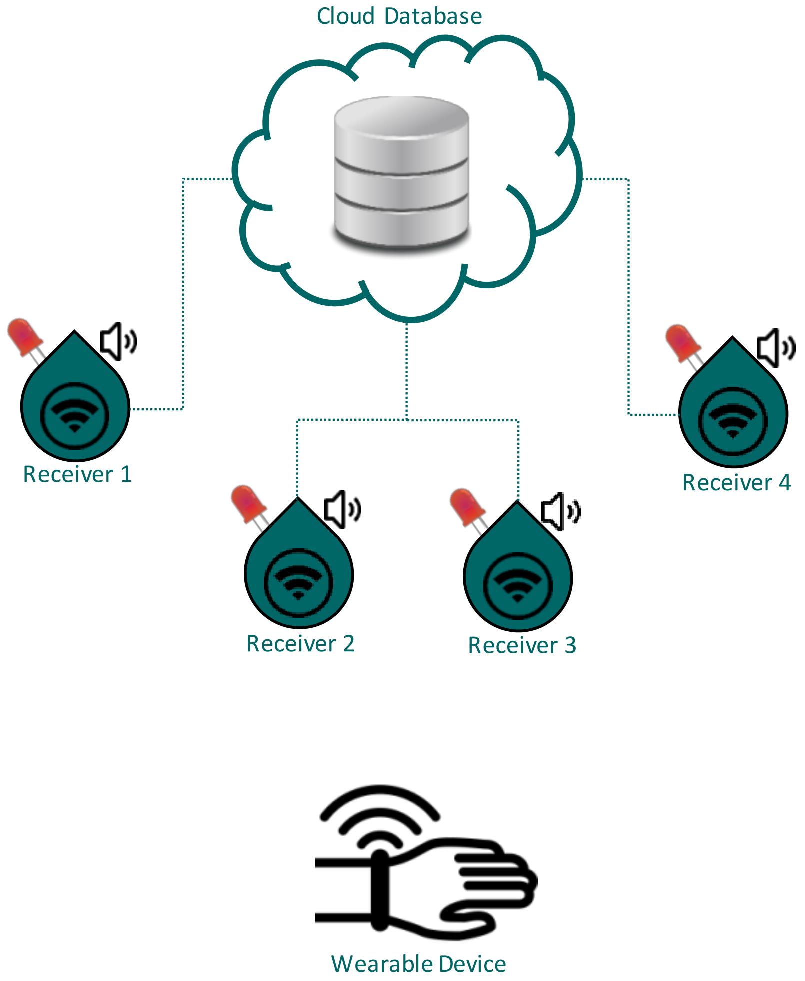
Home Interactive Notification Tracking

Critical Design Review

09-09-2016



<u>Group B</u>

Maria-Camila Nuñez (EE)

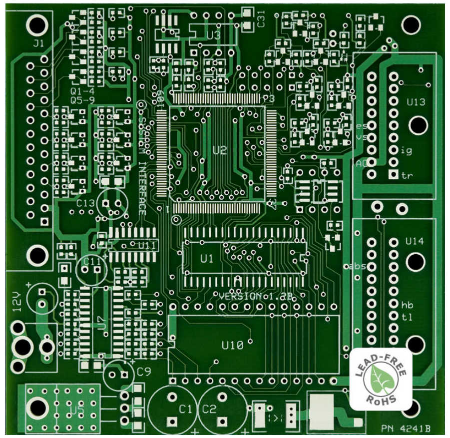
Ramon Jimenez (EE)

Mannuel Cortes (EE, CS)

About HINT

A system that makes notification tracking easy, fun, and interactive for the user.

RSSI



Control

Wearable Device

- Will only communicate with PCB in range
- Will only send RSSI data (received signal strength indication) and receive discrete signals for auxiliary I/O

PCB w/ RF Transceiver

- Will have a TCVR to communicate with both wearable and laptop/phone controller
- Will have main sensory I/O

Laptop/Phone/Cloud

- Will serve as the controller and database

Motivation

- Overall positive impact of the effects parenting has on children growing up
- Facilitate communication between parent and child while making it fun and interactive
- Research indicates that children who have some sort of schedule/chores have:
  - Higher self-esteem
  - Sense of responsibility
  - Qualities that contribute to higher success in school

- Scalability
- Internet of Things network
- Interactive notification tracking system
- Implementation of three out the five human senses

Goals and Objectives

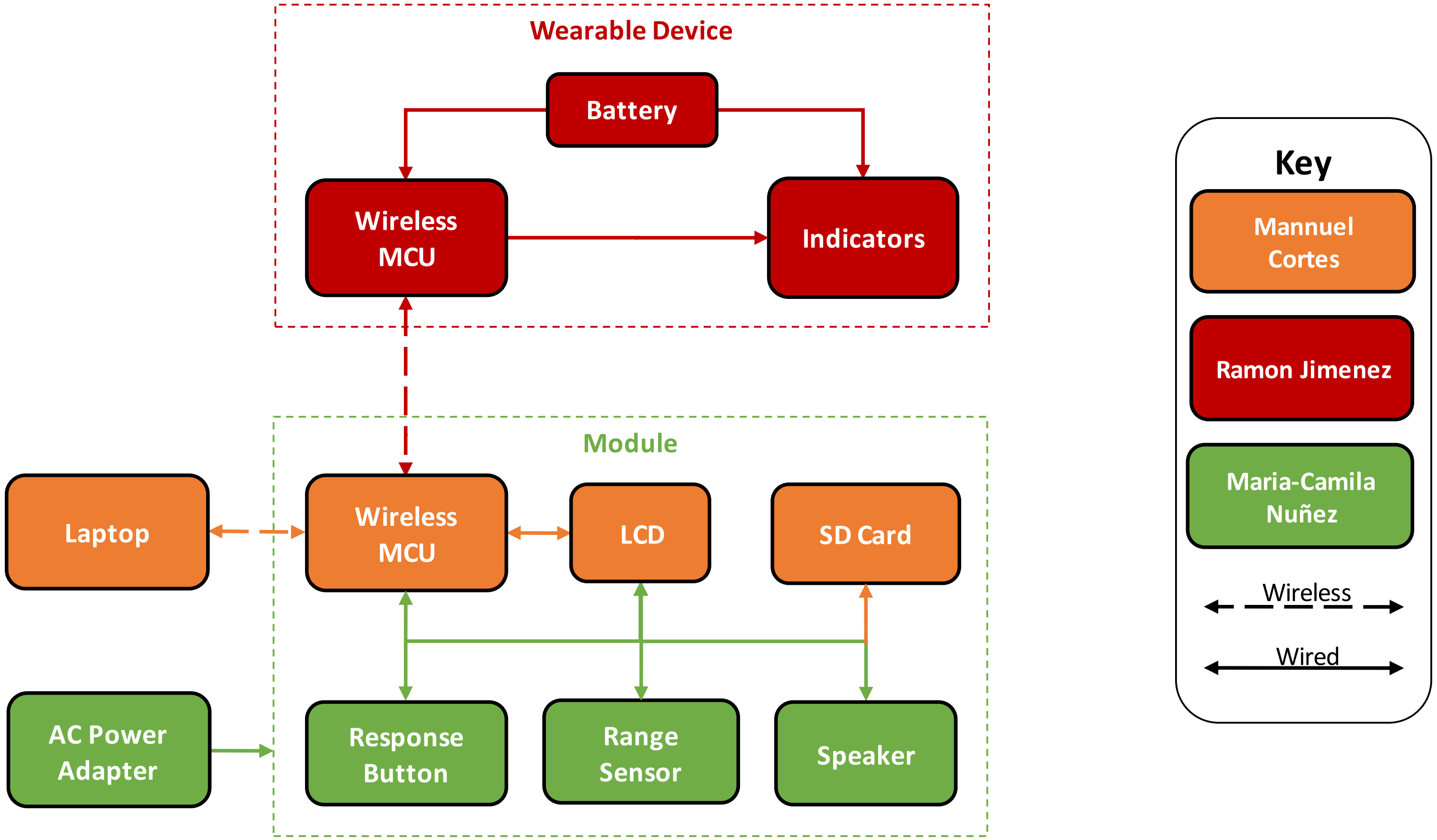
- Provide homeowners and families with best overall experience with HINT
  - User friendly and interactive by not being dependent on a phone to set a schedule/reminders
  - Affordability to other variations of products alike
- HINT will not only notify tasks around the home but will also enforce them
  - Notifications will not be ignored with the help of components in both the module and the wearable
- System is projected to stimulate the human senses to execute tasks obtained through tracking.
  - Sense of sight
  - Sense of touch
  - Sense of hearing

Specifications and Requirements

- Requirements were selected by sponsor and further refined by team
- Design critical requirements displayed in table as shown

Component	Parameter	Requirement
LCD Display	Visual Alerts & Cues	Display tasks to be completed
Module Circuit Board	Maximum Power Consumption	12 W
Response Button	User Interaction Interface	Large & interactive
Speaker	Auditory Alerts	Tone/voice
Ultrasonic Range Sensor	Minimum Detection Range	20 ft
Wearable Circuit Board	Maximum Power Consumption	.05 W
Wearable Circuit Board	Sensory Output Notifications	2 outputs
Wearable Device	Maximum Size	40 mm x 15 mm
Wearable Power Supply	Maximum Charge Time	3 hrs
Wearable Power Supply	Battery	Rechargeable
Wireless Communication Chip	Minimum Range	15 ft
Wireless Communication Chip	RSSI Sensitivity Accuracy	±5 dB

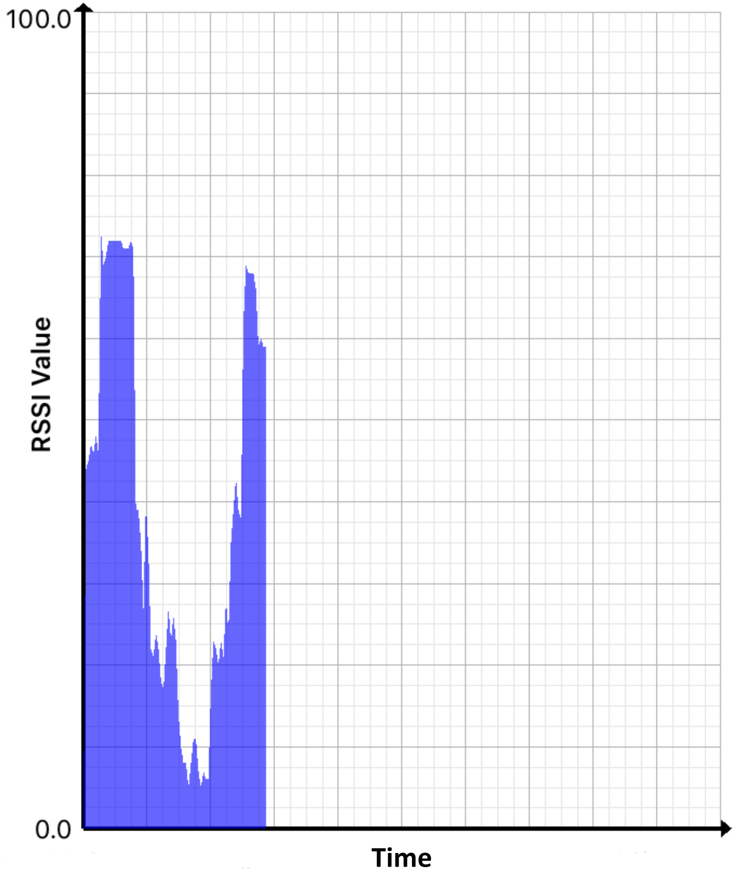
Design Overview



How HINT Works

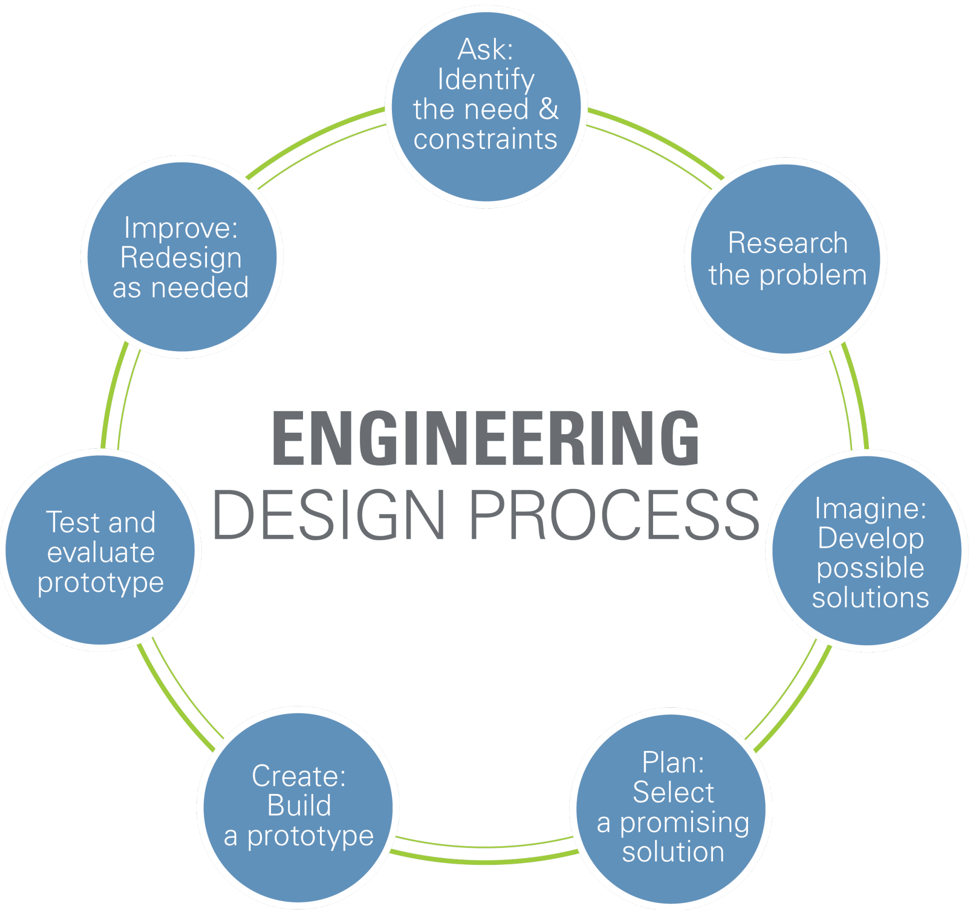
- HINT will use a combination of RSSI and range/motion detection to determine the proper time to output a notification
- RSSI – Received Signal Strength Indicator
  - Will be used with Ultrasonic Sensor to trigger notifications
  - Algorithm to be determined for approximate distance calculation by converting value to dBm and evaluating the power signal
- Range/motion detection
  - We will speak about this in the components (Ultrasonic Sensor) section

Signal Strength Measurement



Design Approach

- System function Identification
- Research
- Requirements Specification
  - Marketing requirements
    - Customer needs
  - Engineering requirements
    - Technical aspects
    - Performance aspects
- Design Phase
- Prototyping Phase
- System Integration and Test
- Reflect and Redesign

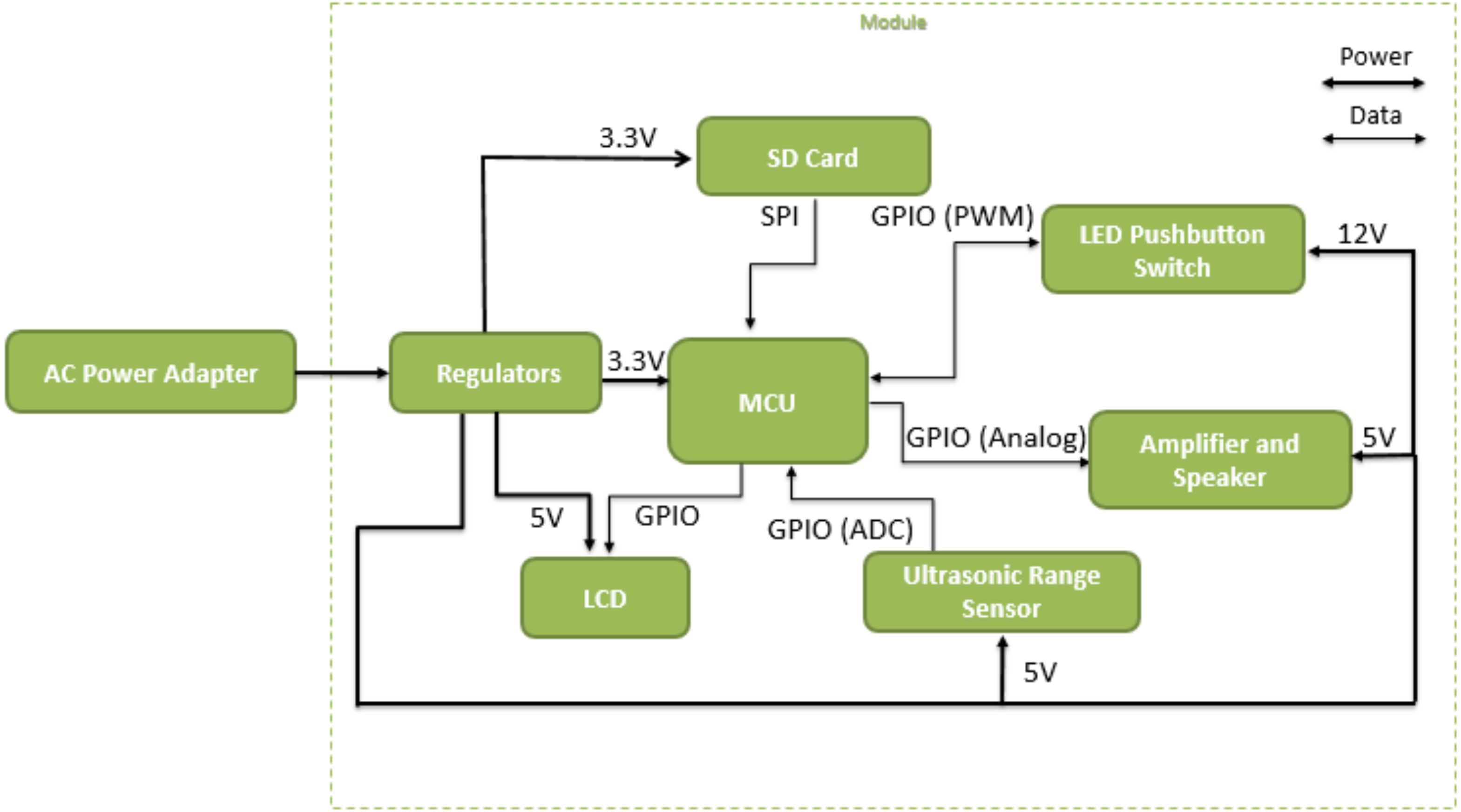


Work Distribution

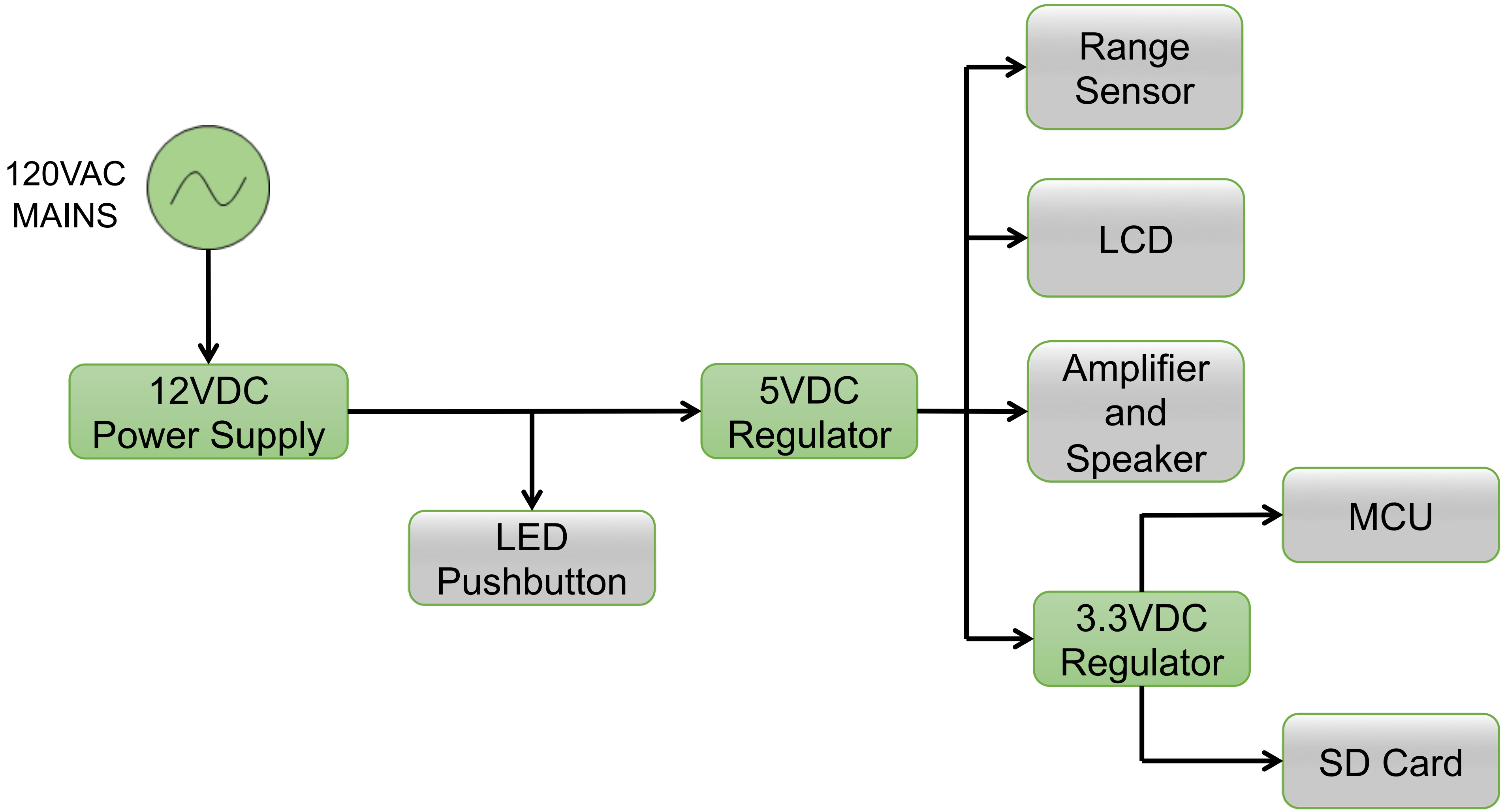
Function	Primary	Secondary
Wearable Power	Ramon Jimenez	Maria-Camila Nunez
Wearable Software	Ramon Jimenez	Manny Cortes
Range Sensor Integration	Maria-Camila Nunez	Ramon Jimenez
Module Software	Manny Cortes	Ramon Jimenez
LCD Integration	Manny Cortes	Maria-Camila Nunez
Speaker Integration	Maria-Camila Nunez	Manny Cortes
RSSI	Ramon Jimenez	Maria-Camila Nunez
Pushbutton Integration	Maria-Camila Nunez	Manny Cortes
MCU Routing	Manny Cortes	Ramon Jimenez

Module

- Primary job is to utilize a sensory output notification system when user is detected
- It will work in conjunction with the wearable through Bluetooth Low Energy communication interface
- When user is detected by the motion sensor, and a predetermined RSSI value is met, there will be an output signal sent to the components on the module
- A signal will also be sent to the wearable to enable notification components to initiate their respective functions

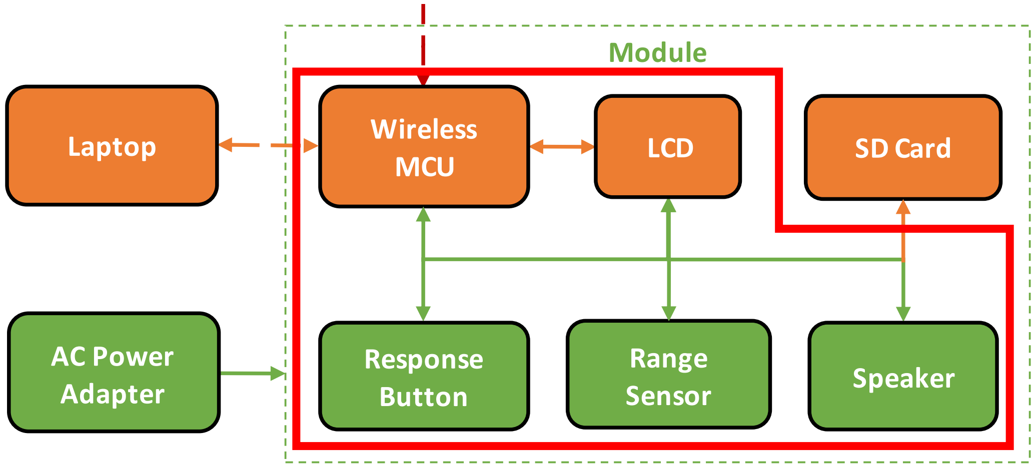


Power Distribution



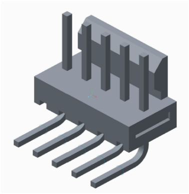
Main Components

- Wireless MCU
- Ultrasonic Range Sensor
- LED Pushbutton
- LCD
- Speaker/Amplifier

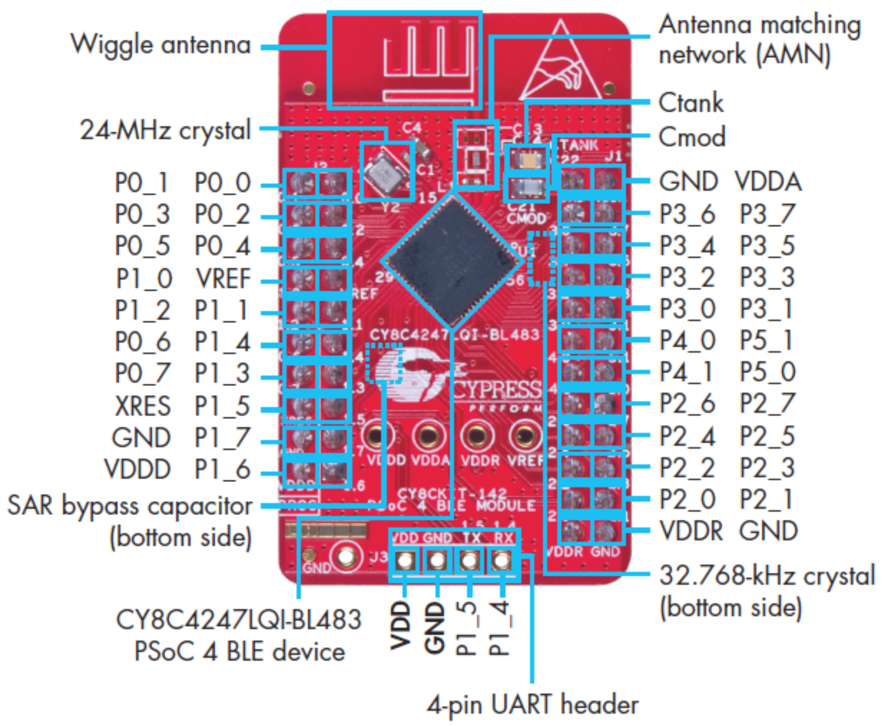


Wireless MCU

- Microcontroller module with integrated trace antenna, oscillator, and RF front end
  - Removes the need for RF PCB design
- Uses a 32-bit, 48-MHz PSoC 4 BLE Microcontroller
  - 128 kB Flash
  - 16 kB SRAM
  - Integrated voltage regulation
  - 2.4 GHz RF Transceiver
  - ADC, DAC, and Serial peripherals
  - 36 Programmable GPIO pins
  - Ample development support
- All necessary pins route to headers J1 and J2
- Can be programmed/debugged with Cypress MiniProg3 USB kit
  - Mates with Molex connector 022-05-3051

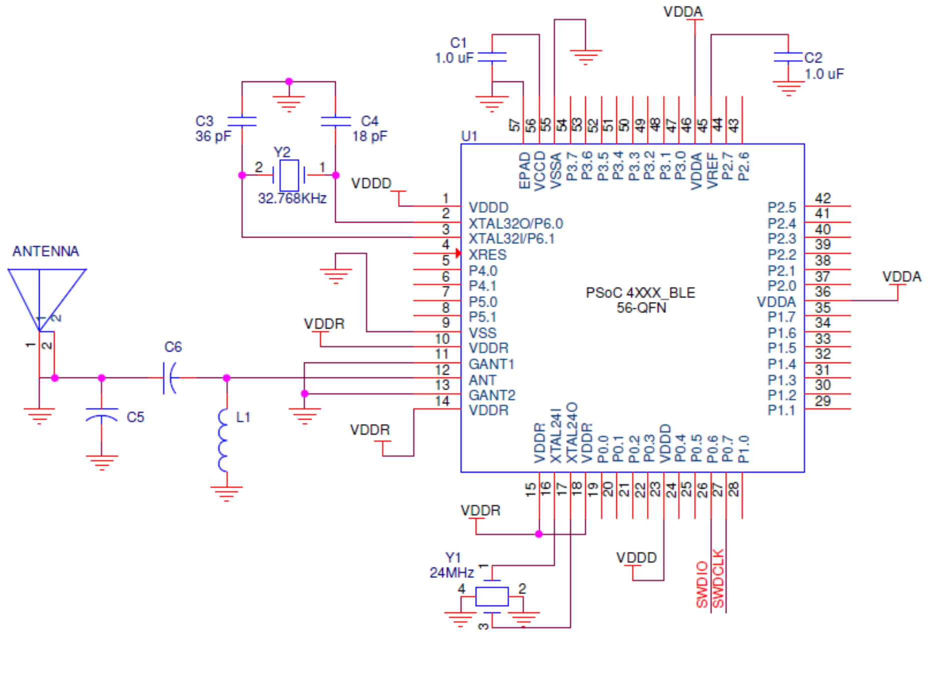


Cypress CY8KIT-142 Module

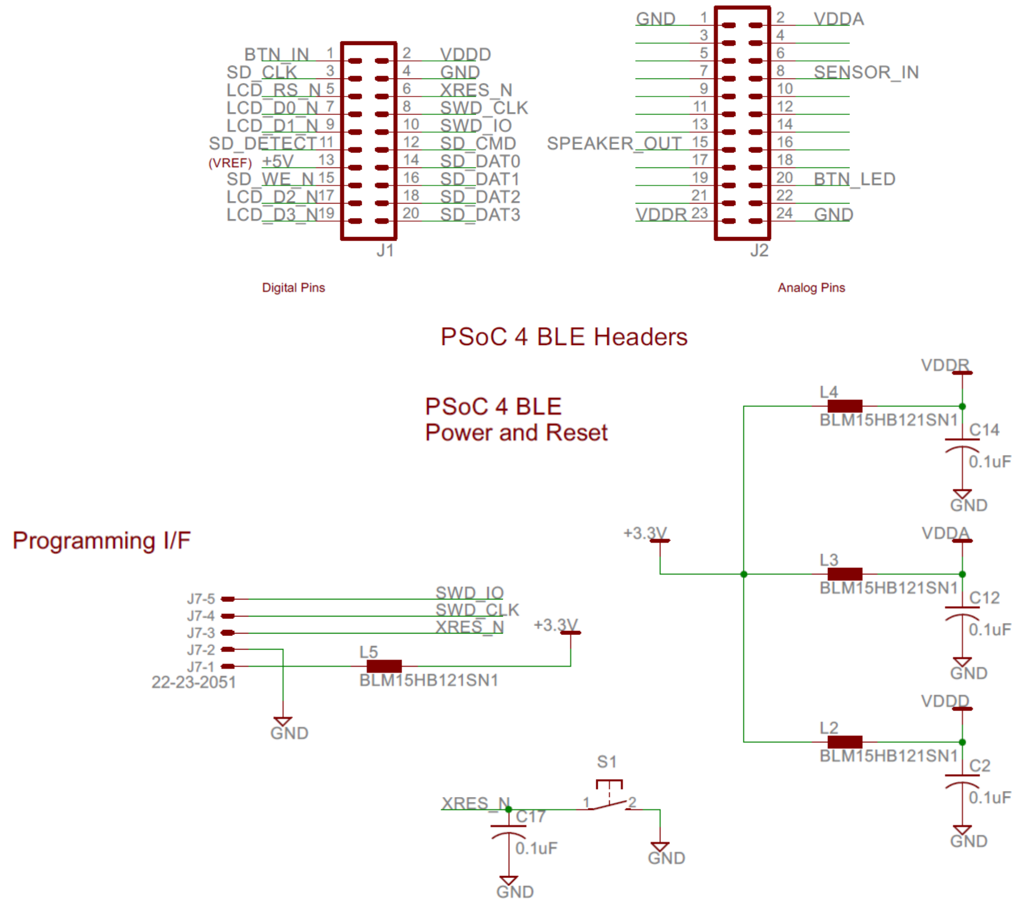


44.45mm x 25.4mm

Wireless MCU



Simplified Schematic of BLE Module



Interfaces of BLE Module in HINT Design

Ultrasonic Range Sensor

- Concept is to be utilized for range and distance calculation
- Follows requirement of a broad distance detection range
- Three interface output formats
- 2.5V to 5.5V supply with 2mA typical current draw
- Readings can occur up to every 50ms
- Analog voltage pin outputs voltage which corresponds to the distance

- Voltage Scaling

$$Vi = \frac{Vcc}{512}$$

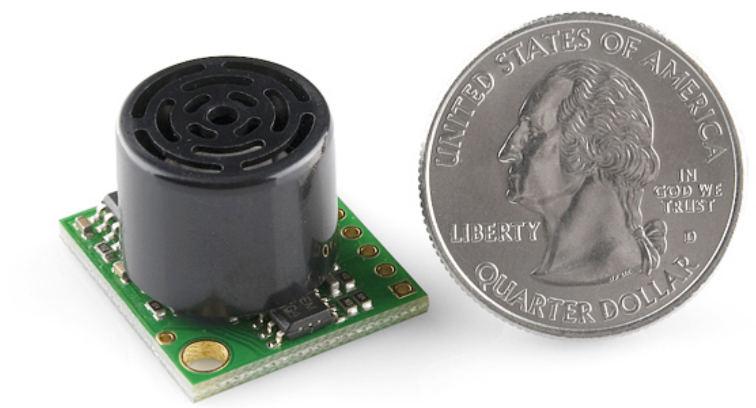
Vcc = supplied voltage
Vi = volts per inch

- Range

$$Ri = \frac{Vm}{Vi}$$

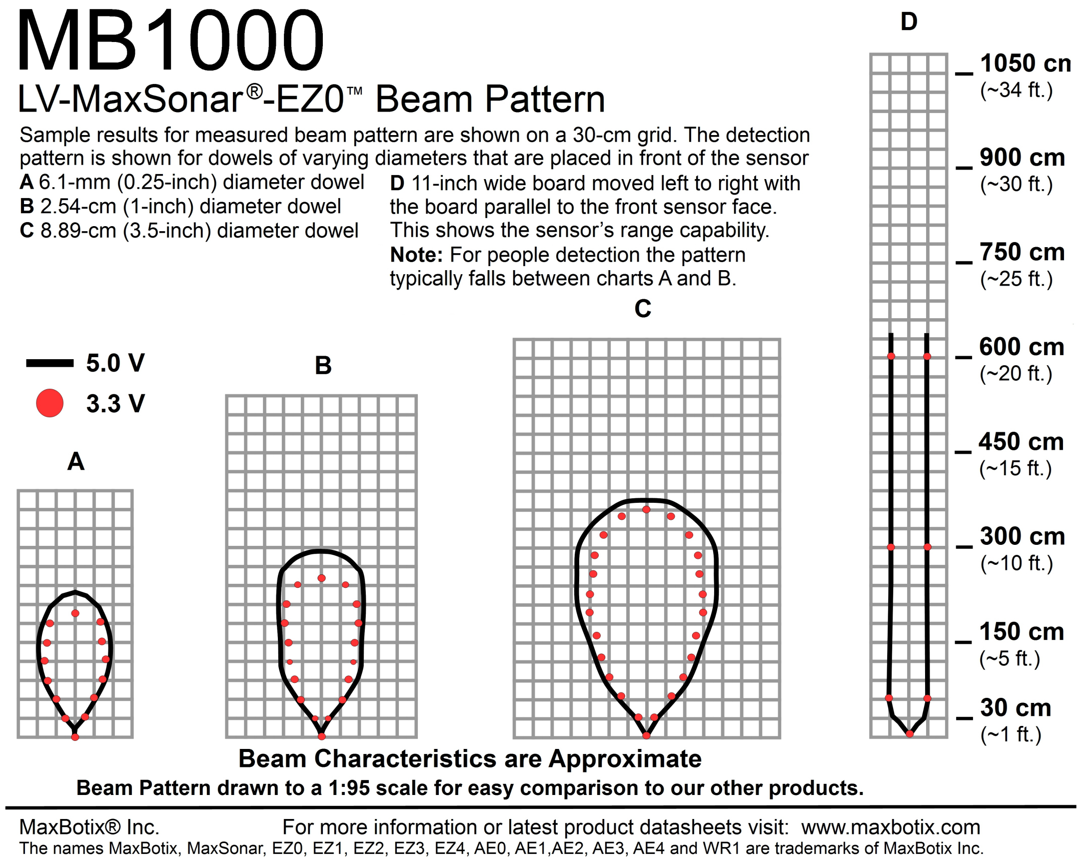
Vm = measured voltage
Ri = range in inches

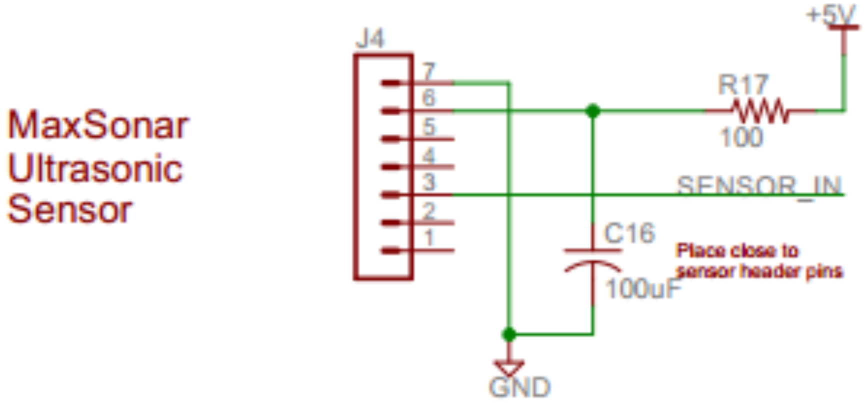
MaxBotix LV-MaxSonar – EZ0



Ultrasonic Range Sensor

- High sensitivity and wide beam sensor
- Each beam pattern is a 2D representation of the detection area of the sensor
- Beam patterns are read by looking at target size and distance detection



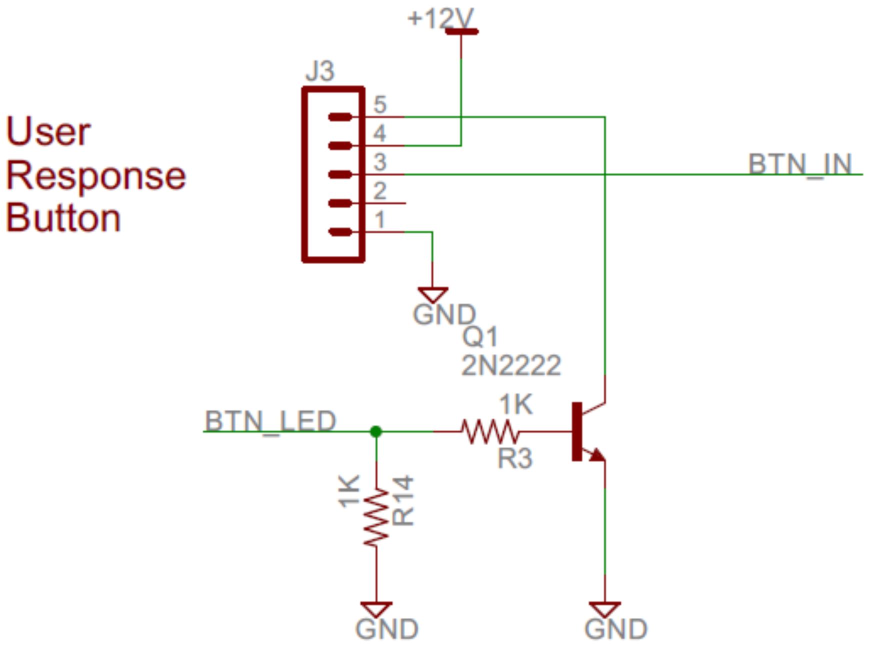


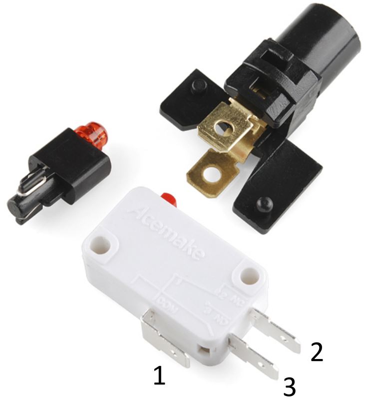
- In case of electrical noise, a power filter was attached to the Vcc and GND pins in order to help mitigate the noise
- The capacitor value is of low ESR (Equivalent Series Resistance) which increases stability and load life

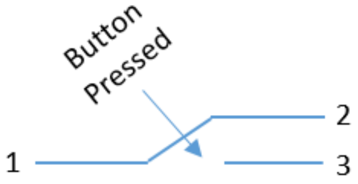
LED Pushbutton

- Concept is to turn on with conjunction with notification on LCD display
- Follows visibility requirement, it is 4 inches in diameter
- Follows HINT's purpose
- Reliable for longevity use of 10 million cycles, and can be easily replaced
- 12V device, with internal 460Ω current limiting resistor
- 20 mA max current draw; 0.24W max power dissipation
- 5 terminal device with independent LED and switch circuit
- Can be easily “connectorized” and routed to a header

Sparkfun Big Dome Pushbutton

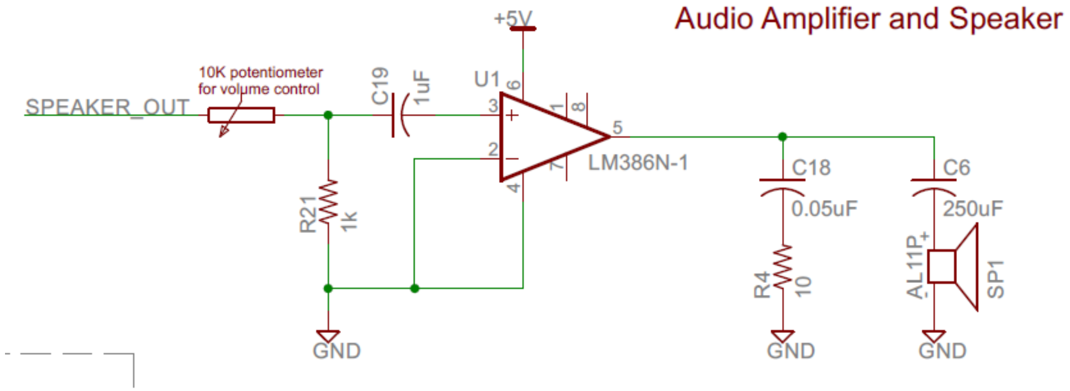






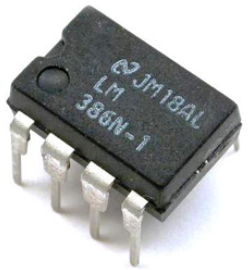
Speaker

- Speaker enforces that notifications will not be ignored
- Synchronizes with the vibrating indicator on the wearable design as an auxiliary reminder
- 8Ω, 0.5W Speaker
- Interfaced through a T.I. LM386 low-voltage audio amplifier to improve audio quality
    - 5V part with max current draw of 8mA
    - Applies gain for stronger audio output
    - Comes in a DIP-8 package for easy prototyping



With pins 1 and 8 open, gain = 20 dB

General Purpose Speaker



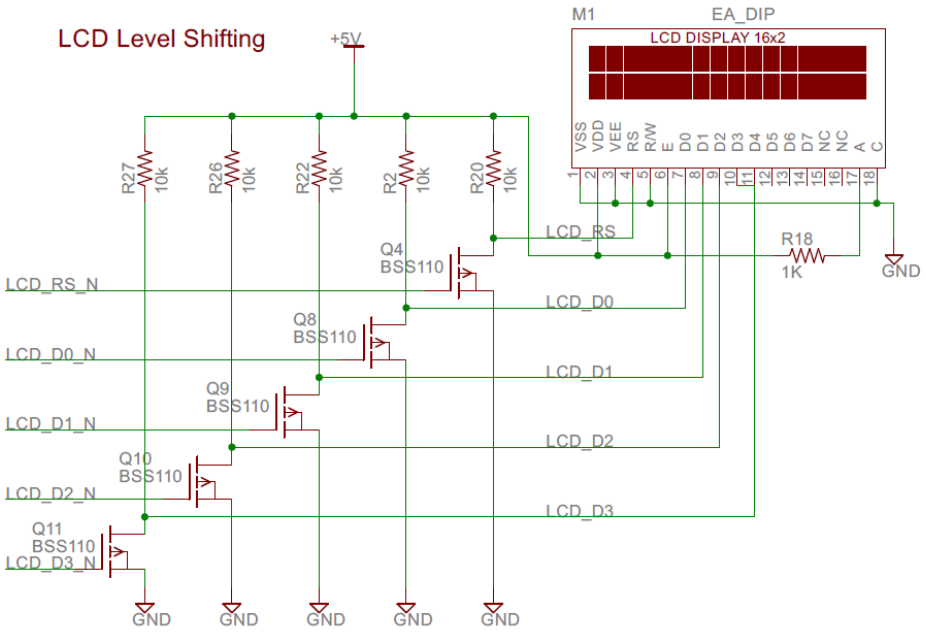
10mm x 6.35mm

LCD

- The LCD is only digital output to supplement the sensory I/O
- Will give the specific instructions on the scheduled task
- 2x16 characters suffices for short task descriptions
  - The simple display doesn't distract or take away from the sensory aspect of the project
- Blue screen with white LED backlight
- 5V part with 45 mA current draw (including backlighting)
- DIP module and 8 or 4-bit interface for easy prototyping

Electronic Assembly DIP162

75mm x 27mm



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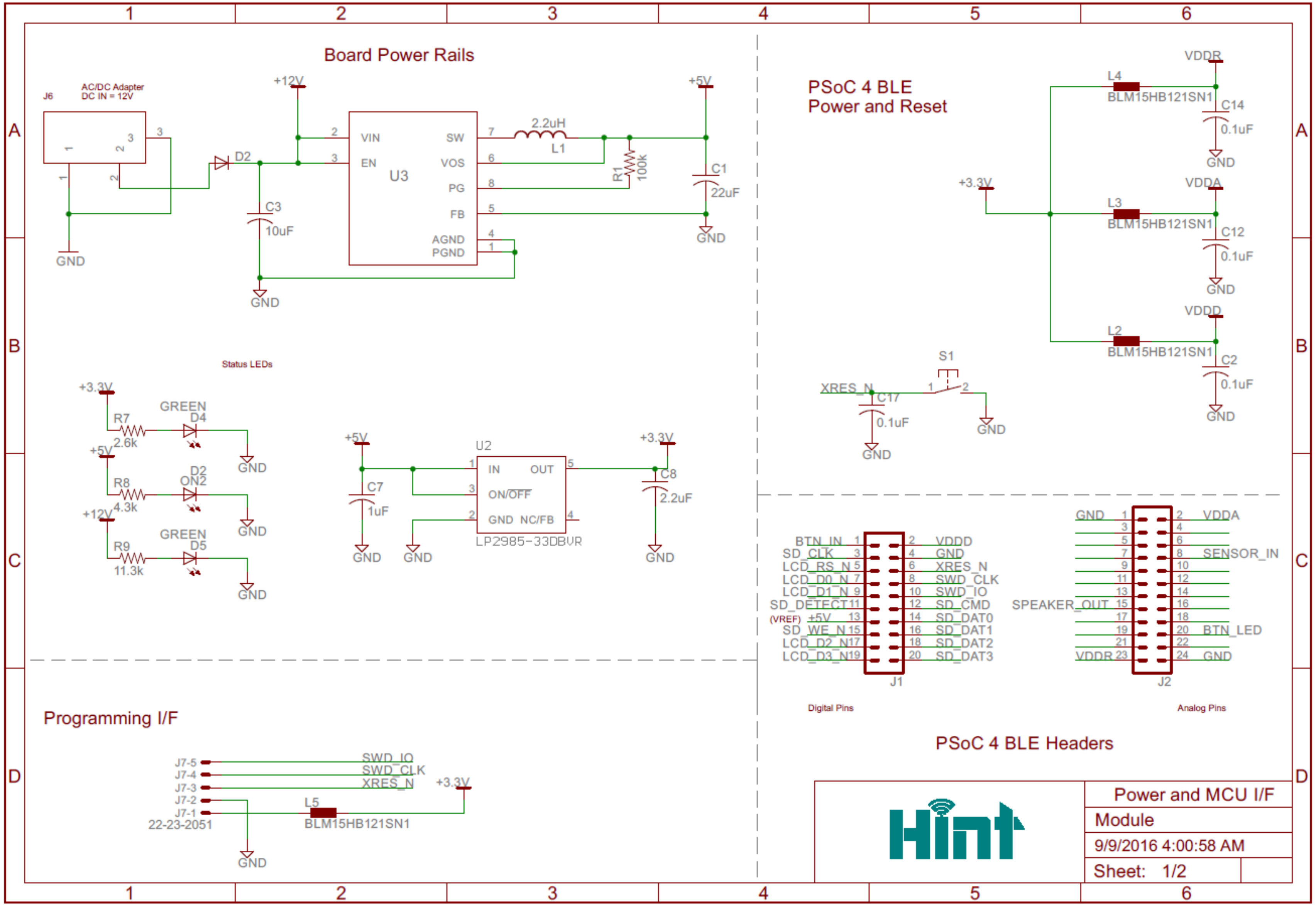
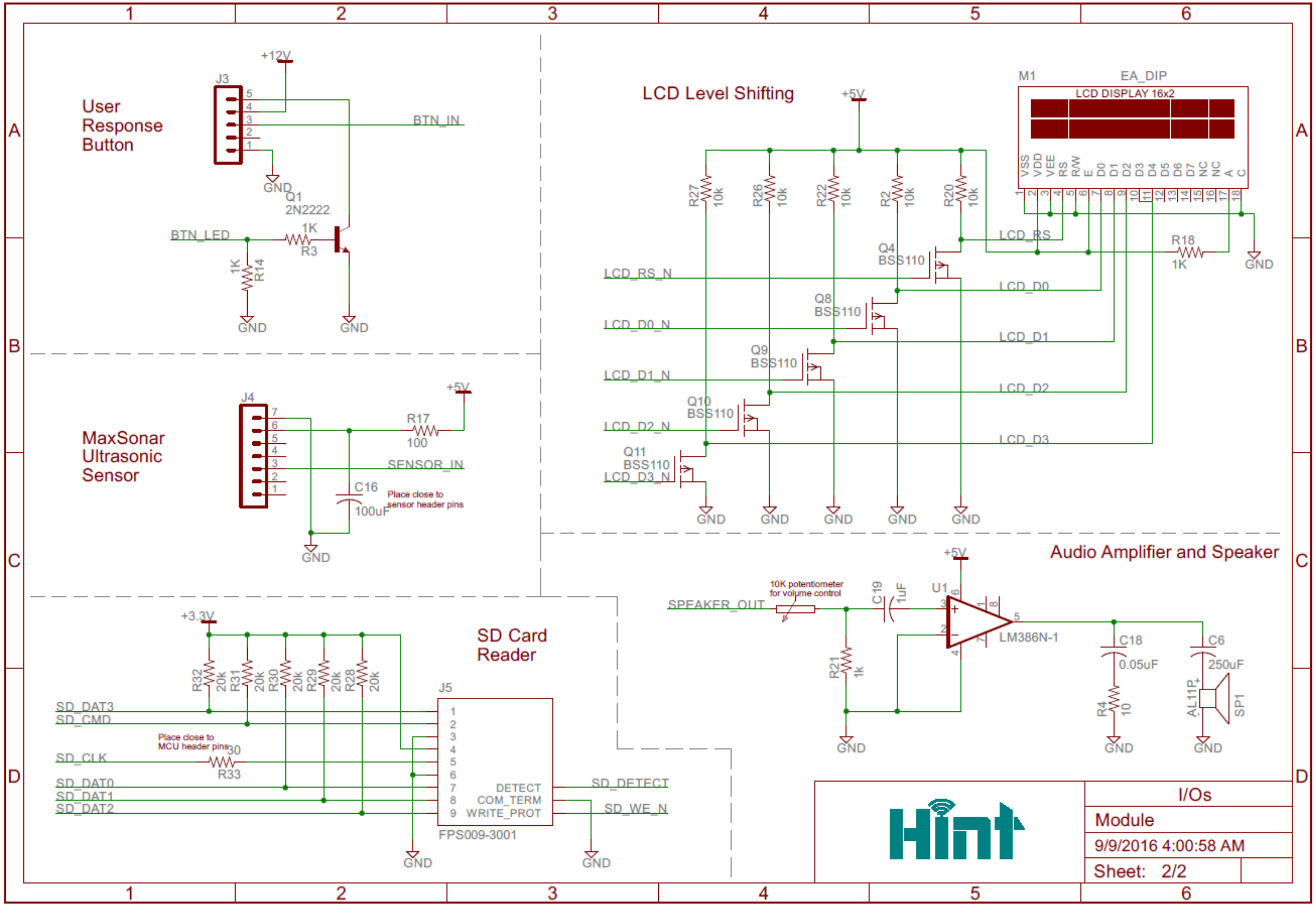
Schematics


Board Power Rails
AC/DC Adapter DC IN = 12V
J6
D2
+12V
U3
VIN
EN
SW
VOS
PG
FB
AGND
PGND
2.2uH
L1
R1
100k
+5V
C1
22uF
C3
10uF
GND
Status LEDs
+3.3V
R7
2.6k
GREEN
D4
+5V
R8
4.3k
D2
ON2
+12V
R9
11.3k
GREEN
D5
U2
IN
OUT
ON/OFF
GND NC/FB
LP2985-33DBVR
C7
1uF
C8
2.2uF
PSoC 4 BLE
Power and Reset
VDDR
L4
BLM15HB121SN1
C14
0.1uF
VDDA
L3
C12
VDDD
L2
C2
S1
XRES_N
C17
BTN_IN
SD_CLK
LCD_RS_N
LCD_D0_N
LCD_D1_N
SD_DETECT
(VREF) +5V
SD_WE_N
LCD_D2_N
LCD_D3_N
VDDD
XRES_N
SWD_CLK
SWD_IO
SD_CMD
SD_DAT0
SD_DAT1
SD_DAT2
SD_DAT3
J1
Digital Pins
VDDA
SENSOR_IN
SPEAKER_OUT
BTN_LED
VDDR
J2
Analog Pins
PSoC 4 BLE Headers
Programming I/F
J7-5
J7-4
J7-3
J7-2
J7-1
22-23-2051
SWD_IO
SWD_CLK
XRES_N
L5
BLM15HB121SN1
Hint
Power and MCU I/F
Module
9/9/2016 4:00:58 AM
Sheet: 1/2

Schematics



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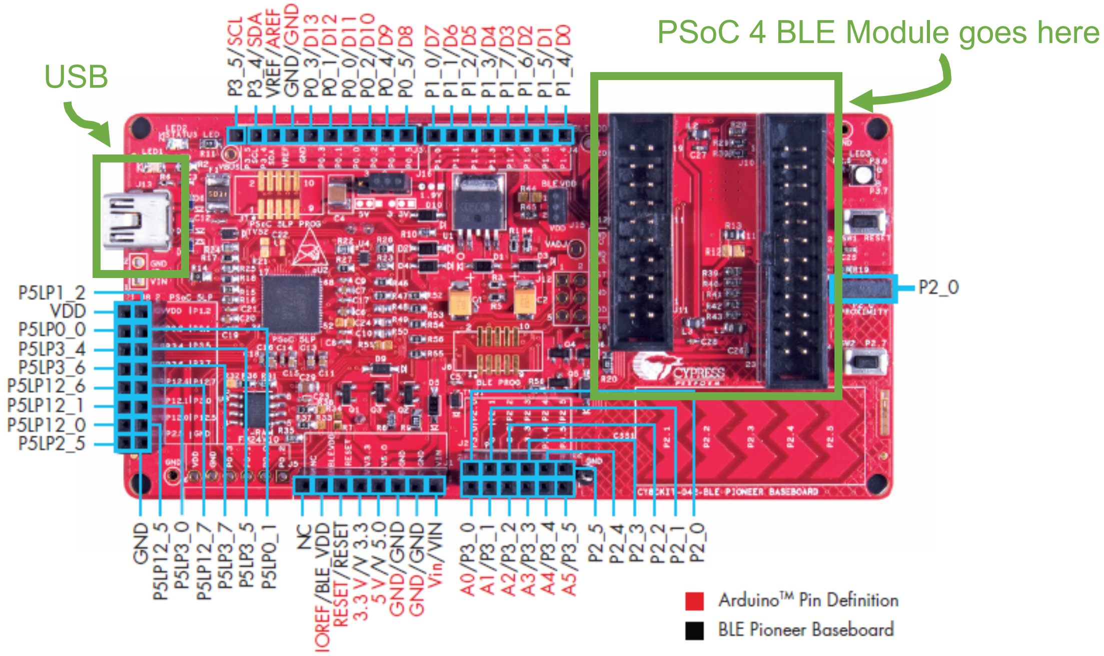
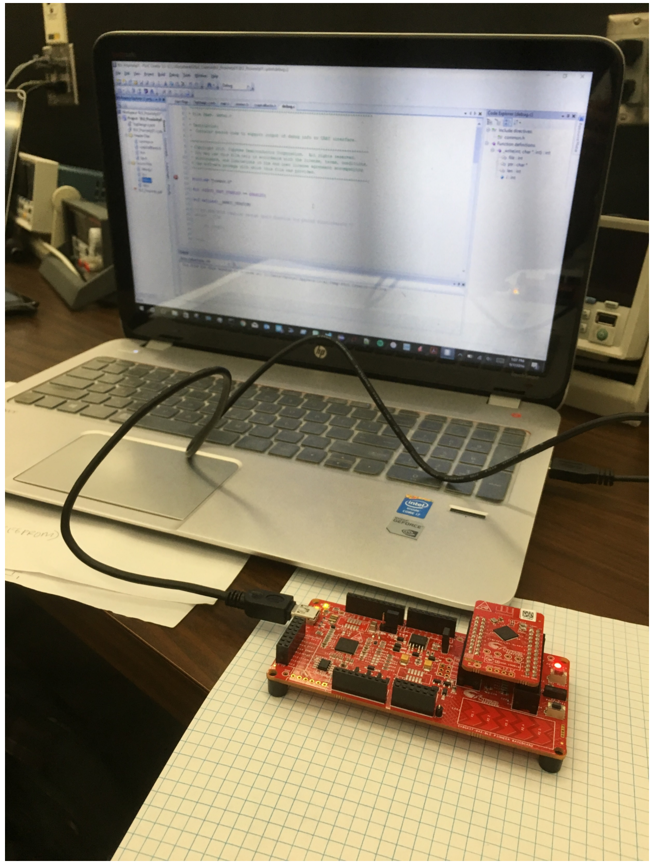
Prototype

- Prototype uses a Cypress CY8CKIT-042-BLE Pioneer Development Board
- Board contains a USB debugger and is programmed through the USB port
- Board receives 5VDC and can supply 3VDC from on-board regulator
- All GPIO and serial pins can wired to breadboards out of the headers



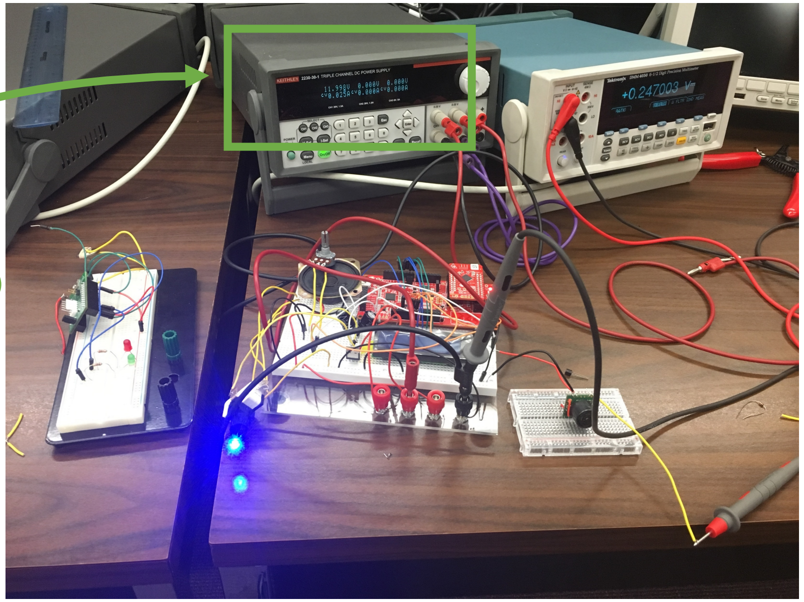
BLE Pioneer Development Board

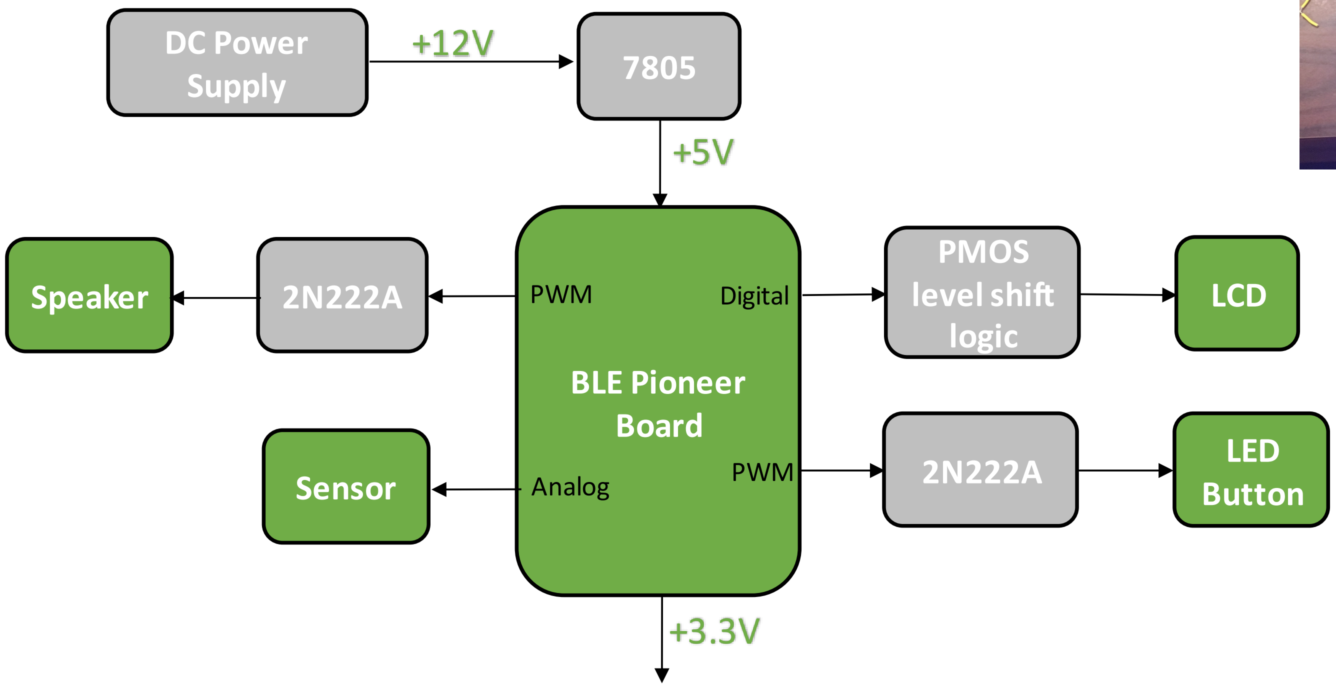


Prototype

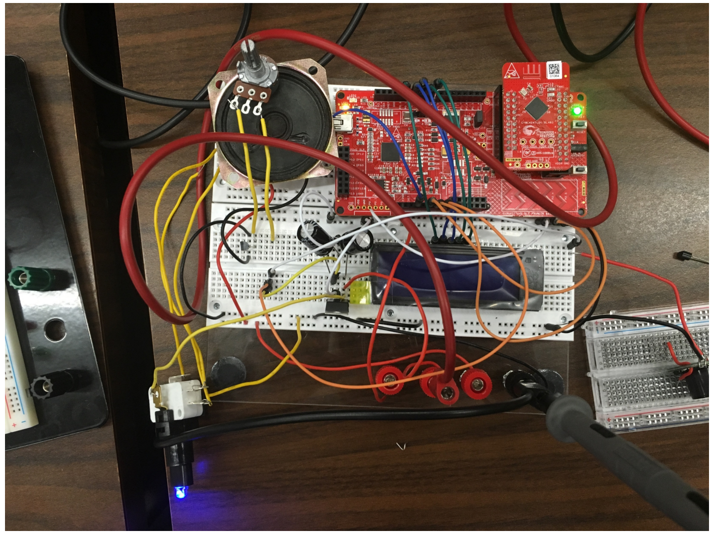
- Prototype verified all hardware and initial software
- Voltage rails performed as expected
- Components act as expected

25 mA
@ 12V
(will go up)





Prototype Setup



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Difficulties and Successes

Difficulties:

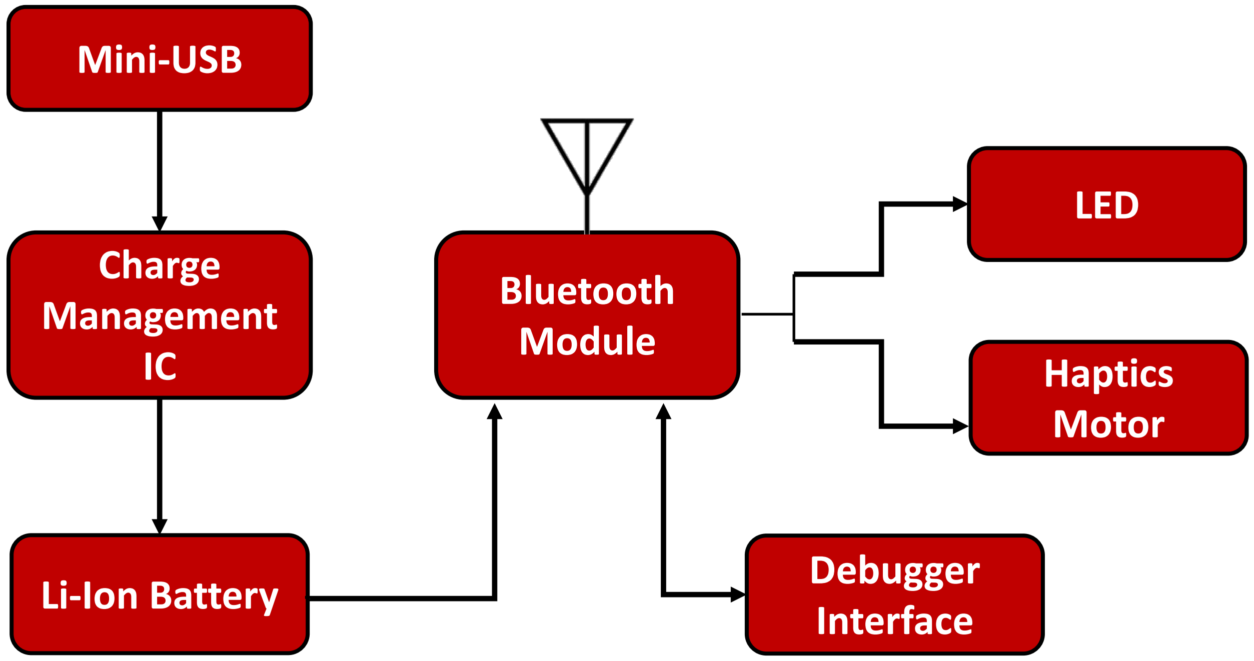
1. The project was first designed using a communication protocol called Zigbee. It was chosen due to its easiness in integrating multiple components in a low power mesh network but later realized the module we selected couldn't have firmware updates. Our sponsor also wanted future compatibility with phone applications, so Bluetooth Low Energy (BLE) was selected.
2. Communication topology had to change because BLE does not support mesh networks.
3. Our sponsor asked if we can put a speaker instead of a buzzer (original design) in case of future voice output.
4. Prototype components were running on different voltage supplies, causing communication issues.
5. The LED pushbutton (as easy as it sounds) had very poor documentation and resulted in being 5 terminals with unknown function to us.

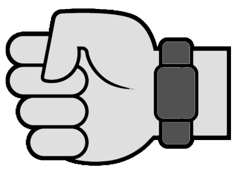
Successes:

1. Successfully found BLE modules with easy integration and minimum-to-none external RF design.
   - Able to receive samples of development kits from Cypress Semiconductor Co.
2. Made module the central role for the prototype design, with capability of pairing to the wearable and a laptop. This design will be a standalone project without a network of "modules."
3. Successfully designed hardware for outputting audio with good quality and good gain and mass storage device.
4. Successfully designed level shifting circuitry during prototype.
5. Tested hardware for LED push-button and determined operating flexibility.

Wearable

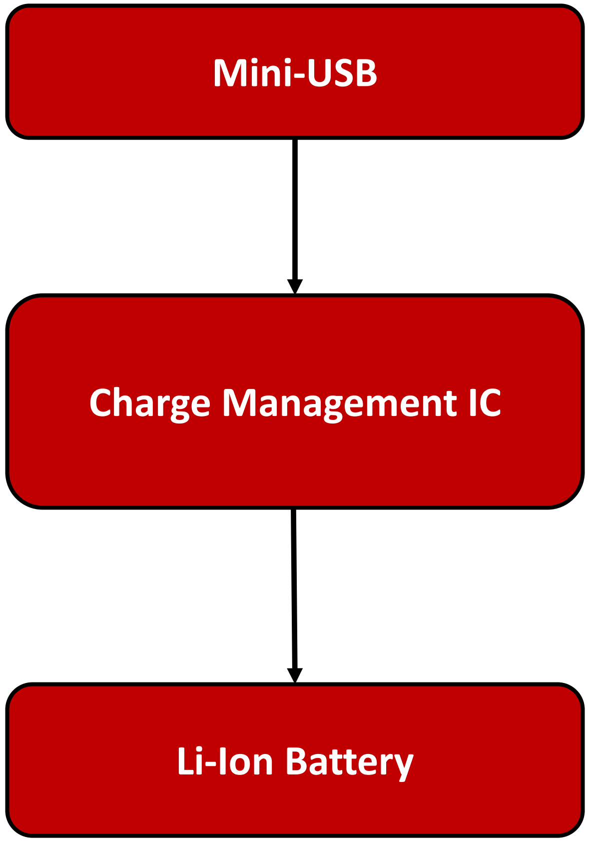
- Device utilizing Bluetooth Low Energy for proximity detection by the Module through RSSI
- Will constantly be connected to the Module when within range
- In conjunction with alerts outputted on Module, it will notify user of alerts through haptics and LED
- Designed to be an accessory worn on the wrist





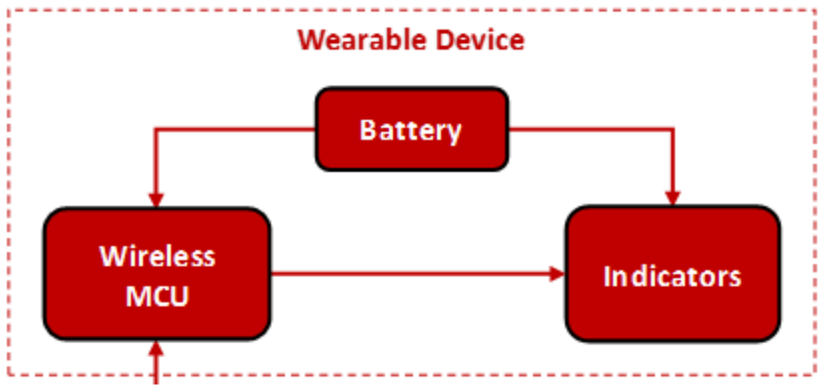
Wearable Power Distribution

- There are 3 main components for power:
  - Mini USB
    - AC Adapter
    - Laptop
  - Battery Charge Management IC
    - Manages battery charge
  - Lithium Ion Battery



Main Components

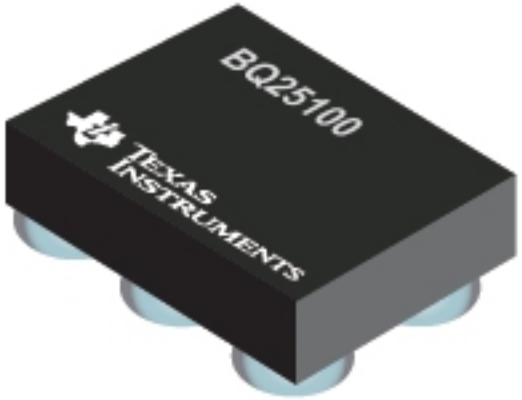
- Wireless MCU (PRoC)
- Battery and PMIC
- LED and vibrating motor



Battery Charge Management IC

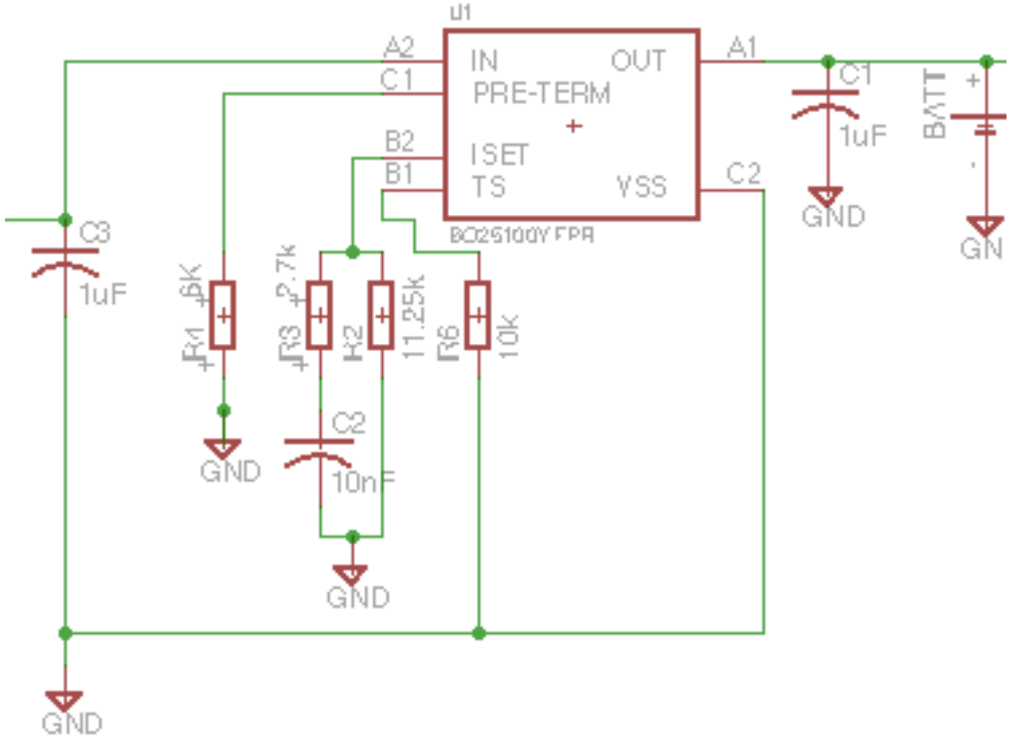
- Purpose
  - Efficient charging of the battery
- Points
  - Charges battery at specified programmed current
  - Prevents damage being done to the cells during charge cycles
  - High input voltage range for low cost unregulated adapters
  - Adjustable termination and pre-charge current
  - Various protection features
- Specs
  - Charge current: 10mA to 250 mA
  - Input Voltage: 3.5V to 28 V
  - Output Voltage: 4.25 V to 4.37 V
  - Package Size: 1.60 mm x 0.90 mm

Texas Instruments - BQ25100



Battery Charge Management IC

- Charge Current I_{SET}:
  - $R_{ISET} = \frac{K_{ISET}}{I_{OUT}}$; $I_{SET} = 12mA$
- Pre-charge / Termination Current Threshold
  - $R_{Term} = \%Term \times K_{Term}$; 10%
  - $R_{Term} = \%Prechg \times K_{Prechg}$; 20%
- Temperature Sense
  - Bypassed with 10kΩ resistor



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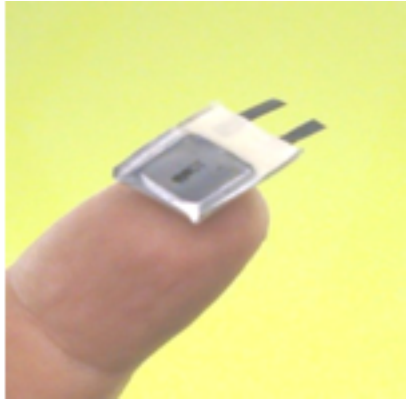
Battery Charge Management IC

- Purpose
  - Supply power to Wearable Device
- Specs
  - Charge current: 12 mA – 24 mA
  - Discharge Cut-off Voltage: 2.75 V
  - Charge Voltage: 4.2 V
  - Charge Time: 2.5 H @ (12 mA)
  - Weight: 2.25 g
  - Package Size: 3 mm x 9 mm x 10 mm

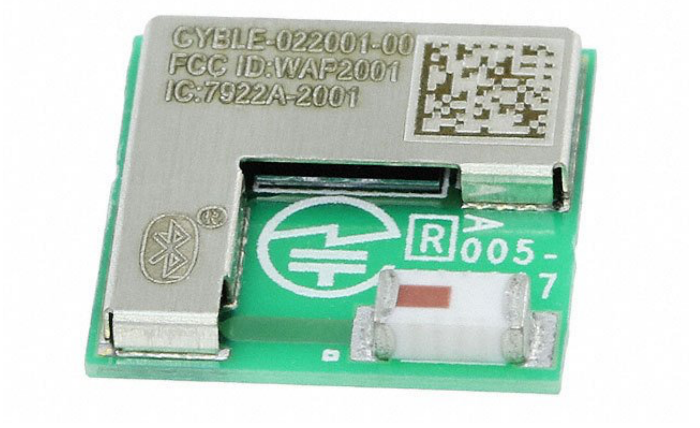
PowerStream – GM300910

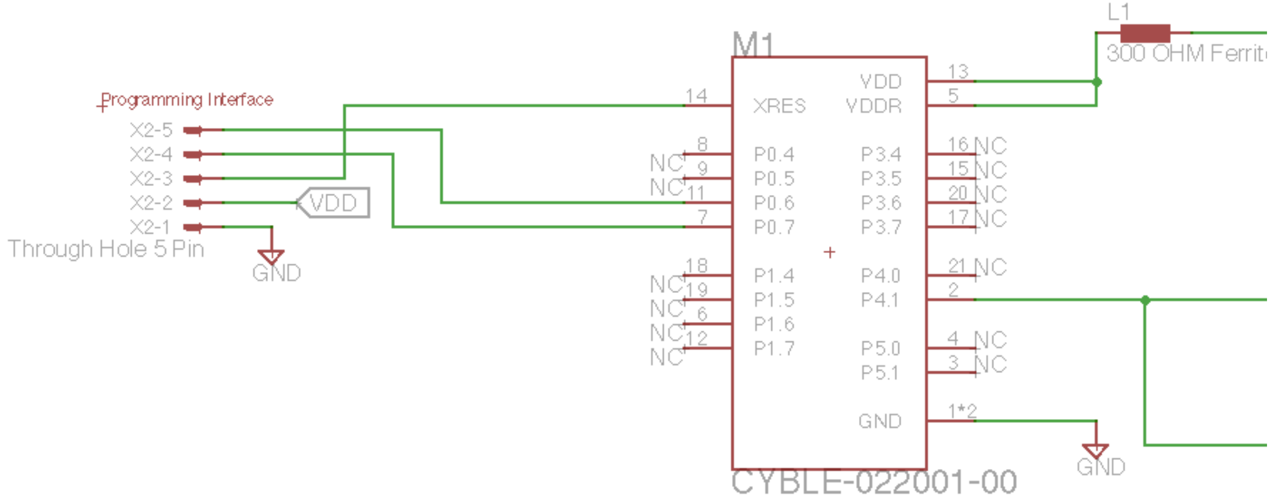


Bluetooth Module

- Purpose
  - Communicate RSSI value with module for proximity detection
- Points
  - Bluetooth 4.1 single-mode module
  - Very low current draw
  - Includes BLE stack
  - On-board ceramic antenna
  - Voltage is internally regulated over range
  - Smallest form factor found with antenna
- Specs
  - Input Voltage: 1.8 V to 5.5 V
  - Package Size: 10 mm x 10 mm
  - 32-bit processor
  - 128-KB flash memory
  - 16-KB SRAM memory
  - 16 GPIOs
  - SWD programming interface

Cypress – CYBLE-022001-00



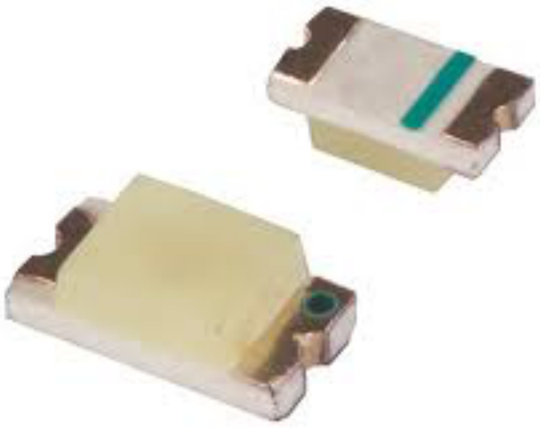


Sensory Outputs

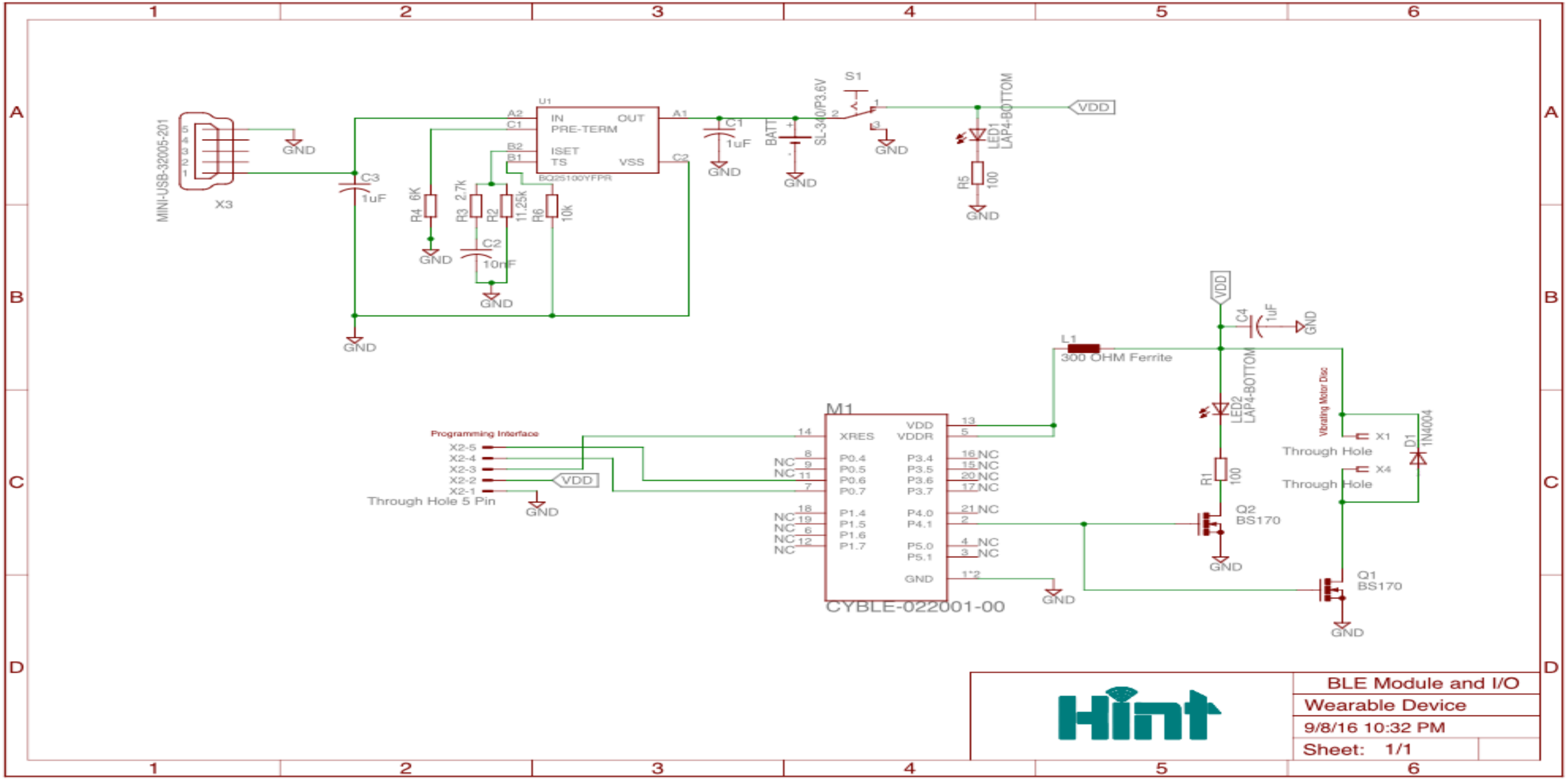
- Purpose
  - Reinforce notification outputs on module
- Parts
  - Vibrating Motor Disc
    - Voltage: 2 V to 5 V
      - 3 V current draw: 60 mA
  - SMD LED
    - Voltage: 2.1 V to 2.5 V
    - Red color

Vibrating Motor Disc

SMD LED



Schematics



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Wearable
- Components
- Schematics
- Prototype
- Difficulties
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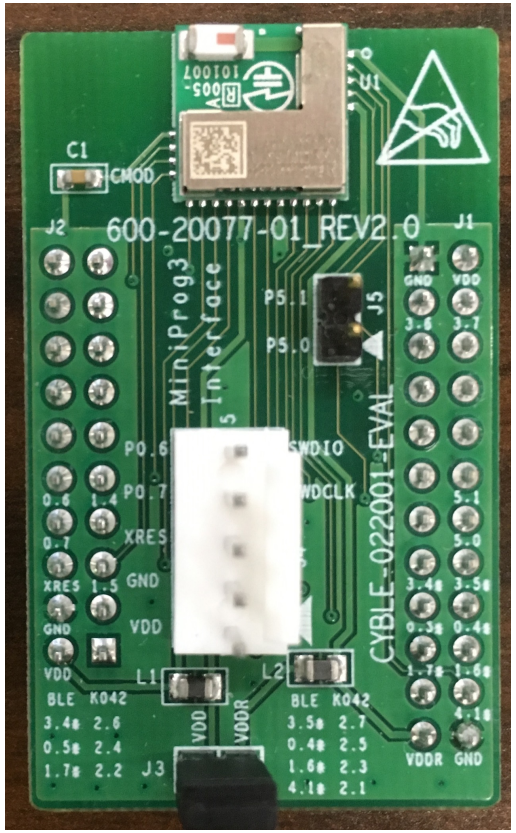
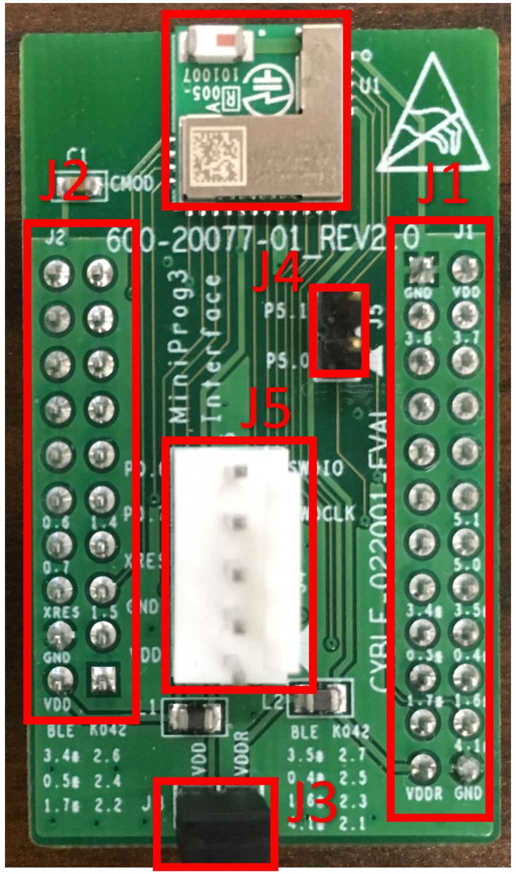
Prototype

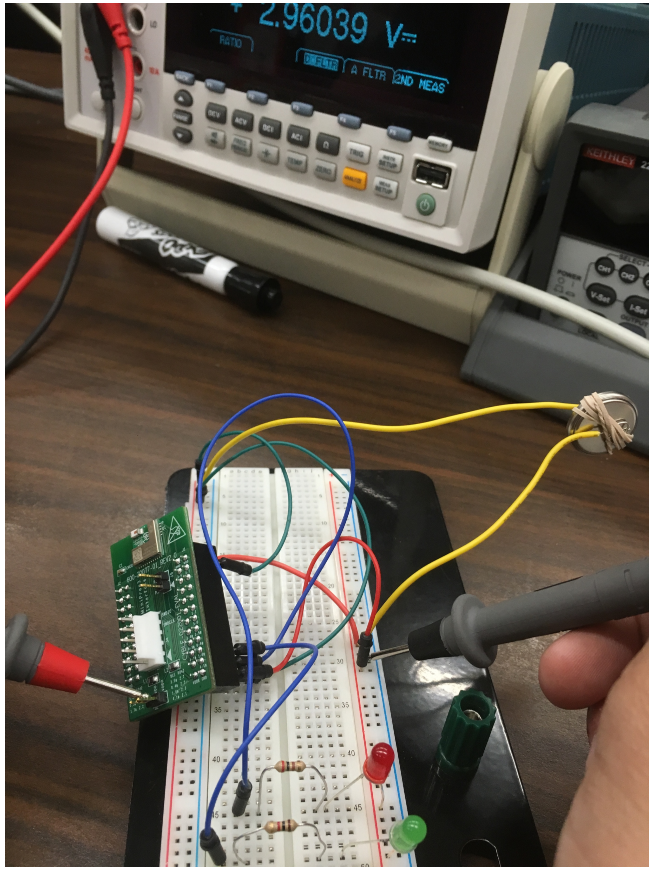
- Contains Cyble-022001-00 module
- Can be programmed through MiniProg3 interface or CY8CKIT-042 PSoC 4 Pioneer Kit
- Being used to complete software
- Cyble-022001-00 hardware connection verified through ringing pins

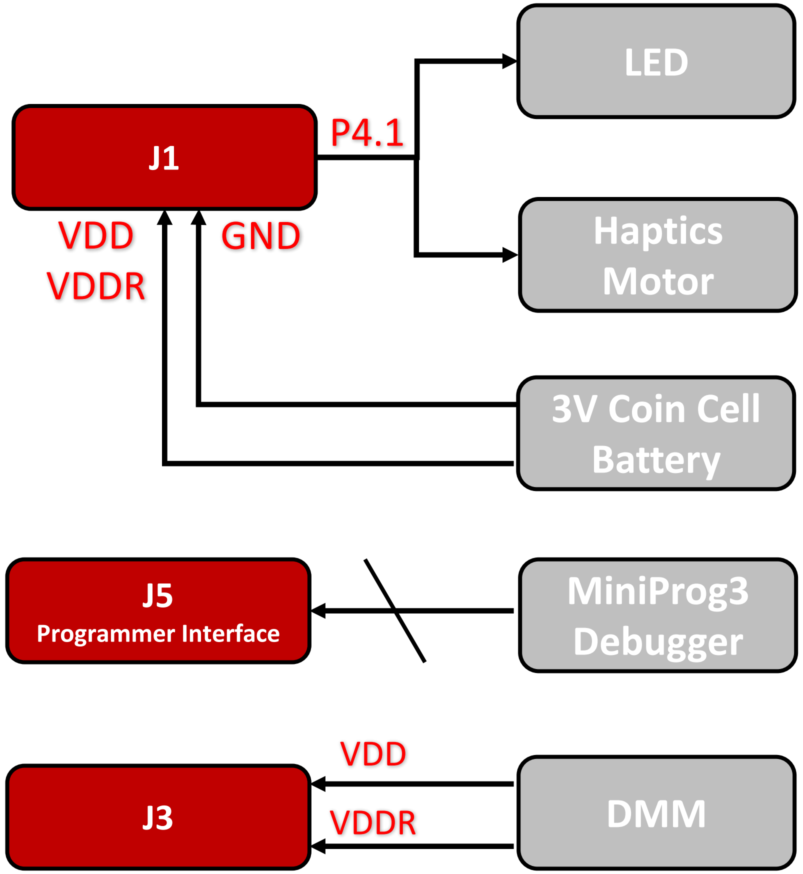
Cypress EZ-BLE PRoC Evaluation Board



Prototype Hardware Test Setup







Hardware test setup for power to module, and tested GPIO connection outputs

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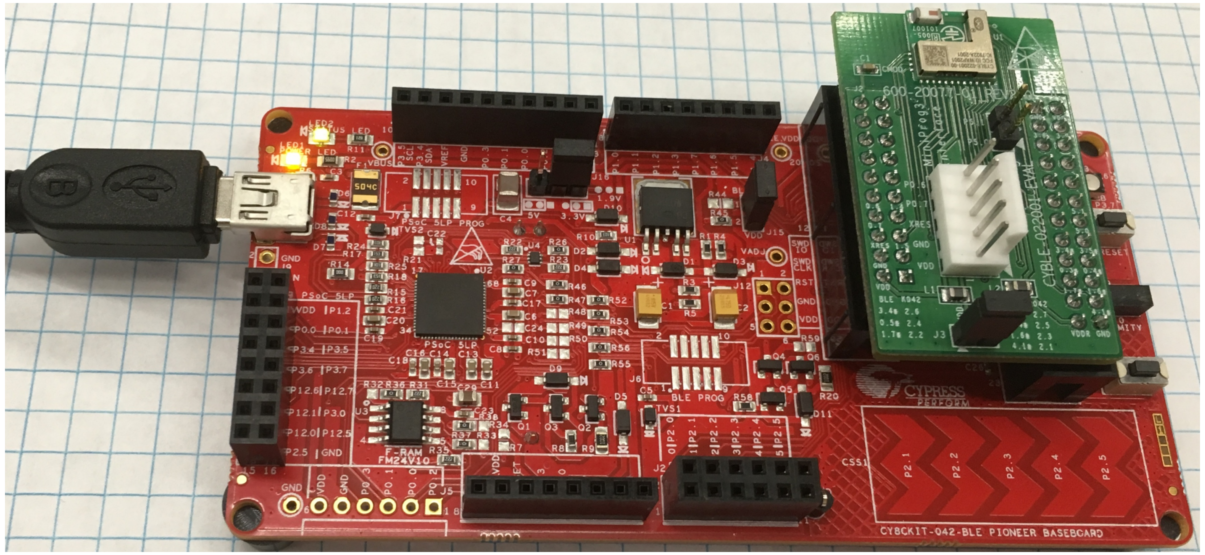
Prototype

- Testing evaluation board with the KIT042
- This board allows the programming of the BLE Module to be programmed over USB rather than SWD
- Code will be finalized through setup shown

CY8CKIT-042 PSoC 4 Pioneer Kit



Difficulties and Successes

Difficulties:

1. Size
   a. Design required to be small as to fit on wrist easily
   b. This limited components that could be chosen for PCB
   c. Due to small components PCB expense goes up to accommodate service
2. Power
   a. Choosing a good battery magement IC candidate
   b. Selected a battery that fits within design constraints and supplies enough power
3. Sponsor
   a. Working with customer on specification changes on the fly
4. Software
   a. Programming BLE Module to interface with the Module

Successes:

1. Finding components that were small enough to accommodate design constraints
2. Finalizing component selection and creating schematic
3. Retrieving the evaluation boards (FREE) to be able to program ahead of PCB receive date
4. Sponsor providing the funds to purchase required components

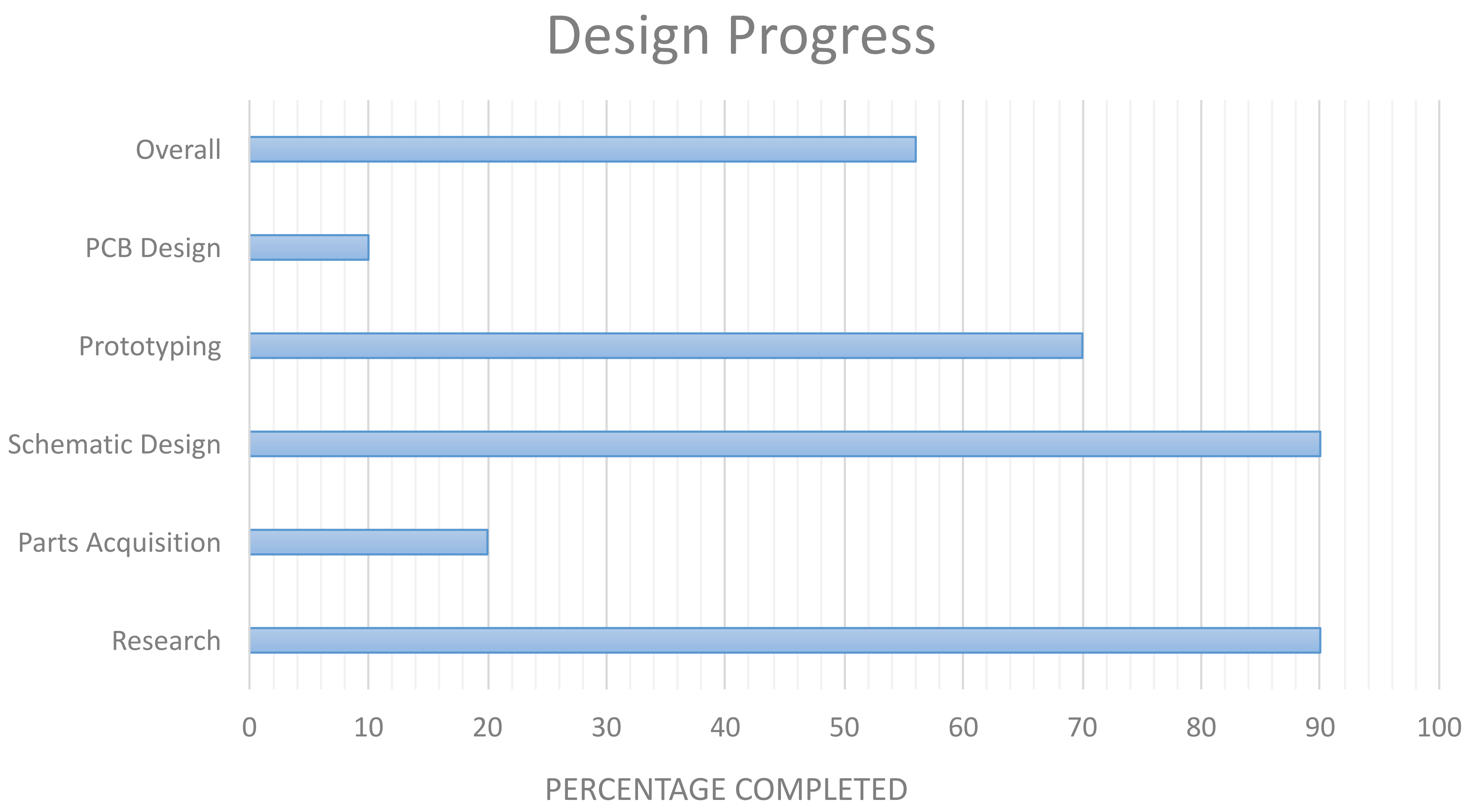
Development

- Development is being done with Cypress PSoC Creator 3.3
- Many example designs (especially RSSI related) ease the software development
- Cypress also supplies an iPhone application that measures RSSI readings from any BLE chip
    - This helps prototype module to wearable communication
- All GPIO and serial interface control is being added to the BLE software projects

Budget

Subsystems	Parts and Materials	Projected Qty	Price/Unit	Projected Cost	Current Cost
Module	Module Microcontroller	3	$24	$72	Free (Sample)
	BLE Development Kit	1	$49	$49	Free (Sample)
	Module LCD Display	1	$27	$27	$27
	Response Button	2	$10	$20	$20
	Range Sensor	1	$27	$27	$27
	Buzzer/Speaker	1	$8	$8	Free (Sample)
	Printed Circuit Board	2	$150	$300	-
	Other PCB Expenditures	N/A	$75	$75	-
	AC Adapter	1	$25	$25	Free (Owned)
	Circuit Components	N/A	$40	$40	-
	Enclosure	N/A	$50	$50	-
Wearable	Wearable Microcontroller	3	$12	$36	-
	BLE Development Kit	1	$20	$20	Free (Sample)
	Vibration	3	$2	$6	-
	Printed Circuit Board	2	$150	$300	-
	Other PCB Expenditures	N/A	$75	$75	-
	Battery	2	$15	$30	-
	Power Management IC	2	$2	$4	-
	Circuit Components	N/A	$40	$40	-
	Enclosure	N/A	$30	$30	-
Both	Programmer/Debugger	1	$89	$89	-
Totals		Total Cost:		**$1,234**	**$74**
		Sponsorship:		**$1,000**	

Overall Progress



Path Forward

- Finalize hardware design (schematic)
- Finalize software design
- Finish integrating hardware and software in the prototype
- PCB design
- Testing and final integration

Questions?