

The University of Queensland
School of Information Technology & Electrical Engineering
COMS3100/7100 Introduction to Communications

Tutorial 10

These exercises relate to material in Lectures 27–28, but also CCR, pp. 435–453.

Exercises:

- ★ 10.1 (a) Sketch the unipolar RZ line coded waveform for the bit sequence 10100001. Assume the bit interval is $1\ \mu\text{s}$.
- (b) Repeat (a) for the Manchester NRZ line code.
- (c) Based on your answers to (a) and (b), what are the advantages of the Manchester NRZ line code compared to the unipolar NRZ line code. Assume the preference is: minimum DC; minimum bandwidth (location of first spectral null) and maximum timing information, *i.e.*, indication of beginning, middle or end of each bit interval.
- 10.2 A compact disc produces 44100 symbols per second using 65536 different symbols (2^{16})
- (a) Find the bandwidth required to transmit the output as a binary PAM signal.
- (b) Find M so that that the output could be transmitted as an M -ary signal on a telephone line having a bandwidth of 3 kHz.
- (c) Comment on what is required of the channel to be able to transmit in only 3 kHz, compared to 44.1 kHz.
- 10.3 For a baseband communication system, your company has inherited a design for a *polar ternary NRZ* line code modem, *i.e.*, each pulse can take the amplitudes 0 or $\pm A$. Your company is planning to build a product based on these modems to communicate binary information.
- (a) The current product plan calls for the modem to be used in a mode that emulates polar binary NRZ, *i.e.*, only the amplitudes $\pm A$ would be used: one bit per symbol. However, your colleague claims she can increase the bit rate by 50% by using all three amplitude levels and setting amplitudes in pairs, *i.e.*, each symbol would consist of two consecutive pulses. How would this scheme work? Demonstrate the bit-rate advantage for your design assuming the bits 100110 are to be transmitted.

- (b) Extending this idea by using larger numbers of consecutive pulses in each symbol, show that further increases in bit rate can be achieved. *Hint*: Consider a symbol of 7 consecutive pulses.
- 10.4 (a) Find and sketch the power spectrum of a binary PAM signal with polar RZ format and rectangular pulses, assuming independent and equiprobable message bits.
- (b) Repeat part (a) for the split-phase Manchester format.
- ★ 10.5 In Lecture 27, the BER of a binary unipolar NRZ system with AWGN and employing a LPF was found to be $P_e = Q\left(\sqrt{\frac{1}{2}\text{SNR}}\right)$. For polar NRZ, the corresponding expression is $P_e = Q(\sqrt{\text{SNR}})$. If the noise power at the detector is $1 \text{ nW}/r_b$, find the required signal power to achieve a BER of 10^{-6} for:
- (a) unipolar NRZ and
- (b) polar NRZ.

Hint: Use CCR Table T.6, pp. 790–791.

- ★ 10.6 Suppose, in the derivation of the optimal threshold for unipolar NRZ, we assume that $\Pr\{E_0\} \neq \Pr\{E_1\}$. What is the new value for the optimal threshold v_{opt} in terms of these probabilities?