Assignment #6 Due Today 11:59 PM

No assignment this week.

Midterm 2: Thu 10-10:50 AM MLM 026
- Chapter 3
  Sections 3.1 - 3.7
  + Section 2.3 (source transformation)
- Closed book/notes
  Reference notesheet will be provided (posted)
- NO CALCULATORS
- Sample exam posted (more details later today)

Help Session Today 6-7 pm WNGR 153

Opamps
In a negative feedback arrangement \( v_n = v_p \)

KCL @ input nodes ONLY
NO KCL at the output node

Difference Amplifier
\( V_p = V_n \)

KCL @ \( V_p \)
\[ \frac{V_2 - V_p}{R_1} = \frac{V_p}{R_2} \]
\[ V_p = \frac{R_2}{R_1 + R_2} V_2 \]
(voltage division)
\[
KCL @ v_n: \quad \frac{v_1 - v_n}{R_1} = \frac{v_n - v_o}{R_2}
\]

\[
v_o = -\frac{R_2}{R_1} v_1 + \left( \frac{R_2}{R_1} + 1 \right) v_n
\]

\[
= -\frac{R_2}{R_1} v_1 + \left( \frac{R_2 + R_1}{R_1} \right) v_n
\]

Since \( v_n = v_o = \frac{R_2}{R_1 + R_2} v_2 \)

\[
v_o = -\frac{R_2}{R_1} v_1 + \left( \frac{R_2 + R_1}{R_1} \right) \frac{R_2}{R_1 + R_2} v_2
\]

\[
v_o = \frac{R_2}{R_1} (v_2 - v_1)
\]

**Example**

\[
\frac{v_o}{v_i} = -\frac{R_1}{R_1} = -\frac{50}{10} = -5
\]

\[
v_o = -\frac{60}{20} v_1 - \frac{60}{30} (-5 v_2)
\]

\[
= -3 v_1 + 10 v_2
\]
Review

- **Nodal analysis (node voltage analysis)**
  1) identify all nodes
  2) define a reference (ground) node
     specified for the exam
  3) KCL at each node in terms of node voltages
  4) Solve the equations for unknown node
     convention: current leaving a node is positive
     voltage sources:
     1) one terminal is grounded
     2) connected between two non-ground nodes

\[ V_A - V_B = V_s \]

Mesh current analysis

- Identify mesh currents
  convention: clockwise direction
- Write KVL in terms of mesh currents for each mesh
- Solve equations for mesh currents

Current sources:
  1) part of a single mesh fixes the mesh current
  2) common to two meshes

KVL for a supermesh

Superposition principle

Analyze circuit with only one independent source (repeat for each independent source)
Zero out other independent sources
\[ V_s \rightarrow \text{Short circuit (wire)} \]
\[ I_s \rightarrow \text{open circuit (break)} \]

Solve a set of simpler problems

Sum up contributions from all sources to get the final result

Source transformation:

\[ V_s \]
\[ R \quad \Leftrightarrow \quad I_s \]
\[ V_s = I_s R \]
\[ I_s = V_s / R \]

Thevenin/Norton Equivalent Circuits

**Thevenin**

**Norton**

\[ V_{Th} = V_{\text{open-circuit across terminals } a \text{ and } b} \]

Use a circuit analysis method

**Determining** \[ R_{Th} \]

If there is no dependent source then can use the equivalent resistance method

Zero out (deactivate) all independent sources

Then use series/parallel conversions to find Req

With dependent sources

1. Short circuit method
2. External source method

1). Short terminals \( a \) and \( b \) and calculate the short circuit current \( I_{sc} \)
\[ R_{Th} = \frac{V_{Th}}{I_{SC}} \]

2) **External source method**

Zero out (deactivate) all independent sources

Dependent sources remain intact

Apply an external voltage \( V_{ex} \) and measure the external current \( I_{ex} \)

\[ R_{Th} = \frac{V_{ex}}{I_{ex}} \]

For Norton Equivalent \( R_N = R_{Th} \); \( I_N = \frac{V_{Th}}{R_{Th}} \)

Maximum power transfer

\[ R_L = R_S \]

\[ P_{max} = \frac{V_S^2}{4R_S} \]