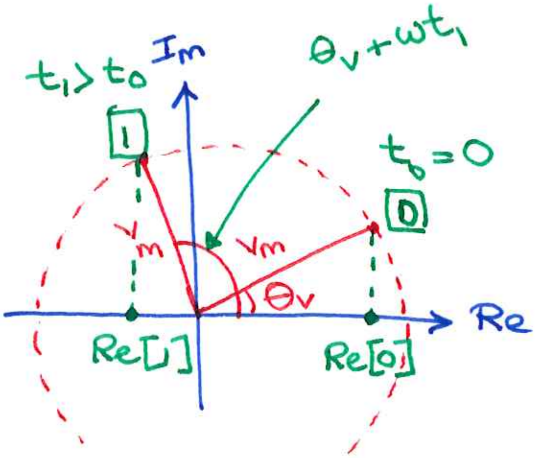
Tutorial 1

Phasors

: $V_m \cos(\omega t + \theta_v) = \mathrm{Re}\left[V_m e^{j(\omega t + \theta_v)} \right]$

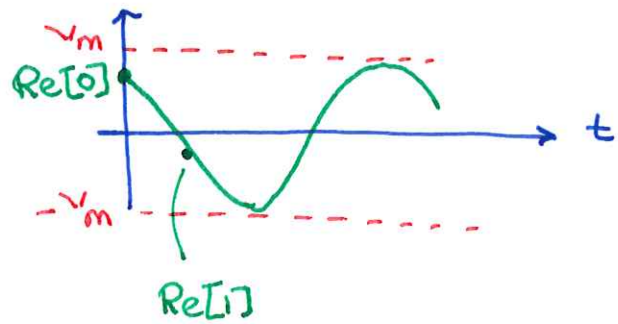
Can we plot $V_m e^{j(\omega t + \theta_v)}$? This is a polar number (vector) with magnitude V_m and time-varying phase $(\omega t + \theta_v)$



$V_m e^{j(\omega t + \theta_v)}$:

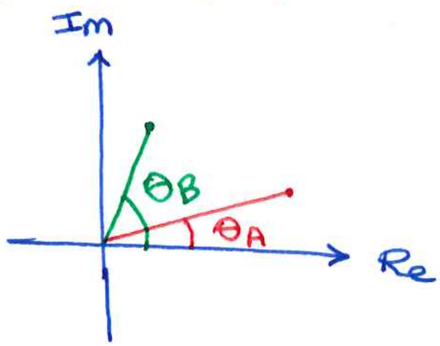
- rotates ccw in complex plane
- $V_m \angle \theta_v$ is a snapshot at $t = 0$

$V_m \cos(\omega t + \theta_v)$ is the projection of this rotating vector on the real axis



Leading & Lagging

- Try to keep phase angles between $-180°$ & $180°$



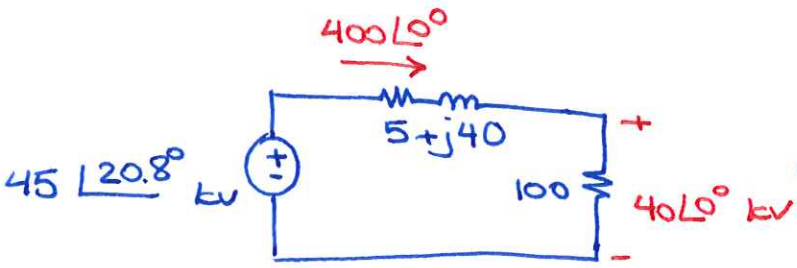
$\theta_B > \theta_A$ ∴ phasor B leads A

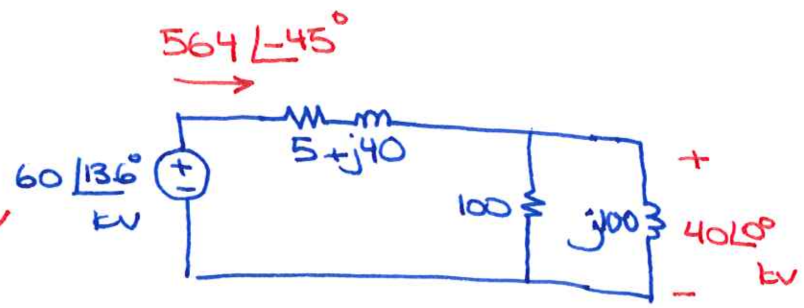
• To remember $\overline{V}$ & $\overline{I}$ relationship for L & C:

ELI the ICE man!

voltage leads current current leads voltage

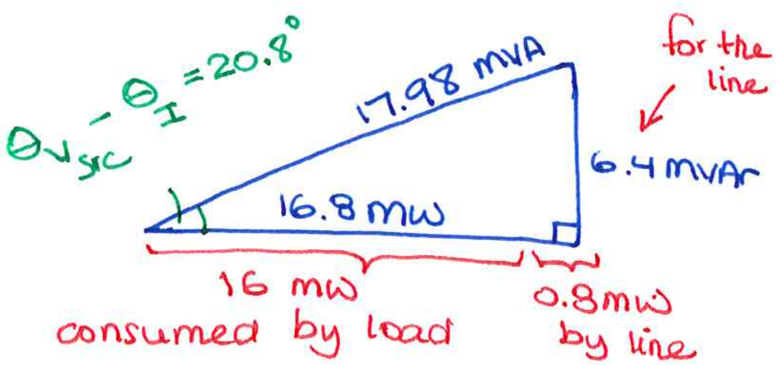
• Let's revisit the class example:

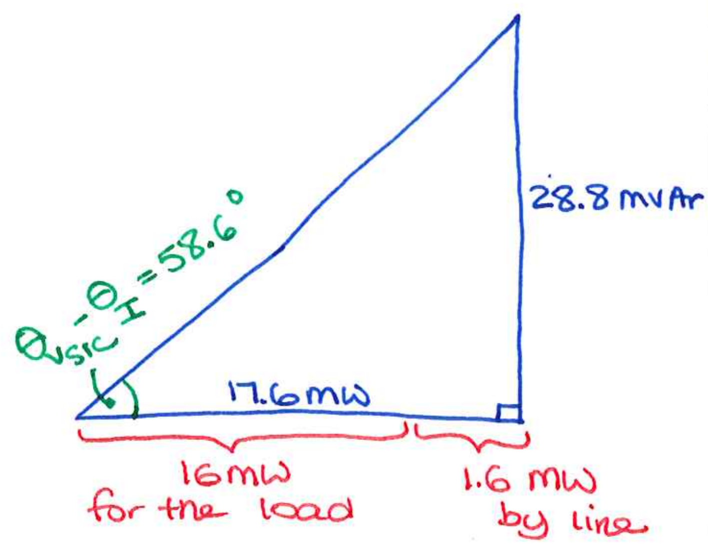




Question 1:

• Source Power Triangle





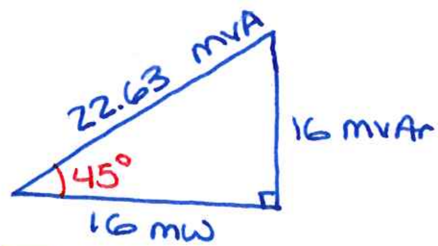
higher line current results in more line losses.

• Load power triangle

16 MW, 16 MVA

Power triangle with Q = 0

$$PF = \frac{P}{S} = \cos(\theta_{v_{load}} - \theta_I) = 1$$

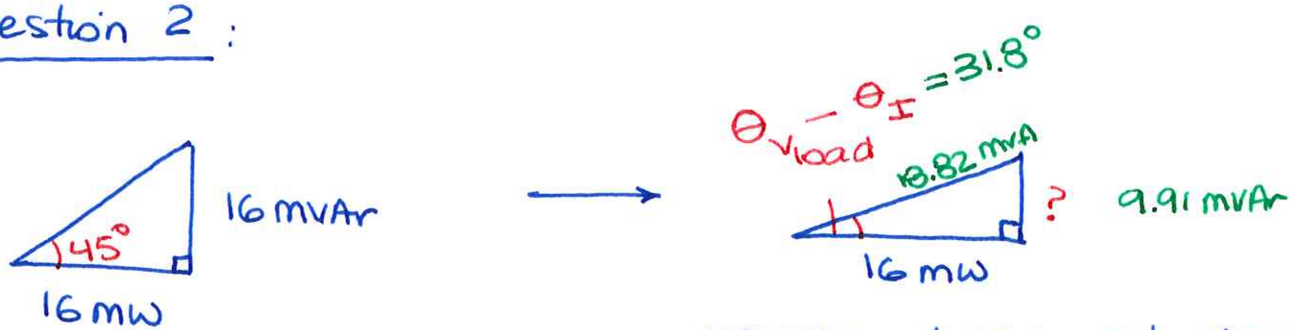


$$\overline{S}_{load} = \overline{V}_{load} \cdot \overline{I}^*$$

$$= (40\angle 0° \text{ kV})(564\angle +45°)$$

$$= \underbrace{16}_{P\,(MW)} + j\,\underbrace{16}_{Q\,(MVAr)}$$

Question 2 :



· usually not allowed to change real power requirement

In the new configuration, $\theta_{V_{load}} - \theta_I = \cos^{-1}(0.85) = \pm 31.8°$

lagging PF $\therefore \theta_I < \theta_V \therefore \theta_V - \theta_I > 0$

$$S_{new} = \frac{P}{PF_{new}} = \frac{16\ mW}{0.85} = 18.82\ mVA$$

$$Q_{new} = \sqrt{S_{new}^2 - P_{new}^2} = 9.91\ mVAr$$

Need to "supply" Q of $16 - 9.91 = 6.083$ mVAr by adding a capacitor.

$$Q_{cap} = \frac{V^2}{X_{cap}} \therefore X_{cap} = \frac{V^2}{Q_{cap}} = \frac{(40\,kV)^2}{-6.083\ mVAr} = -263\ \Omega$$

"supply" Q

$$X_{cap} = \frac{-1}{\omega C} \therefore C = \frac{-1}{\omega \cdot X_{cap}} = \frac{-1}{2\pi \times 60 \times (-263)} = 10.1\ \mu F$$

we can assume North American f = 60 Hz