HOW TO WRITE MESH and NODE EQUATIONS OF A NETWORK
IN MATRIX FORM BY INSPECTION

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(i) MESH EQUATIONS FOR RESISTIVE NETWORKS

Step 1
Convert all current sources into voltage source equivalent by employing Norton/Thevenin transformation.

Step 2
Identify the loops (number them) and define the loop currents (both direction and number) on the new circuit diagram. All loop currents must be defined to flow in the same direction, i.e., all clockwise or all counterclockwise.

Step 3
Assuming that you have named the loop currents as,

\{ I_1, I_2, I_3, \ldots, I_N \}

where N is the total number of loops, write the loop equation in matrix form as shown below.

\[
\begin{bmatrix}
V_1 \\
V_2 \\
\vdots \\
V_N \\
\end{bmatrix}
= 
\begin{bmatrix}
R_{11} & R_{12} & \cdots & R_{1N} \\
R_{21} & R_{22} & \cdots & R_{2N} \\
\vdots & \vdots & \ddots & \vdots \\
R_{N1} & R_{N2} & \cdots & R_{NN} \\
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
\vdots \\
I_N \\
\end{bmatrix}
\]

where,

(a) \( V_i \) is the algebraic sum of all the voltage sources driving the loop current \( I_i \) in its chosen direction. (If \( I_i \) enters the voltage source at its (-) terminal that voltage source contributes to the sum with a (+) value; otherwise (-).)


(b) \( R_{ii} \) is the diagonal element of the resistance Matrix. It corresponds to the loop "i" and it is equal to the \((+\)\) sum of all the resistances around that loop.

(c) \( R_{ij} = R_{ji} \), where \( i \neq j \), represents the off-diagonal elements of the resistance matrix. It stands for the coupling between the loop "i" and the loop "j". It is equal to the negative sum of the resistances common to both loops. If they do not share a common branch it is equal to zero.

**Step 4**

If \( V_i \) contains any current-dependent voltage source, they should be transferred to the right side (into the resistance matrix) before a matrix inversion is attempted to solve for the unknown loop currents.

**Example**
\[ R \rightarrow R \]
\[ C \rightarrow \frac{1}{jωC} \]
\[ L \rightarrow jωL \]

\[ \mathbf{Z} = \begin{bmatrix} R_1 + (jωL_1 + jωC_1) & - (jωL_1 + jωC_1) & - (R_4 + jωC_2) \\ + (jωL_1 + jωC_1) & R_2 + jωC_1 & - R_5 \\ - (R_4 + jωC_2) & + R_5 & - R_5 \end{bmatrix} \]