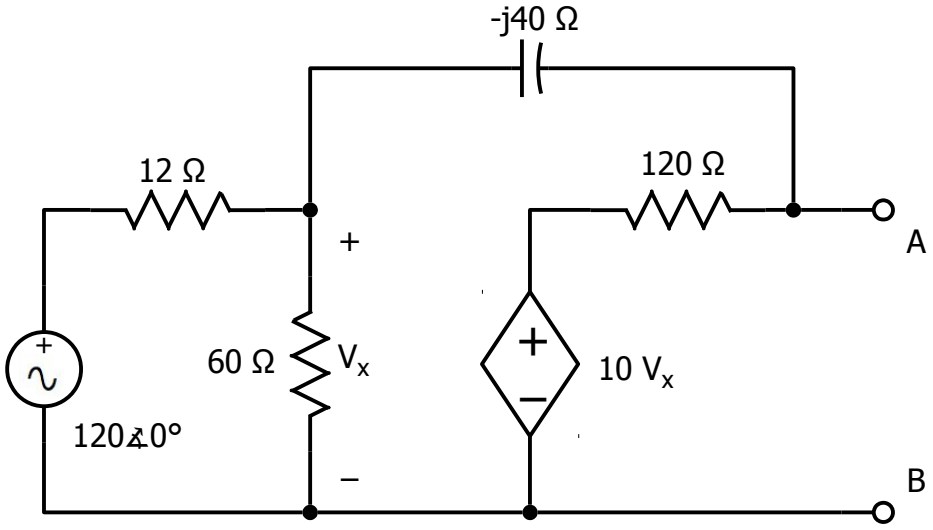
EE3 Fall 2020
Homework Problem 8

Find the Thévenin Equivalent of this circuit.



Solution on next page.

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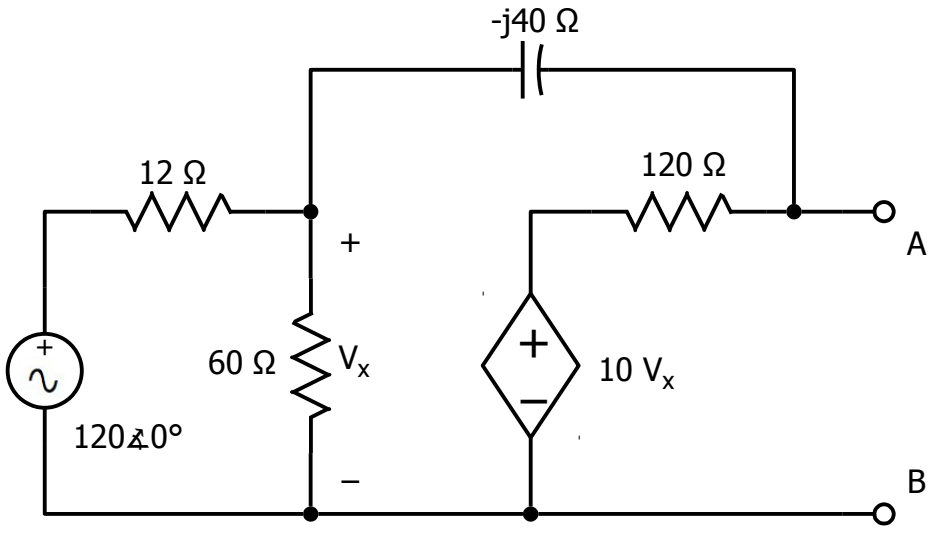


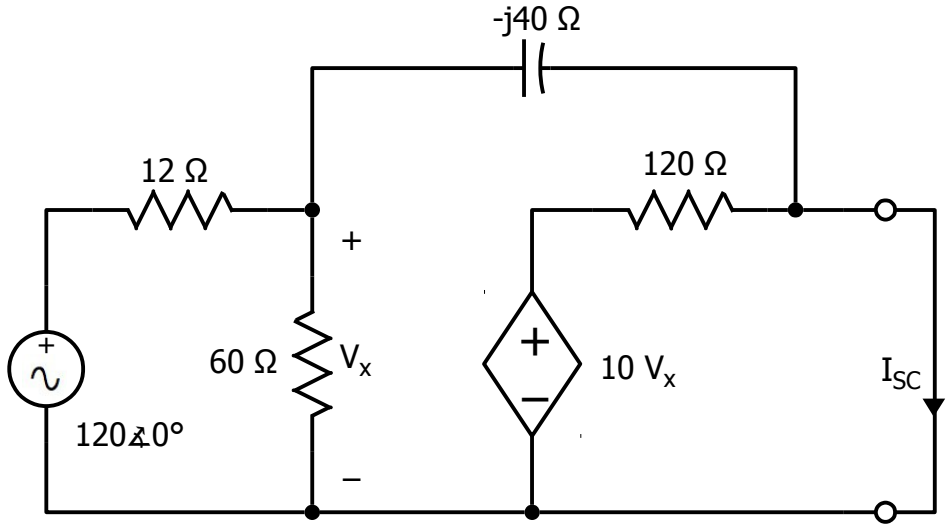
To find v_{TH}:

$$\frac{v_{AB}-v_x}{-j\,40}+\frac{v_{AB}-10v_x}{120}=0$$

$$\frac{v_x-120}{12}+\frac{v_x}{60}+\frac{v_x-v_{AB}}{-j\,40}=0$$

$$\begin{bmatrix} -1/j\,40+1/120 & 1/j\,40-10/120 \\ 1/j\,40 & 1/12+1/60-1/j\,40 \end{bmatrix}\begin{bmatrix} v_{AB} \\ v_x \end{bmatrix}=\begin{bmatrix} 0 \\ 10 \end{bmatrix}$$

$$v_{TH}=v_{AB}=784-j\,288$$

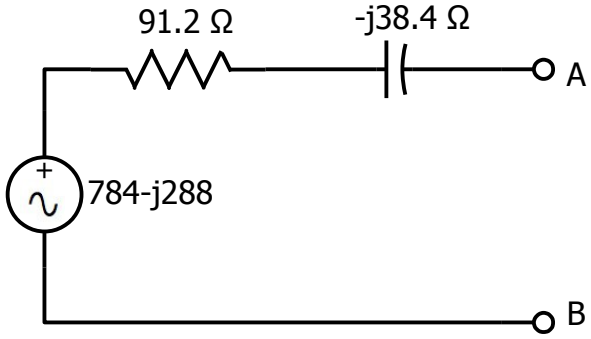


$$i_{SC}+\frac{0-10v_x}{120}+\frac{0-v_x}{-j\,40}=0$$

$$\frac{v_x}{-j\,40}+\frac{v_x}{60}+\frac{v_x-120}{12}=0$$

$$\begin{bmatrix} 1 & -10/120-1/(-j\,40) \\ 0 & 1/(-j\,40)+1/60+1/12 \end{bmatrix}\begin{bmatrix} i_{SC} \\ v_x \end{bmatrix}=\begin{bmatrix} 0 \\ 10 \end{bmatrix}$$

$$Z_{TH}=\frac{v_{TH}}{i_{SC}}=\frac{784-j\,288}{-8.43+j\,0.39}=91.2-j\,38.4\ \Omega$$



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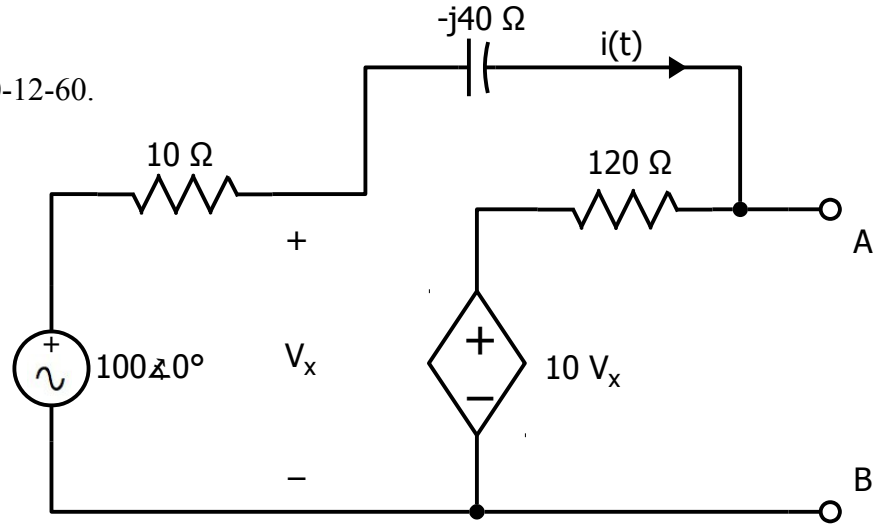
Open-Circuit Voltage v_{AB}:
Find internal Thévenin Equivalent of 120-12-60.

$v_{intTH} = v_{OC} = 120\angle 0°\left(\frac{60}{72}\right) = 100\angle 0°$

$R_{intTH} = 60\|12 = 10\ \Omega$



For v_{origth}, KCL at Point A:

$\frac{v_{AB}-10v_x}{120}-i(t)=0$

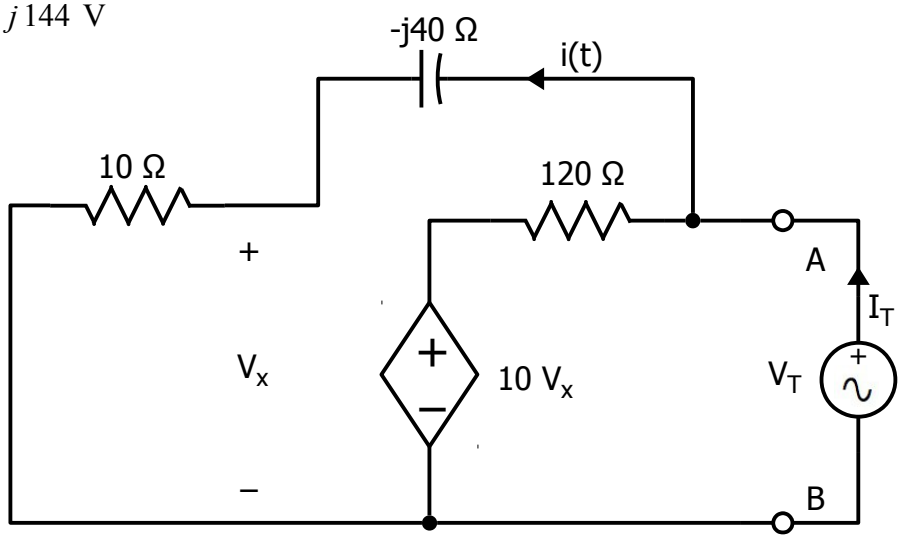
By KVL: $-100+10i(t)+v_x=0$

$i(t)=\frac{100-v_{AB}}{10-j40}$

$$\begin{bmatrix} 1/120 & -10/120 & -1 \\ 0 & 1 & 10 \\ -1/(10-j40) & 0 & -1 \end{bmatrix}\begin{bmatrix} v_{AB} \\ v_x \\ i(t) \end{bmatrix}=\begin{bmatrix} 0 \\ 100 \\ -100/10-j40 \end{bmatrix}$$

$v_{origTH} = v_{AB} = 784-j288$ V; $v_x = 208+j144$ V

$i(t) = -10.8-j14.4$ A



For Z_{origTH}, KCL at Point A:

$\frac{V_T-10V_x}{120}+\frac{V_T}{10-j40}-I_T=0$

$v_x = 10i(t) = 10\left(\frac{V_T}{10-j40}\right)$

$\frac{V_T}{120}-\frac{100\,V_T}{120\cdot(10-j40)}+\frac{V_T}{10-j40}=I_T$

$Z_{origTH}=\frac{V_T}{I_T}=\frac{1}{1/120-100/(120\cdot(10-j40))+1/(10-j40)}$

$Z_{origTH} = 91.2-j38.4\ \Omega$