City&
Guilds

9210-116
Level 6 Graduate Diploma in Engineering
Electronics and telecommunications

Sample Paper

You should have the following for this examination
- one answer book
- non-programmable calculator
- pen, pencil, ruler, drawing instrument

No additional data is attached

General instructions
- This examination paper is of **three** hours duration.
- This examination paper contains **ten** questions in Section A and Section B.
- Answer **five** questions in total with at least one question from each section.
- All questions carry equal marks. The maximum marks allocated to each part within a question are shown alongside.
- An electronic, non-programmable calculator may be used, but the candidate **must** show clearly the steps prior to obtaining final numerical values.
- Drawings should be clear, in good proportion and in pencil. Do **not** use red ink.

Section A

1 a) Define the 'Peak Inverse Voltage (PIV) rating' for a semiconductor power diode. (2 marks)

b) Using integration, show that the average value of a half wave rectified sine wave with amplitude 'A' is $\frac{A}{\pi}$. (4 marks)

c) It is required to design a low cost charger for a battery operated portable device. The charger output should be 6.5 V d.c. and should be powered from 240 V a.c. mains.

i) Draw the circuit of a simple half wave rectifier that uses a single power diode and a step down transformer that could be used as this charger. (6 marks)

ii) Calculate the PIV rating for this diode. (4 marks)

iii) Calculate the turns ratio of the step down transformer. (4 marks)

2 a) Explain why the Bipolar Junction Transistor (BJT) is called a 'bipolar' device. (2 marks)

b) i) Draw a single stage BJT amplifier circuit with self-bias. (3 marks)

ii) Briefly explain the purpose of coupling capacitors in the amplifier circuit. (2 marks)

c) Figure Q2.1 shows an amplifier stage used in an audio circuit.

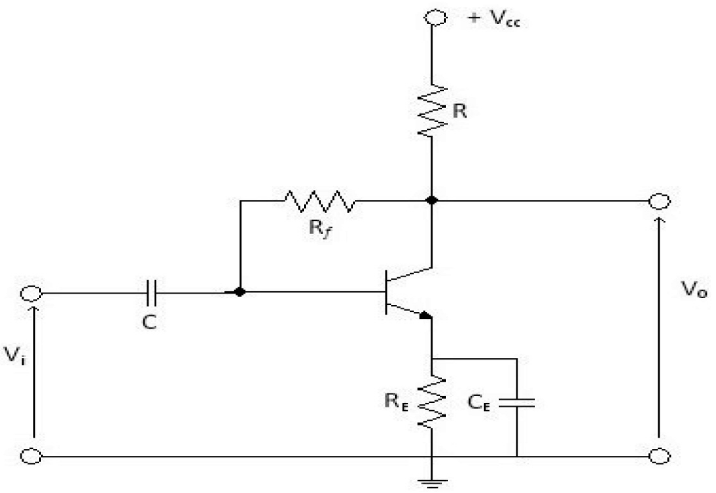

Figure Q2.1

i) Draw the small signal equivalent circuit for this circuit using the hybrid model for the transistor assuming that only the two hybrid parameters h_{ie} and h_{fe} are significant. (5 marks)

ii) Hence, obtain an expression for the voltage gain of this amplifier. (5 marks)

iii) Show that this circuit will operate as an inverting amplifier only if (3 marks)

$$R_f > \frac{h_{ie}}{h_{fe}}$$

3 a) In digital line transmission, systems it is necessary to regenerate the signal at repeaters placed at regular intervals of the line.

i) Explain why this is necessary. (2 marks)

ii) Compare the 'regeneration of digital signals' with 'amplification of analogue signals'. (4 marks)

b) i) Figure Q3.1 shows a simple regeneration circuit that uses a single op-amp, and a d.c. reference V_{ref}. Using a sine wave as an example input for V_i, explain the operation of this circuit. (3 marks)

ii) Identify a possible defect in the operation of this circuit. (1 mark)

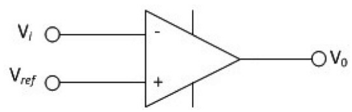

Figure Q3.1

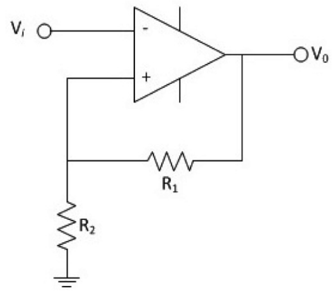

Figure Q3.2

c) Figure Q3.2 shows an improved version of this regenerator circuit.

i) Using a sine wave as an example input for V_i, explain the operation of this circuit. (6 marks)

ii) Draw an improved version of this circuit that places the two thresholds symmetrically above and below a d.c. voltage 'E'. (4 marks)

4 a) i) Using De-Morgan's theorem, show that a NAND gate with its inputs inverted will act as an OR gate. (3 marks)

ii) Hence, draw the combinational logic circuit that uses only NAND gates, to implement the following Boolean function. (3 marks)

$$Y = \overline{A}\overline{B}C + \overline{A}B\overline{C} + A\overline{B}\overline{C} + ABC$$

b) i) Write the truth table for a 2-channel data selector that selects 1 out of 2 binary inputs X_1 or X_0 based on a single control input P. (2 marks)

ii) With the aid of a diagram, show how three such 2-channel data selectors could be connected together to form a single 4-channel data selector that selects 1 out of 4 binary inputs X_0, X_1, X_2, or X_3 based on the binary number P_1P_0 represented by the 2 control inputs P_0 and P_1. (6 marks)

c) i) Write the Boolean function in the 'sum of products' form for the 4-channel data selector described in b) ii) above. (2 marks)

ii) Hence, design the circuit for a 4-channel data selector using only NAND gates. (4 marks)

5 a) i) Draw the state diagram for a clocked D flip-flop (delay flip-flop). (2 marks)

ii) With the aid of a diagram, show how a clocked D flip-flop could be realized using J-K flip-flop and a minimum of combinational logic elements. (2 marks)

b) It is necessary to construct a divide by 3 asynchronous counter using D flip-flops.

i) Draw the state diagram for this counter. (5 marls)

ii) State the minimum number of delay flip-flops that are necessary to construct this counter. (1 mark)

iii) Identify a possible hazard that can arise in the operation of this counter if it is designed based on the state diagram drawn for b) i) above. (2 marks)

c) i) Draw an improved version of the state diagram for the counter, which does not have the hazard identified in b) iii) above. (4 marks)

ii) Design combinational circuits for the inputs of all flip-flops for this counter. (4 marks)

Section B

6 a) Three sets of communication equipment A, B and C are being operated inside a room. A spectrum analysis of the r.f. radiation within the room showed that radio frequency energy existed in the following frequency bands
220 MHz – 250 MHz, 14 MHz – 17 MHz, 800 MHz – 900 MHz
In addition, the following observations are made about this equipment.

- 'B' is connected to a very large antenna located outside the room.
- 'A' is operating on a very low power battery.

i) Identify the 3 sets of equipment with the given frequency ranges of operation. (6 marks)

ii) State which of the 3 sets of equipment are restricted to line of sight communication. (2 marks)

b) i) Define 'depth of modulation' as applicable to Amplitude Modulation (AM). (2 marks)

ii) Describe the 'sidebands' created by amplitude modulation of a radio frequency carrier by a pure tone. (2 marks)

c) A VHF AM transmitter operating at 200 MHz is under test using a 2 MHz test tone as the baseband input.

i) Taking the amplitude of the carrier as 'A' and the depth of modulation as 'm', sketch the spectrum of the transmitter output. (4 marks)

ii) With modulation switched off the output, power was measured and it was found to be 400 mW. When modulation was switched on, the output power was 450 mW. Calculate the modulation depth used in the transmitter. (4 marks)

7 a) Briefly explain the need for the 'digitization' of a voice channel before it could be transmitted over a PCM system. (4 marks)

b) Describe the term 'frame' as applicable to a TDM system. (4 marks)

c) The 30-channel PCM system actually uses 32 time slots in each frame. One time slot is dedicated for frame alignment while another is dedicated to carry the signalling of **two** channels. Each of the remaining 30 time slots are filled with the voice sample of a telephone channel coded using 8 bits. Assuming that the highest frequency of a telephone channel is 4 kHz, calculate the bit rate of the 30-channel TDM bit stream. (6 marks)

d) A 'multiframe' in the 30 channel PCM system is a group of consecutive frames that are sufficient to carry the signalling of all 30 channels. If the duration of a multiframe is 2 ms, show that a multiframe has a sufficient number of frames to carry the signalling of all 30 channels plus one additional frame. (6 marks)

8 a) With the aid of sketches, explain the following as applicable to a directional antenna.

i) Maxima. (2 marks)

ii) Null. (2 marks)

b) The variation of the impedance along the length 'x' of a lossless transmission line with one end short circuited and seen from the other end, could be expressed as

$$Z = R_0 \tan(\frac{2\pi x}{\lambda}) \text{ ------------------------------ } (1)$$

Where the symbols have their usual meanings.

Similarly, the impedance along the length 'x' of a lossless transmission line with one end open circuited and seen from the other end, could be expressed as,

$$Z = R_0 \cot(\frac{2\pi x}{\lambda}) \text{ ----------------------------- } (2)$$

Using the expressions given in equations (1) and (2) above show that

i) A quarter wavelength of a short-circuited line would appear as an open circuit. (3 marks)

ii) A quarter wavelength of an open circuited line would appear as a short circuit. (3 marks)

c) Figure Q8.1 shows a duplexer arrangement used in a primitive transceiver where the transmitter of high power r.f. pulse energy and the receiver of resulting weak r.f. echoes of the same carrier frequency share a common antenna.

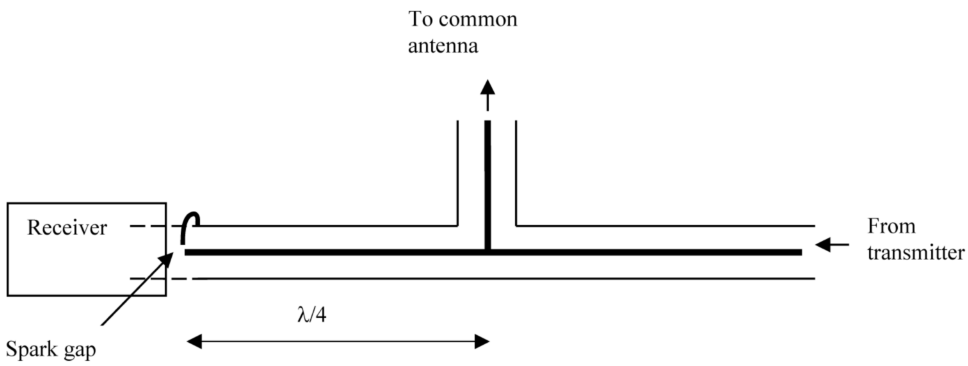

Figure Q8.1

At the input where the receiver is coupled, there is a small gap between the core and the sheath of the coaxial line. Whenever the transmitter is transmitting, the high power causes an arc in this gap and effectively creates a short circuit.

i) Explain why the high power r.f. pulses from the transmitter are coupled only to the antenna and not to the receiver. (5 marks)

ii) Explain why the weak r.f. echoes from the antenna are coupled only to the receiver input and not to the transmitter output. (5 marks)

9 a) Briefly explain what is meant by a 'Local Area Network'. (3 marks)

b) Draw the TCP/IP Protocol Stack and briefly describe the function of the following layers.

i) Internet layer. (2 marks)

ii) Transport layer. (2 marks)

iii) Link layer. (2 marks)

c) Write a short description of the following application layer protocols identifying their common uses.

i) File Transfer Protocol (FTP). (3 marks)

ii) Secure Shell (SSH). (3 marks)

d) Briefly explain the difference between the '**infrastructure mode**' and the '**ad hoc mode**' of operating Wi-Fi networks. (5 marks)

10 a) i) List **three** advantages of using Fibre Optic networks instead of Copper based cable networks. (3 marks)

ii) Sketch the longitudinal cross section (parallel to the axis) of a strand of single mode optical fibre and label the different parts. (2 marks)

iii) State the type of multiplexing used in optical fibre networks to increase its capacity. (1 mark)

b) Describe the following as applicable to optical fibre networks.

i) Splicing. (2 marks)

ii) Electrical to optical interface. (2 marks)

c) It is required to connect 2 multiplexers in a communication network using an optical fibre cable without any repeaters in between. 40 independent optical channels are to be optically multiplexed onto the cable to support a total aggregate bit rate of 2 Gbps. The electrical multiplexing method used in the network introduces 30% of overhead bits. The Bandwidth-Distance Product of the fibre cable is 0.8 GHz.km.

i) Calculate the actual bit rate of a single optical channel. (5 marks)

ii) Hence, calculate the maximum length of the fibre cable that could be used to connect the two multiplexers. (5 marks)