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**Parasitic communication protocol for radio-frequency wireless power
transmission**

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**Protocole de communication parasite pour le transfert d'énergie sans fil par
rayonnement radiofréquence** IEC 62980:2022

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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Terms, definitions and abbreviated terms	8
3.1 Terms and definitions.....	9
3.2 Abbreviated terms.....	9
4 Overview	10
5 Communication procedures for RF WPT	11
5.1 General.....	11
5.2 Communication procedures for parasitic downlink communication.....	12
5.3 Communication procedures for parasitic uplink communication.....	13
5.4 Backscatter downlink/uplink data flow	14
5.5 WPT process	15
6 Physical layer	16
6.1 Modulation/coding method	16
6.1.1 General	16
6.1.2 Downlink modulation method	16
6.1.3 Uplink modulation method	17
6.1.4 Downlink coding method	17
6.1.5 Uplink coding method	18
6.2 Frame structure	18
6.2.1 General	18
6.2.2 Downlink frame structure	18
6.2.3 Uplink frame structure	20
7 Datalink layer	21
7.1 Message definition.....	21
7.1.1 General	21
7.1.2 Select step	24
7.1.3 Inventory step.....	26
7.1.4 Access step.....	29
7.2 Data encoding.....	31
7.2.1 General	31
7.2.2 FM0 encoding.....	31
7.2.3 Miller encoding	32
8 RF WPT control protocol.....	33
8.1 Wireless charging architecture	33
8.1.1 General	33
8.1.2 Power control purpose of RF WPT	34
8.1.3 HIE-AP operation control	34
8.1.4 SSN operation control.....	35
8.2 RF WPT process.....	36
8.2.1 General	36
8.2.2 General WPT management.....	37
8.2.3 SSN control	38
8.2.4 SSN static parameter.....	39

8.2.5 SSN dynamic parameter	40
Annex A (informative) Regulation and certification	42
Bibliography.....	43
Figure 1 – Usage of RF-WPT	10
Figure 2 – RF-WPT structure of using parasitic Wi-Fi communication technology.....	11
Figure 3 – Parasitic downlink/uplink communication procedures	12
Figure 4 – Specific parasitic downlink communication procedures.....	13
Figure 5 – Specific parasitic uplink communication procedures	14
Figure 6 – Data flow during parasitic downlink/uplink communication	15
Figure 7 – RF WPT access procedures	15
Figure 8 – RF WPT control protocol	16
Figure 9 – PIE method packet configuration.....	17
Figure 10 – Modulation and coding of the downlink preamble	17
Figure 11 – Modulation and coding of the downlink preamble	18
Figure 12 – Modulation and coding of the uplink preamble.....	18
Figure 13 – Modulation and coding of the uplink payload	18
Figure 14 – Physical layer structure of the downlink frame.....	19
Figure 15 – Physical layer structure of the uplink frame	20
Figure 16 – Model of command transmission between the STA and SSN.....	22
Figure 17 – Diagram of sequential command transmission between the STA and SSN.....	22
Figure 18 – SSN memory structure	24
Figure 19 – Message exchange in the select step.....	25
Figure 20 – CRC-16 circuit example.....	26
Figure 21 – Message exchange method of the inventory step	27
Figure 22 – Basic functions for FM0 encoding.....	31
Figure 23 – State diagram for FM0 encoding generation	31
Figure 24 – Basic functions for Miller encoding	32
Figure 25 – State diagram for FM0 encoding generation	32
Figure 26 – Encoding theory combining basic Miller functions.....	33
Figure 27 – Basic configuration of the RF wireless charging network of the proposed standard	34
Figure 28 – HIE-AP operation in RF WPT in the proposed standard.....	35
Figure 29 – SSN operation in RF WPT in the proposed standard	35
Figure 30 – Operating range of the rectified battery voltage	36
Figure 31 – RF WPT information acquisition and control protocol of the proposed standard	37
Table 1 – Downlink preamble structure	19
Table 2 – Downlink payload structure	19
Table 3 – Downlink frame check CRC	20
Table 4 – Uplink preamble structure.....	20
Table 5 – Uplink frame detection field structure	21
Table 6 – Downlink payload structure	21

Table 7 – CMD list	23
Table 8 – Responses for each CMD	23
Table 9 – Select CMD	25
Table 10 – Valid response	26
Table 11 – Query CMD field	27
Table 12 – QueryRep CMD field	28
Table 13 – QueryAdj CMD field	28
Table 14 – Valid_Query response field	28
Table 15 – Ack CMD field	29
Table 16 – Valid_Ack response field list	29
Table 17 – Read CMD field	30
Table 18 – Data field of the response to the read command	30
Table 19 – Write CMD field	30
Table 20 – Data field of the response to the write command	30
Table 21 – WPT CMD field	37
Table 22 – WPT sub-CMD list	38
Table 23 – SSN control field	38
Table 24 – Detailed WPT field description	38
Table 25 – Response to the SSN control CMD	39
Table 26 – SSN static parameter field	39
Table 27 – Rectifier maximum power field	39
Table 28 – Rectifier minimum constant voltage	39
Table 29 – Rectifier maximum constant voltage	39
Table 30 – Rectifier minimum constant voltage	40
Table 31 – SSN dynamic parameter field	40
Table 32 – Rectifier dynamic voltage field	40
Table 33 – Rectifier dynamic current field	40
Table 34 – Output dynamic voltage of the battery terminal	40
Table 35 – Output dynamic current of the battery terminal	41
Table 36 – Battery temperature of the SSN	41
Table 37 – SSN critical state field	41
Table 38 – Rectifier desired minimum voltage	41

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PARASITIC COMMUNICATION PROTOCOL FOR RADIO-FREQUENCY WIRELESS POWER TRANSMISSION

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

Draft	Report on voting
100/3797/FDIS	100/3818/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.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and 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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INTRODUCTION

This document provides a parasitic backscatter communication protocol for battery-free internet-of-things (IoT) devices and sensors for radio-frequency (RF) wireless power transmission (WPT) without additional infrastructure.

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PARASITIC COMMUNICATION PROTOCOL FOR RADIO-FREQUENCY WIRELESS POWER TRANSMISSION

1 Scope

This document defines procedures for transferring power to non-powered IoT devices using the existing ISM band communication infrastructure and RF WPT and a protocol for a two-way, long-distance wireless network in which IoT devices and APs communicate using backscatter modulation of ISM-band signals. Three components are required for two-way, long-distance wireless communication using backscatter modulation of ISM-band signals:

- an STA that transmits wireless power and data packets to SSNs by forming ISM-band signal channels between HIE-APs,
- a battery-free SSN that changes the sensitivity of the channel signals received from the STA using backscatter modulation, and
- an HIE-AP that practically decodes the channel signals whose sensitivity was changed by the SSN.

In this document, the procedures for CW-type RF WPT using communication among these three components are specified based on application of the CSI or RSSI detection method of ISM-band communication.

This document proposes a convergence communication protocol that can deploy sensors, which can operate at low power (dozens of microwatts or less) without batteries, collect energy, and perform communication, to transmit power to SSNs using RF WPT based on parasitic communication. This method can be applied to application service areas such as domestic IoT, the micro-sensor industry, and industries related to environmental monitoring in the future.

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 63006:2019, *Wireless Power Transfer (WPT) – Glossary of terms*

IEC TR 63239:2020, *Radio frequency beam wireless power transfer (WPT) for mobile devices*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions 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 Terms and definitions

3.1.1

BCU

backscatter communication unit

device that responds to a command from an STA with backscatter through load modulation, and that enables communication without power

3.1.2

BU

battery unit

battery and circuit capable of receiving wireless power to support the operations of devices and sensors

3.1.3

HIE-AP

hybrid information and energy access point

device that decodes the channel signals whose sensitivity was changed by the SSN into digital signals (0 or 1)

Note 1 to entry: An HIE-AP forms an STA and ISM-band channels for communication, detects the CSI or RSSI level of the response using backscatter from the SSN, and transmits the response data from the SSN to the STA. It also transmits CW-type power to the SSN for RF WPT.

3.1.4

impedance modulation

method of changing the sensitivity of the received signal from the channel between the STA and HIE-AP by using backscatter modulation in the SSN according to the data

3.1.5

SSN

smart sensor node

device that changes the sensitivity of the received channel signals using backscatter modulation

Note 1 to entry: SSNs include IoT devices, wearable devices, and micro-sensors.

Note 2 to entry: An SSN consists of a backscatter communication unit (BCU) that supports communication without power, a smart sensor unit (SSU) that identifies various sensors, and a battery unit (BU) that receives WPT.

3.1.6

SSU

smart sensor unit

sensor that can be attached to an SSN.

Note 1 to entry: Each sensor requires a different amount of power.

3.1.7

STA

station

device that can perform communication by occupying an ISM-band channel

Note 1 to entry: It transmits wireless power and data packets to SSNs by forming a channel and using the pulse interval encoding (PIE) method.

3.2 Abbreviated terms

ASK	amplitude shift keying
BCU	backscatter communication unit
BU	battery unit
CRC	cyclic redundancy check
CSI	channel state information

CW	continuous wave
FCS	frame check sequence
HIE-AP	hybrid information and energy access point
ISM	industrial scientific and medical equipment
NDP	null data packet
PIE	pulse interval encoding
RFID	radio-frequency identification
RFU	reserved for future use
RSSI	received signal strength indicator
RWP	response waiting packet
SSN	smart sensor node
SSU	smart sensor unit
STA	station

4 Overview

RF WPT includes WPT using energy harvesting, magnetic induction, or magnetic resonant methods, and involves the wireless transmission of power to sensors and facilities for practical use by employing RF waves. This document proposes a method of performing RF WPT to battery-free sensors or facilities. When developing the technology of this document, the developer shall refer to IEC 63006:2019 and IEC TR 63239:2020. The overall structure of parasitic communication for RF WPT proposed in this document is depicted in Figure 1. Parasitic communication (or ambient backscatter) uses existing radio frequency signals, such as radio, television and mobile telephony, to transmit data without a battery or power grid connection. Each such device uses an antenna to pick up an existing signal and convert it into tens to hundreds of microwatts of electricity. This document defines procedures for a bi-directional, long-distance wireless communication protocol for communication using backscatter modulation of industrial, scientific, and medical (ISM)-band frequency signals between stations (STA) and smart sensor nodes (SSNs), such as IoT devices, sensors, tags, and wearable devices, and for RF WPT from a hybrid information and energy access point (HIE-AP) to nearby SSNs.



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Figure 1 – Usage of RF-WPT

Three components are required for the bi-directional, long-distance wireless communication protocol using backscatter modulation of ISM-band signals, as shown in Figure 2:

- STA: performs communication by occupying a communication channel and transmits wireless power and data packets for communication to the SSN in the PIE method.

- HIE-AP: decodes the channel signals whose sensitivity was changed by the SSN into digital signals of 0 or 1. It forms a channel with the STA for communication, detects the CSI level of the response from the SSN that used backscatter, and transmits the response data from the SSN to the STA. It also transmits CW-type power to the SSN for RF WPT.
- SSN: changes the sensitivity of the channel signals received from the STA using backscatter modulation and consists of a BCU, an SSU, and a BU.
 - BCU: responding to a command from an STA with backscatter through load modulation and can respond with backscatter using the wireless power transmitted by the STA.
 - SSU: various sensors that can be attached to the SSN, each of which requires a different amount of power.
 - BU: battery and circuit capable of receiving wireless power to support the operation of nodes and sensors.

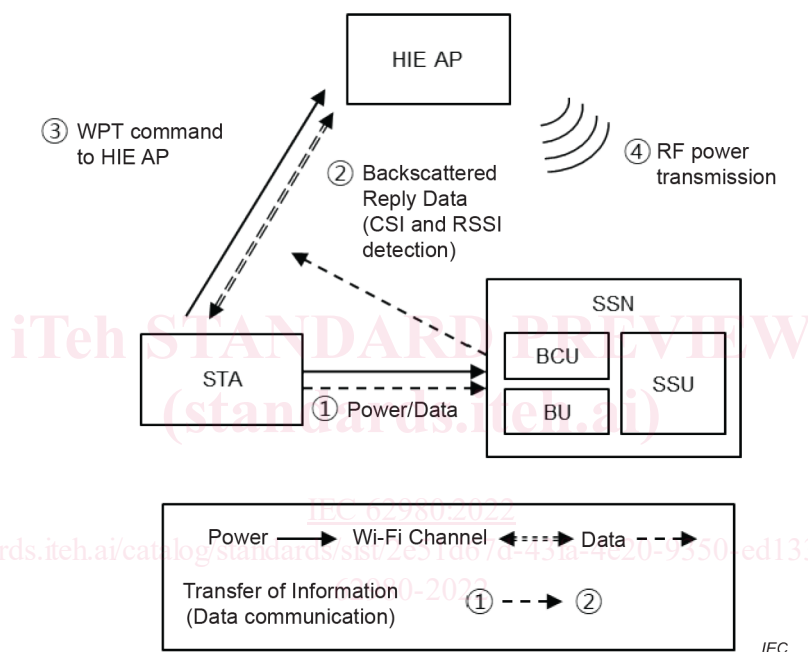


Figure 2 – RF-WPT structure of using parasitic Wi-Fi communication technology

To summarize the operation process, RF power is first transmitted from the STA to the SSN to drive the BCU of the SSN. Then, the SSN sends its data for the STA to the channel formed between the STA and HIE-AP by changing its load, and the HIE-AP can receive data from the SSN by decoding the CSI level of the information sent from the SSN. The information sent from the SSN includes ID information, battery information, and sensor data. The STA sends wireless power to the HIE-AP. The HIE-AP performs and controls RF WPT in real time based on the information received from the SSN on battery, voltage of the SSN itself, and remaining battery level.

Multi-device wireless charging systems that use the in-band field communication to exchange data and control signals utilize the same frequency within the field area to increase the efficiency of frequency. Information relating to regulation and certification is presented in Annex A.

5 Communication procedures for RF WPT

5.1 General

The parasitic communication technology involved in downlink and uplink RF WPT can be described separately. In downlink transmission, information is sent from the STA to the SSN, while in uplink transmission, information is sent from the SSN to the STA as shown in Figure 3.

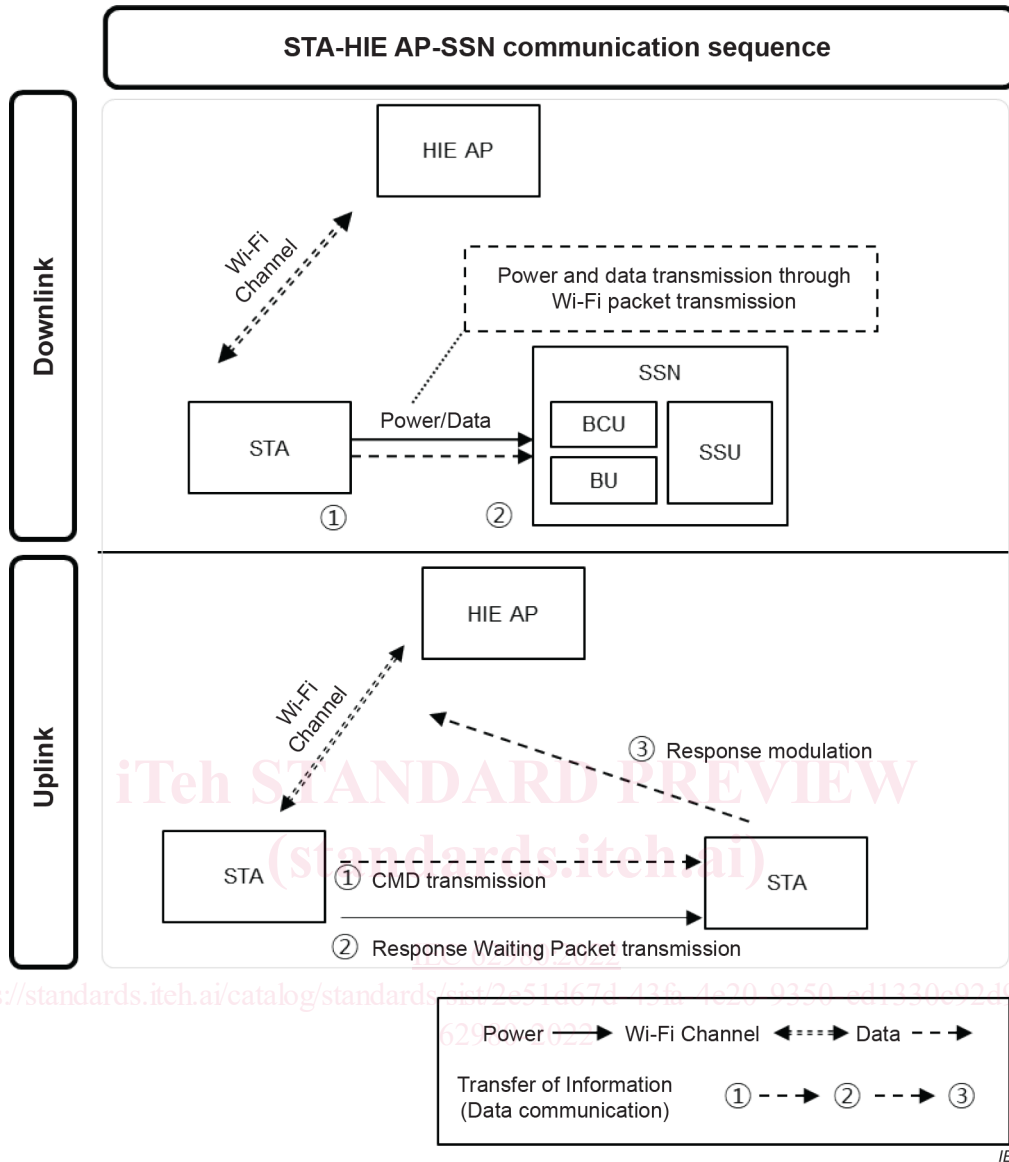


Figure 3 – Parasitic downlink/uplink communication procedures

5.2 Communication procedures for parasitic downlink communication

The downlink communication procedures are illustrated in Figure 4. First, the STA and HIE-AP form a communication channel. The STA transmits a data packet to the AP and SSN simultaneously (① -> ②). The SSN decodes the received packet, then interprets the information sent from the STA. And the STA performs its operation following command using the energy contained in the packet.

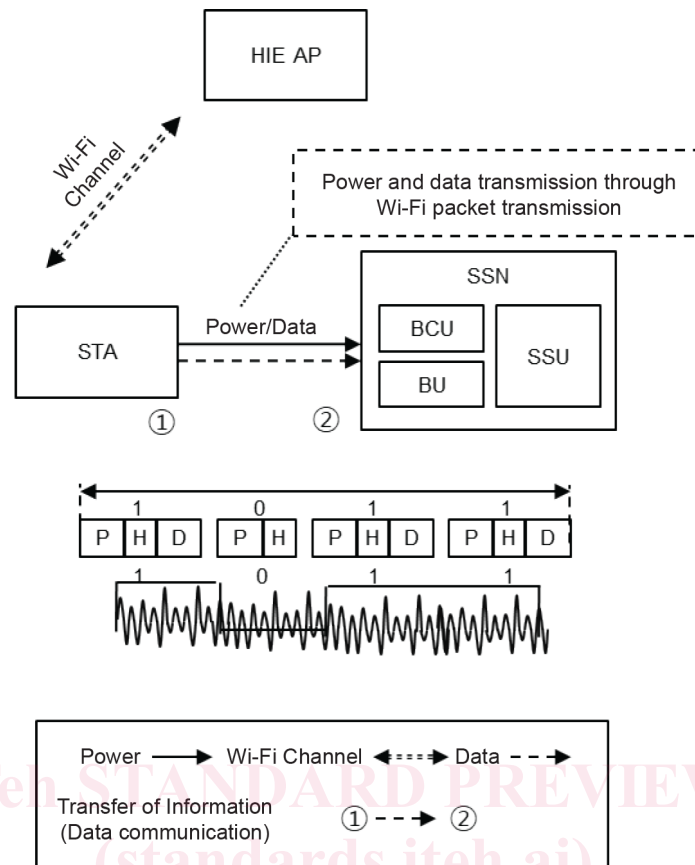


Figure 4 – Specific parasitic downlink communication procedures

5.3 Communication procedures for parasitic uplink communication

The uplink communication procedures are depicted in Figure 5. In uplink communication, a separate HIE-AP is required to read the information from the SSN (① -> ② -> ③). First, the STA creates a channel with the HIE-AP and measures the sensitivity of the received signals through the RSSI or the CSI. This procedure is employed because the SSN does not directly perform active communication, but rather changes the sensitivity of the signals received from the channel between the STA and HIE-AP through backscatter modulation when the STA continuously sends power and packets. This signal change eventually affects the RSSI or the CSI of the received signal strength of the HIE-AP. In this way, when the SSN changes the sensitivity of the received signal through a kind of amplitude shift keying (ASK) method using backscatter modulation, the HIE-AP measures the sensitivity of the received Wi-Fi signal and decodes the information from the SSN according to the sensitivity (specifically, 1 is assigned when the received sensitivity is better than the reference sensitivity, and 0 otherwise).