**Lab – Electronic Sensors and Comparator Circuits**

**Objectives**

-To learn about various electronic sensors – thermistors and photocells

-To learn about comparators

-To test the electrical properties of these sensors

-To use a sensor and a comparator for DC Feedback control of a fan or motor

A control circuit allows to you to turn on another part of a circuit or device when needed and off when it is not. These types of circuits use electronic sensors to monitor the environment in order to determine when another part of the circuit or device needs to be “on” or “off”.

In today’s experiment you will be building a control circuit that uses a heat sensitive sensor, and an op amp functioning as a comparator to determine when a cooling fan (motor) needs to turn on or off. A comparator is an electronic circuit that compares two analog voltages at its inputs and gives an output that is either a high (positive) voltage or a low (negative) voltage. The high or low signal generated at the output would then be used to make a transistor conducting and turn on a load such as a motor.

**Equipment**

Measuring Equipment: Digital Multimeter

Power Supply (±15V) or Powered Breadboard with at least 15V of power, jumper wires, BNC (Bayonet Neill–Concelman) cables

Resistors: one 22k Ohm, one 20k Ohm, one 10k Ohm, one 3.3k Ohm,

Potentiometer: 10 kOhm

Power Resistor: one 50 Ohm with 3-5W power resistor or a hair dryer/heat gun

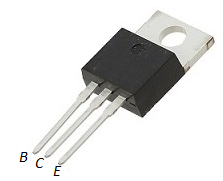
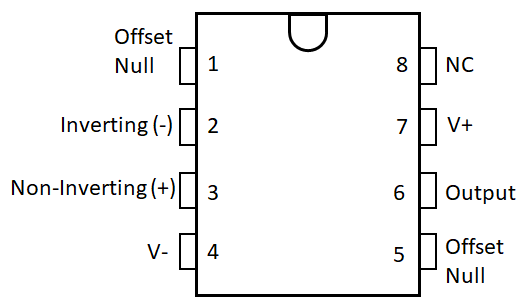
Thermistor: 10kOhm Thermistor

Light Dependent Resistor (LDR)

Electric Motor: 1.5-3.0V DC Motor

LM393 Integrated Circuit Comparator or 741 IC Op Amp

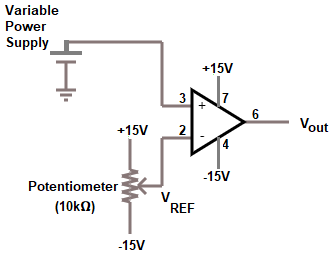
Power transistor (TIP31AG, IRF 510 or equivalent)



*Figure 1 - Pin Diagrams for TIP31AG power transistor and 741 Op-Amp*

**Activity 1- Comparator Circuit with a DC input Signal**

1. Build the circuit below on a breadboard. You will need a Variable power supply and a multimeter. Make sure that you have +15V connected to one terminal of the potentiometer and -15V connected to another terminal with center terminal being connected to pin 2 of the IC 741 OP Amp. Also, the OP Amp needs to have power at pins 7 and 4 as shown in the diagram below. **Note:** Pins 1, 5 and 8 are not used. If the signal is noisy connect a 1.0 mF capacitor between pin 7 and ground as well as between pin 4 and ground.

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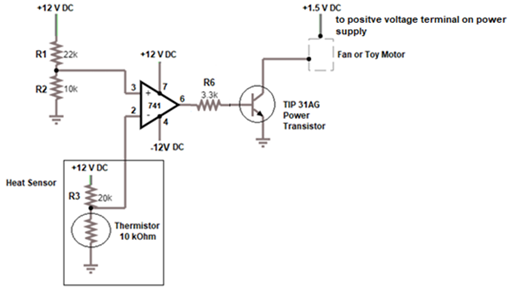
*Figure 1- Comparator Circuit with DC input signal[[1]](#endnote-1)*

1. Connect the positive probe of the multimeter to pin 2 on the OP amp and the negative probe to ground. Adjust the potentiometer until the voltage on the multimeter reads 1 V. This will be your reference voltage (VREF)
2. Turn on the variable power supply and set the input voltage to pin 3 of IC 741 to +5V.
3. Measure and record the output voltage(Vout) at pin 6.
4. Now slowly adjust the variable power supply voltage until it is near zero. Measure and record the voltage at pin 6. What happened to the output voltage?
5. Adjust the variable power supply voltage back to +5V. Now adjust the potentiometer until VREF is about 3V.
6. Slowly decrease the power supply voltage until it is below VREF. Measure and record the voltage at pin 6

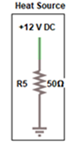
In your notebook comment on what happened to the output every time the reference voltage VREF was changed.

**Activity 2 – DC Feedback Control Circuit – Comparator Applications**

Wire up the circuit below on your breadboard. **Important:** The black plug on the power supply that you will use for the motor (or fan) needs to be connected to ground plug on the breadboard.



*Figure 3 – DC Feedback Control circuit*



*Figure 4 – Heat source circuit*

**Heat Source**

1. Build the heat source circuit in Figure 4 separately since the leads on the power resistor won’t fit on the breadboard. Use a stand-alone power supply when building the circuit. When testing the DC Feedback control circuit, you will need to position the heat source and fan unit close to the thermistor. The heat sensor should be built on the lower corner of your breadboard.

**Note:** You can also use your fingers as a heat source. The natural temperature of your fingers in a lab environment should be enough to change the resistance of the thermistor for this experiment.

**SAFETY**: The power resistor will get hot when connected to the power supply.

Calculate the maximum power dissipated by the resistor R5 using the electric power equation,

Record this value.

*P* = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Watts

**DC Feedback Control Circuit with a thermistor**

1. You will be using an op amp (741) functioning as a comparator to build the feedback circuit of figure 3. The output of the op amp is connected to a power transistor (TIP 31AG). Make sure that the pins on the chip and the power transistor are connected correctly. Look at the pin diagrams above to determine how the pins should be connected to the other sections of the circuit.
2. Calculate the voltage between resistors R1 and R2. Use the voltage divider equation below to determine this value. The voltage from this voltage divider will act as the reference voltage for the op amp comparator and is the input at pin 3.
3. Calculate the voltage between resistors R3 and R4 using the voltage divider equation. Assume that the thermistor has a value of 10 kOhm at room temperature.
4. Turn on the power to the feedback circuit. Make sure the voltages are set to +12 V. Do not apply power to the power resistor at this point.
5. Measure the voltages from the two voltage dividers and compare them to the voltages you calculated above.

**Question1:** How do the voltages from the voltage compare – similar or very different? Is the fan on or off?

1. Position the power resistor near the thermistor and then apply power. It should begin to heat up.

**Question2:** Monitor the output voltage from the thermistor voltage divider by connecting the red probe of the multimeter to the top leg of the thermistor and the black probe to ground. Describe how the output changes as the temperature change. How will this affect the voltage at pin 2 of the comparator?

1. Eventually the fan should switch on. Position the fan so that it can blow on the thermistor to cool it. An inch or two away should be fine. Move the heat source away when the fan turns on.
2. As the fan cools the thermistor, it should eventually turn off.
3. Demonstrate the operation of the circuit to the instructor.

**Question3:** Monitor the output voltage of the op amp by connecting the red probe of the multimeter to pin 6 of the op amp and the black probe to ground. Describe how it changes as the fan turns on and off.

**DC Feedback Control Circuit with an LDR**

1. Turn off power to your breadboard and to the power resistor. Replace the thermistor with a light dependent resistor (LDR).

**Question4:** Monitor the output voltage from the LDR voltage divider by connecting the red probe of the multimeter to the top leg of the LDR and the black probe to ground. Describe how it changes and what happens to the fan.

1. All schematic diagrams were created with Falstad circuit simulator (https://falstad.com/circuit/) [↑](#endnote-ref-1)