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

Submission Title: Proposal for a spectrum mask

Date Submitted: 15 January 2017
Source: Thomas Kürner, TU Braunschweig

E-Mail: kuerner@ifn.ing.tu-bs.de

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

Proposal for a spectrum mask in IEEE P802.15.3d

Sebastian Rey, Thomas Kürner

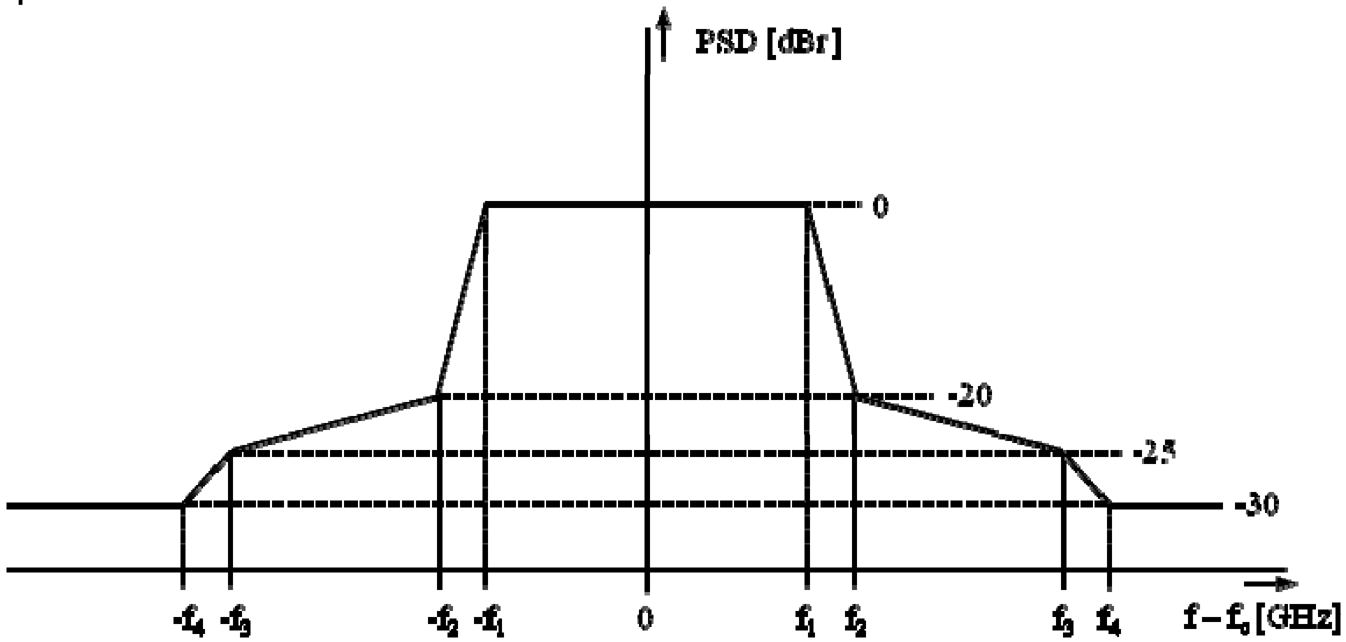
TU Braunschweig

Outline

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

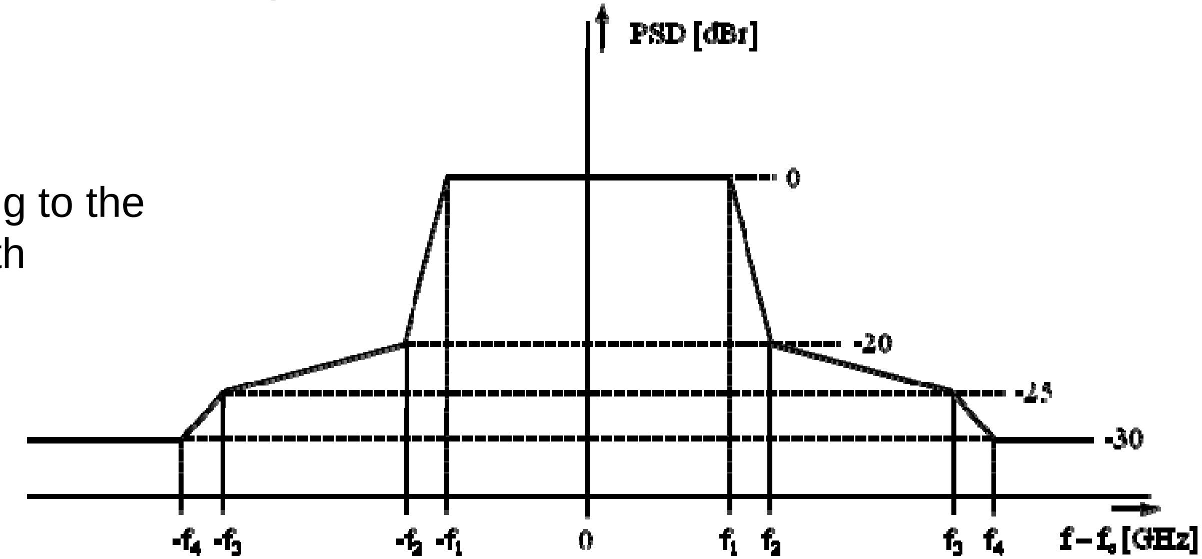
Definition of a generic PSD mask

- 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 f1 according to the channel bandwidth
  - f2= f1 + a
  - f3= f1 + b
  - f4= f1 + c



- Comparison with 3e and 3c:
  - f1= 0.94 GHz = bandwidth/2 – 0.14 GHz = 2.16 GHz/2 – 0.14 GHz
  - Proposal : f1 = bandwidth/2 – 0.14 GHz for each possible bandwidth
  - f2= 1.1 GHz = f1 + a = f1 + 0.16 GHz
  - f3= 1.6 GHz = f1 + b = f1 + 0.66 GHz
  - f4= 2.2 GHz = f1 + c = f1 + 1.26 GHz

What does the spectrum look like?

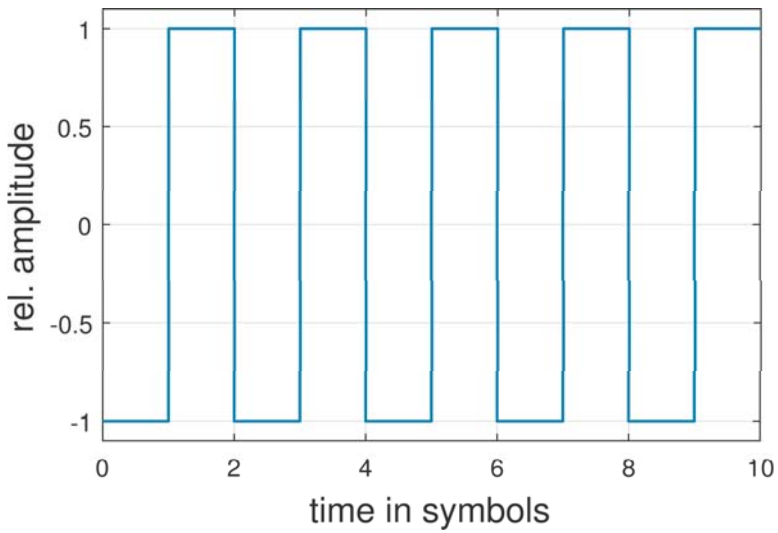
The data signal s(t) can be described as a rectangular sequence of symbols

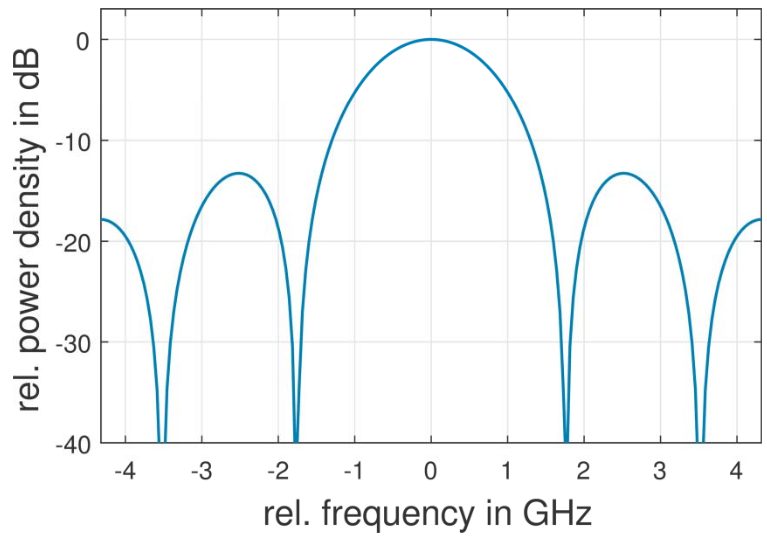
- Assuming ideal operation of ideal hardware (infinite bandwidth)
- (in the following the signal is illustrated for a BPSK with the symbols „-1“ and „1“. The argumentation also holds for higher order modulations)
- Worst case of max. bandwidth for continuous change from “-1” to “1” and back again.
-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

What does the spectrum look like?

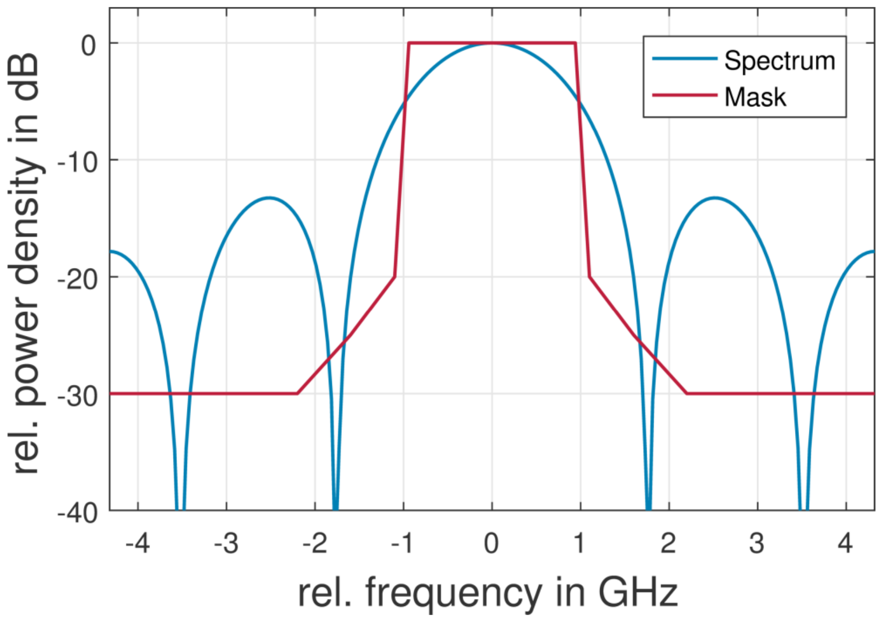
- The spectrum is the fourier transform of the signal with a sinc shape
- Power density is normalized to 0 dB (b=1)

$$s(t) = \mathrm{rect}\left(\frac{t}{T}\right) \qquad \mathcal{F}\{s(t)\} = S(f) \qquad S(f) = b \cdot sinc(\pi \cdot T \cdot f) \qquad T = \frac{1}{R_C}$$





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

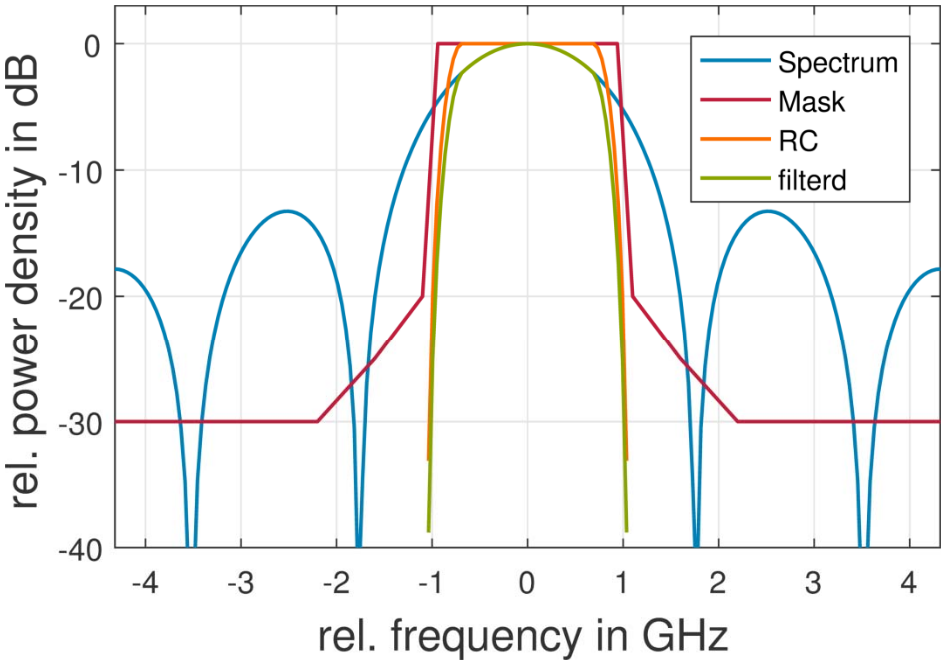
Transfer function of a raised cosine filter

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

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

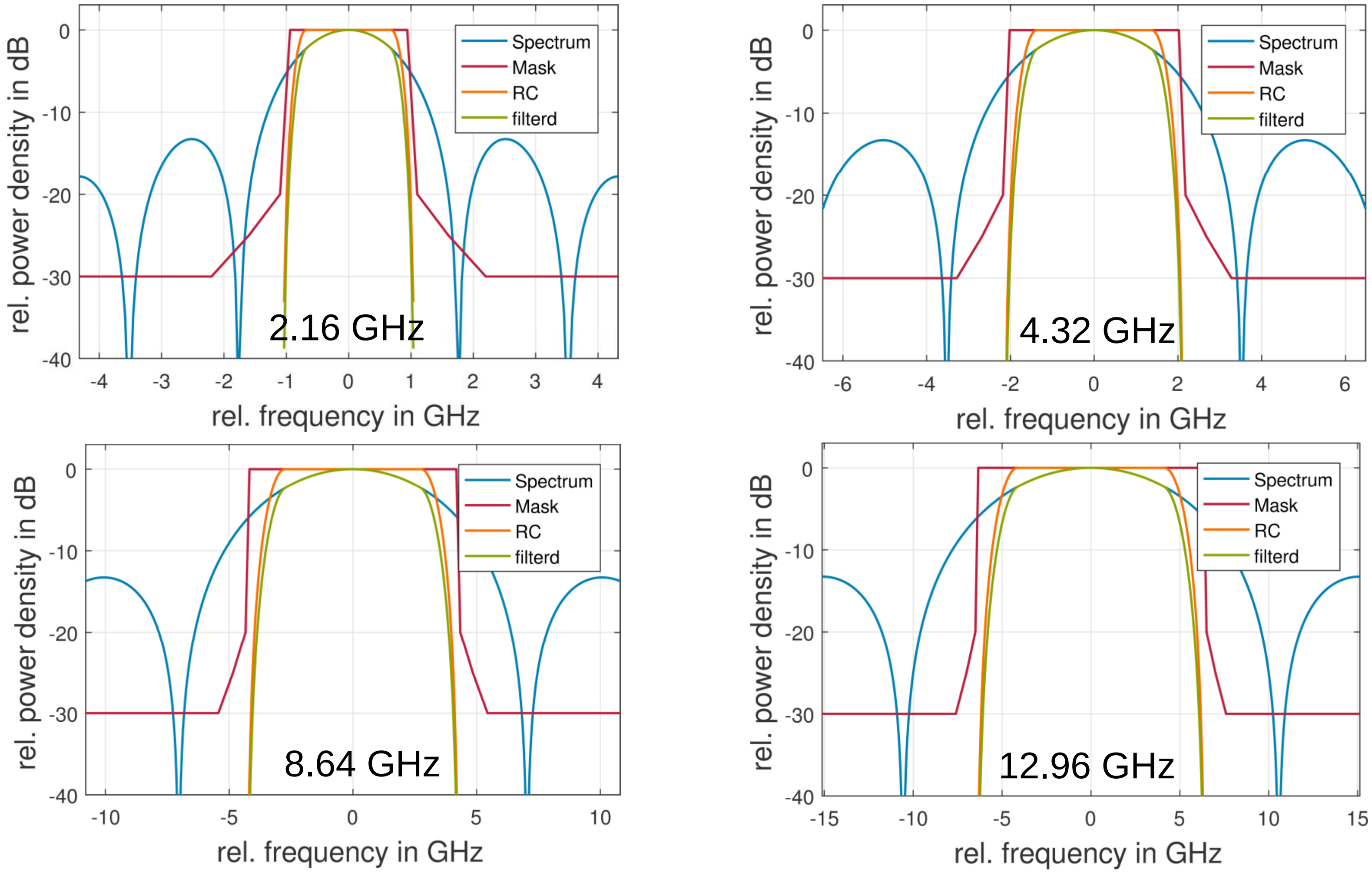
- In the following H(f) is normalized so that the passband is 0 dB.

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