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Part 3: Relay Protocol for Extended Range

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

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Foreword

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

This first edition of ISO/IEC 15149-3, together with ISO/IEC 15149-1, ISO/IEC 15149-2, and ISO/IEC 15149-4, cancels and replaces ISO/IEC 15149:2011, which has been technically revised.

ISO/IEC 15149 consists of the following parts, under the general title *Information technology — Telecommunications and information exchange between systems*:

— *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 Authentication*

Introduction

This part of ISO/IEC 15149 provides protocols for magnetic field area networks (MFAN). MFAN can support the service based on wireless communication and wireless power transfer in harsh environments. 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 authenticate nodes to communicate in magnetic field area network.

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

Part 3:
Relay Protocol for Extended Range

1 Scope

This part of ISO/IEC 15149 specifies relay protocol to extend effective network coverage of magnetic field area networks. The addressing, request and response codes are defined.

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 terms and definitions given in ISO/IEC 15149-1:2014 and the following apply.

3.1
wireless power transfer
WPT
mechanism in which a unit having enough power wirelessly transfer it to other units

3.2
Magnetic Field Area Network
MFAN
wireless network that provides reliable communication in harsh environments using magnetic field

3.3
Magnetic Field Area Network - Coordinator
MFAN-C
device that manages the connection and release of nodes within the communication area and the sending and receiving time of data in an MFAN

3.4
Magnetic Field Area Network – Node
MFAN-N
device except the coordinator that forms a network in an MFAN

3.5
Magnetic Field Area Network – Repeater
MFAN-R
device among MFAN-Ns that performs partial functions of coordinator

4 Symbols and abbreviated terms

The following acronyms are used in this document:

RSRq Repeater Set-up Request

RSRs Repeater Set-up Response

RSRA Repeater Set-up Response Acknowledgement

5 Overview

MFAN is a wireless communication network that can transmit and receive data over a magnetic field in a low frequency band (30kHz~300kHz.) Wireless communication over a magnetic field enables reliable communication and extends the communication system coverage around metal, soil, and water. It is designed using those characteristics of the magnetic field communication. It uses a low carrier frequency for reliable communication and large magnetic field area in harsh environments, a simple and robust modulation like BPSK for a low implementation cost and error probability, and a dynamic coding technique like Manchester or NRZ-L coding for noise robustness. In essence, it provides several kbps data transmission within a distance of several meters.

There are three types of devices associated to MFAN: MFAN-C, MFAN-N, and MFAN-R. Only a single MFAN-C is to exist per a single MFAN, while together with several associated MFAN-Ns consist MFAN. MFAN-R, capable of creating a relay network, connects out-of-boundary MFAN-Ns to MFAN.

Within MFAN, the primary and the first device to be settled is MFAN-C. Once the coordinator is ready to broadcast request packets, MFAN superframe is initiated. MFAN-C is in charge of association, disassociation, and management of data transmission with MFAN-Ns and MFAN-Rs. There is only a single channel within MFAN communication range, which means there will be no more than a single network in MFAN. Therefore, except for a single MFAN-C, the rest devices are to be either MFAN-N or MFAN-R. All the devices of MFAN are classified as MFAN-C, MFAN-N, and MFAN-R, but any device can take the role of MFAN-C, MFAN-N, or MFAN-R. MFAN-C and each MFAN-N are connected on 1:1 basis.

6 Network elements

6.1 General

The network elements of MFAN relay network consist of time and physical elements.

6.2 Time element

MFAN relay network is capable of utilizing TDMA management. MFAN-C manages a group of MFAN-Ns and MFAN-Rs by allocating appropriate request time slot. Depending on the status of MFAN-Ns and MFAN-Rs, response period is adjusted.

The structure of MFAN relay network superframe is described in Figure 1. The superframe is divided into three stages: request period, response period, and spontaneous period. The length of each stage is variable. The superframe is initiated when MFAN-C transfer response request packet during the request period. The response request packet contains information for MFAN-Ns and MFAN-Rs to return relevant response back to MFAN-C during the response period. MFAN-Ns may be approved to participate as MFAN-Rs upon the request of MFAN-C.

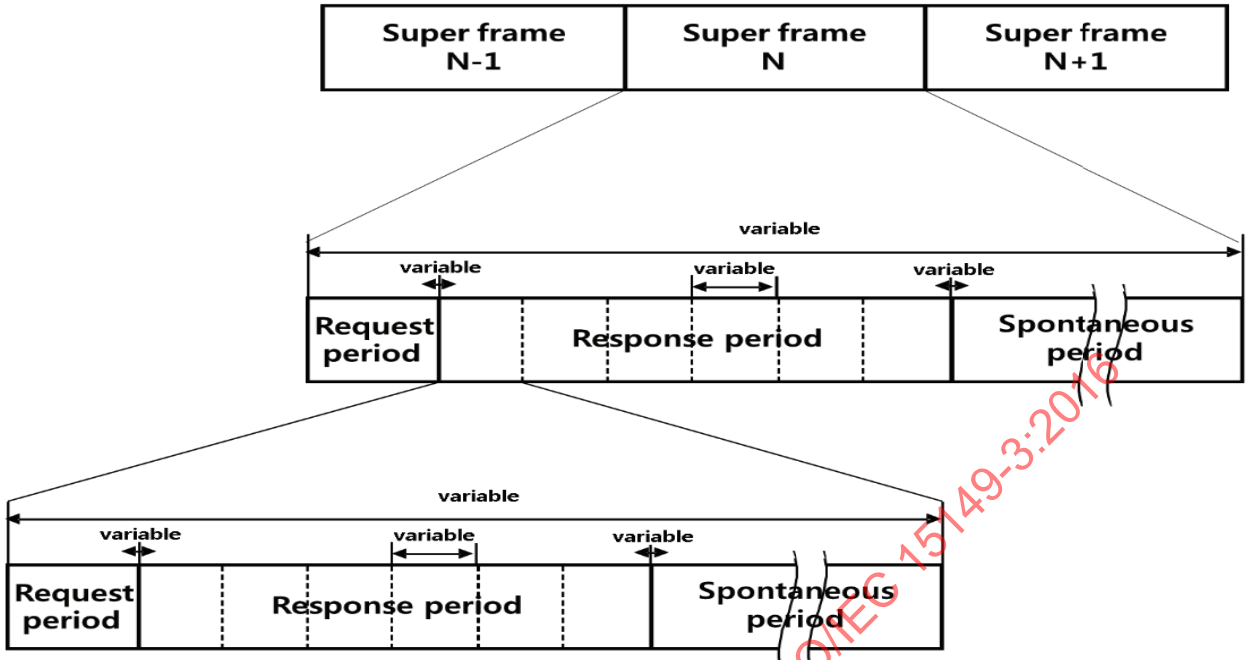

Figure 1 — Superframe structure of relay network

If approved, MFAN-R shall be allocated of time slot just like other MFAN-Ns. However, within the time slot, MFAN-R shall sub-divide again its time slot to create superframe within its time slot. In this case, MFAN-R creates a relay network with MFAN-Ns unreachable from the MFAN-C.

6.2.1 Request period

In the request period of MFAN relay network, MFAN-R shall delivers response request packet to MFAN-Ns so they can return relevant response packet during response period.

6.2.2 Response period

In the response period of MFAN relay network, MFAN-Ns which are joined to MFAN relay network by MFAN-R return response packet back to MFAN-R based on the response request packet. Response period is divided into a number of time slots by the number of devices in MFAN relay network. The length of each time slot is variable depending on the length of response packet and acknowledgement packet. The time slots are numbered in periodical order to be allocated to appropriate MFAN-N. MFAN-R manages the allocation of time slots for data and packet transmission.

6.2.3 Spontaneous period

The spontaneous period of MFAN relay network begins when there is not a device returning response packet for a certain length of time. In this period, MFAN-Ns which are joined to MFAN relay network by MFAN-R can transfer data without the request of MFAN-R. The period lasts during the time which is allocated for MFAN-R by MFAN-C.

6.3 Physical element

The physical element of MFAN relay network consists of devices that are MFAN-C, MFAN-N, and MFAN-R. MFAN relay network is a network that enables communication between a MFAN-C and individual MFAN-Ns and MFAN-Rs; its basic element is device. Depending on its role, a device is categorized as MFAN-C, MFAN-N or MFAN-R. MFAN-C manages the entire MFAN relay network, and there will only be a single MFAN-C within a relay network. MFAN-C manages MFAN-Ns and MFAN-Rs by broadcasting

response request packets. Accordingly, MFAN-Ns and MFAN-Rs return appropriate response packet. The structure of MFAN relay network is shown in Figure 2.

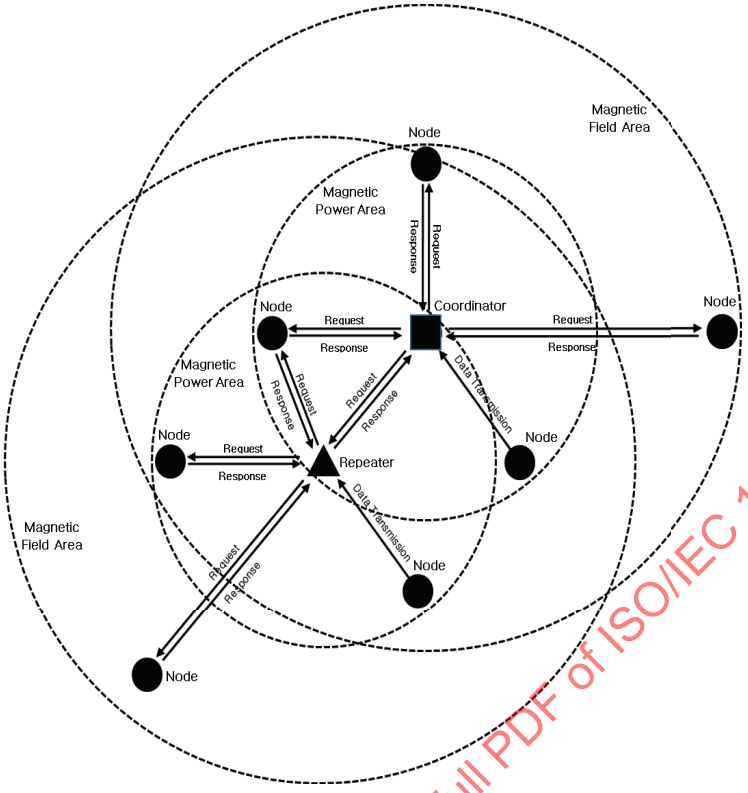

Figure 2 — The structure of relay network

6.3.1 MFAN-C

MFAN-C is in charge of the management of MFAN relay network with response request packet. There is only a single MFAN-C in a relay network.

6.3.2 MFAN-N

MFAN-N is a device that is associated to an MFAN relay network, and is not an MFAN-C or MFAN-R. As much as 65,519 MFAN-Ns can link to a relay network at the same time. It returns response packets according to the RR packet sent by MFAN-C or MFAN-R.

6.3.3 MFAN-R

MFAN-R is a selective MFAN-N that performs functions of MFAN-C. It creates separate relay network within its response period to connect unreachable MFAN-Ns from MFAN-C.

6.4 Address element

Specified in ISO/IEC 15149-1:2014, 5.4.

6.4.1 Node ID

Node ID is an identifier used instead of UID to identify nodes, and it has a 16 bit address assigned by MFAN-C. Some node IDs are reserved in Table 1.

Table 1 — Reserved node ID

Node ID	Content	Remarks
0xFFFF	All nodes	When broadcasting or transmitting all nodes
0xFFFE	Unjoined node	Default ID for MFAN-N
0xFFFD	Unjoined repeater node	Default ID for MFAN-R
0xFFF0 – 0xFFFC	Reserved	-

7 Network functions

7.1 General

MFAN relay network superframe consists of request period, response period, and spontaneous period.

7.2 Request period

During the request period, MFAN-R broadcasts response request packet to entire devices. Having received, MFAN-Ns decide whether to return response packet back to MFAN-R or not. MFAN-R can group devices to receive selective responses from designated devices.

7.3 Response period

During the response period selective MFAN-Ns grouped by MFAN-R returns response packet back to MFAN-R. Once MFAN-R receives response packet from MFAN-Ns, MFAN-R sends acknowledgement packet to confirm reception. If MFAN-Ns do not receive acknowledgement packet from MFAN-R, the MFAN-Ns continuously send response packet until they can receive acknowledgement packet, during response period.

7.4 Spontaneous period

Spontaneous period begins when there is not a MFAN-N sending response packet from a certain amount of time. The period lasts until MFAN-R request for response request packet that is a start of new superframe. Exceptionally, MFAN-N is able to transfer data during spontaneous period without the request of MFAN-C, or MFAN-R.

8 Network status

8.1 General

In an MFAN relay network, MFAN-N undergoes the following status: Network configuration, network association, network disassociation, network association check, data transmission, and network release.

8.2 Network configuration

During the request period, MFAN-C may transfer repeater request packet to designated MFAN-Ns to create MFAN-R. As MFAN-N returns repeater response packet, a relay network is configured. In the repeater request packet, there is MFAN ID, so MFAN-Ns can identify associating network. The minimum relay network consists of a MFAN-R only; it has request period and spontaneous period.

8.3 Network association

When MFAN-C broadcasts association request packet, MFAN-R delivers received association request packet during its response period that is request period of relay network. Upon reception, MFAN-Ns probe on the received packet to association with appropriate network. If MFAN-Ns find the right

network, they send association response packet to MFAN-R. Once again MFAN-R delivers received packet to MFAN-C to wait for acknowledgement packet. When MFAN-R delivers the final acknowledgement to MFAN-Ns and they receive, relay network association is completed.

8.4 Network disassociation

Associated MFAN-Ns can disassociate from MFAN either independently, or upon MFAN-C request. Depending on the current network status, or service policy, MFAN-C may request disassociation to MFAN-Ns via MFAN-R. The status of independently disassociated MFAN-Ns is updated from the next association request packet.

8.5 Network association check

The association status of MFAN-Ns in relay network can be requested by MFAN-C via MFAN-R. In order to check network association status, MFAN-C transfers association status request packet to MFAN-Ns via MFAN-R. MFAN-Ns return association status response packet to MFAN-C via MFAN-R. As acknowledgment packet is delivered from MFAN-C to MFAN-Ns using the same procedure, network association check is completed.

8.6 Data transmission

When MFAN-C of relay network request for data response packet during request period, MFAN-R returns received data response packet from MFAN-Ns during response period. As MFAN-C receives data response packet, it returns acknowledgement packet to MFAN-Ns via MFAN-R to complete data transmission.

8.7 Network release

There are two types of relay network release. One is normal release by the request of MFAN-C; the other is abnormal release due to abnormal situations. In normal release, MFAN-C decides the release of network and request such to all the MFAN-Ns associated. In abnormal release, there may be a number of reasons such as MFAN-N and MFAN-R both leaving out the MFAN coverage.

8.8 MFAN device status

Specified in ISO/IEC 15149-1:2014, 6.7.

9 MAC layer frame format

9.1 General

The MAC frame of MFAN consists of the frame header and the frame body. The frame header has information for data among MFAN-Ns, and the frame body has the data for transmissions between MFAN devices. Specified in ISO/IEC 15149-1:2014, Clause 8.

9.2 Frame format

Specified in ISO/IEC 15149-1:2014, 8.2.

9.3 Frame type

Specified in ISO/IEC 15149-1:2014, 8.3.

9.4 Payload format

9.4.1 Request frame

9.4.1.1 Request code

Values for request code for MFAN relay network are as following from the Table 2 below.

Table 2 — Request code

Category	Request code	Content	Remarks
Network	0x01	Association request	Request for association response to unjoined nodes
	0x02	Disassociation request	Request for disassociation response to joined nodes
	0x03	Association status request	Request for association status response to joined nodes
	0x04 – 0x0F	Reserved	-
Data	0x11	Data request	Request for data transmission to joined nodes
	0x12 – 0x1F	Reserved	-
Configuration	0x21	Group ID set-up request	Request for group ID change to joined nodes
	0x22	Repeater set-up request	Request for repeater allocation among nodes
	0x23 – 0x2F	Reserved	-
Wireless Power Transfer	0x31	Power transfer request	Request for power transfer response to joined nodes
	0x32	Power transfer beacon request	Request for power transfer beacon to joined nodes
	0x33 – 0x3F	Reserved	-
Reserved	0x40 – 0xFF	Reserved	-

9.4.1.2 Request block

a) Repeater set-up request

The block format of RSRq is shown in Figure 3. The first 2 bytes are for node ID, the next 1 byte is for the slot number, and the last 1 byte is for the number allocated for the repeater.

Unit: Byte

2	1	1
Node ID	Slot number	Repeater number

Figure 3 — Block format of repeater set-up request

9.4.2 Response frame

9.4.2.1 Response code

Values for response code for MFAN relay network are as following from the Table 3 below.

Table 3 — Response code

Category	Response code	Content	Remarks
Network	0x01	Association response	Transmission of node UID
	0x02	Disassociation response	Transmission of node UID
	0x03	Association status response	Transmission of node UID
	0x04 – 0x0F	Reserved	-
Data	0x11	Data response	Transmission of requested data
	0x12 – 0x1F	Reserved	-
Set-up	0x21	Group ID set-up response	Transmission of UID and group ID after changes in group ID
	0x22	Repeater set-up response	Transmission of UID and repeater number
	0x23 – 0x2F	Reserved	-
Wireless Power Transfer	0x31	Power transfer response	Transmission of requested data to receive wireless power transfer
	0X32 – 0x3F	Reserved	-
Reserved	0x40 – 0xFF	Reserved	-

9.4.2.2 Response block

b) Repeater set-up response

The block format of RSRs is shown in Figure 4. The first 8 bytes are for UID, the next 1 byte is for the number allocated for the repeater.

Unit: Byte

8	**1**
UID	Repeater number

Figure 4 — Block format of repeater set-up response

9.4.3 Response confirmation frame

9.4.3.1 Response confirmation code

Values for response confirmation code for MFAN relay network are as following from the Table 4 below.