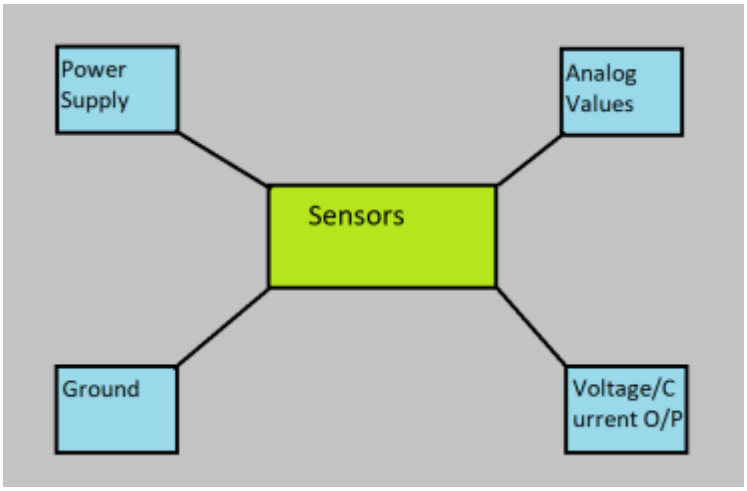
Analog Sensors Vs. Digital Sensors

Introduction

In this article, we will discuss different types of Analogue and Digital Sensors exits in the industry. Thus, We frequently use different types of sensors in several electrical and electronic applications. Sensors have become an integral part of the Embedded System. Right from your mobile to security systems installed at home. These are classified as chemical, pressure, temperature, position, force, proximity, thermal, presence, flow, optical, automotive, sound, speed, magnetic, electric, heat, fibre-optic sensors, analog, and digital sensors.

Sensors and it's Working

Generally, A sensor is an appliance that detects changes in physical or electrical or other quantities. So, it produces an electrical or optical signal output as an acknowledgement of the change in that specific quantity. So, a Sensor is a module or chip that observes the changes happening in the physical world and sends feedback to the microcontroller or microprocessor. Excitation (Power supply) and Grounding must be provided to the sensor for the proper working.



Sensor – Block Diagram

Classification of Sensors

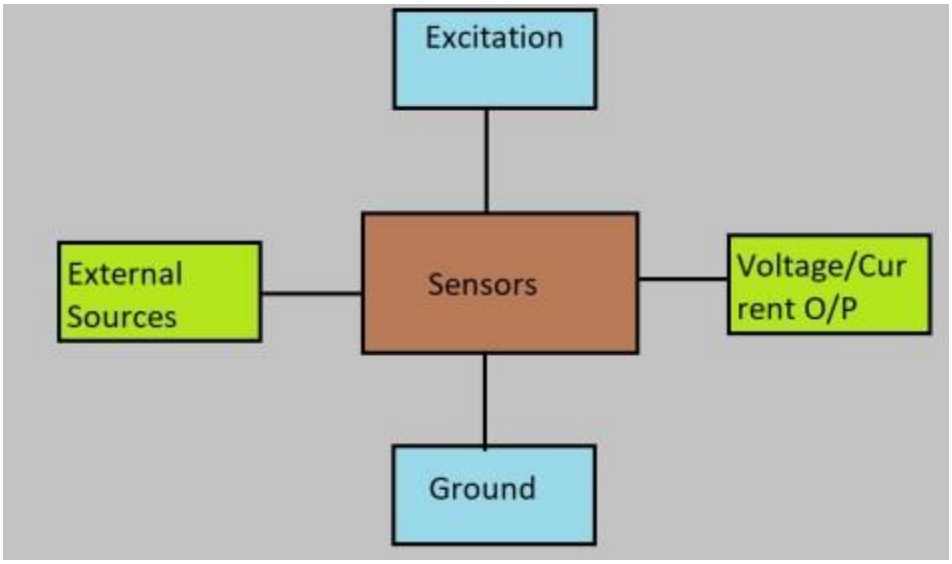
Micro-controller accepts two types of inputs depending up on the type of sensor i.e. analog or digital.

- Analog Sensors
- Digital Sensors

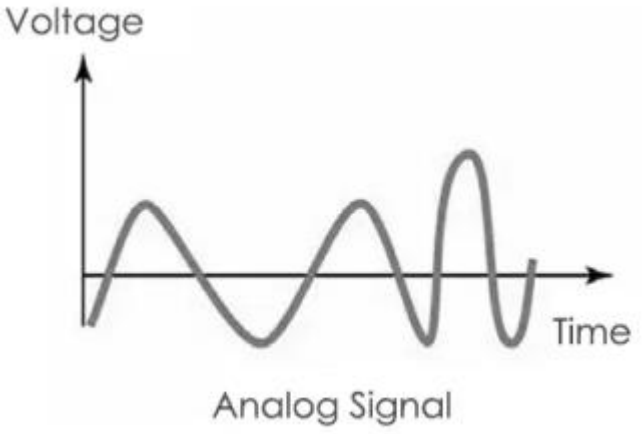
Analog Sensors

There are different types of sensors that produce continuous analog output signal and these sensors are analog sensors. This continuous output signal produced by the analog sensors is proportional to the measurand. Generally, There are various types of analog sensors; practical examples of various types of analog sensors are as follows: accelerometers, pressure sensors, light sensors, sound sensors, temperature sensors, and so on.

So, the Analogue sensor senses the external parameters (wind speed, solar radiation, light intensity, etc.) and gives analog voltage as an output. Thus, The output voltage may be in the range of 0 to 5V. Moreover, *Logic High* is “1” (3.5 to 5V) and *Logic Low* is “0” (0 to 3.5 V).



Block Diagram- Analog Sensors



Analog Accelerometers

Generally, the accelerometer sensor is to measure the acceleration exerted upon the sensor. On the other hand, the acceleration is in two or three axis-vector components that make up the sum/net acceleration. Accelerometers have quite a few uses. You can probably think of a few already—glass breakage detector, video game remote controls, or even electronic bubble levels for when you are trying to hang a picture frame on the wall. These accelerometers typically give us two types of data:

1. Static force applied on the sensor due to gravity→tilt/orientation detection
2. Force/acceleration exerted upon the sensor→movement/force detection

robu.in

So, These accelerometers are available as an analogue and digital sensors, based on the output signal. Thus, the Analog accelerometer produces a constant variable voltage based on the amount of acceleration applied to the accelerometer.

Analog Light Sensors

There are different types of light sensors available such as photo-resistors, photo-diodes, photovoltaic cells, photo-tubes, photo-multiplier tubes, photo-transistors, charge-coupled devices, and so on. But, LDR (Light Dependent Resistor or photo-resistor) is a light sensor in this light sensor circuit. These LDR sensors are passive and don't produce any electrical energy.

But, the resistance of the LDR changes with the change in the (light illuminated on the LDR) daylight intensity. LDR sensor is a terrain in nature, even in dirty and rough external environments. Hence, LDR is preferable to other light sensors as it can be used even in the outdoor lighting of homes and in automatic street lights as well.

Analog Sound Sensors

The sound sensor is one type of module used to notice the sound. Generally, this module is used to detect the intensity of sound. The applications of this module mainly include switch, security, as well as monitoring. The accuracy of this sensor can be changed for ease of usage.

www.tomsonelectronics.com

This sensor employs a microphone to provide input to buffer, peak detector, and an amplifier. This sensor notices a sound, & processes an o/p voltage signal to a microcontroller. After that, it executes the required processing.

This sensor is capable to determine noise levels within DB's or decibels at 3 kHz 6 kHz frequencies approximately wherever the human ear is sensitive. In smartphones, there is an android application namely decibel meter used to measure the sound level.

Analog Pressure Sensors

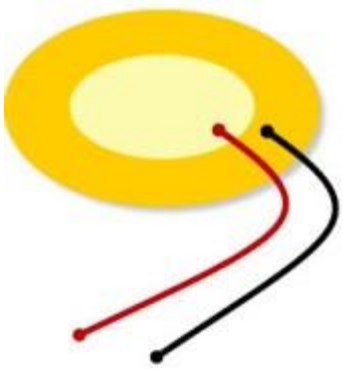
A **pressure sensor** is a device for pressure management of gases or liquids. The pressure is an expression of the force required to stop a fluid from expanding and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed.

Pressure sensors are used for control and monitoring in thousands of everyday applications. It can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively be called pressure transducers, pressure transmitters, pressure senders, pressure indicators, piezometers, and **manometers**, among other names.

www.ezgiz.com

Pressure sensors can vary drastically in technology, design, performance, application suitability, and cost. A conservative estimate would be that there may be over 50 technologies and at least 300 companies making pressure sensors worldwide.

There is also a category of pressure sensors that are designed to measure in a dynamic mode for capturing very high-speed changes in pressure. Example applications for this type of sensor would be in the measuring of combustion pressure in an engine cylinder or in a gas turbine. These sensors are commonly manufactured out of piezoelectric materials such as quartz.



www.ezgiz.com

Some pressure sensors are pressure switches, which turn on or off at a particular pressure. For example, a water pump can be controlled by a pressure switch so that it starts when water is released from the system, reducing the pressure in a reservoir.

Analog Temperature Sensors

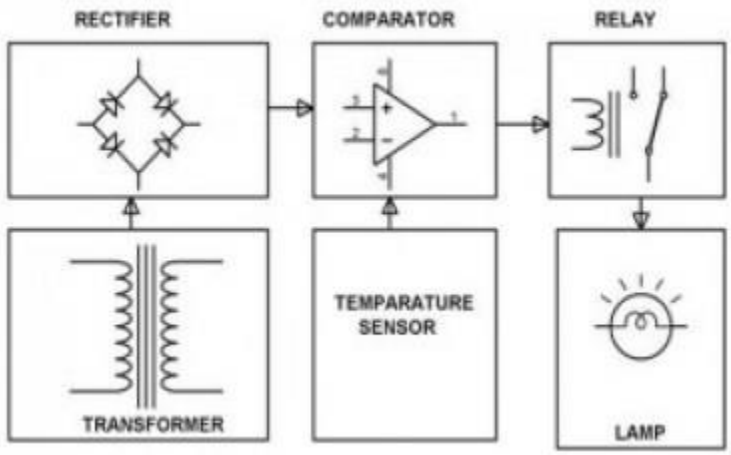
Analog temperature sensors provide a highly linear output voltage or current proportional to temperature. Their low power minimizes self-heating enabling accuracy up to ±0.13°C. Analog temperature sensors are very easy to use, requiring no compensation circuitry, look-up tables, or calibration.

Temperature sensors are widely available as both digital and analog sensors. So, Typically used analog temperature sensors are thermistors. There are different types of thermistors for different applications. The thermistor is a thermally sensitive resistor that used for detecting changes in temperature. If the temperature increases, then the electrical resistance of the thermistor increases. Similarly, if the temperature decreases, then the resistance decreases. Thus, used in various temperature sensor applications.

robu.in

Example:

On the other hand, A practical example of the analog temperature sensor is a thermistor based temperature control system. This project used to maintain a constant temperature in an enclosed area. A block diagram of the temperature control system consists of the lamp that represents a cooler, temperature sensor or thermistor, relay.



Edgefxkits.com

If the temperature exceeds a certain value, then the lamp switches on automatically indicating a cooler for bringing back temperature to normal value. Operational along with a negative temperature coefficient thermistor used for activating relay-in case if the temperature exceeds a certain range. This process of activating relay for switching on cooler (in this system shown as a lamp) done automatically, hence there is no need to monitor the temperature in person. The thermistor is the most frequently used analog temperature sensor, because of its low-cost advantage. Whenever changes occur in temperature, then the input parameters to the op-amp will be altered. Thus, op-amp delivers an output that energizes the relay and the load turns on or off accordingly.

If we use a digital temperature sensor instead of analog temperature sensor, then the accuracy of temperature control system can be improved.

Magnetic Sensor (Position Sensor)

Magnetic sensor definition is a sensor that is used to notice disturbances as well as changes within a magnetic field such as strength, direction, and flux. There are different types of detection sensors that can work on some of the characteristics like light, pressure, temperature. These sensors are separated into two groups. The first one is used to calculate the total magnetic field, whereas the second one is used to calculate vector components of the field.

troncart.com

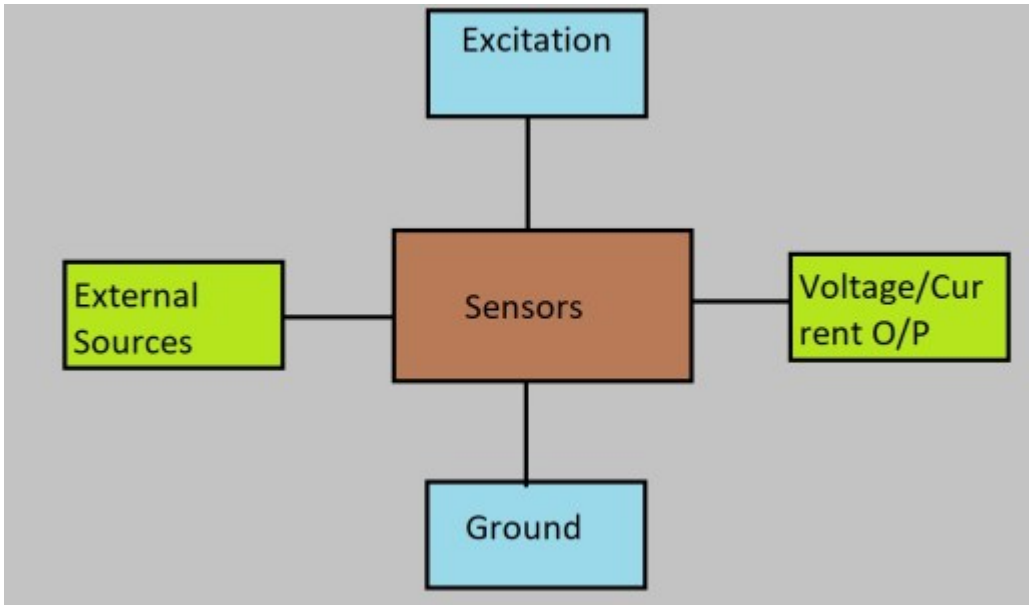
The vector components in the magnetic field are individual points and the techniques which are used for making these sensors mainly involved in a variety of blends of electronics and physics.

So, The magnetic sensor comprises a chip with a magnetoresistive component which is used to detect a magnetic vector & a magnet intended for magnetic vector biasing which can be detected by the magnetoresistive component. Thus, The chip which is used in the sensor can be used for sensing the change within the magnetic vector. This vector notices the behavior of a magnetic body depending on a change of resistance value of the magnetoresistive component. Whenever the magnetic vector biasing occurred due to the magnet in co-operation by the magnetic body, then it will be the motion inside the sensing chip. This sensor can be used to compass functionality, which is accessible during the Navigation menu.

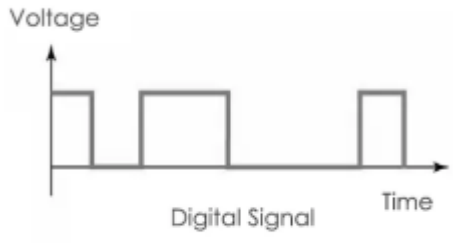
Digital Sensors

Unlike analog sensor, **Digital Sensor** produce discrete values (0 and 1's). Discrete values often called digital or binary signals in digital communication.

Electronic sensors or electrochemical sensors in which data conversion and data transmission take place digitally are digital sensors. These digital sensors are replacing analog sensors as they are capable of overcoming the drawbacks of analog sensors. The digital sensor consists of majorly three components such as senor, cable, and transmitter. But, In digital sensors, the signal measured directly converted into digital signal output inside the digital sensor itself. So, this digital signal transmitted through cable digitally. There are different types of digital sensors that overcome the disadvantages of analog sensors.



Block Diagram- Digital Sensors
iot4beginners.com



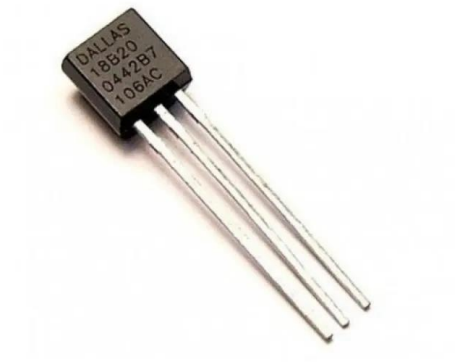
Digital Accelerometers Sensors

bm-es.com

The method of generation of variable frequency square wave output by the digital accelerometer is pulse-width modulation. The readings taken by the pulse width modulated accelerometer at a fixed rate, generally at 1000 Hz (but this can be configured by a user based on the IC used). So, The output PWM signal, pulse width, or duty cycle is proportional to the acceleration value.

Digital Temperature Sensors

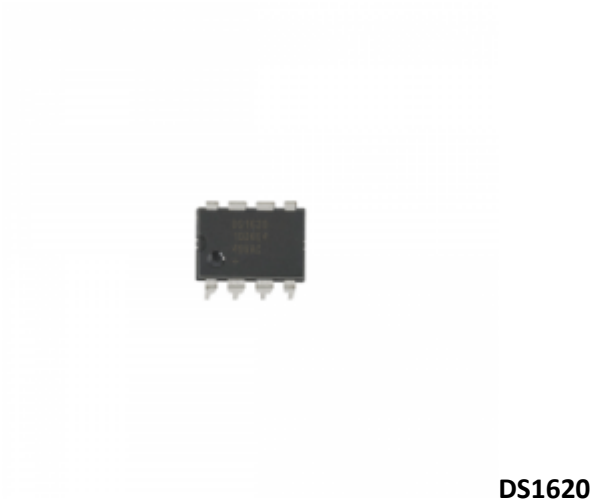
Temperature sensing is ubiquitous. Historically, temperature sensors have had well-known applications in environmental and process control as well as in test and measurement and communications. New communications applications range from base stations of all sizes to cellular handsets. Temperature sensors also found inside automotive engines and transmissions, where controllers adjust operating parameters based on temperature. But, they're on circuit boards with big, fast processors and FPGAs. There are traditional temperature sensors and silicon-based temperature sensors. Traditional sensors comprise thermistors, resistance temperature detectors (RTDs), and thermocouples. They are analog devices, so their outputs must be digital before they can be used in a digital-control loop



www.parallax.com

On the other hand, Temperature sensors don't have to be analog. Silicon-based temperature-sensing ICs that output precise digital representations of the temperatures they are measuring. This simplifies the design of the control system, compared to approaches that require external signal conditioning and an analog-to-digital converter (ADC).

The **DS1620** Digital Thermometer and Thermostat provides 9-bit temperature readings which indicate the temperature of the device. With three thermal alarm outputs, the DS1620 can also act as a thermostat. So, T_{HIGH} drove high if the DS1620's temperature is greater than or equal to a user-defined temperature TH. T_{LOW} drove high if the DS1620's temperature is less than or equal to a user-defined temperature TL. T_{COM} drove high when the temperature exceeds TH and stays high until the temperature falls below that of TL.



DS1620

www.parallax.com

DS1620 Pin Diagram

www.parallax.com

User-define temperature settings store in non-volatile memory, so parts are prior to insertion in a system, as well as used in standalone applications without a CPU. Temperature settings and temperature readings are all communicated to/from the DS1620 over a simple 3-wire interface.

Digital Humidity Sensors

A humidity sensor (or hygrometer) senses, measures, and reports both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is relative humidity. Relative humidity becomes an important factor when looking for comfort.

robu.in

Humidity sensors work by detecting changes that alter electrical currents or temperature in the air.

There are three basic types of humidity sensors:

- Capacitive
- Resistive
- Thermal

Problem with digital sensors:

Digital sensors have a low calculation range. For example, digital temperature sensors such as HYT 271 and SHT series have a lower temperature range.

www.ebay.com

But analog temperature sensors (RTD) have higher resolution (positive and negative temperature). So, This feature makes analog sensors suitable for wide temperature range and stability. The analog output from the sensor is processed by the ADC (Analog to Digital Converter) of the microcontroller.

Characteristics of Analog and Digital Sensors

Factors	**Analog Sensors**	**Digital Sensors**
Waves	Denoted by Sine Waves	Denoted by Square Waves
Signal	Continuous Signal is representing physical measurements	Digital signal representing discrete time sig modulation
Data Transmission	Subject to deterioration by noise	Noise immune without deterioration
Bandwidth	Less Bandwidth	More Bandwidth
Power	Draws large power	Negligible Power
Memory	Stored in the form of the wave signal	Stored in the form of binary bit
Impedance	Low impedance	High Impedance of order 100 megaohm

Errors	Observational error occurs	Free from Observational error