Pulse shaping and bandpass signaling: Binary modulation schemes

EE 160: Principles of Communication Systems

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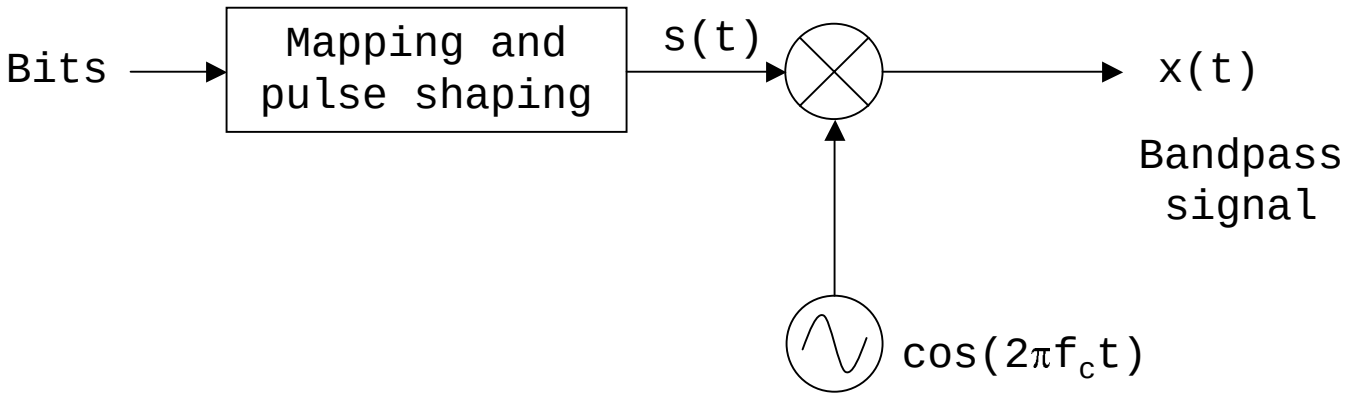
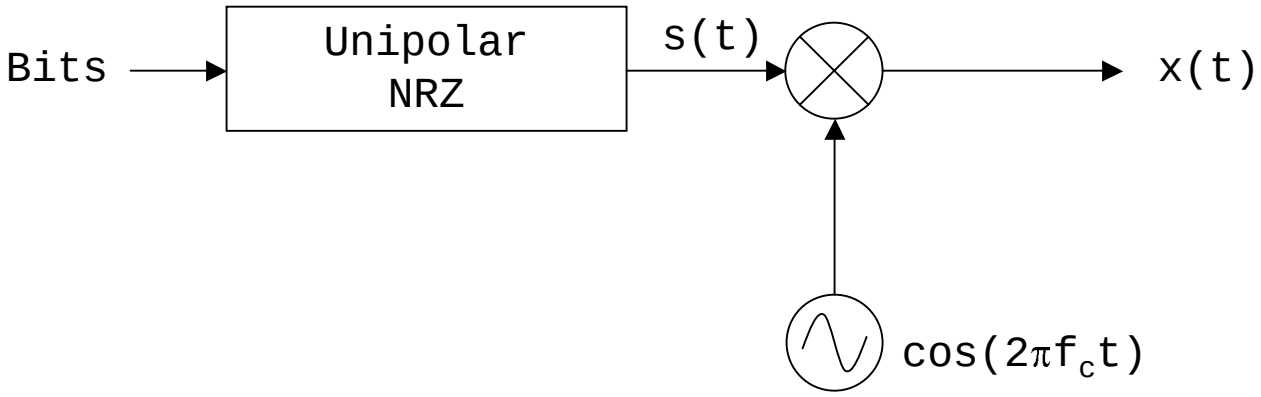
Block diagram

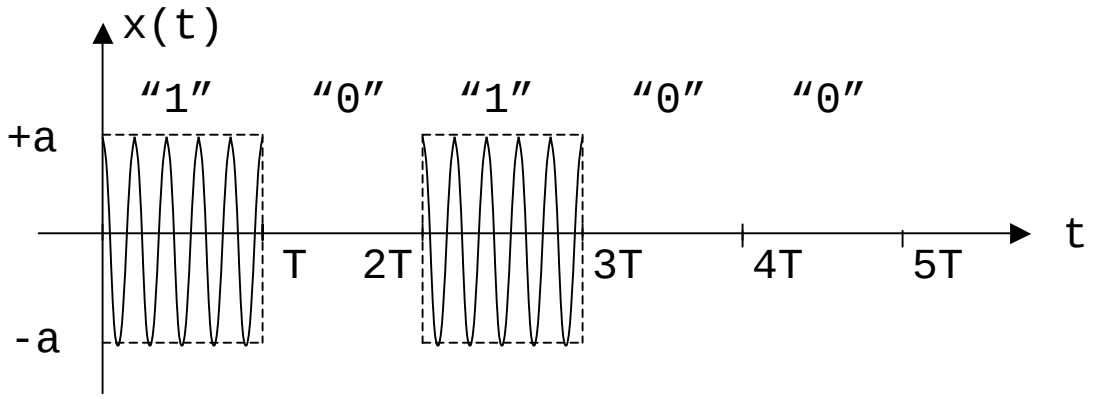


Power spectral density:

$$S_x(f) = \frac{1}{4}[S_s(f+f_c) + S_s(f-f_c)] \qquad (1)$$

Digital modulation 1: On-off keying (OOK)



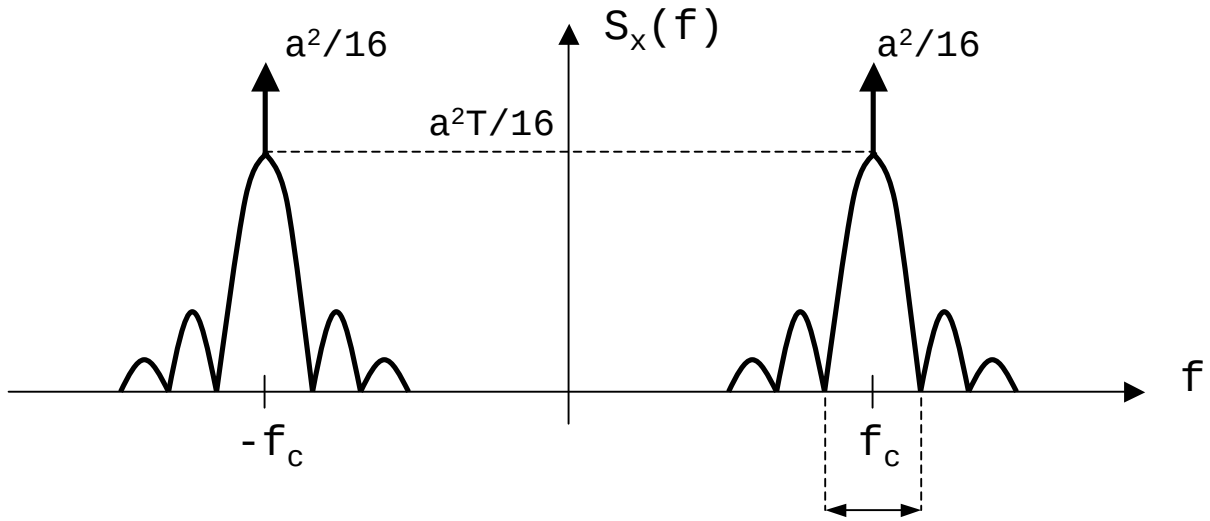


Similar to conventional AM

Power spectral density of OOK

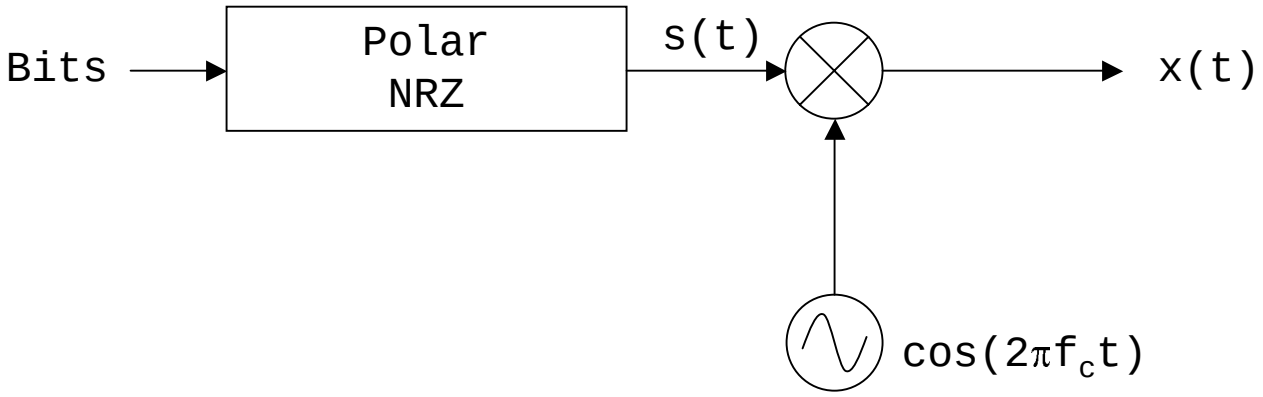
Using eq. (1):

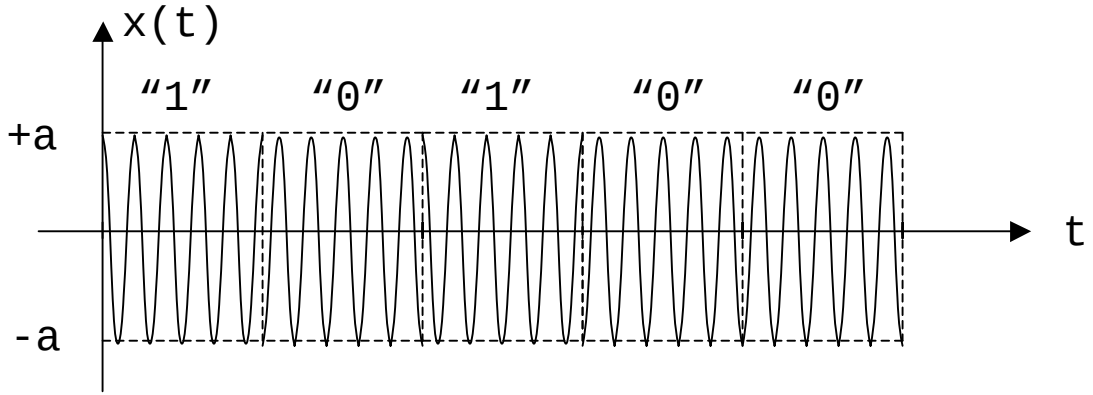
$$S_x(f) = \frac{a^2 T}{16}\left[\text{sinc}^2[T(f+f_c)] + \text{sinc}^2[T(f-f_c)]\right] + \frac{a^2}{16}\left[\delta(f+f_c) + \delta(f-f_c)\right]$$



W=2/T: Null-to-null bandwidth

Digital modulation 2: Binary phase-shift keying (BPSK) or amplitude-shift keying (ASK)



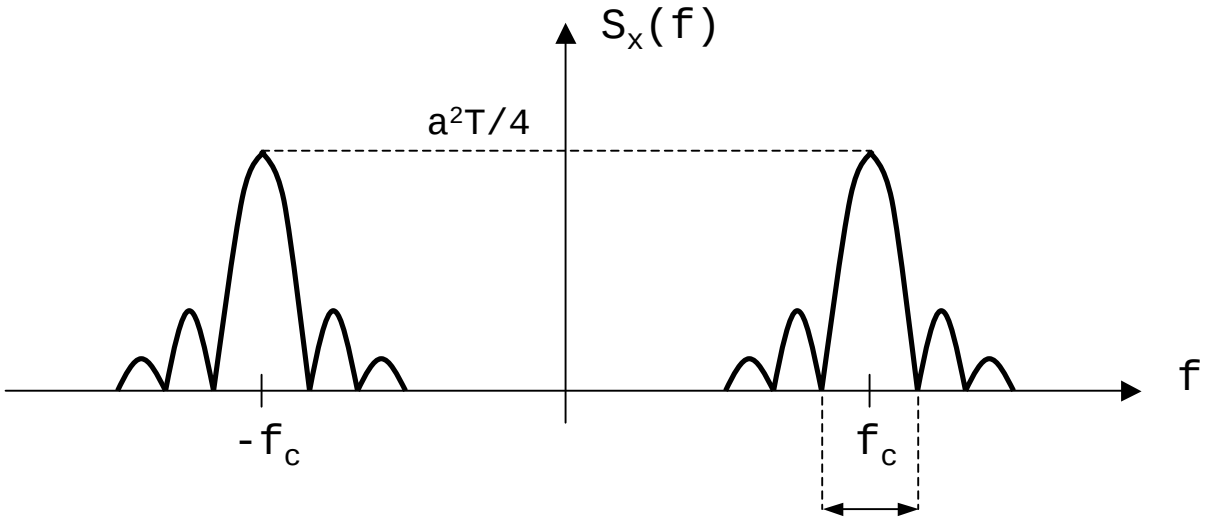


Similar to DSB-SC AM

Power spectral density of BPSK/ASK

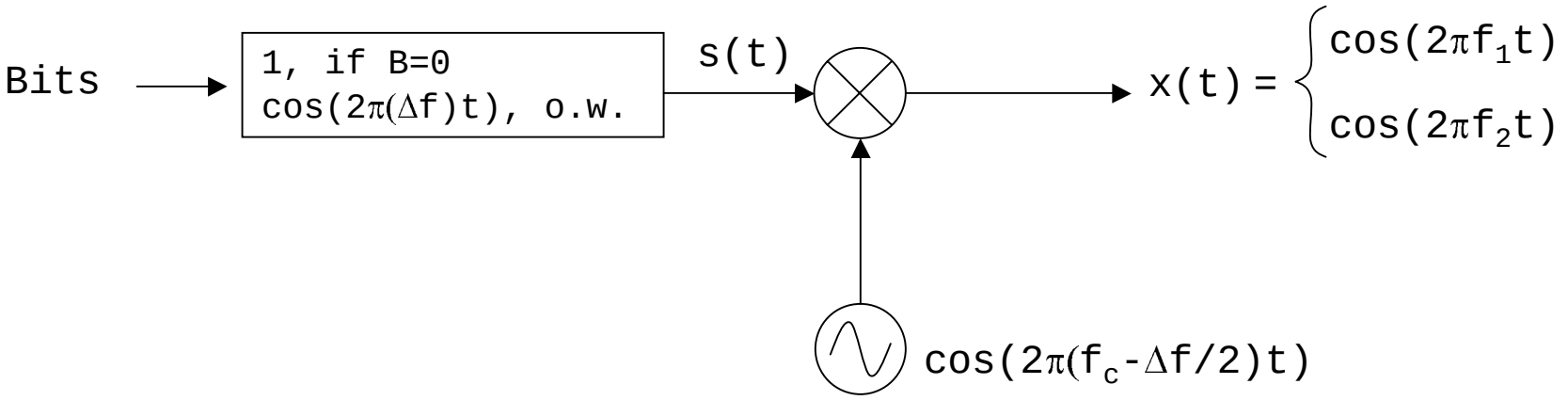
Using eq. (1):

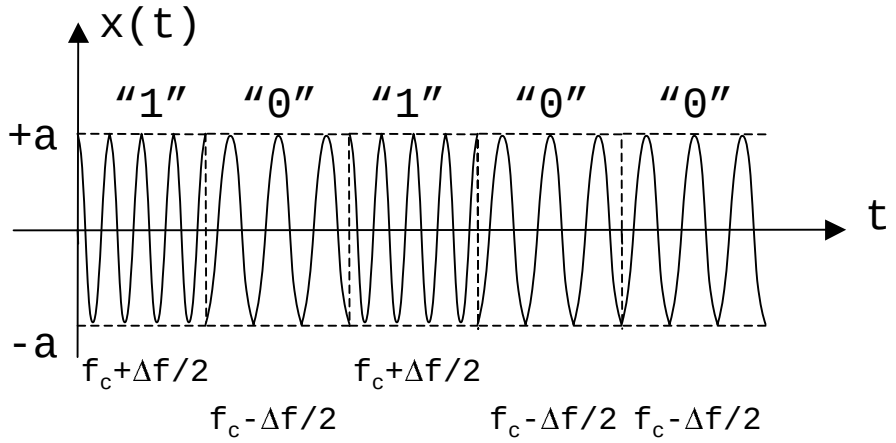
$$S_x(f) = \frac{a^2T}{4}\left[\text{sinc}^2[T(f+f_c)] + \text{sinc}^2[T(f-f_c)]\right]$$



W=2/T: Null-to-null bandwidth

Example 3: Binary frequency-shift keying (BFSK)





Power spectral density of BFSK

In general: $f_1 - f_2 = \Delta f$

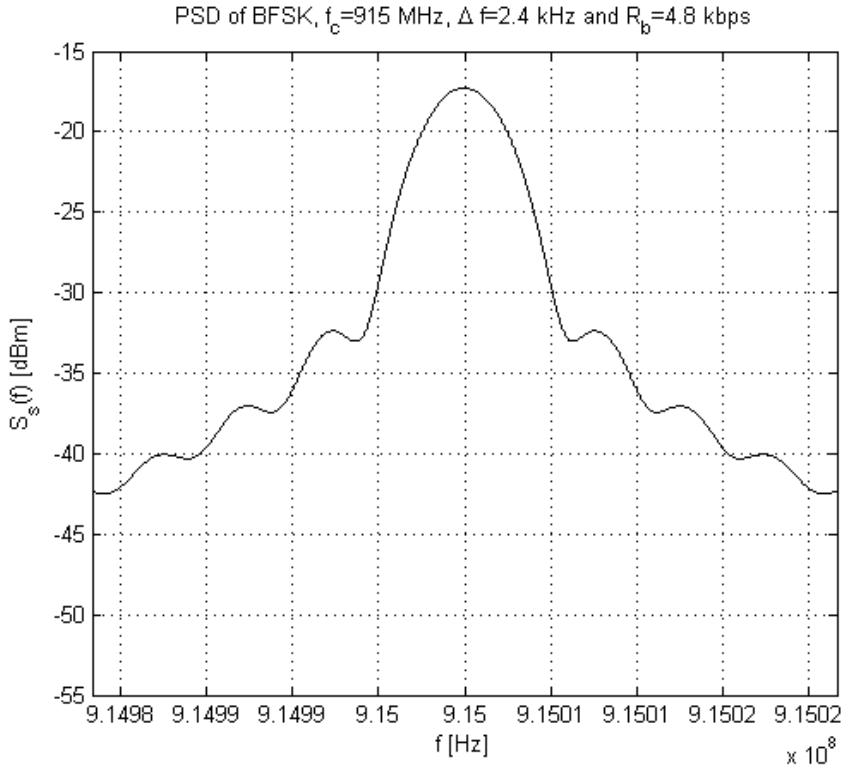
$$S_{\text{FSK}}(f) = \frac{1}{4T_b^2} \sum_{n=-\infty}^{\infty} \left\{ \left[\left| S_0\left(\frac{n}{T_b}\right) \right|^2 + \left| S_1\left(\frac{n}{T_b}\right) \right|^2 \right] \delta\left(f - \frac{n}{T_b}\right) \right\} + \frac{1}{4T_b} \left[|S_0(f)|^2 + |S_1(f)|^2 \right],$$

where

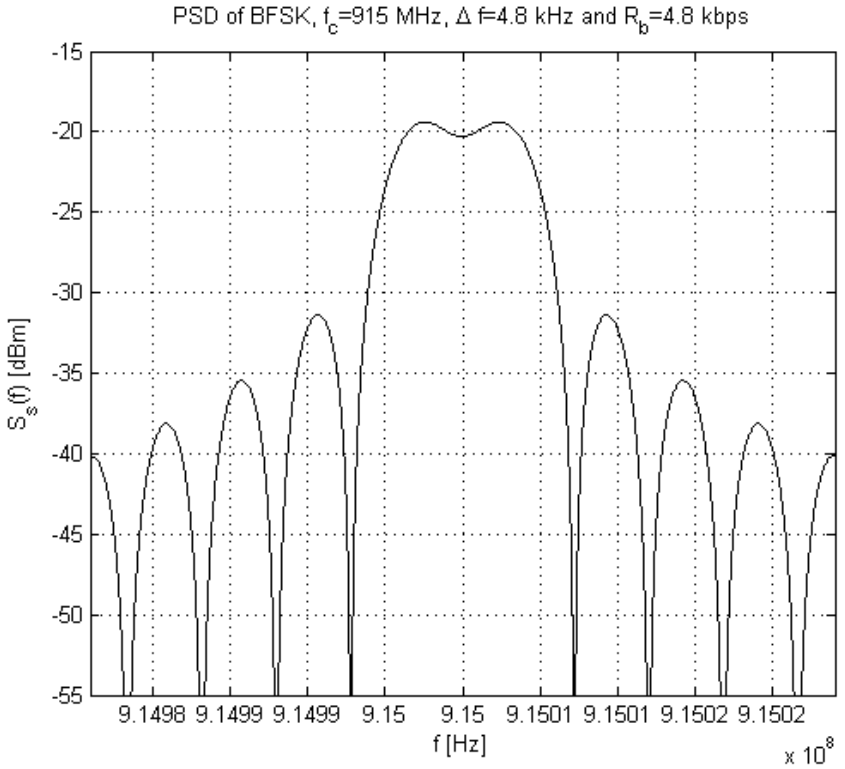
$$S_i(f) = \mathcal{F}\{s_i(t)\} = \frac{1}{2}\sqrt{\frac{2E_b}{T_b}} \left[\text{sinc}(T_b(f + f_i)) + \text{sinc}(T_b(f - f_i)) \right] e^{-j(\pi f T_b + \Theta_i)}, \quad i = 1, 2.$$

(Proakis)

BFSK spectrum as a function of Δf – part 1 (Rb = 4800 bps and f_c = 915 MHz)

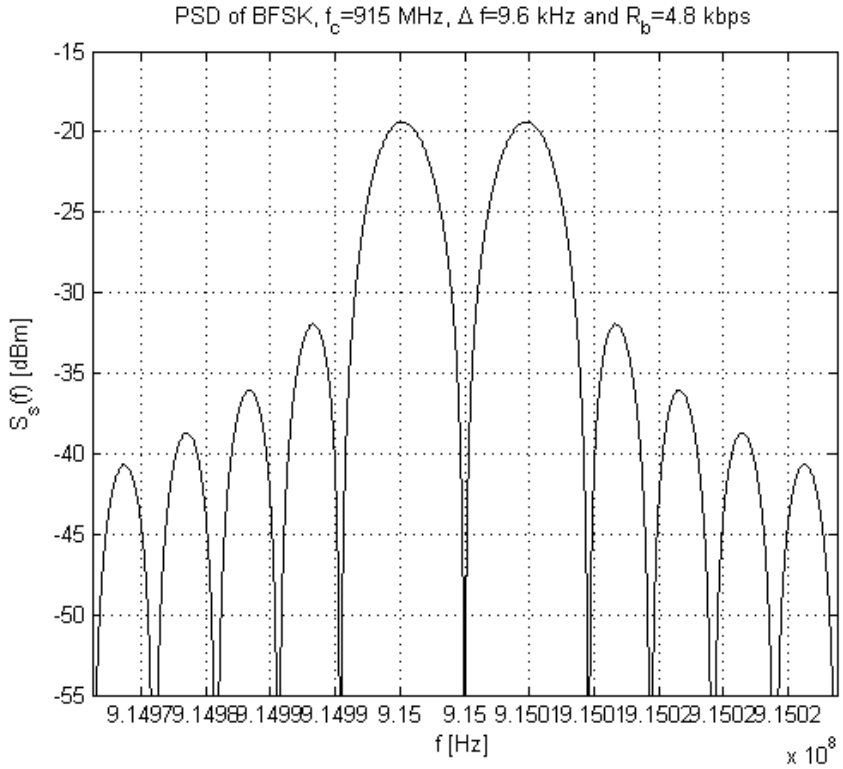


Δf = 2400 Hz

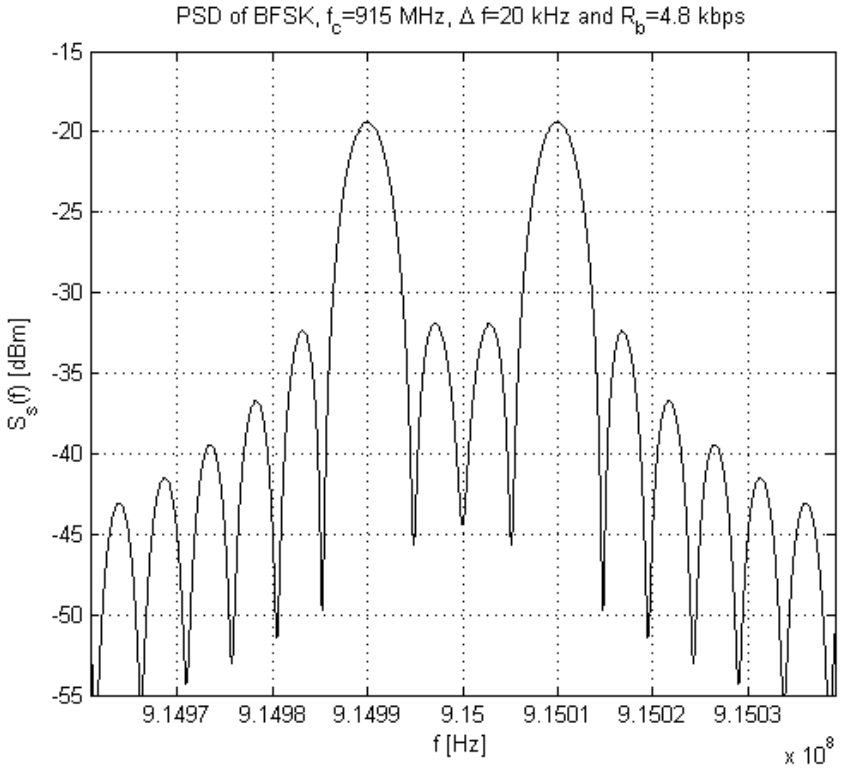


Δf = 4800 Hz

BFSK spectrum as a function of Δf – part 2 (Rb = 4800 bps and f_c = 915 MHz)



Δf = 9600 Hz



Δf = 20000 Hz