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GATE – 2019

Questions with Detailed Solutions

ELECTRICAL ENGINEERING

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Subject wise weightage

S.No.	Name of the Subject	1 Mark	2 Marks	Total
01	Electric Circuits	2	4	10
02	EM Theory	1	2	5
03	Signals and Systems	2	1	3
04	Electrical Machines	3	4	11
05	Power Systems	4	4	12
06	Control Systems	2	3	8
07	Electrical & Electronic Measurements	0	1	2
08	Digital Electronics & Microprocessors	0	2	4
09	Analog Electronics	2	2	6
10	Power Electronics	2	4	10
11	Engineering Mathematics	7	3	13
12	Aptitude	2	4	10
13	English	3	1	5
			Total Marks	**100**

Section : General Aptitude

01. Newspapers are a constant source of delight and recreation for me. The _____ trouble is that I read _______ many of them.

(a) only, quite
(b) even, quite
(c) even, too
(d) only, too

01. Ans: (d)

Sol: Meaning single, too many

End of Solution

02. It takes two hours for a person X to mow the lawn. Y can mow the same lawn in four hours. How long (in minutes) will it take X and Y, if they work together to mow the lawn?

(a) 120
(b) 90
(c) 60
(d) 80

02. Ans: (d)

Sol: Given data:

X → 2

Y → 4

The work done by X in 1 hour $= \frac{1}{2}$

The work done by Y in 1 hour $= \frac{1}{4}$

The work done by X + Y in 1hour $= \frac{1}{2} + \frac{1}{4}$

$= \frac{3}{4}$

Time taken by X+Y to do work $= \frac{1}{3/4}$ hour

$= \frac{4}{3}$ hour $= 80$ min

End of Solution

03. The missing number in the given sequence 343, 1331, _______ 4913 is
(a) 2744 (b) 2197 (c) 3375 (d) 4096

03. Ans: (b)

Sol: 343, 1331, _____, 4913

7^3, 11^3, 13^3, 17^3

cubes of prime numbers.

343, 1331, 2197, 4913.

End of Solution

04. I am not sure if the bus that has been booked will be able to ______ all the students
(a) deteriorate (b) accommodate (c) fill (d) sit

04. Ans: (b)

End of Solution

05. The passengers were angry __________ the airline staff about the delay
(a) on (b) about
(c) with (d) towards

05. Ans: (c)

End of Solution

06. Given two sets X = {1, 2, 3} and Y = {2, 3, 4}, we construct a set Z of all possible fractions where the numerators belong to set X and the denominators belong to set Y. The product of elements having minimum and maximum values in the set Z is ____________.

(a) $\frac{1}{12}$ (b) $\frac{1}{8}$

(c) $\frac{1}{6}$ (d) $\frac{3}{8}$

06. Ans: (d)

Sol: Given data:

$$\text{Set z} = \left\{\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{2}{2}, \frac{2}{3}, \frac{2}{4}, \frac{3}{2}, \frac{3}{3}, \frac{3}{4}\right\} \qquad \max = \frac{3}{2}$$

$$\min = \frac{1}{4}$$

$$\max \times \min = \frac{3}{2} \times \frac{1}{4} = \frac{3}{8}$$

End of Solution

07. Consider five people- Mitra, Ganga, Rekha, Lakshmi and Sana, Ganga is taller than both Rekha and Lakshmi. Lakshmi is taller than Sana. Mita is taller than Ganga. Which of the following conclusions are true?

1. Lakshmi is taller than Rekha
2. Rekha is shorter than Mita
3. Rekha is taller than Sana
4. Sana is shorter than Ganga

(a) 1 only (b) 1 and 3
(c) 3 only (d) 2 and 4

07. Ans: (d)

Sol: Ganga > Rekha, Lakshmi

Lakshmi > Sana

Mita > Ganga

Mita > Ganga > Rekha, Lakshmi

Lakshmi > Sana

End of Solution

08. The ratio of the number of boys and girls who participated in an examination is 4 : 3. The total percentage of candidates who passed the examination is 80 and the percentage of a girls who passed is 90. The percentage of boys who passed is ________.

(a) 90.00 (b) 80.50
(c) 55.50 (d) 72.50

08. Ans: (d)

Sol: By allegation

B : G	x%	90%
4 : 3		

$$\frac{4(x)+3(90)}{(4+3)} = 80$$

$$4x + 270 = 560$$

$$4x = 290$$

$$x = 72.5$$

End of Solution

09. How many integers are there between 100 and 1000 all of whose digits are even?

(a) 100 (b) 90 (c) 60 (d) 80

09. Ans: (a)

Sol: Numbers should contain digits 0, 2, 4, 6, 8 only

$4 \times 5 \times 5 = 100$

End of Solution

10. An award-winning study by a group of researchers suggests that men are as prone to buying on impulse as women but women feel more guilty about shopping.

Which one of the following statements can be inferred from the given text?

(a) Some men and women indulge in buying on impulse

(b) All men and women indulge in buying on impulse

(c) Few men and women indulge in buying on impulse

(d) Many men and women indulge in buying on impulse

10. Ans: (b)

Sol: Para suggest that men and women are the same in buying habit.

End of Solution

Section : Electrical Engineering

01. Which one of the following functions is analytic in the region $|z| \le 1$?

(a) $\frac{z^2-1}{z+2}$ (b) $\frac{z^2-1}{z-0.5}$ (c) $\frac{z^2-1}{z}$ (d) $\frac{z^2-1}{z+j0.5}$

01. Ans (a)

Sol: Given the region $|z| \le 1$

$f(z) = \frac{z^2-1}{z+2}$ is not analytic at $z = -2$

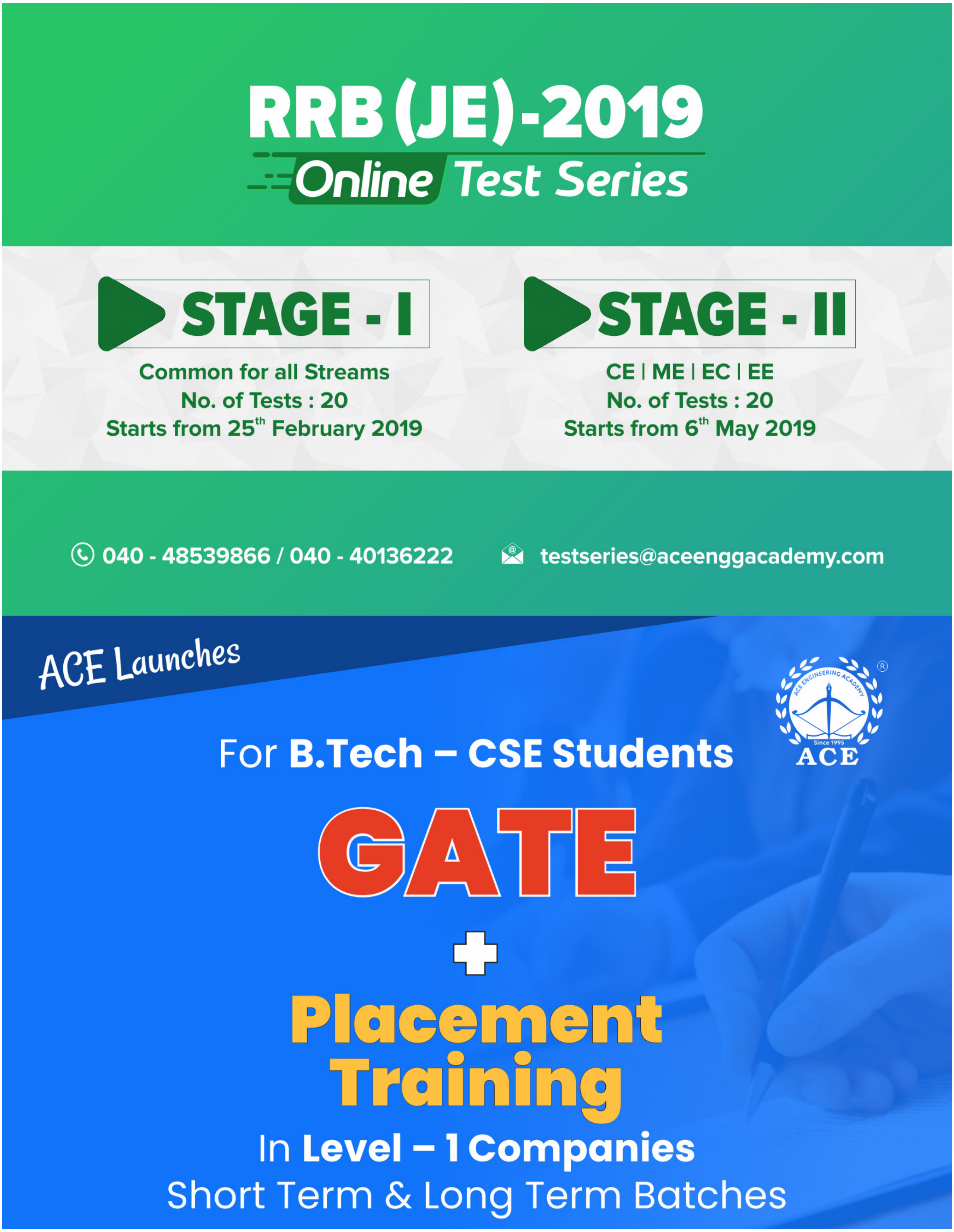
and $|z| = |-2| = 2 > 1$ lies outside of given region $|z| = 1$

$\therefore f(z) = \frac{z^2-1}{z+2}$ is analytic in the given region

End of Solution

02. A six-pulse thyristor bridge rectifier is connected to a balanced three-phase, 50 Hz AC source. Assuming that the DC output current of the rectifier is constant, the lowest harmonic component in the AC input current is

(a) 100 Hz (b) 250 Hz (c) 150 Hz (d) 300 Hz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02. Ans: (b)

Sol: Six pulse thyristor bridge rectifier. It is 3-φ full wave bridge rectifier. If output current is constant, then input supply current is quasi square wave. The line current is free from triple n (3n) harmonics i.e 3,9,6...

Lowest order harmonic = 5^{th} harmonic

$= 5\times 50 = 250$ Hz

End of Solution

03. The rank of the matrix, $M = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$, is ______.

03. Ans: 3

Sol: Given matrix $M = \begin{pmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{pmatrix}$

$R_3 \leftrightarrow R_1 \quad \begin{pmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{pmatrix}$

$R_2 \to R_2 - R_1 \begin{pmatrix} 1 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 1 & 1 \end{pmatrix}$

$R_3 \to R_3 + R_2 \quad \begin{pmatrix} 1 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & 2 \end{pmatrix}$

Rank = Number of Non zero rows in Echelon form

= 3

End of Solution

04. M is a 2 × 2 matrix with eigenvalues 4 and 9. The eigenvalues of M^2 are

(a) 2 and 3 (b) −2 and −3 (c) 4 and 9 (d) 16 and 81

04. Ans: (d)

Sol: Given that eigen values of $M_{2\times 2}$ are 4, 9,

$\Rightarrow$ eigen values of M^2 are $(4)^2$, $(9)^2$

$\therefore$ eigen values of M^2 are 16, 81

05. The inverse Laplace transform of $H(s) = \frac{s+3}{s^2+2s+1}$ for $t \geq 0$ is

(a) $3te^{-t} + e^{-t}$ (b) $2te^{-t} + e^{-t}$ (c) $4te^{-t} + e^{-t}$ (d) $3e^{-t}$

05. Ans (b)

Sol: $H(s) = \frac{s+3}{(s+1)^2} = \frac{s}{(s+1)^2} + \frac{3}{(s+1)^2}$

$t^n e^{-at} u(t) \leftrightarrow \frac{n!}{(s+a)^{n+1}}$

$n = 1;\ a = 1$

$te^{-t} u(t) \leftrightarrow \frac{1}{(s+1)^2}$ ....(1)

$3t\, e^{-t} u(t) \leftrightarrow \frac{3}{(s+1)^2}$ .... (2)

Apply Time Differentiation property

$$\frac{d}{dt}[te^{-t}] \longleftrightarrow \frac{s}{(s+1)^2}$$

$e^{-t} - te^{-t} \leftrightarrow \frac{s}{(s+1)^2}$ .... (3)

Adding (2) + (3)

$$e^{-t} + 2t\, e^{-t} \leftrightarrow \frac{s+3}{s^2+2s+1}$$

End of Solution

06. The characteristic equation of a linear time-invariant (LTI) system is given by

$$\Delta(s) = s^4 + 3s^3 + 3s^2 + s + k = 0$$

The system is BIBO stable if

(a) $0 < k < \frac{8}{9}$ (b) $k > 3$ (c) $0 < k < \frac{12}{9}$ (d) $k > 6$

06. Ans:(a)

Sol: Given data:

Δ (s) = $S^4 + 3S^3 + 3S^2 + S + K = 0$

s^4	1	3	K
s^3	3	1	0
s^2	$\frac{8}{3}$	K	0
s^1	$\left(\frac{\frac{8}{3}-3K}{\frac{8}{3}}\right)$	0	0
s^0	K	0	0

$$\left(\frac{\frac{8}{3}-3K}{\frac{8}{3}}\right) > 0$$

$$\left(\frac{8}{3}-3k\right) \quad 0$$

$$3K < \frac{8}{3}$$

$$K < \frac{8}{9}$$

$$\left(0 < K < \frac{8}{9}\right)$$

End of Solution

07. The symbols, a and T, represent positive quantities and u(t) is the unit step function. Which one of the following impulse responses is NOT the output of a causal linear time-invariant system?

(a) $e^{+at}u(t)$ (b) $e^{-a(t+T)}u(t)$ (c) $e^{-a(t-T)}u(t)$ (d) $1+e^{-at}u(t)$

07. Ans (d)

Sol: If $h(t) = 1 + e^{-at}u(t)$

represents a Non casual system. But where as option (a), (b), (c) represent casual systems

End of Solution

08. The partial differential equation $\frac{\partial^2 u}{\partial t^2} - c^2\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) = 0$; where `c $\neq 0$ is known as

(a) Poisson's equation (b) Laplace equation

(c) Wave equation (d) heat equation

08. Ans (c)

Sol: Given equation is wave equation

End of Solution

09. The Y_{bus} matrix of a two-bus power system having two identical parallel lines connected between them in pu is given as

$$Y_{bus} = \begin{bmatrix} -j8 & j20 \\ j20 & -j8 \end{bmatrix}$$

The magnitude of the series reactance of each line in pu (round off up to one decimal place) is ________.

09. Ans: 0.1

Sol:

$$Y_{bus} = \begin{matrix} & 1 & 2 \\ 1 & -j8 & j20 \\ 2 & j20 & -j8 \end{matrix}$$

The series admittance of line connected between bus1 and 2 is $y_{12} = -Y_{12} = -j20$

as two lines are in parallel, each line admittance will be,

$$y_{line} = \frac{-j20}{2}$$

$$= -j10 \text{ pu}$$

series impedance of line, $z_{line} = \frac{1}{-j10} = j0.1$ pu

End of Solution

10. A 5 kVA, 50 V/100 V, single-phase transformer has a secondary terminal voltage of 95 V when loaded. The regulation of the transformer is

(a) 4.5% (b) 1% (c) 9% (d) 5%

10. Ans: (d)

Sol: 5 kVA, 50V/100V 1-φ transformer secondary terminal under load = 95 V

voltage regulation = $\frac{V_1' - V_2}{V_1'} \times 100 = \frac{100-95}{100} \times 100 = 5\%$

End of Solution

11. The open loop transfer function of a unity feedback system is given by $G(s) = \frac{\pi e^{-0.25s}}{s}$.
In G(s) plane, the Nyquist plot of G(s) passes through the negative real axis at the point
(a) (−1.25, j0) (b) (−0.75, j0) (c) (−0.5, j0) (d) (−1.5, j0)

11. Ans (c)

Sol: Given data:

$$G(s)= \frac{\pi e^{-0.25S}}{s}$$

$$\omega_{pc} \Rightarrow \angle G(j\omega) = -180°$$

$$-180° = +90° + 0.25\omega \times \frac{180°}{\pi}$$

$$90° = \frac{45^0 \omega}{\pi} \Rightarrow \omega_{pc} = 2\pi \text{ r/sec}$$

$$\text{Magnitude} = \frac{\pi}{\omega_{pc}} = \frac{\pi}{2\pi} = 0.5$$

Inter section point with negative real axis ⇒ (-0.5, j0)

End of Solution

12. A co-axial cylindrical capacitor shown in Figure (i) has dielectric with relative permittivity $\varepsilon_{r1} = 2$. When one-fourth portion of the dielectric is replaced with another dielectric of relative permittivity ε_{r2}, as shown in Figure (ii), the capacitance is doubled. The value of ε_{r2} is ________.

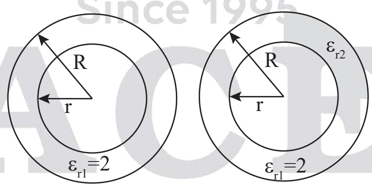

Fig. (i) Fig. (ii)

12. Ans: 10

Sol: The capacitance of a coaxial cable

$$C = \frac{2\pi\varepsilon\ell}{\ell n(b/a)}$$

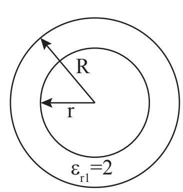

Fig. (i)

$$C_a = \frac{2\pi 2\varepsilon_0 \ell}{\ell n(b/a)}$$

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The two capacitors are connected in parallel

$C_b = C_1 + C_2$

$$C_b = \frac{3\pi 2\varepsilon_0 \ell}{2\ell n(b/a)} + \frac{\pi\varepsilon_r \varepsilon_0 \ell}{2\ell n(b/a)}$$

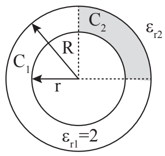


Fig. (ii)

Given

$C_b = 2\,C_a$

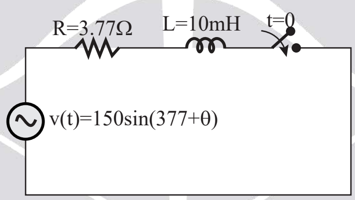
$$C_b = \frac{3\pi\varepsilon_0}{\ell n(b/a)} + \frac{\pi\varepsilon_0 \varepsilon r_2}{2\ell n(b/a)} = \left[\frac{2\pi 2\varepsilon_0}{\ell n(b/a)}\right] (2)$$

$$3 + \frac{\varepsilon_{r_2}}{2} = 8$$

$$\varepsilon_{r_2} = 10$$

End of Solution

13. In the circuit shown below, the switch is closed at t = 0. The value of θ in degrees which will give the maximum value of DC offset of the current at the time of switching is



(a) 60 (b) −30 (c) 90 (d) −45

13. Ans: (d)

Sol: $i(t) = \frac{V_m}{|Z|}\sin(\omega t + \theta - \phi) + Ae^{\frac{-t}{\tau}}$

$|Z| = \sqrt{R^2 + (\omega L)^2}$

$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$

Now $i(0^-) = i(0) = i(0^+) = 0$ A

So, at t = 0 ⇒ i = 0

So, $A = \frac{-V_m}{|Z|}\sin(\theta - \phi)$

So, Total solution

$$i(t) = \frac{V_m}{|Z|}\sin(\omega t + \theta - \phi) - \frac{V_m}{|Z|}\sin(\theta - \phi)e^{\frac{-t}{\tau}}$$

DC offset value is $\frac{-V_m}{|Z|}\sin(\theta - \phi)e^{\frac{-t}{\tau}}$

Maximum when, $\sin(\theta - \phi) = -1$

So, $\theta - \phi = -90^o$

$\theta = -90^o + 45$

$\theta = -45^o$

End of Solution

14. The output voltage of a single-phase full bridge voltage source inverter is controlled by unipolar PWM with one pulse per half cycle. For the fundamental rms component of output voltage to be 75% of DC voltage, the required pulse width in degrees (round off up to one decimal place) is ________.

14. Ans: 112.8

Sol: 1-φ full bridge inverter operating with unipolar PWM and one pulse per half cycle. It is a single pulse modulation

$$V_0 = \sum_{n=1,3}^{\infty}\left\{\frac{4V_s}{n\pi}\sin\frac{n\pi}{2}\sin nd\right\}\sin n\omega t$$

RMS value of fundamental component

$$(v_0 1) = \left\{\frac{4V_s}{\pi}\times\sin\frac{\pi}{2}\times\sin d\right\}\frac{1}{\sqrt{2}}$$

$$0.75V_s = \frac{4V_s}{\pi}\times 1\times\sin d\times\frac{1}{\sqrt{2}}$$

$$\Rightarrow \sin d = \frac{0.75\times\pi\sqrt{2}}{4} = 0.833$$

$d = 56.4°$

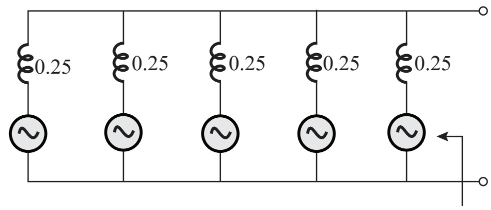
width of pulse (2d)= 112.8°

End of Solution

15. Five alternators each rated 5 MVA, 13.2 kV with 25% of reactance on its own base are connected in parallel to a busbar. The short-circuit level in MVA at the busbar is _________.

15. Ans: 100

Sol: Five alternatnators are in parallel



Thevenin's equivalent reactance, $X_{th} = \frac{0.25}{5}$ pu

3- f short circuit level at the bus bar,

$$SCMVA_{(3-\varphi)} = \frac{\text{Base MVA }(3-\phi)}{X_{th}\text{ (pu)}} = \frac{5}{\left(\frac{0.25}{5}\right)} = \frac{25}{0.25} = 100 \text{ MVA}$$

End of Solution

16. The output response of a system is denoted as y(t), and its Laplace transform is given by $Y(s) = \frac{10}{s(s^2+s+100\sqrt{2})}$ The steady state value of y(t) is

(a) $100\sqrt{2}$ (b) $\frac{1}{100\sqrt{2}}$ (c) $10\sqrt{2}$ (d) $\frac{1}{10\sqrt{2}}$

16. Ans (d)

Sol: Given data:

Steady state value is Y (∞)

$$\therefore\ Y(\infty) = \underset{s\to 0}{\text{Lt}}\ s\,Y(s)$$

$$= \underset{s\to 0}{\text{Lt}}\ s.\frac{10}{s(s^2+s+100\sqrt{2})}$$

$$= \frac{10}{100\sqrt{2}} = \frac{1}{10\sqrt{2}}$$

$$\therefore\ Y(\infty) = \frac{1}{10\sqrt{2}}$$

End of Solution

17. The parameter of an equivalent circuit of a three-phase induction motor affected by reducing the rms value of the supply voltage at the rated frequency is

(a) magnetizing reactance (b) stator resistance

(c) rotor leakage reactance (d) rotor resistance

17. Ans(a)

Sol:

$$Q_R \propto \frac{V}{f}$$

Magnetizing reactance is dependent on the air gap flux

End of Solution

18. A system transfer function is $H(s) = \dfrac{a_1 s^2 + b_1 s + c_1}{a_2 s^2 + b_2 s + c_2}$. If $a_1 = b_1 = 0$, and all other coefficients are positive, the transfer function represents a

(a) band pass filter (b) high pass filter
(c) low pass filter (d) notch filter

18. Ans (c)

Sol: The standard 2nd order LPF $= \dfrac{\omega_0^2}{s^2 + \dfrac{\omega_0}{Q}s + \omega_0^2}$

The standard 2nd order HPF $= \dfrac{Ks^2}{s^2 + \dfrac{\omega_0}{Q}s + \omega_0^2}$

The standard 2nd order BPF $= \dfrac{s^2}{s^2 + \dfrac{\omega_0}{Q}s + \omega_0^2}$

In the given problem

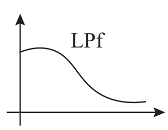
$H(s) = \dfrac{C_1}{a_2 s^2 + b_2 s + c_2}$ represents standard LPF

$H(0) = \dfrac{C_1}{C_2}$;

$H(\infty) = \underset{s\to 0}{Lt}\ SH(s)$

$= \underset{s\to 0}{Lt}\ \dfrac{sC_1}{a_2 s^2 + b_2 s + c_2} = 0$

$\therefore\ H(0) = \dfrac{C_1}{C_2};\ H(\infty) = 0$



End of Solution

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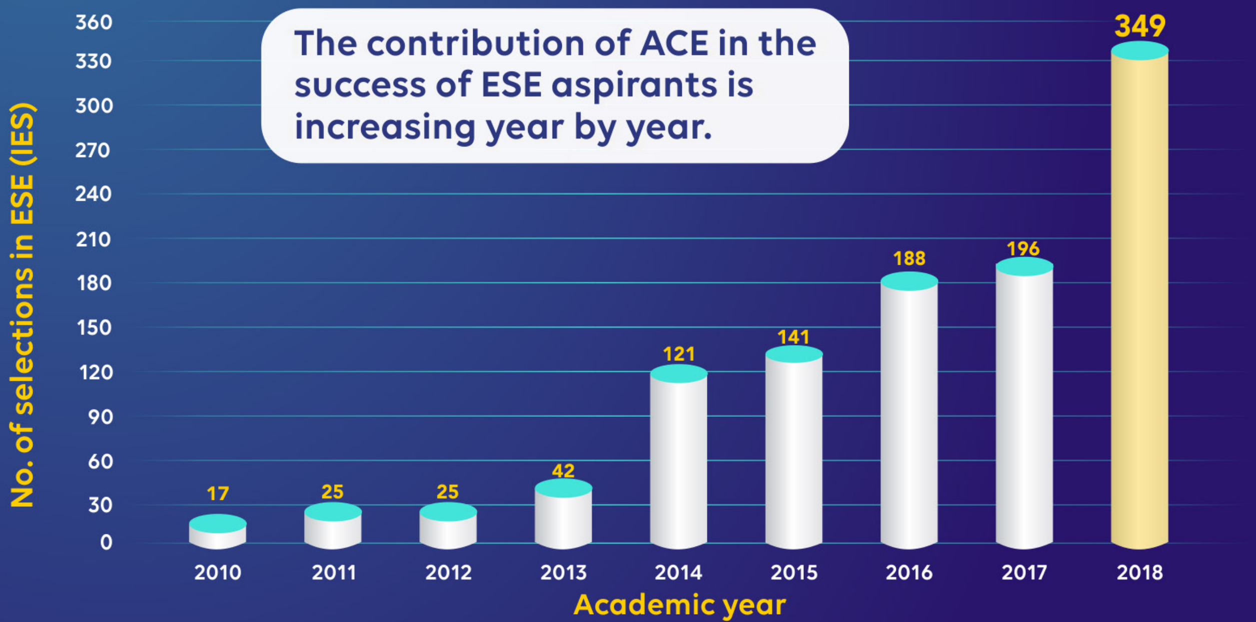

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19. A three-phase synchronous motor draws 200 A from the line at unity power factor at rated load. Considering the same line voltage and load, the line current at a power factor of 0.5 leading is

(a) 200 A (b) 300 A (c) 400 A (d) 100 A

19. Ans: (c)

Sol: $\sqrt{3}\,V_L I_L$ = Power drawn by motor at upf = $\sqrt{3}\,V_L\ 200$

When the power factor changes to 0.5 leading, still power drawn will be the same (if change in losses is neglected).

$\therefore\ \sqrt{3}\,V_L I_L(0.5) = \sqrt{3}\,V_L 200$

$I_L = 400$ A

End of Solution

20. A current controlled current source (CCCS) has an input impedance of 10 Ω and output impedance of 100 kΩ. When this CCCS is used in a negative feedback closed loop with a loop gain of 9, the closed loop output impedance is

(a) 100 kΩ (b) 100 Ω (c) 10 Ω (d) 1000 kΩ

20. Ans: (d)

Sol: CCCS is current-shunt-negative feedback amplifier.

The output impedance $R_{of} = R_0(1 + \beta A)$, Given $A\beta = 9$

$= 100 \times 10^3 (1 + 9)$

$= 1000$ kW

End of Solution

21. The mean-square of a zero-mean random process is $\frac{kT}{c}$, where k is Boltzmann's constant, T is the absolute temperature, and c is a capacitance. The standard deviation of the random process is

(a) $\frac{kT}{c}$ (b) $\frac{\sqrt{kT}}{c}$ (c) $\sqrt{\frac{kT}{c}}$ (d) $\frac{c}{kT}$

21. Ans: (c)

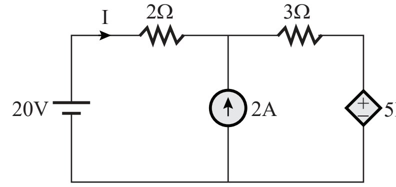
Sol: $V(x) = E[X^2] - (E[X])^2$

Given $E[X^2] = \frac{kT}{c}$ and $E[X] = 0$

Therefore, $V(x) = \frac{kT}{c}$ and

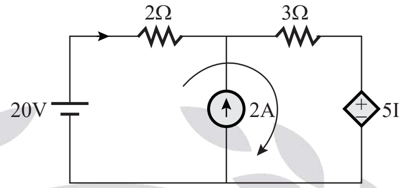
Standard deviation $= \sqrt{V(x)} = \sqrt{\frac{kT}{c}}$

22. The current I flowing in the circuit shown below in amperes (round off to one decimal place) is _______.



22. Ans: 1.4

Sol:



KCL + KVL:

$-20 + 2I + 3(2 + I) + 5I = 0$

$10I = (20 - 6)$

$I = 1.4$ A

End of Solution

23. Given, V_{gs} is the gate-source voltage, V_{ds} is the drain source voltage, and V_{th} is the threshold voltage of an enhancement type NMOS transistor, the conditions for transistor to be biased in saturation are

(a) $V_{gs} > V_{th}$; $V_{ds} \geq V_{gs} - V_{th}$
(b) $V_{gs} < V_{th}$; $V_{ds} \leq V_{gs} - V_{th}$
(c) $V_{gs} < V_{th}$; $V_{ds} \geq V_{gs} - V_{th}$
(d) $V_{gs} > V_{th}$; $V_{ds} \leq V_{gs} - V_{th}$

23. Ans: (a)

Sol: For saturation region $V_{ds} \geq V_{ds}$ (sat), V_{ds} (sat) $= V_{gs} - V_{th}$

$\therefore \quad V_{ds} \geq V_{gs} - V_{th}$

and $V_{gs} > V_{th}$

End of Solution

24. The total impedance of the secondary winding, leads, and burden of a 5 A CT is 0.01 Ω. If the fault current is 20 times the rated primary current of the CT, the VA output of the CT is _____.

24. Ans: 100

Sol: Given data:

The total impedance of CT on secondary side = 0.01 Ω

If fault current is 20 times the rated current on primary then the secondary current also 20 times rated current

So, CT secondary current = 20 × 5 = 100 A

CT burden (VA) = $100^2 \times 0.01$

= 100 VA

End of Solution

25. If $f = 2x^3 + 3y^2 + 4z$, the value of line integral $\int_C$ grad f. dr evaluated over contour C formed by the segments $(-3, -3, 2) \rightarrow (2, -3, 2) \rightarrow (2, 6, 2) \rightarrow (2, 6, -1)$ is _______.

25. Ans: 139

Sol: Given $f = 2x^3 + 3y^2 + 4z$

$$\text{grad } f = i\frac{\partial f}{\partial x} + j\frac{\partial f}{\partial y} + k\frac{\partial f}{\partial z}$$

$6x^2i + 6yj + 4k$

given that C is segment joining

$(-3, -3, 2) \rightarrow (2, -3, 2) \rightarrow (2, 6, 2) \rightarrow (2, 6, -1)$

$$\therefore \int_C \text{grad.dr} = \int_C (6x^2 i + 6yj + 4k).(dxi + dyj + dzk)$$

$$= \int_C (6x^2 dx + 6ydy + 4dz)$$

$$= \int_{(-3,-3,2)}^{(2,6,-1)} (6x^2 dx + 6ydy + 4dz)$$

equation of segment joinging $(-3, -3, 2)$ and $(2, 6, -1)$

$$\frac{x+3}{2-(-3)} = \frac{y+3}{6-(-3)} = \frac{z-2}{-1-2} = t$$

$$\left.\begin{array}{lll} x = 5t-3 & \Rightarrow & dx = 5dt \\ \Rightarrow y = 9t-3 & \Rightarrow & dy = 9dt \\ z = -3t+2 & \Rightarrow & dz = -3dt \end{array}\right\} t = 0 \text{ to } 1$$

$$= \int_{t=0}^{1} 6(5t-3)^2 5dt + 6(9t-3)9dt + 4(-3)dt)$$

$$= \int_{t=0}^{1} 30(25t^2 - 30t + 9)dt + (486t - 162)dt - 12dt$$

$$\left[750\frac{t^3}{3} - 900\frac{t^2}{2} + 270t + 486\frac{t^2}{2} - 162t - 12t\right]_0^1$$

$$[250 - 450 + 270 + 243 - 162 - 12]$$

$= 139$

End of Solution

26. The voltage across and the current through a load are expressed as follows

$$v(t) = -170 \sin\left(377t - \frac{\pi}{6}\right) V$$

$$i(t) = 8\cos\left(377t + \frac{\pi}{6}\right) A$$

The average power in watts (round off to one decimal place) consumed by the load is _____.

26. Ans: 588.89 W

Sol: $V = -170 \sin(377t - 30^o)$

$= -(170\angle -30^o)$

$I = 8\cos(377t + 30^o)$

$= 8\sin(90^o + 377t + 30^o)$

$= +(8\angle 120^o)$

$$S^* = VI^* = -\left(\frac{170}{\sqrt{2}}\angle -30^o\right)\left(\frac{8}{\sqrt{2}}\angle -120^\circ\right)$$

$S^* = -(680\angle -150^o)$

$S^* = -(-588.89 - j340)$

$S^* = 588.89 + j340$

$P_{avg} = 588.89$ W

End of Solution

27. If A = 2xi + 3yj+4zk and u = $x^2 + y^2 + z^2$, then div(uA) at (1, 1, 1) is ______.

27. Ans: 45

Sol: Given the vector

$\overline{A} = 2x\hat{i} + 3y\hat{j} + 4z\hat{k}$

Scalar

$u = x^2+y^2+z^2$

we know

$$\nabla.\left(\underset{\text{scalar}}{\underset{\downarrow}{u}} \quad \underset{\text{vector}}{\underset{\downarrow}{\overline{A}}}\right) = (\nabla u).\overline{A} + u(\nabla.\overline{A})$$

$$\nabla u = \frac{\partial u}{\partial x}\hat{i} + \frac{\partial u}{\partial y}\hat{j} + \frac{\partial u}{\partial z}\hat{k}$$

$(\nabla u) = (2x\,\hat{i} + 2y\,\hat{j} + 2z\,\hat{k})$

$(\nabla u).\overline{A} = (2x\,\hat{i} + 2y\,\hat{j} + 2z\,\hat{k}).(2x\,\hat{i} + 3y\,\hat{j} + 4z\,\hat{k})$

$= 4x^2 + 6y^2 + 8z^2$

$$\nabla.\overline{A} = \frac{\partial Ax}{\partial x}i + \frac{\partial Ay}{\partial y}j + \frac{\partial Az}{\partial z}k$$

$$\nabla.\overline{A} = 2 + 3 + 4 = 9$$

$$\nabla.(u\overline{A}) = (\nabla u).\overline{A} + u(\nabla.\overline{A})$$

$$= 4x^2+6y^2+8z^2 + (x^2+y^2+z^2)\,9$$

$$\nabla.(u\overline{A})| = 13x^2 + 15y^2 + 17z^2$$

$$\nabla.(u\overline{A})|_{(1,1,1)} = 13 + 15 + 17$$

$$= 45$$

End of Solution

28. The closed loop line integral $\oint_{|z|=5} \frac{z^3+z^2+8}{z+2}dz$ evaluated counter-clockwise, is

(a) $+8j\pi$ (b) $+4j\pi$ (c) $-8j\pi$ (d) $-4j\pi$

28. **Ans: (a)**

Sol:

$$\int_{|Z|=5} \frac{z^3+z^2+8}{z+2}$$

Let $f(z) = \frac{z^3+z^2+8}{z+2}$

f(z) is not analytic at $z = -2$

and $z = -2$ lies in side of given curve $|z| = 5$

$$[\text{Res } f(z)]_{z=-2} = \underset{z\to-2}{Lt}\ (z+2)\frac{z^3+z^2+8}{(z+2)}$$

$$= -8 + 4 + 8$$

$$= 4$$

By cauchy's residue theorem,

$$\oint_c \frac{z^3+z^2+8}{z+2}dz = 2\pi j \times (\text{sum of residues of points inside of C})$$

$$= 2\pi j \times 4 = 8\pi j$$

End of Solution

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29. In a 132 kV system, the series inductance up to the point of circuit breaker location is 50 mH. The shunt capacitance at the circuit breaker terminal is 0.05 μF. The critical value of resistance in ohms required to be connected across the circuit breaker contacts which will give no transient oscillation is ______.

29. Ans: 500

Sol: Given data:

Series inductance, L = 50 mH

Shunt capacitance, C = 0.05 μF

Critical resistance required to be connected across breaker which will give no transient oscillation is,

$$R = \frac{1}{2}\sqrt{\frac{L}{C}}$$

$$= \frac{1}{2}\sqrt{\frac{50\times10^{-3}}{0.05\times10^{-6}}} = 500\ \Omega$$

End of Solution

30. A single-phase fully-controlled thyristor converter is used to obtain an average voltage of 180 V with 10 A constant current to feed a DC load. It is fed from single-phase AC supply of 230V, 50 Hz. Neglect the source impedance. The power factor (round off to two decimal places) of AC mains is ______.

30. Ans: 0.7826

Sol: 1-φ full wave rectifier

$V_0 = 180$ V

$I_0 = 10$A

V_s (supply voltage) = 230 V (RMS)

$$V_0 = \frac{2V_m}{\pi}\cos\alpha$$

$$180 = \frac{2\times230\sqrt{2}}{\pi}\cos\alpha = (0.9\cos\alpha)230$$

$$0.9\cos\alpha = \frac{180}{230} = 0.7826$$

Power factor = 0.9 cosα = 0.7826 lag

End of Solution

31. A periodic function f(t), with a period of 2π, is represented as its Fourier series,

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos nt + \sum_{n=1}^{\infty} b_n \sin nt .$$

$$\text{If } f(t) = \begin{cases} A \sin t, & 0 \le 1 \le \pi \\ 0, & \pi \quad t \quad 2\pi \end{cases}$$

the Fourier series coefficients a_1 and b_1 of f(t) are

(a) $a_1 = 0; b_1 = A/\pi$

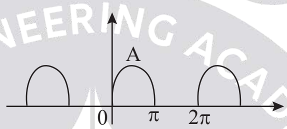
(b) $a_1 = \frac{A}{2}; b_1 = 0$

(c) $a_1 = 0; b_1 = \frac{A}{2}$

(d) $a_1 = \frac{A}{\pi}; b_1 = 0$

31. Ans(c)

Sol: Half wave rectifier;



$$\text{EFS: } X_1 = -\frac{jA}{4} = \frac{1}{2}(a_1 - jb_1)$$

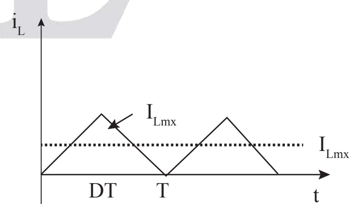
$$a_1 = 0; -\frac{jA}{4} = \frac{-jb_1}{2} \Rightarrow b_1 = \frac{A}{2}$$

End of Solution

32. In a DC-DC boost converter, the duty ratio is controlled to regulate the output voltage at 48 V. The input DC voltage is 24 V. The output power is 120W. The switching frequency is 50 kHz. Assume ideal components and a very large output filter capacitor. The converter operates at the boundary between continuous and discontinuous conduction modes. The value of the boost inductor (in μH) is _____.

32. Ans: 24

Sol:



DC-DC boost converter

$V_0 = 48$ V

$V_s = 24$ V

$$V_0 = \frac{V_s}{1-D} \Rightarrow 48 = \frac{24}{1-D}$$

D = 0.5

$$T = \frac{1}{f_s} = \frac{1}{50 \times 10^3} = 20\mu s$$

output power (P) = 120 watts

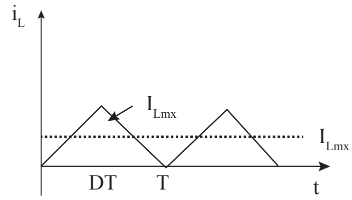
$f_s = 50$ kHz

Inductor operates at the boundary of continuous and discontinuous conduction

In boost converter,

average value of supply current (I_{SA}) = Average value of inductor current (I_{LA})

$$I_{SA} = I_{LA} = \frac{120}{24} = 5\text{Amps}$$



$$I_{LA} = \frac{0 + I_{Lmx}}{2} \Rightarrow I_{Lmx} = 2\times I_{LA} = 2\times5 = 10 \text{ Amps}$$

$$\text{current ripple } ((\triangle I_L) = I_{Lmx} - 0 = I_{Lmx} = 10$$

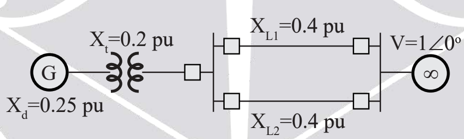
$$\therefore \frac{V_s}{L} \times DT = 10 \Rightarrow \frac{24}{L} \times 0.5 \times 20 = 10$$

$$L = \frac{24 \times 0.5 \times 20}{10} \mu H$$

$$= 24 \ \mu H$$

End of Solution

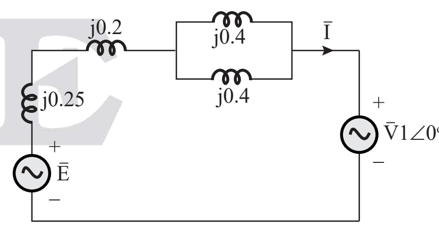
33. In the single machine infinite bus system shown below, the generator is delivering the real power of 0.8 pu at 0.8 power factor lagging to the infinite bus. The power angle of the generator in degrees (round off to one decimal place) is ____.



33. Ans: 20.51°

Sol: Given data:

Per phase equivalent circuit,



Real power injected to ∞-bus, P = 0.8 pu,

cosφ = 0.8 lag

φ = 36.86 lag

$P = VI\cos\varphi$

$$I = \frac{0.8}{1 \times 0.8} = 1 \text{ pu}$$

now, $\bar{I} = 1\angle -36.86^\circ$

$$\overline{E} = \overline{V} + \overline{I}(Z_{eq})$$

$$= 1\angle0° + (1\angle - 36.86°)(j0.65) = 1 + (0.8 - j0.6)(j0.65)$$

$$|E|\angle\delta = 1.3899 + j0.52 \text{ pu}$$

$$\text{The power angle } \delta = \tan^{-1}\left(\frac{0.52}{1.3899}\right) = 20.514°$$

34. A DC-DC buck converter operates in continuous conduction mode. It has 48 V input voltage and it feeds a resistive load of 24 Ω. The switching frequency of the converter is 250 Hz. If switch-on duration is 1 ms, the load power is

(a) 12 W (b) 6 W (c) 48 W (d) 24 W

34. Ans: (b)

Sol: DC-DC buck converter

$V_s = 48V$

$R = 24\Omega$

$f_s = 250$ Hz

$T_{ON} = DT = 1ms$

$$\text{Time period (T)} = \frac{1}{f_s} = \frac{1}{250} = 4ms$$

$$\text{duty cycle (D)} = \frac{T_{ON}}{T} = \frac{1}{4}$$

$$\text{output voltage } (V_0) = DV_s = \frac{1}{4} \times 48 = 12V$$

$$\text{output current } (I_0) = \frac{V_0}{R} = \frac{12}{24} = \frac{1}{2} = 0.5A$$

$$\text{power} = V_0 I_0 = 12 \times 0.5 = 6\text{watts}$$

End of Solution

35. A three-phase 50 Hz, 400 kV transmission line is 300 km long. The line inductance is 1 mH/km per phase, and the capacitance is 0.01 μF/km per phase. The line is under open circuit condition at the receiving end and energized with 400 kV at the sending end, the receiving end line voltage in kV (round off to two decimal places) will be ____.

35. Ans: 418.44

Sol: Given data:

A 3-φ, 50 Hz, 400 kV line

length of line, l = 300 km

inductance and capacitances,

L = 1 mH/km, C = 0.01 μF/km

line was under open circuit condition

input voltage, V_s = 400 kV (LL)

No load receiving end voltage, $V_{r_0} = \frac{V_s}{A}$

Parameter, A = cosβl (assuming line as lossless)

where $\beta = w\sqrt{LC}$ rad/km

$= 2\pi \times 50 \times \sqrt{1 \times 10^{-3} \times 0.01 \times 10^{-6}}$

$= 9.9345 \times 10^{-4}$ rad/km

βl $= 9.9345 \times 10^{-4} \times 300$ rad

= 0.298037 rad

Now, A = cosβl

= cos 0.298037

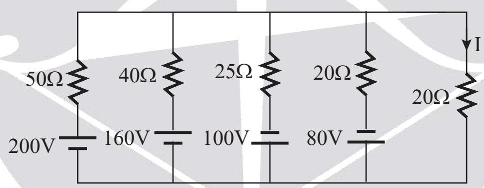
= 0.9559

finally, $V_{r_0(LL)} = \frac{400}{0.9559}$ kV

= 418.447 kV

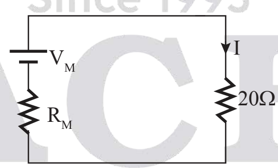
End of Solution

36. The current I flowing in the circuit shown below in amperes is ______.



36. Ans: 0

Sol: Milliman's Theorem



$$V_M = \frac{\frac{+200}{50} + \frac{160}{40} - \frac{100}{25} - \frac{80}{20}}{\frac{1}{50} + \frac{1}{40} + \frac{1}{25} + \frac{1}{20}} = 0 \text{ volts}$$

So, I = 0 Amps

End of Solution

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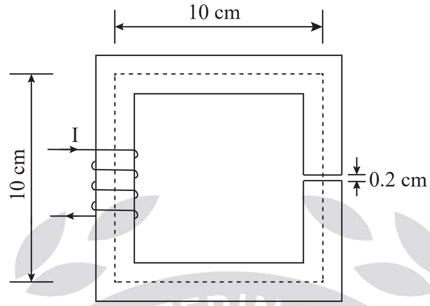
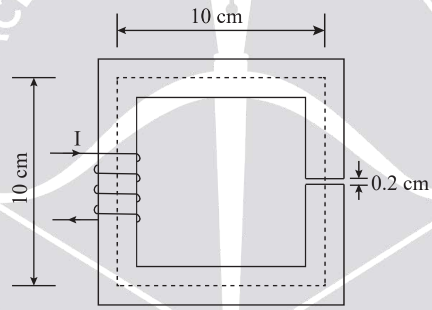
37. The magnetic circuit shown below has uniform cross-sectional area and air gap of 0.2 cm. The mean path length of the core is 40 cm. Assume that leakage and fringing fluxes are negligible. When the core relative permeability is assumed to be infinite, the magnetic flux density computed in the air gap is 1 tesla. With same Ampere-turns, if the core relative permeability is assumed to be 1000 (linear), the flux density in tesla (round off to three decimal places) calculated in the air gap is _______.



37. Ans: 0.83

Sol:



length of the core (l_c) = 39.8 cm

length of the air gap (l_a) = 0.2 cm

We know

MMF = $R_M\ \varphi$

NI = $R_M\ \varphi$

$$\phi = \frac{NI}{R_M}$$

where R_M = reluctance

$$B = \frac{\phi}{A}$$

$$B = \frac{NI}{R_M A}$$

$$B \alpha \frac{1}{R_M}$$

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Case-1

Permeability of the core (μ_c) = ∞

$$(R_M)_1 = R_1 + R_2$$

$$= \frac{\ell_c}{\mu A} + \frac{\ell_a}{\mu_0 A}$$

$$(R_M)_1 = 0 + \frac{0.2}{\mu_0 A}$$

Case-2

Permeability of the core (μ_c) =1000 μ_0

$$(R_M)_2 = R_1 + R_2$$

$$= \frac{39.8}{10^3 \mu_0 A} + \frac{0.2}{\mu_0 A}$$

$$(R_M)_2 = \frac{1}{\mu_0 A}[0.2398]$$

$$\frac{B_1}{B_2} = \frac{(R_M)_2}{(R_M)_1}$$

$$B_2 = \frac{(R_M)_1}{(R_M)_2} = \frac{0.2}{0.2398}$$

$B_2 = 0.83$

End of Solution

38. Consider a state-variable model of a system

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -\alpha & -2\beta \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \alpha \end{bmatrix} r$$

$$y = [1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

where y is the output, and r is the input. The damping ratio ζ and the undamped natural frequency ω_n(rad/sec) of the system are given by

(a) $\zeta = \frac{\beta}{\sqrt{\alpha}}; \omega_n = \sqrt{\alpha}$

(b) $\zeta = \sqrt{\alpha}; \omega_n = \frac{\beta}{\sqrt{\alpha}}$

(c) $\alpha = \sqrt{\beta}; \omega_n = \sqrt{\alpha}$

(d) $\zeta = \frac{\sqrt{\alpha}}{\beta}; \omega_n = \sqrt{\beta}$

38. Ans: (a)

Sol: Given data:

$TF = C\,[SI - A]^{-1} B + D \qquad \because D = 0$

$$TF = C\,\frac{Adj[SI - A]}{[SI - A]}B$$

$$[SI - A] = \begin{bmatrix} S & -1 \\ \alpha & S+2\beta \end{bmatrix}$$

$$TF = \frac{\begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} S+2\beta & 1 \\ -\alpha & S \end{bmatrix}\begin{bmatrix} 0 \\ \alpha \end{bmatrix}}{S(S+2\beta)+\alpha} = \frac{\begin{bmatrix} 1 & 0 \end{bmatrix}\begin{bmatrix} \alpha \\ s\alpha \end{bmatrix}}{s^2 + 2\beta s + \alpha}$$

$$TF = \frac{\alpha}{s^2 + 2\beta s + \alpha}$$

$\omega_n = \sqrt{\alpha}$ rad/sec

$2\,\xi\omega_n = 2\beta$

$$\beta = \xi\omega_n \Rightarrow \xi = \frac{\beta}{\omega_n} = \frac{\beta}{\sqrt{\alpha}}$$

End of Solution

39. A 220 V DC shunt motor takes 3 A at no-load. It draws 25 A when running at full-load at 1500 rpm. The armature and shunt resistances are 0.5 Ω and 220 Ω, respectively. The no-load speed in rpm (round off to two decimal places) is _____.

39. Ans: 1579.32

Sol: DC shunt motor:

No-load (case-1):

$V_t = 220$ V

$I_{L1} = 3A$

$N_1 = ?$

$$I_{sh1} = \frac{V_t}{r_{sh}} = \frac{220}{220} = 1A$$

$\Rightarrow I_{a1} = I_{L1} - I_{sh1}$

$= 2A$

$E_{b1} = V_t - I_{a1}r_a = 220 - (2)(0.5) = 219$ V

Loaded (case 2):

$V_t = 220$ V

$I_{L2} = 25$ A

$N_2 = 1500$ rpm

$I_{sh2} = \frac{V_t}{r_{sh}} = 1A$

$\therefore \varphi = \text{constant}$

Since field current is constant

$I_{a2} = I_{L2} - I_{sh2}$

$= 24$ A

$E_{b2} = V_t - I_{a2} r_a$

$= 220 - (24)(0.5)$

$= 208$ V

$E_b = k_a \varphi \omega \Rightarrow E_b \propto N$

$$= \frac{E_{b1}}{E_{b2}} = \frac{N_1}{N_2} = \frac{219}{208} = \frac{N_1}{1500} \Rightarrow N_1 = 1579.32 \text{ rpm}$$

End of Solution

40. A fully-controlled three-phase bridge converter is working from a 415 V, 50 Hz AC supply. It is supplying constant current of 100 A at 400 V to a DC load. Assume large inductive smoothing and neglect overlap. The rms value of the AC line current in amperes (round off to two decimal places) is ______.

40. Ans: 81.66

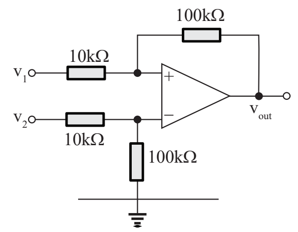
Sol: In a 3-φ bridge rectifier

RMS value of AC line current = $I_0\sqrt{\frac{2}{3}}$

$$= 100\sqrt{\frac{2}{3}} = 81.66 \text{ Amps}$$

End of Solution

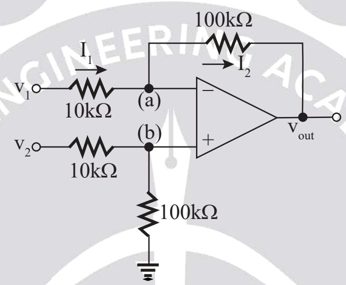
41. In the circuit below, the operational amplifier is ideal. If V_1 = 10 mV and V_2 = 50 mV, the output voltage (V_{out}) is



(a) 500 mV (b) 600 mV (c) 400 mV (d) 100 mV

41. Ans: (c)

Sol:



KCL at (a) $I_1 = I_2$

$$\frac{V_1 - V_a}{10K} = \frac{V_a - V_0}{100K}$$

$$10V_1 - 10V_a = V_a - V_0$$

$$V_0 = 11V_a - 10V_1$$

$$= 11\left(\frac{10}{11}\right)V_2 - 10V_1$$

$$= 10(V_2 - V_1)$$

$$= 10(40 \times 10^{-3})$$

$$= 400 \text{ mV}$$

End of Solution

42 . A 30 kV, 50 Hz, 50 MVA generator has the positive, negative , and zero sequence reactances of 0.25 pu, 0.15pu, and 0.05pu, respectively. the neutral of the generator is grounded with a reactance so that the fault current for a bolted LG fault and that of a bolted three-phase fault at the generator terminal are equal. The value of grounding reactance in ohms (round off to one decimal place) is_______

42. Ans: 1.8

Sol: Given data:

A 3-φ alternator 30 kV, 50 Hz, 50 MVA has sequence reactances

$X_1 = 0.25$ pu, $X_2 = 0.15$ pu, $X_0 = 0.05$ pu

Neutral of alternator grounded with a reactance to make

$|I_{f\,(LG)}| = |I_{f\,(LLL)}|$

$$\frac{3.E_{a1}}{X_1 + X_2 + X_0 + 3X_n} = \frac{E_{a1}}{X_1}$$

$X_1 + X_2 + X_0 + 3X_n = 3X_1$

$0.45 + 3X_n = 0.75$

$X_n = 0.1$ pu

$$Z_{base} = \frac{[\text{kV base}_{(LL)}]^2}{\text{MVA base}_{(3-\phi)}} = \frac{30^2}{50} = 18\,\Omega$$

$\therefore X_n(\Omega) = 0.1 \times 18$

$= 1.8\,\Omega$

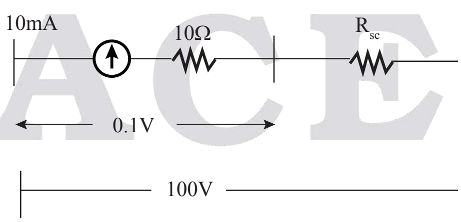
End of Solution

43. A moving coil instrument having a resistance of 10Ω, gives a full-scale deflection when the current is 10mA. What should be the value of the series resistance, so that it can be used as a voltmeter for measuring potential difference up to 100 V?

(a) 9 Ω (b) 990 Ω (c) 99 Ω (d) 9990 Ω

43. Ans:(d)

Sol:



$$R_{sc} = R_m\left[\frac{V}{V_m} - 1\right]$$

$$= 10\left[\frac{100}{0.1} - 1\right]$$

$10[999]$

$= 9990\Omega$

End of Solution

ESE / GATE / PSUs - 2020 ADMISSIONS OPEN

CENTER	COURSE	BATCH TYPE	DATE
LUCKNOW	GATE+PSUs - 2020	Regular Batch	Mid - May 2019
PATNA	GATE+PSUs - 2020	Weekend Batch	16th Feb 2019
VIJAYAWADA	GATE+PSUs - 2020 & 21	Weekend Batch	10th, 24th Feb 2019
VIJAYAWADA	GATE+PSUs - 2020	Summer + Weekend	6th, 15th May 2019
VIJAYAWADA	GATE+PSUs - 2020	Regular Batch	8th, 22nd June 2019
KOLKATA	GATE+PSUs - 2020&21	Weekend Batch	16th Feb 2019
KOLKATA	GATE+PSUs - 2020	Regular Batch	8th June 2019
KOLKATA	ESE+GATE+PSUs - 2021	Evening & Weekend	16th Feb 2019
AHMEDABAD	GATE+PSUs - 2020	Regular Batch	02nd Week of June 2019

GENCO TRANSCO DISCOMs

ELECTRICAL ENGINEERING

Regular Batch : 10th Feb 2019

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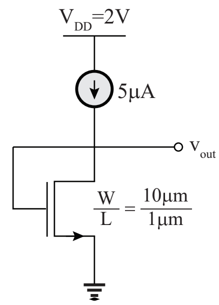
44. The enhancement type MOSFET in the circuit below operates according to the square law. $\mu_n C_{ox} = 100\mu A/V^2$, the threshold voltage (V_T) is 500 mV. Ignore channel length modulation. The output voltage V_{out} is



(a) 2 V (b) 500 mV (c) 600 mV (d)100 mV

44. Ans: (c)

Sol: $V_S = 0$ V and $V_D = V_{out}$,

$\Rightarrow V_{DS} = V_{out}$

$V_{gs} = V_g - V_s = V_{out}$

$V_{th} = 0.5$

$V_{ds}(sat) = V_{gs} - V_{th}$

$= V_0 - 0.5$

As $V_{ds} > V_{ds}$ (sat)

The transistor in saturation region

$$I_D = \frac{1}{2}\mu_x C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_T)^2$$

$$5 \times 10^{-6} = \frac{1}{2} \times 100\ 10^{-6}(10)(V_{GS} - V_T)^2$$

$$5 \times 2 = 1000(V_{GS} - V_T)^2$$

$$V_{GS} - V_T = 10^{-1}\text{V}$$

$$V_{GS} = V_T + 0.1$$

$$= 600 \text{ mV}$$

End of Solution

45. The probability of a resistor being defective is 0.02. There are 50 such resistors in a circuit. The probability of two or more defective resistors in the circuit (round off to two decimal places) is ______

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45. Ans: 0.2642

Sol: P = Probability of defective resister

= 0.02

$n = 50 \Rightarrow \lambda = np = 1$

Lt X be number of defective Resistors

$P(X \geq 2) = 1 - P(X < 2)$

$= 1 - \{P(X = 0) + P(X=1)\}$

$= 1 - \left[\frac{e^{-\lambda}\lambda^0}{0!} + \frac{e^{-\lambda}\lambda^1}{1!}\right]$

$= 1\ \{e^{-1} + e^{-1}\}$

$= 1 - \frac{2}{e}$

$= 0.2642$

End of Solution

46. A 220 V (line), three-phase, Y-connected, synchronous motor has a synchronous impedance of (0.25+j2.5) Ω/phase. The motor draws the rated current of 10 A at 0.8 pf leading. The rms value of line-to-line internal voltage in volts (round off to two decimal places) is_______

46. Ans: 245.32

Sol: $V_L = 220\text{ V} \Rightarrow V_{ph} = \frac{220}{\sqrt{3}} = 127.01.\text{ V}$

$Z_S = 0.25 + j2.5W = 2.512\angle 84.28^o$; $I_a = 10A$, 0.8 lead pf

$E_{ph} = \sqrt{(V\cos\phi - I_aR_a)^2 + (V\sin\phi + I_aX_s)^2}$

$= \sqrt{(127.01\times 0.8 - 10\times 0.25)^2 + (127.01\times 0.6 + 10\times 2.5)^2}$

$= 141.64$ V

$E_L = \sqrt{3}\times E_{ph} = \sqrt{3}\times 141.64 = 245.32$ V

Method 2:

$E_{ph} = V\angle 0 - I_a\angle\varphi Z_S\angle\theta$

$= 127.0.1\angle 0 - 10\angle 36.86 \times 2.512\angle 84.28^o$

$= 141.64\angle -8.71^o$

$E_L = \sqrt{3}\times 141.64 = 245.32$ V

End of Solution

47. The transfer function of a phase lead compensator is given by

$$D(s) = \frac{3\left(s + \frac{1}{3T}\right)}{\left(s + \frac{1}{T}\right)}$$

The frequency (in rad/sec), at which $\angle D(j\omega)$ is maximum, is

(a) $\sqrt{\frac{3}{T^2}}$ (b) $\sqrt{3T^2}$ (c) $\sqrt{\frac{1}{3T^2}}$ (d) $\sqrt{3T}$

47: Ans:(c)

Sol: Given data:

$$D(s)) = \frac{3\left(s + \frac{1}{3T}\right)}{\left(s + \frac{1}{T}\right)}$$

$$\omega_m = \sqrt{\omega_{c1} \times \omega_{c2}} = \frac{1}{\sqrt{3T \times T}} = \frac{1}{\sqrt{3T^2}}$$

End of Solution

48. Consider a 2 × 2 matrix $M = [v_1\ v_2]$, where, v_1 and v_2 are the column vectors. Suppose $M^{-1} = \begin{bmatrix} u_1^T \\ u_2^T \end{bmatrix}$, where u_1^T and u_2^T are the row vectors, Consider the following statements:

Statement 1: $u_1^T\ v_1 = 1$ and $u_2^T\ v_2 = 1$

Statement 2: $u_1^T\ v_2 = 0$ and $u_2^T\ v_1 = 0$

Which of the following options is correct?

(a) Statement 2 is true and statement 1 is false

(b) Both the statements are false

(c) Statement 1 is true and statement 2 is false

(d) Both the statements are true

48. Ans (d)

Sol: $M = (v_1\ v_2) = \begin{pmatrix} a & c \\ b & d \end{pmatrix}$

$$M^{-1} = \begin{pmatrix} u_1^T \\ u_2^T \end{pmatrix} = \begin{pmatrix} e & f \\ g & h \end{pmatrix}$$

$M^{-1}M = I$

$$\Rightarrow \begin{pmatrix} ea+bf & ec+fd \\ ga+hb & gc+hd \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$ea + bf + 1 \Rightarrow u_1^T\ v_1 = 1$

$ec + fd + = 0 \Rightarrow u_1^T\ v_2 = 0$

$ga + hb = 0 \Rightarrow u_2^T\ v_1 = 0$

$gc + hd = 1 \Rightarrow u_2^T\ v_2 = 1$

$\therefore$ Both the statements are correct.

End of Solution

49. A single -phase transformer of rating 25kVA, supplies a 12 kW load at power factor of 0.6 lagging. The additional load at unity power factor in kW (round off to two decimal places) that may be added before this transformer exceeds its rated kVA is ______

49. Ans: 7.21

Sol: Let rated voltage =V volts

12 kW, 0.6 lag → $V\times I_1\times 0.6 = 12000$

$$I_1 = \frac{12000}{0.6V} = \frac{20,000}{V}A.$$

$$\bar{I}_1 = \frac{20000}{V}\angle -53.13^\circ$$

Let UPF load = W kW

VI_2 = W 1000

$$I_2 = \frac{1000W}{V}$$

$$\bar{I}_2 = \frac{1000W}{V}\angle 0^\circ$$

When both loads are present, total current

$$\bar{I} = \frac{1000}{V}[20\angle -53.13 + W\angle 0^\circ]$$

$$= \frac{1000}{V}[12 - j16 + W]$$

$$I = \frac{1000}{V}\left[\sqrt{(12+W)^2 + 256}\right]$$

$$kVA = \sqrt{(12+W)^2 + 256} = 25$$

$(12+W)^2 + 256 = 625$, $(12+W)^2 = 369$, $2+W = 19.21$, $W = 7.21$ kW

End of Solution

50. A delta-connected 3.7 kW, 400 V (line), three-phase, 4 -pole, 50-Hz squirrel -cage induction motor has the following equivalent circuit parameters per phase refereed to the stator: $R_1 = 5.39\Omega$, $R_2 = 5.72\Omega$, $X_1 = X_2 = 8.22\Omega$. Neglect shunt branch in the equivalent circuit. The starting line current in amperes (round off to two decimal places) when it is connected to a 100 V (line), 10 Hz, three-phase AC source is ______

50. Ans: 14.94

Sol: Given equivalent circuit parameters at 50Hz, 400V (Line), 3φ, delta connected induction motor, reference to stator side

$R_1 = 5.39\ \Omega$, $R_2 = 5.72\ \Omega$

$X_1 = X_2 = 8.22\ \Omega$

starting current at 100V, 10Hz supply. Parameter which depends on frequency are X_1 & X_2. Therefore new value of X_1 & X_2 at 10Hz are

$$X_{1\,new} = X_{1\,old} \times \frac{f_{new}}{f_{old}}$$

$$= 8.22 \times \frac{10}{50} = 1.644\ \Omega$$

$$X_{2new} = X_{2old} \times \frac{f_{new}}{f_{old}}$$

$$= 8.22 \times \frac{10}{50} = 1.644\ \Omega$$

$$I_{st}/ph = \frac{V_{ph(new)}}{\sqrt{\left(R_1 + \frac{R_2}{1}\right) + \left(X_{1\,new} + X_{2new}\right)}}$$

$$I_{st}/Ph = \frac{100}{\sqrt{(5.39 + 5.72)^2 + (1.644 + 1.644)^2}}$$

$$= \frac{100}{11.5863}$$

$$= 8.63\text{A}$$

$$I_L = \sqrt{3}\ I_{ph} = \sqrt{3} \times 8.63$$

$$= 14.94\text{ A}$$

End of Solution

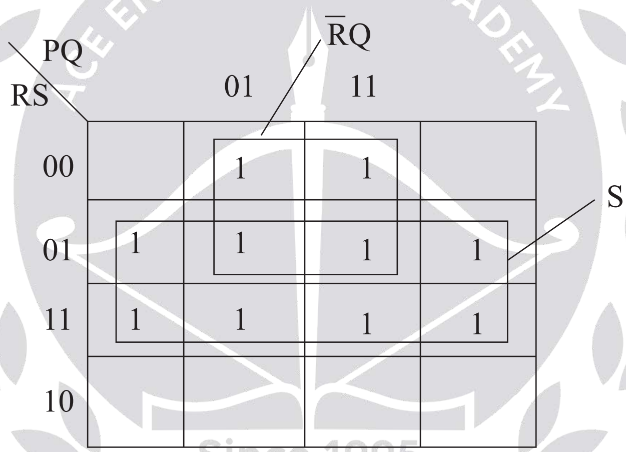
51. The output expression for the Karnaugh map shown below is

RS \ PQ	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

(a) $QR + \overline{S}$ (b) $Q\overline{R} + S$ (c) $QR + S$ (d) $Q\overline{R} + \overline{S}$

51. Ans: (b)

Sol:



$S + \bar{R}Q$

End of Solution

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52. The line currents of a three-phase four wire system are square waves with amplitude of 100 A. These three currents are phase shifted by 120° with respect to each other. The rms value of neutral current is

(a) $\frac{100}{\sqrt{3}}$A (b) 100 A (c) 0A (d) 300 A

52. Ans: (b)

Sol: Given data:

3-φ, 4-wire system carrying line currents as square waves with peak, I = 100 A.

Neutral current, $i_n = i_a + i_b + i_c$

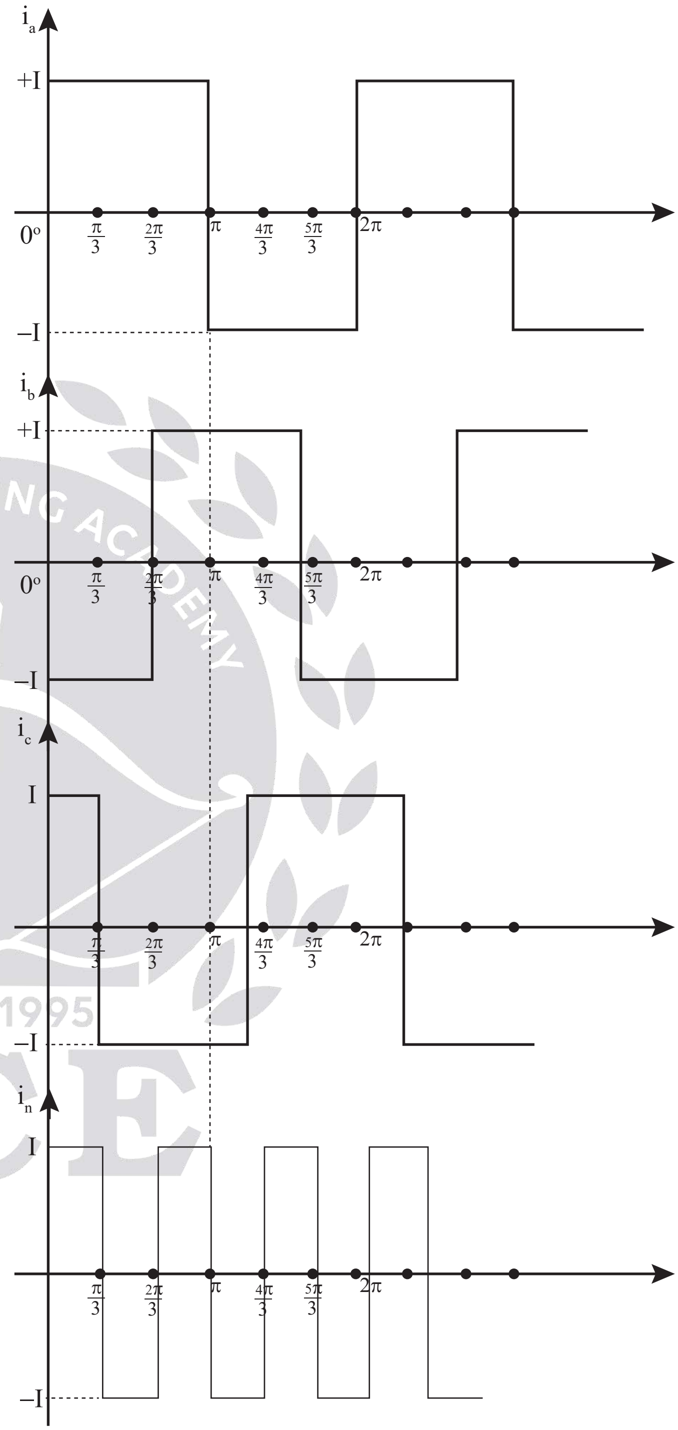
$$I_{n\,rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i_n^2 . d\omega t}$$

$$\left(I_{n\,rms}\right)^2 = \frac{1}{2\pi}\left[I^2 \times \frac{\pi}{3} \times 3 + (-I)^2 \times \frac{\pi}{3} \times 3\right]$$

$$= \frac{1}{2\pi}[2I^2.\pi]$$

$$= I^2$$

$$\left(I_{n\,rms}\right) = I = 100\text{ A}$$



End of Solution

ESE / GATE / PSUs - 2020
ADMISSIONS OPEN

CENTER	COURSE	BATCH TYPE	DATE
HYDERABAD - DSNR	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	ESE + GATE + PSUs - 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Morning/Evening Batch	24th February 2019
HYDERABAD - DSNR	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Abids	ESE + GATE + PSUs - 2020	Morning Batch	24th February 2019
HYDERABAD - Abids	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Weekend Batch	24th February 2019
HYDERABAD - Abids	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Morning/Evening Batch	24th February 2019
HYDERABAD - Kukatpally	GATE + PSUS – 2020	Regular Batches	17th May, 1st, 16th June, 1st July 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Kothapet	ESE + GATE + PSUS – 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Kothapet	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
DELHI	ESE+GATE+PSUs - 2020	Weekend Batches	9th Mar 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Evening Batch	18th Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Day Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2020	Spark Batch	11th May 2019
DELHI	GATE+PSUs - 2020	Short Term Batches	11th, 23rd May 2019
BHOPAL	ESE+GATE+PSUs - 2020	Regular Day Batch	01st Week of June 2019
BHUBANESWAR	GATE+PSUs - 2020	Weekend Batch	16th Feb 2019
BHUBANESWAR	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
CHENNAI	GATE+PSUs - 2020 & 21	Weekend Batch	16th Feb 2019
CHENNAI	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019
BANGALORE	GATE+PSUs - 2020 & 21	Weekend Batch	23rd Feb 2019
BANGALORE	GATE+PSUs - 2020	Regular Batch	17th June 2019

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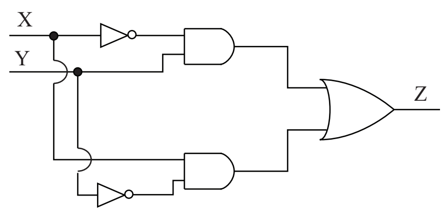
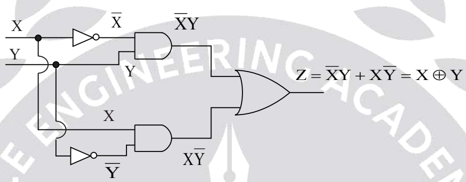
53. In the circuit shown below, X and Y are digital inputs, and Z is a digital output. The equivalent circuit is a



(a) XOR gate (b) NOR gate (c) XNOR gate (d) NAND gate

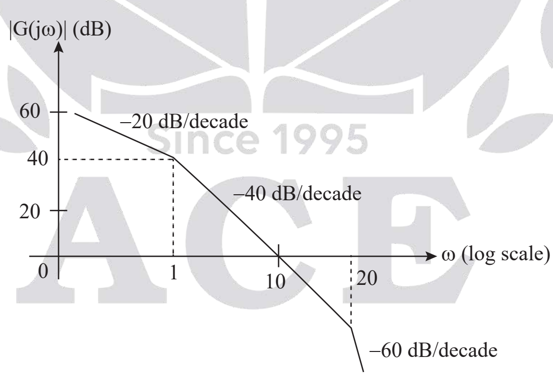
53. Ans:(a)

Sol:



End of Solution

54. The asymptotic Bode magnitude plot of a minimum phase transfer function G (s) is shown below



Consider the following two statements.

Statement I : Transfer function G(s) has three poles and one zero

Statement II: At very high frequency ($\omega \to \infty$), the phase angle $\angle G(j\omega) = -\frac{3\pi}{2}$.

Which one of the following options is correct?

(a) Statement I is false and statement II is true.

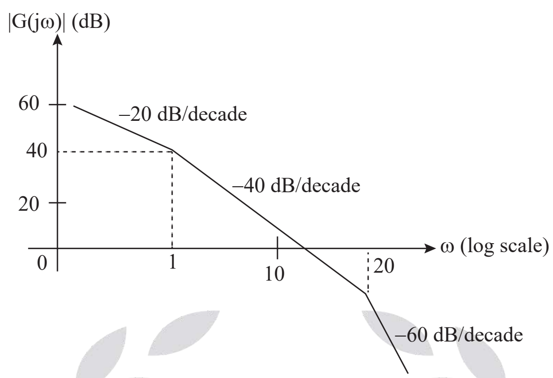
(b) Both the statements are false.

(c) Statement I is true and statement II is false

(d) Both the statements are true.

54. Ans:(a)

Sol: Given data:



$$G(s) = \frac{K}{s(1+s)\left(1+\frac{s}{20}\right)}$$

G(s) has 3 poles at high frequency $\angle G(j\omega) = -270°$

$$\angle G(j\omega) = -90° - \tan^{-1}(\omega) - \tan^{-1}\left(\frac{\omega}{20}\right)$$

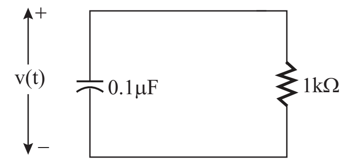
$$= -270°$$

End of Solution

55. A 0.1 μF capacitor charged to 100V is discharged through a 1 kΩ resistor. The time in ms (round off to two decimal places) required for the voltage across the capacitor to drop to 1 V is _________

55. Ans: 0.46

Sol:



$V(0) = V_0 = 100$ V

This is source free 1st order RC

$v(t) = V_0 e^{-t/t}$

$V_0 = 100$ V

$t = R_{eq}C = 1000 \times 0.1 \times 10^{-6}$

$v(t) = 100e^{\frac{-t}{0.1m}}$

$v(t) = 100e^{-10000t}$

$1 = 100e^{-10000t}$

$e^{-10000t} = \frac{1}{100}$

$-10000t = \ln\left(\frac{1}{100}\right) = -4.605$

$t = \frac{4.605}{10000} = 0.46$ msec

End of Solution