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GATE 2016

Detailed Solutions For Electrical Engineering

Date: 07-02-2016
Afternoon Session

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01. The chairman requested the aggrieved shareholders to _______ him.
(A) bare with (B) bore with (C) bear with (D) bare

Ans: (C)

Sol: 'bear with' means to be patient with some one

02. Identify the correct spelling out of the given options:
(A) Managable (B) Manageable (C) Mangaeble (D) Managible

Ans:(B)

Sol: 'manageable' is the correct spelling

03. Pick the odd one out in the following:
13, 23, 33, 43, 53
(A) 23 (B) 33 (C) 43 (D) 53

Ans: (B)

Sol: In the group of given numbers, all are prime numbers but 33 is not

04. R2D2 is a robot. R2D2 can repair aeroplanes. No other robot can repair aeroplanes.
Which of the following can be logically inferred from the above statements?
(A) R2D2 is a robot which can only repair aeroplanes.
(B) R2D2 is the only robot which can repair aeroplanes.
(C) R2D2 is a robot which can repair only aeroplanes.
(D) Only R2D2 is a robot.

Ans: (B)

Sol: The statement 'No other robot can repair aeroplanes' means R2D2 is the only robot which can repair aeroplanes so option (B) is the best inference

05. If $|9y - 6| = 3$, then $y^2 - 4y/3$ is _________.
(A) 0 (B) +1/3 (C) –1/3 (D) undefined

Ans: (C)

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

$9y - 6 = \pm 3$

Case I: $9y - 6 = 3$

$\Rightarrow y = 1$

Case II: $9y - 6 = -3$

$\Rightarrow y = \frac{1}{3}$

Substitute $y = 1$

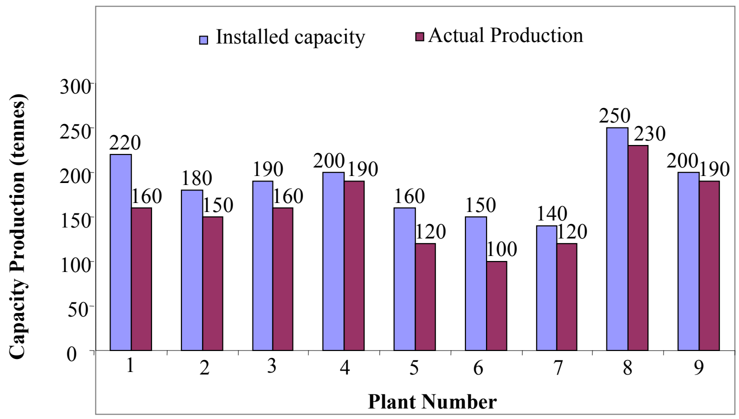
$$y^2 - \frac{4y}{3} = 1^2 - \frac{4(1)}{3} = 1 - \frac{4}{3} = -\frac{1}{3}$$

Substitute $y = \frac{1}{3}$

$$y^2 - \frac{4y}{3} = \left(\frac{1}{3}\right)^2 - \frac{4(1/3)}{3} = \frac{1-4}{9} = -\frac{1}{3}$$

Q. 6 to Q. 10 carry two marks each

06. 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 _______.



Ans: 120

Sol: Installed capacity ≥ 200 tonnes ⇒ large plant
Installed capacity < 200 tonnes ⇒ small plant
Form given multiple pie chart, the large plants are 1, 4, 8 & 9
Total production of large plants = 160 + 190 + 230 + 190 = 770 tonnes
Total production of small plants = 150 + 160 + 120 + 100+ 120 = 650 tonnes
∴ The difference between total production of large plants and small plants in tonnes
= 770 – 650 = 120

07. A poll of students appearing for masters in engineering indicating that 60% of the students believed that mechanical engineering is a profession unsuitable for women. A research study on women with master or higher degrees in mechanical engineering found that 90% 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 pursing higher degrees in mechanical engineering is small.

Ans:(C)

Sol: A poll says that women with masters or higher degrees in mechanical engineers are successful in their professions. This statement leads to the option 'C' which is the best inference

08. 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 from 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) SITs like institutions can only be established in consultation 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

Ans: (C)

Sol: Option (i) and (iii) state phrases like 'in the initial years' and 'SIT like institutions can only be established in consultation with IIT' cannot be logically inferred so (ii) and (iv) are the best inferences i.e. option (C)

09. 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 <u>exactly</u> 6 free throws in 10 attempts?

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

Ans: (A)

Sol: n = no. of attempts = 10

x = free throws successfully = 6

∴ The probability that he will successfully make exactly 6 free throws in 10 atempts

$= n_{C_x}\, p^x . q^{n-x}$ $[\because q = 1 - p]$

$p = 60\% = \frac{60}{100} = 0.6$

$= 10_{C_6} \times (0.6)^6 \times (0.4)^4$

$= 210 \times 0.046656 \times 0.0256$

$= 0.2508$

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

Ans: 7

Sol: $211^{870} + 146^{127} \times 3^{424} = (1)^2 + (6)^3 \times 1$

$= 1 + 216 \times 1$

$= 217$

∴ Units digit = '7'

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Q. 1 to Q. 25 carry one mark each

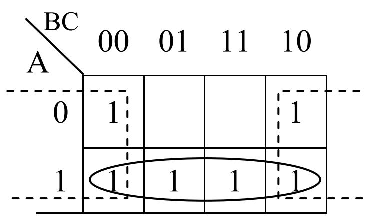
01. The output expression for the Karnaugh map shown below is

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

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

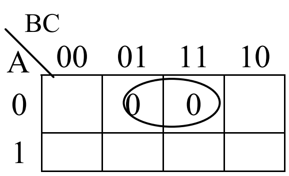
Ans: (B)

Sol:



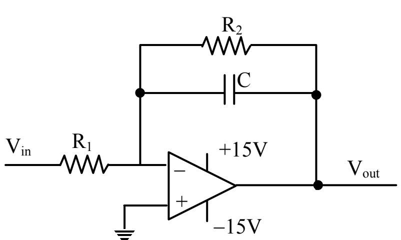
$A + \overline{C}$

(OR)



$A + \overline{C}$

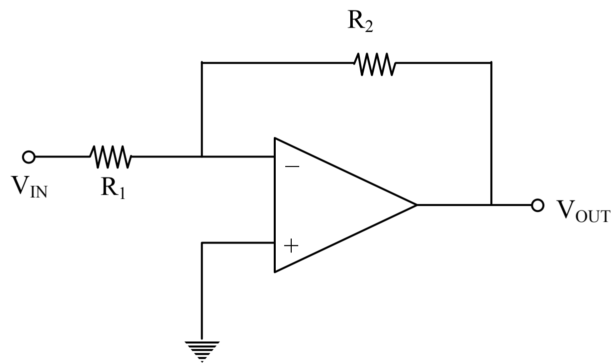
02. The circuit shown below is an example of a



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

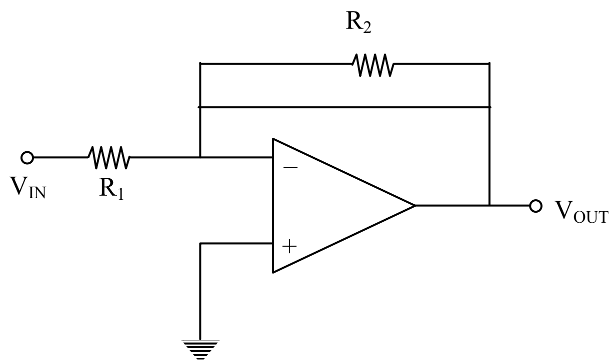
Ans: (A)

Sol: At low frequency, C is OPEN. The circuit looks like as shown below:



This is a inverting amplifier with voltage gain, $\frac{V_{OUT}}{V_{IN}} = -\frac{R_2}{R_1}$

At High frequency, C is SHORT. The circuit looks like as shown below:



$V_- = V_+ = 0$ (Virtual short)

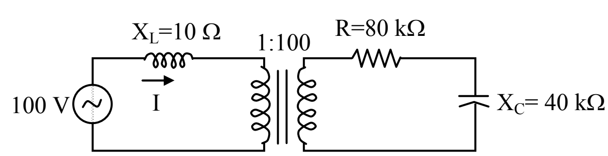
$V_{OUT} = V_- = 0$

$\Rightarrow \frac{V_{OUT}}{V_{IN}} = 0$

Gain is non-zero at low frequency. Gain is zero at high frequency. Clearly, the circuit is a low pass filter.

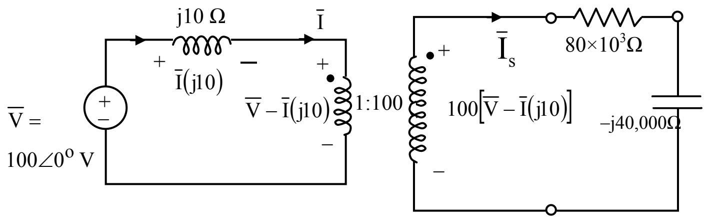
NOTE: You can also get the answer by writing down the transfer function $\frac{V_{OUT}(s)}{V_{IN}(s)}$

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



Ans: 10

Sol:



$$\bar{I}_S = \frac{100[\bar{V} - \bar{I}(j10)]}{(80 - j40)10^3}$$

$$\therefore \text{ From transformer property } \bar{I} = \frac{10^4[\bar{V} - \bar{I}(j10)]}{(8 - j4)10^4}$$

$$(8 - j4)\bar{I} = \bar{V} - j10\bar{I}$$

$$\bar{V} = (8 + j6)\bar{I};$$

$$\bar{I} = \frac{\bar{V}}{8 + j6} = \frac{100\angle 0^\circ}{8 + j6}$$

'I' in magnitude = 10A

04. 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) $54e^{-\frac{t}{6}}u(t) - 54e^{-\frac{t}{3}}u(t)$

Ans: (D)

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

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

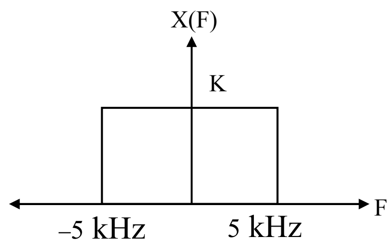
$$Y(s) = \frac{3}{\left(s + \frac{1}{6}\right)} \times \frac{3}{\left(s + \frac{1}{3}\right)} = \frac{9}{\left(s + \frac{1}{6}\right)\left(s + \frac{1}{3}\right)}$$

$$Y(t) = L^{-1}[Y(s)] = 54e^{-\frac{t}{6}}u(t) - 54e^{\frac{-t}{3}}u(t)$$

05. Suppose the maximum frequency in a band-limited signal x(t) is 5 kHz. Then, the maximum frequency in x(t) cos(2000πt), in kHz is _________.

Ans: 6

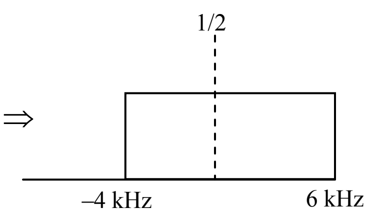
Sol: Given, x(t) is a band-limited signal x(t) with 5kHz



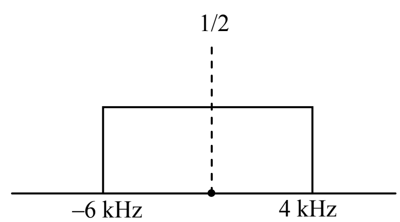
$$x(t)\cos(2\pi \times 1000t) \overset{FT}{\leftrightarrow} \frac{1}{2}\left(X\left(f-1000\right)\right)+X\left(f+1000\right)$$

$$=\frac{1}{2}X\left(f-1kHz\right) + X(f+1\ kHz)$$

$\frac{1}{2}X\left(f-1kHz\right) \Rightarrow$



$\frac{1}{2}X\left(f+1kHz\right) \Rightarrow$



From the above frequency response the maximum frequency present in x(t)cos $(2000\pi t)$ is 6 kHz

06. 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 ananlytic
(D) f(z) is neither continuous nor analytic

Ans: (B)

Sol: $f(z) = z + z^* = 2x$,
z^* is a continuous but not analytic
so, f(z) is continuous but not analytic.

07. A 3 × 3 matrix P is such that, $p^3 = P$. Then the eigen values 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

Ans: (D)

Sol: Given $p^3 = P$

Let λ be an eigen value of p

Then $\lambda^3 = \lambda \Rightarrow \lambda = 0, 1, -1$

08. 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) $e^{-t}u(t)$

Ans: (A)

Sol: $(s^2 + 2s + 1)\ Y(s)$

So, Natural response $L^{-1}\left[\dfrac{1}{(s+1)^2}\right]$

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

09. The value of line integral $\int_c \left(2xy^2dx + 2x^2ydy + dz\right)$

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

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

Ans: (B)

Sol: (0, 0, 0) to (1, 1, 1)

Equation of straight line $\dfrac{x-0}{1-0} = \dfrac{y-0}{1-0} = \dfrac{3-0}{1-0} = t$

$x = t,\ y = t, z = t$

$dx = dt, dy = dt, dz = dt$

$t = 0, t = 1$

$$\int_0^1 \left(4t^3 + 1\right)dt = \left|\frac{4t^4}{4} + t\right|_0^1 = 1 + 1 = 2$$

10. Let f(x) be a real, periodic function satisfying $f(-x) = -f(x)$. The general form 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) $f(x) = a_0 + \sum_{k=1}^{\infty} a_{2k} \cos(kx)$

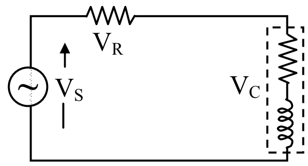
(D) $f(x) = \sum_{k=0}^{\infty} a_{2k+1} \sin(2k+1)x$

Ans: (B)

Sol: Given f(x) is a odd periodic function so, cosine terms will be zero in trigonometric fourier series.

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

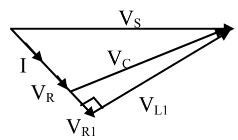
11. A resistance and a coil are connected in series and supplied from a single phase, 100 V, 50 Hz ac source as shown in the figure below. The rms values of plausible voltages across the resistance (V_R) and coil (V_C) respectively, in volts, are



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

Ans: (D)

Sol: $V_C = V_{R1} + j\, V_{L1}$



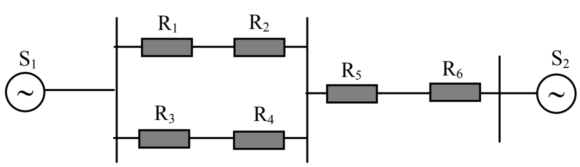
$$V_s = \sqrt{V_R^2 + V_C^2} = \sqrt{60^2 + 80^2} = 100 \text{ V}$$

12. 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 _________.

Ans: 250 W

Sol: $$P = \frac{100}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \cos 60°$$
$$= \frac{1000}{2} \times \frac{1}{2} = 250 \text{ W}$$

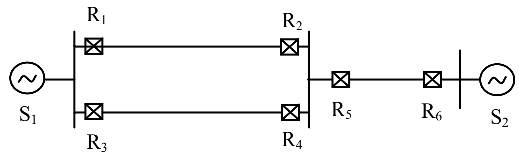
13. A power system with two generators is shown in the figure below. The system (generators, buses and transmission lines) is protected by six overcurrent relays R_1 to R_6. Assuming a mix of directional and nondirectional relays at appropriate locations, the remote backup relays for R_4 are



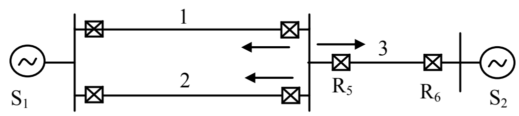
(A) R_1, R_2 (B) R_2, R_6 (C) R_2, R_5 (D) R_1, R_6

Ans: (D)

Sol: Given power system network



According to principles of directional and non directional over current relays placement. In given diagram R_2, R_4, R_5 are directional over current relays as shown below.



For the fault on line-2 R_3 and R_4 must be operated. If R_4 is not operated then R_1 and R_6 will operated because R_2 and R_5 will carry fault current in opposite direction to set direction.

$\therefore$ Backup for R_4 relay are R_1 and R_6

14. 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

Ans: (A)

Sol: Total no. of busses = 100
Generator buses = 10 − 1 = 9 = n
Load busses = 90 = m
Order of Jacobian Matrix= (2m+n) ×(2m+n)
$= (2 \times 90 + 9) \times (2 \times 90 + 9)$
$= 189 \times 189$

15. The inductance and capacitance of a 400 kV, three phase, 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

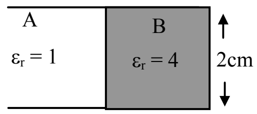
Ans: (B)

Sol: Surge impedance of transmission line = $\sqrt{\frac{L}{C}} = \sqrt{\frac{1.6m}{10n}} = 400\ \Omega$

Surge impedance loading = $\frac{V_R^2}{Z_C} = \frac{400^2}{400} = 400\,\text{MW}$

Load applied on transmission line (300 MW) < surge impedance loading (400 MW)
Then transmission line is capacitive and to maintain rated voltage at receiving end shunt inductance is required.

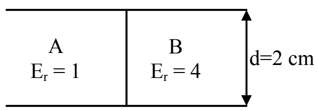
16. A parallel plate capacitor filled with two dielectrics is shown in the figure below. If the electric field in the region A is 4 kV/ cm, the electric field in the region B, in kV/cm is



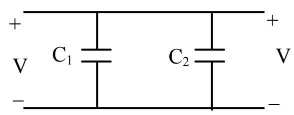
(A) 1 (B) 2 (C) 4 (D) 16

Ans: (C)

Sol:



Here the two capacitors are connected in parallel, so the voltage is same and electric field is also same



So the electric field in the region B is

$E_B = 4$ kV/cm

17. 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 ________.

Ans: 5

Sol: Fault current $\propto \dfrac{1}{\text{Reactance during fault}}$

$$\frac{I_{initial}}{I_{final}} = \frac{I_{sub-transient}}{I_{synchronous}} = \frac{X_{synch}}{X_{subtran}} = \frac{1}{0.2} = 5$$

18. 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 __________.

Ans: 0.707

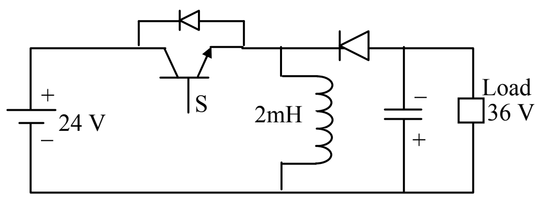
Sol: $A = \left|\dfrac{1}{j\omega+1}\right|_{\omega=1} = \dfrac{1}{\sqrt{2}} = 0.707$

19. 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 __________.

Ans: 57.735

Sol: RMS value of diode current = $\frac{I_o}{\sqrt{3}} = \frac{100}{\sqrt{3}} = 57.735\ \text{A}$

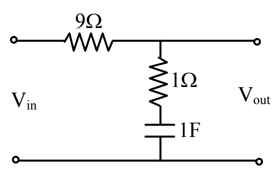
20. A buck-boost DC-DC converter, shown in the figure below, is used to covert 24 V battery voltage to 36 V DC voltage to feed a load of 72 W. It is operated at 20 kHz with an inductor of 2 mH and output capacitor of 1000 μF. All devices are considered to be ideal. The peak voltage across the solid-state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



Ans: 60

Sol: In buck boost converter, the voltage across the switch is $V_{dc} + V_o = 24 + 36 = 60\,\text{V}$

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



Ans: 0.3162

Sol: TF = $\frac{V_0(s)}{V_{in}(s)} = \frac{\frac{1}{s}+1}{1+9+\frac{1}{s}} = \frac{1+s}{1+10s}$

$\omega_m = \frac{1}{T\sqrt{a}} = \frac{1}{\sqrt{10}} = 0.3162$

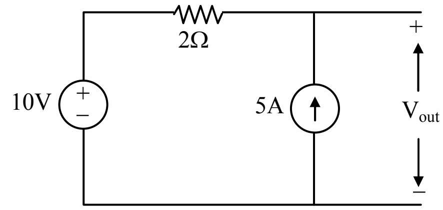
22. The direction of rotation of a single-phase capacitor run induction motor is reversed by
(A) interchanging the terminals of the AC supply.
(B) interchanging the terminals of the capacitor.
(C) interchanging the terminals of the auxiliary winding.
(D) interchanging the terminals of both the windings.

Ans: (C)

Sol: Each terminal of the supply is sometimes positive and sometimes negative. Interchanging the supply terminals does not make any difference. Capacitor is a passive device. Interchanging its terminals does not make any difference.

Interchanging terminals of both the windings leave us in the original state. Direction of reversal is not affected. Interchanging auxiliary winding terminals does reverse the direction of rotation of the rotating magnetic field and hence that of the rotor.

23. In the circuit shown below, 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

Ans: (D)

Sol: $\frac{(V-10)}{2} - 5 = 0$

$V = 20$ V

24. 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

Ans: (D)

Sol: $b = 7 \quad n = 5$

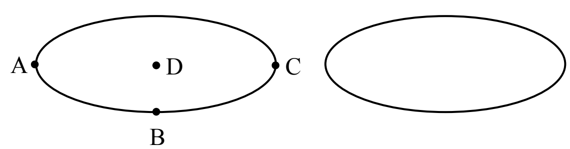
kVL = m = b – n + 1

= 7 – 5 + 1 = 3

KCL = n –1 = 5 – 1 = 4

So, (4) & (3)

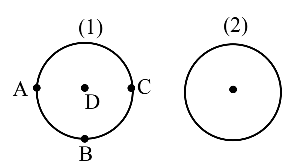
25. Two electrodes, whose cross-sectional view is shown in the figure below, are at the same potential. The maximum electric field will be at the point



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

Ans: (A)

Sol:



Assume that cross section of electrodes is circular. The electric field at A is sum of the two electric fields. So, at A the field is maximum

Q. 26 to Q. 55 carry two marks each

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

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

Ans: (D)

Sol: $\overline{\left(a+\overline{b}+c+\overline{d}\right)+(b+\overline{c})}$

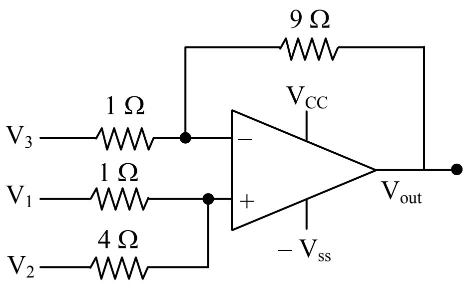
$= \overline{a+\overline{b}+c+\overline{d}+b+\overline{c}}$

$= \overline{a+1+1+\overline{d}}$

$= \overline{1}$

$= 0$

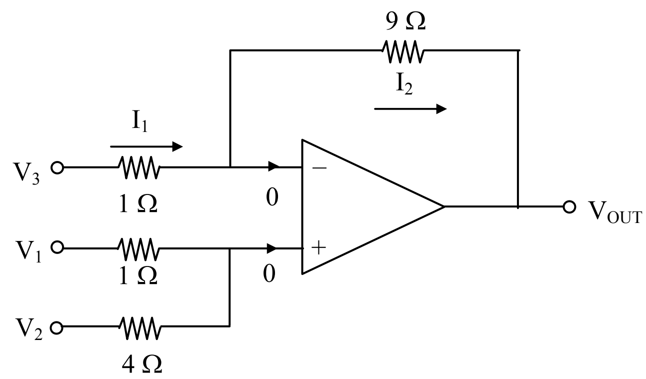
27. For the circuit shown below, taking the opamp as ideal, the output voltage V_{out} in terms of the input voltages V_1, V_2 and V_3 is



(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) $8V_1 + 2V_2 - 9V_3$

Ans: (D)

Sol: $V_+ = V_1 \times \frac{4}{1+4} + V_2 \times \frac{1}{1+4}$



$V_+ = \frac{4V_1}{5} + \frac{V_2}{5}$

$V_- = V_+$ (By virtual short)

$I_1 = \frac{V_3 - V_-}{1\Omega}$

$= V_3 - \frac{4V_1}{5} - \frac{V_2}{5}$

$I_2 = \frac{V_- - V_{OUT}}{9\Omega} = \frac{\frac{4V_1}{5} + \frac{V_2}{5} - V_{OUT}}{9}$

Apply KCL at inverting input terminal;
We get $I_1 = I_2$

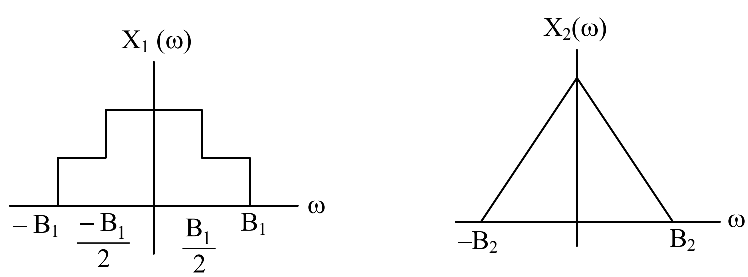
$\Rightarrow V_3 - \frac{4V_1}{5} - \frac{V_2}{5} = \frac{\frac{4V_1}{5} + \frac{V_2}{5} - V_{OUT}}{9}$

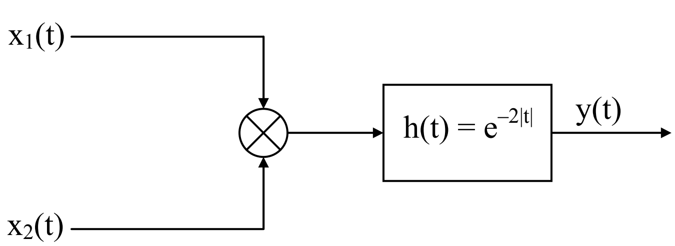
$\Rightarrow 9V_3 - \frac{36V_1}{5} - \frac{9V_2}{5} = \frac{4V_1}{5} + \frac{V_2}{5} - V_{OUT}$

$\Rightarrow V_{OUT} = \frac{40V_1}{5} + \frac{10V_2}{5} - 9V_3$

$\Rightarrow V_{OUT} = 8V_1 + 2V_2 - 9V_3.$

28. 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 above, the minimum sampling rate required to sample y(t), so that y(t) can be uniquely reconstructed from its samples, is

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

Ans: (B)

Sol: $y(t) = x_1(t)\, x_2(t) \otimes h(t)$

$$Y(\omega) = \frac{1}{2\pi}\left(X_1(\omega) \otimes X_2(\omega)\right)H(\omega)$$

$$H(\omega) = \frac{4}{\omega^2 + 4}$$

The maximum frequency $\frac{1}{2\pi}\left(X_1(\omega) \otimes X_2(\omega)\right)$ is band limited with B_1+B_2

Hence, the minimum sampling rate is $2(B_1+B_2)$ ($\because$ minimum sampling rate means nyquist rate)

29. 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

Ans: (D)

Sol: $$2\int_{-\infty}^{\infty}\left[\frac{\sin 2\pi t}{\pi t}\right]dt = \frac{2\times 2}{\pi}\times\int_{0}^{\infty}\left[\frac{\sin 2\pi t}{t}\right]dt$$

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

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

Ans: 7.389

Sol: Given, $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$

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

$S^2Y(s) - S\,y(0) - y'(0) - 4S\,Y(s) + 4y(0) + 4Y(s) = 0$

$S^2\,Y(s) - 1 - 4S\,Y(s) + 4\,Y(s) = 0$

$Y(s)\,[S^2 - 4S + 4] = 1$

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

$$Y(s) = \frac{1}{(S-2)^2}$$

$$y(t) = t.\,e^{2t} \quad \left(\because \frac{1}{s^{n+1}} \overset{L.T}{\leftrightarrow} \frac{t^n}{n!}\right)$$

$y(1) = 1.\,e^2 = 7.389$

31. 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 ______.

Ans: 4.4167

Sol: $F = 5xza_x + (3x^2+2y)a_y + x^2za_z$

(0, 0, 0) to (1, 1, 1)

$$\int_L F.dl = \int 5xzdx + \int (3x^2 + 2y)dy + \int x^2zdz$$

$x = t$, $y = t^2$, $z = t$

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

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

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

$$= \int_{t=0}^{1} (5t^2 + 10t^3 + t^3)dt$$

$$= \left(5\frac{t^3}{3} + 11\frac{t^4}{4}\right)_0^1$$

$$= \frac{5}{3} + \frac{11}{4} = \frac{53}{12} = 4.4167$$

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

Ans: (D)

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

$$\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 3 & 1 \\ 1 & 3 \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} \quad \left(\because \begin{bmatrix} a \\ b \end{bmatrix} = P\begin{bmatrix} x \\ y \end{bmatrix}\right)$$

$3x + y = a$ ……… (1)

$x + 3y = b$ ……… (2)

$a^2 + b^2 = 9x^2 + y^2 + 6xy + x^2 + 9y^2 + 6xy$

$\Rightarrow 10x^2 + 10y^2 + 12xy = 1 \quad (\because a^2 + b^2 = 1)$

$a = 10, b = 10, h = 6$

$h^2 - ab < 0$

It represents ellipse

The lengths of semi- axes are $(AB - H^2)\, r^4 - (A + B)\, r^2 + 1 = 0$

$64\, r^4 - 20\, r^2 + 1 = 0$

$r^2 = \frac{1}{4}$ (or) $r^2 = \frac{1}{16}$

Both r^2 values are positive, so it represents ellipse.

$r = \frac{1}{2}$ (or) $r = \frac{1}{4}$

Length of Major axis = 2r = 1

Length of Minor axis = 2r = $\frac{1}{2}$

Equation of the majors axis is $\left(a - \frac{1}{r_1^2}\right)x + hy = 0$

$(10 - 4)\, x + 6y = 0$

$\Rightarrow x + y = 0$

Equation of the minor axis is $\left(a - \frac{1}{r_2^2}\right)x + hy = 0$

$(10 - 16)\, x + 6\, y = 0$

$\Rightarrow y - x = 0$

Major axis exists along $y = -x$ and minor axis exists along $y = x$

The vector $\begin{bmatrix}1\\1\end{bmatrix}$ lies on the line $y = x$

$\therefore$ Option (D) is correct.

33. Let the probability density function of a random variable X, be given as: $f_x(x) = \frac{3}{2}e^{-3x}u(x) + ae^{4x}u(-x)$ where u(x) is the unit step function.

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

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

Ans: (A)

Sol: $f(x) = \frac{3}{2}e^{-3x}\, u(x) + ae^{4x}\, u(-x)$

For a :

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

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

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

$$a = 2$$

$$p(x \le 0) = \int_{-\infty}^{0} ae^{4x}dx$$

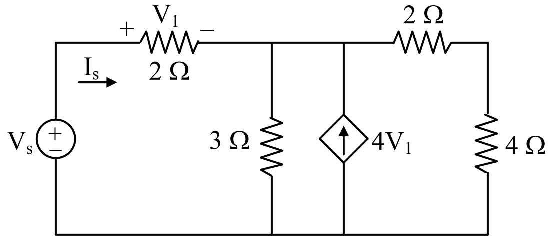
$$= 2\int_{-\infty}^{0} e^{4x}dx$$

$$= 2\left(\frac{e^{4x}}{4}\right)_{-\infty}^{0}$$

$$= \frac{2}{4} = \frac{1}{2}$$

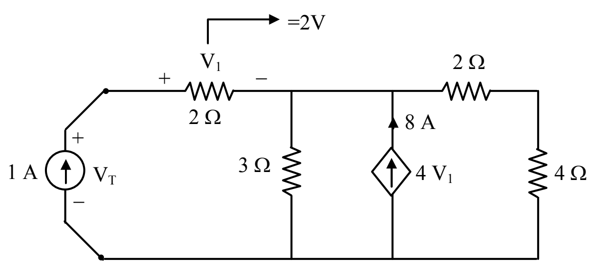
$$\therefore \left(2, \frac{1}{2}\right)$$

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



Ans: 20

Sol:



$$-1 + \frac{V}{3} - 8 + \frac{V}{6} = 0$$

$\Rightarrow -6 + 2V - 48 + V = 0$

$\Rightarrow 3V = 54$

$\Rightarrow V = 18$

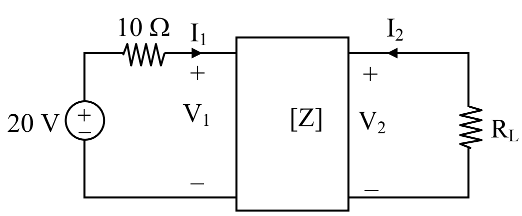
So, KVL at first loop

$$-V_T + 2 + 18 = 0$$

$$V_T = 20$$

So, driving point impedance $= \dfrac{V_T}{1} = 20\ \Omega$

35. 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 ______.



Ans: 35.55

Sol: $V_1 = 40I_1 + 60I_2$ .... (1)

$V_2 = 80I_1 + 100I_2$ .... (2)

Also $20 = 10I_1 + V_1$ .... (3)

$V_2 = -20I_2$ .... (4)

Solving (3) in (1)

$20 - 10I_1 = 40I_1 + 60I_2$

$50I_1 + 60I_2 = 20$

$5I_1 + 6I_2 = 2$ ………. (A)

(4) in (2)

$-20I_2 = 80\, I_1 + 100I_2$

$80I_1 + 120I_2 = 0$

$2I_1 + 3I_2 = 0$ …….. (3)

(A) × 2 ⇒ $10I_1 + 12I_2 = 4$

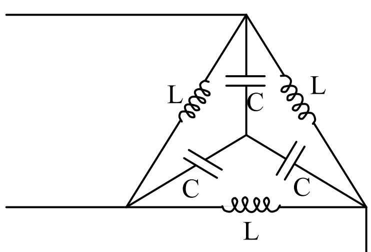
(B) × 5 ⇒ $10I_1 + 15I_2 = 0$

$3I_2 = -4$

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

So, $P_{RL} = P_{20\Omega} = I_2^2(20) = \frac{16}{9} \times 20 = 35.55$ W

36. 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 ______.



Ans: 3

Sol: Converting internal STAR capacitors into Δ, $+j\omega L = +j(2\pi fL) = +j100\pi \times 10 \times 10^{-3} = j\pi\Omega$

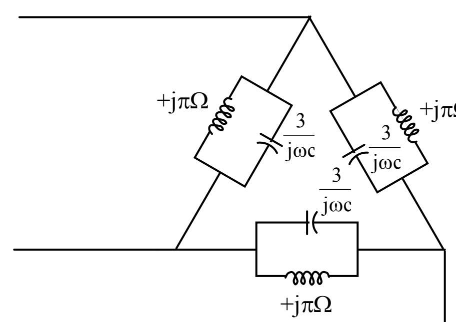
If line currents have to be zero

Then $|X_C| = |X_L|$

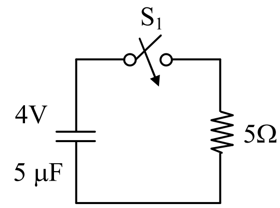
$X_{C2} = \pi\Omega$

$\frac{1}{\omega \frac{C}{3}} = \pi \Rightarrow C = \frac{3}{\omega\pi}$

$C = \frac{3}{2\pi(50)\pi} = 3$ mF



37. 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 ______.



Ans: 7

Sol: $v(t) = 4e^{-t/25\mu}$ and $\tau = RC = 5 \times 5 \times 10^{-6}$

$v(t) = 4e^{-\frac{1000000}{25}t}$

$v(t) = 4e^{-40000t}$

$q(t) = C\,v(t)$

$\Rightarrow q(t) = 5\,\mu\,(4e^{-40000t})$

$\Rightarrow q(t) = 20\,e^{-40000t}\,\mu c$

q(t) at 25 μsec; $= 20e^{-40000\times 25\times 10^{-6}} = 20e^{-1} = 7.357\,\mu c$

q(t) at 100 μsec; $= 20e^{-40000\times 100\times 10^{-6}} = 20e^{-4} = 0.3663\,\mu c$

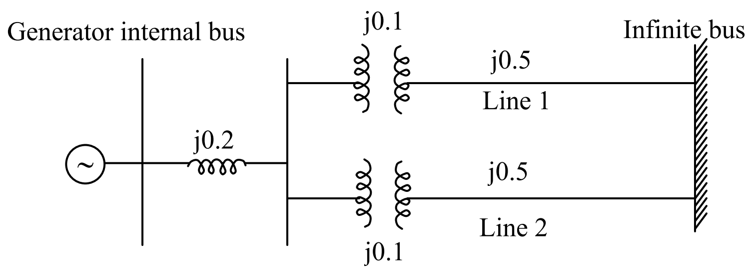
Total charge lost

= (7.357 – 0.366) μc

= 7 μc

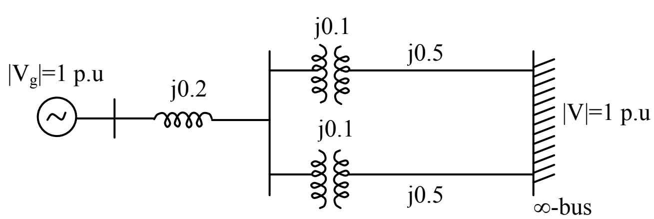
38. The single line diagram of a balanced power system is shown in the figure. The voltage magnitude at the generator internal bus is constant and 1.0 p.u. The p.u. reactances of different components in the system are also shown in the figure. The infinite bus voltage magnitude is 1.0 p.u. A three phase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

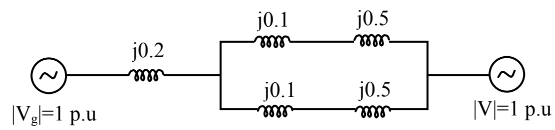


Ans: 2.2857

Sol: Single line diagram of a power system network



Pre fault condition:

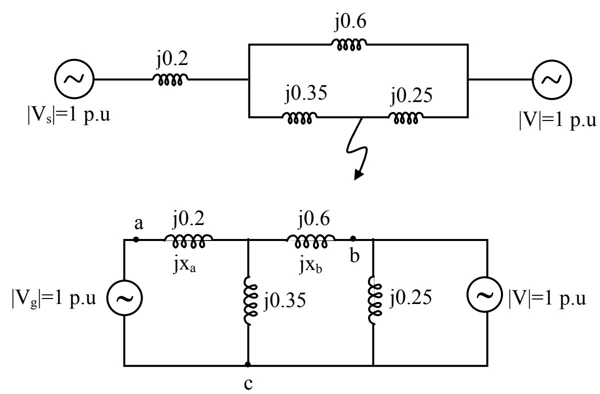


Transfer impedance,

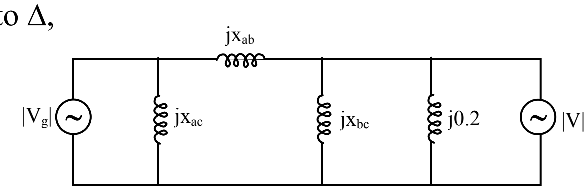
$z_{1eq} = j0.2 + (j0.6 \parallel j0.6) = j0.5$ p.u

Maximum power transfer, $P_{max_1} = \dfrac{|V_g||V|}{|z_{1eq}|} = \dfrac{1\times1}{0.5} = 2$ p.u

During fault at mid point at line-2,



convert Y_{abc} into Δ,



$$x_{ab} = x_a + x_b + \frac{x_a . x_b}{x_c}$$

$$= 0.2 + 0.6 + \frac{0.2\times0.6}{0.35} = 1.143 \text{ p.u}$$

parameter 'B' is $B = jx_{ab} = j1.143$ p.u

max power t/f, $P_{max_2} = \dfrac{|V_g||V|}{|B|} = \dfrac{1\times1}{1.143} = 0.875$ p.u

Now, $\dfrac{P_{max_1}}{P_{max_2}} = \dfrac{2}{0.875} = 2.2857$

39. 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) $0 < T < \frac{8(K+1)}{K-1}$

Ans: (C)

Sol: $CE = 1 + \frac{Ks+K}{(s+Ts^2)(1+2s)}$

$s + Ts^2 + 2s^2 + 2Ts^3 + Ks + K = 0$

$2Ts^3 + (T+2)s^2 + (K+1)s + K = 0$

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

$K > 0$

$(T + 2)(K+1) - 2TK > 0$

$KT + 2K + T + 2 - 2TK > 0$

$K(T - 2T + 2) > -(T + 2)$

$K(T-2) < T + 2$

$K < \left(\frac{T+2}{T-2}\right)$

40. 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 traveling wave to be the velocity of light, the length of the line, in km, is _________.

Ans: 294.8

Sol: At no load condition $V_R > V_S$ indicates Ferranti effect

$V_S = AV_R$ when load is absent

$A = \frac{V_S}{V_R} = 0.95238$

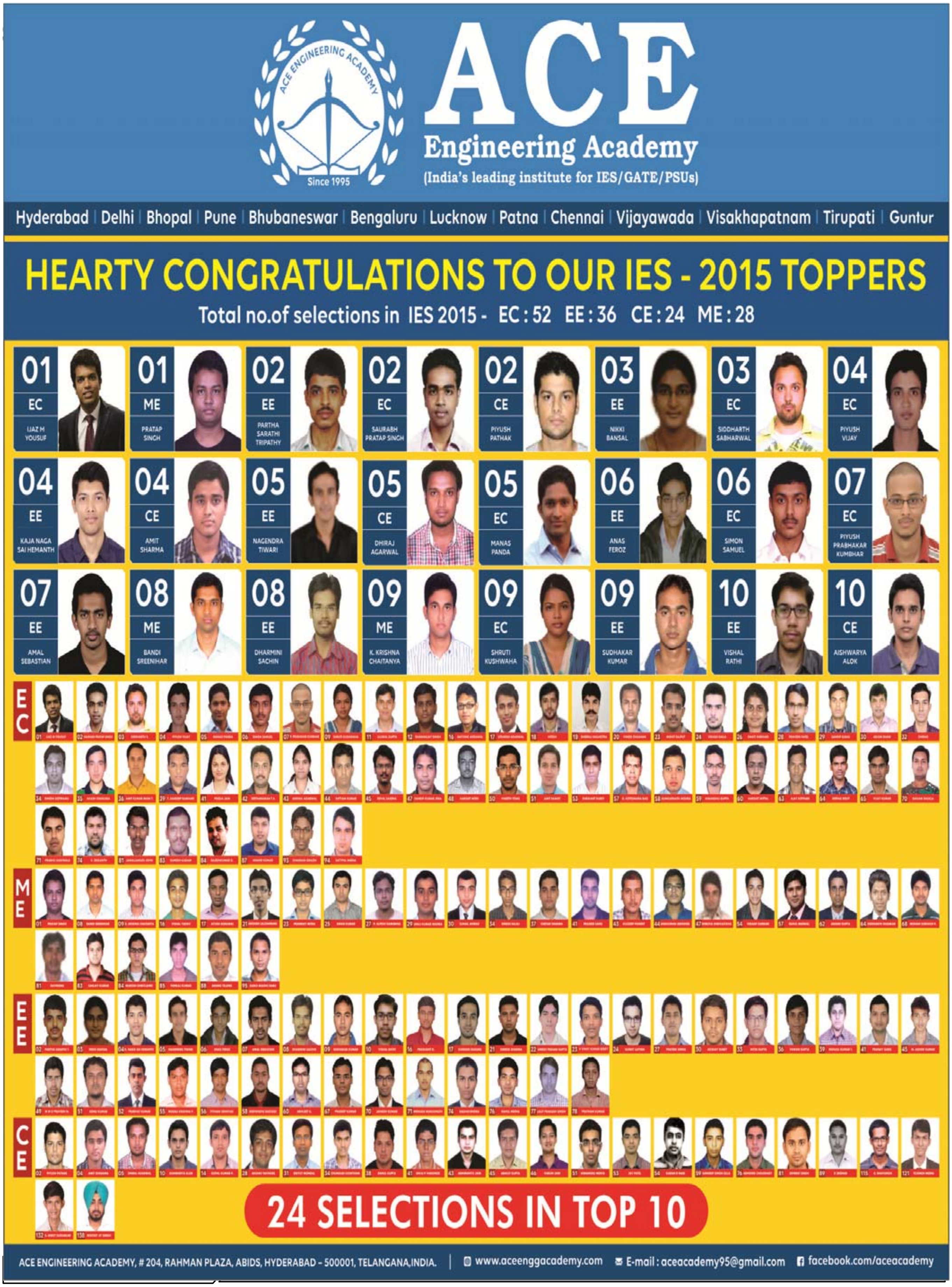
$1 + \frac{YZ}{2} = 0.95238$

$1 - \frac{\omega^2 l^2}{2V^2} = 0.95238$

$l^2 = (1 - 0.95238) \times \frac{2V^2}{\omega^2}$

$l = \sqrt{2} \times \frac{V}{\omega} \times \sqrt{(1-0.95238)}$

$I = 294.8$ km



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Total no.of selections in IES 2015 - EC : 52 EE : 36 CE : 24 ME : 28
01 EC IJAZ M YOUSUF
01 ME PRATAP SINGH
02 EE PARTHA SARATHI TRIPATHY
02 EC SAURABH PRATAP SINGH
02 CE PIYUSH PATHAK
03 EE NIKKI BANSAL
03 EC SIDDHARTH SABHARWAL
04 EC PIYUSH VIJAY
04 EE KAJA NAGA SAI HEMANTH
04 CE AMIT SHARMA
05 EE NAGENDRA TIWARI
05 CE DHIRAJ AGARWAL
05 EC MANAS PANDA
06 EE ANAS FEROZ
06 EC SIMON SAMUEL
07 EC PIYUSH PRABHAKAR KUMBHAR
07 EE AMAL SEBASTIAN
08 ME BANDI SREENIHAR
08 EE DHARMINI SACHIN
09 ME K. KRISHNA CHAITANYA
09 EC SHRUTI KUSHWAHA
09 EE SUDHAKAR KUMAR
10 EE VISHAL RATHI
10 CE AISHWARYA ALOK
EC
ME
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41. 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 _______.

Ans: 0.316

Sol: Industry operated at 0.8 pF with 500 kVA rating to make the pf as unity compensation required is = 500 sinϕ = 500 × 0.6 = 300 kVAr.

If motor used for compensation is taking a real power for 100 MW, its complex power = (100–j300)

Power factor of motor is = $\dfrac{P}{\sqrt{P^2+Q^2}} = \dfrac{100}{\sqrt{100^2+300^2}}$ = 0.316 leading

42. 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 ________.

Ans: 282.8

Sol: $\lambda = \dfrac{\sqrt{i}}{g} \Rightarrow i = g^2\lambda^2$

$$F = \frac{-1}{2}\lambda\frac{di}{dg}$$

$$F = \frac{-1}{2}\lambda\lambda^2 2g$$

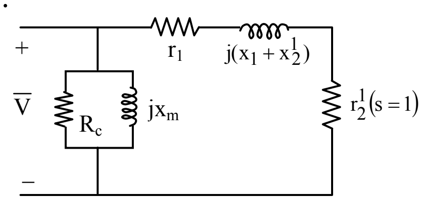
$$|F| = \lambda^3 g$$

$$|F| = 200\sqrt{2} = 282.8 \text{ N}$$

43. 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 110V, in ampere, is ____.

Ans: 31.8

Sol: Equivalent circuit per phase at starting :



All the equivalent circuit parameters are constants (if frequency is constant).

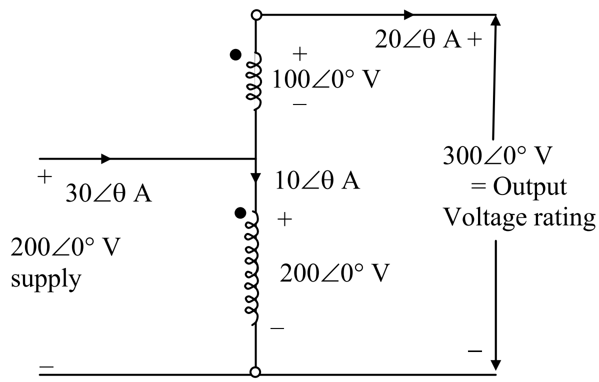
So, current drawn ∝ voltage applied

At 110V, current = $\dfrac{110}{415}\times 120 = 31.8\text{A}$

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

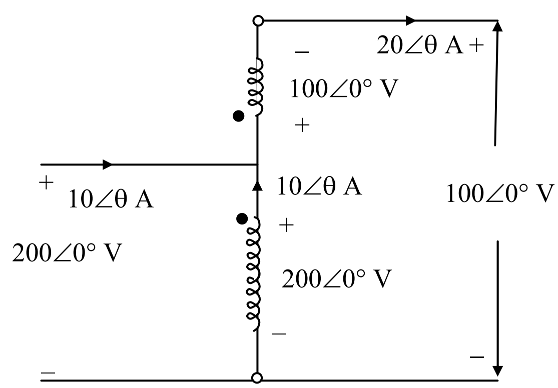
Ans: 6

Sol: To obtain maximum KVA rating, the output voltage rating as well as the output current rating must be the largest possible. For this purpose, the two windings are connected as shown.



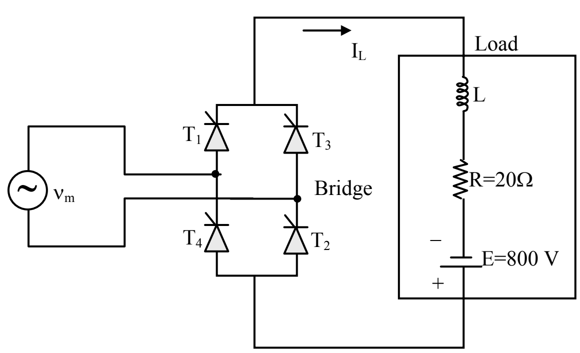
The kVA output rating (maximum possible) = 300×20 = 6 kVA

The connection must be such that dots are as shown. For example consider a connection as below.



Output rating now is 2 KVA only

45. 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 Ω, 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 fed back to the source, in kW is ___________



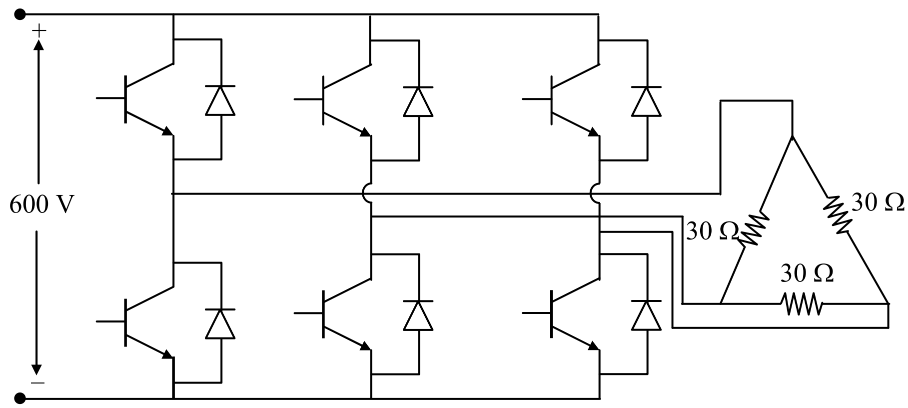
Ans: 6

Sol: $\frac{2V_m}{\pi}\cos\alpha = E + RI_o$

$$\Rightarrow \frac{2\times 200\pi}{\pi}\cos 120^\circ = -800 + 20\times I_o \Rightarrow -200 = -800 + RI_o \Rightarrow I_o = 30\text{ A}$$

As switches are lossless, power fed back to the source = 200 V × 30 A = 6 kW

46. 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 device, the power consumed by the load, in kW, is ________.



Ans: 24

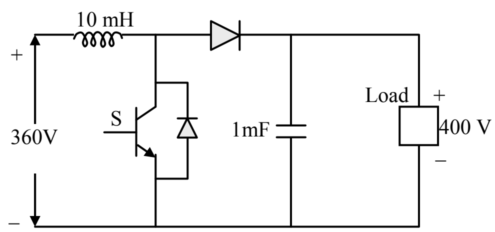
Sol: By converting the load into equivalent star, $R_{ph} = \frac{30}{3} = 10\,\Omega$

In 180° conduction mode, rms value of each phase voltage,

$$V_{ph} = \frac{\sqrt{2}}{3}V_{dc} = \frac{\sqrt{2}}{3}\times 600 = 200\sqrt{2}\text{ V}$$

Power consumed by the load, $P_o = 3\times\frac{V_{ph}^2}{R} = 3\times\frac{\left(200\sqrt{2}\right)^2}{10} = 24\text{ kW}$

47. 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 _______.



Ans: Insufficient data

Sol: For continuous inductor current, $V_o = \frac{V_{dc}}{1-D} \Rightarrow 1-D = \frac{360}{400} \Rightarrow D = 0.1$

As output power is 4 kW at 400 V, I_o = 10 A

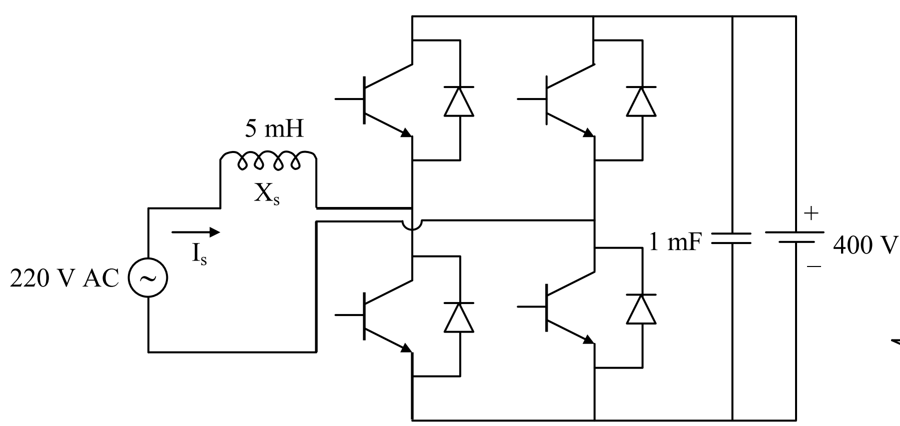
From power balance, $P_{in} = P_{out}$ or $V_{dc} \times I_i = V_o \times I_o$, it will give $I_i = \frac{4000}{360} = 11.11\,A$

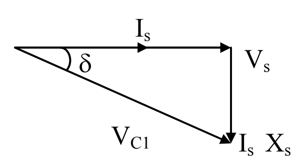
As the switching frequency is not given in the question, we cannot proceed further

But by assuming one condition i.e the current through supply line is constant of 11.11 A then

r.m.s value of switch current $= 11.11 \times \sqrt{\frac{DT}{T}} = 11.11\sqrt{D} = 11.11\sqrt{0.1} = 3.51$ A

48. A single-phase bi-directional voltage source converter (VSC) is shown in the figure below. All devices are ideal. It is used to change 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 _______.





Ans: 5.69

Sol: Fundamental component of VSC voltage, $V_{C1} = \frac{2\sqrt{2}}{\pi} V_{dc} = 0.9 \times 400 = 360$ V

Power flow can be expressed as, $P = \frac{V_s V_{C1}}{X_s} \sin\delta$

$$\Rightarrow 5000 = \frac{220 \times 360}{(100\pi \times 5 \times 10^{-3})} \sin\delta$$

$$\delta = 5.69°$$

49. Consider a linear time invariant system $\dot{x} = Ax$, 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) = α is

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

Ans: (A)

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

$X(t) = e^{At} \times (0)$

$e^{At} = L^{-1}[(sI-A)^{-1}] = \begin{bmatrix} e^{\lambda_1 t} & 0 \\ 0 & e^{\lambda_2 t} \end{bmatrix}$

$X(0) = \alpha$

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

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

50. A second-order real system has the following properties:

a) the damping ratio $\zeta = 0.5$ 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) $\dfrac{102}{s^2+10s+100}$ (C) $\dfrac{100}{s^2+10s+100}$ (D) $\dfrac{102}{s^2+5s+100}$

Ans: (B)

Sol: $TF = \dfrac{102}{s^2+10s+100}$

$\omega_n = 10, \quad \zeta = 0.5$

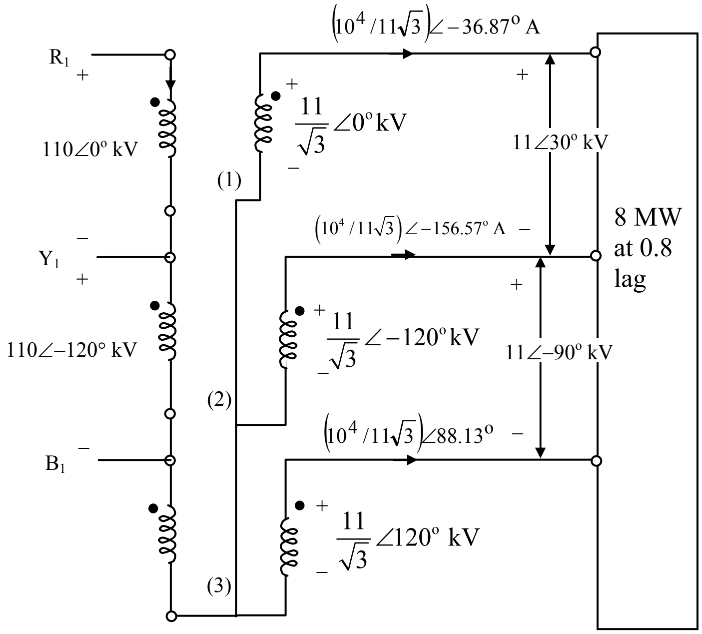
$\text{DC gain} = \dfrac{102}{100} = 1.02$

51. Three single-phase transformers are connected to form a delta-star three-phase transformer of 110kV/ 11 kV. The transformer supplies at 11 kV a load of 8 MW at 0.8 p.f lagging to a nearby plant. Neglect the transformer losses. The ratio phase currents in delta side to star side is

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

Ans: (A)

Sol:



$$\sqrt{3}\ 11000 I_L(0.8) = 8\times10^6,$$

$$I_L = (10^4/11\sqrt{3})\angle-36.87^\circ \text{ A}$$

$$\text{Phase current on primary side} = \left[\left(\frac{11}{\sqrt{3}}\right)/110\right]$$

$$\text{Phase current on star side} = \frac{1}{10\sqrt{3}}(\text{phase current on star side})$$

(OR)

∇ - side phase voltage = 110 kV

Y - side phase voltage = $\frac{11}{\sqrt{3}}$ kV

$$\frac{\Delta-\text{side phase current}}{Y-\text{side phase current}} = \frac{11}{110\sqrt{3}} = \frac{1}{10\sqrt{3}}$$

52. 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

Ans: (A)

Sol: $\frac{d}{ds}\left(\frac{s}{s^2-5s+4}\right)=0$

$(s^2-5s+4)-s[2s-s)=0$

$s^2-5s+4-2s^2+5s=0$

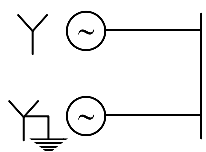
$s^2-4=0$

$s=\pm 2$

$K\big|_{s=2}=\left.\frac{(s-1)(s-4)}{s}\right|_{s=2}=\left|\frac{(2-1)(2-4)}{2}\right|=1$

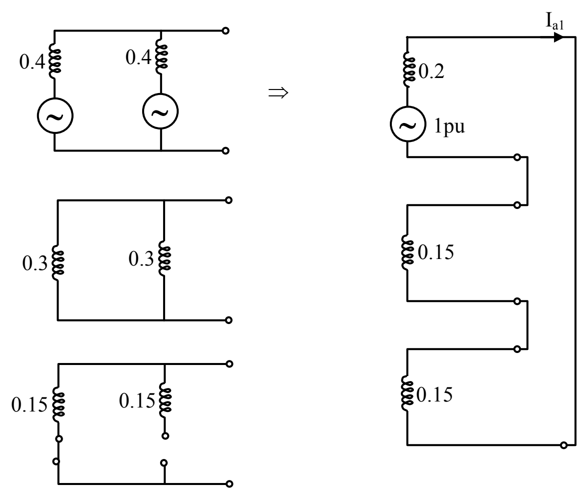
$K=1$

53. Two identical unloaded generators are connected I parallel as shown in the figure. Both the generators are having positive, negative and zero sequence impedances of j0.4 p.u, j0.3 p.u and j0.15 p.u, respectively. If the fault voltage is 1 p.u, for a line-to ground (L-G) fault at the terminals of the generators, the fault current, in p.u is _____.



Ans: 6

Sol: Equivalent circuit for LG fault is



$I_{a1}=\frac{1}{0.2+0.15+0.15}=2$ pu

$I_F=3\times I_{a1}=6$ pu

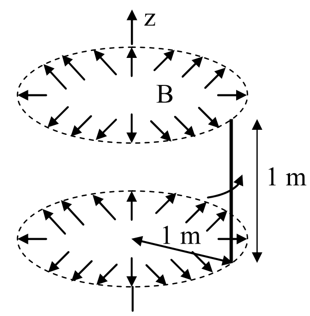
54. An energy meter having meter constant of 1200 revolutions/kWh makes 20 revolutions in 30 seconds for a constant load. The load in kW is _____________.

Ans: 2

Sol: $M.C = \dfrac{rev}{kWh} \Rightarrow 1200 = \dfrac{20}{kW \times \dfrac{30}{3600}}$

$$kW = \frac{20}{1200 \times \dfrac{30}{3600}} = \frac{20}{10} = 2\ kW$$

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



Ans: 9.549

Sol: $V_{emf} = Blv$

$$V = = \frac{1}{1} = 1\ m/s$$

$$V = 1 \times \frac{60}{2\pi} = 9.549\ rpm$$