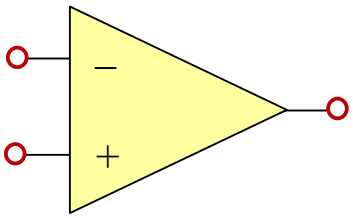
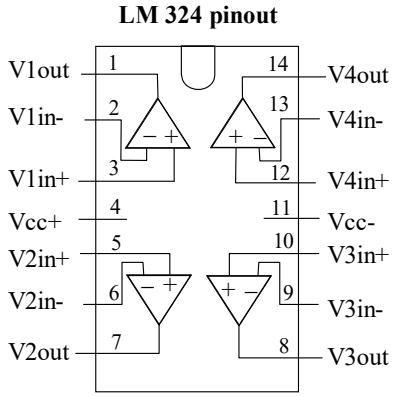
LAB 6 - OP AMPS I (2h)





Operational amplifiers (op amps) are ubiquitous in engineering. In this lab we will work with the LM 324 quad-op-amp chip (4 op amps on 1 chip). Op amps were originally developed to perform analog mathematical calculations. In this lab we will build some standard op amp circuits (e.g., voltage follower, inverting gain, voltage summer, integrator, and differentiator) and observe their output. These circuits will demonstrate the op amp's analog computing capability.

IMPORTANT - be sure to apply power (Vcc+, Vcc-) in correct polarity or else the op amp chip WILL blow up. Otherwise these IC chips are quite robust.

We will power the op amp with (+) and (-) voltage (Vcc+, Vcc-), and we must pass (+) and (–) input voltage signals. Our power supply has limited outputs so we will need to be clever about how we provide these voltages.

Periodically feel the op amp chip. Be careful - touch it quickly at first to verify it's not really hot (it could burn you). The chip should be cool or perhaps slightly warm, but not hot. If so, something is wrong. Turn off power and re-check your circuit. Also, if you start to smell a burnt-plastic or industrial burning smell, you or someone near you has blown up the IC chip. Turn off power and verify if it is you. Put your nose near the IC chip and smell. If it's yours inform the instructor and get another chip.

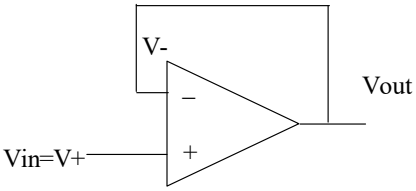
Also refer to the **CT GUIDE** on integrated circuit chips (IC chips) pin numbering.

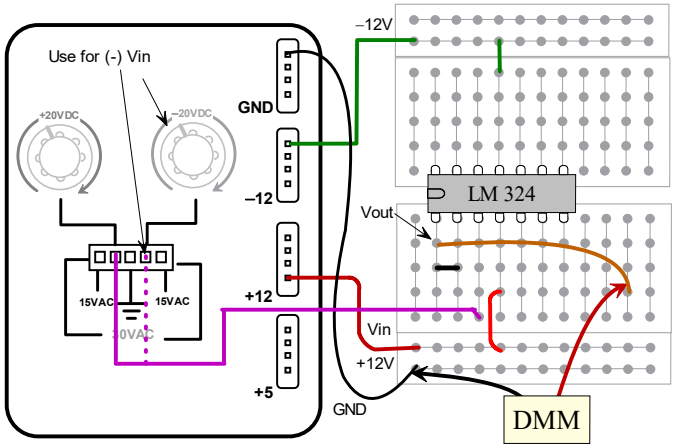
6.1 EQUIPMENT LIST

1. Trainer
2. DMM
3. Resistors, 2k (red-black-red) (x1), 1k (brown-black-red) (x1)
4. LM 324 quad op amp IC chip (suggest brand name like Texas Instruments)
5. STUDENTS BRING A USB FLASH DRIVE

(***) Verify R and C values with DMM

6.2 VOLTAGE FOLLOWER / BUFFER





One standard op amp circuit is the voltage follower (or buffer). This circuit will output the same voltage as the input voltage.

STEPS

1. Construct the circuit shown (power off). We will use op amp #1 of the 4 on the chip.
2. Verify Vcc+ and Vcc- are correct & not reversed (if reversed the chip WILL BLOW).
3. Note the "U" cutout in the given figure is on the LEFT.
4. After completing the circuit, turn trainer ON.

COLLECT DATA (use DMM)

Vary Vin.

When applying (-) voltage, you will need to switch to the (-) variable voltage output pin and adjust using the right side dial.

Measure & record Vout relative to trainer GND using DMM (connect black DMM lead to trainer GND)

Do NOT apply more than 15V (+ or –) input signal to the op amp chip.

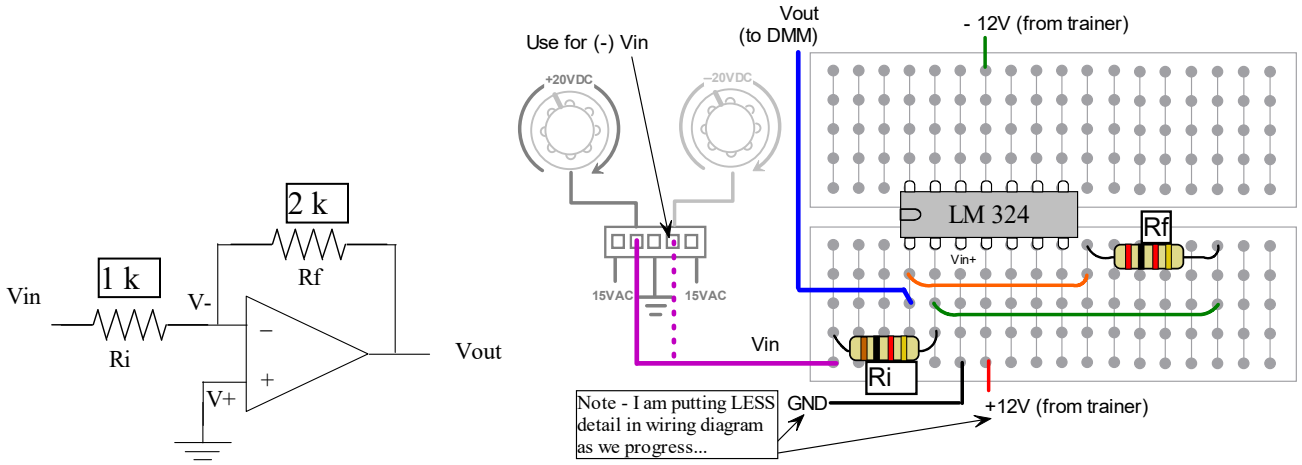
Note, op amps may experience "phase reversal" (output reverses expected sign) when saturated.

(***) Use the collected data and PLOT Vin (x-axis) vs. Vout (y-axis) (use Excel)

(***) What are the saturation levels (both (+) & (-) voltages)? (where Vout flattens out)

6.3 INVERTING GAIN

Another standard op amp circuit is the inverting gain circuit. Here the op amp will take an input voltage and multiply it by a constant. The constant will be a negative though, which means Vout will have its polarity flipped relative to Vin. By selection of the resistors we can control the gain value.



STEPS

1. Construct the circuit shown (power off).
2. NOTE - the wiring diagram is showing less detail (on purpose!). For instance, the diagram shows where to apply +12v, -12v, and GND to the chip but does not show the wires. You must figure this out yourself. As time goes on, I will provide less and less detail on wiring, and expect you to figure out the actual wiring more on your own. Eventually you should be able to construct the circuit with only the schematic provided.
3. After completing the circuit, turn trainer ON.

COLLECT DATA (use the DMM)

Vary Vin.

Measure and record Vout relative to train GND using DMM (connect black DMM lead to trainer GND)

Do NOT apply more than 15V (+ or –) input signal to the op amp chip.

When applying (-) voltage, you will need to switch to the (-) variable voltage output pin and adjust using the right side dial.

(***) Fill out the table in the answer sheet.

(***) What are the saturation levels (both (+) & (-) voltages)?

(***) What is the expected closed-loop gain?

LAB 6 - ANSWER SHEET

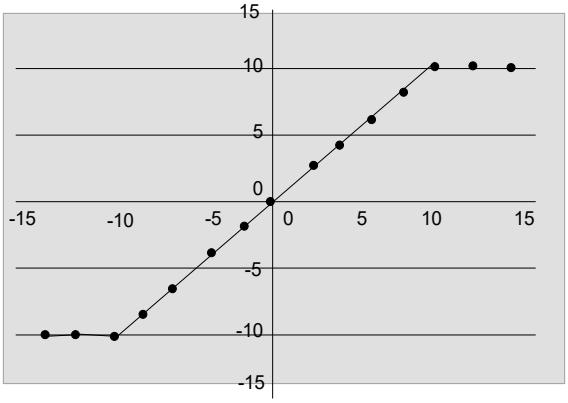
OP AMPS I

Team Number: _____

Name 1: _____ Name 2: _____

6.1 Verify component values: Rs: _____. _____.

6.2 Voltage follower/Buffer



Vin (x) vs. Vout (y)
(use Excel)

Saturation level (+ & -):_____ _____.

Vin	Vout	Vin	Vout
0	_____		
2	_____	-2	_____
4	_____	-4	_____
6	_____	-6	_____
8	_____	-8	_____
10	_____	-10	_____
12	_____	-12	_____
13	_____	-13?	_____

6.3 Inverting Gain

Saturation level (+ & -):_____ _____.
Expected closed-loop gain:_____.

Vin	Vout	Vin	Vout
0	_____		
2	_____	-2	_____
4	_____	-4	_____
5	_____	-5	_____
6	_____	-6	_____
8	_____	-8	_____