ELECTRICAL ENGINEERING 080097

Time : 3 hours *Full Marks* : 200

Instructions :

(1) Answer Question No. ***1*** *which is compulsory and any* ***nine*** *from the rest.*

(2) The figures in the margin indicate full marks for the questions.

1. *(a)* Determine the current in 20 Ω resistor of the network shown in Fig. 1 using Thevenin's theorem : 5

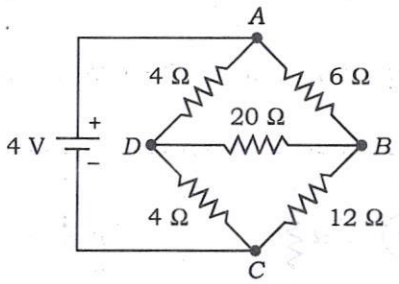

Fig. 1

(b) Find the transfer function $G(s) = X(s) / F(s)$ for the translational mechanical network shown in Fig. 2 : 5

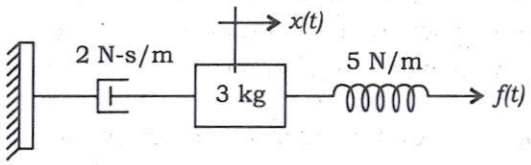

Fig. 2

(c) State three differences between RTD and thermistor. 3

(d) The potential field is given as $V = 2x^2y - 5z$. Find at point $P(-4, 3, 6)$, the potential (V), the electric field intensity (E) with its direction and the electric flux density (D). 4

(e) State two differences between lap winding and wave winding. 3

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2. *(a)* Use mesh current analysis to find the voltage V_x across the current source of Fig. 3 :

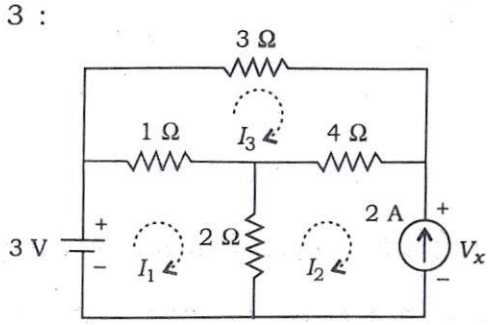

Fig. 3

(b) A balanced 3-phase star-connected load of 120 kW takes a leading current of 100 A when connected across a 3-phase, 3·3 kV, 50 Hz supply. Determine the impedance, resistance, capacitance and power factor of the load.

(c) Determine the time constant of the circuit shown in Fig. 4 :

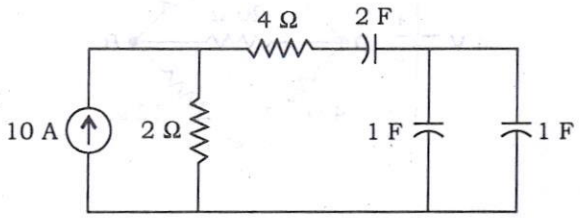

Fig. 4

(d) A 10 mH coil in series with a loss-free capacitor is connected to a variable frequency source which supplies a constant voltage of 10 V. The circuit has a maximum value of 0·1 A at a frequency of 80 kHz. Calculate *(i)* the capacitance of the capacitor and *(ii)* the *Q*-factor of the coil and the half-power frequencies. 5

3. *(a)* State maximum power transfer theorem in an a.c. network. 2

(b) The resonant frequency of the tuned circuit shown in Fig. 5 is 1000 rad/s. Calculate the self-inductances of the two coils and critical value of mutual inductance : 7

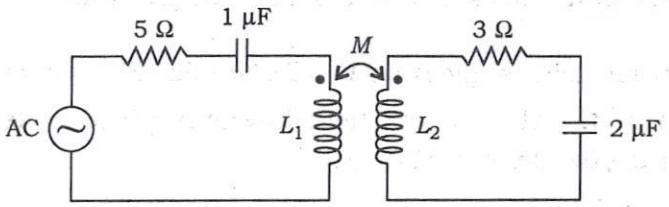

Fig. 5

(c) Distinguish between linear and non-linear system with a suitable example. 3

(d) State controllability and observability of a system. 3

(e) Find the h-parameter of the circuit shown in Fig. 6 : 5

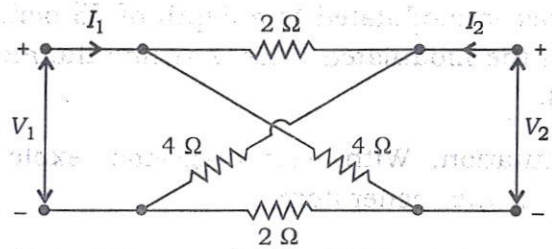

Fig. 6

4. (a) Define short-circuit ratio (SCR) of an a.c. generator. State three significances of SCR. 4

(b) What is meant by back e.m.f. in a d.c. motor? Derive the torque equation of a d.c. motor. 6

(c) A separately excited d.c. motor has an armature resistance of 0·5 Ω. It runs on a 250 V d.c. supply drawing an armature current of 20 A at 1500 r.p.m. Find the torque developed for armature current of 10 A for same field current. 5

(d) A 3-phase star-connected alternator is rated at 1600 kVA, 13·5 kV. The armature effective resistance and synchronous reactance are 1·5 Ω/phase and 30 Ω/phase respectively. Calculate the percentage voltage regulation for a load of 1280 kW at 0·8 leading power factor. 5

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

$$G(s) = \frac{2 \cdot 5K}{s(0 \cdot 4s + 1)(0 \cdot 2s + 1)}$$

(i) Sketch the Nyquist plot to determine phase crossover frequency and gain margin.

(ii) Determine phase margin for $K = 3$. 12

(b) If the potential coil of a wattmeter is subjected to a voltage $v(t)$ and current coil to a current $i(t)$ as given below, find the power read by the wattmeter :

$$v(t) = 10 + 5\sin(\omega t + 45°) + 3\sin(2\omega t + 30°)$$
$$i(t) = 5 + 4\sin(2\omega t - 30°) + 3\sin(\omega t + 45°)$$

(c) A 400 W carrier is modulated to a depth of 75 percent. Calculate the total power in the modulated wave. Assume the modulating signal to be sinusoidal.

6. (a) Define commutation. With neat diagrams, explain the process of commutation in d.c. generators.

(b) The open-loop transfer function of a system is given as

$$G(s)H(s) = \frac{s+1}{(s+4)(s^2+5s+k)}$$

Find the value of k such that the system has a zero steady-state error for a step input.

(c) What is strain gauge? Derive an expression for gauge factor in terms of Poisson's ratio.

(d) An op-amp, having a slew rate of 31·4 V/μs, is connected in a voltage follower configuration. If the input voltage $V_i = 0 \cdot 5 \sin \omega t$, then find the minimum frequency at which the slew rate limited distortion would set in the output.

7. (a) Find the output voltage (V_o) for the circuit shown in Fig. 7 for an input voltage $V_i = 5 \sin 100\pi t$:

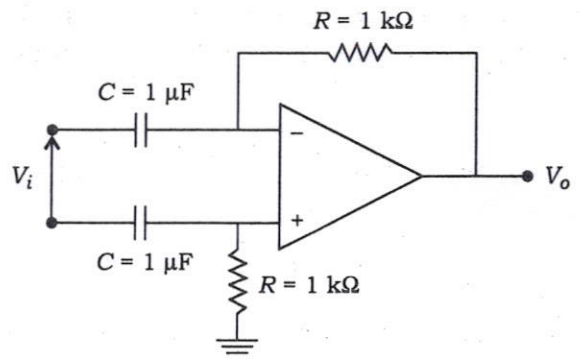

Fig. 7

(b) What would happen if a d.c. motor is directly switched on to the supply without any starter and why? 4

(c) Find the transfer function relating the capacitor voltage, $V_o(s)$ to the input voltage $E_i(s)$ of the circuit shown in Fig. 8 and if a step input is applied, then find the maximum overshoot in the output V_o of the circuit : 6

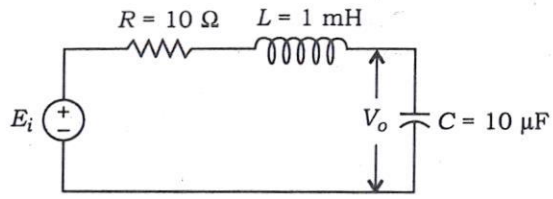

Fig. 8

(d) Why is Maxwell bridge limited to the measurement of medium-Q coils? 4

8. (a) With a neat diagram, explain the principle, working and construction of a PMMC instrument. 8

(b) What happens when an ammeter is connected across a circuit and why? 4

(c) Define the bandwidth of the BJT amplifier. 2

(d) The speed regulation of two 500 kW alternators A and B running in parallel are 100% to 104% and 100% to 105% from full-load to no-load respectively. How will the two alternators share a load of 800 kW? Find the load at which one machine ceases to supply any portion of the load. 6

9. (a) A unity feedback system has open-loop transfer function

$$G(s) = \frac{K(s+5)}{s(s+2)}; \quad K \geq 0$$

(i) Draw a rough sketch of root locus plot such that the complex roots of the characteristic equation move along a circle.

(ii) As K increases, does the system become stable? Justify your answer.

(iii) Find the value of K (if it exists) so that the damping ratio of complex closed poles is 0·3. 15

(b) With a neat labelled diagram, describe the working of a 4-point d.c. shunt motor starter. 5

10. (a) The line-to-line voltage of a 3-phase, 50 Hz, a.c. circuit shown in Fig. 9 is 100 V. Assuming that the phase sequence is *RYB*, find the wattmeter readings W_1 and W_2 : 6

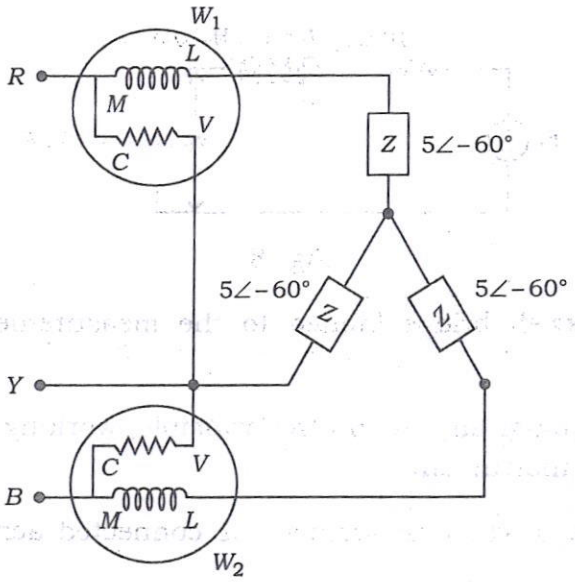

Fig. 9

(b) Find the quiescent collector voltage for the circuit shown in Fig. 10. Assume $V_{BE} = 0{\cdot}7$ V and $V_{CE,\text{ saturation}} = 0{\cdot}2$ V : 6

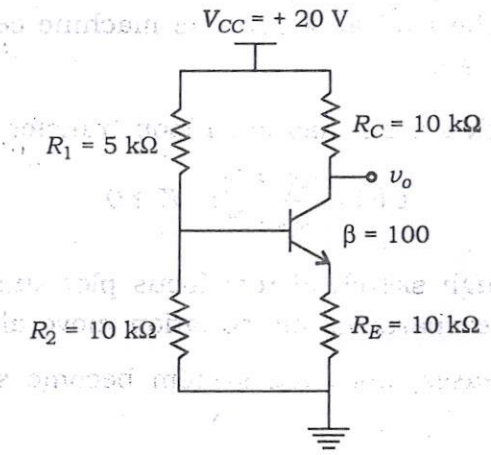

Fig. 10

(c) Which d.c. motor is more suitable for traction purpose and why? 3

(d) Write three mechanical and four electrical instruments/devices used for the measurement of flow rate. 5

11. (a) Derive the general wave equations for the transmission line. 6

(b) Two semi-infinite conducting sheets are placed at right angles to each other. A point charge Q is placed at a perpendicular distance d from both sheets. Find the net force on the charge Q. 5

(c) The open-loop transfer function of a unity feedback system is

$$G(s) = \frac{K(s+1)}{s^3 + \beta s^2 + 2s + 1}$$

Determine the constant K and β for which the system oscillates at 2 rad/s. 6

(d) The current passing through a resistor of $(100 \pm 2)\ \Omega$ is $(2 \cdot 00 \pm 0 \cdot 001)$ A. Calculate the limiting error in the computed value of power dissipation. 3

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

$$G(s) = \frac{25}{s(s+5)}$$

(i) Calculate the natural frequency of oscillations, damped frequency of oscillations, damping factor, damping ratio and the maximum overshoot for a unit-step input.

(ii) Calculate the steady-state error for unit-ramp input.

(iii) If the damping ratio is to be made 0·75 using a tachometer feedback, calculate the tachometer constant and determine the maximum overshoot. 15

(b) Show that the resonant frequency of a series *RLC* circuit is the geometric mean of the lower- and upper-half power frequencies. 5

13. *(a)* Determine the time taken for a step response to reach 98% of the final value of a system given by

$$G(s) = \frac{4}{(s+1)}$$ 6

(b) Determine the load impedance Z_L so that maximum power transfer takes place from the source to the load of Fig. 11. Also determine the maximum power. 6

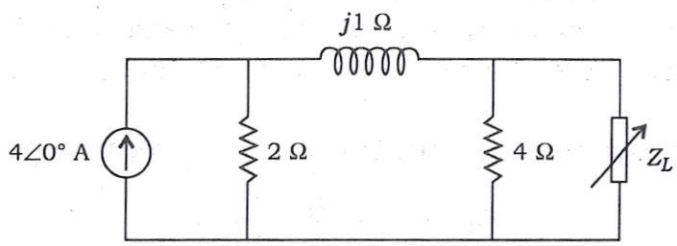

Fig. 11

(c) What is regenerative breaking in d.c. motor? 3

(d) The sum of products form of a Boolean function is $\Sigma(0, 1, 3, 7, 11)$, where the inputs are A, B, C, D (A is MSB and D is LSB). Draw the Karnaugh map and find the equivalent minimize expression of the function. 5

14. *(a)* Draw a circuit using maximum of five gates (AND, OR and NOT) to realize the function $F = \overline{X}\overline{Y} + YZ$, taking X, Y and Z as input. 7

(b) Write four differences between microprocessor and microcontroller. 4

(c) What are bistable multivibrators? Write the names of two multivibrators with its truth table. 5

(d) Draw the energy band diagrams of biased and unbiased p-n junction. 4

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