

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

**Tutorial 11**

These exercises relate to material in Lectures 29–30, but also CCR, pp. 495–499, 526–541, 611–620.

**Exercises:**

- 11.1 (a) The first telephone lines were single wire, earth return. Twisted-pair lines were soon preferred because of their improved crosstalk immunity. Still later, four-wire lines were used to connect exchanges. Why and how?
- (b) The facsimile machine actually pre-dates the telephone, with Giovanni Caselli's *pantélégraphe* entering commercial service in 1865, albeit in a very restricted sense (for special electroplated 'documents' marked with ferrous ink). The early modern (analogue) facsimile machines are a good example of fusion of the ideas behind television and telephony. How?
- (c) When the first telecommunications satellite, TELSTAR I, was launched in 1962, it was hailed as a revolution for international telephony. These days, satellites are only rarely used for international phone calls. Why?
- ★ 11.2 (a) When PCM was introduced on trunks and 'junctions' between exchanges, they replaced analogue TDM and FDM. As a result, spectral efficiency was severely reduced. Why?
- (b) Suppose CD-quality (mono) audio is to be transmitted via PCM. Here, CD quality means a sampling rate of 44.1 ksp/s with 16 bits per sample. How should such a system be designed if 200 kHz of bandwidth is available?
- ★ 11.3 Several high-fidelity audio channels with bandwidth  $W = 15$  kHz are to be transmitted via binary PCM with  $\nu = 12$  bits per sample. Determine how many of the PCM signals can be accommodated on an E1 line. What is the *bandwidth efficiency* when comparing the PCM bandwidth to those of the original analogue signals?
- ★ 11.4 Suppose an OOK signal consists of RZ rectangular pulses with duration  $T_b/2$  where  $r_b = 1/T_b \ll f_c$ .
- (a) Find the equivalent baseband spectrum and sketch the PSD.

(b) Sketch the signal representing the sequence 010110. Then find the ratio of the carrier-frequency power to the average power.

11.5 Suppose a binary FSK signal with discontinuous phase is generated by switch between two oscillators with outputs  $A_c \cos(2\pi f_0 t + \theta_0)$  and  $A_c \cos(2\pi f_1 t + \theta_1)$ . Since the oscillators are unsynchronised, the FSK signal may be viewed as the interleaved sum of two independent OOK signals. Use this approach to find and sketch the PSD.

★ 11.6 In a certain university, students are graded on a 1–7 scale. Suppose it is found, across the whole student population and all courses, the probability of the grade  $G$  is  $p_1 = p_2 = p_3 = 0.05$ ,  $p_4 = 0.35$ ,  $p_5 = 0.25$ ,  $p_6 = 0.15$  and  $p_7 = 0.1$ .

(a) Calculate  $H_2(G)$ .

(b) Assuming grades are a DMS, how much information is contained in the students' semester results 7, 6, 5, 7 and 2, 3, 4, 4? (What's wrong with this assumption?)

(c) Construct the Huffman code for university grades and calculate the average code length.