Batteryless Handheld Game

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Introduction and Motivation

- **Problem:** Design a gaming device without a battery component
- **Need:** Batteries produce waste and ultra low-power and passive devices are becoming increasingly common
- **Solution:** Kinetic energy powered game showing a viable alternative to a battery powered device

Users and Use Cases

- **Use:** Provide a brief entertaining video gaming experience
- **Users:** College Faculty, staff, and students

Functional Requirements:

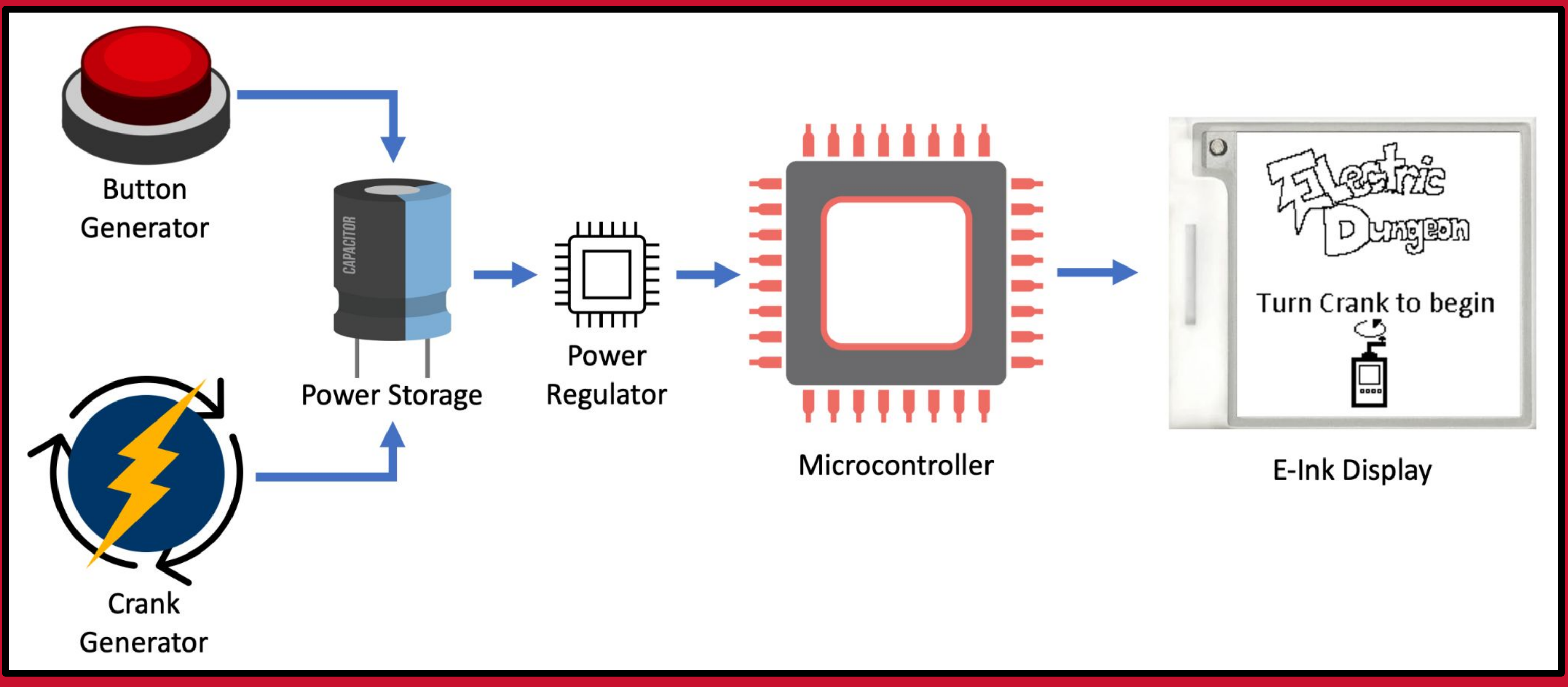
- Device is powered solely from user interaction
- The energy harvesting shall be a part of the gameplay
- The device shall be as portable as a standard laptop

Non-Functional Requirements:

- The game shall be reasonably intuitive
- The game shall run through at least one room challenge state after energy harvesting
- The device shall show a low power screen when it is running out of battery

Constraints

- Cost: Conscientious of ICs/PCB
- Operating Environment: Indoors
- Unique to any other battery free gaming device



Hardware Design

Main Modules

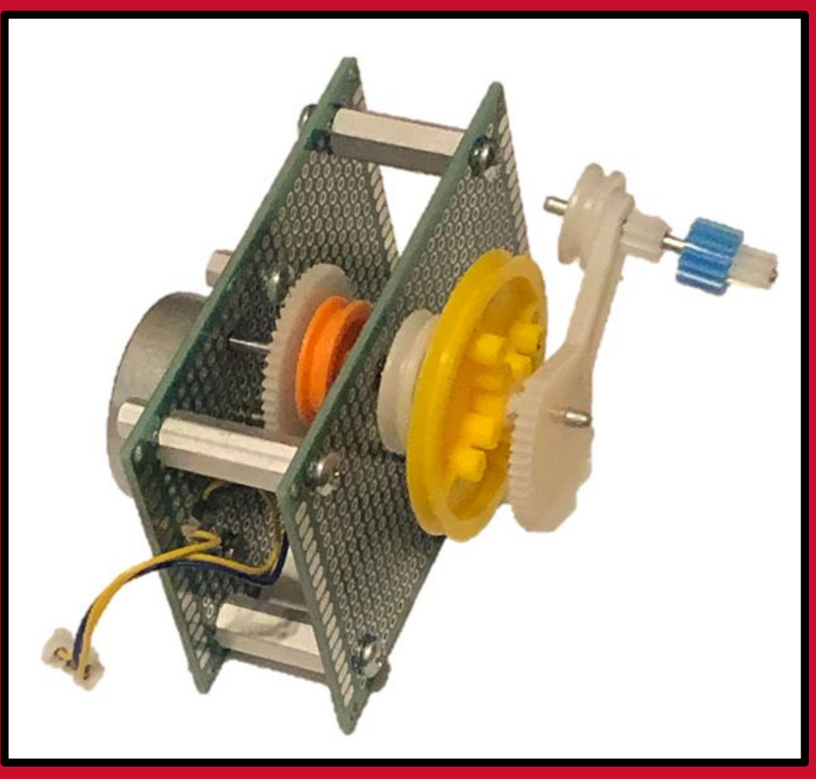
- **Energy Harvesting Devices:** User generated kinetic energy from hand crank or kinetic buttons
- **Energy Storage Device (BQ25504):** stores energy from kinetic energy devices into a supercapacitor
- **Boost Regulator:** Voltage from the supercapacitor is boosted to 3.3V
- **Microcontroller (MSP430):** Runs the software flow
- **E-ink Display:** Used to display game images

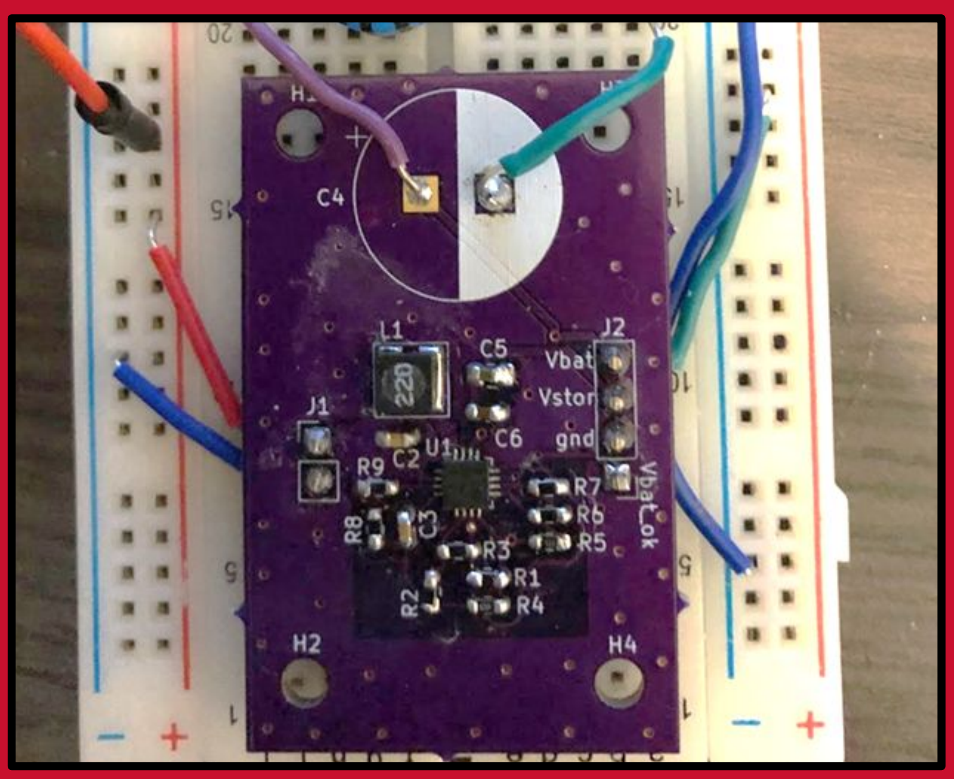
System Functionality

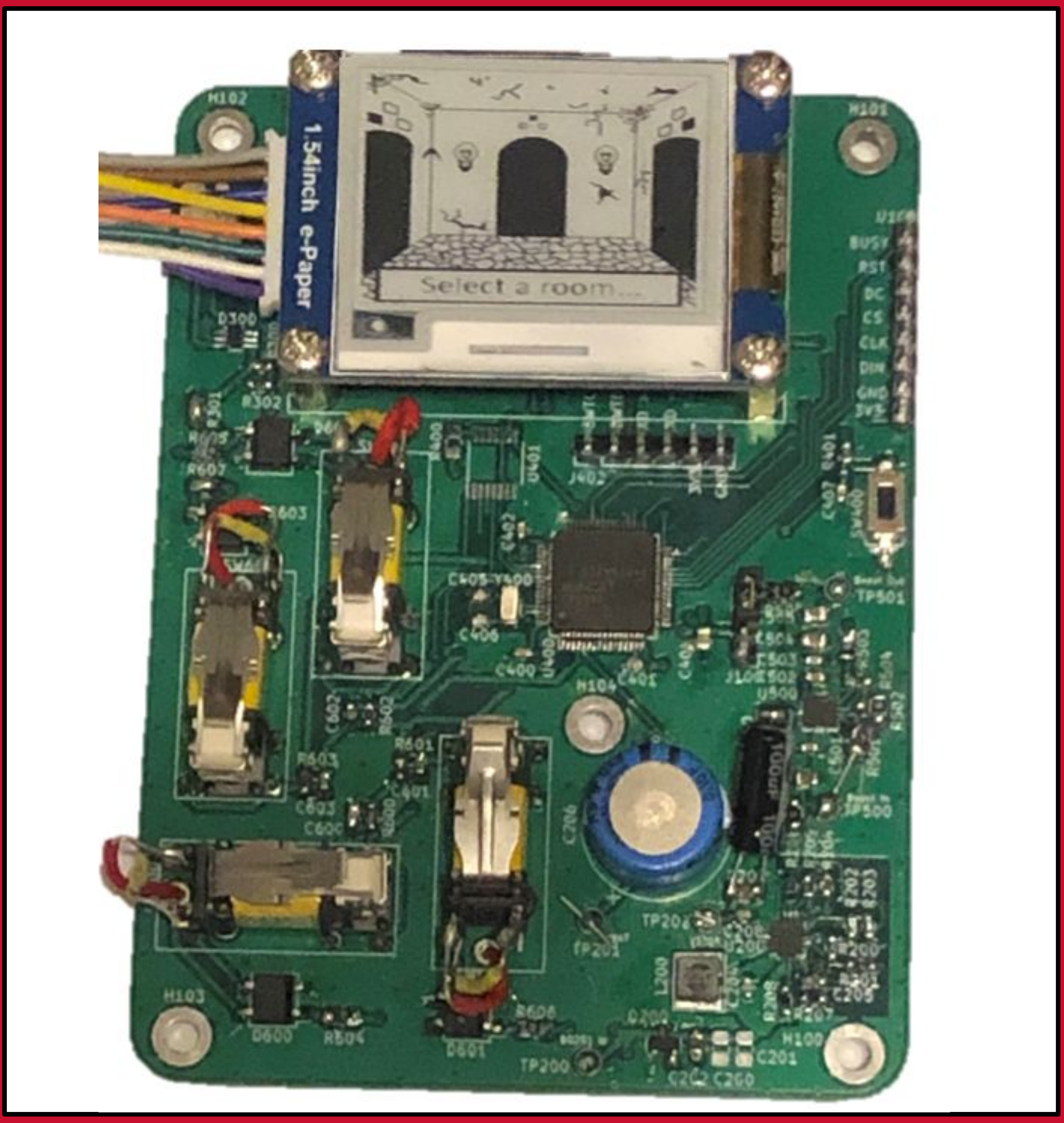
- Energy Harvesting Devices produce power
- Power produced is stored on the supercapacitor
- Constant voltage is output to microcontroller/E-ink

Testing

- Unit Testing
  - Ex: Hand Crank, Energy Storage, Boost Regulation
- Integration Testing:
  - Ex: Energy Storage into Boost Regulation
- System Testing:
  - Ex: Gameplay loop with Hardware and Software







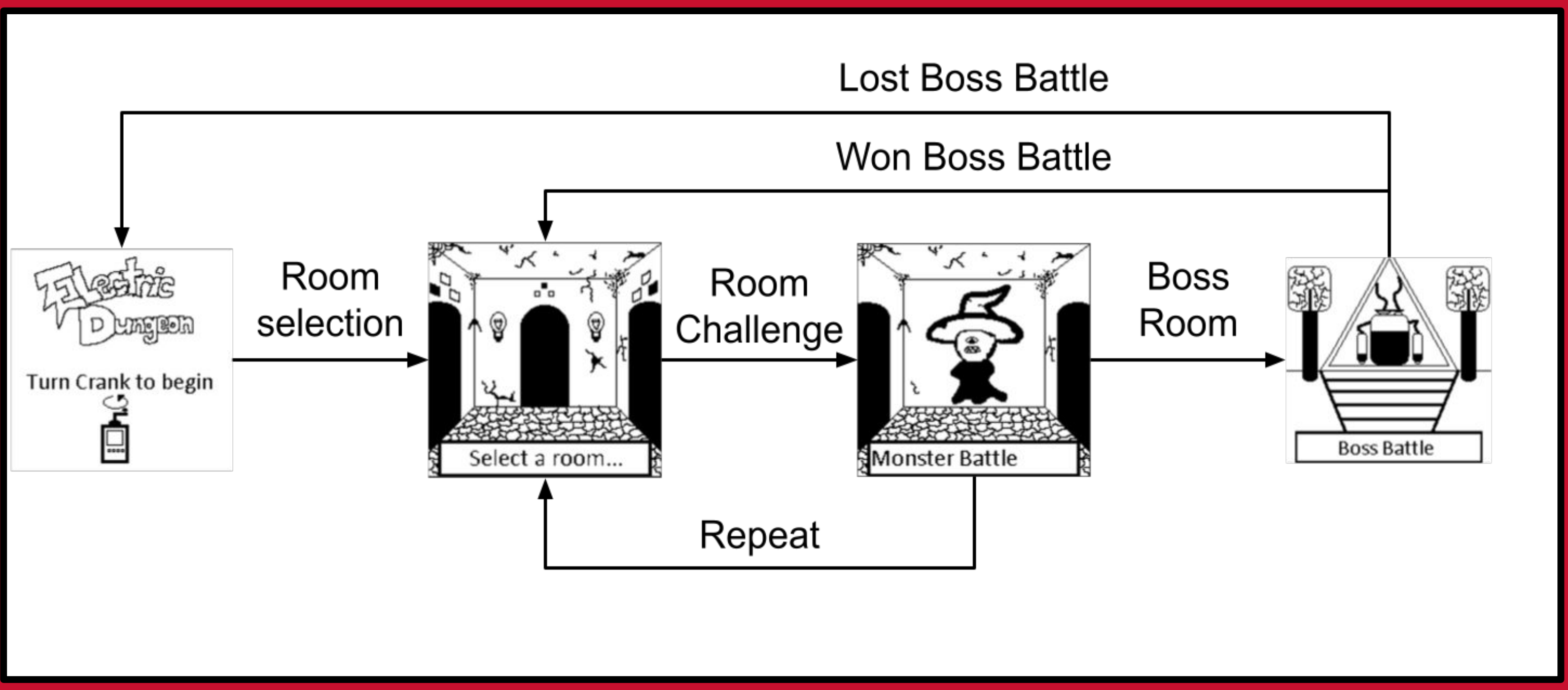
Software Design

Main Gameplay

- Dungeon Crawler based game
- Generate power to attack monsters in room challenges
- Face a boss at the end of dungeon to win the game

Gameplay Flow

- Crank generator to begin startup screen
- Once enough power is generated, display room selection
- Room challenge presented based on room selected
- Run through rooms until boss room encountered
- Fight boss to lose or win the game



Technical Details

Software

- Software implemented in Code Composer Studio and C++
- FRAM and compute through power loss API implements state saving
- 4-wire SPI connection between MCU and display
- ADC used to monitor power supply voltage
- GPIO to utilize button generators in software
- Low Power Modes to disable peripherals when not in use

Hardware

- Schematic and PCB created in KiCAD
- Undervoltage lockout and short circuit protection

Engineering Standards

Software

- Agile software development
- IEEE 12207-1996 - ISO/IEC International Standard - Information Technology - Software Life Cycle Processes
- IEEE C63.5-2019 - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control