Administrivia

- HW #2 is up
- Status on computer accounts?
- A note about lab 3...

Last Time...

- We took a break and studied RC circuits...
- **Do you have questions on RC circuits?**

This Time...

- Thevenin's Theorem
- Prelude to source transforms: Norton's theorem
- An op-amp model

Motivation behind Thevenin's theorem

- Black box concept:

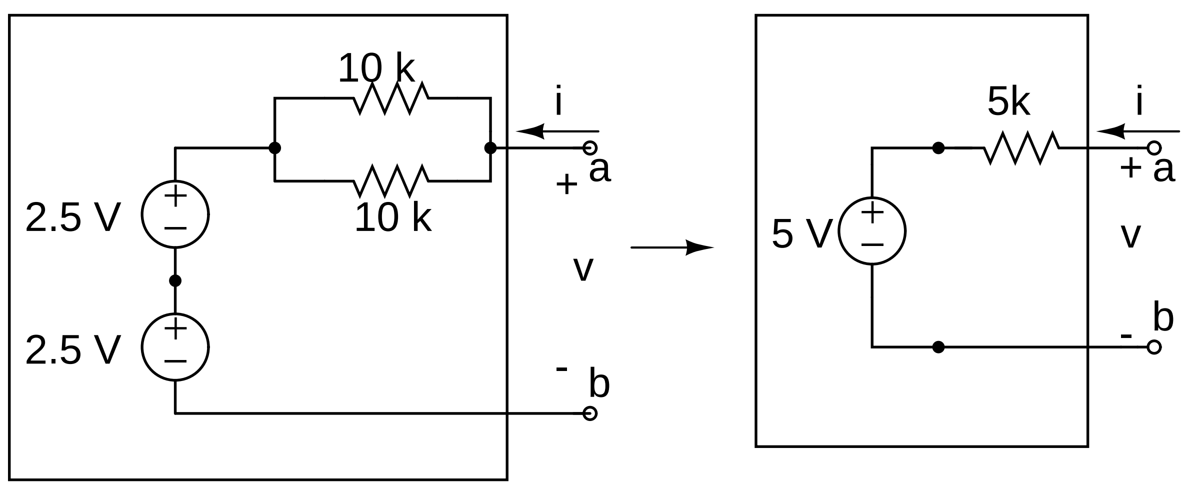


Figure 1. Simplification of circuits

Thevenin's Theorem: version 1

- Goal: Find V_{OC} and R_{TH}
  - If a circuit has only independent sources and resistors:
    - V_{OC}: Find the open-circuit voltage at the terminals of interest
    - I_{SC}: Find short-circuit current at the terminals of interest
    - R_{TH}: $\frac{V_{OC}}{I_{SC}}$
    - Another method to find R_{TH}: Kill all sources and measure equivalent resistance at the terminals of interest.
    - Kill all sources: Replace voltage sources with short circuits and current sources with open circuits.

Some notes about the theorem

- Sign of V_{OC} and I_{SC}
- Have to be careful with dependent sources: an alternative method shown later.

Example 1 (Drill 4.20)

- Find the thevenin equivalent at the terminals a and b for the circuit below.

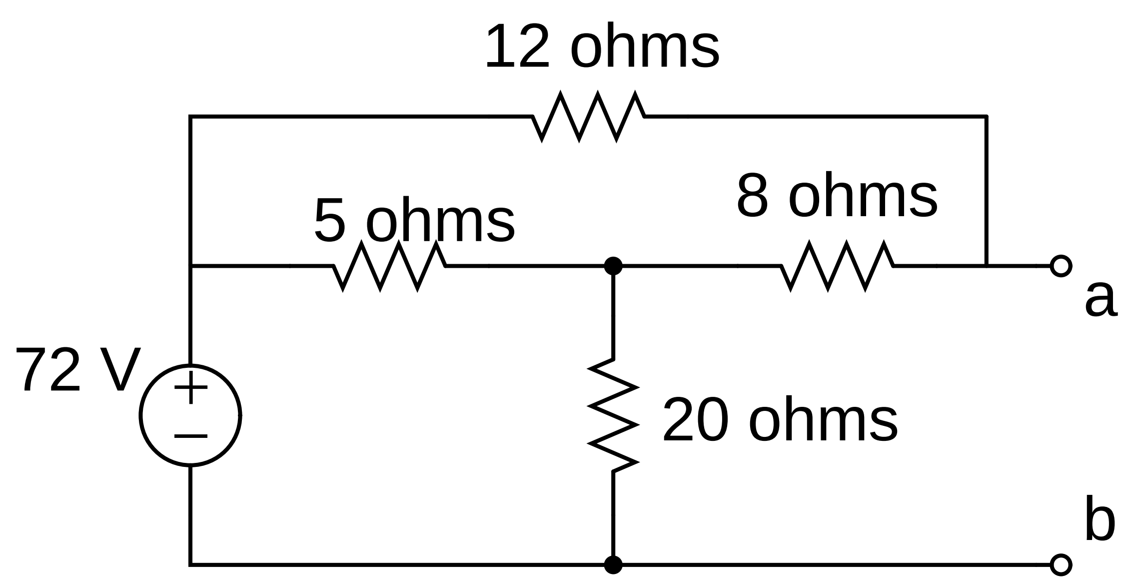


Figure 2. Answer: V_{TH} = 64.8 V and R_{TH} = 6 Ω

A variation on Thevenin's theorem

- If a circuit has dependent and independent sources:
  - Find V_{OC} by finding open-circuit voltage at terminals of interest
  - $R_{TH} = \frac{V_{OC}}{I_{SC}}$
  - However, for R_{TH}, you can also:
    - ∗ Kill all independent sources. Apply a test voltage (V_{TEST}) at the terminals of interest and find test current (I_{TEST}) flowing through the test voltage. $R_{TH} = \frac{V_{TEST}}{I_{TEST}}$.
- If the circuit contains only dependent sources:
  - V_{OC} = ------ and I_{SC} = ------
  - To find R_{TH}, you have to use the test voltage and test current idea.

Example 2

- Find the thevenin equivalent with respect to terminals a,b for the circuit below.

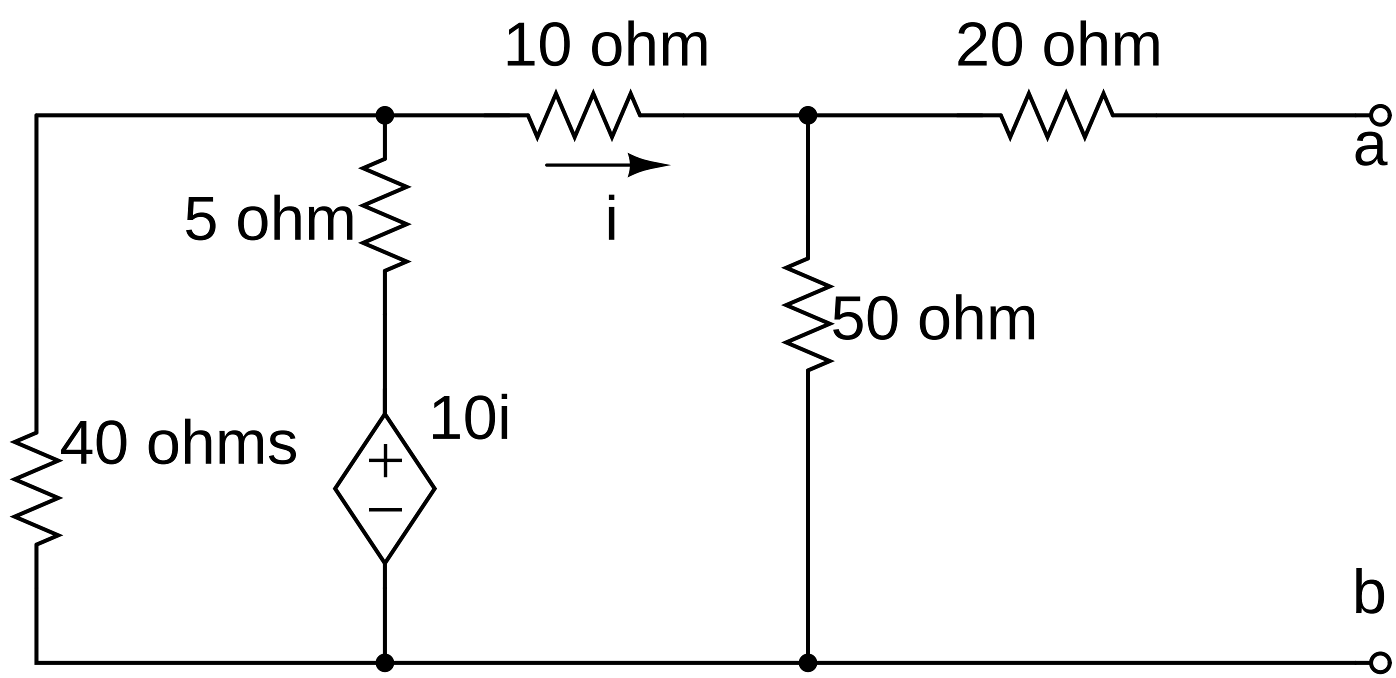


Figure 3. Answer: V_{TH} = ---- R_{TH} = 25 Ω

Example 3

- In the circuit below, switch s1 has been closed for a long time and switch s2 has been closed for a long time. At t=0, switch s1 opens and s2 closes (instantaneously, they are ideal switches). Find v(t) for t $\geq$ 0.

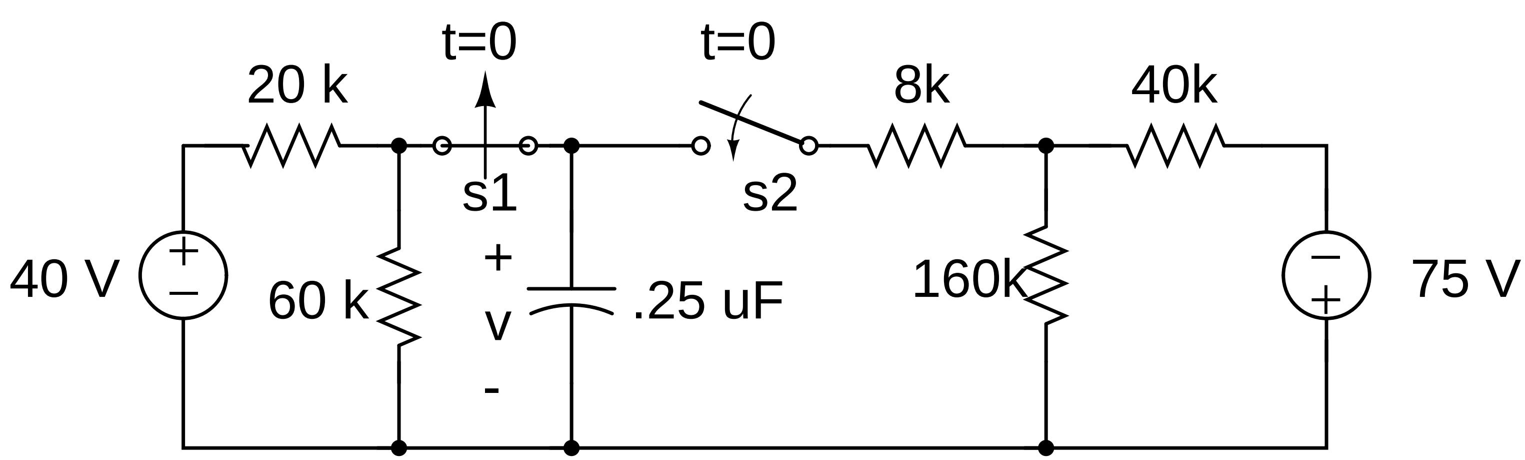


Figure 4. Answer: v(t) = -60 + 90e^{-100t} V, t $\geq$ 0

Summary of Thevenin's theorem

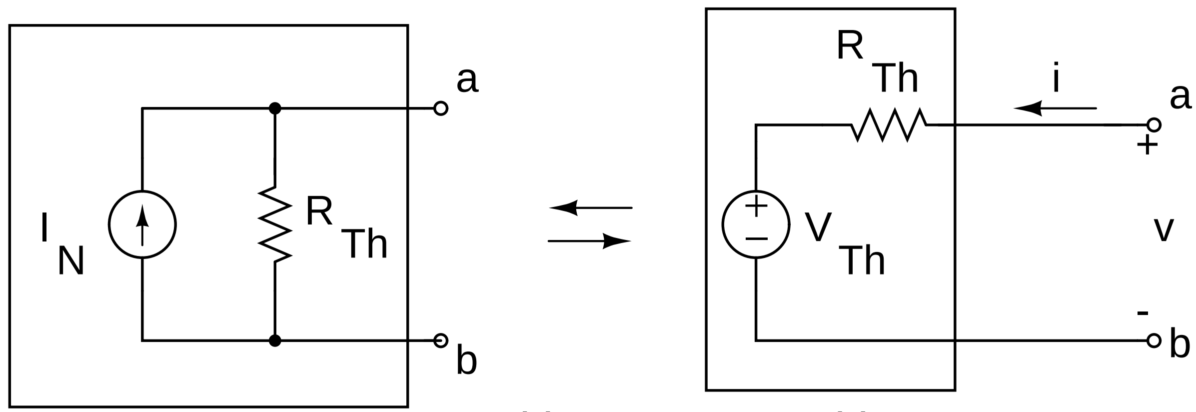
- Goal: Find V_{OC} and R_{TH} at the terminals of interest
  - Circuit with only independent sources and resistors
    - * V_{OC}: Find open-circuit voltage
    - * R_{TH}:
      - · Find short circuit current, I_{SC}. $R_{TH} = \frac{V_{OC}}{I_{SC}}$
      - · Kill all sources and find equivalent resistance

Summary of Thevenin's theorem (contd)

- Circuit with dependent, independent sources and resistors
  - V_{OC}: find open circuit voltage
  - R_{TH}:
    - R_{TH}: $\frac{V_{OC}}{I_{SC}}$
    - Kill all independent sources. The, you can apply a test voltage (V_{TEST}) and measure the test current (I_{TEST}) through it. $R_{TH} = \frac{V_{TEST}}{I_{TEST}}$
- Circuit with only dependent sources and resistors
  - V_{OC} = ----
  - $R_{TH} = \frac{V_{TEST}}{I_{TEST}}$

Norton's theorem

- Related to Ryan Ritterson's post (# 15) in the newsgroup



$$I_{Norton} = I_N = \frac{V_{Thevenin}}{R_{Thevenin}} = \frac{V_{Th}}{R_{Th}}$$

Figure 5. The Norton equivalent

Introduction to the op-amp

- Op-amp: operational amplifier
- History of the op-amp
- Negative feedback of open-loop comparator

Summary

- We studied a very important circuit reduction technique: Thevenin's Theorem
- Worked out som examples.
- Norton's theorem
- Intro to op-amps
- Remember: Practice, practice, practice...

In Conclusion...

- Next time:
  - More op-amps: useful op-amp circuits.
- Reading for Monday: Online notes (up by Friday morning).
- Next week's lectures (6, 7 and 8) up by weekend: print lecture notes, homeworks etc from lecture 6 onwards
- Have a good long weekend!
- Questions?