Smart Helmet

Group 22

Julian Bonnells	CpE
Jorge De Gouveia	CpE
Jeremy Reimers	EE
Blake Scherschel	CpE

Introduction

SMART
HELMET

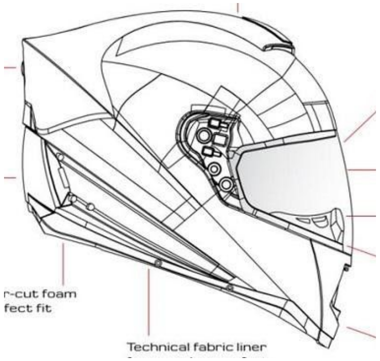
Motivation

- In 2014, 92,00 motorcyclists were injured and 4,586 died in motorcycle related crashes in the United States
  - U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA)
- Motorcycle technology is uncommon in the market
  - Most options are unrealistically expensive
- 86% of bikers are concerned with safety and actively wear a helmet
- Take a proactive approach to safety on the road

Similar Projects

Skully AR-1

- Bluetooth connectivity to smart phone
- Internet connectivity via smart phone
- Open SDK
- $11 million in funding and backed by Intel
- Over 3,000 preorders
- *FAILED:* Declared bankruptcy due to poor product and financial management



NUVIZ Ride:HUD

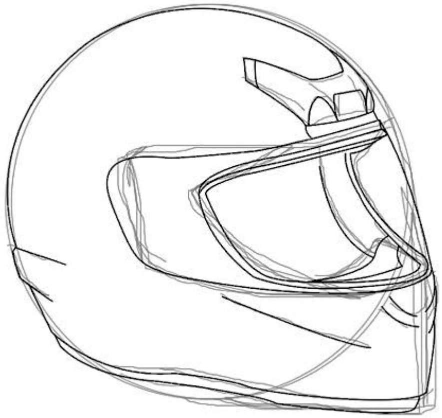
- Bluetooth connectivity to smart phone
- Internet connectivity via smart phone
- LCOS display
- GPS navigation, Helmet Cam, Telemetry Data, Phone Calls, Music
- $200k in crowdfunding
- *FAILED:* Too complex to fabricate

BikeHUD

- Modular Design
- Displays 3 pieces of information a time
- Motorcycle Data, GPS, Audio, Rear Vision, Proximity Safety Alerts
- Released in 2014 for under $500
- Only successful Bike HUD so far

BMW Motorrad Vision HUD

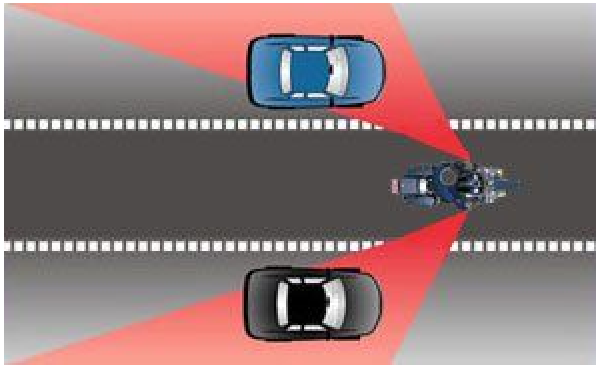
- Features integrated speakers, glass display, diagnostic information, wirelessly controlled menus
- Allows rider to see behind them
- Early stages of development
- Showcased at CES 2016



SMART HELMET

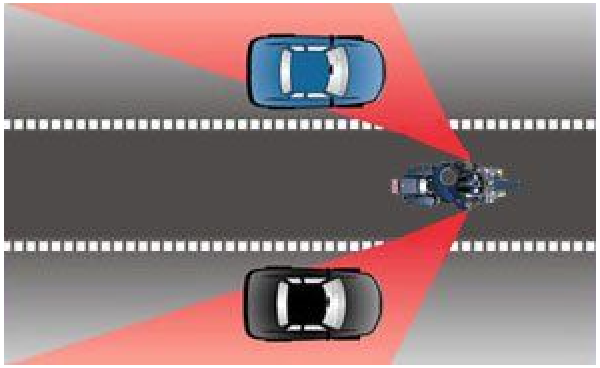
Goals:

- Reduce accidents
  - The Smart Helmet can improve road safety
  - Dangers on the road are an ever-growing concern
  - Save lives
- Increase knowledge of hardware production
  - Process of turning an idea to a product
  - Learn PCB printing process
- Offer better options for motorcycle safety
  - Cheaper
  - Compatible with all bikes
  - Small and unobtrusive



Objectives

- Create a cheaper option for motorcycle safety
  - Competitive price compared to other expensive options
- Smart Helmet will be equipped with a Heads-Up Display (HUD)
  - Visual Proximity Warning
  - Lightweight
  - Wireless
  - Prolonged Battery Life from Solar Panels
  - Does not interfere with driving
- Reliable system
  - High accuracy
  - Minimal design
  - Exchangeable parts



Requirement Specifications

Functional Requirements

- Two modules with separate functions
  - Bike Proximity Sensor Module and Helmet HUD Module
- Information to rider
  - Able to detect surrounding automobiles in close range (20ft) to the rider
  - Interface with the rider's turn signal inputs to read the driver’s intentions
  - Ranging data to a visual display that the user can easily see
- Power
  - The proximity sensor module shall draw power from the motorcycle
  - The helmet system shall draw power from a rechargeable battery
    - The helmet system shall utilize solar energy for extended energy usage

Requirement Specifications

Rear-Mounted Module Hardware Requirements:

- Mounted onto the rear of the motorcycle
- Detect driver's use of the turn signal
- Interface with the proximity sensors
    - Contain proximity sensors in a daisy-chain series
    - Detect an automobile within 20 feet of the motorcycle
- Wirelessly communicate with the helmet module
- Draws power from the motorcycle

Rear-Mounted Module Software Requirements:

- Include functions to activate proximity sensors and receive ranging data
- Consolidate ranging data from all sensors for accurate distance reading
- Implement processes to send data over wireless communication
- Convert ranging data into the appropriate units of measurement

Requirement Specifications

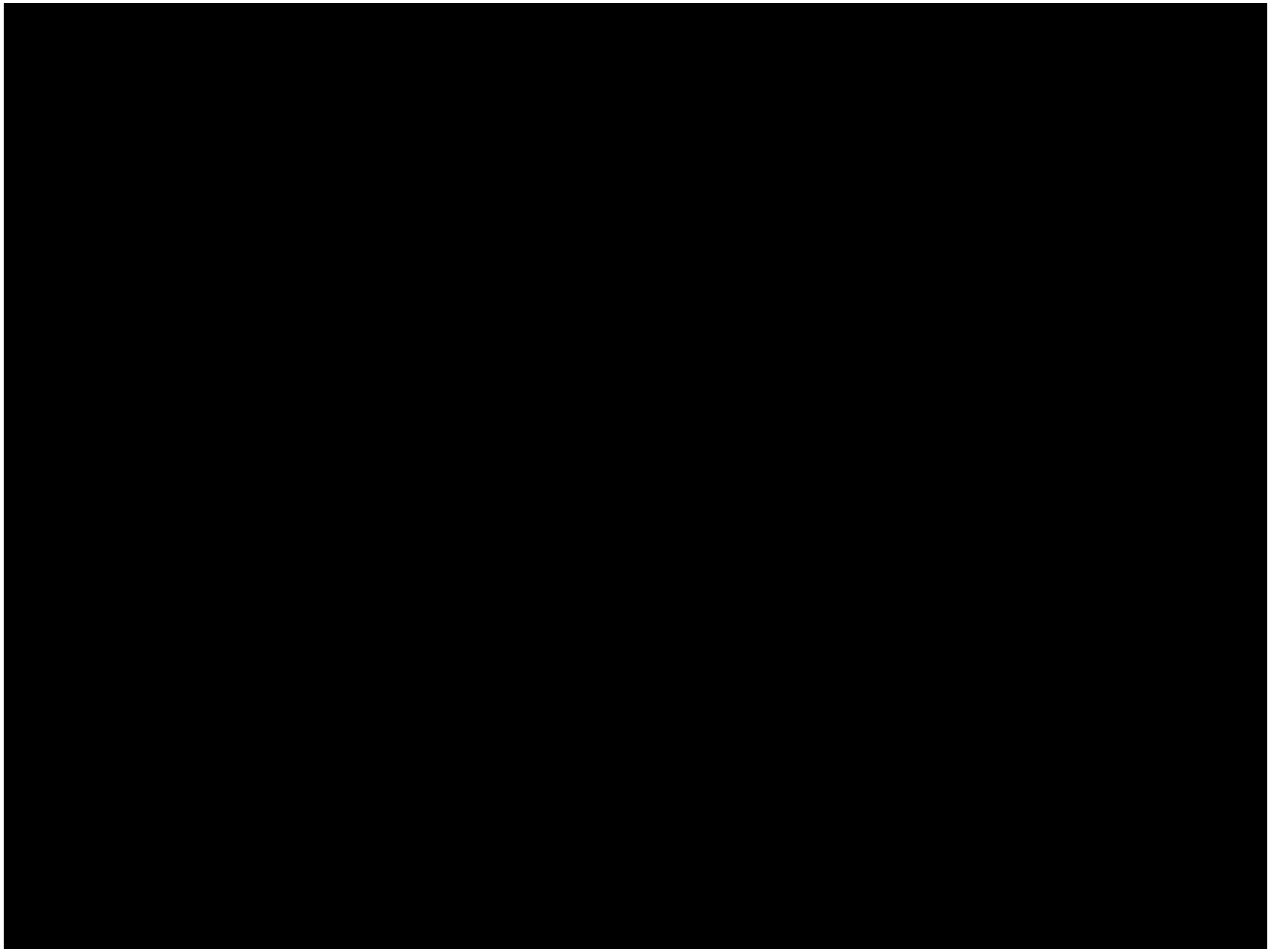
Helmet Module Hardware Requirements

- Mounted onto the rider's helmet
- Wireless communication to receive data from the rear-mounted module
- Visual display to show vital information to the rider
- Audio speaker that will alert the rider of potentially dangerous situations
- Enclosed in order to prevent damage from environmental conditions
- Powered via solar charging and rechargeable battery

Helmet Module Software Requirements

- Implement functions to control the visual display to show proximity data
- Use methodologies for receiving wireless data
- Consolidate ranging data to provide an accurate reading
- Display a symbolic representation of the distance to the visual display

Video Demonstration



Challenges and Restrictions

Time Scheduling

Difficult to find available times for four full-time students. Only so many times we can meet up as a group realistically.

Older Bike

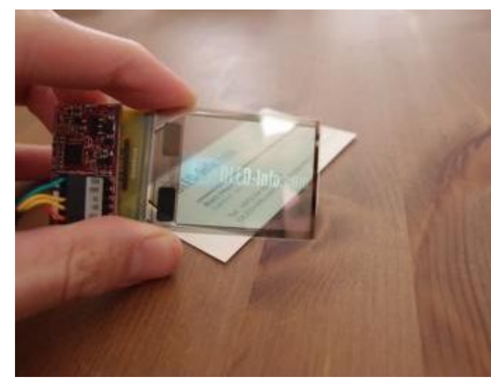
The motorcycle used is completely analog and therefore does not contain any digital outputs or on-board diagnostics.

Sensor Selection

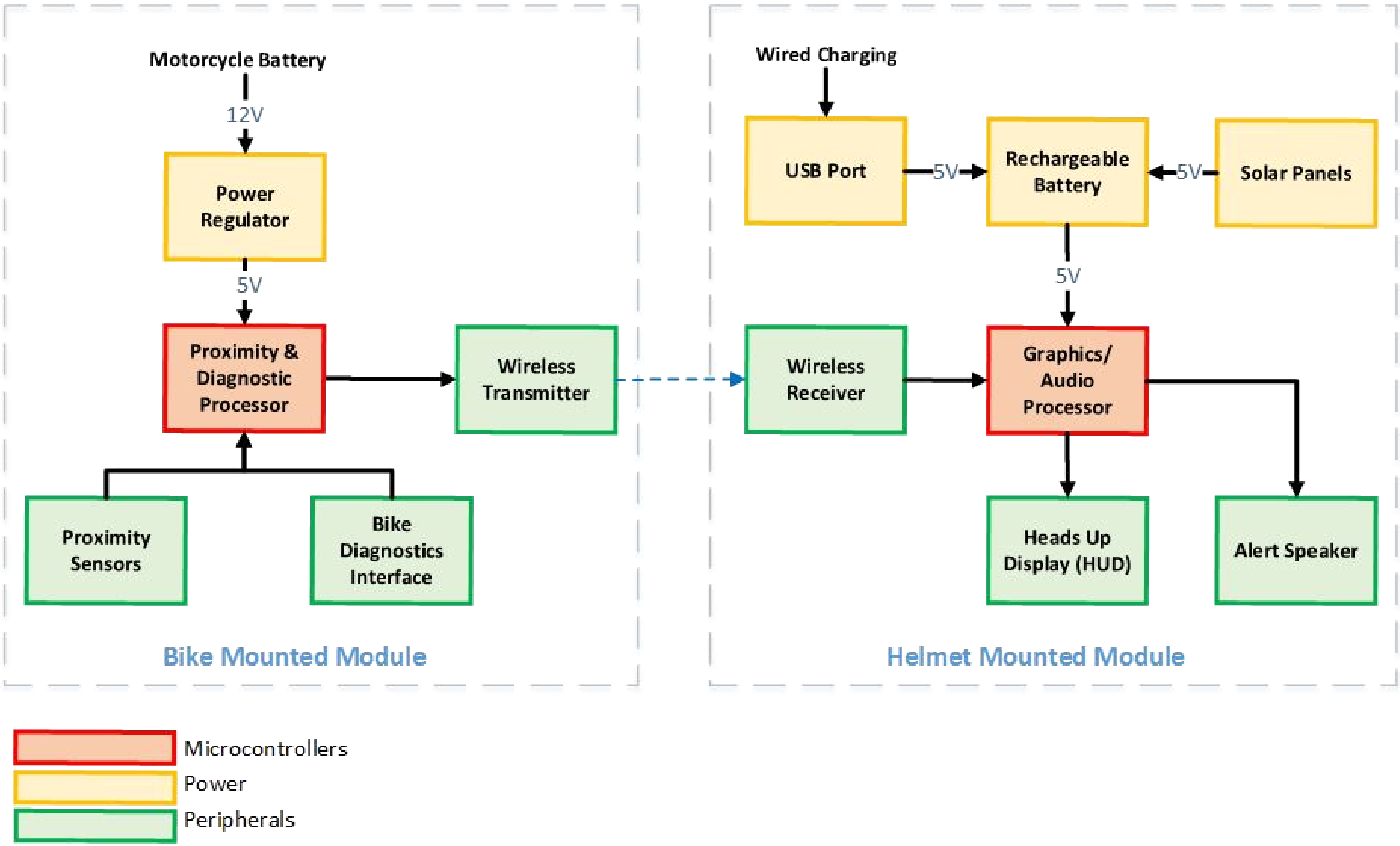
Due to limited budget, the Smart Helmet team must work with lower ranged sensors and chain them together in sets to fulfill the range requirements.

Transparent Display

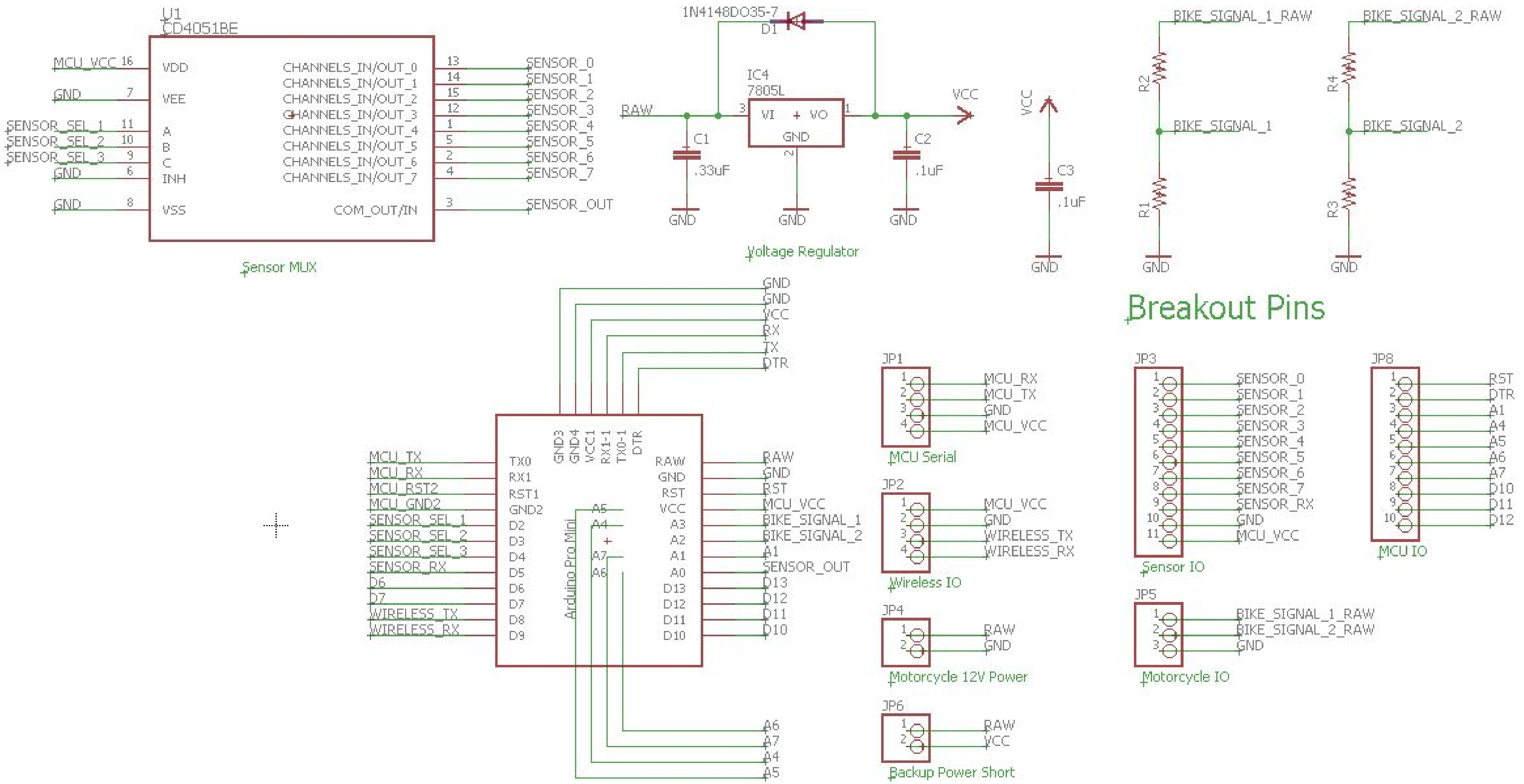
The uTOLED-20-G2 transparent display no longer sold by 4D Systems due to “the manufacturer of the TOLED display glass discontinuing supply due to quality issues.”



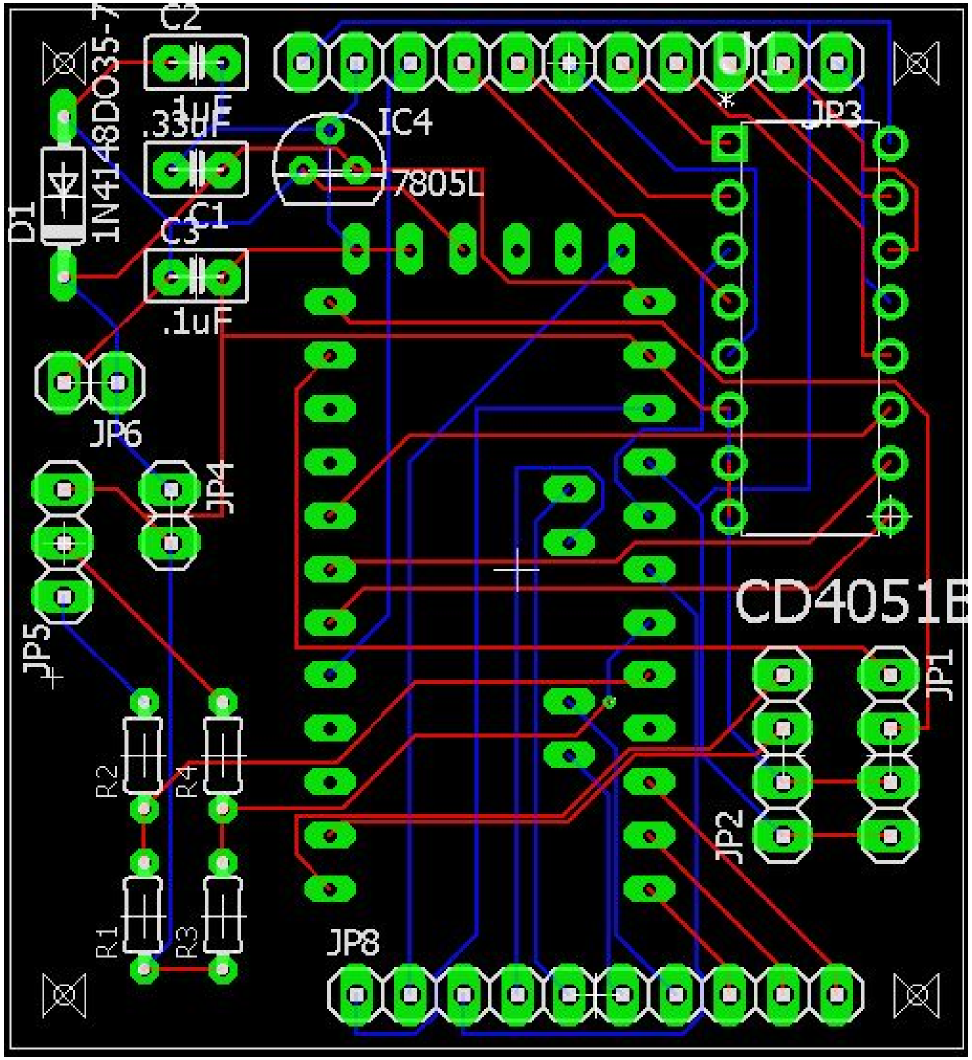
Overall System Block diagram



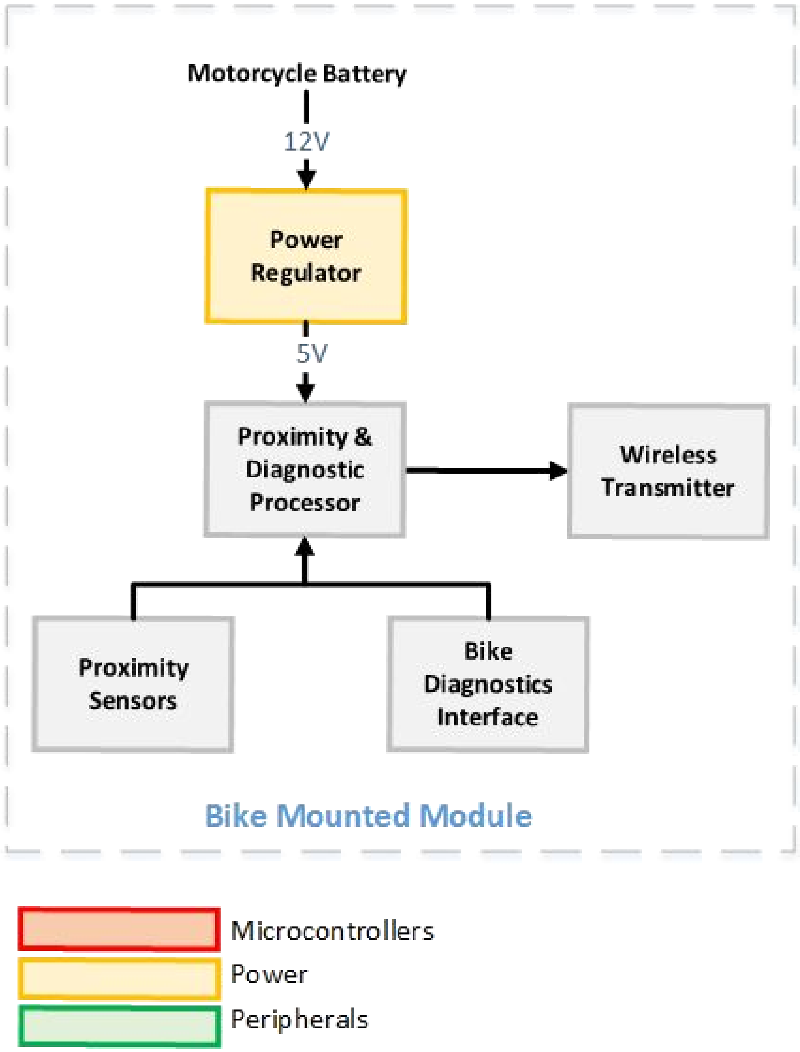
Bike Module - System Overview



Bike Module - PCB



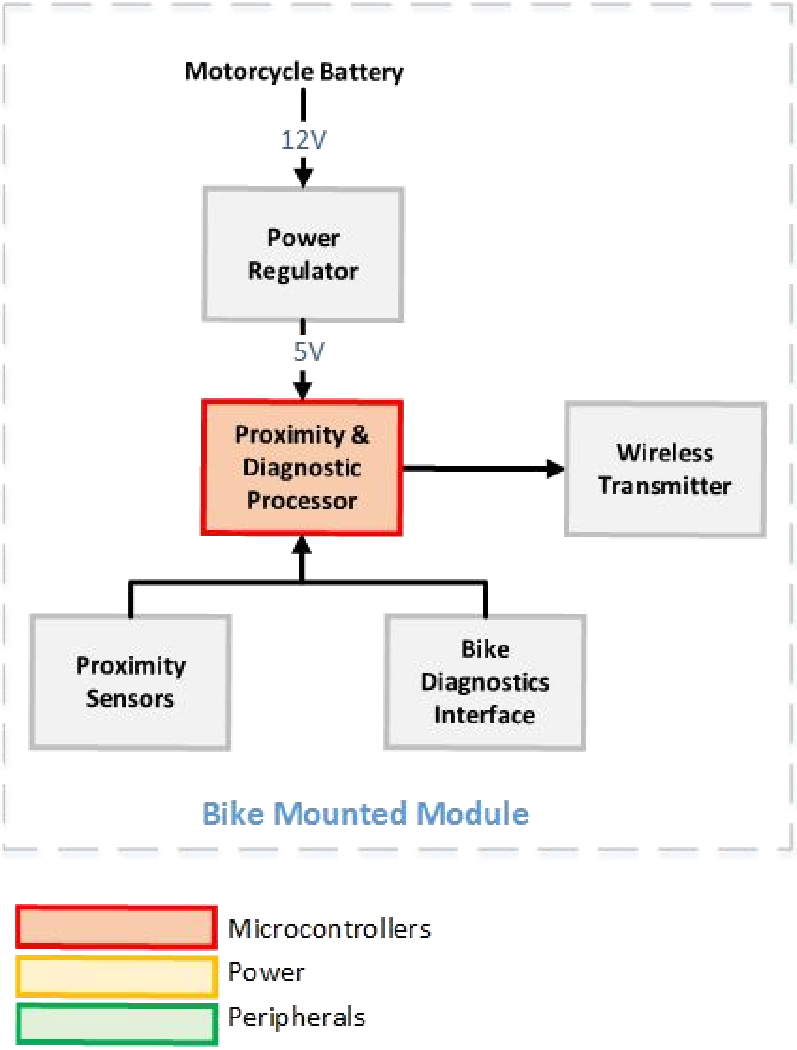
Bike Module - Power Block Diagram



Bike Module - Power

- Front Module and Proximity Sensors Powered by Existing Bike Battery
    - Voltage regulator will ensure each module receives power needed without over-voltage

Bike Module - MCU Block Diagram



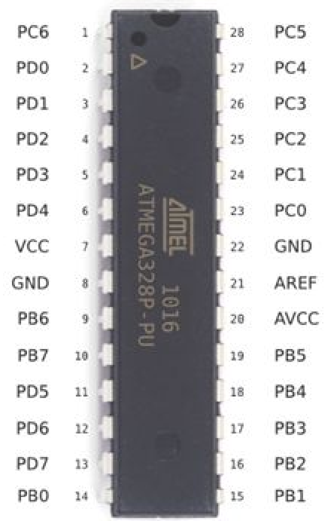
Bike Module - Microcontroller Selection

	I/O Pin Ports	Architecture	Processor Speed	Price
Raspberry Pi 3	26	64/32-bit ARM	1.2 GHz	$40
MSP430	32	16-bit ARM	16 MHz	$20
Arduino Uno	26	8-bit AVR RISC	20 MHz	$10

Bike Module - Microcontroller Specifications

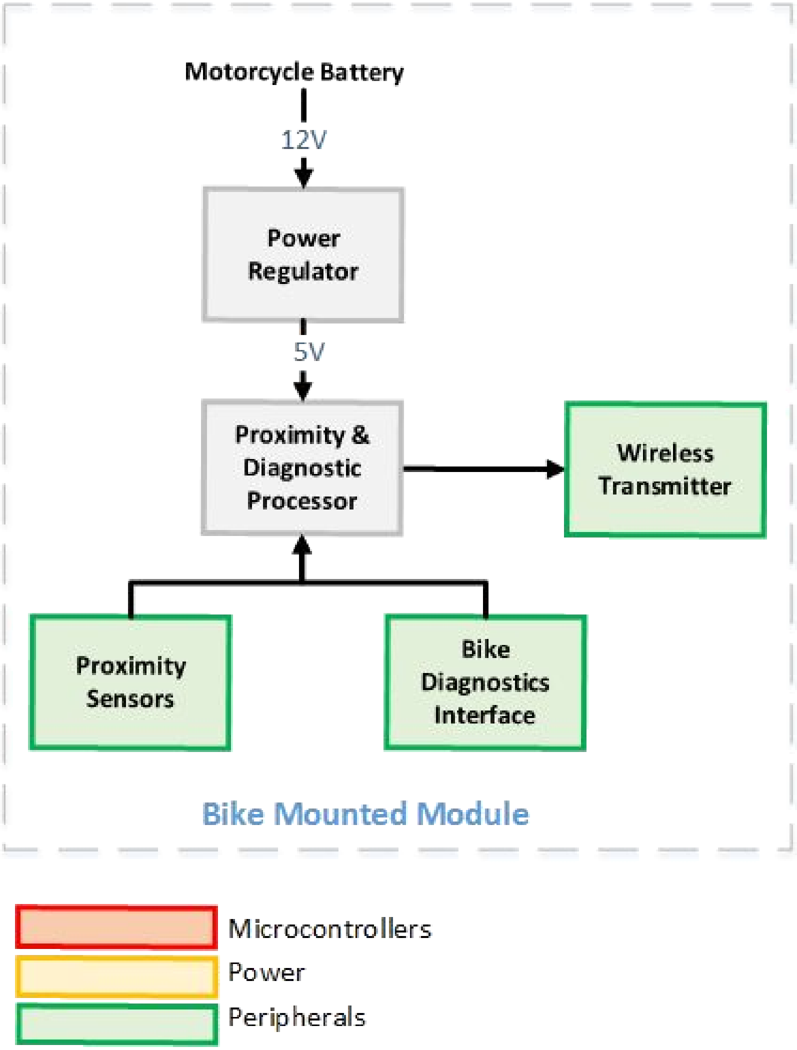
Why we chose the Arduino Uno MCU:

- Removable processing chip
- Sufficient processing power
- Low power consumption
- Relatively low cost
- Easy to mount on PCB



Part No.	EL-CB-001
Name	Atmega 328
Processor Speed	20 MHz
Operating Cores	1
Storage ROM	32 KB
SRAM	2 KB
I/O lines	26

Bike Module - Peripherals Block Diagram



Bike Module - Proximity Sensor Options

Proximity sensors will be mounted on the rear end of the motorcycle to detect vehicles in the driver's blindspot. The available options for proximity sensors came down to sonar, LIDAR, and infrared. Each type of sensor had its respective pros and cons.

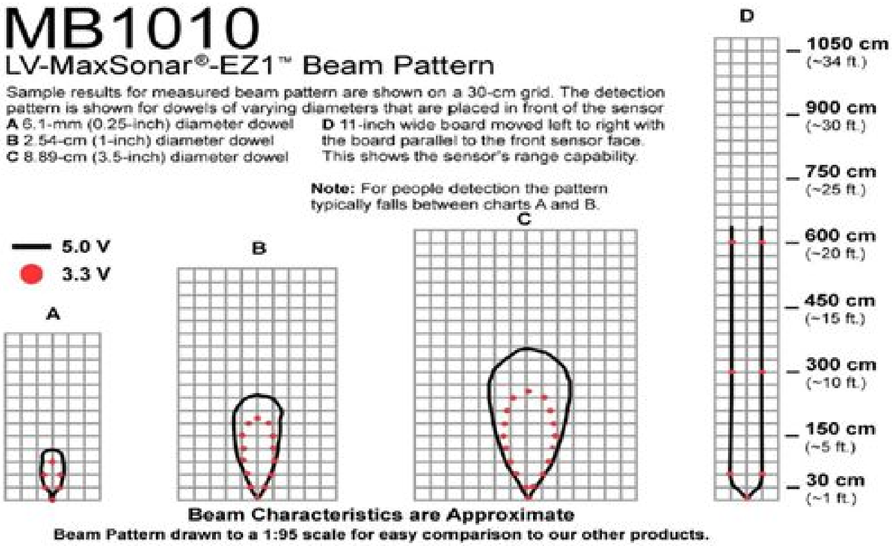
Sensor Types Specification Summary

	Model	Range	Price
Sonar	LV-MaxSonar-EZ1	20 ft	$30
LIDAR	LIDAR-LITE V3	131 ft	$150
Infrared	SHARP GP2Y0A02YK0F	5 ft	$15

Bike Module - Proximity Sensor Selection

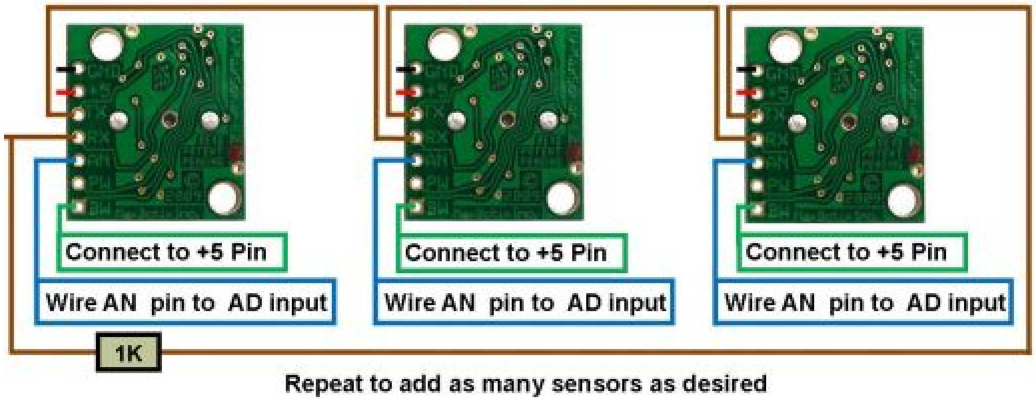
Why we chose the LV-MaxSonar -EZ1 sonar sensor:

- **Relatively low cost**
- **Fulfills distance requirement**
- **Chaining capabilities**
- **Functions at driving speeds**
- **Allows for easy configurations**



Bike Module - Proximity Sensor Connection

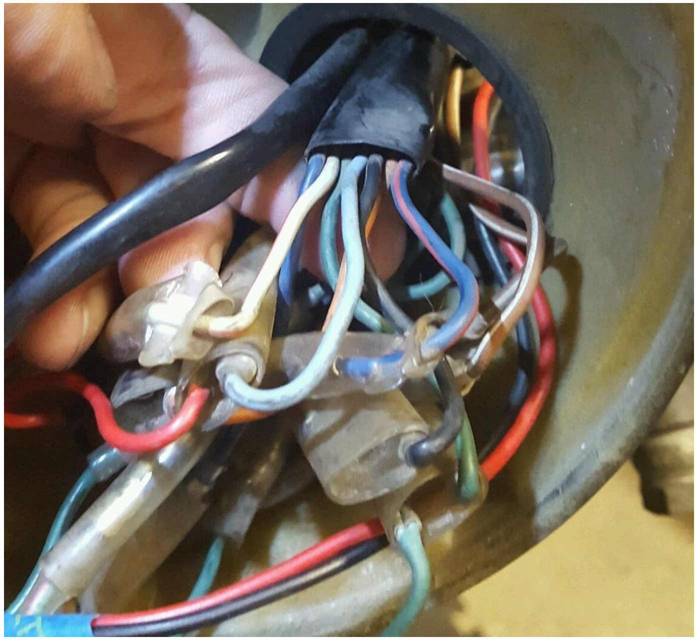
- Multiple MaxSonar sensors will be hardwired together to cover the entirety of a biker's blindspot.
  - All of the sensors are wired directly to ground, power, and an input port on the MCU mounted onto the bike
  - Each of the sensors are chained together using the TX and RX pins on the proximity sensors
    - The sensors will record readings in a cascading order, one after another, until the signal is cut



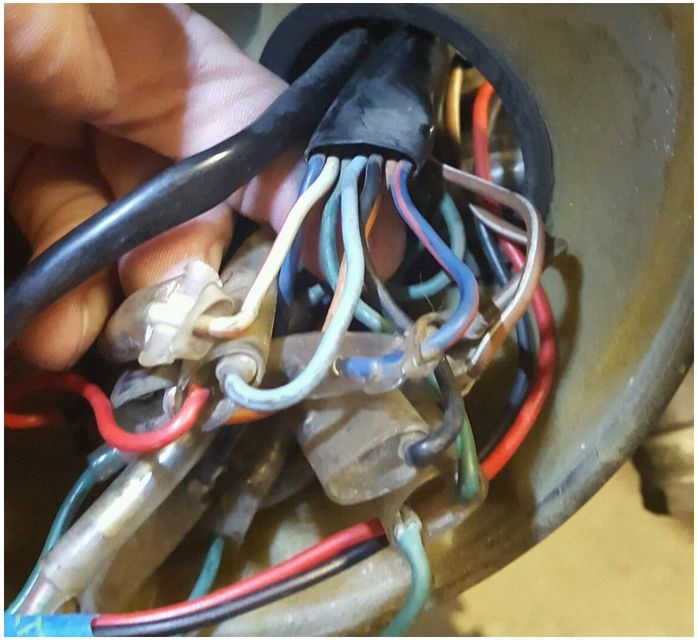
Bike Module - Proximity Sensor Software Logic

Bike Module - Signal Interface

- Interface with motorcycle will be completely analog
  - The bike we are using is an antique
  - Allows the project to work on any model of motorcycle
- Information is 'read' by measuring voltage on turn signal dash wires
  - Left turn signal
  - Right turn signal
  - Additional information available:
    - Change oil notification
    - Engine power
- Hopeful stretch goals
  - Read analog engine RPM
  - Read analog motorcycle speed

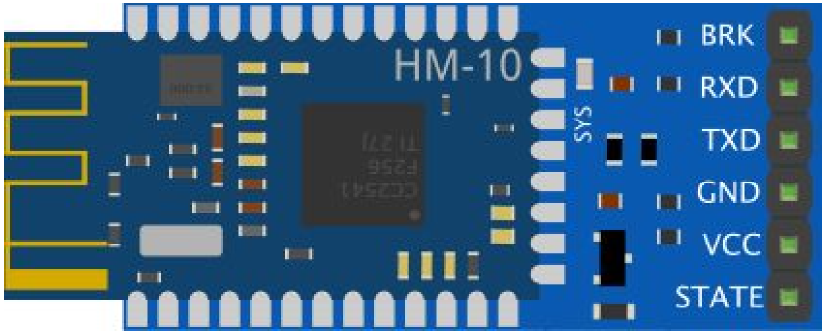


Bike Module - Signal Interface

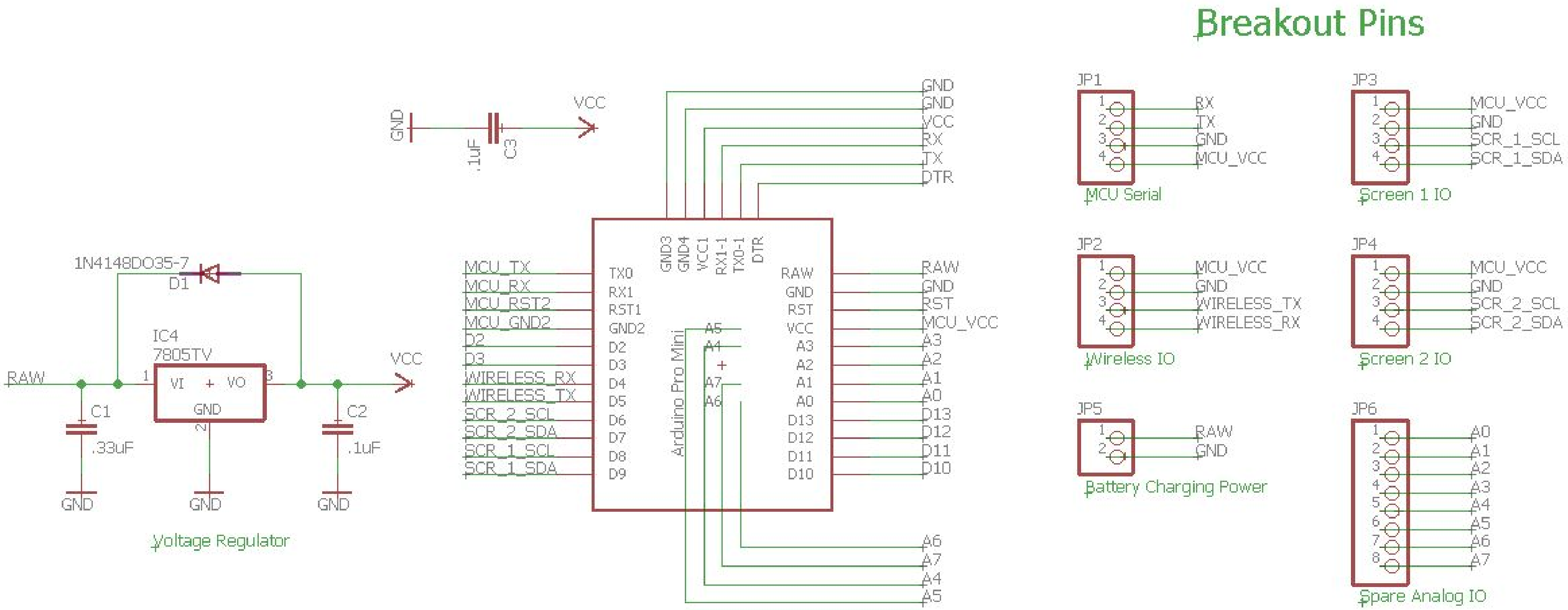


Bike Module - Wireless

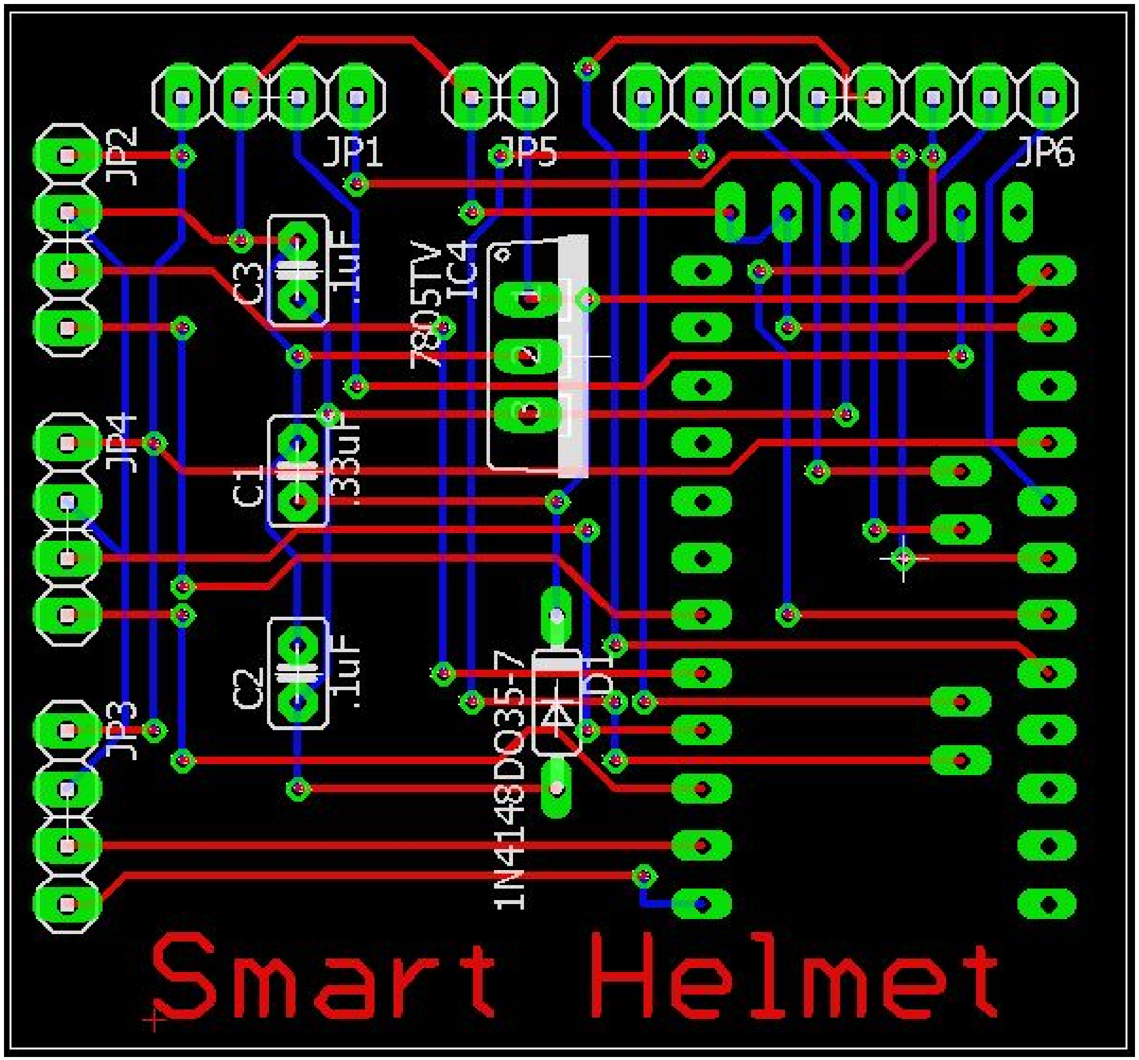
- Using Bluetooth Low-Energy HM-10 Module
  - Communication via UART serial
  - Can be pre-programmed
    - Mode/settings
    - Endpoint
  - Broadcast range is far which allows flexibility
- Set to Master in the Master-Slave relationship
  - Broadcast only (not required)
  - Hosts the connection
    - More energy use compared to Helmet
    - Not limited by battery power



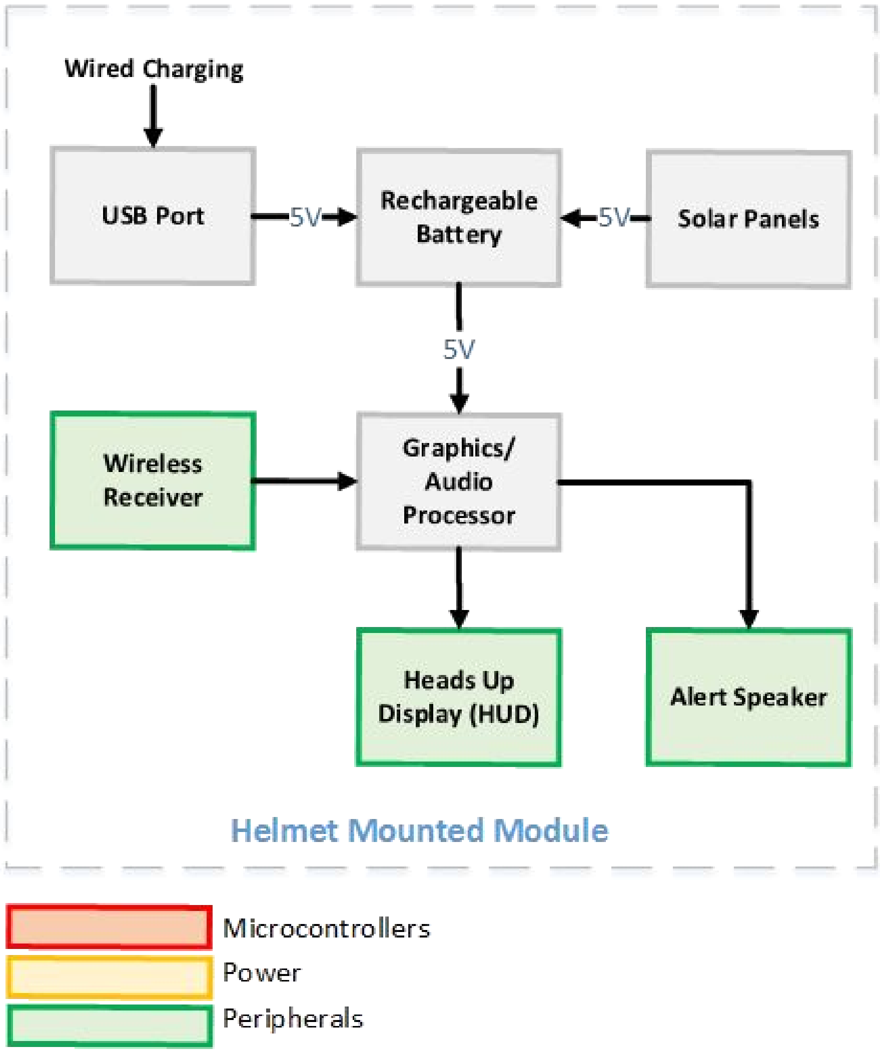
Helmet Module - System Overview



Helmet Module - PCB



Helmet Module - Peripherals Block Diagram



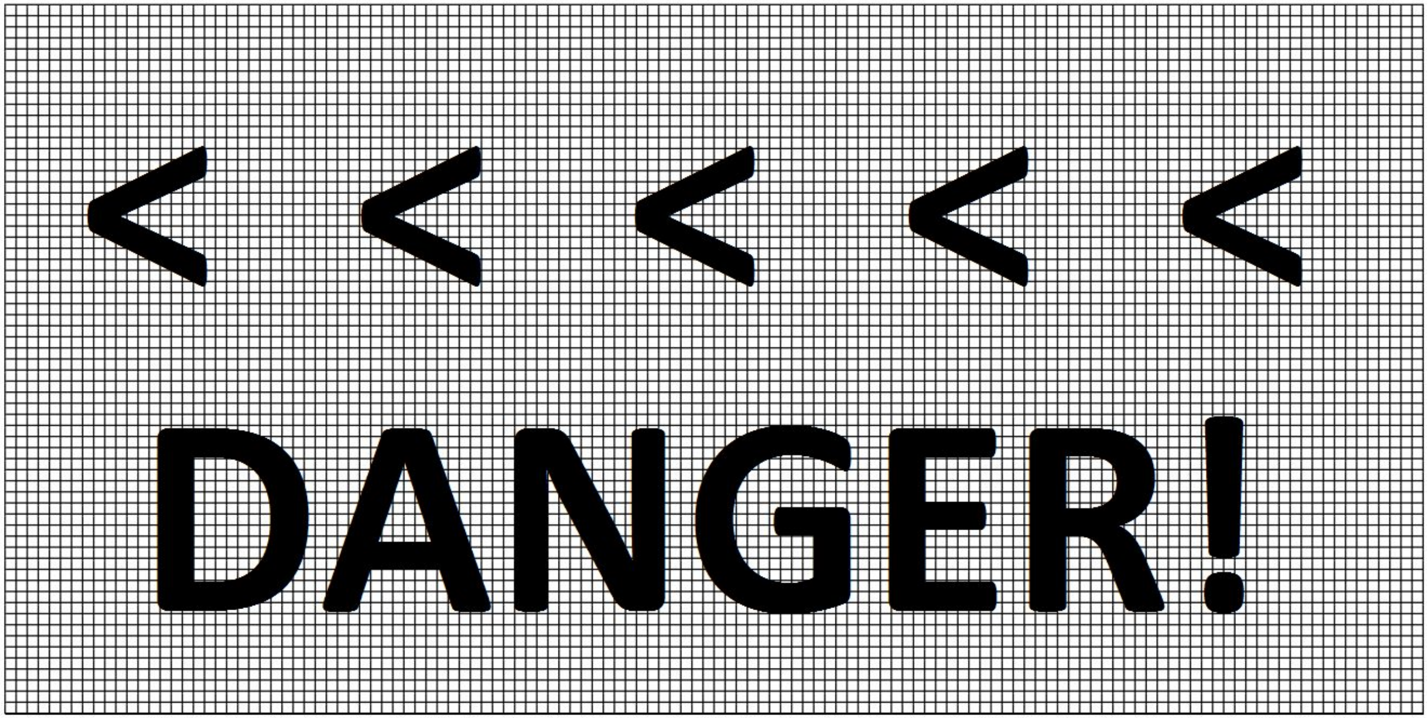
Helmet Module - Peripherals: Display Selection

- Two displays will be mounted onto the outside of the helmet. They will be mounted below the visor one on each side to notify the biker of possible dangers on either blind spot
- LED Strip vs OLED Non-Transparent Screen
  - Power consumption, price, visibility, versatility, and usability are all factors that went into choosing the display type
  - Red LED Strip - $5.99
  - 128x64 OLED LCD LED white display by DIYmall - $9.99
- The OLED was chosen since it provides the Smart Helmet team with more customization options. This allows us to provide the users with more information while still adhering to usability standards

Helmet Module - Display Software

Helmet Module - Software Display Example

- The current display design is using a five symbol rating system to signify how close a vehicle is to the biker's blind spot. When the oncoming vehicle reaches a dangerous level, five arrows will appear (based on which turning signal is active) and the word "Danger" will flash on the appropriate display screen.

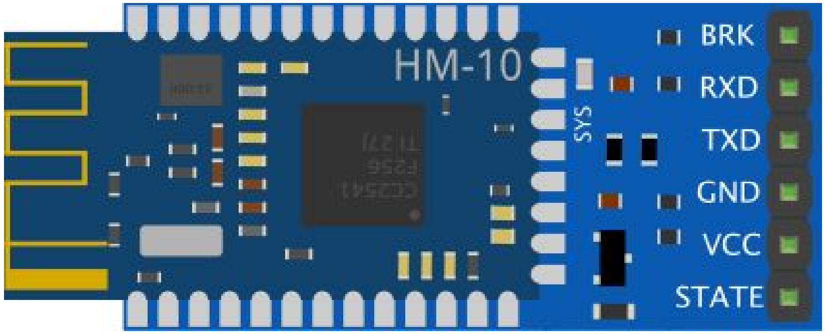


Helmet Module - Audio

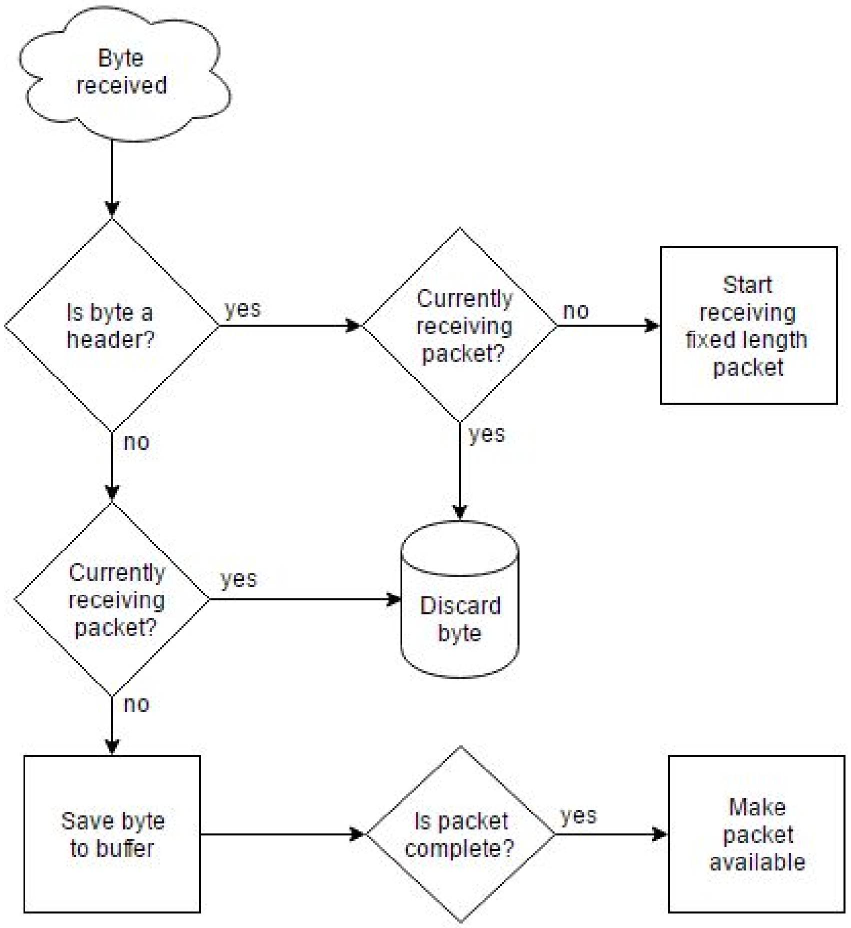
- The Smart Helmet will also be displayed with a low power audio speaker. This speaker will alert the rider when there is an oncoming vehicle at the “Danger” level.
- Since the speaker will be mounted inside the helmet and will be so close to the rider, an audio amplifier is not needed.

Helmet Module - Wireless

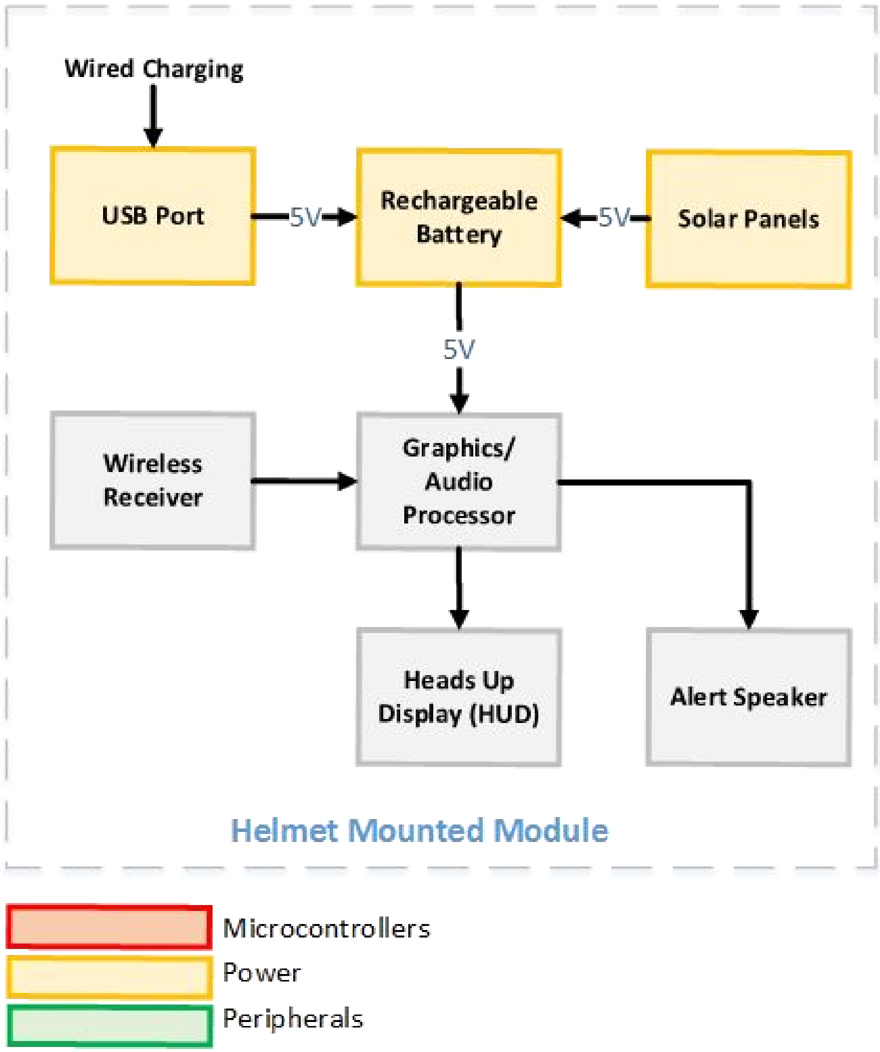
- Also uses Bluetooth Low-Energy HM-10 Module (same as bike endpoint)
  - Communication via UART serial
- Set to Slave in the Master-Slave relationship
  - Receiving only (not required)
    - Smart packet-loss detection in software
    - Can dictate the receiving rate
  - Searches for host on boot
    - Less energy use compared to Bike
    - Limited by battery power



Helmet Module - Wireless

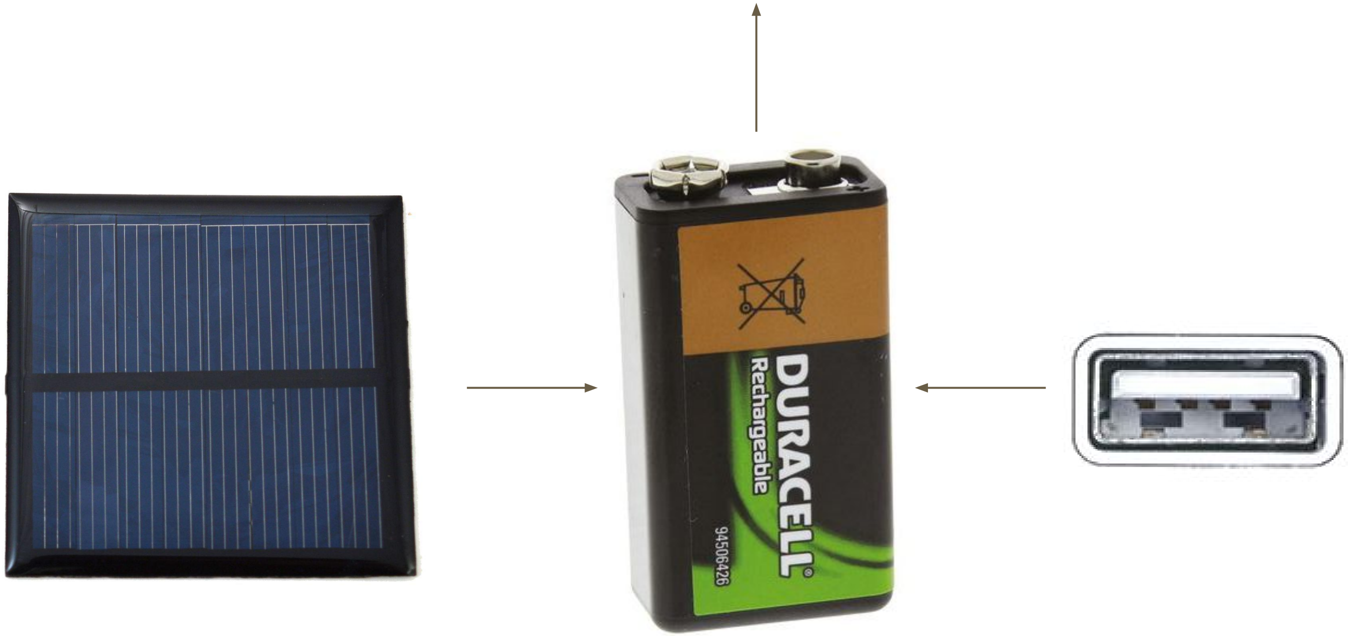


Helmet Module - Power Block Diagram

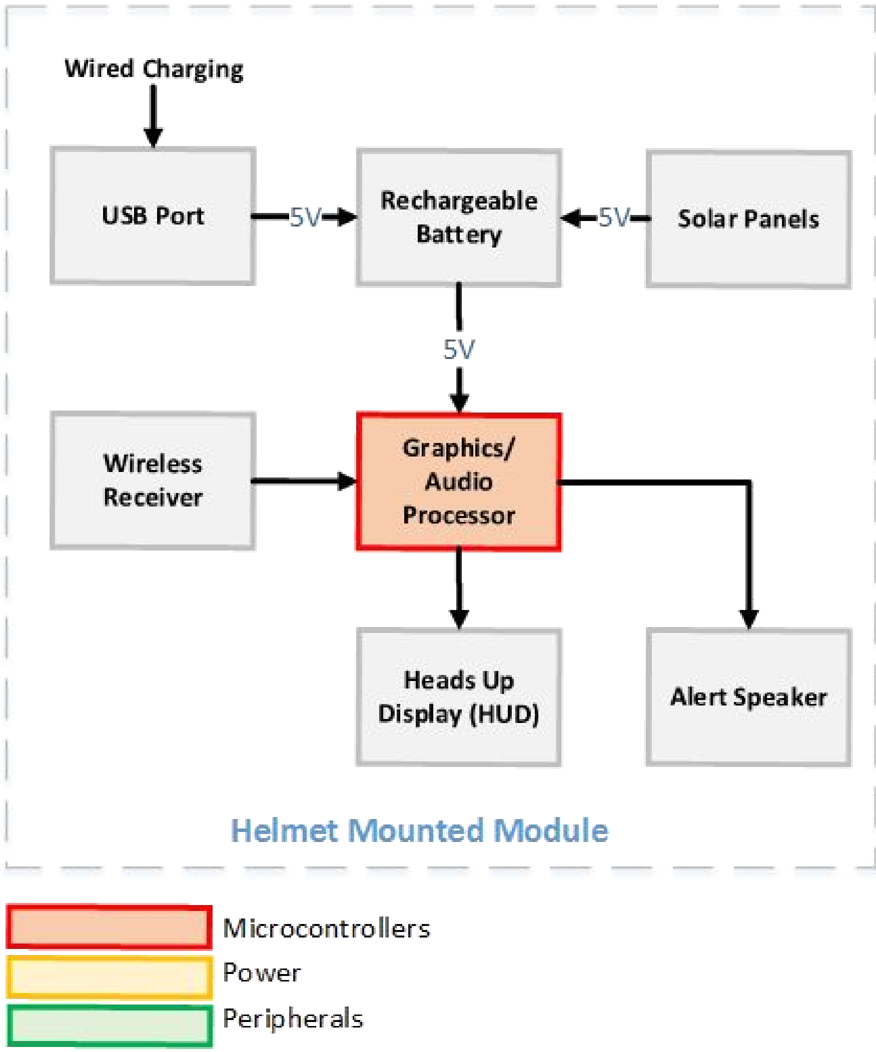


Helmet Module - Power

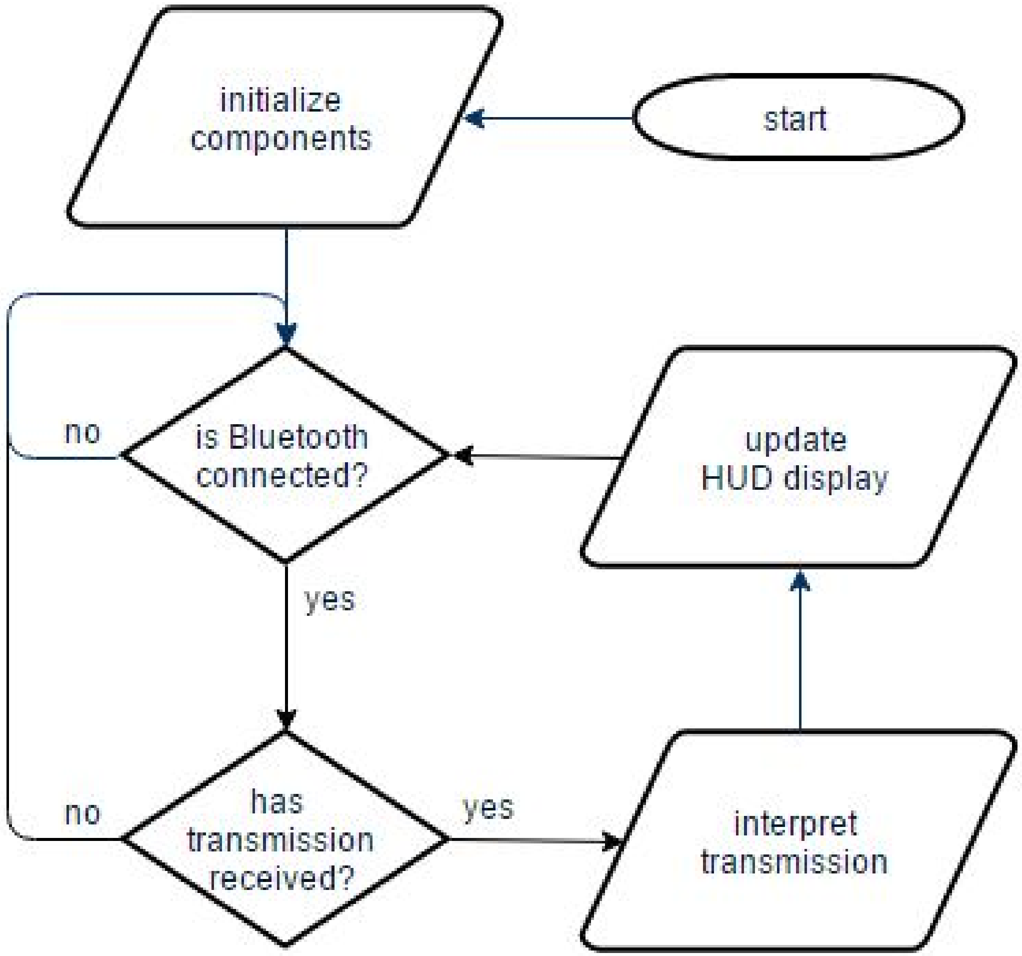
- Heads-Up Display Module Powered by Rechargeable Battery
  - Charged using USB and Solar Power



Helmet Module - MCU Block Diagram



Helmet Module - MCU



Project budget

Proximity Sensors	$240	Solar Panel	$10
Wireless	$30	Battery	$5
Helmet Display	$20	Helmet	$25
Voltage Regulators	$10	PCBs	$40
Battery Charger	$5	Misc	$50
		Total	**$435**

Financing

- No external sponsors or funding
  - Split evenly four ways
  - Personally funded
- Limited budget
  - Encouraged cost effective design
  - Minimalistic design
- No sponsor oversight
  - Freedom to expand on ideas
  - Avoid politics
  - No managerial critique (good and bad)

Progress overview

Senior Design 2 Progress	
Implementation	**Completion**
Build Prototype	100%
Test Prototype	100%
Redesign (If applicable)	2^{nd} Revision
Finalize Prototype	95%
Final Presentation	In Progress

Division of Labor

	MCU	Proximity Sensors	Power	Wireless Communication	Peripherals
Julian	P			S	P
Jorge		P	S		S
Jeremy		S	P		
Blake	S			P	P

Primary (**P**)
Secondary (**S**)

Questions