ELECOMP CAPSTONE SYMPOSIUM
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO℠

SPBBTR

SmartPlug Bluetooth Button Transmitter and Receiver

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Technical Directors: Phil Manning, Nick Costello, Mike Smith

Project Motivation

In California, a water crisis caused by droughts has severely affected the population for nearly every decade for the past two centuries. Growing populations are creating an increasing demand for water which is negatively affecting the natural replenishment of reservoirs. The California Code of Regulations mandates hot-water recirculation to decrease water consumption in order to adapt to the water crisis. Many of these systems use mechanical timers to begin hot-water recirculation or digital controls to log the hot water usage and start the pumps based on the user data it collects.

Both of these methods decrease water usage but they both have their cons. Both mechanical timers and digital control systems suffer from the same flaw of performing their functions at undesired times resulting in a waste of power and water. An addition of a button allows for users to decide when the SmartPlug should begin pumping water, increasing efficiency of water and energy conservation.

Anticipated Best Outcome

A new version of the current SmartPlug in its prototype stage of development that includes a redesigned PCB within the current enclosure and updated firmware to interact with a remote button through bluetooth to control the hot water recirculation pump. The hardware and firmware for the button separate from the SmartPlug is developed. The whole system will include other functions such as a learning algorithm and programmable timer for automatic recirculation on top of manual activation. If possible, a mobile app will be developed that can perform the same actions as the physical button for more convenience.

Fig.2: Current SmartPlug model

Key Accomplishments

Bluetooth Processor Selection: After extensive research, the Nordic Semiconductor, nRF52840 was chosen for the initial testing process. The nRF52840 is built around the 32-bit ARM Cortex-M4 CPU running at a clock speed of 64 MHz. This chip provides the 2.4 GHz bluetooth LE signal that is used for most modern day bluetooth devices. To ensure that future bluetooth products are able to be paired with the Smartplug, we opted for the 2.4GHz BLE rather than the 900Mhz because it has longer range capabilities. In addition, Taco Comfort Solutions have also utilized this Nordic chip on other products. This allows us to modify existing code to fit our criteria.

Bluetooth Testing: In order for the team to develop a good and efficient product, tests were conducted in order to increase the team's understanding of the bluetooth processor being used. Making use of the resources provided by the distributors of the processors and examples from the Arduino IDE. In addition, we were given access to previous projects from our technical directors, Phil Manning and Nick Costello, which can be called upon for reference when coding the new firmware. Through these tests, the team was able to further improve their technical skill to meet their best anticipated outcomes and more.

Development of Central and Peripheral Roles: An integral part of this project in the communication between the Smartplug and button in development. A central role is given to the button as it will be in control of being the process leading to the functions the Smartplug will be performing. The Smartplug is assigned as a peripheral, waiting to receive a signal from the button, then running through the recirculation process of heating and pumping water to the desired location.

Fig.3: Design of bluetooth button

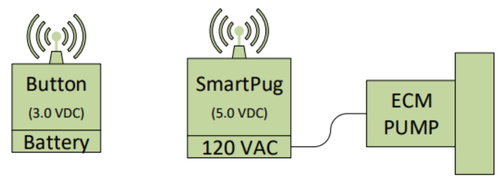

Fig.4: Bluetooth button paired with SmartPlug

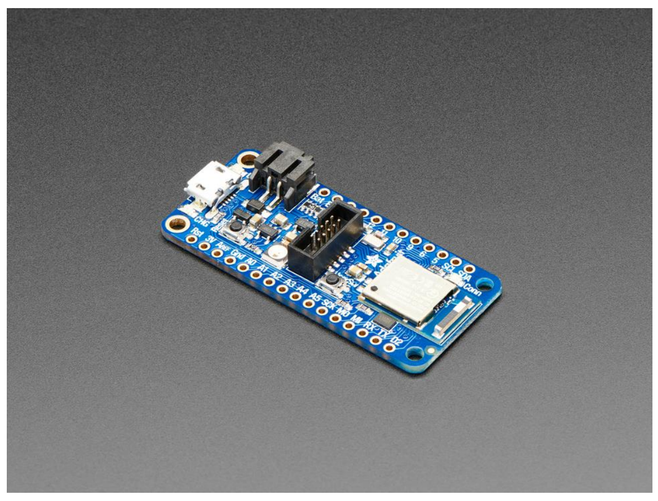

Fig.1: Adafruit nRF52840 Feather Express

Remaining Technical Challenges

Smartplug PCB Design: One challenge that remains in terms of hardware is redesigning the Smartplug's current PCB schematic to fit a bluetooth low-energy capable processor. Currently, we are testing the Nordic Semiconductor's nRF52840 bluetooth low-energy processor on an Adafruit nRF52840 featherboard. If testing goes well and we are satisfied with the results, we intend to replace the existing 8-bit processor on the Smartplug with the Nordic nRF52840 chip to enable bluetooth connectivity. In order to accomplish this task, we need to redesign the current PCB schematic in order to fit this chip and have the proper electrical specifications to operate the chip.

Button PCB Design: Aside from implementing the Nordic chip onto the Smartplug, we also need to implement this chip onto the button that we will be designing. Using Altium, we intend to develop the PCB for the button which meets Taco Comfort Solutions requirements.

Updated firmware for Smartplug and Button: After the Smartplug and button have been developed, in order to use the Nordic nRF52840 chip we must also update the current firmware for the existing Smartplug. This will be accomplished by modifying the current firmware provided by Taco Comfort Solutions to implement the bluetooth low-energy libraries into the C++ code.

Effective Range Testing: Once the Smartplug and button prototypes are finished being designed and the firmware has been updated, we then need to test the prototypes in order to gauge the effective range of the two products. This will be done by testing the Smartplug and button in various environments to see whether or not certain adjustments need to be made.

Smartphone Implementation: Along with the addition of a button to the smartplug, a smartphone app with the same functionality as the button is a feature we are looking into applying to the button. This feature will be able to send a signal to the Smartplug as the button would, through bluetooth communication.

Implications for Company & Economic Impact

Bluetooth accessibility for smart devices are becoming the new standard for the average household. With the development of the button in conjunction to a possible smartphone app, more consumers will likely be intrigued to purchase the product as it will be more user friendly and accessible. Not to mention, consumers with devices such as Amazon Alexas or Google Homes will be able to integrate this product into their existing setups. In terms of economic impact, being able to step foot into the bluetooth market for such a device will help boost sales for the product.