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

Submission Title: [Consideration of MR-FSK Channelization and Clock Frequency Tolerance Using Filtered FSK]

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Abstract: [Evaluation of the MR-FSK channelization scheme and the effect of clock frequency tolerance with filtered FSK as modulation format.]

Purpose: [Technical discussion. Presented to the 802.15.4g SUN Task Group for consideration.]

Consideration of MR-FSK Channelization and Clock Frequency Tolerance Using Filtered FSK

30th November 2010

Khanh Tuan Le

AGENDA

- Background
- Parameters of Interest
- Assessment Data
- Signal Spectrum
- Discussion

Background

- This contribution is submitted as a follow-up to the discussion of the DCN834rev1 at the November meeting in Dallas.
- Comments addressed: CID #186 and #687
- Since the 802.15.4g MR-FSK PHY specifies the use of *filtered* frequency shift keying for good co-existence practice, the most realistically way to evaluate the channelization scheme and the effect of clock frequency tolerance is by using a filtered FSK signal.
- GFSK with BT=0.5 will be used as the filtered FSK modulation format in this evaluation.

Parameters of Interest

Reference: P802.15.4g/D2

- The single sided clock frequency tolerance is defined as:

$$T \le min\left(\frac{T_0 \times R \times h \times F_0}{R_0 \times h_0 \times F}, 50ppm\right)$$

Max frequency tolerance:

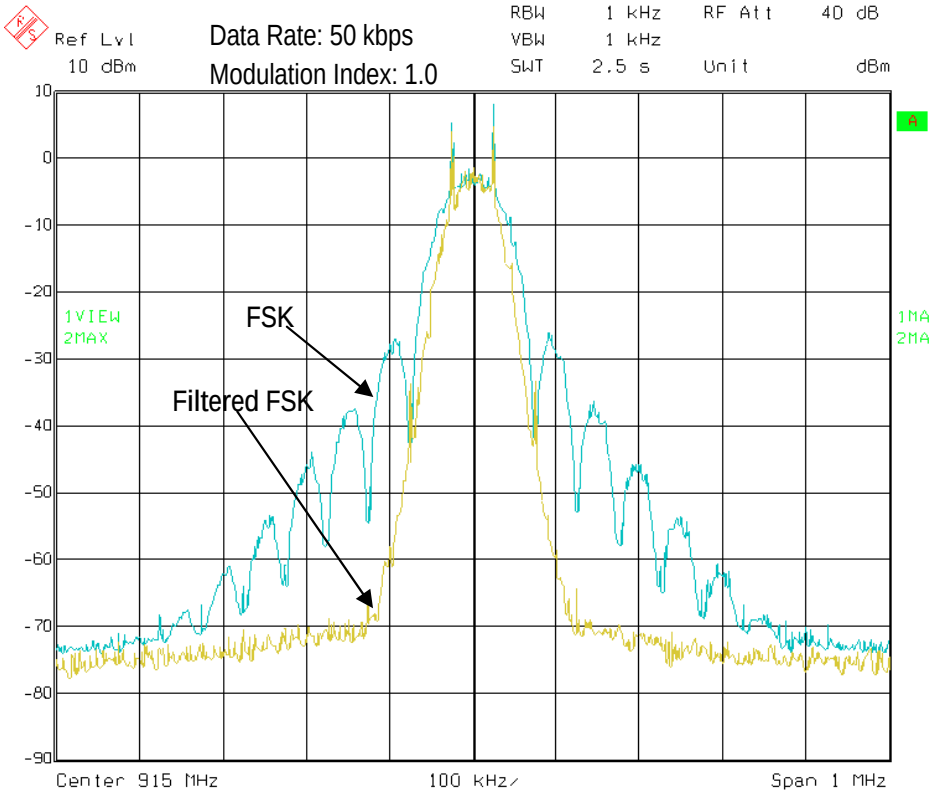
±30 ppm for the 902-928 MHz band

±15 ppm for the 2400-2483.5 MHz band

- Adjacent channel rejection ≥ 10 dB
- Alternate channel rejection ≥ 30 dB

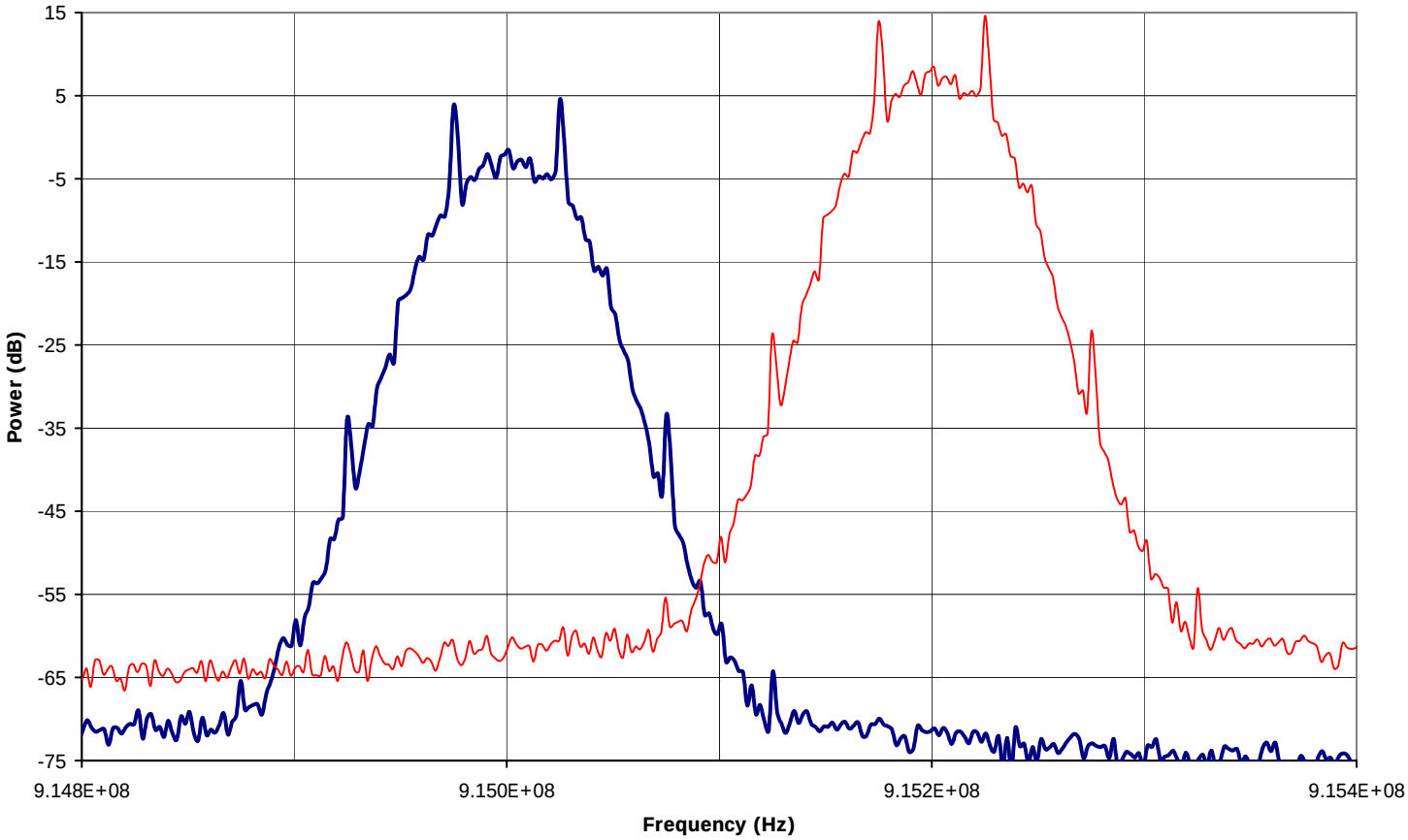
Assessment Data

- Data rate = 50 kbps
- Modulation index = 1.0
- Nominal channel spacing: 200 kHz
- The interfering signal in the adjacent channel is a modulated signal with the same modulation characteristics as the wanted signal.
- The adjacent channel signal power is 10 dB higher than the wanted signal (according to P802.15.4g/D2).
- For worst case assessment the wanted and adjacent channel signals are offseted by the max frequency tolerance value specified in P802.15.4g/D2.



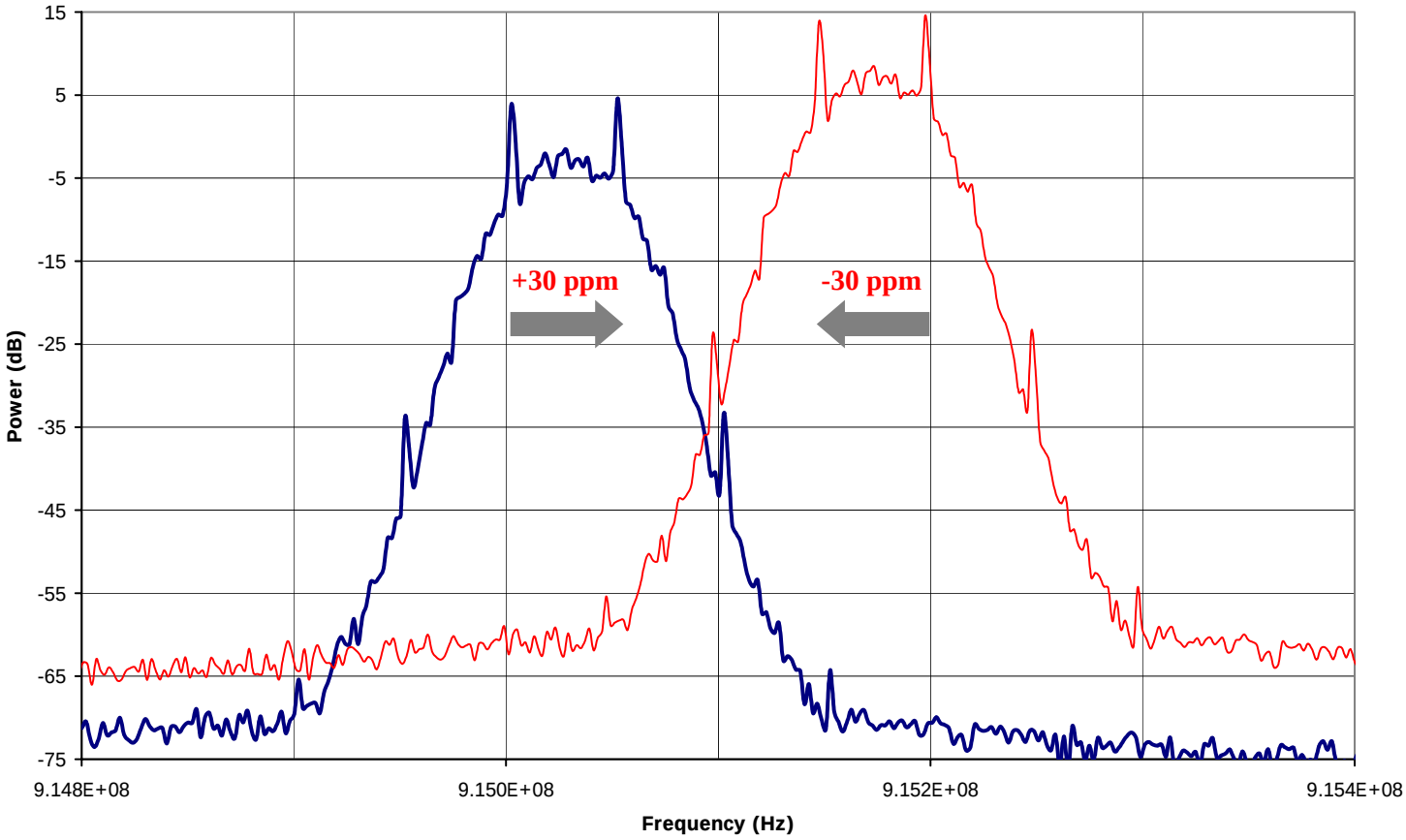
Filtered FSK Signals at 915 MHz, ±0 ppm

- Wanted channel: 915.0 MHz
- Adjacent channel: 915.2 MHz
- Adjacent channel power relative to wanted channel: +10 dB



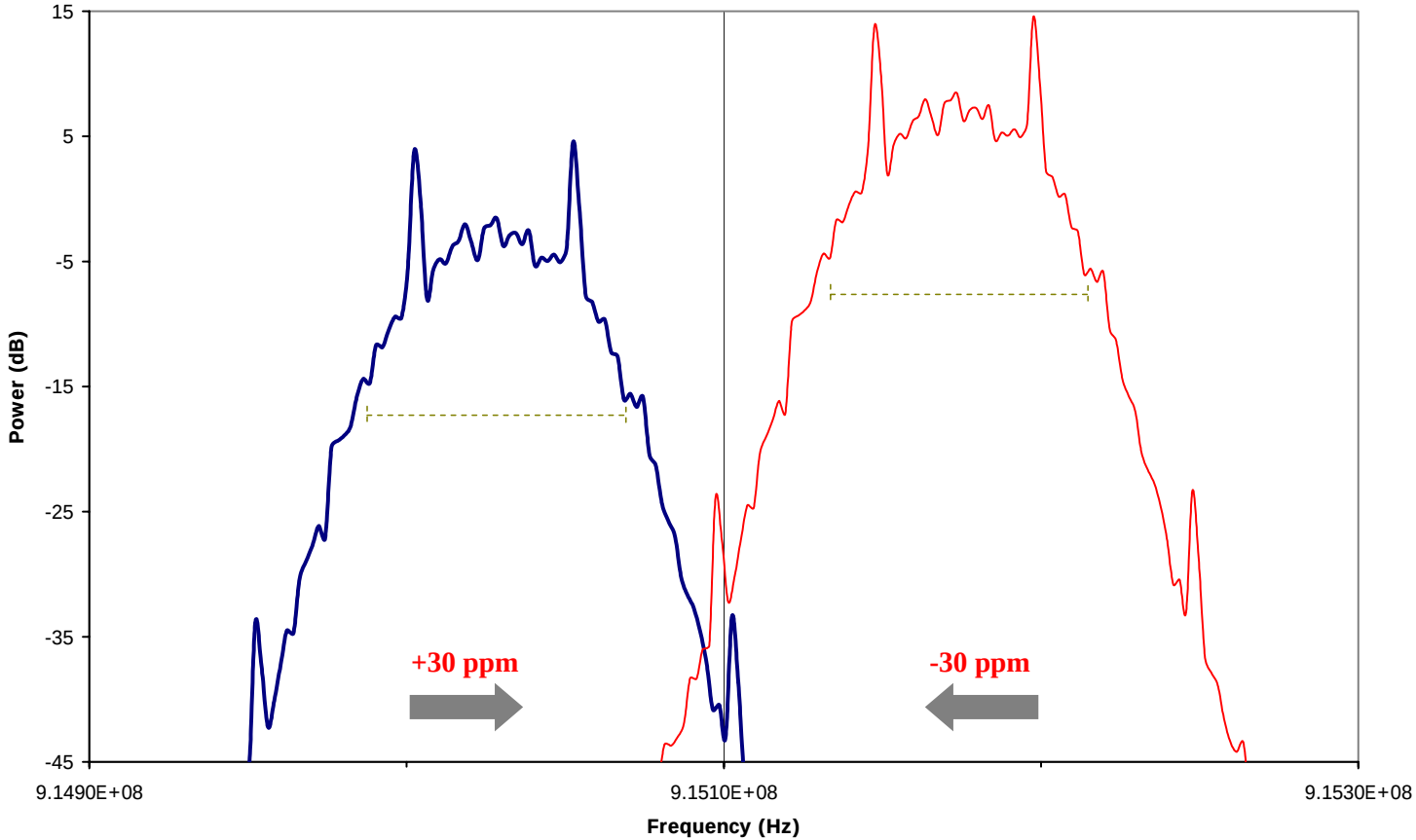
Filtered FSK Signals at 915 MHz, ±30 ppm (1)

- Negligible interfering power leakage from adjacent channel at max frequency tolerance and worst case offset.



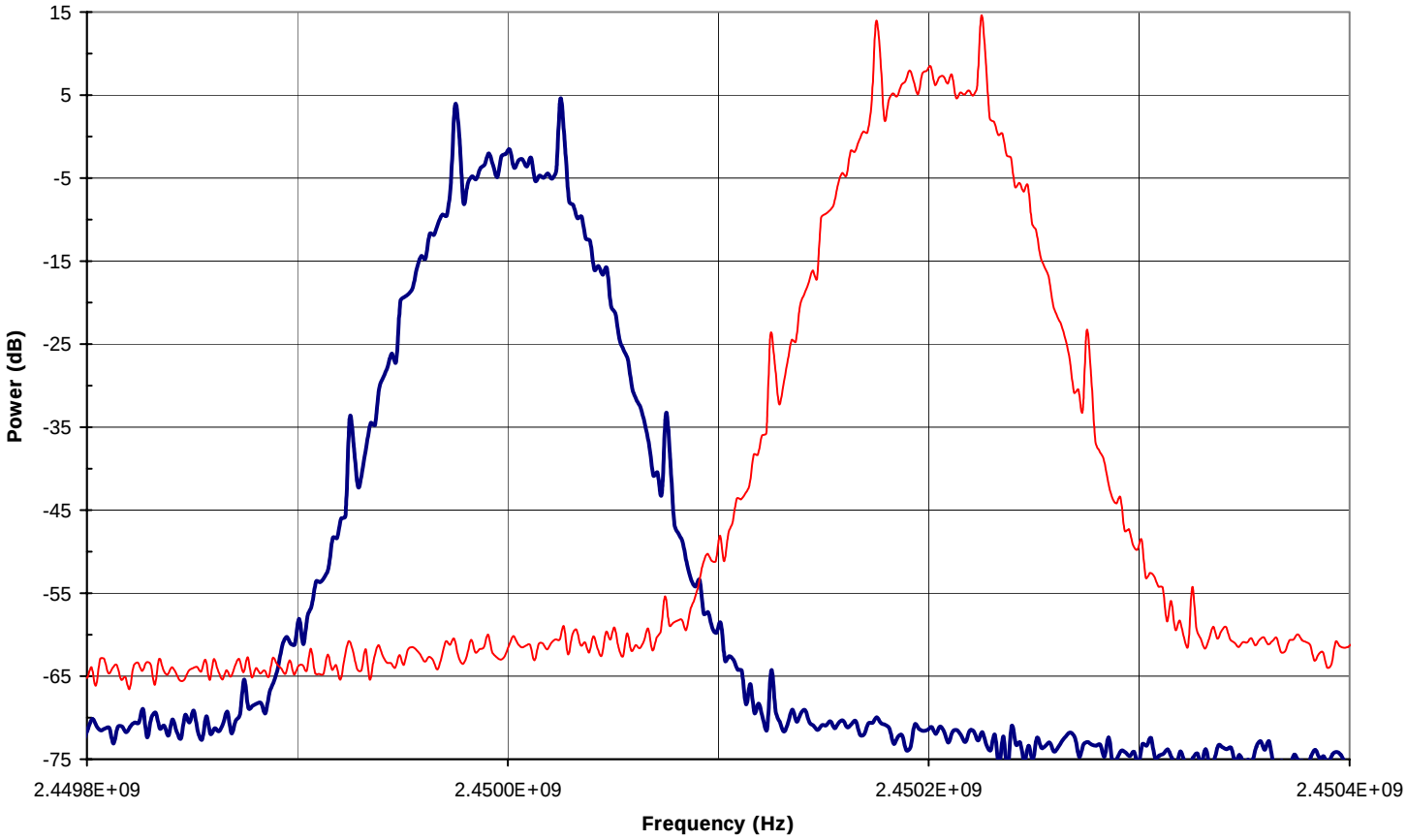
Filtered FSK Signals at 915 MHz, ±30 ppm (2)

- Excellent conditions for signal demodulation at max frequency tolerance and worst case offset.



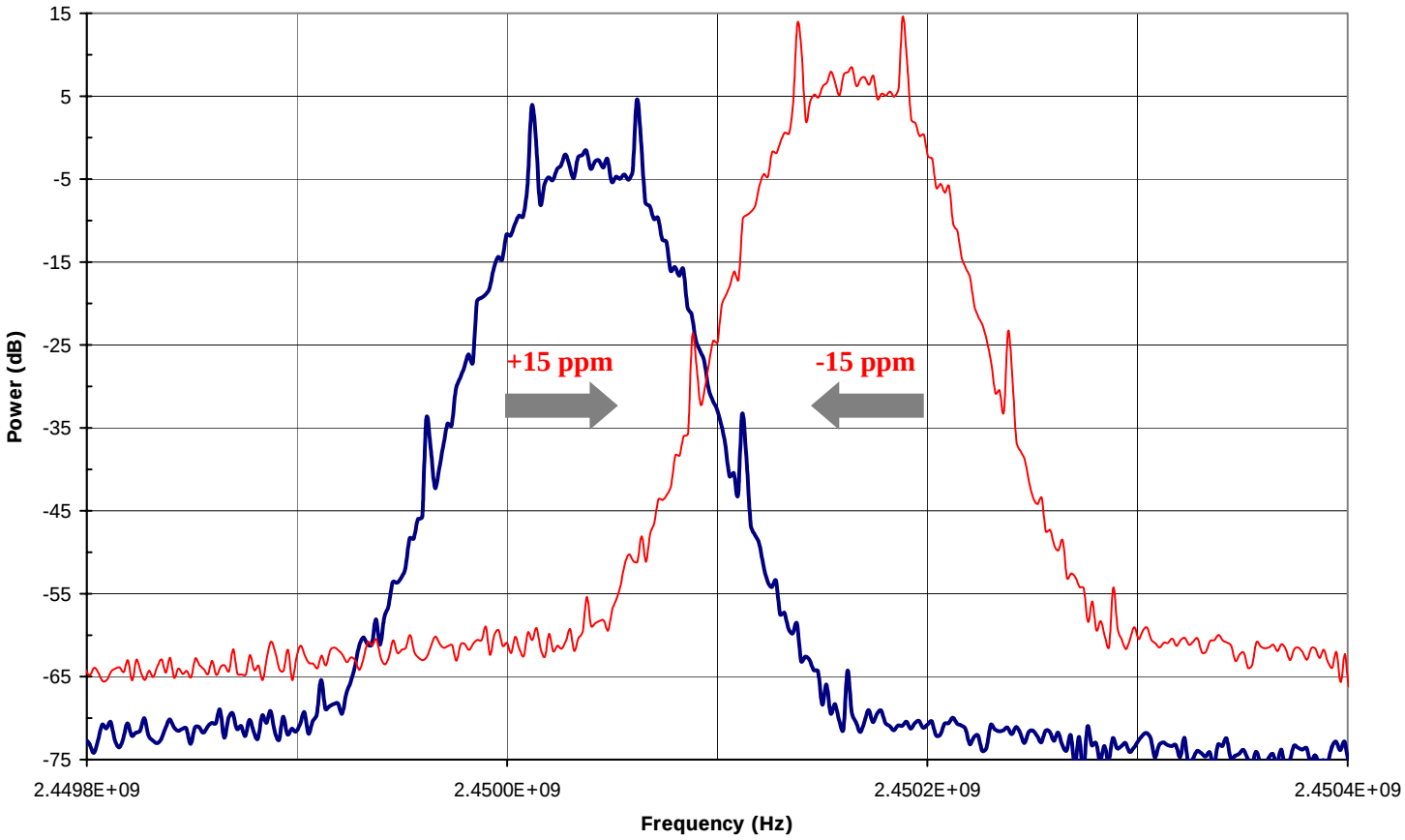
Filtered FSK Signals at 2450 MHz, ±0 ppm

- Wanted channel: 2450.0 MHz
- Adjacent channel: 2450.2 MHz
- Adjacent channel power relative to wanted channel: +10 dB



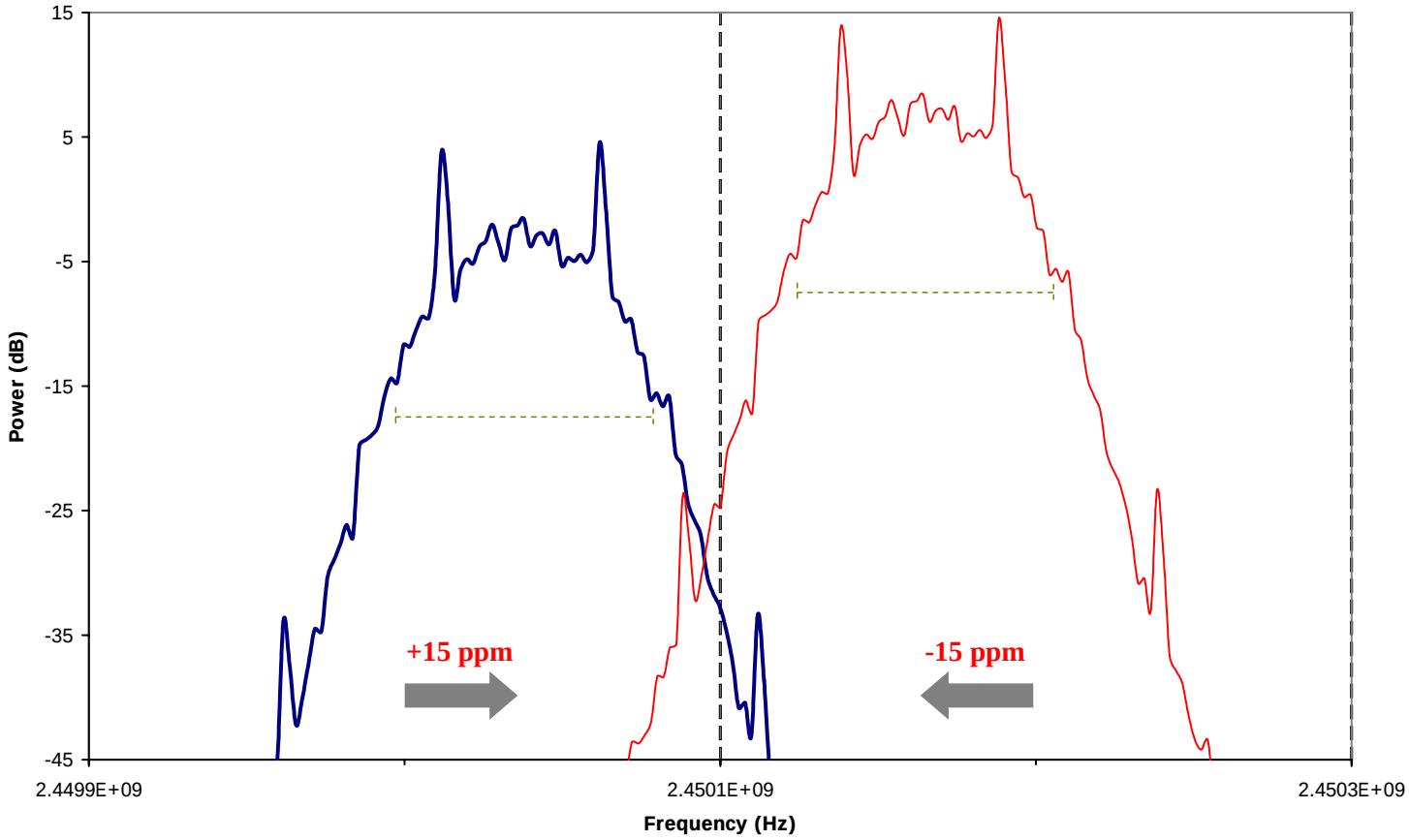
Filtered FSK Signals at 2450 MHz, ±15 ppm (1)

- Negligible interfering power leakage from adjacent channel at max frequency tolerance and worst case offset.



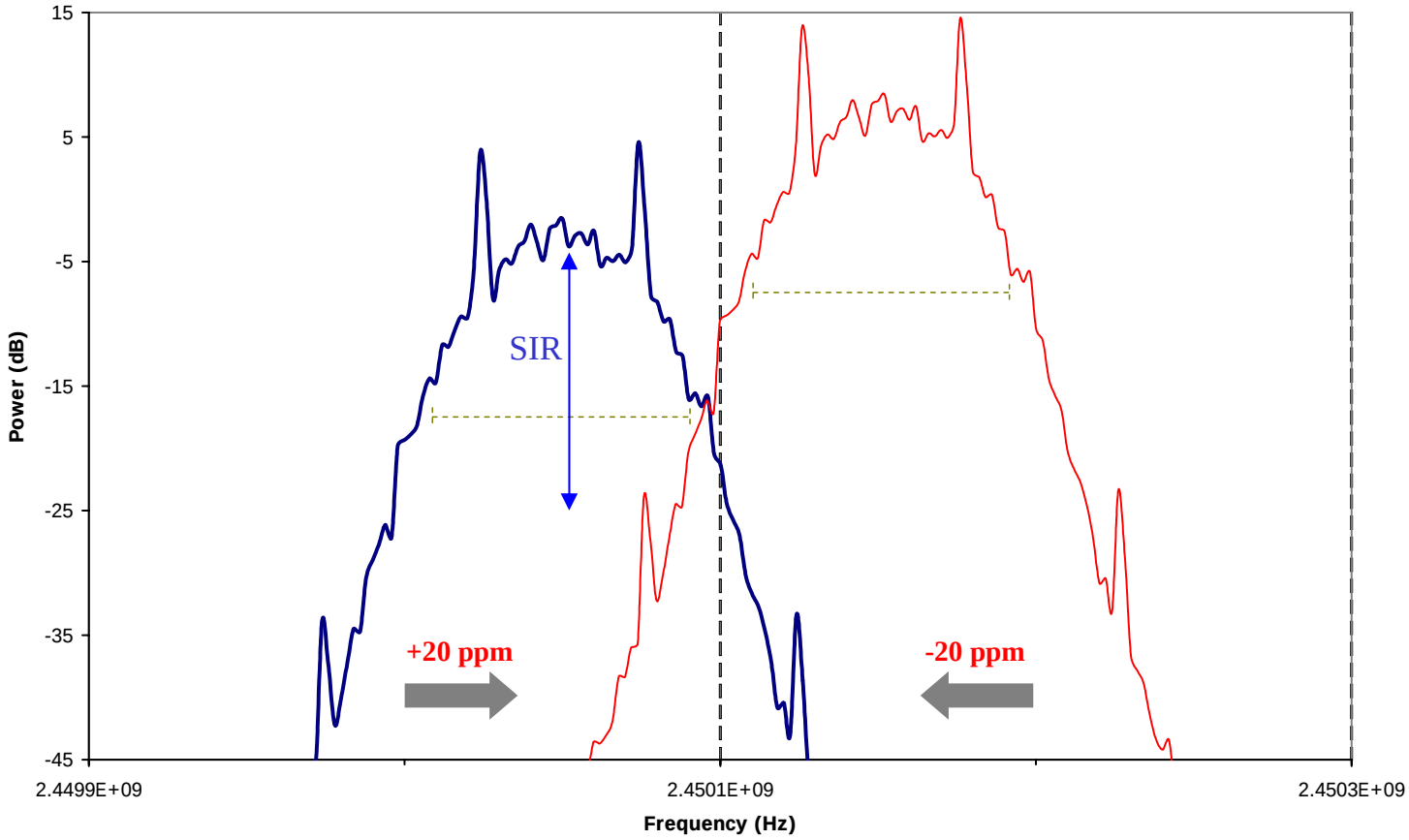
Filtered FSK Signals at 2450 MHz, ±15 ppm (2)

- ±15 ppm (max frequency tolerance)
- Worst case frequency offset
- All signal power contained within the channel
- Good conditions for signal demodulation



Filtered FSK Signals at 2450 MHz, ±20 ppm

- ±20 ppm (33% higher than currently specified)
- Worst case frequency offset
- Most of signal power (>99%) still contained within the channel
- Adequate conditions for signal demodulation



Discussion

- The adjacent and alternate channel test using ‘an unmodulated carrier in the center of that channel’ is most likely too optimistic.
  The recommendation is to change the interfering signal in the adjacent channel to a modulated signal in order to achieve more realistic evaluation of the receiver performance.
  The MR-O-QPSK and MR-OFDM PHY options use modulated interferer.
- The existing channel scheme and clock frequency tolerance work well at the 2400-2483.5 MHz band.
  A clock tolerance of ±20 ppm seems feasible at the 2.4 GHz band without further changes.
- The adjacent channel and alternate channel rejection requirements of respectively +10 dB and +30 dB (relatively simple to implement on low cost low power radios) are at a reasonable level for the 15.4g MR-FSK channelization scheme.

Proposed Comment Resolutions

- **CID 186**
  Comment: “Channel spacing of 200 kHz for the 2400-2483.5 MHz band is not recommended (due to the relative high carrier frequency).”
  Proposed change: “Consider a channel spacing of 400 kHz.”

  Proposed resolution:
  AP: In 6.12a.4.3 change the interfering signal in the adjacent and alternate channel to a modulated signal with the same characteristics as the wanted signal.

- **CID 687**
  Comment: “For the 2400-2483.5 MHz band, a channel spacing of 200 kHz imposes unnecessary tight bounds on the maximum transmit center frequency tolerance (+- 15 ppm for the mandatory mode as shown in 6.12a.4). This specification does not harmonize with the MR-OFDM and MR-O-QPSK PHY operating in the same frequency band with up to +/-20 ppm. See document 15-10-0834 for further details.”
  Proposed change: “Consider a channel spacing of 400 kHz and a symbol rate of 100 kbit/s. See document 15-10-0834 for further details.”

  Proposed resolution:
  AP: Same resolution as CID 186.

Thank you!