GATE 2016 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**

The chairman requested the aggrieved shareholders to _______ him.

(A) bare with (B) bore with
(C) bear with (D) bare

Solution: To bear with someone or something is to be patient with somebody or something.

Hence, the correct option is (C).

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

Identify the correct spelling out of the given options:

(A) Managable (B) Manageable
(C) Mangaeble (D) Managible

Solution:

Hence, the correct option is (B).

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

Pick the odd one out in the following:

13, 23, 33, 43, 53

(A) 23 (B) 33
(C) 43 (D) 53

Solution: We know that except 33, rest are all prime numbers.

Hence, the correct option is (B).

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

R2D2 is a robot, R2D2 can repair aeroplanes. No other robot can repair aeroplanes.

(A) R2D2 is a robot which can only repair aeroplanes
(B) R2D2 is the only robot which can repair aeroplane
(C) R2D2 is a robot which can repair only aeroplane
(D) Only R2D2 is a robot

Solution: As per option (A), R2D2 cannot do anything to an aeroplane apart from repairing. This is not in the scope of the given statements.

As per option (C), R2D2 cannot repair any other thing except aeroplanes. This is also not in the scope of the given statements.

Option (D) contradicts the given statements.

From the given statements it is clear that R2D2 is the only which can repair aeroplanes. Hence, option (B) can be inferred.

Hence, the correct option is (B).

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

If $|9y - 6| = 3$, then $y^2 - 4y/3$ is ______.

(A) 0 (B) +1/3
(C) –1/3 (D) undefined

Solution: We are given that

$$|9y - 6| = 3$$

$$9y - 6 = -3 \Rightarrow y = \frac{1}{3}$$

$$9y - 6 = 3 \Rightarrow y = 1$$

$$\therefore \quad y^2 - \frac{4y}{3} = \frac{1}{9} - \frac{4}{9} = \frac{-1}{3} \text{ or } 1 - \frac{4}{3} = \frac{-1}{3}$$

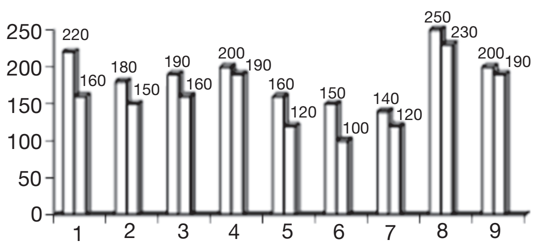
$\therefore$ In either case,

$$y^2 - \frac{4y}{3} = \frac{-1}{3}$$

Hence, the correct option is (C).

Question Number: 6 **Question Type: NAT**

The following graph represents the installed capacity for cement production (in tonnes) and the actual production (in tonnes) of nine cement plants of a cement company. Capacity utilization of a plant is defined as ratio of actual production of cement to installed capacity. A plant with installed capacity of at least 200 tonnes is called a large plant and a plant with lesser capacity is called a small plant. The difference between total production of large plants and small plants in tonnes is ______



Solution: As we know that plants 1, 4, 8, 9 are large while 2, 3, 5, 6, 7 are small.

The total production of the large plants is

$$160 + 190 + 230 + 190 = 770$$

The total production of the small plants is

$150 + 160 + 120 + 100 + 120 = 650$

The difference is $770 - 650 = 120$ tonnes.

Hence, the correct Answer is (120).

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

A poll of students appearing for masters in engineering indicated that 60% of the students believed that mechanical engineering is a profession unsuitable for women. A research study on women with masters or higher degrees in mechanical engineering found that 99% of such women were successful in their professions.

Which of the following can be logically inferred from the above paragraph?

(A) Many students have misconceptions regarding various engineering disciplines

(B) Men with advanced degrees in mechanical engineering believe women are well suited to be mechanical engineers

(C) Mechanical engineering is a profession well suited for women with masters or higher degrees in mechanical engineering

(D) The number of women pursuing higher degrees in mechanical engineering is small

Solution: Option (A) cannot be inferred because the given passage brings out the opinion of students with respect to mechanical engineering only.

Option (B) cannot be inferred because the statement does not make a specific reference to the opinions of men with advanced degrees in mechanical engineering.

Option (C) can be inferred because the research result indicates that nearly all the women with masters or higher degrees in mechanical engineering were successful.

Option (D) cannot be inferred because the passage does not provide any information about the number of women pursuing higher degrees in mechanical engineering.

Hence, the correct option is (C).

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

Sourya committee had proposed the establishment of Sourya Institutes of Technology (SITs) in line with Indian Institutes of Technology (IITs) to cater to the technological and industrial needs of a developing country.

Which of the following can be logically inferred form the above sentence?

Based on the proposal,

(i) In the initial years, SIT students will get degrees from IIT

(ii) SITs will have a distinct national objective

(iii) SIT like institutions can only be established in consolation with IIT

(iv) SITs will serve technological needs of a developing country.

(A) (iii) and (iv) only (B) (i) and (iv) only

(C) (ii) and (iv) only (D) (ii) and (iii) only

Solution: Neither (i) nor (iii) is in the scope of the passage.

Since, SITs are being established with a specific purpose, (iii) can be inferred.

(iv) is a direct extract of the given passage. Hence, only (ii) and (iv) can be inferred.

Hence, the correct option is (C).

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

Shaquille O' Neal is a 60% career free throw shooter, meaning that he successfully makes 60 free throws out of 100 attempts on average. What is the probability that he will successfully make exactly 6 free throws in 10 attempts?

(A) 0.2508 (B) 0.2816
(C) 0.2934 (D) 0.6000

Solution: The probability of exactly 6 successful throws is

$$^{10}C_6\,(0.4)^4\,(0.6)^6$$

$$= \frac{10(9)(8)(7)}{2(3)(4)}\,\frac{256}{10^4}\,\frac{46656}{10^6} = 210$$

(0.0256) (0.046656)

$$= 0.2508$$

Hence, the correct option is (A).

Question Number: 10 **Question Type: NAT**

The numeral in the units position of $211^{870} + 146^{127} \times 3^{424}$ is ______.

Solution: The units digit of the given expression is

$$1 + (6)(1) = 7$$

Hence, the correct Answer is (7).

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**

The output expression for the Karnaugh map shown below is:

A \ BC	00	01	11	10
0	1	0	0	1
1	1	1	1	1

(A) $A + \bar{B}$ (B) $A + \bar{C}$
(C) $\bar{A} + \bar{C}$ (D) $\bar{A} + C$

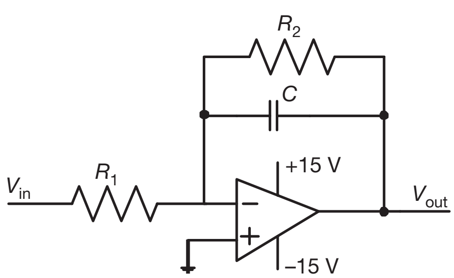
Solution: The output expression for the Karnaugh map given is

$$f = A + \bar{C}$$

Hence, the correct option is (B).

Question Number: 12 **Question Type: MCQ**

The circuit shown below is an example of a:



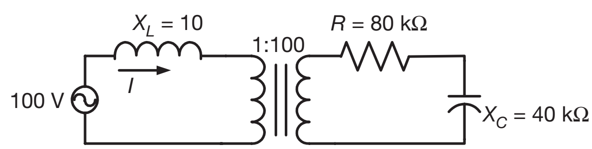
(A) low pass filter (B) band pass filter
(C) high pass filter (D) notch filter

Solution: The circuit given in question is a practical integrator therefore it will act like a low pass filter.

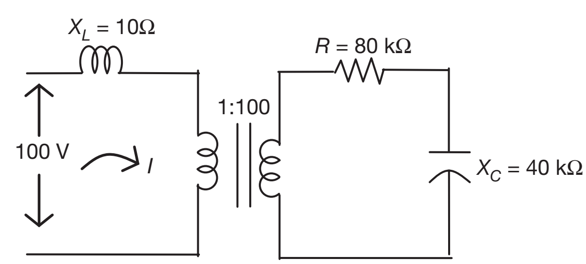
Hence, the correct option is (A).

Question Number: 13 **Question Type: NAT**

The following figure shows the connection of an ideal transformer with primary to secondary turns ratio of 1 : 100. The applied primary voltage is 100 V (rms), 50 Hz, AC. The rms value of the current *I*, in ampere, is ________.



Solution:



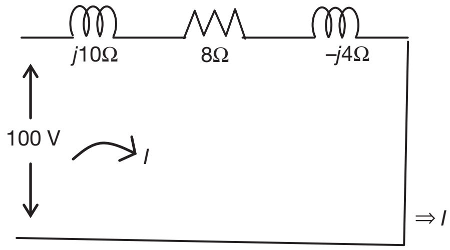
On transferring the secondary parameters to primary side.

$$R_1 = R\left(\frac{V_1}{V_2}\right)^2$$

$$= (80\text{ K})\left(\frac{100}{100\times 100}\right)^2 = \frac{80\times 1000}{100\times 100}$$

$$= 8\Omega$$

$$X_C^1 = 40\text{ K}\left(\frac{1}{100}\right)^2 = 4\Omega$$



$$\bar{I} = \frac{100}{8 + j(10-4)}$$

$$|I| = \frac{100}{10} = 10\text{ A}$$

Hence, the correct Answer is (10).

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

Consider a causal LTI system characterized by differential equation $\frac{dy(t)}{dt} + \frac{1}{6}y(t) = 3x(t)$. The response of the system to the input $x(t)\ 3e^{-\frac{t}{3}}u(t)$, where $u(t)$ denotes the unit step function, is ________.

(A) $9e^{-\frac{t}{3}}u(t)$

(B) $9e^{-\frac{t}{6}}u(t)$

(C) $9e^{-\frac{t}{3}}u(t) - 6e^{-\frac{t}{6}}u(t)$

(D) $54e^{-\frac{t}{6}}u(t) - 54e^{-\frac{t}{3}}u(t)$

Solution: Taking Laplace on both sides

$$\left[s + \frac{1}{6}\right]Y(s) = 3X(s)$$

$$\frac{Y(s)}{X(s)} = \frac{3}{s + \frac{1}{6}}$$

$$Y(s) = \left(\frac{3}{s + \frac{1}{6}}\right)\left(\frac{3}{s + \frac{1}{3}}\right)$$

$$Y(s) = \left[\frac{54}{s + \frac{1}{6}} - \frac{54}{s + \frac{1}{3}}\right]$$

$$Y(t) = 54e^{-t/6}\,u(t) - 54e^{-t/3}\,u(t)$$

Hence, the correct option is (D).

Question Number: 15 **Question Type: NAT**

Suppose the maximum frequency in a band-limited signal $x(t)$ is 5 kHz. Then, the maximum frequency in $x(t)\cos(2000\pi t)$, in kHz, is ________.

Solution: The highest frequency component of

$$x(t) \rightarrow f = 5\text{ kHz }\{x(t)\cos(2\pi \times 1000t)\}$$

$$= \frac{1}{2}\left[x(f-1000) + x(f+1000)\right]$$

∴ The maximum frequency in the product signal is,

$$f + 100 = 5000 + 1000 = 6\text{ kHz}$$

Hence, the correct Answer is (6).

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

Consider the function $f(z) = z + z^*$ where z is a complex variable and z^* denotes its complex conjugate. Which one of the following is TRUE?

(A) $f(z)$ is both continuous and analytic
(B) $f(z)$ is continuous but not analytic
(C) $f(z)$ is not continuous but is analytic
(D) $f(z)$ is neither continuous nor analytic

Solution: Given

$$f(z) = z + z^*$$

Let $z = x + iy$

⇒ $z^* = x - iy$

∴ $f(z) = z + z^*$

$= (x + iy) + (x - iy)$

⇒ $f(z) = 2x$

Clearly $f(z)$ is continuous

Let $f(z) = 2x + i0 = u + iv$

∴ $u = 2x;\ v = 0$

$$\frac{\partial u}{\partial x} = 2;\ \frac{\partial u}{\partial y} = 0;\ \frac{\partial v}{\partial x} = 0 \text{ and } \frac{\partial u}{\partial x} = 2$$

$$\frac{\partial u}{\partial x} = 2 \neq \frac{\partial v}{\partial y}(= 0)$$

∴ The real and imaginary parts of $f(z)$ fails to satisfy the Cauchy–Riemann equations.

Hence $f(z)$ is not analytic.

Hence, the correct option is (B).

Question Number: 17 Question Type: MCQ

A 3×3 matrix P is such that, $P^3 = P$. Then the eigenvalues of P are:

(A) 1, 1, –1
(B) 1, $0.5 + j0.866$, $0.5 - j0.866$
(C) 1, $-0.5 + j0.866$, -0.5, $-j0.866$
(D) 0, 1, –1

Solution: Given that P is a 3×3 matrix such that

$$P^3 = P.$$

Let λ be an eigenvalue of P.

As P is a 3×3 matrix and

$$P^3 = P$$

We have

$$\Rightarrow \quad \lambda^3 - \lambda = 0$$

$$\Rightarrow \quad \lambda(\lambda^2 - 1) = 0$$

$$\Rightarrow \lambda = 0; \quad \lambda^2 - 1 = 0$$

$$\Rightarrow \lambda = 0; \quad \lambda = \pm 1$$

$\therefore$ The eigenvalues of P are 0, 1 and –1.

Hence, the correct option is (D).

Question Number: 18 Question Type: MCQ

The solution of the differential equation, for $t > 0$, $y''(t)\ 2y'(t) + y(t) = 0$ with initial conditions $y(0) = 0$ and $y'(0) = 1$, is ($u(t)$ denotes the unit step function),

(A) $te^{-t}u(t)$
(B) $(e^{-t} - te^{-t})\,u(t)$
(C) $(-e^{-t} + te^{-t})\,u(t)$
(D) $e^{-t}u(t)$

Solution: Given differential equations is

$$y'' + 2y' + y = 0 \quad (1)$$

with the initial conditions

$$y(0) = 0 \text{ and } y'(0) = 1 \quad (2)$$

Applying Laplace transform on both sides of Equation (1),

We have

$$L[y''] + 2L[y'] + L[y] = 0$$

$$\Rightarrow s^2\bar{y} - sy(0) - y'(0) + 2\left(s\bar{y} - y(0)\right) + \bar{y} = 0$$

where $\bar{y} = L[y]$

$$\Rightarrow s^2\bar{y} - s \times 0 - 1 + 2s\bar{y} - 2 \times 0 + \bar{y} = 0 \quad \text{[from Equation (2)]}$$

$$\Rightarrow \quad (s^2 + 2s + 1)\,\bar{y} = 1$$

$$\Rightarrow \quad \bar{y} = \frac{1}{(s^2 + 2s + 1)} = \frac{1}{(s+1)^2}$$

Applying the inverse Laplace transform on both sides,

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

$$\Rightarrow \quad y = L^{-1}\left[\frac{1}{\left(s-(-1)\right)^2}\right]$$

$$= te^{-t} = te^{-t}u(t)$$

$\therefore$ The solution of the given differential equation is

$$y = te^{-t}u(t)$$

Hence, the correct option is (A).

Question Number: 19 Question Type: MCQ

The value of the line integral

$$\int_c (2xy^2dx + 2x^2ydy + dz)$$

along a path joining the origin (0, 0, 0) and the point (1, 1, 1) is:

(A) 0 (B) 2
(C) 4 (D) 6

Solution: We have to evaluate the line integral

$$\int_c (2xy^2dx + 2x^2ydy + dz)$$

along a path joining the origin (0, 0, 0) and the point (1, 1, 1).

Equation of the line joining (0, 0, 0) and (1, 1, 1) is

$$\frac{x-0}{1-0} = \frac{y-0}{1-0} = \frac{z-0}{1-0} = t, \quad \text{(say)}$$

$$\Rightarrow \quad x = y = z = t$$

$$\Rightarrow \quad x = t, y = t$$

and $\quad z = t$

$$\Rightarrow \quad dx = dt, dy = dt \text{ and } dz = dt$$

and t varies from $t = 0$ to $t = 1$

$$\int_c [2xy^2dx + 2x^2ydy + dz]$$

$$= \int_{t=0}^{1} [2(t)(t^2)\,dt + 2(t^2)(t)\,dt + dt]$$

$$= \int_{t=0}^{1} [4t^3 + 1]\,dt$$

$$= t^4 + t\Big]_{t=0}^{1}$$

Hence, the correct option is (B).

Question Number: 20 Question Type: MCQ

Let $f(x)$ be a real, periodic function satisfying $f(-x) = -f(x)$. The general from of its Fourier series representation would be

(A) $f(x) = a_0 \sum_{k=1}^{\infty} a_k \cos(kx)$

(B) $f(x) = \sum_{k=1}^{\infty} b_k \sin(kx)$

(C) $f(x) = a_0 + \sum_{k=1}^{\infty} a_{2k} \cos(kx)$

(D) $f(x) = \sum_{k=0+1}^{\infty} a_{2k+1} \sin(2k+1)x$

Solution: Given

$$f(-x) = -f(x)$$

$\sum_{k=1}^{\infty} a_{2k+1} \sin(2k+1)$ is an odd function.

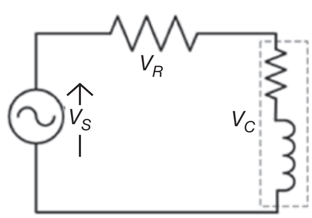
∴ The Fourier series expansion of $f(x)$ consists of only sine terms.

i.e., $f(x) = \sum_{k=1}^{\infty} b_k \sin(kx)$

Hence, the correct option is (B).

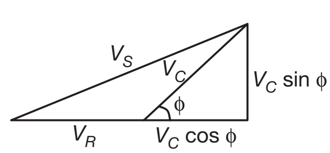
Question Number: 21 Question Type: MCQ

A resistance and a coil are connected in series and supplied form a single phase, 100 V, 50 Hz ac source as shown in the figure below. The rms values of possible voltages across the resistance (V_R) and coil (V_C) respectively, in volts, are:



(A) 65, 35 (B) 50, 50
(C) 60, 90 (D) 60, 80

Solution: Consider the figure given below:



From the above figure, we get

$$V_s^2 = (V_R + V_C \cos\phi)^2 + (V_C \sin\phi)^2$$

$$V_s^2 = V_R^2 + V_C^2 + 2V_R V_C \cos\phi$$

$$\cos\phi = \frac{V_S^2 - V_R^2 - V_C^2}{2V_R V_C}$$

From the given options, option (D) gives $\phi = 90°$.

Hence, the correct option is (D).

Question Number: 22 Question Type: NAT

The voltage (V) and current (A) across a load are as follows.

$$v(t) = 100 \sin(\omega t),$$

$$I(t) = 10 \sin(\omega t - 60°) + 2 \sin(3\omega t) + 5 \sin(5\omega t)$$

The average power consumed by the load, in W is ________.

Solution:

$$V_{rms} = \frac{1000}{\sqrt{2}}$$

$$I_{rms} = \frac{10}{\sqrt{2}}$$

$$\phi = 60$$

Average power consumed

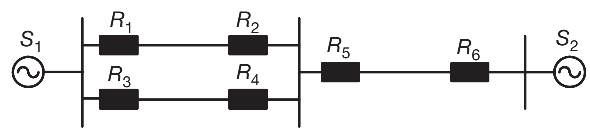
$$P = V_{rms} \cdot I_{rms} \cdot \cos\phi$$

$$= \frac{1000}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \cos 60° = 250 \text{ Watts}$$

Hence, the correct Answer is (250).

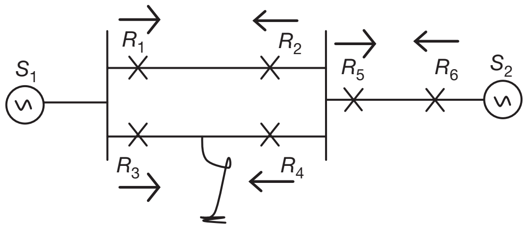
Question Number: 23 Question Type: MCQ

A power system with two generators is shown in the figure below. The system (generators, buses and transmission lines) is protected by six over current relays R_1 to R_6. Assuming a mix of directional and non-directional relays at appropriate locations, the remote backup relays for R_4 are:



(A) R_1, R_2
(B) R_2, R_6
(C) R_2, R_5
(D) R_1, R_6

Solution: Consider the figure given below:



If a fault was taken place b/w (3) and (4) R_3 and R_4 must operate. If R_4 is failed to operate, then to limit $I_1 \rightarrow R_1$ must operate and to limit $I_2 \rightarrow R_6$ must operate.

Hence, the correct option is (D).

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

A power system has 100 buses including 10 generator buses, for the load flow analysis using Newton–Raphson, method in polar coordinates, the size of the Jacobian is:

(A) 189×189 (B) 100×100
(C) 90×90 (D) 180×180

Solution: Load buses

$= 100 - 10 = 90 \rightarrow (m)$

Gen buses $= 10 \rightarrow n$

Size of Jacobian matrix will be

$$= [2m + (n - 1)]\,[2m - (n - 1)]$$
$$= [2 \times 90 + (10 - 1)]\,[2 \times 90 + (10 - 1)]$$
$$= 189 \times 189$$

Hence, the correct option is (A).

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

The inductance and capacitance of a 400 kV, three-phases 50 Hz lossless transmission line are 1.6 mH/km/phase and 10 nF/km/phase respectively. The sending end voltage is maintained at 400 kV. To maintain a voltage of 400 kV at the receiving end, when the line is delivering 300 mW load, the shunt compensation required is:

(A) capacitive (B) inductive
(C) resistive (D) zero

Solution:

$$\text{Surge impedance } (Z_S) = \sqrt{\frac{L}{C}}$$

$$= \sqrt{\frac{1.6 \times 10^{-3}}{10 \times 10^{-9}}} = 400\Omega$$

$$\text{Load impedance } (Z_L) = \frac{(400 \times 10^3)^2}{300 \times 10^6}$$

$$= 533.33\Omega$$

The receiving end voltage will rise more than sending end voltage because the load impedance is more than surge impedance,

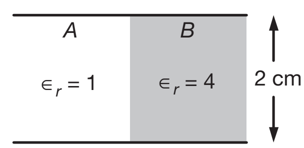
$\therefore \quad V_R V_S \Rightarrow V_R > 400$ kV

An inductive compensation is needed to reduce the voltage to 400 kV.

Hence, the correct option is (B).

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

A parallel plate capacitor filled with two dielectrics is shown in the figure below. If the electric field in the region *A* is 4 kV/cm, the electric field in the region *B*, in kV/cm, is ____.



(A) 1 (B) 2
(C) 4 (D) 16

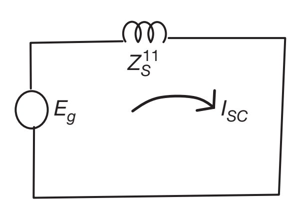
Solution: For parallel plate capacitor electric field is same for region *A* and region *B*, therefore the electric field in the region *B*, is 4 kV/cm.

Hence, the correct option is (C).

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

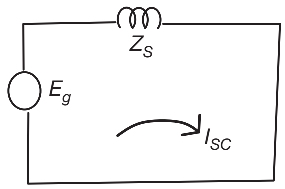
A 50 mVA, 10 kV, 50 Hz, star-connected, unloaded three-phase alternator has a synchronous reactance of 1 p.u and a sub-transient reactance of 0.2 p.u. If a 3-phase short circuit occurs close to the generator terminals, the ratio of initial and final values of the sinusoidal component of the short circuit current is ________.

Solution: Immediately after the short ckt (During-transient period)



$$\Rightarrow \quad I_{SC} = \frac{1.0}{1.0} = 1 \text{ p.u.}$$

At steady state



$$\Rightarrow \quad I_{SC} = \frac{1.0}{1.0} = 1 \text{ p.u.}$$

$$\frac{\text{Initial}}{\text{Final}} = \frac{5}{1.0} = 5$$

Hence, the correct Answer is (5).

Question Number: 28 **Question Type: NAT**

Consider a linear time-invariant system with transfer function

$$H(S) = \frac{1}{(S+1)}$$

If the input is cos (t) and the steady state output is A cos ($t + \alpha$), then the value of A is _________.

Solution: The given transfer function is

$$H(S) = \frac{1}{(S+1)}$$

Now we have

$$A = |H(s)| = \frac{1}{s+1} = \frac{1}{\sqrt{\omega^2 + 1}} = \frac{1}{\sqrt{2}}$$

$$\alpha = -\tan^{-1}(\omega) = -\tan^{-1}(1) = -45°$$

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

Hence, the correct Answer is (0.707).

Question Number: 29 **Question Type: NAT**

A three-phase diode bridge rectifier is feeding a constant DC current of 100 A to a highly inductive load. If three-phase, 415 V, 50 Hz AC source is supplying to this bridge rectifier then the rms value of the current in each diode, in ampere, is ________.

Solution: Diode current rms can be calculated using relation,

$$[I_D]_{\text{rms}} = \frac{I_S}{\sqrt{2}} = \frac{I_0\sqrt{\frac{2}{3}}}{\sqrt{2}}$$

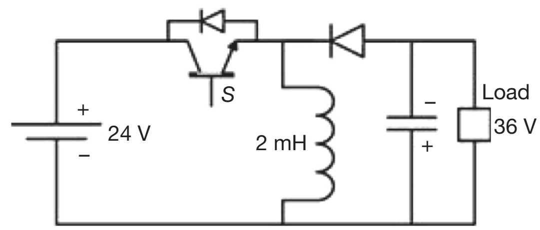
$$= \frac{I_0}{\sqrt{3}}$$

$$= \frac{100}{\sqrt{3}} = 57.735 \text{ A}$$

Hence, the correct Answer is (57.735).

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

A buck-boost DC–DC converter, shown in the figure below, is used to convert 24 V battery voltage to 36 V DC voltage to feed a load of 72 W. it is operated at 20 kHz with an inductor of 2 mH and output capacitor of 1000 μF. All devices are considered to be ideal. The peak voltage across the solid-state switch (S), in volt is _______.



Solution: Load power,

$$P_0 = 72 \text{ W}$$

$$P_0 = V_0 I_0$$

$$V_0 I_0 = 72 \text{ W}$$

$$I_0 = \frac{72}{36} = 2 \text{ A}$$

$$V_0 = \frac{D}{1-D} \times V_{\text{dc}}$$

$$\Rightarrow \quad 36 = \frac{D}{1-D} \times 24$$

Ripple voltage, can be calculates using

$$\Delta V = \frac{I_0}{C} \cdot T_{\text{ON}}$$

$$\Delta v = \frac{I_0 D}{Cf} = \frac{2 \times 0.6}{10^{-3} \times (20 \times 10^3)} = 0.06 \text{ V}$$

The peak voltage will be

$$V_{\text{peak}} = (V_o)_{\text{avg}} + \frac{\Delta V}{2} = 36 + \frac{0.06}{2} = 36.03 \text{ V}$$

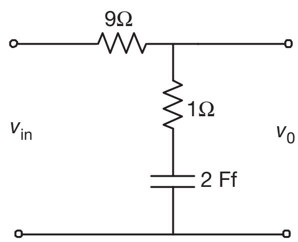
Peak voltage across switch

$$(V_S)_{\text{peak}} = 24 + 36.03 \text{ V} = 60.03 \text{ V}$$

Hence, the correct Answer is (60.03).

Question Number: 31 Question Type: NAT

For the network shown in the figure below, the frequency (in rad/s) at which the maximum phase lag occurs, is ________.



Solution:

$$\frac{V_0(s)}{V_{in}(s)} = \frac{\left[1+\frac{1}{s}\right]}{10+\frac{1}{s}} = \left[\frac{s+1}{10s+1}\right]$$

$$T = 1$$

$$aT = 10 \qquad a = 10$$

$$\omega = \frac{1}{T\sqrt{a}}\, w = \frac{1}{\sqrt{10}}$$

$$= 0.316 \text{ rad/sec}$$

Hence, the correct Answer is (0.316).

Question Number: 32 Question Type: MCQ

The direction of rotation of a single-phase capacitor run induction motor is reversed by:

(A) interchanging the terminals of the AC supply
(B) interchanging the terminals of the capacitor
(C) interchanging the terminals of the auxiliary winding
(D) interchanging the terminals of both the windings.

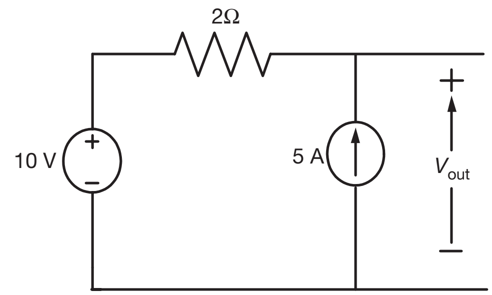
Solution: By interchanging the terminals of auxiliary winding rotating magnetic field directions can be changed

Hence, the correct option is (C).

Question Number: 33 Question Type: MCQ

In the circuit shown on next column, the voltage and current sources are ideal. The voltage (V_{out}) across the current source, in volts, is ____.

(A) 0
(B) 5
(C) 10
(D) 20



Solution: From the figure given above, we get

$$V_{out} = 5[2] + 10 = 20 \text{ V}$$

Hence, the correct option is (D).

Question Number: 34 Question Type: MCQ

The graph associated with an electrical network has 7 branches and 5 nodes. The number of independent KCL equations and the number of independent KVL equations, respectively, are:

(A) 2 and 5 (B) 5 and 2
(C) 3 and 4 (D) 4 and 3

Solution: The number of independent KVL equation

$$= b - n + 1$$
$$= 7 - 5 + 1 = 3$$

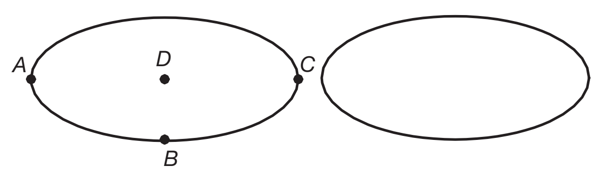
The number of independent KCL equation

$$= (n - 1) = 5 - 1 = 4$$

Hence, the correct option is (D).

Question Number: 35 Question Type: MCQ

Two electrodes, whose cross-sectional view is shown in the figure below, are at the same potential. The maximum electric field will be at the point:



(A) A (B) B
(C) C (D) D

Solution:

Hence, the correct option is (A).

Question Number: 36 Question Type: MCQ

The Boolean expression $\overline{(a+\overline{b}+c+\overline{d})+(b+\overline{c})}$ simplifies to:

(A) 1 (B) $\overline{a \cdot b}$
(C) $a \cdot b$ (D) 0

Solution:

$$f = \overline{(a+\bar{b}+c\bar{d})+(b+\bar{c})}$$

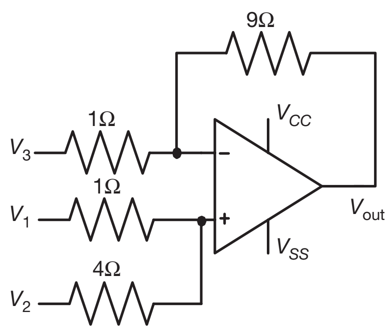
$$f = \overline{(a+\bar{b}+c+\bar{d})}\cdot\overline{(b+\bar{c})}$$

$$f = (\bar{a}\cdot b\cdot\bar{c}\cdot d)(\bar{b}\cdot c) = 0$$

Hence, the correct option is (D).

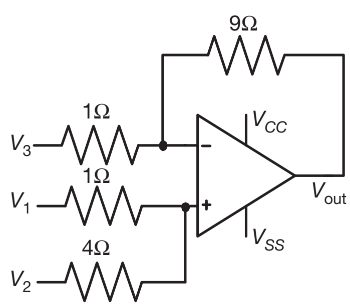
Question Number: 37 **Question Type: MCQ**

For the circuit shown below, taking the opamp as ideal, the output voltage V_{out} in terms of the input voltages V_1, V_2, and V_3 is ______.



(A) $1.8V_1 + 7.2V_2 - V_3$ (B) $2V_1 + 8V_2 - 9V_3$
(C) $7.2V_1 + 1.8V_2 - V_3$ (D) $8V_1 + 2V_2 - 9V_3$

Solution:



By applying virtual GND concept, we get

$$\frac{V_x - V_1}{1} + \frac{V_x - V_2}{4} = 0$$

$$5V_x = 4V_1 + V_2 \qquad (1)$$

$$\frac{V_x - V_3}{1} + \frac{V_x - V_{out}}{9} = 0$$

$$10V_x = 9V_3 + V_{out} \qquad (2)$$

Solving Equations (1) and (2), we have

$$8V_1 + 2V_2 = 9V_3 + V_{out}$$

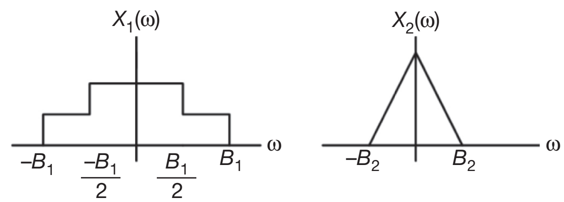
$$V_{out} = 8V_1 + 2V_2 - 9V_3$$

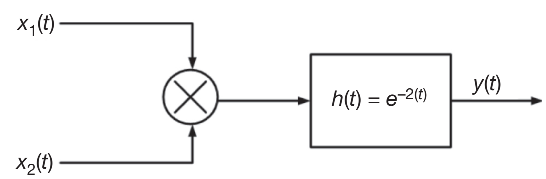
Hence, the correct option is (D).

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

Let $x_1(t) \leftrightarrow X_1(\omega)$ and $x_2(t) \leftrightarrow X_2(\omega)$ be two signals whose Fourier Transforms are as shown in the figure below. In the figure $h(t) = e^{-2|t|}$ denotes the impulse response.

For the system shown below, the minimum sampling rate required to sample $y(t)$, so that $y(t)$ can be uniquely reconstructed form its samples, is





(A) $2B_1$ (B) $2(B_1 + B_2)$
(C) $4(B_1 + B_2)$ (D) ∞

Solution: The product signal $x_1(t)\,x_2(t)$ has the highest frequency component of $B_1 + B_2$.

$\therefore$ As per the Nyquist principle,

$$f_s = 2\,[B_1 + B_2]$$

Hence, the correct option is (*B*).

Question Number: 39 **Question Type: MCQ**

The value of the integral $2\int_{-\infty}^{\infty}\left(\frac{\sin 2\pi t}{\pi t}\right)dt$ is equal to:

(A) 0 (B) 0.5
(C) 1 (D) 2

Solution:

Let
$$I = 2\int_{-\infty}^{\infty}\frac{\sin 2\pi t}{\pi t}\,dt$$

$$= 2\left(2\int_{0}^{\infty}\frac{\sin 2\pi t}{\pi t}\,dt\right)$$

$$\left(\because \frac{\sin 2\pi t}{\pi t} \text{ is an even function}\right)$$

$$\therefore \quad I = \frac{4}{\pi}\int_0^{\infty} \frac{\sin 2\pi t}{t}\, dt \qquad (1)$$

Consider the Laplace transform of $= \dfrac{\sin 2\pi t}{t}$

i.e., $$\left[\frac{\sin 2\pi t}{t}\right] = \int_s^{\infty} L[\sin 2\pi t]\, ds$$

$$\left(\because L\left[\frac{f(t)}{t}\right] = \int_s^{\infty} L[f(t)]\, ds\right)$$

$$= \int_s^{\infty} \frac{2\pi}{s^2 + (2\pi)^2}\, ds$$

$$= \tan^{-1}\left(\frac{s}{2\pi}\right)_s^{\infty}$$

$$= \tan^{-1}\infty - \tan^{-1}\left(\frac{s}{2\pi}\right)$$

$$= \frac{\pi}{2} - \tan^{-1}\left(\frac{s}{2\pi}\right)$$

$$\therefore \quad L\left[\frac{\sin 2\pi t}{t}\right] = \cot^{-1}\left(\frac{s}{2\pi}\right)$$

$$\Rightarrow \int_0^{\infty} e^{-st}\left(\frac{\sin 2\pi t}{t}\right)dt = \cot^{-1}\left(\frac{s}{2\pi}\right)$$

Taking $s = 0$ on both sides,

$$\int_0^{\infty} e^{-oxt}\left(\frac{\sin 2\pi t}{t}\right)dt = \cot^{-1}\left(\frac{0}{2\pi}\right)$$

$$\Rightarrow \int_0^{\infty} \left(\frac{\sin 2\pi t}{t}\right)dt = \cot^{-1}(0)$$

$$\Rightarrow \int_0^{\infty} \left(\frac{\sin 2\pi t}{t}\right)dt = \frac{\pi}{2} \qquad (2)$$

Substituting Equation (2) in (1), we get

$$I = \frac{4}{\pi} \times \frac{\pi}{2}$$

i.e., $$2\int_{-\infty}^{\infty} \frac{\sin 2\pi t}{\pi t}\, dt = 2$$

Hence, the correct option is (D).

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

Let $y(x)$ be the solution of the differential equation $\dfrac{d^2y}{dx^2} - 4\dfrac{dy}{dx} + 4y = 0$ with initial conditions $y(0) = 0$ and $\left.\dfrac{dy}{dx}\right|_{x=0} = 1$. Then the value of $y(1)$ is ________.

Solution: Given differential equation is

$$\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0 \qquad (1)$$

With the initial conditions

$$y(0) = 0 \text{ and } \left.\frac{dy}{dx}\right|_{x=0} = 1 \qquad (2)$$

Applying Laplace transform on both sides of Equation (1),

$$L\left[\frac{d^2y}{dx^2}\right] - 4L\left[\frac{dy}{dx}\right] + 4L[y] = 0$$

$$\Rightarrow s^2\bar{y} - sy(0) - y'(0) - 4(s\bar{y} - y(0)) + 4\bar{y} = 0$$

where $\bar{y} = L[y]$

$$\Rightarrow s^2\bar{y} - s \times 0 - 1 - 4s\bar{y} + 0 + 4\bar{y} = 0$$

$$\Rightarrow (s^2 - 4s + 4)\,\bar{y} = 1$$

$$\Rightarrow \quad \bar{y} = \frac{1}{s^2 - 4s + 4} = \frac{1}{(s-2)^2}$$

Applying inverse Laplace transform on both sides

$$L^{-1}[\bar{y}] = L^{-1}\left[\frac{1}{(s-2)^2}\right]$$

$$\Rightarrow \quad y = xe^{2x}$$

The solution of Equation (1) is

$$y = xe^{2x}$$

Now $\quad y(1) = y_{\text{at } x=1} = 1 \times e^{2\times 1} = e^2$

$\therefore \quad y(1) = 7.389$

Hence, the correct Answer is (7.389).

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

The line integral of the vector field

$$F = 5xz\hat{i} + (3x^2 + 2y)\,\hat{j} + x^2z\hat{k}$$

along a path from (0, 0, 0) to (1, 1, 1) parameterized by (t, t^2, t) is _________.

Solution: We have to find the line integral of the vector field

$$\bar{F} = 5xzi + (3x^2 + 2y)\bar{j} + x^2 z\bar{k}$$

along a path from (0, 0, 0) to (1, 1, 1) parameterized by (t, t^2, t)

i.e., along the path

$$x = t,\ y = t^2 \text{ and } z = t$$

$\Rightarrow$ $dx = dt,\ dy = 2t\,dt$ and $dz = dt$

and t varies from $t = 0$ to $t = 1$

$\therefore$ The required line integral is

$$\int_{(0,0,0)}^{(1,1,1)} F\cdot d\bar{r} = \int_{(0,0,0)}^{(1,1,1)} (5xz\bar{i} + (3x^2 + 2y)\bar{j} + x^2 z\bar{k})\cdot(dxi + dy\bar{j} + dz\bar{k})$$

$$= \int_{(0,0,0)}^{(1,1,1)} [5xzdx + (3x^2 + 2y)\,dy + x^2 zdz]$$

$$= \int_{t=0}^{1} [5(t)(t)\,dt + (3(t)^2 + 2(t^2))\,2tdt + (t)^2(t)\,dt]$$

$$= \int_{t=0}^{1} [5t^2 + 10t^3 + t^3]\,dt$$

$$= \int_{t=0}^{1} [5t^2 + 11t^3]\,dt$$

$$= \frac{5}{3}t^3 + \frac{11}{4}t^4\Big]_{t=0}^{1}$$

$$= \frac{5}{3} + \frac{11}{4}$$

$$= \frac{53}{12} = 4.4167$$

Hence, the correct Answer is (4.4167).

Question Number: 42 **Question Type: MCQ**

Let $P = \begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix}\cdot$ Consider the set S of all vectors $\begin{pmatrix} x \\ y \end{pmatrix}$ such that $a^2 + b^2 = 1$ where $\begin{pmatrix} a \\ b \end{pmatrix} = P\begin{pmatrix} x \\ y \end{pmatrix}\cdot$ Then S is ________.

(A) a circle of radius $\sqrt{10}$

(B) a circle of radius $\frac{1}{\sqrt{10}}$

(C) an ellipse with major axis along $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$

(D) an ellipse with minor axis along $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$

Solution:

Given $P = \begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix}$

Given $a^2 + b^2 = 1$ (1)

and $\begin{pmatrix} a \\ b \end{pmatrix} = P\begin{pmatrix} x \\ y \end{pmatrix} = \begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix}\begin{pmatrix} x \\ y \end{pmatrix}\begin{pmatrix} a \\ b \end{pmatrix}$

$$= \begin{pmatrix} 3x + y \\ x + 3y \end{pmatrix}$$

$\Rightarrow$ $a = 3x + y$ and $b = x + 3y$

From Equation (1),

$$a^2 + b^2 = 1$$

$\Rightarrow$ $(3x + y)^2 + (x + 3y)^2 = 1$

$$9x^2 + 6xy + y^2 + x^2 + 6xy + 9y^2 = 1$$

$$10x^2 + 12xy + 10y^2 = 1$$

$\Rightarrow$ $8(x + y)^2 + 2(x - y)^2 = 1$

$$\frac{(x + y)^2}{1/8} + \frac{(x - y)^2}{1/2} = 1$$

Which represents an ellipse $a < b$

$\therefore$ Major axis is $x + y = 0$ and minor axis is $x - y = 0$.

Hence, the correct option is (D).

Question Number: 43 **Question Type: MCQ**

Let the probability density function of a random variable, X, be given as:

$$f_x(x) = \frac{3}{2}e^{-3x}u(x) + ae^{4x}(-x)$$

where $u(x)$ is the unit step function.

Then the value of 'a' and probe $\{X \le 0\}$, respectively, are:

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

(C) $2, \frac{1}{4}$ (D) $4, \frac{1}{4}$

Solution: Given the probability density function of a random variable X, is

$$f_X(x) = \frac{3}{2}e^{-3x}u(x) + ae^{4x}u(-x)$$

i.e.,
$$f_X(x) = \begin{cases} ae^{4x} & ; \quad -\infty < x < 0 \\ \frac{3}{2}e^{-3x} & ; \quad 0 \le x < \infty \end{cases}$$

we know that

$$\int_{-\infty}^{\infty} f_X(x)\,dx = 1$$

$$\Rightarrow \quad \int_{-\infty}^{0} ae^{4x}dx + \int_{0}^{\infty} \frac{3}{2}e^{-3x}dx = 1$$

$$\Rightarrow \quad \frac{a}{4}e^{4x}\Big]_{-\infty}^{0} + \frac{3}{2}\frac{e^{-3x}}{-3}\Big]_{0}^{\infty} = 1$$

$$\Rightarrow \quad \frac{a}{4} + \frac{1}{2} = 1$$

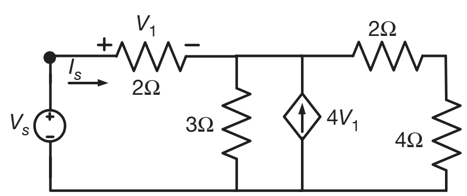
$$\Rightarrow \quad a = 2$$

and
$$P(X \le 0) = \int_{-\infty}^{0} f_X(x)\,dx$$
$$= \int_{-\infty}^{0} ae^{4x}dx$$
$$= 2\frac{e^{4x}}{4}\Big]_{-\infty}^{0} = \frac{1}{2}$$

Hence, the correct option is (A).

Question Number: 44 **Question Type: NAT**

The driving point input impedance seen from the source V_s of the circuit shown below, in Ω is_________.



Solution: From the given figure in question

$$I_S = \frac{V_1}{2}$$

Applying KVL at 3Ω resistor, we get

$$\frac{V - V_S}{2} + \frac{V}{3} - 4V_1 + \frac{V}{6} = 0$$

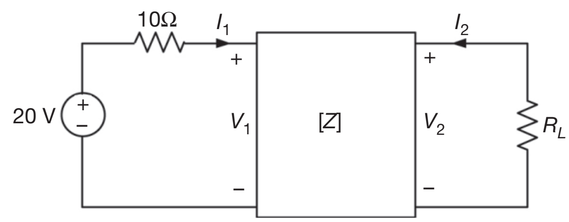
$$3V - 3V_S + 2V - 24V_1 + V = 0$$

$$V = -V_1 + V_S$$
$$-6V + 3V_S - 24V_1 = 0$$
$$3V_s = 30V_1$$
$$V_s = 10V_1$$
$$V_s = 10\,[2I_S]$$
$$Z_{in} = \frac{V_S}{I_S} = 20\Omega$$

Hence, the correct Answer is (20).

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

The Z-parameters of the two port network shown in the figure are $Z_{11} = 40\Omega$, $Z_{12} = 60\Omega$, $Z_{21} = 80\Omega$, and $Z_{22} = 100\Omega$. The average power delivered to $R_L = 20\Omega$, in watts, is _________.



Solution:

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11}I_1 + Z_{12}I_2 \\ Z_{12}I_1 + Z_{22}I_2 \end{bmatrix}$$

$$V_2 = -I_2\,[R_2] = -20I_2 \qquad (1)$$
$$20 = I_2\,[10] + V_1$$
$$20 = I_2\,(10) + 40\,I_1 + 60I_1$$
$$20 = 50I_1 + 60I_2 \qquad (a)$$
$$V_2 = 80I_1 + 100\,I_2 \qquad (2)$$

From Equation (1)

$$-20I_2 = 80I_1 + 100I_1$$
$$-120I_2 = 80I_1$$
$$I_1 = -\frac{3}{2}I_2 \qquad (3)$$

Substitute Equation (3) in (a)

$$20 = 50I_1 + 60\left[\frac{-2}{3}I_1\right]$$

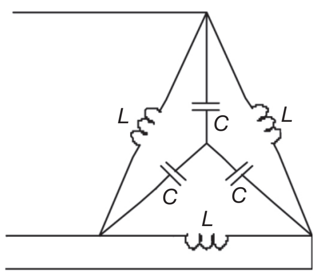
$$20 = 50I_1 - 40I_1$$
$$10I_1 = 20$$
$$I_1 = 2$$
$$I_2 = -4/3$$

$$P_{R_C} = \left(\frac{4}{3}\right)^2 \times 20 = \frac{16}{9} \times 20$$
$$= 35.55 \text{ W}$$

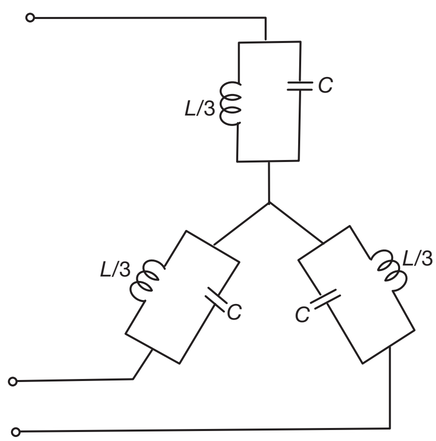
Hence, the correct Answer is (35.55).

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

In the balanced 3-phase, 50 Hz, circuit shown below, the value of inductance (L) is 10 mH. The value of the capacitance (C) for which all the line currents are zero, in millifarads, is ________.



Solution: Consider the simplified circuit shown below:



Given, $I_L = 0 \Rightarrow$ capacitor must supply inductor current

$$I_C = I_L \quad V_{ph}(j\omega c) = \frac{V_{ph}}{j\omega(L/3)}$$

$$\omega c = \frac{3}{\omega L}$$

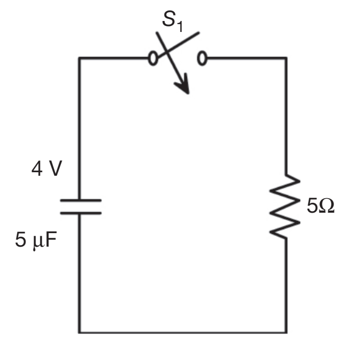
$$\Rightarrow \quad \omega^2 = \frac{3}{LC}$$

$$\Rightarrow \quad C = \frac{3}{10 \times 10^{-3}} = 3 \text{ mF}$$

Hence, the correct Answer is (3).

Question Number: 47 **Question Type: NAT**

In the circuit shown below, the initial capacitor voltage is 4 V. switch S_1 is closed at $t = 0$. The charge (in μC) lost by the capacitor form $t = 25$ μS to $t = 100$ μS is ________.



Solution:

$$V_C(t) = V_f + (V_i - V_f)\, e^{-t/T}$$
$$V_C(t) = 0 + (4 - 0)\; e^{-t/25\times10^{-6}}$$
$$V_C(t) = 4e^{-t\times10^4\times4}$$
$$Q = cv_c(t)$$
$$= (5 \times 10^{-6})\,[4e^{-(t\times4\times104)}]$$

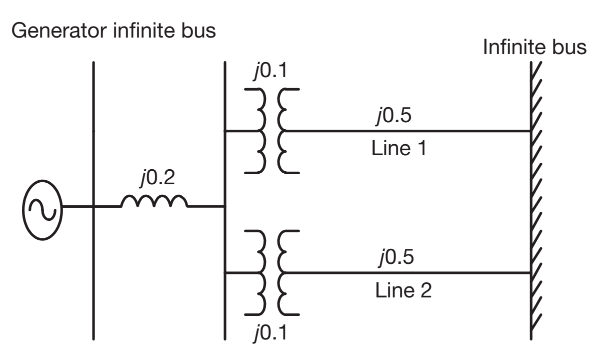
Charge lost (Q) from $t = 25$ µs to $t = 100$ µs can be calculated as

$$Q = 5 \times 10^{-6} \times 4\,[e^{-1} - e^{-4}]$$
$$= 6.99\ \mu C$$

Hence, the correct Answer is (6.99).

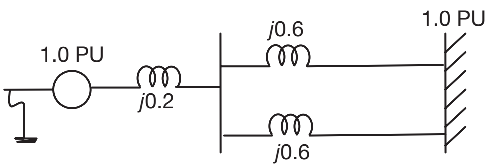
Question Number: 48 **Question Type: NAT**

The single line diagram of a balanced power system is shown in the figure. The voltage magnitude at the generator internal bus is constant and 1.0 p.u. the p.u reactances of different components in the system are also shown in the figure. The infinite bus voltage magnitude is 1.0 p.u. A three phase fault occurs at the middle of line 2.



The ratio of the maximum real power that can be transferred during the pre-fault condition to the maximum real power that can be transferred under the faulted condition is ______

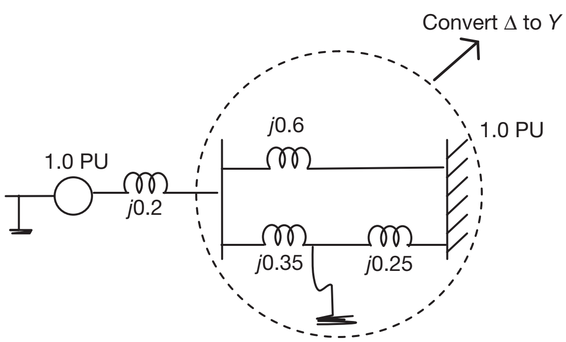
Solution: For pre-fault condition:



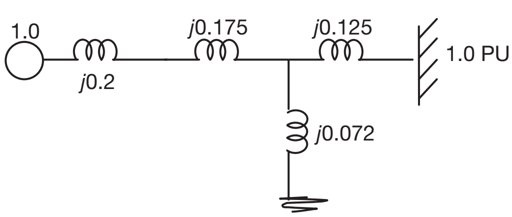
The maximum power can be calculated using

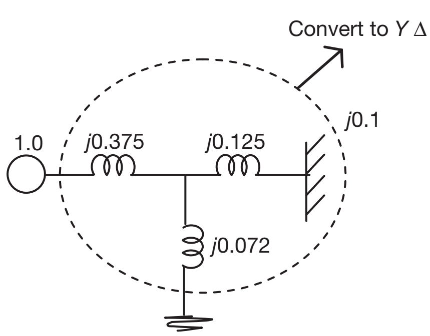
$$P_{\max} = \frac{(1.0)\ (1.0)}{X_q} = \frac{(1.0)(1.0)}{j0.5} = 2 \text{ PU}$$

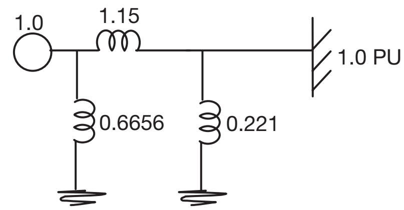
During the fault:



The above circuit can be drawn as follows.







The maximum power can be calculated using

$$P_{\max} = \frac{(1.0)(1.0)}{1.15} = 0.869 \text{ PU}$$

The ratio of the maximum real power that can be transferred during the pre-fault condition to the maximum real power that can be transferred under the faulted condition is

$$\frac{P_{\text{pre-fault}}}{P_{\text{during fault}}} = \frac{2}{0.869} = 2.3$$

Hence, the correct Answer is (2.3).

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

The open loop transfer function of a unity feedback control system is given by

$$G(S) = \frac{K(S+1)}{S(1+Ts)(1+2S)},\ K > 0,\ T > 0$$

The closed loop system will be stable if,

(A) $0 < T < \frac{4(K+1)}{K-1}$

(B) $0 < K < \frac{4(T+2)}{T-2}$

(C) $0 < K < \frac{T+2}{T-2}$

(D) $0 < T < \frac{8(K+1)}{K-1}$

Solution:

$$1 + G(S) = 0$$

$$S\ (1 + TS)\ (1 + 2S) + KS + K = 0$$

$$(2T)\ S^3 + (2 + T)\ S^2 + (1 + K)\ S + K$$

RH criteria

S^3	$2T$	$1+K$
S^2	$2+T$	K
S^1	$\frac{(2+T)(1+K) - 2TK}{2+T}$	0
S^0	K	0

For the system is to be stable, first column elements should be positive

Given $T > 0$, hence $2 + T > 0$

$$(1 + K) > \frac{2TK}{2 + T}$$

$$K > 0$$

$$1 > K\left[\frac{2T}{2 + T} - 1\right]$$

$$1 < K\left[\frac{T - 2}{T + 2}\right]$$

$$\therefore \quad 0 < K < \frac{T + 2}{T - 2}$$

Hence, the correct option is (C).

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

At no load condition, a 3-phase, 50 Hz, lossless power transmission line has sending-end and receiving-end voltages of 400 kV and 420 kV respectively. Assuming the velocity of travelling wave to be the velocity of light, the length of the line, in km, is ________.

Solution:

$$\cos h\nu L = A = \left.\frac{V_S}{V_R}\right|_{\text{no load}}$$

$$1 + \frac{YZ}{2} = \frac{400}{420}$$

$$1 + \frac{(j\omega c)(j\omega c)}{2} = \frac{400}{420}$$

$$\frac{20}{420} = \frac{\omega^2 LC}{2}$$

$$\frac{1}{21} = \frac{\omega^2 l^2}{2U^2}$$

$$\upsilon^2 = \frac{21}{2}\omega^2 l^2$$

$$\upsilon = \omega l\sqrt{\frac{21}{2}}$$

$$l = \frac{3 \times 10^8}{314 \times \sqrt{\frac{21}{2}}} = 294.847 \text{ mm}$$

Hence, the correct Answer is (294.847).

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

The power consumption of an industry is 500 kVA, at 0.8 p.f. lagging. A synchronous motor is added to raise the power factor of the industry to unity. If the power intake of the motor is 100 kW, the p.f. of the motor is ________.

Solution:

$$P_L = (500)\,(0.8) = 400 \text{ kW}$$

$$Q_L = (500)\,(0.6) = 300 \text{ kW}$$

$$\therefore \quad Q_{\text{motor}} = 300 \text{ kVAR}$$

$$Q_{\text{motor}} = 100 \text{ kW}$$

$$\text{P.f. of the motor} = \frac{P_{\text{motor}}}{\sqrt{P_m^2 + Q_m^2}}$$

$$= \frac{100}{\sqrt{100^2 + 300^2}}$$

$$= 0.316 \text{ lead}$$

Hence, the correct Answer is (0.316).

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

The flux linkage (λ) and current (i) relation for an electromagnetic system is $\lambda = (\sqrt{i})/g$. When $i = 2$ A and g (air-gap length) = 10 cm, the magnitude of mechanical force on the moving part, in N, is ________.

Solution: The mechanical force will be

$$F = (i^{3/2})/\,2g^2 = 23/2/(2 \times 0.1 \times 0.1) = 141.4 \text{ N}$$

Hence, the correct Answer is (141.4 N).

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

The starting line current of a 415 V, 3-phase, delta connected induction motor is 120 A, when the rated voltage is applied to its stator winding. The starting line current at a reduced voltage of 110 V, in ampere is ________.

Solution: The starting current of a 3-phase *IM* is

$$I_{st} = \frac{V}{R_q^2 + X_q^2}$$

$$I_{st} \propto \text{V}$$

$$\frac{I_1}{I_2} = \frac{V_1}{V_2}$$

$$\Rightarrow \quad I_2 = \left(\frac{V_1}{V_2}\right)I_1$$

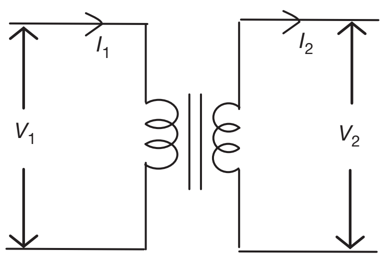
$$= \left(\frac{110}{415}\right)(120)$$
$$= 31.80 \text{ A}$$

Hence, the correct answer is 31.8.

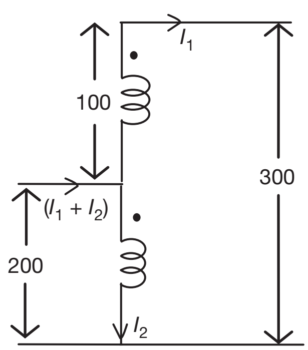
Question Number: 54 **Question Type: NAT**

A single-phase, 2 kVA, 100/200 V transformer is reconnected as an auto-transformer such that its kVA rating is maximum. The new rating, in kVA is _______.

Solution:



Primary voltage $V_1 = 100$ V,
Secondary voltage
$$V_2 = 200 \text{ V}$$
Now primary current will be
$$I_1 = \frac{2\times 1000}{100} = 20 \text{ A}$$
and secondary current will be
$$I_2 = \frac{2\times 1000}{200} = 10 \text{ A}$$
If it is connected as an auto transformer

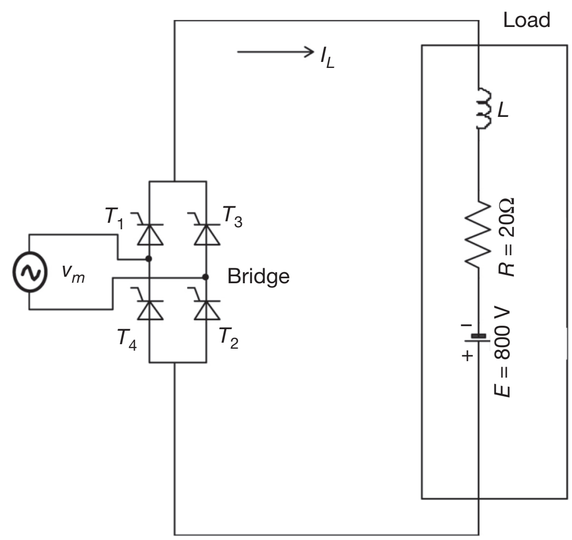


VA rating $= (300)(20)$
$= 6000$
$= 6$ kVA

Hence, the correct Answer is (6).

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

A full-bridge converter supplying an RLE load is shown in figure. The firing angle of the bridge converter is 120°. The supply voltage $v_m(t) = 200\pi \sin(100\pi t)$ V, $R = 20\Omega$, $E = 800$ V. The inductor L is large enough to make the output current I_L a smooth dc current. Switches are lossless. The real power feedback to the source, in kW, is __________.



Solution:

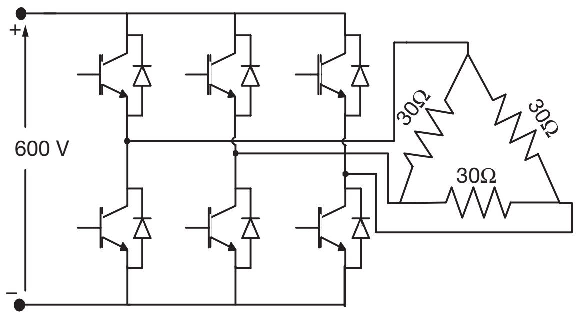
Given $E = 800$ V
$R = 20\Omega$

Output voltage, can be calculated using relation
$$V_0 = -E + I_0 R$$
$$V_0 = -800 + I_0 \times 20 \quad (1)$$
We also know that output voltage can be expressed as
$$V_0 = \frac{2V_m}{\pi}\cos\alpha$$
$$= \frac{2\times 200\pi}{\pi}\cos 120$$
$$= -200 \text{ V} \quad (2)$$
From Equations (1) and (2), we get
$$-200 = -800 + I_0 \times 20$$
$$I_0 = 30 \text{ A}$$
Power feedback to the source,
$$P_0 = V_0 I_0 = 200 \times 30$$
$$= 6 \text{ kW}$$

Hence, the correct Answer is (6).

Question Number: 56 **Question Type: NAT**

A three-phase Voltage Source Inverter (VSI) as shown in the figure is feeding a delta connected resistive load of 30Ω/phase. If it is fed from a 600 V battery, with 180° conduction of solid-state devices, the power consumed by the load, in kW, is ________.



Solution:

$$V_{dc} = 600 \text{ V}$$
$$R = 10 \text{ Ohms}$$

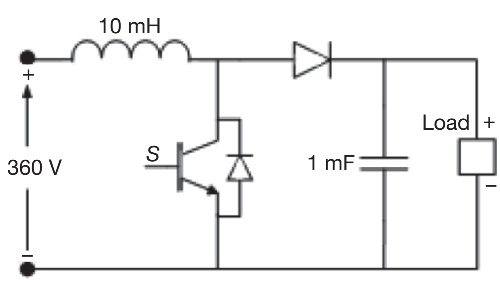
Output power, $P_o = V_L I_L \cos\phi$

$$= \frac{V_L^2}{R} = \frac{2V_{dc}^2}{3R} = \frac{2\times(600)^2}{3\times 10}$$
$$= 24 \text{ kW}$$

Hence, the correct Answer is (24).

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

A DC-DC boost converter, as shown in the figure below, is used to boost 360 V to 400 V, at a power of 4 kW. All devices are ideal. Considering continuous inductor current, the rms current in the solid state switch (S), in ampere is _______.



Solution:

Output voltage, $V_0 = 400$ V

DC input voltage

$$V_{dc} = 360 \text{ V}$$

Output power $P_0 = 4 \text{ kW} = 4000$ W

$$V_0 = \frac{V_{dc}}{1-D}$$
$$400 = \frac{360}{1-D}$$
$$D = 0.1$$

Output power can be expressed as

$$P_0 = V_0 I_0$$
$$4000 = 400 \times I_0$$
$$I_0 = 10 \text{ A}$$

Average current across the inductor

$$(I_L)_{avg} = \frac{I_0}{1-D} = \frac{10}{1-0.1} = \frac{10}{0.9} \text{ A}$$

RMS current across the inductor

$$(I_L)_{rms} = \sqrt{(I_L)_{avg}^2 + (I_L \text{ripple})_{rms}^2}$$
$$(I_L)_{\text{ripple rms}} = \frac{\Delta I_L}{2\sqrt{3}}$$

By neglecting ripple current,

$$I_{L(\text{ripple rms})} = 0$$
$$(I_L)_{rms} = (I_L)_{avg} = \frac{10}{0.9} \text{ A}$$
$$(I_{SW})_{rms} = \sqrt{D}(I_L)_{rms}$$
$$= \sqrt{0.1} \times \frac{10}{0.9} = 3.513 \text{ A}$$

Hence, the correct Answer is (3.51).

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

A single-phase bi-directional voltage source converter (VSC) is shown in the figure given on next page. All devices are ideal. It is used to charge a battery at 400 V with power of 5 kW from a source V_s = 220 V (rms), 50 Hz sinusoidal AC mains at unity p.f. If its AC side interfacing inductor is 5 mH and the switches are operated at 20 kHz, then the phase shift (δ) between AC mains voltage (V_s) and fundamental AC rms VSC voltage (V_{c1}), in degree, is ________.

Solution:

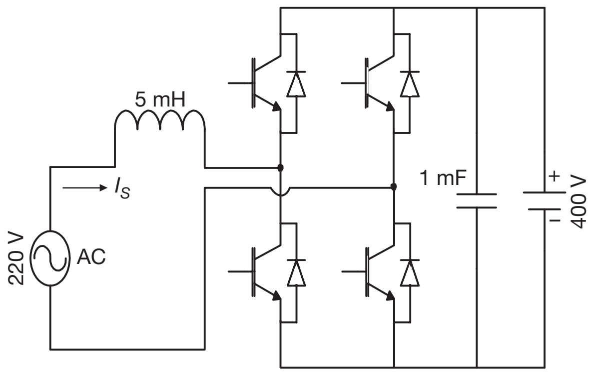
DC power $P_{DC} = 5 \text{ kW} = 5000$ W

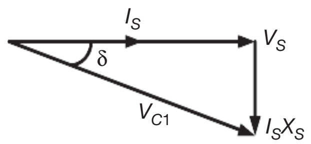
AC power $P_{AC} = V_{sr1} I_{sr1} \cos\theta$

$$= 220 \times I_{sr1} \times 1$$

Now we know that

$$P_{AC} = P_{DC}$$
$$I_{sr} = \frac{5000}{220} = 22.73 \text{ A}$$





$$X_s = \omega L = 100\pi \times 5 \times 10^{-3}$$

$$\sin\delta = \frac{I_{sr} \cdot x_s}{V_s}$$

$$\sin\delta = (\,22.73)\,(100\pi \times 5 \times 10^{-3})/V_s$$

$$\delta = 9.21°$$

Hence, the correct Answer is (9.21).

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

Consider a linear time invariant system $x = Ax$, with initial condition $x(0)$ at $t = 0$. Suppose α and β are eigenvectors of (2 × 2) matrix A corresponding to distinct eigenvalues λ_1 and λ_2, respectively. Then the response $x(t)$ of the system due to initial condition $x(0) = \alpha$ is:

(A) $e^{\lambda_1 t}\alpha$ (B) $e^{\lambda_2 t}\beta$

(C) $e^{\lambda_2 t}\alpha$ (D) $e^{\lambda_1 t}\alpha + e^{\lambda_2 t}\beta$

Solution:

$x(t)\, e^{At}\, x(0)$

$$A = \begin{bmatrix} \lambda_1 & 0 \\ 0 & \lambda_2 \end{bmatrix}$$

and $x(0) = \alpha$

$$E^{At} = L^{-1}(SI - A) - 1$$

$$= \begin{bmatrix} \lambda_1 & 1 \\ e & \lambda_2 \\ 0 & e \end{bmatrix}$$

$$X(t)\, e^{At}\, x(0) = \begin{bmatrix} \lambda_1 t & 0 \\ e & \lambda_2 t \\ 0 & e \end{bmatrix} \begin{bmatrix} \alpha \\ 0 \end{bmatrix}$$

$$X(t) = e^{\lambda_1 t}\alpha$$

Hence, the correct option is (A).

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

A second-order real system has the following properties:

(a) the damping ratio δ = 0.5 and undamped natural frequency $\omega_n = 10$ rad/s
(b) the steady state value of the output, to a unit step input, is 1.02.

The transfer function of the system is

(A) $\dfrac{1.02}{S^2 + 5S + 100}$ (B) $\dfrac{1.02}{S^2 + 10S + 100}$

(C) $\dfrac{100}{S^2 + 10S + 100}$ (D) $\dfrac{102}{S2 + 5S + 100}$

Solution: Second order characteristic equation is

$$S^2 + 2\delta\omega_n S + \omega_n^2 = 0$$

Now we have δ = 0.5 and $\omega_n = 10$ rad/s. Substituting the values, we get the characteristic equation as

$$S^2 + 10S + 100 = 0.$$

$$\text{DC gain} = \frac{102}{100} = 1.02$$

Hence, the correct option is (B).

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

Three single-phase transformers are connected to from a delta-star three-phase transformer of 110 kV/11 kV. The transformer supplies at 11 kV as load of 8 mW at 0.8 p.f. lagging to a near by plant. Neglect the transformer losses. The ratio of phase currents in delta side to star side is ________.

(A) $1 : 10\sqrt{3}$ (B) $10\sqrt{3} : 1$

(C) 1 : 10 (D) $\sqrt{3} : 10$

Solution: Δ/Y connection [110 kV/11 kV]

$$\frac{\text{Load on } Y \text{ side}}{\text{11 kV, 8 mV, 0.8 p.f. log}}$$

⇒ Δ side MVA rating is also 10 MVA

Δ side line current will be

$$10 \text{ mVA} = \sqrt{3} * 110 * 10^3 * I_L$$

$$I_L = \frac{10 \times 10^6}{\sqrt{3} \times 110 \times 10^3} = 52.48 \text{ A}$$

$$\Rightarrow \quad I_{ph} = \frac{52.48}{\sqrt{3}} = 30.30 \text{ A}$$

Y side:

$$10 \text{ MVA} = \sqrt{3} * 11 \times 10^3 * I_L$$

$$\Rightarrow \quad I_L = \frac{10 \times 10^6}{\sqrt{3} * 11 \times 10^3} = 524.86 \text{ A}$$

$$\Rightarrow \quad I_{ph} = I_L = 524.86 \text{ A}$$

The ratio $\frac{I_{ph}(\Delta)}{I_{ph}(Y)} = \frac{30.30}{524.86} = 0.0577$

$$= \frac{1}{10\sqrt{3}}$$

Hence, the correct option is (A).

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

The gain at the breakaway point of the root locus of a unity feedback system with open loop transfer function $G(S) = \frac{KS}{(S-1)(S-4)}$ is:

(A) 1 (B) 2
(C) 5 (D) 9

Solution: Open loop transfer function

$$G(S) = \frac{KS}{(S-1)\,(S-4)}$$

Characteristic equation is

$$1 + G(S) = 0$$

$$\Rightarrow \; (S-1)\,(S-4)\,KS = 0$$

$$K = -\frac{(S-1)\,(S-4)}{S}$$

Break away point occurs at a point

$$\frac{dK}{dS} = 0$$

$$\frac{dK}{dS} = -\left[\frac{S(2S-5) - (S^2 - 5S + 4)}{S^2}\right]$$

$$2S^2 - 5S = S^2 - 5S + 4$$

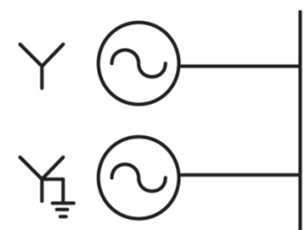
$$S = \pm 2$$

$$K = -\frac{(2-1)\,(2-4)}{2} = 1$$

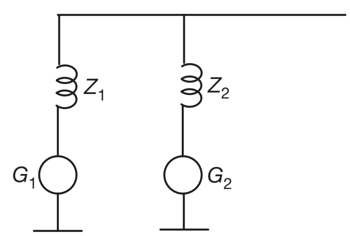
Hence, the correct option is (A).

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

Two identical unloaded generators are connected in parallel as shown in the figure. Both the generators are having positive, negative and zero sequence impedances of *j*0.4 pu., *j*0.3 pu., and *j*0.15 pu., respectively If the pre-fault voltage is 1 pu., for a line-to-ground (*L* – *G*) fault at the terminals of the generators, the fault current, in pu., is _________.

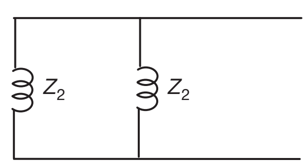


Solution: Two generators in parallel



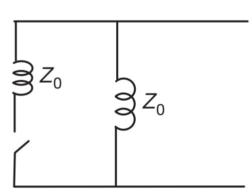
* Equivalent positive sequence impedance.

$$Z_{1eq} = \frac{(0.4)(0.4)}{0.8} = 0.2 \text{ PU}$$



* Equation negative sequence impedance.

$$Z_{2eq} = \frac{(0.3)(0.3)}{0.6} = 0.15 \text{ PU}$$



* Equation zero sequence impedance is

$$Z_{0eq} = 0.15 \text{ PU}$$

($\because$ First generator neutral is disconnected form ground)

$$\therefore \quad I_{a1} = \frac{E_g}{Z_{1eq} + Z_{2eq} + Z_{0eq}}$$

$$= \frac{1.0}{0.2 + 0.15 + 0.15} = 2 \text{ PU}$$

$$I_f = 3I_{a1} \qquad (\because L - G \text{ fault})$$

$$= (3)\,(2) = 6 \text{ PU}$$

Hence, the correct Answer is (6).

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

An energy meter, having meter constant of 1200 revolutions/kWh, makes 20 revolutions in 30 seconds for a constant load. The load, in kW, is ________.

Solution: Energy meter constant,

$$K = 1200 \frac{\text{rev}}{\text{kWh}}$$

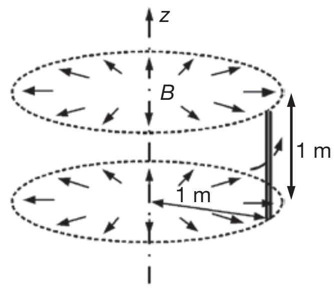
Load power (in kW)

$$P = \frac{20 \times 60 \times 60}{1200 \times 30} = 2 \text{ kW}$$

Hence, the correct Answer is (2).

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

A rotating conductor of 1 m length is placed in a radially outward (about the z-axis) magnetic flux density (B) of 1 Tesla as shown in figure given on next column. Conductor is parallel to and at 1 m distance from the z-axis. The speed of the conductor in r.p.m. required to induce a voltage of 1 V across it, should be ________.



Solution:

Flux density $(B) = 1$ Tesla

Length $l = 1$ m

Distance $r = 1$ m

Now using the relation

$$E = Blv$$

$$1 = 1 \times 1 \times v$$

$$v = 1 \text{ m/s}$$

$$v = rw$$

$$1 \quad rw$$

$$w = 1$$

$$\frac{2\pi N}{60} = 1$$

$$N = (60/2\pi) \text{ rpm}$$

$$= 9.54 \text{ rpm}$$

Hence, the correct Answer is (9.54).