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

Part 1:
Air interface

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

Partie 1: Interface radio

Reference number
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Foreword

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

This first edition of ISO/IEC 15149-1 cancels and replaces ISO/IEC 15149:2011, of which it constitutes a minor revision.

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*

Relay Protocol for Extended Range and *Security Protocol for Authorization* will form the subjects of future Parts 3 and 4, respectively.

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.

This part of ISO/IEC 15149 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 secuity 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 1: Air interface

1 Scope

This part of ISO/IEC 15149 specifies the physical layer and media access control layer protocols of wireless network over a magnetic field in a low frequency band (~300 KHz) for wireless communication in harsh environment (i.e., around metal, underwater, underground, etc.).

The physical layer protocol is designed for the following scope:

— low carrier frequency for large magnetic field area and reliable communication in harsh environment;

— simple and robust modulation for a low implementation cost and error performance;

— variable coding and bandwidth for a link adaptation.

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

— simple and efficient network topology for low power consumption;

— variable superframe structure for compact and efficient data transmission;

— dynamic address assignment for small packet size and efficient address management.

This part of ISO/IEC 15149 supports several Kbps data transmission in wireless network within a distance of several meters. It can be applied to various services such as the following areas:

— environmental industry to manage pollution levels in soil and water using wireless underground or underwater sensors;

— construction industry to monitor the integrity of buildings and bridges using wireless, inner-corrosion sensors;

— consumer-electronics industry to detect food spoilage in wet, airtight storage areas and transfer the sensing data from the inside to the outside;

— agricultural industry to manage the moisture level as well as mineral status in soil using wireless, buried sensors;

— transportation industry to manage road conditions and traffic information using wireless, underground sensors.

2 Terms and definitions

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

2.1
magnetic field area network
MFAN
wireless network that provides reliable communication in harsh environments using magnetic field

2.2
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

2.3
magnetic field area network node
MFAN-N
device, except the coordinator, that forms a network in an MFAN

3 Symbols and abbreviated terms

The following acronyms are used in this part of ISO/IEC 15149:

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
HCS	header check sequence
LSB	least significant bit
MAC	media access control
MFAN	magnetic field area network
MFAN-C	magnetic field area network coordinator
MFAN-N	magnetic field area network node
NRZ-L	non-return-to-zero level
PHY	physical layer protocol
RA	response acknowledgement
RR	response request
SIFS	short interframe space
TDMA	time division multiple access
UID	unique identifier

4 Overview

MFAN is a wireless communication network that can transmit and receive data over a magnetic field in a low frequency band. 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.

Also, it uses a simple and efficient network topology like a star topology for low power consumption. The dynamic address assignment is used for the small packet size and efficient address management, and the adaptive link quality control is considered with variable data transmission speed and coding. The devices in MFAN are specified into two elements according to the role: MFAN-C for a coordinator, and MFAN-N for a node. In a network, there can be one coordinator. When a node joins the network, the coordinator assigns the time-slots for each device upon the node's request and the coordinator's decision. So, TDMA is considered for the data transmission.

As shown in Figure 1, MFAN-Ns are buried under the ground, and MFAN-C is placed above the ground. If MFAN-N receives the sensing data from the sensors, MFAN-N sends its received data to MFAN-C over a magnetic field. MFAN-C sends the received data from MFAN-N to the monitoring center by either wireless or wired communication for long distance.

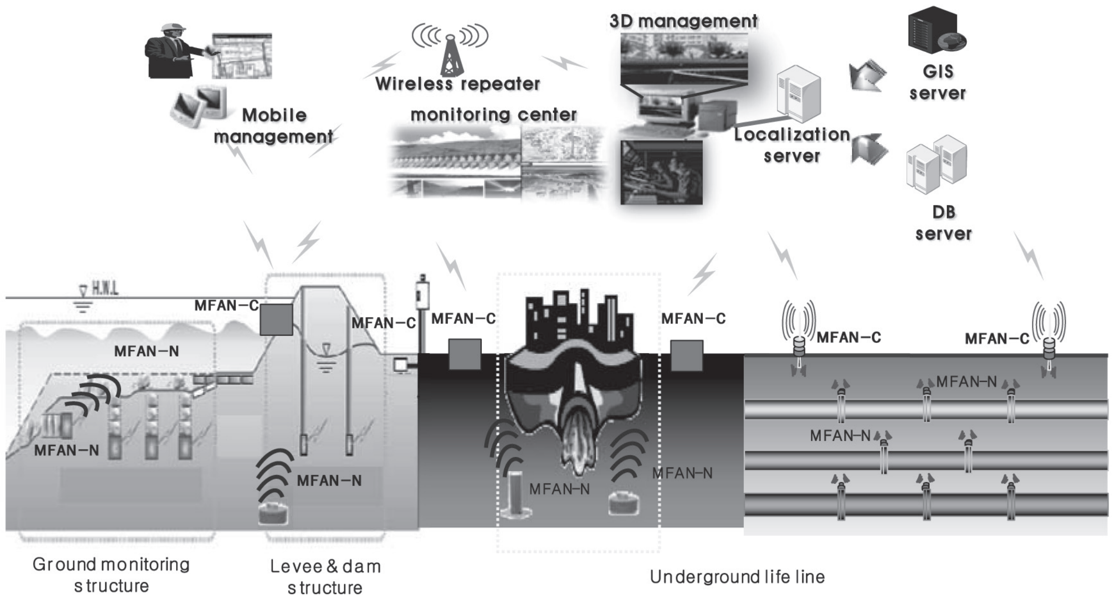

Figure 1 — Underground monitoring system

Wireless communication in harsh environment has been significantly required in various industries. It is difficult for a sensor node to transmit its data by a radio frequency around metal, soil, and water with the existing standards of wireless communication. MFAN is an alternative standard that enables several sensor nodes inside metal, soil, and water to transfer their data to a coordinator outside using the characteristics of magnetic field. Therefore it can be applied to various services in harsh environment.

For example, in ground status monitoring as shown in Figure 2, the sensor nodes can be buried under the ground to sense ground cave-in, ground sinking, land sliding, and so on. Another example of MFAN is the underground infrastructure management in Figure 3. In this example, the sensor nodes are attached to the pipes, and can detect gas or water leaks and notify its location. For the building and bridge management in Figure 4, the sensor nodes can be placed on beams and columns to detect the integrity of the structure. In pollution monitoring as shown in Figure 5, the sensor nodes can detect the quality of the soil and water. It can detect poisonous chemical, pH(Hydrogen ion exponent), and temperature by sensor nodes that are placed below ground and water.

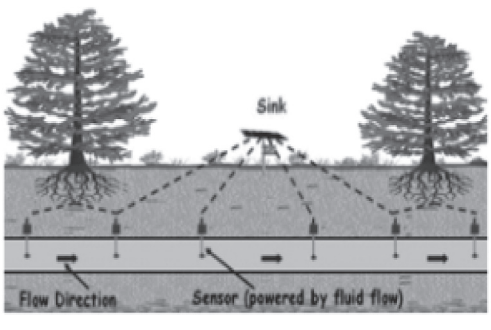

Figure 2 — Ground status monitoring

Figure 3 — Underground infrastructure management

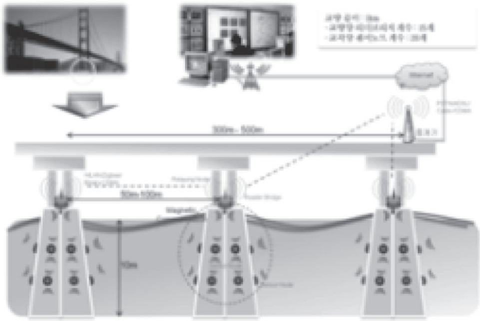

Figure 4 — Building & bridge management

Figure 5 — Pollution monitoring

5 Network elements

5.1 General

The main elements of MFAN are divided into time and physical element. The time element refers to the superframe consisting of a request period, a response period, and a spontaneous period, and the physical element refers to the network consisting of MFAN-C and MFAN-Ns. The most basic one in the physical element is the node. Node is classified into two types: MFAN-C to manage the network and MFAN-N to communicate with MFAN-C.

Figure 6-7 show the structures of superframe and network which are the time and physical elements, respectively. The node that needs to be decided first in MFAN is MFAN-C, and the superframe begins with MFAN-C transmitting a request packet in the request period. MFAN-C is charged of managing the association, disassociation, release, and scheduling of MFAN-Ns. One MFAN can use one channel where only one node is utilized as MFAN-C and the rest of them become MFAN-N. The rest of the nodes in

MFAN excluding MFAN-C become MFAN-N. Note that any nodes can become either MFAN-C or MFAN-N depending upon its role. Basically, a peer-to-peer connection between MFAN-C and MFAN-N is considered.

5.2 Time element

The time element used in MFAN is the time slot of the TDMA method. MFAN-C manages the MFAN-N group that transmits data in the response period, and the time slots are self-arranged by the selected MFAN-Ns. The superframe of MFAN, as shown in Figure 6, consists of a request period, a response period, and a spontaneous period, and the lengths of the request and response period are variable. The superframe begins with MFAN-C transmitting a RR packet to MFAN-Ns in the request period.

The RR packet has information which MFAN-Ns can send response packets during response periods, and the selected MFAN-Ns can transmit the response packet in the response period according to the RR packet information.

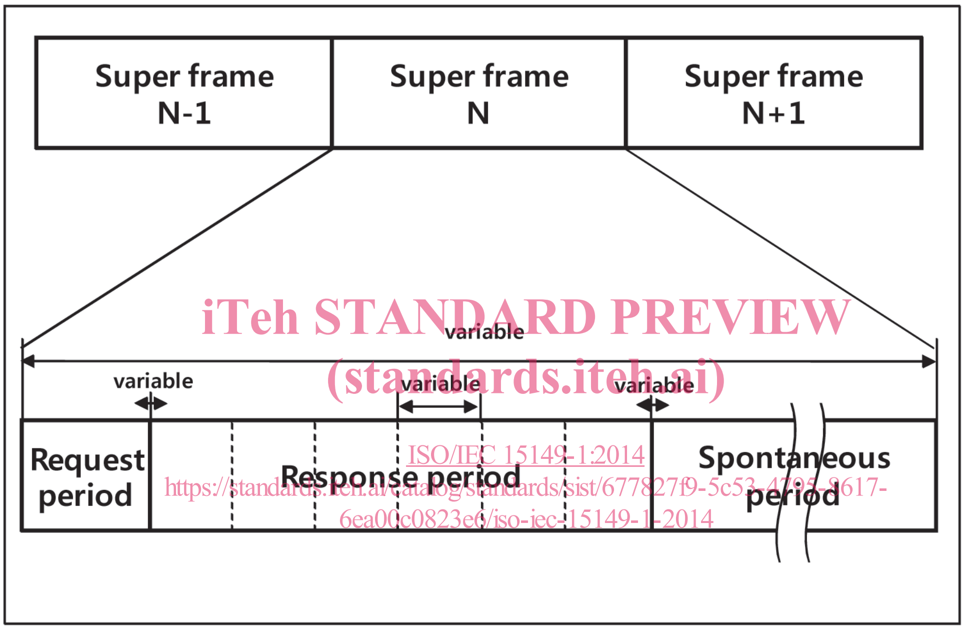

Figure 6 — MFAN superframe structure

5.2.1 Request period

In the request period, MFAN-C transmits the RR packet with the information about the usage of MFAN-Ns in order for MFAN-N to send the response packet during response periods.

5.2.2 Response period

In the response period, MFAN-N can transmit response packet according to the received RR packet of MFAN-C, and the response period can be divided into several time slots according to the number of the selected MFAN-Ns in MFAN. Each time slot length is variable according to the length of the response frame and the acknowledgement. If the MFAN-C schedules a response period, the slot number is decided by the order of the divided time slot. Otherwise the slot number is zero. MFAN-C assigns time slots to either MFAN-N or a particular group for the use of the response period, and the nodes in the assigned group independently transmit the data frame in the response period.

5.2.3 Spontaneous period

The spontaneous period begins when there is no node transmitting the response packet for a certain period of time. In this period, nodes can transmit data even without MFAN-C's request. This period is maintained until MFAN-C transmits a request packet.

5.2.4 Network activation

The superframe of MFAN is divided into the request period, the response period, and the spontaneous period. MFAN-C and MFAN-Ns in MFAN operate in each period as follows:

5.2.4.1 Request packet transmission within the request period

In the request period, MFAN-C sends the RR packet to MFAN-Ns. Based on this, the MFAN-N that have received the RR packet decide whether to transmit response packets in the response period. MFAN-C can determine the MFAN-N group to transmit in the response period.

5.2.4.2 Response packet transmission within the response period

The MFAN-Ns selected by MFAN-C can transmit the response packet in the response period. When MFAN-N transmits the response packet in the response period, MFAN-C that has received the response packet transmits the RA packet. MFAN-N that has not received the RA packet transmits response packets every time-slot until it receives a RA packet from MFAN-C.

5.2.4.3 Data packet transmission in the spontaneous period

A spontaneous period begins if MFAN-N does not transmit any response packets for a certain period of time, and this period is maintained until MFAN-C transmits a RR packet. In the spontaneous period, MFAN-N can transmit data without the request of MFAN-C.

5.3 Physical element

The physical element configuring MFAN is divided into MFAN-C and MFAN-N in which all MFAN-Ns are connected into MFAN-C (i.e. a central connectivity device). The basic element, node, is distinguished into MFAN-C and MFAN-N according to its role. MFAN-C manages the whole MFAN and there must exist only one MFAN-C per one network. MFAN-C manages MFAN-N by sending the RR packet. MFAN-N must transmit response packets according to MFAN-C's management. MFAN can be configured as shown in Figure 7.

5.3.1 MFAN-C

MFAN-C is a node that manages MFAN; only one MFAN-C exists per one network, and it manages and controls MFAN-N by the RR packet.

5.3.2 MFAN-N

MFAN-N is a node that resides within an MFAN (excluding MFAN-C), and a maximum of 65,519 MFAN-Ns can exist per network. It transmits response packets according to the RR packet transmitted by MFAN-C.