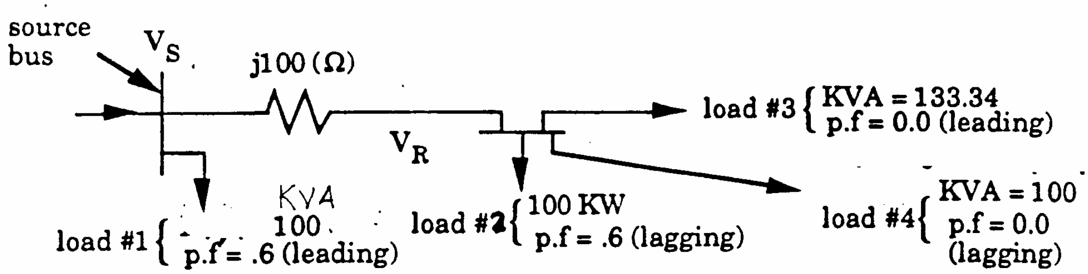
EE341 Homework #2

Review of three-phase circuit analysis.
Please read the lectures on three-phase circuit analysis in the Appendix, and understand the problems and solutions give below. Then write Matlab programs based on the solutions given to solve them.

Please submit your complete code with comments and the running results.

HOMEWORK # 2

Problem 1. Consider a 3-ϕ distribution feeder as shown below:



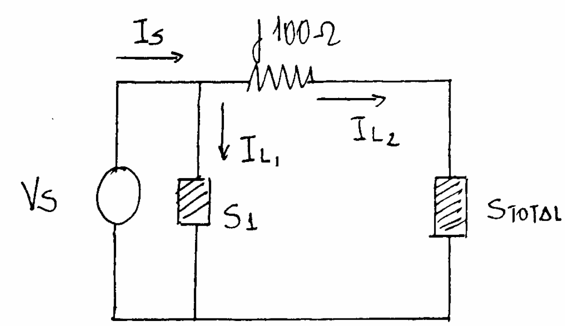
Compute the following:

1) The souce voltage V_s, if V_R is to be maintained at 4.4 ~~V~~ KV (V_R=4.4 kV line value).

2) The source current and power factor at the source.

3) The total complex power supplied by the source

4) How much reactive power should be connected to the source bus for obtaining unity power factor at the source bus?



$$S_1^{\phi} = \frac{100}{3} \angle -53.13^\circ \text{ KVA}$$

$$S_{TOTAL}^{\phi} = 47.14 \angle 45^\circ \text{ KVA}$$

PRobl. 2 - cont.

(1) V_S ?

$$V_R^{\phi} = \frac{4.4\ KV}{\sqrt{3}} = 2.54 \angle 0^\circ\ KV$$

$$S^{\phi}_{TOTAL} = V_R^{\phi}\, I_{L2}^{*}$$

L → LOAD

$$I_{L2}^{*} = \frac{47.14\ KVA}{2.54\ KV} \Rightarrow I_{L2} = 18.6 \angle -45^\circ\ A$$

$$V_S = Z_{LINE} \times I_{L2} + V_R$$

$$V_S = j\,100 \times 18.6 \angle -45^\circ + 2540 = 4{,}073.4 \angle 18.83^\circ\ V$$

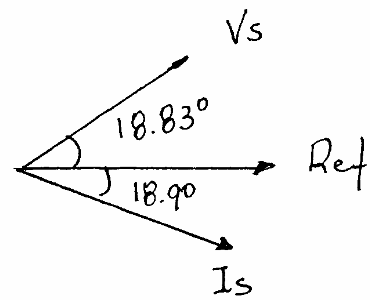
$$V_{LL}^{S} = \sqrt{3}\ V_S = 7055{,}3 \angle 18.83^\circ\ V$$

(2)

$$I_{L1}^{*} = \frac{33.33 \angle -53.13^\circ}{4073.4 \angle 18.83^\circ} \Rightarrow 8.18 \angle -71.96^\circ\ A$$

$$I_S = I_{L1} + I_{L2} = 16.6 \angle -18.9^\circ\ A$$

P.F.



$\theta = 37.73^\circ$

PF = 0.79

LAGGING

Prob (2) - cont.

(3) $S_s = V_s I_s^* = 67{,}618 \angle 37.73^\circ$ VA

$S_s^{3\phi} = 202.855 \angle 37.73^\circ$ KVA → 160 KW + j 124 KVAr

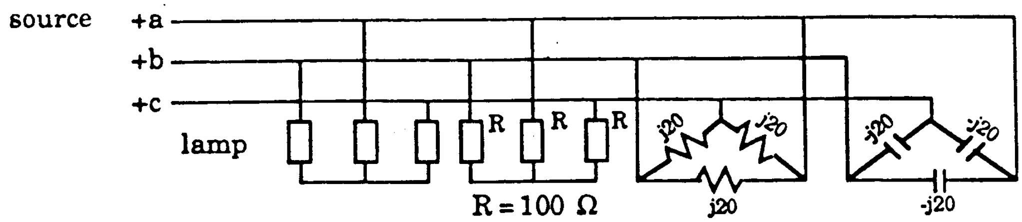
TOTAL THREE-PHASE COMPLEX POWER SUPPLIED BY THE SOURCE.

(4) How much reactive power → PF = 1 at the source BUS.

$S_c = -j\,124$ KVAr

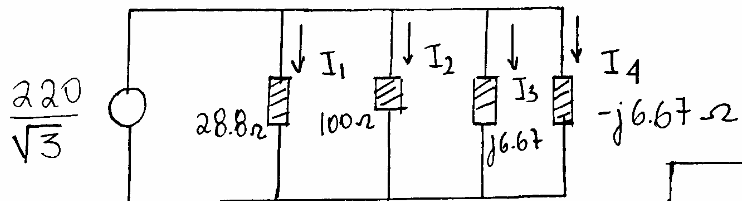
HOMEWORK # 2

Problem 2. A balanced three-phase, three-wire feeder has three balanced loads as shown:



Each lamp is rated 500 watts and 120 volts. The line-to-line voltage on the feeder is 220 volts and remains constant under the loads. Find the source current in the feeder lines and the power delivered by the source.

$I_S \longrightarrow$ $\qquad I_S = I_1 + I_2 + I_3 + I_4 = \underline{5.68\,A}$



$$R_{LAMP} = \frac{(120)^2}{500} = 28.8\,\Omega$$

$$S_\phi = V_\phi I_\phi^*$$
$$S_\phi = 127 \times 5.68$$
$$S_{3\phi} = 2{,}164\ W$$

$$I_1 = \frac{127\angle 0^\circ}{28.8} = 4.41\angle 0^\circ\ A$$

$$I_2 = \frac{127\angle 0^\circ}{100} = 1.27\angle 0^\circ\ A$$

$$I_3 = \frac{127}{j6.67} = 19.04\angle -90^\circ\ A \rightarrow I_4 = 19.04\angle 90^\circ\ A$$

A-2 Figure A-17 shows a three-phase power system with two loads. The Δ-connected generator is producing a line voltage of 480 V, and the line impedance is $0.09 + j0.16\ \Omega$. Load 1 is Y-connected, with a phase impedance of $2.6\ \angle 36.87°\ \Omega$, and load 2 is Δ-connected, with a phase impedance of $5\ \angle -24°\ \Omega$. Answer the following questions:

(*a*) What is the line voltage of the two loads?
(*b*) What is the voltage drop on the transmission lines?
(*c*) Find the real and reactive powers supplied to each load.
(*d*) Find the real and reactive power losses in the transmission line.
(*e*) Find the real power, reactive power, and power factor supplied by the generator.

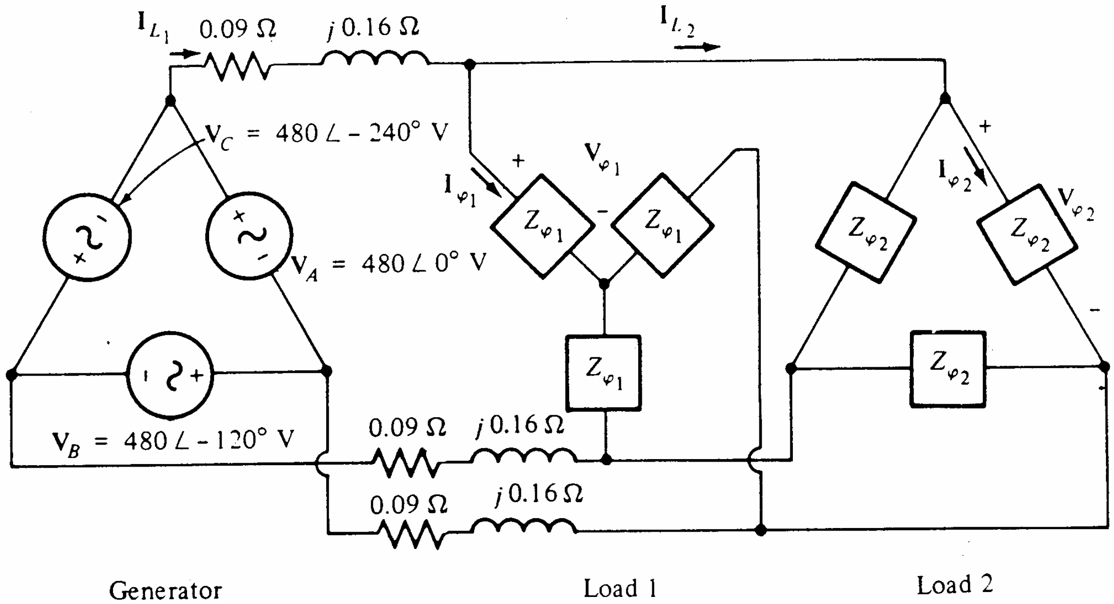
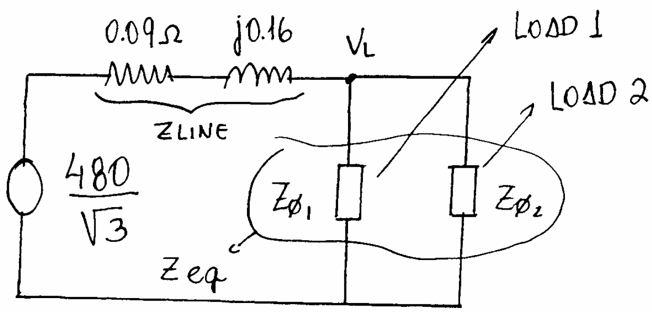


Figure A-17 The system in Prob. A-2.

CONVERT THE TWO DELTAS TO EQUIVALENT WYES, AND GET THE PER-PHASE EQUIVALENT CIRCUIT.



Problem (3) - cont.

a) LINE VOLTAGE OF THE TWO LOADS

$$V_{LOAD} = \frac{480}{\sqrt{3}} \times \frac{1.17 \angle -0.84^\circ}{1.268 \angle 6.47^\circ} = 255.6 \angle -7.31^\circ \text{ V}$$

↳ VOLTAGE DIVIDER

$$V_{LL} = \sqrt{3} \times 255.6 = 442.7 \angle -7.31^\circ \text{ V}$$

b) VOLTAGE DROP ON THE LINE

$$\Delta V_{LINE} = V_{SOURCE} - V_{LOAD}$$

$$\Delta V_{LINE} = 277.12 - 255.6 \angle -7.31^\circ = 40.19 \angle 54^\circ \text{ V}$$

c) REAL AND REACTIVE POWERS TO EACH LOAD

$$P_{3\phi} = 3 \frac{V_{LOAD}^2}{Z_{LOAD}} \cos\theta \qquad Q_{3\phi} = 3 \frac{V_{LOAD}^2}{Z_{LOAD}} \sin\theta$$

LOAD 1	LOAD 2
$P_1 = 60.3$ KW	$P_2 = 107.6$ KW
$Q_1 = 45.2$ KVAr	$Q_2 = -47.9$ KVAr

d) REAL AND REACTIVE LOSSES IN THE LINE

$$I_{LINE} = \frac{\Delta V_{LINE}}{Z_{LINE}} = \frac{40.19 \angle 54^\circ}{0.183 \angle 60.64^\circ} = 219.6 \angle -6.64^\circ \text{ A}$$

Prob. (3) - cont.

$$P_{LINE} = 3 \times I_{Line}^2 \times R_L = 3 \times (219.6)^2 \times 0.09 = 13 \text{ kW}$$

$$Q_{LINE} = 3 \times I_{Line}^2 \times X_L = 3 \times (219.6)^2 \times 0.16 = 23 \text{ KVAr}$$

e) REAL POWER, REACTIVE POWER AND POWER FACTOR

→ GENERATOR

$$P_{GEN} = P_{LINE} + P_1 + P_2 = 180.9 \text{ KW}$$

$$Q_{GEN} = Q_{LINE} + Q_1 + Q_2 = 20.3 \text{ KVAr}$$

$$PF = \cos\left(\tan^{-1} \frac{Q_{GEN}}{P_{GEN}}\right) = 0.9937$$

LAGGING