PIR Sensor in Motion Detection & Identification System

The Pyro-electric Infra-Red (PIR) sensor is an extremely useful device for detecting the presence of a moving body. This is due to its ability to sense the infrared radiation that every living body emits.

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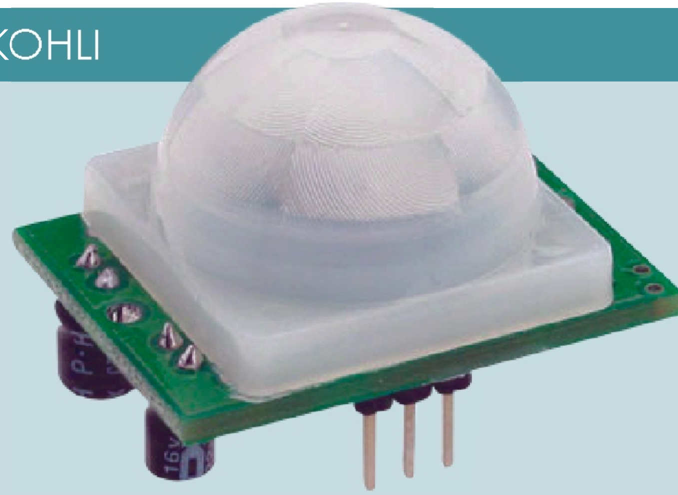

A PIR detector is a motion detector that senses the heat emitted by a living body. These are often fitted to security lights so that they will switch on automatically if approached. They are very effective in enhancing home security systems. They are used in various number of applications like :

• Intrusion sensor • Light control • Temperature measurement • Flame detector • Automatic door switch • Visitor detector • Home security • Life safety

How do PIR Sensors Work?

PIR stands for Passive Infra-Red. The "motion sensing" feature on most lights (and security systems) is a passive system that detects infrared energy. These sensors are therefore known as PIR (passive infrared) detectors or pyroelectric sensors. Instead of emitting a beam of light or microwave energy that must be interrupted by a passing person in order to "sense" that person, the PIR is simply sensitive to the infrared energy emitted by every living thing. When an intruder walks into the detector's field of vision, the detector "sees" a sharp increase in infrared energy.

A PIR sensor light is designed to turn on when a person approaches, but will not react to a person standing still. The lights are designed this way. A moving person exhibits a sudden change in infrared energy, but a slower change is emitted by a motionless body. Slower changes are also caused by gradual fluctuations in the temperature of the environment. If the light were sensitive to these slower changes, it would react to the sidewalk cooling off at night, instead of the motion of a burglar.

No motion detection system is perfect, but PIR sensors are by far the most sensitive and advanced option. PIR sensor lights are ideal additions to any home security system.

A PIR Sensor in a Motion Detection System Design

Part of the appeal of the PIR sensor is its ability to reliably distinguish moving bodies from other objects, as well as from stationary bodies. Its basic mode of operation is to detect the difference in heat

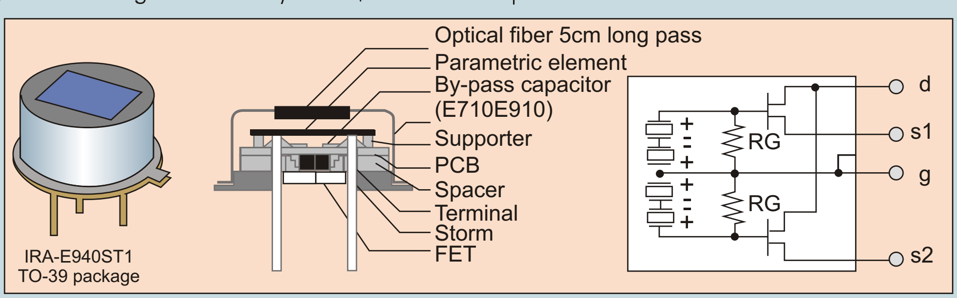

Fig. 1: Murata's IRA-E940ST1 PIR sensor

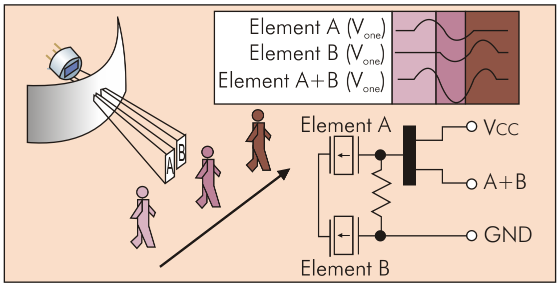

Fig. 2 : A PIR sensor works by sensing the difference in infra-red radiationbetween one sensing element and another

signature between two 'segments' in its field of view. The model of the internal structure of a PIR sensor (see Figure 1) clearly illustrates this operating principle.

To avoid triggering upon sensing normal temperature variations or disturbances in airflow, a dual-element PIR sensor connects two elements in pairs. These are inverted with respect to each other in terms of polarization. When the two inverted elements are exposed to the same infrared radiation level, they cancel each other out, generating a zero-output signal as a result.

This means that the detected body will have to move into or between the two elements' field of view to cause the sensor to generate an output signal. In this way, a dual- or quad-element sensor is able to reject false detections accurately and effectively.

By using a dual- or quad-element sensor, it is also possible to detect the direction in which the object is moving. The quad-element sensor in Figure 1 has two outputs: this means that it can indicate in which area the movement is occurring (for instance, on the ceiling or on the floor), and at the same time whether the object is moving in the horizontal or vertical plane. The dual sensor can only indicate movement in one axis; for example, the horizontal plane.

When specifying a sensor, the number of elements is only the first consideration.

Other important parameters that vary between sensors are frequency response, which determines the sensor's ability to detect low and high speed movements, the angle of the field of view, which will affect the size of the sensor's coverage area and immunity to RF and background noise.

Configuring the Lens

The sensor itself is inefficient if it does not have a lens to focus the radiation. The most commonly used lens type is the Fresnel lens, due to its low losses and small form factor. A Fresnel lens is a compressed plano-convex lens that comprises a set of discontinuous surfaces (see Figure 3).

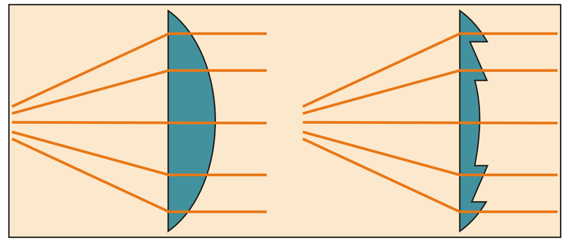

Fig. 3 : Convex lens (left) and Fresnel lens (right)

The grooves on the lens are arranged facing the PIR sensor. This leaves a flat, dust and weather proof surface facing the outside and protecting the otherwise vulnerable sensor.

The Signal Conditioning Circuit

To be usable, the signal from the sensor has to be amplified and then converted into a digital value

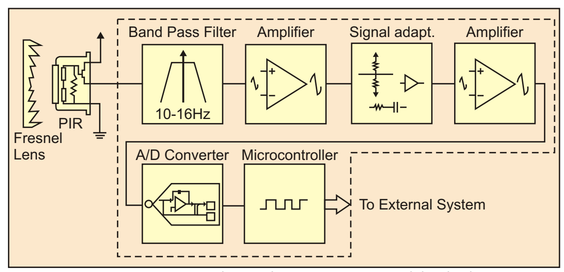

Fig. 4 : PIR sensor signal conditioning circuit: block diagram

for further analysis in software. A typical block schematic for this application is shown in Figure 4.

There are several ways to design a circuit to realize this schematic. The two preferred approaches use either discrete analog components, or, in a more integrated implementation, a mixed-signal programmable array such as a Cypress Semiconductor Programmable System-on-Chip (PSoC) device.

The Discrete Solution

The most common approach to PIR sensor signal conditioning is to design the amplifier and signal conditioning stage by using discrete components such as operational amplifiers, comparators, diodes, resistors and capacitors. Next in the signal path, a microcontroller with an integrated ADC performs signal identification and also supports connection to a communications interface, such as a radio.

This traditional approach occupies a large PCB footprint. But a PIR sensor produces a very low signal level, so it is essential to keep PCB traces short and the design compact to avoid creating unwanted antennas. These can pick up background noise and RF signals, which can cause the device to trigger falsely. If the PIR sensor is connected to a wireless network (for instance, as part of an intruder alarm system), the danger of this is particularly high.

The PSoC Solution

A second approach, which produces a more compact result, is to use a PSoC device from Cypress. The PSoC is a programmable mixed-signal controller with an 8-bit core and a set of analog and digital blocks that can be used to create the functionality needed.

Analog blocks that can be realized in the PSoC include ADCs, DACs, filters, amplifiers and comparators. Integrated digital functions include timers, counters, UARTs, SPI and PWMs. Designers using a PSoC will be able to realize the blocks shown in Figure 4 with far fewer components than in the discrete implementation described above.

Different devices in the PSoC family provide different numbers and types of digital and analog blocks, offer different memory sizes and use different packages. The first step in implementing a PIR sensor with a PSoC device should be to identify the required analog and digital functionality. When the block diagram is defined, an appropriate device with the right number of programmable blocks can be selected.

A Pyroelectric Biometric Sensor System for Human Identification

A novel pyroelectric sensor system uses biometrics to extract human walking features and to provide high-identification capability for intelligent machines and secure systems.

The pyroelectric infrared (PIR) sensor makes possible high-performance IR radiation detection at room temperature, while cost and low power consumption make it attractive for security applications. Tracking human targets with such a system has been described in figure 5, but little attention to date has been paid to walking, which can also be employed for purposes of identification and scene surveillance in security applications. It can also be used for tracking multiple persons.

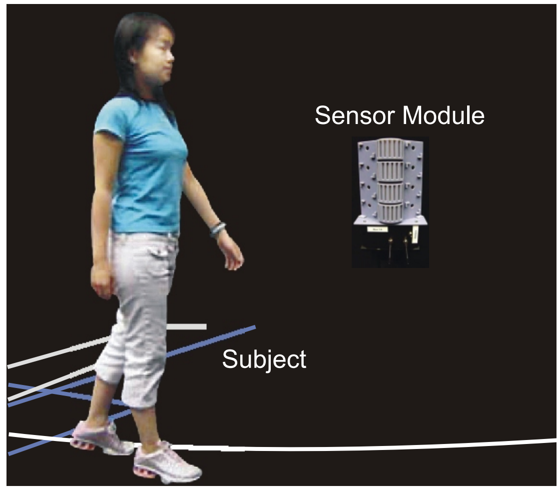

Fig.5 : Experimental setup for the pyroelectric infrared (PIR) sensor-based recognition system.

When humans walk, the motion of various parts of the body, including the torso, arms, and legs, produces a characteristic signature. Much work on motion analysis as a behavioral biometric has used video cameras to stream large amounts of data from which the identity of the person of interest can be extracted in a computationally expensive way. A continuous-wave radar has been developed to record the signature corresponding to the walking human gait. A new method has been proposed by which the features of motion are represented by the processed content of the temporal signal, generated by humans crossing the field of view (FOV) of the PIR sensor module.

Feature representation is key to biometric recognition. From a thermal perspective, each person represents a distributed IR source, the distribution function of which is determined by shape and IR emissivity of the skin at every point. Combined with idiosyncrasies of carriage, heat will uniquely impact a surrounding sensor field, even while the subject follows a prescribed path. By measuring the response thus generated within the FOV of a sensor module, it is possible to model data to create a code vector that uniquely identifies the person.

Conclusion

While a number of technologies for motion detection exist, including ultrasonic and microwave radiation sensors, the PIR sensor is popular for its ease-of-setup and high performance. In addition, PIR sensors are inexpensive and draw little power.