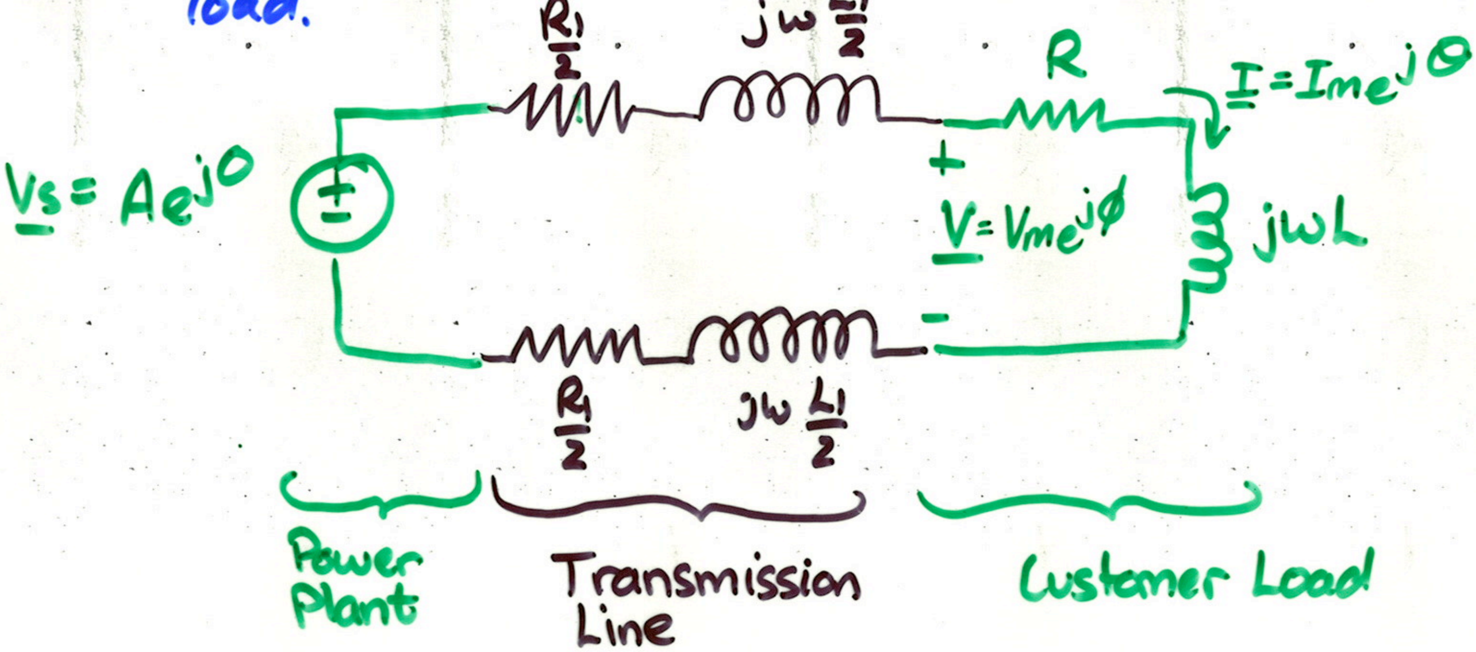
Application

consider the following frequency-domain model of a power plant, transmission line and customer load.



Impedance of line = $\underline{Z}_{LINE} = R_1 + j\omega L_1$

Power absorbed by line = $\frac{I_m^2}{2} Re\{\underline{Z}_{line}\} = \frac{I_m^2 R_1}{2}$

The power company has to supply power at a specified voltage V. However some of the power is absorbed by the line. ~~Hep~~ How much is absorbed in the line?

let Vc and Pc be the voltage and average power requested by the customer

$$P_{c_s} = \frac{V_m I_m}{2} pf$$

$$\Rightarrow \quad I_m = \frac{2P}{V_m \, pf}$$

Hence power dissipated in the line is

$$P_{LINE} = 2\left(\frac{P}{V_m \, pf}\right)^2 R_1$$

Hence higher the power factor, the less power is lost in the line

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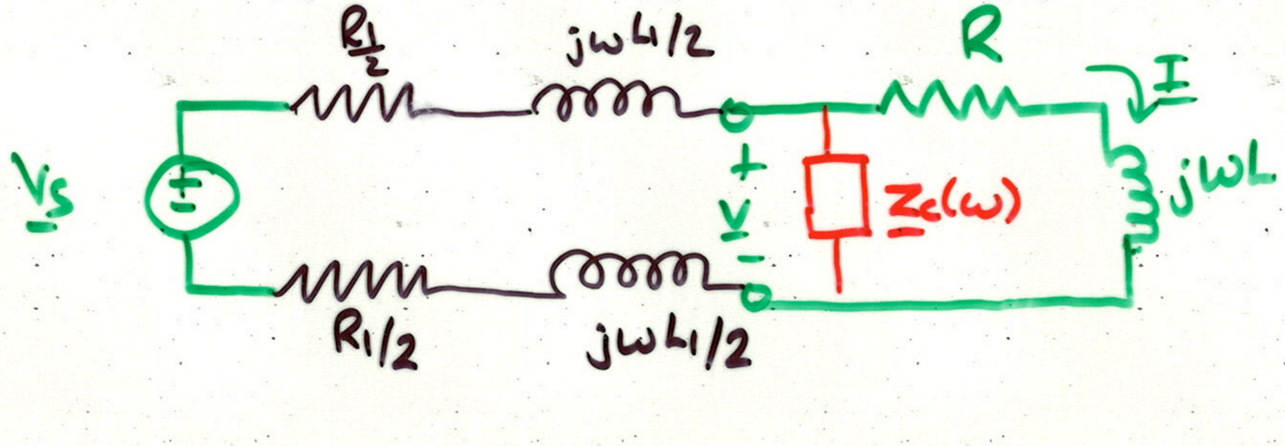
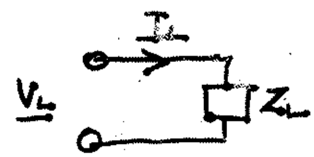
* In practice, power companies charge extra for low power factor loads (large power factor angle)
* As a result, customers often try to "correct" their power factor using a parallel impedance



Power Factor Correction — Again

Consider a load:



Complex power

$$S_L = \frac{\underline{V}_L \underline{I}_L^*}{2}$$

$$= |S_L| e^{j \angle S_L}$$

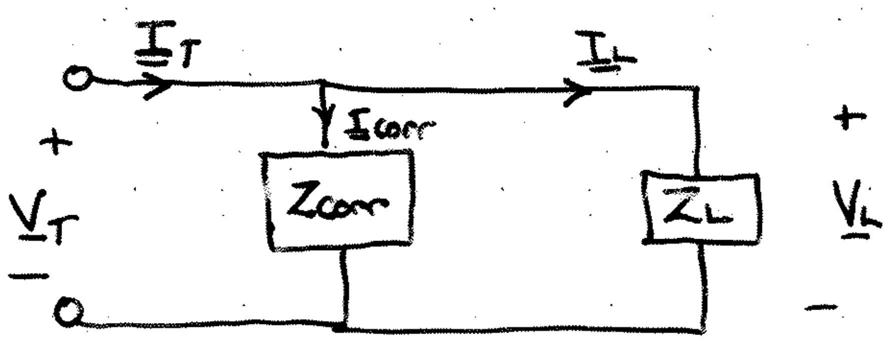
$$= P_{av,L} + j Q_L.$$

Power factor: $\cos(\angle S_L)$

if $\angle S_L > 0$: lagging

if $\angle S_L < 0$: leading

- Now suppose we want to increase the power factor while keeping the average power the same.
- We will try to do this with an element in parallel



$$S_T = P_{AV,L} + j\,Q_T$$

and desired power factor is $\cos(\theta_T) = pfc$

What is Q_{corr}?

$$Q_{corr} = Q_T - Q_L$$

$$= P_{AV,L}\tan(\theta_T) - Q_L$$

$$= P_{AV,L}\tan\left(\cos^{-1}(pfc)\right) - Q_L$$

$$Q_{corr} = \mathrm{Im}\left\{\frac{\underline{V}_T\,\underline{I}_{corr}^{*}}{2}\right\}$$

If $Q_{corr} < 0$ it will be a capacitor

$$\Rightarrow \underline{I}_{corr} = j\omega C\,\underline{V}_T$$

$$\Rightarrow Q_{corr} = -\frac{|V_T|^2\omega C}{2}.$$

Seeing as we have found Q_{corr} we can find C

Recall $S_L = P_{AV,L} + j\, Q_L$

Recall that complex powers are additive

$$\Rightarrow \quad S_T = \frac{\underline{V_T}\, \underline{I_T}^*}{2} = S_L + S_{corr} \qquad (*)$$

How to choose Z_{corr} so that S_T has the desired power factor.

Eqn (*) Is a complex sum.

- we want the real part to stay the same and the imaginary part to change in order to obtain the new power factor.

Consider the case where both S_L and S_T have lagging power factors.