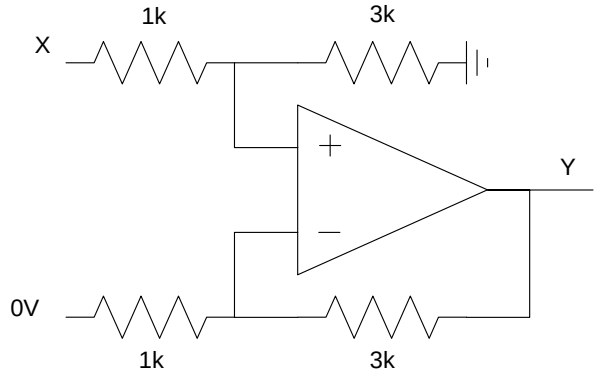
ECE 321 - Homework #1

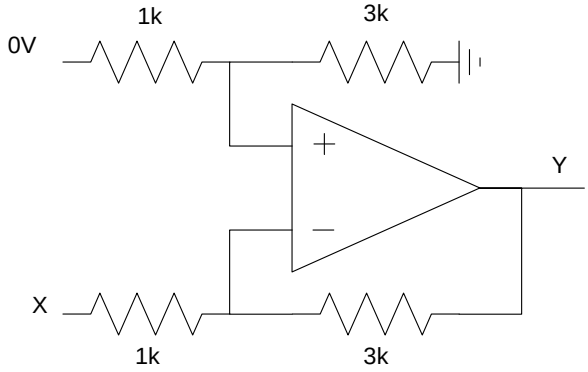
Instrumentation Amplifiers, Push-Pull Amplifiers. Due Monday, November 6th, 2017

1) Design a circuit to imlement the function

a) $Y = 3X$

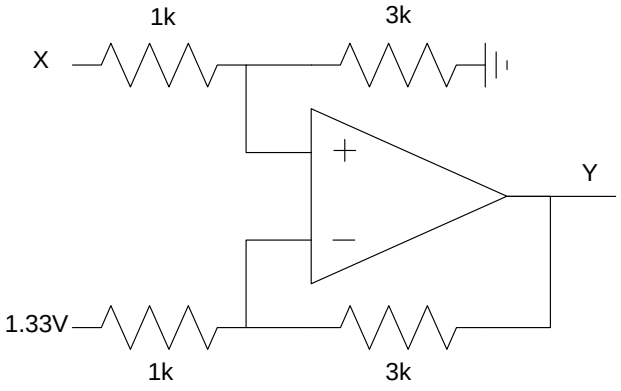


b) $Y = -3X$



c) $Y = 3X - 4$

$Y = 3\left(X - \frac{4}{3}\right)$



2) An A/D converter on a microcontroller requires a 0..5V signal. Design a circuit which converts -10V..+10V to 0..5V.

Simplest is to use three resistors. The function you're trying to implement is

$$Y = \frac{1}{4}X + 2.5$$

Assume you have a +10V source available. This is also

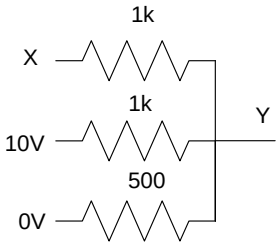
$$Y = \frac{1}{4} \cdot X + \frac{1}{4} \cdot 10V$$

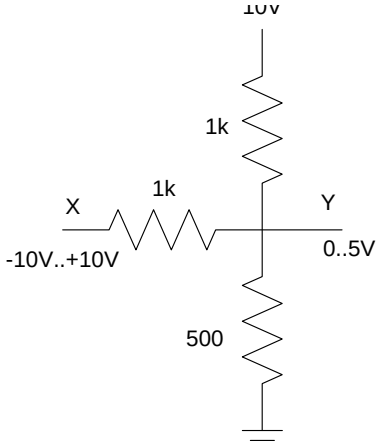
For a resistor circuit, it takes a weighted averave. For this to work, the sum of the numerator terms must match the denomionator terms. Rewrite this as

$$Y = \frac{1}{4} \cdot X + \frac{1}{4} \cdot 10V + \frac{2}{4} \cdot 0V$$

This is a weighted average with

- X = weight 1
- 10V = weight 1
- 0V = weight 2

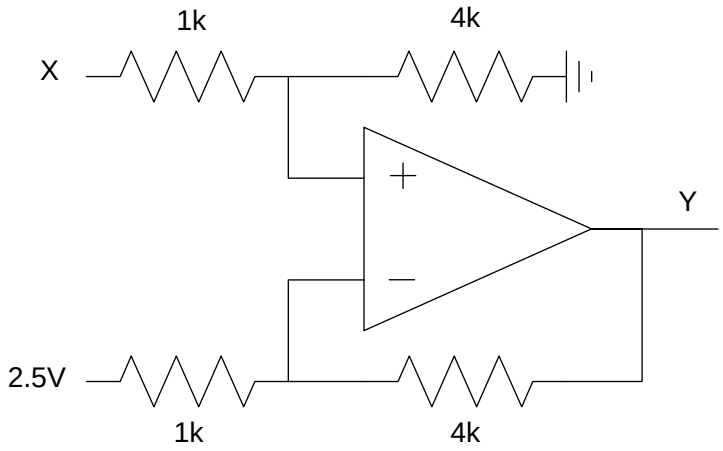




3) The output of a D/A converter is 0..5V. Design a circuit to convert this to -10V..+10V

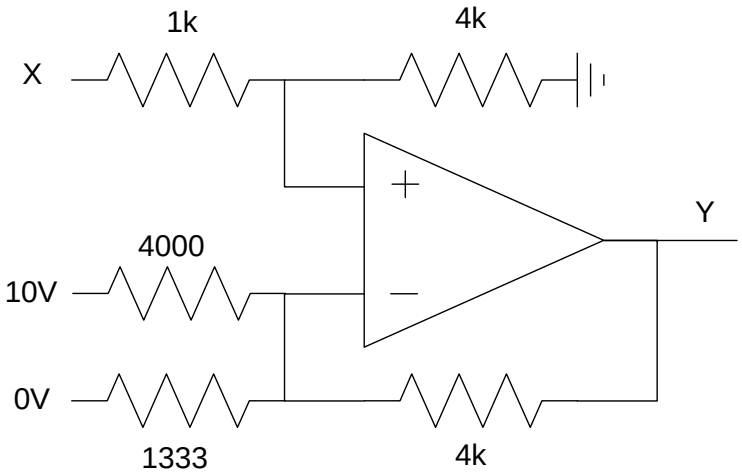
$$Y = 4X - 10$$

$$Y = 4(X - 2.5)$$



Note: If you don't have a 2.5V source available, create it using Thevenin equivalents:

- Vth = 2.5V
- Rth = 1k



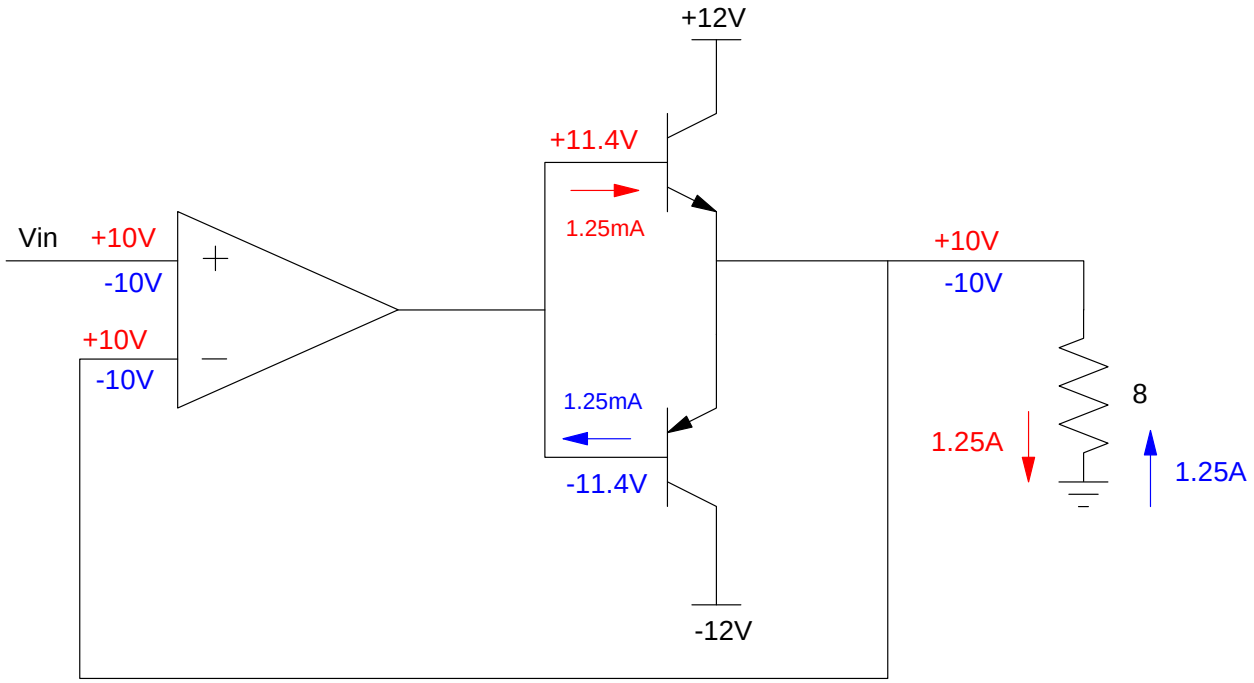
Requirements:

- Input: -10V .. +10V capable of 20mA
- Output: 8 Ohm speaker
- Relationship: Y = X
- Tolerance: Y = X +/- 0.2V

4) Analysis: Design a push-pull amplifier which meets the above requirements. Compute the voltages and currents at

- Vin = -10V DC
- Vin = +10V DC
- Vin = +1V DC

(check the two endpoints and one or two points inbetween)



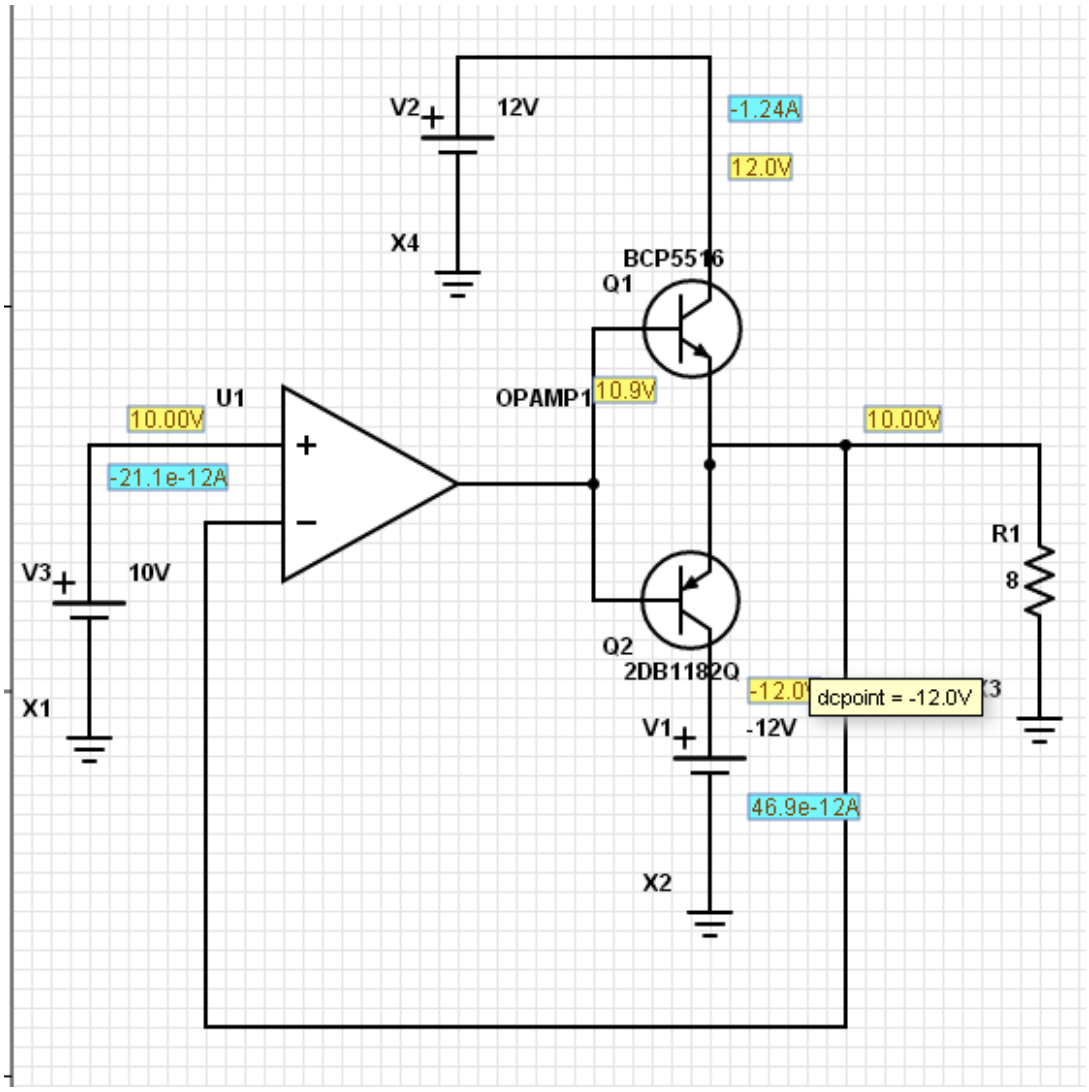
5) Simulation: Check your analysis using PartSim. Verify its operation at

- Vin = -10V DC
- Vin = +10V DC
- Vin = +1V DC

Using a Diodes Inc Medium Power transistor to represent the TIP112 and TIP117, at +10V

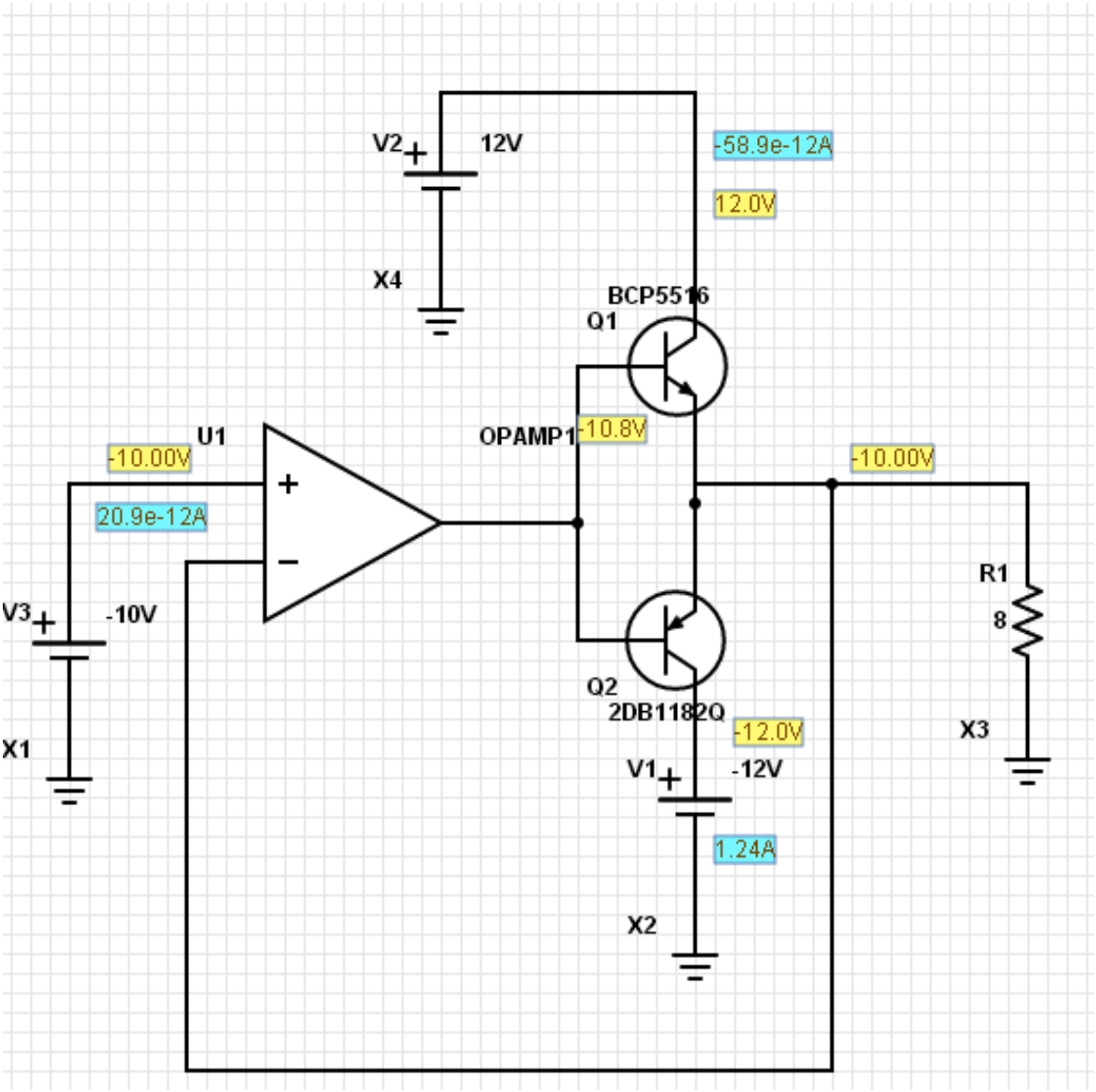
Vin = +10V

- The NPN is supplying 1.24A
- The PNP is off (6pA)
- The base voltage is 10.8V (vs. 11.4V different since the simulation transistor isn't a Darlington pair
- The output is +10V



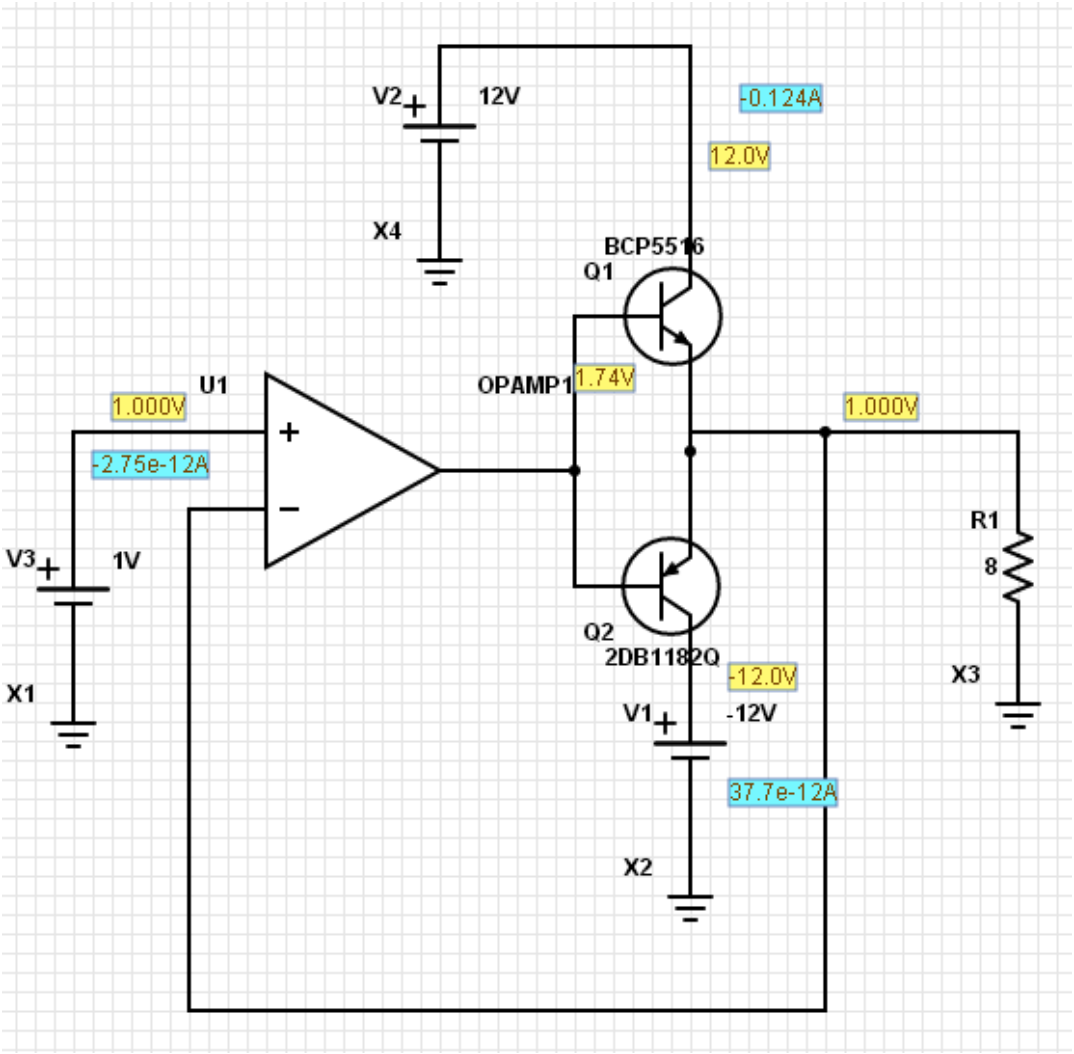
Vin = -10V

- The PNP is sinking (pulling) 1.24A
- The NPN is off (58pA)
- The base voltage is -10.8V (vs. -11.4V different since the simulation transistor isn't a Darlington pair
- The output is -10V



Vin = +1V

- The NPN is supplying 0.124A
- The PNP is off (37pA)
- The base voltage is 1.74V (vs. 2.4V different since the simulation transistor isn't a Darlington pair
- The output is +1.00V



The simulation matches up with my calculations except for the base voltage. This is due to the simultionusing a single power transistor rather than a Darlington pair.

	Vin = +10V		Vin = +1V		Vin = -10V	
	Vb	Vout	Vb	Vout	Vb	Vout
Calculated	11.4V	10.00V	2.4V	1.00V	-11.4V	-10.00V
Simulated	10.8V	10.00V	1.74V	1.00V	-10.8V	-10.00V

6) Validation: Build the push-pull amplifier and verify its operation at

- Vin = -10V DC
- Vin = +10V DC
- Vin = +1V DC

	Vin = +10V		Vin = +1V		Vin = -10V	
	Vb	Vout	Vb	Vout	Vb	Vout
Calculated	11.4V	10.00V	2.4V	1.00V	-11.4V	-10.00V
Simulated	10.8V	10.00V	1.74V	1.00V	-10.8V	-10.00V
Measured						

Note: Save your circuits. We'll be using them in the following weeks.