Prelab: Simulate the circuit used in parts 1 and 2 of the Lab and record the simulated results. Your Prelab is due at the beginning of lab and will be checked off by the TA's after the lab starts.

Purpose:

The objective of this laboratory is to investigate the properties of a LMC6484 Operational Amplifier and a 555 Timer. The LMC6484 is a low power Op-Amp that will be used in the single supply mode of operation requiring only one Power Supply. The Operational Amplifier here will be used with a Thermistor Sensor in open loop mode as a comparator. Its output in Part-2 will be driving a Power MOSFET (being used as a power switch) which will be used to handle the higher current of the motor. Later the 555 Timer set up as a One-Shot and connected between the output of the OP-Amp and the input to the MOSFET. The Timer here will then control the length of time the motor will operate. Please wire up the Thermistor/OP-Amp circuit on the right side of your Proto-board, that should leave enough space for you to wire up the Timer and MOSFET circuits in the middle and right side of the board since they will all be connected in the last part of the experiment.

Part 1:

Set-up the following circuit using the LMC6484 in single supply operation. The IRF520 and the Motor will be added in part 2 of the experiment. The Thermistor will be used as the sensor here in the first part of the experiment. In the simulation, R3 was used to simulate Thermistor used in this experiment. In this first part the Thermistor will replace R3 in your bench circuit. When the circuit is completed, turn on the Oscilloscope and then the power supply. Note the Oscilloscopes Channel 2 input goes to the Inverting Input, Channel 1, to the Non-Inverting Input and Channel 3 is connected to the Output.
Thermistor Sensor Controls Motor Operation.

Adjust the Oscilloscopes Channels to 5 volts/division. Then initially adjust the Vref 1K ohm Pot, R2 so that the Channel one trace on the Oscilloscope at 4 volts. Now adjust the Sensor Level 10K Pot R6, so that it’s trace on the oscilloscope is just below 4 volts. If this is not possible, re-adjust the Vref Pot either up or down until you can adjust the R6 Pot level to just a little less that the Vref level on the Oscilloscope.
Once these settings have been achieved, pinch the Thermistor between two fingers to raise it's temperature which should lower it's resistance causing the Vi input level to rise above the Vref Level sending the OP-Amp Output High lighting the LED. Record the two Input and Output Levels. If the LED did not light, you will need to re-adjust the Sensor Level Pot R8 voltage a little closer to the Vref Level on the Oscilloscopes screen, then pinch the Thermistor again and repeat this procedure until the LED lights up. Then record the results.

When you have achieved lighting the LED. Slightly re-adjust the Vref Level so that you slightly change the temperature at which the Thermistor lights the LED. Record these new Levels. What you are doing here is adjusting what temperature turns on the LED. This is a very small change so be careful when changing the Pot settings.

Part 2:

In Part 2, do not disturb the circuit you set up in Part 1. Here you are going to add a IRF520 MOSFET to drive a Motor. The Motor is also added at this time as well. The MOSFET is in your kit, it is rectangular in shape, has a metal heat sink on its back and three leads on one of its shorter sides. It is shown from a top view, to the right of the LMC6484 in the Photo above. The MOSFET will be used here to act as a switch to turn the Motor ON and OFF since the Motor current is too large for the OP-AMP to handle.

The Gate(Pin # 1) of the MOSFET is connected to Pin # 1 of the LMC6484, Pin # 3, the Source of the MOSFET, is connected to Ground and Pin # 2, the Drain of the MOSFET, is connected to one end of the Motor. The other end of the Motor is connected to +12 volts.

Now connect the Oscilloscope probes as shown on the schematic diagram. Then repeat all the steps in Part 1 with the Thermistor. Try to set the Vref adjustment so that the LED lights up
with a quick pinch of the Thermistor. When the Motor turns on, point the spinning tape at the Thermistor since it acts like a Fan. The cool air from the Fan should cool down the Thermistor turning off the Motor. However, if you adjust the Vref just right the Motor should turn back on if you had set the Thermistors Vref just to just turn the Motor on a room Temperature. This On and Off condition should continue until you shut the Power Supply Off. Record all the Oscilloscope voltages at which this occurs. Make note of what waveforms have noise and/or voltage spikes on them. When finished, do not disturb your wiring since the circuit will be added to in part 4 of the Lab.

**Part 3: The 555 Timer in Astable and Monostable Operation.**

In this first part of the Timer experiment you are going to set up the Timer as an Astable Multivibrator which means it will generate is own rectangular output waveform based on the components used in the timing circuit. The Timer is an 8 –Pin DIP IC with pin-1 to the left of the notch or the dot mark on the top of the IC (Integrated Circuit)package. Remember the pin numbers start from the left side(looking down from the top) and go counter-clockwise down the left side and up the right side of the IC. The diagram below is helpful in defining the IC pin numbers and where they go.

Using the pin-out reference in the above diagram, wire up the circuit in the Multisim schematic shown in the diagram below. **Be very careful in how you wire in the 100UF Capacitor noting the negative side is connected to ground and the positive side is connected to the 10K Resistor R2. If you are not sure ask a TA to check out its wiring before you energize your circuit since inappropriate wired Electrolytic Capacitors can EXPLODE !!!**

A photograph of a typical wiring on a Proto-board is shown below the schematic.
After you have verified that you have wired everything up correctly, energize the circuit. The circuit is operating correctly if the LED is blinking (Off /ON) at a few seconds interval.
In the second part of this Timer experiment the Astable circuit you wired above will be slightly modified to convert it into a Monostable or One-Shot Pulse generating circuit. The One-Shot operates differently that the Astable circuit in that it only generates a pulse when it is told to when a pulse on its trigger input. The width of the output pulse is controlled by the resistor R1 and the capacitor C1. The larger their values the longer the pulse will stay high. In the last part the output of this circuit will be connected to the gate (input) of the MOSFET which will in turn cause the motor to turn ON. The motor will then run for the time interval you set – up on the timer.

To modify the Astable circuit into a One-Shot, remove resistor R2 and replace it with a wire jumper. Then connect a wire jumper from pin-6 to pin-7 and remove the wire going from pin-7 to the bottom of the resistor R1. Replace the R1(1K) with a 20K resistor and C1 with a 330uf. Next wire up the 100K resistor R2, the diode D2 and the capacitor C3(10uf). Then connect a wire from pin-2 to the junction of components C3, R2 and D2.

To test the circuit, energize it and connect another wire going from pin-2 to ground. Just touch this wire to ground momentarily to trigger the One-Shot, the LED should turn on for 8 to 10 seconds and not turn on again till you trigger it by grounding pin-2.

**Monostable Multivibrator:**

![Monostable Multivibrator Circuit Diagram]

- **D2** 1N4006G
- **R1** 20kΩ
- **R2** 100kΩ
- **C1** 330µF
- **C2** 0.1µF
- **C3** 10µF
- **J2** Push Button J2 is a momentary switch.
- **V1** 12 V
- **t = 1.1(R1)C1** for Pulse Width
Part 4: THIS PART 3, IS OPTIONAL IF YOU HAVE TIME.

Essentially in Part 4, you connect the output of the LMC6484, pin-1 to capacitor C3 of your One-shot. Then connect to output of the One-shot pin-3 to the gate of the MOSFET. Then energize your circuit and operate it like you did in Part-1. The only difference is now the motor should run for around 10 seconds the stop.
The circuit and explanation below is slightly different than above. Some of the resistor and capacitor values and their labels are different than those above but give a slightly different design to accomplish the same end. This circuit has extra filtering to reduce motor noise which might adversely affect the above circuit and why I have left this part as optional because of the time it would take to modify the above circuit is to noisy.

In part 4, wire up the 8-pin dip 555 Timer as shown in the schematic below. Also refer to the attachments on the Timer and IRF-520 accompanying Lab 5 if there is questions about the pin-outs or the devices in general.

The Timer will be used here to control the length of time the Motor will run. That time will be controlled by resistor R5 and capacitor C1. Where \( t = 1.1(R5)(C1) \) which is about 10 seconds. Since the Timer is very sensitive to noise and inductive transients from the Motor additional filtering will need to be added to the circuit to minimize this problem. The additional filtering and new components are explained in the steps that follow the Timer information diagrams.

1. The Gate, pin 1 of the MOSFET is disconnected from pin 1 (Output) of the LM 324 an reconnected to pin 3 of the 555 Timer through a 1K resistor. A reminder on all IC's, that pin 1 is on the left side of the notch or small circular impression on top of the IC. All IC's are number starting at pin 1 upper left hand corner, then down the left side ending with pin 4(for the Timer in this case). Then going up the right side starting with pin 5 and ending with pin 8, upper right hand corner.
2. Diode D2 (1N2004) and capacitor C5 (0.1uF) are connected in parallel(across the wires that go to the Motor). This is acting as a noise filter for the inductive Motor.
3. Capacitors C4(0.1uF) and C6(100uF) should be connected from the +12 volt supply to ground. The capacitors are both used as filters for noise on the Power Supply bus(Power Rail). The 100uF is low frequency noise and the 0.1uF for the high frequency noise.

4. The Timer also requires the addition of a filter network consisting of R9(100K), D1(1N4004) and C2(10uF). One end of C2 is connected to the Output of LM324(pin 1) and the other end is connected to the trigger(pin 2) of the Timer and well as the R9,D1 network, see schematic.

5. The rest of the Timer Pins are connected as follows. Both pins 8 and 4 are connected to the +12 volt supply. Pins 6 and 7 are connected together with a 100K resistor going to the +12 volt supply and a 100uF capacitor to ground, see schematic. Finally, put a 0.1uF capacitor from pin 5 to ground.
When everything is connected according to the schematic diagram, turn on the Power Supply. The Motor may initially turn on due to a Power Supply transient but should shut off in about 10 seconds. A working circuit should turn on the LED after pinching the Thermistor for a few seconds or so. When the LED goes out the Motor should start up and run for around 10 seconds and shut off. Remember the purpose of this circuit is to turn the Motor ON for a fixed length of time which is controlled by R5 and C1 when the temperature of the Thermistor starts to drop.

Record the four Oscilloscope waveforms, again noting those with noise and/or voltage spikes on them. Turn off the supply and make the minor changes noted in part 5 of this experiment.

If the Motor does not shut off, turn off the Supply and re-check your layout for any wiring mistakes. Turn the supply again. If the circuit still does not work properly, meaning the Motor does not shut OFF, disconnect one lead of the Motor. Pinch the Thermistor till the LED lights up, now check the output of the Timer pin 3. When the LED goes out the output level on the Oscilloscope should go high to about 10 volts for about 10 seconds. If this part works OK then the problem is most likely your circuit needs more filtering from the transients generated by the Motor when it is connected into the circuit. If nothing has worked up to this point ask for help from TA or the instructor.

Part 4:

In this last part of the experiment we are going to run the Timer as an Astable Multivibrator which means it will generate its own output waveform based on the components in the timing circuit. This repetitive output waveform will then drive the Motor turning it OFF and ON continuously.

To accomplish the above, first remove the wire going from the output of the LM324, pin 1, to the 10uF capacitor which goes to pin 2 of the Timer. Also, remove R9 (100K) and D1(Diode) and the jumper wire going from pins 6 and 7 of the Timer. Now install a 51K resistor between pins 6 and 7 of the Timer and then connect a jumper wire from pin 2 of the Timer to pin 6 of the Timer. This completes the wiring change.

Turn on the Power Supply and note that the Timer should be now be controlling the operation of the Motor as stated above. The LM324 has no function in this part since we connected it from the circuit.

Finally, record both the Timer output and Motor input waveforms as you did in part 4.
Write up:

Being the last week of class, there is not write up for this Laboratory!