Pedo-Watch:
Elec 327 Final Project

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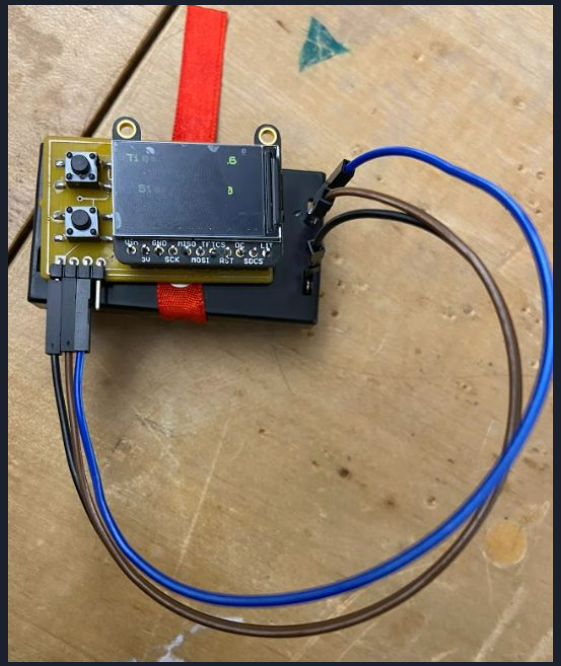
Design Problem:
Low-power pedometer watch for fitness and health enthusiasts

Design Concept:

- Energy-efficient pedometer
- Displays time (military) and number of steps via color TFT screen
- Button functionality to set/reset time and step count

Source: https://www.verywellfit.com/realalt-3dtrisport-walking-3d-pedometer-review-4782140

Final Product: Pedo-Watch



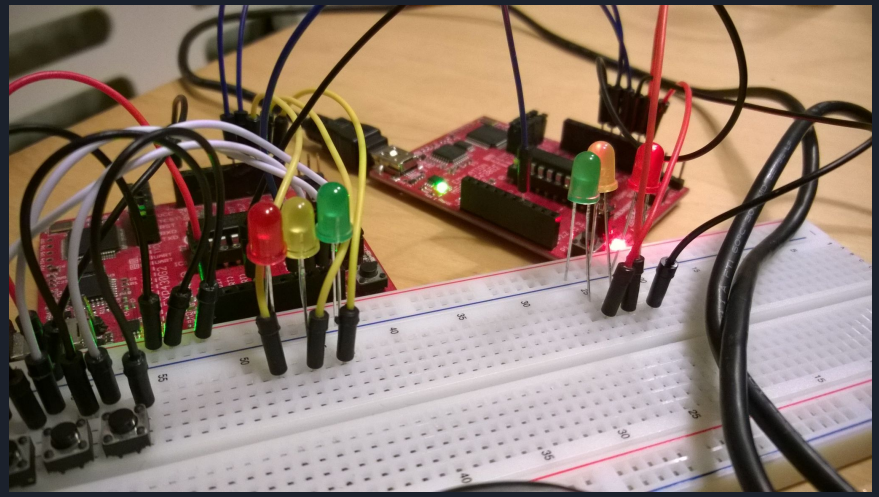
Materials

- Texas Instruments Launchpad
- 20-pin MSP430G2553
- Adafruit 1.14” 240 x 135 pixel screen
- KX126-1063 IC
- Two buttons
- Two 1k Ohm resistors
- 4.7k Ohm resistor
- 100k Ohm resistor
- Two 47 nF capacitors
- Two 0.1uF capacitors

Serial Peripheral Interface (SPI) Configuration

Serial Peripheral Interface (SPI) Configuration

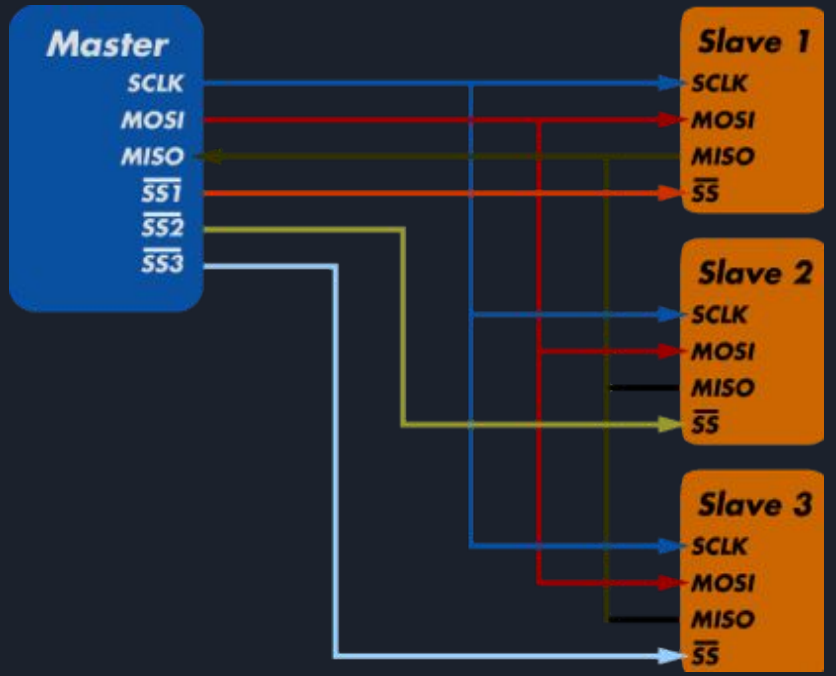
- Serial communication interface chosen due to high clock speed needed for updating step count/time
- Master Device: MSP430G2553
- Slave Devices:
  - Pedometer
  - Screen



Source: https://www.tns-labs.org/msp430-spi-communication/

SPI Configuration (Continued)

- Chip Select (CS) pin determines slave device that the master device writes information to
- MISO (Master-in, Slave-out) and MOSI (Master-out, Slave-in) configurations determine direction of information transmission

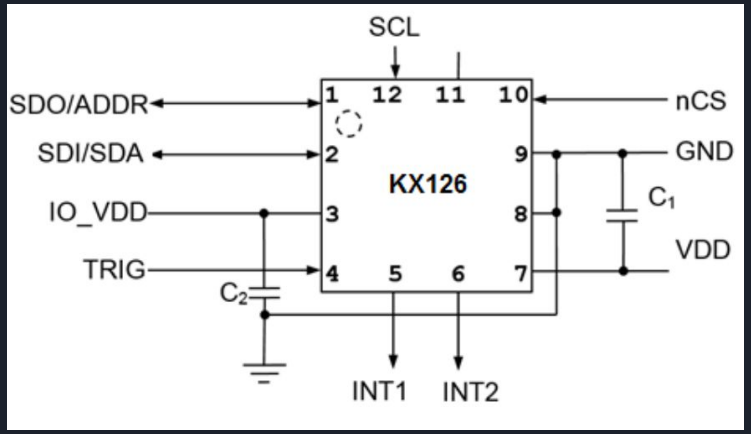


Source: https://www.totalphase.com/blog/2020/07/what-is-spi-protocol-how-to-debug-spi-communication/

KX126-1063 Pedometer Configuration & Implementation

Pedometer Configuration

- Chip: KX126-1063 IC
- Clock Speed: 0.5 MHz
- Write: send two bytes - address and value for address
- Read - Send two bytes - address and dummy variable to provide clock
- Initial Software Reset
- Set pedometer configuration mode
    - Adjust step threshold control register



Source: https://download.mikroe.com/documents/datasheets/KX126-1063.pdf

Pedometer Implementation

- Two 8-bit displacement registers
- Interrupt Pin 2 – GPIO 2.2 - automatically adds steps
- Interrupt updates steps displayed after every 12 steps

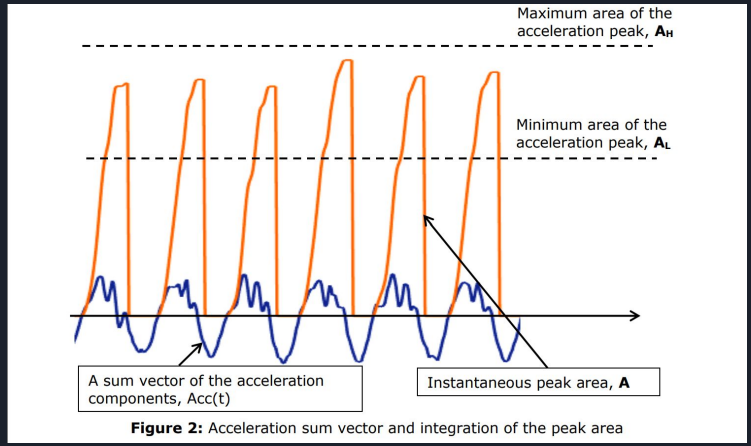


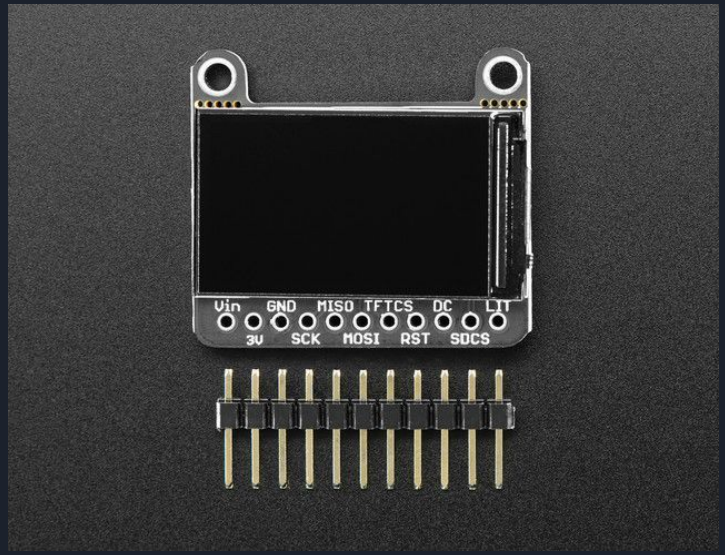
Figure 2: Acceleration sum vector and integration of the peak area

Source: https://www.researchgate.net/figure/Displacement-velocity-and-acceleration-for-a-cam-with-a-constant-velocity-profile-for_fig2_337140375

TFT Screen Implementation

TFT Screen Configuration

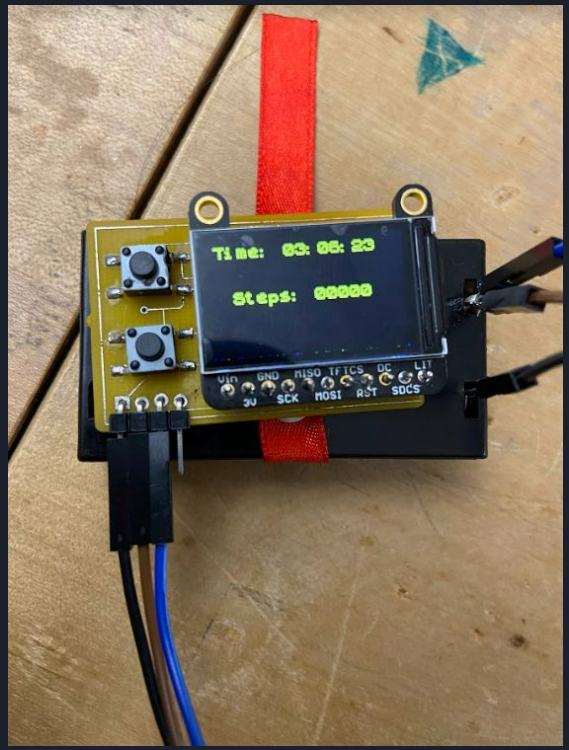
- Chip: ST7789VW
- Clock Speed: 8 MHz
- Initialize software reset
- Configure master, phase, and asynchronous modes to enable SPI
- CASET/RASET commands specify row/column for pixel drawn



Source: https://learn.adafruit.com/adafruit-1-14-240x135-color-tft-breakout/pinouts

TFT Screen Implementation

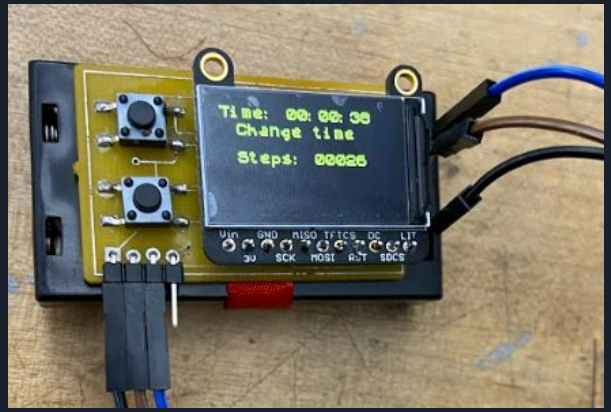
- Write byte to transmission buffer UCB0TXIFG
  - Draw pixel with color specified by byte
- Iterate drawing color pixels to draw text including step counter and time

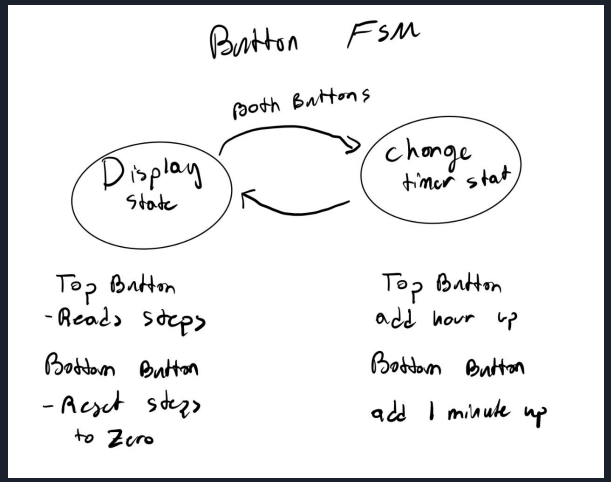


Button Implementation

Button Implementation

- Have a FSM for button function
  - Having two buttons, top and bottom button
- State 1: Displaying
  - Top button reads steps
  - Bottom button reset steps to 0
  - Press both to change state to change time
- State 2: Change Time
  - Top button changes hours
  - Bottom button changes minutes
  - Press both to change state to displaying

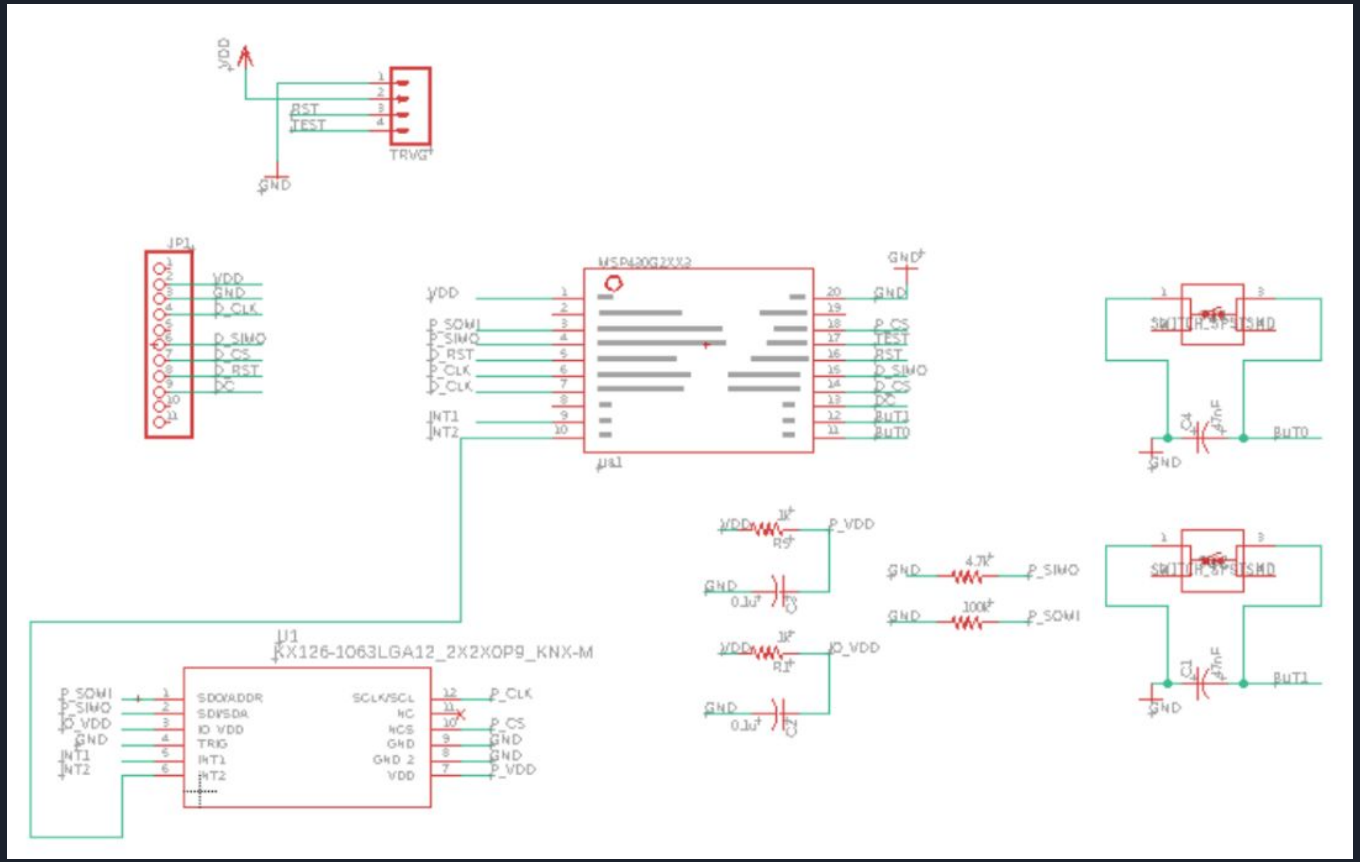




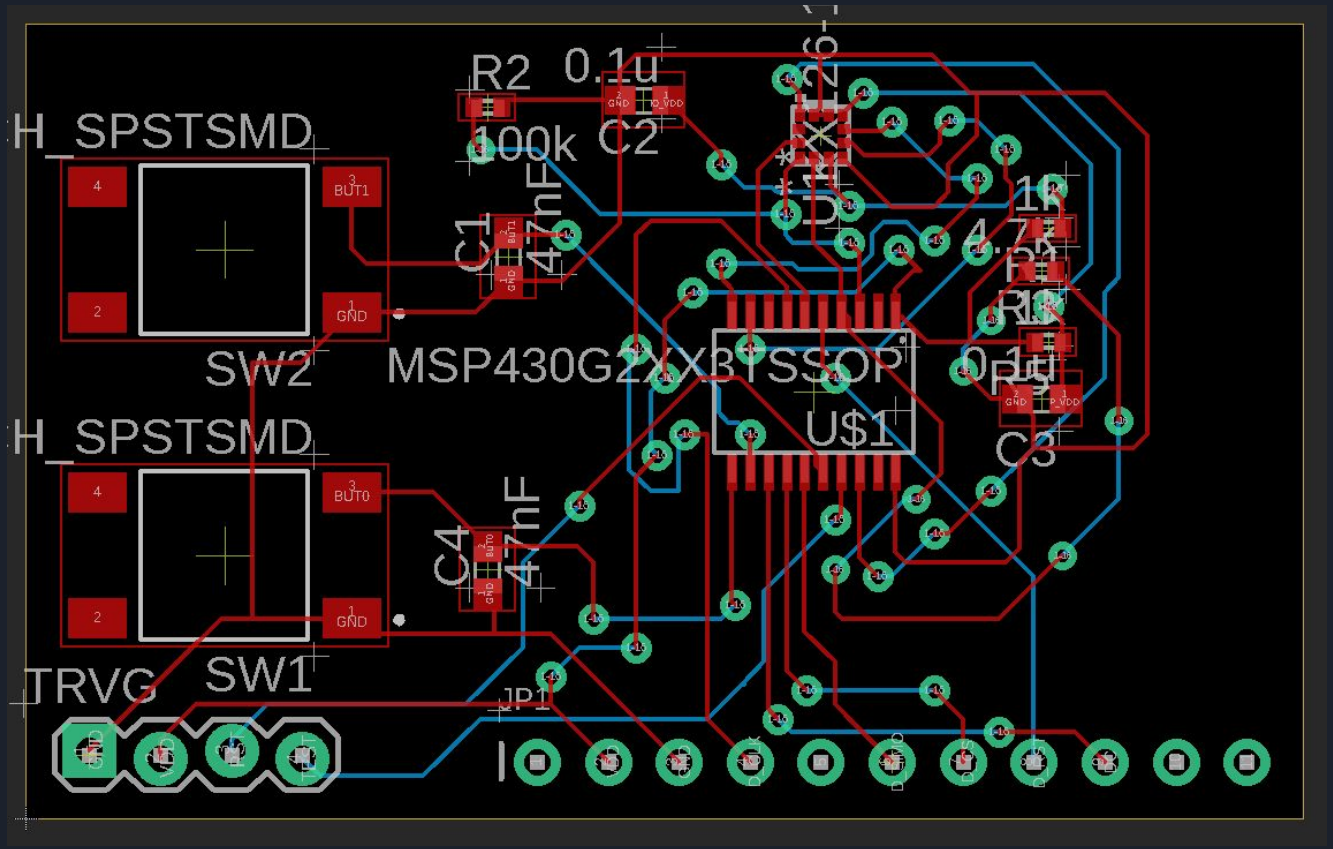
PCB Design

PCB Layout

- Other components:
  - 4 pins connecting Launchpad
  - Resistors/capacitors for pedometer and button connections
- Only DVCC/DVSS pins shared
- Vacant pins: P1.0, P2.0, P2.6
- Remaining pins allocated to certain purpose for a specific component



PCB Eagle Schematic

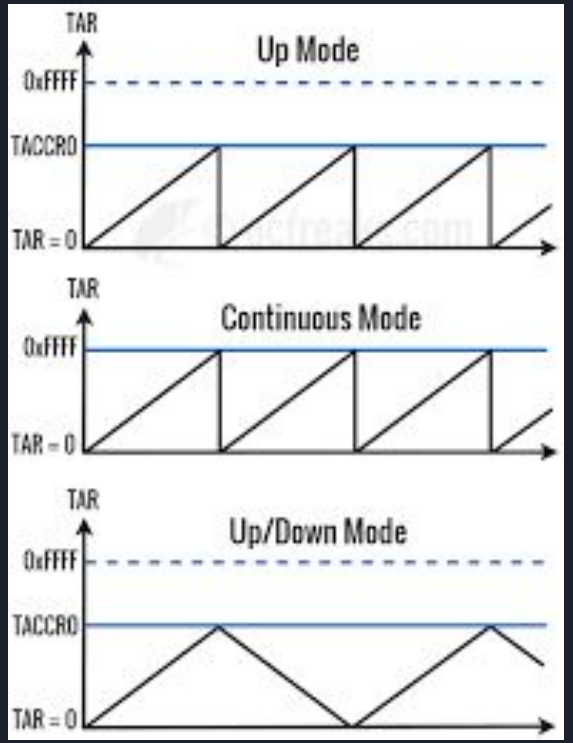


PCB Eagle Board

Low-Power Implementation

Low-Power Implementation

- Use interrupts for delaying tasks
  - delay() function uses CCR0 interrupt to put MSP430 to sleep awaiting an input time
  - Active low button interrupt updates step count displayed after each 12 steps

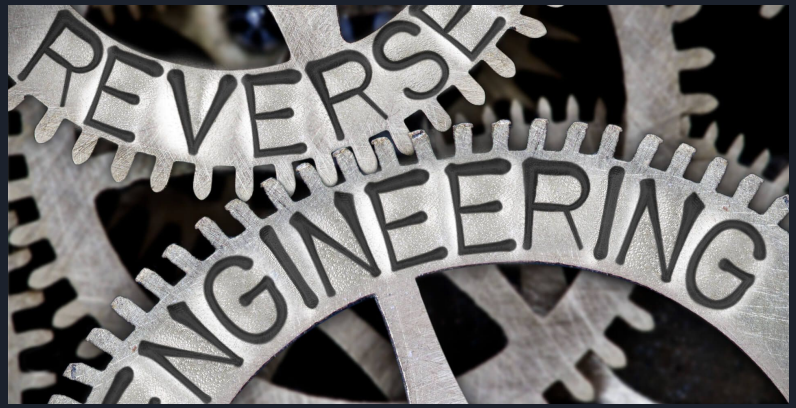


Source: http://www.ocfreaks.com/msp430-timer-programming-tutorial/

Challenges

Challenges

- Initial difficulties interfacing with pedometer and screen
  - “Reverse engineer” commands via running sample code and probe with oscilloscope
  - Correct timing with writing to transmission buffer



Source: https://searchengineland.com/reverse-engineer-online-advertising-strategy-288994

Takeaways

Takeaways

- Heavily-utilize interrupts when prioritizing low-power consumption
- Datasheets and “Reverse engineering” devices are very effective for understanding devices’ functionality
  - Run sample code and probe to find necessary commands