

1. (a) Explain what is meant by digital communication. Outline the advantages of digital communication over analogue communication. [8 marks]
- (b) State the sampling theorem. Explain what is meant by the *Nyquist rate* and *aliasing*. [8 marks]
- (c) An analogue speech signal is bandlimited to 8 kHz and sampled at 1.25 times the Nyquist rate and quantised to 256 levels. What is the bit rate of the digital signal required to represent this analogue signal? Comment on the result. [8 marks]
- (d) Explain what is meant by *companding*. Comment on where the A-law and the  $\mu$ -law for *companding* may be used. [9 1/3 marks]
2. (a) Explain with the aid of a block diagram the operation of a delta modulation (DM) system. Outline the advantages of the DM system. [8 marks]
- (b) Describe the two types of quantisation error that can occur in a DM system. [8 marks]
- (c) A  $1 V_{pp}$ , 10 kHz sinusoid is to be converted to a digital signal by DM with a step size of 50mV. Determine the minimum sampling rate that will allow the DM system to follow the fastest changes in the input analogue signal. [9 1/3 marks]
- (d) Explain what is meant by *waveform coding* and *source coding* in the context of digitizing human speech. In each case give an example that is representative of the technique. [8 marks]
3. (a) Explain what is meant by *multiplexing*. Describe each of the following techniques: *frequency division multiplexing (FDM)*, *time division multiplexing (TDM)*, and *code division multiplexing (CDM)*. In each case indicate where the technique might be used. [8 marks]
- (b) Compare the performance of frequency division multiple access (FDMA) and time division multiple access (TDMA) in terms of throughput and average delay. State all assumptions made in carrying out the comparison. [9 1/3 marks]
- (c) Using appropriate diagrams describe the structure of a frame and multiframe in the 30 channel PCM TDM signal. Include in your answer how synchronisation and signalling information is carried in the signal. [8 marks]
- (d) Explain what is meant by *plesiochronous operation* and *plesiochronous digital hierarchy*. [8 marks]

4. (a) Explain what is meant by *attenuation* and *dispersion* in the context of digital baseband signal transmission.

[8 marks]

- (b) Explain what is meant by an *amplifying repeater* and a *regenerative repeater*.

[8 marks]

- (c) Compare the performance of an amplifying repeater and a regenerative repeater by deriving an expression for the average probability of error after  $m$  hops for each case. You may assume binary polar signaling in the presence of AGWN where the average probability of error  $P_e$  is given by

$$P_e = Q\left(\sqrt{\frac{2E_s}{N_0}}\right)$$

where  $Q(\cdot)$  is the complementary error function,  $E_s$  is the average symbol energy and  $N_0$  is the average noise power spectral density.

[9 /13 marks]

- (d) Explain how intersymbol interference (ISI) can arise in the transmission of digital baseband signals over bandlimited channels.

[8 marks]