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ESE 2020 : 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]

1.	(b)	**16.**	(a)	**31.**	(a)	**46.**	(d)	**61.**	(c)
2.	(c)	**17.**	(c)	**32.**	(c)	**47.**	(d)	**62.**	(d)
3.	(d)	**18.**	(b)	**33.**	(a)	**48.**	(a)	**63.**	(b)
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7.	(c)	**22.**	(c)	**37.**	(b)	**52.**	(d)	**67.**	(a)
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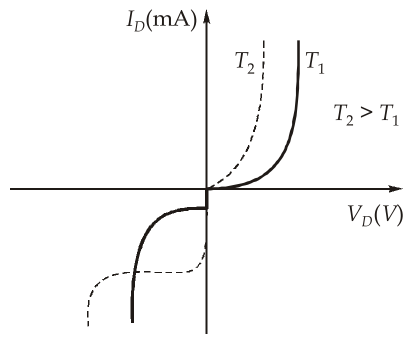
13.	(a)	**28.**	(d)	**43.**	(a)	**58.**	(a)	**73.**	(d)
14.	(d)	**29.**	(c)	**44.**	(b)	**59.**	(a)	**74.**	(a)
15.	(c)	**30.**	(b)	**45.**	(a)	**60.**	(a)	**75.**	(b)

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

1. (b)

Temperature dependence of characteristics of Si diode,



- In the forward bias region the characteristics of a Silicon diode shift to the left with increase in temperature.
- The reverse breakdown voltage of a semiconductor diode will increase or decrease with temperature depending on zener potential.
- For breakdown voltage less than 5 V, breakdown voltage will increase with temperature and vice-versa.
- In the reverse region the reverse saturation current of a Silicon diode increases with rise in temperature.

2. (c)

$$V_{GS} = 0$$

$\therefore$ $$I_D = I_{DSS} = 10 \text{ mA}$$

$$V_{DS} = 20 \text{ V} - (10 \text{ mA})(1.7 \text{ k}\Omega) = 3 \text{ V}$$

3. (d)

DC resistance, $$R_D = \frac{V_D}{I_D} = \frac{0.7}{2 \text{ mA}} = 350\ \Omega$$

4. (a)

Imagin 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.

$\therefore$ $$I_Z = 0$$

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

5. (c)

The given circuit is voltage doubler circuit.

In the positive half cycle, C_1 charges to V_m,

In the negative half cycle, C_2 charges to V_m,

$$\therefore \quad V_0 = 2\,V_m$$

and PIV across diodes = $2\,V_m$

6. (d)

At, $I_c = 0$ mA

From KVL:

$$-V_{CC} + V_{CE} = 0$$

$$V_{CE} = V_{CC} = 20\text{ V}$$

From KVL in base emitter loop:

$$-V_{CC} + I_B R_B + V_{BE} = 0$$

$$R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{20 - 0.7}{25\ \mu\text{A}} = 772\ \text{k}\Omega$$

8. (c)

Effective reduction in base width causing the minority carrier concentration gradient to increase.

9. (b)

$$V_{\text{out}}(\omega t) = -\int_0^{\omega t} \frac{1}{R_1 C} V_1(\omega t)\,d\omega t - \int_0^{\omega t} \frac{1}{R_2 C} V_2(\omega t)\,d\omega t$$

$$= -\int_0^{\omega t} 2\sin(\omega t)\,d\omega t - \int_0^{\omega t} 2\cos(\omega t)\,d\omega t$$

$$= 2\cos(\omega t) - 2\sin(\omega t)$$

$$= 2(\cos\omega t - \sin\omega t)$$

$$= 2\sqrt{2}(\cos(\omega t + 45°))$$

$$= 2.83\cos(\omega t + 45°)\text{ V}$$

10. (a)

$$I_C = \beta I_B + (1 + \beta) I_{CBO}$$

$$\beta = \frac{I_C - I_{CBO}}{I_B + I_{CBO}} = \frac{(5 \times 10^{-3}) - (0.2 \times 10^{-6})}{(100 \times 10^{-6}) + (0.2 \times 10^{-6})} = 49.89 \approx 50$$

12. (d)

By applying KVL in base emitter loop,

$$I_B R_B + V_{BE} + (1 + \beta) I_B R_E + (-20) = 0$$

$$I_B = \frac{V_{EE} - V_{BE}}{R_B + (\beta + 1) R_E} = \frac{20 - 0.7}{240 + (90 + 1) \times 2}$$

$$= \frac{19.3\text{V}}{(240+182)\text{k}\Omega} = 45.73\ \mu\text{A}$$

By applying KVL in collector emitter loop,

$$V_{CEQ} = V_{EE} - I_E R_E$$
$$= V_{EE} - (\beta + 1) I_B R_E$$
$$= 20 - (91 \times 45.73 \times 10^{-6} \times 2 \times 10^3)$$
$$= 11.68\ \text{V}$$

13. (a)

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

$$I_D = 9\left(1 - \frac{(-2)}{(-3.5)}\right)^2 = 1.65\ \text{mA}$$

14. (d)

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

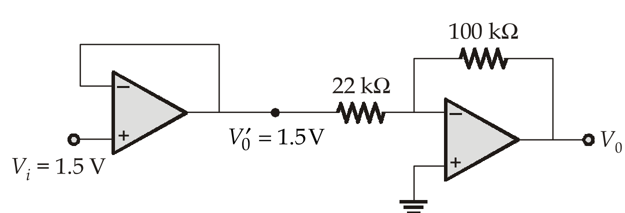
$$g_m = \frac{\partial}{\partial V_{GS}}\left[I_{DSS} + \frac{I_{DSS} V_{GS}^2}{V_P^2} - \frac{2 V_{GS} I_{DSS}}{V_P}\right] = \frac{2 I_{DSS}}{V_P}\left[\frac{V_{GS}}{V_P} - 1\right]$$

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

15. (c)

- Gain reduction takes place in low frequency band due to coupling and bypass capacitors selected while the reduction of gain in high frequency band is due to internal capacitance of amplifiers.
- At low frequency, internal capacitance have high value and therefore look like open and have no effect on transistor's performance.

16. (a)



$$V_0 = V_0' \times \frac{-R_F}{R}$$

$$V_0 = 1.5 \times \frac{-100}{22} = -6.818\ \text{V}$$

17. (c)

Cutoff frequency of first order Lowpass filter is,

$$f_C = \frac{1}{2\pi RC} = \frac{1}{2\times\pi\times 2.2\times 10^3\times 0.05\times 10^{-6}}$$
$$= 1.45 \text{ kHz}$$

18. (b)

$$I_E = \frac{V_{EE}-0.7}{R_E} \qquad \text{(DC bias current)}$$
$$= \frac{9-0.7}{43} = 193\ \mu\text{A}$$
$$I_C = \frac{I_E}{2} = 96.5\ \mu\text{A}$$
$$\text{Value of } r_e = \frac{V_T}{I_C} = \frac{26}{96.5}\times 10^3 \approx 269\ \Omega$$

AC voltage gain, $$A_V = \frac{R_C}{2r_e} = \frac{47\times 1000}{2\times 269} \approx 87.23$$

19. (d)

$$V_0 = V_{I0}\left(\frac{R_1+R_f}{R_1}\right)$$
$$= 1.2\left(\frac{2+150}{2}\right) = 91.2 \text{ mV}$$

20. (b)

Both input and output impedance decreases by voltage shunt feedback.

$$Z_{if} = \frac{Z_i}{(1+A\beta)}$$
$$Z_{0f} = \frac{Z_0}{(1+A\beta)}$$

21. (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.

22. (c)

At bridge balance condition,

$$\left(\omega\frac{L}{2}\right)5k = \omega \times 10 \times 10^{-3} \times 10k$$

$$L = 40 \times 10^{-3} \text{ H}$$

$$= 40 \text{ mH}$$

23. (d)

Resonance occurs at frequency f_1, with capacitance C_1,

$$f_1 = \frac{1}{2\pi\sqrt{L(C_1 + C_d)}}$$

and resonance occurs at frequency f_2, with capacitance C_2,

$$f_2 = 2f_1$$

$$f_2 = \frac{1}{2\pi\sqrt{L(C_2 + C_d)}}$$

$$\therefore \quad \frac{1}{2\pi\sqrt{L(C_2 + C_d)}} = \frac{2}{2\pi\sqrt{L(C_1 + C_d)}}$$

$$\frac{L(C_1 + C_d)}{L(C_2 + C_d)} = 4$$

$$C_1 + C_d = 4C_2 + 4C_d$$

$$C_1 - 4C_2 = 3C_d$$

$$C_d = \frac{C_1 - 4C_2}{3}$$

$$C_d = \frac{460 - 4(100)}{3} = \frac{60}{3} = 20 \text{ pF}$$

24. (c)

At balance condition,

$$Z\left[R_4 \parallel \frac{1}{j\omega C_4}\right] = R_3 \cdot \frac{1}{j\omega C_2}$$

$$Z\left[\frac{R_4}{1+j\omega C_4 R_4}\right] = \frac{R_3}{j\omega C_2}$$

$$Z = \frac{R_3 + j\omega R_3 R_4 C_4}{j\omega C_2 R_4}$$

$$Z = \frac{C_4}{C_2}R_3 + \frac{R_3}{j\omega C_2 R_4}$$

So it is combination of R and C in series.

25. (a)

The resolution of potentiometer without the gearing arrangement

$$= \frac{1}{200}\text{mm} = 5\ \mu\text{m}$$

with the gearing arrangement which causes 4 revolutions of the potentiometer shaft with one revolution of main shaft $= \frac{5}{4}\mu\text{m} = 1.25\ \mu\text{m}$

26. (d)

In digital oscilloscopes, CRT is much cheaper than an analog storage oscilloscope.

27. (b)

Error on reading 100 mV $= 100\text{ mV} \times \frac{0.5}{100} = 0.5$ mV

also, error due to ±5 counts $= \frac{200}{1999} \times 5\text{ mV} = 0.5$ mV

Hence, Total error = 0.5 + 0.5

= 1.0 mV

∴ Meter will read between (100 – 1)mV and (100 + 1) mV

i.e. between 99 mV and 101 mV.

29. (c)

Given, Power factor = 1

$\cos\phi = 1$

$\phi = 0$

$\tan\phi = \tan 0° = 0$

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

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

$$W_1 = W_2$$

30. (b)

A highly non-inductive resistance is connected in series with the moving coil to limit the current to a small value.

31. (a)

Given, $\cos\phi = 0.5$

$\phi = 60°$

Total input power, $P = W_1 + W_2$

$= 50000$ W

Now, $$V_L I_L = \frac{P}{\sqrt{3}\cos\phi} = \frac{100000}{\sqrt{3}}$$

∴ readings of the wattmeters are

$$W_1 = V_L I_L \cos(30° - \phi)$$

$$= \frac{100000}{\sqrt{3}}\cos(-30°) = 50 \text{ kW}$$

$$W_2 = V_L I_L \cos(30° + \phi)$$

$$= \frac{100000}{\sqrt{3}}\cos 90° = 0 \text{ kW}$$

32. (c)

$$V(t) = \begin{cases} t & 0 < t < 1 \\ 1 & 1 < t < 2 \end{cases}$$

$$V_{avg} = \frac{1}{T}\int_0^T V(t)dt = \frac{1}{2}\left[\int_0^1 t\,dt + \int_1^2 1\,dt\right]$$

$$= \frac{1}{2}\left\{\left[\frac{t^2}{2}\right]_0^1 + [t]_1^2\right\}$$

$$= \frac{1}{2}\left[\frac{1}{2} - 0 + 2 - 1\right] = \frac{3}{4} = 0.75 \text{ V}$$

33. (a)

Total resistance of meter-1 = Resistance of meter movement + Resistance of multiplier

= 2 + 18

= 20 kΩ

∴ Sensitivity of meter-1 = $\frac{20}{10}$ = 2 kΩ/V

Total resistance of meter-2 = Resistance of meter movement + Resistance of multiplier

= 2 + 298

= 300 kΩ

$\therefore$ Sensitivity of meter-2 = $\frac{300}{300}$ = 1 kΩ/V

$\therefore$ meter-1 is more sensitive.

34. (c)

Final steady deflection, $\theta = \frac{I^2}{K} \cdot \frac{dM}{d\theta}$

$$\theta = \frac{(25)^2}{10^{-6}} \times 0.0035 \times 10^{-6} = 2.1875 \text{ (radian)}$$

$$\theta = 125.33°$$

35. (b)

The sensitivity of meter movment for dc.

$$S_{dc} = \frac{1}{I_{fs}} = \frac{1}{10^{-3}} = 1000\ \Omega/\text{V}$$

For half wave rectifier, the a.c. sensitivity,

$$S_{ac} = 0.45 \times 1000 = 450\ \Omega/\text{V}$$

Total resistance of circuit for a.c. operation

$$= S_{ac}\,V = 450 \times 10 = 4500\ \Omega$$

Resistance of multiplier, $R_s = S_{ac}\,V - R_m - R_d$

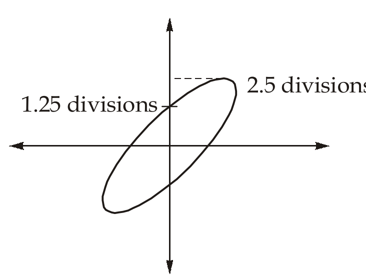
$$= 4500 - 300 - 0$$

$$= 4200\ \Omega$$

36. (b)

An accurately calibrated standard variable frequency source is used to supply voltage to the X-plates.

37. (b)



$$\sin\phi = \frac{Y_1}{Y_2} = \frac{1.25}{2.50} = 0.5$$

$\therefore$ $\phi = 30°$

Possible angles are 30° and 330° bus as slope of major axis of ellipse is positive, hence ϕ = 30° is valid.

38. (b)

$$\frac{\text{Input (unknown) voltage}}{\text{Output voltage}} = \frac{V_x}{V_2} = \frac{100}{2} = 50$$

Also, $$\frac{R_1 + R_2}{R_2} = \frac{V_x}{V_2} = 50$$

or, $$R_1 = 49R_2$$

But, $$R_1 + R_2 = 100 \text{ M}\Omega$$

∴ $$R_2 = 2 \text{ M}\Omega \text{ and } R_1 = 98 \text{ M}\Omega$$

39. (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.

41. (b)

Both the statements are correct but statement-II is not the exact reason for statement-I.

Common collector configuration are widely used in impedance matching applications because of their high input impedance.

42. (d)

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

43. (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

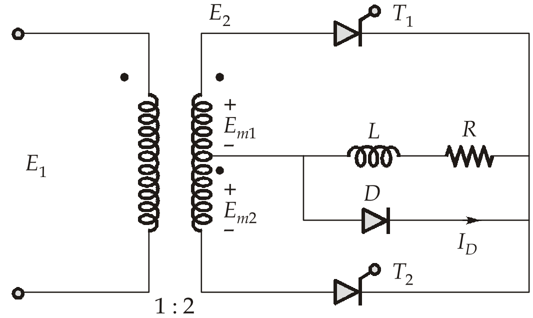
46. (d)

Drift layer must be fairly long in high voltage devices to accomodates the long deplection layer.

47. (d)

Average output voltage is,

$$E_{dc} = \frac{1}{\pi}\int_{\alpha}^{\pi} E_{m1} \sin \omega t d(\omega t)$$



$$\frac{E_2}{E_1} = \frac{2}{1}$$

$$E_2 = 2E_m \sin \omega t$$

Since transformer is tapped in middle

$$\therefore \quad E_{m1} = E_{m2} = \left(\frac{2E_m}{2}\right) = E_m$$

$$E_{dc} = \frac{1}{\pi}\int_{\alpha}^{\pi} E_m \sin \omega t d(\omega t) = \frac{E_m}{\pi}(1+\cos\alpha)$$

$$I_{dc} = \frac{E_{dc}}{R} = \frac{E_m}{\pi R}(1+\cos\alpha)$$

Freewheeling diode conducts when voltage goes negative for a period of α.

$$\therefore \quad I_{Df} = \frac{\alpha}{\pi} I_{dc} = \frac{E_m}{\pi}\frac{(1+\cos\alpha)}{R}\frac{\alpha}{\pi}$$

$$I_{Df} = \frac{E_m}{\pi^2}\frac{(\alpha+\alpha\cos\alpha)}{R}$$

48. **(a)**

Until t_1 ,$V_d > V_R$

$\therefore$ V_L is positive, the current builds up and the energy stored in inductor increases.

49. **(a)**

Average power loss in the power transistor for a switching frequency of 2 kHz is given as :

$$= \frac{V_{cc}I_{cs}}{6} f . t_{on} + \frac{V_{cc}I_{cs}}{6} f . t_{off}$$

$$= \left(\frac{220\times 80}{6}\times 2\times 10^3 \times 1.5\times 10^{-6} + \frac{220\times 80}{6}\times 2\times 10^3 \times 4\times 10^{-6}\right)$$

$$= 8.8 + 23.46 = 32.26 \text{ W}$$

50. **(d)**

All the expressions are correct

$$\text{IPF} = \text{CDF} \times \text{DPF} = \frac{\text{DPF}}{\sqrt{1+(\text{THD})^2}}$$

$$(\text{CDF})^2 = \frac{1}{1+(\text{THD})^2}$$

$$\text{THD} = \sqrt{\frac{1}{\text{CDF}^2} - 1}$$

51. **(d)**

Power MOSFET and GTO both can be controlled during turn on and turn off operation. TRIAC and SCR are controlled only during turn on operation.

52. (d)

To work in inverter mode, the converter firing angle should be 90° ≤ α ≤ 180° and the dc voltage should act as source.

53. (d)

Average output voltage,

$$V_0 = \frac{1}{2\pi}\left[\int_{\alpha}^{\pi} V_m \sin\omega t\, d\omega t + \int_{\pi}^{2\pi} -V_m \sin\omega t\, d\omega t\right]$$

$$V_0 = \frac{1}{2\pi}[V_m(\cos\alpha + 1) + 2V_m]$$

$$V_0 = \frac{V_m}{2\pi}(3 + \cos\alpha)$$

$$V_0 = \frac{230\sqrt{2}}{2\pi}\left[3 + \cos\frac{\pi}{4}\right] = 191.91 \text{ V}$$

Load current, $$I_0 = \frac{(V_0 - E)}{R} = \frac{(191.91 - 120)}{10} = 7.19 \text{ A}$$

Power absorbed by battery,

$$P = E\, I_0 = 120 \times 7.19 = 862.8 \text{ W} \approx 863 \text{ W}$$

54. (c)

$$V_s = L\frac{di}{dt}$$

$$\int_0^{\mu} V_m \sin\omega t\, d\omega t = \int_0^{I_d} \omega L_s di$$

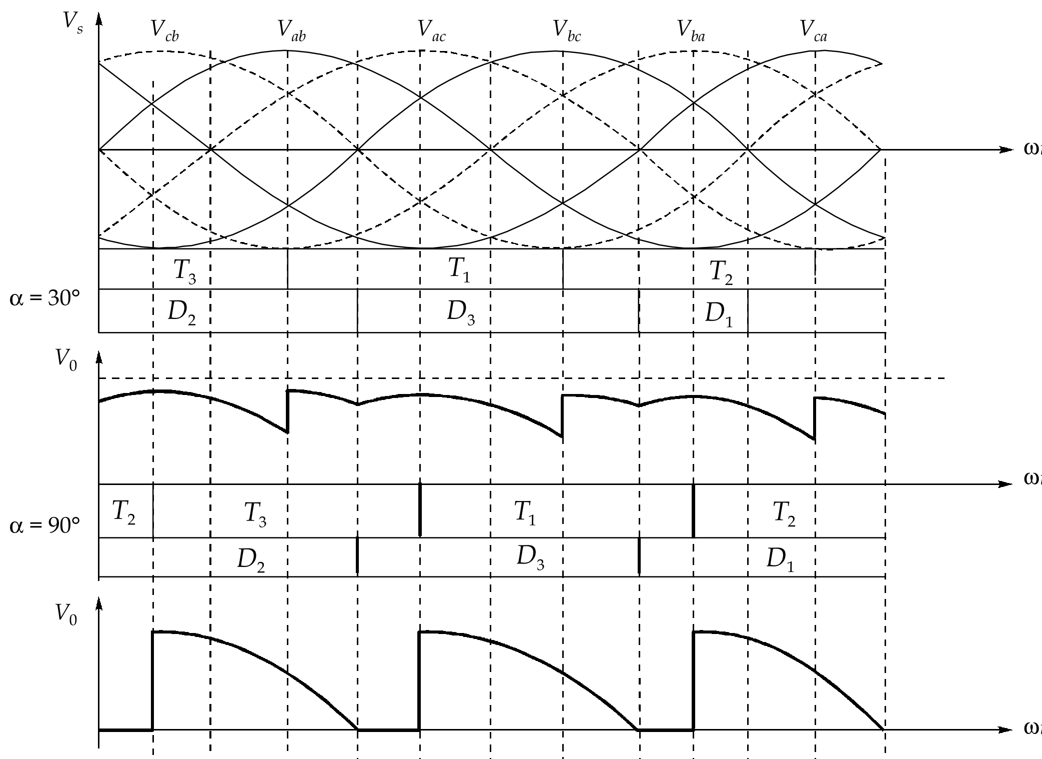
$$V_m(1 - \cos\mu) = \omega L_s I_d$$

$$\mu = \cos^{-1}\left(1 - \frac{\omega L_s I_d}{V_m}\right)$$

$$\mu = \cos^{-1}\left(1 - \frac{120\pi \times 5 \times 10^{-3} \times 10}{120\sqrt{2}}\right)$$

$$= \cos^{-1}(0.89) = 27.26°$$

56. (c)



A three-phase semiconverter has the unique feature of working as a six-pulse converter of $\alpha < 60°$ and as a three-pulse converter for $\alpha \geq 60°$, a careful observation of above figure reveals this.

58. (a)

Because MOSFETs have a positive temperature coefficient they can be easily connected in parallel. If a MOSFET shared increased current initially, it heats up faster, its resistance increases and this increased resistance causes this current to shift to other devices in parallel.

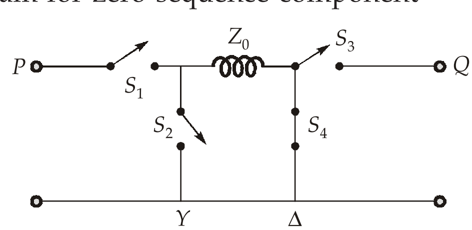
60. (a)

If the rate of rise of anode current (di/dt) is large as compared to spread velocity of carriers across the cathode junction, local hot spots will be formed near gate connection. This increases the junction temperature and may damage the device.

Section C : Power Systems-2

61. (c)

According to switching diagram for zero sequence component



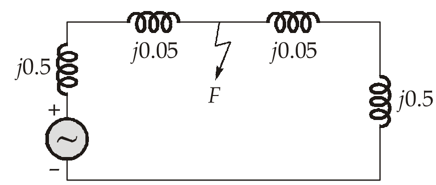
Since in the primary side it is Y-connected without grounding so S_1 and S_2 are open and in secondary side it is Δ-connected so S_3 is open and S_4 is closed.

62. (d)

All statements are correct.

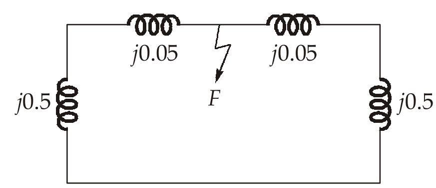
63. (b)

For Z_1 :



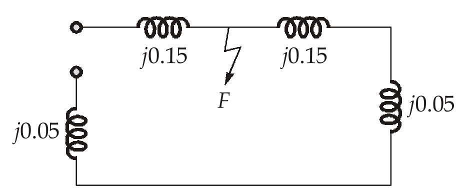
$$Z_1 = j0.55 \,||\, j0.55 = j0.275 \text{ p.u.}$$

For Z_2 :



$$Z_2 = j0.275 \text{ p.u.}$$

For Z_0 :



$$Z_0 = j0.15 + j0.05 = j0.2 \text{ p.u.}$$

Fault current for LG fault,

$$I_F = \frac{3 \times 1.0}{j0.275 + j0.275 + j0.2} = -j4.0 \text{ p.u.}$$

64. (d)

All statements are correct.

65. (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

66. (b)

Under steady state condition initially,

$$P_m = P_e = 1 \text{ p.u.}$$

If load increases by 3% then electrical power becomes 1.03 p.u.

$$\text{Accelerating power} = \text{Mechanical input} - \text{Electrical output}$$
$$= 1.00 - 1.03 = -0.03 \text{ p.u.}$$

67. (a)

$$M = J\omega_{sm} = \frac{\frac{J2\times\pi\times N_s}{60}}{10^6} \text{ MJ-sec/Mech rad}$$

$$= 30000\times\frac{2\times3.14\times1500}{60\times10^6} = 4.71 \text{ MJ-sec/Mech rad}$$

68. (d)

$$Z_{23} = \frac{-1}{Y_{23}} = \frac{1}{y_{23}} = \frac{1}{-j10}$$

$$Z_{23} = j0.1$$

69. (d)

Given,
$$I_a = (500 + j150) \text{ A}$$
$$I_b = (100 - j600) \text{ A}$$
$$I_c = (-300 + j\,600) \text{ A}$$

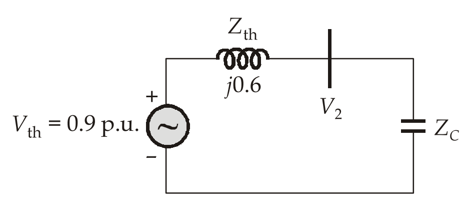
The zero sequence current of phase a is,

$$I_{a0} = \frac{1}{3}(I_a + I_b + I_c)$$

$$= \frac{1}{3}(300 + j150)$$

$$I_{a0} = (100 + j50) \text{ A}$$

70. (b)



$$V_2 = 0.95 \text{ p.u.,}$$

$$V_2 = V_{th}\times\frac{Z_C}{Z_C + Z_{th}}$$

$$\Rightarrow \quad \frac{0.95}{0.9} = \frac{Z_C}{Z_C + j0.6}$$

$$\Rightarrow \quad Z_C(0.0526) = -j0.6$$

$$Z_C = -j11.407 \text{ p.u.}$$

71. (b)

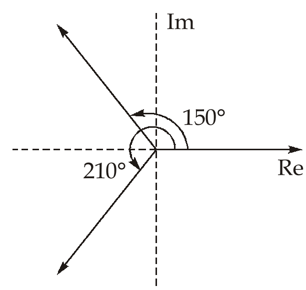
$$\vec{V}_A = I_a Z_a$$

$$\vec{V}_B = I_b Z_b$$

$$\vec{V}_c = I_c Z_c$$

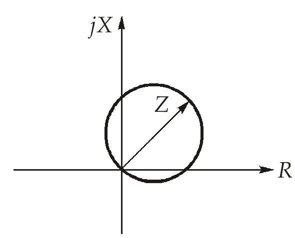
$$\vec{V}_{a1} = \frac{Z}{3}\left[I_a + \alpha I_b + \alpha^2 I_c\right]$$

$$= \frac{Z}{3}[1\angle 0° + 1\angle 210° + 1\angle 150°]$$



$$\frac{Z}{3}[1 - 2\sin 60°] = \frac{Z}{3}(1-\sqrt{3})$$

72. (d)



The operating area is mainly spread in *Ist* 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

73. (d)

All are correct.

75. (b)

Addition of a regulating transformer modifies the Y_{bus} matrix.

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