LCR METER

Contents:

- Introduction
- LCR meter basics
- Bridge Method
- LCR Bridge Measurement Guidelines
- References

Introduction

- LCR meters or LCR bridges are items of test equipment or test instrumentation used to measure the inductance, capacitance, and resistance of components.
- LCR meters tend to be specialist items of test equipment, often used for inspection to ensure that the components arriving are correct. They can also be used in a development laboratory where it is necessary to test and measure the true performance of particular components.
- The LCR meter or LCR bridge takes its name from the fact that the inductance, capacitance and resistance are denoted by the letters L, C, and R respectively. Some versions of the LCR meter use a bridge circuit format as the basis of its circuit giving the name that is often used.

Cont…

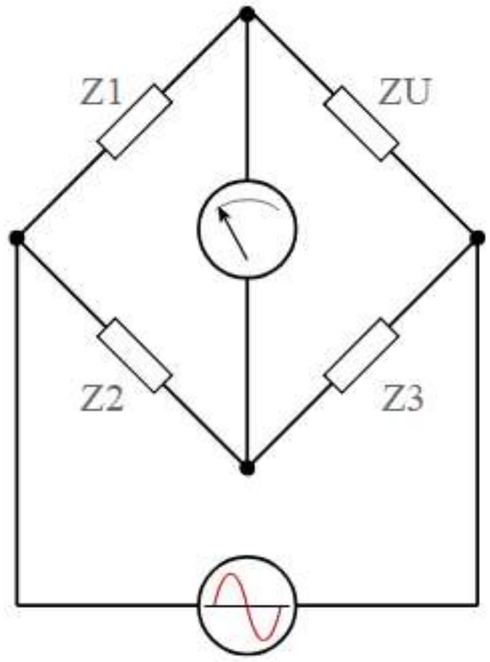
- A variety of meters are available. Simpler versions of LCR meters provide indications of the impedance only converting the values to inductance or capacitance.
- More sophisticated designs of LCR bridge are able to measure the true inductance or capacitance, and also the equivalent series resistance and tanδ of capacitors and the Q factor of inductive components. This makes them valuable for assessing the overall performance or quality of the component.

LCR meter basics

Two main circuit techniques are used to form the basis of an LCR meter.

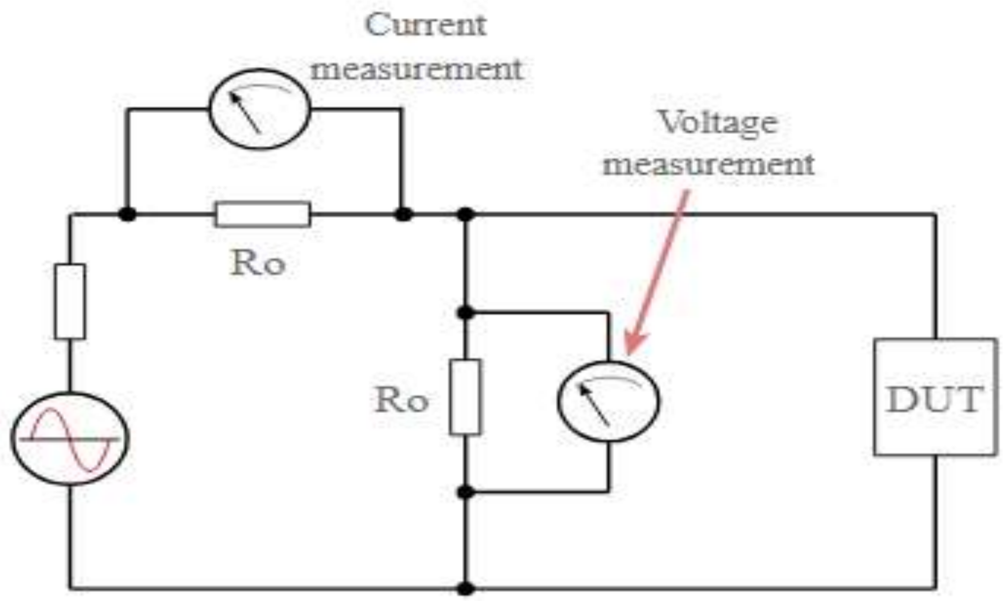
- ***Bridge method***
- ***Current-voltage measurement***

Bridge method



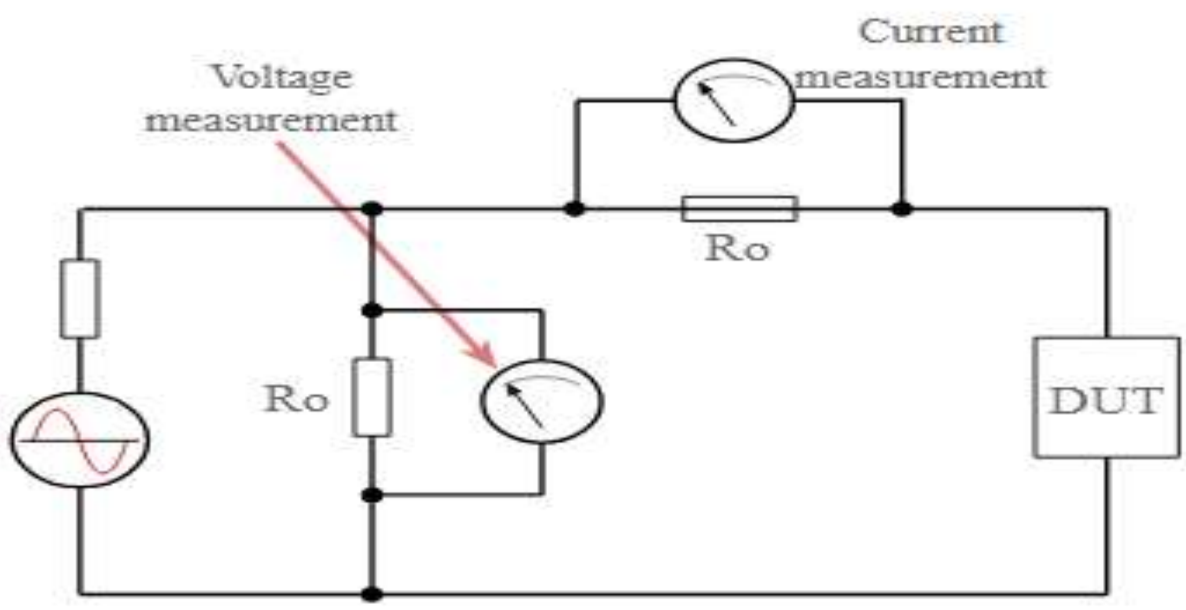
Basic bridge based LCR meter circuit

Current-voltage measurement:



IV LCR Measurement for low impedance circuits

Cont…



IV LCR Measurement for high impedance circuits

LCR bridge measurement guidelines

- ***Effect of lead length:*** At frequencies above 1 MHz or so the lead length can start to have an effect. As a rough guide a good estimate for lead inductance is around 10 nH per cm of lead. For the best measurements kep the leads as short as possible.
- ***Measure at operational frequency:*** When making measurements using an LCR meter it helps to use a test frequency as close to the actual operational frequency as possible. This means that the effects of any stray effects or changes due to frequency are minimised - for example inductor cores may have different properties at different frequencies. This can make a noticeable difference in some instances.

Cont…

- ***Adjust test amplitude:*** In the same way that it is good practice to measure at a frequency that is as close to the operational frequency as possible, the same is true for the test amplitude. This is because component values may vary with the signal applied. This is particularly true for inductors that use cores such as ferrite that may introduce losses. These may be amplitude dependent.
- ***Discharge capacitors before measurement:*** Some capacitors may carry a residual charge under some circumstances. It is best to discharge them before any measurements. As charge on some capacitors can linger for some time, it is always best to discharge them before any tests.

Reference:

- https://www.electronics-notes.com/articles/test-methods/lcr-meter-bridge/primer-basics.php
- https://ieeexplore.ieee.org/document/1604290
- https://ieeexplore.ieee.org/document/7529776
- https://ieeexplore.ieee.org/document/8282577
- https://www.youtube.com/watch?v=3wwd9Ducixc

Three Phase Power Measurement

What Is Three-Phase Power?

- Three-phase power is a common method of alternating-current electric power generation, transmission, and distribution.
- It is a type of polyphase system and is the most common method used by electric grids worldwide to transfer power.
- A polyphase system is a means of distributing alternating-current electrical power.
- An electrical grid is an interconnected network for delivering electricity from suppliers to consumers.

Methods Of Measurement of Three-Phase Power

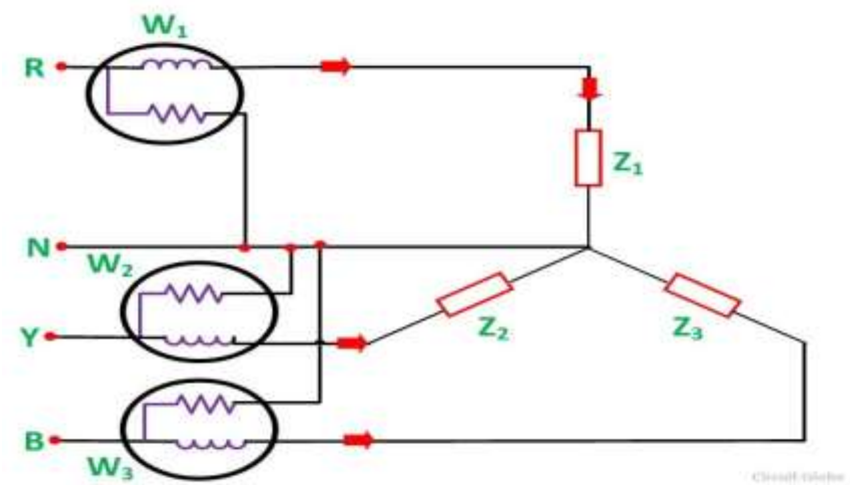
- Various methods are used measurement of three phase power in three phase circuits on the basis of number of wattmeter used.
- We have three methods:-

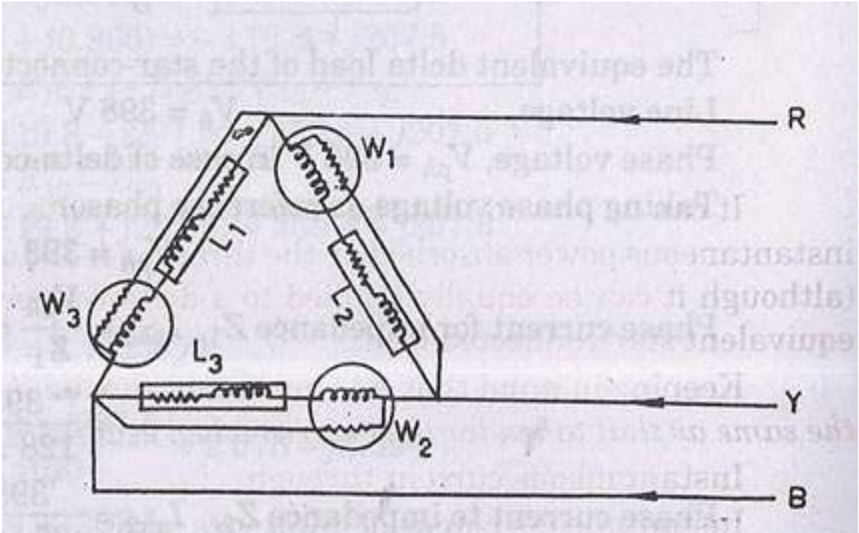
1) Three wattmeter method
2) Two wattmeter method
3) Single wattmeter method

Measurement of Three Phase Power by Three Wattmeter Method

- Three Wattmeter method is used to measure power in a 3 phase, 4 wire system.
- However, this method can also be used in a 3 phase, 3 wire delta connected load, where power consumed by each load is required to be determined separately.
- The Three-wattmeter method can be used for star and delta connected unbalnced loads.

The connections for Star/Delta connected loads for measuring power by Three wattmeter method is shown below:-





- The pressure coil of all the Three wattmeter namely W_1, W_2 and W_3 are connected to a common terminal known as the neutral point. The product of the phase current and line voltage represents as phase power and is recorded by individual wattmeter.

- The total power in a Three wattmeter method of power measurement is given by the algebraic sum of the readings of Three wattmeter. i.e.

$$\text{Total power } P = W_1 + W_2 + W_3$$

- Where,

  $W_1 = V_1 I_1$

  $W_2 = V_2 I_2$

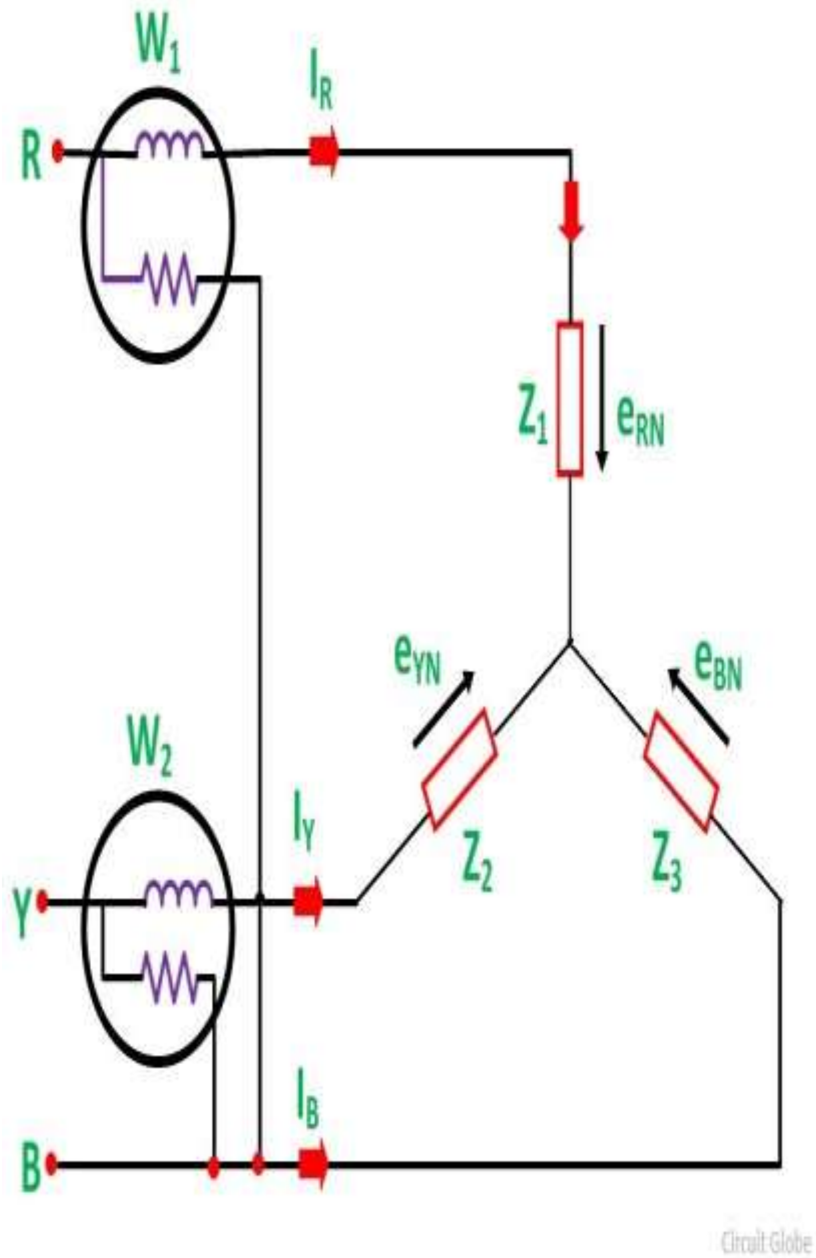
  $W_3 = V_3 I_3$

- Except for 3 phase, 4 wire unbalanced load, 3 phase power can be measured by using only Two Wattmeter Method.

Measurement of three Phase Power by Two Wattmeter Method

- Two Wattmeter Method can be used to measure the power in a 3 phase, 3 wire star or delta connected balanced or unbalanced load.
- In Two wattmeter method the current coils of the wattmeter are connected with any two lines, say R and Y and the potential coil of each wattmeter is joined across the same line, the third line i.e. B.
- The two wattmeter method is used for the power measurement in the 3-phase system, irrespective of whether the load is balanced or unbalanced.

Measurement of Power by Two Wattmeter Method in Star Connection



Let W_1 and W_2 Be the two wattmeter.

Let e_{RN} and e_{BN} the phase voltages across the three loads

i_R, i_Y and i_B be the phase currents respectively.

- The instantaneous current through the current coil of Wattmeter, W_1 is given by the equation shown below.

$$W_1 = i_R$$

- Instantaneous potential difference across the potential coil of Wattmeter, W_1 is given as

$$W_1 = e_{RN} - e_{BN}$$

- Instantaneous power measured by the Wattmeter, W_1 is

$$W_1 = i_R\,(e_{RN} - e_{BN}) \;\ldots\ldots\ldots(1)$$

- The instantaneous current through the current coil of Wattmeter, W_2 is given by the equation

$$W_2 = i_Y$$

- Instantaneous potential difference across the potential coil of Wattmeter, W_2 is given as

$$W_2 = e_{YN} - e_{BN}$$

- Instantaneous power measured by the Wattmeter, W_2 is

$$W_2 = i_Y (e_{YN} - e_{BN}) \quad \dots\dots\dots..(2)$$

- Therefore, the Total Power Measured by the Two Wattmeter W_1 and W_2 will be obtained by adding the equation (1) and (2).

$$W_1 + W_2 = i_R(e_{RN} - e_{BN}) + i_Y(e_{YN} - e_{BN})$$

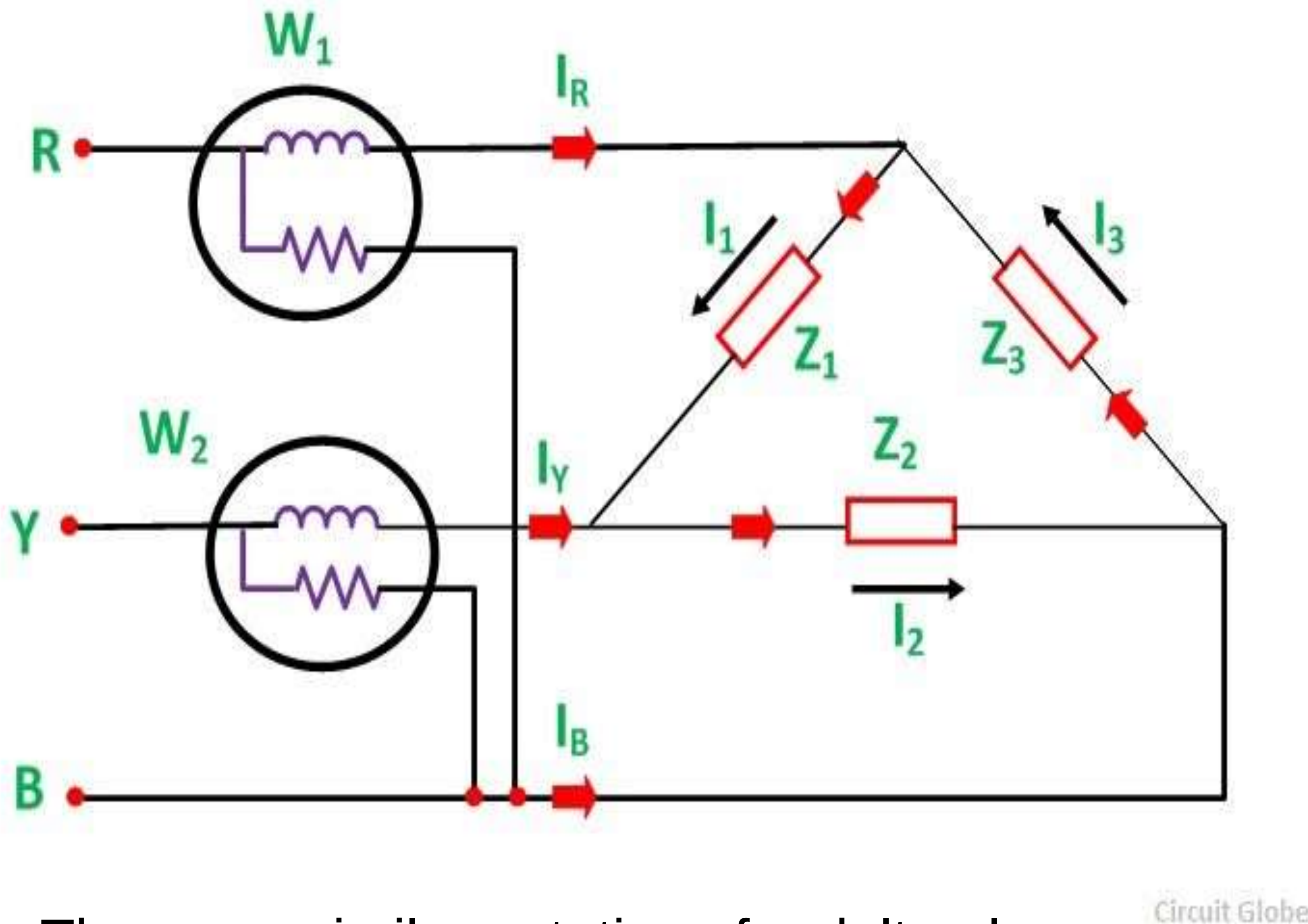
$$W_1 + W_2 = i_R e_{RN} + i_Y e_{YN} - e_{BN}(i_R + i_Y) \quad \text{or}$$

$$W_1 + W_2 = i_R e_{RN} + i_Y e_{YN} + i_B e_{BN} \quad (\text{i.e. } i_R + i_Y + i_B = 0)$$

$$W_1 + W_2 = P$$

- Here P is the total power absorbed in the three loads at any instant.

Measurement of Power by Two Wattmeter Method in Delta Connection



There are similar notations for delta also.

- The instantaneous current through the coil of the Wattmeter, W_1 is given by the equation

$$W_1 = i_R = i_1 - i_3$$

- Instantaneous Power measured by the Wattmeter, W_1 will be

$$W_1 = e_{RB}$$

- Therefore, the instantaneous power measured by the Wattmeter, W_1 will be given as

$$W_1 = e_{RB}\,(i_1 - i_3)\ \ldots\ldots\ldots (3)$$

- The instantaneous current through the current coil of the Wattmeter, W_2 is given as

$$W_2 = i_Y = i_2 - i_1$$

- The instantaneous potential difference across the potential coil of Wattmeter, W_2 is

$$W_2 = e_{YB}$$

- Therefore, the instantaneous power measured by Wattmeter, W_2 will be

$$W_2 = e_{YB}\,(i_2 - i_1) \;\ldots\ldots\ldots(4)$$

- Hence, to obtain the total power measured by the Two Wattmeter the two equations, i.e. equation (3) and (4) has to be added.

$$W_1 + W_2 = e_{RB}(i_1 - i_3) + e_{YB}(i_2 - i_1)$$

$$W_1 + W_2 = i_1 e_{RB} + i_1 e_{YB} - i_3 e_{RB} - i_1 e_{YB}$$

$$W_1 + W_2 = i_2 e_{YB} + i_3 e_{BR} - i_1(e_{YB} + e_{BR}) \quad (i.e. -e_{RB} = e_{RB})$$

$$W_1 + W_2 = i_1 e_{RY} + i_2 e_{YB} + i_3 e_{BR} \quad (i.e\ e_{RY} + e_{YB} + e_{BR} = 0)$$

$$W_1 + W_2 = P$$

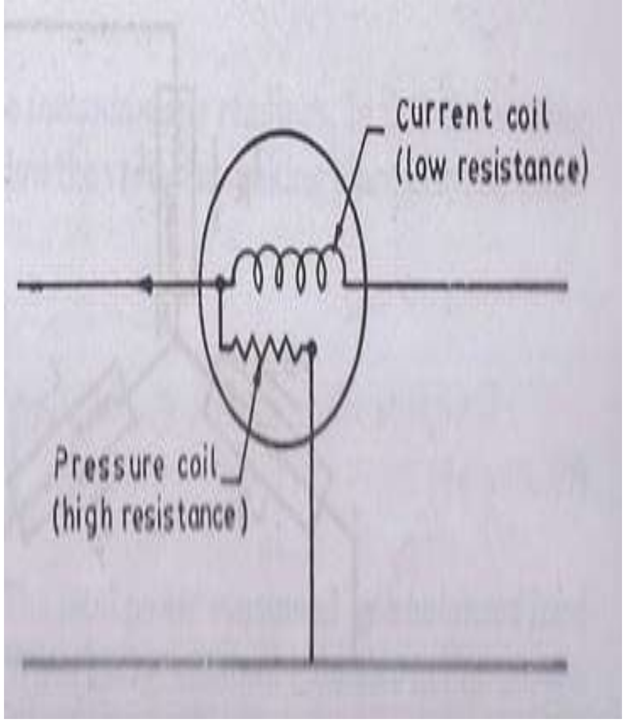
- Here P is the total power absorbed in the three loads at any instant.

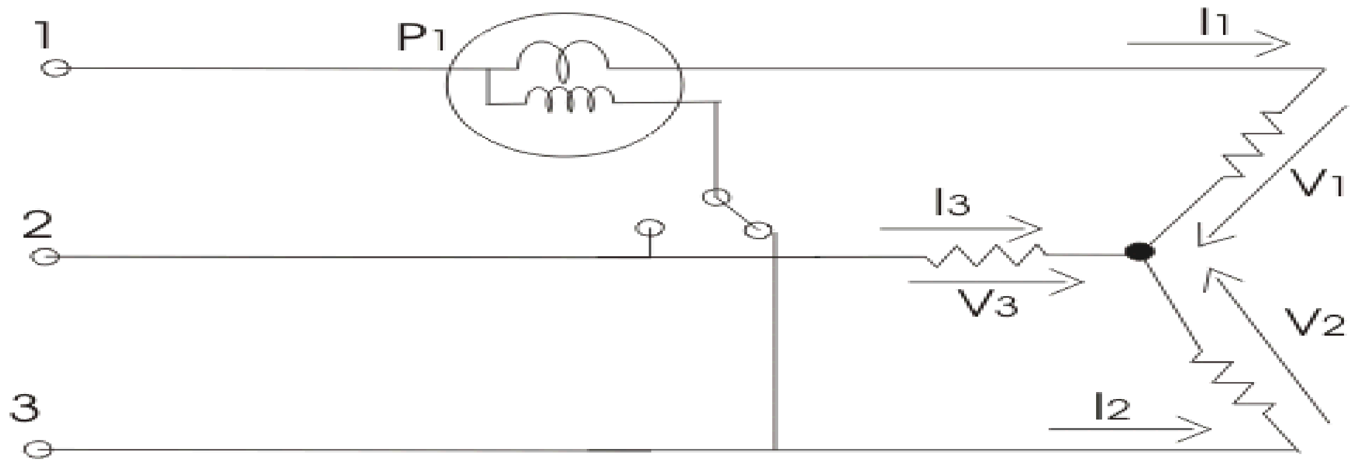
- The power measured by the Two Wattmeter at any instant is the instantaneous power absorbed by the three loads connected in three phases.

- In fact, this power is the average power drawn by the load since the Wattmeter reads the average power because of the inertia of their moving system.

Measurement of Power by Single Phase Wattmeter Method

- Power is measured in the electric circuit using a wattmeter.
- A single phase wattmeter consists of two coils; namely the current coil and the pressure coil.
- The Current coil is connected in series with the line and thus carries the line current.
- The Pressure coil is connected in parallel with the line.
- The Wattmeter gives the power per phase.





- The wattmeter gives the value of power per phase.

- Therefore, Total power = 3 X Power per phase
= 3 X wattmeter reading

- The one wattmeter method is used for power measurement in the 3-phase star connected balanced load.

Thank You

Transducers

CONTENTS

- WHAT IS TRANSDUCER
- ELECTRICAL TRANSDUCER
- CLASSIFICATION OF TRANSDUCERS
- SELECTION CRITERIA OF THE TRANSDUCERS
- BASIC CONSTRUCTION OF TRANSDUCERS
- RESISTANCE TEMPERATURE DETECTOR
- THERMISTORS
- LVDT
- RVDT
- STRAIN GUAGE
- BOURDON TUBE
- APPLICATIONS,ADVATAGES AND DISADVANTAGES

WHAT IS TRANSDUCER

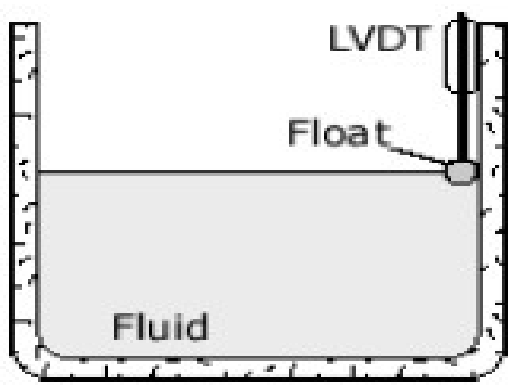
The transducer is defined as the device which convert the one form of energy into another form of the energy

Example:

- Temperature transducers
- Thermocouples
- Resistance-Temperature Detectors (RTD)
- Thermistors
- Resistive position transducers
- Displacement transducers
- Strain gauge

ELECTRICAL TRANSDUCERS

- The electrical transducers is one which converts the non-electrical quantity into the equivalent electrical quantity.
- Non-electrical quantity such as force, displacement, stress, temperature.
- Electrical quantity such as current , voltage



CLASSIFICATION OF TRANSDUCERS

- On the basis of transduction form used.
- As primary and secondary transducers.
- As passive and active transducers.
- As analog and digital transducers.
- As transducers and inverse transducers

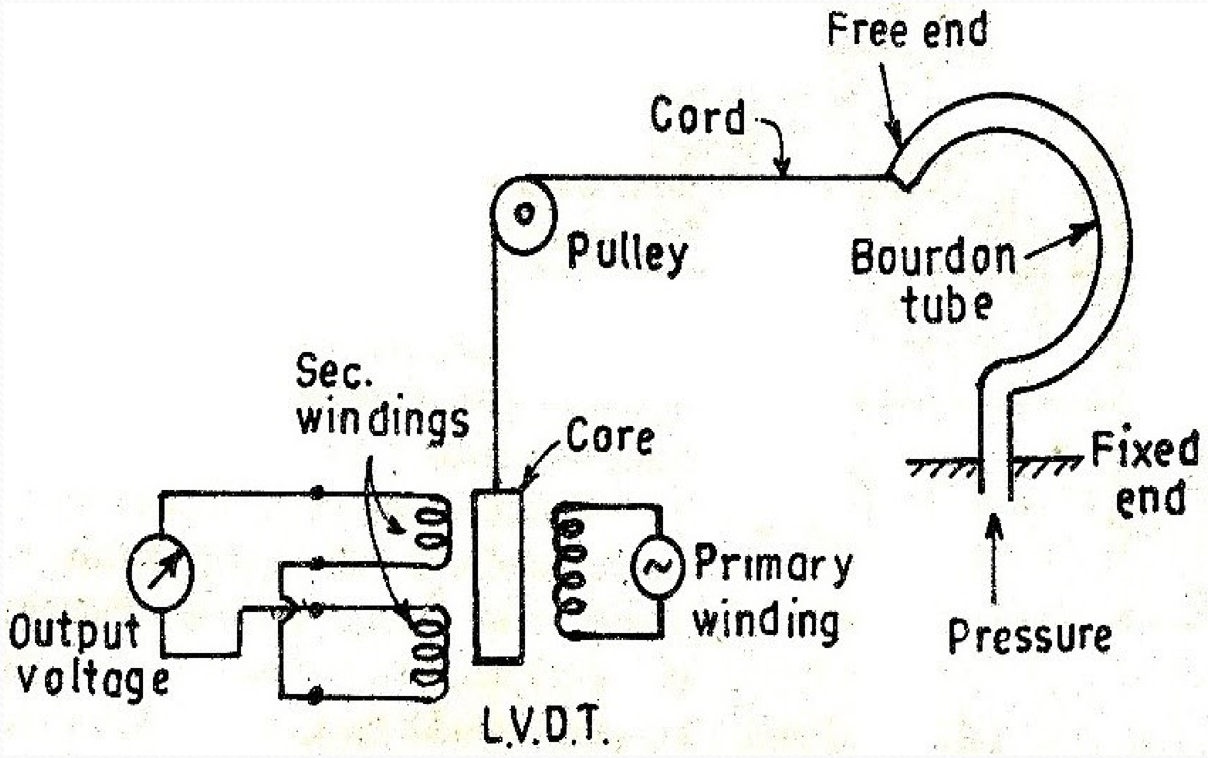
On the basis of transduction form used

- Resistive Transducers.
- Capacitive Transducers.
- Inductive Transducers.
- Voltage and current Generating Transducers.

Primary and secondary transducers

Example

LVDT and bourdon tube



Passive and Active Transducers

- If transducers derive the power require for transduction from an power source, then this kind of transducer are known as passive transducer

Example

- LVDT
- RVDT

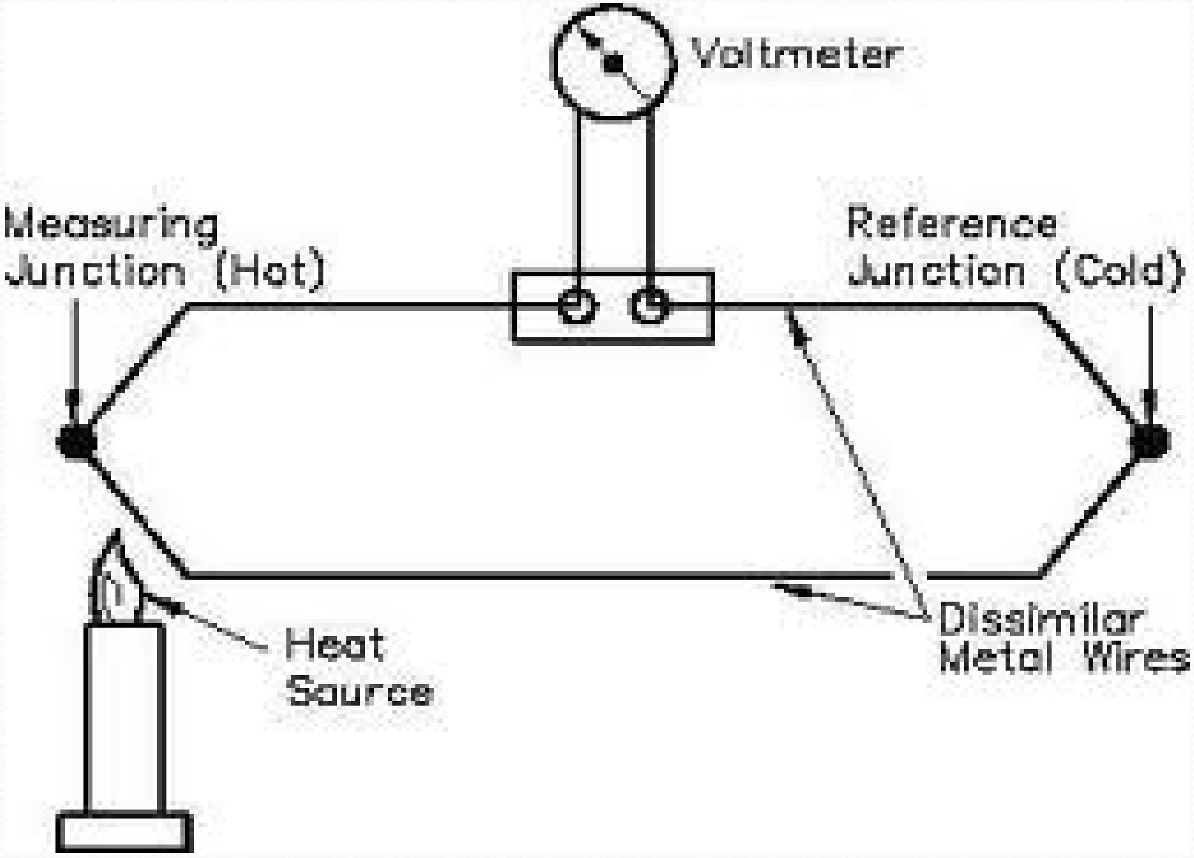
CONT…

When there is no need for any source then these type of transducers are Active transducers

Example are :

- Thermocouple
- Piezoelectric crystal

THERMOCOUPLE

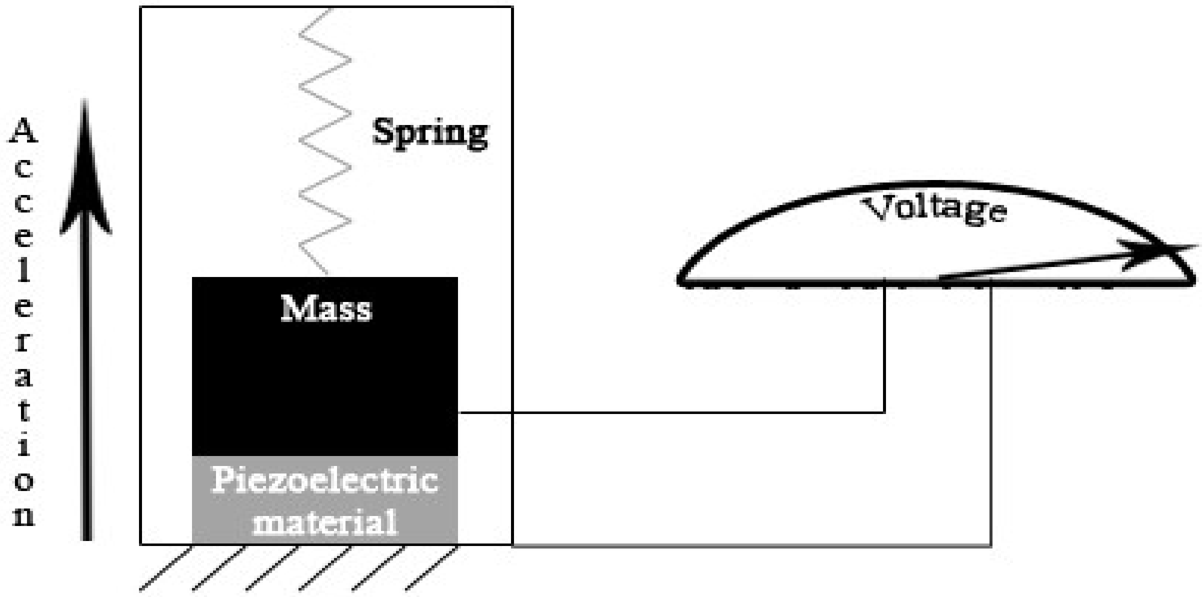


TYPES OF THERMOCOUPLE

TYPE	NAME	RANGE
T	Copper-Constantan	-250 to 400
J	Iron-Constantan	-200 to 850
E	Cromel-Constantan	-200 to 850
K	Chromel-Alumel	-180 to 1100
W	Tungesten-Rhenium	0 to 2600
R	Platinum13%-Rhodium	0 to 1750
S	Platinum10%-Rhodium	0 to 1750
B	Platinum30%-Rhodium 6%	0 to 1800

Piezoelectric crystal

- Quartz ,Rochelle salt, Lithium sulphate or barium titanate.



Inverse Transducers

These type of transducers convert a electrical quantity into non-electrical quantity

Example

- Piezoelectric crystal
- Analog ammeter
- voltmeter

SELECTION CRITERIA OF THE TRANSDUCERS

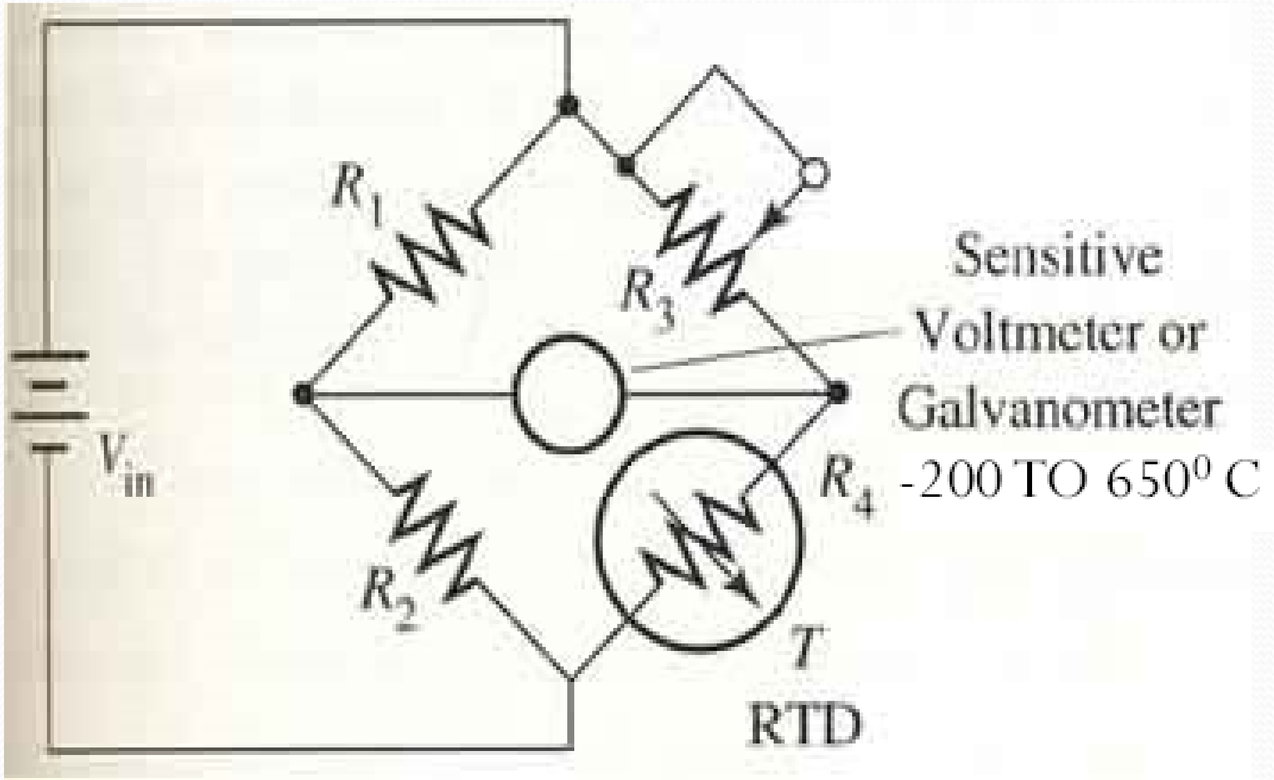
- Operating principle
- Sensitivity
- Operating range
- Accuracy
- Errors
- Environmental capability
- Insensitive to unwanted Signal
- Stability

BASIC CONSTRUCTION OF TRANSDUCERS

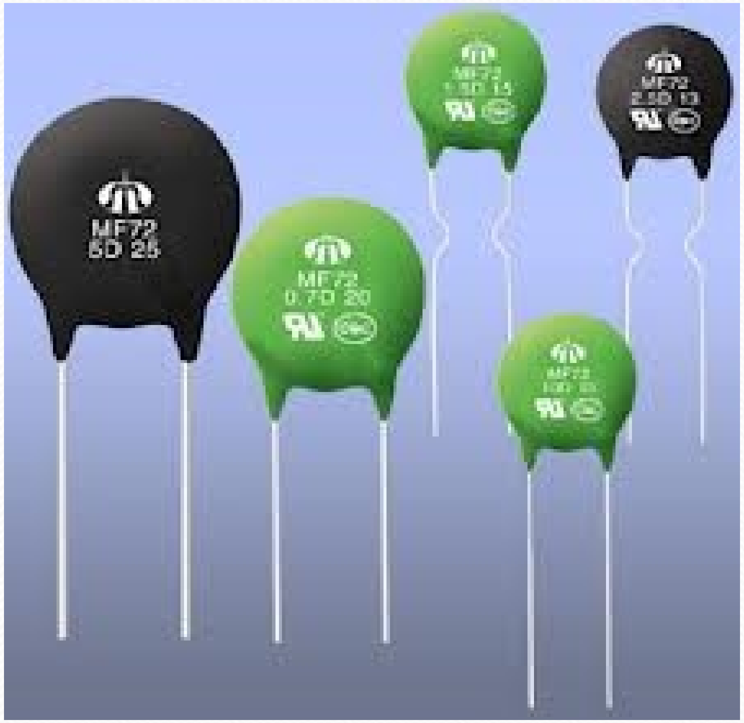
It consist of two important parts

- Sensing element.
- Transduction element.

RESISTANCE TEMPERATURE DETECTOR

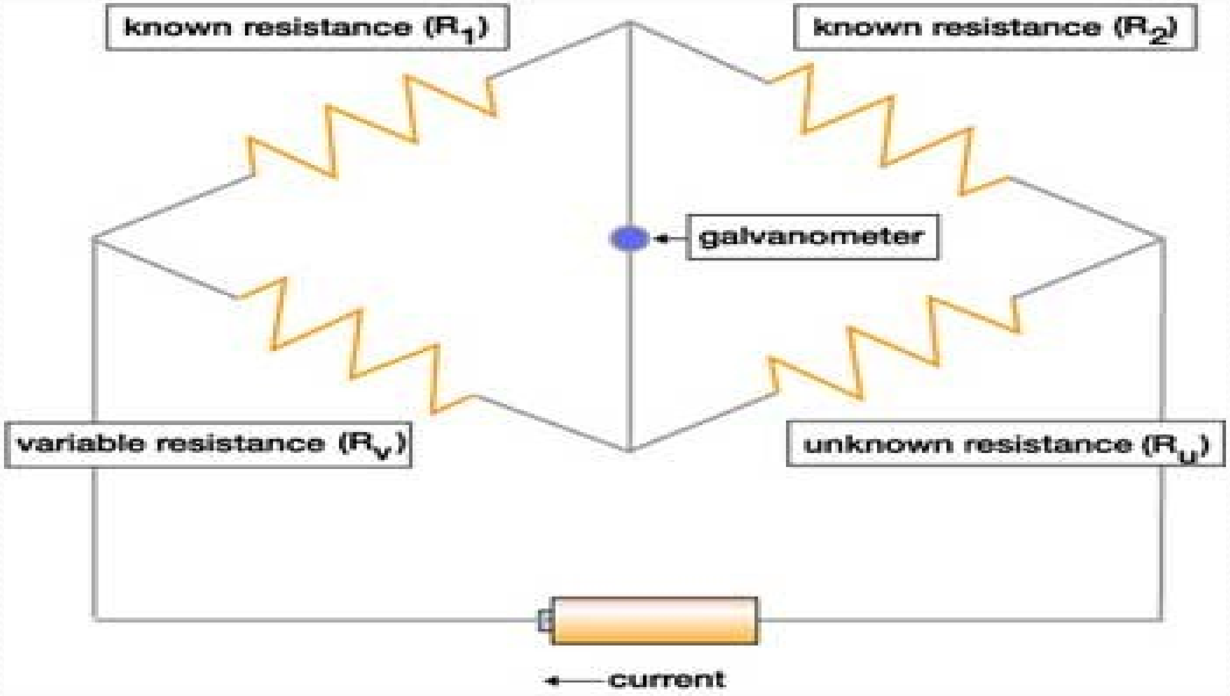


THERMISTORS



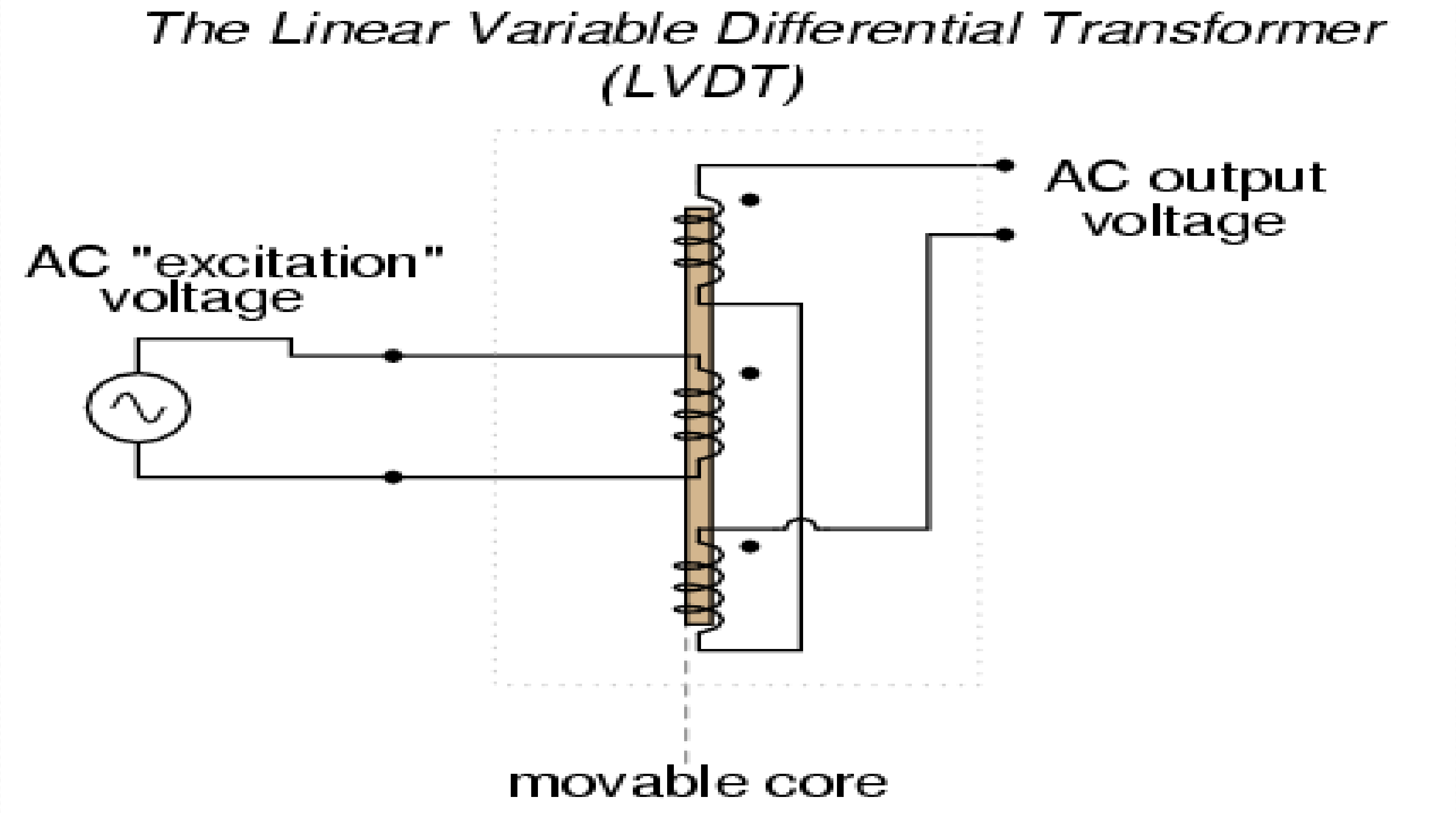
- Thermistors are used for the measurement of precision temperature

Cont…

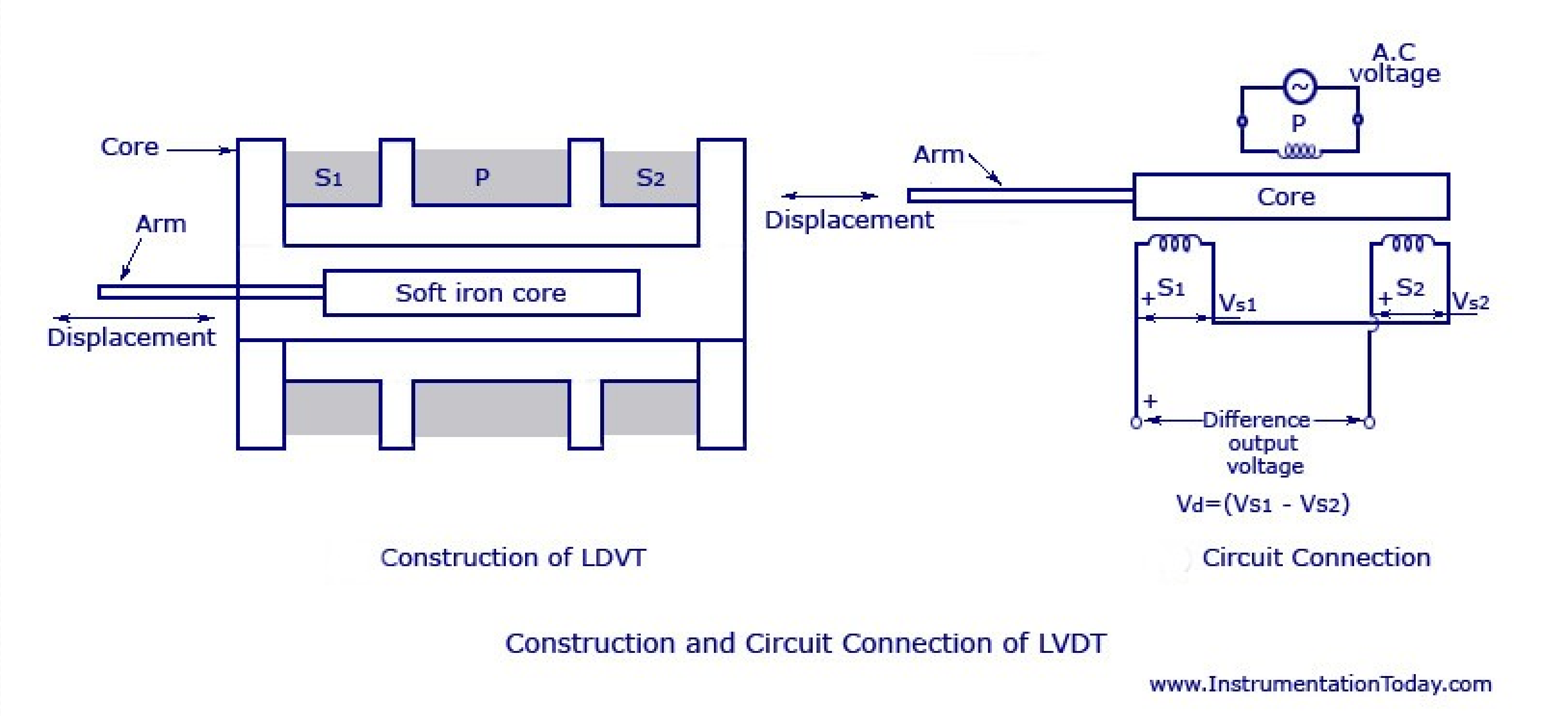


known resistance (R_1)
known resistance (R_2)
galvanometer
variable resistance (R_v)
unknown resistance (R_u)
current

LVDT

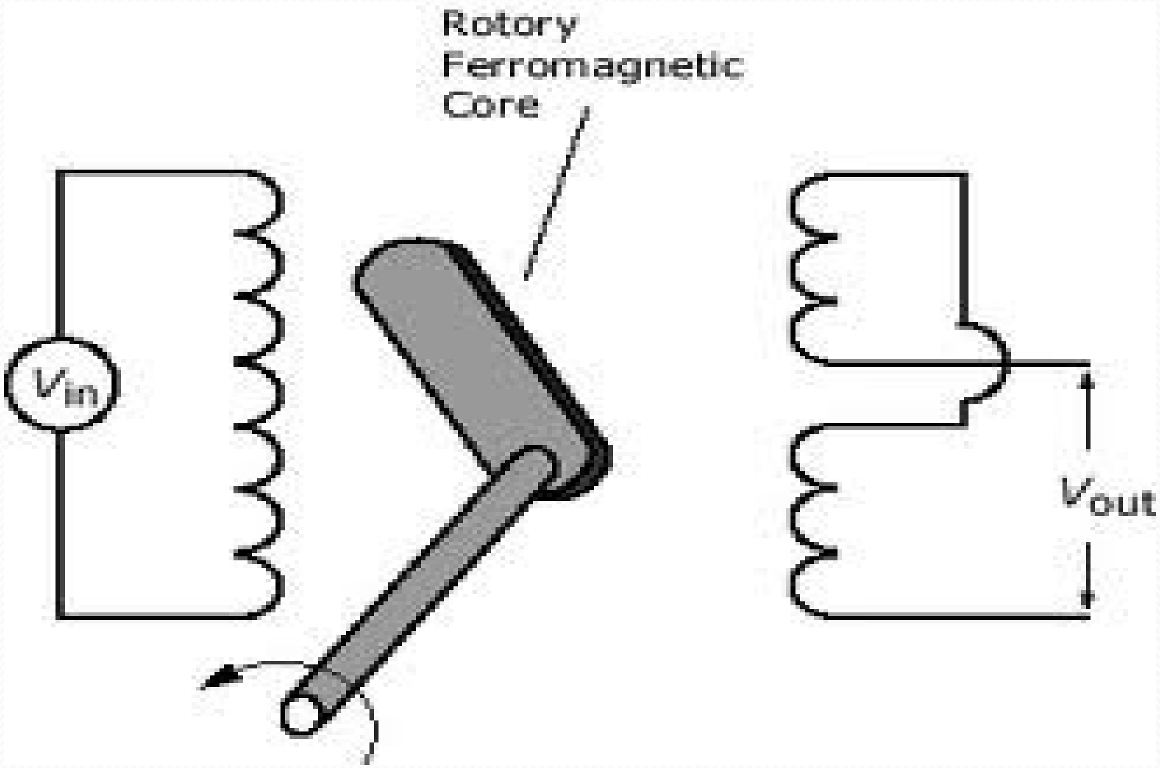

The Linear Variable Differential Transformer
(LVDT)
AC output
voltage
AC "excitation"
voltage
movable core

Cont…



Core
S1
P
S2
Arm
Soft iron core
Displacement
Construction of LDVT
A.C voltage
P
Arm
Displacement
Core
S1
Vs1
S2
Vs2
Difference output voltage
Vd=(Vs1 - Vs2)
Circuit Connection
Construction and Circuit Connection of LVDT
www.InstrumentationToday.com

RVDT



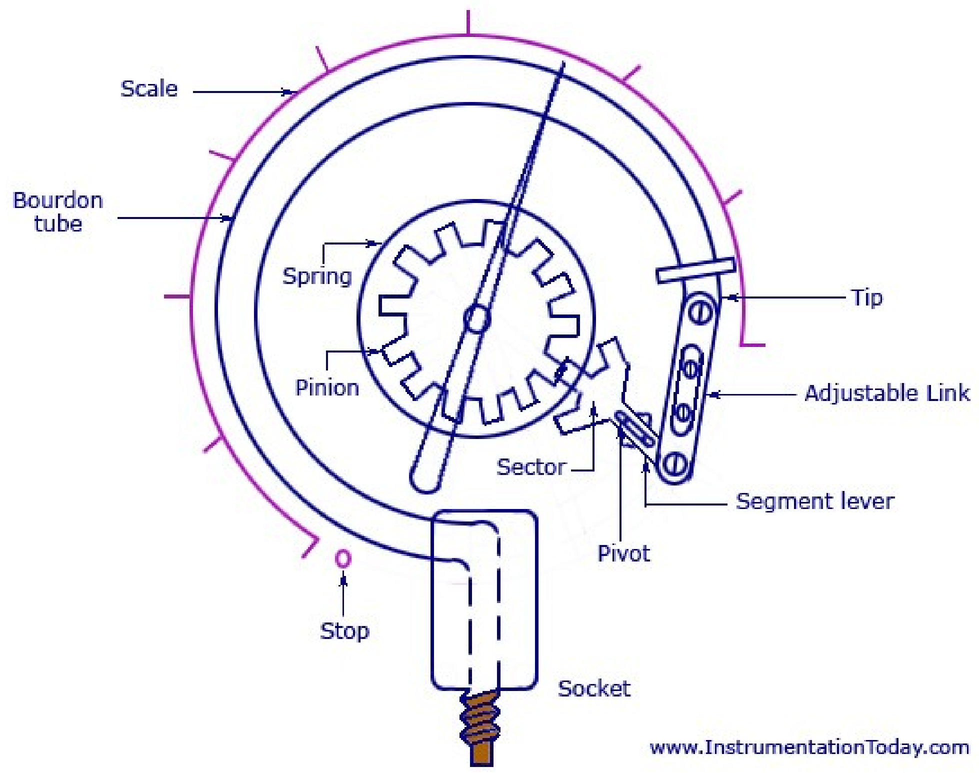
STRAIN GAUGE

- It works on Piezoresistive effect.
- These are used for measurement of stress and strain
- If an elastic material is subjected to tension then its resistance changes.

BOURDEN TUBE

- Curved metallic tubes with
- Elliptical cross section
- Sealed at one end
- Tends to straighten when pressure applied.
- Angular sensitivity proportional to pressure applied

BOURDEN TUBE



Bourdon Tube Pressure Gauge

APPLICATION

- Audio/video equipment
- Pressure indication
- Measurement of displacement
- Alarms

ADVANTAGES

- Power requirement is very low for controlling the electrical or electronic system.
- Output can be indicated and recorded remotely from the sensing element.
- Electrical amplification and attenuation can be easily done.
- An amplifier may be used to amplify the electrical signal according to requirement.

DISADVANTAGES

- RTD produce mechanical vibrations
- Their cost is high
- Thermistors are unsuitable for wide temperature
- Relative large displacement is required for appreciable output for LVDT
- Bourdon tubes do not provide the precise measurement.

CONCLUSION

- Transducers are used to convert one form energy to another.
- All the transducers are very useful in all the application such as microphone , speaker etc.

REFERENCES

- http:/123seminarsonly.com/Latest-Seminar-Topics/Latest-Seminar-Topics-021.html
- From A.k .Sawhney/3rd sem/chapter5/Pageno.5.1-5.187
- http://en.wikipedia.org/wiki/Transducer


thank
you . . .

Queries

MEASUREMENT OF TEMP.

Er. Sohan Sharma
Lect.(EE)
GPES Cheeka

Outline….

- # Introduction
- # Temperature
- # Heat
- # Scale
- # Glass-Thermometer
- # Bi-metallic Thermometer
- # RTD
- # Thermocouple
- # Thermistor
- # IC Sensor
- # How to choose

INTRODUCTION

- ✓ The accurate measurement of temperature is vital across abroad spectrum of human activities,
  - ❖ Including industrial processes (e.g. making steel) Manufacturing;
  - ❖ Health and safety.
- ✓ In fact, in almost every sector, temperature is one of the key parameters to be measured.
- ✓ Different people will have different perceptions of what is hot and what is cold.

Temperature ?

- scalar quantity
- Degree of hotness or coldness
- Molecular K.E. ↑ = Temperature ↑

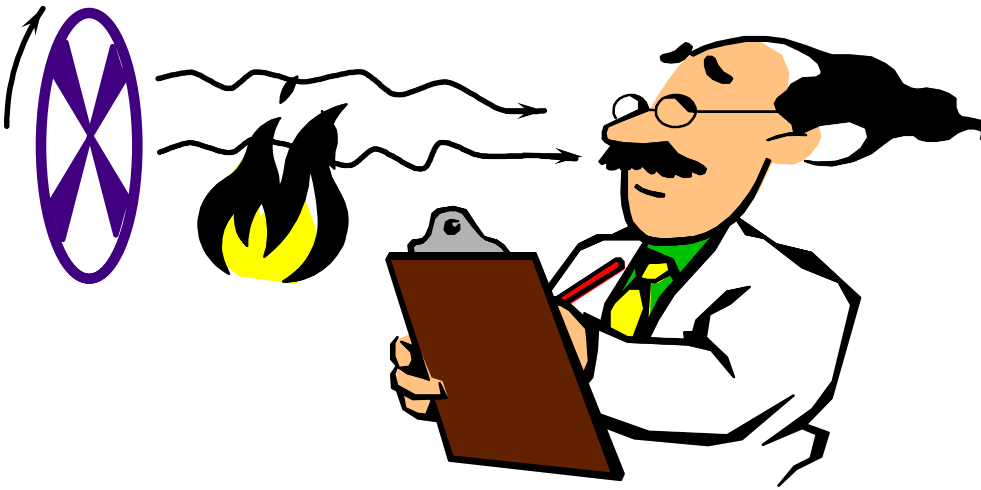
Heat ?

- Form of energy.
- Measured in calories or BTU'S[British Thermal Units].

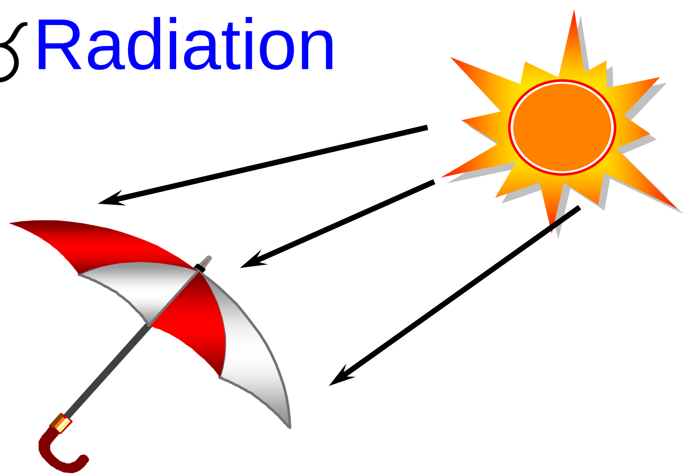
How is heat transferred?

- Conduction
  - Metal coffee cup

- Convection



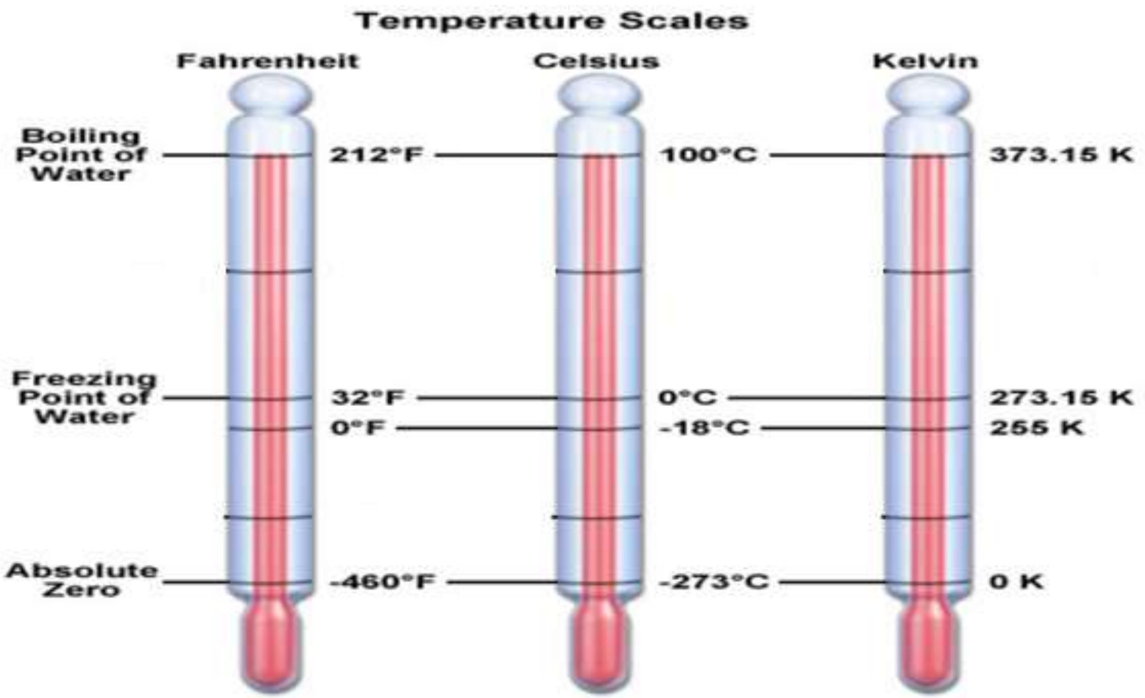
- Radiation



Scale

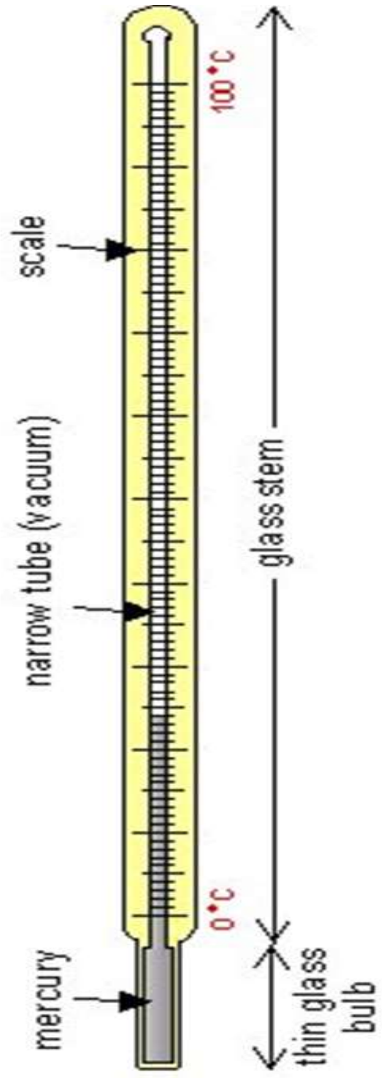
- Temperature - measure of the thermal energy.
- Measured in degrees [°]using scales.

1. Fahrenheit.[°F]
2. Celsius or centigrade. [°C]
3. Kelvin .[°K]



1.Liquid – in – Glass Thermometer

- The volume of mercury changes slightly with temperature.
- The space above the mercury may be filled with nitrogen or it may be at less than atmospheric pressure, a partial vacuum

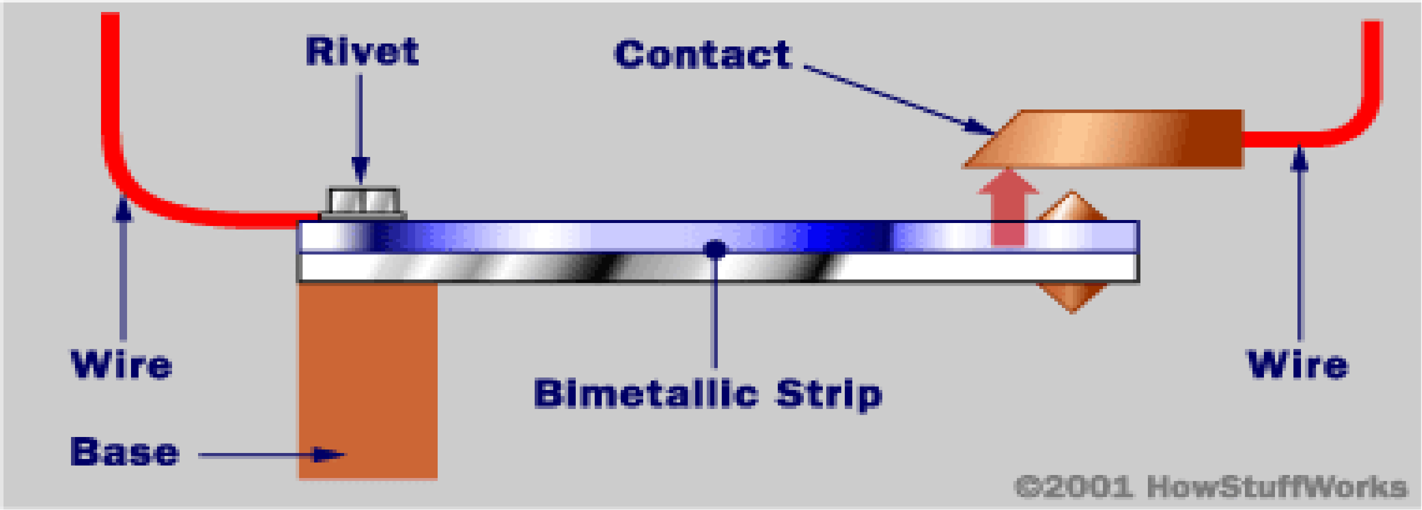


- **Thermal expansion:**

$$V = V_0(1 + \gamma T)$$

2.Bimetallic Thermometer

✓ Temperature Indicators (TI) or Temperature Gauges (TG)

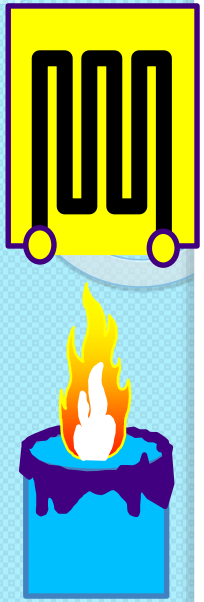


Principles :

- ❑ Expansion/Contraction - change in temperature.
- ❑ Different metals -- different co-efficient of temperatures.

  The rate of volumetric change depends on this co-efficient of temperature.

3.Resistance Temperature Detector (RTD)



- Resistance thermometer
- PRINCIPLE :

  TEMPATURE ↑↓= RESISTANCE ↑↓

- Positive temperature coefficient
- $R = R_0(1 + AT + BT^2)$ $T > 0$ C

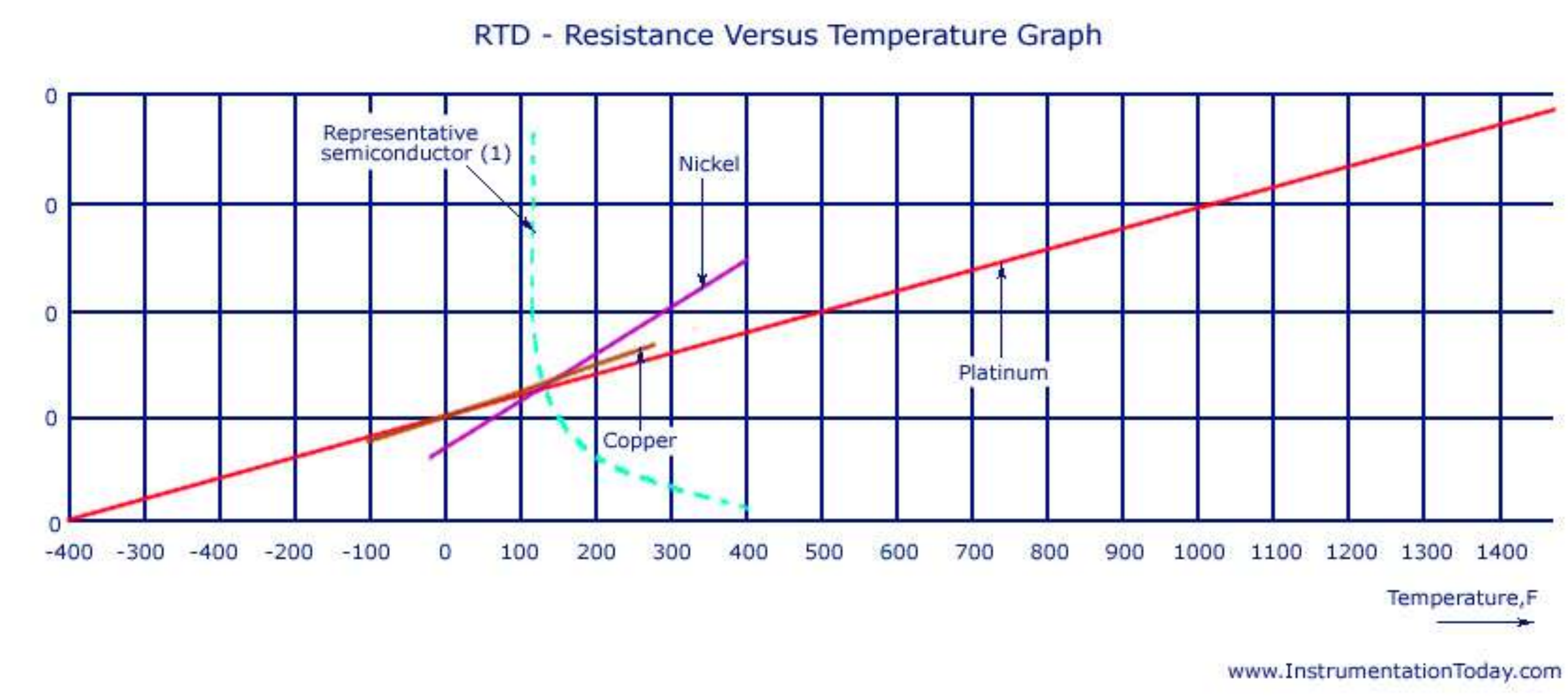
RTD Types

- classified according to the different sensing elements used -

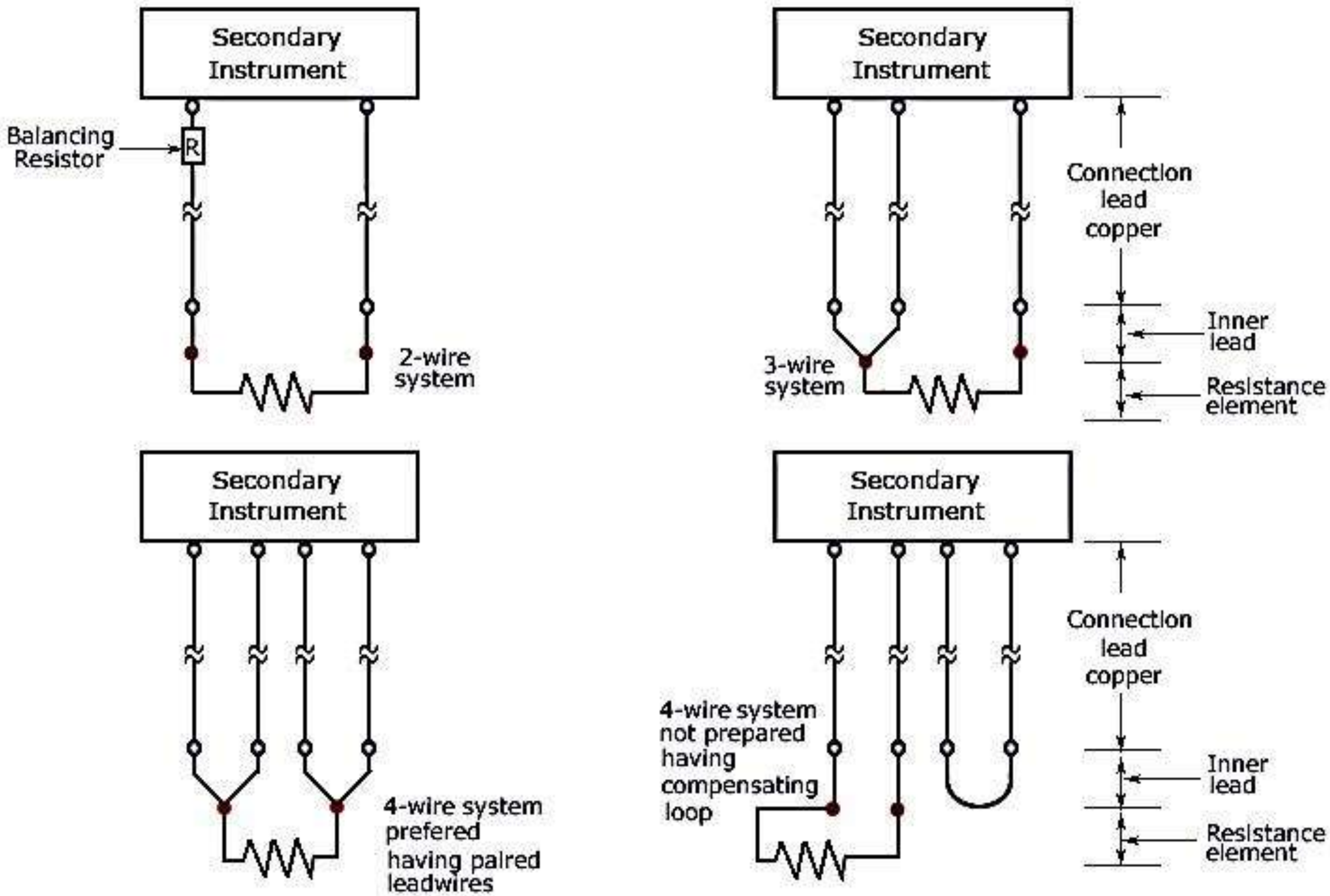
Platinum

Nickel

Copper



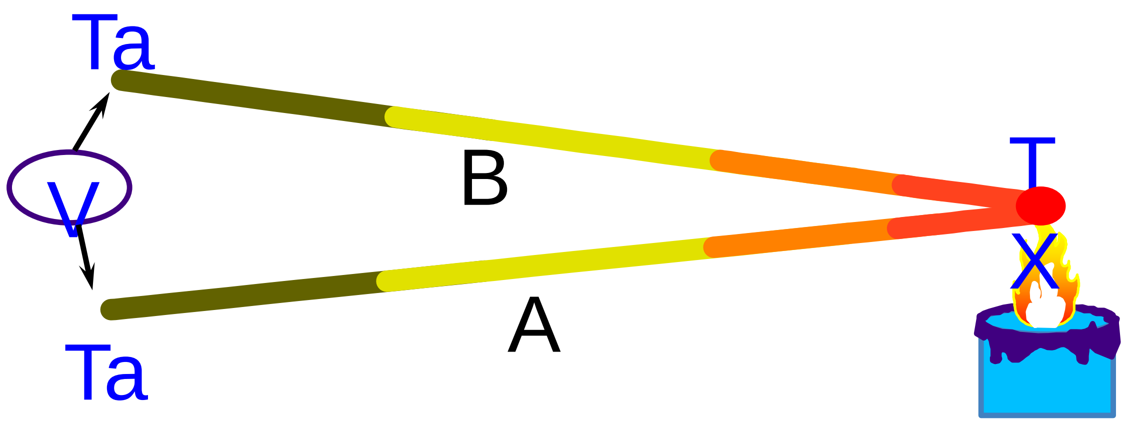
Resistance Temperature Detector (RTD) - 2-Wire,3-Wire,4-Wire Systems



For each arrangement,the secondary instrument measures the resistance of the wires drawn with a heavy line

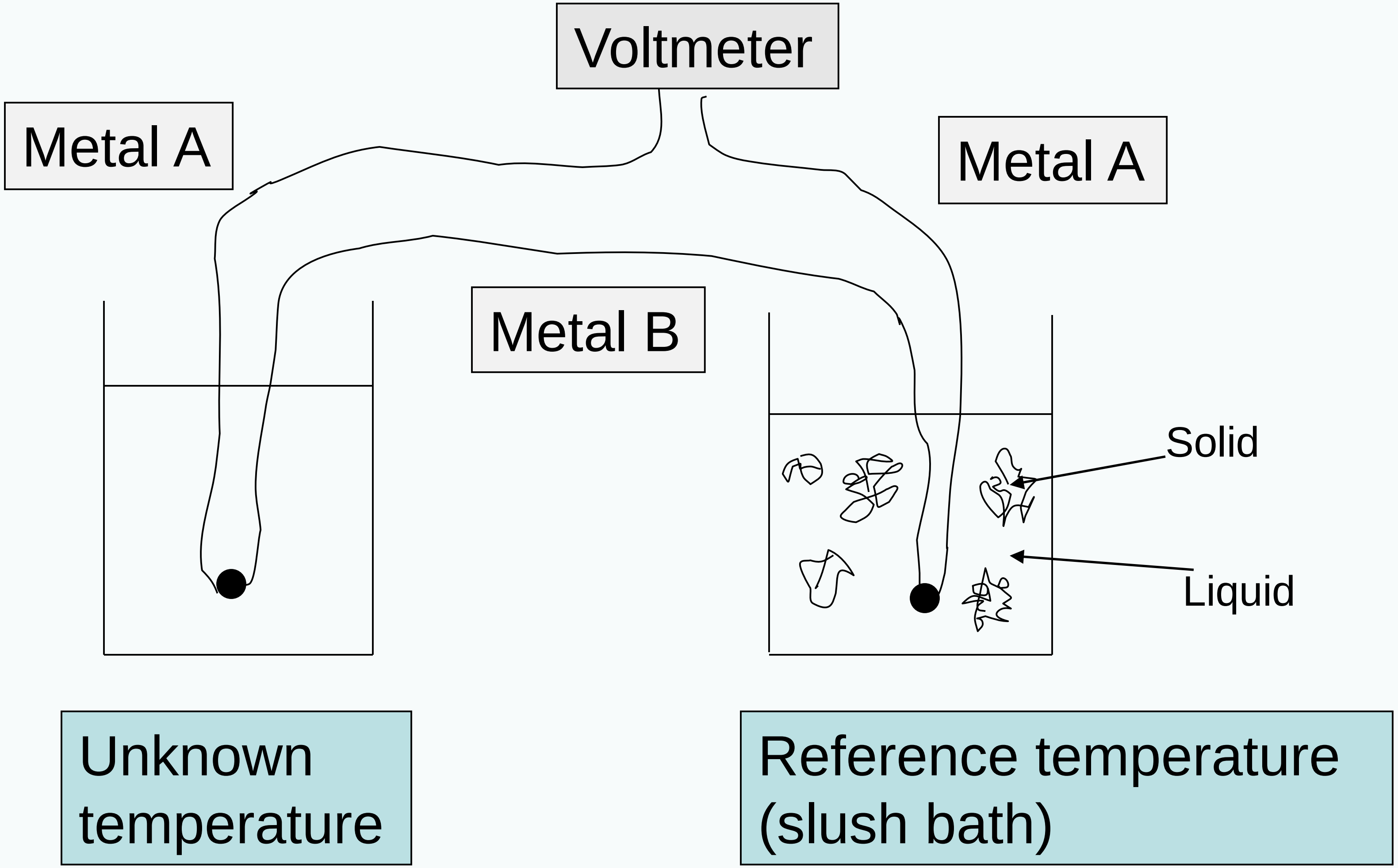
www.InstrumentationToday.com

4.Thermocouples



- Seebeck Effect

Typical Thermocouple Configuration



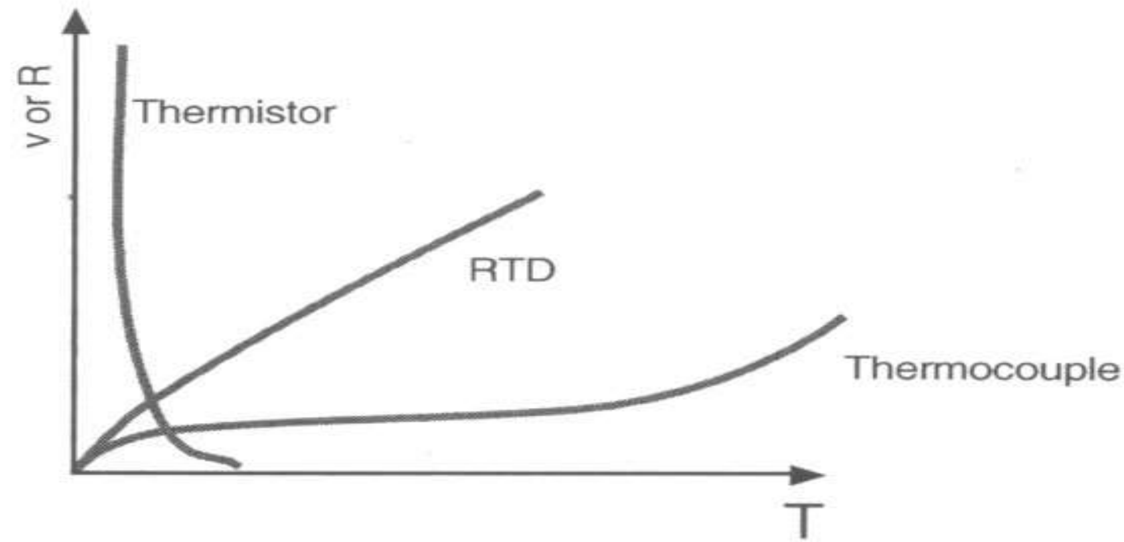
Thermocouple Types

Type	Metals	See beck Coif: uV/C
J	Fe-Con	50
K	Ni-Cr	40
T	Cu-Con	38
S	Pt./Rh-Pt.	10
E	Ni/Cr-Con	59
N	Ni/Cr/Si-Ni/Si	39

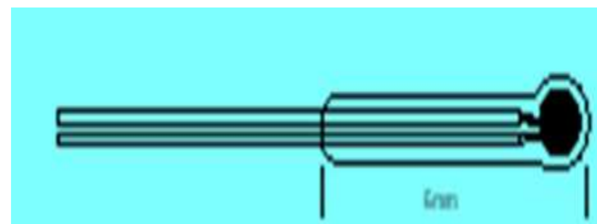
5.Thermistors

- Thermally sensitive resistors
- Highly sensitive and very reproducible resistance vs. temperature.
- Limited range
- Typically used over a small temperature range (due to non-linear characteristics)
- Thermistors do not do well at high temperatures and show instability with time
- Manufactured from oxides of nickel, magnesium, iron, cobalt,manganese,titatinum and other metals.
- NTC Thermistor
- **Steinhart – Equation** : $1/T = a + b \ln(R)+\ln^3(R)$

Thermistor Non-Linearity

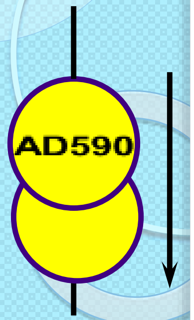


a. Epoxy Coated Thermistor Bead.

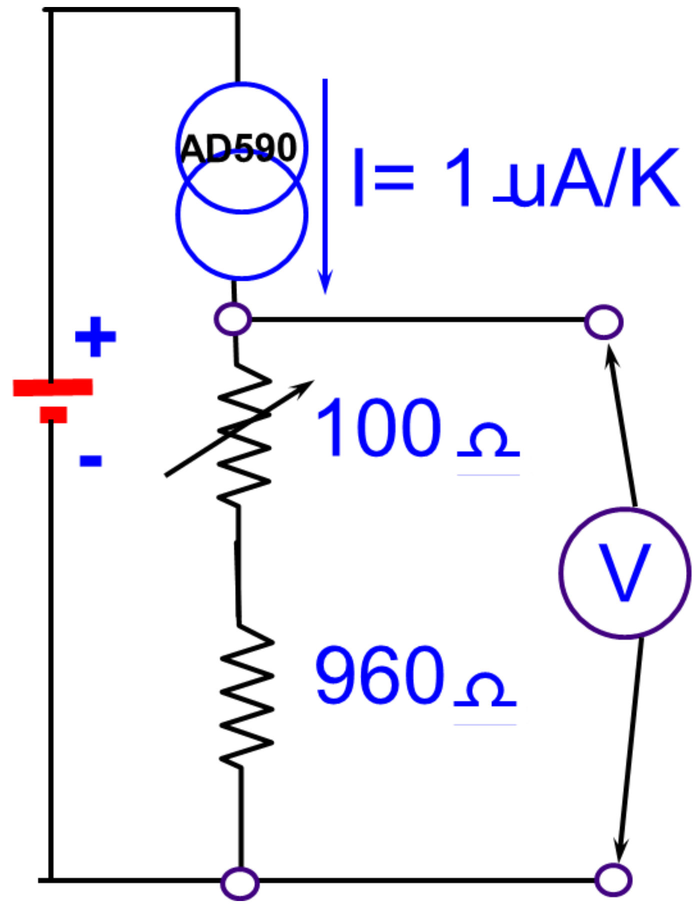


b. Glass Coated Thermistor Bead.

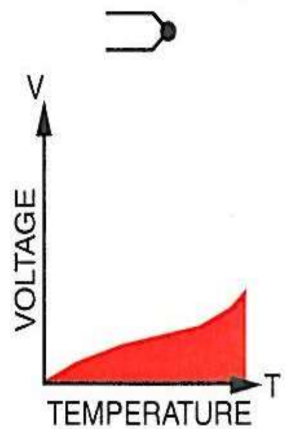
6. I.C. Sensor

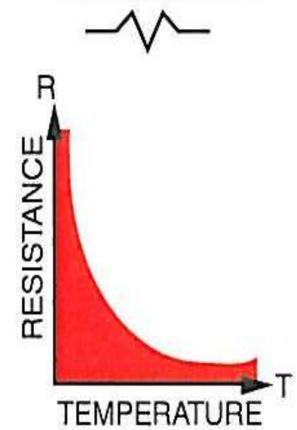


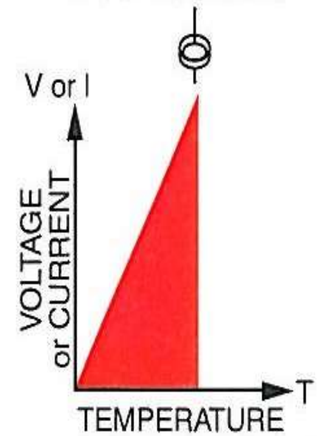
- V&I signal output
- Output ↑ = Temp.↑
- Very linear
- Accurate @ room ambient
- Limited range
- Cheap



Practical Temperature Measurements*







	Thermocouple	RTD	Thermistor	I. C. Sensor
Advantages	☐ Self-powered ☐ Simple ☐ Rugged ☐ Inexpensive ☐ Wide variety ☐ Wide temperature range	☐ Most stable ☐ Most accurate ☐ More linear than thermocouple	☐ High output ☐ Fast ☐ Two-wire ohms measurement	☐ Most linear ☐ Highest output ☐ Inexpensive
Disadvantages	☐ Non-linear ☐ Low voltage ☐ Reference required ☐ Least stable ☐ Least sensitive	☐ Expensive ☐ Current source required ☐ Small Δ R ☐ Low absolute resistance ☐ Self-heating	☐ Non-linear ☐ Limited temperature range ☐ Fragile ☐ Current source required ☐ Self-heating	☐ T<200°C ☐ Power supply required ☐ Slow ☐ Self-heating ☐ Limited configurations

More temperature measurement possibilities

- ✓Thyorister
- ✓Thermowell
- ✓Infrared Thermometer
- ✓pyrometer

How to Choose a Temperature Control Device or System ?

Things to take into account

- Standards
- Cost
- Accuracy
- Stability over time (esp. for high temperatures)
- Sensitivity
- Size
- Contact/non-contact
- Temperature range
- Fluid

Examples

Measurement

- Photochemical process control:
- Flower petal:
- Molten glass:
- Induction furnace:
- 100 degree Heat aging oven:

Sensor

- RTD (most accurate)
- Thermistor (lowest thermal mass)
- Optical pyrometer (hi temp, no contact)
- RTD (if <800C); or T/C (Beware magnetic I noise)
- Any of the 4 sensors

Reference :

- http://www.omega.com/temperature/z/zsection.asp
- http://www.instrumentationtoday/temperature/asp
- http://www.instrumentationtools/temperaturesensors/.jsp

THANK YOU