Sensors Approach to Industrial Automation – A Theoretical Study

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Abstract

Accurate monitoring and process control based on conditions is the main aim of any automation system. Real time monitoring and control, safety enhancement, security, increased efficiency etc. are some of the aspects behind an automation. To monitor the process and to provide real time data, a sensor plays an important role in an automation. Sensors provides a data or real time condition of particular parameters under test or status of any inputs. On the basis of that information or data from sensors, the designed system of any application can control the process. As per the applications need, various sensors are available. In this paper an attempt is made to cover some basic information of sensors used in an industrial automation, their use and benefits.

Keywords

Sensors, Benefits of Sensors, Various Applications, Types of sensors based on requirement.

Introduction

PLC is the basic tool used in an industrial automation as a controller. To control the process as per program written for particular application, a PLC takes an input data from sensors. A sensor is device that sense the changes in parameters and converts it into a suitable form for processing. It interacts with the physical condition and convert the changes into electrical quantity i.e. voltage or current. There are various types of sensors are available as per application need which are classified on the basis of power requirement (active or passive type), types of output (analog or digital), principle of parameter detection (temperature, pressure, level, flow, proximity) etc. To select a sensor for any particular application, some of the parameters are taken into a consideration which includes accuracy, range, response time, environmental condition, interfacing (Contact or Non -contact) etc.

I. Benefits of Sensors

1. It provides real time data which is useful to take any decision or to control the process.
2. It prevents from occurring hazardous conditions.
3. The data from sensor are used to automate the processes.
4. Sensors plays a crucial role in the designing of smart automation system.
5. It is use to monitor environmental parameters like water quality, air quality, noise etc which is helpful for public health and to be ready with any emergency plan.
6. The use of sensors minimized the waste, prevented from failure, optimized energy consumption etc. This all are led to the purpose of cost saving.
7. The working capability of sensors in extreme environment conditions provides it a versatility property.
8. Sensors also adapt the scalability property.

II. Areas of Industrial Automation

Sensors, controller, programming software and hardware are the components required to design any particular application. The various sensors requirement is based on application parameters. The various areas of industrial automation are mentioned below.

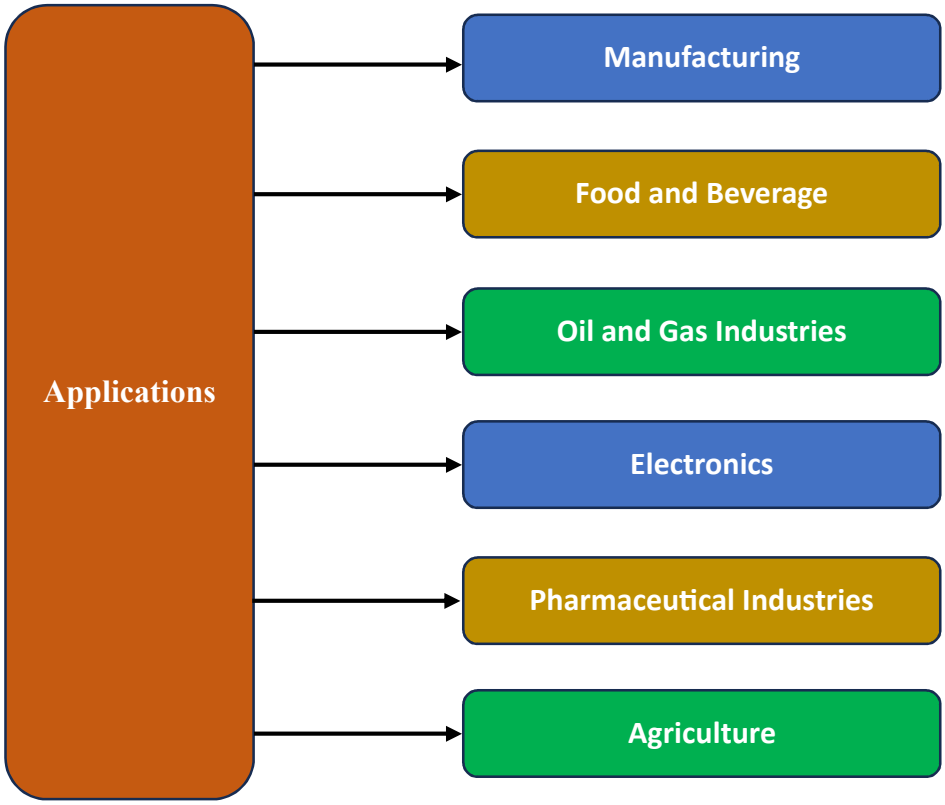

Figure 1.1

III. Analog and Digital Sensors

Analog Sensors	Digital sensors
1. Analog sensors provide an output which continuous electrical signal which is proportional to the measurand quantity. 2. Example – Temperature sensor	1. Digital sensors provide an output which is in a discrete form (binary form). 2. Example – Push Button

IV. Output Based Sensors

- **Analog Sensor**

1. It provides a continuous signal which is proportional to the measurand quantity.
2. It provides an output in the form of voltage i.e. 0 - 10 V or in the form of current i.e. 4 – 20 mA
3. It measures the continuous value of parameter like temperature, flow and provides respective signal in the form of voltage or current.

- **Digital Sensor**

1. It provides a signal which is in the form of discreate value or binary form.
2. It provides an output in the form 1/0, ON/OFF, True/False.
3. Proximity sensor, limit switches, photoelectric sensors are the examples of digital sensors which detects the presence of an object and delivers a signal in the form of voltage.

V. Output Signal Based Sensors

- **Current Output Sensors**

The sensors which provide an output in the form of current are preferable over a sensor which provides voltage output due to various advantages which includes

1. It provides better performance or accuracy for long distance data transmission.
2. It prevents from signal changes and signal degradation by avoiding errors coming from wire.
3. Fault detection is easy with it as 4 mA signal is used to indicate the zero-measurement condition of any parameters. So, when 0 mA signal is received, it shows the fault detection condition.

- **Voltage Output Sensors**

1. The voltage output sensors are used for short distance data transmission.
2. It is used where voltage drop is not too much important thing.
3. It is used where noise is not major consideration.
4. It requires simple wiring and power consumption is less.

VI. PNP and NPN Sensors

PNP Sensor: When PNP sensors are activated, it outputs the voltage signal (e.g. 24 Volts)

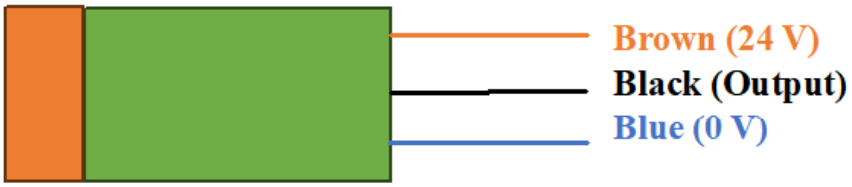

Figure 1.2

NPN Sensor: When NPN sensors are activated, it outputs the 0 volts voltage signal.

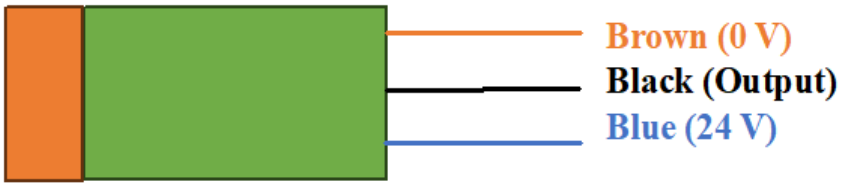

Figure 1.3

VII. Automation System Design Steps

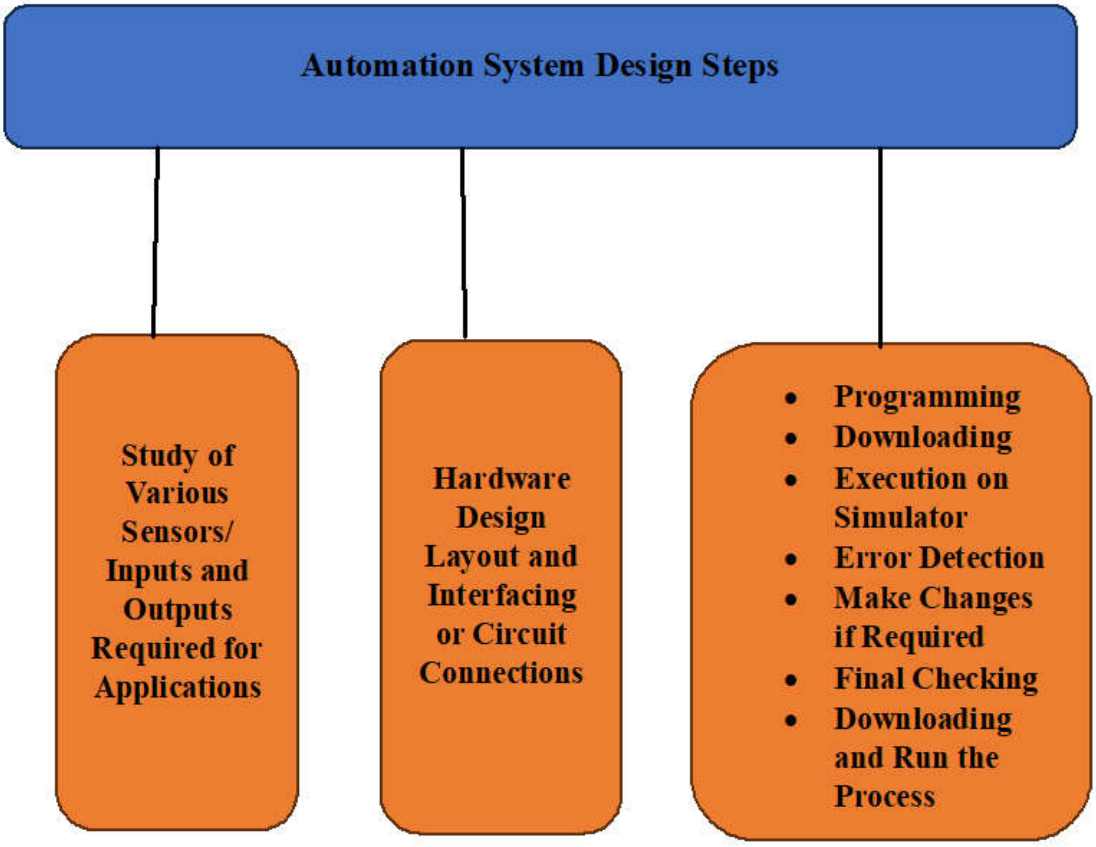

Figure 1.4

VIII. Types of Sensors

The following are the some of the sensors used in an industrial automation.

1. **Proximity Sensors –** These are used to detect any object without contact. It comes in various types which includes inductive, capacitive, ultrasonic and photoelectric type.

1. Inductive type is used to detect only metal objects.
2. Capacitive type is used to detect non-metals. It detects the changes in capacitance to detect solid, liquids and powders in metallic containers.
3. Ultrasonic type produces or emits waves in form of sound and receives an echo to find or calculate the distance. It is suitable for long distance object detection.
4. Photoelectric type uses light to detect an object. It is of various types,
   (i) In beam type, the transmitter and receiver are separately placed.
   (ii) In retro reflective sensor, both the transmitter (emitter) and receiver are kept at same place and a reflector is used separately at a distance from transmitter and receiver to reflect light beam back to the sensor. The entering object between sensor and reflector, interrupts the beam of light and a sensor observed this change and the respective output changes.

(iii) In diffuse type, the emitter and receiver are placed in one package. When the emitted light hits any object in a path it scattered in all direction. The receiver receives the reflected light and indicates the presence of an object. In this no reflector is used. the object itself acts as a reflector.

2. Temperature Sensors

Temperature sensors are used to measure the hotness and coldness condition. Further it converts that measured thermal energy into an electrical energy or signal. It comes with various types which includes RTD, thermocouple, thermistor, semiconductor ICs. The accuracy, range, response time are some of the factors taken into consideration in selection of any particular temperature sensor.

- **Resistance Tempereature Detectors (RTDs)** – RTDs has high accuracy and stable. RTD detects the resistance changes in metal and provides the respective measure of temperature. The metal element used in RTD changes its resistance with change in temperature. A circuitry used converts these changes in resistance into a temperature value. The RTD uses a materials like platinum, nickel, copper but platinum is mostly used. It comes with various configurations which are 2 wires configuration, 3 wires configuration, 4 wires configuration or more which are led to accuracy enhancement purpose.
- **Thermocouple** – It consist of two dissimilar metal wires joined at one end known as hot junction which is always kept in contact with the measurand whose temperature is to detect and the other end is referred as reference junction or cold junction. It is useful for measurement of wide temperature range but its accuracy is less.
- **Thermistor** – In this type, the resistance changes with temperature. It comes in two categories one is NTC and other is PTC. In NTC, the resistance decreases with increase in temperature where as in PTC, the resistance increases with increase in temperature.
- **Semiconductor ICs** – This provides an output voltage proportional to temperature changes.

3. Level Sensors

The level sensors are used to measure any particular point level measurement or continuous level measurement. The point level indicates the certain point where the level is reached or present whereas the continuous level indicates the changes coming in the level when it increases or decreases (rise or fall in level). So, it is classified according to that

Point Level Measurement	Continuous Level Measurement
Capacitive Float switch Vibrating Fork Conductivity (Resistance)	Radar Ultrasonic

In point level sensor, it detects the particular point level of substance and provides an electrical signal. The continuous level sensors are used detect the surface of any liquid, solid or any substance and convert into a suitable electrical signal according to the level of substance.

4. Pressure Sensor

A pressure sensor senses the force or pressure exerted by liquid or gases using pressure sensitive element and convert into a proportional electrical signal.

Type	Measurement Way
Absolute Pressure Type	It measures the pressure which is relative to a vacuum.
Differential Pressure Type	It is used to measure the difference between two pressures.
Gauge Pressure Type	It measures the pressure which is relative to the atmospheric pressure (surrounding pressure)
Vacuum Pressure Type	It is measurement which is less than the atmospheric pressure (surrounding pressure)

There are various types of pressure sensors which includes

1. Aneroid barometer
2. Manometer Pressure sensor
3. Vacuum Pressure sensor
4. Sealed Pressure sensor
5. Bourdon Tube
6. Strain Gauge
7. Piezoelectric

The selection of any particular sensor depends on various parameters which includes the type of sensor, operating temperature and pressure range, accuracy, resolution, need of supply voltage, type of output required etc.

5. Flow Sensor

Flow sensor is used to measure the rate or quantity of flow of liquid or gases passing through pipes as well as it can regulate the flow rate. There are number of advantages of flow sensor use in an industry which includes the consistent flow rate, real time data to adjust flow rate, safety and preventing from hazardous condition by detecting blockages or problem of pipe bursts, preventing from overflow or under flow supply of quantity, tracking the flow movement etc.

There are various types of flow sensors are available some of them are listed below which are based on their principle of measurement.

1. Ultrasonic flow sensor – It uses sound waves for the detection of flow.
2. Electromagnetic flow sensor
3. Mass Flow type
4. Velocity type
5. Differential Pressure type

Outcome

The paper gives the theoretical study about sensors approach to an industrial automation system.

It focused on benefits, applications, and types of sensors as per requirement.

Further it mentioned basic information about various sensors based on parameters of measurement.

Conclusion

The paper highlights on sensors study which includes various things related with Sensors. The paper first covers the basic idea of sensor, its use and advantages. Further it explains the various types of sensors based on type of output (i.e. analog or digital), Output Signal (i.e. voltage or current), based on output signal value (i.e. PNP and NPN). It also gives the basic information about various sensors as per application parameters need.

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