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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Parasitic communication protocol for radio-frequency wireless power transmission

Protocole de communication parasite pour le transfert d'énergie sans fil par rayonnement radiofréquence

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PARASITIC COMMUNICATION PROTOCOL FOR RADIO-FREQUENCY WIRELESS POWER TRANSMISSION

FOREWORD

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- withdrawn,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

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.

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 than 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.

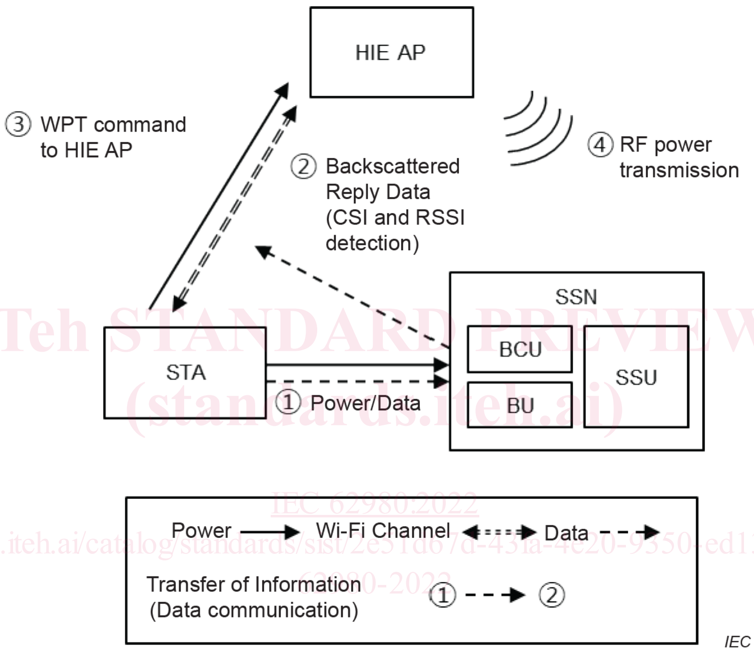

Figure 2 – RF-WPT structure of using parasitic Wi-Fi communication technology

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.

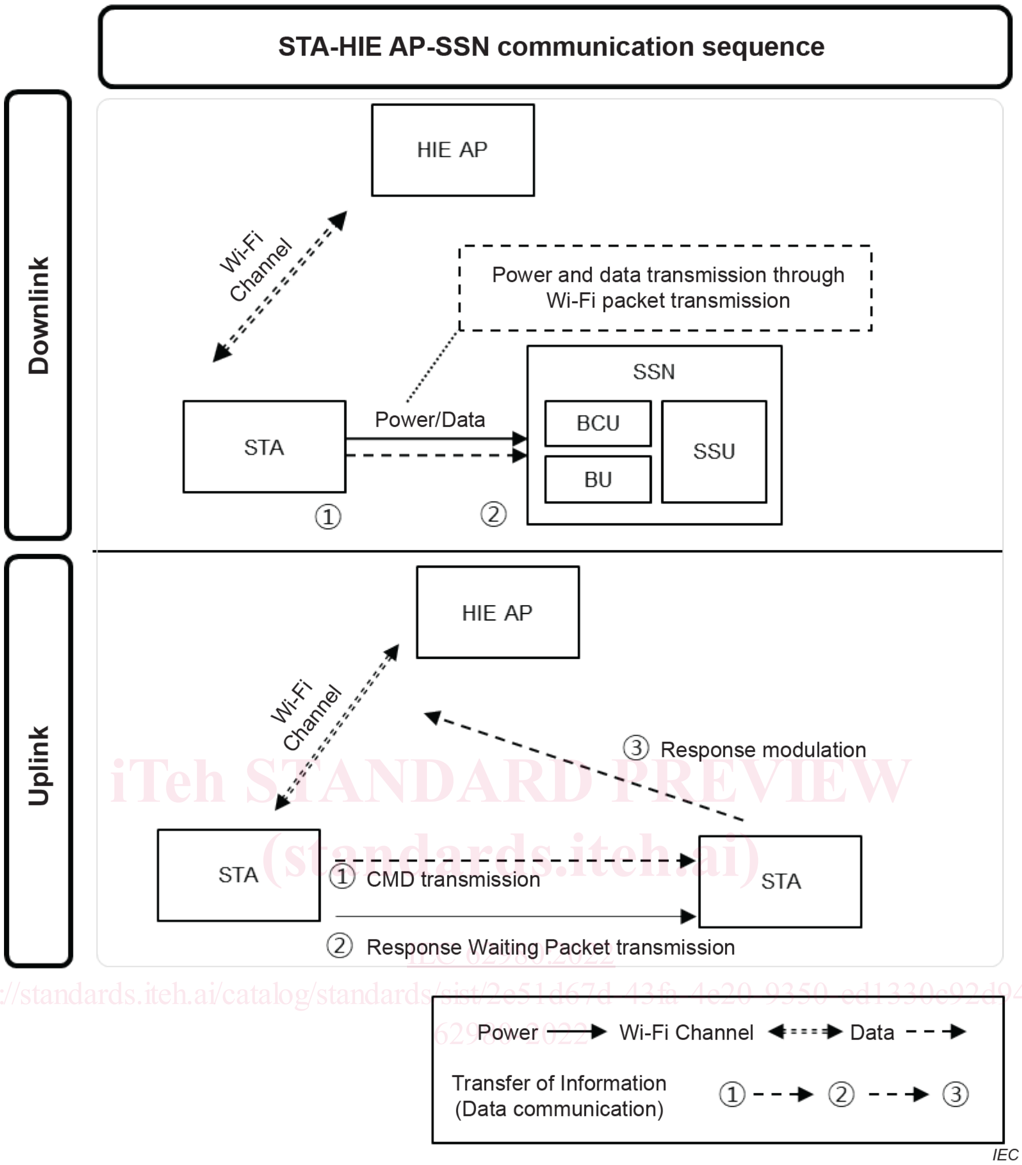

Figure 3 – Parasitic downlink/uplink communication procedures

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.

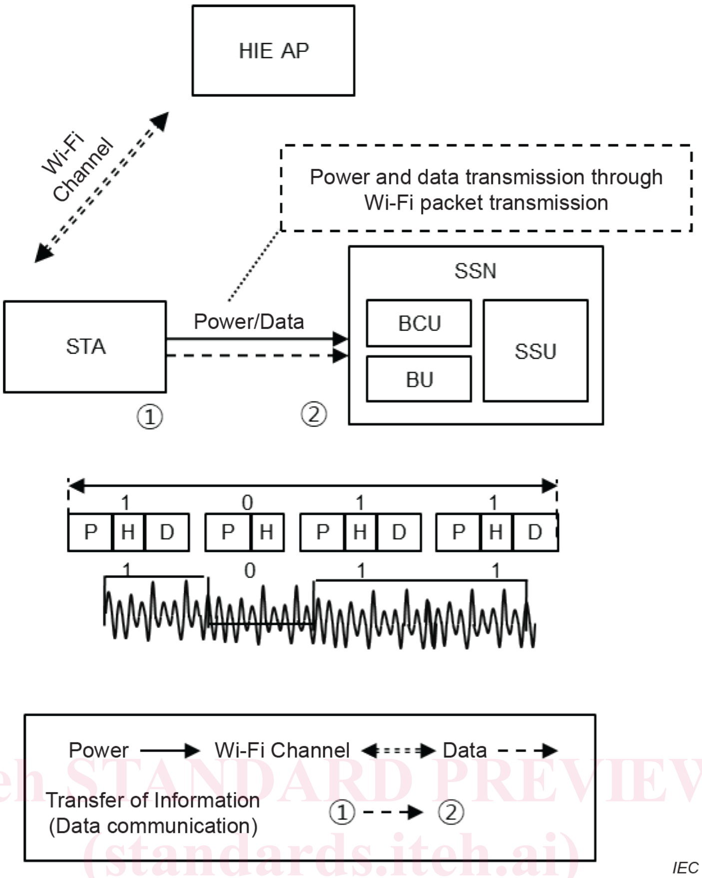

Figure 4 – Specific parasitic downlink communication procedures

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).