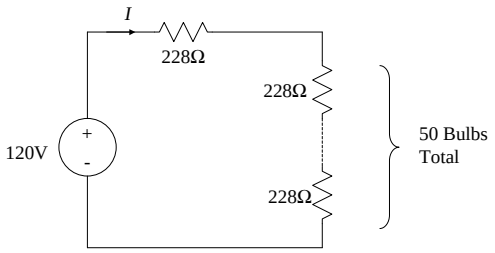
Single Loop Circuits and Voltage Division

Single Loop Circuit

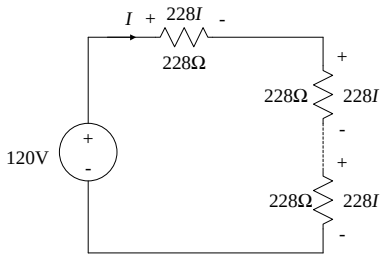
- A single loop circuit is one which has only a single loop.
- The same current flows through each element of the circuit-the elements are in series.
- We will consider circuits consisting of voltage sources and resistors.

Example: Christmas Lights



Solve for *I*

- The same current *I* flows through the source and each light bulb-how do you know this?
- In terms of *I*, what is the voltage across each resistor? Make sure you get the polarity right!
- To solve for *I*, apply KVL around the loop.



$228I + 228I + \ldots + 228I - 120V = 0$

$I = 120V/(50 \times 228\Omega) = 10.5mA$

Some Comments

- We can solve for the voltage across each light bulb:

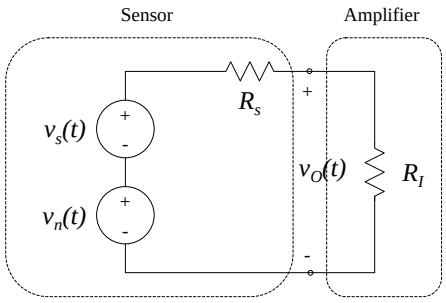
  $V = IR = 10.5mA\ 228\Omega = 2.4V$

- This circuit has one source and several resistors. The current is:

  Source voltage/sum of resistances

  (Series resistances sum)

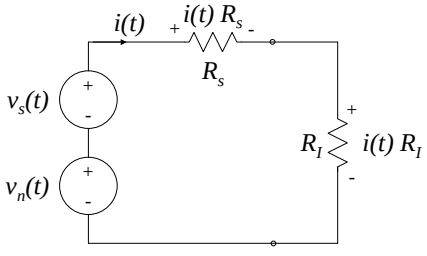
Example: Instrumentation



How to Find $v_O(t)$

- Assign a current *i(t).*
- Assign voltages across the two resistors.
- Use Ohm's law to express the voltages in terms of the current.
- Use KVL around the loop to get an equation for *i(t).*
- Use Ohm's law to compute $v_O(t)$.

How to Find $v_O(t)$



How to Find $v_O(t)$

- Apply KVL around the loop:

  $i(t)\,R_S + i(t)\,R_I - v_s(t) - v_n(t) = 0$

- Solve for $i(t)$:

$$i(t) = \frac{v_s(t) + v_n(t)}{R_S + R_I}$$

How to Find $v_O(t)$

- Use Ohm's law:

$$v_O(t) = R_I i(t) = [v_s(t) + v_n(t)]\frac{R_I}{R_S + R_I}$$

Some Comments

- The current $i(t)$ is:

  sum of voltage sources/sum of resistors

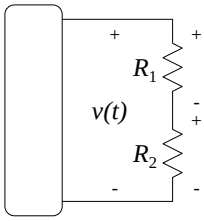
- This approach works for any single loop circuit with voltage sources and resistors.

Amplifier Input Resistance

- If R_I is small relative to R_S, what happens to $v_O(t)$?
- If R_I is large relative to R_S, what happens to $v_O(t)$?
- Which condition is preferable, and why?

Voltage Division

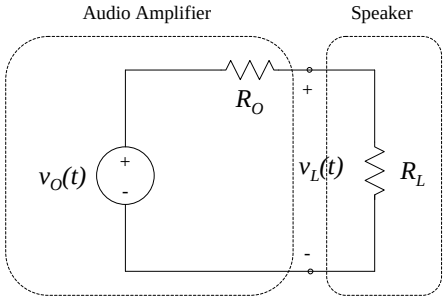
Consider two resistors **in series** with a voltage v(t) across them:



$$v_1(t) = v(t)\frac{R_1}{R_1 + R_2}$$

$$v_2(t) = v(t)\frac{R_2}{R_1 + R_2}$$

Example: Audio Amplifier



Example: Audio Amplifier

- Find $v_L(t)$ for the following values:

$v_O(t) = 5\text{V}$

$R_O = 6\Omega$

$R_L = 4\Omega$

Example: Audio Amplifier

$$v_L(t) = v_O(t)\frac{R_L}{R_O + R_L}$$

$$v_L(t) = 5\text{V}\frac{4\Omega}{4\Omega + 6\Omega} = 2\text{V}$$

Let $R_O = 4\Omega$ and $v_O(t) = 5\text{V}$
Compute the power dissipated in R_L for each of the following values for R_L. Which gives the highest dissipated power?

1Ω, 2Ω, 3Ω, 4Ω,
5Ω, 6Ω, 7Ω, 8Ω

Suppose you have three resistors (R_1, R_2, and R_3) in series with a voltage $v(t)$ across the series combination. What is the voltage $v_1(t)$ across R_1?

Use voltage division to compute the voltage across a Christmas light bulb in a string of 50 identical bulbs. Assume an outlet voltage of 120V.