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doc.: IEEE 802.15-17-0038-00-003d proposal\_for\_a\_spectrum\_mask

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**Re:** n/a

**Abstract:** This document provides a proposal for a spectrum mask for inclusion in the draft standard IEEE 802.15.3d

**Purpose:** Discussion document for the TG 3d

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# Proposal for a spectrum mask in IEEE P802.15.3d

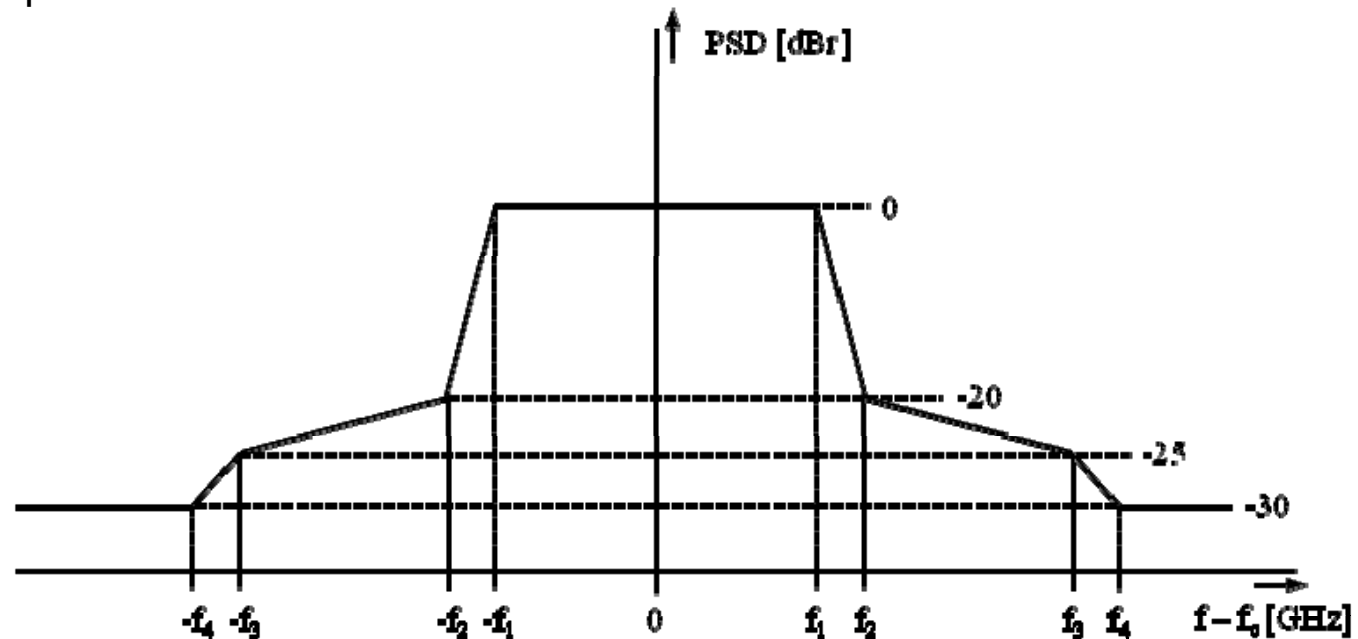
Sebastian Rey, Thomas Kürner  
TU Braunschweig

# Outline

- Proposed spectrum mask
- Compare the spectrum of the transmitted signal with the spectrum mask
- Compare a bandlimited signal with the spectrum mask

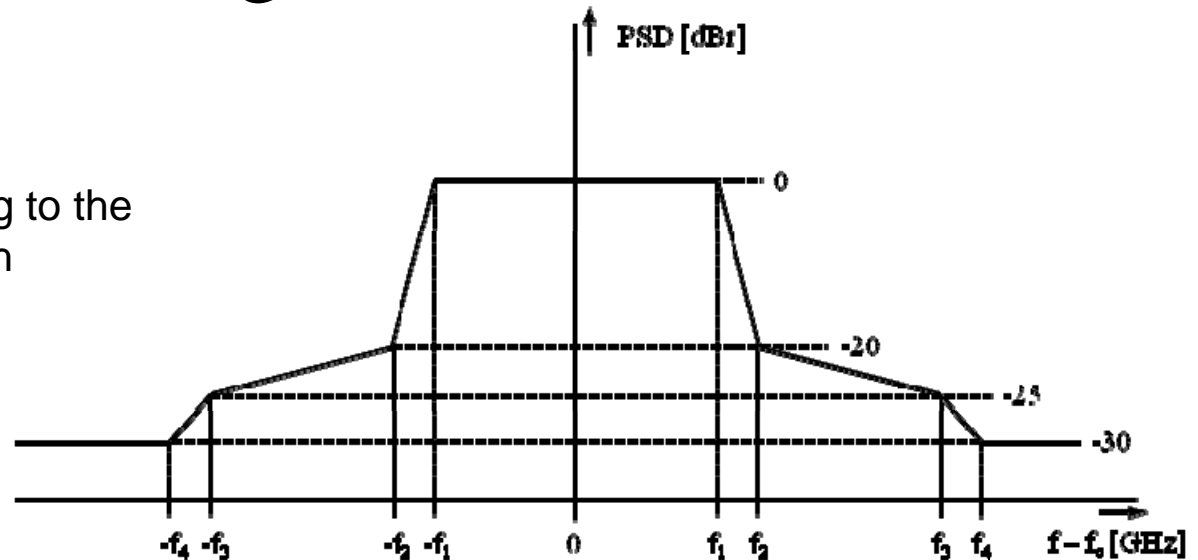
# Definition of a generic PSD mask

- Defining a spectrum mask is a regulatory task.
- Currently, no mask available
- A generic mask is proposed following the concept of TG3e with bandwidth-specific parameters



# Definition of a generic PSD mask

- Proposal:
  - Adapt  $f_1$  according to the channel bandwidth
  - $f_2 = f_1 + a$
  - $f_3 = f_1 + b$
  - $f_4 = f_1 + c$



- Comparison with 3e and 3c:
  - $f_1 = 0.94 \text{ GHz} = \text{bandwidth}/2 - 0.14 \text{ GHz} = 2.16 \text{ GHz}/2 - 0.14 \text{ GHz}$
  - Proposal :  $f_1 = \text{bandwidth}/2 - 0.14 \text{ GHz}$  for each possible bandwidth
  - $f_2 = 1.1 \text{ GHz} = f_1 + a = f_1 + 0.16 \text{ GHz}$
  - $f_3 = 1.6 \text{ GHz} = f_1 + b = f_1 + 0.66 \text{ GHz}$
  - $f_4 = 2.2 \text{ GHz} = f_1 + c = f_1 + 1.26 \text{ GHz}$

# What does the spectrum look like?

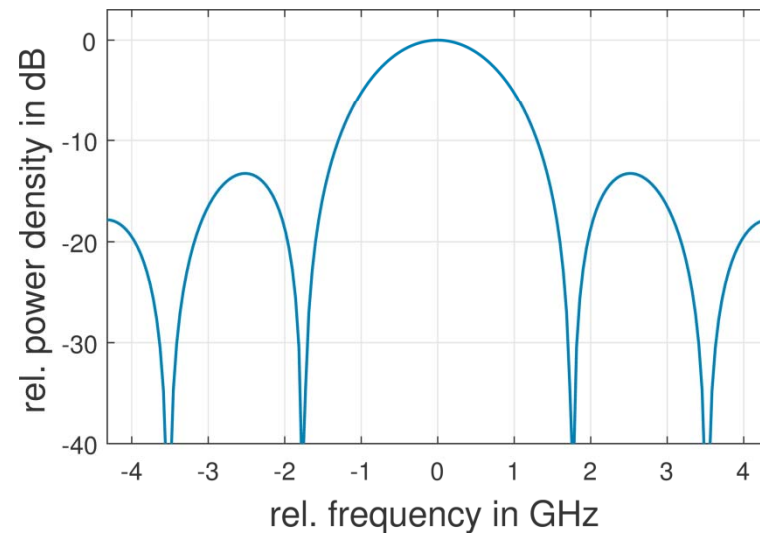
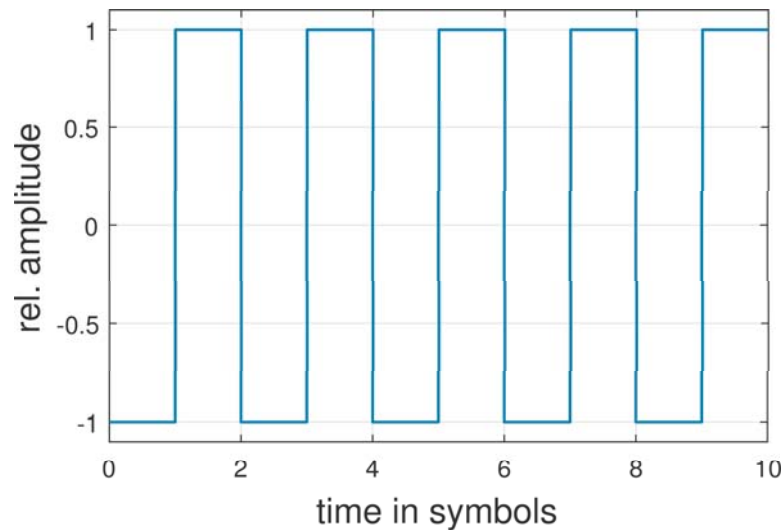
The data signal  $s(t)$  can be described as a rectangular sequence of symbols

- Assuming ideal operation of ideal hardware (infinite bandwidth)
- (in the following the signal is illustrated for a BPSK with the symbols „-1“ and „1“. The argumentation also holds for higher order modulations)
- Worst case of max. bandwidth for continuous change from “-1” to “1” and back again.
- Bit rate on the radio channel is  $R_c=1.760$  GSymbols/s for a 2.16 GHz channel

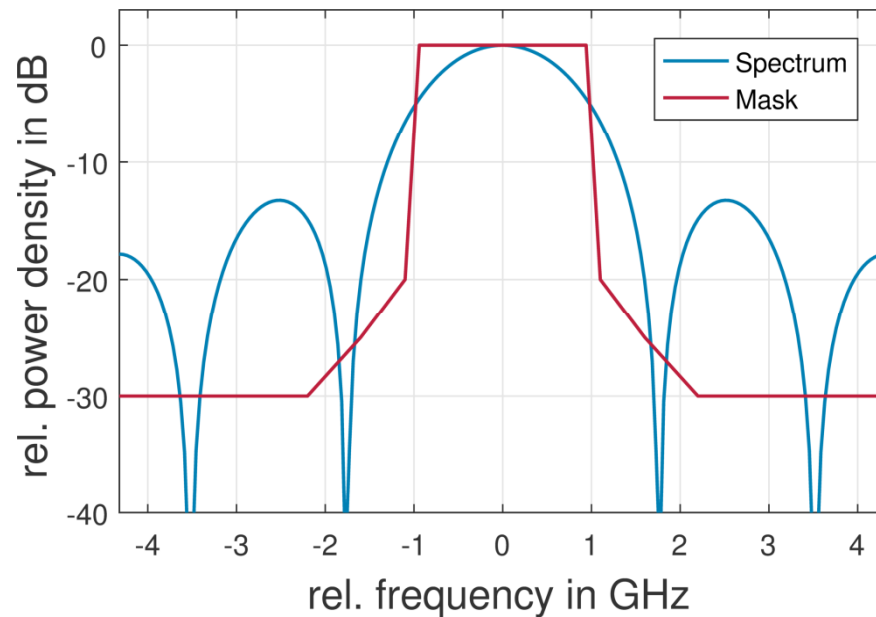
# What does the spectrum look like?

- The spectrum is the fourier transform of the signal with a sinc shape
- Power density is normalized to 0 dB (b=1)

$$s(t) = \text{rect}\left(\frac{t}{T}\right) \quad \mathcal{F}\{s(t)\} = S(f) \quad S(f) = b \cdot \text{sinc}(\pi \cdot T \cdot f) \quad T = \frac{1}{R_c}$$



# Comparison with spectrum mask



- Spectrum is too wide
- (The lines connecting f2, f3 and f4 look almost like one single line)
- Filtering of the signal required



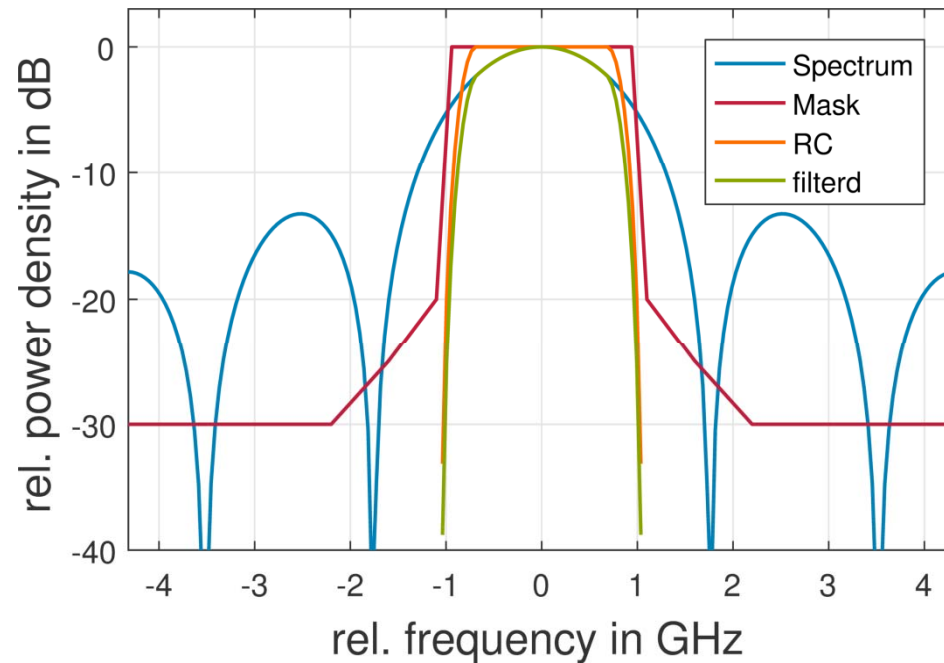
# Transfer function of a raised cosine filter

- Given chip rate, e.g.  $R = 1.76$  GSymbols/s for 2.16 GHz channel
- Symbol duration  $T = \frac{1}{R}$
- Roll-off factor e.g.  $\beta = 0.22$

$$H(f) = \begin{cases} T & |f| \leq \frac{1-\beta}{2T} \\ \frac{T}{2} \left[ 1 + \cos \left( \frac{\pi T}{\beta} \left[ |f| - \frac{1-\beta}{2T} \right] \right) \right] & \frac{1-\beta}{2T} < f < \frac{1+\beta}{2T} \\ 0 & \text{otherwise} \end{cases}$$

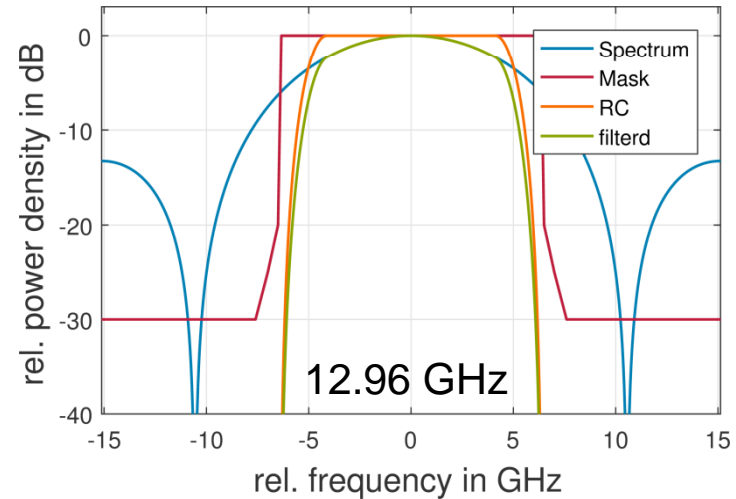
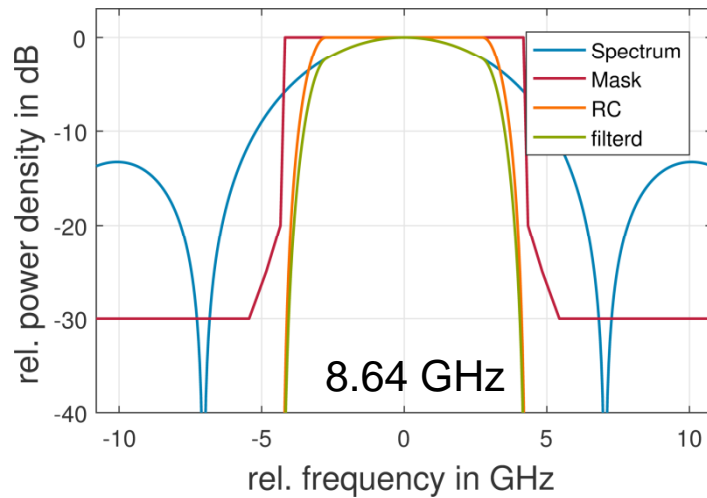
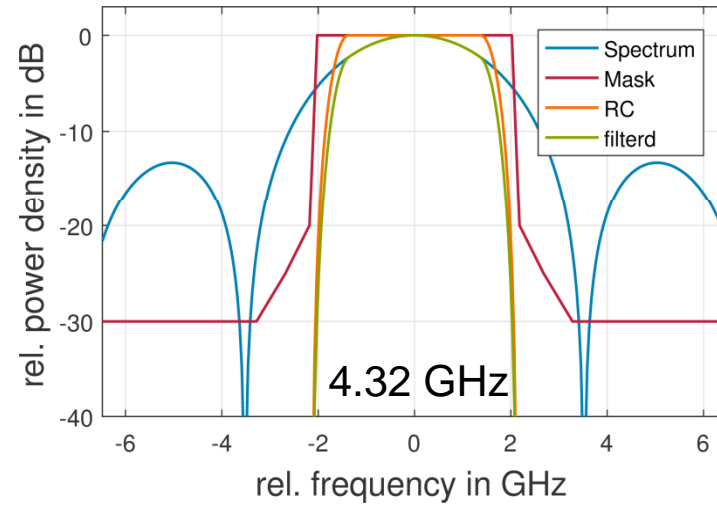
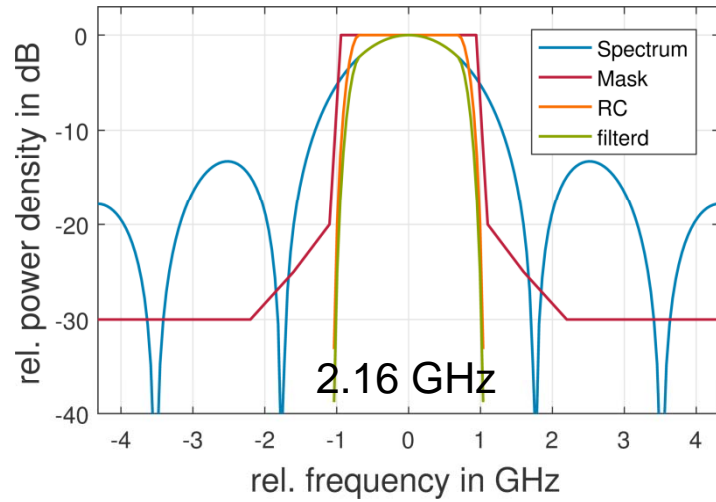
- In the following  $H(f)$  is normalized so that the passband is 0 dB.

# Comparison with the PSD mask



Multiplication of the filter transfer function (RC) with the signal spectrum fulfills the spectrum mask.

# Comparison with the PSD mask



# Comparison with the PSD mask

