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Chapter 19

Methods of AC Analysis

Robbins and Miller

Circuit Analysis with Devices:
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Dependent Sources

- Voltages and currents of independent sources
  - Not dependent upon any voltage or current elsewhere in the circuit
- In some circuits
  - Operation of certain devices replaces device with an equivalent model

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Dependent Sources

- Models are dependent upon an internal voltage or current elsewhere in the circuit

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Dependent Sources

- Have a magnitude and phase angle determined by voltage or current at some other circuit element multiplied by a constant *k*
- Magnitude of *k* is determined by parameters within particular model

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Dependent Sources

- Units of constant correspond to required quantities in the equation

Source Conversion

- A voltage source E in series with an impedance Z
  - Equivalent to a current source I having the same impedance Z in parallel
- I = E/Z
- E = IZ

Source Conversion

- Voltages and currents at terminals will be the same
  - Internal voltages and currents will differ

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Source Conversion

- A dependent source may be converted by the same method
- Controlling element external to circuit
- If controlling element is in the same circuit as the dependent source
  - Procedure cannot be used

Mesh Analysis

- Method exactly the same as for dc
  - Convert all sinusoidal expressions into phasor notation
  - Convert current sources to voltage sources
  - Redraw circuit, simplifying the given impedances

Mesh Analysis

- Assign clockwise loop currents to each interior closed loop
- Show polarities of all impedances

Mesh Analysis

- Apply KVL to each loop and write resulting equations
- Voltages that are voltage rises in the direction of the assumed current are positive
  - Voltages that drop are negative

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Mesh Analysis

- Solve the resulting simultaneous linear equations or matrix equations

Nodal Analysis

- Method is exactly the same as for dc
- Nodal analysis will calculate all nodal voltages with respect to ground
- Convert all sinusoidal expressions into equivalent phasor notation

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Nodal Analysis

- Convert all voltage sources to current sources
- Redraw the circuit
  - Simplifying given impedances and expressing impedances as admittances

Nodal Analysis

- Assign subscripted voltages to nodes
  - Select an appropriate reference node
- Assign assumed current directions through all branches
- Apply KCL to each node
- Solve resulting equations for node voltages

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Delta-to-Wye Conversion

- Impedance in any arm of a Y circuit
  - Determined by taking the product of two adjacent Δ impedances at this arm
  - Divide by the summation of the Δ impedances

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Delta-to-Wye Conversion

$$\mathbf{Z}_1 = \frac{\mathbf{Z}_b \mathbf{Z}_c}{\mathbf{Z}_a + \mathbf{Z}_b + \mathbf{Z}_c}$$

$$\mathbf{Z}_2 = \frac{\mathbf{Z}_a \mathbf{Z}_c}{\mathbf{Z}_a + \mathbf{Z}_b + \mathbf{Z}_c}$$

$$\mathbf{Z}_3 = \frac{\mathbf{Z}_a \mathbf{Z}_b}{\mathbf{Z}_a + \mathbf{Z}_b + \mathbf{Z}_c}$$

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Wye-to-Delta Conversions

- Any impedance in a Δ
  - Determined by summing all possible two-impedance product combinations of the Y
  - Divide by impedance found in opposite branch of the Y

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Wye-to-Delta Conversions

$$Z_a = \frac{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}{Z_1}$$

$$Z_b = \frac{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}{Z_2}$$

$$Z_c = \frac{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}{Z_3}$$

Bridge Networks

- Bridge circuits are used to measure the values of unknown components
- Any bridge circuit is balanced when the current through branch between two arms is zero

Bridge Networks

- The condition of a balanced bridge occurs when

$$\frac{\mathbf{Z}_1}{\mathbf{Z}_3} = \frac{\mathbf{Z}_2}{\mathbf{Z}_4}$$

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Bridge Networks

- When a balanced bridge occurs in a circuit
  - Equivalent impedance of bridge is found by removing central **Z** and replacing it by a short or open circuit
- Resulting **Z** is then found by solving series-parallel circuit

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Bridge Networks

- For an unbalanced bridge
  - **Z** can be determined by Δ-to-Y conversion or mesh analysis

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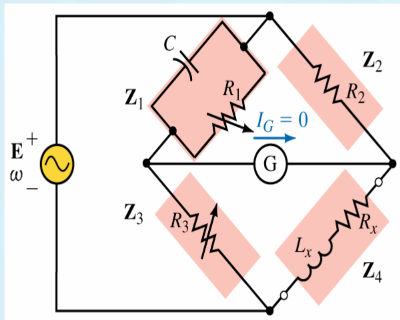
Maxwell Bridge

- Used to determine the *L* and *R* of an inductor having a large series resistance
- $L = R_2R_3C \quad R = R_2R_3/R_1$

Maxwell Bridge



Maxwell Bridge

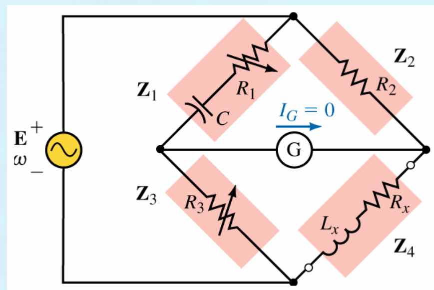
Hay Bridge

- Used to measure the *L* and *R* of an inductor having a small series resistance

Hay Bridge

$$L_x = \frac{R_2 R_3 C}{\omega^2 R_1^2 C^2 + 1}$$

$$R_x = \frac{\omega^2 R_1 R_2 R_3 C^2}{\omega^2 R_1^2 C^2 + 1}$$



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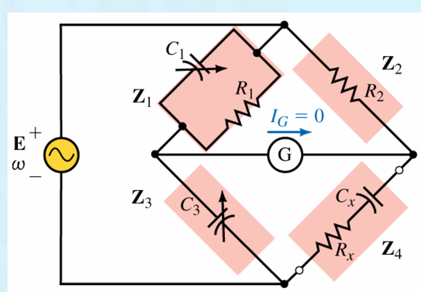
Schering Bridge

- Used to determine an unknown capacitance

$$C = \frac{R_1 C_3}{R_2}$$

$$R = \frac{C_1 R_2}{C_3}$$



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