City & Guilds

9210-137
Level 6 Graduate Diploma in Engineering
Electro techniques

Sample Paper

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

No additional data is attached

General instructions
- This examination paper is of **three hours** duration.
- This examination paper contains **ten** questions.
- Answer **any five** questions.
- All questions carry equal marks. The maximum marks for each section within a question are given against that section.
- 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.

1 a) Consider the circuit shown in Figure Q1a)

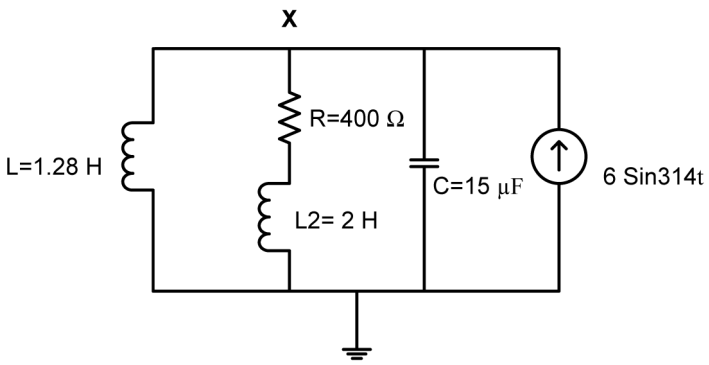

Figure Q1a)

i) Draw the circuit diagram in the phasor domain. (5 marks)
ii) Determine the potential at point X using the nodal voltage method. (5 marks)

b) Consider the circuit shown in Figure Q1b) L1 = 0.2 H, L2 = 0.5 H; R = 80 Ω; V1 = 100 V; V2 = 150 V; f = 50 Hz.

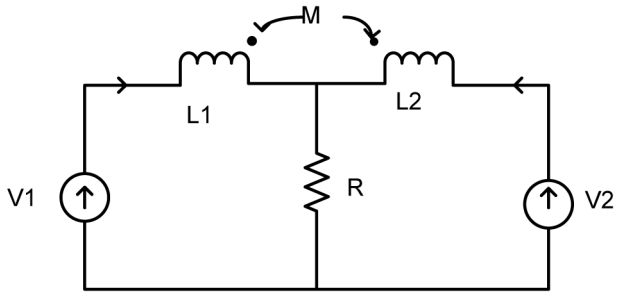

Figure Q1b)

i) If coefficient of coupling is 0.75, determine the mutual inductance. (2 marks)
ii) Calculate the reactance of the circuit. (3 marks)
iii) Use the mesh method to calculate currents in the circuit. (5 marks)

2 a) Describe briefly, the advantages of the use of three phase delta connected systems over star connected systems. (5 marks)

b) A three-phase, Y-connected supply is connected to a delta connected balanced load via connecting wires. Voltage at phase A of the supply is 220∠30° V and phase sequence is ACB. Per-phase impedance of the connecting wires is 4 + j3. Per-phase value of the impedance of the load is 40 + j30 Ω.

i) Determine phase voltages of phases B and C. (2 marks)
ii) Calculate line currents. (7 marks)
iii) Calculate voltage and current through the load. (6 marks)

3 a) Explain how the maximum power transfer from source to load is achieved with the help of a transformer. (2 marks)

b) What are the measures taken to minimize the hysteresis and eddy current losses at the design stage of a transformer? (4 marks)

c) A 50 kVA, 6600 V/200 V single-phase transformer has primary and secondary resistance of 7.8 and 0.0085 respectively. When this transformer is at no load it takes 0.326 A at 0.25 power factor lagging.

i) Calculate the rated load current of the transformer. (2 marks)

ii) Determine the resistance of the transformer as seen from the secondary side. (3 marks)

iii) Calculate the total loss of the transformer at full load. (5 marks)

iv) If the full load has been reduced to 25% of the full load determine the efficiency of the transformer (power factor is 0.85). (4 marks)

4 a) List **three** main disadvantages of a single-phase induction motor when compared with a three-phase induction motor of similar capacity. (3 marks)

b) In a slip ring induction moto, the starting torque can be improved by adding external resistance to the rotor circuit. However, beyond a certain value of this additional resistance, the starting torque starts to reduce. Explain the reason for this. (3 marks)

c) i) A 10 HP, 220 V, 50 Hz, four pole wound rotor induction motor has a rated speed of 1425 rpm. Per-phase parameters of a simplified equivalent circuit of the motor are
Rs = 0.2 Ω; XL = 0.84 Ω; Xm = 12 Ω; Rr' = 0.256 Ω

ii) Determine the current taken from the supply. (8 marks)

iii) Calculate the power and power factor of the motor. (6 marks)

5 a) Give reasons for following statements.

i) Permanent magnet moving coils are used only for the measurement of DC quantities. (3 marks)

ii) Induction cup type instruments are used only for the measurement of AC quantities. (3 marks)

b) With the help of a suitable diagram, explain how two wattmeters are used to measure the power of a three-phase three-wire system. (4 marks)

c) i) Prove that the torque (T) produced by a moving coil permanent magnet type instrument equal to the product of flux linkage through the coil and the current through the coil. (6 marks)

ii) A permanent magnet moving coil ammeter has the following specifications.
Number of turns : 100
Depth of the coil: 3 cm
Width of the coil: 2.5 cm
Flux density in the air gap: 0.15 Wb/m2
At the full-scale deflection, the controlling torque is 5x10–5 Nm. What is the maximum current that can be measured by this instrument? (4 marks)

See next page

6 a) Determine the output signals of circuits shown in Figure Q5ai) and Q5aii) for a sine wave input signal.

i)

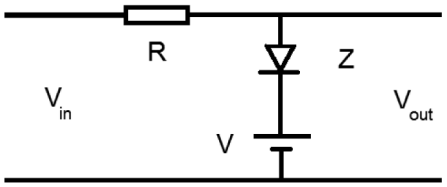

Figure Q5ai)

(4 marks)

ii)

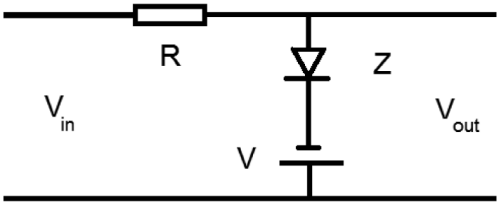

Figure Q5aii)

(4 marks)

b) A voltage regulator circuit is shown in Figure Q5b). Determine the following for R = 1kΩ and R = 3kΩ.

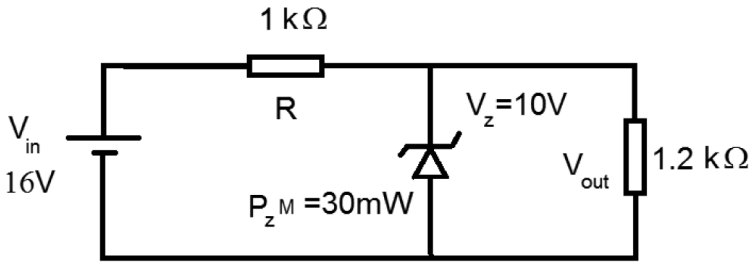

Figure Q5b)

i) Voltage across load. (3 marks)
ii) Voltage across series resistor. (3 marks)
iii) Current through Zener diode. (3 marks)
iv) Power dissipation across Zener diode. (3 marks)

7 a) i) State **three** BJT transistors biasing techniques. (3 marks)

ii) Sketch the relevant electronics circuits. (3 marks)

b) i) Determine the Thevenin's equivalent circuit of the amplifier circuit shown in Figure Q6b). (4 marks)

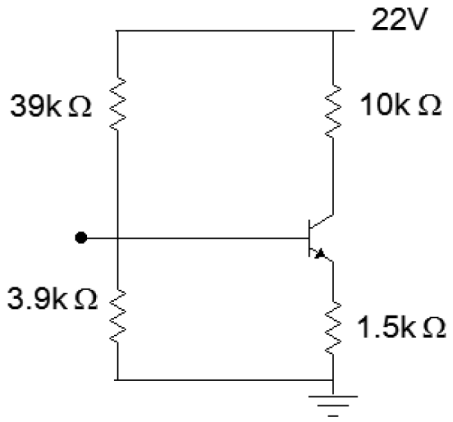

Figure Q6b)

ii) Current gain of the amplifier is 150; hence find the collector current and collector emitter voltage of the circuit. (10 marks)

8 a) State **three** characteristics of an operational amplifier. (3 marks)

b) Sketch a summing amplifier circuit using an operational amplifier. (7 marks)

c) i) An analogue to digital converter can convert maximum 5 V input signal into a 3-bit digital number. A proximity sensor in the circuit generates a signal from 0 mV to 10 mV to convert analogue signals to digital signals. Design a suitable electronic circuit. (8 marks)

ii) Find the resolution of the circuit. (2 marks)

9 a) Simplify the following Boolean expressions using Boolean algebra and K-map.

i) $AB\overline{C} + A\overline{B}\overline{C} + ABC + A\overline{B}C$ (2 marks)

ii) $\overline{A}\overline{C} + B\overline{C} + \overline{A}BC + ABC$ (2 marks)

b) i) Implement the following function using **NOR** gates having a maximum fan-in of three.

i) $f_1 = (\overline{A} + B)(C + D)(B + \overline{C})(A + D)(\overline{A} + C)$

ii) $f_2 = \overline{A}B + B\overline{C}D + A\overline{B}\overline{D}$ (8 marks)

ii) A device accepts numbers in the range 000 to 111 that represent 0 to 7. The output of the circuit is true if the inputs to the circuit represent a prime number and is false otherwise. Design a circuit using AND, OR and NOT gates to carry out the function. (8 marks)

10 a) State the state transition tables of the following flip flops. (8 marks)

i) SR flip flop.

ii) JK flip flop.

iii) D flip flop.

iv) T flip flop.

b) A 3-bit weighted resistor DAC has a V_{ref} = 12 V and a feedback resistor (R_f) = R. Find the resolution and the full-scale analogue output current. (4 marks)

c) Design a 3-bit synchronous counter using D Flip-Flop and logic gates. You have to show the state diagram, state table, K-map, logic expressions and the circuit implementation very clearly. (8 marks)