

IEEE Standard for Low-Rate Wireless Networks

Amendment 2: Ultra-Low Power Physical Layer

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.15.4q™-2016
(Amendment to
IEEE Std 802.15.4™-2015
as amended by IEEE Std 802.15.4n™-2016)

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Approved 29 January 2016

IEEE-SA Standards Board

Abstract: Two alternate physical layers (PHYs), TASK and RS-GFSK, are specified in this amendment in addition to the PHYs of IEEE Std 802.15.4-2015. The amendment also defines the medium access control (MAC) modifications needed to support the implementation of the TASK and RS-GFSK PHYs. These alternate PHYs enable low-cost, ultra-low power consumption, as well as extended battery life, in various frequency bands and geographical regions under multiple regulatory domains.

Keywords: amendment, IEEE 802.15.4™, IEEE 802.15.4q™, low data rate, LR-WPAN, PAN, personal area network, PHY, physical layer, radio frequency, RF, ultra-low power, wireless personal area network, WPAN

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Introduction

This introduction is not part of IEEE Std 802.15.4q™-2016, IEEE Standard for Low-Rate Wireless Networks—Amendment 2: Ultra-Low Power Physical Layer.

For over a decade, the IEEE P802.15 Working Group successfully developed wireless personal area network (WPAN) standards (IEEE Std 802.15.4™) with low energy consumption in mind. However, further reduction in energy consumption is desired to address emerging markets like wearable devices, electronic shelf labeling, and automation where the energy sources, driven by size and cost constraints, are limited to small batteries (e.g., coin cell batteries). These energy sources have substantially less capacity and peak power ratings than traditional batteries (e.g., size AA or AAA). This trend calls for an amendment that aims for further reduction in energy consumption and peak power. It is expected that this amendment could also benefit the traditional markets, which have already been successfully addressed by IEEE Std 802.15.4.

This amendment specifies two alternative physical layers (PHYs), TASK and RS-GFSK, in addition to the PHYs of IEEE Std 802.15.4-2015. The amendment also defines the medium access control (MAC) modifications needed to support the implementation of the TASK and RS-GFSK PHYs. Both PHYs are specified for 2.4 GHz and several sub-gigahertz bands using multiple data rates up to 1 Mb/s.

The TASK PHY specifies a physical layer based on amplitude shift keying with ternary amplitude sequence spreading (TASK). This PHY allows implementation of transceivers with low complexity and enables low power consumption. As an important feature, this PHY also supports communications in both coherent and noncoherent modes of reception and thereby allows tradeoff between receiver complexity and performance.

The RS-GFSK PHY specifies a physical layer based on Gaussian frequency shift keying (GFSK). This PHY provides low-power benefits by the availability of higher data rates, reduced overhead in the PHY protocol data unit (PPDU), and transmission (TX) power control. In addition, the RS-GFSK PHY provides options to interoperate with the existing SUN FSK PHY (which involves smart utility network frequency shift keying). A wide range of applications will benefit from the energy savings enabled by the RS-GFSK PHY, including electronic shelf labels, home area networks, smart irrigation systems, and smart metering.

Thejaswi et al. [B18] describe the features and benefits of TASK PHY. Details on the use and merits of the RS-GFSK PHY are provided by de Ruijter [B5a].^a

^aThe numbers in brackets correspond to the numbers of the bibliography in Annex A.

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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.

3. Definitions, acronyms, and abbreviations

3.2 Acronyms and abbreviations

Insert the following abbreviations in alphabetical order into 3.2:

RS-GFSK	rate switch Gaussian frequency shift keying
SiPC	single parity check
TASK	ternary amplitude shift keying

5. General description

5.6 Architecture

5.6.1 PHY

Insert in 5.6.1 the following list item at the end of the dashed list of the second paragraph:

- For TASK PHY and RS-GFSK PHY: Nair et al. [B9b].²

6. MAC functional description

Insert the following subclause (6.17) after 6.16:

6.17 Using Link Margin IE in an RS-GFSK PAN

A device may include an RS-GFSK Link Margin IE within an enhanced acknowledgment. The RS-GFSK Link Margin IE shall only be transmitted as part of an Enh-Ack frame.

If a device receives an Enh-Ack frame containing an RS-GFSK Link Margin IE, it may adjust its transmit power within its power control range in all following GTS transmissions directed to the originating device. The transmit power control shall ignore the RS-GFSK Link Margin IE when the device is transmitting non-GTS frames. The RS-GFSK Link Margin IE is described in 7.4.4.32.

If an acknowledgment for a transmission to a particular device is not received, the transmit power for transmissions to that device may be increased for the next transmission attempt.

The algorithm that controls the transmission of the RS-GFSK Link Margin IE and the algorithm that acts on the reception of the RS-GFSK Link Margin IE are outside the scope of this standard.

If the security level, as described in 9.4.1.1, of the incoming Enh-Ack frame containing the RS-GFSK Link Margin IE is lower than that of the frame being acknowledged, then the RS-GFSK Link Margin IE shall be ignored.

²The numbers in brackets correspond to the numbers of the bibliography in Annex A.

7. MAC frame formats

7.4 IEs

7.4.4 Nested IE

7.4.4.1 Format of Nested IE

Insert the following rows into Table 7-16 by Sub-ID value order, and change the reserved row as indicated:

Table 7-16—Sub-ID allocation for short format

Sub-ID value	Name	Enhanced Beacon	Enhanced ACK	Data	Multipurpose	MAC command	Format subclause	Use description	Used by	Created by
0x37	RS-GFSK Link Margin IE		X				7.4.4.32	6.17	UL, MAC	UL, MAC
0x38	RS-GFSK Device Capabilities IE	X	X	X	X		7.4.4.33	6.17, 32.3	UL, MAC	UL, MAC
~~0x37~~ 0x39–0x7f	Reserved									

Insert the following subclauses and figures (7.4.4.32 and 7.4.4.33 with Figure 7-101a through Figure 7-101c) after 7.4.4.31:

7.4.4.32 RS-GFSK Link Margin IE

The RS-GFSK Link Margin IE is optional and shall only be used in Enh-Ack frames that use the RS-GFSK-PHY. The IE Content field of the RS-GFSK Link Margin IE shall be formatted as illustrated in Figure 7-101a.

Bits: 0–5	6–7
Link Margin	Reserved

Figure 7-101a—RS-GFSK Link Margin IE Content field format

The Link Margin field shall be set to the available link margin, represented as a twos-complement number, defining the link margin in decibels with a range from –31 dB to 32 dB, in steps of 1 dB. The Link Margin field shall comply with the following equation:

$$\text{Link Margin} = S_{\text{received}} - S$$