Electrical Assignment - 4

Aditya Singh
2K19/A14/35

1. $P = 3 V_p I_p \cos\phi$ $\left(V_p = \frac{V_L}{\sqrt{3}} \right)$ for star system.

$5000 \times 10^3 = \sqrt{3} \times 10{,}000 \times I_p \times 0.8$

$I_p = 360.84$ A.

Active component $= I_p \cos\phi$

$= 360.84 \times 0.8 = \underline{289 \text{ A}}$.

Reactive component $= I_p \sin\phi$

$= 360.84 \times \sqrt{1-(0.8)^2} = \underline{266 \text{ A}}$

if $\cos\phi = 0.9$

$P = \sqrt{3} \times 10^4 \times 360.84 \times 0.9$

$= \underline{5625 \text{ KW}}$.

2. a) $I_p = 286$ A $\left(P = 3 V_p I_p \times \cos\phi \Rightarrow \right)$

$\left(P = \frac{2000 \times 746}{0.93} = 3 \times 2200 \times I_p \times 0.85 \right)$

for delta connection,

$I_L = \sqrt{3} I_p$

$I_L = 286 \times 1.732 = \underline{496 \text{ A}}$.

active component $= 496 \times 0.85$

$= \underline{421 \text{ A}}$

reactive component $= 496 \times 0.52$

$= \underline{252 \text{ A}}$.

b). each motor phase current, $I_p = \underline{286 \text{ A}}$

active component $= 286 \times 0.85$

$= \underline{243 \text{ A}}$

reactive component $= 286 \times 0.526$

$= \underline{151 \text{ A}}$

$\boxed{3}$ $\cos\phi = \frac{8}{\sqrt{8^2+64}} = \underline{0.8}$.

$\left(V_p = \frac{V_L}{3}, \; I_p = I_L\right)$ for star connection,

$V_p = \frac{230}{\sqrt{3}} = 132.79 \text{ V}$

$I_p = \frac{V_p}{Z_p}$, $|Z_p| = \sqrt{8^2+6^2} = 10 \ \Omega$

$= \frac{132.79}{10} = \underline{13.27 \text{ A}}$

$I_p = I_L = 13.3 \text{ A}$

$P = 3 V_p I_p \cos\phi = 132.79 \times 13.3 \times 3 \times 0.8$

$= \underline{4250 \text{ W}}$.

$V_L = \frac{KVA \times 1000}{\sqrt{3} I_L}$, $VA = \sqrt{3} \times 230 \times 13.3$

$= \underline{5280 \text{ VA}}$.

Reactive VA $= \sqrt{VA^2 - W^2}$

$= \sqrt{5280^2 - 4250^2} = \underline{3130 \text{ A}}$.

$\boxed{4}$

$$V_p = \frac{V_L}{\sqrt{3}} = \frac{1100}{\sqrt{3}} = 635.08\ V$$

$$P = 3 V_p I_p \cos\phi$$

$$150 \times 10^3 = 3 \times 635.08 \times 100 \cos\phi$$

$$\cos\phi = 0.787$$

$$|Z_p| = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}, \quad I_p = \frac{635.08}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$$

$$\frac{R}{\sqrt{R^2 + \frac{1}{(\omega C)^2}}} = 0.787$$

$$\underline{R = 5\,\Omega}$$

$$\frac{25}{\sqrt{25 + \frac{1}{(100\pi C)^2}}} = 6.35$$

$$\underline{C = 810\ \mu F}.$$

$\boxed{5}$

$$V_p = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = \underline{231\ V}$$

$\cancel{\cos\phi}$ $\quad P = 3 V_p I_p \cos\phi$

$$= 3 \times 231 \times 15 \times \sqrt{3}$$

$$= \underline{18\ KW}.$$

$\boxed{6}$

$$V_p = \frac{V_L}{\sqrt{3}} = \frac{460}{\sqrt{3}} = 265.58\ V$$

$$P = 3 I_p V_p \cos\phi$$

$$8000 = 3 \times 265.58 \times I_p \times 0.8$$

$$I_p = 12.55\ A..$$

$$|Z_P| = \frac{265.58}{12.55} = 21.16\ \Omega$$

$$Z = 21.16 \angle 37^\circ$$

Let $V_1 = 265.58 \angle 0^\circ$

$V_2 = 265.58 \angle -120^\circ$

$V_3 = 265.58 \angle 120$

V across $Z_1 = V_1 - V_3 = 265.58\angle 0 - 265.58 \angle 120$

$Z = 21.16 \angle 37^\circ$

$$I_{Z_1} = \frac{V}{Z} = \frac{V_{Z_1}}{Z} = \underline{21.7\ A}$$

$V_{Z_2} = V_2 - V_3$,

$$I_{Z_2} = \frac{V_2 - V_3}{Z} = \underline{21.7\ A}$$

$I_{Z_1} + I_{Z_2} + I_{Z_3} = 0$.

$$I_{Z_3} = \underline{37.6\ A}$$

$\boxed{7}$

$W_1 = \sqrt{3} V_p I_p \cos(30 - \phi)$ in a two wattmeter system,

$W_2 = \sqrt{3} V_p I_p \cos(30 + \phi)$

$W_1 + W_2 = \sqrt{3} V_p I_p (2 \cos 30^\circ \cos \phi)$

$= 3 V_p I_p \cos\phi$.

$W_1 - W_2 = \sqrt{3} V_p I_p (-2 \sin 30 \sin(-\phi))$

$= \sqrt{3} V_p I_p \sin\phi$

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

$$\frac{5}{3\sqrt{3}} = \cot\phi$$

$$\phi = \cot^{-1}\left(\frac{5}{3\sqrt{3}}\right) = 46.1$$

Power factor $= \cos\phi = \cos(46.1) = \underline{0.693}$.

$\boxed{8}$

$W_2 = -0.5\,kW$ (reversal of current coil)

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

$$\frac{5-0.5}{5+0.5} = \sqrt{3}\cot\phi, \quad \phi = 64.71^\circ$$

Power factor, $\cos(64.71) = \underline{0.427}$ (lag).

$\boxed{9}$ Input power $= W_1 + W_2 = -2+7 = \underline{5\ kW}$.

$$\frac{W_1+W_2}{W_1-W_2} = \sqrt{3}\cot\phi, \quad \phi = 72.2^\circ.$$

Power factor, $\cos(72.2) = \underline{0.305}$ (lead)

$\boxed{10}$ $$\cos\phi = \frac{10}{\sqrt{10^2+(17.32)^2}} = 0.5 \qquad \phi = 60^\circ.$$

$$\frac{W_1+W_2}{W_1-W_2} = \sqrt{3}\cot\phi \qquad \frac{W_1+W_2}{W_1-W_2} = 1$$

$w_1 = 14,520 \text{ W}$, $w_2 = 0$.

11

$$\frac{w_1 + w_2}{w_1 - w_2} = \sqrt{3}\cot\phi$$

input power = $w_1 + w_2 = 400$ kW.

$$\frac{300+100}{300-100} = \sqrt{3}\cot\phi \,, \quad \phi = 40.89°.$$

Power factor, $\cos(40.89) = 0.756$ (lag)

$P = 3 V_p I_p \cos\phi$

$$400 \times 10^3 = 3 \times 200 \times \frac{I_L}{\sqrt{3}} \times 0.756$$

$$I_L = 152 \text{ A}$$

Output power = input × efficiency

$= 400 \times 0.9 = 360$ kW.

$= \frac{360 \times 1000}{746} = 490$ horsepower.

12

$P = w_1 + w_2 = 3 V_p I_p \cos\phi$

$$= 3 \times \frac{V_L}{\sqrt{3}} \times 50 \times 0.4 = 7.621 \text{ kW}$$

$$\frac{w_1 + w_2}{w_1 - w_2} = \sqrt{3}\cot\phi \qquad w_1 - w_2 = 10.08$$

$w_1 = 8.85$ kW

$w_2 = -1.23$ kW

END