Automation and Robotics (20EC53I)
Week 3 Day 2: Morning Session

3.2.1. Types of Sensors Used in Industrial Automation

Introduction:

A Sensor is a device that identifies the progressions in electrical or physical or other quantities and in a way to deliver a yield as an affirmation of progress in the quantity. In simple terms, Industrial Automation Sensors are input devices which provide an output (signal) with respect to a specific physical quantity (input).

Sensors used in Automation:

In the industrial automation, sensors play a vital part to make the products intellectual and exceptionally automatic. These permit one to detect, analyze, measure and process a variety of transformations like alteration in position, length, height, exterior and dislocation that occurs in the Industrial manufacture sites.

These sensors also play a pivotal role in predicting and preventing numerous potential proceedings, thus, catering to the requirements of many sensing applications.

The following are the various types of sensors used in automation:

- Temperature Sensors
- Pressure sensors
- MEMS Sensors
- Torque Sensors
- Positioning and Displacement
- Linear Position Sensor
- Angular Position Sensor
- Potentiometric position sensors
- Capacitive displacement sensors
- Linear variable differential transformer (LVDT)

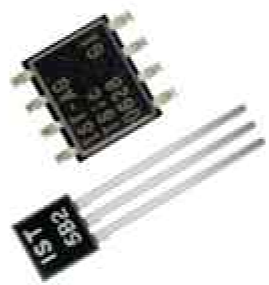
Temperature Sensors:

A **temperature sensor** is a device that collects information concerning the temperature from a resource and changes it to a form that can be understood by another device. These are commonly used category of sensors which detect Temperature or Heat and it also measures the temperature of a medium.

Digital Temperature Sensors and Humidity & Temperature Sensors are few of the main temperature sensors used in automation.

Digital Temperature Sensors:

These **Digital Temperature Sensors** are silicon-based temperature- sensing ICs that provide accurate output through digital representations of the temperatures they are measuring. This simplifies the control system's design, compared to approaches that involve external signal conditioning and an analog-to digital converter (ADC).



Humidity & Temperature Sensors:

The **Temperature & Humidity sensors** attribute a temperature & humidity sensor complex with a measured digital signal output. By utilizing the technique and temperature & limited digital-signal-acquisition humidity sensing technology, it ensures high consistency and exceptional long-standing stability.

Applications of Temperature Sensors:

- They are weatherproof & designed for continuous temperature measurement in air, soil, or water
- Exceptional accuracy and stability
- For measurements in complex industrial applications
- For measurements under rough operating conditions
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Pressure Sensors:

The **Pressure Sensor** is an Instrument that apprehends pressure and changes it into an electric signal where the quantity depends upon the pressure applied.

Turned parts for Pressure Sensors and Vaccum Sensors are few of the major pressure sensors used in Industrial automation.

Turned parts for Pressure Sensors

These **Pressure sensors** are widely used in Industrial and hydraulic systems, these are high pressure industrial automation sensors also used in climate control systems.

Vaccum Sensors

Vaccum Sensors are used when the Vaccum pressure is below atmospheric pressure levels and it can be difficult to sense through mechanical methods. These sensors generally depend on a heated wire with electrical resistance correlating to temperature. When vaccum pressure increases, convection falls down and wire temperature up rises. Electrical resistance increases proportionally and is calibrated adjacent to pressure in order to give an effective measurement of the vaccum.

Applications of Pressure Sensors:

- Used to measure pressure below than the atmospheric pressure at a given location

- Used in weather instrumentation, aircrafts, vehicles, and any other machinery that has pressure functionality implemented
- Pressure sensors can be used in systems to measure other variables such as fluid/gas flow, speed, water level, and altitude

MEMS Sensors (Micro-electro-mechanical Systems)

These **MEMS industrial automation sensors** convert measured mechanical signals into electrical signals.

Acceleration and Motion MEMS are few important sensors used in industrial automation.

Acceleration sensors

Micro-electro-mechanical Systems (MEMS) **Acceleration Sensors** are one of the main inertial sensors; and are dynamic sensor competent of have a greater range of sensing capabilities.

Motion sensors

Micro-electro-mechanical system (MEMS) **motion sensors** use data processing algorithms designed on a motion interaction platform which integrates numerous low-cost MEMS motion sensors with ZigBee wireless technology to carry personified interactions while working together with machines. Sensor signal processing systems mainly solve noise cancellation; signal smoothing, gravity influence partition, coordinate system alteration, and position information recovery .Widely used in the automotive Industry in ABS technology.

Applications of MEMS Sensors:

- These have numerous applications ranging from industry, entertainment, sports to education. For example, triggering airbag deployments or monitoring of nuclear reactors
- Used to measure static acceleration (gravity), tilt of an object, dynamic acceleration in an aircraft, shock to an object in a car, vibration of an object. Cell phones, washing machines or computers.
- Used to detect motion.

Torque sensors

The **torque sensors** complete with essential mechanical stops, raise overload capacity and offer additional guard during mounting and operation.

Rotating Torque & Torque Transducers are few important sensors used in industrial automation.

Rotating Torque Sensors

This **Rotating Torque** industrial automation sensors used for measuring reaction of rotating torque. These torque meters complete with essential mechanical stops increase surplus capacity and offer extra safety during mounting and operation.

Torque Transducers

These **torque transducers** utilize superior strain gage technology to indulge the most challenging necessities for static and dynamic applications of sensors.

Applications of Torque Sensors:

- Used to Measure the speed of rotation and maintenance necessities
- Used to measure Mass and mass moment of inertia
- The amount of the torque to be calculated, from the point of vision of quasi-static process
- Used to measure the highest speed of rotation, oscillating torque

Positioning and Displacement

Certain sensors helps in determining the physical position of a device in the world's frame of reference. That is, it measures the distance traveled by a device starting from its reference position. Based on the motion of a device, the position sensors used in them are categorized as Linear Position Sensor or Angular Position Sensor.

Linear Position Sensor: This plays an important role in the automation control, where accurate (precision) positioning is required. It measures the linear position of a device. A very good example of this type of sensor is the Linear variable differential transformer (also known as LVDT). It is a type of transformer that is used to sense and measure linear displacement.

Angular Position Sensor: This sensor often referred to as a rotary sensor calculates the orientation of an object with respect to a specific reference position as has been expressed by the amount of rotation necessary to change from one rotation to the other about a specific axis. It measures the relation established by any position with respect to any other position. These are used, where long term reliability is required.

Whereas based on the sensing principles used, the position sensors can be classified into different categories.

Potentiometric position sensors: These use resistive effect as the sensing principle. It is wear-free as these do not have any contacting parts. In these types of sensors, the position marker is attached to the moving part of the application, whose position needs to be measured. The sensing element is a resistive or a conductive track, where a wiper (for example) is attached to the part of the device, whose displacement has to be measured. The wiper remains in contact with the track. As the device moves, the wiper also moves and the resistance between one end point of the track and the wiper changes. This makes resistance a function of the wiper position. In this, the change in resistance per unit change in wiper position is linear. The ease to use these sensors makes them advantageous.

Applications

The applications for position sensors as a whole are broad. They can be used in anything from motion control of a robot, tank-level sensing or even in semiconductor process equipment.

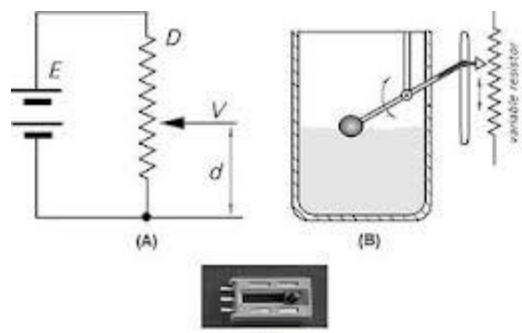


Fig. 1. (A) Potentiometer as a position sensor; (B) gravitational fluid level sensor with a float; (C) linear potentiometer.

Capacitive displacement sensors: These are based on the principle of ideal plate type capacitors, where the moving object is attached to the dielectric or to the plates of the capacitor to generate the changes in the capacitance. These are the devices that are capable of high resolution measurement of the position or the change of position of any conductive target. These can also measure the density or the thickness of non-conductive material. These types of sensors are found in manufacturing and machining facilities all around the world.

Application

It is used in the precision positioning of objects at the nanometer level and in the measurement of precision thickness of disk drives, assembly line testing and machine tool metrology. It is widely used in machining.

Linear variable differential transformer (LVDT): Popularly known as differential transformer is an electromagnetic device that produces an electrical voltage, which is proportional to the displacement of a movable magnetic core. It is used to measure the linear displacement of the device. These are robust and frictionless. It operates on the principle of electromagnetic coupling and thus, can measure even the infinitesimally small changes in the core. The electromagnetic coupling refers to the transfer of modulated data from one part of the system to the other due to the electric and the magnetic field between them. It is frictionless and can work under high shock and vibration levels.

All these above mentioned sensors are increasingly utilized in the automation industry. The recent surge in commercial demonstration of these sensor systems highlights their unique capabilities.

3.2.2. Practice Session

Aim: **-** Build/ simulate circuit on temperature sensor (resistive type)

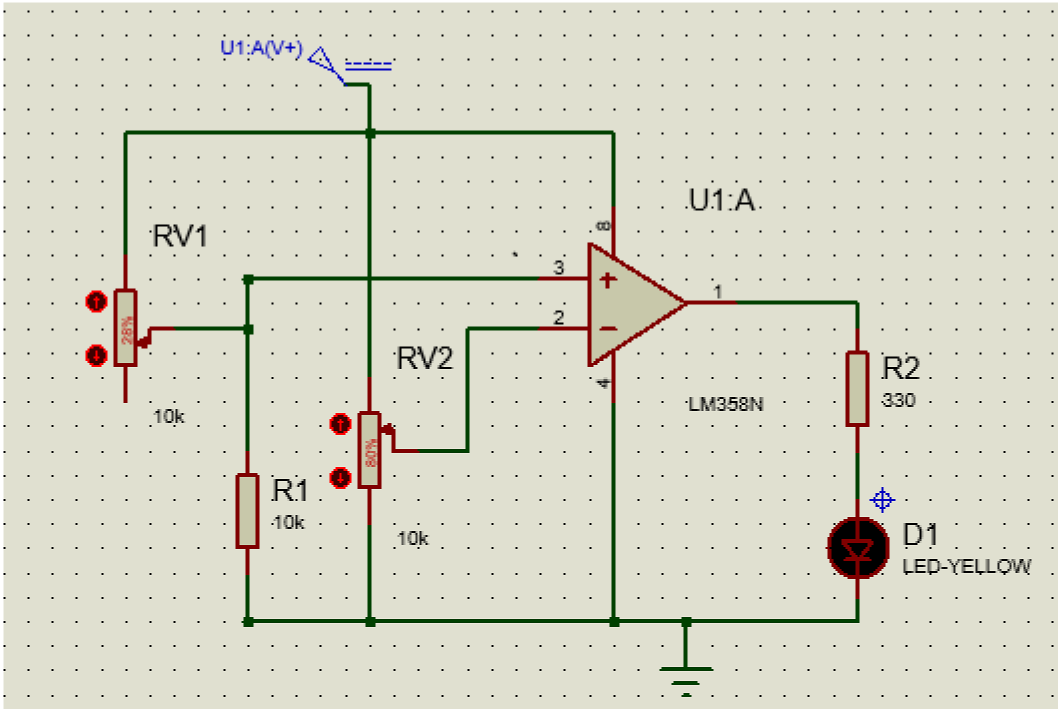
and verify it's working.

Components required: -

- IC**:** LM358
- Thermistor NTC 10K Ohms
- Resistors 330 Ohms ,10K ohm,10K POT

- LED

Circuit diagram: -



Working: -

Case1: When thermistor is heated, the resistance of the thermistor decreases and current flows through the Thermistor. Now the Voltage develops across 10Kohm resistor i.e R1 and this voltage is fed to the pin No.3 of the comparator. With the help of Variable resistor a reference voltage is fed to the pin No.2(Whose Voltage must be less than the Pin No.3).Now the Comparator o/p becomes high and Led turns ON with the help of current limiting resistor.

Case2: When the thermistor is not heated, the resistance of Thermistor becomes high. less current flows through the Thermistor and there will be less voltage drop across 10Kohm resistor. Now the Voltage at Pin No.3 is less than the pin No.2 Now the Comparator o/p becomes is Zero and the LED turns off.

Procedure: -

- Construct the circuit as per the circuit diagram.
- Switch on the 5V Power supply to the circuit.

- Heat the Thermistor body.
- When the thermistor gets heated, Observe the LED glowing.
- When thermistor is cool observe the LED turns OFF.

Result: - From the above experiment we observed, the LED is ON when thermistor is heated and OFF when it cools.