BINARY BANDPASS MODULATION PROBLEM SHEET

(extracted from *Digital Communications* by Andy Bateman- Addison Wesley pp138-139)

1. A coherent binary ASK data system has a phase error of 25° in the recovered carrier reference. What will be the percentage reduction in symbol output voltage from the mixer detector and how much must the input symbol energy be increased to compensate for the loss due to carrier error?

Voltage Loss = 1- cos(25) = 0.0937 = 9.4%
Energy increase ratio = x
Normalised energy = 1= x.$(\cos 25)^2$ => x = 1.217

2. A binary ASK modem uses non-coherent detection. With reference to the BER curves for binary ASK in the notes, what is the Eb/No value required to achieve an error probability of less than 1 in 10^2? What is the equivalent performance of a coherent ASK scheme at this E_b/N_0 value.

Non-Coherent ASK Detection Requires Approximately 12dB Eb/No to achieve a BER = 10^{-2}.
For the same Eb/No coherent ASK achieves a BER = 10^{-5}.

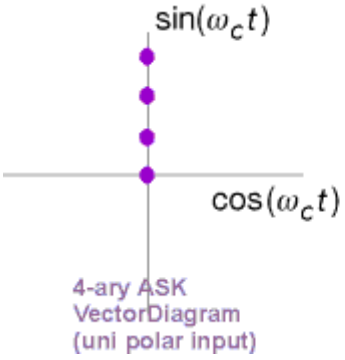
3. A coherent binary ASK modem is found to have a phase error in the recovered carrier of 45°. Will the performance of this modem be improved if non-coherent detection is used instead of the imperfect coherent detection process?

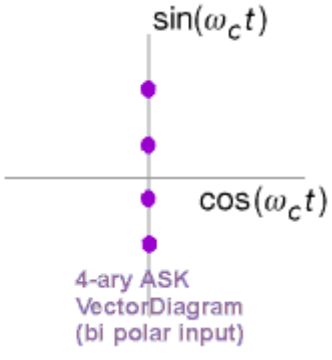
Loss in signal power due to phase error = $(\cos(45))^2$ = 0.5 = 3dB.
The difference in Eb/No requirement between coherent and non-coherent ASK is approximately 3dB. Thus, these two systems will perform equally. The non-coherent system will be simpler however.

4. Draw the constellation diagram for a four-level ASK modulation format using a sin $\omega_c t$ carrier when the modulation input is:

   A four level unipolar signal

   A four level bipolar signal.





5. What is the bit error probability for non-coherent binary FSK for an E_b/N_0 value of 10 dB? What approximate E_b/N_0 is required to achieve the same BER performance for coherent FSK and coherent ASK?

For non-coherent binary FSK, BER = 0.5exp(-Eb/2No) = 3.37×10^{-3}
From the BER curves it can be seen that coherent ASK and FSK require around 2dB less Eb/No to achieve the same performance.

6. A designer has been asked to build a radio data modem that must be tolerant to a frequency error in the receiver system. He is less concerned about the noise tolerance of the modem. Which modulation format, ASK or FSK, would you recommend for this task?

ASK is less sensitive to frequency error since the information is conveyed by the envelope of the signal.

7. A binary PSK modem is designed to work within a bandwidth of 8 kHz. What is the maximum data rate that can be delivered if a raised cosine filter with $\alpha = 1$ is used?

$C=B\log_2 M/(1+\alpha) = 8 \times 10^3 \times 1/2 = 4$kbits/s.

8. What is the bandwidth efficiency of a BPSK modem with a pulse-shaping filter with $\alpha = 0.5$?

$C/B = \log_2 M/(1+\alpha) = 1/1.5 = 0.66$ bits/s/Hz (Contradicts Bateman)

9. When cables are installed in a building, it is not unusual for the engineers to get the connections of the twisted pair reversed. How can a binary signalling scheme be designed to cope with this eventuality and maintain correct polarity data transfer?

Differential Encoding (as applied to DEPSK) can solve this problem.

10. A DPSK transmitter can generate an average power of 1 nW at the input to a receiver which has a noise power density of 0.5×10^{-12} Watts/Hz. If the symbol rate is 100 symbols per second, what is the BER performance for a DPSK decoder in the receiver?

For Binary Transmission, Eb = Average Power x Symbol Period
$= 10^{-9} / 100 = 10^{-11}$
For DPSK, BER = 0.5exp(-Eb/No) = $0.5\exp((-1 \times 10^{-11})/(0.5 \times 10^{-12}))$
$= 1.03 \times 10^{-9}$