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Wireless power transfer – Management – Part 2: Multiple device control management

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Part 2: Multiple device control management

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

FDIS	Report on voting
100/2900/FDIS	100/2939/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

The IEC 62827 (Wireless Power Transfer – Management) series provides the management protocol for a wireless power transfer system in which power sources can deliver power to receivers at a distance. The IEC 62827 series consists of the following parts:

- Part 1: Common components
- Part 2: Multiple device control management
- Part 3: Multiple source control management

Part 1 of IEC 62827 defines the definition and functionality for wireless power transfer systems.

Part 2 of IEC 62827 specifies the management protocol of wireless power transfer for multiple devices.

Part 3 of IEC 62827 specifies the management protocol of wireless power transfer for multiple sources.

WIRELESS POWER TRANSFER – MANAGEMENT –

Part 2: Multiple device control management

1 Scope

This part of IEC 62827 defines a wireless power management protocol for wireless power transfer to multiple devices in a wireless power management system. Various functions of wireless power management systems are justified. The wireless power management frames and messages that work between the management block of a power source and the management block or the coupler block of a device, or the coupler block of a power source, are defined as well to execute various functions. Also, the procedures for each functionality are described based on its frames and messages.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62827-1, *Wireless power transfer – Management – Part 1: Common components*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 62827-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Definitions

3.1.1
COM ID
ID which is allocated to power a receiver within the wireless data communication zone of the wireless power source

3.1.2
wireless data communication zone
area where a wireless power source can transfer data to wireless power receivers without physical contact

3.1.3
wireless power management frame
format of the data which is exchanged between a wireless power source and a wireless power receiver

3.1.4
wireless power management message
data which is exchanged between a wireless power source and a wireless power receiver

3.1.5
wireless power management protocol
set of rules which determines how a wireless power source communicates with wireless power receivers in the wireless power management system

3.1.6
wireless power management system
management system that is capable of transferring electric power from either one or multiple wireless power source(s) to either one or multiple wireless power device(s) with wireless communication

Note 1 to entry: In the event that areas or regions, where both data and power can be transferred, are emphasized, the term “Wireless Power Transfer Network” may be used.

3.1.7
wireless power management system
<device> wireless power receiver that can receive electric power from wireless power sources

3.1.8
wireless power management system
<repeater> wireless power relay transmitter that can transfer electric power from one or multiple wireless power source(s) to one or multiple wireless power receiver(s)

3.1.9
wireless power management system
<source> wireless power source that can transfer electric power to a number of wireless power receivers or relay transmitters

3.1.10
wireless power receiver
device that receives electric power wirelessly

3.1.11
wireless power source
transmitter that delivers electric power to power receiver

3.1.12
wireless power transfer
transfer of electric power without the physical contact of electrodes

3.1.13
wireless power transfer system
system that wirelessly transfers electric power from a wireless power source to a wireless power receiver

3.1.14
wireless power transfer zone
area where a wireless power source can transfer electric power to wireless power receivers without physical contact

3.1.15
WPT ID
ID which is allocated to the device within the wireless power transfer zone of wireless power source

3.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply:

ABNR	abnormal
API	application programming interface
APP	application
DMTC	device management to coupler
DST	destination
ELGB	eligibility
MAC	medium access control
MFAN	magnetic field area network
MGMT	management
MTM	MGMT to MGMT
NFC	near field communication
PHY	physical
RFID	radio frequency identification
RSSI	received signal strength indicator
RX	receiving
RxPower	received power
SCHDL	scheduling
SMTA	source management to application
SRC	source
UCID	unique coupler ID
WDCZ	wireless data communication zone
WPMS	wireless power management system
WPMS–D	wireless power management system – device
WPMS ID	wireless power management system identification
WPMS–R	wireless power management system – repeater
WPMS–S	wireless power management system – source
WPT	wireless power transfer
WPTS	wireless power transfer system
WPTZ	wireless power transfer zone

4 Overview

WPMS, which is defined in IEC 62827-1, is a management protocol system for wireless power transfer to a number of WPMS–Ds. WPT is a technology that replaces the conventional wired charging method with wireless charging. It utilizes the characteristics of magnetic fields and electric fields to deliver power wirelessly. In the market, there are a large number of wireless charging devices, designed under various kinds of protocols, which are not interoperable. The inconvenience it causes to users could cost an unnecessary large sum of money, and uneconomical expenditure. WPMS aims to provide consumers of wireless charging devices an option to be able to fully utilize a system that is compatible with a number of existing technologies. Also, to break away from conventional 1:1 wireless charging (1:1 WPT), WPMS will be managing power transfer to multiple WPMS–Ds at a time (1:N WPT), using various WPT modes.

Figure 1 – Usage examples of WPMS services

- The WPMS technology can be applied to the following industry fields, and others that require a constant power supply. WPMS services can be provided as shown in Figure 1.Mobile terminals: charging services can be provided within mobile terminals anytime and anywhere.
- Home appliances: to make entangled cable mess neat and convenient, the use of WPMS technology can offer the benefits of minimal wiring and freedom of furniture arrangement.

In order to provide effective WPT to multiple WPMS–Ds, a proper management protocol shall be thoroughly structured as shown in Figure 2. This protocol enables WPMS–S or WPMS–R to control WPMS–Ds for efficient WPT process, regardless of MAC and PHY types. Under the structure of WPMS, it will be able to incorporate both out-band WPT systems, which use Wi-Fi, Bluetooth, ZigBee, NFC, RFID etc., and in-band WPT systems, which use MFAN etc. The WPMS can exchange the messages between such blocks as APP block, MGMT block and coupler block. See Annex A for additional information. It shall have the system structure shown in Figure 2.

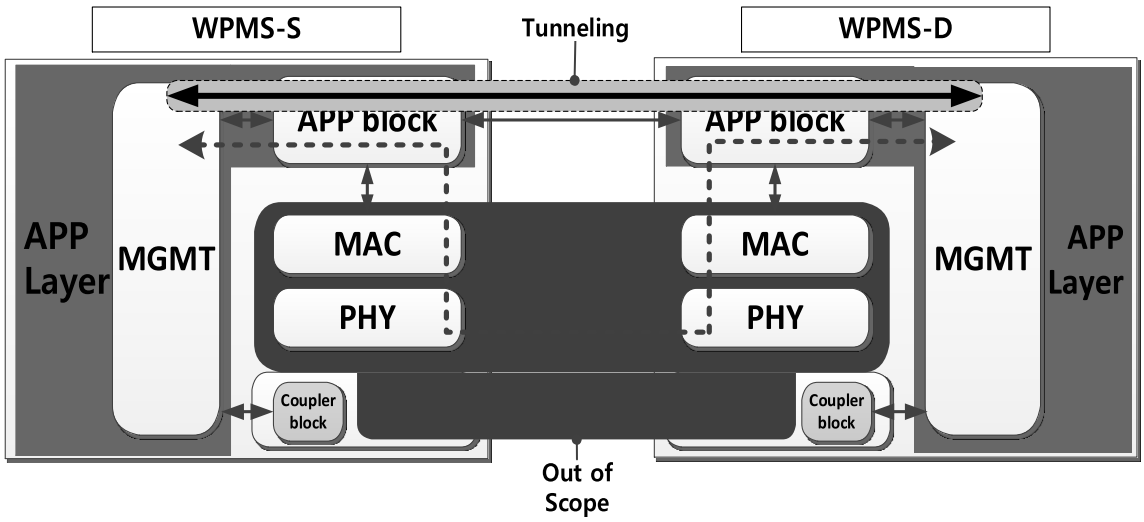

Figure 2 – WPMS structure

In order to efficiently provide WPT services to multiple WPMS–Ds, a proper signalling system is required; it shall be incorporated for the exchange of WPT data and control signals. For the compatibility of the WPT, users may select various frequency bands for the WPT as well.

Within the WPMS's range, WPMS–Ss or WPMS–Rs can provide WPTs with several watts to several hundred watts. The closer the distance between WPMS–Ss and WPMS–Ds, the greater the efficiency becomes. As shown in Figure 1, provided that enough infrastructure is installed, an omnipresent charging environment is created.

Functions like optimal WPT mode selection are included for the best WPT efficiency. Also, the WPMS includes emergency controls that provide counter-measures to contingencies, such as sudden WPMS–D detection and disappearance. General WPT environments are controlled by WPMS–Ss, which manage connection, separation, and release of WPMS–Ds. In order to increase the efficiency of WPMS, WPTS can use in band communication which utilizes the frequency to transfer data as well as power.

5 Functionalities

5.1 General

In order to design a management protocol that can construct reliable and efficient WPTS for multiple WPMS–Ds, it needs to include all the fundamental functions, yet not repetitively. In WPMSs, there are two ways of controlling compatibility: indirect control and direct control. Also, functions are categorized into six distinctive functions. They are initialization, association, general WPT management, abnormal WPT management, inter–device WPT management, and termination.

5.2 Compatibility

5.2.1 General

There are two ways of control, depending on the compatibility with WPTS and WPMS. If WPTS does not support WPMS, WPMS will control indirectly; otherwise, it will control directly.

5.2.2 Indirect control

Under indirect control, a WPMS-S detects nearby a WPMS-D through a frequency scan. Once detected, a WPMS-S will at least acknowledge the number and type of WPMS-Ds within its range. WPMS-S will manage WPMS-Ds only as they are defined in each WPTS specification.

5.2.3 Direct control

If WPMS application is compatible with WPTS, direct control can be used. In this case, the application can communicate with WPTS to receive various pieces of information from it. As a consequence, a WPMS-S can manage the entire WPMS more effectively. In order to fully utilize direct control, there shall be appropriate adjustments to each WPTS specification.

5.3 Initialization

5.3.1 General

Before a WPMS-S can initiate a WPT service to multiple WPMS–Ds, establishing communication with WPMS-Ds should precede.

5.3.2 Frequency band scan

To identify WPMS-Ds within the WPTZ, the WPMS-S periodically broadcasts connection requests to match with all WPMS-Ds of diverse frequency bands. The broadcasting is processed in in-band and out-band scans in order to support diverse types of WPMS-Ds.

5.3.3 Initiation power transfer

When there is not a single WPMS-D detected from the frequency band scan, the WPMS-S considers the possibility of a powered down WPMS-D. To wake up powered down WPMS-Ds if there are any, the WPMS-S periodically transfers initiation power in several frequencies, when there is no WPMS-D associated to the WPMS-S. When there are WPMS-Ds in the WPMS that is currently receiving the WPT, the ongoing WPT may wake up powered down WPMS-Ds.

5.4 Association

5.4.1 General

Once WPMS-Ds have been initiated, they need to be associated by WPMS-S to be properly scheduled for efficient WPT.

5.4.2 Communication connection

Once WPMS–Ds are detected from frequency band scans, the WPMS–S sends connection requests to WPMS–Ds. WPMS–Ds that have received a connection request will reply back to WPMS–S with their addresses. The WPMS–S will check on the received device address, and register the address. Accordingly, the WPMS–S will allocate a COM ID to each WPMS–D.

5.4.3 WPT eligibility check

As a WPMS–D is connected to the WPMS–S and allocated a COM ID, the WPMS–S will request it’s the device status of the WPMS–D – frequency, battery information, received signal strength, and so on. The WPMS–D will return information in response data. With the data, the WPMS–D calculates eligibility with various factors, such as the distance to WPMS–Ds. Consequently, the WPMS–S will inform the WPMS–Ds whether they are eligible for WPT or not. According to the result of the eligibility check, the final candidate for WPT service will be determined, and receive WPT ID.

5.5 General charging management

5.5.1 General

When more than one authenticated WPMS–D is within the WPTZ, the WPMS–S initiates the WPT service. Distinctively, there are four modes for WPT in WPMS: simultaneous WPT mode, sequential WPT mode, foaming WPT mode, and compound WPT mode. The user may configure any of the modes according to charging status of WPT.

5.5.2 Simultaneous WPT

When there is one WPMS–D for WPT, or if the user wishes to transfer power with multiple WPMS–Ds, simultaneous WPT mode will be selected. In this mode, WPMS–S broadcasts wireless power to all WPMS–Ds within the WPTZ at the same time. For fine tuning, test power is transferred to WPMS–Ds before proper WPT. The efficiency is calculated after receiving reception power level from WPMS–Ds. Accordingly, the WPMS–S calculates optimal impedance matching, and WPT is performed to all WPMS–Ds within the WPTZ. The process continues unless WPT is terminated.

5.5.3 Sequential WPT

When there are multiple WPMS–Ds, the user may choose to precede WPT in sequential WPT mode. In this mode, the WPMS–S will divide WPT period into several time slots, and allocate each time slot to each WPMS–D to maximize WPT efficiency. The WPMS–S will inform the WPMS–Ds of the WPT schedule: when to turn on and off the coupler antenna. For each individual WPT in each time slot, an optimal impedance matching is carried out for maximum efficiency. The sequential WPT cycle is terminated when the WPT of the last time slot is completed.

5.5.4 Foaming WPT

When there are multiple WPMS–Ds, the user may choose to precede WPT in foaming WPT mode. In this mode, power is transferred to multiple WPMS–Ds, but it is focused onto designated WPMS–Ds with a greater efficiency. The WPMS–S with received device statuses calculates priority and transfers power according to the priority, either by sequential or simultaneous WPT mode. It can be done by allocating various time divisions, using a different number of coils, and so on. A foaming WPT cycle is terminated at the same point as where simultaneous and sequential WPT modes are completed.

5.5.5 Compound WPT

When there are multiple WPMS–Ds, the user may choose to precede WPT in compound WPT mode, a combination of simultaneous, sequential, and foaming WPT. In this mode, a WPMS–S may undertake WPT with various characteristics. It may allocate a group of WPMS–Ds in a time slot, or give a primary order while in simultaneous WPT, at the user's command. A compound WPT cycle is terminated at the same point as where simultaneous and sequential WPT modes are completed.

5.6 Abnormal status management

5.6.1 General

During WPT, the service stops immediately to resolve any abnormality within the WPMS, if any abnormal situation is detected. The abnormal situation is categorized into source situation detected by the source and device situation detected by the device.

5.6.2 Source status detection

5.6.2.1 General

WPMS–S constantly measures voltage and current from the coupler to take appropriate counter actions when a sudden variation is detected. When voltage/current variation is detected, the WPMS–S cuts WPT immediately to investigate the cause. It will either be of WPMS–D set distortion or foreign material detection.

5.6.2.2 Device reposition

When WPT is stopped after voltage/current variation detection, WPMS–S firstly considers the case of WPMS–D appearance or disappearance: WPMS–S will send a device status request to WPMS–Ds. If new WPMS–Ds respond to the request, or if existing WPMS–Ds do not respond, the WPMS–S considers the abnormal situation was due to Distortion of the set of WPMS-Ds. WPMS–S will re-calculate optimal impedance matching to start a new WPT.

5.6.2.3 Foreign material appearance

When all WPMS–Ds have responded to device status requests after voltage/current variation detection, the WPMS–S will know that the set of WPMS–Ds has not been changed. If the voltage/current variation is not from the Distortion of the set of WPMS-Ds it has to be from the foreign material. Since the foreign material could be temporary, the WPMS–S wil initiate another WPT service according to acknowledging that there is foreign material. If the foreign material is temporary and removed, the voltage/current variation will return to previous level; if the foreign material is persistent and negatively impacts WPT, WPMS–S will inform the user of it.

5.6.3 Device status detection

5.6.3.1 General

A WPMS–D constantly measures its own power level for any abnormal situations. When it detects an abrupt variation in discharge rate or full charge alert, the WPMS–D reports the situation to the WPMS–S in order to exit from WPT.

5.6.3.2 Discharge rate variation

When the PWMS–D starts to run various operations and discharge rate changes drastically, the WPMS–D informs the WPMS–S of it. The WPMS–S immediately cuts the WPT to recalculate the proper power level to be transferred. When the adjustment is finished, WPT is re-started at an appropriate level.

5.6.3.3 Full charge

When the WPMS–D is fully charged from the WPT, the WPMS–D informs the WPMS–S of it. The WPMS–S will command the WPMS–D to turn off the power coil, and recalculate the schedule without the fully charged WPMS–D. The same procedure applies afterwards.

5.7 Inter–device WPT management

Certain WPMS–Ds are able to carry out basic functions of WPT. In that case, inter-device WPT becomes possible. When a WPMS–S does not exist within the range of the WPMS–D, it may request a power supply from nearby WPMS-Ds that are using the same type of protocol, and that are capable of performing WPT. Upon the request, power transferring WPMS-D informs its user of the request. If the user approves it, simultaneous WPT on 1:1 basis is performed until timeout, or the user commands termination. Figure 3 shows the function of inter-device WPT management.

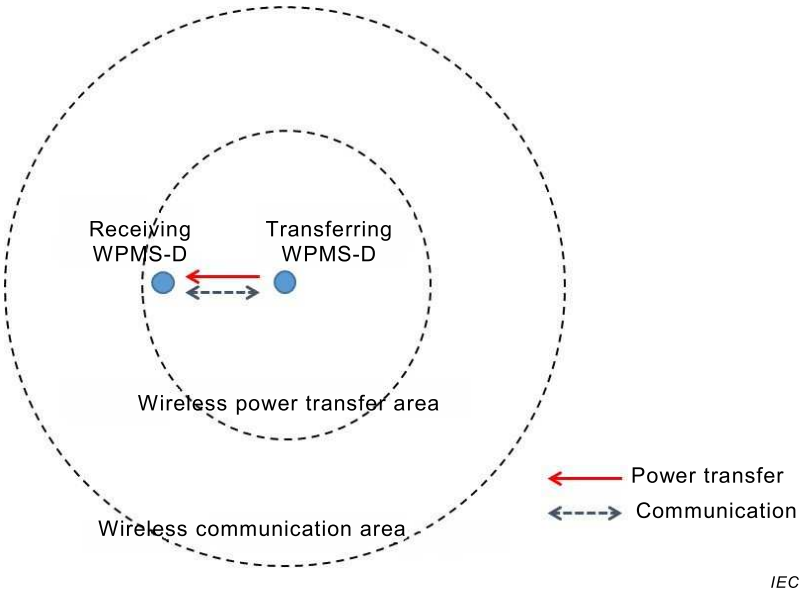

Figure 3 – Function of inter–device WPT management

5.8 Termination

Upon the command of the user, WPT will be terminated anytime by the WPMS–S. The WPMS–S will cut off WPT. The WPMS–Ds will wait for the requests when the WPMS–S is ready for the next WPT.

6 Protocols

6.1 General

For an efficient WPT, relevant information should be well communicated between the WPMS–S and WPMS–Ds. The overall process is carried out in diverse frame formats, which control and manage WPMS–Ds. Actual communication messages are sent in such formats. Universal compatibility of the format under the lower levels of the OSI layer is assumed to begin with. It operates on the basis of time division; if the lower-layer protocol does not support TDMA (if supporting primitive does not exist), there should be appropriate programing for similar tasks to make it work at a lower layer.

6.2 ID structure

6.2.1 Unique coupler ID

UCID consists of 8 bytes. It is a unique ID allocated to a coupler. It is signed by the manufacturer. WPMS uses UCID to identify individual WPMS–Ds to allocate device ID. It is large in size, so UCID is used only for allocation of device ID, or when WPMS–Ds need to communicate without device ID allocation. It consists of group ID, IC manufacturer's code and serial number, as shown in Figure 4.

Unit: Byte

1	1	6
Group ID	IC manufacturer's code	IC manufacturer's serial number

Figure 4 – UCID structure

6.2.2 Group ID

WPMS–Ds can be grouped by applications. Group ID is the identifier for the grouped WPMS-Ds within a WDCZ. It is used to control multiple devices simultaneously. A WPMS-S can request a response from a specific device group in order to mitigate packet collision. The value of group IDs is in Table 1. Its value is defined by the user in order to distinguish groups.

Table 1 – Group ID

Group ID	Remarks
0x00 ~ 0xEF	Valid group ID
OxF0 ~ 0xFE	Used for selecting specific groups for future use
0xFF	All groups

6.2.3 Wireless Power management system ID

WPMS ID consists of 1 byte. It is allocated by WPMS–S, only; it is used to distinguish WPMS–Ss from each other when there are several WPMS–Ss nearby. WPMS ID is always used with device ID.

6.2.4 Device ID

6.2.4.1 General

Device ID consists of 1 byte. It is allocated to every connected WPMS–D. There are two types of device ID: COM ID for communication and WPT ID for WPT shown in Table 2.

Table 2 – ID structure

ID field	Type
0XXXXXXX	COM ID
1XXXXXXX	WPT ID

6.2.4.2 COM ID

COM ID is allocated to the device upon association with the WPMS–S within the WDCZ.

6.2.4.3 WPT ID

WPT ID is allocated to a WPMS–D when it is within the WPTZ and ready for power reception.

6.3 Frame format

6.3.1 General

For the definition of the frame format below, it is a frame format that is used for the application layer in the system. In addition, for a frame format in a low layer such as the MAC layer and physical layer, it is followed by its specification. For WPMS–Ds to communicate effectively, the following frame structure shown in Figure 5 is used. It is composed of frame header and frame body. Data for WPT is transmitted in such a format.

Unit: byte

1	1	1	1	1	1	1	N (0–255)	1
SRC WPMS ID	SRC ID	DST WPMS ID	DST ID	Frame type	Sequence No.	Payload length	Payload	CRC
Frame header							Frame body	

Figure 5 – Frame format

6.3.2 Frame header

6.3.2.1 General

The frame header consists of information related to the control and management of WPMS-Ds. It includes fields for SRC WPMS ID, SRC ID, DST WPMS ID, DST ID, frame type, sequence number, and payload length. The information located in the frame header contains general information about the frame except actual data.

6.3.2.2 Source WPMS ID

One byte of SRC WPMS ID is used for the WPMS address of the source to distinguish from which system the frame is transferred.

6.3.2.3 Source ID

One byte of SRC ID is used for the address of WPMS–S to distinguish where the frame is transferred from.

6.3.2.4 Destination WPMS ID

One byte of DST WPMS ID is used for the WPMS address of destination to distinguish to which system the frame is transferred.

6.3.2.5 Destination ID

One byte of DST ID is used for the address of WPMS–Ds to distinguish where the frame is transferred from. If the value of Destination ID is 0x7F or 0xFF, it indicates that the frame is broadcast to all WPMS–Ds.

6.3.2.6 Frame type

One byte of the frame type field is used to distinguish the type of frame; refer to 6.4 for the detailed information on frame type.

6.3.2.7 Sequence number

One byte of the sequence number field is allocated to each consecutive code frame to prevent frame loss during message transfer.

6.3.2.8 Payload length

One byte of the payload length field indicates the length (0 to 255 bytes) of the payload field followed by the payload length.

6.3.3 Frame body

6.3.3.1 General

The frame body consists of information related to the actual data. It includes fields for payload, CRC. The actual data is located within payload, and CRC checks for any errors in the payload.

6.3.3.2 Payload

The payload field is variable in length to include actual data required for WPT; refer to 6.5 for detailed information on payload format.

6.3.3.3 CRC

The CRC field (1 byte) is used to check whether the frame body has been received without error. The standard generator polynomial creating the frame check sequence is as follows:

$$G(x) = x^8 + x^5 + x^4 + 1$$

6.4 Frame type

6.4.1 General

There are two types of frame as described below from Table 3: data frame, and acknowledgement frame. They are distinguished, since the payload structure for each frame type is different. Details of payload can be found in 6.5.

Table 3 – Frame type value

Frame Type	Value	Content
Data Frame	0x00	Used to send request, response, and notification.
Acknowledgement frame	0x01	Used to confirm the receipt of certain frames.
Reserved	0x02 ~ 0xFF	

6.4.2 Data frame

The data frame is used in general situations. The entire request, response, and notification is sent in data format shown in Figure 6.

Unit: byte

<table>
<tr><td>7</td><td>1</td><td>1</td><td>L1</td><td>L2</td><td>.....</td><td>Ln</td><td>1</td></tr>
<tr><td rowspan="3">Frame header</td><td>Data Code</td><td>Length (= ΣLn)</td><td>Data Block–1</td><td>Data Block–2</td><td>....</td><td>Data Block–n</td><td rowspan="2">CRC</td></tr>
<tr><td colspan="6">Data frame payload</td></tr>
<tr><td colspan="7">Frame body</td></tr>
</table>

Figure 6 – Data frame format

6.4.3 Acknowledgement frame

The payload of the acknowledgement frame shown in Figure 7 informs the WPMS-S of reception by sending only the header with no frame payload to notify reception for relevant data. It can be used for more cases in the future.

Unit: byte

<table>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>SRC WPMS ID</td><td>SRC ID</td><td>DST WPMS ID</td><td>DST ID</td><td>Frame type</td><td>Sequence No.</td><td>CRC</td></tr>
<tr><td colspan="6">Frame header</td><td>Frame body</td></tr>
</table>

Figure 7 – Acknowledgement frame format

6.5 Payload format

6.5.1 General

The payload format varies depending on the type of data.

6.5.2 Data frame

6.5.2.1 General

The payload format of the data frame consists of the data code, length, and a number of data blocks as shown in Figure 8. If the value of Destination ID is 0xFF, it indicates a frame to be sent to all WPMS–Ds. Each block includes the appropriate data information.

Unit: byte

1	1	L1	L2	.....	Ln
Data Code	Length (=ΣLn)	Data Block–1	Data Block–2	....	Data Block–n

Figure 8 – Payload format of data frame

6.5.2.2 Data code

The contents for the data code in the payload and data block of the corresponding data code are as shown in Table 4:

Table 4 – Data codes

Category	Code	Code Name	Description
Request	0x01	Connection Request	WPMS–D connection request by WPMS–S
	0x02	Device Status Request	Request for all WPMS–D information
	0x03	WPT Request	Request for WPT to WPMS–D
	0x04	Coil Control Request	Abnormal situation management with coil
	0x05	Group ID Set–up Request	Request set Group ID to WPMS–D
	0x06	Inter–device WPT Request	WPT request to WPMS–D
	0x07~0x4f	Reserved	
Response	0x51	Connection Response	Response for the connection request of WPMS–D
	0x52	Device Status Response	Response for the device status request
	0x53	WPT Response	Response to WPT request
	0x54	Coil Control Response	Response for coil control request
	0x55	Group ID Set–up Response	Response for Group ID set–up request
	0x56	Inter–device WPT Response	Response for inter–device WPT request
	0x57~0x9f	Reserved	
Notifica-tion	0xa1	COM ID Notification	Notification of whether wireless power transfer of WPMS–D is eligible or not
	0xa2	WPT ID Notification	WPT ID allocation, and WPMS–D's zone notification
	0xa3	WPT Mode Notification	WPT mode notification
	0xa4	WPT Schedule Notification	Scheduling information notification
	0xa5	WPT Termination Notification	Notification of Wireless power transfer termination
	0xa6	Full Charge Notification	Notification of full charge of WPMS–D
	0xa7	Discharge Rate Variation Notification	Notification of variation in discharge rate of WPMS–D
	0xa8~0xef	Reserved	
Reserved	0xf1~0xff	Reserved	

6.5.2.3 Length

The length field (1 byte) indicates the sum of the data block lengths, and the field value varies depending on the request block length and the number of blocks.

6.6 Data block

6.6.1 General

All information in the WPMS is transferred in data format. The data is contained in a data block. They are categorized and sent as a request block, a response block, and a notification block.

6.6.2 Request block

6.6.2.1 General

A request block is used to request certain actions or data from other WPMS–Ss or WPMS–Ds. There are requests for connection, device status, WPT, coil control, and inter-device WPT.

6.6.2.2 Connection request

For a connection request, a block is unnecessary. If a frame is sent with a connection request code, the connection request is broadcast.

6.6.2.3 Device status request

A device status request block consists of 3 bytes as shown in Figure 9. The first byte is for the Group ID, the second byte is for the COM ID, and the next byte is for the flag for the containing data. The flag indicates which type of data the WPMS–S wishes to receive: RSSI (received signal strength), frequency, remaining battery, battery discharge, maximum power level, current power level, product type. If the flag indicates corresponding data to be responded, the WPMS–D will send appropriate data (refer to 6.6.3.3).

Unit: byte

1	1	1
Group ID	COM ID	Flag for containing data

Figure 9 – Block format of device status request

6.6.2.4 WPT request

A WPT request consists of 2 bytes as shown in Figure 10. The first byte is for the Group ID, and the next byte is for WPT ID.

Unit: byte

1	1
Group ID	WPT ID

Figure 10 – Block format of WPT request

6.6.2.5 Coil control request

A coil control request block consists of 4 bytes as shown in Figure 11. The first byte is for Group ID, the second byte is for the COM ID, the third byte is for the coil control, and the last byte is for the coil control time duration. The coil control is: 0 if the coil needs to stay on, or 1 if the coil needs to be turned off.

Unit: byte

1	1	1	1
Group ID	COM ID	Coil on/off	Time(ms)

Figure 11 – Block format of coil control request

6.6.2.6 Group ID set–up request

Group ID set–up request block consists of 2 bytes as shown in Figure 12. The first byte is for the COM ID, and the last byte is the group ID to be set up.

Unit: byte

1	1
COM ID	Group ID

Figure 12 – Block format of Group ID set–up request

6.6.2.7 Inter–device WPT request

An inter-device WPT request block consists of 10 bytes as shown in Figure 13. The first 8 bytes are for the UCID, the ninth byte is for the maximum power required, and the last byte is for the power required.

Unit: byte

8	1	1
UCID	Maximum Power Required (W)	Time Length(ms)

Figure 13 – Block format of inter–device WPT request

6.6.3 Response block

6.6.3.1 General

A response block is used to respond to a request block. There is response for connection, device status, WPT, coil control, and inter-device WPT.

6.6.3.2 Connection response

A connection response block consists of 8 bytes as shown in Figure 14. It is for the UCID.

Unit: byte

8
UCID

Figure 14 – Block format of connection response

6.6.3.3 Device status response

A device status response block consists of 8 bytes as shown in Figure 15. The first byte is for the flag. Each following byte, a total of 7 bytes, refers to the flag and contains appropriate data in the corresponding block.

Unit: byte

1	1	1	1	1	1	1	1
Flag	Reception Signal Strength	Frequency	Remain Battery	Discharge Rate of Battery	Max of Reception Power	Current Reception Power	Product Type

Figure 15 – Block format of device status response

6.6.3.4 WPT response

A WPT response block consists of 3 bytes as shown in Figure 16. The first byte is for WPT ID, the second byte is required max power, and the third byte is for required time.

Unit: byte

1	1	1
WPT ID	Required Max Power(W)	Required Time(ms)

Figure 16 – Block format of WPT response

6.6.3.5 Coil control response

A coil control response block consists of 2 bytes as shown in Figure 17. The first byte is for the WPT ID, the second byte is the result. It has value of 0 for denial, and 1 for acceptance.

Unit: byte

1	1
WPT ID	result

Figure 17 – Block format of coil control response

6.6.3.6 Group ID set–up response

A group ID set–up response block consist of 9 bytes as shown in Figure 18. The first 8 bytes are for UCID with the changed group ID and the last byte is for the assigned group ID.

Unit: byte

8	1
UCID	Assigned group ID

Figure 18 – Block format of coil control response

6.6.3.7 Inter–device WPT response

An inter-device WPT response block consists of 10 bytes as shown in Figure 19. The first 8 bytes are for the UCID, next byte is for the acceptance result: 0 for deny and 1 for accept. The last byte is for the WPT duration in ms.

Unit: byte

8	1	1
UCID	Accept/Deny	WPT duration (ms)

Figure 19 – Block format of inter–device WPT response

6.6.4 Notification block

6.6.4.1 General

A notification block allows unilateral data transfer from a WPMS–S to a PWMS–D, or from a WPMS–D to a WPMS–S.

6.6.4.2 COM ID notification

A COM ID notification block consists of 2 bytes as shown in Figure 20. The first byte is for the COM ID, the next byte is for the acceptance result: 0 is for deny, and 1 is for accept.

Unit: byte

1	1
COM ID	Accept/Deny

Figure 20 – Block format of COM ID notification

6.6.4.3 WPT ID notification

A WPT ID notification block consists of 3 bytes as shown in Figure 21. The first byte is for the COM ID, the next byte is for the WPT ID and the last byte is to distinguish the type of zone: 0 is for communication zone, and 1 is for charging zone.

Unit: byte

1	1	1
COM ID	WPT ID	Zone Type

Figure 21 – Block format of WPT ID notification

6.6.4.4 WPT mode notification

A WPT mode notification consists of 1 byte as shown in Figure 22. It is used to distinguish the type of WPT mode: 0 is for sequential, 1 is for simultaneous, 2 is for forming, and 3 is for compound.

Unit: byte

1
Mode

Figure 22 – Block format of WPT mode notification

6.6.4.5 WPT schedule notification

A WPT schedulenotification consists of 3 bytes as shown in Figure 23. The first byte is for the WPT ID, the next byte is for the slot number, and the last byte is for the time duration (ms) allocated for WPT.

Unit: byte

1	1	1
WPT ID	Slot number	WPT duration (ms)

Figure 23 – Block format of WPT schedule notification

6.6.4.6 WPT termination notification

A WPT termination notification block consists of 1 byte as shown in Figure 24. It is for the WPT ID.

Unit: byte

1
WPT ID

Figure 24 – Block format of WPT termination request

6.6.4.7 Full charge notification

A full charge notification block consists of 1 byte as shown in Figure 25. It is for the WPT ID.

Unit: byte

1
WPT ID

Figure 25 – Block format of full charge notification

6.6.4.8 Discharge rate variation notification

The discharge rate variation notification block consists of 3 bytes as shown in Figure 26. The first byte is for the WPT ID, and the following byte is for the discharge rate (%/h). The last byte is for the maximum power level (W).

Unit: byte

1	1	1
WPT ID	Discharge rate of Battery (%/h)	Maximum power level (W)

Figure 26 – Block format of discharge rate variation notification

7 Procedures

7.1 General

There are five procedures to provide the most efficient WPT service to multiple WPMS–Ds: association, general WPT management, abnormal situation management, inter–device WPT management, and termination.

7.2 Association

As for the connection request, the WPMS–S sends a communication signal (connection request). Having received it, the WPMS–D sends its own WPMS–D address as a response to the connection request. The WPMS–S checks the received WPMS–D address and decides the association of the designated WPMS–D. If the WPMS–D is not allowed for WPT, the WPMS–S sends a denial message; if the WPMS–D is allowed for WPT, COM ID is allocated. The WPMS–D sends COM ID notification to the WPMS–S. The WPMS–S will request device status once the WPMS–D joins the WPMS. In return, the WPMS–D that has received the device status request will send its information (residual battery level, battery discharge rate, charging frequency, required reception power strength, etc.) to the WPMS–S in device status response. In turn, the WPMS–S will analyse the received data and checks on the eligibility of WPT to the WPMS–D. When the WPMS–D is within the WPTZ and it is eligible, the WPMS–S allocates a WPT ID and considers the WPMS–D as a candidate for the WPT service shown in Figure 27.

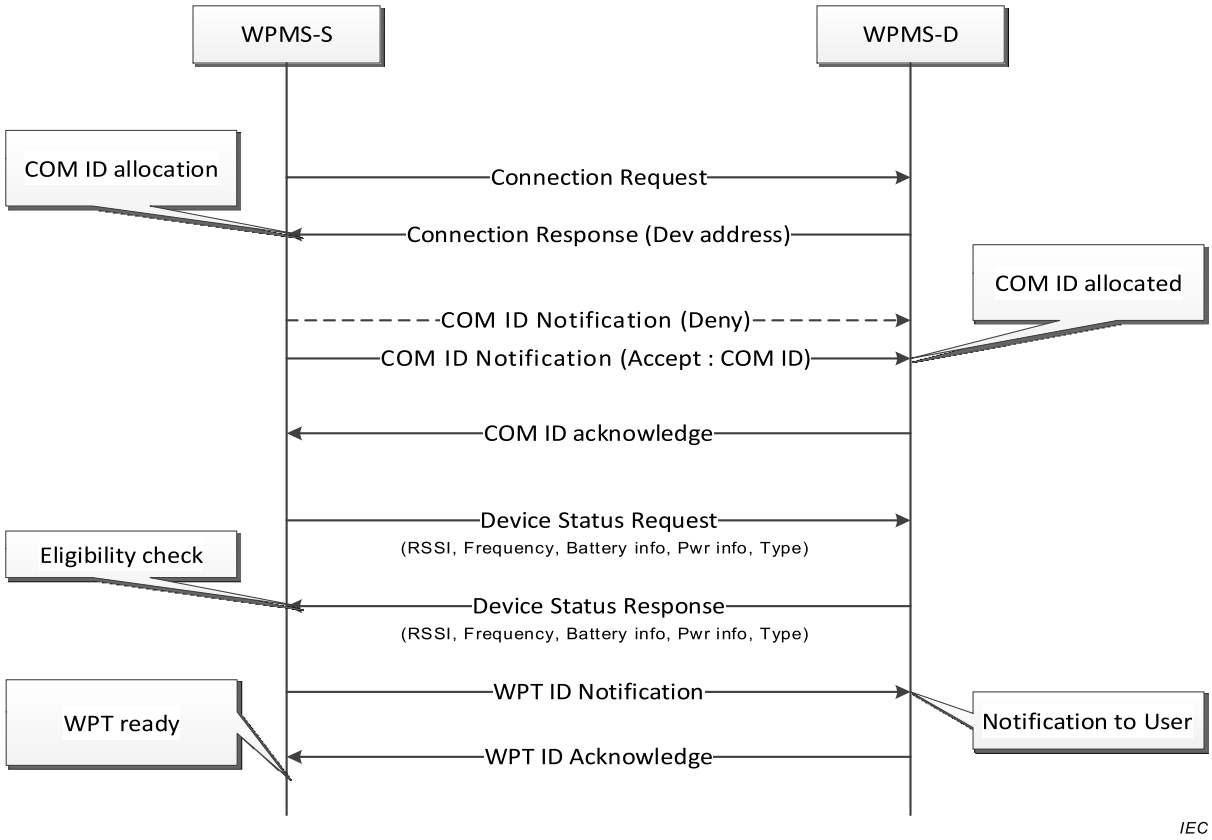

Figure 27 – Association

7.3 Group ID Set–up

The WPMS–S is able to set up groups of selective WPMS–Ds as shown in Firgure 28. The WPMS–S may send a group ID setup request packet, which contains the assigned group ID. WPMS–Ds check for the destination of the packet; if the packet is for a WPMS–D, it returns the group ID as a response. Upon reception of a response packet, the WPMS–S sends an acknowledgement packet. Group setup is completed when the WPMS–D confirms the acknowledgement packet. If the WPMS–D does not send a WPMS–D acknowledgement until timeout, it then sends the response packet again.

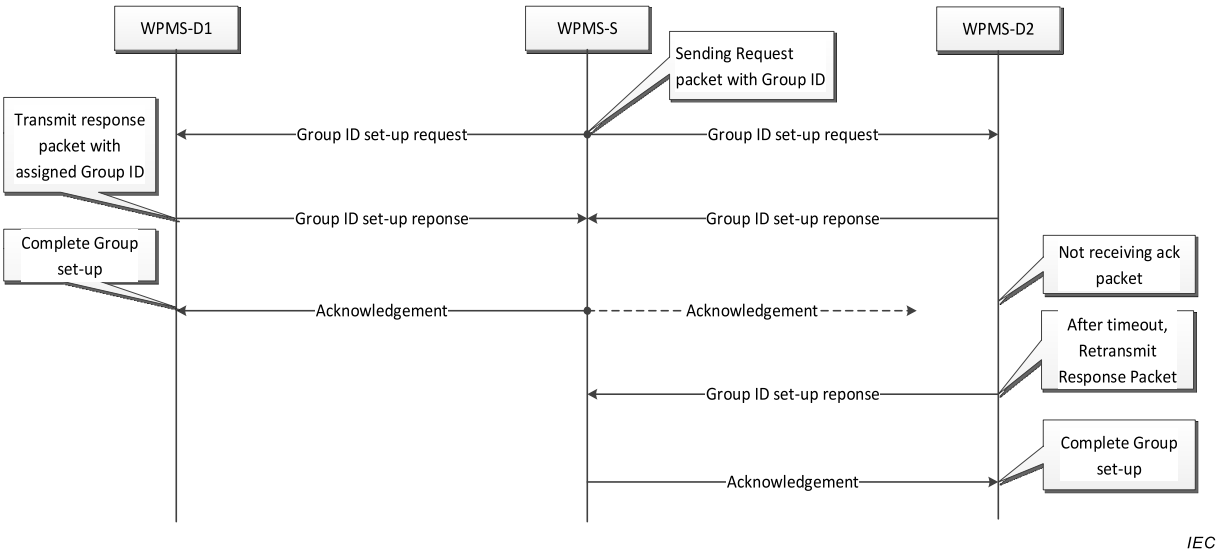

Figure 28 – Group ID set–up

7.4 General WPT management

7.4.1 Simultaneous WPT

Before WPT, WPMS–S tests for frequency level. If it matches, the WPMS–S transmits test power; the WPMS–S carries out current and voltage sensing and finds appropriate impedance matching. Afterwards, secondary in-depth test power is transferred from the WPMS–S, and the WPMS–S requests for device status to receive received power level at the WPMS–D. The WPMS–D will return appropriate data in the device status response. Efficiency is calculated with the data received, and the optimal impedance matching will be completed. With the second impedance matching, the WPT service starts. The service continues until there is an abnormal situation or WPT is terminated by the WPMS–S as shown in Figure 29.

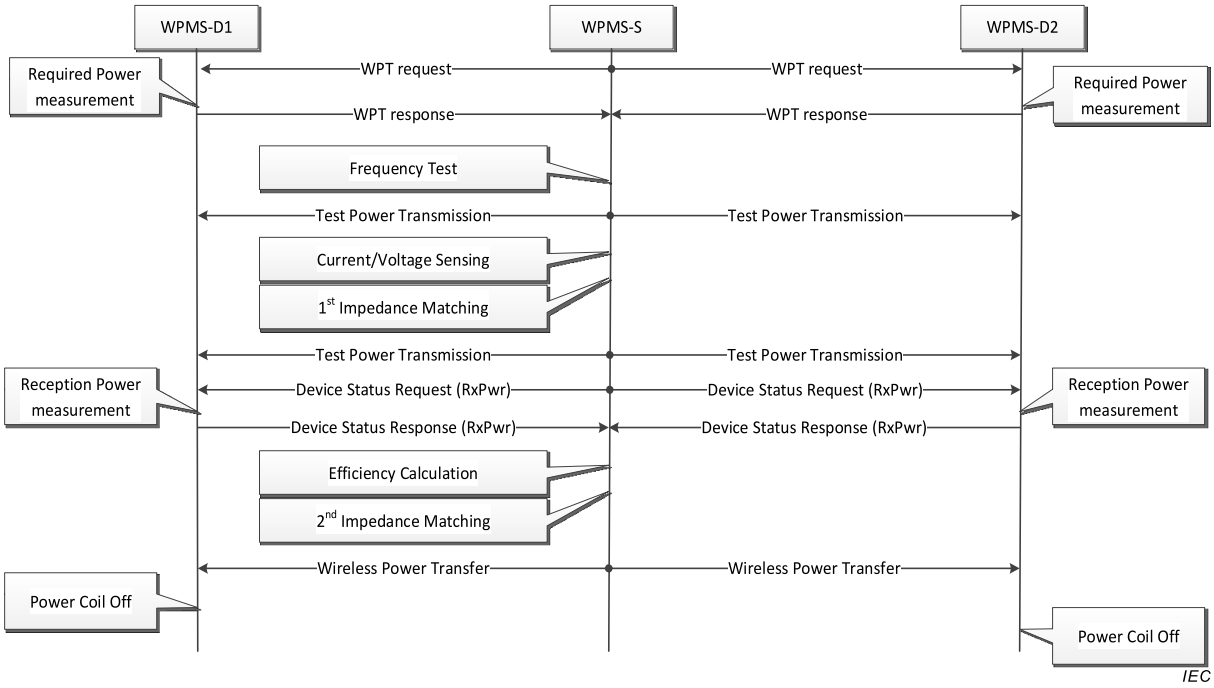

Figure 29 – Simultaneous WPT

7.4.2 Sequential WPT

In the sequential WPT mode, the WPMS–S calculates schedules based on WPMS–D information; the WPMS–S informs all WPMS–Ds of the sequences and times for WPT service. Each WPMS–D receives WPT only when WPMS–D is on the right time slot. When the time slot is not for WPMS–Ds, they turn off the power coil to maximize the efficiency of overall WPT.

This WPT procedure is same as the procedure for simultaneous WPT as shown in Figure 30.

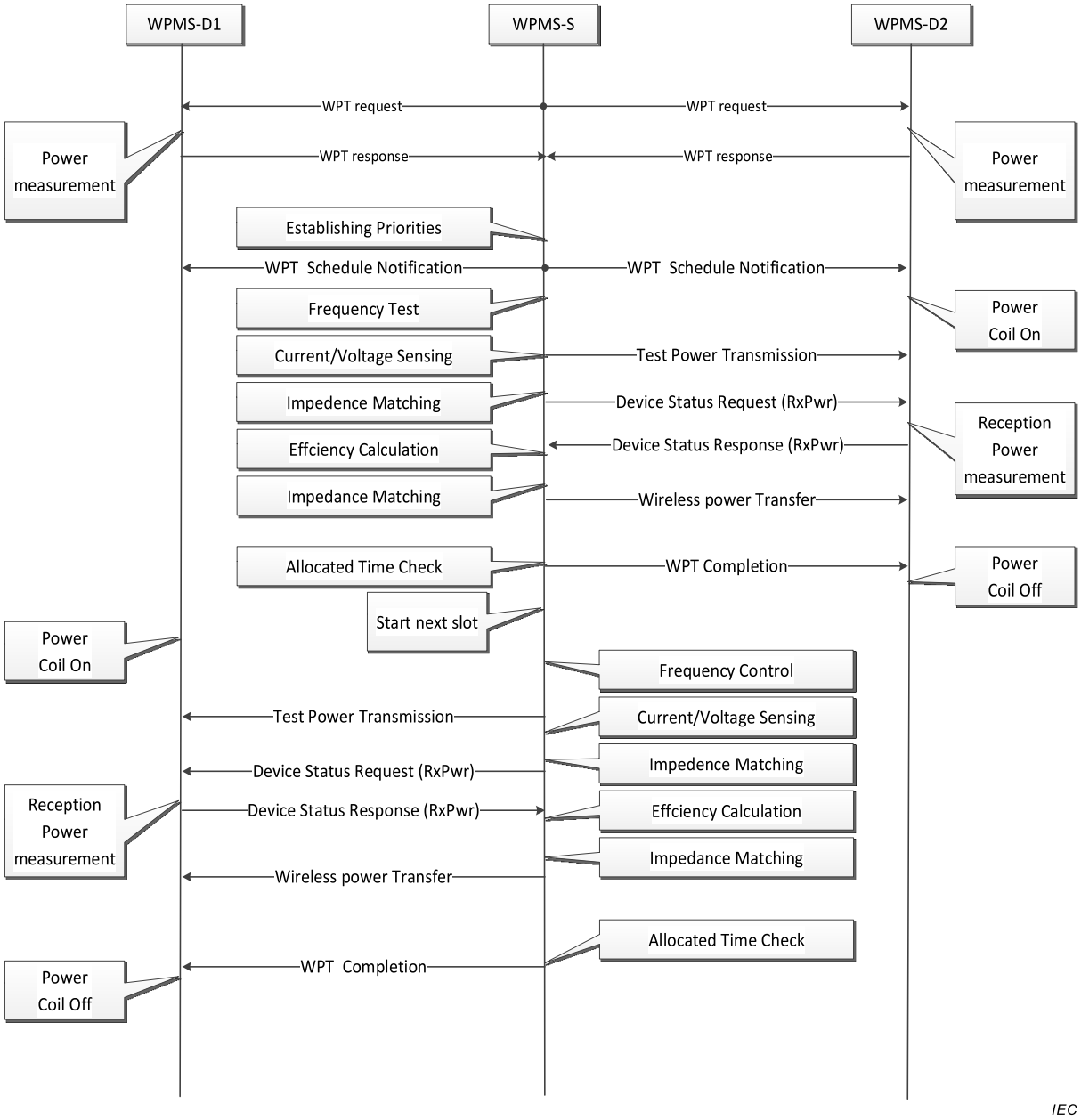

Figure 30 – Sequential WPT

7.4.3 Foaming WPT

In the foaming WPT mode, the WPMS–S calculates and sets a priority amongst WPMS–Ds based on the device status and user configuration. The procedure is much similar to simultaneous and sequential WPT, except for the priority setup along with WPT schedule notification. If foaming is carried out along with simultaneous WPT, it shall be done by the WPMS–S's adjustment with an extra coil. If foaming is carried out along with sequential WPT, it shall be done by the WPMS–S's adjustment of the time length or by controlling the WPMS-S’s coil. The current WPT procedure is the same as the procedure for simultaneous WPT as shown in Figure 31.

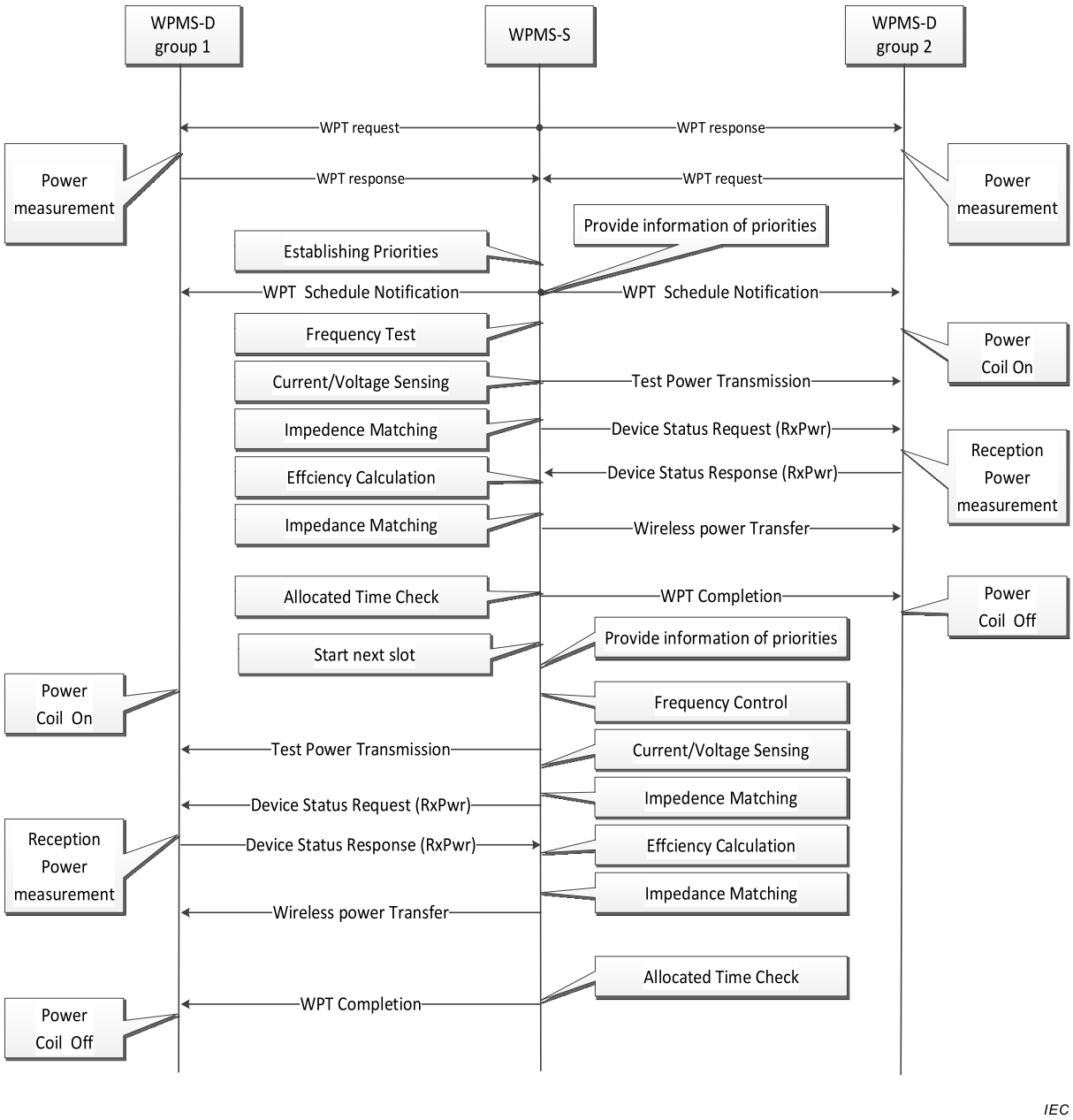

Figure 31 – Foaming WPT

7.4.4 Compound WPT

The procedure for compound WPT is the same as the procedure for sequential WPT as shown Figure 32, except for the power receiving object being a group of WPMS–Ds per each time slot instead of a single WPMS–D. The WPMS–S will manage the priorities between WPMS-Ds to receive WPT. Accordingly, The WPMS–S will divide time slots and allocate them to WPMS-Ds.

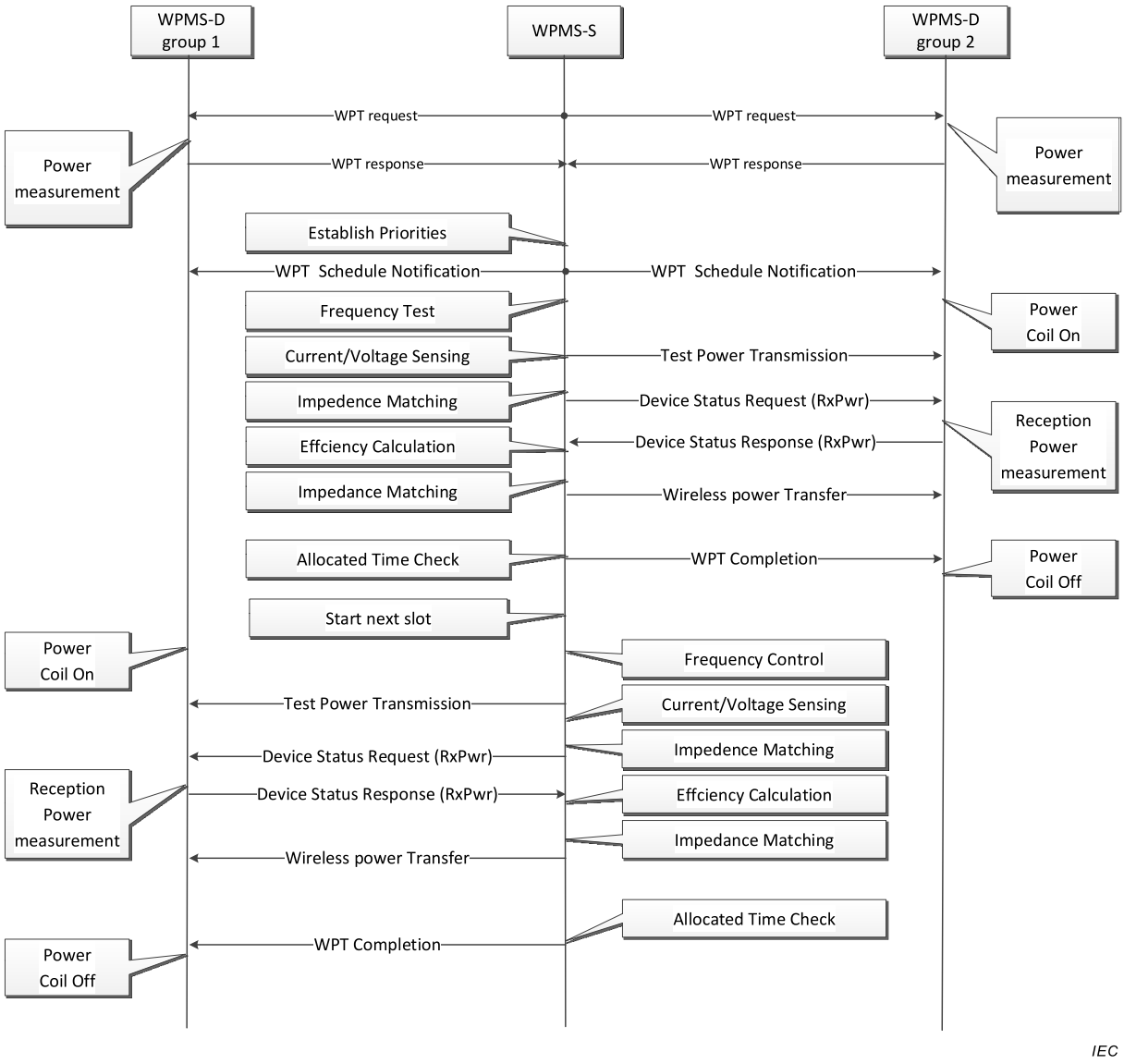

Figure 32 – Compound WPT

7.5 Abnormal situations management

7.5.1 General

The current and voltage values are constantly measured to detect abnormal situations. When a variation in current/voltage value is measured or impedance derived is too large, WPMS-S considers it to be an abnormal situation. Then the WPMS–S determines whether the abnormal situation arose from foreign material, WPMS–D appearance and disappearance, full charge of WPMS–D, or if the abrupt variation is the discharge rate. It undertakes procedures accordingly to resolve abnormal situations.

7.5.2 Source status detection

When the WPMS–D detects variation in current/voltage, WPMS–D considers it to be an abnormal situation as shown in Figure 33. Immediately, the WPMS–S stops WPT and requests for device status (charging information) from all WPMS–Ds in order to specify the abnormal situation.

If variation in current/voltage was due to the appearance of a new WPMS–D or the disappearance of an existing WPMS–D, a different set of WPMS–Ds will reply with device

status to the WPMS–S. Accordingly, the WPMS–S will calculate and update new optimal impedance matching, before proceeding to WPT.

If the reply is from the same set of WPMS–Ds, then the WPMS–S takes it to be a detection of foreign material. To find out whether the interference is temporary or continuous, the WPMS-S tries WPT up to N times. If the variation persists, the foreign material is considered continuous and the WPMS–S informs the user of it with the alarm function.

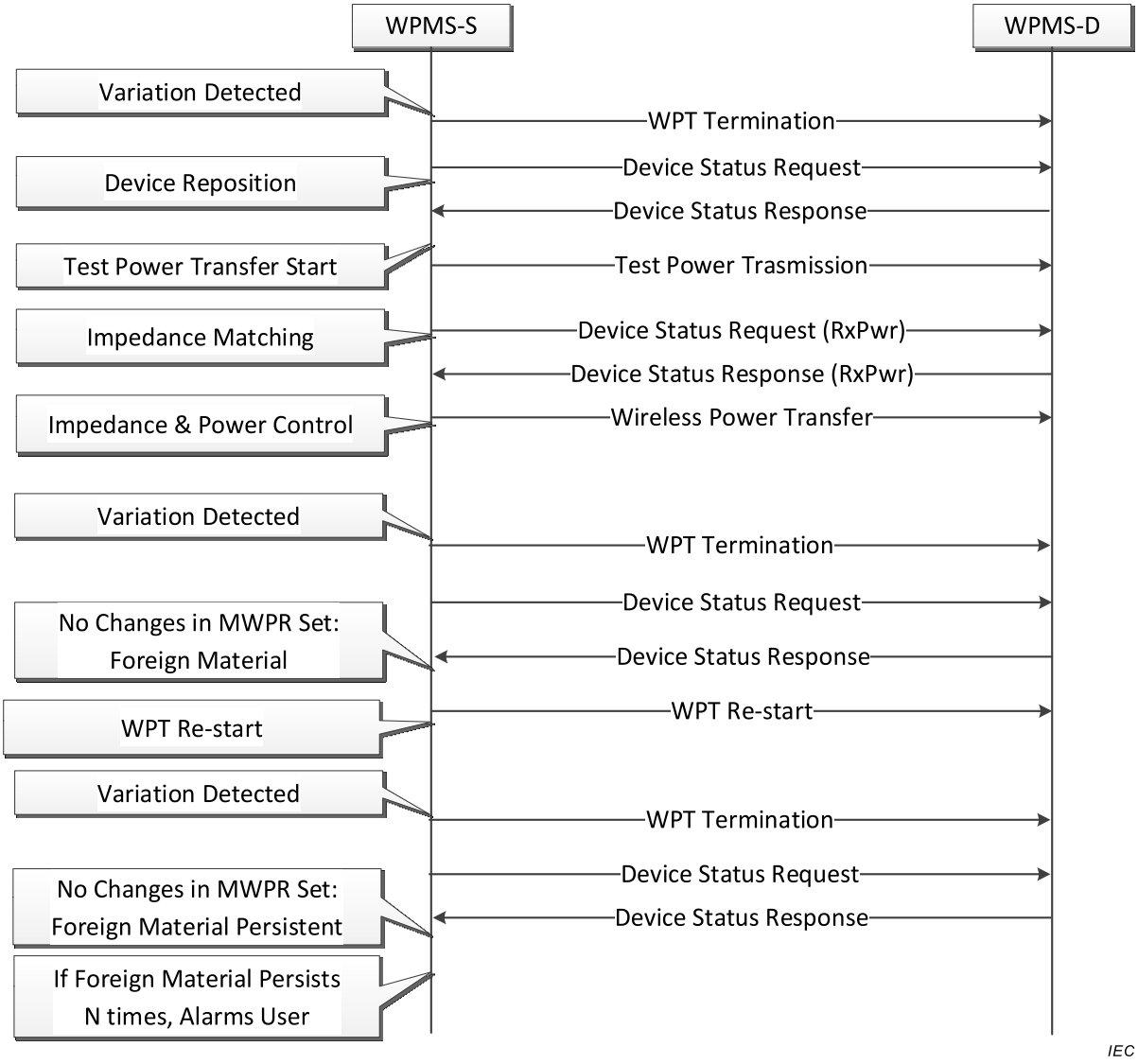

Figure 33 – Source status detection

7.5.3 Device status detection

7.5.3.1 Full charge

When the WMS–D detects itself as being fully charged, the WPMS–D informs the WPMS–S of its full charge status and turns off the power coil as shown Figure 34. When full charge information is received, the WPMS–S excludes the fully charged WPMS–D from WPT candidates and starts to provide WPT to other WPMS–Ds.

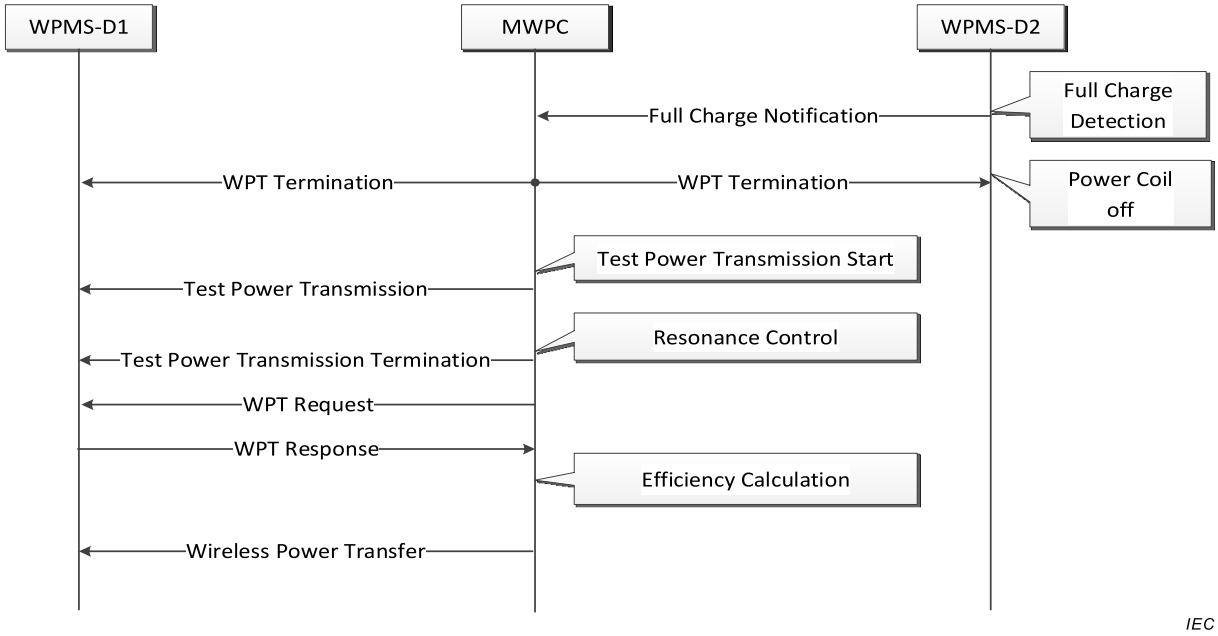

Figure 34 – Full charge detection

7.5.3.2 Discharge rate variation

When a WPMS–D detects any abrupt variation in its battery discharge rate, it sends abrupt discharge variation rate data to the WPMS–S as shown in Figure 35.

The WPMS–S considers it to be users using a WPMS–D. The WPMS–S is informed of such abnormality and changes the output power so as not to violate safety regulations for exposure to electric and magnetic fields. It cuts the WPT service for a moment to change the output power level before restarting the service.

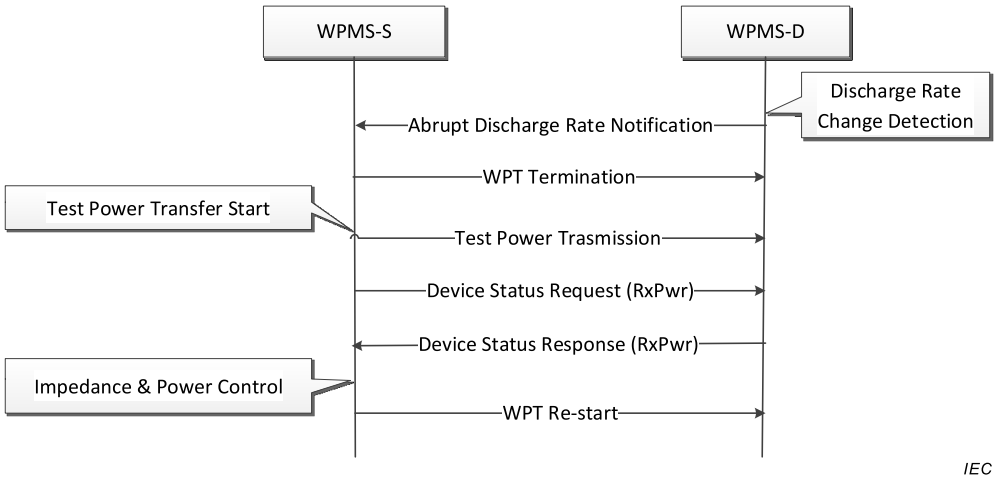

Figure 35 – Discharge rate variation detection

7.6 Inter–device WPT management

When the WPMS–D is unable to locate the WPMS–S within its range, it can request WPT to near the WPMS–D instead as shown in Figure 36. For this case in particular, the WPMS-D in need of WPT will send an inter-device WPT request to a WPMS–D capable of performing WPT, if detected. A WPT to a WPMS–D will return an inter-device WPT response with eligibility. If accepted, each WPMS–D will inform users of it, and the WPMS–D in need of WPT will be able to receive WPT for the time length provided.

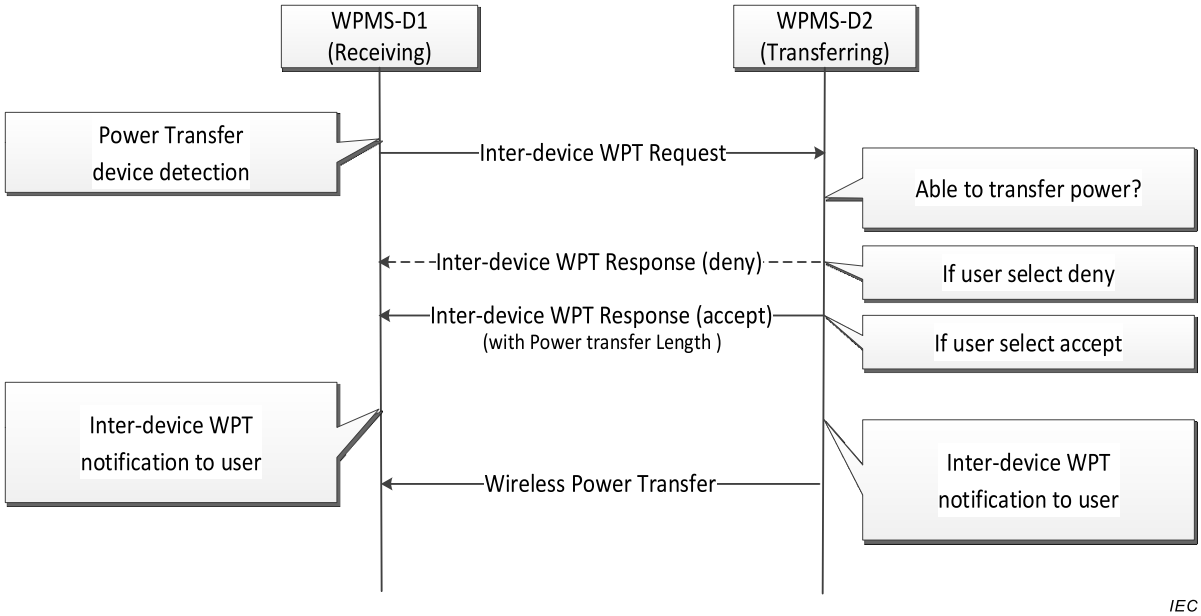

Figure 36 – Inter–device WPT

7.7 Termination

When the user commands WPT to be terminated to the WPMS–S, the WPMS–S cuts off WPT and waits for the next request in standby mode as shown in Figure 37.

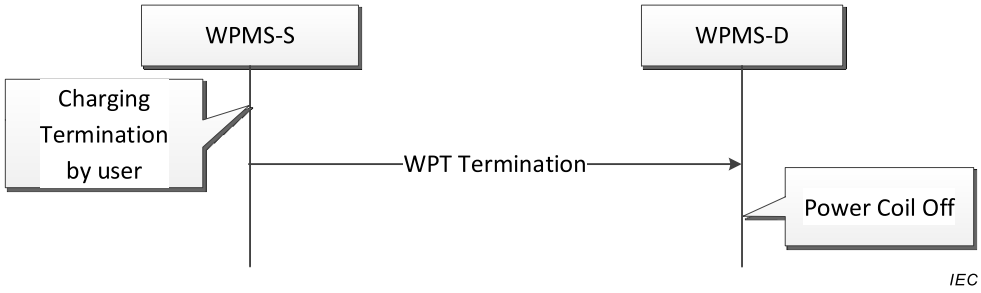

Figure 37 – Termination

Annex A
(informative)

Messages

A.1 General

This annex describes an API between the application and APP block, an interface between MGMT block and MGMT block, an interface between MGMT block and APP block, interfaces between APP layer and MAC layer, and interfaces between MGMT block and coupler block to support WPMS functions.

A.2 API between application and APP block

A.2.1 General

A WPMS–S APP offers a display of power status, such as the amount of remaining power and WPT efficiency.

A.2.2 ID display

A.2.2.1 General

The application sends the received WPMS–D ID information to the WPMS–S APP block. After checking the corresponding WPMS–D is eligible to receive WPT, it is informed to the APP block with the required information. The definition of the interfaces is as follows:

```
SMTA–ID.display          {
                          WPT_ID
                          Eligibility
                         }
```

For the values for the above message, refer to Table A.1 below.

Table A.1 – Values for ID display

Parameter	Type	Value	Description
WPT_ID	Number	0x00 to 0xFF	A number is granted to an eligible power receiver.
Eligibility	Binary	0 or 1	0: Eligible 1: Ineligible
Reserved			

A.2.2.2 ID display request

After checking WPT eligibility with the received ID information of an WPMS–D, the WPMS–S application sends the ID and eligibility information to the APP block for display. Consequently, the APP block displays the received information.

A.2.3 Power status display

A.2.3.1 General

When the WPMS–S application gathers power status information from every WPMS–D, it sends the information to the APP block for display.

SMTA–Device.display {
Frequency,
BatteryRemain,
BatteryDischarge,
MaxPower,
RxPower,
Type,
RSSI,
}

For the values for the above message, refer to Table A.2 below.

Table A.2 – Values for power status display

Parameter	Type	Value	Description
Frequency	Number	30 kHz to 300 MHz	In the case of a system that uses multiple wireless power transfer frequency bands, the frequency information to be scheduled to use in the corresponding power transfer.
BatteryRemain	Number	0 % to 100 %	Residual battery level of the receiver
BatteryDischarge	Number	0 to 1 000 A	The extent of battery discharge
MaxPower	Number	−50 to 100 dBm	Receiver's acceptable power level
RxPower	Number	−50 to 100 dBm	Received power reception level
Type	Description	Receiver type	Description to distinguish the receiver type
RSSI	Number	−80 to 100 dBm	Reception signal strength
Reserved			

A.2.3.2 Power status display request

It is required when the WPMS–S application collects power status information. The WPMS–S APP, in turn, displays the received power status information.

A.2.4 WPT mode selection display

A.2.4.1 General

Users can select the WPT mode via the UI display. The WPMS–S confirms the user's selection on the UI display. When users select the sequential WPT mode, users can select the priority of WPMS–Ds.

SMTA–Mode.display {
ModeRequest,
ModeResponse,
WPT_ID,
Priority
}

For the values for the above message, refer to Table A.3 below.

Table A.3 – Values for WPT mode selection display

Parameter	Type	Value	Description
ModeRequest	Binary	0 or 1	0: Display 1: Not display
ModeResponse	Binary	0x00 ~ 0x07 (flag)	1st bit(LSB): Simultaneous mode 2nd bit: Time division mode 3rd bit: Foaming mode Multi select: Compound mode
WPT_ID	Number	0x00 to 0xFF	WPMS–D number
Priority	Number	1 to 100	Sequence number of each WPMS–D
Reserved			

A.2.4.2 User selection request

It is required when the WPMS–S MGMT block needs the users' selection for the WPT mode. As a result, the APP block displays the received user selection request.

A.2.4.3 User selection response

It is required when the APP block sends the information related to the users' selection of WPT mode. As a result, the MGMT block calculates the related parameters according to the users' selection.

A.2.5 Scheduling information display

A.2.5.1 General

When sequential WPT mode is selected, the MGMT block calculates the related information such as priority and allocated time amount. And then the MGMT block sends the calculation results to the APP block for display. The definition of the interfaces is as follows:

SMTA–SCHDL.display {
WPT_ID,
BatteryRemain,
BatteryDischarge,
Priority,
TimeAmount,
}

For the values for the above message, refer to Table A.4 below.

Table A.4 – Values for scheduling information display

Parameter	Type	Value	Description
WPT_ID	Number	0x00 to 0xFF	WPMS–D number
BatteryRemain	Number	0 % to 100 %	Residual battery level of the receiver
BatteryDischarge	Number	0 % to 1 000 %	The extent of battery discharge
Priority	Number	1 to 100	Sequence number of each WPMS–D
TimeAmount	Number	1 to 100 000 s	Charging time allocated to the receiver
Reserved			

A.2.5.2 Scheduling information display

It is required when the MGMT block sends the scheduling-related information to the APP block. As a result, the APP block displays the received scheduling-related information.

A.2.6 Abnormal situations display

A.2.6.1 General

When the WPMS–S detects abnormal situations such as foreign materials and sudden disappearance of WPMS–Ds, the WPMS–S displays the related information with an alarm so that users resolve the abnormal situation.

SMTA–ABNR.display {
Abnormal
RxPower
Resolved
}

For the values for the above message, refer to Table A.5 below.

Table A.5 – Values for abnormal situation display

Parameter	Type	Value	Description
Abnormal	Binary	0 or 1	0: Not applicable 1: Abnormal situation
RxPower	Number	−50 to 100 dBm	Received power level
Resolved	Binary	0 or 1	0: Unresolved 1: Resolved
Reserved			

A.2.6.2 Abnormal situations management request

It is required when the WPMS–S detects an abnormal situation and sends the related information to the APP block. As a result, the WPMS–S displays the situation so that users resolve the situation.

A.2.6.3 Abnormal situations management response

It is required when the WPMS–S APP block receives a signal from users for resolving the situation. As a result, the WPMS–S APP block sends the resolution-related information to the MGMT block.

A.3 Interface between MGMT and MGMT

A.3.1 General

This item is mainly focused on the messages between MGMT blocks. Based on the messages delivered from and to the MGMT block, the process of connection, disconnection, and WPT is carried out. Although it might seem as if the messages in between MGMT blocks are communicated directly via tunnelling, it undergoes the general procedure and messages are passed down on to the lower layer, then to other devices: MGMT(A) –> APP –> MAC –> PHY –> PHY –> MAC –> APP –> MGMT(B). In order to perform the functionalities defined in Clause 5, the interfaces shall be exchanged between MGMT blocks of the WPMS–S and the WPMS–D for efficient WPT. The system management and control shall be accompanied

based on the exchanged interfaces. The interfaces exchanged between MGMT blocks are as follows:

A.3.2 WPMS–D identification

A.3.2.1 General

Based on the ID data from WPMS–D, WPMS–S determines whether the WPMS–D is eligible or not for the service. The definition of the interface is as follows:

MTM–SCAN.request {
Request_join,
WPT_ID,
}

For the values for the above message, refer to Table A.6 below.

Table A.6 – Values for WPMS–D identification

Parameter	Type	Value	Description
Request_join	Binary	0 or 1	0: Standby request 1: Receiver connection request
WPT_ID	Number	0x00 ~ 0xFF	Receiver ID
Reserved			

A.3.2.2 WPMS–D ID request

It is required when the WPMS–S sends the association requests to WPMS–Ds. As a result, the WPMS–D receives the ID request command from the WPMS–S.

A.3.2.3 WPMS–D ID response

It is required when the response is ready for the ID request from WPMS–S. As a result, the WPMS–S receives the ID data from WPMS–Ds. The data is used by WPMS–Ss to determine whether the corresponding WPMS–D is eligible for the WPT service.

A.3.3 WPT authentication

A.3.3.1 General

The WPMS–S determines whether each WPMS–D is eligible for WPT based on the received ID data and informs all WPMS–Ds of the result. The definition of the interfaces is as follows:

MTM–ELGB.inform {
Accept_deny,
WPT_ID,
}

For the values for the above message, refer to Table A.7 below.

Table A.7 – Values for WPT authentication

Parameter	Type	Value	Description
Accept_deny	Binary	0 or 1	0: Ineligible for WPT 1: Eligible for WPT
WPT_ID	Number	0x00 ~ 0xFF	A number is granted to an eligible power receiver as an ID.
Reserved			

A.3.3.2 WPT authentication notification

It is required for a WPMS–S to determine whether the service is eligible or not and informs the corresponding WPMS–D of the result. As a result, it selects eligible WPMS–Ds for WPT and provides WPT to those WPMS–Ds in the future.

A.3.3.3 WPMS–D power status information

This interface is exchanged between WPMS–S and an WPMS–D for optimal power transfer according to the power status. The definition of the interfaces is as follows:

MTM–Device.request {
Frequency,
BatteryRemain,
BatteryDischarge,
MaxPower,
RxPower,
Type,
RSSI,
}

For the values for the above message, refer to Table A.8 below.

Table A.8 – Values for WPMS–D power status information

Parameter	Type	Value	Description
Frequency	Number	30 kHz to 300 MHz	In case of the system that uses multiple wireless power transfer frequency bands, the frequency information to be scheduled to use in the corresponding power transfer.
BatteryRemain	Number	0 % to 100 %	Residual battery level of the receiver
BatteryDischarge	Number	0 to 1000 A	The extent of battery discharge
MaxPower	Number	−50 to 100 dBm	Receiver's acceptable power level
RxPower	Number	−50 to 100 dBm	Received power reception level
Type	Description	Receiver type	Description to distinguish the receiver type
RSSI	Number	−80 to 100 dBm	Reception signal strength
Reserved			

A.3.3.4 WPMS–D information request

Before performing WPT, recognizing the power status is required. As a result, the WPMS–S gathers the required power status information from all WPMS–Ds.

A.3.3.5 WPMS–D information response

It is required when the WPMS–D power status information is ready to be sent to the WPMS–S. As a result, the WPMS–S gathers the required power status information from all WPMS–Ds, and manages and controls for optimal WPT.

A.3.4 Zone recognition

A.3.4.1 General

WPMS–S determines which zone each WPMS–D belongs to (charging zone or communication zone) based on the data sent from WPMS–Ds, and informs those WPMS–Ds of the result. The definition of the interfaces is as follows:

MTM–ZONE.inform {
Zone,
}

For the values for the above message, refer to Table A.9 below.

Table A.9 – Values for zone recognition

Parameter	Type	Value	Description
Zone	Binary	0 or 1	0: Charging zone 1: Communication zone
Reserved			

A.3.4.2 Zone recognition notification

It is required for the WPMS–S MGMT block to determine the zone of each WPMS–D and to send the result to the WPMS–S APP block. After determining the zones of all WPMS–Ds, the WPMS–S prepares WPT for WPMS–Ds in the charging zone and keeps the standby status for WPMS–Ds in the communication zone. When a WPMS–D in the communication zone comes into the charging zone, the WPT is prepared.

A.3.5 WPT mode

A.3.5.1 General

Based on the collected information from all WPMS–Ds, the WPMS–S computes and determines the best WPT mode, and informs the selected WPT mode to all WPMS–Ds. The definition of the interfaces is as follows:

MTM–MODE.inform {
CharMode,
}

For the values for the above message, refer to Table A.10 below.

Table A.10 – Values for WPT mode

Parameter	Type	Value	Description
CharMode	Number	1 to 5	1: Sequential WPT mode 2: Simultaneous WPT mode 3: Forming WPT mode 4: Compound WTP mode 5: Reserved
Reserved			

A.3.5.2 WPT mode information

It is required when the WPMS–S APP block selects WPT mode and informs the WPMS–D APP block of the selected mode. After the WPMS–D APP block recognizes the WPT mode, preparation for receiving power is possible according to the instruction from WPMS–S.

A.3.5.3 WPT mode response

It is required when the MGMT block of a WPMS–D receives the WPT mode from the WPMS–S MGMT block and informs the WPMS–S MGMT block of the response. After WPMS–S confirms the response of a WPMS–D, it starts the specified WPT mode.

A.3.6 Scheduling information

A.3.6.1 General

It is the information used in the sequential WPT mode. It includes the allocated slot number and time for each WPMS–D after scheduling. The definition of the interfaces is as follows:

MTM–SCHDL.inform {
SlotNumber,
TimeAmount,
}

For the values for the above message, refer to Table A.11 below.

Table A.11 – Values for scheduling information

Parameter	Type	Value	Description
SlotNumber	Number	1 to 100	Allocated Slot number for each WPMS–D
TimeAmount	Number	1 to 100 000 s	Time to charge each WPMS–D
Reserved			

A.3.6.2 Scheduling information notification

It is required to inform each WPMS–D of the scheduling information after calculating the scheduling value in the sequential WPT mode. By notifying scheduling information, it prevents confusion of the WPT and performs the scheduling.

A.3.6.3 Scheduling information response

It is required when the response is sent to the WPMS–S after receiving the scheduling data. The WPMS–S can check the response of a WPMS–D and perform the scheduling-based WPT.

A.3.7 Abnormal situations management

A.3.7.1 General

In case of any abnormal situation, WPMS–S detects it and informs the corresponding WPMS–D of the situation. The definition of the interfaces is as follows:

MTM–ABNR.inform {
Abnormal,
CharOff,
RxPwr
}

For the values for the above message, refer to Table A.12 below.

Table A.12 – Values for abnormal situations management

Parameter	Type	Value	Description
Abnormal	Binary	0 or 1	0: Not applicable 1: Abnormal situation
CharOff	Binary	0 or 1	0: Charging coil Off 1: Charging coil On
RxPwr	Number	−50 to 100 dBm	Received power level
Reserved			

A.3.7.2 Abnormal situations management

It is required when the WPMS–S detects an abnormal situation and provides a solution. In the event of any abnormal situation, the WPMS–S sends information and commands to the WPMS–D MGMT block for control.

A.3.7.3 Abnormal situations management response

It is required when a WPMS–D provides the observed value and required information to the WPMS–S to solve an abnormal situation. The WPMS–S gets information from a WPMS–D to make accurate and quick decisions or actions.

A.3.8 WPMS–D full charge notification

A.3.8.1 General

When a WPMS–D is fully charged, the WPMS–D notifies the WPMS–S of this event. The definition of the interfaces is as follows:

MTM–FULL.inform {
Full,
}

For the values for the above message, refer to Table A.13 below.

Table A.13 – Values for WPMS–D full charge notification

Parameter	Type	Value	Description
Full	Binary	0 or 1	0: Not charged 1: Full charge
Reserved			

A.3.8.2 WPMS–D full charge notification

It is required when the full charge of a WPMS–D needs to be informed to a WPMS–S. After the WPMS–S recognizes this event, it stops the WPT service for the WPMS–D and excludes the WPMS–D from the WPT candidates.

A.3.8.3 WPMS–D full charge notification response

It is required when a WPMS–S is ready to send the response packet for full charge notification. It informs the response to the notified WPMS–D.

A.3.9 WPT termination notification

A.3.9.1 General

When terminating the WPT at the request of the user, the termination command is sent to all WPMS–Ds to terminate the current WPT. The definition of the interfaces is as follows:

MTM–END.inform {
End,
}

For the values for the above message, refer to Table A.14 below.

Table A.14 – Values for WPT termination notification

Parameter	Type	Value	Description
End	Binary	0 or 1	0: Complete 1: Continuous
Reserved			

A.3.9.2 WPT termination notification

It is required when terminating a WPT at the request of the user. As a result, the WPT is stopped.

A.3.9.3 WPT termination reception response

It is required when sending the response after a WPMS–D receives a WPT termination notification. It checks whether the WPMS–D has received a WPT stop event or not.

A.3.10 Inter–device WPT

A.3.10.1 General

When a WPMS–D is not able to find a WPMS–S, it can request a WPT to other WPMS–Ds in the neighbourhood. A WPMS–D power requester requests WPT to a WPMS–D power provider, and the power provider can send a response to the power requester. The definition of the interfaces is as follows:

DMTM–.request {
DeviceWPT_request,
DeviceWPT_response
}

For the values for the above message, refer to Table A.15 below.

Table A.15 – Values for inter-device WPT

Parameter	Type	Value	Description
DeviceWPT_requet	Binary	0 or 1	0: no request 1: WPT request
DeviceWPT_response	Binary	0 or 1	0: disable 1: enable
Reserved			

A.3.10.2 Inter-device WPT request

It is required when a WPMS–D power requester finds a WPMS–D power provider which is able to provide WPT. Consequently, the WPMS–D power provider sends the request information to the APP block to notify the request to users.

A.3.10.3 Inter-device WPT response

It is required when the WPMS–D power provider MGMT block receives the user's choice through the APP block. Consequently, the WPMS–D power provider MGMT block sends the user's choice to the WPMS–D power requester MGMT block.

A.4 Interface between MGMT block and APP block

A.4.1 General

It defines the interfaces between the WPMS–D MGMT block and the APP block for coupler management and control of the WPMS–D. If lower layers such as MAC and PHY support functions of upper layers, then the functions are processed by the lower layers.

A.4.2 Data request

A.4.2.1 General

When data is required from the MGMT block, it is informed to the WPMS–Ds. The definition of the interfaces is as follows:

Receiver information {
Frequency,
BatteryRemain,
BatteryDischarge,
MaxPower,
RxPower,
Type,
RSSI,
}

For the values for the above message, refer to Table A.16 below.

Table A.16 – Values for data request

Parameter	Type	Value	Description
Frequecy	Number	30 kHz to 300 MHz	In case of the system that uses multiple wireless power transfer frequency bands, the frequency information to be scheduled to use in the corresponding power transfer.
BatteryRemain	Number	0 % to 100 %	Residual battery level of the receiver
BatteryDischarge	Number	0 to 1 000 A	The extent of battery discharge
MaxPower	Number	−50 to 100 dBm	Receiver's acceptable power level
RxPower	Number	−50 to 100 dBm	Received power reception level
Type	Description	Receiver type	Description to distinguish the receiver type
RSSI	Number	−80 to 100 dBm	Reception signal strength
Reserved			

A.4.2.2 Receiver information request

It is required when a MGMT block requires receiver information from registered WPMS–Ds. As a result, the MGMT block requests receiver information from the APP block.

A.4.2.3 Receiver information response

It is required when the APP block receives receiver information request from the WPMS–S or WPMS–Ds. As a result, the APP block delivers receiver information to the MGMT block.

A.5 Interface between APP layer and MAC layer

A.5.1 General

It should be able to identify the MAC layer from the APP layer. If the MAC layer of the system supports WPT, it should cooperate with APP layter.

MAC–Information {
MAC_Type,
MAC_Version,
MAC_Address,
}

For the values for the above message, refer to Table A.17 below. Table A.18 contains the value for MAC_type.

Table A.17 – Values of MAC identification

Parameter	Type	Value	Description
MAC_Type	Binary	0~1111	Type of MAC
MAC_Version	Binary	0 ~ 100	Version of MAC
MAC_Address	Binary	0 ~ unlimited	Address of MAC
Reserved			

Table A.18 – Mac Type code

Code	MAC_type
0000	MFAN
0001	Bluetooth
0010	802.15.4
0011	NFC
0100	802.11
0101	RFID
0110~1111	reserved

A.5.2 MAC identification request

It is required when an APP block identifies the type of MAC layer. As a result, the APP block receives information on the MAC layer from the system. Upon receiving information on MAC, the proper value for the packet header will be used.

A.6 Interface between MGMT block and Coupler Block

A.6.1 General

It defines the interface between the WPMS–D MGMT block and the coupler block for coupler management and control of the WPMS–D.

A.6.2 Scheduling control

A.6.2.1 General

The WPMS–D MGMT block includes information for the coupler block control based on the received coupler control command to meet the scheduling. The definition of the interface is as follows:

DMTC–SCHDL.control {
Request_SchedulingControl
}

For the values for the above message, refer to Table A.19 below.

Table A.19 – Values for scheduling control

Parameter	Type	Value	Description
Request_SchedulingControl	Binary	0 or 1	0: Keep the current status 1: Control request
Reserved			

A.6.2.2 Scheduling control notification

It is required when the WPMS–D receives the scheduling information from the WPMS–S. Consequently, the WPMS–D MGMT block controls the coupler block based on the received scheduling information.

A.6.3 Current/voltage sensing

A.6.3.1 General

The WPMS–D MGMT block performs the current/voltage sensing to sense the variation of the reception network or to calculate the reception power, and the MGMT block defines the required information. The definition of the interface is as follows:

DMTC–SENS.request {
Request_Sensing,
Current,
Voltage,
}

For the values for the above message, refer to Table A.20 below.

Table A.20 – Values for current/voltage sensing

Parameter	Type	Value	Description
Request_Sensing	Binary	0 or 1	0: No request 1: Transfer request
Current	Number	0 to 1 000 A	Measured current
Voltage	Number	0 to 1 000 V	Measured voltage
Reserved			

A.6.3.2 Current/voltage sensing request

It requests sensing whenever wireless power is received for a specific time. Consequently, the WPMS–D MGMT block sends the control command to the coupler block to sense the voltage and current while receiving power.

A.6.3.3 Current/voltage sensing response

It is required when requesting the current/voltage sensing for the WPMS–D MGMT block to calculate the receiving power. Consequently, the WPMS–D coupler block sends the measured current and voltage to the WPMS–D MGMT block.

A.6.4 Abnormal situation control

A.6.4.1 General

The WPMS–D MGMT block controls the WPMS–D coupler block with the calculated parameters to solve an abnormal situation and includes the required information. The definition of the interfaces is as follows:

DMTC–ABNR.control {
Request_AbnormalControl,
}

For the values for the above message, refer to Table A.21 below.

Table A.21 – Values for abnormal situation control

Parameter	Type	Value	Description
Request_Abnormal Control	Binary	0 or 1	0: No change 1: Control request
Reserved			

A.6.4.2 Abnormal situation control notification

It is required when the abnormal situation control information is received from the WPMS–D APP block. Consequently, the WPMS–D MGMT block controls the coupler block based on the received abnormal situation control information.

A.6.5 WPT termination control

A.6.5.1 General

The WPMS–D MGMT block controls the coupler block for WPT termination and includes the related information. The definition of the interfaces is as follows:

DMTC–END.control {
Request_EndControl,
}

For the values for the above message, refer to Table A.22 below.

Table A.22 – Values for WPT termination control

Parameter	Type	Value	Description
Request_EndControl	Binary	0 or 1	0: No change 1: Control request
Reserved			

A.6.5.2 WPT termination control notification

It is required when WPT termination control information is received from the WPMS–D MGMT block. The WPMS–D MGMT block controls the coupler block based on the received WPT termination control information.

A.6.6 Full charge

A.6.6.1 General

When the battery of a WPMS–D is fully charged, the coupler block control is required for terminating WPT and the related information is included. The definition of the interfaces is as follows:

DMTC–FULL.control {
Request_FullControl,
}

For the values for the above message, refer to Table A.23 below.

Table A.23 – Value for full charge notification

Parameter	Type	Value	Description
Request_Full Control	Binary	0 or 1	0: No change 1: Control request
Reserved			

A.6.6.2 Full charge notification

It is required when the WPMS–D MGMT block confirms the full charge of the battery. In order for the WPMS–D MGMT block not to receive power, it controls the WPMS–D coupler.

A.6.7 Inter-device WPT

A.6.7.1 General

The WPMS power requester MGMT block controls the coupler block for receiving WPT from the power provider.

DMTC–WPTD.control {
Request_WPTDControl,
}

For the values for the above message, refer to Table A.24 below.

Table A.24 – Values for inter-device WPT

Parameter	Type	Value	Description
Request_WPTD Control	Binary	0 or 1	0: Not receive WPT 1: Receive WPT
Reserved			

A.6.7.2 Inter-device WPT control

It is required when the WPMS power requester MGMT block receives the input about WPT between receivers from users. The WPMS power requester coupler block receives WPT from the power provider.

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