IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)
Title	**Spectral mask for FSK**
Date Submitted	[June, 2010
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Re:	[d1P802-15-4g_Draft_Standard.pdf]
Abstract	[This document describes changes to add an FSK mask to the draft.]
Purpose	[To resolve comments in LB51.]
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1. 802.15.1/Bluetooth

802.15.1 uses the following modulation

— GFSK (but no filter specified or tested in compliance)
— BT = 0.5
— 0.28 < modulation index < 0.35, min deviation 115 kHz
— Zero crossing error less than ±1/8 of a symbol period.

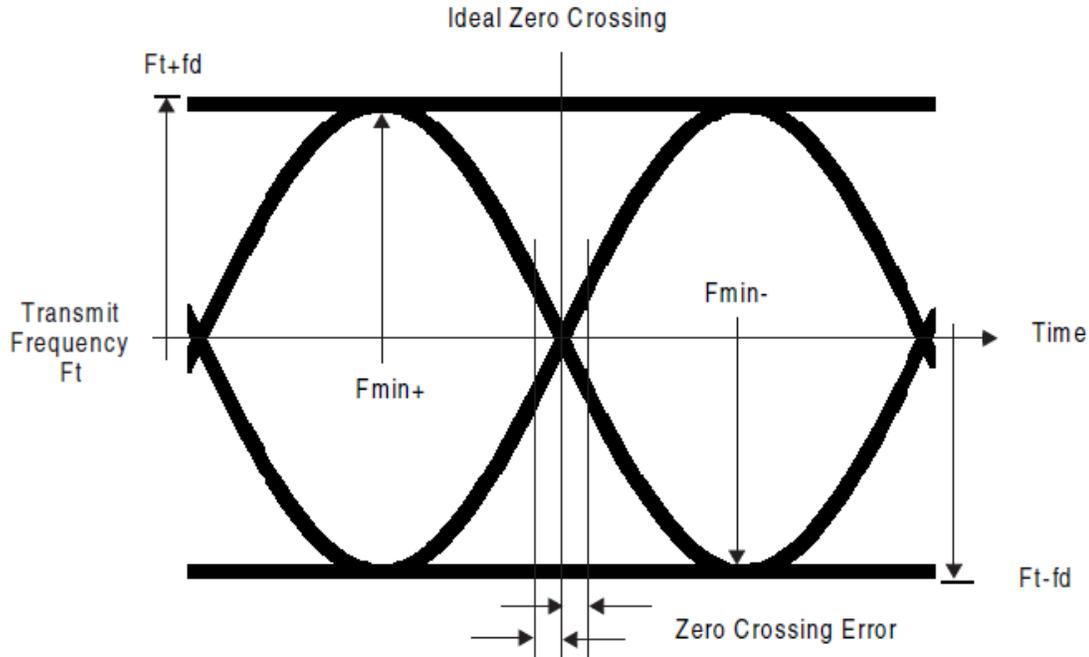The modulation is illustrated in Figure 1.

Figure 1—Modulation figure for 802.15.1

The requirement for accuracy is:

"For each transmission, the minimum frequency deviation, $F_{min} = \min\{|F_{min}+|, Fmin-\}$, which corresponds to 1010 sequence, shall be no smaller than ± 80% of the frequency deviation fd with respect to the transmit frequency Ft, which corresponds to a 00001111 sequence."

The TX mask is defined as follow:

— Adjacent channel power on adjacent channels with a difference in RF channel number of two or greater.
— This adjacent channel power is defined as the sum of the measured power in a 1 MHz RF channel in a 100 kHz bandwidth using maximum hold.
— Device transmits on RF channel M, and the adjacent channel power is measured on RF channel number N.
— The transmitter shall transmit a pseudo-random data pattern in the payload

The requirements are given in Table 1.

Table 1—802.15.1 transmit spectrum mask

Frequency offset	Transmit power
± 500 kHz	−20 dBc (FCC requirement)
2 MHz (|M −N| = 2)	−20 dBm
3 MHz or greater (|M −N| ≥ 3)	−40 dBm
NOTE–If the output power is less than 0 dBm, then, wherever appropriate, the FCC's 20 dB relative requirement overrules the absolute adjacent channel power requirement stated in this table.	

Note that there is no requirement for power in the channel directly adjacent to the RF channel (|M − N| = 1).

2. Suggested text for 802.15.4g

2.1 Comment resolution items for FSK/GFSK

2.1.1 Use FSK to mean both FSK and GFSK

This subclause resolves comments: 294, 298, 299, 300, 301, 302, 303, 306, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 379, 385, 396, 397, 398, 399, 400, 513, 514, 527, 528, 530, 531, 532, 533, 534, 536, 537, 538, 539, 540, 556, 560, 561, 562, 563, 564, 573, 574, 575, 576, 619, 620, 621, 622, 696, 701, 730, 733, 736, 739, 742.

Resolution: Accept in principle, change "GFSK" to be "FSK throughout the document. Change "(G)FSK" to be "FSK" throughout the document. With the following exceptions: page 13, line 4; page 14, line 33; page 22, line 48; page 30, line 32; page 30, line 35; page 31, line 5; page 47, line 21, page 47, line 37. For those exceptions, the following changes are to be made:

Delete the footnotes, Page 13, line 4, page 14, line 33

Page 22, line 48, change the last dashed list item to two items:

— ModulationScheme indicates if it is FSK or GFSK
— FSK BT is used if the the ModulationScheme value is set to GFSK

page 47, line 21 - Change Range cell for ModulationScheme to be "FSK, GFSK, OFDM, OQPSK-DSSS, OQPSK-MDSS", Change Range cell for FSKModulationOrder to be "2-LEVEL, 4-LEVEL", change the Description cell to "The modulation order if the ModulationScheme is FSK or GFSK. Not valid for other values of ModulationScheme.".

Page 47, line 35 - Change the Description cell for FSKModulationIndex to "The modulation index if the ModulationScheme is FSK or GFSK. Not valid for other values of ModulationScheme.".

page 47, line 37 - Change FSKBT to have a Type of "Float", a Range of "0.3-1.0" and a Description of "The BT value if the ModulationScheme is GFSK. Not valid for other values of ModulationScheme.".

Note: The last rows of the Table 31a now look like those shown in Table 2:

Replace subclause 6.12a.1 with the following:

Table 2—Elements of GenericPHYDescriptor

Name	Type	Range	Description
ModulationScheme	Enumeration	FSK, GFSK, OFDM, OQPSK-DSSS, OQPSK-MDSS	The modulation scheme of the Generic PHY entry. The remaining Generic PHY parameters are determined based on the modulation scheme.
FSKModulationOrder	Enumeration	2-LEVEL, 4-LEVEL	The modulation order if the Modulation-Scheme is FSK or GFSK. Not valid for other values of ModulationScheme.
FSKModulationIndex	Float	0.25-2.50	The modulation index if the Modulation-Scheme is FSK or GFSK. Not valid for other values of ModulationScheme..
FSKBT	Float	0.3-1.0	The BT value if the ModulationScheme is GFSK. Not valid for other values of Modula-tionScheme.

The modulation for the MR-FSK PHY shall be FSK with the filtering required to meet the transmit spectral mask, as defined in 6.12a.4. If GFSK is used as the form of FSK, then the BT value shall be 0.5 for the frequency bands in Table 1a and Table 1b.

End changes for the exceptions.

2.1.2 Other FSK related comments

Comment 557 (E): Accept in principle: GFSK is defined in 802.15.4d, and so is a part of the base standard.

Comments 611, 612, 1197, 1198, 1208: Accept in princple: BT is now defined as 0.5 for GFSK and modulation, FSK or GFSK, is selected by the modulation type parameter.

2.2 Comments resolution for TX spectral mask and modulation accuracy.

For comments: 332, 333, 334, 335, 336, 337, 360, 361, 362, 363, 364, 389, 390, 391, 392, 404, 405, 406, 1218, 1227, 1228, 1229, 1230, 1231, 1232, 1326, 1327, 1347, 1348, 1349, 1350, 1361, 1510, 1513, 1515, 1517, 1519.

Resolution: Accept in prinicple, add the new subclauses defined in document 15-10-0331-01-004g, section 2.2, to the draft.

Changes begin here:

Delete the following rows and their corresponding values from Table 75e:

Modulation index range

Adjacent channel rejection

Alternate channel rejection

Add the following new subclauses to 6.12a.4.

6.12a.4.1 Transmit spectral mask

The transmit power measurement shall use a 1 kHz resolution bandwidth and integrate the power over bandwidth, BW, given in Table 3 centered on the adjacent channel center frequency.

Table 3—Integration bandwidth for channel power measurement

Data rate	Integration BW	Channel spacing
50 kb/s	100 kHz	200 kHz
150 kb/s	225 kHz	400 kHz
200 kb/s	300 kHz	400 kHz
Generic PHY: R kb/s	$1.5*R$ kHz	$2*R$ kHz

For a given RF transmit channel, M, and an adjacent or alternate channel, N, in the regulatory bandwidth, the power in the adjacent or alternate channel relative to the power in the RF transmit channel shall be less than the value given in Table 4.

Table 4—802.15.1 transmit spectrum mask

Frequency offset	Adjacent channel power relative to channel power
$1 \le |M-N| \le 2$	–20 dBc
$|M-N| \ge 3$	–40 dBc

6.12a.4.2 Modulation

The modulation for MR-FSK is either 2 levels (2-FSK) or 4 levels (4-FSK). The modulation index for the MR-FSK modes is defined in Table 1a.

The symbols and terms for 2-FSK signal is illustrated in Figure 2.

For 2-FSK, the error in the modulation, Δfd, at mid-symbol time shall be less than

— $\pm0.2*\Delta$f for modulation indexes less than or equal to 0.5,
— $\pm0.3*\Delta$f for modulation indexes greater than 0.5,

where Δf is defined in 6.12a.1.2.

The zero crossing error shall be less than $\pm1/8$ of a symbol period.

The symbols and terms for 4-FSK are illustrated in Figure 3.

For 4-FSK, the error in the modulation at mid-symbol time shall be less than $\pm0.2*\Delta$f, where Δf is defined in 6.12a.1.2.

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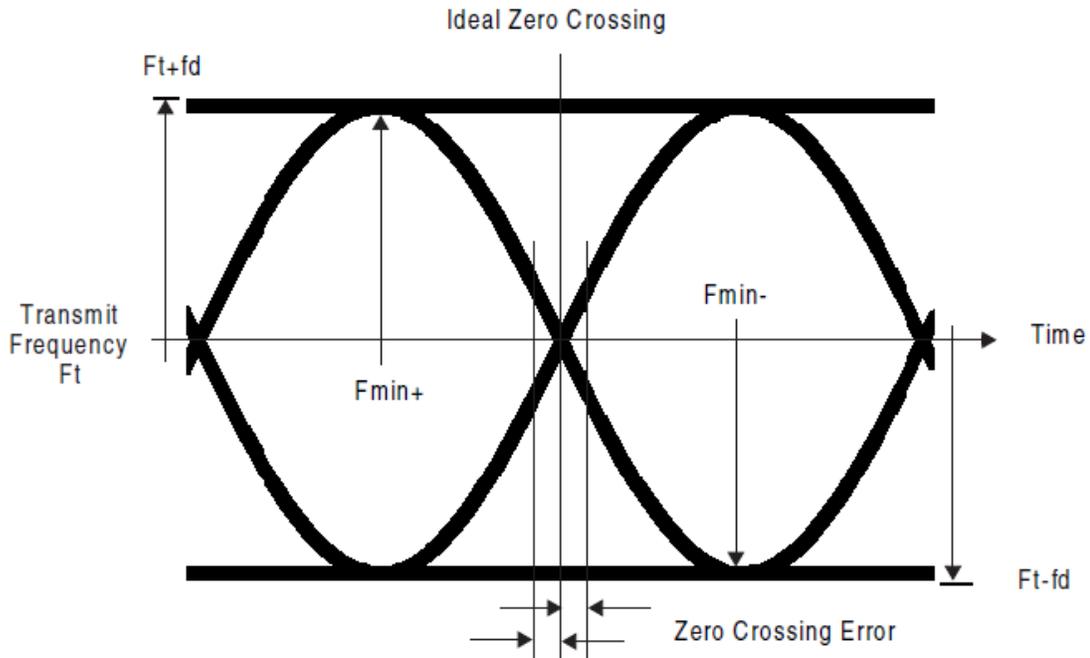36
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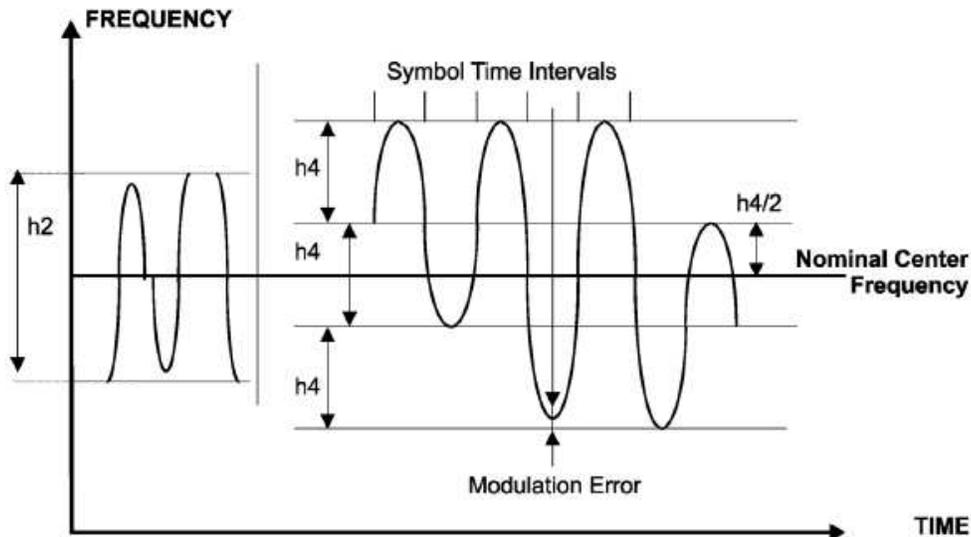46
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Figure 2—2-FSK modulation

Figure 3—4-FSK modulation

6.12a.4.3 Receiver jamming resistance

The minimum jamming resistance levels are given in Table 5. The adjacent channels are the ones on either side of the desired channel that is closest in frequency to the desired channel, and the alternate channel is more than one removed from the desired channel in the operational bandwidth. The adjacent channel rejection shall be measured as follows: the desired signal shall be a compliant MR-FSK PHY signal, as defined

by 6.12a.1, of pseudo-random data at the center frequency of the desired channel. The desired signal is input
to the receiver at a level 3 dB above the receiver sensitivity given in Table 75e.

Table 5—Minimum receiver jamming resistance requirements for MR-FSK PHYs

Adjacent channel rejection	Alternate channel rejection
0 dB	30 dB

In either the adjacent or the alternate channel, an unmodulated carrier in the center of that channel is input at
the relative level specified in Table 5. The test shall be performed for only one interfering signal at a time.
The receiver shall meet the error rate criteria defined in 6.1.7 under these conditions.

End changes

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