GATE 2017 Solved Paper
Electrical Engineering
Set – 2

Number of Questions: 65 **Total Marks: 100.0**

Wrong answer for MCQ will result in negative marks, (–1/3) for 1 Mark Questions and (–2/3) for 2 Marks Questions.

General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Q. 1 to Q. 5 carry 1 mark each and Q. 6 to Q. 10 carry 2 marks each

Question Number: 1 **Question Type: MCQ**

"We lived in a culture that denied any merit to literary works, considering them important only when they were handmaidens to something seemingly more urgent—namely ideology. This was a country where all gestures, even the most private, were interpreted in political terms.

The author's belief that ideology is not as important as literature is revealed by the word:

(A) "culture"
(B) "seemingly"
(C) "urgent"
(D) "political"

Solution:

As literature is revealed by the word "seemingly" the author's belief that ideology is not as important.

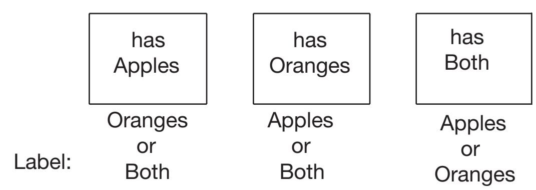
Hence, the correct option is (C).

Question Number: 2 **Question Type: MCQ**

There are three boxes shown in the figure. One contains apples, another contains oranges, and the last one contains both apples and oranges. All three are known to be incorrectly labelled. If you are permitted to open just one box and then pull out and inspect only one fruit, which box would you open to determine the contents of all three boxes?

(A) The box labelled "Apples"
(B) The box labelled "Apples and Oranges"
(C) The box labelled "Oranges"
(D) Cannot be determined

Solution:



Let us choose a box labelled "apples". If an orange comes out, it can be either be having oranges or both. Hence, can't say.

Similarly, if we choose box labelled "oranges", the same scenario will occur.

Now, if we choose a box labelled "Both", then

(i) If an orange comes out, then the box labelled "Apples" has both and box labelled "oranges" has Apple.

(ii) If an apple comes out, then box labelled "apples" has oranges and box labelled "oranges" has both.

Hence, option (B).

Hence, the correct option is (B).

Question Number: 3 **Question Type: MCQ**

X is a 30 digit number starting with the digit 4 followed by the digit 7. Then the number X^3 will have:

(A) 90 digits (B) 91 digits
(C) 92 digits (D) 93 digits

Solution:

Given X is a 30 digit

Starts with 4 followed by 7

Let the number be $X = (47\, X_{28}\, X_{27}\, X_{26}\, X_{25} \ldots X_0)$

$\therefore$ The number lies between,

$$47 \times 10^{28} < X < 48 \times 10^{28}$$

Now, X^3 will be in between,

$$(47 \times 1028)^3 < X^3 < (48 \times 10^{28})^3$$

$$(47)^3 \times 10^{84} < X^3 < (48)^3 \times 10^{84}$$

$$103823 \times 10^{84} < X^3 < 110592 \times 10^{84}$$

∴ A total of (6 + 84) = 90 digits

∴ The number X^3 will have 90 digits.

Hence, the correct option is (A).

Question Number: 4 **Question Type: MCQ**

The number of roots of $e^x + 0.5x^2 - 2 = 0$ in the range [–5, 5] is:

(A) 0 (B) 1
(C) 2 (D) 3

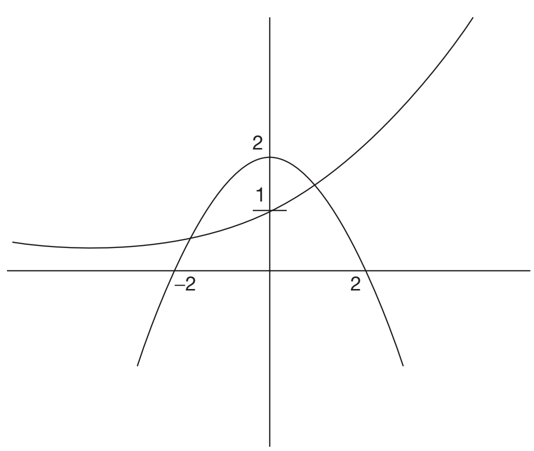
Solution:

The given equation is

$$e^x + 0.5x^2 - 2 = 0$$

$$e^x + \frac{1}{2}x^2 - 2 = 0$$

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



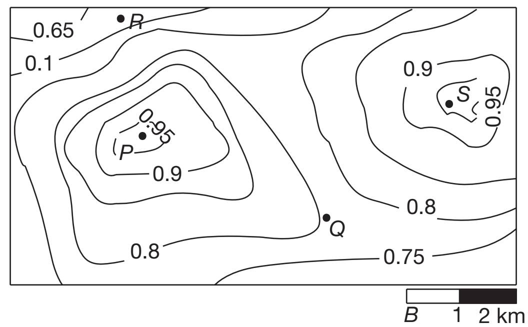
No. of solutions = 2

Hence, no. of roots = 2.

Hence, the correct option is (C).

Question Number: 5 **Question Type: MCQ**

An air-pressure contour line joins locations in a region having the same atmospheric pressure. The following is an air-pressure contour plot of a geographical region. Contour lines are shown at 0.05 bar intervals in this plot.



If the possibility of a thunderstorm is given by how fast air pressure rises or drops over a region, which of the following regions is most likely to have a thunderstorm?

(A) *P* (B) *Q*
(C) *R* (D) *S*

Solution:

We know that there should be pressure difference between the land and sea in order to have the rain. The region which is having low pressure is most likely to have heavy rainfall/thunderstorm. Region *R* has lowest pressure hence most likely to have thunderstorm in this region.

Hence, the correct option is (C).

Question Number: 6 **Question Type: MCQ**

There are five buildings called *V*, *W*, *X*, *Y* and *Z* in a row (not necessarily in that order). *V* is to the West of *W*. *Z* is to the East of *X* and the West of *V*. *W* is to the West of *Y*. Which is the building in the middle?

(A) *V* (B) *W*
(C) *X* (D) *Y*

Solution:

As given, *V* is to west of *W*

$$\therefore \quad V \leftarrow W \qquad (1)$$

Z is east of *X* and west of *Y*

$$X \rightarrow Z \leftarrow V \qquad (2)$$

W is to the west of *Y*

$$W \leftarrow Y \qquad (3)$$

From Eqs. (1), (2), and (3), we have the order of direction as

Hence, the middle building is *V*.

Hence, the correct option is (A).

Question Number: 7 **Question Type: MCQ**

A test has twenty questions worth 100 marks in total. There are two types of questions. Multiple choice questions are worth 3 marks each and essay questions are worth 11 marks each. How many multiple choice questions does the exam have?

(A) 12 (B) 15
(C) 18 (D) 19

Solution:

If "e" is the number of essay questions and "m" is the number of multiple choice questions

Test has 20 questions for 100 marks

Each essay (e) = 11 marks

Each multiple choice (m) = 3 marks

Therefore,

$$e + m = 20 \quad (1)$$

and

$$3m + 11e = 100 \quad (2)$$

Solving Eqs. (1) and (2), we get

$$m = 15.$$

Hence, no. of multiple choice questions = 15.

Hence, the correct option is (B).

Question Number: 8 **Question Type: MCQ**

Choose the option with words that are not synonyms.

(A) Aversion, dislike
(B) Luminous, radiant
(C) Plunder, loot
(D) Yielding, resistant

Solution:

We know that "yielding" means giving up and "resistant" means the one who resists. Thus both of these words are not synonyms .

Hence, the correct option is (D).

Question Number: 9 **Question Type: MCQ**

Saturn is __________ to be seen on a clear night with the naked eye.

(A) Enough bright (B) Bright enough
(C) As enough bright (D) Bright as enough

Solution:

The correct sentence is

"Saturn is Bright enough to be seen on a clear night with the naked eye."

Hence, the correct option is (B).

Question Number: 10 **Question Type: MCQ**

There are 3 red socks, 4 green socks and 3 blue socks. You choose 2 socks. The probability that they are of the same colour is:

(A) 1/5 (B) 7/30
(C) 1/4 (D) 4/15

Solution:

We are given that we have 3 red socks, 4 green socks, 3 blue socks When 2 out of all picked, probability that they are of same colour

$$P\text{ (same colour)} = \frac{\text{No. of ways in which 2 same colour socks can be selected}}{\text{Total no. of ways in which 2 out of total can be selected}}$$

$$= \frac{{}^3C_2 + {}^4C_2 + {}^3C_2}{{}^{10}C_2}$$

$$= \frac{3+6+3}{45} = \frac{4}{45}$$

Hence, the correct option is (D).

Electrical Engineering

Number of Questions: 55 **Section Marks: 85.0**

Q. 11 to Q. 35 carry 1 mark each and Q. 36 to Q. 65 carry 2 marks each

Question Number: 11 **Question Type: MCQ**

When a unit ramp input is applied to the unity feedback system having closed loop transfer function $\frac{C(s)}{R(s)} = \frac{K_{s+b}}{s^2 + as + b}, (a > 0, b > 0, K > 0)$, the steady state error will be

(A) 0 (B) $\frac{a}{b}$
(C) $\frac{a+K}{b}$ (D) $\frac{a-K}{b}$

Solution:

Closed loop transfer function is

$$\frac{C(s)}{R(s)} = \frac{K_{s+b}}{s^2 + as + b}$$

And is closed loop unity feedback system.

Error, cal be calculated as

$$E(s) = R(s) - C(s)$$

$$= R(s)\left[1 - \frac{K_{s+b}}{s^2 + as + b}\right]$$

Steady state error, can be calculated as

$$e_{ss} = \lim_{x\to\infty}\left[\frac{s^2 + as + b - ks - b}{s^3 + as^2 + b}\right]$$

$$= \lim_{x\to\infty}\left[\frac{s^2 + as - ks}{s^3 + as^2 + bs}\right] \qquad \cdots\frac{0}{0}$$

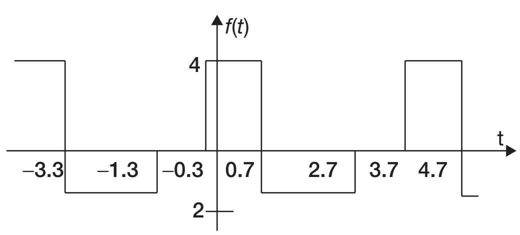
Using L-hospital method, we get

$$\lim_{x\to\infty}\frac{2s + a - k}{3s^2 + 2sa + b} = \frac{a-k}{b}$$

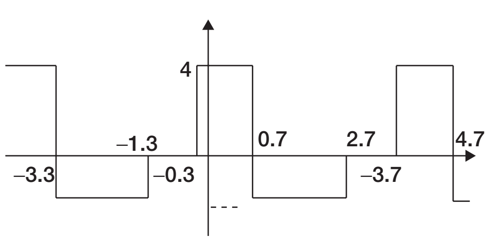
Hence, the correct option is (D).

Question Number: 12 **Question Type: NAT**

The mean square value of the given periodic waveform *f*(*t*) is ______



Solution:



Mean square value of the given periodic function is

$$= \frac{0 + \int_{-0.3}^{0.7}(4)^2\,dt + \int_{0.7}^{2.7}(-2)^2\,dt + 0}{\text{Time period}}$$

$$= \frac{\int_{-0.3}^{0.7}16dt + \int_{0.7}^{2.7}4dt}{3.7 - (-0.3)}$$

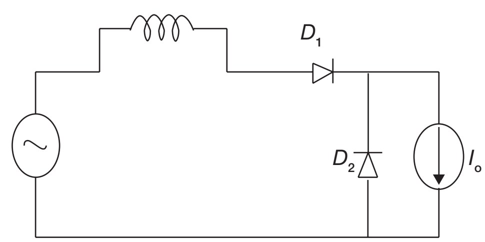
$$= \frac{16(0.7 + 0.3) + 4(2.7 - 0.7)}{4}$$

$$= \frac{16 + 8}{4} = 6$$

Hence, the correct answer is (6).

Question Number: 13 **Question Type: MCQ**

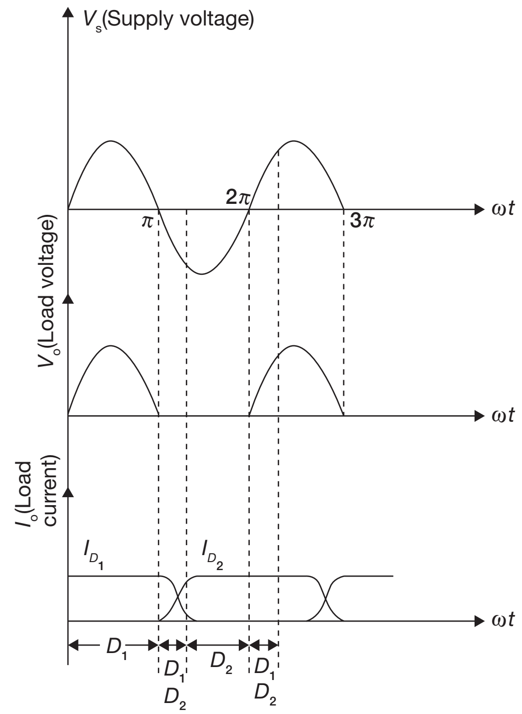
In the circuit shown in the figure, the diodes are ideal, the inductance is small and I ≠ 0. Which one of the following statements is TRUE?



(A) D_1 conducts for greater than 180° and D_2 conducts for greater than 180°.
(B) D_2 conducts for more than 180° and D_1 conducts for 180°.
(C) D_1 conducts for 180° and D_2 conducts for 180°.
(D) D_1 conducts for more than 180° and D_2 conducts for 180°.

Solution:

Diode D_1 is forward-biased during the positive half cycle 0° to 180° and D_2 is reverse-biased during this period. After this period current through D_1 starts decaying and current through D_2 starts rising in order to maintain load current I_0 constant and waveforms of the same are shown in the figure.



Thus, both the diodes conduct for more than 180°.

Hence, the correct option is (A).

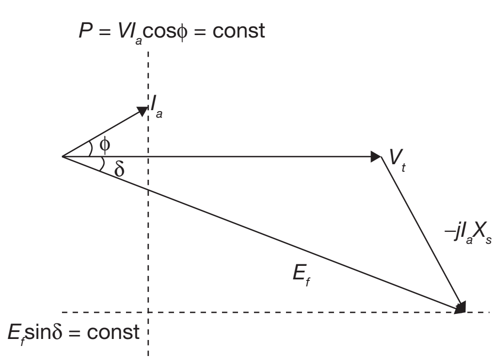
Question Number: 14 **Question Type: MCQ**

If a synchronous motor is running at a leading power factor, its excitation induced voltage (Ef) is

(A) Equal to terminal voltage V_t
(B) Higher than the terminal voltage V_t
(C) Less than terminal voltage V_t
(D) Dependent upon supply voltage V_t

Solution:

Synchronous motor running at leading pf, *i.e.*, I_a leading V_t.



From the phasor diagram shown in the figure, it is clearly obvious that E_f is greater them V_t in magnitude.

Hence, the correct option is (B).

Question Number: 15 **Question Type: MCQ**

A 3-phase, 4-pole, 400 V, 50 Hz squirrel-cadge induction motor is operating at a slip of 0.02. The speed of the rotor flux in mechanical rad/sec, sensed by a stationary observer is closest to

(A) 1500 (B) 1470
(C) 157 (D) 154

Solution:

Given a 3-phase, 4P, 50 Hz, 400 V Squirrel-cage induction motor.

Slip = 0.02

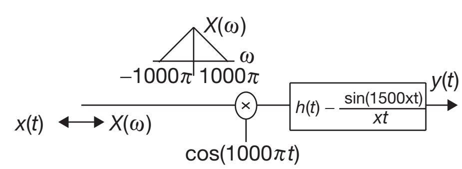
Speed of rotor flux with respect to stationary observer in mech radians per second will be

$$\omega_{sm} = \frac{2}{P} \times 2\pi f$$
$$= \frac{2}{4} \times 2\pi \times 50$$
$$= 50\pi$$
$$= 157 \text{ mech rad/ sec}$$

Hence, the correct option is (C).

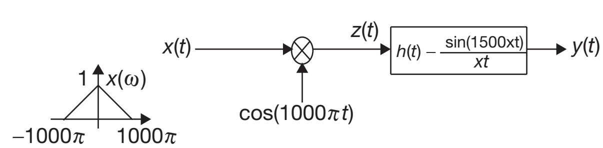
Question Number: 16 **Question Type: MCQ**

The output $y(t)$ of the following system is to be sampled, so as to reconstruct it from its samples uniquely. The required minimum sampling rate is



(A) 1000 samples/s (B) 1500 samples/s
(C) 2000 samples/s (D) 3000 samples/s

Solution:

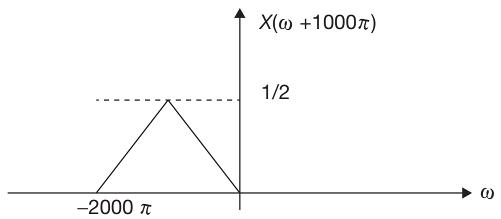


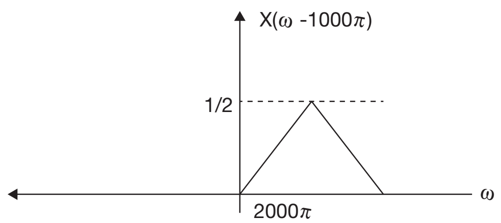
From the block diagram, shown in the figure, we get

$$z(t) = x(t).\cos 1000\pi t$$

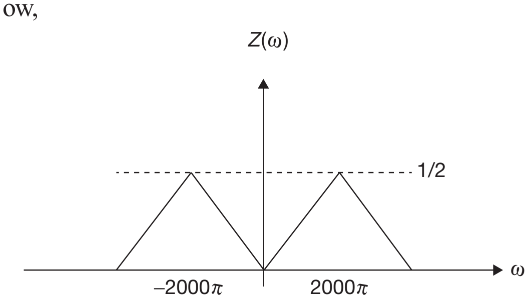
Using modulation property of Fourier Transform, we get

$$Z(\omega) = \frac{1}{2}[X(\omega + 1000\pi) + X(\omega - 1000\pi)]$$



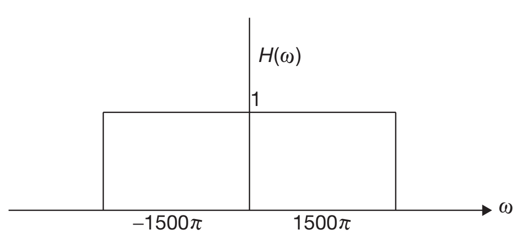


Now,



Now,

$$h(t) = \frac{\sin 1500\pi}{\pi t}$$



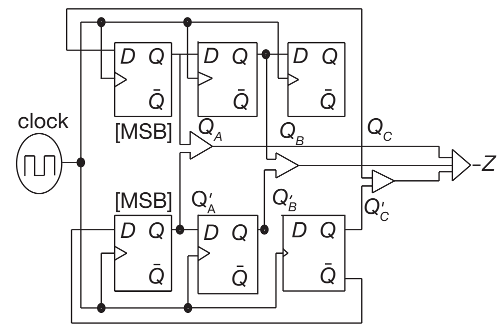
Therefore, $H(\omega)$ is a low pass filter and it will pass frequency component of $Z(\omega)$ upto 1500 π rad/sec.

Hence, required minimum sample rate is 1500 samples/sec.

Hence, the correct option is (B).

Question Number: 17 **Question Type: NAT**

For the synchronous sequential circuit shown in the figure, the output Z is 0 for the initial conditions $Q_A Q_B Q_C = Q'_A Q'_B Q'_C = 100$



The minimum number of clock cycles after which the output Z would again become 0 is _____

Solution:

Given:

$$Q_A Q_B Q_C = 100$$
$$Q'_A Q'_B Q'_C = 100$$

The output Z for the given circuit is given by

$$Z = (Q_A \oplus Q'_A) + (Q_B \oplus Q'_B) + (Q_C \oplus Q'_C) \quad \text{(i)}$$

Now, tabulating the values of outputs of flip-flops and Z as shown in the table.

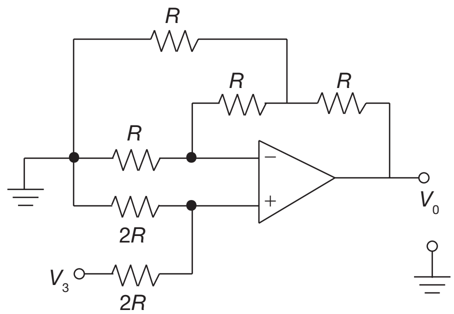
Clock	Q_A Q_B Q_C	Q'_A Q'_B Q'_C	Z	
0	1 0 0	1 0 0	0	→ initial
1	0 1 0	1 1 0	1	
2	0 0 1	1 1 1	1	
3	1 0 0	0 1 1	1	
4	0 1 0	0 0 1	1	
5	0 0 1	0 0 0	1	
6	1 0 0	1 0 0	0	→ after 6 clock pulse

Hence, the output Z is "0" after 6 clock pulses.

Hence, the correct answer is (6).

Question Number: 18 **Question Type: MCQ**

For the circuit shown in the figure, assume that the OPAMP is ideal.

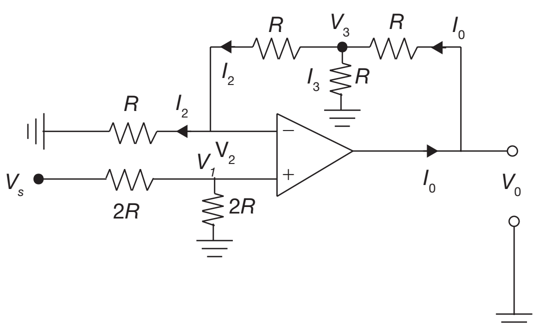


Which one of the following is TRUE?

(A) $v_0 = v_s$ (B) $v_0 = 1.5\ v_s$
(C) $v_0 = 2.5\ v_s$ (D) $v_0 = 5\ v_s$

Solution:

Redrawing the given circuit as shown in the figure,



We know that for an ideal op-amp

$$v_1 = v_2$$

Also,

$$v_1 = V\left(\frac{2R}{2R+2R}\right)$$

$$= V_s\left(\frac{2R}{4R}\right) \quad (1)$$

$$= \frac{V_s}{2}$$

Applying KCL at node v_3, we get

$$I_0 = I_3 + I_2 \quad (2)$$

$$V_2 = I_2 R \quad (3)$$

Applying KVL at the input terminals of op-amp and node V_3, we get

$$-V_3 + I_2 R + V_2 = 0$$

$$I_2 R = V_3 - V_2 \quad (4)$$

$$V_3 = V_2 + I_2 R$$

$$I_3 = \frac{V_3}{R} \quad (5)$$

From Eqs. (3) and (5), we get

$$I_2 = \frac{V_2}{R},$$

$$I_3 = \frac{V_3}{R}$$

Substituting in Eq. (4), we get

$$V_3 = V_2 + \left(\frac{V_2}{R}\right)R$$

$$= 2V_2$$

$$= 2V_1 \qquad (\because V_1 = V_2)$$

$$2V_1 = 2\times V_s / 2\ldots(\text{from eq.1})$$

$$V_3 = V_s \quad (6)$$

$$I_0 = I_3 + I_2$$

$$= \frac{V_3}{R} + \frac{V_2}{R}$$

$$= \frac{V_s}{R} + \frac{V_2}{R}(\text{from eq. (7)})$$

$$= \frac{V_s}{R} + \frac{V_s}{2R}(\because V_1 = V_2)$$

$$= V_s\left(1+\frac{1}{2}\right)$$

$$= 1.5\left(\frac{V_s}{R}\right) \quad (8)$$

Applying KVL at output, we get

$$-V_0 + I_0 R + V_3 = 0$$

$$\Rightarrow \quad V_3 = V_3 + I_0 R$$

$$\Rightarrow \quad V_0 = V_3 + I_0 R$$

$$V_0 = V_s + \frac{V_s}{R}(1.5)R$$

[from eq. (7)]

$$V_0 = V_s + V_s(1.5)$$

$$V_0 = V_s(1+1.5)$$

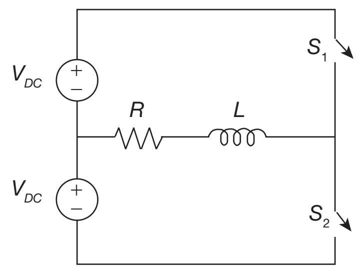
$$V_0 = 2.5V_s$$

Hence, the correct option is (C).

Question Number: 19 **Question Type: MCQ**

The figure shows a half-bridge voltage source inverter supplying an RL-load with $R = 40\ \Omega$ and $L = \left(\frac{0.3}{\pi}\right)H$.

The desired fundamental frequency of the load voltage is 50 Hz. The switch control signals of the converter are generated using sinusoidal pulse width modulation with modulation index $M = 0.6$. At 50 Hz, the RL-load draws an active power of 1.44 kW. The value of DC source voltage V_{DC} in volts is



(A) $300\sqrt{2}$ (B) 500
(C) 500 (D) $1000\sqrt{2}$

Solution:

Given resistance and inductance is

$$R = 40\ \Omega, \quad L = \left(\frac{0.3}{\pi}\right)H$$

Modulation index (M)

$$= 0.6$$

$$P_L = 1.44\ \text{kW}$$

$$M = \frac{V_{01(Peak)}}{\frac{V_{DC}}{2}}$$

$$V_{01(Peak)} = \frac{V_{DC}}{2} \times M$$

$$V_{01(rms)} = \frac{V_{DC}}{2\sqrt{2}} \times M$$

$$= \frac{V_{DC}}{2\sqrt{2}} \times 0.6$$

$$= \frac{0.3V_{DC}}{\sqrt{2}}$$

$$Z_1 = \sqrt{R^2 + (\omega L)^2}$$

$$= \sqrt{(40)^2 + \left(2\pi \times 50 \times \frac{0.3}{\pi}\right)^2}$$

$$= \sqrt{(40)^2 + (30)^2}$$

$$= 50\Omega$$

$$\cos\phi = \frac{40}{50}$$

$$= 0.8$$

$$\phi = \cos^{-1}(0.8)$$

$$= 36.86$$

$$P_L = V_{01} I_{01} \cos\phi$$

$$1.44\ \text{K} = V_{01} \frac{(V_{01})}{Z_1} \cos\phi$$

$$1440 = \left(\frac{0.3V_{DC}}{\sqrt{2}}\right)^2 \frac{1}{50} \times 0.8$$

$$\frac{1440 \times 2 \times 50}{(0.3)^2 \times 0.8} = V_{DC}^2$$

$$V_{DC} = 1414.21\ \text{V}$$

$$= 1000\sqrt{2}\ \text{V}$$

Hence, the correct option is (D).

Question Number: 20 **Question Type: NAT**

Consider the system described by the following state space representation

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

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

If $u(t)$ is a unit step input and $\begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, the value of output $y(t)$ at $t = 1$ sec (rounded off to three decimal places) is______

Solution:

$$A = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}$$

$$B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$C = [1 \quad 0]$$

Initial values $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

$$u(t) = 1 \quad \Rightarrow \quad u(s) = \frac{1}{s}$$

State equation $\dot{x}(t) = A\, X(t) + B_{u(t)}$

Converting into Laplace domain

$$s\,X(s) - X(0) = A\,X(s) + B_{u(s)}$$

$$[sI - A]X_{(s)} = X_{(0)} + B_{u(s)}$$

$$X(s) = [sI - A]^{-1}\{X(0) + B_{u(s)}\} \qquad (1)$$

$$[sI - A]^{-1} = \left[\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}\right]^{-1}$$

$$= \begin{bmatrix} s & -1 \\ 0 & s+2 \end{bmatrix}^{-1}$$

$$= \frac{1}{s(s+2)}\begin{bmatrix} s+2 & 1 \\ 0 & s \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{s} & \frac{1}{s(s+2)} \\ 0 & \frac{1}{(s+2)} \end{bmatrix}$$

$$B_{u(s)} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}\frac{1}{s}$$

$$= \begin{bmatrix} 0 \\ \frac{1}{s} \end{bmatrix}$$

Substituting the values of $[sI - A]^{-1}$, $B_{u(s)}$, $X(0)$ in Eq. (1), we get

$$X(s) = \begin{bmatrix} \frac{1}{s} & \frac{1}{s+2} \\ 0 & \frac{1}{(s+2)} \end{bmatrix}\left[\begin{bmatrix} 1 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{s} \end{bmatrix}\right]$$

$$= \begin{bmatrix} \frac{1}{s} & \frac{1}{s(s+2)} \\ 0 & \frac{1}{(s+2)} \end{bmatrix}\begin{bmatrix} 1 \\ \frac{1}{s} \end{bmatrix}$$

$$= \begin{bmatrix} \left(\frac{1}{s} + \frac{1}{s^2(s+2)}\right) \\ \frac{1}{s} \end{bmatrix}$$

$$Y(s) = C\,X(s) + D_{u(s)}$$

$$= [10]\begin{bmatrix} \left(\frac{1}{s} + \frac{1}{s^2(s+2)}\right) \\ \left(\frac{1}{s}\right) \end{bmatrix}$$

$$[\because D = [0]]$$

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

$$= \frac{1}{s} + \frac{1}{2s^2} - \frac{1}{4s} + \frac{1}{4(s+2)}$$

$$y(t) = L^{-1}\left[\frac{3}{4s} + \frac{1}{2s^2} + \frac{1}{4(s+2)}\right]$$

$$y(t) = \frac{3}{4} + \frac{t}{2} + \frac{1}{4}e^{-2t}, \text{ at } t = 1$$

We get

$$y(t) = \frac{3}{4} + \frac{1}{2} + \frac{1}{4}e^{-2} = 1.2838 \simeq \boxed{1.284}$$

Hence, the correct answer is (1.284).

Question Number: 21 **Question Type: MCQ**

The range of K for which all the roots of the equation $s^3 + 3s^2 + 2s + K = 0$ are in the left half of the complex s-plane is

(A) $0 < K < 6$
(B) $0 < K < 16$
(C) $6 < K < 36$
(D) $6 < K < 16$

Solution:

The given equation is

$$f(x) = s^3 + 2s^2 + 2s + K = 0$$

For all roots in left half of s-plane, using Routh criteria

s^3	1	2
s^2	3	K
s^1	$\frac{6-K}{3}$	0
s^0	$\left(\frac{\left(\frac{6-K}{3}\right)K - 0}{\left(\frac{6-K}{3}\right)}\right)$	0

$$\therefore \quad \frac{6-K}{3} > 0 \quad \text{and} \quad K > 0$$

$$\Rightarrow 6 - K > 0$$

$$\Rightarrow K < 6 \quad \text{and} \quad K > 0$$

$$\therefore 0 < K < 6$$

Hence, the correct option is (A).

Question Number: 22 **Question Type: MCQ**

The roots locus of the feedback control system having the characteristic equation $s^2 + 6Ks + 2s + 5 = 0$, where $K > 0$, enters into the real axis at

(A) $s = -1$ (B) $s = -\sqrt{5}$

(C) $s = -5$ (D) $s = \sqrt{5}$

Solution:

The characteristic equation is

$$s^2 + 6ks + 2s + 5 = 0$$

$$1 + \frac{6ks}{s^2 + 2s + 5} = 0 \qquad (2)$$

Comparing the Eq. (i) with 1 + G(s) = 0, We get

$$G(s) = \frac{6sk}{s^2 + 2s + 5}$$

In order to find the point at which the root locus enters the real axis we have to find the break away/break-in point. In order find break away/break-in point,

$$\frac{dk}{ds} = 0$$

i.e., $$\frac{dk}{ds} = -\frac{[6(s^2 + 2s + 5) - 6s(2s + 2)]}{(6s)^2} = 0$$

$$\Rightarrow -\frac{[6(s^2 + 2s + 5) - 6s(2s + 2)]}{(6s)^2} = 0$$

$$\Rightarrow 6(s^2 + 2s + 5) = 6s(2s + 2)$$

$$\Rightarrow s^2 + 2s + 5 - 2s^2 - 2s = 0$$

$$\Rightarrow -s^2 + 5 = 0$$

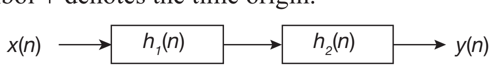
$$\Rightarrow \quad s^2 = 5$$

$$\therefore \quad s = \pm\sqrt{5}$$

If $s = \sqrt{5}$ root locus plot becomes unstable.

Hence, $s = -\sqrt{5}$ is the break-away/break-in point.

A cascade system having the impulse responses $h_1(n) = \{1, 1\}$ and $h_2(n) = \{1, 1\}$ is shown in the figure, where symbol ↑ denotes the time origin.



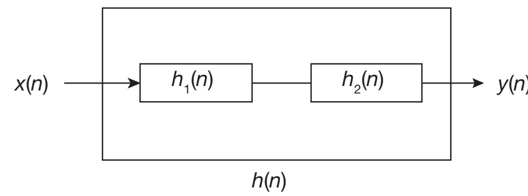
Hence, the correct option is (B).

Question Number: 23 **Question Type: MCQ**

The input sequence $x(n)$ for which the cascade system produces an output sequence $y(n) = \{1, 2, 1, -1, -2, -1\}$ is

(A) $x(n) = \{1, 2, 1, 1\}$
(B) $x(n) = \{1, 1, 2, 2\}$
(C) $x(n) = \{1, 1, 1, 1\}$
(D) $x(n) = \{1, 2, 2, 1\}$

Solution:

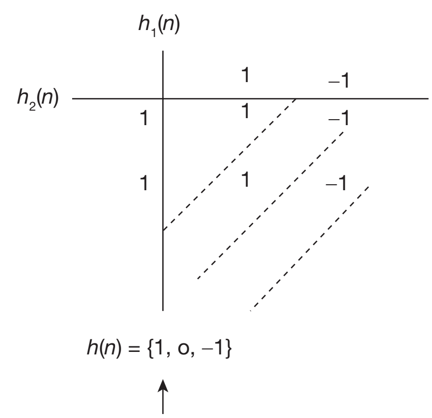


Now, $h(n)$ = overall system impulse response

$$= h_1(n) * h_2(n)$$

$$= \{1, -1\} * \{1, 1\}$$

Convolution by tabulation method,



We know that,

$$H(z) = \sum_{n=-\infty}^{\infty} h(n) \cdot z^{-n}$$

$$= 1 \cdot z^{-0} + 0 \cdot z^{-1} - 1 \cdot z^{-2} = 1 - z^{-2}$$

As we know,

$$H(z) = \frac{y(z)}{x(z)}$$

$$y(z) = \sum_{n=-\infty}^{\infty} y(n) \cdot z^{-n}$$

$$= 1 + 2z^{-1} + z^{-2} - z^{-3} - 2z^{-4} - z^{-5}$$

$$x(z) = \frac{y(z)}{H(z)}$$

$$= \frac{1 + 2z^{-1} + z^{-2} - z^{-3} - 2z^{-4} - z^{-5}}{1 - z^{-2}}$$

$$\Rightarrow \quad x(z) = 1 + 2z^{-1} + 2z^{-2} + z^{-3}$$

$$x(n) = \{1, 2, 2, 1\}$$
$$\uparrow$$

Hence, the correct option is (D).

Question Number: 24 **Question Type: MCQ**

A person decides to toss a fair coin repeatedly until he gets a head. He will make at most 3 losses. Let the random variable Y denote the number of heads. The value of var(Y). Where var(.) denotes the variance, equals:

(A) $\frac{7}{8}$ (B) $\frac{49}{64}$

(C) $\frac{7}{64}$ (D) $\frac{105}{64}$

Solution:

Maximum no. of losses = 3

The various combinations of three tosses = 8

The random variable Y denotes no. of heads

The various combinations are,

$$\begin{matrix} H & H & H & \rightarrow (\text{'0' heads}) \\ H & T & H \\ H & T & T \\ T & H & T \\ T & T & H \\ H & H & T \\ T & H & H \\ T & T & T \end{matrix}$$

From the above combinations,

The probability for "0" heads $= \frac{1}{8}$

The probability for atleast one head $= \frac{7}{8}$

$$\therefore \quad E(Y) = y_1 P(y_1) + y_2 P(y_2)$$
$$= 0 \times \frac{1}{8} + 1 \times \frac{7}{8} = \frac{7}{8}$$
$$E(Y^2) = 0^2 \times \left(\frac{1}{8}\right) + 1^2 \times \left(\frac{7}{8}\right) = \frac{7}{8}$$
$$\therefore \quad \text{Variance}(Y) = E(Y^2) - [E(Y)]^2$$
$$= \frac{7}{8} - \left(\frac{7}{8}\right)^2 = \frac{7}{8} - \frac{49}{64}$$
$$= \frac{56 - 49}{64} = \frac{7}{64}$$

Hence, the correct option is (C).

Question Number: 25 **Question Type: NAT**

Two generating units rated 300 MW and 400 MW have governor speed regulation of 6% and 4%, respectively from no load to full load. Both the generating units are operating in parallel to share a load of 600 MW. Assuming free governor action, the load shared by the larger unit is _______ MW.

Solution:

For first generator

Rating = 300 MW

Governor speed regulation = 6%

$\therefore$ Frequency droop coefficient

$$K_{P_1} = \frac{-\left(\frac{6}{100} \times f_{0_1}\right)}{300}$$
$$\{f_{0_1} = \text{no load frequency of Gen. 1}\}$$
$$f_1 = K_{P_1} \times (P_1) + f_{0_1} \quad (3)$$

For second generator

Rating = 400 MW

Governor speed regulation = 4%

$\therefore$ Frequency droop coefficient

$$K_{P_2} = \frac{-\left(\frac{4}{100} \times f_{0_2}\right)}{300}$$
$$\{f_{0_2} = \text{no load frequency of Gen. 2}\}$$
$$f_2 = K_{P_2} \times (P_2) + f_{0_2} \quad (4)$$
$$\text{Given} \quad f_{0_1} = f_{0_2} = f_0$$

Since, both machine operate parallel so

$$f_1 = f_2$$
$$\Rightarrow \frac{-0.06 f_0}{300} P_1 = \frac{-0.04 f_0}{400} P_2$$
$$\Rightarrow 2P_1 = P_2 \quad (5)$$
$$\text{and} \quad P_1 + P_2 = 600 \text{ MW} \quad (6)$$

Using Eqs. (3) and (4)

$$P_1 = 200 \text{ MW}$$

And

$$P_2 = 400 \text{ MW}$$

$\therefore$ Load shared by larger unit

i.e., $P_2 = 400$ MW

Hence, the correct answer is (400 MW).

Question Number: 26 **Question Type: MCQ**

The eigenvalues of the matrix given below are:

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix}$$

(A) (0, –1, –3) (B) (0, –2, –3)
(C) (0, 2, 3) (D) (0, 1, 3)

Solution:

The given matrix is

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix}$$

Now,

$(A - \lambda I) = 0$

$$(A - \lambda I) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix} - \begin{bmatrix} \lambda & 0 & 0 \\ 0 & \lambda & 0 \\ 0 & 0 & \lambda \end{bmatrix}$$

$$= \begin{bmatrix} \lambda & 1 & 0 \\ 0 & -\lambda & 1 \\ 0 & -3 & (-4-\lambda) \end{bmatrix}$$

On solving,

$$\Rightarrow \quad (-\lambda)\left[(-4-\lambda)-(-3)\right]-1\left[0\right]+0=0$$

$$\Rightarrow \quad \lambda^2(4+\lambda)+3\lambda=0$$

$$\Rightarrow \quad \lambda^3+4\lambda^2+3\lambda=0$$

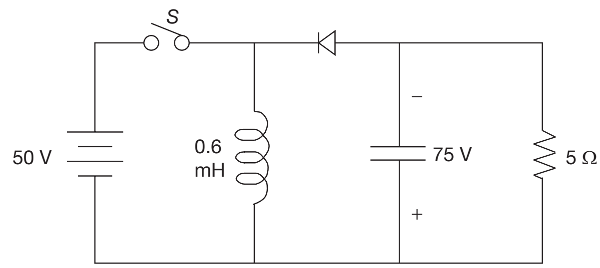
$$\Rightarrow \quad \lambda\left(\lambda^2+4\lambda+3\right)=0$$

$$\therefore \quad \lambda=\left(0,-1,-3\right)$$

Hence, the correct option is (A).

Question Number: 27 **Question Type: NAT**

In the circuit shown all elements in the figure, are ideal and the switch S is operated at 10 kHz and 60% duty ratio. The capacitor is large enough so that the ripple across it is negligible and at steady state acquires a voltage as shown. The peak current in amperes drawn from the 50V DC source is _________. (Give the answer up to one decimal place)



Solution:

The given ckt is a Buck Boost converter

Given data,

$$V_s = 50 \text{ V}$$
$$L = 0.6 \text{ mH}$$
$$V_C = V_0 = 75 \text{ V}$$
$$f = 10 \text{ kHz}$$
$$\text{duty cycle} \quad D = 0.6$$

The output voltage of Buck Boost converter is given by,

$$V_0 = \frac{DV_s}{(1-D)}$$

$$= \frac{0.6V_s}{(1-0,6)}$$

$$= \frac{0.6}{0.4}V_s$$

$$\frac{V_0}{V_s} = \frac{6}{4} = \frac{3}{2}$$

$$\Rightarrow \quad V_0 = \frac{3}{2} \times 50 = 75 \text{ V}$$

Load current

$$(I_0) = \frac{V_0}{R} = \frac{75}{5} = 15A$$

Source current is given by

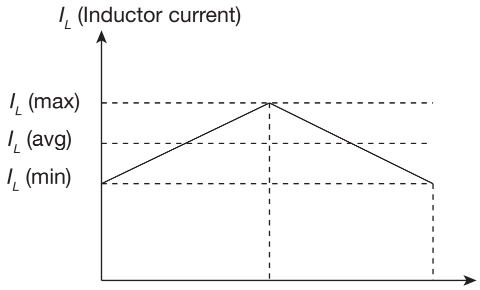
$$(I_S) = \frac{D}{(1-D)} I_0$$

$$= \frac{3}{2} \times 15$$

$$= 22.5 \text{ A}$$

The wave form of current through the inductor shows load current is sum of source current and capacitor current,

$$I_L(\text{avg}) = (I_s)_{\text{avg}} + (I_0)_{\text{avg}}$$
$$= 22.5 + 15$$
$$= 37.5$$

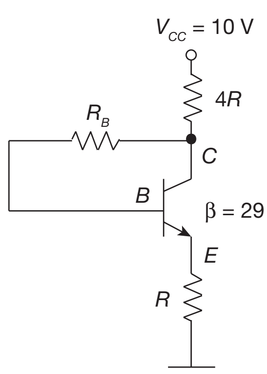


$$\text{Current ripple, } \Delta I_L = \frac{DV_s}{fL}$$
$$= \frac{0.6 \times 50}{10 \times 10^3 \times 0.6 \times 10^{-3}}$$
$$= 5 \text{ A}$$
$$(I_L)_{\max} = (I_L)_{\text{avg}} + \frac{\Delta I_L}{2}$$
$$= 37.5 + \frac{5}{2}$$
$$= 40 \text{ A}$$
$$\text{Peak current } I_{\text{peak}} = (I_L)_{\max} = 40 \text{ A}$$

Hence, the correct answer is (40).

Question Number: 28 **Question Type: MCQ**

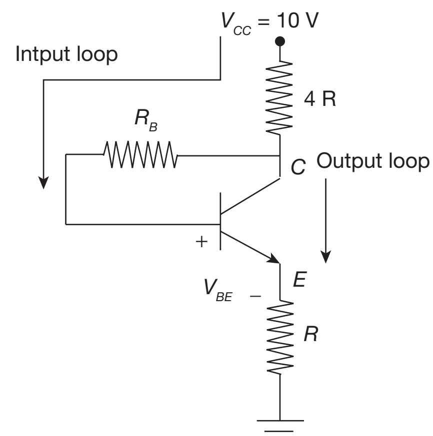
For the circuit shown in the figure, it is given that $V_{CE} = \frac{V_{CC}}{2}$. The transistor has $\beta = 29$ and $V_{BE} = 0.7$ V when the B-E junction is forward-biased.



For this circuit, the value of $\frac{R_B}{R}$ is

(A) 43 (B) 92
(C) 121 (D) 129

Solution:



Given:

$$V_{CE} = \frac{V_{CC}}{2}$$
$$\beta = 29$$
$$V_{BE} = 0.7 \text{ V}$$

Applying KVL at input, we get,

$$-10 + I_B(1+\beta)4R + I_B R_B + V_{BE} + (1+\beta)I_B C$$
$$-10 + I_B(1+29)4R + I_B R_B + 0.7 + (30)I_B C$$
$$9.3 = 150 I_B R + I_B R_B \quad (1)$$

Applying KVL at output, we get

$$-10 + 4R(1+\beta)I_B + V_{CE} + (1+\beta)I_B R = 0$$
$$10 = 4R(1+29)I_B + (1+29)RI_B + \frac{V_{CC}}{2} = 0$$
$$10 = 150 I_B R + 5$$
$$5 = 150 I_B R \quad (2)$$

Substituting Eq. (2) in Eq. (1), we get

$$9.3 = 5 + I_B R_B$$
$$I_B R_B = 4.3 \quad (3)$$

From Eq. (1), we get

$$9.3 = I_B R\left[150 + \frac{R_B}{R}\right]$$

$$= \frac{5}{150}\left[150 + \frac{R_B}{R}\right]$$

[From eq. (2)]

$$\frac{9.3\times 150}{5} = 150 + \frac{R_B}{R}$$

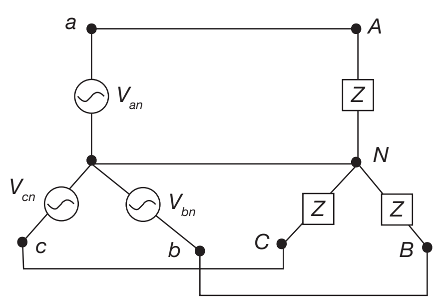
$$\frac{93\times 15}{5} - 150 = \frac{R_B}{R}$$

$$\Rightarrow \boxed{\frac{R_B}{R} = 129}$$

Hence, the correct answer is (D).

Question Number: 29 **Question Type: MCQ**

For the balanced Y-Y connected 3-phase circuit shown in the figure, the line-line voltage is 208V rms and the total power absorbed by the load is 432W at a power factor of 0.6 leading.



The approximate value of the impedance Z is:

(A) $33\angle -53.1°\Omega$
(B) $60\angle 53.1°\Omega$
(C) $60\angle -53.1°\Omega$
(D) $180\angle -53.1°\Omega$

Solution:

RMS Line to line voltage (V_L) = 208 V

Total power absorbed by load (P) = 432 W

Operating power factor = 0.6 leading

Power absorbed by 3 f load,

$$P = \sqrt{3}V_L I_L \cos\phi$$

$$432 = \sqrt{3}(208)(I_L)(0.6)$$

$$I_L = \frac{432}{\sqrt{3}\times 208\times 0.6}$$

$$= 1.9985 \text{ A}$$

We known in star connection,

$$I_L = I_{ph}$$

$$\therefore \quad Z = \frac{V_{ph}}{I_{ph}}$$

$$= \frac{V_L/\sqrt{3}}{I_{ph}}$$

$$= \frac{208/\sqrt{3}}{1.9985}$$

$$= 60.08\ \Omega$$

$\therefore$ Approximate value of Z

$$= 60.08\angle -\cos^{-1}(0.6)$$

$$Z = 60.08\angle -53.13°$$

Hence, the correct option is (C).

Question Number: 30 **Question Type: NAT**

A 3-phase, 2-pole, 50 Hz, synchronous generator has a rating of 250 MVA, 0.8 pf lagging. The kinetic energy of the machine at synchronous speed is 1000 MJ. The machine is running steadily at synchronous speed and delivering 60 MW power at a power angle of 10 electrical degrees. If the load is suddenly removed, assuming the acceleration is constant for 10 cycles, the value of the power angle after 5 cycles is___________ electrical degrees.

Solution:

No of poles (P) = 2

No. of phases = 3

f = 50 Hz (frequency)

S = 250 MVA (rating)

$\cos\phi$ = 0.8 lag

Kinetic energy = 1000 MJ

P_e = 60 MW

δ_0 = 10°

When load is removed P_e = 0, then

$$P_a = P_m - P_e$$

$$= P_m - 0$$

$$P_a = P_m$$

$$i.e.,\ P_m = 60 \text{ MW}$$

50 cycles in 1 sec,

10 cycle in?

$$t = \frac{10 \times 1}{50} = 0.2\,\text{sec}$$

We know inertia constant (M)

$$= \frac{KE}{180f} = \frac{1000}{180 \times 50} = 0.111\ \text{MJ/deg- Hz}$$

We know,

$$P_a = M\frac{d^2\delta}{dt^2}$$

Integrating on both sides, we get

$$P_a\frac{t^2}{2} = \delta M$$

$$\delta = \frac{P_a t^2}{2M}$$

$$\delta = \frac{(60M) \times (0.1)^2}{2(0.11)M}$$

$$\delta = \frac{60 \times (0.1)^2}{2(0.11)}$$

$$\delta = 2.7°$$

∴ The value of power angle after 5 cycles

$$= (\delta + \delta_0) \quad (5)$$

$$= (2.7 + 10)$$

$$= \boxed{12.7°}$$

Hence, the correct answer is (12.7°).

Question Number: 31 **Question Type: NAT**

A 3-phase, 50 Hz generator supplies power of 3 MW at 17.32 kV to a balanced 3-phase inductive load through an overhead line. The per phase line resistance and reactance are 0.25 Ω and 3.925 Ω, respectively. If the voltage at the generator terminal is 17.87 kV, the power factor of the load is________.

Solution:

$$f = 50\text{ Hz}$$

$$P_R = 3\text{ MW}$$

(receiving end power)

$$V_R = 17.32\text{ kV(line to line)}$$

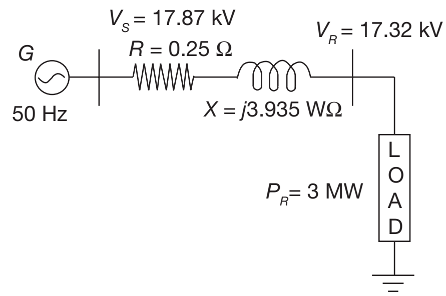
$$R = 0.25\ \Omega\text{/phase}$$

$$X_L = 3.925\ \Omega\text{/phase}$$

$$V_S = 17.87\text{ kV (line to line)}$$

$$\cos\phi = ?$$

We know, $P_R = \sqrt{3}V_R I_R \cos\phi$



$$I_R = \frac{P_R}{\sqrt{3}V_R\cos\phi} \quad (1)$$

$$\left(\frac{V_S}{\sqrt{3}} - \frac{V_R}{\sqrt{3}}\right) = I_R(R\cos\phi + X_L\sin\phi)$$

$$\frac{(V_s - V_R)}{\sqrt{3}} = \frac{P_R}{\sqrt{3}V_R\cos\phi}(R\cos\phi + X_L\sin\phi)$$

[From eq. (1)]

$$V_S - V_R = \frac{P_R}{V_R\cos\phi}(R\cos\phi + X_L\sin\phi)$$

$$(V_S - V_R) = \frac{P_R}{V_R}(R + X_L\tan\phi)$$

$$\frac{V_R}{P_R}(V_S - V_R) - R = X_L\tan\phi$$

$$\tan\phi = \frac{V_R}{P_R \times L}(V_S - V_R) - \frac{R}{X_L}$$

$$= \frac{17.32 \times 10^3}{3 \times 10^6 \times 3.925}(17.87 \times 10^3 - 17.32 \times 10^3) - \frac{0.25}{3.925}$$

$$\tan\phi = 0.7453$$

$$\phi = \tan^{-1}(0.7453)$$

$$\phi = 36.697°$$

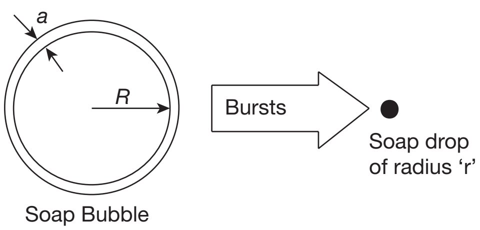
$$\therefore \quad \cos\phi = \cos 36.697$$

$$= 0.8018$$

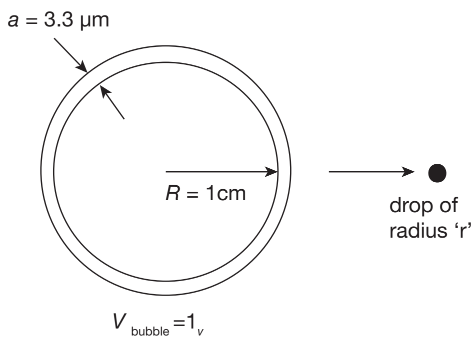
The power factor of the load is 0.8018.
Hence, the correct answer is (0.8018).

Question Number: 32 **Question Type: NAT**

A thin soap bubble of radius R = 1 cm, and thickness a = 3.3 μm($a << R$), is at a potential of 1V with respect to a reference point at infinity. The bubble bursts and becomes a single spherical drop of soap (assuming all the soap is contained in the drop) of radius r. The volume of the soap in the thin bubble is $4\pi R^{2a}$ and that of the drop is $\frac{4}{3}\pi r^3$. The potential in volts, of the resulting single spherical drop with respect to the same reference point at infinity is _______. (Give the answer up to two decimal places.)



Solution:



Using volume conservation,

$$4\pi R^2 a = \frac{4}{3}\pi r^3$$

$$\Rightarrow \quad 3R^2 a = r^3$$

$$\Rightarrow \quad r = 0.00096655 \text{ m}$$

$$V_{\text{bubble}} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

$$= 1V \qquad (1)$$

$$V_{\text{drop}} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r} \qquad (2)$$

From Eqs. (1) and (2), we get

$$\frac{V_{\text{bubble}}}{V_{\text{drop}}} = \frac{r}{R}$$

$$\Rightarrow \quad \frac{1}{V_{\text{drop}}} = \frac{0.000996655}{(0.01)}$$

$$\Rightarrow \quad V_{\text{drop}} = 10.03\,V$$

Hence, the correct answer is (10.03 V).

Question Number: 33 **Question Type: NAT**

A 25 kVA, 400 V, Δ-connected, 3-phase, cylindrical rotor synchronous generator requires a field current of 5 A to maintain the rated armature current under short-circuit condition. For the same field current, the open-circuit voltage is 360 V. Neglecting the armature resistance and magnetic saturation, its voltage regulation (in percentage with respect to terminal voltage), when the generator delivers the rated load at 0.8 pf leading, at rated terminal voltage is ___________.

Solution:

Given data, $S = 25$ kVA

$$V = 400 \text{ V}(l-l)$$

$$I_0 = 5 \text{ A (field current)}$$

$$V_0 = 360 \text{ V}(OC \text{ voltage})$$

$$R_a = 0$$

$$I_{\text{rated}} = \frac{25\times10^3}{\sqrt{3}\ V} = \frac{25000}{\sqrt{3}\times400} = 36.08 \text{ A (line-line)}$$

$$I_{\text{rated/phase}} = \frac{36.08}{\sqrt{3}} \text{ (for } \Delta \text{ winding)} = 20.833 \text{ A}$$

$$\text{then,} \quad X_s = \frac{V_{0/\text{Phase}}}{I_{\text{rated/Phase}}} = \frac{360}{20.833}\left[\because V_{0/(l-l)} = V_{0/\text{Phase}} \text{ for } \Delta\right]$$

We know voltage regulation can be calculated by calculating E.

$$E = [(V\cos\phi + I_aR_a)^2 + (V\sin\phi - I_aX_s)^2]^{1/2}$$

$$= \begin{bmatrix}[(400)(0.8)+(0)20.83]^2 \\ +[400\times0.6-(17.28)(20.83)]^2\end{bmatrix}^{\frac{1}{2}}$$

$$= \left[(400\times0.8)^2 + ((400\times0.6-(17.28)(20.83))^2\right]^{1/2}$$

$$= [(320)^2 + (240-359.9424)^2]^{\frac{1}{2}}$$

$$= \left[(320)^2 + (119.9424)^2\right]^{1/2} = 341.739 \text{ V}$$

$$\therefore \quad \% \text{ Voltage regulation} = \frac{E-V}{V}\times100$$

$$= \frac{341.739-400}{400}\times100$$

$$= -0.145\times100 = \boxed{-14.50\%}$$

Hence, the correct answer is (–14.50).

Question Number: 34 Question Type: NAT

A star-connected, 12.5 kW, 208 V (line), 3-phase, 60 Hz squirrel cage induction motor has following equivalent circuit parameters per phase referred to the stator. R_1 = 0.3 W, R_2 = 0.3 W, X_1 = 0.41 W, X_2 = 0.41 W. Neglect shunt branch in the equivalent circuit. The starting current (in Ampere) for this motor when connected to an 80 V (line), 20 Hz, 3-phase AC source is __________.

Solution:

Given data,

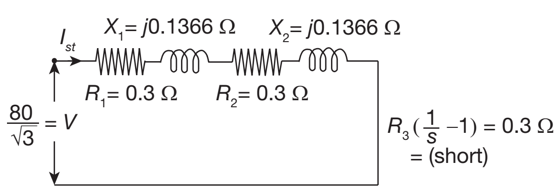
$$V = 208 \text{ (line-line)}$$
$$P = 12.5 \text{ kW}$$
$$f = 60 \text{ Hz}$$
$$R_1 = 0.3\ \Omega$$
$$R_2 = 0.3\ \Omega$$
$$X_1 = 0.41\ \Omega \text{ at } 60 \text{ Hz}$$
$$X_2 = 0.41\ \Omega \text{ at } 60 \text{ Hz}$$
$$V_{st} = 80V \text{ (line-line)}$$

at 20 Hz

$$X_1 = \frac{20}{60} \times 0.41 = 0.1366\ \Omega$$
$$X_2 = \frac{20}{60} \times 0.41 = 0.1366\ \Omega$$

at starting $s = 1$.

Hence, $R_2\left(\frac{1}{s} - 1\right) = 0\ \Omega.$



Starting current,

$$|I_{st}| = \frac{V_{st}}{\sqrt{(R_1 + R_2)^2 + (X_1 + X_2)^2}}$$
$$= \frac{80/\sqrt{3}}{\sqrt{(0.3 + 0.3)^2 + (0.1366 + 0.1366)^2}}$$
$$= \frac{80/\sqrt{3}}{\sqrt{(0.6^2 + (0.273)^2}}$$
$$= \frac{80}{\sqrt{3} \times 0.6591} = 70.06 \text{ A}$$

Hence, the correct answer is (70.06 A).

Question Number: 35 Question Type: MCQ

Which of the following systems has maximum peak overshoot due to a unit step input?

(A) $\frac{100}{s^2 + 10s + 100}$ (B) $\frac{100}{s^2 + 15s + 100}$

(C) $\frac{100}{s^2 + 5s + 100}$ (D) $\frac{100}{s^2 + 20s + 100}$

Solution:

As we know that damping ratio (ξ)

$$\xi \uparrow = M_P \downarrow$$

Checking value of ξ for all options,

(A) $\frac{100}{s^2 + 10s + 100} \Rightarrow \omega_n = 10$

$$2\xi\omega_n = 10$$
$$\Rightarrow \quad 2\xi = 1$$
$$\Rightarrow \quad \xi = 0.5$$

(B) $\frac{100}{s^2 + 15s + 100} \Rightarrow \omega_n = 10$

$$2\xi\omega_n = 15$$
$$20\xi = 15$$
$$\xi = \frac{3}{4}$$
$$= 0.75$$

(C) $\frac{100}{s^2 + 5s + 100} \Rightarrow \omega_n = 10$

$$2\xi\omega_n = 5$$
$$\xi = \frac{5}{20}$$
$$= 0.25$$

(D) $\frac{100}{s^2 + 20s + 100} \Rightarrow \omega_n = 10$

$$2\xi\omega_n = 20$$
$$\xi = \frac{20}{20}$$
$$= 1$$

Hence, option (C)

M_P will be highest at $\xi = 0.25$.

Hence, the correct option is (C).

Question Number: 36 Question Type: MCQ

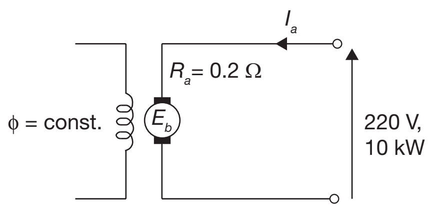
A 220 V, 10 kW, 900 rpm separately excited DC motor has an armature resistance R_a = 0.02 Ω. When the motor operates at rated speed and with rated terminal voltage, the electromagnetic torque developed by the motor is 70 Nm. Neglecting the rotational losses of the machine, the current drawn by the motor from the 220 V supply is:

(A) 34.2 A (B) 30 A
(C) 22 A (D) 4.84 A

Solution:

Rated torque = 70 Nm.

$I_{\text{rated}} = ?$



In separately excited motor, field flux remains constant.

Now $V = E + I_a R_a$

$$\Rightarrow \quad 220 = E + I_a(0.02) \qquad (1)$$

$$\text{and} \quad E = \frac{NP\phi}{60A} \qquad (2)$$

$$T = \frac{ZP\phi I_a}{2\pi A} \qquad (3)$$

From Eqs. (2) and (3), we get

$$\frac{E}{T} = \frac{(N)(2\pi)}{60 I_a}$$

$$\Rightarrow \quad EI_a = \frac{(900)(2\pi)(70)}{60}$$

$$= 6597.344 \qquad (4)$$

From Eqs. (1) and (4), we get

$$220 = \frac{6597.344}{I_a} + I_a(0.02)$$

$$\Rightarrow \quad (0.02)I_a^2 - 220 I_a + 6597.344 = 0$$

$$\Rightarrow \quad I_a = 10969.92,\ 30.07 \text{ A}$$

Discarding excessively high armature current value, we get rated current value 30.07 A ≈ 30 A.
Hence, the correct option is (B).

Question Number: 37 Question Type: MCQ

The value of the contour integral in the complex-plane

$$\oint \frac{z^s - 2z + 3}{z - 2} dz$$

along with the contour |z| = 3, taken counter-clockwise is:

(A) $-18\pi i$ (B) 0
(C) $14\pi i$ (D) $48\pi i$

Solution:

Given contour Integral is

$$\oint \frac{z^3 - 2z + 3}{z - 2} dz \text{ where } f(z) = \frac{z^3 - 2z + 3}{(z - 2)}$$

and the contour is |z| = 3 in counter-clockwise.
The pole z = 2 lies inside the contour |z| = 3.
Using residue theorem, we get

$$\text{Res}(f(z)) = \lim_{x \to \infty} (z - 2)\left[\frac{z^3 - 2z + 3}{(z - 2)}\right]$$

$$= 8 - 2(2) + 3$$

$$= 7$$

Using Cauchy's residue theorem, we get

$$\oint \frac{z^3 - 2z + 3}{(z - 2)} dz = 2\pi i[\text{Res}(f(z))]$$

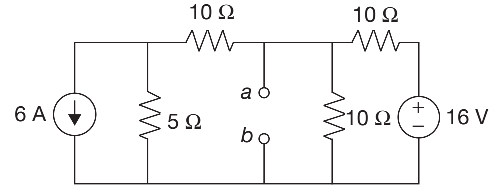
$$= 2\pi i(7)$$

$$= 14\pi i$$

Hence, the correct option is (C).

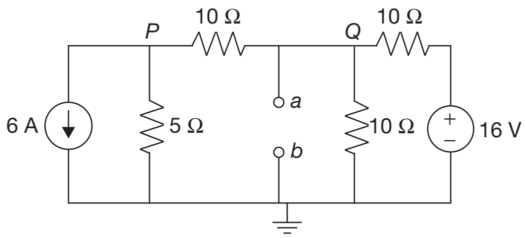
Question Number: 28 Question Type: MCQ

For the network given in figure, the Thevenin's voltage V_{ab} is:



(A) –1.5 V (B) –0.5 V
(C) 0.5 V (D) 1.5 V

Solution:



Applying KCL at points P and Q,

At P:

$$6 + \frac{V_P}{5} + \frac{V_P - V_Q}{10} = 0$$

$$\Rightarrow \quad V_Q - 3V_P = 60$$

At Q:

$$\frac{V_Q}{10} + \frac{V_Q - 16}{10} + \frac{V_Q - V_P}{10} = 0$$

$$\Rightarrow \quad 3V_Q - V_P = 16$$

Solving Eqs. (1) and (2), we get

$$V_Q = -\frac{3}{2}$$
$$= -1.5 \text{ V}$$

As V_Q is V_{ab},

Hence $V_{ab} = -1.5$ V.

Hence, the correct option is (A).

Question Number: 39 **Question Type: NAT**

A 120 V DC shunt motor takes 2 A at no load. It takes 7 A on full load while running at 1200 rpm. The armature resistance is 0.8 Ω, and the shunt field resistance is 240 Ω. The no load speed, in rpm, is __________.

Solution:

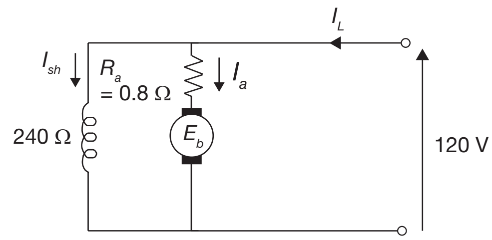
DC shunt motor,

In No load:

$$I_0 = 2A$$
$$N_0 = ?$$

In Full load:

$$I_L = 7 \text{ A}$$
$$N = 1200 \text{ rpm}$$



As the voltage across shunt is constant (120 V), I_{sh} remains constant,

$$I_{sh} = \frac{120}{240} \text{ A} = 0.5 \text{ A}$$

for No load, $I_0 = 2$ A

and $I_0 = I_{a0} + I_{sh}$

$$2 = I_{a0} + 0.5$$

$$\Rightarrow \quad I_{a0} = 1.5 \text{ A}$$

Now, $v_{t0} = E_0 + I_{a0} R_a$

$$120 = E_0 + (1.5)(0.8)$$

$$\Rightarrow \quad E_0 = 118.8 \text{ V}$$

At full load,

$$I_L = I_a + I_{sh}$$
$$7 = I_a + 0.5$$
$$\Rightarrow \quad I_a = 6.5 \text{ A}$$

Now, $V_t = E_b + I_a R_a$

$$\Rightarrow \quad 120 = E_b + (6.5)(0.8)$$
$$\Rightarrow \quad E_b = 114.8 \text{ V}$$

Now,

as $E \propto \phi N$

and ϕ = constant for DC shunt motor.

$$\therefore \quad E \propto N$$

Hence $\frac{E_b}{E_0} = \frac{N}{N_0}$

$$= \frac{114.8}{118.8}$$

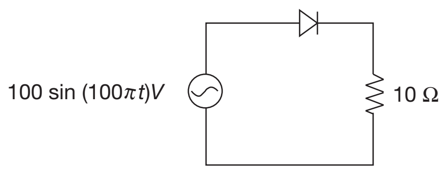
$$\Rightarrow \quad N_0 = \frac{114.8}{118.8} \times 1200$$

$$N_0 = 1241.811 \text{ rpm.}$$

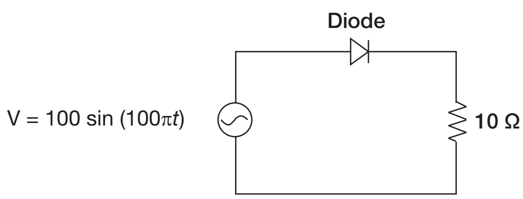
Hence, the correct answer is (1241.811).

Question Number: 40 **Question Type: NAT**

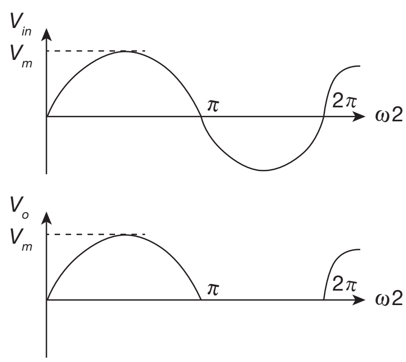
In the circuit shown in the figure, the diode used is ideal. The input power factor is ________. (Give the answer up to two decimal places)



Solution:



In the above half-wave diode rectifier,



$$V_0 = \frac{V_m}{\pi}$$

$$\therefore \quad I_0 = \frac{\left(\frac{V_m}{\pi}\right)}{R}$$

$$I_{S_{rms}} = \sqrt{\frac{1}{2\pi}\int_0^{\pi}\left(\frac{V_m \sin\omega t}{R}\right)^2 d(\omega t)}$$

$$I_{S_{rms}} = \sqrt{\frac{V_m^2}{2\pi R^2}\int_0^{\pi}\sin^2\omega t \; d(\omega t)}$$

$$= \frac{V_m^2}{2\pi R^2}\sqrt{\int_0^{\pi}\left(\frac{1-\cos 2\omega t}{2}\right)d(\omega t)}$$

$$= \left(\frac{V_m}{2R}\right)$$

$$I_{S_{rms}} = I_{L_{rms}}$$

Input power factor

$$= \frac{\text{Power output at load}}{\text{Power input at source}}$$

$$\text{input } p.f = \frac{V_{L\text{ rms}} \times I_{L\text{ rms}}}{V_{S\text{ rms}} \times I_{S\text{ rms}}} \quad (1)$$

$$V_{L\text{ rms}} = R \times I_{L\text{ rms}}$$

$$= R \times \frac{V_m}{2R} = \frac{V_m}{2}$$

$$\text{input } p.f = \frac{V_{L\text{ rms}}}{V_{S\text{ rms}}} = \frac{\frac{V_m}{2}}{\frac{V_m}{\sqrt{2}}}$$

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

$$\text{input } p.f = 0.707$$

Hence, the correct answer is (0.707).

Question Number: 41 **Question Type: NAT**

A $10\frac{1}{2}$ digit timer counter possesses a base clock of frequency 100 MHz. When measuring a particular input, the reading obtained is the same in:

(i) Frequency mode of operation with a gating time of one second and

(ii) Period mode of operation (in the x10 ns scale).

The frequency of the unknown input (reading obtained) in Hz is________.

Solution:

Frequency of base clock (n) = 100 MHz

Gate time (t) = 1 sec.

Given the reading obtained in frequency mode and period mode is same

1. In frequency mode

$$f = \frac{n}{t}$$

$$f = \frac{100 \times 10^6}{1}$$

$$f = 10^8$$

2. In period mode, we know period P of input signal is the inverse of its frequency

$$P = \frac{1}{f}$$
$$P = \frac{1}{10^8}$$
$$= 10^{-8}$$
$$= 10 \times 10^{-9}$$
(Converting into n-sec scale)
$$P = 10\ ns$$

The frequency and period displayed on $10\frac{1}{2}$ digit scale. We know in $10\frac{1}{2}$ digit scale the most significant bit shows only (0, 1) and remaining digit display from (0 to 9).

Thus, frequency is displayed as $\boxed{100000000.00}$ Hz.

Period is displayed as $\boxed{100000000.00}$ n sec.

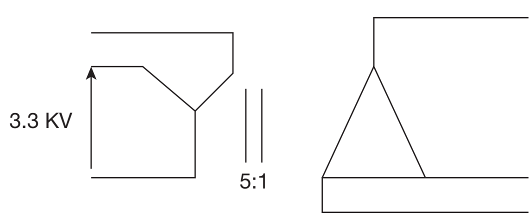
$$\boxed{f = 100000000.00 \text{ Hz}}$$

Hence, the correct answer is (100000000.00).

Question Number: 42 **Question Type: NAT**

If the primary line voltage rating is 3.3 kV (Y side) of a 25 kVA. Y-Δ transformer (the per phase turns ratio is 5:1), then the line current rating of the secondary side (in Ampere) is _________.

Solution:



Transformer rating = 25 kVA

Finding primary line current,

$$I_{P_L} = \frac{25 \times 10^3}{\sqrt{3} \times 3.3 \times 10^3}$$
$$= 4.373 \text{ A}$$

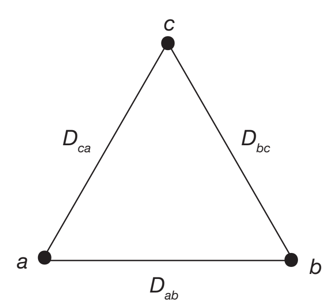
Now, transforming phase currents

$$\frac{I_{P_L}}{I_{S_{Ph}}} = \frac{1}{5} \left(\because I_{P_{\text{Line}}} = I_{P_{\text{Phase}}} \text{ in star connection} \right)$$
$$\Rightarrow \quad I_{S_{Ph}} = 4.373 \times 5 = 21.86 A$$
$$\text{Now} \quad I_{S_L} = \sqrt{3}\, I_{S_{Ph}}$$
$$= \sqrt{3} \times 21.86$$
$$= 37.8787 \text{ A}$$

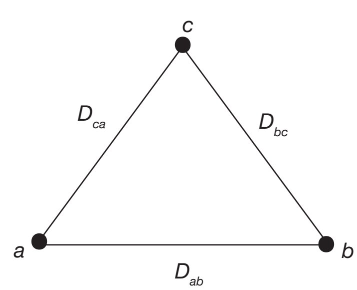
Hence, the correct answer is (37.8787).

Question Number: 43 **Question Type: NAT**

Consider an overhead transmission line with 3-phase, 50 Hz balanced system with conductors located at the vertices of an equilateral triangle of length $D_{ab} = D_{bc} = D_{ca} = 1$ m as shown in figure. The resistances of the conductors are neglected. The geometric mean radius (GMR) of each conductor is 0.01 m. Neglecting the effect of ground the magnitude of positive sequence reactance in Ω/km (rounded off to three decimal place) is _________.



Solution:



frequency

$$f = 50 \text{ Hz}$$
$$D_{ab} = D_{bc} = D_{ca} = 1 \text{ m}$$
$$GMR = 0.01 \text{ m}$$

we know, $L = 2\times10^{-7}\ \ln\left(\frac{GMD}{GMR}\right)$ …(1)

Since, it is equilateral spacing therefore,

$\therefore\ GMD_A = GMD_B = GMD_C = GMD = 0.01$ m

$$\therefore\ L = 2\times10^{-7}\ \ln\left(\frac{1}{0.01}\right)$$
$$= 2\times10^{-7}\ \ln(100)$$
$$= 9.2103\times10^{-7}\text{ H}$$

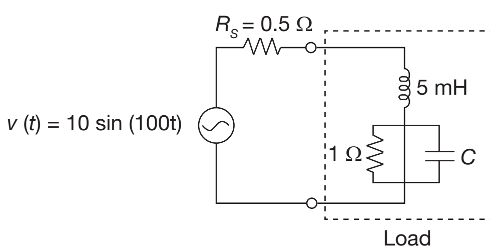
Positive sequence reactance

$$(X_L)$$
$$= 2\pi fL$$
$$= 2\pi\times50\times9.2103\times10^{-7}$$
$$= 2.8935\times10^{-4}\ \Omega/\text{m}$$
$$= \boxed{0.28935\ \Omega/\text{km}}$$
$$\approx 0.289\ \Omega/\text{km}$$

Hence, the correct answer is (0.289).

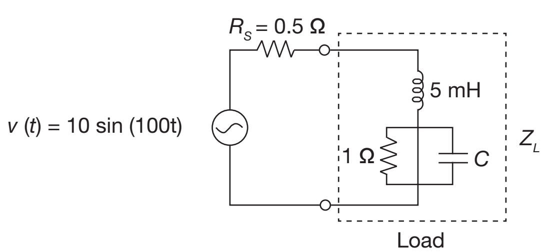
Question Number: 44 **Question Type: MCQ**

In the circuit shown in the figure, the value of capacitor C required for maximum power to be transferred to the load is



(A) 1 nF (B) 1 μF
(C) 1 mF (D) 10 mF

Solution:



For max power transfer theorem,

$$Z_L = Z_S^*$$

Calculating Z_L,

$$Z_L = j\omega L + \frac{R/j\omega C}{R+\frac{1}{j\omega C}}$$

$$\Rightarrow Z_L = j(100)(5\times10^{-3}) + \frac{1}{j(100C)+1}$$
$$= j(0.5) + \frac{1-j100C}{1+10000C^2}$$

Equating real parts of *ZS* and *ZL*

$$0.5 = \frac{1}{1+10000C^2}$$
$$\Rightarrow\quad C^2 = \frac{1}{10000}$$
$$\Rightarrow\quad C = 10^{-2}$$
$$\Rightarrow\quad C = 10\text{ mF}$$

Hence, the correct option is (D).

Question Number: 45 **Question Type: MCQ**

Let

$$g(x) = \begin{cases} -x & x\le1 \\ x+1 & x\ge1 \end{cases} \quad\text{and}\quad f(x) = \begin{cases} 1-x & x\le0 \\ x^2 & x\ge0 \end{cases}.$$

Consider the composition of *f* and *g*., *i.e.,* $(f{\circ}g)(x) = f(g(x))$. The number of discontinuities in $(f{\circ}g)(x)$ present in the interval $(-\infty, 0)$ is:

(A) 0 (B) 1
(C) 2 (D) 4

Solution:

$$g(x) = \begin{cases} -x, & x\le1 \\ x+1, & x\ge1 \end{cases}$$

$$f(x) = \begin{cases} 1-x, & x\le0 \\ x^2, & x\ge0 \end{cases}$$

$$f{\circ}g(x) = f(g(x)) = \begin{cases} 1-g(x), & g(x)\le0 \\ (g(x^2)), & g(x)\ge0 \end{cases}$$

$$= \begin{cases} 1-(-x), & -x\le0,\ x\le1 \\ 1-(x+1), & x+1\le0,\ x\ge1 \\ (-x^2), & -x>0,\ x\le1 \\ (x+1)^2, & x+1>0, x\ge1 \end{cases}$$

$$= \begin{cases} 1+x & 0 \le x \le 1 \\ x^2 & x < 0 \\ (x+1)^2 & x > 1 \end{cases}$$

$$f(g(x)) = \begin{cases} x^2 & x < 0 \\ x+1 & 0 \le x \le 1 \\ (x+1)^2 & x > 1 \end{cases}$$

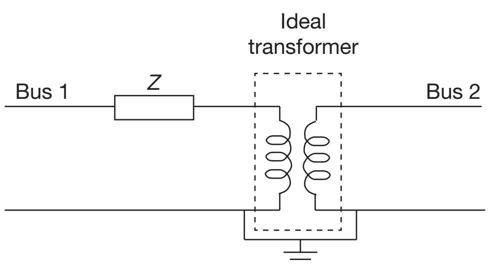
$f \circ g(x)$ is continuous at every point in $((-\infty, 0)$.

$\Rightarrow$ Number of points of discontinuities = 0.

Hence, the correct option is (A).

Question Number: 46 **Question Type: MCQ**

The figure shows the per-phase representation of a phase-shifting transformer connected between buses 1 and 2, where α is a complex number with non-zero real and imaginary parts.

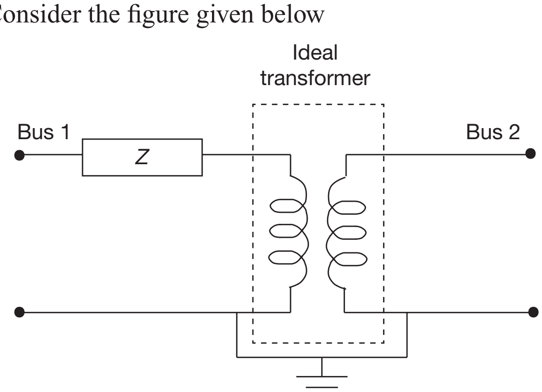


For the given circuit, Y_{bus} and Z_{bus} are bus admittance matrix and bus impedance matrix, respectively, each of size 2 × 2. Which one of the following statements is TRUE?

(A) Both Y_{bus} and Z_{bus} are symmetric
(B) Y_{bus} is symmetric and Z_{bus} is unsymmetric
(C) Y_{bus} is unsymmetric and Z_{bus} is symmetric
(D) Both Y_{bus} and Z_{bus} are unsymmetric

Solution:

Consider the figure given below



Addition of transformer will affect the existing symmetry of the Z_{BUS} and Y_{BUS} and thereby making both of (Z_{BUS}) and (Y_{BUS}) unsymmetric.

Hence, the correct option is (D).

Question Number: 47 **Question Type: MCQ**

Consider a solid sphere of radius 5 cm made of a perfect electric conductor. If one million electrons are added to this sphere, these electrons will be distributed

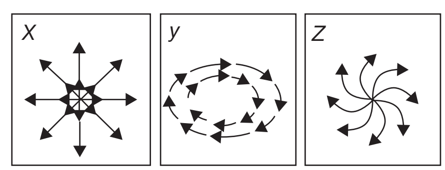
(A) Uniformly over the entire volume of the sphere
(B) Uniformly over the outer surface of the sphere
(C) Concentrated around the centre of the sphere
(D) Along a straight line passing through the centre of the sphere

Solution:

The electric field inside a perfect electric conductor is 0, hence all the charge added to the sphere will be distributed uniformly over the surface of the sphere, so that at every point on the sphere, the electric field from the surface of the sphere is radial in direction.
Hence, the correct option is (B).

Question Number: 48 **Question Type: MCQ**

The figures show diagrammatic representations of vector fields, $\vec{X}$, $\vec{Y}$ and $\vec{Z}$, respectively. Which one of the following choices is TRUE?



(A) $\nabla.\vec{X} = 0, \nabla \times \vec{Y} \ne 0, \nabla \times \vec{Z} = 0$

(B) $\nabla.\vec{X} \ne 0, \nabla \times \vec{Y} = 0, \nabla \times \vec{Z} \ne 0$

(C) $\nabla.\vec{X} \ne 0, \nabla \times \vec{Y} \ne 0, \nabla \times \vec{Z} \ne 0$

(D) $\nabla.\vec{X} = 0, \nabla \times \vec{Y} = 0, \nabla \times \vec{Z} = 0$

Solution:

From the given figures, we can observe that

Fig (1): X is diverging field hence its divergence of X i.e., $v \bullet X * 0$

Fig (2): Y is circularly rotating field hence its curl of Y i.e., $(V \text{ x } Y) * 0$.

Fig (3): Z is also a circularly rotating field hence its curl of Z, i.e., $(V \text{ x } Z) * 0$

Hence, option (C) satisfies the above three conditions.

Hence, the correct option is (C).

Question Number: 49 **Question Type: MCQ**

A stationary closed Lissajous pattern on an oscilloscope has 3 horizontal tangencies and 2 vertical tangencies for a horizontal input with frequency 3 kHz. The frequency of the vertical input is

(A) 1.5 kHz (B) 2 kHz

(C) 3 kHz (D) 4.5 kHz

Solution:

$$\frac{fy}{fx} = \frac{\text{No. of horizontal tangencies}}{\text{No. of vertical tangencies}}$$

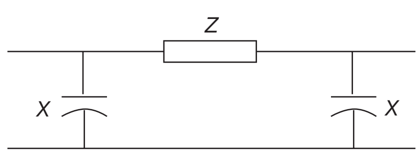
$$\frac{f_y}{3\text{ kHz}} = \frac{3}{2}$$

$$f_y = 4.5\text{ kHz}$$

Hence, the correct option is (D).

Question Number: 50 **Question Type: NAT**

The nominal-π circuit of a transmission line is shown in the figure



Impedance $Z = 100\angle 80^\circ\,\Omega$ and reactance $X = 3300\ \Omega$.

The magnitude of the characteristic impedance of the transmission line in Ω, is _____. (Give the answer up to one decimal place).

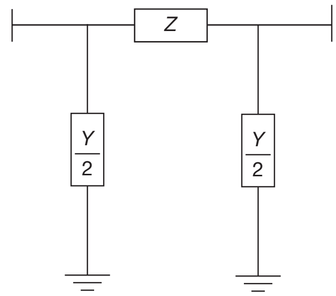
Solution:

The impedance and reactance is

$$Z = 100\angle 80^\circ$$

$$X = 3300\ \Omega$$

The general structure of nominal Π network is:



Comparing this network with given Network, we get

$$\frac{Y}{2} = \frac{1}{3300}$$

$$Y = \frac{2}{3300}$$

$$Y = \frac{1}{1650}\ \Omega$$

$$|z| = 100\ \Omega$$

The magnitude of characteristic impedance for a transmission line is

$$(Z_c) = \sqrt{\frac{Z}{Y}}$$

$$= \sqrt{\frac{100}{(1/1650)}}$$

$$= \sqrt{1650 \times 100}$$

$$= \sqrt{165000}$$

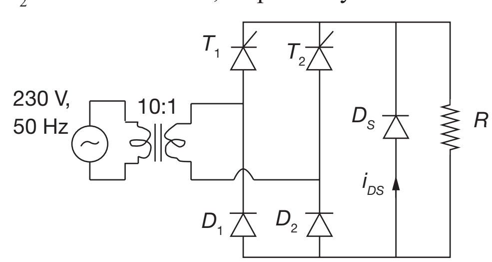
$\therefore$ Characteristic impedance

$$\boxed{Z_C = 406.20\ \Omega}.$$

Hence, the correct answer is (406.20 Ω).

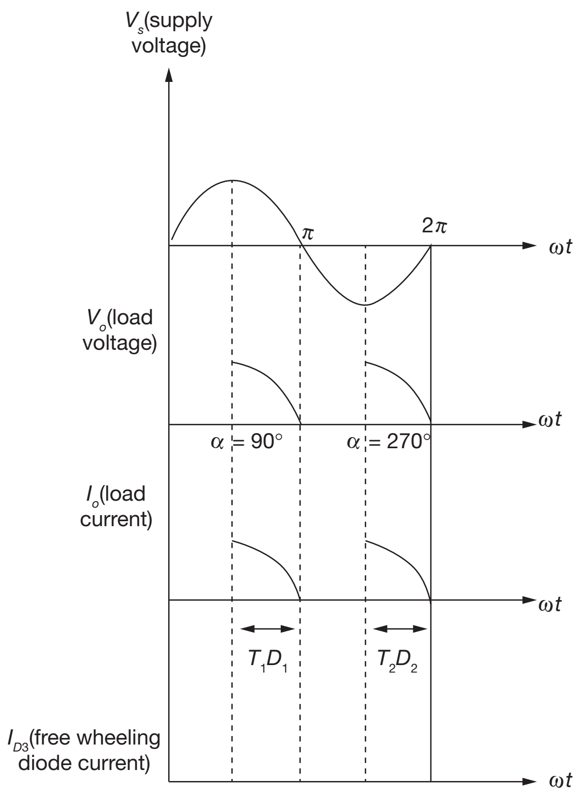
Question Number: 51 **Question Type: NAT**

The figure shows the circuit diagram of a controlled rectifier supplied from a 230 V, 50 Hz, 1-phase voltage source and a 10:1 ideal transformer. Assume that all devices are ideal. The firing angles of the thyristors T_1 and T_2 are 90° and 270°, respectively.



The RMS value of the current through diode D_3 in amperes is _________.

Solution:
In the given circuit diagram the load is a resistance and hence, there is no stored energy in the resistor (which will make the freewheeling diode to conduct) and hence, there is no current in the freewheeling diode D_3 and the same can be shown in the waveforms shown in the figure.



Whenever, current flow in load is continuous, freewheeling diode comes into conduction. Here current in load is discontinuous therefore the RMS value of current through diode D_3 is 0 amperes.

Hence, the correct answer is (0).

Question Number: 52 **Question Type: NAT**

Assume that in a traffic junction, the cycle of the traffic signal lights is 2 minutes of green (vehicle does not stop) and 3 minutes of red (vehicle stops). Consider that the arrival time of vehicles at the junction is uniformly distributed over 5 minute cycle. The expected waiting time (in minutes) for the vehicle at the junction is _________.

Solution:
Let time of arrival be a random variable x.

$$f(x) = \begin{cases} \frac{1}{5}, & 0 \le x \le 5 \\ 0, & \text{else where} \end{cases}$$

Assume waiting time be $g(x)$, a function of arrival time.

$$g(x) = \begin{cases} 0, & 0 \le x \le 2 \quad \text{(Greenlight)} \\ 5 - x, & 2 \le x \le 5 \quad \text{(Redlight)} \end{cases}$$

Average waiting time = $E(g(x))$

$$= \int_0^5 g(x) f(x) dx$$

$$= \int_0^2 0 \times \frac{1}{5} dx + \int_2^5 (5-x) \times \frac{1}{5} dx$$

$$= \left[x - \frac{x^2}{10} \right]_2^5$$

$$= \frac{9}{10} = 0.9$$

Hence, the correct answer is (0.9).

Question Number: 53 **Question Type: NAT**

Let $y^2 - 2y + 1 = x$ and $\sqrt{x} + y = 5$. The value of $x + \sqrt{y}$ equals_____. (Give the answer up to three decimal paces).

Solution:
Given:

$$y^2 - 2y + 1 = x \tag{1}$$

and

$$x + \sqrt{y} = 5 \tag{2}$$

Using Eqs. (1) and (2), we get

$$y^2 - 2y + 1 = (5 - y)^2$$
$$\Rightarrow y^2 - 2y + 1 = 25 + y^2 - 10y$$
$$\Rightarrow 8y = 24$$
$$\Rightarrow y = 3 \quad \text{and} \quad x = 4$$
$$\therefore \quad x + \sqrt{y} = 4 + \sqrt{3}$$
$$= 4 + 1.732 = 5.732$$

Hence, the correct answer is (5.732).

Question Number: 54 Question Type: MCQ

The transfer function $C(s)$ of a compensator is given below,

$$C(s) = \frac{\left(1+\frac{s}{0.1}\right)\left(1+\frac{s}{100}\right)}{(1+s)\left(1+\frac{s}{10}\right)}.$$

The frequency range in which the phase (lead) introduced by the compensator reaches the maximum is

(A) $0.1 < \omega < 1$ (B) $1 < \omega < 10$
(C) $10 < \omega < 100$ (D) $\omega > 100$

Solution:

The transfer function given is a lead-lag compensator

$$C(s) = \frac{\left(1+\frac{s}{0.1}\right)\left(1+\frac{s}{100}\right)}{(1+s)\left(1+\frac{s}{10}\right)}$$

Comparing with the standard transfer function of lead compensator

$$C(s) = \frac{(1+T_1 s)(1+T_2 s)}{(1+\beta T_1 s)(1+\alpha\beta T_2 s)}$$

$$T_1 = \frac{1}{0.1}, T_2 = \frac{1}{100} \Rightarrow \omega_1 = 0.1 \omega_4 = 100$$

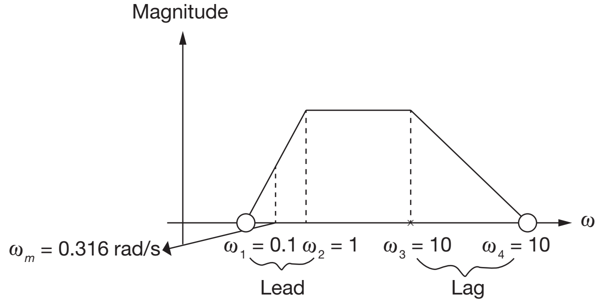
$$\beta T_1 = 1, \alpha T_2 = \frac{1}{10} \Rightarrow \omega_2 = 1\ \omega_3 = 10$$

$$\beta = 0.1, \quad \alpha = 10$$

The location of zeros at $\omega = 0.1, 100$

The location of poles at $\omega = 1, 10$

Now drawing the bode plot for the given pole zero locations is shown in the figure.



Phase lead occurs between $\omega_1 = 0.1$ and $\omega_2 = 1$. The frequency at which maximum phase lead occurs also lie in between $\omega = 0.1$ and 1 and its value is

$$\omega_m = \frac{1}{\sqrt{\beta \times T_1^2}} = \frac{1}{T_1\sqrt{\beta}} = 0.316 \text{ rad/s}$$

Hence, the correct option is (A).

Question Number: 55 Question Type: MCQ

Two resistors with nominal resistance values R_1 and R_2 have additive uncertainties ΔR_1 and ΔR_2, respectively. When these resistances are connected in parallel, the standard deviation of the error in the equivalent resistance R is

(A) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\Delta R_1\right\}^2 + \left\{\frac{\partial R}{\partial R_2}\Delta R_2\right\}^2}$

(B) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_2}\Delta R_1\right\}^2 + \left\{\frac{\partial R}{\partial R_1}\Delta R_2\right\}^2}$

(C) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2 \Delta R_2 + \left\{\frac{\partial R}{\partial R_2}\right\}^2 \Delta R_1}$

(D) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2 \Delta R_1 + \left\{\frac{\partial R}{\partial R_2}\right\}^2 \Delta R_2}$

Solution:

Since, resistors R_1 and R_2 are connected in parallel, uncertainties are

$$w_{R_1} = \Delta R_1$$
$$w_{R_2} = \Delta R_2$$

The deviation of error is given by standard formula,

$$w_R = \pm\sqrt{\left(\frac{\partial R}{\partial R_1}\right)^2 w_{R_1}^2 + \left(\frac{\partial R}{\partial R_2}\right)^2 w_{R_2}^2}$$

$$= \pm\sqrt{\left(\frac{\partial R}{\partial R_1}\right)^2 \Delta R_1^2 + \left(\frac{\partial R}{\partial R_2}\right)^2 \Delta_2^2}$$

Hence, the correct option is (A).

Question Number: 56 Question Type: NAT

In a load flow problem solved by Newton-Raphson method with polar coordinates, the size of the Jacobian is 100 × 100. If there are 20 PV buses in addition to *PQ* buses and a slack bus, the total number of buses in the system is.

Solution:

Size of Jacobian [*J*] = 100

No. of PV bases [*NPV*] = 20

One slack bus,

Let total no. of buses = *N*

Using $J = 2N - N_{PV} - 2$

$\Rightarrow 100 = 2N - 20 - 2$

$\Rightarrow 2N = 122$

$\Rightarrow N = 61$

Hence, the correct option is (61).

Question Number: 57 **Question Type: NAT**

Let *x* and *y* be integers satisfying the following equations

$$2x^2 + y^2 = 34$$
$$x + 2y = 11$$

The value of (*x* + *y*) is

Solution:

The given equations are

$$2x^2 + y^2 = 34 \quad (1)$$

and

$$x + 2y = 11 \quad (2)$$

Solving Eqs. (1) and (2), we get

$$2x^2 + \left(\frac{11-x}{2}\right)^2 = 34$$

$$\Rightarrow 8x^2 + 121 + x^2 - 22x = 136$$
$$\Rightarrow 9x^2 - 22x - 15 = 0$$

Now using Sridharacharya formula, we get

$$x = \frac{22 \pm 32}{18} = 3, \frac{-10}{18}$$

Discarding $-\frac{10}{18}$ as a root, as it is given that 18*x* and *y* are integers.

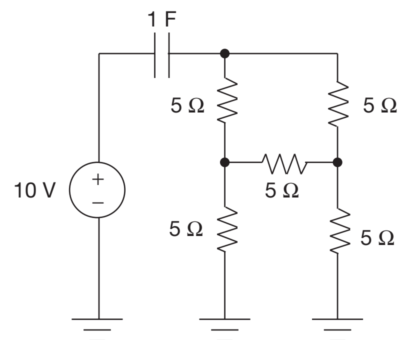
$\therefore \quad y = 4$

Hence, value of (*x* + *y*) = 3 + 4 = 7

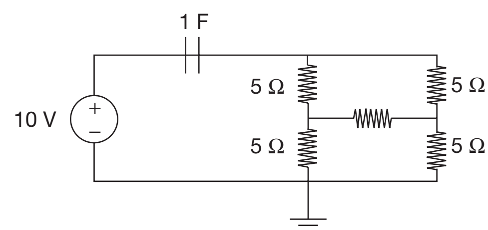
Hence, the correct answer is (7).

Question Number: 58 **Question Type: NAT**

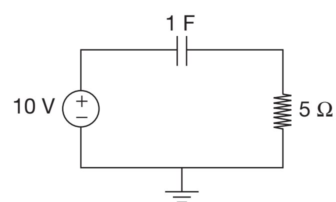
The initial charge in the 1F capacitor present in the circuit shown in the figure is 0. The energy in joules transferred from the DC source until steady state condition is reached equals. (Give the answer up to one decimal place).



Solution:



In the given CKT, the bridge is balanced, hence the equivalent resistance would be 5 Ω.



The current in the CKT will decay according to $i = i_0 e^{-t/RC}$ till the steady state, when the CKT will be open and capacitor will be charged upto +10 V in opposition of the voltage source. Energy transferred from voltage source will be

$$= \int_0^\infty E_i dt$$

$$= \int_0^\infty (10)\left(\frac{10}{5}\right) e^{-t/RC} dt$$

$$= 20 \int_0^\infty e^{-t/RC} dt$$

$$= 20(-e^{t/RC} \cdot RC)\Big|_0^{\infty}$$
$$= 20RC = 20\times 5\times 1$$
$$= 100 \text{ J}$$

Hence, the correct answer is (100).

Question Number: 59 **Question Type: MCQ**

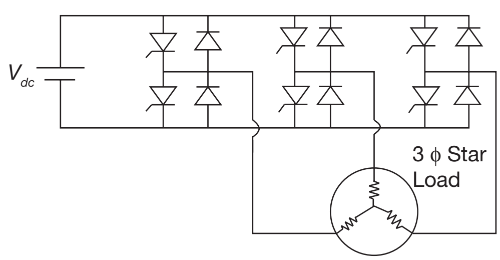
A three-phase voltage source inverter with ideal devices operating in 180° conduction mode is feeding a balanced star-connected resistive load. The DC voltage input is V_{dc}. The peak of the fundamental component of the phase voltage is

(A) $\frac{V_{dc}}{\pi}$ (B) $\frac{2V_{dc}}{\pi}$

(C) $\frac{3V_{dc}}{\pi}$ (D) $\frac{4V_{dc}}{\pi}$

Solution:

Consider the figure given



Rms value of line voltage will be

$$V_{Ln} = \frac{4V_{dc}}{\sqrt{2}n\pi}\cos\left(\frac{n\pi}{6}\right)$$

For fundamental, $n = 1$, rms line voltage. Therefore,

$$V_{L_1} = \frac{4V_{dc}}{\sqrt{2}\pi}\cos\left(\frac{\pi}{6}\right)$$
$$= \frac{4V_{dc}}{\sqrt{2}\pi}\frac{\sqrt{3}}{2}$$
$$= \frac{\sqrt{2}V_{dc}\sqrt{3}}{\pi}$$
$$= \frac{\sqrt{6}V_{dc}}{\pi}$$

Fundamental rms of phase voltage will be

$$= \frac{\frac{\sqrt{6}V_{dc}}{\pi}}{\sqrt{3}}$$
$$= \frac{\sqrt{2}V_{dc}}{\pi}$$

Peak of fundamental of phase voltage will be

$$= \left(\frac{\sqrt{2}V_{dc}}{\pi}\right)(\sqrt{2}) = \frac{2V_{dc}}{\pi}$$

Hence, the correct option is (B).

Question Number: 60 **Question Type: MCQ**

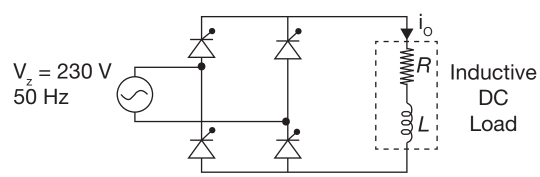
A phase-controlled, single-phase, full-bridge converter is supplying a highly inductive *DC* load. The converter is fed from a 230 V, 50 Hz, *AC* source. The fundamental frequency in Hz of the voltage ripple on the *DC* side is

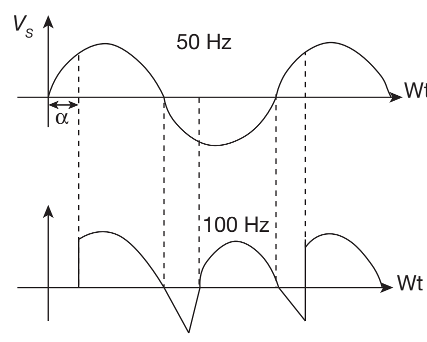
(A) 25 (B) 50

(C) 100 (D) 300

Solution:

Single phase, full bridge converter supplying highly inductive *DC* load.





From the figure, we conclude that

$$f_{v_0} = 2f_{v_s}$$
$$= 2(50)$$
$$= 100 \text{ Hz}$$

Hence, the correct option is (C).

Question Number: 61 **Question Type: MCQ**

An urn contains 5 red balls and 5 black balls. In the first draw, one ball is picked at random and discarded without noticing its colour. The probability to get a red ball in the second draw is

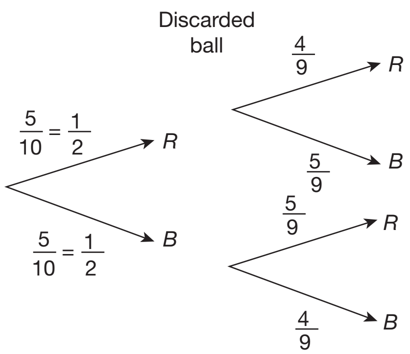
(A) $\frac{1}{2}$ (B) $\frac{4}{9}$

(C) $\frac{5}{9}$ (D) $\frac{6}{9}$

Solution:

5 Red balls and 5 Black balls.

One ball discarded in first draw



The probability of favourable branches from above figure will be

$$\left(\frac{1}{2}\times\frac{4}{9}\right)+\left(\frac{1}{2}\times\frac{5}{9}\right)$$

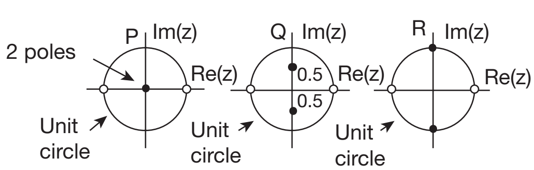
$$=\frac{4}{18}+\frac{5}{18}$$

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

Hence, the correct option is (A).

Question Number: 62 **Question Type: MCQ**

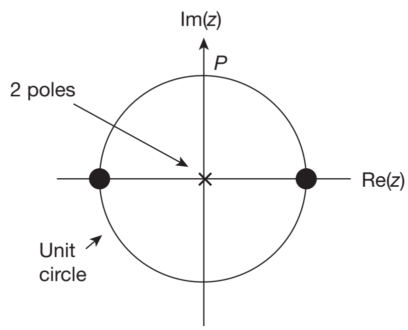
The pole-zero plots of three discrete-time systems P, Q and R on the z-plane are shown in the figure



Which one of the followings is TRUE about the frequency selectivity of these systems?

(A) All three are high-pass filters
(B) All three are band-pass filters
(C) All three are low-pass filters
(D) P is low-pass filter, Q is a band-pass filter and R is a high-pass filter

Solution:



$$\therefore \quad H(z)=\frac{k(z-1)(z+1)}{(z)(z)}$$

$$=\frac{k(z^2-1)}{z^2}$$

At low frequency,

$$z=1$$

$$H(1)=\frac{k(0)}{1}$$

$$=0$$

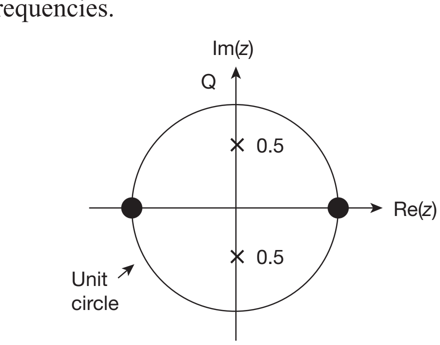
At high frequency,

$$z=-1$$

$$H(-1)=\frac{k(0)}{1}$$

$$=0$$

It is a band pass filter as output is 0 at both high and low frequencies.



Poles at $Z = 0.5i, -0.5i$

Zeroes at

$$z = 1, -1$$

$$\therefore \quad H(z) = \frac{k(z-1)(z+1)}{(z-0\cdot 5i)(z+0\cdot 5i)}$$

$$= \frac{k(z^2-1)}{z^2+0.25}$$

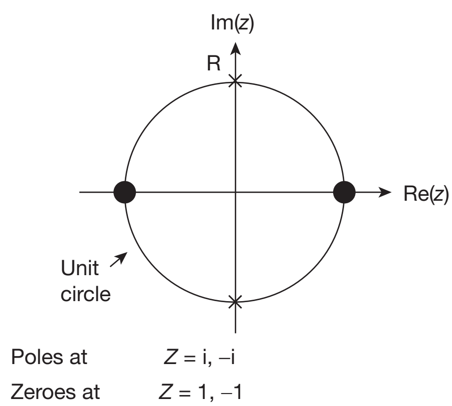
At low frequency

$$z = 1$$

$$H(1) = \frac{k(0)}{1+0.25}$$

$$= 0$$

It is a band pass filter as output is 0 at both low and high frequencies



$$\therefore \quad H(z) = \frac{k(z-1)(z+1)}{(z-i)(z+i)}$$

$$H(z) = \frac{k(z^2-1)}{(z^2+1)}$$

At low frequency

$$z = 1$$

$$H(1) = \frac{k(0)}{2}$$

$$= 0$$

At high frequency

$$z = -1$$

$$H(-1) = \frac{k(0)}{2}$$

$$= 0$$

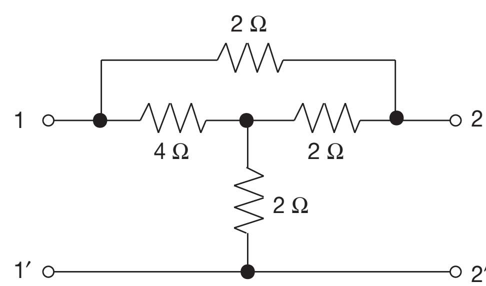
It is a band pass filter as output is 0 at both low and high frequencies.

Hence, all the three are band pass filters.

Hence, the correct option is (B).

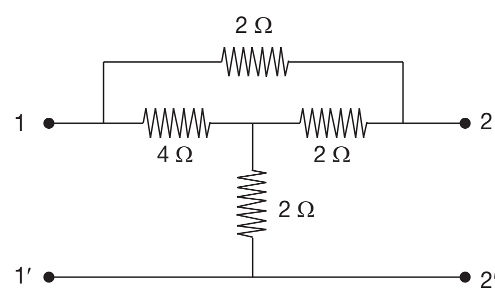
Question Number: 63 **Question Type: NAT**

For the given 2-port network, the value of transfer impedance z_{21} in ohms is _________

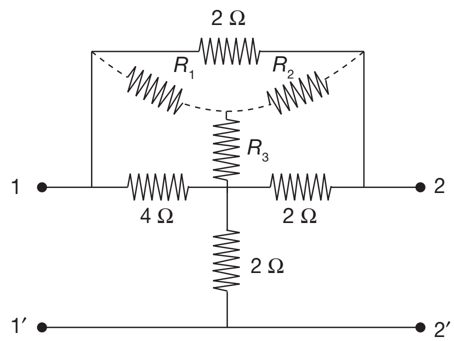


Solution:

Given circuit diagram is

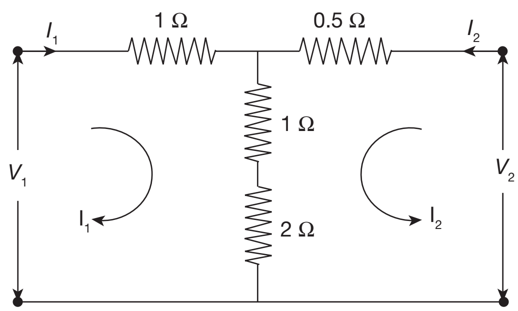


Converting the above circuit diagram into standard T-network by using Y–Δ transformation, we get



$$R_1 = \frac{4\times 2}{2+4+2} = \frac{8}{8} = 1\,\Omega$$
$$R_2 = \frac{2\times 2}{2+4+2} = \frac{4}{8} = 0.5\,\Omega$$
$$R_3 = \frac{4\times 2}{2+4+2} = \frac{8}{8} = 1\,\Omega$$

Redrawing the given T-network with the above values



applying KVL at the input and output loops, we get

$$V_1 = 4I_1 + 3I_2$$
$$V_2 = 3I_1 + 3.5I_2$$

We know

$$Z_{21} = \left.\frac{V_2}{I_2}\right|_{I_2-0}$$

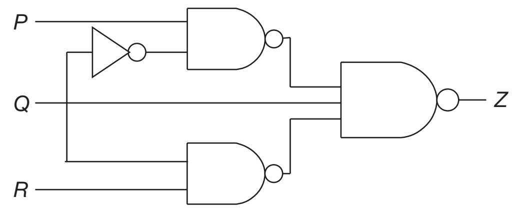
$$\therefore \quad Z_{21} = \frac{V_2}{I_1} = 3\,\Omega$$

The value of Z_{21} in ohms is $\boxed{3\,\Omega}$.

Hence, the correct Answer is (3).

Question Number: 64 **Question Type: MCQ**

For a 3-input logic circuit shown in the figure, the output Z can be expressed as

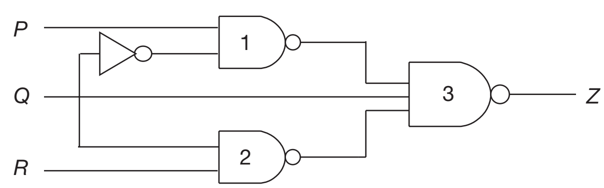


(A) $Q+\bar{R}$ (B) $P\bar{Q}+R$

(C) $\bar{Q}+R$ (D) $P+\bar{Q}+R$

Solution:

Given ckt diagram is,



Output of NAND gate 1 is $= \overline{P\bar{Q}}$

Output of NAND gate 2 is $= \overline{QR}$

Output of NAND gate 3 is $= \overline{\left(\overline{P\bar{Q}}\right)(Q)\left(\overline{QR}\right)}$

$$= \overline{\overline{P\bar{Q}}} + \overline{(Q)} + \overline{\overline{QR}}$$
$$= P\bar{Q} + \bar{Q} + QR$$
$$= \bar{Q}(P+1) + QR$$
$$[\because (1+P) = 1]$$
$$= \bar{Q} + QR$$

Hence, the correct option is (C).

Question Number: 65 **Question Type: NAT**

Consider a function $f(x, y, z)$ given by

$$f(x,y,z) = (x^2 + y^2 - 2z^2)(y^2 + z^2)$$

The partial derivative of this function with respect to x at the point, $x = 2$, $y = 1$ and $z = 3$ is _____

Solution:

$$f(x,y,z) = (x^2 + y^2 - 2z^2)(y^2 + z^2)$$

To find: $\left.\dfrac{\partial f}{\partial x}\right|_{x=2, y=1, z=3}$

$$f(x,y,z) = x^2 y^2 + y^4 - 2y^2 z^2 + x^2 z^2 + y^2 z^2 - 2z^4$$

$$\frac{\partial f}{\partial x} = 2xy^2 + 0 - 0 + 2xz^2 + 0 - 0$$

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

$$= 4 + 36 = 40$$

Hence, the correct answer is (40).