Team #17

User Presence Detection

ALLEGION™

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Customer Background

Allegion, a leader in door security, owns over 30 companies focused on protecting residential and commercial spaces. They design locks, door closers, access control systems, and even entire doors. With a team of experts, Allegion develops codes and standards to ensure top-notch security. They've also sponsored Purdue Polytechnic Institute's capstone projects for years.

Problem Statement

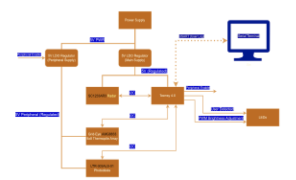
Implementing low power and reliable methods of detecting users as they approach presents many factors to account for. We will need to adjust the light intensity of the keypad based off ambient light and track accurate sensor(s) readings to distinguish between a user and "false detections". Objects passing by must not alert the system that a user is approaching. As this is poised to be used on security applications, a serial prompt alerting the user will also be generated for homeowners to review. This entire system is to be packaged as a low-power product suitable for long-lasting outdoor use, necessitating the use of power-saving components and appropriate weatherproofing to keep the system safe while not obstructing the sensor(s).

Requirements

Req. #	DESIGN REQUIREMENTS / RATIONALE	DESIGN TARGETS	VALIDATION	COMMENTS
1	Device must be able to withstand outdoor and indoor environment	Product has operating temperature of -35C to 66C on the outside escutcheon and -10C to 49C for the inside escutcheon	Electronics show no proof of corrosion, deterioration, or damage after environmental exposure	Allegion disclosed that we will be modifying their existing product Schlage Encode BE489WB CAM [20]
	The device we will be modifying is meant for indoor and outdoor use with rated specifications, so our addon module most conform to the pre-existing range of temperatures [22]			
2	Device power consumtion should meet the provided average.	Electrical Constraint of 300 μW	Ammeter reading	This power consumption average does not include the LED array and back lighting [20]
	Allegion will provide an average current to keep the device low power. [20]			
3	Device must adjust the lighted keypad's brightness	Maximum: Display is at "X" Lumens for an ambient light of "Y" Lumens Minimum: Display is at "Z" Lumens for an abient light of "V" Lumens	Lux Meter Measurement	Allegion disclosed this during the meeting as well as in the project description [20,22]
	Keypad must be dynamically illuminated at night for the numbers to be visible [21].			
4	Device must report when a user approaches	Notify the user with a terminal prompt	Device is able to export said log. For prototyping purposes the log may be displayed to a serial monitor or LCD display.	Allegion said that the system must keep a log of user detections [20]
	The device is meant to be a user-presence detection system within a secure lock [21].			

Experimentation and Concepts

Initial Flowchart General IO:



Mathematical Model:

$$E_{daily\ consumption\ per\ day} = \sum_{i=1}^{n} [(I_1 * V_1) * \Delta t_1] + [(I_2 * V_2) * \Delta t_2] \ldots + [(I_n * V_n) * \Delta t_n]$$

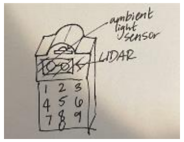
$$T_{available\ time} = \frac{E_{bat_{kWh}}}{E_{daily\ consumption\ per\ day}}$$

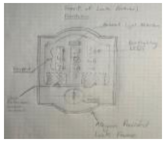
$$T_{remaining} = T_{available\ time} - 182\ days$$

$$E_{remaining\_kWh} = T_{remaining} * E_{daily\ consumption\ per\ day}$$

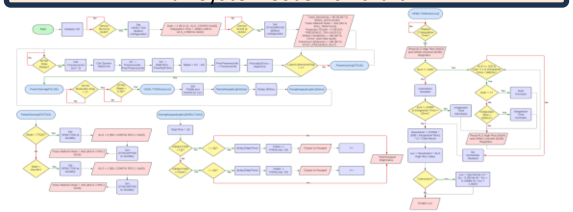
$$P_{average} = \frac{(E_{remaining\_kWh} - E_{bat_{kWh}})}{(182\ days * 24\ hours)}$$

Initial Models:



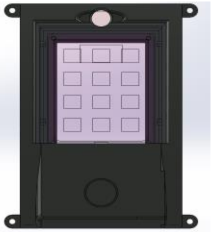


Full System Code Flowchart:

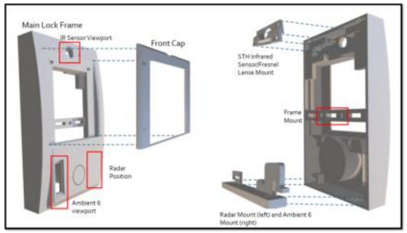


Final Design

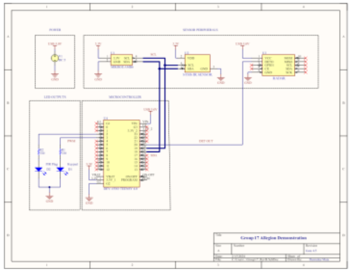
Front View Rendering:



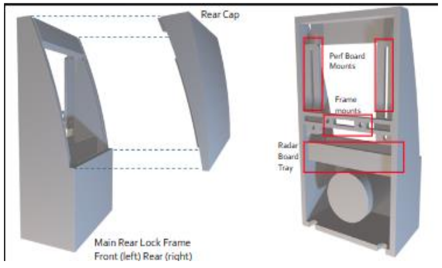
External 3D Model:



Final Wiring Diagram:

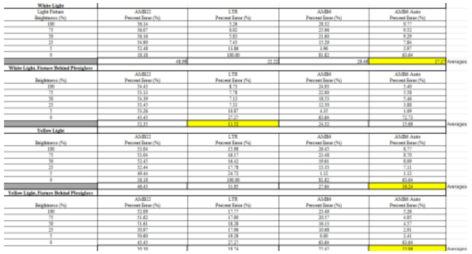


Internal 3D Model:

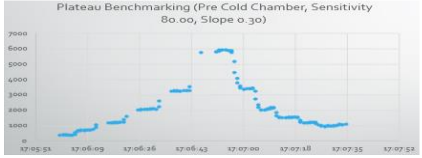


Testing

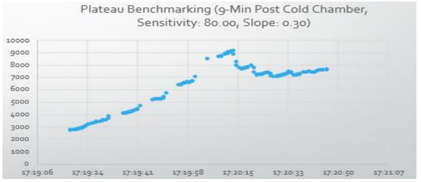
Ambient Light Sensor Selection Testing:



Hysteresis Testing Original:



Hysteresis Testing After 24 Hrs at –40° C:



Future Recommendations

After experimenting with different sensor technologies, Team 17 made several observations for Allegion. First, to have a weatherproof design, all sensors must be able to detect through a medium. This eliminates technologies that rely on taking surface temperature measurements or similar, including thermopile technology. Instead, technologies that detect infrared energy or technology that can detect through mediums such as radar are recommended. Furthermore, any technology that is based on temperature measurements should be paired with dynamic thresholding algorithms or other sensors to account for the wide range of climates.