Lecture 5: Chapter 4 cont'd.

Administrivia

AMWR due time to 2:00 pm on Monday? ⇒ OK.

Printing out lab reports before lab,

[but, we do have a printer in lab, no quota]

Chapter 4: Finish up nodal analysis

* A finding note on ground

Recall:

\[
\begin{align*}
&\text{1SA} \\
&60\text{n} \\
&v_1 \\
&15\text{n} \\
&i_1 \\
&2\Omega \\
&v_2 \\
&\text{SA}
\end{align*}
\]

\[\downarrow\] Simplify circuit

\[
\begin{align*}
&\text{1SA} \\
&12\text{n} \\
&v_1 \\
&\text{loop 2} \\
&v_5 \\
&2\text{n} \\
&v_2 \\
&\text{SA}
\end{align*}
\]
\[ \text{Loop 2 KVL: } V_1 - V_5 - V_2 = 0 \Rightarrow V_1 - V_2 = V_5 \]

\[ \text{KCL @ node A': } 15 = \frac{V_1}{12} + \frac{V_1 - V_2}{5} \]

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Point: Use ground \( [\pm \infty \text{ V}] \) to simplify circuit analysis, it is not necessary (most of the time). However, please get used to it because:

(a) It does simplify circuit analysis
(b) You will see it in circuit schematics
(c) See it a lot in op-amps and nonlinear circuits.

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Finishing up nodal analysis: **Floating-voltage source**

Def: A floating-voltage source is a voltage source that is not connected to ground.
Assessing objective 4.5 (p. 121)

(2): Use node-voltage method to find V in the circuit shown.

Step 1: Pick \( \frac{1}{2} \)

Step 2: KCL at unknown node

\[
\begin{align*}
KCL @ V_A: & \quad 4.8 = i_x + i_A \\
KCL @ V_i: & \quad i_A = i_B + i_c \quad KCL @ V_B: \quad i_c = i_D + i_E
\end{align*}
\]
Step 3: Rewrite branch currents in terms of unknown node voltages.

\[ \begin{align*}
\text{\( V_A \)}: & \quad 4.8 = \frac{V_A}{7.5} + \frac{V_A - V}{2.5} \\
\text{\( V \)}: & \quad \frac{V_A - V}{2.5} = \frac{V}{10} + i_C \\
\text{\( V_B \)}: & \quad i_C = \frac{V_B}{2.5} + \frac{V_B - 12}{1}
\end{align*} \]

Step 4: Use constraint equation:

\[ V_B - V = i_C = \frac{V_A}{7.5} \]

Solve

\[ V = 8 \text{ V} \]

1. Read supernode on your own....
2. Skip 4.5 through 4.8: you are not responsible for mesh analysis.
(4.9) Source transforms

* Linear system *

Consider: \( y = f(x) \)

- \( f \) is the function, \( f(x) \) is a number.

System: Def: It's a function whose domain is a function & range is a function.

Ex: Audio signal \( \xrightarrow{\text{Bass-treble \ H controller}} \) Audio signal \( \xrightarrow{y} \)

\[ y = H(x) \]

\[ y(t) = H(x(t)) \times \]

\[ y(t) = H(y(t)) \]

So who cares? A: Need to define a linear system.
\( h \) is linear system means:

\[
g(x_1 + \beta x_2) = \alpha g(x_1) + \beta g(x_2)
\]

\( h \) is linear system:

\[
g(x_1 + x_2) = g(x_1) + g(x_2)
\]

\[
g(\alpha x) = \alpha g(x)
\]

Examples:

(a) Nonlinear

\[
g_1(x_1 + x_2) = (x_1 + x_2)^2 = x_1^2 + x_2^2 + 2x_1x_2
\]

\[
g_1(x_1) + g_1(x_2) = x_1^2 + x_2^2
\]
b) Linear

\[ i \rightarrow \frac{1}{R} \rightarrow v \rightarrow i \]

Input: \( i \)
Output: Voltage

\[ V = RI \] : Linear!

In the case of circuits, there is another practical approach to linearity:
Look at graphs of circuit variables (\( i, v \)). Example: \( i-v \) graphs, \( V_{out} vs. V_{in} \), etc.

For instance, Resistor

\[ \text{fixed} \]

\[ \text{straight line} \]

\[ i-v \] graphs

\[ \text{linear elements!} \]
I will actually cover 4.10, 4.11 then I will cover 4.9.

**Thevenin Equivalent or Thevenin’s Theorem**

[Diagram of a linear circuit with annotations: Two measurements, i_iSC, Voc, and a linear circuit with a voltage source and current through a linear circuit.]
$KVL: \quad V_{OC} = V \quad \text{[No drop across resistor because } i = 0]\]$

(2)

\[i_{SC} = \frac{V_{OC}}{R_m}\]

\[\Rightarrow R_m = \frac{V_{OC}}{i_{SC}}\]

Example: [Best cooked this up in lecture]

\[6V\]

\[\text{(ii) Find thevenin equivalent at ab.}\]
To find thevenin equivalent: find \( V_{oc}, \, I_{sc} \).

\[ R_m = \frac{V_{oc}}{I_{sc}} \]

**Step 1: Find \( V_{oc} \)**

\[ 5 \, \Omega \]
\[ 10 \, \Omega \]
\[ 5 \, \Omega \]
\[ 5 \, \Omega \]
\[ 5 \, \Omega \]
\[ 5 \, \Omega \]

\[ 6 \, V \]

\[ V_{oc} = ? \]
$V_{oc} = 3 \text{ V}$ [Voltage divider]

$I_{sc} = ?$

$X \rightarrow \text{"killed" by short circuit at } ab.$

$\therefore I_{sc} = \frac{b}{5}$

$I_{sc} = 1.2 \text{ A}$

Note: $\frac{1}{\text{Res}}$
\[ R_m = \frac{V_{oc}}{I_{sc}} = \frac{3}{1.2} = 2.5 \Omega \]

**Circuit Analogy:**

\[ 2.5 \Omega \]

**Comment:**

1. If a circuit includes only independent (no dependent) sources & resistors, a shortcut to finding \( R_m \).
Since I can find an equivalent resistance for a voltage source & current source to find $R_m$:

$$\begin{align*}
\text{Equivalent Resistance:} & \quad (5 + 5) \parallel 10 \parallel 5 \\
& \quad = 10 \parallel 10 \parallel 5 = 5 \parallel 5 = 2.5 \Omega
\end{align*}$$
(2) If a circuit has only dependent sources & resistors:

\[ V_{oc} = ? \]

\[ i > 0 \enspace \text{[open-circuit]} \]

\[ \Rightarrow V_x = 0 \]

\[ \therefore V_{oc} = 0 \]
$i_{sc} = 0$

$k_{Vx} \quad 5V_x = -V_x$

$\Rightarrow V_x = 0 \Rightarrow i = 0$

$\therefore i_{sc} = 0$

$R_m = \frac{V_{oc}}{i_{sc}} = \frac{0}{0}$ undefined!

Point: We will see this on Friday.

On Friday: (1) Finish Chapter 4
(2) Lab lecture
(3) Start Chapter 6