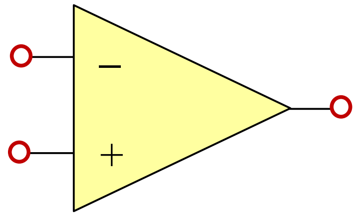
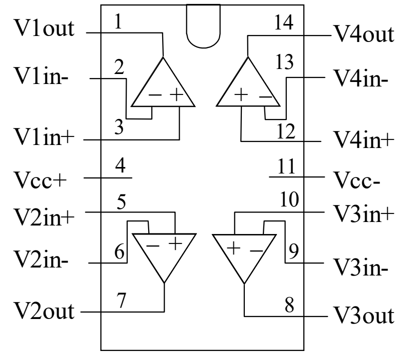
LAB 7 - OP AMPS II (1.5h)



LM 324 pinout



Let's do more exercises with op amps. Here we will create circuits that allow op amps to do various mathematical operations such as addition, differentiation, and integration.

Please use the same precautions as in the prior op amp lab. Ensure power (Vcc+, Vcc-) is applied 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 its yours inform the instructor and get another chip.

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

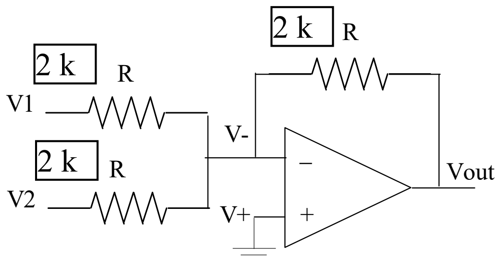
7.1 EQUIPMENT LIST

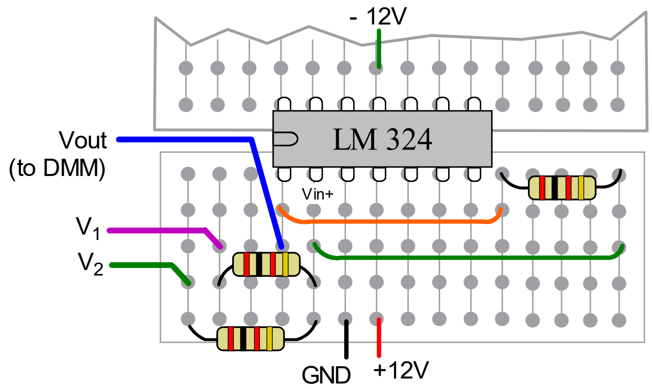
1. Trainer
2. Oscilloscope (& scope probes)
3. Function generator ("FG") (BK Precision 4011A) (+FG breakout cable)
4. DMM
5. Resistors, 2k (red-black-red) (x3), 1k (brown-black-red) (x1)
6. Capacitor, 0.1 μF
7. LM 324 quad op amp IC chip (suggest brand name like Texas Instruments)
8. STUDENTS BRING A USB FLASH DRIVE

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

7.2 VOLTAGE SUMMER

Op amps were originally designed to perform analog mathematical computations. One of them is to add. Here we will see a circuit that takes 2 analog voltage values and adds them. Like the inverting gain, the added value is inverted (Vout adds but also multiples by a negative relative to Vin).





STEPS
1. Construct the circuit shown (power off). All Rs = 2 kΩ
2. NOTE - the wiring diagram is showing less detail (on purpose!)
3. Measure output relative to trainer GND. (DMM black lead to trainer GND).
4. After completing circuit construction turn trainer ON.

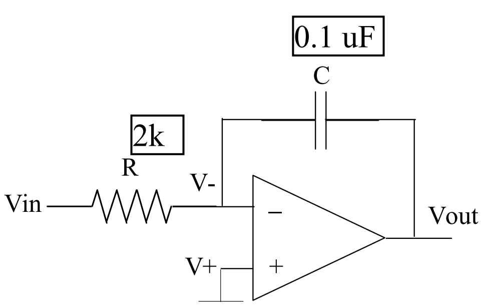
COLLECT DATA

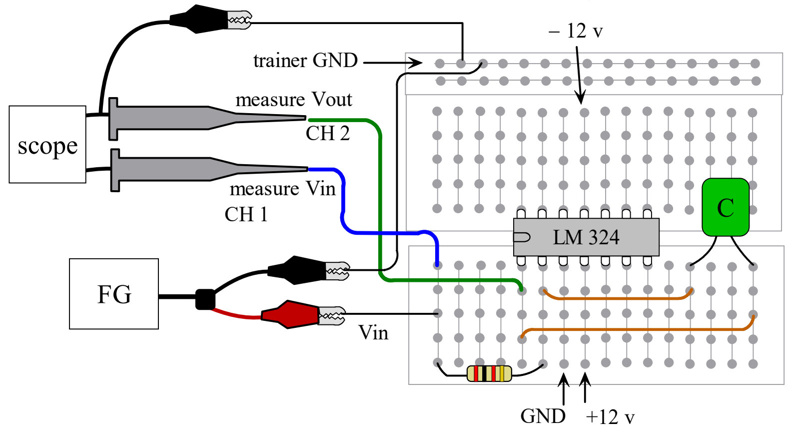
Vary V_1 & V_2 and measure and record Vout using DMM (relative to trainer GND).
Due to the limitations of the trainer power supply, we must be clever about where to get V_1 & V_2.
V_1 comes from the variable (+) supply (controlled with the left dial).
V2 comes sometimes comes from the dedicated 5V supply pin, or the (-) variable supply (controlled with right dial).

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

7.3 INTEGRATOR

Op amps can also perform calculus computations such as integration. Here Vin will be a square wave, which is like a piece-wise constant. What is the integral of a constant? So what waveform would you expect if you integrate the square wave? Note that Vout can have a DC offset unless a resistor is placed in parallel to the capacitor. In lieu of that, you can set Vout on the scope to be AC coupled to not display this DC offset.





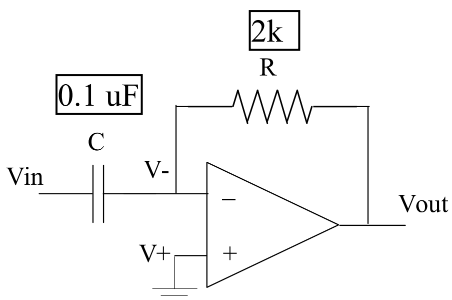
STEPS
1. Construct the circuit shown (power off). C = 0.1 uF, R = 2 k.
2. Vin is from the FG (red clip). Tie FG GND to trainer GND.
3. Vout is measured using the scope. Attach the ground clip of scope to trainer GND.

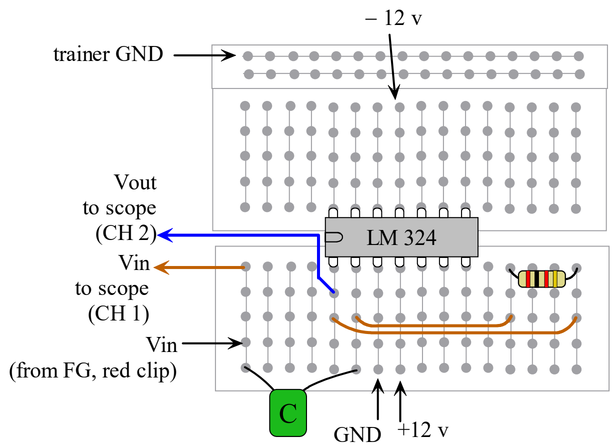
COLLECT DATA

Vin comes from the FG. Set FG to output a SQUARE wave (2 Vpp (**higher?**), f ~500 Hz, 0 offset).
You may have to press the -20 dB button on the FG.
Output will be to the scope now.
Display both Vin and Vout on the scope (CH 1 = Vin, CH 2 = Vout, both AC coupled).
Set both vertical offsets to 0. Do NOT use Autoset.
(***) Capture the trace. What was the expected output wave?

7.4 DIFFERENTIATOR

Op amps can take derivatives too. Here Vin is a triangle wave, which is a piece-wise sloped linear function. If you take a derivative of a sloped line, what is the result? That is, what waveform would you expect when differentiating a triangle wave?





STEPS

1. Construct the circuit shown (power off). C = 0.1 uF, R = 2 k
2. Vin is from the FG (red clip). Tie FG GND to trainer GND.
3. Vout is measured using the scope. Attach the ground clip of scope to trainer GND.

COLLECT DATA

Vin comes from the FG. Set FG to output a TRIANGLE wave (2 Vpp (**higher?**), f ~ 500 Hz, 0 offset).
Output will be to the scope now. Display both Vin and Vout on the scope.
Set both vertical offsets to 0. Do NOT use Autoset.
(***) Capture the trace. (what output wave was expected?)

LAB 7 - ANSWER SHEET

OP AMPS II

Team Number: ___________

Name 1: ______________________________ Name 2: ______________________________

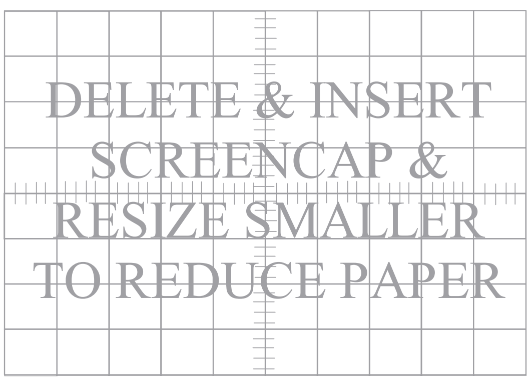
7.1 Verify component values: Rs: ______. ______. ______. ______. C:__________.

7.2 Summer

V_1	V_2	Vout (meas)	Vout (theory)
0	0	_____	_____
2	5	_____	_____
3	5	_____	_____
4	-12	_____	_____
6	-7	_____	_____
7	-9	_____	_____
8	-6	_____	_____

6.5 Integrator

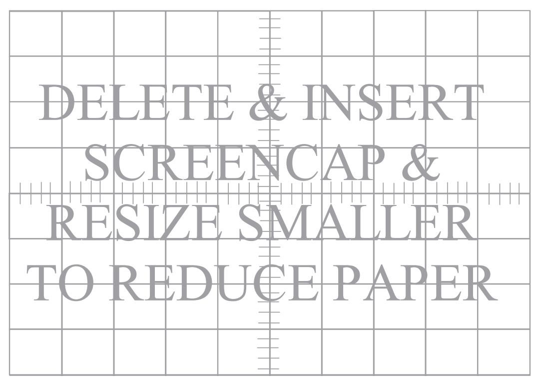
Expected output wave: ____________.



INTEGRATOR

6.6 Differentiator

Expected output wave: _____________.



DIFFERENTIATOR