City & Guilds

9210-214
Level 7 Post Graduate Diploma in Engineering
Telecommunication systems engineering

Sample Paper

You should have the following for this examination
- one answer book
- non-programmable calculator
- pens, pencils, ruler

No additional data is attached

General instructions
- This examination paper is of **three hours** duration.
- This paper contains **eight (08)** questions.
- Answer **any five (05)** questions.
- The marks allocated to each question or parts of the question are shown in the brackets in the right hand margin. They are given for guidelines only.
- An electronic calculator may be used but candidates must show sufficient steps to justify their answers.
- Drawings should be clear, in good proportion and in pencil.

1 a) What is defined by the logical topology of a network? (3 marks)

b) How does the logical topology differ from the physical topology? (5 marks)

c) How can a single physical topology support multiple logical topologies? (3 marks)

d) Briefly describe the role of the access network and the transmission network in telecommunications. (4 marks)

e) Compare and contrast the traditional local loop with the digital subscriber loop in terms of the physical medium, length, available bandwidth, services provided, and network side termination. (5 marks)

2 a) The amplitude of a message signal, $m(t)$ is varied in the range of $\pm m$. The signal is sampled at the Nyquist rate and uses linear quantization. The amplitude range is divided into L uniformly spaced intervals. State any assumptions you make in answering the questions below.

i) Prove that the mean square quantization error is given by,

$$\overline{q^2} = \frac{m_p^2}{3L^2}$$ (5 marks)

ii) Prove that the peak signal to average quantization noise ratio is given by,

$$\left(\frac{S_0}{N_q}\right)_{peak} = 3L^2$$ (4 marks)

b) Consider an audio signal with spectral components limited to the frequency band 300 to 3300 Hz. Assume that a sampling rate of 8000 samples/s will be used to generate a Pulse Code Modulated (PCM) signal. The ratio of peak signal power to average quantization noise power at the output needs to be 30 dB.

i) What is the minimum number of uniform quantization levels needed, and what is the minimum number of bits per sample needed? (4 marks)

ii) Calculate the system bandwidth required for the detection of such a PCM signal. (3 marks)

iii) If we want to reproduce 1 hour of this waveform, calculate the number of sample that needs to be stored. (2 marks)

iv) Calculate the required data rate in bits/s. (2 marks)

3 a) State four (04) different services that can be provided by satellite systems. (4 marks)

b) Briefly explain the **attitude control** of satellite system. (3 marks)

c) Briefly explain about the station keeping in satellite system. (3 marks)

d) A broadcasting satellite system is operating in the Ku band with a downlink frequency of 12 GHz. The ground station transmit power is 6 W and the available bandwidth is 3 MHz. The distance between the ground station and the satellite is 42000 km. The ground station is equipped with a 3 m diameter parabolic antenna with an aperture efficiency of 0.5. The antenna has a noise temperature of 35 K and it is matched to a receiver which has a noise temperature of 100K. Calculate,

i) the gain of the ground station antenna (2 marks)

ii) the free space loss of the downlink (2 marks)

iii) the effective input radiated power (EIRP) of the system (2 marks)

iv) the noise power density at the receiver (2 marks)

v) noise power at the receiver. (2 marks)

4 a) Compare and contrast the direct and external modulation in optical communication with appropriate sketches. (6 marks)

b) Illustrate the following concepts with appropriate diagrams and a brief explanation.

i) Optical absorption. (2 marks)

ii) Spontaneous emission. (2 marks)

iii) Stimulated emission. (4 marks)

c) The bit rate of an optical link is 1 Gbps, the dispersion at 1.55 µm is 17 ps/nm-km and the attenuation is 0.25 dB/km. The transmitter has a spectral width of 1 nm, and an output power of 0.5 mW. The receiver requires –30 dBm of input power in order to achieve the desired bit error rate. Find the possible longest link length and mention which impairment limit the link length. (6 marks)

[Velocity of light in vacuum (c) = 3.0×10^8 ms^{-1}]

5 a) Distinguish between 3G and 4G cellular networks. (6 marks)

b) Provide a descriptive comparison between fixed channel allocation and dynamic channel allocation. (6 marks)

c) Differentiate micro and macro diversity. (2 marks)

d) A cellular system has an allocation of 1.5 MHz of bandwidth in each direction, and uses FDMA/FDD with 50 kHz channels. The area is covered by 20 hexagonal cells. Find the possible number of simultaneous calls,

i) if a 7- cell reuse pattern is used (4 marks)

ii) if a 4- cell reuse pattern is used. (2 marks)

6 a) i) State four (04) types of handoffs. (4 marks)

ii) Briefly explain the term 'frequency reuse'. (2 marks)

iii) Compare Direct Sequence Spread Spectrum (DS-SS) and Frequency Hopping Spread Spectrum (FH-SS). (4 marks)

b) A time division multiplexed/time division duplex (TDM/TDD) data stream on a certain RF carrier is shown in Figure Q6 b).

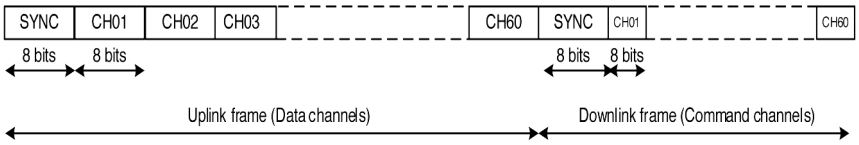

Figure Q6 b)

i) How many duplex users does this carrier support? Explain. (3 marks)

ii) If the total frame duration is 250 µs, find the uplink data rate for each user. (2 marks)

iii) Find the overall data rate on the downlink. (2 marks)

iv) If a single user requires an uplink data rate of 64 kb/s, suggest a method to provide this through the system. (3 marks)

7 a) i) State three (03) different types of cells found in cellular systems. (3 marks)

ii) What is mobility management? (2 marks)

b) Briefly describe the following.

i) Cell splitting. (3 marks)

ii) Cell sectoring. (3 marks)

c) Explain in detail the fading effects in a wireless channel. (9 marks)

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8 a) Compare and Contrast Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). (6 marks)

b) State two (02) different advantages of a wireless access system over a wire-line access system. (2 marks)

c) A cable-television operator uses an optical bus to distribute video channels to its subscribers. Each receiver needs a minimum of 100 nW to operate satisfactorily. Optical taps couple 5% of the power to each subscriber. Assuming a 0.5 dB insertion loss for each tap and 1 mW transmitter power, estimate the number of subscribers that can be added to the optical bus. (12marks)