



BSI Standards Publication

Qi Specification version 2.0

Part 6: Communications Protocol

National foreword

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The UK participation in its preparation was entrusted to Technical Committee EPL/100, Audio-visual equipment.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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European foreword

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- latest date by which the national standards conflicting with the (dow) 2028-03-31 document have to be withdrawn

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

QI SPECIFICATION VERSION 2.0 –

Part 6: Communications Protocol

FOREWORD

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It is based on *Qi Specification version 2.0, Communications Protocol* and was submitted as a Fast-Track document.

The text of this International Standard is based on the following documents:

Draft	Report on voting
100/4251/FDIS	100/4281/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

The structure and editorial rules used in this publication reflect the practice of the organization which submitted it.

This document was developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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- reconfirmed,
- withdrawn, or
- revised.



Qi Specification

Communications Protocol

Version 2.0

April 2023

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RELEASE HISTORY

Specification Version	Release Date	Description
v2.0 Final Draft	April 2023	Initial release of the v2.0 Qi Specification.

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1 General

The Wireless Power Consortium (WPC) is a worldwide organization that aims to develop and promote global standards for wireless power transfer in various application areas. A first application area comprises flat-surface devices such as mobile phones and chargers in the Baseline Power Profile (up to 5 W) and Extended Power Profile (above 5 W).

1.1 Structure of the Qi Specification

General documents

- Introduction
- Glossary, Acronyms, and Symbols

System description documents

- Mechanical, Thermal, and User Interface
- Power Delivery
- Communications Physical Layer
- Communications Protocol
- Foreign Object Detection
- NFC Tag Protection
- Authentication Protocol

1.2 Scope

The *Qi Specification, Communications Protocol* (this document) defines the messaging between a Power Transmitter and a Power Receiver. The primary purpose of this messaging is to set up and control the power transfer. As a secondary purpose, it provides a transport mechanism for higher-level applications such as Authentication. The communications protocol comprises both the required order and timing relations of successive messages.

1.3 Compliance

All provisions in the *Qi Specification* are mandatory, unless specifically indicated as recommended, optional, note, example, or informative. Verbal expression of provisions in this Specification follow the rules provided in ISO/IEC Directives, Part 2.

Table 1: Verbal forms for expressions of provisions

Provision	Verbal form
requirement	“shall” or “shall not”
recommendation	“should” or “should not”
permission	“may” or “may not”
capability	“can” or “cannot”

1.4 References

For undated references, the most recently published document applies. The most recent WPC publications can be downloaded from <http://www.wirelesspowerconsortium.com>.

1.5 Conventions

1.5.1 Notation of numbers

- Real numbers use the digits 0 to 9, a decimal point, and optionally an exponential part.
- Integer numbers in decimal notation use the digits 0 to 9.
- Integer numbers in hexadecimal notation use the hexadecimal digits 0 to 9 and A to F, and are prefixed by "0x" unless explicitly indicated otherwise.
- Single bit values use the words ZERO and ONE.

1.5.2 Tolerances

Unless indicated otherwise, all numeric values in the *Qi Specification* are exactly as specified and do not have any implied tolerance.

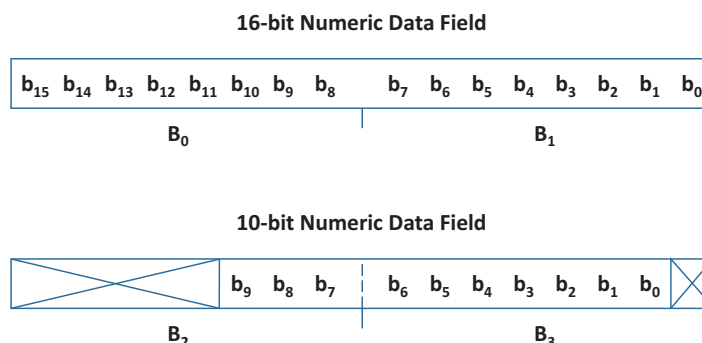
1.5.3 Fields in a data packet

A numeric value stored in a field of a data packet uses a big-endian format. Bits that are more significant are stored at a lower byte offset than bits that are less significant. [Table 2](#) and [Figure 1](#) provide examples of the interpretation of such fields.

Table 2: Example of fields in a data packet

	b₇	b₆	b₅	b₄	b₃	b₂	b₁	b₀
B₀	(msb) 16-bit Numeric Data Field (lsb)							
B₁								
B₂	Other Field					(msb)		
B₃	10-bit Numeric Data Field						(lsb)	Field

Figure 1. Examples of fields in a data packet



1.5.4 Notation of text strings

Text strings consist of a sequence of printable ASCII characters (i.e. in the range of 0x20 to 0x7E) enclosed in double quotes ("). Text strings are stored in fields of data structures with the first character of the string at the lowest byte offset, and are padded with ASCII NUL (0x00) characters to the end of the field where necessary.

EXAMPLE: The text string "WPC" is stored in a six-byte field as the sequence of characters 'W', 'P', 'C', NUL, NUL, and NUL. The text string "M:4D3A" is stored in a six-byte field as the sequence 'M', ':', '4', 'D', '3', and 'A'.

1.5.5 Short-hand notation for data packets

In many instances, the *Qi Specification* refers to a data packet using the following shorthand notation:

<MNEMONIC>/<modifier>

In this notation, <MNEMONIC> refers to the data packet's mnemonic defined in the *Qi Specification, Communications Protocol*, and <modifier> refers to a particular value in a field of the data packet. The definitions of the data packets in the *Qi Specification, Communications Protocol*, list the meanings of the modifiers.

For example, EPT/cc refers to an End Power Transfer data packet having its End Power Transfer code field set to 0x01.

1.6 Power Profiles

A Power Profile determines the level of compatibility between a Power Transmitter and a Power Receiver. [Table 3](#) defines the available Power Profiles.

- *BPP PTx*: A Baseline Power Profile Power Transmitter.
- *EPP5 PTx*: An Extended Power Profile Power Transmitter having a restricted power transfer capability, i.e. $P_L^{(pot)} = 5 \text{ W}$.
- *EPP PTx*: An Extended Power Profile Power Transmitter.
- *BPP PRx*: A Baseline Power Profile Power Receiver.
- *EPP PRx*: An Extended Power Profile Power Receiver.

Table 3: Capabilities included in a Power Profile

Feature	BPP PTx	EPP5 PTx	EPP PTx	BPP PRx	EPP PRx
Ax or Bx design	Yes	Yes	No	N/A	N/A
MP-Ax or MP-Bx design	No	No	Yes	N/A	N/A
Baseline Protocol	Yes	Yes	Yes	Yes	Yes
Extended Protocol	No	Yes	Yes	No	Yes
Authentication	N/A	Optional	Yes	N/A	Optional

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.

Table 4 summarizes the main features of the two protocol variants.

Table 4: Comparison of the Baseline Protocol and the Extended Protocol

Feature	Baseline Protocol	Extended Protocol
Power Transmitter design	Type Ax and type Bx designs only	All designs
Power Receiver to Power Transmitter Communications	Load modulation at a fixed 2 kHz clock	Load modulation at a fixed 2 kHz clock
Power Transmitter to Power Receiver Communications	N/A	Frequency shift keying at a frequency dependent clock of $f_{op}/512$
Operating phases	Ping, configuration, and power transfer	Ping, configuration, negotiation, and power transfer
Power level calibration	N/A	At the start of the power transfer phase
Authentication	N/A	Using data transport streams in the power transfer phase

2.2 Power Transfer Contract

A Power Transfer Contract comprises the settings and limits governing the power transfer. The Power Receiver sets up an initial Power Transfer Contract as applicable to the Baseline Protocol. The first part of [Table 5](#) shows the elements of this initial (or baseline) Power Transfer Contract. The Power Transmitter receives all information to duplicate the baseline Power Transfer Contract in the configuration phase of the protocol.

Some elements of the Power Transfer Contract are negotiable, enabling the Power Transmitter and Power Receiver to determine new values for these elements in the negotiation phase of the protocol (Extended Protocol only). In the Baseline Protocol, all elements of the Power Transfer Contract keep their values until the power transfer ends.

The Extended Protocol makes use of an extended Power Transfer Contract that contains the additional elements shown in the second part of [Table 5](#). See the *Qi Specification, Power Delivery*, and [Section 6, Negotiation phase](#), for details about the use of these elements.

Table 5: Power Transfer Contract

Element	Symbol	Unit	Negotiable	Comment
<i>Elements of a baseline Power Transfer Contract</i>				
Reference Power	$P_r^{(\text{ref})}$	W	Yes*	The reference power level for RP8 and RP data packets. The CFG data packet provides the initial value. See Section 8.14, Received Power—RP8 (0x04; status update) , for an example of its usage.
Received Power window size	t_{window}	ms	No	The properties of the time window for measuring the Received Power. The CFG data packet provides these values. See Figure 62 in Section 7.3, Power transfer phase timings .
Received Power window offset	t_{offset}	ms	No	
Power Control Hold-off	t_{delay}	ms	No	The delay between the CE data packet and the power level adjustment window. Defaults to 5 ms. See Figure 61 in Section 7.3, Power transfer phase timings .
Received Power reporting resolution	N/A	N/A	Yes*	The resolution of the reported Received Power. Defaults to 8 bit (RP8 data packet).
<i>Additional elements of an extended Power Transfer Contract</i>				
FSK polarity, modulation depth, and number of cycles per bit	N/A	N/A	Yes	Power Transmitter to Power Receiver communications parameters. The CFG data packet provides the initial values for the polarity and modulation depth. The number of cycles per bit defaults to 512.
Potential Load Power	$P_L^{(\text{pot})}$	W	No	The highest Guaranteed Load Power level the Power Transmitter can negotiate. No default. See Section 2.2.1, Load Power level negotiation , and the <i>Qi Specification, Power Delivery</i> , for details.

Table 5: Power Transfer Contract (Continued)

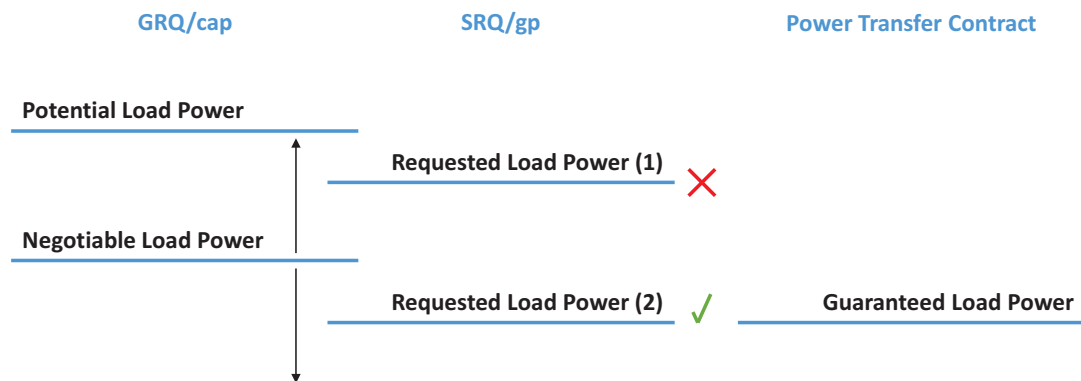
Element	Symbol	Unit	Negotiable	Comment
Guaranteed Load Power	$P_L^{(gtd)}$	W	Yes	The negotiated power level. Defaults to 5 W. See Section 2.2.1, Load Power level negotiation , and the <i>Qi Specification, Power Delivery</i> , for details.
Re-ping delay	t_{reping}	ms	Yes	The delay between an EPT/rep data packet and the next Digital Ping. Defaults to 12.6 second.

*In the negotiation phase of the Extended Protocol

2.2.1 Load Power level negotiation

A Power Receiver can typically operate at multiple target power levels. To determine the most appropriate one, the Power Receiver negotiates a Guaranteed Load Power level with the Power Transmitter. [Figure 3](#) shows the steps involved.

Figure 3. Load Power levels



The Potential Load Power level is the highest Load power level the Power Transmitter can negotiate at any time. The Negotiable Load Power level is the highest Load power level the Power Transmitter is willing to negotiate at a given time. Usually, the Negotiable Load Power level is equal to the Potential Load Power level. However, in some conditions, the Power Transmitter may set the Negotiable Load Power level to a lower value. A first example of such a condition is an operating temperature that can cause the Power Transmitter to overheat when transferring power at the highest level. A second example is an insufficiently capable power supply driving the Power Transmitter. The Power Receiver can retrieve the Potential Load Power level and the Negotiable Load Power level from the Power Transmitter using a GRQ/cap data packet.

The Requested Load Power is the Load power level at which the Power Receiver intends to operate. It provides this power level to the Power Transmitter using an SRQ/gp data packet. If the Requested Load Power level is less than or equal to the Negotiable Load Power level, the power level negotiation is successful, and both the Power Transmitter and Power Receiver store the Requested Load Power level as a Guaranteed Load Power level in their copies of the Power Transfer Contract.

[Section 6, Negotiation phase](#), [Section 8.18.3, SRQ/gp—Guaranteed Load Power: parameter field and responses](#), and [Section 9.4, Power Transmitter Capabilities—CAP \(0x31\)](#), provide details and examples of power level negotiation sequences.

The Load Power level a Power Transmitter can support depends on several factors.

- The designs of the Power Transmitter and Power Receiver
- The position of the Power Receiver in the Operating Volume
- The power supply of the Power Transmitter
- The Load of the Power Receiver
- The operating temperature

The Potential Load Power, Negotiable Load Power, and Requested Load Power levels used in the negotiation process are meaningful only if the Power Receiver has a design that is “similar” to one the reference designs listed in [Table 6](#). See the *Qi Specification, Power Delivery*, for details.

NOTE: A Power Receiver may attempt to draw more power than the Guaranteed Load Power level, and a Power Transmitter may provide more power than the Guaranteed Load Power level or Potential Load Power level. However, the system operation is undefined in those cases. See the *Qi Specification, Power Delivery*, for details.

Table 6: Power Levels

Power Level	Reference Power Receiver*
5 W	Power Receiver example 1, Power Receiver example 2
8 W	Power Receiver example 3
12 W	Power Receiver example 5
15 W	Power Receiver example 4

2.2.2 Examples

[Table 7](#), [Table 8](#), and [Table 9](#) provide examples of Power Transfer Contracts. In the Extended Protocol, the initial Power Transfer Contract contains the elements of the baseline Power Transfer Contract plus the elements of the extended Power Transfer Contract.

Table 7: Example of a baseline Power Transfer Contract when leaving the configuration phase

Element	Symbol	Power Receiver Value	Power Transmitter Value
Reference Power	$P_r^{(ref)}$	5 W	5 W
Received Power window size	t_{window}	8 ms	8 ms
Received Power window offset	t_{offset}	8 ms	8 ms
Power Control Hold-off	t_{delay}	5 ms	5 ms
Received Power reporting resolution	N/A	8 bit	8 bit

Table 8: Example of an extended Power Transfer Contract when entering the negotiation phase

Element	Symbol	Power Receiver Value	Power Transmitter Value
Reference Power	$P_r^{(\text{ref})}$	5 W	5 W
Received Power window size	t_{window}	8 ms	8 ms
Received Power window offset	t_{offset}	8 ms	8 ms
Power Control Hold-off	t_{delay}	5 ms	5 ms
Received Power reporting resolution	N/A	8 bit	8 bit
FSK polarity, modulation depth, and number of cycles per bit	N/A	Positive / Category 0/512	Positive / Category 0/512
Potential Load Power	$P_L^{(\text{pot})}$	Unknown	15 W
Guaranteed Load Power	$P_L^{(\text{gtd})}$	5 W	5 W
Re-ping delay	t_{reping}	1000 ms	1000 ms

Table 9: Example of an extended Power Transfer Contract when leaving the negotiation phase

Element	Symbol	Power Receiver Value	Power Transmitter Value
Reference Power	$P_r^{(\text{ref})}$	10 W	10 W
Received Power window size	t_{window}	8 ms	8 ms
Received Power window offset	t_{offset}	8 ms	8 ms
Power Control Hold-off	t_{delay}	5 ms	5 ms
Received Power reporting resolution	N/A	16 bit	16 bit
FSK polarity, modulation depth, and number of cycles per bit	N/A	Positive / Category 0/512	Positive / Category 0/512
Potential Load Power	$P_L^{(\text{pot})}$	15 W or unknown*	15 W
Guaranteed Load Power	$P_L^{(\text{gtd})}$	8 W	8 W
Re-ping delay	t_{reping}	500 ms	500 ms

* If the Power Receiver does not request the CAP data packet in the Extended Protocol, the Potential Load Power remains unknown in the Power Receiver's copy of the Power Transfer Contract.

2.3 Data packet types

Whereas the Power Transmitter starts the communications protocol by applying a Digital Ping (at the end of the ping phase), the Power Receiver drives the execution of the remaining phases of the protocol. This means that the Power Receiver initiates all data packet communications, and that the Power Transmitter waits to send a data packet or Response Pattern until explicitly invited to do so.

NOTE: Although it is the Power Receiver that drives the communications protocol, the Power Transmitter may adjust the power level or stop the power transfer completely at any time if it considers that necessary to ensure safe system operation. For additional information, see the *Qi Specification, Power Delivery*.

The Power Receiver can send four kinds of data packets:

- *Status update*—the Power Transmitter does not reply to these data packets.
- *Power control*—the Power Transmitter adjusts the power level in response to these data packets.
- *Simple query*—invites the Power Transmitter to reply with a Response Pattern (ACK, NAK, ND, ATN).
- *Data request*—invites the Power Transmitter to reply with a full data packet.

NOTE: The Baseline Protocol uses status update and power-control data packets only.

The Power Transmitter should not respond to data packets that suffer from communications errors. The reason is that data packet corruption could result in the Power Transmitter providing the wrong type of response, confusing the Power Receiver. The lack of a response is a clear signal to the Power Receiver that something went wrong and that it should resend the data packet.

2.4 High-level messages and data transport streams

The purpose of most communications in the protocol is to configure and control the power transfer. However, the Extended Protocol also supports data transport streams, which can pass high-level messages (often unrelated to the power transfer) between the Power Transmitter and Power Receiver. Examples of such messages include the authentication messages that the Power Transmitter and Power Receiver can use to verify each other's credentials in a tamper-resistant manner.

NOTE: The goal of authentication is to ensure that the Power Transmitter and/or the Power Receiver have passed independent tests certifying safe operation.

A Power Receiver to Power Transmitter data transport stream consists of a sequence of simple-query data packets, with the payloads of these data packets carrying the high-level message data. The Power Receiver can initiate a data transport stream at any time in the power transfer phase. Conversely, when a Power Transmitter has a high-level message to send to the Power Receiver—and has ensured that the latter can process that message—it can draw the Power Receiver's attention by responding with an ATN Response Pattern to an incoming simple-query data packet in the power transfer phase. This signals the Power Receiver to transmit a series of data-request data packets enabling the Power Transmitter to send a data transport stream.

2.5 Backward compatibility

Table 10 summarizes the key differences between previous versions and version 1.3 of the *Qi Specification, Communications Protocol* (this document), other than those associated with the new data transport stream and authentication functionalities. Power Transmitters and Power Receivers should examine their counterpart's version number to handle these differences appropriately.

NOTE: Prior to version 1.3, the definition of the communications protocol was contained in section 5 of the *Qi Wireless Power Transfer System, Power Class 0 Specification, Parts 1 and 2, Interface Definitions*.

Table 10: Backward compatibility

Version	Backward compatibility notes
1.0.x	Baseline Protocol differences to version 1.3 The value contained in an RP8 data packet represents a rectified power level rather than a Received Power level.
1.1.x	—
1.2.x	No Baseline Protocol differences to version 1.3 Extended Protocol differences to version 1.3 - A Power Transmitter does not support a defined delay between the removal of the Power Signal and the next Digital Ping - A Power Transmitter does not support a Power Receiver aborting the negotiation phase and proceeding to the power transfer phase of the baseline protocol - A Power Transmitter does not support FOD/rf data packets (but it should be resilient to receiving such data packets) - In the negotiation phase, a Power Transmitter responds with ND to simple-query data packets having one or more reserved bits set to ONE rather than ignoring those bits - A Power Transmitter does not accept additional SRQ/en data packets after sending an ACK Response Pattern to the first SRQ/en data packet at the end of the negotiation phase. If a Power Receiver sends a second SRQ/en data packet, the Power Transmitter interrupts the power transfer. Note that there is no power transfer interruption when both the Power Receiver and Power Transmitter are v1.3 compliant. - A Power Receiver does not recognize ATN Response Patterns. Accordingly it will not send DSR data packets inviting the Power Transmitter to send CAP data packets with the aim to trigger the Power Receiver into renegotiating. - A Power Transmitter may send CHS, PROP, and/or reserved data packets while calibrating (that is, before sending its first RP/0 or RP/4 data packet in the power transfer phase).
1.3.x	Extended protocol differences to version 2.0 A Power Transmitter does not support a reduced number of cycles per FSK bit.

3 Power Receiver and Power Transmitter identification

A Power Receiver identifies itself to a Power Transmitter with the following information.

- The version of the *Qi Specification* with which the Power Receiver complies.
- A Power Receiver Manufacturer Code (PRMC) identifying the Power Receiver's manufacturer.
- A basic device identifier identifying the Power Receiver among multiple Power Receiver's present in the Operating Volume.

NOTE: The basic identifier may change from time to time as defined in [Section 8.11, Identification—ID \(0x71; status update\)](#).

- An optional extended device identifier providing additional information.
- Optionally a Wireless Power ID (WPID). See [Section 6.4, Wireless power ID](#), for details.

In the Extended Protocol, the Power Receiver can request the Power Transmitter to identify itself to the Power Receiver with the following information.

- The version of the *Qi Specification* with which the Power Transmitter complies.
- A Power Transmitter Manufacturer Code (PTMC) identifying the Power Transmitter's manufacturer.
- A Power Transmitter Certificate. See *Qi Specification, Authentication Protocol*, for details.

NOTE: In the Baseline Protocol, a Power Receiver cannot retrieve a PTMC from the Power Transmitter. However, this does not mean that the latter does not have an associated PTMC. The product registration of the WPC requires the manufacturer of the Power Transmitter to submit a self-declaration form listing the PTMC.

A Power Transmitter shall not use the PRMC in any way that limits the design freedom of the Power Receiver. Conversely, a Power Receiver shall not use the PTMC in any way that limits the design freedom of the Power Transmitter.

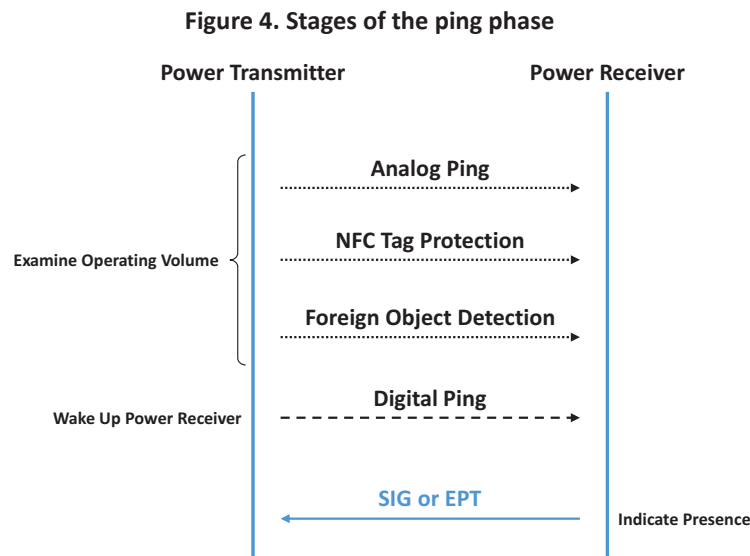
The purpose of the PRMC and PTMC is to enable Power Transmitters and Power Receivers of the same manufacturer recognize Proprietary (PROP) data packets more easily.

As an example, a manufacturer can have multiple Power Receiver Products with substantially different design properties such as coupling factor, Friendly Metal arrangement, etc. When using knowledge of the PRMC only, a Power Transmitter can therefore easily make incorrect assumptions about these properties. By adjusting its operation based on its assumptions, such as adjusting thresholds etc., interoperability failure is likely to occur.

4 Ping phase

At the start of the ping phase, the Power Transmitter does not yet know whether a Power Receiver is present within its Operating Volume. The Power Receiver is not aware of the Power Transmitter either, because its systems are typically inactive due to the lack of a Power Signal.

Figure 4 illustrates the stages of the ping phase. In the first three stages (dotted arrows), the Power Receiver is not active. Moreover, the Power Transmitter should ensure that any signals it uses in these phases do not wake up the Power Receiver. In the fourth stage (dashed arrow), the Power Transmitter attempts to wake up the Power Receiver. In the last stage (solid arrow), the Power Receiver starts its communications.



Before initiating a Digital Ping to solicit a response from a Power Receiver, the Power Transmitter should go through the following stages.

- Detect objects. For this purpose, the Power Transmitter can use Analog Pings or a variety of alternative methods. The *Qi Specification, Power Delivery*, provides a number of examples.
- Optionally apply NFC tag protection as defined in the *Qi Specification, NFC Tag Protection*.

The *Qi Specification, NFC Tag Protection*, provides recommendations about how to execute the above steps.

NOTE: Instead of performing NFC tag detection, a Power Transmitter may limit the Power Signal throughout the power transfer to levels that do not damage NFC tags. The *Qi Specification, NFC Tag Protection*, provides guidelines and methods to determine safe power levels.

- Collect information that helps to decide whether Foreign Objects are present in addition to a Power Receiver. For this purpose, the Power Transmitter can use a variety of methods commonly known as pre-power FOD methods. The *Qi Specification, Foreign Object Detection*, defines these methods.

After performing the above steps and determining that there potentially is a Power Receiver in its operating Volume, the Power Transmitter initiates a Digital Ping to solicit a response from the Power Receiver, which is either a Signal Strength (SIG) data packet or an End Power Transfer (EPT) data packet. If there is no such response, the Power Transmitter stays in the ping phase and should repeat the above steps.

NOTE: Power Transmitters employing multiple coils to enable a greater positioning freedom for a Power Receiver typically initiate a Digital Ping multiple times using different coil. Typically, such Power Transmitters abort the protocol after receiving the SIG data packet from the Power Receiver until they have determined the optimum coil to use for the power transfer. The *Qi Specification, Power Delivery*, provides examples of this approach.

4.1 Ping phase state diagram

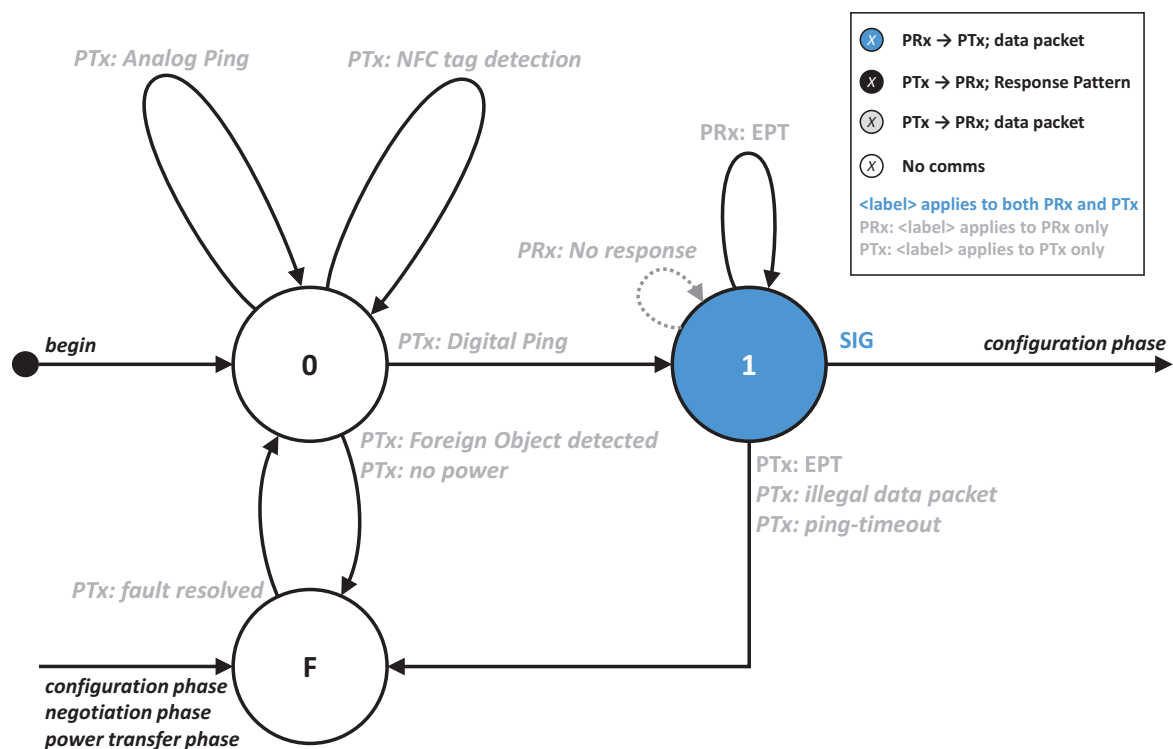
The *Qi Specification, Communications Protocol* (this document) describes the protocol using state diagram that apply to both the Power Transmitter and the Power Receiver. In most states, the Power Transmitter or Power Receiver can send or receive a data packet. Depending on this data packet, the Power Transmitter and Power Receiver switch to the next state. In the case of communications errors, the Power Transmitter and Power Receiver can switch to different states. The power transfer protocol provides mechanisms to resynchronize the Power Transmitter and Power Receiver to the same state.

Some state transitions apply only to the Power Transmitter or only to the Power Receiver, as indicated by their labels. Most of these transitions relate to error conditions such as timeouts or unexpected content in a received data packet. Additionally, some state transitions list multiple conditions. Satisfying any one of those conditions is sufficient to follow such a transition to the next state.

The description of state transitions that apply to both the Power Transmitter and the Power Receiver use the data packet sender's perspective. The data packet receiver's perspective of these transitions simply is to have received the data packet correctly. If the data packet receiver does not receive the data packet correctly, a transition that is associated with an appropriate timeout applies.

The state diagram shown in [Figure 5](#) applies to both the Baseline Protocol and the Extended Protocol.

Figure 5. State diagram of the ping phase



4.1.1 Transitions from state 0

State 0 is the first state of the protocol. The Power Transmitter switches to this state after completing its power-up initialization functions. In this state, the Power Transmitter attempts to detect the presence of a Power Receiver, NFC tags, and Foreign Objects. The following transitions are possible from this state.

- *PTx: Analog Ping.* The Power Transmitter has attempted to detect objects using an Analog Ping or an alternative method. See the *Qi Specification, Power Delivery*, for details.
- *PTx: NFC tag detection.* The Power Transmitter has attempted to detect NFC tags in the Operating Volume. See the *Qi Specification, NFC Tag Protection*, for the recommended approach.
- *PTx: Digital Ping.* The Power Transmitter has found an object that is likely to contain a Power Receiver and therefore has initiated a Digital Ping.
- *PTx: Foreign Object detected.* The Power Transmitter has detected a Foreign Object, or NFC tag, which prevents it from initiating a Digital Ping. See the *Qi Specification, Foreign Object Detection*, for examples.
- *PTx: no power.* The Power Transmitter has discovered that it cannot sustain a power transfer to the Power Receiver.

NOTE: The Power Transmitter may conclude that it cannot sustain a power transfer when the Power Receiver repeatedly requests it to terminate the power transfer using EPT/nr or EPT/an data packets (in the negotiation phase and/or power transfer phase). For example, the Power Transmitter cannot sustain a power transfer is when the Power Transmitter is plugged into an underrated USB power source.

4.1.2 Transitions from state 1

State 1 is the first state of the protocol in which the Power Receiver participates actively. The following transitions are possible from this state.

- *SIG.* The Power Receiver has sent a SIG data packet.
- *PRx: EPT.* The Power Receiver has sent an EPT data packet.
- *PTx: EPT.* The Power Transmitter has received an EPT data packet.
- *PTx: illegal data packet.* The Power Transmitter has received a data packet other than SIG or EPT.
- *PTx: ping timeout.* The Power Transmitter has not detected the start of a data packet before the Digital Ping timeout t_{ping} . See [Section 4.2.3, Digital Ping timeout](#), for the timeout value.
- *PRx: no response.* In exceptional cases, the Power Receiver may choose not to respond to a Digital Ping.

4.1.3 Transitions from state F

In state F, the Power Transmitter resolves any fault condition that can occur in execution of the protocol. The Power Transmitter can reach this state from any of the other protocol phases, in particular when

- It receives an EPT data packet.
- It times out on a data packet from the Power Receiver.
- It detects a protocol error (e.g. on receiving an unexpected data packet).
- It decides to abort the protocol for internal reasons (e.g. when executing consecutive Digital Pings on multiple coils).

NOTE: Reception of an EPT data packet does not necessarily mean that a fault has occurred. For example, it can involve a request from the Power Receiver to delay restarting the protocol. See [Section 8.8, Extended Identification—XID \(0x81; status update\)](#), for a list of error codes.

Upon entering state F, the Power Transmitter shall remove the Power Signal within the time window $t_{\text{terminate}}$.

- *PTx: fault resolved:* The Power Transfer has resolved the fault conditions and is ready to restart execution of the protocol.

4.2 Ping phase timings

Table 11 provides an overview of the timing constraints that apply to the ping phase.

Table 11: Timing constraints in the ping phase

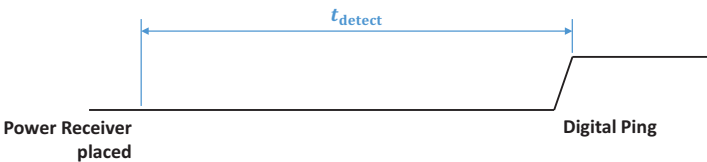
Parameter	Side	Symbol	Minimum	Target	Maximum	Unit
Detection time window	PTx	t_{detect}	N/A	N/A	5,000	ms
Wake-up window	PRx	t_{wake}	19	40	64	ms
Digital Ping timeout	PTx	t_{ping}	65	65	70	ms
Power termination window	PTx	$t_{\text{terminate}}$	N/A	N/A	28	ms
Reset window	PRx	t_{reset}	N/A	25	28	ms
No Power Signal window	PTx	t_{nopower}	32	N/A	N/A	ms
Next Digital Ping window	PTx	t_{nextping}	See Table 25 in Section 8.7, <i>End Power Transfer—EPT (0x02; power control)</i>			

For the timing details and other properties of the Analog Pings the Power Transmitter may use to detect objects, see the *Qi Specification, Power Delivery*.

4.2.1 Power Receiver detection

The Power Transmitter shall initiate a Digital Ping at t_{detect} from the user placing a Power Receiver within its Operating Volume.

Figure 6. Detection time window

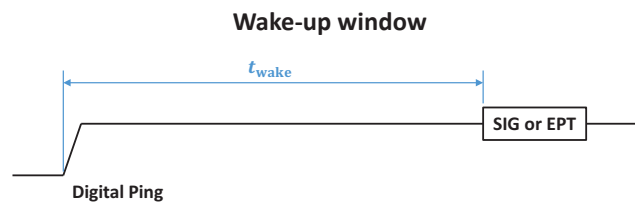


NOTE: The black line represents the Power Signal, which initially is zero and increases when the Power Transmitter initiates the Digital Ping. The Power Transmitter may apply Analog Pings before initiating the Digital Ping. Such Analog Pings would show as brief departures of the black line from the zero level.

4.2.2 Power Receiver wake-up

If the Power Receiver intends to engage with the Power Transmitter, it shall send a SIG data packet at t_{wake} after the Power Transmitter has initiated the Digital Ping. If the Power Receiver does not intend to engage with the Power Transmitter, it shall either send an EPT data packet at t_{wake} after the Power Transmitter has initiated a Digital Ping, or not respond at all.

NOTE: A Power Transmitter may use multiple Digital Pings to enhance the positioning freedom of a Power Receiver. A Power Receiver should therefore respond consistently with a SIG data packet to such Digital Pings. See [Section 8.17, Signal Strength—SIG \(0x01; status update\)](#), for an explanation of how the Power Receiver should determine the Signal Strength Value in the SIG data packet.

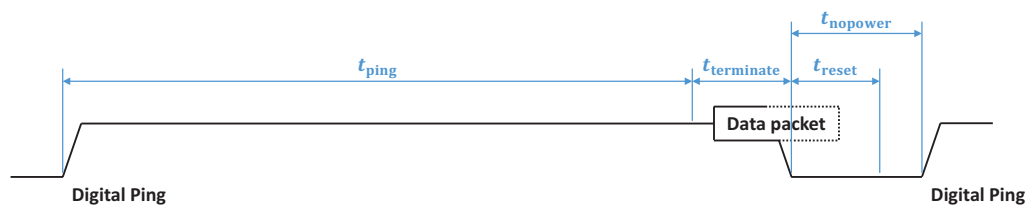


NOTE: See the *Qi Specification, Communications Physical Layer*, for the reference time of the start of a data packet.

4.2.3 Digital Ping timeout

If the Power Transmitter has not detected the start of a data packet at t_{ping} , it shall remove the Power Signal at $t_{\text{terminate}}$. The start of the Digital Ping timeout is the application of the Power Signal.

Figure 7. Digital Ping timeout

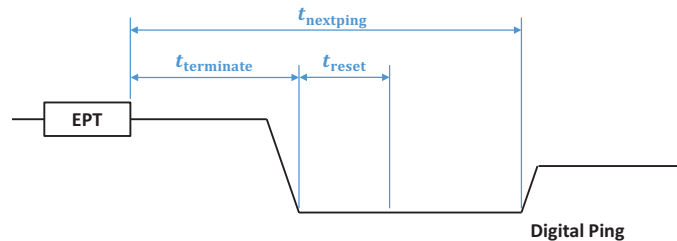


NOTE: See [Section 4.2.5, Power Receiver reset](#), for details about t_{reset} and t_{nopower} .

4.2.4 End Power Transfer (EPT) data packet

A Power Transmitter shall remove the Power Signal at $t_{\text{terminate}}$ from the end of an EPT data packet and switch to state F of the ping phase, regardless of the End Power Transfer Code contained in the data packet. After removing the Power Signal, the Power Transmitter shall initiate a first Digital Ping at t_{nextping} from the end of the EPT data packet. The value of t_{nextping} depends on the value contained in the EPT data packet.

Figure 8. End Power Transfer data packet timing



After sending a first EPT data packet, the Power Receiver should continue to send EPT data packets while the Power Signal is present. The transmission of these data packets shall comply with the timing constraints for consecutive data packets provided in [Section 5.2.2, Consecutive data packets](#).

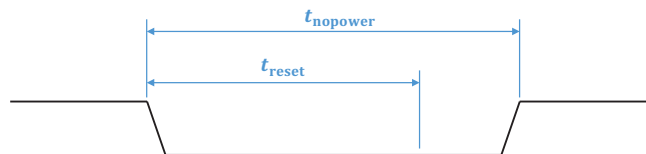
NOTE: Consecutive EPT data packets may contain different values in their End Power Transfer Code fields.

4.2.5 Power Receiver reset

The Power Transmitter shall not apply an Analog Ping or initiate a Digital Ping in the time window t_{nopower} after removing the Power Signal. The Power Receiver shall discard the Power Transfer Contract at t_{reset} after the Power Transmitter removes the Power Signal. If the Power Signal reappears before the Power Receiver has discarded the Power Transfer Contract, it may continue with the protocol from the state it was in when the Power Signal disappeared.

NOTE: The time window t_{nopower} applies in particular to consecutive Digital Pings in Power Transmitters that use multiple coils to enable a greater positioning freedom for Power Receivers.

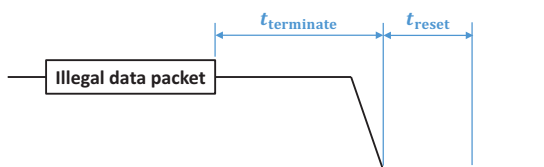
Figure 9. Reset time window



4.2.6 Illegal data packet

The Power Transmitter shall remove the Power Signal at $t_{\text{terminate}}$ after receiving an illegal data packet.

Figure 10. Illegal data packet timeout



NOTE: If the time to receive the first data packet in the ping phase takes longer than the time to receive a SIG or EPT data packet, the Power Transmitter should treat that data packet as an illegal data packet and remove the Power Signal without waiting to receive the remainder of the data packet.

5 Configuration phase

The configuration phase is the part of the protocol in which:

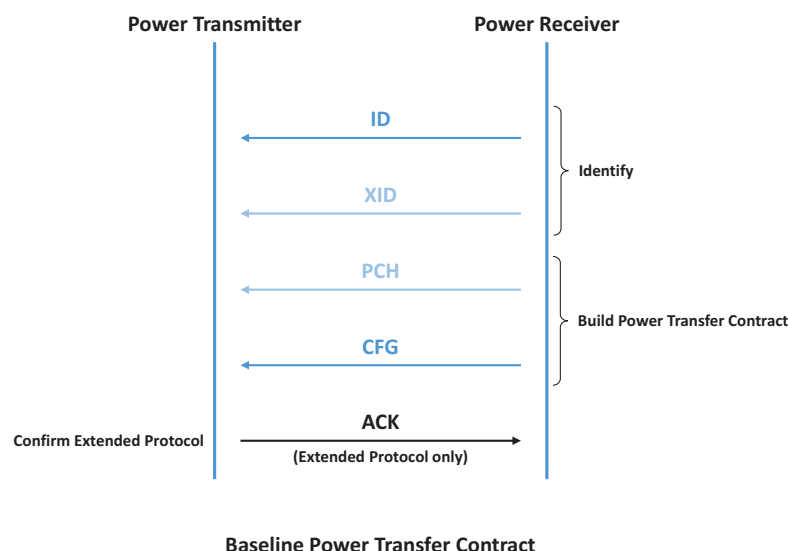
- The Power Receiver identifies itself to the Power Transmitter.
- The Power Receiver and Power Transmitter establish a baseline Power Transfer Contract. See [Section 2, Overview](#), for details about the information contained in the Power Transfer Contract.
- The Power Receiver and Power Transmitter determine the protocol variant to use in the power transfer.

In the configuration phase, the Power Transmitter and Power Receiver continue to operate using the Digital Ping parameters. This means that the power and current levels in both the Power Transmitter and Power Receiver change only if a user moves the Power Receiver from its position within the Operating Volume.

NOTE: Multi-coil Power Transmitters may proceed into the configuration phase to obtain the Power Receiver's identification data before executing a new Digital Ping with a different coil configuration. This enables such Power Transmitters to discriminate between multiple Power Receivers located within their Operating Volumes. See the *Qi Specification, Power Delivery*, for examples of this approach.

Figure 11 summarizes the data flow in the configuration phase. The Power Receiver identifies itself using an Identification (ID) data packet and optionally an Extended Identification (XID) data packet. It provides data for use in the Power Transfer Contract using an optional Power Control Hold-off (PCH) data packet and a Configuration (CFG) data packet. In the final step, the Power Transmitter acknowledges Extended Protocol (if applicable).

Figure 11. Data flow in the configuration phase

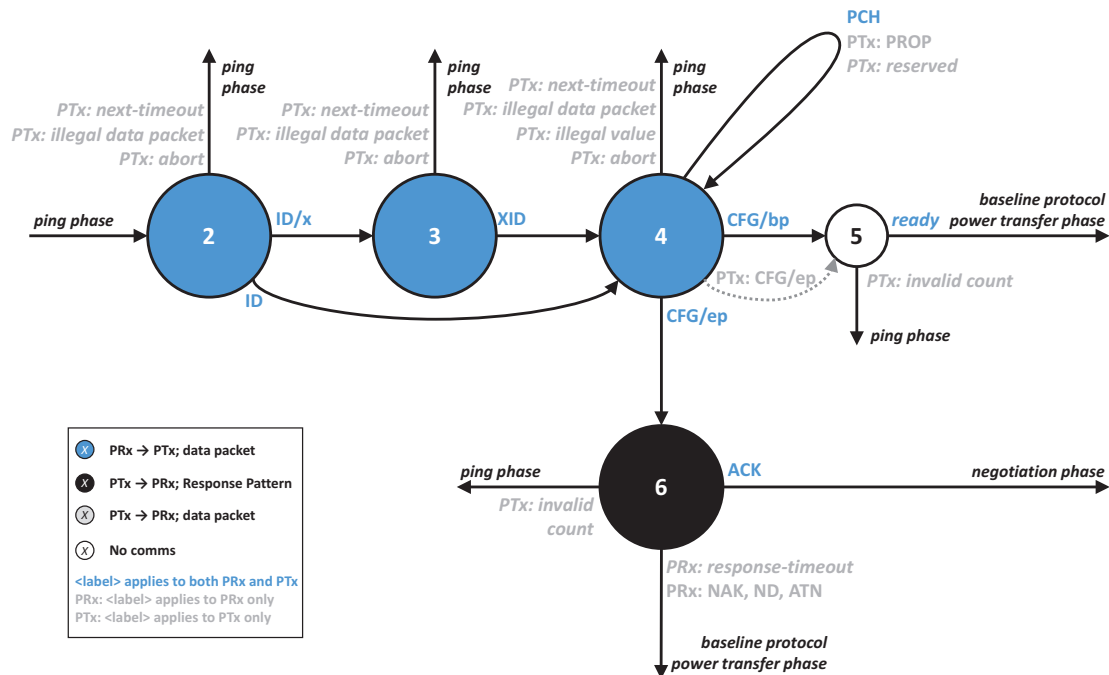


5.1 Configuration phase state diagram

The state diagram shown in Figure 12 applies to both the Baseline Protocol and the Extended Protocol.

NOTE: For details about how to interpret this diagram, see Section 4.1, *Ping phase state diagram*.

Figure 12. State diagram of the configuration phase



5.1.1 Transitions from state 2

In state 2, the Power Receiver identifies itself to the Power Transmitter. The following transitions are possible from this state.

- *ID*. The Power Receiver has sent an ID data packet with its Ext bit set to ZERO. See Section 8.11, *Identification—ID (0x71; status update)*, for the meaning of the Ext bit.
- *ID/x*. The Power Receiver has sent an ID data packet having its Ext bit set to ONE.
- *PTx: illegal data packet*. The Power Transmitter has received a data packet other than ID.
- *PTx: next-timeout*. The Power Transmitter has not detected the start of a data packet from the Power Receiver before the next data packet timeout t_{next} . See Section 5.2.2, *Consecutive data packets*.
- *PTx: abort*. The Power Transmitter may abort further execution of the protocol for internal reasons. For example, a multi-coil Power Transmitter may execute Digital Pings on several coils in order to determine the optimum coil configuration for the power transfer, aborting the protocol after receiving the SIG data packet. See Section 5.1.6, *Examples*, for details.

When switching to the ping phase, the Power Transmitter enters state F (and removes the Power Signal).

5.1.2 Transitions from state 3

In state 3, the Power Receiver provides optional extended identification data. The following transitions are possible from this state.

- *XID*. The Power Receiver has sent an XID data packet.
- *PTx: illegal data packet*. The Power Transmitter has received a data packet other than XID.
- *PTx: next-timeout*. The Power Transmitter has not detected the start of a data packet from the Power Receiver before the next data packet timeout t_{next} . See [Section 5.2.2, Consecutive data packets](#), for the timeout value.
- *PTx: abort*. The Power Transmitter may abort further execution of the protocol for internal reasons. For example, a multi-coil Power Transmitter may execute Digital Pings on several coils in order to determine the optimum coil configuration for the power transfer, aborting the protocol after receiving the ID data packet. See [Section 5.1.6, Examples](#), for details.

When switching to the ping phase, the Power Transmitter enters state F (and removes the Power Signal).

5.1.3 Transitions from state 4

In state 4, the Power Receiver provides the elements of the baseline Power Transfer Contract to the Power Transmitter. The following transitions are possible from this state.

- *PCH*. The Power Receiver has sent a PCH data packet.
- *PTx: PROP*. The Power Transmitter has received a PROP data packet. See [Table 17](#) in [Section 8, Power Receiver data packets](#), for the list of proprietary data packets. The Power Transmitter shall ignore all unsupported PROP data packets, but still include them in the count of optional data packets.

NOTE: The state diagram does not provision for the Power Receiver to send proprietary data packets in the configuration phase. The requirement that the Power Transmitter ignore all proprietary data packets enables a future enhancement of the protocol in which the Power Receiver may send proprietary data packets in the configuration phase. However, plans for such an enhancement of the protocol do not currently exist.

- *PTx: reserved*. The Power Transmitter has received a reserved data packet. See [Table 17](#) in [Section 8, Power Receiver data packets](#), for the list of defined data packets and reserved data packets. The Power Transmitter shall ignore all reserved data packets, but still include them in the count of optional data packets.
- *CFG/bp*. The Power Receiver has sent a CFG data packet with its Neg bit set to ZERO. This means that the Power Receiver supports the Baseline Protocol only.
- *CFG/ep*. The Power Receiver has sent a CFG data packet with its Neg bit set to ONE. This means that the Power Receiver supports both the Baseline Protocol and the Extended Protocol.
- *PTx: illegal data packet*. The Power Transmitter has received a data packet not listed on any one of the transitions of state 4.

- *PTx: illegal value.* The Power Transmitter has received a PCH data packet containing a Power Control Hold-offTime outside the allowed range. See [Section 8.12, Power Control Hold-off—PCH \(0x06; status update\)](#), for the allowed range. The Power Transmitter has received a CFG data packet that does not comply with the format defined in [Section 8.4, Configuration—CFG \(0x51; simple query\)](#). See [Section 5.2.4, Illegal value in a data packet](#), for the timeout value.
- *PTx: next-timeout.* The Power Transmitter has not detected the start of a data packet from the Power Receiver before the next data packet timeout t_{next} . See [Section 5.2.2, Consecutive data packets](#), for the timeout value.
- *PTx: abort.* The Power Transmitter may abort further execution of the protocol for internal reasons. For example, a multi-coil Power Transmitter may execute Digital Pings on several coils in order to determine the optimum coil configuration for the power transfer, aborting the protocol after receiving the Identification (ID) or Extended Identification (XID) data. See [Section 5.1.6, Examples](#), for details.
- *PTx: CFG/ep.* A Power Transmitter that does not support the Extended Protocol shall switch to state 5, regardless of the value of the NEG bit in the CFG data packet. In exceptional cases, a Power Transmitter that does support the Extended Protocol may decide to continue in the Baseline Protocol (not sending an ACK Response Pattern), even if the Power Receiver indicates that it supports the Extended Protocol.

NOTE: In this case, the Power Receiver goes through state 6 to the power transfer phase of the Baseline Protocol.

When switching to the ping phase, the Power Transmitter enters state F (and removes the Power Signal).

5.1.4 Transitions from state 5

In state 5, the Power Transmitter verifies the Count field of the received CFG data packet. The Power Receiver follows the ready transition (unconditionally). The following transitions are possible from this state.

- *Ready*. The Power Receiver and the Power Transmitter switch to the power transfer phase of the Baseline Protocol. Prior to switching, the Power Transmitter shall verify that the Count field of the CFG data packet matches the number of PCH, PROP and reserved data packets received in state 4.
- *PTx: invalid count*. The Power Transmitter has received a CFG data packet containing a Count field that does not match the number of optional data packets received in state 4. See [Section 5.2.4, *Illegal value in a data packet*](#), for the timeout value.

When switching to the ping phase, the Power Transmitter enters state F (and removes the Power Signal).

5.1.5 Transitions from state 6

In state 6, the Power Transmitter decides whether to use the Baseline Protocol or the Extended Protocol. The following transitions are possible from this state.

- *ACK*. The Power Transmitter has agreed to continue using the Extended Protocol.
NOTE: The Power Transmitter may decide to use the Baseline Protocol and not send an ACK, even if it supports the Extended Protocol.
NOTE: If the Power Transmitter responds to the CFG data packet with ACK, it switches to the negotiation phase of the Extended Protocol. However, if the Power Receiver does not receive the ACK correctly, it times out and switches to the power transfer phase of the Baseline Protocol. As a result, there is an operating phase mismatch between the Power Transmitter and Power Receiver. But when the Power Receiver sends its first data packet in the power transfer phase (e.g. a CE data packet), the Power Transmitter discovers the mismatch and switches to the power transfer phase of the Baseline Protocol as well. See [Figure 22 in Section 6.6, *Negotiation phase state diagram*](#), for additional details on this mechanism. Alternatively, the Power Transmitter may switch to state F in the ping phase (and remove the Power Signal) to resolve the mismatch.
- *PTx: invalid count*. The Power Transmitter has received a CFG data packet containing a Count field that does not match the number of optional data packets received in state 4. See [Section 5.2.4, *Illegal value in a data packet*](#), for the timeout value.
- *PRx: response-timeout*. The Power Receiver has not detected an ACK response to its CFG data packet before the response timeout $t_{\text{responsetimeout}}$ presumably because the Power Transmitter does not support the Extended Protocol. See [Section 5.2.3, *Configuration \(CFG\) data packet*](#), for the timeout value.
- *PRx: NAK/ND/ATN*. The Power Receiver has received an unexpected response.

When switching to the ping phase, the Power Transmitter enters state F (and removes the Power Signal).

5.1.6 Examples

5.1.6.1 Optimum coil selection in a multi-coil Power Transmitter

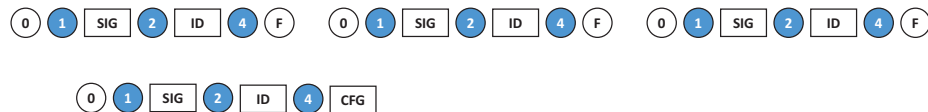
Figure 13 and Figure 14 provide examples of communications sequences of a multi-coil Power Transmitter executing multiple Digital Pings to select an optimum coil for the power transfer. In the example of Figure 13, the Power Transmitter repeatedly goes through state 0 (executing a Digital Ping), state 1 (receiving a SIG data packet), state 2 (storing the Signal Strength data and aborting the Digital Ping), and state F (resolving the issue, which in this case means selecting a different coil for the next Digital Ping). Eventually, the Power Transmitter has collected a sufficient number of Signal Strength Values from multiple coils. It then selects the optimum coil for the power transfer for use in the final sequence, in which it continues to receive the CFG data packet.

In the example of Figure 14, the Power Transmitter retrieves ID data packets (in addition to SIG data packets), in order to discriminate between multiple Power Receivers that can be positioned in its Operating Volume.

Figure 13. Example of a communications sequence in a multi-coil Power Transmitter to select a coil



Figure 14. Another example of a communications sequence in a multi-coil Power Transmitter to select a coil



5.2 Configuration phase timings

Table 12 provides an overview of the timing constraints that apply to the communications and other actions in the configuration phase.

Table 12: Timing constraints in the configuration phase

Parameter	Side	Symbol	Minimum	Target	Maximum	Unit
Silent window	PRx	t_{silent}	6	7	N/A	ms
Next data packet window	PRx	t_{start}	11.5	N/A	19	ms
Next data packet timeout	PTx	t_{next}	22	N/A	25	ms
Power termination window	PTx	$t_{\text{terminate}}$	See Table 11 in Section 4.2, <i>Ping phase timings</i>			
Reset window	PRx	t_{reset}	See Table 11 in Section 4.2, <i>Ping phase timings</i>			
Response start window	PTx	t_{response}	See Table 14 in Section 6.7, <i>Negotiation phase timings</i>			
Response timeout	PRx	$t_{\text{responsetimeout}}$				

5.2.1 Generic constraints

A Power Receiver shall start to transmit the preamble of a next data packet at t_{silent} from the end of the data packet directly preceding it.

Figure 15. Generic timing constraints



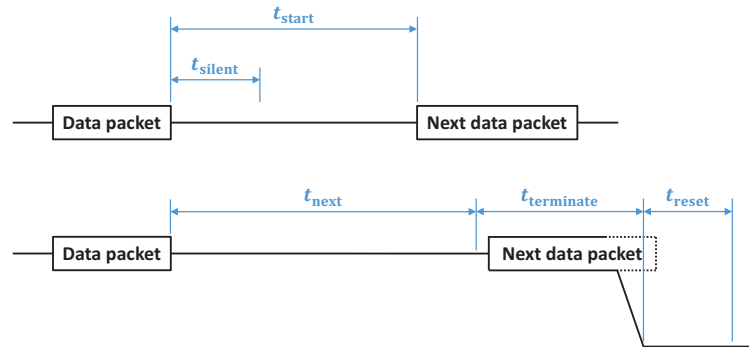
NOTE: Most figures in the *Qi Specification, Communications Protocol* (this document) do not show the preamble explicitly. See the *Qi Specification, Communications Physical Layer*, for the reference times defining the start and end of a data packet.

5.2.2 Consecutive data packets

A Power Receiver shall start sending the next data packet at t_{start} from the end of the preceding data packet. The SIG data packet sent in the ping phase counts as a preceding data packet. See the *Qi Specification, Communications Physical Layer*, for the reference times defining the start and end of a data packet.

If the Power Transmitter has not detected the start of a data packet at t_{next} , it shall remove the Power Signal at $t_{\text{terminate}}$.

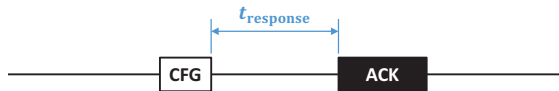
Figure 16. Timing of consecutive data packets



5.2.3 Configuration (CFG) data packet

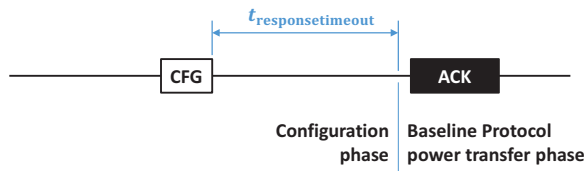
A Power Transmitter shall start to transmit its response at t_{response} from the end of a simple-query data packet or a data-request data packet.

Figure 17. Power Transmitter response timing



If a Power Receiver has not detected the start of a Response Pattern or data packet at $t_{\text{responsetimeout}}$ from the end of a simple-query or data-request data packet, it shall switch to the power transfer phase of the Baseline Protocol.

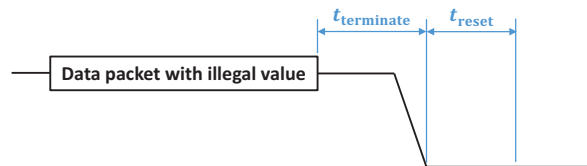
Figure 18. Power Receiver response timeout



5.2.4 Illegal value in a data packet

The Power Transmitter shall remove the Power Signal at $t_{\text{terminate}}$ after receiving a data packet containing an illegal value.

Figure 19. Illegal value timeout



5.2.5 Illegal data packet

The Power Transmitter shall remove the Power Signal at $t_{\text{terminate}}$ after receiving an illegal data packet.

Figure 20. Illegal data packet timeout

