KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

EE 360: ELECTRIC ENERGY ENGINEERING

HW # 1: Three-Phase Circuits

Problem # 1:

A balanced three phase, 866-V, 60-Hz, Y-connected source feeds a balanced Δ-connected load via a 100-km long three wire transmission line. The impedance of each wire of the transmission line is 1 **+ *j* 2** Ω. The per phase impedance of the load is 177 – *j* 246 Ω. Determine the line and phase currents of the source and the load, the power absorbed by the load, and the power dissipated by transmission line.

$$Z_Y = \frac{Z_\Delta}{3} = 59 - j82\ \Omega$$

$$V_{ph} = \frac{866}{\sqrt{3}} = 500\angle 0$$

$$Z_{tot} = 1 + j2 + 59 - j82 = 60 - j80 = 100\angle -53.13^\circ\ \Omega$$

$$I = \frac{500}{60 - j80} = 5\angle 53.13^\circ\ A$$

$$I_{ph\ source} = I_L = 5\angle 53.13^\circ$$

$$I_{ph\ load} = \frac{I_L}{\sqrt{3}\angle -30} = \frac{5}{\sqrt{3}}\angle 83.13^\circ = 2.887\angle 83.13^\circ$$

$$V_{L_{load}} = V_{ph_{load}} = I_{ph} * (177 - j246)$$

$$= 874.93\angle 28.87^\circ$$

$$P_{Load} = 3 I_{ph}^2 R_{ph} = 3 * (2.887)^2 * 177 = 4425.75\ W$$

$$P_{line} = 3 * I_L^2 R_{Line} = 3(5)^2 * 1 = 75\ W$$

Problem # 2:

A three phase 50-hp, 440-V, 60-Hz, induction motors operates on full-load with an efficiency of 89% and a power factor of 0.85 lagging. Calculate the total kVA rating of the capacitor bank required to raise the power factor to 0.95 lagging. What will be the capacitance per phase if the capacitor bank is Δ-connected.

$$P_{out} = 50 * 746 \quad , \quad P_{i/p} = \frac{P_{o/p}}{\eta}$$

$$P_{i/p} = \frac{50 * 746}{0.89 * 1000} = 41.91 \text{ KW}$$

At Pf = 0.85 lag.

$$S = \frac{P}{\cos\phi} = \frac{41.91}{0.85} = 49.3 \text{ KVA}$$

$$Q_{old} = \sqrt{S^2 - P^2} = 25.98 \text{ KVAR}$$

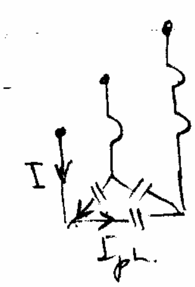
At Pf = 0.95 lag

$$S = \frac{41.91}{0.95} = 44.12 \text{ KVA}$$

$$Q_{new} = \sqrt{S^2 - P^2} = 13.78 \text{ KVAR}$$

$$Q_c = Q_{add} = Q_{new} - Q_{old} = -12.2 \text{ KVAR}$$

$$I = \frac{Q_c}{\sqrt{3} V_L} = \frac{12.2 * 1000}{\sqrt{3} * 440} = 15.99 \text{ A}$$



$$I_{ph} = 9.23 \text{ A}$$

$$X_c = \frac{440}{9.23} = 47.65 \ \Omega$$

$$X_C = \frac{1}{2\pi f C} \Longrightarrow C = 55.67 \ \mu F$$

Problem # 3:

A balanced 3-phase, 173-V, 60-Hz source supplies two balanced 3-phase loads as follows. Load 1 is a Δ-connected load with a phase impedance of (18+*j*24) Ω, and load 2 is a Y-connected with a phase impedance of 10∠53.13° Ω.

(a) Find the power factor of the entire load.

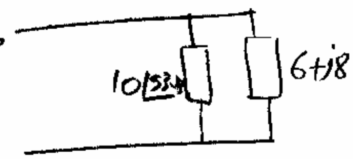
(b) Find the total line current supplied.

(c) Find the total real, reactive, and apparent powers.

(d) If two wattmeters are connected to measure the total power supplied. Find the reading on each instrument.

Convert Δ to Y $\quad Z_1 = \frac{18+j24}{3} = 6+j8$

$$Z_t = \frac{(6+j8)(10\angle 53.13)}{6+j8+10\angle 53.13} = 3+j4 = 5\angle 53.1^\circ$$



a) $pf = 0.6$ (lag)

b) $I_L = I_{ph} = \frac{173/\sqrt{3}}{5\angle 53.1} = 20\angle -53.1^\circ$

c) $P_t = \sqrt{3} * 173 * 20 * 0.6 = 3.596$ KW

$Q_t = \sqrt{3} * 173 * 20 * 0.8 = 4.794$ KVAR

$S_t = \sqrt{3} * 173 * 20 = 5.993$ KVA

d) $\phi = \cos^{-1} 0.6 = 53.1^\circ$

$W_1 = 173 * 20 * \cos(30+53.1) = 416$ W

$W_2 = 173 * 20 * \cos(30-53.1) = 3182$ W

Note $W_1 + W_2 = P_t$

Problem # 4:

A 480-V distribution system supplies two parallel loads as follows. Load 1 is a Δ-connected load with a phase impedance of $10\angle 30^\circ\ \Omega$, and load 2 is a Y-connected load with a phase impedance of $5\angle -36.87^\circ\ \Omega$.

(a) Find the overall power factor.

(b) Find the total line current.

Since load 1 is Δ-Con

$V_{ph} = V_L = 480\ V$

$I_{ph} = \frac{480}{10} = 48\ A$

$P_1 = 3 V_{ph_1} I_{ph_1} \cos\phi_1 = 3*480*48 \cos 30$

$= 59.9\ KW$

$Q_1 = 34.6\ KVAR$

Since load 2 is Y-Con

$V_{ph} = \frac{V_L}{\sqrt{3}} = 277\ V$

$I_{ph} = \frac{277}{5} = 55.4\ A$

$P_2 = 3 V_{ph_2} I_{ph_2} \cos\phi_2 = 3*277*55.4*\cos(-36.87^\circ)$

$= 36.8\ KW$

$Q_2 = -27.6\ KVAR$

$P_{tot} = P_1 + P_2 = 96.7\ KW$

$Q_{tot} = Q_1 + Q_2 = 7\ KVAR$

$\phi_{tot} = \tan^{-1} \frac{Q_{tot}}{P_{tot}}$

$\phi_{tot} = 4.14^\circ$, $pf_{tot} = \cos\theta = 0.997$ lag.

$I_L = \frac{P_{tot}}{\sqrt{3} V_L \cos\phi_{tot}} = 117\ A$