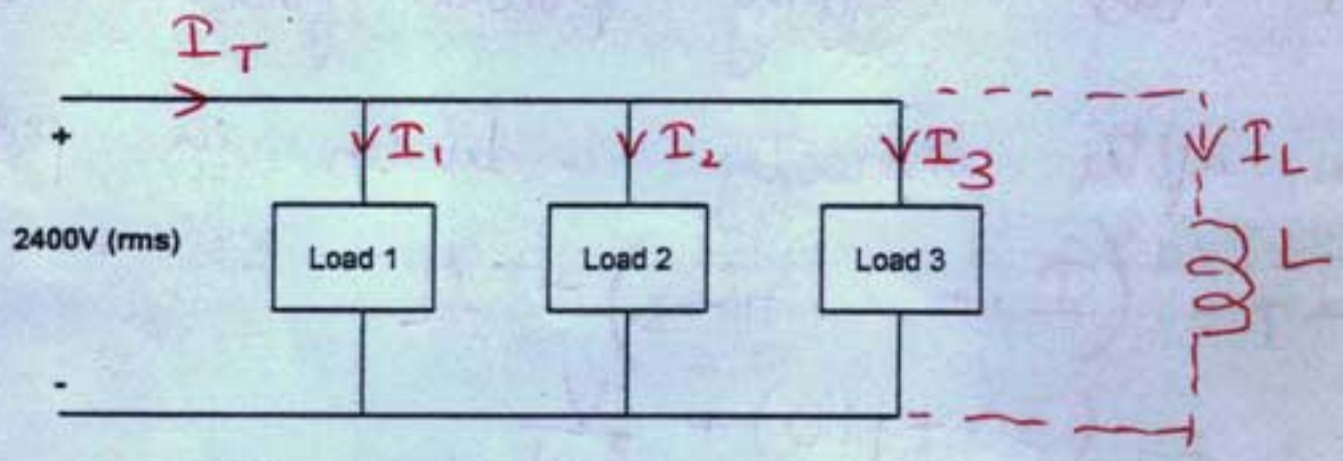
Design Project
EE204 (031)

$f = 60Hz$

In an industry three loads are connected in parallel across a $2400\angle 0^\circ$ (rms) line as shown in the Figure below. Load 1 absorbs 18kW and 24kVAR. Load 2 absorbs 60kVA at a power factor of 0.6 leading. Load 3 absorbs 18kW at unity power factor. Design the value of a reactive component that should be connected in parallel to the loads to result in an overall power factor of 1.



Load 1 $P_{av} = 18KW$; $Q = 24KVAR$.

$18{,}000 = VI\cos\theta$; $24000 = VI\sin\theta$

$\tan\theta = \frac{Q}{P} \Rightarrow \theta = \tan^{-1}\frac{24}{18} = 53.13^\circ \Rightarrow \cos\theta = 0.6$

$\therefore 18{,}000 = (2400)\,I \times 0.6 \Rightarrow I = \frac{18{,}000}{2400 \times 0.6} = 12.5A$

$I_1 = 12.5\angle -53.13^\circ$

Load 2 $|S| = 60KVA$; $\cos\theta = 0.6$ leading

$VI = 60{,}000$

$P = VI\cos\theta \Rightarrow 60{,}000 \times 0.6 = P \Rightarrow P = 36000W$.

$\therefore 36{,}000 = (2400)(I) \times 0.6 \Rightarrow I = 25A$.

$I_2 = 25\angle +53.13$

Load 3 $P_{av} = 18KW$. $\cos\theta = 1$.

$18{,}000 = (2400)\,I \times 1 \Rightarrow I = 7.5$

$I_3 = 7.5\angle 0^\circ$.

$$I_T = I_1 + I_2 + I_3$$

$$= 12.5\angle -53.13 + 25\angle +53.13 + 7.5$$

$$= 7.5 - j10 + 15 + j20 + 7.5$$

$$I_T = 30 + j10 = 31.62\angle +18.43^\circ$$

Since $\theta_V = 0^\circ$ & $\theta_I = +18.43^\circ$

$\therefore \theta_V - \theta_I = -18.43^\circ$ leading.

Therefore we need to connect something in parallel that has lagging power factor i.e. inductor.

Now after connecting inductor in parallel.

$$I_T = (I_1 + I_2 + I_3) + I_L$$

$$= (30 + j10) + \frac{V}{j\omega L}$$

$$= 30 + j10 + \frac{2400}{j \times 2 \times \pi \times 60 \times L}$$

$$I_T = 30 + j10 - j\frac{6.366}{L}$$

$$I_T = 30 + j\left(10 - \frac{6.366}{L}\right)$$

To have unity power factor $\theta_I = \theta_V$ i.e. imaginary part of current must be zero because $\theta_V = 0^\circ$ (no imaginary part with voltage)

$$10 - \frac{6.366}{L} = 0 \Rightarrow L = \frac{}{0.636}\ H$$