Name: *Roll Number:*

Q0: /2	**Q1**: /2	**Q2**: /3	**Q3**: /3	**Tot:** /10

Laboratory 1

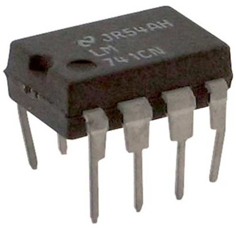
Introduction to Opamps

Objective:

In this assignment we will introduce you to the simple LM741 opamp IC. You will learn how to reliably make connections and build circuits around this IC. We will use the LM741 for many experiments during the rest of the semester, so please make sure that at the end of this lab, you are thoroughly familiar with making circuit connections to the LM741

LM741 as a voltage comparator and its characteristics

Fig 1 shows a picture and the pin diagram of the LM741



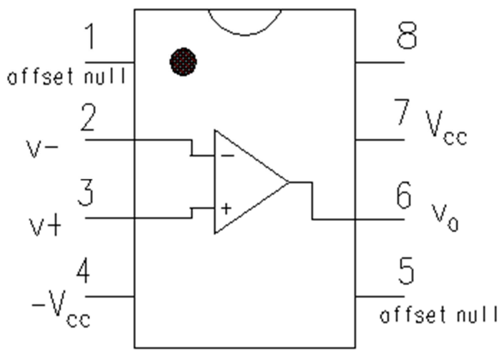
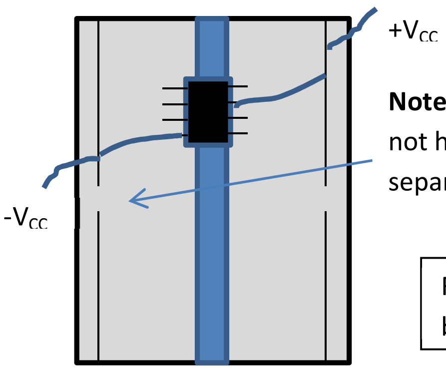


Fig 1: Picture and pinout of LM741

Note the numbering of pins as viewed from the top, with the semicircular notch facing up. You must always remember this when connecting the IC on a breadboard as shown in Fig 2



Note: two halves of the edge trace do not have a connection. You can use them separately, or jumper together

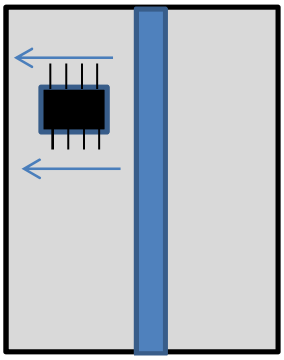


Fig 2: Connecting the LM741 on a breadboard

CORRECT: Each pin has a separate breadboard trace. $+V_{CC}$ and $-V_{CC}$ are connected along the edge traces

WRONG ! Pins 1-4 and 5-8 are shorted to each other

Connect up an LM741 as shown in Fig 2 (correctly!) Apply +12V and -12V as the $+V_{CC}$ and $-V_{CC}$ to power the IC. The COM=$(+V_{CC} – V_{CC})/2$ = 0 terminal from the power supply provides a zero reference voltage for other components in your circuit. You can connect it to one of the edge traces of your breadboard.

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Fig 3 shows the functional block diagram of the 741. The general equation governing the behavior of this circuit is $V_O = G(V_+ - V_-)$ where V_+ and V_- are the voltages at the two input terminals of the opamp, and G is a very large open-loop gain factor ~ 10^6. For today's exercise, we would like to use this functionality to compare a square wave *single-ended* signal V_{in} to a reference DC voltage V_{ref}. Every time V_{in} rises above a preset V_{ref}, V_O should immediately go to the maximum allowed value. You can use the function generator to provide V_{in} and one of the benchtop supply outputs to set V_{ref}.

Be sure to make a note in the following diagram of the signal and ground connections of the single ended input V_{in} you are applying from the front panel of the function generator. Also mark all the signal and ground connections for V_{ref} and V_{out}

For now leave the two offset null pins unconnected (we will learn their use later)

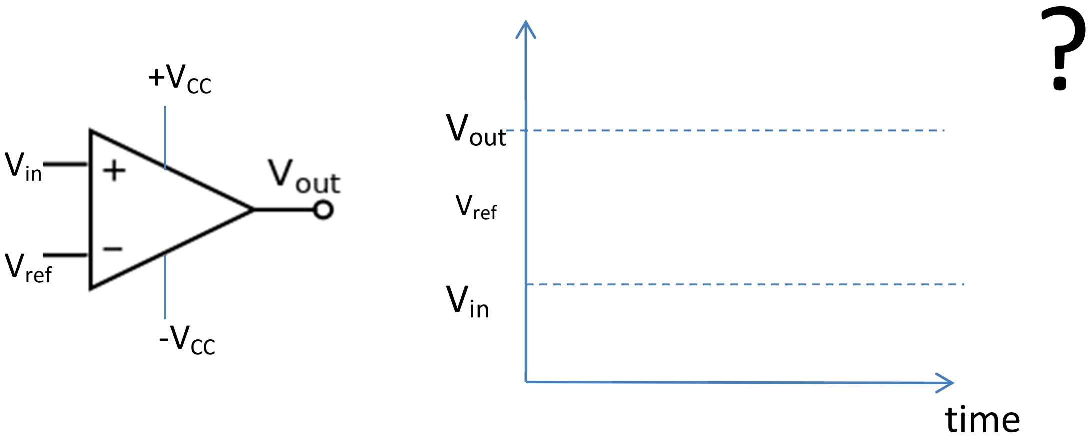

Fig 3: Use LM741 to compare a changing V_{in} to a fixed reference V_{ref} .
Question 0: Mark in the left diagram your signal and ground connections.

Question 1: Observe and note the time traces of V_{out} and V_{in} in the figure above.

Question 2: You will note that V_{out} changes state with a slight time lag after V_{in} exceeds V_{ref}. Look through the LM741 datasheet to determine if this lag matches the specified value. (It is technically called the slew rate)

How does the slope of V_{out} change as you change the frequency of V_{in}?

Does it change for different values of V_{ref}?

Question 3: Now *disconnect* V_{ref} and make a connection from the output V_{out} to V_- (keeping V_{in} connected to V_+ as before). You have now 'closed the loop' and made a feedback circuit around the opamp. Repeat the observations of Question 1 above. Using the opamp equation $V_{out} = G(V_+ - V_-)$ above, work out the relation between V_{out} and V_{in} Are your observations in agreement with this relation? Voila! this is the simplest *negative* feedback circuit you can make with an opamp – we will see many more later.