Engg. Services Exam, 2011

Sl. No. 33801 D–RSR–L–RRA

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.

Part—A

1. *(a)* Give five properties of static magnetic field intensity. What are the different methods by which it can be calculated? Write a Maxwell's equation relating this in integral and differential forms. 12

(b) Explain the following : 10

(i) Poynting vector and its significance

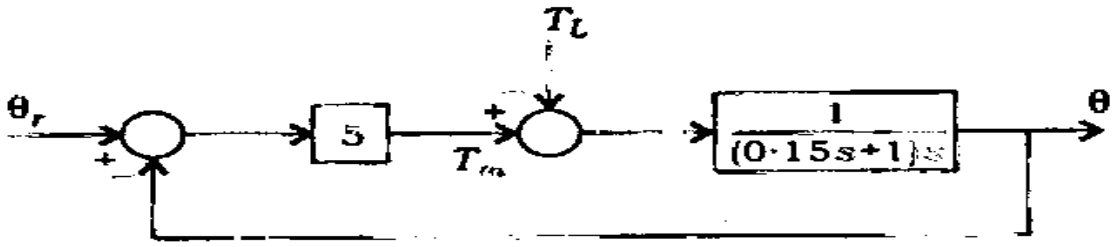
(ii) Loss tangent of dielectrics as used in wave propagation

(iii) Intrinsic impedance of a wave medium

(c) What is a distortionless line? How to achieve distortionless condition on the line? Derive the necessary equations. 10

2. (a) Show the electrical connection diagram and model the armature voltage-controlled d.c. motor in a block diagram form. Assume the necessary variables and obtain transfer function for change in position of armature to the change in armature voltage. Express the transfer function in standard form. 12

(b) For the system represented by a block diagram shown below, evaluate the closed-loop transfer function. Calculate damping factor, frequency of oscillation (if any), steady-state error if the input is unit ramp in θ_r : 10



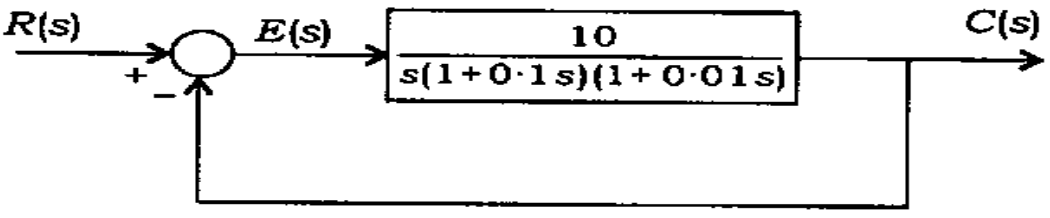
(c) (i) For a second-order system, the location of poles is known to be $-3 \pm j7$. Calculate peak time, % overshoot and approximate settling time for ±2% range. 5

(ii) What are the properties of linear systems not valid for non-linear systems? Explain each briefly. 5

3. (a) (i) Determine the complete stability information by using Routh criteria for a unity feedback closed system modelled by a plant TF

$$G(s) = \frac{128}{s(s^7 + 3s^6 + 10s^5 + 24s^4 + 48s^3 + 96s^2 + 128s + 192)}$$ 6

(ii) For the system shown in the figure below, draw the Nyquist diagram and determine the margins of stability : 6



(b) (i) A system is represented by the following transfer function model :

$$G(s) = \frac{C(s)}{R(s)} = \frac{s+5}{(s+1)(s+2)(s+3)}$$

Obtain the state-space model for this system such that the system matrix is in diagonalized form. The choice of state variables needs to be clearly indicated. 5

(ii) A system is modelled by state-space model as

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ 2 & -3 \end{bmatrix} X + \begin{bmatrix} 1 \\ -2 \end{bmatrix} u$$

$$Y = [1 \quad 0] X$$

Evaluate the state transition matrix and the autonomous response of the system with initial condition $x(0) = [1 \quad 2]^T$. 5

(c) Draw the schematic diagram of a 2-phase servomotor and draw the torque-speed characteristic. What care is taken to obtain linear characteristic? Derive the linearized transfer function under load condition. 10

Part—B

4. (a) Give the properties of superconductors. What are type I and type II superconductors? Indicate their behaviour with respect to applied magnetic field. 12

(b) Explain the Hall effect in semi-conductors and define Hall constant. What do you mean by negative Hall constant? 12

(c) Explain the following : 12

(i) Complex dielectric constant

(ii) Ceramics as insulating materials

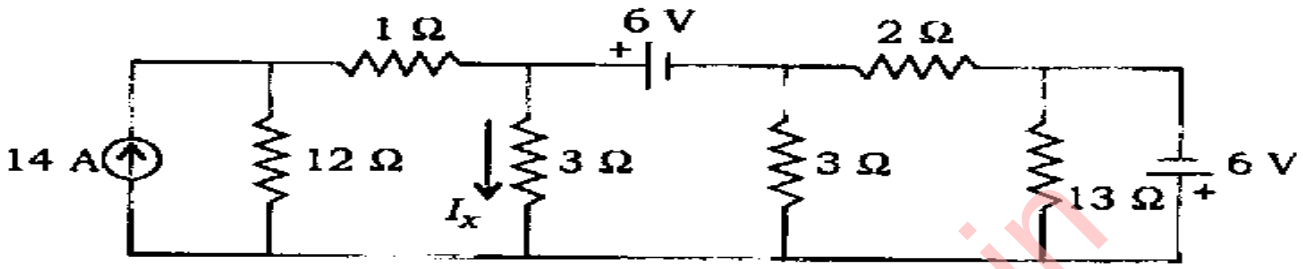
5. (a) Name the basic polarization mechanisms which occur in a dielectric. A dielectric material contains 2×10^{19} polar molecules/m^3, each of dipole moment $1 \cdot 8 \times 10^{-27}$ C-m. Assuming that all the dipoles are aligned in the direction of electric field $\vec{E} = 10^5 \vec{a}_x$ V/m,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

(b) With respect to magnetic behaviour, give the classification of magnetic materials. Discuss general electric and magnetic characteristics of ferrites and their applications. 16

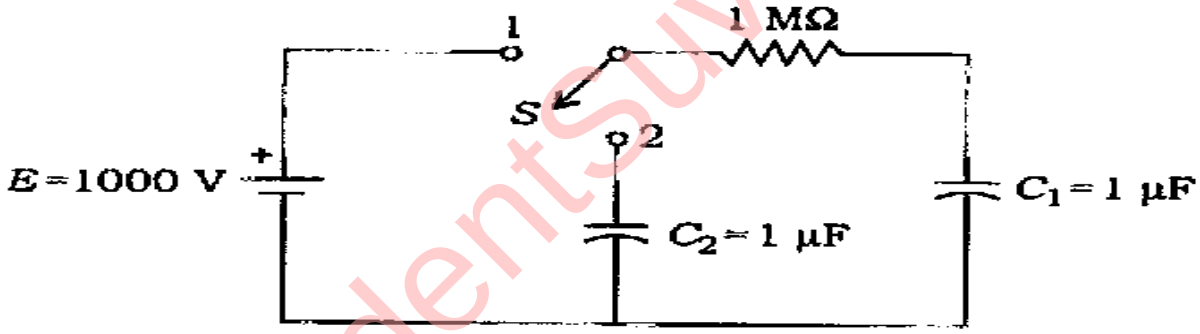
(c) Describe in detail the thermal break-down of solid dielectrics under application of alternating as well as direct voltages. 10

Part—C

6. *(a)* Find the current I_x which flows through the 3 Ω resistor in the circuit of the figure below : 12



(b) In the circuit of the figure below, switch S has been in position 1 for a long time :



(i) Find the complete solution for the current in the circuit when S is put to position 2.

(ii) How long does it take in seconds for the transient to disappear (current to decay within 1%)?

(iii) Determine the voltage which appears across each capacitor at steady state. 12

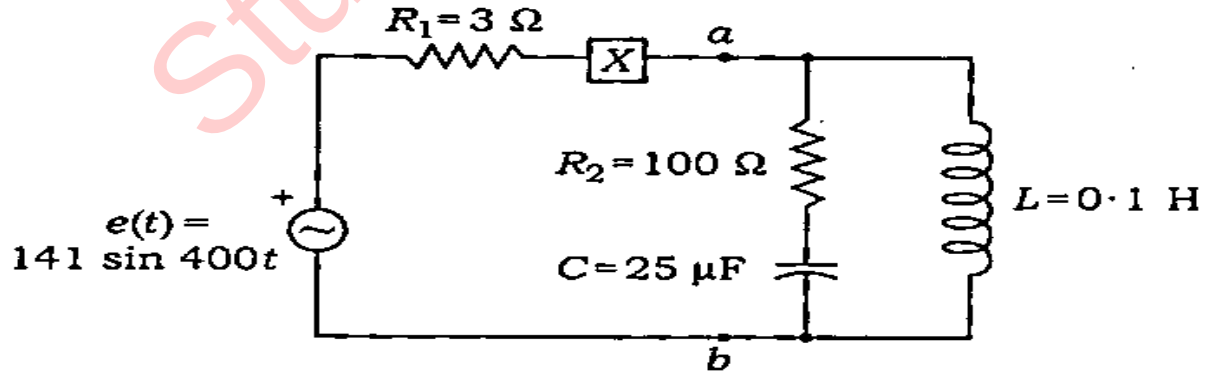
(c) A single-phase motor takes 50 A at a p.f. of 0·5 lag from a 250 V, 50 Hz supply. What must be the value of the shunting capacitor to raise the overall p.f. to 0·9 lag? How does the capacitor affect the line and motor currents? 12

7. (a) A fixed capacitance ($X_C = 20$ ohms) is placed in parallel with a series combination of resistance ($R = 8$ ohms) and variable inductance (X_L ohms), having negligible resistance. An alternating voltage of 120 volts is applied across the parallel combination. Show that the value of X_L which will produce unity power factor resonance is given by

$$X_L = \frac{X_C}{2} \pm \sqrt{\frac{X_C^2}{4} - R^2}$$

Determine the minimum value of the current drawn from the supply. 12

(b) A circuit has the configuration depicted in the figure below :



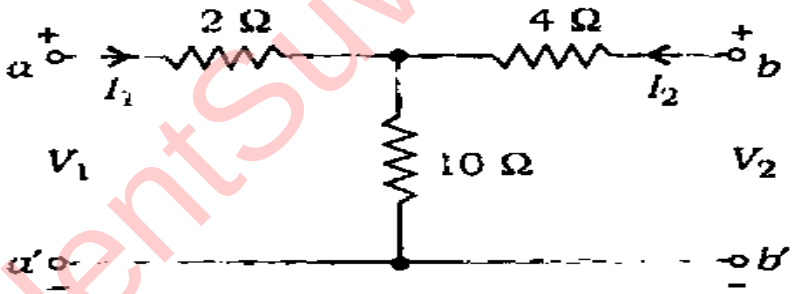
(i) Find the equivalent impedance appearing to the right of points *ab*.

(ii) Determine the value of the reactance X which makes the source current in phase with the source voltage.

(iii) Should the reactance X of part (ii) be inductive or capacitive? Find the required value of L or C.

(iv) Compute the effective value of the source current for the condition described in part (ii). 12

(c) Find $ABCD$ parameters for the two-port network shown in the figure below : 12



Part—D

8. (a) Explain, with a diagram, how Wien's bridge can be used for experimental determination of frequency. Derive the expression for frequency in terms of bridge parameters. 12

(b) The power factor of a circuit is determined by $\cos\phi = P / VI$, where P is the power in watt, V the voltage in volt and I is the current in ampere. The relative errors in power, current and voltage are respectively ±0·5%, ±1% and ±1%.

Calculate the relative error in power factor. Also calculate the uncertainty in power factor if the errors were specified as uncertainties. 10

(c) An electric utility supplies power to 1 MW load at power factor (p.f.) 0·85 and at 11 kV. The utility wants to measure the voltage, current and power factor continuously using 250 V voltmeter, 10 A ammeter and 250 V, 10 A power factor meter. Draw circuit diagram of the scheme.

Discuss, why the p.f. meter does not come back to zero reading like voltmeter and ammeter after disconnecting the supply to it. 10

9. (a) Describe the principle of frequency measurement using digital technique. Draw its block diagram. The unknown input signal of 2 V square wave is of 3·5 kHz. Determine the display indication if the gate enable time is *(i)* 0·1 second, *(ii)* 1 second and *(iii)* 10 seconds. 10

(b) Suggest a negative temperature coefficient device for the measurement of temperature (0 °C–150 °C). Describe the resistance-temperature characteristic, voltage-current characteristic and current-time characteristic of thermistors. Draw a circuit for measurement of temperature using thermistor. The output relation for a thermistor transducer is given by

$$R = R_0 \, e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

For $T_0 = 300$ K, $\beta = 3420$, $R_0 = 1$ kΩ and $R = 2$ kΩ, calculate T. 10

(c) Draw the line diagram of data acquisition system from process plant to computer system. Explain the function of each component. What do you understand by smart transducer? Discuss it in brief. 12

10. (a) A parallel-plate capacitor with plate area of 10 cm^2 and plate separation of 6 mm has a voltage $50\sin(10^3 t)$ volt applied to its plates. Determine the displacement current, assuming $\varepsilon = 2\varepsilon_0$. 10

(b) State Ampere's circuit law. A hollow conducting cylinder has inner radius a and outer radius b, and carries a current I along the positive z-direction. Find $\vec{H}$ everywhere. 12

(c) For a lossless two-wire transmission line, show that—

(i) the phase velocity $u = c = \frac{1}{\sqrt{LC}}$;

(ii) the characteristic impedance

$$Z_0 = \frac{120}{\sqrt{\varepsilon_r}} \cosh^{-1} \frac{d}{2a}$$ 10

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D-RSR-L-RRB

ELECTRICAL ENGINEERING

Paper II

(Conventional)

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

INSTRUCTIONS

Candidates should attempt FIVE questions in all.

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 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.

1. A (a) The purpose of providing dummy coils in the armature of a DC machine is to

(i) increase voltage induced

(ii) decrease the armature resistance

(iii) provide mechanical balance for the rotor

(iv) reduce the copper loss

(b) If an induction motor is operating at 60% of its synchronous speed, the maximum efficiency under ideal conditions (theoretically possible) is

(i) 100%

(ii) 40%

(iii) 50%

(iv) 60%

(c) Current chopping phenomenon is associated with

(i) over current relays

(ii) synchronous generator

(iii) induction motor

(iv) power transformer

(d) "Over reaching" and "Under reaching" are experienced in

(i) frequency relays

(ii) over current relays

(iii) distance relays

(iv) under voltage relays

(e) In a full wave rectifier circuit with centre-tap transformer, independently of the filter used, the peak inverse voltage across each diode is equal to

(i) V_m

(ii) $2\,V_m$

(iii) $\frac{V_m}{2}$

(iv) $\frac{V_m}{\sqrt{2}}$

where V_m is the maximum transformer voltage measured from the midpoint (centre-tap) to either end.

(f) Among DTL, RTL, ECL and CMOS logic families, ECL has the propagation delay and power dissipation/gate respectively as

(i) low, high

(ii) low, low

(iii) high, low

(iv) high, high

(g) Which one of the following has the highest priority ?

(i) RST 7·5

(ii) RST 5·5

(iii) TRAP

(iv) HOLD

(h) In PAM, the carrier wave consists of a periodic train of rectangular pulses and the carrier frequency is equal to

(i) the bandwidth of the modulating signal

(ii) the sampling rate of the modulating signal

(iii) atleast ten times greater than the bandwidth of the modulating signal

(iv) twice the bandwidth of the modulating signal

(i) The main drawback of a phase control of 1-phase controlled rectifier circuit is

(i) it requires more gate current

(ii) radio frequency interference

(iii) more power loss

(iv) efficiency is less

(j) The important features of rotor ON-OFF control are

(i) fast response, smooth variations in speed

(ii) better power factor at low speeds and wide range of speed control

(iii) speed can be varied, suitable for group drives

(iv) All of the above *2×10=20*

1. B (a) Why is armature control superior to field control scheme in the case of a DC shunt motor ?

(b) Draw the zero sequence network of the transformer connections shown below :

(c) Determine the diffusion capacitance due to holes in a Ge diode when the forward biased current is I = 26 mA. Given that mean life time of holes, τ = 20 μ sec at T = 300°K.

(d) With a block diagram, explain the basics of transmitter and receiver of PCM system.

(e) Show that a fully controlled 1-phase AC-DC bridge converter can operate in two quadrants.

4×5=20

SECTION A

2. (a) Explain No voltage release (NVR) and Over load release (OLR) coils provided in a DC motor starter. *10*

(b) A 400 V shunt motor draws 30 A while supplying the rated load at a speed of 120 rad/s. The armature resistance is 1·0 ohm and the field winding resistance is 250 ohms. Determine the external resistance that must be inserted in series with the armature circuit so that armature current does not exceed 150% of its rated value when the motor is plugged. Find the braking torque at the instant of plugging. *10*

(c) A 6600 V/400 V/110 V Star/Star/Mesh connected three-phase transformer has a magnetizing current of 5·5 A and balanced three-phase loads of 1000 kVA at 0·8 lag on secondary and 200 kVA, 0·5 leading power factor load on the tertiary. Find the primary current and power factor. Neglect losses. *20*

3. (a) How will the breakdown slip and breakdown torque be affected when the rotor resistance is increased ? *10*

(b) A 4-pole, 50 Hz, 3-phase induction motor delivers a shaft torque of 110 N-m at full load and running at 950 rpm. Calculate (i) rotor copper loss (ii) power input to the rotor. The mechanical losses account for 100 W. *10*

(c) An industrial load of 4000 kW is supplied at 11 kV, the power factor being 0·8 lagging. A synchronous motor is required to meet an additional load of 1500 HP (1103·25 kW) and at the same time to raise the resultant power factor to 0·95 lagging. Determine the kVA capacity of the motor and the power factor at which it must operate. Take the efficiency of the motor as 80%. 20

SECTION B

4. (a) Starting from fundamentals, derive the equations for sending end voltage and sending end current for a long transmission line. Use the distributed parameter form of representation of the long line. Obtain the A, B, C, D parameters of the line. *18*

(b) A synchronous generator is rated 20 MVA, 13·8 kV. It has X_1 = 0·25 p.u., X_2 = 0·35 p.u. and X_0 = 0·10 p.u. The neutral is solidly grounded. The machine is on no load and is operating at rated voltage when a D-L-G fault occurs at its terminals. Find the subtransient current in all the phases and the fault (all in amps) and the line-to-line voltages in all the phases (in kV). *20*

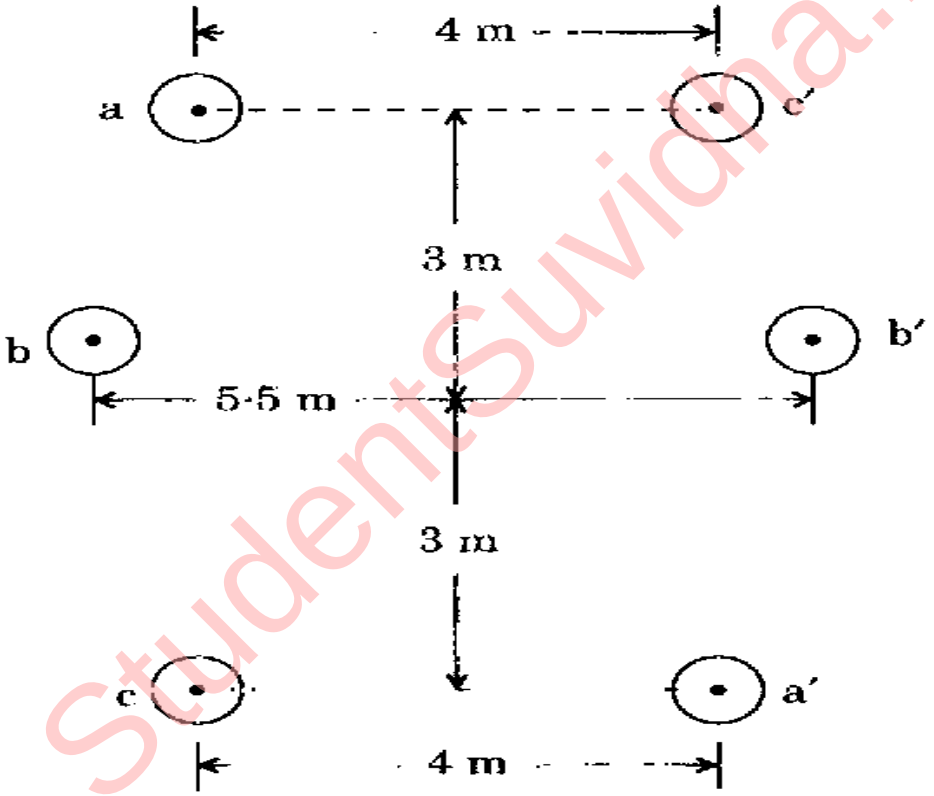
(c) Sketch typical swing curves for a synchronous machine (i) showing that the machine is stable after a disturbance (ii) showing that the machine is unstable after a disturbance. *2*

5. (a) A ring feeder with five sections and fed at one point is to be protected using Directional over current (DOC) Relays and Over current (OC) Relays with suitable time grading. Explain the working of the scheme. Show the location of D.O.C's and O.C's and their time of operation. Assume a time grading of 5 ms between the relays. The fastest relay needs 5 ms for it to operate. *15*

(b) (i) A surge of 100 kV is incident on a line having a surge impedance of 400 ohms. It meets a cable having a surge impedance of 40 ohms. Derive expression for the transmitted voltage and reflected voltage and compute their values. 7

(ii) Explain the practical importance of this situation. 3

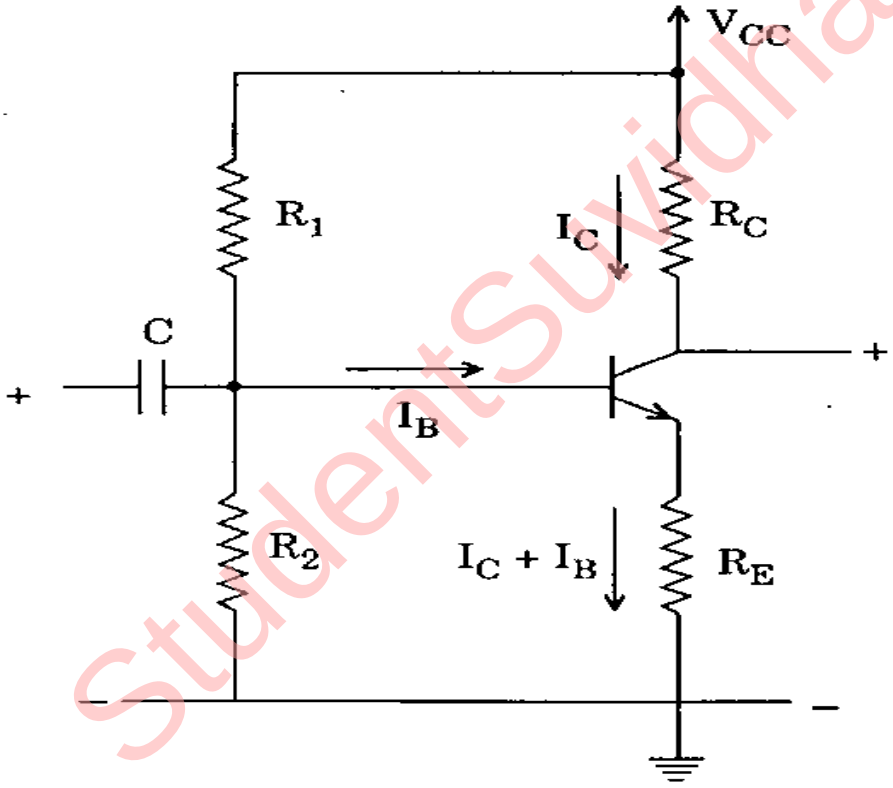
(c) A 3-phase double circuit line is arranged as shown below :



The conductors are transposed. The radius of each conductor is 0·75 cm. Phase sequence is ABC. Find the Inductance per phase per km. 15

SECTION C

6. (a) The circuit shown uses a silicon transistor with $\beta = 50$, $V_{BE} = 0{\cdot}6$ V, $V_{CC} = 22{\cdot}5$ V and $R_C = 5{\cdot}6$ K. Find the values of the resistors R_E, R_1 and R_2 so that Q point is set at $V_{CE} = 12$ V and $I_C = 1{\cdot}5$ mA. The stability factor, S must be ≤ 3.



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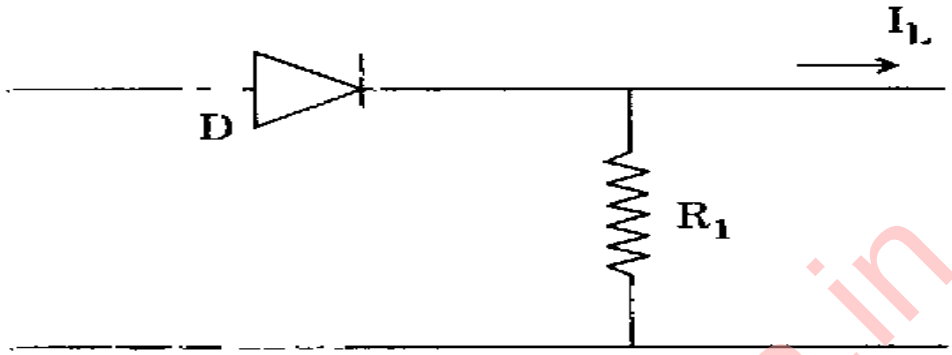
(b) An input of E = + 50 V is applied to the clipping circuit. The output current from the circuit is to be I_L = 20 mA and the negative output voltage is not to exceed 0·5 V.



Calculate the value of R_1. Specify the diode in terms of forward current, power dissipation and peak reverse voltage. Assume the reverse saturation current I_S is 5 μA and forward voltage of diode, V_F = 0·7 V. *12*

(c) Construct a logic circuit to give an output $X = (\overline{AB} + \overline{A}C)\overline{(AD + C)}$ without any reduction in number of gates. Give the logic circuits in step by step. *8*

7. (a) Explain Memory mapped I/O. *15*

(b) Explain Interrupts and Serial I/O of 8085. *15*

(c) List the machine cycles of 8085. *10*

SECTION D

8. (a) With a neat circuit diagram and waveforms, explain how envelope detector detects AM signal. *16*

(b) A sinusoidal modulating wave of amplitude 5 V and frequency 1 kHz is applied to a frequency modulator. The frequency sensitivity of the modulator is 40 Hz/V. The carrier frequency is 100 kHz. Calculate

(i) frequency deviation

(ii) modulation index

(iii) instantaneous frequency of the FM wave.

Also write the expression of the FM waveform. *16*

(c) Consider an FDM system using AM-SSB modulation to transmit 24 independent voice inputs. Assume a bandwidth of 4 kHz for each voice input. Determine the transmission bandwidth. Compare the bandwidth with that of a standard 8-bit PCM with TDM. Assume bit duration is 0·647 μs. *8*

9. (a) In Fig. 9(a), the source voltage is 100 V and the load resistance is 10 ohm. The SCR can withstand a dv/dt value of 50 V/μs. If the snubber discharge current must be limited to 2 A, find the value of the snubber resistor and capacitor. 8

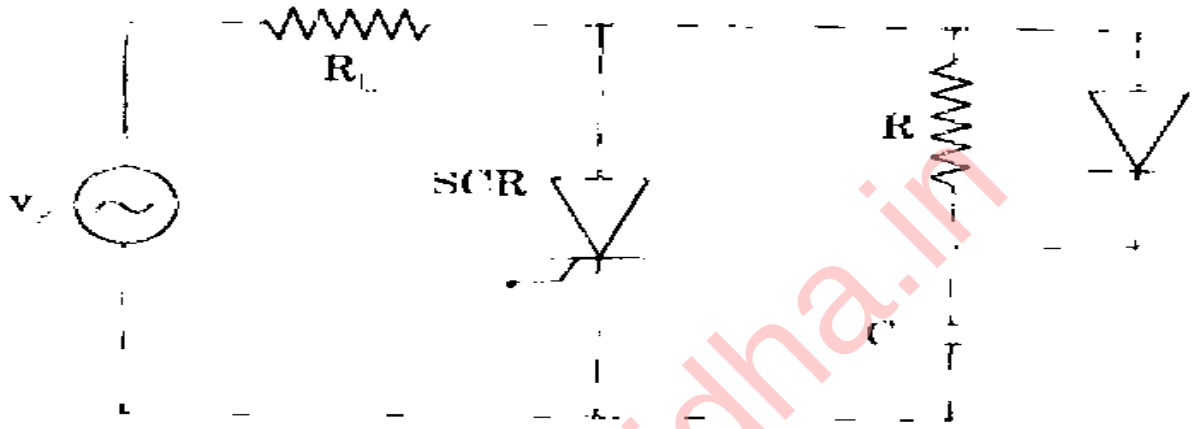


Fig. 9(a)

(b) In a 1 phase AC-AC voltage controller feeding a (i) lighting load (ii) heating load, suggest a suitable control method. 12

(c) In a phase controlled circuit using a 1 phase 230 V, 50 Hz supply, the triggering angle is adjusted to 30° in both half cycles of a resistive load. Calculate the r.m.s. value of the output voltage. 8

(d) Explain the switching characteristics of Power MOSFET. 12