Energy Harvesting Stop Button

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Assignment

A single public transport bus in Trondheim has more than 24 stop buttons that are intricately wired. The idea with this project is to replace these with wireless stop buttons that can be put anywhere in the bus, reducing the cost of installation and maintenance. The energy harvesting aspect will remove the need to change batteries in current wireless alternatives. Using Nordic Semiconductors nRF52 system on a chip and its Bluetooth Low Energy functionality to send a wireless signal to a central in the bus, which signals the bus to stop. Even though this is presented as a stop button, the possible applications are countless.

1 Energy Harvesting

Using an electromechanical generator as the source of energy to run the stop button, the AFIG-0007 from ZF Electronics, depicted in figure 1, was chosen.

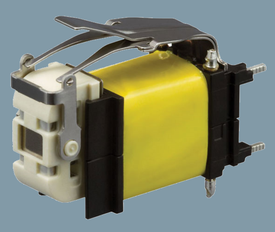

Figure 1: The AFIG-0007 Electromechanical generator

Generating an energy pulse on both press and release, approximately 0.27mWs was generated by each button push, which in theory should be enough power to run the nRF52 long enough to send a Bluetooth Low Energy signal.

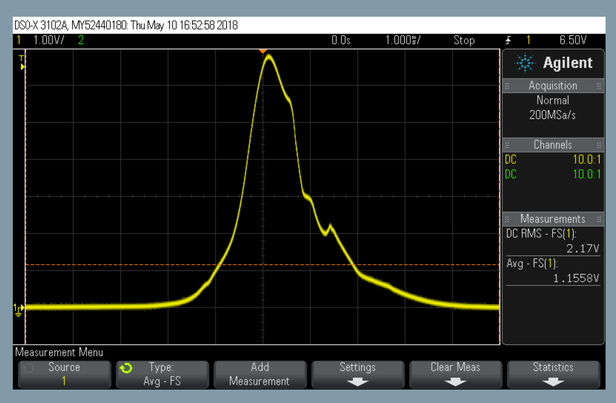

Figure 2: One energy pulse created by a press of the button

As the power from the button is an AC, it has to be rectified and regulated into a DC output that is within the operating voltage of the nRF52 (1.7 to 3.6 Volts).

2 nRF52832

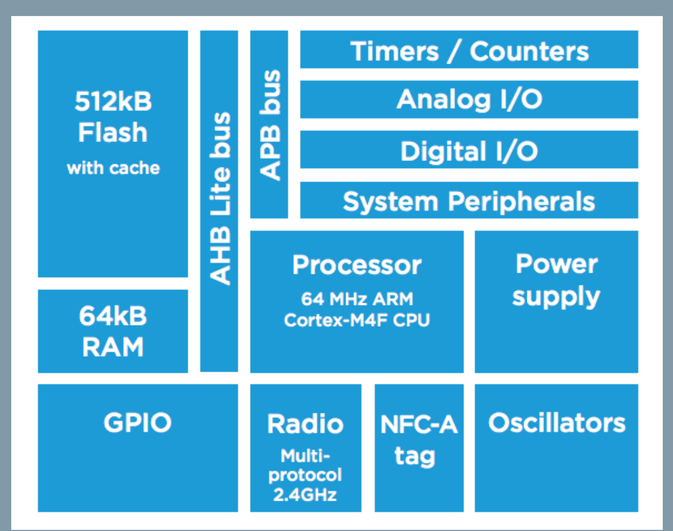

Figure 3: nRF52 System on a Chip

The nRF52 System on a Chip is a powerful, highly flexible ultra-low power multiprotocol system on a chip ideally suited for Bluetooth Low Energy and 2.4GHz ultra low-power wireless applications. The nRF52 is built around a 32-bit ARM Cortex-M4F CPU with 512kB flash storage + 64kB RAM. The embedded 2.4GHz transceiver supports Bluetooth Low Energy which is utilized in this project.

3 Network Setup

The flowchart in figure 4 illustrates the different processes occurring in the central and relayer devices. Showing how they scan for Bluetooth Low Energy signals from the stop button and how they communicate.

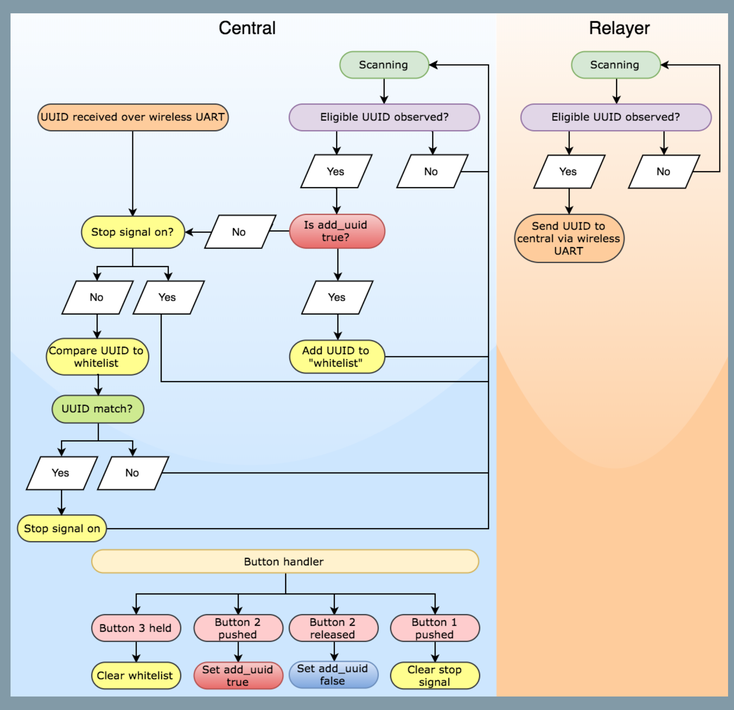

Figure 4: System flowchart

The stop button is a non-connectable broadcasting device that advertises a 128-bit custom UUID. The custom UUID is either observed directly by the central or via the relayer, setting a stop signal.

4 Circuit Board Design

PCB design is a vital part of today's electronics devices. A PCB is a multi-layered board that mechanically supports and electrically connects a circuit.

The main concern when designing the circuit board was that the size had to fit inside a generic bus stop button casing. The circuit board design was based on the nRF52's reference design, and combined with the energy harvesting circuitry made for this project. The final design had a total of 35 components on a $4.71cm^2$ circuit board.

Having all the components soldered onto a single circuit board provides the mechanical backbone needed to handle the stress such an application is exposed to.

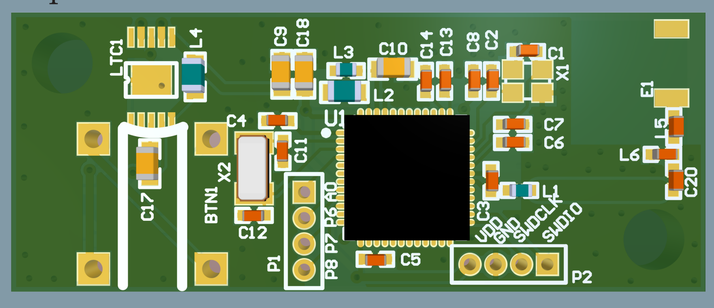

Figure 5: A 3D fabricated PCB design of the final circuit board.

5 3D Design

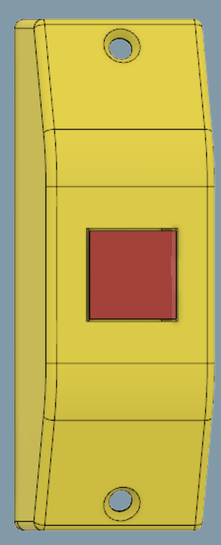

Figure 6: Stop button

For the purpose of this project, the button design is restricted to a prototype that looks and functions in a similar fashion as today's bus stop button design. The final 3D design of the button casing is shown in figure 6.

The 3D printed casing supports the build of the circuit board design, and makes it suitable for hard handling, increasing the stop buttons lifespan.

6 Final Product

Looking at the buses that are present today (2018) in Trondheim, the length of a bus vary from 9 to 19 meters. To make sure that all stop buttons can reach the central with their respective Bluetooth Low Energy signal, the stop button was made to be able to transmit a signal 20 meters to the central.

To add an option for artculated, and other buses exceeding 20 meters, a relayer able to forward the stop buttons Bluetooth Low Energy signals to the central, was made to be mounted near the middle of a bus.

7 Further Work

- Improve and optimize the energy harvesting circuit.
- Test active rectification technology to reduce energy loss and prevent reverse current.
- Firmware optimization
- Reduce cost per unit.

8 GitHub

For more information on this project, check out the GitHub link below.

https://github.com/simenrostad/Bachelor-Nordic_Semi