IEEE P802.15
Wireless PANs

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| LB 93 Comment Resolution for CID14, 177 and 200 |
| Date: 2014-07-11 |
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Abstract

This submission proposes resolutions for CID 149, 177 and 200 which metion about transmission spectral mask and interference rejection level.

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGah Draft. This introduction is not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TG4n Draft (i.e. they are instructions to the 802.15 editor on how to merge the text with the baseline documents).***

***TG4n Editor: Editing instructions preceded by “TG4n Editor” are instructions to the TG4n editor to modify existing material in the TG4n draft. As a result of adopting the changes, the TG4n editor will execute the instructions rather than copy them to the TG4n Draft.***

24.3.6 Timing-related parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CID | Page | Sub-clause | Line | Comment | Proposed Change | Response |
| 149 | 25 | 21.2.4 | 9 | I don't see a specification for receiver interference rejection | Add (given requirements of 15-14-0081-01-004n) | Revise |
| 177 | 18 | 21.2.2.1 | 13 | Technical issue.Subclause 21.2.4.4 does not specify transmission spectrum mask. And any subclause does not mention transmission spectrum mask. From interoperability point of view, subclause of transmission spectrum mask should be prepared. | Add a subclause that explains transmission spectrum musk for CMB GFSK PHY. | Revise |
| 200 | 18 | 21.2.2.1 | 13 | the transmission spectral mask, as defined in 21.2.4.4 could not be found. | Spectrum mask be included, and please correct the number of referred paragraph. | Revise |

**Discussion:***.*

1. **Transmission spectral mask for CMB GFSK PHY**

DCN 14-81r1 does not show receiver interference rejection for CMB GFSK PHY. Hence, referring to DCN14-81r1 is not enough to solve this issue. The following discussion shows a proposal for a transmission spectral mask and interference rejection level for CMB GFSK PHY.

It is easier for everyone to used one spectral mask for all CMB GFSK PHY modes. Hence, specification of a transmission spectral mask should be written in normalized frequency which definition is actual frequency [Hz]/ symbol rate [b/s]. Besiseds this, 99% occupation bandwidth should be considered to determine transmission spectral mask because main robe of modulation signal is included in this 99% occupation bandwidth. The next values are calculation result of 99% occupation bandwidth for modulation index is 1 and 0.5 valuerespectively where BT value is 0.7.

Table 1 Normailzed 99% occupation bandwidth

|  |  |
| --- | --- |
| Modulation idex | Normailzed 99% occupation bandwidth |
| 0.5 | 1.1 (0.55×2) |
| 1.0 | 1.8 (0.9×2) |

The following parameters should be considered to specify transmission spectral mask as well from device manufacture point of view.

* VCO Phase noise
* Charge pump noise
* Delta-Sigma circuit noise (in case of fractional synthesizer)
* PLL loop filter characteristics
* Parts to parts variation
* Voltage variation
* Temperature variation
* Frequency offset (+/-20ppm, see DCN 14-236r0)

Therefore, the following calculation results consider these paramters. PVT variation (parts-to-parts, voltage and temperature variation) is assumed 10dB in this study.

Resolution bandwidth (RBW) is also one of the key prameters to speciy the transmission spectral mask. The lowest data rate specified by CMB GFSK PHY is 50 kb/s and the resolution bandwidth should be 1/10 × 50 kHz = 5 kHz to get a stable measurement of transmission spectral mask.

Figures 1-1, 2-1, 2-2, 3-1 and 3-2 shown in below are calculation results considering above items.

The red colored solid curves show CMB GFSK modulation signals. The orange colored solid curves show a proposal of a transmission spectral mask for CMB GFSK PHYs. The holizontal axis shows normalized frequency and the vertical axis shows power spectral density (PSD) in dB.

|  |  |
| --- | --- |
| Figure1-150kbps, modulation index = 1.0, BT = 0.7 |  |

|  |  |
| --- | --- |
| Figure2-1100kbps, modulation index = 0.5, BT = 0.7 | Figure2-2100kbps, modulation index = 1.0, BT = 0.7 |
| Figure3-1200kbps, modulation index = 0.5, BT = 0.7 | Figure3-2200kbps, modulation index = 0.5, BT = 0.7 |

Then next Table 2 shows detail information of the proposal of transmission spectral mask (the orange colored solid curve in the above figure) for CMB GFSK PHYs.

Table 2 Proposal of transmission spectral mask for CMB GFSK PHY

|  |  |
| --- | --- |
| Normailze frequency(frequency [Hz]/ symbol rate [b/s]) | Power spectram density [dB] |
| -2 and below | -35 |
| from -2 to -1.5 | -25 |
| from -1.5 to -1 | -10 |
| from -1 to +1 | 0 |
| from +1 to 1.5 | -10 |
| from +1.5 to +2 | -25 |
| +2 and above | -35 |

1. **Interference rejection level forCMB GFSK PHY**

The following is a discussion of interference rejection level based on the above proposal of transmission spectral mask (Table 2). Figures 4-1, 4-2 and 4-3 shown in below explain how to calculate a main, adjacent and alternative channel powoer levels for CMB GFSK PHYs with different data rates.



Figure 4-1 Rough sketch of main, adjacent and alternative channel power for 50kb/s mode



Figure 4-2 Rough sketch of main, adjacent and alternative channel power for 100kb/s mode



Figure 4-3 Rough sketch of main, adjacent and alternative channel power for 200kb/s mode

The next Table 3 shows calculation results of main, adjacent channel and alternative channel power of the proposal of transmission spectral mask shown in Table 2.

Table 3 Main channel vs. adjacent channel and main channel vs. alternative channel power ratio

|  |  |  |  |
| --- | --- | --- | --- |
|  | 50 kb/s mode | 100 kb/s mode | 200 kb/s mode |
| Main channel power | 2.11 | 2.10 | 2.05 |
| Adjacent channel power | 3.2 × 10-3 | 1.6 × 10-3 | 2.7 × 10-2 |
| Alternative channel power | 3.2 × 10-3 | 1.6 × 10-3 | 7.9 × 10-4 |
| Main Ch / Adj. Ch [dB] | 28 | 31 | 19 |
| Main Ch / Alt. Ch [dB] | 28 | 31 | 34 |

1. **Signal to noise power ratio at receiver sensivity level**

The P.802.15.4-REVb-DF1 spec specifies receiver sensitivity level for Filterd FSK as the next formula.

 $S= \left(-91+10×log\left(\frac{Symbol Rate}{50kbps}\right)\right)$

Therefore, receiver sensitivity levels become as shown in Table 4.

Table 4 Receiver sensitivity level for CMB GFSK PHYs

|  |  |  |  |
| --- | --- | --- | --- |
|  | 50 kb/s mode | 100 kb/s mode | 200 kb/s mode |
| Receiver sensitivity level [dBm] | -91 | -88 | -85 |

On the other hand, noise power level within a channel can be written from theoretical point of view.

 $Noise power=k ×T ×Channel width ×NF×Implemenation Loss$

 where

 k : Boltzmann constant = 1.38e-23 J/K

 T : absolute temperature = 358K
 (the worst case temperature judging from an application disucssuin, 85 degree C)

 Channel width : 500kHz (fixed value for all data rates)

 NF : Noise Figure = 10dB

 Implementation loss: 3dB

Hence, noise power within in a 500 kHz channel width becomes -103 dBm. From this noise power level and Table 4, SNR (Signal to Noise power Ratio) can be derived as Table 5.

Table 5 Receiver sensitivity level for CMB GFSK PHYs

|  |  |  |  |
| --- | --- | --- | --- |
|  | 50 kb/s mode | 100 kb/s mode | 200 kb/s mode |
| SNR at receiver sensitivity level [dB] | 12 | 15 | 18 |

1. **Interference rejection level**

From table 3 and table 5, minimum interference rejection level can be derived as below.

Table 6 Main channel vs. adjacent channel and main channel vs. alternative channel power ratio

|  |  |  |  |
| --- | --- | --- | --- |
|  | 50 kb/s mode | 100 kb/s mode | 200 kb/s mode |
| Adjacent channel interference rejection level [dB] | 16(=28-12) | 16(=31-15) | 1(=19-18) |
| Alternative channel interference rejection level [dB] | 16(=28-12) | 16(=31-15) | 16(=34-18) |

1. **Proposal amendment of Draft 1.0**

**Instruction to TG4n Editor: Add the following new subclause titled “Transmission spectral mask” after a subclause of “Transmitter symbol rate” in subclause 21.2.4 CMB GFSK RF requirement.**

**Note: “X” indicates the fourth level new subclause number and this value depends on a new subclause number of “Trasmitter symbol rate” subclause which is added to resolve a CID148.**

21.2.4.X Transmission spectral mask

NOTE 1 - In the presence of additional regulatory restrictions, the CMB device has to respect both the regulatory requirements and the mask defined in this section.

For all CMB GFSK transmission spectral masks, the interim transmit spectral mask shall have
a 0dBr within +/-1 × symbol rate frequency [Hz] range of the center frequency,
a -10 dBr within a range of from 1.5 × symbol rate frequency [Hz] to 1 × symbol rate frequency [Hz] apart from the center frequency,

a -25 dBr within a range of from 1.5 × symbol rate frequency [Hz] to 2 × symbol rate frequency [Hz] apart from the center frequency,
a -35 dBr at frequency offset apart from more than 2 × symbol rate frequency frequency [Hz] from the center frequency,

where dBr is defined as relative power to measured average transmission power within +/1 × symbol rate frequency [Hz] range of the center frequency.

The next table shows this spectral mask for all CMB GFSK PHYs.

Table X.X Transmission spectral mask for CMB GFSK PHY

|  |  |
| --- | --- |
| Normailze frequency by symbol rate(frequency [Hz]/ symbol rate [b/s]) | Power spectram density [dB] |
| -2 and below | -35 |
| from -2 to -1.5 | -25 |
| from -1.5 to -1 | -10 |
| from -1 to +1 | 0 |
| from +1 to 1.5 | -10 |
| from +1.5 to +2 | -25 |
| +2 and above | -35 |

The spectrum analyzer settings for this measurement shall be as follows: the resolution bandwidth is 5 kHz, the video bandwidth is 5 kHz or greater, and the detector is RMS.

**Instruction to TG4n Editor: Add the following new subclause titled “Receiver interference rejection”after a subclause of “Transmission spectral maks” in subclause 21.2.4 CMB GFSK RF requirement.**

**Note: “X” indicates the fourth level new subclause number and this value depends on a new subclause number of “Transmission spectral mask” subclause.**

21.2.4.X Receiver interference rejection

The adjacent channels are those on either side of the desired designated channel that are closest in frequency to the desired designated channel. The alternative channel is more than one removed from the desired designated channel in the operational frequency band.

The adjacent channel rejection shall be measured as follows: the desired signal shall be a compliant CMB GFSK PHY signal, as defined in 21.2.2, 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 21.2.4.3.

In either the adjacent or the alternative channel, an CMB GFSK PHY compliant modulation signal of pseudo-random data that is not syncronozise with the desired signal at the center of that channel is input at the following level relative to the level of the desired signal:

— The adjacent channel rejection shall be greater than or equal to +16 dB for 50 kbps and 100 kbps mode,
 and +1 dB for 200kbps mode.

— The alternative channel rejection shall be greater than or equal to +16 dB for 50, 100 and 200kbps modes.

The test shall be performed for only one interfering signal at a time. The receiver shall meet the error rate criteria defined in 9.1.7 under these conditions.