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Information technology — Telecommunications and information exchange between systems — Magnetic field area network (MFAN) —

Part 2: In-band Control Protocol for Wireless Power Transfer

Technologies de l'information — Téléinformatique — Réseau de zone de champ magnétique (MFAN) —

Partie 2: Protocole de contrôle dans la bande pour le transfert de puissance sans fil

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

ISO/IEC 15149 consists of the following parts, under the general title *Information technology — Telecommunications and information exchange between systems — Magnetic field area network (MFAN)*:

— *Part 1: Air interface*

— *Part 2: In-band control protocol for wireless power transfer*

— *Part 3: Relay protocol for extended range*

— *Part 4: Security protocol for authorization*

Introduction

This International Standard provides protocols for magnetic field area network (MFAN). MFAN can support the service based on wireless communication and wireless power transfer in harsh environment. MFAN is composed of four protocols; air interface, in-band control protocol, relay protocol, and security protocol.

ISO/IEC 15149–1 specifies the physical layer and media access control layer protocols of wireless network over a magnetic field.

ISO/IEC 15149–2 specifies the control protocol for wireless power transfer based on magnetic field area network.

ISO/IEC 15149–3 specifies the relay protocol to extend effective network coverage of magnetic field area network.

ISO/IEC 15149–4 specifies the security protocol to authorize nodes to communicate in magnetic field area network.

Information technology — Telecommunications and information exchange between systems — Magnetic field area network (MFAN) —

Part 2:
In-band Control Protocol for Wireless Power Transfer

1 Scope

This International Standard establishes a system for an in-band network, from which both wireless power transfer and data transmission are carried out simultaneously at the same frequency band. It provides technical solution for a remote and consistent power supply, along with a stable network.

For the purpose of this International Standard, the system is designed based on the principles described in ISO/IEC 15149 (Magnetic Field Area Network). In this way, it is expected to achieve superiority in control of devices, while managing wireless power transfer to multiple devices in request. The focus is on the physical and media access control layer protocol; it will not discuss matters on the upper layer protocols. As together, the PHY and MAC layers have to be able to carry out the following tasks: data transmission, signal control, wireless power transfer.

This International Standard is applicable in various situations and environments, but is expected to perform excellently in the following certain use cases:

— mobile phones: provide ubiquitous charging environments for portable devices;

— home appliances: allow unrestrained placement of appliances with the elimination of wire cables and plugs for power supply.

The media access control layer protocol is designed for the following scope:

— variable superframe structure for wireless power transfer to multiple devices;

— simple and effective network topology for efficient wireless power transfer;

— dynamic address assignment for efficient timesharing among multiple devices.

The physical layer protocol is designed for the following scope:

— one frequency band for both wireless power transfer and magnetic field communication;

— simple and robust modulation for low-cost implementation and minimized margin of error;

— variable coding and bandwidth for dynamic charging environment.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 15149-1:2014, *Information technology — Telecommunications and information exchange between systems — Magnetic field area network (MFAN) — Part 1: Air interface*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
wireless power transfer
WPT
method of consistent and simultaneous power supply to multiple devices within a range without physical contact

3.2
magnetic field area network
MFAN
wireless network that provides reliable communication in harsh environments using magnetic field

3.3
magnetic power network
MPAN
in-band wireless power transfer network that incorporates magnetic field area network (MFAN) in its communication and wireless power transfer within a single frequency band

3.4
magnetic power area network–coordinator
MPAN-C
device that carries out integral operations for magnetic power area network; wireless power transfer, connection and release of devices, and time scheduling of power transfer and data

3.5
magnetic power area network–node
MPAN-N
devices that comprises magnetic power area network and that is not a coordinator

4 Symbols and abbreviated terms

The following acronyms are used in this document:

ARq	Association Request
ARs	Association Response
ARA	Association Response Acknowledgement
ASC	Association Status Check
ASK	Amplitude Shift Keying
ASRq	Association Status Request
ASRs	Association Status Response
ASRA	Association Status Response Acknowledgement
BPSK	Binary Phase Shift Keying
CRC	Cyclic Redundancy Check
DA	Data Acknowledgement
DaRq	Disassociation Request

DaRs	Disassociation Response
DaRA	Disassociation Response Acknowledgement
DRq	Data Request
DRs	Data Response
DRA	Data Response Acknowledgement
FCS	Frame Check Sequence
GSRq	Group ID Set-up Request
GSRs	Group ID Set-up Response
GSRA	Group ID Set-up Response Acknowledgement
LSB	Least Significant Bit
MAC	Media Access Control
NRZ-L	Non-Return-to-Zero Level
PHY	Physical Layer Protocol
PLRC	Power Level Request Command
PLRCA	Power Level Request Command Acknowledgement
PS	Power Status
PSF	Power Status Feedback
PSFI	Power Status Feedback Interval
PT	Power Transfer
PTBRq	Power Transfer Beacon Request
PTEC	Power Transfer Execution Command
PTECA	Power Transfer Execution Command Acknowledgement
PTPC	Power Transfer Permission Command
PTRC	Power Transfer Request Command
PTRq	Power Transfer Request
PTRs	Power Transfer Response
RA	Response Acknowledgement
RR	Response Request
SIFS	Short Inter Frame Space
TDMA	Time Division Multiple Access
UID	Unique Identifier

5 Overview

MPAN is an in-band wireless network system that enables wireless communication and wireless power transfer within a single frequency band. Data and control commands are communicated according to the MFAN system; power is transferred wirelessly according to the consistent WPT system, both at the same frequency band. Due to the characteristics of magnetic field and legal regulations on the power level, the range of MFAN is wider than that of WPT. Within the MPAN, the maximum WPT efficiency is achieved with an MPAN-C taking in charge of every scheduling accordingly for devices in most effective orders.

The MFAN has a low carrier frequency bandwidth of 30 KHz to 300 KHz; the same frequency band is used for WPT. It uses a simple and robust modulation method like BPSK for low cost implementation and low error probability. Also dynamic coding methods like Manchester and NRZ-L are considered in specific against noises. It can provide data transmission speed of several kbps within a distance of several meters. For WPT, unmodulated sine sinusoidal signal is used to enhance WPT efficiency. The MPAN uses a simple and efficient network topology like the 'star topology' for low power consumption. It uses dynamic address assignment for small packet size, so to manage address efficiently as well. Also it incorporates an adaptive link quality control by using various transmission speeds, and coding methods suitable for various MPAN environments.

There are two kinds of devices participating in an MPAN according to their functions: MPAN-C and MPAN-N. Only one MPAN-C may exist within an MPAN, where a number of MPAN-Ns may be registered to. As a base station of MPAN, MPAN-C manages connection and release of MPAN-Ns when there is response to its request. For the data transmission, MPAN uses TDMA method; When an MPAN-N joins MPAN managed by MPAN-C, MPAN-C allocates time-slots for the MPAN-N. WPT and data transmission would begin as MPAN-C requests for the responses of MPAN-Ns.

As shown in Figure 1, MPAN-C and MPAN-Ns are to be located elsewhere within the network. If MPAN-C receives relevant data for WPT — ID, battery information, etc. — from MPAN-Ns, it examines factors like power transfer sequences or the number of time slots for an appropriate WPT. MPAN-C then sends control data back to MPAN-Ns to manage overall WPT operations.

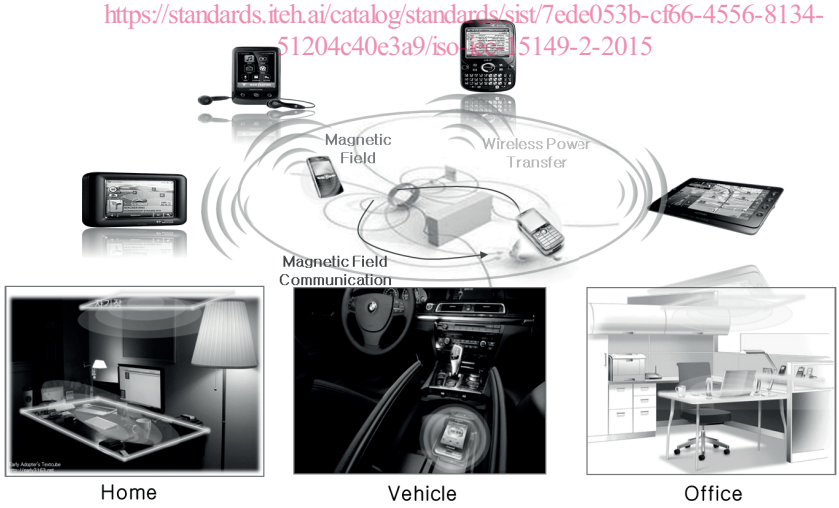

Figure 1 — Wireless Power Transfer System

MPAN can be applied to various industries. It may be applied to a situation where electric devices are in need of constant power supply to function properly. For some industries, significant improvement in efficiency is attainable simply by providing power wirelessly. In any cases, duration of battery life no longer becomes a problem; no need to spare broad space for spacious batteries and charging equipment.

As for an example, there has always been a battery issue when it comes to using mobile devices (Figure 2) due to its running time. MPAN is able to provide a ubiquitous charging environment while on a stable network service. Also for the home appliances (Figure 3), complex wire cables and plugs can be eliminated; a placement of home appliances at one's convenience becomes possible with MPAN.

Figure 2 — Mobile Devices

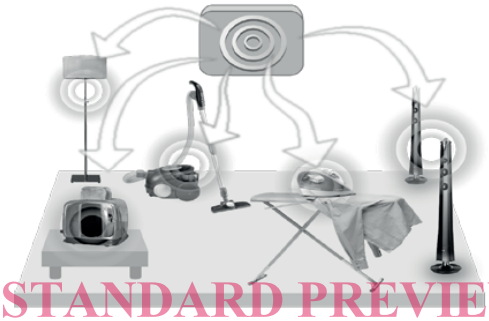

Figure 3 — Home Appliances

6 Network elements

6.1 General

The elements of MPAN, based on the elements of MFAN, are classified in two: time and physical element. The time element refers to the superframe structure consisting of request period, response period, and spontaneous period. The physical element refers to the MPAN devices: MPAN-C and MPAN-Ns. The most basic unit in the physical element is device. A device may be defined according to its role either as an MPAN-C that manages network, or an MPAN-N that communicates with MPAN-C.

When an MPAN is set up, a node is allocated to be an MPAN-C: the device in charge of the perfect control of association, disassociation, release, and time scheduling for MPAN-Ns. The superframe begins when a device is set as an MPAN-C, and starts to transmit request packets during the request period. Within MPAN, only a single channel is permitted by an MPAN-C; the rest devices within the MPAN become MPAN-Ns. Note that a device within an MPAN may participate as an MPAN-C or MPAN-N depending upon its role. For the connection between an MPAN-C and an MPAN-N, a peer-to-peer connection is used.

6.2 Time element

6.2.1 General

The MPAN inherits the same time elements used in MFAN, ISO/IEC 15149-1, which is much similar to the method used in TDMA time slot; MPAN-C arranges times slots for individual MPAN-Ns. MPAN-C manages data from the group of MPAN-Ns during response period. There are some new features newly introduced from ISO/IEC 15149-2 in relation to WPT.

6.2.2 Time element for MPAN

The time element of MPAN, as shown in Figure 4, consists of request period, response period, and spontaneous period. The lengths of request and response period are varied; the length of spontaneous period is subject to the length of request and response period.

The superframe begins when MPAN-C transmits a PTRq packet to MPAN-Ns during the request period. When MPAN-N receives the packet, it sends PTRs packet back as a response. According to the PTRs packets received, MPAN-C sends PTBRq packet with information on the WPT time schedule. In that case, relevant MPAN-Ns can receive WPT during the following response periods. During the power status feedback interval, MPAN-Ns will transmit the PSF packet as a response to the PS beacon from MPAN-C.

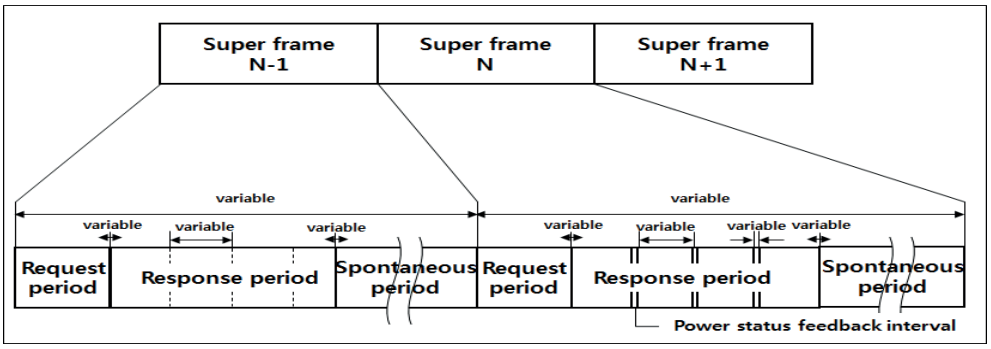

Figure 4 — MPAN superframe structure

6.2.2.1 Request period

During the request period, MPAN-C transmits PTRq packet to invite MPAN-Ns to WPT time schedule. Receiving PTRq packet, MPAN-Ns prepare to take WPT from MPAN-C.

6.2.2.2 Response period

The response period can be divided into several time slots by the number of MPAN-Ns for WPT. The length of each time slot varies according to the total length of WPT. When MPAN-C schedules for a response period, MPAN-C allocates slot numbers to each time slots in a numerical order; if there is not an MPAN-N, the slot number will be zero. MPAN-C may assign each time slot either to an individual MPAN-N or to a group of MPAN-Ns. According to a sequence of the schedule, an MPAN-N or all the MPAN-Ns in a group may receive wireless power simultaneously.

During the response period of MPAN, MPAN-Ns send PTRs to MPAN-C if the node is in need of WPT. The MPAN-Ns put in schedule by MPAN-C can receive WPT during the response period. MPAN-C, with the information received, calculates distance to MPAN-Ns. MPAN-C will then return PTBRq to MPAN-Ns to provide detailed time schedule and start WPT at a power level appropriate for the distance.

Distinguishable to the MFAN response period, the response period of MPAN has PSFI. After each time slot, there is a PSFI for quick power status update and abnormal situation. During WPT, when MPAN-N receives the PS beacon in the PSFI, it transmits the PSF packet to MPAN-C for notifying the updated power status as the response for the PS beacon in the PSFI. When abnormal situation is sensed by the MPAN-C, it is notified to all MPAN-Ns in the PSFI by the MPAN-C. When the MPAN-Ns recognize error by receiving the PS beacon, they wait until receiving a request from the MPAN-C.