Linearity
Superposition
& Source Transformation

EGR 220, Chapter 4
Sept 25, 2018

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

Overview

- Mesh and Nodal review
- Three new analysis techniques, for reducing complexity of circuits
  - Linearity
  - Superposition
  - Source transformation

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
Practice Circuit Analysis 1
• Find all currents and voltages

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Practice Circuit Analysis 2
• Why can’t we use mesh analysis?

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

\[ v_1 \quad 6\Omega \quad v_2 \quad 8V \quad v_3 \quad 12V \quad \]
\[ i \quad \]
\[ 4\Omega \quad \]

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 \( R_{eq} \)?

New theorems:
Linearity
Superposition & Source Transformation

Use linearity to solve for \( i_o \)

• How do we find \( i_o \)?
• What is \( i_o \) if \( V_s \) is 10V?
• What is the power consumed by the load in each situation?
• How do we find $i_o$?
• What is $i_o$ if $V_s$ is 10V?
• What is the power consumed by the load in each situation?

Superposition Warmup

• Could use nodal or mesh analysis
• New technique – **superposition**

Setting Sources = 0

• If a current source = 0A, it acts as a(n):
  1) Short circuit?
  2) Open Circuit?

• If a voltage source = 0V, it acts as a(n):
  1) Short circuit?
  2) Open Circuit?
**Superposition**

- **Voltage divider**

  \[ V_{1R3} = V_1 \left( \frac{(R_2||R_3)}{R_1 + R_2||R_3} \right) \]

  \[ V_{2R3} = V_2 \left( \frac{(R_1|R_3)}{R_2 + R_1||R_3} \right) \]

- Add the result contributed by each source for final value

  \[ V_{R3} = V_{1R3} + V_{2R3} \]

**Superposition**

- **How do we find \( i \) & \( P_{4\Omega} \)?
  - First set \( V_{src} = 0 \)
  - Next set \( I_{src} = 0 \)
  - Since power is not linear, \( 20 \text{ V} \), how do we find it?
Source Transformation & Equivalents

- Voltage $V_{ab}$ and $R_{eq}$ can be measured across any nodes of any device or circuit.
- We are interested in the equivalent $V - I - R$ behavior at the nodes
  - ("sc" = short circuit; "oc" = open circuit)

Source Transformation

- For circuit elements connected across nodes $a$ and $b$, the sources above have identical behavior
  - This means ____________________________
- Caution: maintain polarity of sources

Source Transformation

- Find $i$ in the circuit below
• Find $i$ in the circuit below

Source Transformation
• Find $V_s$ + series-R equivalent circuit:

Example in Homework
• Find $V_o$ using superposition and source transformation
Lab 3: Linearity

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
  - Design it for 1 hour, allow ½ hour for mistakes and learning as you go.

Office Hours?
- Monday:
- Tuesday:
Exam 1

• Next week during lab time, October 3
• All content through Thevenin Equivalent circuits (Thursday’s class)
• Spread yourselves across:
  1. Circuits lab room
  2. Adjoining conference room
  3. Room 146 at end of hall

Summary

• Circuit analysis tools
  o Nodal and mesh analysis, that use...
  o KVL and KCL to get simultaneous equations
  o Ohm’s law to put equations into needed form
  o $R_{eq}$ and voltage/current dividers if they help
• Today
  o Linearity
  o Superposition
  o Source Transformation
• Next class **Thevenin** equivalent
  • READ chapter