



Home Interactive Notification Tracking

11-30-2016



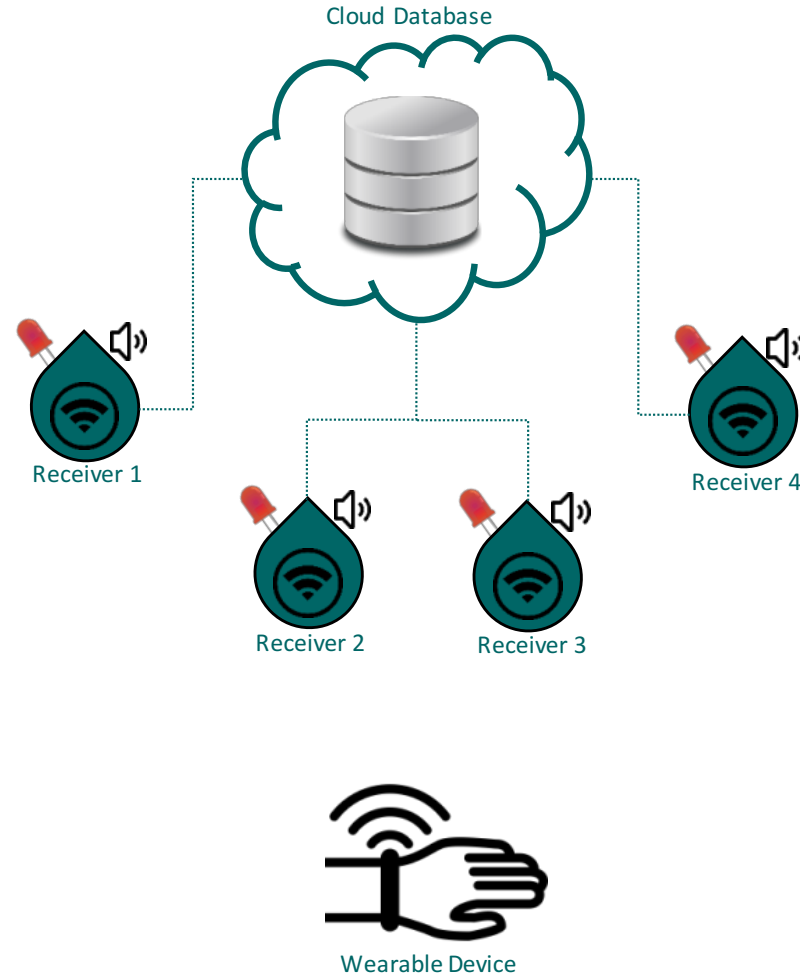
Group B

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About HINT



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

About HINT



Motivation

- Internet of Things network
- Overall positive impact
 - Facilitates communication
 - Research indicates:
 - Higher self-esteem
 - Sense of responsibility
 - Successful qualities



Goals & Objectives

- HINT will provide best overall experience
 - Affordability
 - User friendly and interactive
 - Notification tracking and task learning
 - No dependency on smartphones
- HINT will enforce tasks
 - Reduce notification bypassing
- HINT will stimulate the human senses
 - Sight
 - Touch
 - Hearing

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Specifications and Requirements



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

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

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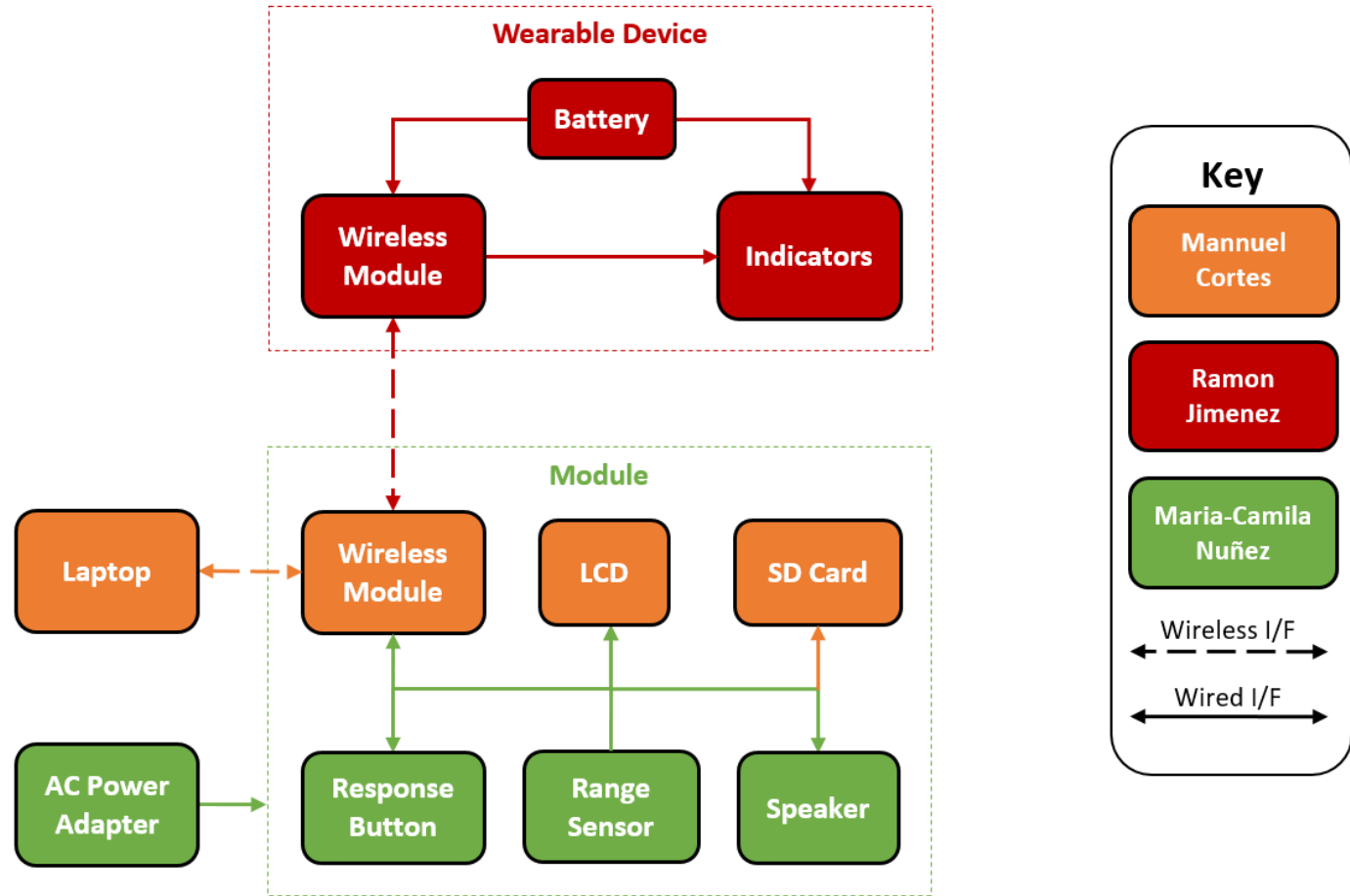
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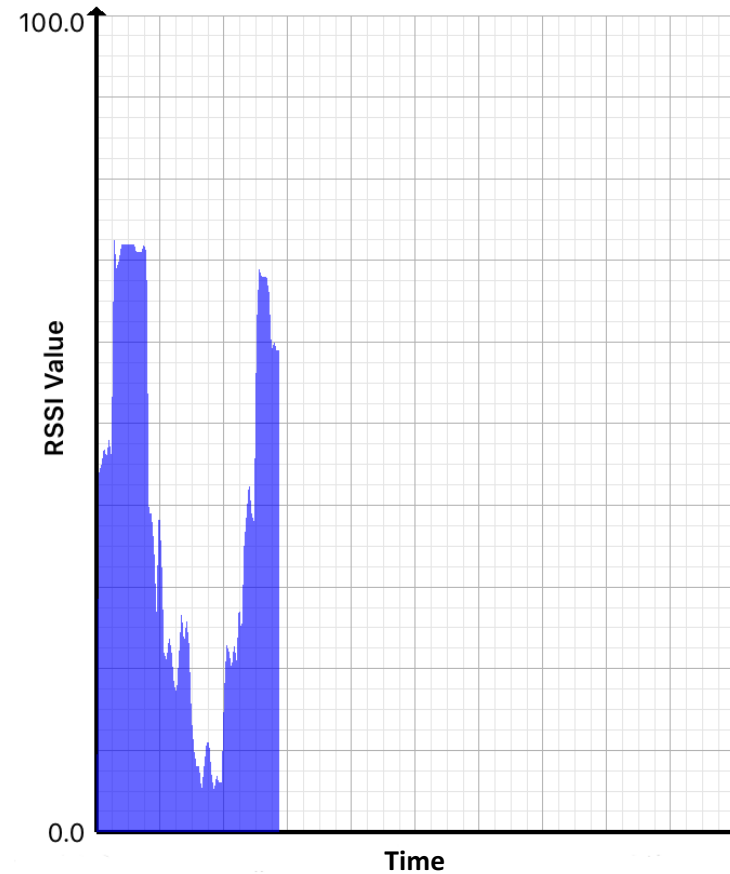
Demo

How HINT Works



- HINT uses a combination of RSSI and range/motion detection to determine the proper conditions to output a notification
- RSSI – Received Signal Strength Indicator
- Range/motion detection
 - Measured with ultrasonic range sensor

Signal Strength Measurement



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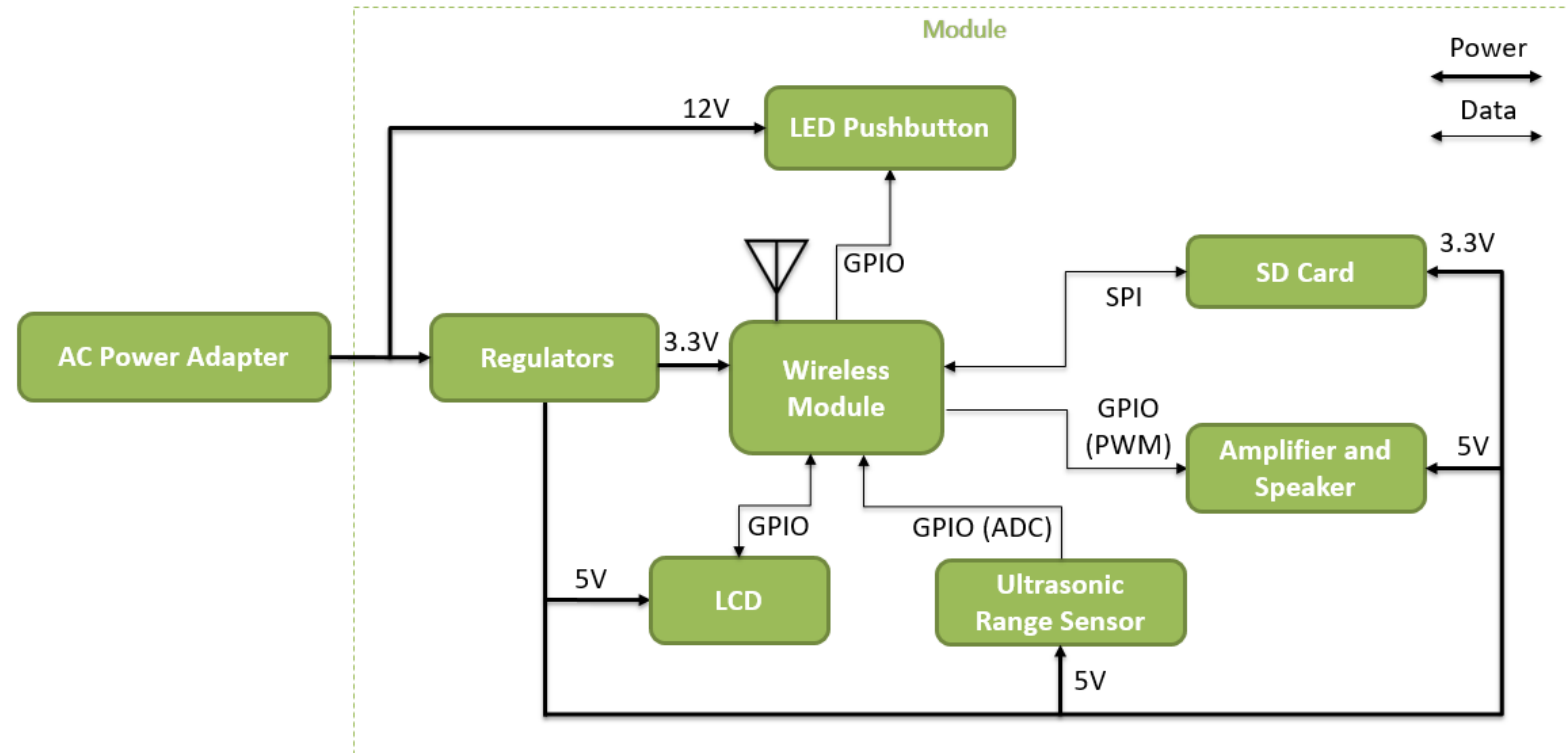
Demo

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

Module



- Primary job
 - User detection
 - Interactive module
- Wireless communication
 - Bluetooth Low Energy
- Detection methods
 - Motion sensor
 - RSSI
- Signal notifications
 - Enable wearable component functions



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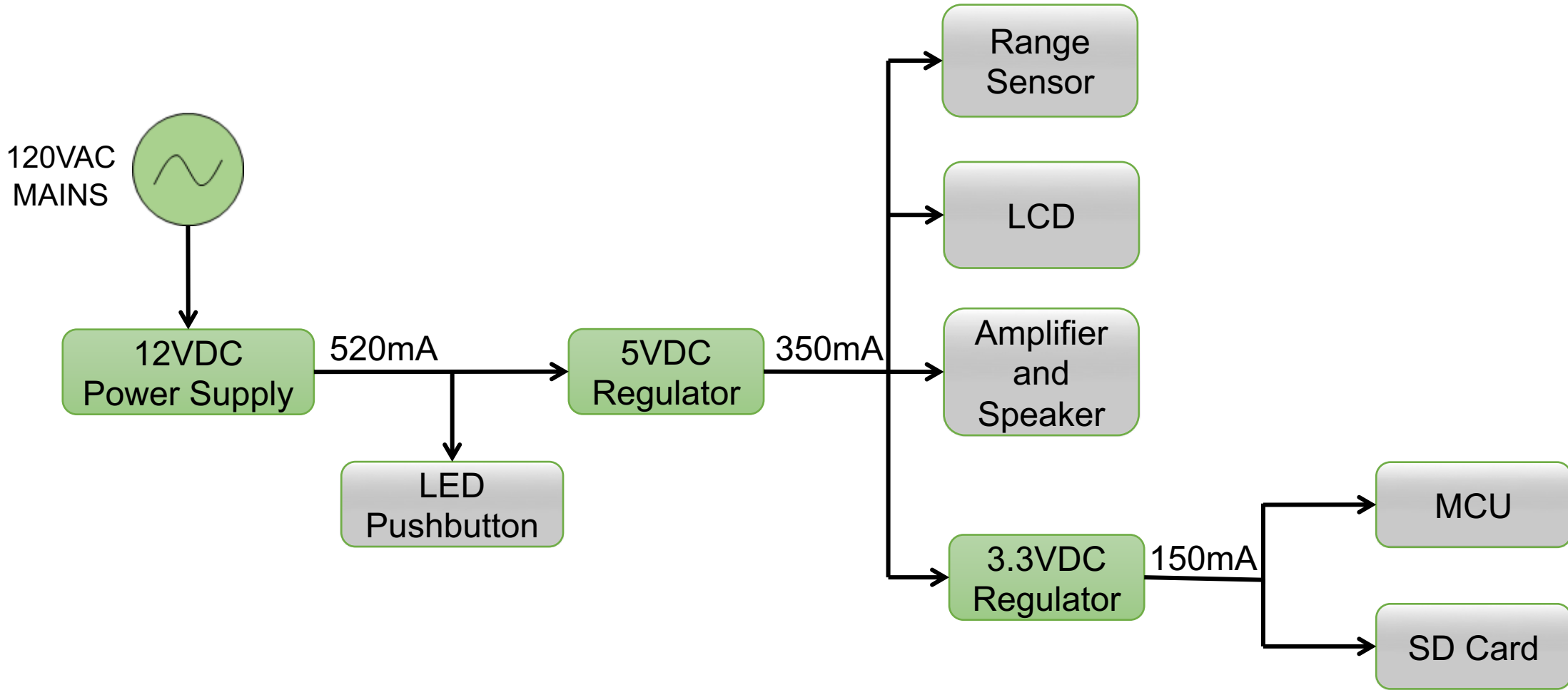
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Power Distribution



Max Current Draws Depicted

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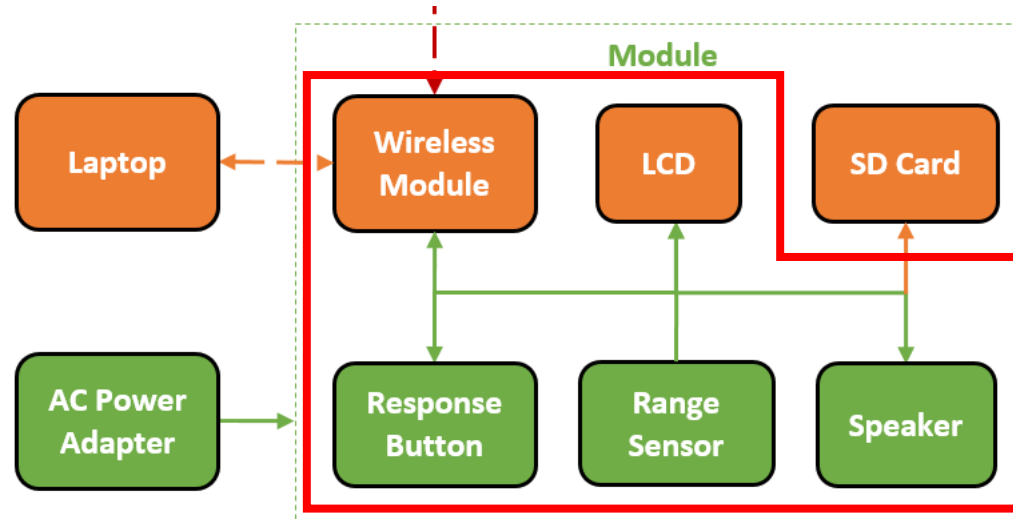
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Main Components



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



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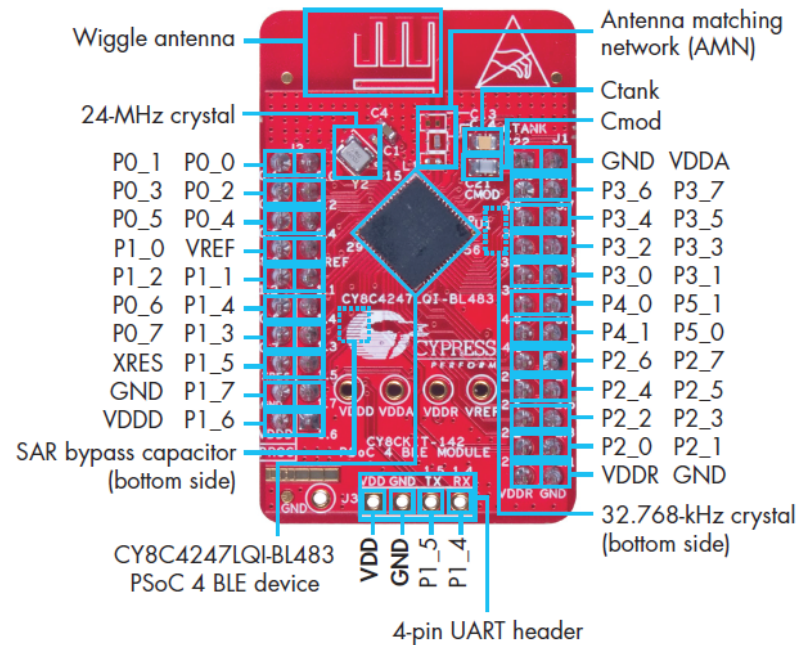
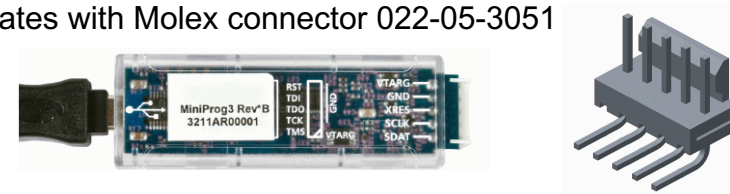
Demo

Wireless Module



- Programmable System on Chip (PSoC) module with integrated trace antenna, oscillator, and Bluetooth Low Energy (BLE) front end
 - Removes the need for RF PCB design
- Uses a 32-bit, 48-MHz ARM Cortex-M0 CPU
- All necessary pins route to headers J1 and J2

- Can be programmed/debugged with the Cypress MiniProg3 USB kit
 - Mates with Molex connector 022-05-3051



Wireless Module	
Manufacturer	Cypress Semiconductor
Part Number	CY8KIT-142
Price	\$9.97
Dimensions	44.45mm x 25.4mm
Specs	<ul style="list-style-type: none"> • 128 kB Flash • 16 kB SRAM • Integrated voltage regulation • 2.4 GHz RF Transceiver • Programmable digital logic • ADC, DAC, and serial communication blocks • 36 Programmable GPIO pins w/ pull-up and pull-down resistors • Ample development support

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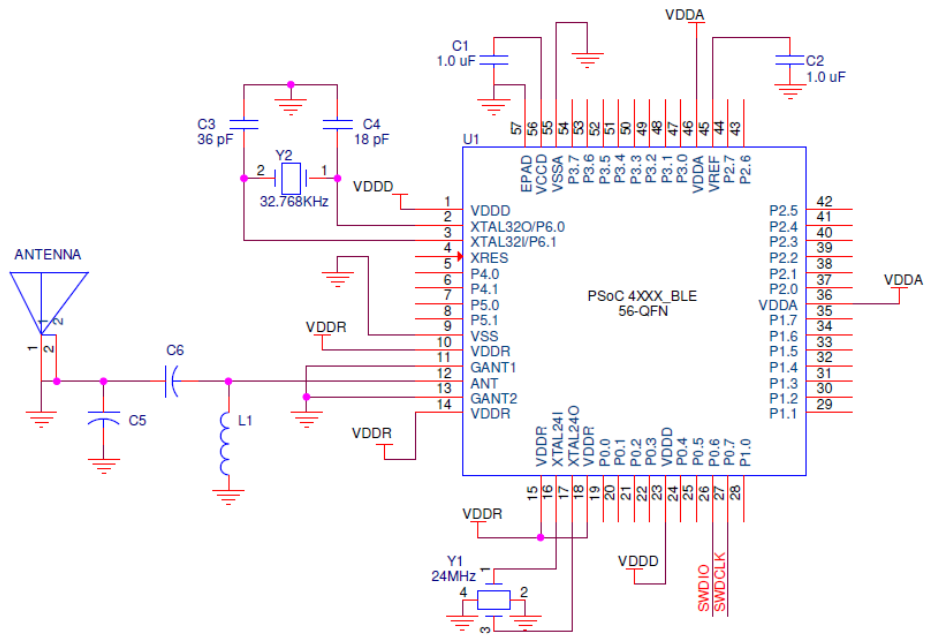
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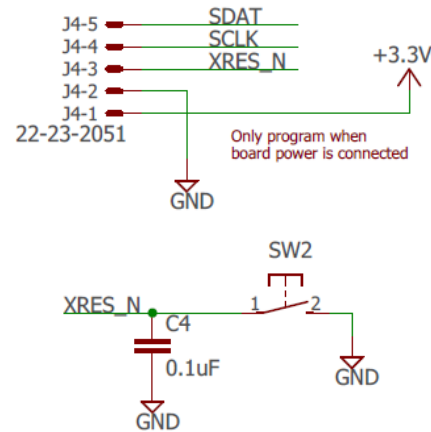
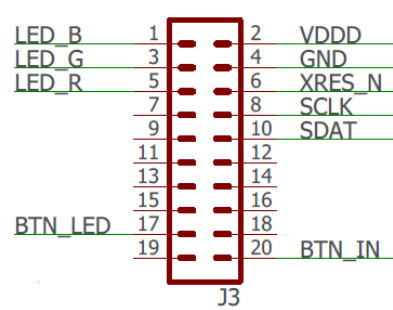
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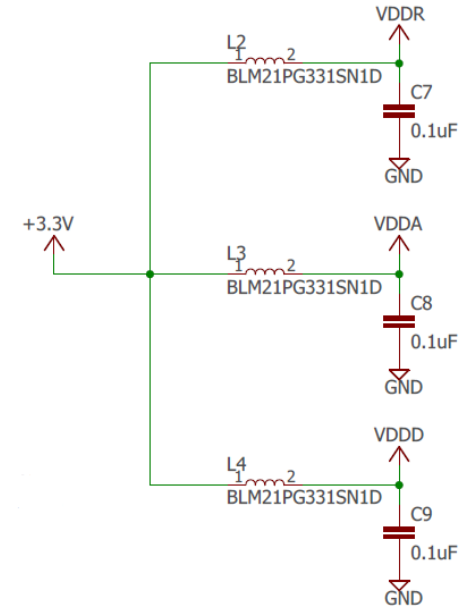
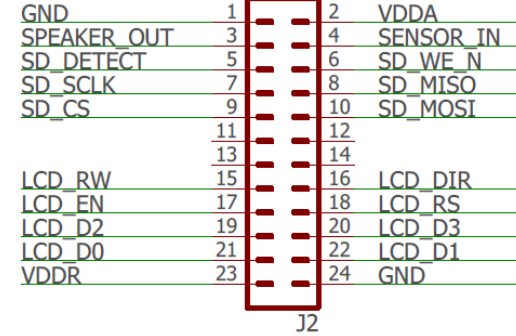
Wireless Module



Simplified Schematic of BLE Module



Interfaces of BLE Module in HINT Design



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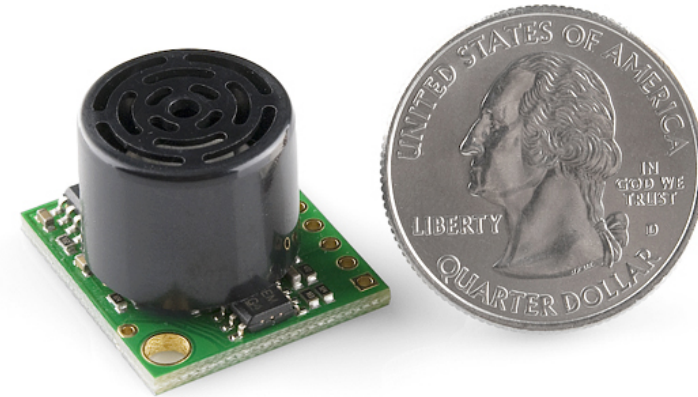
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Ultrasonic Range Sensor



- Concept is to be utilized for range and distance calculation
- Follows requirement of a broad distance detection range
- Analog voltage pin outputs voltage which corresponds to the distance

MaxBotix LV-MaxSonar – EZ0



Ultrasonic Range Sensor	
Manufacturer	MaxBotix
Part Number	LV-MaxSonar – EZ0
Price	\$26.95
Dimensions	22.1mm x 19.9mm
Specs	<ul style="list-style-type: none">•2.5V to 5.5V supply with 2mA typical current draw•Three interface output formats•Operates at 42 KHz

- Voltage Scaling

$$V_i = \frac{V_{cc}}{512}$$

V_{cc} = supplied voltage
 V_i = volts per inch

- Range

$$R_i = \frac{V_m}{V_i}$$

V_m = measured voltage
 R_i = range in inches

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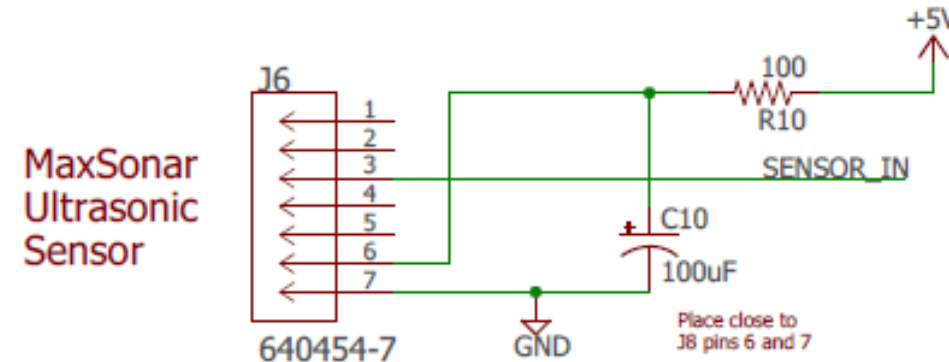
Ultrasonic Range Sensor



- High sensitivity and wide beam sensor
- Detects objects from 0-254 inches
- The beam width is not defined because the actual beam width dynamically changes over the course of the range

LV-MaxSonar®-EZ beam patterns	EZ0™	EZ1™	EZ2™	EZ3™	EZ4™
Detection pattern to a 1/8 inch diameter dowel.					
Detection pattern to a 1/4 inch diameter dowel.					
Detection pattern to a 1 inch diameter dowel.					
Detection pattern to a 3 1/4 inch diameter dowel.					

-5V
• 3.3V
V+ supply voltage.
(Distances overlaid on a 1 foot grid.)



- 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

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LED Pushbutton

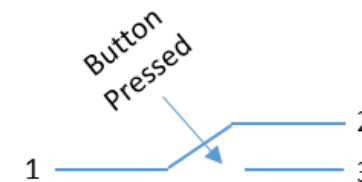
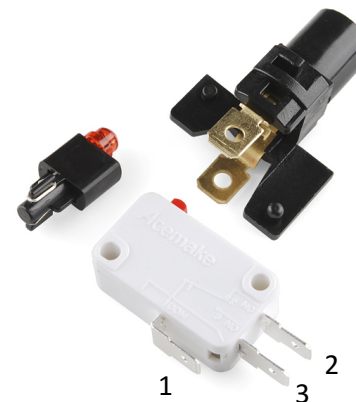


- Follows HINT's purpose
- Concept is to turn on in conjunction with notification on LCD display
- Follows visibility requirement, it is 4 inches in diameter
- Reliable and can be easily replaced
- Can be easily “connectorized” and routed to a header

Sparkfun Big Dome Pushbutton



Big Dome Pushbutton	
Manufacturer	Sparkfun
Part Number	COM-0918
Price	\$10.00
Dimensions	4 inches in diameter
Specs	<ul style="list-style-type: none">•Reliable for 10 million cycles•12V device with internal 460Ω current limiting resistor•5 terminal device with independent LED and switch circuit



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Audio Circuitry

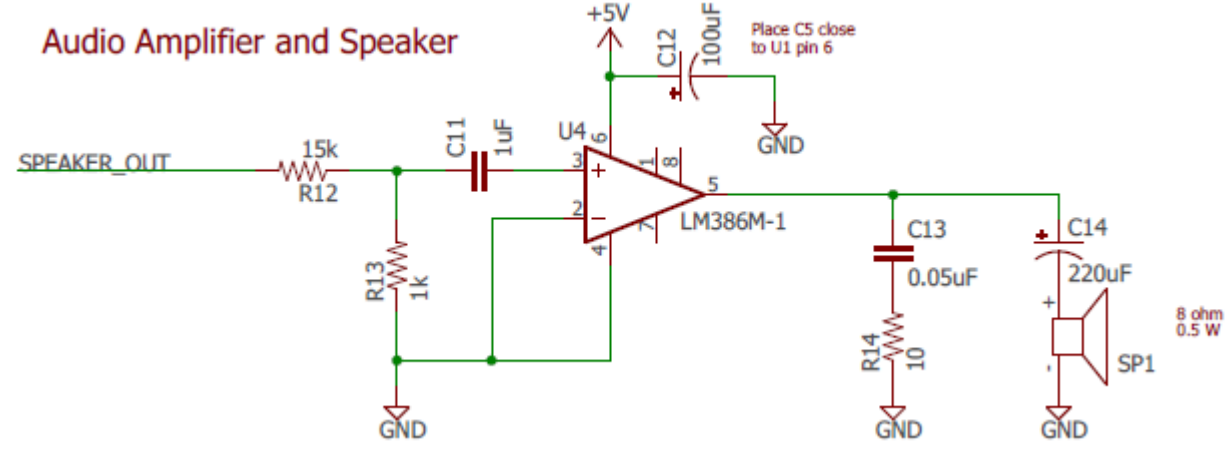
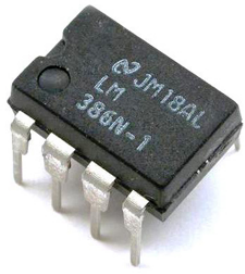


- Speaker enforces that notifications will not be ignored
- Synchronizes with all system notifications
- 8Ω, 0.5W Speaker
- Interfaced through a low-voltage audio amplifier to improve audio quality

General Purpose Speaker



Audio Amplifier



With pins 1 and 8 open, gain = 20 dB

Audio Amplifier	
Manufacturer	Texas Instruments
Part Number	LM386
Price	\$1.21
Dimensions	10mm x 6.35mm
Specs	<ul style="list-style-type: none"> •5V part with current draw of 8mA •Applies gain for stronger audio output •Comes in a DIP-8 package

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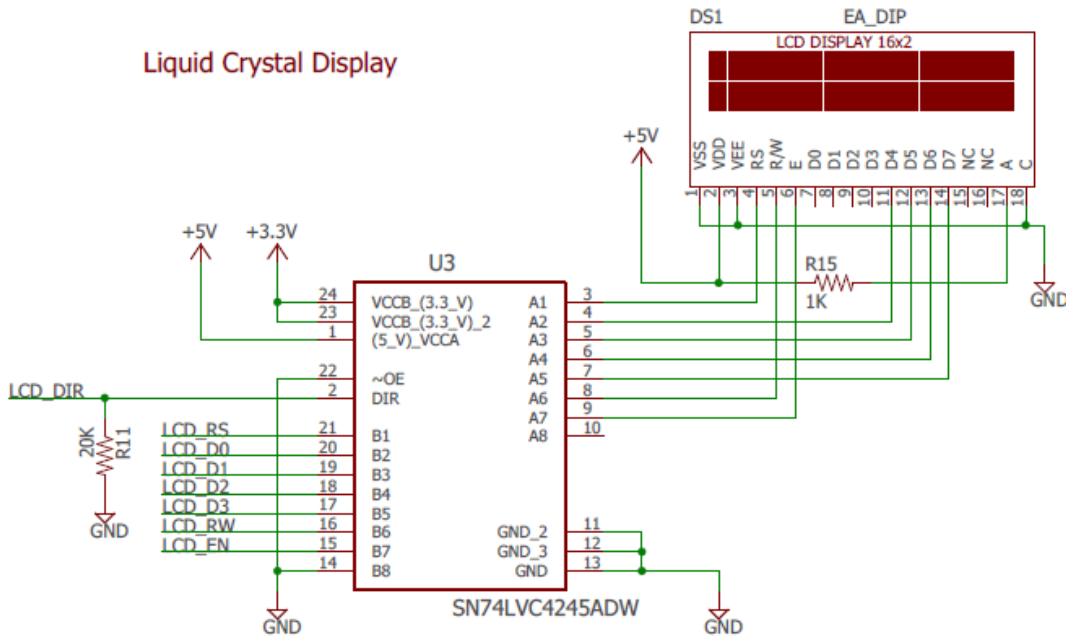
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LCD



- The LCD is the only digital output to supplement the sensory I/O
- Gives 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

Electronic Assembly DIP162



LCD Display	
Manufacturer	Electronic Assembly
Part Number	EA DIP 162-DN3LW
Price	\$27.26
Dimensions	75mm x 27mm
Specs	<ul style="list-style-type: none"> •5V part with 45 mA current draw (including backlighting) •DIP module •Has 8 or 4-bit interface for easy

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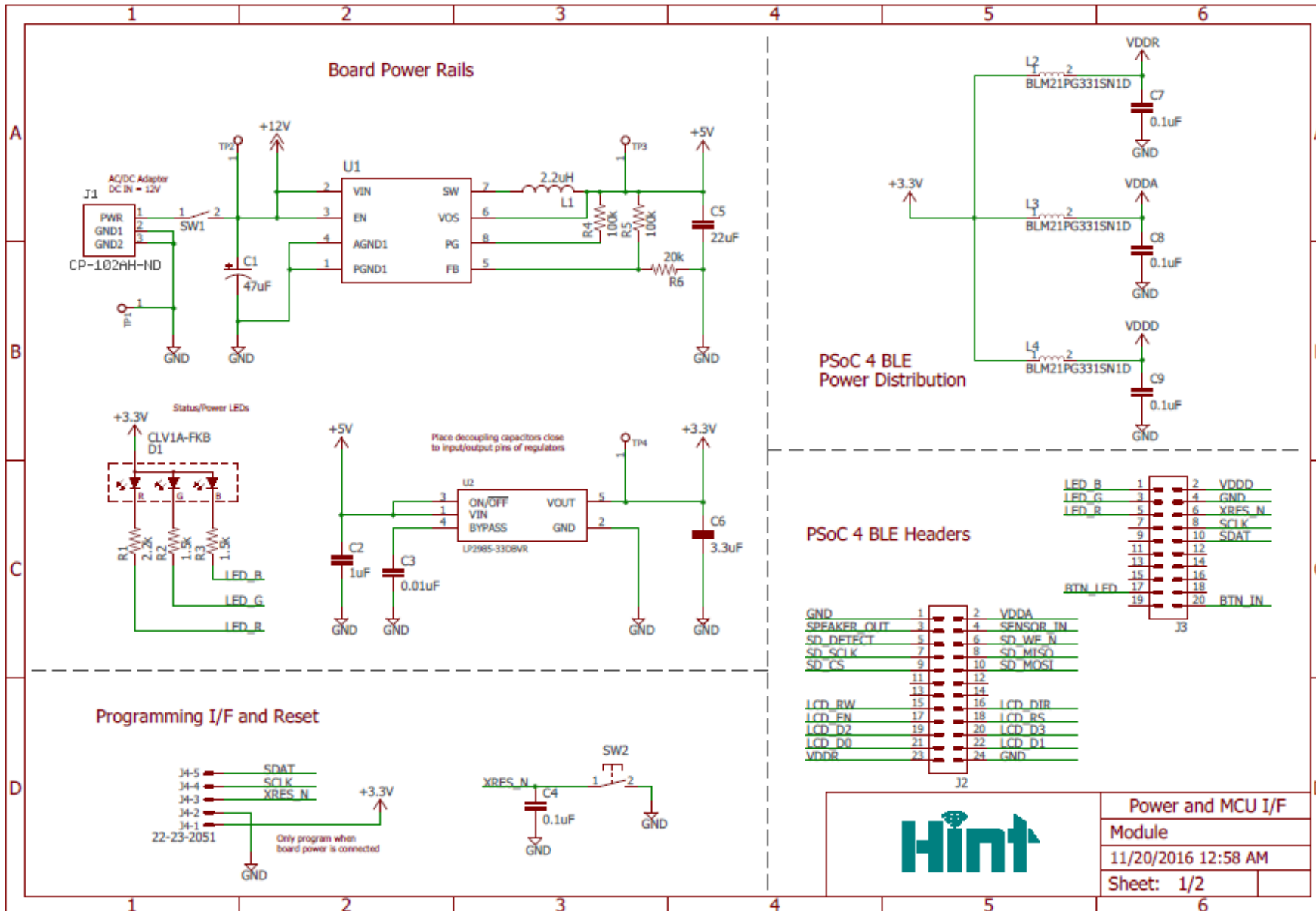
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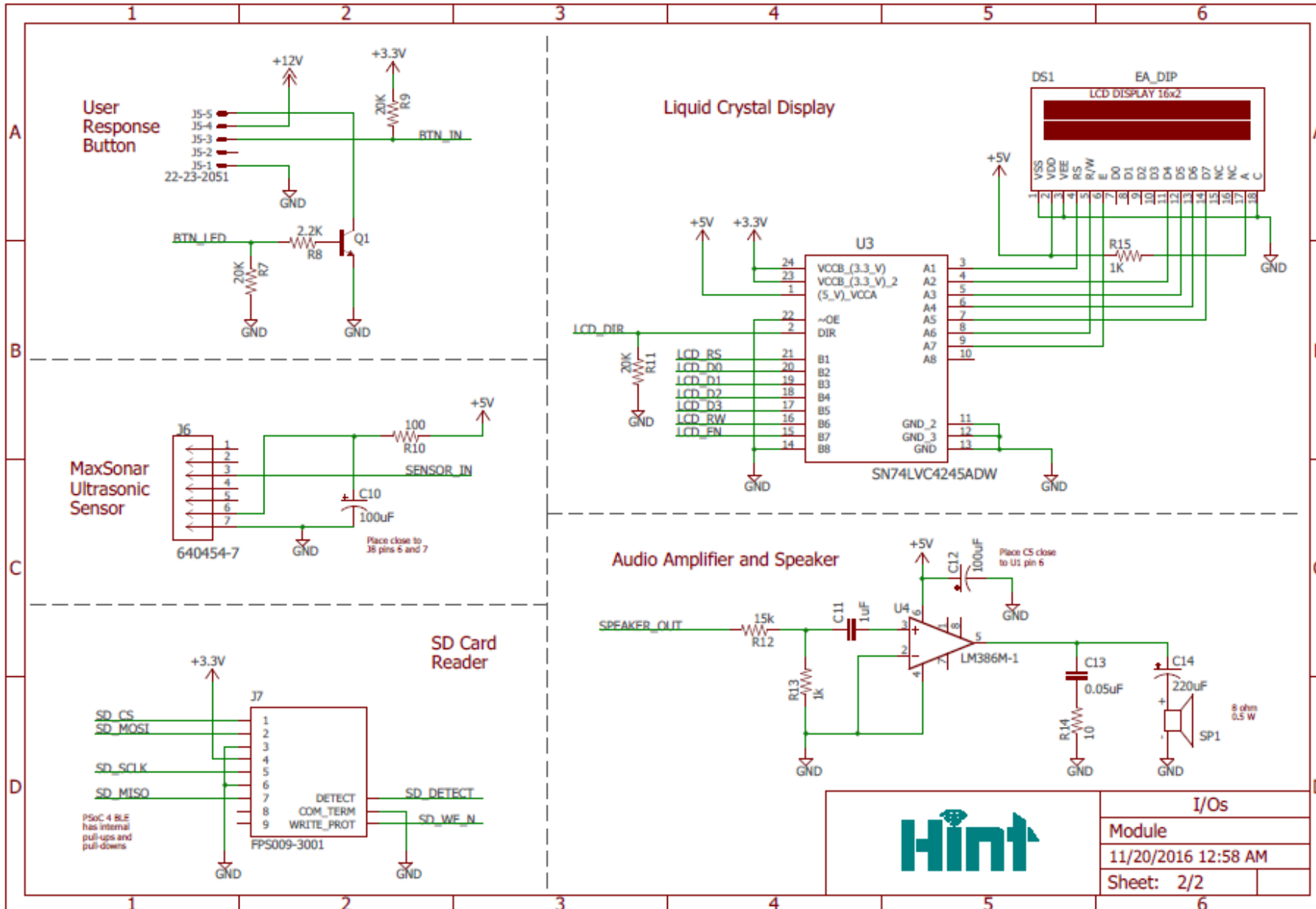
Power and MCU I/F

Module

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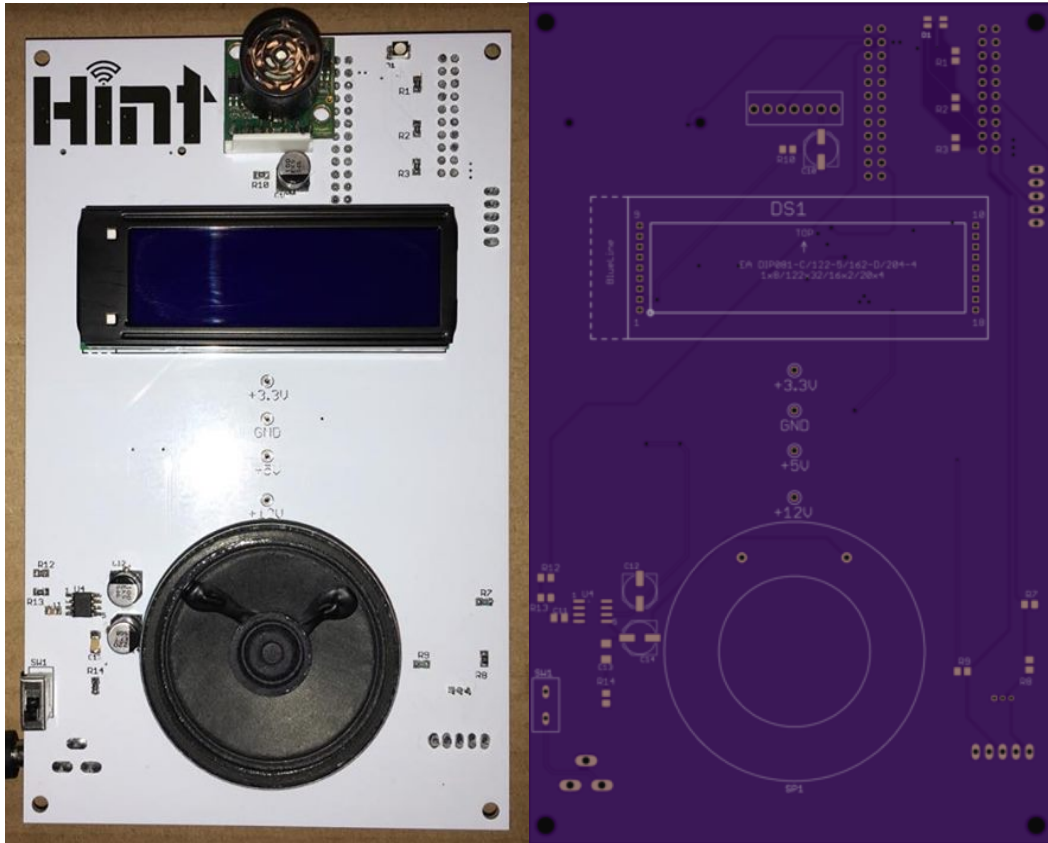


I/Os	
Module	
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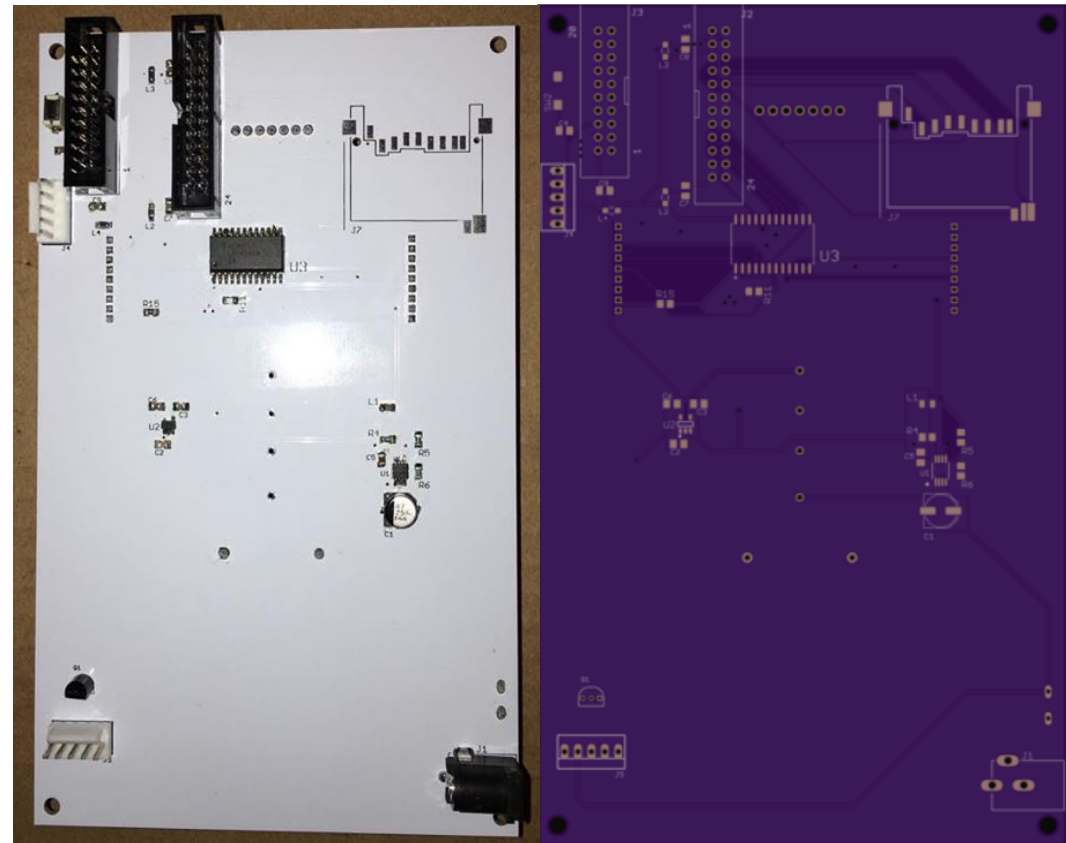
Module PCB



Top Layer



Bottom Layer



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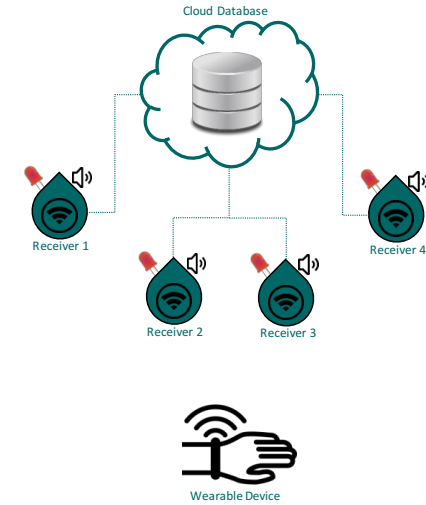
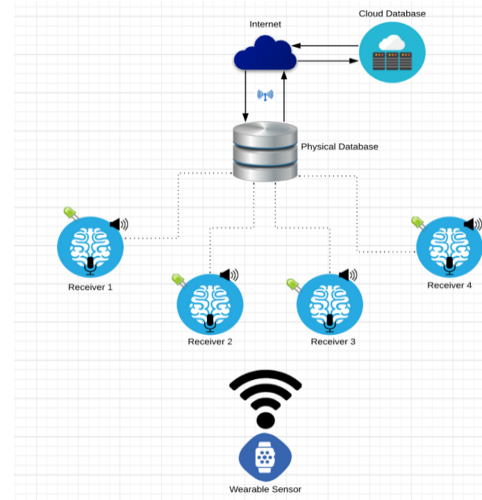
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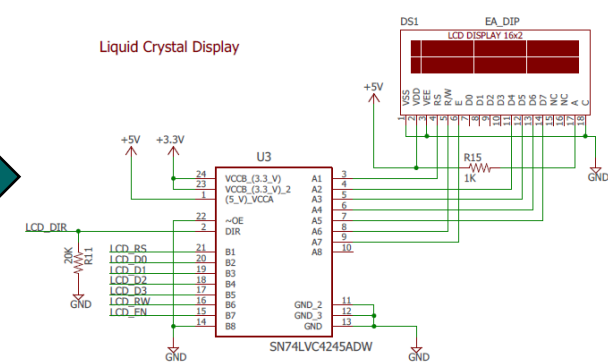
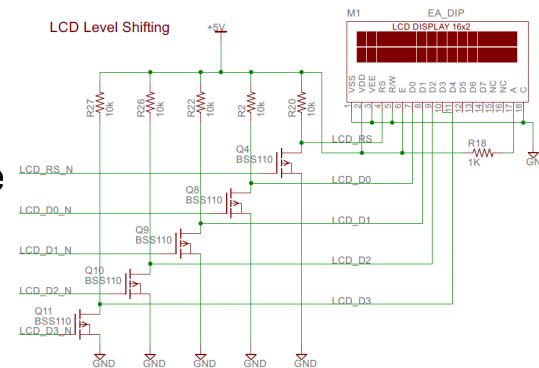
Difficulties:

1. Communication topology change
2. Change of original audio output design
3. Logic levels didn't match
4. LED pushbutton has 5 terminals



Successes:

1. Made module central role
2. Designed hardware for outputting audio
3. Designed level shifting circuitry during prototype
4. Tested hardware and determined operating flexibility



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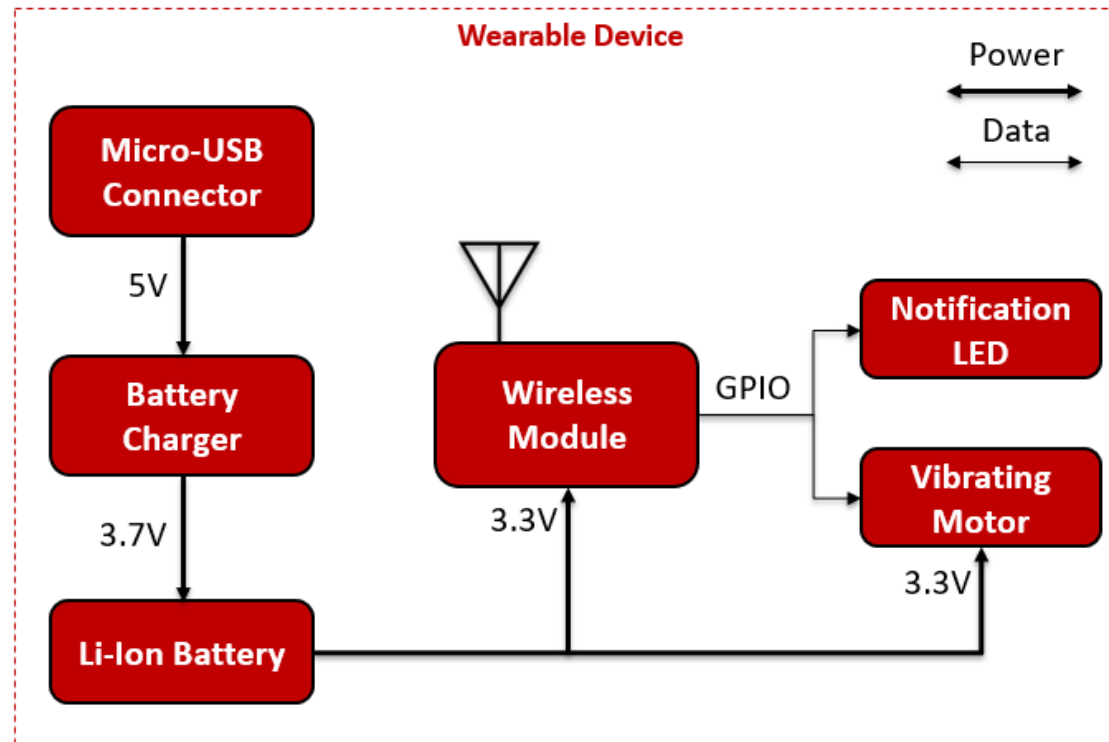
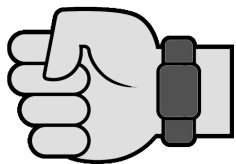
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Wearable



- Device utilizes Bluetooth Low Energy for proximity detection by the Module through RSSI
- Emits notifications when alerted by module
- Designed to be an accessory worn on the wrist



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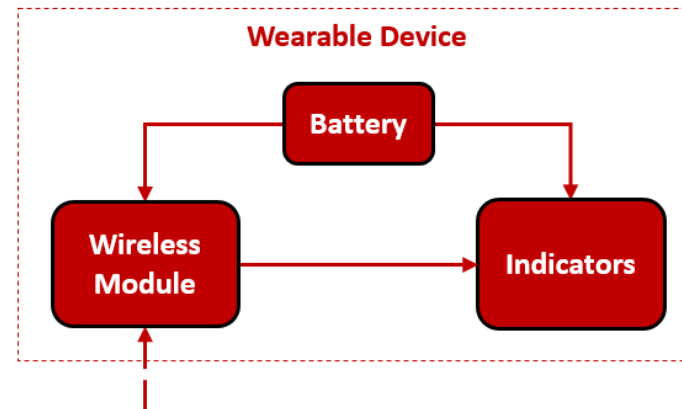
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Main Components



- Wireless Module (PRoC)
- Battery and PMIC
- Notification LED and vibrating motor



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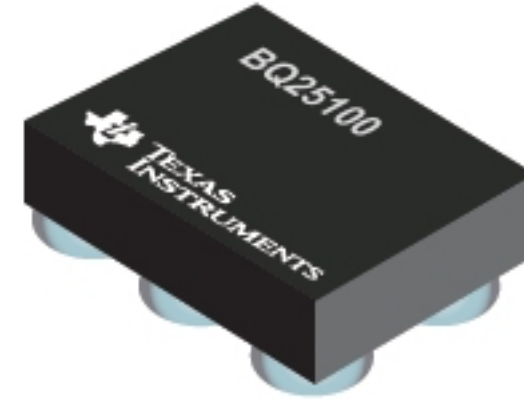
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Battery Charge Management IC



Texas Instruments - BQ25101



- Charges battery at specified programmed current to maximize efficiency
- Prevents damage being done to the cells during charge cycles
- High input voltage range for low cost unregulated adapters
- Programmable termination and pre-charge current
- Various protection features:
 - OVP
 - UVLO
 - TSD
 - SCP

Battery PMIC	
Manufacturer	Texas Instruments
Part Number	BQ25101
Price	\$0.84
Dimensions	1.60mm x 0.90 mm
Specs	<ul style="list-style-type: none">• 10mA to 250mA charge current (programmable)• Input Voltage 3.5V to 28V• Constant 4.25V to 4.37V output voltage

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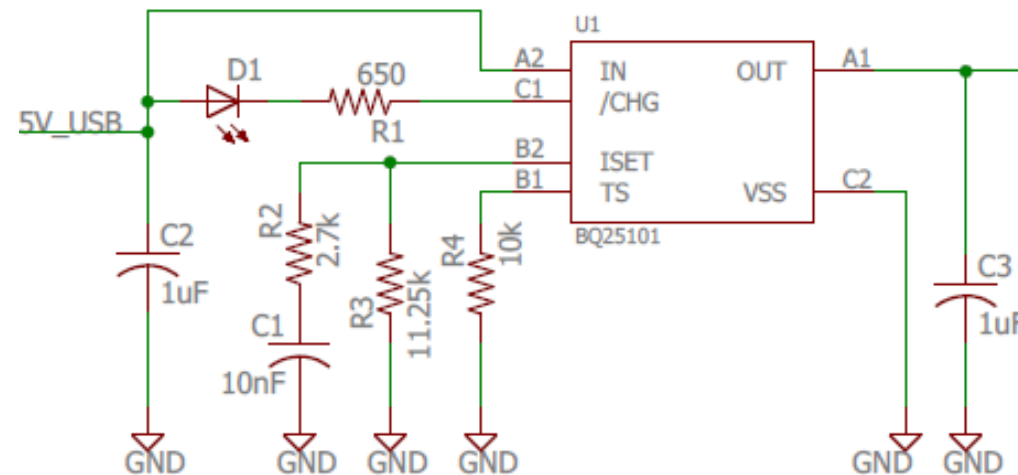
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Battery Charge Management IC



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

BQ25101 Circuit



R_{ISET} = Charge Current Resistance
 R_{Term} = Termination Current Resistance
 K = Gain Factor for IC Charge, Termination, and Pre-charge Current
 $\%Term$ = Percent of Fast Charge Current Where Termination Occurs
 $\%Prechg$ = Percent of Fast Charge Current That is Desired During Pre-charge

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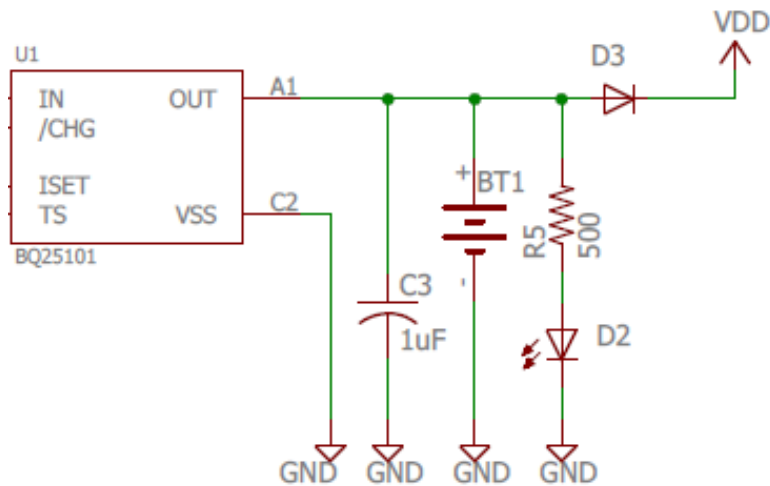
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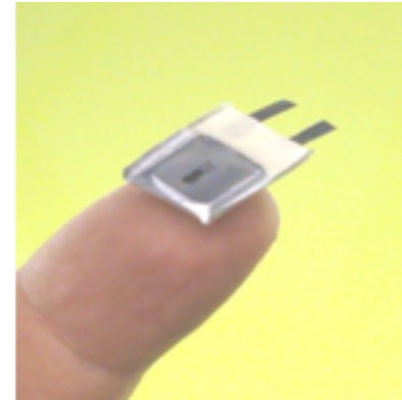
Battery



- Supplies power to wearable BT module and notification peripherals
- Battery life expectation .5 – 1000+ hours
- Small size makes integration with restricted size requirements capable



PowerStream – GM300910



Battery	
Manufacturer	PowerStream
Part Number	GM300910
Price	\$15
Dimensions	3mm x 9mm x 10mm
Specs	<ul style="list-style-type: none">•Charge Current: 12mA – 24mA•Capacity: 15mAh•Weight: 2.25g•Discharge Cutoff Voltage: 2.75V

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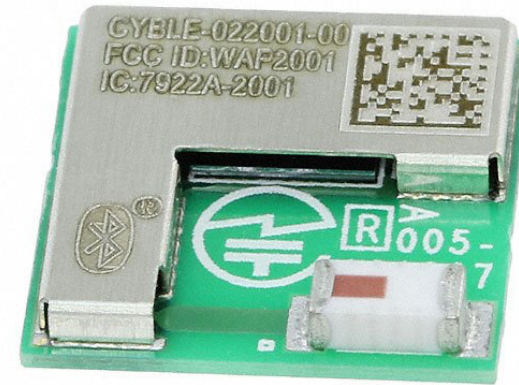
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Bluetooth Module

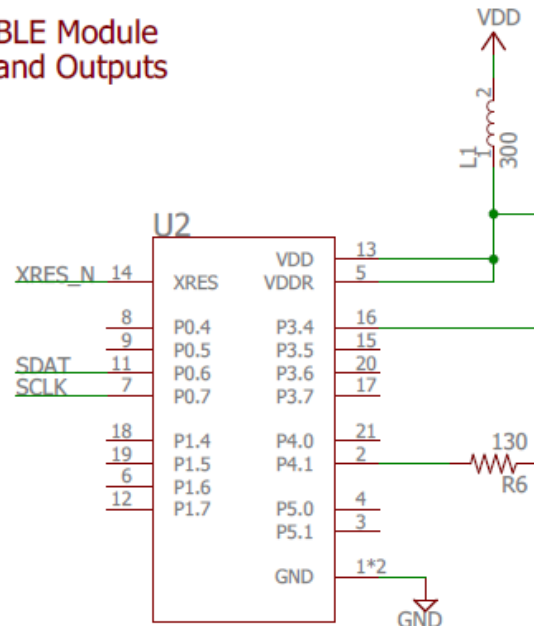


- Communicate RSSI value with module for proximity detection
- Bluetooth 4.1 single-mode module
- Very low current draw
- Includes BLE stack
- On-board ceramic antenna
- Voltage is internally regulated
- Smallest form factor found with antenna

Cypress – CYBLE-022001-00



BLE Module and Outputs



BT Module	
Manufacturer	Cypress
Part Number	Cyble-022001-00
Price	\$7.57
Dimensions	10mm x 10mm
Specs	<ul style="list-style-type: none">•32-bit processor•128-KB flash memory•16-KB SRAM memory•16 GPIOs•SWD programming•Input Voltage: 1.8V – 5.5V

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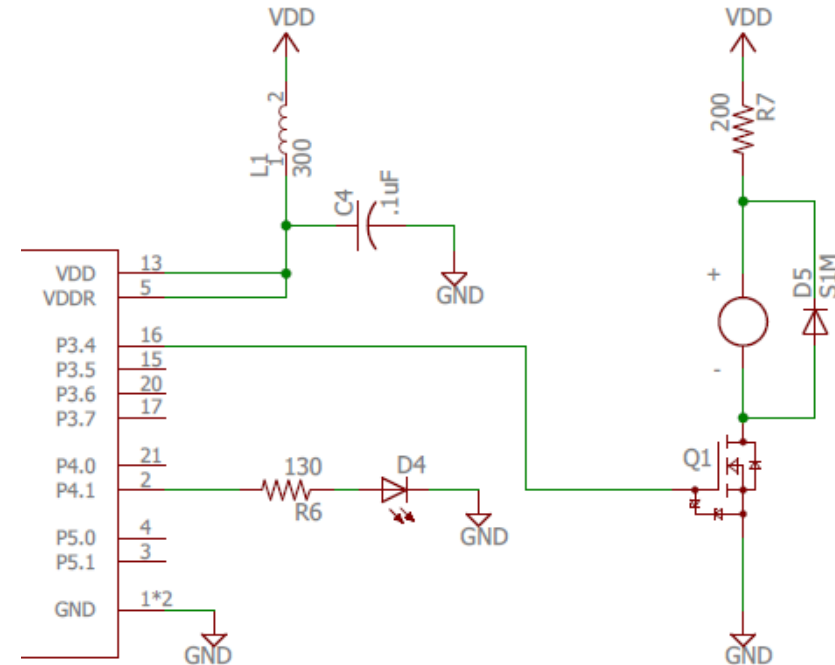
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Demo

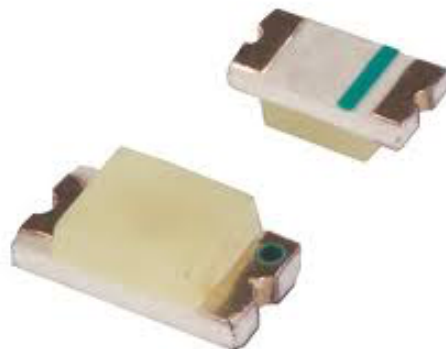
Sensory Outputs



- 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
 - Yellow color



SMD LED



Vibrating Motor Disc



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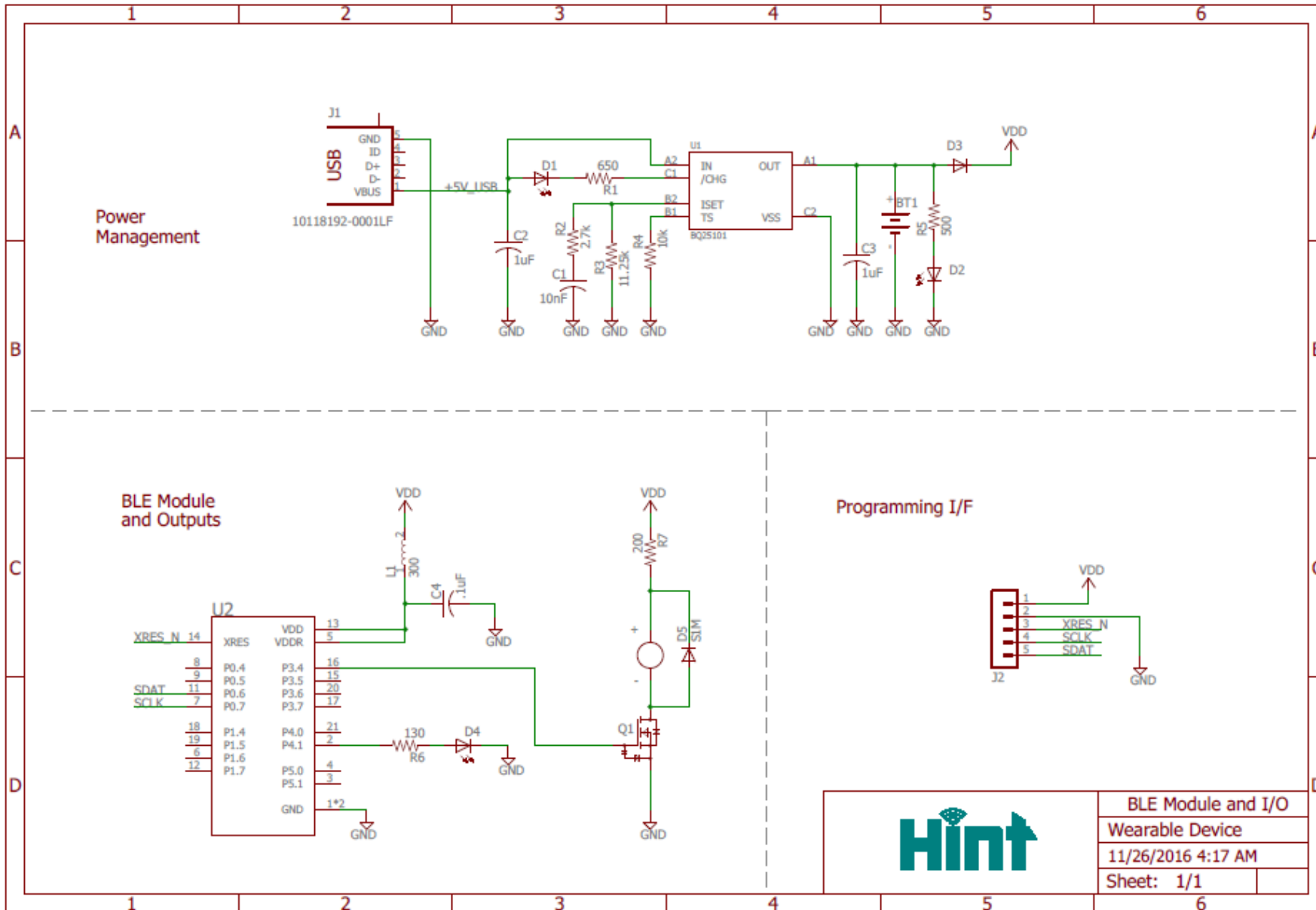
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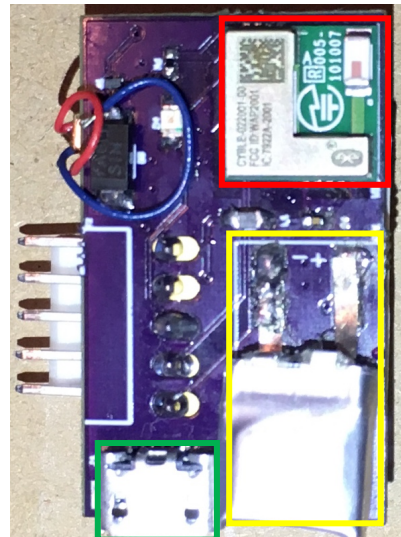
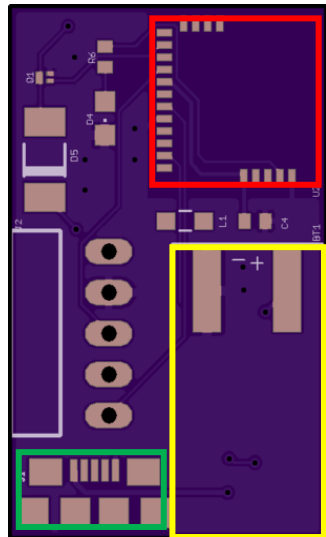
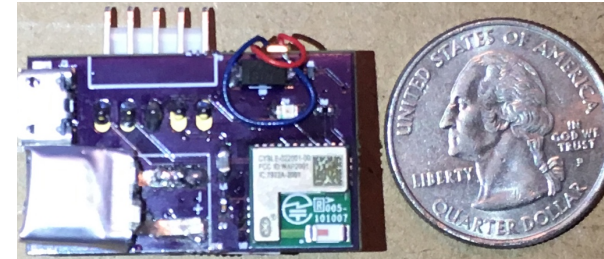


BLE Module and I/O
Wearable Device
11/26/2016 4:17 AM
Sheet: 1/1

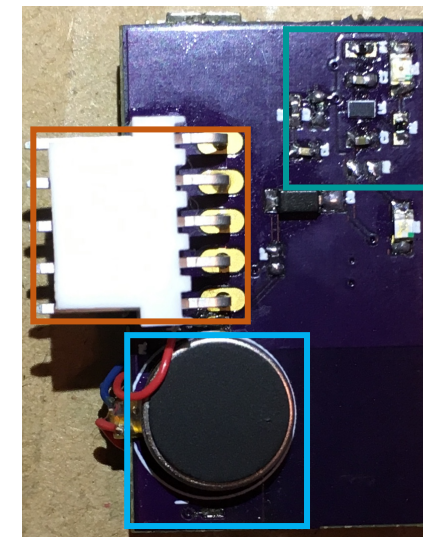
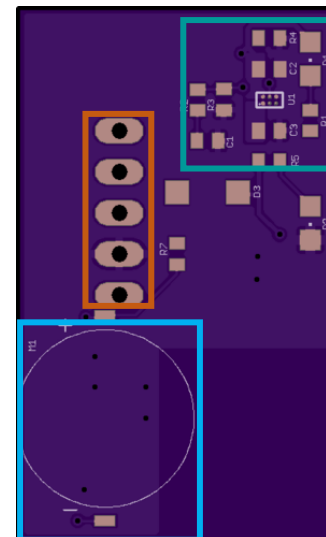
Wearable PCB



- Ordered through OSHPark.com
- Assembled by hand & by Quality Manufacturing Services
- 1.30" x 0.80"



- BLE Module
- Battery
- Micro-USB
- Vibrating Motor
- Batt. Charge Network
- Programming Connector



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Difficulties and Successes



Difficulties:

1. Assembly
 - a. Difficult to solder by hand
 - b. MOSFET proved to be difficult
 - c. Charge management IC (BGA)
 - d. Time consuming
 - e. QMS provided 1-of-2 functional PCBs
2. Software
 - a. Programming wearable to interface with the Module
 - b. RSSI integration proved to be complicated due to Cypress bug

Successes:

1. Assembling PCB by hand (except key components)
2. Functional PCB includes all features
3. RSSI integration



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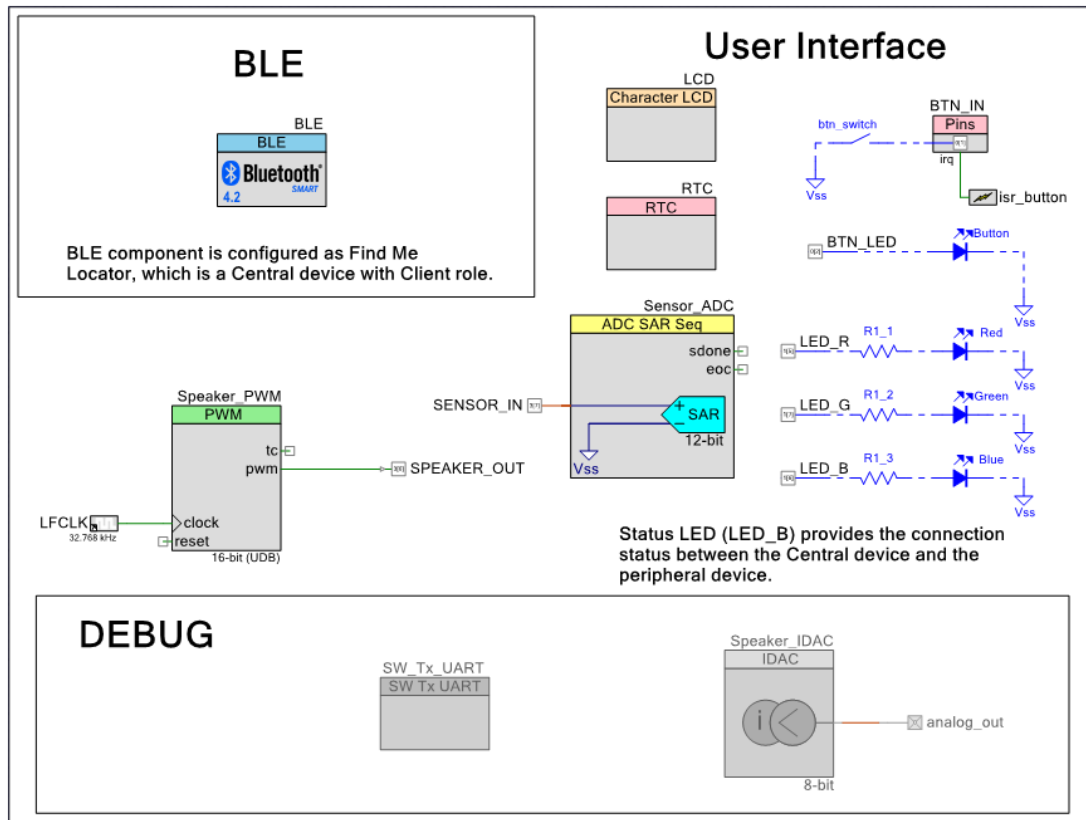
Questions?

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Module Software

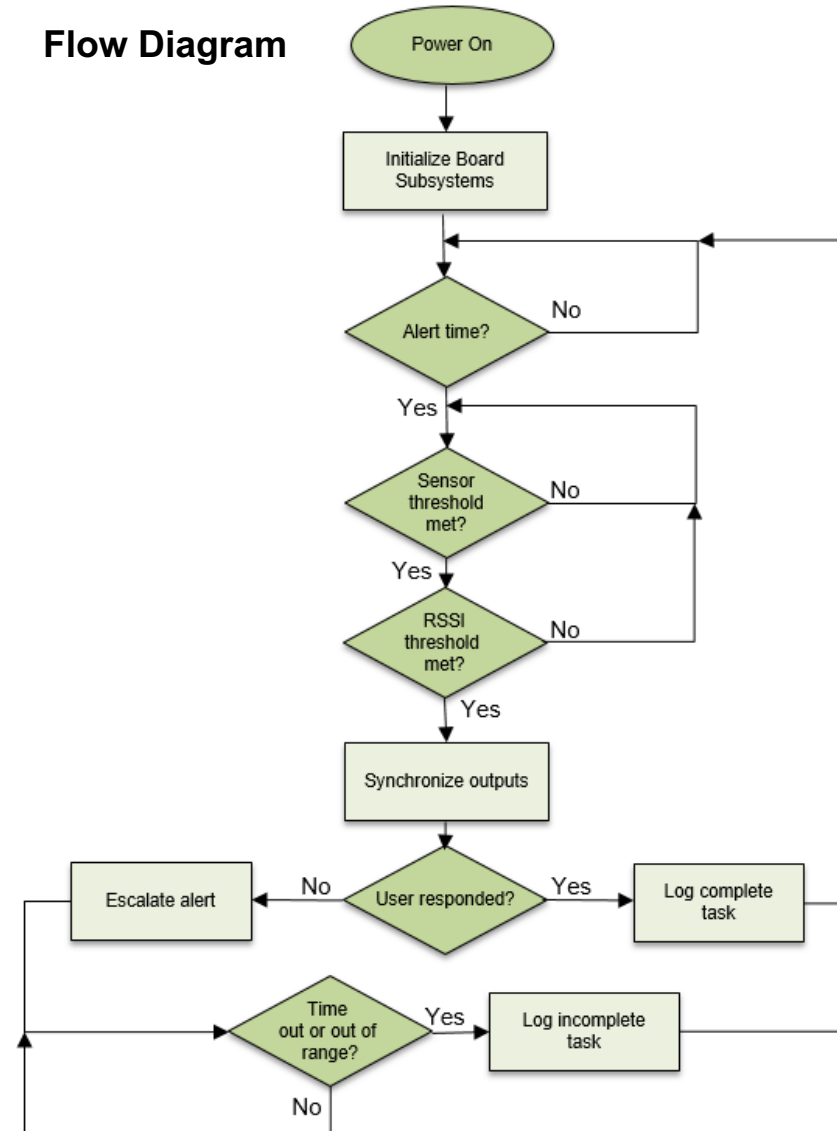


Active Software Blocks



All development done with Cypress PSoC Creator 4.0 with embedded C code

Flow Diagram



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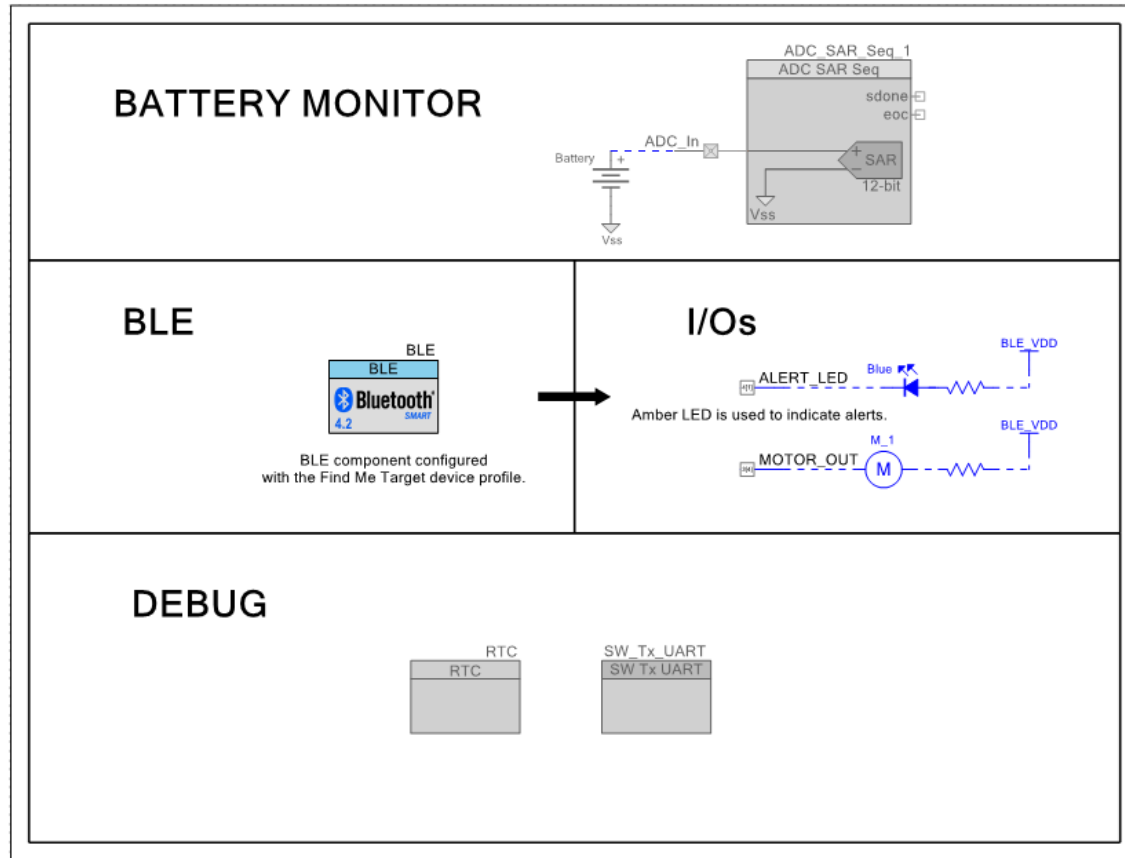
Questions?

Demo

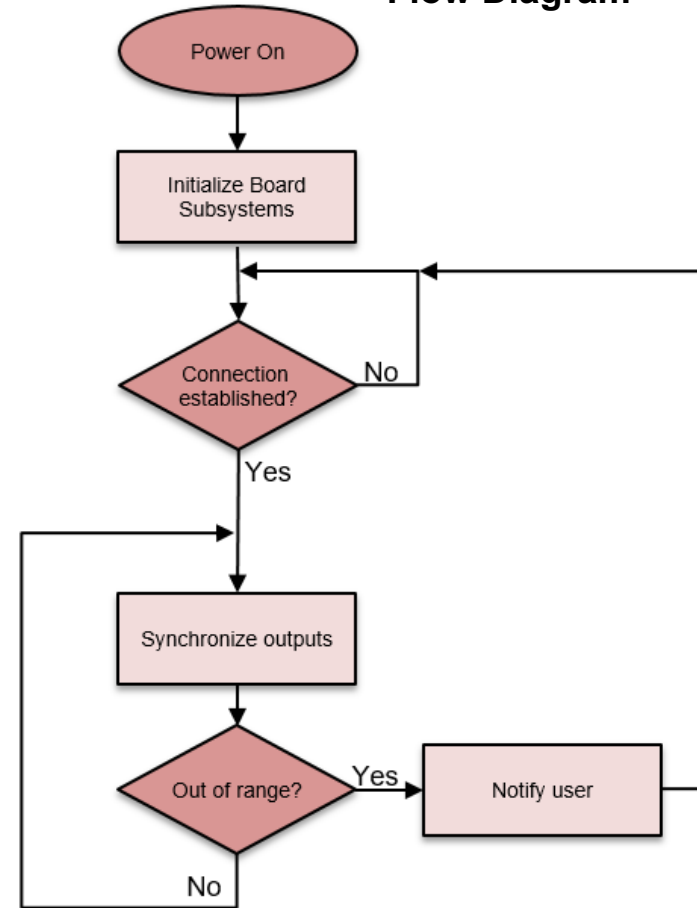
Wearable Software



Active Software Blocks



Flow Diagram



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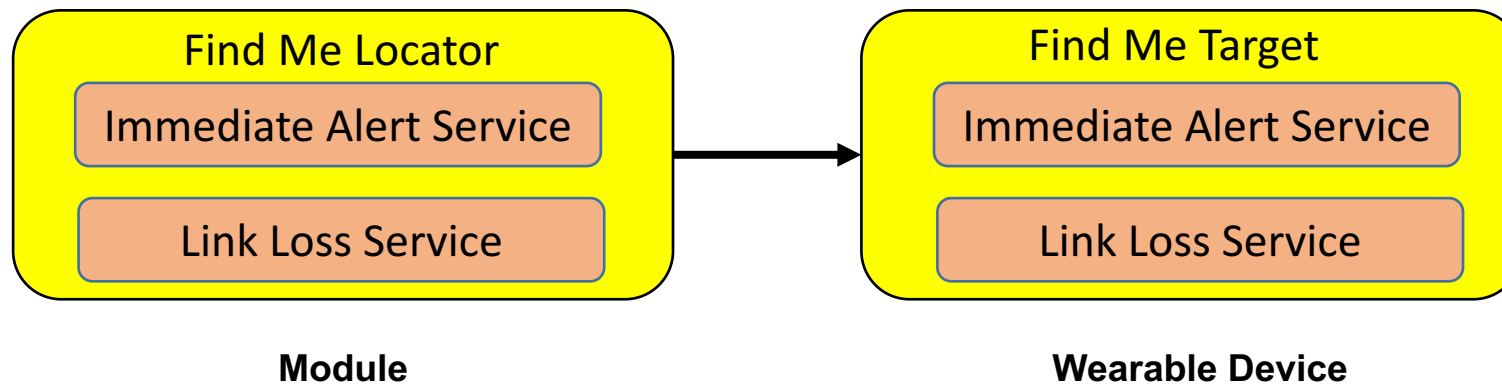
Questions?

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Bluetooth Profile



- Find Me Profile
 - Defines behavior between devices based on alert levels
 - Dependency on General Attribute Profile (GATT)
- Find Me Locator (Central device)
 - Module (GATT Client) looks for 'target'
- Find Me Target (Peripheral device)
 - Wearable (GATT Server) emits alert depending on Client instructions
- Immediate Alert Service – alerts trigger immediately
- Link Loss Service – alerts trigger on BLE connection loss



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Subsystems	Parts and Materials	Projected Qty	Price/Unit	Projected Cost	Current Cost
Module	Module Microcontroller	2	\$10	\$20	\$17
	BLE Development Kit	1	\$49	\$49	\$0
	Module LCD Display	2	\$27	\$54	\$66
	Response Button	2	\$10	\$20	\$28
	Range Sensor	1	\$27	\$27	\$74
	Speaker	4	\$1	\$3	\$4
	Printed Circuit Board	5	\$150	\$750	\$118
	AC Adapter	2	\$6	\$12	\$16
	Enclosure	N/A	\$50	\$50	\$0
Wearable	Wearable Microcontroller	3	\$12	\$36	\$36
	BLE Development Kit	1	\$20	\$20	\$0
	Vibration	2	\$4	\$8	\$8
	Printed Circuit Board	3	\$100	\$300	\$124
	Battery	2	\$15	\$30	\$33
	Power Management IC	2	\$2	\$4	\$4
	Enclosure	N/A	\$30	\$30	\$0
Both	Programmer/Debugger	1	\$89	\$89	\$100
	Board Components	N/A	\$247	\$247	\$247
	Other PCB Expenditures	N/A	\$136	\$136	\$0
Totals		Total Cost:		\$1,413	\$874
		Sponsorship:		\$1,000	

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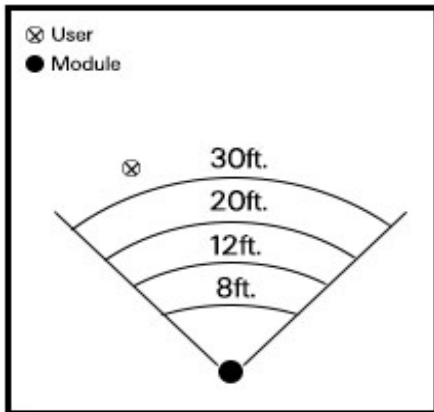
Demo

Demo Test



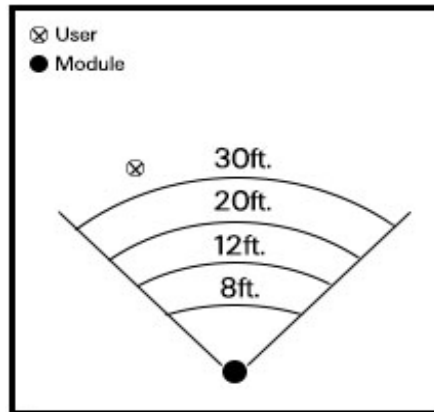
Test Case 1

- User walks out of range during a notification (view response on wearable device)



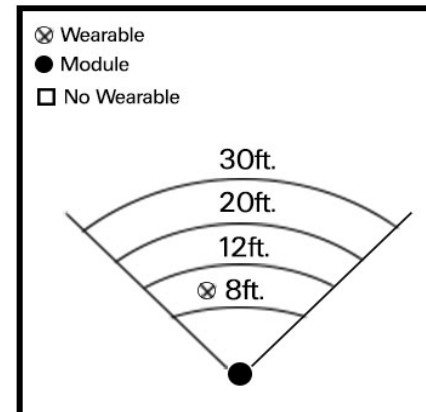
Test Case 2

- User walks out of range during a notification (view response on module)



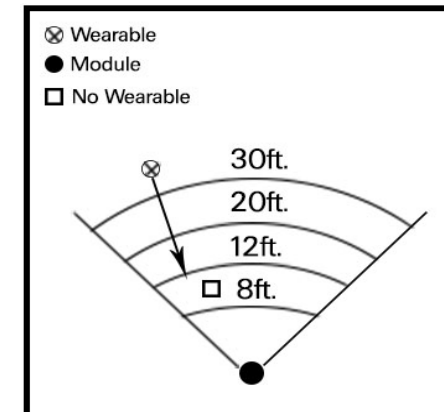
Test Case 3

- User with wearable walks in front of the module and does not respond



Test Case 4

- Person with no wearable walks in front of the module, then user with wearable walks in front of the module



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Test Cases 5-7: Normal operation with user responses