EECS16A DIS7B

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OH: W10AM-12PM PST (HWP)

Playlist (bit.ly/16ajukebox)

1. Glenn Gould Sonata No. 13 E^b Op. 27 No. 1
2. Bach - Little Fugue in G_m
3. Michiru Oshima - Waterlily

Learning Objectives

1. Calculating power using passive sign convention
2. Ideal voltmeter, ideal ammeter characteristics
3. If time (practice): units analysis and common units for circuits

Concept needed for HW (wasn't hit in lecture Tuesday)

(series equivalent of R_1 & R_2)

two resistors connected at one node, nothing else on it

"Resistors R_1 and R_2 are in series"

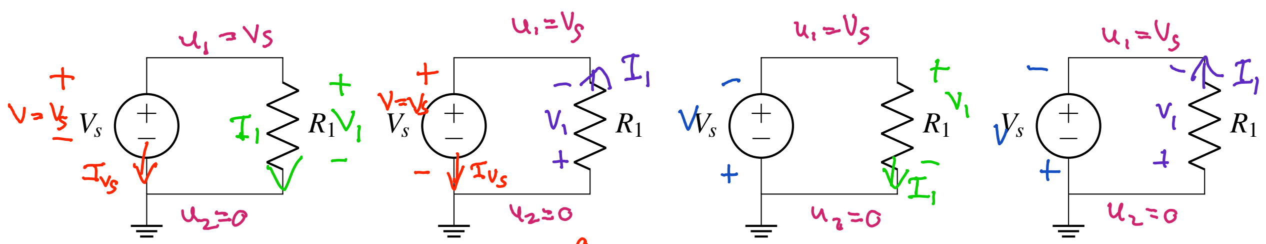
When we have this "simplified" form/equivalent, the middle node disappears

EECS 16A Designing Information Devices and Systems I
Fall 2020 Discussion 7B

$P = VI$ ← power of an element $[W] = [\frac{J}{s}]$ joules (energy), watts

1. Passive Sign Convention and Power

(a) We have made four copies of a circuit below. Following passive sign convention, there are four different possible labelings of current directions and voltage polarities for the circuit. For each copy, label each circuit's voltage source and resistor with current direction and voltage polarity labelings, keeping with passive sign convention.



$u_1 - u_2 = V_1$

$V = u_1 - \cancel{u_2}^{0}$

$V_s = u_1$

$V = -V_s$

$V = u_2 - u_1$

$-V_s = 0 - u_1$

$V_s = u_1$

$V = -V_s$

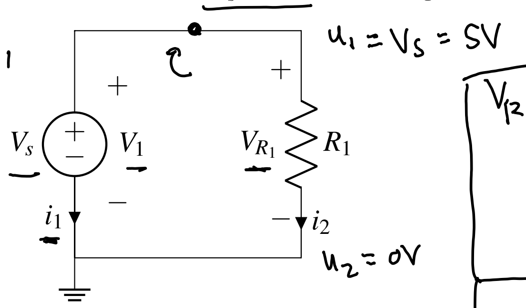
(b) Suppose we consider one of the possible labelings you have found above. Calculate the power dissipated or supplied by every element in the circuit. Let $V_s = 5\,\text{V}$ and let $R_1 = 5\,\Omega$.

$P_{V_s} = V_1 \cdot I_1 = V_s \cdot I_1$

$P_{R_1} = V_{R_1} \cdot I_2 = V_s \cdot I_2$

$= 5V \cdot 1A$

$= \boxed{5W}$ ← > 0 (dissipating)



$V_1 = V_s$

$V_{R_1} = u_1 - u_2$

$= V_s - 0V$

$V_{R_1} = V_s = 5V$

$I_2 = \frac{V_{R_1}}{R_1} = \frac{5V}{5\Omega} = 1A$

KCL @ u_1

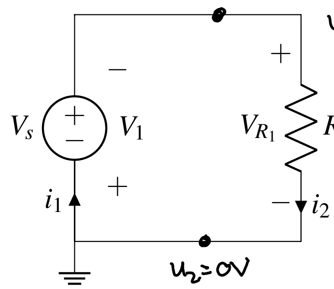
$I_1 + I_2 = 0$

$I_1 = -I_2 = \boxed{-1A}$

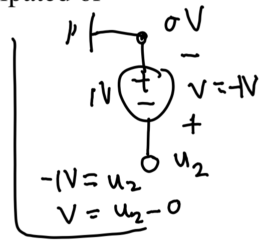
$P_{V_s} = 5V \cdot (-1A)$

$= \boxed{-5W}$ ← < 0 (supplying/generating)

(c) Suppose we choose a second labeling of the circuit as shown below. Calculate the power dissipated or supplied by every element in the circuit. Let $V_s = 5\,\mathrm{V}$ and let $R_1 = 5\,\Omega$.



$u_1 = V_s = 5V$



$\rightarrow V_1 = -V_s = \boxed{-5V}$

$\rightarrow V_{R_1} = u_1 - u_2$
$= V_s - 0V$
$= \boxed{5V}$

$I_2 = \frac{V_{R_1}}{R_1} = \frac{5V}{5\Omega} = \boxed{1A}$

KCL @ top $I_1 = I_2$

$\boxed{I_1 = 1A}$

$P_{V_s} = V_1 I_1 = (-5V)(1A) = \boxed{-5W}$

$P_{R_1} = V_{R_1} I_2 = 5V \cdot 1A = \boxed{5W}$

Q: Ohm's law for sources?

A: Nope, can't use ohm's law for voltage sources + current sources.

(d) Did the values of the element voltages and element currents change with the different labeling? Did the power for each circuit element change? Did the node voltages change? If a quantity didn't change with a difference in labeling, discuss what would have to change for quantity to change.

→ If we follow PSC → Power will be the same

→ Node voltages don't change, no matter the labeling

If we change labeling directions → element current + element voltage will change value

Power changes if we change the circuit

Node voltages change if we change circuit

→ moving ground change node voltage

Note: PSC → for components that are passive (dissipating/absorbing energy) get positive power

→ for components that are active (supplying/generating energy) power → negative

2. Volt and ammeter

Consider the following circuit below. We have also included relevant NVA equations below it.

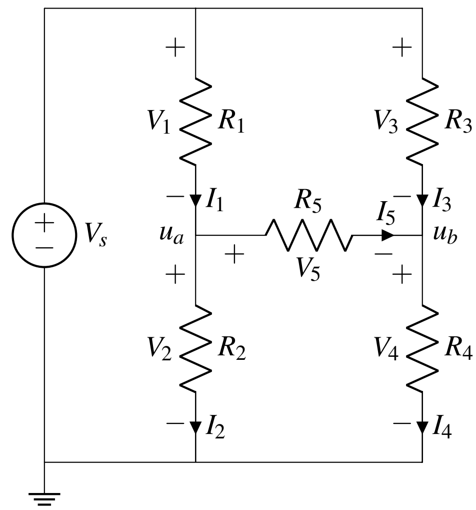


Figure 1: Circuit consisting of a voltage source V_s and five resistors R_1 to R_5.

$\begin{aligned} I_1 &= I_2 + I_5 \\ I_5 + I_3 &= I_4 \end{aligned}$	$\begin{aligned} I_1 &= \frac{V_1}{R_1} = \frac{V_s - u_a}{R_1} \\ I_2 &= \frac{V_2}{R_2} = \frac{u_a - 0}{R_2} \\ I_3 &= \frac{V_3}{R_3} = \frac{V_s - u_b}{R_3} \\ I_4 &= \frac{V_4}{R_4} = \frac{u_b - 0}{R_4} \\ I_5 &= \frac{V_5}{R_5} = \frac{u_a - u_b}{R_5} \end{aligned}$	$\begin{aligned} \frac{V_s - u_a}{R_1} &= \frac{u_a - 0}{R_2} + \frac{u_a - u_b}{R_5} \\ \frac{u_a - u_b}{R_5} + \frac{V_s - u_b}{R_3} &= \frac{u_b - 0}{R_4} \end{aligned}$
KCL	Ohm's law in terms of node voltages	Substitute Ohm's into KCL

(a) The circuit diagram shown in Figure 1 has been redrawn in Figure 2 by adding a voltmeter (letter V in a circle and plus and minus signs indicating direction) to measure voltage $V_{ab} = u_a - u_b$. Assume that the voltmeter is ideal. Are the values of V_{ab} before adding the voltmeter and after adding the voltmeter different? If so, which of the given equations change when doing NVA?

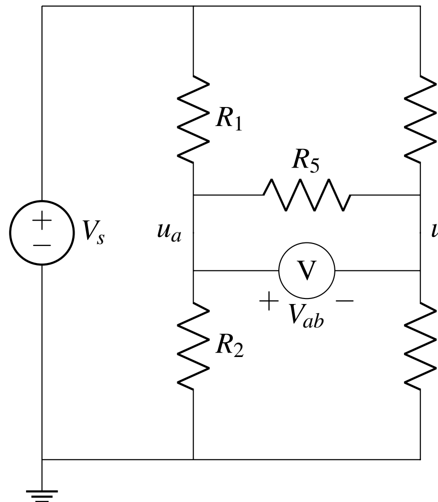
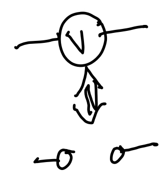
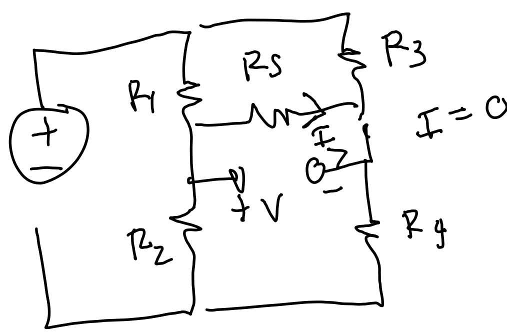


Figure 2: Circuit with voltmeter.

Ideal voltmeter: behaves like an open circuit



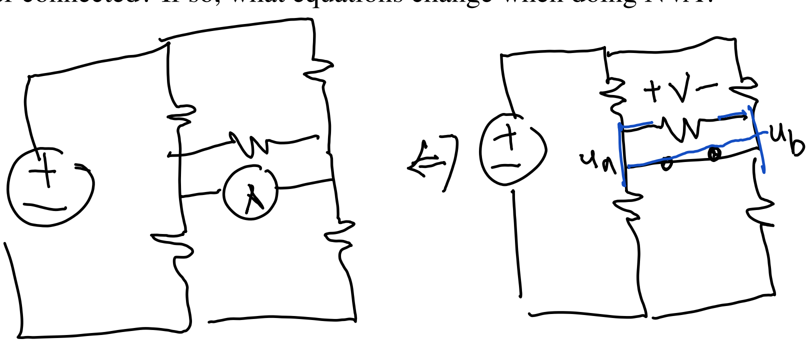


$I = 0$

$V = u_a - u_b$

No affect, ckt stays the same in terms of behavior

(b) Suppose you accidentally connect an ideal ammeter in part (a) to nodes u_a and u_b instead of an ideal voltmeter. Does the value of V_{ab} with the ammeter connected differ from the value of V_{ab} without the ammeter connected? If so, what equations change when doing NVA?



Q: What is the relationship between u_a, u_b?

A: $u_a = u_b$

$V = u_a - u_b = 0V$

$I = \frac{V}{R} = \frac{0}{R} = 0A$

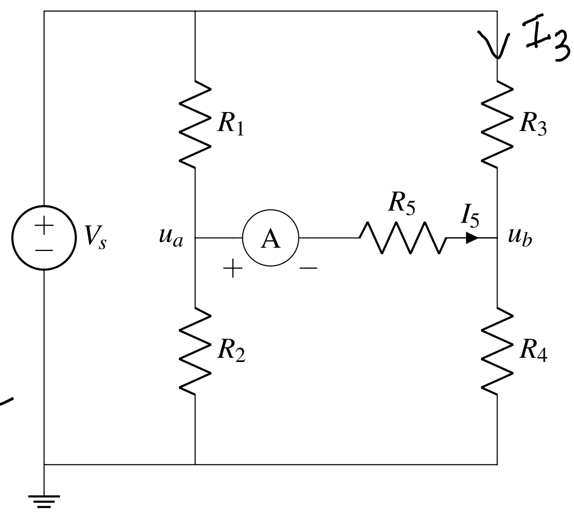
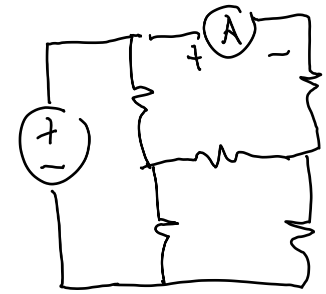
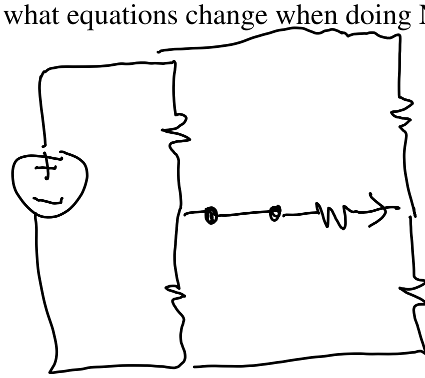


Figure 3: Circuit with ammeter.

If measuring I_3



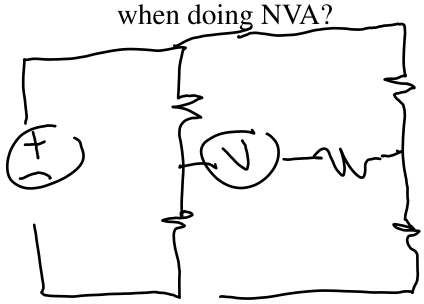
(c) The circuit diagram shown in Figure 1 has been redrawn in Figure 3 by adding an ideal ammeter (letter A in a circle and plus and minus signs indicating direction) in series with resistor R_5. This will measure the current I_5 through R_5. Are the values of I_5 before adding the ammeter and after adding the ammeter different? If so, what equations change when doing NVA?



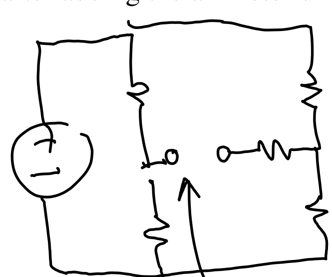
Looks the same as first circuit
⇒ No change in behavior

No change in equations

(d) Your friend accidentally connects a voltmeter in part (c) above, rather than an ammeter. Are the values of I_5 before adding the ammeter and after adding the ammeter different? If so, what equations change when doing NVA?



⇔



current that flowed before no longer can flow!

Behavior is different

Review on how to calculate element voltage from node voltage

⊕ V ⊖

u_a u_b

$V = u_{\oplus} - u_{\ominus}$
$= u_a - u_b$

Key principle: attach voltmeters to same two nodes of element voltage you want to measure

attach ammeters along the same path through which current flows