ARTICLES

ANALYSIS OF DIFFERENT SENSORS USED IN WIRELESS APPLICATIONS

By

M. SIVA SANKAR * P. KAVIPRIYA **

*-** Electronics and Communication, Sathyabama University, Chennai, Tamil Nadu, India.

ABSTRACT

This paper presents an up-to-date review on different types of sensors. The sensor technologies in use today are reviewed and classified according to their functions. In this paper, the sensors are also detailed with respect to their features used in today's technology.

Keywords: Sensors, Features of Sensors, Types, Ultrasonic Principle.

INTRODUCTION

A sensor (also called a detector) is a convertor that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For accuracy, most sensors are calibrated against known standards. A sensor is a device which receives and responds to a signal when touched. Sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. Sensors that measure very small changes must have very high sensitivities. Sensors also have an impact on what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer. Sensors like proximity sensor, temperature sensor, humidity sensor, ultrasonic sensor, piezoelectric sensor and conductivity sensor are used in the proposed systems. Sensors that measure very small changes must have very high sensitivities. Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base. There are also innumerable applications for sensors of which most people are never aware. Applications include cars, machines, aerospace, medicine, manufacturing and robotics. The different types are explained in detail below.

1. Types of Sensors

1.1 Proximity Sensors

Inductive proximity sensors are widely used in various applications to detect metal devices. They can be used in various environments (industry, workshop, iift shaft etc.) and need high reliability. Inductive proximity sensors generate an electromagnetic field and detect the eddy current losses induced when the metal target enters the field. The field is generated by a coil, wrapped round a ferrite core, which is used by a transistorized circuit to produce oscillations [1]. The target, while entering the emf produced by the coil, will decrease the oscillations due to eddy currents developed in the target. If the target approaches the sensor within the so-called Sensing Range, the oscillations cannot be produced anymore: then the detector circuit generates an output signal controlling a relay or a switch. Sensor gives the pulses to the microcontroller at each instance of time when it is embedded or is involved in any of the circuits.[2]. The microcontroller counts the pulses being produced in the system with which the sensors are attached. By using the pulses one can determine different parameters. The cost effective sensors are used in various standard engineered design and in many advanced circuits[5]. Figure 1 shows the proximity sensors whereas Figure 2 shows the sensor being embedded into a chip. A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.[10]

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic targets; an inductive proximity sensor always requires a metal target. The maximum distance that this sensor can detect is defined as "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance.[10]

1.1.1 Features of Proximity Sensors

- Fully potted switch and leads.
- High cycle rate capabilities.
- High speed operation.
- Compact for limited space applications.
- No moving parts, for longer life.
- Corrosion-resistant.
- Wide selection of materials.
- Engineered designs.

1.2 Temperature Sensors

A thermistor is a type of resistor used to measure temperature changes, relying on the change in its resistance with changing temperature. Thermistor is a combination of the words thermal and resistor. The thermistor was first invented by Samuel Ruben in 1930.If it is assumed that the relationship between the resistance and the temperature is linear, (i.e., A first order approximation).

$\Delta R = k*\Delta T$

where,

ΔR=change in resistance

ΔT= change in temperature

K = first order temperature coefficient of resistance.

Thermistors can be classified into two types depending on the sign of 'k'[3]. If k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (PTC) thermistor or, Posistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient (NTC) thermistor. Resistors that are not thermistor are designed to have the smallest possible 'k', so that their resistance remains almost constant over a wide temperature range[3]. Thermistors are nothing but temperature sensitive resistor. There are two types of Thermistors available such as positive temperature coefficient and negative temperature coefficient. Figure 3 represents the symbol of thermistor[3]. These sensors are mostly used in various chemical industries, manufacturing units, laboratories, etc,.

1.3 Humidity Sensors

Humidity measurement can be done using dry and wet bulb hygrometers, dew point hygrometers, and electronic hygrometers. There has been a surge in the demand of electronic hygrometers, often called humidity sensors.[9].Humidity is the amount of water vapour in an air sample. There are 3 different ways to measure humidity:

Figure 1. Proximity Sensors

Figure 2. Sensors when embedded in a chip or a circuit

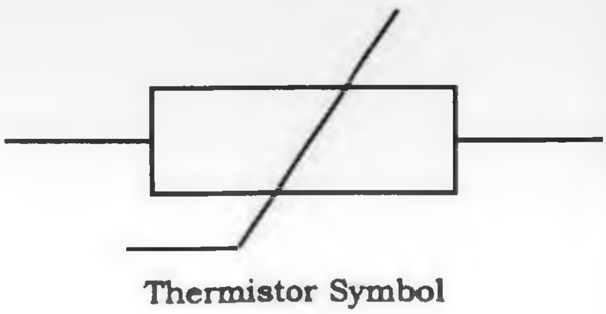

Figure 3. Thermistor Symbol

absolute humidity, relative humidity and specific humidity. Relative humidity is the most frequently encountered measurement of humidity because it is regularly used in weather forecast. It is an important part of weather reports because it indicates the likelihood of precipitation, dew, or fog[4]. Higher relative humidity also makes it feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin. This effect is calculated in a heat index table. Warmer air has more thermal energy than cooler air; thus more water molecules can evaporate and stay in the air in a vapour state rather than a liquid state[4]. This may be why people say that warmer air holds more moisture in warmer air, and there is more energy for more water molecules to hold themselves in the air (and overcome hydrogen bonds which seek to pull water molecules together).The humidity sensor is consisting of a table multivibrator in which capacitance is varied depending upon the humidity level. Controlling or monitoring humidity is of paramount importance in many industrial and domestic applications. [9].

1.4 Conductivity Sensors

Conductivity is defined as the ability of a solution to conduct electrical current. The load carriers are ions (E.g. dissolved salt or acids). In order to measure conductivity, 2 electrodes are used which are set at a fixed distance apart and with a known specified surface[6]. An AC voltage source from the connected transmitter Type 8225 or transmitter/controller Type 8619 is supplied to the electrodes. The measured current is a direct function of the conductivity of the solution. A 4 to 20mA standard signal proportional to the conductivity is available as output signal at the connected transmitter. Different electrode designs are required based on selected cell constants. The conductivity transmitter can be fitted with 4 different measuring cells with constants C=0.01; 0.1; 1 and 10.The conductivity of a proton solution is a measure of its ability to conduct electricity [4]. The SI unit of conductivity is Siemens per meter(S/m). Figure 4 shows the conductivity sensor. Conductivity measurement is used in many industrial and environmental aspects as a fast, inexpensive and reliable way of measuring the ionic content in a solution.[6]

1.5 Ultrasonic Sensors

Ultrasonic sensors emit short, high frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. if they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal receiving the echo. Figure 5 shows the ultrasonic waves transmission.

1.5.1 Ultrasonic Principle

As the distance to an object is determined by measuring the time of flight and not by the intensity of the sound, ultrasonic sensors are excellent at suppressing background interference.[7]. These sensors are of different shape and size due to the development of technology. Virtually all materials which reflect sound can be detected, regardless of their colour. Even transparent materials or thin foils represent no problem for an ultrasonic sensor. Microsonic ultrasonic sensors are suitable for target distances from 20mm to 10m and as they measure the time of flight they can ascertain a measurement with pin point accuracy. Some of our sensors can even resolve the signal to an accuracy of 0.025 mm. Ultrasonic sensors can see through dust-laden air and ink mists.[5] Even thin deposits on the sensor

Figure 4. Conductivity sensor

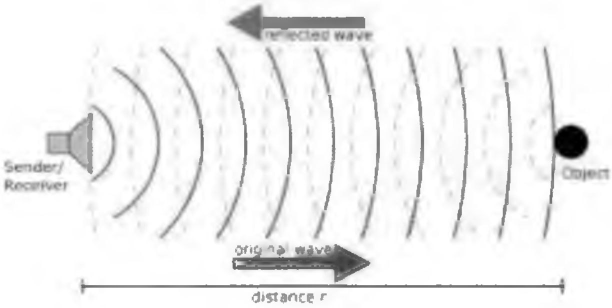

Figure 5. Transmission of Ultrasonic Waves

membrane do not impair its function. Sensors with a blind zone of only 20mm and an extremely thin beam spread are making entirely new applications possibly today, filling levei measurement in wells of microtiter plates and test tubes, as well as the detection of small bottles in the packaging industry, can be implemented with ease. Even thin wires are reliably detected. In ultrasonic testing (UT), very short ultrasonic pulse-waves with centre frequencies ranging from 0.1-15 MHz and occasionally up to 50 MHz are transmitted into materials to detect internal flaws or to characterize materials. A common example is ultrasonic thickness measurement, which tests the thickness of the test object, for example, to monitor pipe work corrosion.

Ultrasonic testing is often performed on steel and other metals and alloys, though it can also be used on concrete, wood and composites, albeit with less resolution. It is a form of non-destructive testing used in many industries including aerospace, automotive and other transportation sectors[4].

1.5.2 Application of Ultrasonic Sensors

1. Ultrasonic sensors are observed in different places in our day to day life. These sensors are used in various multiplexes, airports, etc.

2. One of the most popular examples is the usage of ultrasonic sensors in our vehicle (car). The sensors keep us updated about the situations near by the car. We can easily park or drive our car without any difficulty.

3. Figure 2 represents the role of sensor in a car. These sensors also use radar systems to alert the nearby obstacle to the driver and ensure a safe driving.

1.6 Piezo Electric Sensors

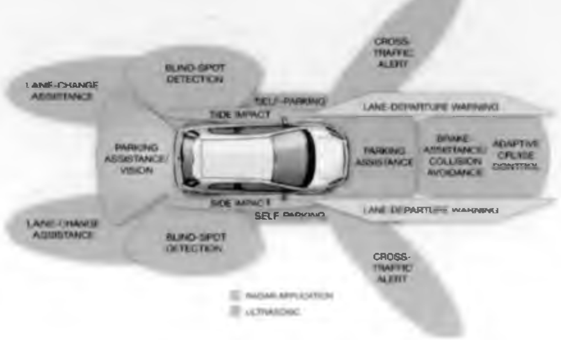

Figure 6. Ultrasonic sensors used in cars to monitor the nearby vehicles and parki

A Piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical signal. Piezoelectricity is the ability of crystals and certain ceramic materials to generate a voltage in response to applied mechanical stress. Piezoelectricity was discovered by Pierre and Curie. The word 'Piezoelectricity' is derived from the Greek word "piezein", which means to squeeze or press.[3]The vibration sensing acts as a piezoelectric sensor. The piezoelectric effect is reversible in that piezoelectric crystals when subjected to an externally applied voltage can change shape by a small amount. The effect finds useful applications such as the production and detection of sound, generation of high voltages, electronics frequency generation, microbalance, and ultra-fine focusing of optical assemblies [3]. The electric field will be generated on the basis of the electrical contacts. The piezoelectric sensor is used for flex, touch, vibration and shock measurement. its basic principle, at the risk of oversimplification, is as follows: whenever a structure moves, it experiences acceleration. A piezoelectric shock sensor, in turn, can generate a charge when physically accelerated. This combination of properties is then used to modify response or reduce noise and vibration[8].

1.6.1 Application of Piezoelectric Sensors

Piezoelectric sensors have proven to be versatile tools for the measurement of various processes. They are used for quality assurance, process control and process development in many different industries. Piezoelectric sensors are also seen in nature.[6]. Bones act as force sensors. Once loaded, bones produce charges proportional to the resulting internal torsion or displacement. Those charges stimulate and drive the build up of new bone material. This leads to the strengthening of structures where the internal displacements are the greatest. With time, this causes weaker structures to increase their strength and stability as material is laid down proportional to the forces affecting the bone.

Conclusion

Sensors are mainly used in various technologies. Sensors are very useful for humans as they reduce the human efforts and meet their needs. Sensors are used in many electronic equipments like Air Conditioner (A.C.), telephone, washing machine, refrigerator, etc. As technology goes on increasing, new type of sensors will evolve in order to improve the growth of science.

References

[1]. **G. Eason, B. Noble, and I. N. Sneddon, (1955).** "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," *Phil. Trans. Roy. Soc. London*, Vol. A247, pp. 529–551,

[2]. **J. Clerk Maxwell, (1892).** *"A Treatise on Electricity and Magnetism"*, 3rd ed., Vol. 2. Oxford: Clarendon, pp. 68–73.

[3]. **William J.Fleming, (2001).** "Overview of sensors", *IEEE Sensors Journal*, Vol. 1, No. 4, December.

[4]. **Wikipedia. (2009).** *Ultrasonic testing*. Retrieved from http://en.wikipedia.org/wiki/Ultrasonic_testing

[5]. **FARGO controls Inc (2041).** *Proximity Sensors*. Retrieved from http://www.fargocontrols.com/sensors.html.

[6]. **Roger Jean seaglet, (1980).** *"How things work"* 2nd edition, Vol. 2.

[7]. **Wikipedia (2014).** *Ultrasonic sensor*, Retrieved from http://en.wikipedia.org/wiki/Ultrasonic_testing.

[8]. **Digi-key Corporation (2011).** *Fundamentals-of-piezoelectric-shock-and-vibration-sensors*, Retrieved from http://www.digikey.com/en/articles/techzone/2011/dec/fundamentais-of-piezoelectric-shock-and-vibration-sensors.

[9]. **Preethi Jain.,** *"Humidity Sensor" Engineers Garage*, Retrieved from http://www.engineersgarage.com/articles/humidity-sensor.

[10]. **Wikipedia (2008).** *Proximity Sensor* Retrieved from http://en.wikipedia.org/wiki/Proximity_sensor.

ABOUT THE AUTHORS

Siva Sankar is currently pursuing B.E. degree in Electronics and Communication Engineering from Sathyabama University, Chennai. He has published many papers in National and International Conferences and Journals. His area of interest includes Wireless Communication, Antenna and Wave propagation and Sensors.

Kavipriya is currently working as an Assistant Professor in Sathyabama University. She is pursuing Ph.D. She acquired B.E degree in Electronics and Communication Engineering from A.V.C College of Engineering, Mannampandal, Mayiladuthurai and M.E degree in Applied Electronics Engineering from Sathyabama University. She has published more than 10 research papers in National and International conferences and Journals. She is having more than 13 years in teaching experience. Her area of interest includes Wireless Communication and Networks.