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

**Submission Title:** ETSI EN 300 220-1 Modulation Bandwidth Limits for MR-FSK PHYs
**Date Submitted:** 28th October, 2011
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**Re:** []

**Abstract:** []

**Purpose:** To assist the BRC with Sponsor Ballot Recirculation comment resolution

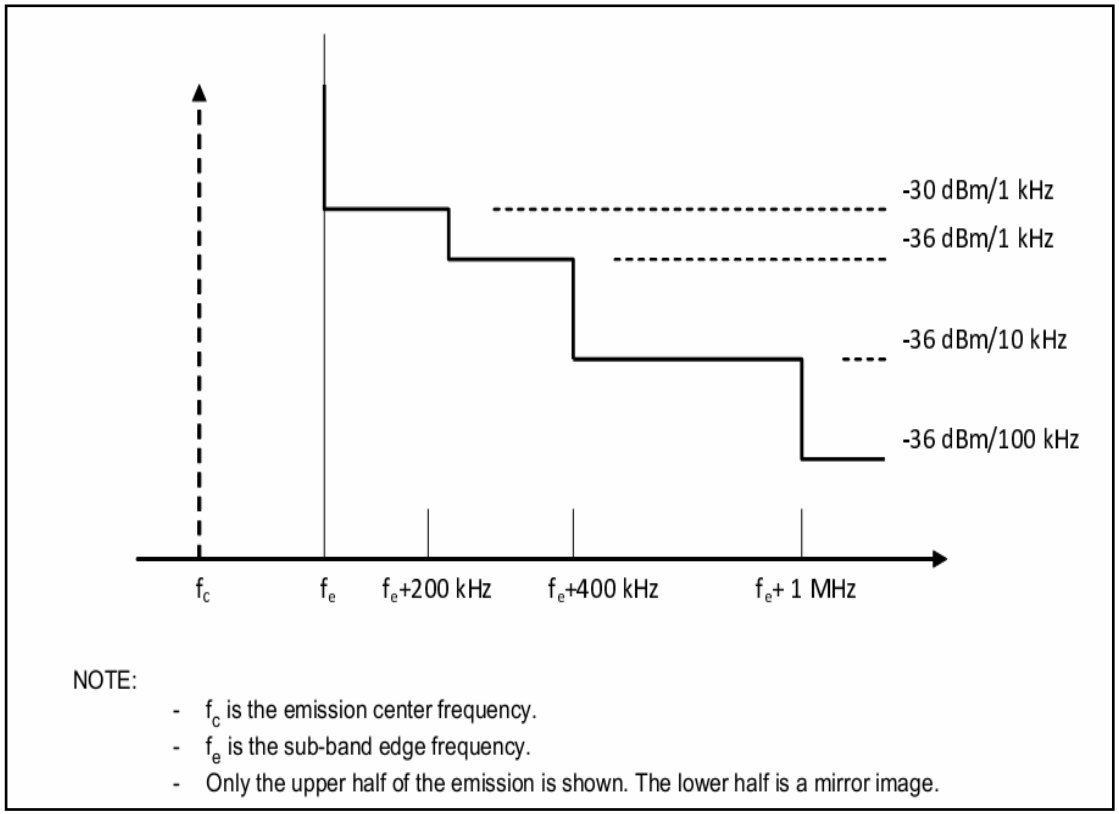
# 802.15.4g Channelization

- Channelization:
  - Table 68a of the draft describes the following channelization plan for the MR-FSK PHY:
    - PHY Mode 1 (CSM): 34 channels of 200 kHz spacing, with channel 0 center frequency at 863.125 MHz
    - PHY Mode 2, 3: 17 channels of 400 kHz spacing, with channel 0 center frequency at 863.225 MHz
  - From analysis of table 5 of ETSI EN 300 220-1 v2.3.1 it can be expected that 802.15.4g devices will seek to comply with the operating mode, below:

| Frequency Bands/frequencies | Applications | Maximum radiated power, e.r.p. / power spectral density | Channel spacing | Spectrum access and mitigation requirement (e.g. Duty cycle or LBT + AFA) |
|---|---|---|---|---|
| 863,000 MHz to 870,000 MHz (see note 4)<br><br>Modulation bandwidth up to 300 kHz is allowed (see clause 7.7.3) | Non-specific use (Narrow/wideband modulation) | 25 mW | ≤100 kHz (see note 6) | 0,1 % or LBT + AFA (see notes 2, 3 and 9) |

# Modulation Bandwidth

- ETSI EN 300 220-1 v2.3.1 Definition:
  - Modulation bandwidth is defined in Section 7.7 of the above ETSI standard and can be illustrated as follows:



# Modulation Bandwidth

- Lower and Upper Frequency Point Definition
  - The difference between the two frequencies $f_a$ and $f_b$ obtained with resolution bandwidth 1 kHz and level 1 uW is the modulation bandwidth.
  - From the table on Slide 2 the maximum permissible modulation bandwidth shall be 300 kHz, however summarizing Section 7.7.3 of the ETSI standard, Where the band is divided into sub-bands the limits shall apply to the sub-band edge frequencies. In the table below $f_{e,lower}$ and $f_{e,upper}$ are the lower and upper edges of the band in which the equipment operates.
  - From discussions with Notified Bodies, the definition of sub-band edge can be taken to imply the channel bandwidth edge

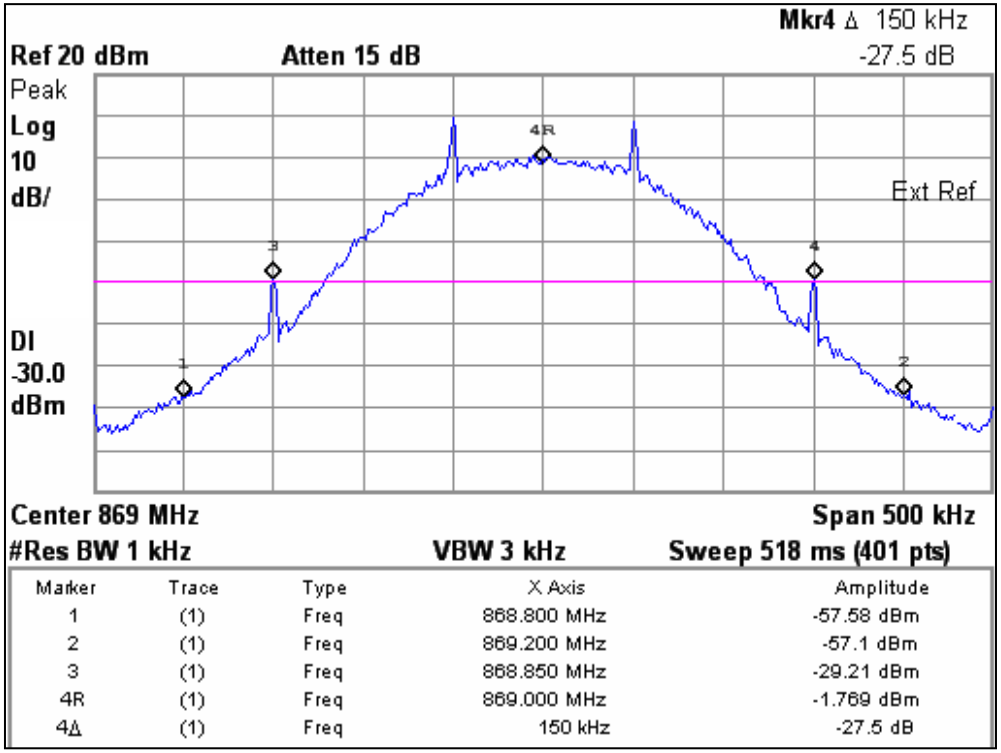
| RBW (kHz) | LIMIT | | Lower Envelope Point Minimum Frequency | Upper Envelope Point Maximum Frequency |
|---|---|---|---|---|
| | (µW) | (dBm) | | |
| 1 | 1 | -30 | $f_{e, lower}$ | $f_{e, upper}$ |
| 1 | 250 | -36 | $f_{e, lower}$ – 200 kHz | $f_{e, upper}$ + 200 kHz |
| 10 | 250 | -36 | $f_{e, lower}$ – 400 kHz | $f_{e, upper}$ + 400 kHz |
| 100 | 250 | -36 | $f_{e, lower}$ – 1 MHz | $f_{e, upper}$ + 1 MHz |

# Modulation Bandwidth

- Lower and Upper Frequency Point Analysis
  - MR-FSK PHY Mode 2 and 3 for the 863 – 870 MHz band define a 400 kHz channel spacing
  - ETSI defines a MAXIMUM modulation bandwidth of 300 kHz (fC ± 150 kHz)
  - The impact of this interpretation is illustrated in the following slides. For the purposes of objectivity the test spectra were generated by a Rhode & Schwarz SMIQ VSG and laboratory amplifier set to output an indicated power level of +14 dBm (~25 mW erp), and current generation sub-GHz FSK transceivers from respected silicon vendors.
  - Test method is consistent with the ETSI standard

# Modulation Bandwidth

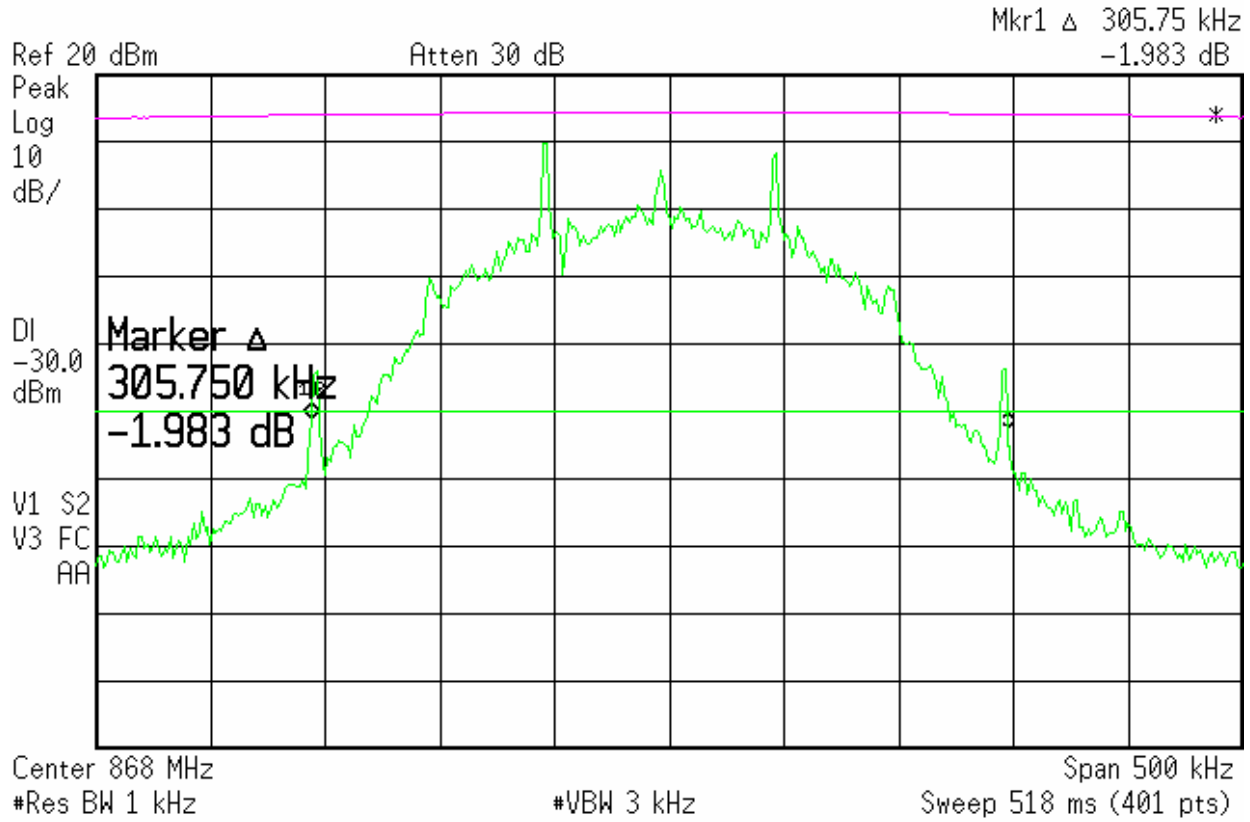
- PHY Mode 2 GFSK (BT = 0.5) – R&S VSG
  - Markers 3 and 4: 300 kHz modulation bandwidth limits




| Marker | Trace | Type | X Axis | Amplitude |
|---|---|---|---|---|
| 1 | (1) | Freq | 868.800 MHz | -57.58 dBm |
| 2 | (1) | Freq | 869.200 MHz | -57.1 dBm |
| 3 | (1) | Freq | 868.850 MHz | -29.21 dBm |
| 4R | (1) | Freq | 869.000 MHz | -1.769 dBm |
| 4Δ | (1) | Freq | 150 kHz | -27.5 dB |

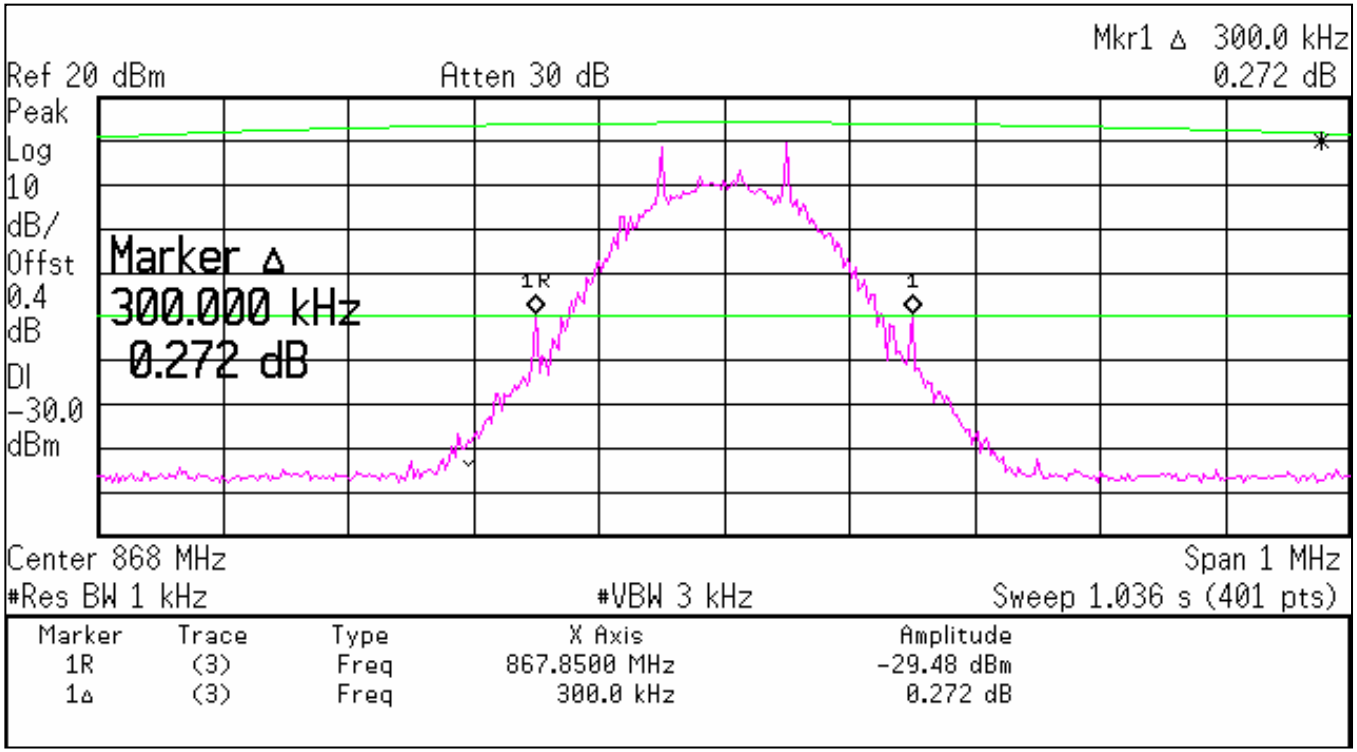
# Modulation Bandwidth

- PHY Mode 2 GFSK (BT = 0.5) – Vendor “A”
  - Modulation Bandwidth ~ 305 kHz



# Modulation Bandwidth

- PHY Mode 2 GFSK (BT = 0.5) – Vendor “B”
  - Modulation Bandwidth ~ 300 kHz



# Modulation Bandwidth

- Conclusions
  - As can be seen from the modulation bandwidth plots, the margin of compliance to the ETSI modulation bandwidth is marginal.
- Recommendations
  - The BRC to determine whether the MR-FSK modulation parameters for Operating Modes #2 and #3 be amended to ensure compliance with European regulatory requirements

# Modulation Bandwidth

- Incompleteness Record
  - Further analysis of PHY Mode 2 – GFSK (BT = 0.5)
  - Analysis of PHY Mode 3 - GFSK (BT = 0.5)