W'06 : 6 FN : EL 406 (1467)

MEASUREMENT AND CONTROL

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

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Group A

1. (*a*) Explain the construction, operation and dynamic behaviour of permanent magnet moving coil (PMMC) mechanism. How can the temperature compensation be achieved in a PMMC instrument? 10

(*b*) In a circuit shown in *Fig. 1*, the voltage across the resister of value 25 kΩ is to be measured first by using a voltmeter of sensitivity of 1 kΩ/V and then with a voltmeter of sensitivity of 20 kΩ/V. Calculate the reading of the voltmeter in each case and the percent error in the measurement. 10

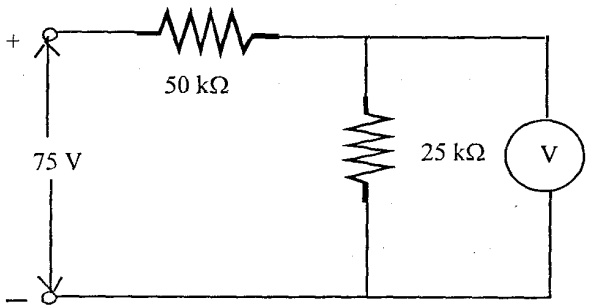

Fig. 1

(*a*) What are the advantages and disadvantages of Rationalized MKS system of units? What are the values of dielectric permittivity ε_0 and magnetic permittivity μ_0 of free space in Rationalized MKS system (RMKS). Verify the dimensional correctness of the equation, Power = voltage × current in RMKS system. 10

(*b*) As shown in *Fig. 2*, the inductance L and resistance R of a coil are to be determined using Anderson's bridge. Calculate the values of L and R if balance is obtained when $Q = S = 1000\,\Omega$, $P = 500\,\Omega$, $r = 200\,\Omega$, $C = 2\,\mu F$. 10

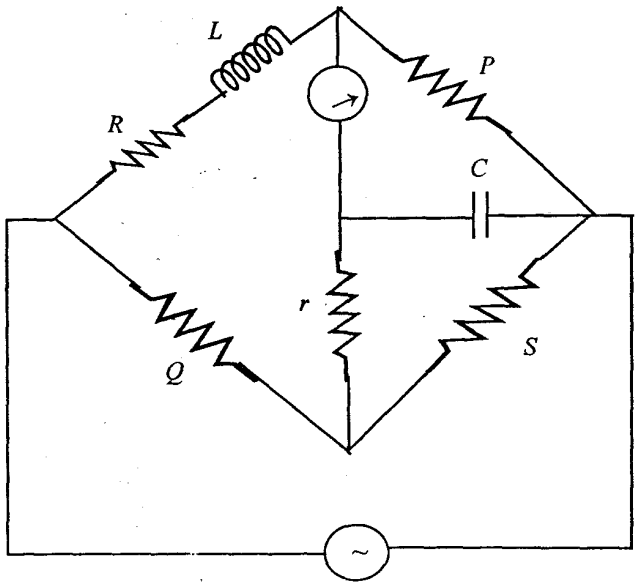

Fig. 2

3. (*a*) Discuss with circuit diagram the working of a Schering bridge. Indicate its usefulness and limitations. 10

(*b*) Determine the balance condition for a Owen bridge shown in *Fig. 3* and calculate the effective inductance and resistance of the coil if for a frequency of 1000 cps the values of the circuit elements at balance are as under:

$R_1 = 10\,\Omega$, $R_2 = 842\,\Omega$, $C_1 = 1\,\mu F$, $C_2 = 0 \cdot 135\,\mu F$. 10

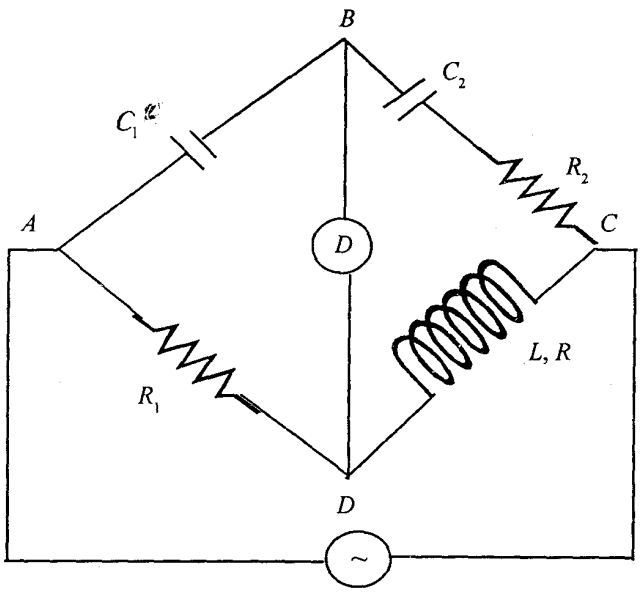

Fig. 3

4. (*a*) Explain how the construction of a flux meter differs from that of a moving coil ammeter or voltmeter. 8

(*b*) Describe a method of using an ac potentiometer for measuring the loss in an iron ring made up of thin stampings. Explain how the loss may be calculated in terms of the maximum density and state any assumptions made. 12

Group B

5. (*a*) List the advantages and disadvantages of an open loop system. 5

(*b*) List the advantages and disadvantages of a closed loop system. 5

(*c*) A voltage amplifier without feedback has a nominal gain of 500. The gain, however, varies in the range of 475 to 525 due to parameter variations. In order to reduce the per unit change to 0·02, while maintaining the original gain of 500, if the feedback is introduced, find the new direct transfer gain G and the feedback factor H. 10

6. (*a*) Given the state equations $dx(t)/dt = Ax(t)$, where $A = \begin{bmatrix} \sigma & -\omega \\ \omega & \sigma \end{bmatrix}$ σ and ω are real numbers

(*i*) Find the state-transition matrix of A.

(*ii*) Find the eigenvalues of A. 10

(*b*) Draw the state diagrams for the following systems

$$\frac{dx(t)}{dt} = Ax(t) + Bu(t)$$

(*i*) $A = \begin{bmatrix} -3 & 2 & 0 \\ -1 & 0 & 1 \\ -2 & -3 & -4 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

(*ii*) same A as in (*i*), but with

$$B=\begin{bmatrix}0 & 1\\ 1 & 0\\ 1 & 0\end{bmatrix}$$

10

7. (*a*) The loop transfer function of a single-loop feedback control system is given as

$$G(s)\,H(s)=\frac{K(s+5)}{s(s+2)(1+Ts)}$$

The parameters K and T may be represented in a plane with K as the horizontal axis and T as the vertical axis. Determine the regions in the T versus K parameter plane in which the closed loop system is asymptotically stable and unstable. Indicate the boundary on which the system is marginally stable. 10

(*b*) The block diagram of a position control system with velocity feedback is shown in *Fig. 4*. Determine the value of α so that the step response has maximum overshoot of 10%. What is the steady-state error? 10

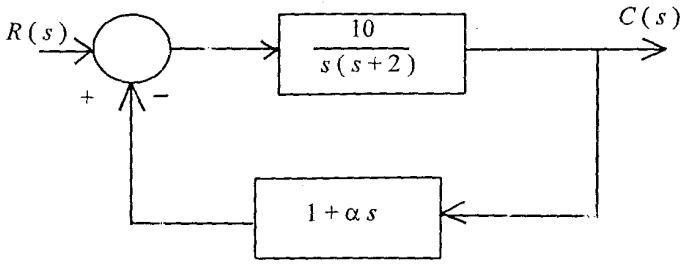

Fig. 4

8. (*a*) Explain why it is important to conduct frequency domain analysis of linear control systems. 5

(*b*) Give the definitions of gain margin and phase margin. 5

(*c*) The open loop transfer function of a unity feedback system is given by

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

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

(*ii*) Sketch the root locus diagram for the system described for positive values of K, τ_1, τ_2. Show how the root locus gets modified with addition of (*I*) a zero (*II*) a pole. 10

Group C

9. Answer the following: 2×10

(*i*) To increase voltage measurement range of a voltmeter, it is

(*a*) shunted by a high resistance

(*b*) put in series with a high resistance

(*c*) put in series with a low resistance

(*d*) shunted by a low resistance

(*ii*) Kelvin double bridge is used for measuring

(*a*) high resistance

(*b*) low inductance

(*c*) low resistance

(*d*) high inductance

(*iii*) Permeameters are essentially pieces of apparatus constructed for the testing of

(*a*) magnetic specimens in the form of bars

(*b*) magnetic specimens in the form of ring

(*c*) magnetic specimens both in the forms of bars and rings

(*d*) none of the above

(*iv*) Hay's bridge is suitable for measuring

(*a*) inductances having high Q-values

(*b*) resistances below one ohm

(*c*) inductances having low Q-values

(*d*) capacitances having low value

(*v*) Dynamometer type wattmeters are suitable for

(*a*) both ac and dc circuits

(*b*) only ac circuits

(*c*) only dc circuits

(*d*) only high voltage ac circuits

(*vi*) Adding a zero to the loop transfer function of the closed loop system will

(*a*) always increase the bandwidth

(*b*) always decrease the bandwidth

(*c*) have no effect on bandwidth

(*d*) reduce the stability

(*vii*) The general effect of adding a pole to the loop transfer function is to

(*a*) make the closed loop system more stable

(*b*) increase the bandwidth

(*c*) make the closed loop system less stable

(*d*) double the bandwidth

(*viii*) Number of intersect of the asymptotes of the complete root loci is

(*a*) unknown

(*b*) two

(*c*) three

(*d*) one

(*ix*) For the second order prototype system, when the undamped natural frequency increases, the maximum overshoot of the output

(*a*) stays the same

(*b*) increases

(*c*) decreases

(*d*) just doubles

(*x*) Gain crossover frequency is the frequency at which the gain of $L(jw)$ is

(*a*) 10 dB

(*b*) 5 dB

(*c*) 0 dB

(*d*) 100 dB

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Group A

1. (*a*) Describe the construction and working of a PMMC type of instrument. Derive the expression for deflection for a PMMC ammeter, if it is spring controlled. Comment upon shape of the scale. 6

(*b*) The coil of a moving coil galvanometer has 250 turns and is suspended in a uniform magnetic field of 0·05 T. The torsion constant is $1 \cdot 5 \times 10^{-7}$ Nm/radian. The coil is 15 mm wide and 20 mm high with a moment of inertia of $1 \cdot 5 \times 10^{-7}$ kgm^2. The galvanometer resistance is 200 Ω and total damping is 4×10^{-8} Nm/radian/sec. Determine the (*i*) steady state deflection of the galvanometer spot on the scale in mm when a current of 2·5 μA flows through the galvanometer and the scale is at a distance of 1·5 m from the mirror, (*ii*) current sensitivity, (*iii*) voltage sensitivity, (*iv*) frequency of oscillations relative damping. 14

2. (*a*) Name two of the problems associated with measurement of low resistances? How are they overcome? Describe the Kelvin's double bridge for the comparison of two low resistances. Give theory of the bridge and arrangement necessary in order that the greatest precision possible may be obtained. 10

(*b*) Explain, with a neat circuit diagram, the Lloyd Fisher method of testing core loss of laminated sheet steel. Make necessary derivations and explain how eddy current and hysteresis losses may be evaluated separately. Can you explain why a separate sine wave generator may be required for this test? 10

3. (*a*) Draw a neat schematic diagram of the Anderson bridge. Also, derive the equation of balance of Schering bridge. Draw the phasor diagram under null conditions and explain how loss angle of capacitor can

(*b*) If in an Anderson bridge for the measurement of inductance, the arm AB consists of unknown impedance having inductance L and resistance R as shown in Fig. 1. The arms BC, CD and DA consist of resistances having values 1 kQ, 1 kQ and 500 Q, respectively. A resistance of 100 Ω and a capacitance of 3 μF are connected, respectively to the arm DE and CE. An a.c. supply of 100 Hz is applied between the terminals A and C and a detector is connected between the terminals B and E. The detector indicates null under the above conditions. Determine the values of R and L connected to the arm AB. 10

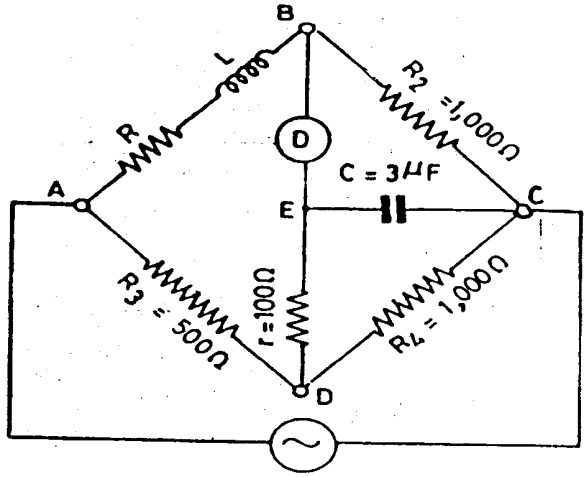

Fig. 1 Anderson bridge

4. (*a*) Explain how you can measure high voltage by the sphere gap method. Discuss the effect of humidity, if any, on your measurement. Do you measure the rms value of the voltage or the peak value ? Can you mention *any one* limitation of this method ? 6

(*b*) What is an impulse wave and how is it specified ? Explain briefly how the testing of electrical strength of insulating oil is carried out. Explain the nature of surge waveform. 7

(*c*) Describe a suitable method for measurement of time interval with approximate diagram. 7

Group B

5. (*a*) The unit impulse response of a system is $e^{-t}(1 - \cos 3t)$. Determine its transfer function. 5

(*b*) Name *three* typical time domain specifications for control systems. Explain with a diagram. 6

(*c*) Draw signal flow graph in the Laplace domain for a system given by the equation

$$\frac{d^2y}{dx^2} + \frac{2}{3}\frac{dy}{dx} + \frac{11y}{2} = x.$$ Ignore initial conditions. 9

6. (*a*) Find the closed-loop bandwidth, natural frequency and damping for a system having $G(s) = 81 / [s(s + 18)]$ with unity feedback. 8

(*b*) An automatic speed control system uses an error detector whose gain is 1 V/(rad/s), the error signal is given to an electric motor having a torque constant 75 Nm/V. The combined moment of inertia and coefficient of viscous friction of the motor and load are 10 kgm^2 and 5 Nm/(rad/s), respectively. If the reference input setting is suddenly increased by 60 rpm, obtain an expression relating the load speed and time. Also, calculate steady state speed and steady state error. 12

7. (*a*) Determine the condition for stability of the closed-loop system having the open-loop transfer functions of the equation

$$G(s)\,H(s) = \frac{K}{s(1 + T_1 s)(1 + T_2 s)}$$ 10

(*b*) Construct the Bode plot for an open loop system having

$$G(s) = \frac{10(s + 10)}{s(s + 2)(s + 5)}$$

From the plot, obtain the gain margin and phase margin for the corresponding unity feedback close-loop system. Comment on the stability of the system. 10

8. (*a*) Sketch the root loci of control system having open transfer function

$$G(s) = \frac{k}{83{\cdot}33(s + {\cdot}001)(s + 2)(s + 6)}$$

Determine the value of the proportional controller gain in the forward path necessary for the damping factor of the closed loop system to be 0·5. Also, find the gain at the breakaway point and at the point where locus intersects the imaginary axis. 10

(*b*) Compare the constructional and functional differences between a.c. and d.c. tachogenerators. 10

Group C

Explain the following in brief: 1×20

(*i*) Why is a megger provided with a slipping clutch ?

(*ii*) How will you measure the peak value of a high alternating voltage ?

(*iii*) Why are ring specimens preferred over rod or strips for magnetic testing ?

(*iv*) Why is vibration galvanometer widely used as detector for operation of a.c. bridges ?

(*v*) Why are not dynamometer type instruments usually used for d.c. measurements ?

(*vi*) Why should an ammeter be of very low resistance ?

(*vii*) What is the difference between fundamental and derived quantities ?

(*viii*) What happens when an induction type instrument is connected to d.c. supply ?

(*ix*) What is meant by power factor ?

(*x*) How will the stability be affected if a zero is added to the transfer function of a second order system ?

(*xi*) State the procedures for reduction of block diagram.

(*xii*) What will be the control action of a PID on a basic control action of controllers ?

(*xiii*) What do you mean by absolute stability ?

(*xiv*) What do you mean by real axis loci ?

(*xv*) What do you mean by compensator ?

(*xvi*) Write the gain and % resolution of a potentiometer.

(*xvii*) Define positional servomechanism.

(*xviii*) How will the gain be affected if a zero is added to the transfer function of a second order system ?

(*xix*) How do you reduce multiloop system into a single loop system ?

(*xx*) What is the main difference between a moving coil and a moving iron instrument ?

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Group A

1. (*a*) What are different standards of measurement? What purpose do they serve? 6

(*b*) Discuss the following standards: 3×3

(*i*) Voltage standards

(*ii*) Resistance standards

(*iii*) Capacitance standards.

(*c*) What are the advantages of SI units? State the SI units of the following quantities: Mmf, Flux density, Frequency. 5

2. (*a*) Explain, with suitable diagrams, the construction and principle of operation of a power factor meter. What are its merits and demerits? 8

(*b*) A four terminal resistance of approximately 50 μΩ was measured with the help of Kelvin double bridge under the following conditions:

Value of standard resistance	= 100·03 μΩ
Resistance of inner ratio arms	= 100·31 Ω and 200·00 Ω
Resistance of outer ratio arms	= 100·24 Ω and 200·00 Ω
Value of low resistance link	= 700 μΩ

Calculate the magnitude of error in the measurement. Derive the equations. 12

3. (*a*) What are different types of a.c. potentiometers? How do you calibrate an a.c. potentiometer? 5

(*b*) Calculate the inductance of a coil from the following measurements on an a.c. potentiometer. Voltage drop across 0·1 Ω; standard resistor connected in series with the coil = 0·613 ∠12° 6′ V, voltage across the test coil through a 100/1 volt-ratio box = 0·781 ∠50° 48′ V, f = 50 Hz. 7

(*c*) Describe a method to determine the B-H loop experimentally. 8

4. (*a*) Explain the nature of surge waveform. Describe a high voltage multistage impulse generator. 8

(*b*) How will you measure r.m.s. value of high voltage? 6

(*c*) Show how a Schering bridge is used to test a high voltage insulator. 6

Group B

5. (*a*) What are synchros? Explain, with suitable sketches, the principle of operation of a synchro control transmitter. Show how a pair of synchros can be used as an error detector. 8

(*b*) Convert the system, shown in Fig. 1, into a unity feedback system. 7

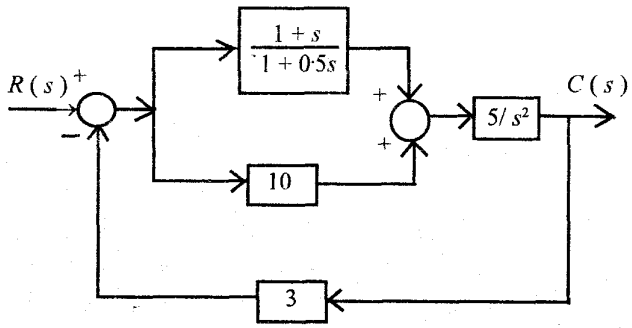

Fig. 1

(*c*) Explain how a gyroscope operates. 5

6. (*a*) For a unity feedback system,

$$G(s) = \frac{36}{s(s+0{\cdot}72)}$$

determine the characteristic equation and hence calculate damping ratio, peak time, settling time, peak overshoot and number of cycles completed before output settles for unit step input. 10

(*b*) Obtain the transfer function of the system whose governing equations are given by 6

$$\dot{x}_1 = -4x_1 - x_2 + 3u$$
$$\dot{x}_2 = -2x_1 - 3x_2 + 5u$$
$$y = x_1 + 2x_2.$$

(*c*) State the properties of state transition matrix. 4

7. (*a*) A unity feedback system has

$$G(s) = \frac{200}{s(s+1)(s+10)}.$$

Draw the Bode plots and determine gain margin and phase margin. 14

(*b*) Sketch the polar plot for the following for positive frequencies: 6

$$G(s) = \frac{K(1+sT_1)}{(1+sT_2)}, \text{ where } T_1 > T_2.$$

8. (*a*) Calculate the value of K for which the feedback system having loop T.F. is stable: 8

$$G(s)H(s) = \frac{K}{s(s+2)(s^2+2s+2)}$$

(*b*) Write short notes on *any three* of the following: 4×3

(*i*) Absolute stability

(*ii*) Breakaway points

(*iii*) Angle of departure and arrival of a root locus

(*iv*) Centroid

(*v*) Nyquist criterion of stability.

Group C

9. Choose the *correct* answer for the following: 1×20

(*i*) Which of the following does *not* have the same units as others? The symbols have their usual meanings.

(*a*) L/R

(*b*) RC

(*c*) $\sqrt{LC}$

(*d*) $1/\sqrt{LC}$

(*ii*) The dimensions of power are

(*a*) ML^2T^{-3}

(*b*) $M^2L^2T^{-3}$

(*c*) M^2LT^{-3}

(*d*) M^2LT^{-2}

(*iii*) The voltmeter of choice for measuring the emf of a 100 V d.c. source would be

(*a*) 100 V, 1 mA

(*b*) 100 V, 2 mA

(*c*) 100 V, 10 kΩ/V

(*d*) 100 V, 100 Ω/V

(*iv*) The power delivered to a three-phase load can be measured by the use of two wattmeters only when the

(*a*) load is balanced

(*b*) load is unbalanced

(*c*) three phase load is connected to the source through three wires

(*d*) three phase load is connected to the source through four wires

(*v*) The Wheatstone bridge method of resistance measurement is ideally suitable for the measurement of resistance values in the range of

(*a*) 0·001 Ω to 1 Ω

(*b*) 0·1 Ω to 100 Ω

(*c*) 100 Ω to 10 kΩ

(*d*) 100 kΩ to 10 MΩ

(*vi*) For standardisation of Drysdale a.c. potentiometer, the instrument used is a

(*a*) PMMC ammeter

(*b*) rectifier ammeter

(*c*) thermocouple instrument

(*d*) precision type electrodynamometer ammeter

(*vii*) In the bridge, shown in Fig. 2, $z_1 = 450\,\Omega$, $z_2 = (300 - j600)\,\Omega$, and $z_3 = (200 + j100)\,\Omega$.

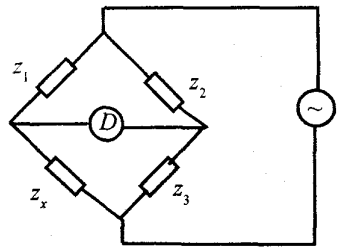

Fig. 2

The value of unknown impedance, z_x at balance is

(*a*) $(100 + j150)\,\Omega$

(*b*) $(100 - j150)\,\Omega$

(*c*) $(300 + j100)\,\Omega$

(*d*) $(0 + j150)\,\Omega$

(*viii*) Anderson bridge is used for the measurement of

(*a*) time period

(*b*) frequency

(*c*) inductance

(*d*) capacitance

(*ix*) A PMMC instrument can be used as a flux meter by

(*a*) using a low resistance shunt

(*b*) removing the control springs

(*c*) making the control spring stronger

(*d*) using a high series resistance

(*x*) Sphere gap voltmeter, when measuring a.c. voltage, measures

(*a*) peak value

(*b*) instantaneous value

(*c*) rms value

(*d*) average value

(*xi*) A linear time-invariant system initially at rest, when subjected to a unit-step input, gives a response $y(t) = te^{-t}$; $t > 0$. The transfer function of the system is

(*a*) $1/(s+1)^2$

(*b*) $1/s(s+1)^2$

(*c*) $s/(s+1)^2$

(*d*) $1/s(s+1)$

(*xii*) The step response of a system with transfer function $G(s) = 1/(1+sT)$ attains more than 98% of its final value in time t equal to

(*a*) $2T$

(*b*) $3T$

(*c*) $4T$

(*d*) $5T$

(*xiii*) The characteristic equation of a feedback control system is given by

$$2s^4 + s^3 + 2s^2 + 5s + 10 = 0$$

The number of roots in the right half of the s-plane is

(*a*) 3

(*b*) 2

(*c*) 1

(*d*) zero

(*xiv*) The diagram in Fig. 3 gives the Nyquist plot for positive frequencies of an open loop transfer function:

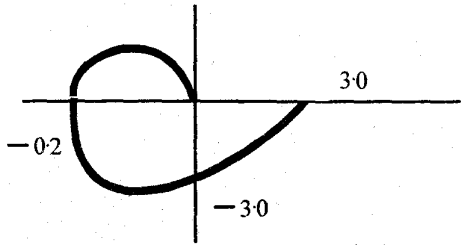

Fig. 3

What is the gain margin?

(*a*) 0·2

(*b*) 0·33

(*c*) 3·0

(*d*) 5·0

(*xv*) A second order system with no zero has its poles located at $(-3 + j4)$ and $(-3 - j4)$ in the s-plane. Which of the following pairs gives its natural frequency (ω_n) and damping factor (ζ), respectively?

(*a*) $\omega_n = 5, \zeta = 0{\cdot}60$

(*b*) $\omega_n = 5, \zeta = 0{\cdot}80$

(*c*) $\omega_n = 4, \zeta = 0{\cdot}75$

(*d*) $\omega_n = 3, \zeta = 0{\cdot}60$

(*xvi*) A system has fourteen poles and two zeros. What is the slope of its high frequency asymptote in the magnitude plot ?

(*a*) - 40 db/decade

(*b*) - 240 db/decade

(*c*) - 280 db/decade

(*d*) - 320 db/decade

(*xvii*) The determinant Δ of the signal flow graph, shown in the Fig. 4, is

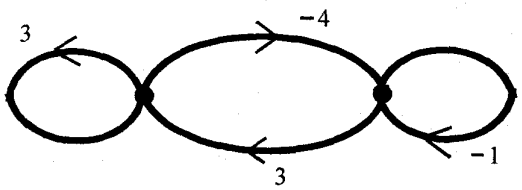

Fig. 4

(*a*) - 13

(*b*) - 12

(*c*) 8

(*d*) 11

(*xviii*) The pair of synchros used for remote indication of position is

(*a*) synchro transmitter and repeater.

(*b*) synchro transmitter and control transformer.

(*c*) synchro differential transmitter and control transformer.

(*d*) synchro resolver and control transformer.

(*xix*) The transfer function for the state variable representation

$$\dot{X} = AX + BU, \quad Y = CX + DU$$

is given by

(*a*) $D + B(sI - A)^{-1} C$

(*b*) $D + C(sI - A)^{-1} B$

(*c*) $C + D(sI - A)^{-1} B$

(*d*) $B + C(sI - A)^{-1} D$

(*xx*) For the unity feedback control system having forward path transfer function

$$G(s) = \frac{25}{s(0{\cdot}5s + 1)(s + 5)},$$

the velocity error constant is

(*a*) 0

(*b*) 5

(*c*) 25

(*d*) ∞.

S'08 : 6 FN : EL 406 (1467)

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Group A

1. (*a*) Describe, with a neat sketch, one form of modern precision moving iron ammeter for a.c. circuits. Prove that no frequency error is introduced when using a shunt having the same time conduct as the instrument. 8+6

(*b*) The full scale torque of 5 A moving iron ammeter is 0·1 g-cm. Estimate, in μH per radian, the rate of change of self-inductance of the instrument at full scale. 6

2. (*a*) With the help of a neat circuit diagram, explain how an imperfect capacitor may be tested by a Schering bridge. Make necessary diagrams. Draw the phasor diagram of voltages and currents of the bridge arms at balance condition of the bridge. 12+2

(*b*) In a Schering bridge balance, the following values are obtained:

$C_2 = 100\,\mu F$, $R_3 = 100\,\Omega$, $R_4 = 300\,\Omega$, $C_4 = 0{\cdot}5\,\mu F$, $f = 50\,Hz$.

Find the unknown capacitance C_1 and loss angle δ. The diagram is shown in Fig. 1. 6

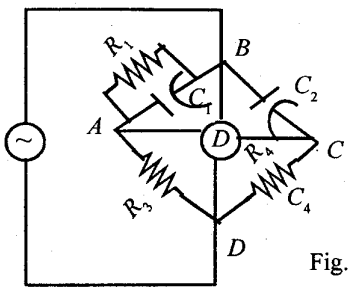


Fig. 1

3. (*a*) Describe, with a neat sketch, a d.c. standard potentiometer. How would you make it direct reading? 6+2

(*b*) Draw a connection diagram and explain how you would determine an unknown resistance with the help of a direct reading potentiometer. 4

(*c*) A standard cell of 1·0185 V used with a simple d.c. potentiometer balances at 50 cm. Calculate the (*i*) emf of a cell that balances at 72 cm, (*ii*) percentage error in a voltmeter which balances at 64·5 cm when reading 1·33 V, and (*iii*) percentage error in an ammeter that reads 0·43 A when balance is obtained at 43·2 cm with p.d. across a resistor of 2 ohm in the ammeter circuit. 8

4. (*a*) Explain how you can determine the magnetization or BH curve for a ring specimen from step-by-step method. Hence, describe the determination of hysteresis loop. 6+4

(*b*) Describe the construction and theory of operation of a Grassot fluxmeter. 10

Group B

5. (*a*) Explain the terms 'open-loop control' and 'closed-loop control' of an industrial process, with the aid of suitable schematic or block diagrams where necessary. 6

(*b*) What are the advantages and disadvantages of 'open-loop control' and 'closed-loop control'? 7

(*c*) Determine the position, velocity, and acceleration error constants for the unity feedback system whose open-loop transfer function is

$$G(s) = \frac{50}{(1+0{\cdot}1s)(1+2s)}$$ 7

6. (*a*) State the procedure to draw signal flow graphs from a block diagram. How can you construct signal flow graph from linear equations? 5+5

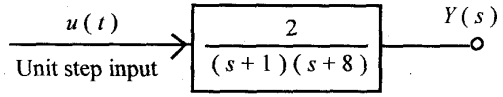
(*b*) What is a synchro? What are different types of synchros? Explain their constructional features and the principle of operation. 10

7. (*a*) Given the system characteristic equation as

$$s^4 + 6s^3 + 21s^2 + 36s + 20 = 0$$

Determine whether the system is stable or not by applying Routh-Hurwitz criterion. 8

(*b*) Find the unit step response, $y(t)$, for the following system: 12



8. (*a*) How can you select state variables for different systems? 5

(*b*) Write state variable equation for a mechanical system shown in Fig. 2: 10

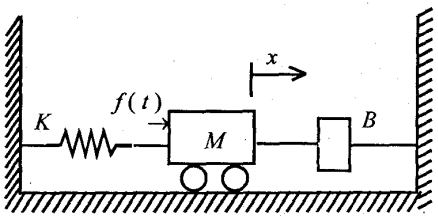


Fig. 2

(*c*) Find the state variable description (i.e., matrices *A*, *B* and *C*) for the following transfer function: 5

$$G(s) = Y(s)/U(s) = 2/(s^3 + 4s^2 + 5s + 2)$$

Group C

9. (*A*) Choose the *correct* answer for the following: 1×10

(*i*) If we leave the secondary winding of a current transformer open, then

(*a*) nothing will happen

(*b*) CT will blast

(*c*) there will not be any current in primary

(*ii*) The potentiometer can be categorized into the category of

(*a*) standard instrument.

(*b*) indicating instrument.

(*c*) comparison instrument.

(*iii*) The ratio error in CT is attributed to

(*a*) power factor of the primary.

(*b*) exciting current.

(*c*) leakage flux.

(*iv*) For instrument with a very weak magnetic field, we use

(*a*) air friction damping.

(*b*) fluid friction damping.

(*c*) eddy-current damping.

(*v*) The calibration on a.c. and d.c. is same for all

(*a*) electrodynamic ammeter.

(*b*) moving-iron instrument.

(*c*) rectifier type instrument.

(*vi*) If an instrument have cramped scale for larger values of the indicated quantity, it should obey a

(*a*) square law.

(*b*) logarithmic scale law.

(*c*) uniform scale.

(*vii*) Swamping resistance is a resistance which is added to the coil circuit to

(*a*) reduce the temperature error.

(*b*) reduce error due to thermal emf.

(*c*) increase sensitivity.

(*viii*) The thermal emfs in the bridge measurement

(*a*) does not affect the measurement.

(*b*) causes a small error in the measurement.

(*c*) causes considerable trouble in balancing the bridge.

(*ix*) Changes in atmospheric temperature, humidity, stray magnetic field, etc. cause

(*a*) systematic error

(*b*) instrumental error

(*c*) environmental error

(*x*) The most efficient method of damping used in electrical measuring instruments is

(*a*) air friction

(*b*) fluid friction

(*c*) eddy-current

(*B*) Explain the following in brief: 1×10

(*i*) What is the effect of adding a pole to any system ?

(*ii*) What are Bode plots ?

(*iii*) What is meant by the type of a transfer function ?

(*iv*) What is a tachometer ?

(*v*) What are the effects of feedback on poles and zeros of a stable transfer function ?

(*vi*) What is a root locus ?

(*vii*) What is compensation ?

(*viii*) What is the effect on polar plot if a non-zero pole is added to a transfer function ?

(*ix*) When is the transfer function said to be minimum phase ?

(*x*) What are state variables ?

W'08 : 6 FN : EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What is meant by the dimensions of a quantity? Derive the dimensions of potential difference in the electrostatic system in terms of mass, length and time. In the course of a calculation, an expression of the following form was arrived at:

$$I = E\left\{\frac{1}{z_1} + \frac{jwM}{z_2}\left(\frac{1}{R} + \frac{C}{L}\right)\right\}$$

Show that there must have been an algebraic error and point out the term(s) which require correction. 12

(*b*) The electrical power in a circuit is proportional to the voltage and to the resistance of the circuit, each raised to some power. Determine these powers by the use of dimensions of quantities involved. 8

2. (*a*) Describe, with a neat diagram of connections, the loss of charge method of determining the insulation resistance of a length of cable. Prove the formula used for this determination and calculate the insulation resistance of a short length of cable in which the voltage falls from 100 to 80 in 20 sec, the capacitance being 0·0003 μF. 10

(*b*) Describe the Kelvin double bridge for the comparison of small resistances. Give the theory of the bridge and detail the arrangements necessary in order that the greatest precision possible may be obtained. 10

3. (*a*) What are the conditions to be fulfilled by a ballistic galvanometer ? Describe the construction of such an instrument and explain how to determine the constant and the logarithmic decrement. 10

(*b*) Explain carefully how the construction of a flux meter differs from that of a moving coil ammeter or voltmeter. 10

4. (*a*) Describe, with connection diagram, how the peak value of a high voltage may be measured by means of a neon tube. Explain how the method is applied to the calibration of an extra high voltage voltmeter. How would you arrange to detect the certainty the striking of the neon tube ? 10

(*b*) Describe an equipment for the production of high voltages for surge or impulse tests. Explain the action of the circuit described and show precisely how the shape of the impulse wave can be controlled. 10

Group B

5. (*a*) Draw signal flow graphs for the following sets of algebraic equations. These equations should be arranged in the form of cause and effect relations before signal flow graphs can be drawn. Show that there are many possible signal flow graphs for each set of equations : 10

(*i*) $x_1 = -x_2 - 3x_3 + 3$
$x_2 = 5x_1 - 2x_2 + x_3$
$x_3 = 4x_1 + x_2 - 5x_3 + 5$

(*ii*) $2x_1 + 3x_2 + x_3 = -1$
$x_1 - 2x_2 - x_3 = 1$
$3x_2 + x_3 = 0$

(*b*) The state equations of a linear time invariant system are represented by

$$[dx(t)/dt] = Ax(t) + Bu(t)$$

Find the state transition matrix, $\phi(t)$, the characteristic equation and the eigenvalues of A for the following cases : 10

(*i*) $A = \begin{bmatrix} 0 & 1 \\ -2 & -1 \end{bmatrix}$, $B = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$

(*ii*) $A = \begin{bmatrix} -3 & 0 \\ 0 & -3 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

(*iii*) $A = \begin{bmatrix} -5 & 1 & 0 \\ 0 & -5 & 1 \\ 0 & 0 & -5 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

6. (*a*) The following transfer functions are given for a single-loop non-unity feedback control system. Find the steady state errors due to a unit step input and a unit ramp input : 10

(*i*) $G(s) = 1/(s^2+s+2),\ H(s) = 1/(s+1)$

(*ii*) $G(s) = 1/[s^2(s+12)],\ H(s) = 5(s+2)$

(*b*) Given the forward path transfer function of unity feedback control systems:

(*i*) $$G(s) = \frac{k(s+4)(s+20)}{s^3(s+100)(s+500)}$$

(*ii*) $$G(s) = \frac{k(s+1)}{s^3+2s^2+3s+1}$$

Apply the Routh-Hurwitz criterion to determine the stability of the closed-loop system as a function of k. Determine the value of k that will cause sustained constant amplitude oscillations in the system. Determine the frequency of oscillation. 10

7. (*a*) The characteristic equation of linear control systems are given as follows. Construct the root loci for $k \geq 0$. 10

(*i*) $s^3+3s^2+(k+2)s+5k=0$

(*ii*) $s^3+5ks^2+10=0$

(*iii*) $s^3+2s^2+2s+k(s^2-1)(s+2)=0$

(*b*) A unit feedback control system has the forward path transfer function as given below. Construct the root-locus diagram for $k \geq 0$. Find the values of k at all breakaway points: 10

(*i*) $G(s) = k/[s(s+10)(s+20)]$

(*ii*) $G(s) = k/[s(s+1)(s+3)(s+5)]$

(Continued)

8. (*a*) The forward path transfer function of a unity feedback control system is

$$G(s) = (1+T_2 s)/[s(s+1)^2]$$

Compute and plot the unit step responses of the closed-loop system for $T_2 = 0,\ 0{\cdot}5$ sec, 1 sec, 10 sec and 50 sec. Assume zero initial conditions. Comment on the effects of various values of T_2 on the step response. 10

(*b*) The forward path transfer function of a unity feedback control system is

$$G(s) = \frac{k(1+0{\cdot}2s)(1+0{\cdot}1s)}{s^2(1+s)(1+0{\cdot}01s)^2}$$

(*i*) Construct the Bode and Nyquist plots of $G(jw)/k$ and determine the range of k for system stability. 5

(*ii*) Construct the root loci of the system for $k \geq 0$. Determine the values of k and w at the point where the root loci cross the jw-axis, using the information found from the Bode plot. 5

Group C

9. Choose the *correct* answer for the following: 2×10

(*i*) Force exerted upon a magnetic pole, of strength m units placed at the centre of a circular wire of radius r due to a current i flowing in an arc of the circle of length l,is given by

(*a*) $F = mi^2l/r^2$

(*b*) $F = mil/r^2$

(*c*) $F = m^2il/r^3$

(*d*) $F = mil^2/r^2$

(*ii*) In any system of units, the permeability of free space, μ_0, and permittivity of free space, ε_0, are related with c, the velocity of light, by the equation

(*a*) $\mu_0\varepsilon_0 = c$

(*b*) $\mu_0/\varepsilon_0 = \sqrt{c}$

(*c*) $\mu_0\varepsilon_0 = 1/c^2$

(*d*) $\mu_0\varepsilon_0 = 1/c$

(*iii*) Measured value of a 1 Ω resistance, having current carrying capacity of 100 mA, when measured with a voltmeter of 5 Ω resistance giving 100 mV reading in ammeter-voltmeter method, is

(*a*) 1·2 Ω

(*b*) 0·833 Ω

(*c*) 2 Ω

(*d*) 1·5 Ω

(*iv*) The frequency and amplitude of waveform of the current in the slide wire portion of the potentiometer, i.e., of the supply must, in all a.c. potentiometers, be exactly the

(*a*) double as those of the voltage to be measured.

(*b*) half of the voltage to be measured.

(*c*) triple as those of the voltage to be measured.

(*d*) same as those of the voltage to be measured.

(*v*) If a discrete data system is described by the diference equation

$$y(k+2) + 5y(k+1) + 3y(k) = r(k+1) + 2r(k),$$

the transfer function of the system is simply

(*a*) $(z+1)/(z^2+2z+3)$

(*b*) $(z+3)/(z^2+6z+4)$

(*c*) $(z+2)/(z^2+5z+3)$,

(*d*) $(z+4)/(z^2+3z+4)$

(*vi*) If the loop transfer function of a single-loop feedback control system is given as

$G(s)H(s) = [K(s+5)]/[s(s+2)(1+T_s)$,

(*a*) parameters K and T may be represented in a plane with K as the horizontal axis and T as the vertical axis.

(*b*) parameters K and T cannot be represented in a plane.

(*c*) parameters K and T can be represented in two planes perpendicular to each other.

(*d*) parameters K and T can be represented in two planes inclined to each other at an angle of 60°.

(*vii*) If the closed loop system transfer function is given by

$$(s-1)/(1+s)(s^2+2),$$

the system is

(*a*) unstable

(*b*) marginally stable

(*c*) stable

(*d*) marginally unstable.

(*viii*) If the forward path transfer function of unity feedback control system is

$$G(s) = [k(s+10)(s+20)]/(s^2(s+2),$$

the value of k that will cause sustained constant amplitude oscillation in the system is

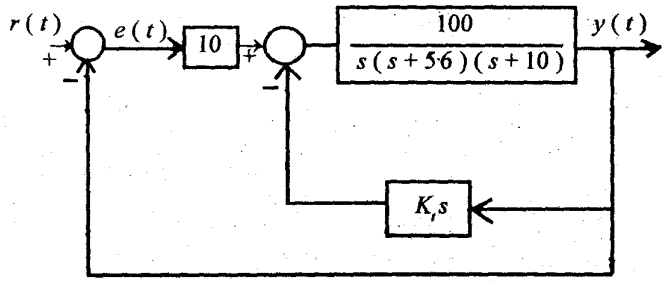
(*a*) $k = 1$

(*b*) $k < 5$

(*c*) $k > 4{\cdot}6667$

(*d*) $k > 5$

(*ix*) The block diagram of a motor-control system with tachometer feedback is shown below:



The range of the tachometer constant, k_t, is

(*a*) $k_t = 1$

(*b*) $k_t = \sqrt{2}$

(*c*) $k_t > 5$

(*d*) $k_t > 0{\cdot}081$

(*x*) If the forward path transfer function of a unity feedback control system is

$$G(s) = \frac{k}{s(1+0{\cdot}1s)(1+0{\cdot}5s)},$$

the step, ramp and parabolic error constants are

(*a*) $k_p = \infty$, $k_v = k$, $k_a = 0$

(*b*) $k_p = 0$, $k_v = k$, $k_a = 1$

(*c*) $k_p = 0$, $k_v = k$, $k_a = \infty$

(*d*) $k_p = k$, $k_v = k$, $k_a = 1$

S'09 : 6 FN : EL 406 (1467)

MEASUREMENT AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) The inductance of a moving iron instrument is given by

$$L = (12 + 6\theta - \theta^2)\ \mu H$$

where θ is the deflection (in radians) from zero position. The spring constant is 12×10^{-6} Nm/rad. Calculate the deflection for a current of 8 A. 6

(*b*) With a neat diagram, give the description of permanent magnet moving coil instruments. A moving coil instrument has following data: Number of turns = 100, width of coil = 20 mm, depth of coil = 30 mm, flux density in air gap = 0·1 Wb/m^2. Calculate the deflecting torque when carrying a current of 10 mA. Also, calculate the deflection if spring constant is 2×10^{-6} Nm/degree. 8+6

2. (*a*) With the help of a neat diagram, explain how an inductor can be tested using Anderson's bridge. Draw the phasor diagrams. 6+6

(*b*) An Owen's bridge is used to measure the properties of a sample of sheet steel at 2 kHz. At balance, arm *ab* is test specimen, arm *bc* is $R_3 = 100\,\Omega$, arm *cd* is $C_4 = 0{\cdot}1\,\mu$F, and arm *da* is $R_2 = 834\,\Omega$ in series with $C_2 = 0{\cdot}124\,\mu$F. Derive balance conditions and calculate the effective impedance of the specimen under test conditions. 8

3. (*a*) Describe standard a.c. potentiometer. 8

(*b*) Explain the method of working of Owen bridge. 8

(*c*) What are the applications of d.c. potentiometer? 4

4. (*a*) Give a detailed description of methods used for determination of B-H curve? Draw diagrams wherever necessary. 12

(*b*) Give the construction and working of fluxmeter? 8

Group B

5. (*a*) Define open and closed loop control system. Give its advantages and disadvantages. 10

(*b*) Find the overall transfer function of the system whose signal flow graph is shown in Fig. 1. 10

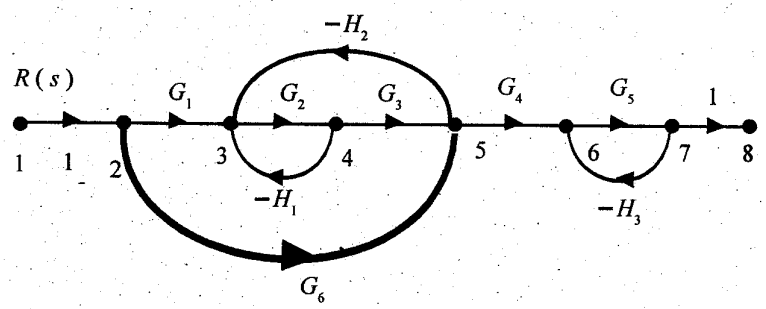


Fig. 1

6. (*a*) Derive the relationship between state equations and transfer functions. 12

(*b*) Measurements, conducted on a servomechanism, show the system response to be $C(t) = 1 + 0{\cdot}2\,e^{-60t} - 1{\cdot}2\,e^{-10t}$ when subjected to a unit step input. Obtain an expression for closed loop transfer function. Determine the undamped natural frequency and damping frequency. 8

7. (*a*) Given the system characteristics

$$2S^4 + S^3 + 3S^2 + 5S + 10 = 0.$$

Determine whether the system is stable or not by applying Routh-Hurwitz criterion. 8

(*b*) The open loop transfer function is given by

$$G(s) = 1/s\,(1+s)\,(1+2s)$$

Sketch the polar plot and determine the gain margin and phase margin. 12

8. (*a*) Explain the principles of gyroscope. 8

(*b*) Define the following terms: (*i*) PI controller; (*ii*) PD controller; and (*iii*) PID controller. 3 × 2

(*c*) What is polar plot and write the state model equation of a system. 6

Group C

9. Choose the *correct* answer for the following: 10 × 2

(*i*) Zener sources, when used as voltage standards,

(*a*) are reverse biased.

(*b*) can be designed to cover a wide range of voltages.

(*c*) are immune to the effects of short circuits.

(*d*) All of the above.

(*ii*) High resistances are provided with guard terminal. This guard terminal is used to

(*a*) bypass the leakage current.

(*b*) guard the resistance against stray electrostatic fields.

(*c*) guard the resistance against overloads.

(*d*) None of the above.

(*iii*) Frequency can be measured by using

(*a*) Maxwell's bridge.

(*b*) Schering bridge.

(*c*) Heavyside Campbell bridge.

(*d*) Wien's bridge.

(*iv*) Maxwell's inductance capacitance bridge is used for masurement of inductance of

(*a*) low Q coils.

(*b*) medium Q coils.

(*c*) high Q coils.

(*d*) low and medium Q coils.

(*v*) In a fluxmeter,

(*a*) the controlling torque is produced by weights attached to moving coil.

(*b*) the controlling torque is produced by springs.

(*c*) there is no controlling torque.

(*d*) None of the avove.

(*vi*) The gain required by the signal, when it travels from one node to another, is called

(*a*) input node.
(*b*) mixed node.
(*c*) transmittance.
(*d*) branch.

(*vii*) Automatic controller is the combined unit of amplifier, controller and

(*a*) error detector.
(*b*) feedback.
(*c*) potentiometer.
(*d*) tachometer.

(*viii*) Cut-off rate is the slope of the log-magnitude curve near the

(*a*) cut-off frequency
(*b*) gain cross-over frequency.
(*c*) resonant frequency.
(*d*) phase cross-over frequency.

(*ix*) Which is defined as the time taken for response to reach 50% of the final value for the very first time?

(*a*) Rise time
(*b*) Delay time
(*c*) Peak overshoot
(*d*) Peak time

(*x*) If all the roots of characteristic equation has negative real parts, then the system is

(*a*) unstable.
(*b*) stable.
(*c*) limitedly stable.
(*d*) asymptotically stable.

W'09 : 6 FN : EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Why is standardisation required in potentiometer ? 3

(*b*) Describe the principle, construction and operation of an alternating current potentiometer. 12

(*c*) How can an alternating current potentiometer be used for the calibration of a voltmeter ? 5

2. (*a*) Explain how an inductance may be measured by comparison with a standard capacitor in an alternating current bridge. 8

(*b*) Explain the theory of working of Schering bridge and show how it is used for the measurement of dielectric loss and power factor. 12

3. (*a*) How can you separate the eddy-current loss and hysteresis loss component from the total core loss ? 6

(*b*) Explain how can you determine the magnetisation or B-H curve for a ring specimen by a step-by-step method. Hence, describe the determination of hysteresis loop. 14

4. (*a*) Describe *any two* methods for the measurement of peak of high voltage. 10

(*b*) What is meant by impulse voltage ? Describe *two* methods for impulse generation. 10

Group B

5. (*a*) Define open loop and closed loop control system. State the advantages and disadvantages of both the systems. Compare between the two systems. 12

(*b*) Determine the transfer function of an electrical network shown in Fig. 1 : 6

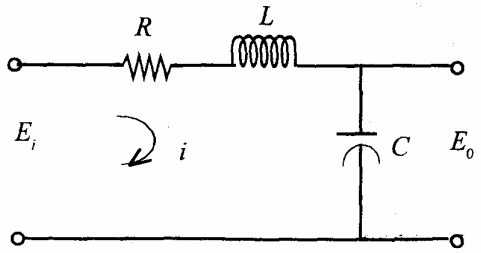


Fig. 1

(*c*) Draw the analogous electrical circuit of the system shown in Fig. 2 using force-voltage analogue : 2

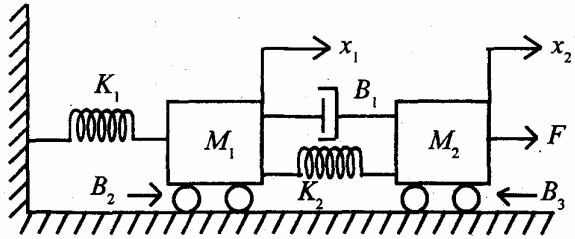


Fig. 2

6. (*a*) What is root locus ? What are the rules for construction of root loci ? 10

(*b*) Show that the root loci for a control system with $G(s) = K(s + 1)/s(s - 1)$, $H(s) = 1$ is a circle with centre at $(-1, 0)$ and radius $\sqrt{2}$. 10

7. (*a*) Obtain the response of a first order system with unit step unit. 6

(*b*) What is the meaning of frequency response of a system ? What is its significance ? What are the advantages and disadvantages of frequency domain analysis ? 8

(*c*) The closed loop transfer function is given by

$$G(s) = \frac{s(s^2 + 9s + 19)}{s^3 + 7s^2 + 14s + 8}$$

Determine the response of the system when a unit step is applied at the input. 6

8. (*a*) Explain the concept of stability. What is Routh-Hurwitz criterion ? 10

(*b*) Check the stability of the system having the following characteristic equation : 5

$$s^4 + 2s^3 + 3s^2 + 4s + 5 = 0$$

(*c*) A feedback system has an open loop transfer function

$$G(s)H(s) = \frac{Ke^{-s}}{s(s^2 + 5s + 9)}$$

Determine, by use of Routh criterion, the maximum value of K for the closed loop system to be stable. 5

Group C

9. Choose the *correct* answer for the following : 10×2

(*i*) Power has the dimension

(*a*) L^2M

(*b*) L^2MT^{-3}

(*c*) L^2MT^{-2}

(*d*) LMT^{-2}

(*ii*) Grassort fluxmeter is a special type of Ballistic galvanometer in which

(*a*) controlling torque is small and damping is heavy.

(*b*) controlling torque and damping are large.

(*c*) controlling torque is large but damping is small.

(*d*) controlling torque and damping are small.

(*iii*) The dielectric loss of capacitance can be measured by

(*a*) Hay's bridge

(*b*) Schering bridge

(*c*) Maxwell bridge

(*d*) Anderson bridge

(*iv*) The potentiometer can be categorized into the category of

(*a*) standard instruments.

(*b*) indicating instruments.

(*c*) comparison instruments.

(*d*) calibrating instruments.

(*v*) For the measurement of very-very high resistance (insulation resistance), the instrument used is

(*a*) an avometer.

(*b*) a multimeter.

(*c*) a megger.

(*d*) an ohmmeter.

(*vi*) Transfer function of a system is defined as the ratio of output to input in

(*a*) Laplace transform.

(*b*) Z-transform.

(*c*) Fourier transform.

(*d*) algebraic form.

(*vii*) (*i*) Nyquist criteria is in frequency domain.

(*ii*) Bode plot is in frequency domain.

(*iii*) Root locus plot is in time domain.

(*iv*) Routh-Hurwitz criteria is in time domain.

(*a*) (*i*), (*ii*) and (*iii*) are correct.

(*b*) (*ii*), (*iii*) and (*iv*) are correct.

(*c*) (*i*) and (*ii*) are correct.

(*d*) All four are correct.

(*viii*) In a feedback control system, output is a function of

(*a*) output and input.

(*b*) input and feedback signal.

(*c*) reference and output.

(*d*) None of the above.

(*ix*) If neither the output nor any variables of the system are fed back to the input of the system, then system is known as

(*a*) feedback system.

(*b*) open-loop control system.

(*c*) single variable closed-loop control system.

(*d*) system with single pole at origin.

(*x*) The Routh's criterion tells us the number of roots lying

(*a*) in the left-hand half of S-plane.

(*b*) in the right-hand half of S-plane.

(*c*) on the origin of S-plane.

(*d*) None of the above.

S'10 : 6 FN : EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

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Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Derive the dimensions of (*i*) e.m.f., (*ii*) permeability, (*iii*) resistivity, and (*iv*) electric flux density in L, M, T, I system of dimensions. 8

(*b*) Describe the construction and working of a co-ordinate type a.c. potentiometer. Explain how an unknown voltage can be measured with it. 12

2. (*a*) Derive the equations of balance for an Anderson's bridge. Draw the phasor diagram for conditions under balance. Discuss the advantages and disadvantages of the bridge. 12

(*b*) An insulating specimen is connected in the arm *AB* of a Schering bridge. The other three arms of the bridge are as follows: Arm *BC* 100 ohm (non-inductive); arm *CD* 309 ohm (non-inductive) in parallel with a capacitance of 0.5 μF (loss free); arm *DA* 100 μμF capacitor (loss free). Calculate capacitance-equivalent series resistance and loss angle of the specimen, if the bridge is excited by 50 Hz supply connected across *AC*. 8

3. (*a*) Describe the method for determination of B-H curve of a magnetic material using the method of reversals. Why are ring specimens preferred over rods or strips for magnetic testing? 10+2

(*b*) In a test of a specimen of total weight 13 kg, the measured values of iron loss at a given value of peak flux density were 17.2 W at 40 Hz and 28.9 W at 60 Hz. Estimate the values of hysteresis and eddy current losses in W/kg at 50 Hz for the same value of peak flux density. 8

4. (*a*) Describe different electrostatic type of voltmeters used for measurement of r.m.s. value of high voltages. Explain their advantages and disadvantages. 10

(*b*) What are the different methods of measurement of frequency in the power frequency range. Explain the working of a mechanical resonance-type frequency meter. 10

Group B

5. (*a*) Draw the block diagram of series R-L-C circuit, where V_i and V_0 are the input and output voltages as shown in Fig. 1. Also, find the transfer function of that circuit. 10

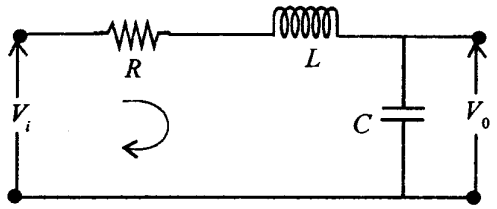


Fig. 1

(*b*) Draw the signal flow graph and determine C/R for the block diagram shown in Fig. 2. 10

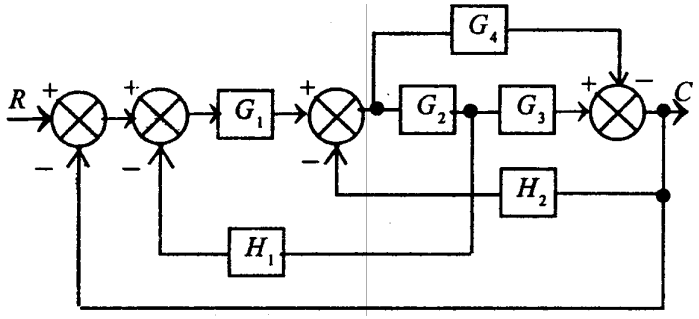


Fig. 2

6. (*a*) A system is characterised by the equation

$$\frac{y(s)}{u(s)} = \frac{20(4s+2)}{s^3+5s^2+8s+2}$$

Find its state and output equation and express in matrix form. 10

(*b*) Consider the system shown in Fig. 3:

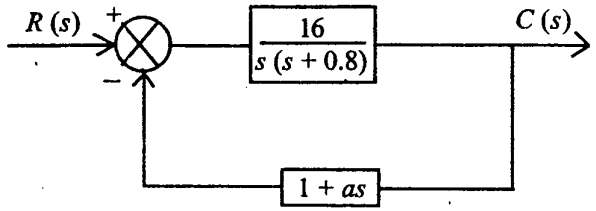


Fig. 3

Determine the value of a such that the damping ratio is 0.5. Also, obtain the values of rise time and maximum overshoot M_p in its step response. 10

7. Sketch the Bode plot for the open-loop transfer function for the unity feedback system given below:

$$G(s) = \frac{50}{(s+1)(s+2)}$$

From the plot, find G.M. and P.M. and assess the stability. 20

8. (*a*) Determine the stability of the system whose characteristic equation is given by

$$2s^4 + 2s^3 + s^2 + 3s + 2 = 0$$

by Routh-Hurwitz criterion. 10

(*b*) Write a short note on synchro control transformer. 10

Group C

9. Choose the *correct* answer for the following: 10×2

(*i*) The dimension of resistance in CGS e.m. system is

(*a*) $[\mu LT^{-1}]$

(*b*) $[\mu^{-1}LT^{-1}]$

(*c*) $[\mu^{-1}MLT^{-1}]$

(*d*) $[\mu LT^{-2}]$

(Continued)

(*ii*) An imperfect capacitor is represented by a capacitance, C_p, in parallel with a resistance R_p. The value of its dissipation factor ($\tan\delta$) is

(*a*) $1/\omega^2 C_p R_p$

(*b*) $1/\omega C_p R_p$

(*c*) $\omega C_p R_p$

(*d*) $\omega^2 C_p R_p$

(*iii*) A 53 Hz reed-type frequency meter is polarized with d.c. The new range of frequency meter is

(*a*) 26.5 Hz

(*b*) 53 Hz

(*c*) 106 Hz

(*d*) None of the above.

(*iv*) The readings of a polar-type a.c. potentiometer, when measuring the reactance of a coil, are $I = 12\angle 13.8°$, $V = 27.8\angle 29.7°$. The reactance of the coil is

(*a*) -2.22 ohm

(*b*) 2.22 ohm

(*c*) 2.317 ohm

(*d*) 0.634 ohm

(*v*) Frequency can be measured by using

(*a*) Maxwell's bridge.

(*b*) Schering bridge.

(*c*) Heviside Campbell bridge.

(*d*) Wien's bridge.

(*vi*) The error detector element in a control system gives the

(*a*) sum of the reference signal and feedback signal.

(*b*) sum of the reference signal and error signal.

(*c*) difference of the reference signal and feedback signal.

(*d*) difference of the reference signal and output signal.

(*vii*) The equation governing a control system is given by

$$\frac{d^2c(t)}{dt^2} + \frac{5dc(t)}{dt} + 4c(t) = 3r(t).$$

The transfer function for the system is

(*a*) $\frac{C(s)}{R(s)} = \frac{3}{(s+1)(s+4)}$

(*b*) $\frac{C(s)}{R(s)} = \frac{5}{(s+1)(s+4)}$

(*c*) $\frac{1}{s^2+3s+4}$

(*d*) $\frac{C(s)}{R(s)} = \frac{4}{s^2+3s+5}$

(*viii*) The Routh-Hurwitz criterion gives

(*a*) absolute stability.

(*b*) gain margin.

(*c*) relative stability.

(*d*) phase margin.

(*ix*) The root-locus lies only on the negative real axis. Then the time response is

(*a*) overdamped.

(*b*) underdamped.

(*c*) oscillatory.

(*d*) sustained oscillation.

(*x*) For a stable system,

(*a*) both G.M. and P.M. are negative.

(*b*) both G.M. and P.M. are positive.

(*c*) G.M. is positive and P.M. is negative.

(*d*) G.M. is negative and P.M. is positive.

W'10 : 6 FN : EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What do you mean by dimensions of quantity ? The energy stored in a parallel plate capacitor per unit volume is given by $W = K \varepsilon^a v^b d^c$, where K = constant, ε = permittivity, v = voltage between plates, and d = distance between plates. Find the values of *a, b, c.* 10

(*b*) Explain two wattmeters method to measure the total power in a three-phase circuit. 10

2. (*a*) Describe Kelvin's double bridge method for the measurement of low resistance. 10

(*b*) Draw the circuit diagram and phasor diagram of the owen bridge. Derive its equation for determining unknown quantities. 10

3. (*a*) Calculate the inductance of a coil from the following measurements on an a.c. potentiometer. Voltage drop across 0.1 Ω standard resistor connected in series with the coil = 0.613 ∠12° 6′V, voltage across the test coil through a 100/1 volt-ratio box = 0.781 ∠50° 48′ V, frequency = 50 Hz. 10

(*b*) Describe a method of reversals for the measurement of B-H curve of a magnetic material. 10

4. (*a*) Describe a high voltage impulse generator. 10

(*b*) Explain the electrical resonance frequency meter with a neat diagram. 10

Group B

5. (*a*) Find the transfer function of the electrical network shown in Fig.1 : 10

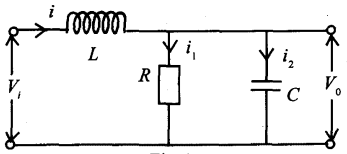


Fig. 1

(*b*) Find C/R for the system,whose block diagram representation is shown in Fig. 2, by the signal flow graph technique. 10

7. (*a*) Sketch the Bode plot for the transfer function given by $G(s)\,H(s) = 50/[(s+1)(s+2)]$. 10

(*b*) Using Routh-Hurwitz criterion, determine the relation between K and T so that unity feedback control system, whose open loop transfer function given below, is stable :

$$G(s) = \frac{K}{s\,[s\,(s+10)+T]}$$ 10

8. (*a*) Write the procedure for plotting root-locus. 8

(*b*) Examine the closed-loop stability of a system whose open-loop transfer function is given by

$$G(s)H(s) = \frac{50}{(s+1)\,(s+2)}$$

using Nyquist criterion. 8

(*c*) Explain the d.c. tachogenerator. 4

Group C

9. Choose the *correct* answer for the following : 10 × 2

(*i*) The dimensions of inductance in CGS C.S. system are

(*a*) $[\varepsilon L^{-1} T^{2}]$

(*b*) $[\varepsilon^{-1} ML^{-1} T^{2}]$

(*c*) $[\varepsilon^{-1} L\, T^{-2}]$

(*d*) $[\varepsilon^{-1} L^{-1} T^{2}]$

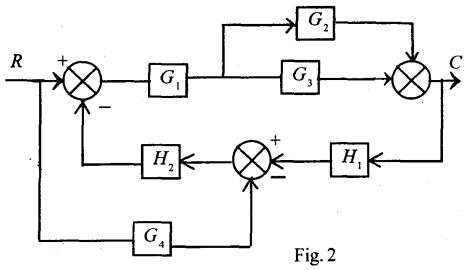


Fig. 2

6. (*a*) A system is described by $d^3y(t)/dt^3 = u(t)$, where $y(t)$ is the observed output and $u(t)$, the input. Find the state and output equations of the system. Also, find the state transition matrix in S-domain. 10

(*b*) The block diagram of a unity feedback control system is shown in Fig. 3 :

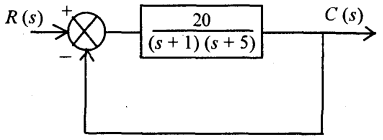


Fig. 3

Determine (*i*) open-loop transfer function of system, (*ii*) characteristic equation of the system, (*iii*) W_n, (*iv*) ξ, (*v*) W_d, (*vi*) t_p, (*vii*) M_p, (*viii*) time at which the first undershoot occurs, (*ix*) time period of oscillations, and (*x*) number of cycles complete before reaching the steady state. 10

(*ii*) The method of measuring earth resistance is

(*a*) fall of potential method.

(*b*) earth tester.

(*c*) loss of charge method.

(*d*) Both (*a*) and (*b*) above.

(*iii*) Inductance of low Q coil can be measured by using

(*a*) Schering bridge.

(*b*) Anderson's bridge.

(*c*) Hay's bridge.

(*d*) d.c. Sauty's bridge.

(*iv*) Sphere gaps are used for the measurement of

(*a*) instantaneous values of voltage.

(*b*) r.m.s. values of voltage.

(*c*) peak values of voltage.

(*d*) average values of voltage.

(*v*) A moving iron instrument can be used for current and voltage measurements

(*a*) in a.c. circuits only.

(*b*) in d.c. circuits only.

(*c*) in both a.c. and d.c. circuits for any value of frequency (in case of a.c.).

(*d*) in both a.c. and d.c. circuits for frequencies up to about 125 Hz (in case of a.c.).

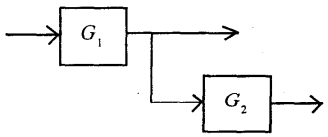
(*vi*) For the system

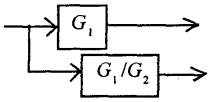
$$\frac{C(s)}{R(s)} = \frac{16}{s^2+8s+10},$$

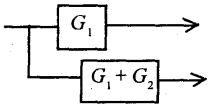
the nature of the time response will be

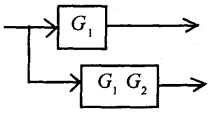
(*a*) over-damped.
(*b*) under-damped.
(*c*) critically damped.
(*d*) None of the above.

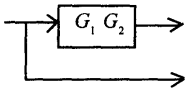
(*vii*) Indicate the correct equivalent of the block diagram shown below :



(*a*)


(*b*)


(*c*)


(*d*)


(*viii*) If the root locus branches cross the imaginary axis, the system becomes

(*a*) over-damped.
(*b*) critical.
(*c*) stable.
(*d*) unstable.

(*ix*) For a stable system, the

(*a*) gain cross-over occurs earlier than phase cross-over.
(*b*) phase cross-over occurs earlier than gain cross-over.
(*c*) gain cross-over and phase cross-over frequencies are very near to each other.
(*d*) gain cross-over and phase cross-over frequencies are concident.

(*x*) The system, with an open-loop transfer function $G(s)\,H(s) = 1/s\,(1+s)$, is

(*a*) type 2 and order 1.
(*b*) type 1 and order 1.
(*c*) type 0 and order 0.
(*d*) type 1 and order 2.

S'11:6 FN: EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define the terms 'units', 'absolute units', 'fundamental units' and 'derived units', with an example in each case. 10

(*b*) Explain the measurement of power in three-phase circuits using three wattmeter method with a neat diagram. 10

2. (*a*) Draw a neat diagram of Anderson bridge and derive the equations of balance. 10

(*b*) Describe the working of a low voltage Schering bridge. 10

3. (*a*) Describe the measurement of flux density in ring specimen with a neat diagram. 10

(*b*) Determine the hysteresis loop by the method of reversals. 10

4. (*a*) What is meant by impulse testing of transformer ? Give the procedure for impulse testing of transformer. 10

(*b*) Explain various high voltage tests on porcelain insulators. 10

Group B

5. (*a*) State Mason's gain formula. Give the procedure for converting block diagram to signal flow graph. 10

(*b*) Using block diagram reduction technique, determine the overall transfer function $C(s)/R(s)$ for the system shown in Fig. 1. 10

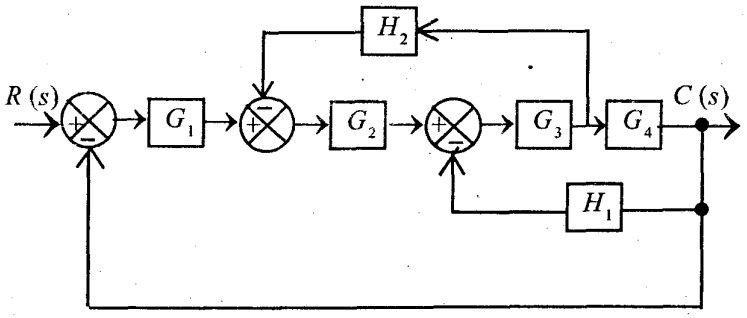


Fig. 1

6. (*a*) The open loop transfer function of a servo system with unity feedback is $G(s) = 10/s(0.1s + 1)$. Evaluate the static error constants of the system. Obtain the steady state error of the system, when subjected to an input given by the polynomial

$$r(t) = a_0 + a_1 t + \frac{a_2}{2} t^2.$$ 10

(*b*) Obtain the response of unity feedback system whose OLTF is $G(s) = 4/[s(s + 5)]$ and when the input is unit step. 10

7. (*a*) Using Routh's array, determine the stability of the system whose characteristic equation is $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$. Also, determine the number of roots lying on right half of s-plane, left half of s-plane and on imaginary axis. 10

(*b*) State the rules for construction of root locus. 10

8. (*a*) Explain construction and working of synchros with a neat diagram. 10

(*b*) Write short notes on (*i*) Gyroscopes, and (*ii*) Servo potentiometers. 5 + 5

Group C

9. Choose the *correct* answer for the following : 10 × 2

(*i*) The base units in SI system are

(*a*) metre, kilogram, second

(*b*) metre, kilogram, second, ampere

(*c*) metre, kilogram, second, ampere, kelvin, candela, mole

(*d*) metre, kilogram, second,, ampere, kelvin, candela

(*ii*) The power in a three-phase circuit is measured with the help of two wattmeters. One reading of one of the wattmeters is positive and that of the other is negative. The magnitude of readings is different. It can be concluded that the power factor of the circuit is
- (*a*) unity.
- (*b*) zero (lagging).
- (*c*) 0.5 (lagging).
- (*d*) less than 0.5 (lagging).

(*iii*) Frequency can be measured by using
- (*a*) Maxwell's bridge.
- (*b*) Schering bridge.
- (*c*) Heaviside Campbell bridge.
- (*d*) Wien's bridge.

(*iv*) The standardization of a.c. potentiometer is done by
- (*a*) directly using a.c. standard voltage sources.
- (*b*) using d.c. standard sources and transfer instruments.
- (*c*) using d.c. standard sources and d'Arsonval galvanometer.
- (*d*) using a.c. standard sources and transfer instruments.

(*v*) Sphere gaps are used for measurement of
- (*a*) instantaneous values of voltage.
- (*b*) rms values of voltage.
- (*c*) peak values of voltage.
- (*d*) average values of voltage.

(*vi*) Transfer function can be derived for
- (*a*) non-linear system only.
- (*b*) linear and non-linear systems.
- (*c*) linear system.
- (*d*) any system.

(*vii*) For a critically damped system, the value is
- (*a*) $\delta = 0$
- (*b*) $0 < \delta < 1$
- (*c*) $\delta = 1$
- (*d*) $\delta > 1$

(*viii*) The type number of a system is given by
- (*a*) number of zeros of loop I.F. at origin.
- (*b*) number of poles of loop I.F. at origin.
- (*c*) any where in left-half of *s*-plane'
- (*d*) None of the above.

(*ix*) In Nyquist stability criterion, when there is a clockwise encirclement of the $-1 + j0$ point, the system is always
- (*a*) stable.
- (*b*) unstable.
- (*c*) partially stable.
- (*d*) Both (*b*) and (*c*) above.

(*x*) A tachogenerator is a
- (*a*) mechanical device.
- (*b*) electrical device.
- (*c*) electro-mechanical device.
- (*d*) hydraulic device.

W'11:6 FN:EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain, with the help of a neat sketch, the construction of an electrodynamic type moving coil ammeter. Give the equation for torque of the ammeter and the principal advantages and disadvantages of these instruments. State the causes of change of accuracy with change of temperature and frequency. 10

(*b*) Explain the constructional details of a Weston standard cell and give the precautions in using standard cells. 5

(*c*) What are different types of standards of measurement ? Explain their application areas. 5

2. (*a*) Describe the construction and working of a polar-type potentiometer. Explain the method for standardising it. 6

(*b*) Explain the constructional features of a flux meter. Show that for a flux meter

$$N\phi = K\ (\theta_2 - \theta_1)$$

where N is the number of turns in the search coil used ; ϕ, the change in flux ; θ_1 and θ_2, the initial and final readings in the flux meter ; and K, a constant. 7

(*c*) An a.c. bridge is connected as follows : Branch *AB* is an inductive resistor, branches *BC* and *ED* are variable resistors, branches *CD* and *DA* are non-reactive resistors of 400 Ω each and branch *CE* is a condenser of 2 μF capacitance. The supply is connected to *A* and *C* and the detector to *B* and *E*. Balance is obtained when the resistance of *BC* is 400 Ω and that of *ED* is 500 Ω. Determine the resistance and inductance of *AB*. 7

3. (*a*) Explain how high voltage can be measured using the sphere gap method. Discuss the effect of humidity, if any. What does this method measure r.m.s. or peak value of the voltage ? What are the limitations of the method ? 8

(*b*) Describe a method for measurement of time interval. 5

(*c*) What is meant by impulse voltage ? What is its application ? Describe a method for generation of impulse wave. 7

4. (*a*) The ratio of the readings of two wattmeters connected to measure power in a balanced 3ϕ, three-wire load is 5 : 3. The load is known to be inductive with a lagging power factor. Calculate the power factor of the load. Derive the formula used. 10

(*b*) Describe, with the help of a diagram, the loss of charge method for determination of insulation resistance of a length of cable. The value of a high resistance is measured by loss of charge method. A capacitor having a capacitance of 2.5 μF is charged to a potential of 500 V d.c. and is discharged through the high resistance. An electrostatic voltmeter, kept across the high resistance, reads the voltage as 300 V at the end of 60 sec. Calculate the value of high resistance. 10

Group B

5. (*a*) Use the block diagram reduction technique and signal flow graph method to determine the overall transfer function of the system shown in Fig. 1. 4 + 6

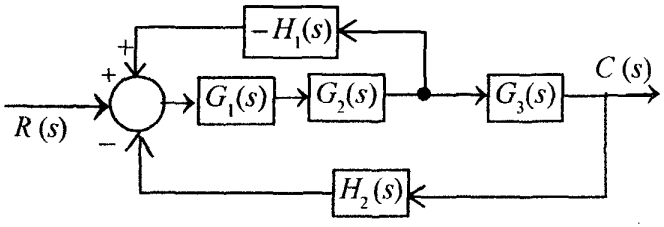


Fig. 1

(*b*) What is a synchro ? Describe the principles of operation of a synchro transmitter and a synchro control transformer with neat sketches and constructional features. What are the uses of synchros ? 10

6. (*a*) The forward path of a unity feedback system is described by

$$G(s) = \frac{36}{s(s+0.72)}.$$

Determine its characteristic equation, damping ratio, peak overshort, peak time, settling time, and number of cycles completed before output settles for unit step input. 10

(*b*) Obtain the transfer function $Y(s)/U(s)$ of the system whose governing equations are given below: 10

$$\dot{x}_1 = -4x_1 - x_2 + 3u$$
$$\dot{x}_2 = 2x_1 - 3x_2 + 5u$$
$$y = x_1 + 2x_2$$

7. (*a*) For a feedback system

$$G(s)\ H(s) = \frac{3\ (s+2)\ (s+5)}{s^2\ (s^2+20s+500)}.$$

Sketch the Bode plots. 10

(*b*) Draw Nyquist plot for

$$G(s)\ H(s) = \frac{K}{s\ (s+1)\ (s+5)}$$

and discuss stability. 10

8. (*a*) The system dynamics is given by

$$\frac{d^4c}{dt^4} + 2\frac{d^3c}{dt^3} + 2\frac{d^2c}{dt^2} + (K+3)\frac{dc}{dt} + K = K\left(\frac{dr}{dt} + r\right)$$

Determine the limiting positive values of K for stability. 10

(*b*) Write brief notes on the following : 2 + 4 + 4

(*i*) Breakaway points

(*ii*) Phase margin and gain margin

(*iii*) Effect of addition of poles and zeros on root locus.

Group C

9. Choose the *correct* answer for the following : 20 × 1

(*i*) The dimensions of emf is

(*a*) $I^{-1}ML^2T^{-3}$

(*b*) $I^{-1}ML^2T^{-2}$

(*c*) $I\ ML^2T^{-3}$

(*d*) $I\ M^{-1}L^2T^{-3}$

(*ii*) Tesla (T) is the unit of

(*a*) flux

(*b*) permeability

(*c*) flux density

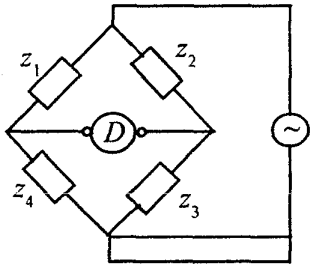
(*d*) magnetic lines of force

(*iii*) Two meters X and Y require 20 mA and 30 mA, respectively to give full scale deflection. Then
(*a*) X is more sensitive.
(*b*) Y is more sensitive.
(*c*) both X and Y are equally sensitive.
(*d*) it would not be possible to assess the sensitivity on the basis of the given data.

(*iv*) In two wattmeter method of power measurement, one of the wattmeters will show negative reading when the load power factor angle is strictly
(*a*) less than 30°.
(*b*) less than 60°.
(*c*) greater than 30°.
(*d*) greater than 60°.

(*v*) For standardisation of Drysdale a.c. potentiometer, the instrument used is
(*a*) rectifier-type ammeter.
(*b*) PMMC ammeter.
(*c*) thermocouple-type ammeter.
(*d*) precision-type electrodynamometer ammeter.

(*vi*) In the bridge shown in figure, $z_1 = 450\ \Omega$, $z_2 = (300 - j\,600)\ \Omega$, $z_3 = (200 + j\,100)\ \Omega$, the value of unknown impedance z_4 at balance is
(*a*) $(0 + j\,150)\ \Omega$
(*b*) $(100 - j\,150)\ \Omega$
(*c*) $(100 + j\,150)\ \Omega$
(*d*) $(300 + j\,100)\ \Omega$



(*vii*) The Schering bridge is used for measuring
(*a*) resistance and inductance.
(*b*) inductance and capacitance.
(*c*) capacitance and frequency.
(*d*) dielectric loss and power factor.

(*viii*) A flow meter is provided with a
(*a*) large controlling-torque-damping ratio.
(*b*) heavy electromagnetic damping and very small controlling torque.
(*c*) heavy electromagnetic damping and large controlling torque.
(*d*) small electromagnetic damping and small controlling torque.

(*ix*) A sphere gap voltmeter, when measuring a.c. voltage, measures
(*a*) rms value.
(*b*) average value.
(*c*) peak value.
(*d*) peak-to-peak value.

(*x*) A signal of 10 mV at 75 MHz is to be measured. Which of the following instruments can be used ?
(*a*) VTVM
(*b*) Digital multimeter
(*c*) Moving iron voltmeter
(*d*) Cathode ray oscilloscope

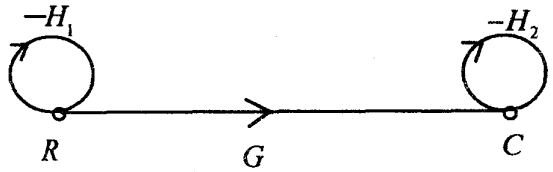
(*xi*) The final value of function

$$F(s) = \frac{5}{s(s^2 + 2s + 2)}$$

is equal to

(*a*) 0
(*b*) 2/5
(*c*) 5/2
(*d*) 5

(*xii*) The overall transfer function of the system shown in figure is



(*a*) $C/R = G$
(*b*) $C/R = G(1 + H_2)$
(*c*) $C/R = G/(1 + H_1)(1 + H_2)$
(*d*) $C/R = G/(1 + H_1 + H_2)$

(*xiii*) The unit-step response of a negative feedback system with open loop transfer function

$$G(s) = \frac{6}{s+5} \text{ is}$$

(*a*) $1 - e^{-5t}$

(*b*) $6 - 6\,e^{-5t}$

(*c*) $\frac{6}{11} - \frac{6}{11}\,e^{-11t}$

(*d*) $\frac{6}{5} - \frac{6}{5}\,e^{-5t}$

(*xiv*) If a ramp input is applied to a type 2 system, the steady state error will be

(*a*) positive constant.
(*b*) negative constant.
(*c*) zero
(*d*) positive infinity

(*xv*) The transfer function of a system is given by

$$G(s) = \frac{K}{s^2 + 4s + K},$$

where K is the gain of the system. If the system is critically damped, the value of K should be

(*a*) 4
(*b*) 3
(*c*) 2
(*d*) 1

(*xvi*) If a system has an open loop transfer function $(1 - s)/(1 + s)$, its gain at frequency $w = 1$ rad/sec will be

(*a*) 1
(*b*) 0.5
(*c*) zero
(*d*) – 1

(*xvii*) The characteristic equation of a system is given by $s^4 + 6s^3 + 11s^2 + 6s + K = 0$. For the system to be stable, the value of K should be

(*a*) zero
(*b*) $0 < K < 10$
(*c*) $10 < K < 20$
(*d*) $20 < K < 30$

(*xviii*) The gain margin of the system whose Nyquist plot cuts the negative real axis at a distance of 0.4 is
(*a*) – 0.6
(*b*) – 0.4
(*c*) 0.4
(*d*) 2.5

(*xix*) The root locus of a system has four separate root loci. The system can have
(*a*) two poles and two zeros.
(*b*) four poles and four zeros.
(*c*) four poles or four zeros.
(*d*) six poles and two zeros.

(*xx*) Which one of the following is an error detector in a position control system ?
(*a*) Synchro transmitter and control transformer
(*b*) Synchro trasmitter and repeater.
(*c*) Synchro transmitter and resolver.
(*d*) Synchro transmitter and generator.

S'12:6 FN:EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Derive the dimensions of (*i*) permeability, (*ii*) permittivity, (*iii*) resistivity, (*iv*) conductivity in L, M, T, I system of dimension. 10

(*b*) Describe the construction and working of PMMC instrument. Derive the equation for deflection of moving system, if the instrument is spring-controlled. 5 + 5

2. (*a*) Draw a neat diagram of Kelvin double bridge method of measurement of low resistance. Derive the equation of balance for this bridge. 5 + 5

(Turn Over)

(*b*) Derive the balance equations and draw the phasor diagram of Anderson's bridge. 5 + 5

3. (*a*) Describe the method of determination of B-H curve of a magnetic material using method of reversals. 10

(*b*) What is meant by impulse testing of transformer ? Give the procedure for impulse testing of a transformer. 10

4. (*a*) Explain the measurement of power in three-phase circuits using two wattmeter method with neat circuit and vector diagrams. 8

(*b*) Describe the working of a low voltage Schering bridge. Derive the equations for capacitance and dissipation factor. Draw the neat phasor diagram of the bridge under conditions of balance. 8

(*c*) What are the modifications to be incorporated in a low voltage Schering voltage for it to be used on high voltages. 4

Group B

5. (*a*) Represent the following set of equations by a signal flow graph and determine the overall gain relating x_5 and x_1 : 3 + 7

$$x_2 = ax_1 + fx_2$$
$$x_3 = bx_2 + lx_4$$
$$x_4 = cx_3 + hx_5$$
$$x_5 = dx_4 + gx_2$$

(*b*) Determine the overall transfer function relating C and R for the system whose block diagram is shown in Fig. 1. 10

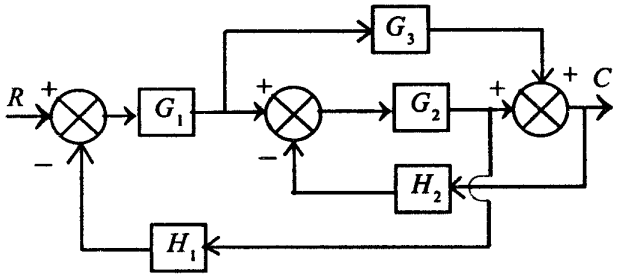


Fig. 1

6. (*a*) The forward path transfer function of a unity feedback control system is given by

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

Obtain an expression for unit step response of the system. 10

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

$$G(s) = \frac{K(s+2)}{s^3 + \beta s^2 + 4s + 1}$$

Determine the value of k and β such that the closed-loop unit step response has $w_n = 3$ rad/sec and $\xi = 0.2$. 5 + 5

7. (*a*) Determine the stability of a system having following characteristic equation by using Routh-Hurwitz stability criterion :

$$s^6 + s^5 + 5s^4 + 3s^3 + 2s^2 - 4s - 8 = 0$$ 10

(*b*) The open-loop transfer function of a control system is given by

$$G(s)\ H(s) = \frac{k}{s(s+6)\ (s^2+4s+13)}$$

Determine the (*i*) break away points, and (*ii*) angle of departure from complex poles. 5 + 5

8. Discuss in brief the following with their specific use in control system : 4 × 5

(*a*) Synchros
(*b*) Gyroscopes
(*c*) Servo potentiometers
(*d*) Force-voltage analogy.

Group C

9. Choose the *correct* answer from the following : 10 × 2

(*i*) The dimension of torque in SI units is
(*a*) ML^2T^{-2}
(*b*) M^2LT^{-2}
(*c*) $ML^{-2}T^{-2}$
(*d*) $M^2L^2T^{-2}$

(*ii*) To measure 2V, if one selects 0-100 V range voltmeter, which is accurate within ±1%, the error in the measurement may be up to
(*a*) ± 0.02%
(*b*) ± 1%
(*c*) ± 2%
(*d*) ± 50%

(*iii*) The controlling torque in a spring controlled meter is proportional to
(*a*) θ
(*b*) θ^2
(*c*) $1/\theta$
(*d*) $1/\theta^2$

(*iv*) Loss of charge method is used for measurement of
(*a*) low R.
(*b*) high R.
(*c*) low L.
(*d*) high L.

(*v*) The capacitance and dielectric loss of a capacitor is generally measured by
(*a*) Anderson bridge.
(*b*) Schering bridge.
(*c*) De Sauty's bridge.
(*d*) Hay's bridge.

(*vi*) Potentiometers are used in control system
(*a*) to improve frequency response.
(*b*) to improve time response.
(*c*) to improve stability.
(*d*) as error sensing transducer.

(*vii*) If unit step function is applied to first order system, the steady state error will be
(*a*) T
(*b*) zero.
(*c*) unity.
(*d*) varying with time.

(*viii*) Root locus diagram can be used to determine
- (*a*) absolute stability.
- (*b*) relative stability.
- (*c*) conditional stability.
- (*d*) None of the three above.

(*ix*) When the gain margin is positive and the phase margin is negative, the system is
- (*a*) stable.
- (*b*) unstable.
- (*c*) oscillatory.
- (*d*) highly stable.

(*x*) For Nyquist plot, we use
- (*a*) open loop function.
- (*b*) closed loop function.
- (*c*) characteristic function.
- (*d*) any one of the above.

W'12: 6 FN: EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) Derive the dimensional equations for (*i*) current, (*ii*) pole strength, (*iii*) magnetic flux, (*iv*) reluctance, and (*v*) performance. 5×2

(*b*) Differentiate between recording and integrating instruments. Also, give a suitable example of each type of instrument. 6

(*c*) Describe various operating forces (in brief), needed for proper operation of an analog indicating instrument. 4

2. (*a*) Describe the construction details and operational principle of a drysdale polar-type potentiometer. How is it standardized ? What is the function of phase shifting transformer in the potentiometer ? 8

(*b*) Describe, with the help of a neat circuit diagram, how an a.c. potentiometer can be used for calibration of wattmeters. 4

(*c*) A co-ordinate-type potentiometer is used for determination of impedance of a coil and the results obtained are : voltage across a 1.0 ohm resistor in series with the coil; 0.238 V on in-phase dial and (–) 0.085 V on quadrature dial, voltage across a 10 : 1 potential divider used with the coil; 0.3375 V on in-phase dial and 0.232 V on quadrature dial. Calculate resistance and reactance of the coil. 8

3. (*a*) Explain, with the help of a neat diagram, the method of reversals for experimental determination of hysteresis loop of a magnetic specimen. 10

(*b*) A manufacturer lists grain-oriented steel sheet of 0.3 mm thick. The resistivity of material is 50×10^{-8} ohm-m. The hysteresis loop is essentially rectangular in form with a coercive force of 12 A/m for all peak values of the flux densities between 0.8 and 1.6 Wb/m^2. A sinusoidal flux density of 1 Wb/m^2 (peak) at 100 Hz is used. The density of the material used is 7650 kg/m^3. Find the total loss per kg. 10

4. (*a*) Describe how an unknown capacitance can be measured by De Sauty's bridge. What are the limitations of this bridge and how are these circumvented by using modified version of De Sauty's bridge. Draw a neat phaser diagram for this bridge in support of your answer. 10

(*b*) Explain the function and working of Wagner earth device. 4

(*c*) What are the modifications in functional features incorporated in De Sauty's bridge for measurement of parameter of imperfect capacitor. 6

Group B

5. (*a*) Obtain the transfer function $Y(s)/X(s)$ of the SFG (signal flow graph) as shown in Fig. 1 : 10

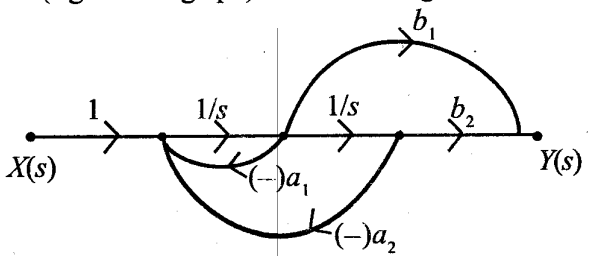


Fig. 1

(*b*) Evaluate $C(s)/R(s)$ transfer function from the block diagram as shown in Fig. 2 : 10

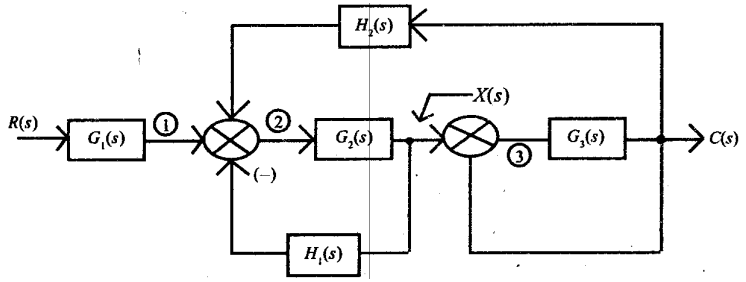


Fig. 2

6. (*a*) In the closed-loop system as shown in Fig. 3, find the sensitivities S_{G1}^{T} and S_{G2}^{T} : 12

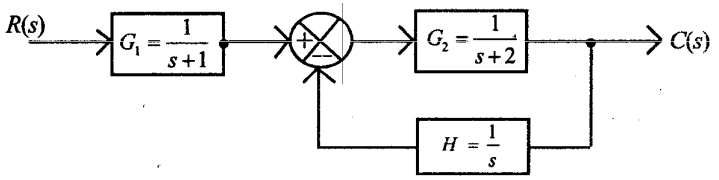


Fig. 3

(*b*) Justify that negative feedback system introduces reduction in sensitivity. 8

7. (*a*) Determine the range of '*k*' for which the system given by characteristic equation

$$s^4 + 20ks^3 + 5s^2 + 10s + 15 = 0$$

is stable. 10

(*b*) Is the system shown in Fig. 4 is stable or not ? 6

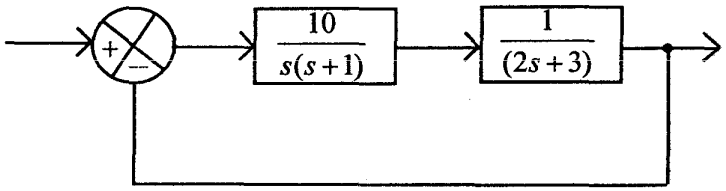


Fig. 4

(*c*) State and explain necessary conditions for stability. 4

8. (*a*) Find the transfer function of a field-controlled d.c. motor. 6

(*b*) What do you understand by modulators and demodulators ? Discuss their utility in control systems. 8

(*c*) Differentiate between a.c. servomotor and d.c. servomotor. 6

Group C

9. Choose the *correct* answer for the following : 10 × 2

(*i*) The reliability of an instrument refers to

(*a*) measurement of changes due to temperature variation.

(*b*) degree to which repeatability continues to remain within specified limits.

(*c*) the life of the instrument.

(*d*) the extent to which the characteristics remain linear.

(*ii*) The difference between the measured value and true value is called the

(*a*) relative error.

(*b*) absolute error.

(*c*) gross error.

(*d*) probable error.

(*iii*) For absolute measurement of current, the method commonly used is

(*a*) electro-dynamometer method.

(*b*) tangent galvanometer method.

(*c*) Rayleigh current balance method.

(*d*) Lorenz method.

(*iv*) The burden of current transformer is expressed in

(*a*) volt-ampere rating.

(*b*) current rating of secondary winding.

(*c*) current and voltage of secondary winding.

(*d*) Watt rating.

(*v*) Perchance the current coil and potential coil of a wattmeter are changed accidently and supply is given to the wattmeter, then

(*a*) wattmeter will not read.

(*b*) current coil will burn out.

(*c*) potential coil will burn out.

(*d*) nothing out of (*a*) or (*b*) or (*c*) will happen, but the wattmeter will read up to 50 percent of f.s.d.

(*vi*) Anderson bridge is used for the measurement of

(*a*) inductance.

(*b*) capacitance.

(*c*) resistance.

(*d*) kWhr.

(*vii*) A VTVM is more reliable in comparison to volt-ohm meter a multimeter for measuring of voltage across low impedance as

(*a*) it has high input impedances.

(*b*) it has high sensitivity.

(*c*) it does not alter the measured value.

(*d*) All of the three above.

(*viii*) A double beam CRO has

(*a*) two screens.

(*b*) two electron guns.

(*c*) two different grade phosphor coatings.

(*d*) two horizontal deflection plates.

(*ix*) The thermocouples make use of

(*a*) Seeback effect.

(*b*) Thompson effect.

(*c*) Peltier effect

(*d*) Piezo-electric effect.

(*x*) A synchro is used to

(*a*) accelerate a rotating shaft.

(*b*) convert an angular position of a shaft into an electrical signal.

(*c*) convert linear motion into an angular motion.

(*d*) amplify low frequency signal.

S'13 : 6 FN : EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

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Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain the measurement standards and their classifications in detail. 10

(*b*) Explain about the errors in measurement. 10

2. (*a*) Briefly explain the construction and working of induction-type watt-hour meter (single-phase type). 15

(*b*) Write a short note about the potentiometer. 5

3. (*a*) Write the general equation of bridge (a.c.) balance condition and draw the phasor diagram at balance. 6

(*b*) An a.c. bridge circuit working at 1000 Hz is shown in Fig.1. In arm AB is a 0.2 μF pure capacitance, in arm BC is a 500 Ω pure resistance and arm CD contains an unknown inpedance and arm DA has a

300 Ω resistance in parallel with a 0.1 μF capacitor. Find the R and C constants. 14

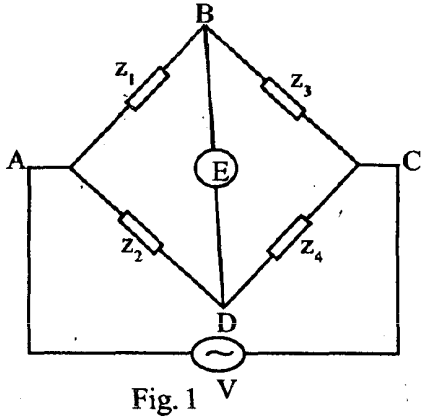

Fig. 1

4. Explain the measurement of power in a three-phase circuit with two watt-meter method, in detail and (*a*) draw the phasor diagram; and (*b*) derive expression for power. 10+10

Group B

5. (*a*) Obtain the transfer function of the given system in Fig.2: 10

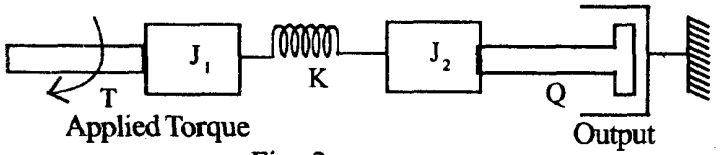

Fig. 2

(*b*) Obtain the transfer function of armature controlled d.c. motor. 10

6. (*a*) Explain the working of synchros transmitter and draw the suitable diagram. 10

(*b*) Obtain the response of unity feedback system whose open loop transfer function is G(s) = 4/[s(s + 5)] and the input is unit step as shown in Fig. 3: 10

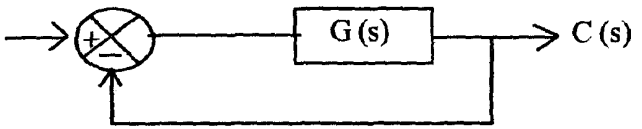

Fig. 3

7. (*a*) Define the following: 4 × 3

(*i*) Bode plot

(*ii*) Polar plot

(*iii*) M and N circle

(*iv*) Nichol's chart

(*b*) Sketch Bode plot for the following transfer function and determine the system gain, k, for the gain cross-over frequency to be 5 rad/sec: 8

$$G(s) = \frac{ks^2}{(1+0.2s)(1+0.02s)}$$

8. (*a*) A unity feedback control system has an open loop transfer function

$$G(s) = \frac{k}{s(s^2+4s+3)}$$

Sketch the root-locus. 15

(*b*) Write a short note about the system stability. 5

Group C

9. Choose the *correct* answer for the following: 10 × 2

(*i*) A null-type of instrument as compared to a deflection -type instrument has

(*a*) a higher accuracy.

(*b*) a lower sensitivity.

(*c*) a faster response.

(*d*) All of the three above.

(*ii*) A pressure measurement instrument is calibrated between 10 bar and 250 bar. The scale span of the instrument is

(*a*) 10 bar

(*b*) 260 bar

(*c*) 240 bar

(*d*) 300 bar

(*iii*) Fluid friction damping can be used in

(*a*) horizontally mounted instrument.

(*b*) vertically mounted instrument.

(*c*) Both of the above.

(*d*) None of the three above.

(*iv*) A potentiometer is basically a

(*a*) deflection-type instrument.

(*b*) null-type instrument.

(*c*) Both (*a*) and (*b*) above.

(*d*) digital instrument.

(*v*) Standardization of potentiometer is done in order that they become

(*a*) accurate.

(*b*) precise.

(*c*) accurate and direct reading.

(*d*) accurate and precise.

(*vi*) Frequency can be measured by using

(*a*) Maxwell's bridge.

(*b*) Schering bridge.

(*c*) Weir's bridge.

(*d*) Wheatstone bridge.

(*vii*) The equations under balance conditions for a bridge are $R_1 = R_2 R_3 / R_4$, $L_1 = R_2 R_3 C_4$, where R_1 and L_1 are respectively unknown resistance and inductance in order to achieve converging balance :

(*a*) R_2 and R_3 should be chosen as variables.

(*b*) R_2 and C_4 should be chosen as variables.

(*c*) R_4 and C_4 should be chosen as variables.

(*d*) R_3 and C_4 should be chosen as variables.

(*viii*) Feedback oscillator's have a closed loop gain of

(*a*) G/(1–GH)

(*b*) G/(1 + GH)

(*c*) G/(1±GH)

(*d*) H/(1+ GH)

(*ix*) A second-order underdamped system has a damping factor of 0.8. It is subjected to a sinusoidal input of unit amplitude. It has resonant peak of

(*a*) 108%

(*b*) 92%

(*c*) 20%

(*d*) It has no resonant peak

(*x*) The base units in SI system are

(*a*) metre, kg, second

(*b*) metre, kg, second, ampere

(*c*) metre, kg, second, Kelvin, candela, mole

(*d*) metre, kg, candela, Kelvin, second

W'13 : 6 FN : EL 406 (1467)

MEASUREMENTS AND CONTROL

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Classify standards of measurement on the basis of their function and application. 10

(*b*) Derive the dimensions of resistivity, magnetic flux, permittivity, and electric field strength. 10

2. (*a*) Describe Carey Foster's slide wire bridge for the measurement of medium resistance. 10

(*b*) An Owen bridge is used to measure the impedance of a coil at 1kHz. The bridge configuration is as follows:

AB : Coil under test BC : R_3 100 Ω

CD : C_4 0.1 μF DA : R_2 834 Ω in series with C_2 = 0.124 μF

Calculate the parameter of coil under test and draw the phasor diagram of the voltage and current in the bridge arm at balance. 10

3. (*a*) Describe the Lloyd Fisher square method of measuring iron losses in a ferromagnetic material. 10

(*b*) An iron ring specimen of 4 cm^2 cross-sectional area and mean length of 1m is wound with 200 turns. A secondary coil of 100 turns is wound over and connected to a ballistic galvanometer for measurement of permeability of specimen. The ballistic galvanometer gives a through of 100 scale divisions on current reversal of 5 A in the coil. Calculate the permeability. Assume galvanometer constant = 1μC/ divison and resistance of measuring circuit = 1000 Ω 10

4. Write short notes on the following: 4 × 5

(*a*) Cascading of transformers for high voltage

(*b*) Sphere gap voltmeter

(*c*) Impulse generator

(*d*) Testing of insulators.

Group B

5. (*a*) Explain, with an example, what do you mean by an open-loop control system. What are the limitations of open-loop control system ? 5 + 5

(*b*) Find the input output transfer function of the system shown in Fig. 1 : 10

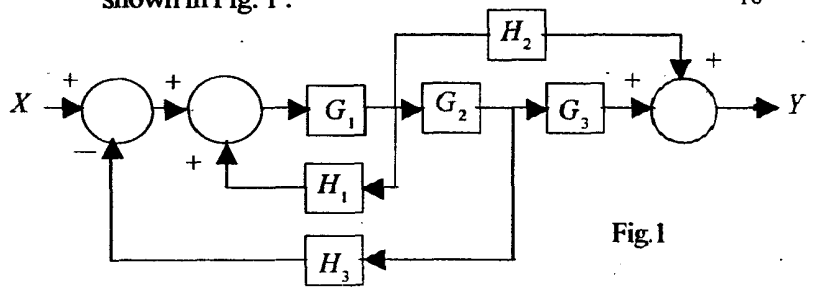

Fig.1

6. (*a*) Obtain the state model for a system whose transfer function is given as

$$G(s) = \frac{1}{s^3 + 9s^2 + 26s + 24}$$ 10

(*b*) Obtain the unit step response of a unity feedback system whose open-loop transfer function is

$$G(s) = \frac{4}{s(s+5)}$$ 10

7. (*a*) Apply Routh-Hurwitz criterion to the following equation and investigate the stability : 10

$$s^5 + 2s^4 + 24s^3 + 48s^2 - 25s - 50 = 0$$

(*b*) For the system having open-loop transfer function

$$G(j\omega)\ H(j\omega) = \frac{K}{j\omega\,(j0.1\omega + 1)(j\omega + 1)}$$

sketch the asymptotic Bode plot and determine the value of K so that the (*i*) gain margin is 15 db, and (*ii*) phase margin is 60°. 5 + 5

8. (*a*) Sketch the root locus plot for the system having open-loop transfer function 10

$$G(s)\ H(s) = \frac{K}{s(s+6)(s^2 + 4s + 13)}$$

(*b*) Explain briefly servomotors. Classify different types of servomotors and mention their applications. 10

Group C

9. Choose the *correct* answer for the following: 10×2

(*i*) A basic PMMC meter has marking 0-10 mA, 5 Ω. Its Ω/V rating is

(*a*) 5
(*b*) 100
(*c*) 500
(*d*) 10000

(*ii*) In MI meter, the scale used is a

(*a*) linear scale.
(*b*) non-linear scale.
(*c*) square law scale.
(*d*) None of the three above.

(*iii*) Kelvin double bridge is used for the measurement of

(*a*) resistance.
(*b*) self-inductance.
(*c*) mutual inductance.
(*d*) capacitance.

(*iv*) The range of a voltmeter can be extended by connecting a

(*a*) low resistance across the meter.
(*b*) high resistance in series with the meter.
(*c*) capacitor across the meter.
(*d*) coil in series with the meter.

(*v*) For Nyquist plot, we use

(*a*) open-loop function.
(*b*) closed-loop function.
(*c*) characteristic function.
(*d*) Any one of the three above.

(*vi*) The angle made by asymptotes in a root locus plot is given by

(*a*) $\frac{(2l+1)180}{n-m}$ degree

(*b*) $\frac{(2l+1)180}{n+m}$ degree

(*c*) $\frac{(2l-1)180}{n-m}$ degree

(*d*) $\frac{(2l-1)180}{n+m}$ degree

(*vii*) If unit step function is applied to first order system, the steady state error will be

(*a*) T
(*b*) zero.
(*c*) unity.
(*d*) vary with time.

(*viii*) Potentiometer is used in control system

(*a*) to improve the frequency response.
(*b*) to improve stability.
(*c*) to improve time response.
(*d*) as error sensing transducer.