Lecture Part 2 - Nodal analysis

Administrivia → Lets change H-W problems 2.72 (Thevenin) & 2-85 (superposition) to be due along with H-W #2. Note: (as called 2-53! (no mesh analysis)

Nodal analysis (or Node-voltage analysis)

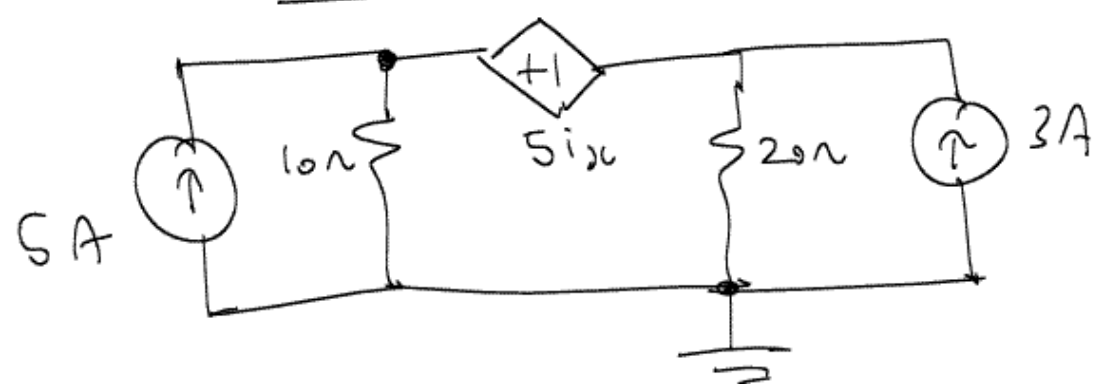
Goal: Find unknown voltages in the circuit.

VERY GENERAL METHOD, PSPICE uses it, everyone use it.

It is VERY algorithmic. Note: On the test, I won't ask you to solve (i.e. explicitly find) voltages for more than 2 unknown voltages.

Example: (p. 2.47 p. 109)

(Q:) Find unknown node voltages using nodal analysis.



Note: (1) I use the convention in KVL:

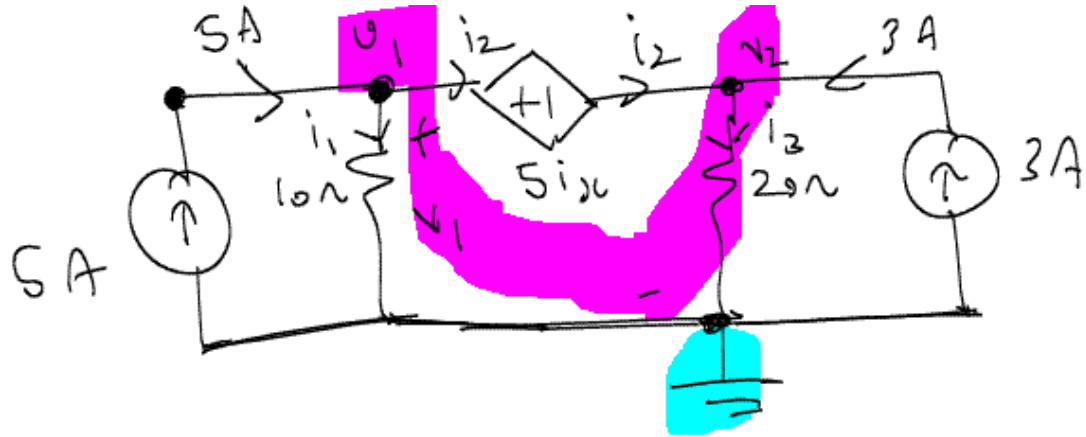
$$\sum\left(\text{Currents into a node}\right) = \sum\left(\text{Currents out of a node}\right)$$

(2) Book uses mostly:

$$\sum\left(\text{Currents out of a node}\right) = 0$$

You are free to use (1) or (2), but (1) is more intuitive.

Lets go through step-by-step the nodal-analysis technique.



Step 1: Mark ground node. If it not given, bottom node in a circuit is usually a good choice. Try to minimize number of unknown node voltages) → will become obvious through practice!

Step 2: Label unknown node voltage.

Step 3: KCL at each unknown node (except ground node!)

KCL @ node v_1: $-5 + i_1 + i_2 = 0$

$$\Rightarrow \boxed{i_1 + i_2 = 5}$$

KCL @ node v_2: $3 \cancel{=} i_2 + i_3$

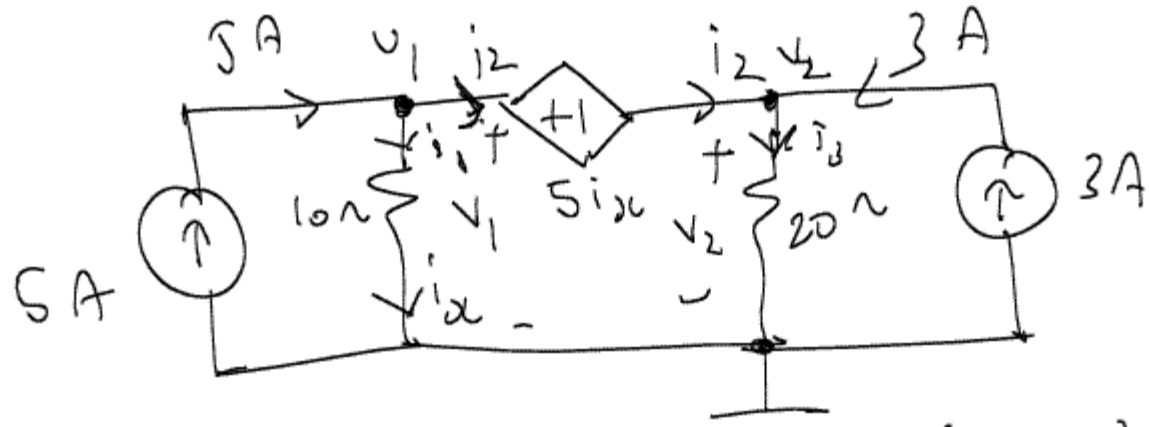
going out

oops

inconsistent

going out

$$\boxed{3 + i_2 = i_3}$$



in equations from step (3)

<u>Step 4:</u> Replace currents with unknown node voltages.

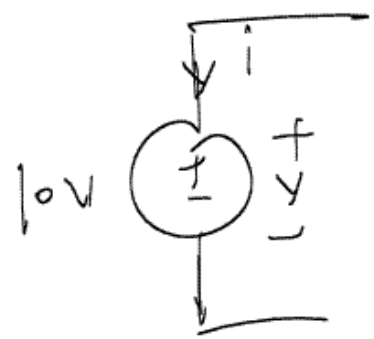
<u>Node v_1:</u> $5 = i_1 + i_2$

$$i_1 = \frac{v_1}{10\Omega}, \quad i_2 \overset{?}{=} v_1 - v_2 \quad \times$$

$$\overset{?}{=} \frac{v_2}{20} \quad \times$$

Notice you cannot write an expression for i_2, because i_2 is going through a dependent voltage source. In other words, you can't find the current through a voltage source using the voltage source alone!

<u>Because:</u>



$v = 10\,V$] No i dependency

<u>Note:</u> Back of this statement! You don't know VOLTAGE ACROSS A CURRENT SOURCE, DO NOT

ASSUME VOLTAGE ACROSS CURRENT SOURCES IS ZERO!

Going back, @ V_1: $\boxed{5 = \frac{V_1}{10} + i_2}$ — (1)

Now, @ V_2: $3 + i_2 = i_3$

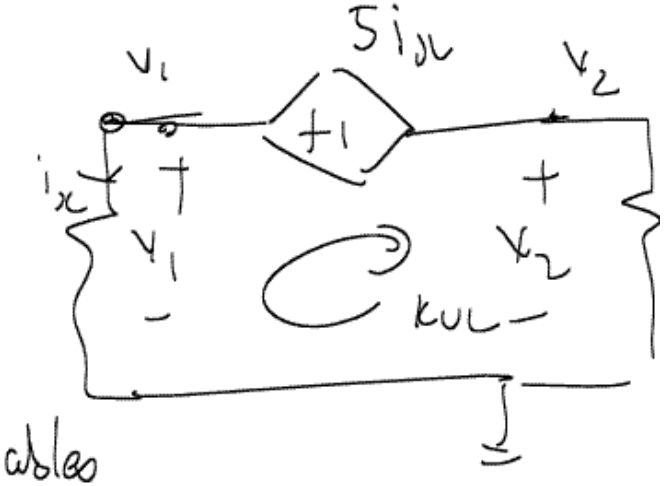
$$\Rightarrow \boxed{3 + i_2 = \frac{V_2}{20}} \quad \text{— (2)}$$

Eliminate i_2 using (1) & (2):

$$\boxed{3 + \left(5 - \frac{V_1}{10}\right) = \frac{V_2}{20}}$$

Step 5:* Constraint equation. Since we still have too many unknowns, look for constraint equation.

$$V_1 - V_2 = 5 i_x$$



Step 6:* Finally, we eliminate variables in dependent sources. Here, $i_x = i_1$!

$$\therefore \boxed{3 + \left(5 - \frac{V_2}{10}\right) = \frac{V_2}{20}}$$

$$\boxed{\begin{aligned} v_1 - v_2 &= 5 i_x \\ i_x = i_1 &= \frac{v_1}{10} \end{aligned}}$$

Solving:

$$v_1 - v_2 = 5\left(\frac{v_1}{10}\right) \Rightarrow v_1 - v_2 = \frac{v_1}{2}$$

$$\Rightarrow \frac{1}{2} v_1 = v_2 \Rightarrow \boxed{v_1 = 2v_2}$$

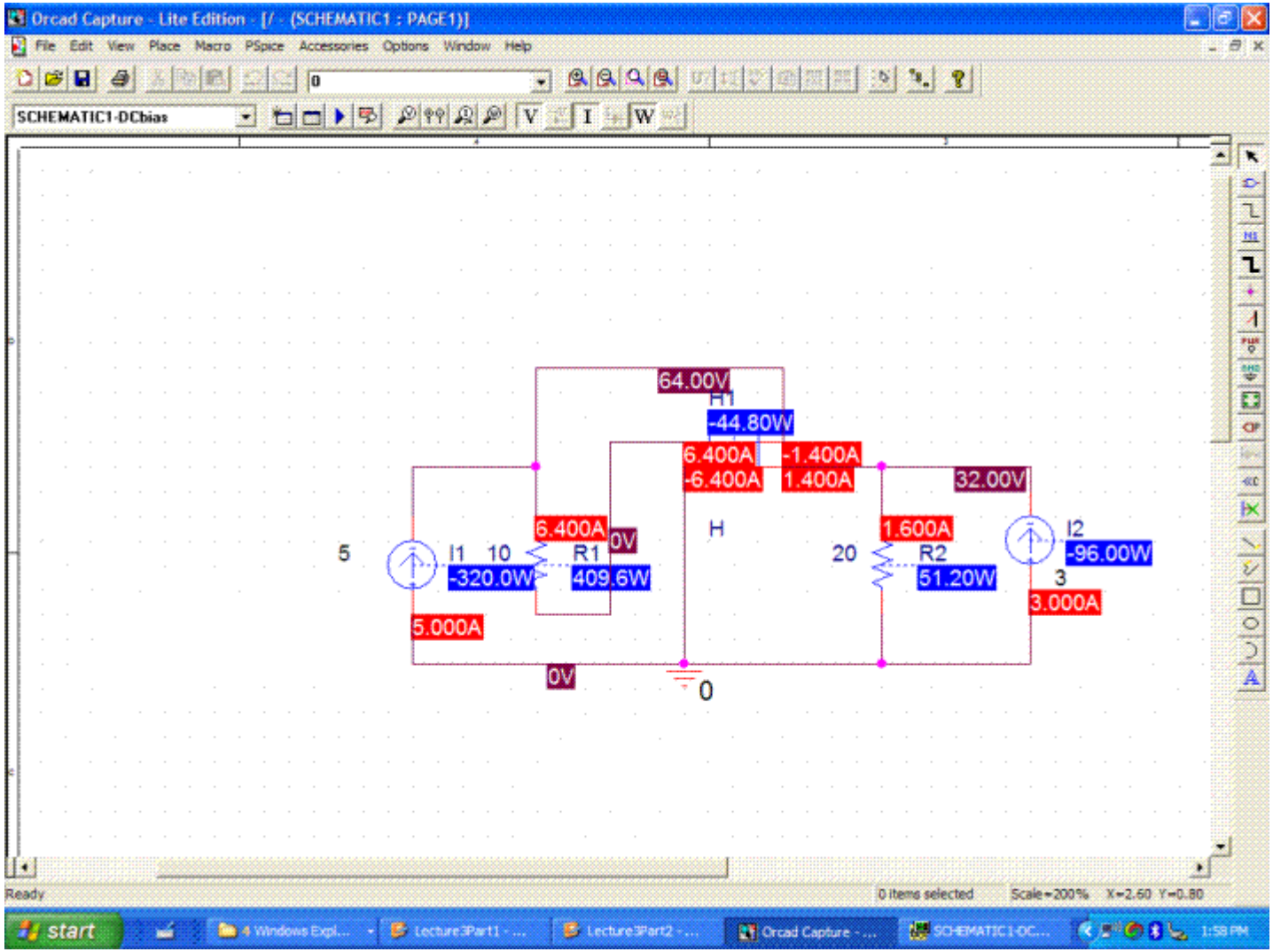
$$\therefore \quad 3 + 5 - \frac{2v_2}{10} = \frac{v_2}{20} \Rightarrow 8 = \frac{2v_2}{10} + \frac{v_2}{20}$$

$$\Rightarrow 8 = \frac{4v_2}{20} + \frac{v_2}{20}$$

$$8 = \frac{v_2}{4} \Rightarrow \boxed{\begin{aligned} v_2 &= 32\,V \\ \therefore v_1 &= 64\,V \end{aligned}}$$

Now, let's solve this problem using PSPICE!

You have the student version of PSPICE on one of the CDs which came with the book (Appendix D in your book has the tutorial). USE PSPICE!


Orcad Capture - Lite Edition - [/ - (SCHEMATIC1 : PAGE1)]
File Edit View Place Macro PSpice Accessories Options Window Help
SCHEMATIC1-DCbias
64.00V
H1
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6.400A
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-1.400A
1.400A
32.00V
6.400A
0V
H
1.600A
I2
5
I1
10
R1
20
R2
-96.00W
-320.0W
409.6W
51.20W
3
3.000A
5.000A
0V
0
Ready
0 items selected
Scale=200%
X=2.60 Y=0.80
start
1:58 PM

I will put zipped project online

Next week: Monday → Finish Chapter 2, chapter 3

Wednesday
Friday → chapter 4

Note: (1) Office hours on Sunday ⇒ check google groups!

(2) H.W #1 changes:

change H.W problems 2.72 (Thevenin) & 2.85 (superposition) to be due along with H.W #2. Note: (as called 2.53! (no mesh analysis)