CLASS TEST

S.No.: 01SKEE_ABCDEFGHI_4925

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POWER SYSTEM-2

ELECTRICAL ENGINEERING

Date of Test : 04/09/2025

ANSWER KEY

1.	(b)	7.	(d)	13.	(d)	19.	(c)	25.	(b)
2.	(c)	8.	(d)	14.	(a)	20.	(a)	26.	(a)
3.	(c)	9.	(b)	15.	(a)	21.	(a)	27.	(b)
4.	(a)	10.	(a)	16.	(b)	22.	(d)	28.	(a)
5.	(b)	11.	(d)	17.	(d)	23.	(b)	29.	(d)
6.	(c)	12.	(a)	18.	(c)	24.	(b)	30.	(c)

DETAILED EXPLANATIONS

1. (b)

We know that, $RRRV = \frac{V_m}{\sqrt{LC}} \sin\left(\frac{t}{\sqrt{LC}}\right)$

For short line, L and C decreases

So, $\frac{V_m}{\sqrt{LC}}$ increases

2. (c)

In LLG fault,

$$I_{positive} + I_{negative} + I_{zero} = 0$$

Here, $j1.653 - j\,0.5 - j1.153 = 0$

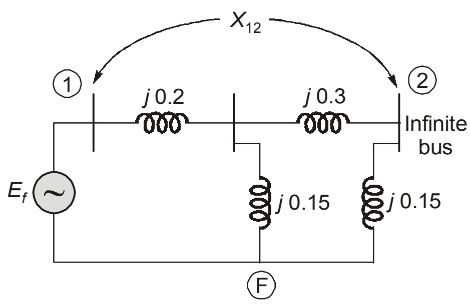
3. (c)

$$\text{SLG fault current } I_f = \frac{3E}{X_1 + X_2 + X_0 + 3X_n} = 1$$

or, $3X_n = 3 - (0.75)$

or, $X_n = 0.75$ pu

4. (a)



$$X_{12} = \frac{j(0.2\times0.15 + 0.3\times0.15 + 0.2\times0.3)}{0.15} \quad \text{(Using star to delta transformation)}$$

$$= j\left(0.2 + 0.3 + \frac{0.2\times0.3}{0.15}\right) = j0.9 \text{ p.u.}$$

5. (b)

$$\text{Synchronizing power coefficient} = P_{max}\cos\delta_0 = \frac{dP_e}{d\delta}$$

Here, $P_{max} = 2,$

$\delta = 30°$

$\therefore$ $S_p = 2\cos 30°$

$$= 2\times\frac{\sqrt{3}}{2} = \sqrt{3}$$

6. (c)

For a solid LG fault,

Fault current is: $$(I_F)_{LG} = \frac{3E}{(2X_1 + X_0 + 3X_n)}$$ (Here, $X_1 \approx X_2$ for synchronous generator)

Similarly, for a solid 3-ϕ fault

$$(I_F)_{3\text{-}\phi} = \frac{E}{X_1}$$

For LG fault current to be less than 3-ϕ fault current,

$$\frac{3E}{2X_1 + X_0 + 3X_n} < \frac{E}{X_1}$$

or, $$2X_1 + X_0 + 3X_n > 3X_1$$

or, $$X_n > \frac{1}{3}(X_1 - X_0)$$

Hence, option (c) is correct.

7. (d)

Voltage drop in each phase of generator is

$$\begin{bmatrix} \Delta V_a \\ \Delta V_b \\ \Delta V_c \end{bmatrix} = \begin{bmatrix} j2 & j1 & j1 \\ j1 & j2 & j1 \\ j1 & j1 & j2 \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

or we can write in sequence components,

$$\begin{bmatrix} \Delta V_{a0} \\ \Delta V_{b0} \\ \Delta V_{c0} \end{bmatrix} = \begin{bmatrix} X_0 & 0 & 0 \\ 0 & X_1 & 0 \\ 0 & 0 & X_2 \end{bmatrix} \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}$$

$$X_0 = X_s + 2X_m = j2 + 2(j1) = j4 \text{ p.u.}$$
$$X_1 = X_s - X_m = j2 - j1 = j1 \text{ p.u.}$$
$$X_2 = X_s - X_m = j2 - j1 = j1 \text{ p.u.}$$

$$I_f = I_a = \frac{3E_a}{X_1 + X_2 + X_0} = \frac{3 \times 1}{j(4+1+1)} = -j0.5 \text{ p.u.}$$

$$\begin{bmatrix} \Delta V_a \\ \Delta V_b \\ \Delta V_c \end{bmatrix} = \begin{bmatrix} j2 & j1 & j1 \\ j1 & j2 & j1 \\ j1 & j1 & j2 \end{bmatrix} \begin{bmatrix} -j0.5 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 1 \\ 0.5 \\ 0.5 \end{bmatrix}$$

$$\begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \begin{bmatrix} E_{an} \\ E_{bn} \\ E_{cn} \end{bmatrix} - \begin{bmatrix} \Delta V_a \\ \Delta V_b \\ \Delta V_c \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} 1 \\ 0.5 \\ 0.5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0.5 \\ 0.5 \end{bmatrix}$$

8. (d)

We know that,
$$(Z_{\text{p.u.}})_{\text{new}} = (Z_{\text{p.u.}})_{\text{old}} \times \frac{(\text{MVA})_{\text{new}}}{(\text{MVA})_{\text{old}}} \times \frac{(\text{kV})^2_{\text{old}}}{(\text{kV})^2_{\text{new}}}$$

For G_1 and M_1:

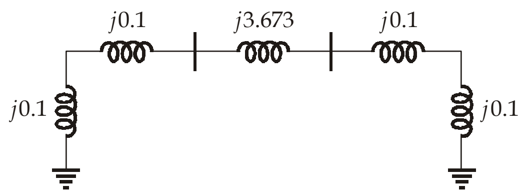
$$(X_{\text{p.u.}})_{\text{new}} = 0.05 \times \frac{80}{40} \times \left(\frac{11}{11}\right)^2 = j\,0.1 \text{ p.u.}$$

For line:

$$(X_{\Omega})_{\text{base}} = \frac{(\text{kV})^2}{\text{MVA}} = \frac{33^2}{80} = 13.6125\ \Omega$$

$$(X_{\text{p.u.}})_{\text{line}} = \frac{\text{Actual value}}{\text{Base value}} = \frac{50}{13.6125}$$

$$= j\,3.673 \text{ p.u.}$$



9. (b)

3-ϕ fault current:

Let system is under no load condition before fault,

$\therefore \quad E = 1\angle 0° \text{ p.u.}$

$$\text{3-}\phi \text{ fault current, } I_f = \frac{E}{X_1}$$

$$\Rightarrow \quad X_1 = \frac{1}{-j5} = j0.2 \text{ p.u.}$$

Line-line fault current:

$$I_f = \frac{\sqrt{3}E}{X_1 + X_2}$$

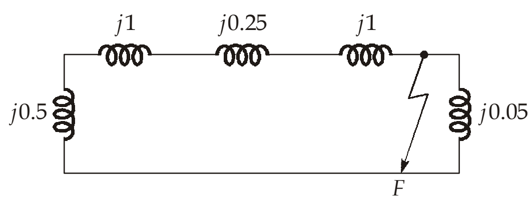
$$\Rightarrow \quad X_1 + X_2 = \frac{\sqrt{3}}{-j2.5}$$

$$\Rightarrow \quad j\,0.2 + X_2 = j\,0.69 \text{ p.u.}$$

$$\Rightarrow \quad X_2 = j\,0.49 \text{ p.u.}$$

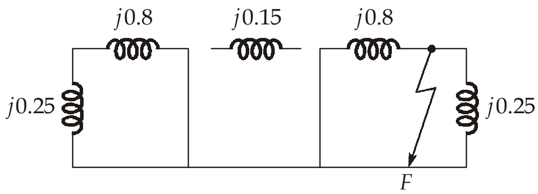
10. (a)

Positive and negative sequence reactance diagram:



$$Z_1 = Z_2$$
$$= j\,2.75 \,||\, j\,0.5 = j\,0.423 \text{ p.u.}$$

Zero sequence reactance diagram:



$$Z_0 = j\,0.8 \,||\, j\,0.25 = j\,0.19 \text{ p.u.}$$

Considering system at no load before fault

i.e. $E = 1.0\angle 0° \text{ p.u.}$

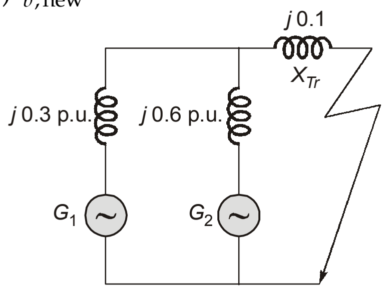
$$(I_F) = 3\left(\frac{E}{Z_1 + Z_2 + Z_0}\right) = 3\left(\frac{1}{j0.423 + j0.423 + j0.19}\right)$$
$$I_f = -j2.896 \text{ p.u.}$$

11. **(d)**

Let us choose a base of 15 MVA, 11 kV on LV side of transformer.

We know that: $$Z_{(\text{pu})\text{new}} = Z_{p(\text{old})} \times \frac{(MVA)_{b.\text{new}}}{(MVA)_{b,\text{old}}} \times \frac{(kV)^2{}_{b,\text{old}}}{(kV)^2{}_{b,\text{new}}}$$

$\therefore$ $$X_{g_1} = 0.2 \times \frac{15}{10} = 0.3 \text{ p.u.}$$
$$X_{g_2} = 0.2 \times \frac{15}{5} = 0.6 \text{ p.u.}$$
$$X_{\text{Tr}} = 0.1 \text{ p.u.}$$



$\therefore$ $$I_F'' = \frac{E_g}{Z_1} = \frac{1.0}{(j0.3 \,||\, j0.6) + j0.1}$$
$$= -j\,3.333 \text{ p.u.}$$

Thus, I_{G1}'' = Substransient current of generator-1 = $-j\,3.333$ pu

12. **(a)**

Since the generators are in parallel, they will operate at the same frequency at steady load.

Let load on generator 1 (200 MW) = x MW

load on generator 2 (400 MW) = $(600 - x)$ MW

and reduction in frequency = Δf

$\therefore$ $$\frac{\Delta f}{x} = \frac{0.04 \times 50}{200} \quad \text{... (i)}$$

and $$\frac{\Delta f}{600 - x} = \frac{0.05 \times 50}{400} \quad \text{... (ii)}$$

Equating Δf in (i) and (ii),

x = 230.769 ≈ 231 MW (load on generator-1)

$600 - x$ = 369 MW (load on generator-2)

$\therefore$ System frequency $= 50 - \frac{0.04 \times 50}{200} \times 231 = 47.69$ Hz.

13. **(d)**

Since the new branch is connected between bus-2 and reference bus, therefore

$$Z_{\text{bus, new}} = Z_{\text{bus,old}} - \frac{1}{(Z_{kk}+Z_s)}\left[2^{\text{nd}} \text{ column}\right][2^{\text{nd}} \text{row}]$$

or,
$$Z_{22,\text{ new}} = Z_{22,\text{old}} - \frac{1}{(Z_{22}+Z_s)}(Z_{22})(Z_{22})\ 0 = 0.34 - \frac{1(0.34)(0.34)}{(0.34+0.1)}$$

$$= 0.0772 \text{ pu}$$

Also,
$$Z_{23,\text{ new}} = Z_{23,\text{old}} - \frac{1}{(Z_{22}+Z_s)}(Z_{22})(Z_{23})$$

$$= 0.25 - \frac{1}{(0.34+0.1)}(0.34)(0.25)$$

$$= 0.0568 \text{ pu}$$

14. **(a)**

From coordination equation,

$$\frac{dF_n}{dP_{Gn}} \cdot \frac{1}{1 - \frac{\partial P_L}{\partial P_{Gn}}} = \lambda$$

Given,
$$P_L = 0.5P_{G1}^2$$

So,
$$\frac{dF_1}{dP_{G1}} \cdot \frac{1}{1-P_{G1}} = \frac{dF_2}{dP_{G2}} \cdot \frac{1}{1-0}$$

$\Rightarrow$
$$10000 \times \frac{1}{1-P_{G1}} = 12500$$

$$P_{G1} = \frac{1}{5}\text{p.u.}$$

as the base value of 100 MVA

$$P_{G1} = \frac{1}{5} \times 100 = 20 \text{ MVA}$$

$$P_L = 0.5P_{G1}^2 = 0.5 \times \left(\frac{1}{5}\right)^2 = 0.02 \text{ p.u.}$$

$$= 0.02 \times 100 = 2 \text{ MVA}$$

$$P_D = P_{G1} + P_{G2} - P_L$$

$$40 = 20 + P_{G2} - 2$$

$\Rightarrow$
$$P_{G2} = 22 \text{ MVA}$$

15. **(a)**

We use switch diagram to draw the zero-sequence network.

16. (b)

We know that, $RRRV = \frac{V_m}{\sqrt{LC}} \sin\left(\frac{t}{\sqrt{LC}}\right)$

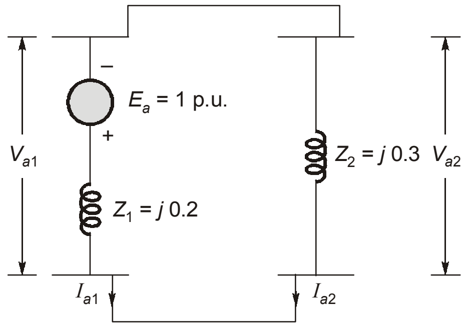
For short line, L and C decreases

So, $\frac{V_m}{\sqrt{LC}}$ increases

17. (d)

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} V_{a1} \\ V_{a2} \\ V_{a0} \end{bmatrix}$$

Sequence network representing L-L fault on phases b and c,



$$I_{a1} = -I_{a2} = \frac{1}{j0.5} = -j\,2 \text{ p.u.}$$

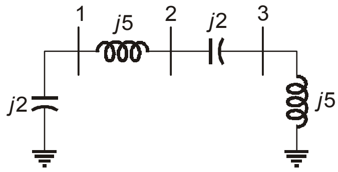
from the above network

$$V_{a1} = V_{a2}$$
$$V_{a1} = E_a - I_{a1} X_1$$
$$= 1 - (-j2)(j\,0.2) = 0.6 \text{ p.u.}$$

$\therefore$ $$V_{a1} = V_{a2} = 0.6 \text{ p.u.}$$
$$V_{ab} = V_a - V_b$$
$$= (V_{a1} + V_{a2} + V_{a0}) - (\alpha^2 V_{a1} + \alpha V_{a2} + V_{a0})$$
$$= 2V_{a1} - (\alpha^2 + \alpha)V_{a1} = (2 - \alpha^2 - \alpha)\,0.6$$
$$V_{ab\text{ p.u.}} = 1.8 \text{ p.u.}$$
$$V_{ab} = 1.8 \times 11 = 19.8 \text{ kV}$$

18. (c)

In the question the values given at capacitors are admittance values and at inductors are impedance values.



$$Y = \begin{bmatrix} j2 - j0.2 & j0.2 & 0 \\ j0.2 & j2 - j0.2 & -j2 \\ 0 & -j2 & j2 - j0.2 \end{bmatrix}$$

$$[Y]_{bus} = j\begin{bmatrix} 1.8 & 0.2 & 0 \\ 0.2 & 1.8 & -2 \\ 0 & -2 & 1.8 \end{bmatrix}$$

19. (c)

$$V_R = V_m(1 - \cos \omega t)$$

$$\omega = \frac{1}{\sqrt{LC}},$$

$$V_m = \text{per phase peak voltage}$$

$$\omega = \frac{1}{\sqrt{0.5\times10^{-3}\times8\times10^{-3}}} = 500 \text{ rad/sec}$$

$$V_m = \left(\frac{33}{\sqrt{3}}\right)\times\sqrt{2}\text{ kV} = 26.94 \text{ kV}$$

at $V_R = 26.94\,(1 - \cos(500 \times 1.57 \times 10^{-3}))$

$V_R = 7.88$ kV [Keep the capacitor in radians mode]

20. (a)

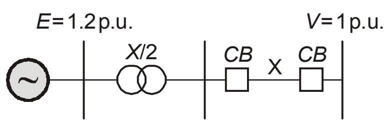
At healthy condition

$$\text{Total impedance} = \frac{X}{2}+\frac{X}{2} = X$$

$$P = \frac{EV}{X} = \frac{1.2\times1}{X} = 5 \text{ p.u.}$$

$$X = \frac{1.2}{5} = 0.24 \text{ p.u.}$$

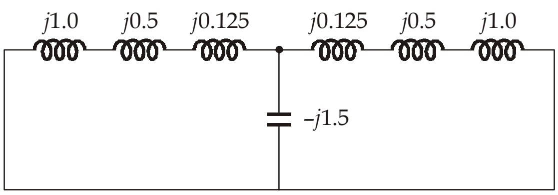
at faulty condition after CB open



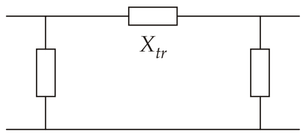
$$P = \frac{EV}{X_{Total}} = \frac{1.2\times1}{X+\frac{X}{2}} = \frac{2\times1.2}{3\times0.24}$$

$$P = 3.33 \text{ p.u.}$$

21. (a)



Converting star into delta:



The transfer reactance, $X_{tr} = j1.625 + j1.625 + \dfrac{j1.625 \times j1.625}{-j1.5}$

$= 1.48$ p.u.

22. (d)

$$Z_{\text{Bus (new)}} = \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.3+0.5 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.3 \\ 0.3 & 0.8 \end{bmatrix}$$

23. (b)

The reactance in p.u. $= Z_{\text{p.u.}} = Z_\Omega \times \dfrac{\text{MVA}_{(b)}}{(\text{kV})_b^2}$

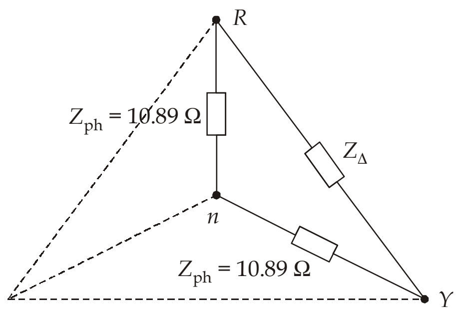
$$Z_\Omega = Z_{\text{p.u.}} \times \frac{(kV_b)^2}{(\text{MVA})_b}$$

$$= 0.10 \times \frac{(33)^2}{10} = 10.89\ \Omega$$

So reactance per phase $= Z_{ph} = 10.89\ \Omega$

$$Z_\Delta = 3 \times Z_{ph} = 3 \times 10.89$$

$$Z_\Delta = 32.67\ \Omega$$



24. (b)

$$S_{D2} = (0.8 + j0)\text{ p.u.}$$

This 0.8 p.u. active power is supplied by the generator G_1

$$\therefore \quad 0.8 = \frac{1 \times 1}{0.5}\sin\delta$$

$$\delta = \sin^{-1}\left(\frac{0.8}{2}\right) = 23.58°$$

$$Q_R = \frac{|V_1| \times |V_2|}{X}\cos\delta - \frac{|V_1|^2}{X}$$

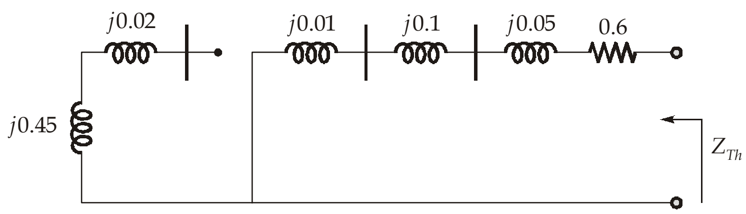
$$= \frac{1}{0.5}\cos(23.58°) - \frac{1}{0.5}$$

$$Q_R = -0.167\text{ p.u.}$$

The VAR rating of the capacitor = 0.167 p.u.

25. (b)

The zero sequence impedance network from point P and ground



The Thevenin's equivalent zero sequence impedance

$$Z_{Th} = (0.6 + j\,0.16) \text{ p.u.}$$

26. (a)

$$|I''| = \frac{E}{|X_d''|} = \frac{1}{0.22} = 4.54 \text{ p.u.}$$

$$I_{base} = \frac{\text{MVA}_b}{\sqrt{3}(\text{kV}_b)} = \frac{100\times10^6}{\sqrt{3}\times11\times10^3} = 5248.6 \text{ A} = 5.248 \text{ kA}$$

The magnitude of initial symmetrical rms current

$$= 4.54 \times 5.248 = 23.82 \text{ kA}$$

27. (b)

Kinetic energy ∝ frequency^2

$$W \propto f^2$$

$$\frac{W_1}{W_2} = \frac{f_1^2}{f_2^2}$$

$$f_2 = f_1\sqrt{\frac{W_2}{W_1}} = 50\times\sqrt{\frac{500-(0.5\times50)}{500}} \quad [\because W = GH = 100\times5 \text{ MJ}]$$

$$= 48.734 \text{ Hz}$$

Percentage deviation in frequency,

$$= \frac{50-48.734}{50}\times100 = 2.532\%$$

Thus we can say that I_1 and I_3 currents are going into bus thus they are PQ bus and I_2 is going away from bus

∴ Bus-2 is generator bus (PV bus).

28. (a)

Fault current at bus 3 is,

$$I_{f3} = \frac{V_3(0)}{Z_{33}+Z_f} = \frac{1}{j0.2780 + j0.15}$$

$$I_{f3} = -j\,2.336 \text{ p.u.}$$

$$|I_{f3}| = 2.336 \text{ p.u.}$$

29. (d)

Zero sequence current in R line is

$$\vec{I}_{R_0} = \frac{1}{3}\times\text{Current in neutral wire}$$

$$= \frac{1}{3}\times300\angle300° = 100\angle300° \text{ A}$$

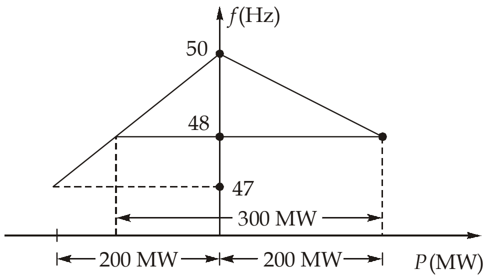
$$\text{Current in } Y\text{-line} = \vec{I}_Y = \vec{I}_{R_0} + a^2\vec{I}_{R_1} + a\vec{I}_{R_2}$$

$$= (100\angle300°) + (1\angle120°)^2\,(200\angle0°) + (1\angle120°)\,(100\angle60°)$$

$$= (100\angle300°) + (200\angle-120°) + (100\angle180°)$$

$$\vec{I}_Y = (300\angle-120°) \text{ A}$$

30. (c)



New frequency of operation of 200 MW alternator,

$$f_1 = 50 - \frac{2}{200} P_1$$

and,

$$f_2 = 50 - \frac{3}{200} P_2$$

Total load, $P_1 + P_2 = 300$ MW ...(i)

Units operated in parallel so,

$$f_1 = f_2 = f$$

$$50 - \frac{2}{200} P_1 = 50 - \frac{3}{200} P_2$$

$$2P_1 - 3P_2 = 0 \quad \text{...(ii)}$$

From equations (i) and (ii), we get

$$P_1 = 180 \text{ MW}$$
$$P_2 = 120 \text{ MW}$$

Machine (1) which has better speed regulation will be loaded first to its full load rating, so it will operate on maximum load of 200 MW.

$$2P_1 - 3P_2 = 0 \quad \text{...(iii)}$$
$$2 \times 200 - 3P_2 = 0$$
$$P_2 = \frac{400}{3} = 133.33 \text{ MW}$$

Total power delivered by two machine without overloading

$\therefore$ $P_1 + P_2 = 200 + 133.33 = 333.33$ MW

■■■■