I.E.S. (Conv.) - 2003

ELECTRICAL ENGINEERING

PAPER – I

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt SIX questions, selecting TWO question from Section - A, ONE from Section - B, ONE from Section - C and TWO from Section – D. Assume suitable data, if necessary and indicate the same clearly.

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SECTION A

1. (a) Determine a non-negative value of R such that the power consumed by the 2-Ω resistor in the figure shown is maximum,

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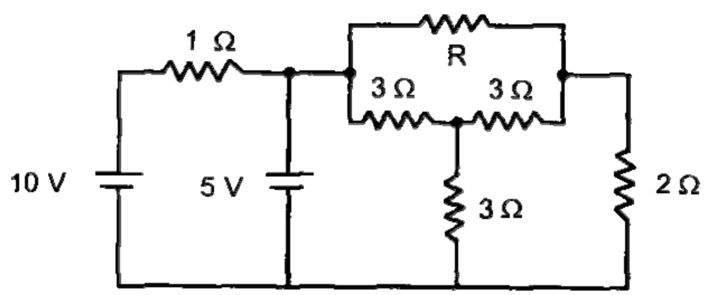

(b) Determine the value of I and R in the circuit shown in the figure.

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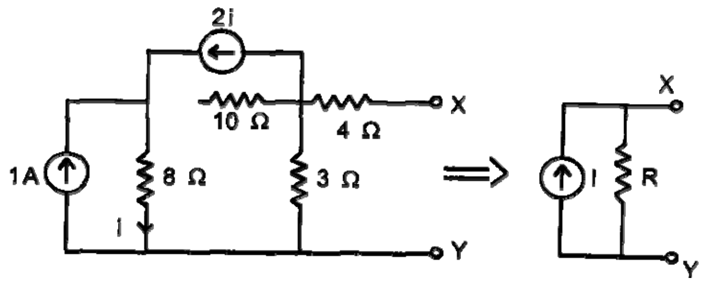

(c) In the circuit shown in the figure, S is closed at time t = 0. Determine i_c (t) and the time constant

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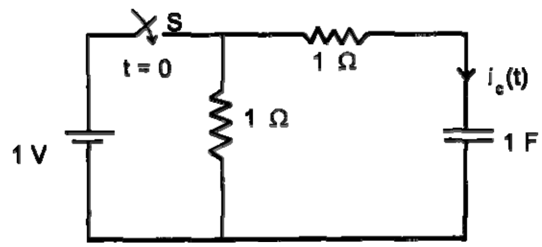
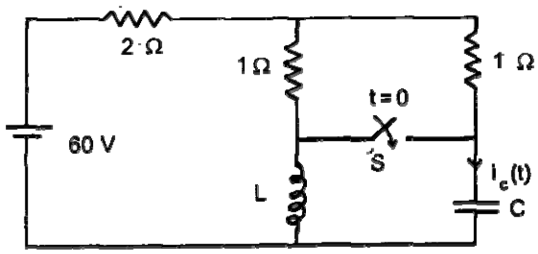


2. (a) In the circuit shown in the figure, S is closed at t = 0. Find the current i(t) through the capacitor at t = 0.

12



(b) A 2-port network N_1 has

$z_{11} = z_{12} = z_{21} = z_{22} = 1\ \Omega$. A similar 2-port network N_2 is connected in cascade to N_1. Determine the z-parameters of the composite network.

8

(c) Briefly describe the working of a two-phase servomotor. Derive its transfer function and sketch its torque-speed characteristics

3. (a) What are the different frequency response plots? Sketch the polar plot for the transfer function given below

$$G(s) = \frac{100(s-5)}{s(s+10)}$$

(b) Define gain margin. Calculate the gain margin for the system for which

$$GH(s) = \frac{1}{s\left(1+\frac{s}{2}\right)\left(1+\frac{s}{10}\right)}$$

(c) A system is represented by

X = AX + Bu

Y = CX.

All the states 'X' are available for measurement. Explain the procedure to design a state variable feedback to place the poles of the closed loop system at the eigenvalues of a matrix T.

10

SECTION B

4. (a) Three parallel transmission wires are charged with linear densities (+) 2D, (—) D and (—) D in coulomb per meter length respectively. Obtain the condition for points on equipotential surfaces inside the parallel wires. Hence or otherwise show that, if three wire sections occupy the corners of an equilateral triangle then along the centroid axis over the whole length potential V = 0. Explain briefly the formula used.

12

(b) Explain dipole moment. A dielectric slab of flat surface with relative permittivity of 5 is disposed with its normal to a uniform field with flux density 2.0 coulombs per m2. The volume of the slab is 0.1 m^3. It is uniformly polarized. Calculate its dipole moment.

12

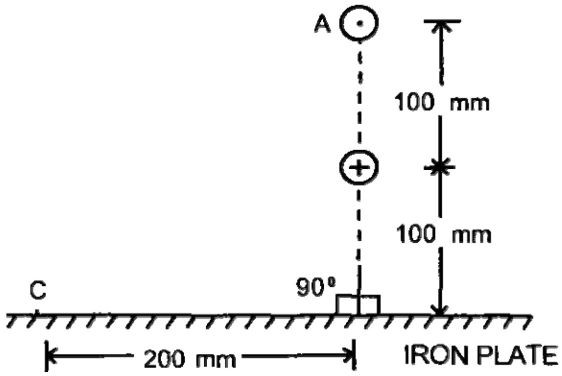
(c) Calculate the value of capacitance of a spherical capacitor consisting of two concentric spheres of radii 60 mm and 80 mm with air as dielectric medium between the two. Derive the formula used.

12

5. (a) A long fluid conductor of circular cross-section of radius 50 mm and relative permeability 1.005 carries an electric current of 100 A. Calculate the pressure at the centre of the conductor. Derive the formula used.

12

(b) Two long thin parallel conductors perpendicular to the plane of the paper and parallel to the surface of an infinite iron plate of high permeability, each carrying a steady current of 100 A in opposite directions are shown in figure.



Calculate the magnetic field strength at a point C, 200 mm away from the bottom point on iron plate below the conductors. Also calculate the mechanical force per unit length on the conductor A.

12

(c) The electric field intensity associated with a plane wave traveling in a perfect dielectric medium ($\mu_r = 1$) is given by

$$E_x(s,t) = 14.14 \cos\left(2\pi \times 10^7 t - \frac{\pi z}{10}\right)$$

in volts per metre. Calculate the values of velocity of propagation and intrinsic impedance.

12

SECTION C

6. (a) Write the notable shortcoming of the free electron model. How is it overcome by band-theory of solids? Sketch the energy bands of diamond. With the help of energy band diagram, explain an insulator.

12

(b) Explain the silver contacts The Fermi energy for silver is determined from the relation

$$W_F = \frac{h^2}{8m}\left(\frac{3n}{\pi}\right)^{2/3}$$

Calculate the value of Fermi velocity of the electrons in silver. Given Planck's constant = 6.624×10^{-3} Js, free electrons per meter cube = 5.86×10^{28}, mass of each electron = 9.108×10^{-31} kg.

12

(c) "Hall effect has played a decisive role in revealing the mechanism of conduction in semiconductors." Explain the statement.

The single carrier holes in a doped silicon sample is 2.05×10^{22} m^{-3} calculate its Hall coefficient. Electron charge = 1.602×10^{-19} coulombs.

12

7. (a) Discuss the B — H characteristics of a ferromagnetic material below the critical temperature. Give its significance. Match the values of Curie temperatures for ferromagnetic elements Cc, Fe, Gd and Ni with the values of Curie temperatures 289 K, 631 K, 1043 K and 1393 K.

12

(b) Give the general electrical and magnetic characteristics of ferrites. List its applications. 12

(c) Discuss the trends of insulating materials used in modern electrical and electronic devices. 12

SECTION D

8. (a) If $\mu = \dfrac{\pi r^4 (p_1 - p_2)}{8Ql}$, determine the dimensions of μ. (r and l are radius and length, $p_{1,\,2}$ are pressures, Q is flow).

If $r = (0.5 \pm 0.01)$ mm

$p_1 = (200 \pm 3)$ kPa

$p_2 = (150 \pm 2)$ kPa

$Q = 4 \times 10^{-7}$ m^3/sec

Calculate the absolute error in μ. 12

(b) In a Hay bridge, the four arms are $R_1 - L_1$, R_2, R_3, - C_3, R_4 connected in clockwise order. Show that, under the phase-null' condition, Q of the coil is given by

$$Q = \frac{\text{Voltage across } C_3}{\text{Voltage across } R_3}$$

12

(c) What are the requirements of an ideal S/H circuit? How are they realized in practical S/H circuit? 8

9. (a) Mention the various types of analog to digital converters in the increasing order of speed of operation.

Why is a dual slope ADC preferred in a digital voltmeter?

An 8-bit successive approximation type of ADC uses a clock frequency of 1 MHz. Calculate the time of conversion. 12

(b) What is a strain gage?

A strain gage is cemented to an iron post of length 1 m, which is subjected to a compressible force. The nominal resistance of the gage is 200 Ω. The change in resistance of the strain gage is measured to be 0.7 0. The final length of the iron post is 999 mm. Calculate the gage factor of the strain gage. 12

(c) Explain giving a neat sketch how an LVDT can be used to measure pressure. 8

10. (a) Sketch the circuit diagram for power measurement in a 3-phase circuit using two wattmeters and show that total power is given by the algebraic sum of the wattmeters readings using vector diagrams. 12

(b) The following 10 observations were recorded when measuring a voltage

1	2	3	4	5	6	7	8	9	10
41.7	42	41.8	42	42.1	41.9	42.5	42	41.9	41.8

Find (i) Mean

(ii) Standard deviation

(iii) Probable error of one reading.

10

(c) Explain how thermistor can be used for temperature measurement.

The resistance at temperature T Kelvin is given by

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

where R_0 = 1050 Ω at 27° C,

the corresponding β = 3140.

What is the temperature when the thermistor resistance is 2330Ω?

10

I.E.S-(Conv.) - 2003

ELECTRICAL ENGINEERING

PAPER - II

Time Allowed: 3 Hours **Maximum Marks: 200**

Candidates should attempt FIVE questions in all, including Question No. 1 which is compulsory. The remaining FOUR questions are to be attempted by selecting at least ONE question from each of the Sections A, B, C and D. Assume suitable data, if necessary and indicate them clearly.

SECTION A

Q. No. 1 is compulsory. Tick out the correct answer.

1. (A) (a) A fault current of 2000 A is passing on the primary side of a 400/5 C, T. On the secondary side of the CT., an Inverse-time over current relay is connected whose plug setting is set at 50%. The plug setting multiplier will be

(i) 25 (ii) 50 (iii) 10 (iv) 30

(b) An alternator (star connected) is connected to Delta- Star transformer with star neutral earthed. On the star side of the transformer a single line-to-ground fault occurs. This is equivalent to

(i) A line-to-ground fault on the generator side of the transformer.

(ii) A line-to-line fault on the generator side of the transformer.

(iii) A 3-phase fault on the generator side of the transformer.

(iv) A single-line-to-ground fault on the generator side of the transformer.

(c) Y_{BUS} as used in load flow study, and Z5 as used for short circuit study are

(i) the same

(ii) inverse of each other

(iii) are not related to each other

(d) The low voltage winding of a 400/230 V single phase 50 Hz transformer is to be connected to a 25 Hz supply. In order to keep the magnetization current at the same level in both the cases the voltage at 25 Hz should be

(i) 230 V (ii) 460 V (iii) 115 V (iv) 65 V

(e) A 3-phase induction motor draws 1000 kVA at a p.f. of 0.8 lag. A synchronous condenser is connected in parallel to draw an additional 750 WA at a p.f. of 0.6 lead. The p.f. of the total load supplied by the mains is:

(i) Unity (ii) 0.707 lead (iii) 0.6 lag (iv) zero

(f) A 3-phase synchronous motor has

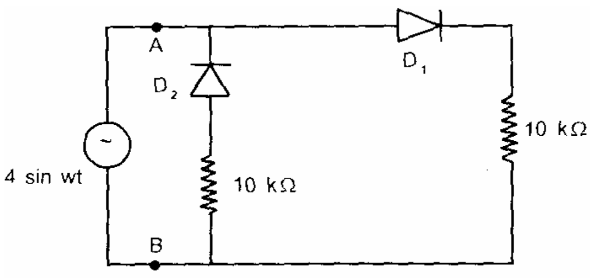
(i) High starting torque

(ii) No starting torque

(Hi) Low starting current

(iv) Low starting torque

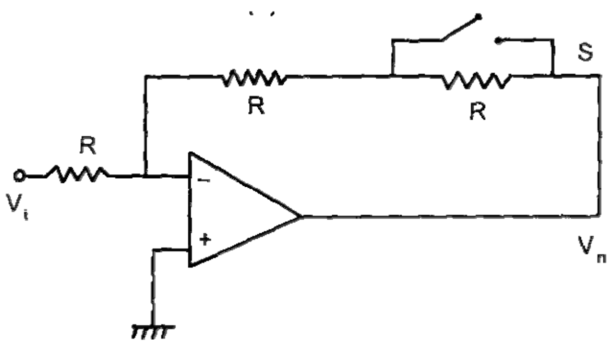
(g)



A voltage source V_{AB} = 4 sin wt, is applied across the terminals A and B of the circuit above. The diodes are assumed to be ideal. The impedance offered by the circuit across the terminals A and, B in kilo ohms is:

(i) 5 (ii) 20 (iii) 10 (iv) 100

(h)



The magnitude of the gain in the inverting operational amplifier circuit shown above is Y, with the switch open. When the switch is closed the magnitude of the gain is

(i) -Y

(ii) Y/2

(iii) 2Y

(iv) -2Y

(i) The binary representation of 100 110 is numerically equivalent to

(i) The decimal representation of 46

(ii) The octal representation of 46

(iii) The octal representation of 26

(iv) The decimal representation of 26

(j) In H.V.D.C. Converter station equipment using thyristors it is necessary to use a large number of thyristors in series because

(i) Current rating of thyristors are low

(ii) Voltage rating of thyristors are low

(iii) Thyristors always fail to an internal open circuit

(iv) None of the above

(B) Explain the following with necessary diagrams

(a) Synchronous impedance of an alternator

(b) A 3-phase static var compensator

(c) A triac-diac device used for a stepless fan regulator

(d) A directional over current relay used for parallel feeder protection.

4 × 5

2. (a) Find the synchronous impedance and reactance of a single-phase alternator in which a given field current produces an armature current of 250 A, on short circuit and a generated e.m.f. of 1500 V on open circuit. The armature resistance is 2.0 ohms. Calculate the terminal potential difference when a load of 250 A at 6.6 kV at a lagging p.f. of 0.8 is switched off.

15

(b) A series motor of resistance 1.0 ohm between the terminals runs at 1000 r.p.m. at 220 V with a current of 15 A. Find the speed at which it will run when connected in series with a 4.5 ohms resistance and taking a current of 10 A at the same supply voltage. Assume linear magnetization characteristic.

(c) Discuss briefly the different methods used for electrical braking of d.c. motors.

10

3. (a) A 100 kVA transformer has its maximum efficiency of 98% at full load and unity p.f. During the day it is loaded as follows

12 hrs —20 kW at a p.f. of 0.5 lag

6 hrs —20 kW at a p.f. of 0.9 lag

6 hrs —20 kW at a p.f. of 0.8 lag.

Calculate the “all day efficiency of the transformer.

16

(b) A 1200 V, 50 Hz star connected induction motor has a star connected slipring rotor with a transformation ratio of 3.75. The rotor resistance per phase is 0.016 ohm and leakage inductance of 0.8 mH/Phase. Neglect stator impedance. Find:

(i) rotor starting current per phase with slip ring short circuited,

(ii) the rotor p.f. at starting,

(iii) the external resistance per phase required to obtain a starting current of 125 An the stator,

(iv) the rotor current of 4% slip and

(v) the rotor p.f. at 4% slip.

16

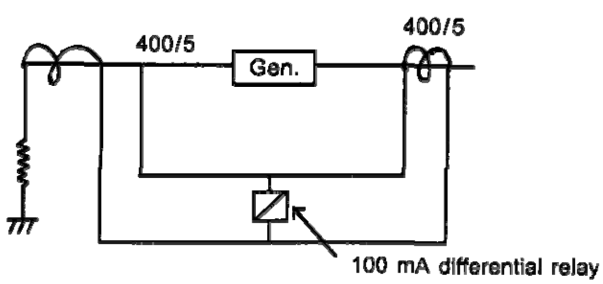
(c) Discuss the relative merits and demerits of single cage and double cage induction motors.

8

SECTION B

4. (a) (i) Discuss the general principle of operation of a generator differential protection scheme. Give the 3-phase connection of the biased scheme.

(ii) The scheme shown below is used for protection of the generator winding by an ordinary differential relay, having a minimum pick up current of 100 mA. The C.T.S. on the grounded neutral and the live ends have actual ratios of 79 and 91 respectively though their nominal ratios are same. Show that the differential relay will trop even when the generator is delivering, full load current of (400 + j0.0) A, to the bus and there is no fault in the differential zone.



(iii) To overcome the defect in the question 4 (a) (ii) a percentage differential relay having the same minimum pick-up current of 100.mA and 20% slope was used. Drawing the slope characteristic of the relay show that the undesired tripping has been avoided.

7 + 5 + 6

(b) A 20 MVA, 33 kV, 3-phase alternator is subjected to different types of short circuits and the following are the value of fault current:

3 phase short circuit —319 A

single line-to-ground fault —659 A

line-to-line fault —435 A.

Determine the positive, negative and zero sequence reactance's of the generator in per unit and in ohms. Neglect resistive part.

12

(c) Discuss the merits and demerits of a vacuum circuit breaker for low voltage applications.

10

5. (a) Give a neat sketch of a 12-pulse Bipolar HVDC station indicating the position of various equipment. Give the uses and limitations of each equipment.

15

(b) Two 200 MVA alternators operate in parallel. The frequency drops in the first marching from 50 Hz at no load to 48 Hz at full load, whereas in case of the other machine, the frequency drops from 50 Hz to 47 Hz under the same conditions

(i) How the two machines will share a total load of 300 MW?

(ii) Determine the maximum load at unity power factor which can be delivered by the two machines without overloading any of them.

13

(c) The fuel inputs of plants 1 and 2 are given as

$$F_1 = 0.2p_1^2 + 40P_1 + 120 \text{ Rs/hr.}$$

$$F_1 = 0.2p_2^2 + 30P_2 + 150 \text{ Rs/hr.}$$

Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading of each machine is 100 MW and 25 MW, the demand is 180 MW and transmission losses are neglected. If the load is equally shared by both units, determine the saving obtained by loading the units as per incremental cost.

12

SECTION C

6. (a) Draw the programming model of an Intel 8085 microprocessor and explain its different parts. Explain why address bus is time multiplexed? Explain allow why 'ALE' signals is used? How the microprocessor communicates with slow speed peripherals with the help of the 'Ready' signal?

18

(b) Write down the Addressing modes of the following instructions

(i) ACI 20 H

(ii) CMA

(iii) STA 2500 H

(iv) LXI H, 2005 H

(v) XCHG

(vi) MOV E, L

6 × 1

(c) How would you implement the following Fortran program in 8085 assembly level language:

```
60    IF(X - Y)45,50,52
45    GO TO 90
50    Y = Y - 1
      GO TO 60
52    X = X - 2
      GO TO 60
90    END.
```

Assume the statement to be an Arithmetic 'IF' statement. X and V are eight bit binary numbers stored in memory locations 2000 H, 2001 H respectively.

10

(d) Determine in each case the final values in Accumulator and Carry flags after the following instructions are executed:

	Accumulator	Carry
Initial stage	95*H*	1

(i) RAL,

(ii) RRC,

(iii) XRI A5 H,

(iv) CPI A 9H,

(v) ORI C9 H,

(vi) ANI 33 H.

In each case it may be assumed to start with the same initial values of Accumulator and Carry flags.

6 × 1

7. (a) Develop a voltage follower circuit using JFET. Bring out the distinctions between the constructional and operational feature of a JFET and MOSFET.

10

(b) Make a distinction between the "voltage" feedback and "current" feedback in amplifier circuits. Discuss the merits in each case and derive the expression for the net output impedance in each case.

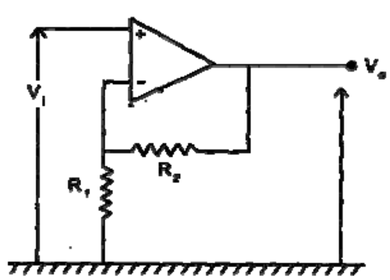
15

(c) Draw the logic symbols and explain the operations of a D-type and a T-type flip-flop.

8

(d) The operational amplifier circuitry is given below. Determine its gain and indicate its applicability.

7



8. (a) Explain the operation of a Schmitt trigger circuit using an operational amplifier. Discuss the effect of hysteresis in such a circuit.

8

(b) Explain briefly the functions of "De-multiplexer" and 'Multiplexer". Explain with necessary diagram the operation of a 4 to 1 line Multiplexer.

12

(c) Explain with diagram the principle of operation of an ND converter based on "successive approximation method" How is it better than an AD converter based on "Counter type"?

12

(d) Discuss how counters are used for measurement of frequency 2 Give a typical block diagram used for precise measurement of frequency.

8

SECTION D

9. (a) What are the frequency range of the following bands:-

(i) MF (ii) H.F. (iii) VHF (iv) UHF (v) Microwave, (vi) Optical range.

Mention a typical application for each.

12

(b) What is a GTO? Discuss its advantages over a normal thyristor. Discuss the advantages of a GTO over a bipolar transistor in low power applications.

8

(c) What is a d.c. chopper? Discuss with necessary circuit diagrams the principle of operation of a

(i) step down chopper,

(ii) step-up chopper.

Give comments on chopping frequency.

12

(d) What is an Unijunction transistor? Draw a basic UJT pulse trigger circuit with typical waveforms and explain its operation.

8

10. (a) Define Amplitude modulation" and "Modulation Index". Write down the equations for the

(i) amplitude and

(ii) the instantaneous voltage of the amplitude modulated wave.

Sketch the graph of an amplitude modulated wave.

10

(b) The antenna current of an AM transmitter is 7.5 A; when only the carrier is sent, but it increases to 8.65 A, when the carrier is sinusoidally modulated. Find the percentage modulation. Determine the antenna current when the depth of modulation is 0.75.

15

(c) A 20 MHz carrier is modulated by a 450 Hz audio sine wave. If the carrier voltage is 4.5 V and the maximum deviation is 10 kHz, write down the equation of this modulated wave for (i) F.M., and (ii) P.M. If the modulated frequency is only changed to 1.8 kHz, all else remaining constant, write down the new equations for (iii) F.M. and (iv) P.M.

15