PROJECT REPORT

Manufacturing and Assembly of

Double Row Angular Contact Bearing

Research & Development

National Engineering Industries, Jaipur

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Chapter 1: Company Introduction

Company Profile

NEI was founded by the renowned industrialist, Shri B. M. Birla, in 1946 under the name of 'National Bearing Company Limited' and commenced manufacturing operations in 1950.

The first bearing was manufactured in 1950 with a modest start of 30000 bearings in 19 sizes. In 1958, the name of the company was changed to National Engineering Industries Limited (NEI) owing to its rapid expansion in engineering expertise, but it chose to retain its original trademark NBC. The company had a gross turnover of ₹1352 crore in 2013-14.NEI is capable of developing bearings from 10mm bore to 2000mm outer diameter, in over 1500 sizes.

NBC Bearings is the premier brand of India's leading bearings manufacturer and exporter, National Engineering Industries Ltd (NEI). NBC is a pioneer, renowned for excellence in quality and delivery for over 60 years. An integral part of the US$ 1.6Bn CK Birla Group, NBC produces over 150 million bearings each year in more than 1000 sizes to serve a host of varied customers across India and 29 other countries in 5 continents.

The industry is spread over 119acres in Jaipur and 56 in Gunsi (Newai).This is the only unit in the country manufacturing wide variety and range of bearing such as Ball Bearings, Tapered Roller Bearings, Double row Angular Contact (DRAC) bearings, Cylindrical and Spherical Roller bearings, axle boxes for railway applications; Cartridge Taper Roller bearings, Large Diameter bearings for Industrial applications and allied Engineering products. The development of National Engineering Industries Ltd., was pioneered with a theme "Indignations and Self-reliance".

NEI uses a heat treatment machine (furnace) from Chugairo, Japan. The grinding technology is sourced from Izumi of Japan, Nova of Italy, LMT of Sweden and FMT of Italy. NEI operates 22 grinding lines out of which 17 are used for Deep Groove Ball Bearing (DGBB) and five are used for Double Row Angular Contact (DRAC) Bearings. NEI has technical calibration with NTN (Japan) and Amsted Rail (Brenco, USA).

NEI has extensively embarked upon system improvement and implemented modern concept of Total Quality Management.

The company's financial growth is robust and it has set an ambitious growth path for itself with a sharp focus on exports, entry in new product segments and cultivation of people best practices.

Research and Development

NEI invests in R&D activities. The company has developed a low torque bearing that can reduce friction up to 20%, which results in fuel efficiency. The product was developed as a result of understanding the various torque contributors to the bearing such as grease, seal and internal bearing geometry. The low torque grease has been developed by various fundamentals on tribo-meter along with the design of low torque seal and optimization of internal geometry to improve fuel efficiency. The research work has been split into tribology (the lubrication science), advanced materials, advanced processes, product design, virtual simulation and testing. For simulation of actual work conditions there are 35 test rigs, which include four for railways.

Milestones

- **1946** - National Bearings Company Limited (NBC) founded in Jaipur by Late Shri B M Birla Technical collaboration with Hoffman, UK.
- **1950** - Ball Bearing production started.
- **1958** - Company is renamed National Engineering Industries Limited (NEI); NBC Trademark retained.
- **1967** - Tapered Roller Bearing Division launched.
- **1975** - Spherical Roller Bearings production begins.
- **1981** - Second Plant inaugurated in Newai.
- **1982** - Technical collaboration with Brenco, USA for Cartridge Tapered Roller Bearings.
- **1985** - Technical collaboration with NTN Corporation, Japan.
- **1995** - ISO / TPM / TOM journey begins.
- **1996** - Technical collaboration with Izumi, Japan.
- **2006** - Third Plant inaugurated in Manesar.
- **2008** - NBC receives TPM Excellence Award.
- **2010** - NBC receives Deming Award.
- **2012** - NBC receives the ACMA awards for Manufacturing and Technology Excellence.
- **2014** - Production commences at our fourth plant at Savli (near Vadodara), Gujarat.
- **2015** - Deming Grand Prize Winner.

NEI Goods and Services and Its Consumers

Rolling Stock:-

- DLW(Diesel Locomotive Work)
- CLW(Chittaranjan Locomotive Work)
- ICF(Integral Coach Factory)
- RCF(Railway Coach Factory,Chennai)
- CIMMCO
- BEML(Bharat Earth Movers Ltd.,Bangalore)
- Hindustan Motors Ltd.
- Maruti Udyog Ltd.
- Mahindra & Mahindra

Automobiles – LCV:-

- Ashok Leyland
- Force Motors
- Tata Motors
- Eicher Motors

Automobiles – Two/Three Wheelers:-

- Bajaj Auto Ltd.
- Hero Honda Motors Ltd.
- Honda Motorcycle & Scooters India Ltd.
- Suzuki Motocycle India
- Majestic Auto
- Piaggio India Ltd.
- Royal Enfield Ltd.
- Yamha Motors India Pvt. Ltd.
- TVS

Tractors:-

- Eicher
- Escorts
- Hmt
- International Tractors
- Mahindra & Mahindra
- Punjab Tractors
- TAFE
- VST Tillers

Electric Motors and Pumps:-

- Crompton Greaves
- G.E. Motors
- Kirloskar Electric
- NGEF
- MICO

Fans:-

- Bajaj Electricals
- Crompton Greaves

Chapter 2: Bearings

What are bearings?

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

Types of bearings

According to design and shape, there are many types of bearings used in industries. The main bearing can be classified as follows.

ACCORDING TO THE FRICTION

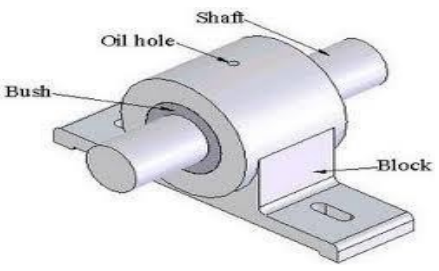
On the basis of friction, bearing can be classified as:

A. Friction Bearings

As the name implies, the bearing surface is in contact with moving surface or the shaft which produces more friction. These bearings are made of cast iron, bronze, brass, baibit and white metal having hollow round shape, lubricant is used for slow moving and heavy weighted running on shaft. It is sub-divided into following types.

A1. Solid bearings

It is a simple hole made in cast iron to support the shaft and form running fit. This is used for small and light shafts moving at low speed. A hole is provided on its face of lubrication.



A1. Solid Bearing

A2. Split Bearings

These are same like solid bearings but have an arrangement of split. Split bearings are made in halves and assembled in special plumber blocks. It has color on its external surfaces and also made in two parts as shown in figure.

A2. Split Bearing

A3. Self-aligning bush Bearings

It consist of mainly two parts. The first one is cast iron block and other is bush. These bearing bush are made up of brass or any other soft material in round shape. To protect it from moving, a screw is fixed at one end and this screw is fixed to the bush and half in block.

A3. Self-aligning bush bearing

A4. Adjustable slide Bearings

It can adjust the tightness between bearings and the shaft. This type of bearing has provision for wear adjustment. The bearing is fitted in the tapered hole of the housing for adjustment of wear. The bearing is draw inside by means of a slotted ring unit.

A4. Adjustable slide Bearings

A. Anti-Friction Bearings

The main purpose of these bearings is to minimize the friction in bearing. Due to this reason, the speed of an object increases and temperature decreases. Such bearing have long life.

These bearing also sub-divided into following categories.

B1. Ball bearings

A ball bearing is a rolling-element bearing that use balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and supports radial and axial loads. The width of these bearing is smaller than the bore diameter or ball. On the basis of load and groove cut, ball bearings are classified in the following types.

- Single row ball Bearings

These bearing have only one groove cut in outer and inner rings with the ball in identical line.

Single row ball Bearings

- Double row ball Bearings

These bearing have two groove cut in outer and inner ring lie in two rows of the bearing.

Double row ball Bearings

- Self-aligning ball Bearings

These bearings can withstand with journal loads. These loads are generally inclined due to shaft misalignment. These types of bearings have a spherical bore on the outer race.

Self-aligning ball bearing

- Angular contact ball Bearings

These bearings are designed to take an axial thrust as well as radial loads.

Angular contact ball Bearings

- Thrust ball Bearings

These bearings are useful for taking vertical thrust load but cannot take any radial load. Some special thrust bearings are available which can also take horizontal end thrust.

Thrust ball Bearings

B2. Roller bearings

Roller bearings uses cylinders (rollers) to maintain the separation between the moving parts of the bearing. The purpose of a roller bearing is to reduce rotational friction and support radial and axial loads. Compared to ball bearings, roller bearings can support heavy radial loads and limited axial loads. They can operate at moderate to high speeds (although maximum speeds are typically below the highest speeds of ball bearings). On the basis of uses, roller bearings are classified in following types.

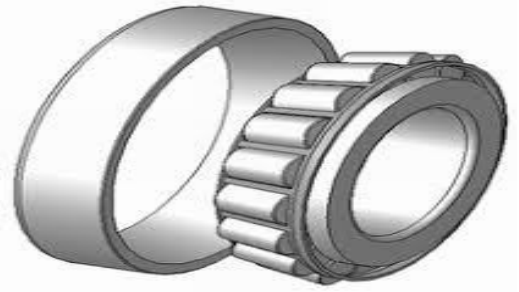
- Self-aligning roller Bearings

These bearings are self-adjustable and it is not affected by non-centering of shaft deformation flexure of shaft and bearing block, so it can compensate the concentricity error caused by these reason.

Self-aligning roller Bearings

- Tapered roller Bearings

These bearings are used to take thrust only one direction. For opposing thrust, the bearings must be mounted in opposite pair. These mainly used for high axial thrust loads.



Tapered roller Bearings

- Needle roller Bearings

These types of bearings have very small roller diameter. Rolling element is called needle roller. These are used where the outside diameter of bearing is restricted due to limited bearing space in the housing. The needles fitted in a circular cage which is push fit in its housing.

Needle roller Bearings

- Cylindrical roller Bearings

These bearings are used in such places, where more load is to be bear. Here are made of hollow cylindrical roller.

Cylindrical roller Bearings

- Barrel roller Bearings

The roller in this type of bearing has barrel shape. Its diameter up to full length is uneven. These bearings are self-alignment type bearing, so due to this reason, it has no difficulty to maintain shaft in straight line.

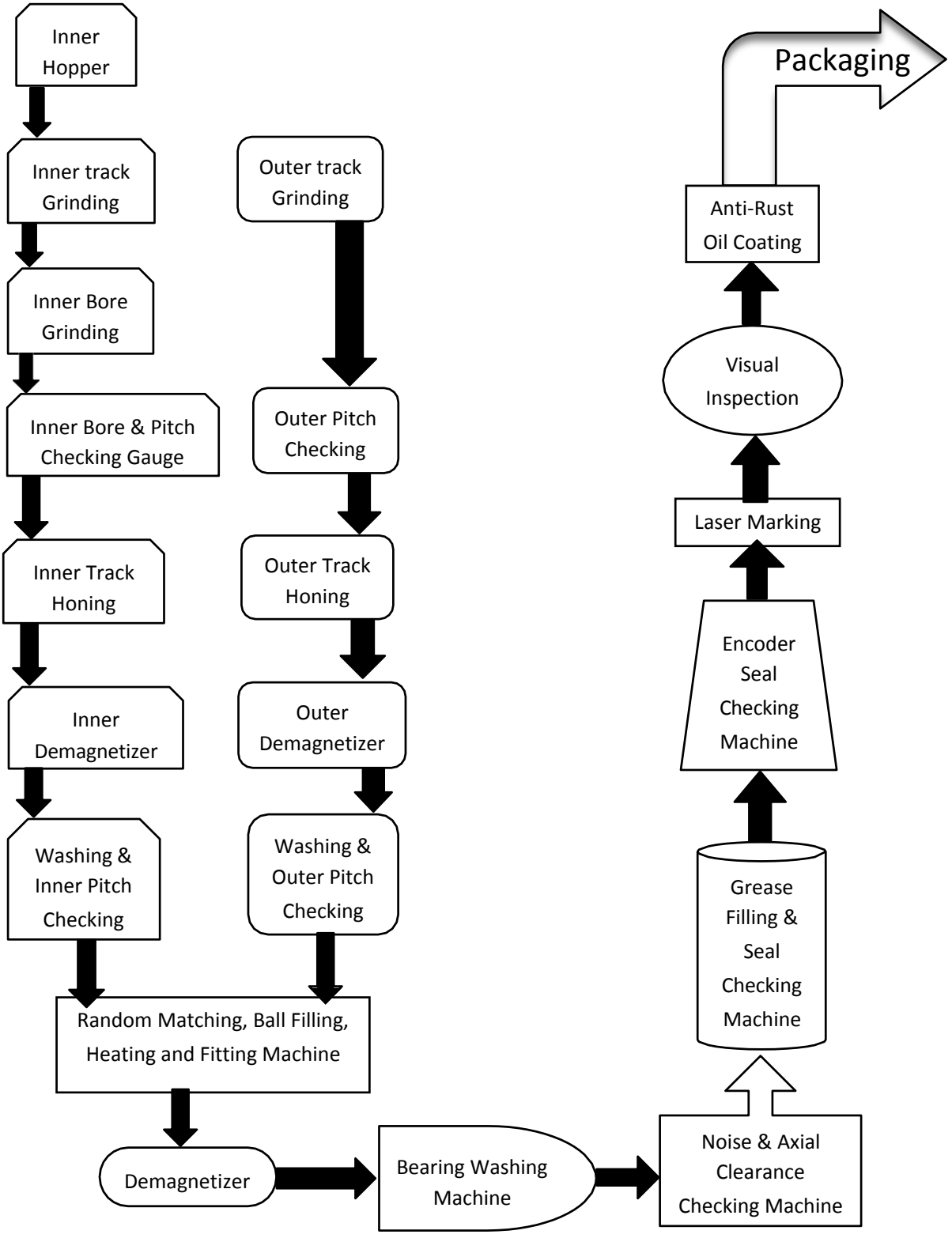
Barrel roller Bearings

- Spherical roller Bearings

These bearings are used in such places where chance of angular condition in shaft may be possible. In these bearings, rollers are fitted in ball cage in such a way that in angular condition in inner and outer race, the energy transfer can be possible in full capacity.

Spherical roller Bearings

Chapter 3: Manufacturing Process of DRAC



Flow Diagram

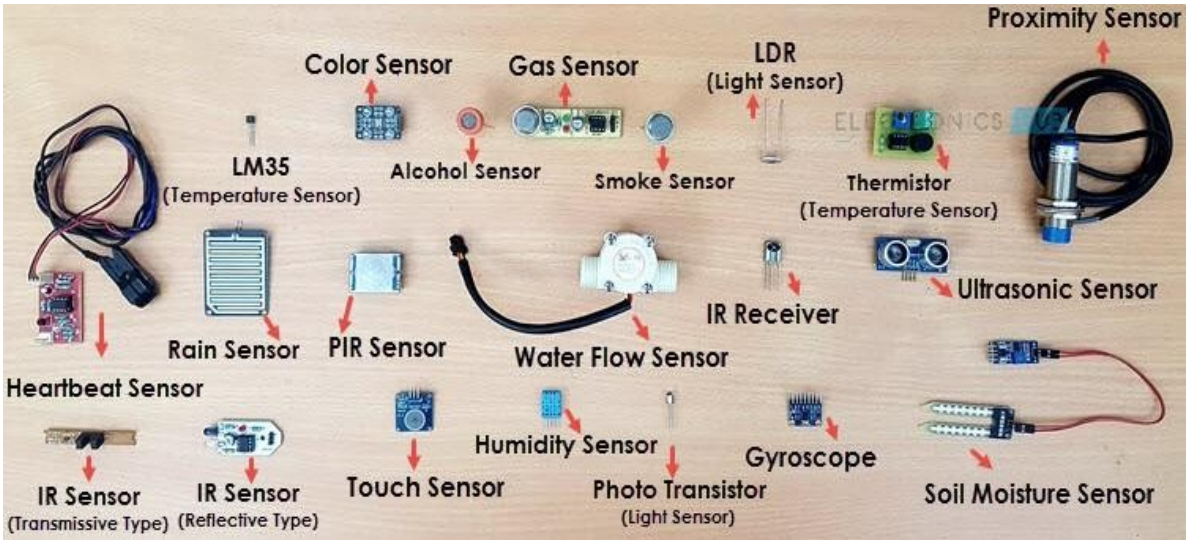
Chapter 4: Sensor and Technology

What are Sensors?

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. Sensors produces a voltage or output signal response which is proportional to the change in the quantity that they are measuring.

Example: Motion sensors in various systems including home security lights, automatic doors and bathroom fixtures typically send out some type of energy, such as microwaves, ultrasonic waves or light beams and detect when the flow of energy is interrupted by something entering its path.

Types of Sensors and their Application



Quantity Being Measured	Input device (Sensor)	Output Device (Accutator)
Light	-Light Dependent Resistor(LDR) -Photodiode -Photo-Transistor -Solar cell	-Lights & Lamps -LED's & Displays -Fiber Optics
Temperature	-Thermocouple -Thermistors -Thermostat -Resistive Temperature Detectors(RTD)	-Heater -Fan
Force/Pressure	-Strain Gauge -Pressure Switch -Load Cell	-Lifts & Jacks -Solenoid -Panel Meters
Position	-Potentiometer -Encoders -LVDT -Reflective/Slotted Opto-Switch	-Motor -Solenoid -Panel Motors
Speed	-Techo-Generator - Reflective/Slotted Opto-Coupler -Doppler Effect	-AC & DC Motors -Stepper Motor -Brake
Sound	-Carbon Microphone -Piezoelectric Crystals	-Bell -Buzzzers -Loudspeakers

1. Accelerometer & Gyroscope Sensor

Acceleration creates a force that is equally by the force-detection mechanism of the accelerometer. Acceleration crates a force that is captured by the force-detection mechanism of the accelerometer.

Working

Acceleration is related to the change in the capacitance of a moving mass. This sensing technique is known for its high accuracy, stability, low power dissipation and simple structure to build.

$$C = \frac{(\mathcal{E}_0 \, X \, \mathcal{E}r \, X \, A)}{(F\text{arad})}$$

ξ_0 = Permitted free space

ξ_r = Relative material permitted between plates

A = Area of overlap between electrodes

D = Separation between the electrodes

Differential pairn capacitance is composed of a single movable mass (one planar surface), that is placed along with a mechanical spring between two, fixed, reference silicon substrates or electrodes. The movement of mass cause a change in capacitance by which we can derive the displacement of our mass and its direction.

Accelerometers mearsue linear acceleration (specified in mv/g) along one or several axis.A gyroscope measures angular velocity (specified in mV/deg/s). if we take our accelerometer and impose a rotation to it (i.er., a roll), the distances d1 and d2 will not change. Consequently the accelerometer's output will not respond to change in angular velocity.

Applications

- In automobiles for detecting car crashes and for triggering air bags.
- In mobiles, like switching between portrait and landscape mode.
- In GPS, for tracking.

Accelerometer in laptops protect hard drives from damage. If the laptop ware to suddenly drop while in use, the accelerometer would detect the sudden free fall and immediately turn off the hard disk to avoid the reading heads into the hard drive platter.

2.Smoke, Gas and Alcohol Sensor

Electrochemical gas sensors are gas detectors that measure the concentration of a target gas by oxidizing or reducing the target gas at an electrode and measuring the resulting current.

Working

The gas diffuses into the sensor, through the back of the porous membrane to the working electrode where it is oxidized or reduced. This electrochemical reaction measuring, amplifying and performing other signal processing functions, the external circuit maintains the voltage across the sensor or between electrode the working and counter electrodes for a three electrode cell. At the counter electrode an equal and opposite reaction occurs, such that if the working electrode is an oxidation, then the counter electrode is a reduction.

Types of Gas Sensors

MQ-2	Methane, Butane, LPG, Smoke
MQ-3	Alcohol, Ethanol, Smoke
MQ-4	Methane, CNG Gas
MQ-5	Natural gas, LPG
MQ-7	Carbon Monoxide
MQ-8	Hydrogen Gas
MQ-131	Ozone
MQ-135	Air Quality
MQ-138	Benzene, Toluene, Alcohol, Propane

Applications

- Detects or measure gases like LPG, Alcohol, Propane, Hydrogen, CO and Methane.
- Air quality monitor
- Gas leak alarms

3.Color Sensor

The color sensor detects the color of the surface, usually in the RGB scale. Color sensors have a variety of applications including detection of environment, choosing the right product and sorting. The detection of color compared to the vision sensor is much faster and cheaper.

TCS3200 Color Sensor

Working

The sensor switches each primary color RGB, one by one and checks what intensity of color is reflected by the surface of detection. This reflected intensity is converted to 8 bit value. For example a RED surface will strongly reflect RED. While a yellow surface will reflect RED and GREEN both. According to the induction principle of the three primary colors which create various other colors in nature, once the value of three primary colors is confirmed, the color of the tested object is known. Knowing the value of RGB helps people gain the color of the light which is projected on to the sensor since each color correspond to only one value of RGB.

Application

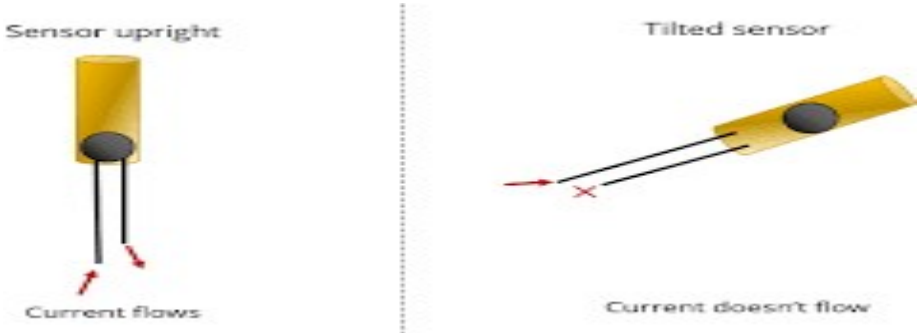
Color sensors are generally used for two specific application: true color recognition and color mark detection. Sensors used for true color recognition are required to “see” different colors or to distinguish between shades of a specific color. They can be used either a sorting or matching mode. In sorting mode, output is activated when the object to be identified is close to the set color .in matching mood, output is activated when the object to be detected identical to the color stored in memory. Color mark detection sensors do not detect the color the mark, rather, they “see” differences or changes in the mark in contrast with other marks or background. They are sometimes referred to as contrast sensors.

4.Tilt Sensors

Tilt sensors measure the tilting position with reference to gravity, and are used in numerous applications. They enable the easy detection of orientation or inclination, may also be known as tilt switches or rolling ball sensors.

The key benefits of tilt sensors include;

1. Compact and simple to use and adapt
2. High resolution and accuracy
3. very cost effective
4. Low power consumption
5. Can be read by industry standard data loggers



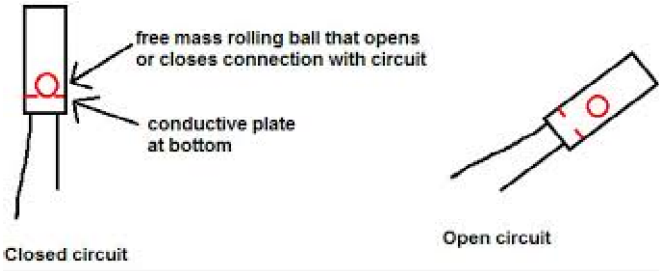
Tilt Sensors

Working

A tilt sensors has a metallic ball that is designed to move the two pins of the instrument from the 'on' to the 'off' position, and vice versa, if the sensor reaches a pre-determined angle. When the sensors gets power, the rolling ball falls to the bottom of the sensor to form an electrical connection. When the sensor is tilted, the rolling ball doesn't fall to the bottom so that the current cannot flow the two end terminals of the sensors.

Application

- The sensors provides valuable information about both the vertical and horizontal inclination of an airplane, which helps the pilot to understand how to tackle obstacles during the flight.
- To monitor the angle at which a mobile phone or tablet is held for the auto-rotate function.
- To indicate roll of boats, vehicles and aircraft.
- To measure the angle at which a satellite antenna 'looks' toward a satellite.



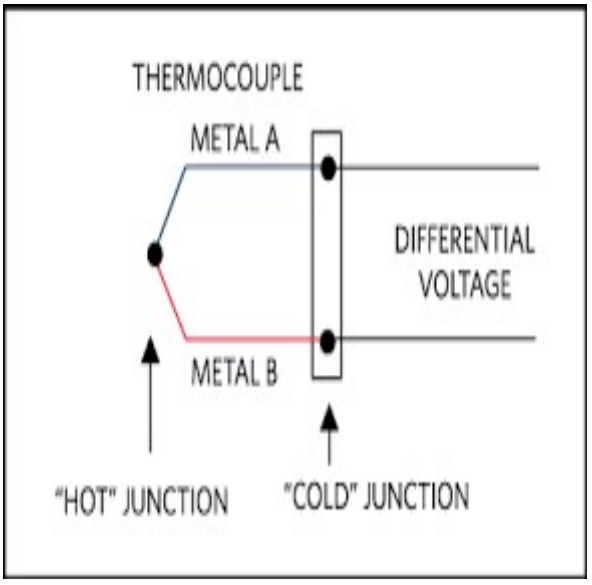
Tilt Sensor Working

5. Thermal or heat or Temperature Sensors

A device which gives temperature measurement as an electrical signal is called as temperature sensors. This electrical signal will be in the form of electrical voltage and is proportional to the temperature measurement. There are different types or sensors used for measuring temperature, such as contact type temperature sensors. These are again divided as mechanical temperature sensors like thermometer, Bimetal. Electrical temperature sensors like Thermistors, Thermocouple, Resistance thermometer and Silicon band gap temperature sensors. IC DS1621, A digital thermometer is used as a temperature sensor, thermostat, which provides 9-bit temperature readings.

An example for a temperature sensor is LM35. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature. The LM35 is operates at -55^{o} to +150^{o}C. In the features of lm35 it is given to be +10 milli volt degree centigrade. It means that with increase I output of 10 mV by the sensor Vout pin the temperature value increased by one. The different types of temperature sensors include the following

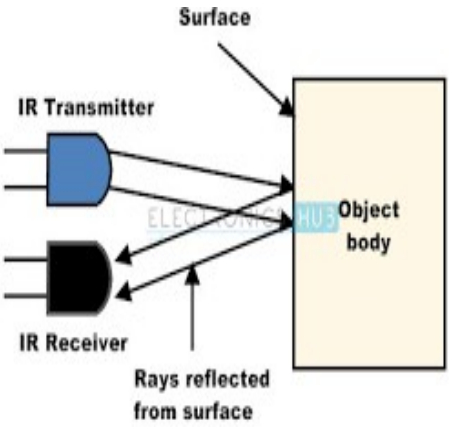
A. Thermocouple



B. Thermistors

C. Resistor Temperature Detector

D. Infrared Sensor



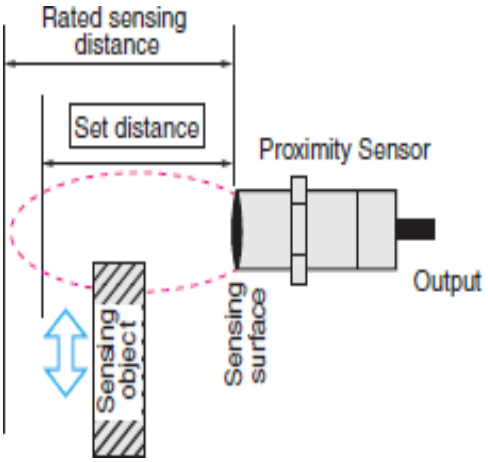
E. Thermometer

Application

- These are used in HVAC (heating Ventilation and Air Conditioning) system for controlling the temperature of shopping malls building, university building, hospital building and industrial and commercial buildings.
- These are used in mechanical engines for measuring the engine oil temperature and engine bearing temperature.

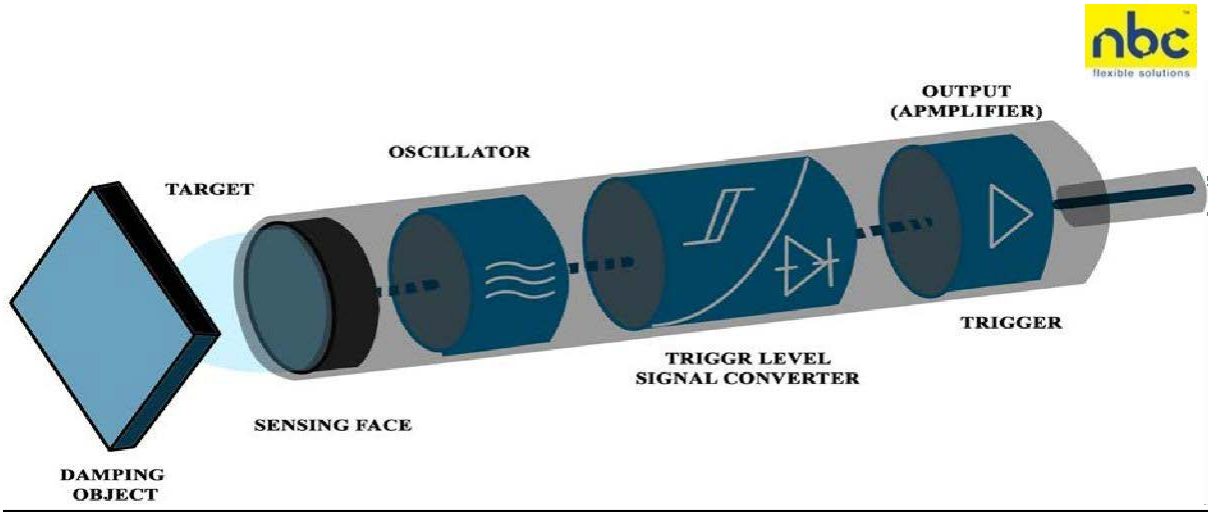
6. Proximity Sensors

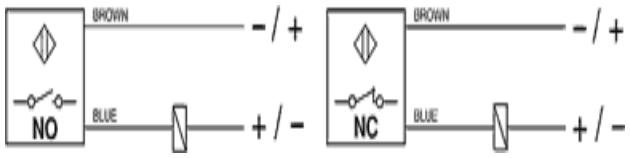
A sensor that can be used for detecting the presence of objects surrounding it without having any physical contact is termed as proximity sensor. This can be done using the electromagnetic field or electromagnetic radiation beam in which the field or return signal changes in the event of the presence of any object in its surrounding. This object sensed by the proximity sensor is termed as target.



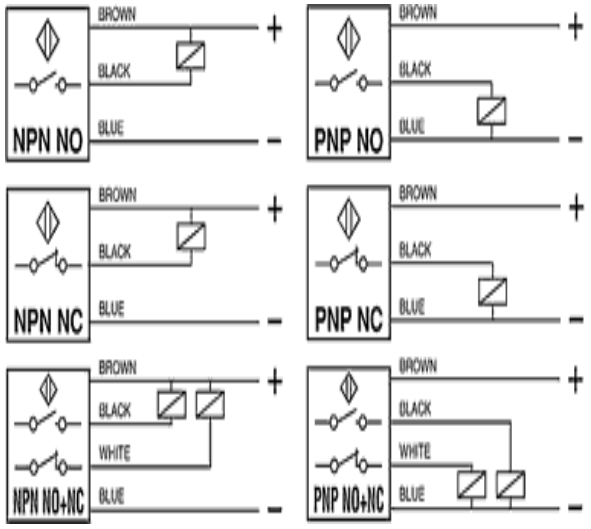
Working

The inductive proximity sensor is used for detecting the metal object and the circuit doesn't detect any objects other than metals. The proximity sensor circuit diagram represents the field produced by the coil, which is generated by providing a power supply. Whenever this field is distributed by detecting any metal object (as a metal object enters this field), then an eddy current will be generated that circulates within the target. Due to this, load will be caused on the sensor that decreases the electromagnetic field amplitude. If the metal object (called as target) is moved towards the proximity sensor, then the eddy current will be increased accordingly. Thus, the load on the oscillator will increase, which decreases the field amplitude.





2 Wire



3-4 Wire

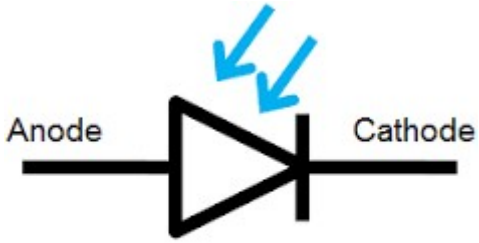
Application

A simple metal detector can be designed using proximity sensor and LC circuit.

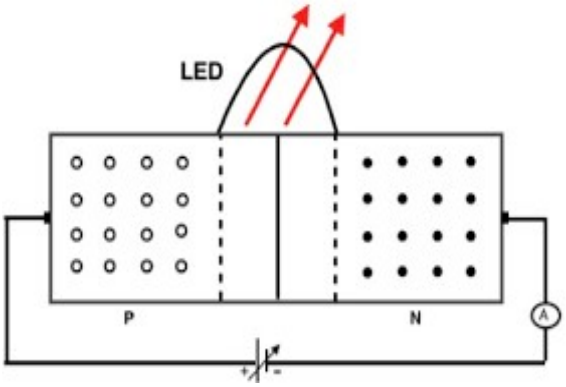
These proximity sensor circuit is frequently used in mobile phones.

7. Optical sensor or Light sensor

A light sensor is an electronic device used to detect the light. There are several types of light sensors. A photo cell or photo resistor is a small sensor which changes its resistance when the light shines on it. A CCD(Charged Coupled Device) transports electrically charged signals and can be found in digital cameras and night-vision devices. Photomultipliers detect light and multiply it.



Photodiode symbol



Types

- Photo conductive cells
- Photo junction cells
- Photo emission cells
- Photo voltaic cells

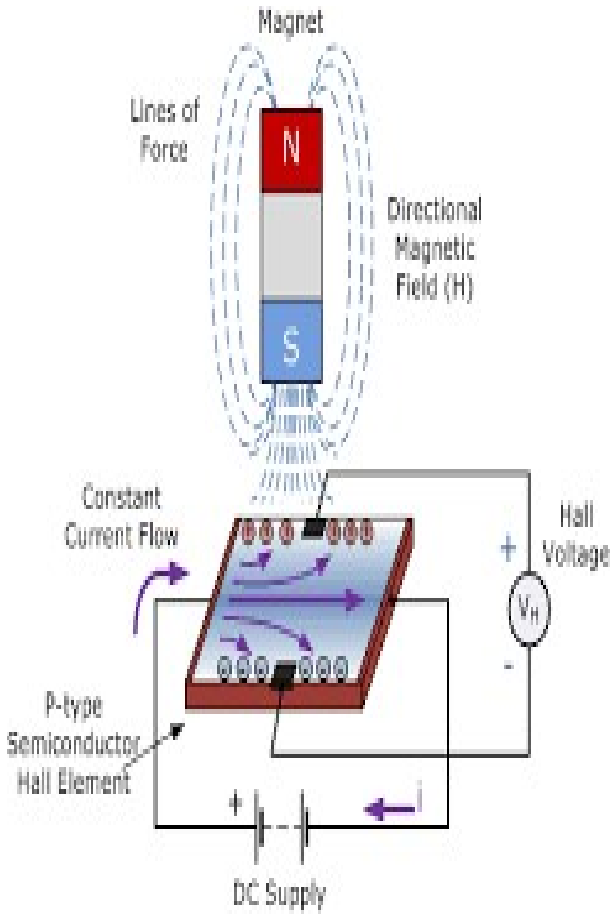
Working

The construction of the photodiode light sensor is similar to that of a conventional PN junction diode except that the diodes outer casing is either transparent or has a clear lens to focus the light onto the PN junction for increased sensitivity. When light falls upon the junction more electron/hole pairs are formed and the leakage current increases. This leakage current increases as the illumination of the junction increases. Thus the photodiode current is directly proportional to the light intensity falling onto the PN junction

Application

It is used in computers and motion detectors. Optical sensor are integral part of many common devices including computers, copy machine (Xerox) and light fixtures that turn on automatically in the dark. Some of the common application include alarm system, synchros for photographic flashes and system that can detect the presence of objects.

8. Hall Effect



Hall Effect Sensor

A hall effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall effect sensor are used for proximity switching positioning, speed detection and current sensing applications. In a hall effect, a thin strip of metal has a current applied along it. In the presence of a magnetic field, the electron in the met metal strip are deflected towards one edge, producing a voltage gradient across the short side of the strip. A hall effect sensor is combined with threshold detection so that it act as and is called a switch. Hall effect sensor are commonly used to time the speed of wheels and shafts.

Working

When a beam of charged particles passes through a magnetic field, forces act on the particles and the beam is deflected from a straight path. The flow of electron through a conductor forms a beam of charged carriers. As a consequence one plane of the conductor will become negatively charged and the opposite side will become positively charged. The voltage between these planes is called the hall voltage.

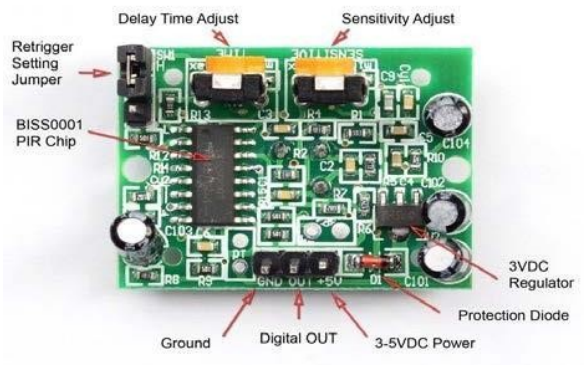
Application

Primarily there are two major application of hall viz:

- Rotary hall effect sensor - For measuring rotational motion.
- Linear hall effect sensor - For measuring linear motion.

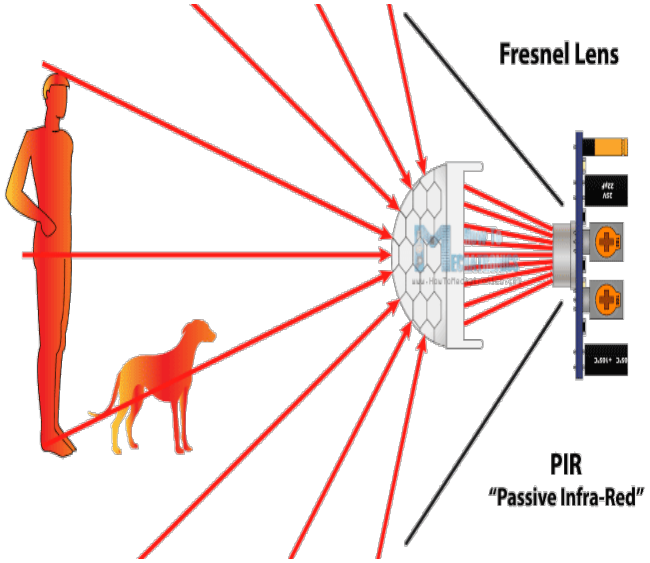
9. PIR Sensor

An electronic sensor used for measuring the infrared light radiation to emit from object units field of view is called as a PIR sensor or piezoelectric sensor. Every object that has a temperature above absolute zero emit heat energy in the form of radiation radiating at infrared wavelength which is invisible to human eye, but can be detected by special purpose electronic devices as PIR motion detection.



Working

An IR sensor consist of an IR LED and IR photo diode, together they are called bas photo-coupler or opto-coupler. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the receiver, the output of the sensor is defined.



Application

Automatic Door opening system is a typical applications of PIR sensors. Which is intended for automatic door closing and opening operation based on body movement near the door.

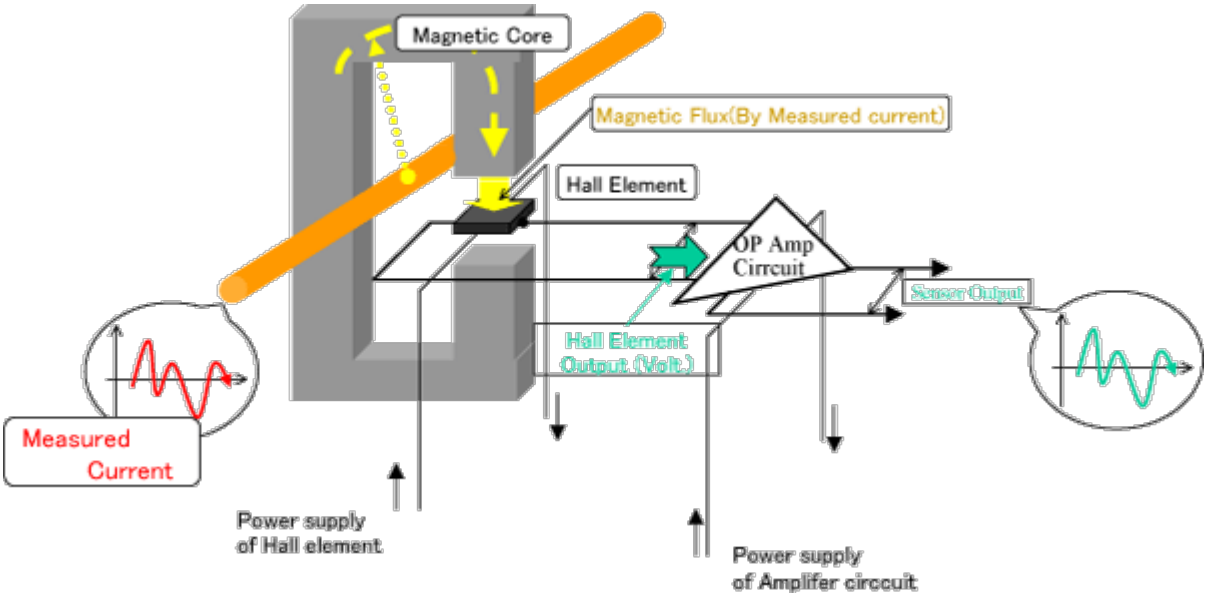
- Radiation Thermometer
- Human Body Detection
- Moisture Analyser
- Remote Sensing
- Flame Monitor
- Gas Analyser

10. Current Sensor

A current sensor is a device that detect electric current in a wire and generates a signal proportional to that current. The generated signal could be analog voltage current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, or can be stored before further analysis in a data acquisition system or can be used for the purpose of control.

Working

Current sensor is a device which detects and converts current to get an output voltage, which is directly proportional to the current in the designed path. When current is passing through the circuit, a voltage drops across the path where the current is flowing. Also a magnetic field is generated near the current carrying conductor. These above phenomena are used in the current sensor design technique. In an open loop current sensor the magnetic flux is createdby the primary current (If) is concentrated in a magnetic circuit and measured using a hall device. The output from the hall device is then signal conditioned to provide an exact (instantaneous) representation of the primary current.

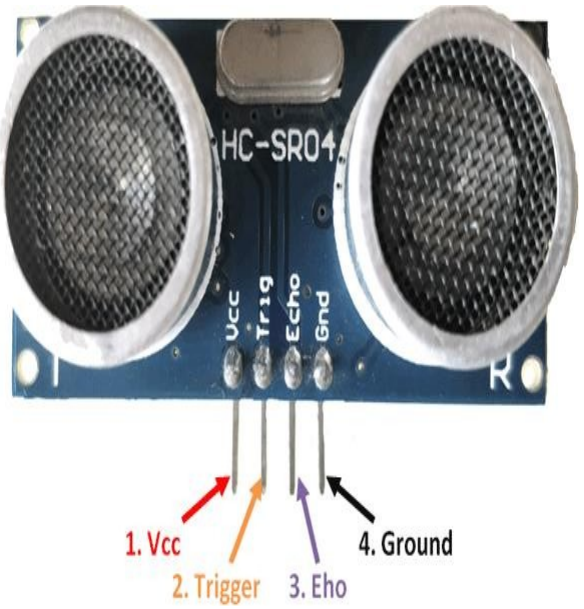


Application

- Current control band detection of over current in various types of inverters.
- Used for general-purpose inverter, various types of power conversion equipment to control and to detect over current.
- It is also used to measure DC current from the battery.

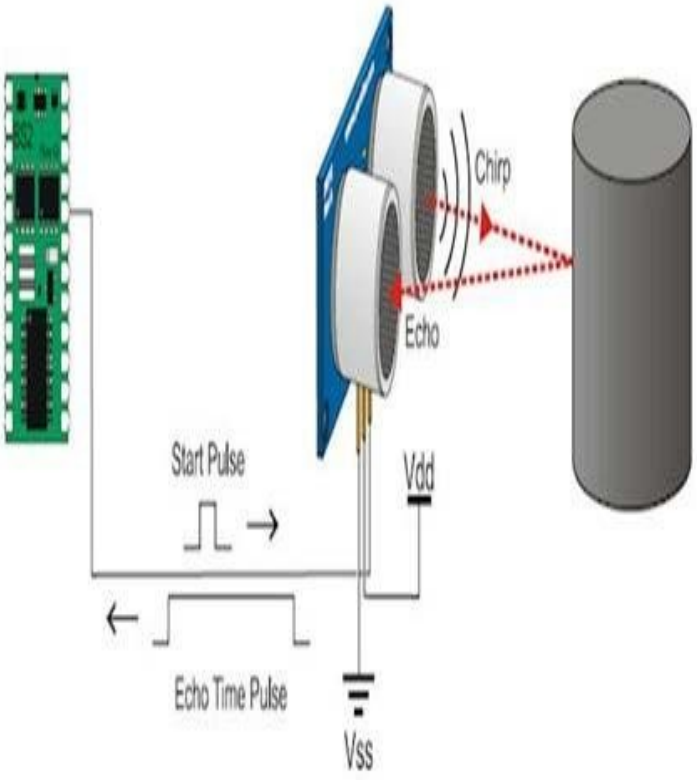
11. Ultrasonic Sensor

The principle of ultrasonic sensor is similar to sonar or radar in which interpretation of echo's form radio or sound waves to evaluate the attributes of a target by generating the high frequency sound waves (around 40 KHz). The transducer used for converting energy into ultrasound or sound waves with ranges above human hearing range is called ultrasonic transducer.



Working

When an electrical pulse of high voltage is applied to the ultrasonic transducer it vibrates across a specific spectrum of frequencies and generates a burst of sound waves. Whenever any obstacles comes ahead of the ultrasonic sensor the sound waves will reflect back in the form of echo and generates an electric pulse. It calculates the time taken between sending. The sound waves and receiving the echo. The echo pattern will be compared with the pattern of sound waves to determine detected signals condition.

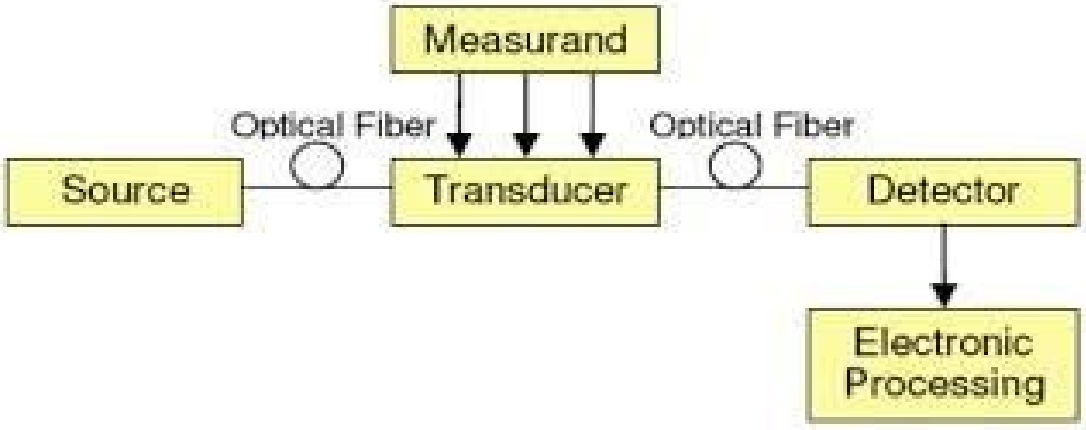


Application

- Ultrasonic sensor are used for distance measuring application.
- It can also use for water level detection.
- Ultrasonic sensors are used to detect the presence of targets and to measure the distance to targets in many robotized processing plants and process plants.

12. Fiber Optics Sensor

A fiber optic sensor is a sensor that uses ("intrinsic sensor"), or as a means of relaying signals from a remote sensor to the electronics that process the signal. The general structure consist of an optical source (laser, LED, laser diode, etc.), Optical fiber, sensing or modulator element, an optical detector and processing electronics.



Based on the application, a fiber optic sensor can be classified as follows:

Physical sensor: Used to measure physical properties like temperature, stress etc.

Chemical sensor: Used for pH measurement, gas analysis, spectroscopicstudies etc.

Bio-medical sensor: Used in bio-medical application like measurement of blood flow, glucose content etc.

Fiber optic sensor type

- Intensity based
- Wavelength modulated
- Phase modulated
- Polarization modulated

Working

There are three principle of operation of fiber optic sensors. These three major types are:

- The intensity modulated sensor
- The phase modulated sensor
- The wavelength modulated sensor

Intensity modulated sensors are based on the principle of letting a physical disturbance such as temperature cause a change in the received light through am optical fiber. Phase modulated sensors is based on the principle of comparing the phase of light in the sensing fiber with a reference fiber in an interferometer. Wavelength modulated sensors are based on the principle that a physical disturbance such as temperature or strain changes the reflected wavelength of the light.

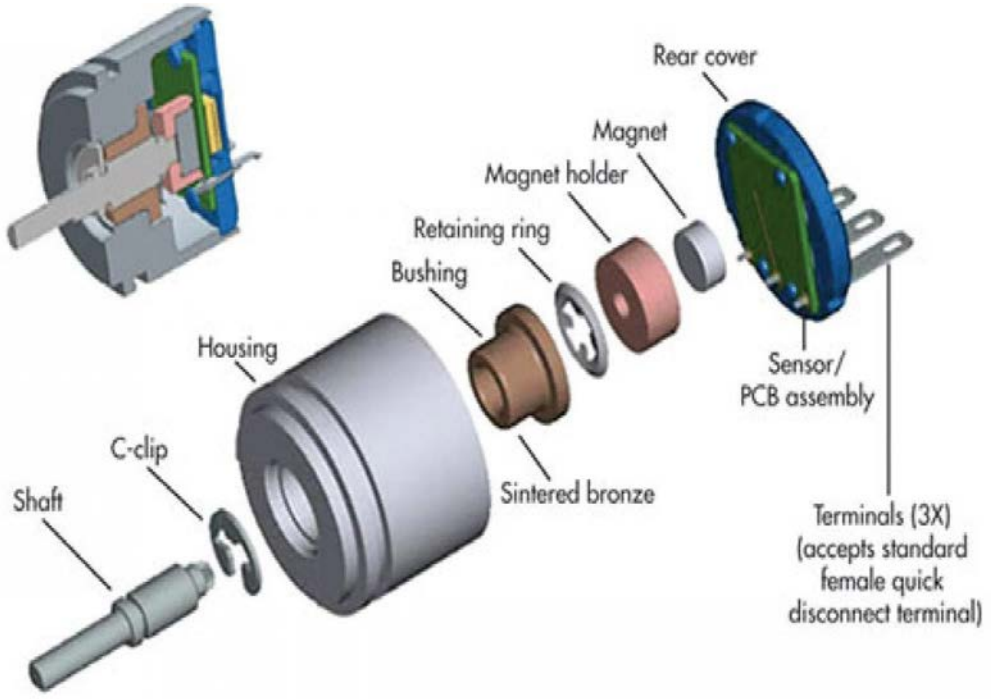
Application

- Monitoring the physical health of structures in real time.
- Measurement of physical properties such as strain, displacement, temperature, pressure, velocity and acceleration in structures of any shape or size.

Chapter 5: Rotary Magnetic Encoder

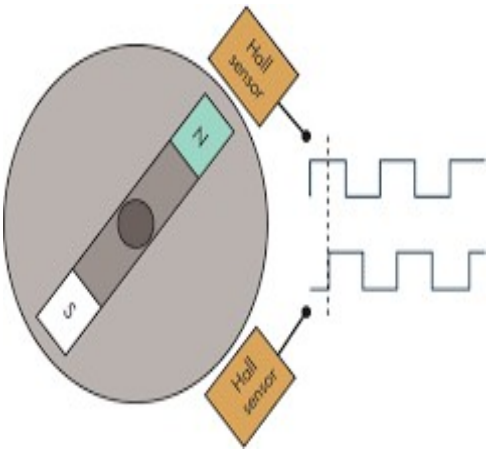
Magnetic sensing technology is best for operations in very high temperatures and environments with extreme shock and vibration. Magnetic encoders tend to have fewer resolution options and lower precision than their optical counterparts and can be more susceptible to environmental magnetic interference. Ideal applications for magnetic encoders include wind energy, tree harvesting, traction motors for rail equipment and pavement profiling.

Encoders, whether rotary or linear, absolute or incremental, typically use one of two measuring principles—optical or magnetic. While optical encoders were, in the past, the primary choice for high resolution applications, improvements in magnetic encoder technology now allow them to achieve resolutions down to one micron, competing with optical technology in many applications. Magnetic technology is also, in many ways, more robust than optical technology, making magnetic encoders a popular choice in industrial environments.



Magnetic rotary encoders

Magnetic rotary encoders rely on three main components: a disk, sensors, and a conditioning circuit. The disk is magnetized, with a number of poles around its circumference. Sensors detect the change in magnetic field as the disk rotates and convert this information to a sine wave. The sensors can be Hall effect devices, which sense a change in voltage, or magnetoresistive devices, which sense a change in magnetic field. The conditioning circuit multiples, divides, or interpolates the signal to produce the desired output. The resolution of a magnetic rotary encoder is determined by the number of magnetic poles around the disk and by the number of sensors. Incremental encoders (whether magnetic or optical) use quadrature output and can employ X1, X2, or X4 encoding to further increase resolution. The primary difference between incremental and absolute encoders, regardless of sensing technology, is that absolute versions assign a unique binary code, or word, to each measuring position. This allows them to track the encoder's exact position, even if power is discontinued.



Chapter 6: Programmable Logic Controller

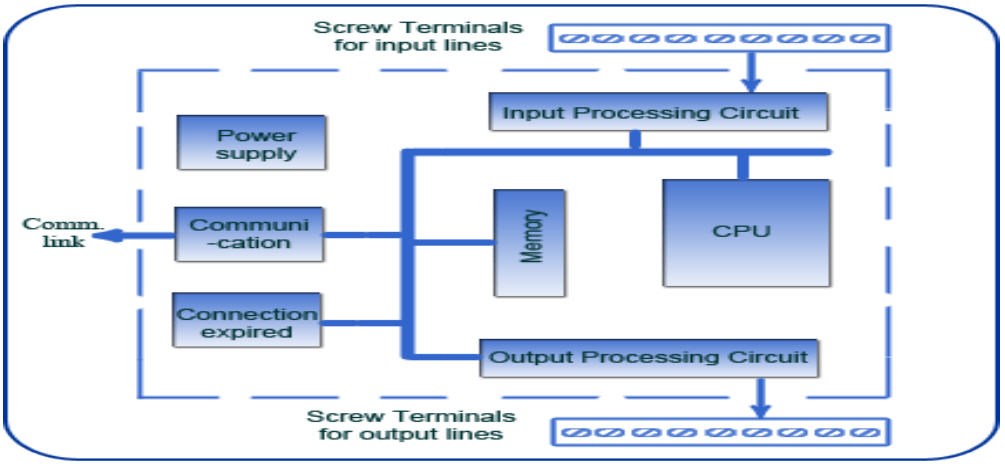
Initially industries used relays to control the manufacturing processes. The relay control panels had to be regularly replaced, consumed lot of power and it was difficult to figure out the problems associated with it. To sort these issues, Programmable logic controller (PLC) was introduced.

PLC is a digital computer used for the automation of various electro-mechanical processes in industries. These controllers are specially designed to survive in harsh situations and shielded from heat, cold, dust, and moisture etc. PLC consists of a microprocessor which is programmed using the computer language.

The program is written on a computer and is downloaded to the PLC via cable. These loaded programs are stored in non – volatile memory of the PLC. During the transition of relay control panels to PLC, the hard wired relay logic was exchanged for the program fed by the user. A visual programming language known as the Ladder Logic was created to program the PLC.

PLC Hardware

The hardware components of a PLC system are CPU, Memory, Input/Output, Power supply unit, and programming device. Below is a diagram of the system overview of PLC.



Working & Application

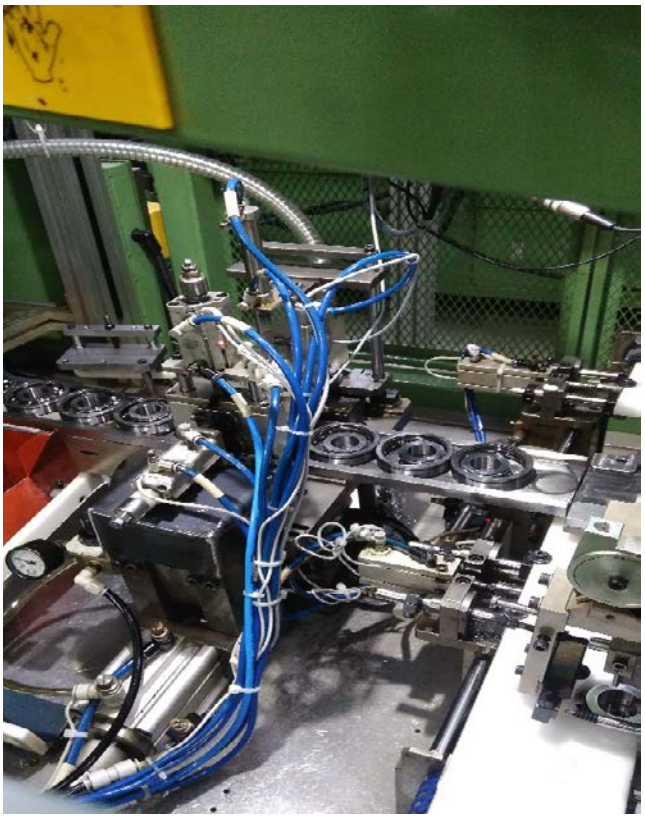
The Programmable logic controller functions in four steps:

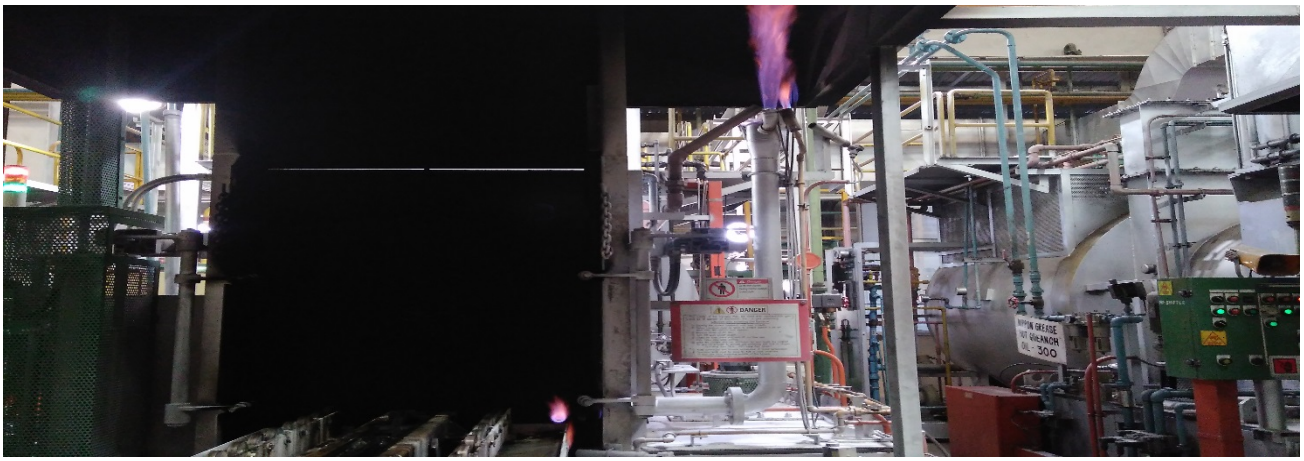
- Input scan: The state of the input is scanned which is connected externally. The inputs include switches, pushbuttons, and proximity sensors, limit switches, pressure switches. Ideally, they are transformers and not relays.
- Program scan: The loaded program is executed to carry out the function appropriately.
- Output scan: The input sources have a control over the output ports to energize or de-energize them. The outputs include solenoids, valves, motors, actuator, and pumps. Depending on the model of PLC, these relays can be transistors, triacs or relays.
- Housekeeping

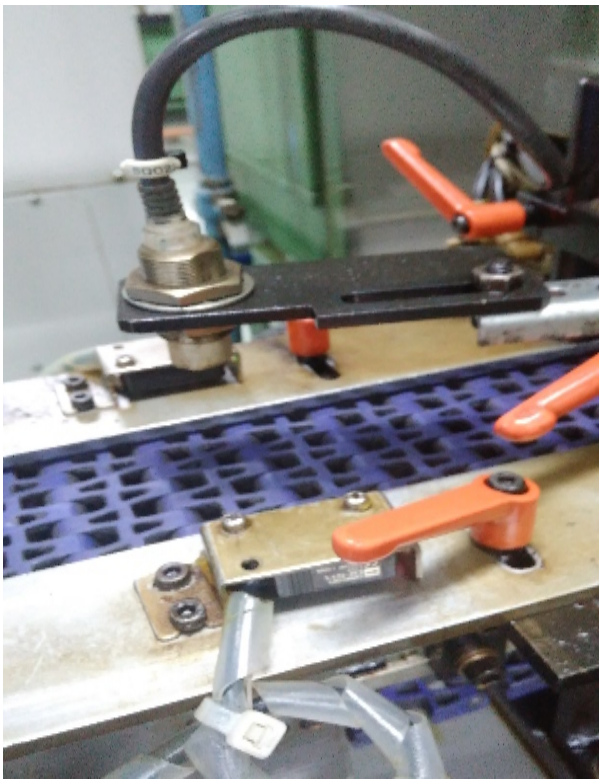
The simple suitable application is a conveyor system. The requirements of the conveyor systems are as follows:

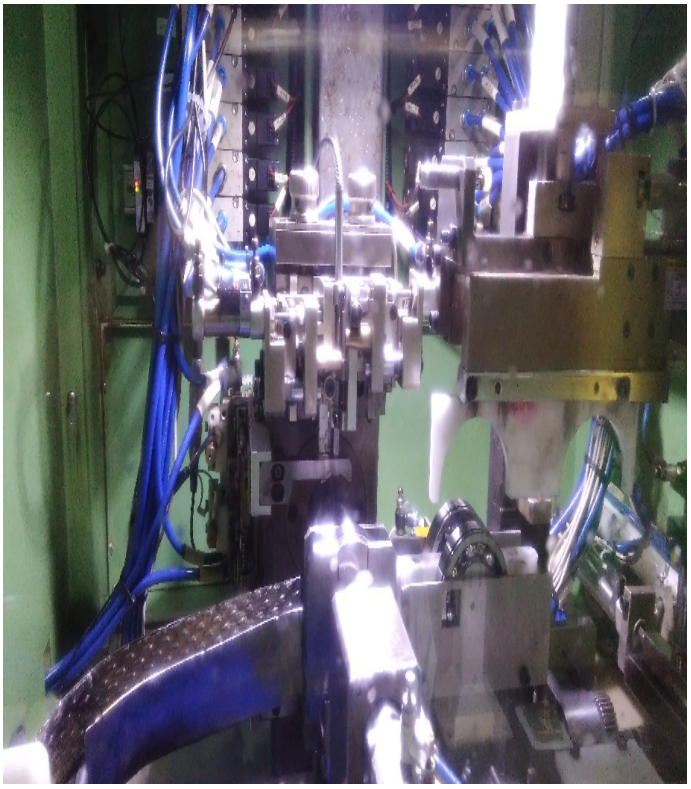
- A programmable logic controller is used to start and stop the motors of the conveyor belt.
- The conveyor system has three segmented conveyor belts. Each segment is run by a motor.
- To detect the position of a plate, a proximity switch is positioned at the segment's end.
- The first conveyor segment is turned ON always.
- The proximity switch in the first segment detects the plate to turn ON the second conveyor segment.
- The third conveyor segment is turned ON when the proximity switch detects the plate at the second conveyor.
- As the plate comes out of the detection range, the second conveyor is stopped after 20 secs.
- When the proximity switch fails to detect the plate, the third conveyor is stopped after 20 secs.

Gallery









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