GATE 2023

ELECTRICAL ENGINEERING

Memory based Questions & Solutions

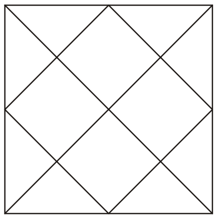
Exam held on 05th Feb, 2023 Forenoon Session

Corporate Office: 44-A/1, Kalu Sarai, New Delhi-110016
MADE EASY Centres : Delhi , Hyderabad , Jaipur, Bhopal, Lucknow, Bhubaneswar, Pune, Kolkata

9021300500 | www.madeeasy.in

SECTION - A GENERAL APTITUDE

Q.1 How many triangle are present in the given figure?



(a) 12
(b) 16
(c) 24
(d) 20

Ans. (d)

Total number of triangles is 20.

End of Solution

Q.2 The digit in the unit's place of the product $3^{999} \times 7^{1000}$ is

(a) 9
(b) 7
(c) 1
(d) 3

Ans. (b)

$\Rightarrow 3^{999} \times 7^{1000}$ As, $999 = 249 \times 4 + 3$

$\Rightarrow 3^3 \times 7^0$ $1000 = 250 \times 4 + 0$

$\Rightarrow 7 \times 1$

End of Solution

Q.3 _______ : PERMIT :: ENFORCE : RELAX

(a) Allow
(b) License
(c) Forbid
(d) Reinforce

Ans. (c)

FORBID is antonym of PERMIT.

End of Solution

Q.4 Given a fair six faced dice where the faces are labelled as 1, 2, 3, 4, 5 and 6. What is the probability of getting 1 on the first roll of the dice and 4 on the second roll of the dice?

(a) $\frac{5}{6}$
(b) $\frac{1}{6}$
(c) $\frac{1}{36}$
(d) $\frac{1}{3}$

Ans. (c)

$$P(1) = \frac{1}{6}$$

$$P(4) = \frac{1}{6}$$

$$\text{Required probability} = \frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$$

End of Solution

Q.5 Rita told Mary, "I am thinking of watching a film this weekend".

Indirect Speech:

Rita told Mary that she ______ of watching a film that weekend.

(a) am thinking
(b) was thinking
(c) is thinking
(d) thought

Ans. (b)

Option (b) is correct.

End of Solution

Q.6 A recent survey shows that 65% of tobacco users were advised to stop consuming tobacco. The survey also shows that 3 out of 10 tobacco users attempted to stop using tobacco. Based only on the interpretation of the above passage which one of the following options can be logically inferred?

(a) Approximately 30% of the tobacco users successfully stopped consuming tobacco.
(b) A majority of tobacco users who were advised to stop consuming tobacco did not attempt to do so.
(c) A majority of tobacco users who were adviced to stop consuming tobacco made an attempt to do so.
(d) Approximately 65% of tobacco users successfully stopped consuming tobacco.

Ans. (b)

End of Solution

■■■■

MADE EASY

NST-2
NATIONAL SCHOLARSHIP TEST 2024

For **ESE, GATE & PSUs 2024**

Offline & Online Long-Term Courses

Register at : www.madeeasy.in

Last Date to Register (Online) : 21st Feb, 2023

Test Date (Online) : 27th Feb, 2023

Time Duration	Total Questions	Total Marks	Negative Marking	Streams
45 Minutes	50 Questions	100 Marks	0.66 Marks	CE, ME, EE, EC, CS, CH

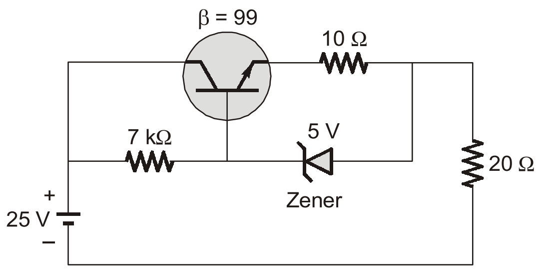
9021300500 | nst@madeeasy.in | nst.madeeasy.in | Scan to Register

Scholarship applicable on batches commencing between

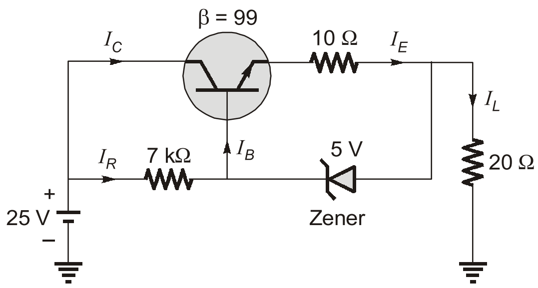
1st March, 2023 to 31st May, 2023

SECTION - B TECHNICAL

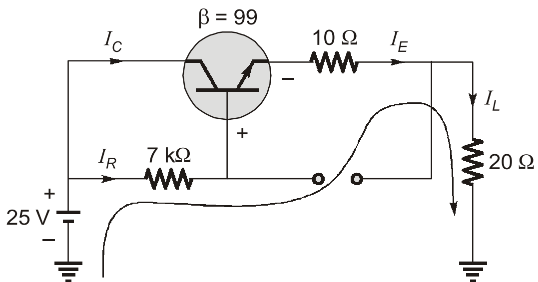
Q.1 The zener diode in circuit has a breakdown voltage of 5 V. The current gain β of transistor in active region is 99. Ignore base - emitter voltage drop V_{BE}. The current through the 20 Ω resistance in mA is _______ . (Round off 2 decimal places)



Ans. (250)



Assume zener off



$$25 = 7K \times I_B + I_E(10\Omega + 20\Omega)$$

$$25 = 7K \times I_B + I(1 + \beta)\, I_B(30\Omega)$$

$$25 = 7K \times I_B + 3000\Omega \times I_B$$

$$25 = 7K \times I_B + 3K\, I_B$$

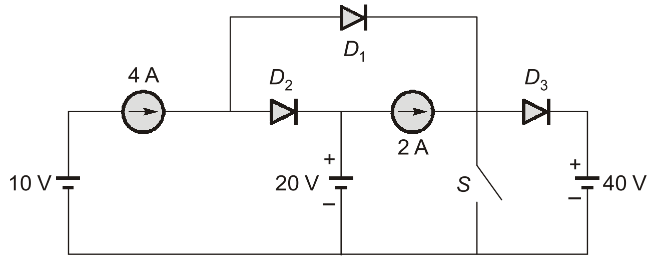
$$25 = 10K \times I_B$$

$$I_B = \frac{25}{10K} = 2.5\,\text{mA}$$

$$I_E = (1 + \beta)I_B$$
$$= (1 + 99) \times 2.5 \text{ mA}$$
$$= 100 \times 2.5 \text{ mA}$$
$$= 250 \text{ mA}$$

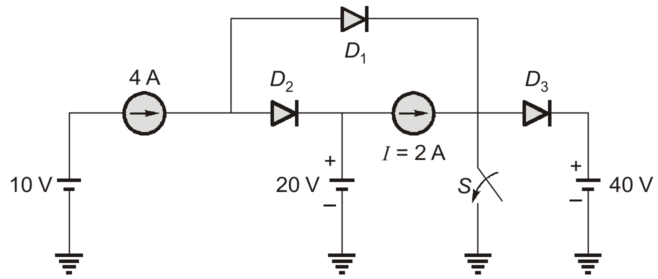
End of Solution

Q.2

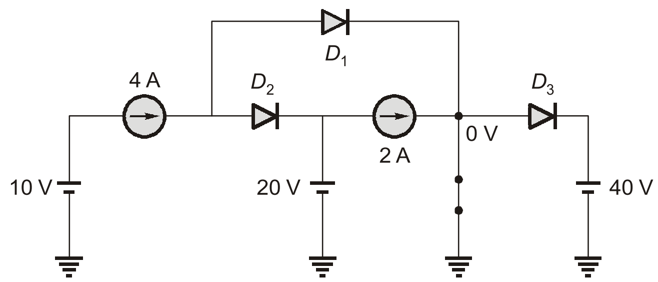


(a) When switch S is off, D_1 is reverse biased.
(b) When switch S is on, D_1 and D_2 conducts.
(c) When switch S is on, conductors D_2 , D_3 are reversed biased.
(d) When switch S is off, D_1 conductors, D_2 in reversed biased D_3 conductos.

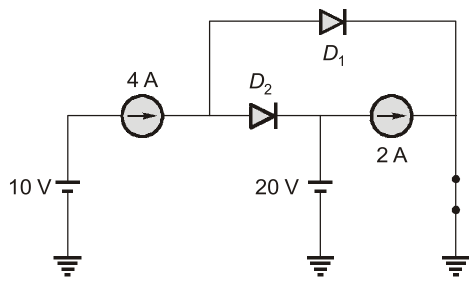
Ans. (a, c)



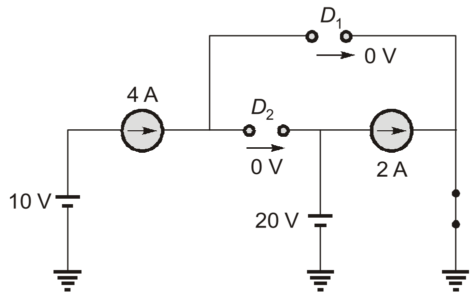
When switch on,



D_3 off by observation

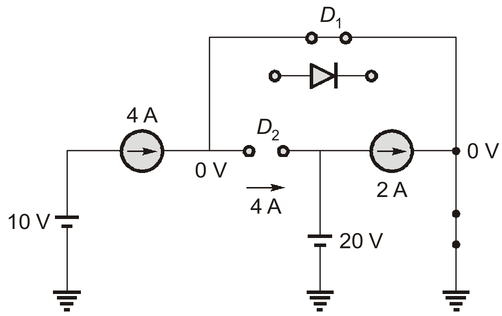


Assume D_1 and D_2 off



KCL validates not possible

Assume D_1 on, D_2 off

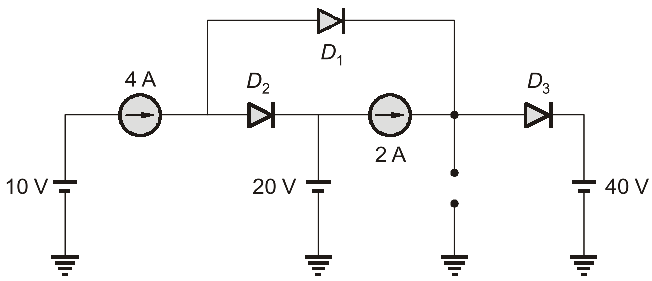


When D_1 on D_2 off

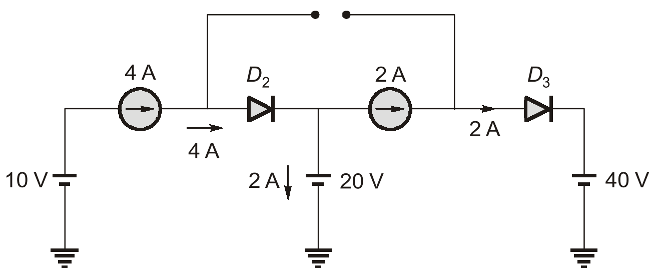
This assumption when switched:

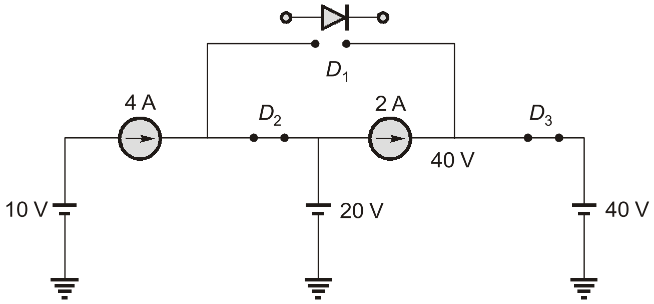
D_1 on , D_2 off, D_3 off correct

When switch is off,



Assume D_1 off



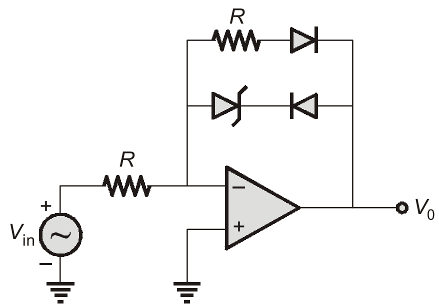


D_1 off

Switch off : D_1 off, D_2 and D_3 on.

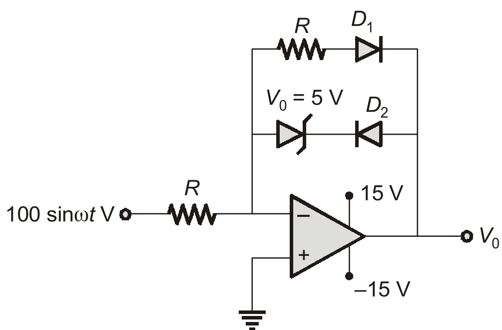
End of Solution

Q.3 $V_{in} = 10\sin(100t)$ V.



$V_Z = 5$ V, diodes are ideal. $V_{0(max)}$ = ______ . $V_{0(min)}$ = _____ .

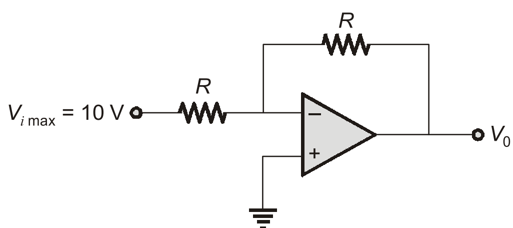
Ans. **(##)**



$V_{0\ min}$ and $V_{0\ max}$

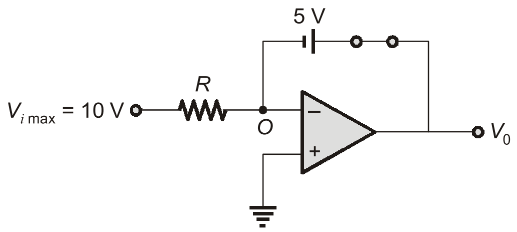
$$V_{i\ max} = 10 \text{ V}$$

D_1 on, D_2 off



$$V_0 = -V_i$$
$$\text{Minimum } V_0 = -10 \text{ V}$$
$$V_{i\,min} = -10 \text{ V}$$

$D_{1\,off}$, $D_{2\,on}$, zerer on



$$V_0 = +5 \text{ V } (V_{0\,max})$$
$$V_{0\,max} = +5 \text{ V}, \; V_{0\,min} = -10 \text{ V}$$

End of Solution

Q.4 The discrete-time fourier transform of a signal $x[n]$ is $X[\Omega] = (1 + \cos\Omega)e^{-j\Omega}$. Consider that $x_p[n]$ is a periodic signal of period $N = 5$ such that $x_p[n] = x[n]$, for $n = 0, 1, 2$.

Note that $x_p[n] = \sum_{k=0}^{N-1} a_k e^{j\frac{2\pi}{N}kN}$. The magnitude of the fourier series coefficient a_k at $k = 3$ is _____ (round off to 3 decimal palces.

Ans. **(0.038)**

Given that :

$$x(n) \Longleftrightarrow X(e^{j\Omega}) = (1 + \cos\Omega)e^{-j\Omega}$$

and $\quad x_p(n)$ = Periodic signal $\Longleftrightarrow$ a_K = DFS-coefficient with $N = 5$

where $\quad x_p(n) = \begin{cases} x(n), & \text{for } n = 0,1,2 \\ 0, & \text{for } n = 3, 4 \end{cases}$

Shortcut : $\quad a_K = \dfrac{X(e^{jK\Omega_o})}{N}$, where $\Omega_o = \dfrac{2\pi}{N} = \dfrac{2\pi}{5}$

$$= \frac{1}{5}(1+\cos K\Omega_o)\cdot e^{-jK\Omega_o}$$

$$= \frac{1}{5}\left[1+\cos\frac{2\pi}{5}K\right]\cdot e^{-j\frac{2\pi}{5}K}$$

Now, $\quad |a_K| = \dfrac{1}{5}\left[1+\cos\dfrac{2\pi}{5}K\right]$

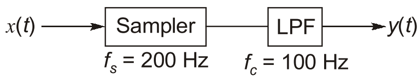
Put $K = 3$; $\quad |a_3| = \dfrac{1}{5}\left[1+\cos\dfrac{6\pi}{5}\right] = \dfrac{1}{5}(1-0.809) = 0.038$

End of Solution

Q.5 A signal $x(t) = 2\cos(180\pi t)\cos(60\pi t)$ is sampled at 200 Hz and then passed through an ideal low pass filter having cut-off frequency of 100 Hz. The maximum frequency present in the filtered signal in Hz is ____ (round off to the nearest interger).

Ans. (80)

Given that :



$$x(t) = 2\cos(180\pi t)\cos(60\pi t)$$
$$= \cos(240\pi t) + \cos(120\pi t)$$

where $f_1 = 120 \text{ Hz}, \; f_2 = 60 \text{ Hz}$

Frequency components present at sampler output

$$: f_1, \; f_s \pm f_1, \; 2f_s \pm f_1, \; .....$$
$$f_2, \; f_s \pm f_2, \; 2f_s \pm f_2, \; .....$$
$$: 120, \; 200 \pm 120, \; .....$$
$$60, \; 200 \pm 60, \; .....$$
$$: 120, \; 80, \; 320, \; .....$$
$$60, \; 140, \; 260, \; .....$$

Now, LPF will pass only 60 Hz and 80 Hz because these frequencies are less than cut-off frequency 100 Hz.

i.e., LPF-output : 60 Hz, 80 Hz.

So, maximum frequency available at LPF o/p is 80 Hz.

End of Solution

Q.6 The period of the discrete-time signal $x[n]$ described by the equation below is N = _____ (round off to the nearest integer).

$$x[n] = 1 + 3\sin\left(\frac{15\pi}{8}n + \frac{3\pi}{4}\right) - 5\sin\left(\frac{\pi}{3}n - \frac{\pi}{4}\right)$$

Ans. (48)

$$x[n] = 1 + 3\sin\left(\frac{15\pi}{8}n + \frac{3\pi}{4}\right) - 5\sin\left(\frac{\pi}{3}n - \frac{\pi}{4}\right)$$

$$= 1 + 3\sin\left(\omega_1 n + \frac{3\pi}{4}\right) - 5\sin\left(\omega_2 n - \frac{\pi}{4}\right)$$

where, $\omega_1 = \frac{15\pi}{8}, \; w_2 = \frac{\pi}{3}$

Now, $N_1 = \frac{2\pi}{\omega_1}K_1 = \frac{2\pi}{\frac{15\pi}{8}}K_1 = \frac{16}{15}K_1$

$$= 16 \text{ (for } K_1 = 15)$$

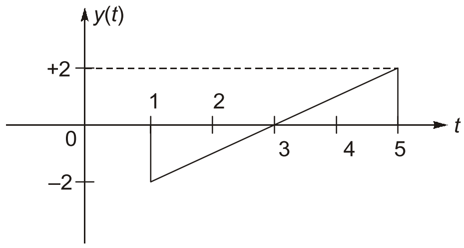
$$N_2 = \frac{2\pi}{\omega_2}K_2 = \frac{2\pi}{\frac{\pi}{3}}K_2 = 6K_2 = 6 \text{ (for } K_2 = 1)$$

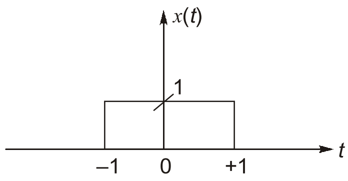
Time-period of $x(n)$ is :

$$N = \text{LCM}[N_1, N_2] = \text{LCM}[16, 6] = 48$$

End of Solution

Q.7 $z(t) = x(t)*y(t)$ is maximum at $t = T_1$, then T_1 is ____.

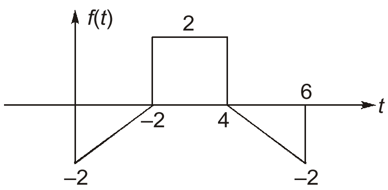




Ans. (4)

$$z(t) = y(t) * x(t) = y(t) * [u(t+1) - u(t-1)]$$
$$= y(t) * u(t) * [\delta(t+1) - \delta(t-1)]$$
$$= u(t) * [y(t) * \delta(t+1) - y(t) * \delta(t-1)]$$
$$= u(t) * [y(t+1) - y(t-1)]$$
$$= u(t) * f(t) \text{ where } f(t) = y(t+1) - y(t-1)$$

$\Rightarrow$
$$z(t) = \int_{-\infty}^{t} f(\tau)d\tau$$



Now,
$$z(t)|_{t=0} = 0$$
$$z(t)|_{t=2} = \text{Area of } f(t) \text{ upto “}t = 2\text{”}$$
$$= -\left(\frac{1}{2}\times 2\times 2\right) = -2$$
$$z(t)|_{t=4} = \text{Area of } f(t) \text{ upto “}t = 4\text{”} = -2 + 4 = 2$$
$$z(t)|_{t=6} = \text{Area of } f(t) \text{ upto “}t = 6\text{”} = 0$$

$\therefore$ $z(t)$ is maximum at $t = 4$.

End of Solution

Q.8 $x(t) \xrightarrow{FT} X(\omega)$

$$X(\omega) = \begin{cases} 1, & |\omega| < \omega_o \\ 0, & |\omega| > \omega_o \end{cases}$$

Which one is true?

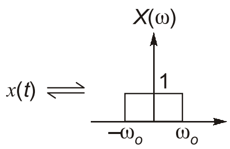
(a) At $t = \frac{\pi}{2\omega_o}$, $x(t) = \frac{1}{\pi}$

(b) $x(t)$ tends to be impulse as $\omega_o \to \infty$

(c) $x(o)$ decreases as ω_o increases

(d) At $t = \frac{\pi}{2\omega_o}$, $x(t) = -\frac{1}{\pi}$

Ans. (b)

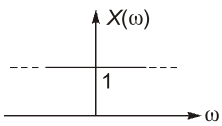


$$\therefore \quad x(t) = \frac{\sin \omega_o t}{\pi t}$$

At $t = \frac{\pi}{2\omega_o}$, $x\left(\frac{\pi}{2\omega_o}\right) = \frac{\sin\frac{\pi}{2}}{\pi \cdot \frac{\pi}{2\omega_o}} = \frac{2\omega_o}{\pi^2}$

$\therefore$ Option (a) and (d) are wrong.

If $\omega_o \to \infty$, then



i.e., $X(\omega) = \text{DC-signal} = 1$

$\therefore \quad x(t) = \delta(t)$

So, option (b) is correct.

Now, $x(0) = \frac{\text{Area of } X(\omega)}{2\pi} = \frac{2\omega_o}{2\pi} = \frac{\omega_o}{\pi}$

$\therefore$ $x(0)$ will increase if ω_o increases.

So, option (c) is wrong.

End of Solution

Q.9 Which one of the following is TRUE for $X(z) = \dfrac{4z}{\left(z-\frac{1}{5}\right)\left(z-\frac{2}{3}\right)(z-3)}$

(a) DTFT of $x[n]$ converges if ROC is such that $x[n]$ is right handed side sequence.

(b) DTFT of $x[n]$ converges if ROC is $\frac{2}{3} < |z| < 3$

(c) DTFT of $x[n]$ converges if ROC is $|z| > 3$

(d) DTFT of $x[n]$ converges if ROC is such that $x[n]$ is left handed side sequence.

Ans. (b)

If ROC is $\frac{2}{3} < |Z| < 3$ then it is including $Z = 1$ circle or unit-circle. So, DTFT will converge.

End of Solution

Q.10 Which one of the following is/are TRUE?

(a) If LTI system is CAUSAL, it is stable.

(b) If Impulse Response $0 < |h(n)| < 1$ for all n, then LTI system is stable system.

(c) If discrete LTI system has impulse response $h[n]$ of finite duration the system is stable.

(d) A discrete time LTI system is causal if and only if its response to a step input $U[n]$ is zero for $n < 0$.

Ans. (d)

As we know for causal LTI-system :

$$h(n) = 0, \; n < 0$$

If input is $u(n)$, then step-response $S(n)$ will start either from $n = 0$ or right-side of $n = 0$.

i.e., $$S(n) = 0, \; n < 0$$

End of Solution

Q.11 Consider the state-space description of an LTI system with matrices $A = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$; $C = \begin{bmatrix} 3 & -2 \end{bmatrix}$, $D = 1$. For the input, $5\sin(\omega t)$, $\omega > 0$, the value of ω for which the steady state output of the system will be zero, is ____ (round off to the nearest integer).

Ans. (2)

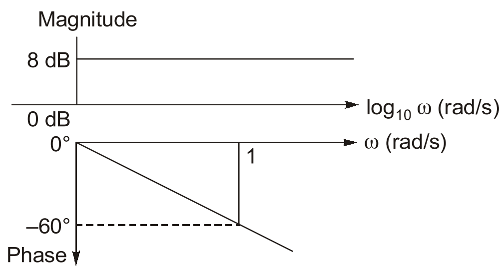
Given :
$$A = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$$
$$B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$
$$C = [3, \quad -2]$$
$$D = 1$$

The transfer function
$$TF = C[sI - A]^{-1}B + D$$
$$[sI - A]^{-1} = \begin{bmatrix} s & -1 \\ 1 & s+2 \end{bmatrix}^{-1}$$
$$= \frac{1}{(s^2+2s+1)}\begin{bmatrix} s+2 & 1 \\ -1 & s \end{bmatrix}$$
$$TF = \frac{1}{(s^2+2s+1)}[3 \quad -2]\begin{bmatrix} s+2 & 1 \\ -1 & s \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix} + 1$$
$$TF = \frac{1}{(s^2+2s+1)}[3 \quad -2]\begin{bmatrix} 1 \\ s \end{bmatrix} + 1$$
$$TF = \frac{(3-2s)}{(s^2+2s+1)} + 1 = \frac{s^2+4}{(s^2+2s+1)}$$
$$H(j\omega) = \frac{4-\omega^2}{(1-\omega^2+2j\omega)}$$

The output will be zero, for $\omega^2 - 4 = 0$
$$\omega = 2 \text{ rad/sec}$$

End of Solution

Q.12 The magnitude and phase plots of an LTI system are shown in the figure. The TF of the system is



(a) $\dfrac{e^{-2.514s}}{s+1}$

(b) $2.51e^{-1.047s}$

(c) $1.04e^{-2.514s}$

(d) $2.51e^{-0.032s}$

Ans. (b)

The transfer function, $TF = Ke^{-sT_d}$ (tranportation lag)

Given magnitude, $M = 8 \text{ dB} = 20 \log [K]$

$K = 2.511$

and angle at $\omega = 1$ rad/sec $= -60°$

$$\text{Angle, } \phi = -\omega T_d \times \frac{180°}{\pi}$$

$$60° = -1 \times T_d \times \frac{180°}{\pi}$$

$$T_d = 1.047$$

So, required transfer function

$$TF = 2.511 e^{-1.047 s}$$

End of Solution

Q.13 consider a lead compensator of the form

$$K(s) = \frac{1+\frac{s}{\alpha}}{1+\frac{s}{\alpha\beta}}, \; \beta > 1, \; \alpha > 0$$

The frequency at which this compensator produces maximum phase lead is 4 rad/s. At this frequency, gain amplification provided by controller asymptotic bode magnitude plot of $K(s)$ is 6 dB, then α, β are respectively

(a) 2.66, 2.25
(b) 1, 16
(c) 2, 4
(d) 3, 5

Ans. (c)

$$TF = \frac{1+\frac{s}{\alpha}}{1+\frac{s}{\alpha\beta}}, \alpha > 0, \beta > 1$$

$$TF = \frac{s+\alpha}{(s+\alpha\beta)}$$

Given : $\omega_m = \sqrt{\alpha(\alpha\beta)} = 4$

$$\alpha\sqrt{\beta} = 4 \quad ...(1)$$

Given at $\omega = \omega_m$

$$x = \frac{1}{\beta}$$

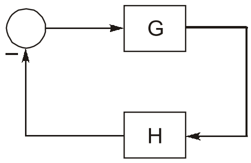
Amplification, $M = 10\log_{10}\frac{1}{x} = 6$

$$10 \log_{10}(\beta) = 6$$
$$\beta = 4$$

and $$\alpha = \frac{4}{\sqrt{4}} = 2$$

End of Solution

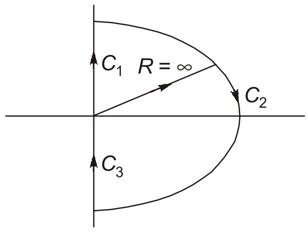
Q.14 In Nyquist plot of OLTF $GH = \frac{3s+5}{s-1}$ corresponding to feedback loop shown below, the infinite semicircle arc of Nyquist contour in s-plane is mapped into a point.



(a) GH = 0
(b) GH = –5
(c) GH = ∞
(d) GH = 3

Ans. **(d)**

Given : OLTF, $$GH = \frac{3s+5}{(s-1)}$$



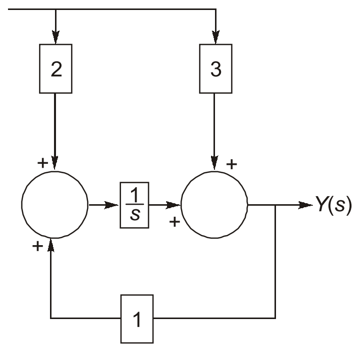
Here for mapping C_2,

$$GH = \lim_{R\to\infty} \frac{3Re^{j\theta}+5}{Re^{j\theta}-1}$$

$$GH = 3$$

End of Solution

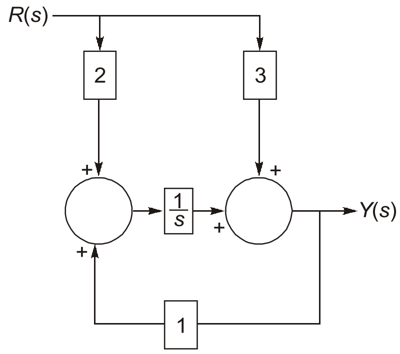
Q.15 For the block diagram shown in the figure, the transfer function $\frac{Y(s)}{R(s)}$ is



(a) $\frac{2s+3}{s+1}$ (b) $\frac{3s+2}{s+1}$

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

Ans. **(c)**



By signal flow graph

$$\frac{Y(s)}{R(s)} = \frac{3+\frac{2}{s}}{1-\left(\frac{1}{s}\right)} = \frac{3s+2}{(s-1)}$$

End of Solution

Q.16 A continuous-time system that is initially at test is described by $\frac{dy(t)}{dt} + 3y(t) = 2x(t)$, where $x(t)$ is the input voltage and y(t) is the output voltage. The impulse response of the system is

(a) $\frac{1}{3}e^{-2t}u(t)$ (b) $2e^{-3t}$

(c) $3e^{-2t}$ (d) $2e^{-3t}u(t)$

Ans. (d)

$$\frac{dy(t)}{dt} + 3y(t) = 2x(t) \quad ...(1)$$

For impulse response

$$x(t) = \delta(t)$$

$$\therefore \quad y(t) = h(t)$$

So, taking laplace transform of equation (1)

$$sH(s) + 3H(s) = 2(1)$$

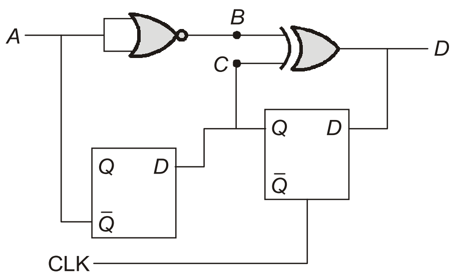
$$H(s) = \frac{2}{s+3}$$

$$\Updownarrow$$

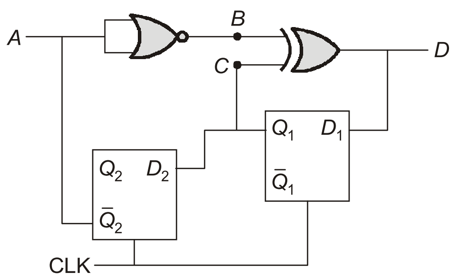
$$h(t) = 2e^{-3t}u(t)$$

End of Solution

Q.17 Neglecting delays of logic gates in the circuit shown in figure, the decimal equivalent of binary sequence [ABCD] of initial logic which will not change with clock is _____ .



Ans. (8)



From circuit,

$$D_1 = B \oplus C = Q_2 \oplus Q_1 ,$$

$$D_2 = Q_1$$

Let, $$Q_2Q_1 = 00$$

CLK	D_2	D_1	Q_2	Q_1
			0	0
(clock pulse)	0	0	0	0

} No change

Sequence :

$ABCD$

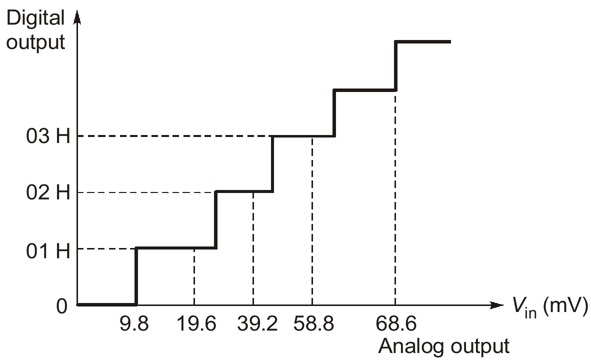
$\bar{Q}_2 Q_2 Q_1 (Q_1 \oplus Q_2)$

1 0 0 0

The decimal equivalent of 1000 is $(8)_{10}$.

End of Solution

Q.18 A 8-bit ADC converts analog voltage in the range of 0 to +5 V to corresponding digital code as per conversion characteristics shown below, the V_{in} = 1.992 volt. Which of the given option is true?



(a) 64 H
(b) 65 H
(c) 66 H
(d) 67 H

Ans. (c)

$$V_{in} = 1.992\text{ V},$$
$$n = 8,$$
$$V_{fs} = 5\text{ V}$$

We know, from graph

$$\text{Step size} = \frac{V_{fs}}{2^n - 1}$$

$$\text{Step size} = \frac{5}{2^8 - 1} = \frac{5}{255}$$

Analog input = Step size × (decimal equivalent of binary code)

$$1.992 = \frac{5}{255} \times D$$

$$D = \frac{1.992 \times 255}{5} = (101.592)_{10}$$

For decimal equivalent of 101,

$$\text{Analog input} = \frac{5}{255} \times 101 = 1.980$$

Here 1.98 is less than 1.992 so, we have to take decimal equivalent as 102

$$\text{For } (102)_{10} \text{ Analog input} = \frac{5}{255} \times 102 = 2$$

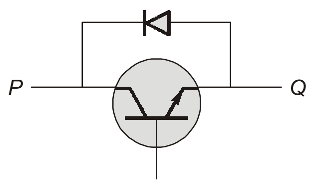
2 is near about 1.992 so, decimal equivalent will 102

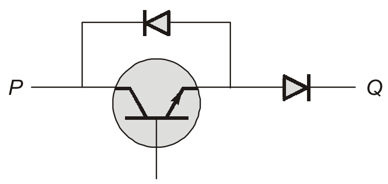
In hexadecimal, $(102)_{10}$ = 66 H

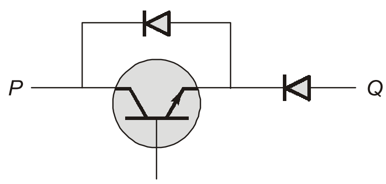
End of Solution

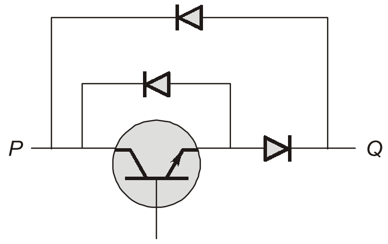
Q.19 A semiconductor switch need to block the voltage V of only one polarity ($V > 0$) during off state as shown in fig. (i) and carry current in both directions during on state in fig. (ii), which of the following switch configuration will realise the same?

Fig. (i) Fig. (ii)

(a) 

(b) 

(c) 

(d) 

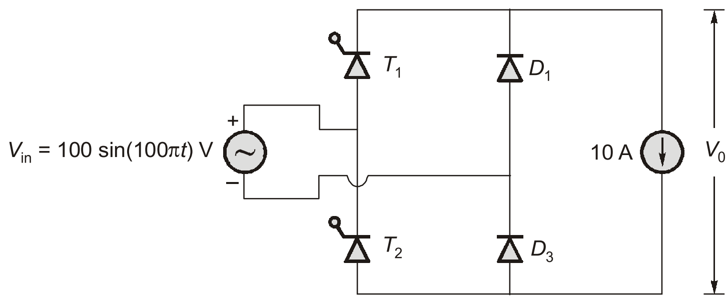
Ans. (a, d)

From given configuration, the current flows in both direction (Bidirectional). The switch also has on drop voltage.

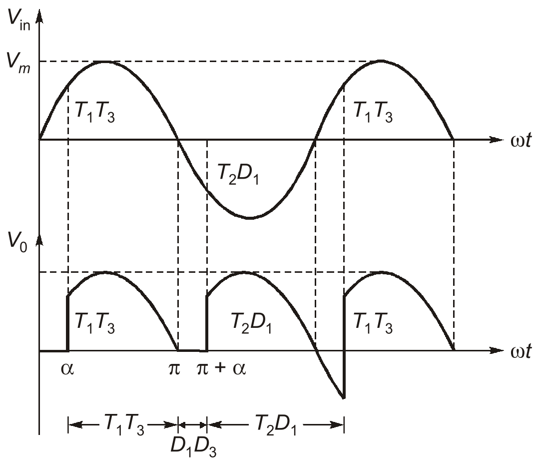
The switch configuration in option (a) and (d) can provide bidirectional current.

End of Solution

Q.20 The signal phase rectifier consisting of three thyristors. T_1, T_2, T_3 and a diode D_1 feed power to a 10 A constant current load. T_1 and T_3 are final at α = 60° and T_2 is fixed at α = 240°. The reference for α is the positive zero crossing of V_{in}. The average voltage V_0 across the load in volts is ________ . (Round off to 2 decimal places)



Ans. (39.78)



The average output voltage,

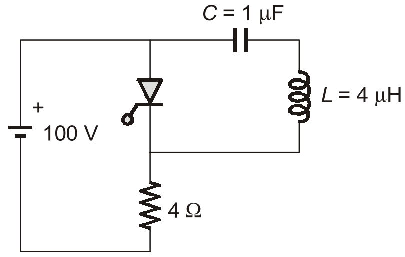
$$V_0 = \frac{1}{2\pi}\left[\int_{\alpha}^{\pi} V_m \sin\omega t\, d(\omega t) + \int_{\pi+\alpha}^{2\pi+\alpha} -V_m \sin\omega t\, d(\omega t)\right]$$

$$V_0 = \frac{V_m}{2\pi}[1+3\cos\alpha]$$

$$= \frac{100}{2\pi}[1+3\cos 60°] = 39.78 \text{ V}$$

End of Solution

Q.21 The circuit shown in the figure has reached steady state with thyristor 'T' in off condition. Assume that the latching and holding currents of the thyristor are zero. The thyristor is turned ON at t = 0. sec. The duration in micro seconds for which the thyristor would conducted, before it turns off is _______. (Round off 2 decimal places)



Ans. (7.33)

Case-1 :

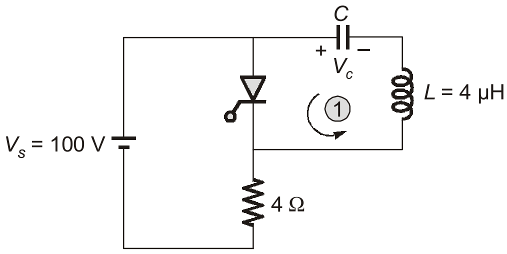
Steady state condition before t = 0 sec

The capacitor is charged already with supply voltage V_S = 100 V

Case-2 :

Now thyristor T is turned on

Mode-1:



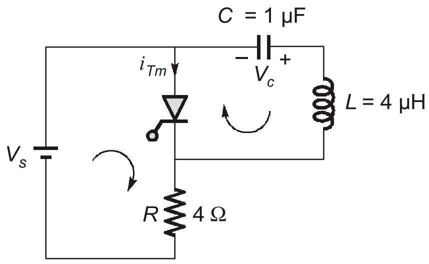
At starting V_C = 100 V

The capacitor will discharge through LC circuit

at the end, $t_1 = \pi\sqrt{LC}\,\text{sec}$,

the capacitor voltage will become V_C = −100 V (polarity is changed)

Mode-2:



The thyristor current, $i_{Tm} = \dfrac{V_s}{R} - I_p \sin\omega_0 t$

at the end,

$$I_0 = \frac{V_s}{R} - I_p \sin\omega_0 t$$

$$i_{Tm} = 0 \qquad (\therefore\ T_m \to \text{off})$$

So, $$\omega_0 t_2 = \sin^{-1}\left(\frac{I_0}{I_p}\right)$$

$$I_p = V_s\sqrt{\frac{C}{L}} = 100\sqrt{\frac{1}{4}} = 50\ \text{A}$$

and $$I_0 = \frac{V_s}{R} = \frac{100}{4} = 25\ \text{A}$$

So, $$t_2 = \sqrt{LC}\sin^{-1}\left(\frac{25}{50}\right) = \frac{\pi}{6}\sqrt{LC}$$

So total time for conduction,

$$t_1 + t_2 = \pi\sqrt{LC} + \frac{\pi}{6}\sqrt{LC}$$

$$= \frac{7\pi}{6}\sqrt{1\times10^{-6}\times4\times10^{-6}}$$

$$t_1 + t_2 = 7.33\ \mu\text{sec}$$

End of Solution

Q.22 The chopper circuit shown in figure (i) feeds power to a 5 A DC constant current source. The switching frequency of chopper is 100 kHz. All the components can be assumed to be ideal. The gate signals of switches S_1 and S_2 are shown in figure (ii), average voltage across the 5 A current source is

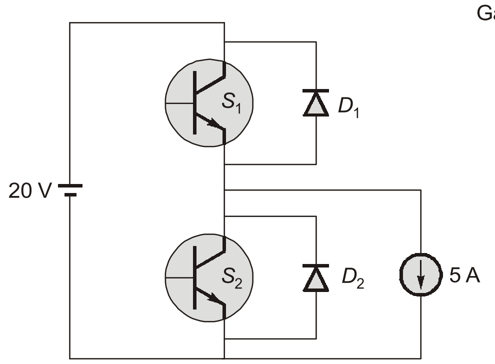


Fig. (i)

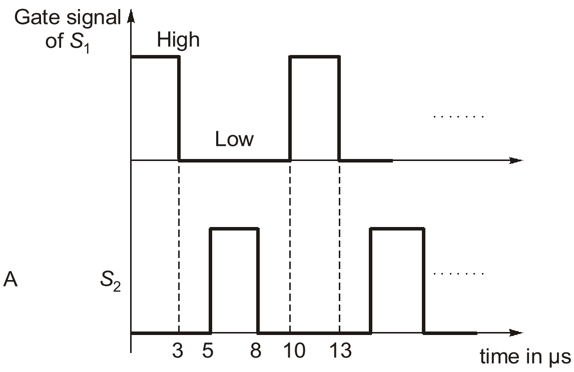
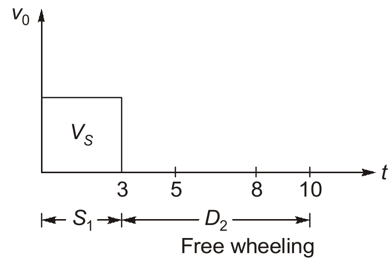


Fig. (ii)

Ans. (6)

Let voltage across 5 Amp current is v_0



So, average voltage,

$$V_{0\,(avg)} = \frac{20\times3}{10} = 6\ \text{V}$$

End of Solution

Q.23 A three phase 415 V, 50 Hz, 6-pole, 960 rpm, 4 HP squirrel cage induction motor drives a constant torque constant load at rated speed operating from rated supply and delivering rated output. If the supply voltage and frequency are reduced by 20%, the resultant speed of the motor in rpm is _____ (neglecting the stator leakage impedance and rotational losses) (round off to the nearest integer).

Ans. (760)

Method 1 :

$$N_s = 120 \times \frac{50}{6} = 1000 \text{ rpm}$$

$\Rightarrow$ Slip speed = 40 rpm

Here, V/f = Constant. So, slip speed remains constant.

For $f = 50 \times 0.80 = 40$ Hz, the synchronous speed

$$N_{s2} = 120 \times \frac{40}{6}$$

$$N_{s2} = 800 \text{ rpm}$$

So, motor speed $N_2 = N_{s2}$ – slip speed

$$= 800 - 40 = 760 \text{ rpm}$$

Method 2 :

Torque, $$T \propto \frac{sV^2}{f}$$

$$\frac{T_2}{T_1} = \frac{s_2}{s_1}\left(\frac{V_2}{V_1}\right)^2\left(\frac{f_2}{f_1}\right)$$

$$1 = \frac{s_2}{0.04}(0.8)^2 \times \frac{1}{0.8}$$

$$s_2 = 0.05$$

So, $$N_2 = N_{s2}(1-s_2) = \frac{120 \times f_2}{P}(1-s_2)$$

$$N_2 = \frac{120 \times 40}{6}(1-0.05) = 760 \text{ rpm}$$

End of Solution

Q.24 A 10-pole, 50 Hz, 240 V, single phase induction motor runs at 540 rpm while driving rated load. The frequency at induced rotor current due to backward field is

(a) 100 Hz (b) 95 Hz
(c) 5 Hz (d) 10 Hz

Ans. (b)

The slip for backward slip,

$$s_b = 2 - s_f = 2 - s$$

The slip, $$s = \frac{N_s - N}{N_s} = \frac{600-540}{600} = 0.1$$

So, $s_b = 2 - 0.1 = 1.9$

So, frequency due to backward field,

$$s_b f = 1.9 \times 50 = 95 \text{ Hz}$$

End of Solution

Q.25 The following column present various modes of induction machine operation and the range of slip.

a. Running in generator mode	p. From 0.0 to 1.0
b Running in motor mode	q. From 1.0 to 2.0
c. Plugging in motor mode	r. From –1.0 to 0.0

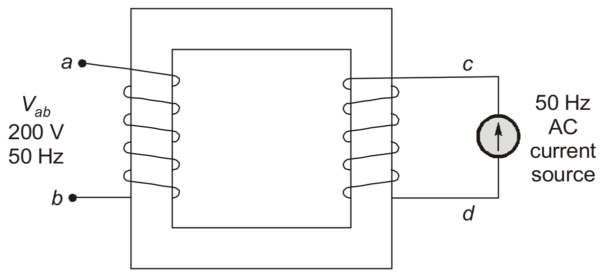
(a) a-p, b-r, c-q
(b) a-r, b-q, c-p
(c) a-q, b-p, c-r
(d) a-r, b-p, c-q

Ans. (d)

Mode	Slip Range
Generator Mode	–1.0 to 0.0
Motor Mode	0.0 to 1.0
Plugging Mode	1.0 to 2.0

End of Solution

Q.26 When the winding c-d of the single phase, 50 Hz, two winding transformer is supplied from AC current source of frequency 50 Hz, the rated voltage of 200 V (rms), 50 Hz is obtained at open circuit terminal a–b. The cross-section area of core 5000 mm^2 and the average core length transversed by mutual flux is 500 mm. the maximum flux density in the core B_{max} = 1 Wb/m^2 and the relative permeability of the core material is 5000. The leakage impedance of winding a-b and winding c-d of 50 Hz are $(5 + j1000\pi \times 0.16)\ \Omega$ and $(11.25 + j100\pi \times 0.36)\ \Omega$ respectively. Considering the magnetizing characteristics to be linear & neglect core loss. The self-inductance of winding a–b in milli-henry is _____. (Round off 1 decimal places).



Ans. (2058.43)

Given :

$l = 500 \text{ mm} = 0.5 \text{ m}$

$A = 5000 \text{ mm}^2 = 5 \times 10^{-3} \text{ m}^2$

$\mu_r = 5000$

$E = 200 \text{ V}$

So, $$R = \frac{l}{\mu_o \mu_R A} = \frac{0.5}{4\pi \times 10^{-7} \times 5000 \times 5 \times 10^{-3}} = 15915.49$$

and $$E = 4.44 f N B_m A$$

$$N = \frac{E}{4.44 f N B_m A} = \frac{200}{4.44 \times 50 \times 1 \times 5 \times 10^{-3}}$$

$$N \cong 181$$

$$L = \frac{N^2}{R} = \frac{181}{15915.49} = 2058.43 \text{ mH}$$

End of Solution

Q.27 A three-phase synchronous motor with synchronous impedance of (0.1 + *j*0.3) per unit per phase has a static stability limit of 2.5 per unit. The corresponding excitation voltage is per unit is _____. (round off to 2 decimal place).

Ans. **(1.6022)**

Given : $$Z_s = (0.1 + j0.3) = \sqrt{0.1^2 + 0.3^2} \angle \tan^{-1}\left(\frac{0.3}{0.1}\right)$$

$$Z = 0.3162 \angle 71.56° \text{ pu}$$

The developed power will be maximum, if $\delta = \theta$

$$P_m = \frac{E_f V}{Z_s} - \frac{E_f^2}{Z_s} \cos\theta$$

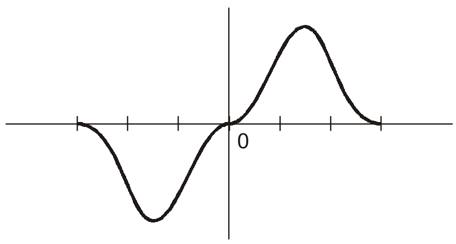
$$2.5 = \frac{E_f(1)}{0.3162} - \frac{E_f^2}{0.3162} \cos(71.56)$$

$$E_f^2 - 3.162 E_f + 2.5 = 0$$

$$E_f = 1.6022 \text{ pu}$$

End of Solution

Q.28 Which one of the following options represent the given graph?



(a) $x2^{-|x|}$ (b) $|x|2^{-x}$

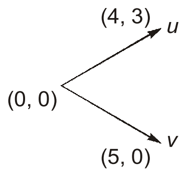
(c) $x2^{-x}$ (d) $x^2 e^{-|x|}$

Ans. **(a)**

Only option (a) is odd function.

End of Solution

Q.29 In the figure, the vectors u and v are related as $Au = v$ by a transformation matrix A. The correct choice of A is



(a) $\begin{bmatrix} \frac{4}{5} & \frac{3}{5} \\ -\frac{3}{5} & \frac{4}{5} \end{bmatrix}$

(b) $\begin{bmatrix} \frac{4}{5} & \frac{3}{5} \\ \frac{3}{5} & \frac{4}{5} \end{bmatrix}$

(c) $\begin{bmatrix} \frac{4}{5} & -\frac{3}{5} \\ \frac{3}{5} & \frac{4}{5} \end{bmatrix}$

(d) $\begin{bmatrix} \frac{4}{5} & -\frac{3}{5} \\ \frac{3}{5} & -\frac{4}{5} \end{bmatrix}$

Ans. **(a)**

$$\begin{bmatrix} \frac{4}{5} & \frac{3}{5} \\ \frac{-3}{5} & \frac{4}{5} \end{bmatrix}\begin{bmatrix} 4 \\ 3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \end{bmatrix}$$

Correct option is (a).

End of Solution

Q.30 Three points in the x-y planes are (–1, 0.8) (0, 2.2) and (1, 2.8). The value of the slope of the best fit straight line in the least square sense is _______.

Ans. **(1)**

Let the straight line, $y = ax + b$

By least square approximation,

$$\Sigma y_i = a\,\Sigma x_i + b\,n \quad \text{...(i)}$$

$$\Sigma x_i y_i = a\,\Sigma x_i^2 + b\,\Sigma x_i \quad \text{...(ii)}$$

x	y	x^2	xy
–1	0.8	1	–0.8
0	2.2	0	0
1	2.8	1	2.8
Σ 0	5.8	2	2

$$5.8 = a(0) + 3b \quad \text{...(iii)}$$

$$2 = a(2) + 0(b) \quad \text{...(iv)}$$

$$a = 1$$

End of Solution

Q.31 For a given vector $W = [1\ 2\ 3]^T$, the vector normal to the plane defined by $W^T x = 1$ is

(a) $[3\ 2\ 1]^T$
(b) $[-2, -2, 2]^T$
(c) $[1, 2, 3]^T$
(d) $[3, 0\ -1]^T$

Ans. (c)

$$W^T x = 1$$

$$[1\ \ 2\ \ 3]\begin{bmatrix} x \\ y \\ z \end{bmatrix} = 1$$

$$\Rightarrow \quad \phi : x + 2y + 3z = 1$$

$$= i(1) + j(2) + 3k$$

Vector normal to the plane is $\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$

End of Solution

Q.32 A quadratic function of 2 variables is given as

$$F(x_1, x_2) = x_1^2 + 2x_2^2 + 3x_1 + 3x_2 + x_1 x_2 + 1$$

The magnitude of the maximum rate of change of the function at the point (1, 1) is ____.

Ans. (10)

Let, $\phi = x_1^2 + 2x_2^2 + 3x_1 + 3x_2 + x_1 x_2 + 1$

$$\vec{\nabla}\phi = i\,\phi_{x1} + j\phi_{x2}$$

$$= i(2x_1 + 3 + x_2) + j(4x_2 + 3 + x_1)$$

$$\vec{\nabla}\phi\Big|_{(1,1)} = 6\hat{i} + 8\hat{j}$$

$$\left|\vec{\nabla}\phi\right| = \sqrt{6^2 + 8^2} = 10$$

End of Solution

Q.33 The expected number of trails for first occurrence of a 'head' in a biased coin is known to be 4. The probability of first occurrence of a 'head' in the second trails is ____.

Ans. (0.1875)

By Geometrical distribution,

$$E(x) = \frac{1}{P}$$

$$V(x) = \frac{q}{P^2}$$

$$E(x) = 4 = \frac{1}{P}$$

$$q = 1 - \frac{1}{4} = \frac{3}{4}$$

$$P(H) = \frac{1}{4},$$

$$P(T) = \frac{3}{4}$$

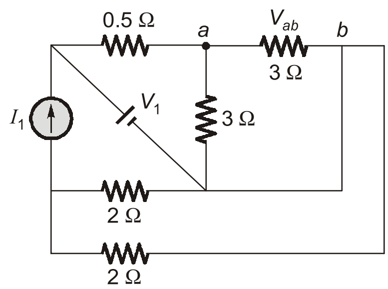
Required probability, $P(E) = P(T\ H)$

$$= \frac{3}{4} \times \frac{1}{4} = \frac{3}{16} = 0.1875$$

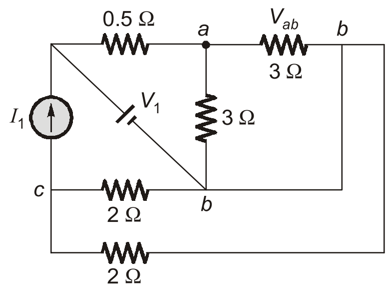
End of Solution

Q.34 $V_1 = 8$ V, $I_1 = 8$ A

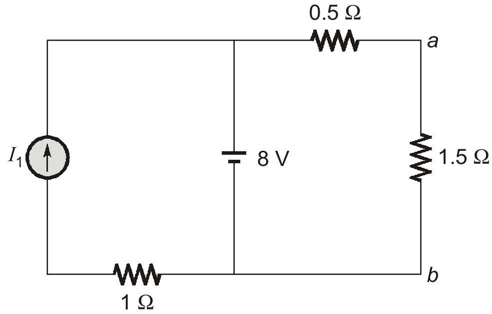
$V_{ab} = ?$



Ans. (6)



Circuit can be redrawn

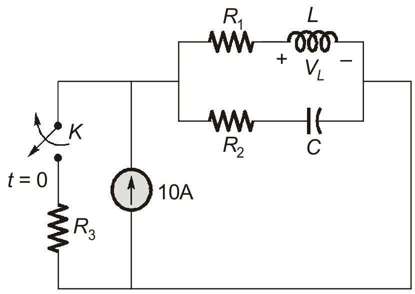


By applying voltage division rule, we can get

$$V_{ab} = 8 \times \frac{1.5}{1.5 + 0.5} = 6 \text{ V}$$

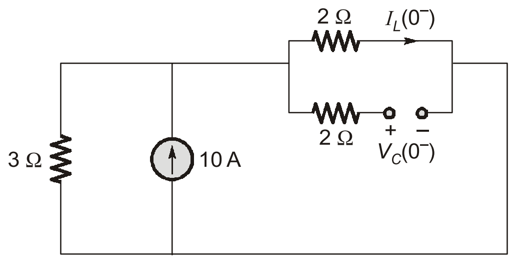
End of Solution

Q.35 $R_1 = 2\ \Omega$, $R_2 = 2\ \Omega$, $R_3 = 3\ \Omega$
$L = 10$ mH, $C = 100\ \mu$F
Switch is opened at $t = 0$ sec,
The V_L at $t = 0^+$ will be _______ .



Ans. (8)

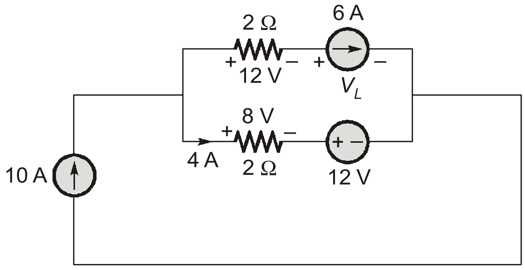
For $t = 0^-$



$$I_L(0^-) = 10 \times \frac{3}{3+2} = 6\ \text{A}$$

$$V_C(0^-) = 6 \times 2 = 12\ \text{V}$$

For $t = 0^+$

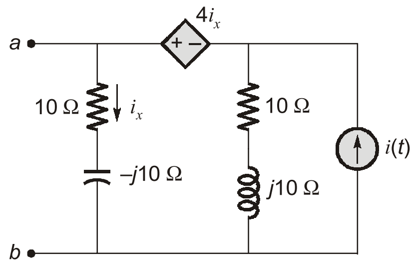


$$20 = 12 + V_L$$

$$V_L = 8\ \text{V}$$

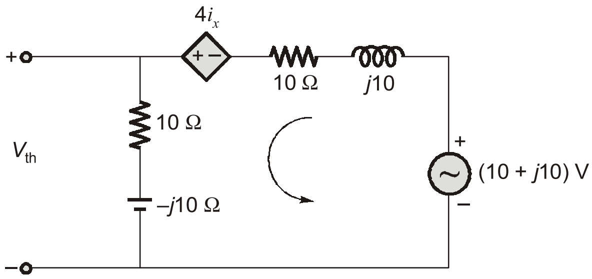
End of Solution

Q.36 For the circuit shown, if $i(t)$ = sin 1000t A, the instantaneous value of the Thevenin's equivalent voltage (in volt) across the terminal a - b at t = 5 msec is ______ . (Upto 2 decimal places)



Ans. **(–11.98)**

Applying source transformation



$$V_{th} = i_x(40 - j10)$$

Applying KVL

$$10 + j10 = (10 + j10)i_x - 4i_x + (10 - j10)i_x$$

$$i_x = \frac{10 + j10}{16}$$

$$V_{th} = i_x(10 - j10)$$

$$= \frac{100 + 100}{16} = 12.5 \text{ Volts}$$

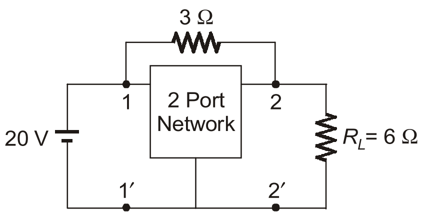
$$V_{th} = 12.5 \sin 1000t$$

$$= 12.5 \sin 1000 \times 5 \times 10^{-3}$$

$$= -11.98 \text{ V}$$

End of Solution

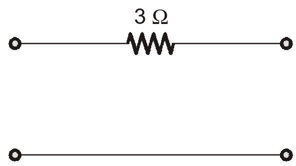
Q.37 The power dissipated in R_L load in watts is _______ .



$$[Y]_M = \begin{bmatrix} 5 & -2.5 \\ -2.5 & 1 \end{bmatrix} S$$

Ans. (238)

$$Y = [Y]_A + [Y]_B$$



$$Y_A = \begin{bmatrix} \frac{1}{3} & -\frac{1}{3} \\ -\frac{1}{3} & \frac{1}{3} \end{bmatrix}$$

$$Y_B = \begin{bmatrix} 5 & -2.5 \\ -2.5 & 1 \end{bmatrix} s$$

$$Y = \begin{bmatrix} \frac{1}{3} & -\frac{1}{3} \\ -\frac{1}{3} & \frac{1}{3} \end{bmatrix} + \begin{bmatrix} 5 & -2.5 \\ -2.5 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{16}{3} & -\frac{8.5}{3} \\ -\frac{8.5}{3} & \frac{4}{3} \end{bmatrix}$$

$$I_1 = \frac{16}{3}V_1 - \frac{8.5}{3}V_2 \quad \text{...(1)}$$

$$I_2 = -\frac{8.5}{3}V_1 + \frac{4}{3}V_2 \quad \text{...(2)}$$

Put $I_2 = 0$ and $V_1 = 20$ V

$$0 = -\frac{8.5}{3} \times 20 + \frac{4}{3}V_2$$

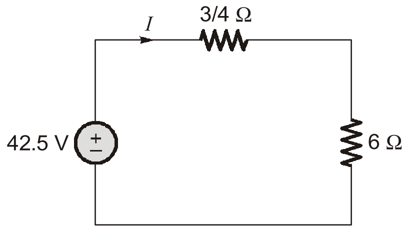
$$V_{th} = V_2 = \frac{8.5 \times 20}{4} = 42.5 \text{ V}$$

$$R_{th} = \frac{V_2}{I_2}$$

$$I_2 = \frac{4}{3}V_2$$

$$\frac{V_2}{I_2} = \frac{3}{4}\Omega$$

Equivalent circuit

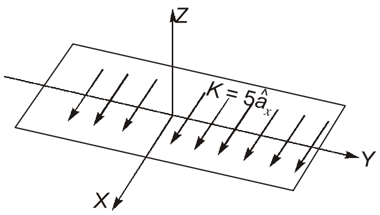


$$I = \frac{42.5}{\frac{3}{4}+6} = 6.296 \text{ A}$$

$$P = I^2R_L = (6.296)^2 \times 6$$
$$= 238 \text{ W}$$

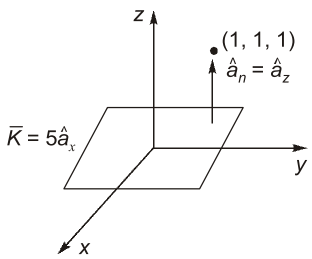
End of Solution

Q.38 An infinite surface of linear current duration $K = 5\hat{a}x$ A/m exists on the x-y planes as shown in the figure. The magnitude of the magnetic field intensity (H) at a point (1, 1, 1) due to the surface current in ampere/meter is _______. (Round off to 2 decimal places)



Ans. (2.5)

Magnetic field due to sheet current is



$$\bar{H} = \frac{1}{2}(\bar{K} \times \hat{a}_n) \text{ A/m}$$

Here, $\bar{K} = 5\hat{a}_x$

$\hat{a}_n = \hat{a}_z$

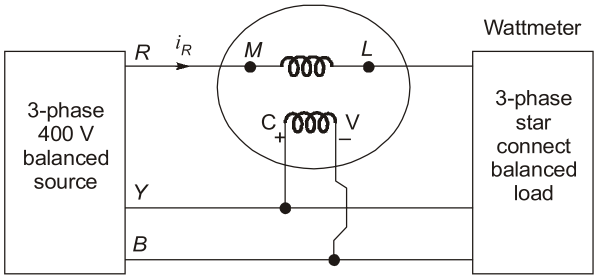
$\therefore$ $\bar{H} = \frac{1}{2}(5\hat{a}_x \times \hat{a}_z) = 2.5(-\hat{a}_y)$

Here, $\bar{H} = -2.5\hat{a}_y$ A/m

So, $|\bar{H}| = 2.5$ A/m

End of Solution

Q.39 A 3-phase, star-connected balanced load is supplied from a 3-phase, 400 V (rms), balanced voltage source with phase sequence R-Y-B, as shown in the figure. If the wattmeter reading is –400 W and the line current is I_R = 2 A (rms), then the power factor of the load per phase is _____.



(a) 0.8666 leading
(b) Unity
(c) 0.5 leading
(d) 0.707 lagging

Ans. **(0.866)**

Given : $V_{line} = 400 \text{ Volt} \Rightarrow$ Y-connected

$$V_{phase} = \frac{V_{line}}{\sqrt{3}} = \frac{400}{\sqrt{3}}$$

$$I_{line} = I_{phase} = 2 \text{ Amp}$$

Wattmeter reading = –400 Watt

This Wattmeter connection is related to reactive power measurement by single wattmeter method.

So, Wattmeter reading $= \sqrt{3} \cdot V_{ph} \cdot I_{ph} \sin(\phi)$

$$-400 \text{ Watt} = \sqrt{3} \times \frac{400}{\sqrt{3}} \times 2 \times \sin(\phi)$$

$$\sin(\phi) = -\frac{1}{2}$$

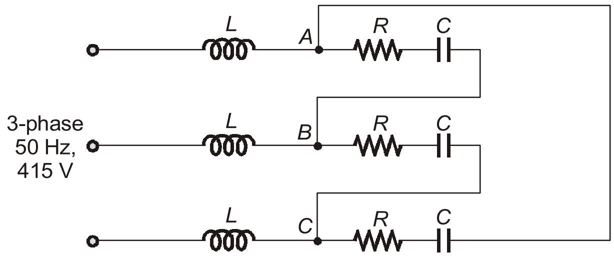
$$\Rightarrow \quad \phi = \sin^{-1}\left(-\frac{1}{2}\right) = -30° \Rightarrow \text{Leading}$$

$$\text{P.f. of load} = \cos(\phi) = \cos(-30°)$$

$$\text{P.f.} = 0.866 \text{ leading}$$

End of Solution

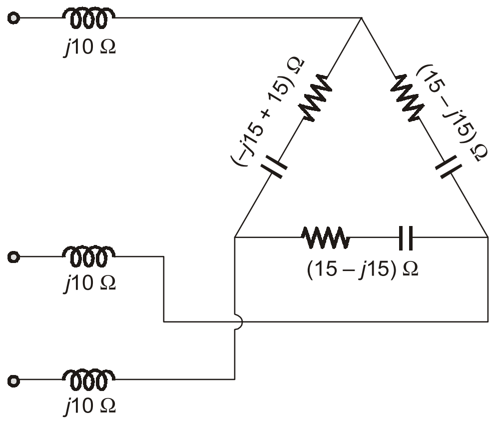
Q.40 A balanced delta connected load consisting of the series connection of one resistor (R = 15 Ω) and (C = 212.21 μF) in each phase is connected to 3φ, 50 Hz, 415 V supply terminals through a line having on inductance of L = 31.83 mH per phase shown in the figure. Considering the charge in the supply terminal voltage with loading to be negligible, the magnitude of the voltage across the terminals VAB in volts.



Ans. (415)

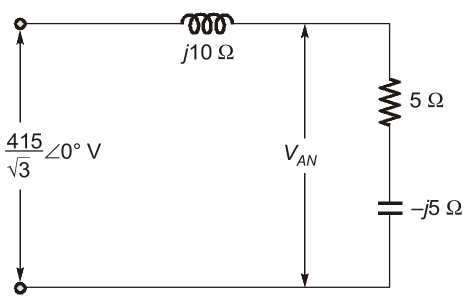
$$X_L = 2\pi fL = 2\pi \times 50 \times 31.83 \times 10^{-3} = 10\ \Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 212.21 \times 10^{-6}} = 15\ \Omega$$



Star to delta ⇒ $Z_Y = \frac{Z_\Delta}{3} = \frac{15 - j15}{3} = (5 - j5)\ \Omega$

The per phase equivalent circuit



Per Phase Equivalent Circuit

$$V_{AN} = \frac{(5-j5)}{(5-j5+j10)} \times \frac{415}{\sqrt{3}} = \frac{(5-j5)}{(5+j5)} \times \frac{415}{\sqrt{3}}$$

$$|V_{AN}| = \frac{415}{\sqrt{3}}\ \text{V}$$

So, $V_{AB} = 415$ V

End of Solution

Q.41 (Y_{bus}) matrix of a 3-bus power system is given below :

$$Y_{Bus} = \begin{matrix} \\ 1 \\ 2 \\ 3 \end{matrix}\begin{bmatrix} 1 & 2 & 3 \\ -j15 & j10 & j5 \\ j10 & -j13.5 & j4 \\ j5 & j4 & -j8 \end{bmatrix}$$

Consider that there is no shunt inductor connected to any of the buses. Which of the following cannot be true?

(a) Line charging capacitor of finite value present in line 2-3 only and shunt capacitor of finite value present in bus 3 only.

(b) Line charging capacitor of finite value present in line 2-3 only and shunt capacitor of finite value present in bus 2 only.

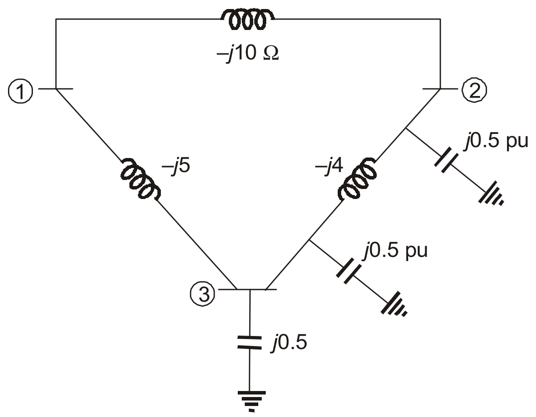
(c) Line charging capacitor present at all 3 buses.

(d) Line charging capacitor of finite value is present in line 2-3 only and shunt capacitor of finite value is present in bus-1 only.

Ans. (a)

$$Y_{Bus} = j\begin{bmatrix} -15 & 10 & 5 \\ 10 & -13.5 & 4 \\ 5 & 4 & -8 \end{bmatrix} \begin{matrix} \text{Sum} \\ = 0 \\ = j0.5 \\ = j1 \end{matrix}$$

No shunt branch is present at 1st bus.



Line 1–2 ⇒ No line charge susceptance.
Line 1–3 ⇒ No line charge susceptance.
Line 2–3 ⇒ Line charge susceptance is present.
3rd bus has shunt bus capacitance connected to it.

End of Solution

Q.42 The expressions of fuel cost of two thermal generating units as a function of the respective power generation

$F_1(P_{G1}) = (0.1aP^2_{G1} + 40P_{G1} + 120)$ Rs/hr; $0 \le P_{G1} < 350$ MW

$F_2(P_{G2}) = (0.2P^2_{G2} + 30P_{G2} + 100)$ Rs/hr; $0 \le P_{G2} < 350$ MW

where a is a constant, for given value of a optimal as P_{G1} = 175 MW and P_{G2} = 115 MW. If a is increased by 10%, then with the load remaining dispatch is carried out, then changes in P_{G1} and the total cost of generation, $F (= F_1 + F_2)$ in Rs/hr will be as follows :

(a) Both P_{G1} and F will increase.
(b) P_{G1} will decrease and F will increase.
(c) P_{G1} will increase and F will decrease.
(d) Both P_{G1} and F will decrease.

Ans. (c)

$$F_1(P_{G1}) = (0.1aP^2_{G1} + 40P_{G1} + 120)$$
$$F_2(P_{G2}) = (0.2P^2_{G2} + 30P_{G2} + 100)$$
$$IC_1(P_{G1}) = (0.2aP_{G1} + 40) \text{ Rs/Mwhr}$$
$$IC_2(P_{G2}) = (0.4P_{G2} + 30) \text{ Rs/Mwhr}$$
$$IC_1 = IC_2 \text{ (for optimal sheduling)}$$

Given : $P_{G1} = 175$ MW, $P_{G2} = 115$ MW

So, $0.2 \times a \times 175 + 40 = 0.4 \times 115 + 30$

$$a = 1.028$$

Now, $a' = 1.1a = 1.1314$

Now again, economic scheduling

$$P_{G1} + P_{G2} = 290 \qquad ...(1)$$
$$0.2 \times 1.1314P_{G1} + 40 = 0.4P_{G2} + 30$$
$$0.226P_{G1} - 0.4P_{G2} = -10 \qquad ...(2)$$

Solving (1) and (2)

$$P_{G1} = 169.33 \text{ MW}$$
$$P_{G2} = 120.68 \text{ MW}$$

Here P_{G1} will be decreased.

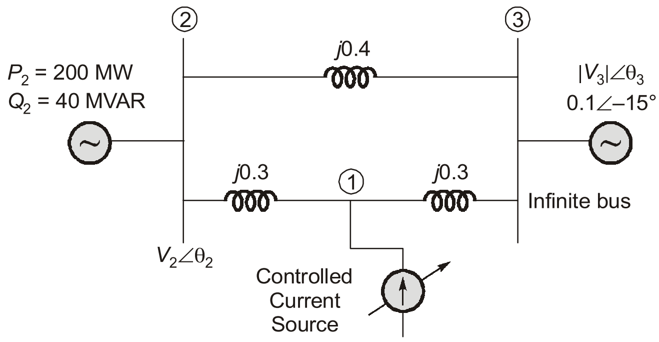
$$F_{old} = F_1(P_{G1} = 175) + F_2(P_{G2} = 115)$$
$$F_{old} = (0.1 \times 1.028 \times 175^2 + 40 \times 175 + 120) + (0.2 \times 115^2 + 30 \times 115 + 100)$$
$$F_{old} = 16463.25 \text{ Rs/hr}$$

$$F_{new} = F_1(P_{G1} = 169.33) + F_2(P_{G2} = 120.68)$$
$$F_{new} = 16768.63 \text{ Rs/hr}$$

So, F is increased here.

End of Solution

Q.43 The three bus power system shown in the figure has one alternator connected to bus 2, which supplies 200 MW and 40 MVAr powr. Bus 3 is infinite Bus having a voltage magnitude $|V_3|$ = 1.0 pu power. Bus and angle of –15°. Available current source $|I| \angle\varphi$ is connected as bus 1 and controlled such that the magnitude of bus 1 voltage is maintained at 1.05 pu and phase angle of source voltage current $\phi = \theta_1 \pm \pi/2$, where θ_1, is the phase angle of bus 1. Voltage the tree buses can be categorized for load flow analysis as :



(a) Bus 1 - slack bus; Bus 2 P–|V|; Bus, B3 PQ bus
(b) Bus 1 - P|V| Bus; Bus 2 = PQ bus; Bus 3 - Slack bus
(c) Bus 1 - P-Q bus; Bus 2 - P-Q Bus; Bus 3 - Slack
(d) Bus 1 - P-|V| bus; Bus 2 - P-IVI bus; Bus 3 - Slack bus

Ans. (b)

Bus (3) has 0.1∠–15° pu. So, it is slack bus.
Bus (2) has load of (200 + 40). So, it is PQ bus.
Bus (1) is PV bus.

End of Solution

Q.44 The power system shown in the figure (i) has alternator supplying a synchronous motor load through Y-Δ transformer, the positive negative and zero sequence diagram of the system shown in figure (ii), (iii) and (iv) respectively. All reactance in the sequence diagrams are in pu for a bolted line to line fault (fault + impedance = 0) between phase band c at bus-1 neglecting all prefault current the magnitude of fault current (from phase b to c) in pu is

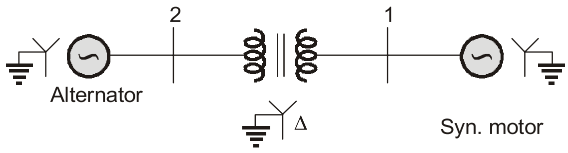


Fig. (i)

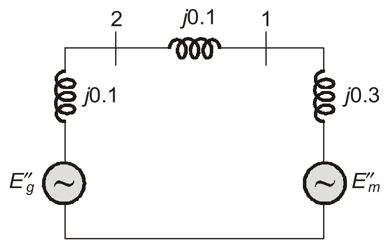


Fig. (ii)

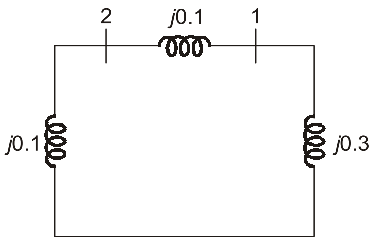


Fig. (iii)

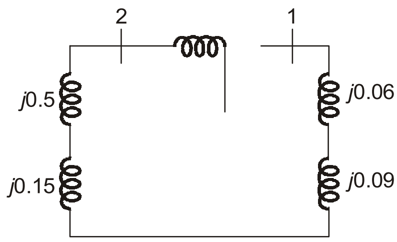


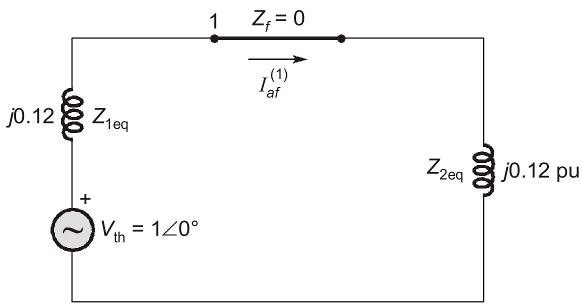
Fig. (iv)

Ans. (7.21)

$$(Z_{1eq})_{bus\,1} = j0.2 \parallel j0.3 = \frac{j0.2\times 0.3}{0.5} = j0.12 \text{ pu}$$

$$(Z_{2eq})_{bus\,1} = j0.2 \parallel j0.3 = j0.12 \text{ pu}$$

The per phase equivalent circuit for LLG fault.



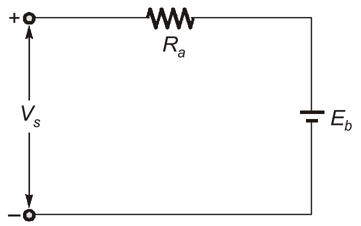
$$I_{af}^{(1)} = \frac{1\angle 0^\circ}{j0.12 + j0.12} = 4.16 \text{ pu}$$

So, fault current, $I_F = \sqrt{3}\times I_{of}^{(1)} = 7.21 \text{ pu}$

End of Solution

Q.45 A separately excited DC motor rated 400 V, 15 A, 1500 rpm driving a constant torque load at rated speed operating from 400 V DC supply draws rated current. The armature resistance is 1.2 Ω. If the supply voltage drops by 10% with field current unaltered then the resultant speed of the motor in rpm is ______ (round off to the nearest integer).

Ans. (1343)



Given torque is constant, $T = K\phi I_a$ = Constant

Field is also unchanged, ϕ = Constant

So, I_a = Constant

The back emf with rated voltage

$$E_{b1} = V_s - I_aR_a = 400 - 1.2 \times 15$$

$$E_{b1} = 382 \text{ V}$$

and back emf with 10% drop in supply voltage

$$E_{b2} = V_s - I_{a2}R_a = 400 \times 0.90 - 1.2 \times 15$$

$$E_{b2} = 342 \text{ V}$$

We know $E_b \propto N$ (for separately excited motor)

So,
$$\frac{E_{b2}}{E_{b1}} = \frac{N_2}{N_1}$$

$$N_2 = \frac{342}{382} \times 1500 = 1342.93$$

$$N_2 \approx 1343 \text{ rpm}$$

End of Solution