

AN2414

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Associated Project: Yes

Associated Part Family: CY8C24x23A, CY8C27x43

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Software Version: PSoC Designer™ 4.3

Associated Application Notes:

[AN2105](#)

[PSoC Application Notes Index](#)

Application Note Abstract

This application note describes a complete proximity sensing application using a PIR motion sensor.

Introduction

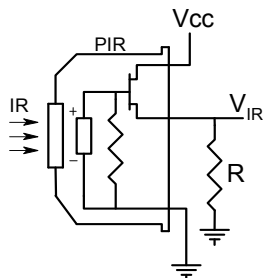
The analog blocks of PSoC® can be used to process the signal from a PIR (Pyroelectric Infrared) motion sensor and detect the presence of objects that emit infrared light. This application note describes an application where PSoC is used to detect the presence of human beings to control an electric load. This circuit can be used for controlling a porch light or operating a door.

The complete board is available as an Evaluation Kit from Cypress Semiconductor as CY3236A-PIRMOTION.

Brief Theory of PIR sensing

Humans, at normal body temperature, radiate infrared light waves at an approximate wavelength of 10 μm . A Pyroelectric Infrared Sensor can detect this infrared radiation and convert it to an electric charge. This charge is buffered through a FET and can be converted to voltage variations using a load resistor.

Figure 1. Single Element Pyroelectric Detector



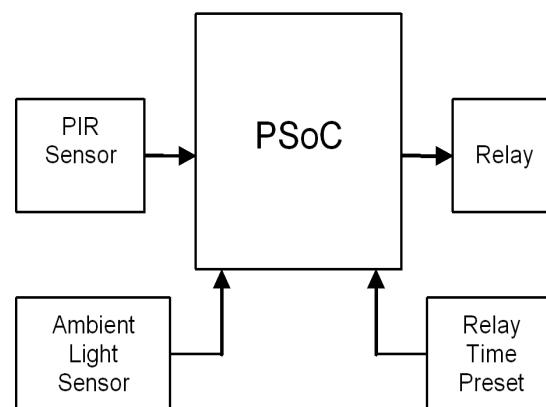
This voltage is measured using an ADC and, after some digital signal processing, can be used to detect the presence of human beings.

For details of the PIR sensing method, refer to Application Note AN2105, "Pyroelectric Infrared Motion Detector, PSoC Style" by Dave Van Ess.

The Hardware

Figure 2 shows the block diagram of the PIR board. The heart of the circuit is the PSoC. The PIR signal is fed to the analog blocks of the PSoC.

Figure 2. Block Diagram



The PSoC processes the signal from the PIR and, based on the inputs from the light sensor and the Relay Time Preset, controls the relay. The light sensor senses the ambient light and feeds the PSoC with an analog signal proportional to the ambient light. The Relay Time Preset control is a preset that provides a 0 to 5V signal to the PSoC. The Ambient Light Sensor can be used in applications such as automatic porch light control, where the load need not be switched on during daylight. Similarly, the Relay Time Preset can be used to control the duration for which the relay remains on when infrared wavelengths are detected. This can be used to set the time a door remains open to allow a person to pass or the time the porch light remains on.

“Appendix A. Schematic Diagram” on page 5 shows the schematic diagram of the board. U1 is the main power regulator that regulates the 12V input supply to 5V. U2 is the main processor, which is a CY8C27443-24PVXI PSoC device with 12 analog blocks, eight digital blocks, 16K Flash, and 256 bytes of RAM. U3 is the PIR325 sensor from Glolab Corporation. R10 and C7 form an RC filter to remove any noise from the supply rails before feeding power to the PIR sensor. R12 is the load resistor that converts the current from the PIR sensor to voltage. R12 and C9 form a low pass filter. The output of the PIR sensor is fed to the PSoC’s first amplifier stage using C8 and R11. C8 and R11 act as a high pass filter and also shift the PIR signal from Vss to Analog Ground, which is 2.5V. R13 and C10 decouple the AGND to Vss and attenuate any noise present on the AGND. Inside the PSoC, the signal from the PIR is amplified with a gain of 16. The output of the first stage is brought out at pin 3 of the PSoC and is fed back to the second amplifier stage by high pass filter C6 and R9. The output of the second stage amplifier is fed to an internal ADC and the output of the ADC is processed in firmware to detect the presence of infrared light; the relay is operated.

LED D7, which is connected to P[1]4, is used to indicate that the sensor detects infrared light. Two more LEDs, D5 and D6, have been provided on the board. They can be used for other operations, for example detecting direction of movement, etc. Transistor Q1 is used to drive a 12V SPDT relay, which can control an electrical load connected to J3.

Apart from the main PIR signal processing, there are two other functions performed by the PSoC. The first is ambient light sensing. A photo sensor, RPM-075PTT86 from ROHM CO LTD., is used to detect ambient light. The photo current from the sensor is converted to voltage using a preset R8. The voltage across R8 is fed to the PSoC. The PSoC amplifies this voltage using an amplifier, measures the output and decides, based on the ambient light threshold, whether to control the relay when infrared light is detected. The second function is the Relay On Time. Potentiometer R7 feeds the PSoC with a voltage Vss to Vdd. PSoC measures this voltage and based on the value of the voltage, adjusts the duration for which the relay is activated.

Device Configuration

The analog and digital user module placement within PSoC Designer are shown in [Figure 6 on page 6](#) and [Figure 7 on page 6](#). The project uses three analog blocks and two digital blocks for the actual PIR implementation. Two more analog blocks are used for a 9-bit DAC. The DAC9 is purely for debugging purposes. If desired, the CY8C24x23A device family can be used in a similar design in place of the CY8C27443.

1. ADCINCVR: The incremental ADC is configured as a 12-bit ADC. This is used to measure the PIR signal, voltage from the Relay Time Preset and the voltage from the photo transistor.
2. PGA: Two amplifier stages are used. The first amplifier is used as the first amplification stage for the PIR signal. The second amplifier performs three functions. It is used as the second stage amplifier for the PIR signal with a gain of 48, or to buffer the voltage from Relay Time Preset to the ADC with a gain of 1, or to amplify the voltage generated by the photo transistor by a gain of 4 and feed it to the ADC. The gain change and switching of signals are done inside the ADC state machine in firmware.
3. Counter8: One 8-bit counter is used as a time base generator. The input to this counter is VC3, whose output is 93.75 kHz. The period of the counter is set to 188, which produces an output signal of 498.6 Hz, with an interval of approximately 2 ms. Inside the ISR of this counter, once every 62 counter interrupts, a flag is set to indicate that 0.125 seconds have elapsed. So, this sets the basic timing of the project to approximately 0.125 seconds
4. DAC9: This 9-bit DAC is used to output the processed PIR signal, which can be observed externally. This is only for debugging purposes and in actual product implementation can be removed.

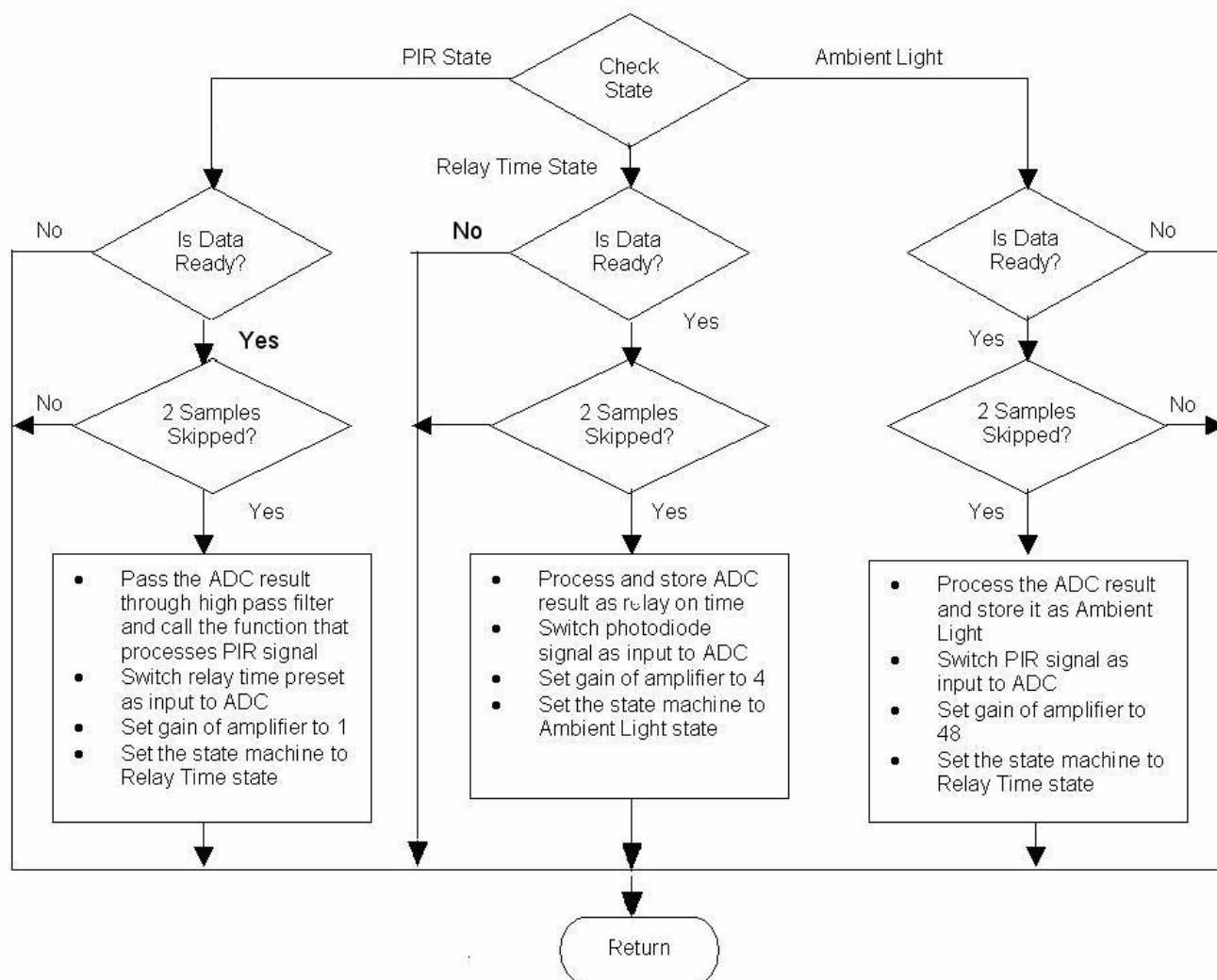
Firmware

The following are the operations performed by the firmware.

1. Initialize the hardware.
2. Enter an infinite loop where the following operations are performed.
 - ADC state machine is executed. The ADC state machine properly switches the PIR and Relay Time Preset, processes the photo transistor signals, and sets the amplifier gain settings. This also stores the ADC result in the appropriate variable for processing.
 - If the state is PIR state, the PIR signal value is passed through a digital high pass filter. Then if the PIR signal exceeds the threshold and if the ambient light level is below the threshold, the Relay is switched on. The motion detect LED connected to P1[4] is also switched on.
 - If 1/8 of a second has elapsed, the ProcessTimer function is called. Inside this function the Relay On Time, Motion LED On Time, and initial POR delay operations are taken care of.

[Figure 3 on page 3](#) and [Figure 4 on page 4](#) show the flowcharts of the firmware.

Figure 3. Flowchart of the ADC State Machine



ADC State Machine

This state machine takes care of measuring the signals. It is executed once every main loop. There are three states that loop continuously.

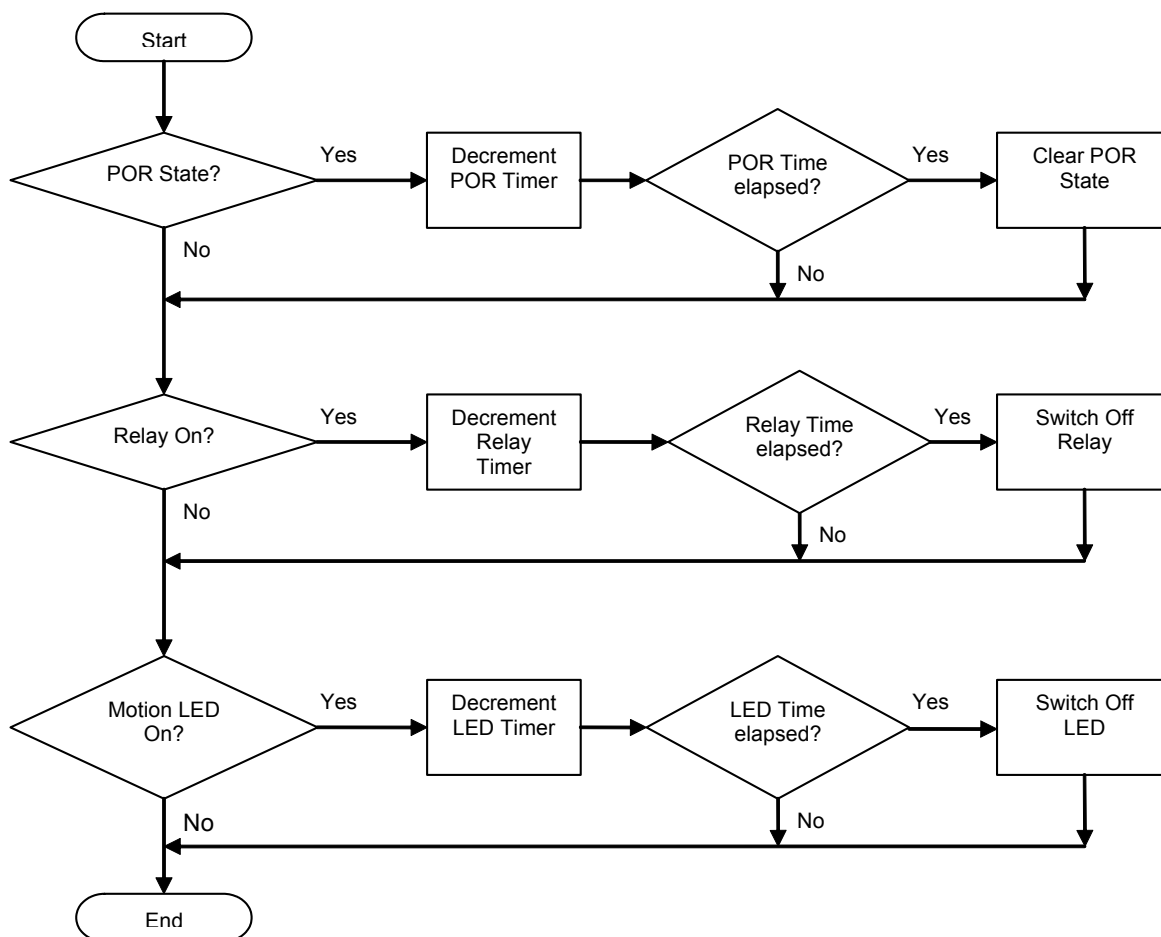
PIR Signal State: In this state, two samples are dropped (to obtain a valid reading after input has been switched) and the valid sample from the PIR is passed through a digital high pass filter. Then if the processed signal is greater than the PIR threshold and is less than the ambient light threshold, the relay and the motion detect LED are switched on. The gain of the second stage amplifier is set to 1 and the Relay Time Preset voltage is connected to the second stage. The state machine is updated to "Relay Time State."

Relay Time State: In this state, two samples are dropped and the third valid sample is stored in the Relay variable. This

value is used by the ProcessTimer function to properly switch off the relay after the set time has elapsed. The photo transistor is connected to the second stage amplifier and the gain of the second stage is set to 4. The state machine is updated to "Ambient Light State."

Ambient Light State: In this state, two samples are dropped and the third valid sample is stored as the ambient light value. This value is used in the decision to switch on the relay during the "PIR Signal State." The output of the first gain stage is connected to the second gain stage, and the gain of the second gain stage is set to 48. The state machine is set to "PIR Signal State" and the measurement cycle repeats.

Figure 4. Flowchart of the ProcessTimer Function



ProcessTimer Function

The ProcessTimer function is called every 0.125 seconds from the main loop. This function handles three timing operations.

POR: Initially when the power to the board is switched on, the input needs some time to stabilize around AGND. So, the PIR signal is not processed for about 60 seconds after power on. During power on, a flag in a RAM variable is set to indicate "POR" state. The ProcessTimer function decrements a POR counter and when this counter reaches zero, clears the POR flag in the RAM. Once the POR flag is cleared, normal processing of the PIR signal takes place.

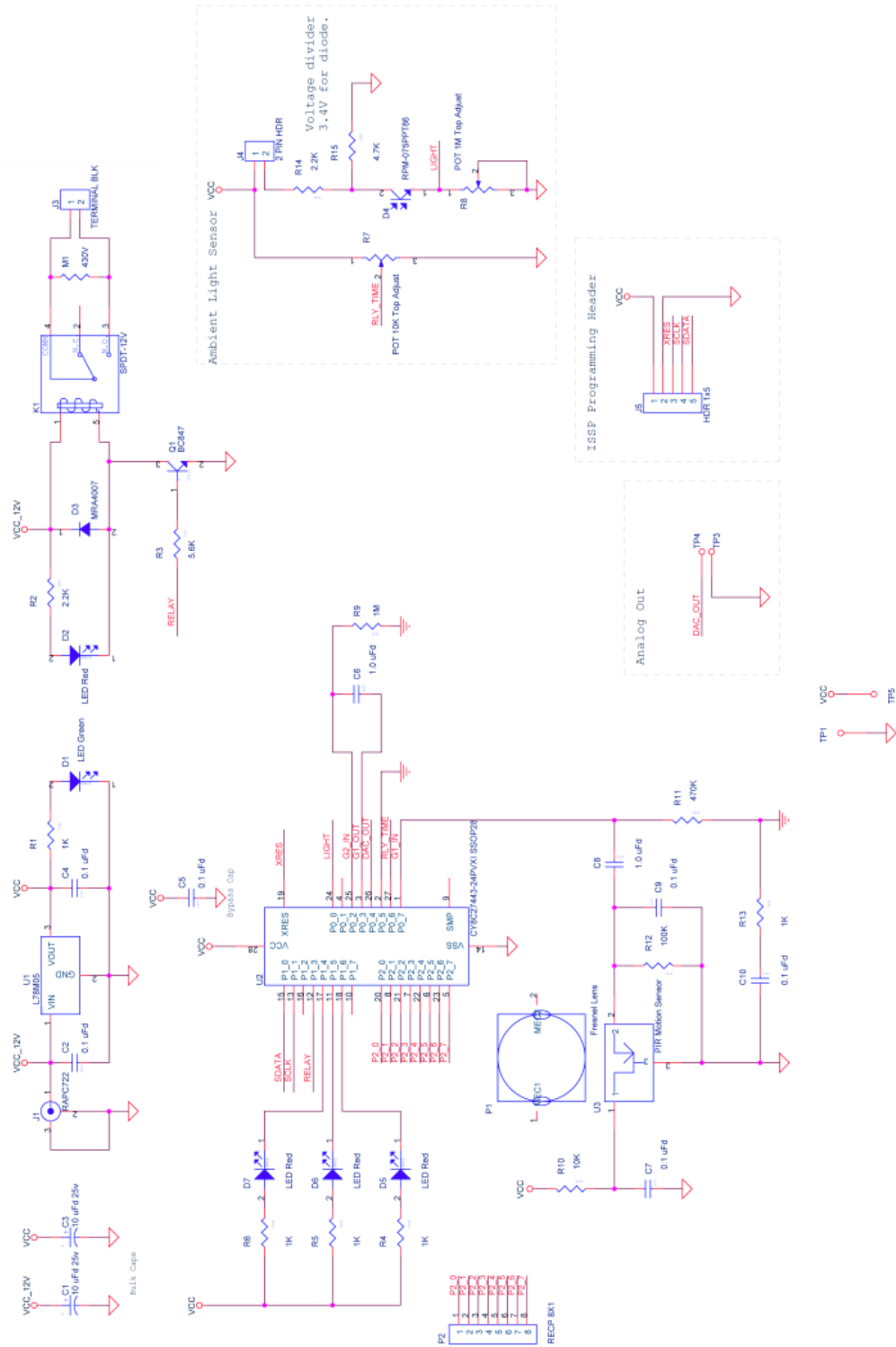
Relay On Time: If the relay is switched on, the function decrements a counter which is initialized to the time indicated by the Relay Time Preset. When this counter reaches zero, the relay is switched off.

Motion LED On Time: If the motion LED is on, the function decrements a counter which is initialized to about 1 second when motion is detected. When this counter reaches zero, the motion LED is switched off.

Summary

This application note discusses an application in which a PIR sensor is used to detect the presence of infrared light and use that light to control an electrical load. Other improvements are possible using the same circuit. LEDs D5 and D6, which are unused, can indicate direction of movement. In a PIR sensor there are two elements. One element produces a positive signal and the other produces a negative signal. Logic can be added in the firmware to detect the sequence of occurrence of positive and negative signals to decide if the movement is from "Right to Left" or "Left to Right" and LEDs D5 and D6 can be operated accordingly.

Figure 5. Appendix A. Schematic Diagram



Appendix B. Resource Placement

Figure 6. Analog User Module Placement

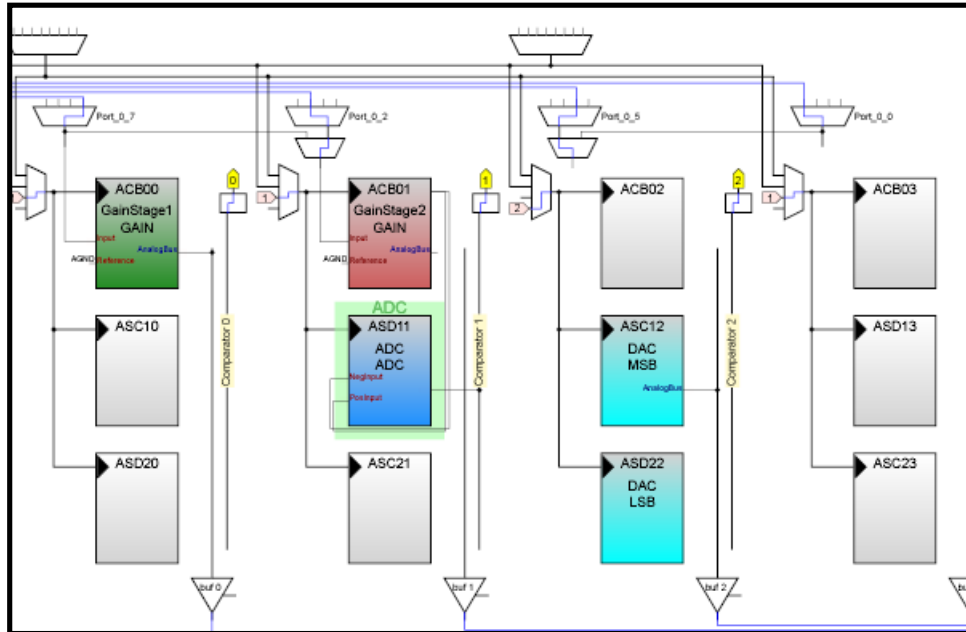
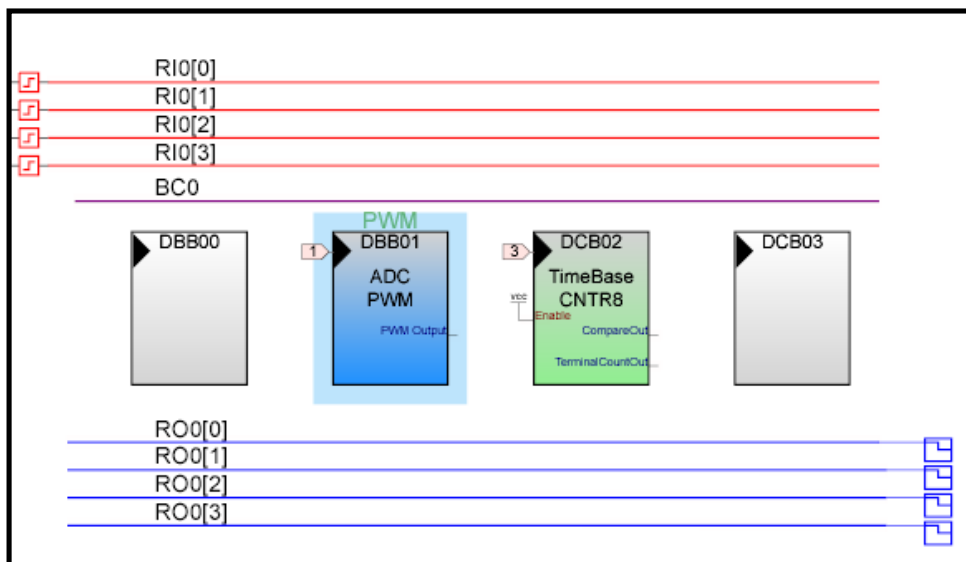


Figure 7. Digital User Module Placement



Document History Page

Document Title: Sensing - Proximity Sensing Using PIR

Document Number: 001-41440

Revision	ECN No.	Orig. of Change	Submission Date	Description of Change
**	1541809	GRAA	10/04/07	New application note
*A	2621966	DRSW	12/15/08	Resized Figure 2

In March of 2007, Cypress recataloged all of its Application Notes using a new documentation number and revision code. This new documentation number and revision code (001-xxxxx, beginning with rev. **), located in the footer of the document, will be used in all subsequent revisions.

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