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POWER SYSTMS

ELECTRICAL ENGINEERING

Date of Test : 30/09/2026

ANSWER KEY ➤

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

DETAILED EXPLANATIONS

1. (c)

$$\frac{dF_1}{dP_1} = 20 + 0.1\,P_1,$$

$$\frac{dF_2}{dP_2} = 16 + 0.2\,P_2$$

For economic operation

$$20 + 0.1\,P_1 = 16 + 0.2\,P_2$$

$$4 = -0.1\,P_1 + 0.2\,P_2 \quad \text{...(i)}$$

$$P_1 + P_2 = 200 \text{ MW} \quad \text{...(ii)}$$

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

$$P_2 = 80 \text{ MW}$$

and $P_1 = 120$ MW

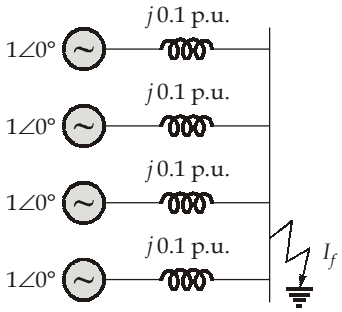
But the limits of generator 2 is $20 \le P_2 \le 60$ MW

$$P_1 = 140 \text{ MW}, P_2 = 60 \text{ MW}$$

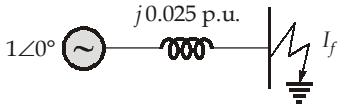
2. (c)

For given power system we can draw

Base MVA = 15 MVA



Simplified layout or equivalent circuit,



Short circuit current, $I_f = \frac{E_g}{X} = \frac{1}{j0.025} = 40\angle -90°$

Short circuit MVA = $I_f \times$ Base MVA

$= 40 \times 15 = 600$ MVA

3. (b)

Primary line current = $I_{LP} = \frac{10 \times 10^6}{\sqrt{3} \times 132 \times 10^3} = 43.74$ A

CT connected to primary of transformer is delta connected.

So, the current in the secondary of the CT is $\frac{5}{\sqrt{3}}$A

$\therefore$ The CT ratio of primary of the transformer is, 43.74/(5/1.732)
The secondary line current of the transformer is,

$$I_{LS} = \frac{10 \times 10^6}{\sqrt{3} \times 66 \times 10^3} = 87.47 \text{ A}$$

$\therefore$ The CT ratio on the secondary is, $\frac{87.47}{5}$.

4. (c)

Charging current, $I_C = \frac{V_{\text{phase}}}{X_C}$

Also, $X_C = \frac{1}{Y} = \frac{1}{C} = \frac{1\angle -90°}{0.4 \times 10^{-4}}$

$$V_{\text{phase}} = \frac{110 \times 10^3}{\sqrt{3}} \text{V}$$

$$I_C = \frac{110 \times 10^3}{\sqrt{3}\left(\frac{1\angle -90°}{0.4 \times 10^{-4}}\right)} \text{V} = 2.540\angle 90° \text{ A}$$

5. (b)

Reactive power, Q = Active power × tan ϕ
$= 100 \times 10^3 \times \tan(\cos^{-1} 0.8))$
$Q = 75$ kVAR

The capacitor bank should supply

$Q = 75$ kVAR

$$Q_{\text{ph}} = \frac{75000}{3} = 25 \text{ kVAR}$$

$$Q_{\text{ph}} = V_{\text{ph}}^2 \omega C_{\text{ph}}$$

$$C_{\text{ph}} = \frac{Q_{ph}}{V_{\text{ph}}^2 \times 2\pi f}$$

$$C_{\text{ph}} = \frac{25000}{\left[\frac{10 \times 10^3}{\sqrt{3}}\right]^2 \times 2\pi \times 50} = 2.38 \times 10^{-6} \text{ F}$$

6. (d)

Given, $Y_{12} = -(y_{12}) = -j24$

Series admittance of each line,

$$\frac{Y_{12}}{2} = -j\frac{24}{2} = -j12$$

Series reactance of each line,

$$= \frac{1}{-j12} = 0.0883 \text{ p.u.}$$

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7. **(c)**

$$P_{rated} = 200 \text{ MW}$$

$$\Delta f = \left(\frac{1}{B_{p.u.} + \frac{1}{R}}\right)(\Delta P_C - \Delta P_D)$$

Here, $\frac{1}{R}$ is in $\frac{\text{P.u.} - \text{MW}}{\text{Hz}}$;

So R is in $\frac{\text{Hz}}{\text{P.u.} - \text{MW}}$

$$R = \frac{4}{100} \times 50 = 2 \text{ Hz/p.u.-MW}$$

$$R\left(\frac{\text{Hz}}{\text{MW}}\right) = \frac{2}{P_{rated}} = \frac{2}{200} = 0.01 \text{ Hz/MW}$$

8. **(d)**

$$X_{L\text{-sh}} = \frac{B}{1 - A} = \frac{160\angle 90°}{1 - 0.8} = \frac{160\angle 90°}{0.2}$$
$$= 800\angle 90° \ \Omega$$

9. **(c)**

Given, $L = 40$ mH, $C = 0.08$ μF

The critical resistance needed,

$$R_{cr} = \frac{1}{2}\sqrt{\frac{L}{C}} = \frac{1}{2}\sqrt{\frac{40 \times 10^{-3}}{0.08 \times 10^{-6}}} = 353.55 \ \Omega$$

10. **(a)**

Transmitted voltage, $V_T = 2\left[\frac{Z_C}{Z_L + Z_C}\right] \times V$

$$= \frac{2 \times 300}{300 + 500} \times 100 \text{ kV} = \frac{2 \times 300}{800} \times 100 = 75 \text{ kV}$$

11. **(c)**

Given, $R = 0.04$ p.u.

$$\Delta f_1 = 0.04 \times 60 = 2.4 \text{ Hz}$$

We know that, $\frac{\Delta f_1}{\Delta P_1} = \frac{\Delta f_2}{\Delta P_2}$

$$\frac{2.4}{100} = \frac{0.02}{\Delta P_2}$$

$$\Delta P_2 = \frac{0.02 \times 100}{2.4} = \frac{5}{6} = 0.83 \text{ MW}$$

12. **(a)**

Given, $V_S = 400$ kV, $l = 250$ km

$L_1 = 1$ mH/km/phase, $C_1 = 0.02$ μF/km/phase

$$V = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{1\times10^{-3}\times0.02\times10^{-6}}} = 2.236\times10^5 \text{ km/sec}$$

$$\beta = \frac{2\pi f l}{V} = \frac{2\pi\times50\times250}{2.236\times10^5} = 0.3512$$

$$A = 1-\frac{\beta^2}{2} = 1-\frac{0.1233}{2} = 0.9383$$

$$V_R = \frac{V_S}{A} = \frac{400}{0.9383} = 426.30 \text{ kV}$$

13. (a)

The secondary current, $I_S = \frac{I_P}{n}$

Where, $n = \frac{500}{5}$

$$I_S = 7500\times\frac{5}{500} = 75 \text{ A}$$

Relay current setting = 125% of 5A = 1.25 × 5 = 6.25 A

Plug setting multiplier (PSM) = $\frac{75}{6.25} = 12$

Using data in characterstic table is

Operating time corresponding to PSM = 12 is 2.8 sec (at TMS = 1)

Operating time of relay = 2.8 sec × 0.4 = 1.12 sec.

14. (d)

Given admittance matrix

$$Y_{bus} = \begin{bmatrix} -j7 & j4 & j5 \\ j4 & -j8 & j6 \\ j5 & j6 & -j9 \end{bmatrix} \text{p.u.}$$

On comparing with standard form shown below

$$Y_{bus} = \begin{bmatrix} y_{11}+y_{12}+y_{13} & -y_{12} & -y_{13} \\ -y_{21} & y_{21}+y_{22}+y_{23} & -y_{23} \\ -y_{31} & -y_{32} & y_{31}+y_{32}+y_{33} \end{bmatrix}$$

$y_{31} + y_{32} + y_{33} = -j9,$

$-y_{31} = j5,$

$-y_{32} = j6$

Using above values

$(-j5) - j6 + y_{33} = -j9$

$y_{33} = j2$

Compensating after 60% of shunt capacitor

$= j2 \times 0.6 = j1.2$

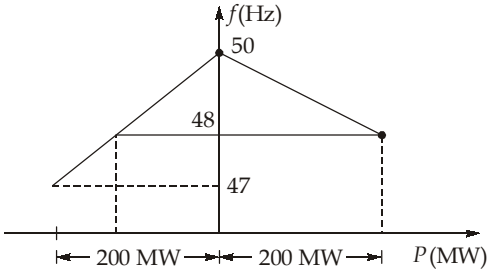
∴ New value after compensation with 60% of shunt capacitance

Hence new value : $-j9 - j1.2$

$= -j\ 10.2$

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15. (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

$P_1 = 180$ MW

$P_2 = 120$ 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

$$P_1 + P_2 = 200 + 133.33 = 333.33 \text{ MW}$$

16. (a)

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

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

V_m = per phase peak voltage

$$\omega = \frac{1}{\sqrt{0.5 \times 10^{-3} \times 8 \times 10^{-3}}} = 500 \text{ rad/sec}$$

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

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

$V_R = 7.88$ kV (Keep the calculator in radian mode)

17. (c)

Plug setting multiplier of relay 1

$$= \frac{2700}{1\times 1\times \frac{200}{1}} = 13.5$$

Operating time corresponding to 13.5 PSM is 2.6

Actual operating time of relay 1

$$= 2.6 \times \text{TMS} = 2.6 \times 0.15 = 0.39 \text{ sec}$$

$$\frac{V_2}{V_1} = \frac{I_1}{I_2}$$

$$\frac{33}{132} = \frac{I_1}{2700}$$

$$I_1 = 675 \text{ A}$$

$$\text{PSM of relay 2} = \frac{675}{1\times 1\times \frac{100}{1}} = 6.75$$

Operating time corresponding to PSM 6.75 is 3.6 *s*.

$$\text{TMS for relay 2} = \frac{0.39+0.6}{3.6} = 0.275$$

18. (b)

Percentage protected winding

$$= \left(1-\frac{IR}{V}\right)\times 100 = \left(1-\frac{10\times 0.8\times \frac{800}{5}}{\frac{22}{\sqrt{3}}\times 1000}\right)\times 100$$

$$= \left(1-\frac{1280}{12701.70}\right)\times 100 = (1 - 0.1007) \times 100 = 89.92\%$$

19. (b)

$$V_{a0} = g_0 \delta m_0 r \ln\left(\frac{d}{r}\right)$$

Air density factor, $$\delta = \frac{3.92b}{t+273} = \frac{3.92\times 75}{273+20}$$

$$\delta = 1.0034$$

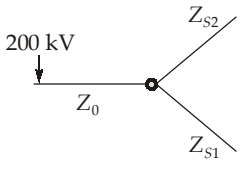
$$V_{a0} = 0.85\times 21\times 2\times 1.0034 \ln\left(\frac{300}{2}\right)$$

$$= 179.48 \text{ kV/phase}$$

Critical disruptive voltage $= 179.48\times\sqrt{3} = 310.86$ kV

20. (c)

$$\frac{V''}{V} = \frac{\frac{2}{Z_0}}{\frac{1}{Z_0}+\frac{1}{Z_{s1}}+\frac{1}{Z_{s2}}} = \frac{\frac{2}{500}}{\frac{1}{500}+\frac{1}{1000}+\frac{1}{600}}$$



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$$\frac{V''}{200\times10^3} = \frac{6}{7} = 0.8571$$

$$V'' = 171.42 \text{ kV}$$

21. (c)

$$\text{SIL} = \frac{400\times400}{Z_{sc}}$$

$$Z_{sc} = \frac{Z_s}{\sqrt{1+K_{csh}}} = \frac{400}{\sqrt{1+0.25}} = 357.77\ \Omega$$

$$\text{SIL} = \frac{400\times400}{357.77}\times10^6 = 447.21 \text{ MW}$$

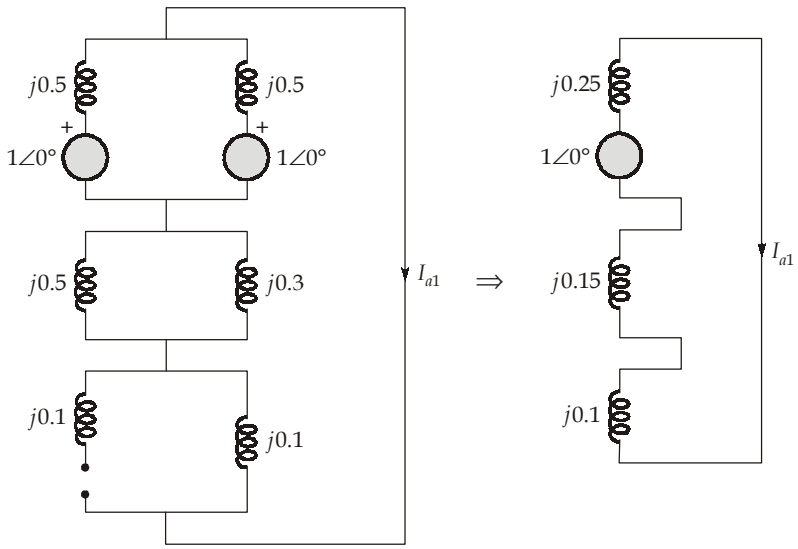
$$P = P_{max}\sin\delta$$

or $$200 = 447.21\sin\delta$$

or $$\delta = \sin^{-1}\left(\frac{200}{447.21}\right) = 26.56°$$

22. (c)

Simplified 2 generator layout can be drawn,



So, $$I_f = 3I_{a1} = 3\times\frac{1}{0.25+0.15+0.1}$$

$$= 3\times2 = 6 \text{ p.u.}$$

23. (c)

By equalizing the station,

$$P_{G_1} = P_{G_2} = 20 \text{ p.u.}$$

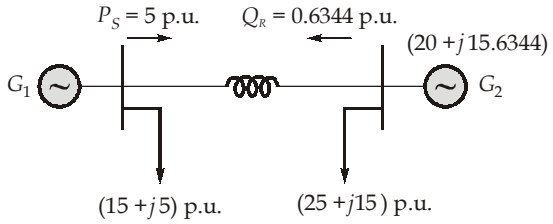
Now, $$5 = \frac{|E||V|}{|X|}\sin\delta = \frac{1\times1}{0.05}\sin\delta$$

$$\delta = 14.47°$$

$$Q_R = \frac{|V_1||V_2|}{X}\cos\delta - \frac{|V_1|^2}{X} = -0.6344 \text{ p.u.}$$

Total load on station 2 = $(25 + j15) + (-5 + j0.6344)$

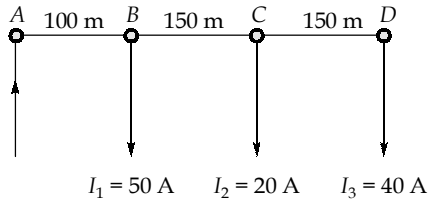
$= (20 + j15.6344)$



Power factor of station 2 = $\cos\left(\tan^{-1}\left(\frac{15.6344}{20}\right)\right)$

$= 0.788$ lagging

24. (a)



The resistance of line = 0.25 Ω per 1,000 meters.

Resistance of section AB,

$$R_{AB} = 0.25 \times \frac{100}{1000} = 0.025\ \Omega$$

Resistance of section BC = Resistance of section CD

$$R_{BC} = R_{CD} = 0.25 \times \frac{150}{1000} = 0.0375\ \Omega$$

Given, I_1 = 50A, I_2 = 20 A and I_3 = 40 A

Voltage at D, V_D = 400 V

Voltage at C, $V_C = V_D + I_3R_{CD}$

$= 500 + 40(0.0375) = 501.5$ V

Voltage at B, $V_B = V_C + (I_2 + I_3)R_{BC}$

$= 501.5 + 60 \times 0.0375$

$= 503.75$

Voltage at A, $V_A = V_3 + (I_1 + I_2 + I_3)R_{AB}$

$= 503.75 + (40 + 20 + 50) \times 0.025 = 506.5$ V

25. (c)

$$P_R = \frac{V_S V_R}{Z}\cos(\theta - \delta) - \frac{V^2}{Z}\cos\theta$$

For maximum power transfer,

$\theta = \delta$

and also it is given that, $V_R =$ $V_S = V$

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$$P_{R\ max} = \frac{V^2}{Z} - \frac{V^2}{Z}\cos\theta$$

$$Z = \sqrt{R^2 + X^2}$$

$$\cos\theta = \frac{R}{Z}$$

$$P_{R\ max} = \frac{V^2}{\sqrt{R^2 + X^2}} - \frac{V^2 R}{\left(R^2 + X^2\right)}$$

$$Z = R + jX$$

So, keeping $\frac{dP_{R\max}}{dX} = 0$

We get, $X = \sqrt{3}R$

$$X = \sqrt{3} \times \sqrt{3}$$

$$X = 3\ \Omega$$

26. (a)

$$\vec{I_R} = 100\angle 0°\text{A} \quad ; \quad \vec{I_Y} = 100\angle -120°\text{A} \quad ; \quad \vec{I_B} = 100\angle -240°\text{A}$$

$$I_{R0} = \frac{1}{3}\left(\vec{I}_R + \vec{I}_Y + \vec{I}_B\right)$$

$$\vec{I}_{Ro} = \frac{1}{3}[100\angle 0° + 100\angle 240° + 100\angle 120°] = 0\ \text{A}$$

$$\vec{I}_{R1} = \frac{1}{3}\left[\vec{I}_R + a\vec{I}_Y + a^2\vec{I}_B\right]$$

$$= \frac{1}{3}(100\angle 0° + (1\angle 120°)(100\angle -120°) + (1\angle 240°)(100\angle -240°))$$

$$= 100\ \text{A}$$

$$\vec{I}_{R2} = \frac{1}{3}\left[\vec{I}_R + a^2\vec{I}_Y + a\vec{I}_B\right]$$

$$= \frac{1}{3}(100\angle 0° + (1\angle 240°)(100\angle -120°) + (1\angle 120°)(100\angle -240°)) = 0\ \text{A}$$

27. (c)

We know that, $X_L = 4\Omega$, $C = 0.02\ \mu F$

$$L = \frac{X_L}{2\pi f} = \frac{4}{2\pi \times 60} = \frac{1}{30\pi} = 0.0106\ \text{H}$$

The frequency of transient oscillation,

$$f_n = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.0106 \times 0.02 \times 10^{-6}}} = 10.93\ \text{kHz}$$

The rate of rise of restriking voltage

$$= \frac{d}{dt}[V_m(1 - \cos\omega_n t)]$$

$$RRRV = V_m \omega_n \sin\omega_n t$$

$\therefore$ Maximum value of RRRV $= V_m \omega_n$

$$= 2\pi f_n \times V_m$$

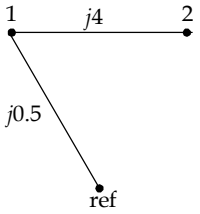
$$V_m = \frac{100}{\sqrt{3}}\sqrt{2} \times 1000 = 81649.66 \text{ V}$$

$$(\text{RRRV})_{\max} = 2\pi \times 10.93 \times 10^3 \times \frac{100\sqrt{2}}{\sqrt{3}} \times 10^3$$

$$= 5607.308 \times 10^6 \text{ V/s or } 5.607 \text{ kV/}\mu\text{sec}$$

28. (d)

Existing system and bus matrix is



$$Z_{\text{Bus}} = \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j4.5 \end{bmatrix}$$

Modifying line with reactance $j2$ is equivalent to adding a line in parallel with impedance $j4$. Thus it is type-4 modification.

$$[Z_{\text{new}}] = [Z_{old}] - \frac{1}{Z_{11} + Z_{22} - 2Z_{12} + Z_s} \begin{bmatrix} \text{subtract} \\ 2^{\text{old}}\text{ column} \\ \text{to first column} \end{bmatrix} [\text{Transpose}]$$

$$[Z_{\text{Bus}}]_{\text{new}} = \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j4.5 \end{bmatrix} - \frac{1}{j0.5 + j4.5 - 2(j0.5) + j4} \begin{bmatrix} j0 \\ -j4 \end{bmatrix} \begin{bmatrix} j0 & -j4 \end{bmatrix}$$

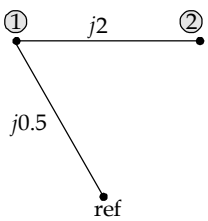
$$= \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j4.5 \end{bmatrix} - \frac{1}{j8} \begin{bmatrix} 0 & 0 \\ 0 & -16 \end{bmatrix}$$

$$= \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j4.5 \end{bmatrix} - \begin{bmatrix} 0 & 0 \\ 0 & -\frac{16}{j8} \end{bmatrix}$$

$$= \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j4.5 - \frac{j16}{8} \end{bmatrix} = \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j2.5 \end{bmatrix}$$

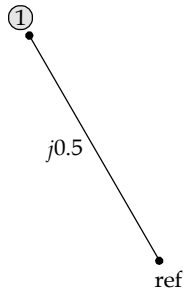
Alternative :

New system will



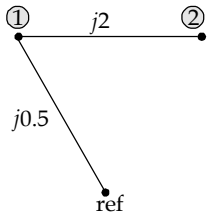
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First branch :



$Z = [\, j0.5]$

Type – 2 modification



$$Z = \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j0.5 + j2 \end{bmatrix} = \begin{bmatrix} j0.5 & j0.5 \\ j0.5 & j2.5 \end{bmatrix}$$

29. (b)

For single line to ground fault , fault current is

$$I_f = 3I_a^{(0)}$$

and $$I_a^{(0)} = \frac{-V_a^{(0)}}{Z_{g_0}}$$

$$V_a^{(0)} = \frac{1}{3}[V_a + V_b + V_c] = \frac{1}{3}[0 + 1.013\angle -102.25° + 1.013\angle 102.25°]$$

$$= -0.1433 \text{ p.u.}$$

$$I_a^{(0)} = -\left(\frac{-0.1433}{j0.1}\right) = -j1.43 \text{ p.u.}$$

$$I_f = 3 \times (-j1.43) = -j4.29 \text{ p.u.}$$

$$I_f = -j4.29 \times \left(\frac{20000}{\sqrt{3} \times 13.8}\right) = -j3.59 \text{ kA}$$

30. (a)

Given,Operating torque, $T_o = aVI\cos(\phi - \alpha)$

Restraining torque, $T_r = bV^2$

For relay to operate, $T_o > T_r$

$$aVI\cos(\phi - \alpha) > bV^2$$

$$Y\cos(\phi - \alpha) > \frac{b}{a}$$

$$\frac{a}{b} > \frac{1}{Y\cos(\phi - \alpha)}$$

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