(i)

$$P_b = Q\left(\sqrt{\frac{3N}{K-1}}\right) = Q\sqrt{\frac{3\times 511}{63-1}}$$

$$= Q\times(4.9725) = 3.3\times 10^{-7}$$

In determining the above result, we assume that all interpreters provide equal power, the same as the desired user. All users are considered orthogonal & independent and the Gaussian approximation is assumed to be valid.

—x—x—

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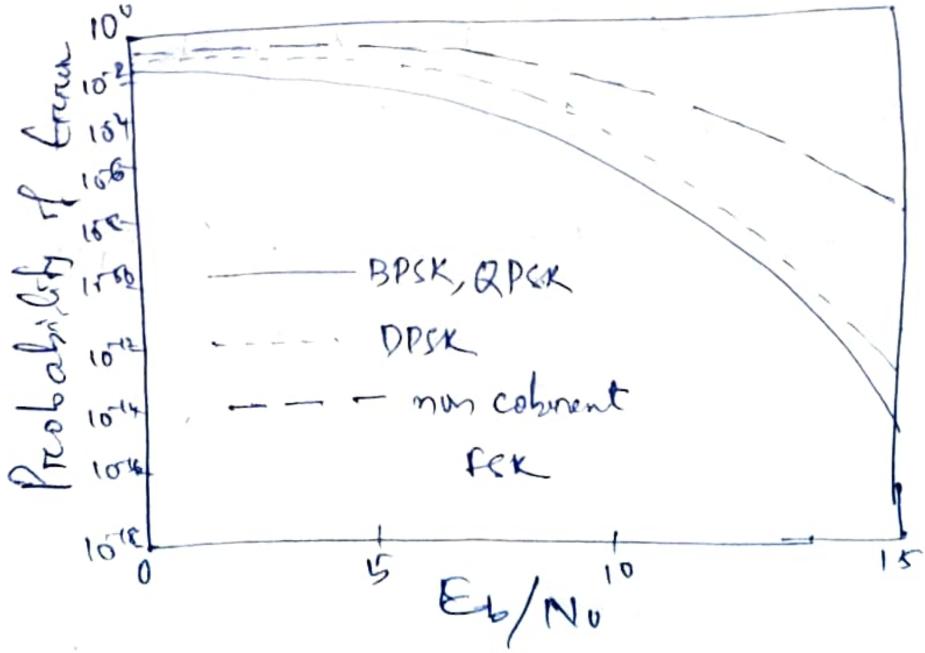
5.4) $P_{e,\,BPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$, $P_{e,\,DPSK} = \frac{1}{2}\exp\left(-\frac{E_b}{N_0}\right)$

$P_{e,\,QPSK} = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$, $P_{e,\,FSK\,NC} = \frac{1}{2}\exp\left(-\frac{E_b}{2N_0}\right)$

BPSK, DPSK and QPSK are all linear constant envelope modulation techniques. They can save bandwidth but are poor in power efficiency. Pulse shaping can make the modulation technique non-constant envelope and even more bandwidth efficient. BPSK and QPSK all need coherent detection which is more complicated than the non-coherent detection. FSK is non-linear constant envelope modulation. Using class C amplifier, it is power efficient but occupies a larger BW than linear modulation schemes, even when pulse shaping is used, FSK techniques are not as bandwidth efficient as linear techniques. FSK can use non-coherent detection.



$= 0.75 \Rightarrow B = \frac{0.75}{T_s} = 14.4$ kHz

$= \frac{1.1774}{2B} = 4.088 \times 10^{-5}$

$\Rightarrow H_G(f) = \exp(-1.67 \times 10^{-9} f^2)$

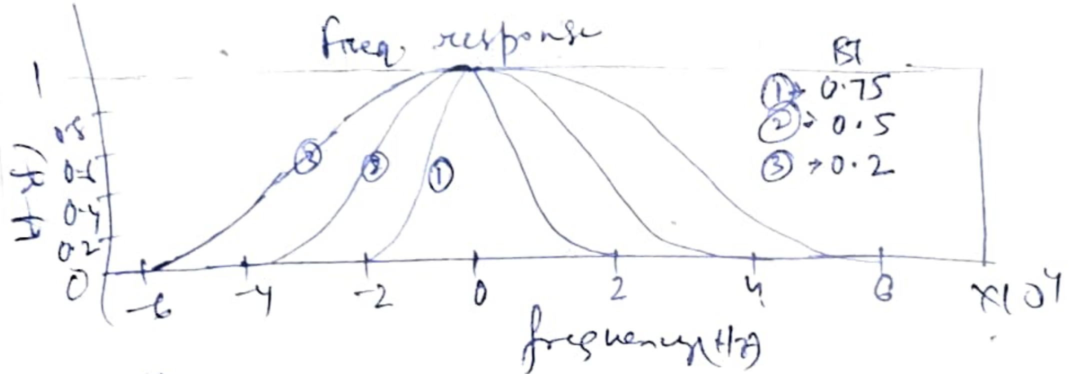
$h_G(t) = \frac{\sqrt{\pi}}{\alpha} \exp\left(-\frac{\pi^2}{\alpha^2} t^2\right) = 4.334 \times 10^4 \exp(-5.598 \times 10^9 t^2)$

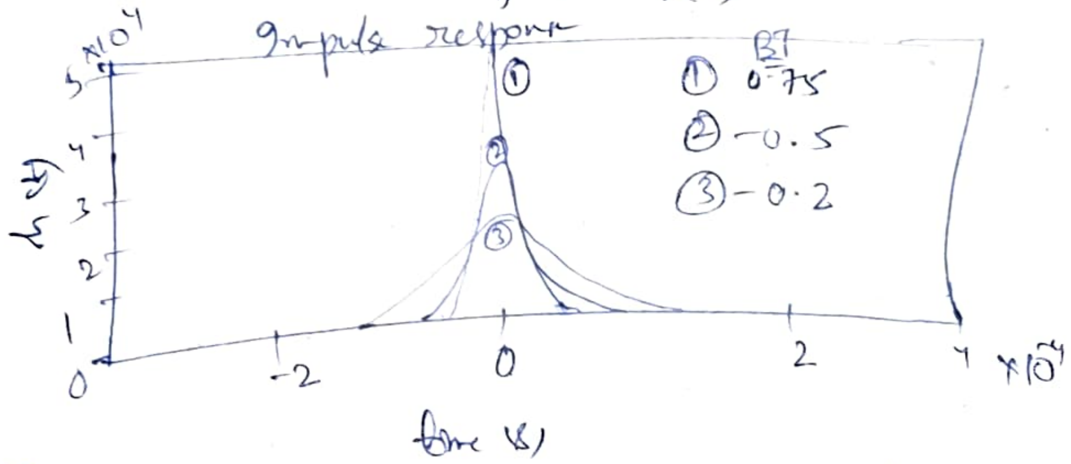
Using matlab,

$BT_s = 0.5 \Rightarrow f_{out} = 2.82 \times 10^{-3}$

$BT_s = 0.2 \Rightarrow f_{out} = 2.21 \times 10^{-7}$

$BT_s = 0.75 \Rightarrow f_{out} = 9.91 \times 10^{-3}$





6.18 $S_{msk}(t) = m_I(t) \cos\left(\frac{\pi t}{2T_b}\right) \cos(2\pi f_c t)$

$+ m_Q(t) \sin\left(\frac{\pi t}{2T_b}\right) \sin(2\pi f_c t)$

① $m_I(t) = 1, \; m_Q(t) = 1$

$S_{msk}(t) = \cos\left[2\pi f_c t - m_I(t) m_Q(t) \frac{\pi t}{2T_b} + 0\right]$

i) for IS-54 $R = 48.6$ kbps , $B = 30$ kHz

$\Rightarrow \eta_B = \frac{R}{B} = \frac{48.6}{30} = 1.62$ bps/Hz.

For GSM , $R = 270.833$ kbps , $B = 200$ kHz

$\Rightarrow \eta_B = \frac{270.833}{200} = 1.35$ bps/Hz

For PDC . $R = 42$ kbps , $B = 25$ kHz $\Rightarrow \eta_B = \frac{42}{25}$

$= 1.68$ bps/Hz

for IS-95 : $R = 9.6$ kbps , $B = 1.2288$ MHz

$\Rightarrow \eta_B = \frac{k \cdot R}{B} = \frac{k \times 9.6 \times 10^3}{1.2288 \times 10^6} = k \cdot 7.8 \times 10^{-3}$ b/H

If SNR = 20 dB = 100, the theoretical spectral efficiency $\eta_{B\,max} = \log_2(1+SNR) = \log_2(1+100)$

$= 6.66$ bps/Hz

(6.15)

$$H_{RC}(f) = \begin{cases} 1 & \forall \; 0 \le |f| \le \frac{1-\alpha}{2T_s} \\ \frac{1}{2}\left\{1 + \cos\left[\frac{\pi(|f| \cdot 2T_s - (1-\alpha))}{2\alpha}\right]\right\} & \forall \; \frac{1-\alpha}{2T_s} \le |f| \le \\ 0 & \forall \; |f| > \frac{1+\alpha}{2T_s} \end{cases}$$

$$h_{RC}(t) = \frac{\sin\left(\frac{\pi t}{T_s}\right)}{\pi t} \cdot \frac{\cos\left(\frac{\pi\alpha t}{T_s}\right)}{1 - \left(\frac{4\alpha t}{2T_s}\right)^2}$$

fraction of the total radiated energy that'll fall of the band $= \left(1 - \left(\int_{-15k}^{15k} H^2_{RC}(f)\left(\frac{\sin(\pi f T_s)}{\pi f T_s}\right)^2 df\right) \Big/ \int_{-\frac{(1+\alpha)}{2}R_s}^{\frac{(1+\alpha)}{2}R_s} H^2_{RC}(f)\left(\frac{\sin \pi}{\ldots}\right.\right.$

(2) when $m_I(t) = 1$, $m_Q(t) = -1$,

$$S_{MSK}(t) = \cos\left[2\pi f_c t - m_I(t)\, m_Q(t)\frac{\pi t}{2T_b} + \phi_k\right]$$

(3) when $m_I(t) = -1$, $m_Q(t) = 1$,

$$S_{MSK}(t) = -\cos\left[2\pi f_c t + \frac{\pi t}{2T_b}\right]$$

$$= \cos\left[2\pi f_c t - m_I(t) \cdot m_Q(t)\frac{\pi t}{2T_b} + \pi\right]$$

(4) when $m_I(t) = -1$, $m_Q(t) = -1$,

$$S_{MSK}(t) = \cos\left[2\pi f_c t - m_I(t)\, m_Q(t)\frac{\pi t}{2T_b} + \pi\right]$$

Thus

$$S_{MSK}(t) = \cos\left[2\pi f_c t - m_I(t)\, m_Q(t)\frac{\pi t}{2T_b} + \phi_k\right]$$

where $\phi_k = \begin{cases} 0 & \text{if } m_I(t) = 1 \\ \pi & \text{if } m_I(t) = -1 \end{cases}$

(6.19) for a binary message stream 01100101, the serial data stream is converted to two parallel data streams, each with symbol rate as one half of the bit rate. The even data bits $m_I(t)$ 0100 are first offset by one bit period and then multiplied by $x(t)$, the odd data bit $m_Q(t)$ are multiplied by $y(t)$. The sum of these two multiplication results is the MSK signal.

(12) (a) $T = 10^{-6}$ s

$R = \frac{1}{T} = 10^{6} s^{-1}$

$BW = 2R = 2\times10^{6}$ Hz

(b) $\alpha = 1$, $BW = (1+1)\times10^{6} = 2\times10^{6}$ Hz

(c) $RF\ BW = (1+\frac{1}{3})10^{6} = 1.333\times10^{6}$ Hz

(d) Nyquist pulses $\Rightarrow t = kT_s$ $(k \neq 0)$

Jitter is at 10^{-6} s $\Rightarrow$ timing offset is exactly one symbol.

Thus there will be No ISI except for the next symbol, which will be perfectly received i.e the receiver will be off sync by T.

(e) $\Delta f = \frac{1}{4T_b} = \frac{R_b}{4} = \frac{10^{6}}{4} = 250$ kHz

(f) No side lobes occur at $BT < \frac{1}{2}$

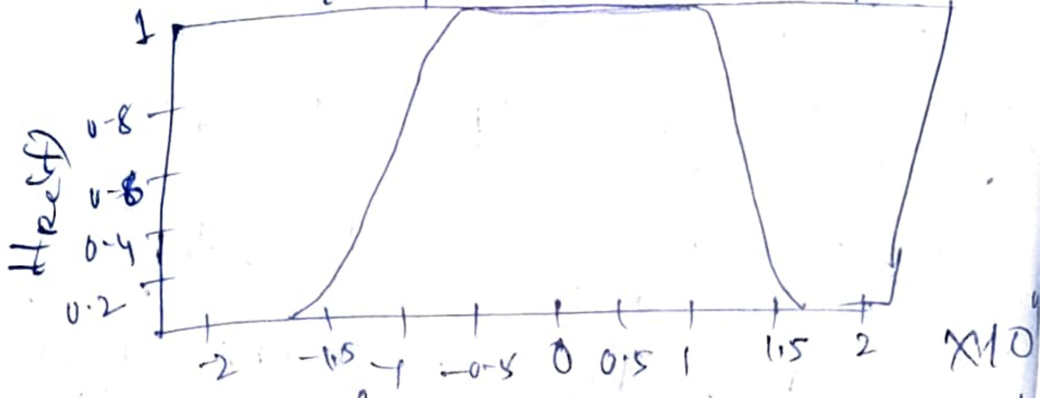
There will be two side lobes (one on each side of receiver)

(6.13) For $SNR = 30dB = 1000$, $B = 200$ kHz, the maximum possible data rate, $C = B\log_2(1+\frac{S}{N})$

$= 200\times10^{3}\log_2(1+1000) = 1.99$ Mbps. The data rate is 270.833 kbps which is only about 0.136 C

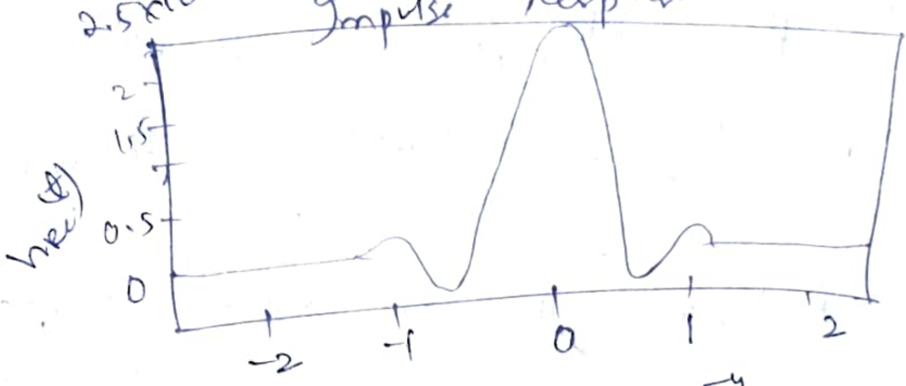
$= 3\times10^{-5} = 0.003\ \%$

freq. response of raised cosine filter



frequency (Hz) $\alpha = 0.35$, $R_s = 24.3k$

Impulse response



time (s) $\times10^{-4}$

(6.16) $BT_s = 0.5$, $T_s = \frac{1}{19.2\,ksps}$

$\Rightarrow B = \frac{0.5}{T_s} = 0.5\times19.2\times10^{3} = 9.6\ kHz$

$\Rightarrow \alpha = \frac{1.1774}{2B} = \frac{1.1774}{2\times9.6\times10^{3}} = 6.13\times10^{-5}$

$\Rightarrow H_a(f) = \exp(-\alpha^2 f^2) = \exp(-3.75\times10^{-9} f^2)$

$h_a(t) = \frac{\sqrt{\pi}}{\alpha}\exp\left(-\frac{\pi^2 t^2}{\alpha^2}\right) = 28907.08\exp(-2.62\times10^{9} t^2)$

$BT_s = 0.2 \Rightarrow B = \frac{0.2}{T_s} = 0.2\times19.2\times10^{3} = 3.84\ kHz$

$\Rightarrow \alpha = \frac{1.1774}{2B} = 1.533\times10^{-4}$

$\Rightarrow H_a(f) = \exp(-\alpha^2 f^2) = \exp(-2.35\times10^{-8} f^2)$

$\Rightarrow h_a(t) = 11559\exp(-4.195\times10^{8} t^2)$