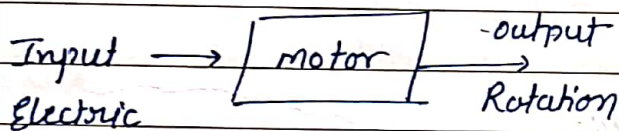
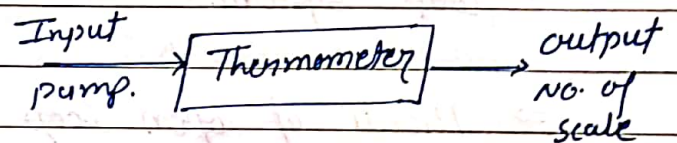


The main principal of mechatronics is to connect or co-related all the system or technique of various fields to generate all the reliable and more economical system.

All those collaboration the mechatronics module perform the best production economy optimize the best method and flexible manufacturing system.



(a) System



(b) Measurements.

Control system:-

Control system is classified into two categories

1. Open loop System:-

In open loop system the output is the final result and the remaining is unused.

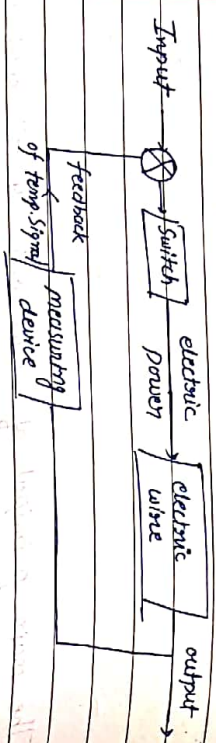
2. Close loop system:-

In closed loop system a measuring device is connected b/w the comparison elements and after the output.

1. Open loop system:-



2. Closed loop system:-



* Merits and demerits of open & close system:-

- Merits of open loop system:-
 - Simple and easy to operate
 - Low of cost with good reliability but the major demerit is there no correction of air to overcome the elements open loop system.

⇒ Merits of open loop system:-

- It is comparatively more accurate and with exact results.
- * Demerits:-
 - All these close loop system is more reliable and accurate but factual there are some demerits it is more complex so more costly with a greater chance of brake down.

Microprocessors:-

Use of microprocessors are now rapidly increasing and replacing the mechanical can operated and it is use by general instruments for control function.

It is more flexible in microprocessor on controller consist of one chip which integrate all memory & more adaptable and acceptable form of microprocessor is programmable logic controller. This controller system use programmable memory to store instruction and follow the various function like sequences logic coding and counting algebraic and arithmetic to control events and can always reprogrammable for different task.



Diagram:- Programmable logic controller

⇒ following are some application of mechatronics:-

(i) Automotive Engineering-
The equipment is use in design of sub-system like ABS mechanism is the new language of automobile.

(ii) Sensing & control system:-
On two wheels and four wheels sensor technique is so common for preventing the things like thumb impression automobile control system.

(iii) Transportation and vehicle system.

(iv) Integrate circuit manufacturing system for fax and scan rate in the fully based on mechatronics.

(v) In aircraft flight control technique and navigation system.

Flexible Manufacturing System (FMS):-

The name indicates the manufacturing system with flexibility about the changes in variation according to the requirement.

Industrial sector FMS consist of many control automatic system devices computer numerical control (CNC) and many other system such as inspection machine mandly FMS is divided into two categories.

1. In-line flexibility:-

It related the production work the use of robotic manufacturing system computer system and other devices in the production segments. Industries are improving the work quality, benefits and results.

The main advantage of an FMS is high flexibility in control & adjust the manufacturing process like time effort load and minimum the error to get the optimum results and transporter to manufacture the new products.

2. Routing flexibility:-

Routing means alternative work station can be used in the case of any broke down the some operation can be performs and alternative rule if there is any failure without wasting the time.

* Merits and of flexible manufacturing systems:-

- Reduce manufacturing cost by flexibility it is easy to detect the different system and we choose the most appropriate systems option.
- It increase the stability of the system.

- Cost of the total production on per product will automatically reduce.
- If increase the efficiency of the m/c.
- Adaptability of new computer operation like CNC/CAD/complex.
- Improve the all over quality of the system and increase the production rate.

* Demerits of flexible manufacturing systems:-

CNC (Computer numerical control):-

New CNC must not only key with advances mic tool tech but there are various other manufacturing and mic operation facility CNC is doing all the work & mic function which are not easy with NC system easy to understand and use.

CNC reduces operation time which increase the productivity of rate.

The development of CNC in many year along with the development of local area net working has present evolved in the modern concept of direct numerical control and distributed numerical control.

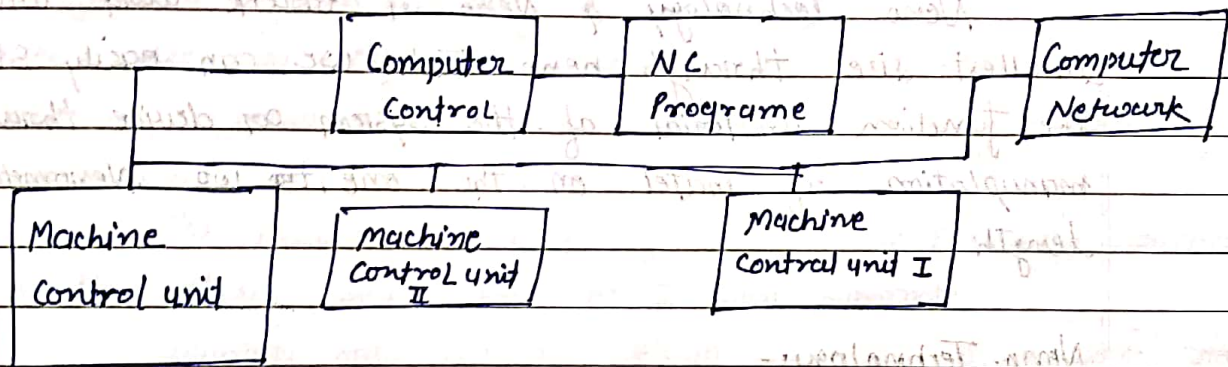


Diagram:- CNC machine.

* Scenario of CNC technology and developments:-

⇒ High speed and multi

operation mic method:-

(i) Mic in a single center and hard machining are gaining ground these technologies are non-conventional machining.

(ii) Industrial Robots:-

Automatic advance technology to the science fiction concept of future stick mic a very important stage of mic tool development accept accept & the main function is operate

(iii) Computer Added Design:-

All data and info. are contain in the internal

computer model car and programming with automatic creation of program in the car computer.

iv Flexible manufacturing cell system:-
It is a combination of mic. tool which are

capable for doing complete job of components from raw material to final product.

* Basis of micro & nano-technology:-

Micro and nano technology has quite vital (important) role in the development of various engineering sectors and many other field.

Nano Technology & Nano is 'smallest' word which mean smallest size through nano Tech. we can easily study about the function, material of the system or device through control manipulation of mater on the one to one nanometer scale length.

Nano-Technology:-

It is the branch of engineering in which we include current works and introduce more advance techniques in any system and study the effects of every factor from your bottom to the top. Introducing new parameters, tool & operation to improve the performance & quality of the product.

Ex: They make & some tool are being explored, explained for their capacity, to deliver products repair DNA systems like and many other application.
Physical, chemical, mechanical, electrical, optical, magnetic.

Nano technology are introduced for better betterment of quality.

(iii) Some researcher work on area of nanotechnology and use of nanomaterial would have on human health, health and environments.

(iv) Study and effects of nano-toxic and application of nanotechnology are promoted by some govt.

Achievement of nano technology:-

There are two very exciting present recent advances in nanotechnology. They may result in a massive increase in memory capacity of your brain and i-pants.

The material is made up of lens of but nanoscale suspended in clean plastic spun flat on a glass substrate.

Principal data can be return site with in the same area in the material without interfere each other.

Microprocessor based controllers:-

MP based controller are new or micro controller which are digital device. It is composed of million of transistors with on a single semi conductor piece. The advantages

Advantages of using MP based controller are:-

- 1 Higher integration capacity
- 2 Consume less power
- 3 More compact occupy less space
- 4 Smooth control is possible
- 5 Uncontrollable performs
- 1 Variety of program is possible, feasible.

A microprocessor based controller uses programmable memory to store instructions and to implement functions such as logic timing counting and arithmetic control also it can be reprogrammable for different tasks.

Many type of micro-processor based general purpose dedicated system application are developed such as...

1. Home application appliances control:- Washing machine, heating system, air conditioner.
2. Actuator control systems:- Speed control of electric motor.
3. Computer, peripheral peripherals control:- monitor, printer and disk drive.
4. Traffic control systems:- Traffic light control and speed gun.
5. Automobile control system:- engine control & locking system.
6. Production line:- assembly & line packing, labelling.
7. Robotics: Automation & autonomous guided vehicle.

* Micro electronics:-

A key enabling technology in modern industry with its speed developing... and great impact on evolution its holds a prominent position as it has earned much expertise in the field of technological industry.

Sustainable mobility energy supply demographic change and industrial digitization are fields that has strengths electronics in the light of detailed knowledge of micro electronics.

of analog circuit as well as digital circuit has delivered smaller faster and the chipier devices.

Micro electronics has serve at its top in studio stereo microscope and optical light deduced metrology analysis transmitted & reflected light in metallurgical microscope, microelectronics at the past of coherent lasers enable a wide range of its application.

1. The major year for areas where laser plays chemical scale
2. Semi conductor manufacturing.
3. Micro machining.
4. Advance packaging and interconnects.
5. Flat panel displays displays.

Sensors & Detectors

Sensors:-

Sensor is the equipment which is to produce a signal and indicating through many senses like heat, vibration, the quantity being measured, the sensor is a device through which we sense the present condition, situation or state of the objects, the variable value on output which reflect a complete condition & ~~see~~ change the final results.

Sensors detect ~~from~~ an changes in quantity and provide a corresponding output generally as an electrical and optical signal for ex. a thermocouple produce temp. to an output volt. sensor one use in everyday objects such as touch sensitivity, elevator buttons and narrow lanes which thin dim as button by touching the base decided in numerical application in which most people use thermocouple response to a temp change and output a proportional change in electromotive force, there for a thermocouple can hold as a sensor on a ~~transmission~~ transducer.

Application of sensors:-

1. In the automobile anti locking system, break brake system are the ex. of sensor.
2. In acceleratory dial indicating the spindle count has a sensor.

Types of sensor:-

There are mainly eight type of sensors are use according to these working process & ability.

(i) Potentiometer:-

(ii) Proximity sensor/Prox sensor

(iii) Airflow Pneumatic Sensor

(iv) Light Sensor

(v) Tactial Sensor

(vi) Hall effect sensor

(vii) Piezoelectric sensor

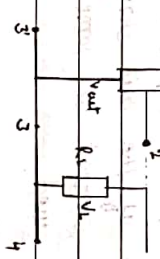
(viii) Smart sensor

(i) Potentiometer sensors:-

In this type of sensor a resistance element is attached with a sliding contact and that element is able to move in an particular range the element generally use for linear or rotary displacement. the produced displacement is being converted into a potential equipment difference.



Fig:- A Potentiometer



The circuit connected to the load

Supply $R_0(1-u)$

R_L V_L

Circuit is potentiometer to derive

where V_0, R_0, R_L
 V_0

V_0 - Output voltage bias switch 2, 3 & a junction of input voltage.

V_5 - Constant input voltage bias switch 1, 3, 5.

R_{23} - Resistance bias switch 2, 3, R_{13} - Resistance bias switch 1, 3, 5.

When the contact between the angular displacement can be converted into a potential diff. the voltage output will change with the every turn of the slider can be converted on a wire wound

(ii) Proximity sensors:-

A proximity sensor is a sensor by which the introducing element changes the straight on an analog signal when it is close to but not exactly touching a device. The main application of proximity sensors are as follows

1. It is easy to count the moving object.
2. They are mainly two sub type of sensor
i) Inductive proximity sensor

When an alternating current is supply to the coil and magnetic field is generated if the metal piece is present in close proximity with magnetic field then eddy current are produced in it similarly the impedance of the coil changes and produce the amplitude of the alternate current at some level when there is a need a switch is used

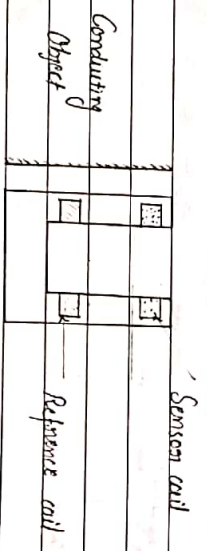


Figure:- Eddy current proximity sensors.
ii) Capacitive proximity sensor:-

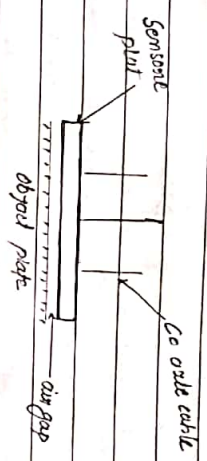
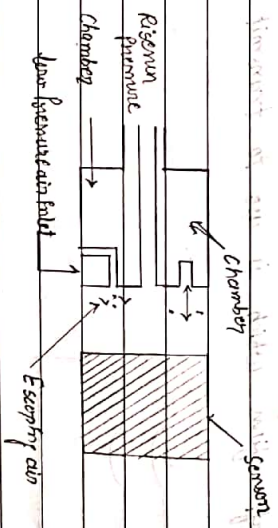


Figure:- Capacitive proximity sensor

(iii) Pneumatic sensors:-

As the name explain the meaning of sensor it include the use of compressed air displacement on the proximity of an object being transform into a change in air pressure.

Low pressure air passed through the chamber in front of the sensor plate when the absence of any due by object this is sensing air intake and it reduces the pressure closely to the sensor output coat hence in the presence of close by object the air can not easily in scope and due to this the out pressure increases in the sensor output coat.



(iv) Light sensor:-

As light sensor photo diode play in important role photodiode work as a semiconductor junction which are connected into a circuit in reverse bias then it produce very high resistance so that when light strike on the junction the diode resistance drops & the current which flows in the circuit increases rapidly

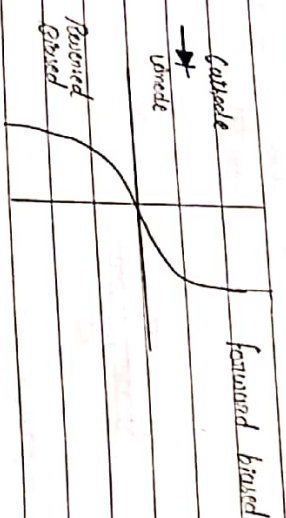


Diagram - Dielectric characteristics.

iv) Tactile sensor:-

Tactile sensor is also known as pressure sensor. poly vinylidene fluoride (PVDF) sheet is most commonly use form of tactile sensor. tactile is generally use to sense force. sense can fill the touch of human hand which come into the object on device. The sensor use for touch display screen where a physical contact has to be sensed. They use upper PVDF and lower PVDF both are separated a soft film which is use to transmit the vibration.

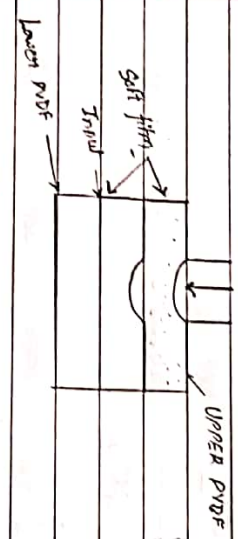
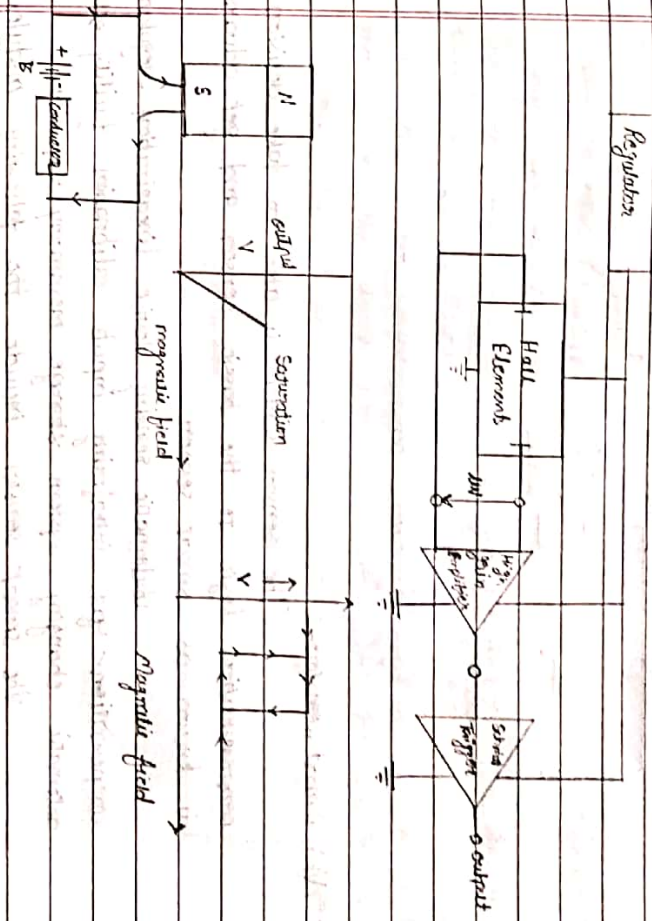


Diagram:- Tactile Sensor

Voltage is apply to the lower PVDF and due to this mechanical oscillation occur. The medium layer of film transmit the oscillation to the upper PVDF and due to this high vibration generated and due to passing the vibration effect upper PVDF film & output alternating voltage is seen changed.

v) Hall effect sensor:-

There is a magnetic field and when the charge particles being pass through it producing forces act on the particles & the beam is deflected from its straight line path. condition in which a current is following a work like a beam of moving charges and thus deflected by a magnetic field.



vi) Pyroelectric sensor:-

Pyroelectric sensor based on pyroelectric material lithium tantalate (most commonly used) the distinctive material due to heat flows which generate change when such type of material is heated to a particular temp just below the curie temp. In an electric field and the material cooled slowly in the field electric dipole with in the material line up and it becomes polarised (for fig lithium tantalate (LiTaO3)).

The piezoelectric sensor work as a charge generator which generates charge when they is fluctuation in the temp. as shown in fig. the temp changes in charge ΔQ is proportional to the change in temp. at.

$$\Delta Q = k \Delta T$$

where k = Sensitivity constant for the crystal.

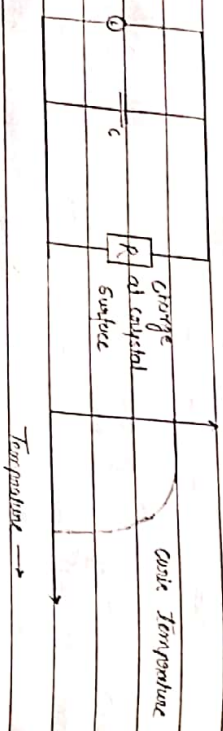


Fig:- Piezoelectric sensor

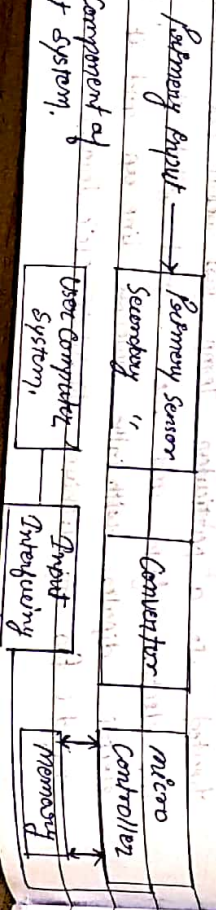
(Viii) Smart sensors:-

The sensor which is able to take decision or communication logic to the basic sensor and get advance feedback is known as smart sensor.

Automatic sensing device linearization, regularity, compensation for interfering inputs, calibration facility, self test, automatic changing system, storage memory capacity.

The smart sensors include the following modules

- Network application processors
- Manufacture independent interface.
- Smart Transducers Interface module.
- Transducers electronic data sheet.



Measurement of Acceleration:-

Acceleration means change in speed according to the time generally the sensor is use to find the acceleration of a moving object the sensor which is use to measure is known as accelerometer.

The accelerometry are divided into two categories for

- Piezoelectric Accelerometer.
- Seismic Accelerometer.

Piezoelectric Accelerometer:-

The piezoelectric accelerometer is the simplest and mostly commonly common use transducer.

- The piezoelectric accelerometer is consist of ceramic mass solid base piezoelectric element piezoelectric crystal output voltage.
- The piezoelectric crystal is placed b/w the two electrode and mass plate the force applied on piezoelectric material can be observed the change in the electrostatic force the piezoelectric element is placed b/w two electrodes.

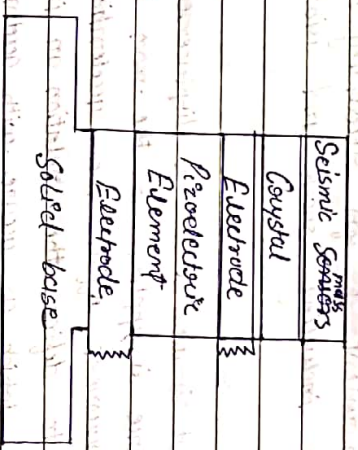


Diagram:- Piezoelectric Accelerometer.

Merits of piezoelectric are:

- Easy construction and working principle.
- Small weight as well as size of the equipment.
- High sensitivity which is very essential.
- High frequency rate (10Hz - 50Hz)
- High acceleration from a fraction of gravitation.

Demerits of piezoelectric are:

- The sensitivity degrades with time making the longevity of the device is less than that of signal crystal material.
- Limited range of frequency unsuitable for those applications where the input frequency lower than 10Hz.

Application of piezoelectric accelerometers:-

This accelerometer are used in various industries in laboratories in environmental works for product stress lower as a equipment for measurement of for recording dynamic loads in mechanical variables including shock and vibration.

Seismic Displacement:-

It is also known as displacement sensing device when the force is applied to the mass than displacement occurs and this displacement affect the acceleration. The seismic accelerometer is use to define the relation an interdependency diff^{er} major displacement which occurs with acceleration.

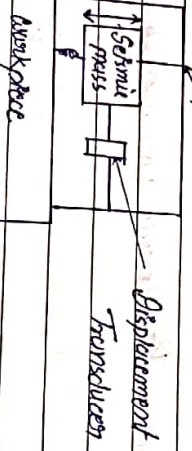


Diagram - Seismic Accelerometer

Advantages:-

- The device normally use to find the vibration range.
- Easy construction & light weight.
- Cheap in cost.

Measurement gauge:-

A gauge is placed on full upon on object & resulting from the object interaction with another object whenever there is an interaction b/w two objects there is a force on every objects.

Strain gauge load cell:-

The strain gauge load cell consist of a structure that elastically deforms when subjected to a force and a strain gauge network that produces an electrical signal proportional to this deformation.

Strain gauge is use in length of gauge wire to produce the desired resistance in the form a flat belt coil this coil is bonded b/w two thin insulating seat sheet of paper or plastic such a get gauge can't be use directly to major deformation it has to be fixed properly to a member to be strained.

This is also used a force measuring transducer which is based on electrical resistance strain gauge to monitor when it is strained bond due to some external forces due to this strain.

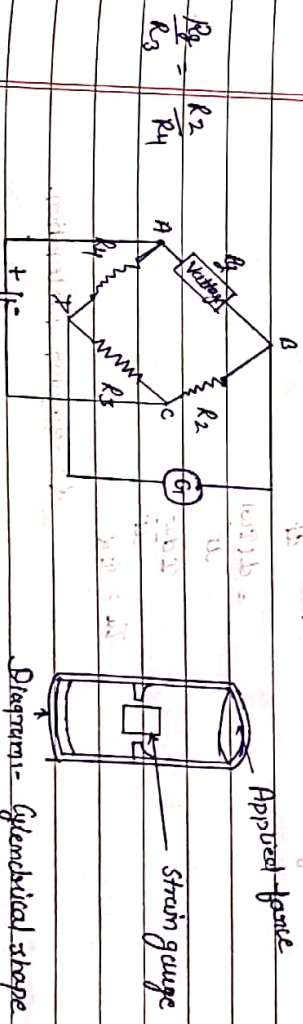


Diagram:- The Wheatstone strain gauge bridge. Diagram:- Cylindrical shape load cell.

Measurement of Torque:- Torque is the tendency of a force to rotate

a body about an axis. Rotational motion control by forces in accordance with Newton's law because a force directly affect only that component of motion in it line of action force acting in any plane that include the axis produce no tendency for rotation about that axis rotation can be resisted attend in velocity a the gradual force F_t acting at a small radial distance from the axis.



$$T = F \times r \times \sin \theta$$

Dis: force at point r produce

Diagram:- Measurement of torque Torque

The torque is found from tangential component of F_t as

$$T = F_t \times r \times \cos \theta$$

Rotation about axis

Angular momentum $L = I\omega$

I = moment of inertia $T = mrg^2$

ω = Angular Velocity

Angular torque $T_a = \frac{dL}{dt}$

$$= d(I\omega)$$

$$\frac{dL}{dt}$$

$$T_a = I \alpha$$

α = Angular acceleration

Linear sensor:-

Linear variable differential transformer:-

The linear variable differential transformer is widely used in the productive transducer this is use to convert the linear displacement into the electric signal so this is also known as the displacement type transducer this is also a passive transducer because it require the AC source for transduction of linear displacement into the electric signal.

Construction of LVDT:-

A linear variable differential transformer consist of one primary winding and two secondary winding the windings are arranged and next to each other they are wound over a hollow bobbin which is wellly of a non magnetic and insulating material

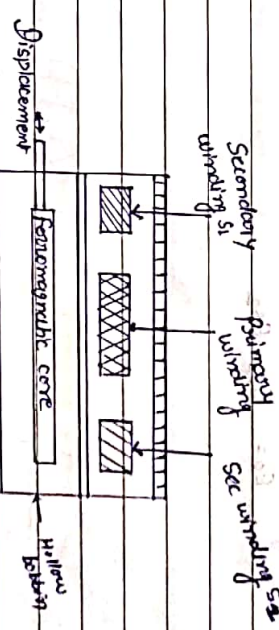
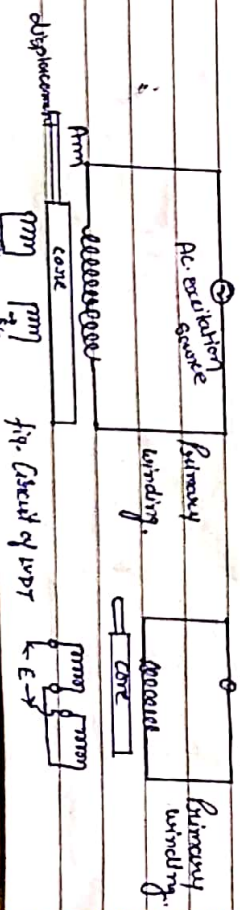


Fig:- Sectional view of the LVDT

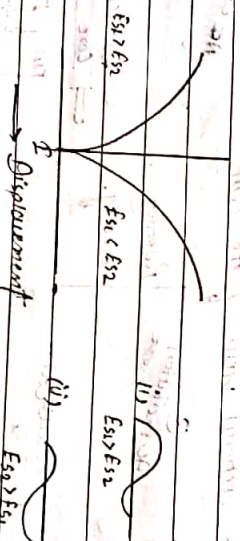
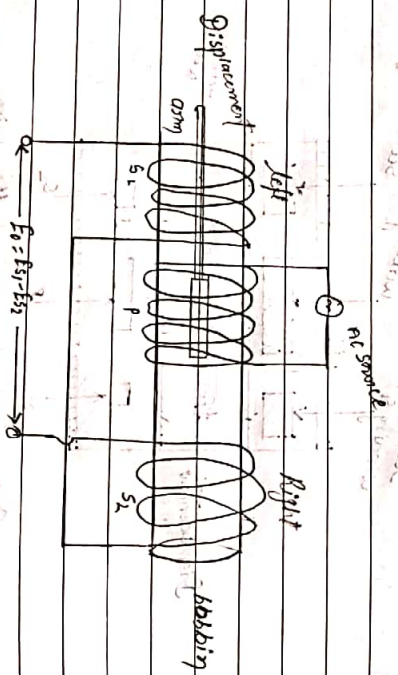


working of LVDT:-
It is work upon the principle of transformer

that is mutual induction principle. This principle states that when an current is flow through the primary winding the AC excitation source then an alternating magnetic field is generated due to which the AC voltage is induced in the secondary winding.

→ When the primary winding exciting by an alternating source then due to the principle of mutual induction alternating current voltage is induced into the two secondary winding.

Thus the output voltage of LVDT is the difference of two voltage
 $E_0 = E_{S1} - E_{S2}$
 induced in respective winding the difference output voltage.



Case 1:- when $E_{S1} = E_{S2}$

$E_0 = E_{S1} - E_{S2}$
 $E_0 = 0$

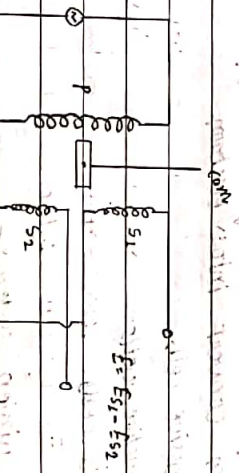
Case 2 when $E_{S1} > E_{S2}$ then $E_0 = E_{S1} - E_{S2}$ +ive
 Case 3 when $E_{S1} < E_{S2}$ then $E_0 = E_{S1} - E_{S2}$ -ive

* RVDT (Rotational variable differential transducer):-

The rotary variable differential transducer is similar to the LVDT except that it convert rotary motion an angular displacement in state instead of linear displacement into the electrical signal.

Working principle of RVDT:-

RVDT works upon the same principle of mutual induction as which has explain in working of LVDT. The working of a RVDT is similar to that of an LVDT they are also there three possibility of rotary motion.



Case 1st - $E_{S1} = E_{S2}$, $E_0 = E_{S1} - E_{S2} = 0$

Case 2nd :- $E_{S1} > E_{S2}$, $E_0 = E_{S1} - E_{S2}$ +ive

Case 3rd :- $E_{S1} < E_{S2}$, $E_0 = E_{S1} - E_{S2}$ -ive

RVDT

* Light Detection:-

A light detection is a device which is also known as a light detection instrument which is used to identify the presence of light often with the help of finding a photon with in response to light.

A light detector in such a device recognizes the presence and intensity of light and inside a process that changes the screen brightness for ease of viewing light detectors are used in various fields in research work physics optical field in chemistry and biology.

light sensor:-

A light sensor is a device which produces output signal to show the intensity of light by measuring the radiant energy that present very small frequency normally called light

light sensor are also called as photoelectric devices because they convert light energy into electricity that means photon convert into electron.

- (i) Photo emissive cells
- (ii) Photo conductive cells
- (iii) Photo voltaic cells.

Image and vision systems:-

Vision system:-

Vision system is the technology and method used provide imaging based on automatic inspection and analysis for such application as automatic inspection process and gear robot guidance in industries. the vision related to though distanced from computer vision the primary use of vision are automatic inspection. fundamental robot guidance other like

Vision are include

- 1 Engine part inspection.
- 2 Label inspection on products.
- 3 Final inspection
- 4 Robot guidance and checking orientation of component.
- 5 Food pack check.

Image sensor:-

Image sensor is a device that convert at application of optical image into an electronics signal it is mostly used in digital camera modules and other imaging devices in image sensor they are two main types of image sensor which charge coupled device (CCD) and complementary metal oxide semi conductor (CMOS)

(i) Charge coupled devices:-

The charge couple device is the most common mechanism for converting optical images to electrical signal in term the CCD is known by many people because of their use video camera and digital still camera

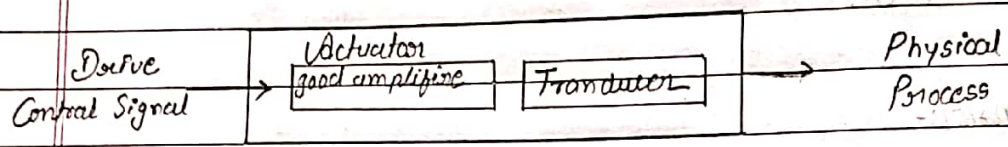
(ii) Complementary metal oxide semiconductor:-

CMOS image sensor convert light into electrons in most CMOS devices there are several transition at each pixel that amplify and move the charge using more traditional charge the CMOS approach is more flexible because each pixel can be read individually.

* Actuators:-

An actuator is a type of motor that is responsible for moving a mechanism it is operated a source of energy electrically or electric current. Hydraulic fluid pressure convert that energy to motion and actuators is the mechanism by which control system act upon an environment most mechatronic involve motion of some sort.

In other word it is a physical devices that transform electrical chemical or thermal energy into mechanical energy internally and can be broke down into two separate module the signal convert the control signal into a high power signal.



Figures:- Actuators:-

Types of actuators:-

- (i) Hydraulic actuator
- (ii) Pneumatic actuator.
- (iii) Piezoelectric actuator
- (iv) Electro mechanical actuator.

* Hydraulic Transducers:- Actuators:-

A hydraulic actuator consist of a cylinder shape fluid motor that engas uses hydraulic power to facilitate mechanical operation the mechanical motion use an output. External of linear oscillatory and oscillation motion becuz liquid is nearly incompressible a hydraulic actuator can exert considerable force.

The hydraulic cylinder consist of a hollow cylindrical tube along with a piston can slide that turn double acting is use when pressure is applied on each side of piston that term signal acting is use when the fluid pressure is applied to just fun. side of the piston the piston can move in only one direction a spring been frequently use to give the piston a return stroke.

