**1. (a)** Explain how digital communication differs from analogue 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 6 kHz and sampled at 1.25 times the Nyquist rate and quantised to 128 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 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. Briefly explain how their impact on the performance of a DM system can be minimized.

[8 marks]

**(c)** A 500 $mV_{pp}$, 5 kHz sinusoidal input signal is to be converted to a digital signal using 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. Outline any disadvantages of these techniques.

[8 marks]

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

[5 marks]

**(b)** Describe the following line codes:

(i) Polar return-to-zero (RZ)
(ii) Manchester
(iii) Alternate Mark Inversion (AMI)

In each case, sketch the line code for the input binary data sequence 11001011 and outline its advantages and disadvantages.

[12 marks]

**(c)** Describe how a timing clock signal may be extracted from the AMI 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.

[6 marks]

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

[6 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.

[10 marks]

**(d)** Describe with the aid of a block diagram the two basic steps in the detection of baseband binary signals. Include in your answer how a correlator could be used in the detection process.

[11 1/3 marks]