Application of mesh current method to solve AC circuit.

Mesh method will be used to find expressions for currents and voltages in circuit. Mesh current method is based on Kirchhoff's voltage law (KVL). Number of equations for Kirchhoff's voltage law (KVL) and mesh current method is given by formula:

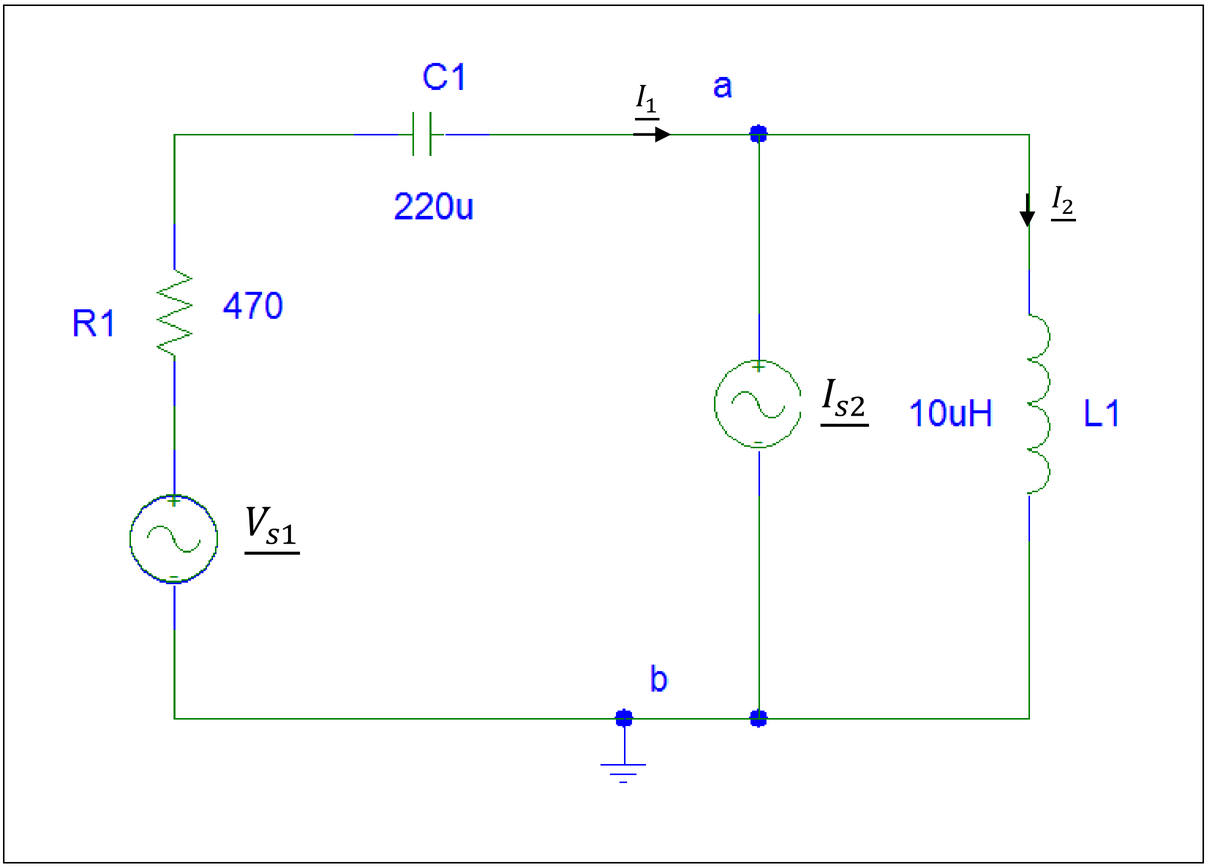
$$KVL \rightarrow m-(n-1)$$

$$m - number\ of\ branches$$

$$n - number\ of\ nodes$$

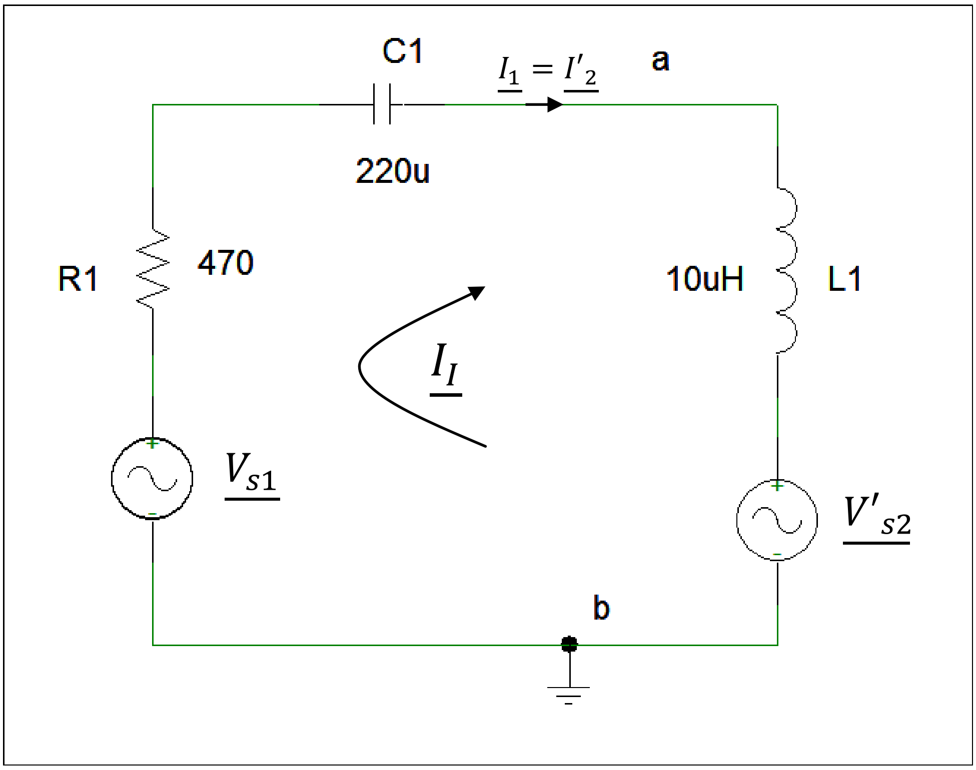
In circuit below are two nodes. Number of equations is then

$$KVL \rightarrow m-(n-1) = 2-1 = 1$$



Drawing 1. Electric AC circuit.

In mesh current method we have to transform all current sources to voltage sources. In mesh current method we have to write mesh equation where on one side is sum of all voltage sources in circuit and on the second equation side is sum voltages which are an effect of mesh current. As you can see on drawing 1 in circuit is one physical sinusoidal current source $\underline{I_{s2}}$. That current source has to transformed into relevant "virtual" voltage source $\underline{V'_{s2}}$.



Drawing 2. Electric AC circuit from drawing 1 with transformed current source.

$$\underline{V'_{s2}} = \underline{I_{s2}} \cdot \underline{Z_{L1}} = \underline{I_{s2}} \cdot j \cdot \omega \cdot L1$$

Remember also about relation between impedance and admittance.

$$\underline{Y} = \frac{1}{\underline{Z}} \text{ and } \underline{Z} = \frac{1}{\underline{Y}}$$

Equation for mesh I

$$\Sigma(\underline{E})_I = \underline{V_{s1}} - \underline{V'_{s2}} = \underline{I_I} \cdot \left(\underline{Z_{R1}} + \underline{Z_{C1}} + \underline{Z_{L1}}\right)$$

$$\Sigma(\underline{E})_I = \underline{V_{s1}} - \underline{V'_{s2}} = \underline{I_I} \cdot \left(R1 - j \cdot \frac{1}{\omega \cdot C1} + j \cdot \omega \cdot L1\right)$$

Obviously

$$\omega = 2 \cdot \Pi \cdot f$$

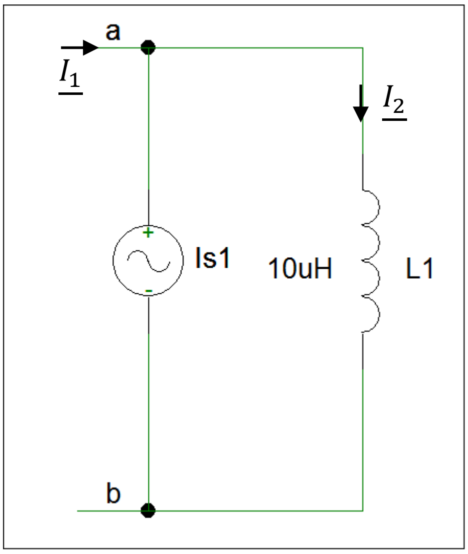
Now we will calculate mesh current $\underline{I_I}$ from mesh equation for mesh I.

$$\underline{V_{s1}} - \underline{V'_{s2}} = \underline{I_I} \cdot \left(R1 - j \cdot \frac{1}{\omega \cdot C1} + j \cdot \omega \cdot L1\right)$$

$$\underline{I_I} = \frac{\underline{V_{s1}} - \underline{V'_{s2}}}{\left(R1 - j \cdot \frac{1}{\omega \cdot C1} + j \cdot \omega \cdot L1\right)}$$

$$\underline{I_I} = \frac{\underline{V_{s1}} - \underline{I_{s2}} \cdot j \cdot \omega \cdot L1}{\left(R1 - j \cdot \frac{1}{\omega \cdot C1} + j \cdot \omega \cdot L1\right)}$$

Mesh current $\underline{I_I}$ is designated. Now we will calculate branch currents $\underline{I_1}$ and $\underline{I_2}$.



Drawing 3. Branch with inductive $L1$ connected in parallel with current source $\underline{I_{s2}}$ before transformation.

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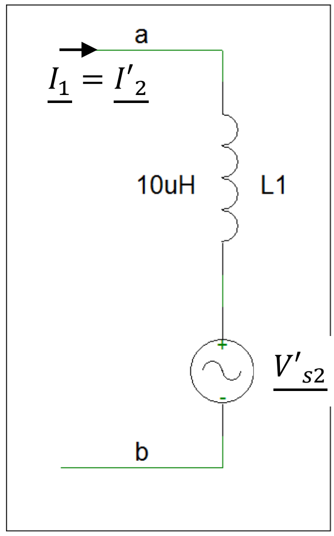

Drawing 4. Branch with inductive $L1$ connected and voltage source $\underline{V'_{s2}}$ after transformation

Branch currents are given by equations:

$$\underline{I_1} = \underline{I_I}$$

$$\underline{I'_2} = \underline{I_I}$$

To calculate current $\underline{I_2}$ we have to take under consideration how circuit has looked before transformation of current source $\underline{I_{s2}}$ to voltage source $\underline{V'_{s2}}$.

$$\underline{I'_2} + \underline{I_{s2}} - \underline{I_2} = 0 \rightarrow \underline{I_2} = \underline{I'_2} + \underline{I_{s2}}$$

$$\underline{I_2} = \underline{I_I} + \underline{I_{s2}}$$