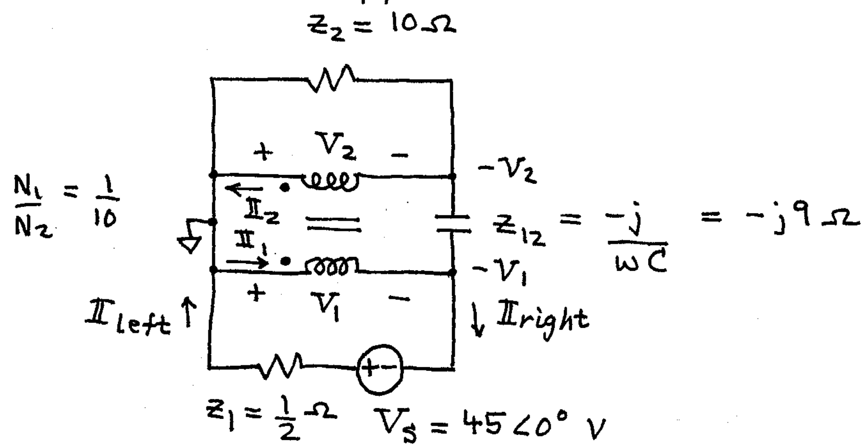
Alternate approach:



On the left, we have current

$$I_1 - I_2 + \frac{V_2}{Z_2} = I_{left}$$

On the right, we have current

$$-\frac{V_2 - -V_1}{Z_{12}} + I_1 = I_{right}$$

We have $I_{left} = I_{right}$

and the following ideal transformer eq'ns:

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \equiv \mathcal{N} \quad \text{or} \quad V_2 = \frac{V_1}{\mathcal{N}}$$

$$\frac{I_1}{I_2} = \frac{N_2}{N_1} = \frac{1}{\mathcal{N}} \quad \text{or} \quad I_2 = I_1 \mathcal{N}$$

Making all these substitutions, we have

$$\mathbb{I}_1 - \mathbb{I}_1 \mathcal{N} + \frac{\mathbb{V}_1}{\mathcal{N}} \frac{1}{Z_2} = \frac{-\frac{\mathbb{V}_1}{\mathcal{N}} + \mathbb{V}_1}{Z_{12}} + \mathbb{I}_1$$

or
$$-\mathbb{I}_1 \mathcal{N} = \mathbb{V}_1 \left[\frac{\left(1 - \frac{1}{\mathcal{N}}\right)}{Z_{12}} - \frac{\frac{1}{\mathcal{N}}}{Z_2} \right]$$

or
$$\frac{\mathbb{V}_1}{\mathbb{I}_1} = \frac{-\mathcal{N}}{\left(1 - \frac{1}{\mathcal{N}}\right) \frac{1}{Z_{12}} - \frac{1}{\mathcal{N}} \frac{1}{Z_2}}$$

$$\frac{\mathbb{V}_1}{\mathbb{I}_1} = \frac{1}{\frac{1-\mathcal{N}}{\mathcal{N}^2} \frac{1}{Z_{12}} + \frac{1}{\mathcal{N}^2} \frac{1}{Z_2}}$$

$$\frac{\mathbb{V}_1}{\mathbb{I}_1} = Z_{12} \frac{\mathcal{N}^2}{1-\mathcal{N}} \parallel Z_2 \mathcal{N}^2$$

$$\frac{\mathbb{V}_1}{\mathbb{I}_1} = \mathcal{N}^2 \cdot \frac{Z_{12}}{1-\mathcal{N}} \parallel Z_2$$

Using the values for this problem:

$$\frac{\mathbb{V}_1}{\mathbb{I}_1} = \left(\frac{1}{10}\right)^2 \cdot \frac{-j9}{1 - \frac{1}{10}} \parallel 10 = \left(\frac{1}{10}\right)^2 \cdot \frac{-j9}{\frac{9}{10}} \parallel 10$$

$$'' = \left(\frac{1}{10}\right)^2 \cdot -j10 \parallel 10 = \frac{1}{10} \cdot -j \parallel 1 = \frac{1}{10} \frac{-j}{1-j}$$

$$'' = \frac{1}{10} \frac{1+j}{1+j} \cdot \frac{-j}{1-j} = \frac{1-j}{20} \ \Omega$$

or $\quad V_1 = \mathcal{N}^2 \cdot \frac{z_{12}}{1-\mathcal{N}} \Big\| z_2 \cdot \mathbb{I}_1 = \frac{1 - j\Omega \cdot \mathbb{I}_1}{20}$

We have $\quad \mathbb{I}_{left} = \mathbb{I}_1 (1-\mathcal{N}) + \mathcal{N} \dfrac{\mathcal{N}^2 \frac{z_{12}}{1-\mathcal{N}} \Big\| z_2 \, \mathbb{I}_1}{\mathcal{N} z_2}$

In terms of V_1, we have

$$\mathbb{I}_1 = \frac{V_1}{\mathcal{N}^2 \cdot \frac{z_{12}}{1-\mathcal{N}} \Big\| z_2}$$

$$\mathbb{I}_{left} = \frac{V_1}{\mathcal{N}^2 \cdot \frac{z_{12}}{1-\mathcal{N}} \Big\| z_2} (1-\mathcal{N}) + V_1 \frac{1}{\mathcal{N} z_2}$$

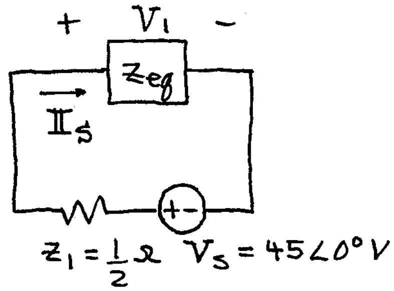
$$= V_1 \left[\frac{1-\mathcal{N}}{\mathcal{N}^2} \left(\frac{1-\mathcal{N}}{z_{12}} + \frac{1}{z_2} \right) + \frac{1}{\mathcal{N} z_2} \right]$$

$$= V_1 \left[\frac{(1-\mathcal{N})^2}{\mathcal{N}^2} \frac{1}{z_{12}} + \frac{1-\mathcal{N}}{\mathcal{N}^2} \frac{1}{z_2} + \frac{\mathcal{N}}{\mathcal{N}^2} \frac{1}{z_2} \right]$$

$$= V_1 \left[\frac{(1-\mathcal{N})^2}{\mathcal{N}^2} \frac{1}{z_{12}} + \frac{1}{\mathcal{N}^2 z_2} \right]$$

$$\mathbb{I}_{left} = \frac{V_1}{\mathcal{N}^2 \cdot \frac{z_{12}}{(1-\mathcal{N})^2} \Big\| z_2}$$

We define $\quad z_{eq} \equiv \dfrac{V_1}{\mathbb{I}_{left}} = \mathcal{N}^2 \cdot \dfrac{z_{12}}{(1-\mathcal{N})^2} \Big\| z_2$



$$V_1 = V_S \cdot \frac{Z_{eq}}{Z_1 + Z_{eq}}$$

$$Z_{eq} = N^2 \frac{Z_{12}}{(1-N)^2} \,\Big\|\, Z_2 = \left(\frac{1}{10}\right)^2 \cdot \frac{-j9}{\left(1-\frac{1}{10}\right)^2} \,\Big\|\, 10\ \Omega$$

$$= \frac{1}{100} \cdot \frac{-j9}{\left(\frac{9}{10}\right)^2} \,\Big\|\, 10\ \Omega$$

$$= \frac{1}{100} \cdot -j\frac{100}{9} \,\Big\|\, 10\ \Omega$$

$$= -j\,\frac{1}{9} \,\Big\|\, \frac{1}{10}\ \Omega$$

$$Z_{eq} = \frac{\frac{-j}{90}}{\frac{1}{10} - j\frac{1}{9}} = \frac{-j}{9-j10} = \frac{1}{10+j9}$$

$$V_1 = V_S \frac{\frac{1}{10+j9}}{\frac{1}{2} + \frac{1}{10+j9}} = 45 \frac{1}{\frac{10+j9}{2} + 1}\ V$$

$$V_1 = \frac{45(2)}{12+j9}\,V = \frac{90}{12+j9} = \frac{30}{4+j3}$$

$$V_2 = \frac{V_1}{N} = V_1 \cdot 10 = \frac{30 \cdot 10}{4+j3}$$

$$I = -\frac{V_2}{Z_2} = -\frac{30 \cdot \cancel{10}}{4+j3}\,\frac{1}{\cancel{10}} = \frac{-30}{4+j3}$$

$$= -\frac{30}{25}(4-j3)\ A$$

$$= -\frac{6}{5}(4-j3) = -\frac{6}{5}\cdot 5\angle -36.9^\circ\ A$$

$$I = 6\angle 143.1^\circ\ A$$

$$i(t) = 6\cos(\omega t + 143.1^\circ)\,A, \quad \omega = \frac{20}{9}\cdot 10^4\ \text{r/s}$$