

How to Bias PIR Sensors to Prolong Battery Life in Wireless Motion Detectors



Bahram Mirshab

Wireless, battery-operated, passive infrared (PIR) motion detectors (represented in Figure 1) are gaining popularity in monitoring systems for smart buildings. In these systems, for a single CR2032 coin-cell battery to power the entire circuit close to the circuit's lifetime, both the PIR sensor and related analog front end (AFE) must have current consumption below 3µA.

In this blog post, I'll answer some hypothetical questions about PIR transducers and how careful design can significantly lengthen battery life in wireless motion detectors.

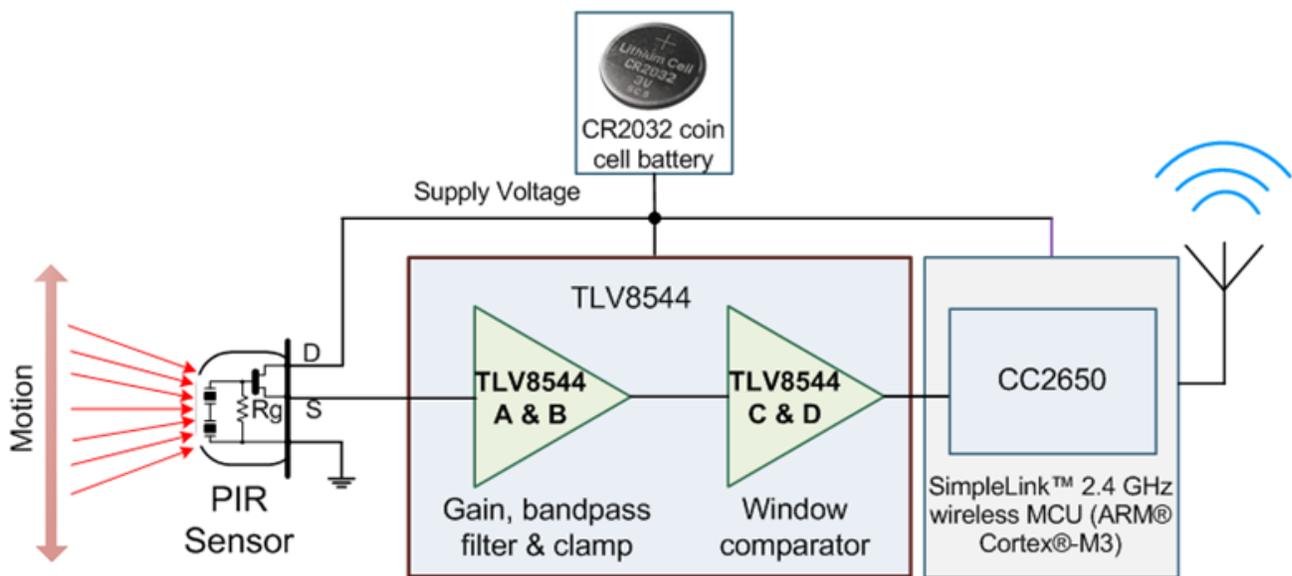


Figure 1. Block Diagram of a Wireless Battery-operated PIR Motion-detector System

What Are PIR Transducers?

PIR motion-detector transducers consist of two or more pyroelectric elements within a package. The PIR transducers generate a signal due to a change in the thermal energy pattern caused by a moving object in the field of view. The wavelength of the infrared energy spectrum falls within 1µm (1µm = 10⁻⁶ meters) to 1,000µm. The human body's radiated thermal energy wavelength is between 7µm and 15µm (typically 12µm). PIR motion sensors mainly operate in the far IR wavelength range of 4µm to 20µm.

Why Not Power Cycle the PIR Sensor to Reduce Power?

The PIR sensor takes many seconds to ramp from power up to produce a stable output signal. Thus, power cycling the PIR sensor to lower power consumption is not practical in PIR motion-detector applications because motion is not detectable during power up. Therefore, the sensor and related analog interface signal path must be always on.

How Can I Reduce PIR Transducer Current Consumption?

A simple solution for reducing PIR transducer current consumption is to starve the PIR transducer by using a 3.0V supply (the PIR's supply range is 2V to 15V) and use a very large value for the bias resistor, R2 (for example, 1.3M Ω) instead of the manufacturer-recommended value of 47k Ω , thus reducing the sensor current consumption from a fraction of a milliamp to about 0.5 μ A. See [Figure 2](#).

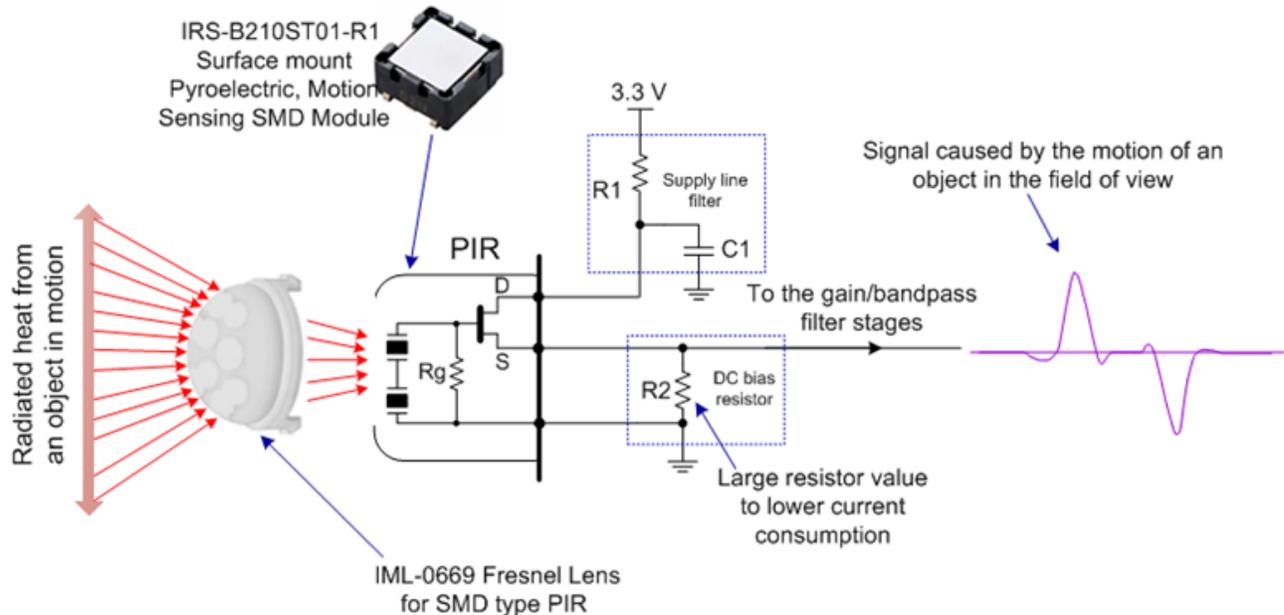


Figure 2. Surface-mount PIR Sensor, Fresnel Lens, Related Passive Components and Output Signal

What Is the Penalty for Starving a PIR Transducer?

Reducing the PIR transducer comes at the expense of decreased sensitivity and higher voltage noise at the sensor output. This is a fair trade-off for a drastically increased battery lifetime. With proper filtering and additional gain in the analog path, you can minimize the drawbacks of the biasing method.

What Type of Circuit Compensates for These Losses?

[Figure 3](#) shows a solution comprising a two-stage active bandpass filter with 3dB corner frequencies of 0.7Hz and 10Hz and a total gain of 94dB. The entire analog path was implemented in the TI [TLV8544](#) quad nanopower (op amp), designed specifically for cost-optimized applications. The values of the components for the PIR interface circuit is provided in [Figure 3](#).

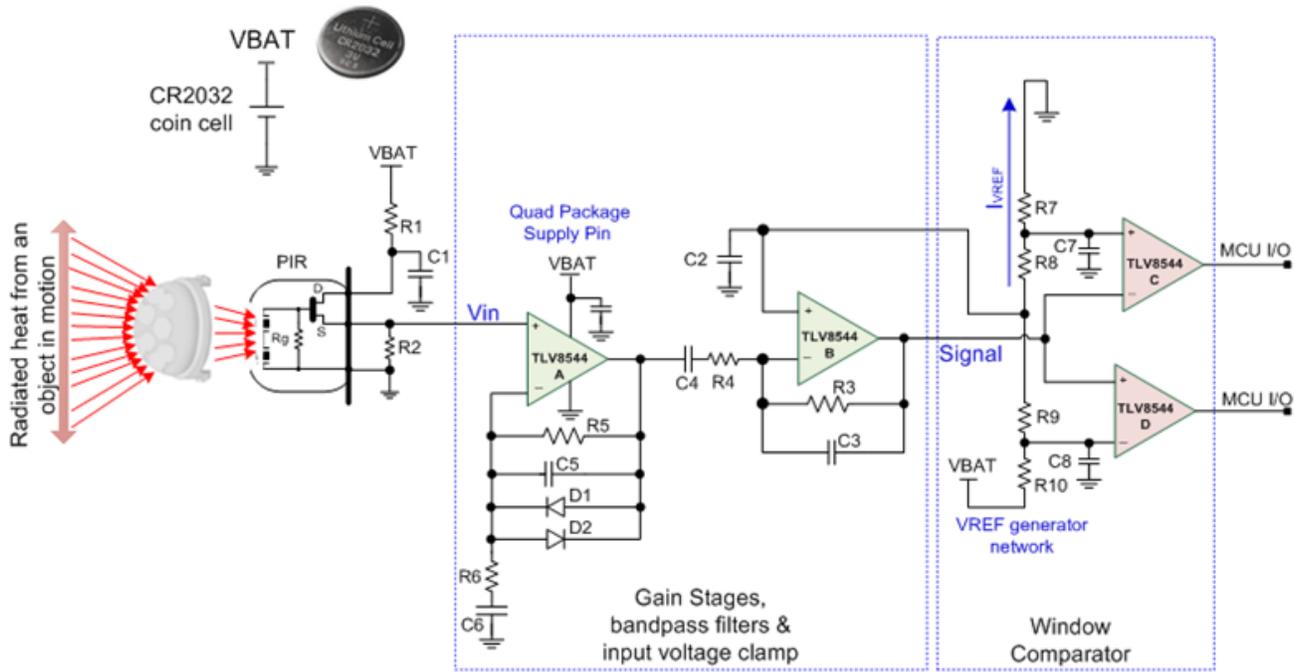


Figure 3. The Analog Stages for Filtering and Amplifying the Sensor Signal

Component	Value	Component	Value
R1	619kΩ	C5	0.01μF
R2	1.3MΩ	C6	33μF
R5	1.5MΩ	C4	3.3μF
R6	6.81kΩ	C3	1000pF
R4	68.1kΩ	C7, C8, C2	0.1μF
R3	15MΩ	C1	0.1μF/100μF
R7, R8, R9, R10	15MΩ	N/A	N/A

Figure 4. Passive Component Values of the PIR Interface Circuit

What Is the Total Current Consumption of the PIR and Analog Path?

You can find the total consumption of the analog interface plus the sensor with the equation below,

$$I_{\text{total}} = I_{\text{PIR}} + I_{\text{VREF}} + I_{\text{QTLV8544}}$$

where I_{PIR} is the current consumption of the PIR transducer; I_{VREF} is the leakage current of the reference generator network to ground and I_{QTLV8544} is the current consumption of the TLV8544.

$$I_{\text{PIR}} \approx 0.5\mu\text{A (Measured)}$$
$$I_{\text{VREF}} \approx \frac{3.3\text{V}}{4 * 15^6} = 0.055\mu\text{A}$$
$$I_{\text{QTLV8544}} = 4 \text{ channel} * 400\text{nA/ch} \approx 1.6\mu\text{A}$$
$$I_{\text{total}} = 0.5\mu\text{A} + 0.055\mu\text{A} + 1.6\mu\text{A} \approx 2.16\mu\text{A}$$

In our solution, the current consumption is 2.16μA, helping to lengthen the lifetime of the CR2032 coin-cell battery.

Conclusion

There is increasing demand to extend the battery life of wireless PIR motion detectors. Power cycling the sensor and related analog interface is not practical, but there are other ways to lower the PIR sensor current consumption drastically. Learn more about PIR design in the application note, *“Design of Ultra-Low Power Discrete Signal Conditioning Circuit for Battery-Powered Wireless PIR Motion Detectors.”*

Additional Resources

- Download the [TLV8544](#) nanopower op amp datasheet.
- Evaluate nanopower op amp functionality as an AFE in a PIR motion-detector system using the [TLV8544 BoosterPack](#) and find additional information in the [user's guide](#).

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated