E151 Lecture 1 – Intro and Linear Networks Review

Matthew Spencer
Harvey Mudd College
ENGR151

Disclaimer

These are note for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I'm putting them up as a courtesy. Remember that they are not intended as a substitute for lecture.

Why Take This Class

- Teaching analog circuit design
- "Analog is dead and digital is king" – some strawman
- Used ADC in E80, why not apply to every analog problem? (board list)
  - Speed, noise, dynamic range, power ← All tightly linked
  - Expensive, complex to design and use, delicate
  - Why is outside the scope of this class … but true
- What other analog tool do you know (op-amp). Why not? (board list)
  - Low power output
  - Limited bandwidth
  - We WILL learn why here ← YOU WILL BUILD ONE

What Makes Up Our Goals?

- Learning goals: you will learn how to build an op-amp (as list)
  - Really good at basics: RC dynamics and KVL/KCL
  - Basic semiconductor physics and intuition for how devices work in circuits
  - Single and multi-stage linear amplifiers
  - Analog building blocks and "talking the talk"
  - Fearless in lab and rational debugging
- Four major types of analysis (as list)
  - Large signal
  - Small signal
  - Dynamic
  - Other (mostly differential)

How Are We Doing This?

Mon	11:59PM	Turn in Lab Notebook & Problems
Tue	Lecture	Lab debrief
Wed		
Thu	12:01PM	Turn in self-graded problems
	Lecture	Quiz on lecture material (ind, + group)
	Afternoon	Lab + problems released
Fri	Lab	Oscope lesson & work time

- Lab deliverable is notebook: next slide
- Problems don't need to be done before lab, just related
- More later on design project, problems solo, DP + lab partners

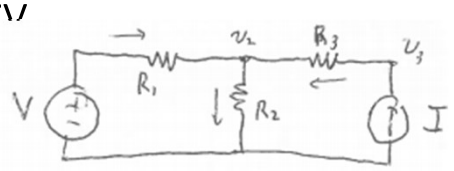
Lab Notebook Demo

- My example posted
- Chronological – that helps you reference from boss qs
- Informal and handwritten – clear, but not a writeup, always evidence
- Correct – you need to get right measurements in this class, like 80

- This should help you both in and out of lab
- Lab password
- Break to gather partners, come back to tech work.

E84 was Linear Circuit Theory

- Small groups, find i2 3 different ways for



① KCL $i_2 = \frac{V - v_2}{R_1} + I$ & $v_2 = i_2 R_2 \rightarrow$ $i_2 = \frac{V}{R_1} - \frac{i_2 R_2}{R_1} + I$

$I = \frac{v_3 - v_2}{R_3}$

$i_2\left(1 + \frac{R_2}{R_1}\right) = \frac{V}{R_1} + I$

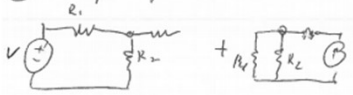
$i_2 = \frac{\frac{V}{R_1} + I}{1 + R_2/R_1}$

② kVL $V = i_1 R_1 + (i_1 + I) R_2$

$i_1 = \frac{V - I R_2}{R_1 + R_2}$

$i_2 = \frac{V + I R_1}{R_1 + R_2} = \frac{V/R_1 + I}{1 + R_2/R_1}$

③ Superposition



$i_2 = \frac{V}{R_1 + R_2} + I \frac{R_1}{R_1 + R_2}$

Split into "superposition subcircuits" and "turn off" supplies
- Split into equivalent summed circuits really common here
- Why the heck do we "turn off" sources

Matrix Picture of Circuit Linearity

- Split matrix into vectors and turn them off one at a time.

$$\begin{bmatrix} V \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} R_1 & R_2 & 0 \\ 0 & R_2 & 0 \\ 0 & R_2 & R_3 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ I \end{bmatrix} = \begin{bmatrix} R_1 \\ 0 \\ 0 \end{bmatrix} i_1 + \begin{bmatrix} R_2 \\ R_2 \\ R_2 \end{bmatrix} i_2 + \begin{bmatrix} 0 \\ 0 \\ R_3 \end{bmatrix} I$$

Can find I contrib. Indept $R_1 + R_2$

① make superpos subckts by "turning off" all but 1 S/C (short/open)
② Sub eq
③ Sum across all contribs subckt

Dependent Sources (I solve)

- V source or I source controlled by some other spot in circuit