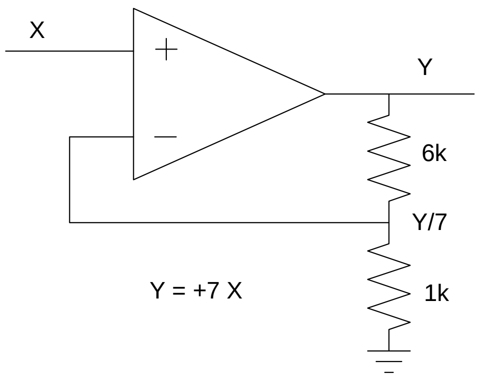
ECE 321 - Homework #1

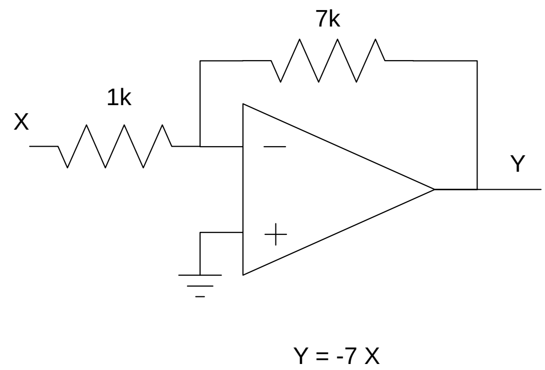
Op-Amp Amplifiers, Push-Pull Amplifiers. Due Monday April 3, 2017

1) Design an op-amp amplifier to implement the following functions:

a) $y = 7x$

b) $y = -7x$

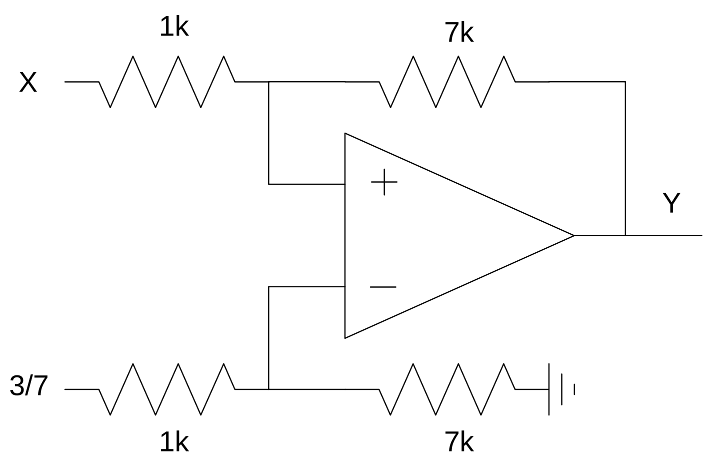




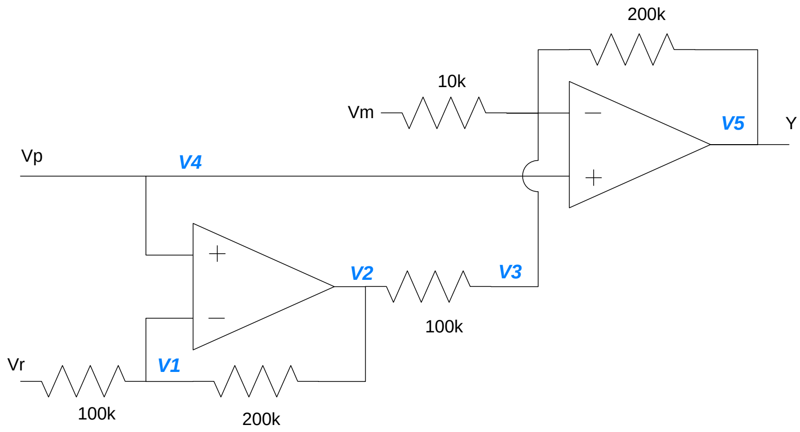
c) $y = 7x - 3$

Rewrite as

$$y = 7\left(x - \tfrac{3}{7}\right)$$



2) Write N equations to solve for N unknown voltage nodes. Assume ideal op-amps.



There are 5 voltage nodes, so you need 5 equations to solve for 5 unknowns. Start with the outputs of the op-amps

V2:

$$V_1 = V_4$$

V5:

$$V_3 = V_4$$

Now write the other three equations

V1

$$\left(\frac{V_1 - V_r}{100k}\right) + \left(\frac{V_1 - V_2}{200k}\right) = 0$$

V3:

$$\left(\frac{V_3 - V_2}{100k}\right) + \left(\frac{V_3 - V_m}{10k}\right) + \left(\frac{V_3 - V_5}{200k}\right) = 0$$

V4:

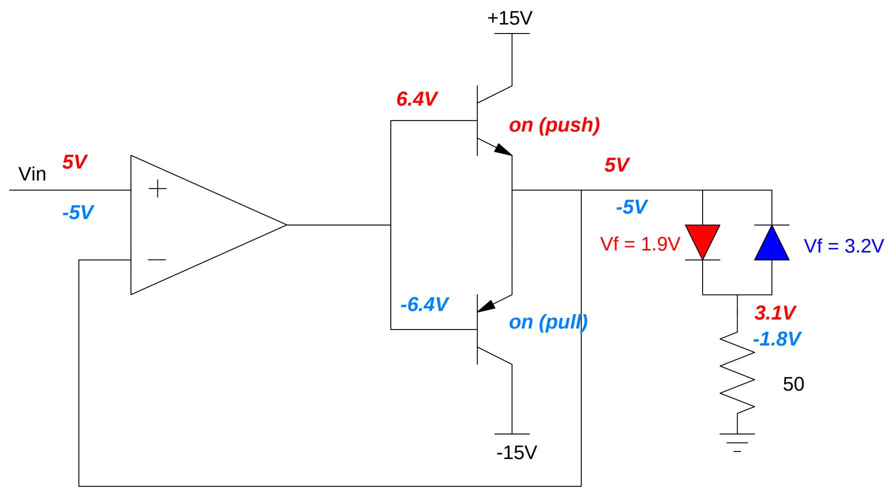
$$V_4 = V_p$$

3: Push-Pull Amplifier (voltage output): Find the voltages for the following push-pull amplifier when

- a) Vin = +5V
- b) Vin = -5V

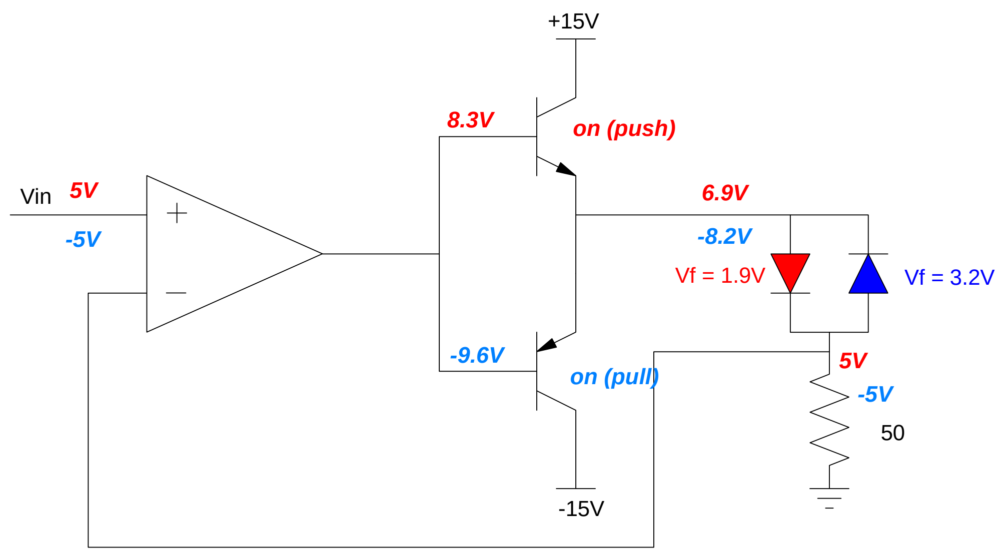
Assume the transistors are Darlington pairs (TIP)

- $\beta = 1000$
- $|V_{be}| = 1.4V$
- $|V_{ce:sat}| = 0.9V$



4: Push Pull Amplifier (Current Output): Find the voltages for the following push-pull amplifier when

- a) Vin = +5V
- b) Vin = -5V



Design a push-pull amplifier

5) Requirements: Speficy the

Input:

- -5V to +5V analog,
- capable of 10mA,

Output:

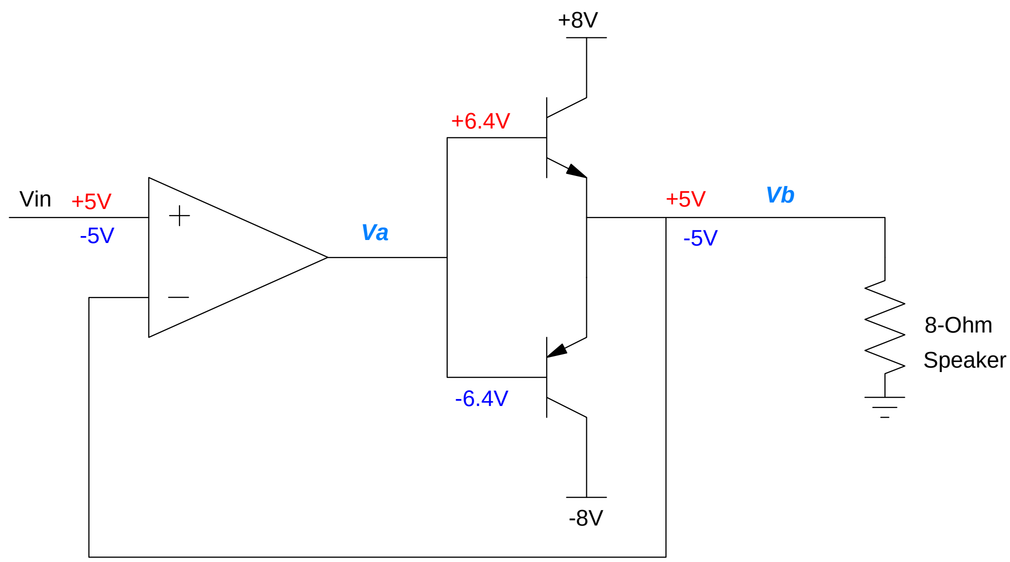
- 8 Ohm speaker

Relationship

- $y = x$,
- $\pm 200mV$ (current = voltage / 50, Vout = Vin)

6) Analysis:

- Since the tolerance is 200mV, you need to use an op-amp to remove the crossover distortion.
- At the extremes (+/- 5V), you need at least +/- 6.4V to power this circuit. Let the power supply be +/- 8V
- The input current is the current into an op-amp (ideally zero - less than 10mA in any case)
- The output current will be 5V / 8 Ohms = 625mA . Pick transistors capable of 625mA (TIP 112 and TIP 117)

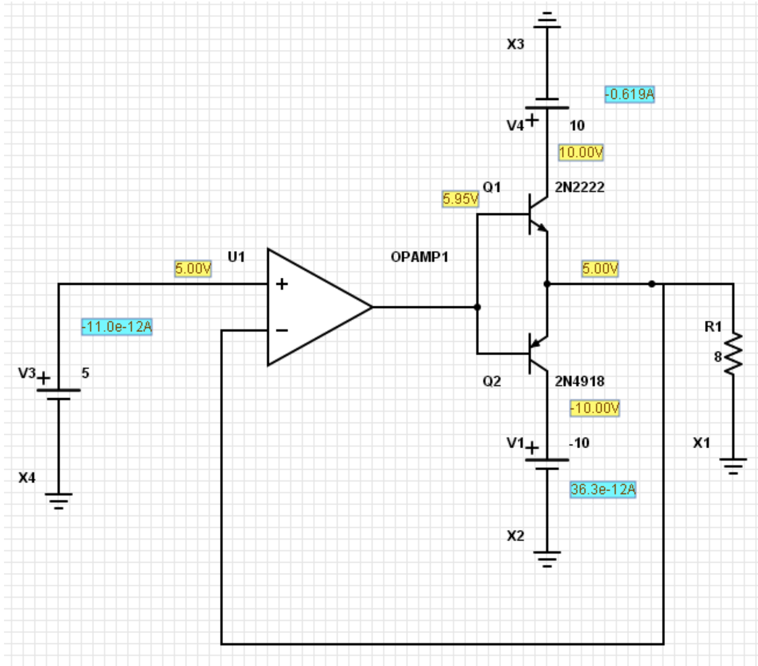


Vin	Va			Vb (Output)		
	Calculation problem 6	Simulation problem 7	Lab problem 8	Calculation problem 6	Simulation problem 7	Lab problem 8
+5V	+6.4V	+5.95V	+6.37V	+5V	+5.00V	+4.95V
+1V	+2.4V	+1.92V	+2.24V	+1V	+1.00V	+0.98V
-5V	-6.4V	-5.58V	-6.27V	-5V	-5.00V	-4.96V

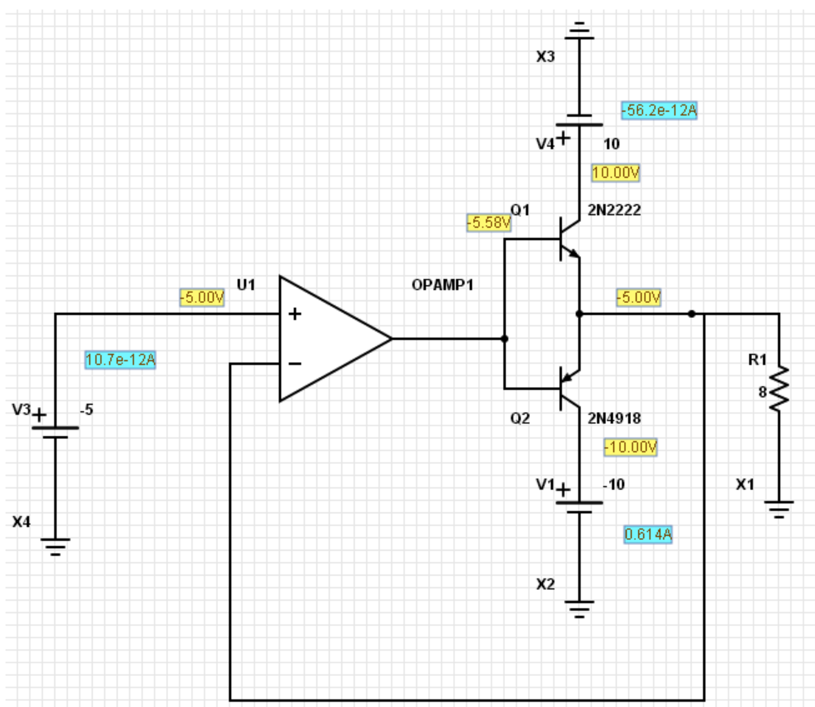
The calculated, simulate, and measured (lab) voltage at the output (Vb) all agree within 100mV - verifying our design.

Va is off for the simulation since the transistor we used is a Darlington pair where the simulation used a single transistor.

7) Simulation: Test your design in simulation via PartSim or similar program



PartSim Simulation for Vin = +5V. NPN = on, PNP = off (push)
Voltages match calculations except for Vb. This is a single transistor (Vbe = 0.7V) instead of a Darlington pair



PartSim Simulation for Vin = -5V. NPN = off, PNP = on (pull)
Voltages match calculations except for Vb. This is a single transistor (Vbe = 0.7V) instead of a Darlington pair

8) Validation: Build your circuit in lab. Collect data to verify your analysis and simulation results.