gradeup

GATE 2020

Electrical Engineering

Solution

GENERAL APTITUDE

1.

Ans. C

Sol This book, including all its chapters **is** interesting. The students as well as the instructor **are** in agreement about it.

2.

Ans. B

Sol. People were prohibited **from parking** their vehicles near the entrance of the main administrative building.

3.

Ans. C

Sol. Do: Undo : Trust : **Distrust**

4.

Ans. B

Sol. Stock market **plunged** at the news of the coup

5.

Ans C

Sol. Teams having member greater than one with Q as his always member

Case-1: 2 member in the team

$$Q\ \_\_\quad {}^{3}C_{1} = \frac{3!}{2!1!} = 3$$

Case-2: 3 members in the team

$$Q\ \_\_\ \_\_\quad {}^{3}C_{2} = \frac{3!}{2!1!} = 3$$

Case-3: 4 member in the team

$$Q\ \_\_\ \_\_\ \_\_\quad {}^{3}C_{3} = \frac{3!}{3!1!} = 1$$

3 + 3 + 1 = 7

6.

Ans B

Sol. In 1993, the holding period of loans is 360 days & after each revision one quarter of days was reduced.

After 1^{st} revision: Number of days left = 360 – 90 = 270

After 2^{nd} revision: Number of days left = 270 – 90 = 180

After 3^{rd} revision: Number of days left = 180 – 90 = 90

Hence, the holding period of loans in 2004 after the third revision was 90 days.

7.

Ans C

Sol. $\underset{(-2)}{Z \_\_ WV} \quad \underset{(-3)}{\_\_ RQP} \quad \underset{(-4)}{\_\_ KJIH}$

8.

Ans. B

Sol. $\underset{9}{\underline{X}}\ \underset{10}{\underline{X}}\ \underline{3}\ \underline{7} = 9 \times 10 = 90$

$\underset{9}{\underline{X}}\ \underline{3}\ \underline{7}\ \underset{10}{\underline{X}} = 9 \times 10 = 90$

$\underline{3}\ \underline{7}\ \underset{10}{\underline{X}}\ \underset{10}{\underline{X}} = 10 \times 10 = 10$

= 90 + 90 + 100 = 280

X 3 7 X and X X 3 7 will repeat twice

= 280 – 1 = 279

9.

Ans. A

Sol. Let radius of circle = r = AO = OB = OC

$\overline{AC} = \sqrt{r^2 + r^2} = \sqrt{2}r = \overline{CB}$

$\frac{\overline{AC} + \overline{CB}}{\overline{AB}} = \frac{\sqrt{2}r + \sqrt{2}r}{2r}$

$= \frac{2\sqrt{2}r}{2r} = \sqrt{2}$

10.

Ans C

Sol. Revenue of Q in 2015 is 20 % more than in 2014.

Q has earned a profit of 10% on expenditure in 2014.

Let the total revenue of Q in 2014 be x

Total revenue of Q in 2014 is

1.2x = 45

x = 37.5

Let expenditure of Q in 2014 be y,

%profit on expenditure is given as

$$10 = \frac{\text{revenue - expenditure}}{\text{expenditure}} \times 100$$

$$0.1 = \frac{37.5 - y}{y}$$

0.1y = 37.5 – y

1.1.y = 37.5

y = 34.09 or 34.1

TECHNICAL

11.

Ans A

Sol. $ax^3 + bx^2 + cx + d$

Let a = 1, b = 2, c = 2, d = 1

$f(x) = x^3 + 2x^2 + 2x + 1$

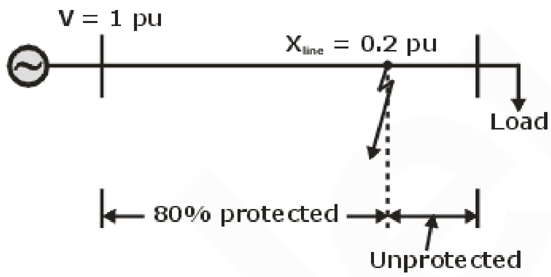
if x = 0 is a solution

f(0) = 0 implies that d = 0

12.

Ans. A

Sol.

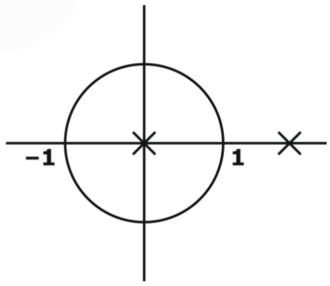


$$I_f = \frac{V}{0.8 \times \text{line}} = \frac{1}{0.8 \times 0.2} = \frac{1}{0.16} = 6.25$$

13.

Ans B

Sol. $\oint_c \frac{(z^2+1)}{z(z-2)} dz$



$$\oint_c \frac{(z+1)}{z(z-2)} = 2\pi i(\text{Re}(z=0)]$$

$$= 2\pi i\left[\frac{0+1}{0-2}\right]$$

$$= 2\pi i\left[-\frac{1}{2}\right] = -\pi i$$

14.

Ans 2

Sol. $G(s) = \frac{k}{(s+a)(s-b)(s+c)}$

No. of open loop poles in right half of s plane

P = 1

Nyquist plot encircles the origin of (1 + G(s)) plane once in clockwise direction

N = – 1

We know that

N = P – Z

Z = P – N

= 1 –(–1) = 2

No. of closed loop polos Z = 2

No. of closed loop poles lying in the right half of s plane = 2

15.

Ans 1.7 – 1.75

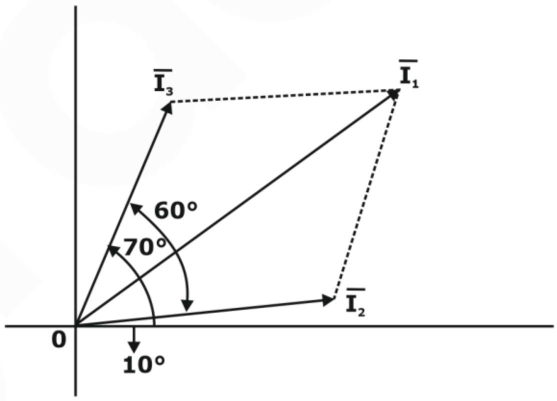
Sol. Reading of $A_2(I_2) = 1\angle 10°$ A

Reading of A_3 $(I_3) = 1\angle 70°$ A

Apply KCL,

$$\overline{I_1} = \overline{I_2} + \overline{I_3}$$

$$\overline{I_1} = 1\angle 10° + 1\angle 70°$$



Using parallelogram method.

$$I_1 = \sqrt{I_2{}^2 + I_3{}^2 + 2I_2I_3\cos 60°}$$

$$= \sqrt{(1)^2 + (1)^2 + 2(1)(1)\cos 60°} = \sqrt{3}$$

$I_1 = 1.732$ A

16.

Ans 0.88 – 0.8863

Sol. $\frac{dy}{dx} + y = 2x$

This is linear first order differential equation.

Integrating factor = $e^{\int 1dx} = e^x$

Solution is given as

$ye^x = \int e^x 2x\,dx + c$

$ye^x = 2\left[xe^x - e^x\right] + c$

$y = 2(x-1) + ce^{-x}$

At x = 0, y = 1

c = 3

$y = 2(x-1) + 3e^{-x}$

At x = ln 2, then y =

$y = 2(\ln 2 - 1) + 3e^{-\ln 2}$

$y = 2(\ln 2 - 1) + \frac{3}{2}$

$y = -0.6137 + 1.5 = 0.886$

17.

Ans. D

Sol. Voltage gain of common source amplifier, $A_V = -g_m R_D$

$= -520 \times 10^{-6} \times 4.7 \times 10^3 = -2.44$

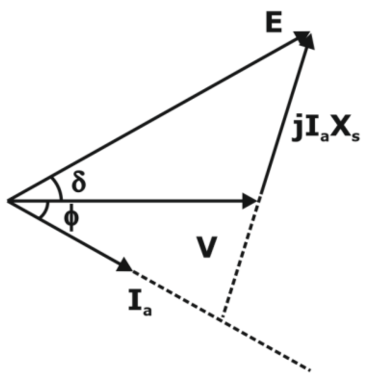
18.

Ans.

Sol. The voltage regulation for lagging loads ($R_a = 0$)

FIG

E is always greater than V, hence voltage regulation is always positive

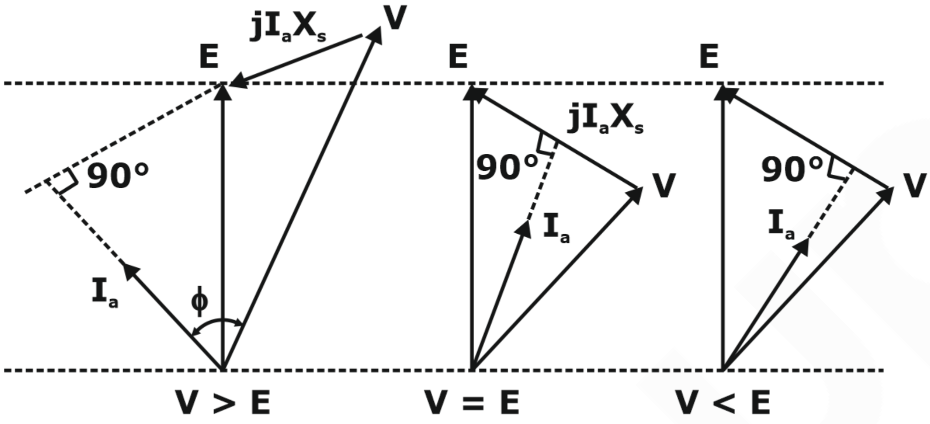


The voltage regulation for leading loads (R_a = 0)

There is no generalisation like lagging loads, the voltage regulation depends upon two factors for a

(i) Quantity of load (load magnitude)

(ii) Quality of load (load power facor)



19.

Ans. D

Sol. $\frac{d^2y(t)}{dt^2} + 4y(t) = 6r(t)$

r(t) is Input

y(t) is output

Taking Laplace transform both sides

$s^2y(s) + 4y(s) = 6\ R(s)$

$(s^2+4)\ y(s) = 6R(s)$

$T(s) = \frac{Y(s)}{R(s)} = \frac{6}{(s^2+4)}$

For calculation of poles,

$s^2 + 4 = 0$

$s = \pm j2$

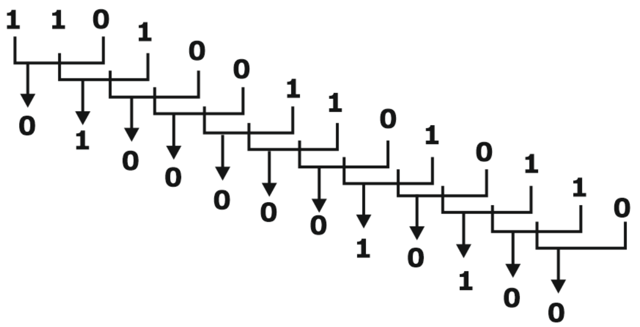
Poles of this system are

+ 2j, −2j

20.

Ans. C

Sol. In case of overlapping sequence detector, to detect (1,0,1) in the input sequence (1,1,0,1,0,0,1,1,0,1,0,1,1,0) is



Hence, the output of the sequence detector is (0,1,0,0,0,0,0,1,0,1,0,0).

21.

Ans. C

Sol. 1. $\int_{-1}^{l} \cos\left(\frac{n\pi x}{l}\right)\cos\left(\frac{n\pi x}{l}\right)dx = \begin{cases} 2l & \text{if} \quad n = m = 0 \\ l & \text{if} \quad n = m \neq 0 \\ 0 & \text{if} \quad m \neq n \end{cases}$

2. $\int_{0}^{l} \cos\left(\frac{n\pi x}{l}\right)\cos\left(\frac{n\pi x}{l}\right)dx = \begin{cases} l & \text{if} \quad n = m = 0 \\ l/2 & \text{if} \quad n = m \neq 0 \ \ b \\ 0 & \text{if} \quad m \neq n \end{cases}$

3. $\int_{-1}^{l} \sin\left(\frac{n\pi x}{l}\right)\sin\left(\frac{n\pi x}{l}\right)dx = \begin{cases} l & \text{if} \quad m = n \\ 0 & \text{if} \quad m \neq n \end{cases}$

4. $\int_{0}^{l} \sin\left(\frac{n\pi x}{l}\right)\cos\left(\frac{n\pi x}{l}\right)dx = \begin{cases} l/2 & \text{if} \quad n = m \\ 0 & \text{if} \quad n \neq m \end{cases}$

5. $\int_{-l}^{l} \sin\left(\frac{n\pi x}{l}\right)\cos\left(\frac{n\pi x}{l}\right)dx = 0$

A. $\frac{l}{\pi}\sin m\theta \cos n\theta = 0$

Put l = π in rule 4

$\int_{0}^{\pi} \sin\left(\frac{n\pi x}{\pi}\right)\sin\left(\frac{m\pi}{\pi}\right)dx$

Given that, m ≠ n

$\frac{1}{\pi}\int_{0}^{\pi} \sin x \sin mx dx = 0$

(C). $\frac{1}{2\pi}\int_{-\pi}^{\pi} \sin p\theta \cos\theta d\theta = 0$

Put l = π in rule 5

$$\int_{-\pi}^{\pi} \sin\left(\frac{n\pi x}{\pi}\right)\cos\left(\frac{m\pi x}{\pi}\right)dx$$

Given that $m \neq 0$

$$\int_{-\pi}^{\pi} \sin nx \cos mx \, dx = 0$$

(D). $\underset{\alpha\to\infty}{\mathrm{Lt}} \frac{1}{2\alpha}\int_{-\alpha}^{\alpha} \sin p\theta \, d\theta = 0$

When, $\alpha \to \infty$,

$$\frac{1}{2\infty}\int_{-\infty}^{\infty} \sin p\theta \sin\theta d\theta = \frac{1}{\infty}(\text{finite}) = 0$$

22.

Ans. C

Sol. $x[n] = \left(\frac{1}{2}\right)^{(n-k)} \cdot u(n-k)$

$|z| > \frac{1}{2}$

$$\frac{1}{1-\frac{1}{2}z^{-1}} \xleftrightarrow{Z.T.} \left(\frac{1}{2}\right)^{n} \cdot u[n]$$

$|z| > \frac{1}{2}$

23.

Ans A

Sol.

24.

Ans 162.41 – 162.59

Sol. $P_i = P_h + P_e$

$$\left.\begin{aligned} P_h &= KhfB_m^{1.6} = K_1 f \\ P_e &= Kcf^2Bm^2 = k_2 f^2 \end{aligned}\right\} \text{Keeping } \frac{V}{f} = \text{constant}$$

$K_1.50 + K_2.(50)^2 = 450$

$K_1 + K_2.(50) = \frac{450}{50} = 9$

at $160V_1$, 40 Hz

$K_1.40 + K_2.(40)^2 = 370$

$K_1 + K_2.(4) = \frac{370}{40} = 8$

$$\begin{array}{l} K_1 + K_2.50 = 9 \\ \underline{\overset{-}{K_1} \overset{-}{+} K_2.40 \overset{-}{=} 8} \end{array}$$

$$K_2.10 = 1 \Rightarrow K_2 = \frac{1}{10}$$

$$K_1 = 9 - \frac{1}{10} \times 50 = 4$$

∴ 100V, 25 Hz

$P_e = p_h = K_c$

$= K_1.(25) + K_2.(25)^2$

$$= 4 \times 25 + \frac{1}{10} \times (25)^2$$

= 100 + 62.5 = 162.5 watt

25.

Ans 19.90 – 20.20

Sol. We know that output waveform can be expressed in Fourier series form

From the given wave form,

$$V_{on}(t) = \sum_{n=1,3,5}^{\infty} \frac{4V_s}{n\pi} \sin\left(\frac{n\pi}{2}\right) \sin nd \sin n\omega t$$

п – 26 = 2d

$$d = \frac{\pi}{2} - 6$$

for eliminating 3rd harmonics

$$\frac{4V_s}{3\pi} \sin\left(\frac{3\pi}{2}\right) \sin 3d = 0$$

sin3d = 0

$$3d = \pi \Rightarrow d = \frac{\pi}{3}$$

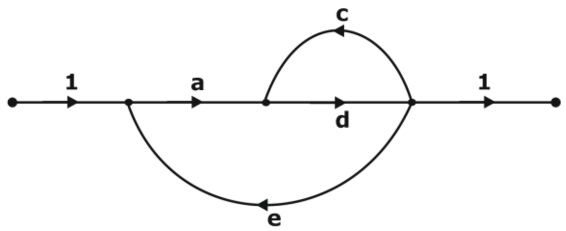
$$\left|\frac{V_{05}}{V_{01}}\right| = \left|\frac{\frac{4V_s}{5\pi} \sin\left(\frac{5\pi}{2}\right) \sin 5d}{\frac{4V_s}{\pi} \sin\left(\frac{\pi}{2}\right) \sin d}\right|$$

$$= \frac{1}{5} \times 100\% = 20\%$$

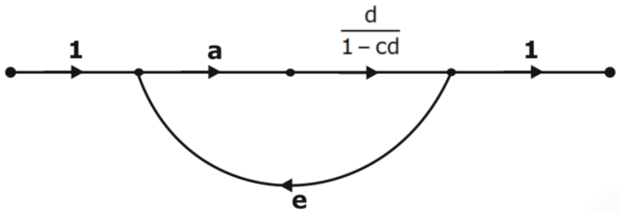
26.

Ans. B

Sol. Given signal flow graph is



It can be reduced as



It is matching with option (2)

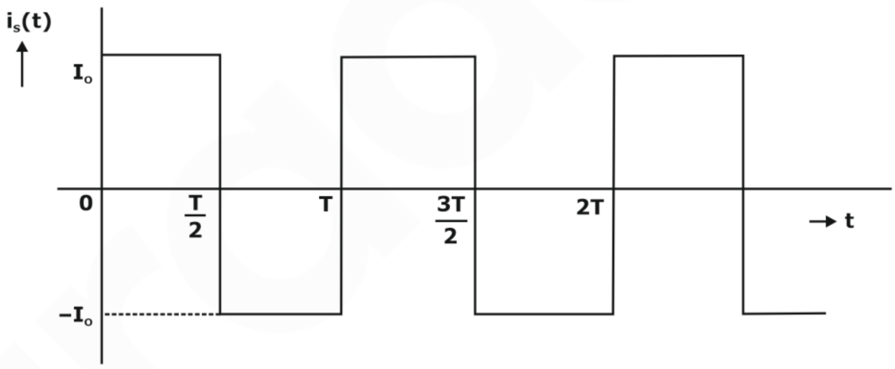
So, given signal flow graph and option (2) are equivalent.

27.

Ans. D

Sol. In a single-phase full bridge diode rectifier, since load is a series combination of finite resistance (R) and a very high Inductance (L). Load current is constant (I_o)

Source current is square wave form.



Fourier series representation of source current

$$i_s(f) = \sum_{n=1,3,5}^{\infty} \frac{4I_o}{n\pi} \sin n\omega t, \quad \text{where } \omega = \frac{2\pi}{T}$$

Two most dominant frequency

Components are f,3f [fundamental and third harmonics]

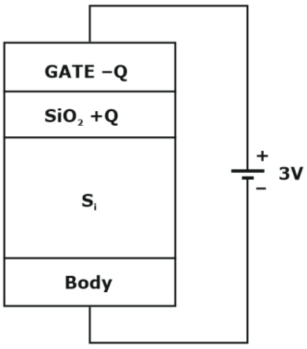
50 Hz, 150 Hz.

28.

Ans 0

Sol. So. The shematic shown is a MOS capacitor

When + 3V in applied, change inside the SiO_2 layer is + Q. Since it is MOS capacitor, the change in the GATE is Q.



29.

Ans. A

Sol. For generator buses, the solution of economic load dispatch is a processor to the load flow analysis.

30.

Ans. C

Sol. Given that:

x_R = rms value of x(t)

x_A = average value of x(t)

also, as x(t) = x(t - T), i.e., x(t) is a periodic waveform with period T

therefore, the rms value of x_R is given as

$$x_R = \sqrt{\frac{1}{T}\int_T x^2(t)\,dt}$$

And the average value of x_A is given as

$$x_A = \frac{\int_T x(t)\,dt}{T}$$

Now, therefore y(t) is also periodic signal with period "T",

Now, rms value is

$$y_R = \sqrt{\frac{1}{T}\int_T y^2(t)\,dt} = \sqrt{\frac{1}{T}\int_T k^2x^2(t)\,dt}$$

$$y_R = \sqrt{k^2\frac{1}{T}\int_T x^2(t)\,dt} = k\sqrt{\frac{1}{T}\int_T x^2(t)\,dt} = kx_R$$

Now, average value is

$$y_A = \frac{\int_T y(t)\,dt}{T} = \frac{\int_T ky(t)\,dt}{T} = k\frac{\int_T y(t)\,dt}{T} = kx_A$$

31.

Ans 3

Sol. Voltage across parasitic inductance,

$$V_L = L_{par}\frac{di}{dt}$$

The value of $\frac{di}{dt}$ is highest at point 3. Hence voltage across parasitic inductance is highest at point 3.

So, IGBT experiences the highest current stress at point 3.

32.

Ans A

Sol. Load Impedance

Z = 10 ∠ –60° = 10 cos 60 – j 10 sin 60°.

= (5 – j 8.66) Ω

Load is capacitive.

Maximum load power = 2 kW = 2000 watts.

Power consumed by load $P = I^2R$

$2000 = I^2 \times R$

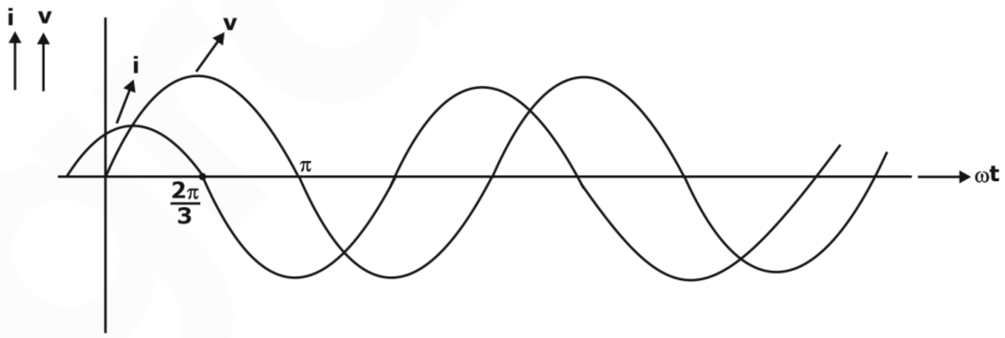
I = 20 aptitude

Output R.M.S. Voltage

V = IZ = 20 × 10 = 200 volt.

Maximum R.M.S output voltage = 200 volt.

Since load is capacitive, current would lead the voltage.



Minimum range of variation in L is (0 to 120°)

Note:- After 120°, current would change direction.

33.

Ans 4.10 – 4.40

Sol. Given data,

f = 50 Hz

P = 4

No. load slip = s_1 = 1% = 0.01

Full load slip = s_2 = 5% = 0.05

Let, No load speed = N_1

Full load speed = N_2

$$\because N_S = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

$N_1 = N_S(1 - s_1) = 1500\ (1 - 0.01) = 1485$ rpm

$N_2 = N_S(1 - s_2) = 1500\ (1 - 0.05) = 1425$ rpm

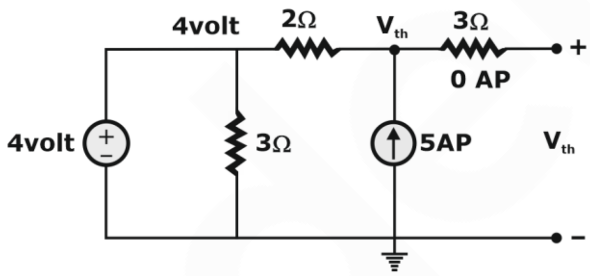
$$\text{Speed Regulation} = \frac{N_1 - N_2}{N_2} \times 100$$

$$= \frac{1485 - 1425}{1425} \times 100 = 4.21\%$$

34.

Ans 13.80 – 14.20

Sol.



Apply KCL at node A

$$\frac{V_{th} - 4}{2} = 5$$

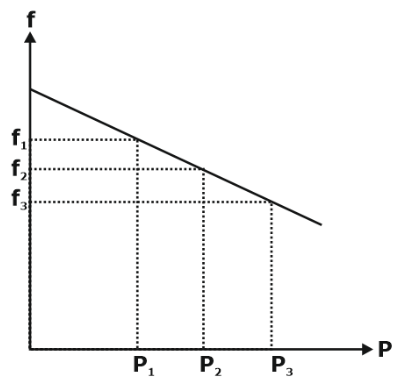
$V_{th} - 4 = 10$

$V_{th} = 14$ V

35.

Ans 125 – 135

Sol.



$f_1 = 50$ Hz, $f_2 = 49.75$ Hz, $f_3 = 49.25$ Hz.

$P_1 = 100$ MW, $P_2 = 110$ MW, $P_3 = ?$

$$\frac{f_1 - f_2}{P_2 - P_1} = \frac{f_2 - f_3}{P_3 - P_2} \qquad \text{(Same droop)}$$

$$\frac{0.25}{10} = \frac{0.5}{P_3 - 110}$$

$\Rightarrow P_3 = 110 = 20$

$P_3 = 130$ MW

36.

Ans A

Sol. $H(s) = \dfrac{s^2 + 100}{s - p}$

D.C. gain = 5

D.C. gain = $H(s)|_{s=0}$

$$= \left.\frac{s^2 + 100}{s - p}\right|_{s=0} = 5$$

$$\frac{100}{-p} = 5 \Rightarrow p = -20$$

$$H(s) = \frac{s^2 + 100}{(s + 20)}$$

For frequency domain $s = j\omega$

$$H(j\omega) = \frac{100 + (j\omega)^2}{20 + (j\omega)} = \frac{100 - \omega^2}{(20 + j\omega)}$$

$$\text{Gain} = |H(j\omega)| = \left|\frac{100 - \omega^2}{20 + j\omega}\right|$$

$$= \frac{100 - \omega^2}{\sqrt{400 + \omega^2}}$$

Frequency at unity gain

$$\frac{100 - \omega^2}{\sqrt{400 + \omega^2}} = 1$$

$(100 - \omega^2)^2 = (400 + \omega^2)$

Soling this equation

$\omega = 8.84$ rad/sec and 11.08 rad/sec.

Smallest positive frequency = 8.84 rad/sec.

37.

Ans -3.05 - -2.95

Sol. f = ya_x - xa_y

$$\int_c f.d\ell = \int_c (ya_x - xa_y).(dxa_x + dya_y)$$

$$= \int_c (ydx - xdy)$$

But $y = x^2$

$dy = 2xdx$

$$\int_c f.d\ell = \int_c x^2dx - x(2xdx)$$

$$= \int x^2dx - 2x^2dx = -\int x^2dx$$

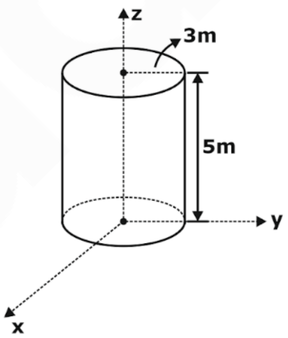
$$= -\int_{-1}^{2} x^2dx = -\left[\frac{x^3}{3}\right]_{-1}^{2}$$

$$= -\left[\frac{8}{3} - \left(-\frac{1}{3}\right)\right] = -3$$

38.

Ans. B

Sol. $\vec{D} = (15\,\hat{a}_r + 2r\,\hat{a}_\phi - 3rz\,\hat{a}_z)\ C/m^2$



$$Q_{enclosed} = \int \vec{D}.\vec{ds} = \int (\nabla.\vec{D})dv$$

$$\nabla.\vec{D} = \frac{1}{r}\frac{\partial}{\partial r}rD_r + \frac{1}{r}\frac{\partial}{\partial \phi}D_\phi + \frac{\partial D_z}{\partial z}$$

$$= \frac{1}{r}\frac{\partial}{\partial r}(15r) + \frac{1}{r}\frac{\partial}{\partial \phi}(2r) + \frac{\partial}{\partial z}(-3rz)$$

$$= \frac{15}{r} + (-3r) = \frac{15}{r} - 3r$$

$$Q_{enclosed} = \int_v \left(\frac{15}{r} - 3r\right) r\,dr\,d\phi\,dz$$

$$= \int_0^5 \int_0^{2\pi} \int_0^3 (15 - 3r^2) dr\, d\phi\, dz$$

$$= \int_0^5 \int_0^{2\pi} \left| 15r - \frac{3r^3}{3} \right|_0^3 d\phi\, dz$$

$$= \int_0^5 \int_0^{2\pi} (45 - 27) d\phi\, dz$$

= 18 × 5 × 2π = 180π C

39.

Ans. C

Sol. $\varepsilon_x = 2.25$

$$\vec{E} = 2\pi\hat{a}\pi + \frac{3}{\pi}\hat{a}_\phi + 6\hat{a}_z$$

Gauss Law,

$$\nabla \cdot \vec{E} - = \frac{\rho V}{\varepsilon_0 \varepsilon_\pi}$$

$$\Rightarrow \frac{\rho V}{\varepsilon_0 \varepsilon_\pi} = \frac{1}{\pi}\frac{\partial}{\partial \pi}(\pi E_\pi) + \frac{1}{\pi}\frac{\delta E_\phi}{\partial \phi} + \frac{\partial Ez}{\partial z} = \frac{1}{\pi}\frac{\partial}{\partial \pi}(2\pi^2) + \frac{1}{\pi}\frac{\partial}{\partial \phi}\left(\frac{3}{\pi}\right) + \frac{\partial}{\partial z}(b)$$

$$= \frac{1}{\pi} \times 4\pi = 4$$

$\rho_v = \epsilon_0(2.25 \times 4) = (9.00)\epsilon_0 = 9\epsilon_0$

40.

Ans. B

Sol. By Schwarz inequality,

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

$$z(t) = \int_{-\infty}^{\infty} |x(\tau)| |h(t - \tau)| d\tau$$

Hence z(t) ≥ y(t) for all value of t.

41.

Ans 210

Sol. M ← 2001H

A ← 21H

M ← 2002H

[A] ← [A] + [M]

[A] ← 21H + B1H

M ← 2003H

Display
21H + B–1H
$(21)_{16} = (33)_{10}$
$(B - 1)_{16} = (177)_{10}$
$= (210)_{10}$
So, it display 210.
42.
Ans
Sol. (4.70 – 4.80)
$I = I0^{e}$
$V_T = 29 \pm 2mV$

$$\ln\left(\frac{I}{I_0}\right) = \frac{V_D}{\eta V_T}$$

$$\ln I - \ln I_0 = \frac{V_D}{\eta V_T}$$

Differentiating partiality with respect + 0 V_T

$$\frac{\partial I}{I} = 0 + \frac{V_D}{\eta}\left(\frac{-1}{V_T^2}\right) \times \partial V_T$$

$$\frac{\partial I}{I} = \frac{-IV_0}{V_T^2}$$

$\eta = 1$
Resultant uncertainty

$$w_{res} = w_I\sqrt{\left(\frac{\partial I}{\partial V_T}\right)^2 \times w_v^2} = \pm\frac{\partial I}{\partial V_T} \times w_v$$

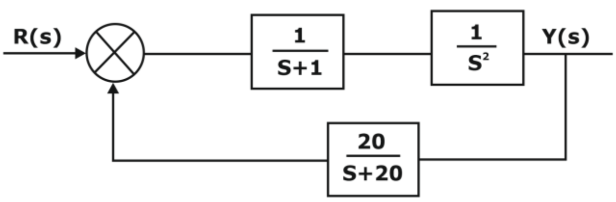
$$w_{res} = w_I = \pm\frac{IV_0}{V_T^2} w_V$$

$$W_I = \pm\frac{IV_0}{V_T^2} w_v \pm \frac{I \times 0.02}{(0.029)^2} \times 0.02$$

$= \pm\ 0.0475I$

$$\frac{w_I}{I} = \pm 0.0475 \times 100 = \pm\ 7.75\%$$

43.
Ans. B
Sol.



Closed loop characteristic equation

$1 + G(s)\,H(s) = 0$

$$1+\frac{1}{(s+1)}\frac{1}{s^2}\frac{20}{(s+20)}=0$$

$s^2(s+1)(s+20)+20=0$

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

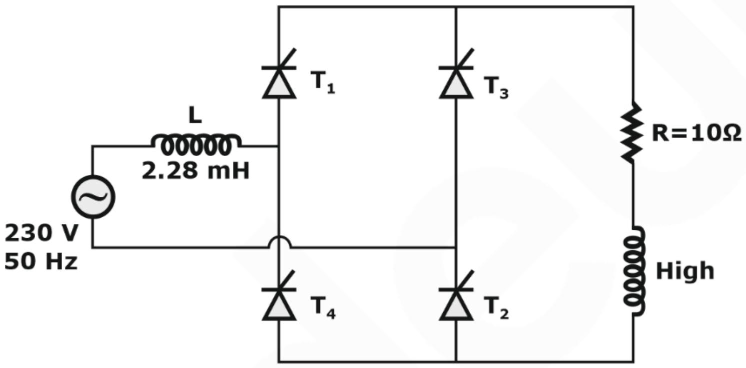
It is 4^{th} order system (degree = 4) It is unstable system because coefficient of s is zero.

It is 4^{th} order unstable system.

44.

Ans 4.51 – 5.10

Sol.



$$v_0=\frac{1}{\pi}\int_{\alpha+\mu}^{(\pi+\alpha)}V_m\sin\omega t\,d\omega t$$

$$=\frac{V_m}{\pi}\left[\cos\alpha+\cos(\alpha+\mu)\right]$$

$$I_0=\frac{V_0}{R}=\frac{V_m}{\pi R}\left[\cos\alpha+\cos(\alpha+\mu)\right]\qquad\ldots\text{(i)}$$

from α to (α + μ)

$$L_s\frac{di}{dt}=V_m\sin\omega t$$

$$\int_{-I_0}^{I_0}di=\frac{V_m}{\omega L_s}\left[-\cos\omega t\right]_{\alpha}^{(\alpha+\mu)}$$

$$2I_0=\frac{V_m}{\omega L_S}\left[\cos\alpha-\cos(\alpha+\mu)\right]$$

$$I_0=\frac{V_m}{2\omega L_s}\left[\cos\alpha-\cos(\alpha+\mu)\right]\ldots\text{(ii)}$$

from eqn. (i) & eqn. (ii)

$$\frac{V_m}{\pi R}\left[\cos\alpha+\cos(\alpha+\mu)\right]=\frac{V_m}{2\omega L_s}\left[\cos\alpha-\cos(\alpha-\mu)\right]$$

$$\frac{\cancel{V_m}}{\pi R}\left[\cos\alpha+\cos(\alpha+\mu)\right]=\frac{\cancel{V_m}}{2\omega L_s}\left[\cos\alpha-\cos(\alpha+\mu)\right]$$

$$\frac{2\omega L_s}{\pi R}\left[\cos\alpha+\cos(\alpha+\mu)\right]=\left[\cos\alpha-\cos(\alpha+\mu)\right]$$

$$\cos\alpha\left[1-\frac{2\omega L_s}{\pi R}\right]=\cos(\alpha+\mu)\left[1+\frac{2\omega L_s}{\pi R}\right]$$

$$\cos(\alpha+\mu)=\frac{\cos\alpha\left[1-\frac{2\omega L_s}{\pi R}\right]}{\left(1+\frac{2\omega L_s}{\pi R}\right)}$$

$$\cos(45^\circ+\mu)=\frac{1}{\sqrt{2}}\left(\frac{1-0.0456}{1+0.0456}\right)$$

$$=\frac{1}{\sqrt{2}}\left(\frac{0.9544}{1.0456}\right)$$

cos(45° + μ) = 0.6454

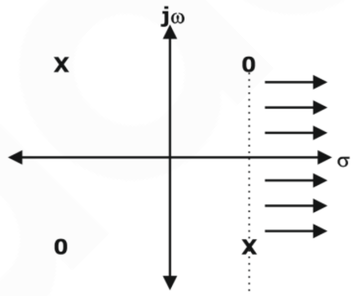
45° + μ = 49.804

μ = 4.804°

45.

Ans. D

Sol.



Unstable because ROC does not include unity circle.

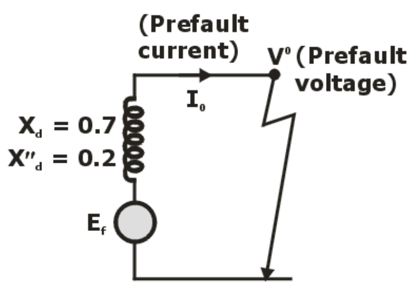
All pass : poles and zeroes are in image.

→ poles are not real conjugate.

46.

Ans 1.01 – 1.03

Sol.



$$I^0 = \frac{E_f - V^0}{j0.7} = \frac{(1 + j0.7) - 1}{j0.7} = 1 \text{ pu.}$$

Now, $E_f'' = v^0 + I^0 (j \times d'') = 1 + j0.2$

$E_f'' = 1.02$ p.u.

47.

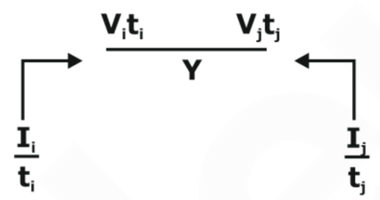
Ans A

Sol.

Let current I_i

$V_1 = V_i t_i$ and $V_2 = V_j t_j$

$$I_1 = \frac{I_i}{t_i} \;\&\; I_2 = \frac{I_j}{t_j}$$



$$\frac{I_i}{t_i} = \left(V_i t_i - V_j t_j\right) y \Rightarrow I_i = V_i t_i^2 .yV_j t_j .y.t_j$$

Similarly

$$\frac{I_j}{t_j} = \left(V_j t_j - V_i t_i\right) y$$

$$I_j = -V_i t_i t_j y + V_j t_j^2 .y$$

$$\therefore [Y] = \begin{bmatrix} yt_i^2 & -yt_i t_j \\ -yt_i t_j & yt_j^2 \end{bmatrix}$$

48.

Ans A

Sol.

For a conservative field,

$$\oint \vec{f}.\overrightarrow{d\ell} = 0$$

or $\nabla \times \vec{f} = 0$

$$\begin{vmatrix} \hat{a}x & \hat{a}y & \hat{a}z \\ \frac{d}{dx} & \frac{d}{dy} & \frac{d}{dz} \\ (5y - K_1 z) & (3z + K_2 x) & (K_3 y - 4x) \end{vmatrix}$$

$= \hat{a}_x(K_3 - 3) - \hat{a}y(-4 + K_1) + \hat{a}z(K_2 - 5)$

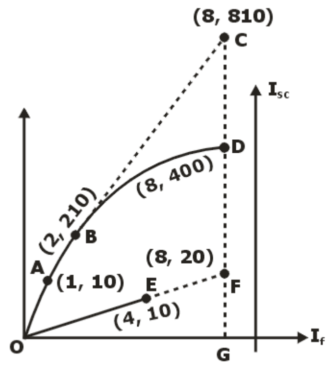
= 0

$\Rightarrow K_3 = 3, K_1 = 4, K_2 = 5$

49.

Ans A

Sol.



& $Z_s(\text{Sat}) = \frac{I_{OC}}{I_{SC}}$.

- Extend Seg OAB to Point C.

Coordinates of C(8, 810)

- Extend OE to F

Coordinates of F(8, 20)

Now, $Z_S(\text{unsat}) = \frac{GC}{GF} = \frac{810}{20}$

$Z_S(\text{sat}) = \frac{GD}{GF} = \frac{400}{20}$

$\frac{Z_s(\text{unsat})}{Z_s(\text{sat})} = \frac{810}{400} = 2.025$

50.

Ans B

Sol.

51.

Ans 4.95 – 5.05

Sol.

f = 10 KHz

$T = \frac{1}{f} = \frac{1}{10 \times 10^3} = 100\ \mu\text{sec}.$

D = 0.6

T_{ON} = DT = 0.6 × 100 = 6 μsec

T_{OFF} = (1 – D) T = 40 μsec.

Consider Ist cycle:

During T_{ON}

$V_L = V_S$ = 50 volt

$$V_L = L\frac{di}{dt}$$

$$\int_{I_{min}}^{I_{max}} di = \frac{V_L}{L}\int dt$$

$$= \int_0^{I_{max}} di = \frac{50}{10\times10^{-3}}\int_0^{T_{ON}} dt$$

$I_{max} = 5 \times 10^3 \times T_{ON}$

$= 5 \times 10^3 \times 60 \times 10^{-6}$

$= 300 \times 10^{-3}$ = 300 mA

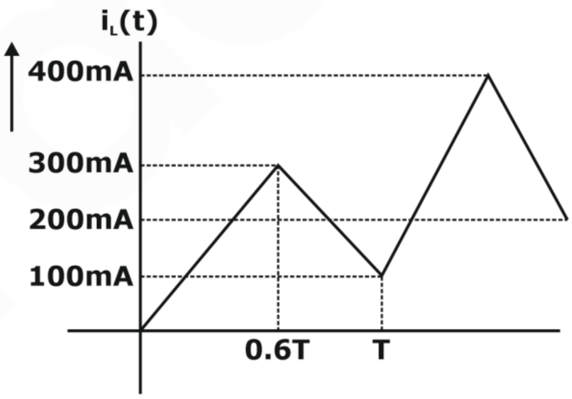
During T_{off} (V_L = –50 volt)

$$\int_{I_{max}}^{I_{min}} di = \frac{-50}{10\times10^{-3}}\int_{T_{ON}}^{T} dt$$

$(I_{min} - 300) = -5 \times 10^3 \times 0.4 \times 10 \times 10^{-6}$

= – 200 mA

I_{min} = 100 mA



Current in Inductor after Ist cycle = 100 mA

Current in Inductor after 10th cycle = 100 × 10 = 1000 mA = 1 A

Energy stored in Inductor = $= \frac{1}{2}LI^2$

$$= \frac{1}{2}\times 10mH \times (1)^2$$

= 5 mJ

52.

Ans A

Sol. $y = 3x^2 + 3x + 1$

$$\frac{dy}{dx} = 6x + 3 = 0$$

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

$$\frac{d^2y}{dx^2} = 6(+ve) \quad \text{so it is minimum}$$

Minimum value of y at $x = -1/2$

$$y = 3\left[\frac{-1}{3}\right]^2 + 3\left[\frac{-1}{2}\right] + 1$$

$$= \frac{3}{4} - \frac{3}{2} + 1 = \frac{3-6+4}{4} = \frac{1}{4}$$

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

for maximum value, calculate y at boundary

$$y|_{x=0} = 3(0)^2 + 3(0) + 1 = 1$$

$$y|_{x=-2} = 3[-2]^2 + 3[-2] + 1$$

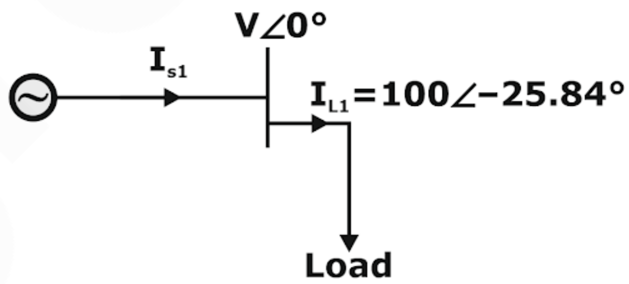
$= 12 - 6 + 1$

$y_{max} = 7$

53.

Ans 123 – 127

Sol.

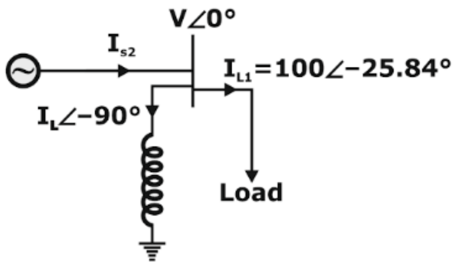


$f_1 = 0.9$, $\cos \varphi_1 = 0.9$

$\varphi_1 = 25.84°$

$|I_{L1}| = 100A$

$I_{L1} = 100 \angle - 25.84°$



(i) $I_{S1} = I_{L1} = 100\angle - 25.84°$

(ii) $I_{S2} = I_{L1} + I_L \angle - 90°$

$= 100 \angle - 25.84 + I_L \angle - 90°$

$Q_{sh\ reactor} = Q_{load}$

$VI_L = VI_{L1} \sin 25.84$

$I_L = 100 \sin 25.84$

$= 43.58$ A

then, $I_{s2} = 100 \angle - 25.84 + 43.58 \angle - 90°$

$= 100 \text{ cm } 25.84 + 43.58 \text{ cm } 90° + 100 \sin(-25.84) + I\ 43.58 \sin(-90°)$

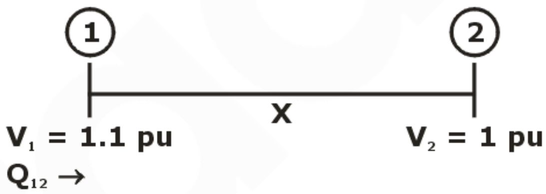
$= 90.00147 - 87.165$

$\simeq 125.3 \angle -44°$

54.

Ans. 1.11 – 1.13

Sol.



$Q_{12} \rightarrow$

$$Q_{12} = \frac{|V_1|^2}{x} - \frac{|V_1||V_2|}{X}\cos\delta$$

For a highly stable system, δ is very small, cosδ ≃ 1

$$Q_{12} = \frac{|V_1|^2}{x} - \frac{|V_1||V_2|}{X}$$

$$Q_{12} = \frac{|V_1|}{x} - (|V_1| - |V_2|) \ldots(1)$$

Let, for $Q_{12} \rightarrow 102\ Q_{12}$(20% increase)

$V_1 \rightarrow V'_1$

Then,

$$\frac{1.2Q_{12}}{Q_{12}} = \frac{|V_1'|(|V_1'||V_2'|)}{X} \times \frac{X}{|V_1|(|V_1| - |V_2|)}$$

$$1.2 = \frac{|V_1'|(|V_1'|-1)}{1.1(1.1-1)}$$

$|V'_1|^2 - |V'_1| - 0.132 = 4$

$|V'_1| = 1.118$, (-0.118 not possible)

$\simeq 1.12$ (Rounded off to two decimal places)

55.

Ans. A

Sol. $T(s) = \frac{K}{(\tau s + 1)}$

$r(t) = 5u(t)$

$R(s) = \frac{5}{s}$

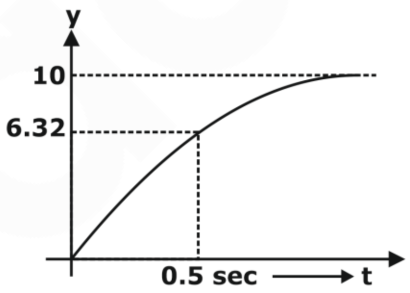
$C(s) = T(s).R(s) = \frac{K}{(\tau s+1)} \times \frac{5}{s}$

$$C(\infty) = \lim_{s\to 0} sC(s) = \lim_{s\to 0} s\frac{5K}{s(\tau s+1)}$$
$$= 5K$$

According to question

$C(\infty) = 10$

$5K = 10 \Rightarrow K = 2$



Time constant

$\tau = 0.5$

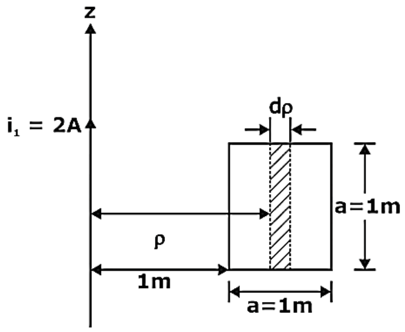
$T(s) = \frac{K}{(Ts+1)}$

$= \frac{2}{(0.5s+1)}$

56.

Ans 138.10 – 139.20

Sol. Given data,



$M = \frac{\phi}{i_1}$

where, φ is the flux linked with square loop due to current in the wire.

Let, magnetic field intensity due to long wire be,

$\vec{H} = \frac{I}{2\pi\rho}\hat{a}_\phi$

$\vec{B} = \frac{\mu I}{2\pi\rho}\hat{a}_\phi$

Now flux linked with the elemental strip,

$d\phi = \vec{B}.\vec{ds}$

$= \frac{\mu I}{2\pi\rho}(1.d\rho)$

$\phi = \frac{\mu I}{2\pi}\int_1^2 \frac{d\rho}{\rho}$

$= \frac{\mu I}{2\pi}\ln 2$

Now,

$M = \frac{\phi}{i_1} = \left(\frac{\mu I}{2\pi}\ln 2\right) \times \frac{1}{I}$

$= \frac{4\pi \times 10^{-7}}{2\pi} \times 0.693$

= 1.386×10^{-7} H

= 138.6 x 10-9 H = 138.6 nH

57.

Ans B

Sol. $I_D = I_S\left[e^{V_D/nVT} - 1\right]$ in the diode current equality for forward bios and reverse bias.

$I_1 = I_3\left[e^{-0.03/\frac{15}{3}\times 26mV} - 1\right]$

$2 \div 1 \Rightarrow 1.5\left[e^{-0.03/0.03} - 1\right] = \left[e^{VD/0.03} - 1\right]$

$\Rightarrow V_D = -0.0887V \simeq -0.09V$

58.

Ans B

Sol. For maximum power transfer, R_1 should be as small as possible 4 R_2 should be as large or possible.

∴ Option D in correct.

59.

Ans. A

Sol.

$y(z) - az^{-1}\, y(z) = b_0x(z) - b_1z^{-1}\, x(z)$

$$\frac{y(z)}{x(z)} = \frac{b_0 - b_1z^{-1}}{1 - az^{-1}}$$

So, system must be causal.

60.

Ans 54 – 56

Sol.

we know that voltage across capacitor

$V_c(t) = V_c(\infty) + [V_c(0) - V_c(\infty)]e^{-t/\tau}$

In case (i)

$0 = 10 + [-V_1 - 10]\, e^{-0.4t/\tau}$

$0 = 10 + [10 + V_1]\, e^{-0.4}$

$10 + V_1 = 10e^{8.4}$ ...(i)

In case (ii)

$0 = 10 + [-V_2 - 10]e^{-0.2}$

$10 + V_2 = 10e^{0.2}$ ...(ii)

$(10 + V_1) = 10e^{+0.4}$

$10 + V_1 = 10 \times 1.491$

$10 + V_1 = 14.91$

$V_1 = 4.91$ volt$(10 + V_2) = 10e^{0.2}$

$= 10 \times 1.221$

$10 + V_2 = 12.21$

$V_2 = 2.21$ volt

% change in Initial capacitor voltage

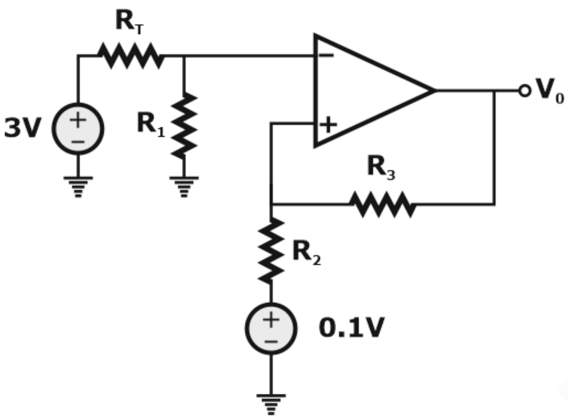
$$= \frac{4.91 - 2.21}{4.91} \times 100$$

$= 0.5498 \times 100 = 54.98\ \% \approx 55\%$

61.

Ans 0.08

Sol.



Given

R_T = 2(1 + 2T) k Ω

Case-i α = –4%

$$R_T = 2\left(1 - \frac{4 \times 150}{100}\right) = -10k\Omega$$

$$V_0 = 3 \times \frac{1k\Omega}{}$$

$$V_0 = 3 \times \frac{R_1}{R_1 + R_T}\left(1 + \frac{R_3}{R_2}\right) - 0.1 \times \frac{R_3}{R_3}$$

V_0 = –1.2

Case-ii R_T = 2(1 + 2T)

α = –3.75%

R_T = –9.25

$$V_0 = 3 \times \frac{1}{1 - 9.25}[3] - 0.2$$

V_0 = –1.290

Case-iii α = 4.25

R_T = 2(1 + 2T)

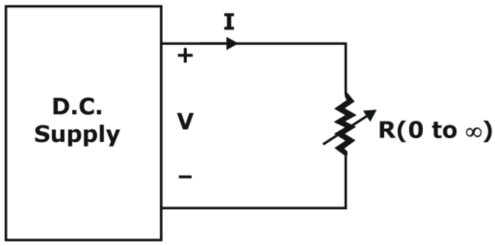
R_T = 10.75

V_0 = –1.12

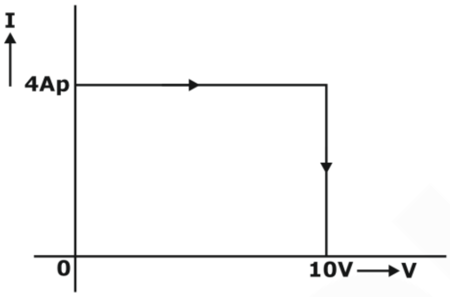
V_0 = –1.2 ± 0.08

Error = 0.08.

62.
Ans A
Sol.

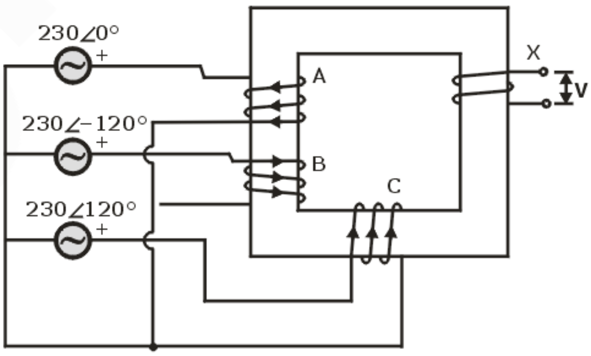


V – I Characteristic of D.C. supply



$$R = \frac{V}{I} = \frac{10}{4} = 2.5\Omega$$

If R > 2.5Ω , I < 4 A
If R < 2.5 Ω , V < 10 volt
Load Resistance for maximum power transferred
R_L = 2.5 Ω
Corresponding load voltage
V_o = IR = 4 × 2.5 = 10 Volt
Corresponding load current
I_o = 4 A
R_L = 2.5 Ω , I_o = 4 A , V_o = 10 volt.
63.
Ans 45.90 – 46.10
Sol.



$$V = \frac{2}{20}(130\ \angle 0^\circ) - \frac{2}{20}(230\angle -120^\circ) - \frac{2}{20}(230\ \angle 120^\circ) = 46\angle 0^\circ$$

64.
Ans D
Sol. Closed loop characteristic equation
1 + G(s) H(s) = 0

$$1+\frac{5^2+5+1}{5^3+25^2+25+k}\times 1=0$$

$5^3 + 35^2 + 35 + K + 1 = 0$

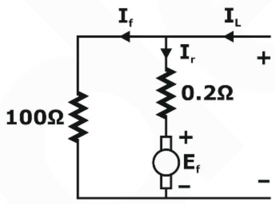
Routh array

$$\begin{array}{c|cc} 5^3 & 1 & 3 \\ 5^2 & 3 & k+1 \\ 5 & \frac{8-k}{3} & 0 \\ 5^0 & k+1 & 0 \end{array}$$

For poles on jω,

$$\frac{8-k}{3}=0 \Rightarrow K=8$$

Value of K = 8
65.
Ans B
Sol. Given—



$$I_f=\frac{250}{100}=2.54$$

at No load:-
E_1 = 250 – 0.2 × 5 – 2 = 247 V.
at loaded condition:
I_L = 50A
∴ I_a = 50 – 2.5 = 47.5 A
∴ E_2 = 250 – 47.5 × 8.2 – 2 = 238.5

$$\because E=\frac{P\phi N}{60A}\propto \phi N$$

$$\therefore \frac{E_1}{E_2}=\frac{\phi_1.N_1}{\phi_2.N_2}$$

$$\Rightarrow \frac{E_2}{E_1}=\frac{\phi_2.N_2}{\phi_1.N_1}$$

$$\Rightarrow \frac{238.5}{247}=\frac{0.95\phi_1.N_2}{\phi_1.1200}$$

N_2 = 1219.688 ≈ 1220 rpm

****