महाराष्ट्र विद्युत अभियांत्रिकी सेवा (मुख्य) परीक्षा - २०२३, दि. २८ जानेवारी, २०२४
(पेपर - I)

2023

Q18

BOOKLET NO.
300101

Electrical Engineering
Paper – I

Time Allowed : Three Hours | **Maximum Marks : 200**

Medium : English | **Type of Paper : Conventional**

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting question :

1. There are **EIGHT** questions divided in two Sections, out of which **FIVE** are to be attempted.
2. Questions no. 1 and 5 are compulsory. Out of the remaining questions, THREE are to be attempted choosing at least ONE question from each Section.
3. The number of marks carried by a question/sub question is indicated against it.
4. Keep in mind the word limit indicated in the question if any.
5. Wherever option has been given, only the required number of responses in the serial order attempted shall be assessed. Unless struck off, attempt of a question shall be counted even if attempted partly. Excess responses shall not be assessed and shall be ignored.
6. Candidates are expected to answer all the sub-questions of a question together. If sub-question of a question is attempted elsewhere (after leaving a few page or after attempting another question) the later sub-question shall be overlooked.
7. Any page or portion of the page left blank in the Answer Booklet must be clearly struck off.
8. Unless otherwise mentioned, symbol and notation have their usual standard meanings. Assume suitable data, if necessary and indicate the same clearly.
9. Neat sketches may be drawn, wherever required.
10. The medium of answer should be mentioned on the answer book as claimed in the application and printed on admission card. The answers written in medium other than the authorized medium will not be assessed and no marks will be assigned to them.

Note – 1. Candidates will be allowed to use Scientific (Non-programmable type) calculators.

SEAL

P.T.O.

SECTION – A

Q1. Answer **any five** of the following : **(8×5=40)**

(a) A periodic voltage waveform has been shown in Fig. 1.0. Determine the following :

i) Frequency of the waveform

ii) RMS value

iii) Average value

iv) Form factor.

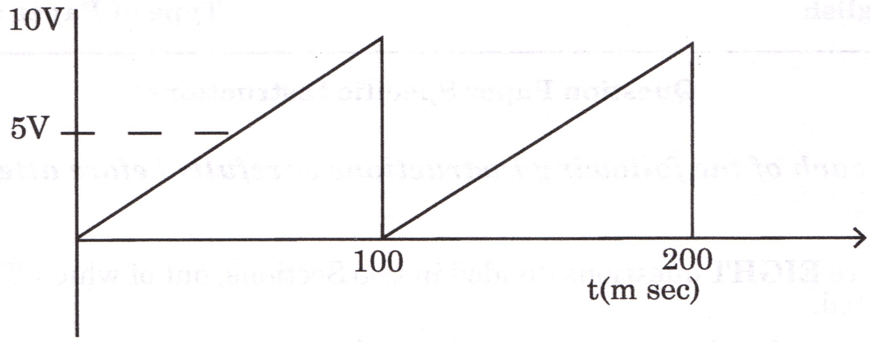

Fig. 1.0

(b) Find the z-parameters for the network shown in Fig. 2.0.

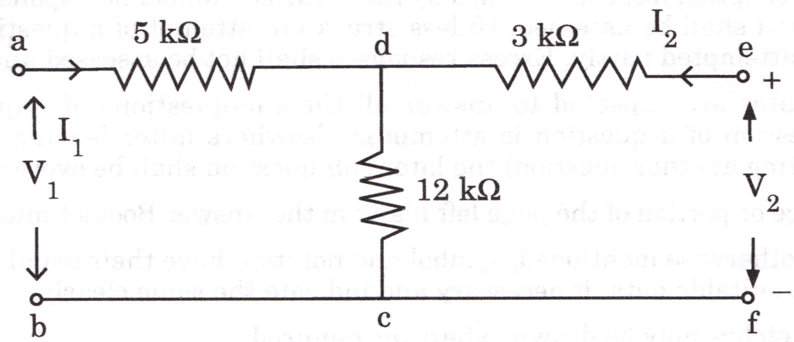

Fig. 2.0

(c) Obtain the current i_1 using KVL for the circuit shown in Fig. 3.0.

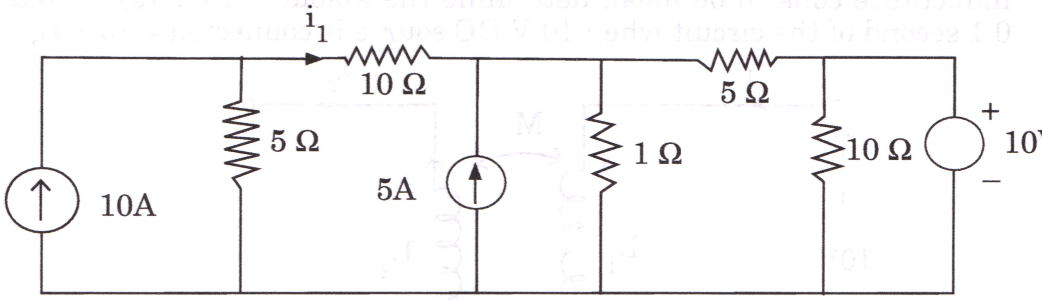

Fig. 3.0

(d) State and discuss the Coulomb's law and Gauss's law.

(e) State and discuss the Biot-Savart law and Ampere's circuital law.

(f) A single phase 4 KVA, 200 V/100 V, 50 Hz transformer with laminated CRGO steel core has rated no-load loss of 450 W. When the high voltage winding is excited with 160 V, 40 Hz sinusoidal AC supply, the no-load losses are found to be 320 W. When high voltage winding of the same transformer is supplied from a 100 V, 25 Hz sinusoidal AC source for this condition determine the no-load loss of the transformer.

(g) A single phase, 2000 V alternator has armature resistance and reactance of 0.8 ohms and 4.94 ohms respectively. Determine the voltage regulation of the alternator at 100 A load and 0.8 leading power factor.

Q2. (a) Use Thevenin's theorem to determine the power loss in 10 Ω resistance of the circuit given in Fig. 4.0. **15**

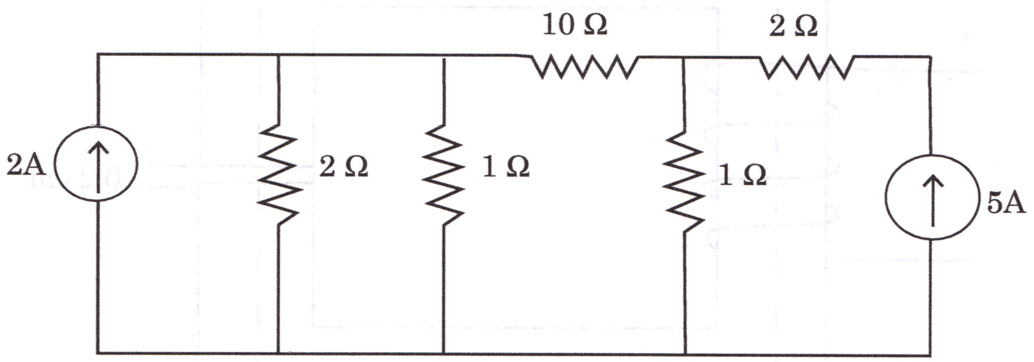

Fig. 4.0

(b) In the Network shown in Fig. 5.0, $L_1 = 1$ H; $L_2 = 2$ H, M=1.2 H. Assume inductance coils to be ideal, determine the amount of energy stored after 0.1 second of the circuit when 10 V DC source is connected across L_1. **15**

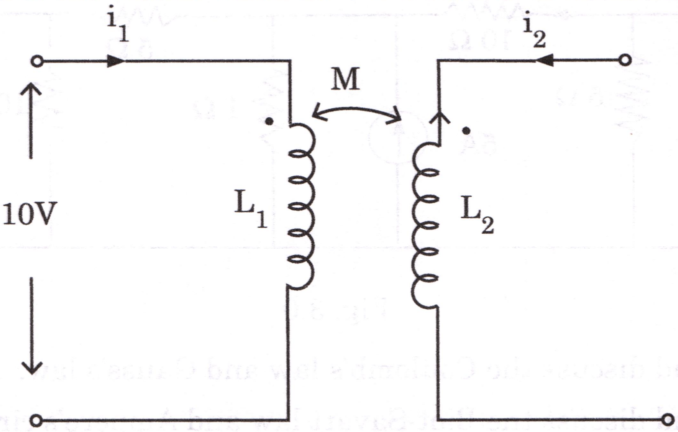

Fig. 5.0

(c) Determine the energy stored in a system of four identical point charges of Q = 5 nC at a corners of a square 1 meter on a side. Determine the energy stored in the system when only two charges at opposite corners of the square are present. **10**

Q3. (a) The magnetic circuit shown in Fig. 6.0 has uniform cross-sectional area and air gap of 0.2 cm. The mean length of the core is 40 cm. Assume that leakage and fringing fluxes are negligible when core relative permeability is assumed to be infinite, the magnetic flux density computed in the air gap is 1 tesla with same ampere-turns if the core relative permeability is assumed to be 1000 (linear). Calculate the flux density in the air gap. **15**

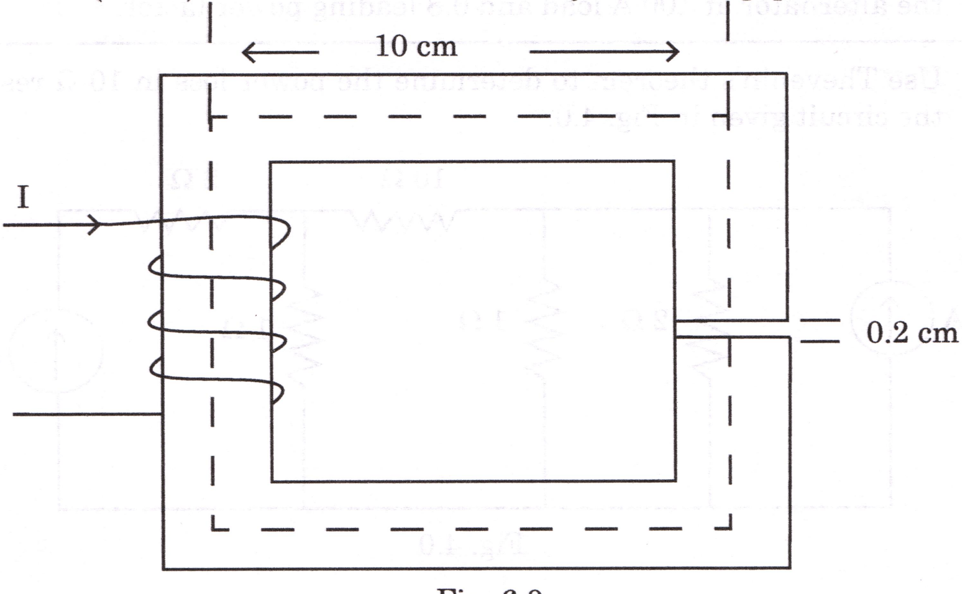

Fig. 6.0

(b) A 230 V, 250 rpm, 100 A separately excited DC motor has an armature resistance of 0.5 Ω. The motor is connected to 230 V DC supply and rated DC voltage is applied to the field winding. It is driving a load whose torque-speed characteristics is given by $T_L = 500 - 10\,\omega$, where ω is rotational speed expressed in rad/sec and T_L is load torque in Nm. Find the steady state speed at which the motor will drive the load and armature current drawn by it from the source. Neglect the rotational losses of the machine. **15**

(c) Two identical synchronous generators each of 100 MVA, are working in parallel supplying 100 MVA at 0.8 lagging pf at rated voltage. Initially the machines are sharing load equally, if the field current of 1^{st} generator is reduced by 5% and of second generator is increased by 5%. Determine the sharing of load (MW and MVAR) between the two generators. Assume $X_d = X_a = 0.8$ PU, no field saturation and rated voltage across the load. Reasonable approximation may be made. **10**

Q4. (a) Find the voltage drop across 4 Ω and 10 Ω resistors for the circuit shown in Fig 7.0, using mesh current analysis. **15**

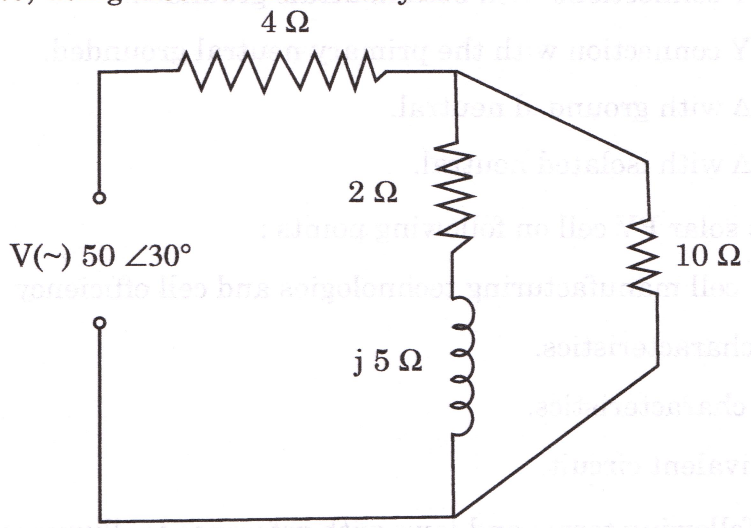

Fig. 7.0

(b) A 50 HP, 6 pole 50 Hz slip ring induction motor runs at 960 rpm on full load with rotor current of 40 A. Allowing 300 W for the copper loss in the short circuiting gear and 1200 W for mechanical losses, find R_z (Rotor resistance per phase) of 3 phase rotor winding. **15**

(c) Three-phase, three winding Δ/Δ/ Y (1.1 KV/6.6 KV/400 V) transformer is energised from AC mains at the 1.1 KV side. It supplies 900 KVA load at 0.8 power factor lag from the 6.6 KV winding and 300 KVA load at 0.6 power factor lag from the 400 V winding. Determine the RMS line current in Amperes drawn by the 1.1 KV winding from the mains. **10**

SECTION – B

Q5. Answer **any five** of the following : **(8×5=40)**

(a) Draw and discuss the block diagram of Hydro-electric power plant. State the types of water turbines used in hydro-electric power plant.

(b) The neutral of 10 MVA, 11 KV alternator is earthed through a resistance of 5 ohm. The earth fault relay is set to operate at 0.75 A. The CT have a ratio of 1000/5. What percentage of the alternator winding is protected ?

(c) Draw the zero-sequence equivalent circuit for following transformer configurations :

i) Y – Y connections with both neutrals grounded.

ii) Y – Y connection with the primary neutral grounded.

iii) Y – Δ with grounded neutral.

iv) Y – Δ with isolated neutral.

(d) Discuss solar PV cell on following points :

i) P.V. cell manufacturing technologies and cell efficiency.

ii) I-V characteristics.

iii) P-V characteristics.

iv) Equivalent circuit.

(e) Define following terms and laws with reference to illumination :

i) Lumens

ii) Utilization factor

iii) Space to height ratio

iv) Inverse square law

(f) State and discuss the procedure for synchronization of DG set with utility supply. How the load sharing is adjusted ?

(g) In a medium sized engineering industry a 340 m^3/hr reciprocating compressor is operated to meet compressed air requirement at 7 bar. The compressor is in loaded condition for 80% of the time. The compressor draws 32 KW during load and 7 KW during unload cycle.

After arresting the system leakages, the loading time of the compressor came down to 60%.

Calculate the annual energy saving at 6000 hours of operation per year.

Q6. (a) A three phase, 60 Hz, 500 KV transmission line is 300 km long. The line inductance is 0.97 mH/km per phase and its capacitance is 0.0115 μF/km per phase. Assume a lossless line. **15**

i) Determine the line phase constant β, the surge impedance Z_c, velocity of propagation υ and the line wavelength λ.

ii) The receiving end rated load is 800 MW, 0.8 power factor lagging at 500 KV. Determine the sending end quantities and voltage regulation.

(b) i) State the various types of energy storage systems. Discuss with block diagram, magnetic energy storage system.

ii) Discuss smart grid on following points :

i) Architecture

ii) Benefits

iii) Technologies associated with smart grid

iv) Characteristics of smart grid. **15**

(c) An alternator is connected to an infinite bus as shown in Fig. 8.0. It delivers 1.0 PU current at 0.8 pf lagging at V = 1.0 PU. The reactance X_d of the alternator is 1.2 PU. Determine the active power output and steady state power limit. Keeping the active power fixed, if the excitation is reduced, find the critical excitation corresponding to operation at stability limit. **10**

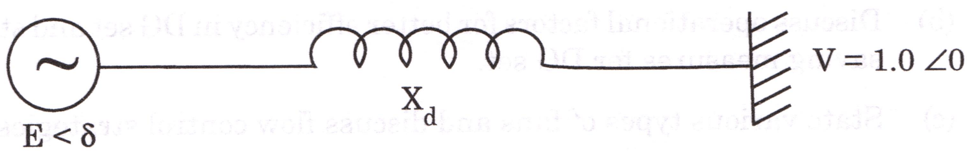

Fig. 8.0

Q7. (a) A drawing hall 30 metres by 13 metres with a ceiling height of 5 metres is to be provided with a general illumination of 120 lux. Taking a co-efficient of utilization of 0.5 and depreciation factor of 1.4, determine the number of fluorescent tubes required, their spacing mounting height and total wattage. Taking luminous efficiency of fluorescent tube as 40 lumens/watt for 80 watt tube. **15**

(b) A centrifugal clear water pump rated for 800 m^3/hr was found to be operating at 576 m^3/hr with discharge valve throttled. The pump speed is 1485 rpm. The discharge pressure of the pump before the throttle valve is 2 kg/cm^2g. Pump draws the water from a sump 4 metres below the centerline of the pump. The input power drawn by the motor is 124 KW at a motor efficiency of 92%. **15**

i) Find the efficiency of the pump.

ii) If the normal required water flow rate is 500 m^3/hr to 700 m^3/hr, what in your opinion should be the most energy efficient option to get the required flow rate variation ?

iii) And what would be the pump shaft power for the most energy efficient option if the pump is delivering the flow rate of 550 m^3/hr ?

(c) Compare single phase online UPS with single phase offline UPS on following points : **10**

i) Detailed circuit diagram of both UPS.

ii) Relative advantages and disadvantages.

iii) Requirement of transfer switch.

iv) Applications.

SEAL

Q8. (a) Discuss following relaying scheme for transmission line protection with relay characteristics : **15**

i) Over current relaying

ii) Distance relaying

iii) Pilot relaying.

(b) Discuss operational factors for better efficiency in DG set and state the energy saving measures for DG set. **15**

(c) State various types of fans and discuss flow control strategies. **10**
