

ECE 321 - Homework #1

Op Amp Amplifiers, Push-Pull Amplifiers. Due Monday, November 9th

Please make the subject "ECE 321 HW#1" if submitting homework electronically to Jacob_Glower@yahoo.com (or on blackboard)

For all problems, assume you are using

- MCP602 Op Amps (max current = 50mA)
- KSD880YTU transistors (from Digikey)
 - $\beta = 100$
 - $|V_{be}| = 0.7V$
 - 3A max current
- 3904 (NPN) 3906 (PNP) transistors
 - $\beta = 200$
 - $|V_{be}| = 0.7V$
 - 200mA max current

Amplifier:

Design a circuit to implement

- 1a) $Y = +4X$
- 1b) $Y = -4X$
- 1c) $Y = 15 - 10X$

Mixer

2) Design a circuit to mix three signals together:

- $Y = 2A + 4B + 7C$

Push-Pull Amplifier

3) Design a circuit so that $Y = X$

- $X = -5V$ to $+5V$, 10mA max
- $Y = -5V$ to $+5V$, 200mA (25 ohm speaker (net))

4) Simulate in CircuitLab

Lab (Hardware)

The following circuit

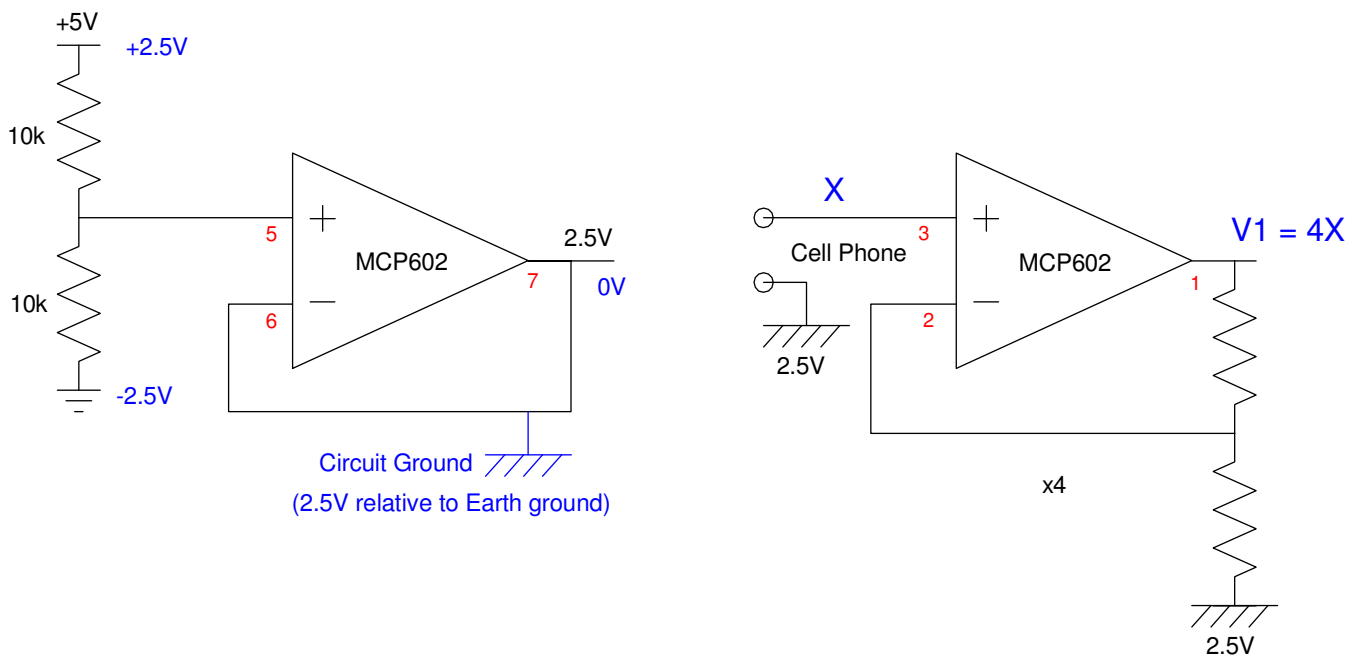
- a) Creates a 2.5V power supply from a single +5V supply. This 2.5V supply then acts like circuit ground
 - +5V behaves like +2.5V relative to circuit ground (2.5V)
 - +2.5V behaves like 0V
 - +0V behaves like -2.5V relative to circuit ground (2.5V)
- b) Amplifies the output of a cell phone (or computer or 555 timer)
 - V1 is 4X
 - Riding on a 2.5V offset (centered on circuit ground)

If you would like to modify this circuit to mix two (or more) audio signals, feel free to do so.

5) Simulate this circuit in CircuitLab with X being a 1Vpp 1kHz sine wave

6) Build this circuit in hardware

- Verify that $Y = 4X$ (use a volt meter with an AC measurement for X and V1)
- Verify that you can hear the voltage at V1 if you connect a speaker to V1 through a 100 Ohm resistor (2V @ 100 Ohms = 20mA, meaning you don't over-load the op-amp)



The output of the first op-amp serves as circuit ground for the rest of the circuit. X is 1Vpp sine wave centered on 2.5V

A class-A amplifier (push-only) is shown below.

- The 2.5V source from problem #4 is only capable of sourcing & sinking 25mA, meaning we can't use it as the speaker ground. The speaker requires too much current.
- If instead we use the power supply ground (shown below), we are always driving the speaker (current is always positive).
- This results in a push-only type amplifier (the PNP (pull) transistor will never turn on, so it's eliminated)

7) Compute the voltage and currents when

- $V_1 = +3.5V$ (+1V relative to 2.5V circuit ground)
- $V_1 = +2.5V$ (+0V relative to 2.5V circuit ground)
- $V_1 = +1.5V$ (-1V relative to 2.5V circuit ground);

8) Simulate this circuit in CircuitLab with

- V_1 being a DC signal {3.5V, 2.5V, 1.5V}
- V_1 being a 1kHz 1Vpp sine wave centered at 2.5V

9) Build this circuit in hardware and verify it does work correctly

- $V_3 = V_1$ when V_1 is a DC signal {3.5V, 2.5V, 1.5V}
- The tune from your cell phone plays on the speaker without distortion (more or less)

10) Demo. Demonstrate your cell phone amplifier really works.

