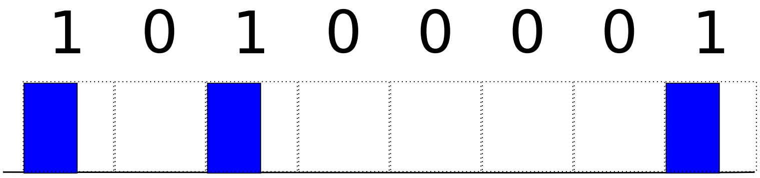
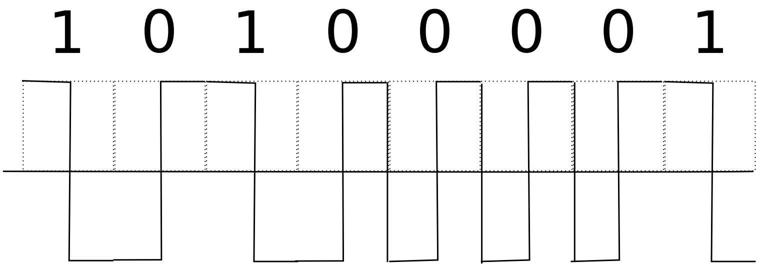
10.1 Sketch Unipolar RZ:



Sketch Manchester:



Minimize DC - Manchester has 0 DC (average is always 0).

Minimum Bandwidth - Similar - but Unipolar RZ is a bit better.

Maximum Timing Information - Manchester always has a transition during the middle of each bit period. RZ only has timing information during '1's.

10.2 (CD Audio as PAM)

Bandwidth as binary PAM.

$r_b = 44100 \times 16 = 705.6$ kbps

Bandwidth required needs to be $\geq \frac{1}{2} r_b = 352.8$kHz

If only have 3 kHz, need to have $L = \log_2 M$ symbols.

$\frac{705600}{L} \leq 2B = 6$kHz

117.600 bits per symbol.

$M = 2^{118}$ unique symbols.

Having such a high M, means that the SNR needs to be extremely large. Otherwise it is highly possible for bit errors to occur.

10.3 . (tenary system)

10.4 For these we use the formula presented in lectures:

$G_x(f) = \frac{1}{D} G_p(f) G_a(e^{j2\pi fD})$

This has two components, the PSD of the input data (G_a), and the ESD of the pulse G_p.

Since we are using rectangular pulses, the ESD of the pulse depends on the period of the pulse. Therefore we calculate the autocorrelation of the structure depending on the probability of certain bits.

Autocorrealtion of the first bit is: R(0) = 0.5 (ONE) + 0.5 (ZERO)

Autocorrelation of future bits is going to be zero, because all the possibilities (0->0, 0->1, 1->0, 1->1) although equiprobable (0.25 probability), end up cancelling each other out.

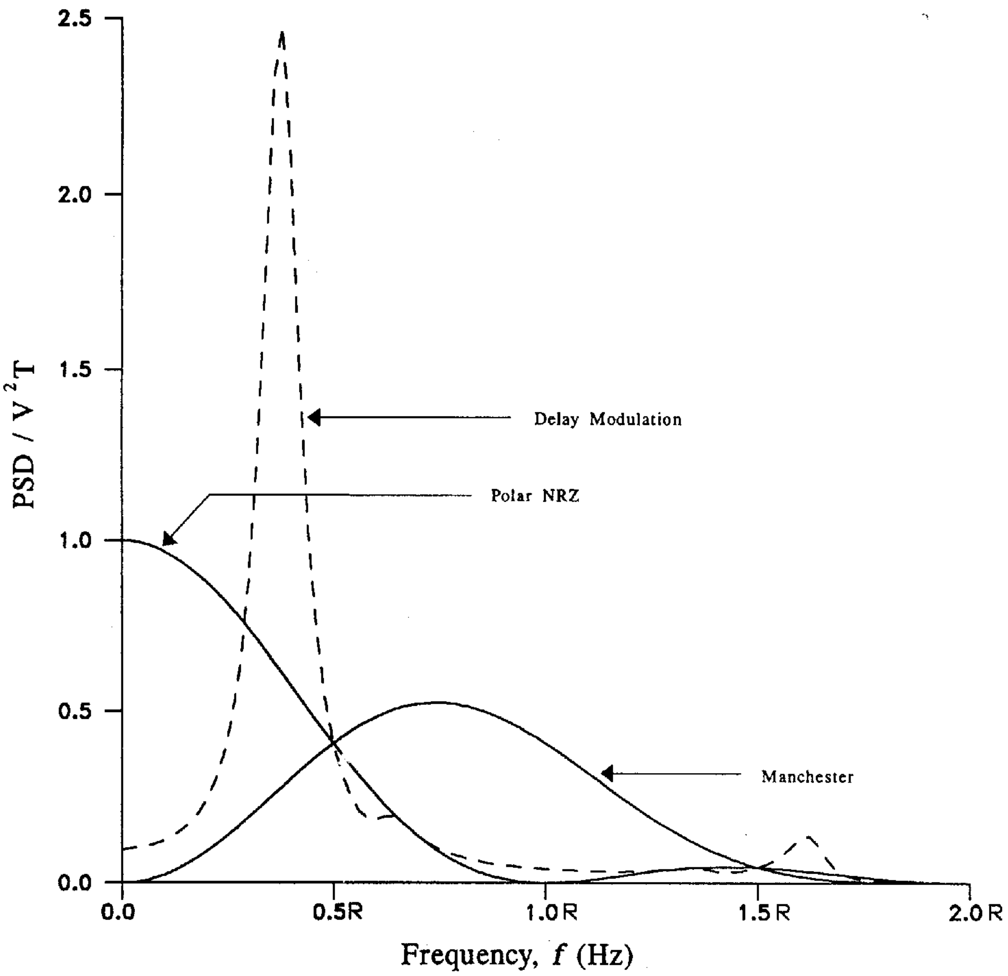
After doing this should be able to get the following answers:

PSD of Polar RZ:

$P\,(f) = \frac{A^2 T_b}{4}\left(\mathrm{sinc}^2(\pi f T_b)^2\right)\sin^2(\pi f T_b)$

PSD of Manchester:

$P\,(f) = A^2 T_b\,\mathrm{sinc}\,(\pi f T_b/2)\,\sin^2(\pi f T_b/2)$



10.5 $P_e = Q\left(\frac{A}{2\sigma}\right) \leq 10^{-6} \Longrightarrow \frac{A}{2\sigma} \geq 4.76$

Unipolar NRZ: $P_e = Q\left(\sqrt{SNR}\right)$

$4.76^2 \leq \left(\frac{A}{2\sigma}\right)^2 \leq \frac{S_R}{\left(N_0 \frac{r_b}{2}\right)}$

$\Longrightarrow S_R \geq 4.76^2 \times \frac{1}{2} \times 10^{-9}/r_b = 0.0113\mu W$

Polar NRZ: $P_e = Q\left(\sqrt{\frac{1}{2}SNR}\right)$.

$\left(\frac{A}{2\sigma}\right)^2 \leq \frac{1}{2}\frac{S_R}{N_0 r_b/2}$

$\Longrightarrow S_R \geq 0.0226\mu W$

10.6 $p_y(y|H_0) = p_n(y + A/2), p_y(y|H_1) = p_n(y - A/2), p_n(n) = \frac{1}{\sqrt{2\pi\sigma^2}}e^{-n^2/2\sigma^2}$

$$\text{so} P_0 \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(V+A/2)^2/2\sigma^2} = P_1 \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(V-A/2)^2/2\sigma^2}$$

$$P_0/P_1 = e^{[(V+A/2)^2-(V-A/2)^2]/2\sigma^2} = e^{VA/\text{sigma}^2}$$

$$\text{Hence, } VA/\sigma^2 = \ln(P_0/P_1) \implies V_{opt} = \frac{\sigma^2}{A}\ln(P_0/P_1)$$