

Transmit Center Frequency Tolerance for MR-FSK

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November 1, 2010

IEEE P802.15

Wireless Personal Area Networks

Title: Transmit Center Frequency Tolerance for MR-FSK

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Source: Michael Schmidt - Atmel (email: michael.schmidt@atmel.com)

Re: Task Group 15.4g LB59 comment resolution

Abstract: Comment resolutions related to MR-FSK PHY

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Motivation

This document describes the proposed resolution of LB59 on some comments related to MR-FSK PHY regarding the transmit center frequency tolerance.

According to P802.15.4g/D2, MPM support (section 6.1a) and requirements on the single sided clock frequency tolerance Tol (section 6.12a.4) will impose the following requirements on a 4g device:

| frequency band (MHz) | channel spacing (kHz) | h | f_s (kbit/s) | max. Tol (ppm) |
|-------------------------|--------------------------|-----|-------------------|---------------------|
| 470-510 | 200 | 1 | 50 | ≈ 50 |
| 863-870 | 200 | 1 | 50 | ≈ 30 |
| 902-928 | 200 | 1 | 50 | ≈ 30 |
| 950-958 | 200 | 1 | 50 | ≈ 30 |
| 2400-2483.5 | 200 | 1 | 50 | ≈ 15 |

- ▶ Binary FSK with modulation index $h = 1$ and symbol rate $f_s = 1/T$.

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- ▶ The power spectral density is given by¹

$$S_{xx}(f) = \frac{4T}{\pi^2} \left[\frac{\cos(\pi fT)}{1 - (2fT)^2} \right]^2 + L_{\delta}^{\pm \frac{1}{2T}}(f)$$

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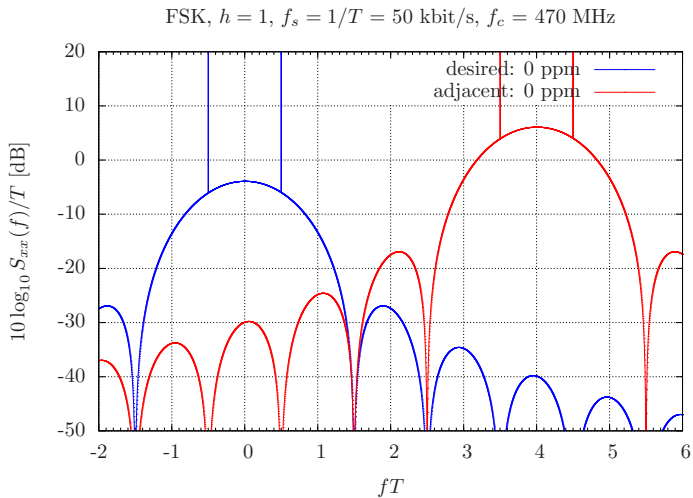
- ▶ The adjacent channel is located at $4/T$ offset from the desired channel.

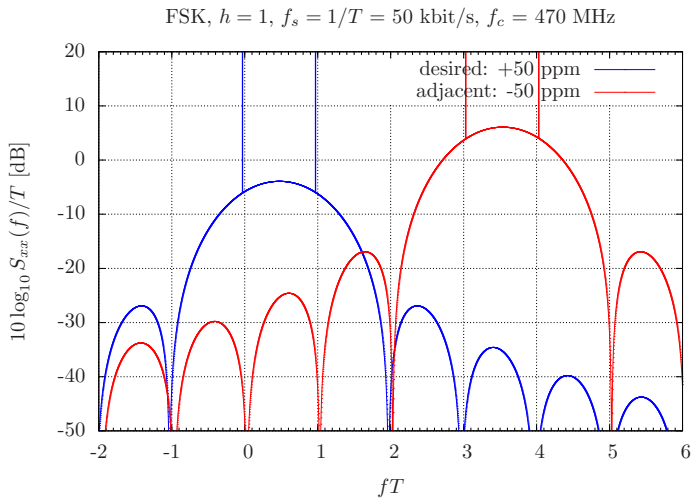
- ▶ The adjacent channel is located at $4/T$ offset from the desired channel.
- ▶ The power of the adjacent channel is 10 dB above the desired channel.

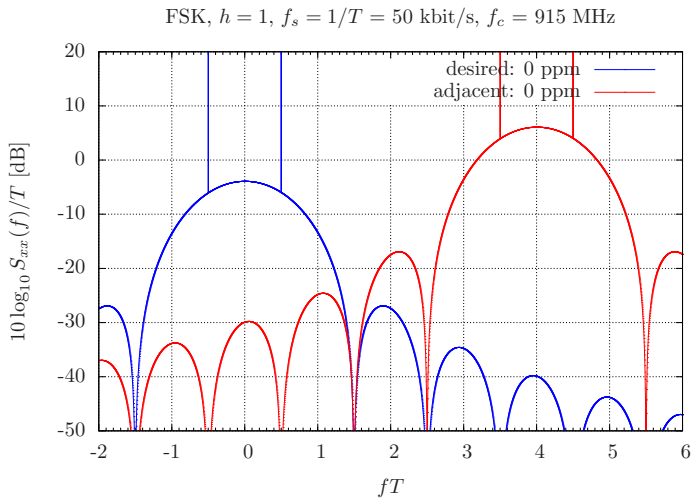
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- ▶ Let ϵ be the frequency tolerance in ppm.

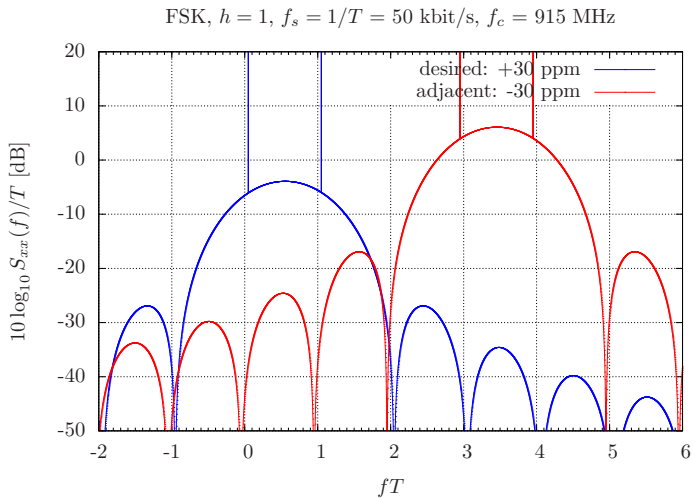
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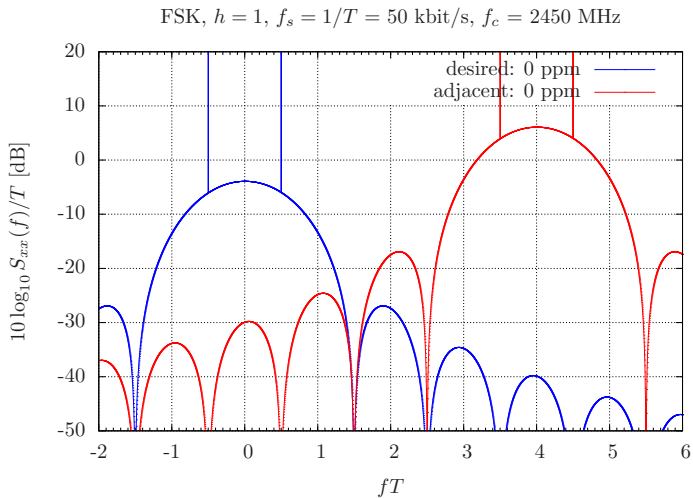
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- ▶ Let ϵ be the frequency tolerance in ppm.
- ▶ The desired channel is shifted $+\epsilon$ ppm w.r.t. the carrier frequency $f_c^{desired}$.
- ▶ The adjacent channel is shifted $-\epsilon$ ppm w.r.t. the carrier frequency $f_c^{adjacent}$.

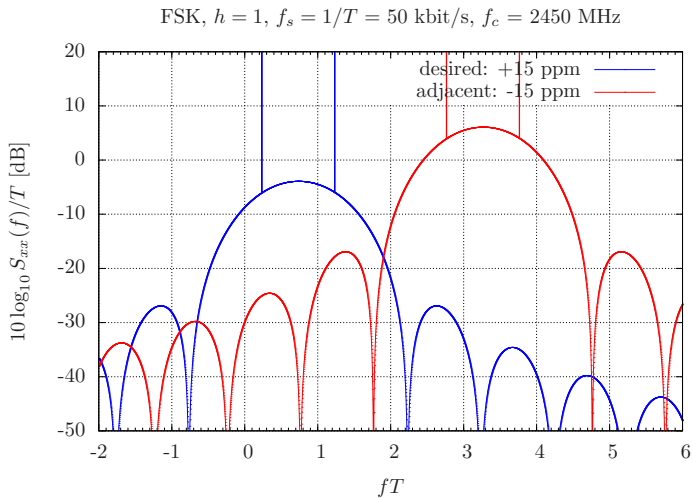


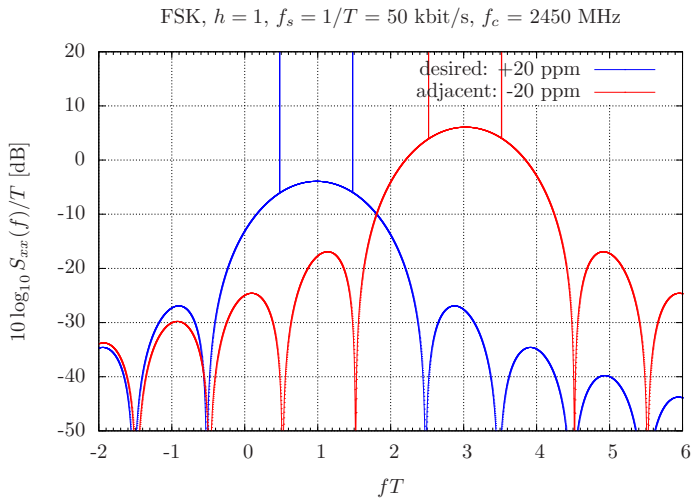


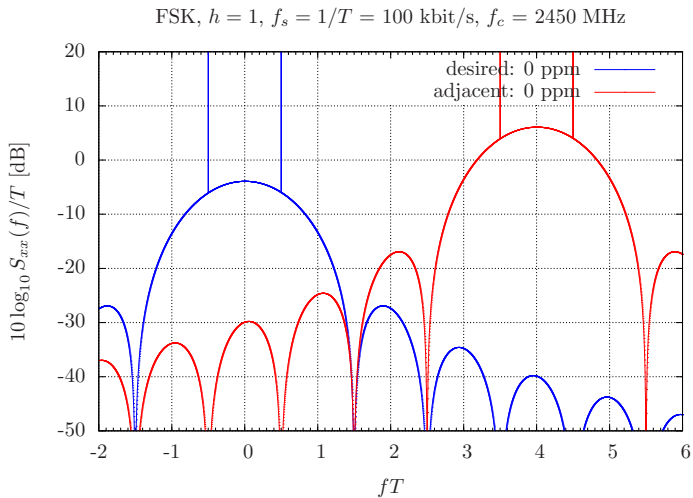


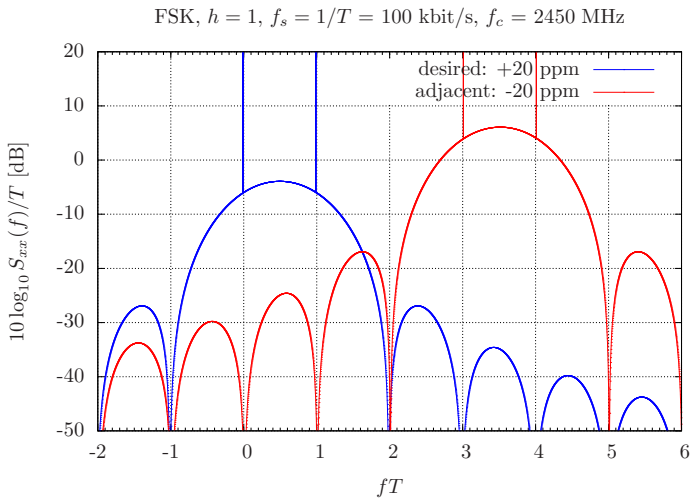












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- ▶ This does not harmonize with the specification of the MR-OFDM and MR-O-QPSK PHY (both PHYs tolerate up to ± 20 ppm).
- ▶ Compared to the tolerance of ± 40 ppm (IEEE-802.15.4-2006), even the required ± 20 ppm will add noticeable costs for test, calibration and board design.
- ▶ Hence, care should be taken with regard to the transmit center frequency tolerance.

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 - ▶ There influence due to clock frequency tolerance is quite substantial.
- ▶ Though the specification are consistent with regard to the receiver jamming resistance (see section 6.12a.4.3, assuming an unmodulated carrier at a fixed offset), there will be moderate adjacent channel rejection in practical applications at 2400-2483.5 MHz.

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| 2400-2483.5 | 200 \rightarrow 400 | 1 | 50 \rightarrow 100 | ≈ 15 \rightarrow ≈ 20 |