PLTW Engineering

10-12/Electronics Sensors – Analog and Digital

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10-12/DE

Lesson: **5/19/2020**

Objective/Learning Target: Students will be able to identify and explain different analog and digital sensors used with electronics circuits.

Analog sensors

Analog sensors produce a continuous output signal or voltage which is generally proportional to the quantity being measured.

Physical quantities such as Temperature, Speed, Pressure, Displacement, and Strain are all analog quantities as they tend to be continuous in nature.

For example, the temperature of a liquid can be measured using a thermometer or thermocouple which continuously responds to temperature changes as the liquid is heated up or cooled down.

Analog sensors

Analog sensors tend to produce output signals that are changing smoothly and continuously over time.

These signals tend to be very small in value from a few mico-volts to several milli-volts, so some form of amplification is required.

Analog sensors

Circuits which measure analog signals usually have a slow response and low accuracy.

Also analog signals can be easily converted into digital type signals for use in micro-controller systems by the use of analog-to-digital converters.

Digital sensors

As its name implies, Digital Sensors produce a discrete digital output signals or voltages that are a digital representation of the quantity being measured.

Digital sensors produce a Binary output signal in the form of a logic “1” or a logic “0”, (“ON” or “OFF”).

Digital sensors

Digital signals or quantities have very high accuracies and can be both measured and “sampled” at a very high clock speed.

The accuracy of the digital signal is proportional to the number of bits used to represent the measured quantity.

This accuracy can be maintained as digital quantities are manipulated and processed very rapidly, millions of times faster than analog signals.

Active vs Passive sensors

Active sensors require an external power supply to operate, called an excitation signal which is used by the sensor to produce the output signal.

Active sensors are self-generating devices because their own properties change in response to an external effect producing for example, an output voltage of 1 to 10v DC or an output current such as 4 to 20mA DC.

Strain gauge

Active sensors can also produce signal amplification.
A good example of an active sensor is an LVDT sensor or a strain gauge.

Strain gauges are pressure-sensitive resistive bridge networks that are external biased (excitation signal) in such a way as to produce an output voltage in proportion to the amount of force and/or strain being applied to the sensor.

Passive sensors

Unlike an active sensor, a passive sensor does not need any additional power source or excitation voltage.

Instead a passive sensor generates an output signal in response to some external stimulus.

For example, a thermocouple which generates its own voltage output when exposed to heat.

Passive sensors are direct sensors which change their physical properties, such as resistance, capacitance or inductance.

Common types of position sensors

Potentiometers come in a wide range of designs and sizes such as the commonly available round rotational type or the longer and flat linear slider types.

When used as a position sensor the moveable object is connected directly to the rotational shaft or slider of the potentiometer.

How does a potentiometer work?

It has a wiper contact linked to a mechanical shaft that can be either angular (rotational) or linear (slider type) in its movement, and which causes the resistance value between the wiper/slider and the two end connections to change giving an electrical signal output that has a proportional relationship between the actual wiper position on the resistive track and its resistance value.

In other words, resistance is proportional to position.

Common types of position sensors

Inductive Proximity Sensors can also be called an *Eddy current sensor*.

While they do not actually measure displacement or angular rotation they are mainly used to detect the presence of an object in front of them or within a close proximity, hence their name “proximity sensor”.

Proximity sensors

Proximity sensors, are non-contact position sensors that use a magnetic field for detection with the simplest magnetic sensor being the reed switch.

In an inductive sensor, a coil is wound around an iron core within an electromagnetic field to form an inductive loop.

Proximity sensors

When a ferromagnetic material is placed within the eddy current field generated around the inductive sensor, such as a ferromagnetic metal plate or metal screw, the inductance of the coil changes significantly.

The proximity sensors detection circuit detects this change producing an output voltage.

Quiz yourself

1. Analog sensors produce what type of output or voltage?
2. Do analog signals change harshly or smoothly?
3. Circuits that measure analog signals can be described how?
4. Describe the difference between digital 1's and Zeros.
5. Which are faster? Analog or digital signals?
6. Do active sensors require a power supply?
7. A potentiometer works by varying which electrical value?

Helpful links

Overview of digital and analog sensors

Youtube video showing different analog and digital sensors