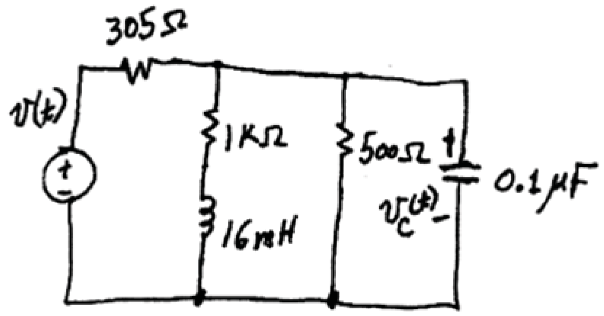
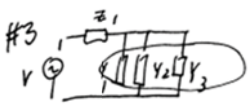
EECE499 HOMEWORK #5
Due: (W) March 16

Phasor Analysis

1. Find the voltage $v_c(t)$ by steady-state analysis, where $v(t) = \cos(2\pi f t + 45°)\ [V]$ with $f = 10^4$ [Hz].



#3



$Y_T = Y_1 + Y_2 + Y_3 \rightarrow Z_2 = \frac{1}{Y_T}$

$\bar{I} = \frac{\bar{V}}{Z_1 + Z_2}$ $\quad \bar{V} = 1\angle 45°$

$\rightarrow \bar{V}_C = \bar{I} \cdot Z_2 = \frac{Z_2}{Z_1 + Z_2}\bar{V}$

$\omega = 2\cdot\pi\cdot f = 2\cdot\pi\cdot 10^4$

$Z_1 = 305 + j0$

$Y_1 = \frac{1}{1000 + j\omega 16\times10^{-3}}$, $Y_2 = \frac{1}{500}$, $Y_3 = j\omega\, 0.1\times10^{-6}$

$Y_1 = 5\times10^{-4} - j5\times10^{-4}$ $\quad Y_2 = 2\times10^{-3}$ $\quad Y_3 = j6.28\times10^{-3}$

$Y_T = 0.0025 + j0.0058. \rightarrow Z_2 = \frac{1}{Y_T} = 62.67 - j145.4$

$\bar{V}_C = 1\angle 45° \cdot \frac{Z_2}{Z_1 + Z_2} = 1\angle 45°\ 0.4\angle -45° = 0.4\angle 0°$

$\therefore v_C(t) = 0.4\cos(2\pi f t)\ [V]$

Single-Phase Problems

2. In a computer center, there are three single-phase computer devices (description listed below) installed in parallel. The magnitude of the voltage of each device is 208 [V].

Disk: 6.157 kVA at pf = 0.79 lag
Drum: 16.93 kW at pf = 0.96 lag
CPU: 22.694 kW while the current through the CPU = 127 [A]

Find the power factor of the combined computer device (i.e., *pf* of the computer center).

2. Disk: $P_{disk} = |S_{disk}|\cos\theta = (6.157)(0.79) = 4.864$ [kW], θ=37.814

therefore, $Q_{disk} = (6.157)(\sin 37.814) = 3.775$ [kVar]

Finally, $S_{disk} = (4864 + j3775)$

Drum: $P_{drum} = 16.93$ [kW], from power factor of 0.96, $|S_{drum}| = \dfrac{16930}{0.96} = 17635$ [VA]

therefore, $Q_{drum} = 17635 \sin 16.26 = 4937$

Finally, $S_{drum} = (16930 + j4937)$

CPU: From P=VIcosθ, $\cos\theta = \dfrac{22694}{(208)(127)} = 0.86$

Therefore, $Q_{cpu} = 22694(\tan 30.68) = 13464$

Finally, $S_{cpu} = (22694 + j13464)$

$S_T = S_{disk} + S_{drum} + S_{cpu} = 44488 + j22176$ ----->angle θ=26.49

Therefore, power factor of the combined load is : **cos23.14=0.895**

3. A load on a 60-Hz system requires 12kW at 0.8 pf lagging when operated at 120V. The impedance of the feeder supplying the load is 0.4+j0.2 Ω. (See circuit below) (**40+α** points)

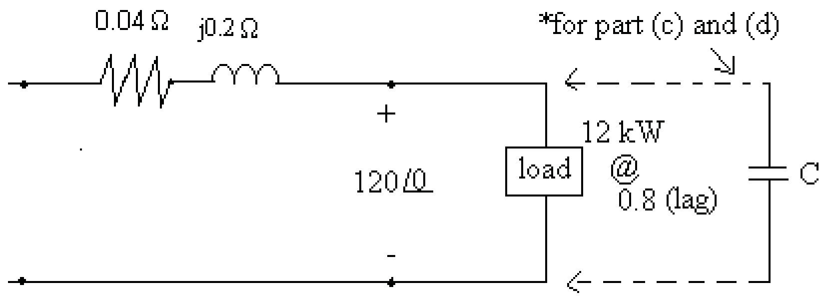
(a) What is the magnitude of the voltage at the source?(10 pts)

(b) What is the power loss in the feeder line? (10 pts)

(c) To improve the pf of the load to 0.96 (lagging), what size capacitor (in microfarads) at the load end is needed? (10 pts)

(d) After the capacitor is installed, what is the power loss in the feeder line, if the load voltage is maintained at 120 V? (10 pts) - **skipped**

(d) After the capacitor is installed, what is the magnitude of the voltage at the source, if the load voltage is maintained at 120 V ? (extra 5 pts)



3. (a) Complex power of the load is: $S = 15000(0.8) + j(15000)(0.6) = 12000 + j9000$ VA

Therefore, the current through the load can be found : $\bar{I}_l^* = \dfrac{12000 + j9000}{120} = 100 + j75$

Therefore, $\bar{I}_l = 100 - j75 = 125\angle -30.96$

Therefore, $\bar{V}_s = 120 + (0.04 + j0.20)(100 - j75) = 139 + j17 = 140\angle 6.97$

Finally, $|\bar{V}|_s = 140$

(b) $P_{line} = |I|^2\ R_{line} = (125)^2(0.04) = 625$ [W]

(c) To make power factor 0.96 (lagging) by adding capacitor (i.e., adding negative Q)

From $\cos\theta = 0.96$, θ=16.26.

Therefore, $\tan\theta = 0.29 = \dfrac{Q_{sum}}{P} = \dfrac{Q_{load} + Q_{cap}}{P} = \dfrac{9000 + Q_{cap}}{12000}$

Therefore, $Q_{cap} = -5500$

Since the voltage across the capacitor is the same as that of the load
(note: current through the capacitor is unknown. Do not use the current we derived in part (a))

We use the equation of : $Q = \dfrac{|V|^2}{X}$, then, $X = \dfrac{|V|^2}{Q} = \dfrac{120^2}{-5500} = -2.62$

From $X = -\dfrac{1}{wC} = -\dfrac{1}{2\pi fC} = -\dfrac{1}{120\pi C} = -2.62$, we have $C = 1012\mu F$

(d) With new complex power with capacitor installed, $S = 12000 + j3500$

The current is $\bar{I}_l = \dfrac{12000 - j3500}{120} = 100 - j29.17 = 104.17\angle -16.26$

$P_{line} = |I|^2\ R_{line} = (104.17)^2(0.04) = 434$ [W] (Skipped)

(d) $\bar{V}_s = 120 + (0.04 + j0.20)(100 - j29.17) = 129.83 + j18.83 = 131.19\angle 8.25$

Finally, $|\bar{V}|_s = 131.19$

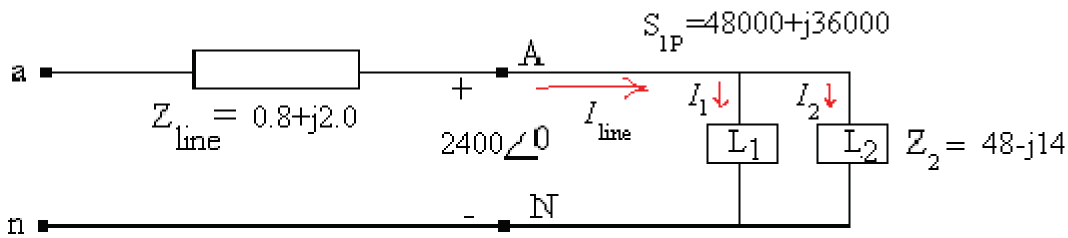
Three-Phase Problem

4. A three-phase line has an impedance of 0.8 + j 2.4 Ω/ϕ. The line feeds two balanced three-phase loads that are connected in parallel. The first load is absorbing a total of 144 kW and 108kVar. The second load is Δ-connected and has an impedance of 144 – j 42 Ω/ϕ. The line-to-neutral voltage at the load end of the line is 2400 V. What is the magnitude of the *line voltage* at the source end of the line? (**30** points)

4. Single phase complex power: $S_{1\phi} = 48000 + j36000$

The Y-equivalent load of the second load is: $Z_Y = \frac{1}{3}(144 - j42) = 20 - j14$

NOW 1-phase equivalent circuit.



From Load 1: $\bar{I}_1 = \frac{48000 - j36000}{2400} = 20 - j15$

From Load 2: $\bar{I}_2 = \frac{2400}{48 - j14} = 46.08 + j13.44$

Therefore, the line current is: $\bar{I}_{line} = \bar{I}_1 + \bar{I}_2 = 66.08 - j1.56$

Then, the phase voltage at the source end is:

$$\bar{V}_{an} = 2400 + (0.8 + j2.4)(66.08 - j1.56) = 2451.61 + j157.34 = 2461.64\angle 3.66$$

Therefore, the line voltage is:

$$|V_{ab}| = \sqrt{3}(2461.64) = 4263.69 \text{ [V]}$$