

Physics 116A Notes

Fall 2004

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Draft v.0.9

- Notes Copyright 2003 David E. Pellett unless stated otherwise.
- References:
 - Text for course:
Fundamentals of Electrical Engineering, second edition, by Leonard S. Bobrow, published by Oxford University Press (1996)
 - Others as noted

Linear Circuits and Thévenin Outline

- Finish DC Circuit Concepts
 - Mesh Analysis (define, do example)
 - Principle of superposition (define, do example)
 - Thévenin equivalent and Norton equivalent
 - * Definitions
 - * Examples (continued next time)

Linearity and Superposition

- *Linear* DC circuits
 - Resistor: $V = IR$ or $I = GV$ where R and $G \equiv 1/R$ are constants: automatically linear
 - allow only *linear* dependent sources ($V_2 = kI_1$ where k is a constant, etc.)
- Nonlinear devices, e.g., nonlinear dependent sources, *excluded*
- However, will eventually see that
 - One can *linearize* nonlinear devices approximately near some operating point (keep linear term in Taylor's series expansion about the operating point—small signal AC model of diodes and transistors)

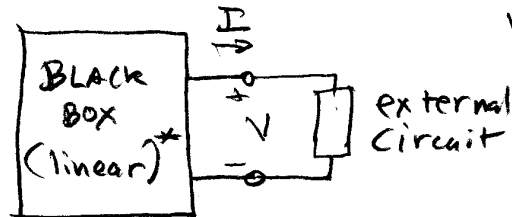
Linearity and Superposition (continued)

- Call some particular variable (e.g., the voltage, V' , across two arbitrary nodes of a circuit) the *response* of the circuit to the various *independent* voltage and current sources.
 - The response could just as well be some current, I' , through an arbitrary branch of the circuit
 - Let n be the number of independent voltage and current sources
- Define V'_k as the response due to the k^{th} source (i.e., with all but the k^{th} independent source set to zero – dependent sources left as-is).
- Then the total response is $V' = V'_1 + V'_2 + \dots + V'_k + \dots + V'_n$.
 - For a current as the response, $I' = I'_1 + I'_2 + \dots + I'_k + \dots + I'_n$.

Thévenin and Norton Equivalents

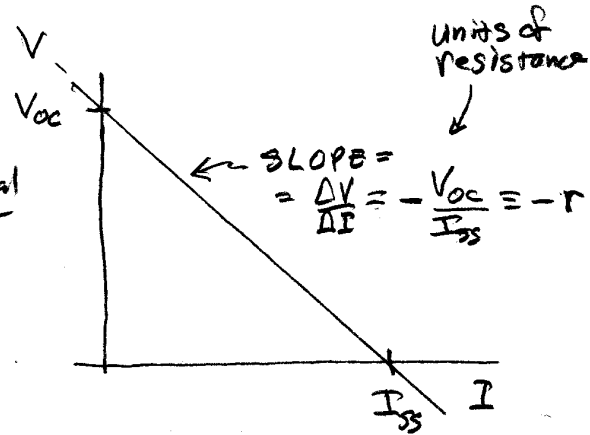
- Useful for circuit analysis
- Useful as model for linear circuit “black box” with two terminals

Thevenin Equivalent



Response must be linear, defined by V_{oc} and I_{ss} in most cases.

* no dependent sources which depend explicitly on external variables.

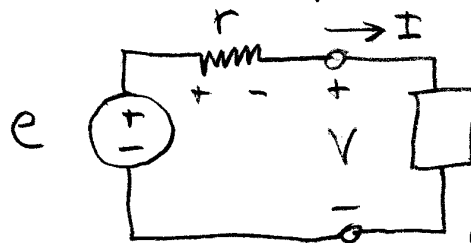


$$y = mx + b$$

$$V = -rI + V_{oc}$$

$$\text{let } e \equiv V_{oc}$$

Then
Black box is equivalent to:

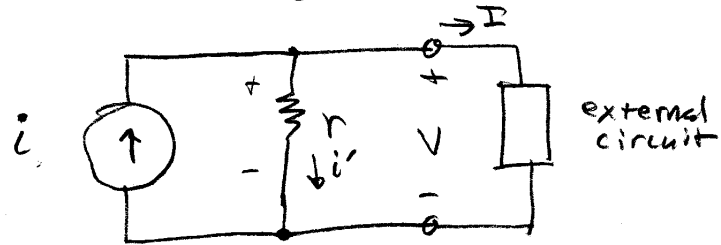


$$\text{since } V = e - Ir$$

(May have to apply an external voltage source to find r in some cases)

Norton Equivalent

Norton equivalent: same thing but with current source.



$$i = i' + I \Rightarrow i' = i - I$$

$$V = i' r = (i - I) r = \underline{i r - I r}$$

Note that $i \equiv I_{SS}$. Two parameters, r and I_{SS}

connect w/ Thévenin relation -

$$V = e - I r \Rightarrow e (\text{Thévenin}) = i (\text{Norton}) r$$

$$i (\text{Norton}) = \frac{e (\text{Thévenin})}{r \text{ (same } r)}$$

(get r across terminals if you turn source to zero in either case)

Alternatively $e \equiv V_{oc} = i r \Rightarrow i = e/r$