

Using Pyroelectric Infra-Red (PIR) Sensors for Motion Detection

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Executive Summary

Motion detection of an object can be achieved by using some stimulus and sensing its reflection as in RADAR, or by sensing the natural signals generated by an object. This article discusses motion detection of an object by sensing the infrared signal radiated from the object.

Infrared radiation exists in the electromagnetic spectrum at a wavelength that is longer than visible light. Infrared radiation cannot be seen but it can be detected. Objects that generate heat also generate infrared radiation and those objects include animals and the human body, whose radiation is strongest at a wavelength of 9.4 μm . To detect this signal, a transducer is required that converts the infrared signal to a form detectable with conventional circuitry.

Pyroelectric Sensors

The pyroelectric sensor is made of a crystalline material that generates a surface electric charge when exposed to heat in the form of infrared radiation. When the amount of radiation striking the crystal changes, the amount of charge also changes and can then be measured with a sensitive FET device built into the sensor as shown in Figure-1. The sensor elements are sensitive to radiation over a wide range, so a filter window is added to the TO5 package to limit incoming radiation to the 8 to 14 μm range that is most sensitive to human body radiation.

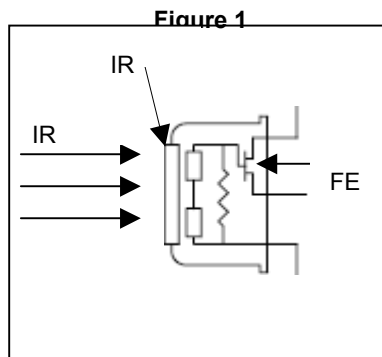
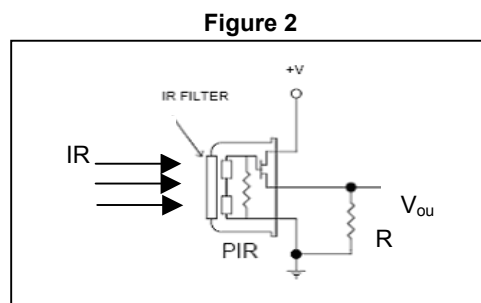
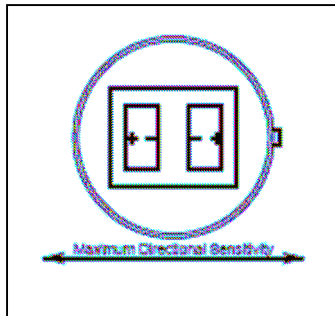


Figure-2 shows how an external resistor “R” connected to a radiation source converts the FET current to a voltage. A well-filtered power source from 3 to 15 volts should be connected to the FET drain terminal.



The output voltage is a function of the amount of Infrared Radiation (IR) sensed at the input. Unfortunately, the output is also affected by vibration, radio interference, and sunlight. To overcome this problem the sensor has two sensing elements, as shown in Figure-3, connected in a voltage-bucking configuration. This arrangement cancels signals caused by vibration, temperature changes and sunlight. A body passing in front of the sensor will activate first one and then the other element whereas other sources will affect both elements simultaneously and be cancelled. The radiation source must pass across the sensor in a horizontal direction when sensor pins 1 and 2 are on a horizontal plane so that the elements are sequentially exposed to the IR source.

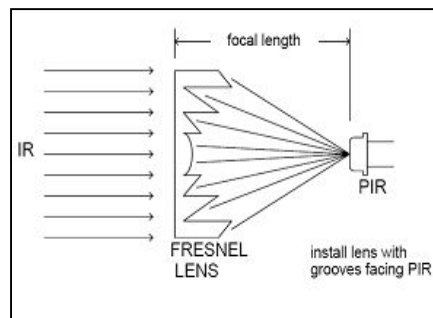
Figure 3



The distance from the front of the sensing elements to the front of the filter window is around 0.045 inch (1.143 mm), so a lens is required for detecting motion any more than a few feet away. Figure-4 shows a Fresnel lens placed in front of the PIR detector. A Fresnel lens is a Plano Convex lens that has been collapsed on itself to form a flat lens that retains its optical characteristics but is much smaller in thickness, therefore having less absorption losses.

The Fresnel lens is made of an infrared transmitting material that has an IR transmission range of 8 to 14 μm . It is designed to have its grooves facing the IR sensing element so that a smooth surface is presented to the subject side of the lens, which is usually the outside of an enclosure that houses the sensor.

Figure 4

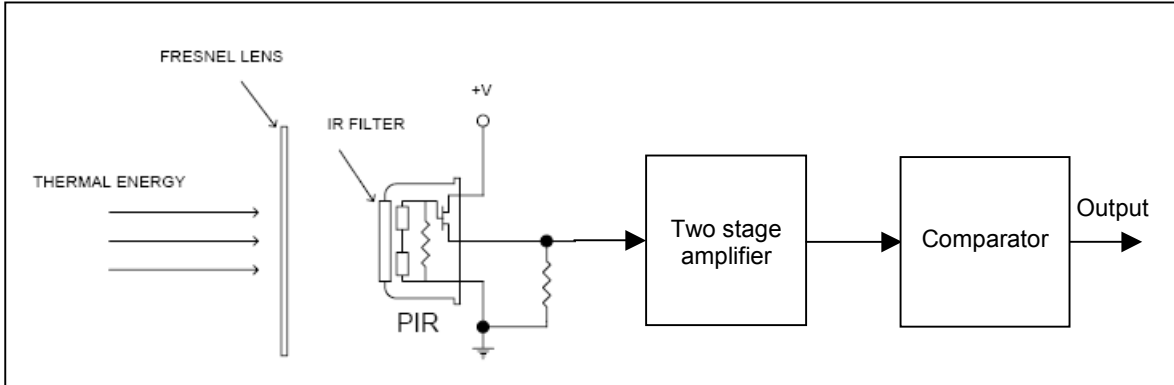


Application

Now after looking at a PIR sensor it is time to learn how to condition the signal from sensor to detect the human motion.

Figure-5 shows how the FET source terminal connects through a pull down resistor to ground and feeds into a two-stage amplifier having signal-conditioning circuits. The amplifier is typically bandwidth limited to below 10 Hz to reject high frequency noise and is followed by a window comparator that responds to both the positive and negative transitions of the sensor output signal.

Figure 5



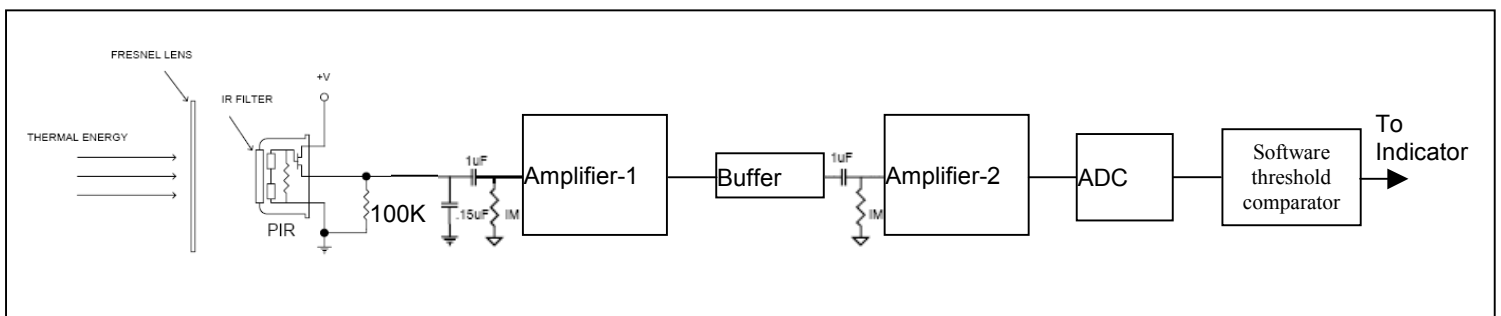
To build the above circuit with discrete components we may require four op-amps: two op-amps for the amplification stage and two for the comparator stage. We need two op-amps for the comparator stage to respond to both the positive and negative transitions of the sensor output signal.

Let us think about building the above application using a microcontroller. The question that arises is how we can reduce the external components, mainly the active ones, if we are using the microcontroller.

One answer is to use a product that is particularly well suited for this task, such as the PSoC family of mixed signal-arrays from Cypress.

Figure-6 shows application block diagram using a microcontroller. The signal condition circuit is built around using the simple R and C.

Figure 6





A 100-k Ω resistor is connected to the source of the PIR detector. A 0.15 μ F capacitor is connected in parallel to the resistor. This combination of components makes a 10 Hz low-pass filter. A 0.16 Hz high-pass filter is made with a 1 μ F capacitor and a 1 M Ω resistor. Amplifier-1 provides a gain of 16 to the signal. It is brought out to buffer and is high-pass coupled into the input of Amplifier-2 to provide another gain of 16 for a total gain of 256. The signal is then fed to a 13-bit ADC where the signal is digitized at 240 samples per second. The digital values from the ADC are software compared for threshold levels on either side, and an indicator is activated to identify the detection of human motion.

Conclusion

Using PSoC there is no need for external active components to buffer, amplify and detect a moving infrared signal source.



References

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