Announcements:

1. Next quiz will be due on Monday next week
2. Next HW will be due on Wednesday next week
3. Graded midterms are being scanned today; available for pickup Wednesday from TAs

EECS 70A: Network Analysis

Lecture 7

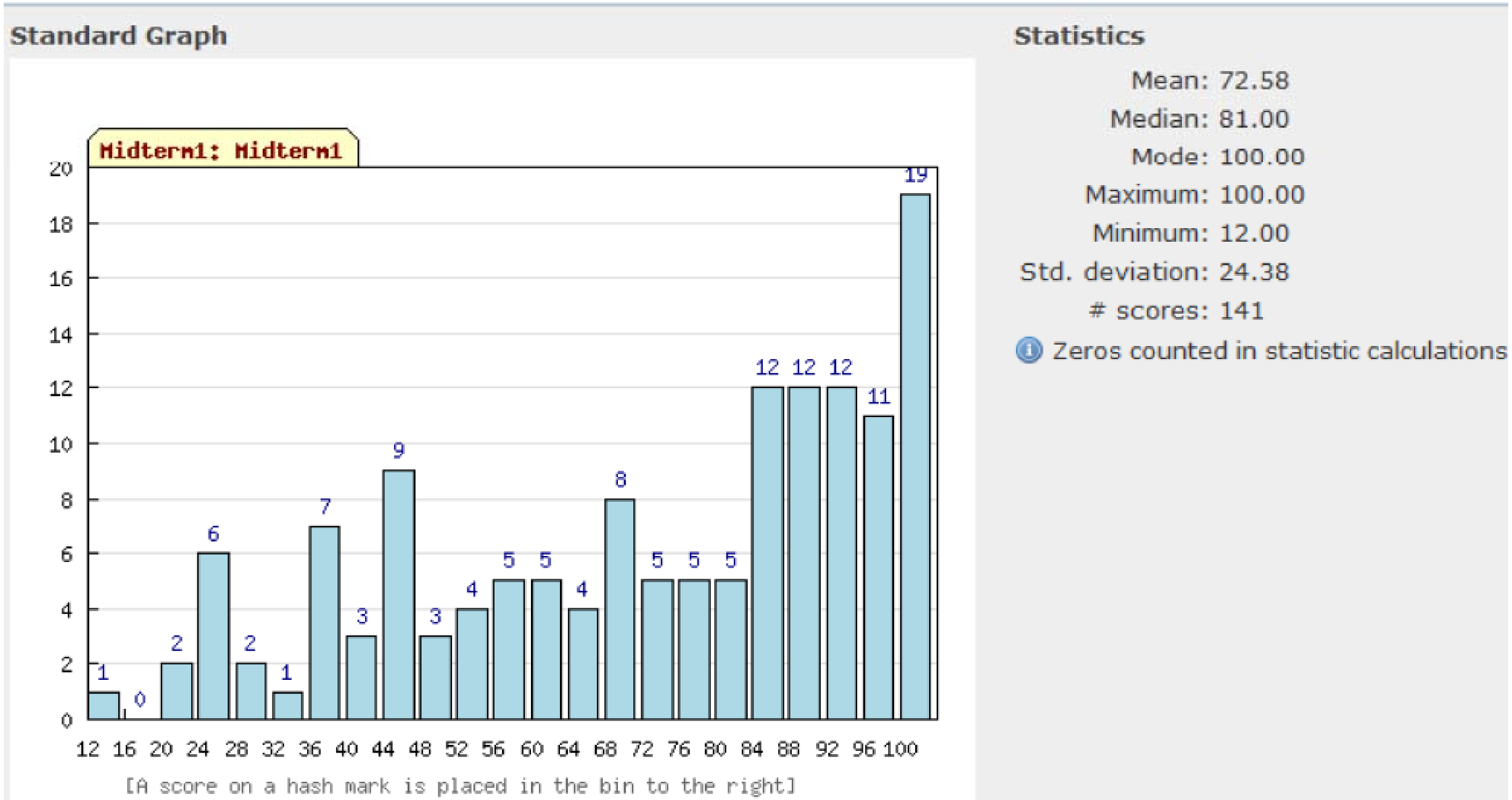
Today's Agenda

- TLTC Midterm Student Feedback Survey
- Midterm 1 results
- Review of Nodal Analysis
- Review of Mesh Analysis
- Example problems using both techniques
- Thevinin/Norton theorem

TLTC Midterm Feedback Survey

- The good:
  - Recorded lectures
  - online notes/tablet pc
- To improve:
  - Need more complex examples in class
- To drop:
  - Demos

Midterm results



Detailed solutions posted online. Please make sure you understand them!

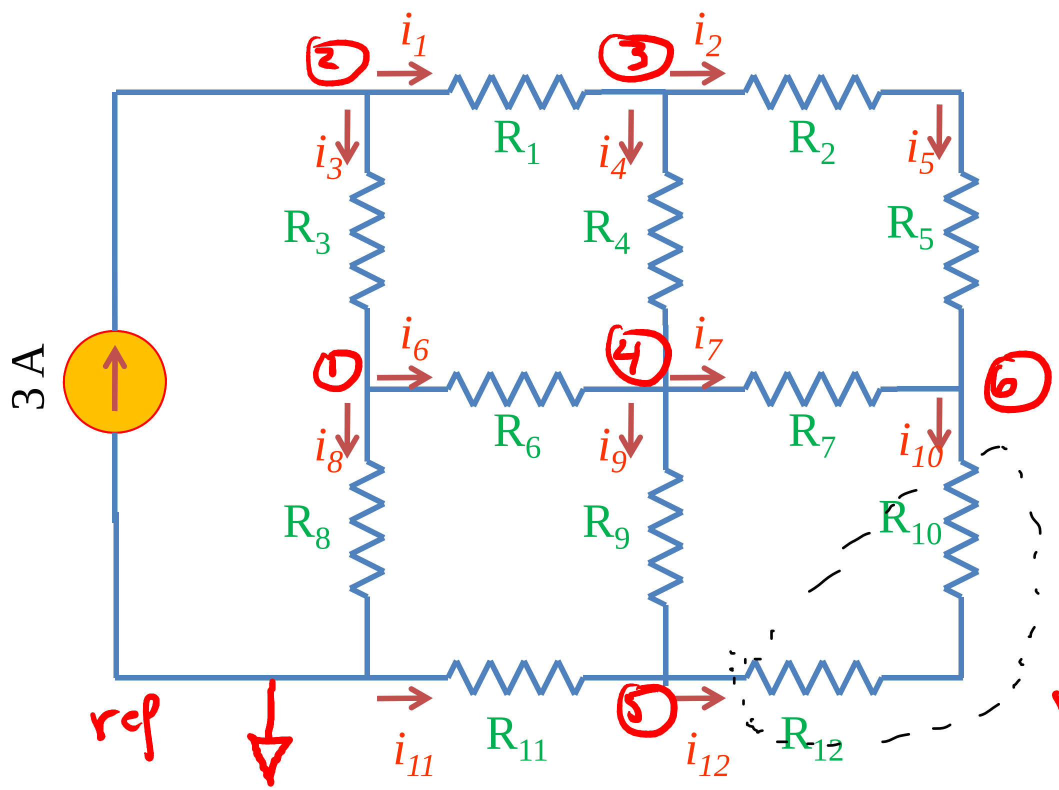
Nodal analysis summary

1. Define reference node
2. Label remaining nodes (e.g. V_1, V_2, V_3, …)
3. Apply KCL + Ohm's law
4. Solve for nodal voltages (e.g. using Kramer's rule)
5. Solve for currents

Nodal analysis example

1. Define a reference node.
2. Label remaining nodes.
3. Apply KCL + ohm.

$G_1 = \frac{1}{R_1}$, $G_2 = \frac{1}{R_2}$ etc



6 variables

$V_1 \; V_2 \; V_3 \; V_4 \; V_5 \; V_6$

Need 6 eqns.

$i_{11} + i_9 = i_{12}$

$\frac{0 - V_5}{R_{11}} + \frac{V_4 - V_5}{R_9} = \frac{V_5 - V_6}{R_{12} + R_{10}}$

(1) $i_3 = i_6 + i_8$

$i_8 + i_6 - i_3 = 0$

$\frac{V_1 - 0}{R_8} + \frac{V_1 - V_4}{R_6} - \frac{V_2 - V_1}{R_3} = 0$

$V_1\left(\frac{1}{R_8} + \frac{1}{R_3} + \frac{1}{R_6}\right) + V_4\left(-\frac{1}{R_6}\right) + V_2\left(-\frac{1}{R_3}\right) = 0$

(1) $V_1(G_8 + G_3 + G_6) + V_4(-G_6) + V_2(-G_3) = 0$

Typical notation:

i_1 is current through R_1. (Same as before)

V_1 is voltage of node 1 relative to reference node. (Different from before)

We will do this entire problem in class…

Using these techniques, you can attempt the "monster problem" as extra credit on HW3…

$$(G_0+G_3+G_6)V_1 + (-G_3)V_2 + (0)V_3 + (-G_6)V_4 + (0)V_5 + (0)V_6 = (0)$$

$$(-G_3)V_1 + (G_1+G_3)V_2 + (-G_1)V_3 + (0)V_4 + (0)V_5 + (0)V_6 = (3)$$

$$(0)V_1 + (-G_1)V_2 + (G_1+G_4)V_3 + (-G_4)V_4 + (0)V_5 + (-G_5)V_6 = (0)$$

$$(G_6)V_1 + (0)V_2 + (G_4)V_3 + (-G_4-G_6-G_7-G_9)V_4 + (G_9)V_5 + (G_7)V_6 = (0)$$

$$(0)V_1 + (0)V_2 + (0)V_3 + (-G_9)V_4 + (G_{10}+G_{12}+G_9+G_4)V_5 + (-G_{10}-G_{12})V_6 = (0)$$

WRONG   WRONG

$$(0)V_1 + (0)V_2 + \left(\frac{G_2\cdot G_5}{G_2+G_5}\right)V_3 + (G_7)V_4 + \left(\frac{G_{12}G_{10}}{G_{12}+G_{10}}\right)V_5 + \left(-\frac{G_2G_5}{G_2+G_5} - \frac{G_{12}G_{10}}{G_{12}+G_{10}} - G_7\right)V_6 = (0)$$

$$V_1 = \frac{|N_1|}{|D|} \qquad V_2 = \frac{|N_2|}{|D|}$$

$$V_1 = \frac{|N_1|}{|D|} \qquad G_{23} \equiv \frac{G_2 + G_3}{G_2 G_3} \qquad G_{12\,10}^{-1} \equiv \frac{G_{12} + G_{10}}{G_{10} G_{12}}$$

$$|N_1| = \begin{vmatrix} 0 & -G_2 & 0 & -G_6 & 0 & 0 \\ 3 & G_1 + G_3 & -G_1 & 0 & 0 & 0 \\ 0 & -G_1 & G_1 + G_4 & -G_4 & 0 & -G_5 \\ 0 & 0 & G_4 & -(**) & G_9 & G_7 \\ 0 & 0 & 0 & -G_9 & (***) & G_{10}G_{12} \\ 0 & 0 & G_{23} & G_7 & G_{12\,10} & (*4) \end{vmatrix}$$

(: same)

$$D = \begin{vmatrix} G_0 + G_3 + G_6 & \cdot & \cdot & \cdot & \cdot & \cdot \\ -G_3 & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \\ G_6 & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix}$$

$$V_1 = \frac{|N_1|}{|D|} \qquad G_{23} \equiv \frac{G_2 + G_3}{G_2 G_3} \qquad G_{12\,10}^{-1} \equiv \frac{G_{12} + G_{10}}{G_{10} G_{12}}$$

$$|N_1| = \begin{vmatrix} 0 & -G_2 & 0 & -G_6 & 0 & 0 \\ 3 & G_1 + G_3 & -G_1 & 0 & 0 & 0 \\ 0 & -G_1 & G_1 + G_4 & -G_4 & 0 & -G_5 \\ 0 & 0 & G_4 & -(**) & G_9 & G_7 \\ 0 & 0 & 0 & -G_9 & (***) & G_{10} G_{12} \\ 0 & 0 & G_{23} & G_7 & G_{12\,10} & (*4) \end{vmatrix}$$

(∴ same)

$$D = \begin{vmatrix} G_0 + G_3 + G_6 & \cdot & \cdot & \cdot & \cdot & \cdot \\ -G_3 & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \\ G_6 & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot \end{vmatrix}$$

$$
\left|\begin{array}{c|ccccc}
0 & -G_2 & 0 & -G_6 & 0 & 0 \\
3 & G_1+G_3 & -G_1 & 0 & 0 & 0 \\
0 & -G_1 & G_1+G_4 & -G_4 & 0 & -G_5 \\
0 & 0 & G_4 & -(**) & G_9 & G_7 \\
0 & 0 & 0 & -G_9 & (***) & G_{10}G_{12} \\
0 & 0 & G_{23} & G_7 & G_{12\,10} & (*4)
\end{array}\right| =
$$

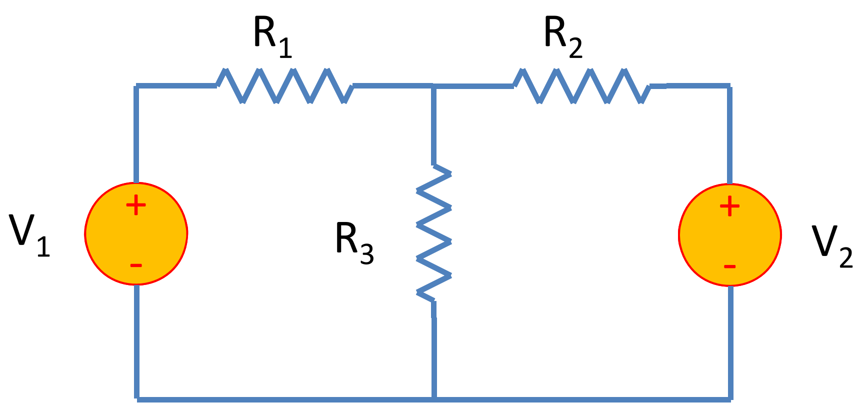
$$
0\,|\quad| - 3\,|M_3| + 0\,|\quad| - 0\,|\quad| + 0\,|\quad| - 0\,|\quad|
$$

$$
= -3 \left|\begin{array}{ccccc}
-G_2 & 0 & -G_6 & 0 & 0 \\
-G_1 & G_1+G_4 & & & \\
0 & G_4 & & \cdots & \\
0 & 0 & & & \\
0 & G_{22} & & &
\end{array}\right|
$$

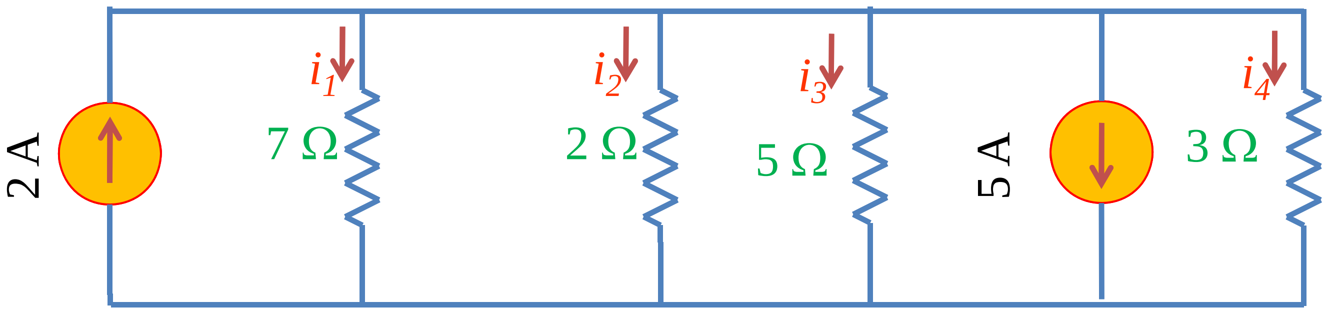
Mesh analysis summary

1. Assign mesh currents i_1, i_2, … i_n
2. Apply KVL to each mesh
3. Solve for mesh currents (e.g. using Kramer’s rule)
4. Then solve for voltages

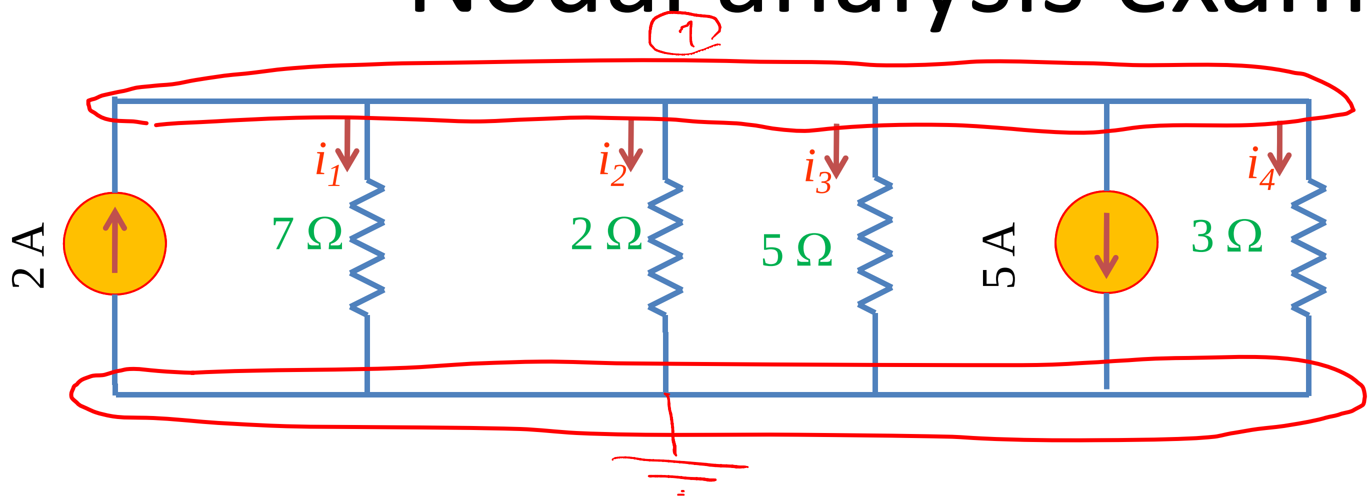
Assigning mesh currents



Nodal vs. mesh analysis?



Nodal analysis example



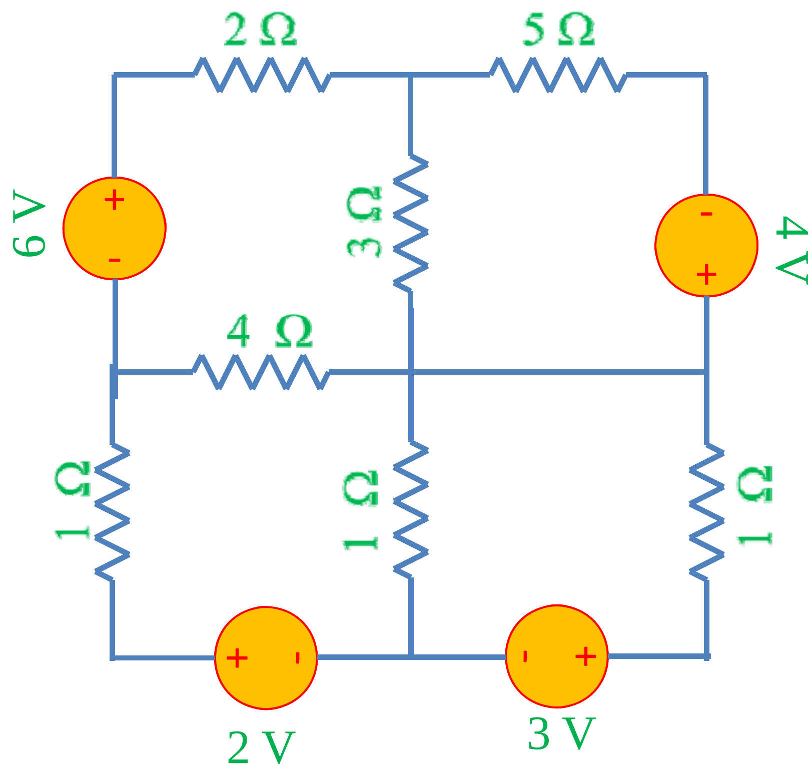
KCL : $i_1 + i_2 + i_3 + i_4 + 5A - 2A = 0$

$$\frac{V_1}{7} + \frac{V_1}{2} + \frac{V_1}{5} + \frac{V_1}{3} + 5 - 2 = 0$$

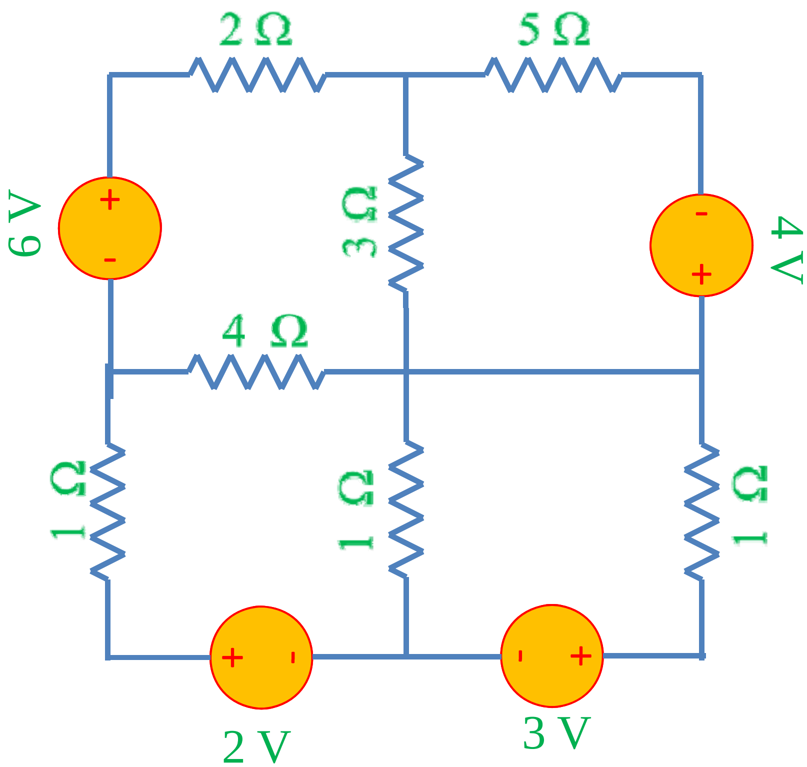
$$V_1 \left(\frac{1}{7} + \frac{1}{2} + \frac{1}{5} + \frac{1}{3} \right) = -3$$

$$V_1 = -2.5\,V$$

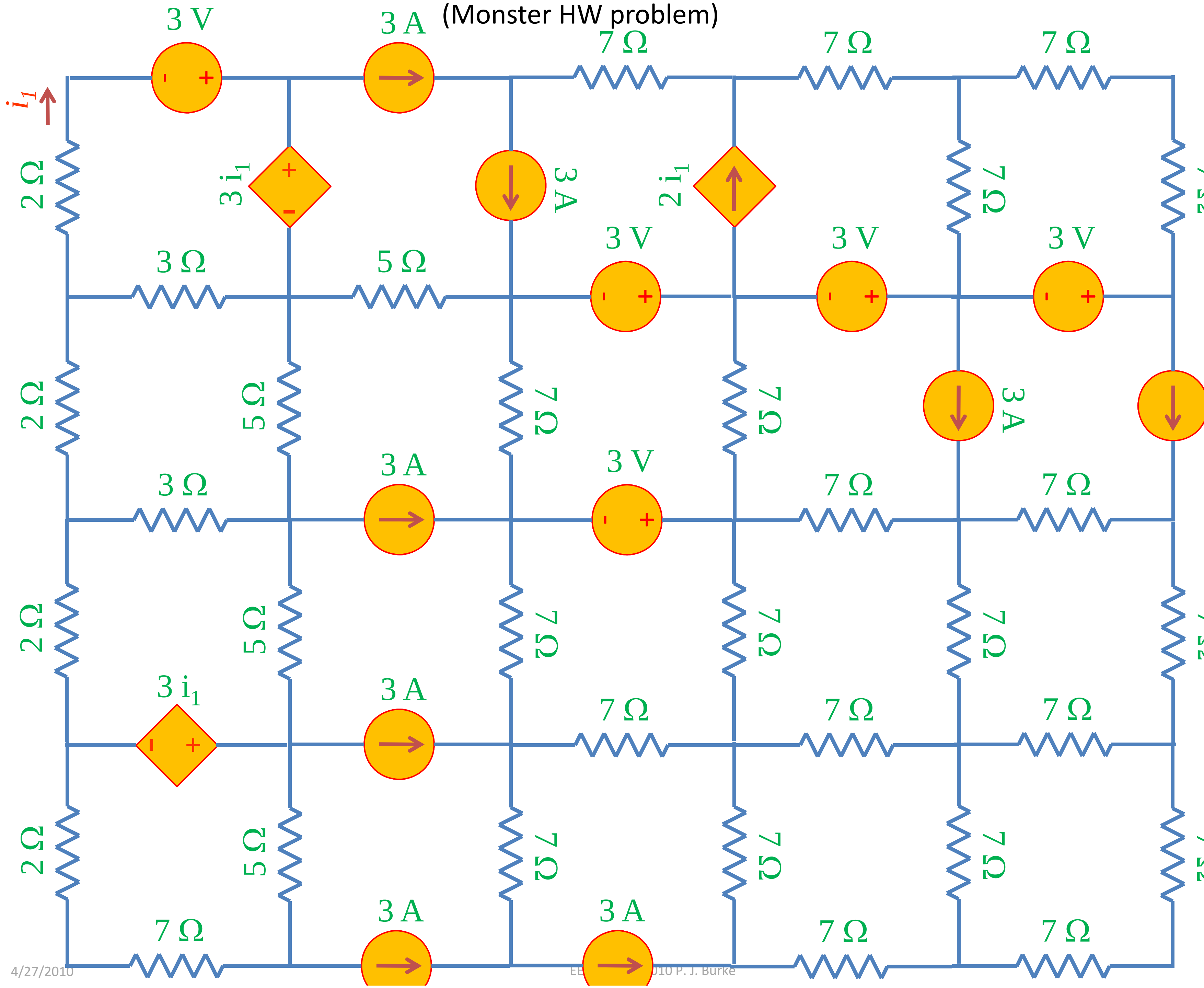
Nodal vs. Mesh Analysis

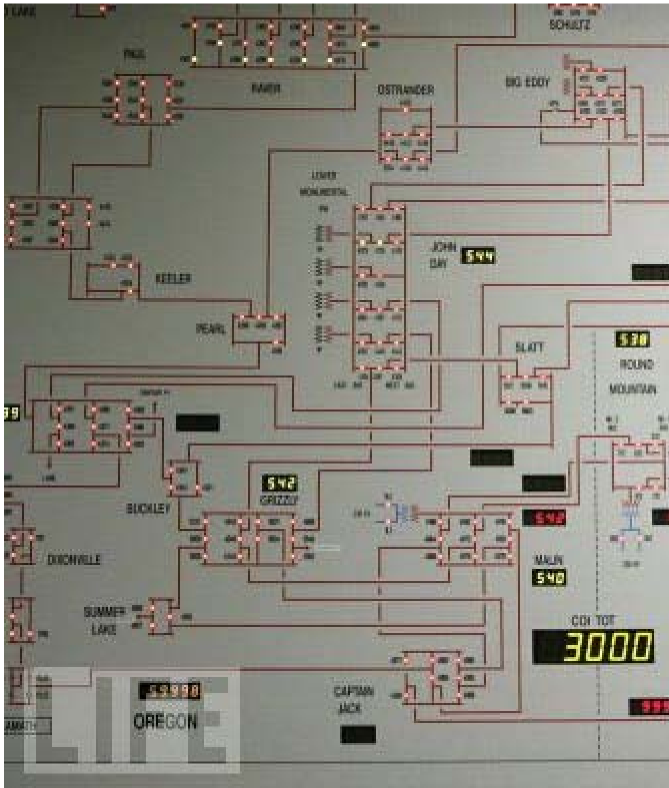


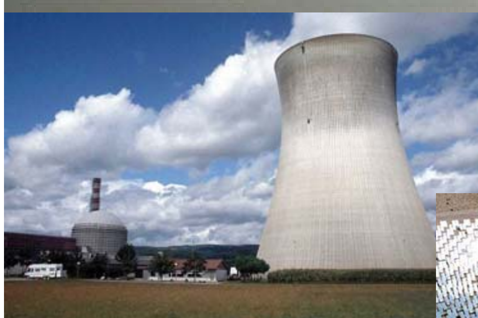
Nodal vs. Mesh Analysis

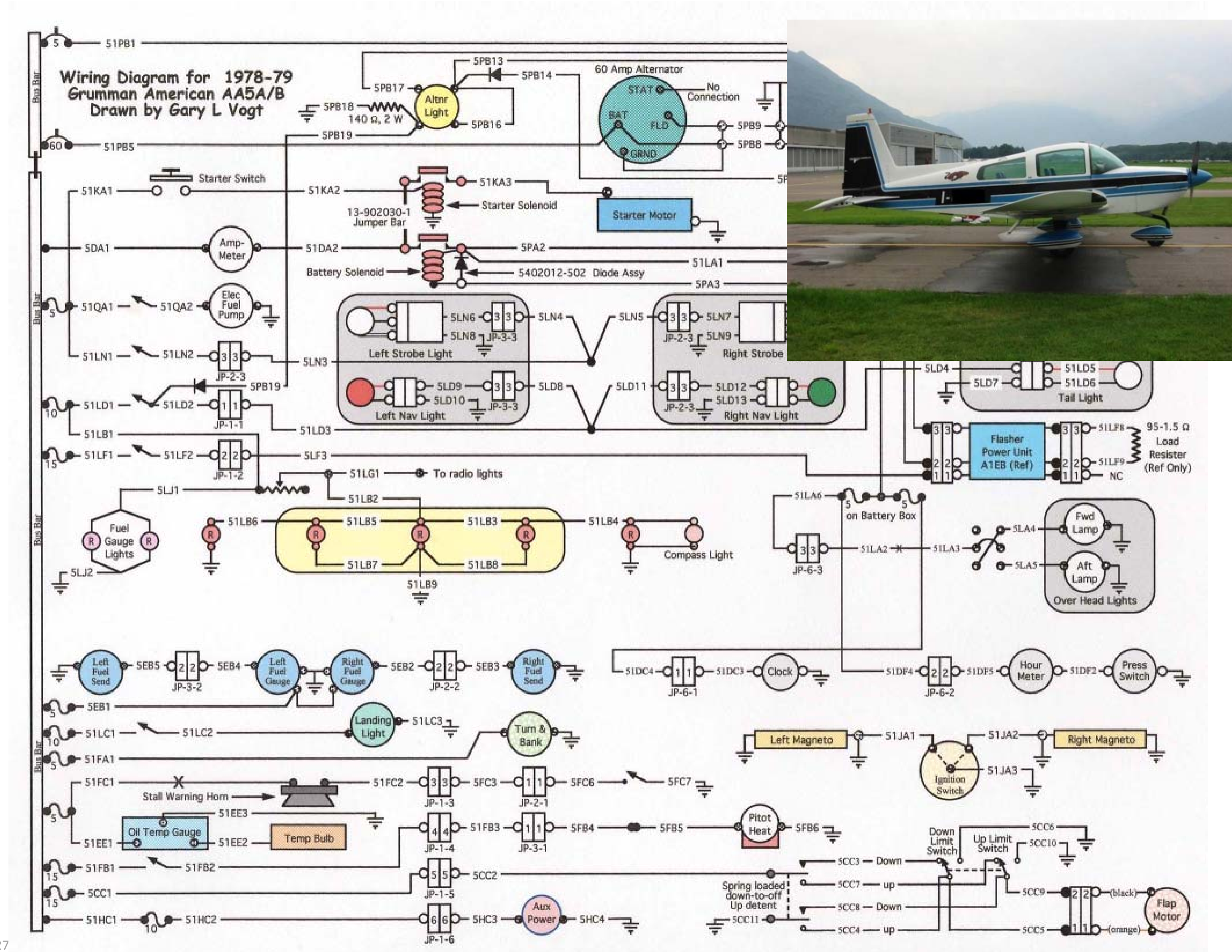


(Monster HW problem)



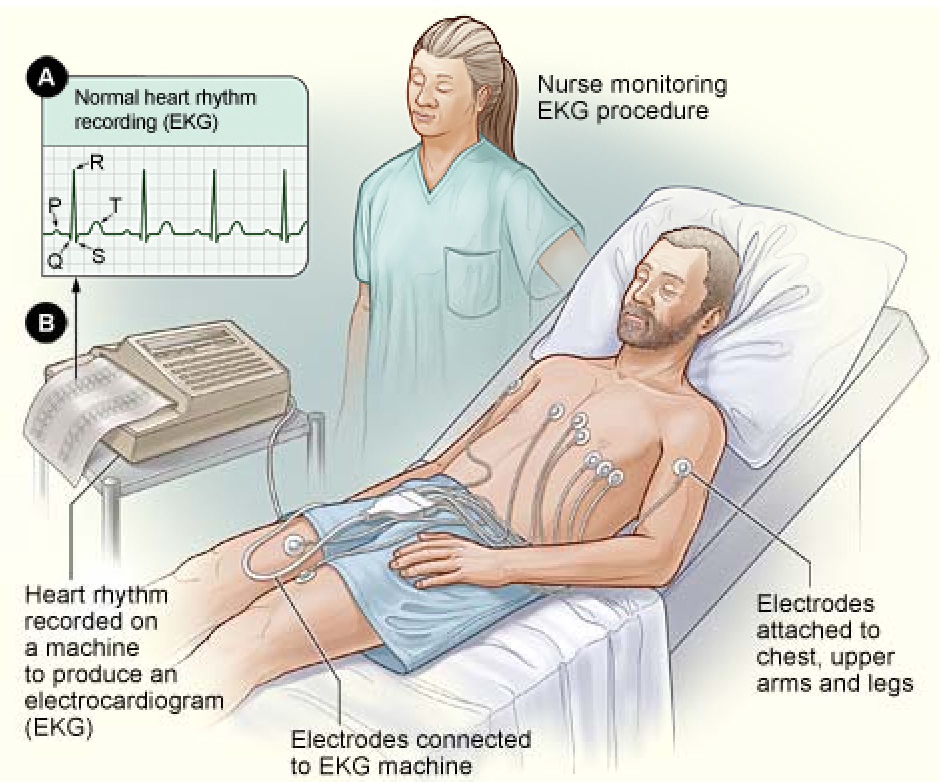

SCHULTZ
VANTAGE
HANFORD
OSTRANDER
BIG EDDY
ASHE
McNARY
JOHN DAY
KEELER
PEARL
SLATT
ROUND MOUNTAIN
152
TRACY
GRIZZLY
BUCKLEY
DIXONVILLE
MALIN
SUMMER LAKE
3000
CAPTAIN JACK
OREGON
LIFE



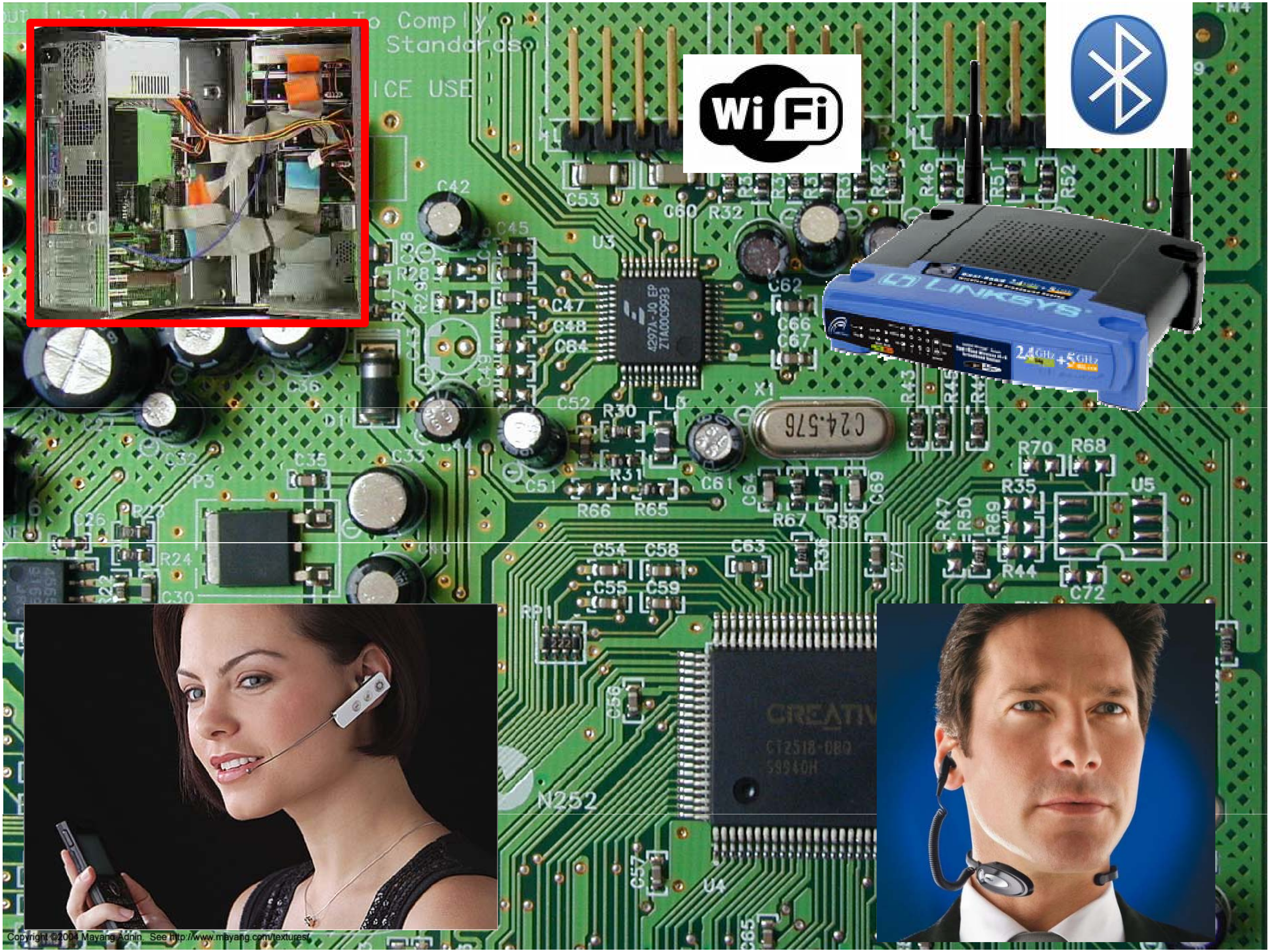


Wiring Diagram for 1978-79
Grumman American AA5A/B
Drawn by Gary L Vogt
Bus Bar
51PB1
51PB5
5PB13
5PB14
5PB17
5PB18
140 Ω, 2 W
Altnr Light
5PB16
5PB19
60 Amp Alternator
STAT
BAT
FLD
GRND
No Connection
5PB9
5PB8
Starter Switch
51KA1
51KA2
51KA3
13-902030-1 Jumper Bar
Starter Solenoid
Starter Motor
5DA1
Amp-Meter
51DA2
5PA2
51LA1
Battery Solenoid
5402012-502 Diode Assy
5PA3
51QA1
51QA2
Elec Fuel Pump
5LN6
5LN8
JP-3-3
5LN4
5LN5
5LN7
JP-2-3
5LN9
Left Strobe Light
Right Strobe
51LN1
51LN2
JP-2-3
5LN3
5PB19
5LD9
5LD10
5LD8
5LD11
5LD12
5LD13
Left Nav Light
Right Nav Light
5LD4
5LD7
51LD5
51LD6
Tail Light
51LD1
51LD2
JP-1-1
51LD3
51LB1
51LF1
51LF2
JP-1-2
5LF3
Flasher Power Unit A1EB (Ref)
51LF8
51LF9
NC
95-1.5 Ω Load Resister (Ref Only)
51LG1
To radio lights
51LB2
5LJ1
Fuel Gauge Lights
5LJ2
51LB6
51LB5
51LB3
51LB4
51LB7
51LB8
51LB9
Compass Light
51LA6
on Battery Box
JP-6-3
51LA2
51LA3
5LA4
5LA5
Fwd Lamp
Aft Lamp
Over Head Lights
Left Fuel Send
5EB5
JP-3-2
5EB4
Left Fuel Gauge
Right Fuel Gauge
5EB2
JP-2-2
5EB3
Right Fuel Send
51DC4
JP-6-1
51DC3
Clock
51DF4
JP-6-2
51DF5
Hour Meter
51DF2
Press Switch
5EB1
51LC1
51LC2
Landing Light
51LC3
Turn & Bank
51FA1
Left Magneto
51JA1
51JA2
Right Magneto
51JA3
Ignition Switch
51FC1
Stall Warning Horn
51FC2
JP-1-3
5FC3
JP-2-1
5FC6
5FC7
51EE3
Oil Temp Gauge
51EE1
51EE2
Temp Bulb
JP-1-4
51FB3
JP-3-1
5FB4
5FB5
Pitot Heat
5FB6
Down Limit Switch
Up Limit Switch
5CC6
5CC10
51FB1
51FB2
5CC2
JP-1-5
5CC1
5CC3 — Down
5CC7 — up
5CC8 — Down
5CC4 — up
Spring loaded down-to-off Up detent
5CC11
5CC9
5CC5
(black)
(orange)
Flap Motor
51HC1
51HC2
JP-1-6
5HC3
Aux Power
5HC4

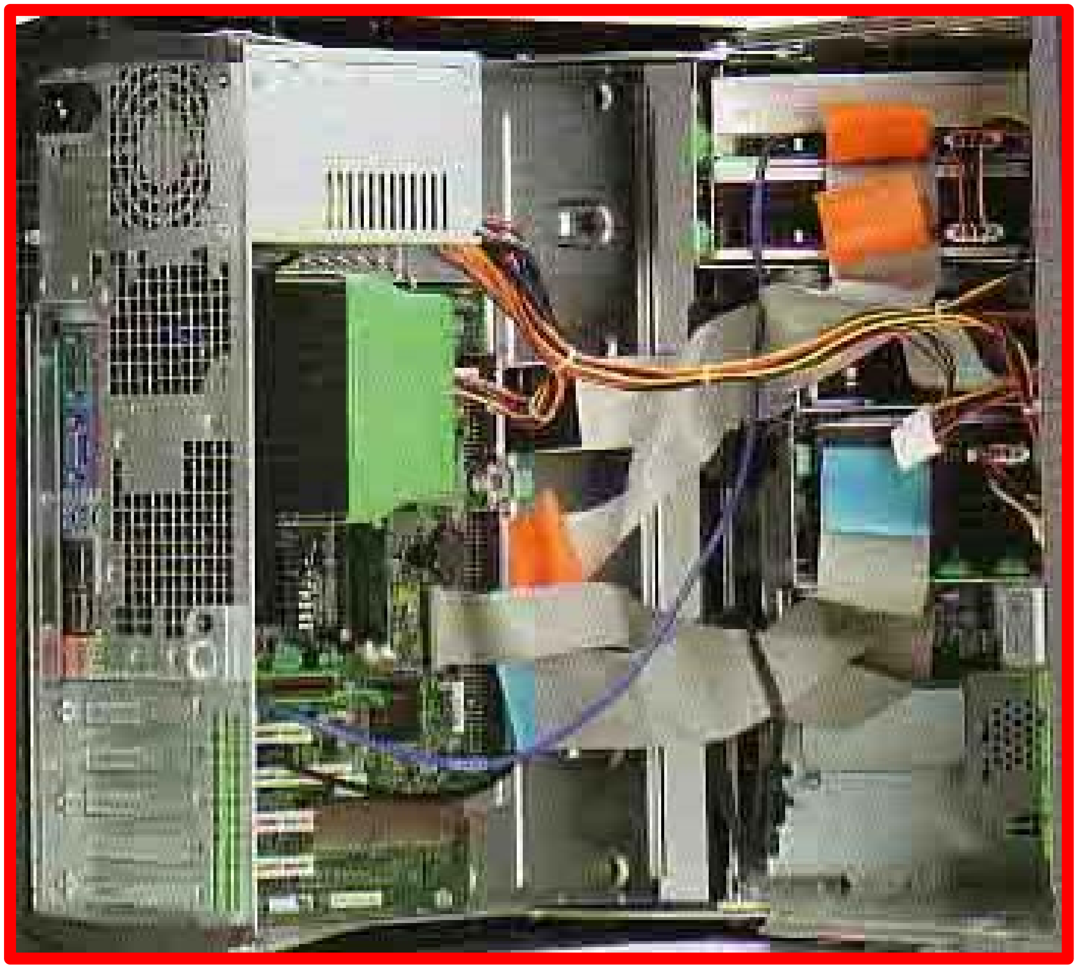

A380
AIRBUS
AIRLINERS.NET


A
Normal heart rhythm recording (EKG)
R
P
T
Q
S
B
Nurse monitoring EKG procedure
Heart rhythm recorded on a machine to produce an electrocardiogram (EKG)
Electrodes connected to EKG machine
Electrodes attached to chest, upper arms and legs


Sold Out

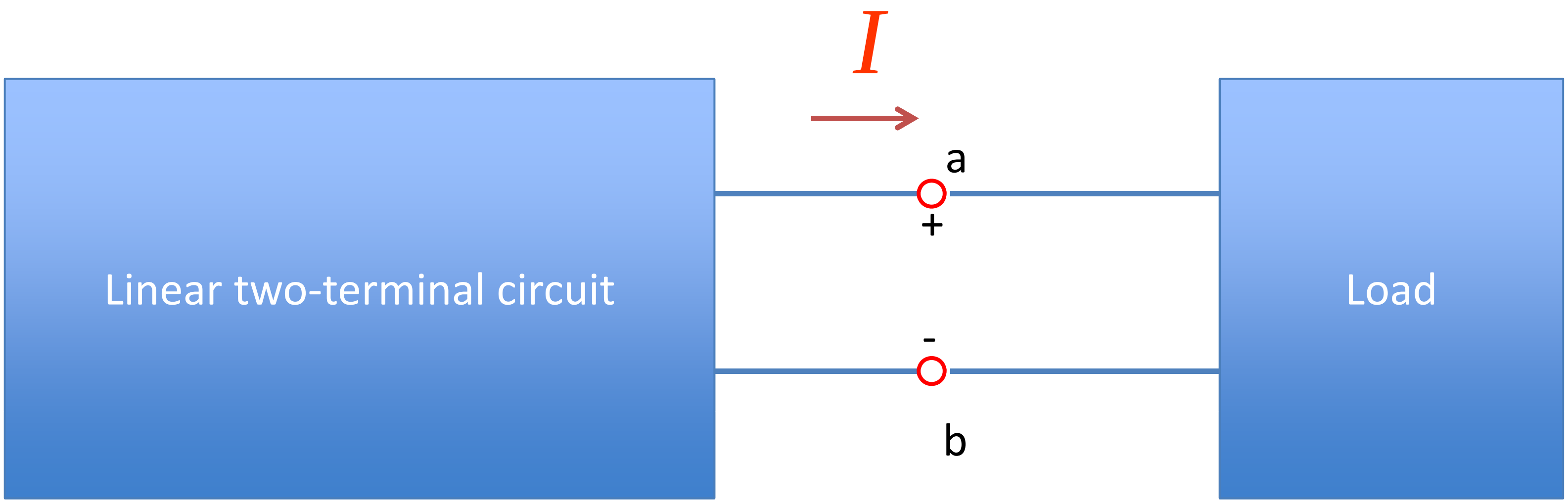

Wi Fi
LINKSYS
2.4GHz + 5GHz

Compartmentalization: Need for simplicity

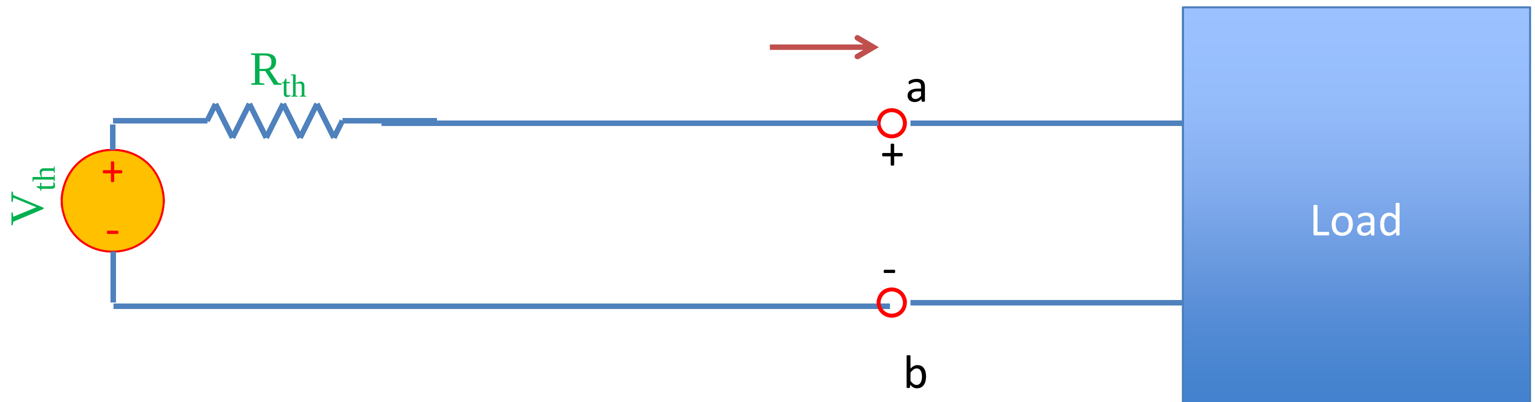


Power brick image.
And ask class to show their own…
Demo: Computer?

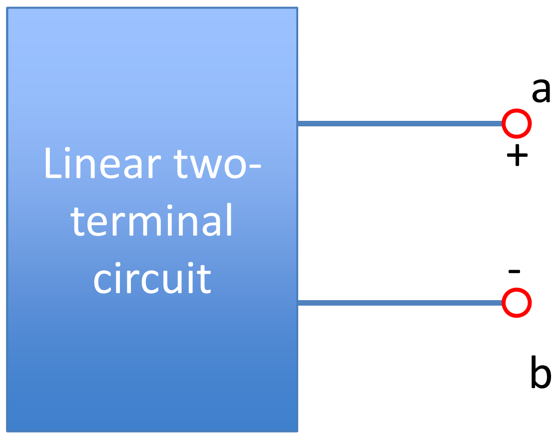
Thevenin's Theorem



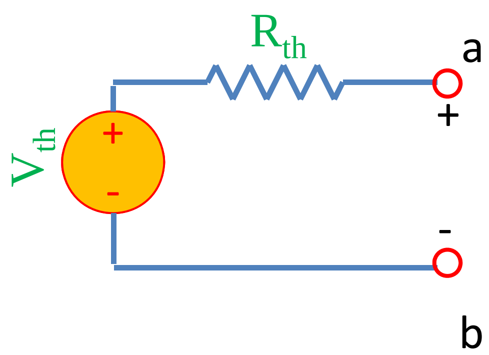
Equivalent to:



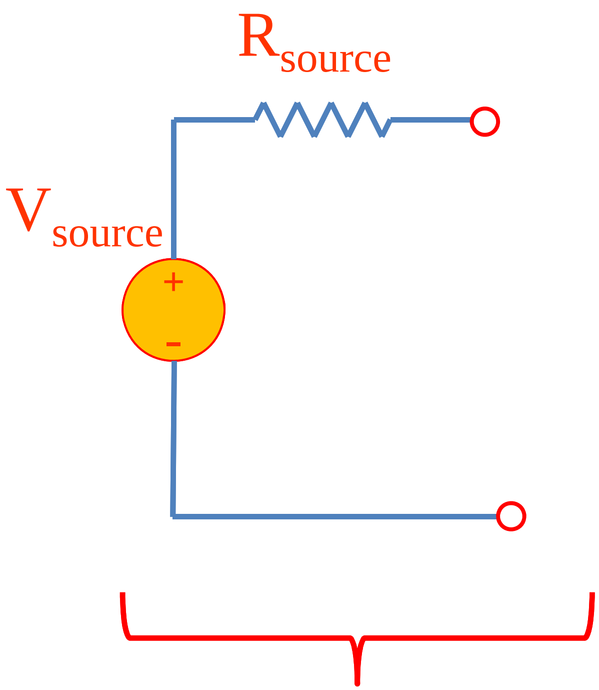
Finding V_{th}, R_{th}



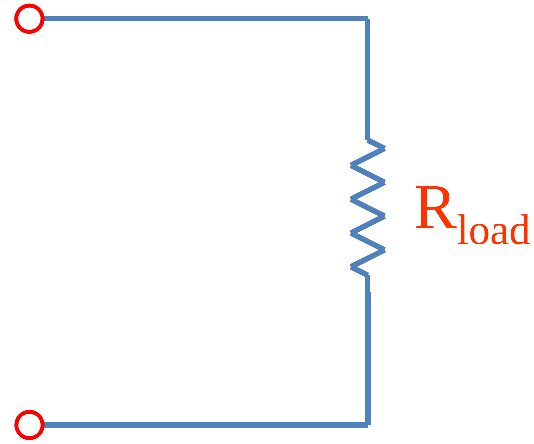
Equivalent to:



Source/load



Thevenin Thm:
Any circuit can be represented by this equivalent circuit.



$$V_{load} = \frac{R_{load}}{R_{load} + R_{source}} V_{source}$$

Derivation:

Case 1:

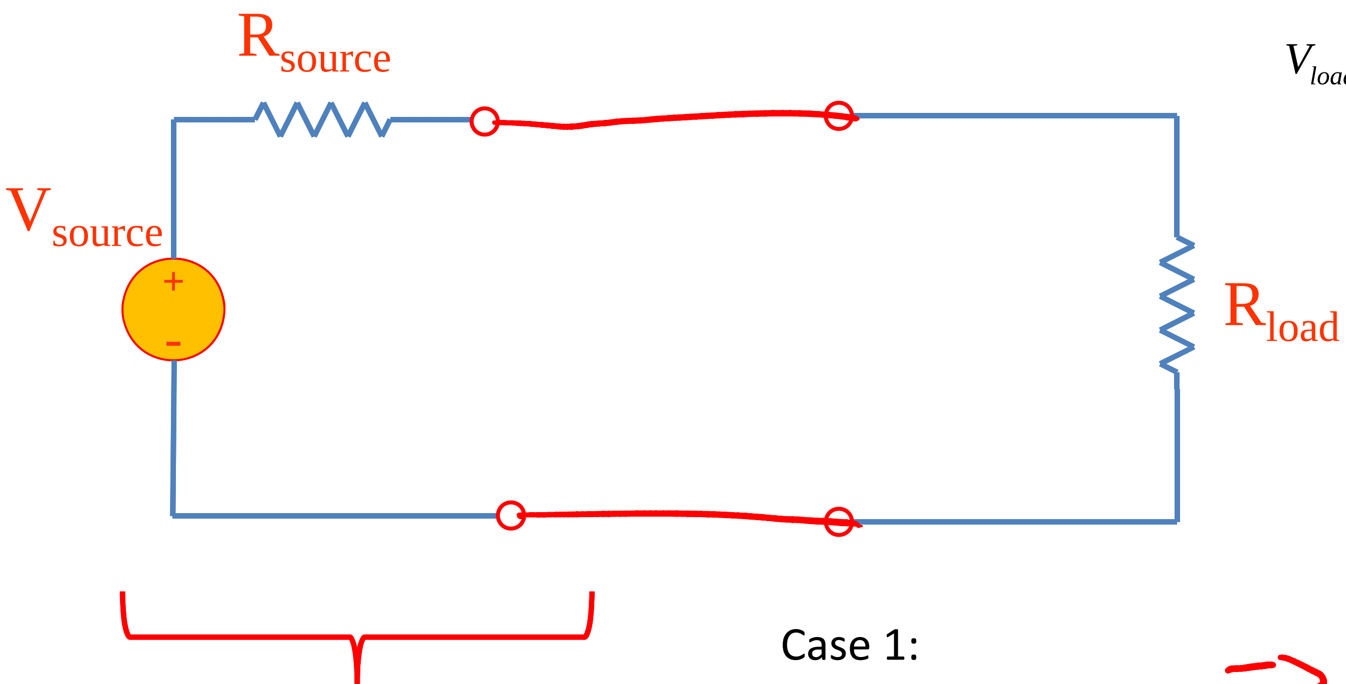
$$R_{load} >> R_{source}$$

Case 2:

$$R_{source} >> R_{load}$$

We say R_{load} "*loads down*" the source.

Source/load



$$V_{load} = \frac{R_{load}}{R_{load} + R_{source}} V_{source}$$

Derivation:

Thevenin Thm:
Any circuit can be represented by this equivalent circuit.

Case 1:

$$R_{load} >> R_{source}$$

$\Rightarrow V_{load} \approx V_{source}$

Case 2:

$$R_{source} >> R_{load}$$

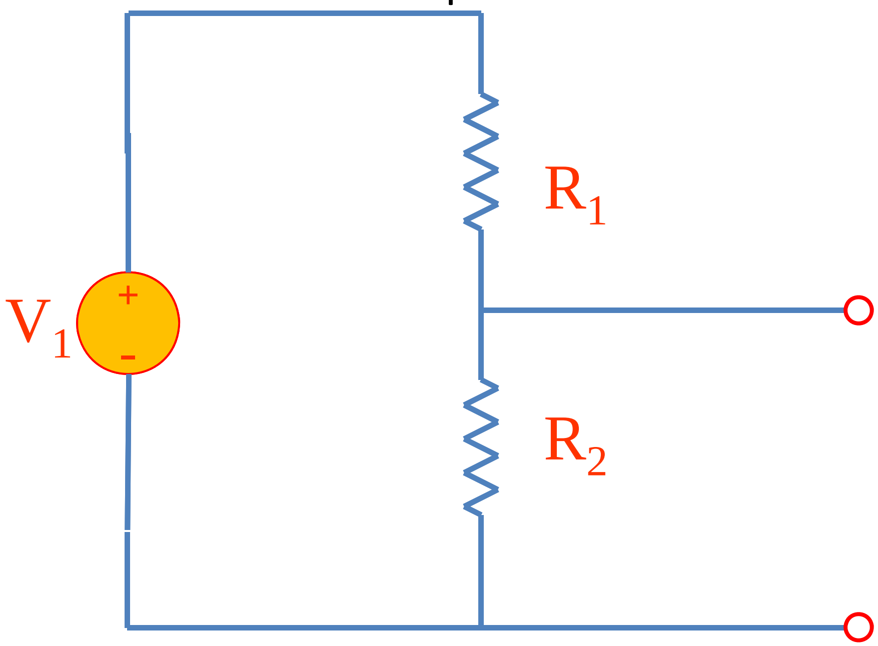
$V_{load} \to 0$

$\approx \frac{R_{load}}{R_{source}} V_{source}$

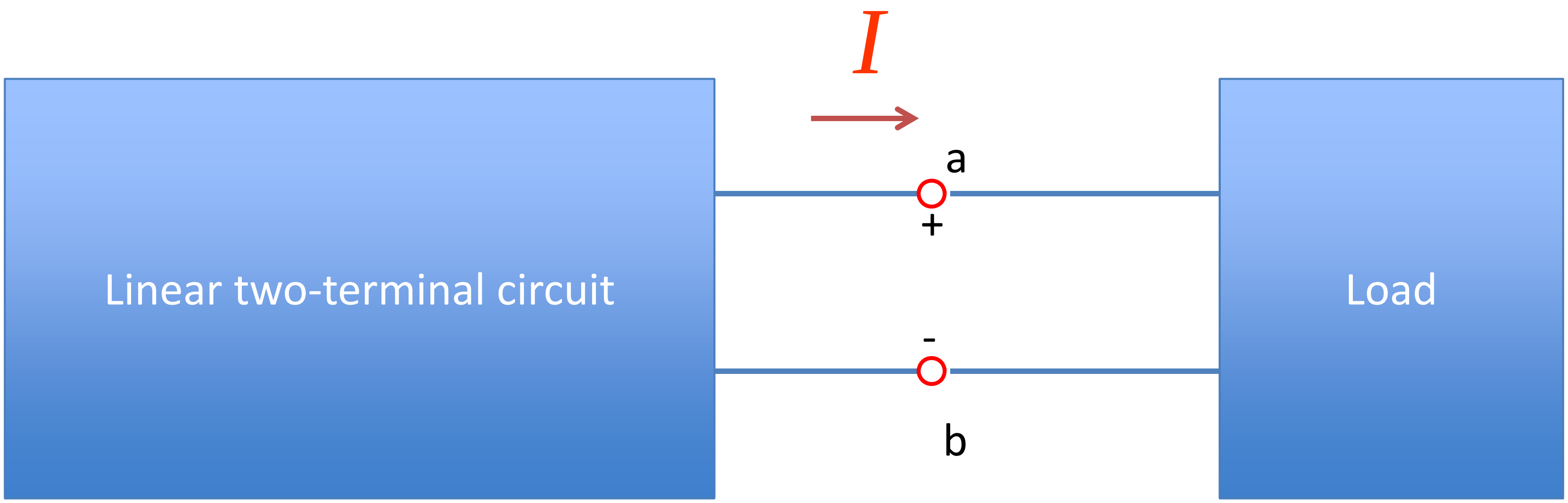
We say R_{load} "*loads down*" the source.

Example

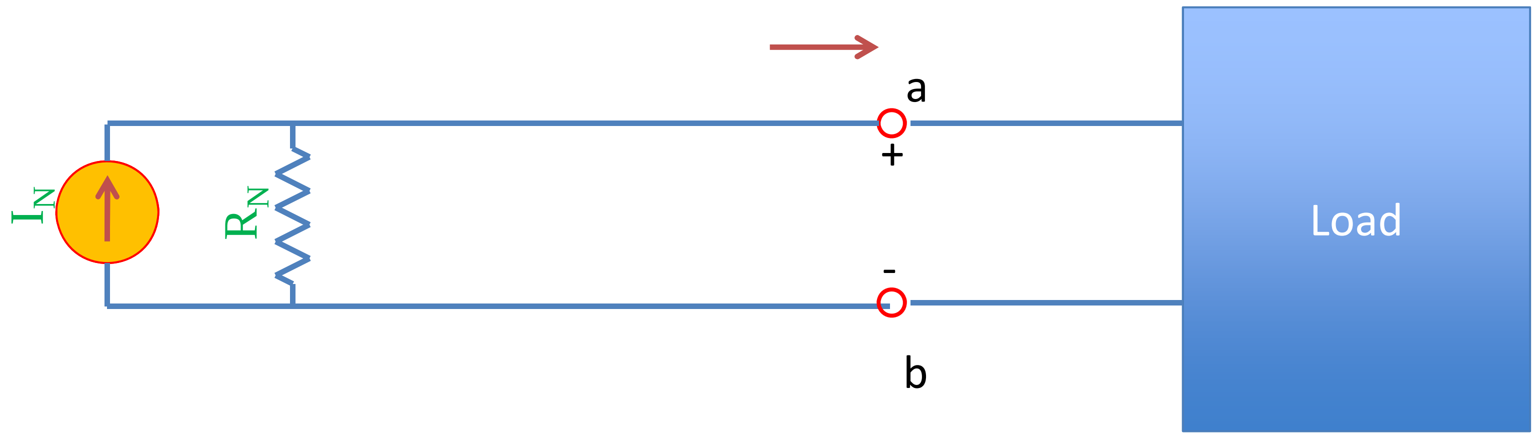
Find Thevenin equivalent circuit:



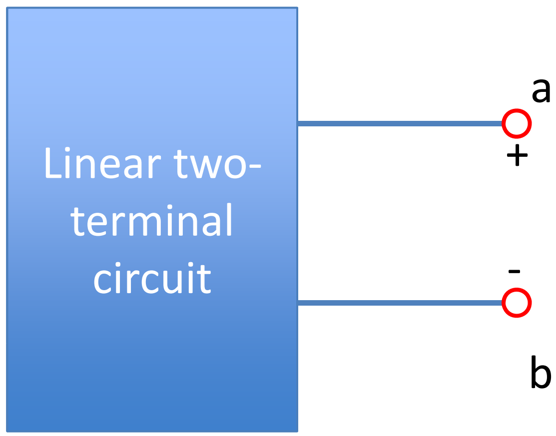
Norton's Theorem



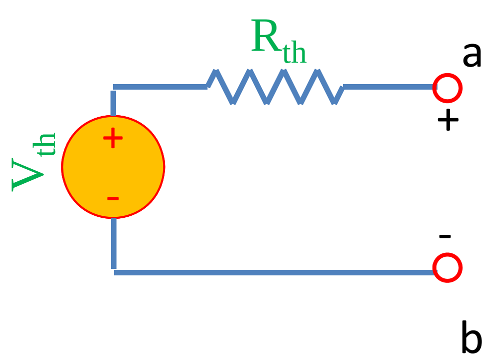
Equivalent to:



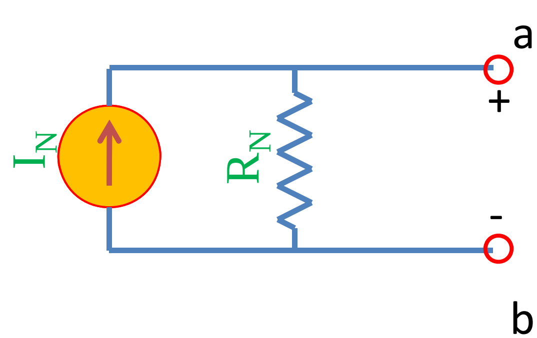
Finding V_{th}, R_{th}



Equivalent to:

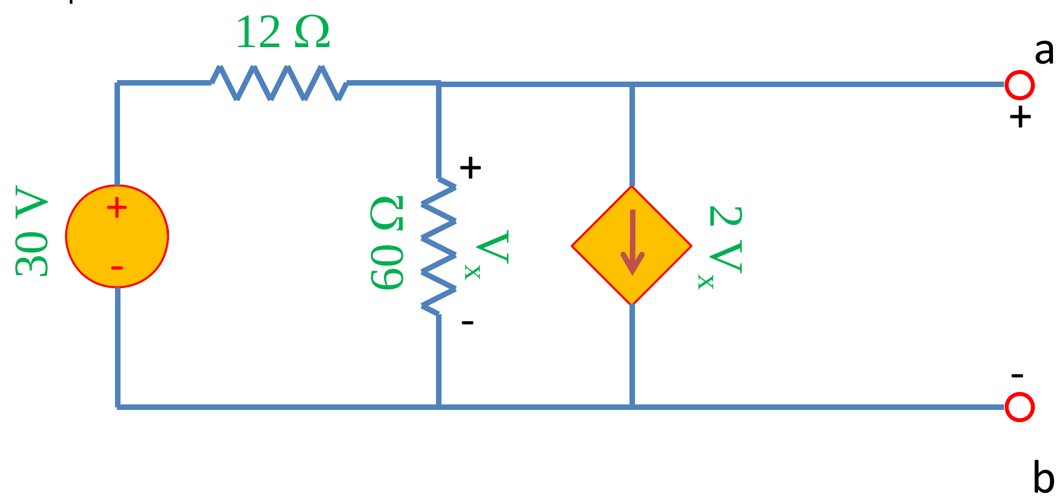


Equivalent to:

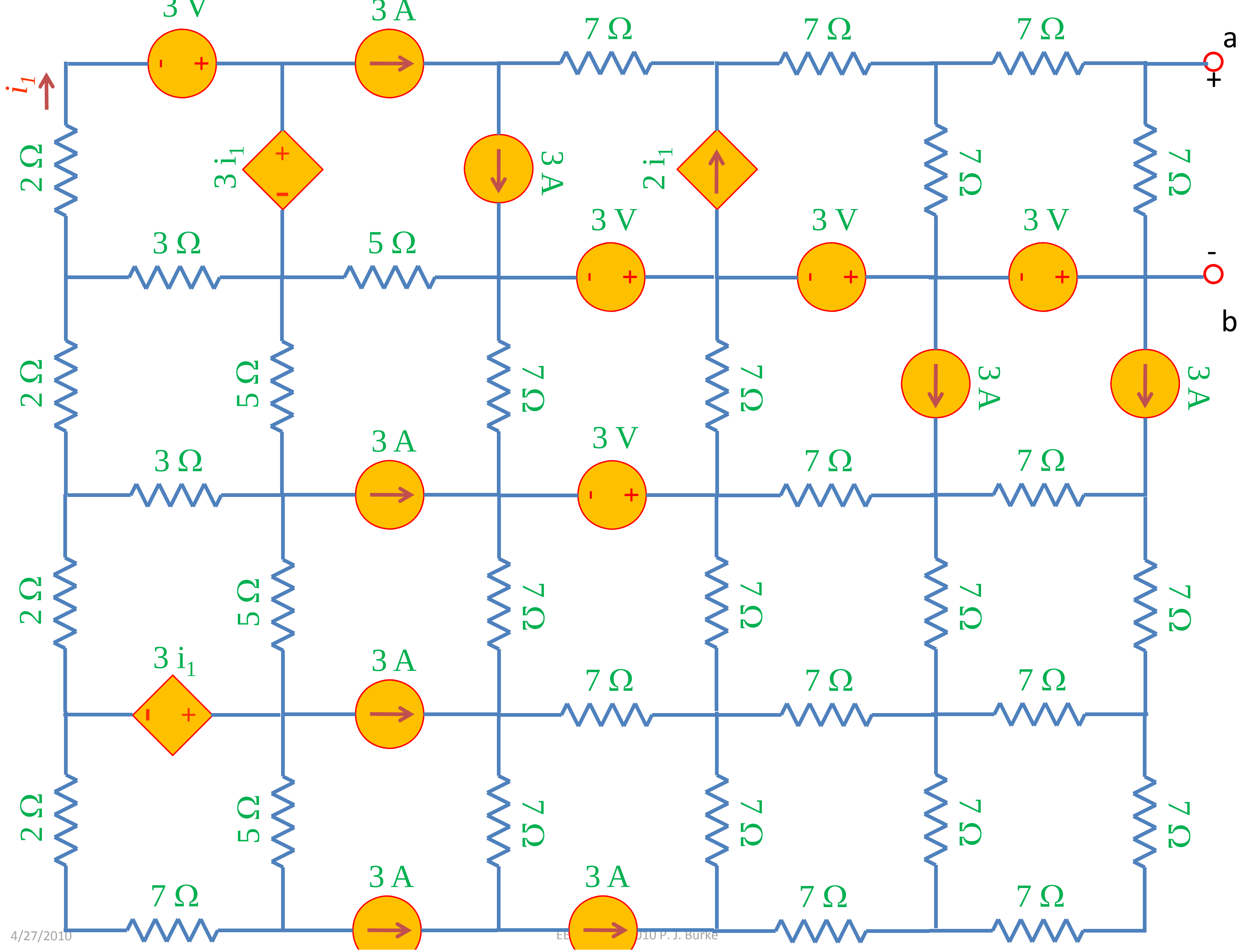


Example

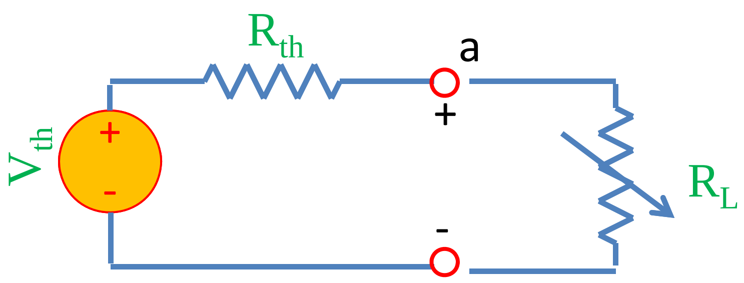
Find the Thevenin & Norton equivalent circuit of the circuit below with respect to terminals a and b:



(Monster HW problem: Part 2):Find the Thevenin & Norton equivalent circuit of the circuit below with respect to terminals a and b:



Power

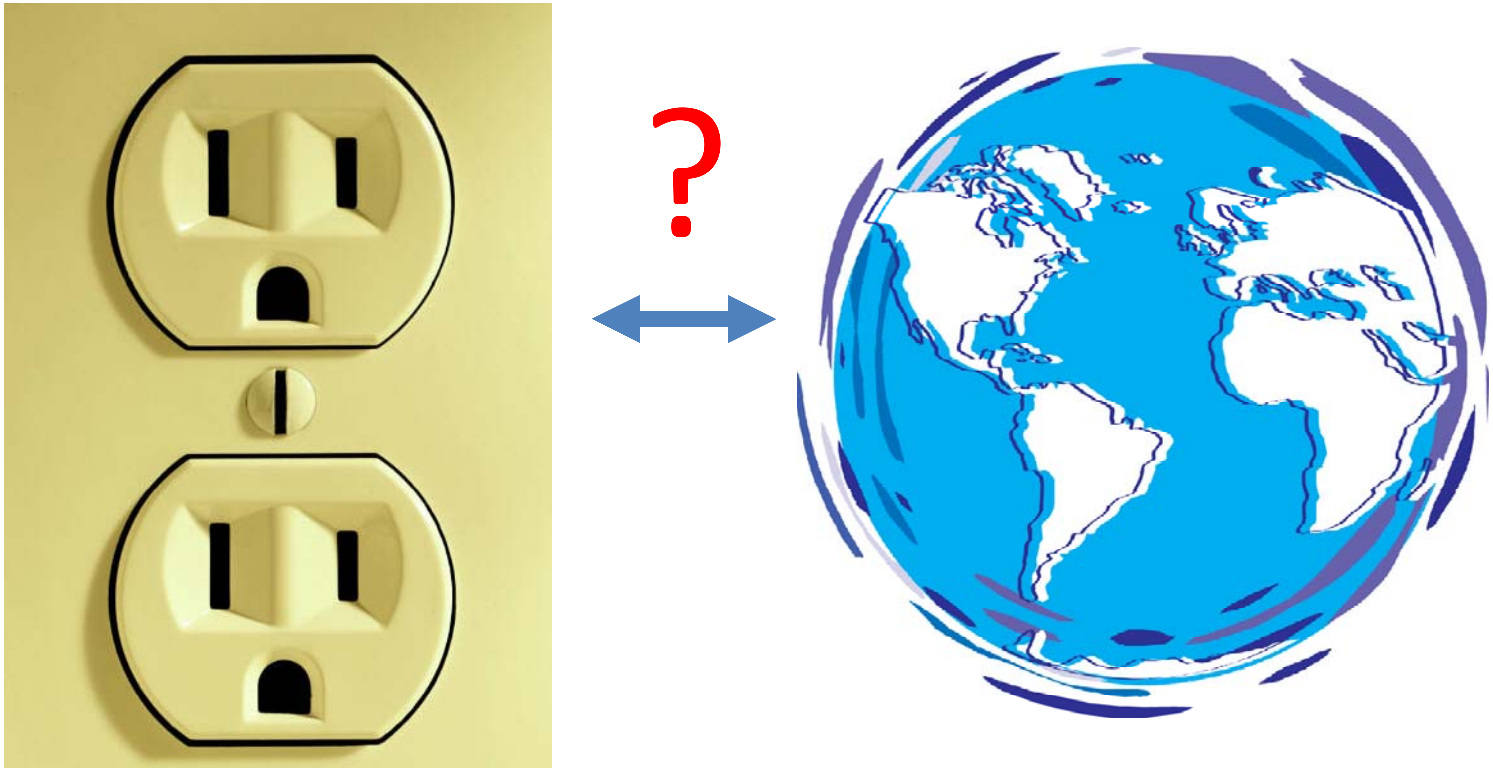


Arrow means R_L variable (e.g. by a knob)

Power delivered to load = ?

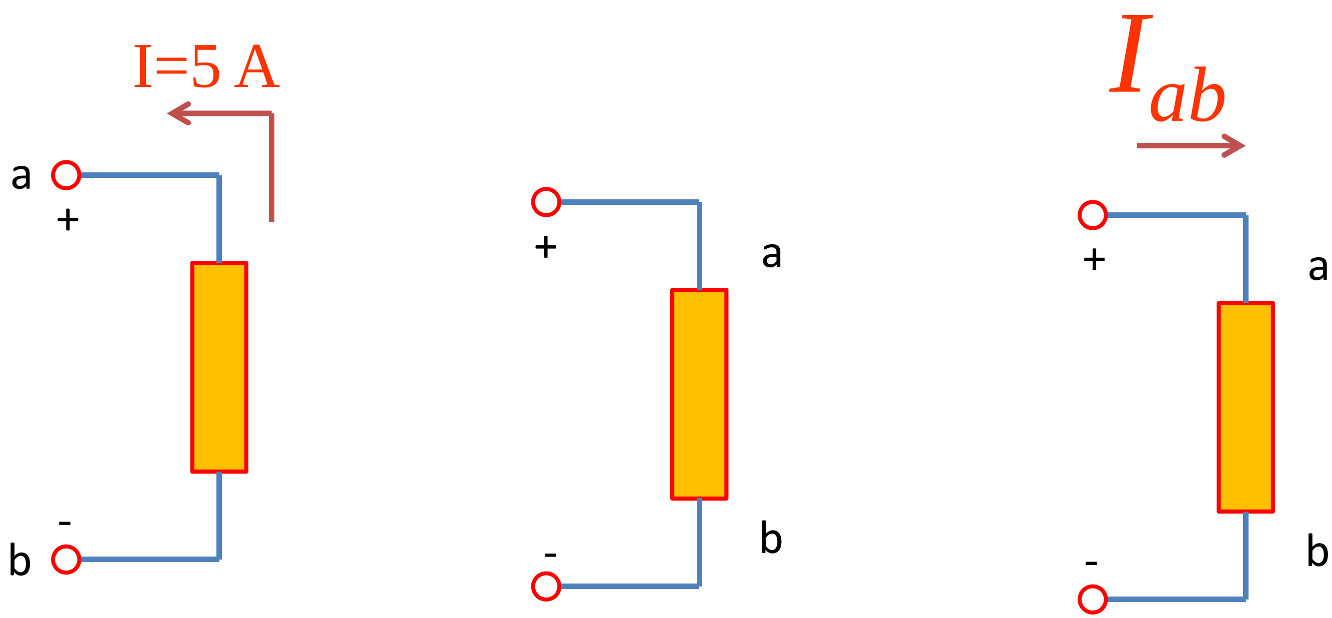
Questions?

Ground?

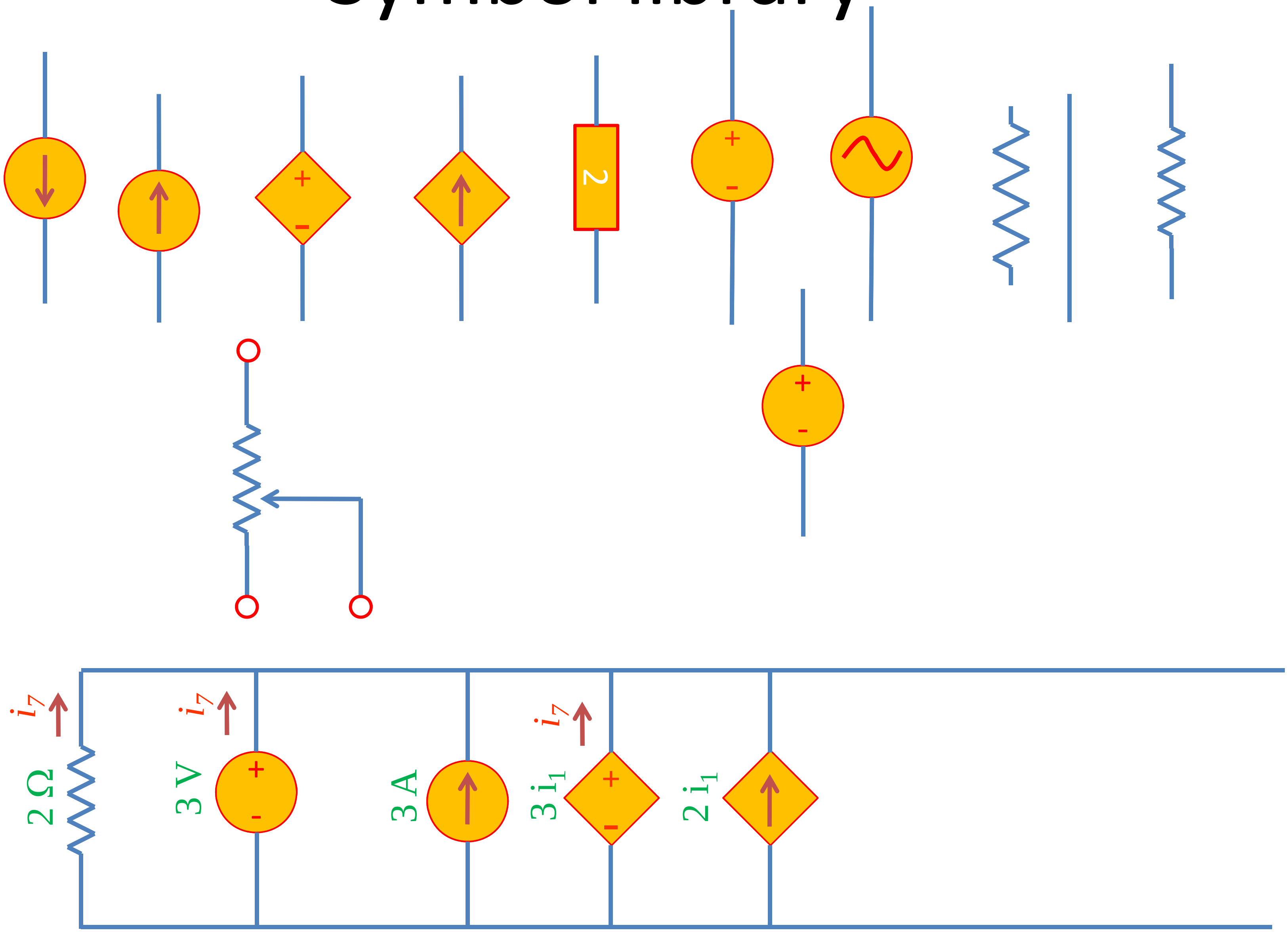


Ground
Reference
Earth

Symbol library



Symbol library



Symbol & circuit library