I.E.S.-(Conv.)-1990

ELECTRICAL ENGINEERING

PAPER - I

Time Allowed: Three Hours Maximum Marks : 200

Candidates should attempt SIX question, selecting TWO 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

Answer must be written in English.

PART A

1. (a) State and prove Millman's theorem.

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(b) In the network shown in Fig. 1, using Millman's theorem, or otherwise find the voltage between A and B.

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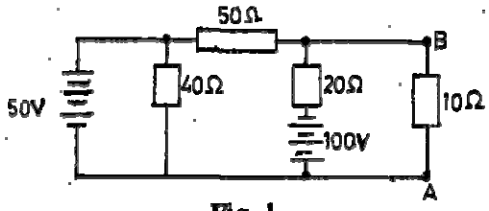

Fig. 1

(c) State and explain Thevenin's and Norton's equivalence.

6

(d) Fig. 2 shows the small signal equivalent circuit of an electronic amplifier. Circuit parameters are as follows:

$\mu = 100, \quad R_1 = 150\ k\Omega$

$r_p = 68.5\ k\Omega, \quad R_2 = 100\ k\Omega$

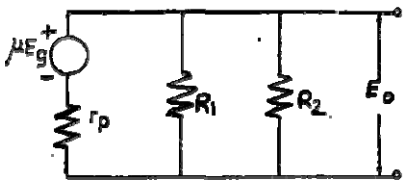

Fig. 2

Find current source equivalent of voltage source of μE_g and hence find the value of output voltage E_0. Given E_g = 500 m V.

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2. (a) The circuit shown in Fig 3 has been in the condition shown (switch S open) for a long time. The switch is then suddenly closed.

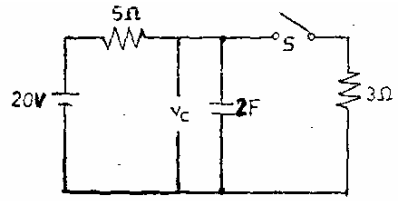

Fig. 3

(i) What is the value of v_c before and immediately after the switch is closed? Explain.

4

(ii) Find the expression for v_c as function of time when switch S is closed at t = 0.

12

(iii) What is the value of time constant of transient term?

2

(b) A series circuit consisting of a resistance R of 0.5 ohm, an inductance L of 0.25 H and a capacitance C of 2 F is connected across a variable frequency constant voltage source.

(i) Find driving point admittance function and plot its poles and zeros.

5

(ii) Using above pole-zero plot, find expressions for Amplitude response M(ω) and Phase response $\phi(\omega)$.

5

(iii) Find Amplitude and Phase of above admittance function at ω=1.

5

3. (a) Synthesize the function

$$F(s) = \frac{3(s+2)(s+4)}{s(s+3)}$$

(i) as an RC impedance in Foster form;

10

(ii) as an RL admittance in Cauer form.

10

(b) Fig. 4 shows the equivalent circuit of the single-stage common-emitter transistor amplifier. Draw the signal flow diagram for the above circuit indicating clearly the node variables and branch transmittances. Calculate the gain using Mason's rule.

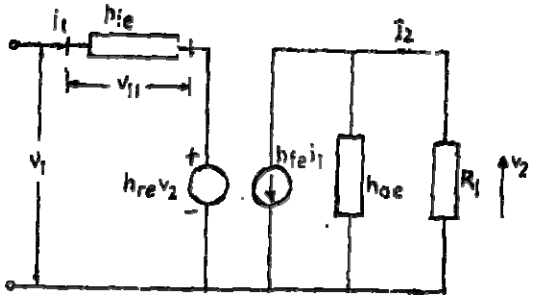

Fig. 4

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PART B

4. (a) Explain the following:

(i) Electrostatic potential 3

(ii) Electric flux density 3

(iii) Gauss' Law 3

(b) A spherical volume of radius R has a volume charge density p C/m^3 given by

p = Kr

where r is the radial distance K is a constant. Develop expressions for electric field intensity and electric potential and sketch their variation with respect to r.

18

(c) Develop an expression for magnetic field intensity both inside and outside a solid cylindrical conductor of radius a carrying a current I with uniform current density.

9

5. (a) Starting from the Maxwell's equations derive wave equations in free space.

12

(b) A plane wave propagating through glass having relative permittivity 5 has the magnitude of electric field vector as 100 V/m and the frequency 1 MHz. Calculate

(i) velocity and phase shift constant of the wave; 4

(ii) magnitude of magnetic field intensity 4

(c) The approximate radiation fields of certain antenna expressed in spherical coordinate system are

$$H = \frac{1}{r}\sin\theta\cos(\omega t - \beta r).i\phi$$

$$\bar{E} = \frac{K}{r}\sin\theta\cos(\omega t - \beta r).i\theta$$

Determine the instantaneous and average power flow out of the volume surrounded by the spherical surface of radius r with centre at origin.

16

PART C

6. (a) Explain the phenomenon of 'Electronic polarization' in dielectric medium.

8

(b) Define electronic polarizability and show that

$$\alpha_e = \frac{\in_0 (\in_r - 1)}{N}$$

where α_e = electronic polarizability

ε_r = relative permittivity

N = number of atoms/m^3

12

(c) Discuss the classification of magnetic materials on the basis of occurrence of permanent atomic magnetic dipoles.

8

(d) Explain the magnetization curve of a ferro-magnetic material with special reference to its domain structure and orientations of magnetic moments.

8

7. (a) Explain the following terms with reference to atomic interpretation of Ohm's law:

(i) Drift velocity 4

(ii) Mobility of electron 4

(iii) Relaxation time 4

(b) A uniform silver wire has resistivity of 1.54 x 10^{-8} ohm-m at room temperature. An electric field of 1.2 V/m is applied along the wire. Find the avenge drift velocity and the mobility of electrons. Assume—

conduction electrons per m^3 = 6.0 x 10^{28}

charge on one electron = 1.6 x 10^{-19} C

6

(c) Describe the Hall effect phenomena in semi-conductors

6

(d) Explain with the help of neat sketches as to how the following quantities vary in p- and n-regions of an idealised p - n junction diode under equilibrium conditions:

Charge density, concentration of electrons and holes, electrostatic potential.

12

PART D

8. (a) Discuss the salient constructional features of an electrical type fluxmeter in contrast to the other permanent magnet moving-coil type instruments and explain how flux linkages can be measured.

12

(b) A fluxmeter is connected to a search coil having 200 turns and a mean area of 500 mm^2. Resistance of the search coil is 1 ohm and fluxmeter has 120 scale divisions. The search coil is placed at the centre of a solenoid 1 meter long, wound with 700 turns. When a current of 4 A is reversed, there is a deflection of 25 scale divisions. Calculate the resistance of shunt required for use with the search coil if this Fluxmeter is used to measure 0.65 x 10^{-4} wb.

12

(c) Draw a neat sketch of a cathode ray tube marking thereon its various parts. Describe briefly the functions and working of following parts:

(i) Electron gun assembly

(ii) Deflection system assembly

8

9. (a) Explain the principle and working of a photo-electric tachometer. What axe its advantages and disadvantages over other types of speed transducers?

12

(b) Identify the most desirable characteristics of displacement and force transducers. Suggest one electrical transducer for each of them and indicate the merits of electrical transducers.

8

(c) Explain how the Wien-Bridge circuit can be used to measure unknown frequencies. State it's another important application.

12

10. (a) What is meant by 'Multiplexing' in a telemetering system? Describe briefly the method of 'Time Division Multiplexing' (TDM).

12

(b) Explain the principle of Frequency Modulated (FM) recording. What are the advantages of an FM recorder over the conventional type?

12

(c) Explain how you use a seven segment LED display device as a decimal digit display.

8

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ELECTRICAL ENGINEERING

PAPER - II

Time allowed: Three Hours **Maximum Marks: 200**

Candidates should attempt FIVE questions in all, choosing at least ONE from each Section.

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

Answers must be written in English.

PART A

1. (a) Explain what is meant by 'Synchronous Impedance' of an alternator.

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(b) Find the synchronous impedance and reactance of a single- phase alternator in which a given field current produces an armature current of 250 amperes on short-circuit and a generated e.m.f. of 1500 volts on open circuit. The armature resistance is 2 ohms. Hence calculate the terminal p.d. when a load of 250 amperes at 6.6 kV and lagging power factor 0.8 is switched off.

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(c) A 3-phase alternator having a reactance of 10 ohms has art armature current of 220 amperes at unity power factor when running on 11 kV constant frequency bus-bars. If the steam admission be unchanged and the e.m.f. raised by 25% determine graphically or otherwise the new value of machine current and power factor.

15

2. (a) Discuss the relative merits and disadvantages of single cage and double cage induction motors. If the standstill impedance of the outer cage of a double cage machine is 0.3 + j 0.4 ohm and of the inner cage is 0.1 + j 1.5 ohms, compare the relative currents and torques of the two cages

(i) at standstill;

(ii) at a slip of 5%.

15

(b) An induction motor with a star-delta starter is supplied through a feeder from V volts, 50 Hz mains. Coming to line drop, the starling current is found to be the same with star as well as delta connections. From a short-circuit test on the motor, when delta connected, the following data were obtained; V = 200 V; I = 125 A; power factor = 0.4 (line values). Determine the resistance of the feeder. If a second feeder of the same cross-section be rim in parallel with the original feeder, find the percentage increase in the starting torque obtained with each connection

20

(c) What is 'on load tap changing facility' in a power transformer? What is its application in power system control?

5

SECTION B

3. (a) A 3-phase, 50-Hz overhead transmission line 100 km long with 132 kV between lines at the receiving end has the following constants:

Resistance per km per phase = 0.15 ohm

Inductance per km per phase = 1.20 mH

Capacitance per km per phase = 0.0084 μF

Determine, using nominal T method, the voltage, current and power factor of the sending end when the load at the receiving end is 70 MW at 0.8 power factor lagging.

20

(b) Define suing efficiency. Explain how this efficiency can be raised by the introduction of arcing horns.

If the voltage across the units in a 2-unit suspension insulator is 60% and 40% respectively, of the line voltage, determine the ratio of the capacitance of the insulator to that of its capacitance to earth.

15

(c) What is Ferranti effect in a lightly loaded long EHV transmission line? What steps ale taken to correct the adverse effects due to Ferranti effect in a power system with many long EHV lines?

5

4. (a) What are the sequence of events that follow a sudden increase in load (say 0.1% of system capacity) in a power system which was under balanced steady-state operating conditions prior to this disturbance?

10

(b) Two identical synchronous machines of rating 100 MW, 50 Hz operating in parallel have the following characteristics:

Machine 1 : Speed droop R = 4%

Speed changer set to give 50% rated load at rated speed.

Machine 2 : Speed drop R = 4%

Speed changer set to give 75% rated load at rated speed.

(i) Determine the load taken by each machine for a total load of 150 MW and the frequency of operation.

(ii) What adjustment should be made by the speed changers of the machines to share the load as in (i) but with a frequency of 50Hz?

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(c) Distinguish between steady-state stability and transient stability of a power system. Explain the difference between the two by taking an example of a ‘single machine connected to an infinite bus system’.

10

SECTION C

5. (a) The open-loop transfer function of a unity feed-back control system is given by

$$G(s)=\frac{k}{(s+2)(s+4)(s^2+6s+25)}$$

By applying Routh-Hurwitz criterion determine

(i) the range of k for which the closed-loop system will be stable;

(ii) the values of k which will cause sustained oscillations in the closed-loop system.

What are the corresponding oscillation frequencies?

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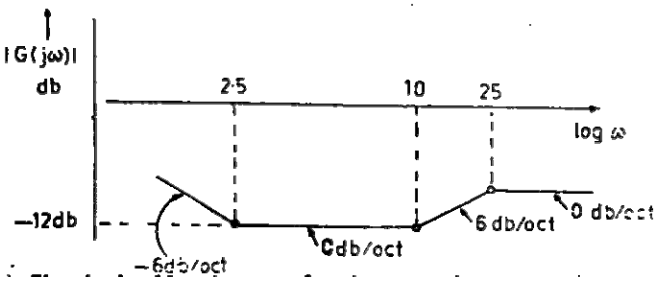
(b) Asymptotic approximation of Bode magnitude plot of open- loop transfer function, G(s), of a system is given in Fig. 5(b). Determine G(s).



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(c) Sketch the Nyquist plot for the control system whose loop transfer function is given by

$$G(s)H(s)=\frac{1}{s(1+0.2s)(1+0.05s)}$$

Determine the gain margin and comment on the stability of the system.

15

6. (a) The open-loop transfer function of a unity feed-back control system is given by

$$G(s)=\frac{k(s+4)}{s(s+1)}$$

Sketch the Root locus plot of the system and determine the value of the gain k so that the system is critically damped.

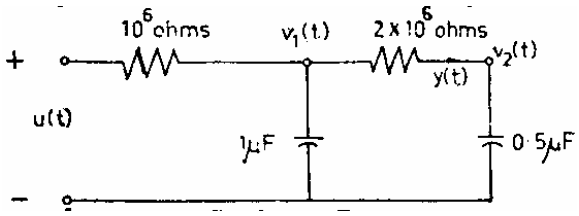
15

(b) Sketch the Root Locus plots and briefly explain qualitatively the improvements in system performance (stability and steady state error) that are obtainable by introducing a compensating zero (s + 3) to the unity feedback system whose open-loop transfer function is

$$G(s)=\frac{k}{s(s+2)(s+6)}$$

10

(c) Write the differential equations characterizing the network given in Fig. 6(c) and hence obtain the state equation $\dot{x}=\underline{A}\underline{x}+\underline{B}\underline{u}$ and the output equation $Y=c\underline{x}+Du$. Take the voltages across the capacitors, v_1 (t) and v_2 (t) as the two state variables and the current through the 2x 10^6 ohm resistor as the output variable.



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SECTION D

7. (a) (i) Explain the basic structure of a P-channel, enhancement type MOSFFf.

(ii) State the merits and demerits of digital MOSFET circuits compared to the corresponding bipolar circuits.

10

(b) Discuss the effect of voltage series feedback on the input and output resistances of a feedback voltage amplifier by deriving the necessary expressions.

10

(c) State the explain the Barkhausen conditions for sustained sinusoidal oscillations.

8

(d) Explain the operation of a Schmidt trigger circuit using operational amplifier. Give the expression for hysteresis in such a circuit.

12

8. (a) Simplify the following Boolean expression using Karnaugh Map

$$F = \bar{A}C + \bar{A}B + A\bar{B}C + BC$$

8

(b) Draw the logic symbols and explain the operation of a D-type and T-type Flip-flop.

8

(c) Explain the operation of a synchronous decade counter with relevant diagrams.

12

(d) What are multiplexers and demultiplexers? Explain with relevant diagrams the operation of a 4-to-l line multiplexer.

12

SECTION E

9. (a) The impulse response of a linear network is given by

$h(s) = e^{-t}$; $t \geq 0$

$= 0$; $t < 0$

Find the output of the network for an imput signal given by

$u(t) = 1$; $0 \leq t \leq T$

$= 0$ otherwise

9

(b) Justify the following statements:

10

(i) In FM pre-emphasis improves the S_0/N_0 ratio of the signal

(ii) In PCM companding improves the dynamic range of the system

(c) A 50-MHz carrier delivers 100W power to a load. The carrier is now frequency modulated by a 1 kHz signal causing a maximum frequency deviation of 6 kHz. This frequency modulated signal is coupled to the load through an ideal band pass filter with 50 MHz centre frequency and 12.5 kHz bandwidth. Find the power delivered to the load. Comment on the result.

9

(d) What are the frequency range for the following bands? Mention a typical application for each:

12

(i) MF (ii) HF (iii)VHF (iv) UHF (v) Microwave (vi) Optical range

10. (a) Write FORTRAN arithmetic statements to compute y from each of the following equations, keeping the computing time a minimum:

6

(i) $\dfrac{2a+b}{b/c-yl}=x$

(ii) $y=\dfrac{\phi}{\phi-1}p_1v_1\left[\left(\dfrac{p_2}{p_1}\right)^{\frac{\phi-1}{\phi}}-1\right]$

(iii) $y=2.72\log_e z+\sqrt{\sin^2 x-bz^2}+\sin x$

(b) Write the values stored in registers named X and SUM after the execution of the following programme:

```
      X = 1
      SUM = 0
100SUM = SUM + X *
      X = X + 2.0
      If (X–8.0) 100, 100, 200
      200 STOP
      END
```

6

(c) Write a FORTRAN programme to compute and print factorial N:

(i) using a DO statement

(ii) without using a DO statement

12

(d) Draw a flowchart and write a FORTRAN programme to solve the 'force free' state equation $\underline{X}(t)=\underline{A}\underline{X}(t)$ and print the solution $\underline{X}(t);t\geq 0$ using modified Euler numerical integration method given $\underline{X}(t=0)$ and the time-invariant matrix $\underline{A}$. The programme should accommodate a maximum of 10 state variables.

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