GATE - 1995

EE : Electrical Engineering

Duration : Three Hours — *Maximum Marks : 150*

SECTION –A
(100 MARKS)

1. This question has 25 statements. Each statement is accompained by four answers of which only one is correct. Indicate the correct answer as A, B, C, or D on the first page of the answer book. Each statement carries ONE mark.

1.1. The impulse response of an initially relaxed linear system is $e^{-2t}\,U(t)$. To produce a response of $t\,e^{-2t}\,U(t)$, the input must be equal to

(*a*) $2\,e^{-t}\,U(t)$ (*b*) $\frac{1}{2}\,e^{-2t}\,U(t)$

(*c*) $e^{-2t}\,U(t)$ (*d*) $e^{-t}\,U(t)$

1.2. The closed-loop transfer function of a control system is given by

$$\frac{C(s)}{R(s)} = \frac{2(s-1)}{(s+2)(s+1)}$$

For a unit step input the output is

(*a*) $-3\,e^{-2t} + 4\,e^{-t} - 1$

(*b*) $-3\,e^{-2t} - 4\,e^{-t} + 1$

(*c*) zero

(*d*) infinity

1.3. The Laplace transformation of $f(t)$ is $F(s)$. Given $F(s) = \frac{\omega}{s^2 + \omega^2}$, the final value of $f(t)$ is

(*a*) infinity (*b*) zero

(*c*) one (*d*) none of these

1.4. A system is described by the state equation $\dot{X} = AX + BU$.

The output is given by $Y = CX$

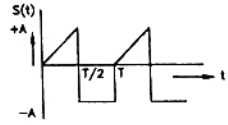
where $A = \begin{bmatrix} -4 & -1 \\ 3 & -1 \end{bmatrix}$ $B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ $C = [1, 0]$.

Transfer function G(s) of the system is

(*a*) $\frac{s}{s^2 + 5s + 7}$ (*b*) $\frac{1}{s^2 + 5s + 7}$

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

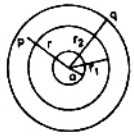
1.5. The rms value of the periodic waveform e(t), shown in figure



(*a*) $\sqrt{\frac{3}{2}}\,A$ (*b*) $\sqrt{\frac{2}{3}}\,A$

(*c*) $\sqrt{\frac{1}{3}}\,A$ (*d*) $\sqrt{2}\,A$

1.6. A spherical conductor of radius '*a*' with charge '*q*' is placed concentrically inside an uncharged and unearthed spherical conducting shell of inner and outer radii r_1 and r_2 respectively. Taking potential to be zero at infinity, the potential at any point P within the shell ($r_1 < r < r_2$) will be



(*a*) $\frac{q}{4\pi\varepsilon_0 r}$ (*b*) $\frac{q}{4\pi\varepsilon_0 a}$

(*c*) $\frac{q}{4\pi\varepsilon_0 r_2}$ (*d*) $\frac{q}{4\pi\varepsilon_0 r_1}$

1.7. A monochromatic plane electromagnetic wave travels in vacuum in the position x direction (x, y, z system of coordinates). The electric and magnetic fields can be expressed as

(*a*) $E(x, t) = E_0 \cos(kx - \omega t)\,\bar{a}_y$

$H(x, t) = H_0 \cos(kx - \omega t)\,\bar{a}_z$

(*b*) $E(x, t) = E_0 \cos(kx - \omega t)\,\bar{a}_y$

$H(x, t) = H_0 \cos(kx - \omega t - \frac{\pi}{2})\,\bar{a}_z$

(*c*) $E(x, t) = E_0 \cos(kx - \omega t)\,\bar{a}_y$

$H(x, t) = -H_0 \cos(kx - \omega t)\,\bar{a}_z$

(*d*) $E(x, t) = E_0 \cos(kx - \omega t)\,\bar{a}_y$

$H(x, t) = H_0 \cos(kx - \omega t - \frac{\pi}{2})\,\bar{a}_z$

1.8. Supply to one terminal of a delta-*wye* connected three-phase core type transformer which is on no-load, fails. Assuming magnetic circuit symmetry, voltages on the secondary side will be

(*a*) 230, 230, 115 (*b*) 230, 115, 115

(*c*) 345, 115, 115 (*d*) 345, 0, 345

1.9. An induction motor is fed from a balanced three-phase supply at rated voltage and frequency through a bank of three single phase transformers connected in delta-delta. One unit of the bank develops fault and is removed. Then

(*a*) single phasing will occur and the machine fails to start

(*b*) single phasing will not occur but the motor terminal voltages will become unbalanced and the machine can be loaded to the extent of 57.7% of its rating

(*c*) the machine can be loaded to the extent of 57.7% of its rating with balanced supply at its terminals

(*d*) the machine can be loaded to the extent of 66 $\frac{2}{3}$% with balanced supply at its terminals.

1.10. A synchronous motor on load draws a current at a leading power factor angle ϕ. If the internal power factor angle – which is the phase angle between the excitation *e.m.f.* and the current in the time phasor diagram is Ω, then the air gap excitation *m.m.f.* lags the armature *m.m.f.* by

(*a*) Ψ (*b*) $\frac{\pi}{2} + \Psi$

(*c*) $\frac{\pi}{2} - \Psi$ (*d*) $\Psi + \Phi$

1.11. A differentially compounded d.c. motor with interpoles and with brushes on the neutral axis is to be driven as a generator in the same direction with the same polarity of the terminal voltage. It will then

(*a*) be a cumulatively compounded generator but the interpole coil connections are to be reversed

(*b*) be a cumulatively compounded generator without reversing the interpole coil connections

(*c*) be a differentially compounded generator without reversing the interpole coil connections

(*d*) be a differentially compounded generator but the interpole coil connections are to be reversed

1.12. The surge impedance of a 400 km long overhead transmission line is 400 ohms. For a 200 km length of the same line, the surge impedance will be

(*a*) 200 Ω (*b*) 800 Ω

(*c*) 400 Ω (*d*) 100 Ω

1.13. The insulation level of a 400 kV EHV overhead transmission line is decided on the basis of

(*a*) lightning over voltage

(*b*) switching over voltage

(*c*) corona inception voltage

(*d*) radio and TV interference

1.14. In order to have a lower cost of electrical energy generation,

(*a*) the load factor and diversity factor should be low

(*b*) the load factor should be low but diversity factor should be high

(*c*) the load factor should be high but diversity factor should be low

(*d*) the load factor and diversity factor should be high

1.15. The main criterion for selection of the size of a distribution for a radial distribution system is

(*a*) voltage drop

(*b*) corona loss

(*c*) temperature rise

(*d*) capital cost

1.16. The insulation resistance of a cable of length 10 *km* is 1 MΩ. For a length of 100 *km* of the same cable, the insulation resistance will be

(*a*) 1 MΩ

(*b*) 10 MΩ

(*c*) 0.1 MΩ

(*d*) 0.01 MΩ

1.17. A 3½ digit, 2 V full scale slope ADC has its integration time set to 300 ms. If the input to the ADC is (1 + 1 sin 314 *t*) V, then the ADC output will be

(*a*) 1.000

(*b*) 1.999

(*c*) 1.414

(*d*) 1.500

1.18. Four ammeters M1, M2, M3 and M4 with the following specifications are available.

Instrument	Type	Full scale value (A)	Accuracy % of FS
M1	3½ digit dual slope	20	± 0.10
M2	PMMC	10	± 0.20
M3	Electrodynamic	5	± 0.50
M4	Moving iron	1	± 1.00

A current of 1 A is to be measured. To obtain minimum error in the reading, one should select meter

(*a*) M1 (*b*) M2
(*c*) M3 (*d*) M4

1.19. A Kelvin double bridge is best suited for the measurement of

(*a*) inductance (*b*) capacitance
(*c*) low resistance (*d*) high resistance

1.20. In an 8085 microprocessor, after the execution of XRA A instruction

(*a*) the carry flag is set
(*b*) the accumulator contains FF_H
(*c*) the zero flag is set
(*d*) the accumulator contents are shifted left by one bit

1.21. A certain oscilloscope with 4 cm by 4 cm screen has its own sweep output fed to its input. If the *x* and *y* sensitivities are same, the oscilloscope will display a

(*a*) triangular wave (*b*) diagonal line
(*c*) sine wave (*d*) circle

1.22. A single phase diode bridge rectifier supplies a highly inductive load. The load current can be assumed to be ripple free. The ac supply side current waveform will be

(*a*) sinusoidal (*b*) constant *dc*
(*c*) square (*d*) triangular

1.23. A *dc* to *dc* transistor chopper supplied from a fixed voltage dc source feeds a fixed resistive-inductive load and a free-wheeling diode. The chopper operates at 1 *kHz* and 50% duty cycle. Without changing the value of the average dc current through the load, if it is desired to reduce the ripple constent of load current, the control action needed will be

(*a*) increase the chopper frequency keeping its duty cycle constant
(*b*) increase the chopper frequency and duty cycle in equal ratio
(*c*) decrease only the chopper frequency
(*d*) decrease only the duty cycle.

1.24. An inverter capable of supplying a balanced three-phase variable voltage variable frequency output is feeding a three-phase induction motor rated for 50 Hz and 440 V. The stator winding resistances of the motor are negligibly small. During starting, the current inrush can be avoided without sacrificing the starting torque by suitably applying

(*a*) low voltage at rated frequency
(*b*) low voltage keeping the *V/f* ratio constant
(*c*) rated voltage at low frequency
(*d*) rated voltage at rated frequency

1.25. The inverse of the matrix $S = \begin{bmatrix} 1 & -1 & 0 \\ 1 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ is

(*a*) $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 1 & 1 \end{bmatrix}$ (*b*) $\begin{bmatrix} 0 & 1 & 1 \\ -1 & -1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$

(*c*) $\begin{bmatrix} 2 & 2 & -2 \\ -2 & 2 & -2 \\ 0 & 2 & 2 \end{bmatrix}$ (*d*) $\begin{bmatrix} 1/2 & 1/2 & -1/2 \\ -1/2 & 1/2 & -1/2 \\ 0 & 0 & 1 \end{bmatrix}$

2. This question consists of 25 statements with blanks. Fill in the blanks with the correct answer. Each statement carries ONE mark. (1 × 25 = 25)

2.1. Given the matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$.

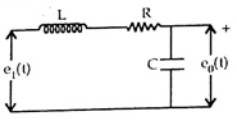
Its eigen values are_____

2.2. The steady state error due to a step input for type 1 system is_____

2.3. Closed loop stability implies that $[1 + G(s)\,H(s)]$ has only _____ in the left half of the s-plane.

2.4. The convolution of the functions $f_1(t) = e^{-2t}\,U(t)$ and $f_1(t) = et\,U(t)$ is equal to _____

2.5. For the circuit shown in the Figure. the transfer fuction is equal to_____



2.6. A series R–L–C circuit has the following parameter values : R 10Ω, L = 0.01 H, C = 100 mF.
The Q factor of the circuit at resonance is_____

2.7. An induction motor runs stably under constant torque load at 1250 rpm off a 50 Hz supply. Its number of poles is_____

2.8. The distribution factor for a 36 slot stator with three-phase, 8-pole winding, having 120° phase spread, is_____

2.9. When started by means of an auto transformer with 50% tapping, supply current at start of an induction motor is reduced to_____ of that when started by means of a star-delta starter.

2.10. The percentage impedance of a 100 kVA, 11 kV/400 V, delta/wye, 50 Hz transformer is 4.5%. For the circulation of half the full load current during short circuit test, with low voltage terminals shorted, the applied voltage on the high voltage side wili be_____

2.11. The rated load of an underground cable is always_____ its natural load.

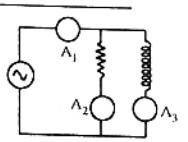
2.12. In load-flow analysis, a voltage-controlled bus is treated as a load bus in subsequent zero for a_____ limit is violated.

2.13. The positive sequence component of the voltage at the point of fault in a power system is zero for a_____ fault.

2.14. If the inductance and capacitance of a power system network upto a circuit breaker location are 1 H and 0.01 μF respectively, the value of the shunt resistor across the circuit breaker, required for critical damping of the restriking voltage is _____.

2.15. The distance relay with inherent directional property is known as_____ realy.

2.16. In the circuit of Fiigure, ammeter A_2 reads 12 A and A_3 reads 9 A. A_1 will read_____



2.17. Two 100 V full scale PMMC type dc voltmeters having figure of merits (FOM) of 10 kΩ/V and 20 kΩ/V are connected in series. The series combination can be used to measure a maximum dc voltage of_____.

2.18. Fringing in a capacitive type transducer can be minimised by providing a_____.

2.19. The common mode voltage of a unity gain (voltage follower) op-amp buffer in terms of its output voltage V_0 is_____.

2.20. For a J-K flip-flop its J input is tied to its own Q output and its K input is connected to its own Q output. If the flip-flop is fed with a clock of frequency 1 MHz, its Q output frequency will be_____.

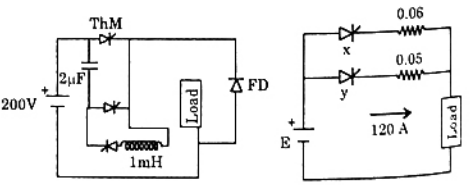
2.21. An oscilloscope is operated in the X-Y mode. The figure 8 is displayed on the oscilloscope screen. If the frequency of the X-input is 1 kHz, the y-input frequency is_____.

2.22. A three-phase ac-to-dc diode bridge rectifier is supplied from a three-phase, 440 V source. The rectifier supplies a purely resistive load. The average dc voltage across the load will be_____ V.

2.23. A single phase inverter with square wave output voltage will have inits output waveform a fifth harmonic component equal to _____ percentage of the fundamental.

2.24. Consider the chopper circuit of Figure. The chopper operates at 400 Hz and 50% duty cycle. The load current remains almost ripple free at 10 A. Assuming the input voltage to be 200 V and the devices to be ideal, the turn-off time available to the thyristor Th M is_____ μs.

2.25. Figure. shows two thyristors each rated 500 A (continuous) sharing a load current. Current through thyristor *y* is 120 A. The current through thyristor *x* will be nearly_____A.

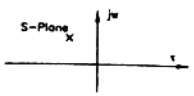


3. Questions 3.1 to 3.5 each consists of FIVE items onthe left hand side marked A, B, C, D and E and five or more items on the right hand side marked P, Q, R, S, T and U. Pick the item on the right hand side that properly matches with the left hand side and write as a matched pair. (For eg. A – R; B – T). Each proper matching carries ONE mark. Not : There are only FIVE pairs for a set.

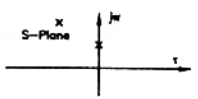
3.1. Root locations of the characteristic equations of second order systems.

A.

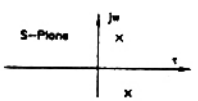
B.



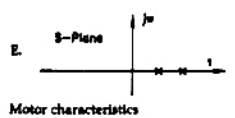
C.



D.



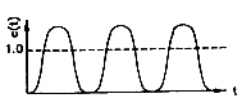
E.



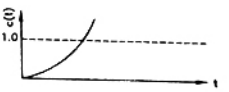
Motor characteristics

Unit step responses of second order systems

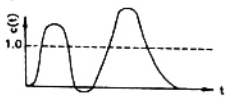
P.



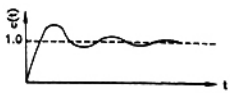
Q.



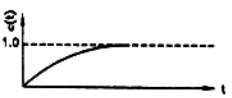
R.



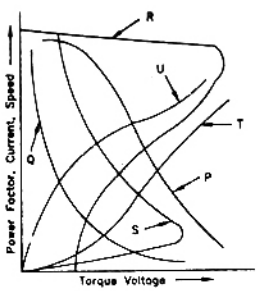
S.



T.



3.2. Motor characteristics



(a) Speed-torque characteristics of induction machind under motoring operation.
(b) Current torque characteristics of a dc series motor
(c) Power factor variation with voltage of an induction motor under no-load operation
(d) Speed torque characteristics of induction machine under dc injection dynamic braking operation
(e) Speed-torque characteristics of dc series motor.

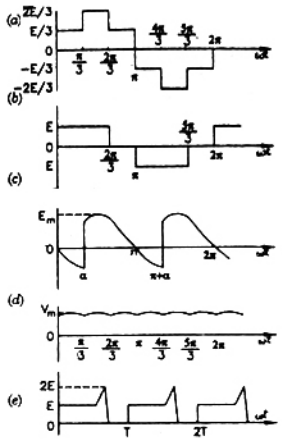
3.3. Type of Relay Most suited for

(*a*) Buchholz relay	(P) Feeder
(*b*) Translay relay	(Q) Transformer
(*c*) Carrier current, phase comparison relay	(R) Radial distributed
(*d*) Directional over current relay	(S) Generator
(*e*) Negative sequence relay	(T) Ring main distributor
	(U) Long overhead transmission line

3.4. Type of bridge Application

(*a*) Wien bridge	(P) Measurement of resistance
(*b*) Maxwell bridge	(Q) High *Q* inductors
(*c*) Scherring bridge	(R) Measurement of frequency
(*d*) Anderson bridge	(S) High voltage capacitors
(*e*) Blumleim bridge	(T) Low *Q* inductors
	(U) Insensitive to stray electrostatic fields

3.5. Output wave forms



(P) Single phase fully controlled ac-dc converter

(Q) Voltage commtated dc-ac chopper (E = input dc voltage)

(R) Phase voltage of a star connected balanced three phase load fed from a three-phase inverter with 180° conduction. (inpt dc voltage = E)

(S) Line voltage of a six stepped inverter with input dc voltage E

(T) Three-phase diode bridge rectifier.

ANSWERS

1.1 (*c*)	**1.2** (*a*)	**1.3** (*d*)	**1.4** (*a*)	**1.5** (*b*)	**1.6** (*a*)	**1.7** (*a*)	**1.8** (*a*)	**1.9** (*c*)	**1.10** (*d*)
1.11 (*b*)	**1.12** (*c*)	**1.13** (*b*)	**1.14** (*d*)	**1.15** (*a*)	**1.16** (*c*)	**1.17** (*b*)	**1.18** (*d*)	**1.19** (*c*)	**1.20** (*c*)
1.21(*b*)	**1.22** (*c*)	**1.23** (*a*)	**1.24** (*b*)	**1.25** (*d*)					