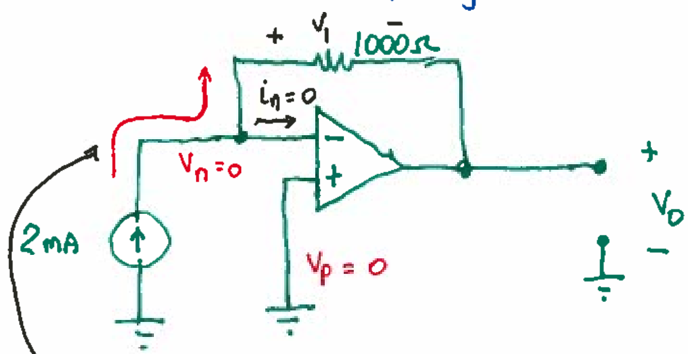
Wednesday, March 1, 2016

Example 2: Find V_o in the following



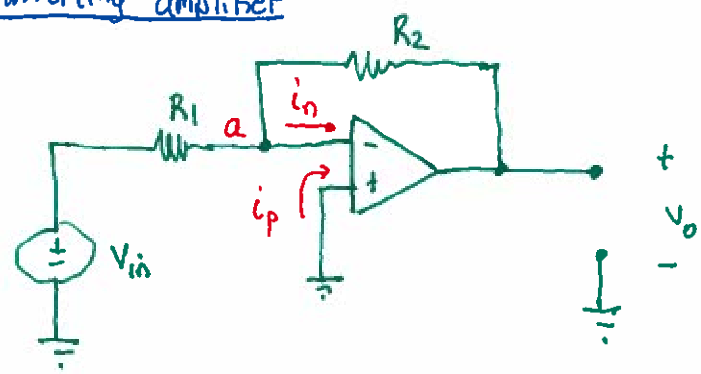
current diverted by op-amp input (since $i_n = 0$, virtual open-circuit)

So $V_1 = 2\text{ mA} \times 1000$
$= 2V$

And $V_1 = V_n - V_o$
so $V_o = 0 - V_1$
$= -2V$

There are many interesting and useful circuits that can be made. Simplest among them are some basic amplifier configurations.

The inverting amplifier



Let's demonstrate perhaps the easiest way to analyze op-amp problems.

Tip 1: All the interesting stuff happens at the op-amp input terminals. Usually start there.

Tip 2: Node equations at the input terminals tend to greatly simplify the job.

Tip 3: Seldom do you need to write node equations at the op-amp outputs (usually taken care of by Tip #2).

Write a node equation at a. Summing-point constraints tell us that

- $i_n = i_p = 0$
- $V_a = 0$ (since V_d across input terminals is zero).

Node a: $$\frac{V_a - V_{in}}{R_1} + \frac{V_a - V_o}{R_2} + \cancel{i_n}^{\,0} = 0$$

And we know $V_a = 0$, so

$$\frac{0 - V_{in}}{R_1} + \frac{0 - V_o}{R_2} = 0$$

$$\frac{V_o}{R_2} = -\frac{V_{in}}{R_1}$$

$$\text{so} \quad V_o = -\frac{R_2}{R_1} V_{in}$$

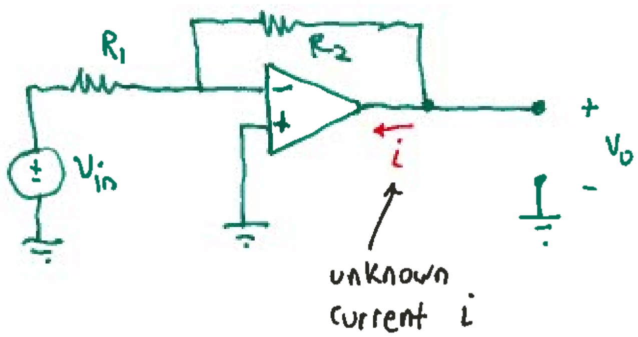
which may be written as

$$A_V = \frac{V_o}{V_{in}} = -\frac{R_2}{R_1}$$

closed-loop gain

negative implies "inverting" amplifier

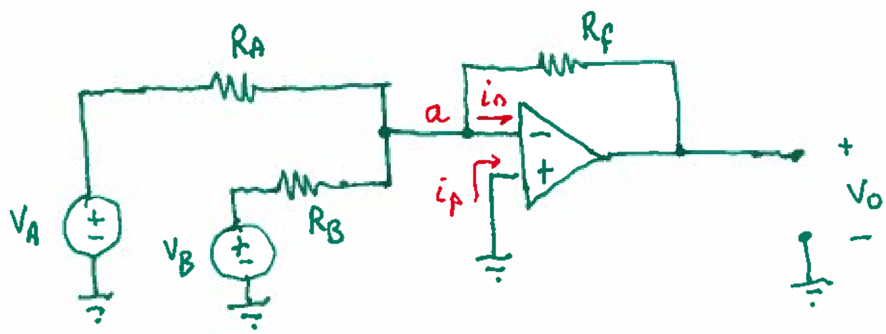
Why didn't we write an equation at node V_o.



$$\frac{V_o - V_a}{R_2} + i = 0$$

Most people forget this! - if we need i, then this is the equation to use.

Another useful inverting amplifier circuit



As before, we can write a node equation at node a.

$$\frac{V_a - V_A}{R_A} + \frac{V_a - V_B}{R_B} + \cancel{i_n}^{\,0} + \frac{V_a - V_o}{R_f} = 0$$

The op-amp imposes $V_a = 0$, $i_n = i_p = 0$, so find V_o.

$$\frac{0 - V_A}{R_A} + \frac{0 - V_B}{R_B} + \frac{0 - V_o}{R_f} = 0$$

$$\frac{V_o}{R_f} = -\frac{V_A}{R_A} - \frac{V_B}{R_B}$$

$$\text{so } V_o = -\frac{R_f}{R_A} V_A - \frac{R_f}{R_B} V_B$$

If we choose $R_A = R_B = R$, $V_o = -\frac{R_f}{R}(V_A + V_B)$

This is an inverting summing amplifier (e.g., part of an audio mixing circuit)

The non-inverting amplifier