I.E.S.-(Conv.) 1989

ELECTRICAL ENGINEERING

PAPER - I

Time allowed: 3 hours Maximum marks: 200

Candidates should attempt six questions, selecting

two questions from Part A, one from Part B, one from Part C and two from Part D.

Answers must be written in English.

PART A

1. (a) Explain the following:

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(i) Superposition Principle.

(ii) Maximum Power Transfer Theorem.

(iii) Unit Step and Unit Impulse Functions.

(b) In the network shown in Fig. 1.(a), find the value of RL such that maximum possible power will be transferred to RL. Find also the value of the maximum power and the power supplied by source under these conditions.

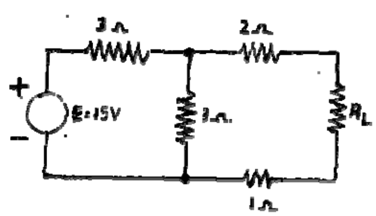

Fig. 1(a)

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(c) Considering i(t) as input and v(t) as output in the network shown in Fig. 1(b) find unit step response and the unit ramp response with v(0) = 0.

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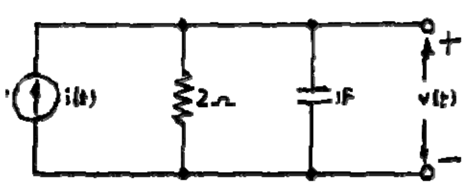

Fig. 1(b)

2. (a) Explain clearly the following :

(i) Poles and zeros of a network function

(ii) Frequency response of a network.

(b) For the network shown in Fig 2(a).

(i) find the transfer function H(s) and plot its poles and zeros.

(ii) using poles and zeros plot of (i), determine H(j 10) and steady state current is (l) if $f(t) = 9 \cos (10i + 30^{o})$

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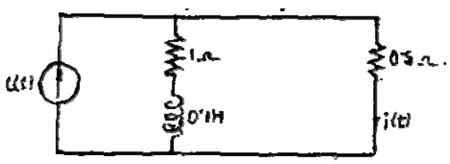

Fig. 2(a)

(c) Admittance parameters of the pi-network shown in Fig. 2 (b) are

$Y_{11} = 0.09s$. $Y_{12} = Y_{21} = -0.05s$, $Y22 = 0.07s$

Find the value, of Re, Rs, Rc.

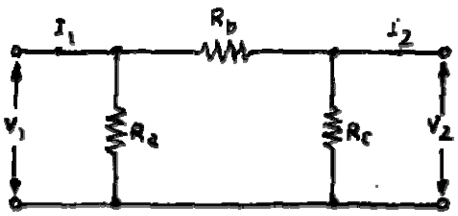

Fig. 2(b)

3. (a) Mentlos the conditions to be satisfied for a function F(s) to be physically realizable.

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(b) A function F(s) has

poles 0, –2

zeros –1, –3

Taking scale factor to be 1, synthesize F(s) as an impedance function in Foster's form.

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(c) Explain briefly 'Mason's rule' for computing the GAIN from input node to output node in a Signal Flow Graph.

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PART B

4. (a) State and explain Gauss' law in point and integral forms.

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(b) A spherical volume charge density distribution is given by

$$\rho = \rho_s \left(1 - \frac{\gamma^2}{a^2}\right); \quad r \leq a$$

$$= 0 \qquad ; \quad r \leq a$$

where a is the radius of spherical charge distribution.

Find the distance from the centre where the electric field intensity due to this charge distribution is maximum. What is the value of maximum electric field intensity?

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(c) An infinitely long, straight filamentary conductor carrying current I is placed along x-axis in cylindrical co-ordinates. Find the expressions for magnetic field and magnetic vector potential at a point in the plane Z = 0.

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5. (a) Starting from Ampere's Circuital Law And Faraday's Law obtain the corresponding Maxwell's equations in integral form. Using appropriate theorems of Vector Calculus, derive these equations in differential forms.

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(b) State the properties of a linearly, polarized, uniform plane wave.

(c) Find the velocity of a plane wave in a lossless medium having a relative permittivity of 4 and relative permeability of unity.

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(d) Assuming TEM wave travelling in the positive z-direction in non-dissipative medium, write the expressions for $E_z(z, t)$ and $H_y(z, t)$.

Making use of analogy, write voltage and current expressions for a loss-less transmission line for any (z, t).

16

PART B

6. (a) Explain the basis on which solid materials are classified as conductors, insulators and semi-conductors. Differentiate these types of materials with reference to Energy Band Diagrams.

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(b) Describe the 'Hall Effect' and explain its relation to the mechanical force exerted by a magnetic field on a conductor.

A current or 50 A is passed through a metal strip which is subjected to a magnetic field of flux density 1.2 T. The magnetic field is directed at right angle to the current direction and the thickness of the strip in the direction of magnetic field is 0.5 mm. The Hall voltage is found to be 150 μV. Calculate the number of conduction electrons per cubic metre in the metal.

Derive the formula you may use.

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(e) Distinguish clearly between 'Zener' and 'Avlanche' breakdown in the barrier layer of a semi-conductor.

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7. (a) Explain the phenomenon of Magnetostriction'.

6

(b) Define residual magnetism and coercive force. How are these properties explained in terms of microscopic structure of solids?

10

(c) Define the dielectric constant and loss-tan gent of a dielectric material. Discuss their dependence on frequency.

8

(d) Explain what is meant by permanent dipole moment. How the presence of permanent dipoles contributes to the dielectric constant? Discuss the temperature dependence of the dielectric constant.

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PART D

8. (a) Compare the relative advantages and disadvantages of sleasuring a resistance by (i) null method (ii) substitution method.

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(b) Describe Kelvin's double bridge method for measurement of low resistances.

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(c) Hay's a.c. bridge is used to measure effective resistance and self inductance of an iron-cored coil. Its four arms are arranged as follows

Arm AB : The unknown coil (L_x, R_x).

Arm BC : Non-reactive resistor (1000 ohms).

Arm CD : Non reactive resistor (833 ohms) in series with a standard capacitor of 0.38 μF.

Arm DA : Non-reactive resistor (16800 ohms).

Calculate the value of effective resistance and self-inductance. The bridge is supplied with 50 Hz frequency source. Derive the formula used and draw a complete phasor diagram.

16

9. (a) Discuss different methods of recording data. Discuss their relative advantages and disadvantages.

Explain the working of X-Y recorder with the help of suitable diagrams.

12

(b) Describe with diagrams the working of—

(i) electrostatic focusing arrangement

(ii) internal and external synchronization in CRO.

10

(c) Describe the working of an instrument used to measure harmonic contents in a periodic non-sinusoidal waveform.

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10. (a) Briefly explain the principle of any two of the following transducers used for measuring linear displacement:

8

(i) Inductive transducer.

(ii) Capacitive transducer.

(iii) Strain gauges.

(iv) Piezoelectric transducers.

(b) A strain gauge having resistance of 120 ohms is mounted on steel cantilever beam. When a certain force is applied at the free end it produces a stress of 100 MN/m^2 at the section where strain gauge is mounted. The change in gauge resistance is round to be 0.15 ohm due to this stress. Calculate the gauge factor. Given Young's modulus for steel is 200 GN/m^2.

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(c) With the help of a functional block diagram explain the principle of operation of a integrating type digital voltmeter (DVM). What is the resolution of a 3½ digit DVM having a range of 10 V?

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ELECTRICAL ENGINEERING

PAPER - II

Time allowed: 3 hours **Maximum marks: 200**

Candidates should attempt six questions, selecting

two questions from Part A, one from Part B, one from Part C and two from Part D.

Answers must be written in English.

1. Explain briefly any five of the following, supporting your answer with relevant circuits, performance characteristics, etc., wherever necessary

40

(a) Techniques adopted for braking of d.c. motors.

(b) Hunting phenomenon in synchronous machines.

(c) Natural load of an a-c. transmission line and the factors limiting the distance of transmission.

(d) Purpose and action of a delta-connected tertiary winding in Y-Y connected transformers.

(e) Role of tachogenerators in automation position control schemes

(f) Schmitt trigger circuit, its operation and application.

(g) Memory systems for storage of data.

SECTION A

2. (a) A 400-V. 3-phase, 50-Hz 6-pole Y-connected induction motor, when running light at normal voltage and frequency takes power input of 1.2 kW and the line current is 8.25 A. With the rotor locked and 180 V applied to the stator, the power input is 5.25 kW and the line current is 45 A. The stator resistance measured between two line terminals when hot is 0.9 Ω.

Draw the approximate equivalent circuit of the motor and calculate the net mechanical power output and torque when working at a slip of 4%.

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(b) Distinguish the torque-speed characteristics of induction motors meant for (i) continuous running under full-load and (ii) a.c. servomotor

Indicate, in each case, the design criteria and the means adopted for achieving the desired performance.

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3. (a) Derive the expression for the synchronizing power of a synchronous generator with a cylindrical rotor when connected to an infinite bus-bars.

Discuss the effect of an excitation failure.

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(b) What is understood by 'synchronous condenser'? Explain its operation and application.

10

(c) Explain how a salient pole machine can develop torque without field excitation.

15

4. (a) What is the optimum reactance/resistance ratio for maximum power transfer in transmission lines ? Is it satisfied in practice, if not, what is done to increase the power limit?

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(b) Determine the maximum theoretical power that may be transmitted via a short 3-phase line of impedance of (10+j30) Ω per phase and with 132 kV maintained at each end. What phase difference exists between the terminating voltages under these conditions ?

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(c) Describe one type of protection that is used for detecting faults local to the transformer.

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(d) What are 'phase-sequence filters' and what are they applied for? Give one circuit diagram for each filter, explaining its working.

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SECTION B

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

$$G(s) = \frac{K}{s(1+s\tau_1)(1+s\tau_2)}$$

(i) Using the Routh-Hurwitz method, determine the necessary conditions for the system to be stable.

(ii) Determine the gain margin and hence the condition for stability.

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(b) Explain the usefulness of root-locus diagrams in the design of feedback-control systems.

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(c) Sketch the root-locus diagram for the system described in (a) for positive values of K, τ_1 and r_2. Show how the root-locus gets modified with the addition of (i) a zero and (ii) a pole. Discuss the effect of each on the performance of the system, if the system is already stable before the addition.

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6. (a) The open-loop gain of a servomechanism is given in Fig. 1 against frequency using logarithmic straight

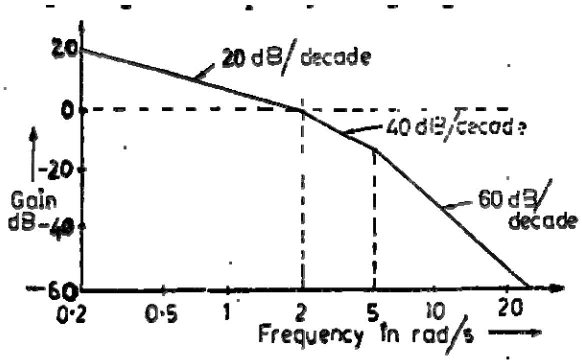

Fig. 1

line approximation (i.e.. the Bode-plot). Assuming that all the elements are of first-order type, write down the open- loop transfer function of the system and plot its open-loop phase against frequency on the same scale. State any assumptions made.

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(b) Applying any necessary corrections for the approximate plots, determine the gain margin and phase margin and thereby comment on the stability of the system.

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(c) What is meant by 'integral-error' compensation and when is it desired for application? Illustrate your answer by suggesting a suitable example with its transfer-function.

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7. (a) Write a IORTRAN expression corresponding to each of the following mathematical expressions:

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(i) $\left[(a+b)^2+(3c)^3\right]^{a/b}$

(ii) $\cos\left[\log_{10}(a+3b)\right]/\sqrt{a^2+b^2}$

(iii) $\sin(x-2y)+\varepsilon^z y-|x^2-y^2|$

(iv) $\sqrt{x-y^3}-\dfrac{z^3}{\cos(a+b)}$

(v) $e^{|a|}-b^2/|c|$

(b) Draw a flowchart and write the FORTRAN programme to find all the 3.digit prime numbers.

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(c) Briefly explain the terms 'algorithms' and 'arithmetic assignment statements' and suggest the role of each in computation.

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(d) Indicate the function of a 'compiler' in a digital computer. Describe the steps involved in obtaining the solution for a problem by using a digital computer.

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SECTION C

8. (a) Distinguish the constructional and operational features of a WET and a MOSFET. Show how a voltage follower circuit is made up by using a JFET.

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(b) Distinguish a 'difference' amplifier and a 'differential' amplifier and show how a differential amplifier is made up by using a high-gain d.c. amplifier with relevant feedback.

(c) Define common-mode rejection-ratio and show how the accuracy of a voltmeter is affected by it. How is the ratio estimated for an amplifier?

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(d) Draw the circuit of an instrumentation amplifier and discuss its distinguishing features.

9. (a) Obtain the expression for the gain of the operational-amplifier circuit shown in Fig. 2 and indicate its applicability.

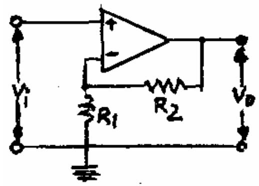

Fig. 2

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(b) Work out the feedback-factor for the circuit shown in Fig. 3 and derive the gain of the amplifier A and the frequency of oscillation at which the circuit oscillates stably. In case the amplifier circuit of Fig. 2 replaces the amplifier, A, Indicate the suitable values desired for R_1 and R_2.

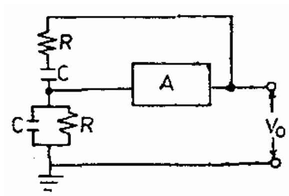

Fig. 3

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(c) Distinguish between 'voltage' feedback and 'current' feedback in amplifier circuits. Suggest the merit of each and for each case derive the expression for the net output Impedance showing the influence of feedback.

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10. (a) Derive equations representing a frequency modulated voltage and a phase-modulated voltage. Therefrom define the terms, 'frequency deviation', 'modulation index' and 'bandwidth' of the modulated voltage.

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(b) Distinguish between a 'narrow-band' and 'wideband' modulated signal. Show, by means block diagrams how a narrow-band FM signal is generated.

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(c) Simplify the following logic function

$$X=(B+C)(B+D)(C+D)$$

and show that $X=BC+BD$.

Realize the function by suitable logic gates.

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(d) Draw the circuit and symbol of a clocked RS flip flop and explain the-operation. Indicate the truth-table.

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