ECE 201, Section 3
Lecture 12

Prof. Peter Bermel

September 17, 2012

Exam #1: Thursday, Sep. 20 6:30-7:30 pm

- Most of you will be in WTHR 200, unless told otherwise
- Review session tonight at 8 pm (MATH 175) – will go over posted Review Exam #1
- Posted answers to 3 sample exams on Blackboard to help you study
- I'll have office hours 12:30-1:30 pm MWF in EE 331A and by appointment

Exam #1 Key Concepts

- Basic concepts: current, voltage, charge, Ohm’s law, KCL, KVL, current & voltage division
- Combining resistors in series and parallel
- Resistor networks: node, supernode, loop analysis
- Source transformation

Basic Concepts

- Current *I* represents the flow of charge:

$$I = \frac{dq}{dt}$$

- Voltage *V* creates potential energy *U* for charges:

$$U = qV$$

- Power dissipated (passive sign convention):

$$P = IV$$

- Ohm's Law for resistors:

$$V = IR$$

Basic Concepts: Kirchoff's Laws

Kirchoff's Current Law (KCL)

– Sum of all currents entering a node or Gaussian surface is zero at all times:

$$\sum_{k=1}^{N} I_k(t) = 0\,, \text{for all t}$$

Kirchoff's Voltage Law (KVL)

– Voltage drop between any two nodes is direction-dependent and path-independent (i.e., $V_{AB} = V_A - V_B$)

– Sum of voltage drops over any closed loop is zero

Voltage and Current Division in Resistors; Resistor Networks

- Series resistors:

$$R_{eq} = \sum R_l$$

$$V_k = VR_k/R_{eq}; \text{ currents equal}$$

- Parallel resistors

$$G_{eq} = \sum G_l$$

$$I_k = IR_{eq}/R_k; \text{ voltages equal}$$

- Series-parallel circuits
  - Analyzed iteratively

Resistor Network Analysis Approaches

- **Nodal analysis**
- Modified nodal analysis
- Nodal analysis with floating voltage sources
- **Loop analysis**
- All approaches should generally yield the same physical results
- Best choice generally involves least number of unknowns, and will depend on details of problem

Formula Sheet for Exam 1

$I=dQ/dt$

$V=IR$ or $I=GV$

$R=1/G$

In series:

$R_{eq}=\Sigma_k R_k$

$V_k=VR_k/R_{eq}$

In parallel:

$G_{eq}=\Sigma_k G_k$

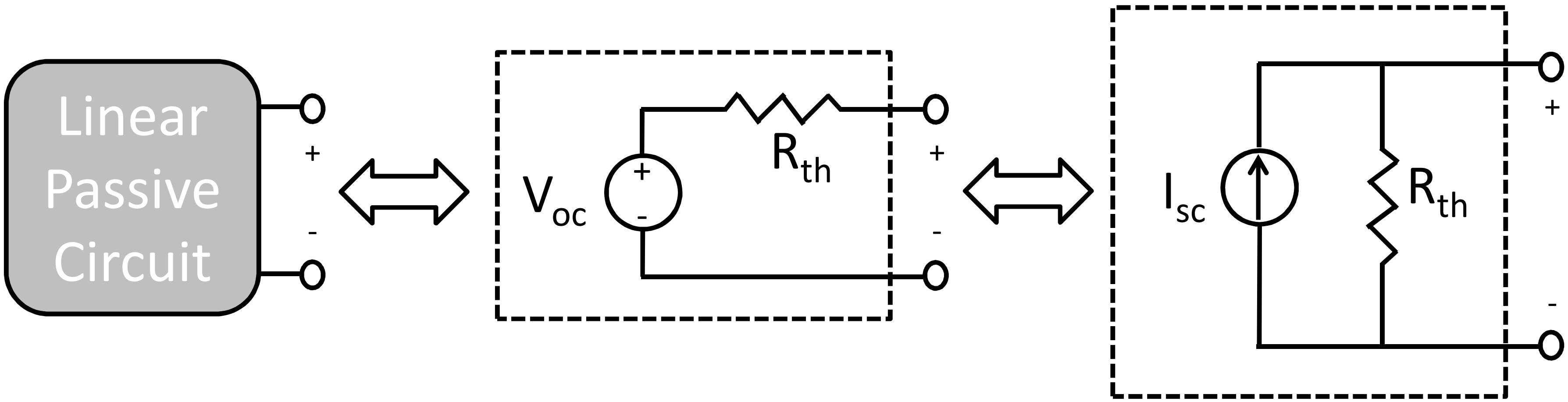
$I_k=V/R_k=IR_{eq}/R_k$

$P=IV$

Test-Taking Strategies

- Preparing for the exam:
  - Review relevant notes (especially these)
  - Practice exams (time at least one)
  - Previous exams from this semester
- Read each question carefully and figure out exactly what to calculate; no ‘trick’ questions
- Time management:
  - No more than 4 minutes per question until all done
  - Guess among plausible options, if needed
  - Take 30 sec break if feeling stressed

Thevenin and Norton Circuits



Thévenin
equivalent circuit

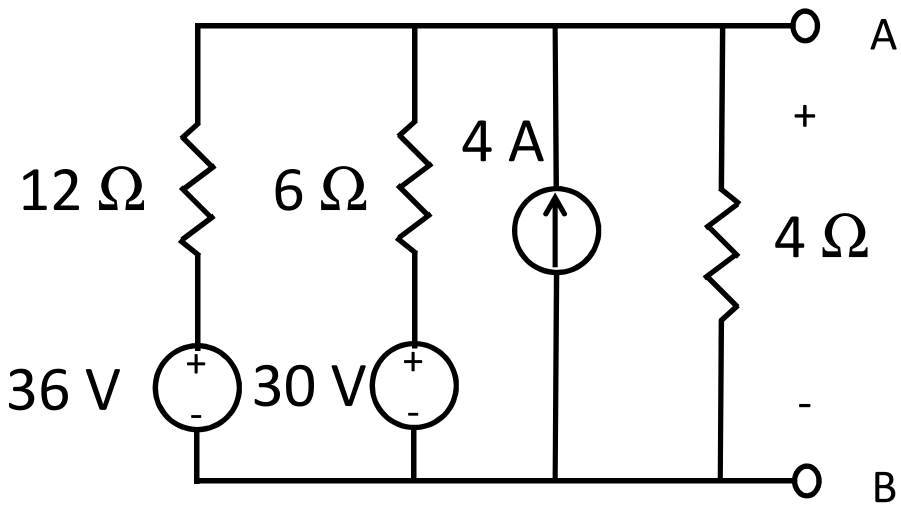
Norton
equivalent circuit

Equivalent circuits related by:

$$V_{oc} = I_{sc}R_{th}$$

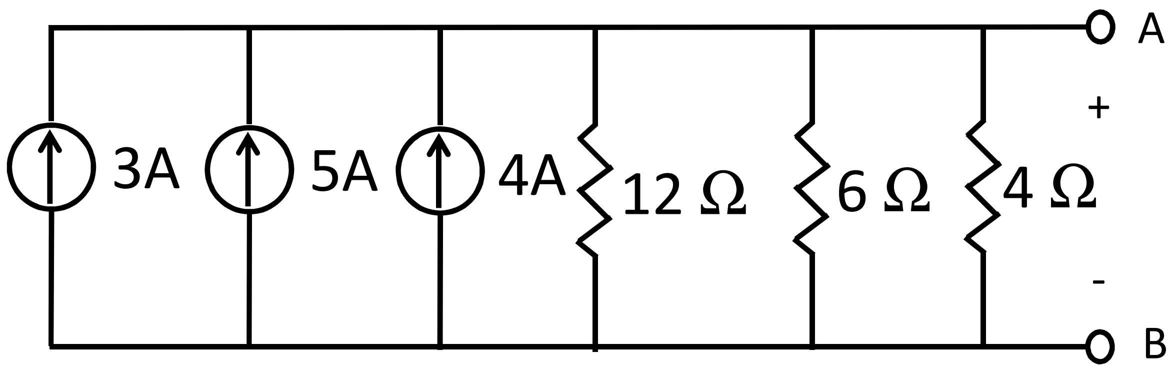
Example 1

- For this network:
  - What is the Thévenin equivalent circuit?
  - What is the Norton equivalent circuit?



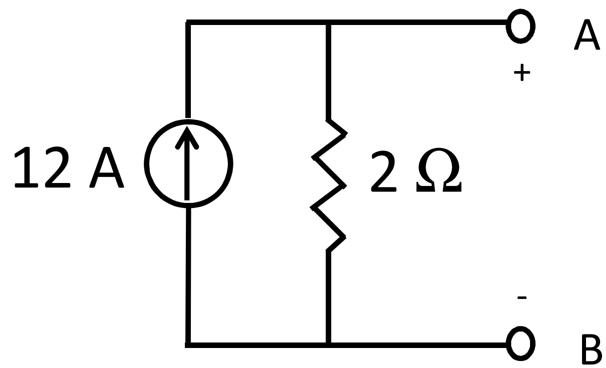
Solution

- Use source transformation theorem to write this equivalent circuit:

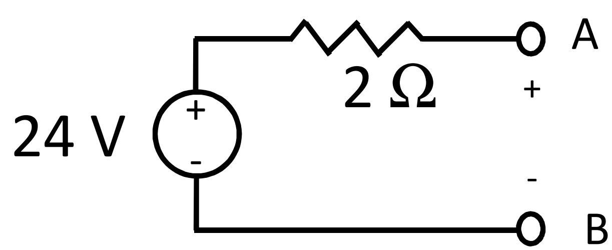


Solution

- Combine resistors and current sources in parallel to obtain Norton equivalent:

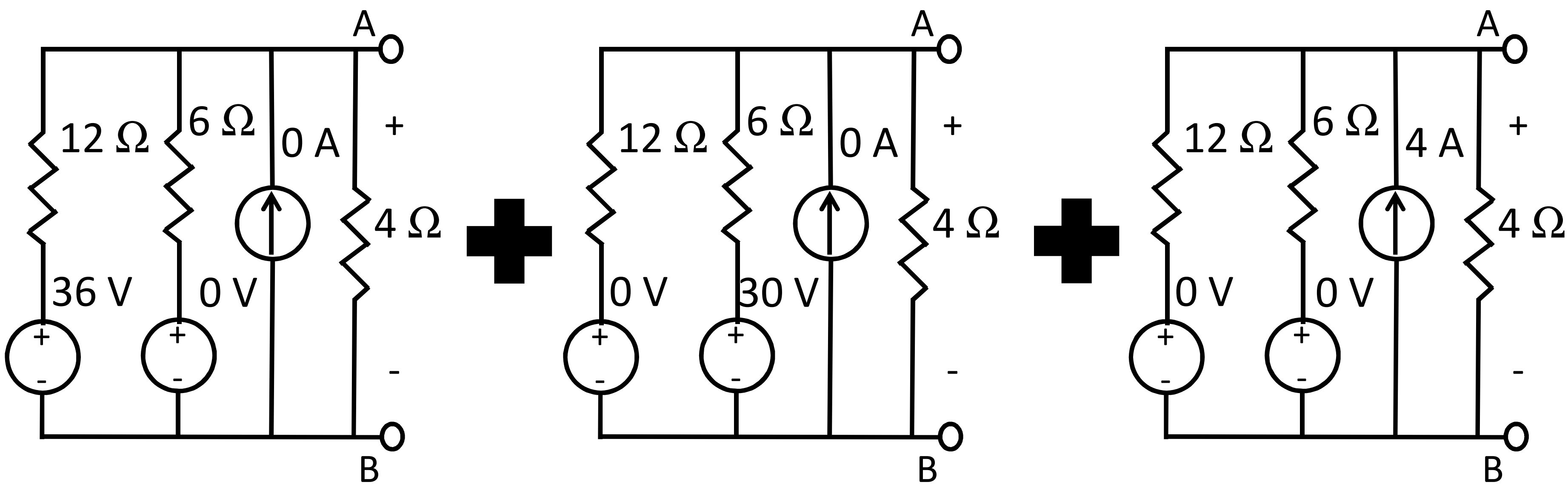


- Transform into Thévenin equivalent:



Alternate Solution

- Use superposition to obtain:
  - Open circuit voltage from individual contributions



$$\Delta V_{oc} = \frac{12/5}{12/5+12} \cdot 36\ V$$

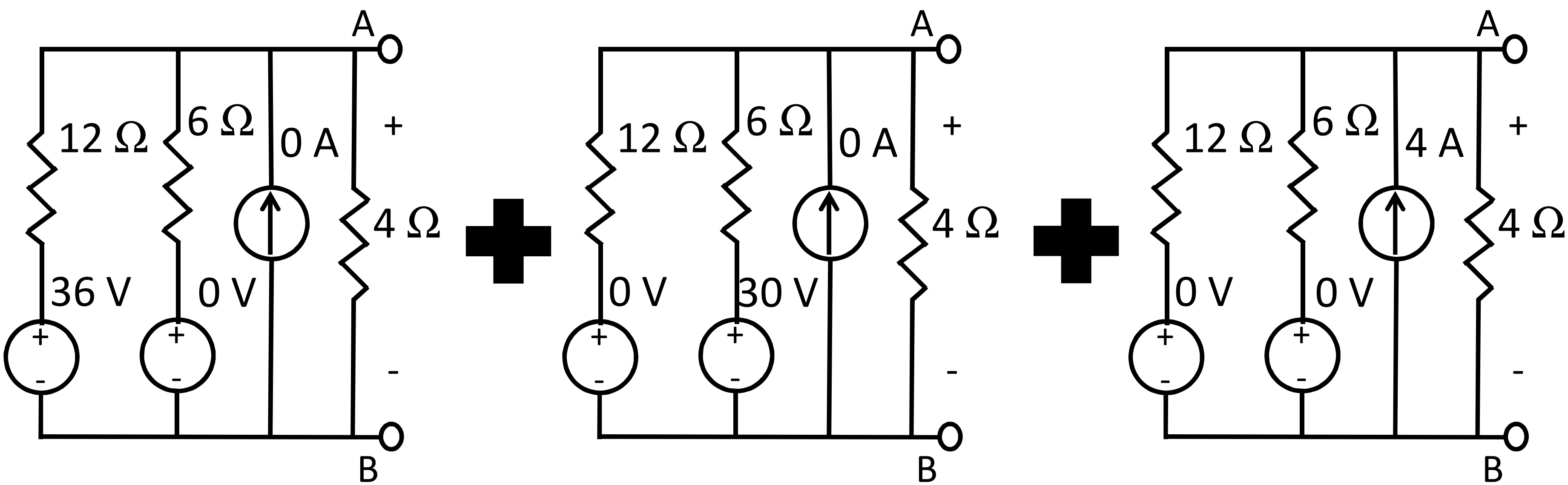
$$\Delta V_{oc} = \frac{3}{3+6} \cdot 30\ V$$

$$\Delta V_{oc} = \left(\frac{1}{12}+\frac{1}{6}+\frac{1}{4}\right)^{-1} \cdot 4\ A$$

V_{oc}=6 + 10 + 8 V=24 V yields Thévenin equivalent voltage

Alternate Solution

- Use superposition to obtain:
  - Short circuit current from individual contributions

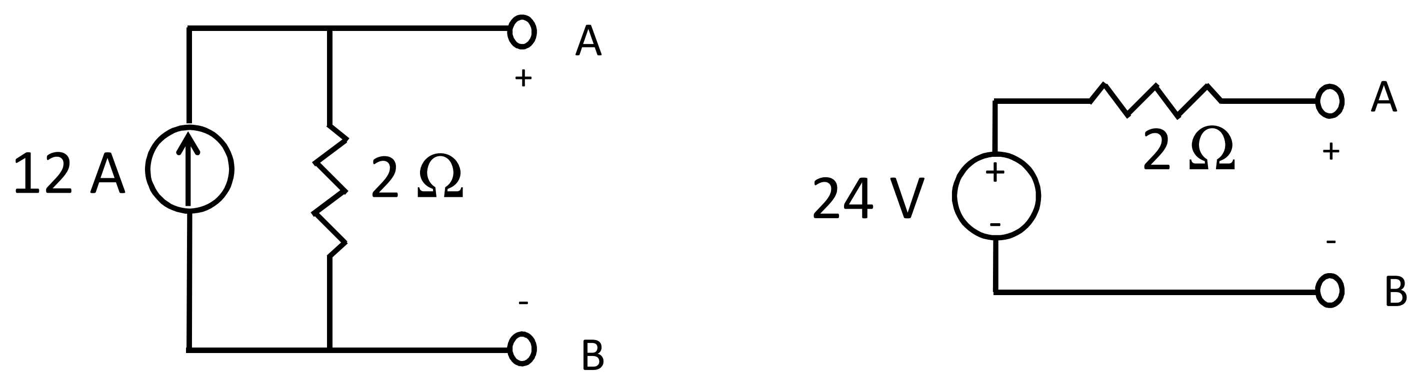


$$\Delta I_{sc} = \frac{1}{12\ \Omega} \cdot 36\ V \qquad \Delta I_{sc} = \frac{1}{6\ \Omega} \cdot 30\ V \qquad \Delta I_{sc} = 4\ A$$

I_{sc}=3 + 5 + 4 A = 12 A yields Norton equivalent current

Alternate Solution

- Take quotient of Thévenin voltage and Norton current yields R_{th}=2 Ω and the following equivalent circuits:

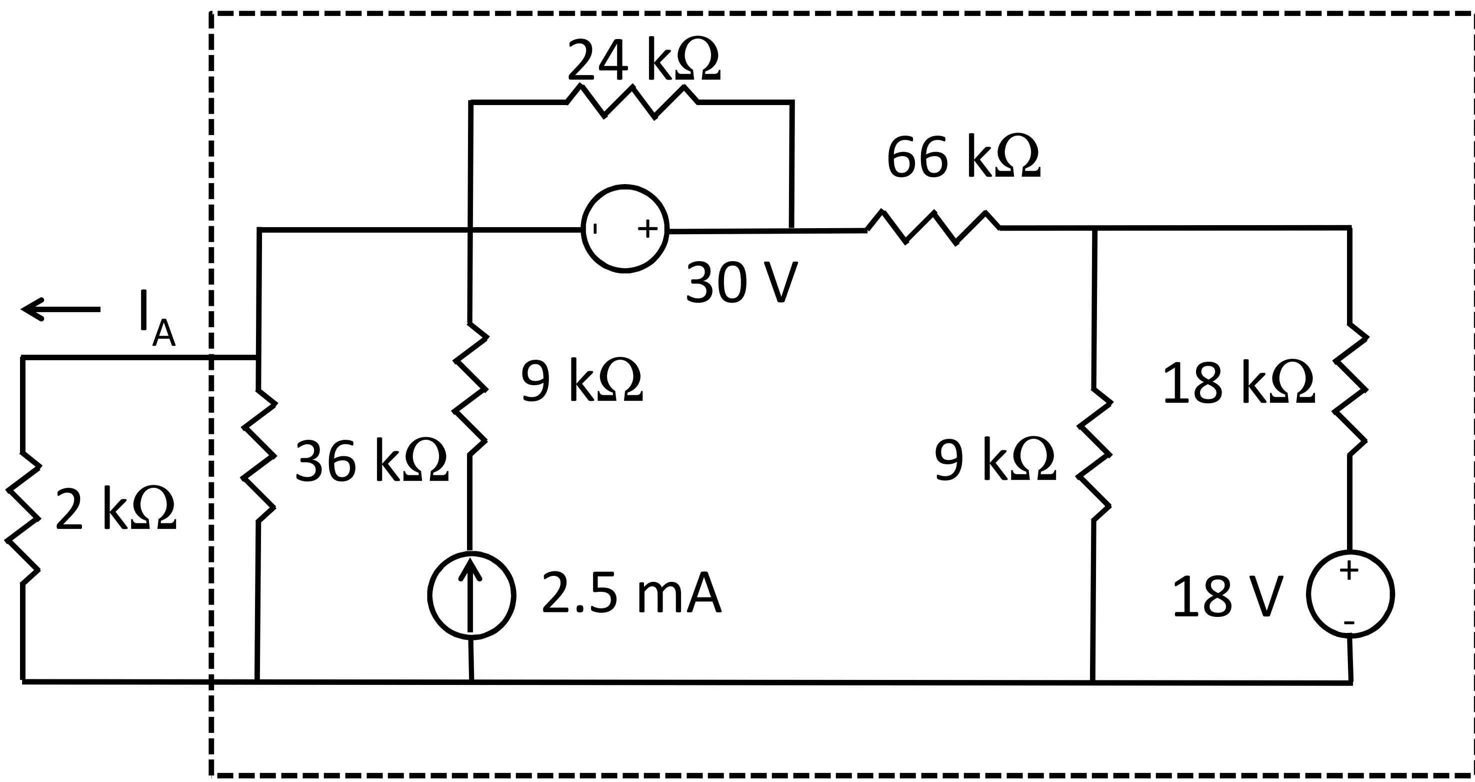


Equivalencies for Complex Circuits

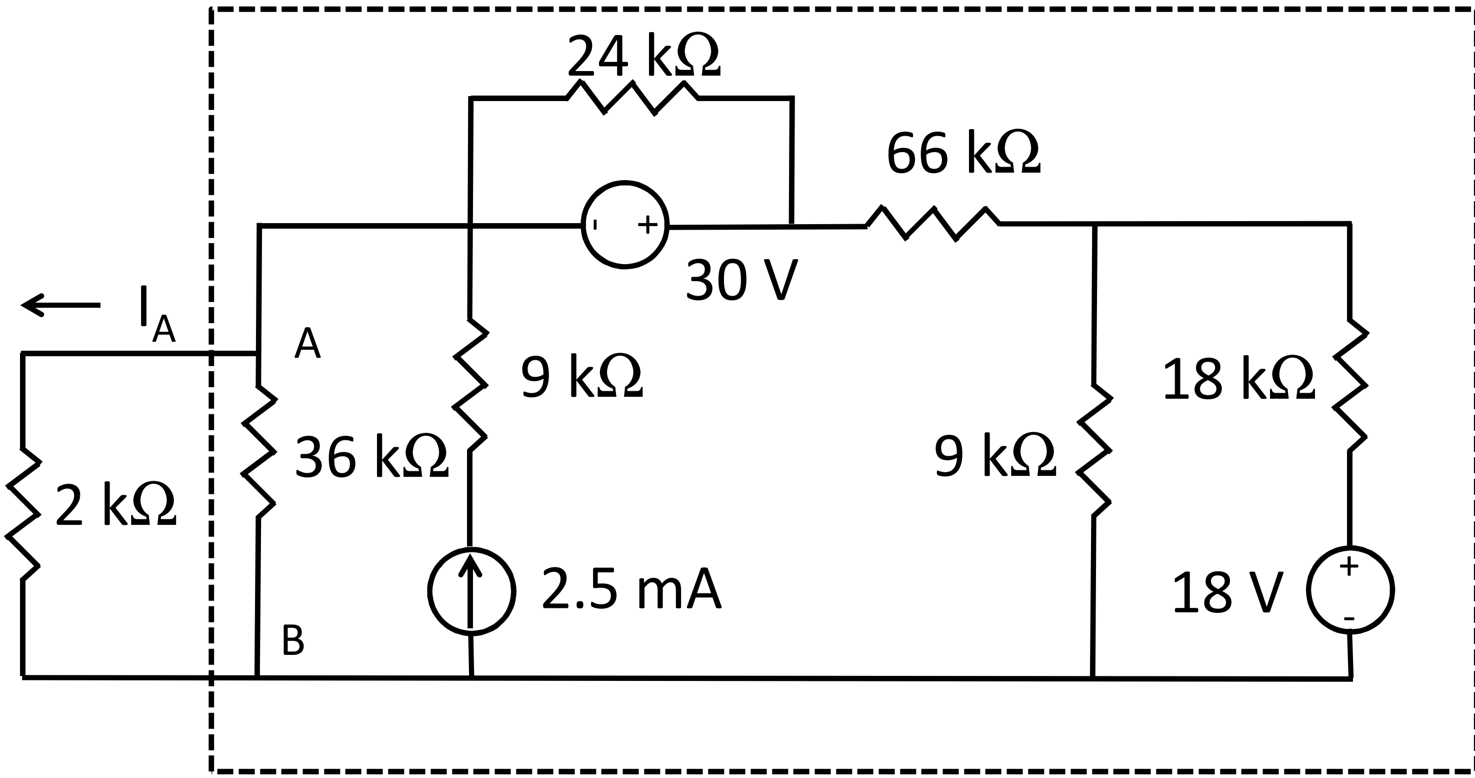
- Thevenin theorem → general 2-terminal linear network obeying $V_{AB} = \rho I_A + \nu$ must have $R_{th}=\rho$, $V_{oc}=\nu$
- Norton theorem → general 2-terminal linear network following $I_A = \gamma V_{AB} - \sigma$ must have $G_{th}=\gamma$, $I_{sc}=\sigma$

Example 2

(a) Find the Thévenin equivalent of the circuit below
(b) Find the output current and power at the load

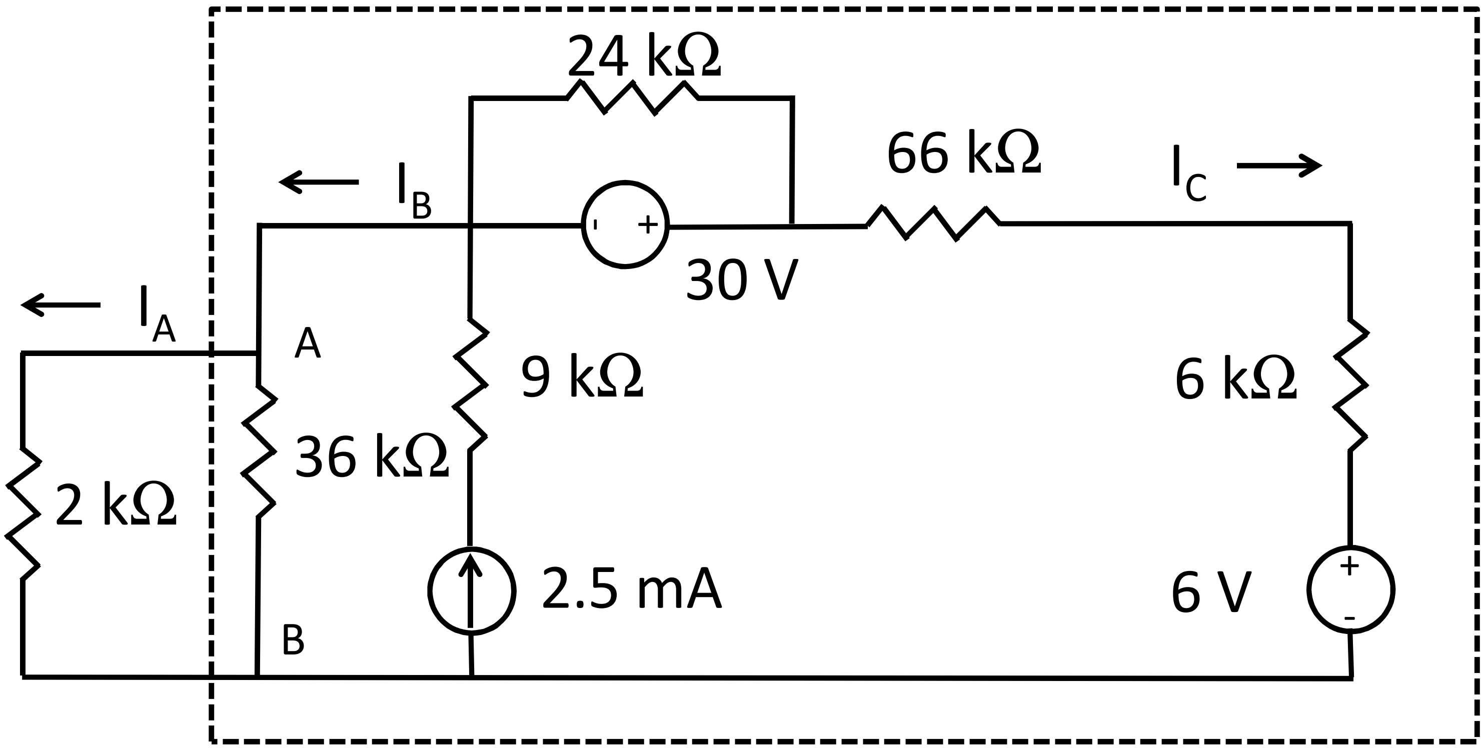


Solution



$$R_R = \left(\frac{1}{9} + \frac{1}{18}\right)^{-1} = 6\ \text{k}\Omega;\ I = 1\ \text{mA};\ \text{V=6 V}$$

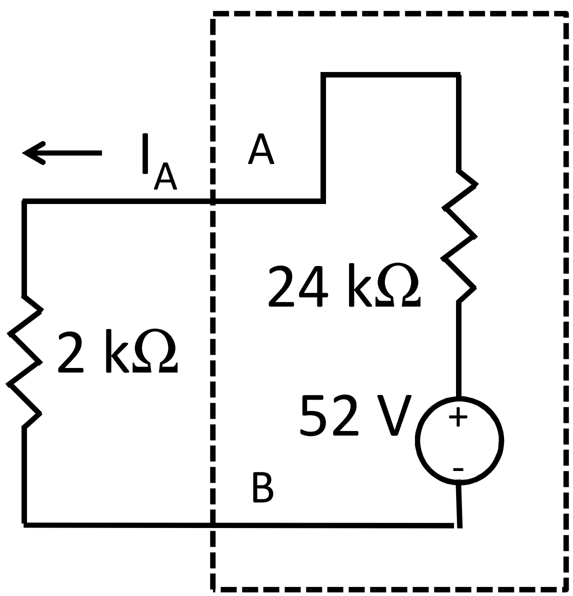
Solution



$$R_{th} = \left(\frac{1}{72} + \frac{1}{36}\right)^{-1} = 24\ \text{k}\Omega$$

$$I_B + I_C = 2.5\ \text{mA};\ 36 I_B = V';\ (66+6) I_C = 30 - 6 + V'$$

Solution



$$R_{th} = \left(\frac{1}{72} + \frac{1}{36}\right)^{-1} = 24\ \mathrm{k}\Omega$$

$$I_B = 13/9\ \mathrm{mA};\ V_{oc} = 52\ V;\ I_A = 2\ \mathrm{mA};\ P_A = 8\ \mathrm{mW}$$

Homework

- HW #11 due today by 4:30 pm in EE 325B
- HW #12 due Fri.: DeCarlo & Lin, Chapter 6:
  - Problem 3
  - Problem 6
  - Problem 8(a),(b)