MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO
DEPARTMENT OF TEXTILE ENGINEERING

LAB # 02

THERMOELECTRIC TRANSDUCERS

Roll No:	**Date:**
Checked by:	**Grade:**

Object: To determine the characteristics of Thermocouple and analyze their working through MCM 14/EV Transducers Module

Equipment required:

- Experiment module MCM14/EV.
- Digital Multimeters
- Power supply Mod. PSUIEV (+/-12V).

Theory:

1. **Thermoelectric Effect Sensors (Thermocouple)**

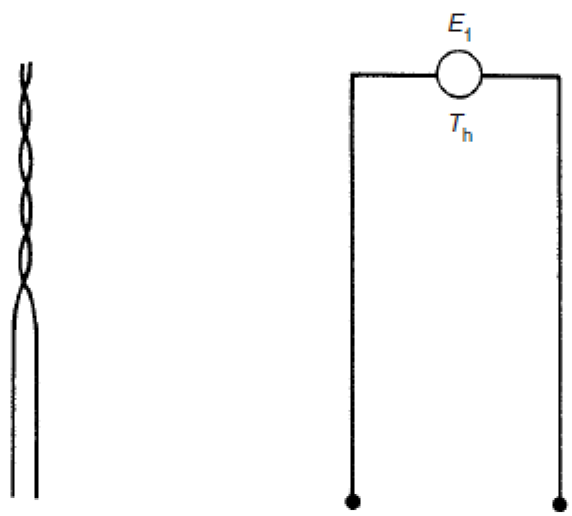
Thermoelectric effect sensors rely on the physical principle that, when any two different metals are connected together, an e.m.f., which is a function of the temperature, is generated at the junction between the metals.

Despite an increasing variety of temperature sensors, the self-generating thermocouple remains the most generally used sensor for thermometry because of its versatility, simplicity, and ease of use. Any pair of electrically conducting and thermoelectrically dissimilar materials coupled at an interface is a *thermocouple.* The legs are thermoelements.

The *Seebeck effect* produces a voltage in all such thermoelements where they are not at a uniform temperature. Any electric interface between dissimilar electric conductors is a *real thermoelectric junction.* A free end of a thermoelement is a *terminus*, not a junction.
It is the thermoelements that determine thermocouple *sensitivity* and calibration; but, it is the temperatures of the end-points of thermoelements (i.e., junction temperatures) that determine the *net* emf observed in thermometry.

Thermocouples are manufactured from various combinations of the base metals copper and iron, the base-metal alloys of alumel (Ni/Mn/Al/Si), chromel (Ni/Cr), constantan (Cu/Ni), nicrosil (Ni/Cr/Si) and nisil (Ni/Si/Mn), the noble metals platinum and tungsten, and the noble-metal alloys of platinum/rhodium and tungsten/rhenium. Only certain combinations of these are used as thermocouples and each standard combination is known by an internationally recognized type letter, for instance type K is chromel–alumel.

A typical thermocouple, made from one chromel wire and one constantan wire, is shown in Fig:01 . For analysis purposes, it is useful to represent the thermocouple by its equivalent electrical circuit, shown in Figure 14.2(b). The e.m.f. generated at the point where the different wires are connected together is represented by a voltage source, E1, and the point is known as the hot junction. The temperature of the hot junction is customarily shown as T_h on the diagram. The e.m.f. generated at the hot junction is measured at the open ends of the thermocouple, which is known as the reference junction.



(a). (b)

Fig:01 (a) Thermocouple (b) Equivalent circuit

In order to make a thermocouple conform to some precisely defined e.m.f.–temperature characteristic, it is necessary that all metals used are refined to a high degree of pureness and all alloys are manufactured to an exact specification. This makes the materials used expensive, and consequently thermocouples are typically only a few centimeters long. It is clearly impractical to connect a voltage-measuring instrument at the open end of the thermocouple to measure its output in such close proximity to the environment whose temperature is being measured, and therefore *extension leads* up to several metres long are normally connected between the thermocouple and the measuring instrument.

2. Thermocouple types

The five standard base-metal thermocouples are chromel–constantan (type E), iron–constantan (type J), chromel–alumel (type K), nicrosil–nisil (type N) and copper–constantan (type T). These are all relatively cheap to manufacture but they become inaccurate with age and have a short life. In many applications, performance is also affected through contamination by the working environment. To overcome this, the thermocouple can be enclosed in a *protective sheath*, but this has the adverse effect of introducing a significant time constant, making the thermocouple slow to respond to temperature changes. Therefore, as far as possible, thermocouples are used without Protection.

3. Thermocouple manufacture

Thermocouples are manufactured by connecting together two wires of different materials, where each material is produced so as to conform precisely with some defined composition specification. This ensures that its thermoelectric behavior accurately follows that for which standard thermocouple tables apply. The connection between the two wires is effected by welding, soldering or in some cases just by twisting the wire ends together. Welding is the most common technique used generally, with silver soldering being reserved for copper–constantan devices.

The diameter of wire used to construct thermocouples is usually in the range between 0.4mm and 2 mm. The larger diameters are used where ruggedness and long life are required, although these advantages are gained at the expense of increasing the measurement time constant. In the case of noble-metal thermocouples, the use of large diameter wire incurs a substantial cost penalty.

4. Thermopile

The thermopile is the name given to a temperature-measuring device that consists of several thermocouples connected together in series, such that all the reference junctions are at the same cold temperature and all the hot junctions are exposed to the temperature being measured, as shown in Fig:02. The effect of connecting n thermocouples together in series is to increase the measurement sensitivity by a factor of n. A typical thermopile manufactured by connecting together 25 chromel–constantan thermocouples gives a measurement resolution of 0.001°C.

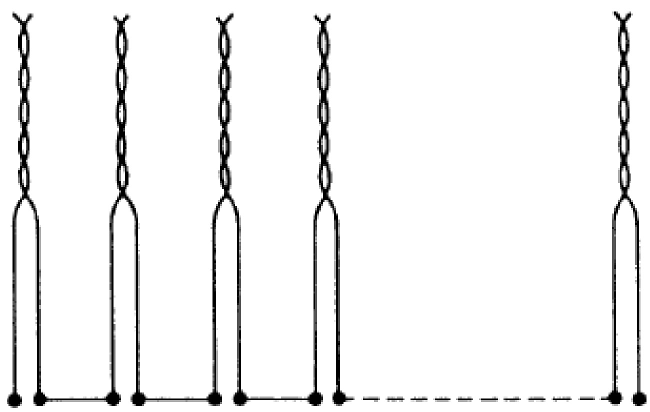


Fig:02 Thermopile

5. Lab Procedure

This lab is also being conducted using MCM14/EV Transducers Module. The voltage generated at the thermocouple inside it can be measured between point 5 and other terminal of thermocouple. The module also contains a signal conditioning circuit in which thermocouple voltage is being amplified and the amplified voltage can be measured at OUT (7).

Lab Exercises

1. Activate the heating element using heater switch.
2. Measure the voltage and then temperature between OUT (7) and ground for RTD.
3. Use the temperature measured with the RTD as sample variable to judge the voltages measured at the thermocouple junction.
4. Fill the following table.

RTD (mV)	Temperature (° C)	TH* (mV)	TH* (V)
300	30		
350	35		
400	40		
450	45		
500	50		
550	55		
600	60		
650	65		
700	70		
750	75		
800	80		