Temperature Transducer

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What is transducer?

- Transducer is a device which transforms energy from one type to another, even if both energy types are in the same domain.
  - It is a temperature monitoring device/sensor

Types of Transducer

- **Active transducer**

  An active transducer is defined as a transducer which generates its own electrical voltage during conversion. It does *not* require any external battery supply for its working.

- **Passive transducer**

  Passive transducer is defined as the transducer which requires *external* battery voltage to operate.

The output magnitude of the active transducer is higher than that of the passive type.

Classification based on

Function

- Displacement (Linear potentiometer)
- temperature (Thermocouple, semiconductor)
- force (strain gauge, piezoelectric crystal)

Physical property

- Inductive (LVDT)
- photo-voltaic (optical modulating transducer)
- piezo-electric (mechanical modulating transducer)

- **Electromagnetic**

  Antenna, Tape head, Hall effect sensor

- **Electrochemical**

  pH probes, Hydrogen sensor

- **Electromechanical**

  Galvanometer, Rotary motor, Linear variable differential transformer, Accelerometer

- **Electroacoustic**

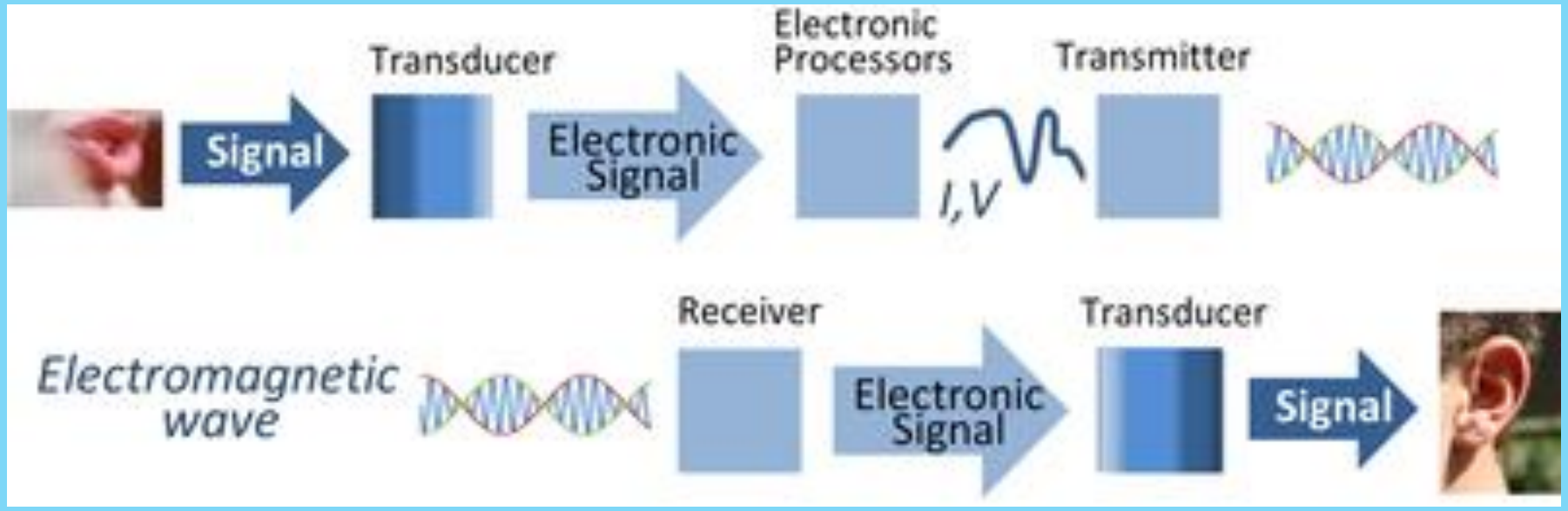
  Loudspeaker, Microphone

- **Electroptical**

  Fluorescent lamp , Light-emitting diode, Laser Diode, Photodiode, Photoresistor

- **Thermoelectric**

  Resistance temperature detector , Thermocouple, Thermistor


Transducer
Electronic Processors
Transmitter
Signal
Electronic Signal
I,V
Receiver
Transducer
Electromagnetic wave
Electronic Signal
Signal

Temperature transducer

More about temperature transducers

- Temperature transducers are very common nowadays.
- Temperature is one of the most commonly measured physical magnitude.
- They are used in the heating, ventilation and air-conditioners, production process temperature.
- Temperature transducers make temperature visible to the user like the accurate temperature of a material to influence the melting process.
- Temperature transducers can detect environmental or surface temperature by means of a thermo-element or a resistor transforming it into an electric signal.
- A temperature transducer connected to a control device which allows to test the temperature in a place and controller can be activated if necessary.

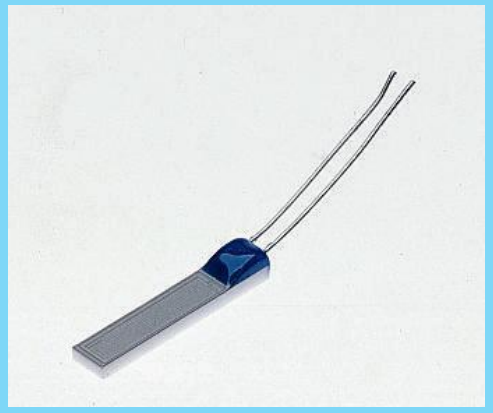
Types of temperature transducers

- Resistive temperature detectors (RTD)
- Thermistors
- IC sensor
- Thermocouple

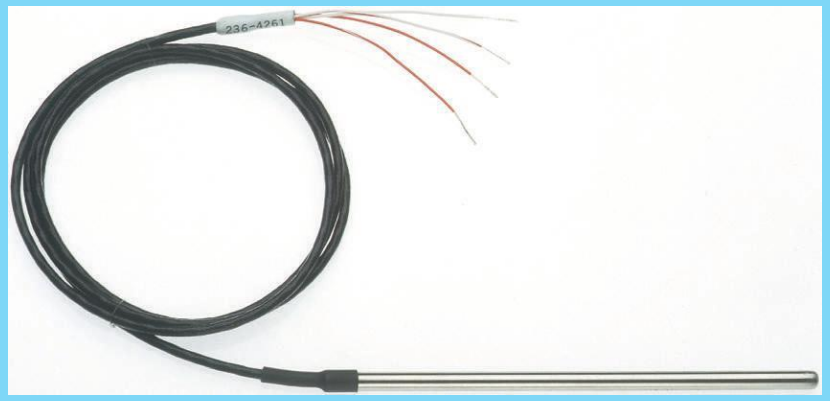
Types of temperature transducers

- **Resistive temperature detectors (RTD)**

  - typical devices use platinum wire (such a device is called a platinum resistance thermometers or PRT)
  - Resistance of the RTD element is measure by measuring the voltage drop across RTD element
  - By tabulating the resistance values temperature of the resistance can be measured
  - Platinum, Nickel, Copper, Tungsten
  - It consists of a piece of wire wrapped around ceramic, glass core, metal sheath
  - Very useful in limited size applications due to their compact size
  - *linear* but has poor *sensitivity*

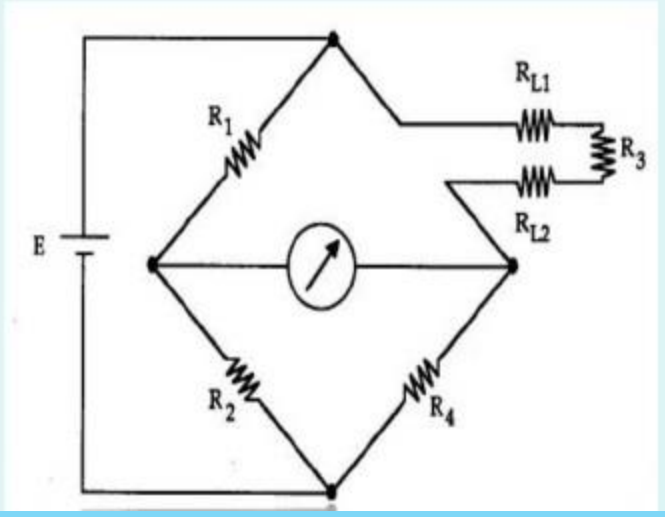


A typical PRT element

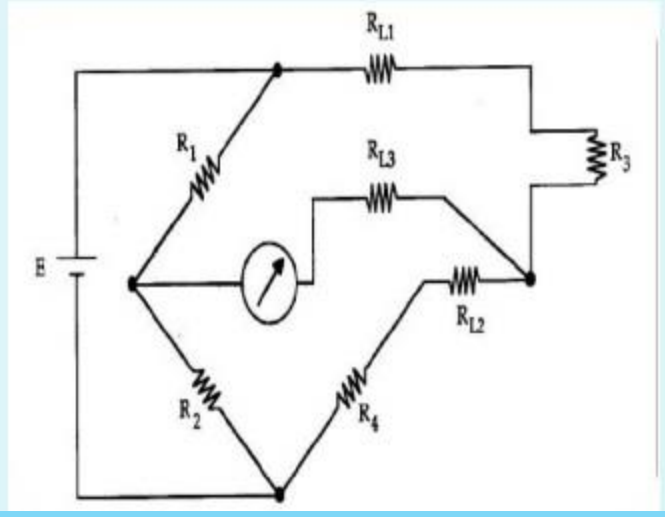


A sheathed PRT

Two wired RTD circuit



Three wired RTD circuit



Advantages

– Most suitable, accurate and more linear than thermocouple

Disadvantages

– Expensive, Slow, Current source required

– Resistance change is small

– Wide range (-200 to 850 ^{o}C)

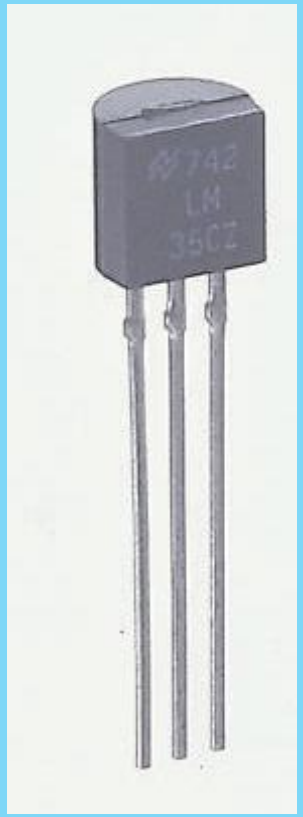
- **Thermistors**
  - use materials with a high thermal coefficient of resistance
  - *sensitive* but highly *non-linear*
  - *Limited range (-40 to 200 ^{o}C)*

A typical disc thermistor

A threaded thermistor

- **Advantages and disadvantages**
  - High resistance 1 to 100 kΩ
  - Small physical size, fast response
  - Low cost than RTD
  - Very high sensitivity and resolution than RTD (1000 times)
  - Highly nonlinear resistance to temperature relationship

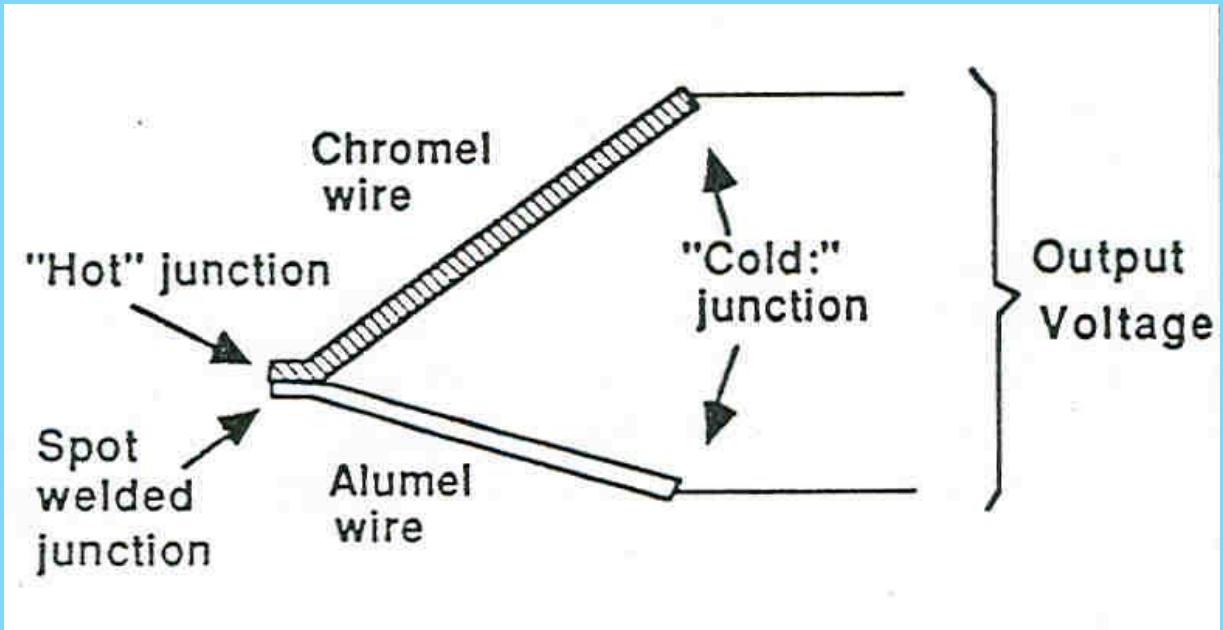
- **IC sensors**
  - a semiconductor device with the properties of a diode (we will consider semiconductors and diodes)
  - *inexpensive*, *linear* and *easy to use*
  - *limited temperature range* (perhaps -50°C to 150 °C) due to nature of semiconductor material



pn-junction sensor

- **IC sensor**
  - Built on a silicon chip
  - *Voltage or current is nearly linear with temperature*
  - *Input is needed*
  - *Accuracy is about 1 to 0.5 ^{o}C*
  - *Cost is low*

- **Thermocouple**



- The ends that are joined together are referred to as the “hot” junction and the other ends are referred to as the “cold” junction.

- The magnitude of the output voltage depends on the temperature difference between the “hot” and “cold” junctions and on the materials used.
- Types T, J, E, K, N, S, R, B

Advantages

- *Self powered*
- *Simple*
- *Strong*
- *Inexpensive*
- *Wide temperature range (200-1750 ^{o}C)*

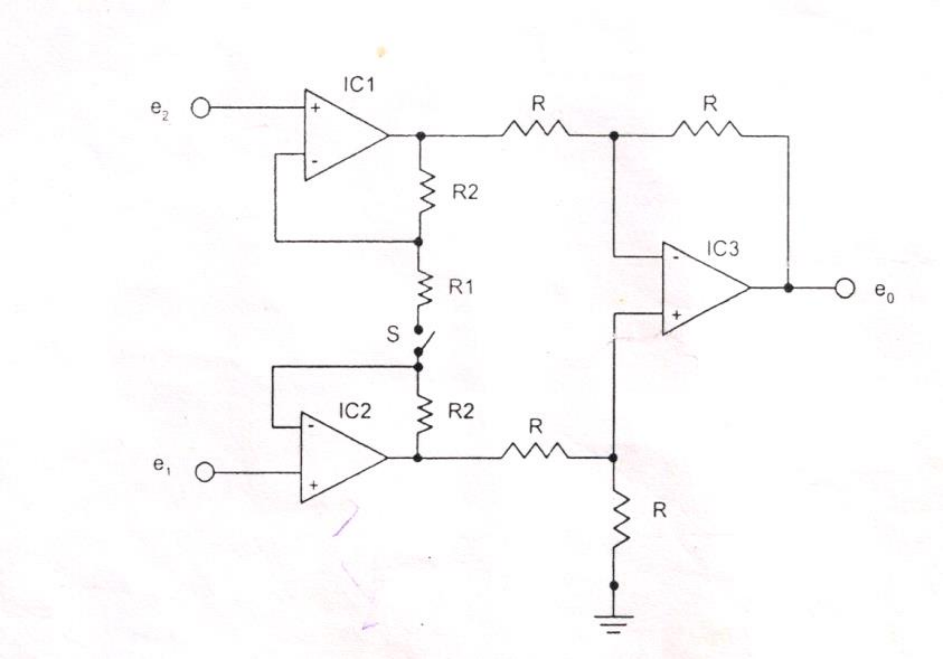
Disadvantages

- *Nonlinear*
- *Low voltage*
- *Reference required*
- *Least stable*
- *Least sensitive*

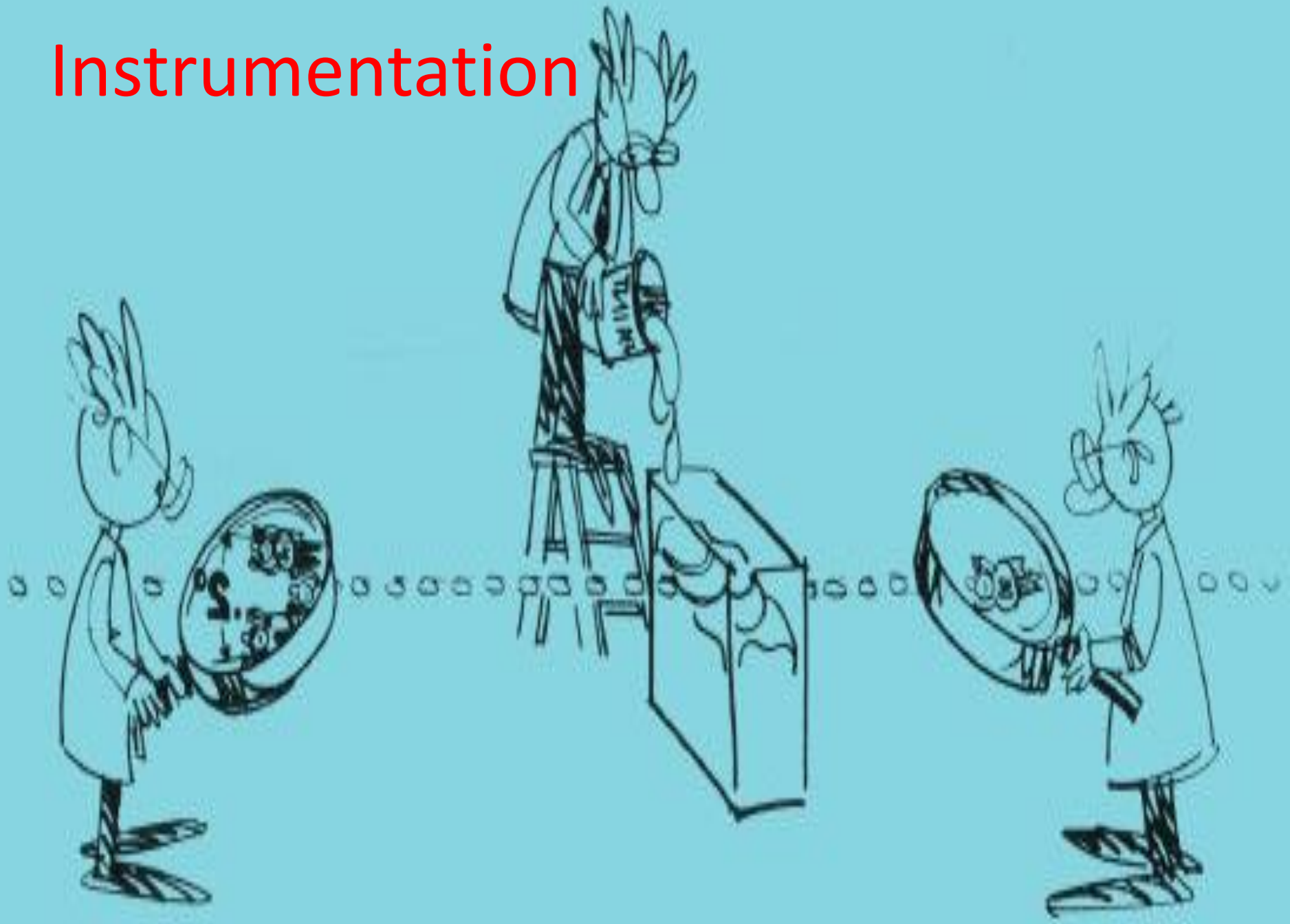
Temperature transducer

- **Aim :** To study the characteristic of a variety of temperature transducers and also verify the performance of the instrumentation amplifier used.

- **Apparatus:** Temperature transducer kit, different transducer (IC sensor, thermocouple, thermistor, temperature controlled oven.
- **Diagram:**

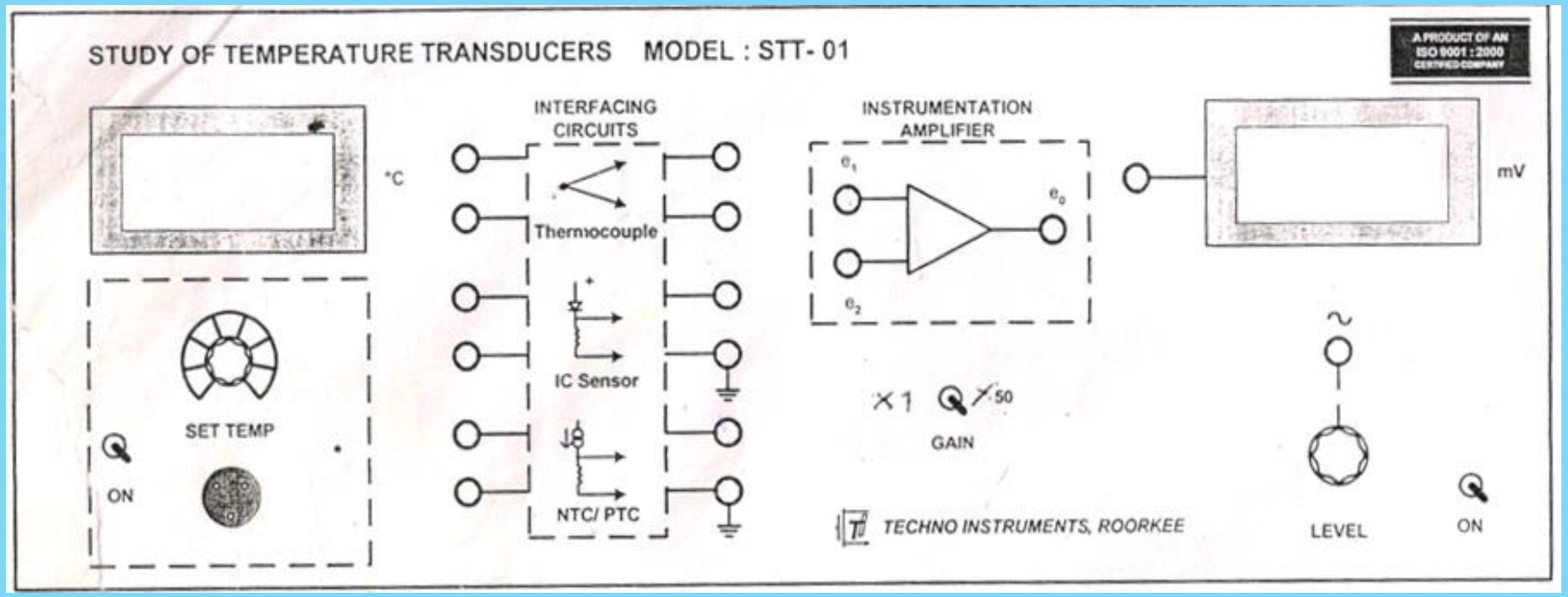


Instrumentation



Instrumentation contd.

Front side display



System features

- An instrumentation amplifier, gain of which can be switched between 1 and 50
- Interfacing circuits for the transducers
- A voltmeter for displaying the amplifier output
- A sine waver source of variable amplitude for amplifier studies. [500 HZ, 0-2.5 V (p-p)]

Instrumentation amplifier

An instrumentation amplifier is a type of differential amplifier that has been equipped with input buffer amplifiers to eliminate the need for input impedance matching

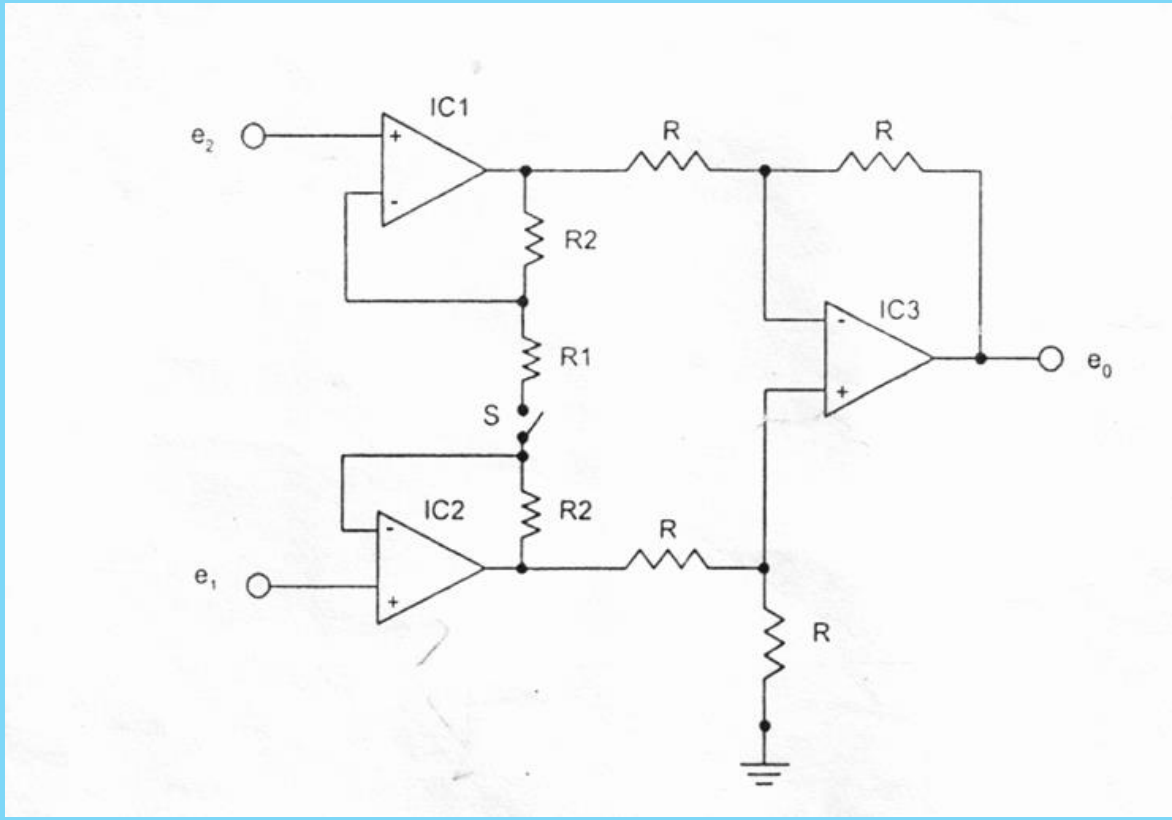
Suitable for use in measurement and test equipment

Instrumentation amplifiers are used where great accuracy and stability of the circuit required.

Characteristics of instrumentation amplifier

- very low DC offset
- low drift
- low noise
- very high open-loop gain
- very high common-mode rejection ratio
- very high input impedances

Instrumentation amplifier



Instrumentation amplifier

- Differential mode gain

$$A_v = \frac{e_0}{e_1 - e_2} = \left(1 + \frac{2\,R_2}{R_1}\right)$$

- Common mode gain

$$A_c = \frac{e_0}{e_c}$$

- Common mode gain

$$\text{CMRR} = 20\,log_{10}\frac{A_v}{A_c}\ dB$$

Interfacing Circuit

All the outputs are amplified through common instrumentation amplifier, therefore individual interfacing circuits are needed for the transducers

- Thermocouple
- Semiconductor temperature transducers
- Thermistors (NTC/PTC)
- Digital voltmeter
- Sine wave signal
- Temperature controlled oven

- **Observation Table:**

Gain measurement

a) Gain set at 1

Differential Gain			**Av**	**Common mode gain**		**Ac**	**CMRR**
input		Out put	e0/e1-e2	Input	Out put	e0/e1-e2	20*log(Av/Ac)
e1	e2	e0		e1 =e2	e0		
1000	0						
0	1000						

CMRR – common mode rejection ratio

- **Characteristic of thermocouple** (chromel alumel)
- **Amplifier gain = 50**

Sr. No.	Temperature (^{o}C)	Amplifier output, mv
1		
2		
3		

- **Characteristic of semiconductor sensor, AD590**
- Ambient temperature = Amplifier gain = 1

Sr. No.	Temperature (^{o}C)	Amplifier output, mv
1		
2		
3		

Characteristic of negative temperature coefficient thermistor

- Ambient temperature = Amplifier gain = 1

Sr. No.	Temperature (C)	Amplifier output, mv
1		
2		
3		

Graph: Plot graph of temperature vs amplifier output for each type of transducer.

Result


Questions

Thank you for attention