Phys 374

Exp5. Temperature measurements with thermocouple and diode.

Experiment Procedure:

In this experiment you will learn two methods to measure temperature.

Part 1: Thermocouple:

In the first part you will use two thermocouples to measure the temperature difference between them. You will build a circuit to measure voltage difference generate between the wires of the thermocouple. The figure shows the circuit of a voltage amplifier based on an operational amplifier. In this circuit there are two thermocouples, an operational amplifier (OP 07) and couple of resistors.

Task 1: Built the circuit and measure the temperature of liquid nitrogen, room temperature and your body temperature. Plot a graph showing the measured voltage as a function of temperature.

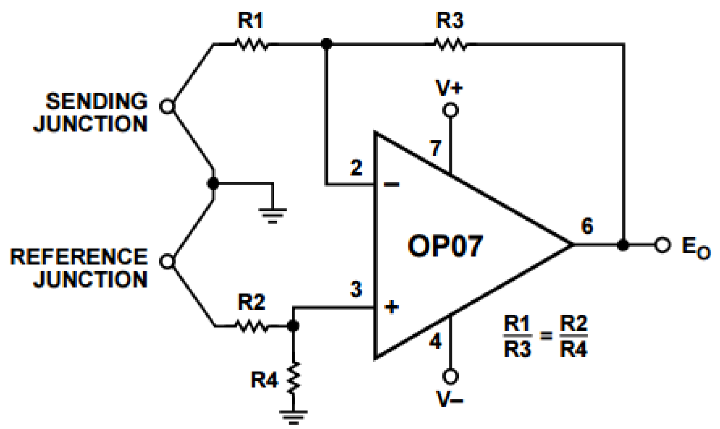


Figure 1 The circuit diagram for thermocouple based temperature measurement.

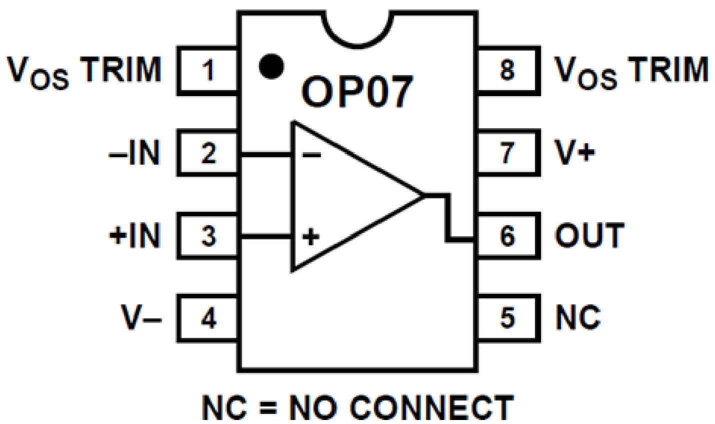
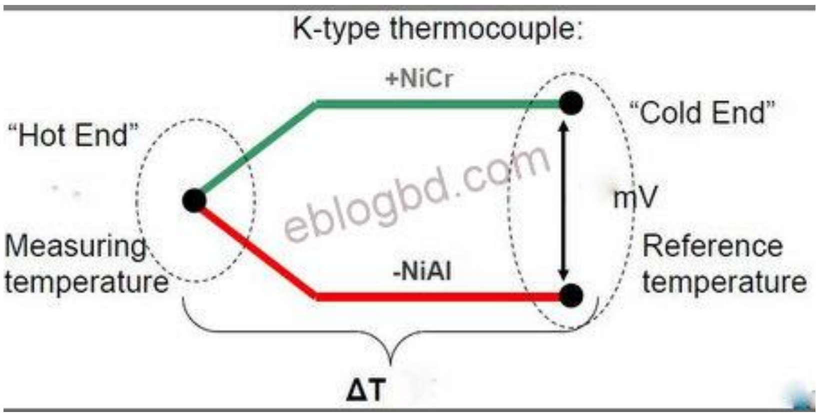


Figure 2 Pin configuration of OP 07

A **Thermocouple** is a sensor used to measure temperature. **Thermocouples** consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured.



Part 2: Temperature measurement with a semiconductor diode

Diode Temperature Sensors: The ordinary semiconductor diode may be used as a temperature sensor. The diode is the lowest cost temperature sensor and can produce more than satisfactory results if you are prepared to undertake a two point calibration and provide a stable excitation current.   Almost any silicon diode is ok. The forward biased voltage across a diode has a temperature coefficient of about 2.3mV/°C and is reasonably linear. The measuring circuit is simple as shown to the right. The bias current should be held as constant as possible - using constant current source, or a resistor from a stable voltage source.
Without calibration the initial error is likely to be too large - in the order of ±30°C - the largest of all the contact type temperature sensors. This initial error is greatly reduced if sensor grade parts are used.

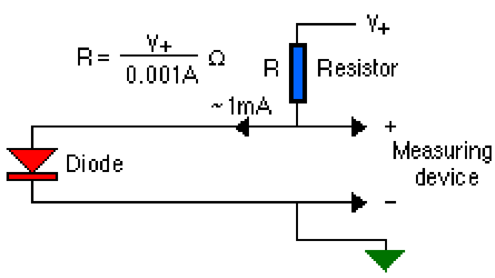
One advantage of the diode as a temperature sensor is that it can be electrically robust - tolerant to voltage spikes induced by lightning strike. This is particularly true if power diodes (e.g. the common 1N4004) are used and a second back to back diode is used to limit power dissipation during high peak currents.

The transistor sensor is used in diode mode by connecting the base and collector together. If this is not done, the sensor is wired between base and emitter and the excitation current reduced by a factor of about 100. The result is a very low power, sensitive and linear sensor. The simplicity and performance of the sensor is under valued.

To improve the performance of the diode as a temperature sensor, two diode voltages (V_1 and V_2) can be measured at different currents (I_1 and I_2), typically selected to be about 1:10 ratio. The absolute temperature can be calculated from the equation:

$$T = (V_1 - V_2) / (8.7248 \times 10^{-5} \ln(I_1 / I_2))$$

The result is in Kelvins (K). This is the method employed by most integrated circuit temperatures sensors and explains why some output a signal proportional to absolute temperature.



Task 2: Built the circuit and measure temperature of Liquid nitrogen, room temperature and your body temperature using a semiconducting diode. . Plot a graph showing the measured voltage as a function of temperature.

Figure 3 The circuit for diode as a temperature sensor.