

E151 Lecture 2 – Thevenin and 2 Port Hacks

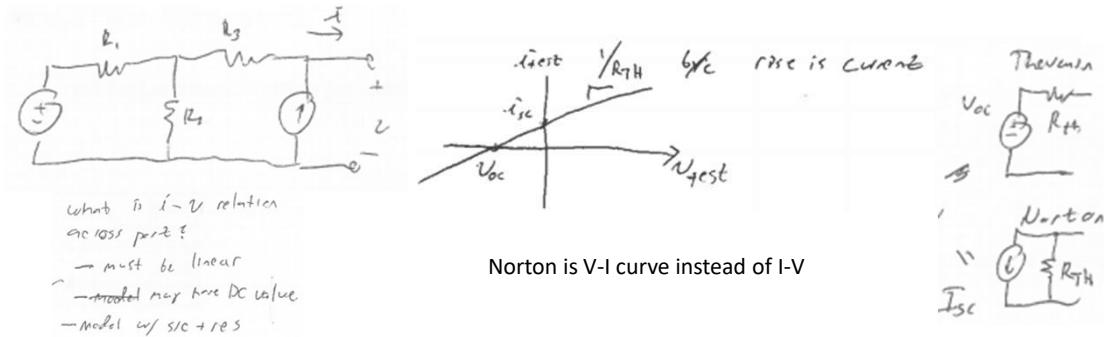
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Disclaimer

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.

Thevenin

- Don't care about circuits floating in space – want to connect them
- Connecting them to stuff can cause loading, need i-v relationships
- Place we make a connection called a port (where we apply vt) eg:

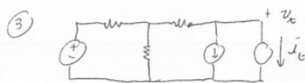


Example Find Thevenin Impedance 2 Ways

- Options: voc/isc (slope), simplify network (offset & resistor model)
- Then I show 3rd way: test sources (derivative of circuit)

$$\textcircled{1} \quad v_{oc} = v_3 = I(R_3 + R_1 \parallel R_2) + V \frac{R_2}{R_1 + R_2} \quad \text{by super pos} \quad R_{1/isc} = I + \frac{V}{R_3 + R_1 \parallel R_2} \cdot \frac{R_2}{R_1 + R_2}$$

$$\textcircled{2} \quad R_{TH} = R_3 + R_1 \parallel R_2 \quad \checkmark \text{ shorted \& opened sources}$$



$$v_o = V \frac{R_2}{R_1 + R_2} + (I + i_o)(R_3 + R_1 \parallel R_2)$$

$$\frac{dv_o}{di_o} = R_3 + R_1 \parallel R_2 \quad (\text{eg to small signal model, setting } v \& i \text{ to } 0)$$

(super handy for ignoring tricky circuit details!)

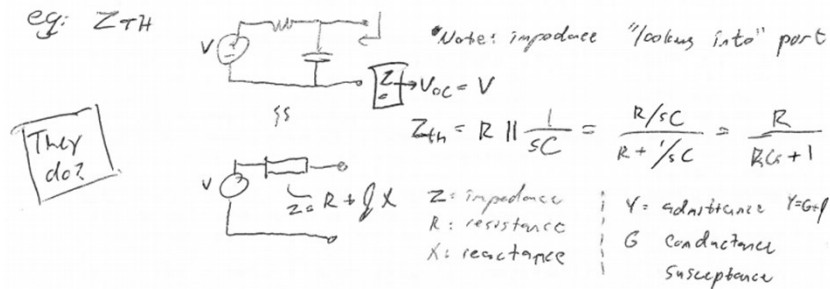
- can pick current or voltage test
- ask how much i or v at (find dv/di)
- I easy here bc \parallel w/ I
- MUST use this technique of dept. s/c:

MUST SHUT OFF SOURCES for di/dv. (Small wiggles go to die)

Odds and Ends

- Non-resistive impedances?

- Just fine, have a Z_{th} (general case) rather than R_{th} (like homework)



- What if no sources? In quadrants 1&4, dissipative, called "passive"

What are 2 ports?

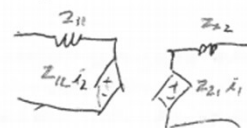
- 2 port devices are common and useful: eg
 - Dividers, Transformers, Amplifiers, Wires
- 2 ports don't have Thevenin resistances, instead defined by matrices
 - Needs linearity and passivity to work
- (Explain link to model quickly)
- Try to avoid b/c lots of matrix math
 - Become 1 ports if you know the load
 - Later we'll approximate $Z_{12}=0$ for amplifiers
 - In other classes, use b/c easy to measure

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

Z parameters

Z_{xy} the voltage @ port x caused by the current @ port y .

- easy way to remember how it's eq. Ckt model



Dynamics Review – Initial and Final Values

- What do we want to know dynamics responses to?
 - Sines → transfer functions work great
 - Steps → ... time domain, need some trick
 - Ramps → integrated steps, next
 - Exponentials → basically ramps, next
- We can get time domain responses from xfer fn with IVT/FVT

– IVT

$$\lim_{t \rightarrow 0} f(t) = \lim_{s \rightarrow \infty} sF(s) \quad \text{– FVT} \quad \lim_{t \rightarrow \infty} f(t) = \lim_{s \rightarrow 0} F(s)$$

Don't forget that LT $F(s)$ implicitly involves initial condition, so the IC is added to IVT/FVT value