Pyroelectric Motion Detector Application

Asist.ing. Mihai Timiş
Technical University "Gh.Asachi" Iaşi
mtimis@cs.tuiasi.ro

ABSTRACT. In this paper we consider the problem of design & use a pyroelectric motion detector circuit. First we define the terms like infrared radiation and pyroelectric infrared sensors (PIR). Secondly we show a design of pyroelectric infrared motion detector. Applications to detect motion are many like: generating some stimulus and sensing its reflection, sensing some natural signal generated by an object.
Keywords: Pyroelectric Sensors (PIR), Infrared Sensors, Operational Amplifier, Microcontroller, MSP430, Digital, Analog.

1 Foreword

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 including animals and the human body whose radiation is strongest at a wavelength of 9.4mm.

PIR sensors allow motion detectors to be built that do not require a stimulus signal. Relying only on a body's radiated infrared radiation, a passive detector is less expensive to construct. The purpose circuit schema integrates all the active circuitry required to construct a motion detector.

2 Infrared Radiation

Infrared is the portion of the electromagnetic spectrum that falls between microwaves and visible light. Infrared has wavelengths longer than visible

light but shorter than microwaves. Humans, at normal body temperature, radiate most strongly in the infrared, at an approximate wavelength 10 μm. To detect this signal, a transducer is required that converts the infrared signal to a form detectable with conventional circuitry.

3 Pyroelectric Infrared 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. 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 14mm range which is most sensitive to human body radiation.

A pyroelectric sensor is made of ceramic material that generates a surface charge when exposed to infrared radiation. As the amount of radiation changes, so does the charge. Being a high impedance signal, a FET is used to buffer this potential as shown in figure 1:

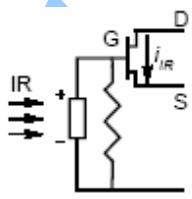

Figure 1: Pyroelectric Charge Measured with a FET

This sensor is sensitive to a wide range of radiation. To optimize for human detection, a filter window is added to limit the incoming radiation to a range of 8 μm to 14 μm. It is shown in figure 2 with an external resistor to convert the FET current to a voltage:

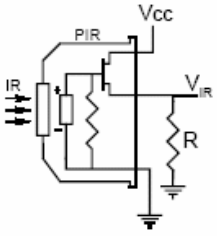

Figure 2: Single Element

The output voltage is a function of the amount of Infrared Radiation (IR) sensed at the input.

The sensing elements are connected such that one subtracts from the other.

A body passing in front of the sensor activates first one and then the other element while vibration, and other background signals, affect both elements simultaneously and are cancelled. The layout of the two elements allows for maximum sensitivity along a single axis. A typical dual-element layout is shown in figure 3.

Figure 3: Dual-Element Pyroelectric Layout

Each application's requirements determine how the sensor is mounted for desired directional sensitivity.

Figure 4 shows a quad element sensor that eliminates directional sensitivity:

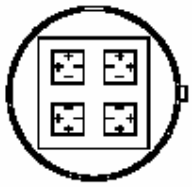

Figure 4: Quad Element Pyroelectric Layout

Figure 5 shows how typically, the FET source terminal pin 2 connects through a pulldown resistor of about 100 K to ground and feeds into a two stage amplifier having signal conditioning circuits and a gain of 10,000 that produces a 0 to Vcc transition at its output. A well filtered power source of from 3 to 15 volts should be connected to the FET drain terminal pin 1. The amplifier is typically bandwidth limited to about 10Hz 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.

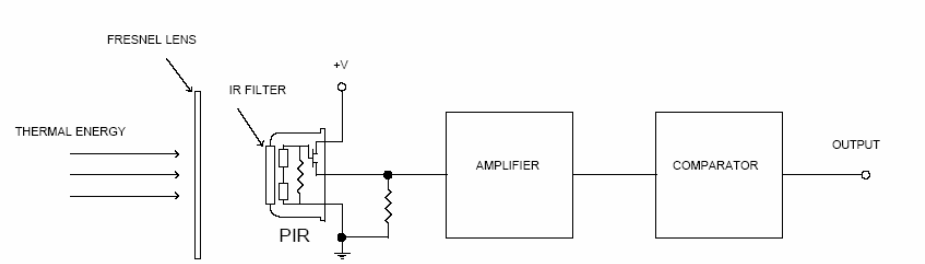

Figure 5

A body passing in front of the sensor will activate first one and then the other element as shown in figure 6 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.

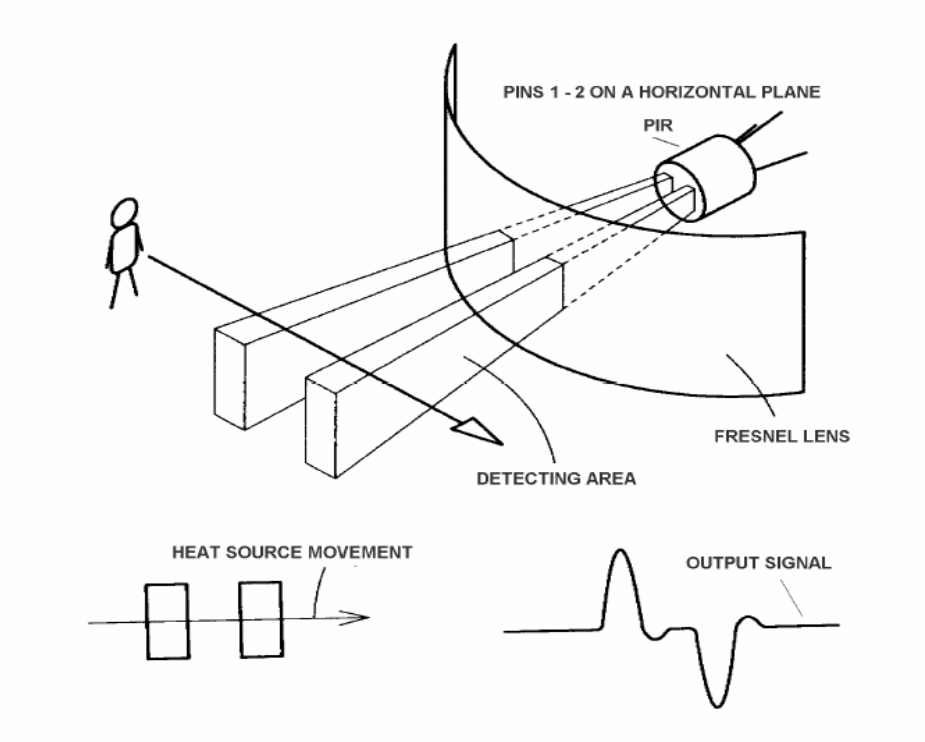

Figure 6

We want to design & use a pyroelectric circuit that senses the presence of the human body, this application is very useful in case of complex alarms systems. Our intention is to use this design on a mobile robot explorer for presence detection of a body (human, animals).
In scheme figure 7 we use a pyroelectric sensor (PIR sensor). The operational amplifier (U1A) is used for capture the information from pyroelectric sensor and amplified it. The entire schema is feed by a 5Vcc voltage (JR4).

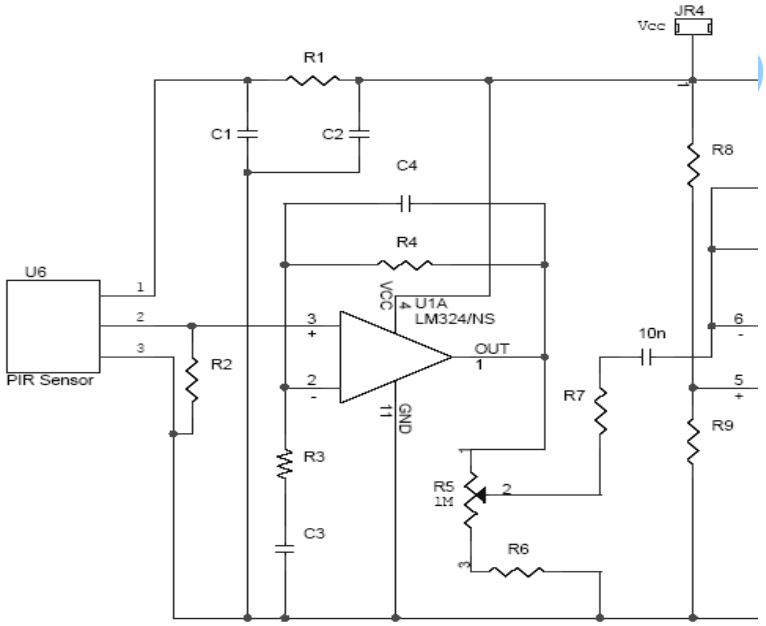

Figure 7

All these informations captured from pyroelectric sensor are output to an MSP430 microcontroller (JR2), like in figure 8. The MSP430 icrocontroller takes all data sent by PIR , process it and take the decision to start or stop the alarm.

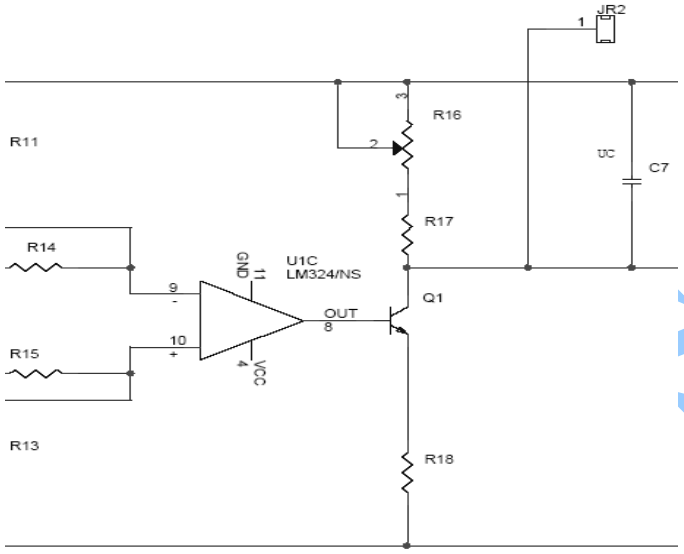

Figure 8

Conclusion

The designed system was made for simple construction of a PIR motion detector. The application of such a system could be used like example to monitor human body presence, complex alarm systems, mobile robots and so on. The domain in which this application can be used is very large.

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