

IEEE Standard for
Local and metropolitan area networks—

Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)

Amendment 2: Active Radio Frequency Identification (RFID) System Physical Layer (PHY)

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

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USA

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IEEE Std 802.15.4™-2011)

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**IEEE Standard for
Local and metropolitan area networks—**

**Part 15.4: Low-Rate Wireless Personal Area
Networks (LR-WPANs)**

**Amendment 2: Active Radio Frequency
Identification (RFID) System Physical Layer (PHY)**

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IEEE Computer Society**

Approved 6 February 2012

IEEE-SA Standards Board

Abstract: This amendment provides two PHYs (MSK and LRP UWB) that can be used in a wide range of applications requiring various combinations of low cost, low energy consumption, multi-year battery life, reliable communications, precision location, and reader options. This PHY standard supports the performance and flexibility needed for future mass deployments of highly populated autonomous active RFID systems anywhere in the world.

Keywords: active RFID, ad hoc network, IEEE 802.15.4, IEEE 802.15.4f, low data rate, low power, LR-WPAN, mobility, PAN, personal area network, radio frequency, RF, RFID, RTLS, short range, wireless, wireless personal area network, WPAN

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Introduction

This introduction is not part of IEEE Std 802.15.4f-2012, IEEE Standard for Local and metropolitan area networks—Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)—Amendment 2: Active Radio Frequency Identification (RFID) System Physical Layer (PHY).

This amendment specifies two alternate PHYs (MSK and LRP UWB) in addition to those of IEEE Std 802.15.4-2011. In addition to the new PHYs, the amendment also defines those MAC modifications needed to support their implementation.

The alternate PHYs support principally low cost, low energy consumption, multi-year battery life, reliable communications, precision location, and sensor applications under multiple regulatory domains. The PHYs are as follows:

- MSK PHY
- Low rate PRF UWB PHY

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IEEE Standard for Local and metropolitan area networks—

Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)

Amendment 2: Active Radio Frequency Identification (RFID) System Physical Layer (PHY)

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¹Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

1. Overview

1.2 Scope

Change the first item of the dashed list as follows:

- Devices operating in the license-free 433.05 MHz to 434.79 MHz, 868 MHz to 868.6 MHz, 902 MHz to 928 MHz, ~~and~~ 2400 MHz to 2483.5 MHz, ~~and~~ 6289.6 MHz to 9185.6 MHz bands

1.3 Purpose

Change the second and third paragraphs as follows:

In addition, ~~one of the~~ alternate PHYs provides precision ranging ~~capability~~ capabilities that ~~is~~ are accurate to one meter.

Multiple PHYs are defined to support a variety of frequency bands including

- 433.05 MHz to 434.79 MHz (worldwide, varies by region)
- 868 MHz to 868.6 MHz
- 902 MHz to 928 MHz
- 2400 MHz to 2483.5 MHz
- 6289.6 MHz to 9185.6 MHz
- 314 MHz to 316 MHz, 430 MHz to 434 MHz, and 779 MHz to 787 MHz band for LR-WPAN systems in China
- 950 MHz to 956 MHz in Japan

3. Definitions, acronyms, and abbreviations

3.1 Definitions

Insert the following items in alphabetical order:

active radio frequency identification (RFID): The use of an electromagnetic radio signal, not derived from electromagnetic or inductive coupling, to communicate to or from a device through a variety of modulation and encoding schemes in order to uniquely read the identity of the device. To generate the radio signal, these devices must employ some source of power such as integrated batteries or harvesting of ambient energy from the surrounding environment.

active radio frequency identification (RFID) tag: A device that may be attached to an asset that transmits a periodic radio emission for the purpose of asset identification and/or location.

location enhancing information postamble (LEIP): An optional set of bits added after the completion of a frame that are used to enhance the ability to locate the transmitter.

radio frequency identification (RFID): The use of electromagnetic or inductive coupling in the radio frequency (RF) portion of the spectrum to communicate to or from a tag through a variety of modulation and encoding schemes to uniquely read the identity of an RF tag.

reader: A device that receives signals from active radio frequency identification (RFID) or real time locating system (RTLS) transmitters.

real time locating system: A set of radio frequency receivers and associated computing equipment used to determine the position of a transmitting device relative to the placement of the aforementioned receivers.

3.2 Acronyms and abbreviations

Insert the following items in alphabetical order:

CPFSK	continuous phase frequency shift keying
LEIP	location enhancing information postamble
LRP	low rate pulse repetition frequency (PRF)
MSK	minimum shift keying
OOK	on-off keying
RFD-RX	reduced function device—receive only
RFD-TX	reduced function device—transmit only
RFID	radio frequency identification
RTLS	real time locating system

4. General description

4.1 General

Change the last paragraph as follows:

Two different device types can participate in an IEEE 802.15.4 network; a full-function device (FFD) and a reduced function device (RFD). The FFD is a device that is capable of serving as a personal area network (PAN) coordinator or a coordinator. An RFD is a device that is not capable of serving as either a PAN coordinator or a coordinator. An RFD is intended for applications that are extremely simple, such as a light switch or a passive infrared sensor; it does not have the need to send large amounts of data and only associates with a single FFD at a time. Consequently, the RFD can be implemented using minimal resources and memory capacity, and serve as a RFD-TX or RFD-RX device.

4.2 Components of the IEEE 802.15.4 WPAN

Change the first paragraph as follows:

A system conforming to this standard consists of several components. The most basic is the device. Two or more devices communicating on the same physical channel constitute a WPAN. However, this WPAN includes at least one FFD, ~~which operates as the PAN coordinator.~~ operating as the PAN coordinator or at least one RFD-RX operating as the termination point for RFD-TX communications.

4.3 Network topologies

Change the first paragraph as follows:

Depending on the application requirements, an IEEE 802.15.4 LR-WPAN operates in either of two topologies: the star topology or the peer-to-peer topology. Both are shown in Figure 1. In the star topology the communication is established between devices and a single central controller, called the PAN coordinator. A device typically has some associated application and is either the initiation point or the termination point for network communications. A PAN coordinator can also have a specific application, but it can be used to initiate, terminate, or route communication around the network. The PAN coordinator is the primary controller of the PAN. All devices operating on a network of either topology have unique addresses, referred to as extended addresses. A device will use either the extended address for direct communication within the PAN or the short address that was allocated by the PAN coordinator when the device associated. The transmission of the extended and short address fields is optional for RFD-TX devices. The PAN coordinator will often be mains powered, while the devices will most likely be battery powered. Applications that benefit from a star topology include home automation, personal computer (PC) peripherals, games, and personal health care.

4.3.1 Star network formation

Change the first paragraph as follows:

The basic structure of a star network is illustrated in Figure 1. After an FFD is activated, it can establish its own network and become the PAN coordinator. All star networks operate independently from all other star networks currently in operation. This is achieved by choosing a PAN identifier that is not currently used by any other network within the radio communications range. Once the PAN identifier is chosen, the PAN coordinator allows other devices, potentially both FFDs and RFDs, to join its network. The higher layer can use the procedures described in 5.1.2 and 5.1.3 to form a star network. An RFD-RX may also serve as a PAN coordinator termination point for RFD-TXs using the ALOHA mechanism as described in 8.2.7.

4.4 Architecture

4.4.1 Physical layer (PHY)

Change the last paragraph as follows:

A discussion of the coexistence of the various IEEE 802.15.4 PHYs with other wireless systems is given in “Coexistence analysis of IEEE Std 802.15.4 with other IEEE standards and proposed standards” [B4] and “TG4f Coexistence Assurance Document” [B22].

5. MAC protocol

5.1 MAC functional description

Change the second paragraph as follows:

There are two device types: a full-function device (FFD) and a reduced-function device (RFD). The FFD may operate in three modes serving as a personal area network (PAN) coordinator, a coordinator, or a device. An RFD shall only operate as a device, RFD-TX device, or RFD-RX device.

5.1.2 Starting and maintaining PANs

5.1.2.1 Scanning through channels

Change the first paragraph as follows:

All devices, except for the RFD-RX and RFD-TX devices, shall be capable of performing passive and orphan scans across a specified list of channels. In addition, an FFD shall be able to perform energy detection (ED) and active scans. The next higher layer should submit a scan request for a particular channel page containing a list of channels chosen only from the channels specified by *phyChannelsSupported* for that particular channel page.

5.1.2.1.2 Active and passive channel scan

Change the fifth paragraph as follows:

If a beacon frame is received when *macAutoRequest* is set to TRUE, the list of PAN descriptor structures shall be stored by the MAC sublayer until the scan is complete; at this time, the list shall be sent to the next higher layer in the *PANDescriptorList* parameter of the *MLME-SCAN.confirm* primitive. A device, optional for RFD-RX and RFD-TX devices, shall be able to store at least one PAN descriptor. A beacon frame shall be assumed to be unique if it contains both a PAN identifier and a source address that has not been seen before during the scan of the current channel.

5.1.3 Association and disassociation

5.1.3.1 Association

Change the text as follows:

The MAC sublayer of an unassociated device shall initiate the association procedure by sending an association request command, as described in 5.3.1, to the coordinator of an existing PAN; This is optional for RFD-RX and RFD-TX devices. ~~;~~ If the association request command cannot be sent due to a channel access failure, the MAC sublayer shall notify the next higher layer.

On receipt of the acknowledgment to the association request command, the device shall wait for at most *macResponseWaitTime* for the coordinator to make its association decision; the PIB attribute *macResponseWaitTime* is a network-topology-dependent parameter and may be set to match the specific requirements of the network that a device is trying to join. If the device is tracking the beacon, it shall attempt to extract the association response command from the coordinator whenever it is indicated in the beacon frame. If the device is not tracking the beacon, it shall attempt to extract the association response command from the coordinator after *macResponseWaitTime*. If the device, optional for RFD-RX and RFD-TX devices, does not extract an association response command frame from the coordinator within *macResponseWaitTime*, the MLME shall issue the *MLME-ASSOCIATE.confirm* primitive, as described in 6.2.2.4, with a status of *NO_DATA*, and the association attempt shall be deemed a failure. In this case, the next higher layer shall terminate any tracking of the beacon. This is achieved by issuing the *MLME-SYNC.request* primitive, as described in 6.2.13.1, with the *TrackBeacon* parameter set to FALSE.

If the value of the Association Status field of the command is not “Association successful,” if there were a communication failure during the association process due to a missed acknowledgment, or if the association response command frame were not received, the device, optional for RFD-RX and RFD-TX devices, shall set *macPANId* to the default value (0xffff).

5.1.4 Synchronization

5.1.4.2 Synchronization without beacons

Change the first paragraph as follows:

All devices, except for RFD-RX and RFD-TX devices, operating on a nonbeacon-enabled PAN (*macBeaconOrder* = 15) shall be able to poll the coordinator for data at the discretion of the next higher layer.

5.1.5 Transaction handling

Change the third paragraph as follows:

The information contained in the indirect transmission request forms a transaction, and except for RFD-RX devices serving as PAN coordinator termination points, the coordinator shall be capable of storing at least one transaction. On receipt of an indirect transmission request, if there is no capacity to store another transaction, the MAC sublayer shall indicate to the next higher layer a status of TRANSACTION_OVERFLOW in the appropriate corresponding primitive.

5.1.6 Transmission, reception, and acknowledgment

5.1.6.1 Transmission

Change the third paragraph as follows:

The Source Address field, if present, shall contain the address of the device sending the frame. When a device has associated and has been allocated a short address (i.e., *macShortAddress* is not equal to 0xffff or 0xfffff), it shall use that address in preference to its extended address (i.e., *macExtendedAddress*) wherever possible. When a device has not yet associated to a PAN, it shall use its extended address in all communications requiring the Source Address field. If the Source Address field is not present, the originator of the frame shall be assumed to be the PAN coordinator or RFD-TX device, and the Destination Address field shall contain the address of the recipient, optional for RFD-TX devices.

5.3 MAC command frames

5.3.1 Association request command

Change the third paragraph as follows:

All devices, except for RFD-RX and RFD-TX devices, shall be capable of transmitting this command, although an RFD is not required to be capable of receiving it.

5.3.2 Association response command

Change the third paragraph as follows:

All devices, except for RFD-RX and RFD-TX devices, shall be capable of receiving this command, although an RFD is not required to be capable of transmitting it.

5.3.3 Disassociation notification command

Change the second paragraph as follows: