MULTI LEVEL MODULATION PROBLEM SHEET

(extracted from *Digital Communications* by Andy Bateman- Addison Wesley pp159-160)

1. An 8-ary ASK scheme makes use of a root raised cosine filter in both the transmitter and the receiver, with an α of 0.33. What is the bandwidth required to support a data rate of 64kbps?

2. A digital voice link requires a bit error performance of no worse than 1 error in 10^3. From the bit error plot for M-ary ASK, what is the approximate E_b/N_0 required for binary ASK and an 16-ary ASK modem?

3. An 32-ary ASK modem has a symbol error rate of 2 in 10^5 under worst case conditions. What is the approximate bit error rate assuming Gray coding has been used.

4. An 4-ary orthogonal FSK modem has a symbol rate of 2400 symbols per second. If the lowest symbol frequency is 8kHz, What will the other symbol frequencies be?

5. What is the maximum bandwidth efficiency possible for a modem required to operate with an E_b/N_0 of –1.2dB.

6. If the peak signal power for a 16-QAM system is 200 W, measured in a 50Ω load, what are the amplitudes of the different symbol vectors in the transmitted waveform? (Neglect any filtering effects)

7. A 16-QAM data link operates at 256 kbps. What is the underlying symbol rate on the channel, and what is the occupied bandwidth if 2 root raised cosine filters are employed, one in the transmitter and one in the receiver, each with an α of 0.5?

8. What is the minimum bandwidth required to support a 256 kbps data stream using:
   (a) four-level bipolar baseband signalling
   (b) four level polar baseband signalling
   (c) BPSK
   (d) QPSK
   (e) 64-QAM

9. A microwave line-of-sight communication link uses 256-QAM to convey 32Mbps. The bandwidth occupied by the signal is 7 MHz.
   (a) What is the value of α used in the raised cosine filter.
   (b) If the signal to noise ratio on the link is 40dB, what is the theoretical maximum capacity for the channel in a 7MHz bandwidth?

10. A customer requires a microwave radio link to provide a bit rate of 2 Mbps in a bandwidth of 400kHz. The minimum signal to noise ratio on the channel is 30dB.

    Can the channel support the require capacity, and how many symbol states would be required?