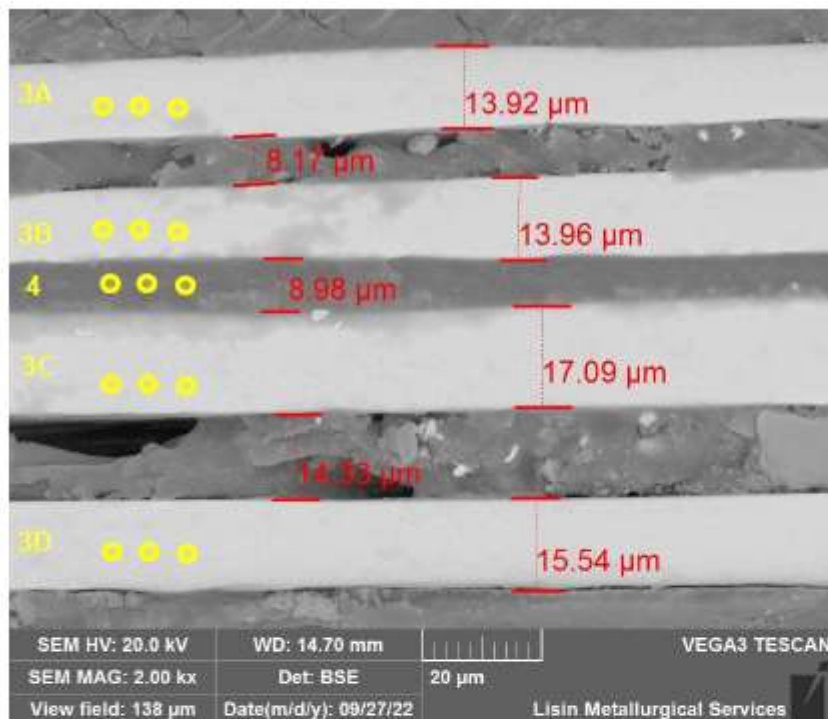
Smartphones

The S22 Ultra includes a ferrite layer, as specified by this part of the claim. In particular, the wireless charging coil assembly includes a ferrite layer behind the receiver coil (gray side; towards the interior of the phone) away from the surface of the device as seen below.



The SEM cross-section image of the receiver coil structure below shows the various layers in this structure. In this image, the Black side at the bottom of the image is close to the (outer) surface of the portable device as described in the claim and the grey side is towards the interior of the phone. Layers shown as 3 are ferrite (Iron / Silicon / Al) layers as shown further below.





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

Earbuds

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



Wearables

On information and belief, similarly to the S22 Ultra and Buds2, the Watch4 receiver coil includes a ferrite layer, as specified by this part of the claim.

a receiver circuit designed to operate near a resonant frequency of a circuit formed by the receiver coil, the receiver circuit, and a compatible base unit primary coil and associated circuit when adjacent to the portable device for inductive powering or charging; wherein the receiver circuit is part of a receiver unit and comprises:

The 500 Claim 23 Accused Products include a receiver circuit as specified by this part of the claim.

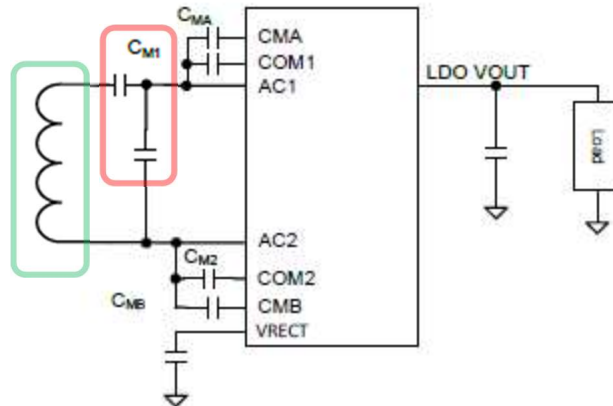
Smartphones

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

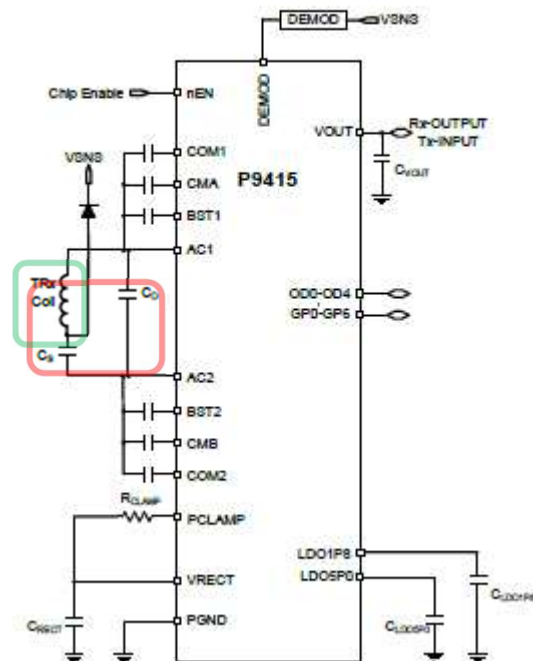
The receiver circuit in the S22 Ultra includes a wireless power transceiver ASIC (e.g., the 9320S ASIC) in combination with external capacitors and other external circuitry, as shown above with respect to claim 1.

The representative 9415 ASIC, receiver coil (green rectangle) and external capacitors (red rectangle below from the IDT 9415-R datasheet) form a receiver circuit as specified by this part of the claim as shown below (from the representative 9320S ASIC datasheet). The receiver circuit is designed to operate near a resonant frequency of a circuit formed by the receiver coil, the receiver circuit, and a compatible base unit primary coil and associated circuit when adjacent to the portable device.

Figure 16. Rx Modulation Components



Typical Applications Schematic

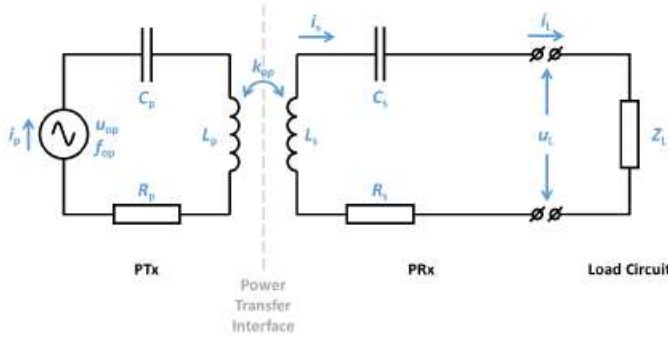


The WPC Standard, as seen below, specifies an operating frequency f_{op} of 100-200 kHz and a receiver resonant frequency f_s of 100 kHz. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 37 and 38. Thus, per the WPC Standard, the 500 Claim 23 Accused Products are designed to operate at frequencies near the resonant frequency of a wireless power transfer circuit formed by the receiver coil, receiver circuit and a compatible primary coil and associated circuit when nearby. The relationship between the receiver coil and the primary coil when nearby is shown by the coupling factor (coupling coefficient) k_{op} between the coils in the section below.

Whereas a Power Transmitter can hold its Primary Coil current to a sufficiently low level, placing a hard limit on the Primary Coil current can prevent a Power Receiver from reaching its target power level when it has connected its load. A better solution is to define more than one limit according to the amount of power that is transmitted: the Power Transmitter should use a low current limit if the Transmitted Power is low to prevent an over-voltage from occurring in the Power Receiver, and it should use a high current limit if the Transmitted Power is high to enable the Power Receiver to reach its target Operating Point without creating an over-voltage in the Power Receiver. The system model and analysis below explain this approach in more detail.

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

Figure 10. Simplified system model



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

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

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

Table 7. Parameters of the simplified model

Power Transmitter			Power Receiver		
L_p	25	μH	L_s	35	μH
f_p	100	kHz	f_s	100	kHz
Q_p	100		Q_s	40	
u_{op}	2...24	V (pk)	u_L	12	V (rms)
f_{osc}	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

The coupling coefficient (k_{op} above) between the receiver coil and primary coil is described below
E.g., WPC 1.2.4 Standard, Parts 1 and 2, Introduction, page 9 and page 12.



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.

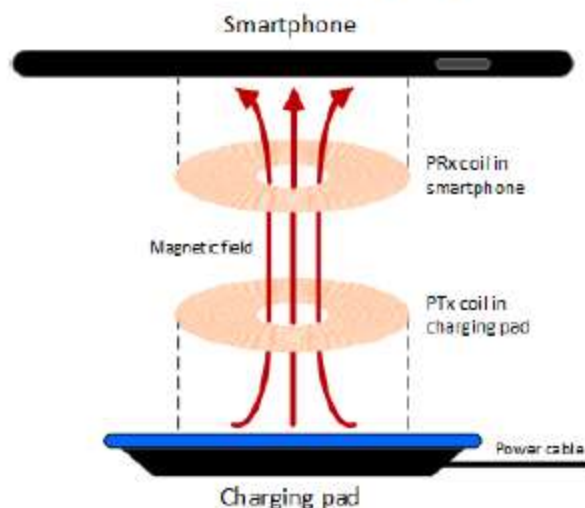
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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



4.4 Coupling requirements

Coupling occurs when current changes in one coil creates a voltage in the other coil via magnetic induction.

Coupling is highest—with the most efficient power transfer—when:

- the PTx and PRx use exactly the same coil
- the PTx and PRx are perfectly aligned
- the distance between the coils is small (less than the diameter of the coils)
- the coils are externally shielded by ferrite

Conditions that decrease coupling (and power transfer efficiency) include different power transmitter/power receiver coil sizes and shapes, coil misalignment, excessive distance between coils, and the presence of foreign objects on the power transmitter.

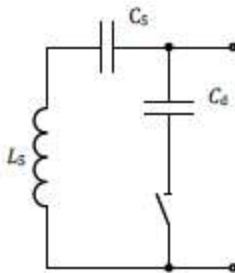
Furthermore, in the description of the resonant circuit of the receiver below (E.g., WPC 1.2.4 Standard, Parts 1 and 2, Power Interface, pages 26-27) the receiver is designed to operate near a resonant frequency of a circuit formed by the receiver coil, the receiver circuit, and a compatible base unit primary coil and associated circuit when adjacent to the portable device.

3.1.1 Dual resonant circuit

The dual resonant circuit of the Power Receiver comprises the Secondary Coil and two resonant capacitances. The purpose of the first resonant capacitance C_s is to enhance the power transfer efficiency. The purpose of the second resonant capacitance C_d is to enable a resonant detection method.

Figure 6 illustrates the dual resonant circuit. The switch in the dual resonant circuit is optional. If the switch is not present, the capacitance C_d shall have a fixed connection to the Secondary Coil L_s . If the switch is present, it shall remain closed² until the Power Receiver transmits its first Packet (see Section 5.1.3.1).

Figure 6. Dual resonant circuit of a Power Receiver



The dual resonant circuit shall have the following resonant frequencies:

$$f_s = \frac{1}{2\pi \cdot \sqrt{L'_s \cdot C_s}} = 100^{+x}_{-y} \text{ kHz},$$

$$f_d = \frac{1}{2\pi \cdot \sqrt{L_s \cdot \left(\frac{1}{C_s} + \frac{1}{C_d}\right)^{-1}}} = 1000^{\pm 10\%} \text{ kHz}.$$

In these equations, L'_s is the self-inductance of the Secondary Coil when placed on the Interface Surface of a Power Transmitter and—if necessary—aligned to the Primary Cell; and L_s is the self-inductance of the Secondary Coil without magnetically active material that is not part of the Power Receiver design close to the Secondary Coil (e.g. away from the Interface Surface of a Power Transmitter). Moreover, the tolerances x and y on the resonant frequency f_s are $x = y = 5\%$ for Power Receivers that specify a Maximum Power value in the Configuration Packet of 3 W and above, and $x = 5\%$ and $y = 10\%$ for all other Power Receivers.

² The switch shall remain closed even if no power is available from the Secondary Coil.



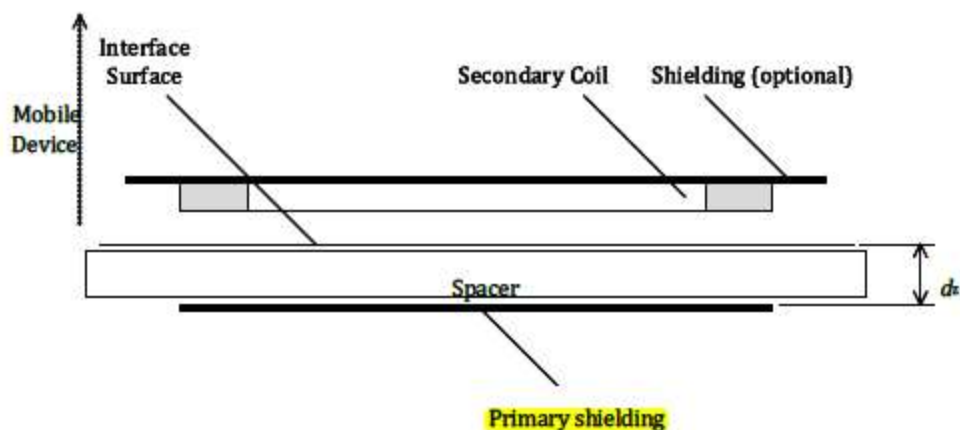
The quality factor Q of the loop consisting of the Secondary Coil, switch (if present), resonant capacitance C_s and resonant capacitance C_d , shall exceed the value 77. Here the quality factor Q is defined as:

$$Q = \frac{2\pi \cdot f_d \cdot L_s}{R}$$

where R is the DC resistance of the loop with the capacitances C_s and C_d short-circuited.

Figure 7 shows the environment that is used to determine the self-inductance L'_s of the Secondary Coil. The primary Shielding shown in Figure 7 consists of material PC44 from TDK Corp. The primary Shielding has a square shape with a side of 50 mm and a thickness of 1 mm. The center of the Secondary Coil and the center of the primary Shielding shall be aligned. The distance from the Receiver Interface Surface to the primary Shielding is $d_s = 3.4$ mm. Shielding on top of the Secondary Coil is present only if the Receiver design includes such Shielding. Other Mobile Device components that influence the inductance of the Secondary Coil shall be present as well when determining the resonant frequencies. The excitation signal that is used to determine L_s and L'_s shall have an amplitude of 1 V RMS and a frequency of 100 kHz.

Figure 7. Characterization of resonant frequencies



Earbuds

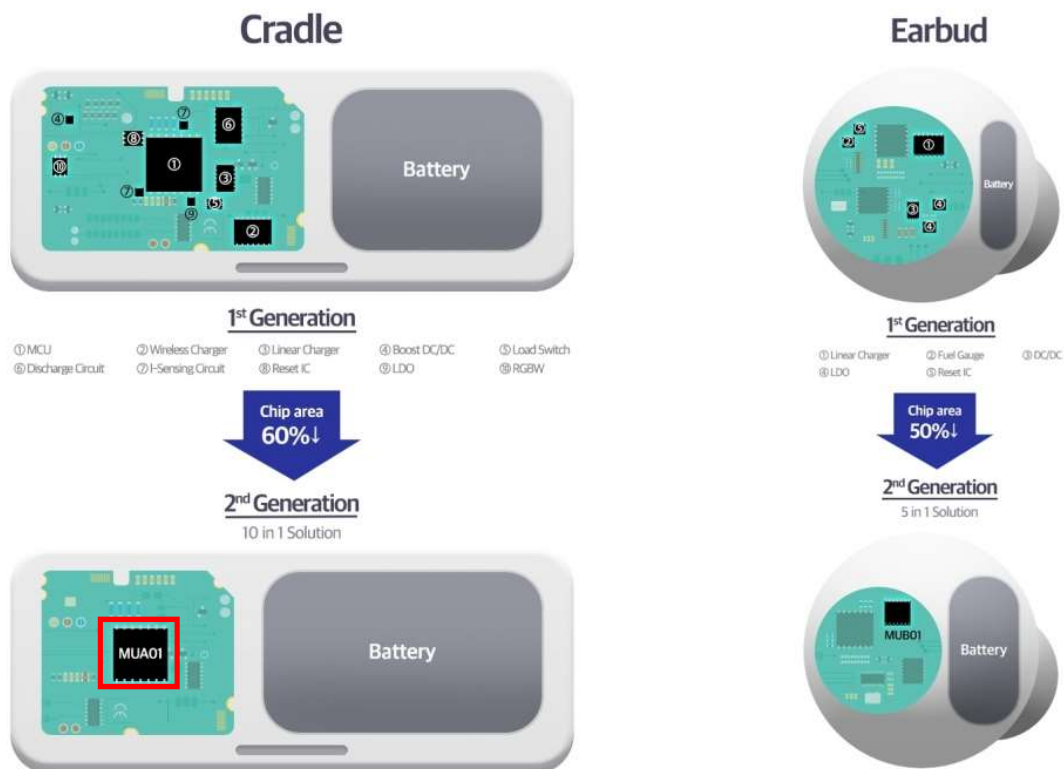
The Buds2 case includes a WPC compatible receiver circuit (as specified by later parts of this claim) that is powered by the inductive charging system. For example, the Buds2 case includes a power management integrated circuit (PMIC) such as the MUA01 that comprises in part a receiver circuit including resonant capacitors that is powered inductively.

<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/>



As another example, the MUA01 is found in the Buds+.

On information and belief, the wireless charging receiver section of the representative MUA01 PMIC included in the Buds2 case with respect to the 500 patent is similar to the representative 9415 ASIC and/or the representative 9222 ASIC shown above and below.

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 designed to operate near a resonant frequency of a circuit formed by the receiver coil, the receiver circuit, and a compatible base unit primary coil and associated circuit when adjacent to the portable device.

Wearables

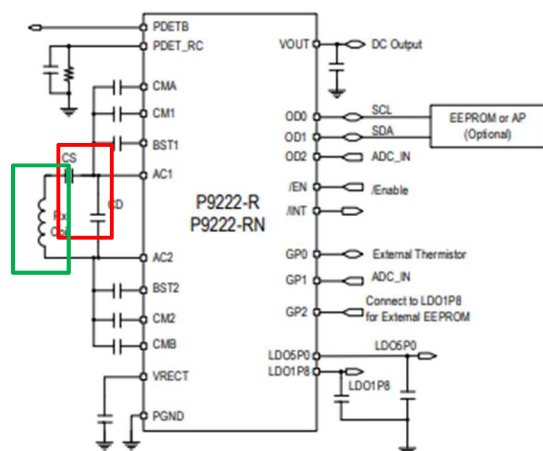
The Watch4 includes a receiver circuit (as specified by this claim) that is powered by the inductive charging system. The 9222 ASIC (or equivalent) included in the Watch4 is powered by the received inductive power from the transmitter. The Watch4 includes a receiver circuit comprising a rectifier and a capacitor (as claimed in the next section), 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-rnn-datasheet>

The receiver circuit as specified by this part of the claim and as shown below (from the representative 9222 ASIC datasheet) comprises the representative 9222 ASIC, receiver coil (green rectangle) and external capacitors (red rectangle). The receiver circuit is designed to operate near a resonant frequency of a circuit formed by the receiver coil, the receiver circuit, and a compatible base unit primary coil and associated circuit when adjacent to the portable device.

Block Diagram

Figure 1. Simplified Block Diagram



WPC Standard

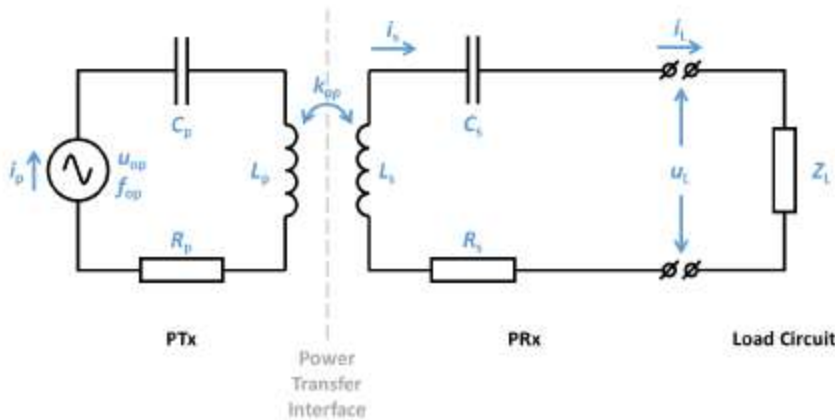
That this part of the claim is met is also indicated by the WPC Standard, as shown below.

A high level model (E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 37-38; see also WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 37-38) of the receiver circuit when the receiver coil is placed in the vicinity of the transmitter coil is shown below identifying the receiver coil and the receiver circuit including the receiver resonant capacitor C_s and the base unit primary coil and associated circuit including the primary resonant capacitor C_p . The relationship between the primary coil and the receiver coil when nearby is shown by the coupling factor (coupling coefficient) k_{op} between the coils in the section below.

Whereas a Power Transmitter can hold its Primary Coil current to a sufficiently low level, placing a hard limit on the Primary Coil current can prevent a Power Receiver from reaching its target power level when it has connected its load. A better solution is to define more than one limit according to the amount of power that is transmitted: the Power Transmitter should use a low current limit if the Transmitted Power is low to prevent an over-voltage from occurring in the Power Receiver, and it should use a high current limit if the Transmitted Power is high to enable the Power Receiver to reach its target Operating Point without creating an over-voltage in the Power Receiver. The system model and analysis below explain this approach in more detail.

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

Figure 10. Simplified system model



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

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

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

Table 7. Parameters of the simplified model

Power Transmitter			Power Receiver		
L_p	25	μH	L_s	35	μH
f_p	100	kHz	f_s	100	kHz
Q_p	100		Q_s	40	
u_{op}	2...24	V (pk)	u_L	12	V (rms)
f_{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

The coupling coefficient (k_{op} above) between the primary coil and receiver coil is described below.
 E.g., WPC 1.2.4 Standard, Introduction, pages 9 and 12.



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.

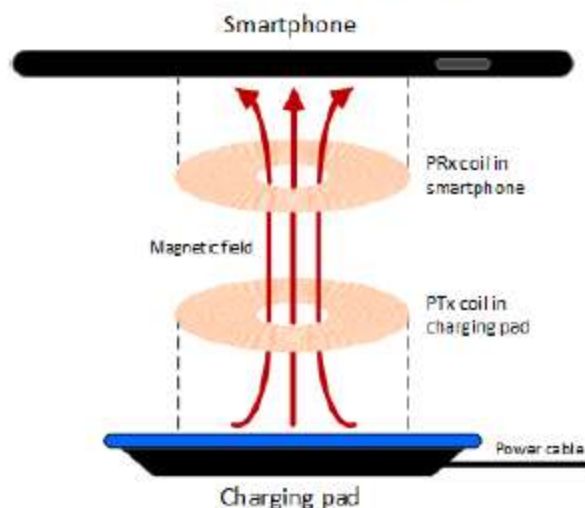
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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



4.4 Coupling requirements

Coupling occurs when current changes in one coil creates a voltage in the other coil via magnetic induction.

Coupling is highest—with the most efficient power transfer—when:

- the PTx and PRx use exactly the same coil
- the PTx and PRx are perfectly aligned
- the distance between the coils is small (less than the diameter of the coils)
- the coils are externally shielded by ferrite

Conditions that decrease coupling (and power transfer efficiency) include different power transmitter/power receiver coil sizes and shapes, coil misalignment, excessive distance between coils, and the presence of foreign objects on the power transmitter.

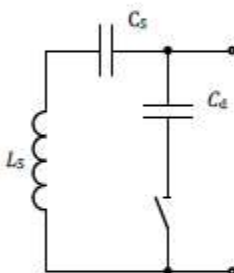
WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 26 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 27) provides more detail about the WPC required receiver circuit and describes the receiver coil and receiver circuit (including the receiver capacitor) to be designed to have a resonance around 100 kHz when the receiver coil is placed on the transmitter coil and aligned with the transmitter coil.

3.1.1 Dual resonant circuit

The dual resonant circuit of the Power Receiver comprises the Secondary Coil and two resonant capacitances. The purpose of the first resonant capacitance C_s is to enhance the power transfer efficiency. The purpose of the second resonant capacitance C_d is to enable a resonant detection method.

Figure 6 illustrates the dual resonant circuit. The switch in the dual resonant circuit is optional. If the switch is not present, the capacitance C_d shall have a fixed connection to the Secondary Coil L_s . If the switch is present, it shall remain closed² until the Power Receiver transmits its first Packet (see Section 5.1.3.1).

Figure 6. Dual resonant circuit of a Power Receiver



The dual resonant circuit shall have the following resonant frequencies:

$$f_s = \frac{1}{2\pi \cdot \sqrt{L'_s \cdot C_s}} = 100^{+x}_{-y} \text{ kHz},$$

$$f_d = \frac{1}{2\pi \cdot \sqrt{L_s \cdot \left(\frac{1}{C_s} + \frac{1}{C_d}\right)^{-1}}} = 1000^{\pm 10\%} \text{ kHz}.$$

In these equations, L'_s is the self-inductance of the Secondary Coil when placed on the Interface Surface of a Power Transmitter and—if necessary—aligned to the Primary Cell; and L_s is the self-inductance of the Secondary Coil without magnetically active material that is not part of the Power Receiver design close to the Secondary Coil (e.g. away from the Interface Surface of a Power Transmitter). Moreover, the tolerances x and y on the resonant frequency f_s are $x = y = 5\%$ for Power Receivers that specify a Maximum Power value in the Configuration Packet of 3 W and above, and $x = 5\%$ and $y = 10\%$ for all other Power Receivers.



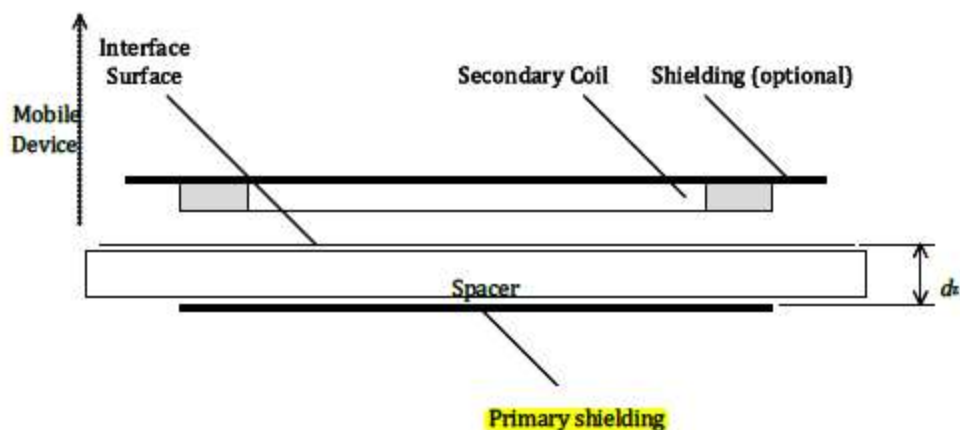
The quality factor Q of the loop consisting of the Secondary Coil, switch (if present), resonant capacitance C_s and resonant capacitance C_d , shall exceed the value 77. Here the quality factor Q is defined as:

$$Q = \frac{2\pi \cdot f_d \cdot L_s}{R}$$

where R is the DC resistance of the loop with the capacitances C_s and C_d short-circuited.

Figure 7 shows the environment that is used to determine the self-inductance L'_s of the Secondary Coil. The primary Shielding shown in Figure 7 consists of material PC44 from TDK Corp. The primary Shielding has a square shape with a side of 50 mm and a thickness of 1 mm. The center of the Secondary Coil and the center of the primary Shielding shall be aligned. The distance from the Receiver Interface Surface to the primary Shielding is $d_s = 3.4$ mm. Shielding on top of the Secondary Coil is present only if the Receiver design includes such Shielding. Other Mobile Device components that influence the inductance of the Secondary Coil shall be present as well when determining the resonant frequencies. The excitation signal that is used to determine L_s and L'_s shall have an amplitude of 1 V RMS and a frequency of 100 kHz.

Figure 7. Characterization of resonant frequencies



This resonant frequency is near the range used during WPC inductive power transfer (WPC 1.2.4 Standard, Parts 1 and 2, Power Interface, page 38; *see also* WPC 1.2.3 Standard, Parts 1 and 2, Power Interface, pages 38). WPC systems typically operate in the range 100-200 kHz near the resonant frequency.

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_{ping}	24	V (pk)	Z_L	0.1...1000	Ω
f_{ping}	175	kHz	Z_{ping}	800	Ω

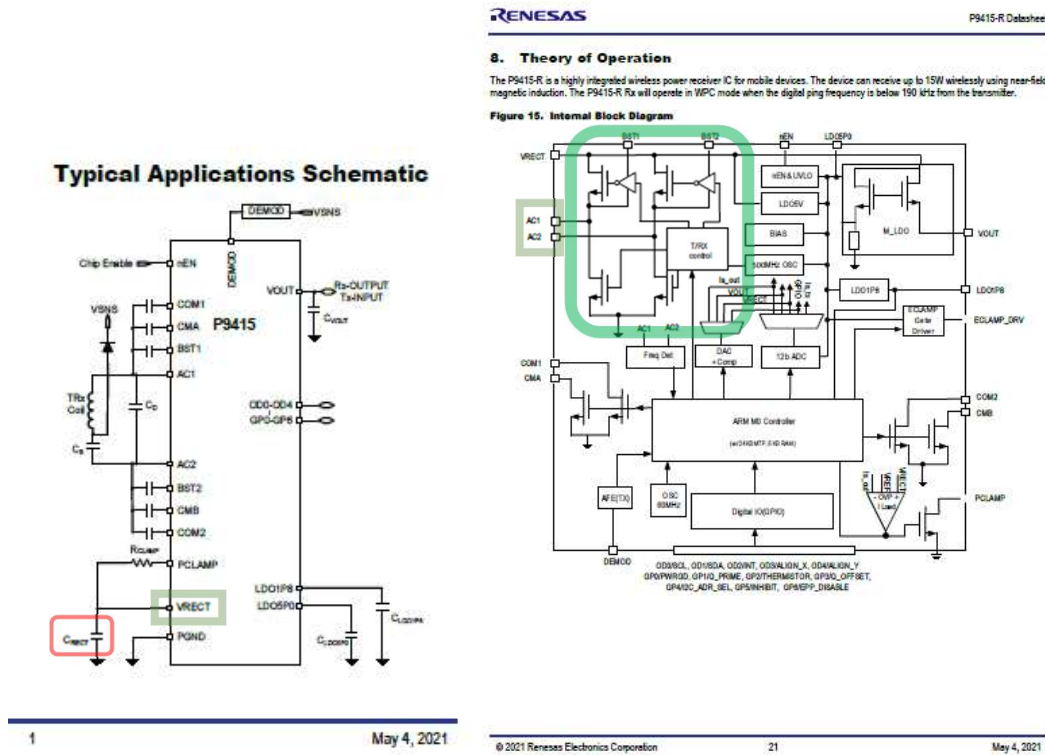
a receiver rectifier circuit including one or more rectifiers and one or more capacitors; and

The 500 Claim 23 Accused Products include a receiver rectifier circuit as specified by this part of the claim.

Smartphones

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

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



8.3 Rx Mode Functions

8.3.1 Synchronous Rectifier

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

9.4 Input Capacitor (VRECT Capacitors)

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

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

SAMSUNG ELECTRONICS GALAXY S22 ULTRA (SM-S908U)

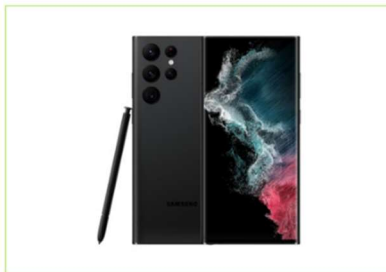
BRAND
 Samsung Electronics

PRODUCT NAME
 Galaxy S22 Ultra

MANUFACTURER PART NUMBER
 SM-S908U

PRODUCT TYPE
 Power Class 0 Receiver

REGISTRATION DATE
 February 9, 2022



ADDITIONAL DETAILS

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

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

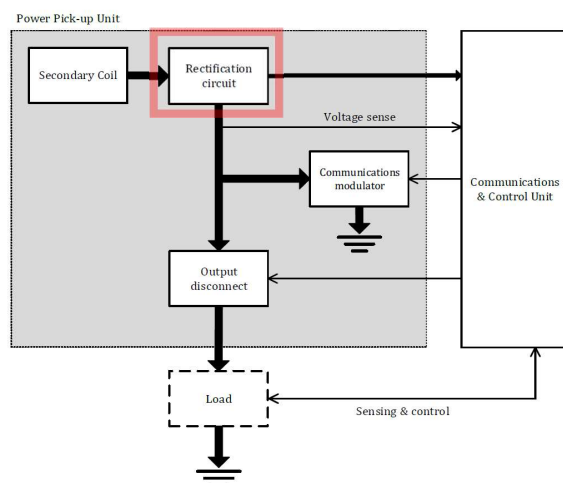


3 Power interface

3.1 Power Receiver design requirements (PRx)

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

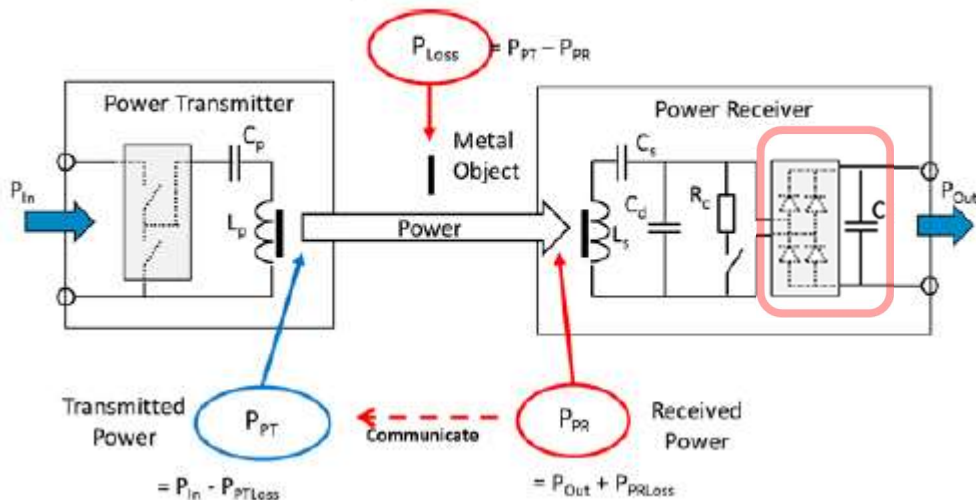
Figure 4. Functional block diagram for a Baseline Power Profile Power Receiver



- 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 (green rectangle) and an accompanying external capacitor (red rectangle), as shown below.

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



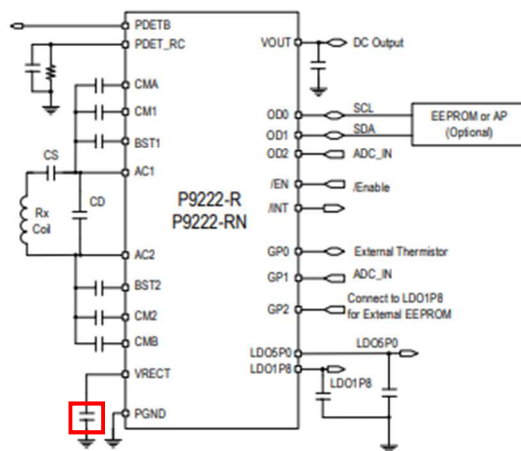
Wireless Power Receiver for Low Power Applications

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.

Block Diagram

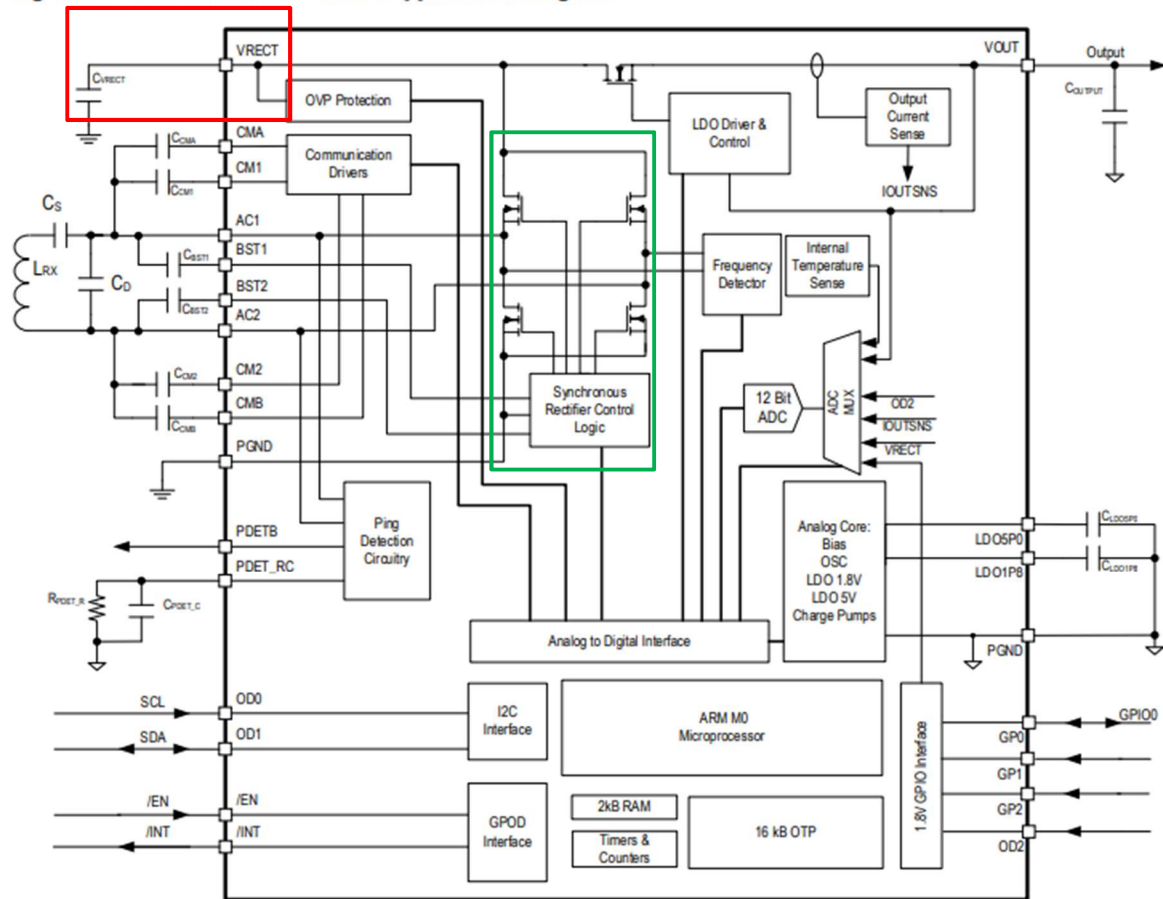
Figure 1. Simplified Block Diagram



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

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



5.1.2 Rx Operation

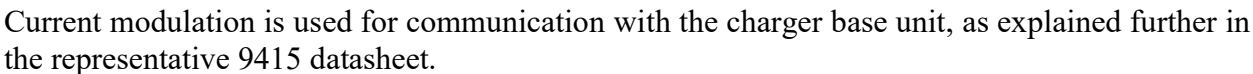
The wireless power is stored on a capacitor(s) connected to the VRECT pin in Rx mode. Until the voltage across the VRECT capacitor exceeds the under-voltage lock-out (UVLO) threshold, the rectification is performed by the body diodes of the synchronous full bridge rectifier FETs. After the internal biasing 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.

Smartphones

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

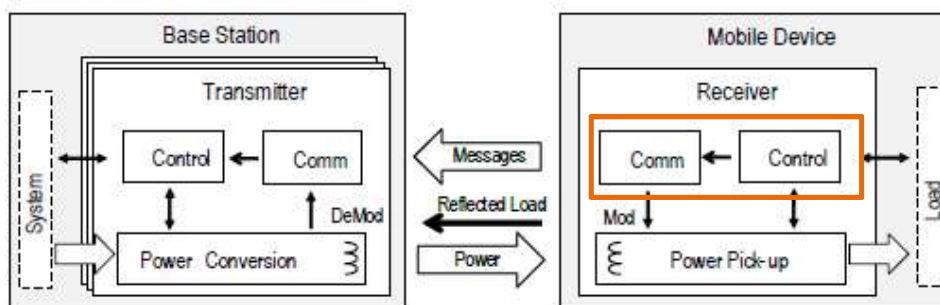


6. Wireless Power Charging System

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.

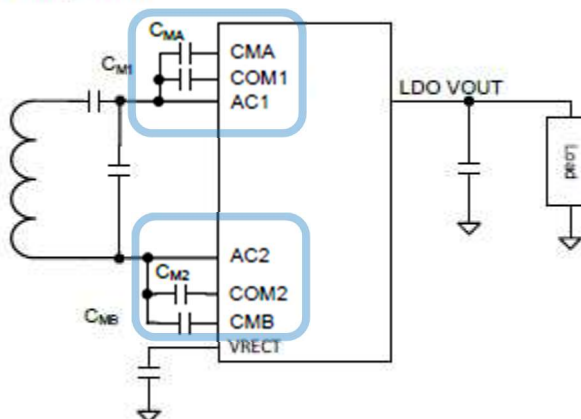
Figure 2. Block Diagram of WPC System



8.2.5 WPC Modulation/Communication

The P9415-R operates in WPC using a single LC tank Rx coil and requires AC modulation capacitor connections for WPC communication. The LC tank also should be tuned to achieve maximum efficiency (C_{MA} , C_{MB} , C_{M1} , C_{M2} connected to pins CMA, CMB, COM1, COM2) in order to accomplish WPC modulation.

Figure 16. Rx Modulation Components



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

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

Furthermore, the current modulation used by the S22 Ultra for communication with the transmitter 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.

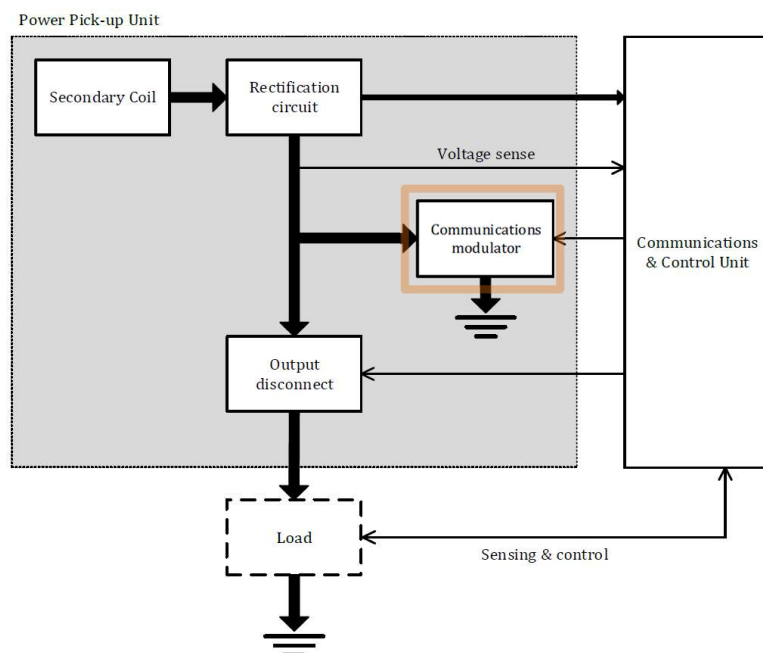
Furthermore, the communication and control circuit is a required component in the WPC Standard and is powered inductively per the WPC Standard. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 23-24 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 24-25).

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 Buds2 case includes a wireless power ASIC (such as the MUA01) that is WPC certified and has 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 rectangle). The four FETs are located in the Communications Drive (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

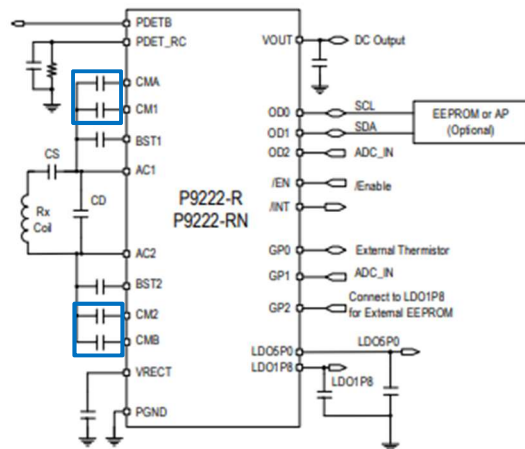
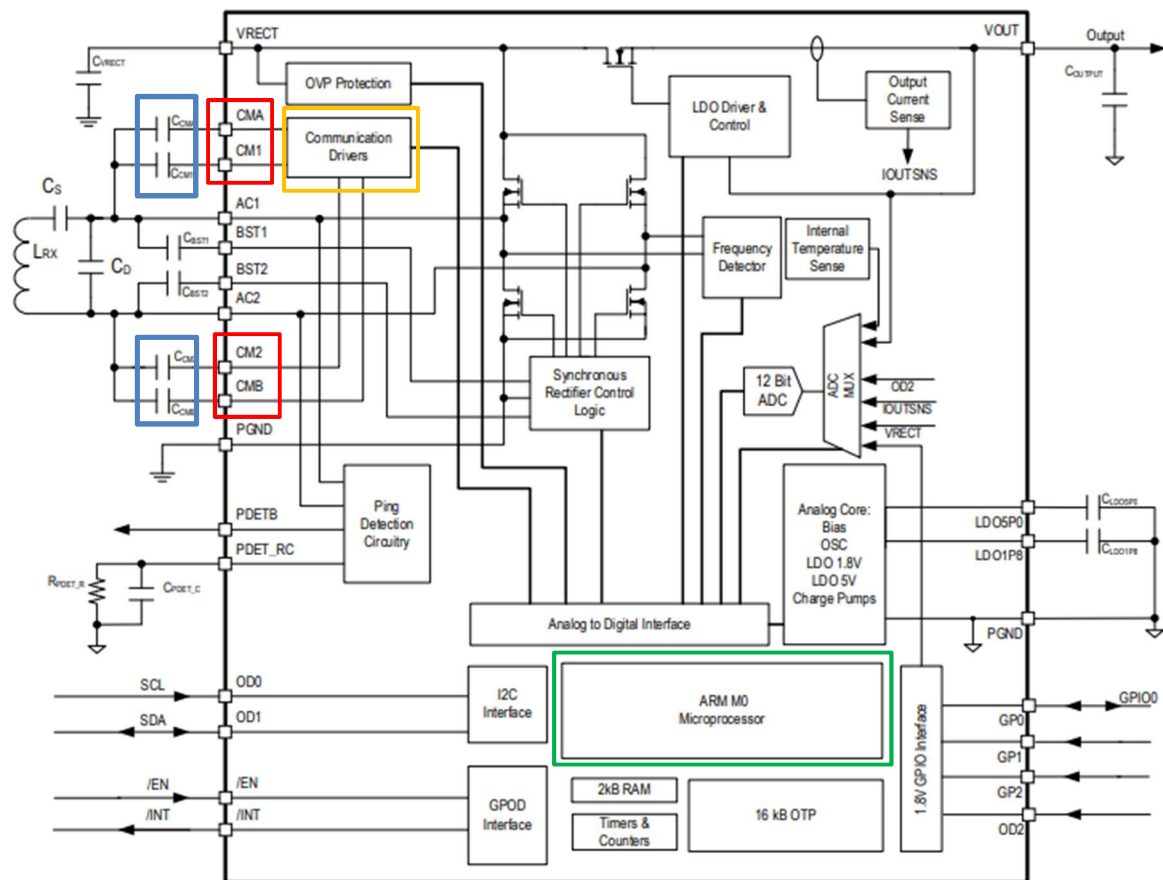


Figure 2. P9222-R/RN Block and Application Diagram

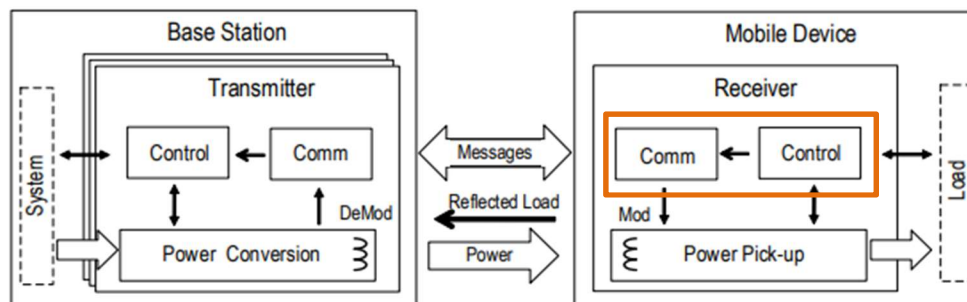


3. Description of the Wireless Power Charging System

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



Receiver-to-transmitter communication is accomplished by modulating the load applied to the receiver, i.e., amplitude-shift keying (ASK). To the transmitter, this appears as an impedance change, which results in measurable variations of the transmitter's output waveform. Modulation is done with AC modulation, using internal switches to connect external capacitors from AC1 and AC2 to ground.

The P9222-R/RN communicates with the base station by sending ASK communication packets to WPC transmitters. Each communication packet has the following structure:

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.

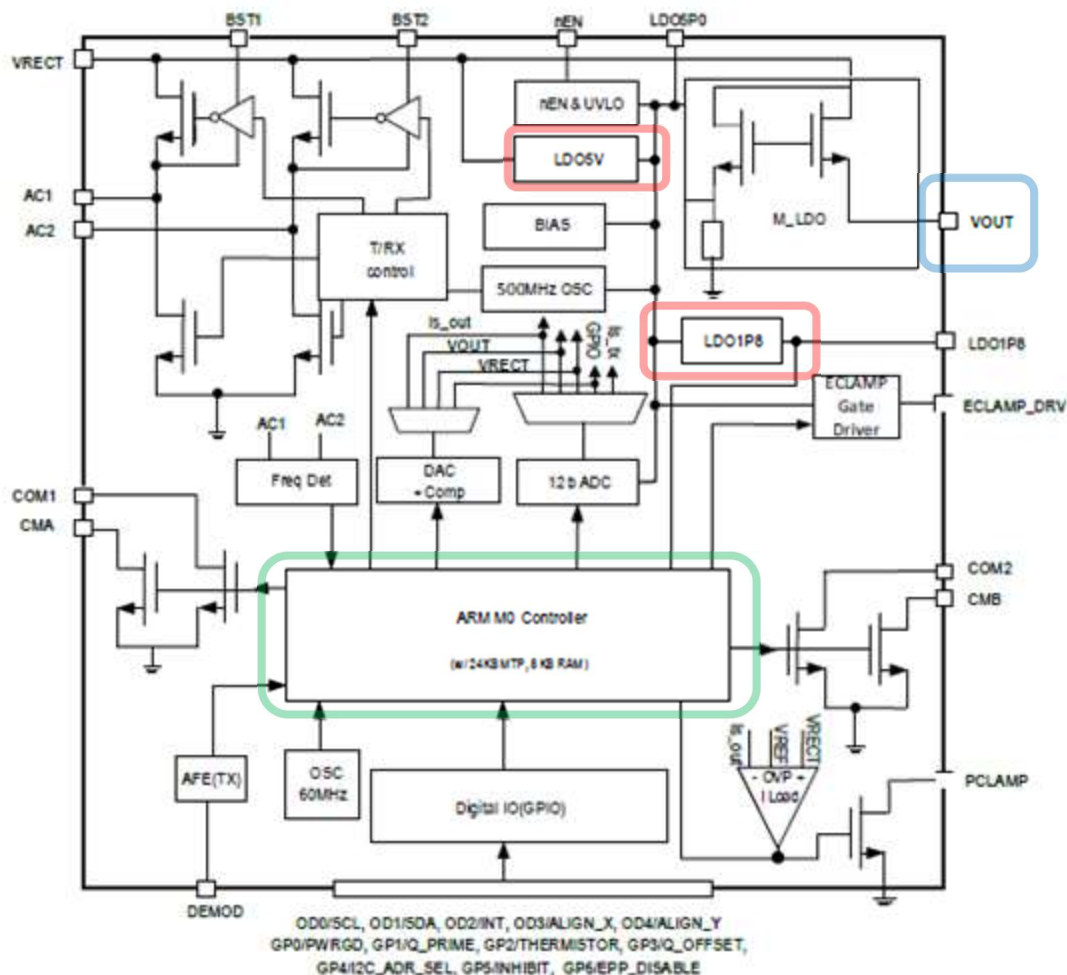
wherein when a current is generated in the receiver coil inductively by the primary coil in the base unit, the current is rectified by the one or more rectifiers and smoothed by the one or more capacitors in the receiver rectifier circuit and is used to power and activate the receiver communication and control circuit and to power or charge the portable device; and

The 500 Claim 23 Accused Products are configured to operate as specified by this part of the claim when receiving wireless power.

Smartphones

In the S22 Ultra, the rectified and smoothed inductive power from the base unit during wireless charging powers the voltage regulator (such as LDO5V and LDO1P8 shown in the red rectangles below in the representative 9415 ASIC) powering the 9415 ASIC microcontroller (green rectangle below) and the rest of the ASIC circuitry through the LDO5V and LDO1P8 in the 9415 ASIC and power or charge the portable device through the Vout pin (blue rectangle) as claimed.

Figure 15. Internal Block Diagram



The Buds2 case comprises a MUA01 ASIC which includes a voltage regulator to power its internal microcontroller, similar to the voltage regulator(s) included in the representative 9415 ASIC of the S22 Ultra (above) and/or the representative 9222 ASIC of the Watch4 (below). On information and belief, in the Buds2 case, inductive power from the base unit during wireless charging powers the voltage regulator (similar to the LDO5V and LDO1P8 in the representative 9415 ASIC above) powering the MUA01 ASIC microcontroller and powers or charges the Earbud case.

Wearables

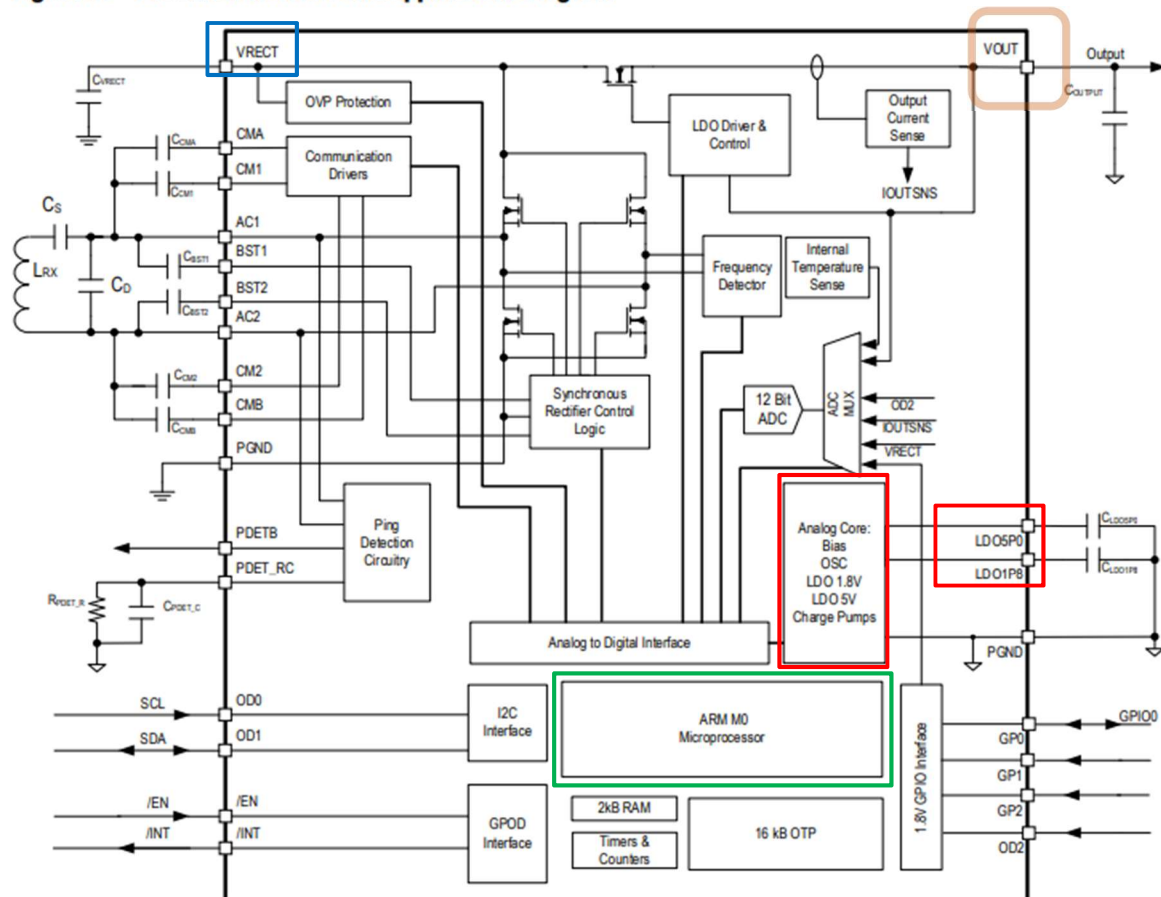
In the Watch4, inductive power from the base unit during wireless charging powers the voltage regulator (such as the Low Drop Out (LDO) regulators, LDO 5V and LDO 1.8V (red rectangles)) powering the 9222 ASIC microcontroller and powers or charges the portable device through its Vout pin (brown rectangle).

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

RENESAS

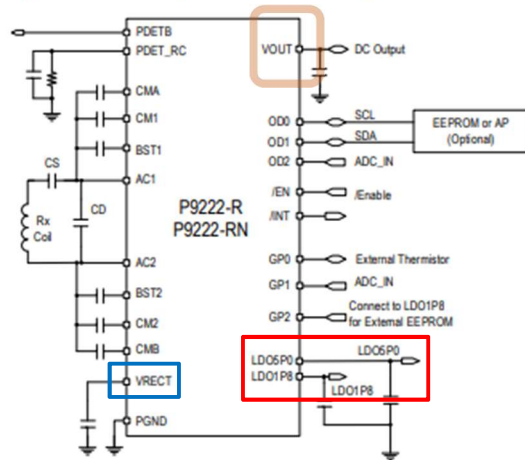
P9222-R/RN Datasheet

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



Block Diagram

Figure 1. Simplified Block Diagram



WPC Standard

Following the WPC Standard, the 500 Claim 23 Accused Products inductively power the wireless charging receiver in the portable 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).



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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

wherein upon powering and activation of the receiver circuit by a primary coil in the base unit, the receiver circuit: communicates information corresponding to a voltage at an output of the receiver rectifier circuit and information associated with the portable device and/or receiver unit to enable the base unit to identify the portable device and/or receiver unit, to determine any appropriate charging or powering algorithm therefor, and to identify one or more primary coils of the base unit most aligned with the receiver coil for use in charging or powering the portable device; and subsequently, periodically communicates information corresponding to an output voltage or current of the receiver rectifier circuit to the base unit 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 or powering of the portable device.

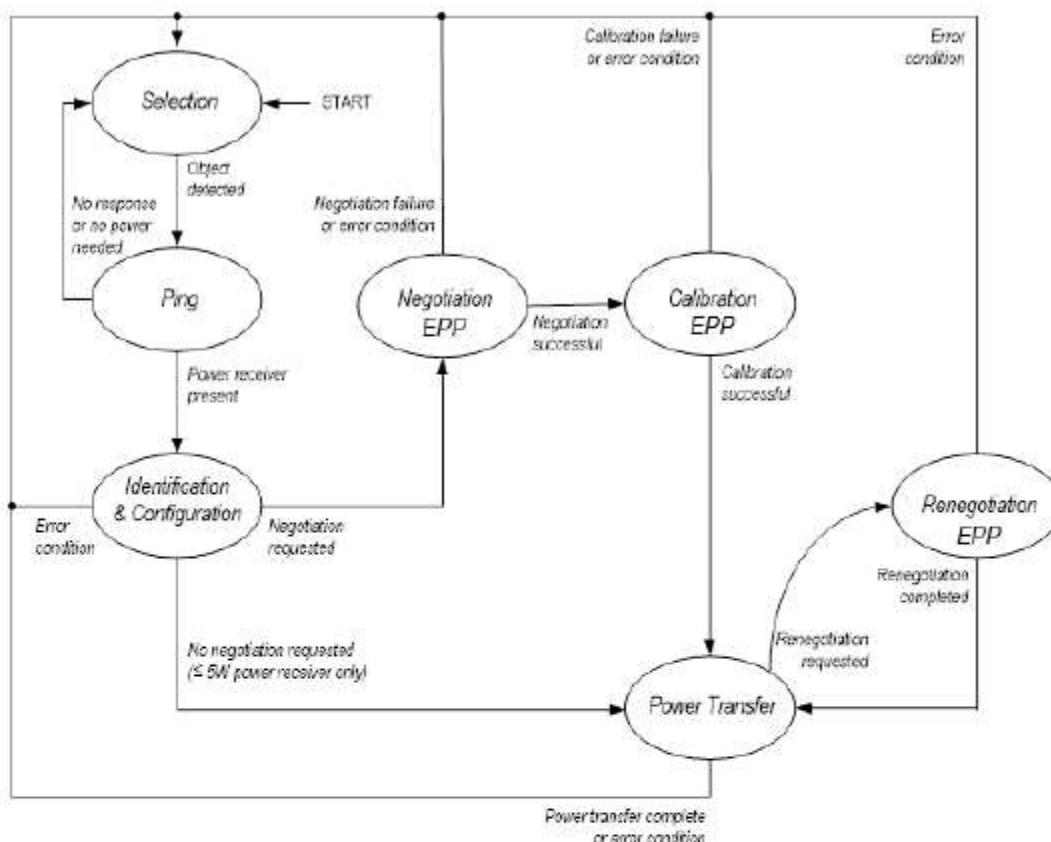
The 500 Claim 23 Accused Products are configured to operate as specified by this part of the claim when receiving wireless power.

Smartphones

In the S22 Ultra, after its receiver circuit is activated by inductive power, the S22 Ultra proceeds to communicate with the transmitter 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 the ASIC follows the WPC Standard phases in Extended Power Profile (EPP) at > 5 W power received or Baseline Power Profile (BPP) at < 5 W and begins communicating with the charger during the ping and later Identification and Configuration phase as per. As shown below, EPP includes the Negotiation, Calibration and Renegotiation phases while BPP does not. After the Identification and Configuration phase (in BPP) or a Negotiation phase (in EPP if requested), the receiver and charger enter the Power Transfer phase to charge or power the portable device as per this part of the claim.

Figure 20. WPC System Feedback Control



The P9415-R goes through six phases: Selection, Ping, Identification & Configuration, Negotiation, Calibration, and Power Transfer.

8.2.8 Selection

In this phase, the P9415-R senses or delivers the wireless power and proceeds to the Ping state. It monitors the rectified voltage or DEMOD signal, and when the voltage is above the V_{UVLO_rising} threshold, the P9415-R prepares to communicate with the base station or enter power Ping mode.

8.2.9 Ping

In this phase, the P9415-R transmits a Signal Strength Packet as the first communication packet to instruct the base to keep the power signal ON (or the P9415-R detects a Signal Strength Packet). After sending/receiving the Signal Strength Packet, the P9415-R proceeds to the Identification and Configuration phase. If, instead, an End of Power Packet is sent or an invalid response is sent, then it remains in the Ping phase.

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

- Signal Strength Packet
- End of Power Packet

8.2.10 Identification and Configuration (ID and Config)

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

- Identification Packet
- Configuration Packet

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

8.2.13 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

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).

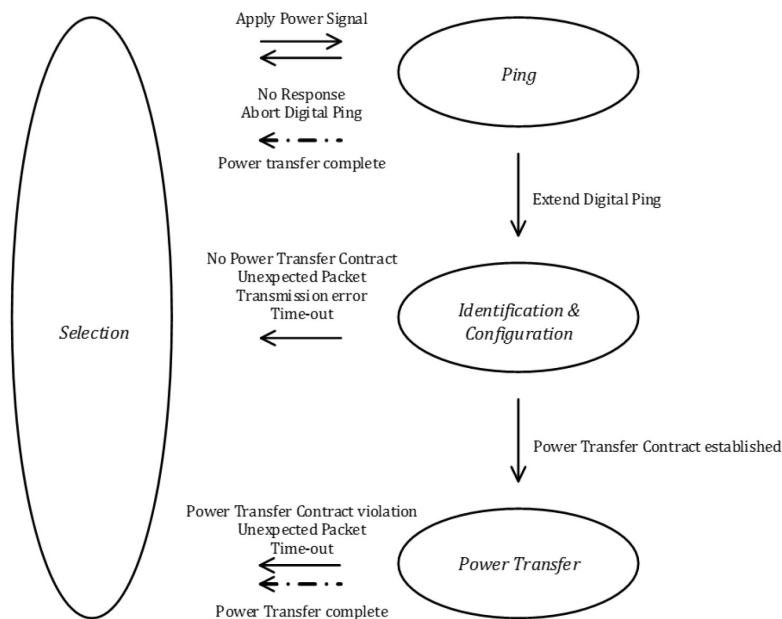
5.2 Power Receiver to Power Transmitter communications interface

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.

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.

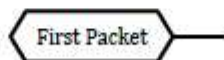
Initially, the receiver circuit in the S22 Ultra receives inductive power from the base unit (ping) for a period of time sufficiently long and of sufficient power to wake up the receiver circuit and so that the receiver circuit can communicate with the base unit. The receiver circuit upon being activated, 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:

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

Following the Identification and Configuration phase, the receiver enters the Power Transfer phase. This phase is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 82 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 49).



5.1.3.6 Power transfer phase (PRx perspective)

In the *power transfer* phase, the Power Receiver controls the power transfer from the Power Transmitter, by means of control data that it transmits to the latter. For this purpose, the Power Receiver shall transmit zero or more of the following Packets:

- Control Error Packet. The Power Receiver shall set the Control Error Value to zero if the actual Control Point is equal to the desired Control Point. The Power Receiver shall set the Control Error Value to a negative value to request a decrease of the Primary Cell current. The Power Receiver shall set the Control Error Value to a positive value to request an increase of the Primary Cell current. See Sections 5.1.1, *Overview (informative)*, and 5.1.2.6.1, *Power transfer control*.
- Received Power Packet.
- Charge Status Packet.
- End Power Transfer Packet.
- Any Proprietary Packet (as listed in Table 26).

Furthermore, and in accordance with the WPC Standard, the 500 Claim 1 Accused Products during the Power Transfer phase operate as follows as specified by this section of the claim. *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).



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

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

Dependent Claims (off claim 23)

24. The portable device of claim 23, wherein the communication and control circuit communicates information including one or more codes identifying the manufacturer of the portable device, a unique portable device and/or receiver unit ID, a charge algorithm profile, and a power requirement of the portable device and/or receiver unit.

Mojo Mobility Inc. v. Samsung Elecs. Co. Ltd., et al., No. 2:22-cv-00398 (E.D. Tex)
 Ex. 3 to Feb. 28, 2023 PR 3-1 Contentions: Infringement of U.S. Patent 11,201,500 by Samsung
 The 500 Claim 23 Accused Products are each configured to operate as specified by this part of the claim, as illustrated below.

WPC Standard

The communication transmitted by a receiver 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).



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 Power Class 0 Specification

Version 1.2.4

Information interface

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) <div>Manufacturer Code</div> (LSB)							
B ₂								
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 transmitted by the receiver 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:

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

25. The portable device of claim 23, further wherein the receiver circuit can additionally receive communication from the base unit via the receiver coil inductively from the primary coil for bi-directional communication.

The 500 Accused Smartphones and the 500 Accused Wearables with fast charging capability (e.g., the Watch5) additionally infringe this dependent claim, as each can additionally receive communication from the base unit via the receiver coil inductively from the primary coil for bi-directional communication. See claim 9 above for additional evidence related to the bi-directional communication.

Smartphones

For example, the S22 Ultra can additionally receive higher power levels using Samsung Wireless Fast Charge mode from Samsung chargers, such as the Samsung 5200 Duo or 5400 Duo at 10W+ using the Samsung Wireless Fast Charge / Samsung Proprietary Power Delivery extension (PPDE) which is based on the WPC Extended Power Profile (EPP) specification.

[https://developer.samsung.com/mobile/wireless-fast-charge.html#:~:text=Samsung%20Wireless%20Fast%20Charge%2C%20a,Power%20Profile%20\(EPP\)%20specification](https://developer.samsung.com/mobile/wireless-fast-charge.html#:~:text=Samsung%20Wireless%20Fast%20Charge%2C%20a,Power%20Profile%20(EPP)%20specification)



On This Page

- o 1. Introduction to Samsung Proprietary Power Delivery Extension
- o 2. Purpose
- o 3. Conformance requirement
- o FAQ

Samsung Wireless Fast-Charge Guide

↓ Samsung Wireless Fast-Charge Guide v1.0.2

1. Introduction to Samsung Proprietary Power Delivery Extension

Samsung Proprietary Power Delivery Extension (PPDE) is the technology that enables Samsung mobile devices to be fast-charged with the wireless fast charger. Samsung Wireless Fast Charge is a brand of Samsung PPDE technology.

This specification document covers the minimum requirement of Samsung PPDE technology embodiment. It is also a technical standard document of Samsung Electronics. The specification defines the protocol such as proprietary packets, work flow and sequence. THE USE OF THIS SPECIFICATION DOES NOT ALLOW DEVELOPERS TO USE SAMSUNG'S LOGO NOR THE BRAND NAME. SAMSUNG WILL NOT BE RESPONSIBLE FOR ANY AND ALL CLAIMS AND/OR DAMAGES ARISING FROM OR RELATED TO THE DEVELOPER'S WIRELESS PRODUCT.

2. Purpose

Samsung has been a pioneer and an advocate of the wireless charging technology by implementing it in smartphones since 2015. Samsung smartphones are certified by the Wireless Power Consortium (WPC), compliant to WPC Basic Power Profile (BPP) specification of 5W. Samsung smartphones are also compliant to Power Matter Alliance (PMA) standard specification. **Samsung Wireless Fast Charge, a proprietary extension to WPC BPP specification has enhanced the wireless power delivery higher than 5W to Samsung smartphones for the sake of user's benefit, which is not compatible with generic WPC Extended Power Profile (EPP) specification.** Samsung is enthusiastic to help any 3rd-party developers to use this document, in order to establish the safe and reliable eco-system of Samsung Wireless Fast Charge. From this document, 3rd party developers can learn to design their wireless charger products to fast-charge Samsung smartphones.

3. Conformance requirement

Any manufacturers deploying Samsung PPDE technology are obligated to attain the WPC (Wireless Power Consortium) certification of their wireless charger products including Samsung PPDE compliance test at designated ATLs (Authorized Test Labs).

Information about WPC PPDE compliance test is available at : <https://members.wirelesspowerconsortium.com/members/members-info/swg/proprietary-mode-safety-tests.html> [Login Required]

WPC EPP uses bi-directional communication between the charger and receiver including frequency shift keying (FSK) communication received by the receiver from the base unit for a verification process to ensure that a receiver unit that can be charged or powered by the system is present and to determine the voltage or power requirements of the receiver unit as per this claim.

E.g., WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 13 (see also WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 106).



4.5 PTx and PRx communication protocol

To set up power transfer and assist in its control, a power transmitter and power receiver execute a communication protocol with each other. The power receiver uses amplitude shift keying to communicate requests and other information to the power transmitter by modulating its reflected impedance. The power transmitter uses frequency shift keying (FSK) to provide synchronization and other information to the power receiver by modulating its operating frequency.

Wearables

The Watch5 also includes a receiver circuit that can additionally receive communication from the base unit via the receiver coil inductively from the primary coil for bi-directional communication as required by this claim. See claim 9 above for additional evidence related to the bi-directional communication.

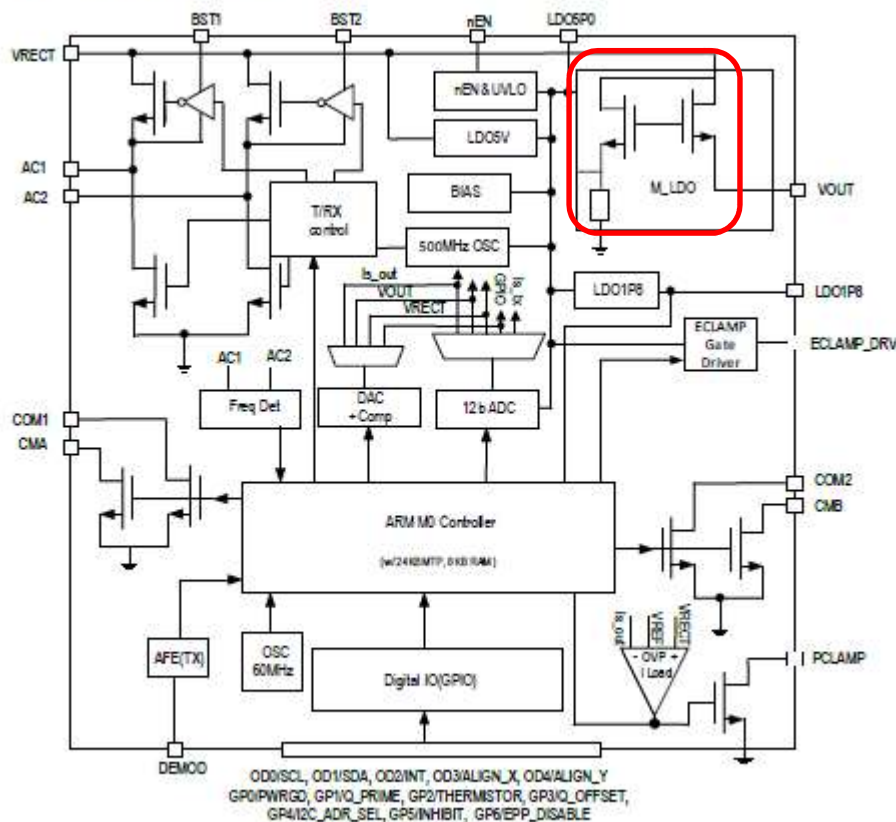
26. The portable device of claim 23, further including an output disconnect switch under the control of the receiver communication and control circuit to disconnect the battery from the receiver rectifier circuit output.

The 500 Claim 23 Accused Products additionally infringe this dependent claim, as each include an output disconnect switch that is structured and operates as specified by this claim, as illustrated below for the representative products.

Smartphones

In the S22 Ultra with the representative 9415 ASIC, during the “Power Transfer” phase, after initial ping and Identification and Configuration phase communications, 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 of the 9415 ASIC datasheet) under the control of the communication and control circuit (including the microcontroller) is enabled as described per this claim.

Figure 15. Internal Block Diagram



8.2.1 Startup

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

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

8.2.2 Power Transfer

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

8.2.4 Status/Interrupt Output

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

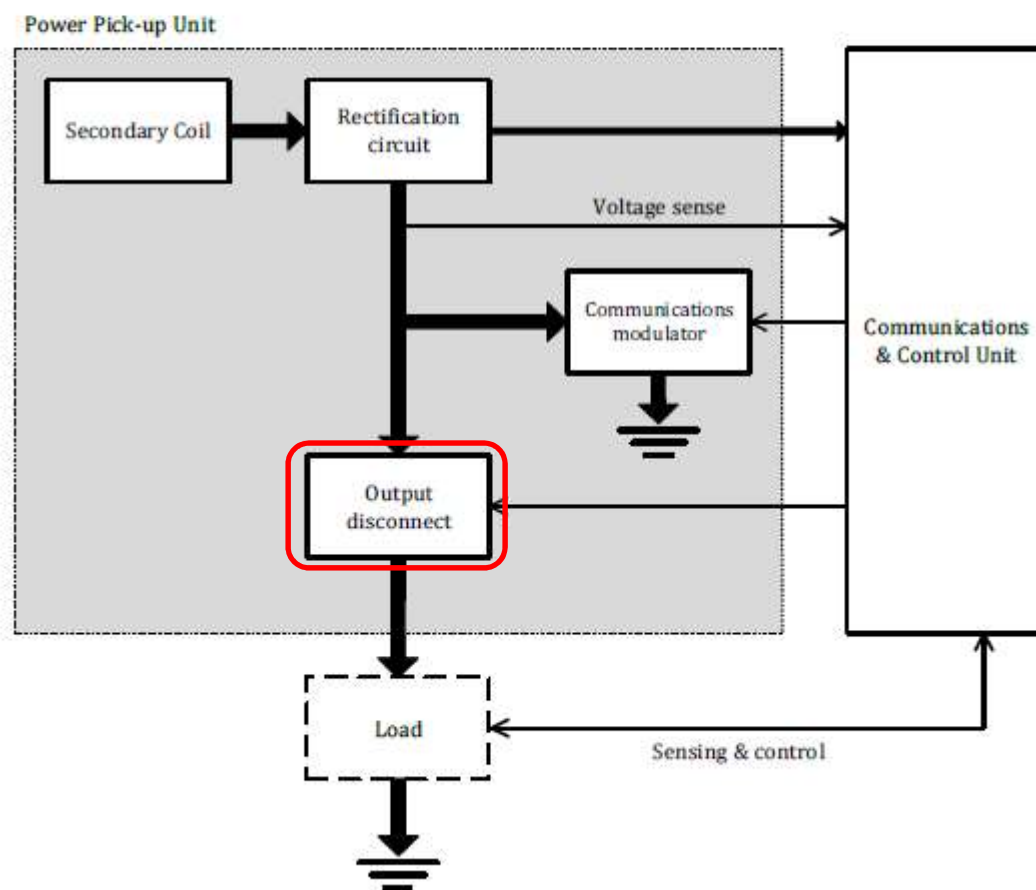
Furthermore, the Output Disconnect Switch (red rectangle) is required in the WPC Standard. (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 23-24, 28.)

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 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.

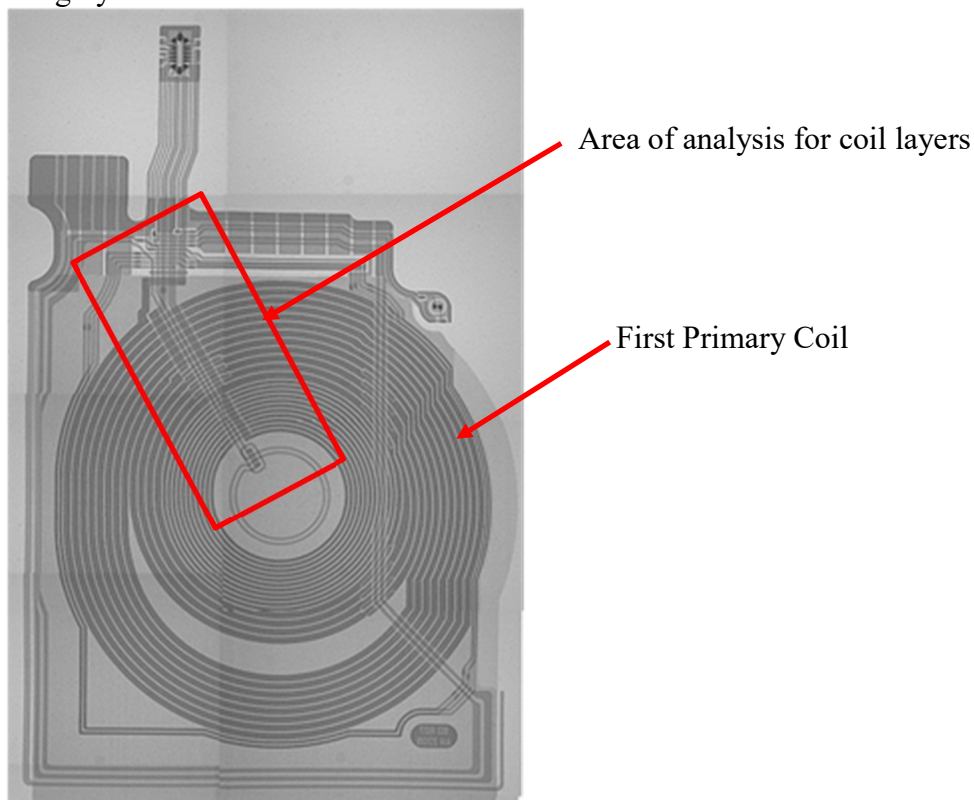
5.12 MLDO Output Enable Conditions

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.

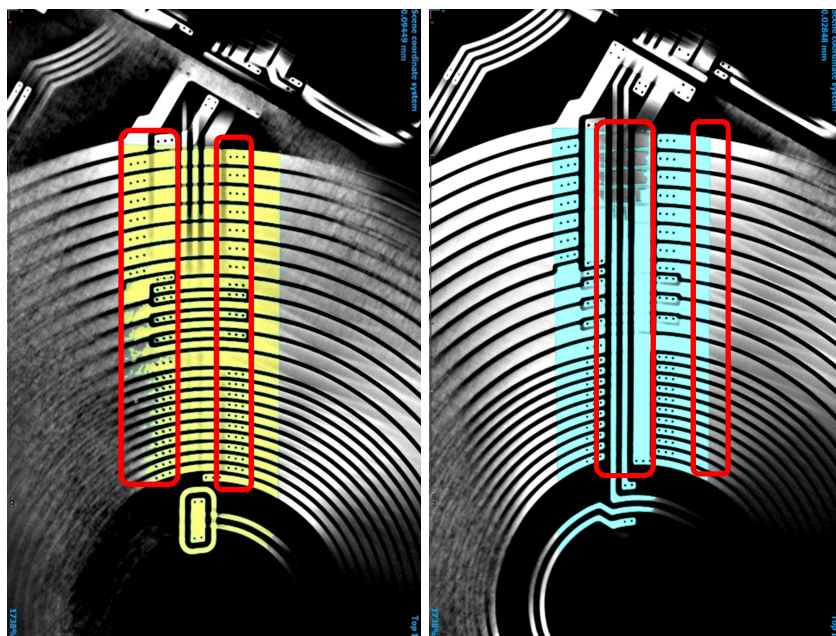
27. The portable device of claim 23, wherein the receiver coil is constructed of a Printed Circuit Board comprising multiple layers connected by vias and a layer of ferrite material.

The 500 Accused Smartphones include a receiver coil constructed of a Printed Circuit Board comprising multiple layers connected by vias and a layer of ferrite material.

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



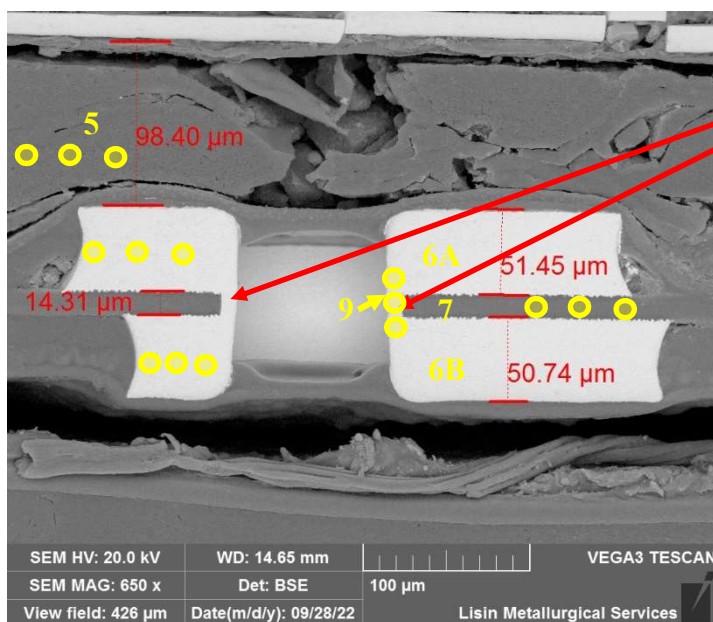
The two images below with 3D x-ray imagery distinguish between the two coil layers present. The images show the substantially similar spiral-shaped coil patterns in each layer. The vias connecting the two layers (black dots) are shown in the 2 below images in the red rectangles.



Coil Layer 1

Coil Layer 2

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



copper via connecting the layers

Normalized mass concentration [%]

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

Normalized mass concentration [%]

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

Normalized mass concentration [%]

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

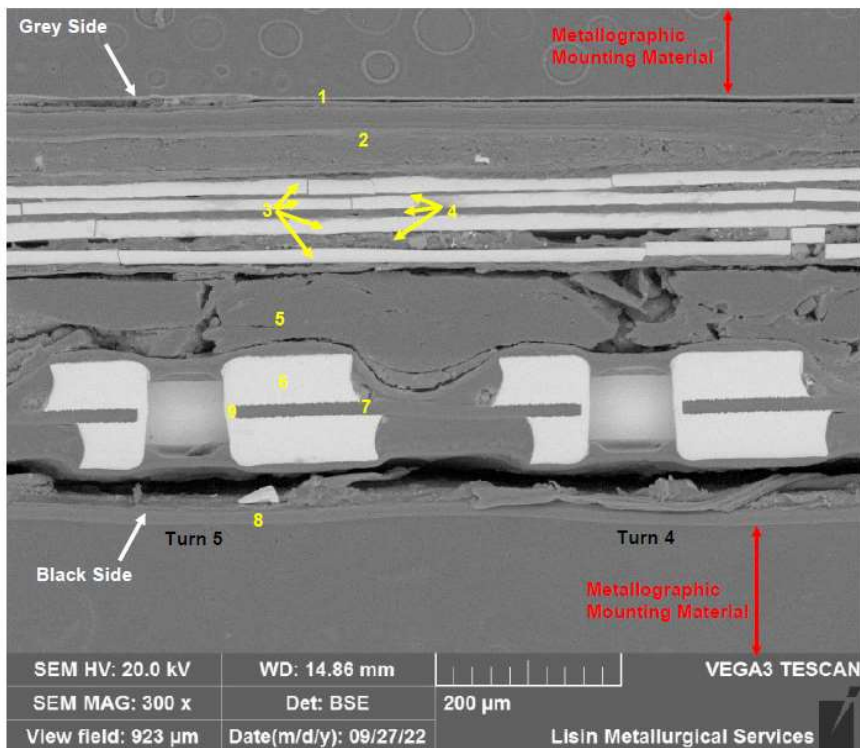
Normalized mass concentration [%]

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

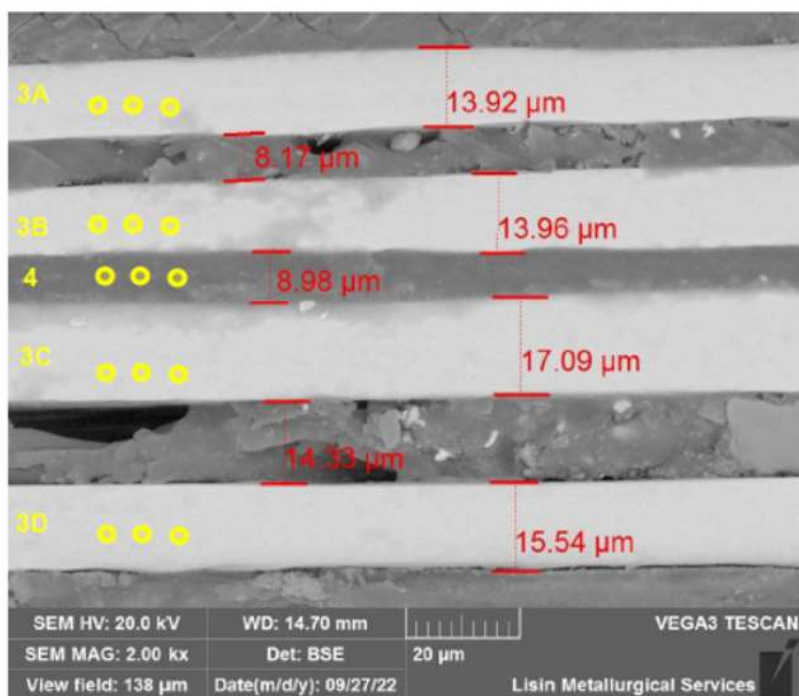
Normalized mass concentration [%]

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

Furthermore, the layers shown as layers 3 (towards the interior of the smartphone compared to the copper layers shown above) were analyzed.



These layers 3 were found to contain ~91% iron, ~ 7% silicon and some aluminum consistent with a ferrite layer material.



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

28. The portable device of claim 23, wherein the receiver circuit communicates an end of charge message to terminate power transfer from the base unit upon the battery reaching a desired charged state.

The 500 Claim 23 Accused Products send a charge message also known as the End Power Transfer Packet as shown in the WPC standard to terminate power transfer upon the battery of the portable device reading a desired charged state as required by this claim. (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 83. *See also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 80.)



Moreover, if the Power Receiver has transmitted an End Power Transfer Packet, the Power Receiver shall remain in the *power transfer* phase until the Power Transmitter removes the Power Signal. Furthermore, the Power Receiver should transmit additional End Power Transfer Packets if the Power Transmitter does not remove the Power Signal.⁷ For battery-charging applications, it is recommended that the Power Receiver sends an End Power Transfer Packet containing an End Power Transfer Code 0x01 on detecting that the battery is fully charged.

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.

29. The portable device of claim 23, wherein the receiver circuit further comprises a regulator or charge management circuit, coupled to the output of the receiver rectifier circuit, that regulates or controls an output voltage or output current provided to the battery, to ensure proper charging of the battery.

The 500 Claim 23 Accused Products include a receiver circuit further comprising a regulator or charge management circuit, coupled to the output of the receiver rectifier circuit, that regulates or controls an output voltage or output current provided to the battery, to ensure proper charging of the battery.

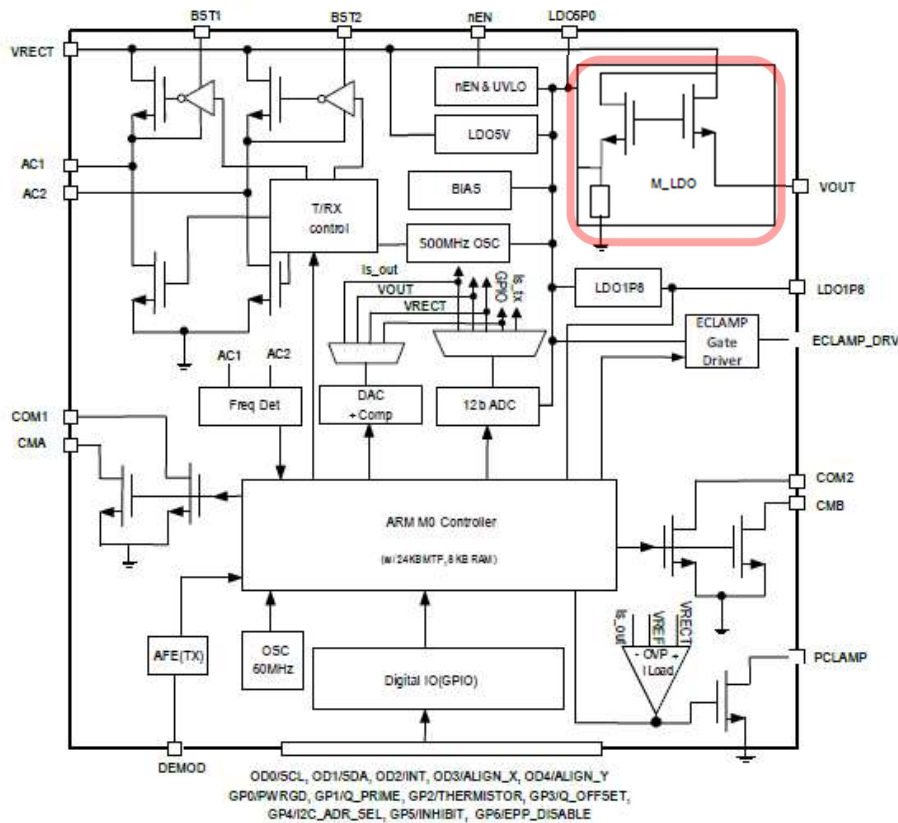
Smartphones

The S22 Ultra includes a voltage regulator as specified by this part of the claim. The 9415 ASIC includes an MLDO (red rectangle) coupled to the output of the receiver rectifier circuit that controls the output voltage of the P9415 to the battery of the portable device. The MLDO is a Low Drop Out (LDO) regulator.

8. Theory of Operation

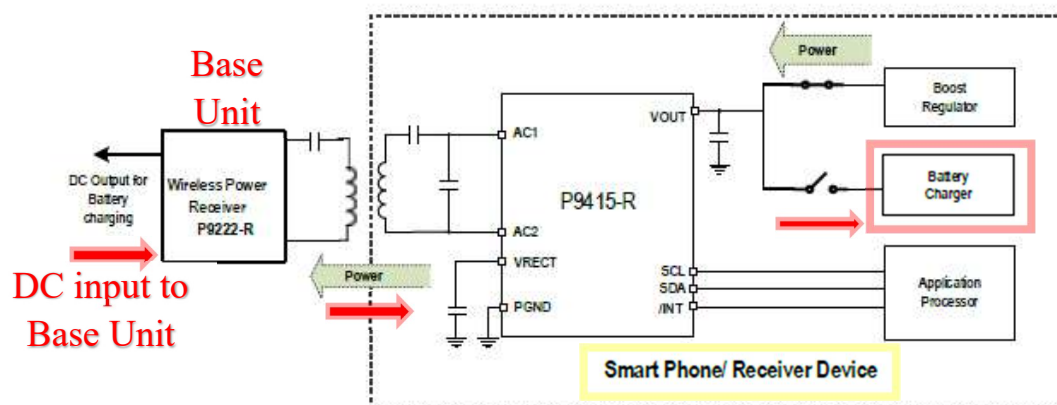
The P9415-R is a highly integrated wireless power receiver IC for mobile devices. The device can receive up to 15W wirelessly using near-field magnetic induction. The P9415-R Rx will operate in WPC mode when the digital ping frequency is below 190 kHz from the transmitter.

Figure 15. Internal Block Diagram



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

Figure 21. Enabling WattShare™ (TRx) Mode



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

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



Figure 1. Samsung Galaxy S22 board shot

On information and belief, such an external Battery Charger regulates or controls an output voltage or current to charge the battery, as specified by this part of the claim. As an example of such a battery charger, see datasheet for a similar NXP battery charger below:

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

7 A 2:1, 1:2, and 1:1 mode switched capacitor direct charger

Short data sheet

1 General description

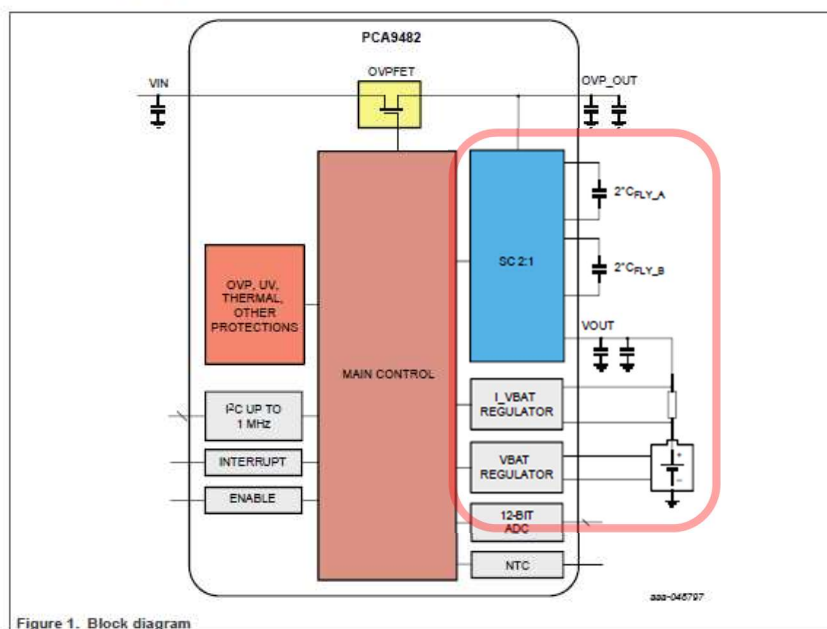
The PCA9482UK is a highly-integrated switched-capacitor converter with an embedded OVPFET, targeted to provide two times the output current for fast charging applications with a 1-cell battery. The device works in 2:1 switching operation with very high efficiency (>96.5 %, at $V_{OUT} = 4\text{ V}$,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

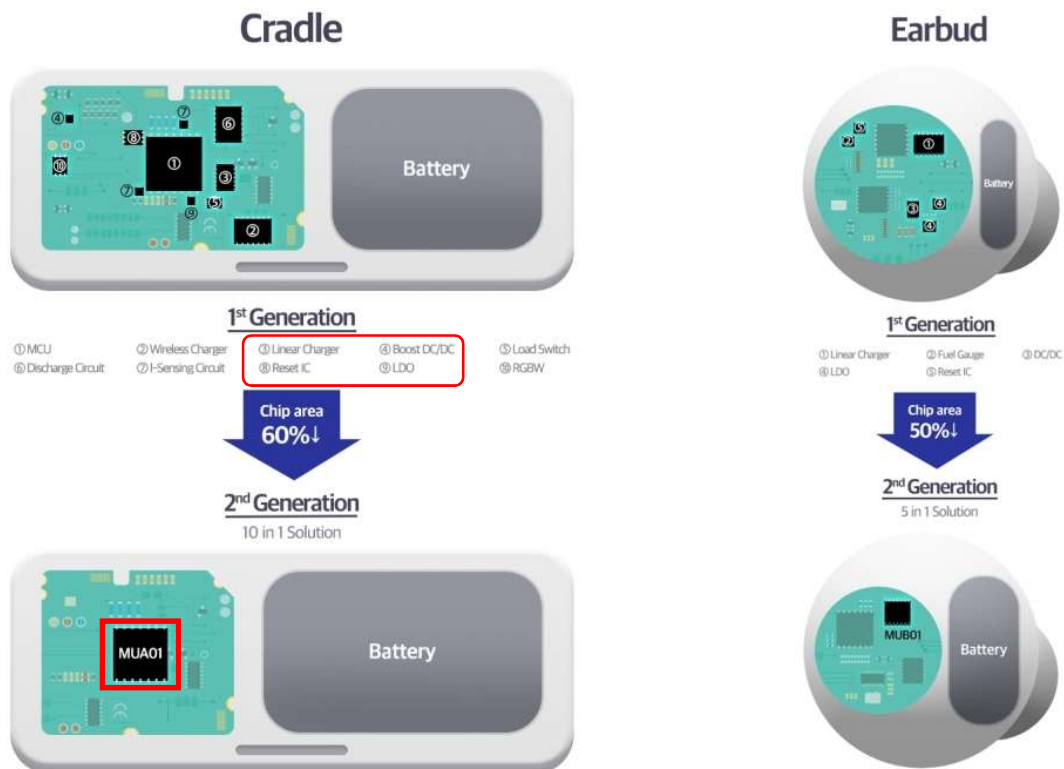
The device features all the functions with I²C-bus interface, with up to 1 MHz.

5 Block diagram



Earbuds

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

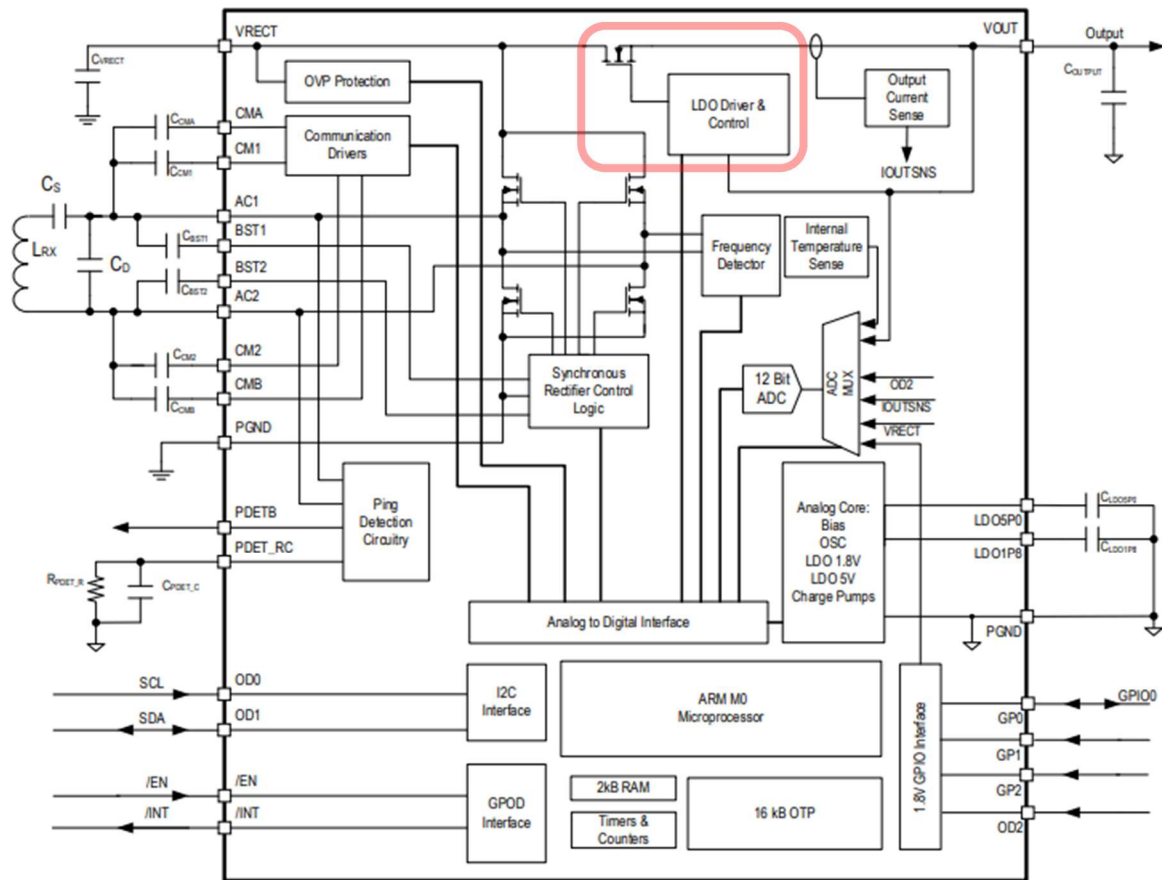


Wearables

The Watch4 includes an LDO voltage regulator (red rectangle below) coupled to the output of the receiver rectifier circuit that controls the output voltage of the P9415 to the battery of the portable device as specified by this part of the claim.

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

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



On information and belief, similarly to S22 Ultra, the Watch4 includes a charger IC to regulate or control an output voltage or current to charge the battery as per this claim.

30. The portable device of claim 23, further comprising a base unit circuit to enable the portable device to operate as an inductive charger or power supply using the receiver coil of the portable device to inductively charge or power another portable device including a battery which is capable of receiving power inductively.

The 500 Accused Smartphones additionally infringe this dependent claim as they further comprise a base unit circuit to enable the portable device to operate as an inductive charger or power supply using the receiver coil of the portable device to inductively charge or power another portable device including a battery which is capable of receiving power inductively.

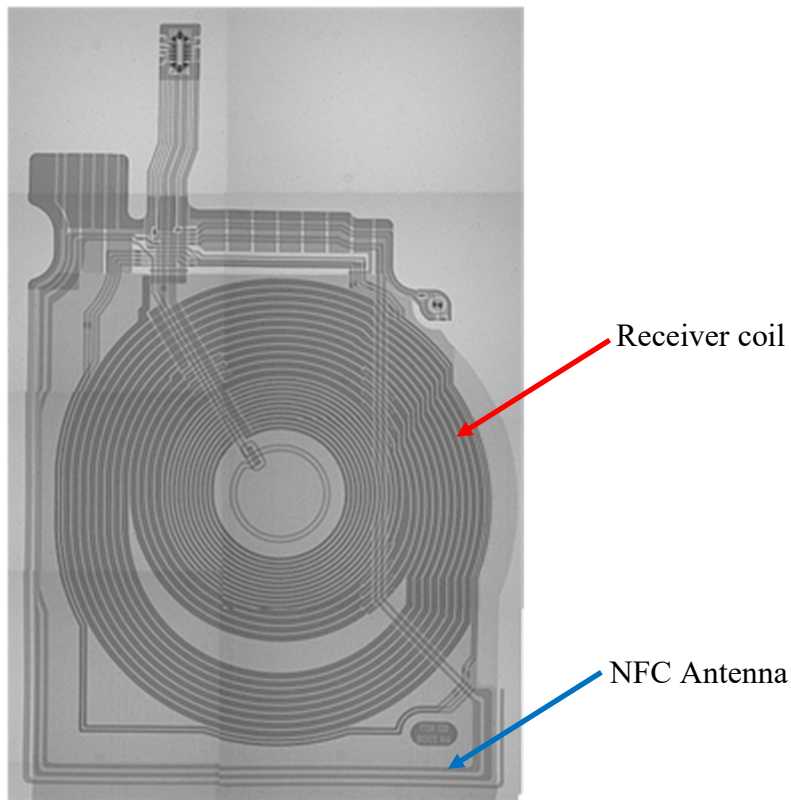
For example, the S22 includes the “Wireless PowerShare” feature with a system to transfer power inductively to another device as described in this part of the claim, as set forth above for claim 1 with respect to the 500 Accused Smartphones.

31. The portable device of claim 23, whereby the receiver coil and/or receiver circuit further comprises a near-field communication (NFC) antenna and/or circuit.

The 500 Accused Smartphones and the 500 Accused Wearables additionally infringe this dependent claim as they include an NFC antenna and circuit, as claimed.

Smartphones

The S22 Ultra, representative product comprises an NFC Antenna as shown below in the top-view x-ray.



The S22 Ultra NFC Antenna is also described in the Samsung FCC filing.

<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

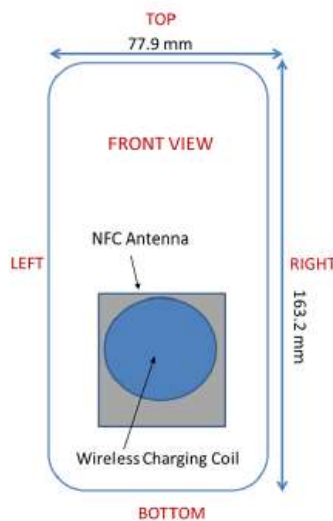




Figure F-2
NFC Antenna Locations

FCC ID A3LSMS908U		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

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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

Wearables

The Watch4 includes an NFC Antenna and circuit for its NFC operation.

<https://www.samsung.com/global/galaxy/galaxy-watch4/specs/>
 Galaxy Watch4

GALAXY WATCH4 FITNESS HEALTH DESIGN ECOSYSTEM **SPECS**

Specifications

Design

Color

44mm 40mm

Armor Aluminum
LTE / Bluetooth

Black Green Silver Black Pink gold Silver

Connectivity

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

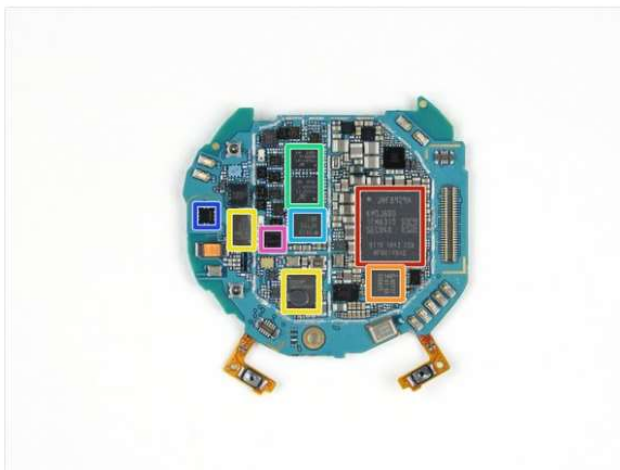
*Beidou may not be available in certain regions.
 *LTE connectivity only available in LTE models.

VIEW MORE CARRIERS

Upon information and belief, the NFC circuit for Watch4 is similar to the representative Watch shown below.

<https://www.ifixit.com/Teardown/Samsung+Galaxy+Watch+Teardown/117519>

Step 9



• The other side though has a bit more to offer:

- Samsung Exynos 9110 SoC (dual-core, 1.15 GHz)
- NXP Semiconductor **PN80T** NFC controller w/ secure element
- Broadcom BCM430131 WiFi/BT chip and BCM47758 GPS/GLONASS w/ sensor hub chip
- Skyworks **SKY77651-21** and **SKY77652-11** multimode/multiband power amplifier modules for 3G/LTE
- Samsung Shannon 910 envelope tracker (likely)
- STMicroelectronics **LPS22HH** barometric pressure sensor
- ST Micro **ST33G1M2** 32-bit ARM® SecurCore® SC300 (secure element)