Index

1. Question Paper Analysis
2. Question Paper & Answer keys
ANALYSIS OF GATE 2016
Electrical Engineering

GATE-2016- EE 7 Feb -Afternoon Session-8

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>NO OF QUESTION</th>
<th>Topics Asked in Paper</th>
<th>Level of Toughness</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Theory</td>
<td>1 M: 4 2 M: 2</td>
<td>Reduction of networks with controlled voltage and current sources; Transient; Resonance; AC circuit analysis</td>
<td>Moderate</td>
<td>8</td>
</tr>
<tr>
<td>Control System</td>
<td>1 M: 2 2 M: 3</td>
<td>Routh Stability; Lag-lead system; Bode plot and transfer function</td>
<td>Tough</td>
<td>8</td>
</tr>
<tr>
<td>Signal &amp; System</td>
<td>1 M: 2 2 M: 2</td>
<td>LTI system; Fourier transform; Laplace transform</td>
<td>Tough</td>
<td>6</td>
</tr>
</tbody>
</table>
### Digital Electronics

| 1 M: 1 | 2 M: 2 | Boolean algebra K-Map | Easy | 5

### Analog Circuits

| 1 M: 1 | 2 M: 1 | Op.AMP analysis; Amplifier | Easy | 3

### EMT

| 1 M: 2 | 2 M: 2 | *Electrostatic field - Properties | Moderate | 6

### Measurement

| 1 M: 1 | 2 M: 2 | Power Factor measurement; Energy meter | Moderate | 5

### Electrical Machines


### Power System

| 1 M: 3 | 2 M: 4 | Stability; LLG fault; Line parameters Transmission Line | Tough | 11

### Power Electronics

| 1 M: 2 | 2 M: 3 | VSI; Rectifier - full wave - input power factor, efficiency; Chopper; Converter | Tough | 8

### Mathematics

| 1 M: 5 | 2 M: 5 | Complex integration; Differential Equation; infinite series; Probability-basic. | Moderate | 15

### GA

| 1 M: 5 | 2 M: 5 | Time & Work; Paragraph; English fill in Blank; Number theory; Venn Diagram; Mensuration & Area. | Easy | 15

### Total

| 65 | Moderate | 100

* Indicates Questions from New Syllabus

### Faculty Feedback:

- The question paper was bit tough and was little offbeat than conventional GATE papers.
- Plenty of Numerical Answer Type (NAT) questions asked.
- Online Calculator was difficult to handle without Practice.
- Numerical & Verbal ability was relatively easy.
- Practice previous Year Questions & Online Test Series will be beneficial.
GATE-2016

Question Paper

&

Answer Keys
GATE 2016 Examination
Electrical Engineering

Test Date: 07/02/2016
Test Time: 9:00 AM to 12:00 PM
Subject Name: ELECTRICAL ENGINEERING

Section: General Aptitude

Q NO. 1.
The chairman requested the aggrieved shareholders to ____________ him.

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

[Ans. C]

Q NO. 2.
Identify the correct spelling out of the given options:

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

[Ans. B]

Q NO. 3.
Pick the odd one out in the following:

13, 23, 33, 43, 53

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

[Ans. B]

13, 23, 43, 53 are all prime numbers; Only 33 is composite 33, (11 × 3); Odd one out is 33.

Q NO. 4.
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]
Q NO. 5.

If \(|9y - 6| = 3\), then \(y^2 - 4y/3\) is ________.

- (A) 0
- (B) +1/3
- (C) -1/3
- (D) undefined

[Ans. C]

\(|9y - 6| = 3\)

\(\Rightarrow\) Either \((9y - 6 = 3)\) or \((9y - 6 = -3)\); \(\Rightarrow y = 1\) or \(y = 1/3\)

\[y^2 - \frac{4y}{3}\]

Put \(y = 1/3\);

\(\left(\frac{1}{3}\right)^2 - \frac{4}{3} \times \frac{1}{3} = -\frac{1}{3}\)

or \(y^2 - \frac{4y}{3}\)

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

Q NO. 6.

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. *] Range: 120 to 120
According to information in question
Large plants are 1, 4, 8, 9 which are having installed capacity of at least 200 tonnes.
Total production of large plant \[160 + 190 + 230 + 190 \] = 770
Remaining plant number 2, 3, 5, 6, 7 all are small plants with capacity less than 200 tonnes.
Total production of small plants = 150 + 160 + 120 + 100 + 120 = 650
Difference = 750 – 650 = z120

Q NO. 7.
A poll of students appearing for masters in engineering indicated that 60% of the students believed 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.

[Ans. C]

Q NO. 8.
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) SIT-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]
Q NO. 9.
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

[Ans. A]
Probability of free throw = \(\frac{60}{100} = 0.6\)
Probability of NOT free throw = \(1 - 0.6 = 0.4\)
So required probability of exactly 6 throws in 10 attempts will be given by
\[\binom{10}{6} (0.6)^6 \times (0.4)^4 = 0.2508\]

Q NO. 10.
The numeral in the units position of \(211^{870} + 146^{127} \times 3^{424}\) is_____.

[Ans. ∗] Range: 7 to 7

Unit digit of \(211^{870} + 146^{127} \times 3^{424}\) is \(1 + 6 \times 1 = 7\)
Section: Technical

Q NO. 1.

The output expression for the Karnaugh map shown below is

\[
\begin{array}{ccc|c|c}
A & B & C & & \\
00 & 01 & 11 & 10 & \hline
0 & 1 & 0 & 0 & 1 \\
1 & 1 & 1 & 1 & 1
\end{array}
\]

(A) \( A + B \)  \hspace{0.5cm} (B) \( A + \bar{C} \) \hspace{0.5cm} (C) \( \bar{A} + \bar{C} \) \hspace{0.5cm} (D) \( \bar{A} + C \)

\[\text{Ans. B}\]

Q NO. 2.

The circuit shown below is an example of a

\[
\begin{align*}
V_{\text{in}} & \quad R_1 \quad \text{R}_{2} \quad C \\
\text{+15 V} & \quad \text{+15 V} \quad V_{\text{out}}
\end{align*}
\]

(A) low pass filter. \hspace{0.5cm} (B) band pass filter. \hspace{0.5cm} (C) high pass filter. \hspace{0.5cm} (D) notch filter.

\[\text{Ans. A}\]

\[
V_{\text{out}} = \left[ \frac{R_2 \cdot \frac{1}{j\omega C}/R_2 + 1/j\omega C}{R_1} \right] V_{\text{in}}
\]
Q NO. 3.

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 _________.

\[ V_{\text{out}} = -\frac{R_2}{R_1(R_2j\omega C + 1)} \]

So the system is a low pass filter

\[ V_{\text{in}} = \frac{R_2}{R_1(R_2j\omega C + 1)} \]

\[ R = 80 \text{k}\Omega \]
\[ X_C = 40 \text{k}\Omega \]
\[ 100 \text{V} \]
\[ X_L = 10 \Omega \]
\[ 1:100 \]
\[ R = 80 \text{k}\Omega \]
\[ 100 \text{V} \]
\[ X_C = 40 \text{k}\Omega \]

[Ans. *] Range: 9.5 to 10.5

The below circuit can be drawn by transferring secondary circuit to primary side.

\[ I = \frac{100V}{(8 + 10j - 4)\Omega} = \frac{100V}{(8 + 6j)\Omega} \]

So the rms value of \( I \) will be 10 A.

Q NO. 4.

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]

The differential equation

\[ \frac{dy(t)}{dt} + \frac{1}{6}y(t) = 3x(t) \]

So, \( sY(s) + \frac{1}{6}Y(s) = 3X(s) \)
Y(s) = \frac{3X(s)}{(s + \frac{1}{6})}; x(s) = \frac{9}{(s + \frac{1}{3})}

So, Y(s) = 9 \left(\frac{1}{s + \frac{1}{3}}\right) - 54 \left(\frac{1}{s + \frac{1}{6}}\right)

So, y(t) = (54e^{-\frac{t}{6}} - 54e^{-\frac{t}{3}})u(t)

Q NO. 5.
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.] Range: 6 to 6
Since x(t) is band limited to 5 kHz then maximum frequency in x(t) cos (2000πt) is 6 kHz.

Q NO. 6.
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

[Ans. B]
f(z) = z + z*
f(z) = 2x is continuous (polynomial)
u = 2x \quad v = 0
u_x = 2 \quad u_y = 0
v_x = 0 \quad u_y = 0
C.R. equation not satisfied.
∴ Nowhere analytic.

Q NO. 7.
A 3 x 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

[Ans. D]
By Cayley Hamilton theorem
\lambda^3 = \lambda
\lambda = 0, 1, −1
Q NO. 8.

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) \( te^{-t}u(t) \)  \hspace{1cm} (B) \( (e^{-t} - te^{-t})u(t) \)  \hspace{1cm} (C) \( (-e^{-t} + te^{-t})u(t) \)  \hspace{1cm} (D) \( e^{-t}u(t) \)

[Ans. A]

The differential equation is
\[ y''(t) + 2y'(t) + y(t) = 0 \]
So, \( s^2Y(s) - sy(0) - y'(0)) + 2[sY(s) - y(0)] + Y(s) = 0 \)
So, \( Y(s) = \frac{sy(0) + y'(0) + 2y(0)}{(s^2 + 2s + 1)} \)
Given that \( y'(0) = 1, y(0) = 0 \)
So, \( Y(s) = \frac{1}{(s + 1)^2} \)
So, \( y(t) = te^{-t}u(t) \)

Q NO. 9.

The value of the line integral
\[ \int_C (2xy^2 \, dx + 2x^2y \, dy + dz) \]
along a path joining the origin \( (0, 0, 0) \) and the point \( (1, 1, 1) \) is

(A) 0  \hspace{1cm} (B) 2  \hspace{1cm} (C) 4  \hspace{1cm} (D) 6

[Ans. B]

\[ \int_C \vec{F} \cdot d\vec{r} \]
Where \( \vec{F} = xy^2 \hat{i} + 2x^2 y \hat{j} + \hat{k} \)
\( \nabla \times \vec{F} = 0 \)
(\( \vec{F} \) is irrotational \( \Rightarrow \vec{F} \) is conservative)
\( \vec{F} = \nabla \phi \) (\( \phi \) is scalar potational function)
\( \phi_x = 2xy^2 \)
\( \phi_y = 2x^2y \)
\( \phi_z = 1 \)
\( \Rightarrow \phi = x^2y^2 + z + C \)
Where, \( \vec{F} \) is conservative
\[ \int_C \vec{F} \cdot d\vec{r} = \int_{(0,0,0)}^{(1,1,1)} d\phi = [x^2y^2 + z]_{(0,0,0)}^{(1,1,1)} = 2 \]
Q NO. 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]

Q NO. 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

\[
\begin{align*}
(A) & \quad 65, 35 \\
(C) & \quad 60, 90 \\
(B) & \quad 50, 50 \\
(D) & \quad 60, 80
\end{align*}
\]

[Ans. C]

Q NO. 12.
The voltage (V) and current (I) across a load are as follows.
\[
\begin{align*}
t(t) & = 100 \sin(\omega t) \\
i(t) & = 10 \sin(\omega t - 60^\circ) + 2 \sin(3\omega t) + 5 \sin(5\omega t)
\end{align*}
\]
The average power consumed by the load, in W, is

[Ans. *] Range: 249 to 251

Method 1:
The average power consumed by the load \( P = V_I I_1 \cos \phi_1 \)

Method 2:
\[
\begin{align*}
V(t) & = 100 \sin(\omega t) \\
i(t) & = 10 \sin(\omega t - 60^\circ) + 2 \sin(3\omega t) + 5 \sin(5\omega t) \\
P & = V(t) i(t) \\
& = 1000 \sin(\omega t) \cdot \sin(\omega t - 60^\circ) + 200 \sin(\omega t) \cdot \sin(3\omega t) + 500 \sin(\omega t) \sin(5\omega t) \\
& = 500 [\cos(\omega t - \omega t + 60^\circ) - \cos(\omega t + \omega t - 60^\circ)] + 100[\cos(\omega t - 3\omega t) - \cos(\omega t + 3\omega t)] \\
& \quad + 250 [\cos(\omega t - 4\omega t) - \cos(6\omega t)] \\
& = 500 \cos 60^\circ = 250 \text{ W}
\end{align*}
\]
Average value of \( \cos (2\omega t - 60^\circ), \cos (2\omega t), \cos (4\omega t), \cos (6 \omega) \) will be zero.
Q NO. 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 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) $R_1$, $R_5$

[Ans. D]

Q NO. 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) $189 \times 189$  
(B) $100 \times 100$  
(C) $90 \times 90$  
(D) $180 \times 180$

[Ans. A]
Size of the Jacobian matrix is, $2m - m - 1 \times 2n - m - 1$
Given that 10 generator buses, we need to assume with in the 10 buses one bus as slack bus then $(2 \times 100 - 10 - 1) \times (2 \times 100 - 10 - 1) = 189 \times 189$

Q NO. 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]

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

$SIL = \frac{400 \times 400}{400} = 400 \text{ MW}$

In the second case $SIL$ decreases means $Z_n$ increases.

$Z_n$ increases with increase in inductance ‘$L$’

So, it is inductive; Load < $SIL$ means, line behaves capacitive to compensate it inductor to be placed.
Q NO. 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

\[
\begin{array}{l}
\text{A} \quad \varepsilon_r=1 \\
\text{B} \quad \varepsilon_r=4 \\
\end{array}
\]

2 cm

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

[Ans. C]

Q NO. 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.*] Range: 4.9 to 5.1

\[
I'' = \frac{E_g}{X''_d}, I = \frac{E_g}{X}; \quad \frac{I}{I''} = \frac{X}{X''_d} = \frac{1.0}{0.2} = 5.0 \text{ p.u}
\]

Q NO. 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.*] Range: 0.69 to 0.72

\[
H(s) = \frac{1}{(s + 1)}
\]

Put \(s = j\omega\), \(H(j\omega) = \frac{1}{j\omega + 1}\)

\[
|H(j\omega)| = \frac{1}{\sqrt{\omega^2 + 1}}
\]

\(\therefore\) Input \(x(t) = \cos(t)\)

Here \(\omega = 1 \text{ rad/sec}\)

and \(|x(t)| = 1\); Hence, steady state output

\[
y(t) = |x(t)| \times |H(j\omega)|_{\omega=1} \cos[t + \angle H(j\omega)]
\]

\[
A = \frac{|x(t)| \times |H(j\omega)|}{|H(j\omega)|_{\omega=1}} = 0.707
\]

\[
A = \frac{1}{\sqrt{2}} = 0.707
\]
Q NO. 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. *] Range: 57 to 58
In the 3-φ diode bridge rectifier each diode conducts for 120° for one complete cycle

\[ I_{D_{rms}} = \sqrt{\frac{1}{2\pi} \int_{0}^{2\pi/3} I_{0}^2 \, dt} = \sqrt{\frac{2\pi}{2\pi \times 3}} \]
\[ = \frac{I_{0}}{\sqrt{3}} = \frac{100}{\sqrt{3}} = 57.7 \text{ A} \]

Q NO. 20.
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 __________.

[Ans. *] Range: 59.5 to 60.5
When switch ‘S’ is OFF, diode D is ON then

\[ \therefore \text{Peak voltage across switch} = 24 + 36 = 60 \text{ V} \]

Q NO. 21.
For the network shown in the figure below, the frequency (in rad/s) at which the maximum phase lag occurs is __________.

[Ans. *] Range: 0.30 to 0.33
\( \therefore \) Assuming \( R_1 = 9 \, \Omega; R_2 = 1 \, \Omega \)

We can write

\[
\begin{align*}
V_o(s) &= R_2 + \frac{1}{sC} \\
V_{in}(s) &= \frac{R_2}{1 + R_2 + \frac{1}{sC}} \\
&= \frac{1 + (R_1 + R_2)Cs}{1 + R_2 \cdot Cs} \\
&= \frac{1 + \left(\frac{R_1 + R_2}{R_2}\right) R_2 Cs}{1 + \left(\frac{R_1 + R_2}{R_2}\right) R_2 Cs}
\end{align*}
\]

Let \( R_2 C = T \)

\[
R_1 + R_2 = \beta
\]

Hence

\[
\begin{align*}
V_o(s) &= 1 + Ts \\
V_{in}(s) &= \frac{1}{(1 + \beta Ts)}
\end{align*}
\]

Which represent a lag compensator

\( \therefore \) Here \( T = R_2 C = 1.1 = 1 \, \text{sec} \)

\( \beta = \frac{1 + 9}{1} = 10 \)

Maximum phase lag occurs at frequency

\[
\omega_n = \frac{1}{Tr} = \frac{1}{1 \sqrt{10}} = 0.316 \, \text{rad/sec}
\]

**Q NO. 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]

Inter changing the terminals of the auxiliary winding

**Q NO. 23.**

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

![Circuit Diagram]

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

[Ans. D]
Q NO. 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]

Number of KCL equation = n - 1 = 5 - 1 = 4
Number of KVL equation = b - (n - 1) = 7 - (5 - 1) = 3

Q NO. 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]

Q NO. 26.

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

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

[Ans. D]

\[
F = (a + b + c + d) + (b + \overline{c}) = (a + b + c + d) \cdot (b + \overline{c})
\]
\[
= \overline{a} \cdot b \cdot \overline{c} \cdot d \cdot b \cdot c
\]
\[
= 0
\]
Q NO. 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:

\[
\begin{align*}
V_A &= \left(\frac{4}{5}V_1 + \frac{1}{5}V_2\right); \quad V_{out} = -9V_3 + 10V_A = -9V_3 + 8V_1 + 2V_2
\end{align*}
\]

\[\text{(A)} \ 1.8V_1 + 7.2V_2 - 9V_3 \quad \text{(B)} \ 2V_1 + 8V_2 - 9V_3 \quad \text{(C)} \ 7.2V_1 + 1.8V_2 - 9V_3 \quad \text{(D)} \ 8V_1 + 2V_2 - 9V_3\]

[Ans. D]

Q NO. 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.

\[
\begin{align*}
x_1(t) &\quad \text{and} \quad x_2(t) \quad \text{for the system shown above, the minimum sampling rate required to sample } y(t), \text{ so that } y(t) \text{ can be uniquely reconstructed from its samples, is}
\end{align*}
\]

\[\text{(A)} \ 2B_1 \quad \text{(B)} \ 2(B_1+B_2) \quad \text{(C)} \ 4(B_1+B_2) \quad \text{(D)} \ \infty\]
[Ans. B]
Given that
Bandwidth of $X_1(\omega) = B_1$
Bandwidth of $X_2(\omega) = B_2$
System has $h(t) = e^{-2|t|}$ and input to the system is $x_1(t) \cdot x_2(t)$
The bandwidth of $x_1(t)$ is $B_1 + B_2$
The bandwidth of output $B_1 + B_2$
So sampling rate will be $2(B_1 + B_2)$

Q NO. 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]
The Fourier transform of
$\frac{2 \sin(\tau/2)}{t} \rightarrow 2\pi \text{rect} \left( \frac{\omega}{\frac{\tau}{2}} \right)$
$\frac{\sin(2\pi t)}{\pi t} \rightarrow \text{rect} \left( \frac{\omega}{4\pi} \right)$
So, $\int_{-\infty}^{\infty} \frac{\sin(2\pi t)}{\pi t} e^{-j\omega t} dt = \text{rect} \left( \frac{\omega}{4\pi} \right)$
Putting $\omega = 0$ in above equation
$\int_{-\infty}^{\infty} \frac{\sin(2\pi t)}{\pi t} dt = 1$
$2 \int_{-\infty}^{\infty} \frac{\sin(2\pi t)}{\pi t} dt = 2$

Q NO. 30.

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

[Ans. *] Range: 7.0 to 7.5
A. $e^{m^2}$  B. $-4m + 4 = 0$
$m = 2, 2$
$y = (C_1 + C_2 x)e^{2x}$
$y(0) = 0 \Rightarrow C_1 = 0$
$y = C_2 xe^{2x}$
$y' = C_2 e^{2x} + 2C_2 xe^{2x}$
$\Rightarrow C_2 = 1$
$y = xe^{2x}; y(1) = e^2 = 7.38$
Q NO. 31.

The line integral of the vector field \( \mathbf{F} = 5xz \, \mathbf{i} + (3x^2 + 2y) \, \mathbf{j} + x^2z \, \mathbf{k} \) along a path from \((0,0,0)\) to \((1,1,1)\) parametrized by \((t, t^2, t)\) is ______.

[Ans. *] Range: 4.40 to 4.45

\[ E = 5xz \, \mathbf{i} + (3x^2 + 2y) \, \mathbf{j} + x^2z \, \mathbf{k} \]

\[ = \int_{c} \mathbf{F} \cdot d\mathbf{r} \]

\[ = \int 5xz \, dx + (3x^2 + 2y) \, dy + x^2z \, dz \]

\[ x = t, y = t^2, z = t, t = 0 \text{ to } 1 \]

\[ dx = dt; dy = 2t \, dt; dz = dt \]

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

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

\[ = \left[ \frac{5t^3}{3} + \frac{11t^4}{4} \right]_{0}^{1} = \frac{5}{3} + \frac{11}{4} = \frac{53}{12} = 4.41 \]

Q NO. 32.

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

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 \( \begin{bmatrix} 1 \\ 0 \end{bmatrix} \)
(D) an ellipse with minor axis along \( \begin{bmatrix} 1 \\ 1 \end{bmatrix} \)

[Ans. D]

Q NO. 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 \( \text{Prob}\{X \leq 0\} \), respectively, are

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

[Ans. A]

\[ f_X(x) = \begin{cases} \frac{ae^{4x}}{3} & x < 0 \\ \frac{3}{2} e^{-3x} & x \geq 0 \end{cases} \]

\[ \int_{-\infty}^{\infty} f_X(x) = 1 \]
\[ \int_{-\infty}^{\infty} ae^{4x} \, dx + \int_{0}^{\infty} \frac{3}{2} e^{-3x} \, dx = 1 \]
\[ \left[ \frac{ae^{4x}}{4} \right]_{-\infty}^{0} + \left[ \frac{3}{2} e^{-3x} \right]_{0}^{\infty} = 1 \]
\[ a \cdot \frac{3}{4} + \frac{1}{6} = 1 \]
\[ a = 2 \]
\[ P(x < 0) = \int_{0}^{\infty} 2e^{4x} \, dx \]
\[ = \left[ \frac{e^{4x}}{2} \right]_{-\infty}^{0} = \frac{1}{2} \]

Q NO. 34.

The driving point input impedance seen from the source \( V_s \) of the circuit shown below, in \( \Omega \), is \( \boxed{___} \).

[Ans. *] Range: 19.5 to 20.5

To find impedance seen by \( V_s \)

\[ Z_s = \frac{V_s}{I_s} \]
\[ V_1 = 2I_s \]

Applying KCL at node A

\[ I_s + 4V_1 = \frac{V_A}{3} + \frac{V_A}{6} \]
\[ V_A = V_s - V_1 \text{ and } V_2 = 2I_s \]

So, \( I_s + 8I_s = \frac{V_s - 2I_s + V_s - 2I_s}{3} + \frac{V_s - 2I_s}{6} \)
\[ \Rightarrow 54I_s = 2V_s - 4I_s + V_s - 2I_s \]
\[ \Rightarrow 3V_s = 60I_s \]
\[ V_s \]
\[ I_s = 20 \Omega \]
Q NO. 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 ________.

\[
\begin{align*}
\text{Given } Z_{11} &= 40 \, \Omega; Z_{12} = 60 \, W \\
Z_{21} &= 80 \, \Omega; Z_{22} = 100 \, \Omega \\
\text{From the figure } V_2 &= -20I_2 \quad \text{......①} \\
\text{And } V_1 &= 40I_1 + 60I_2 \quad \text{......②} \\
V_2 &= 80I_1 + 100I_2 \quad \text{......③} \\
\text{From equation ① and ③ we get} \\
-20I_2 &= 80I_1 + 100I_2 \\
\Rightarrow I_2 &= -\frac{2}{3}I_1 \quad \text{......④} \\
\text{Using equation ② and ④, we get} \\
V_1 &= 40I_1 + 60I_2 = 40I_1 + 60\left(-\frac{2}{3}\right)I_1 \\
V_1 &= 0 \\
\text{From the figure, } 20 &= 10I_1 + V_1 \\
\text{Since } V_1 &= 0 \\
\text{So, } I_1 &= 2A \\
\text{So, } I_2 &= -\frac{4}{3}A \\
\text{Power dissipated in } R_L &= I_2^2 R_L = \left(\frac{4}{3}\right)^2 \times 20 = \frac{16}{9} \times 20 = 35.55 \, W
\end{align*}
\]
Q NO. 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 \( \)__________. 

\[ \begin{align*}
L &\quad C \\
\quad &\quad C \\
\quad &\quad L \\
\end{align*} \]

\[ \begin{align*}
L &\quad L \\
C/3 &\quad C/3 \\
C/3 &\quad L \\
\end{align*} \]

**[Ans. *]** Range: 2.9 to 3.1

Using star to delta conversion

\[ 50 \times 2\pi = \frac{1}{\sqrt{LC/3}} \]

\[ 100\pi = \frac{1}{\sqrt{LC/3}} \]

Since, \( L = 10 \text{ mH} \)

\( C \) will be 3.03 mF

Q NO. 37.

In the circuit shown below, the initial capacitor voltage is 4 V. Switch \( S_1 \) is closed at \( t = 0 \). The charge (in \( \mu C \)) lost by the capacitor from \( t = 25 \mu s \) to \( t = 100 \mu s \) is \( \)__________. 

\[ S_1 \]

\[ \begin{align*}
4V &\quad 5\mu F \\
&\quad 5\Omega \\
\end{align*} \]

**[Ans. *]** Range: 6.8 to 7.2
Q NO. 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 ________.

\[
Q(t) = \left(\frac{4}{5} e^{-t/\tau}\right); \quad \tau = RC = 25 \times 10^{-6} \text{ sec}
\]

Change lost by capacitor from \( t = 25 \mu s \) to \( 100 \mu s \) is

\[
\int_{25 \mu s}^{100 \mu s} i(t) \, dt = 6.99 \times 10^{-6} \text{ C}
\]

[Ans. *] Range: 2.20 to 2.35

The ratio \( P_x \) \( P_y \) \( X_0 \) \( X_1 \)
Q No. 39.

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

\[ G(s) = \frac{K(s + 1)}{s(1 + Ts)(1 + 2s)}, \quad K > 0, T > 0. \]

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]
Open loop transfer function
\[ G(s) = \frac{K(s + 1)}{s(1 + Ts)(1 + 2s)}; \, K > 0 \text{ and } T > 0 \]
For closed loop system stability, characteristic equation is
\[ 1 + G(s)H(s) = 0 \]
\[ 1 + \frac{K(s + 1)}{s(1 + Ts)(1 + 2s)} \cdot 1 = 0 \]
\[ s(1 + Ts)(1 + 2s) + k(s + 1) = 0 \]
\[ 2Ts^3 + (2 + T)s^2 + (1 + k)s + k = 0 \]
Using Routh’s criteria
\[
\begin{array}{c|cccc}
 & s^3 & 2T & (1 + k) \\
 & s^2 & (2 + T) & K \\
 & s^1 & (2 + T)(1 + k) - 2Tk & 0 \\
 & s^0 & K \\
\end{array}
\]
For stability, \( k > 0 \)
And \( (2 + T)(1 + k) - 2Tk > 0 \)
\( k(2 + T - 2T) + (2 + T) > 0 \)
Or, \( -(T - 2)k + 2(2 + T) > 0 \)
\( -(T - 2)k + 2(2 + T) > 0 \)
\( -k > -\frac{(2 + T)}{(T - 2)} \)
\( -k > -\frac{(2 + T)}{(T - 2)} \)
Or, \( k < \frac{T + 2}{T - 2} \)
Hence for stability,
\[ 0 < k < \frac{T + 2}{T - 2} \]

Q NO. 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. *] Range: 294.0 to 298.0
At no load, \( V_s = AV_R \)
400 = A 420
\[ A = \frac{400}{420} = 0.9524 \]
\[ A = 1 + \frac{YZ}{2} = 1 + \frac{(r + j\omega L)(g + j\omega C)}{2} \]
For lossless line \( r = 0, \, g = 0 \)
Then, \( A = 1 - \frac{\omega C}{\omega L} \)
\[ \beta l = \sqrt{\omega L \omega C} \]
\[ A = 0.9524 = 1 - \frac{\beta^2 l^2}{2} \]
\[ \beta l = 0.3085 \]
\[\beta = 0.3085\]
\[V = \frac{l}{2\pi}\]
\[\bar{r} = \frac{\beta}{30 \times 10^5} = \frac{2\pi}{50} \left(\frac{0.3085}{l}\right)\]
\[l = 294.59 \text{ km}\]

**Q NO. 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. *] Range: 0.31 to 0.33

\[P_1 = 500 \times 0.8 = 400 \text{ kW}\]
\[Q_1 = 500 \times 0.6 = 300 \text{ kVAR}\]

The power factor is to be raised to unity

The motor has to supply 300 kVAR

The motor rating is 100 kW, 300 kVAR

\[\phi_m = \tan^{-1}\left(\frac{Q}{P}\right)\]
\[\phi_m = \tan^{-1}\left(\frac{300}{100}\right) = 71.56\]

Power factor of motor = \(\cos \phi_m = \cos 71.56 = 0.316\)

**Q NO. 42.**

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

[Ans. *] Range: 186 to 190

**Q NO. 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 110 V, in ampere, is

[Ans. *] Range: 31.0 to 33.0

415 V, 3-phase, \(\Delta\) connected induction motor \((I_{st})_{line} = 120 \text{ A}\) at rated voltage.

At, \(V = 110 \text{ V}, \text{i.e. reduced voltage}\)

\[I_{st} = x(I_{st})_{rated}\]

Where, \(x = \frac{V_{\text{reduced}}}{V_{\text{rated}}}\)

\[x = \frac{110}{415}\]

\[(I_{st})_{110 \text{ V}} = \left(\frac{110}{415}\right) \times 120 = 31.807 \text{ A}\]
Q NO. 44.
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 ________.

[Ans. *] Range: 5.9 to 6.1

\[ 2 \text{ kVA, } 100/200 \text{ V transformer, } a_{2\text{winding}} = \frac{200}{100} = 2 \]

\[ (\text{kVA})_{\text{auto max}} = (a_{2\text{winding}} + 1)(\text{kVA})_{2\text{winding}} = (2 + 1) \times 2 = 6 \]

Q NO. 45.
A full-bridge converter supplying an RL 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, \( R=20 \Omega \), \( E=800 \text{ V} \). The inductor \( L \) is large enough to make the output current \( I_o \) a smooth dc current. Switches are lossless. The real power fed back to the source, in kW, is ________.

[Ans. *] Range: 5.9 to 6.1

\[ V_o = 2 \frac{V_m}{\pi} \cos \alpha = 2 \frac{200\pi}{\pi} \cos 120^\circ \]

\[ V_o = -200 \text{ V} \]

\[ |V_o| = 200 \text{ V} \]

Power balance equation, \( E I_o = I_o^2 R + V_o I_o \)

\[ 800 I_o = I_o^2 (20) + 200 I_o \]

\[ I_o = 30 \text{ A} \]

\[ I_o = I_{or} \]

Power fed to source = \( V_o I_o \)

\[ = 200 \times 30 = 6 \text{ kW} \]
Q NO. 46.
A three-phase Voltage Source Inverter (VSI) as shown in the figure is feeding a delta connected resistive load of 30 Ω/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 _________.

\[ V_{L} = V_{\text{ph}} = \frac{2}{\sqrt{3}} V_{s} \]
\[ V_{\text{ph}} = \frac{2}{\sqrt{3}} \times 600 \]
\[ P = 3 \times \frac{V_{\text{ph}}^{2}}{R} = 3 \times \frac{2}{\sqrt{3}} \times 600^{2} \times 30 = 24 \text{ kW} \]

Q NO. 47.
A DC-DC boost converter, as shown in the figure below, is used to boost 360V 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 amperes, is _________.

\[ I_{S} \]
\[ T_{\text{on}} \]
\[ T \]

[Ans. *] Range: 3 to 4
\[ V_o = \frac{1}{1 - \alpha} \]
\[ V_s = \frac{1}{1 + \alpha} \]
\[ 400 = \frac{360}{1 - \alpha} \]
\[ \alpha = 0.1 \]
\[ V_s I_s = \text{Power} \]
\[ 360 I_s = 4000 \]
\[ I_s = 11.1 \text{ A} \]

Neglecting ripple in \( i_s \), switch \( \text{rms} \) current is given by
\[ I_s = I_s \left( \frac{T_{on}}{T} \right)^{1/2} \]
\[ = I_s \sqrt{1 - \alpha} = 11.1 \sqrt{0.1} = 3.5 \text{ A} \]

Q NO. 48.

A single-phase bi-directional voltage source converter (VSC) is shown in the figure below. All devices are ideal. It is used to charge a battery at 400 V with power of 5 kW from a source \( V_i = 220 \) 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 (\( \delta \)) between AC mains voltage \( V_s \) and fundamental AC rms VSC voltage \( V_{C1} \), in degree, is

\[ \tan \delta = \frac{I_s X_s}{V_s} \]
\[ \delta = \tan^{-1} \left( \frac{22.72 \times 2\pi \times 50 \times 5 \times 10^{-3}}{220} \right) \]
\[ \delta = 9.21^\circ \]

[Ans. *] Range: 9.1 to 9.3

Q NO. 49.

Consider a linear time invariant system \( \dot{x} = Ax \), with initial condition \( x(0) \) at \( t = 0 \). Suppose \( \alpha \) and \( \beta \) are eigenvectors of \( (2 \times 2) \) matrix \( A \) corresponding to distinct eigenvalues \( \lambda_1 \) and \( \lambda_2 \) 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) \( e^{\lambda_1 t} \alpha + e^{\lambda_2 t} \beta \)
[Ans. A]
\[ x = Ax \]
Eigen values are \( \lambda_1 \) and \( \lambda_2 \)
We can write,
\[ \phi(t) = \begin{bmatrix} e^{\lambda_1 t} & 0 \\ 0 & e^{\lambda_2 t} \end{bmatrix} \]
Response due to initial conditions,
\[ x(t) = \phi(t).x(0) \]
\[ x(t) = \begin{bmatrix} e^{\lambda_1 t} & 0 \\ 0 & e^{\lambda_2 t} \end{bmatrix} \begin{bmatrix} \alpha \\ 0 \end{bmatrix} = \alpha e^{\lambda_1 t} \]

**Q NO. 50.**

A second-order real system has the following properties:

a) the damping ratio \( \xi = 0.5 \) 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

\[ \begin{align*}
(A) & \quad \frac{1.02}{s^2 + 5s + 100} \\
(B) & \quad \frac{102}{s^2 + 10s + 100} \\
(C) & \quad \frac{100}{s^2 + 10s + 100} \\
(D) & \quad \frac{102}{s^2 + 5s + 100}
\end{align*} \]

[Ans. B]

Damping ratio \( \xi = 0.5 \)

Undamped natural frequency \( \omega_n = 10 \) rad/sec

Steady state output to a unit step input \( C_{ss} = 1.02 \)

Hence, steady state error \( e_{ss} = 1.02 - 1.00 = 0.02 \)

\[ s^2 + 2\xi\omega_n s + \omega_n^2 = 0 \]
\[ s^2 + 2 \times 0.5 \times 10 s + 100 = 0 \]
\[ s^2 + 10s + 100 = 0 \]

From options, if we take option B

Then,
\[ C_{ss} = \lim_{s \to 0} s.C(s) = \lim_{s \to 0} \frac{s \times 102}{s^2 + 10s + 100} = \frac{102}{s^2 + 10s + 100} \]

Hence option B is correct answer

**Q NO. 51.**

Three single-phase transformers are connected to form a delta-star three-phase transformer of 110 kV/ 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 of phase currents in delta side to star side is

\[ \begin{align*}
(A) & \quad 1 : 10\sqrt{3} \\
(B) & \quad 10\sqrt{3} : 1 \\
(C) & \quad 1 : 10 \\
(D) & \quad \sqrt{3} : 10
\end{align*} \]

[Ans. A]
At 11 kV, load is 8 MW, 0.8 PF lagging

\[ \frac{(V_{ph})_\Delta}{(V_{ph})_Y} = \frac{(I_{ph})_Y}{(I_{ph})_\Delta} \]

\[ \Rightarrow \frac{(I_{ph})_\Delta}{(I_{ph})_Y} = \frac{(V_{ph})_Y}{(V_{ph})_\Delta} \]

\[ \Rightarrow (I_{ph})_\Delta = (I_{ph})_Y \times \frac{(V_{ph})_Y}{(V_{ph})_\Delta} \]

\[ \frac{(I_{ph})_\Delta}{(V_{ph})_Y} = \frac{11/\sqrt{3}}{110} = 1:10\sqrt{3} \]

Q NO. 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]

OLTF \( \Rightarrow G(s) = \frac{Ks}{(s-1)(s-4)} \)

Now, characteristics equation

\[ 1 + G(s)H(s) = 0 \]

\[ \frac{Ks}{(s-1)(s-4)} + 1 = 0 \]

\[ \Rightarrow Ks + (s^2 - 5s + 4) = 0 \]

For break away point: \( \frac{dK}{ds} = 0 \)

\[ \frac{dK}{ds} = -\left[1 - 0 - \frac{4}{s^2}\right] = 0 \]

We get \( s = \pm 2 \)

Therefore valid break away point is \( s = 2 \), now gain at \( s = 2 \) is

\[ \Rightarrow K = \frac{\text{Product of distances from all the poles to break away point}}{\text{Product of distance from all the zeros to break away point}} \]

Gain, \( K = \frac{1 \times 2}{2} = 1 \)
Q NO. 53.

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 \( j0.4 \) p.u., \( j0.3 \) p.u. and \( j0.15 \) p.u., respectively. If the pre-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 __________

\[
I_f = 3 I_{a1} = \frac{3}{0.2 + 0.15 + 0.15}
\]

\( I_f = 6 \) p.u.

[Ans. *] Range: 5.5 to 6.5
Q NO. 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. *] Range: 1.9 to 2.1
1200 rev/kWh, 20 rev, 30 sec
\[ P_{loss} = \frac{20 \times 3600}{1200 \times 30} = 2 \text{ kW} \]

Q NO. 55.
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 below. 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 _________.

[Ans. *] Range: 9.4 to 9.7
Voltage induced = \( \int_{0}^{1} E_m \, dl \)  
(Where \( E_m \) is induced electric field)  
\( E_m = \) volts  
Since, voltage induced = 1 V  
So, \( E_m = 1 \text{ V/m} \)  
As we know \( E_m = \frac{\mathbf{V} \times \mathbf{B}}{m} \)  
Where \( \mathbf{V} = (\text{Radius of path}) \times (\text{Angular velocity}) \)  
\( \frac{1V}{m} = (V \times 1 \text{ Tesla}) \)  
\( v = 1 \text{ m/sec} \)  
\( v = r \times \omega = 1 \text{ m/sec} \)  
Since, \( r = 1 \text{ m}; S \omega = 1 \text{ rad/sec} \)  
Now from this we get \( \omega = 2 \times \pi \times \frac{N}{60} = 1 \text{ rad/sec} \)  
\( N = \frac{30}{\pi} = 9.55 \text{ revolutions per minute} \)