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 4 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?

[8 marks]

(d) Explain what is meant by *companding*. Comment on where the A-law and the μ–law for *companding* may be used.

[9 1/3 marks]

2. (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]

3. (a) Outline some of the desirable properties that a line code for digital baseband signalling should exhibit.

[8 marks]

(b) Describe the following line codes:

(i) Unipolar non return-to-zero (NRZ)
(ii) Polar return-to-zero (RZ)
(iii) Bipolar RZ

In each case, sketch the line code for the input binary data sequence 11101001 and state its advantages and disadvantages.

[9 marks]

(c) Describe how a timing clock signal may be extracted from the bipolar RZ line code.

[8 1/3 marks]

(d) Describe the HDB3 line code and briefly outline its advantages.

[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 $Q(.)$ 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]