27/7/18

CHAPTER-1
MEASURING SYSTEM

* Measurement

The Measurement of a given quantity is ~~essiently~~ essentially a act or the result of comparison between the quantity (whose magnitude is unknown) and a Pre-defined Standard.

Elements of Measuring System :-

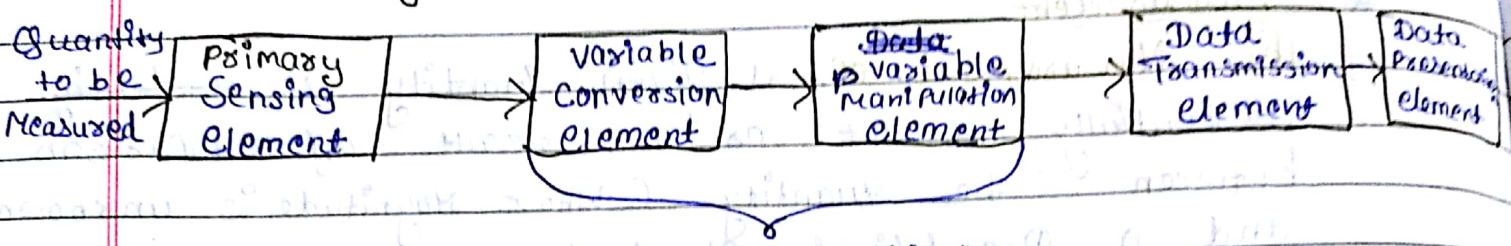
* Instrument → An Instrument may be defined as a device or a system which is designed to maintain a Functional relationship between Prescribed Property of a physical Variable and must include ways and means of communication to a human Observer.

* There are 3 types of functional elements are there in the measurement system.

1. Primary Sensing element.
2. Variable Conversion element.
3. Data Presentation element.

Primary Sensing element →

* Block diagram of Measuring system :-



* Noise ⇒ A spurious current or voltage extraneous to the current or voltage of interest in an electrical or electronic circuit is called as Noise. Inject Noise is a signal that doesn't convey any useful information.

~~Noise Factors~~

Signal to Noise Ratio :-

⇒ The ratio of Signal to Noise ratio ⇒ $\frac{S}{N} = \frac{\text{Signal power}}{\text{Noise power}}$

$$\Rightarrow \frac{(\text{Signal of interest expressed in volts})^2}{(\text{unwanted Noise expressed in volts})^2}$$

There are three types of Noise.

1. Generated Noise.
2. Conducted Noise
3. Radiated Noise.

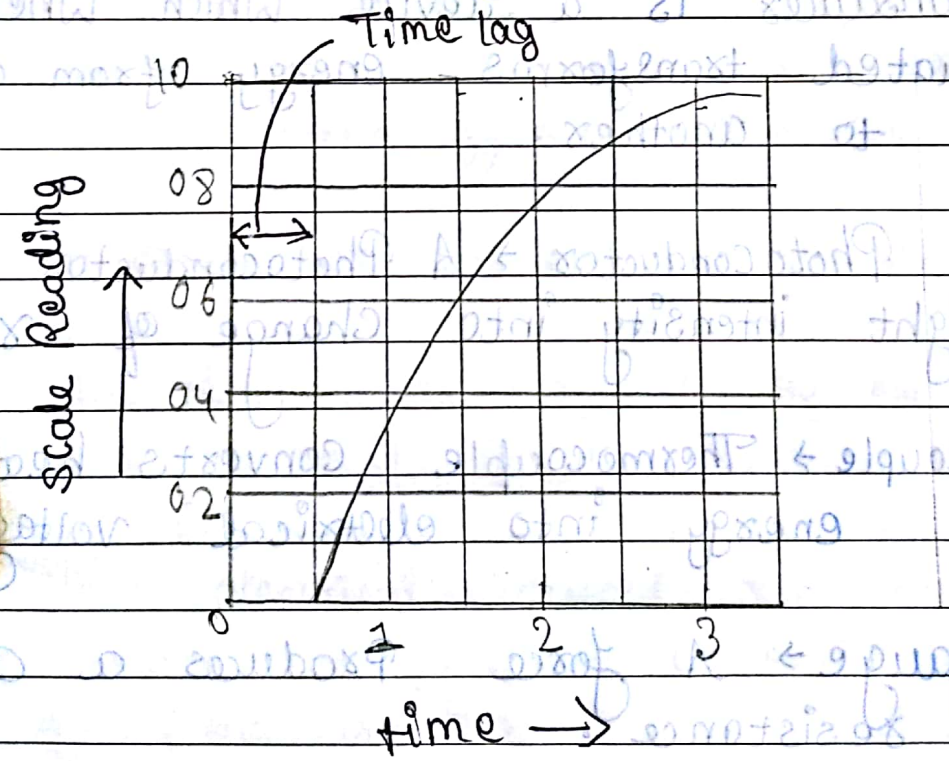
Noise Factor

$$F = \frac{\text{Signal power / Noise power at Input}}{\text{Signal power / Noise power at output.}}$$

★ Time lag error

In any instrument system it must take time for a change in input to show up on the indicated output. if the indicated output is incorrect because it has not yet responded to the change then we have time lag error.

A good example of time lag error is an ordinary glass thermometer.



CHAPTER-02

TRANSDUCERS

Transducer → Transducer is a device which convert the Physical quantity to electrical quantity.

* Elements of Measuring Device. or Major components of Measuring System.

① Input Device

② Signal conditioning & Processing Device

③ output Device.

A transducer is a device which when actuated transforms energy from one form to another.

Example → Photoconductor → A Photoconductor converts light intensity into change of resistance

Thermocouple → Thermocouple converts heat energy into electrical voltage.

Strain gauge → A force produces a change of resistance.

Piezoelectrical crystal → An acceleration produces a voltage

Note → The first stage of ~~transducers~~ Measurement System may simply be called as a Transducer stage instead of transducers ditector stage.

Electrical Transducer → The Transducer is a device which converts physical condition or a physical quantity into an electrical signal.
The Another name of Transducer is pickup.

Advantages of electrical Transducer.

① Electrical Amplification and attenuation can be done easily and that to with static devices.

② The mass inertia effects are minimized. (inertia - change of state)

③ The effects of friction are minimized.

④ The electrical or electronic system can be control with a very small power level.

⑤ The electrical output can be easily used, transmitted and processed for the purpose of measurement.

⑥ Telemetry is used in almost all Sophisticated Measurement System.

Note: Telemetry → Telemetry is an automated communication process by which measurements and other data are collected at remote or inaccessible points and transmitted to receiving equipments for monitoring.

⑦ There has been an explosive development in the field of electronic components and devices.

Classification of Transducer

The Transducer can be classified,

① on the basis of transduction form used.

② on the basis of primary & secondary Transducer.

③ As Passive & Active transducer.

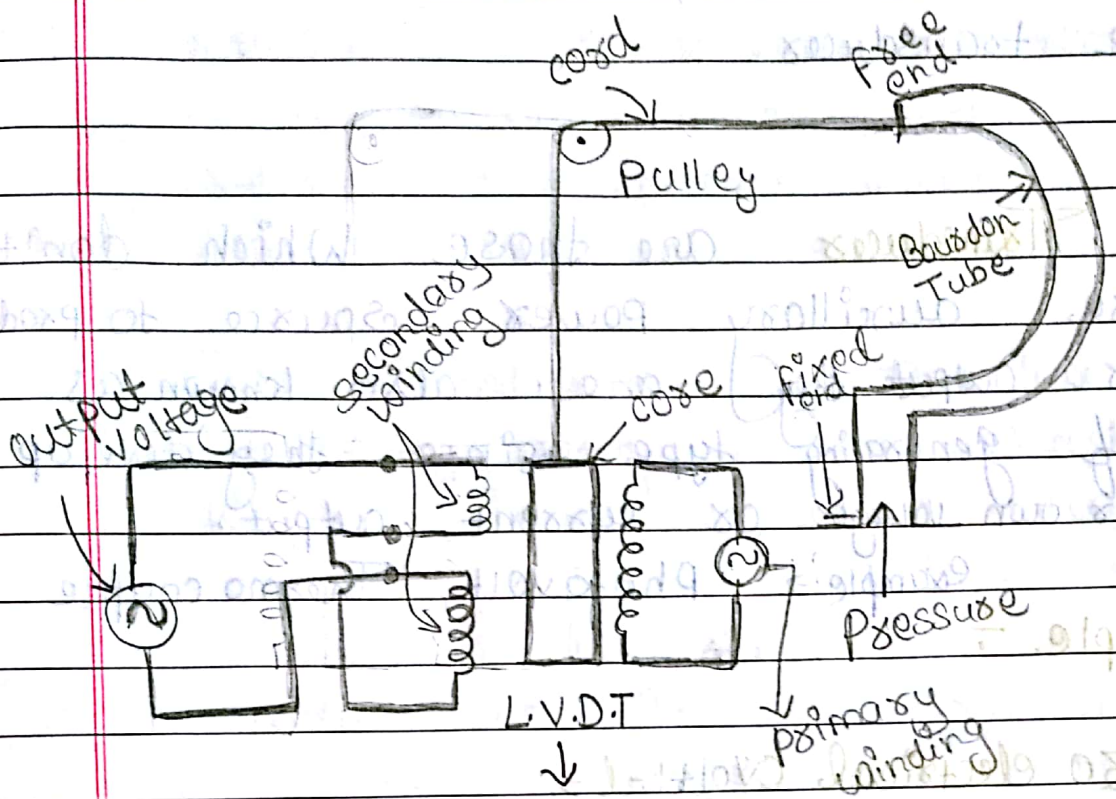
④ As Analog & Digital Transducer.

⑤ As Transducer and inverse transducer.

① Classification based on Transduction:-

The process of conversion of one form of energy to another form is called Transduction.

② Classification of Primary & secondary Transducer

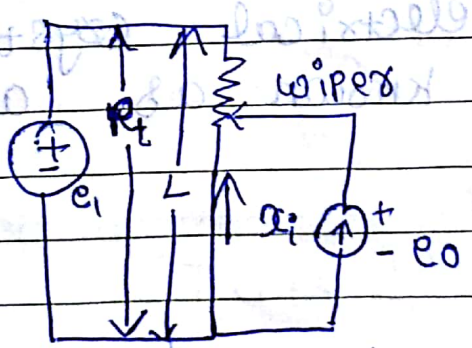


[Linear Variable Differential Transducer - L.V.D.T].

③ Active & Passive transducer

Passive Tranducers derive Power required for transduction from an auxillary power they derive Part of the Power required for conversion from the physical quantity under measurement.

They are also known as externally powered transducer.



Potentio meter.

$$x_i = \left(\frac{e_0}{e_i}\right) L$$

x_i - linear displacement.
e_0 - output voltage, e_i - input voltage
L - length of Potentiometer.

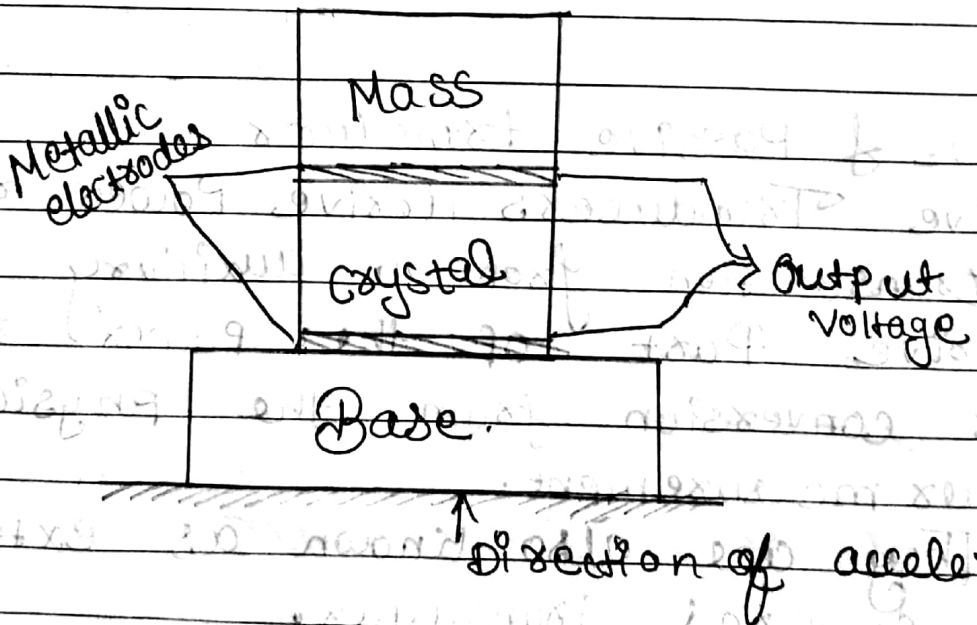
In the absence of external power the transducer can't work hence, it is called as the passive transducer.

Active Transducer are those which don't require auxillary power source to produce their output they are also known as self generating type since they develop their own voltage or current output.

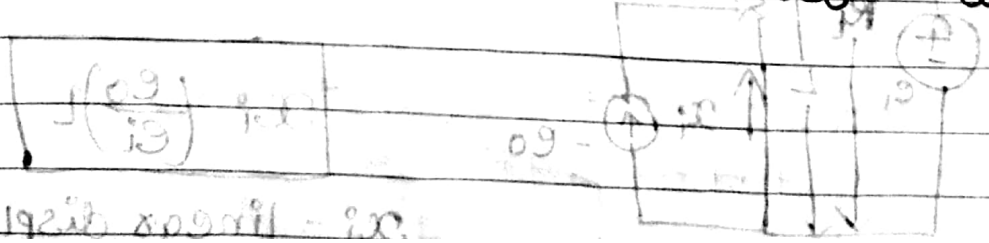
example → Photovolt, Thermo couple

Example :-

Peizo electrical crystal →



The Peizo electrical crystal transducer is also known as accelerometer.



(4) Analog & Digital Transducer.

Analog → The transducer that convert input quantity into an analog output which is a continous function of time.
Ex- LVDT, strain gauge.

Digital Transducer → The transducer that convert the input quantity into an electrical output which is in the form of pulses.

(5) Transducers or Inverse Transducer.

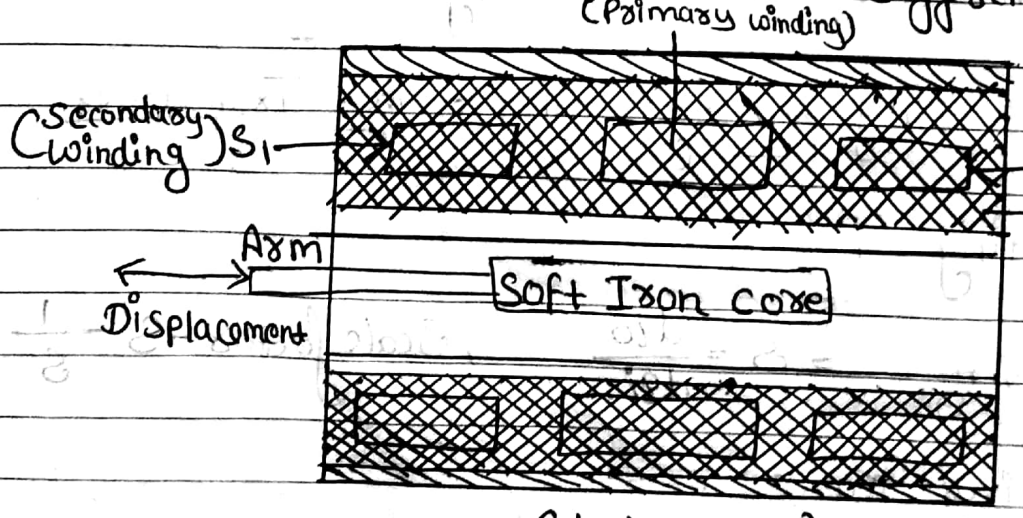
Transducer → Transducer is a device which convert Non electrical quantity into an electrical quantity.

Inverse Transducer → It is a device which converts the electrical quantity into an non-electrical quantity.

- Factors Influencing Choice of Transducer.
  - Operating Principle
  - Sensitivity. $= S = \frac{d\theta_o}{d\theta_i}$, Scale factor $= S' = \frac{1}{S} = \frac{d\theta_i}{d\theta_o}$
  - operating Range.
  - Accuracy

- Cross Sensitivity.
- Errors.
- Loading effects - The transducer should have a high input impedance and low output impedance to avoid the loading effects.
- Enviornmental compatibility.
- Insensitivity to unwanted signal.
- Usage and Ruggedness.
- Electrical aspects
- Stability & Reliability.
- Static Characteristics.

L.V.D.T [Linear Variable Differential Transformer]



(L.V.D.T)

Q Explain the construction and Principle of working of LVDT?

OR

Explain with a diagram for pressure measurement with the help of LVDT?

OR

Explain the Principle of LVDT with the help of suitable diagram.

Answer

→ Introduction → The most widely used inductive transducer to translate linear motion into electrical signal is known as linear variable differential transformer [L.V.D.T], sometimes it is also known as Linear variable Displacement Transducer.

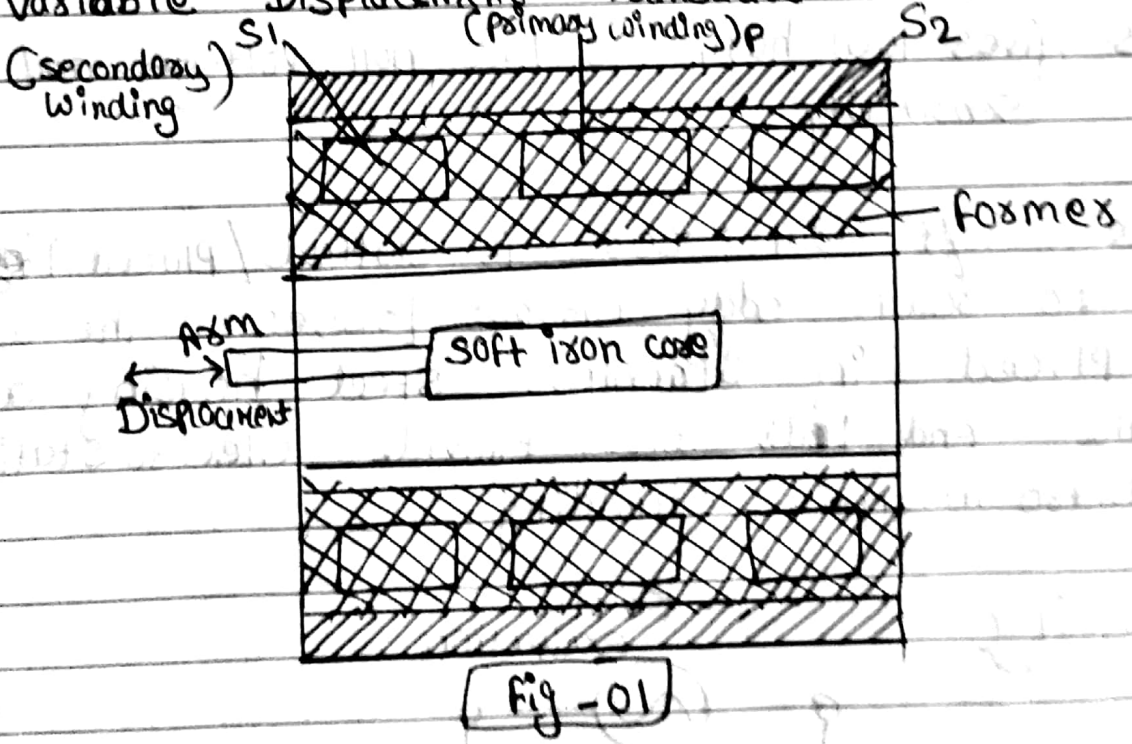


Fig -01

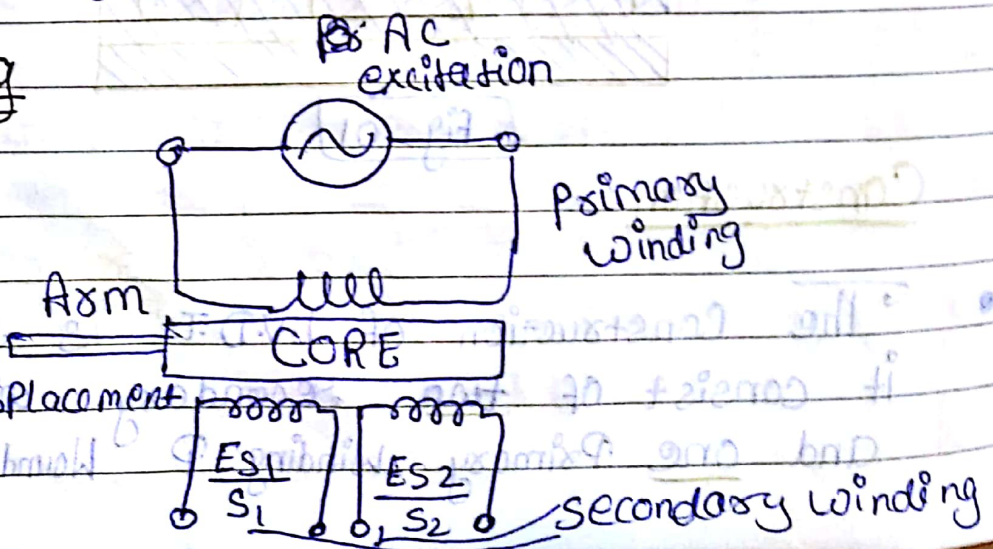
Construction.

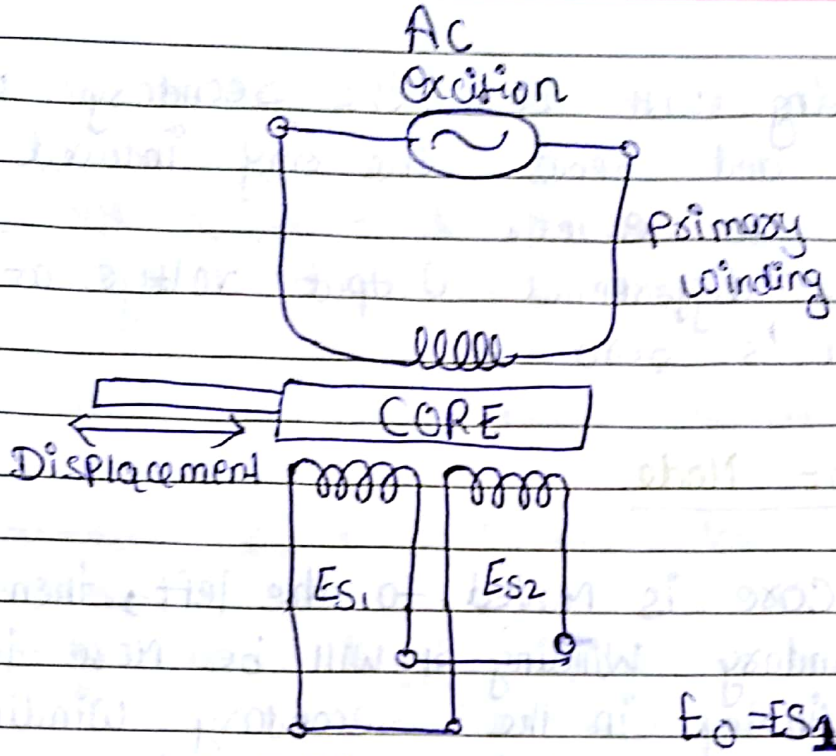
- The construction of L.V.D.T is shown in fig-01 it consist of two secondary winding S_1 & S_2 and one Primary Winding P Wound on Cylindrical

formex.

- The Secondary Windings have equal Numbers of turns and are identically Placed on the either side of primary winding. The Primary winding is connected to an ~~alt~~ alternating current source.
- A Movable soft iron core is Placed inside the formex. The displacement to be measured is applied to the arm attached to the soft iron core.
- The core is made of high Permeability, Nickle Iron which is hydrogen annealed.
- This gives low harmonics Low null voltage and high sensitivity.
- The Soft iron core is slotted / placed longitudinal to reduce eddy current losses. The assembly is placed in stainless steel housing and the end lids are Provide electrostatic and electro magnetic sheilding.

Working





$E_0 = E_{S1} - E_{S2}$

(fig (1.1))

- Since the Primary winding is connected to an alternating source it Produces an alternating Magnetic field. Which inturn in-duces alternating current voltages in the two secondary winding.

- The output voltage of secondary S_1 is E_{S1} & that of secondary S_2 is E_{S2}. In order to convert the output S_1 & S_2 the two secondaries S_1 & S_2 are connected in series opposition as shown in fig. 1.1.

- The differential output voltage

$$E_0 = E_{S1} - E_{S2} \quad \text{---(1)}$$

Normal position.

When the core is acts its normal (null) position

The flux linking with both the Seondary winding is equal and hence the emf induced in them are also equal.
Thus the differential Output voltage at null position is Zero.

Displacement Mode

When the core is moved to the left, then flux linking Secondary Winding S_1 will be More than the flux linking in the secondary winding S_2, and hence the emf induced E_{S_1} in S_1 will be More than E_{S_2} in S_2.
Thus the differential output voltage $E_0' = E_{S_1} - E_{S_2}$

If the core is moved to the right the flux linkage in the Winding S_2 will be more than in S_1 and hence the emf induced in S_2 i.e. E_{S_2} will be More than in S_1.
∴ the differential Output voltage $E_0'' = E_{S_2} - E_{S_1}$ and is 180° out of phase with the Primary voltage.
∴ The two differential voltage are 180° out of phase with each other.

Note:- The amount of voltage change in either Seondary winding is Proportional to the Moment of the core. Hence we have an indication of amount of linear Motion.

Advantages

① High Range → It Measures the displacement of from 1.25 mm to 250 mm.

② Friction and Electrical Isolation →

③ Imunity from External effects.

④ High Input & High sensitivity. - The sensivity of L.V.D.T is 40 v/mm.

⑤ ~~Rough~~ Ruggedness.

⑥ Low Hysteresis

⑦ Low Power consumption → Less than 1 watt power consumption.

Disadvantage

① Relatively large displacements are required for larages differential output voltage.

② They are sesitive to stray Magnetic feilds.
If the shielding is provided the Magnetic feild effect can be reduce.

③ Many a times due to higher vibrations the

result is affected.

④ Temperature affects the Performance of the transducer.

→ To reduce the temp. effect we can use magnin wire instead of Copper wire.

⑤ The receiving Instrument Must be ~~operated~~ is selected to operate on Ac signal or Demodulator Network Must be used to convert into DC signal.

★ Strain Gauge or Gauge factor.

It is a device that converts Force into electrical signal (The electrical signal is measured as change in resistance).

Let us consider a Strain Gauge Made of a Circular wire.

∀, A = Area of cross section
D = Diameter
L = Length of wire.
ρ = Resistivity of the Material.

$$\therefore R = \rho \frac{L}{A} \quad -(1)$$

⇨ Where R is the Resistance of unstrained Guage.

Let a tensile stress δ we applied to the wire.

This Produces a Positive strain due to which the length of the wire is Increased and the area is decreased.

Let,

ΔA = Change in Area.

ΔL = Change in Length

ΔD = Change in Diameter

ΔR = Change in Resistance.

In order to find how ΔR depends upon the Material Physical quantity the expression of R is differentiated with respect to stress δ.

$$\frac{dR}{d\delta} = \frac{d}{ds}\left\{\rho \frac{L}{A}\right\}$$

(VI)- Formula ⇒ $\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx}$ $\left\{ \frac{d}{dx}\left[\frac{u}{v}\right] = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2} \right.$

Solution ⇒ $\int \frac{d}{d\delta}\left\{\frac{L}{A}\right\}^{u}_{v} + \frac{L}{A}\frac{d\rho}{ds} = \rho\left\{\frac{A\frac{dL}{ds} - L\frac{dA}{ds}}{A^2}\right\}\frac{L}{A}\frac{ds}{ds}$

$$\Rightarrow \frac{\rho}{A}\frac{dL}{ds} - \rho\frac{L}{A^2}\frac{dA}{ds} + \frac{L}{A}\frac{d\rho}{ds} \quad -(2)$$

Dividing Eqn - (II) by $R = \frac{\rho L}{A}$ - equation (I)

$$\frac{1}{R}\frac{dR}{ds} = \frac{1}{L}\frac{dL}{ds} - \frac{1}{A}\frac{dA}{ds} + \frac{1}{\rho}\frac{d\rho}{ds} \quad \text{(III)}$$

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} - \frac{\Delta A}{A} + \frac{\Delta \rho}{\rho}$$

It is evident from equation (III) that the pex unit change in resistance is due to

(1) Pex unit ~~dute to~~ Change in length $\frac{\Delta L}{L}$

(2) Pex unit change in Area $= \frac{\Delta A}{A}$

(3) Pex unit change in resistivity $= \frac{\Delta \rho}{\rho}$

$A = \pi r^2$

$$A = \frac{\pi D^2}{4}$$

$$\frac{dA}{ds} = \frac{\pi}{4} \cdot 2D \frac{dD}{ds} = \frac{\pi}{2} D \cdot \frac{dD}{ds} \quad \text{(IV)}$$

$$\frac{1}{A}\frac{dA}{ds} = \frac{1}{\frac{\pi D^2}{4}} \cdot \frac{\pi}{2} D \frac{d \cdot D}{ds}$$

$$\frac{1}{A}\frac{dA}{ds} = \frac{2}{D}\frac{dD}{ds} \quad \text{(V)}$$

Putting the of equation (5) in equation (3) we get

$$\frac{1}{R}\frac{dR}{ds} = \frac{1}{L}\frac{dL}{ds} - \frac{2}{D}\frac{dD}{ds} + \frac{1}{\rho}\frac{d\rho}{ds} \quad -(6)$$

Poissions Ratio $V = \frac{\text{Lateral Strain}}{\text{Longitudnal strain}}$

$$= \frac{\frac{dD}{D}}{\frac{dL}{L}} = V.$$

$$\Rightarrow \frac{dD}{D} = -\frac{V dL}{dL} \quad -(7)$$

$$\frac{1}{R}\frac{dR}{ds} = \frac{1}{L}\frac{dL}{ds} + \frac{2V dl}{l \cdot ds} + \frac{1}{\rho}\frac{d\rho}{ds} \quad -(8)$$

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + 2V\frac{\Delta L}{L} + \frac{\Delta \rho}{S} \quad -(9)$$

The gauge factor is defined as the ratio of per unit change in resistance to per unit change in length.

$$G_f = \frac{\Delta R/R}{\Delta L/L} \quad -(10)$$

$$\text{Or } \frac{\Delta R}{R} = G_f \times \frac{\Delta L}{L} = G_f \times \varepsilon \quad -(11)$$

$\forall \varepsilon$ = Strain $\frac{\Delta L}{L}$

From eqn no. (9) and (10)

$$G_f = \frac{\frac{\Delta L}{L} + \frac{2V\Delta L}{L} + \frac{\Delta \rho}{\rho}}{\frac{\Delta L}{L}}$$

$$G_f = \frac{\frac{\Delta L}{L} + 2V + \frac{\Delta \rho}{\rho}}{\frac{\Delta L}{L}} \quad \text{— (12)}$$

$$= 1 + 2V + \frac{\Delta \rho / \rho}{\varepsilon} \quad \text{— (13)}$$

$$\boxed{G_f = 1 + 2V} \quad \text{— (14)}$$

Eqn (14) is valid only when piezo resistive effect i.e. change in resistivity due to strain is negligible.

Note → The poisons ratio of almost all the metals is between 0 & 0.5. This gives a gauge factor of approximately 2.

★ Types of strain gauge.

(1) Unvonded Metal strain gauge.

(2) vonded Metal wire strain gauge.

③ Vonded Metal foil Strain gauge

④ Vaccum deposited thin Metal FilM Strain gauge.

⑤ Sputtex deposited thin Metal Strain gauge.

⑥ Vonded semiconductor Strain gauge.

⑦ Defused Metal Strain gauge.

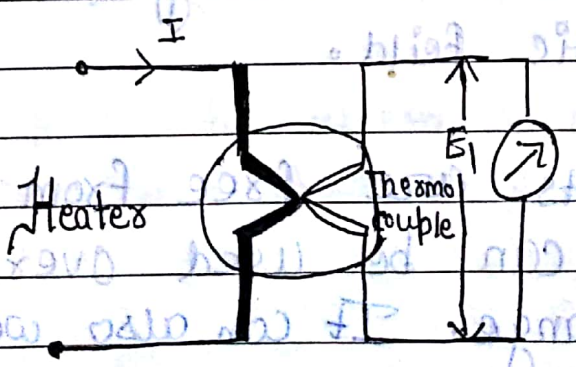
★ Thermocouple →

Introduction → When two Metals having different Work Function axe Placed togathex a voltage is generate at the junction which is neaxly Proportional to the tempxatuxe. This Junction is called as thexmcouple.

heat enexgy

This Principle is used to convext into electrical enexgy.

Work - Function → The MiniNum amount of enexgy xequixed to emit an electxon fxom its outex Most shell is known as Work Function.



Diagxam Of Thexmocouple.

The heat and the junction is Produce by the electrical current Flowing in heater element. While the thermocouple produces an emf and its output process which can be Measured With the help of PMMC instrument. The emf Produced is ProPortional to the temprature and hence the RMS Value of current. Therefore the Scale of PMMC instrument can be Calibrated to read the current Passing to the heater.

The thermo couple can be used for both AC and DC application the Most important and attractive features of thermocouple instrument is that they can be used for Measurement of current and voltage at very high Frequency.

Advantages of Thermocouple

- The thermocouple instrument currently indicate the RMS value of current and voltage irrespective of the Wave form.
- This instruments are not effected by Stray Magnetic feild.
- This instruments are free from Frequency error and hence can be used over a very wide Frequency range. It can also work above the frequency range of 50 Hz.

- This instruments can measure the currents in the range of 0.5 to 20 Amp.
- This instruments have high sensitivity.
- They are very useful when used as transfer instruments to calibrate dc instruments by Potentiometer and Standard Cell.

Disadvantages :-

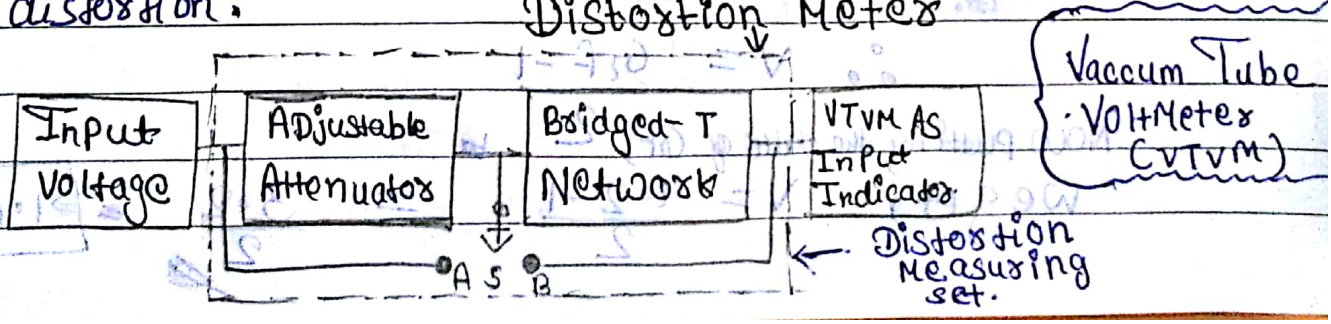
- At normal rated current the heater attains a temprature of 300°c. If we pass twice the rated current the heater would give a temprature of nearly 4 times the normal temprature. i.e. 1200°C. it is obvious that square law rate will bring the heater to nearly its burn out temprature.

→ UNIT- 1st

★ Distortion → The act of twisting and altering something out of its true natural or original state, is known as distortion.

★ Distortion is the alternation of the original shape or other characteristics of something is called the distortion.

Distortion Meter



NUMERICAL

Q. The output voltage of a LVDT is 1.5 volt at maximum displacement at a load of 0.5 mega ohm. the deviation from the linearity and it is ± 0.003 volt from a straight line through origin find the percentage linearity at the given load. The deviation from the linearity is maximum?

Solution → % linearity

$$\pm \frac{0.003}{1.500} \times 100$$

$$\Rightarrow \boxed{\pm 0.2}$$

Q. A resistive wire strain gauge uses a soft iron wire of small diameter. the gauge factor is + 4.2. Neglecting the piezo resistive effect calculate the poissions Ratio.

Solution →

$$G_f = 1 + 2\nu + \frac{\Delta \rho}{\rho}$$

Now Neglecting piezo resistive effect.

$$\therefore G_F = 1 + 2\nu$$

$$\therefore \nu = \frac{G_F - 1}{2}$$

Now putting the value of G_F, 2

we get, $\nu = \frac{4.2 - 1}{2} = \frac{3.2}{2} \Rightarrow \boxed{1.6}$

Q.) A Compressive Force is applied to a ~~Substrue~~ Structural Member. the strain is 5 micro strain Two seprate strain gauges are attached to the Structural member one is a nickle wire strain gauge having a gauge factor of -12.1 and the other nicrome wire strain gauge having a gauge factor of ~~Two~~ 2. calculate the value of resistance of the gauges after they are strained. The resistance of the strain gauge after being strained is 120 Ω.

Solution →

Given data

$\varepsilon = -5$ micro strain. $\quad \{1 \text{ microstrain} = 1 \mu m/m\}$

$\varepsilon = -5 \times 10^{-6}$

$G_f = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\varepsilon} \quad \{\Delta L/L = \varepsilon.$

G_f of Nickle wire $= -12.1$

$\Delta R = G_f \times \varepsilon \times R_1$

$= (-12.1) \times (-5 \times 10^{-6}) \times 120$

$= 7.26 \times 10^{-3}\ \Omega = 7.26\ m\Omega$

G_f of Nicrome wire $= ?$

$\Delta R = G_f \times \varepsilon \times R_1$

$\Rightarrow 2 \times (-5 \times 10^{-6}) \times 120$

$\Rightarrow 1.2 \times 10^{-3}$

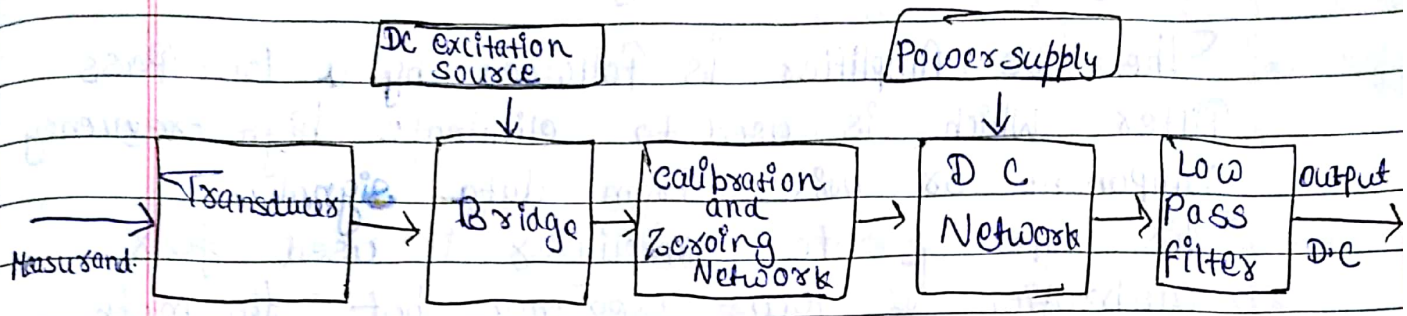
$\Rightarrow 1.2\ m\Omega$ //

Thus we can say that when nickle wire is subjected to compressive strain the value of change in resistance increase by a value of 7.26 mΩ and when nichrome wire is subjected to a compresi Ω. the value of change in resistance decreases by 1.2 Ω

13/08/18

CHAPTER-03

SIGNAL CONDITIONER



D.C. Signal conditioning System.

DC signal conditioning System:

The greatest disadvantage of dc signal conditioning system is the problem of drift. To eliminate the Problem of drift we use AC signal conditioning system.

The transducer used in DC signal conditioning System is resistive transducer ~~or variable resistance transducer or variable inductive transducer.~~ The resistance transducer like strain gauges, consitude of one arm or more than one arm of wheat stone bridge which is excited by an isolated dc source The bridge can be balanced by a potentio meter and can also be calibrated for unbalanced condition.

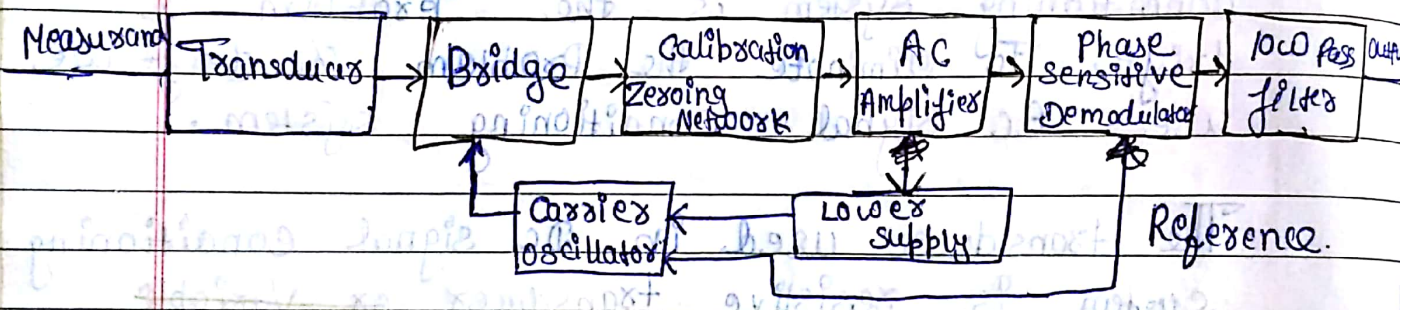
The dc amplifier should posses a characteristics of balanced differential input give a high common mode Rejection Ratio [CMRR]

and good thermal and long term stability.

The DC Amplifier is followed by a low Pass Filter which is used to eliminate high frequency component or noise from data signal.

This type of dc amplifier is used for calibration of low frequency but the main disadvantage of using such signal conditioning system is that it requires a stable differential input.

AC Signal Conditioning System.



- In order to overcome the problems that are encountred in dc systems, AC systems are used. The transducer used are variable inductive transducer or variable resistive transducer. In AC system the carrier type AC signal conditioning System are used as shown in fig. they are employed between carrier frequency of 50 Hz to 200 KHz. The carrier frequencies are much higher, they are atleast 5 to 10 times the signal frequency.

The output of the transducer is forwarded to bridge network that requires amplitude modulate Carrier signals. The signal frequency is amplify through the AC amplifier.

Transducer Parameter Variation modulate the carrier frequency at the bridge output is amplified and demodulated. The demodulation is phase sensitive so that the Polarity of DC output indicate the direction of parameter change in the bridge output.

AC systems have to be used for variable reactance transducer where the signals have to be transmitted via a long cable to connect the transducer to the signal conditioning equipments

Signal Conditioner.

The first stage with which we become familer in the measurement system is detecter transducer stage the quality is detected and transduced into an electrical form in most of the cause the first stage have to be modified before it become usable and satisfactory to drive the signal presentation stage which is the third and last stage of the measurement that consisting the indicating recording displaying data processing element and may consist of control elements.

★ DC Amplifier

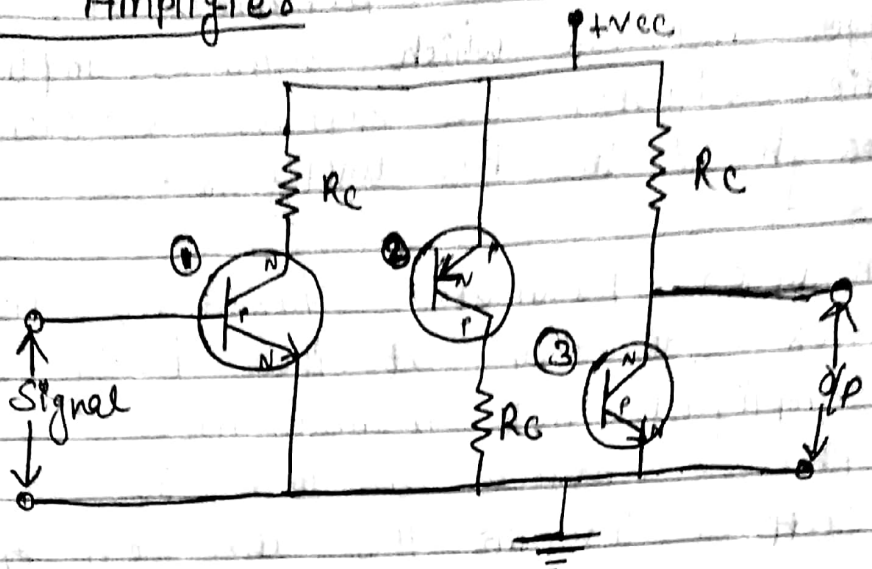


Fig. (1)

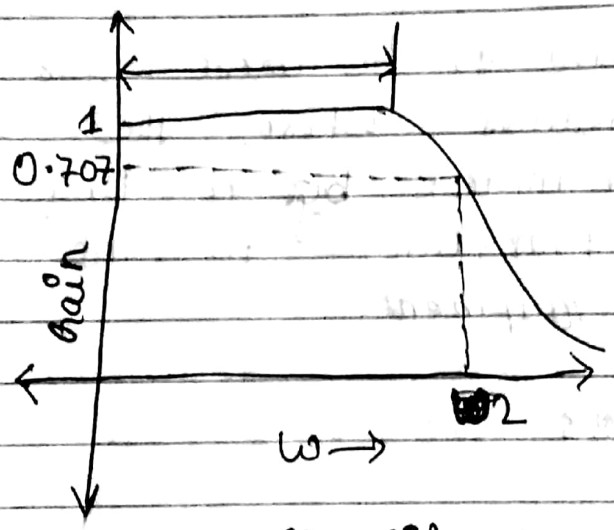


Fig - (2)

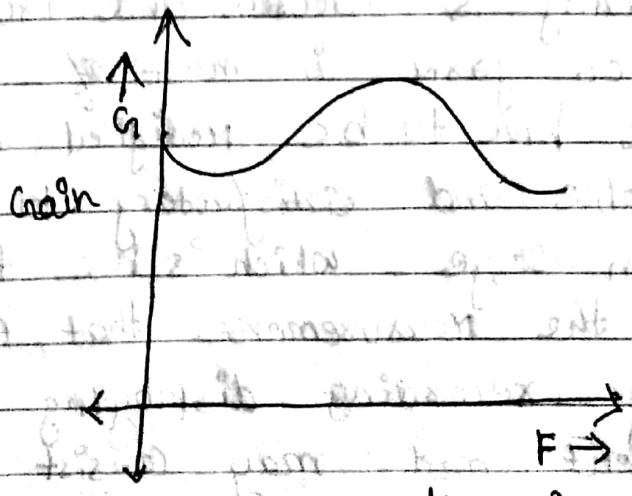


Fig (3).

For the signals of less than 10 Hz frequency we use dc coupled or dc amplifier. From the fig (1) it can be seen that a multistage amplifier is shown different types of transistors are connected. It can be seen that in the first phase NPN Transistor is coupled with PNP Transistor of the second phase and which inturn is again coupled with NPN Transistor.

Transistor 1 is supplied with impure signal. With the help of transistor amplification process are amplified signal is received at load Rc. The amplified signal received at load Rc is again forwarded for amplification to Transistor T2 at the signal is amplified. Hence we can say that For getting the desired output we can connect as many as transistors possible.

Transfer characteristics of DC coupled Amplifier.

- It should have stable input signal so that the value of Common mode rejection ratio should be less.
- Its thermal stability should be high.

Advantages of DC coupled Amplifier.

(1) Small frequency signal can easily be amplified and be transmitted.

(2) It can re-stablish the over load conditions.

(3) Due to less number of resistance in the circuit easy circuit is constructed.

(4) Due to Cheap cost of coupling the over all circuit is cheaper.

Disadvantages of Dc Coupled Amplifier.

(1) Higher frequency signals cannot be flow in the circuit.

(2) Due to temprature variation the operating point of the circuit gets disturb.

(3) The frequency respond the diagram of dc coupled amplifier is shown in fig.(3).

★ CHOPPER AMPLIFIER

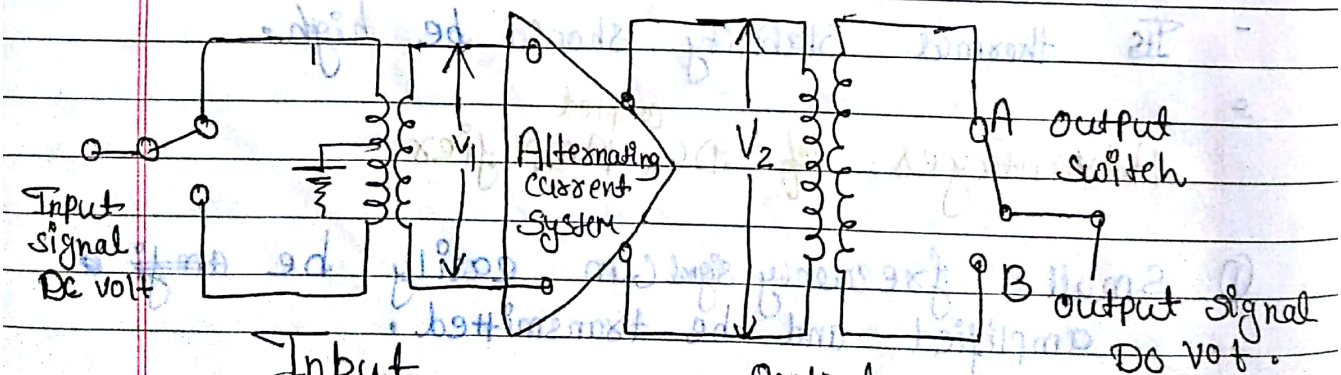


fig-(1).

The drawbacks of instability and non-conversion of higher frequency signals in dc coupled amplifier can be removed by using Chopper Amplifiers. The converted signal should be firstly converted into an ac signal and this ac signal should again converted into desired dc output signal, with the help of Chopper amplifier the frequency range from 60 to 400 Hz can easily be transmitted. For getting higher gain chopper amplifier is employed as it creates very little noise.

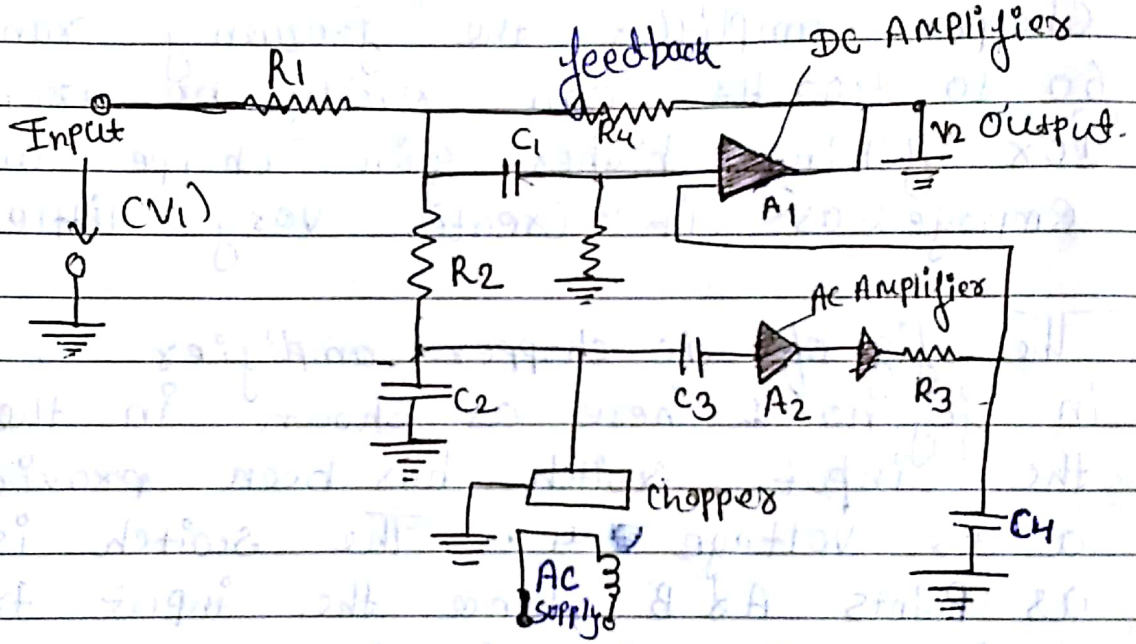
The fig. of dc chopper amplifier is as shown in fig no. 1, here as shown in the circuit the input switch has been provided with a dc voltage V_1. The switch is connected as Points A & B, hence the input transformer receives the AC signal and the secondary winding receives AC signal with the help of AC Amplifier the output of input transformer is amplified which inturn is supplied to output transformer in the primary winding. ~~The secondary transformer is centrally tapped~~ The output transformer secondary winding is centrally tapped and is grounded After connecting the output switch through the Points A & B The signal is received. The output signal received is ~~dc~~ dc signal.

★ Advantages of Chopper Amplifier

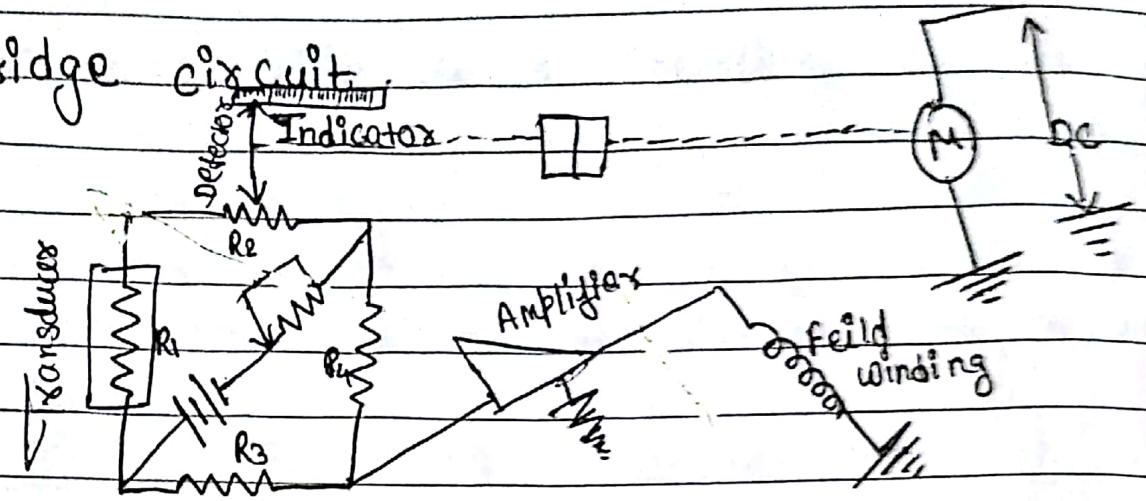
→ It has no effect of deflection.

→ It isolates input circuit from output circuit

★ CHOPPER STABILIZED AMPLIFIER



A Bridge circuit



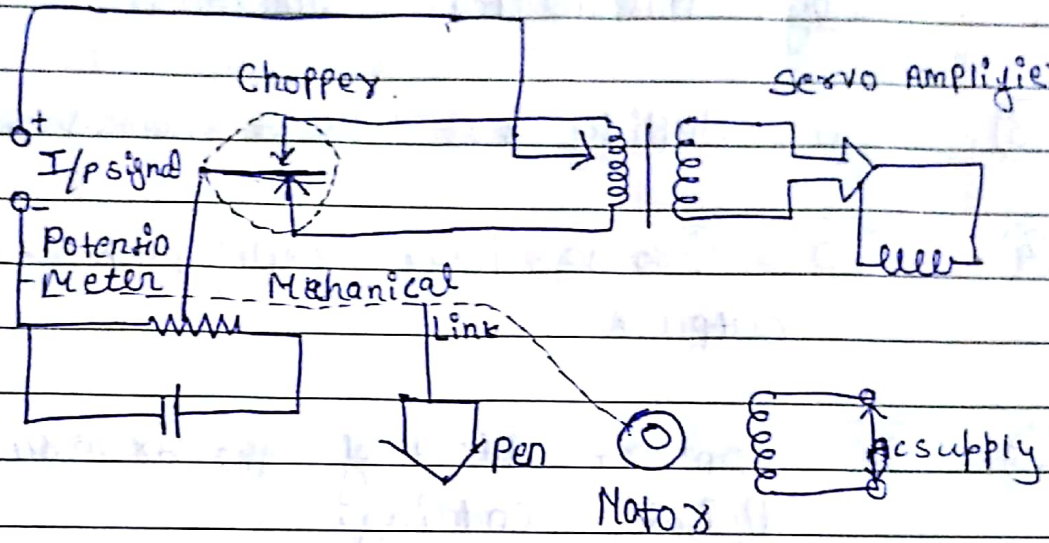
In a bridge circuit 4 resistances are connected one across the arm, out of which one arm is reserved for transducer resistance as shown in fig. When the bridge is in stable condition or balanced condition the equation for its stability is $R_1/R_2 = R_3/R_4$

$$\Rightarrow \boxed{R_1/R_2 = R_3/R_4}$$

In this condition no signal or no current is flown towards the feild winding and due to which motor is in off mode. and zero signal is indicated in the scale as soon as we connect resistance transducer in arm-1 the bridge circuit gets unstable and due to which unstable signal is flown through the amplifier towards the feild winding. Hence motor gets started and a reading is shown in the scale.

This process continous till the bridge once again comes in a stable position.

Self balancing Potentiometric Recorder :-



This type of instrument for calculation of unknown voltage. The value is provided to slide wire which is connected with the scale and hence we get the value of the potential or voltage. The slide wire is connected to the dc current source The known & the unknown voltage difference is calculated and send to the error Measurement instrument. This function is repeated till the network is fully stablized.

Input Modifier →

What is the Nessecity of Input Modifier :-

① To Convert the input voltage or current into the digital codding.

② To Stablize two or more than Two transducers input that are represented by Mathematical equation.

③ To Amplify the transducer output directly

④ To Provide linear amplification to the transducer output.

⑤ To Convert Most of the transducer output into digital codding.

⑥ To remove the unwanted frequency through filter through filter form the transducer and other devices.

⑦ For Comparing the Impedances.

⑧ To remove the thermo-electric error from the Input.

⑨ For Increasing the Frequency band the transducer limitations are either increase or boosted.

→ For input Modification we use the following below mentioned Circuits :-

① Current sensitive circuit.

② Ballast Resistance circuit

③ Bridge circuit

④ Instrumentation Amplifiers.

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10/9/18

CHAPTER-04

Indicator & Recorders

⇒ The last quantity in any instrument system which with the help of indicator and recorders give the resultant or the final output.

There are two types of end devices

1. Analog devices
2. Digital devices

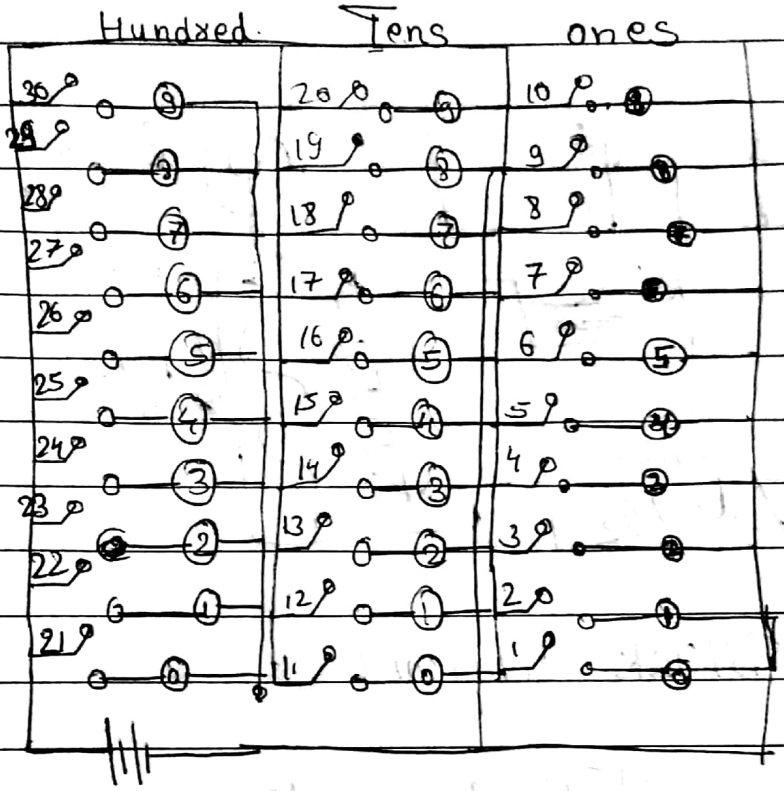
Analog devices

1. Strip or Circular Chart
2. Plotter
3. Oscilloscope
4. Null Point Potentiometer
5. Guage
6. Magnetic tape recorder
7. Thermo-meter
8. Manometer

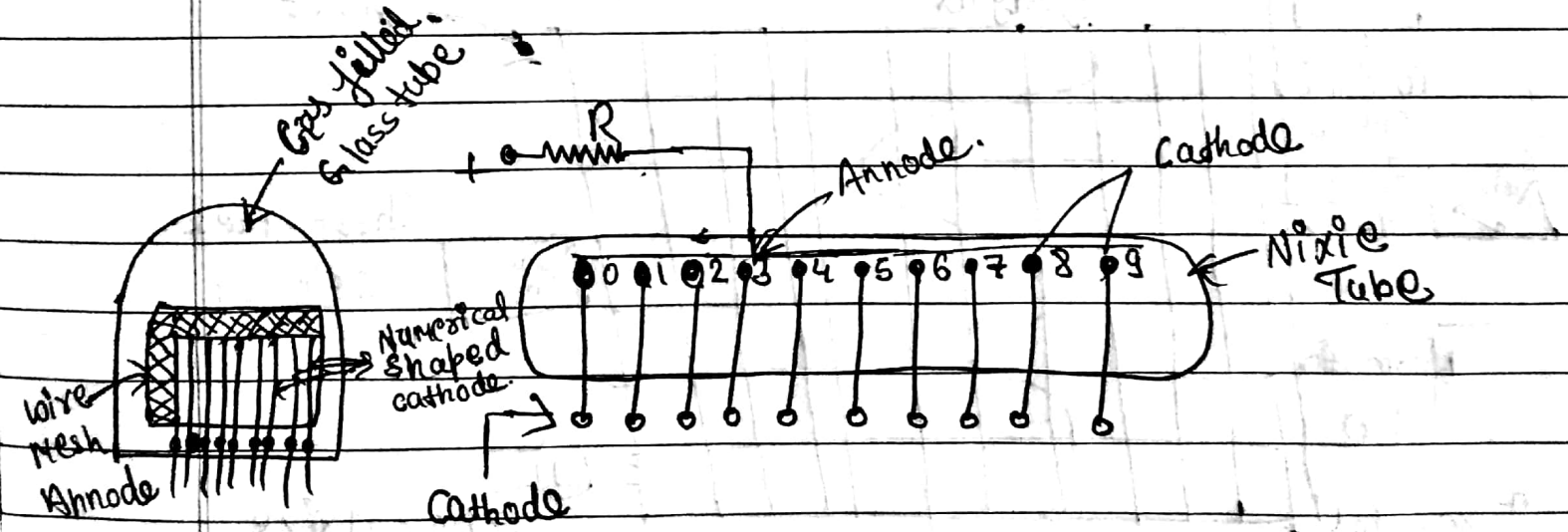
Digital devices

1. Numbered drum device
2. Lighted Numbered bank
3. Punch card
4. Punched Paper tape
5. Codded Pulse Magnetic tape recorder.

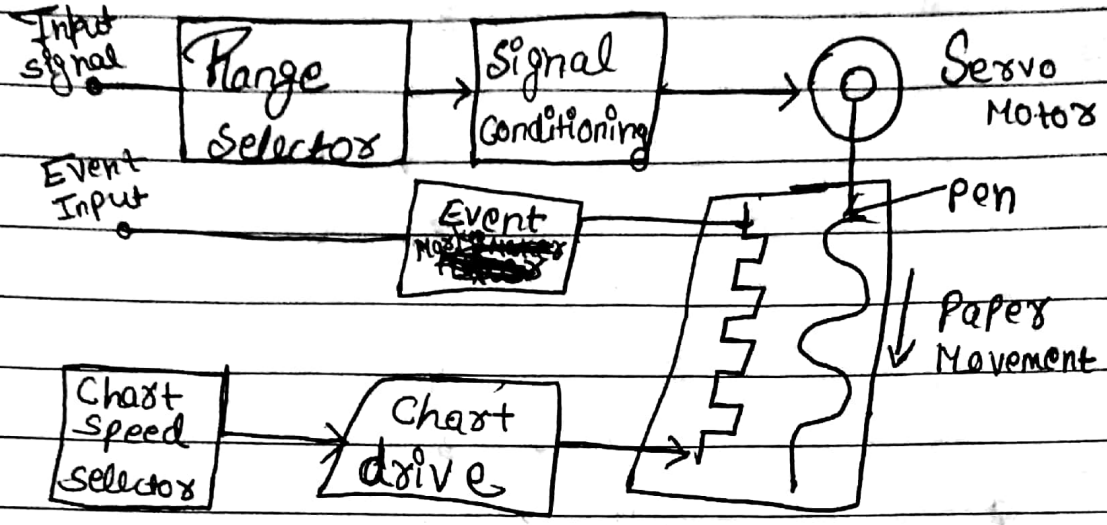
Number Indicating System



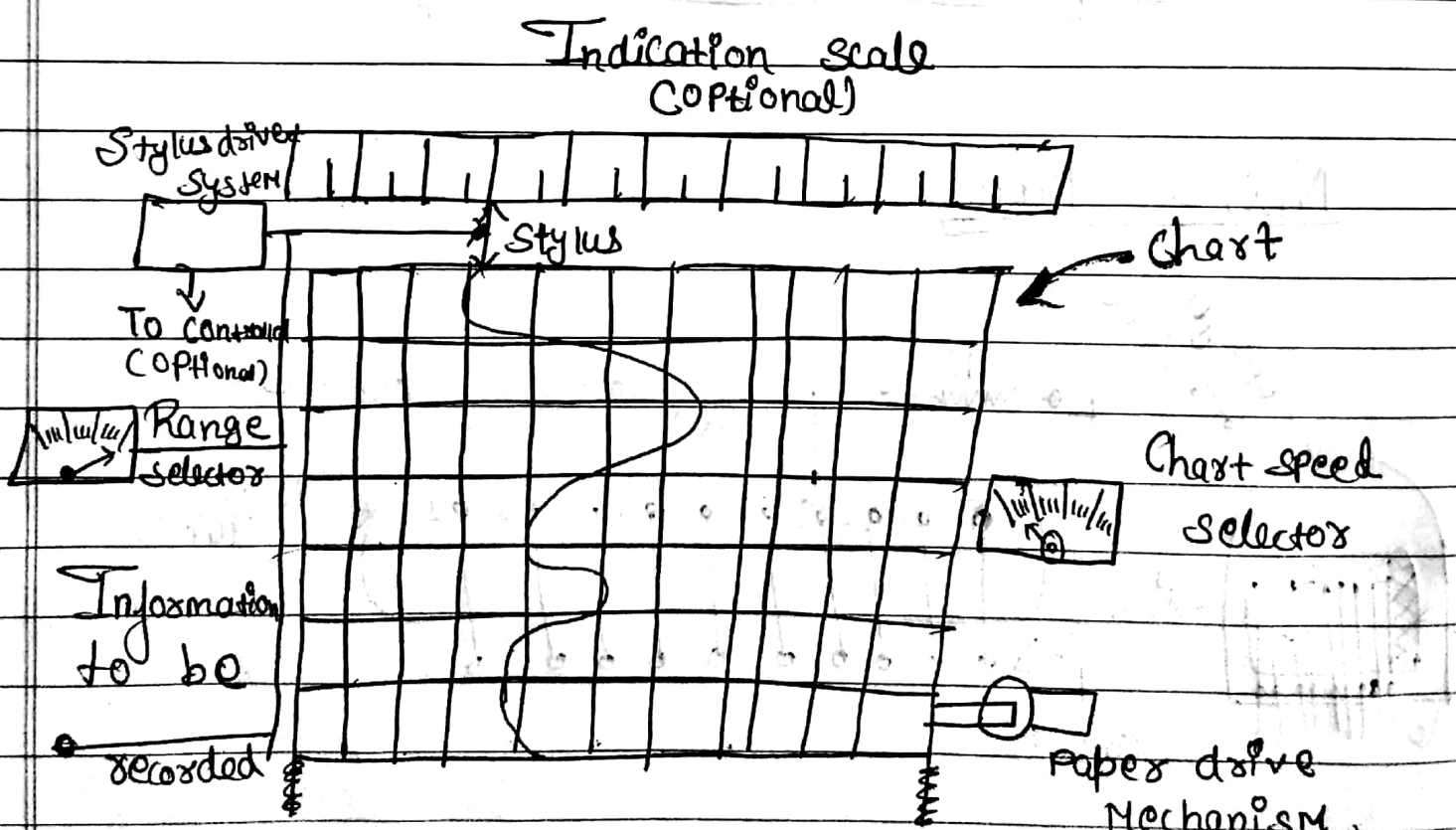
Nixie Tube



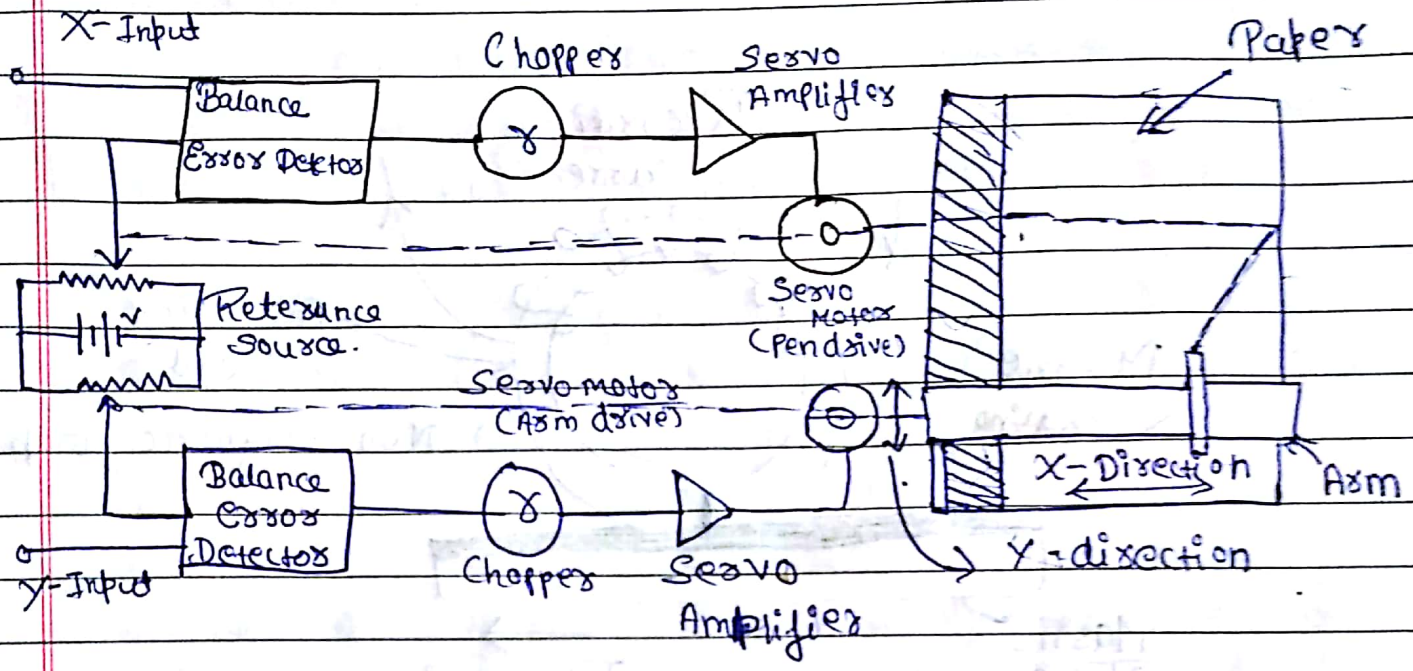
Strip Chart Recorder



Block Diagram



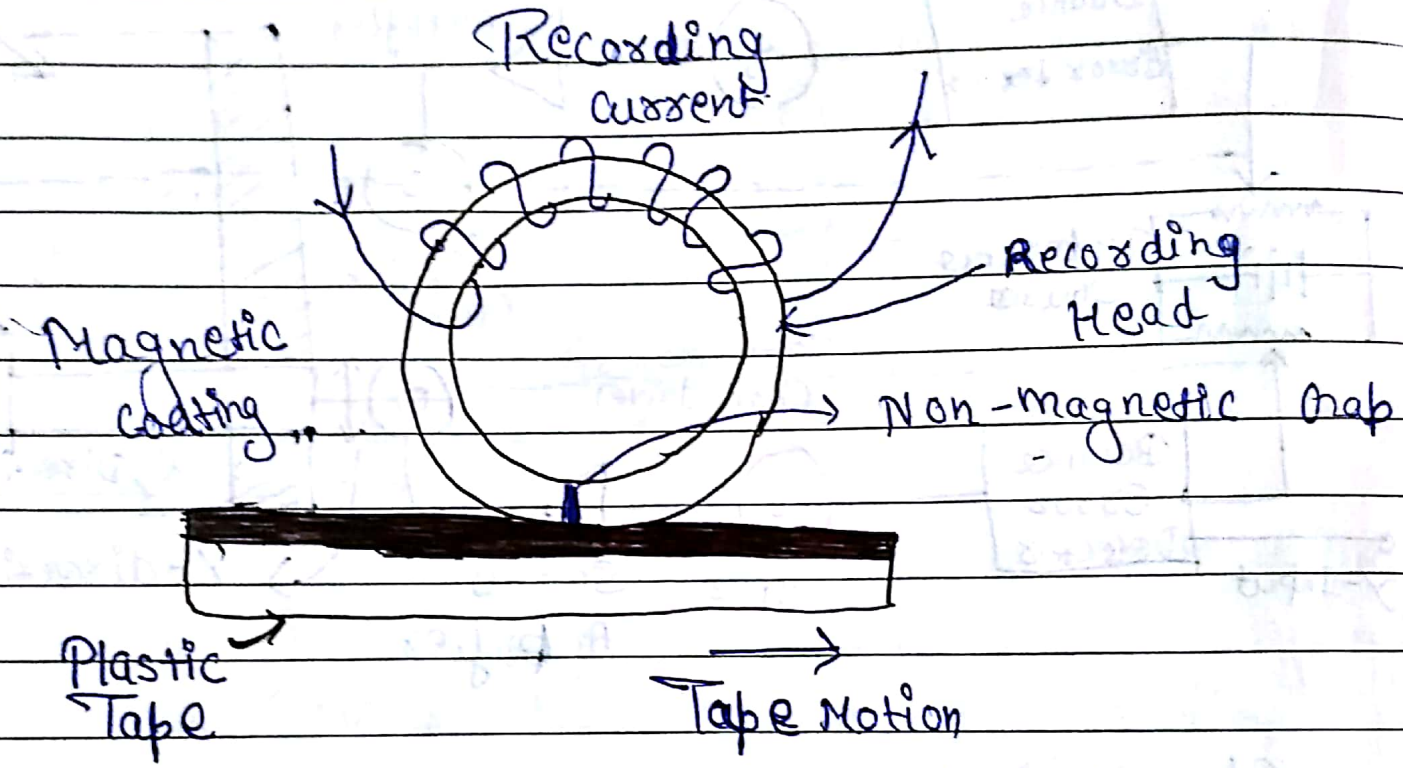
X-Y Recorder



Characteristics

- 6Hz Frequency
- ±·3% accuracy
- 2 cm of height recorded.
- 1.5 mΩ
- Chart size - 250 mm / 80 mm.

Magnetic Tape Recorder



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CHAPTER-05
MEASUREMENT OF PHYSICAL QUANTITIES

During the Measurement of physical quantities of various elements are necessary which are as under:

1. Electrical Transducer
2. Recorded value
3. Pressure Transducer.
4. Measuring Elements
5. Head Pressure
6. Actuator

Pressure Measurement :

There are two types of Pressure

(I) Static Pressure
(II) Dynamic Pressure

➡ Static Pressure → Static Pressure are those Pressure which are constant for a period of time.
example → Air pressure.
For the measurement of static Pressure we use barometer and sometimes electric barometer, and for calculation of higher Pressure we use standard gauge.

➡ Dynamic Pressure → The Pressure in which Pressure changes with respect to the time example of dynamic pressure is Steamengine in which the speed

of engine changes to the pressure inside the engine. To measure the pressure in the steam engine two things are essential

(1) Which can display the value of the pressure

(2) Which provide the details of the speed of engine.

For, showing the relationship between the aforesaid things screen is necessary

★ Pirani Gauge :-

It is a robust thermal conductivity gauge used for the measurement of pressure in vaccum system. It was invented in 1906 by marsalo pirani.

Construction → The pirani gauge consist of a metal sensor wire usually gold Plated tungstun or platinum suspended in a tube which is connected to the system whose vaccum is to be measured.

The connection is usally made either by a ground glass joined or a flanged metal connector sealed with O ring.
The sensor wire is connected to a electrical circuit form which offer a

Calibration a pressure reading may be taken.

Mode of operation

In order to understand the technolgy consider that in a gas feild system their are four ways that a heated wire transfers heat to its surrounding

(1) Gas Conduction at higher Pressure

$$E \propto \frac{dT}{dx}$$

Where, x representing the distance from heated wire

(2) Gas Transports at low pressure

$$E \propto \frac{P(T_1 - T_0)}{\sqrt{T_0}}$$

(3) Thermal Rediations :-

$$E \propto (T_1^4 - T_0^4)$$

(4) End losses through the support structure.

A heated metal wire (sensor wire) or simply sensor) ~~sup~~ suspended in a gas will lose heat to the gas as its molecules collide with the wire and remove heat. If the gas pressure is reduced the number of molecules present will fall proportionality and the wire will loose heat more slowly.

Measuring the heat loss is an indirect indication of pressure.
There are three possible schems that can be done.

① Keep the bridge voltage constant and measure the change in resistance as a function of pressure.

② Keep the current constant and measure the change in resistence as a function of pressure.

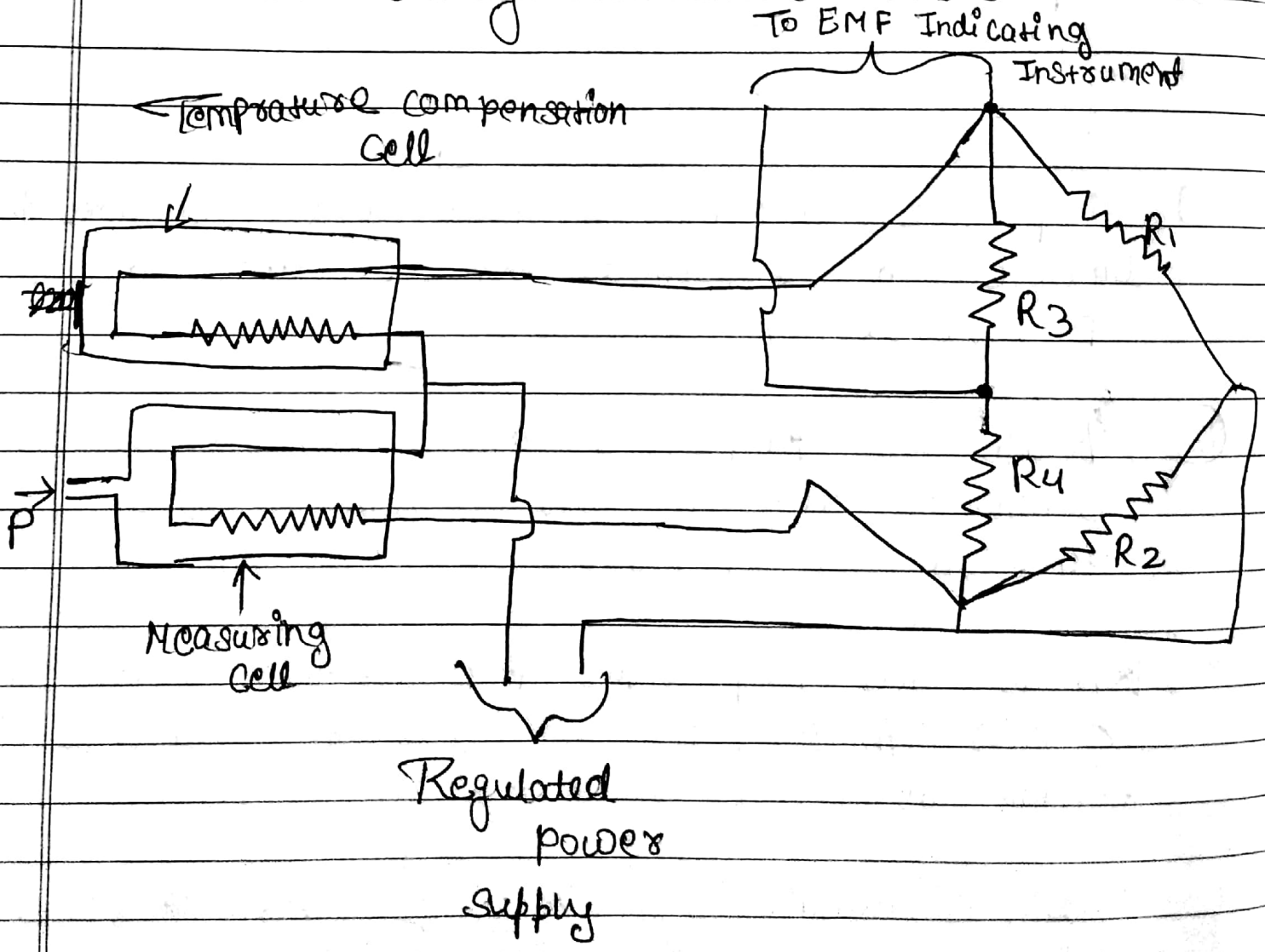
③ Keep the temprature of a sensor wire constant and measure the voltage as a function of pressure.

→ ~~In~~ Note the keeping the ~~pressu~~ temprature constant emplies that the end losses and the thermal radiation losses are constant.

The electrical resistance of wire varies its temprature so the resistance indigates the temprature of the wire. In many system the

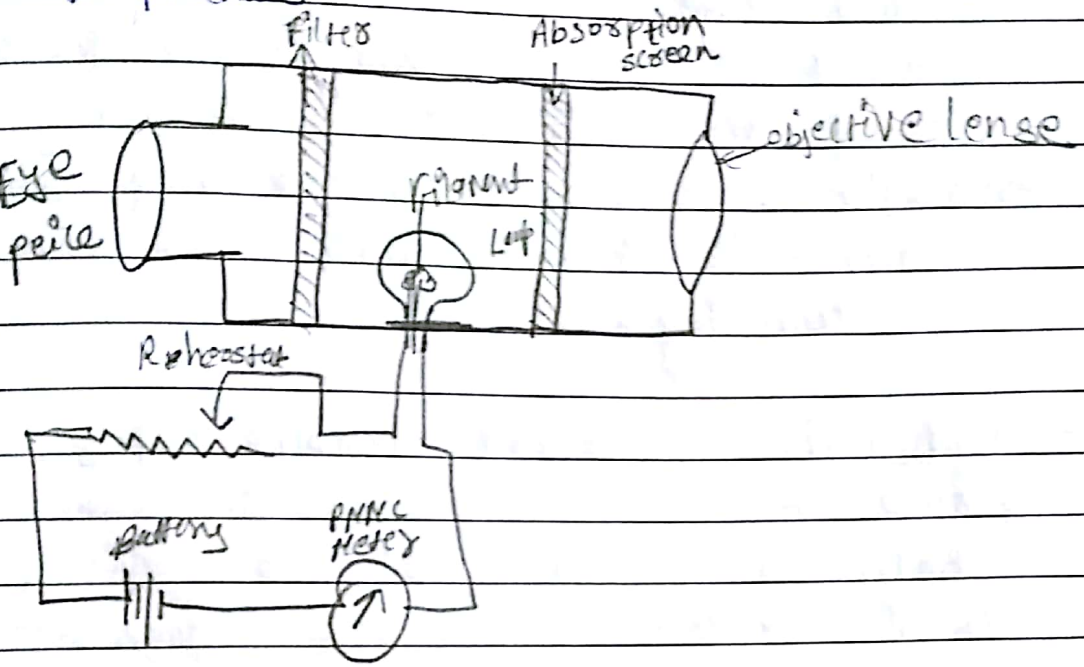
wire is heated at a constant resistance by controlling the voltage through the wire. The resistance can be said during a bridge circuit. The voltage required to achive this balance is therefore a measure of the Vacuum.

The gauge may be used for pressure between point ~~5 torr~~ 5 Torr. to 1×10^{-4} Torr. The thermal conductivity or heat capacity of the gas effex the read out ~~from~~ the meter and therefore the apparatus may need calibrating before accurate readings are obtainable.



Optical Pyrometer

- The radiation from a heated body at high temperature.



- common type disappering filament pyrometer
- Widely used for accurate measurement of temperature of furnaces, Molten Metal and other heated material.

Turbine Flow meter

- It is volumetric flow meter and available in wide range.
- The output is in the form of digital electrical signal of frequency is directly proportional to the flow rate and total count is proportional to total quantity.

- Hydraulic supported turbine rotor.
- permanent magnet sealed inside the rotor body is polarised 90° to the axis of rotation.
- As the rotor rotate so does the magnet therefore rotating magnetic field is produced.
- produce AC voltage pulse
- frequency of these voltage proportional to rate of flow.

1/10/13

CHAPTER-06
MATERIAL ANALYSIS

Humidity is a term to describe amount of water vapours present in the air, water, vapour. The gaseous state of vapour is generally available to general eye Humidity. The Amount of water vapour needed to achive saturation increases as the temperature increases. Relative humidity is expressed as a percentage that indicates a present stage of absolute humidity to a maximum humidity at a given temperature. Humidity plays an important role for surface life for animal life dependent on perspiration to regulate internal body temperature high humidity impairs heat exchange efficiency by reducing the rate of Moisture evaporation from skin surfaces.

Relative Humidity

The relative humidity of an air water mixture is defined as the ratio of Partial Pressure of Water Vapour in the Mixture to the equilibrium vapour Pressure of Water over a flat Surface of Water Vapour.

$$\phi = \frac{P_{H_2O}}{P^*_{H_2O}}$$

P_{H_2O} is the Partial Pressure of Water Vapour and $P^*_{H_2O}$ is the equilibrium vapour pressure of water.

Absolute Humidity

The Absolute humidity is the total Mass of Water Vapour Present in a given Volume ~~of~~ or Mass of air.

$$AH = \frac{m_{H_2O}}{V_{net}}$$

Where, m_{H_2O} is the Mass of Water Vapour.
and
V_{net} is the Volume of air and Water Vapour Mixture.

Specific Humidity or [Moisture Content].

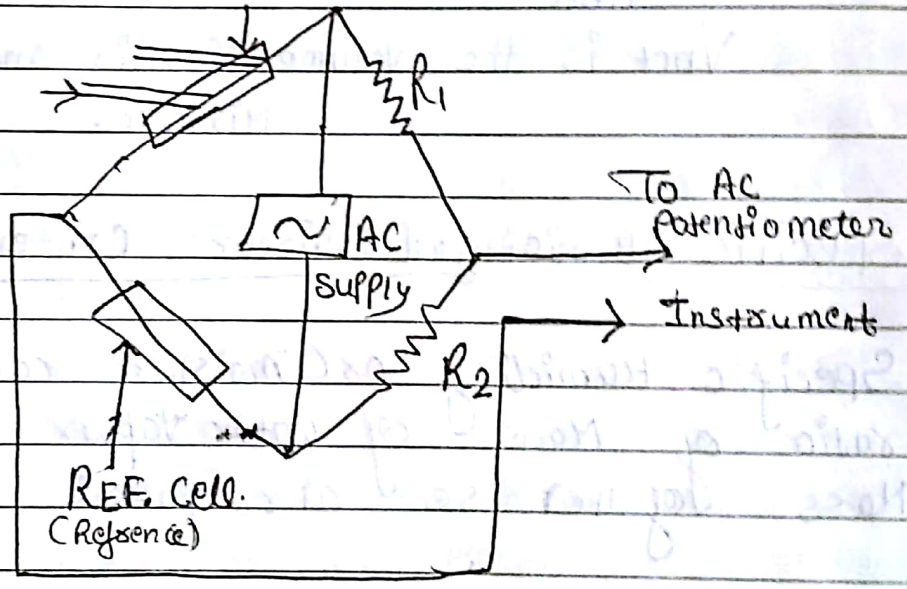
Specific Humidity or (moisture content) is the ratio of Mass of Water Vapour to the total Mass of the noise air Parcel.

PH Measurement

PH is a logarithmic scale used to specified the acidity or basicity of a aqua solution it is approximately the Negative of the base 10 logarithmum of a ~~moto~~ molar concentration of a hydrogen ion more precisely it is the negative of base 10 of the activity of the Hydrogen ion.

Solution of a PH less than 7 are acidic and solution with PH greater than 7 are basic Pure water is neutral at PH 7 being neither an acid nor a base. Contrary to the popular belive the PH value can be less than zero or ~~greathe~~ greater than 14 for very strong acid or base.

Gas Analysis



Different gases differ from each other by the type of heat flowing capability this characteristics of gases is known as Thermal Conductivity air at 273°K the value of thermal ~~Condivi~~ conductivity of air is 1.

S.No	Gas	Thermal conductivity
(1)	CO_2 Carbon di oxide	.585
(2)	CO Carbon mono oxide	.968
(3)	Helium	6.08
(4)	Hydrogen	7.35
(5)	Nitrogen	1.015
(6)	Oxygen	1.037

For calculation of thermal conductivity of gases, the knowledge of basic constituents and the quality of gas should be known.

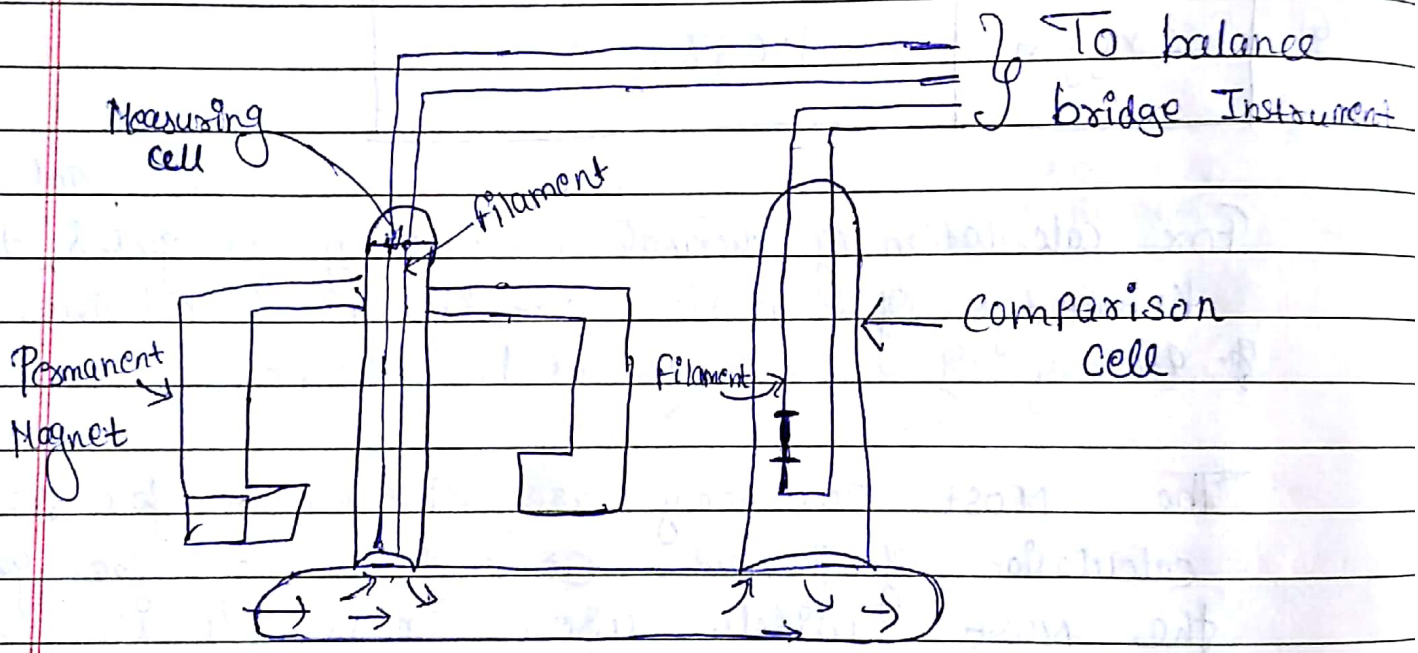
The most commonly used instrument for the calculation of thermal conductivity of the gas the most widely used instrument is gas analysis cell.

This cell consists of two chambers that consists of a wire in the arms of the bridge as shown in the figure.

In the first chamber the gas whose thermal conductivity is to be measured is kept and another chamber a reference gas is used.

The wire of sampling chamber, The size of wire increases as the thermal conductivity decreases. because in the arms of the bridge the space for the moment of the gas is very small. and with the help of Widdh stone principle we can calculate the thermal conductivity of the given gas.

OXYGEN ANALYSIS



The oxygen gas shows a greater paramagnetism effect than expected enhance gets polarized When this kept under a magnetic feild Nitrogen dioxide gas also shows Paramagnetism effect in the comparison cell and the measuring cell have the same value of resistance wire but the measuring cell is kept in the magnetic feild. The gas

tube is ~~kept~~ attached in the downward side of the chamber. if the oxygen gas is present in the gas tube and we know the property of the oxygen is to get deflected in the presence of magnetic feild it gets heated and hence we come to know that the measuring gas is oxygen which is then is forwarded to the balance & bridge instrument for the calculation

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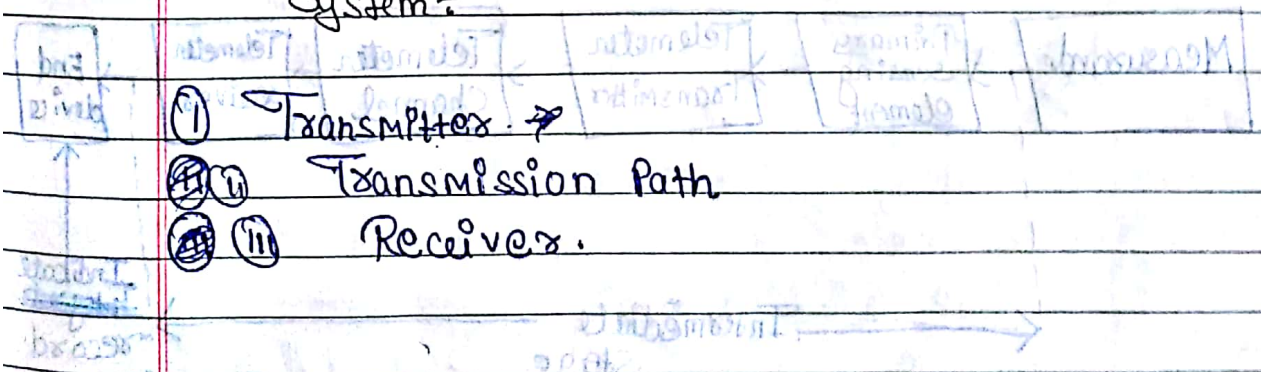
CHAPTER-07
TELEMETRY

Introduction → The Telemetry is a technology which enables a user to collect data from several measurement points at inassecible or inconvenient location, transmit that data to a ~~convi~~ convenient location and present the several individual measurement in a usable form. It simply means measurement at distance.

Data-Transmission → It refers to the process of transfering of data or information from one place to another, there is a variety of situations where in measurement is carried out at one location and its value is required at a remote location, for indication, records, control action inessations. The distances involved may be as small as in the case of ~~instrume~~ instrumentation inside a labroraty or it can be large as in case of air craft and space craft instrumentation. In all these cases the primary intrest is to transfer data with full accuracy.

The three basic component of a data transmission system :-

(i) Transmitter
(ii) Transmission Path
(iii) Receiver.



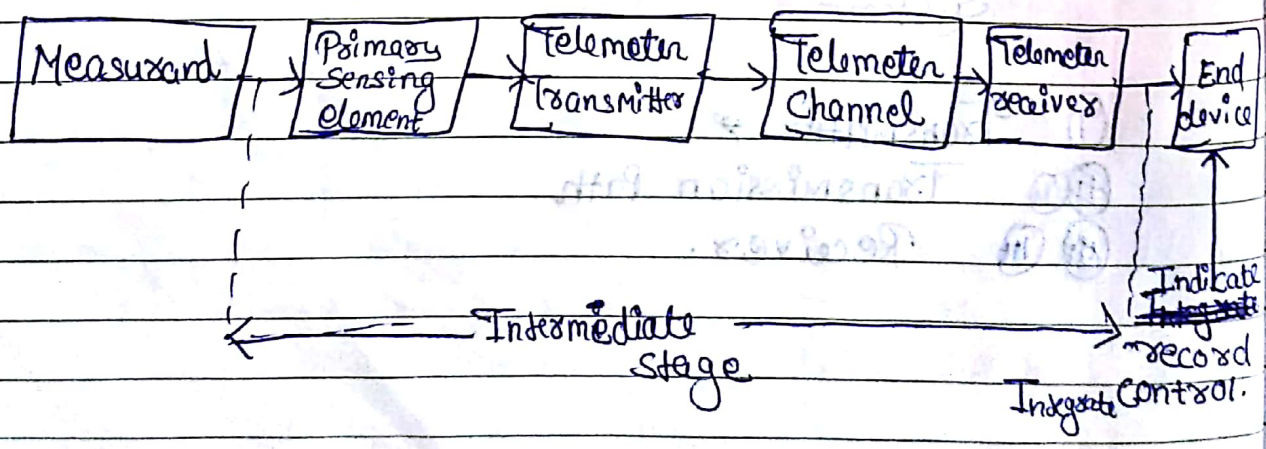
There are three types or methods of data transmissio. i.e. used in a measuring system they are :-

1. Hydraulic transmission
2. Pneumeatic transmission
3. Electrical & Electronic transmission

General Telemetry System:-

Telemetry May be defined as a measurement at a distance a general Telemetry System is shown in figure. The primary detectors and the end device of the telemetry System have the same function and position and functional goals as in generalized measurement system. However there are three System elements in the intermediate State which are peculiar to a telemetring system. They are

(i) Telemeter transmitter.
(ii) Telemeter Channel
(iii) Telemeter receivex.



The function of a telemetex transmittex is to convext the output of a primary sensing element in to an electxical signal and to transmit it ovex a telemetxing channel.

The signal is in electxical foxmate and is xeceived by a xeceivex at the xemote location. this signal is converted into a usable foxm by the xeceivex and is indicated ox xecoxded by an end device. Which is gxaduated in texms of the Measuxand. The end device may be a contxol element which may be used fox the contxol of the input quantity thxough a Feedback loop to pxoduce a desixed output.

Types of Telemetxy System:

Thexe are two types of telemetxy system.

(1) Landline Telemetxy

(11) Radio Fxequency Telemetxy (RF).

Landine Telemetxy are of 3 types

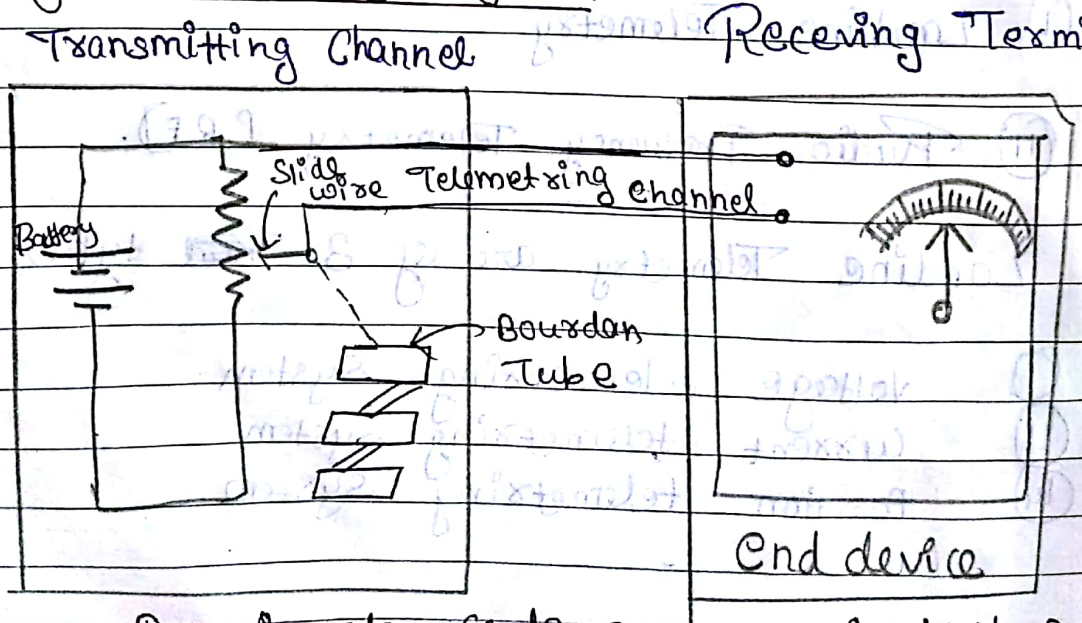
(1) voltage telemetxing System
(11) cuxxent telemetxing System
(14) fosition telemetxing System.

★ Landline Telemetry system → It requires a telemeter channel which is a physical link between the telemeter transmitter and receiver this physical link may be a cable, a specially laid out wire, existing telephone or telegraph cable or a power line carries the land line telemetring is, infact, a direct transmission or information through cables and transmission line.

The direct Transmission via cables employs current, voltage, frequency, position or impulses to convey the information.

Current, Voltage & Position types of systems can be used only for short distances while for long distance telemetry pulse and frequency type are used.

★ Voltage Telemetry system.



Potentiometer scale graduated in KN/M^2.

Construction →

A Voltage telemetring system transmits the measure variable as a function of ac or dc Voltage. A simple voltage system is shown in the figure above. a slide wire potentiometer is connected in series with a battery. The sliding contact is positioned by a pressure sensitive bourdoun tube. The telemetry channel consist of a pair of wires connected to a voltage measuring device such as a null balance dc potentiometer indicator or recorder.

Working :-

As the measured pressure changes the bourdoun tube actuates the sliding contact there by changes the voltage the dc Null balance potentiometer measures the voltage and positions are pointer on a scale calibrated interms of pressure being measured.

Note → ① The use of a null balance dc Potentiometer reduces a current carried by a telemetring channel to minium where the resistance is Negligible.

② Most of the system use primary elements which produce a voltage signal this elements includes thermocouples tecometers and a differential transformer.

→ Application

The Voltage telemetry System are used in industry upto a distance of 300 Meter in which self balancing potentiometers are the usual receivers of such system.

A Voltage telemetry System is suitable for adding several output voltages in series.

Disadvantages

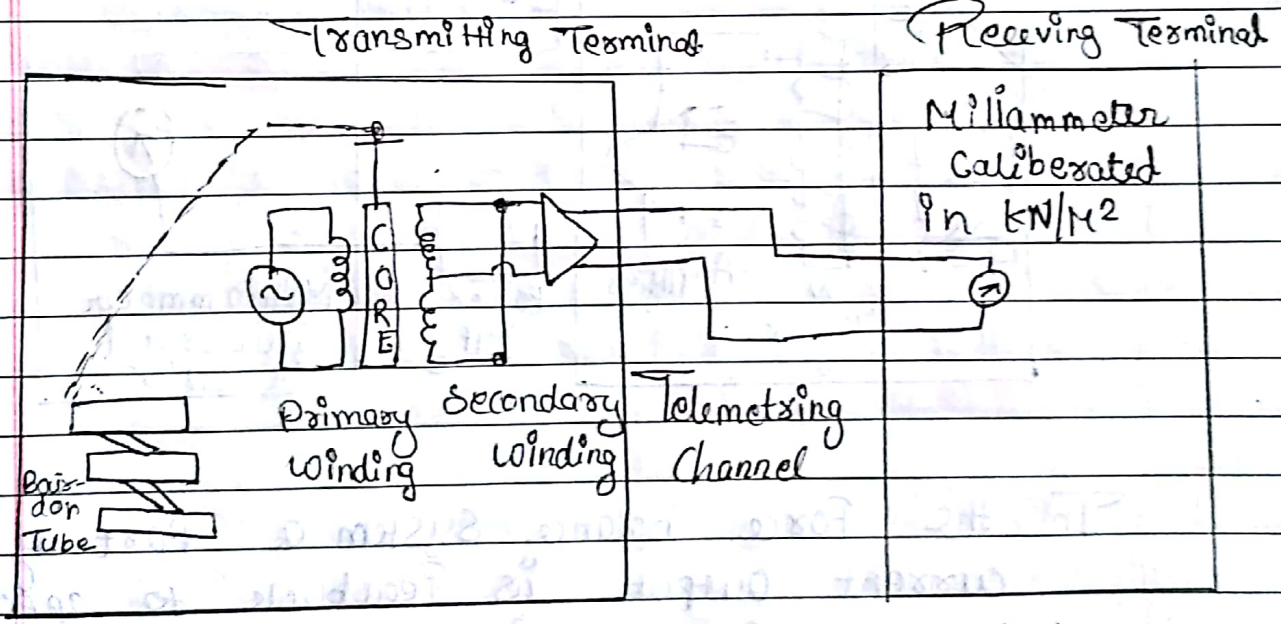
(1) It requires high quality circuits then a current system hence more expensive equipments are required.

(2) The System is generally not adoptable to the use of many receiver working at the same time.

Current Telemetring system.

As the Pressure which is a Measurand changes the bourdon tube moves and changes the position of the sliding contact on the slide wire, thereby changing the current in the circuit this current is measured with the help of a miliammeter whoese scale is graduated in terms of pressure.

~~Moto~~ Motion Balance current telemetring system

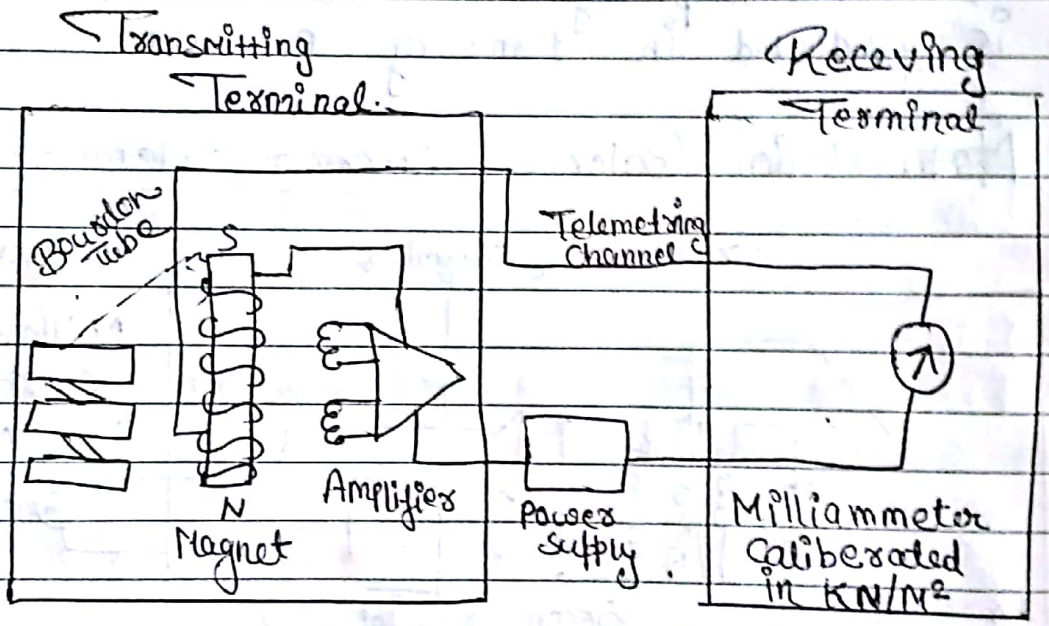


In a Motion balance system. The slide wire is replaced by a Position detector like an LVDT. the pressure acting on the bourdon tube causes a displacement which moves the Core of LVDT there by producing a voltage output which is amplified and

rectified. This voltage produce a dc current of the order of 20 MiliAmpere in the telemetring channel and is measured by a dc mAmmeter.

The scale of dc MiliAmmeter is calibrated in terms of pressure being measured.

Force Balance Current Telemetring System.

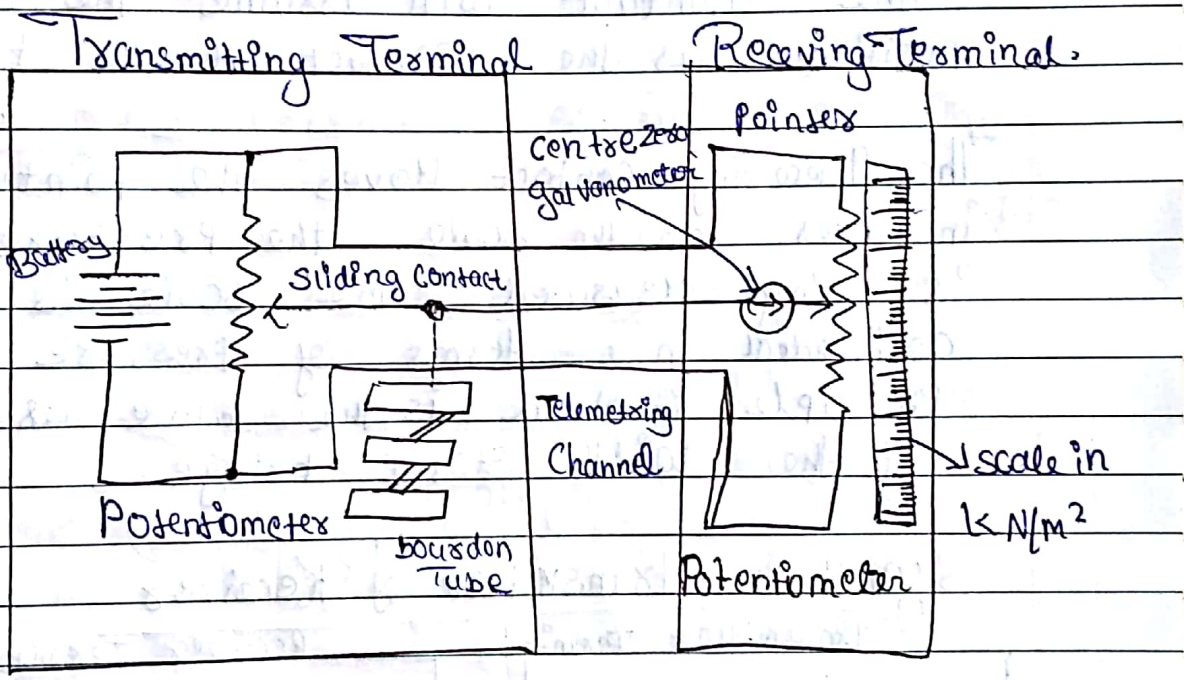


In the Force balance system a part of current output is feedback to oppose the motion of input variable the system is operated by the bourdon tube which rotates the Feedback Force coil which inturn changes the flux linkages between Primary & secondary coil. The change in flux linkages varies the amplitude of amplifier. The output signal is

Connected to the Feed back force coil which Producing a force opposes the bourdon tube input.

A force balance system increases the accuracy as smaller motions are required which results in better linearity.

Position Telemetring system.



A Position telemetring system transmits and reproduces the measureds variable by positioning variable resistors or other electrical components in a bridge circuit for so as to produce proportional changes at both the transmitter and the receiver end. This is known as bridge type system.

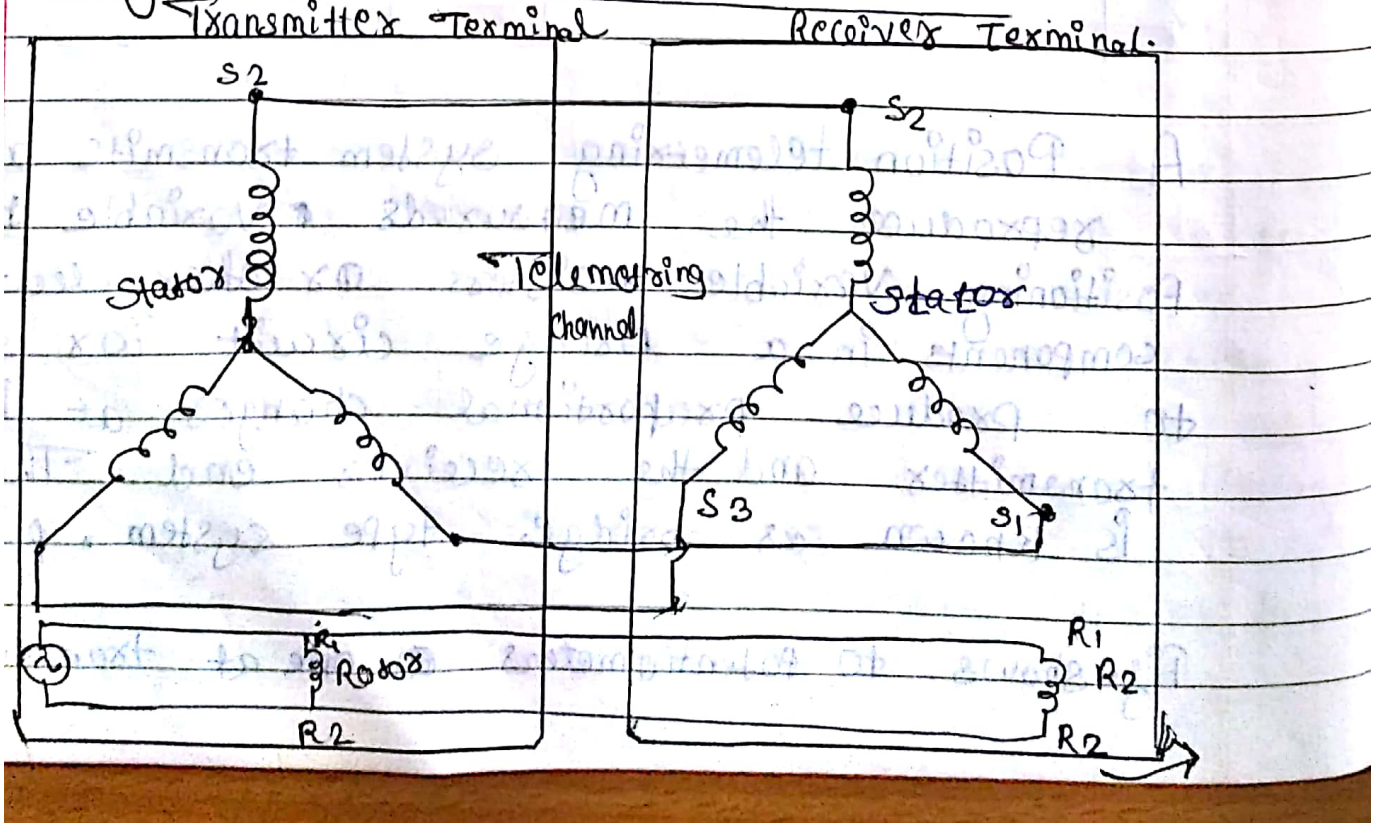
Fig. shows to potentiometers one at transmitting

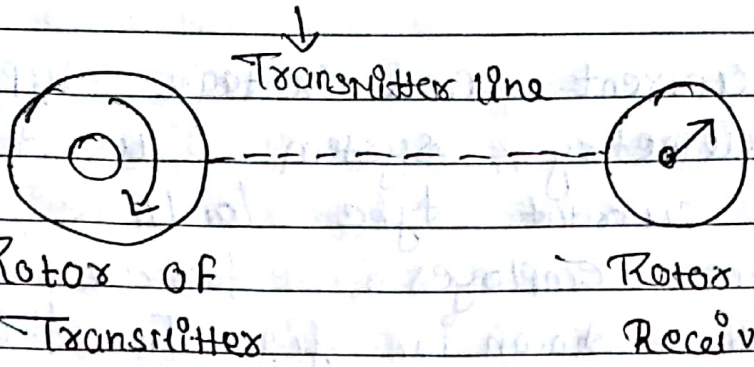
act and the other act at the receiving end the two potentiometer energised by a common power supply. The sliding contact at the transmitting end is position by the bourdon tube as pressure is apply to the ~~tatte~~ later.

If the sliding contact at the receiving end is positioned until the centre zero galvanometer indicates zero the position of the contact will assume the same position as the contact at the transmitter.

The receiving contact moves the pointer which indicates on the scale the pressure which is being measured the scale is directly calibrated in a terms of pressure the principle involved is the same ~~as~~ as that of the width stone bridge.

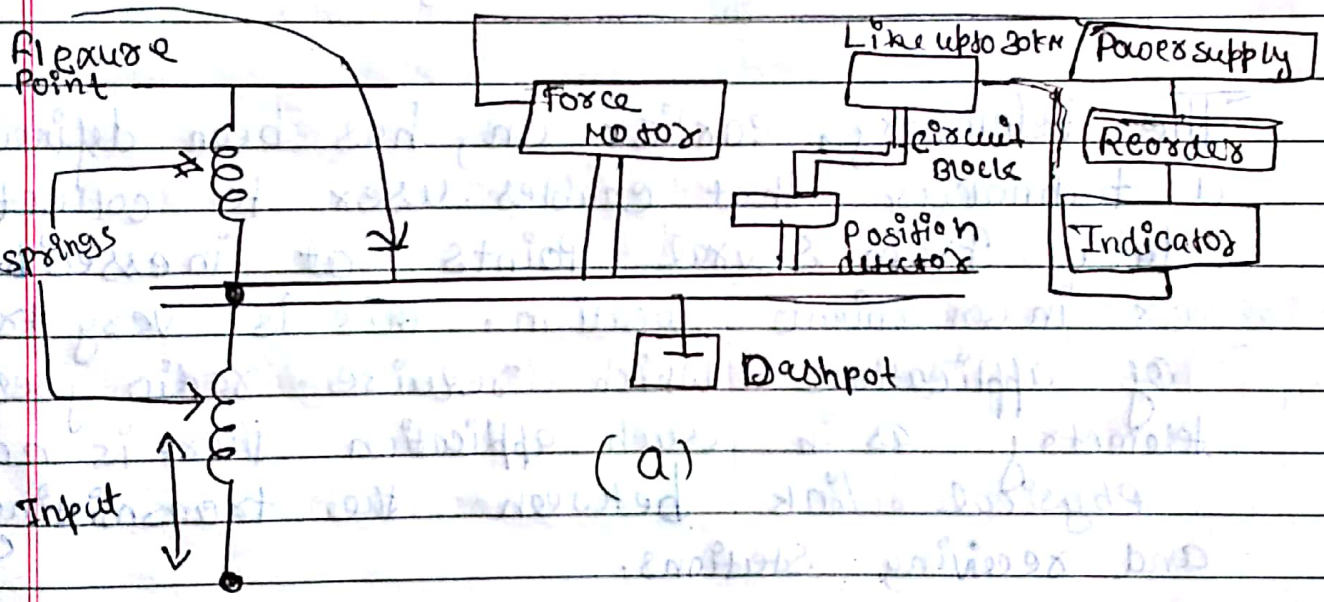
Synchro Transmitter & Receiver



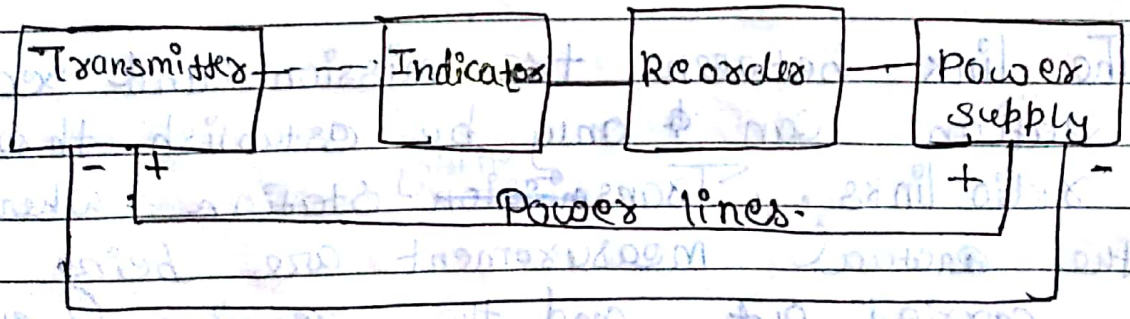


Another most commonly used position telemetry system utilize of synchro transmitter and receiver this is purely an ac telemetry syste

✱ Landline Telemetry Feedback system.



(a)



(b)

The current and voltage types of ~~tele~~ land line telemetry system use Feedback system. The current type landline telemetry system employes a torque balance method which is shown in fig. In this method a dc envions connecting a measurement transmitter ~~to~~ measuring device is used to apply a torque to balance a torque generated System.

Radio Frequency Telemetry [RF Telemetry]

The telemetry, earlier on, has been defined as a technology that enables users to collect data from several points at inaccessible or inconvenient location. This is very true of applications which require radio frequency telemetry as in such application there is no physical link between the transmitting and receiving stations.

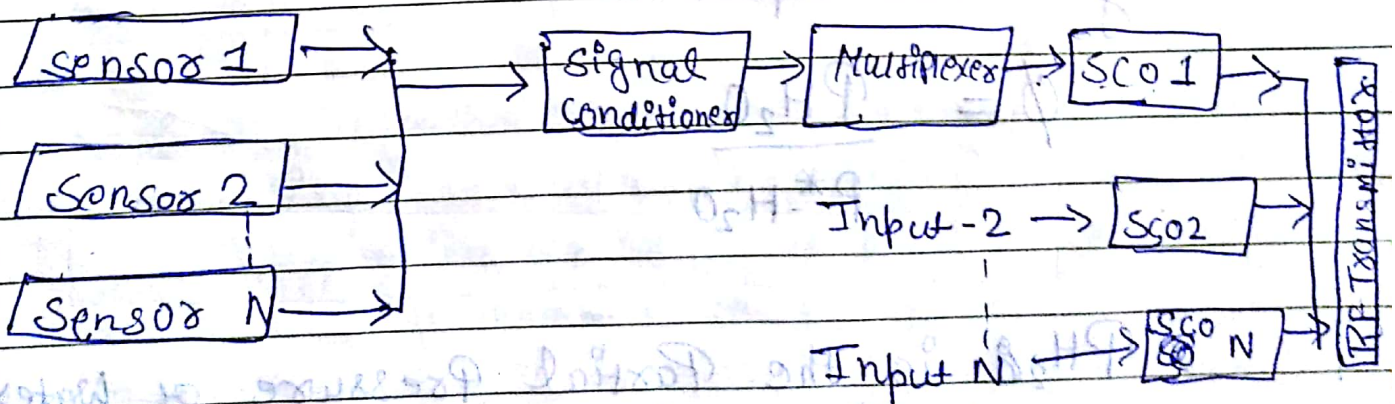
The link between transmission and receving station can only be establish through radio links. Transmitting station where the actual measurement are being carried out and the receving station where the measurand is measured recorded and information is used for control purpose

Such type of telemetry is used for air planes, rocket, space craft where data is transmitted through radio links from air craft to land station or from land station to the air craft.

RF Telemetry system is usally more suitable if the data is to be transmitted over distances greater than 1 KM. certain parts of radio frequency spectrum have been alocated for telemetry and micro wave links above about 4mHz. radio waves at this frequency tends to travel in a straight lines require in repeater station with disc like antinas on high building and towers in every 30 to 60 KM.

⇒ In Rf telemetry system a signal or data to be transmitted is first modulated.

Block diagram



CHAPTER-08

PROCESS CONTROL

→ Control System

When the output quantity in a system can be varied by varying the input quantity, the system is called control system.

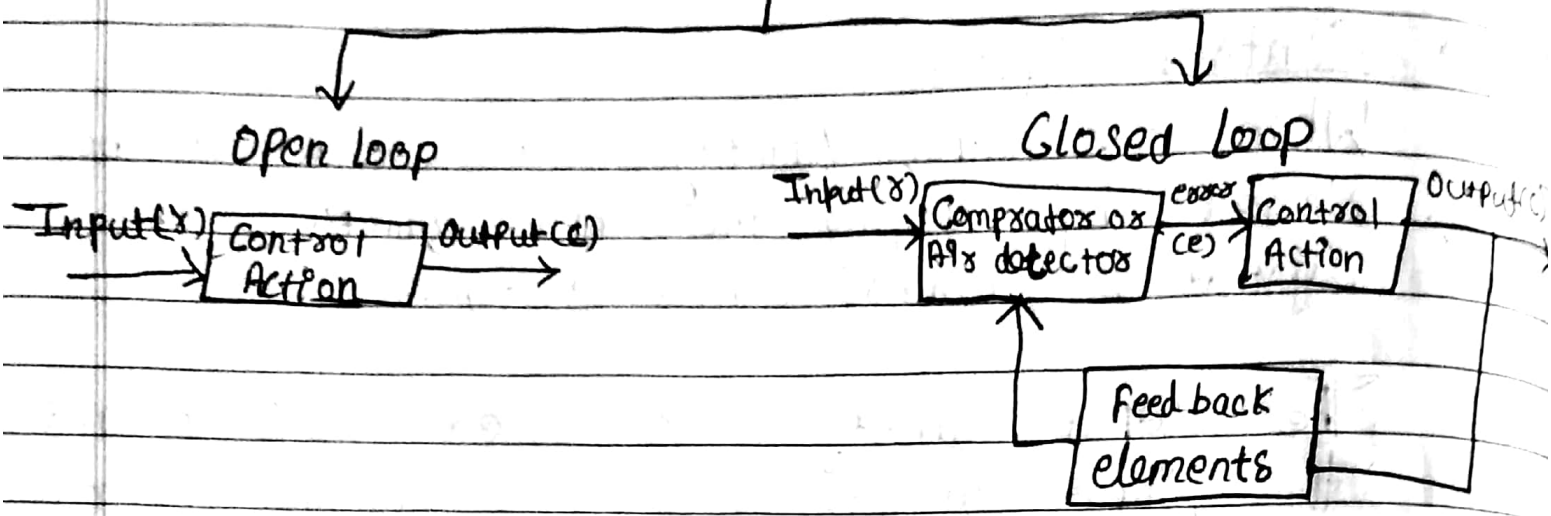
The output quantity is controlled variable and the input quantity is called command signal.

Importance of Control System:-

A control system is a combination of elements arranged in a planned manner where in each element causes an effect to produce a desired output. This cause and effect relationship is governed by mathematical relationship.

In our daily life there are numerous objectives that need to be accomplished we need to regulate the temprature and humidity of homes and buildings for comfortable living. For transportation we need to control the automobile and air-plane to go from one point to another accurately and safely. Industrial Manufacturing Process contain numerous objectives for Product that will satisfy the precission and effectiveness requirements the means of achiving this objective usually involve the use of the control system.

Process control

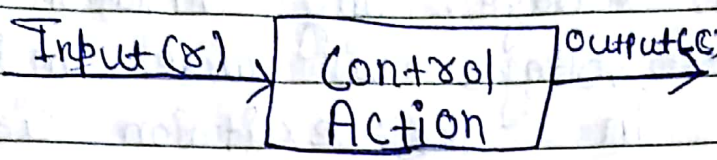


Open loop System

In an open loop system the output quantity is not fedback to the input quantity. In this system the controlled variable remains constant for a constant command signal, Provided that no external disturbance effects the control system. The output may be varried to any desired value by varrying the input quantity correspondingly but if there are external disturbances or internal system parameter variation during the operation then the output varries in an uncontrolled way it is also called as manual controlled system.

The open loop system is satisfactory only if the output fluctuations can be tolerated, or system limits the parameters variable and external disturbances are well controlled.

Here, the Input (r) controls the output (c) through a control action process. The output has no effect on the control action.



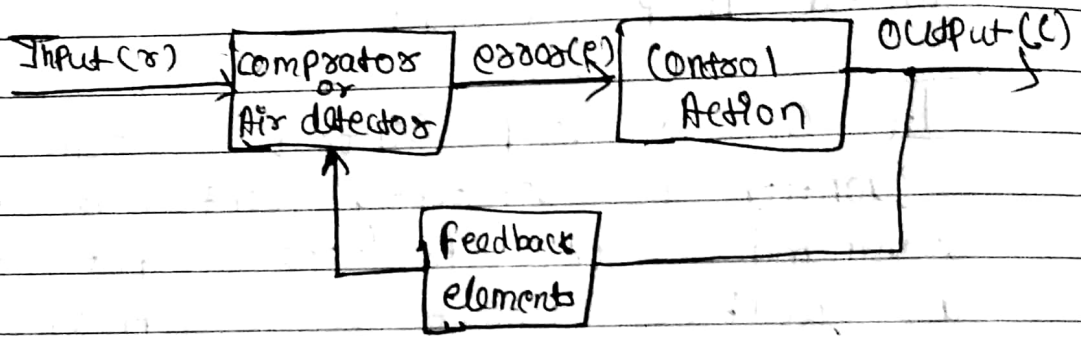
A Seprately excited dc generator is a example of open loop system.

Closed loop system

In closed loop control system the output quantity is constently controlled by sending a command signal to the input quantity through a feedback element without feedback the system becomes open loop system. The system consists of feedback element, error detector reference input controlled and converting unit. Closed loop control system is also called as automatic control system.

In this system output has a effect on control action through feed back. The control action is actuated by an error signal (e) which is the difference between the input signal (r) and the output signal (c). This process of comparison between the output & Input maintain the out at a desired level through control action process.

For example, to Maintain constant output voltage of a dc generator the output voltages feedback and compare with the input reference voltage. any variation in the output voltage will cause and an out of balance in the excitation circuit which will bring back the necessary condition for restoring constant output voltage. The balance will be restored only when the output voltage is Maintained constant.



⇒ **Variable →**

Variables are the Process or Condition Which changes after a definet interval of time. This can be measured Temprature, Pressure etc.

⇒ **Servo-Mechanism →**

By the defination Servo-Mechanism is a type of helping instrument or device but by the type of Work it peryorm it should be called as a Complete System or a

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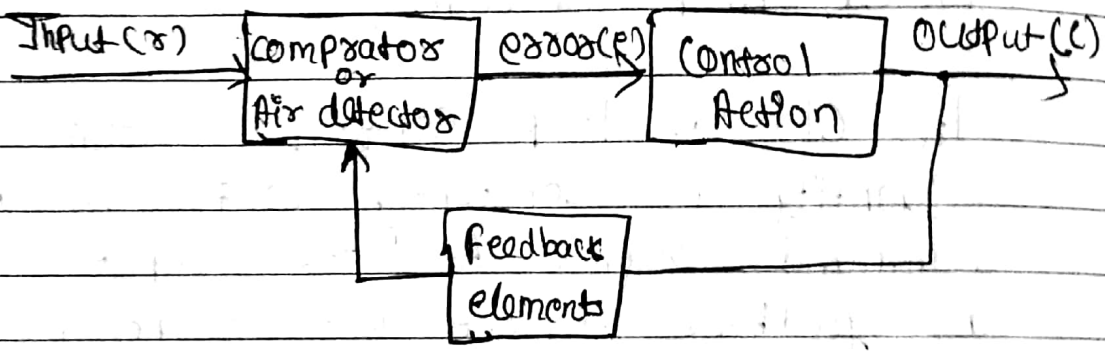

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~~Synchro~~ Servo.

In control system a servo mechanism sometimes shortened to servo it is a automatic device that uses error sensing Negative feedback to correct the action of mechanism it usally include built in enclosex or other position feedback Mechanism to ensure the output is achiving the desired effect.

The term correctly apply only to the system where the feedback or error correction signal help control mechanical position, speed or other parameters for example an automatic Power window control is not a servo mechanism as their is no automatic feedback that controls position. The operator does this by observation.

There are three types of servo-mechanism

① Type 0 servo mechanism

② Type 1 servo mechanism

③ Type 2 servomechanism.

① Type 0 servomechanism- under study state condition they produce ~~the~~ constant value of output with a constant error signal.

☆ ON - OFF CONTROL

It is a type of a control action in which there are two types of system i.e. on & off. When the Measuring value is ~~equal to the~~ less than the actual value then the instrument gets started and ~~it is start~~ the Process is continue till the set Point or the actual value is not achived. once the set Point is achived the instrument comes to off Position automatically. In this way the on-off control ~~theft~~ works. The example of a such type of system is a refrigirator in which temprature is measured by a thermocouple and as the temprature of the Refrigirator increases a signal is given to compressor motor so that it gets started. As soon as the refrigirator again comes to the set value the switch is made off. This is how a refrigirator works.