Mesh & Nodal Analysis

EGR 220, Chapter 3
Feb 11, 2020

Overview

• Use Ohm’s Law, KVL & KCL for simultaneous equations with...

• Nodal Analysis
  • One equation per node
  • Solve for node voltages

• Mesh Analysis
  • One equation per loop
  • Solve for loop currents (not necessarily the same as element currents)

Recap Voltage Divider: Series R

• Solve for $v_1$ and $v_2$
  • Think about which resistor will have the larger V drop

Recap Current Divider: Parallel R

• Solve for $i_1$ and $i_2$
  • Think about which R will carry the larger current
Write Expressions for I, using Ohm’s Law & “V\text{drop}”

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.

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

Nodal Analysis

• How do we find \(v_1\), \(v_2\) and power dissipated in the resistors?
Concept Check: Voltage Across

- $v_1$, $v_2$ are voltage values relative to what?
- What is the voltage across the $4\Omega$ 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 (linearity for resistor behavior; superposition of sources)

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*

Mesh Analysis Warmup

- If we draw loop currents to be opposing through \( R_3 \)...
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
```

• Find all currents and voltages

Discussion Circuit Analysis

• How can you find the voltages indicated?
• Compare ability to use nodal analysis vs. mesh analysis.
• How to find the voltages indicated?

Practice Circuit Analysis 2
• Find all currents and voltages

• Find all currents and voltages

Practice Analysis
Practice Analysis

Practice Analysis (posted)

• How would we apply the tools learned so far?
  • KCL $\rightarrow$ Nodal analysis
  • KVL $\rightarrow$ Mesh analysis
  • Current or voltage divider with $R_{eq}$?

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

$\Rightarrow$ Exam 1 Through Mesh & Nodal $\Leftarrow$

• Next core theorem: Thevenin Equivalent Circuit
Important Notes

• Read the textbook!
  • We have limited in-class time
• Check out the applets link
  • on webpage from the first week of class
• Homework
  • show and develop clear thinking
  • learn from the homework

Lab 3: Linearity

Lab 3: Superposition

Lab 3 Preview

• Design your own lab – to verify 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
  • Design it for 1 ¾ hour, allow time for mistakes and learning as you go, in our 2 ½ hour lab time.
Lab 2 Experiments – Find $R_{\text{Multimeter}}$

$R = 10 \text{M} \Omega$

![Circuit Diagram](image1.png)

Agilent multimeter configured as a voltmeter, adding internal resistance $R_i$ to the circuit.

$R = 10 \text{k} \Omega$

![Circuit Diagram](image2.png)

Agilent multimeter configured as a voltmeter, adding internal resistance $R_i$ to the circuit.