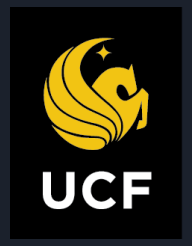
EEL 4915 – Senior Design II

Presented by:

Joseph Brown BSCpE candidate
Michelle Dubon BSEE candidate
Victor Lopez BSEE candidate
Manuel Nunez BSEE candidate

Advisor:

Dr. Lei Wei *Ph.D. M.E. B.E*



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FriendlyEyes

FriendlyEyes

Electromechanical system designed to emulate the role of human vision in scanning our surroundings while walking, aimed to offer an alternative to the white cane while providing wider functionality.

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Background & Motivation

- According to the International Agency for the Prevention of Blindness, there is an estimated 43 million people living with blindness around the world, and 295 million people living with moderate to severe visual impairment.
- There have not been any significant breakthroughs in this regard.
- No available solution accounts for more than one or two necessary functions.

Define where in space an object is located, as well as how far it is relative to self,

Engage a state of alert when something is coming our way, &

he possibility of falling because of terrain changes.

Requirement Specifications

FriendlyEyes must be able to scan user's field of view up to 7 m away and produce a mechanical output.
FriendlyEyes must issue and prioritize alerts prompted by objects coming into 10 m from the user and doing so with speeds faster than 2 m/s relative to the Earth.
FriendlyEyes must keep track of its distance from the ground and alert the user of sudden changes in the level of the terrain ahead of an incident.
FriendlyEyes must produce all alerts within 1/8 seconds of sensing.
FriendlyEyes must be powered by a rechargeable battery, and the system must run for ≥8 hours on a single charge.
FriendlyEyes must be safe for anyone who wears it; therefore, it must: .be able to assess known and common dangerous materials such as glass, .keep its temperature low, .handle the risk for ESD, .and go through an arduous testing procedure.

Proposed Solution

“to implement an electromechanical system housed within a piece of clothing that takes input from sensors, performs calculations and outputs a localized vibration, all powered from a rechargeable battery.”

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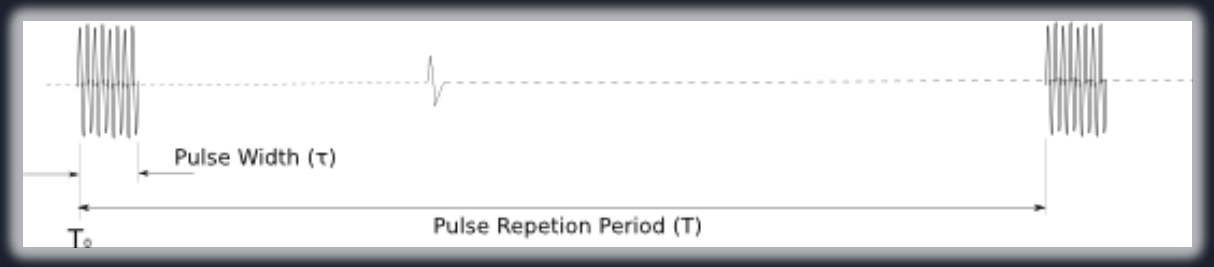
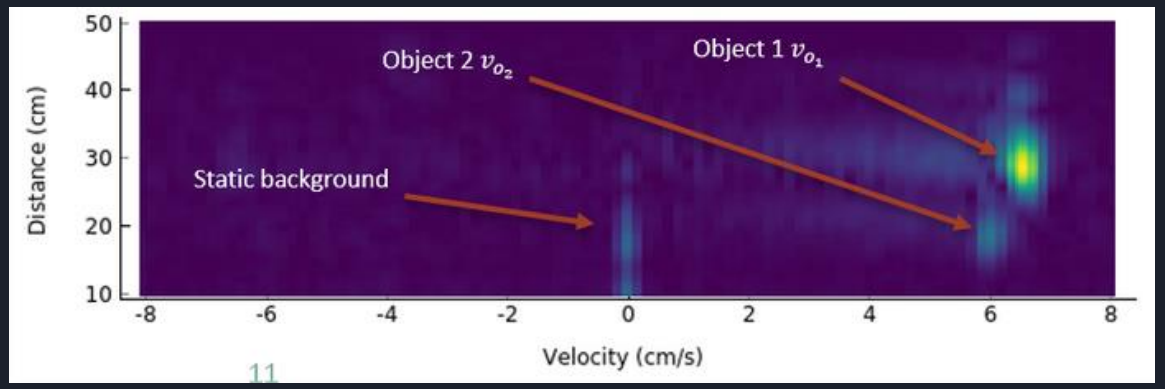
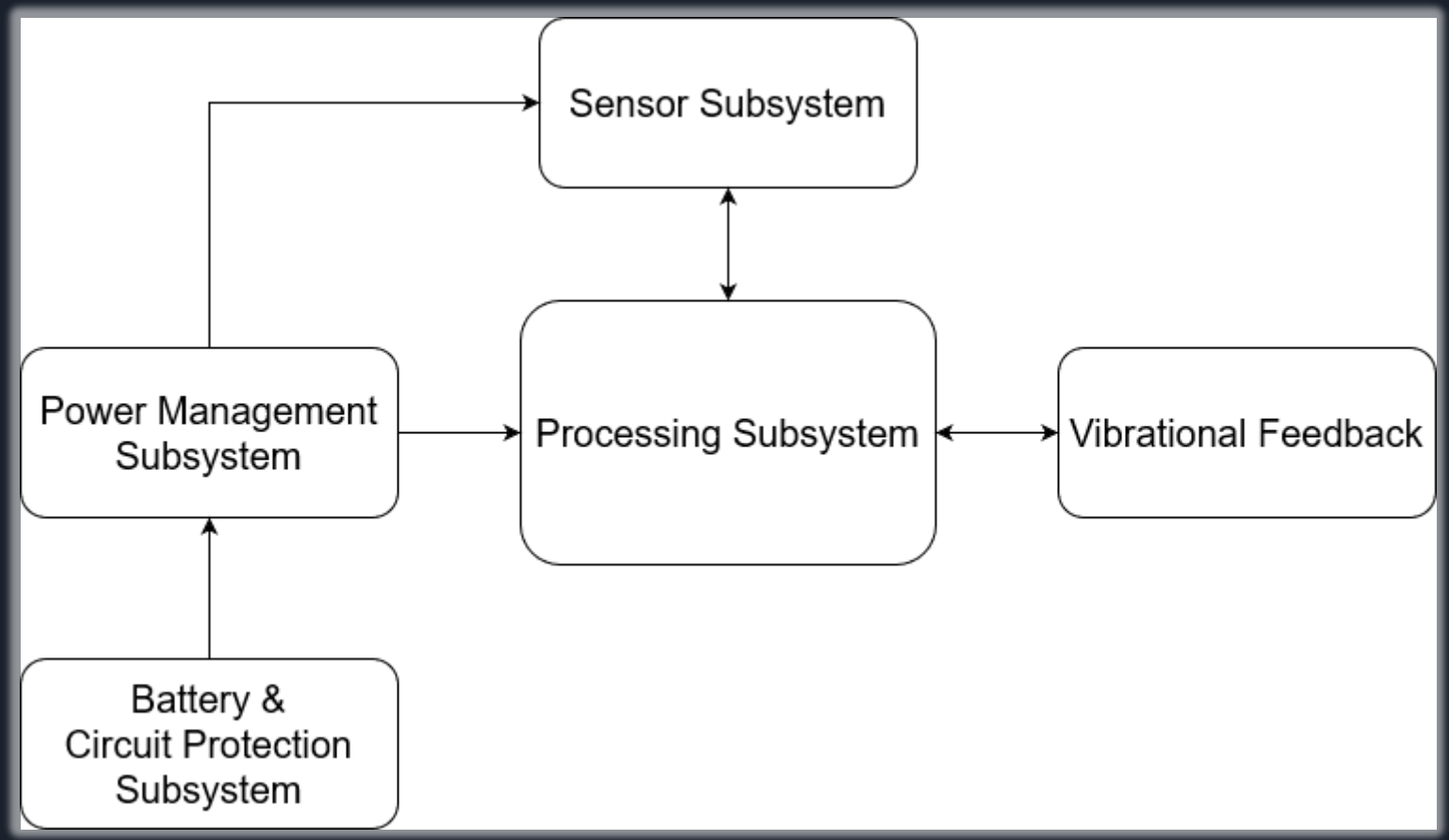
Working Principle





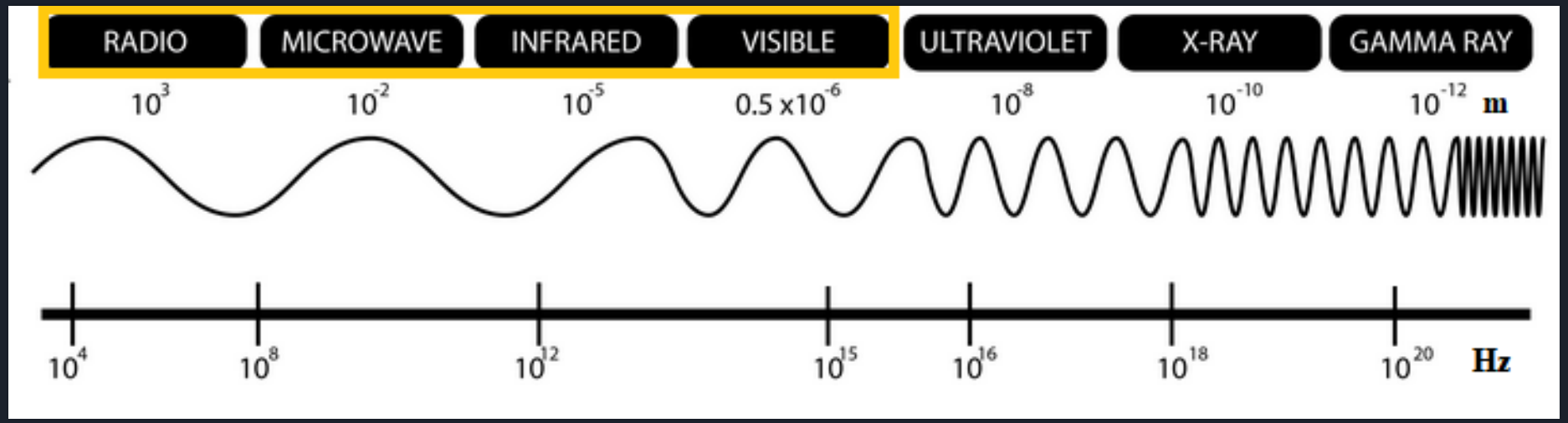
Simplified Block Diagram



Wireless Sensing Technologies

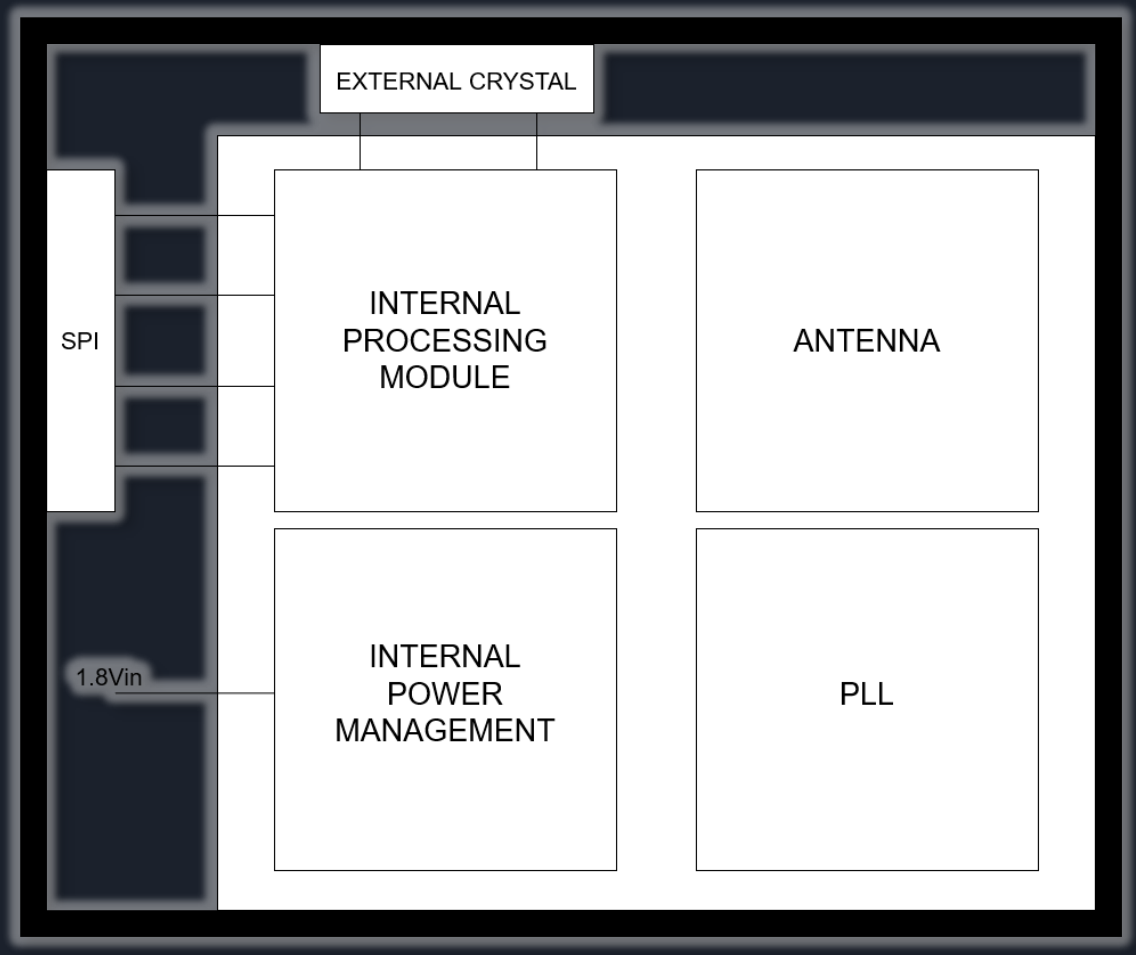
	Acoustic	Radio				Optical	
Parameter	Ultrasonic	Instrumentation	Continuous-wave	Doppler	Pulsed	Infrared	LiDAR
Best for	Distance	Navigation	Motion	Motion, Presence	Distance, Position	Motion, Presence	Motion, Presence, Distance, Position
Range							
Weather							
Cost							

Wireless Sensing Technologies

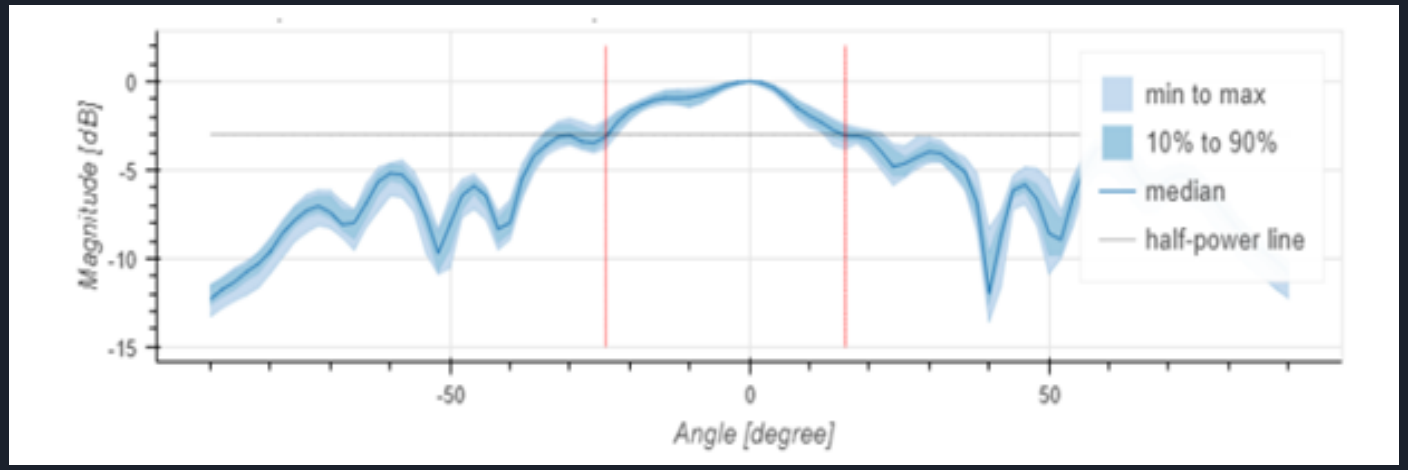


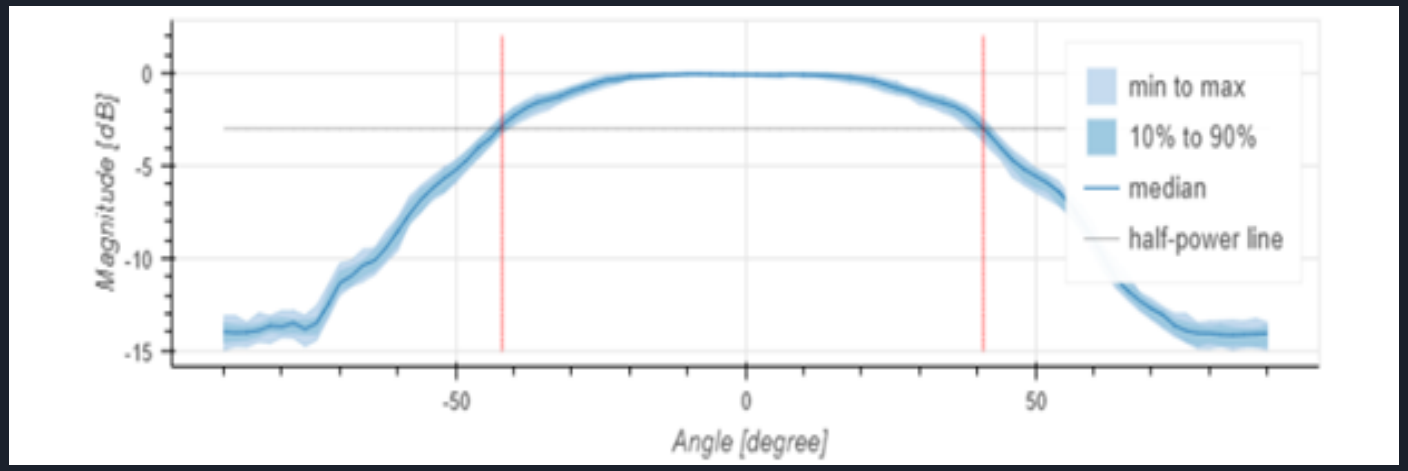
Acconeer A1 PCR sensor

Main Characteristics
60GHz operating frequency
SPI communication
~$11 (IC) + ~$3 (PMIC & misc)
20mW consumption at 100Hz refresh rate



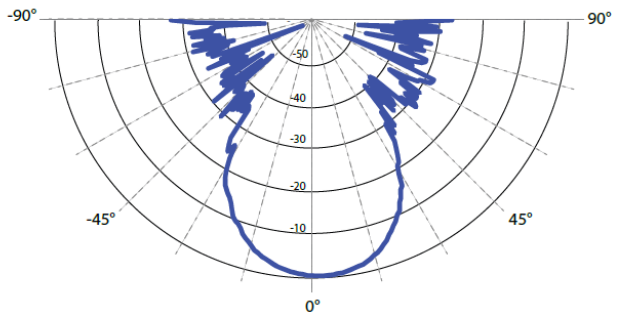
- Half-power beamwidth: 40(E-plane)/80(H-plane)

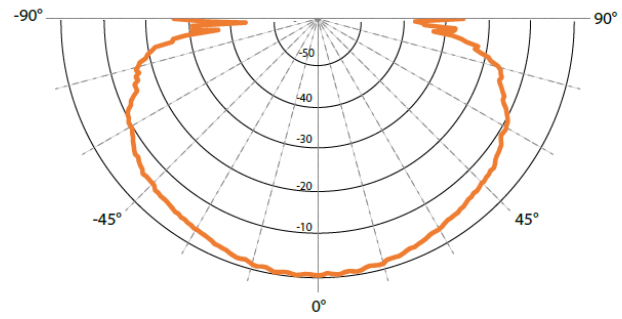




InnoSent INS-3330

Main Characteristics
24GHz operating frequency.
UART communication.
On-board DSP.
Application specific



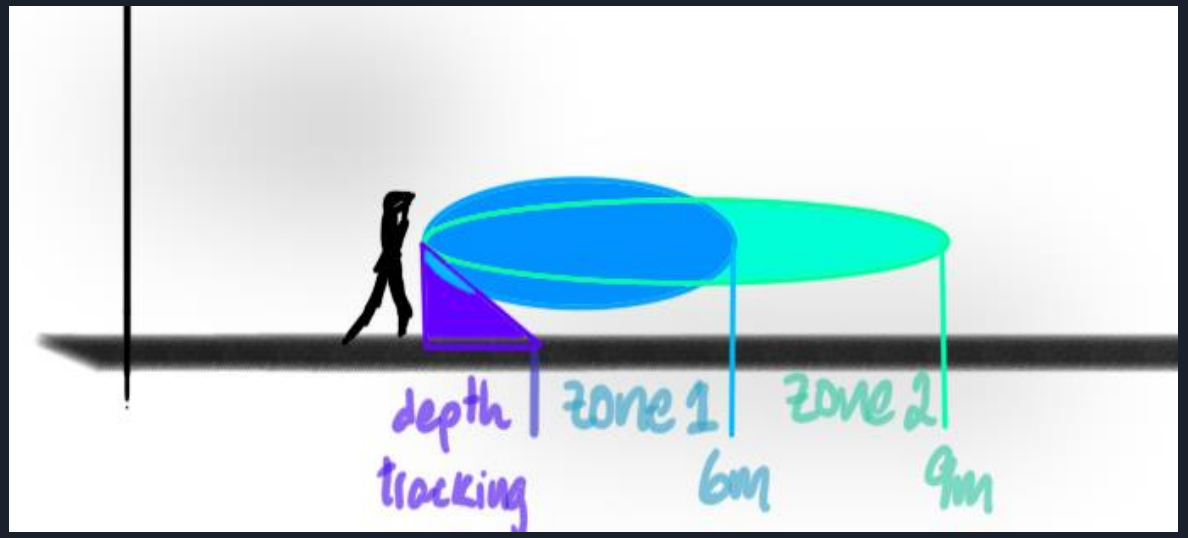


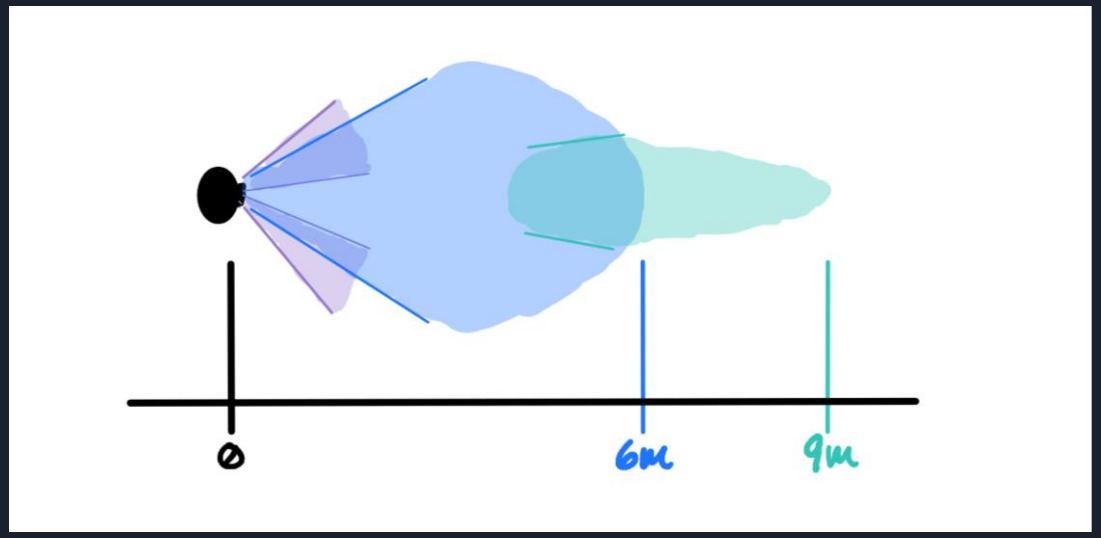
system pattern (-10dB)	azimuth	system_az		43		°
	elevation	system_el		116		°

DFRobot URM09

Main Characteristics
Ultrasonic operating frequency.
1-Wire communication.
Limited computational requirements.
Cheap, easy to obtain, and integrate

Sensor module:	A1	INS-3330	URM09
Denomination	Zone 1	Zone 2	Depth-tracking
Operating frequency	60GHz	24GHz	<50kHz
Communication interface	SPI	UART	1-Wire
Range covered	(0.3 – 6)m	(5 – 9)m	N/A
Power consumption			
Input Voltage	1.8V	5V	5V





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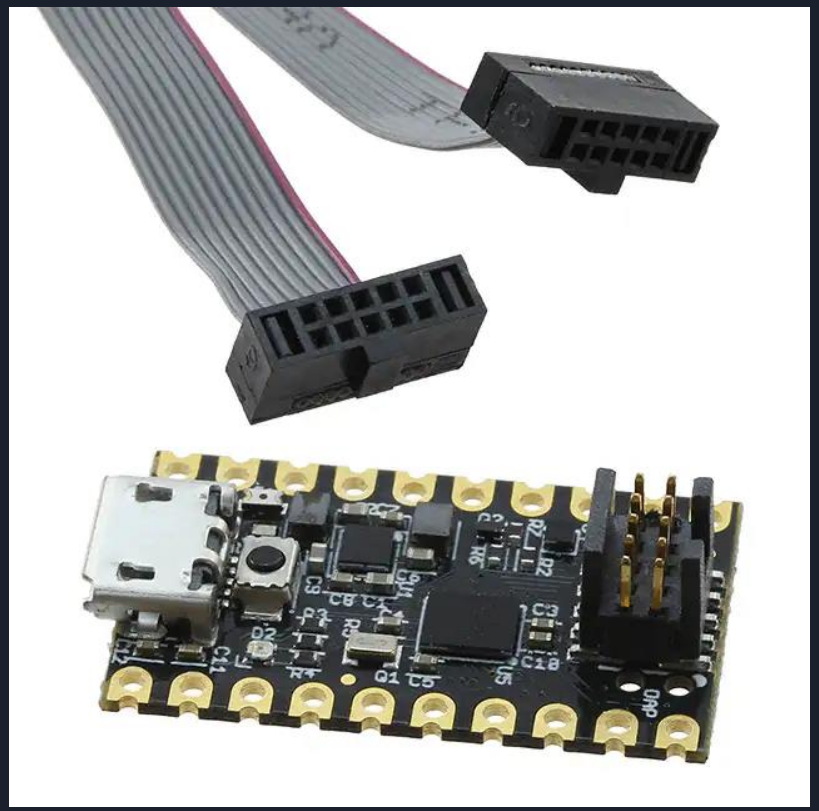
MCU Selection

	MSP430 FR5964	NXP K32L2B	STM32 F048C6	ATmega 328P	MAX 32625
Storage (kilobytes)	256	256	32	32	256 or 512
Random Access Memory (KB)	8	32	6	2	128 or 160
ADC Resolution	12-bit	16-bit	12-bit	10-bit	10-bit
CPU Speed	16 MHz	48 MHz	48 MHz	16 MHz	96 MHz
GPIO Count	68	50	37	23	40
Communication Peripherals	4 I2C, 4 UART	2 I2C, 1 UART, 2 SPI	1 I2C, 2 USART, 2 SPI, 1 USB 2.0	1 I2C, 2 SPI, 1 USART	2 I2C, 3 UART, 3 SPI, 1 USB 2.0
Voltage Range	1.8v – 3.6v	1.71v – 3.6v	1.65v – 1.95v		1.14v - 3.6v
Price (USD)	$2.68	$3.42 - $5.14	$2.02	$2.60	$10.52

JB

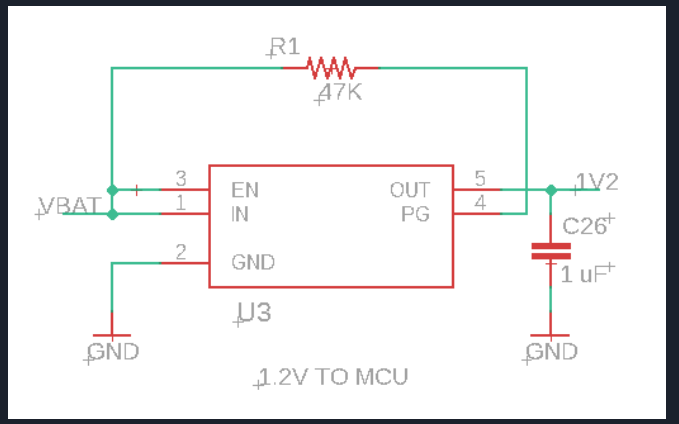
Development Board/SDK

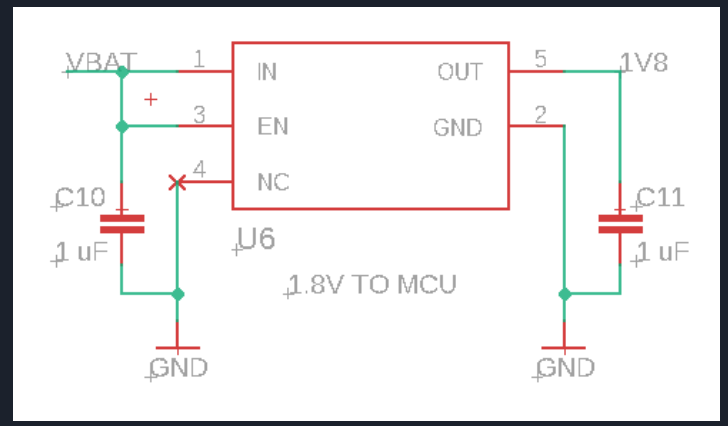


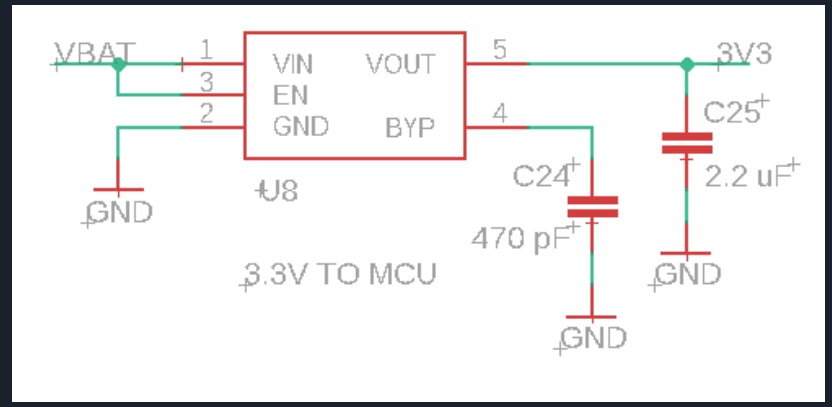
- MBED and MBED Studio
- *Standardization* of ARM MCUs via Hardware Abstraction
- Many resources available

Microcontroller Power Delivery

- NCP115ASN180T2G
  - 1V8 fixed output voltage, 300mA maximum output current
  - 1V7 to 5V5 input voltage range
- MIC5205-3.3YM5-TR
  - 3V3 output voltage, 150mA maximum output current
  - 2V5 to 16V input voltage range
- MIC5258-1.2YM5-TR
  - 1V2 output voltage, 150mA maximum output current
  - 2V6 to 6V input voltage range
- These three voltage regulators supply power to the MAX32625 processor.







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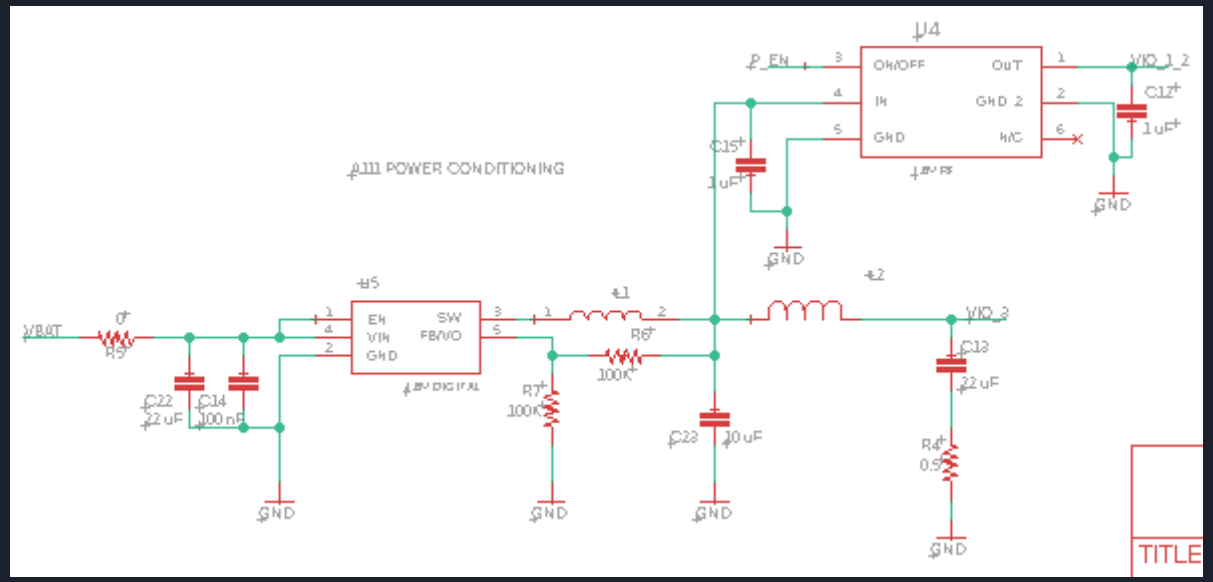
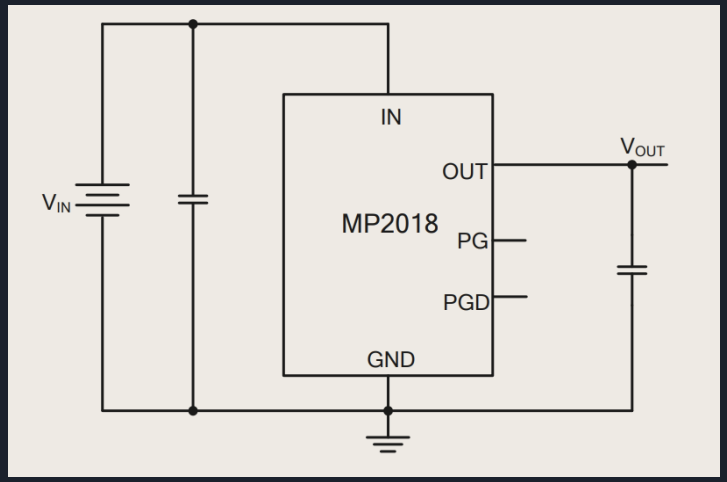
A1 Power Conditioning

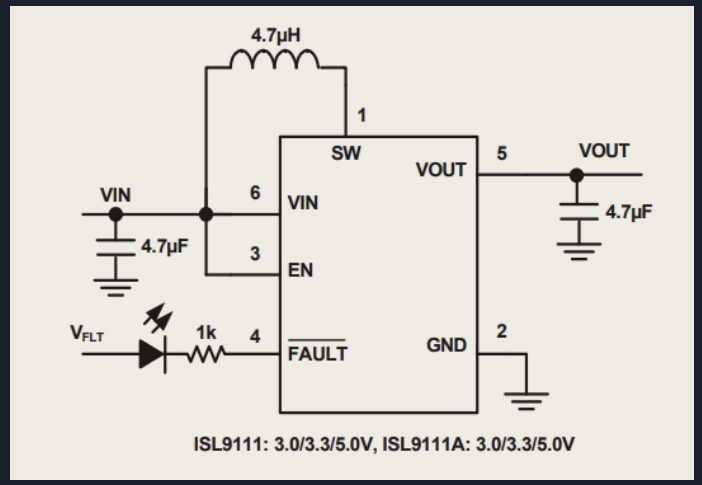
- ST1S12G18R
  - Selectable fixed output voltage of 1.2V and 1.8V, 700mA maximum output current
  - 2.5V to 5.5V input voltage range
- SIP32431DR3-T1GE3
  - High -enable logic load switch
    - Programmable voltage: 1.8V
    - 1400mA maximum output current
  - 1.5V to 5.5V input voltage
- These two voltage regulators are used to power the A111 radar sensor.



INS3330 & URM09 Power Delivery

- ISL9111AEH50Z-T7A
  - 5V output voltage, 800mA output current
  - 0.5V to 4.8V input voltage range
- This voltage regulator supplies power to the INS3330 radar sensor and the URM09 ultrasonic sensor.
- MP2018GZD-33-P
  - Selectable 3.3V or 5V fixed output voltage regulator, 5000mA maximum output current
  - 3V to 16V input voltage range
- This MP2018 voltage regulator will be used for battery charging and stability.





Main Components' Power Requirements

	A111	MAX32625	INS3330	URM09
Voltage	1.8V	3.3V, 1.8V, 1.2V	5V	3.3V to 5.5V
Current Draw	300mA	100mA	55mA	20mA
Power Consumption	540mW	330mW	275mW	100mW
Powered By:	SIP32431DR3-T1GE3	MIC5205-3.3YM5-TR (3V3), NCP115ASN180T2G(1V8) and MIC5258-1.2YM5-TR (1V2)	ISL9111AEH50Z-T7A	ISL9111AEH50Z-T7A

Secondary Batteries

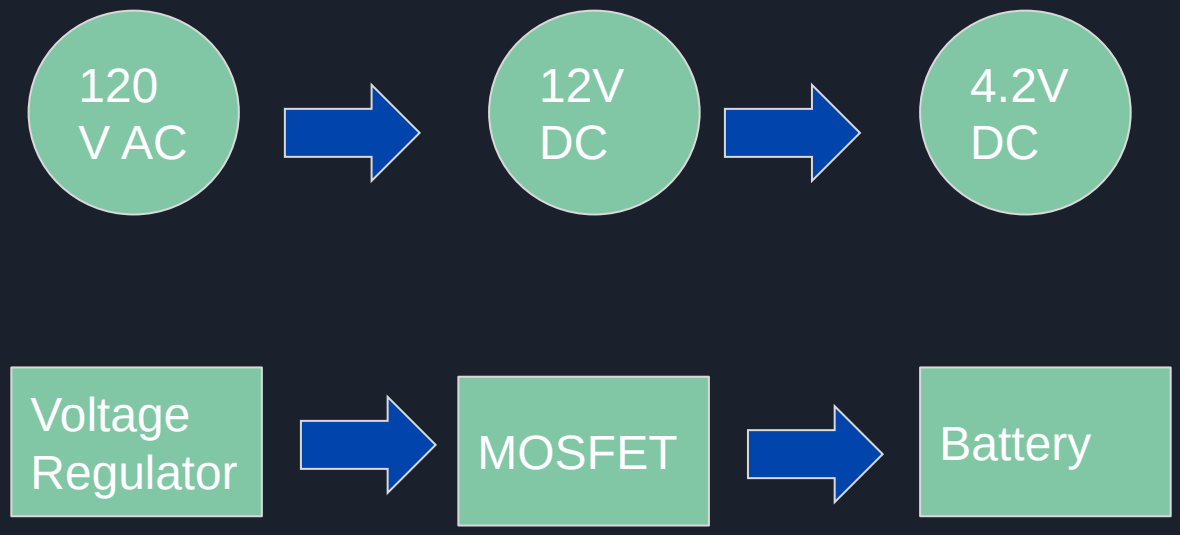
Battery Types	Lithium-Ion	Lithium-Polymer	Nickel-Cadmium	Nickel-Metal Hydride	Lead Acid
Rechargeable	Yes	Yes	Yes	Yes	Yes
Nominal Voltage	3.7V	3.7V	1.2V/cell	1.2V	2V
Energy Density	100-265 Wh/kg	185-220 Wh/L	50-75 Wh/kg	170-420 Wh/L	80-90 Wh/kg
Shelf Life	3-6 years	3-5 years	1.5-3 years	3-5 years	2 years
Cost	High ($140 per kWh)	High (about $100 per kWh)	Low (about $7.50 per kWh)	Medium (about $83 per kWh)	High (about $500 per kWh)

VL

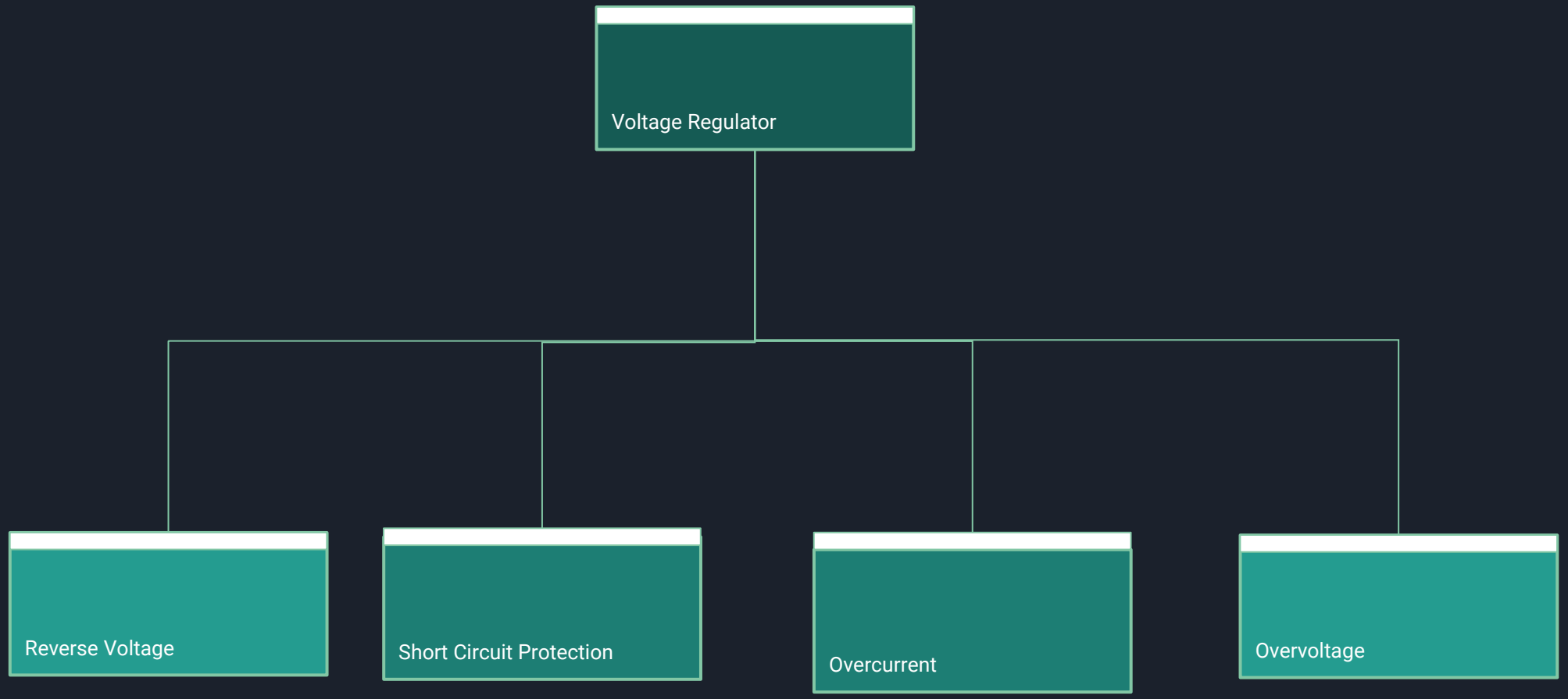
Battery Constraints, Size, and Integration

- ➔ Constraints:
  - Small
  - Lightweight
- ➔ Size:
  - 115 grams
  - 99.0mm x 67.0mm x 8.1mm
- ➔ Integration:
  - The battery will be attach to the vest near to the Power PCB

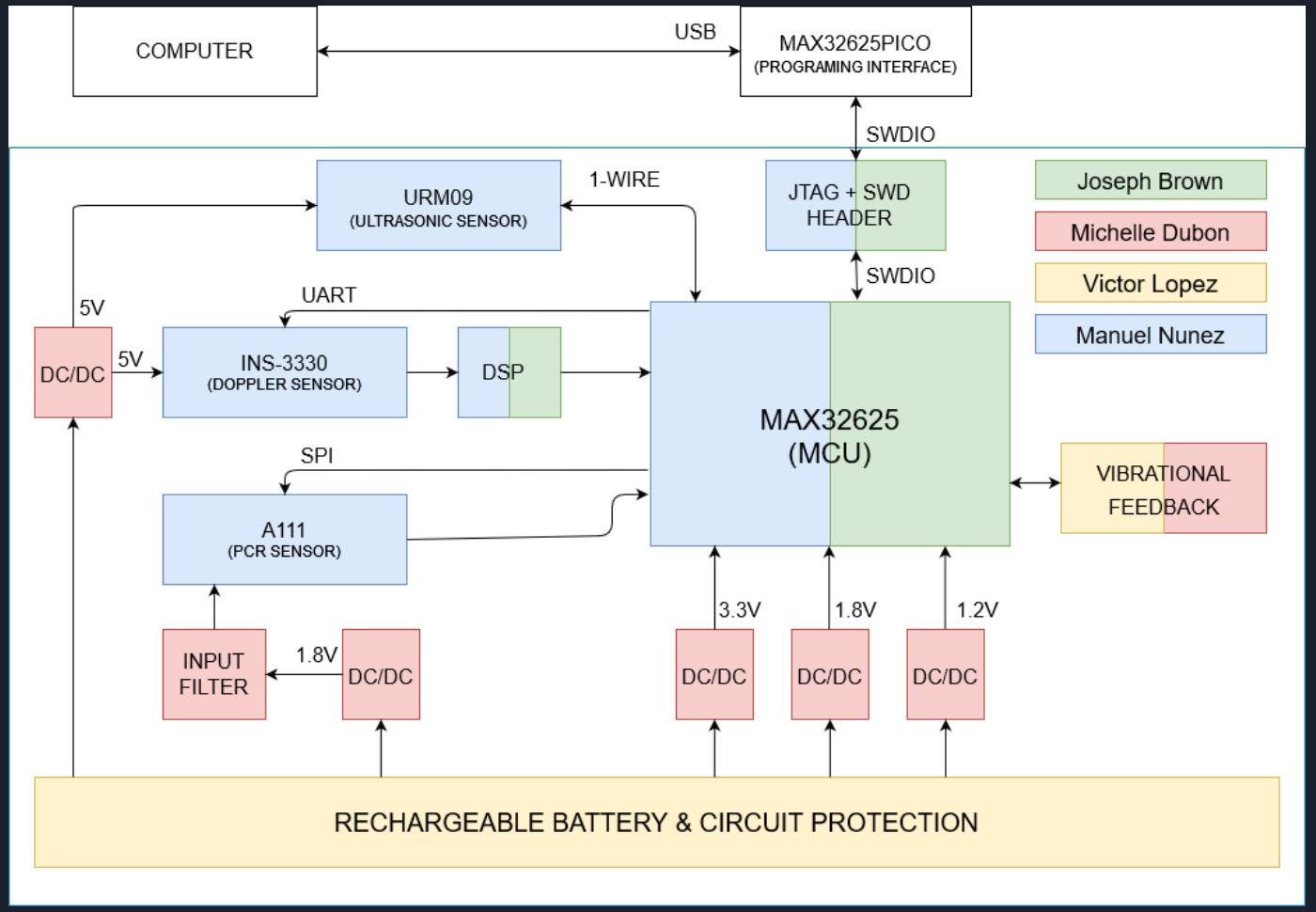
Charging Station



Security System



Comprehensive System Block Diagram



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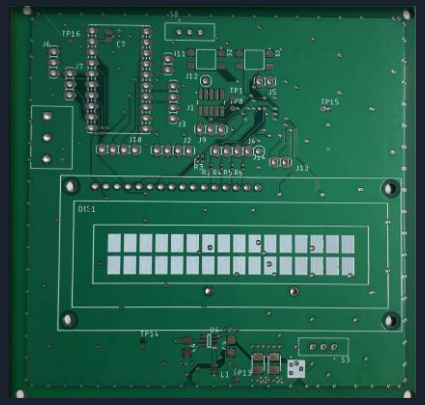
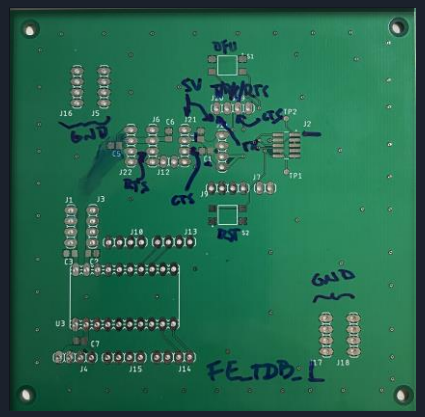
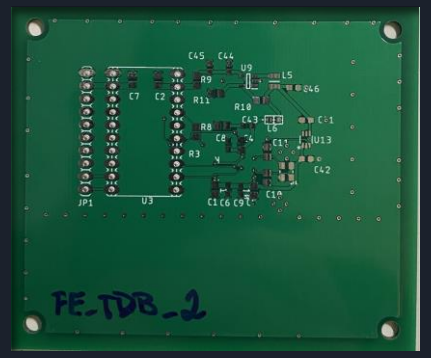






Phased approach

Integration Progress

Sensor & Processing Subsystems

- Interfaced all hardware separately.
- Successfully flashed MCU on standalone implementation.
- Tested A1, INS3330, URM09 with provided code and GUIs.
- Mapped system-level software architecture.
- Defined next steps

Battery Subsystem

- Early signs that our battery meets requirements.
- Setting up battery characterization process.
  - Charge and discharge tests
  - Dedicated IC to collect data.

MN VL

Difficulties

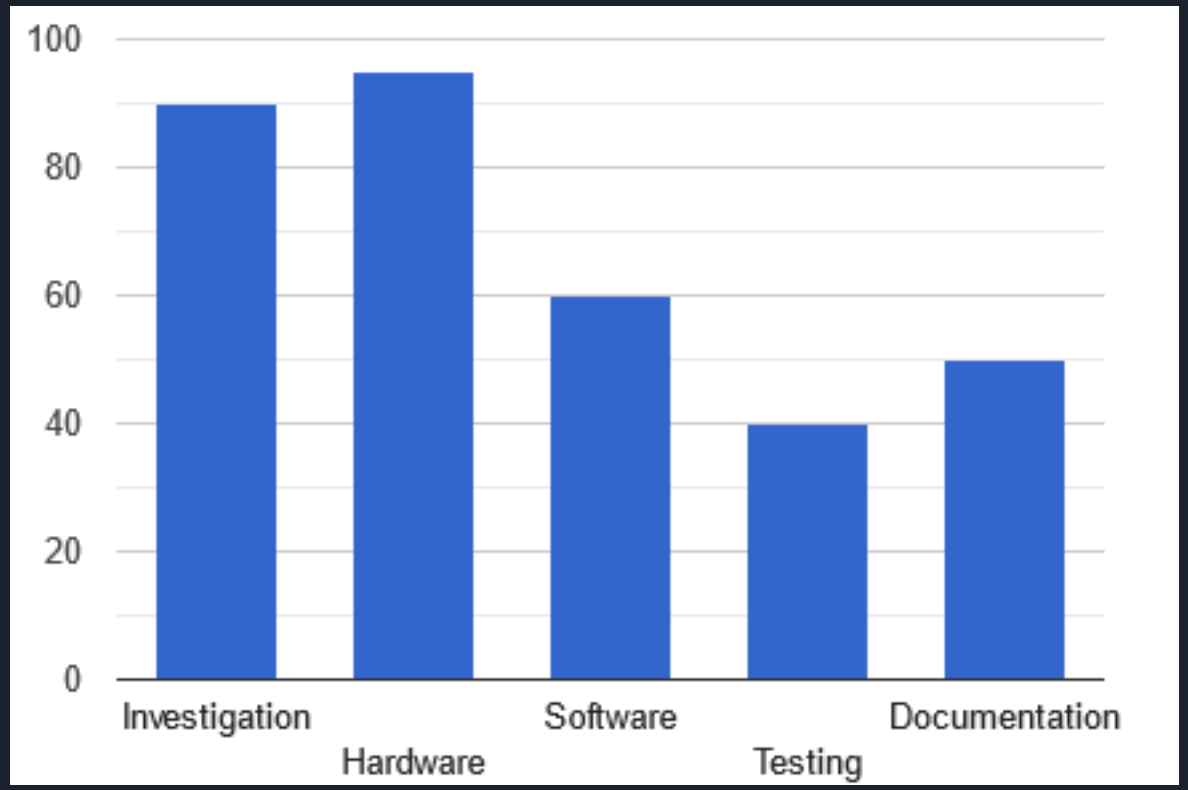
- Resolution vs Cost, tilt, lenses.
- Integration
- Wiring distribution/vibrating motors position
- Time available for testing

Next Steps

- Continue testing and characterization process,
- Integration
- ESD Considerations
- Move towards first stretch goal

Budget

Subsystem	Item	Cost
Sensor Subsystem	A1 INS-3330 URM09	$48.30
Processing Subsystem	MAX32625	$7.35
Power Management Subsystem	6x PMIC	~$5.00
Battery and Circuit Protection Subsystem	LiPo Battery + AC-DC charging system	~$40.00
Miscellaneous expenses	Common components, PCB fabrication, etc	~$15.00
		~$115.00


100
80
60
40
20
0
Investigation
Hardware
Software
Testing
Documentation

Progress %