ELECTRICAL ENGINEERING

Paper—II

(Conventional)

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

INSTRUCTIONS

Candidates should attempt FIVE questions in all.

All questions carry equal marks.

Question No. 1 is compulsory. The remaining FOUR questions are to be attempted by selecting ONE question each from Sections A, B, C and D.

The number of marks carried by each part of a question is indicated against each.

Answers must be written only in ENGLISH.

Assume suitable data, if necessary and indicate the same clearly.

Unless otherwise indicated, symbols and notations have their usual meanings.

Draw suitable sketches, wherever required.

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Important note :—

Candidates are to answer all parts and sub parts of a question being attempted contiguously on the answer-book. In other words, all parts and sub parts of a question being attempted are to be completed before attempting the next question on the answer book.

Pages left blank in the answer-book, if any, are to be struck out. Answers that follow blank pages may not be given credit.

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1. (a) A salient pole alternator has $X_d = 1\cdot4$, $X_q = 1\cdot0$ and $r_a = 0$. If this alternator delivers rated kVA at unity pf and at rated voltage, find its power angle and excitation voltage.

   (b) What are the objectives of 'optimal scheduling of hydro-thermal units' ?

   (c) Answer the following with respect to the circuit shown :
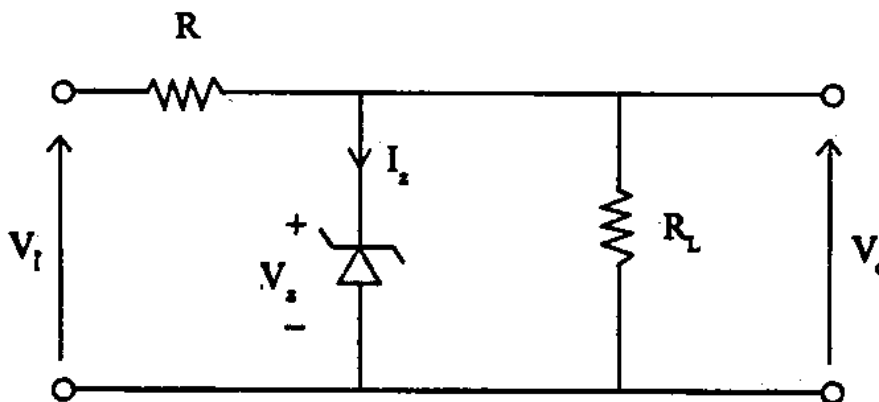
(i) Why is it called a 'shunt regulator' ?

(ii) Which is the regulating element ?

(iii) Draw the v-i characteristic of the regulating element.

(iv) Mark the portion of the curve used for regulation.

(v) Show the range of current over which regulator will operate satisfactorily.

(d) For 8085 microprocessor, if the stack pointer points to 0000 H, in which memory location will stack contents be stored, if the stack is to be used ?

(e) Explain the requirements for an SCR to be triggered by a gate pulse.

(f) A 240 V dc shunt motor has a torque constant of 5 Nm/A and its armature circuit resistance is 0·5 Ω. At what speed in rad/sec and in rpm should the motor be driven so as to obtain regenerative braking torque of 250 Nm ?

(g) In a power system, how is the receiving end voltage controlled ?

(h) Determine the simplest (minimal) expression for Y for the logic circuit shown.
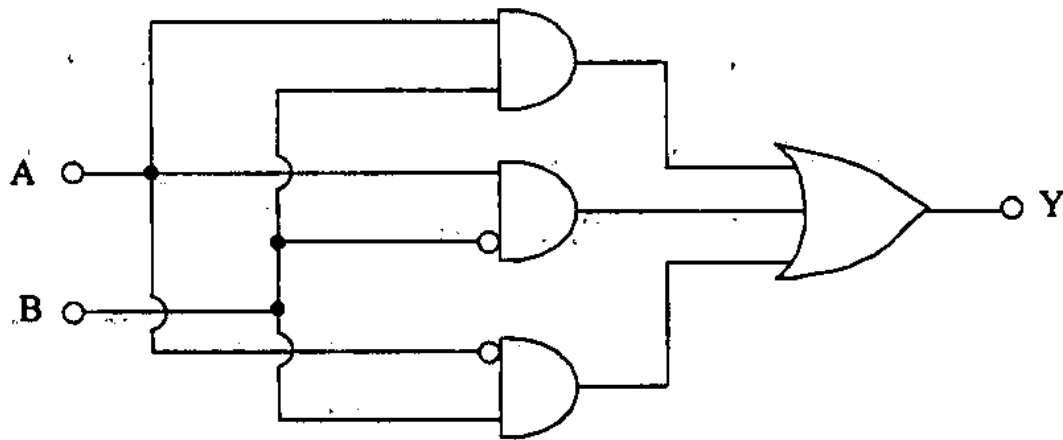
(i) What is time-division multiplexing ? With reference to pulse communication system, show the use of time-division multiplexing by drawing a block diagram.

(j) State the different forced commutation methods used for improving the power factor in controlled AC-DC rectifiers. $4 \times 10 = 40$

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SECTION—A

2. (a) (i) In open-circuit test on a 1-phase transformer, the ohmic losses are usually neglected in comparison with core loss. Justify. 4

(ii) If stator impedance of a three-phase induction motor is neglected, show from its equivalent circuit that maximum torque T_{em} per phase is given by

$$T_{em} = \frac{1}{w_s} \cdot \frac{V_1^2}{2x_2}$$

and hence show that $\dfrac{T_e}{T_{em}} = \dfrac{2}{\dfrac{s_{mT}}{s} + \dfrac{s}{s_{mT}}}$

where s is any slip and s_{mT} = slip at which maximum torque occurs. 8

(b) A full-pitched coil, having N turns, rotates with an angular velocity of w_r rad per sec in a field flux ϕ. Give an expression for the flux linkages with the coil as a function of time t and derive therefrom an expression for the emf generated in this coil.

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Discuss nature of the two components of emf expression so obtained. Hence show that the speed voltage lags by 90° the flux that produces it.   20

(c) A single-phase transformer has voltage regulation of 6% and 6·6% for lagging power factors of 0·8 and 0·6 respectively. Full-load ohmic loss is equal to iron loss. Calculate (i) the lagging pf at which full-load voltage regulation is maximum and (ii) the full-load efficiency at unity power factor.   8

3. (a) For the rotor circuit of a 3-phase induction motor, show that locus of the tip of rotor-current phasor I_2 is a circle with diameter equal to E_2/x_2. Symbols have their usual meaning.   6

(b) A 3-phase, 7 MVA, 11 kV, star-connected alternator is synchronized with an infinite bus at rated voltage. Now the steam input to the machine set is increased till the synchronous machine begins to operate with a load angle of 40°. The

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synchronous machine has $Z_s = 0 + j12 \, \Omega$. Calculate the pf, armature current and the active and reactive powers delivered to infinite bus under these conditions.

Without any change in steam input, how can this alternator be made to deliver zero reactive power to the bus ? Calculate armature current, excitation voltage and load angle under these conditions.

Draw phasor diagrams at the time of synchronizing, when (i) load angle is 40° and (ii) no reactive power flows. 20

(c) (i) Explain, with the help of motor sketch and phasor diagram, how rotating magnetic field is produced in a single-phase shaded-pole motor. Discuss the direction of rotor rotation. 7

(ii) A 400-V dc shunt motor, with an armature resistance of 0·2 Ω, runs at 1000 rpm and

takes an armature current of 60 A. If the field flux is suddenly increased by 20%, obtain, at this instant, new values of armature current and the torque in terms of initial torque.

What is the operating mode of dc shunt machine under these conditions ? State the assumption made, if any. 7

SECTION—B

4. (a) A 3-phase, 50 Hz transmission line at 11 kV delivers a load of 1000 kW at 0·8 p.f. (lagging) over 10 kms.

Calculate the line current, receiving end voltage and efficiency of transmission.

Resistance and reactance of each line conductor may be assumed to be 0·5 Ω/km and 0·56 Ω/km respectively. 10

(b) (i) Differentiate between load-frequency control and economic dispatch control.

(ii) Show from the first principles that the power consumed in a 3-phase load can be computed from the symmetrical components, provided the currents and voltages are known.

$$5+10=15$$

(c) (i) In a power system power is supplied to a short-line through transformer connected to bus-bar. If a line-to-ground fault occurs on one of the lines and is cleared by a circuit breaker close to transformer (on line side), derive the expression for restriking voltage and its natural frequency.

(ii) A 220 kV circuit breaker is used to protect a transmission line. During a fault due to short circuit the demagnetization effect of armature reaction brought down voltage to 95% of rated voltage, p.f. had been 0·5 lagging and natural frequency of oscillation was observed to be 20 kHz. Calculate maximum restriking voltage and average RRRV for both grounded and ungrounded faults.

$$5+10=15$$

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5. (a) (i) Define steady-state stability and stability limit with the help of P-S characteristic. What are the techniques available to improve steady-state stability ?

(ii) A synchronous generator is connected to an infinite bus with power supply at 0·45 p.u. of maximum capacity. Find the critical clearing angle for the fault to be cleared if it is known that the reactance of generator and line becomes four times of prefault value. The maximum power deliverable after clearing of fault is 70% of the original maximum value. Use equal area criterion to obtain solution. 4+6=10

(b) (i) Explain the principle of operation of sulphur-hexafluoride circuit breakers with neat figures and list its advantages.

(ii) What is a low inductive current chopping problem in circuit breakers and how it is overcome to have smooth decay of restriking voltage ?

(iii) In a 132 kV system, the phase-to-ground capacitance is 0·01 μF and the inductance is 4 H. Calculate the voltage appearing across the electrodes of C_B if a magnetizing current at 5 amperes is interrupted. Calculate the critical resistance to be connected, to eliminate restriking. 5+5+5=15

(c) (i) Draw the connections and explain the operation of a differential (relay) protection of a 3-phase Δ-Y transformer.

(ii) A 50 MVA, 132/66 kV, λ-Δ transformer is protected by differential protection.
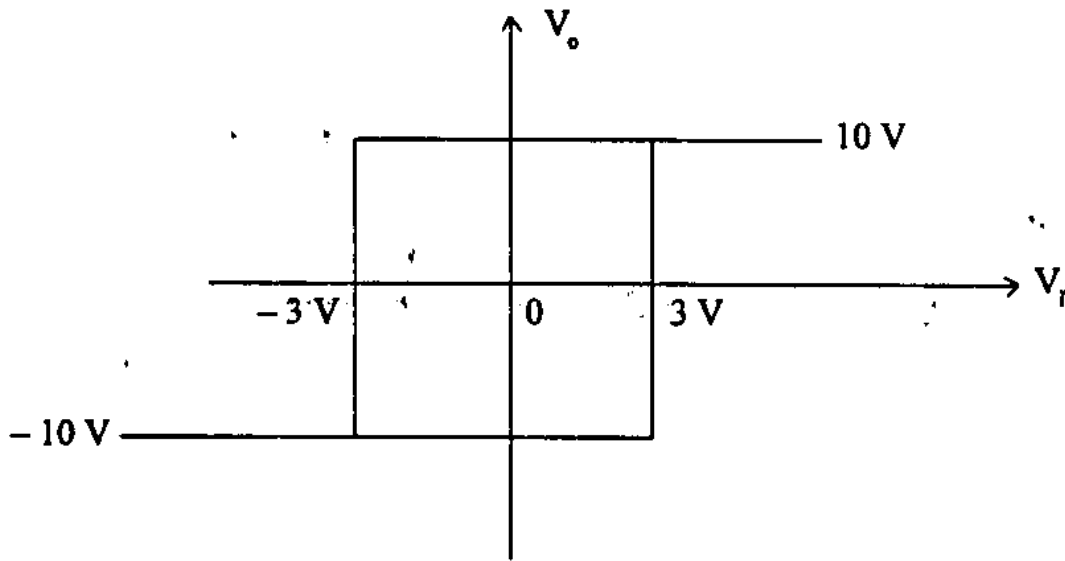
Draw a connection diagram and calculate the suitable C.T. ratio. 5+10=15

SECTION—C

6. (a) Design a circuit using minimum number of OA to realize the equation :

$$V_o = 2V_1 + 5V_2.$$ 10

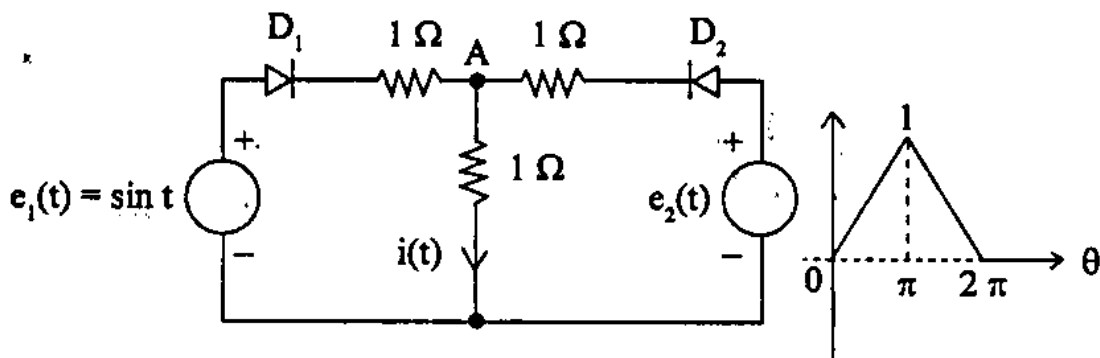(b) A circuit has the following voltage transfer characteristic.

Design a circuit to realize this characteristic.
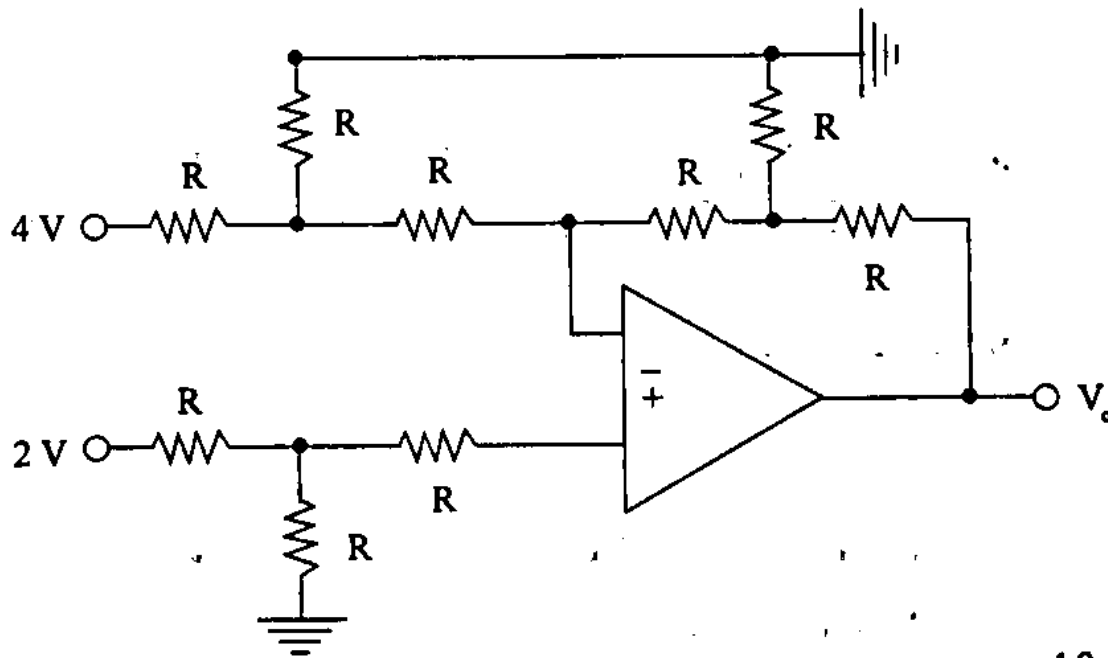
Plot the waveforms for V_o when

(i) $V_i = 5 \sin wt$

(ii) $V_i =$ Half-wave rectified of 5 sin wt. 10

(c) In the circuit shown, calculate and sketch the current i(t) over the period $0 \le \theta \le 2\pi$. Assume the diodes to be ideal.

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(d) Determine the output voltage V_o of the circuit shown in the figure.

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7. (a) By drawing a suitable waveform, explain a typical instruction cycle (IC) of an 8085 microprocessor.   8

(b) Write an assembly language program for an 8085 microprocessor, which will store the contents of accumulator and flag register at 2000 H and 2001 H memory locations respectively using PUSH and POP instructions. Write comments for selected instructions.   10

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(c) When returning back to the main program from Interrupt Service Routine (ISS), in 8085 microprocessor, the software instruction EI is inserted at the end of the ISS. Why ? 6

(d) For an 8085 microprocessor, write an assembly language program for the multiplication of two 8-bit numbers by shift-add routine method. Two 8-bit binary numbers are stored in two 8-bit registers and the result is stored in a register pair. Write comments in selected instructions. 16

SECTION—D

8. (a) The antenna current of an AM transmitter is 8 A, when only the carrier is sent, but it increases to 8·93 A, when the carrier is modulated by a single sine wave. Find the percentage modulation. Determine the antenna current, when the percent of the modulation changes to 80%. 16

(b) Give one example for each of the following :—

    (1) Uncontrolled turn-on and off.

    (2) Controlled turn-on and uncontrolled turn-off.

    (3) Controlled turn-on and off.

    (4) Continuous gate signal requirement.

    (5) Pulse gate requirement.

    (6) Unipolar voltage capability.

    (7) Bidirectional current capability.

    (8) Unidirectional current capability.   8

(c) Explain in detail different power losses in semiconductor power devices.   16

9. (a) A 1-ϕ circuit for temperature regulation uses ON-OFF control. The ac input is 220 V, 1-ϕ, 50 Hz supply. The circuit has a variable frequency, constant ON time. If the input voltage goes up by 10%, calculate the percentage change required in the triggering frequency of the chopper.   16

(b) Explain the single pulse width modulation technique to control the output voltage of a 1-ϕ inverter. 16

(c) Explain the working of a thyristor-controlled reactor-fixed capacitor. 8