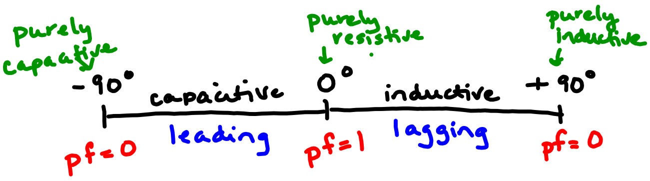
$$pf = \cos(\theta - \phi)$$
$$= \cos(\angle Z_L)$$
$$= \cos(\angle \hat{S}_L)$$



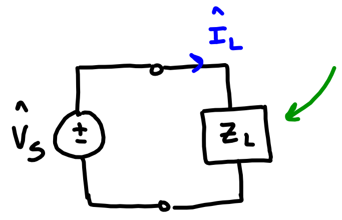
$P = V_{rms} I_{rms} \cdot pf$

- pf is closer 1 — P_{avg} increase
- pf approaches 0 — P_{avg} decrease

English Industries

Load: $P = 10\,kW$
$pf = 0.6$ lagging

$|\hat{V}_S| = 120$ Vrms



$\hat{V}_S = 120\angle 0°$ Vrms

$P = V_{rms} I_{rms}\, pf$

$10\times 10^3 = 120(I_L)(.6)$

$I_L = 138.89$ Arms

$\angle Z_L = \cos^{-1}(.6)$
$= +53.13°$

$|Z_L| = \dfrac{V_S}{I_L} = \dfrac{120}{138.89} = 0.86\,\Omega$

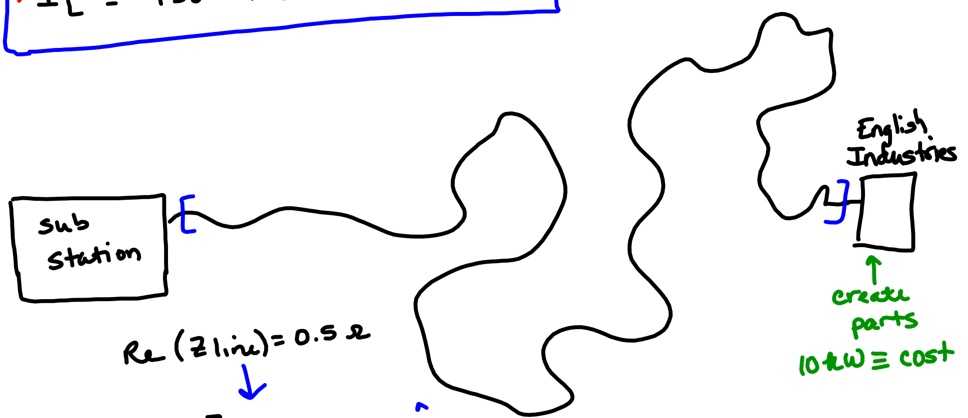
$$\boxed{Z_L = 0.86\angle 53.13°\,\Omega}$$

$\theta - \phi = \angle Z_L$

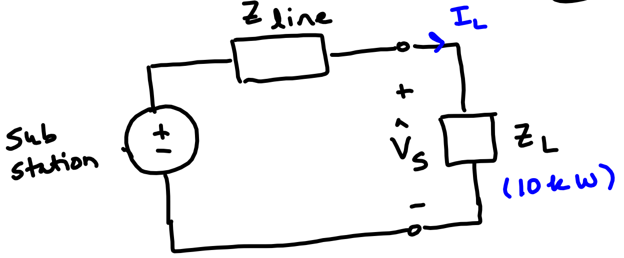
$0 - \phi = 53.13°$

$\phi = -53.13°$

$$\boxed{\hat{I}_L = 138.89\angle -53.13°\ \text{Arms}}$$



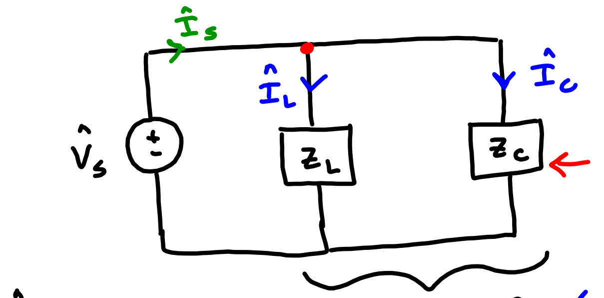
$Re(Z_{line}) = 0.5\,\Omega$



$P_{line} = I_L^2(0.5)$
$= (138.89)^2(.5)$
$= 9.64\,kW$

expensive.

use power factor compensation to reduce P_{line}



Z_c = compensating load.

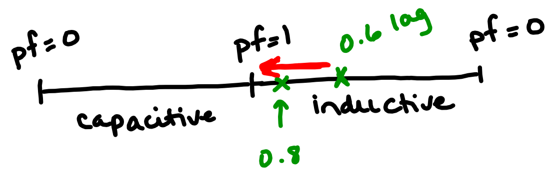
adding Z_c:

- don't want the average power delivered to the load
- V_s cannot change
- change power factor of the Z_L + Z_c loads.

$\hat{I}_L = 138.89 \angle -53.13°$ Arms

$P_{CL} = P_{Z_L}$

$P_{CL} = P_{ZL} + \cancel{P_c}^{\,0}$



$P = V_s \cdot I_s \cdot pf_{CL}$

$10kW = 120\,(I_s)(pf_{CL})$

$I_s = \dfrac{10kW}{(120)\cdot(pf_{CL})}$

make larger

$pf_{CL max} = 1$

our design : $pf_{CL} = 0.8$ lagging

$\angle Z_{CL} = \cos^{-1}(.8)$

$\angle \hat{V}_s \quad \angle \hat{I}_s \quad = 36.87°$

$Z_{CL} = Z_L \,||\, Z_c$

$\theta - \phi = 36.87$

$0 - \phi = 36.87$

$\phi = -36.87$

$I_s = \dfrac{10\times10^3}{(120)(.8)}$

$= 104.16$ Arms

$\hat{I}_s = 104.16 \angle -36.87°$ Arms

$\hat{I}_c = \hat{I}_s - \hat{I}_L$ (by KCL)

$= 48.62 \angle 90°$ Arms

$|Z_c| = \dfrac{1}{\omega C} = 2.47$

$C = \dfrac{1}{(2.47)(\omega)}$

$Z_c = \dfrac{\hat{V}_s}{\hat{I}_c}$

$= \dfrac{120 \angle 0°}{48.62 \angle 90°}$

$= 2.47 \angle -90°\ \Omega$

$f = 60\,Hz \qquad \omega = 2\pi(60) \cong 377$ rad/s

$C = \dfrac{1}{(2.47)(377)}$

$\boxed{C = 1.08\,mF}$

$P_{line} = (I_s)^2(.5)$

$= (104.16)^2(0.5)$

$P_{line} = 5.42$ kW