I.E.S. (Conv.) - 2007

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.

SECTION A

1. (a) A parallel plate capacitor of width w, Length *l*, and separation d has a solid dielectric slab of permittivity ε in the space between the plates. The capacitor is charged to a voltage V_o by a battery, as shown in Figure 1 (below). Assuming that the dielectric slab is withdrawn to the position shown, determine the force acting on the slab.

12

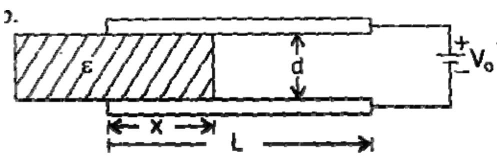


Figure 1

(b) A uniform plane wave with the field components Ex and Hy has an electric field amplitude of 100 ∠30° V/m and propagates at f = 2 MHz in a conductive region having the parameters $\mu = \mu_0$, $\varepsilon = 9\varepsilon_0$. and $(\sigma/\omega\varepsilon) = 0.5$.

(i) Find the values of attenuation constant, phase constant, phase velocity, wavelength, skin depth and intrinsic impedance for this wave.

(ii) Express the electric and magnetic fields in both their complex and real time forms, with the numerical values of (i) inserted.

10

(c) Region 1 (z < 0) is free space, whereas region 2(z > 0) is a material medium characterized by a $\sigma = 10^{-4}$ (s/m), $\varepsilon = 5\varepsilon_0$, and $\mu = \mu_0$. For a uniform plane wave having the electric field

$$E_i = E_0 \cos\left(3\pi \times 10^5 t - 10^{-3}\pi z\right) ax\left(V/m\right)$$

incident normally on the interface z = 0 from region 1, obtain the expression for the transmitted wave electric field.

10

2. (a) Determine the overall transfer function C/R of the system shown below (Figure 2) by block diagram reduction technique.

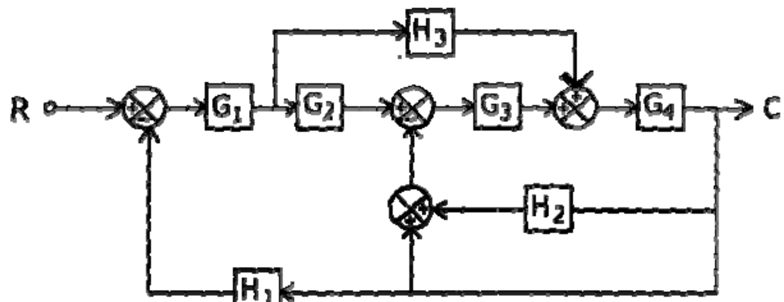


Figure 2

(b) Draw the signal flow graph of the above system and verigy the results by using Mason's gain formula.

(c) A unity feedback control system has an open loop transfer function $G(s) = \frac{K(s+1)}{s(s-1)}$.

Show that the root loci of complex roots are part of a circle with (-1, 0) as centre and radius = $\sqrt{2}$. Sketch the root locus with K as a variable parameter.

10

3. (a) Consider $G(s)H(s) = \frac{5(s+3)}{s(s-1)}$. Sketch the complete Nyquist plot and then determine the stability of the closed loop system

12

(b) The transient response of a second order system when subjected to unit step input is found to have peak overshoot of 16.2 per cent, occurring at a time $t = \frac{\pi}{5\sqrt{3}}$ seconds. If this system is subjected to a sinusoidal input of 1 volt, determine (i) frequency of input at which amplitude of steady state response will have maximum value, (ii) maximum value of steady state output.

10

(c) The asymptotic log magnitude curve for open loop transfer function is sketched in Figure 3 below. Determine the transfer function.

10

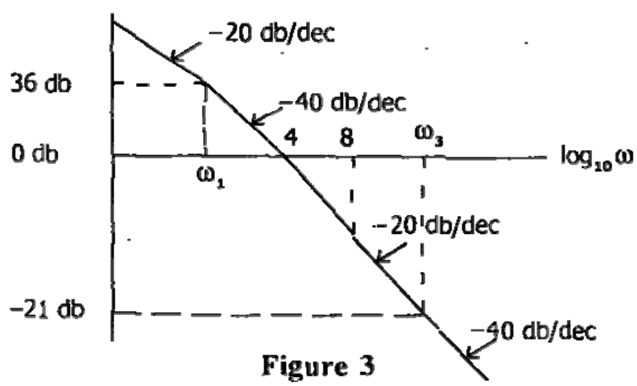


Figure 3

SECTION B

4. (a) Distinguish between metals, insulators and semiconductors.

12

(b) What are the technically important superconductors? What are the physical changes observed at the transition temperature? What are the general properties of superconductors?

12

(c) Prove that "superconductors are perfectly diamagnetic". Photoelectric threshold of metallic copper is at λ = 3000 A.U. Find out (i) the work function of the metal and (ii) maximum kinetic energy of the photoelectrons ejected, when ultraviolet light of λ = 2536 A.U. falls on the metal surface. Given I A.U = 10^{-10} meter;

1 Joule = 1.6×10^{-19} eV.

12

5. (a) What are the factors that will increase the dielectric loss in dielectric materials?

What properties should the insulating materials have to avoid breakdown?

What are the important applications of insulating materials?

12

(b) Draw the variation of resistance with temperature in an intrinsic semiconductor.

Find the value of insulation resistance of a dielectric whose volume resistivity is 5×10^{16} ohm-m and surface resistivity is 10^{18} ohm.

12

The dimensions of the dielectric are as follows:

The thickness through which the current flows = 5 cm

The length of the dielectric = 8 cm

The width of the dielectric = 3 cm.

(c) Distinguish between Dia, Para and Ferro magnetic materials.

12

SECTION C

6. (a) For the network shown in Figure 4, determine the node voltages.

12

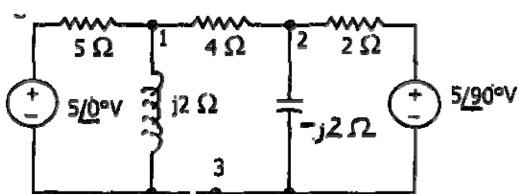


Figure 4

(b) Calculate the voltage V across the resistance R in Figure 5 by the principle of superposition.

12

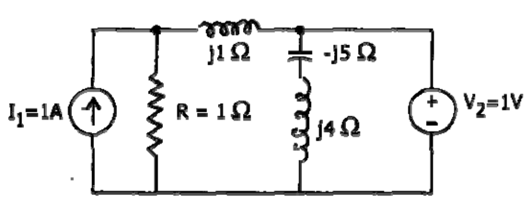
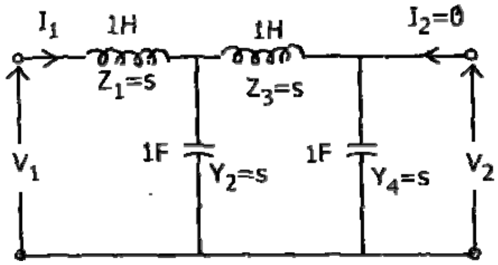


Figure 5

(c) Write the driving-point impedance of the ladder network in Figure 6.

12

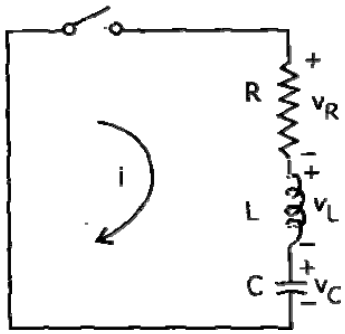
Figure 6



7. (a) In Figure 7, R = 200Ω, L = 0.10H, C = 13.33 μF, and $V_C(0^-) = 200V$. Obtain the current transient, if the switch is closed at t = 0.

12

Figure 7



(b) A three-phase, 4-wire, CBA system, with an effective line voltage of 169.7 V, has three impedance of 20 ∠-30° Ω in a Y-connection (Figure 8). Determine the line currents and draw the voltage — current phasor diagram.

12

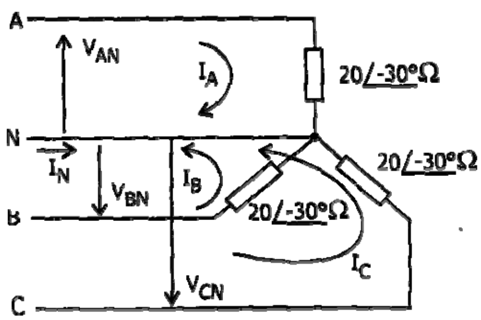


Figure 8

(c) Compare the resonant frequency of the circuit shown in Figure 9 for R = 0 to that for R = 50Ω

12

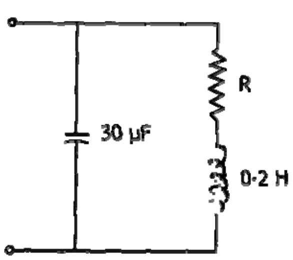


Figure 9

SECTION D

8. (a) Describe the construction of a resistance standard of 1 Ω value. Discuss the techniques used to minimize the errors in this.

10

(b) The limiting errors for a four dial resistance box are:

Units: ± 02% Tens ± 0.1%

Hundreds ± 0.05% Thousands ± 0.02%

10

If the resistance value is set at 4325 Ω calculate the limiting error for this value.

(c) Describe the constructional details and working of a single phase electrodynamometer type of power factor meter. Prove that the displacement of moving system is equal to the phase angle of the system.

12

9. (a) What are the different problems associated with measurement of low resistances? Explain the principle of working of Kelvin's Double Bridge and explain how the effect of contact resistance of leads is eliminated.

10

(b) Prove that for electrodynamometer type of wattmeters:

$$True\ \ Power = \frac{\cos\phi}{\cos\beta\cos(\phi-\beta)} \times \text{actual wattmeter reading}$$

Where ϕ = power factor of the circuit

$$\beta = \tan^{-1}\frac{\omega L}{R}$$

where L and R are the inductance and resistance of the pressure coil.

Explain why errors are large when power factor is low.

10

(c) Explain the advantages of electronic voltmeters over conventional type voltmeters. Describe the circuit diagram of a differential amplifier type electronic voltmeter using two FETs.

12

10. (a) Describe the use of thermocouple for the measurement of temperature.

A copper-constantan thermocouple with 0°C reference junction temperature was found to have linear calibration between 0°C and 400°C and emf at maximum temperature equal to 20.68 mV. Determine (i) the correction which must he made to the indicated emf if the cold junction temperature is 25°C, (ii) the temperature of the hot junction if the indicated emf is 8.92 mV with cold junction temperature of 25°C.

10

(b) How is a differential output taken from an inductive transducer? Explain the advantages when such inductive transducers are used for measurement of displacement.

10

(c) What is multiplexing in telemetering system? Explain "Time Division Multiplexing" and "Frequency Division Multiplexing".

12

I.E.S. (Conv.) - 2007

ELECTRICAL ENGINEERING

PAPER - II

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

Candidates should attempt FIVE Questions in all Questions No. 1 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. Tire number of marks carried by each question is indicated at the end of the question.

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

Question No. I is Compulsory

1. (A) Choose and write the correct answer

$2 \times 10 = 20$

(a) An iron cored transformer is working at a maximum flux density of 08 web/m^2. Its core is replaced by silicon steel core, working at a maximum flux density of 1.2 web/m^2. If the total flux is to remain the same, what is the reduction in volume expressed as a percentage of the original volume? The frequency and voltage per turn are the same in both cases.

(i) 33% (ii) 9%

(iii) 22% (iv) 11%

(b) What happens to the speed when the flux is reduced by 10% in a 200 V D.C. Shunt Motor having an armature resistance of 0.2 ohm carrying a current of 50 Amps and running at 960 RPM prior to weakening of field. The total torque may be assumed constant. Neglect losses.

(i) 1250 RPM (ii) 1066 RPM

(iii) 920 RPM (iv) 576 RPM

(c) An 8 pole alternator runs at 750 RPM. It supplies power to a 6 pole Induction Motor which has a full load slip of 3%. The full load speed of the motor is

(i) 1050 RPM (ii) 970 RPM

(iii) 960 RPM (iv) 1250 RPM

(d) A 500 kVA, 1100 V, 50 Hz Y connected 3 phase Alternator has stator resistance of 0.1 ohm/phase and Synchronous Impedance of 1 5 ohm/phase. The alternator is supplying full load at unity power factor. The induced e.m.f. per phase for this condition is

(i) 769V (ii) 832V

(iii) 692 V (iv) 935 V

(e) The making capacity of a circuit breaker is

(i) Less than the asymmetrical breaking capacity of the breaker.

(ii) Greater than the asymmetrical breaking capacity of the breaker.

(iii) Equal to the symmetrical breaking capacity of the breaker.

(iv) Equal to the asymmetrical breaking capacity.

(f) A single phase Full-Bridge diode rectifier delivers a constant load current of 10 A, Average and RMS values of source current, are respectively

(i) 5 A, 10 A (ii) 10A, 10A

(iii) 5A, 5A (iv) 0A, 10 A

(g) The Hoolean expression $ABC + \overline{A}BC + AB\overline{C} + \overline{ABC}$ is equivalent to

(i) OR GATE (ii) AND GATE

(iii) DC-NOR GATE (iv) EX-OR GATE

(h) In FM broadcast, maximum deviation is 75 kHz and maximum modulating frequency is 15 kHz. In view of Carson's rule, the maximum required bandwidth is

(i) 15 kHz (ii) 30 kHz

(iii) 150 kHz (iv) 180 kHz

(i) Which signal of 8085 microprocessor is used to insert wait states 7

(i) Ready (ii) ALE

(iii) HOLD (iv) INTR

(j) An operational Amplifier is basically a

(i) Low gain A.C. Amplifier

(ii) High gain D.C. Amplifier

(iii) High gain R.C. coupled Amplifier

(iv) Low gain Transformer-coupled Amplifier

(B) (a) Describe the meaning of "armature reaction". How does it affect the performance of a D.C. Generator? How can the performance be improved with regard to the above?

(b) Explain the choice of synchronous machine on the basis of the generating station.

(c) Why do you use Double Cage Induction Motor? Explain disadvantages if any.

(d) Find the simplified form of the Boolean expression

$AB + \overline{B}D + AD$

(e) Write the meaning of the following instructions used in 8085:

MOV M, r

INR r

RLC

CMA

$4 \times 5 = 20$

SECTION A

2. (a) A 3 phase load of 40 kW, 380 V having a p.f. of 0.8 (lagging) receives its power through a 3 phase auto transformer from a 3 phase 440 V 3 φ supply. The auto transformer is connected in star. The neutral is NOT grounded. Neglect exciting current and impedance of the transformer winding.

(i) Draw the diagram depicting the above situation.

(ii) Calculate the currents entering the load from the auto transformer.

(iii) Calculate the currents entering the transformer from the supply side.

(iv) Show the currents flowing in the transformer windings along with directions.

3 + 4 + 4 + 4

(b) A 230 V, D.C. Machine has Ra = 0.3Ω and Rsh 160 Ω respectively. It is running as a motor on NO LOAD at 1000 RPM taking an armature current of 3.3 A at rated voltage. When the motor is run on FULL LOAD at rated voltage, the line current has a value of 40 Amps. Calculate the speed and torque developed for this condition, assuming that armature reaction weakens the no load flux by 4%.

10

(c) Describe with all relevant circuit diagrams and graphs, the method of determining the regulations of a 3 phase altemator using ZPF method. Compare the results of this method with EMF and MMF Methods.

10 + 5

3. (a) Using the distributed parameter form of transmission line model, obtain the equations for V_S and I_S, in terms of V_R, I_R' line resistance/km, r, line inductance per km, *l*, conductance per km, g, capacitance per km, c, propagation constant, gamma γ and characteristic impedance, Z_c.

15

(b)

Draw the positive sequence, negative sequence and zero sequence Impedance networks for the above 3 phase transformer connections.

7 × 2 = 14

(c) A 3 phase generator is rated 7500 kVA and 13.8 kV. It has $X_d^{''} = 9\%, X_d^{'} = 15\%, X_d = 100\%$

This generator is connected to a 3 phase transformer (step up) through a 3 phase circuit breaker which has a speed of 5 cycles. The generator is operating on NO LOAD and at rated Voltage. Under this condition, a 3 phase fault occurs between the breaker and the transformer.

Calculate

(i) Sustained short circuit current in the C.B.

(ii) Initial symmetrical RMS current in the breaker.

(iii) Maximum possible D.C. component of short circuit current in the C.B.

(iv) Momentary current rating of C.B.

(v) Current to be interrupted by the breaker.

(vi) Interrupting kVA.

1 + 5 × 2 = 11

SECTION B

4. (a) Describe with suitable diagrams how the stator winding of a 3 phase alternator is protected from

(i) Earth faults on the stator winding

(ii) Unbalanced currents in the stator winding

(iii) Overloading of alternator

(iv) Earth Fault on the Rotor winding

4 × 3 = 12

(b) A surge of 100kv travelling in a line of natural Impedance 600 ohms arrives at a junction with two lines of Impedances 800 ohms and 200 ohms respectively. Find the surge voltages and currents transmitted into each branch line. Derive the equation you are using.

16

(c) A 50 Hz synchronous generator is connected to an infinite bus through a line. The p.u. reactances of the generator and the line are j 0.3 p.u. and j 0.2 p.u. respectively. The generator no load voltage is 1.1 p.u. and that of the infinite Bus is 1.0 p.u. The inertia constant of the generator is 3 MW—sec/MVA.

(i) If the generator is loaded to 60% of its maximum power transfer capacity and a small perturbation is given, calculate resulting natural frequency of oscillations.

(ii) If the generator is loaded to 75% of its maximum power transfer capacity and a small perturbation is given, calculate the new natural frequency of oscillations.

12

5. (a) The admittances between the various buses is a power system are given in the Table below. Obtain the YBUS

Matrix.

Table

Buses	**Admittances in p.u.**
1 – 2	0.10
1 – 4	0.20
2 – 3	0.25
2 – 4	0.50
3 – 1	0.40
4 – 3	0.50

(b) A 3 phase generator is rated 25 MVA, 13.2 kV and $X_d^{''}$ = 0.20 p.u., X_2 = 0.30 p.u. and X_0 = 0.10 p.u.

The neutral is solidly grounded. A Line-to-Line fault occurs on phases B and C of the generator. Calculate

(i) I_b in amps (ii) I_C in amps

(iii) V_{AB} in Volts (iv) V_{BC} in Volts and

(v) V_{CA} in Volts

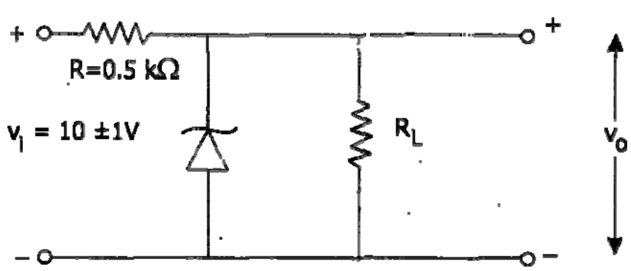
15

(c) There are 6 conductors in a Double circuit Transmission line. Each conductor has a radius of 12 mm. The 6 conductors are arranged horizontally. The centre to centre distance between all the conductors is 2 m. The sequences of conductors are from left to right as follows: a, b, c, a’, b’, c’. Calculate the inductance per km per phase of this system.

10

SECTION C

6. (a)



A Zener regulator circuit is shown above in which the nominal supply voltage is 10 V but can vary by ± 1V. The ratings of Zener are; V_Z = 6.8 V, I_z = 5 mA, r_z = 20 Ω and I_{zk} = 0.2 mA. Determine

(i) The output voltage for no load when supply is 10 V.

(ii) Change in output voltage at no load due to supply variation of ± I V

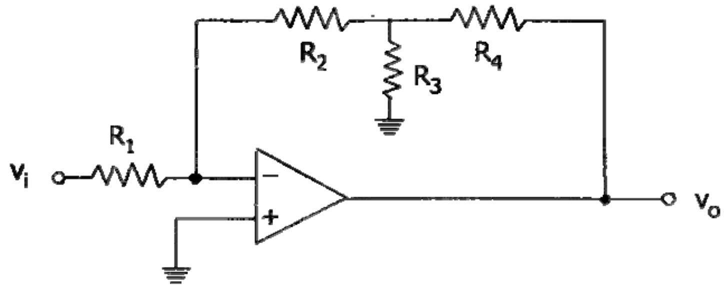
(iii) Change in output voltage when RL = 2 kΩ.

(iv) Output voltage at nominal supply when $R = R_L$.

(v) Minimum value of R_L for which Zener operates in breakdown region.

15

(b)



(c) Derive an expression for the closed loop gain v_0/v_i of the circuit shown above. Assume ideal OP AMP. 10 Using J-K flip-flop, design a counter which has the following count sequence:

0	0	0
0	0	1
0	1	0
1	0	0
1	0	1
1	1	0

Draw the excitation table, logic diagram and state diagram.

7. (a) Draw the state diagram, logic diagram and timing diagram for a decimal BCD ripple counter. Explain the operation mentioning the conditions for state transition of each flip-flop.

15

(b) (i) Draw a single-stage, double-ended, transistorized differential amplifier and define offset and drift. What are the measures taken to minimize offset and drift?

(ii) Sketch a single-stage, R.C. coupled, transistorized, common-emitter amplifier using npn transistor. Draw its frequency response. Why the gain is low at very low and very high frequencies? How the bandwidth of the amplifier is determined from this response?

8 + 7

(c) Draw the flow chart and write the assembly language program in 8085 to add two numbers of 8-bit data using direct addressing. The data is stored in memory locations $(4200)_H$ and $(4201)_H$ and the result is to be stored in memory locations $(4202)_H$ and $(4203)_H$.

10

SECTION D

8. (a) Draw the circuit diagram of a transistorized, collector coupled, astable multivibrator and explain the generation of square wave.

In a symmetrical, collector-coupled, astable multivibrator $R_1 = R_2 = 1\ M\Omega$ and $C_1 = C_2 = 0.01\ \mu F$. Find the frequency of operation.

8 + 2

(b) (i) An FM signal is given as

$S(t) = A_c \cos \omega_c (1 + m_f \cos \omega_m t)\, t$.

Determine the instantaneous frequency of the given FM signal.

(ii) State the law that provides the limit for information capacity of a communication channel for given signal to noise ratio and name it.

6 + 4

(c) State and explain sampling theorem for base-band signals. Compare natural sampling with flat-topped sampling.

10

(d) What is meant by "heterodyning"? Draw the block diagram of a super heterodyne AM radio receiver and mention the role of I.F.

10

9. (a) (i) With proper diagrams, explain the working of a step up chopper.

(ii) A step up chopper has input voltage of 220 V and output voltage of 660 V. If the non-conducting time of thyristor-chopper is 100 μ secs, compute the pulse width of the output voltage. If the pulse width is halved, for constant frequency operation, find the new output voltage.

6 + 6

(b) A 230 V, 50 Hz one pulse SCR controlled converter is triggered at a firing angle of 40° and the load current extinguishes at an angle of 120°. Find the circuit turn off time, average output voltage and the average load current for R = 5 ohms and L = 2 mH.

12

(c) Draw the diagram of connections of 3 phase Bridge Inverter using six Thyristors. It is based on 120° mode of conduction. Draw the Time diagram showing conduction periods of 6 Thyristors and the phase voltages.

8 + 8 = 16