GATE : 2008

EE : Electrical Engineering

Duration : Three Hours | *Maximum Marks : 150*

Read the following instructions carefully

1. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.

2. All the questions in this question paper are of objective type.

3. Questions must be answered on **O**bjective **R**esponse **S**heet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **Each question has only one correct answer.** In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as a wrong answer.

4. Questions 1 through 20 are 1-mark questions and questions 21 through 85 are 2-mark questions.

5. Questions 71 through 73 is one set of common data questions, questions 74 and 75 is another pair of common data questions. The question pairs (76, 77), (78, 79), (80, 81), (82, 83) and (84, 85) are questions with linked answers. The answer to the second question of the above pairs will depend on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question in the pair will not be evaluated.

6. Un-attempted questions will carry zero marks.

7. **NEGATIVE MARKING:** For Q.1 to Q.20, ***0.25*** mark will be deducted for each wrong answer. For Q.21 to Q.75, ***0.5*** mark will be deducted for each wrong answer. For the pairs of questions with linked answers, there will be negative marks only for wrong answer to the first question, i.e; for Q.76, Q.78, Q.80, Q.82 and Q.84, ***0.5*** mark will be deducted for each wrong answer. There is no negative marking for Q.77, Q.79, Q.81, Q.83 and Q.85.

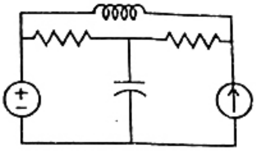
8. Calculator **without data connectivity** is allowed in the examination hall.

9. Charts, graph sheets and tables are NOT allowed in the examination hall.

10. Rough work can be done on the question paper itself. Additional blank pages are given at the end of the question paper for rough work.

Q.1 – Q.20 carry one mark each.

1. The number of chords in the graph of the given circuit will be



(a) 3

(b) 4

(c) 5

(d) 6

2. The Thevenin's equivalent of a circuit operating at $\omega = 5$ rad/s, has $V_{oc} = 3.71\angle -15.9°$ V and $Z_0 = 2.38 - j\,0.667\ \Omega$. At this frequency, the minimal realization of the Thevenin's impedance will have a

(a) resistor and a capacitor and an inductor

(b) resistor and a capacitor

(c) resistor and an inductor

(d) capacitor and an inductor

3. A signal $e^{-\alpha t}\sin(\omega t)$ is the input to a Linear Time Invariant system. Given K and ϕ are constants, the output of the system will be of the form $Ke^{-\beta t}\sin(\upsilon t + \phi)$ where

(a) β need not be equal to α but υ equal to ω

(b) υ need not be equal to ω but β equal to α

(c) β equal to α and υ equal to ω

(d) β need not be equal to α and υ need not be equal to ω

4. X is a uniformly distributed random variable that takes values between 0 and 1. The value of E $\{X^3\}$ will be

(a) 0

(b) $\frac{1}{8}$

(c) $\frac{1}{4}$

(d) $\frac{1}{2}$

5. The characteristic equation of a (3 × 3) matrix P is defined as

$$\alpha(\lambda) = |\lambda I - P| = \lambda^3 + \lambda^2 + 2\lambda + 1 = 0.$$

If I denotes identity matrix, then the inverse of matrix P will be

(a) $(P^2 + P + 2I)$

(b) $(P^2 + P + I)$

(c) $-(P^2 + P + I)$

(d) $-(P^2 + P + 2I)$

6. If the rank of a (5 × 6) matrix Q is 4, then which one of the following statements is correct?

(a) Q will have four linearly independent rows and four linearly independent columns

(b) Q will have four linearly independent rows and five linearly independent columns

(c) QQ^T will be invertible

(d) Q^TQ will be invertible

7. A function y(t) satisfies the following differential equation

$$\frac{dy(t)}{dt} + y(t) = \delta(t)$$

Where $\delta(t)$ is the delta function. Assuming zero initial condition, and denoting the unit step function by u(t), y(t) can be of the form

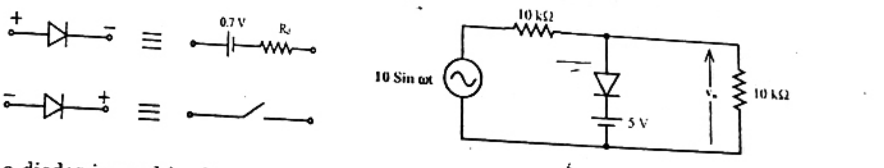
(a) e^t

(b) e^{-t}

(c) $e^t u(t)$

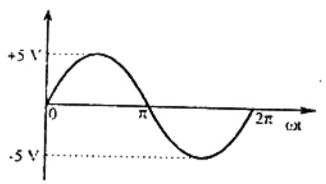
(d) $e^{-t} u(t)$

8. The equivalent circuits of a diode, during forward biased and reverse biased conditions, are shown in the figure.

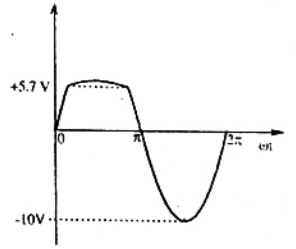


If such a diodes is used in clipper circuit of figure given above, the output voltage (v_0) of the circuit will be

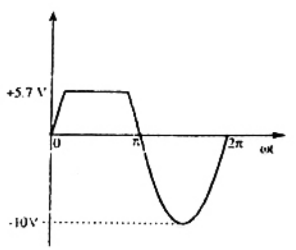
(a)



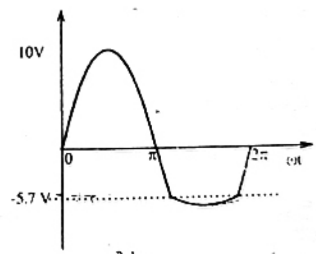
(b)



(c)



(d)



9. Two 8-bit ADCs, one of single slope integrating type and other of successive approximation type, take T_A and T_B times to convert 5 V analog input signal to equivalent digital output. If the input analog signal is reduced to 2.5V, the approximate time taken by the two ADCs will respectively, be

(a) T_A, T_B

(b) $\frac{T_A}{2}, T_B$

(c) $T_A, \frac{T_B}{2}$

(d) $\frac{T_A}{2}, \frac{T_B}{2}$

10. An input device is interfaced with Intel 8085A microprocessor as memory mapped I/O. The address of the device is 2500H. In order to input data from the device to accumulator, the sequence of instructions will be

(*a*) LXI H, 2500H
MOV A, M

(*b*) LXI H, 2500H
MOV M, A

(*c*) LHLD 2500 H
MOV A, M

(*d*) LHLD 2500H
MOV M, A

11. Distributed winding and short chording employed in AC machines will result in

(*a*) increase in emf and reduction in harmonics.

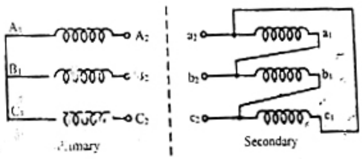
(*b*) reduction in emf and increase in harmonics.

(*c*) increase in both emf and harmonics.

(*d*) reduction in both emf and harmonics.

12. Three single-phase transformers are connected to form a 3-phase transformer bank. The transformers are connected in the following manner

The transformer connection will be represented by



(*a*) Y d0

(*b*) Y d1

(*c*) Y d6

(*d*) Y d11

13. In a stepper motor, the detent torque means

(*a*) minimum of the static torque with the phase winding excited.

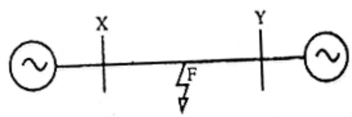
(*b*) maximum of the static torque with the phase winding excited.

(*c*) minimum of the static torque with the phase winding unexcited.

(*d*) maximum of the static torque with the phase winding unexcited.

14. A two machine power system is shown below. Transmission line XY has positive sequence impedance of Z_1 Ω and zero sequence impedance of Z_0 Ω.

An 'a' phase to ground fault with zero fault impedance occurs at the centre of the transmission line. Bus voltage at X and line current from X to F for the phase 'a', are given by V_a Volts and I_a Amperes, respectively. Then, the impedance measured by the ground distance relay located at the terminal X of line XY will be given by



(*a*) $\frac{Z_1}{2}\,\Omega$

(*b*) $\frac{Z_0}{2}\,\Omega$

(*c*) $\frac{(Z_0 + Z_1)}{2}\,\Omega$

(*d*) $\frac{V_a}{I_a}\,\Omega$

15. An extra high voltage transmission line of length 300 km can be approximated by a lossless line having propagation constant $\beta = 0.00127$ radians per km. Then the percentage ratio of line length to wavelength will be given by

(a) 24.24%
(b) 12.12%
(c) 19.05%
(d) 6.06%

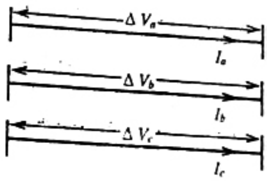
16. A 3-phase transmission line is shown in the figure

Voltage drop across the transmission line is given by the following equation

$$\begin{bmatrix}\Delta V_a\\ \Delta V_b\\ \Delta V_c\end{bmatrix} = \begin{bmatrix}Z_s & Z_m & Z_m\\ Z_m & Z_s & Z_m\\ Z_m & Z_m & Z_s\end{bmatrix}\begin{bmatrix}I_a\\ I_b\\ I_c\end{bmatrix}$$

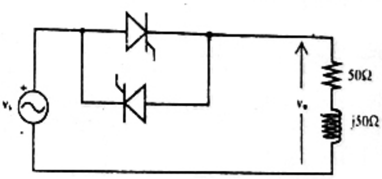
Shunt capacitance of the line can be neglected. If the line has positive sequence impedance of 15 Ω and zero sequence impedance of 48 Ω, then the values of Z_s and Z_m will be

(a) $Z_s = 31.5\ \Omega$; $Z_m = 16.5\ \Omega$
(b) $Z_s = 26\ \Omega$; $Z_m = 11\ \Omega$
(c) $Z_s = 16.5\ \Omega$; $Z_m = 31.5\ \Omega$
(d) $Z_s = 11\ \Omega$; $Z_m = 26\ \Omega$



17. In the single phase voltage controller circuit shown in the figure, for what range of triggering angle (α), the output voltage (v_0) is not controllable?

(a) $0° < \alpha < 45°$
(b) $45° < \alpha < 135°$
(c) $90° < \alpha < 180°$
(d) $135° < \alpha < 180°$



18. A 3-phase Voltage Source Inverter is operated in 180° conduction mode. Which one of the following statements is true?

(a) Both pole-voltage and line-voltage will have 3rd harmonic components
(b) Pole-voltage will have 3rd harmonic component but line-voltage will be free from 3rd harmonic
(c) Line-voltage will have 3rd harmonic component but pole-voltage will be free from 3rd harmonic
(d) Both pole-voltage and line-voltage will be free from 3rd harmonic components

19. The impulse response of a causal linear time-invariant system is given as h(t). Now consider the following two statements

Statement (I) Principle of superposition holds

Statement (II) $h(t) = 0$ for $t < 0$

Which one of the following statements is correct?

(a) Statement (I) is correct and Statement (II) is wrong
(b) Statement (II) is correct and Statement (I) is wrong
(c) Both Statement (I) and Statement (II) are wrong
(d) Both Statement (I) and Statement (II) are correct

20. It is desired to measure parameters of $\frac{230\text{ V}}{115\text{ V}}$, 2 kVA, single-phase transformer. The following wattmeters are available in a laboratory

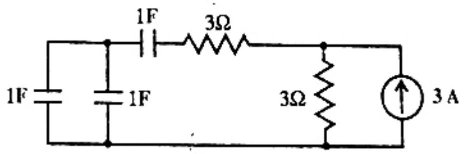
W_1: 250 V, 10 A, Low Power Factor
W_2: 250 V, 5 A Low Power Factor
W_3: 150 V, 10 A, High Power Factor
W_4: 150 V, 5 A, High Power Factor

The wattmeters used in open circuit test and short circuit test of the transformer will respectively be

(*a*) W_1 and W_2
(*b*) W_2 and W_4
(*c*) W_1 and W_4
(*d*) W_2 and W_3

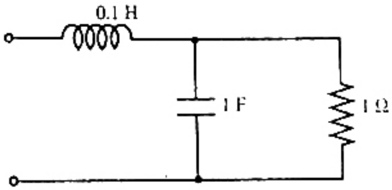
Q.21 to Q.75 carry two marks each.

21. The time constant for the given circuit will be



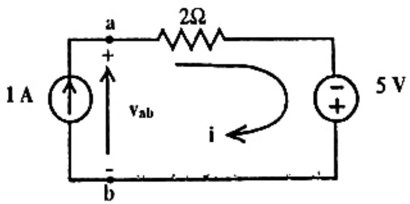
(*a*) $\frac{1}{9}$ s
(*b*) $\frac{1}{4}$ s
(*c*) 4 s
(*d*) 9 s

22. The resonant frequency for the given circuit will be



(*a*) 1 rad/s
(*b*) 2 rad/s
(*c*) 3 rad/s
(*d*) 4 rad/s

23. Assuming ideal elements in the circuit shown below, the voltage v_{ab} will be



(*a*) – 3V
(*b*) 0 V
(*c*) 3 V
(*d*) 5 V

24. A capacitor consists of two metal plates each 500 × 500 mm² and spaced 6 mm apart. The space between the metal plates is filled with a glass plate of 4 mm thickness and a layer of paper of 2 mm thickness. The relative permittivities of the glass and paper are 8 and 2 respectively. Neglecting the fringing effect, the capacitance will be (Given that $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m)

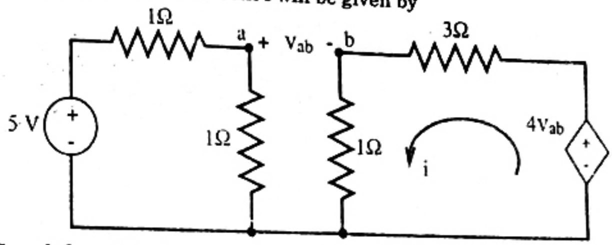
(*a*) 983.33 pF
(*b*) 1475 pF
(*c*) 6637.5 pF
(*d*) 9956.25 pF

25. A coil of 300 turns is wound on a non-magnetic core having a mean circumference of 300 mm and a cross-sectional area of 300 mm². The inductance of the coil corresponding to a magnetizing current of 3A will be

(Given that $\mu_0 = 4\pi \times 10^{-7}$ H/m)

(*a*) 37.68 μH
(*b*) 113.04 μH
(*c*) 37.68 mH
(*d*) 113.04 mH

26. In the circuit shown in the figure, the value of the current i will be given by



(*a*) 0.31 A

(*b*) 1.25 A

(*c*) 1.75 A

(*d*) 2.5 A

27. Two point charges Q_1 = 10 μC and Q_2 = 20 μC are placed at coordinates (1, 1, 0) and (– 1, – 1, 0) respectively. The total electric flux passing through a plane z = 20 will be

(*a*) 7.5 μC
(*b*) 13.5 μC
(*c*) 15.0 μC
(*d*) 22.5 μC

28. Given a sequence x[n], to generate the sequence y[n] = x[3 – 4n], which one of the following procedures would be correct?

(*a*) First *delay* x[n] by 3 sample to generate z_1[n], then pick every 4th smmple of z_1[n] to generate z_2[n], and then finally time reverse z_2[n] to obtain y[n]

(*b*) First *advance* x[n] by 3 samples to generate z_1[n], then pick every 4th sample of z_1[n] to generate z_2[n], and then finally time reverse z_2[n] to obtain y[n]

(*c*) First pick every fourth sample of x[n] to generate v_1[n], time-reverse v_1[n] to obtain v_2[n], and finally *advance* v_2[n] by 3 sample to obtain y[n]

(*d*) First pick every fourth sample of x[n] to generate v_1[n], time-reverse v_1[n] to obtain v_2[n], and finally *delay* v_2[n] by 3 samples to obtain y[n]

29. A system with input x(t) and output y(t) is defined by the input-output relation

$$y(t) = \int_{-\infty}^{-2t} x(\tau)d\tau$$

The system will be

(*a*) causal, time-invariant and unstable
(*b*) causal, time-invariant and stable
(*c*) non-causal, time-invariant and unstable
(*d*) non-causal, time-variant and unstable

30. A signal $x(t) = \text{sinc}(\alpha t)$ where α is a real constant $\left(\text{sinc}(x) = \frac{\sin(\pi x)}{\pi x}\right)$ is the input to a Linear Time invariant system whose impulse response $h(t) = \text{sinc}(\beta t)$ where β is a real constant. If min (α, β) denotes the minimum of α and β, and similarly max (α, β) denotes the maximum of α and β, and K is a constant, which one of the following statements is true about the **output of the system**?

(*a*) It will be of the form K sin (γt) where $\gamma = \min(\alpha, \beta)$

(*b*) It will be of the form K sinc (γt) wher $\gamma = \max(\alpha, \beta)$

(*c*) It will be of the form K sinc (αt)

(*d*) It cannot be a since type of signal

31. Let $x(t)$ be a periodic signal with time period T. Let $y(t) = x(t - t_0) + x(t + t_0)$ for some t_0. The fourier Series coefficients of $y(t)$ are denoted by b. If $b_k = 0$ for all odd k, then t_0 can be equal to

(*a*) $\frac{T}{8}$ (*b*) $\frac{T}{4}$

(*c*) $\frac{T}{2}$ (*d*) 2T

32. H(z) is a transfer function of a *real* system. When a signal $x[n] = (t + j)^n$ is the input to such a system, the output is zero. Further, the region Of Convergence (ROC) of $\left(1 - \frac{1}{2}z^{-1}\right)$ H (z) is the entire Z-plane (except $z = 0$). It can then be inferred that H (z) can have a minimum of

(*a*) one pole and one zero (*b*) one pole and two zero

(*c*) two poles and one zero (*d*) two poles and two zeros

33. Given $X(z) = \frac{z}{(z - a)^2}$ with $|z| > a$, the residue of $X(z)z^{n-1}$ at $z = a$ for $n \geq 0$ will be

(*a*) a^{n-1} (*b*) a^n

(*c*) na^n (*d*) na^{n-1}

34. Consider function $f(x) = (x^2 - 4)^2$ where x is a real number. Then the function has

(*a*) only one minimum (*b*) only two minima

(*c*) three minima (*d*) Three maxima

35. Equation $e^x - 1 = 0$ is required to be solved using Newton's method with an initial guess $x_0 = -1$. Then, after one step of Newton's method, estimate x_1 of the solution will be given by

(*a*) 0.71828 (*b*) 0.36784

(*c*) 0.20587 (*d*) 0.00000

36. A is a m × n full rank matrix with m > n and I is an identity matrix. Let matrix $A^+ = (A^TA)^{-1} A^T$. Then, which one of the following statements is FALSE?

(*a*) $AA^+A = A$ (*b*) $(AA^+)^2 = AA^+$

(*c*) $A^+A = I$ (*d*) $AA^+A = A^+$

37. A differential equation $\frac{dx}{dt} = e^{-2t}\, u(t)$ has to be solved using trapezoidal rule of integration with a step size h = 0.01 s. Function u(t) indicates a unit step function. If x(0–) = 0, then value of x at t = 0.01 s will be given by

(a) 0.00099
(b) 0.00495
(c) 0.0099
(d) 0.0198

38. Let P be a 2 × 2 real orthogonal matrix and $\vec{x}$ is a real vector $[x_1, x_2]^T$ with length $\|\vec{x}\| = \left(x_1^2 + x_2^2\right)^{\frac{1}{2}}$. Then, which one of the following statements is correct?

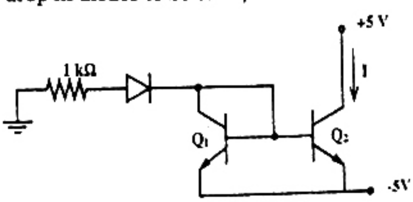
(a) $\|P\vec{x}\| \le \|\vec{x}\|$ where at least one vector satisfies $\|P\vec{x}\| < \|\vec{x}\|$
(b) $\|P\vec{x}\| = \|\vec{x}\|$ for all vectors $\vec{x}$
(c) $\|P\vec{x}\| \ge \|\vec{x}\|$ w here at least one vector satisfies $\|P\vec{x}\| > \|\vec{x}\|$
(d) No relationship can be established between $\|\vec{x}\|$ and $\|P\vec{x}\|$

39. Let $x(t) = \text{rect}\left(t - \frac{1}{2}\right)$ (where *rect* (x) = 1 for $-\frac{1}{2} \le x \le \frac{1}{2}$ and zero otherwise). Then if since $(x) = \frac{\sin(\pi x)}{\pi x}$, the Fourier Transform of x(t) + x(– t) will be given by

(a) $\text{sinc}\left(\frac{\omega}{2\pi}\right)$
(b) $2\,\text{sinc}\left(\frac{\omega}{2\pi}\right)$
(c) $2\,\text{sinc}\left(\frac{\omega}{2\pi}\right)\cos\left(\frac{\omega}{2}\right)$
(d) $\text{sinc}\left(\frac{\omega}{2\pi}\right)\sin\left(\frac{\omega}{2}\right)$

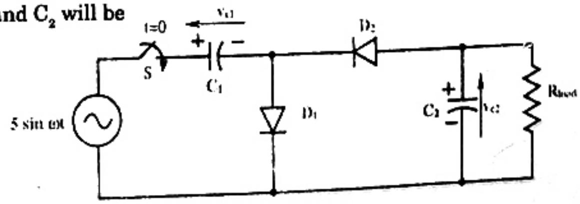
40. Two perfectly matched silicon transistors are connected as shown in the figure. Assuming the β of the transistors to be very high and the forward voltage drop in diodes to be 0.7 V, the value of current I is

(a) 0 mA
(b) 3.6 mA
(c) 4.3 mA
(d) 5.7 mA

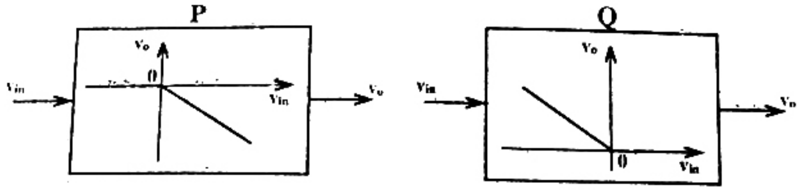


41. In the voltage doubler circuit shown in the figure, the switch 'S' is closed at t = 0. Assuming diodes D_1 and D_2 to be ideal, load resistance to be infinite and initial capacitor voltages to be zero, the steady state voltage across capacitors C_1 and C_2 will be

(a) $v_{c1} = 10V, v_{c2} = 5V$
(b) $v_{c1} = 10V, v_{c2} = -5V$
(c) $v_{c1} = 5V, v_{c2} = 10V$
(d) $v_{c1} = 5V, v_{c2} = -10V$

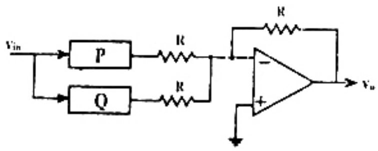


42. The block diagrams of two types of half wave rectifiers are shown in the figure. The transfer characteristics of the rectifiers are also shown within the block.

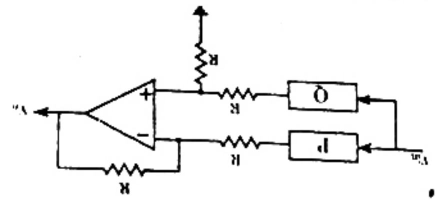


It is desired to make full wave rectifer using above two half-wave rectifiers. The resultant circuit will be

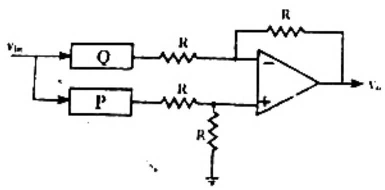
(a)



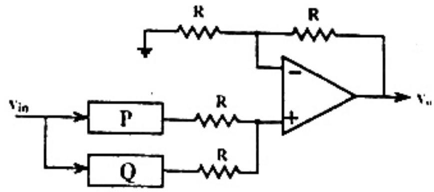
(b)



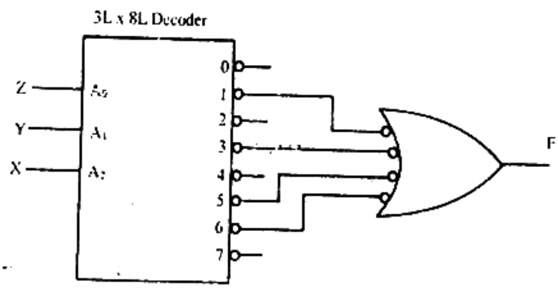
(c)



(d)



43. A 3 line to 8 line decoder, with active low outputs, is used to implement a 3- variable Boolean function as shown in the figure.



The simplified form of Boolean function F (A, B, C) implemented in 'Product of Sum' form will be

(a) $(X + Z).(\overline{X} + \overline{Y} + \overline{Z}).(Y + Z)$

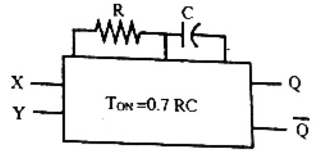
(b) $(\overline{X} + \overline{Z}).(X + Y + Z).(\overline{Y} + \overline{Z})$

(c) $(\overline{X} + \overline{Y} + Z).(\overline{X} + Y + Z).(X + \overline{Y} + Z).(X + Y + \overline{Z})$

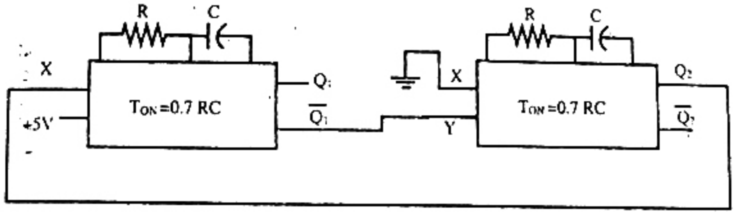
(d) $(\overline{X} + \overline{Y} + \overline{Z}).(\overline{X} + Y + \overline{Z}).(X + Y + Z).(X + \overline{Y} + \overline{Z})$

44. The truth table of a monoshot shown in the figure is given in the table below

X	Y	Q	$\overline{Q}$
0	↑	⎍	⊔
↓	1	⎍	⊔



Two monoshots, one positive edge triggered and other negative edge triggered, are connected as shown in the figure. The pulse widths of the two monoshot outputs, Q_1 and Q_2, are T_{ON_1} and T_{ON_2} respectively.



The frequency and the duty cycle of the signal at Q_1 will respectively be

(*a*) $f = \dfrac{1}{T_{ON_1} + T_{ON_2}}, D = \dfrac{1}{5}$

(*b*) $f = \dfrac{1}{T_{ON_1} + T_{ON_2}}, D = \dfrac{T_{ON_2}}{T_{ON_1} + T_{ON_2}}$

(*c*) $f = \dfrac{1}{T_{ON_1}}, D = \dfrac{T_{ON_1}}{T_{ON_1} + T_{ON_2}}$

(*d*) $f = \dfrac{1}{T_{ON_2}}, D = \dfrac{T_{ON_1}}{T_{ON_1} + T_{ON_2}}$

45. The contents (in Hexadecimal) of some of the memory locations in an 8085A based system are given below

Address	Contents
..	..
26FE	00
26FF	01
2700	02
2701	03
2702	04
..	..

The contents of stack pointer (SP), program counter (PC) and (H, L) are 2700H, 2100H and 0000H respectively. When the following sequence of instructions are executed,

2100 H: DAD SP
2101 H: PCHL

the contents of (SP) and (PC) at the end of execution will be

(*a*) (PC) = 2102H, (SP) = 2700H

(*b*) (PC) = 2700H, (SP) = 2700H

(*c*) (PC) = 2800H, (SP) = 26 FEH

(*d*) (PC) = 2A02H, (SP) = 2702H