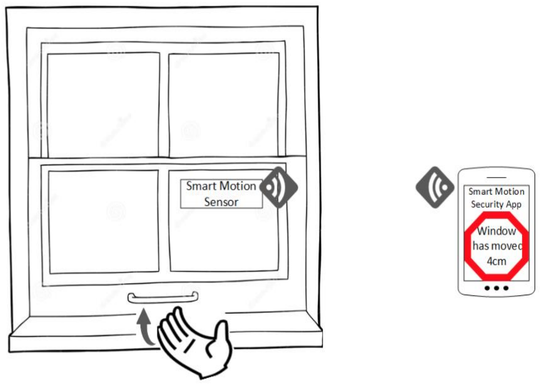
IoT Smart Motion Sensor

Nicholas Luong, Chris Adams, Aiku Shintani, Anthony Zunino
Advisor: Dr. Prodanov

Overview

The Smart Motion Sensor is a proof of concept for an affordable, small, self-sustaining, window sensor which monitors analog window position and possible impacts. The device communicates wirelessly (via BLE) with a smart phone through the control of an android application.

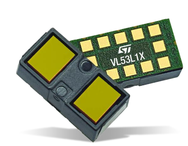


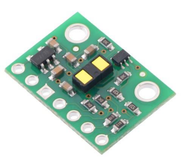
The Smart Motion Sensor utilizes a 1.5V 3000mWh Li-ion battery, power optimization, and 0.5W small solar panel for self-sustainability so that no maintenance is required during the product lifetime. It uses and accelerometer(BMI160) to detect impacts and window movement. Upon detecting window movement, an optical time of flight sensor(VL53L1X) is woken up to measure window distance.

MAX32630FTHR

The Maxim MAX32630FTHR dev board was chosen for accelerated development and its design for IoT applications. The on board ultra low-power MAX32630 Microcontroller, BMI160 Accelerometer, MAX14690 Power Management IC, and PAN1326B BLE module are critical to the system.

The microcontroller was programmed via Mbed OS (open-source RTOS for IoT devices based on Arm processors) in C++.

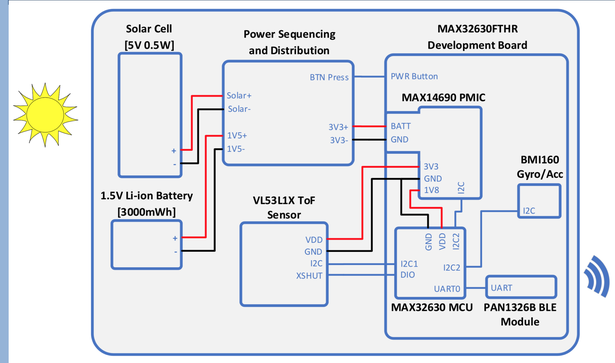




The proximity sensor of choice was the ST VL531X Time of Flight Range Finder Sensor. It utilizes a 940mm class 1 laser to provide fast and accurate ranging up to 4m with 1mm resolution.

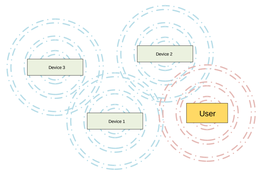
The microcontroller communicates with the proximity sensor, accelerometer and PMIC via I2C and the BLE module via UART.

High Level Block Diagram

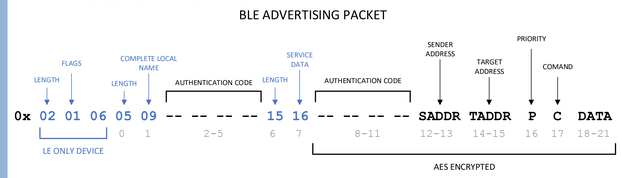


Bluetooth Low Energy Mesh

Each Smart Motion device require a low power wireless communication technology that is also supported by smart phones. BLE is perfect for this application, especially since large amount of data transfer is not required.



The BLE mesh network uses a "flooding" technique that publishes and relays messages. Custom service data advertising packets were created for this application. The biggest challenge in this specific mesh network is that every node is a "low power" node and requires continuous scanning. Sacrificing latency, the solution is to periodically scan for BLE advertisements.

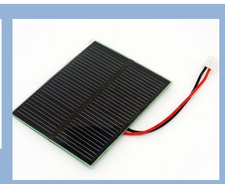


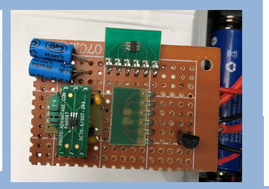
Mechanical Design

The 3D printed enclosure must securely hold all necessary components of the system. For the enclosure to hold everything and be easy to access, many iterations were printed and improved upon to secure the system. A heat insert, which can be melted into the ABS plastic of the enclosure, was utilized for mounting.

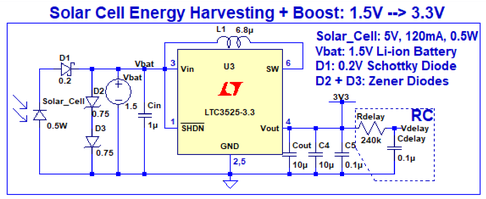
The final iteration of the enclosure: 75 by 55 by 40 mm

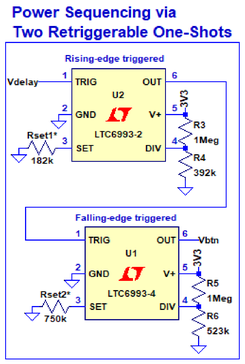
Note: this enclosure is for easy testing and proof of concept. A final product would consist of a much smaller enclosure





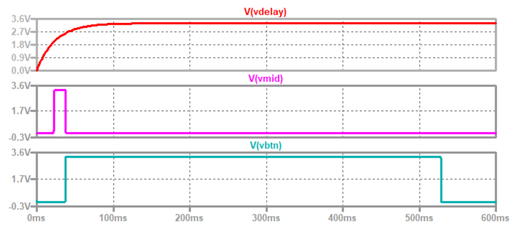
Power Sequencing



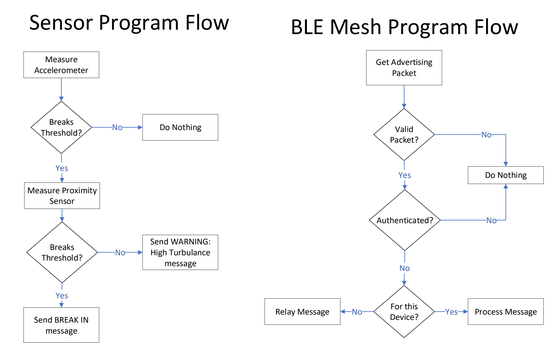


The chosen solar cell provides the Smart Motion Sensor with enough power to achieve self-sustainment. The battery is input to a high-precision Boost converter which boosts the voltage from 1.5V to 3.3V. The generated 3.3V powers the MAX32630FTHR board.

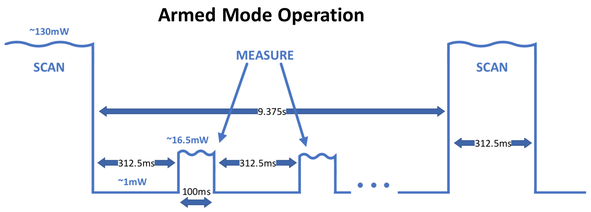
To trigger power sequencing, the first one-shot is used to ensure that sufficient power has been applied to the board. The second one-shot generates a 500ms pulse which is applied to the MAX14690 PMIC.



Program Flow



Power Consumption Timing



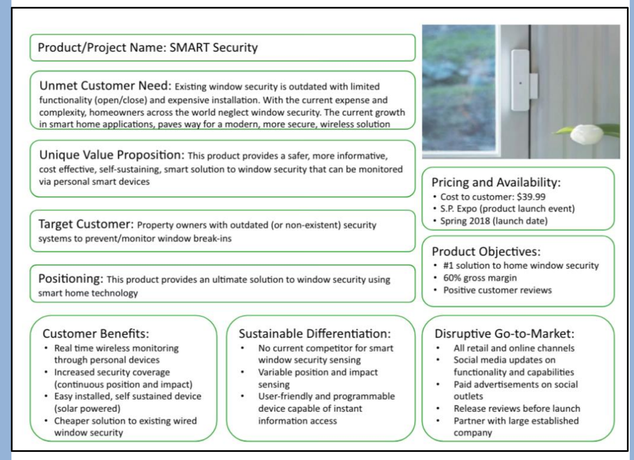
Estimated DC Power Consumption: ~10-15mW
The minimized power consumption is achieved through use of the MAX14690 PMIC, entering LowPower1 as frequent as possible.

Materials + Marketing

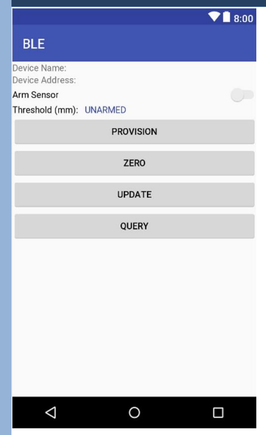
The estimated final product cost of manufacturing is $55.78. Note this price can be pushed down when manufacturing and ordering products in large quantities.

Item #	Part Name	Description	Price
1	MAX32630FTHR	Dev Board	$25.00
2	VL53L1X	Tof Distance Sensor	$11.95
3	SEEED 0.5W Solar Panel 55x70	Solar Panel	$1.95
4	Jugee 1.5V Li-ion	Li-Ion Battery	$7.50
5	LTC3525-3.3	Boost	$2.12
6	LTC6993CS6	One Shot x2	$7.26
7	Assembly	Enclosure, wires, etc.	-
		Total	**$55.78**

Marketing Datasheet



Android App



Allows control of each Smart Motion device. Shown left is the settings screen for device in the network.

Button descriptions:
PROVISION: One time use when SM device is added
ZERO: Zero accelerometer and proximity sensor
UPDATE: Send update to device (Arm/set threshold)
QUERY: Query status of device (arm status/set threshold/measured distance)

Conclusion

This project is a proof of concept for a self-sustaining wireless analog window security system. The next step is to optimize each subsystem. The greatest improvements to the system will come in power savings and packaging. Additionally for this system to be practical, a node with Wi-Fi capabilities must be implemented to enable notifications to a user that is out of the BLE mesh network range. Lastly, android and IOS apps need to be developed for a more user friendly interface.

Acknowledgements

Special thanks to our advisor Dr. Vladimir Prodanov for aiding our design, Maxim for donating MAX32630FTHR boards for development, and Professor Rich Murray for the concept idea