

Scope:

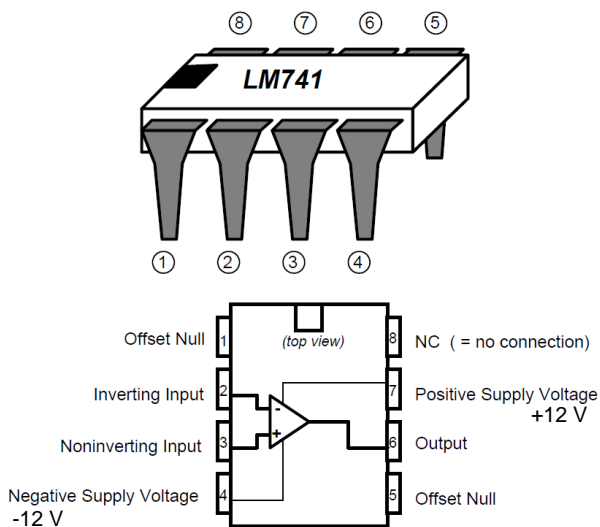
- Basic op amp circuits
- Op amp summing circuits
- Use a signal generator
- Use of oscilloscope to record signals
- Design an op amp circuit to achieve a specified goal

Fig. 7.1 shows the 8-pin DIP (dual in-line package) of a type 741 OP-AMP with its terminals labeled.

Note that there is no “ground” pin on the op amp package. The op amp’s differential inputs “float” with respect to ground.

The offset null (pins 1 and 5) will not be used in this experiment. Those pins must be left unconnected.

Fig. 7.1: Op Amp



Pre-Lab preparation:

- Review Hambley Ch 14, and EELE 250 Lab 6.
- For the circuit shown in Fig. 7.2, find V_{out} in terms of V_{in} assuming an “ideal” op amp and using the AC steady-state impedance of the resistor and the capacitor. If V_{in} is a 1 kHz sine wave signal with $1V_{p-p}$, find the amplitude of V_{out} and the phase angle between V_{in} and V_{out} .
- For the circuit shown in Fig. 7.3, Find V_{out} in terms of $V_1, V_2, V_3,$ and V_4 and fill out a table with your predictions indicated by Table 7.1.
- Design the circuit for step 6 on page 3, referring to the design hint on page 4. Fill out a table with your predictions as indicated by Table 7.2.

Laboratory Experiments:

- 1.) Using the DMM, carefully adjust the bench DC power supply to produce +12V and -12V with respect to a common ground.
- 2.) Breadboard the circuit shown in Fig. 7.2 and apply as the input signal a 1 kHz sine wave with $1 V_{p-p}$.
- 3.) Using the dual trace oscilloscope:
 - Observe and record the input and the output signal amplitudes.
 - What is the phase angle between the input and the output signals?
 - Compare your measurements to your pre-lab calculations.

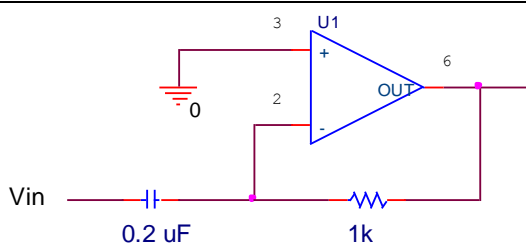


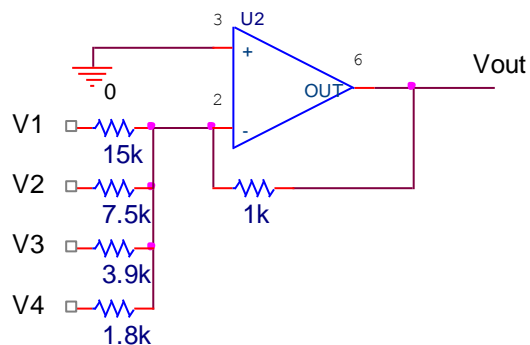
Fig. 7.2

- 4.) Breadboard the inverting summing op amp circuit shown in Figure 7.2. This circuit is a simple “digital-to-analog” converter.
- 5.) Measure the output voltage for each of the eleven input voltage combinations for V1 to V4 indicated in the table. Use the fixed 5V DC supply to provide +5V, and ground to provide 0V. Record your results.

Table 7.1

Binary “Digital” Input V ₄ V ₃ V ₂ V ₁	“1” = +5 volts “0” = 0 volts V ₄ =V ₃ =V ₂ =V ₁ =0	V _{out} Calculated [V]	V _{out} Measured [V]
0000	V ₄ =V ₃ =V ₂ =V ₁ =0		
0001	V ₁ =5V; V ₄ =V ₃ =V ₂ =0		
0010	V ₂ =5V; V ₄ =V ₃ =V ₁ =0		
0011	V ₂ =V ₁ =5V; V ₄ =V ₃ =0		
0100	...etc...		
0101			
0110			
0111			
1000			
1001			
1010			

Fig. 7.3: Inverting summer configured as a D/A converter



6.) In instrumentation circuits it is often necessary to change the voltage range of a signal.

Suppose it is known that an analog input signal varies between -3V and +3V, but we need to adjust the range of this signal so that it varies from 0 to +5V in order to meet the input range of an analog/digital converter circuit.

In other words, we need a circuit that will take an input signal in the range -3V to +3V and map it linearly to the range 0V to +5V.

PRE-LAB: Sketch a graph showing V_{out} vs. V_{in} . In other words, show the output values that correspond to the input values, e.g., when $V_{in} = -3V$, $V_{out} = 0$, and so forth.

PRE-LAB: Devise a circuit using op amps and resistors to do the analog “signal conditioning.” See the design hint on the next page to help get started.

7.) Build your circuit on the breadboard.

8.) Use the signal generator to create a 1kHz sinusoid with amplitude ± 3 volts, and using DC coupling on the oscilloscope, verify that your circuit output is a sinusoid between 0 volts and +5 volts, as required by the design. Explain your results.

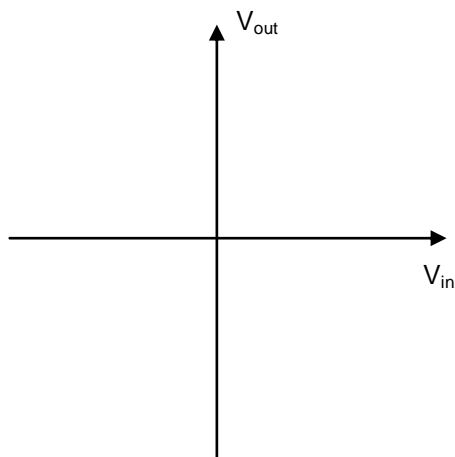


Table 7.2

V_{in}	V_{out} Calculated [V]	V_{out} Measured [V]
-3 volts		
0 volts		
+3 volts		

Op amp circuit design hint

The last part of this lab asks you to figure out a way to make a circuit that will take an input signal in the range -3 to +3 volts and adjust it to fit the range from 0 to +5 volts.

How can you get started with a problem like this?

Like most electronic designs, there are several possible circuits that can achieve the same general goal, so what you need to do is to think about what the circuit needs to accomplish, and then consider different possible ways to make the circuit do what it needs to do.

Here's one way to think about this problem.

- (1) Note that the input signal range covers 6 volts (-3V to +3V), while the output signal range covers 5 volts (0 to +5V). This means that your circuit must attenuate the signal by the factor $5/6$. Can you think of a way that you can slightly attenuate a signal? What about a voltage divider involving two resistors? What about an inverting op amp configuration with $R_2/R_1 = 5/6$?
- (2) Also note that the input signal range is centered on zero, while the output signal range is centered on 2.5 volts. This means that you will have to add a constant (DC) voltage value to the signal so that it is shifted in the positive direction. Can you think of a way to add a constant voltage to a signal? *Recall that one of the reasons operational amplifiers are named "operational" is that they can be used to do mathematical operations.* What about a "summer" circuit to add the DC offset to the signal?
- (3) From this viewpoint it seems like you could attenuate the -3V to +3V signal by $5/6$, causing it to be in the range -2.5V to +2.5V, and then add 2.5 volts to get the desired 0 to +5V range. OR you could add 3 volts to shift the signal up to the range 0 to 6V, and then attenuate by $5/6$ to get the 0 to 5V range. OR maybe there is a way you can do both the shifting and the attenuating with one op amp, or with two inverting op amps, or ...?

Consider some possibilities, and feel free to talk to your instructor, lab partner, and the Lab TA.