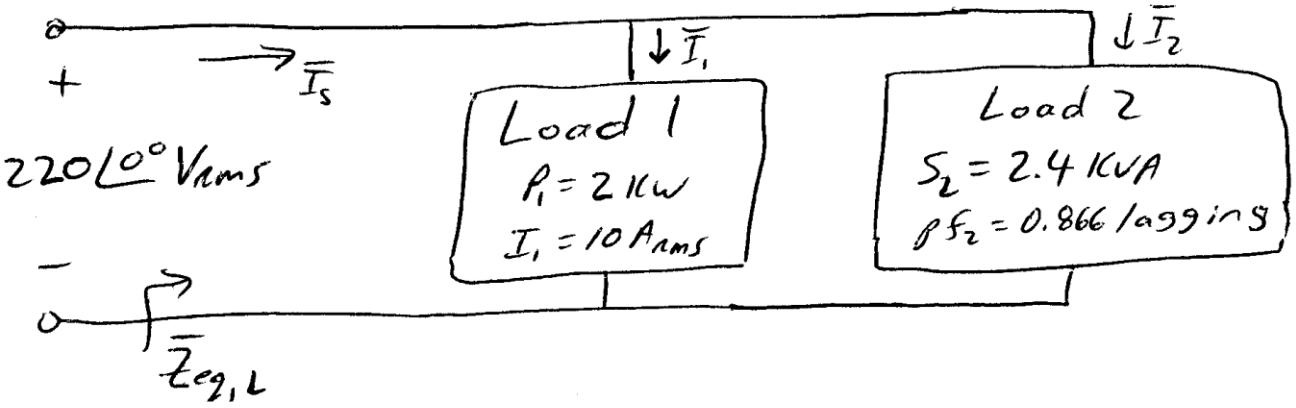
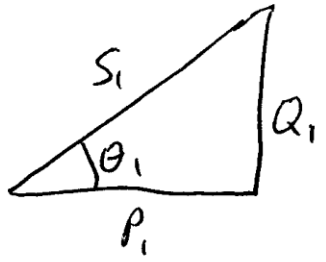
Example- A 220 V_{RMS} power line supplies two load connected in parallel. Load 1 is an AC motor circuit drawing a current of 10 A_{RMS} (measured using a multimeter) and power of 2 kW (measured using a wattmeter). Load 2 is a combination of lights and motors drawing 10.09 A_{RMS} (S_2 = 220*10.09 = 2.4 kVA) with a lagging power factor of 0.866. Analyze each load as well as the overall equivalent load on the power line circuit. [Hint: Motors are resistive-inductive loads.]

⇒ Assume power line is @ 0° (reference)



Load 1

motor ⇒ lagging pf



$S_1 = V_{1,RMS} I_{1,RMS} = 220(10) = 2200$ VA

$P_1 = 2000$ W (given)

$\cos\theta_1 = \frac{P_1}{S_1} = \frac{2000}{2200} = 0.9091$ lagging $= pf_1$

$\theta_1 = \cos^{-1} 0.9091 = 24.62^\circ = \theta_{V_1} - \theta_{I_1}$

$\hookrightarrow \theta_{I_1} = -24.62^\circ$

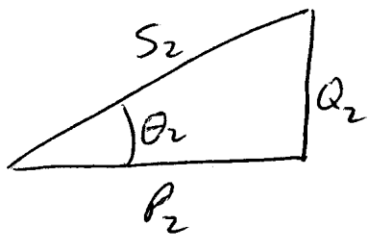
$\bar{I}_1 = 10\angle -24.62^\circ A_{rms}$

$Q_1 = S_1 \sin\theta_1 = 2200 \sin 24.62^\circ = 916.516$ VAR

$\bar{Z}_1 = \frac{\bar{V}_1}{\bar{I}_1} = \frac{220\angle 0^\circ}{10\angle -24.62^\circ} = 22\angle 24.62^\circ \Omega = 20 + j9.16516\ \Omega$

$\bar{S}_1 = P_1 + jQ_1 = 2000 + j916.516$ VA $= 2200\angle 24.62^\circ$ VA

Load 2



$S_2 = 2400\ VA$

$pf_2 = 0.866$ lagging $= \cos\theta_2$

$\hookrightarrow \theta_2 = +30^\circ = \phi_{V_2} - \theta_{I_2}$ ($\phi_{V_2} \to 0$)

(lagging)

$\theta_{I_2} = -30^\circ$

$$I_2 = \frac{S_2}{V_2} = \frac{2400}{220} = 10.9091\ A_{rms}$$

$$\bar{I}_2 = 10.9091 \angle -30^\circ\ A_{rms}$$

$$\bar{S}_2 = \bar{V}_2 \bar{I}_{2rms}^{*} = (220\angle 0^\circ)(10.9091\angle +30^\circ)$$

$$= 2078.46 + j\,1200\ VA$$

P_2 (W) $\quad$ Q_2 (VAR)

$$\bar{Z}_2 = \frac{\bar{V}_2}{\bar{I}_2} = \frac{220\angle 0^\circ}{10.9091\angle -30^\circ} = 20.166\angle 30^\circ\ \Omega$$

$$= 17.465 + j\,10.083\ \Omega$$

$$\bar{S}_{power\ line} = \bar{S}_1 + \bar{S}_2 = 2200\angle 24.62^\circ + 2400\angle 30^\circ$$

$$= 4594.94\angle 27.427^\circ\ VA = 4078.46 + j\,2116.516\ VA$$

$P_{power\ line}$ $\quad$ $Q_{power\ line}$

$pf_{overall} = \cos 27.427^\circ$

$= 0.8876$ lagging

$$\bar{Z}_{overall} = \bar{Z}_1 \,//\, \bar{Z}_2 = \frac{\bar{V}_2}{\bar{I}_1 + \bar{I}_2} = 10.53\angle 27.427^\circ\ \Omega = 9.35 + j\,4.85\ \Omega$$