## US11342777B2 POWERING AND/OR CHARGING WITH MORE THAN ONE PROTOCOL

This chart refers to various versions of the WPC Standard 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).

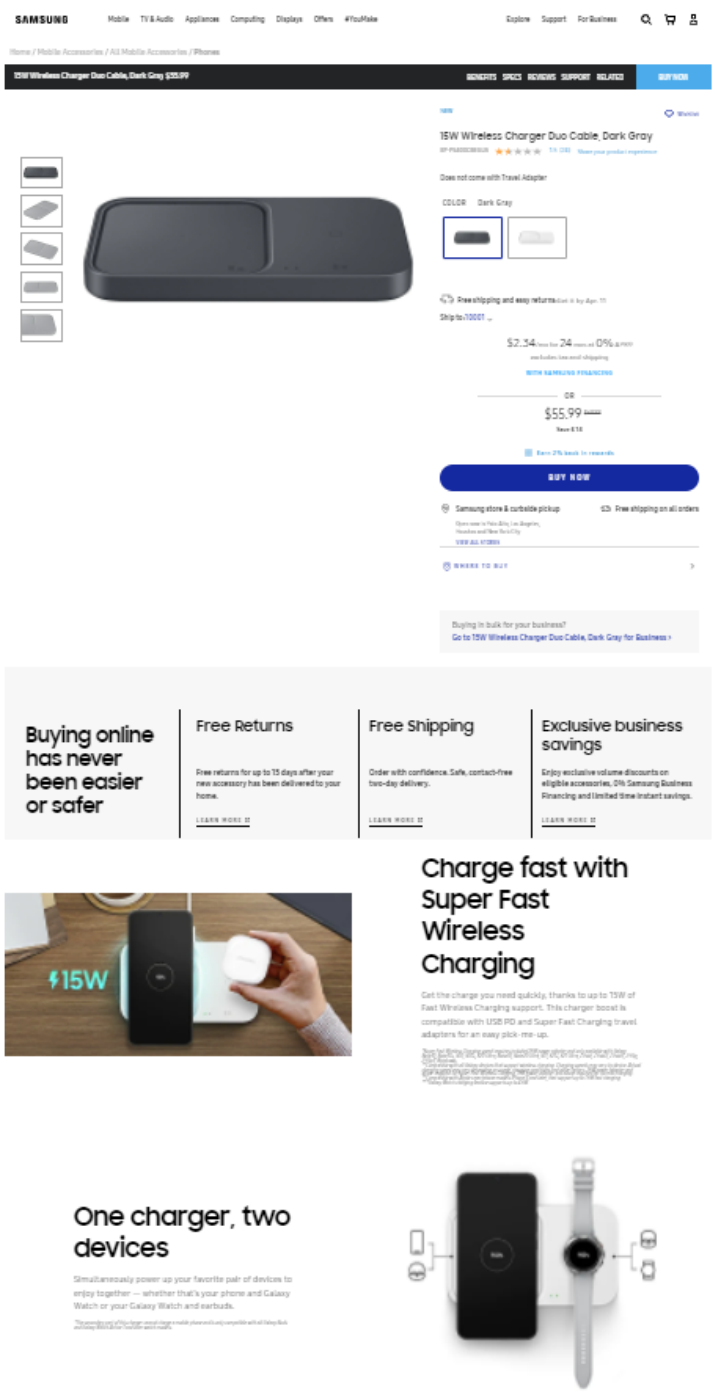
1. A base system for inductive charging of an electronic device comprising an inductive charging receiver and a battery electrically coupled to the inductive charging receiver, the base system comprising:

The 777 Accused Wireless (i.e. inductive) Chargers are accused under this claim (collectively the "777 Claim 1 Accused Products"). As detailed below by representative products, the 777 Claim 1 Accused Products fit the description in this introductory part of the claim, as each includes a base system for providing power inductively as specified by this introductory part of the claim.

**Wireless chargers**

The Samsung 5400 Duo Pad meets this introductory part of claim 1, as it can, on the left side, inductively charge a smartphone or earbud case compatible with the WPC Standard Baseline Power Profile (BPP) at up to 5W and a Samsung Wireless Fast Charge capable smartphone (e.g., an S22 Ultra) 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, and, on the right side, inductively charge a Samsung watch or earbud case at a lower power level.

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




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




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1. Introduction to Samsung Proprietary Power Delivery Extension
2. Purpose
3. Conformance requirement
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]

The Wireless Power Consortium describes the relationship between the PPDE Standards and EPP.

https://www.wirelesspowerconsortium.com/knowledge-base/testing-and-certification/safety-of-proprietary-power-extensions.html

# KNOWLEDGE BASE

A Proprietary Power Delivery Extension (PPDE) delivers more power then available in standard Qi mode. Additional tests are needed to guarantee the safety of products that support a PPDE.

## BACKGROUND

Some mobile phone manufacturers use proprietary extensions (non-standard) to deliver more than 5W into their phones and allow faster charging than the older Baseline Power Profile (BPP) supported at the time. These proprietary extensions are not fully compatible with the newer standardized Extended Power Profile (EPP) and were created for a variety of reasons.

In the short term, it is expected that mobile phone manufacturers will continue to use proprietary extensions. Some wireless chargers will be designed to support these extensions, although the current Qi certification program does not verify their correct and safe operation above 5W.

The WPC will faciliate PPDE safety testing as long as a large fraction of the total number of products seeking certification implements one or more PPDEs. The Steering Group of the WPC will decide yearly on whether to continue or terminate this facility.

## LIST OF PROPRIETARY POWER DELIVERY EXTENSIONS

| Name of the PPDE | Link to PPDE documentation | Version | Start date of voluntary testing | Start date of mandatory testing |
|---|---|---|---|---|
| Samsung Proprietary Extension | Specification - Compliance Tests and Test Equipment (WPC members only) | 1.0.2 | 1 February 2019 | 1 July 2019 |

## EXPLANATION OF TERMINOLOGY:

**PPDE**: Proprietary Power Delivery Extensions.

## Q&A

Q: Is it mandatory to support the Samsung PPDE?

A:No. Support for the Samsung PPDE, or any other PPDE, will not be mandatory. But wireless chargers that support the Samsung PPDE must be tested to make sure that these chargers are safe in combination with phones that support the Samsung PPDE

Q: What's the relationship between PPDE, and BPP and EPP?

A: The Samsung PPDE is an optional feature that manufacturers can add to a Qi charger. The PPDE can be added to a BBP charger as well as an EPP charger. PPDE is not a separate power profile (we only have BPP and EPP).

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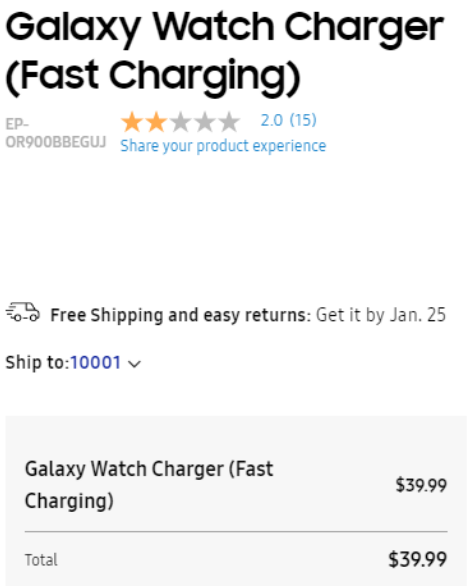
The EP-OR900 Watch Fast Charger (i.e. the "900 Watch Dock" or "900 Watch Charger") can wirelessly charge Samsung Watches, e.g., the Watch4 and Watch5. The 900 Watch Dock and the Watch5, while not indicated as WPC certified, still both use WPC BPP and 'Samsung Fast Wireless Charging' communication and control protocols based on WPC EPP, ASICs and circuit architecture as described below. Earlier models of Samsung Watches (such as Samsung Watch4) are charged at ~1-2 W power levels. On information and belief, by taking advantage of the Samsung Fast Wireless Charging protocol for watches in Watch5, this charge rate has been increased to ~5 W.

While the 900 Watch Dock and Watch5 use a version of the Samsung Wireless Fast Charge protocol for control and communication (a proprietary version of EPP), it appears to be limited to ~5 W versus the up to 15 W capability of other Samsung Wireless Fast Charge chargers and receivers, the Watch5 and 900 Watch Dock are advertised as capable of 'Fast Charging'.

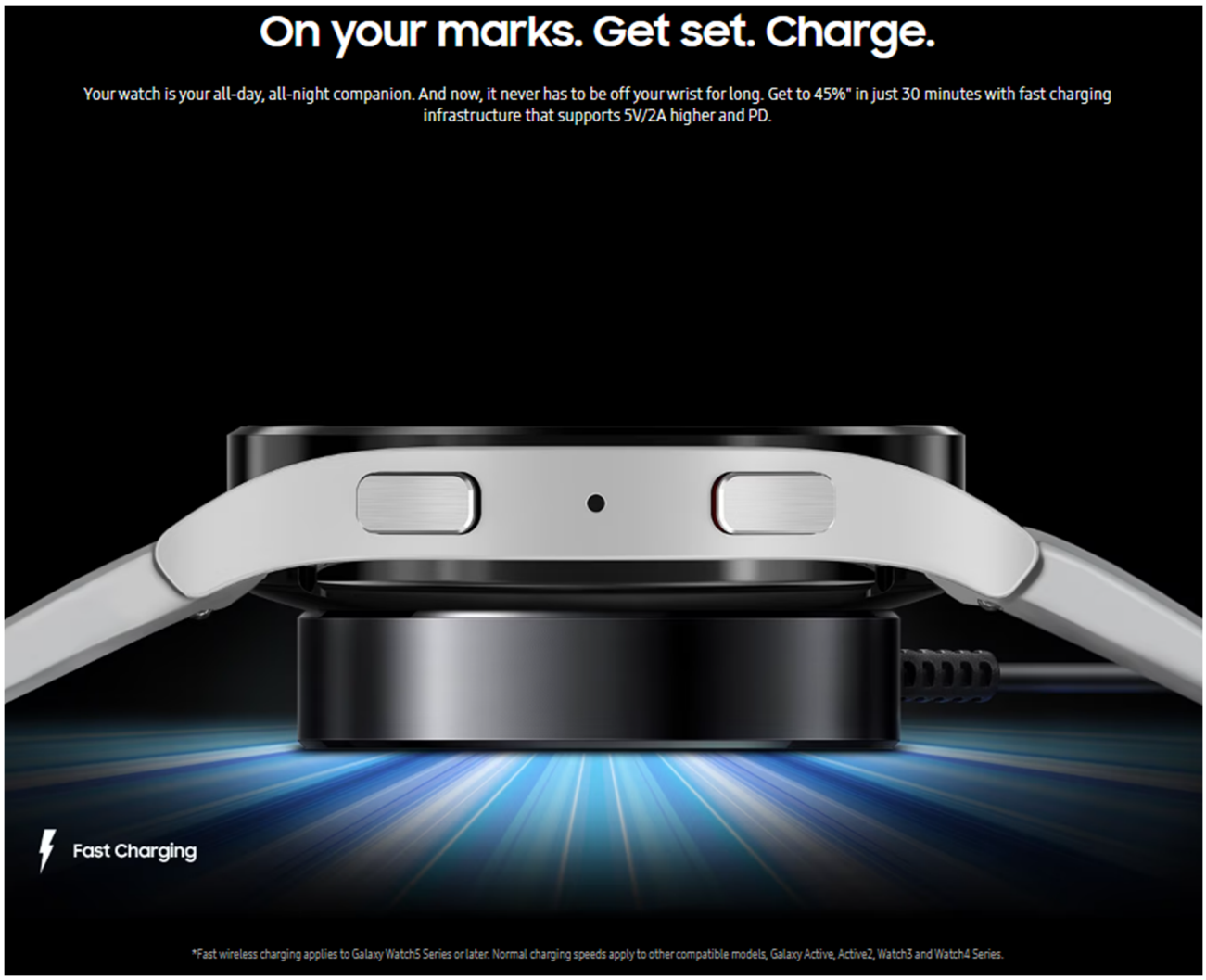
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https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

an inductive charging coil;

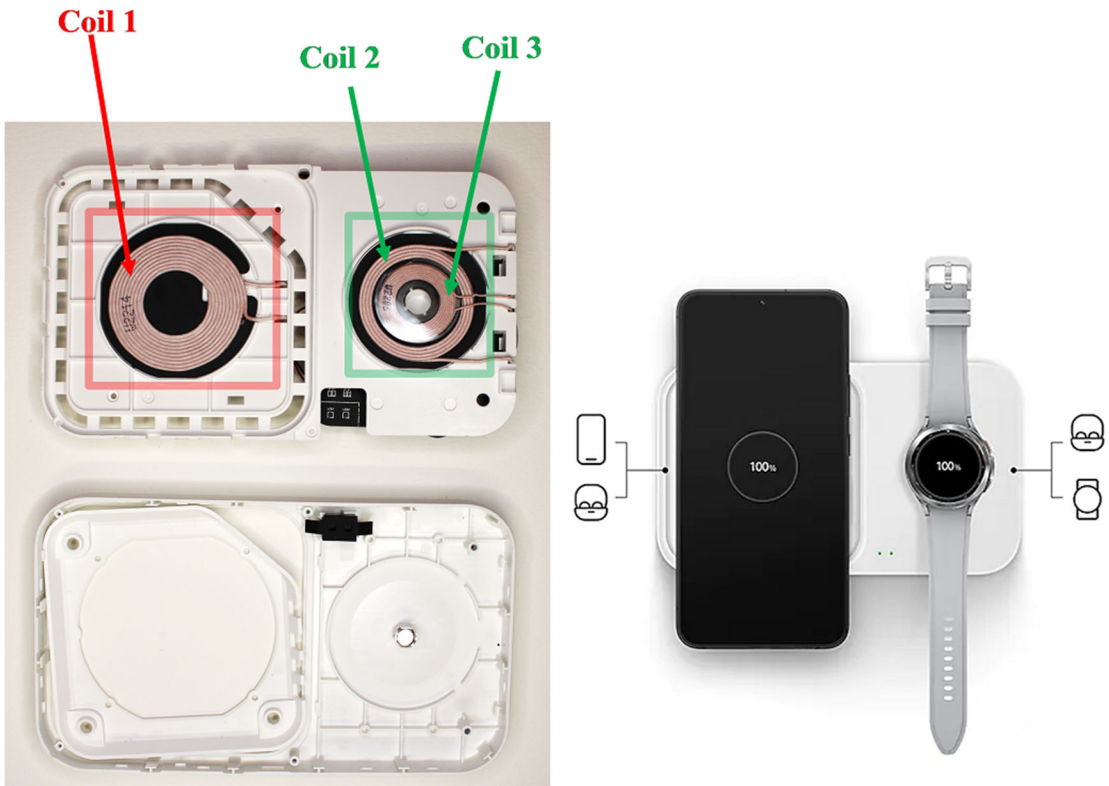
As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each include an inductive charging coil.

**Wireless chargers**

The Samsung 5400 Duo Pad includes multiple inductive charging coils.

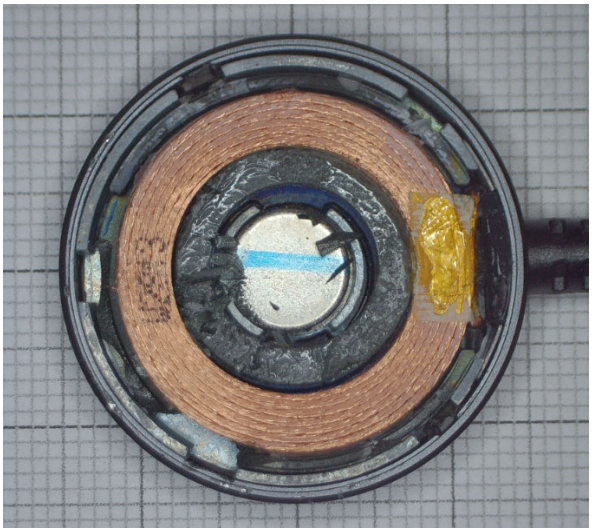



The 5400 Duo Pad includes three charging coils of which the two on the right side are concentric (inner coil for charging a watch and outer coil for charging an earbud case), as shown below. The coil on the left is for charging a smartphone or earbud case.



Internal images of the Samsung 5400 Duo Pad are shown above with the coils identified.

The 900 Watch Dock includes a charging coil as specified by this part of the claim, as shown below.



*See also* https://new.qq.com/rain/a/20221031A04BRZ00

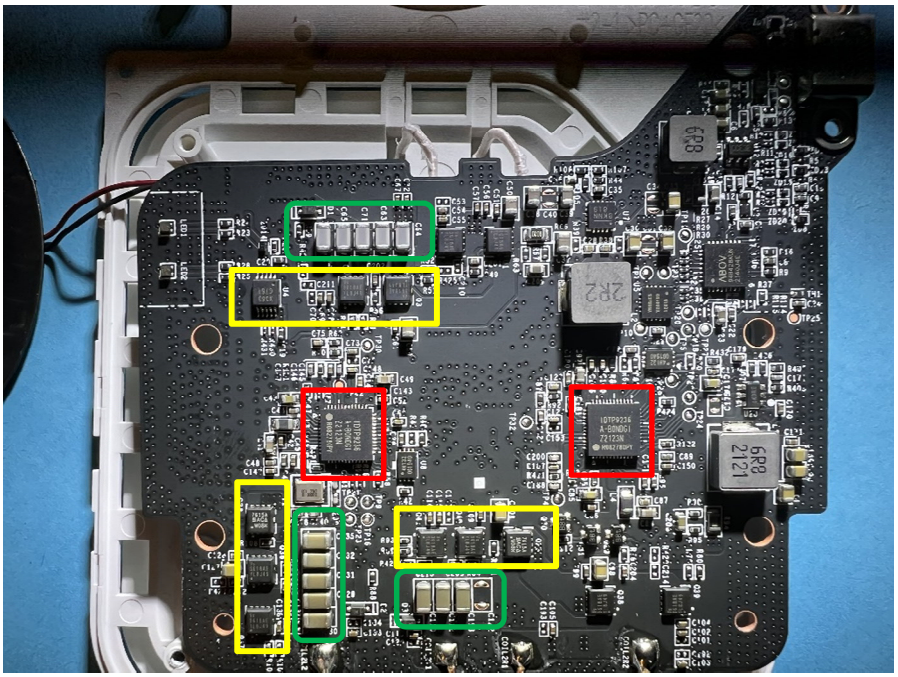


a coil drive circuit electrically coupled to the inductive charging coil, wherein the coil drive circuit provides power to the inductive charging coil by switching a voltage input to the inductive charging coil at an operating frequency;

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each include a coil drive circuit that is coupled to an inductive charging coil, which can switch a voltage input to the inductive charging coil at an operating frequency.

**Wireless chargers**

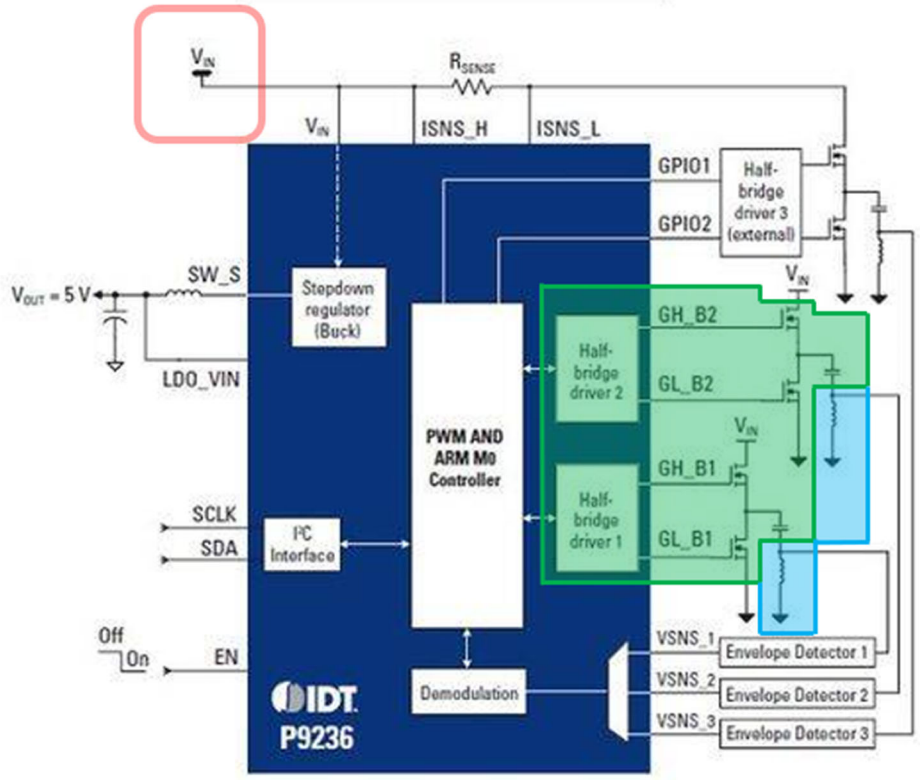
The 5400 Duo Pad includes a coil drive circuit that includes multiple switching circuits associated with its coils which include capacitors (green rectangles), wireless charging ASICs (IDT P9236) (red rectangles), and separate FETs and FET drivers (yellow rectangles), as illustrated below. The coil drive circuit provides power to the inductive charging coils by switching voltage inputs to the respective inductive charging coils at an operating frequency.



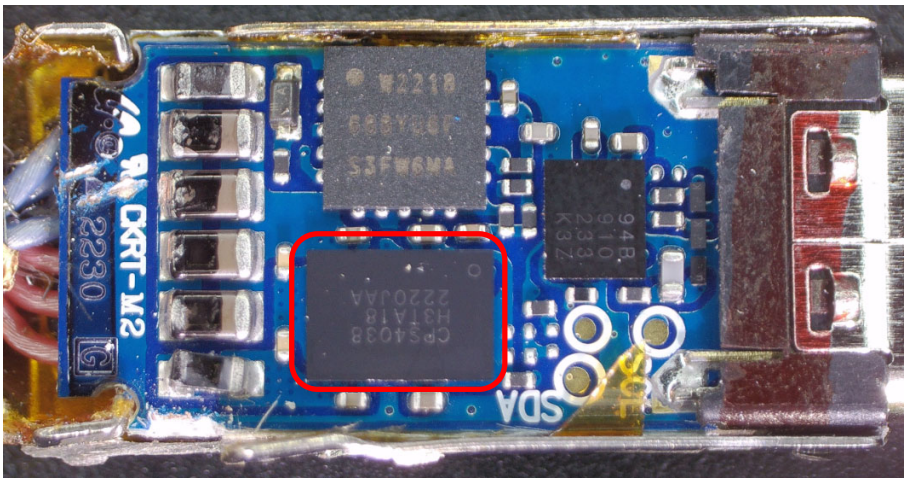
The 2 ICs in the red rectangles are the same and are each **IDT part number P9236.** On information and belief, a representative **circuit diagram for this ASIC part is shown belo**w. Each IC is capable of driving up to 3 coils simultaneously (for position free charging or to use the ASIC for driving multiple coils such as the dual coil (such as one coil inside the other as in the EP-P5400 right side). In this application, Each IC is used for driving one of the charging locations in the product independently.

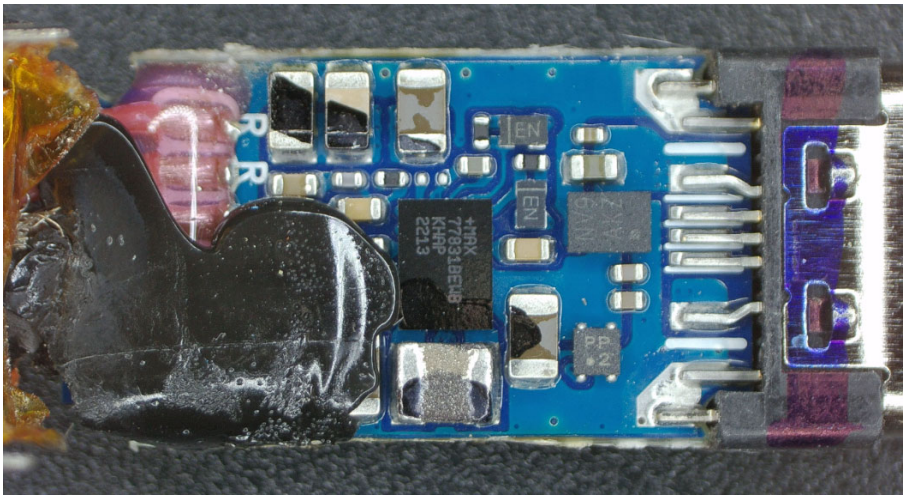
Below are shown the input voltage (Red rectangle below), drive circuit with internal drivers (green shape below) and the coil (s) (blue shape) showing the main elements of the claim section as used for this product.

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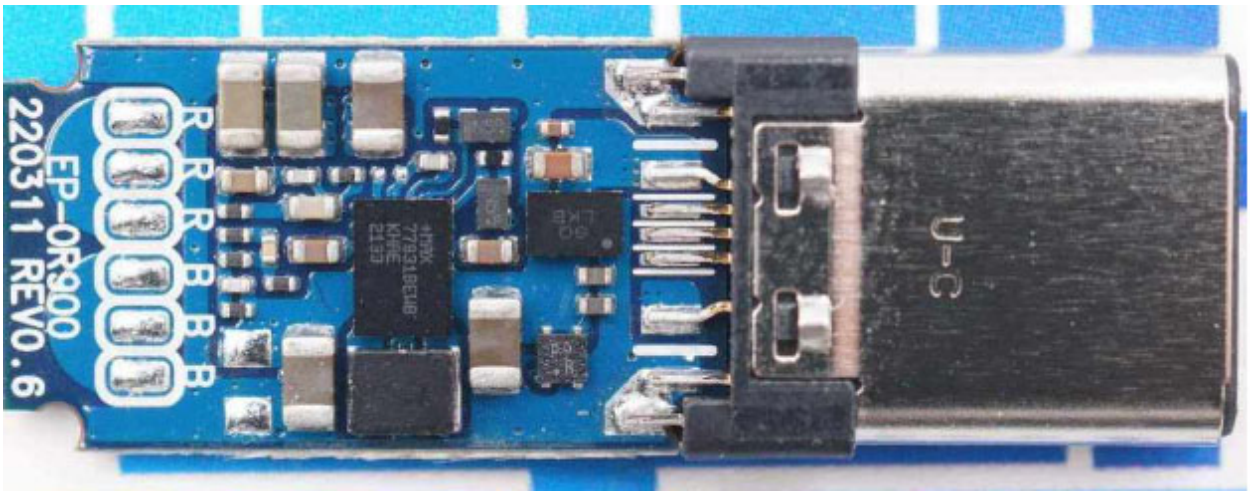


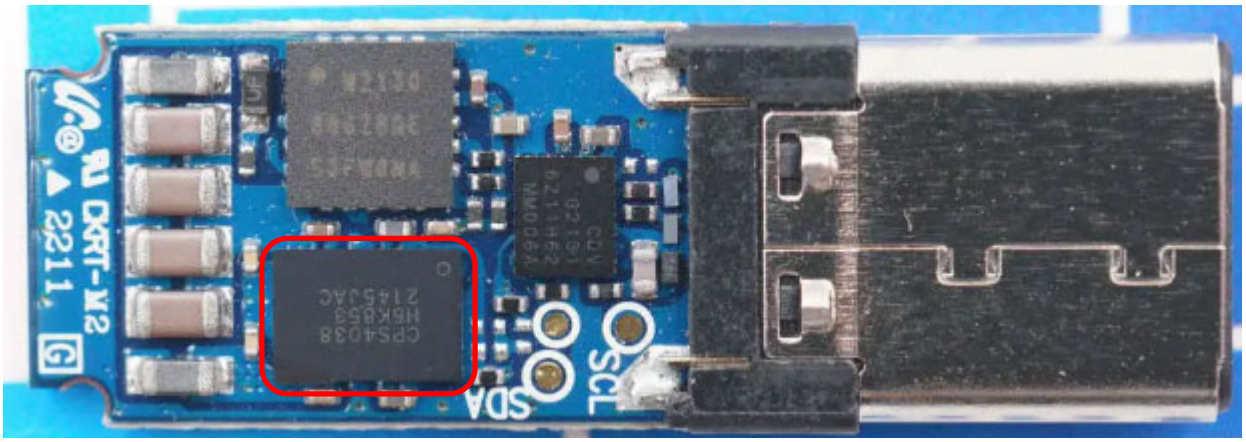

The 900 Watch Dock includes a drive circuit that is structured and operates as specified by this part of the claim. The 900 Watch Dock includes multiple switching circuits associated with its coils which include wireless charging ASICs (Convenient Power CPS4038) (shown in red rectangle below) and other associated components. Images below show the two sides of the printed circuit board for driving the 900 Watch Dock coil.





*See also* https://new.qq.com/rain/a/20221031A04BRZ00




*See also* https://fcc.report/FCC-ID/A3LEPOR900

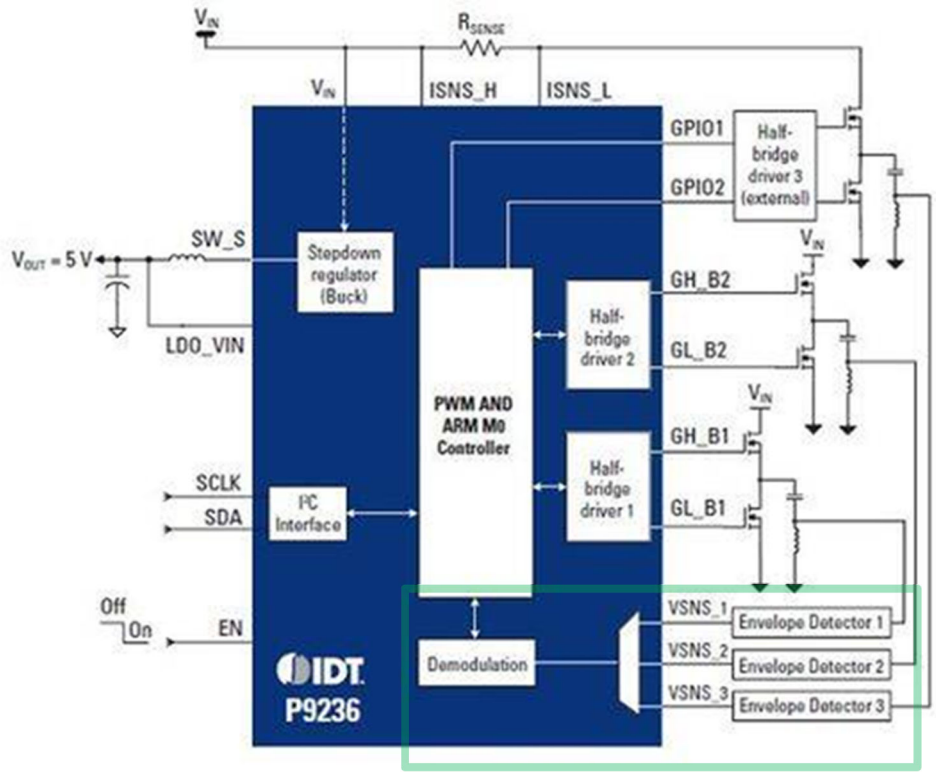
a current detection circuit electrically coupled to the inductive charging coil; and

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each include a current detection circuit that is electrically coupled to an inductive charging coil.

**Wireless chargers**

The 5400 Duo Pad includes a current detection circuit electrically coupled to the inductive charging coil.

This is shown in the IDT P9236 architecture diagram (outlined in green):




The 900 Watch Dock includes a current detection circuit electrically coupled to the inductive charging coil to enable BPP and Proprietary communication with a receiver.

*See* https://convenientpower.com/productdetail/102.html

The CPS4038 is a wireless power receiver compliant with WPC V1.3 standard. The R CPS4038 integrates a synchronous full-bridge rectifier, a low dropout regulator, and a Micro Controller Unit (MCU) for control and communication. The device receives AC power from a WPC compatible wireless transmitter and provides output power up to 40W, which could be used as a power supply for a charger of mobile or consumer devices.

## Features

- Support up to 40W (BPP, EPP and Proprietary) for receiver mode and 10W (BPP and Proprietary) for transmitter mode
- Embedded 32-bit core and on-chip 24kB MTP and 8kB SRAM
- WPC 1.3 compliant wireless power receiver / transmitter
- Full synchronous rectifier/inverter with low RDS_ON
- 2 pairs of communication channel for ASK modulation, independent control
- Ultra-low dropout linear (LDO) regulator with programmable output voltage with 12mV step
- General purpose I/O (GP) pins and Open-Drain(OD) pins
- Support I2C interface for system configuration and customization
- Comprehensive protections
- 12-bit ADC for comprehensive input and output power monitoring
- Rectifier over-voltage protection (OVP)
- Rectifier over-current protection (AC OCP)
- Main LDO over current protection (OCP)
- Over temperature protection (OTP)
- Available in WLCSP-54 package RoHS， Halogen-Free and Lead-Free Compliant

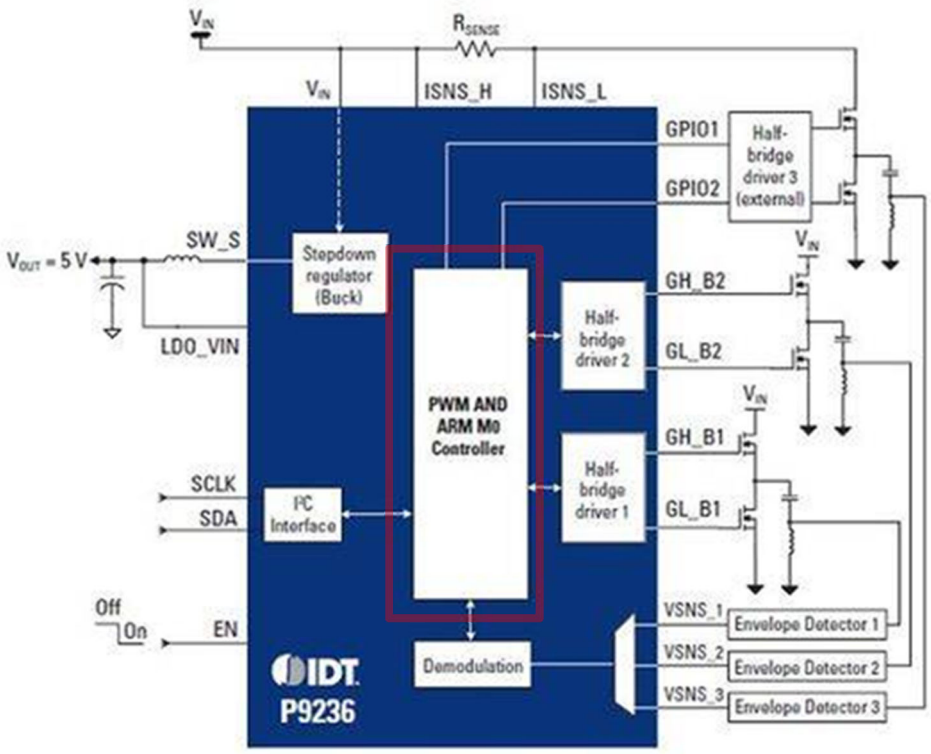
a microcontroller, wherein the microcontroller is configured for:

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each include a microcontroller.

**Wireless chargers**

The 5400 Duo Pad includes a microcontroller.

This is shown in the IDT P9236 architecture diagram (outlined in red):




The 900 Watch Dock includes a microcontroller.

*See* https://convenientpower.com/productdetail/102.html

The CPS4038 is a wireless power receiver compliant with WPC V1.3 standard. The R CPS4038 integrates a synchronous full-bridge rectifier, a low dropout regulator, and a Micro Controller Unit (MCU) for control and communication. The device receives AC power from a WPC compatible wireless transmitter and provides output power up to 40W, which could be used as a power supply for a charger of mobile or consumer devices.

## Features

- Support up to 40W (BPP, EPP and Proprietary) for receiver mode and 10W (BPP and Proprietary) for transmitter mode
- Embedded 32-bit core and on-chip 24kB MTP and 8kB SRAM
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- Full synchronous rectifier/inverter with low RDS_ON
- 2 pairs of communication channel for ASK modulation, independent control
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- Rectifier over-current protection (AC OCP)
- Main LDO over current protection (OCP)
- Over temperature protection (OTP)
- Available in WLCSP-54 package RoHS, Halogen-Free and Lead-Free Compliant

operating in a first mode of operation using a first protocol, wherein the first protocol is an inductive charging communication-and-control protocol that comprises uni-directional messaging, wherein the first mode of operation comprises:

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each operate in multiple modes including a first mode of operation using a first protocol that uses uni-directional messaging.

Chargers and receivers that are compatible with the WPC, follow a certain communication protocol for interoperability for inductive charging. The WPC (Qi) specification defines two communication protocols (Baseline Protocol (<5 W) using uni-directional messaging from the receiver to the charger and Extended Protocol (>5 W)) introduced in WPC 1.2 and later versions using bi-directional messaging between the receiver and the charger.

The infringing products are able to operate in either protocol to enable charging electronic devices that can operate with one of the protocols to allow greater interoperability.

The protocols and their phases are summarized at a high level below.

*See*, WPC 1.3 Standard, Communications Protocol, pages 13,14.

# 2 Overview

When a user places a Power Receiver within the Operating Volume of a Power Transmitter, the two start to communicate with the aim to configure and control the power transfer. The Power Signal provides the carrier for all communications. The *Qi Specification, Communications Physical Layer,* defines the low-level formats of data bits, data bytes, and data packets. The *Qi Specification, Communications Protocol* (this document) defines the payloads of the data packets and their use in the power control protocols.

## 2.1 Protocol phases

The *Qi Specification* defines two communications protocols.

- *Baseline Protocol*—the original protocol introduced in version 1.0 of the Qi Power Class 0 Specification, which uses Power Receiver to Power Transmitter communications only.
- *Extended Protocol*—added in version 1.2 of the Qi Power Class 0 Specification to support bi-directional communications and enhanced Foreign Object Detection (FOD) features. Version 1.3 of the *Qi Specification* adds data transport stream functionality and authentication options.

As shown in Figure 2, the communications protocol comprises several phases. The negotiation phase is not present in the Baseline Protocol.

**Figure 2. Protocol phases**




- *Ping phase.* The Power Transmitter tries to establish communications with a Power Receiver. Before doing so, it typically performs measurements to determine if there are objects such as bankcards, coins or other metals, which can damage or heat up during the power transfer. These measurements proceed without waking up the Power Receiver. See the *Qi Specification, Power Delivery,* for restrictions on such measurements.

  NOTE The Power Transmitter typically postpones a conclusion whether detected metals are Foreign Objects or Friendly Metals to the negotiation phase, after obtaining design information from the Power Receiver. See the *Qi Specification, Foreign Object Detection,* for details about recommended methods.

- *Configuration phase.* The Power Receiver sends basic identification and configuration data to the Power Transmitter. Both sides use this information to create a baseline Power Transfer Contract. Moreover, the Power Transmitter and Power Receiver decide whether to continue with the Baseline Protocol or the Extended Protocol.

  NOTE A Power Receiver can only make use of features such as enhanced FOD, data transport streams, and authentication if it implements the Extended Protocol.

- *Negotiation phase.* This phase is not present in the Baseline Protocol. The Power Transmitter and Power Receiver establish an extended Power Transfer Contract containing additional settings and limits. The Power Receiver also provides design information to the Power Transmitter, which the latter can use to complete FOD before switching to the power transfer phase. See the *Qi Specification, Foreign Object Detection,* for details about this information.
- *Power transfer phase.* This is the phase in which the power transfer to the Power Receiver's Load occurs. In the Extended Protocol, the Power Transmitter and Power Receiver perform a system calibration at the start of this phase. See the *Qi Specification, Foreign Object Detection,* for details about calibration. Occasional interruptions of this phase may occur to renegotiate an element of the Power Transfer Contract. However, the power transfer continues during such renegotiations.

**Wireless chargers**

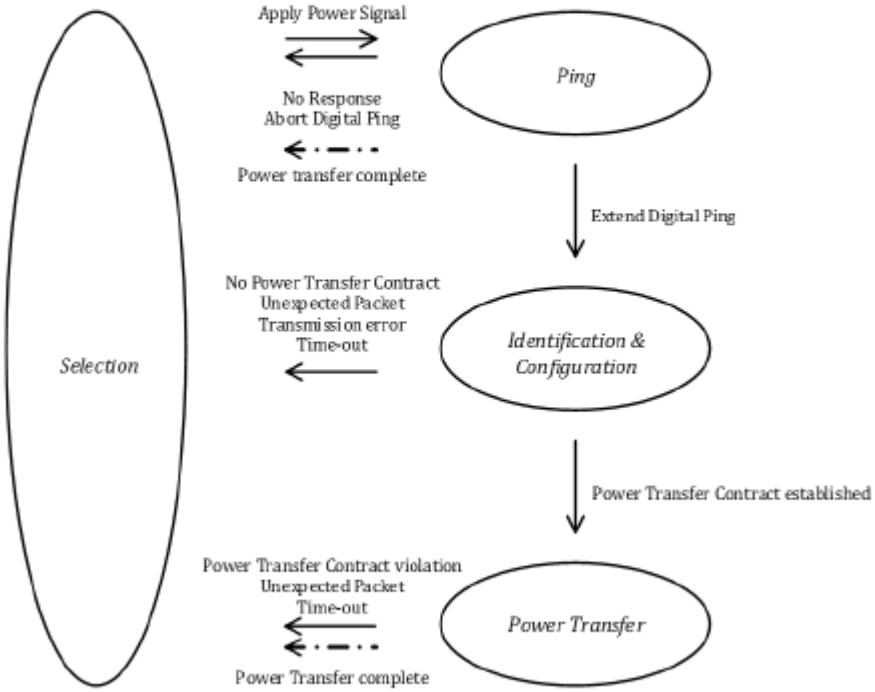
The Samsung 5400 Duo Pad and 900 Watch Dock both operate in multiple modes including a first mode of operation, which on information and belief is the WPC BPP mode. In this mode the 5400 Duo Pad and 900 Watch Dock receive uni-directional communications from the devices being charged. Devices such as earbud pro cases and Samsung Galaxy phones and Watch4 are capable of receiving power (and transmitting communications) in this mode of operation.

In the first mode, the 5400 Duo and 900 Watch Dock each receive communications for wireless charging and perform the wireless charging per WPC BPP, as shown below. *See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 11, 45 (similarly specified in WPC 1.3).

Baseline Power Profile

The minimum set of features applying to Power Transmitters and Power Receivers that can transfer no more than around 5 W of power.

**Figure 16. Power transfer phases—Baseline Power Profile**




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

The uni-directional communication received by the wireless charger in this first mode is illustrated by the WPC per WPC BPP, as shown below. *See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 87 (similarly specified in WPC 1.2.3 and 1.3).




## 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.**

receiving, using the current detection circuit, a first communication from the inductive charging receiver of the electronic device, wherein the first communication is based on the first protocol; and

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each receive a first communication from a device being charged using the first protocol and the current detection circuit.

**Wireless chargers**

The 5400 Duo and 900 Watch Charger also both meet this part of the claim. Uni-directional communication received by the wireless charger in the first mode includes Signal Strength and Identification and Configuration messages (during the Ping and Identification and Configuration phases shown above in WPC 1.2.4 BPP, Interface Definitions, Fig. 16) and Control Error Packet (CEP) and Received Power messages (during the Power Transfer phase, also shown in Fig. 16).

High level operation of a WPC charger and receiver are described 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.

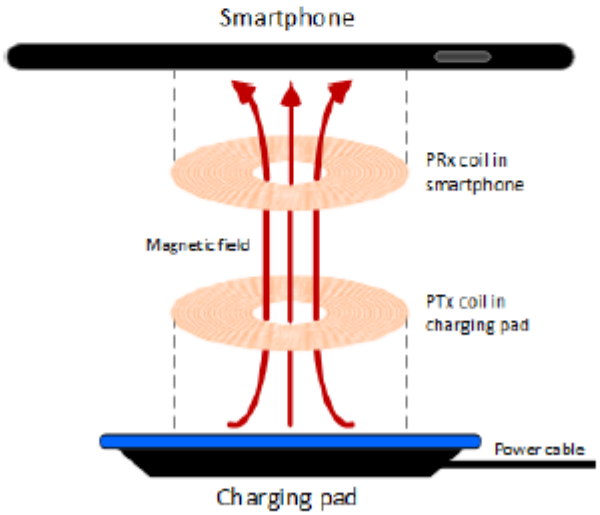
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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

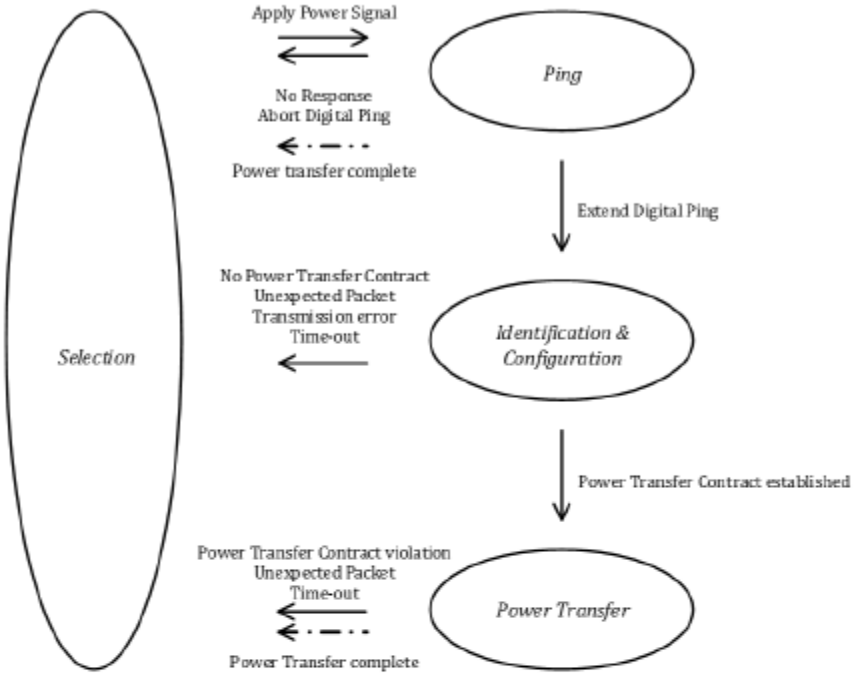
**Figure 6. Qi wireless power transfer using magnetic induction**



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

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

**Figure 16. Power transfer phases—Baseline Power Profile**




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

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

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

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

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

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

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

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

### 5.1.2 Power Transmitter (PTx) perspective

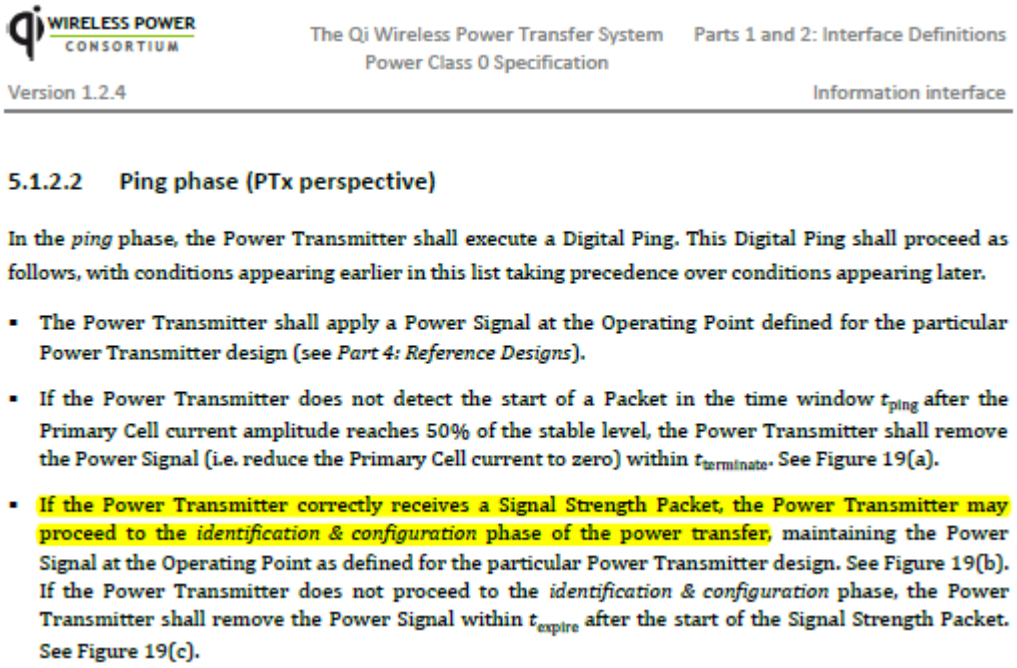
This section defines a protocol that the Power Transmitter shall execute to transfer power to a Power Receiver. Note that three of the seven phases are applicable only to the Extended Power Profile if the Power Transmitter supports the Extended Power Profile.

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

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

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

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



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**5.1.2.2 Ping phase (PTx perspective)**

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

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

#### 5.2.3.1 Signal Strength Packet (0x01)

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

**Table 27. Signal strength**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Signal Strength Value | | | | | | | |

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

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

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

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

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

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

The subsequent Identification and Configuration Phase is described below and includes a unique identification code, a manufacturer code, and a charge algorithm profile (indicating which version of the WPC the receiver complies to). *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) | Manufacturer Code | | | | | | |
| $B_2$ | | | | | | | | (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.

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**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 wireless charger 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:

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

In addition to the receiver power requirement communicated by the receiver to the base station above, the receiver uses the Configuration Packet to indicate its power level and ability to operate according to BPP by using the Neg bit in the Configuration Packet.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 75.

**Baseline Power Profile:** The Power Receiver shall set the Neg bit in its Configuration Packet to ZERO. It should also set the Polarity bit to ZERO and Depth field to 0x0. After the Power Receiver has transmitted a Configuration Packet, the Power Receiver shall proceed to the *power transfer* phase.

Following the Identification and Configuration phase, the wireless charger enters the Power Transfer phase where it receives periodic messages from the receiver to allow it to regulate the output voltage or power from the receiver in a closed loop manner. 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).

The Control Error Packet and Received Power Packet communicated during the BPP Power Transfer phase is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 95-96 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 94).

### 5.2.3.3 Control Error Packet (0x03)

Table 30 defines the format of the message contained in a Control Error Packet.

**Table 30. Control Error**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Control Error Value | | | | | | | |

**Control Error Value.** The (two's complement) signed integer value contained in this field ranges between –128...+127 (inclusive), and provides input to the Operating Point controller of the Power Transmitter. See Sections 5.1.2.6.1, *Power transfer control*, and 5.1.3.6, *Power transfer phase (PRx perspective)* for more details.

#### 5.2.3.4 8-bit Received Power Packet—BPP only (0x04)

Table 31 defines the format of the message contained in a Received Power Packet.

**Table 31. Received Power**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Received Power Value | | | | | | | |

**Received Power Value.** The unsigned integer value contained in this field indicates the average amount of power that the Power Receiver receives through its Interface Surface in the time window indicated in the Configuration Packet. This amount of power is calculated as follows:

$$P_{received} = \left(\frac{\text{Received Power Value}}{128}\right) \times \left(\frac{\text{Maximum Power Value}}{2}\right) \times 10^{\text{Power Class}} \text{ W.}$$

Here, Maximum Power Value and Power Class are the values contained in the Configuration Packet (see Section 5.2.3.7, *Configuration Packet (0x51)*). Section 11, *Foreign Object Detection*, defines how a Power Receiver shall determine its Received Power $P_{received}$.

NOTE An EPP Power Receiver shall use this Packet if it does not receive an ACK Response from the Power Transmitter to its Configuration Packet.

regulating power delivered to the battery of the electronic device in response to the received first communication; and

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they regulate the power delivered to the device being charged in response to the first communication.

**Wireless chargers**

The Samsung 5400 Duo Pad and 900 Watch Dock each delivers and regulates power delivery to the battery of the electronic device, for example to the earbuds case or the watch4 respectively, in response to the received first communication.

On information and belief, during this first mode of operation, the 5400 Duo and 900 Watch Dock operate per WPC BPP protocol regulating the power delivered to the battery of the electronic device in response to the received first communication including the received Control Error Packets. *See 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).

- *power transfer* In this phase, the Power Transmitter continues to provide power to the Power Receiver, adjusting its Primary Cell current in response to control data that it receives from the Power Receiver. Throughout this phase, the Power Transmitter monitors the parameters that are contained in the Power Transfer Contract. A violation of any of the stated limits on any of those parameters causes the Power Transmitter to abort the power transfer, and returns the system to the *selection* phase. Finally, the system may also leave the *power transfer* phase on request of the Power Receiver. Section 5.1.2 defines the system control protocols in the *ping*, *identification & configuration*, and *power transfer* phases from a Power Transmitter perspective. Section 5.1.3 defines the system control protocols in these four phases from a Power Receiver perspective.

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*.

### 5.1.2.6 Power transfer phase (PTx perspective)

In the *power transfer* phase, the Power Transmitter controls the power transfer to the Power Receiver, in response to control data that it receives from the latter. For this purpose, the Power Transmitter shall receive zero or more of the following Packets:

- Control Error Packet.
- Received Power Packet.
- Charge Status Packet.
- End Power Transfer Packet.
- Renegotiate Packet.
- Any Proprietary Packet (as listed in Table 26). If the Power Transmitter does not know how to handle the message contained in the Proprietary Packet, the Power Transmitter shall ignore that message.

#### 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.

WPC further specifies tests for BPP wireless charger to demonstrate regulation and rapid response to load changes in the receiver. *See,* WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 33.

### 3.2.3 Load dump test procedure

#### 3.2.3.1 Baseline Power Profile load dump test

1. Position Test Power Receiver #1 in configuration B on the Interface Surface of the Base Station, with an initial load of 32 Ω, a Power Control Hold-off Time $t_{delay}$ = 100 ms, and an interval time between consecutive Control Error Packets $t_{interval}$ = 250 ms.
2. Establish communication and regulate the rectified voltage to $V_r = 7^{\pm 2\%}$ V.
3. Change the load from its initial value to 10 Ω and regulate the rectified voltage to $V_r = 7^{\pm 2\%}$ V.
4. Change the load from 10 Ω to 127 Ω, $\Delta t_1$ = 50 ms before a sending a Control Error Packet.
5. Verify that the Test Power Receiver continues to regulate and that the Base Station responds to the Control Error Packets by adjusting $V_r$.
6. Measure the rectified voltage ($V_0$, $V_1$, and $V_{min}$) with timings as shown in Figure 9. Load dump test diagram, where $\Delta t_2$ = 1800 ms.
7. Verify that the measured values comply with the limits provided in Table 4.

operating in a second mode of operation using a second protocol, wherein the second protocol is an inductive charging communication-and-control protocol that defines bi-directional messaging, wherein the second mode of operation comprises:

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each operate in multiple modes including a second mode of operation using a second protocol that is based on the WPC Extended Power Profile (EPP) that includes bi-directional messaging.

**Wireless chargers**

The Samsung 5400 Duo Pad and 900 Watch Charger operating in a second mode, each charge their respective electronic devices at higher power levels, respectively at over 5 W for the 5400 and at higher level (up to 5 W) than available with BPP (~1-2 W given the smaller coil sizes) for the 900 Watch Charger according to the Samsung Wireless Fast Charge or the Watch 'Fast Wireless Charging' proprietary protocol (or the Samsung PPDE as discussed above) that, on information and belief, is a proprietary communication and control protocol based on the WPC Extended Power Profile (EPP) bi-directional communication architecture.

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

## 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]

Samsung describes Wireless Fast Charging for their smart phones below.

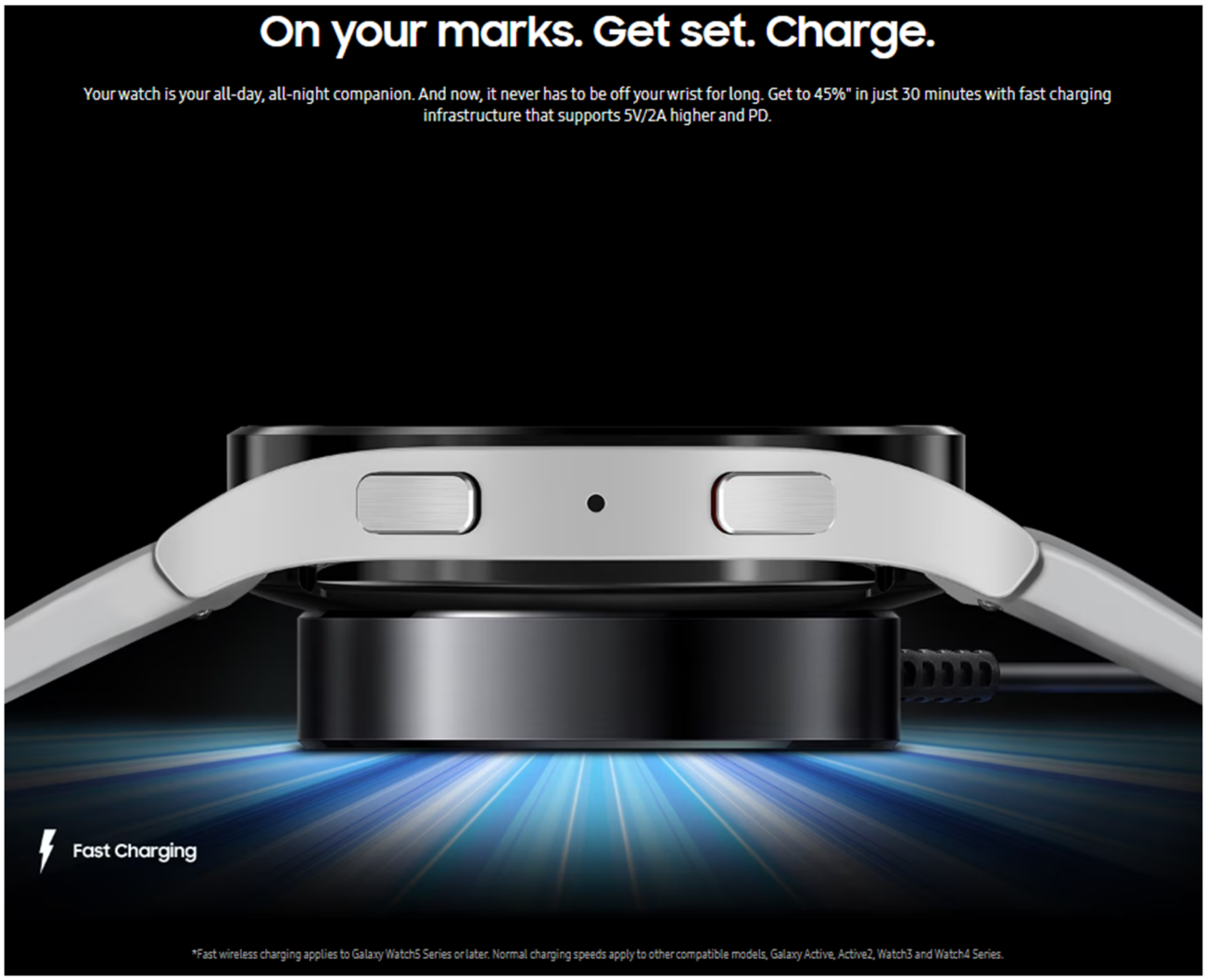
https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-cable-dark-gray-ep-p5400cbegus/#benefits

# Charge fast with Super Fast Wireless Charging

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

Samsung describes the wireless charging capabilities of the 900 Watch Charger below:

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

The Watch5 Dock uses a convenient power CPS4038 ASIC. Part of the datasheet for the CPS4038 is shown below.

https://convenientpower.com/productdetail/102.html

## Features

- Support up to 40W (BPP, EPP and Proprietary) for receiver mode and 10W (BPP and Proprietary) for transmitter mode
- Embedded 32-bit core and on-chip 24kB MTP and 8kB SRAM
- WPC 1.3 compliant wireless power receiver / transmitter

*See also* https://new.qq.com/rain/a/20221031A04BRZ00

CONVENIENT POWER

CPS4038

Datasheet

# High Power Wireless Receiver IC with Tx Mode

## Descriptions

The CPS4038 is a highly efficient, Qi-compliant, single-chip wireless power receiver/transmitter IC. It supports up-to 40W applications at receiver (Rx) mode, which is particularly suitable for phone and portable device applications.

CPS4038 improves the system efficiency with integrated low $R_{DS(ON)}$ full-bridge synchronous rectifier to convert AC power received from the wireless transmitters.

The integrated ultra-low dropout linear (LDO) regulator offers the best performance in battery operated applications.

CPS4038 integrates an MCU and MTP memory to offer user programmability, together with advanced power management circuits to achieve extremely low standby power.

CPS4038 integrates extensive fault protections including over temperature, over current and over voltage protection to ensure the safe operations. A junction temperature sensor is also used for temperature sensing and advanced compensation.

The CPS4038 is available in a WLCSP-54, 2.8mm x 4mm x 0.55mm (0.4mm pitch) package. The junction temperature range is from -40°C to 125°C.

## Features

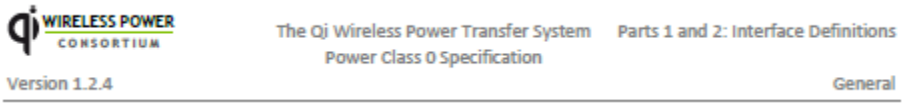
- Support up to 40W (EPP and Proprietary) for receiver mode and 10W (BPP and Proprietary) for transmitter mode
- Embedded 32-bit ARM® Cortex-M0 core and on-chip 24kB MTP and 8kB SRAM
- WPC 1.2.4 compliant wireless power receiver / transmitter
- Full synchronous rectifier/inverter with low $R_{DS\_ON}$
- 2 pairs of communication channel for ASK modulation, independent control
- Ultra-low dropout linear (LDO) regulator with programmable output voltage with 12mV step
- Support Magnetic Secure Transmission (MST) including traditional mode and PCR mode
- Support Ping Detect feature
- General purpose I/O (GP) pins and Open-Drain (OD) pins
- Support I²C interface for system configuration and customization
- Comprehensive protections
  - 12-bit ADC for comprehensive input and output power monitoring
  - Rectifier over-voltage protection (OVP)
  - Rectifier over-current protection (AC OCP)
  - Main LDO over current protection (OCP)
  - Over temperature protection (OTP)
- Available in WLCSP-54 package

## Applications

- Phones
- Wearable Devices
- Accessories

Convenient Power for Samsung

The WPC Standard describes both the Baseline Power Profile (BPP) and the Extended Power Profile (EPP), *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 8, 11 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 8, 11).



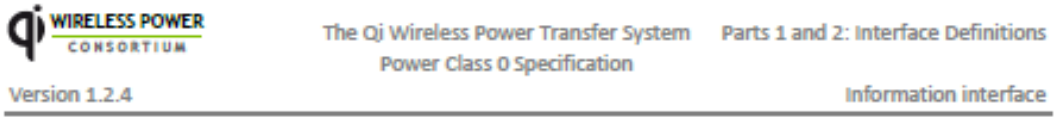

## 1.2 Scope

This document, *Parts 1 and 2: Interface Definitions*, defines the interface between a Power Transmitter and a Power Receiver, i.e. Power Class 0 Base Stations and Mobile Devices. Power Class 0 is the WPC designation for flat-surface devices, such as chargers, mobile phones, tablets, cameras, and battery packs, in the Baseline Power Profile (≤ 5 W) and Extended Power Profile (≤ 15 W).

Extended Power Profile

The minimum set of features applying to Power Transmitters and Power Receivers that can transfer power above 5 W.

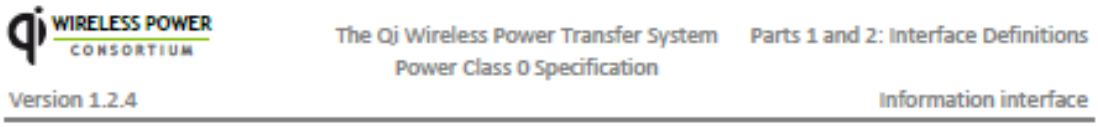
During EPP operation (second mode), the method of communication from the receiver to the wireless charger is by amplitude modulation (similar to the first mode). However, during EPP, the wireless charger also communicates to the receiver using Frequency Shift Keying resulting in a bi-directional communication between the wireless charger and the receiver. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 87, 108 (similarly specified in WPC 1.2.3 and 1.3).




## 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.




## 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.

receiving, using the current detection circuit, a second communication from the inductive charging receiver of the electronic device, wherein the second communication is based on the second protocol;

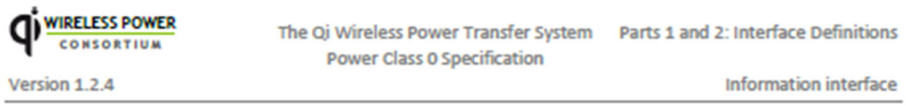
As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each receive, using the current detection circuit, a communication from the inductive charging receiver of the device being charged, communications based on the second profile.

**Wireless chargers**

For the Samsung 5400 Duo Pad, communication in the second mode of operation comprises bi-directional messaging. For example, the left side of the 5400 Duo uses bi-directional communication when charging, at power levels over 5 W, an S22 Ultra, which is capable of being charged at up to 15 Watts in Samsung Wireless Fast Charge 2.0.

As another example. 900 Watch Dock uses bi-directional communication when charging a Watch5, which is capable of being charged at up to 5 Watts using Samsung Watch Fast Wireless Charging.

In this example, in the second mode, the communication received by the 5400 Duo from the S22 Ultra uses current modulation, and communication from the 5400 Duo to the S22 Ultra uses frequency shift keying (FSK) per WPC EPP. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 84 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 86). Similarly in the 900 Watch Dock example, in the second mode, the communication received by the 900 Watch Dock from the Watch5 uses current modulation, and communication from the 900 Watch Dock to the Watch5 uses frequency shift keying (FSK) per WPC EPP. *Id.*

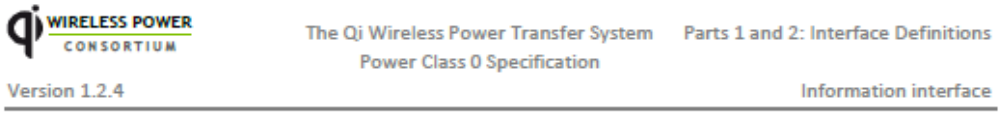



## 5.2 Power Receiver to Power Transmitter communications interface

### 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.

Excerpts from the WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 108 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 106) are shown below.




## 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.

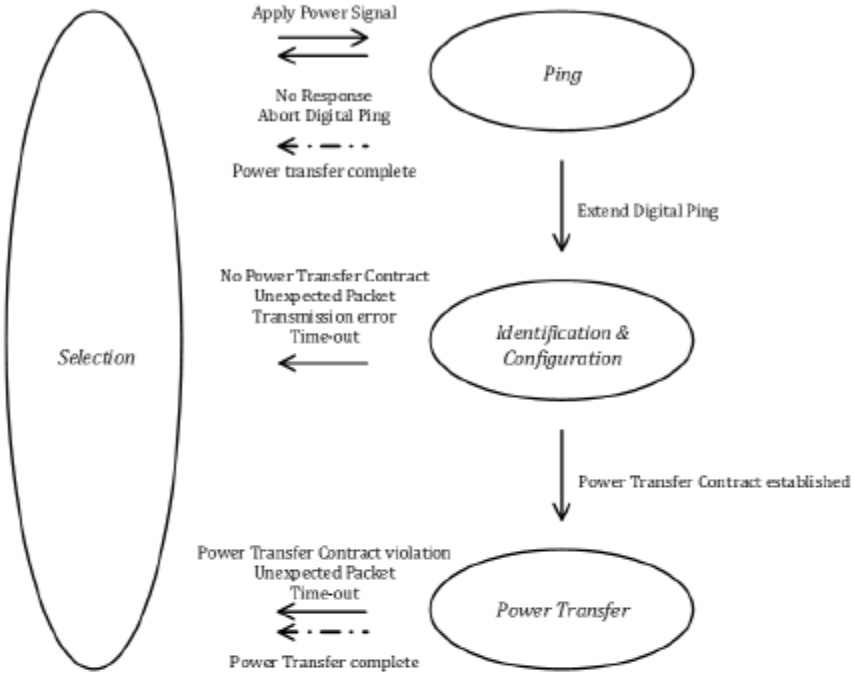
#### 5.3.2.1 Modulation scheme

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:

In the first mode of operation the Wireless Charger follows the BPP protocol as described in detail in the "receiving, using the current detection" section above.

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

**Figure 16. Power transfer phases—Baseline Power Profile**

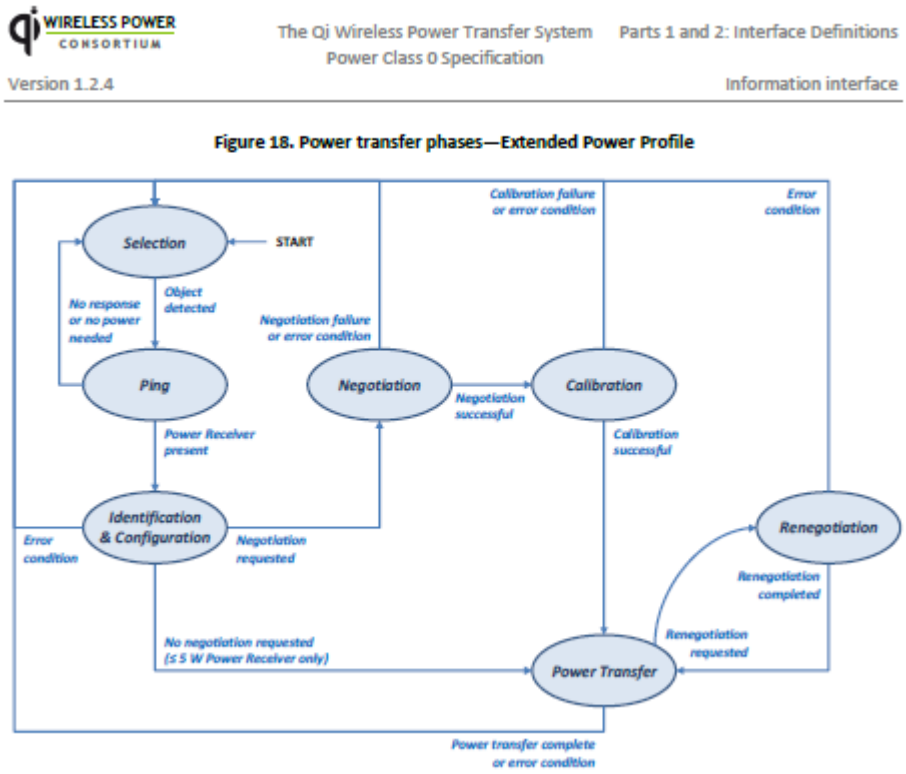



The main activity in each of these phases is the following:

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

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

The Samsung Wireless Fast Charge and Samsung Watch Fast charge (i.e. second mode) are based on the WPC EPP protocol, which is illustrated below in the WPC version 1.2.4 specification *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 48 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 48). The second mode is based on bi-directional communication between the receiver and the base station and has several additional phases and messages over BPP.




In the second mode of operation, Samsung 5400 Duo and the 900 Watch Dock using their current detection circuits each receive a second communication from the receiver of the electronic device being charged based on the second (EPP) protocol.

The second communication includes receiving Signal Strength Packet during the Ping phase and Identification & configuration messages identifying the receiver as operating in the second mode.

*E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 52 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 51).

#### 5.1.2.2 Ping phase (PTx perspective)

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

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

#### 5.2.3.1 Signal Strength Packet (0x01)

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

**Table 27. Signal strength**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Signal Strength Value | | | | | | | |

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

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

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

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

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

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

The subsequent Identification and Configuration Phase is described below and includes a unique identification code, a manufacturer code, and a charge algorithm profile (indicating which version of the WPC the receiver complies to). *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**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Major Version | | | | Minor Version | | | |
| B1 | (MSB) | | | | | | | |
| B2 | Manufacturer Code | | | | | | | (LSB) |
| B3 | Ext | (MSB) | | | | | | |
| ⋮ | Basic Device Identifier | | | | | | | |
| B6 | | | | | | | | (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 wireless charger 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:

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

The receiver uses the Configuration Packet to indicate its power level and ability to operate according to EPP or a proprietary method.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 76, 99.



**Extended Power Profile:** The Power Receiver shall not send Proprietary Packets during the *identification & configuration* phase. Moreover, if the Maximum Power of the Power Receiver exceeds 5 W, it shall set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Maximum Power of the Power Receiver does not exceed 5 W, it may set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Power Receiver does not receive the first bit of an ACK Response within $t_{responsetimeout}$ after the end of the Configuration Packet, it shall:

- assume that the Power Transmitter is not able to negotiate;
- assume that the Power Transmitter supports a Guaranteed Power of 5 W only; and
- proceed to the power transfer phase.

Otherwise, the Power Receiver shall proceed to the *negotiation* phase. See Figure 30 and Figure 24.



**Prop** If this bit is set to ZERO, the Power Transmitter shall control the power transfer according to the method defined in Section 5.1.2.6.1, *Power transfer control*. If this bit is set to ONE, the Power Transmitter may control the power transfer according to a proprietary method instead of the method defined in Section 5.1.2.6.1. However, if this bit is set to ONE, the Power Transmitter shall continue to ensure that the received Control Error Packets comply with the timings defined in Section 5.1.2.6.

NOTE This implies that a Power Transmitter terminates the power transfer if it times out while waiting for a Control Error Packet. Moreover, this implies that setting the Prop bit to ONE does not relieve the Power Receiver from transmitting Control Error Packets on a regular basis. Finally, if the Prop bit is set to ZERO, the Power Transmitter could still decide to abort the power transfer based on information contained in a Proprietary Packet.

**Neg** If this bit is set to ZERO, the Power Transmitter shall refrain from sending a Response. If this bit is set to ONE, the Power Transmitter shall send an ACK Response following the end of the Configuration Packet indicating to the Power Receiver that it is entering the *negotiation* phase. See Section 5.1.2.3, *Identification & configuration phase (PTx perspective)*.

Following the Identification and Configuration phase, the wireless charger enters the Power Transfer phase where it receives periodic messages from the receiver to allow it to regulate the output voltage or power from the receiver in a closed loop manner. 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).

The Control Error Packet and Received Power Packet communicated during the BPP Power Transfer phase is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 95-96 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 94).

### 5.2.3.3 Control Error Packet (0x03)

Table 30 defines the format of the message contained in a Control Error Packet.

**Table 30. Control Error**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Control Error Value | | | | | | | |

**Control Error Value.** The (two's complement) signed integer value contained in this field ranges between –128...+127 (inclusive), and provides input to the Operating Point controller of the Power Transmitter. See Sections 5.1.2.6.1, *Power transfer control*, and 5.1.3.6, *Power transfer phase (PRx perspective)* for more details.

Some of the communications messages from the receiver to the wireless charger have a different structure in EPP (second mode) than BPP (first mode shown above).

*E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 103 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 100, 101).

### 5.2.3.11 24-bit Received Power Packet—EPP only (0x31)

Table 39 defines the format of the message contained in a Received Power Packet.

**Table 39. Message in a 24-bit Received Power Packet**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Reserved | | | | | Mode | | |
| $B_1$ | (MSB) Received Power Value | | | | | | | |
| $B_2$ | Received Power Value (LSB) | | | | | | | |

**Mode.** The bit string in this field provides additional information with respect to the Received Power Value.

**Table 40. Mode field values**

| Mode | Description |
|---|---|
| '000' | Normal value; Response requested |
| '001' | Light-load calibration value; Response requested |
| '010' | Connected-load calibration value; Response requested |
| '011' | Reserved |
| '100' | Normal value; no Response expected |
| '101' | Reserved |
| '110' | Reserved |
| '111' | Reserved |

**Reserved.** These bits shall be set to ZERO.

**Received Power Value.** The unsigned integer contained in this field indicates the average amount of power, $P_{received}$, that the Power Receiver receives through its Interface Surface in the time window indicated in the Configuration Packet. This is expressed as

$$P_{received} = \left(\frac{\text{Received Power Value}}{32768}\right) \times \text{Maximum Power.}$$

In this calculation, the Power Transmitter uses the Maximum Power that is contained in the Power Transfer Contract. The result for $P_{received}$ is in watts. Section 11, *Foreign Object Detection*, defines how a Power Receiver shall determine its Received Power, $P_{received}$.



In addition, operation in the second mode (EPP) includes receiver to wireless charger proprietary messages and EPP only messages that are not used in the first mode of operation (BPP) and are EPP Only.

*E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 104-107 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 101-105).

### 5.2.3.12 General Request Packet—EPP only (0x07)

Table 41 defines the format of the message contained in a General Request Packet.

**Table 41. Message in a General Request Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Request | | | | | | | |

**Request.** This unsigned integer value indicates the kind of information that is requested. To request a particular Packet, set the Request field to the header of that Packet. For example, to request a Power Transmitter Identification Packet, set the Request field to 0x30. See Table 54 for a list of Packet headers. See Section 5.3.3, *Logical layer (PTx to PRx)* for the format of the Packets that the Power Transmitter sends in return.

### 5.2.3.13 Specific Request Packet—EPP only (0x20)

Table 42 defines the format of the message contained in a Specific Request Packet.

**Table 42. Message in a Specific Request Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Request | | | | | | | |
| B1 | Request Parameter | | | | | | | |

**Request.** The unsigned integer in this field contains the request, as defined in Table 43. See Section 5.1.2.4.2.1, *Power Transmitter Responses*, for details on the expected Response from a Power Transmitter.

**Request Parameter.** This field contains a parameter of the request. See the following subsections for details.

**Table 43. Request field values**

| Request | Description | Request Parameter |
|---|---|---|
| 0x00 | End Negotiation | Change count |
| 0x01 | Guaranteed Power | Guaranteed Power Value |
| 0x02 | Received Power Packet Type | Received Power Packet Header |
| 0x03 | FSK Parameters | Polarity and depth |
| 0x04 | Maximum Power | Maximum Power Value |
| 0x05 to 0xEF | Reserved | N.A. |
| 0xF0 to 0xFF | Proprietary | Proprietary |

### 5.2.3.13.1 End Negotiation (0x00)

Table 44 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 44. Format of the Request Parameter field**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | Change Count | | | | | | | |

**Change Count.** The unsigned integer value contained in this field provides a count of the number of parameters in the Power Transfer Contract that have been modified during the *negotiation* phase.

### 5.2.3.13.2 Guaranteed Power (0x01)

Table 45 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 45. Format of the Request Parameter field**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | Reserved | | Guaranteed Power Value | | | | | |

**Guaranteed Power Value.** This field contains the requested amount of Guaranteed Power in units of 0.5 W. For example, the value 10 serves to query if the Power Transmitter supports a Guaranteed Power of 5 W, and the value 30 queries for a Guaranteed Power of 15 W. Based on the Power Transmitter designs defined in *Part 4: Reference Designs*, a Power Receiver should not attempt to negotiate for a Guaranteed Power greater than 15 W.

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.13.3 Received Power Packet Type (0x02)

Table 46 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 46. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Received Power Packet Header | | | | | | | |

**Received Power Packet Header.** This field shall be set to 0x31 to indicate that the Power Receiver intends to use the 24-bit Received Power Packet in the *power transfer* phase.

### 5.2.3.13.4 FSK Parameters (0x03)

Table 47 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 47. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | | | | Polarity | Depth | |

**Polarity.** A ZERO in this bit indicates to the Power Transmitter to use a positive FSK polarity. A ONE in this bit indicates to the Power Transmitter to use a negative polarity. See Section 5.3.2.1, *Modulation scheme*, for details.

**Depth.** The unsigned integer contained in this field selects the FSK modulation depth as defined in Section 5.3.2.1.

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.13.5 Maximum Power (0x04)

Table 48 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 48. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | Maximum Power Value | | | | | |

**Maximum Power Value.** The integer value contained in this field provides an updated scaling factor for the Received Power Value that a Power Receiver reports in a Received Power Packet (see also Sections 5.2.3.4, *8-bit Received Power Packet—BPP only* (0x04) and 5.2.3.11, *24-bit Received Power Packet—EPP only* (0x31)). A Power Receiver should set this value to the twice the maximum amount of power in watts that it expects to provide at its output (see Section 5.2.3.7, *Configuration Packet (0x51)*).

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.14 FOD Status Packet—EPP only (0x22)

Table 49 defines the format of the message contained in an FOD Status Packet.

**Table 49. Message in an FOD Status Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | | | | | Mode | |
| B2 | Reference Quality Factor Value | | | | | | | |

**Mode.** This field indicates the operating mode of the Power Receiver in which the Reference Quality Factor Value applies.

**Table 50. Mode field values**

| Mode | Description |
|---|---|
| '00' | The Power Receiver is powered off |
| '01' | Reserved |
| '10' | Reserved |
| '11' | Reserved |

**Reserved.** These bits shall be set to ZERO.

**Reference Quality Factor Value.** The unsigned integer in this field contains Reference Quality Factor of the Power Receiver. See Section 11.3, *FOD based on quality factor change*, for details.

### 5.2.3.15 Renegotiate Packet—EPP only (0x09)

Table 51 defines the format of the message contained in a Renegotiate Packet.

**Table 51. Message in a Renegotiate Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Reserved | | | | | | | |

**Reserved.** These bits shall be set to ZERO.

transmitting, by modulating the operating frequency with the coil drive circuit, a frequency-modulated third communication to the inductive charging receiver of the electronic device, wherein the frequency-modulated third communication is based on the second protocol; and

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each transmit, by modulating the operating frequency with the coil drive circuit, a frequency modulated communication to the inductive charging receiver, where this communication is based on the WPC EPP protocol.

**Wireless chargers**

On information and belief, in the second mode of operation, the wireless charger communicates to the receiver using Frequency Shift Keying (frequency modulation) as described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 108 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 106) are shown below.



## 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.

#### 5.3.2.1 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:

- *Polarity*. This parameter determines whether the difference between $f_{mod}$ and $f_{op}$ is positive or negative.

  NOTE In both the Configuration Packet and a Specific Request Packet that has its Request field set to 0x03 (FSK Parameters), the Power Receiver encodes the positive polarity as a ZERO and the negative polarity as a ONE. In addition, note that a negative polarity typically increases the voltage induced in the Secondary Coil, and therefore should be used with care.

- *Depth*. This parameter determines the magnitude of the difference between $f_{op}$ and $f_{mod}$.

  NOTE Both the Configuration Packet and the Specific Request Packet (Request 0x03, FSK Parameters)) encode the modulation depth in a two-bit unsigned integer value.

The Samsung 5400 Duo Pad and 900 Watch Dock, when using Samsung Wireless Fast Charge protocol (second mode), on information and belief, transmit Samsung proprietary messages in addition to WPC EPP messages to the device being charged.
One example of such a WPC EPP message is an "acknowledge" message. This is described in

WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 55, 113 (*see also* WPC 1.2.3

Standard, Parts 1 and 2, Interface Definitions, page 111):



**Extended Power Profile:**

- If the Neg bit in the received Configuration Packet is set to ZERO, the Power Transmitter should proceed to the *power transfer* phase without sending a Response.
- If the Neg bit in the received Configuration Packet is set to ONE, the Power Transmitter shall send an Acknowledge Response within $t_{response}$ after the end of the received Configuration Packet (see also Section 5.2.3.7, *Configuration Packet (0x51)*). Subsequently, the Power Transmitter should proceed to the *negotiation* phase. See Figure 21.

**Table 55. Format of a Response**

| | Message | Description | Format |
|---|---|---|---|
| ACK | Acknowledge | Accept a request | '11111111' |
| NAK | Not-Acknowledge | Deny a request | '00000000' |
| ND | Not-Defined | Unrecognized or invalid request | '01010101' |

Some of the other responses sent by the wireless charger in the EPP mode specified in WPC 1.2.4 are shown below:

*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 |
|---|---|
| | **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. |
| | **End Negotiation.** The Power Transmitter shall return to the *selection* phase if the Power Transmitter has not sent an ACK Response earlier in the *negotiation* phase to both<br>▪ a Specific Request Packet with Request = 0x02 (Received Power Packet Type), and<br>▪ an FOD Status Packet.<br>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.<br>▪ 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 *calibration* phase.<br>▪ 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 *negotiation* phase.<br>NOTE This action effectively discards all negotiated changes to the Power Transfer Contract. |
| General Request Packet | 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, *Header*), the Power Transmitter shall send a Power Transmitter Data Not Available Packet (see Section 5.3.3.1, *Power Transmitter data not available Packet (0x00)*).<br>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. |
| FOD Status Packet | 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<br>▪ an ACK Response if it did not detect a Foreign Object; or<br>▪ a NAK Response if it did detect a Foreign Object. In this case, the Power Transmitter shall return to the *selection* phase within 5 seconds irrespective of further communications from the Power Receiver.<br>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<br>▪ adjust its quality-factor threshold based on the Reference Quality Factor Value;<br>▪ compare its measured quality factor to its adjusted threshold; and<br>▪ send an ACK or a NAK Response based on the comparison.<br>See Section 11.3, *FOD based on quality factor change* for details. |

| Packet type | Power Transmitter Response |
|---|---|
| WPID Packet | The Power Transmitter shall send<br>▪ An ACK Response if the WPID Packet was correctly received and the verification was successful.<br>▪ A NAK Response if the WPID Packet was correctly received but the verification failed.<br>▪ An ND Response if the Power Transmitter does not support WPID Packets.<br>If the Power Transmitter supports the optional WPID Packets, it shall verify the Packet contents using the CRC algorithm described in Section 5.2.3.9.1. |
| Proprietary Packet | 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, an ND Response, or a proprietary data Packet. |
| Reserved Packet | The Power Transmitter shall send an ND Response. |

regulating power delivered to the battery of the electronic device in response to the received second communication;

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as they each regulate power delivered to the battery of the device being charged in response to the received second communication.

**Wireless chargers**

The Samsung 5400 Duo Pad and 900 Watch Dock, when using Samsung Wireless Fast Charge or the Watch 'Fast Wireless Charging' proprietary protocol to, for example, charge an S22 Ultra or Watch5 respectively, each regulates the power transfer in response to CEP messages received from the S22 Ultra or Watch5 based on the second protocol (EPP).

In both the first and second modes of operation, the Samsung 5400 Duo Pad and 900 Watch Dock each regulate the power delivered to the receiver per the WPC Standard as shown below:

During this second mode of operation, the 5400 Duo and 900 Watch Dock operate per WPC EPP protocol regulating the power delivered to the battery of the electronic device in response to the received second communication including the received Control Error Packets. *See 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).

- *power transfer* In this phase, the Power Transmitter continues to provide power to the Power Receiver, adjusting its Primary Cell current in response to control data that it receives from the Power Receiver. Throughout this phase, the Power Transmitter monitors the parameters that are contained in the Power Transfer Contract. A violation of any of the stated limits on any of those parameters causes the Power Transmitter to abort the power transfer, and returns the system to the *selection* phase. Finally, the system may also leave the *power transfer* phase on request of the Power Receiver. Section 5.1.2 defines the system control protocols in the *ping*, *identification & configuration*, and *power transfer* phases from a Power Transmitter perspective. Section 5.1.3 defines the system control protocols in these four phases from a Power Receiver perspective.

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*.

### 5.1.2.6 Power transfer phase (PTx perspective)

In the *power transfer* phase, the Power Transmitter controls the power transfer to the Power Receiver, in response to control data that it receives from the latter. For this purpose, the Power Transmitter shall receive zero or more of the following Packets:

- Control Error Packet.
- Received Power Packet.
- Charge Status Packet.
- End Power Transfer Packet.
- Renegotiate Packet.
- Any Proprietary Packet (as listed in Table 26). If the Power Transmitter does not know how to handle the message contained in the Proprietary Packet, the Power Transmitter shall ignore that message.

#### 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.

WPC further specifies tests for EPP wireless chargers to demonstrate regulation and rapid response to load changes in the receiver. Compared to the BPP load dump tests, for example, these are carried out at higher powers and with a different procedure due to differences between operation at EPP compared to BPP:

3.2.3.2 Extended Power Profile load dump test

- Position the Test Power Receiver on the Interface Surface of the Base Station, with an initial load of $R_{init}$, a Power Control Hold-off Time of $t_{delay} = 100$ ms, and an interval time between consecutive Control Error Packets of $t_{interval} = 250$ ms. See Table 5 for the relevant parameters.
- Establish communications and regulate the rectified voltage to $V_r$.
- Change the load from its initial value to $R_{heavy}$ and regulate the rectified voltage $V_r$.
- Change the load from $R_{heavy}$ to $R_{light}$ at $\Delta t_1 = 50$ ms before a sending a Control Error Packet.
- Verify that the Test Power Receiver continues to regulate and that the Base Station responds to the Control Error Packets by adjusting $V_r$.
- Measure the rectified voltages $V_0$, $V_1$, and $V_{min}$ with timings as shown in Figure 9 above, where $\Delta t_2 =$ 1800 ms.
- Verify the measured values with the limits provided in Table 5.

wherein the first mode of operation is associated with a first power level and the second mode of operation is associated with a second power level, and wherein the first power level and the second power level are different.

As detailed below by representative products, the 777 Accused Wireless Chargers each meet this part of the claim as each mode of operation is associated with a charging different power level.

**Wireless chargers**

For WPC chargers such as the 5400 Duo, the power level of BPP is less than or equal to 5 Watts (the first mode) and the power level of Samsung Wireless Fast Charge protocol is over 5 Watts and up to 15 Watts (the second mode), both modes in which the left side of the 5400 Duo can operate.

As discussed above, the 900 Watch dock operates at ~1-2 W with BPP (first mode) and at up to 5 W with the Samsung version of EPP for fast watch chargers (second mode).

https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-with-ta-dark-gray-ep-p5400tbegus/




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




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## 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]

The power level of OR-900 Watch5 charger operating in the second mode charging a Watch5 is shown below.

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** | RF7T8110011HMA |
| **Power Supply** | DC 5 V |
| **Operation Mode** | 5 W |
| **Frequency Range** | 143.5 ~ 146.5 ㎑ |
| **Antenna Type** | Loop Coil Antenna |

As shown below, the OR-900 operating in mode 1 (BPP) charges watches at lower power levels.

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/

*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

The WPC describes the difference in power levels between mode 1 and mode 2 of operation as shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 9 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 9).

### 1.3 Main features of the Qi Wireless Power Transfer System

- **A method of contactless power transfer from a Base Station to a Mobile Device that is based on near-field magnetic induction between coils.**
- **A Baseline Power Profile (BPP) supporting transfer of up to about 5 W and an Extended Power Profile (EPP) supporting transfer of up to about 15 W of power using an appropriate Secondary Coil (having a typical outer dimension of around 40 mm).**

CLAIMS DEPENDENT ON CLAIM 1:

2. The base system of claim 1, wherein the base system is configured to communicate with different types of inductive charging receivers using different inductive charging protocols.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the wireless charger of each is configured to

communicate with different types of inductive charging receivers using different inductive charging protocols.

**Wireless chargers**

The left side charger (Coil 1) in Samsung 5400 Duo Pad is capable of communicating with a Samsung earbud case using BPP and charging it according to that protocol. But when a Samsung smartphone (such as S22 Ultra) is placed on the charger, the charger can communicate with the smartphone using the Samsung Wireless Fast Charge (EPP) protocol and to charge it accordingly.




As previously referenced with respect to Claim 1, the details of which are incorporated herein, some device types, such as smartphones can use Samsung Wireless Fast Charge, and other device types, such as watches and earbud cases, can use BPP.

The Watch Dock 900 can similarly charge a Watch5 using a proprietary Samsung EPP mode at higher power levels but can also operate in mode 1 to charge earlier Watch models at a lower power level, i.e. Watch4.

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/

*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

5. The base system of claim 1, wherein the first mode of operation is a subset of the second mode of operation.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the first mode of operation, is a subset of the second

mode of operation.

**Wireless chargers**

The 5400 Duo Pad and 900 Watch Dock each include use of both BPP and WPC EPP. BPP is a subset of WPC EPP.

As shown above in claim 1, the communication by the receiver to wireless charger can use load modulation by the receiver and resulting amplitude modulation in the wireless charger coil current and a set of messages that are common to both the BPP and Samsung Wireless Fast Charge (or EPP). However, EPP also includes additional wireless charger to receiver messages using frequency shift keying and other messages that are additional to the BPP protocol. BPP is thus a subset of the WPC EPP (or Samsung Wireless Fast Charge protocol). As outlined below by Samsung, Samsung Wireless Fast Charge or the Samsung Watch Fast wireless charging can be seen as a proprietary extension to WPC BPP that underlies much of its structure.

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

## 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.

6. The base system of claim 1, wherein one of the first mode of operation and the second mode of operation is a proprietary mode of operation.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the Samsung Wireless Fast Charge mode of operation includes Samsung proprietary communication mechanisms.

**Wireless chargers**

The 5400 Duo Pad and 900 Watch Dock both include Samsung Wireless Fast Charge which is a Samsung proprietary power delivery extension.




https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-with-ta-dark-gray-ep-p5400tbegus/




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## Samsung Wireless Fast-Charge Guide

Samsung Wireless Fast-Charge Guide v1.0.2

### 1. Introduction to Samsung Proprietary Power Delivery Extension

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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

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### 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]

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

7. The base system of claim 1, wherein the microcontroller is further configured for sending a ping to the electronic device through the inductive charging coil to determine which of the first

mode of operation and second mode of operation to use, wherein the determination is made based on the received communication from the inductive charging receiver of the electronic device in response to the ping.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the microcontroller of each product is further configured for sending a ping to the electronic device through the inductive charging coil to determine which mode of operation to use, where the determination is made based on the response to the ping.

**Wireless chargers**

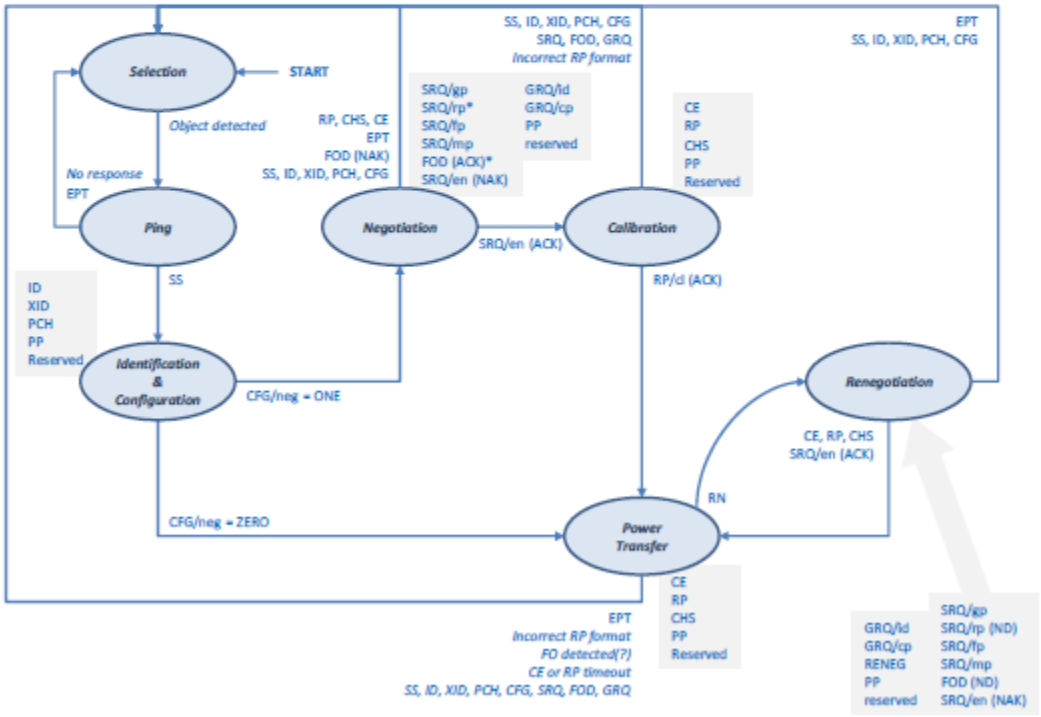
The 5400 Duo Pad and 900 Watch Dock both follows the WPC protocol which determine which mode of operation to use based on the communication received in response to the ping.

The WPC phases, including the ping and response, are as shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 86 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 48).

### 5.1.4 State diagram (informative)

**Figure 34 provides a summary of the transitions between the protocol's seven phases.**

**Figure 34. State diagram**




In response to a ping, a receiver transmits a signal strength packet followed by identification and configuration messages (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 46, 98, 99 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 46, 96, 97). The Prop bit can indicate to a wireless charger if the receiver is capable of a proprietary method of charging (such as Samsung Wireless Fast Charge). The Neg bit also indicates to the wireless charger if the receiver is capable of receiving power at up to 5 W (BPP) or higher levels (EPP or Proprietary method). As shown above in the state diagram, depending on the Neg bit in the Identification and Configuration phase communication from the receiver, the wireless charger may proceed directly to the Power Transfer phase (for BPP receivers; Neg = 0) or to Negotiation, Calibration and then Power Transfer phases for EPP or Proprietary receivers (Neg =1) as required by this claim.

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

WIRELESS POWER CONSORTIUM
The Qi Wireless Power Transfer System Power Class 0 Specification
Parts 1 and 2: Interface Definitions
Version 1.2.4
Information interface

### 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**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Power Class | | Maximum Power Value | | | | | |
| B1 | Reserved | | | | | | | |
| B2 | Prop | Reserved | | | ZERO | Count | | |
| B3 | Window Size | | | | | Window Offset | | |
| B4 | Neg | Polarity* | Depth* | | Reserved | | | |

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

The wireless charger uses the Configuration Packet communicated by the receiver to determine the mode to use.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 75,76, 99.

**Baseline Power Profile:** The Power Receiver shall set the Neg bit in its Configuration Packet to ZERO. It should also set the Polarity bit to ZERO and Depth field to 0x0. After the Power Receiver has transmitted a Configuration Packet, the Power Receiver shall proceed to the *power transfer* phase.

**Extended Power Profile:** The Power Receiver shall not send Proprietary Packets during the *identification & configuration* phase. Moreover, if the Maximum Power of the Power Receiver exceeds 5 W, it shall set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Maximum Power of the Power Receiver does not exceed 5 W, it may set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Power Receiver does not receive the first bit of an ACK Response within $t_{responsetimeout}$ after the end of the Configuration Packet, it shall:

- assume that the Power Transmitter is not able to negotiate;
- assume that the Power Transmitter supports a Guaranteed Power of 5 W only; and
- proceed to the power transfer phase.

Otherwise, the Power Receiver shall proceed to the *negotiation* phase. See Figure 30 and Figure 24.



**Prop** If this bit is set to ZERO, the Power Transmitter shall control the power transfer according to the method defined in Section 5.1.2.6.1, *Power transfer control*. If this bit is set to ONE, the Power Transmitter may control the power transfer according to a proprietary method instead of the method defined in Section 5.1.2.6.1. However, if this bit is set to ONE, the Power Transmitter shall continue to ensure that the received Control Error Packets comply with the timings defined in Section 5.1.2.6.

NOTE This implies that a Power Transmitter terminates the power transfer if it times out while waiting for a Control Error Packet. Moreover, this implies that setting the Prop bit to ONE does not relieve the Power Receiver from transmitting Control Error Packets on a regular basis. Finally, if the Prop bit is set to ZERO, the Power Transmitter could still decide to abort the power transfer based on information contained in a Proprietary Packet.

**Neg** If this bit is set to ZERO, the Power Transmitter shall refrain from sending a Response. If this bit is set to ONE, the Power Transmitter shall send an ACK Response following the end of the Configuration Packet indicating to the Power Receiver that it is entering the *negotiation* phase. See Section 5.1.2.3, *Identification & configuration phase (PTx perspective)*.

8. The base system of claim 1, wherein one of the first mode of operation and the second mode of operation is based on a Wireless Power Consortium standard.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as each device can operate according to both the WPC Standard BPP mode of operation and a Samsung proprietary higher power mode of operation.

**Wireless chargers**

The 5400 Duo Pad and 900 Watch Dock both include the WPC Standard BPP mode of operation and a respective Samsung proprietary higher power mode of operation as is discussed and shown in detail with respect to the "operating in a first mode of operation" and "operating in a second mode of operation" parts of Claim 1 above.

9. The base system of claim 1, wherein the microcontroller is further configured for detecting the presence of a foreign object between the inductive charger of the base system and the inductive charging receiver of the electronic device, wherein the determination is made based on a difference between a measured input power to the inductive charger and a received output power at the inductive charging receiver of the electronic device.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as they each include a microcontroller configured to detect foreign objects between the charger and receiver.

**Wireless chargers**

The microcontrollers of both the representative 5400 Duo Pad and 900 Watch Dock are configured for detecting the presence of foreign objects between the charger and receiver and make the determination based on measured input power and received output power.

WPC EPP describes the method for determining the presence of a Foreign Object between the charger and receiver coil. This method is based on measurement of the input power to the charger and a received output power and making a determination about the presence of a FOD as outlined below and per this claim.

(WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 135, 136 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 133,134).

## 11.4 FOD based on calibrated power loss accounting—EPP only

An Extended Power Profile Power Transmitter may apply different methods for Foreign Object Detection during the *power transfer* phase. One of these methods is the power loss method.

### 11.4.1 Introduction

The power loss $P_{loss}$, which is defined as the difference between the Transmitted Power $P_{PT}$ and the Received Power $P_{PR}$, i.e. $P_{loss} = P_{PT} - P_{PR}$, provides the power absorption in Foreign Objects:

- The Transmitted Power $P_{PT}$ represents the amount of power that leaves the Base Station due to the magnetic field of the Power Transmitter
- The Received Power $P_{PR}$ represents the amount of power that is dissipated within the Mobile Device due to the magnetic field of the Power Transmitter
- The power loss $P_{loss}$ in Foreign Objects represents the amount of power dissipated from the magnetic field of the Power Transmitter in objects that are neither part of the Base Station nor of the Mobile Device.

The Power Transmitter can determine its Transmitted Power $P_{PT}$ by measuring the power $P_{In}$ provided at its input and subtracting any power $P_{PTloss}$ that is dissipated inside the Base Station. This power $P_{PTloss}$ includes, for example:

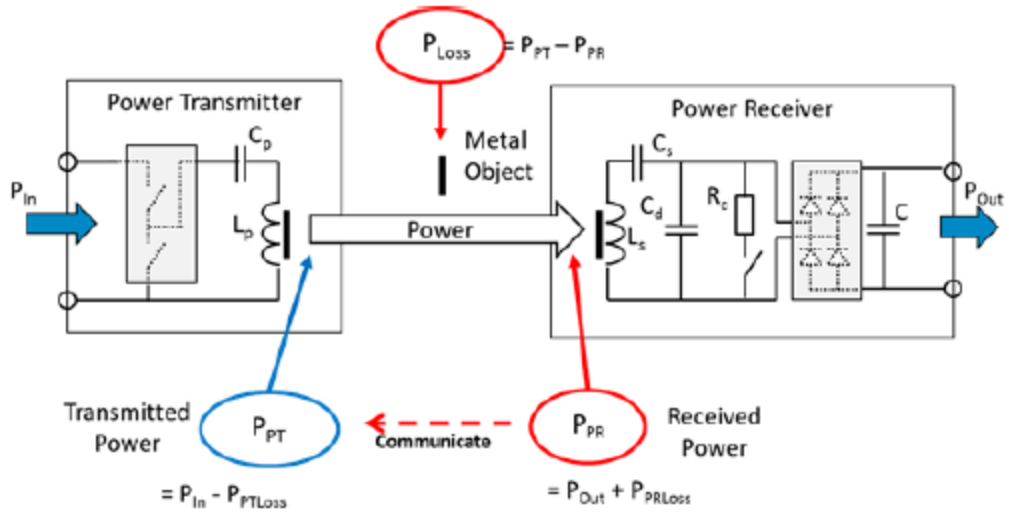
- the power loss in the inverter,
- the power loss in the Primary Coil,
- the power loss in resonance capacitors,
- the power loss in the Shielding of the Primary Coil assembly, and
- the power loss in any metal parts of the Base Station.

The Power Receiver can determine its Received Power $P_{PR}$ by measuring the power $P_{out}$ provided at its output and adding any power $P_{Prloss}$ that is lost inside the Mobile Device. This power $P_{Prloss}$ includes, for example:

- the power loss in the rectifier,
- the power loss in the Secondary Coil,
- the power loss in the resonance capacitor,
- the power loss in the Shielding of the Secondary Coil assembly, and
- the power loss in any metal parts of the Mobile Device.

Figure 47 illustrates the above.

**Figure 47. Power losses illustrated**




After receiving a Received Power Packet, the Power Transmitter can calculate the power loss and compare it to a threshold. If the power loss exceeds this threshold for one or more consecutive Received Power Packets, the Power Transmitter can conclude that a Foreign Object is present on its Interface Surface. To limit heating of the Foreign Object in that case, the Power Transmitter should remove the Power Signal, which terminates the transfer of power to the Power Receiver. Experiments have shown that 300 mW is an appropriate threshold value for limiting heating of Foreign Objects.

Upon Information and belief, the Renesas / IDT 9236 ASIC in the 5400 Duo and the Convenient Power CPS4038 ASIC in the 900 Watch Dock operate similarly to a representative Renesas / IDT P9415-R ASIC used in Galaxy S22 Ultra smartphones and operate as described in the claim.

https://www.renesas.com/us/en/document/dst/p9415-datasheet

### 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 ($C_8$) is used for a given type of receiver coil.

### 8.2.3 Advanced Foreign Object Detection (FOD) WPC MODE

When metallic objects are exposed to an alternating magnetic field, eddy currents cause such objects to heat up. Examples of parasitic metal objects are coins, keys, paperclips, etc. The amount of heating depends on the amplitude and frequency of the magnetic field coupled, as well as on the characteristics of the object such as its resistivity, size, and shape. In a wireless power transfer system, the heating manifests itself as a power loss, and therefore a reduced power transfer efficiency. Moreover, if no appropriate measures are taken, the heating could lead to unsafe situations if the objects reach high temperatures.

WPC power transmitters and receivers also need to compensate for the power loss due to parasitic metals intentionally designed into the final product: i.e., metals that are neither part of the power transmitter, nor of the power receiver, but which absorb power from magnetic field coupling during power transfer, such as Li-ion batteries, metallic cases, etc.



## 9.11 Foreign Object Detection

When metallic objects are exposed to an alternating magnetic field, eddy currents cause such objects to heat up. Examples of such parasitic metal objects are coins, keys, paper clips, etc. The amount of heating depends on the strength of the coupled magnetic field, as well as the characteristics of the object, such as its resistivity, size, and shape. In a wireless power transfer system, the heating manifests itself as a power loss, and therefore a reduction in power-transfer efficiency. Moreover, if no appropriate measures are taken, the heating could be sufficient that the foreign object could become heated to an unsafe temperature.

In the Extended Power Profile, there are two methods of foreign object detection (FOD). One is by measuring the system quality factor before entering the power transfer phase, and the other is to measure the power loss difference between the received power and the transmitted power during the power transfer phase. Before entering the power transfer phase, the P9415-R sends a reference Q-factor (default 30) in the negotiation phase. The transmitter measures the Q-factor on its coil and compares it with the reference Q-factor provided by the P9415-R. If the difference is large, the transmitter presumes that there is a foreign object (FO) between the Tx and Rx and shuts down. The power loss foreign object detection method is used in both the Extended Power Profile (EPP) and the Basic Power Profile (BPP) modes power transfer phase. During the power transfer phase, the P9415-R continuously sends to the transmitter the amount of power received using the Received Power Packet (RPP). The transmitter will compare the RPP packet information received from the receiver with its measured transmitted power. If there is a significant difference the transmitter presumes that there is a foreign object (FO) between Tx and Rx that is absorbing the transmitted power and will stop the power transfer to avoid heating of FO.



10. The base system of claim 1, wherein the base system operates in one of the first mode of operation and the second mode of operation depending on the power output level of the inductive charging receiver.

As detailed below by representative products, the 777 Accused Wireless Chargers each

additionally infringe this dependent claim as different power levels are used for different modes of operation and correspondingly different devices.

**Wireless chargers**

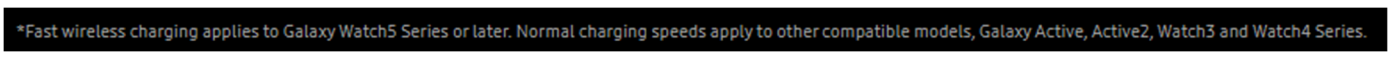
The 5400 Duo Pad and 900 Watch Dock each charge devices using multiple modes of operation and multiple power levels depending on the device being charged.

https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-with-ta-dark-gray-ep-p5400tbegus/




Samsung describes the wireless charging capabilities of the 900 Watch Charger below:

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/



11. The base system of claim 1, wherein the operating frequency for the first mode of operation is within a first frequency range and the operating frequency for the second mode of operation is within a second frequency range, and wherein the first frequency range and the second frequency range are different.

As detailed below by representative products, certain of the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the operating frequencies of the respective modes of operation are each different.

**Wireless chargers**

On information and belief, the Samsung 5400 Duo Pad, as representative of the infringing Samsung chargers, uses different frequency ranges for its different modes of operation and therefore infringes this dependent claim.

On information and belief, the EP-OR900 Watch Fast Charger uses different frequency ranges for each of its two modes (BPP and Samsung Watch Fast Charge) of operation and therefore infringes this dependent claim.

13. The base system of claim 1, wherein the received first communication for the first mode of operation and the received second communication for the second mode of operation are different.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the first communications for each of the first and second modes of operation are different.

**Wireless chargers**

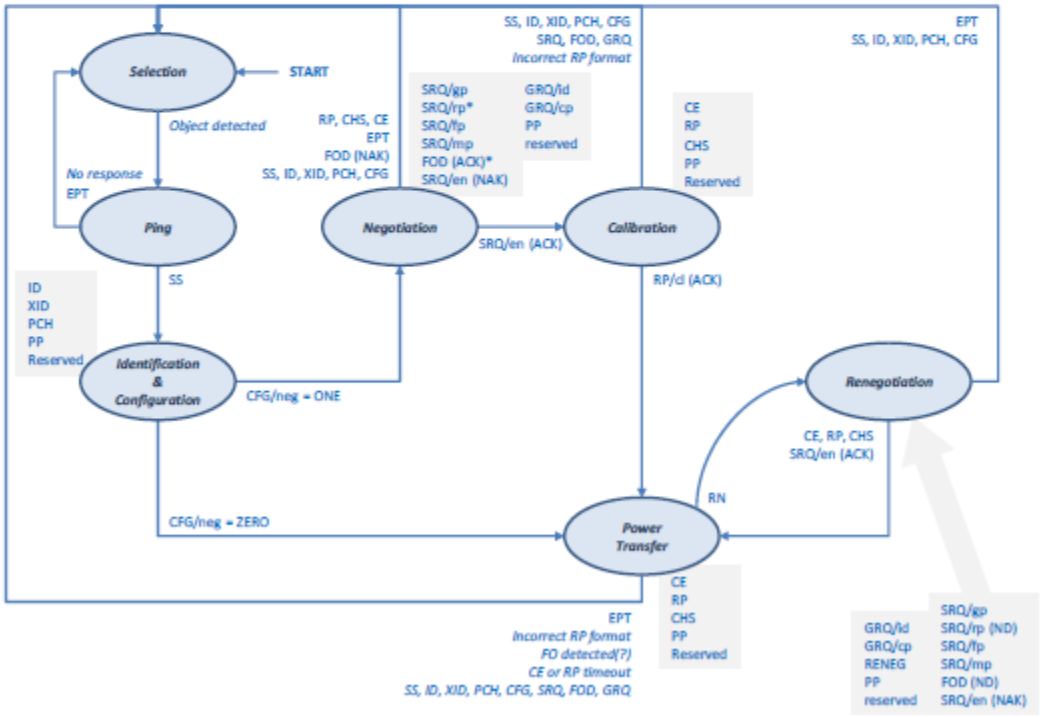
For each of the representative 5400 Duo Pad and 900 Watch Dock the received first communication for the first mode of operation and the received second communication for the second mode of operation are different, as is explained in detail below.

The state diagram for WPC EPP is shown below (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 86. *Also see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 48). As discussed in Claim 1 above, depending on the messages received by the charger during Identification and Configuration phase, the charger can proceed to the power transfer phase (for BPP receivers) or proceed to Negotiation and Calibration phases (for EPP or proprietary receivers). These received messages for the first mode and for the second mode are different to allow the charger to determine which mode the receiver is capable of operating in and to proceed with its operation accordingly. For example, infringing Samsung Chargers capable of operation in the second mode are configured to receive and understand proprietary Samsung Wireless Fast Charge or Watch Fast Wireless charging (900 Watch charger) messages (i.e. second communication) to be able to operate in the second mode.

### 5.1.4 State diagram (informative)

**Figure 34 provides a summary of the transitions between the protocol's seven phases.**

**Figure 34. State diagram**




In addition to specific proprietary or EPP messages shown in Claim 1 above, the structures of received messages by the wireless charger in the two modes are different. An example is shown below for the Received Power Packet received by a wireless charger. The Received Power Packet in the BPP (i.e. first) mode is shown below (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 96. *Also see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 94).

### 5.2.3.4 8-bit Received Power Packet—BPP only (0x04)

Table 31 defines the format of the message contained in a Received Power Packet.

**Table 31. Received Power**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Received Power Value | | | | | | | |

**Received Power Value.** The unsigned integer value contained in this field indicates the average amount of power that the Power Receiver receives through its Interface Surface in the time window indicated in the Configuration Packet. This amount of power is calculated as follows:

$$P_{\text{received}} = \left(\frac{\text{Received Power Value}}{128}\right) \times \left(\frac{\text{Maximum Power Value}}{2}\right) \times 10^{\text{Power Class}} \text{ W.}$$

Here, Maximum Power Value and Power Class are the values contained in the Configuration Packet (see Section 5.2.3.7, *Configuration Packet (0x51)*). Section 11, *Foreign Object Detection*, defines how a Power Receiver shall determine its Received Power $P_{\text{received}}$.

NOTE An EPP Power Receiver shall use this Packet if it does not receive an ACK Response from the Power Transmitter to its Configuration Packet.

While the Received Power Packet in the second mode (EPP) has a different structure and information as shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 103 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 100, 101).

### 5.2.3.11 24-bit Received Power Packet—EPP only (0x31)

Table 39 defines the format of the message contained in a Received Power Packet.

**Table 39. Message in a 24-bit Received Power Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Reserved | | | | | Mode | | |
| B1 | (MSB) Received Power Value | | | | | | | |
| B2 | | | | | | | | (LSB) |

**Mode.** The bit string in this field provides additional information with respect to the Received Power Value.

**Table 40. Mode field values**

| Mode | Description |
|---|---|
| '000' | Normal value; Response requested |
| '001' | Light-load calibration value; Response requested |
| '010' | Connected-load calibration value; Response requested |
| '011' | Reserved |
| '100' | Normal value; no Response expected |
| '101' | Reserved |
| '110' | Reserved |
| '111' | Reserved |

**Reserved.** These bits shall be set to ZERO.

**Received Power Value.** The unsigned integer contained in this field indicates the average amount of power, $P_{received}$, that the Power Receiver receives through its Interface Surface in the time window indicated in the Configuration Packet. This is expressed as

$$P_{received} = \left(\frac{\text{Received Power Value}}{32768}\right) \times \text{Maximum Power.}$$

In this calculation, the Power Transmitter uses the Maximum Power that is contained in the Power Transfer Contract. The result for $P_{received}$ is in watts. Section 11, *Foreign Object Detection*, defines how a Power Receiver shall determine its Received Power, $P_{received}$.

In addition, operation in the second mode (EPP) includes receiver to wireless charger messages that are not used in the first mode of operation (BPP) and are EPP Only. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 104-107 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 101-105).

### 5.2.3.12 General Request Packet—EPP only (0x07)

Table 41 defines the format of the message contained in a General Request Packet.

**Table 41. Message in a General Request Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Request | | | | | | | |

**Request.** This unsigned integer value indicates the kind of information that is requested. To request a particular Packet, set the Request field to the header of that Packet. For example, to request a Power Transmitter Identification Packet, set the Request field to 0x30. See Table 54 for a list of Packet headers. See Section 5.3.3, *Logical layer (PTx to PRx)* for the format of the Packets that the Power Transmitter sends in return.

### 5.2.3.13 Specific Request Packet—EPP only (0x20)

Table 42 defines the format of the message contained in a Specific Request Packet.

**Table 42. Message in a Specific Request Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Request | | | | | | | |
| B1 | Request Parameter | | | | | | | |

**Request.** The unsigned integer in this field contains the request, as defined in Table 43. See Section 5.1.2.4.2.1, *Power Transmitter Responses*, for details on the expected Response from a Power Transmitter.

**Request Parameter.** This field contains a parameter of the request. See the following subsections for details.

**Table 43. Request field values**

| Request | Description | Request Parameter |
|---|---|---|
| 0x00 | End Negotiation | Change count |
| 0x01 | Guaranteed Power | Guaranteed Power Value |
| 0x02 | Received Power Packet Type | Received Power Packet Header |
| 0x03 | FSK Parameters | Polarity and depth |
| 0x04 | Maximum Power | Maximum Power Value |
| 0x05 to 0xEF | Reserved | N.A. |
| 0xF0 to 0xFF | Proprietary | Proprietary |

### 5.2.3.13.1 End Negotiation (0x00)

Table 44 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 44. Format of the Request Parameter field**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | Change Count | | | | | | | |

**Change Count.** The unsigned integer value contained in this field provides a count of the number of parameters in the Power Transfer Contract that have been modified during the *negotiation* phase.

### 5.2.3.13.2 Guaranteed Power (0x01)

Table 45 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 45. Format of the Request Parameter field**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | Reserved | | Guaranteed Power Value | | | | | |

**Guaranteed Power Value.** This field contains the requested amount of Guaranteed Power in units of 0.5 W. For example, the value 10 serves to query if the Power Transmitter supports a Guaranteed Power of 5 W, and the value 30 queries for a Guaranteed Power of 15 W. Based on the Power Transmitter designs defined in *Part 4: Reference Designs*, a Power Receiver should not attempt to negotiate for a Guaranteed Power greater than 15 W.

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.13.3 Received Power Packet Type (0x02)

Table 46 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 46. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Received Power Packet Header | | | | | | | |

**Received Power Packet Header.** This field shall be set to 0x31 to indicate that the Power Receiver intends to use the 24-bit Received Power Packet in the *power transfer* phase.

### 5.2.3.13.4 FSK Parameters (0x03)

Table 47 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 47. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | | | | Polarity | Depth | |

**Polarity.** A ZERO in this bit indicates to the Power Transmitter to use a positive FSK polarity. A ONE in this bit indicates to the Power Transmitter to use a negative polarity. See Section 5.3.2.1, *Modulation scheme*, for details.

**Depth.** The unsigned integer contained in this field selects the FSK modulation depth as defined in Section 5.3.2.1.

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.13.5 Maximum Power (0x04)

Table 48 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 48. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | Maximum Power Value | | | | | |

**Maximum Power Value.** The integer value contained in this field provides an updated scaling factor for the Received Power Value that a Power Receiver reports in a Received Power Packet (see also Sections 5.2.3.4, *8-bit Received Power Packet—BPP only* (0x04) and 5.2.3.11, *24-bit Received Power Packet—EPP only* (0x31)). A Power Receiver should set this value to the twice the maximum amount of power in watts that it expects to provide at its output (see Section 5.2.3.7, *Configuration Packet (0x51)*).

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.14 FOD Status Packet—EPP only (0x22)

Table 49 defines the format of the message contained in an FOD Status Packet.

**Table 49. Message in an FOD Status Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | | | | | Mode | |
| B2 | Reference Quality Factor Value | | | | | | | |

**Mode.** This field indicates the operating mode of the Power Receiver in which the Reference Quality Factor Value applies.

**Table 50. Mode field values**

| Mode | Description |
|---|---|
| '00' | The Power Receiver is powered off |
| '01' | Reserved |
| '10' | Reserved |
| '11' | Reserved |

**Reserved.** These bits shall be set to ZERO.

**Reference Quality Factor Value.** The unsigned integer in this field contains Reference Quality Factor of the Power Receiver. See Section 11.3, *FOD based on quality factor change*, for details.

### 5.2.3.15 Renegotiate Packet—EPP only (0x09)

Table 51 defines the format of the message contained in a Renegotiate Packet.

**Table 51. Message in a Renegotiate Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Reserved | | | | | | | |

**Reserved.** These bits shall be set to ZERO.

14. The base system of claim 1, wherein the frequency range of the power delivered to the battery for the first mode of operation is based on the first protocol and the frequency range of the power delivered to the battery for the second mode of operation is based on the second protocol.

As detailed below by representative products, the 777 Accused Wireless Chargers each additionally infringe this dependent claim as the frequency range of the power delivered to the battery for the first mode of operation is based on the first protocol and the frequency range of the power delivered to the battery for the second mode of operation is based on the second protocol.

**Wireless chargers**

On information and belief, the Samsung 5400 Duo Pad as representative of the infringing Samsung chargers uses different frequency ranges for its different modes of operation and therefore infringes this dependent claim.

On information and belief, the 900 Watch Fast Charger uses different frequency ranges for its operation in BPP mode and a second frequency range for the Samsung Watch Fast Charge mode of operation and therefore also infringes this dependent claim.

15. An electronic device capable of receiving power inductively, the electronic device comprising:

The 777 Accused Smartphones and Wearables are accused under this claim. As detailed below by representative products, the 777 Accused Smartphones and Wearables fit the description in this introductory part of the claim, as each device is configured and capable of receiving wireless power inductively.

**Smartphones**

The Samsung Galaxy S22 Ultra smartphone is capable of receiving power inductively at multiple power levels, for different charging speeds.

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

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

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

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



Fast charger



Fast wireless charger



Super fast charger

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




On This Page

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

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.

The Samsung S22 Ultra smartphone is WPC compliant as a BPP (<5 W) receiver. The Samsung S22 Ultra can also receive power at higher power levels (from 5-15 Watts) using the proprietary Samsung Wireless Fast Charge which is a proprietary version of the WPC Extended Power Profile (EPP). The WPC certification and registration results are shown below.

https://www.wirelesspowerconsortium.com/products/12184

# SAMSUNG ELECTRONICS GALAXY S22 ULTRA (SM-S908U)

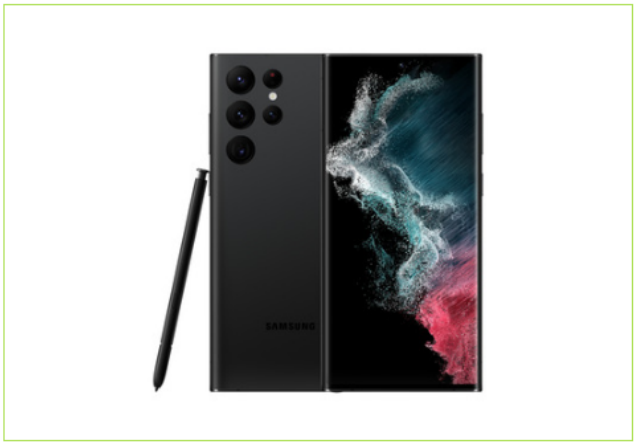
**BRAND**
Samsung Electronics

**PRODUCT NAME**
Galaxy S22 Ultra

**MANUFACTURER PART NUMBER**
SM-S908U

**PRODUCT TYPE**
Power Class 0 Receiver

**REGISTRATION DATE**
February 9, 2022



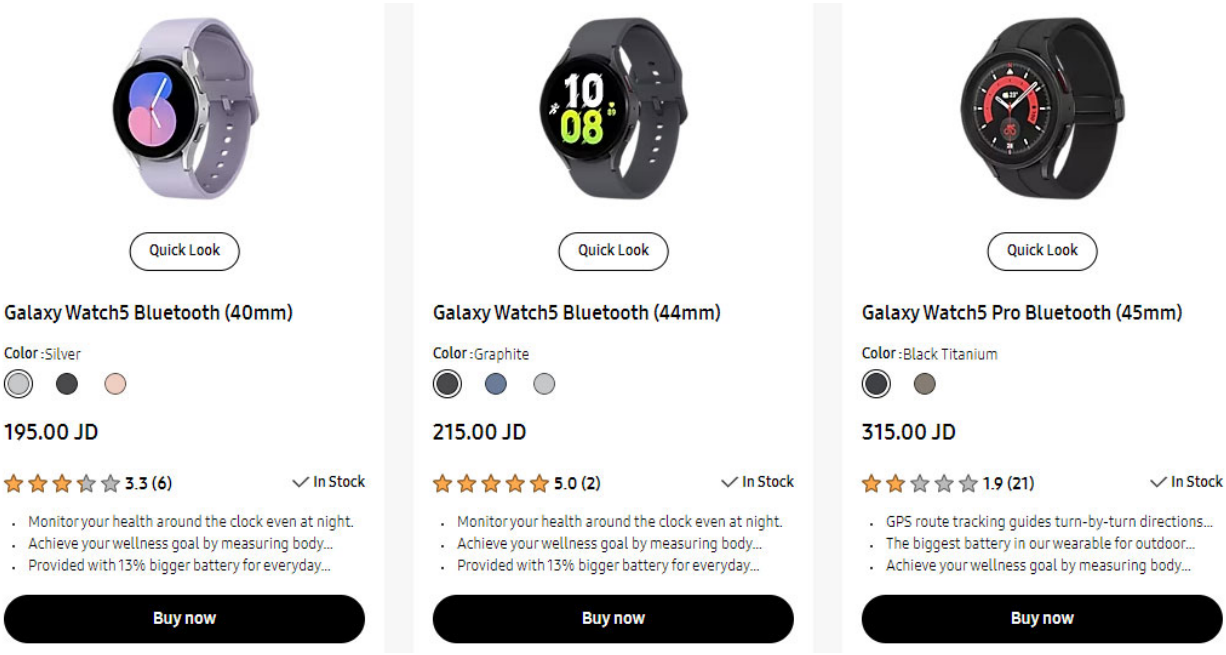
**ADDITIONAL DETAILS**

| | |
|---|---|
| **Qi Registration id** | 12184 |
| **Version** | 1.2.4 |
| **Currently licensed** | Yes |
| **Power profile** | Basic Power Profile |
| **Maximum received power** | 4.4 watts |

## Wearables

The Samsung Watch5 wearable is representative of how the 777 Accused Wearables satisfy this introductory part of claim 1. The Watch5 is capable of receiving power inductively at multiple power levels, for different charging speeds. For example, Watch5 can be charged using an EP-OR825 BPP watch charger at ~ 1-2 W power level and at up to 5 W using the Samsung Watch 'Fast Wireless Charging' with charger EP-OR900 at up to 5 W power level.

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

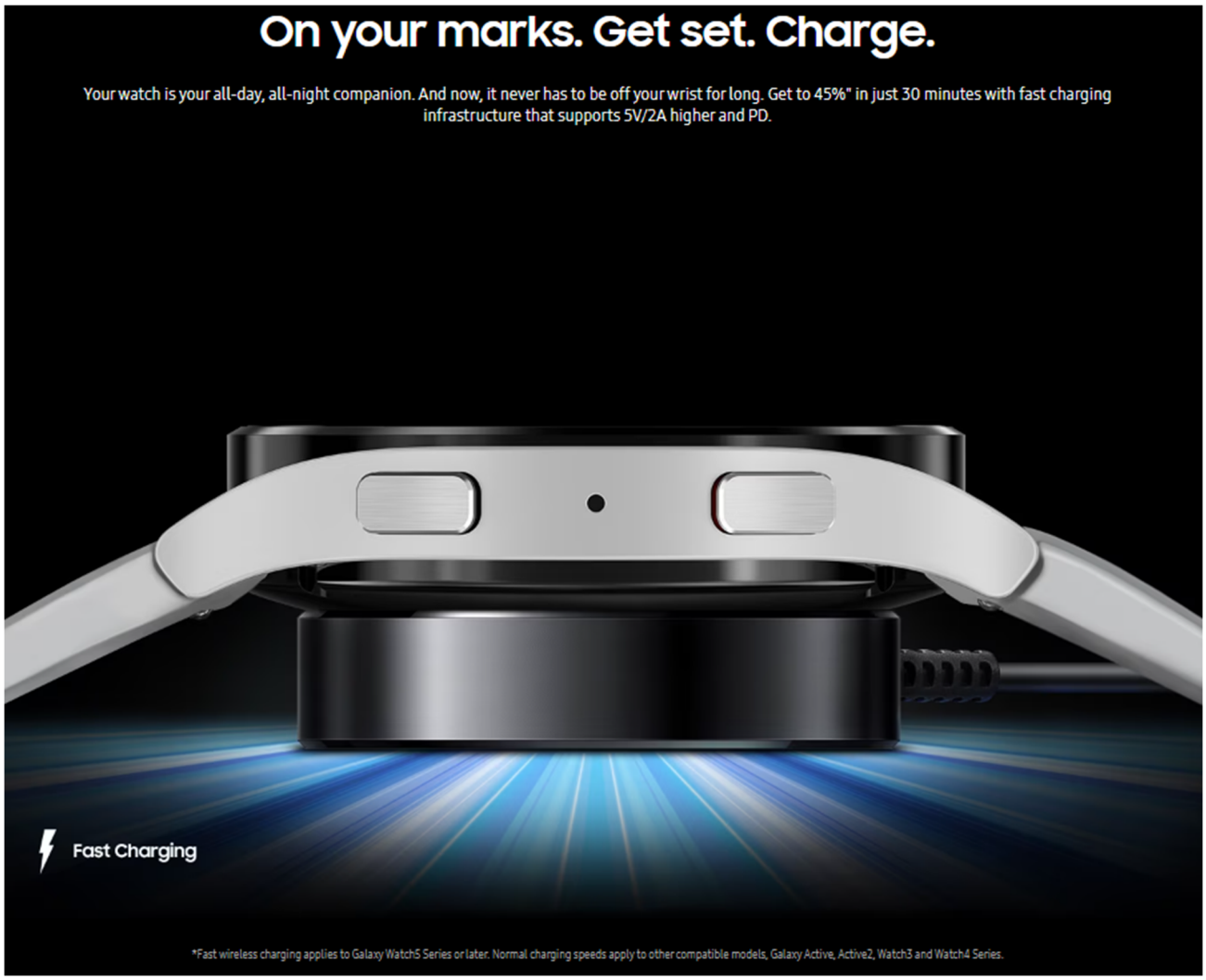



https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/




15. Testing conducted by Samsung in June 2022 using pre-released version of Galaxy Watch5 (BT & LTE), each paired to a Samsung phone; all devices tested with prerelease software, Galaxy Watch Magnetic Fast Charging USB C Cable (EP-OR900), and Samsung 25W USB C Power Adapter (EP-TA800). Charge time varies with region, settings, usage pattern and environmental factors; actual results may vary.

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active

an inductive charging receiver coil;

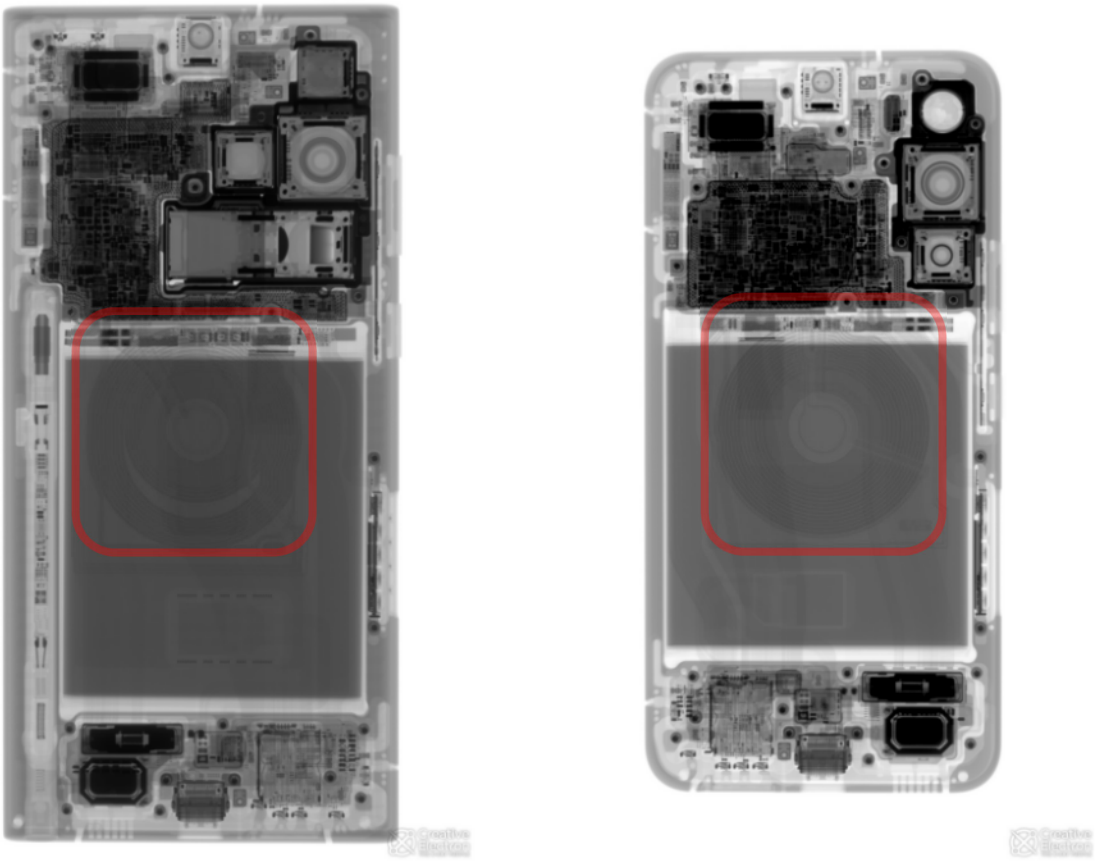
The 777 Accused Smartphones and Wearables each include a coil as specified by this part of the claim, as illustrated below for the representative products.

**Smartphones**

For example, the Samsung Galaxy S22 Ultra smartphone includes a receiver coil, as specified by this part of the claim.

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

X-ray examination



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

**Wearables**

For example, on information and belief, the Samsung Watch5 Wearable includes a receiver coil, as specified by this part of the claim.

https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/




15. Testing conducted by Samsung in June 2022 using pre-released version of Galaxy Watch5 (BT & LTE), each paired to a Samsung phone; all devices tested with prerelease software, Galaxy Watch Magnetic Fast Charging USB C Cable (EP-OR900), and Samsung 25W USB C Power Adapter (EP-TA800). Charge time varies with region, settings, usage pattern and environmental factors; actual results may vary.

*See also* https://fcc.report/FCC-ID/A3LSMR900 (various FCC test reports and internal photos).

On information and belief, the Watch5 includes a planar receiver coil similar to Watch4, (the ring shapes photo below) as shown in the listing below.
https://www.ebay.com/itm/225173935598?nma=true&si=ziHGdlkwhvLsE97LpXFj7979J8g%253D&orig_cvip=true&nordt=true&rt=nc&_trksid=p2047675.l2557




The receiver coil can be seen also in block diagram form in the 9222 datasheet below, which is believed to be representative of the wireless power receiver ASIC included in the Galaxy Watches.

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

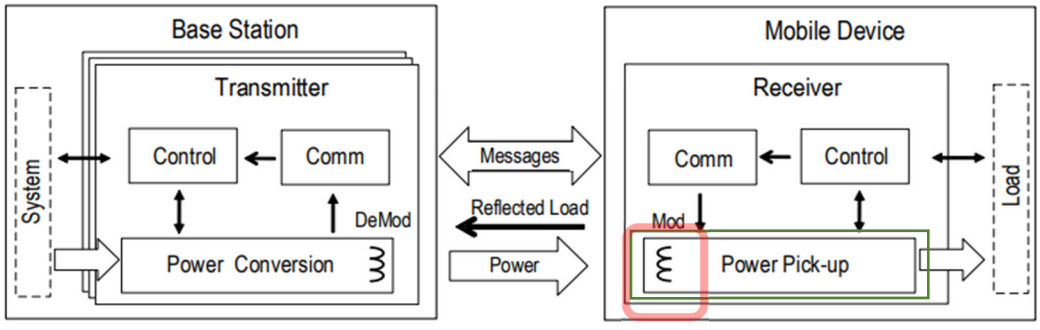
RENESAS P9222-R/RN Datasheet

## 3. Description of the Wireless Power Charging System

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

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

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




a communication transmitter circuit electrically coupled to the inductive charging receiver coil for communicating through the coil;

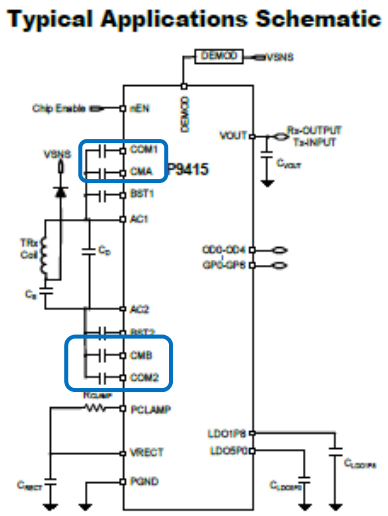
The 777 Accused Smartphones and Wearables each include a communication transmitter circuit that is coupled to the inductive charging receiver coil for communicating through the coil as specified by this part of the claim, this is illustrated below for the representative products.

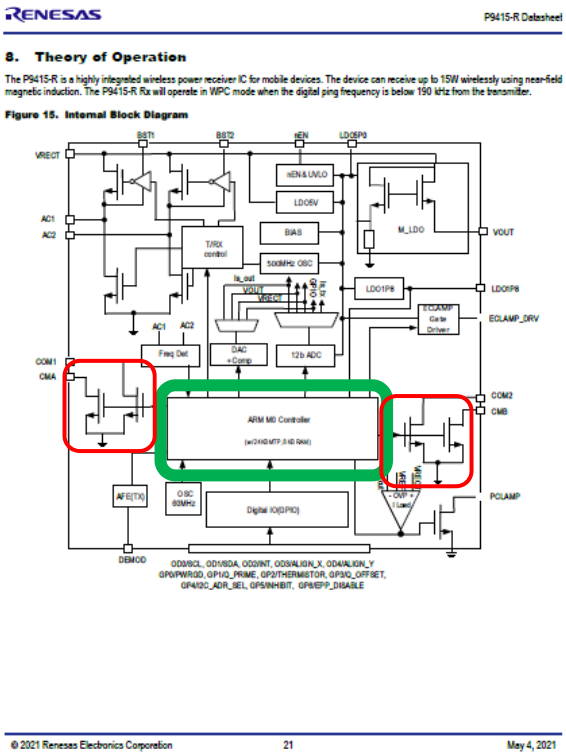
**Smartphones**

The Samsung Galaxy S22 Ultra includes the Renesas P9320S ASIC for receiving and transmitting inductive power, including for transmitting and receiving communications via the inductive charging receiver coil.

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

The S22 Ultra includes a receiver communication and control circuit with a microcontroller by way of the included wireless power transceiver ASIC. As seen in the representative 9415 datasheet, the Communication and Control circuit performs as a communication transmitter circuit which 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 transmit communications 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.



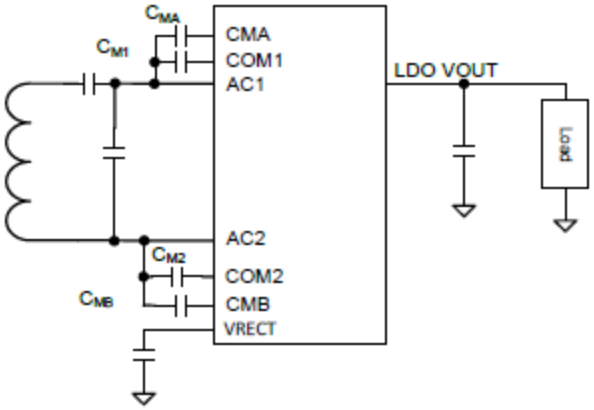




Current modulation is used for communication with the wireless charger, as explained further in the representative 9415 datasheet.

### 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:

**Figure 17. Communication Packet Structure**



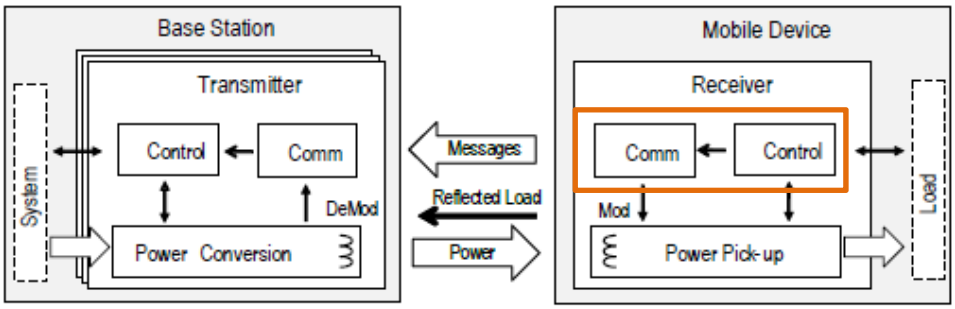

According to the WPC specification, the power receiver communicates with the power transmitter using backscatter modulation. The load seen by the power transmitter's inductor is modulated on the receiver side to send packets. The power transmitter demodulates these signals as a modulation of coil current/voltage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

## 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 WPC[1] 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.

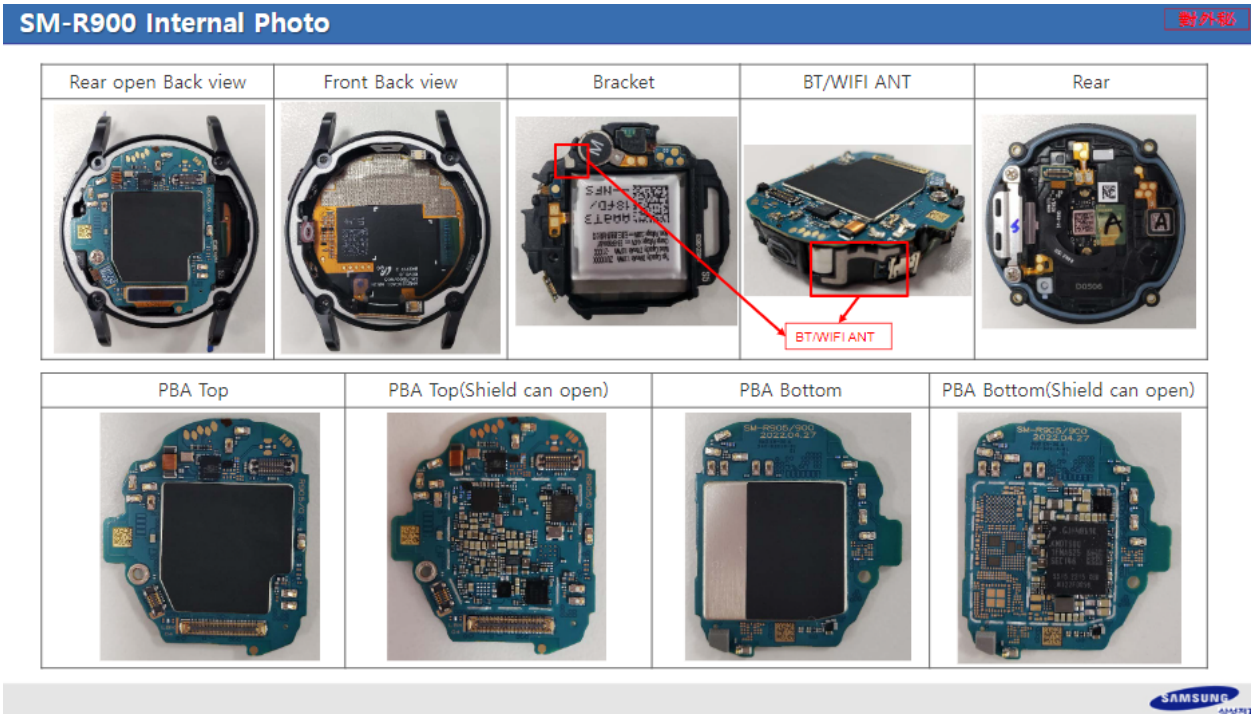
**Figure 2. Block Diagram of WPC System**




**Wearables**

On information and belief, the Samsung Watch5 includes an ASIC for receiving inductive power, including for transmitting and receiving communications via the inductive charging receiver coil.

*See* https://fcc.report/FCC-ID/A3LSMR900 (various FCC test reports and internal photos showing ASICs).




*See also* https://www.androidauthority.com/samsung-galaxy-watch-4-vs-galaxy-watch-5-3194096/

On information and belief, the Samsung Watch5 includes a similar wireless charging ASIC to the Samsung Watch4.

On information and belief, the Watch4 includes a representative receiver IC (e.g., a Renesas/IDT P9222S) (herein the "9222") used for wireless charging.

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.

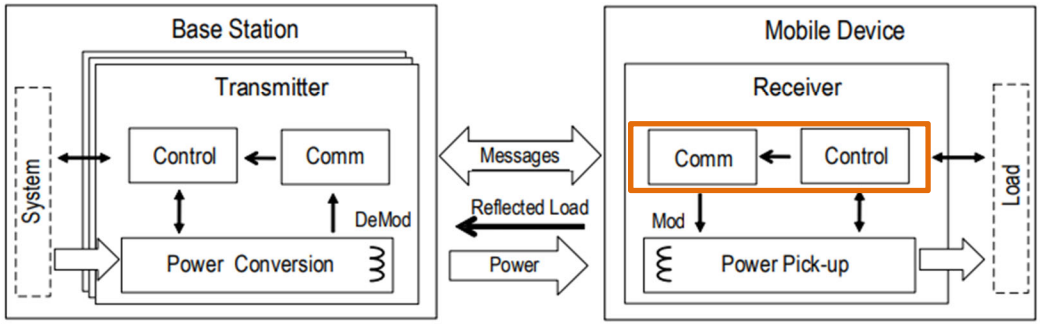
https://www.renesas.com/us/en/document/dst/p9222-rrn-datasheet

## 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**

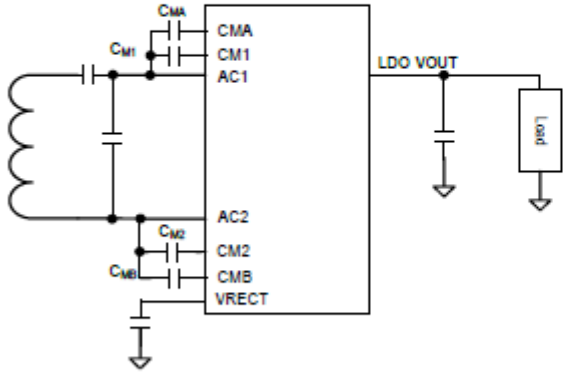



The Watch4 receives an alternating magnetic field that generates a current for inductive power transfer when placed on a compatible charger. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9 (shown above for this claim element with respect to Smartphones). On information and belief, similar to the S22 Ultra, the Watch4 (and Watch5) communicates with the charger by modulating the receiver coil impedance resulting in a modulation in the transmitter coil current / voltage.

### 7.3 WPC Modulation/Communication

The P9222-R/RN operates in the WPC mode using a single LC tank Rx coil and requires AC modulation capacitor connections for WPC communication. The capacitors $C_{M1}$ and $C_{M2}$ (connected to pins CM1 and CM2 respectively; see Figure 21) and the LC tank accomplish WPC modulation. The capacitor values should be tuned to achieve maximum efficiency while still providing adequate communications.

**Figure 21. Rx Modulation Components**






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:

The Watch5 includes a receiver communication and control circuit as specified by this part of the claim, e.g., by way of an included wireless power receiver ASIC such as seen in the representative 9222 datasheet. The communication and control circuit includes a microcontroller (green rectangle) and two communication FETs for modulating COM1 and CMA and two additional FETs for modulating COM2 and COMB (red rectangles). The 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.

*See* https://www.renesas.com/us/en/document/dst/p9222-rrn-datasheet

## Block Diagram

**Figure 1. Simplified Block Diagram**

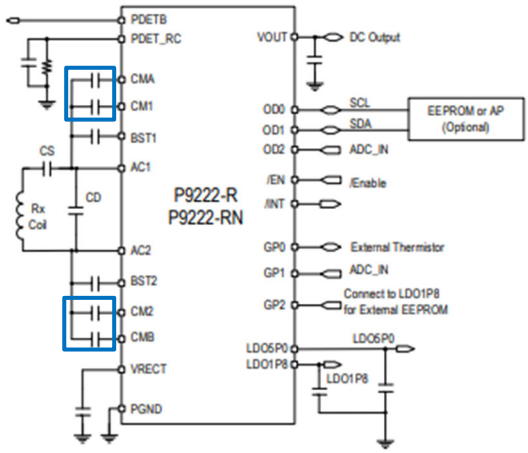
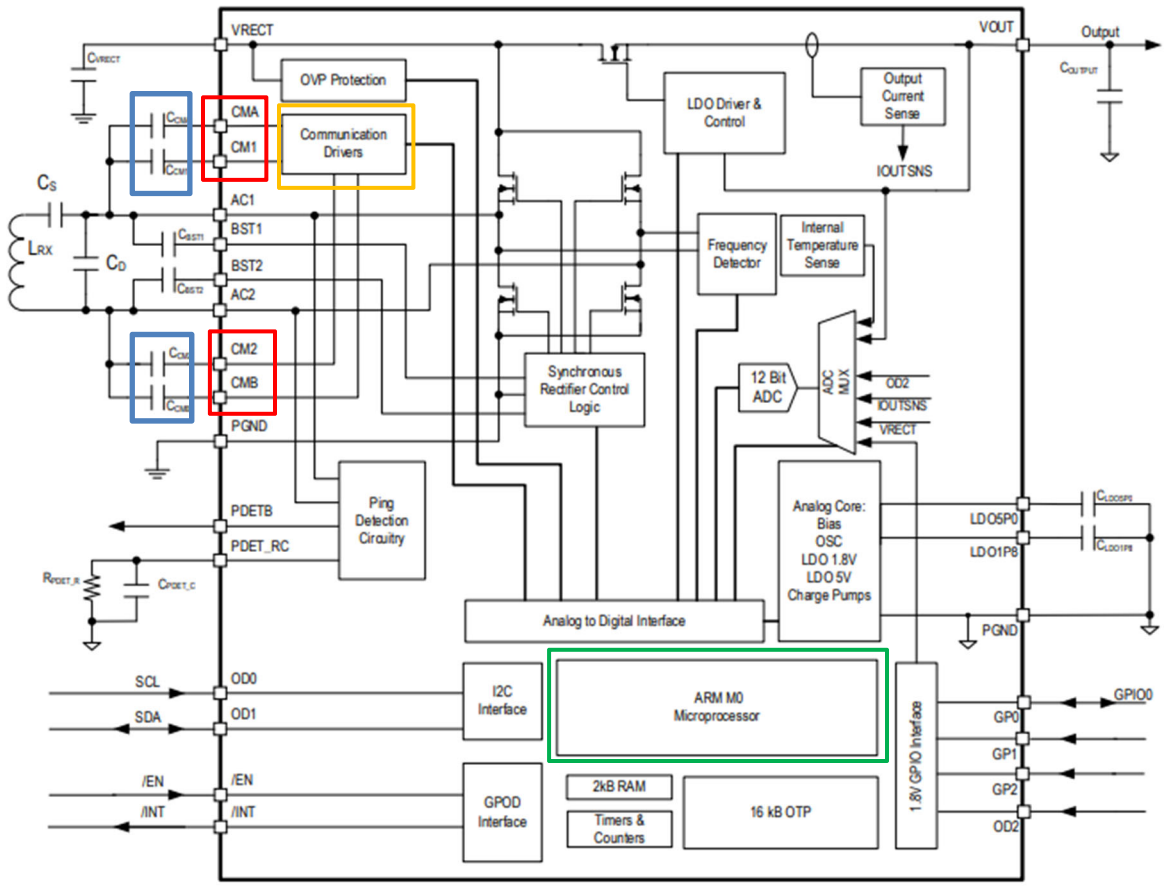





**Figure 2. P9222-R/RN Block and Application Diagram**



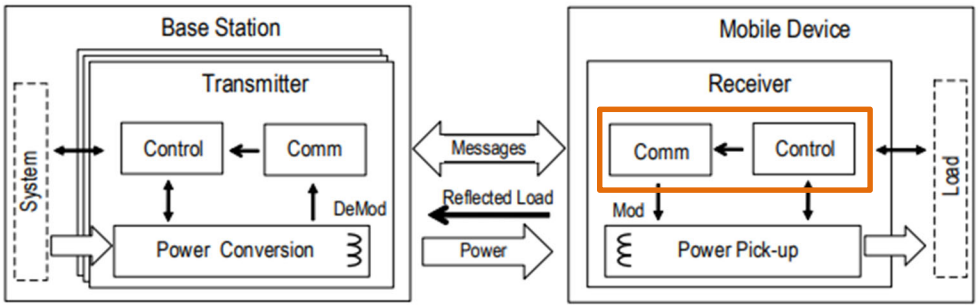
RENESAS P9222-R/RN Datasheet

## 3. Description of the Wireless Power Charging System

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

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

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




**Smartphones and Wearables – WPC**

Furthermore, the current modulation used by the S22 Ultra and Watch5 / Watch4 for communication with the charger follow 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).

WIRELESS POWER CONSORTIUM
The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
Power Class 0 Specification
Version 1.2.4 Information interface

## 5.2 Power Receiver to Power Transmitter communications interface

### 5.2.1 Introduction

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

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

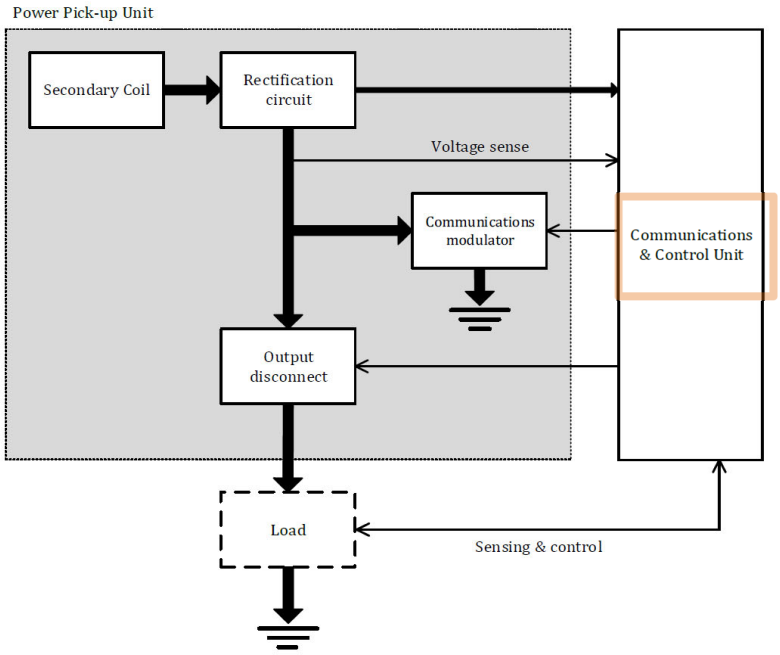


## 3 Power interface

### 3.1 Power Receiver design requirements (PRx)

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

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






a communication receiver circuit electrically coupled to the inductive charging receiver coil for communicating through the coil; and

The 777 Accused Smartphones and Wearables each include a communication receiver circuit that is coupled to the inductive charging receiver coil for communicating through the coil as specified by this part of the claim, this is illustrated below for the representative products.

**Smartphones**

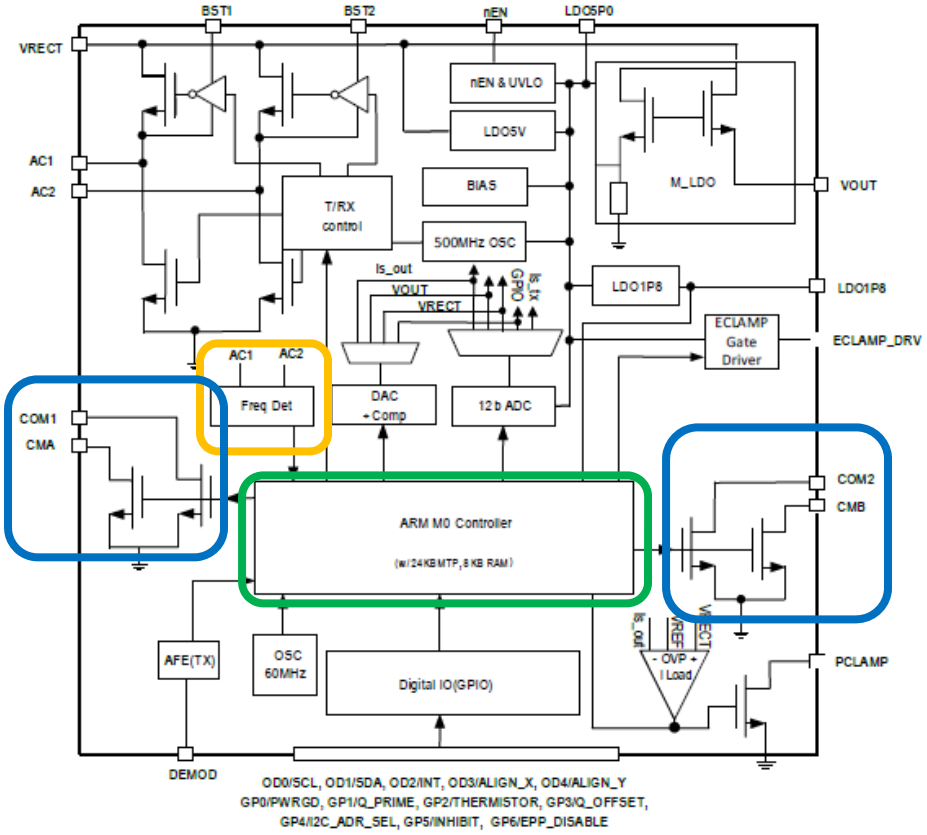
The Samsung Galaxy S22 Ultra includes the Renesas P9320S ASIC for receiving and transmitting inductive power, including for transmitting and receiving communications via the inductive charging receiver coil.

In particular, as an example of the communication receiver circuit, the relevant sections in an exemplary Renesas ASIC for the S22 Ultra are shown below. The 9415-R (15 W Receiver / Transmitter (Rx/Tx) IC for WPC 1.2)) includes a communication modulator including 4 FETs (blue rectangles below) for load modulation of the receiver circuit during communication from the receiver to the charger (during BPP or Samsung Wireless Fast Charge modes) and a communication demodulator (gold rectangle) to detect the frequency modulation of the frequency of power transfer from the wireless charger to detect communication from the charger during operation in the Samsung Wireless Fast Charge (based on WPC EPP). To detect this communication, the ASIC includes a frequency detector (communication receiver circuit) connected to the coil input AC1 and AC2 lines from the receiver coil to detect this Frequency Modulated (FM) signal. The microcontroller in the ASIC (green rectangle) coordinates the operation of the ASIC and detects the communicated messages transmitted and received by this communication receiver circuit.

## 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**



**Power Receiver P9415**
**re™ TRx Mode Datasheet**

## Features

- Single-chip medium power wireless solution
- 24kB Multiple-time programmable (MTP) non-volatile memory for expanded feature support
- WPC 1.2.4 compatible
- Delivers up to 30W as a receiver
- WattShare™ TRx mode with up to 5W Tx capability
- Embedded 32-bit ARM® Cortex®-M0 processor
- Reliable over voltage clamping
- Proprietary Rx-to-Tx modulation/demodulation for two-way communication
- High-performance LDO

**Wearables**

On information and belief, the Samsung Watch5 includes a comparable ASIC to that found in the Watch4, the Renesas P9222S ASIC (which is representative), for receiving and transmitting inductive power, including for transmitting and receiving communications via the inductive charging receiver coil.

The Watch5 includes a receiver 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 communication drivers (blue rectangles below) for load modulation of the receiver circuit during communication from the receiver to the charger (during BPP or Samsung Wireless Fast Charge modes) and a frequency detector (gold rectangle) connected to the coil input AC1 and AC2 lines from the receiver coil to detect the frequency modulation (FM) of the frequency of power transfer from the wireless charger and Analog to Digital Interface (gold rectangle) to detect FM communication from the charger during operation in the Samsung Wireless Fast Charge (based on WPC EPP). These ASIC 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**

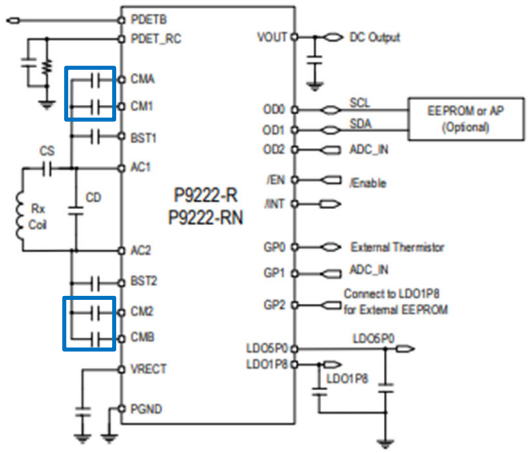
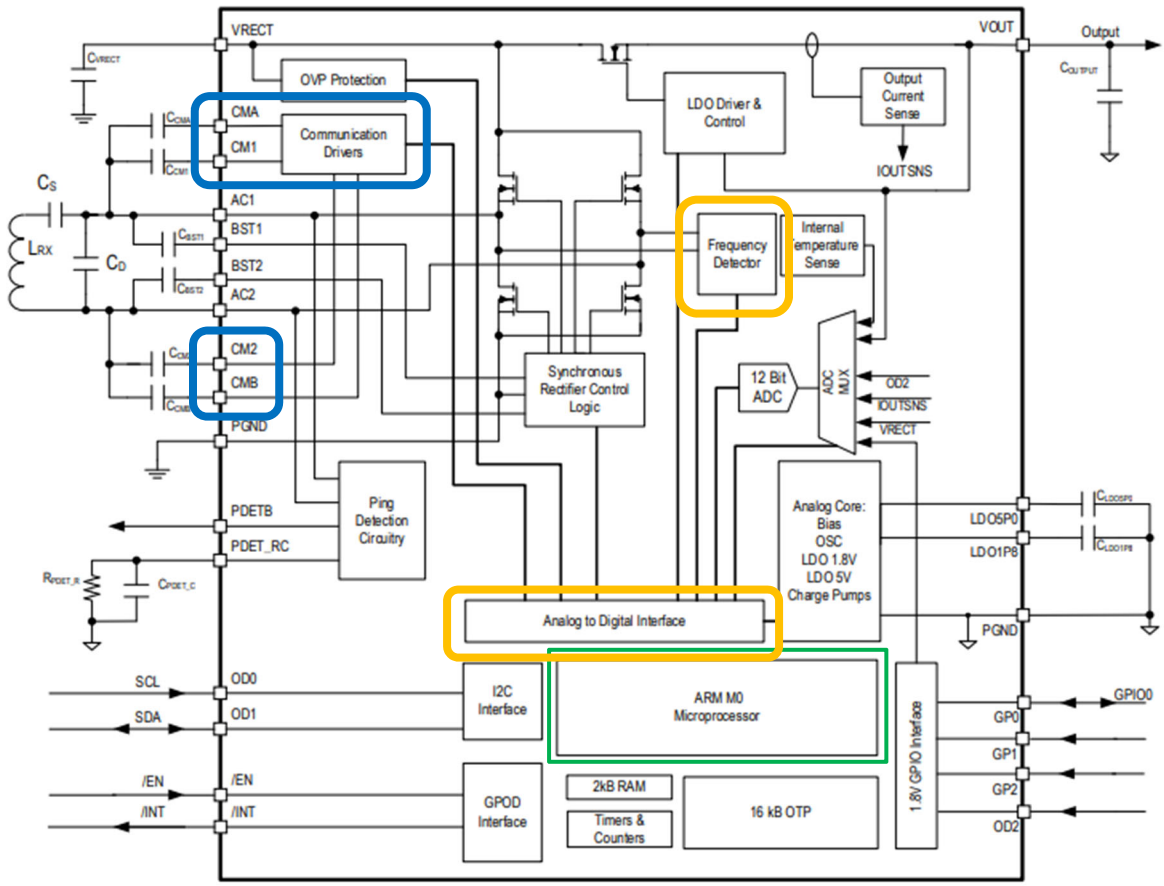
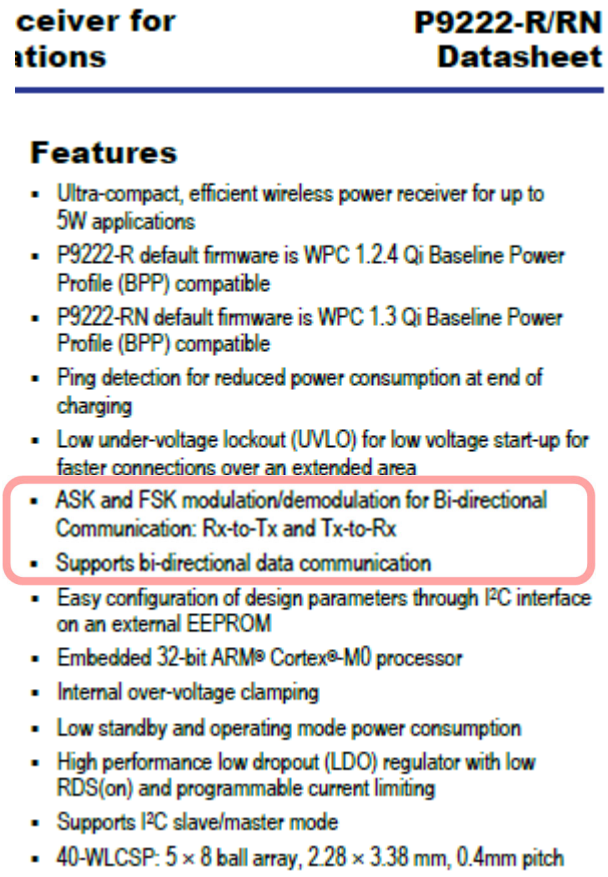





**Figure 2. P9222-R/RN Block and Application Diagram**



As shown below, the 9222 ASIC is capable of bi-directional communication including Amplitude modulation (ASK) for receiver to transmitter communication using its communication transmitter circuit (as shown above) and FSK for receiving communication from the transmitter using its communications receiving circuitry.



ceiver for
ıtions

P9222-R/RN
Datasheet

**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
- Low under-voltage lockout (UVLO) for low voltage start-up for faster connections over an extended area
- ASK and FSK modulation/demodulation for Bi-directional Communication: Rx-to-Tx and Tx-to-Rx
- Supports bi-directional data communication
- Easy configuration of design parameters through I²C interface on an external EEPROM
- Embedded 32-bit ARM® Cortex®-M0 processor
- Internal over-voltage clamping
- Low standby and operating mode power consumption
- High performance low dropout (LDO) regulator with low RDS(on) and programmable current limiting
- Supports I²C slave/master mode
- 40-WLCSP: 5 × 8 ball array, 2.28 × 3.38 mm, 0.4mm pitch

That this part of the claim is met is also indicated by the WPC Standard, as shown below for the S22 Ultra and Watch5, with respect to this part of the claim. In addition to the receiver to Transmitter communication through load modulation described in claim section above, the WPC describes the Transmitter to receiver communications during EPP.

*E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 108, 25, 28 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 106, 26, 29).

## 5.3 Power Transmitter to Power Receiver communications interface

### 5.3.1 Introduction

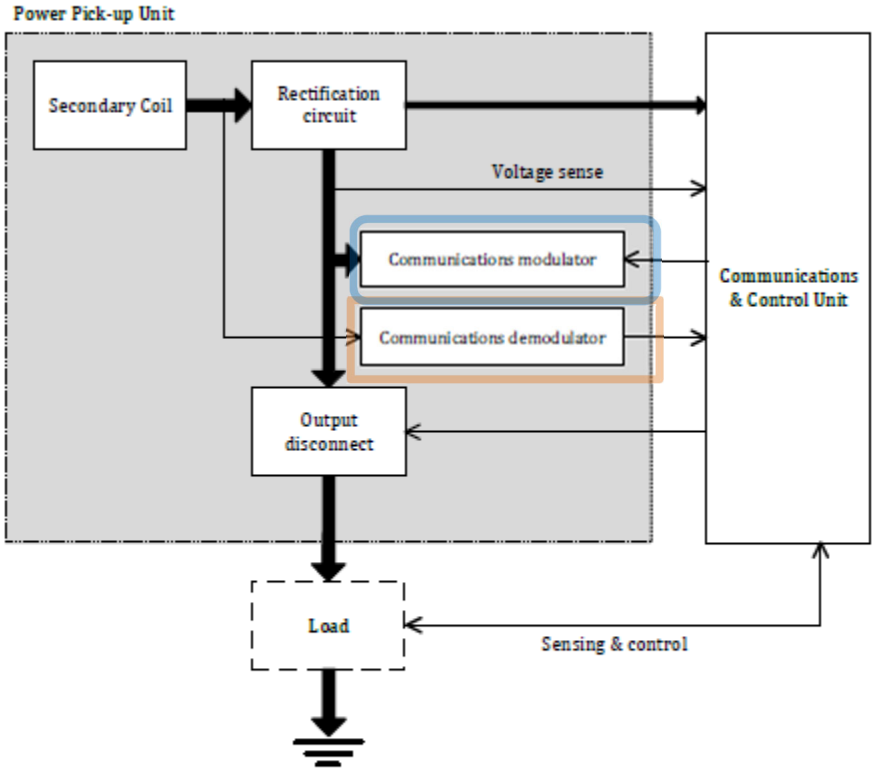
The Power Transmitter communicates to the Power Receiver using Frequency Shift Keying, in which the Power Transmitter modulates the Operating Frequency of the Power Signal.

#### 5.3.2.1 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:

Figure 5 illustrates an example of a functional block diagram for an Extended Power Profile Power Receiver. The communications demodulator enables the communication of data from the Power Transmitter to an Extended Power Profile Power Receiver. The presence of a communications demodulator is the only difference with the functional block diagram of a Baseline Power Profile Power Receiver.

**Figure 5. Functional block diagram for an Extended Power Profile Power Receiver**




Power Pick-up Unit components are described in the subsections below.

A Power Receiver design shall include a dual resonant circuit as defined in Section 3.1.1, a rectification circuit as defined in Section 3.1.2, sensing circuits as defined in Section 3.1.3, a communications modulator as defined in Section 3.1.4, and an output disconnect switch as defined in Section 3.1.6.

A Power Receiver design for the Extended Power Profile shall also include a communications demodulator as defined in Section 3.1.5, and shall be able to function meaningfully if the Power Transmitter restrictions limit the output of power from the Power Receiver to 5 W; see Section 3.1.7.

### 3.1.5 Communications demodulator

For the Extended Power Profile, the Power Receiver shall have the means to demodulate frequency-shift keying (FSK) data from the Power Signal frequency as defined in Section 5.3.2.1, *Modulation scheme*. This Specification leaves the specific method up to the designer of the Power Receiver.

a microcontroller, wherein the microcontroller is configured for:

As detailed below by representative products, the 777 Accused Smartphones and Wearables each meet this part of the claim as they each include a microcontroller.

**Smartphones**

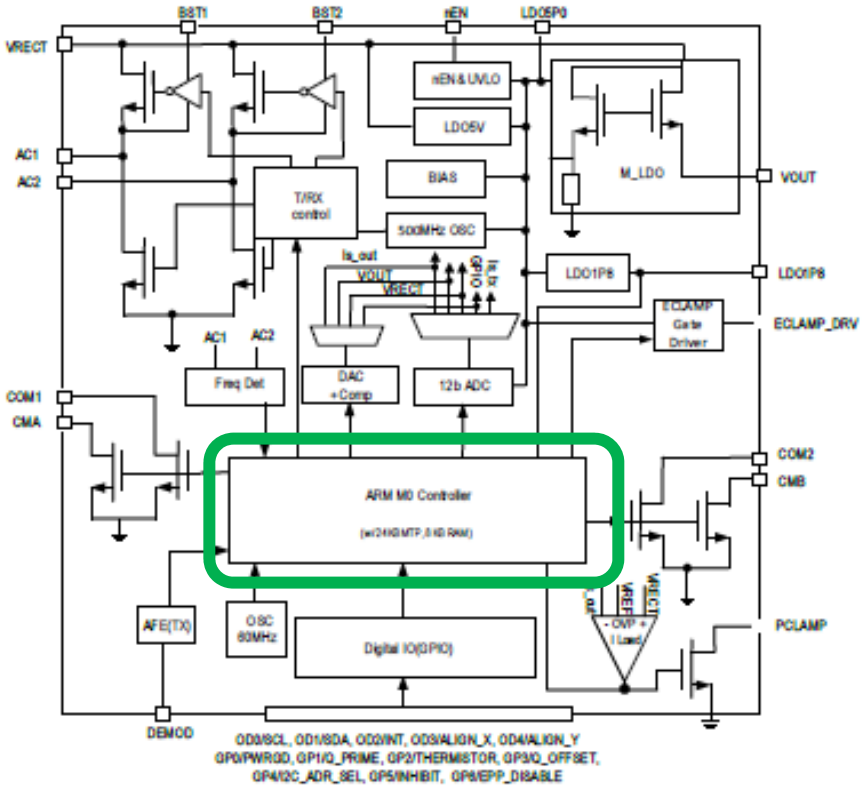
The wireless power transceiver ASIC included in the S22 Ultra includes a microcontroller as specified by this part of the claim as seen in the representative 9415 datasheet.

RENESAS P9415-R Datasheet

**8. Theory of Operation**

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

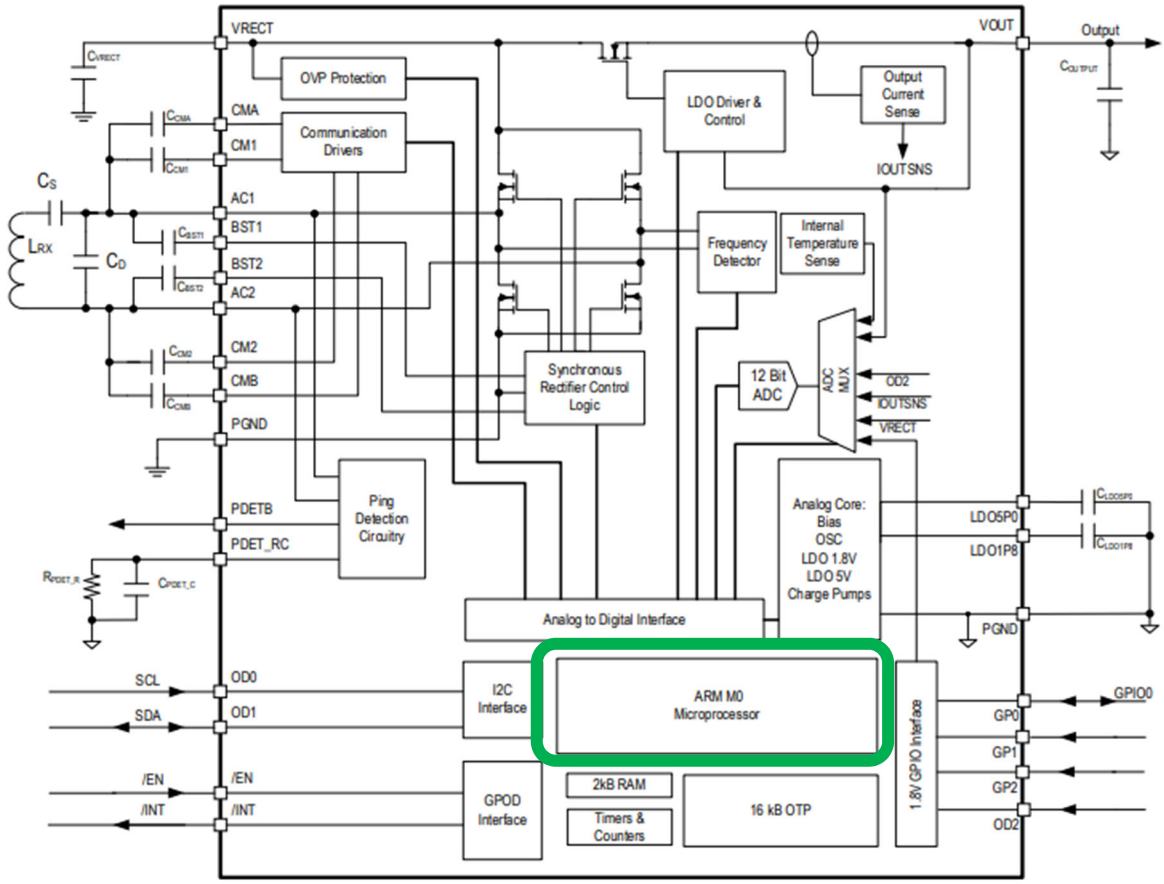
**Figure 15. Internal Block Diagram**




**Wearables**

The wireless power transceiver ASIC included in the Watch5 includes a microcontroller as specified by this part of the claim as seen in the representative 9222S datasheet.

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




operating in a first mode of operation using a first protocol, wherein the first protocol is an inductive charging communication-and-control protocol that comprises uni-directional messaging, wherein the first mode of operation comprises:

As detailed below by representative products, the 777 Accused Smartphones and Wearables each meet this part of the claim as they each include operating in a first mode using a first protocol that comprises uni-directional messaging.

Chargers and receivers that are compatible with the WPC, follow a certain communication protocol for interoperability for inductive charging. The WPC (Qi) specification defines two communication protocols (Baseline Protocol (<5 W) using uni-directional messaging from the receiver to the charger and Extended Protocol (>5 W)) introduced in WPC 1.2 and later versions using bi-directional messaging between the receiver and the charger.

The infringing products are able to operate in either protocol to enable being charged by chargers that can operate with one of the protocols to allow greater interoperability.

*See*, WPC 1.3 Standard, Communications Protocol, pages 13,14.

# 2 Overview

When a user places a Power Receiver within the Operating Volume of a Power Transmitter, the two start to communicate with the aim to configure and control the power transfer. The Power Signal provides the carrier for all communications. The *Qi Specification, Communications Physical Layer,* defines the low-level formats of data bits, data bytes, and data packets. The *Qi Specification, Communications Protocol* (this document) defines the payloads of the data packets and their use in the power control protocols.

## 2.1 Protocol phases

The *Qi Specification* defines two communications protocols.

- *Baseline Protocol*—the original protocol introduced in version 1.0 of the Qi Power Class 0 Specification, which uses Power Receiver to Power Transmitter communications only.
- *Extended Protocol*—added in version 1.2 of the Qi Power Class 0 Specification to support bi-directional communications and enhanced Foreign Object Detection (FOD) features. Version 1.3 of the *Qi Specification* adds data transport stream functionality and authentication options.

As shown in Figure 2, the communications protocol comprises several phases. The negotiation phase is not present in the Baseline Protocol.

**Figure 2. Protocol phases**




- *Ping phase.* The Power Transmitter tries to establish communications with a Power Receiver. Before doing so, it typically performs measurements to determine if there are objects such as bankcards, coins or other metals, which can damage or heat up during the power transfer. These measurements proceed without waking up the Power Receiver. See the *Qi Specification, Power Delivery,* for restrictions on such measurements.

  NOTE The Power Transmitter typically postpones a conclusion whether detected metals are Foreign Objects or Friendly Metals to the negotiation phase, after obtaining design information from the Power Receiver. See the *Qi Specification, Foreign Object Detection,* for details about recommended methods.

- *Configuration phase.* The Power Receiver sends basic identification and configuration data to the Power Transmitter. Both sides use this information to create a baseline Power Transfer Contract. Moreover, the Power Transmitter and Power Receiver decide whether to continue with the Baseline Protocol or the Extended Protocol.

  NOTE A Power Receiver can only make use of features such as enhanced FOD, data transport streams, and authentication if it implements the Extended Protocol.

- *Negotiation phase.* This phase is not present in the Baseline Protocol. The Power Transmitter and Power Receiver establish an extended Power Transfer Contract containing additional settings and limits. The Power Receiver also provides design information to the Power Transmitter, which the latter can use to complete FOD before switching to the power transfer phase. See the *Qi Specification, Foreign Object Detection,* for details about this information.
- *Power transfer phase.* This is the phase in which the power transfer to the Power Receiver's Load occurs. In the Extended Protocol, the Power Transmitter and Power Receiver perform a system calibration at the start of this phase. See the *Qi Specification, Foreign Object Detection,* for details about calibration. Occasional interruptions of this phase may occur to renegotiate an element of the Power Transfer Contract. However, the power transfer continues during such renegotiations.

**Smartphones**

The S22 Ultra operates in the BPP mode of WPC in the first mode. The device is tested and certified for this first communication and control protocol for operation at up to ~ 4.4 Watts. Operation in this first mode comprises uni-directional messaging as required by this section of the claim.

https://www.wirelesspowerconsortium.com/products/12184

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 |

**Wearables**

The Watch5 operates in the BPP mode of WPC in the first mode. The device is tested and certified for this first communication and control protocol for operation at low power levels:

The Watch5 is WPC BPP compatible as specified by the representative Renesas P9222 datasheet. Operation in this first mode comprises uni-directional messaging as required by this section of the claim.

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

- 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

https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/



*See also* https://fcc.report/FCC-ID/A3LSMR900 (various FCC test reports for Watch5).

sending, using the communication transmitter circuit, a first communication to an inductive charger, wherein the first communication identifies the first protocol; and

As detailed below by representative products, the 777 Accused Smartphones and Wearables each meet this part of the claim as they each include sending a first communication to an inductive charger using the communication transmitter circuit, where the communication identifies the first protocol.

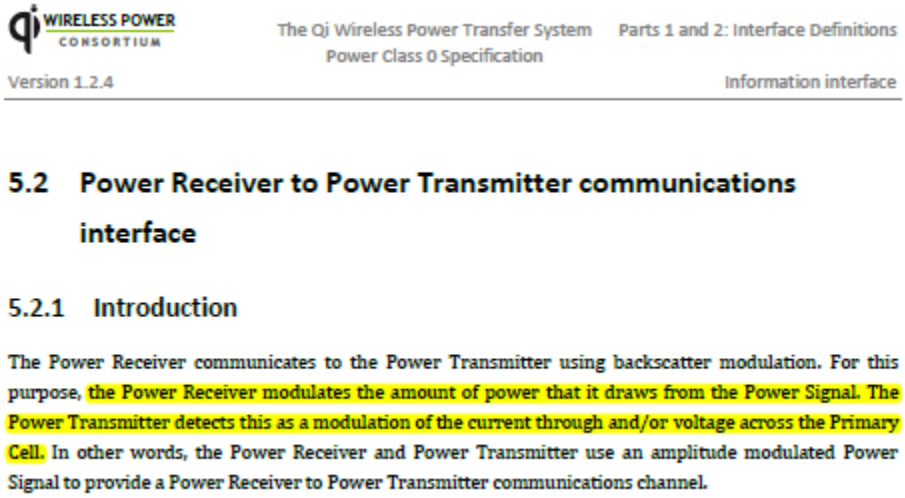
**Smartphones**

When placed on a wireless charger that does not support Samsung Wireless Fast Charge (e.g., a low power charger operating < 5W in WPC BPP mode, the Samsung S22 Ultra operates as an inductive power receiver in the WPC BPP mode (the first protocol) in which the S22 Ultra sends uni-directional communications to the wireless charger using load modulation by the FETs shown in red rectangles in images shown *supra* that enable the wireless charger to wirelessly charge the S22 Ultra.

**Wearables**

Upon information and belief, when placed on a wireless charger that does not support Samsung Watch Fast Charge (e.g., a low power charger operating < 5W in WPC BPP mode such as the Samsung EP-OR825, the Samsung Watch5 operates as an inductive power receiver in the WPC BPP mode (the first protocol) in which the Watch5 sends uni-directional communications to the wireless charger using load modulation by the FETs of the Watch5.

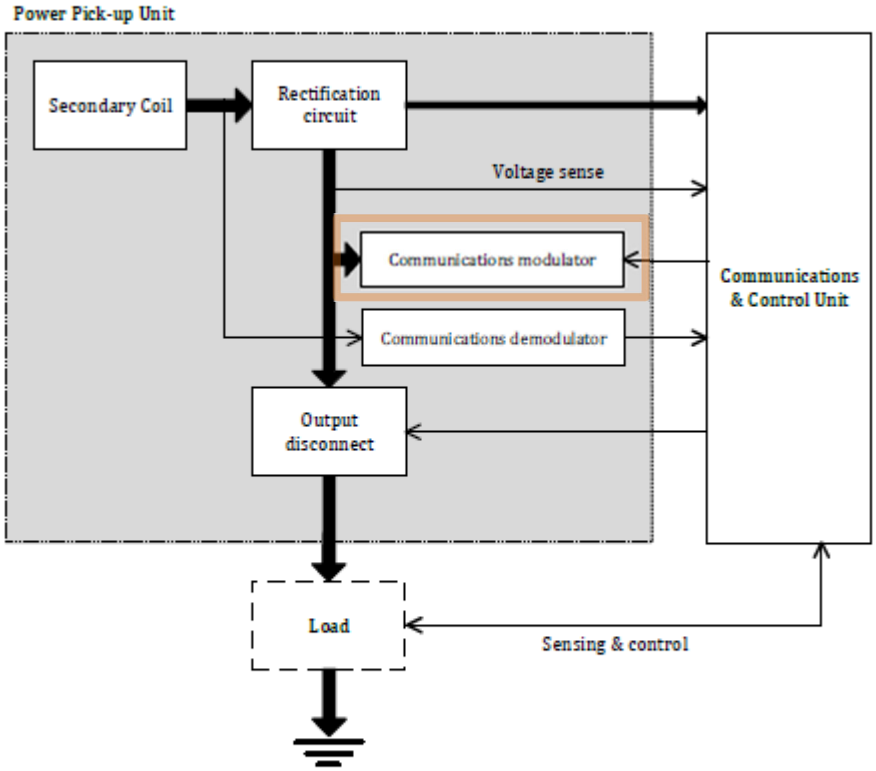
The Samsung S22 Ultra and Samsung Watch5 further meet this claim limitation as they both follow WPC protocols, selected supporting portions of which, are indicated and detailed in the images below.



- A communications modulator (see Section 3.1.4, *Communications modulator*). On the DC side of the Power Receiver, the communications modulator typically consists of a resistor in series with a switch. On the AC side of the Power Receiver, the communications modulator typically consists of a capacitor in series with a switch (not shown in Figure 4).



**Figure 5. Functional block diagram for an Extended Power Profile Power Receiver**




Power Pick-up Unit components are described in the subsections below.

A Power Receiver design shall include a dual resonant circuit as defined in Section 3.1.1, a rectification circuit as defined in Section 3.1.2, sensing circuits as defined in Section 3.1.3, a communications modulator as defined in Section 3.1.4, and an output disconnect switch as defined in Section 3.1.6.

A Power Receiver design for the Extended Power Profile shall also include a communications demodulator as defined in Section 3.1.5, and shall be able to function meaningfully if the Power Transmitter restrictions limit the output of power from the Power Receiver to 5 W; see Section 3.1.7.

### 3.1.4 Communications modulator

The Power Receiver shall have the means to modulate the Primary Cell current and Primary Cell voltage as defined in Section 5.3.2.1, *Modulation scheme*.[3] This version of the Specification leaves the specific loading method as a design choice to the Power Receiver. Typical methods include modulation of a resistive load on the DC side of the Power Receiver and modulation of a capacitive load on the AC side of the Power Receiver.

*See also* Renesas P9222 datasheet, with selected portions shown below.

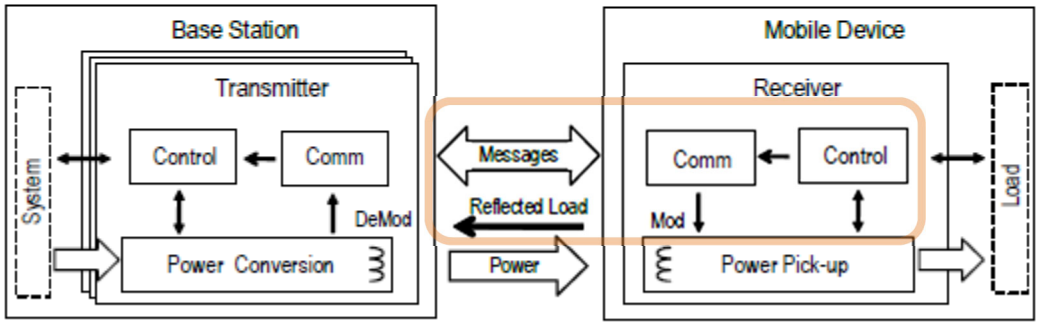


## 3. Description of the Wireless Power Charging System

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**

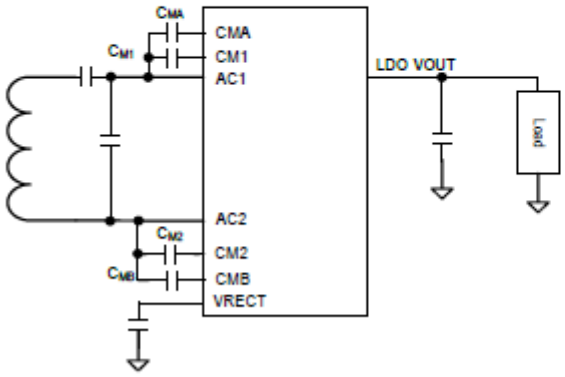



*Note*: For the more current information, see the *WPC Specification* at http://www.wirelesspowerconsortium.com/.

### 7.3 WPC Modulation/Communication

The P9222-R/RN operates in the WPC mode using a single LC tank Rx coil and requires AC modulation capacitor connections for WPC communication. The capacitors $C_{M1}$ and $C_{M2}$ (connected to pins CM1 and CM2 respectively; see Figure 21) and the LC tank accomplish WPC modulation. The capacitor values should be tuned to achieve maximum efficiency while still providing adequate communications.

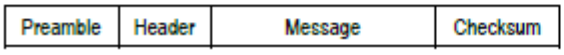
**Figure 21. Rx Modulation Components**



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:

**Figure 22. Communication Packet Structure**




High level operation of a WPC charger and receiver are described below. *E.g.*, WPC 1.2.4 Standard, Introduction, page 9.

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

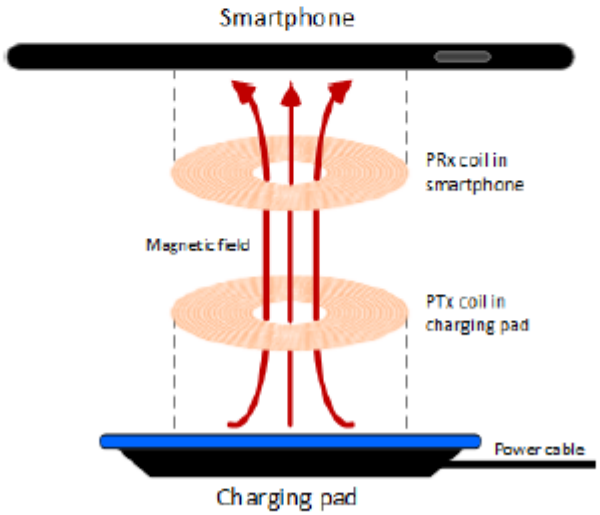
Although a Qi-based system is similar to a conventional transformer in the sense that power is transferred from a first coil to a second coil, it is also very different because of the much lower magnetic coupling between those coils. A conventional transformer has a magnetic coupling coefficient close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

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

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

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

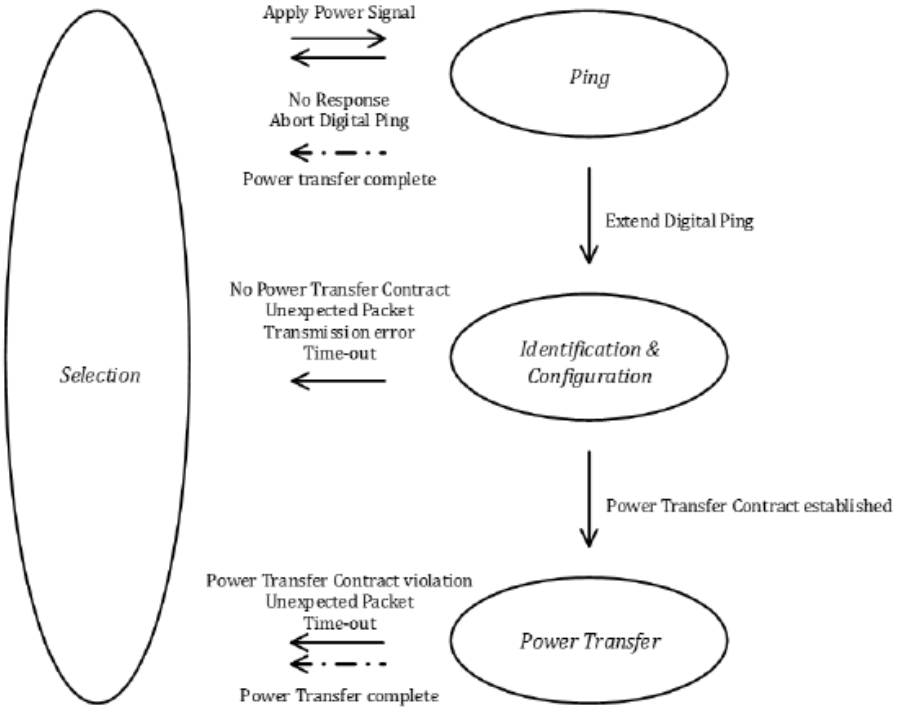
**Figure 6. Qi wireless power transfer using magnetic induction**



The charging process proceeds as per WPC BPP. *See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 93.



**Figure 16. Power transfer phases—Baseline Power 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) | Manufacturer Code | | | | | | |
| $B_2$ | | | | | | | | (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.

*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:

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

**(Extended Power Profile)** The integer value contained in this field provides a scaling factor for the Received Power Value that a Power Receiver reports in a Received Power Packet (see also Sections 5.2.3.4, *8-bit Received Power Packet—BPP only* (0x04) and 5.2.3.11, *24-bit Received Power Packet—EPP only* (0x31)). A Power Receiver should set this field to twice the Maximum Power in watts that it expects to provide at its output. For backward compatibility with Power Transmitters that have been designed according to an earlier revision of this Specification, the value contained in this field shall be at most 10.

NOTE This value corresponds to an expected output power of 5 W. A Power Transmitter stores this value in the Power Transfer Contract, and subsequently uses that stored value to calculate the Received Power, $P_{received}$. If necessary, the Power Receiver can request the Power Transmitter to update the value contained in the Power Transfer Contract during the negotiation phase of the protocol (see Section 5.1.2.4, *Negotiation phase—EPP only (PTx perspective)*).



The Prop bit in the Configuration packet identifies Proprietary modes (such as Samsung Wireless Fast Charge) and the Neg bit is used to identify BPP (Neg =0) or EPP (Neg =1) modes. *See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 99.

**Prop** If this bit is set to ZERO, the Power Transmitter shall control the power transfer according to the method defined in Section 5.1.2.6.1, *Power transfer control*. If this bit is set to ONE, the Power Transmitter may control the power transfer according to a proprietary method instead of the method defined in Section 5.1.2.6.1. However, if this bit is set to ONE, the Power Transmitter shall continue to ensure that the received Control Error Packets comply with the timings defined in Section 5.1.2.6.

NOTE This implies that a Power Transmitter terminates the power transfer if it times out while waiting for a Control Error Packet. Moreover, this implies that setting the Prop bit to ONE does not relieve the Power Receiver from transmitting Control Error Packets on a regular basis. Finally, if the Prop bit is set to ZERO, the Power Transmitter could still decide to abort the power transfer based on information contained in a Proprietary Packet.

**Neg** If this bit is set to ZERO, the Power Transmitter shall refrain from sending a Response. If this bit is set to ONE, the Power Transmitter shall send an ACK Response following the end of the Configuration Packet indicating to the Power Receiver that it is entering the *negotiation* phase. See Section 5.1.2.3, *Identification & configuration phase (PTx perspective)*.

**Polarity** A ZERO in this bit indicates to the Power Transmitter to use a positive FSK polarity. A ONE in this bit indicates to the Power Transmitter to use a negative polarity. See Section 5.3.2.1, *Modulation scheme*, for details.

**Depth** The unsigned integer contained in this field selects the FSK modulation depth as defined in Section 5.3.2.1.

**Reserved** These bits shall be set to ZERO.

**Count** This field contains an unsigned integer value that indicates the number of optional configuration Packets that the Power Receiver transmits in the *identification & configuration* phase.

**Window Size** The unsigned integer contained in this field indicates the window size for averaging the Received Power in units of 4 ms. Its value shall be greater than 1. See also Figure 33(b) in Section 5.1.3.6, *Power transfer phase (PRx perspective)*.

**Window Offset** The unsigned integer contained in this field indicates the interval between the window for averaging the Received Power and the transmission of the Received Power Packet, in units of 4 ms. See also Figure 33(b) in Section 5.1.3.6. To ensure that there is no overlap with the preamble, the value contained in this field shall be greater than $n/8$, where $n$ represents the number of preamble bits.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 75.

**Baseline Power Profile:** The Power Receiver shall set the Neg bit in its Configuration Packet to ZERO. It should also set the Polarity bit to ZERO and Depth field to 0x0. After the Power Receiver has transmitted a Configuration Packet, the Power Receiver shall proceed to the *power transfer* phase.

Following the Identification and Configuration phase, the receiver transmits periodic messages to the wireless charger to allow it to regulate the output voltage or power from the receiver in a closed loop manner. 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).

The Control Error Packet and Received Power Packet communicated during the BPP Power Transfer phase is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 95-96 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 94).

### 5.2.3.3 Control Error Packet (0x03)

Table 30 defines the format of the message contained in a Control Error Packet.

**Table 30. Control Error**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Control Error Value | | | | | | | |

**Control Error Value.** The (two's complement) signed integer value contained in this field ranges between –128...+127 (inclusive), and provides input to the Operating Point controller of the Power Transmitter. See Sections 5.1.2.6.1, *Power transfer control*, and 5.1.3.6, *Power transfer phase (PRx perspective)* for more details.

### 5.2.3.4 8-bit Received Power Packet—BPP only (0x04)

Table 31 defines the format of the message contained in a Received Power Packet.

**Table 31. Received Power**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Received Power Value | | | | | | | |

**Received Power Value.** The unsigned integer value contained in this field indicates the average amount of power that the Power Receiver receives through its Interface Surface in the time window indicated in the Configuration Packet. This amount of power is calculated as follows:

$$P_{received} = \left(\frac{\text{Received Power Value}}{128}\right) \times \left(\frac{\text{Maximum Power Value}}{2}\right) \times 10^{\text{Power Class}} \text{ W.}$$

Here, Maximum Power Value and Power Class are the values contained in the Configuration Packet (see Section 5.2.3.7, *Configuration Packet (0x51)*). Section 11, *Foreign Object Detection*, defines how a Power Receiver shall determine its Received Power $P_{received}$.

NOTE An EPP Power Receiver shall use this Packet if it does not receive an ACK Response from the Power Transmitter to its Configuration Packet.

receiving power using the inductive charging receiver coil;

As detailed below by representative products, the 777 Accused Smartphones and Wearables each meet this part of the claim as they each receive power using an inductive charging receiver coil.

**Smartphones**

The S22 Ultra receives power wirelessly using the inductive charging receiver coil.

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

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

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

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



Fast charger



Fast wireless charger



Super fast charger

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

**Wearables**

The Watch5 receives power wirelessly using the inductive charging receiver coil. *See* various citations and images *supra*.

https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/

operating in a second mode of operation using a second protocol, wherein the second protocol is an inductive charging communication-and-control protocol that defines bi-directional messaging, wherein the second mode of operation comprises: sending, using the communication transmitter circuit, a second communication to the inductive charger, wherein the second communication identifies the second protocol; receiving power using the inductive charging receiver coil; and receiving, using the receiver circuit, a frequency-modulated third communication from the inductive charger based on the second protocol; and

As detailed below by representative products, the 777 Accused Smartphones and Wearables each meet this part of the claim as they each include operating in a second mode using a second protocol that comprises bi-directional messaging, where a second communication identifies the

second protocol, power is received using the inductive charging coil, and frequency modulated communications are also received based on the second protocol.

**Smartphones**

The S22 Ultra operates at power levels over 5 W per the Samsung Wireless Fast Charge proprietary protocol based on the WPC Extended Power Profile (EPP), communicates bi-directionally with the wireless charger.

Samsung Wireless Fast Charge chargers are able to charge Samsung devices capable of receiving Samsung Wireless Fast Charge at higher than 5 watts.

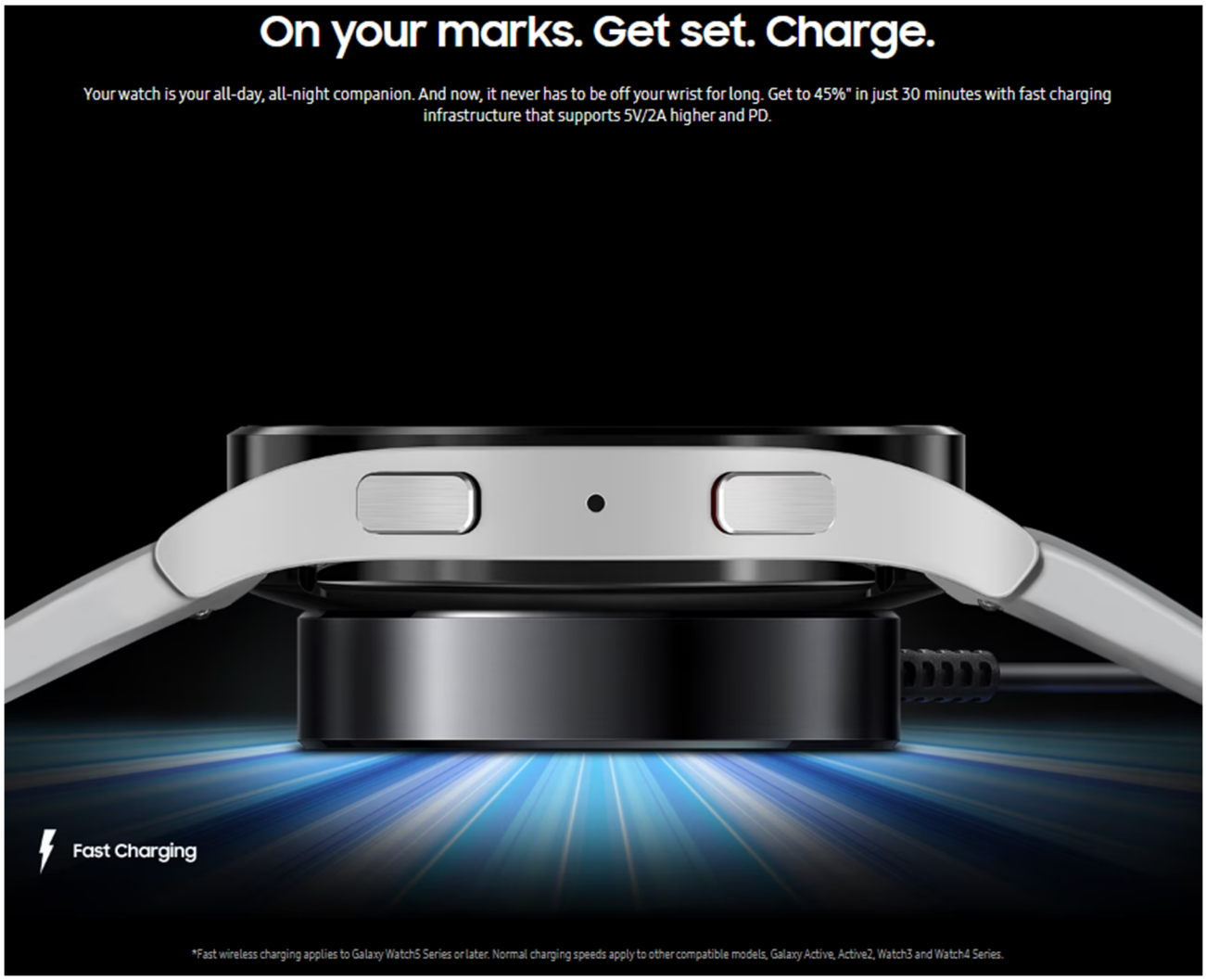
**Wearables**

The Watch5 operates at power levels up to 5 W per the Samsung Watch Fast Charge proprietary protocol based on the WPC Extended Power Profile (EPP), communicating bi-directionally with the wireless charger.

The Watch5 is able to communicate bi-directionally with the Samsung Watch Fast Charge Chargers such as EP-OR900 to charge at higher power levels (up to 5 W) than the first mode (BPP) with lower power level chargers such as EP-OR825.

Samsung describes the wireless charging capabilities of the 900 Watch Charger below:

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/



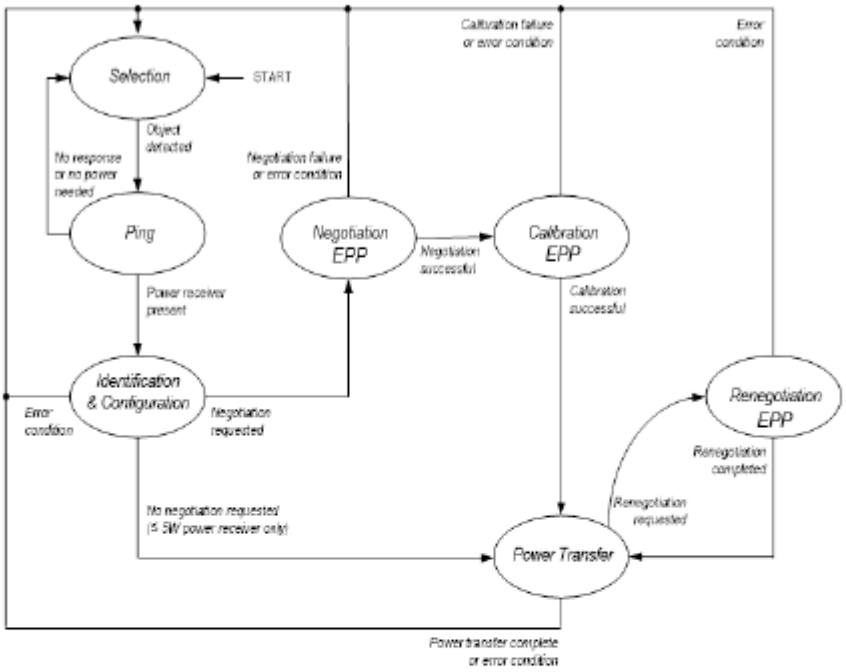

*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

Note: Additional Wearables citations at end of claim section.

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

The representative P9415-R datasheet as the representative ASIC in the S22 Ultra further describes power transfer using the WPC extended power profile.

**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

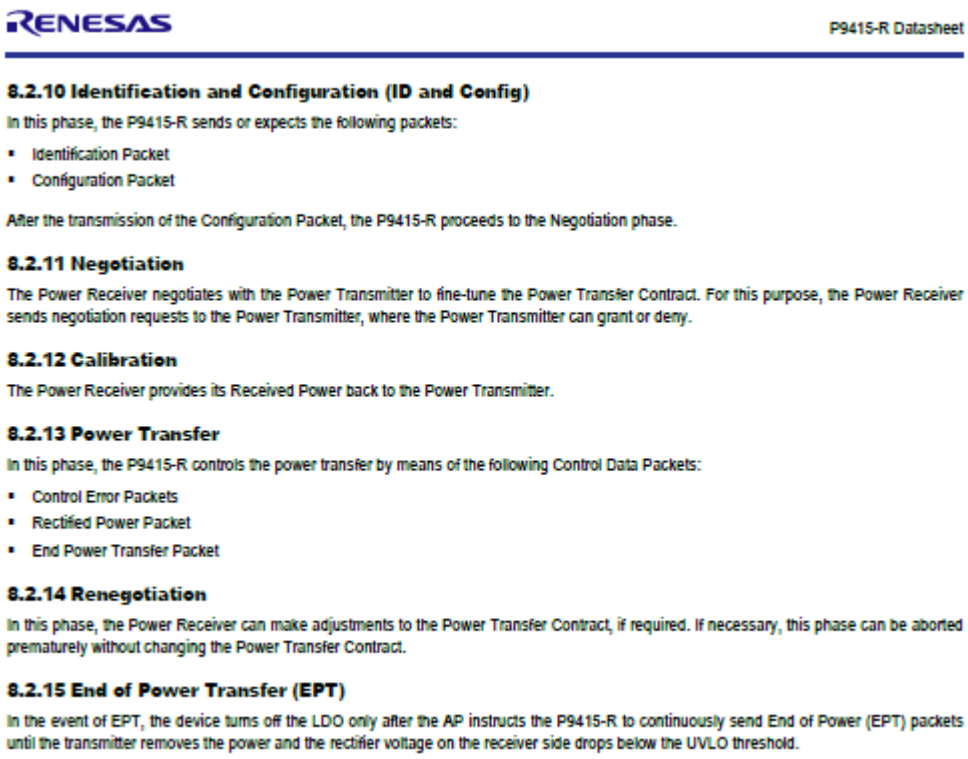
In this phase, the P9415-R senses or delivers the wireless power and proceeds to the Ping state. It monitors the rectified voltage or DEMOD signal, and when the voltage is above the $V_{UVLO\_rising}$ threshold, the P9415-R prepares to communicate with the base station or enter power Ping mode.

### 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



RENESAS P9415-R Datasheet

**8.2.10 Identification and Configuration (ID and Config)**

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

- Identification Packet
- Configuration Packet

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

**8.2.11 Negotiation**

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

**8.2.12 Calibration**

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

**8.2.13 Power Transfer**

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

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

**8.2.14 Renegotiation**

In this phase, the Power Receiver can make adjustments to the Power Transfer Contract, if required. If necessary, this phase can be aborted prematurely without changing the Power Transfer Contract.

**8.2.15 End of Power Transfer (EPT)**

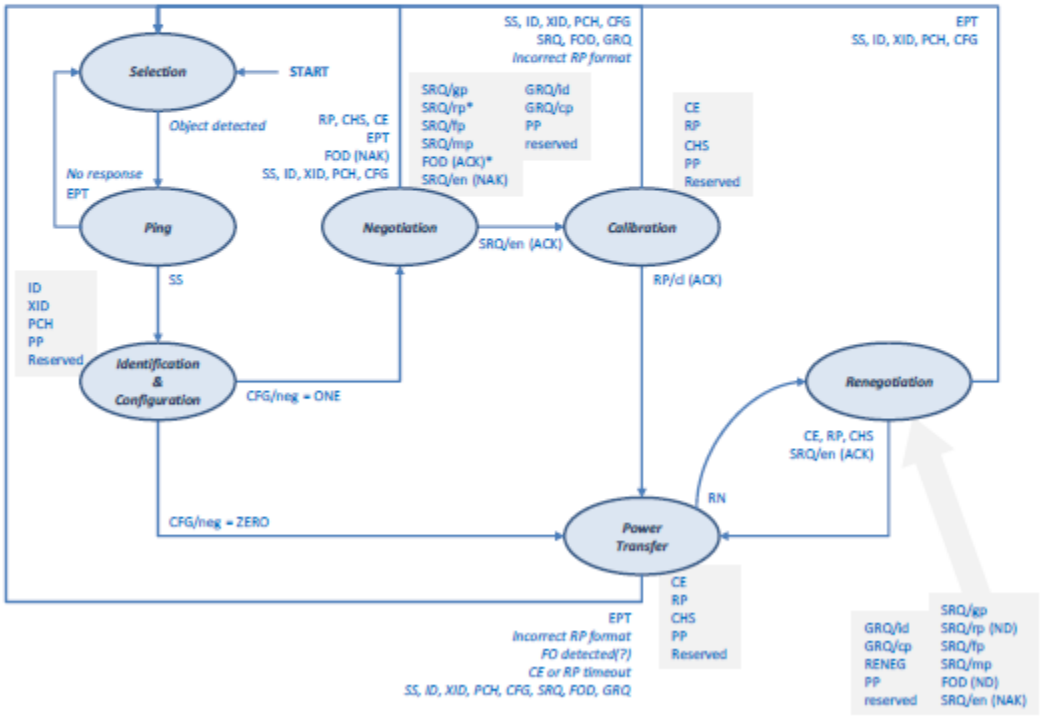
In the event of EPT, the device turns off the LDO only after the AP instructs the P9415-R to continuously send End of Power (EPT) packets until the transmitter removes the power and the rectifier voltage on the receiver side drops below the UVLO threshold.

As described in claim 1 and shown further by the P9415-R data sheet, the WPC phases, including the ping and response, are as shown below. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 86 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 48).

### 5.1.4 State diagram (informative)

Figure 34 provides a summary of the transitions between the protocol's seven phases.

**Figure 34. State diagram**



https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/




15. Testing conducted by Samsung in June 2022 using pre-released version of Galaxy Watch5 (BT & LTE), each paired to a Samsung phone; all devices tested with prerelease software, Galaxy Watch Magnetic Fast Charging USB C Cable (EP-OR900), and Samsung 25W USB C Power Adapter (EP-TA800). Charge time varies with region, settings, usage pattern and environmental factors; actual results may vary.

*See also* https://fcc.report/FCC-ID/A3LSMR900

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

Following the Ping phase, during the identification and Configuration phases, a receiver transmits a Configuration packet (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 98, 99 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 96, 97). The Prop bit can indicate to a wireless charger if the receiver is capable of a proprietary method of charging (such as Samsung Wireless Fast Charge). The Neg bit also indicates to the wireless charger if the receiver is capable of receiving power at up to 5 W (BPP) or higher levels (EPP or Proprietary method). As shown above in the state diagram, depending on the Neg bit in the Identification and Configuration phase communication from the receiver, the wireless charger may proceed directly to the Power Transfer phase (for BPP receivers; Neg = 0) or to Negotiation, Calibration and then Power Transfer phases for EPP or Proprietary receivers (Neg =1) as required by this claim.

### 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**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Power Class | | Maximum Power Value | | | | | |
| B1 | Reserved | | | | | | | |
| B2 | Prop | Reserved | | | ZERO | Count | | |
| B3 | Window Size | | | | | Window Offset | | |
| B4 | Neg | Polarity* | Depth* | | Reserved | | | |

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

WIRELESS POWER CONSORTIUM
The Qi Wireless Power Transfer System Parts 1 and 2: Interface Definitions
Power Class 0 Specification
Version 1.2.4 Information interface

**Prop** If this bit is set to ZERO, the Power Transmitter shall control the power transfer according to the method defined in Section 5.1.2.6.1, *Power transfer control*. If this bit is set to ONE, the Power Transmitter may control the power transfer according to a proprietary method instead of the method defined in Section 5.1.2.6.1. However, if this bit is set to ONE, the Power Transmitter shall continue to ensure that the received Control Error Packets comply with the timings defined in Section 5.1.2.6.

NOTE This implies that a Power Transmitter terminates the power transfer if it times out while waiting for a Control Error Packet. Moreover, this implies that setting the Prop bit to ONE does not relieve the Power Receiver from transmitting Control Error Packets on a regular basis. Finally, if the Prop bit is set to ZERO, the Power Transmitter could still decide to abort the power transfer based on information contained in a Proprietary Packet.

**Neg** If this bit is set to ZERO, the Power Transmitter shall refrain from sending a Response. If this bit is set to ONE, the Power Transmitter shall send an ACK Response following the end of the Configuration Packet indicating to the Power Receiver that it is entering the *negotiation* phase. See Section 5.1.2.3, *Identification & configuration phase (PTx perspective)*.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 76.

**Extended Power Profile:** The Power Receiver shall not send Proprietary Packets during the *identification & configuration* phase. Moreover, if the Maximum Power of the Power Receiver exceeds 5 W, it shall set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Maximum Power of the Power Receiver does not exceed 5 W, it may set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Power Receiver does not receive the first bit of an ACK Response within $t_{responsetimeout}$ after the end of the Configuration Packet, it shall:

- assume that the Power Transmitter is not able to negotiate;
- assume that the Power Transmitter supports a Guaranteed Power of 5 W only; and
- proceed to the power transfer phase.

Otherwise, the Power Receiver shall proceed to the *negotiation* phase. See Figure 30 and Figure 24.

In the second mode of communication (EPP or Proprietary) the receiver communicates using the Configuration packet to identify the receiver is capable of EPP or Proprietary mode Further communication from the receiver to the wireless charger specific to the EPP mode follow as shown below.

Following the Identification and Configuration phase, the receiver sends messages to allow a wireless charger to regulate the output voltage or power from the receiver in a closed loop manner. 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).

The Control Error Packet and Received Power Packet communicated during the BPP Power Transfer phase is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 95-96 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 94).

### 5.2.3.3 Control Error Packet (0x03)

Table 30 defines the format of the message contained in a Control Error Packet.

**Table 30. Control Error**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Control Error Value | | | | | | | |

**Control Error Value.** The (two's complement) signed integer value contained in this field ranges between –128...+127 (inclusive), and provides input to the Operating Point controller of the Power Transmitter. See Sections 5.1.2.6.1, *Power transfer control*, and 5.1.3.6, *Power transfer phase (PRx perspective)* for more details.

Some of the communications messages have a different structure in EPP (second mode) than BPP (first mode shown above).

*E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 103 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 100, 101).

### 5.2.3.11 24-bit Received Power Packet—EPP only (0x31)

Table 39 defines the format of the message contained in a Received Power Packet.

**Table 39. Message in a 24-bit Received Power Packet**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Reserved | | | | | Mode | | |
| $B_1$ | (MSB) Received Power Value | | | | | | | |
| $B_2$ | | | | | | | | (LSB) |

**Mode.** The bit string in this field provides additional information with respect to the Received Power Value.

**Table 40. Mode field values**

| Mode | Description |
|---|---|
| '000' | Normal value; Response requested |
| '001' | Light-load calibration value; Response requested |
| '010' | Connected-load calibration value; Response requested |
| '011' | Reserved |
| '100' | Normal value; no Response expected |
| '101' | Reserved |
| '110' | Reserved |
| '111' | Reserved |

**Reserved.** These bits shall be set to ZERO.

**Received Power Value.** The unsigned integer contained in this field indicates the average amount of power, $P_{received}$, that the Power Receiver receives through its Interface Surface in the time window indicated in the Configuration Packet. This is expressed as

$$P_{received} = \left(\frac{\text{Received Power Value}}{32768}\right) \times \text{Maximum Power.}$$

In this calculation, the Power Transmitter uses the Maximum Power that is contained in the Power Transfer Contract. The result for $P_{received}$ is in watts. Section 11, *Foreign Object Detection*, defines how a Power Receiver shall determine its Received Power, $P_{received}$.

### 5.2.3.12 General Request Packet—EPP only (0x07)

Table 41 defines the format of the message contained in a General Request Packet.

**Table 41. Message in a General Request Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Request | | | | | | | |

**Request.** This unsigned integer value indicates the kind of information that is requested. To request a particular Packet, set the Request field to the header of that Packet. For example, to request a Power Transmitter Identification Packet, set the Request field to 0x30. See Table 54 for a list of Packet headers. See Section 5.3.3, *Logical layer (PTx to PRx)* for the format of the Packets that the Power Transmitter sends in return.

### 5.2.3.13 Specific Request Packet—EPP only (0x20)

Table 42 defines the format of the message contained in a Specific Request Packet.

**Table 42. Message in a Specific Request Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Request | | | | | | | |
| B1 | Request Parameter | | | | | | | |

**Request.** The unsigned integer in this field contains the request, as defined in Table 43. See Section 5.1.2.4.2.1, *Power Transmitter Responses*, for details on the expected Response from a Power Transmitter.

**Request Parameter.** This field contains a parameter of the request. See the following subsections for details.

**Table 43. Request field values**

| Request | Description | Request Parameter |
|---|---|---|
| 0x00 | End Negotiation | Change count |
| 0x01 | Guaranteed Power | Guaranteed Power Value |
| 0x02 | Received Power Packet Type | Received Power Packet Header |
| 0x03 | FSK Parameters | Polarity and depth |
| 0x04 | Maximum Power | Maximum Power Value |
| 0x05 to 0xEF | Reserved | N.A. |
| 0xF0 to 0xFF | Proprietary | Proprietary |

### 5.2.3.13.1 End Negotiation (0x00)

Table 44 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 44. Format of the Request Parameter field**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | Change Count | | | | | | | |

**Change Count.** The unsigned integer value contained in this field provides a count of the number of parameters in the Power Transfer Contract that have been modified during the *negotiation* phase.

### 5.2.3.13.2 Guaranteed Power (0x01)

Table 45 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 45. Format of the Request Parameter field**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | Reserved | | Guaranteed Power Value | | | | | |

**Guaranteed Power Value.** This field contains the requested amount of Guaranteed Power in units of 0.5 W. For example, the value 10 serves to query if the Power Transmitter supports a Guaranteed Power of 5 W, and the value 30 queries for a Guaranteed Power of 15 W. Based on the Power Transmitter designs defined in *Part 4: Reference Designs*, a Power Receiver should not attempt to negotiate for a Guaranteed Power greater than 15 W.

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.13.3 Received Power Packet Type (0x02)

Table 46 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 46. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Received Power Packet Header | | | | | | | |

**Received Power Packet Header.** This field shall be set to 0x31 to indicate that the Power Receiver intends to use the 24-bit Received Power Packet in the *power transfer* phase.

### 5.2.3.13.4 FSK Parameters (0x03)

Table 47 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 47. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | | | | Polarity | Depth | |

**Polarity.** A ZERO in this bit indicates to the Power Transmitter to use a positive FSK polarity. A ONE in this bit indicates to the Power Transmitter to use a negative polarity. See Section 5.3.2.1, *Modulation scheme*, for details.

**Depth.** The unsigned integer contained in this field selects the FSK modulation depth as defined in Section 5.3.2.1.

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.13.5 Maximum Power (0x04)

Table 48 defines the format of the Request Parameter field contained in the Specific Request Packet.

**Table 48. Format of the Request Parameter field**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | Maximum Power Value | | | | | |

**Maximum Power Value.** The integer value contained in this field provides an updated scaling factor for the Received Power Value that a Power Receiver reports in a Received Power Packet (see also Sections 5.2.3.4, *8-bit Received Power Packet—BPP only* (0x04) and 5.2.3.11, *24-bit Received Power Packet—EPP only* (0x31)). A Power Receiver should set this value to the twice the maximum amount of power in watts that it expects to provide at its output (see Section 5.2.3.7, *Configuration Packet (0x51)*).

**Reserved.** These bits shall be set to ZERO.

### 5.2.3.14 FOD Status Packet—EPP only (0x22)

Table 49 defines the format of the message contained in an FOD Status Packet.

**Table 49. Message in an FOD Status Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B1 | Reserved | | | | | | Mode | |
| B2 | Reference Quality Factor Value | | | | | | | |

**Mode.** This field indicates the operating mode of the Power Receiver in which the Reference Quality Factor Value applies.

**Table 50. Mode field values**

| Mode | Description |
|---|---|
| '00' | The Power Receiver is powered off |
| '01' | Reserved |
| '10' | Reserved |
| '11' | Reserved |

**Reserved.** These bits shall be set to ZERO.

**Reference Quality Factor Value.** The unsigned integer in this field contains Reference Quality Factor of the Power Receiver. See Section 11.3, *FOD based on quality factor change*, for details.

### 5.2.3.15 Renegotiate Packet—EPP only (0x09)

Table 51 defines the format of the message contained in a Renegotiate Packet.

**Table 51. Message in a Renegotiate Packet**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Reserved | | | | | | | |

**Reserved.** These bits shall be set to ZERO.

Once the receiver has entered the second mode (EPP or proprietary) the receiver may receive messages [i.e. third communication] from the inductive charger using modulation of the operating frequency of the inductive charger based on the second protocol (mode).

WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 108 describes the method of communication from the inductive charger to the receiver. The inductive charger communicates to the receiver using Frequency Shift Keying (frequency modulation) as described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 108 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 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.

#### 5.3.2.1 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:

- *Polarity*. This parameter determines whether the difference between $f_{mod}$ and $f_{op}$ is positive or negative.

  NOTE In both the Configuration Packet and a Specific Request Packet that has its Request field set to 0x03 (FSK Parameters), the Power Receiver encodes the positive polarity as a ZERO and the negative polarity as a ONE. In addition, note that a negative polarity typically increases the voltage induced in the Secondary Coil, and therefore should be used with care.

- *Depth*. This parameter determines the magnitude of the difference between $f_{op}$ and $f_{mod}$.

  NOTE Both the Configuration Packet and the Specific Request Packet (Request 0x03, FSK Parameters)) encode the modulation depth in a two-bit unsigned integer value.

One example of such a message from the wireless charger to the receiver is an "acknowledge" message. This is described in WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 55.

**Extended Power Profile**:

- If the Neg bit in the received Configuration Packet is set to ZERO, the Power Transmitter should proceed to the *power transfer* phase without sending a Response.
- If the Neg bit in the received Configuration Packet is set to ONE, the Power Transmitter shall send an Acknowledge Response within $t_{response}$ after the end of the received Configuration Packet (see also Section 5.2.3.7, *Configuration Packet (0x51)*). Subsequently, the Power Transmitter should proceed to the *negotiation* phase. See Figure 21.

WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 113.

**Table 55. Format of a Response**

| | Message | Description | Format |
|---|---|---|---|
| ACK | Acknowledge | Accept a request | '11111111' |
| NAK | Not-Acknowledge | Deny a request | '00000000' |
| ND | Not-Defined | Unrecognized or invalid request | '01010101' |

Additional data packets transmitted by the charger to the receiver are described below (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 112).

**Table 54. Packet Types (PTx to PRx)**

| Header* | Packet Types | Message Size |
|---|---|---|
| Negotiation phase | | |
| 0x00 | Power Transmitter Data Not Available | 1 |
| 0x1E | Proprietary | 1 |
| 0x1F | Proprietary | 1 |
| 0x2E | Proprietary | 2 |
| 0x2F | Proprietary | 2 |
| 0x30 | Power Transmitter Identification | 3 |
| 0x31 | Power Transmitter Capability | 3 |
| 0x3F | Proprietary | 3 |
| 0x4F | Proprietary | 4 |
| 0x5F | Proprietary | 5 |
| 0x6F | Proprietary | 6 |
| 0x7F | Proprietary | 7 |
| 0x8F | Proprietary | 9 |

* Header values not listed in this table correspond to Reserved Packet types.

WPC provides a more detailed description of some of the packets that the wireless charger may transmit.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 115.

### 5.3.3.3 Power Transmitter Capability Packet (0x31)

Table 58 defines the format of the message contained in a Power Transmitter Capability Packet.

**Table 58. Power Transmitter Capability**

| | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | $b_0$ |
|---|---|---|---|---|---|---|---|---|
| $B_0$ | Power Class | | Guaranteed Power Value | | | | | |
| $B_1$ | Reserved | | Potential Power Value | | | | | |
| $B_2$ | Reserved | | | | | | WPID | Not Res Sens |

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

**Guaranteed Power Value.** This field identifies the maximum Guaranteed Power value contained in the Power Transfer Contract (PTC-GP) that the Power Transmitter is willing to negotiate under *current* ambient conditions.

Examples of ambient conditions are:

- The temperature of the Power Transmitter
- The amount of power that a Power Transmitter can drain from a power source that is shared with other Power Transmitters
- The presence or absence of Foreign Objects or Friendly Metal

The value in this field is in units of 0.5 W. For example, this field will display a value of 30 for a 15 W Power Transmitter operating in a normal temperature range and with sufficient input power to operate at 15 W. If the ambient temperature rises excessively or other Power Transmitters are added to the same power circuit, this field may drop down to a value of 10, indicating that a maximum of 5 W can be used under the current circumstances. Additional examples are in sections 5.3.3.3.1 and 5.3.3.3.2.

**Potential Power Value.** This field identifies the maximum Guaranteed Power value contained in the Power Transfer Contract (PTC-GP) that the Power Transmitter is willing to negotiate under *ideal* ambient conditions. The value in this field is in units of 0.5 W. The value contained in this field shall not exceed 30 (15 W).

NOTE The Power Receiver should not rely on continuously receiving power that exceeds the PTC-GP. The Power Transmitter may reduce the power available at any time, due to insufficient input power, over-heating, or other circumstances.

wherein the first mode of operation is associated with a first power level and the second mode of operation is associated with a second power level, and wherein the first power level and the second power level are different.

As detailed below by representative products, the 777 Accused Smartphones and Wearables each meet this part of the claim as each of the first mode and the second mode are associated with different charging power levels.

**Smartphones**

In the first mode of operation, the S22 Ultra operates according to WPC BPP and has the following characteristics according to testing and certification by WPC and Samsung:

https://www.wirelesspowerconsortium.com/products/12184

SAMSUNG ELECTRONICS GALAXY S22 ULTRA (SM-S908U)

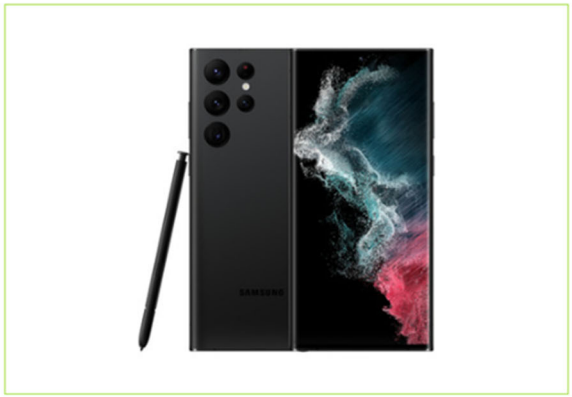
**BRAND**
Samsung Electronics

**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 Samsung Galaxy S22 Ultra smartphone is capable of receiving power inductively at multiple power levels, for different charging speeds, associated with the two modes of receiving wireless power detailed above.

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

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

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

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



Fast charger | Fast wireless charger | Super fast charger

https://www.samsung.com/global/galaxy/what-is/wireless-charging/




For higher power levels delivered, the wireless charger exchanges proprietary codes with Samsung phones to enter into the proprietary Samsung Fast Charge mode to charge Samsung phones at power levels 10+ Watts (depending on the wireless charger and phone receiver capabilities). Samsung Fast Charge wireless charging is built upon a variation of the WPC Extended Power Profile (EPP) bi-directional Communication and Control protocol architecture according to a Proprietary Power Delivery Extension (PPDE) allowed under WPC and uses Frequency Shift Keying (i.e. modulation of the wireless charger frequency) to communicate with the receiver.

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

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.

**Wearables**

In the first mode of operation, the Watch5 operates according to WPC BPP and has the following characteristics according to testing and certification by WPC and Samsung:

The Samsung Watch5 is capable of receiving power inductively at multiple power levels, for different charging speeds, associated with the two modes of receiving wireless power detailed above. *See* various citations *supra*.

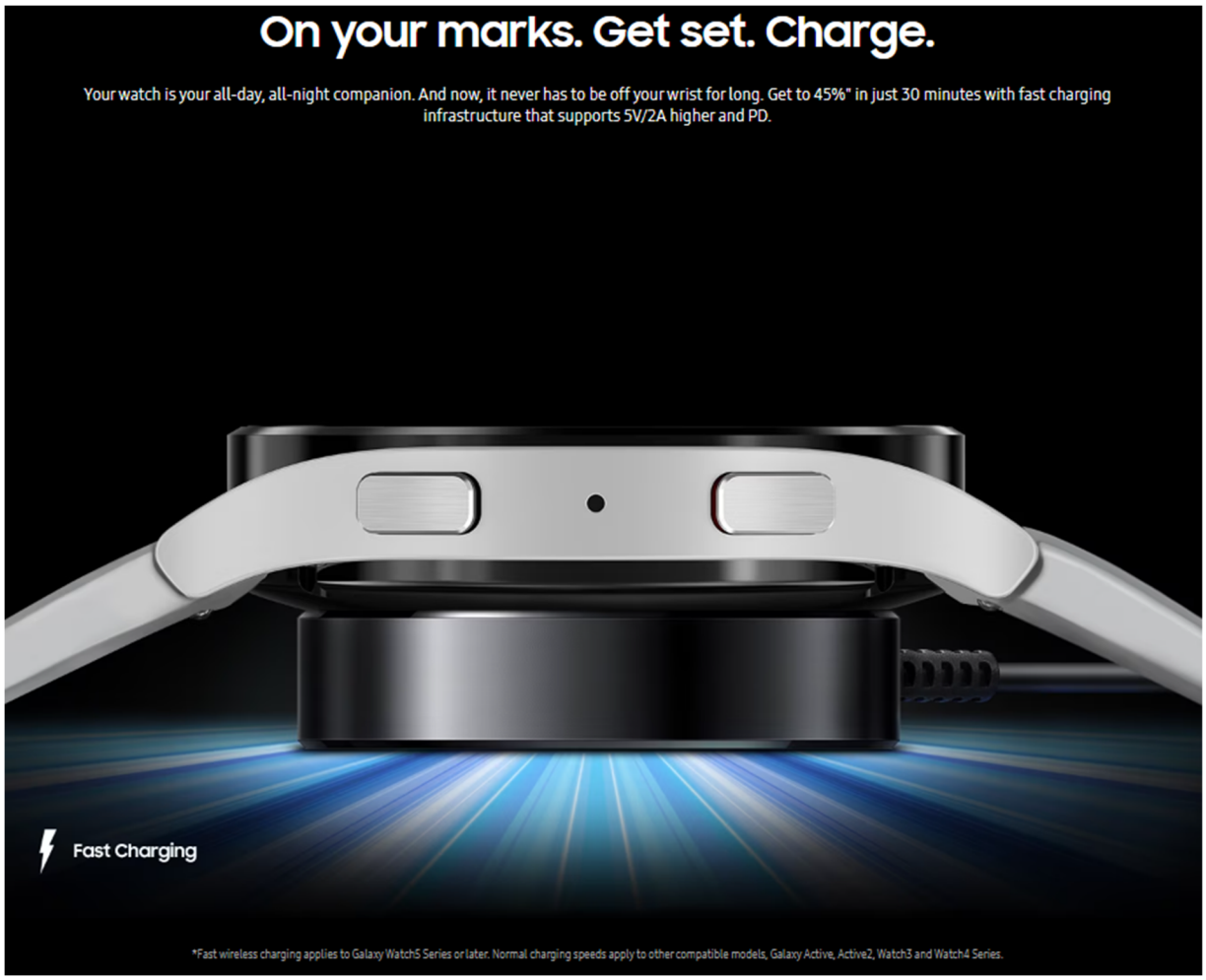
https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/




It takes about 30 minutes to go from 0% up to 45% charge. Yes, you read that right. With a bigger battery than its predecessors and fast charging, you're ready to go in no time. [15,16]

15. Testing conducted by Samsung in June 2022 using pre-released version of Galaxy Watch5 (BT & LTE), each paired to a Samsung phone; all devices tested with prerelease software, Galaxy Watch Magnetic Fast Charging USB C Cable (EP-OR900), and Samsung 25W USB C Power Adapter (EP-TA800). Charge time varies with region, settings, usage pattern and environmental factors; actual results may vary.

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

*See also* https://fcc.report/FCC-ID/A3LSMR900

The power levels for BPP and EPP are described below.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 8 and 120.

### 1.2 Scope

This document, *Parts 1 and 2: Interface Definitions*, defines the interface between a Power Transmitter and a Power Receiver, i.e. Power Class 0 Base Stations and Mobile Devices. Power Class 0 is the WPC designation for flat-surface devices, such as chargers, mobile phones, tablets, cameras, and battery packs, in the Baseline Power Profile (≤ 5 W) and Extended Power Profile (≤ 15 W).

# 7 Power Levels—Extended Power Profile only

## 7.1 Guaranteed Power

The Power Transmitter designs using the Extended Power Profile and defined in *Part 4: Reference Designs* can support a Guaranteed Power of 15 W. A Power Transmitter that is constructed according to one of these Power Transmitter designs can provide the amount of power that Test Power Receiver #MP1 needs to function at its intended Control Point. In particular, this means that if Test Power Receiver #MP1 is positioned appropriately relative to the Power Transmitter, it can provide

- 8 W of power at its output in configuration A;
- 15 W of power at its output in configuration B; and
- 12 W of power at its output in configuration C.

In addition to the receiver power requirement communicated by the receiver to the base station, the receiver uses the Configuration Packet to indicate its power level and ability to operate according to BPP, EPP or a proprietary protocol by using the Neg bit in the Configuration Packet.

*See*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 75, 76 and 99.

**Baseline Power Profile:** The Power Receiver shall set the Neg bit in its Configuration Packet to ZERO. It should also set the Polarity bit to ZERO and Depth field to 0x0. After the Power Receiver has transmitted a Configuration Packet, the Power Receiver shall proceed to the *power transfer* phase.

**Extended Power Profile:** The Power Receiver shall not send Proprietary Packets during the *identification & configuration* phase. Moreover, if the Maximum Power of the Power Receiver exceeds 5 W, it shall set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Maximum Power of the Power Receiver does not exceed 5 W, it may set the Neg field in its Configuration Packet to ONE and monitor for a Response from the Power Transmitter. If the Power Receiver does not receive the first bit of an ACK Response within $t_{responsetimeout}$ after the end of the Configuration Packet, it shall:

- assume that the Power Transmitter is not able to negotiate;
- assume that the Power Transmitter supports a Guaranteed Power of 5 W only; and
- proceed to the power transfer phase.

Otherwise, the Power Receiver shall proceed to the *negotiation* phase. See Figure 30 and Figure 24.



**Prop** If this bit is set to ZERO, the Power Transmitter shall control the power transfer according to the method defined in Section 5.1.2.6.1, *Power transfer control*. If this bit is set to ONE, the Power Transmitter may control the power transfer according to a proprietary method instead of the method defined in Section 5.1.2.6.1. However, if this bit is set to ONE, the Power Transmitter shall continue to ensure that the received Control Error Packets comply with the timings defined in Section 5.1.2.6.

NOTE This implies that a Power Transmitter terminates the power transfer if it times out while waiting for a Control Error Packet. Moreover, this implies that setting the Prop bit to ONE does not relieve the Power Receiver from transmitting Control Error Packets on a regular basis. Finally, if the Prop bit is set to ZERO, the Power Transmitter could still decide to abort the power transfer based on information contained in a Proprietary Packet.

**Neg** If this bit is set to ZERO, the Power Transmitter shall refrain from sending a Response. If this bit is set to ONE, the Power Transmitter shall send an ACK Response following the end of the Configuration Packet indicating to the Power Receiver that it is entering the *negotiation* phase. See Section 5.1.2.3, *Identification & configuration phase (PTx perspective)*.

## CLAIMS DEPENDENT ON CLAIM 15:

17. The electronic device of claim 15, wherein the communication transmitter circuit and the communication receiver circuit in the electronic device are configured to communicate with different types of inductive chargers based on communications exchanged with different types of inductive chargers.

As detailed below by representative products, the 777 Accused Smartphones and Wearables each additionally infringe this dependent claim as the respective communication circuits are configured to communicate with different types of inductive chargers based on communications exchanged between the two.

**Smartphones**

The S22 Ultra can communicate both in BPP (uni-directionally) and Samsung Wireless Fast Charge (bi-directionally) based on WPC EPP, and correspondingly charge at different power levels based on communications exchanged between the respective types of inductive chargers.

**Wearables**

The Watch5 can communicate both in BPP (uni-directionally) and Samsung Watch Fast Wireless Charging (bi-directionally) based on WPC EPP, and correspondingly charge at different power levels based on communications exchanged between the respective types of inductive chargers. As an example, the Watch5 communicates with an EP-OR825 BPP watch charger and charges at ~ 1-2 W power level and communicates with different messages with charger EP-OR900 and charges at up to 5 W power level.




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# 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]

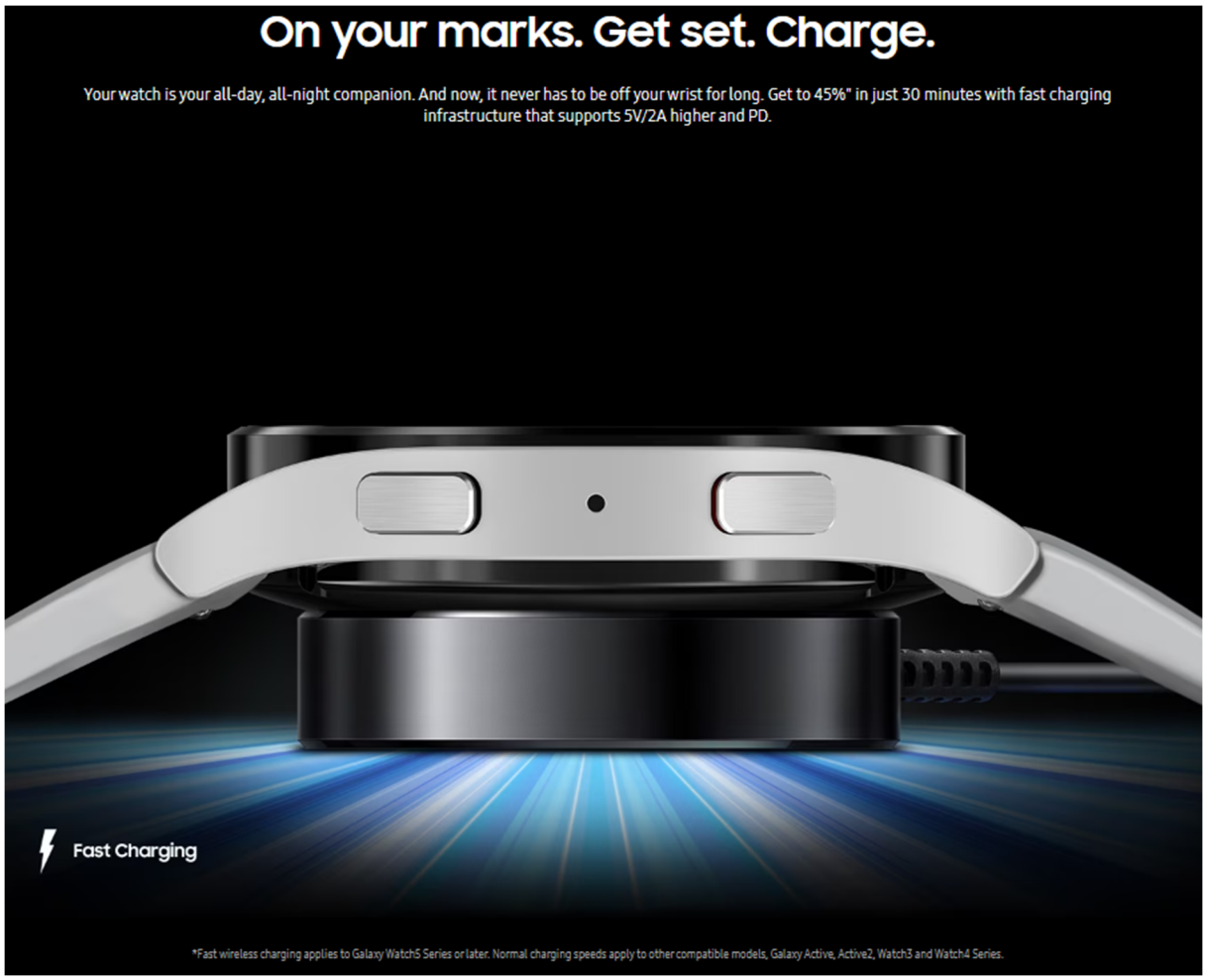
https://developer.samsung.com/mobile/wireless-fast-charge.html#:~:text=Samsung%20Wireless%20Fast%20Charge%2C%20a,Power%20Profile%20(EPP)%20specification.

https://www.samsung.com/levant/watches/galaxy-watch/galaxy-watch5-40mm-silver-bluetooth-sm-r900nzsamea/




15. Testing conducted by Samsung in June 2022 using pre-released version of Galaxy Watch5 (BT & LTE), each paired to a Samsung phone; all devices tested with prerelease software, Galaxy Watch Magnetic Fast Charging USB C Cable (EP-OR900), and Samsung 25W USB C Power Adapter (EP-TA800). Charge time varies with region, settings, usage pattern and environmental factors; actual results may vary.

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

20. The electronic device of claim 15, wherein the microcontroller is further configured for detecting the presence of a foreign object between the inductive charger and the inductive charging receiver of the electronic device during operation by either reporting one of output power or voltage or by reporting a fault condition to the inductive charger to terminate charging.

As detailed below by representative products, the 777 Accused Smartphones and Wearables each additionally infringe this dependent claim as the microcontroller is configured to detect a foreign object between the charger and receiver coil and report a fault condition to terminate the charging.

**Smartphones**

WPC EPP describes the method for determining the presence of a Foreign Object between the charger and receiver coil. This method is based on measurement of the input power to the

charger and a received output power and make a determination about the presence of a FOD as outlined below and per this claim.

(WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 135, 136 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 133,134). *See infra*.

**Wearables**

WPC EPP describes the method for determining the presence of a Foreign Object between the charger and receiver coil. This method is based on measurement of the input power to the charger and a received output power and make a determination about the presence of a FOD as outlined below and per this claim. To implement FOD detection, the microcontroller in the receiver may be configured to report the output power or voltage of the receiver.

(WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 135, 136 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 133,134).

## 11.4 FOD based on calibrated power loss accounting—EPP only

An Extended Power Profile Power Transmitter may apply different methods for Foreign Object Detection during the *power transfer* phase. One of these methods is the power loss method.

### 11.4.1 Introduction

The power loss $P_{loss}$, which is defined as the difference between the Transmitted Power $P_{PT}$ and the Received Power $P_{PR}$, i.e. $P_{loss} = P_{PT} - P_{PR}$, provides the power absorption in Foreign Objects:

- The Transmitted Power $P_{PT}$ represents the amount of power that leaves the Base Station due to the magnetic field of the Power Transmitter
- The Received Power $P_{PR}$ represents the amount of power that is dissipated within the Mobile Device due to the magnetic field of the Power Transmitter
- The power loss $P_{loss}$ in Foreign Objects represents the amount of power dissipated from the magnetic field of the Power Transmitter in objects that are neither part of the Base Station nor of the Mobile Device.

The Power Transmitter can determine its Transmitted Power $P_{PT}$ by measuring the power $P_{In}$ provided at its input and subtracting any power $P_{PTloss}$ that is dissipated inside the Base Station. This power $P_{PTloss}$ includes, for example:

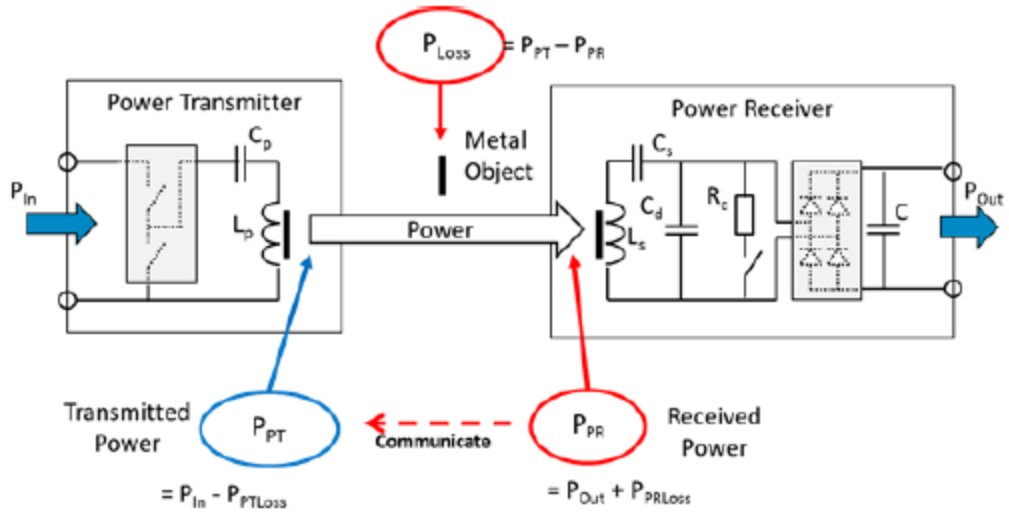
- the power loss in the inverter,
- the power loss in the Primary Coil,
- the power loss in resonance capacitors,
- the power loss in the Shielding of the Primary Coil assembly, and
- the power loss in any metal parts of the Base Station.

The Power Receiver can determine its Received Power $P_{PR}$ by measuring the power $P_{out}$ provided at its output and adding any power $P_{Prloss}$ that is lost inside the Mobile Device. This power $P_{Prloss}$ includes, for example:

- the power loss in the rectifier,
- the power loss in the Secondary Coil,
- the power loss in the resonance capacitor,
- the power loss in the Shielding of the Secondary Coil assembly, and
- the power loss in any metal parts of the Mobile Device.

Figure 47 illustrates the above.

**Figure 47. Power losses illustrated**




After receiving a Received Power Packet, the Power Transmitter can calculate the power loss and compare it to a threshold. If the power loss exceeds this threshold for one or more consecutive Received Power Packets, the Power Transmitter can conclude that a Foreign Object is present on its Interface Surface. To limit heating of the Foreign Object in that case, the Power Transmitter should remove the Power Signal, which terminates the transfer of power to the Power Receiver. Experiments have shown that 300 mW is an appropriate threshold value for limiting heating of Foreign Objects.

Alternately, the receiver may monitor its received power (i.e. output power or voltage) and determine that a Foreign Object may have been inserted. In this case, the receiver may report a fault condition to the wireless charger to terminate charging. See WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 141.

## 11.5 FOD by Power Receiver (Informative)

During power transfer, a Power Receiver can attempt to detect whether a Foreign Object starts to absorb power from the magnetic field by detecting a change in its Received Power $P_{PR}$. Such a change can result from:

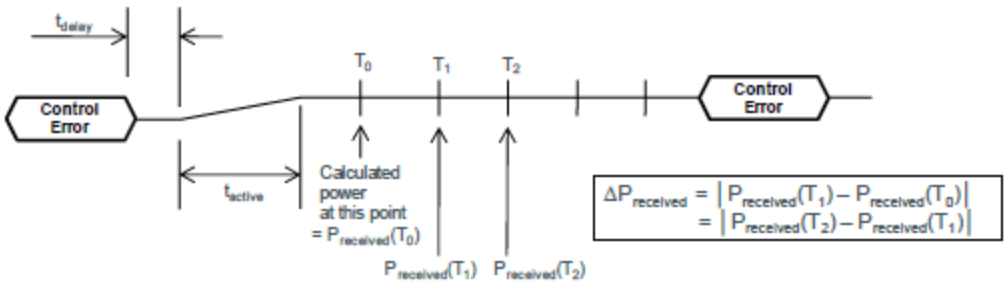
- a change of the Operating Point of the Power Transmitter;
- a change of the position of the Power Receiver on the Interface Surface;
- a change of the gap between the Power Receiver and the Power Transmitter;
- placement of a Foreign Object; or
- a change of the Power Receiver's load.

By monitoring its output power, the Power Receiver can distinguish between a change in its load and the other possible causes for a change in its Received Power. Moreover, since a Power Transmitter typically only changes its Operating Point directly after receiving a Control Error Packet (see Section 5.2.3.3), the Power Receiver can correlate a change in its Received Power to the placement of a Foreign Object. To make this correlation, the Power Receiver has to assume that its position on the Interface Surface does not change.

It is recommended that the Power Receiver measures its Received Power in the periods between Control Error Packets where the Power Transmitter is supposed to keep its Operating Point constant, see Figure 48. In addition, it is recommended that if the difference between two consecutive measurements exceeds a threshold—which typically is in the range of 250 mW to 750 mW—the Power Receiver takes appropriate action. Examples of such actions include the following:

- Informing the user that a Foreign Object may suddenly have appeared on the Interface Surface.
- Informing the Power Transmitter that a Foreign Object may suddenly have appeared on the Interface Surface, e.g. by sending an End Power Transfer Packet with End Power Transfer Code= 0x0B. This Packet should cause the Power Transmitter to terminate and subsequently restart the power transfer. Prior to such restarts, the Power Transmitter should attempt to detect the presence of a Foreign Object, e.g. using the method defined in Section 11.3, *FOD based on quality factor change*.

**Figure 48. Computation of $\Delta P_{received}$**



The Renesas / IDT P9415-R ASIC used in Galaxy S22 Ultra smartphones operates as described in the claim.

https://www.renesas.com/us/en/document/dst/p9415-datasheet

### 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 ($C_8$) is used for a given type of receiver coil.

### 8.2.3 Advanced Foreign Object Detection (FOD) WPC MODE

When metallic objects are exposed to an alternating magnetic field, eddy currents cause such objects to heat up. Examples of parasitic metal objects are coins, keys, paperclips, etc. The amount of heating depends on the amplitude and frequency of the magnetic field coupled, as well as on the characteristics of the object such as its resistivity, size, and shape. In a wireless power transfer system, the heating manifests itself as a power loss, and therefore a reduced power transfer efficiency. Moreover, if no appropriate measures are taken, the heating could lead to unsafe situations if the objects reach high temperatures.

WPC power transmitters and receivers also need to compensate for the power loss due to parasitic metals intentionally designed into the final product: i.e., metals that are neither part of the power transmitter, nor of the power receiver, but which absorb power from magnetic field coupling during power transfer, such as Li-ion batteries, metallic cases, etc.



## 9.11 Foreign Object Detection

When metallic objects are exposed to an alternating magnetic field, eddy currents cause such objects to heat up. Examples of such parasitic metal objects are coins, keys, paper clips, etc. The amount of heating depends on the strength of the coupled magnetic field, as well as the characteristics of the object, such as its resistivity, size, and shape. In a wireless power transfer system, the heating manifests itself as a power loss, and therefore a reduction in power-transfer efficiency. Moreover, if no appropriate measures are taken, the heating could be sufficient that the foreign object could become heated to an unsafe temperature.

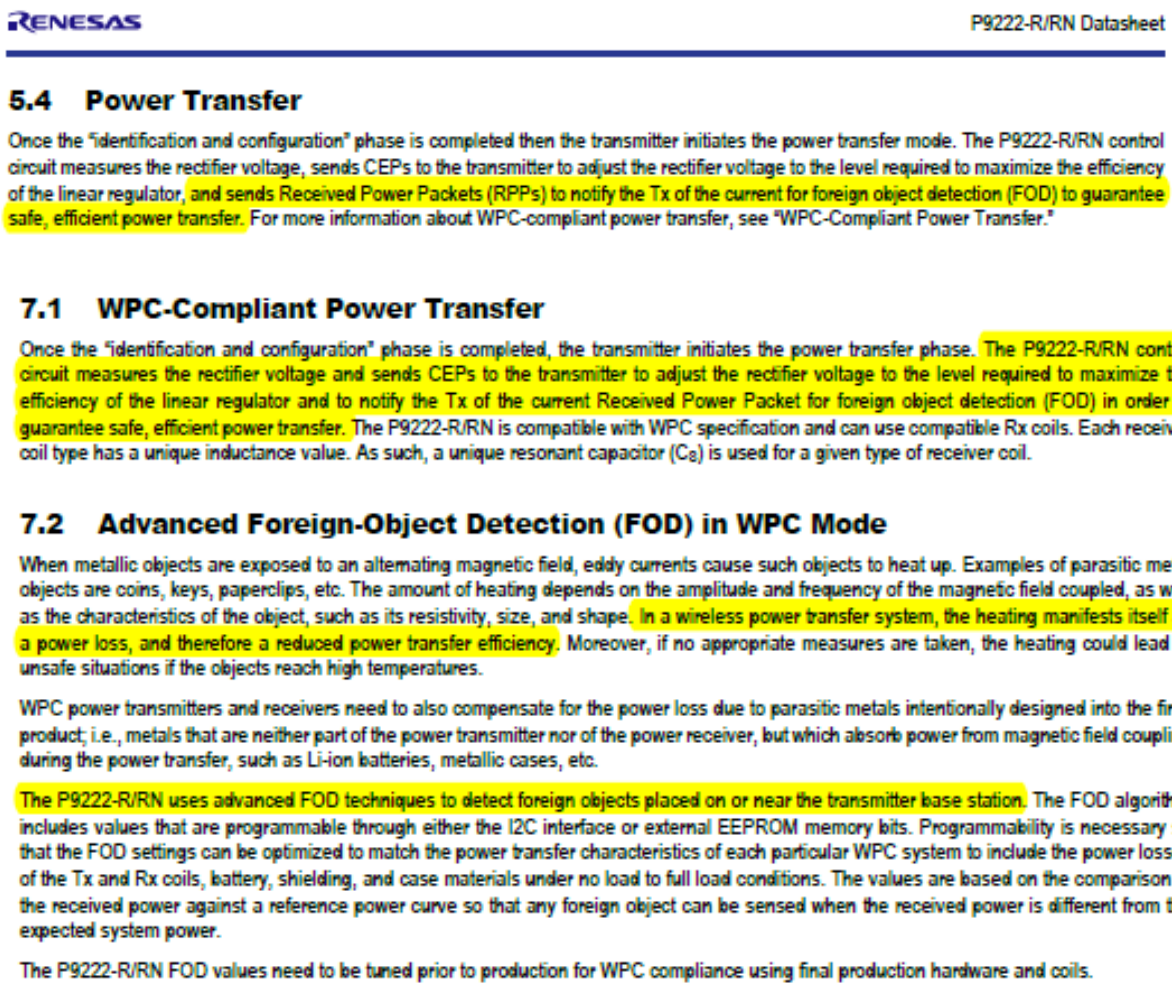
In the Extended Power Profile, there are two methods of foreign object detection (FOD). One is by measuring the system quality factor before entering the power transfer phase, and the other is to measure the power loss difference between the received power and the transmitted power during the power transfer phase. Before entering the power transfer phase, the P9415-R sends a reference Q-factor (default 30) in the negotiation phase. The transmitter measures the Q-factor on its coil and compares it with the reference Q-factor provided by the P9415-R. If the difference is large, the transmitter presumes that there is a foreign object (FO) between the Tx and Rx and shuts down. The power loss foreign object detection method is used in both the Extended Power Profile (EPP) and the Basic Power Profile (BPP) modes power transfer phase. During the power transfer phase, the P9415-R continuously sends to the transmitter the amount of power received using the Received Power Packet (RPP). The transmitter will compare the RPP packet information received from the receiver with its measured transmitted power. If there is a significant difference the transmitter presumes that there is a foreign object (FO) between Tx and Rx that is absorbing the transmitted power and will stop the power transfer to avoid heating of FO.

On information and belief, the Samsung Watch5 includes a similar wireless charging ASIC to the Samsung Watch4.

On information and belief, the Watch4 includes a representative receiver IC (e.g., a Renesas/IDT P9222S) (herein the "9222") used for wireless charging.

The receiver coil can be seen also in block diagram form in the 9222 datasheet below, which is believed to be representative of the wireless power receiver ASIC included in the Galaxy Watches.

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



RENESAS P9222-R/RN Datasheet

### 5.4 Power Transfer

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

### 7.1 WPC-Compliant Power Transfer

Once the "identification and configuration" phase is completed, the transmitter initiates the power transfer phase. The P9222-R/RN control circuit measures the rectifier voltage and sends CEPs to the transmitter to adjust the rectifier voltage to the level required to maximize the efficiency of the linear regulator and to notify the Tx of the current Received Power Packet for foreign object detection (FOD) in order to guarantee safe, efficient power transfer. The P9222-R/RN is compatible with WPC specification and can use compatible Rx coils. Each receiver coil type has a unique inductance value. As such, a unique resonant capacitor ($C_8$) is used for a given type of receiver coil.

### 7.2 Advanced Foreign-Object Detection (FOD) in WPC Mode

When metallic objects are exposed to an alternating magnetic field, eddy currents cause such objects to heat up. Examples of parasitic metal objects are coins, keys, paperclips, etc. The amount of heating depends on the amplitude and frequency of the magnetic field coupled, as well as the characteristics of the object, such as its resistivity, size, and shape. In a wireless power transfer system, the heating manifests itself as a power loss, and therefore a reduced power transfer efficiency. Moreover, if no appropriate measures are taken, the heating could lead to unsafe situations if the objects reach high temperatures.

WPC power transmitters and receivers need to also compensate for the power loss due to parasitic metals intentionally designed into the final product; i.e., metals that are neither part of the power transmitter nor of the power receiver, but which absorb power from magnetic field coupling during the power transfer, such as Li-ion batteries, metallic cases, etc.

The P9222-R/RN uses advanced FOD techniques to detect foreign objects placed on or near the transmitter base station. The FOD algorithm includes values that are programmable through either the I2C interface or external EEPROM memory bits. Programmability is necessary so that the FOD settings can be optimized to match the power transfer characteristics of each particular WPC system to include the power losses of the Tx and Rx coils, battery, shielding, and case materials under no load to full load conditions. The values are based on the comparison of the received power against a reference power curve so that any foreign object can be sensed when the received power is different from the expected system power.

The P9222-R/RN FOD values need to be tuned prior to production for WPC compliance using final production hardware and coils.

21. The electronic device of claim 15, wherein one of the first mode of operation and the second mode of operation is a proprietary mode of operation.

As detailed below by representative products, the 777 Accused Smartphones and Wearables each additionally infringe this dependent claim as one of the modes of operation includes Samsung proprietary communications.

**Smartphones**

The S22 Ultra includes Samsung Wireless Fast Charge which is a Samsung proprietary power delivery extension.

**Wearables**

The Watch5 includes Samsung Watch Fast Charge which is a Samsung proprietary power delivery extension. *See* various citations *supra*.




https://www.samsung.com/us/mobile/mobile-accessories/phones/15w-wireless-charger-duo-with-ta-dark-gray-ep-p5400tbegus/




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## 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]

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

https://www.samsung.com/sg/mobile-accessories/fast-wireless-charger-black-ep-or900bbegww/




*Fast wireless charging applies to Galaxy Watch5 Series or later. Normal charging speeds apply to other compatible models, Galaxy Active, Active2, Watch3 and Watch4 Series.

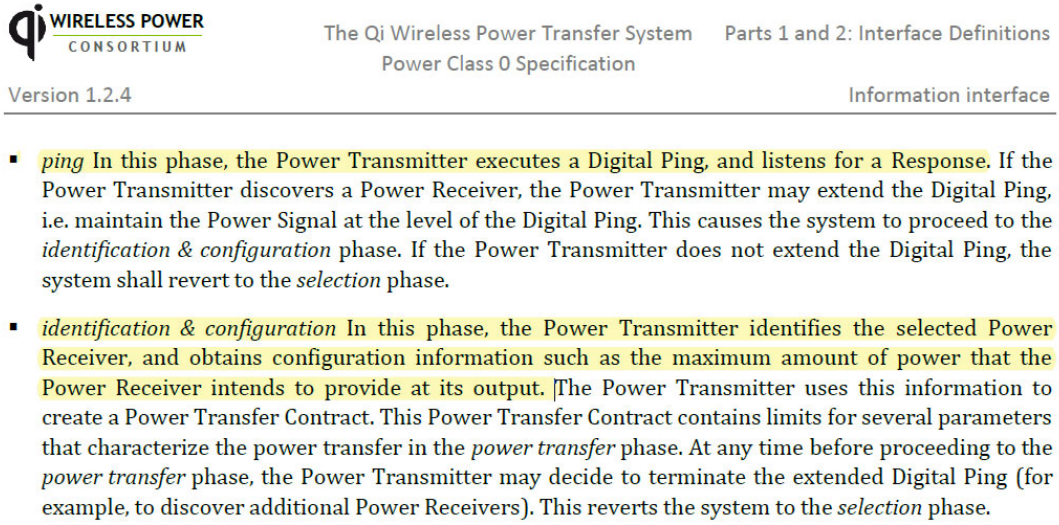
22. The electronic device of claim 15, wherein the micro-controller is further configured for receiving a ping from an inductive charger and sending, in response to the ping, a responsive communication identifying one of the first mode of operation and the second mode of operation.

As detailed below by representative products, the 777 Accused Smartphones and watches each additionally infringe this dependent claim as the microcontroller is configured to receive a ping from an inductive charger and send a response identifying a mode of operation for wireless charging.

**Smartphones**

The S22 Ultra operates according to WPC protocol with respect to the ping and identification phase.
Initially, the wireless charger applies power periodically (ping) for a period of time sufficiently long to wake up the receiver and receive some communication from it, including information corresponding to a voltage at the output of the receiver circuit (i.e., the Signal Strength Packet)

followed by Identification and Configuration packets. *E.g.*, WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 52 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 51). In response to a ping, a receiver transmits a signal strength packet followed by identification and configuration messages (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, page 46 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, page 46).

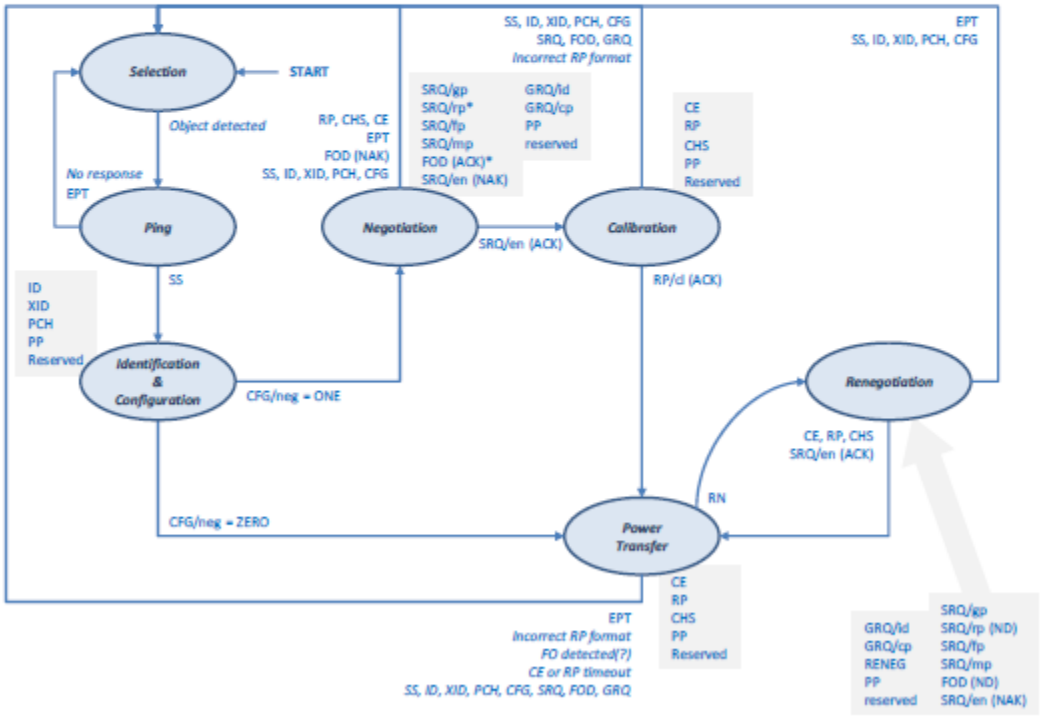



The state diagram for WPC EPP is shown below (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 86. *Also see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 48). As discussed in Claim 1 above, depending on the messages received by the charger during Identification and Configuration phase identifying the S22 Ultra as capable of being charged using Samsung Wireless Fast Charge protocol (mode 2), the charger can proceed to the appropriate power transfer phase (i.e. Negotiation and Calibration phases for EPP or proprietary receivers).

### 5.1.4 State diagram (informative)

**Figure 34 provides a summary of the transitions between the protocol's seven phases.**

**Figure 34. State diagram**




In response to a ping, a receiver transmits a signal strength packet followed by identification and configuration messages (WPC 1.2.4 Standard, Parts 1 and 2, Interface Definitions, pages 98, 99 (*see also* WPC 1.2.3 Standard, Parts 1 and 2, Interface Definitions, pages 96, 97). The Prop bit in the Configuration packet can indicate to a wireless charger if the receiver is capable of the BPP mode of operation (first mode when Prop = 0) or a proprietary method of charging (such as Samsung Wireless Fast Charge when Prop=1). The Neg bit also indicates to the wireless charger if the receiver is capable of receiving power at up to 5 W (BPP) or higher levels (EPP or Proprietary method). As shown above in the state diagram, depending on the Neg bit in the Identification and Configuration phase communication from the receiver, the wireless charger is instructed to proceed directly to the Power Transfer phase (for BPP receivers; Neg = 0) or to Negotiation, Calibration and then Power Transfer phases for EPP or Proprietary receivers (Neg =1) as required by this claim.

### 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**

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| B0 | Power Class | | Maximum Power Value | | | | | |
| B1 | Reserved | | | | | | | |
| B2 | Prop | Reserved | | | ZERO | Count | | |
| B3 | Window Size | | | | | Window Offset | | |
| B4 | Neg | Polarity* | Depth* | | Reserved | | | |

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

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Version 1.2.4
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**Prop** If this bit is set to ZERO, the Power Transmitter shall control the power transfer according to the method defined in Section 5.1.2.6.1, *Power transfer control*. If this bit is set to ONE, the Power Transmitter may control the power transfer according to a proprietary method instead of the method defined in Section 5.1.2.6.1. However, if this bit is set to ONE, the Power Transmitter shall continue to ensure that the received Control Error Packets comply with the timings defined in Section 5.1.2.6.

NOTE This implies that a Power Transmitter terminates the power transfer if it times out while waiting for a Control Error Packet. Moreover, this implies that setting the Prop bit to ONE does not relieve the Power Receiver from transmitting Control Error Packets on a regular basis. Finally, if the Prop bit is set to ZERO, the Power Transmitter could still decide to abort the power transfer based on information contained in a Proprietary Packet.

**Neg** If this bit is set to ZERO, the Power Transmitter shall refrain from sending a Response. If this bit is set to ONE, the Power Transmitter shall send an ACK Response following the end of the Configuration Packet indicating to the Power Receiver that it is entering the *negotiation* phase. See Section 5.1.2.3, *Identification & configuration phase (PTx perspective)*.

**Wearables**

The Watch5 operates similarly to the S22 Ultra as described above and comprises a micro-controller that is configured for receiving a ping from an inductive charger and sending, in response to the ping, a responsive communication identifying one of the first mode of operation and the second mode of operation.

23. The electronic device of claim 15, wherein the received power is within a first frequency range for the first mode of operation and within a second frequency range for the second mode of operation.

As detailed below by representative products, the 777 Accused Smartphones each additionally infringe this dependent claim as the received power is within a first frequency range for the first mode of operation and within a second frequency range for the second mode of operation.

**Smartphones**

On information and belief, the S22 Ultra operates at 112 kHz to 147 kHz when being charged on a Samsung phone operating in PowerShare mode (Samsung S20 Ultra) at or below 5 W in BPP mode (first mode) and at a frequency of 127 kHz when being charged on a wireless charger like EP-5400 at higher power levels using Samsung Wireless Fast Charge (second mode).

**Watch Chargers**

On information and belief, the Watch5 receives power from a charger such as the EP-OR900 in a first frequency range during BPP (first mode) operation and in a second frequency range Watch Fast Charge (second mode) operation and therefore, infringes this dependent claim.

24. A system for inductive charging of an electronic device comprising an inductive charging receiver and a battery electrically coupled to the inductive charging receiver, the base[1] system comprising:

The 777 Accused Wireless Chargers are accused under this claim. The 777 Accused Wireless Chargers each meet this this introductory part of the claim, as each includes a system for providing power inductively as specified by this introductory part of the claim.

an inductive charging coil;

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "inductive charging coil" part of claim 1.

a coil drive circuit electrically coupled to the inductive charging coil, wherein the coil drive circuit provides power to the inductive charging coil by switching a voltage input to the inductive charging coil at an operating frequency;

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "coil drive circuit" part of claim 1.

a current detection circuit electrically coupled to the inductive charging coil; and

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "current detection circuit" part of claim 1.

a microcontroller, wherein the microcontroller is configured for:

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "microcontroller" part of claim 1.

[1] Noting that the term "base" was requested to be deleted by a Certificate of Correction filed with the Patent and Trademark Office on August 16, 2022

operating in a first mode of operation using a first protocol, wherein the first protocol is an inductive charging communication-and-control protocol that comprises uni-directional messaging, wherein the first mode of operation comprises:

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "operating in a first mode of operation" part of claim 1.

receiving, using the current detection circuit, a first communication from the inductive charging receiver of the electronic device, wherein the first communication is based on the first protocol; and

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the first "receiving" part of claim 1.

regulating power delivered to the battery of the electronic device in response to the received first communication; and

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the first "regulating" part of claim 1.

operating in a second mode of operation using a second protocol, wherein the second protocol is an inductive charging communication-and-control protocol that comprises bi-directional messaging, wherein the second mode of operation comprises:

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "operating in a second mode of operation" part of claim 1.

receiving, using the current detection circuit, a second communication from the inductive charging receiver of the electronic device, wherein the second communication is based on the second protocol;

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the second "receiving" part of claim 1.

regulating power delivered to the battery of the electronic device in response to the received second communication; and

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the second "regulating" part of claim 1.

transmitting, by modulating the operating frequency with the coil drive circuit, a frequency-modulated third communication to the inductive charging receiver of the electronic device, wherein the frequency-modulated third communication is based on the second protocol;

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to the "transmitting" part of claim 1.

wherein the operating frequency for the first mode of operation is associated with a first frequency range and the operating frequency for the second mode of operation is associated with a second frequency range, and wherein the first frequency range and the second frequency range are different.

The 777 Accused Wireless Chargers each meet this part of claim 24, as shown above with respect to dependent claim 11.