GATE 2017 Solved Paper
Electrical Engineering
Set – I

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**

The expression $\frac{(x+y)-|x-y|}{2}$ is equal to

(A) The maximum of x and y
(B) The minimum of x and y
(C) 1
(D) None of the above

Solution:

As per question expression is

$$\frac{(x+y)-|x-y|}{2}$$

Also, we know modulus of any number should be a positive value.

Case (1): $x > y$ (here, y is minimum) then $|x-y| = (x-y)$ positive value then

$$\frac{(x+y)-(x-y)}{2} = \frac{(x+y)-(x-y)}{2} = \frac{2y}{2} = y \text{ (minimum of } x \text{ and } y)$$

Case (2): $y > x$ (here, x is minimum) then $|x - y| = (y-x)$ (positive value) then

$$\frac{(x+y)-|x-y|}{2} = \frac{(x+y)-(y-x)}{2} = \frac{2x}{2} = x \text{ (minimum of } x \text{ and } y)$$

In both the cases, we get the minimum of x and y, the correct option is (b).

Hence, the correct option is (B).

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

"The hold of the nationalist imagination on our colonial past is such that anything inadequately or improperly nationalist is just not history."

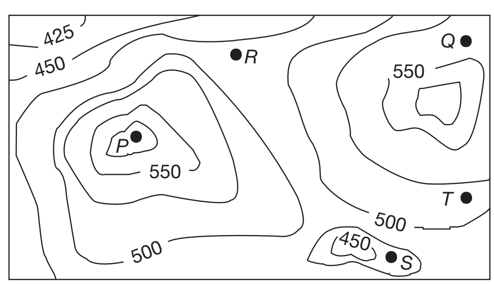
Which of the following statements best reflects the author's opinion?

(A) Nationalists are highly imaginative.
(B) History is viewed through the filter of nationalism.
(C) Our colonial past never happened.
(D) Nationalism has to be both adequately and properly imagined.

Solution: Hence, the correct option is (B).

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

A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25 m intervals in this plot. If in a flood, the water level rises to 525 m. Which of the villages P, Q, R, S, T get submerged?



(A) P, Q (B) P, Q, T
(C) R, S, T (D) Q, R, S

Solution:

Height above mean sea level for

$$P \Rightarrow H_P = 575 \text{ m}$$
$$Q \Rightarrow H_Q = 525 \text{ m}$$
$$R \Rightarrow H_R = 475 \text{ m}$$
$$S \Rightarrow H_S = 475 \text{ m}$$
$$T \Rightarrow H_T = 500 \text{ m}$$

if water level in a flood is 252 m then R,S,T will be submerged.

Hence, the correct option is (C).

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

Six people are seated around a circular table. There are at least two men and two women. There are at least three right-handed persons. Every woman has a left-handed person to her immediate right. None of the women are right-handed. The number of women at the table is

(A) 2
(B) 3
(C) 4
(D) Cannot be determined

Solution:

Total perosns–6

Conditions:

1. Atleast two men and two women
2. Atleast 3 right-handed persons
3. Every women has a left-handed person to her immediate right and all women are left handed.

Let us choose at least two women (minimum) then total left-handed persons = 2 + 1 (1 man is immediate right of one woman when both woman are sitting together) = 3. Remaining three will be right-handed.

Hence, the correct option is (A).

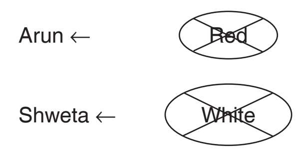
Question Number: 5 **Question Type: MCQ**

Arun, Gulab, Neel, and Shweta must choose one shift each from a pile of four shirt coloured red, pink, blue, and white, respectively. Arun dislike the colour red and Shweta dislikes the colour white. Gulab and Neel like all the colours. In how many different ways can they choose the shirts, so that no one has a shirt with a colour he or she dislikes?

(A) 21 (B) 18
(C) 16 (D) 14

Solution:

Colour – Red, Pink, Blue, White



Case 1: Arun chooses pink shirt then Shweta will have two options Red and blue so number of ways

$$n_1 = {}^1C_1 \cdot {}^2C_1 \cdot {}^2C_1 \cdot {}^1C_1 = 4$$

Case 2: Arun chooses bule shirt, Shweta will have two options Red and Pink, so

$$n_2 = {}^1C_1 \cdot {}^2C_1 \cdot {}^2C_1 \cdot {}^1C_1 = 4$$

Case 3: Arun chooses white, then Shweta will have three options, so

$$n_3 = {}^1C_1 \cdot {}^3C_1 \cdot {}^2C_1 \cdot {}^1C_1 = 6$$

Total number of ways = 4 + 4 + 6 = 14.

Hence, the correct option is (D).

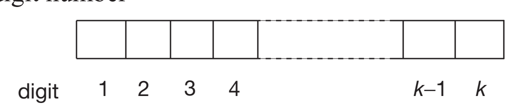
Question Number: 6 **Question Type: MCQ**

The probability that a k-digit number does NOT contain the digits 0, 5, or 9 is

(A) 0.3^k (B) 0.06^k
(C) 0.7^k (D) 0.9^k

Solution:

k-digit number



Excluding digits 0, 5 or 9

Probability

$$P = \frac{{}^7C_1 \cdot {}^7C_1 \cdot {}^7C_1 \cdots {}^7C_1 \quad (k\text{-times})}{{}^{10}C_1 \cdot {}^{10}C_1 \cdot {}^{10}C_1 \cdots {}^{10}C_1 \quad (k\text{-times})}$$

$$= \frac{7.7.7\ldots7 \quad (k\text{-times})}{10.10.10\ldots10 \quad (k\text{-times})}$$

or $P = (0.7)^k$.

Hence, the correct option is (C).

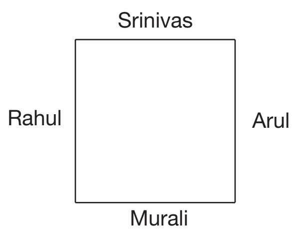
Question Number: 7 **Question Type: MCQ**

Rahul, Murali, Srinivas, and Arul are seated around a square table. Rahul is sitting to the left of Murali.

Srinivas is sitting to the right of Arul. Which of the following pairs are seated opposite each other?

(A) Rahul and Murali
(B) Srinivas and Arul
(C) Srinivas and Murali
(D) Srinvas and Rahul

Solution:



Hence, the correct option is (C).

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

Research in the workplace reveals that people work for many reasons _____

(A) Money beside
(B) Beside money
(C) Money besides
(D) Besides money

Solution:

Beside → "next to"

Besides → "Except"

Hence, the correct option is (D).

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

After Rajendra Chola returned from his voyage to Indonesia, he _____ to visit the temple in Thanjavur.

(A) Was wishing (B) Is wishing
(C) Wished (D) Had wished

Solution: Hence, the correct option is (C).

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

Find the smallest number y such that $y \times 162$ is a perfect cube

(A) 24 (B) 27 (C) 32 (D) 36

Solution:

$y \times 162$ as perfect cube

$162 = 2 \times 3 \times 3 \times 3 \times 3$

to make it perfect cube $y = 2 \times 2 \times 3 \times 3$

or $\boxed{y = 36}$

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**

Consider the system with following input-output relation

$$y[n] = (1 + (-1)^n)x[n]$$

Where, $x[n]$ is the input and $y[n]$ is the output. The system is

(A) Invertible and time invariant.
(B) Invertible and time varying.
(C) Non-invertible and time invariant.
(D) Non-invertible and time varying.

Solution:

The input-output relation is given as

$$y[n] = (1 + (-1)^n)x[n]$$

We know that, if there is a one-to-one correspondence between its input and output signals then the system is said to be invertible

for $n = 1$,

$$y[1] = (1 + (-1)^1)x[1] = 0$$

for $n = 2$,

$$y[2] = (1 + (-1)^2)x[2] = 0$$

for $n = 3$,

$$y[3] = (1 + (-1)^3)x[3] = 0$$

Therefore, for odd values of "n" output will always be zero, so system is non-invertible.

To check time invariance

For delayed input,

$$y[n_1 n_0] = (1 + (-1)^n)\ \ x[n - n_0] \quad (1)$$

For delayed response,

$$y[n_1 n_0] = (1 + (-1)^{n-n_0})x[n - n_0] \quad (2)$$

For time invariant system output for delayed input should be equal to delayed response.

Hence, this system is time varying.

Hence, the correct option is (D).

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

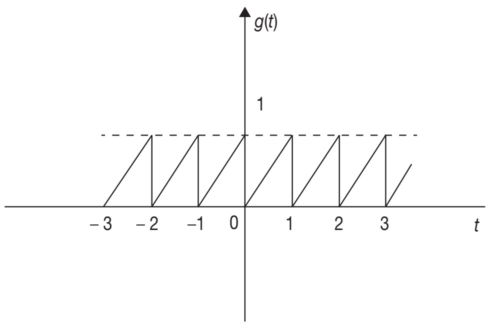
Consider $g(t)$ =

$$\begin{cases} t-\lfloor t \rfloor, & t \geq o \\ t-\lceil t \rceil, & \text{otherwise} \end{cases}, \text{where } t \in R$$

Here, $\lfloor t \rfloor$ represents the largest integer less than or equal to t and $\lceil t \rceil$ denotes the smallest integer greater than or equal to t. The coefficient of the second harmonic component of the Fourier series representing $g(t)$ is ______

Solution:

$$g(t) = \begin{cases} t-\lfloor t \rfloor, & t \geq o \\ t-\lceil t \rceil, & \text{otherwise} \end{cases}$$



$$T = 1$$

$$\omega_0 = \frac{2\pi}{T} = 2\pi$$

$$g(t) = t \qquad 0 \leq t \leq 1$$

$$g(t) = \sum_{n=-\infty}^{\infty} G_n e^{-jn\omega_0 t}$$

$$G_n = \frac{1}{T}\int_{-T/2}^{T/2} g(t) e^{-jn\omega_0 t}\,dt$$

$$= \frac{1}{1}\int_0^1 (t) e^{-j2\pi nt}\,dt$$

$$= \int_0^1 (t) e^{-j2\pi nt}\,dt$$

$$G_n = \int_0^1 t e^{-j2\pi nt}\,dt$$

$$= t \cdot \frac{e^{-j2\pi nt}}{-j2\pi nt}\bigg|_0^1 - \int_0^1 1 \cdot \frac{e^{-j2\pi nt}}{-j2\pi nt}\,dt$$

$$= \frac{-1}{-j2\pi n} - \frac{1}{-j^2 4\pi^2 n^2}(e^{-j2\pi n} - 1)$$

$$G_n = \frac{-1}{j2\pi n}$$

$$G_n = \frac{-1}{j4\pi}$$

$$|G_2| = \frac{1}{4\pi} = 0.0796$$

Hence, the correct answer is (0.0796).

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

The Boolean expression $AB + A\overline{C} + BC$ simplifies to

(A) $BC + A\overline{C}$ (B) $AB + A\overline{C} + B$

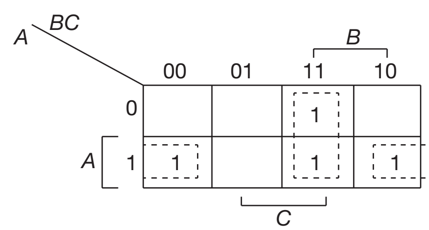
(C) $AB + A\overline{C}$ (D) $AB + BC$

Solution:

The Boolean expression is

$$f = AB + A\overline{C} + BC$$

drawing k-map for above expression, we get



From the above figure, we get

$$f = A\overline{C} + BC$$

Hence, the correct option is (A).

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

Let $z(t) = x(t)*y(t)$, where "*" denotes convolution. Let c be a positive real-valued constant. Choose the correct expression for $z(ct)$

(A) $c.x(ct) * y(ct)$ (B) $x(ct) * y(ct)$

(C) $c.x(t) * y(ct)$ (D) $c.x(ct) * y(t)$

Solution:

Given that

$$z(t) = x(t) * y(t)$$

taking Fourier transform, we get

$$Z(j\omega) = X(j\omega)\cdot Y(j\omega) \tag{1}$$

$$z(t) \to \frac{1}{c} Z\left(\frac{j\omega}{c}\right) \tag{2}$$

Also, by using Eq. (1)

$$Z\left(\frac{j\omega}{c}\right) = X\left(\frac{j\omega}{c}\right)\cdot Y\left(\frac{j\omega}{c}\right)$$

$$\therefore \quad \frac{1}{c}Z\left(\frac{j\omega}{c}\right) = \frac{1}{c}X\left(\frac{j\omega}{c}\right)\cdot Y\left(\frac{j\omega}{c}\right)$$

Multiplying and dividing RHS by c, we get

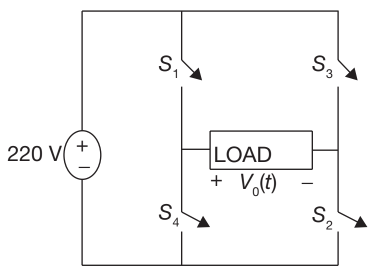
$$\frac{1}{c}Z\left(\frac{j\omega}{c}\right) = \left[\frac{1}{c}\cdot X\left(\frac{j\omega}{c}\right)\cdot\frac{1}{c}Y\left(\frac{j\omega}{c}\right)\right]$$

$$z(t) = c\cdot x(ct) * y(ct)$$

Hence, the correct option is (A).

Question Number: 15 Question Type: NAT

In the converter circuit shown in the figure, the switches are controlled such that the load voltage $v_0(t)$ is a 400 Hz square wave.



The RMS value of the fundamental component of $v_0(t)$ in volts is _____

Solution:

We know that for single phase full bridge inverter,

$$v_0 = \sum_{n=1,3,5\ldots}^{n} \frac{4V_s}{n\pi}\sin n\,\omega t \text{ Volts}$$

Also the RMS value of fundamental component will be

$$\frac{4V_s}{\pi}\times\frac{1}{\sqrt{2}} = \frac{4\times 220}{\pi}\times\frac{1}{\sqrt{2}}$$
$$= 198.069 \text{ Volts.}$$

Hence, the correct answer is (198.069).

Question Number: 16 Question Type: NAT

The positive-, negative-, and zero-sequence reactances of a wye-connected synchronous generator are 0.2 pu, 0.2 pu and 0.1 pu, respectively. The generator is on open circuit with a terminal voltage of 1 pu. The minimum value of the inductive reactance, in pu, required to be connected between neutral and ground so that the fault current does not exceed 3.75 pu if a single line to ground fault occurs at the terminals is _____ (assume fault impedance to be zero). (Give the answer up to one decimal place).

Solution:

Given: Positive-sequence reactance $X_1 = 0.2$ pu

Negative-sequence reactance $X_2 = 0.2$ pu

Zero-sequence reactance $X_0 = 0.1$ pu

Fault current $i_f = 3.75$ pu

For single line to ground fault, the relation for fault current is

$$i_f = \frac{3E}{X_1 + X_2 + X_0 + 3X_n}$$

In above expression, X_n is the reactance connected between neutral and ground.

Therefore, for $E = 1$ pu

$$i_f = \frac{3E}{X_1 + X_2 + X_0 + 3X_n} = 3.75$$

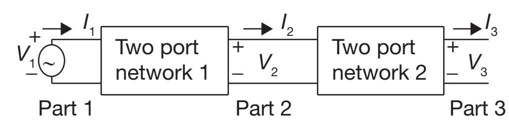
Substituting the values and simplifying the above expression for X_n, we get

$$\boxed{X_n = 0.1 \text{ pu}}$$

Hence, the correct answer is (0.1 pu).

Question Number: 17 Question Type: MCQ

Two passive two-port networks are connected in cascade as shown in Figure. A voltage source is connected at port 1.



Given:

$$V_1 = A_1V_2 + B_1I_2$$
$$I_1 = C_1V_2 + D_1I_2$$
$$V_2 = A_2V_3 + B_2I_3$$
$$I_2 = C_2V_3 + D_2I_3$$

$A_1, B_1, C_1, D_1, A_2, B_2, C_2$, and D_2 are the generalized circuit constants. If the Thevenin equivalent circuit at port 3 consists of a voltage source V_T and an impedance Z_T, connected in series, then

(A) $V_T = \dfrac{V_1}{A_1A_2}$, $Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$

(B) $V_T = \dfrac{V_1}{A_1A_2 + B_1C_2}$, $Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2}$

(C) $V_T = \dfrac{V_1}{A_1A_2}$, $Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2}$

(D) $V_T = \dfrac{V_1}{A_1A_2 + B_1C_2}$, $Z_T = \dfrac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$

Solution:

Equivalent *ABCD* parameters for cascaded network are given by,

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix}\begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix}$$

$$= \begin{bmatrix} A_1A_2 + B_1C_2 & A_1B_2 + B_1D_2 \\ C_1A_2 + D_1C_2 & C_1B_2 + D_1D_2 \end{bmatrix}$$

Therefore,

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} V_3 \\ I_3 \end{bmatrix}$$

Now, open circuit voltage $V_T = V_3$ when $I_3 = 0$.

So, $$V_1 = AV_3 = AV_T$$

$$\Rightarrow \quad V_T = \frac{V_1}{A}$$

$$\Rightarrow \quad V_T = \frac{V_1}{A_1A_2 + B_1C_2}$$

Voltage-source is short circuited to calculate Thevenin equivalent impedance Z_T. So, for voltage source of V_3 feeding current ($-I_3$)

$$Z_T = \frac{V_3}{-I_3}$$

$$0 = AV_3 + BI_3$$

$$\Rightarrow \quad Z_T = \frac{B}{A}$$

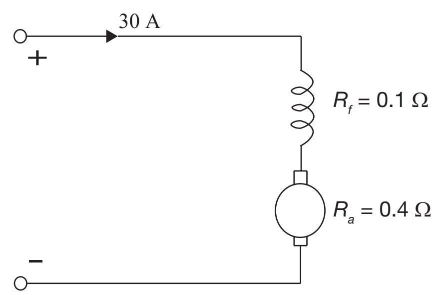
$$Z_T = \frac{A_1B_2 + B_1D_2}{A_1A_2 + B_1C_2}$$

Hence, the correct option is (D).

Question Number: 18 **Question Type: NAT**

A 220 V DC series motor runs drawing a current of 30 A from the supply. Armature and field circuit resistances are 0.4 Ω and 0.1 Ω, respectively. The load torque varies as the square of the speed. The flux in the motor may be taken as being proportional to the armature current. To reduce the speed of the motor by 50%, the resistance in ohms the should be added in series with the armature is _____. (Give the answer up to two decimal places).

Solution:



$$\text{Back E.m.f. } E_1 = 220 - 30(0.1 + 0.4) = 205V$$

$$\text{Torque,} \quad \tau = \phi I_a$$

{Where, ϕ = flux, I_a = armature current}

$$\tau = I_a^2 \tag{1}$$

As in series motor $\phi \propto I_a$

$$\text{Also,} \quad \tau \propto N^2 \tag{2}$$

Where N is the speed of motor

Using Eqs. (1) and (2)

$$I_a^2 \propto N^2 \quad \text{or} \quad I_a \propto N \tag{3}$$

Therefore, to reduce speed by 50%, I_a will reduce to 50%, *i.e.,* 15 A.

Now back emf will change to

$$E_2 = 220 - 15(R + 0.1 + 0.4)$$

Where R is the external resistance added in series with armature.

$$\text{Since,} \quad E \propto \phi \cdot N$$

So,
$$E_1 \propto \phi_1 \cdot N_1$$
$$E_2 \propto \phi_2 \cdot N_2$$
$$\phi_2 = \frac{\phi_1}{2}$$
$$N_2 = \frac{N_1}{2}$$

Thus,
$$205 = \phi_1 N_1 \quad (4)$$
$$220 - 15(R+0.5) = \phi_2 N_2 \quad (5)$$

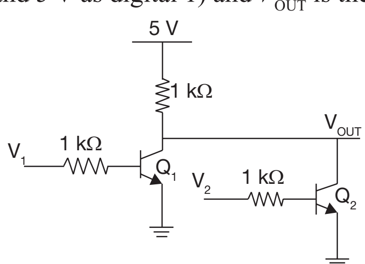
Dividing Eq. (5) by Eq. (4),
$$\frac{220-15(R+0.5)}{205} = \frac{\phi_2 N_2}{\phi_1 N_1} = \frac{(\phi_1/2)\cdot(N_1/2)}{\phi_1 \cdot N_1}$$
$$\frac{220-15(R+0.5)}{205} = \frac{1}{4}$$

On solving,
$$R = 10.75\ \Omega$$

Hence, the correct answer is (10.75 Ω).

Question Number: 19 Question Type: MCQ

The logical gate implemented using the circuit shown in the figure where, V_1 and V_2 are inputs (with 0 V as digital 0 and 5 V as digital 1) and V_{OUT} is the output, is



(A) NOT (B) NOR
(C) NAND (D) XOR

Solution:

From the given circuit it can be deduced that Q_1 will be ON when V_1 is high, Q_2 is ON when V_2 is high

Truth Table

V_1	Q_1	V_2	Q_2	V_{OUT}
High	ON	High	ON	Low
High	ON	Low	OFF	Low
Low	OFF	High	ON	Low
Low	OFF	Low	OFF	High

This is the truth table of NOR gate.

Hence, the correct option is (B).

Question Number: 20 Question Type: MCQ

A function $f(x)$ is defined as
$$f(x) = \begin{cases} e^x, & x < 1 \\ 1nx + ax^2 + bx & x \geq 1 \end{cases},$$

Where $x \in R$.

Which one of the following statement is TRUE?

(A) $f(x)$ is **NOT** differentiable at $x = 1$ for any values of a and b.
(B) $f(x)$ is differentiable at $x = 1$ for the unique value of a and b.
(C) $f(x)$ is differentiable at $x = 1$ for all values of a and b such that $a + b = e$.
(D) $f(x)$ is differentiable at $x = 1$ for all values of a and b

Solution:
$$f(x) = \begin{cases} e^x, & x < 1 \\ 1\text{n}\,x + ax^2 + bx & x \geq 1 \end{cases}$$

$$\text{Left-hand derivative} = \lim_{x\to 1} \frac{f(x) - f(1)}{x-1}$$

Where, $f(1) = \ln(1) + a(1)^2 + b(1) = a + b$

So,
$$\text{Left-hand derivatives (LHD)} = \lim_{x\to 1} \frac{e^x - (a+b)}{x-1}$$

This limit exists if
$$e = a + b \quad (1)$$

Then
$$LHD = \lim_{x\to 1} \frac{e^x}{1} = e$$

$$\text{Right-hand derivative (RHD)} = \lim_{x\to 1} \frac{f(x) - f(1)}{x-1}$$
$$= \lim_{x\to 1} \frac{1n\,x + ax^2 + bx - (a+b)}{x-1}$$

This limit exist if
$$1 + 2a + b = a + b \quad \text{or} \quad a = -1 \quad (2)$$

Hence,
$$RHD = \lim_{x\to 1} \frac{\frac{1}{x} + 2ax + b}{1} = 1 + 2a + b$$

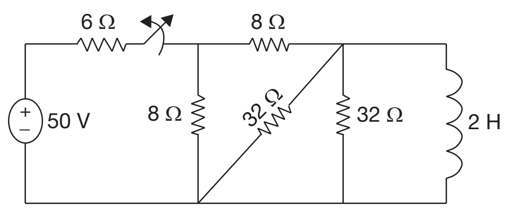
LHD will be equal to RHD if $a = -1$ and $b = e + 1$.

Hence, $f(x)$ is differentiable at $x = 1$ for unique values of a and b.

Hence, the correct option is (B).

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

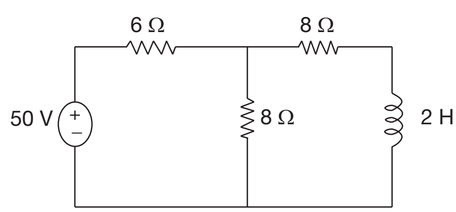
The switch in the figure was closed for a long time. It is opened at $t = 0$. The current in the inductor of 2 H for $t \geq 0$, is



(A) $2.5e^{-4t}$ (B) $5e^{-4t}$
(C) $2.5e^{-0.25t}$ (D) $5e^{-0.25t}$

Solution:

For $t = 0^-$ circuit can be represented as shown in the figure



Inductor can be taken as short circuit at steady state.

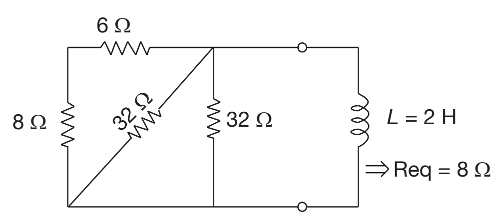
So, current in inductor at $t = 0^-$ will be

$$i_L(0^-) = \frac{50}{6+(8118)} \times \frac{8}{(8+8)}$$

$$\Rightarrow \qquad i_L = 2.5 \text{ A}$$

On opening of switch at $t = 0$, i_L can be given by $i_L(t) = i_L(0)\, e^{-t/\tau}$ where $\tau = L/R$

R is $R_{\text{equivalent}}$ across L to calculate $R_{\text{equivalent}}$,



$$\tau = \frac{L}{R} = \frac{2}{8} = \frac{1}{4}$$

Hence $i_L(t) = 2.5\, e^{-\frac{t}{1/4}}$

or $\quad i_L(t) = 2.5\, e^{-4t}$

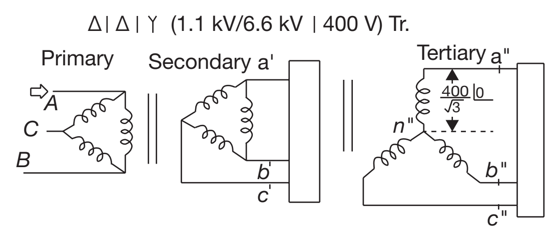
Hence, the correct option is (A).

Question Number: 22 **Question Type: NAT**

A three-phase, three winding Δ/Δ/Y(1.1 kV/6.6 kV/400 V) transformer is energized from AC mains at the 1.1 kV side. It supplies 900 kVA load at 0.8 power factor lag from the 6.6 kV winding and 300 kVA load at 0.6 power factor lag from the 400 V winding. The RMS line current in ampere drawn by the 1.1 kV winding from the mains is _____. (Give the answer up to one decimal place).

Solution:

Given



Let us assume $V_{a''n''}$ as reference,

$$\therefore \quad V_{a''n''} \frac{400}{\sqrt{3}} \angle 0°$$

$$\overset{\Rightarrow}{\text{lag}} \quad \text{Load at tertiary} \rightarrow 300 \text{ kVA},\ 0.6 \text{ Pf}$$

$$\therefore \quad I_a'' = 433.01\angle -53.13 \text{ A}$$

$$\because \quad \frac{\bar{V}_{AB}}{\bar{V}_{a''n''}} = \frac{1.1\times 10^3}{400/\sqrt{3}} = 4.763$$

$$[\bar{V}_{AB} \leftarrow V_{a''n''} \text{ are in phase}]$$

$$\therefore \quad \bar{I}_{AB} (\text{corresponding to } I_a'')$$

$$= 90.91\angle -53.13 \text{ A}$$

We know,

$$\bar{I}_A = \bar{I}_{AB} - \bar{I}_{CA}$$

$$= 90.91\angle -53.13 - 90.91\angle 66.86$$

$$= \sqrt{3} \times 90.91 \times \angle(-53.13 - 30)$$

$$= 157.46\ \angle -83.13 \text{ A}$$

Now, Load at secondary 900 kVA, .8 pF lag

$$\frac{\overline{V}_{AB}}{V_{a'b'}} = \frac{1.1}{6.6} = \frac{1}{6}$$

$$i.e., \overline{V}_{a'b'} = 6.6\angle 0° \text{ kV}$$

$$\therefore \quad \overline{I}_{a'b'} = 45.45\angle -36.87 \text{ A}$$

$$\overline{I}_{AB} = (\text{corresponding to } \overline{I}_{a'b'}) = 272.73\angle -36.87$$

$$\because \quad \overline{I}_{A} = \overline{I}_{AB} - \overline{I}_{AC}$$

$$\therefore \ \overline{I}_{A}(\text{corresponding to } \overline{I}_{a'b'}) = \sqrt{3}\times 272.73\angle -36.87-30$$

$$= 472.38\angle -66.87 \text{ A}$$

$\therefore$ Total line current from supply.

$$\overline{I}_{L} = \overline{I}_{A}(\text{corresponding to load}) + \overline{I}_{A}(\text{corresponding } \Delta \text{ load})$$

$$= 157.46\angle -83.13 + 472.38\angle -66.87$$

$$= 625.01\angle -70.91$$

$\therefore$ RMS line current = 625.01 A

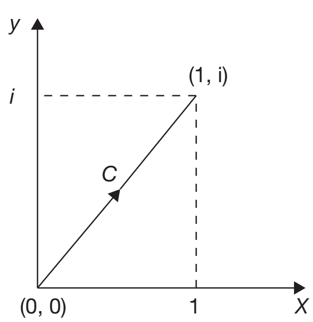
Hence, the correct answer is (625.1 A).

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

Consider the line integral

$$I = \int_c (x^2 + iy^2)dz,$$

Where $z = x + iy$. The line C is shown in the Figure.



The value of I is

(A) $\frac{1}{2}i$ (B) $\frac{2}{3}i$

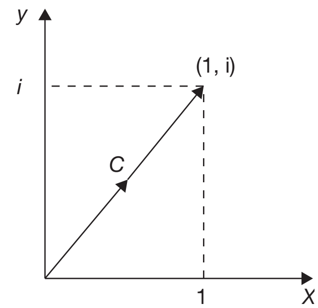
(C) $\frac{3}{4}i$ (D) $\frac{4}{5}i$

Solution:

Given integral

$$I = \int_c (x^2 + iy^2)dz, \ z = x + iy$$

the line c is a straight line passing through origin shown in the figure and its equation is given by $y = x$



substituting $y = x$ in given integral, we get

$$I = \int_c (x^2 + iy^2)(dx + idx)$$

$$= \int_c x^2(1+i)(1+i)dx$$

$$= \int_c x^2(1-1+2i)dx$$

$$= \int_c 2i\, x^2 dx$$

$$= 2i\int_0^1 x^2 dx$$

$$= 2i\left[\frac{x^3}{2}\right]_0^1$$

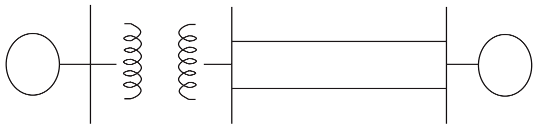
$$= 2i\left[\frac{1}{3} - \frac{0}{3}\right]$$

$$= \frac{2i}{3}$$

Hence, the correct option is (B).

Question Number: 24 **Question Type: NAT**

The figure shows the single line diagram of a power system with a double circuit transmission line. The expression for electrical power is 1.5 sinδ, where δ is the rotor angle. The system is operating at the stable equilibrium point with mechanical power equal to 1 pu. If one of the transmission line circuits is removed, the maximum value of δ, as the rotor swings, is 1.221 radian. If the expression for electrical power with one transmission line circuit removed is $P_{\max}$ sin δ, the value of $P_{\max}$, in pu is _____ (Give the answer up to three decimal places.)



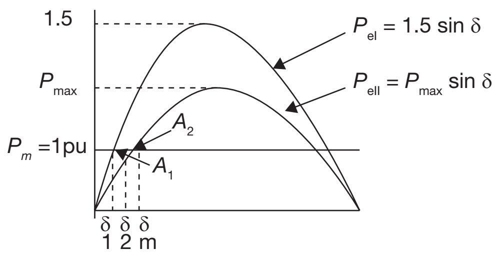
Solution:

With double circuit transmission line

$$P_{eI} = 1.5\sin\delta$$

with single line

$$P_{eII} = P_{\max}\sin\delta$$



Here,

$$\delta_1 = \sin^{-1}\left(\frac{1}{1.5}\right) = 41.81° \text{ or } 0.7297 \text{ radian}$$

$$\delta_m = 1.221 \text{ radian or } 69.96°$$

For stability

$$A_1 = A_2$$

$$\int_{\delta_1}^{\delta_2}(1 - P_{\max}\sin\delta)d\delta = \int_{\delta 2}^{\delta_m}(1 - P_{\max}\sin\delta - 1)d\delta$$

$$\delta\Big|_{\delta_1}^{\delta_2} - P_{\max}(-\cos\delta)\Big|_{\delta_1}^{\delta_2} = P_{\max}(-\cos\delta)\Big|_{\delta_2}^{\delta_m} - \delta\Big|_{\delta_2}^{\delta_m}$$

$$P_{\max} = (\cos\delta_m - \cos\delta_1) = \delta_1 - \delta_m$$

Substituting values and solving for $P_{\max}$

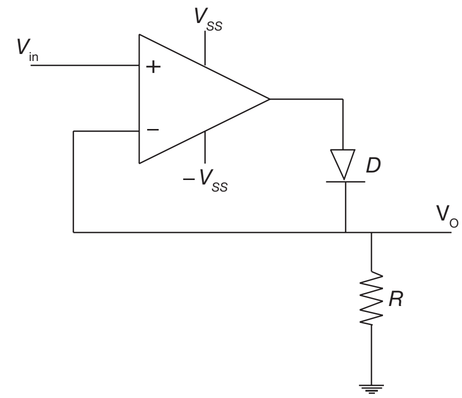
$P_{\max}$ (cos 69.96° – cos 41.81°) = 41.81°– 69.96.°

$$\boxed{P_{\max} = 1.220 \text{ pu}}$$

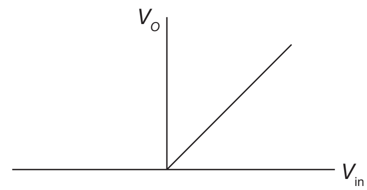
Hence, the correct answer is (1.220 pu).

Question Number: 25 **Question Type: MCQ**

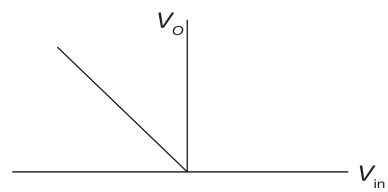
The approximate transfer characteristic for the circuit shown in the figure with an ideal operational amplifier and diode will be



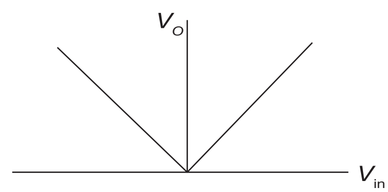
(A)



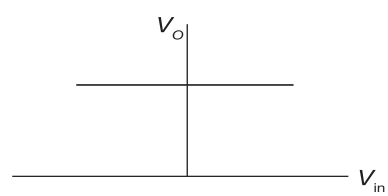
(B)



(C)



(D)



Solution:

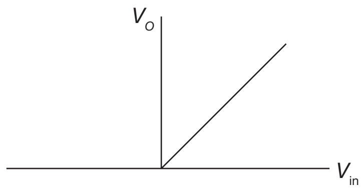
For $V_{in} < 0$

Output of operational amplifier will be negative hence due to presence of diode (reversed biased) in this case output will be 0

For $V_{in} > 0$

Diode will be forward biased so $V_{in} = V_0$

Thus transfer characteristics



Hence, the correct option is (A).

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

A load is supplied by a 230 V, 50 Hz source. The active power P and the reactive power Q consumed by the load are such that 1 kW ≤ P ≤ 2 kW and 1 kVAR ≤ Q ≤ 2 kVAR. A capacitor connected across the load for power factor correction generates 1 kVAR reactive power. The worst case power factor after power factor correction is

(A) 0.447 lag
(B) 0.707 lag
(C) 0.894 lag
(D) 1

Solution:

For worst case power factor

$$P = 1 \text{ kW},$$
$$Q = 2 \text{ kVAR}.$$

After addition of capacitor for power factor correction Q becomes 2–1 = 1 kVAR new

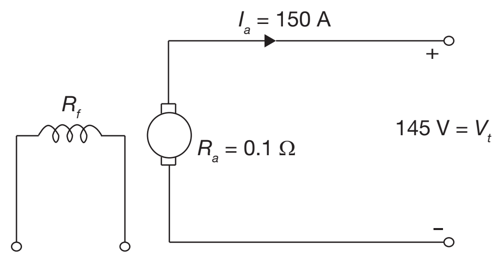
$$\text{Pf} = \cos\left(\tan^{-1}\frac{Q}{P}\right)$$
$$= \cos\left(\tan^{-1}\frac{1}{1}\right)$$
$$= \cos 45°$$
or $$\text{Pf} = 0.707 \text{ lag}$$

Hence, the correct option is (B).

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

A separately excited DC generator supplies 150 A to a 145 V DC grid. The generator is running at 800 RPM. The armature resistance of the generator is 0.1 Ω. If the speed of the generator is increased to 1000 RPM, the current in amperes supplied by the generator to the DC grid is _____. (Give the answer up to one decimal place).

Solution:



N = 800 rpm (speed of generator)

Since, back emf $\quad E = V_t + I_a R_a \qquad (1)$

And $\quad E \propto \phi N \qquad (2)$

For separately excited generator ϕ remains

Constant so $\quad E \propto N \qquad (3)$

For $\quad N = 800$ rpm

$$E1 = 145 + 150 \times 0.1 = 160 \text{ V}$$

Using Eq. (3)

$$E_1 \propto N_1$$

or $\quad 160 \propto 800 \qquad (4)$

For $\quad N = 1000$ rpm

$$E2 \propto 1000 \qquad (5)$$

On solving Eqs. (4) and (5)

$$E2 = 200 \text{ V}$$

Thus $\quad 200 = 145 + I_a \times 0.1$

$$I_a = \frac{200-145}{0.1}$$

or $\quad \boxed{I_a = 550 \text{ A}}$

Hence, the correct Answer is (550 A).

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

Consider the differential equation $(t_2 - 81)\frac{dy}{dt} + 5ty =$ sin(t) with $y(1) = 2\pi$. There exists a unique solution for this differential equation, when t belongs to the interval

(A) (–2, 2) (B) (–10, 10)
(C) (–10, 2) (D) (0, 10)

Solution:

Given differential equation is

$$(t^2 - 81)\frac{dy}{dt} + 5ty = \sin t \qquad (1)$$

Initial condition $y(1) = 2\pi$

Converting the given equation into standard form

$$\frac{dy}{dt}+\left(\frac{5t}{t^2-81}\right)y=\frac{\sin t}{t^2-81} \qquad (2)$$

This is of the form

$$\frac{dy}{dt}+py=Q$$

Where $\quad P=\dfrac{5t}{t^2-81}, \quad Q=\dfrac{\sin t}{t^2-81}$

We know integrating factor (IF) $= e^{\int pdt}$

$$= e^{\int \frac{5t}{t^2-81}dt}$$

$$= e^{\int \frac{5}{2}\left(\frac{2t}{t^2-81}\right)}$$

$$= e^{\frac{5}{2}\ln(t^2-81)^{5/2}} \qquad [\because e^{\ln x}=x]$$

$$\text{IF}=(t^2-81)^{5/2}$$

$$y(\text{IF})=\int Q\ \text{IF}\ dt+c$$

$$y(t^2-81)^{5/2}=\int\frac{\sin t}{(t^2-81)}(t^2-81)^{5/2}dt+c$$

$$y=\int\frac{\sin t(t^2-81)^{5/2}}{(t^2-81)^{5/2}}dt+c(t^2-81)^{-5/2}$$

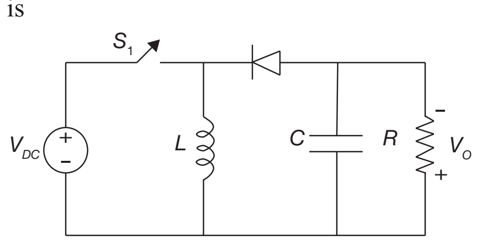
$$y=\int\sin t(t^2-81)^{-1}dt+c(t^2-81)^{-5/2}$$

and solving from the options by verifying initial condition, we get unique solution If $t=\pm9$ then solution is not unique hence range (–10, 10), (–10, 2), (0, 10) can be eliminated, then left option is (–2, 2).

Hence, the correct option is (A).

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

The input voltage VDC for the buck-boost converter shown in the figure varies from 32 V to 72 V. Assume that all components are ideal, inductor current is continuous and output voltage is ripple free. The range of duty ratio D of the convector for which the magnitude of the steady-state output voltage remains constant at 48 V is



(A) $\frac{2}{5}\le D\le\frac{3}{5}$ (B) $\frac{2}{3}\le D\le\frac{3}{4}$

(C) $0\le D\le 1$ (D) $\frac{1}{3}\le D\le\frac{2}{3}$

Solution:

For buck-boost converter

$$V_0=\frac{\alpha}{1-\alpha}V_s$$

where α is duty cycle of converter

V_s = supply voltage

V_0 = output voltage

For V_s = 32 V and V_0 = 48 V

$$48=\frac{\alpha}{1-\alpha}\times 32$$

$$\Rightarrow \qquad \alpha=\frac{3}{5}$$

For $\quad V_s=72\text{ V}$ and $V_0=48\text{ V}$

$$48=\frac{\alpha}{1-\alpha}\times 72$$

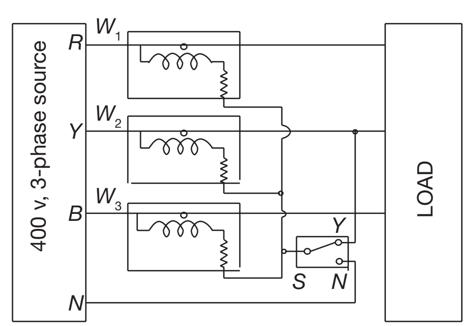
$$\alpha=\frac{2}{5}$$

$$\frac{2}{5}\le\alpha\le\frac{3}{5}$$

Hence, the correct option is (A).

Question Number: 30 **Question Type: MCQ**

The load shown in the figure is supplied by a 400 V (line-to-line), 3-phase source (RYB sequence). The load is balanced and inductive, drawing 3464 VA. When the switch S is in position N, the three wattmeters W_1, W_2 and W_3 read 577.35 W each. If the switch is moved to position Y, the readings of the wattmeters in watts will be:



(A) $W_1 = 1732$ and $W_2 = W_3 = 0$
(B) $W_1 = 0$, $W_2 = 1732$ and $W_3 = 0$
(C) $W_1 = 866$, $W_2 = 0$, $W_3 = 866$
(D) $W_1 = W_2 = 0$ and $W_3 = 1732$

Solution:

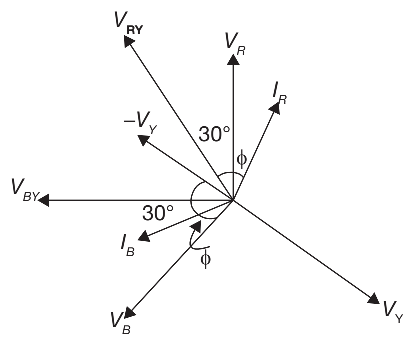
Apparent power = 3464 VA

Real power = 3 × 577.35 W = 1732.05 Watts

When switch is moved to position Y

⇒ Voltage across potential coil of watt-meter two is zero so $W_2 = 0$

For RYB phase sequence



Voltage across potential coil of wattmeter one is V_{RY}.
Voltage across potential coil of wattmeter two is V_{BY}.
So,

$$W_1 = V_{RY} \cdot I_R \cdot \cos(30 + \phi)$$
$$W_2 = V_{BY} \cdot I_B \cdot \cos(30° - \phi)$$

For Pf = 0.5; $\phi = \cos^{-1}(0.5) = 60°$

Thus

$$W_1 = V_{RY} \cdot I_R \cdot \cos(30 + 60°) = 0$$
$$W_2 = V_{BY} \cdot I_B \cdot \cos(30 - 60°) = 1732 \text{ W}$$

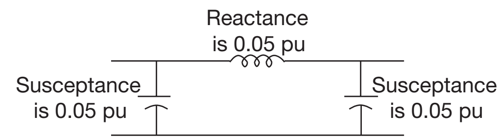
Hence, the correct option is (D).

Question Number: 31 **Question Type: MCQ**

The bus admittance matrix for a power system network is

$$\begin{bmatrix} -j39.9 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j39.9 \end{bmatrix} \text{pu}$$

There is a transmission line, connected between buses 1 and 3, which is represented by the circuit shown in figure



If this transmission line is removed from service, what is the modified bus admittance matrix?

(A) $\begin{bmatrix} -j19.9 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.9 \end{bmatrix}$ pu

(B) $\begin{bmatrix} -j39.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j39.9 \end{bmatrix}$ pu

(C) $\begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.95 \end{bmatrix}$ pu

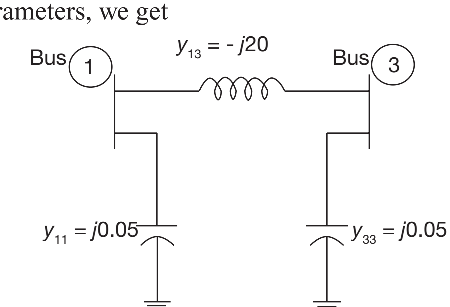
(D) $\begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j19.95 \end{bmatrix}$ pu

Solution:

It is given that y-bus

$$[Y]_{3\times3} = \begin{bmatrix} -j39.9 & j20 & j20 \\ j20 & -j39.9 & j20 \\ j20 & j20 & -j39.9 \end{bmatrix}$$

Converting the given transmission line parameters into Y parameters, we get



The parameters Y_{11}, Y_{13}, Y_{31}, Y_{33} will get affected whenever we remove the transmission line between Bus 1 and Bus 3

$$Y_{11} = -j39.9 - y_{11} - y_{13}$$
$$= -j39.9 - (j0.05) - (-j20)$$
$$= -j39.9 - j0.05 + j20$$
$$= -j19.95$$

$$
\begin{aligned}
Y_{13} &= j20 + y_{13} \\
&= j20 - j20 = 0 \\
Y_{31} &= j20 + y_{13} \\
&= j20 - j20 = 0 \\
Y_{33} &= -j39.9 - y_{33} - y_{31} \\
&= -j39.9 - j0.05 - (-j20) \\
&= -j19.95
\end{aligned}
$$

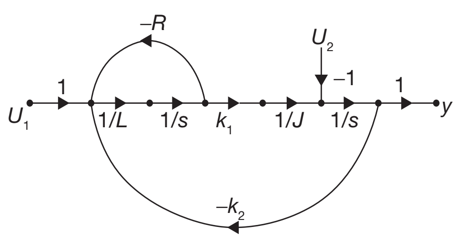
$\therefore$ New Y bus matrix

$$
[Y]_{3\times3} = \begin{bmatrix} -j19.95 & j20 & 0 \\ j20 & -j39.9 & j20 \\ 0 & j20 & -j19.95 \end{bmatrix}
$$

Hence, the correct option is (C).

Question Number: 32 **Question Type: MCQ**

In the system, whose signal flow graph is shown in the figure, $U_1(s)$ and $U_2(s)$ are inputs. The transfer function $\dfrac{Y(s)}{U_1(s)}$ is



(A) $\dfrac{k_1}{JLs^2 + JRs + k_1k_2}$

(B) $\dfrac{k_1}{JLs^2 - JRs - k_1k_2}$

(C) $\dfrac{k_1 - U_2(R + sL)}{JLs^2 + (JR - U_2L)s + k_1k_2 - U_2R}$

(D) $\dfrac{k_1 - U_2(sL - R)}{JLs^2 - (JR + U_2L)s - k_1k_2 + U_2R}$

Solution:

From mason's gain formula, we get

$$TF = \frac{\sum P_k \Delta_k}{\Delta}$$

$$P_1 = \frac{1}{L}\cdot\frac{1}{s}\cdot k_1\cdot\frac{1}{J}\cdot\frac{1}{s} = \frac{k_1}{JLs^2}$$

$$\Delta_1 = 1$$

$$
\begin{aligned}
\Delta &= 1 - \left[\left(\frac{-R}{Ls}\right) + \left(\frac{-k_1k_2}{JLs^2}\right)\right] \\
&= 1 + \frac{R}{Ls} + \frac{-k_1k_2}{JLs^2} \\
\Delta &= \frac{JLs^2 + JRs + k_1k_2}{JLs^2}
\end{aligned}
$$

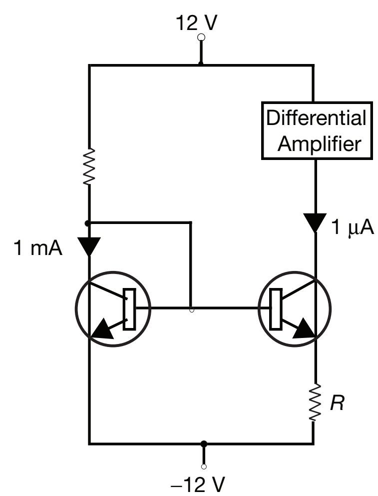
$$\text{TF} = \frac{\dfrac{k_1}{JLs^2}}{\dfrac{JLs^2 + JRs + k_1k_2}{JLs^2}}$$

$$\text{TF} = \frac{k_1}{JLs^2 + JRs + k_1k_2}$$

Hence, the correct option is (A).

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

The circuit shown in the figure uses matched transistors with a thermal voltage V_T = 25 mV. The base currents of the transistors are negligible. The value of the resistance R in kΩ that is required to provide 1 μA bias current for the differential amplifier block shown in _____. (Give the answer up to one decimal place).



Solution:

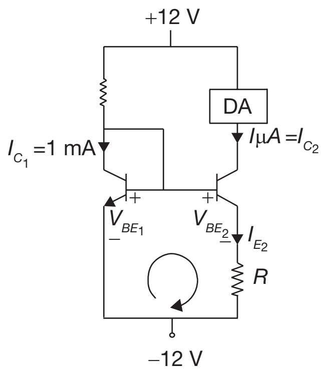
Given data $V_T = 25$ mV

given $I_{B_1} = I_{B_2} \approx 0$ A

$I_{C_1} = 1$ mA

$I_{C_2} = 1$ mA (Bias current)

Applying the KVL for the given circuit, we get



$$-V_{BE_1} + V_{BE_2} + I_{E_2} R = 0$$

$$I_{E2} R = V_{BE_1} - V_{BE_2} \quad (1)$$

$$\because I_{B_2} = 0 \text{ we get}$$

$$I_{E_2} = I_{C_2} = 1\,\mu\text{A} \quad (2)$$

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

$$(1\mu)R = V_{BE_1} - V_{BE_2} \quad (3)$$

$$V_{BE_1} = V_T \ln\left(\frac{I_{C_1}}{I_s}\right) \quad (4)$$

$$V_{BE_2} = V_T \ln\left(\frac{I_{C_2}}{I_s}\right) \quad (5)$$

Substituting Eqs. (4) and (5) in Eq. (3), we get

$$(1\mu)R = V_T \ln\left(\frac{I_{C_1}}{I_s}\right) - V_T \ln\left(\frac{I_{C_2}}{I_s}\right)$$

$$R = \frac{V_T \ln\left(\frac{I_{C_1}}{I_{C_2}}\right)}{(1\mu)}$$

$$= \frac{25m \ln\left(\frac{1m}{1\mu}\right)}{(1\mu)}$$

R = 172.69 kΩ

Hence, the correct Answer is (172.69 kΩ).

Question Number: 34 **Question Type: NAT**

For a system having transfer function $G(s) = \frac{-s+1}{s+1}$, a unit step input is applied at time $t = 0$. The value of the response of the system at t = 1.5 sec (rounded off to three decimal places) is _____

Solution:

$$G(s) = \frac{-s+1}{s+1}$$

For unit step input

$$R(s) = \frac{1}{s}$$

So output

$$y(s) = R(s) \cdot G(s) = \frac{1}{s} \cdot \frac{(-s+1)}{s+1}$$

$$y(t) = L^{-1}\left(\frac{-1}{s+1}\right) + L^{-1}\left(\frac{1}{s(s+1)}\right)$$

$$= -e^{-t} + \int_0^t e^{-t} dt$$

$$= -e^{-t} + (-e^{-t}) + 1$$

$$y(t) = 1 - 2\, e^{-t}$$

$$t = 1.5 \text{ sec}$$

$$\text{at} \quad y(1.5) = 1 - 2e^{-1.5}$$

$$= 0.5537$$

or $\boxed{y(1.5) = 0.554}$

Hence, the correct Answer is (0.554).

Question Number: 35 **Question Type: NAT**

Two parallel connected, three-phase, 50 Hz, 11 kV, star-connected synchronous machines A and B are operating as synchronous condensers. They together supply 50 MVAR to a 11 kV grid. Current supplied by both the machines are equal. Synchronous reactances of machine A and machine B are 1Ω and 3Ω, respectively. Assuming the magnetic circuit to be linear, the ratio of excitation current of machine A to that of machine B is _____. (Give the answer up to two decimal places).

Solution:

As the machines works at same current and same voltage, so they supply same reactive power.

As machines are operating as synchronous condenser so they will work as overexcited synchronous motor.

Total current,

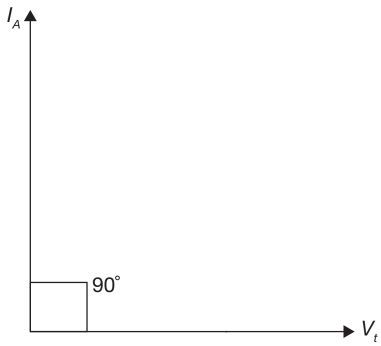
$$I_T = \frac{50 \text{ MVA}}{\sqrt{3} \times 11 \text{ KV}}$$

$$= 2.624 \text{ kA}$$

$$I_A = I_B = \frac{I_T}{2}$$

$$= \frac{2.624 \text{ kA}}{2} = 1.312 \text{ kA}$$

Current taken by motor will be leading because the motor is working as synchronous condenser,



Also, $\vec{E}_A = \vec{V}_T - j\vec{I}_a X_s$

$$= \frac{11 \text{ kV}}{\sqrt{3}} - j(1.312\angle 90° \text{ kA})(1)$$

$$= \frac{11}{\sqrt{3}} + 1.312 \times 1 = 7.662 \text{ kV}$$

Similarly $\quad \vec{E}_B = \frac{11 \text{ kV}}{\sqrt{3}} - j(1.312\angle 90° \text{ kA})(3)$

$$= \frac{11}{\sqrt{3}} + 1.312 \times 3 = 10.286 \text{ kV}$$

Hence, $\frac{I_A}{I_B} \propto \frac{E_A}{E_B} = \frac{7.662}{10.286} = 0.74$

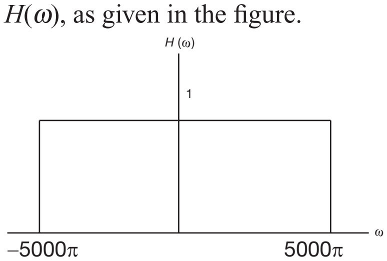
Hence, the correct answer is (0.74).

Question Number: 36 Question Type: MCQ

Let the signal

$$x(t) = \sum_{k=-\infty}^{+\infty} (-1)^k \delta\left(t - \frac{k}{2000}\right)$$

be passed through an *LTI* system with frequency response $H(\omega)$, as given in the figure.



The Fourier series representation of the output is given as

(A) 4000 + 4000cos(2000πt) + 4000cos(4000πt)
(B) 2000 + 2000cos(2000πt) + 2000cos(4000πt)
(C) 4000cos(2000πt)
(D) *A*2000cos(2000πt)

Solution:

We know that function in time domain is

$$x(t) = \sum_{k=-\infty}^{\infty} (-1)^k \delta\left(t - \frac{k}{2000}\right)$$

This function looks like $f(t - T)$ delayed by time T.

Here, $\delta\left(t - \frac{k}{2000}\right)$ is compared with $\delta(t - kT)$

Where $T = \frac{1}{2000}$

The values of $x(t)$ for $k = 0,1,2,\ldots$ are

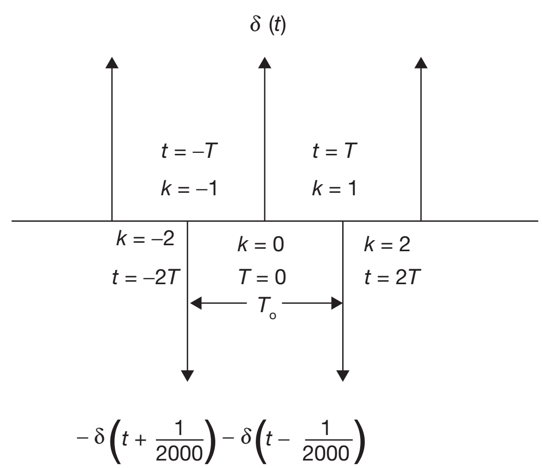
$k = -1,-2,-3,\ldots$

$$x(t) = \delta(t) \qquad \text{for } k = 0$$

$$x(t) = (-1)\delta\left(t - \frac{1}{2000}\right) \qquad \text{for } k = 1$$

$$x(t) = (-1)^{-1}\delta\left(t - \frac{1}{2000}\right) \qquad \text{for } k = -1$$

Drawing the function $x(t)$ for various values of k, we get



The figure shown above passess even half wave symmetry with time period

$$T_0 = 2T = \frac{2}{2000} = \frac{1}{2000}$$

$$\omega_0 = \frac{2\pi}{T} = \frac{2\pi}{\left(\frac{1}{1000}\right)} = 2000\pi$$

In the case of even half wave symmetry $b_n = 0$ and consists of only odd harmonics of a_n.

The frequency components are $\omega_0, 3\omega_{0\ldots}$

i.e., 2000π, $6000\pi\ldots\ldots$

and 2000π is the only frequency available in the above range or $-5000\,\pi$ to $5000\,\pi$

$$\therefore \quad a_n = \frac{2\pi}{T}\int_{-T_0/2}^{T_0/2} f(t)\cos n\omega_0 t\, dt$$

$$= \frac{4}{T_0}\int_0^{T_0/2} f(t)\cos n\omega_0 t\, dt$$

$$a_2 = \frac{4}{T_0}\int_0^{T_0/2} \delta(t)\cos 2\omega_0(0)dt$$

$$= \frac{4}{T_0}\int_0^{T_0/2} \delta(t)\, dt$$

$$= \frac{4}{T_0}(1) = 4000$$

$\therefore$ The output

$y(t) = 4000 \cos \omega_0 + 4000 \cos (3\,\omega_0\, t)+\ldots.$

$= 4000 \cos 2000\pi t + 4000 \cos 6000\pi t + \ldots.$

Hence, $4000 \cos 2000\pi t$ is in the range of -5000π to 5000π.

Hence, the correct option is (C).

Question Number: 37 **Question Type: MCQ**

The output expression for the Karnaugh map shown in the figure is

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	1	1
10	0	0	0	0

(A) $B\overline{D} + BCD$ (B) $B\overline{D} + AB$

(C) $\overline{B}D + ABC$ (D) $B\overline{D} + ABC$

Solution:

The Karnaugh map is given as

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	1	1
10	0	0	0	0

$$f = B\overline{D} + ABC$$

Hence, the correct option is (D).

Question Number: 38 **Question Type: MCQ**

The transfer function of the system $Y(s)/U(s)$ whose state-space equations are given below is:

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

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

(A) $\frac{(s+2)}{(s^2+2s-2)}$ (B) $\frac{(s-2)}{(s^2+s-4)}$

(C) $\frac{(s-4)}{(s^2+s-4)}$ (D) $\frac{(s+4)}{(s^2-s-4)}$

Solution:

Transfer function $TF = C(sI - A)^{-1}B$

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

$$|sI - A| = s(s-1) - 4 = s^2 - s - 4$$

$$[sI - A]^{-1} = \frac{1}{s^2 - s - 4}\begin{bmatrix}s & +2\\ +2 & s-1\end{bmatrix}$$

$$[sI - A]^{-1}B = \frac{1}{s^2 - s - 4}\begin{bmatrix}s & +2\\ 2 & s-1\end{bmatrix}\begin{bmatrix}1\\ 2\end{bmatrix}$$

$$= \frac{1}{s^2 - s - 4}\begin{bmatrix}s+4\\ 2s\end{bmatrix}$$

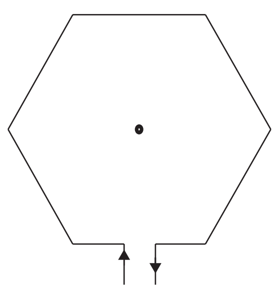
$$C[sI-A]^{-1}B = \frac{1}{s^2-s-4}[1\ \ 0]\begin{bmatrix} s+4 \\ 25 \end{bmatrix}$$

$$T.F. = \frac{s+4}{s^2-s-4}$$

Hence, the correct option is (D).

Question Number: 39 Question Type: NAT

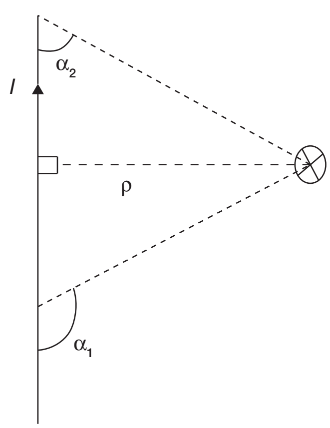
The magnitude of magnetic flux density (b) in micro Teslas (μT), at the center of a loop of wire wound as a regular hexagon of side length 1 m carrying a current (I = 1 A) and placed in vacuum as shown in the figure is _____. (Give the answer up to two decimal places).



Solution:

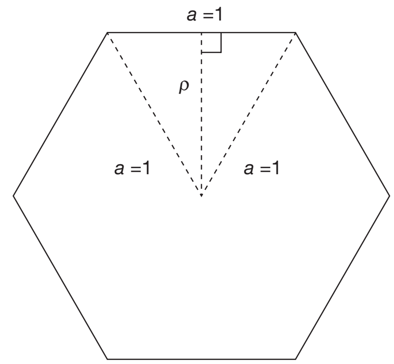
Magnetic field due to finite length of current carrying conductor is given by

$$H = \frac{I}{4\pi\rho}(\cos\alpha_2 - \cos\alpha_1)\hat{a}_\phi \qquad (1)$$



$$\alpha_2 = 60°$$
$$\alpha_1 = 120°$$

In case of regular hexagon



$$\rho = \sqrt{a^2 - \frac{a^2}{4}} \text{ where } a = 1$$

$$= \sqrt{1-\frac{1}{4}} = \frac{\sqrt{3}}{2}m$$

Using formula in eq-(i) magnetic field intensity at centre due to one side of regular Hexagon

$$H' = \frac{1}{4\pi\left(\frac{\sqrt{3}}{2}\right)}[\cos 60° - \cos 120°]\alpha_\phi$$

$$= 0.091888 \text{ H/m}$$

Magnetic field intensity due to all six sides of regular hexagon will be

$$H = 6 \times H'$$
$$= 6 \times 0.091888$$
$$= 0.551329 \text{ H/m}$$

Magnetic flux density is given by relation

$$B = \mu H$$

In vacuum

$$B = \mu_0 H$$
$$= 4\pi \times 10^{-7} \times 0.551329$$
$$= 6.9282 \times 10^{-7} \text{ Tesla}$$

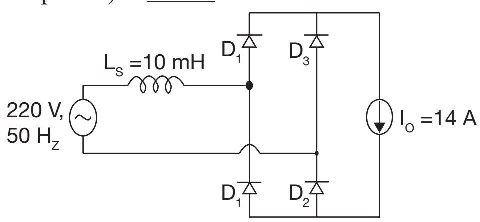
or $\boxed{B = 0.6928\ \mu T}$

$\boxed{B = 0.69\ \mu T}$ upto two decimal places

Hence, the correct answer is (0.69).

Question Number: 40 Question Type: NAT

The figure shows an uncontrolled diode bride rectifier supplied from a 220 V, 50 Hz, 1-phase ac source. The load draws a constant current I_0 = 14 A. The conduction angle of the diode D_1 in degrees (rounded off to two decimal places) is _____



Solution:

For single phase controlled bridge rectifier effect of source inducfance will modify the average output voltage as,

$$V_0 = \frac{V_m}{\pi}[\cos\alpha + \cos(\alpha + \mu)]$$

where μ is overlap angle

But, for diode (uncontrolled) bridge, $\alpha = 0$

So, $$V_0 = \frac{V_m}{\pi}[1 + \cos\mu] \quad (1)$$

Also

$$V_0 = \frac{2V_m}{\pi} - \frac{2\omega L_s}{\pi} I_0 \quad (2)$$

In above expression L_s = source inductance

From Eq. (1) and Eq. (2).

$$\frac{2V_m}{\pi} - \frac{2\omega L_s}{\pi} I_0 = \frac{V_m}{\pi}[1 + \cos\mu]$$

Substituting all the values in above equation

$$\frac{2 \times 220 \times \sqrt{2}}{\pi} - \frac{4\pi \times 50 \times 10 \times 10^{-3} \times 14}{\pi}$$
$$= \frac{220 \times \sqrt{2}}{\pi}[1 + \cos\mu]$$

Solving for $\cos\mu$

$\cos\mu = 0.7173$

$\Rightarrow \quad \mu = 44.17°$

Conduction angle for diode will be $180° + \mu$

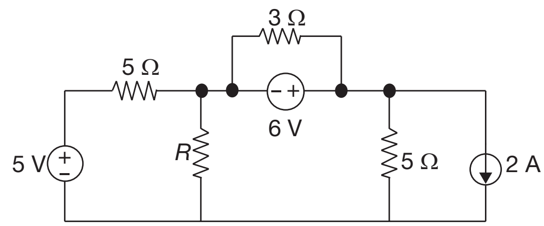
Hence, conduction angle $\gamma = 180° + \mu = 180° + 44.17°$

$\boxed{\gamma = 224.17°}$ upto two decimal places.

Hence, the correct answer is (224.17°).

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

In the circuit shown in the figure, the maximum power transferred to the resistor R is_____W



Solution:

If V_{Th} is the Thevenin's voltage across "R"

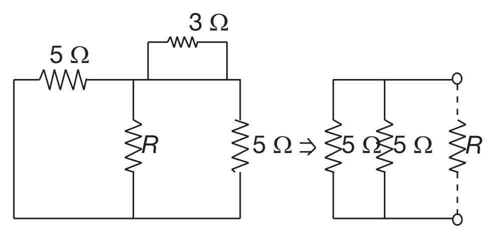
R_{Th} is the Thevenin's resistance across "R"

Maximum power P_{max} across R will be

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}}$$

Calculating Resistance R_{th}

By short circuiting all voltage sources and open circuiting all current sources, the circuit reduces to



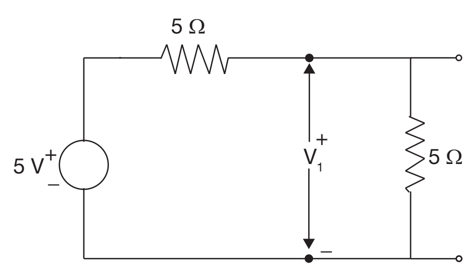
Hence, $R_{Th} = 5\ \Omega || 5\ \Omega = 2.5\ \Omega$

Calculating resistance V_{th}

Using superposition theorem

Taking 5 V source only

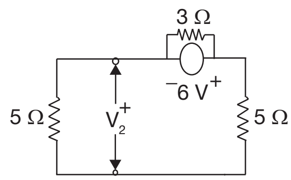
Circuit reduces to



From the above circuit, we get

$$V_1 = \frac{5}{2} = 2.5$$

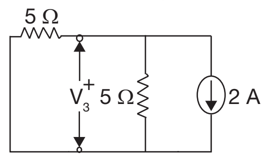
Taking 6 V source only, circuit reduces to



From the above circuit we get

$$V_2 = -3 \text{ V}$$

Taking 2 A current source only,



Form the above circuit, we get

$$V_3 = -5 \text{ V}$$

$$V_{\text{Th}} = V_1 + V_2 + V_3 = 2.5 - 3 - 5 = -5.5 \text{ V}$$

$$P_{\max} = \frac{(5.5)^2}{4 \times 2.5}$$

or $\boxed{P_{\max} = 3.025 \text{ W}}$

Hence, the correct Answer is (3.025 W).

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

A 375 W, 230 V, 50 Hz, capacitor start single-phase induction motor has the following constants for the main and auxiliary windings (at starting):

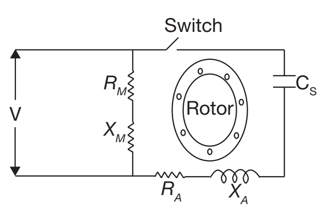
$Z_m = (12.50 + j15.75)\Omega$ (main winding),

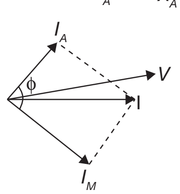
$Z_a = (24.50 + j12.75)\Omega$ (auxiliary winding).

Neglecting the magnetizing branch, the value of the capacitance (in μF) to be added in series with the auxiliary winding to obtain maximum torque at starting is

______

Solution: Capacitor start single phase induction motor





For maximum Torque $\phi = 90°$ between currents of auxiliary winding and mains winding.

$$I_M = \frac{230}{(12.50 + j15.75)}$$

$$\phi_M = -\tan^{-1}\left(\frac{15.75}{12.50}\right)$$

Taking X_c as reactance of capacitor C_s

$$I_A = \frac{230}{(24.50 + j12.75 - jX_c)}$$

$$\phi_M = -\tan^{-1}\left(\frac{12.75 - X_C}{24.50}\right)$$

Taking $\phi_m + 90° = \phi_A$

$$\tan^{-1}\left(\frac{15.75}{12.50}\right) + 90° = \tan^{-1}\left(\frac{12.75 - X_c}{24.50}\right)$$

$$\tan^{-1}\left(\frac{15.75}{12.5}\right) - \tan^{-1}\left(\frac{12.75 - X_c}{24.50}\right) = 90°$$

Taking tan on both sides

$$\frac{\left(\frac{15.75}{12.5}\right) - \left(\frac{12.75 - X_c}{24.50}\right)}{1 + \left(\frac{15.75}{12.5}\right) - \left(\frac{12.75 - X_c}{24.50}\right)} = \tan 90° = \infty$$

$$\therefore 1 + \left(\frac{15.75}{12.5}\right)\left(\frac{12.75 - X_c}{24.50}\right) = 0$$

Solving for X_c

$$X_c = 32.194$$

Also $$X_c = \frac{1}{\omega C_s}$$

$$\Rightarrow C_s = \frac{1}{\omega X_c} = \frac{1}{2\pi \times 100 \times 32.194}$$

or $\boxed{C_s = 98.87 \ \mu\text{F}}$

Hence, the correct Answer is (98.87μF).

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

Consider a causal and stable LTI system with rational transfer function $H(z)$, whose corresponding impulse response begins at $n = 0$. Furthermore, $H(1) = \frac{5}{4}$. The poles of $H(z)$ are $p_k = \frac{1}{\sqrt{2}}\exp\left(j\frac{(2k-1)\pi}{4}\right)$ for $k = 1, 2, 3, 4$. The zeros of $H(z)$ are all at $z = 0$. Let $g[n] = j^n h[n]$. The value of g[8] equals _____. (Give the answer up to three decimal places).

Solution:

Given that

$$P_k = \frac{1}{\sqrt{2}}\exp\left(j\frac{(2k-1)\pi}{4}\right),$$

$$k = 1,\ 2,\ 3,\ 4$$

$$P_1 = \frac{1}{\sqrt{2}}e^{\frac{j\pi}{4}}$$

$$= \frac{1}{\sqrt{2}}\left[\cos\left(\frac{\pi}{4}\right) + j\sin\left(\frac{\pi}{4}\right)\right]$$

$$= \frac{(1+j)}{2}$$

$$P_2 = \frac{1}{\sqrt{2}}e^{\frac{j3\pi}{4}}$$

$$= \frac{1}{\sqrt{2}}\left[\cos\left(\frac{3\pi}{4}\right) + j\sin\left(\frac{3\pi}{4}\right)\right]$$

$$= \frac{(-1+j)}{2}$$

$$P_3 = \frac{1}{\sqrt{2}}e^{\frac{j5\pi}{4}}$$

$$= \frac{1}{\sqrt{2}}\left[\cos\left(\frac{5\pi}{4}\right) + j\sin\left(\frac{5\pi}{4}\right)\right]$$

$$= \frac{(-1-j)}{2}$$

$$P_4 = \frac{1}{\sqrt{2}}e^{\frac{j7\pi}{4}}$$

$$= \frac{1}{\sqrt{2}}\left[\cos\left(\frac{7\pi}{4}\right) + j\sin\left(\frac{7\pi}{4}\right)\right]$$

$$= \frac{(1-j)}{2}$$

System is causal so order of numerator can not be greater than order of denominator. Therefore,

$$H(z) = \frac{K \cdot Z^4}{(Z-P_1)(Z-P_2)(Z-P_3)(Z-P_4)}$$

$$= \frac{K \cdot Z^4}{\left[Z-\left(\frac{1+j}{2}\right)\right]\left[Z-\left(\frac{-1+j}{2}\right)\right]\left[Z-\left(\frac{-1-j}{2}\right)\right]\left[Z-\left(\frac{1-j}{2}\right)\right]}$$

$$H(z) = \frac{KZ^4}{Z^4 + \frac{1}{4}}$$

$$H(1) = \frac{5}{4}$$

$$\frac{K}{1+\frac{1}{4}} = \frac{5}{4}$$

$$\frac{4}{5}K = \frac{5}{4}$$

$$\boxed{K = \frac{25}{16}}$$

$$H(z) = \frac{25}{16}\frac{Z^4}{Z^4 + \frac{1}{4}}$$

$$H(z) = \frac{25}{16}\left[1 - \frac{1}{4}Z^4 + \frac{1}{16}Z^{-8} + \ldots\right]$$

$$h[n] = \frac{25}{16}\left[\delta(n) - \frac{1}{4}\delta(n-4) + \frac{1}{16}\delta(n-8)\ldots\right]$$

$$h[8] = \frac{25}{16}\left[\delta(8) - \frac{1}{4}\delta(4) + \frac{1}{16}\delta(0)\ldots\right]$$

$$= \frac{25}{16}\left[0 - \frac{1}{4}\times 0 + \frac{1}{16}\times 1 + \ldots 0\right]$$

$$h[8] = \frac{25}{16}\times\frac{1}{16} = \frac{25}{256} = 0.098$$

$$g[n] = j^n h[n]$$

$$g[8] = j^8 h[8] = h[8] = 0.098$$

$$\boxed{g\ [8] = 0.098}$$

Hence, the correct answer is (0.098).

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

Let a causal *LTI* system be characterized by the following differential equation, with initial rest condition

$$\frac{d^2y}{dt^2}+7\frac{dy}{dt}+10y(t)=4x(t)+5\frac{dx(t)}{dt}$$

where, $x(t)$ and $y(t)$ are the input and output respectively. The impulse response of the system is [$u(t)$ is the unit step function]

(A) $2e^{-2t}u(t) - 7e^{-5t}u(t)$
(B) $-2e^{-2t}u(t) + 7e^{-5t}u(t)$
(C) $7e^{-2t}u(t) - 2e^{-5t}u(t)$
(D) $-7e^{-2t}u(t) + 2e^{-5t}u(t)$

Solution:

The give differential equation is

$$\frac{d^2y}{dt^2}+7\frac{dy}{dt}+10y(t)=4x(t)+5\frac{dx(t)}{dt}$$

Taking Laplace on both sides (initial rest condition) we get

$$s^2Y(s) + 7sY(s) + 10Y(s) = 4X(s) + 5s\,X(s)$$

$$H(s)=\frac{Y(s)}{X(s)}=\frac{5s+4}{s^2 7s+10}$$

Impulse response $h(t) = L^{-1}\,H(s)$

$$h(t)=L^{-1}\left(\frac{5s+4}{(s+2)(s+5)}\right)$$

$$=L^{-1}\left(\frac{-2}{s+2}+\frac{7}{s+5}\right)$$

$$h(t)=-2e^{-2t}\,4(t)+7e^{-5t}\,4(t)$$

Hence, the correct option is (B).

Question Number: 45 **Question Type: NAT**

Only one of the real roots of $f(x) = x^6 - x - 1$ lies in the interval $1 \le x \le 2$ and bisection method is used to find its value. For achieving an accuracy of 0.001, the required minimum number of iterations is _____

Solution:

In bisection method, the minimum number of iterations is given by $\frac{|b-a|}{2^n}<\varepsilon$

Where

a is the lower limit of interval

b is the upper limit of interval

ε is the error in approximation

n is the number of iteration

Therefore

$$\frac{|2-1|}{2^n}<0.001$$

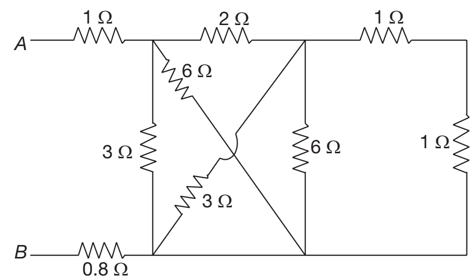
$$\Rightarrow 2^n > 1000$$

$$\Rightarrow \boxed{n=10}$$

Hence, the correct answer is (10).

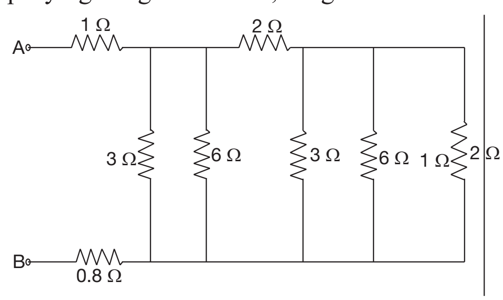
Question Number: 46 **Question Type: NAT**

The equivalent resistance between the terminals A and B is _______ Ω.



Solution:

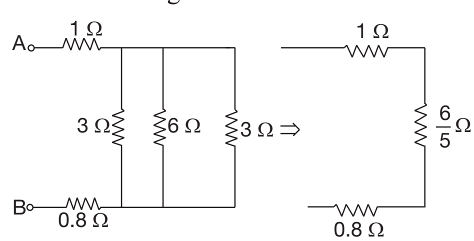
Simplifying the given circuit, we get



Combining parallel resistances 3 Ω, 6 Ω, and 2 Ω, we get the equivalent as

$$3\ \Omega \parallel 6\ \Omega \parallel 2\ \Omega = 1\ \Omega$$

Consider the circuit given below



$$R_{eq}=1+\frac{6}{5}+0.8=\frac{15}{5}\,\Omega$$

$$\text{or}\quad \boxed{R_{eq}=3\,\Omega}$$

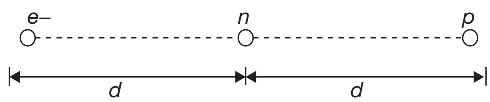
Hence, the correct answer is (3 Ω).

Question Number: 47 Question Type: MCQ

Consider an electron a neutron and a proton initially at rest and placed along a straight line such that the neutron is exactly at the center of the line joining the electron and proton. At $t = 0$, the particles are released but are constrained to move along the same straight line. Which of these will collide first?

(A) The particles will never collide
(B) All will collide together
(C) Proton and neutron
(D) Electron and neutron

Solutions:



Mass of electron, $m_e = 9.1094 \times 10^{-31}$ Kg

Mass of proton, $m_p = 1.6726 \times 10^{-27}$ Kg

Electrostatic force will exist between electron and proton only. If the force is "F" then by relation

$$F = ma$$

Where m is mass of particle and a is acceleration.

We know that mass of electron is lesser than proton, so acceleration of electron will be more than proton.

Using second kinematics equation

$$s = ut + \frac{1}{2}at^2$$

s = distance travelled

u = inital speed

As $u = 0$

$$s = \frac{1}{2}at^2$$

To travel distance "d" electron will take lesser time so electron will collide with neutron first.

Hence, the correct option is (D).

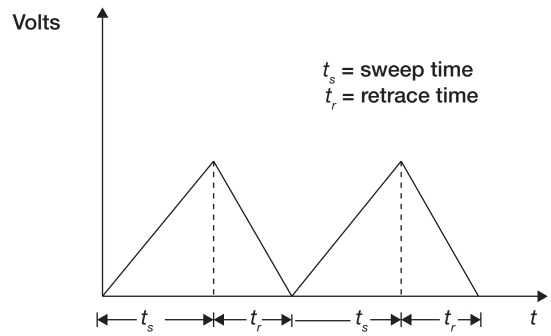
Question Number: 48 Question Type: MCQ

The slope and level detector circuit in a CRO has a delay of 100 ns. The start-stop sweep generator has a response time of 50 ns. In order to display correctly a delay line of

(A) 150 ns has to be inserted into the y-channel
(B) 150 ns has to be inserted into the x-channel
(C) 150 ns has to be inserted into both x and y channels
(D) 100 ns has to be inserted into both x and y channels

Solution:

In a CRO the beam moves left to right across the CRT during the sweep time, the beam quickly moves to the left side of the CRT screen during the retrace time as shown in figure given below.



Slope and level detector has delay time (t_d) = 100 ns

Response time (t_{re}) = 50 ns

Total time taken for one sweep cycle of x-plate

$$= (t_{re} + t_d + t_s + t_r)$$
$$= 150 \text{ ns} + (t_s + t_r)$$

In order to display correctly signal to y-channel has to be applied after a delay of 150 ns.

Hence, the correct option is (A).

Question Number: 49 Question Type: NAT

The following measurements are obtained on a single phase load V = 220 V ± 1%. I = 50A ± 1% and W = 555 W ± 2%. If the power factor is calculated using these measurements the worst case error in the calculated power factor in percent is _____(Give answer up to one decimal place)

Solution:

Given data

$$V = 220 \text{ V} \pm 1\%$$
$$I = 5 \text{ A} \pm 1\%$$
$$W = 555 \text{ W} \pm 2\%$$

Now we know that

$$W = VI\cos\Phi$$

So, $$\frac{\delta W}{W} = \pm\left(\frac{\delta V}{V} + \frac{\Delta I}{I} + \frac{\delta(\cos\Phi)}{\cos\Phi}\right)$$

$$0.02 = \pm\left(0.01 + 0.01 + \frac{\delta(p.f.)}{p.f}\right)$$

In worst case

$$\frac{\delta p.f.}{p.f.} = 0.02 + 0.01 + 0.01$$
$$= 0.04$$
$$= 4\% \text{ or } 4.0\%$$

Hence, the correct answer is (4%).

Question Number: 50 **Question Type: MCQ**

A closed loop system has the characteristic equation given by $s^3 + Ks^2 + (K + 2)s + 3 = 0$. For this system to be stable, which one of the following conditions should be satisfied?

(A) $0 < K < 0.5$
(B) $0.5 < K < 1$
(C) $0 < K < 1$
(D) $K > 1$

Solution:

Using Routh Hurwitz Criteria

$$\begin{array}{ccc} s^3 & 1 & k+2 \\ s^2 & k & 3 \\ s^1 & \dfrac{k(k+2)-3}{k} & \\ s^0 & 3 & \end{array}$$

We know that for stability

$$k > 0 \qquad \text{(i)}$$
$$\frac{k(k+2)-3}{k} \qquad \text{(ii)}$$
$$\Rightarrow \frac{(k-1)(k+3)}{k} > 0$$
$$\Rightarrow \text{Either } k > 1; k > -3$$
$$\text{or } k < 1; k < -3 \qquad \text{(iii)}$$

From equation (i) and (iii), we get $k > 1$.

Hence, the correct option is (D).

Question Number: 51 **Question Type: MCQ**

The matrix $A = \begin{bmatrix} \frac{3}{2} & 0 & \frac{1}{2} \\ 0 & -1 & 0 \\ \frac{1}{2} & 0 & \frac{3}{2} \end{bmatrix}$ has three distinct eigenvalues and one of its eigenvectors is $\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$. Which one of the following can be another eigenvector of A?

(A) $\begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}$ (B) $\begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}$

(C) $\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$ (D) $\begin{bmatrix} 1 \\ -1 \\ 1 \end{bmatrix}$

Solution:

The given matrix is

$$A = \begin{bmatrix} \frac{3}{2} & 0 & \frac{1}{2} \\ 0 & -1 & 0 \\ \frac{1}{2} & 0 & \frac{3}{2} \end{bmatrix}$$

We know that to calculate eigen values of A,

det $(A - \lambda I_3) = 0$

$$\begin{vmatrix} \frac{3}{2}-\lambda & 0 & \frac{1}{2} \\ 0 & -1-\lambda & 0 \\ \frac{1}{2} & 0 & \frac{3}{2}-\lambda \end{vmatrix} = 0$$

$$\left(\frac{3}{2}-\lambda\right)\left[(-1-\lambda)\left(\frac{3}{2}-\lambda\right)\right]$$
$$+\frac{1}{2}\left[0 - \frac{1}{2}(-1-\lambda)\right] = 0$$

$$(-1-\lambda)\left[\left(\frac{3}{2}-\lambda\right)^2 - \frac{1}{4}\right] = 0$$

$$-(1+\lambda)[\lambda^2 - 3\lambda + 2] = 0$$

or $-(1+\lambda)(\lambda-1)(\lambda-2) = 0$

The eigen values of A are –1, 1 and 2.

If X be an eigen vector of A associated to λ, then

$AX = \lambda X$

So, $$\begin{bmatrix} \frac{3}{2} & 0 & \frac{1}{2} \\ 0 & -1 & 0 \\ \frac{1}{2} & 0 & \frac{3}{2} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} = \lambda \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}$$

Simplifying, we get

$$\lambda = 2$$

Thus for $\lambda = +1$ by taking $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$

$$[A + 1I_3]X = 0$$

$$\frac{1}{2}x + \frac{1}{2}z = 0$$

$$-2y = 0$$

$$\frac{1}{2}x + \frac{1}{2}z = 0$$

or $$\frac{1}{2}x + \frac{1}{2}z = 0$$

$$y = 0$$

Hence option (c) satisfies.

Hence, the correct option is (C).

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

A 10-bus power system consists of four generator buses indexed as G_1, G_2, G_3, G_4 and six load buses indexed as L_1, L_2, L_3, L_4, L_5, L_6. The generator-bus G_1 is considered as slack bus and the load buses L_3 and L_4 are voltage controlled buses. The generator at bus G_2 cannot supply the required reactive power demand and hence it is operating at its maximum reactive power limit. The number of non-linear equations required for solving the load flow problem using Newton-Raphson method in polar form is _____.

Solution:

Number of slack buses = 1 (i.e., G_1)

Number of load buses = 5

Total number of buses (N) = 10

Number of PV buses (x_1) = 2 (i.e., G_3 and G_4)

Number of voltage controlled buses (x_2) = 2 (i.e., L_3 and L_4)

The total number of equations to be solved

$$\begin{aligned} &= [2N - 2 - (x_1 + x_2)] \\ &= [2(10) - 2 - (2+2)] \\ &= 20 - 2 - 4 \\ &= 14 \end{aligned}$$

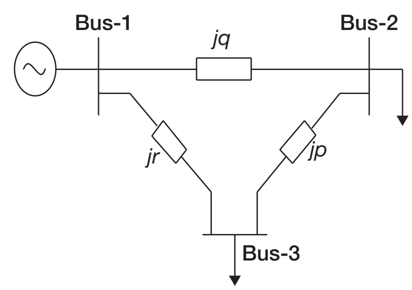
The size of the jacobian matrix

$$\begin{aligned} &= [2N - 2 - (x_1 + x_2)] \times [2N - 2 - (x_1 + x_2)] \\ &= 14 \times 14 \end{aligned}$$

Hence, the correct answer is (14).

Question Number: 53 **Question Type: MCQ**

A 3-bus power system is shown in the figure below, where the diagonal elements of Y bus matrix are: $Y_{11} = -j_{12}$ pu, $Y_{22} = -j15\ pu$ and $Y_{33} = -j7\ pu$



The per unit values of the line reactances p, q and r shown in the figure are

(A) $p = -0.2$, $q = -0.1$, $r = -0.5$
(B) $p = 0.2$, $q = 0.1$, $r = 0.5$
(C) $p = -5$, $q = -10$, $r = -2$
(D) $p = 5$, $q = 10$, $r = 2$

Solution:

From the bus diagram given in problem, we get

$$y_{12} = y_{21} = \frac{1}{jq}$$

$$y_{13} = y_{31} = \frac{1}{jr}$$

$$y_{23} = y_{32} = \frac{1}{jp}$$

Since diagonal elements

$$Y_{11} = y_{11} + y_{12} + y_{13}$$

So, $$\frac{1}{jq} + \frac{1}{jr} = -j12$$

$$\frac{1}{q} + \frac{1}{r} = 12 \quad \text{(i)}$$

Similary for $Y_{22} = -j15$

$$\frac{1}{jq} + \frac{1}{jp} = -j15$$

or $$\frac{1}{q} + \frac{1}{p} = 15 \quad \text{(ii)}$$

For $$Y_{33} = -j7$$

$$\frac{1}{jr} + \frac{1}{jp} = -j7$$

or $$\frac{1}{r} + \frac{1}{p} = 7 \quad \text{(iii)}$$

Simplifying equations (i), (ii) and (iii)

$$\frac{1}{p} = 5; \quad \frac{1}{q} = 10; \quad \frac{1}{r} = 2$$

Hence,

$p = 0.2$, $q = 0.1$, $r = 0.5$

Hence, the correct option is (B).

Question Number: 54 **Question Type: MCQ**

For the power semiconductor devices IGBT, MOSFET, Diode and Thyristor, which one of the following statement is TRUE?

(A) All the four are majority carrier devices
(B) All the four are minority carrier devices
(C) IGBT and MOSFET are majority carrier devices, whereas Diode and Thyristor are minority carrier devices
(D) MOSFET is majority carrier device, whereas IGBT, Diode, Thyristor are minority carrier devices

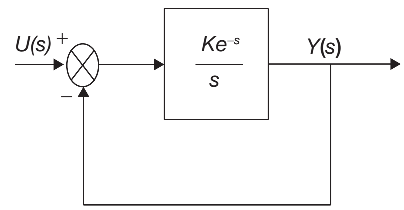
Solution:

MOSFET is the only majority carrier device among MOSFET, DIODE, Thyristor and IGBT. In majority carrier devices conduction is only because of majority carriers whereas in minority carrier devices conduction is due to both majority and minority carriers.

Hence, the correct option is (D).

Question Number: 55 **Question Type: NAT**

Consider the unity feedback control system shown. The value of K that results in a phase margin of the system to be 30° is _____. (Give the answer up to two decimal places.)



Solution:

For unity feedback system with

$$G(j\omega)H(j\omega) = \frac{Ke^{-s}}{s}$$

Phase margin is given by

$$P.M. = 180° + \phi$$

Where,

$$\phi = \angle G(j\omega).H(j\omega)|_{\omega=\omega_{gc}}$$

and

$$|G(j\omega).H(j\omega)|_{\omega=\omega_{gc}} = 1$$

Since,

$$|e^{-j\omega}| = 1$$

So,

$$\frac{k}{\omega} = 1 \ \ at \ \ \omega = \omega_{gc}$$

So,

$$\omega_{gc} = k$$

Now,

$$\phi = \angle G(j\omega)H(j\omega) = -90° - 57.3\omega$$

at

$$\omega_{gc} = k$$

$$\phi = -90° - 57.3\omega$$

$$PM = 180° + \phi = 30°$$

$$\Rightarrow \phi = -150°$$

$$\Rightarrow -90° - 57.3k = -150°$$

$$\Rightarrow k = 1.047$$

Upto two decimal places

$$k = 1.05$$

Hence, the correct answer is (1.05).

Question Number: 56 **Question Type: MCQ**

The transfer function of a system is given by

$$\frac{V_0(s)}{V_i(s)} = \frac{1-s}{1+s}$$

Let the output of the system be $v_0(t) = V_m \sin(\omega t + \phi)$ for the input, $v_i(t) = V_m \sin(\omega t)$. Then the minimum and maximum values of ϕ (in radians) are respectively

(A) $-\frac{\pi}{2}$ and $\frac{\pi}{2}$ (B) $-\frac{\pi}{2}$ and 0

(C) 0 and $\frac{\pi}{2}$ (D) $-\pi$ and 0

Solution:

We know that for transfer function

$$\frac{V_0(s)}{V_i(s)} = \frac{1-s}{1+s}$$

$$\left|\frac{V_0(j\omega)}{V_i(j\omega)}\right| = 1$$

$$\angle\frac{V_0(j\omega)}{V_i(j\omega)} = -2\tan^{-1}\omega$$

Here,

$$v_i(t) = V_m \sin(\omega t)$$

$$v_0(t) = V_m \sin(\omega t + \phi)$$

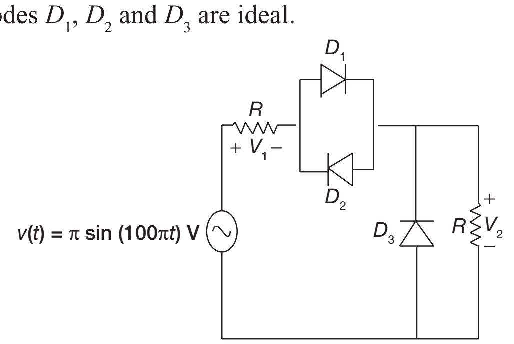
So, for $\omega = 0 \ \ to \ \ \omega = \infty$

$-2\tan^{-1}\omega$ varies from –180° to 0°

Hence, the correct option is (D).

Question Number: 57 **Question Type: MCQ**

For the circuit shown in the figure below, assume that diodes D_1, D_2 and D_3 are ideal.



The DC components of voltages v_1 and v_2, respectively are

(A) 0 V and 1 V (B) –0.5 V and 0.5 V

(C) 1 V and 0.5 V (D) 1 V and 1V

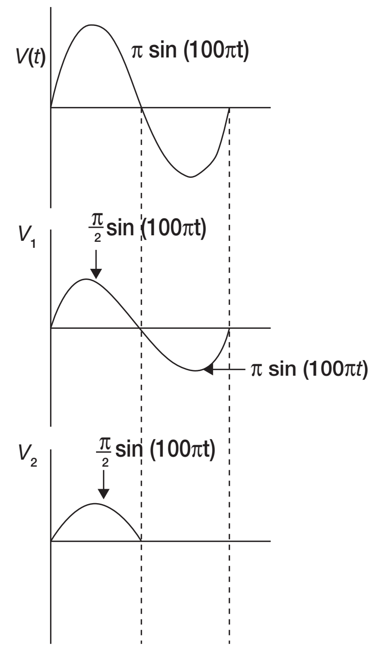
Solution:

During positive half cycle

Diode D_1 is ON but diodes D_2 and D_3 will be OFF

During negative half cycle

Diodes D_2 and D_3 are ON but diode D_1 is OFF



$$V_{1(\text{avg})} = \frac{1}{2\pi}\left[\int_0^{\pi}\frac{\pi}{2}\sin(100\pi t)d(\omega t) + \int_{\pi}^{2\pi}\pi\sin(100\pi t)d(\omega t)\right]$$

$$= \frac{1}{2\pi}[\pi - 2\pi] = -\frac{1}{2} = -0.5 \text{ V}$$

$$V_{2(\text{avg})} = \frac{1}{2\pi}\left[\int_0^{\pi}\frac{\pi}{2}\sin(100\pi t)d(\omega t)\right]$$

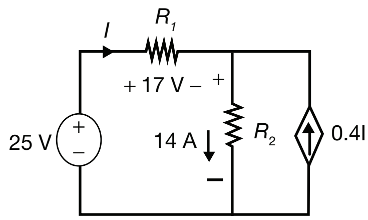
$$= \frac{1}{2\pi}\left[\frac{\pi}{2}(-\cos\pi + \cos 0)\right]$$

$$= \frac{1}{2} = 0.5$$

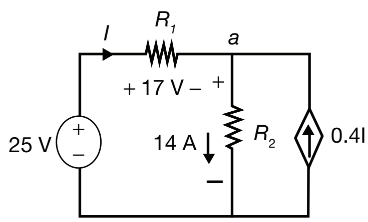
Hence, the correct option is (B).

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

The power supplied by the 25 V source in the figure shown below is _____W



Solution:



Using Kirchoffs current law at node "a" we get

$$I + 0.4I = 14$$

$$\Rightarrow \quad I = 10 \text{ A}$$

Power supplied by 25 V source will be

$$P = 25 \text{ V} \times 10 \text{ A}$$

$$\boxed{P = 250 \text{ watt}}$$

Hence, the correct answer is (250).

Question Number: 59 **Question Type: NAT**

A three-phase, 50 Hz, star-connected cylindrical-rotor synchronous machine is running as a motor. The machine is operated from a 6.6 kV grid and draws current at unity power factor (UPF). The synchronous reactance of the motor is 30 Ω per phase. The load angle is 30°. The power deliver to the motor in kW is _____. (Give the answer up to one decimal place).

Solution:

Given

$$V = 6.6 \text{ kV}$$

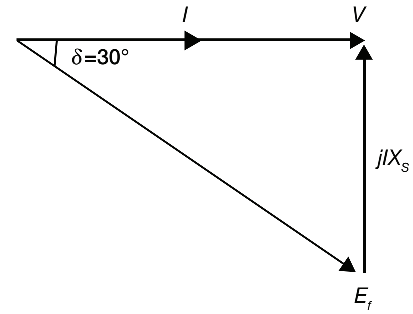
$$\delta = 30°$$

$$P.f. = 1(UPF)$$

Synchronous reactance is $(X_s) = 30\ \Omega$

$$P = \frac{VE_f}{X_s}\sin\delta$$

For unity $P.f.$ for synchronous motor.



From above phasor diagram,

$$E_f \cos\delta = V$$

or,

$$E_f = \frac{V}{\cos\delta} = \frac{6.6 \text{ kV}}{\cos 30°} = 7.62 \text{ kV}$$

Hence,

$$P = \frac{7.62 \times 6.6}{30}\sin 30° \text{ MW} = 0.8383 \text{ MW}$$

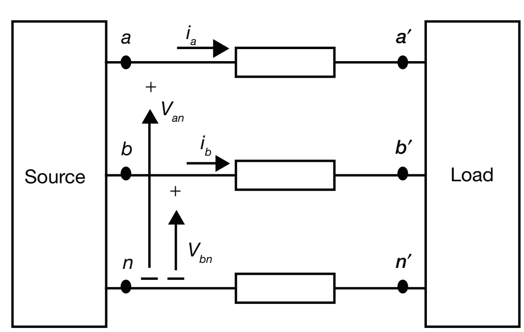
or,

$$\boxed{P = 838.3 \text{ kW}}$$

Hence, the correct answer is (838.3 kW).

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

A source is supplying a load through a 2-phase, 3-wire transmission system as shown in figure below. The instantaneous voltage and current in phase-a are v_{an} = 220sin(100πt)V and i_a = 10sin(100πt)A , respectively. Similarly for phase-b, the instantaneous voltage and current are V_{bn} = 220cos(100πt)V and i_b = 10cos(100πt)A



The total instantaneous power flowing from the source to the load is

(A) 2200 W
(B) 2200 $\sin^2(100\pi t)$W
(C) 4400 W
(D) 2200 $\sin(100\pi t)\cos(100\pi t)$W

Solution:

We know that Instantaneous power is given by relation

$$P = v \cdot i$$
$$P = v_{an} \cdot i_a + v_{bn} \cdot i_b$$
$$= 220\sin(100\pi t)\cdot 10\sin(100\pi t) + 220\cos(100\pi t)\cdot 10\cos(100\pi t)$$
$$= 2200\sin^2(100\pi t) + 2200\cos^2(100\pi t)$$
$$P = 2200\,W$$

Hence, the correct option is (A).

Question Number: 61 Question Type: MCQ

For a complex number z,

$$\lim_{z\to i}\frac{z^2+1}{z^3+2z-i(z^2+2)}$$

(A) $-2i$
(B) $-i$
(C) i
(D) $2i$

Solution:

We know that

$$\lim_{z\to i}\frac{z^2+1}{z^3+2z-i(z^2+2)}$$

The above limit is $\frac{0}{0}$ form, so on differentiating both numerator and denominator, we get

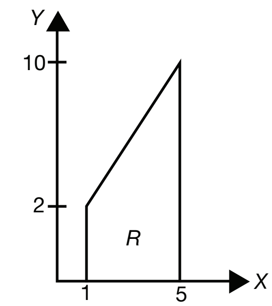
$$\lim_{z\to i}\frac{z^2+1}{3z^2+2-2zi}$$

$$= \frac{2i}{3(i^2)+2-2(i)i} = \frac{2i}{-3+2+2} = 2i$$

Hence, the correct option is (D).

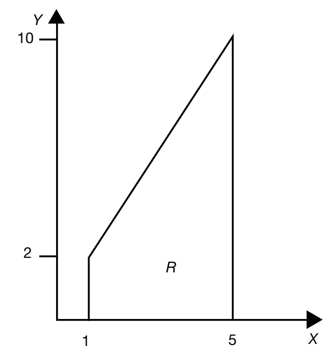
Question Number: 62 Question Type: NAT

Let $I = c\iint_R xy^2\,dxdy$, where R is the region shown in the figure and $c = 6\times10^{-4}$. The value of I equals ______. (Give the answer up to two decimal places).



Solution:

$$I = c\iint_R xy^2\,dx\,dy$$



Region R is bounded by $y = 0$ and $y = 2x$

$$I = c\left[\int_1^5\int_0^{2x} xy^2\,dy\,dx\right]$$
$$= c\left[\int_1^5\left(\frac{xy^3}{3}\right)\Bigg|_0^{2x} dx\right]$$
$$= c\left[\int_1^5 \frac{8}{3}x^4\,dx\right]$$
$$= c\left[\frac{8}{15}x^5\Bigg|_1^5\right] = c\left[\frac{8}{15}\left(5^5-1\right)\right]$$
$$= 6\times10^{-4}\times\left[\frac{8}{15}(5^5-1)\right]$$

$\boxed{I = 0.99}$ (upto two decimal places)

Hence, the correct answer is (0.99).

Question Number: 63 Question Type: MCQ

A 4 pole induction machine is working as an induction generator. The generator supply frequency is 60 Hz. The rotor current frequency is 5 Hz. The mechanical speed of the rotor in RPM is

(A) 1350 (B) 1650
(C) 1950 (D) 2250

Solution:

For 4 pole, 60 Hz induction machine synchronous speed;

$$N_s = \frac{120 \times f}{P}$$
$$= \frac{120 \times 60}{4}$$
$$= 1800 \text{ r.p.m.}$$
$$s = \frac{f_r}{f_s}$$
$$= \frac{5}{60}$$

For induction generator slip is negative,

So,

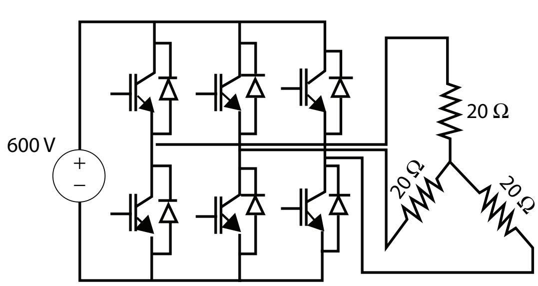
$$\frac{N_s - N_r}{N_s} = -\frac{5}{60}$$
$$\Rightarrow \quad \frac{1800 - N_r}{1800} = \frac{-5}{60}$$
$$\Rightarrow \quad 1800 - N_r = \frac{-5}{60} \times 1800$$
$$\Rightarrow \quad N_r = 1800 + \frac{5}{60} \times 1800$$

$\boxed{N_r = 1950 \text{ r.p.m.}}$

Hence, the correct option is (C).

Question Number: 64 **Question Type: NAT**

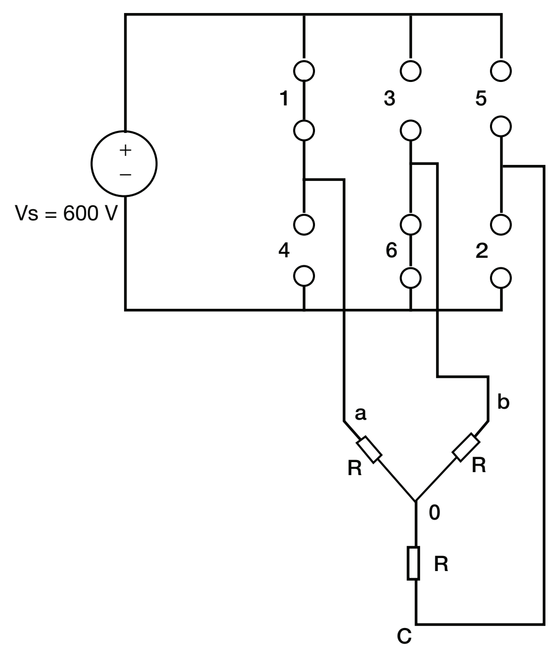
A 3-phase voltage source inverter is supplied from a 600 V DC source as shown in the figure below. For a star connected resistive load of 20 Ω per phase, the load power for 120° device conduction, in kW, is _____

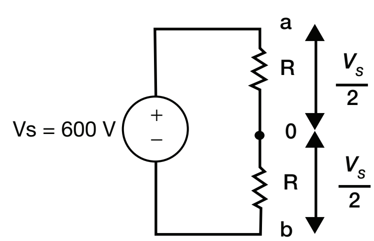


Solution:

In 120° device canduction mode and star connected load:

At any instant only 2 IGBTs will conduct so, when IGBT 1 and 6 are conducting in 0–60° cycle, equivalent ckt can be given as





So power,

$$P = \frac{\left(\frac{V_s}{2}\right)^2}{R} \times 2$$
$$= \frac{V_s^2}{2R}$$
$$P = \frac{(600)^2}{2 \times 20}$$
$$= 9000 \text{ watt}$$

or, $= 9 \text{ kW}$

Hence, the correct answer is (9 wK).

Question Number: 65 **Question Type: MCQ**

A solid iron cylinder is placed in a region containing a uniform magnetic field such that the cylinder axis is parallel to the magnetic field direction. The magnetic field lines inside the cylinder will

(A) Bend closer to the cylinder axis
(B) Bend farther away from the axis
(C) Remain uniform as before
(D) Cease to exist inside the cycliner

Solution:

The magnetic field lines will bend closer to the cylinder axis to find a minimum reluctance path.

Hence, the correct option is (A).