General Description

This application note demonstrates how to create a Motion Detector with a PIR Sensor using GreenPAK2.

Introduction

A passive infrared sensor “PIR sensor” is an electronic sensor that measures infrared (IR) light radiating from objects in its field. It is typically used to sense movement of people, animals, or other objects in the sensors range. It’s inexpensive, low-power and easy to use. The sensor type is often referred to as PIR, "Passive Infrared" or "IR motion".

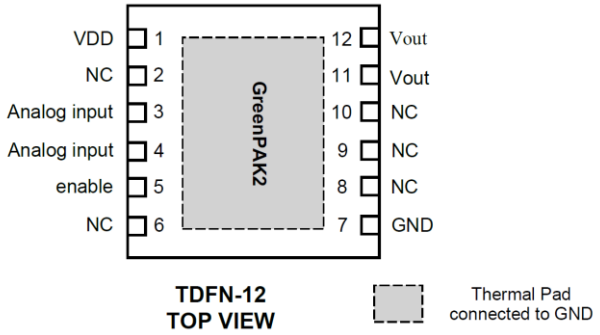

Figure 1. Pin configuration

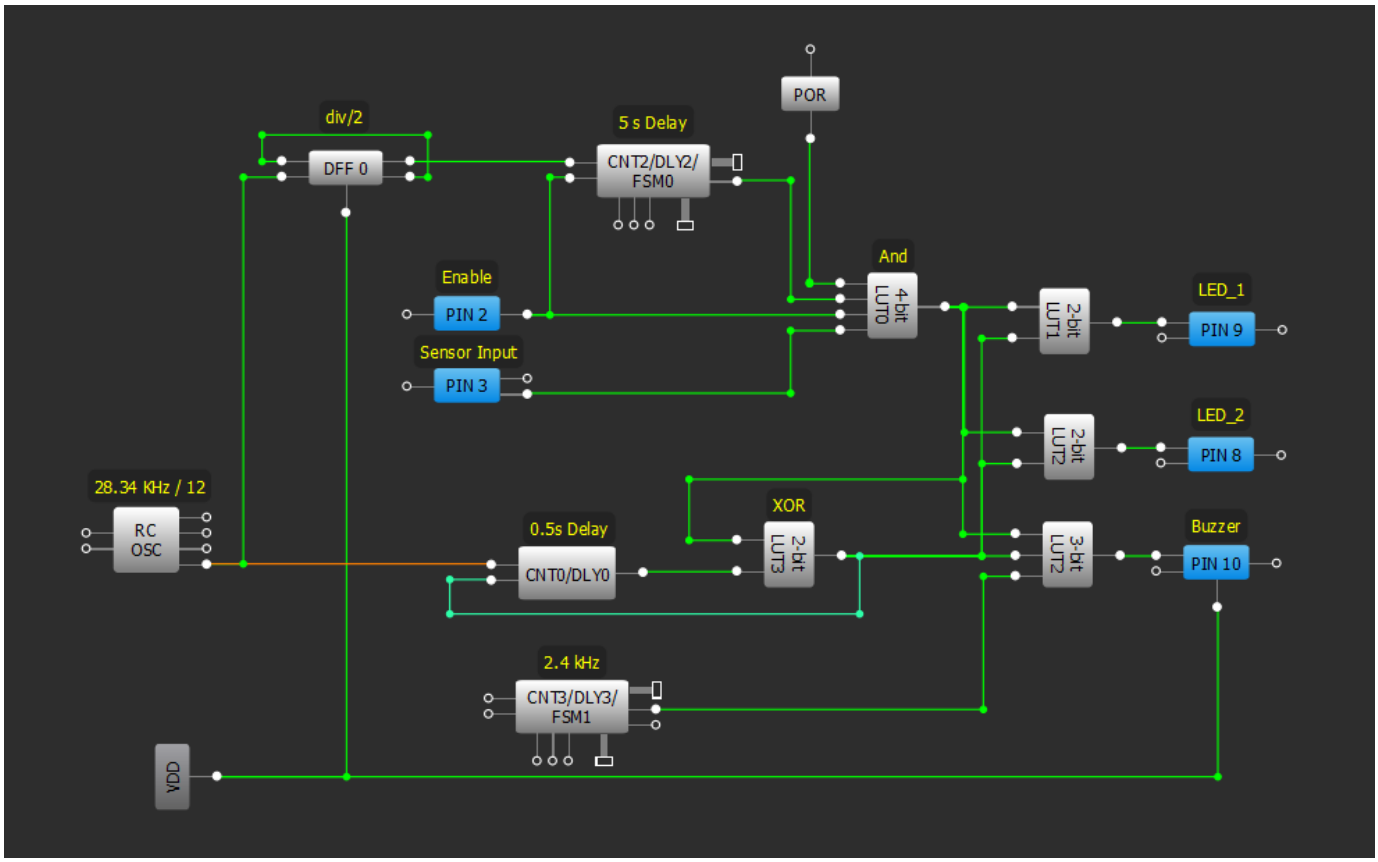

Figure 2. Design connections in GreenPAK2 Designer

The term passive refers to the fact that PIR devices do not provide illumination for detection purposes. They work entirely by detecting IR sources within its field of view and range.

They are commonly used in:

- 1. Security Products.
- 2. Human body sensors and toys.
- 3. Automatically activated lighting systems.
- 4. Industrial automation and control, etc.

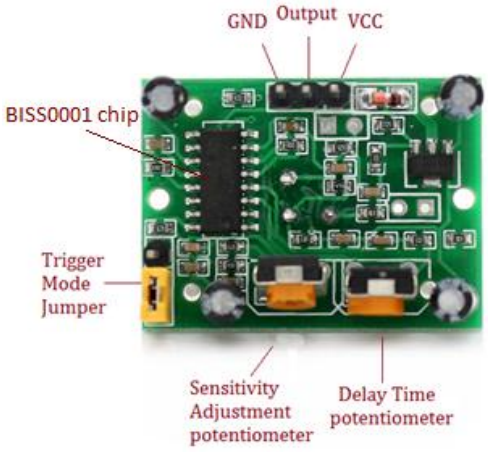

Figure 3. PIR sensor (bottom view)

Note, that PIRs won't tell you how many people are around or how close they are to the sensor.

For this experiment, we are using the HC-SR501 as pictured. It is built around the BISS0001 chip.

Figure 4. PIR sensor (top view)

PIR Model	HC-SR501
Operating voltage range	DC 4.5-20V
Detecting Range	Approx. 7m (Adjustable)
Level output	High 3.3 V /Low 0V
Delay time	5-200S (Adjustable)
Block time	2.5S
Angle Sensor	<100 ° cone angle

Table 1. PIR Model

There are two-trigger modes that can be selected by the jumper. “Repeatable” trigger for when you want the output to keep high if movement continues, and “cannot repeat” trigger where the output goes low after a time delay is exceeded.

The delay time in this example is set to 5s.

Description

The HC-SR501 PIR output is digital, and it is connected directly to PIN3 which is configured as digital input without any pull up/down resistors. This can be seen on the Typical Application Circuit diagram.

Once the Enable switch is closed, the GreenPAK2 is set to wait for 5s before it starts reading from the PIR. That provides settling time for the PIR.

When the PIR detects motion, two LEDs will start blinking simultaneously every 0.5s, and a buzzer will make a sound every 0.5s. This alarm will keep running for 5s. If the PIR continues detecting motion and outputting the trigger signal, the alarm will continue as well.

Circuit Design

In Figure 5, the Enable switch is connected to PIN2, configured as “digital input” having an internal 300k pull down resistor. The resistor ensures that the pin is pulled to GND unless the button is pressed and the pin gets pulled up to VDD.

In this example, the RC OSC is set to be Auto Power On. This option will make sure the RC OSC will work only when it’s needed. It provides the 28.34 KHz clock frequency.

As the minimum internal RC OSC frequency is 28.34 kHz, additional frequency divider based on D-type Flip-Flop (DFF0) with a feedback from its inverting output to data input is used to divide the clock frequency by 2. Clock source for DFF0 is from RC OSC/12 connection.

The Q output from DFF0 is used to clock CNT2/DLY2, (i.e. $(\frac{28.34k}{12} \text{x } \frac{1}{2} = 1.18 \text{ kHz})$).

CNT2/DLY2 is used to provide a 5s delay, which is enough settling time for the PIR. To have the 5s delay, counter data is 5903.

$$Time\ period = (counter\ data + 1)/CLK$$

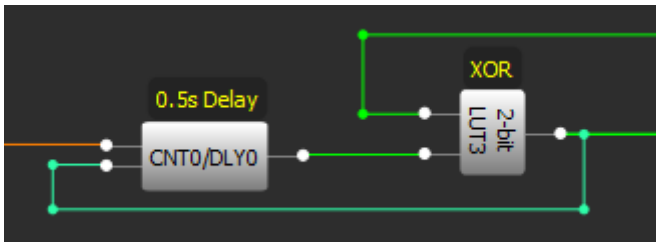

Figure 5. CNT0/DLY0 and 2-bit LUT3 in GreenPAK2 Designer

Symbol	Parameter	Min.	Typ.	Max.	Unit
TDLY0	DLY0 Time Delay	-	500.0706	-	ms
TDLY2	DLY2 Time Delay	-	5	-	s
TCNT3	CNT3 Period Time	-	0.4234	-	ms

Table 2. Design Main Electrical Characteristics

POR and input PINs are connected to 4-bit LUT0 input, and serves for correct startup of the delay cells. Using the POR block ensures that the circuit wouldn't be influenced by external signals before all the blocks have powered up.

CNT0/DLY0 is sourced from RC OSC/12 and is used as a 500ms delay block. Combined with the 2-bit LUT3 (XOR), a 500ms HIGH/500ms LOW signal is generated. When "Sensor Input" is high and "Enable" is ON, the output of 2-bit LUT3 will be high.CNT0/DLY0 will delay the high signal for 500ms, and then the XOR LUT output will go low. CNT0/DLY0 will delay that low signal for 500ms, and then the XOR LUT will go high again, etc.

Piezoelectric Buzzer

Some buzzers have an internal oscillator built into them, and only require a DC voltage to run. These are called internal drive buzzers or self-oscillating buzzer. The ones without that circuitry are called external drive buzzers.

In this example, an external drive buzzer is used. CNT3/DLY3 sourced from RC OSC is configured as a counter and used as a frequency divider to provide the proper oscillation frequency to drive the buzzer, which in this case is 2.4 kHz.

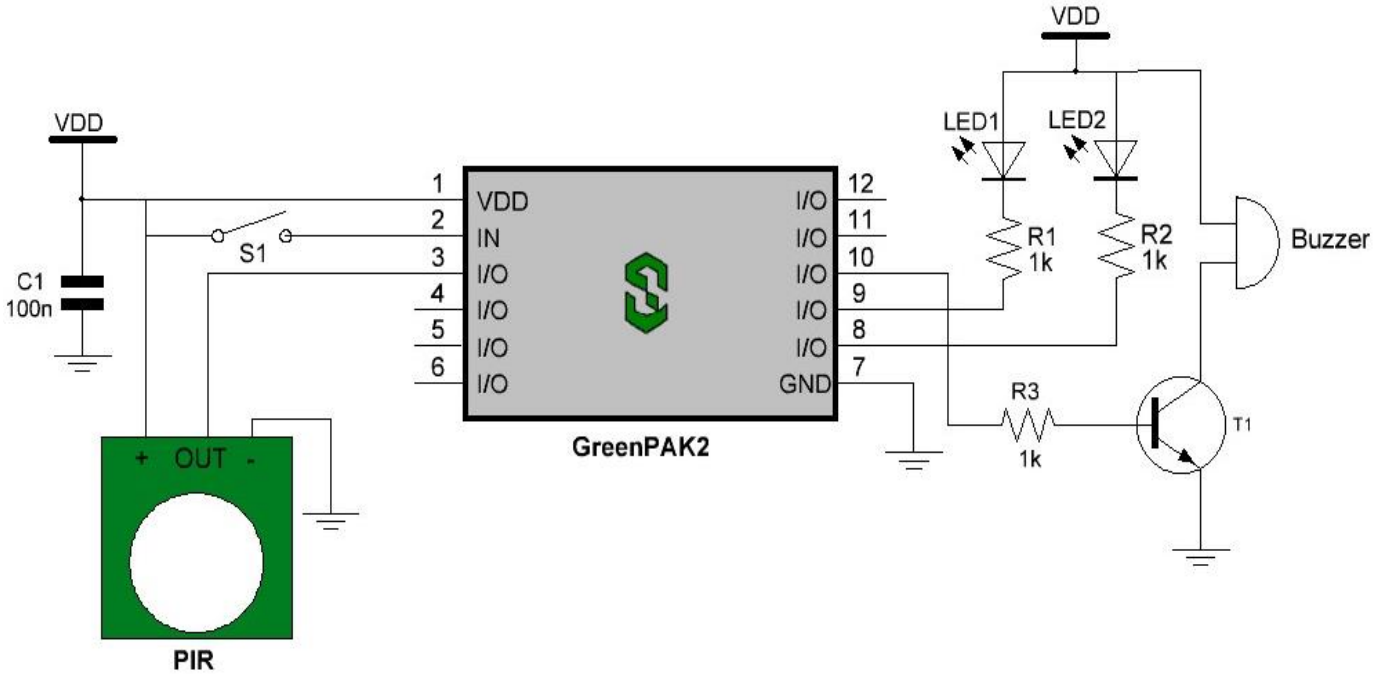

Figure 6. Typical Application Circuit

For proper counter functionality, the counter should be configured as Force Power On.

$$Output\ frequency = \left(\frac{28.34k}{11+1}\right) \approx 2.4\ kHz$$

A typical drive circuit for an external drive buzzer is shown in the Typical Application Circuit Diagram.

PIN2, PIN3 and PIN8: Set Configurable Button.

PIN11 and PIN12: Buffered LED

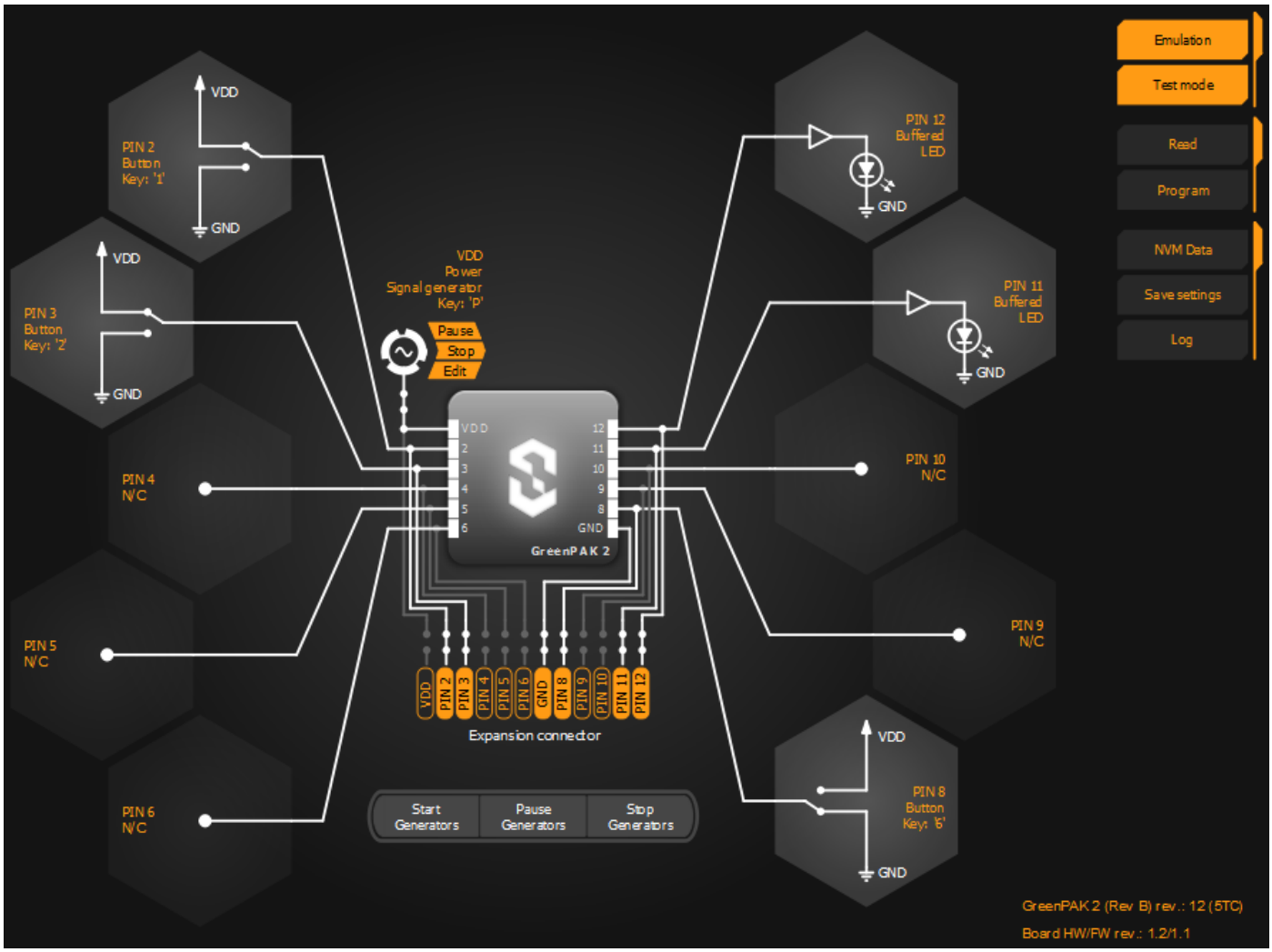

Figure 7. Configuration in GreenPAK2 Emulation Tool

Functionality Waveforms

Functionality waveform of real motion detector with a PIR sensor circuit created in GreenPAK2:
Channel1 (blue/top line) – PIN2 (Enable)

Channel2 (brown/2nd line) – PIN3 (Sensor Input)

Channel3 (green/3rd line) – PIN8 (LED_2)

Channel4 (red/ bottom line) – PIN10 (Buzzer).

One Time Motion Detected (see figure 9).

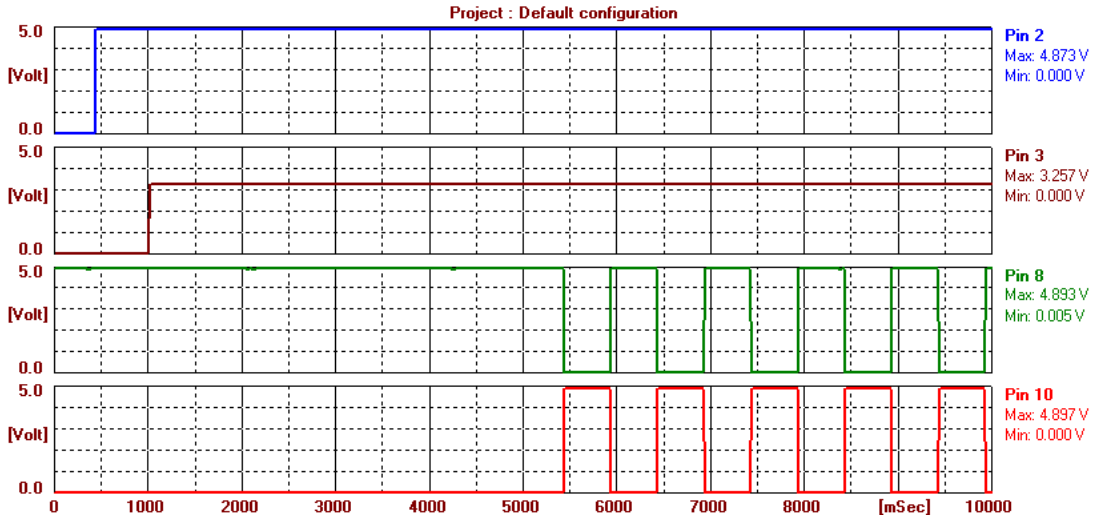

Figure 8. Functionality waveforms of powerup & motion detected

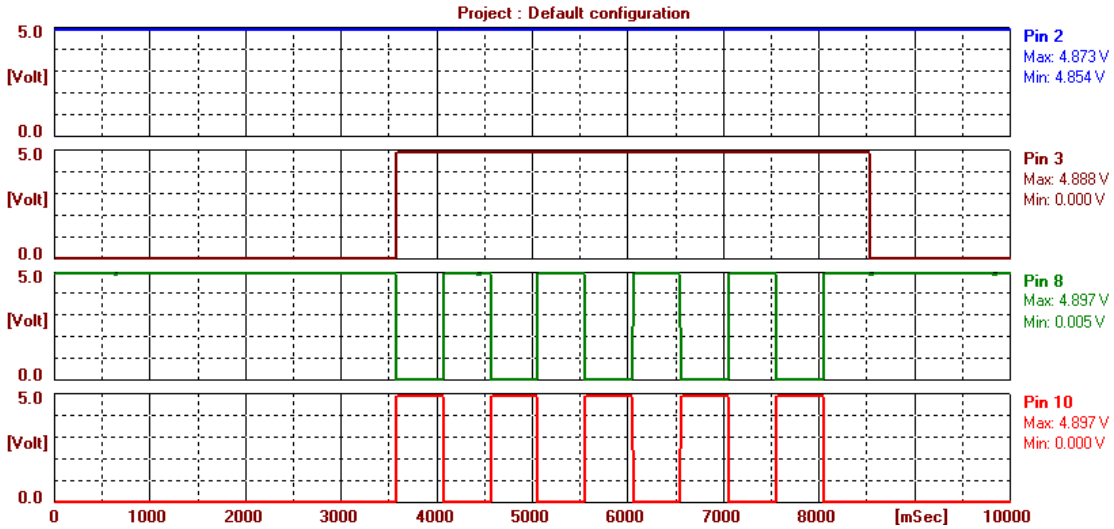

Figure 9. Functionality waveforms of subsequent motion detected

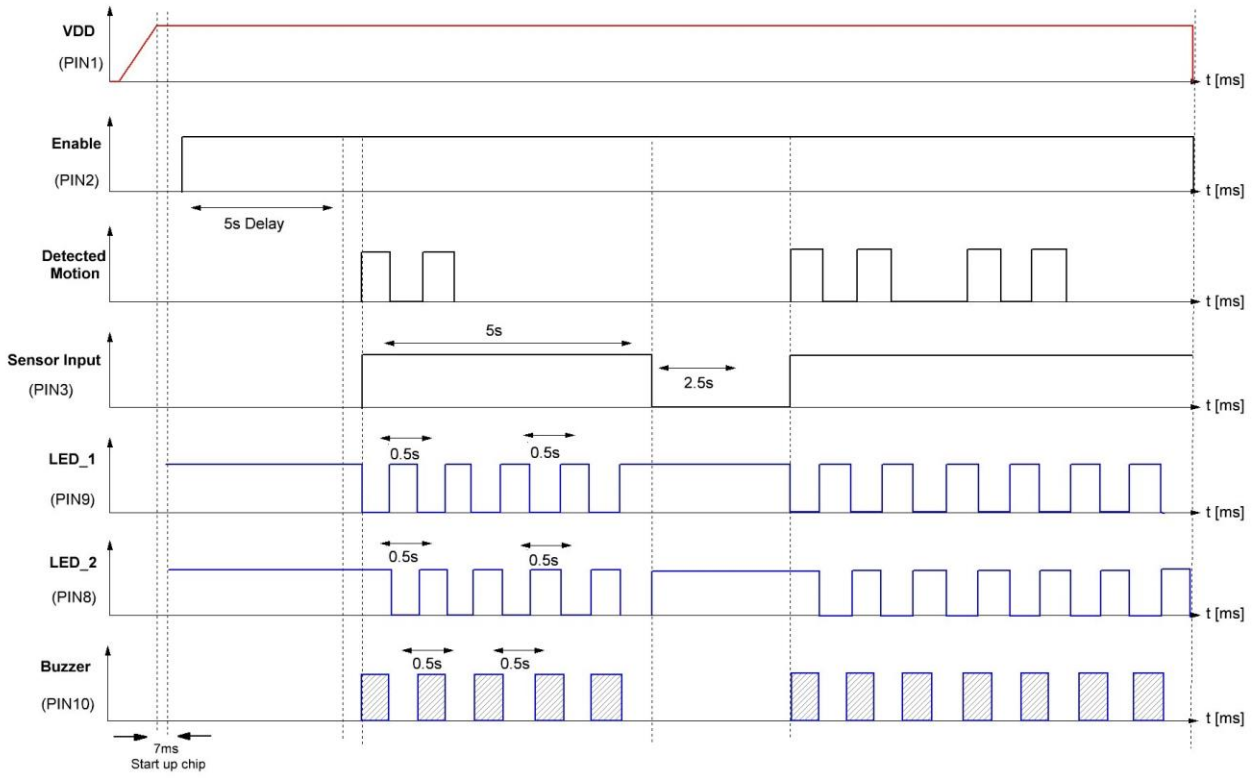

Figure 10. Timing Diagram

Note: For proper operation of circuit, do not forget to correctly configure input and output pins. In case of schematic you see on Figure 2, inputs are configured as digital input with Schmitt trigger, the outputs "PIN8 and PIN9" as open drain, and "PIN10" as push-pull.

Conclusion

PIR sensors are used in many applications that include motion detection. The GreenPAK2 was easily configured to properly manage powerup, varied sensor inputs, and driving of alarm LED's and Piezo buzzer.

About the Author

Name: Majd Obeidat

Background: Majd Obeidat graduated from Jordan University of Science and Technology –Jordan in 2013, studying at the Department of Electrical Power Engineering. Presently he is working with Configurable Mixed Signal ICs (CMICs) and their application notes at Core Nano Technology-Jordan.

Contact: **appnotes@silego.com**

Document History

Document Title: Motion Detector with PIR Sensor

Document Number: AN-1035

Revision	Orig. of Change	Submission Date	Description of Change
A	Majd Obeidat	3/20/2014	New application note

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SILEGO TECHNOLOGY

Silego Technology Inc.
1715 Wyatt Drive
Santa Clara, CA 95054

Phone : 408-327-8800
Fax : 408-988-3800
Website : ww.silego.com