1. $V_t = 3.81\angle 0^\circ$ kV

$S_1 = 1500$ kVA

$\cos\phi = 0.8$

$$\bar{I}_{a_1} = \frac{S_1}{3V_t\cos\phi} = 164.042\,\text{A}\ \angle -36.87^\circ$$

$$\bar{E}_{f_1} = \bar{V}_t + \bar{I}_a(R + jX_s)$$
$$= 4{,}409.7\angle 7.9^\circ\ \text{V}$$

$$\bar{I}_{a_2} = 164.042\angle 0^\circ\ \text{A}$$

$$\bar{V}_{t_2} = \bar{E}_{f_1} - \bar{I}_{a_2}(R + jX_s)$$
$$= 4{,}291\angle -2.85^\circ\ V$$

$\Delta V_t = +12.6\%$

2. $jX_{s_1} = jX_{s_2} = j4.5\,\Omega$

$\bar{E}_{f_1} = 1910\angle 0^\circ$ V

$\bar{E}_{f_2} = 1910\angle -30^\circ$ V

i) $\bar{I}_{circ} = \dfrac{\Delta\bar{E}_f}{j2X_s} = 109.85\,\text{A}\ \angle -165^\circ$

ii) $\bar{V}_{t_1} = \bar{E}_{f_1} - j\bar{I}_{circ}X_{s_1} = 1{,}845\angle -15^\circ\ V$

$\bar{V}_{t_2} = \bar{E}_{f_2} - j\bar{I}_{circ}X_{s_2} = 1{,}845\angle -15^\circ\ V$

iii) $Re\left[3E_f I_a^*\right] = 608\,\text{kW}$

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3. $\bar{E}_{f_1} = 2240\angle 0^\circ$ V
$\bar{E}_{f_2} = 1600\angle 80^\circ$ V

$$\bar{I}_{circ} = \left[\frac{2240\angle 0^\circ - 1600\angle 80}{j9}\right] = 71.1\angle -90^\circ \text{ A}$$

$$\bar{V}_t = 2240\angle 0^\circ - jI_a X_s$$
$$= 1920\angle 0^\circ \text{ V}$$

4. $P_1 = 2.8$MW
$\cos\phi = 0.7$
$S_1 = 4\angle -45.6^\circ$ MVA

$S_2 = 4\angle 0^\circ$ MVA
$P_2 = 4$MW
$Q_1 = -2.857$ MVAr

$\Delta P_2 = 1.2$MW $Q_2 = -Q_1$
$\cos\phi_2 = 0.3872$ Leading

5. $\bar{E}_{fLINE} = 460\text{V}\angle\delta$
$jX_s = j2\Omega$
$\bar{I}_a = 50\angle -36.87^\circ$ A
$\bar{V}_t = \bar{E}_{fLINE} - j(\sqrt{3}\times\bar{I}_a\times X_s)$
$\bar{E}_{f_L} = 460\angle 17.53^\circ$
$\bar{V}_t = 334.7$ V

$$P = \sqrt{3}\times 40\times\bar{V}_{tLine} = \frac{\bar{E}_f V_t \sin(\delta)}{X_s}$$
$$\therefore \delta = \sin^{-1}\left[\frac{40\sqrt{3}X_s}{E_f}\right]$$
$$= 17.53^\circ$$

$P = 23.189$kW
$P = T\omega$
$T = 221.4$Nm

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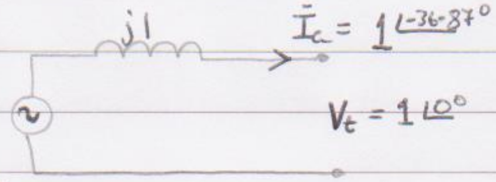
6.



$E_f = 1.79\angle 26.56^\circ$ pu V

$\delta = 26.56^\circ$

i)

$P = Re[V_t I_a^*]$ $\quad$ $Q = I_m[V_t I_a^*]$

$= 0.8\text{pu}$ $\quad$ $= 0.6\text{pu}$

ii) $E_{f_{II}} = 1.2\bar{E}_{f_I}$

Real Power unchanged $\Rightarrow P = 0.8 = \frac{1.2 E_{f_I} V_t}{X_s}\sin(\delta_2)$

$\Rightarrow \sin(\delta_2) = \frac{\sin\delta_1}{1.2} \Rightarrow \delta_2 = 21.88^\circ$

$\bar{E}_{f_{II}} = 2.148\angle 21.88^\circ$ pu V

$\bar{I}_a = 1.276\angle{-51.13^\circ}$ pu A

$\cos\phi = 0.627$

$P = 0.8\text{pu}$ $\quad Q = 0.993\text{pu}$

iii) $E_f = 1.79$ pu V

$P = 1.2(0.8) = 0.96$ pu W

$\delta = \sin^{-1}\left[\frac{P X_s}{E_f V_t}\right] = 32.45^\circ$

$\bar{I}_a = \frac{\bar{E}_f - \bar{V}_t}{j1} = 1.0877\angle{-27.99^\circ}$ pu A

$\cos\phi = 0.883$

$P = 0.96$ pu W $\quad Q = 0.51$ pu VAr

7. $\bar{S} = P + jQ = \bar{V}_t \bar{I}_a^*$

$\bar{V}_t = V_t \angle 0^\circ$

$\bar{E}_f = E_f \angle \delta = E_f \cos(\delta) + jE_f \sin(\delta)$

$$\bar{I}_a = \frac{\bar{E}_f - \bar{V}_t}{jX_s} = \frac{([E_f \cos(\delta) - V_t] + jE_f \sin(\delta))}{jX_s}$$

$$\bar{I}_a = \frac{E_f \sin(\delta)}{X_s} + \frac{[E_f \cos(\delta) - V_t]}{jX_s}$$

$$\bar{S} = \underbrace{\frac{\bar{V}_t E_f \sin(\delta)}{X_s}}_{P} + j\underbrace{\frac{V_t E_f \cos(\delta) - V_t^2}{X_s}}_{Q}$$

$P = 0$ @ $\delta = 0^\circ, 180^\circ$

@ $\delta = 0^\circ$, $Q = -\dfrac{V_t^2}{X_s} + \dfrac{V_t E_f}{X_s}$

@ $\delta = 180^\circ$, $Q = -\dfrac{V_t^2}{X_s} - \dfrac{V_t E_f}{X_s}$

(~~Varies according to the cosine of δ, thus describing a circle, about a centre of $-\frac{V_t^2}{X_s}$.~~)

Thus, the imaginary component varies with the cosine of δ about a central point $-\frac{V_t^2}{X_s}$.

$S = 0$ @ $\delta = \pm 90^\circ \Rightarrow P = \pm \dfrac{V_t E_f}{X_s}$

Thus the real component varies with the sine of the load angle about a central point @ 0.

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8. $P_T = 25MW$ $\qquad$ $\bar{E}_{fa} = 15kV_{L-L} \angle\delta_A$

$\cos\phi = 0.9$ $\qquad$ $\bar{V}_t = 11kV_{L-L}$

$\therefore S_T = 27.7MVA \angle -25.84°$ $\qquad$ $P_A = 10MW$

$jX_s = j4.8\Omega$

$$P_A = \frac{\bar{E}_{fa} V_t}{X_s}\sin(\delta_A) \Rightarrow \delta_A = 16.91°$$

$$\bar{I}_a = \frac{\bar{E}_{fa} - \bar{V}_t}{jX_s} = \left(\frac{1}{\sqrt{3}}\right)1146.179 \angle -37.53° \text{ A}$$

$$\bar{I}_{aph} = 661.75 \angle -37.53° \text{ A}$$

$\cos\phi_A = 0.793$

$S_B = S_T - S_A$

$S_A = \sqrt{3}\, V_t \bar{I}_{aph} = 12.6 \angle -37.53° \text{ MVA}$

$\therefore S_B = 15.648 \angle -16.45° \text{ MVA}$

$\bar{I}_b = 821.34 \angle -16.45° \text{ A}$

$\cos\phi_b = 0.959$

$$\bar{E}_{fb} = \bar{V}_t + j(\sqrt{3}\, \bar{I}_{bph} X_s)$$
$$= 14.497 \angle 26.85° \text{ V}$$

$\delta_b = 26.85°$