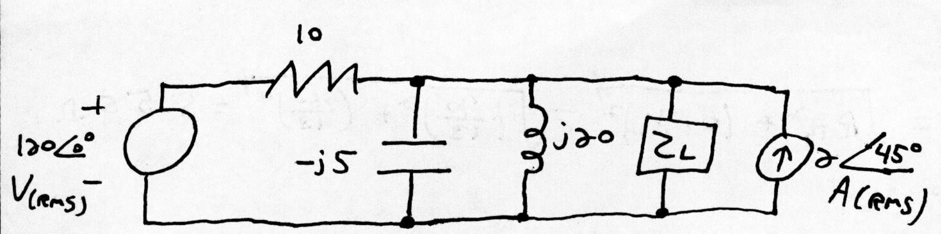


Find Z_L, P_L such that P_L is maximized.

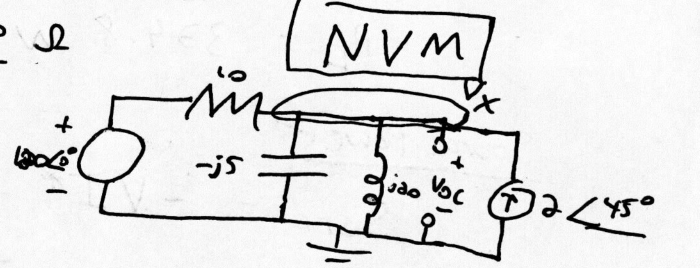
What if Z_L is resistive only?

① First we will do a Thevenin analysis to find Z_{Th}

$$Z_{Th} = 10 \| -j5 \| j20 = \frac{1}{\frac{1}{10} + \frac{1}{j20} - \frac{1}{j5}} = \frac{1}{\frac{2j + 1 - 4}{j20}} = \frac{j20}{2j - 3}$$

$$= \frac{40}{13} - j\frac{60}{13} \approx 5.55\angle -56.3° \ \Omega$$

By node voltage method:



$$\frac{V_x - 120}{10} - \frac{V_x}{j5} + \frac{V_x}{j20} - 20\angle 45° = 0$$

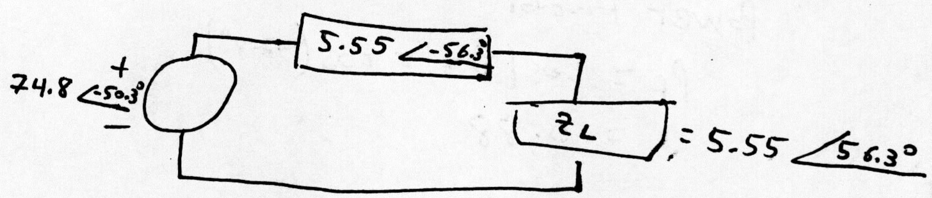
$$V_x\left[\frac{1}{10} - \frac{1}{j5} + \frac{1}{j20}\right] = 12 + 20\angle 45° \quad \therefore \quad V_{oc} = V_x = 74.8\angle -50.3° \ V_{(rms)}$$

② Ideal case

$$\boxed{\begin{aligned} X_L &= -X_{Th} \\ R_L &= \sqrt{R_{Th}^2 + (X_L + X_{Th})^2} \end{aligned}}$$

So $Z_L = \frac{40}{13} + j\frac{60}{13} \ \Omega$

Reforming our Thevenin Equivilant:



$$I = \frac{V_{oc}}{Z_{eq}} = \frac{V_{oc}}{Z_{Th} + Z_L} = \frac{V_{oc}}{\frac{40}{13} - j\frac{60}{13} + \frac{40}{13} + j\frac{60}{13}} = \frac{V_{oc}}{\frac{80}{13}} = (74.8)\left(\frac{13}{80}\right)\angle -50.3°$$

$$= 12.15\angle 50.3° \ A_{(rms)}$$

Load Power

$$S_L = V_L I_L^* = I_L Z_L I_L^* = [12.15][12.15][5.55]\angle 50.3 - 50.3 + 56.3°$$

$$= 867\angle 56.3° \ \text{VA}$$

$$P_L = 867\cos 56.3° = 478.6 \ \text{W}$$

Note since our load impedance (overall) is balanced, we have a unity power factor at the source

$Z_{EQ} = \frac{80}{13}\Omega \qquad S_{src} = (-74.8\angle -50.3°)(12.15\angle -50.3°)^* = -957 \ \text{VA}$

$P_L = -957 \ \text{W}$

③ Non-Ideal

Since $X_L = 0$, $R_L = \sqrt{R_{Th}^2 + (0 + X_{Th})^2} = \sqrt{\left(\frac{40}{13}\right)^2 + \left(\frac{-60}{13}\right)^2} = 5.55\,\Omega$

$Z_L = 5.55\angle 0^\circ\ \Omega$

$$I = \frac{V_{oc}}{Z_{Th} + Z_L} = \frac{V_{oc}}{5.55 + \frac{40}{13} + \frac{-j60}{13}} = \frac{74.8\angle -50.3^\circ}{9.78\angle -28^\circ\ \Omega}$$

$$= 7.65\angle -22^\circ$$

Load Power

$$S = \underbrace{(5.55\angle 0^\circ)}_{Z_L}\underbrace{(7.65\angle -22^\circ)}_{I}\underbrace{(7.65\angle 22^\circ)}_{I^*} = 324.8\angle 0^\circ\ VA$$

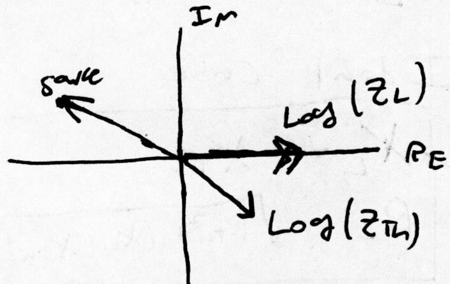
$P_L = 324.8\ W$ [All real power]

Source Power

$$S_{src} = -VI^* = -(74.8\angle -50.3^\circ)(7.65\angle 22^\circ)$$
$$= -572\angle -28^\circ\ VA$$
$$= -504 + j271.3\ VA$$

$P_{src} = -504\ W$

$Q_{src} = 271\ Vars$



Power Factor

$$PF = \cos(\theta_z) = \cos(-28^\circ)$$
$$= 0.88$$

$$S_{Th} = (7.65)^2(5.55\angle -56.3^\circ)$$
$$= 180 - 270j\ VA$$

Since $Q_{src} > 0$

and the load is capacitive $(X_L + X_{Th} < 0)$

the load power is leading.

Capacitive Load $\Longleftrightarrow$ Leading Load

Inductive Load $\Longleftrightarrow$ Lagging Load