DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Hyderabad, Bhopal, Jaipur, Pune, Kolkata

ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 12

Section A : BEE + Analog Electronics + Electrical and Electronic Measurements [All Topics]

Section B : Power Electronics and Drives-1 [Part Syllabus]

Section C : Power Systems-2 [Part Syllabus]

ANSWER KEY

1.	(a)	**16.**	(a)	**31.**	(d)	**46.**	(c)	**61.**	(c)
2.	(d)	**17.**	(d)	**32.**	(c)	**47.**	(a)	**62.**	(b)
3.	(b)	**18.**	(a)	**33.**	(d)	**48.**	(c)	**63.**	(c)
4.	(b)	**19.**	(a)	**34.**	(d)	**49.**	(a)	**64.**	(d)
5.	(b)	**20.**	(a)	**35.**	(a)	**50.**	(d)	**65.**	(c)
6.	(d)	**21.**	(d)	**36.**	(a)	**51.**	(b)	**66.**	(a)
7.	(c)	**22.**	(a)	**37.**	(b)	**52.**	(a)	**67.**	(b)
8.	(c)	**23.**	(d)	**38.**	(d)	**53.**	(b)	**68.**	(d)
9.	(a)	**24.**	(c)	**39.**	(d)	**54.**	(a)	**69.**	(a)
10.	(b)	**25.**	(d)	**40.**	(a)	**55.**	(d)	**70.**	(b)
11.	(c)	**26.**	(c)	**41.**	(b)	**56.**	(b)	**71.**	(a)
12.	(d)	**27.**	(d)	**42.**	(a)	**57.**	(b)	**72.**	(c)
13.	(c)	**28.**	(c)	**43.**	(d)	**58.**	(c)	**73.**	(d)
14.	(b)	**29.**	(b)	**44.**	(d)	**59.**	(a)	**74.**	(c)
15.	(c)	**30.**	(b)	**45.**	(a)	**60.**	(c)	**75.**	(d)

DETAILED EXPLANATIONS

Section A : BEE + Analog Electronics + Electrical and Electronic Measurements

1. (a)

Hole current density

$$J_p = -qD_p \frac{dp(x)}{dx}$$

where, q is the magnitude of electron charge

D_p is a constant called diffusion constant.

$\frac{dp(x)}{dx}$ is concentration gradient.

2. (d)

minimum conductivity occurs at

electron concentration $(n) = n_i\sqrt{\frac{\mu_p}{\mu_n}}$

and hole concentration $(p) = n_i\sqrt{\frac{\mu_n}{\mu_p}}$

So, minimum conductivity

$$\sigma = nq\mu_n + pq\mu_p$$

$$= n_i\sqrt{\frac{\mu_p}{\mu_n}} \cdot q \cdot \mu_n + n_i\sqrt{\frac{\mu_n}{\mu_p}} \cdot q \cdot \mu_p$$

$$\sigma = 2n_i q\sqrt{\mu_p \cdot \mu_n}$$

3. (b)

Given $I_0 = I_{CO}$

From the given circuit we can write

$$I_B = I_1 - I_0$$

The collector current I_C is given as

$$I_C = \beta_{dc} I_B + (1 + \beta_{dc}) I_{CO}$$

$$I_C = \beta_{dc}(I_1 - I_0) + (1 + \beta_{dc}) I_{CO} \quad (\because I_B = I_1 - I_0)$$

$$= \beta_{dc} I_1 - \beta_{dc} I_0 + I_{CO} + \beta_{dc} I_{CO}$$

$$I_C = \beta_{dc} I_1 + I_{CO} \quad (\because I_0 = I_{CO})$$

Stability factor $S = \frac{\partial I_C}{\partial I_{CO}}$

$$S = \frac{\partial I_C}{\partial I_{CO}} = 0 + 1 = 1$$

4. (b)

Linear application:

1. Current-to-voltage converter
2. Log and antilog amplifier

Non-linear application

1. Schmitt triggers
2. Multi vibrators
3. Zero cross detector

5. (b)

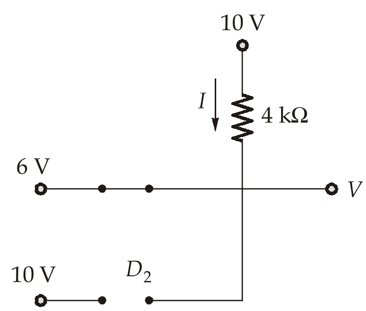
The minimum value of 'R_L' for the zener diode to be a voltage regulator.

$$R_L = \frac{15}{i_{max}} \text{ where } i_{max} = \frac{24-15}{27} = \frac{1}{3}\text{A}$$

$$(R_L)_{min} = 45\ \Omega$$

6. (d)

In the given circuit, diode D_1 conducts and D_2 does not conduct.



Thus, $V = 6$ Volt

and $I = \frac{10-6}{4\text{ k}\Omega}$

$I = 1$ mA

7. (c)

$V_i > 6$ V	$4\text{ V} < V_i < 6V$	$V_i < 4$ V
D_1 ON	D_1 OFF	D_2 ON
D_2 OFF	D_2 OFF	D_1 OFF
$V_0 = 6$ V	$V_0 = V_i$	$V_0 = 4$ V

8. (c)

Turn-ON time of transistor is sum of delay time and rise time and turnoff time of transistor is sum of storage time and fall time.

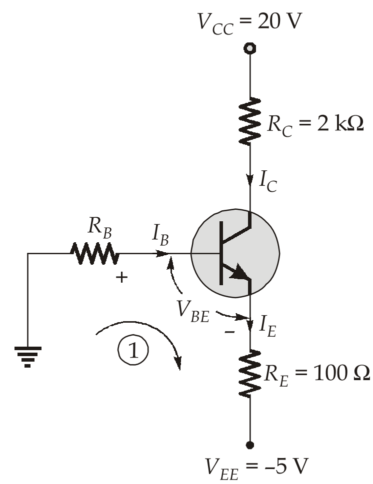
9. (a)

From the relation

$$I_C = \beta I_B$$

$$I_B = \frac{I_C}{\beta}$$

$$I_B = \frac{6}{100} = 0.06 \text{ mA}$$



Applying KVL in loop (1)

$$I_B \times R_B + V_{BE} + I_E R_E - V_{EE} = 0$$

$$I_B R_B = V_{EE} - I_E R_E - V_{BE}$$

$$I_B R_B = V_{EE} - (I_B + I_C) R_E - V_{BE}$$

$$= 5 - (6.06 \times 0.1) - 0.7$$

$$= 3.694 \text{ volts}$$

$$R_B = \frac{3.694}{0.06 \text{ mA}} = 61.56 \text{ k}\Omega$$

10. (b)

Cascode amplifier is a multistage configuration of CE and CB. This amplifier enhances i/o isolation like there is no straight coupling from the O/P to I/P which reduces the miller effect and therefore supplies high bandwidth.

11. (c)

$$f_H = 20 \text{ kHz for one amplifier}$$

$$\text{B.W} = \text{upper cutoff frequency } f_H$$

for n-stage amplifier (cascaded)

upper cut-off frequency is given by

$$f_H^* = f_H \sqrt{2^{1/n} - 1}$$

$f_H \rightarrow$ for single stage
for $n = 2$

$$f_H^* = f_H\sqrt{2^{1/2}-1} \qquad \left\{\because \sqrt{2^{1/2}-1} = \sqrt{0.414} = \sqrt{\frac{414}{1000}} \approx \frac{20}{10\sqrt{10}} = \frac{2}{\sqrt{10}} = 2\times 0.316 \approx 0.62\right\}$$

$$= 20 \times 0.64$$

$$= 12.8 \text{ kHz}$$

12. (d)

Bark Hausen criterion for oscillators

$$A\beta = 1 \angle 0° \text{ or } 360°$$

13. (c)

According to concept of non-inverting amplifier

$$V_0 = V_B\left(1+\frac{R_2}{R_1}\right) = V_B\left(1+\frac{3R}{R}\right) = 4V_B$$

Now,

$$V_B = -2\times\frac{R}{2R} + (2+\sin 100t)\times\frac{R}{2R}$$

$$V_B = \frac{\sin 100t}{2}$$

$$V_0 = 4V_B = 2\sin 100t$$

14. (b)

$$\text{CMRR} = \frac{A_d}{A_{cm}}$$

$$10^7 = \frac{10^5}{A_{cm}}$$

$$A_{cm} = 0.01$$

15. (c)

$$\text{slew rate} = \left(\frac{dV_0}{dt}\right)_{\max} = (A_{CL})\frac{dV_i}{dt}$$

$$\frac{10}{10^{-6}} = (A_{CL})\times\frac{20}{10^{-3}}$$

$$A_{CL} = 500$$

16. (a)

For RC phase shift oscillator

$$f = \frac{1}{2\pi\sqrt{6}RC} = \frac{0.159}{2.44RC}$$

$$f = \frac{0.065}{RC}$$

17. (d)

The phase difference between the output and input of

CE amplifier – 180°

CC amplifier – 0°

CB amplifier – 0°

18. (a)

A monostable multivibrator can be used or a missing pulse detector by connecting a transition between trigger inputs.

19. (a)

For a trans-resistance amplifier

$$\text{Input impedance } Z_{if} = \frac{Z_i}{1+A\beta} \approx 0$$

$$\text{Output impedance } Z_{of} = \frac{Z_0}{1+A\beta} \approx 0$$

20. (a)

An ideal voltage regulator should have constant output voltage and zero internal resistance.

21. (d)

Electrostatic voltmeter, wall mounted instruments uses fluid friction damping.

22. (a)

Imagine that the zener diode is in its off state,

$$V_L = V_i \times \frac{1.2\text{k}}{1\text{k}+1.2\text{k}} = 16 \times \left(\frac{1.2}{1.2+1}\right) = 8.727 \text{ V}$$

Hence voltage across zener diode is less than its breakdown voltage and hence it carries no current.

$\therefore$ $$I_Z = 0$$

$$P_Z = V_Z I_Z = 0 \text{ W}$$

23. (d)

$$g_m = \frac{\partial I_D}{\partial V_{GS}} = \frac{\partial}{\partial V_{GS}}\left[I_{DSS}\left(1-\frac{V_{GS}}{V_P}\right)^2\right]$$

$$g_m = \frac{\partial}{\partial V_{GS}}\left[I_{DSS} + \frac{I_{DSS}V_{GS}^2}{V_P^2} - \frac{2V_{GS}I_{DSS}}{V_P}\right] = \frac{2I_{DSS}}{V_P}\left[\frac{V_{GS}}{V_P}-1\right]$$

$$g_m\big|_{\max} = \frac{2I_{DSS}}{|V_P|}\bigg|_{\text{for } V_{GS}=0} = \frac{2\times 8}{4} = 4$$

24. (c)

The advantage of shunt resistance are, to extend the range of ammeter. To minimize the effect of temperature swamp resistance is connected in series with meter.

25. (d)

$$V_{rms} = \sqrt{2^2 + \frac{3^2}{2}} = \sqrt{\frac{17}{2}} = 2.915 \text{ V}$$

26. (c)

$$\text{Meter constant} = 600 \text{ rev/kWh}$$

$$= \frac{600}{1000 \times 60} \frac{\text{rev}}{\text{watt} - \text{min}}$$

$$= \frac{1}{100} \frac{\text{rev}}{\text{watt} - \text{min}}$$

$$1 \text{ watt} \rightarrow \frac{1}{100} \text{rev/min}$$

$$4 \times 230 \text{ watt} \rightarrow \frac{4 \times 230}{100} \text{rev/min}$$

$$920 \text{ watt} \rightarrow 9.2 \text{ rev/min}$$

$\therefore$ meter constant = 9.2 rev/min

and meter makes 23 revolutions in 2.5 min at full load

$\therefore$ meter makes $\frac{23}{2.5} = 9.2$ rev/min

As meter is making same number of revolutions as meter constant per minute.

$\therefore$ Meter runs neither faster nor slower.

28. (c)

Given, Power factor = 1

$$\cos\phi = 1$$

$$\phi = 0$$

$$\tan\phi = \tan 0° = 0$$

$$\tan\phi = \sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$$

$$0 = \sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$$

$$W_1 = W_2$$

29. (b)

The standardization of a.c. potentiometers is done with the help of standard d.c. source, i.e. a standard cell and a transfer instrument.

30. (b)

$$\text{Power} = VI\cos\phi$$
$$= 230 \times 20 \times 0.7$$
$$= 3220 \text{ W} = 3.22 \text{ kW}$$

Meter constant of energy meter = 800 rev/kWh

$$\text{No. of revolution} = 800 \times 3.22 = 2576 \text{ revolutions}$$

$$\text{Speed of rotation in rpm} = \frac{2576}{60} = 42.93 \text{ rpm}$$

31. (d)

Count range for $3\frac{3}{4}$ digit DVM is from 0 to 3999 i.e. 4000 counts

and $$\text{resolution} = \frac{1}{10^N} = \frac{1}{10^3} = 1 \text{ mV}$$

32. (c)

$$I = \sqrt{(4\sqrt{2})^2 + \frac{1}{2}\left[(4\sqrt{2})^2 + (-4\sqrt{2})^2\right]}$$
$$= \sqrt{32 + \frac{1}{2}[32+32]} = 8 \text{ A}$$

33. (d)

In the moving iron ammeter,

Deflection, $\theta \propto i^2_{\text{rms}}$

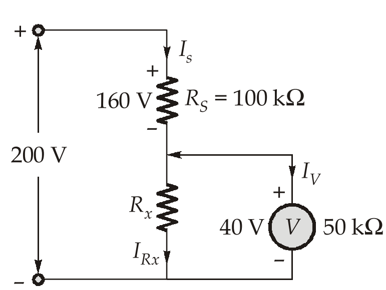
$$\frac{20}{\theta} = \frac{1^2}{\left(\frac{4}{\sqrt{2}}\right)^2} = \frac{1}{8}$$

$$\theta = 160°$$

34. (d)

$$\text{Voltmeter resistance} = S_V \times V_{fs}$$
$$= 500 \times 100 = 50 \text{ k}\Omega$$

Since voltmeter reads 40 V



Voltage drop across, R_s = 200 – 40 = 160 V

$$I_S = \frac{160}{100\,\text{k}\Omega} = 1.6 \text{ mA}$$

$$I_V = \frac{40}{50} = 0.8 \text{ mA}$$

$$I_{Rx} = 1.6 - 0.8 = 0.8 \text{ mA}$$

$$R_x = \frac{40}{0.8} \times 10^3 = 50 \text{ k}\Omega$$

35. (a)

At balance,

$$\left(R - \frac{j}{\omega C}\right)\left(\frac{R\left(\frac{-j}{\omega C}\right)}{R - \frac{j}{\omega C}}\right) = RZ$$

$$R\left(\frac{-j}{\omega C}\right) = R(X + jY) \qquad [\text{Let } Z = X + jY]$$

Comparing the real and imaginary parts we get,

$$RX = 0$$

$$X = 0$$

and $$R\left(\frac{-j}{\omega C}\right) = R\,jY$$

$$Y = \frac{-1}{\omega C}$$

∴ 'Z' is purely capacitive.

Alternate Solution:

Angle condition can also be satisfied.

36. (a)

The moving coil is wound either as a self-sustaining coil or else on a non-metallic former. A metallic former cannot be used as eddy currents would be induced in it by the alternating field.

37. (b)

Given, C_1 = 100 nF,

R_1 = 100 kΩ,

ω = 1000

Bridge at balance condition,

$$Q = \omega C_1 R_1 = 10$$

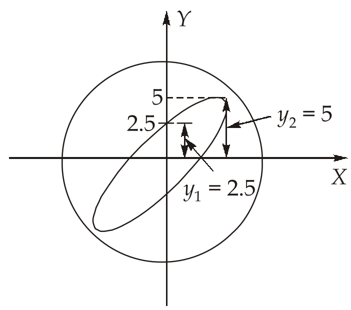
38. (d)

All statements are correct.

39. (d)

The control torque is provided by the voltage coil in case of meggar.

40. (a)



As spot generating the pattern moves in clockwise direction

So, $\sin\phi = \dfrac{y_1}{y_2}$ (Where ϕ = phase differentiate)

$$\sin\phi = \frac{2.5}{5} = 0.5$$

$$\phi = 30°$$

41. (b)

Both statements are correct but statement-II is not the correct explanation of statement-I.

42. (a)

Since in FET, temperature increases, the carrier mobility decreases i.e., current decreases with increase in temperature. The power dissipation at the output terminal of FET decreases.

43. (d)

In PMMC instrument springs carry actuating current, if spring broken pointer always shows no deflection.

44. (d)

A dynamometer type wattmeter has a linear scale while a dynamometer type voltmeter has a non-linear scale.

45. (a)

A current carrying coil moving in a magnetic field is an inverse transducer because current carried by it is converted into a force which causes translational or rotational displacement.

Section B : Power Electronics and Drives-1

46. (c)

Derating factor = 1 – string efficiency

$$0.2 = 1 - \frac{\text{Actual voltage of whole string}}{\text{Individual voltage} \times \text{Number of SCRs in series}}$$

$$0.2 = 1 - \frac{6000}{1000 \times n_s}$$

$$n_s = \frac{6000}{1000 \times 0.8} = 7.5 \approx 8$$

$$0.2 = 1 - \frac{\text{Current rating of whole string}}{\text{Current rating of one SCR} \times \text{number of SCRs in parallel}}$$

$$0.2 = 1 - \frac{1000}{200 \times n_p}$$

$$n_p = \frac{1000}{200 \times 0.8} = 6.25 \approx 7$$

47. (a)

An ideal gate trigger should have short rise time and pulse width of should be greater than turn on time of a SCR.

48. (c)

Average output voltage of 1-ϕ semiconverter

$$V_0 = \frac{V_m}{\pi}(1 + \cos\alpha)$$

maximum possible value of average output voltage

$$V_0 = \frac{2V_m}{\pi} \quad \text{for } \alpha = 0$$

Given

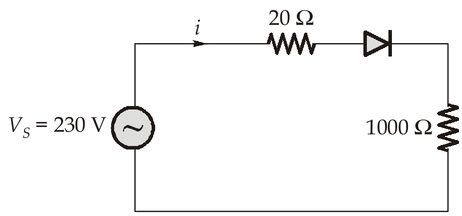
$$0.25\left(\frac{2V_m}{\pi}\right) = \frac{V_m}{\pi}(1 + \cos\alpha)$$

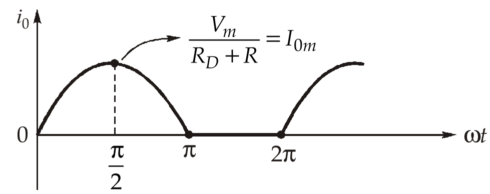
$$1 + \cos\alpha = 0.5$$

$$\cos\alpha = -\frac{1}{2}$$

$$\alpha = 120°$$

49. (a)





$$\text{Peak load current, } I_{om} = \frac{V_m}{R_D + R} = \frac{\sqrt{2} \times 230}{20 + 1000}$$

$$I_{om} = 0.3189 \text{ A}$$

$$\text{Average load current, } \quad I_0 = \frac{1}{2\pi}\int_0^{\pi} I_{0m} \sin\omega t \cdot d(\omega t) = \frac{I_{om}}{\pi} = \frac{0.3189}{\pi} = 0.10 \text{ A}$$

50. (d)

In general latching current > Holding current.

51. (b)

As we know,
$$\left(\frac{di}{dt}\right)_{max} = \frac{V_s}{L}$$

$$L = \frac{V_s}{\left(\frac{di}{dt}\right)_{max}} = \frac{240 \times 10^{-6}}{50} = 4.8\,\mu\text{H}$$

The voltage across SCR is given by

$$V_a = R_s \cdot i$$

$$\left(\frac{dV_a}{dt}\right)_{max} = R_s \left(\frac{di}{dt}\right)_{max}$$

$$R_s = \frac{L}{V_s}\left(\frac{dV_a}{dt}\right)_{max} = \frac{4.8}{240} \times 300$$

$$R_s = 6\ \Omega$$

52. (a)

For E = 140 V, the full converter is operating as a controlled rectifier.

$$\frac{2V_m}{\pi}\cos\alpha = E + I \cdot R$$

$$\frac{2 \times \sqrt{2}}{\pi} \times 230 \times \cos\alpha = 140 + 10 \times 0.6$$

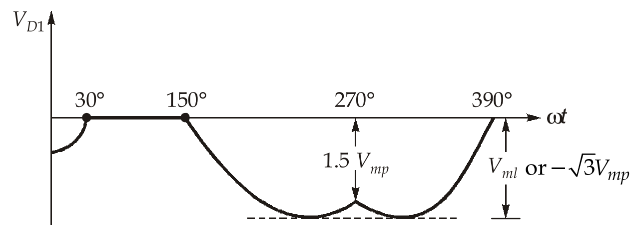
$$0.9 \times 230 \cos\alpha = 146$$

$$\cos\alpha = \frac{146}{207} \approx 0.707$$

$$\alpha = 45°$$

53. (b)

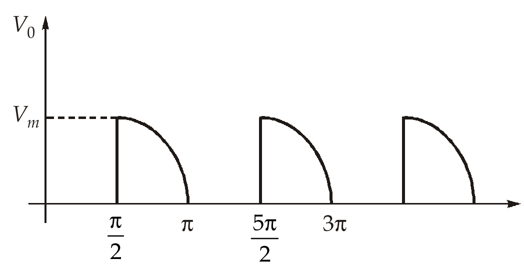
PIV of a diode in 3-phase bridge rectifier is V_{ml} or $\sqrt{3}V_{mp}$.



54. (a)

$$\text{Input power factor} = \frac{3}{\pi}\cos\alpha = \frac{3}{\pi}\times\cos 60° = 0.4792 \text{ lagging}$$

55. (d)



$$V_{0\text{ rms}} = \frac{V_m}{\sqrt{2\times 2\pi}}\sqrt{\left(\pi-\frac{\pi}{2}\right)+\left[\frac{1}{2}\sin 2\left(\frac{\pi}{2}\right)-\frac{1}{2}\sin 2(\pi)\right]}$$

$$V_{0\text{ rms}} = \frac{V_m}{2\sqrt{\pi}}\times\sqrt{\frac{\pi}{2}} = \frac{V_m}{2\sqrt{2}} = \frac{\sqrt{2}\,V}{2\sqrt{2}} = \frac{V}{2}$$

$$P = \frac{\left(\frac{V}{2}\right)^2}{R} = \frac{V^2}{4R}$$

56. (b)

With T as the time of a cycle,

$$\text{average power loss} = \frac{1}{T}\int_0^{2T/3} V_f \cdot I_f\, dt$$

$$P = \frac{2}{3}\cdot V_f \cdot I_f$$

$$V_f = 0.88 + (0.015 \times 50)$$
$$V_f = 1.63 \text{ V}$$
$$\therefore \quad P = \frac{2}{3} \times 1.63 \times 50 = 54.33 \text{ W}$$

57. (b)

On increasing number of pulses, average output voltage increases. As output voltage increases efficiency increases. As waveform become more smooth, form factor decreases (approaches to 1).

58. (c)

59. (a)

The main disadvantage of n-channel MOSFET is that conducting n-channel in between drain and source gives large on-state resistance. This leads to high power dissipation in n-channel.

60. (c)

Output voltage of converter is

$$V_0 = \frac{2V_m}{\pi}\cos\alpha - 2fL_sI_0$$

When I_0 is ripple free

∴ Statement-II is wrong.

Section C : Power Systems-2

61. (c)

A fully transposed transmission has:

- Positive and negative sequence impedances are equal.
- Zero sequence impedance much larger than the positive (or negative) sequence impedances.

62. (b)

$$\text{Stored energy} = GH = 100 \times 8 = 800 \text{ MJ}$$

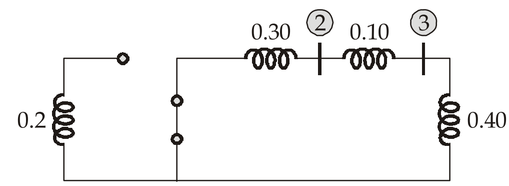
$$P_a = 80 - 50 = 30 = M\frac{d^2\delta}{dt^2}$$

$$M = \frac{GH}{180f} = \frac{800}{180 \times 50} = \frac{4}{45}\text{MJ-s/elect deg}$$

$$\therefore \quad \frac{4}{45}\frac{d^2\delta}{dt^2} = 30$$

$$\alpha = \frac{d^2\delta}{dt^2} = \frac{30 \times 45}{4} = 337.5 \text{ elec deg/s}^2$$

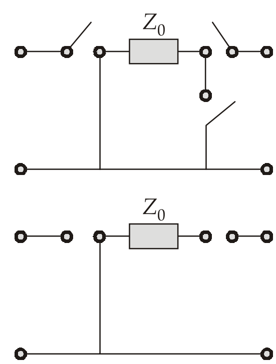
63. (c)



$$X_{eq} = 0.4 \,||\, 0.4 = 0.2 \text{ p.u.}$$

64. (d)

Since the primary is delta connected, the shunt switch of the primary side is closed and the series switch is left open. The secondary is star connected with neutral ungrounded. The series switch is left open the shunt switch is also left open.



Zero sequence equivalent network.

65. (c)

The insulation level is decided based on lighting over voltage and above 345 kV, insulation level is decided based on switching overvoltage.

66. (a)

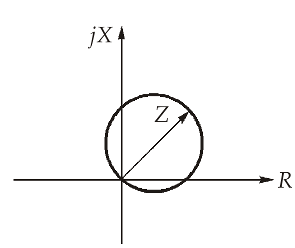
The magnitude of the series admittance of each line

$$= \frac{Y_{12}}{2} = \frac{-(y_{12})}{2} = \frac{-j40}{2} = -j20$$

67. (b)

As zero sequence component is present and magnitudes of I_{a1} and I_{a2} are different hence this is a case of L-L-G fault.

68. (d)



The operating area is mainly spread in I[st] quadrant therefore this relay is considered as directional relay. Mho (admittance) relay also called voltage restrained relay. This prevents the long transmission lines.

Note:

- Reactance relay : Short line
- Impedance relay : Medium line
- Mho relay : Long line

69. (a)

$$I_{f\,LG} = \frac{3E}{X_1 + X_2 + X_0} = \frac{3}{1} = 3 \text{ p.u.}$$

$$I_{f\,3\text{-}\phi} = \frac{E}{X_1} = \frac{1}{0.4} = 2.5 \text{ p.u.}$$

The ratio, $$\frac{I_{f\,LG}}{I_{f\,3-\phi}} = \frac{3}{2.5} = 1.2$$

70. (b)

Newton raphson method takes less number of iterations compared to Gauss Seidel method.

71. (a)

SF_6 circuit breaker is noiseless.

72. (c)

$$\text{Average R.R.R.V.} = \frac{\text{Peak value of restriking voltage}}{\text{Time taken to reach the peak value}}$$

$$= \frac{11000}{\frac{\pi\sqrt{LC}}{2}} = \frac{2 \times 11000}{\pi\sqrt{1 \times 10^{-4} \times 400 \times 10^{-12}}}$$

$$= \frac{2 \times 11000}{\pi \times 2 \times 10^{-7}} = \frac{11}{\pi} \times 10^{10} \text{ V}$$

73. (d)

Step 1: Adding bus 1 to reference bus

$$Z_{bus} = [1]$$

Step 2: Adding new bus 3 to reference bus we get,

$$Z_{bus\,(new)} = \begin{array}{c} \\ 1 \\ 3 \end{array}\begin{array}{c} \begin{array}{cc} 1 & 3 \end{array} \\ \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} \end{array}$$

Step 3: Adding bus 2 new to bus 3 old

$$Z_{\text{bus (new)}} = \begin{matrix} & 1 & 3 & 2 \\ 1 & \\ 3 & \\ 2 & \end{matrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 2 \\ 0 & 2 & 2+3 \end{bmatrix}$$

On rearranging,
$$Z_{\text{bus (new)}} = \begin{matrix} & 1 & 2 & 3 \\ 1 & \\ 2 & \\ 3 & \end{matrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 5 & 2 \\ 0 & 2 & 2 \end{bmatrix}$$

74. (c)

Statement 4 is not correct.

75. (d)

During the fault the voltage at bus 2 is,

$$V_2 = V_f\left(1 - \frac{Z_{23}}{Z_{33}}\right) = 1.0\left(1 - \frac{j1.5}{j2.0}\right)$$

$$V_2 = 0.25 \text{ p.u.}$$

❍❍❍❍