MALAYSIA-JAPAN INTERNATIONAL INSTITUTE OF TECHNOLOGY

(DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING)

LABORATORY SHEET

ELECTRONIC ENGINEERING LABORATORY II

(SMJE 2122)

Measurements and Instrumentation 1

(Temperature Measurements)

Introduction

A transducer is a device that converts one form of signal or information into another.

You can find many examples of transducers in everyday life. The thermostat has an input transducer that senses room temperature and is used to control air conditioning. Many streetlights are equipped with photosensors that are used to turn the lights on when the sun goes down. A speaker is an output transducer that converts electrical signals into sound.

In this lab you will apply this knowledge by measuring temperature using two different transducers on your TRANSDUCER FUNDAMENTALS circuit board.

1. I.C. Temperature Transducer

At the completion of this unit, you will be able to explain the operation of the **IC temperature transducer** and its function as a temperature measurement and control device.

The IC temperature transducer used on your circuit board is an epoxy-encapsulated integrated circuit. Although it is packaged in a 3-terminal TO-92 case, the transducer itself is a 2-terminal device. The center lead is not internally connected.

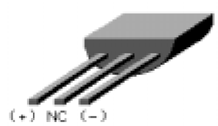

Figure 1. IC Temperature Transducer

The IC functions as a current source whose output current is a function of temperature. At a reference point of 0°C (the freezing point of water), the output current (IREF) is 273.2 µA. Every temperature transducer has a **temperature coefficient** that describes the way the transducer's characteristics change as temperature changes.

The temperature coefficient α (the Greek letter alpha) of the IC transducer on your circuit board is one microamp per degree Celsius ($\alpha = 1$ µA/°C). For any temperature T, the current at that temperature (I_T) may be expressed as follows:

$$I_T = (\alpha \times T) + 273.2\ \mu A \qquad (1)$$

(where I_T is in µA, T is in °C, and $\alpha = 1$ µA/°C).

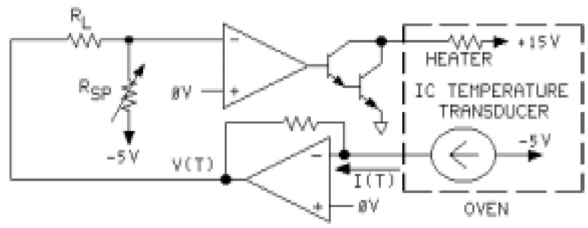

Figure 2. Simplified IC Transducer Circuit

This is a simplified block diagram of the IC TRANSDUCER circuit block. The transducer's current output [I(T)] drives an op amp that is configured as a current-to-voltage converter. The resulting output is a voltage [V(T)] that is a function of the transducer's temperature. The remaining circuitry allows the block to operate as a temperature controller that regulates the temperature inside the oven.

Resistor R_{SP} is used to select a **set point**, or the temperature at which the oven is to be regulated. A second op amp, configured as a comparator, determines whether the oven temperature is above or below the set point. The comparator's output drives a transistor that switches a heater resistor on if the temperature is below the set point, or off if the temperature is above the set point.

Procedure:

1. On the IC transducer circuit block place the shunt on the TEMP header in the 40^{o}C position. Insert a two-post connector in the OVEN ENABLE position.
2. These connectors regulate the oven temperature to 40^{o}C. The oven takes 1-2 minutes to reach this temperature.
3. Set the multimeter to measure DC voltage and connect the leads to TP1 (+) and TP2 (-).
4. By measuring the resistor voltage you can calculate the transducer current using Ohms law, since the resistor and transducer are in series.(Draw an equivalent circuit in the log book)
5. Whilst the temperature is rising to 40^{o}C, observe the measured voltage and decide if the temperature coefficient is positive or negative. Make sure you explain your reasoning even if you think it is obvious.
6. You can determine when the oven temperature has stabilized by observing the OVEN ON LED. When first turned on the LED is alight for a long period of time. As the temperature approaches 40^{o}C, the heater will cycle on and off to maintain the temperature. Allow the LED to cycle several times so the temperature has stabilized and then record the voltage across R1. Use this to calculate the current out of the IC transducer.
7. Repeat steps 4-6 for oven temperatures of 45^{o}C and 50^{o}C. Use the results obtained to confirm the temperature coefficient.

Note: The instructor's manual for the Transducer fundamentals board has some detailed drawings of the board. If you need help in locating points on the board please ask to see these.

2. The Thermistor

At the completion of this unit, students will be able to describe and demonstrate the characteristics and operation of a thermistor. A **thermistor** is a two-wire temperature transducer whose resistance is a function of temperature. The thermistor's schematic symbol is similar to that of a resistor, except that the symbol t° is used to indicate temperature dependence.

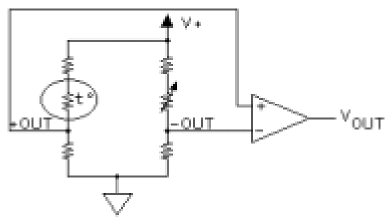

Figure 3. A Thermistor in a Wheatstone bridge arrangement

Thermistors are popular temperature transducers because of their high output, or relatively large resistance change per degree.

A typical thermistor temperature measuring circuit uses the thermistor in a Wheatstone bridge configuration. The bridge output drives an instrumentation amplifier whose output voltage is a function of the thermistor's temperature. You can select amplifier gain and component values for the desired relationship of output voltage to temperature.

Each thermistor type has a different curve of resistance ratio versus temperature. To evaluate the thermistor's resistance at a specific temperature you need to look up the resistance ratio value at that temperature on a table supplied by the manufacturer. The table for the thermistor used here is given in Table 1.

At a given temperature, T, to calculate the resistance you need to find the resistance ratio at that temperature and multiply it by the reference resistance at 25ºC. At a given temperature the resistance deviation is added to the tolerance at 25ºC to determine the overall tolerance. For example at 30ºC the resistance should be (0.8057 x 10000) Ω± 10.4%, that is between 7219 Ω and 8895 Ω.

^{o}C	Resistance Ratio	Temperature Coefficient ($\Omega/^{o}C$)	Resistance Deviation (%)
0	3.2650	5.1	1.5
5	2.5391	5.0	1.2
10	1.9898	4.8	0.8
15	1.5710	4.6	0.5
20	1.2491	4.5	0.2
25	1.0000	4.4	0.0
30	0.8057	4.3	0.4
35	0.6531	4.2	0.7
40	0.5327	4.0	1.0
45	0.4369	3.9	1.3
50	0.3603	3.0	1.5
$R_{25}{}^{o}{}_{C}$ = 10 kΩ±10%			
RT= $R_{25}{}^{o}{}_{C}$ x resistance ration at T			

Table 1. Data for Thermistor

Procedure:

1. Using the procedure described for the IT transducer heat the oven to the same temperatures as used in the previous section.
2. Measure the resistance across the thermistor at each temperature.
3. Compare your measured results with those calculated using the values given in Table 1.
4. Draw a graph of resistance versus temperature and discuss.
5. Compare the thermistor with the IT transducer and fully discuss.