Mesh & Nodal Analysis

Overview

- Analysis tools for complex circuits
  - Many loops (Mesh analysis)
  - Many nodes (Nodal analysis)
- Use Ohm’s Law, KVL & KCL for simultaneous equations with...

  - **Nodal Analysis**
    - One equation per node
  - **Mesh Analysis**
    - One equation per loop

Write Expressions for I, using Ohm’s Law & “V_{drop}”

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Nodal Analysis

• Apply Kirchhoff’s **current** law to solve for nodal voltages
  1) **Label diagram** (nodes, all directions)
     • Initial labeling is arbitrary but must be consistent!
  2) **Obtain equations** using KCL and substituting in Ohm’s law
  3) **Solve equations** for nodal voltages
     • Substitutions, linear algebra (matrices), Matlab
     • Note, negative answers indicate polarity is opposite your initial assumptions and are not incorrect
     • Solution often requires **iteration**, as first attempt may not work.

• How do we find \( v_1 \), \( v_2 \) and power dissipated in the resistors?

Nodal Analysis

• Find \( v_1 \), \( v_2 \) and power dissipated in resistors
Concept Check: Voltage Across
• $v_1, v_2$ are voltage values relative to what?
• What is the voltage across the 4Ω resistor?

Mesh Analysis
• Apply Kirchhoff’s voltage law to solve for loop (mesh) currents
• Other law(s), expression(s) to use?
• Process?
  1)
  2)
  3)

Mesh Analysis Warmup
• How do we find (and label) $i$ through $R_3$?
• Mesh currents versus element currents

Mesh Analysis Warmup
If we draw loop currents to be opposing through $R_3$...
Mesh Analysis

• How do we find $i_1$, $i_2$, $i_3$ and $i$?
• Set up equations
• (be able to write equations in matrix format)

Use Matlab to solve…

```matlab
>> R = [7 2 1; 2 12 0; 1 0 6]
R =
  7  2  1
  2 12  0
  1  0  6
>> V = [8; 6; 2]
V =
  8
  6
  2
>> I = inv(R) * V
I =
  1.0256
  0.3291
  0.1624
```

Mesh Analysis

• Write equations for $i_1$, $i_2$, $i_3$ and $i$

Practice Circuit Analysis 1

• Find all currents and voltages
• Find all currents and voltages

Practice Circuit Analysis 2
• Find the voltages indicated.

Practice Circuit Analysis 3
• Find all currents and voltages
• Find all currents and voltages

![Circuit Diagram](image1)

Practice Analysis (posted)
• How would we apply the tools learned so far?
  o KCL → Nodal analysis
  o KVL → Mesh analysis
  o Current or voltage divider with $R_{eq}$?

![Circuit Diagram](image2)

Practice Analysis

![Circuit Diagram](image3)

Analysis Tools
• Ohm’s law
• KVL: Kirchhoff’s voltage law
• KCL: Kirchhoff’s current law
• Equivalent resistance
• Current divider
• Voltage divider
• Mesh analysis
• Nodal analysis
• Next important theorem: Thevenin Equivalent Circuit

![Circuit Diagram](image4)
Important Notes
• Read the text book!
  o We have limited in-class time
• Check out the applets link
  o on webpage from the first week of class
• Homework
  o show and develop clear thinking
  o learn from the homework

Lab 3: Linearity
\[ \begin{align*}
3 \Omega & \quad \downarrow i_1 \\
12 \text{V} & \quad + \\
3 \Omega & \quad -
\end{align*} \]

Lab 3: Superposition

Lab 3 Preview
• Design your own lab – for Superposition and Linearity in circuits
• Read the chapter to begin learning these analysis methods
• Use simple circuits from the chapter to get ideas for your circuits, to build and test in the lab
• Pre-lab – design your lab experiment
  o Design it for 1 hour, allow ½ hour for mistakes and learning as you go.