Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [MR-FSK TX Spectral Mask Proposal]
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Re: [MR-FSK Spectral Mask Proposal]

Abstract: [This document proposes a measurement method for the MR-FSK PHY that is consistent for all data rates and modulation indexes. It is designed to be appropriate for use with defined FSK modes as well as Generic PHY modes]

Purpose: [802.15.4g Comment Resolution for LB51.]

Introduction

- The 802.15.4g MR-FSK PHY has a wide range of permissible operating modes
  - Mandatory data rates
  - Optional data rates
  - Various channel spacings
  - Different modulation indexes
  - Generic PHY modes
- Difficult to provide one simple spectral mask criteria
- The goal of this presentation is to provide a single measurement method for the spectral mask that will be simple, and as consistent as possible, for all modes of operation

Problem Statement

- Problem:
  - A consistent TX spectral mask methodology is needed in TG4g
  - This is challenging given the many combinations of data rates, channel spacings, and modulation indexes in the TG4g FSK and Generic PHY
- Solution:
  - Given that the FSK signal is uniquely defined by its parameters, define TX spectral mask methodology as a function of such parameters
  - Namely, set integration bandwidth and measurement locations as a function of symbol rate and modulation index, with appropriate corresponding mask values

Spectral Mask Proposal

- Let R be the symbol rate (expressed in units of Hertz) and h the modulation index
- Carson's Rule defines the frequency point that contains 98% of the transmitted power.

$$B \cong 2(\Delta f + fm), \quad \Delta f = hR/2,\ fm = R/2$$
$$B \cong R(1+h)$$

- The power outside B is only 17dB lower than the power inside B.
- Derive Modulation Band Width (MBW) so that if the next channel is spaced over in frequency by this MBW, then there will be little interference between the two:

$$MBW = 1.5 * B$$

- Define measurement points M1 and M2 as integer multiples of MBW:
  - M1 = MBW
  - M2 = 2*MBW

Spectral Mask Proposal (Cont'd)

- Define integration b/w (IBW) as 1.5 R
  - Allows IBW to scale with the mode
  - It is consistent with the IF bandwidth used at a receiver
  - It gave consistent results across all TG4g modes

- Set spectral mask to allow for ~ 10 dB of implementation margin
  - - 25 dBc at M1
  - - 35 dBc at M2

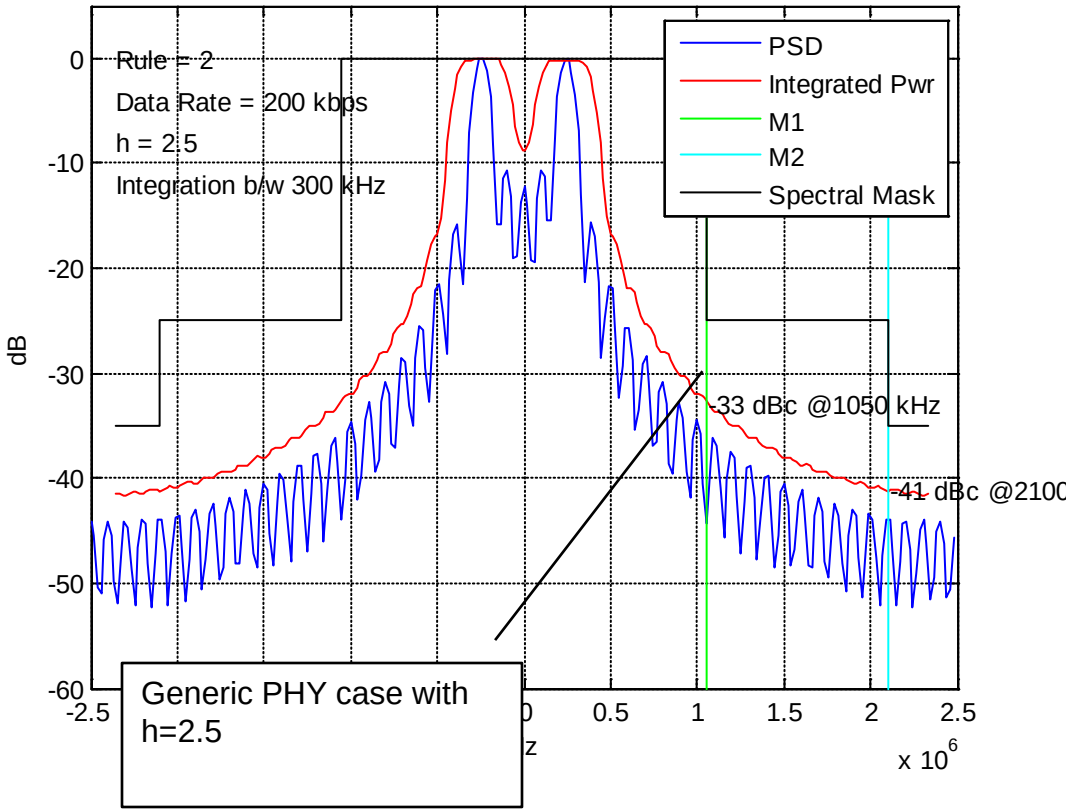
Examples

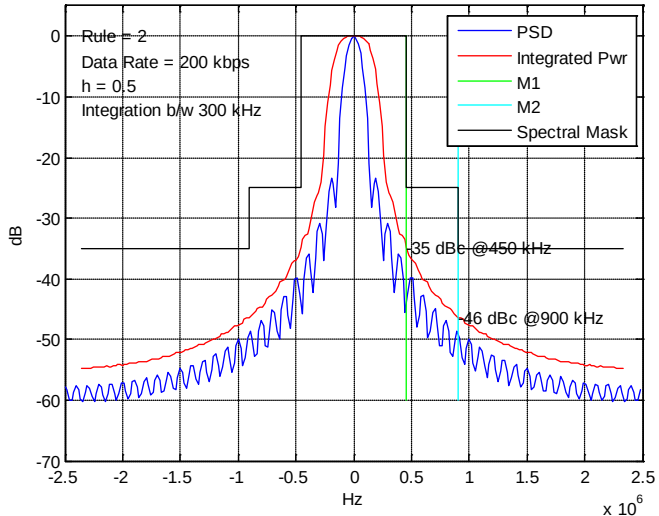
- The following table illustrates the TX spectral mask parameters for various TG4g standard modes:

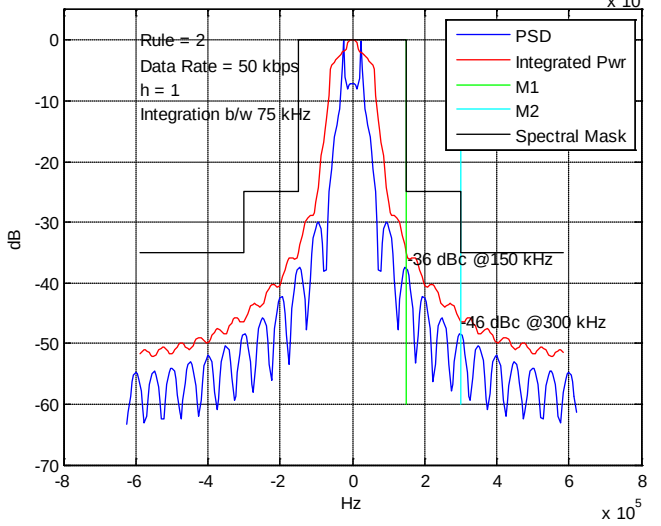
Parameters			Measurements			
Data Rate	h	Integration b/w (kHz)	M1=1.5*R*(1+h) (kHz)	Level at M1 (dBc)	M2=3*R*(1+h) (kHz)	Level at M2 (dBc)
10	0.5	15	22.5	-25	45	-35
20	0.5	30	45	-25	90	-35
40	0.5	60	90	-25	180	-35
50	1	75	150	-25	300	-35
100	1	150	300	-25	600	-35
150	0.5	225	337.5	-25	675	-35
200	0.5	300	450	-25	900	-35

Examples (Cont'd)

- Method produces consistent results for all defined and various Generic PHY modes tested







4-level Modulation

- The same methodology applies
- Carson's rule becomes:

$$B \cong 2(\Delta f + fm), \quad \Delta f = 3 * hR/2, \; fm = R/2$$
$$B \cong R(1 + 3 * h)$$

- Simply replace h by 3h in the channel mask methodology.

Proposed Text

Update section 6.12a.4.1 in document 15-10-0331-04-004g with the following:

The transmit spectral content is defined as the ratio of the total transmitted out-of-channel power in a given frequency interval, compared to the total transmitted in-channel power in the same frequency interval.

In-channel and out-of-channel power shall be measured using a frequency interval equal to 1.5 R, where R is the symbol rate, expressed in units of Hertz.

Out-of-channel power shall be measured at the offset frequencies M1 = 1.5R(1+h) and M2 = 3R(1+h), where h is the modulation index for 2-level modulation, and 3 * the modulation index for 4-level modulation. The transmit spectral content at M1 and M2 shall be less than -25dB and -35dB respectively.

The modulated signal shall use a PN data pattern.

The spectrum analyzer settings for this measurement shall be as follows: the resolution bandwidth is 1 kHz and the video bandwidth is 1 kHz or greater and the detector is RMS.

In addition, a SUN device shall also satisfy regulatory requirements applicable to the transmit spectral mask.