Wake-Up Harvester Design for Batteryless IoT System

Team: sdmay21-14
Advisor/Client: Henry Duwe
Jacob Bernardi, Edmund Duan, Douglas Zuercher, Kwanghum Park, Bryce Staver, Zacharias Komodromos

Motivation

- Many IoT devices are moving to batteryless with harvester
- Communicating with device is difficult due to intermittent power
- A device is needed for testing this concept

Solution

- Batteryless device
- RF capabilities & Wake-Up Radio (WuR) component
- Ability to be woken up by a trigger

Functional Design Requirements

- Wake up only on valid triggers
- Repeat trigger once received
- Enter normal operation once triggered
- Maximum off time no greater than 1 minute

Non-Functional Design Requirements

- Small package size for device (4” x 4”)
- Batteryless device
- Triggerable within 2 meters

Engineering Constraints

- Availability of RF signals to harvest
- Limited amount of energy can be harvested in a given time period
- Power consumption of MCU is set

Operational Environment

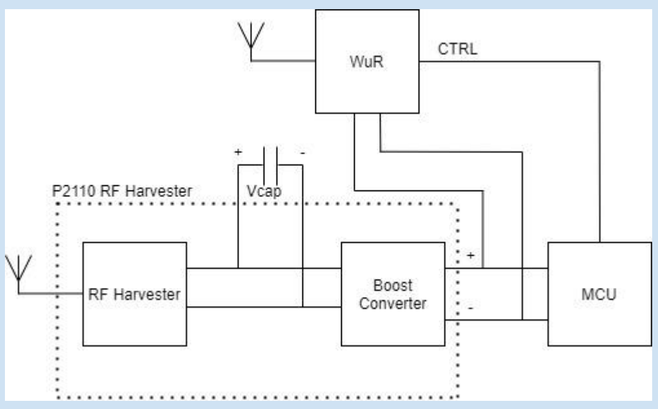
- Indoors in a lab with controlled climate, low dust
- RF signals available for harvesting
- Low interference environment

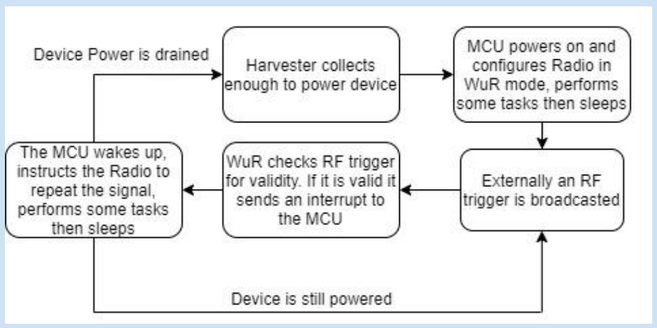
Relevant Standards

- ITU Radio Regulations for ISM bands
- IPC 7351A & B - standard for surface mount land patterns, such as spacing and pad specifications
- IPC-A-610 - standard covering the assembly of PCBs

Project Design

The device will be on a PCB as a one piece system. It will include a harvester, MCU and WuR working together. The harvester will power the whole device with the MCU using the WuR to communicate. The WuR can interrupt the MCU to change its power state.





Security Concerns and Countermeasures

- Not connected to the internet or any other sort of local network
- Susceptible to RF jamming
- If the trigger preamble is correctly guessed, anyone can trigger the device

Intended users and uses

- Intended for researchers at university
- Used to investigate batteryless, wireless RF communication between IoT nodes
- Have WuR trigger the MCU to run a script when RF trigger is detected

Hardware Details

PowerCast P2110B Harvester:

- Most efficient around the 915 MHz range
- Up to 50 mA output current
- ESD sensitive device

TI-CC 1352 Microcontroller:

- Low power standby mode with interrupt capability and active modes
- Wide range of wireless, other communication protocols, and sub1-GHz transceiver
- Wide array of memory available for long term use with 48 pins for multi-use system
- Programming done in Code Composer Studio

AX5043 Transceiver:

- True single chip, narrow-band, ultra low power RF transceiver between 27 - 1050 MHz
- Constant TX output power over the full VDD range of 1.8 - 3.6 V

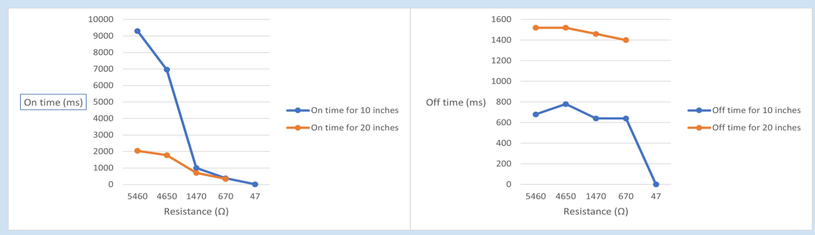
Software Details

All required software for AX5043 and functionality for interrupt are available in our teams GitLab. Includes functions for TX config settings, RX config settings, transmitting and receiving data among other things.

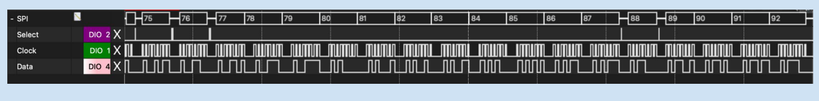
Testing

Testing was done in a clean, controlled environment where factors such as dust, humidity, and electromagnetic noise are not prominent.

Powercast Harvester testing was done by measuring on and off times with oscilloscopes with varying loads and distances from transmitter to get the on and off times.



MCU testing was done in parallel with the transceiver testing. For programming the transceiver, which inadvertently tests the MCU code, we have the following SPI lines of established communication.



For the AX5043 communication, we had one MCU programmed as a controller to generate a packet to send with an AX5043, and wait for some time to receive it back before sending another. The other MCU was programmed as an agent to use the AX5043 to receive a packet and send it back. The following is the number of packets received and sent per minute versus distance.