Reduce False Triggers and Extend Battery Life in PIR Sensing Applications

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Passive Infrared (PIR) sensors are widely used in building automation applications to detect motion from a person or object. An amplifier and window comparator circuit is often used to gain and filter the output of analog-output PIR sensors and to generate microprocessor interrupts during motion events. This circuit can be implemented using a quad op-amp or a dual op-amp plus two comparators. Alternatively, a digital-output PIR sensor with integrated buffers and comparators can be used. Both the analog-output and digital-output PIR sensors have distinct advantages, but also come with trade-offs. Figure 1 illustrates an innovative PIR sensing circuit architecture consisting of an analog-output PIR sensor, a nanopower system monitoring ADC, and a dual-channel signal conditioning amplifier. The ADC includes some unique features that can be used to intelligently monitor the sensor without having to wake up the host MCU.

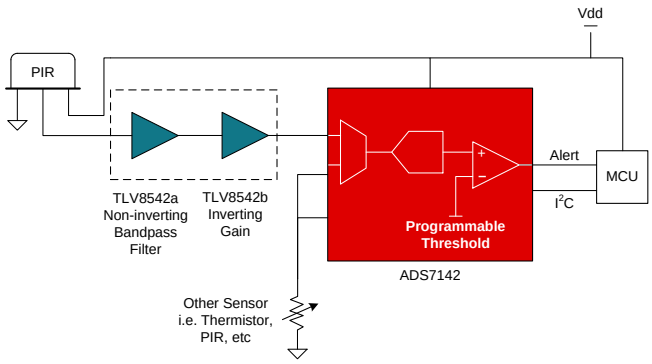

Figure 1. PIR Sensing System Block Diagram

When comparing these different system architectures, it is important to consider the key trade-offs. Table 1 summarizes these common care-abouts and trade-offs assuming cost comparability.

In systems where robustness is important to help avoid false triggers and thereby save overall power consumption and increase overall battery life, the "Dual Op-Amp + ADC + Analog PIR" solution can offer better performance compared to the other solutions.

Table 1. PIR Sensing System Solutions

Circuit	Battery Life	Robustness	No. of ICs
Digital PIR Sensor	Highest power	Fixed sensitivity and filtering of the input signal	1 IC
Quad Op-Amp + Analog PIR	Lower power than Digital PIR	Fixed sensitivity and filtering of the input signal	2 ICs
Dual Op-Amp + Comparator + Analog PIR	Lowest power	Fixed sensitivity and filtering of the input signal	3 ICs
Dual Op-Amp + ADC + Analog PIR	Lower power than the *Quad Op-Amp + Analog PIR* and *Digital PIR Sensor*	Programmable thresholds offer flexible sensitivity and filtering of the input signal	3 ICs

Reduce False Triggers with Programmable Thresholds

The *Dual Op-Amp + ADC + Analog PIR* solution offers programmable comparator thresholds to help fine-tune the sensor trigger window and thereby reduce false triggers. The ADS7142 is a nanopower sensor monitor with an integrated window comparator that uses programmable high and low thresholds and an alert output to wake up the main controller from its lowest power state when motion is detected. These channel-independent thresholds are more flexible than a fixed-value resistor divider *Dual Op-Amp + Comparator + Analog PIR* approach and therefore enable easier device-to-device calibration at the time of production as well as in-the-field calibration. This can help improve the overall accuracy of the PIR sensing circuitry by individually adjusting for the manufacturing variances between sensors. The ADS7142 also incorporates a pre-alert event counter that can help filter out unwanted input noise. This feature ensures that the input signal remains above (or below) the programmed threshold level for a specified number of samples before the alert signal is generated. This helps reduce false triggers due to transients or noise on the PIR sensor output signal. Figure 2 show an example of the event counter programmed to a count of 8 and the effect this has on the Alert output signal based on the PIR sensor output (ADC input) signal.

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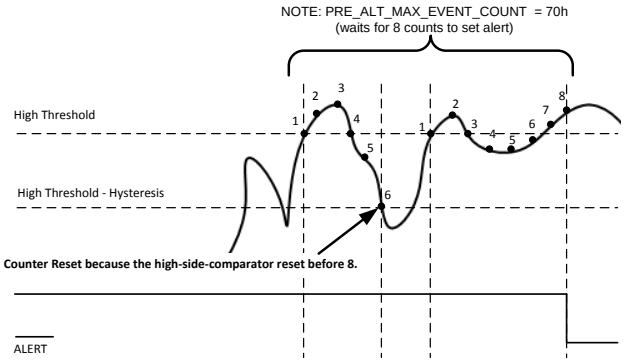

Figure 2. ADS7142 Pre-Alert Counter for Filtering

The ability of the ADS7142 to validate the input signal prior to sending out the alert helps improve the overall robustness of the measurement by avoiding false triggers.

Extend Battery Life with Autonomous Monitoring

In addition to reducing false triggers, the programmable thresholds also enable the system to be more power-efficient. The ADS7142 and op-amp circuit autonomously monitors the input signal which allows the MCU to stay in its lowest power mode longer. The integrated oscillator on the ADS7142 allows the device to operate completely on its own without intervention from the MCU.

This fully-autonomous monitoring is also done at industry-leading low-power levels. At 1.8V, the ADS7142 consumes < 1 µW of power (500 nA at 1.8 V) and the TLV8542 conditions the PIR signal with minimal impact to the power budget, consuming only 550 nA per channel. In a real PIR measurement system, the total combined current consumption of the ADC, op-amp, and PIR sensor was measured to be 2.2 µA. This combined power consumption is less than most integrated, digital-output PIR sensors. Table 2 summarizes this comparison with several different amplifier options. The ADC and Op-Amp power consumption numbers are taken from the datasheet while the PIR sensor power consumption was taken from a measured system. The TLV8802 amplifier consumes 320 nA per channel in a leaded VSSOP package while the TLV8542 consumes 550 nA per channel in a 1.5 mm by 1.5 mm leadless QFN package. The main difference between the TLV8802 and TLV8542 is power versus size with the TLV8802 being lower power and the TLV8542 being smaller.

Table 2. PIR Sensor Solution Comparison

	ADS7142 + LPV8802	ADS7142 + TLV8542	Digital Output PIR Sensor (PYD1588/89)
ADC	500 nA	500 nA	N/A
Op-Amp	640 nA	1.1 µA	N/A
PIR Sensor	600 nA	600 nA	3 µA (typ), 5 µA (max)
Total	1.74 µA	2.2 µA	3 to 5 µA

In addition to being low power, the solution in Figure 1 is also optimized for small size. The QFN package of the ADS7142 measures only 1.5 mm by 2.0 mm while the QFN package of the TLV8542 measures only 1.5 mm by 1.5 mm. With the required passive components, the design can get down to less than 10 x 14 mm. This solution is also competitively priced to be attractive for cost-sensitive designs.

In conclusion, there are several different approaches for conditioning PIR sensor output data in motion detection systems. The *Dual Op-Amp + ADC + Analog PIR* solution offers flexibility for false trigger avoidance and lower power consumption at a competitive price and size compared to a digital-output PIR sensor solution.

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