Engineering Services Examination-2012

Sl. No.

C-FTF-M-FMA

ELECTRICAL ENGINEERING

Paper I

(Conventional)

Time Allowed : Three Hours	*Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt SIX questions, selecting TWO questions from Part – A, ONE from Part – B, ONE from Part – C and TWO from Part – D.

The number of marks carried by each question is indicated at the end of the question.

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.

A detachable graph sheet and semi-log graph sheet are attached to this question paper for your use. Fasten them securely to your answer-book(s).

Important note : All parts and sub-parts of a question are to be attempted contiguously in the answer book. That is, all parts and sub-parts of a question being attempted must be completed before attempting the next question.

Any pages left blank in the answer-book must be clearly struck out. Answers that follow pages left blank may not be given credit.

Part – A

1. (a) Define intrinsic wave impedance for a medium and derive the equation for intrinsic impedance for a lossy dielectric medium (consider $E_x = 0$, $E_y = 0$, $E_z = E_0 e^{-\gamma y}$) 12

(b) A spherical volume density is given by,

$$\rho = \rho_0 \left[1 - \frac{\gamma^2}{a^2}\right]; \ (\gamma \leq a)$$

$$= 0; \ (\gamma > a)$$

(i) Calculate the total charge Q.

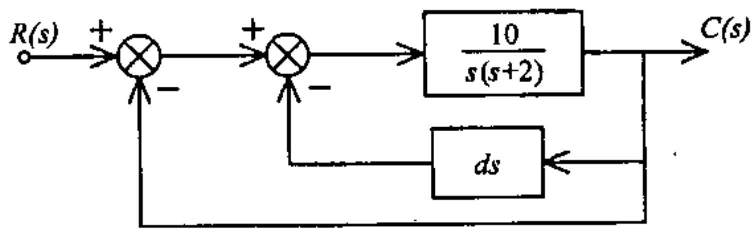
(ii) Find $\vec{E}$ everywhere for $0 < \gamma \leq a$ and $\gamma > a$. 10

(c) Starting from Maxwell's equation

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \text{ and } \nabla \times \vec{H} = \vec{J} + \frac{\partial D}{\partial t}$$

Show that $\nabla \cdot \vec{B} = 0$ and $\nabla \cdot \vec{D} = \rho$. 10

2. (a)



A system is described in the above figure.

(i) In the absence of derivative feedback (i.e. d = 0) determine the damping ratio (δ), natural frequency (ω_n) and the steady state error resulting from a unit-ramp input.

(ii) Determine the derivative feedback constant (d) of which will increase the damping ratio of the system to 0·8. What is the steady state error to unit-ramp input with this setting of the derivative feedback constant.

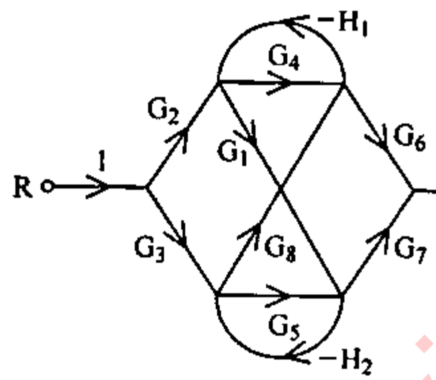
(iii) By changing the forward gain of the amplifier, the steady state error of the system with derivative feedback to unit-ramp input is reduced to same value as in part (i) while the damping ratio is maintained at 0.8. Determine the value of Amplifier gain K_A and the derivative feedback constant. You may use higher gain K_A in place of 10 (as given in the open loop transfer-function). Or you may use an additional amplifier of gain K_A between the two summing points without changing the value of 10 as given in the system. 12

(b) (i) The characteristic equation of a system is given by

$s(s-1)(s^2+4s+20)+K(s+1)=0.$

Find the range of K for which the system is stable. 5

(ii)



Obtain $\frac{C}{R}$ from the signal flow graph shown in the above figure using Mason's Gain Formula. 5

(c) Given $G(s)H(s)=\dfrac{K}{s(s+1)(s+4)}$, sketch the root locus of the system.

(i) Determine the value of K for which the system is at the verge of instability.

(ii) For the damping ratio (δ) 0·34, determine the value of K and the gain margin (GM). 10

3. (a) A state variable description of a system is given by the matrix equation : 12

$$\dot{X} = \begin{bmatrix} -1 & 0 \\ 1 & -2 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \end{bmatrix} r(t), \; Y = \begin{bmatrix} 1 & 1 \end{bmatrix} X$$

Find :

(i) the transfer function $\dfrac{Y(s)}{R(s)}$

(ii) the eigen values of the system

(iii) the state transition matrix

(iv) prove the non-uniqueness of state variables in general

(b) (i) Derive the expression for $c(t)$ (i.e. the output) for a second order system subject to a unit step input. 5

(ii) Derive the expressions for generalised error series and also the generalised error coefficients for unity feedback system., 5

(c) Sketch the complete Bode Plot of the unity feedback system whose open loop frequency function $G(j\omega) = \dfrac{10}{j\omega(0{\cdot}1j\omega+1)(0{\cdot}05j\omega+1)}$

(i) Determine the Gain Margin and Phase Margin.

(ii) Find the open loop gain K for a Gain Margin of 20 db. 10

Part – B

4. (a) Differentiate between intrinsic and extrinsic semiconductors. Explain doping. 12

(b) The resistivity of pure germanium at room temperature is 0·47 ohm-m. Find out the carrier density of germanium at room temperature for the electron mobility of 0·42 m^2/volt-sec and hole mobility of 0·20 m^2/volt-sec. (electron charge $e = 1{\cdot}6 \times 10^{-19}$C) 8

(c) Give and explain the temperature classification of solid insulating materials. Name at least two materials in each class. 16

5. (a) Discuss classification of Magnetic materials. List properties of ferromagnetic materials. In a certain region, $\mu = 4{\cdot}6\ \mu_0$ and $B = 10\ e^{-y}\ \vec{a}_z$. Calculate the values (i) χ_m, (ii) H and (iii) M. 12

(b) (i) Prove with the help of electrons flow that W = VI, where W is the power in watts, V voltage in volts and I current in amperes, in case of conductor materials.

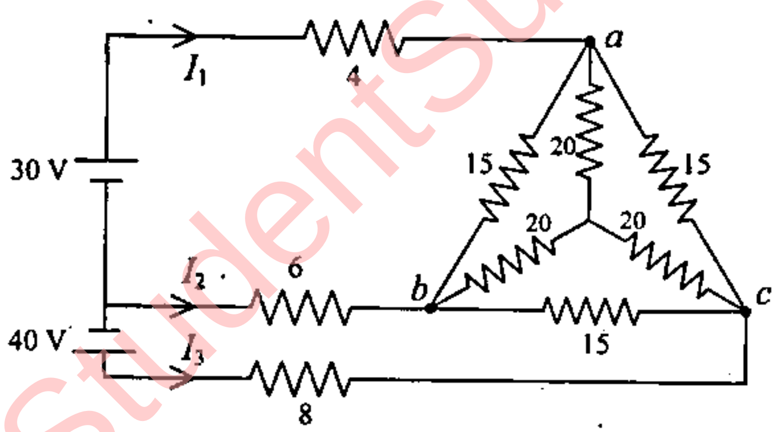
(ii) Find the mean velocity of electron flow in a conductor having a cross-sectional area of $2{\cdot}1 \times 10^{-6}$ m^2 when a current of 20 amperes flows through it. Assume that there are $8{\cdot}5 \times 10^{28}$ electrons/m^3 of the material. Charge on an electron is $1{\cdot}6 \times 10^{-19}$ coulombs. 12

(c) What is "magnetoresistance effect" ? Calculate the current produced in a small germanium plate of area 1 cm^2 and of thickness 0·3 mm when a potential difference of 2 V is applied across the faces. Given : concentration of free electrons in germanium is 2×10^{19}/m^3 and mobilities of electrons and holes are 0·36 m^2/V-s and 0·17 m^2/V-s respectively. 12

Part – C

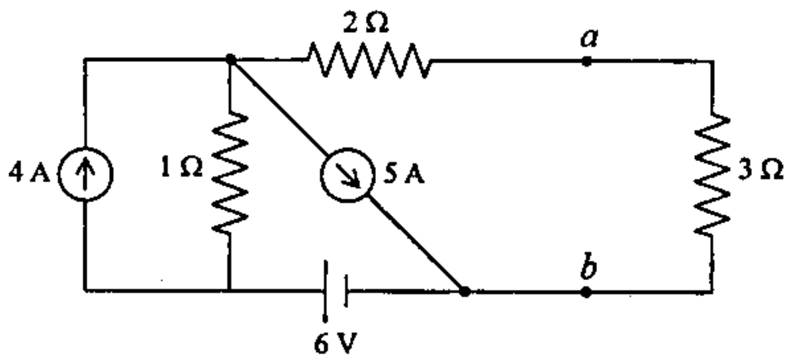
6\. (a) Three single phase loads can be connected in either star or in delta to form three-phase load. Which of these connections results in higher current when connected to a three-phase supply ? During the measurement of power by two-wattmeter method, the total input power to a 3-phase 440-V motor running at a power factor of 0·8 was found to be 25 kW. Find the readings of the two wattmeters. 12

(b)



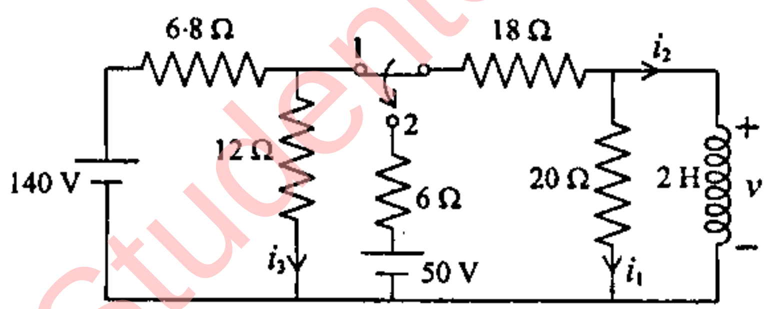
Using star-delta transformation, find the currents I_1, I_2 and I_3 for the above circuit. All the resistances are in ohm. 12

(c)



For the above circuit, determine the voltage across 3 ohm resistor applying Thevenin's theorem. State the maximum power theorem for an ac circuit. 12

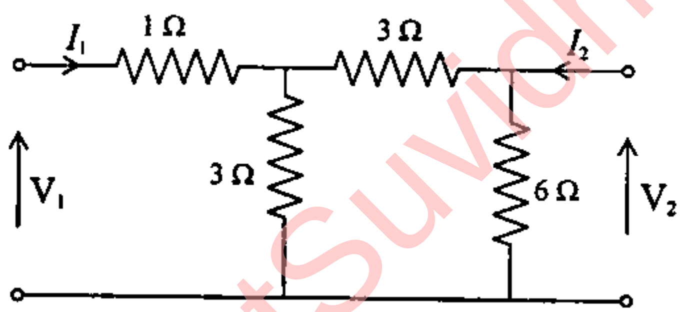
7. (a)



For the above circuit the switch has been in position 1 for a long time. (i) Find the indicated currents, (ii) Find the indicated currents and voltage immediately after the switch has been thrown to position 2. 12

(b) Define bandwidth in a series RLC circuit. Show that bandwidth increases with the increase in the value of resistance. The voltage applied to a series RLC circuit is 8·5 V. The quality factor of the coil is 50 and the value of the capacitor is 320 pF. The resonance frequency of the circuit is 175 KHz. Find the value of the inductance, current flowing in the circuit during resonance and voltage across the capacitor under resonance. Draw phasor diagram. 12

(c)



Obtain z-parameters of a two-port network in terms $ABCD$ parameters. Obtain z-parameters for the circuit shown in the above figure. 12

Part – D

8. (a) (i) Explain, with a histogram, the normal distribution of errors. 4

(ii) What is probable error and what is its significance ? 4

(iii) Explain units, system of units, standard and standard for absolute ampere. 4

(b) Draw the phasor diagram for a two wattmeter method of measuring power in a 3 phase balanced star connected load and derive equations to show that the phase angle of the load

$$\phi = \tan^{-1}\sqrt{3}\frac{(P_1 - P_2)}{P_1 + P_2}$$

where P_1 and P_2 are wattmeter readings. 10

(c) What are normal mode and common mode signals ? How are they reduced ? 10

9. (a) Explain the principle of operation and construction details of a Resistance Temperature device (RTD). 12

(b) Draw a sketch of a variable reluctance accelerometer and explain its working. 10

(c) Draw a circuit diagram of De Sauty Bridge for the measurement of capacitance and obtain an expression for the unknown capacitance. What are the defects of this bridge ? 10

10. (a) In a non-magnetic medium

$$\vec{E} = 4 \sin\left(2\pi \times 10^7 t - 0{\cdot}8x\right)\vec{a}_z \text{ V/m. Find}$$

(i) ε_r, η and (ii) The time-average power carried by the wave. 10

(b) Discuss the force exerted on a current element due to a magnetic field $\vec{B}$ in another current element. 12

(c) A dielectric material contains 2×10^{19} polar molecules/m^3, each of dipole moment $1{\cdot}8 \times 10^{-27}$ C/m. Assuming that all the dipoles are aligned in the direction of the electric field $\vec{E} = 10^5 \, \vec{a}_x$ V/m, find $\vec{P}$ and ε_r. 10

Engineering Services Examination-2012

Serial No.

C–FTF–M–FMB

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.

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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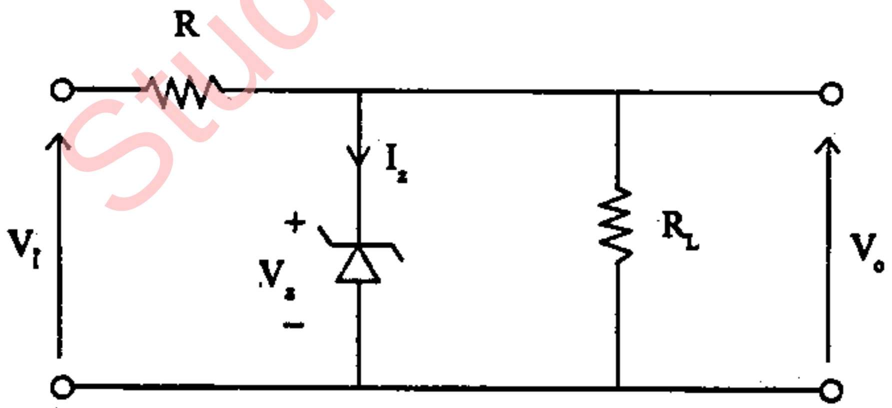
1. (a) A salient pole alternator has $X_d = 1{\cdot}4$, $X_q = 1{\cdot}0$ and $r_a = 0$. If this alternator delivers rated kVA at unity pf and at rated voltage, find its power angle and excitation voltage.

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

   (c) Answer the following with respect to the circuit shown :



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(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.

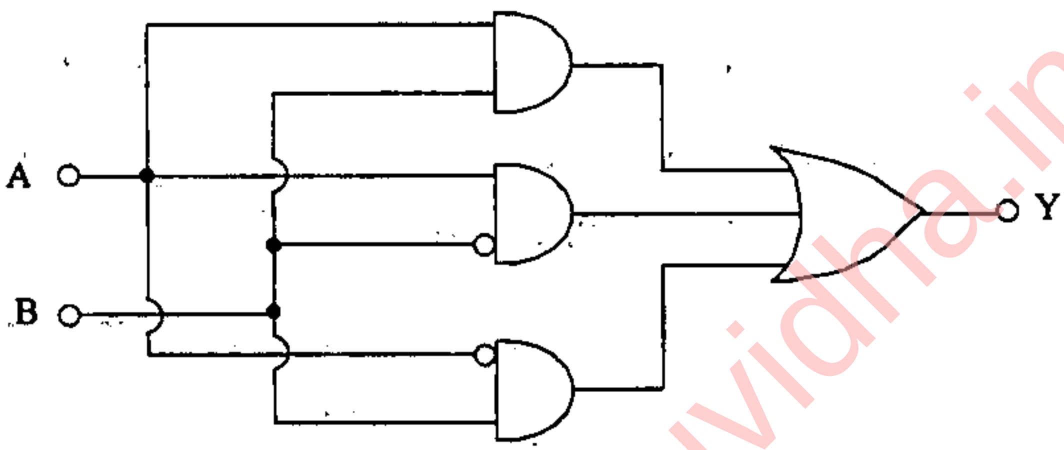
(d) For 8085 microprocessor, if the stack pointer points to 0000 H, in which memory location will stack contents be stored, if the stack is to be used ?

(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. 4×10=40

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.

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

(Contd.)

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

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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

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, ⅄-Δ transformer is protected by differential protection.

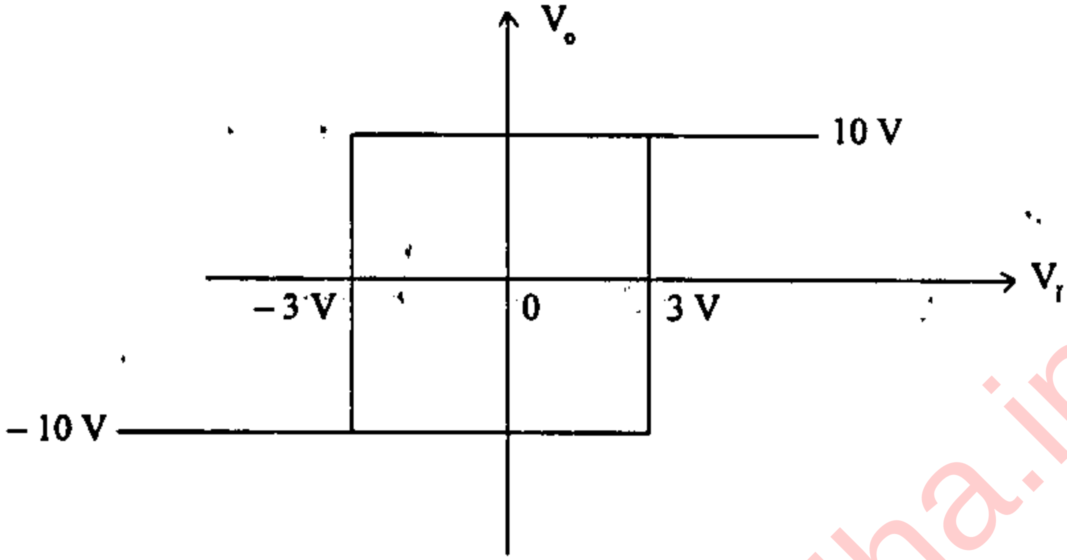
Draw a connection diagram and calculate the suitable C.T. ratio. 5+10=15

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.



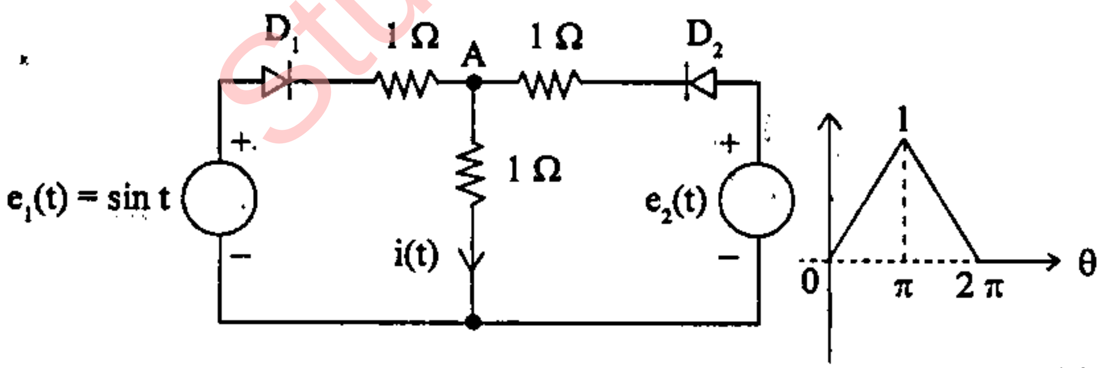
Design a circuit to realize this characteristic.

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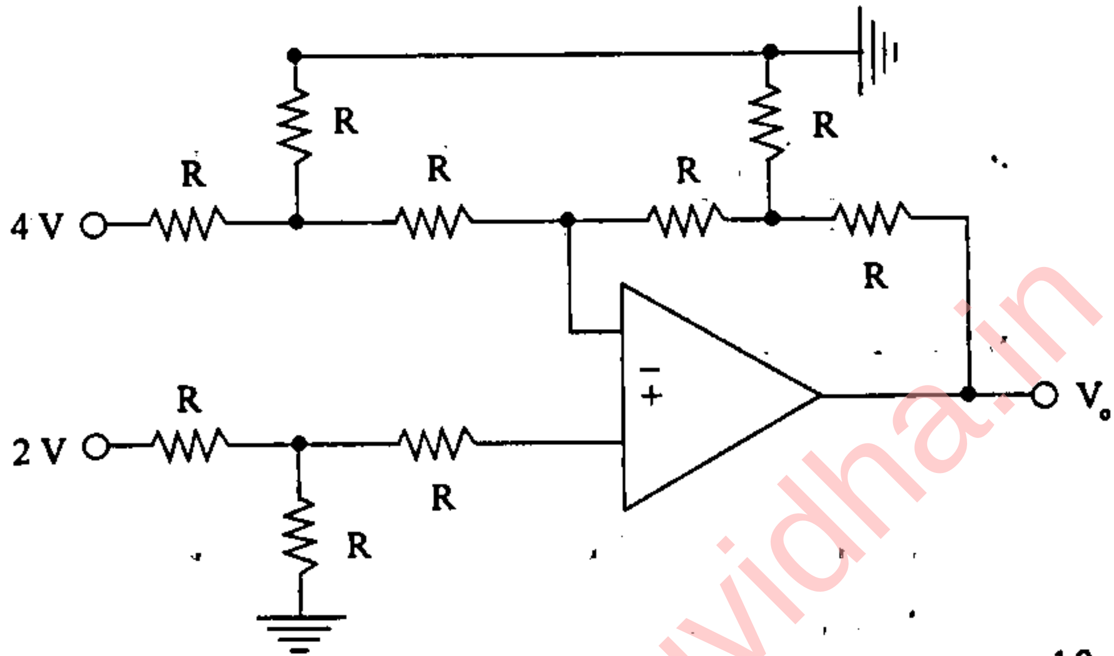
(d) Determine the output voltage V_o of the circuit shown in the figure.



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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

(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