Battery Lifetime Estimation on a Z-Wave 700 Door/Window Sensor

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This document will cover how Z-Wave can achieve ten years on a CR2032 coin cell battery for their Door/Window sensor using the 700 series SiP (ZGM130S[1]) and the SensorPIR sample Application.

With the 700 series, Z-Wave is introducing improved low power functionality and power management. These improvements have resulted in the ability to achieve ten years of battery life for the SensorPIR sample application on a CR2032 battery. This document will go through how this is possible to achieve. This document assumes that the reader knows the Z-Wave sample applications, Simplicity Studio and the 700 series development kit.

Measuring the Power Consumption of the SensorPIR Sample Application

Through the development of the SensorPIR sample application, the Z-Wave team has had a constant focus on developing power-efficient code by continually analyzing the wakeup and sleep current of the SensorPIR sample application. The SensorPIR sample application has a low sleep current (800nA) and a fast wakeup sending a Supervision encapsulated notification(150ms)[2]. In order to measure these times and currents precisely, it is necessary to use precise measurement equipment. The Z-Wave team has used an Agilent Technologies DC Power Analyzer N6705B[3] to measure the power consumption. An Oscilloscope measuring the voltage drop over a low resistor in series with the Device Under Test (DUT) can also do the job[4].

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[1] The datasheet for the ZGM130S can be found here: https://www.silabs.com/documents/public/data-sheets/zgm130s-datasheet.pdf

[2] The wakeup of 150ms is measured on the SensorPIR sample application from the SDK 7.1.12 and is assuming that the customer uses supervision encapsulated notifications.

[3] Agilent DC Power Analyzer N6705B - https://www.keysight.com/en/pd-1842303-pn-N6705B/dc-power-analyzer-modular-600-w-4-slots?cc=US&lc=eng

[4] To see how to measure low power with an Oscilloscope, see page 17 in https://www.silabs.com/documents/public/application-notes/an969-measuring-power-consumption.pdf

It’s important to note the Energy Profiler[5] in Simplicity Studio only has a sampling resolution of 10kHz and low precision for currents under 1mA. Therefore, is it recommended to use more precise measurement equipment for measuring the sleep current and the wakeup.

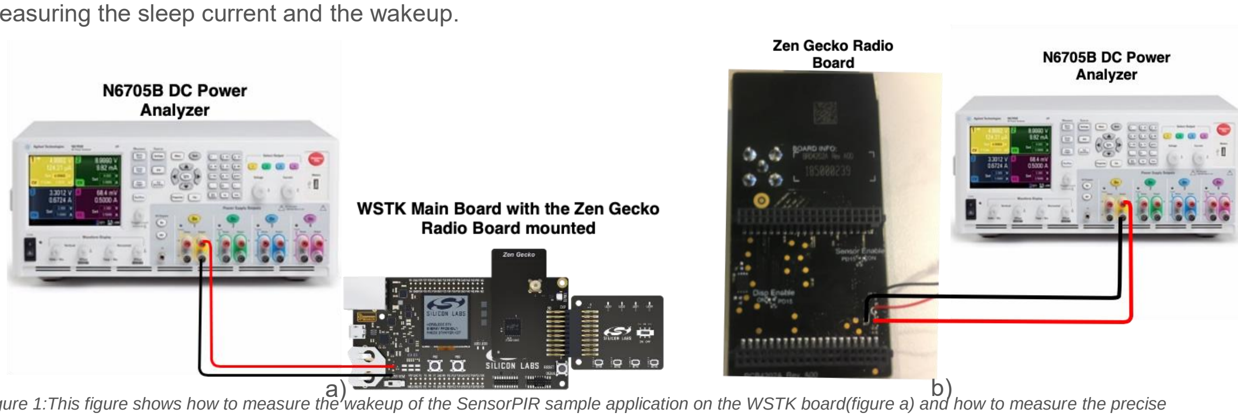

Figure 1:This figure shows how to measure the wakeup of the SensorPIR sample application on the WSTK board(figure a) and how to measure the precise sleep current of the SensorPIR sample application using the DC-Power Analyzer(Measuring directly on the Radio Board.) (figure b).

The power consumption of a sensor device consists of two things; the time where the device is sleeping and the time when the device wakeups and performs an action. Measuring the wakeup can be done as seen in figure 1.a and in order to measure the sleep current of the SensorPIR sample Applications, the setup in figure 1.b should be used.

Calculating the Needed Battery Capacity for Your Design

The Sleep current, average wakeup current and wakeup time can be found through measurements, and it is now possible to calculate the needed battery capacity depending on activation per day using these measurements. For the Z-Wave Door/Window Sensor, 30 wakeups per day have been used to be compliant with the UL-1023 standard[6].

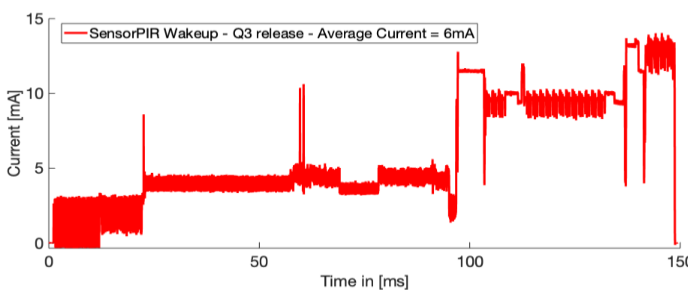

Figure 2: Current Profile of the SensorPIR Wakeup sending a Supervision encapsulated notification. The average current is 6mA and the wakeup takes 150ms. It should be noted that the wakeup time is depending on the placement in the Z-Wave mesh network.

The wakeup that Z-Wave will use to model the energy consumption of the ZGM130s running a SensorPIR sample application is a notification wakeup, sending a supervision encapsulated notification command. Figure 2 shows the current profile measured using the DC Power Analyzer, here the length and the

[5] Link to the Energy Profiler from Silicon Labs: https://www.silabs.com/documents/public/user-guides/ug343-multinode-energy-profiler.pdf

[6] For more information about the UL 1023 standard, visit https://z-wavealliance.org/z-wave-scores-huge-ul-win-for-security-a-first-for-mesh-technology/

average current of the wakeup can be seen.

Assuming 30 wakeups per day with an average current of 6mA for 150ms and a sleep current of 800nA. Using these values, the average current during a day can be found.

The average current a day is then $\frac{800nA \cdot (SecondsInOneDay - TotalAwakeTime) + 6mA \cdot TotalAwakeTime}{SecondsInOneDay} = 1.12\mu A$

Converting the average current, a day to Ah is done simply by multiplying with 24h - $24h \cdot 1.12\mu A = 26.88\mu Ah$

This means a needed battery capacity of 26.88μAh for a day and 9.81mAh for a year during regular operation and still compliant with the UL-1032 standard (30 Wakeups a day, see figure 1). This means that over ten years, the available capacity of the coin cell battery needs to be 98.11mAh (without OTA and SmartStart, assuming 800nA sleep current).

Achieving Ten Years on a Coin Cell Battery (CR2032)

After ten years, the Z-Wave 700 series SiP running the SensorPIR application will have consumed a total of 120mAh from the coin cell battery with OTA and SmartStart. This means the available battery capacity must be over 120mAh. (This depends on where in the mesh network the SensorPIR device is placed, and the power consumption for the OTA and SmartStart inclusion is set as a high value to give a better safety margin.)

A coin cell battery has approximately 235mAh (down to 2V, where the ZGM130s can operate down to 1.8V) and because of the pulse discharges from the wakeups, and the 13.3mA high peak currents during transmission(0dBm) the available battery capacity is lower. Z-Wave has assumed a 40% de-rate factor, which incorporates the self-discharge and other elements that reduce the available battery capacity. This means that the total available battery capacity is 141mAh, which then assures the ten years of battery life on a coin cell battery. This gives room for adding a HAL Sensor/REED Switch and extra current draw from the designed PCB.