EECS 16A Dis 12A Notes

Tuesday, November 9, 2021 5:40 PM

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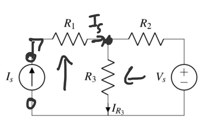
1. Superposition

Consider the following circuit:



(a) With the current source turned on and the voltage source off, find the current I_{R_3}.

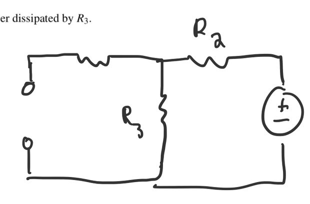
$$I_{R_3} = \frac{R_2 \cdot I_s}{R_2 + R_3}$$

(b) With the voltage source turned on and the current source turned off, find the voltage drop across R_3, V_{R_3}.

$$V_{R_3} = \frac{R_3 \cdot V_s}{R_2 + R_3}$$

(c) Find the power dissipated by R_3.

Voltage source on, find I_{R_3}



$$I_{R_3} = \frac{V_s}{R_2 + R_3}$$

$$I_{R_3} = \frac{I_s \cdot R_2}{R_2 + R_3} + \frac{V_s}{R_2 + R_3}$$

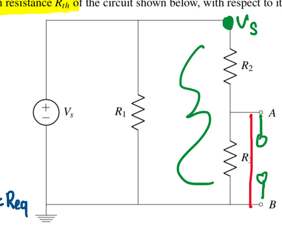
$$P = I^2 R$$

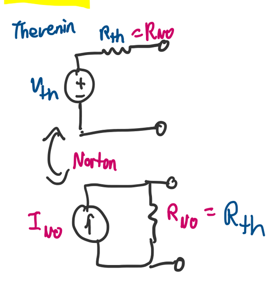
$$P_{R_3} = \left(\frac{I_s \cdot R_2}{R_2 + R_3} + \frac{V_s}{R_2 + R_3}\right)^2 \cdot R_3$$

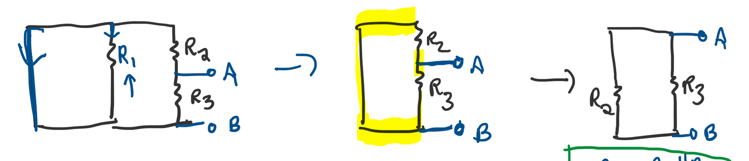
2. Thévenin/Norton Equivalence

(a) Find the Thévenin resistance R_{th} of the circuit shown below, with respect to its terminals A and B.

1. Find V_{th}.
   $V_{th} = V_{oc}$
2. Find R_{th}
   Zero out ind. sources. $R_{th} = R_{eq}$
3. Find I_{NO}
   $\frac{V_{th}}{R_{th}} = I_{NO}$
   $I_{NO} = I_{SC}$







$R_{eq} = R_2 \| R_3$

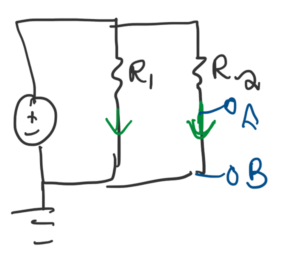
$$R_{th} = \frac{R_2 \cdot R_3}{R_2 + R_3}$$

Another way to solve for R_{th}

1. Find V_{th}

$$V_{AB} = V_{oc} = \frac{R_3}{R_2 + R_3} \cdot V_s$$

2. Find I_{NO}



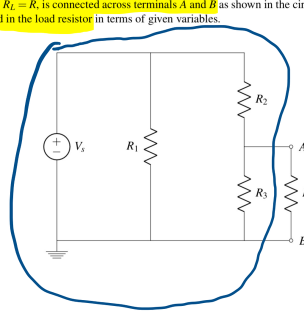
$$I_{R_2} = \frac{V_s}{R_2} = I_{SC}$$

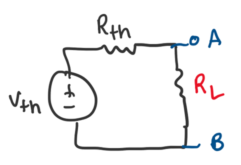
3. Find R_{th}

$$R_{th} = \frac{V_{th}}{I_{NO}} = \frac{V_s \cdot R_3}{R_2 + R_3} \cdot \left(\frac{R_2}{V_s}\right) = \frac{R_2 \cdot R_3}{R_2 + R_3}$$

(b) Now a load resistor, $R_L = R$, is connected across terminals A and B as shown in the circuit below. Find the power dissipated in the load resistor in terms of given variables.

Use thevenin circuit





$$P = IV = \frac{V^2}{R} = I^2 R = \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 \cdot R_L \quad \text{(using } I^2R\text{)}$$

$$I_{tot} = \frac{V_{th}}{R_{th} + R_L}$$

$$= \left(\frac{V_s \cdot R_3}{R_2 + R_3} \cdot \frac{1}{\frac{R_2 R_3}{R_2 + R_3} + R_L}\right)^2 \cdot R_L$$

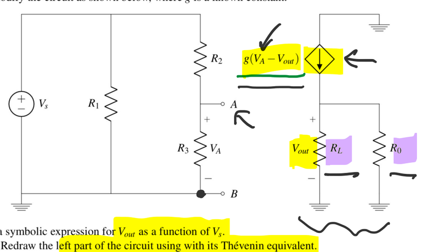
$$P = IV \text{ (using } \frac{V^2}{R}\text{)}$$

$$= \frac{V^2}{R} = \left(\frac{V_{th} \cdot R_L}{R_L + R_{th}}\right)^2 \cdot \frac{1}{R_L}$$

$$= \left(\frac{V_{th}}{R_L + R_{th}}\right)^2 \cdot R_L^2 \cdot \frac{1}{R_L} = \left(\frac{V_s \cdot R_3}{R_2 + R_3} \cdot \frac{1}{\left(R_L + \frac{R_2 R_3}{R_2 + R_3}\right)^2}\right)^2 \cdot R_L$$

Same power

(c) We modify the circuit as shown below, where g is a known constant:



Find a symbolic expression for V_{out} as a function of V_s.
Hint: Redraw the left part of the circuit using with its Thévenin equivalent.

$$I_{R_L} + I_{R_0} = g(V_A - V_{out})$$

$$V_A - V_B = V_A = V_{AB} = V_{th}$$

$$V_A = V_{th} = \frac{V_s \cdot R_3}{R_2 + R_3}$$

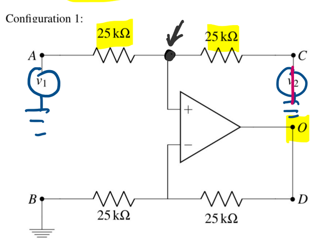
$$V_{out} = g\left(\frac{V_s \cdot R_3}{R_2 + R_3} - V_{out}\right)(R_L \| R_0) = \frac{R_3}{R_2 + R_3} \cdot V_s \cdot \frac{g R_L \| R_0}{1 + g R_L \| R_0}$$

I_{Req} R_{eq}

3. A Versatile Opamp Circuit

For each subpart, determine the voltage at O.

(a) Configuration 1:



Superposition: independent
Zero out all sources, turn on 1 at a time

$v^+ = v^-$

v_2 is turned on:

$$v^+ = \frac{v_2 \cdot 25k\Omega}{25k\Omega + 25k\Omega} = \frac{1}{2} v_2$$

$$v^- = \frac{1}{2} \cdot v_0$$

$v_0 = v_2$

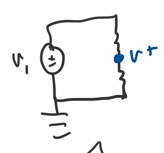
v_1 turned on:

$v^+ = \frac{1}{2} v_1$

$v^- = \frac{1}{2} v_0$

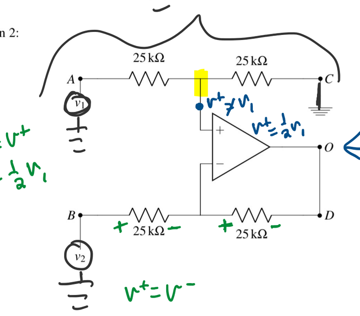
$v_0 = v_1$

$$v_0 = v_2 + v_1$$



$$v^+ = \frac{v_1 \cdot 25k\Omega}{50k\Omega}$$

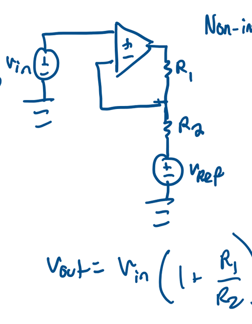
(b) Configuration 2:



$v^- = v^+$

$v^+ = \frac{1}{2} v_1$

$v^+ = v^-$



Non-inverting amplifier

$v_{in} = \frac{1}{2} v_1$

$v_{ref} = v_2$

$R_1 = R_2$

$$v_{out} = v_{in}\left(1 + \frac{R_1}{R_2}\right) - v_{ref}\left(\frac{R_1}{R_2}\right)$$

$$v^+ = \frac{1}{2} v_1$$

Using non-inverting amplifier,

$$v_{out} = \frac{1}{2} v_1 \left(1 + \frac{25k}{25k}\right) - v_2\left(\frac{25k}{25k}\right)$$

$$= v_1 - v_2$$

Alternative method

$$\frac{v_2 - v^-}{25k\Omega} = \frac{v^- - v_0}{25k\Omega}$$

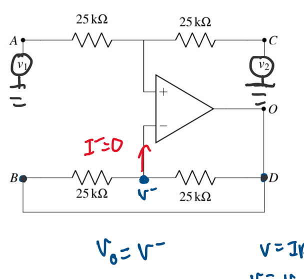
$v_2 + v_0 = 2v^-$

$v_2 + v_0 = 2 \cdot \frac{1}{2} v_1$

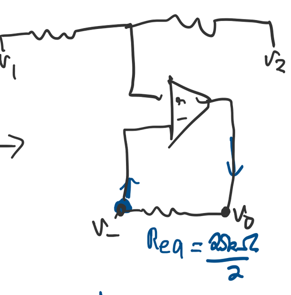
$$v_0 = v_1 - v_2$$

(c) Configuration 3:

The 25kΩ re



the 25kΩ resistors are in parallel



$R_{eq} = \frac{25k\Omega}{2}$

$v_0 = v^-$

$v^- = v^+$

$$v^+ = \frac{v_1 + v_2}{2}$$

$$V_0 = \frac{v_1 + v_2}{2}$$

$v = IR$

$v^- - v_D = IR = 0$

$v^- = v_D = v_0$

No current going through R_{eq} since $I^- = 0$

$$v^- = v_0$$

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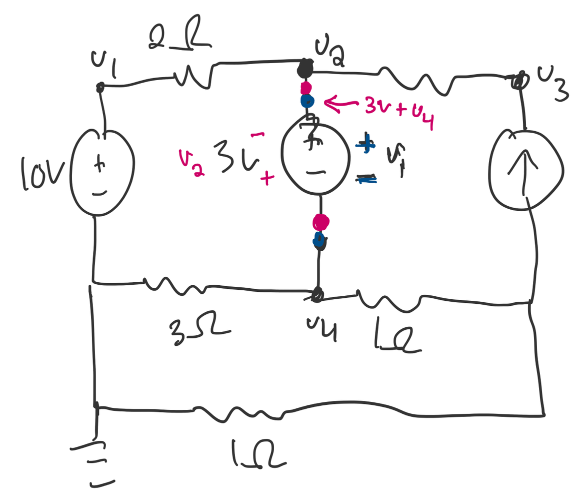
$u_2 = u_4 + 3V = 6V$

$u_4 = 3V$



$v_2 = -v_s$

$v_1 = u_2 - u_4$

$3V = u_2 - 3V$

$u_2 = 6V$

$v_2 = u_4 - u_2$

$v_2 = -v_s$

$= -3V$

$-3V = 3V - u_2$

$u_2 = 6V$