

VEHICLE IMMOBILIZING DEVICE

CLIENT & TECHNICAL ADVISOR:

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FAREZ HALIM

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REDGE SANTILLAN

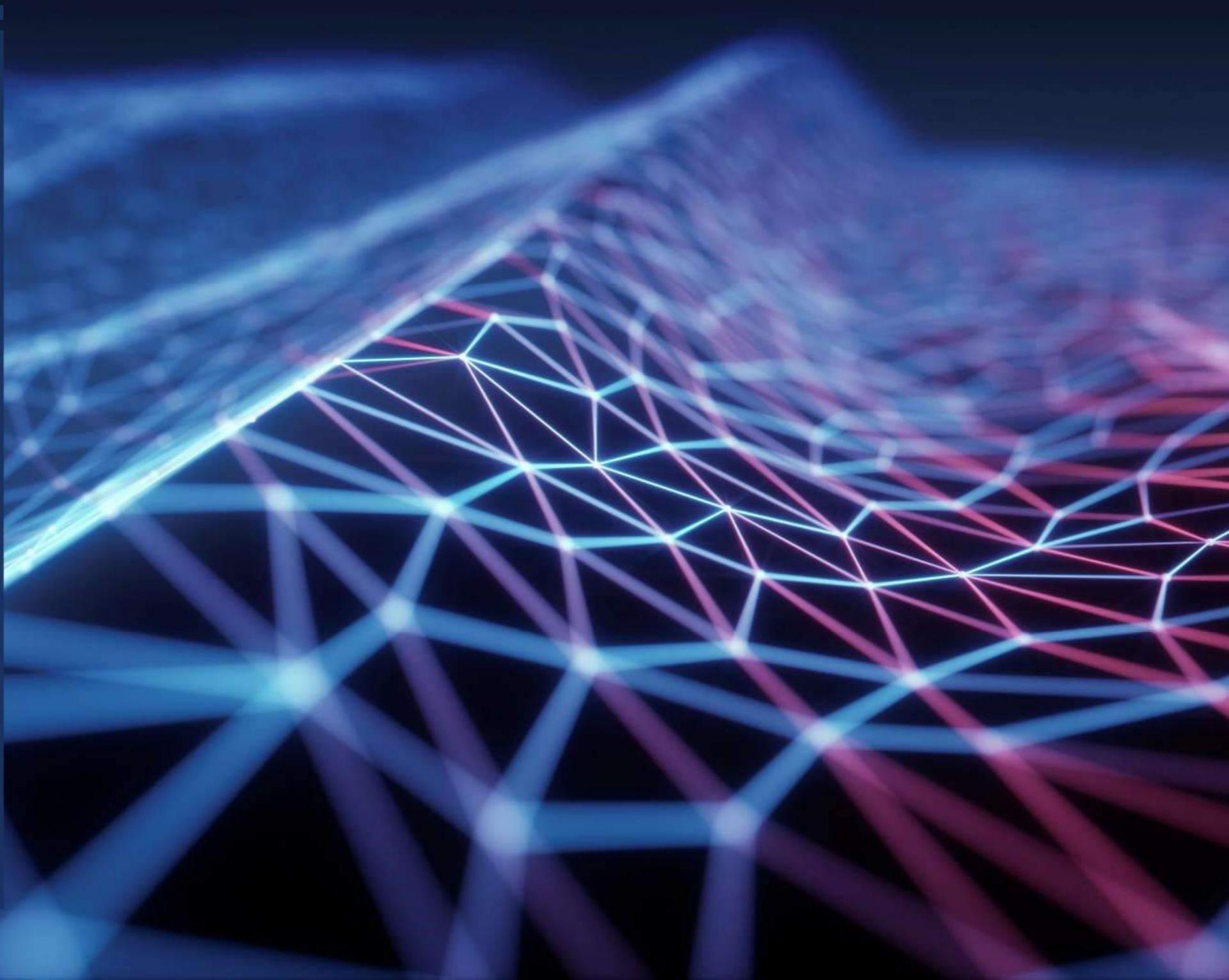
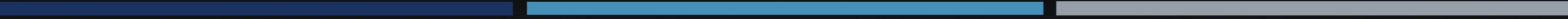


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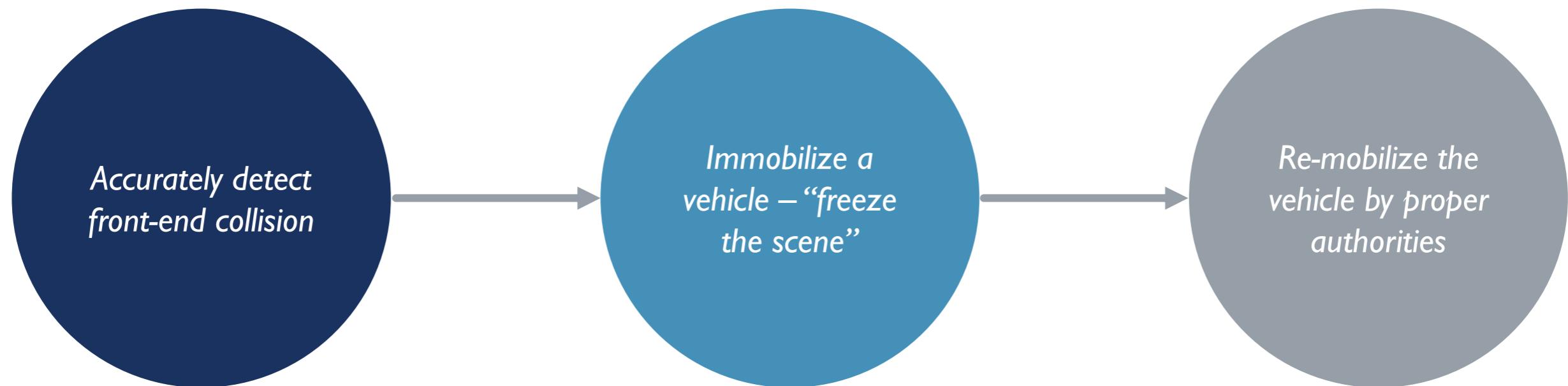
PROJECT OVERVIEW



PROJECT OVERVIEW – BACKGROUND

- In 2015, over 140,000 accidents each causing over \$2000 in damage were reported within Alberta
- Vehicles leaving the scene makes resolution difficult leading to complicated insurance claims
- Initial target end-user: vehicle fleet management companies

PROJECT OVERVIEW – GOAL



PROJECT OVERVIEW – GOAL



Other Goals:

- Tamper-proof
- Secure
- Reliable
- Long-lasting



BACKGROUND INFORMATION

BACKGROUND INFORMATION

How Modern Cars Work: An overview



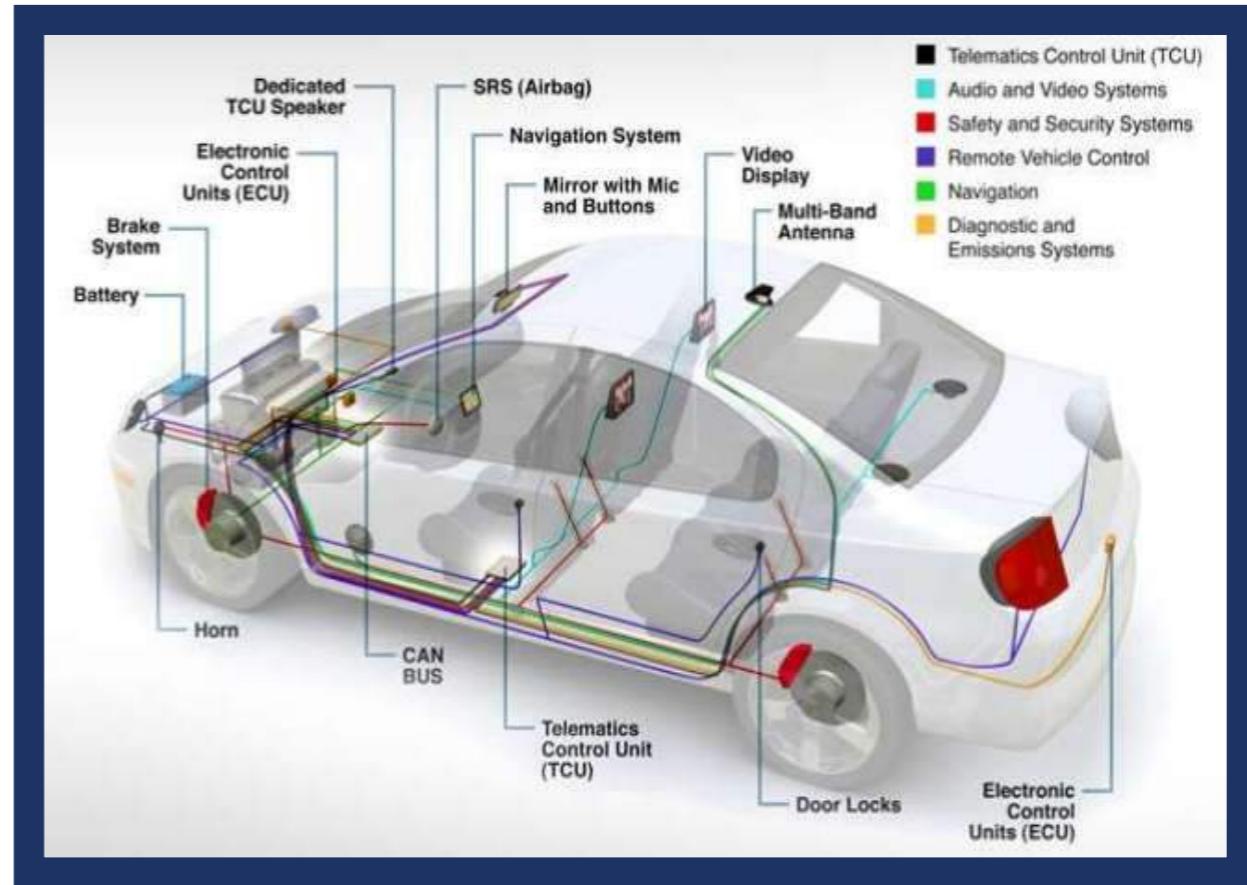
- “Computers with Wheels”
- Electrically controlled, mechanically actuated

BACKGROUND INFORMATION

How Modern Cars Work:

Typical ECUs found
within a car

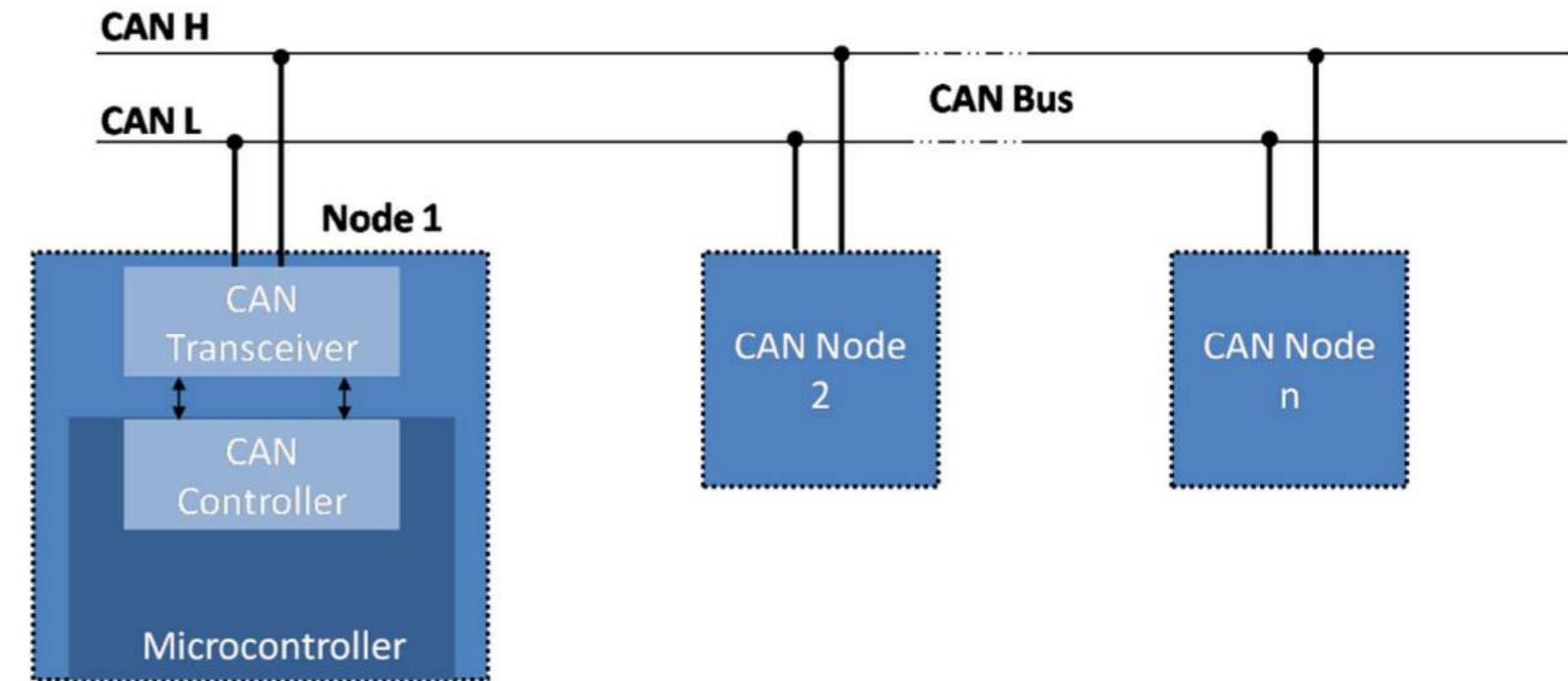
- Transmission Control Unit
- Engine Control Unit
- Powertrain Control Module
- Door Control Unit
- Brake Control Module (ABS)
- Battery Management System
- Electronic Power-Steering Control Unit (PSCU)
- Speed Control Unit



BACKGROUND INFORMATION

How Modern Cars Work:

How do ECUs Talk to each other?



CAN BUS (Controller Area Network)

- Two-wire differential communication protocol
- Fabric that connects ECUs
- Messages within the network are manufacturer dependent

BACKGROUND INFORMATION

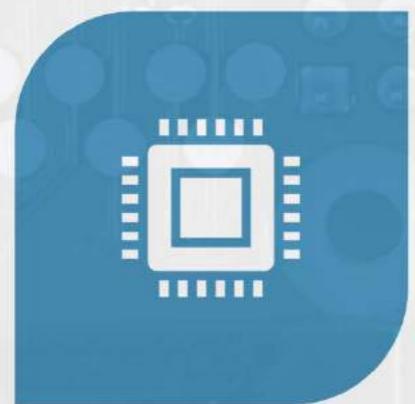
How Modern Cars Work: OBD-II Port (On-Board Diagnostics)

- All cars produced after 1996 in North America come with an 16-pin interface called an OBD-II port
- Mechanics use this to diagnose problems within a car
- Standardized amongst all manufacturers
- Connected to the CAN bus of a car



TECHNICAL DESIGN DETAILS

TECHNICAL DESIGN DETAILS – MODULES



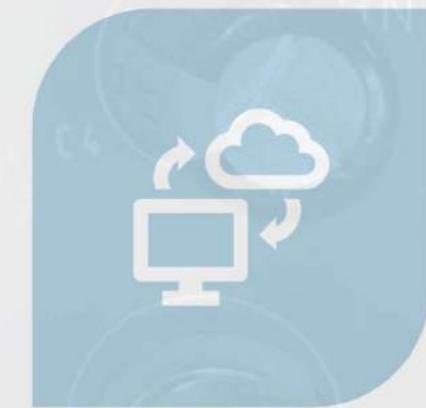
DETECTION

Detects front-end collisions



IMMOBILIZATION

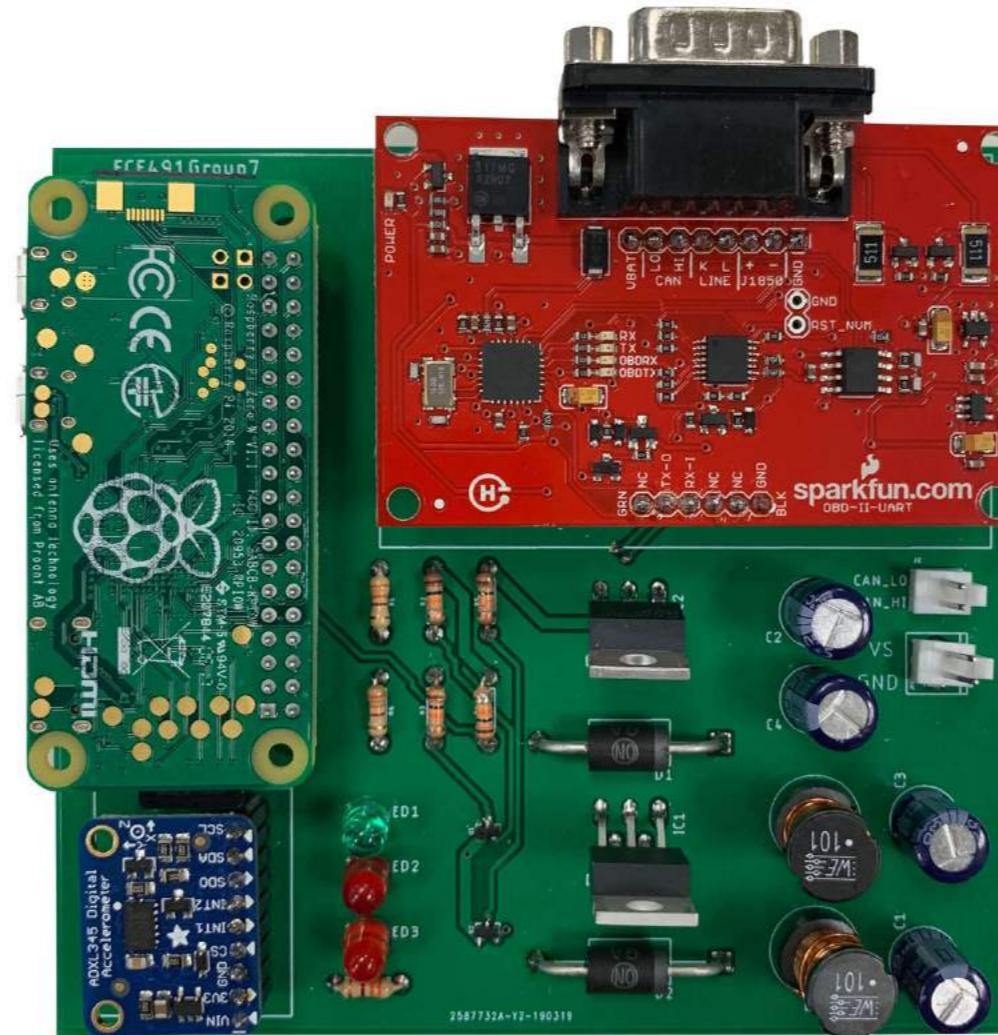
*Immobilizes the vehicle
after the accident*



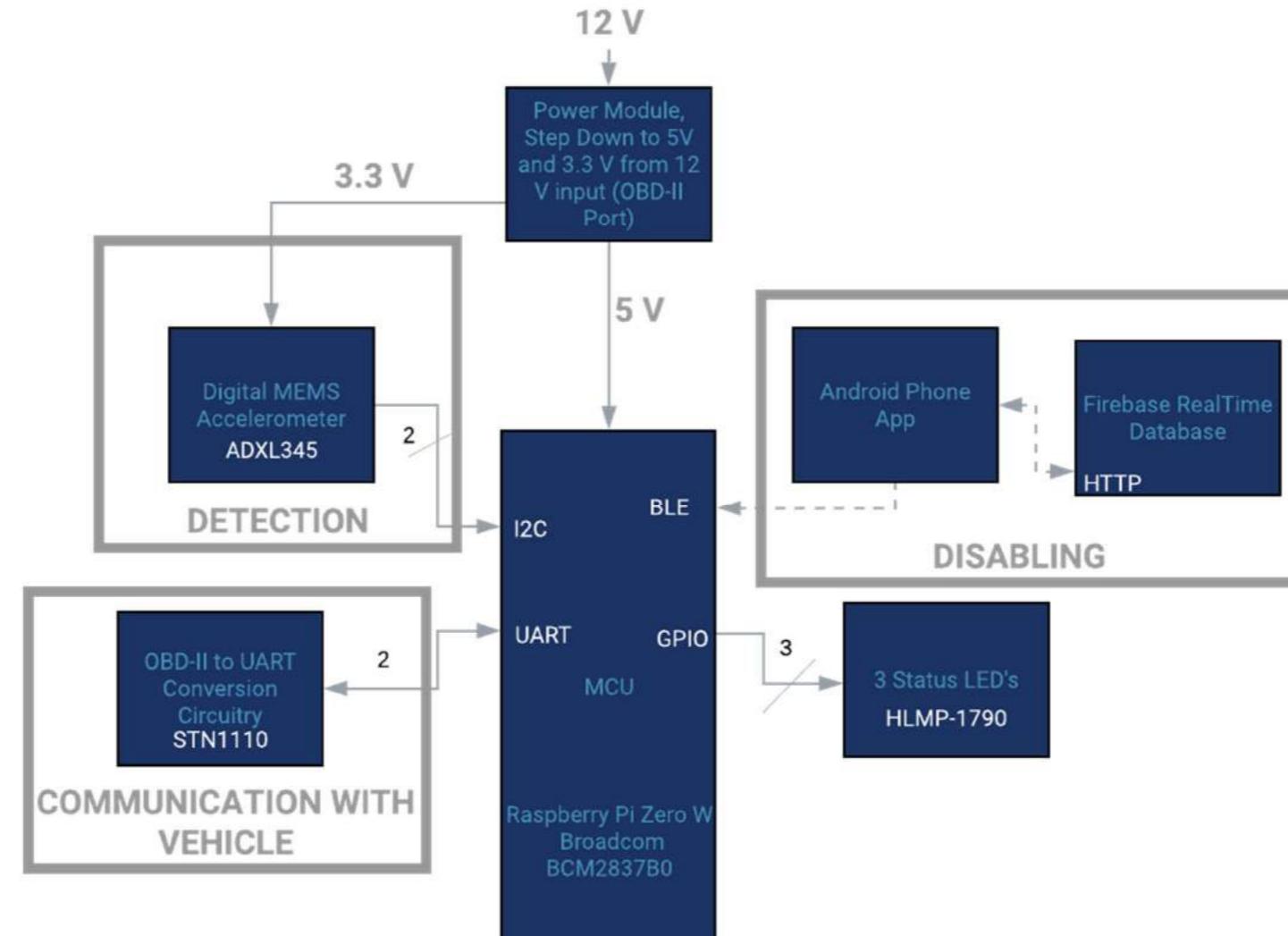
DISABLER

*Safely re-mobilizes the
vehicle (by authorized
personnel)*

TECHNICAL DESIGN DETAILS – PROOF OF CONCEPT



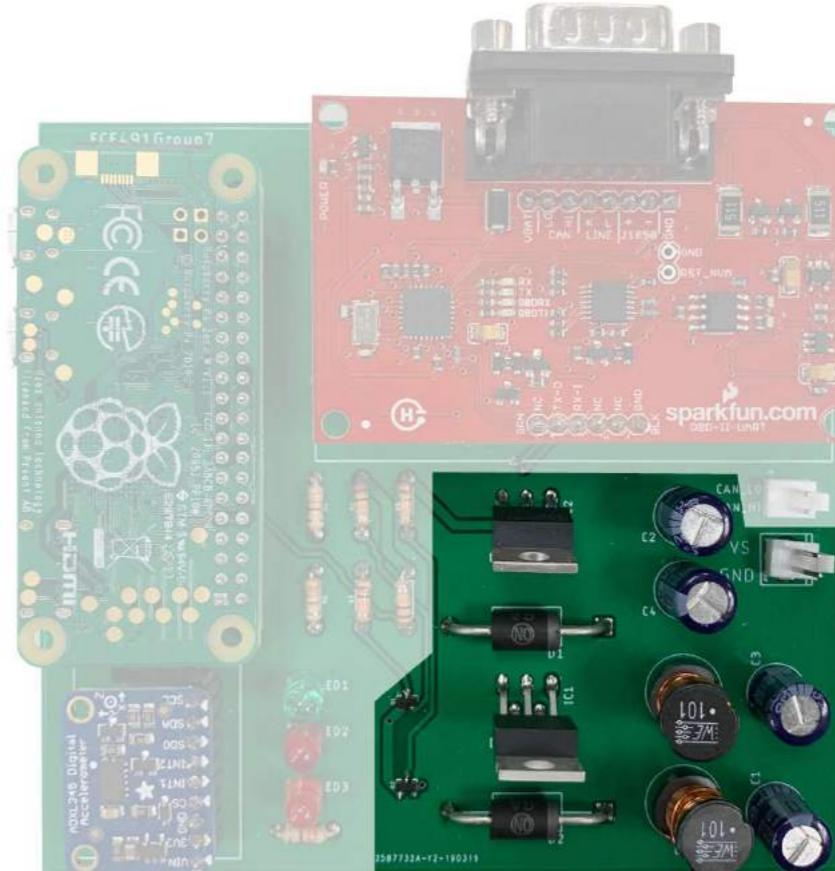
TECHNICAL DESIGN DETAILS – HIGH LEVEL BLOCK DIAGRAM



UART - Universal Asynchronous Receiver/Transmitter, I₂C - Inter-Integrated Circuit, GPIO - General Purpose Input/Output Pin, BLE - Bluetooth Low Energy 4.2, OBDII - On-Board Diagnostics Port within a Car, DB9 - Serial 9-pin Connector

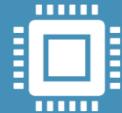
TECHNICAL DESIGN DETAILS

Power



- Takes 12V from:
 - car battery via the OBD-II port
 - external power supply for testing
- Steps down 12V to 5V and 3.3V for device components

TECHNICAL DESIGN DETAILS



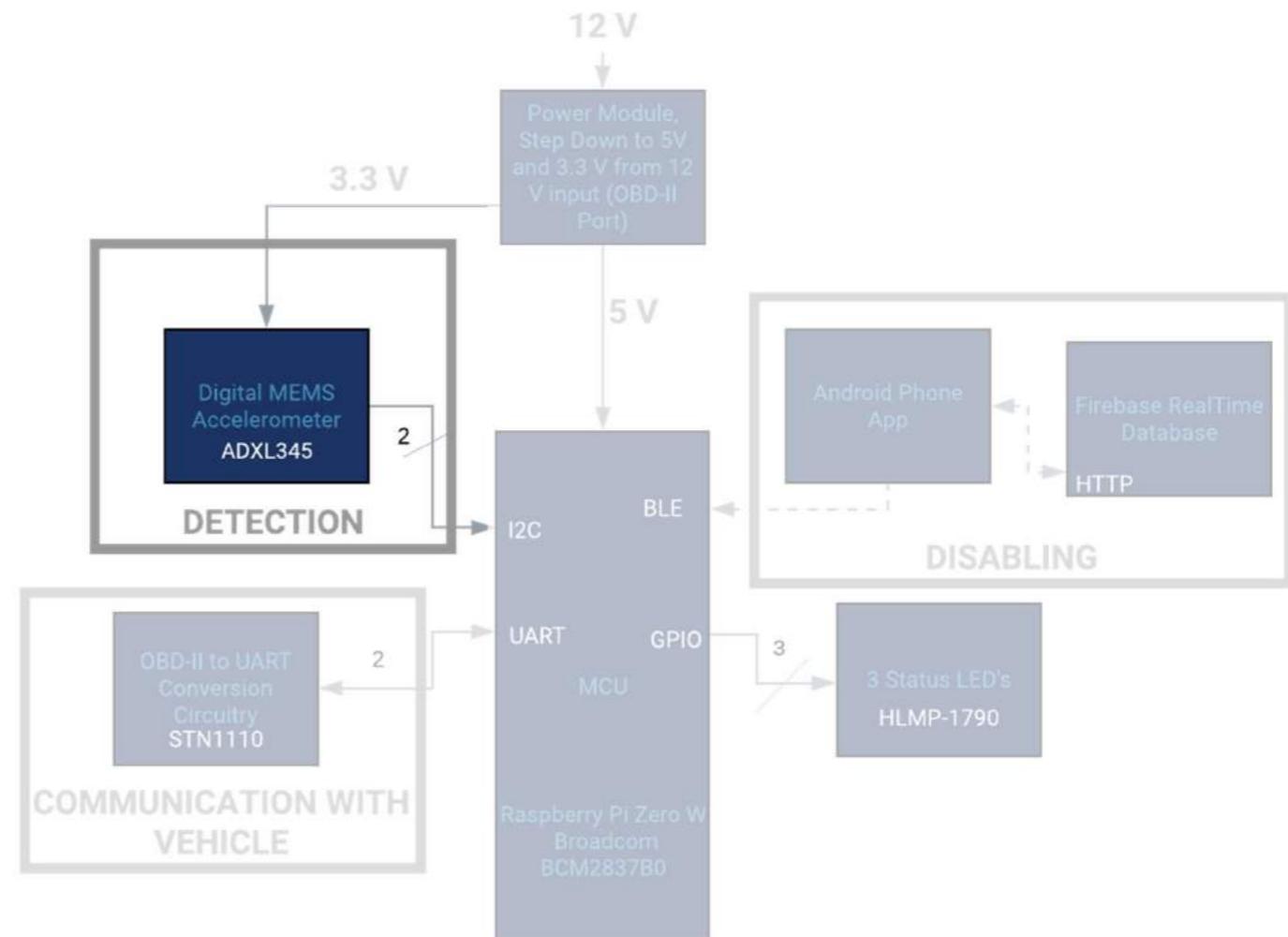
Detection



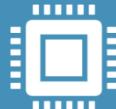
Immobilization



Disabler



TECHNICAL DESIGN DETAILS



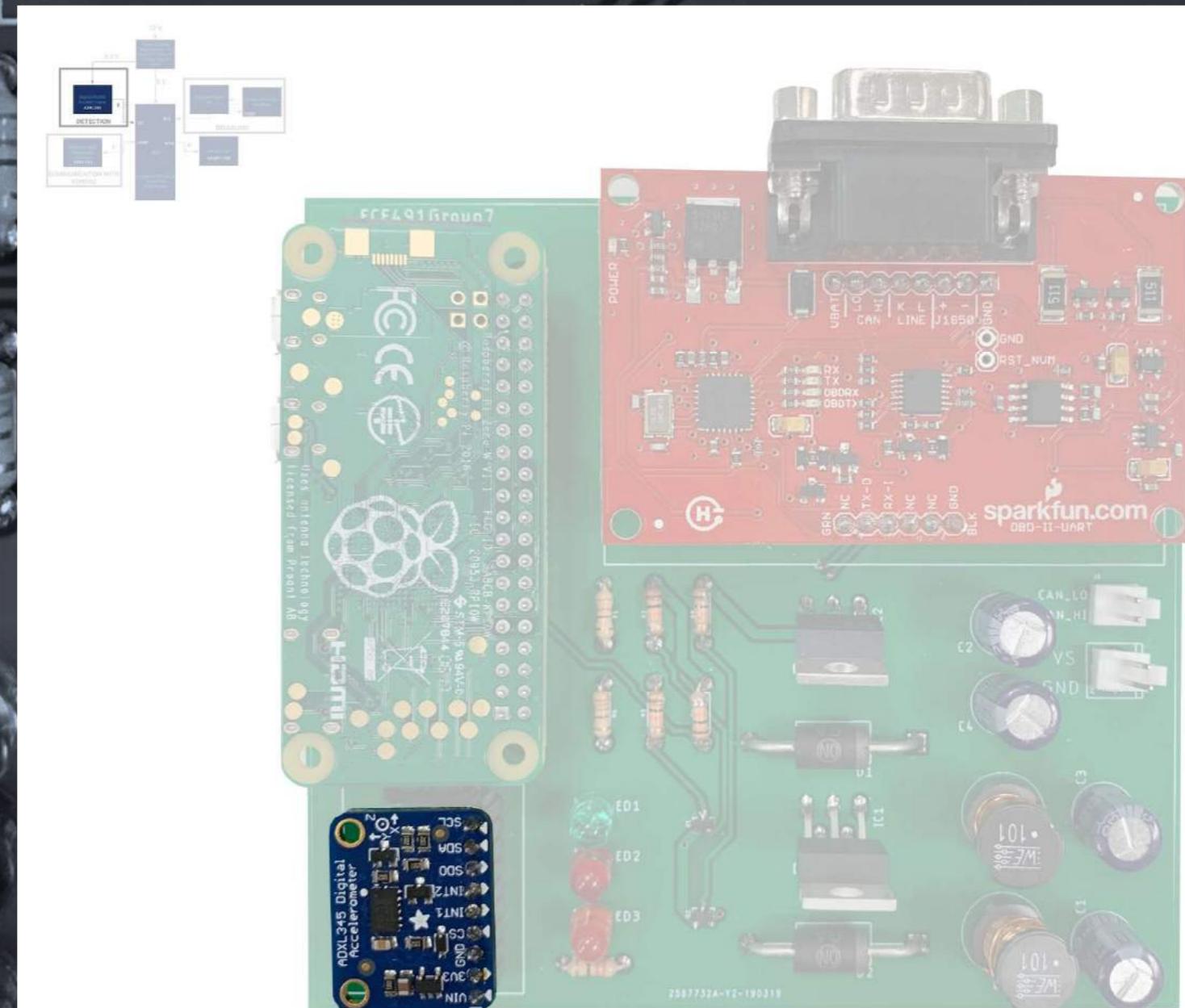
Detection



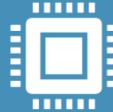
Immobilization



Disabler



TECHNICAL DESIGN DETAILS



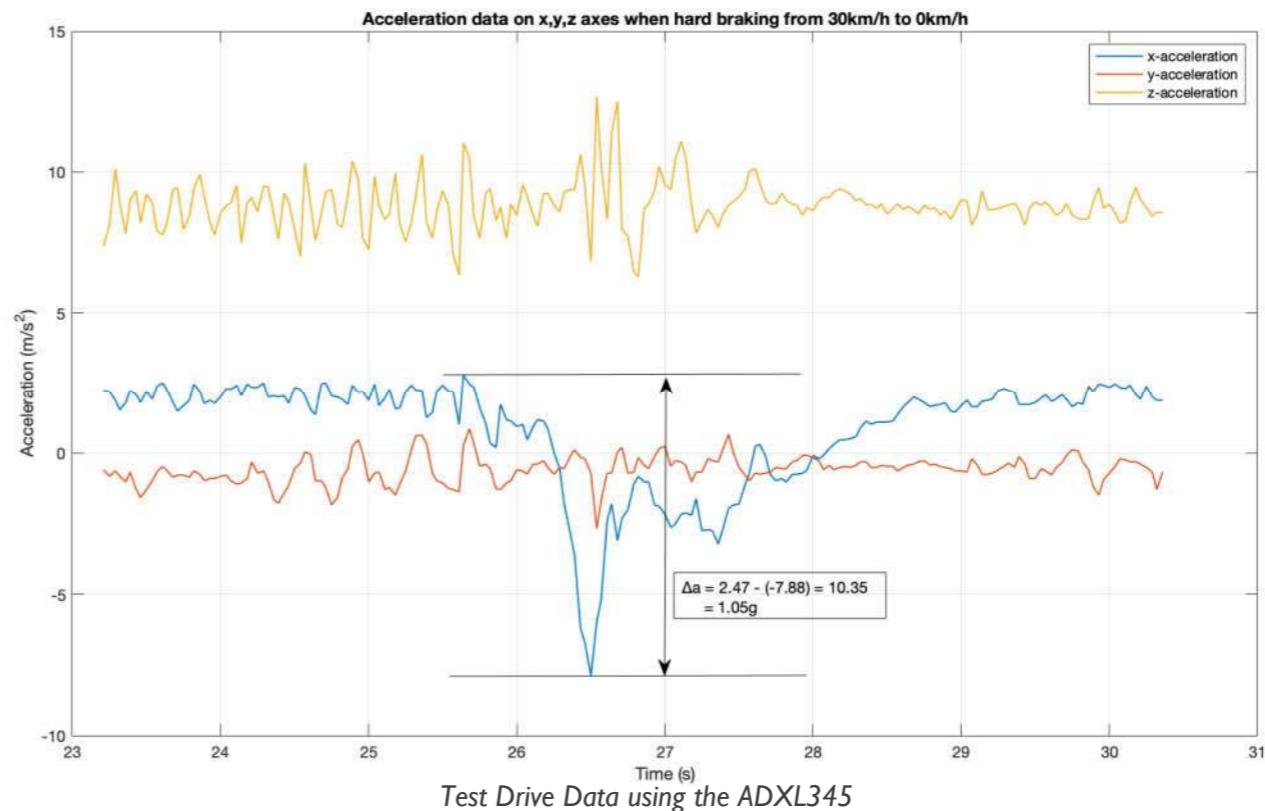
Detection



Immobilization

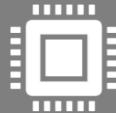


Disabler



- MEMS digital accelerometer is used to detect large spikes in acceleration (3G over a 0.5 second window)
- X-axis or Y-axis used, Z-axis not used on purpose

TECHNICAL DESIGN DETAILS



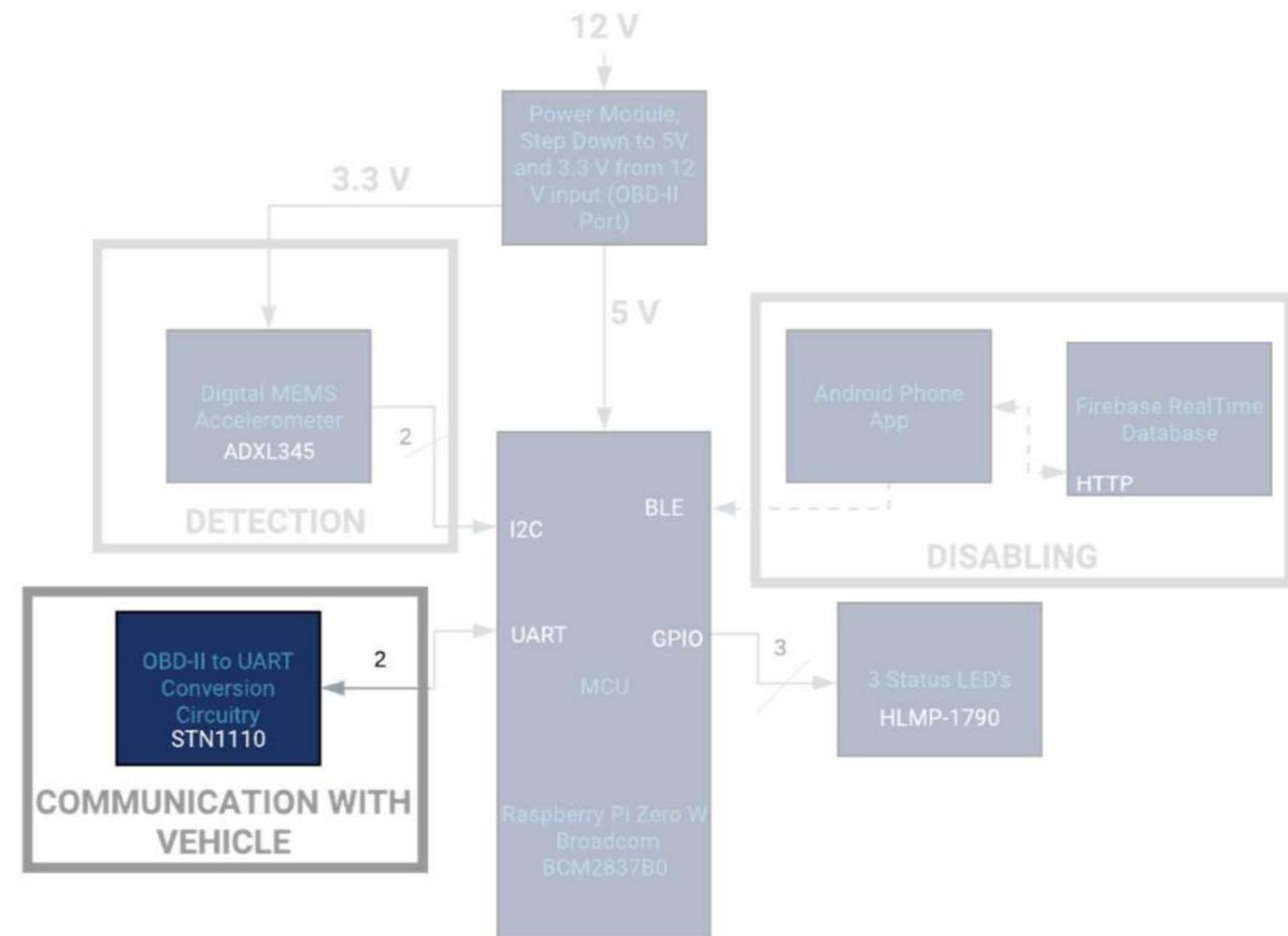
Detection



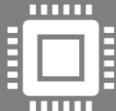
Immobilization



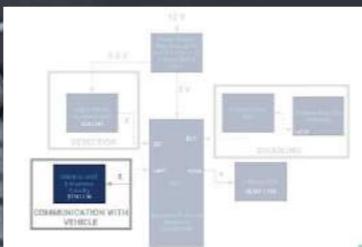
Disabler



TECHNICAL DESIGN DETAILS



Detection



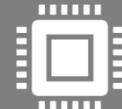
Immobilization



Disabler



TECHNICAL DESIGN DETAILS



Detection



Immobilization



Disabler

Acceleration

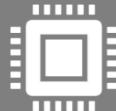


Disabler

Command
to OBD-II

- Checks speed for safety purposes (<5km/h)
- Continuously sends immobilization packets
- Preferred method: brake actuation
- Alternate methods: transmission, engine shutoff, cut fuel, DoS attack

TECHNICAL DESIGN DETAILS



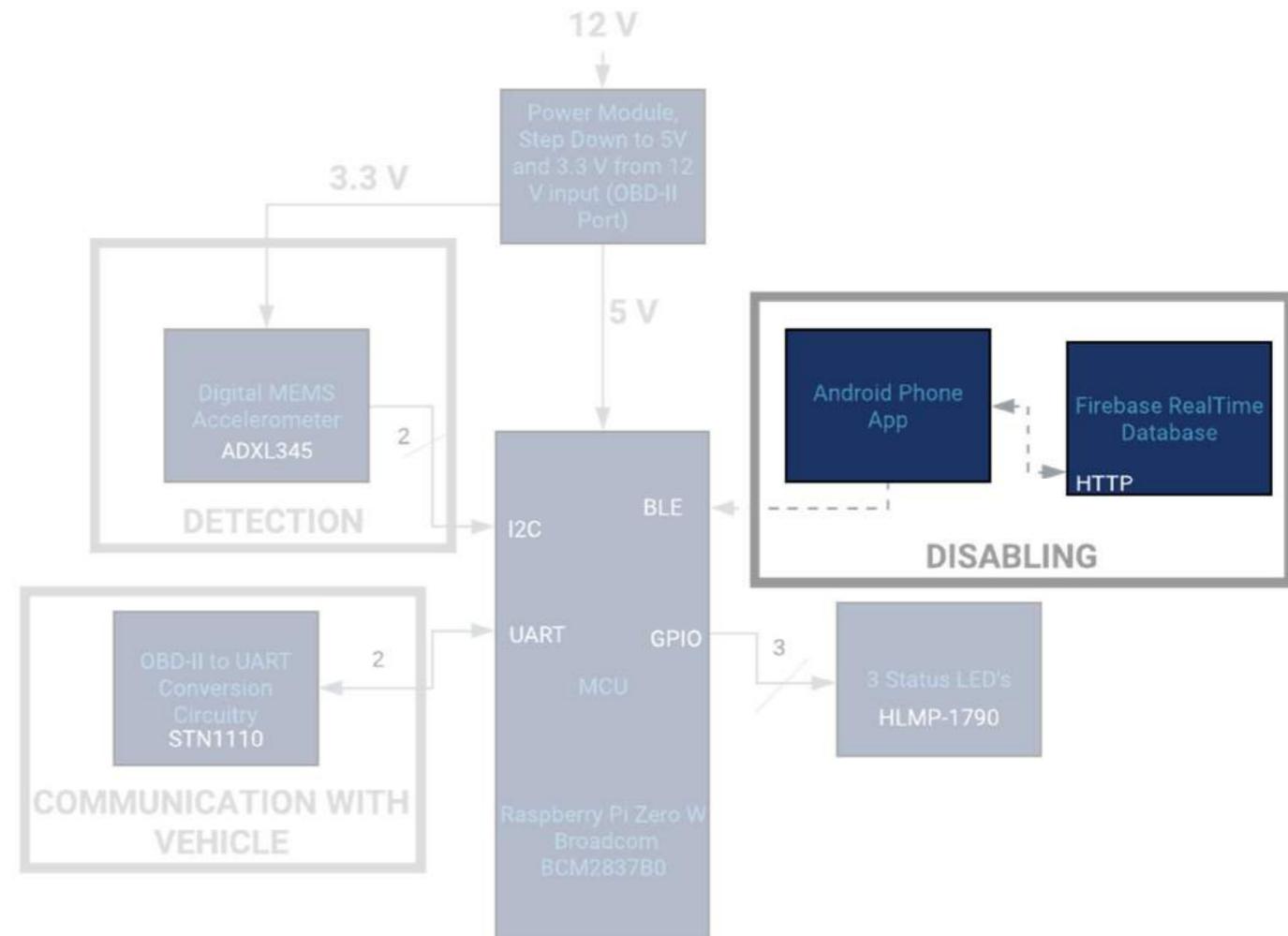
Detection



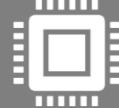
Immobilization



Disabler



TECHNICAL DESIGN DETAILS



Detection



Immobilization

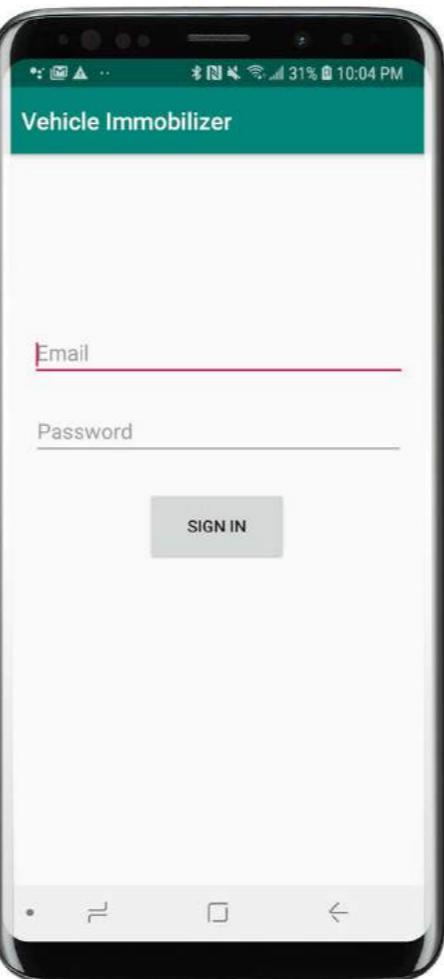


Disabler

2587732A-Y2-190319

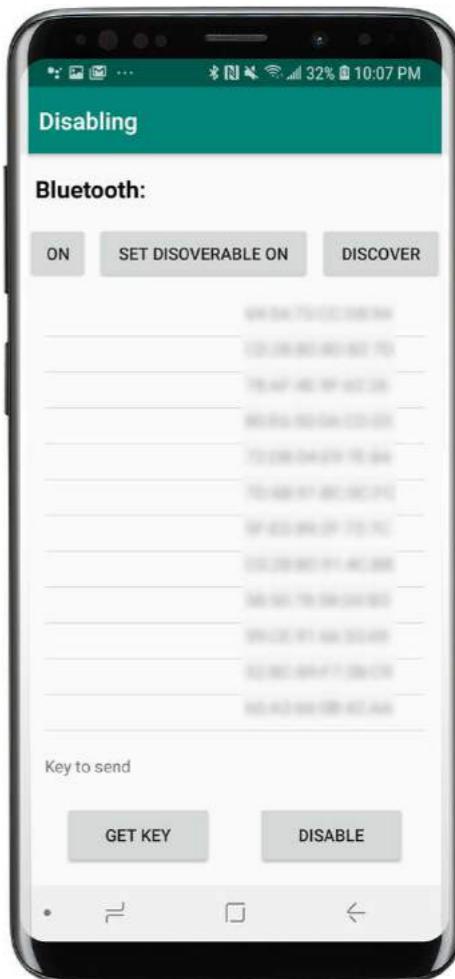
1

Authorized personnel login



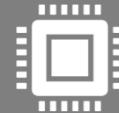
2

Scan, Pair and Send Key



2

TECHNICAL DESIGN DETAILS



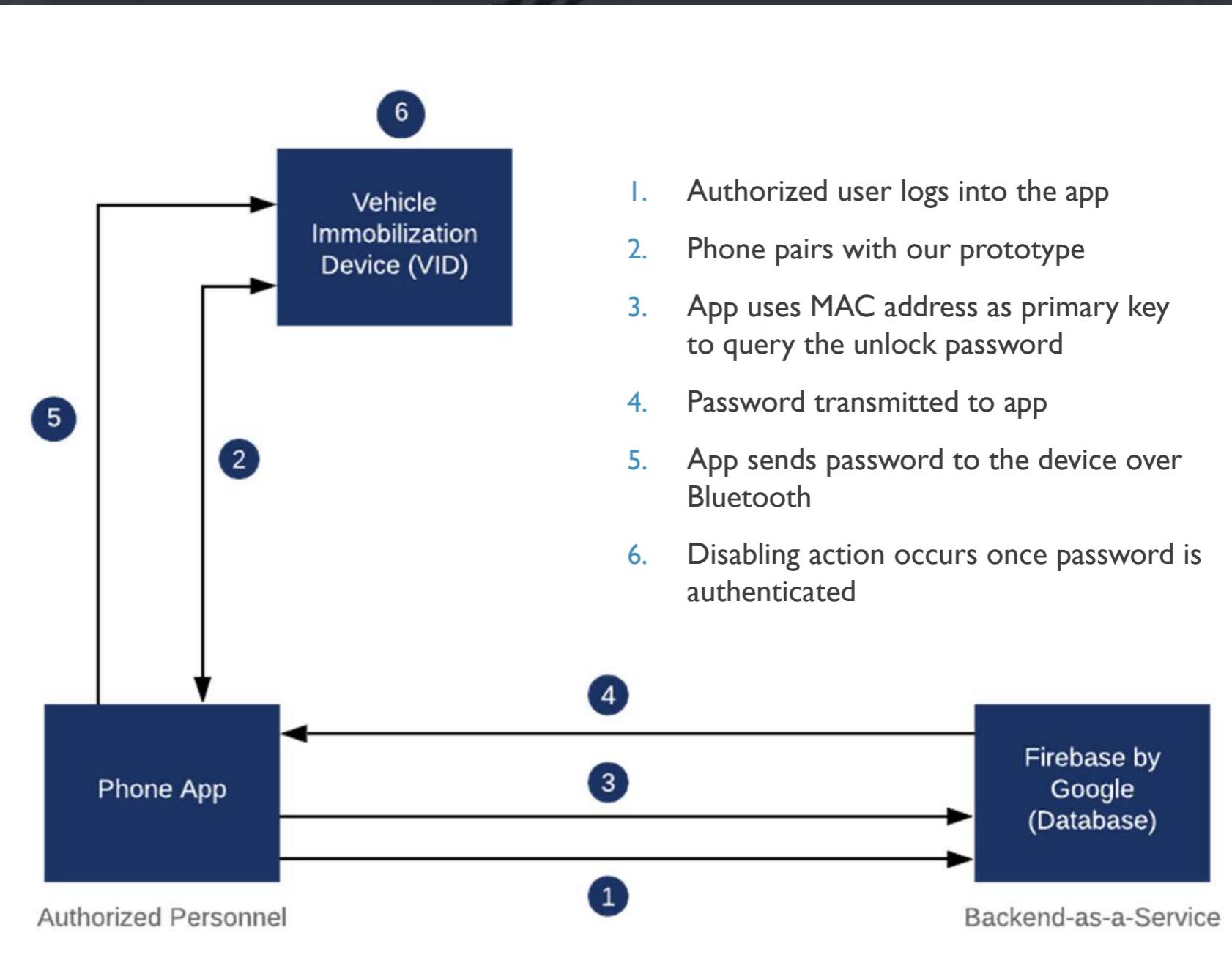
Detection



Immobilization

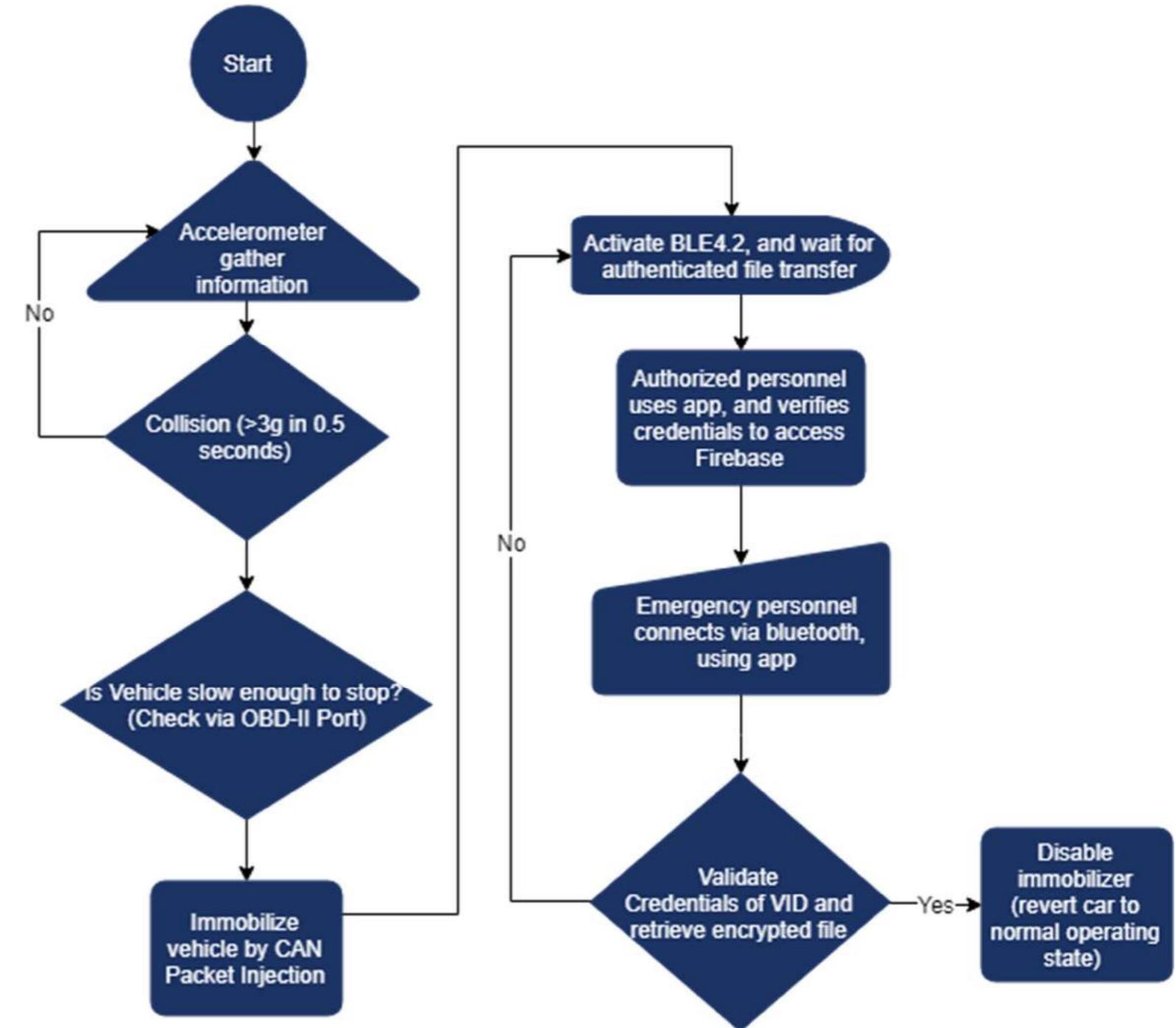


Disabler



TECHNICAL DESIGN DETAILS

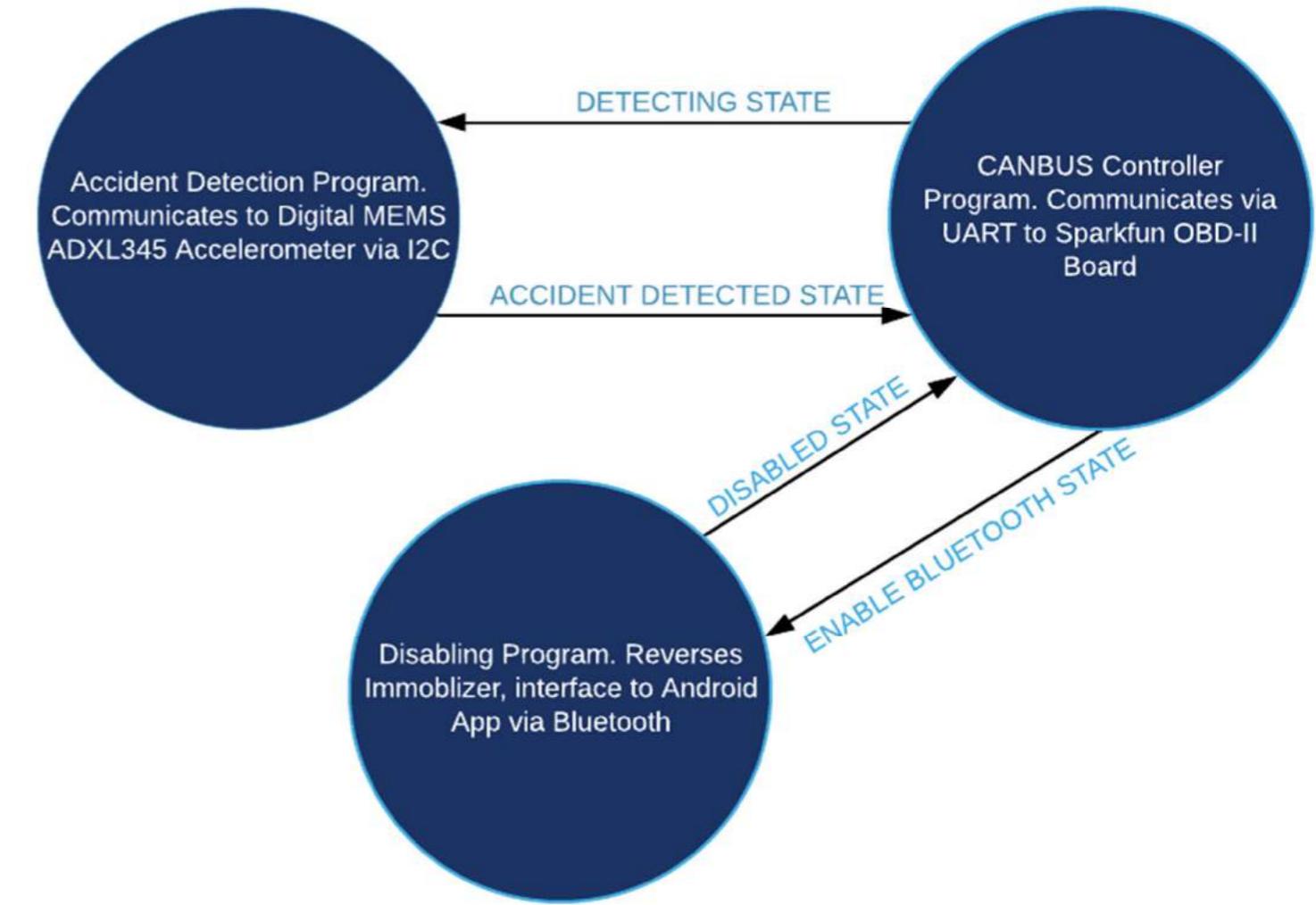
Software Process Device Flowchart



TECHNICAL DESIGN DETAILS

Software Process

State Machine Diagram



1. Detecting State
2. Accident Detected State
3. Enable Bluetooth State
4. Disabled State

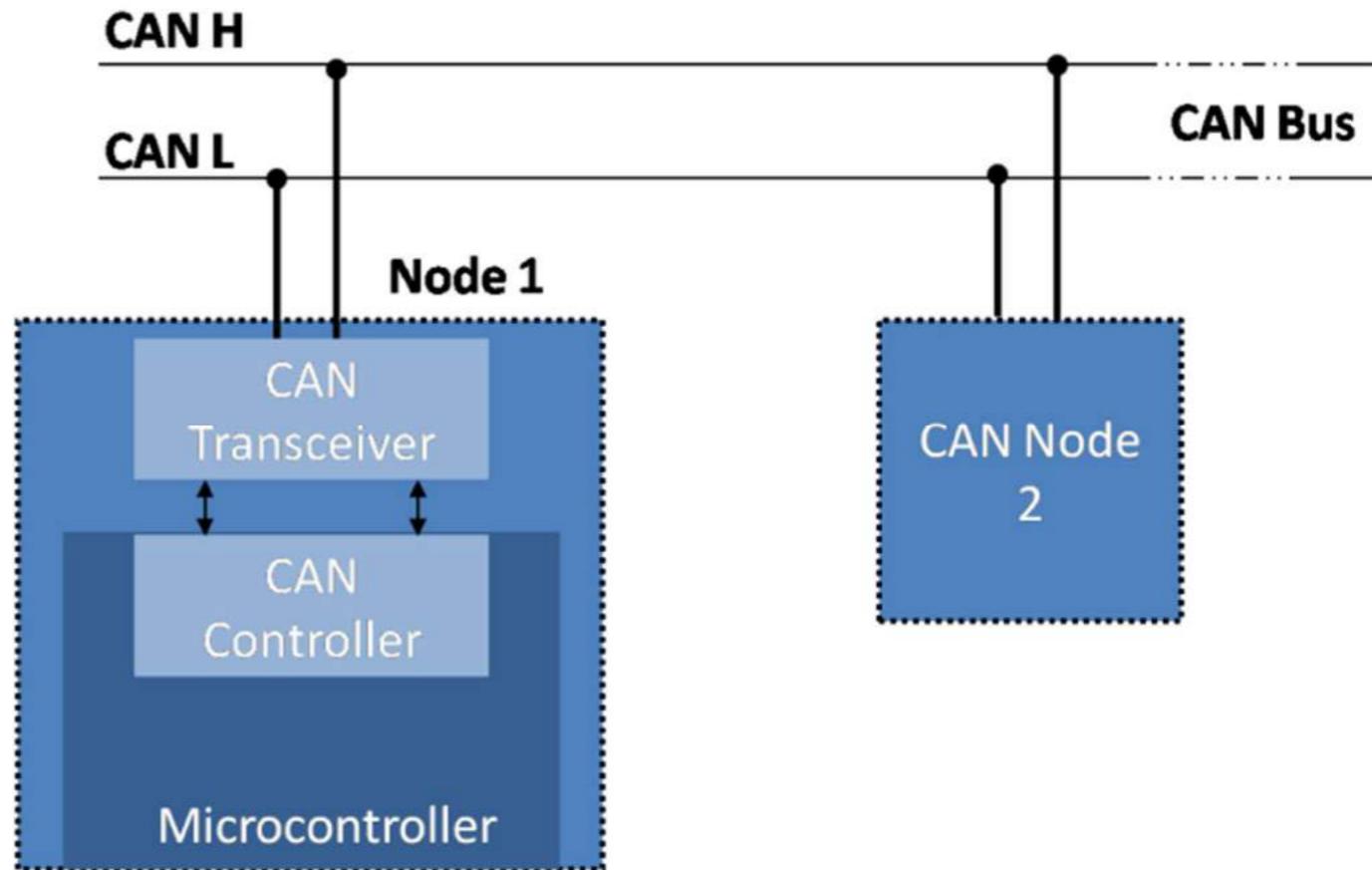


VERIFICATION

VERIFICATION

ECU Simulator

CAN Bus Node

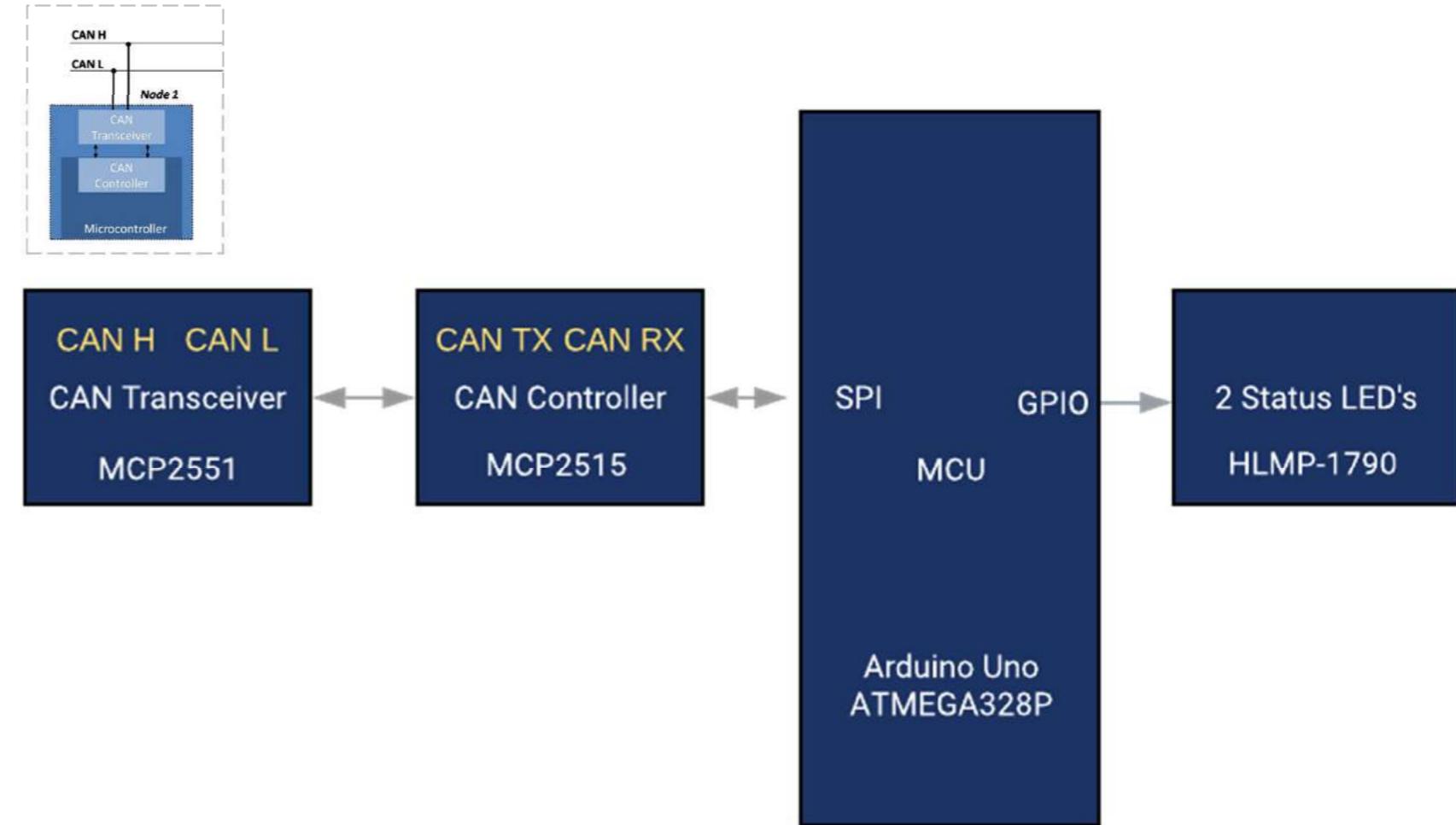


- Acts as a CAN bus node (ECU)
- Simulates standard OBD-II queries sent over CAN bus
- Receives specific CAN packets interpreted as braking or transmission

VERIFICATION

ECU Simulator

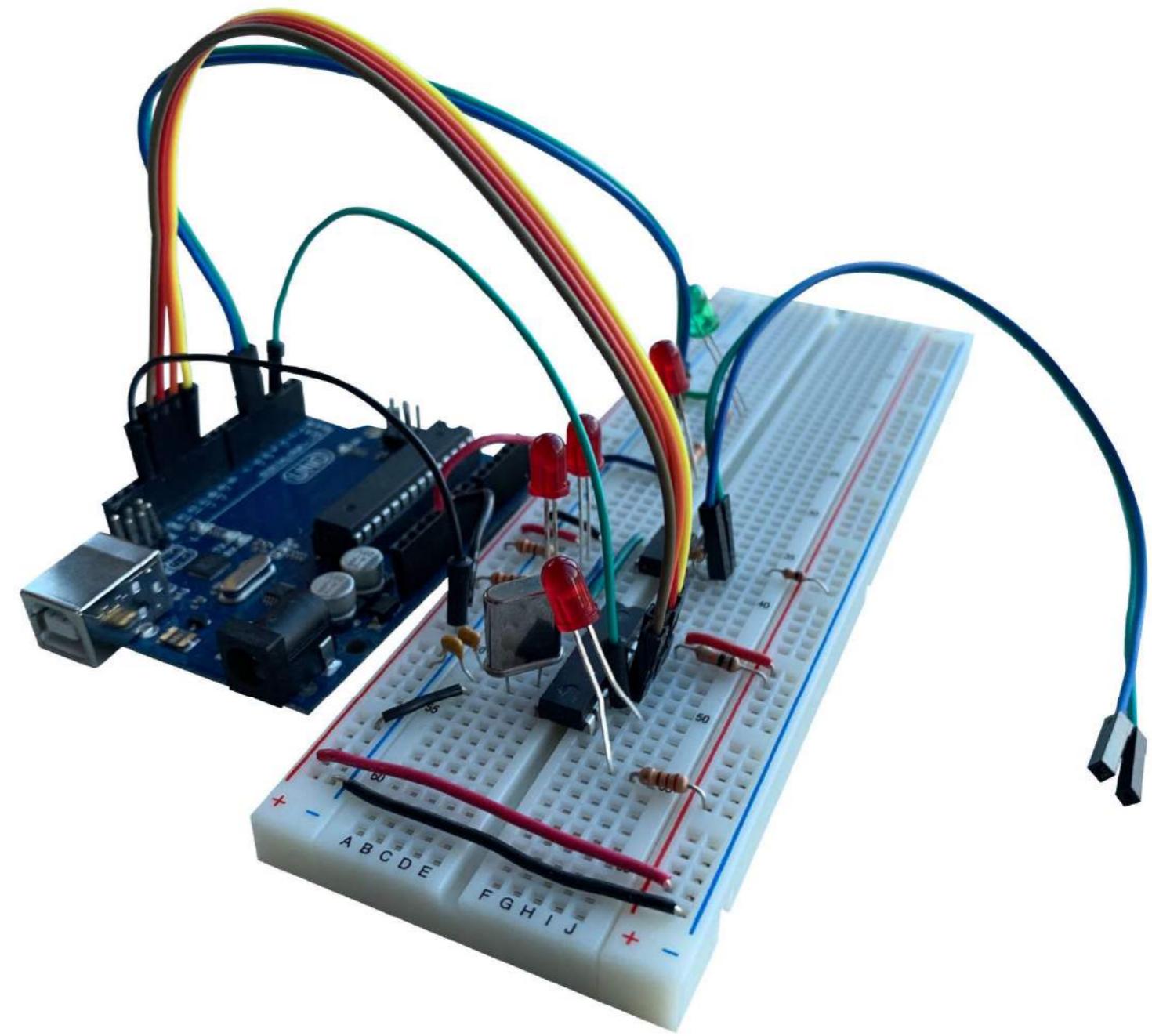
Block Diagram



- Acts as a CAN bus node (ECU)
- Simulates standard OBD-II queries sent over CAN bus
- Receives specific CAN packets interpreted as braking or transmission

VERIFICATION

ECU Simulator
Implementation



VERIFICATION

Video Demo

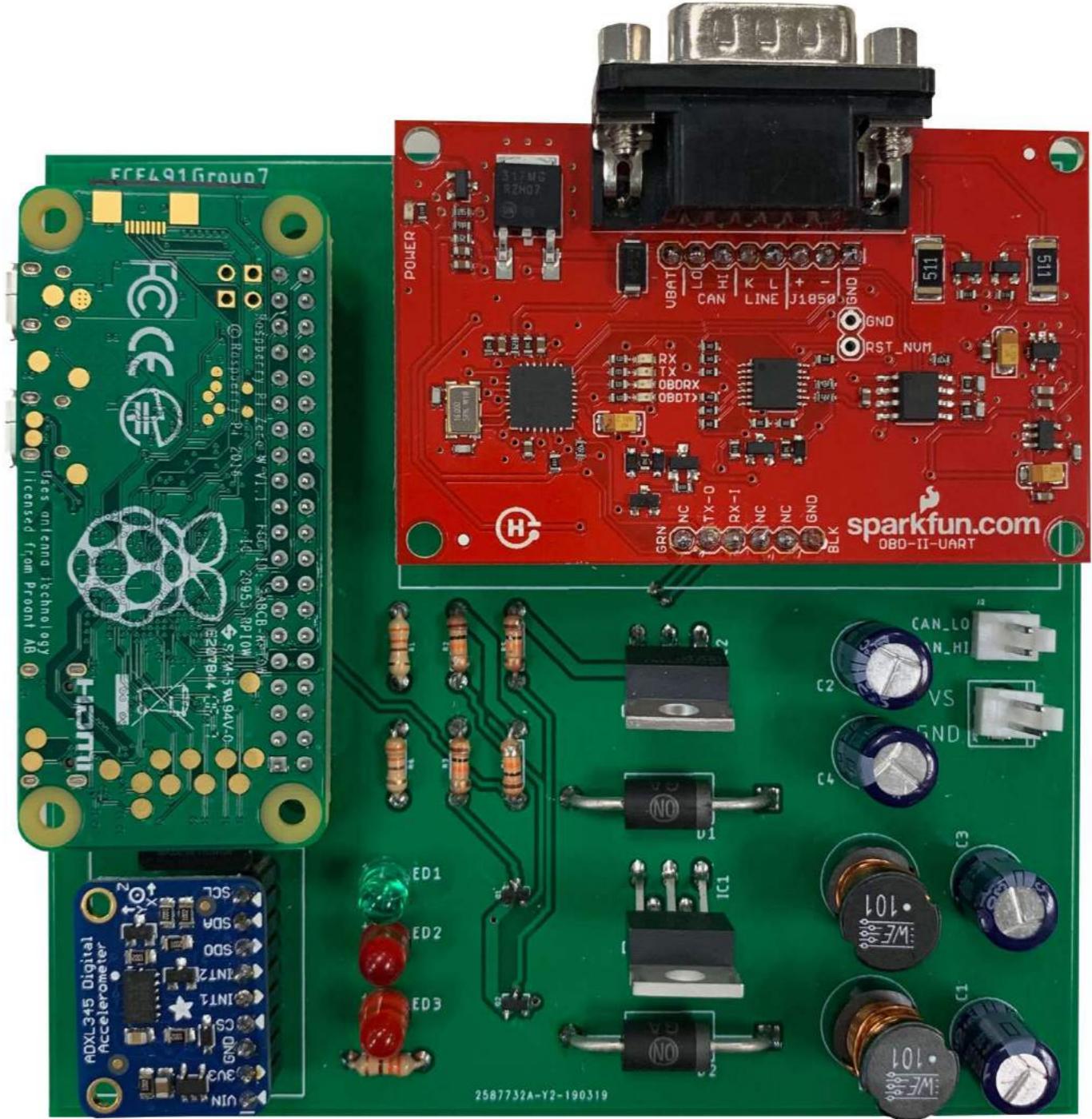




PRODUCT DESIGN

PRODUCT DESIGN

Proof-of-concept



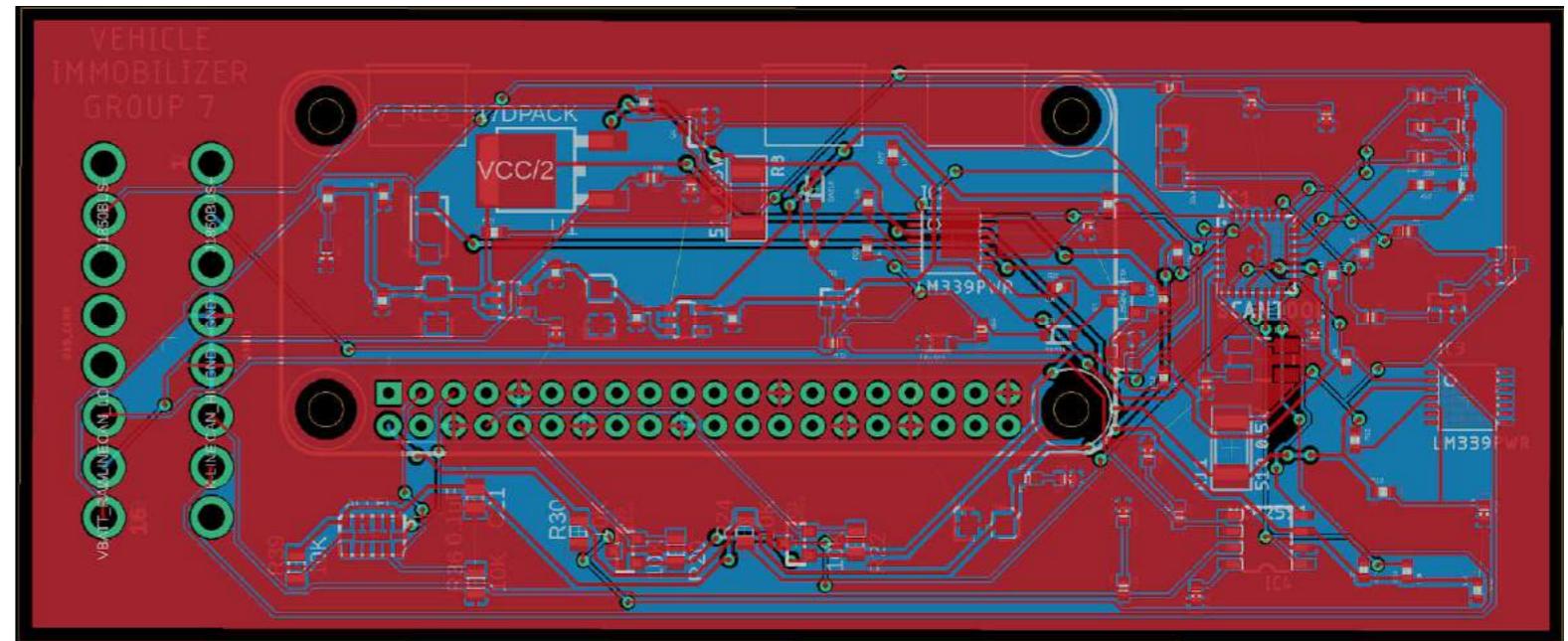
PRODUCT DESIGN

Dongle Form Factor



PRODUCT DESIGN

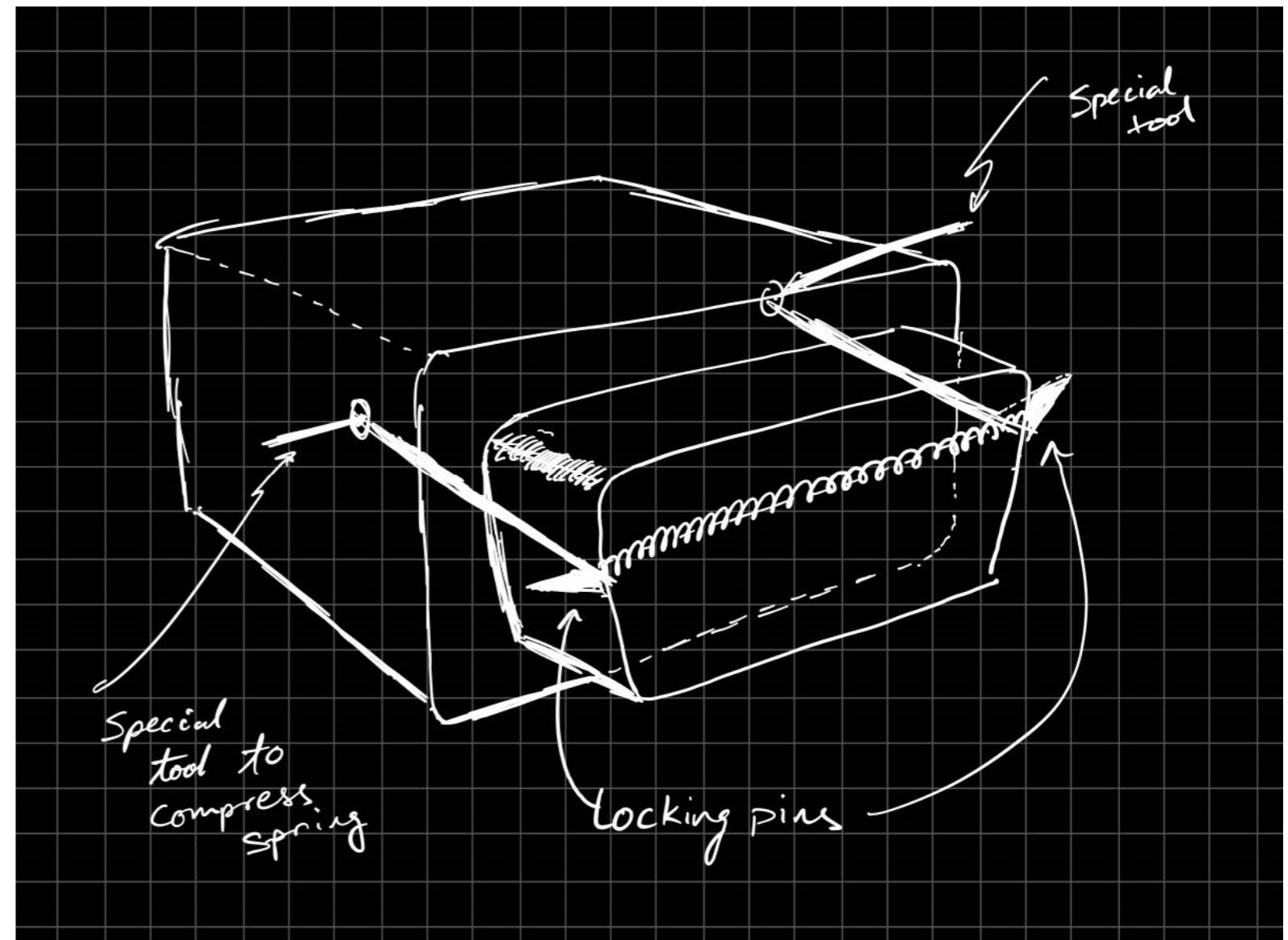
PCB Layout



- Dimensions: ~128mm x ~60mm
 - Smaller form factor

PRODUCT DESIGN

Locking Mechanism



FUTURE CONSIDERATIONS

Low Power Mode

Design and build a power management solution that features a low power mode to minimize power consumption

Proprietary CAN Packet Structures

Query Vehicle Identification Number (VIN) to identify vehicle make & model to for correct immobilization packet structure

Improved Accident Detection

Retrieval of additional data from CAN bus for redundancy checks (i.e. airbag deployment status) & multi-directional collisions

Enhanced Security for Disabling

Implement a more secure authentication software solution (i.e. SHA-256 Authentication)

Location

Store the coordinates of the scene of accident and send them to emergency personnel by adding a GPS module

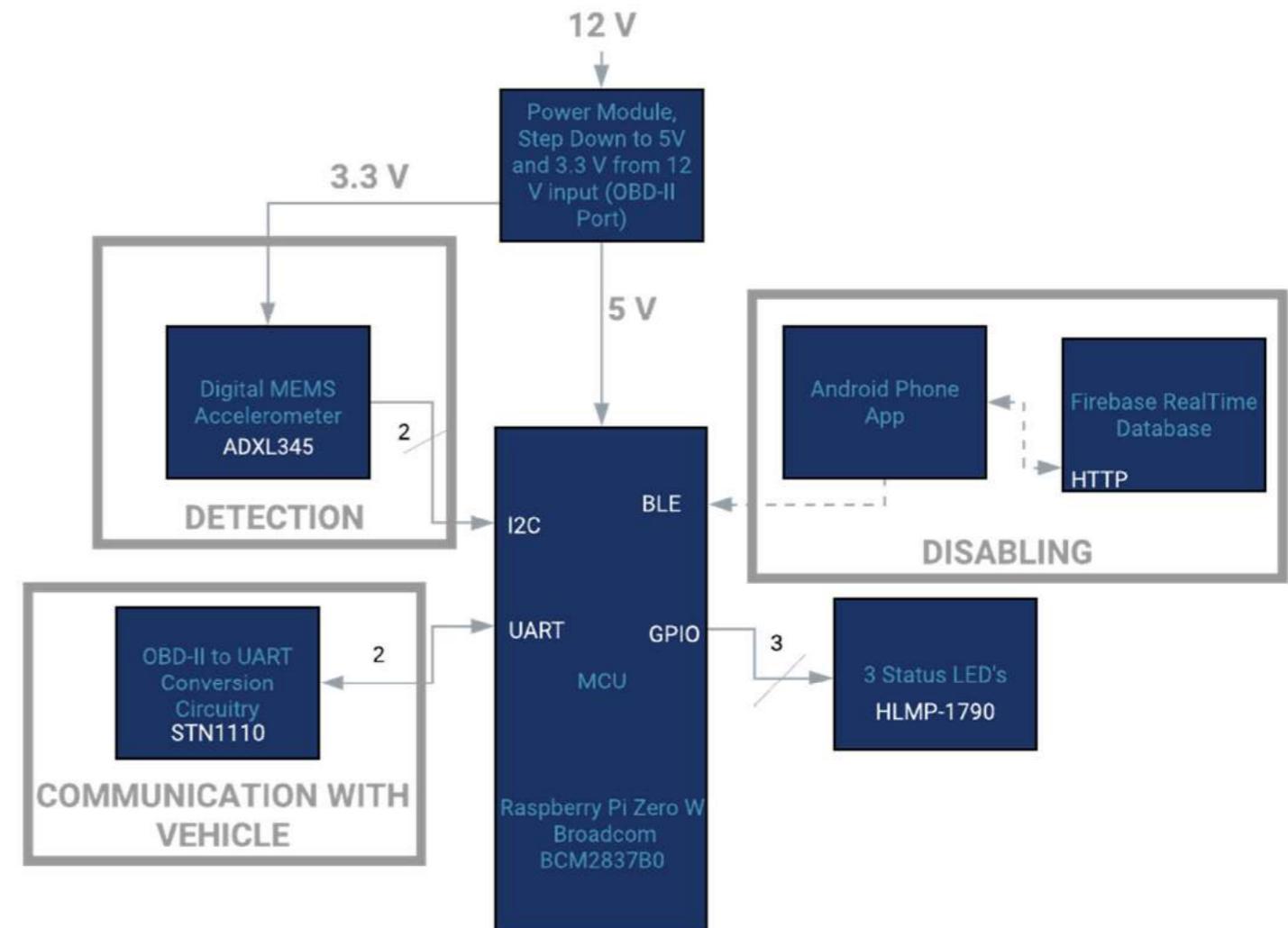


SUMMARY

SUMMARY

Goals

- Accurate collision detection
- Immobilize the vehicle in a reversible manner
- Secure re-mobilization of vehicle by authorized personnel

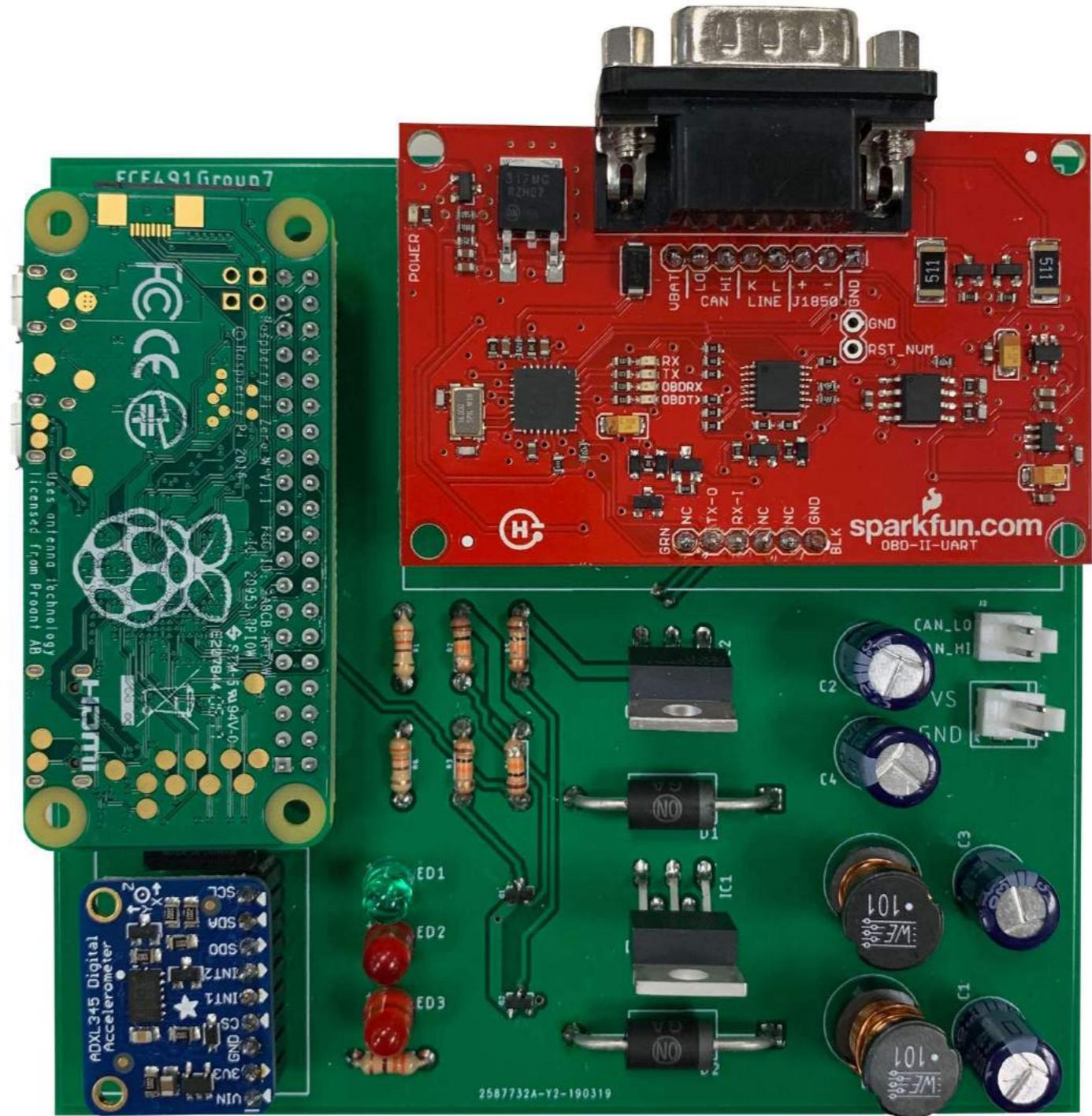


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SUMMARY

Goals

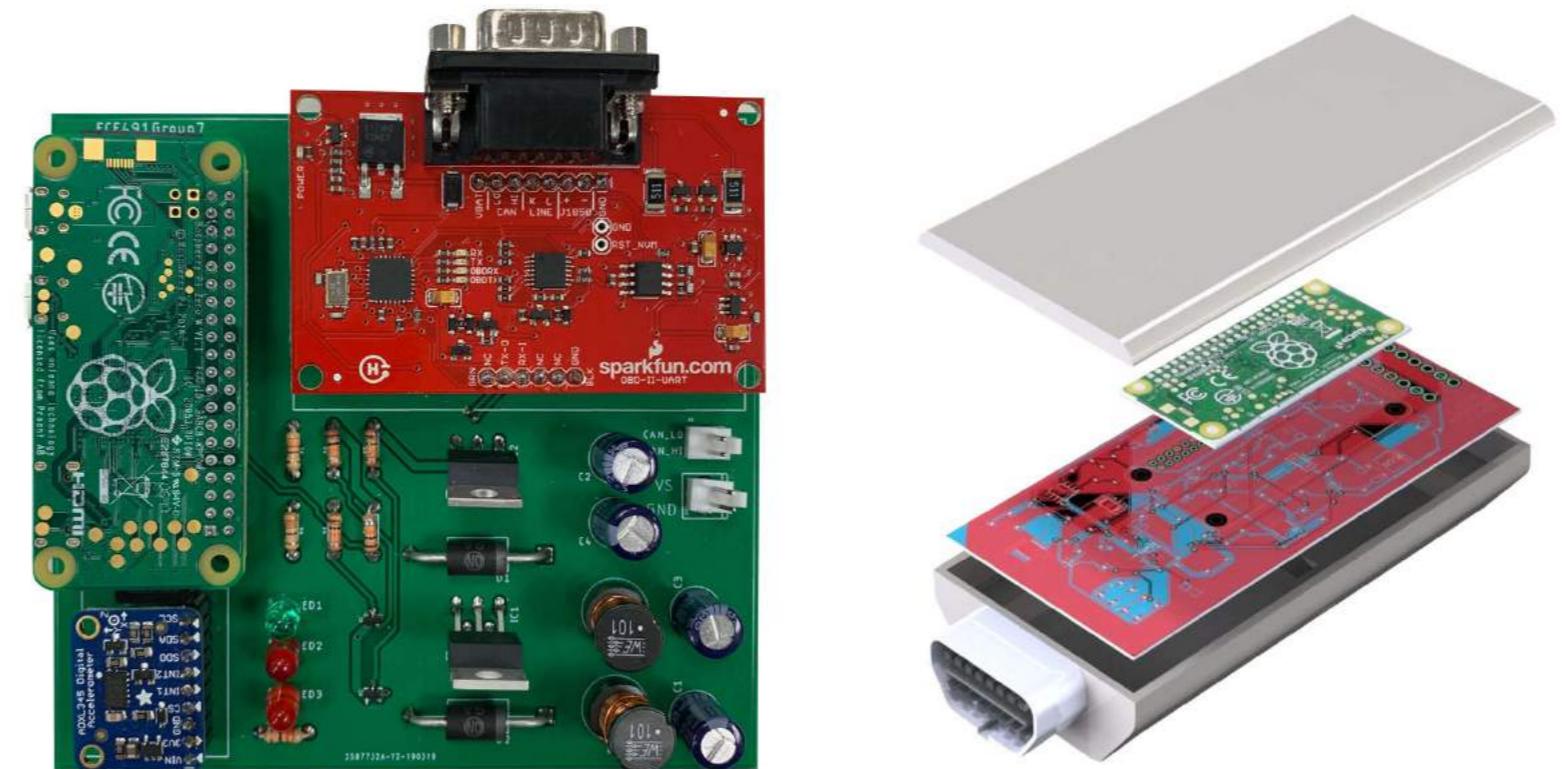
- Accurate collision detection
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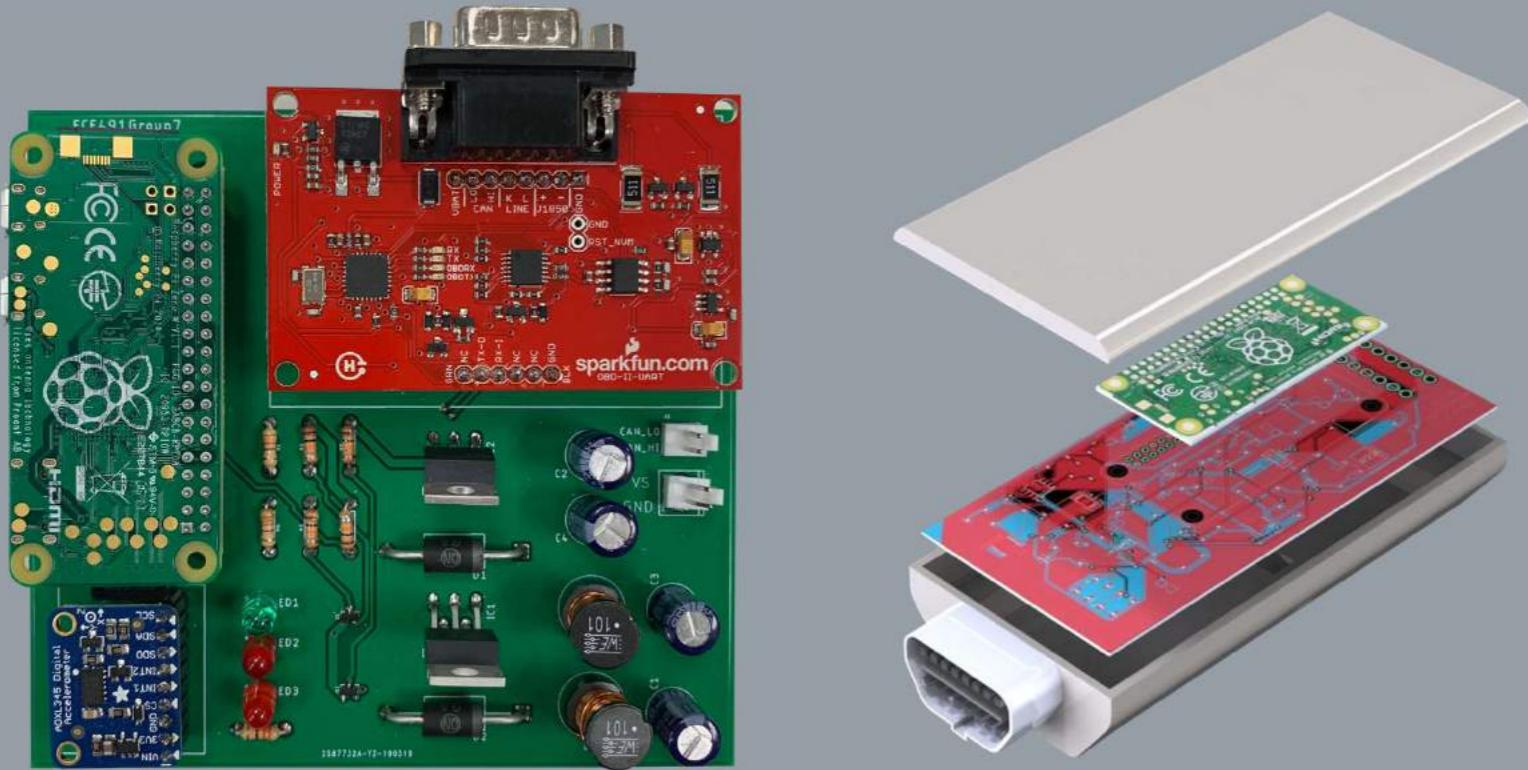


SUMMARY

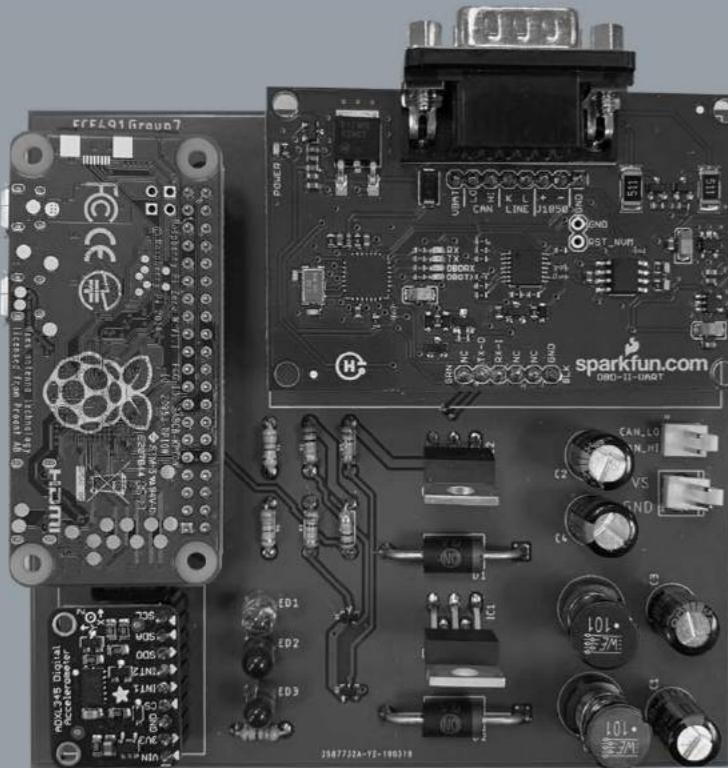
Goals

- Accurate collision detection
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THANK YOU



Q&A

Farez Halim
farez@ualberta.ca

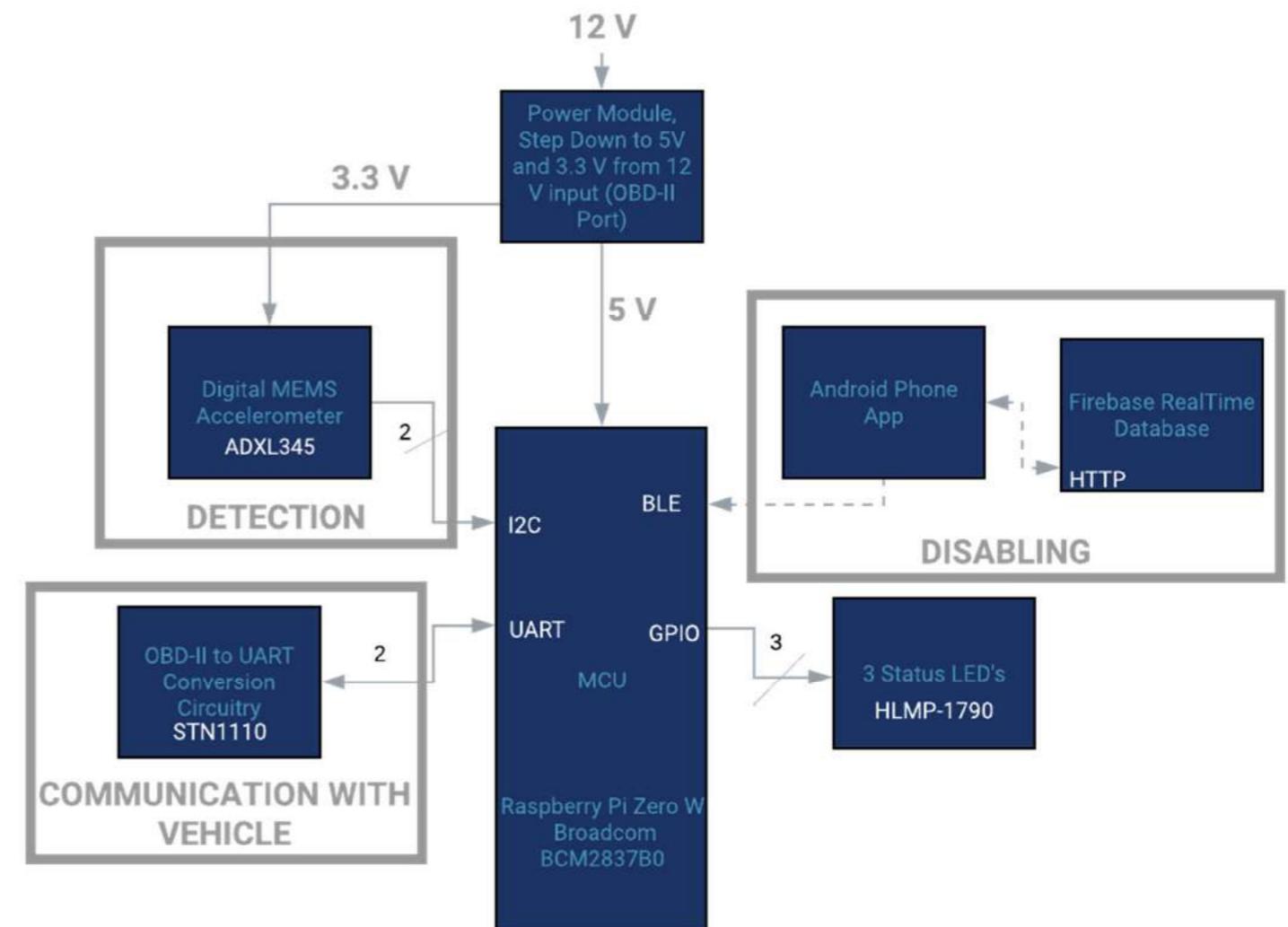
Mohamad Yassin
myassin1@ualberta.ca

Annamalai Chockalingam
chockali@ualberta.ca

Redge Santillan
santilla@ualberta.ca

APPENDIX

Full High Level Block Diagram

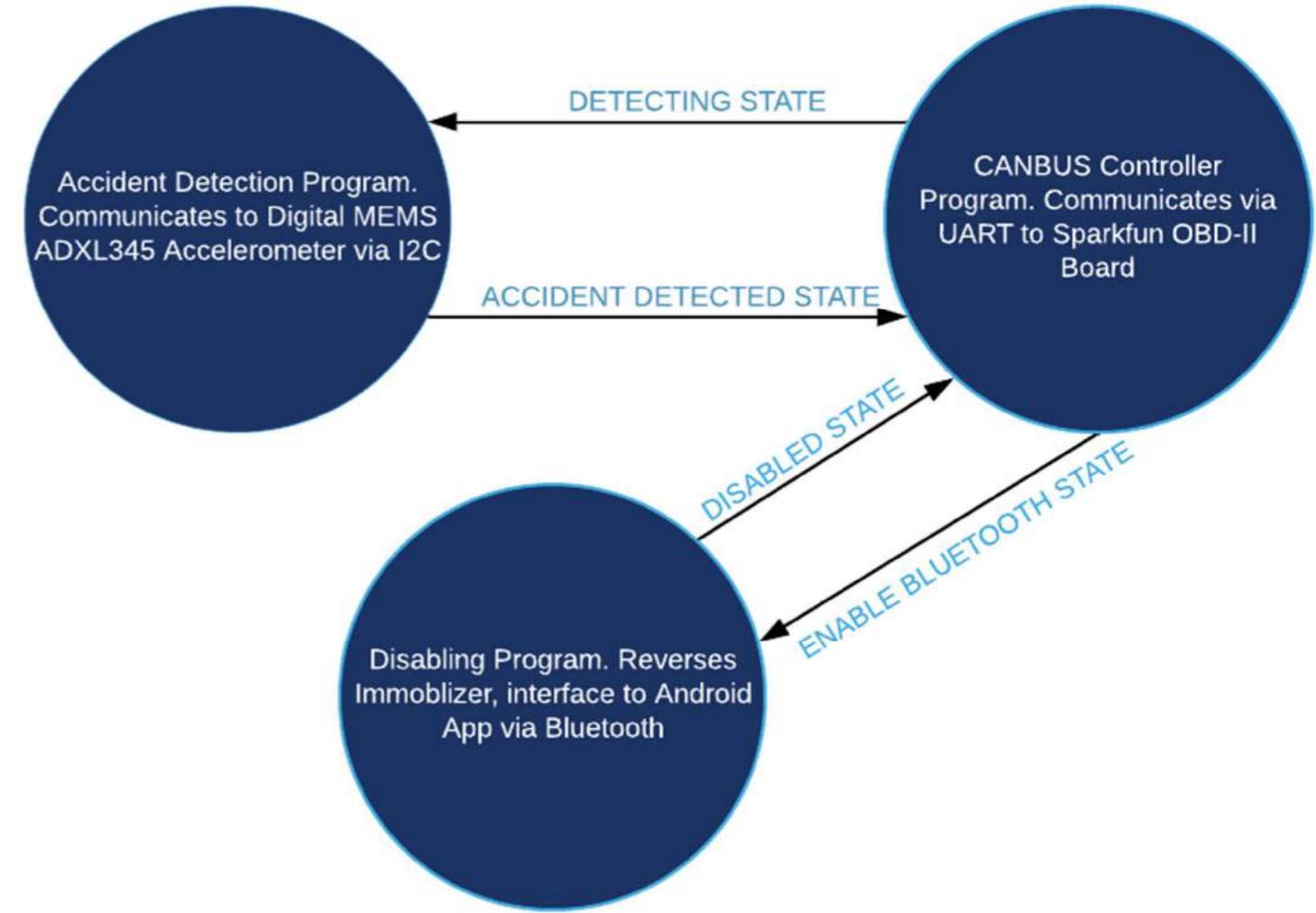


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APPENDIX

Software Process

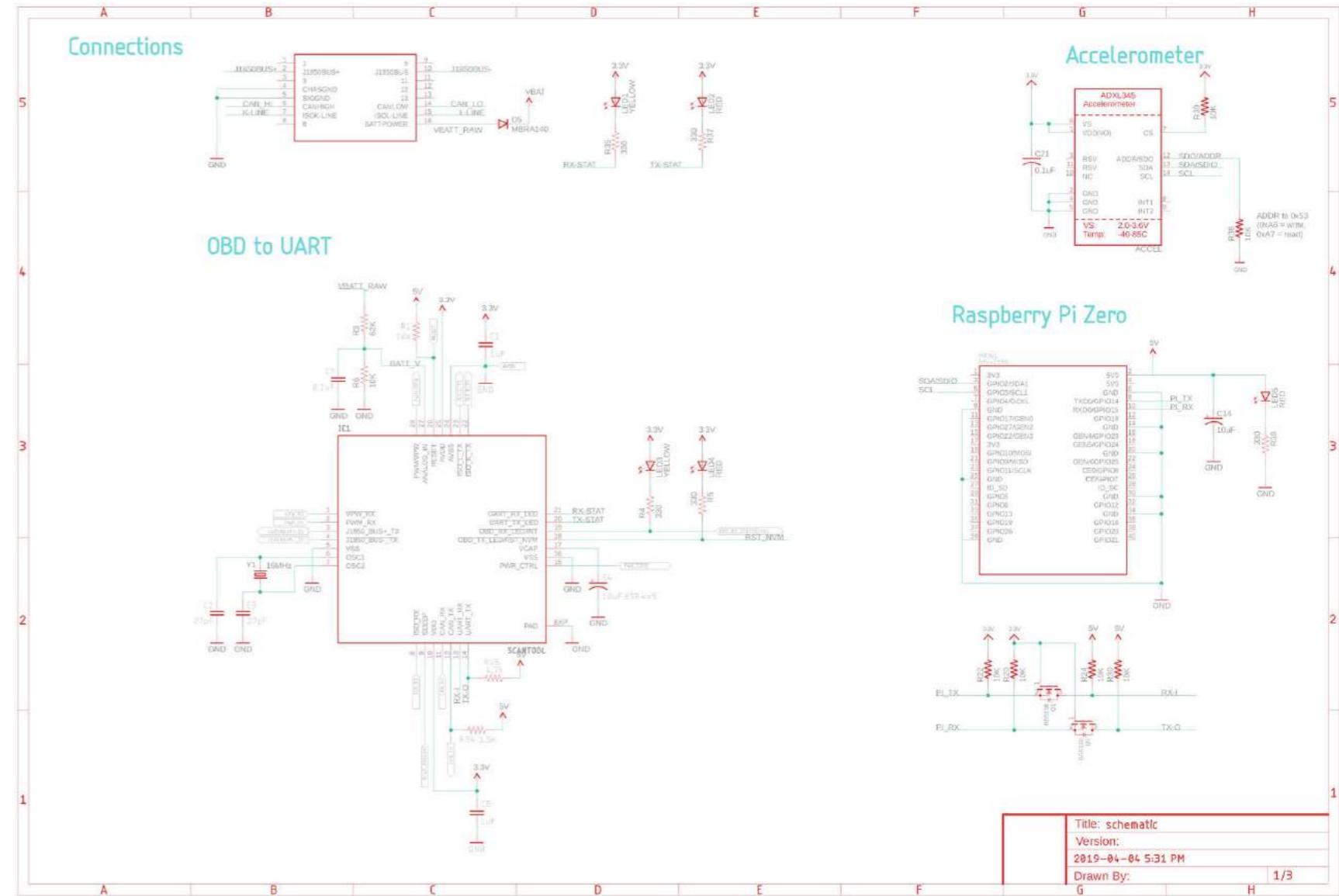
State Machine Diagram



1. Detecting State
2. Accident Detected State
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4. Disabled State

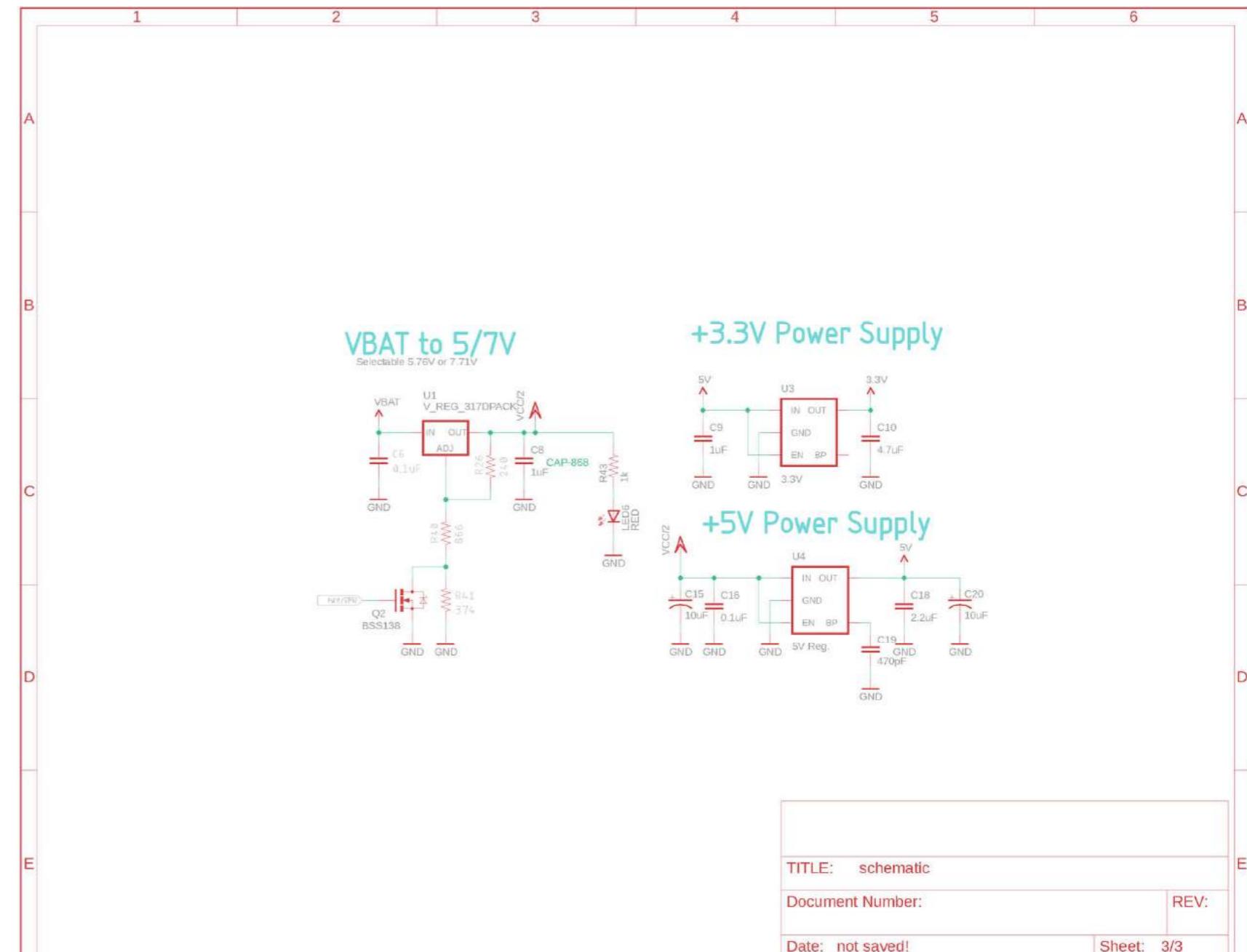
APPENDIX

Schematic – Vehicle Immobilization Device (Page 1 of 4)



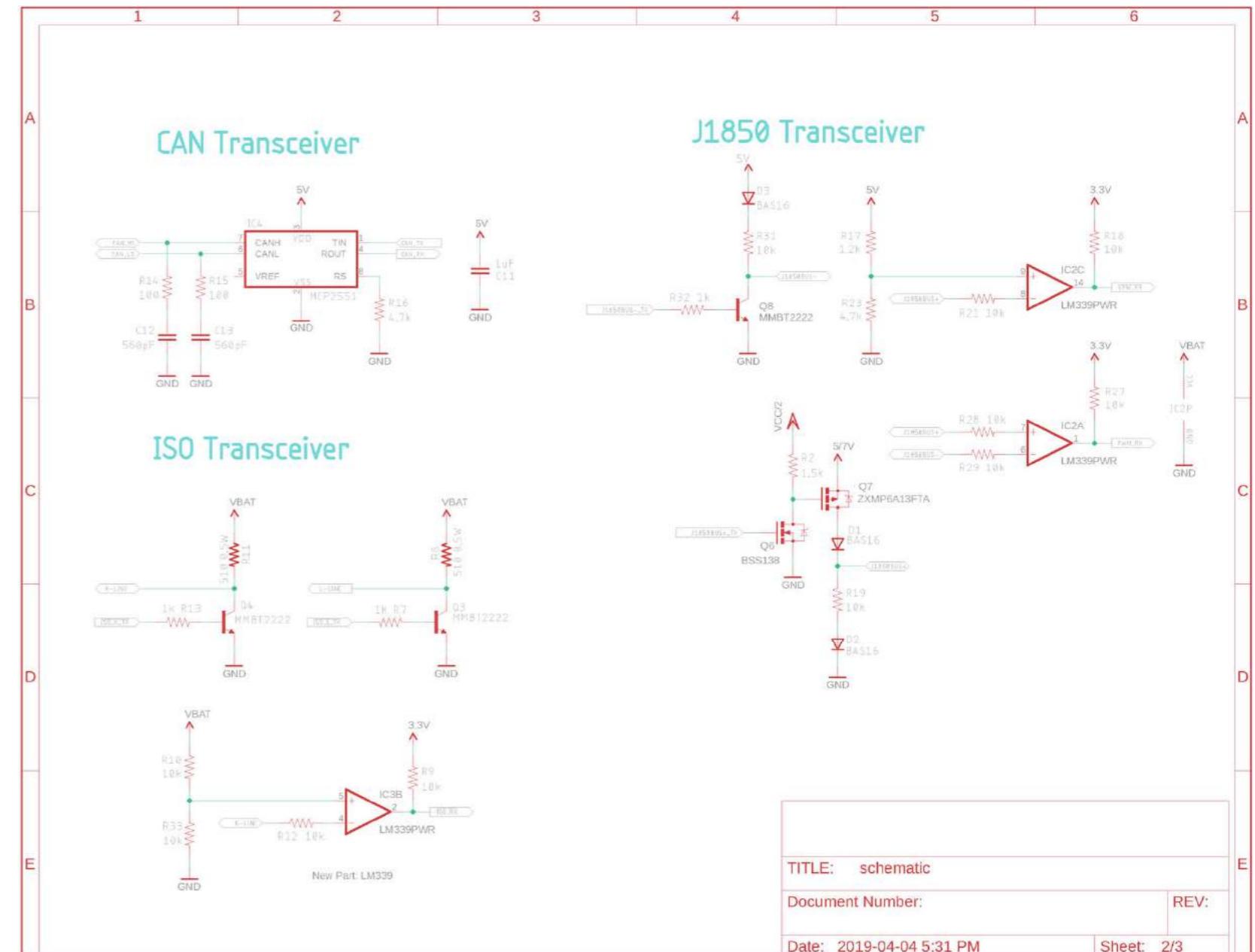
APPENDIX

Schematic – Power Module (Page 2 of 4)



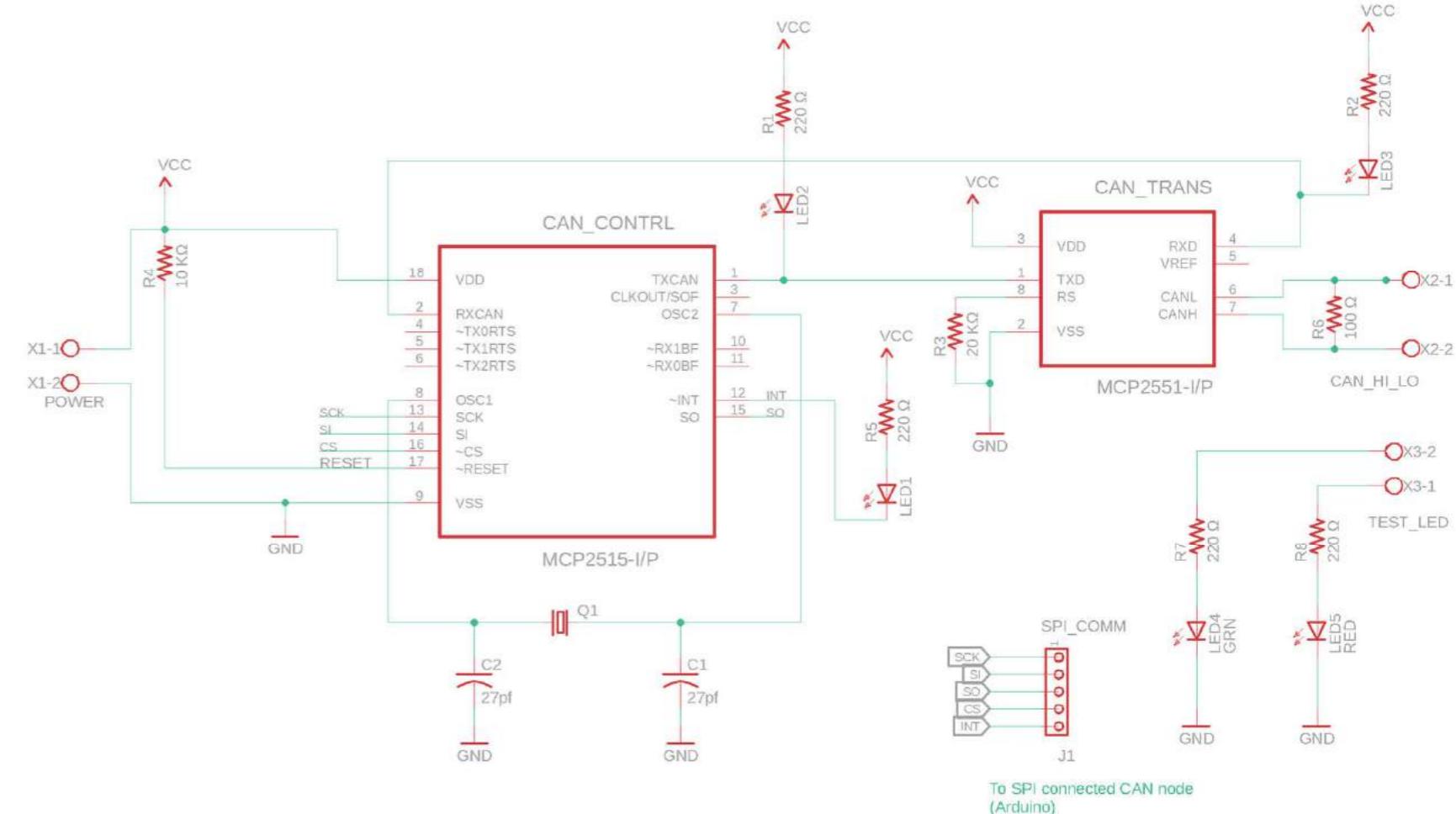
APPENDIX

Schematic – OBD-II Transceivers (Page 3 of 4)



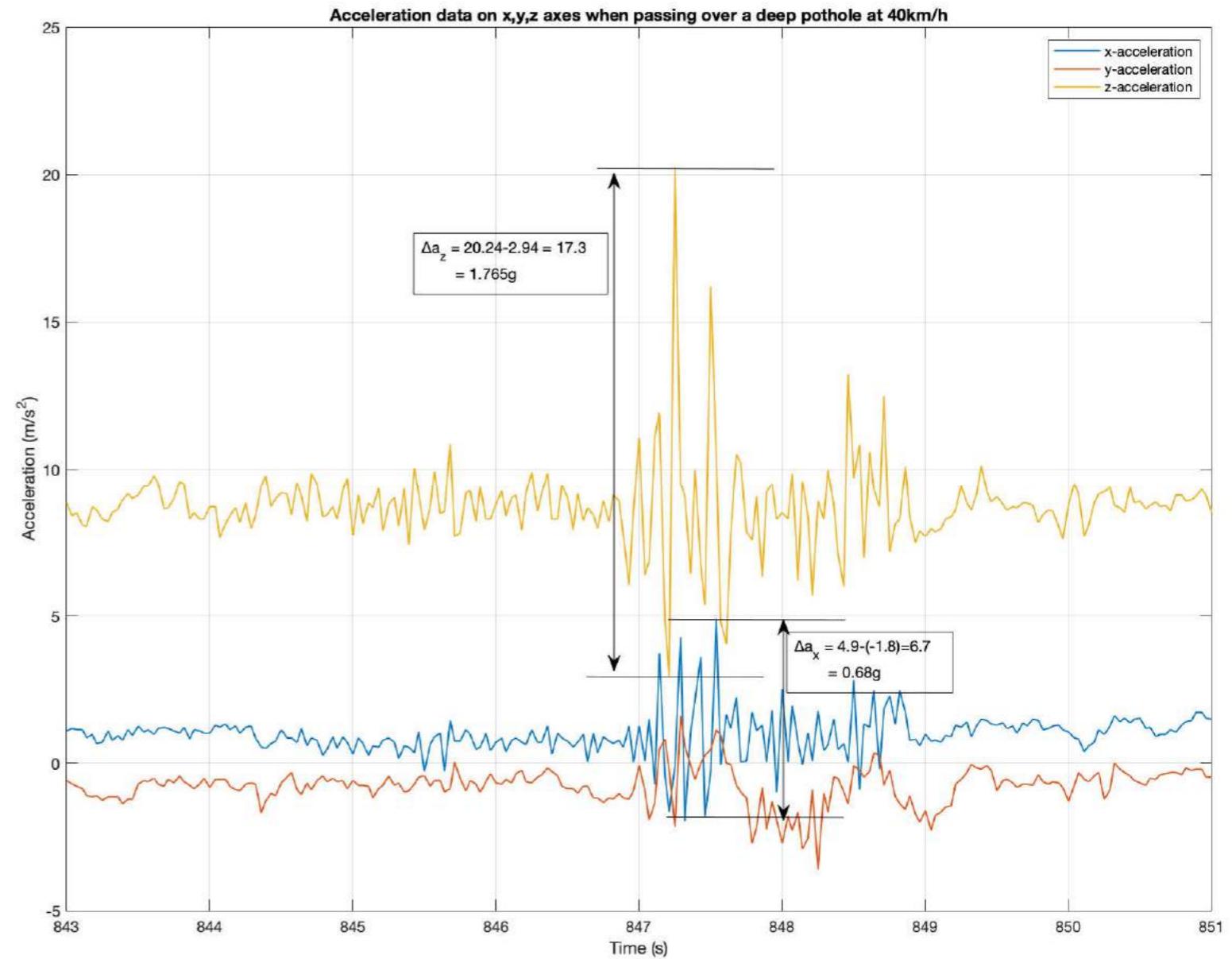
APPENDIX

Schematic – ECU Simulator (Page 4 of 4)



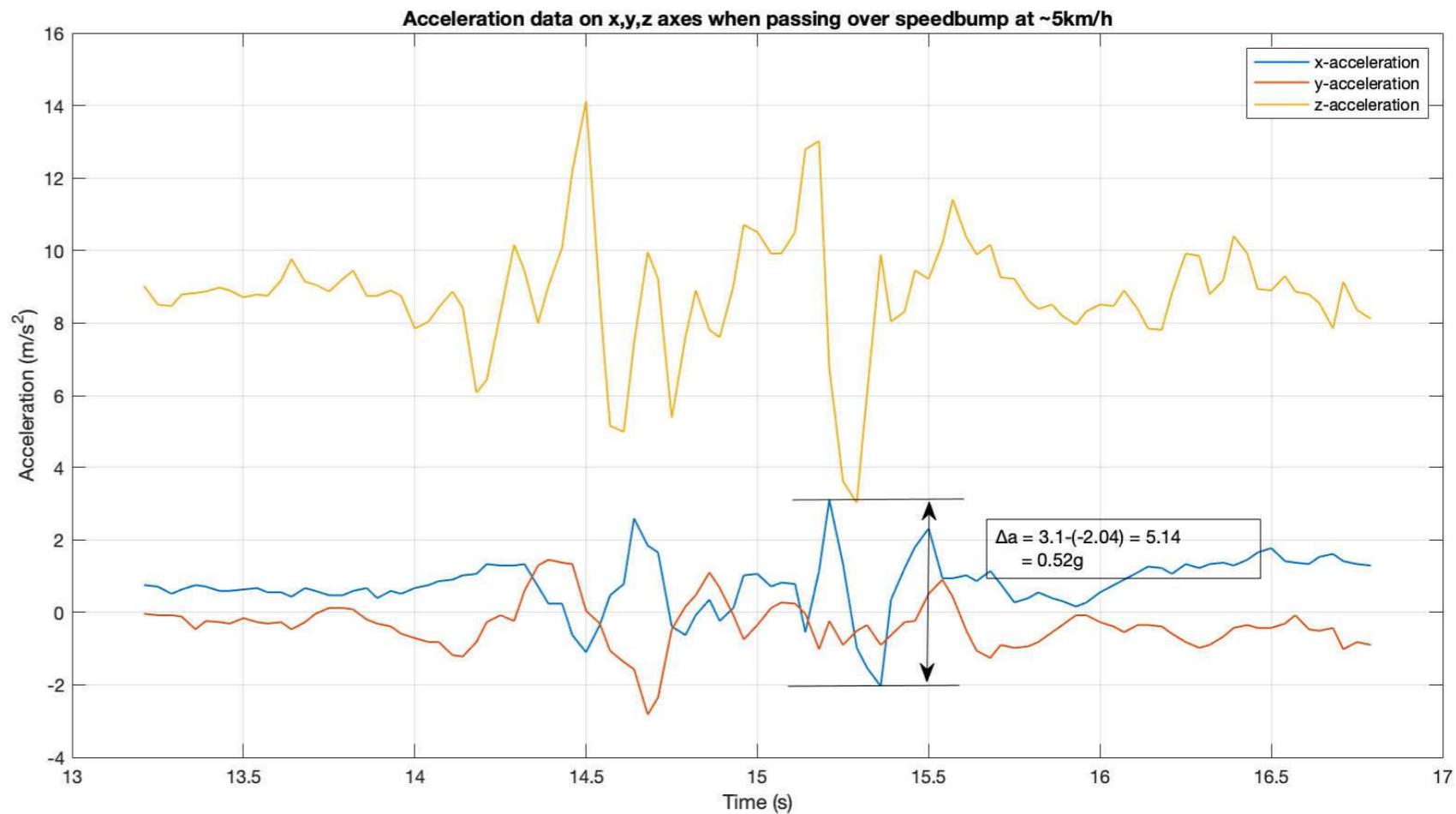
APPENDIX

Graph (2 of 3) – Pothole at
40km/h



APPENDIX

Graph (3 of 3) – Speedbump at 5km/h



APPENDIX

Bill of Materials – Product Design

Complete bill of materials					
	Value	Description	Qty	Unit \$	Total \$
Capacitors					\$ 0.39
	1uF	Capacitor	5	\$ 0.0058	\$ 0.03
	2.2uF	Capacitor	1	\$ 0.0200	\$ 0.02
	27pF	Capacitor	2	\$ 0.0090	\$ 0.02
	4.7uF	Capacitor	1	\$ 0.0320	\$ 0.03
	470pF	Capacitor	1	\$ 0.0127	\$ 0.01
	560pF	Capacitor	2	\$ 0.0065	\$ 0.01
	10uF	Capacitor	4	\$ 0.0490	\$ 0.20
	0.1uF	Capacitor	5	\$ 0.0049	\$ 0.02
	10uF	Capacitor	1	\$ 0.0490	\$ 0.05
Diodes					\$ 1.29
	BAS16	Diode	3	\$ 0.20	\$ 0.60
	MBRA140	Diode	1	\$ 0.69	\$ 0.69
STN1110 - OBD II to UART Interpreter, PDIP Package					\$ 7.65
	SCANTOOL	STN1110 - OBD II to UART Interpreter, QFN-28-S	1	\$ 7.65	\$ 7.65
Quad Differential Comparators					\$ 1.16
	LM339PWR	Quad Differential Comparators	2	\$ 0.58	\$ 1.16
CAN Driver					\$ 1.86
	MCP2551	CAN Driver	1	\$ 1.86	\$ 1.86
Header					\$ 2.00
	DNP	Header	1		
		Header	1		
LEDs					\$ 4.38
	RED	LED	3	\$ 0.32	\$ 0.96
	YELLOW	LED	2	\$ 0.39	\$ 0.78
	GREEN	LED	3	\$ 0.88	\$ 2.64
Transistors NPN					\$ 0.66
	MMBT2222	Transistor NPN	3	\$ 0.22	\$ 0.66

	Value	Description	Qty.	Unit \$	Total \$
Resistors					\$ 2.68
	100	Resistor	2	\$ 0.033	\$ 0.07
	240	Resistor	1	\$ 0.033	\$ 0.03
	330	Resistor	4	\$ 0.072	\$ 0.29
	374	Resistor	1	\$ 0.007	\$ 0.01
	866	Resistor	1	\$ 0.072	\$ 0.07
	1.2k	Resistor	1	\$ 0.072	\$ 0.07
	1.5k	Resistor	2	\$ 0.072	\$ 0.14
	10k	Resistor	20	\$ 0.033	\$ 0.66
	1k	Resistor	4	\$ 0.034	\$ 0.13
	4.7k	Resistor	3	\$ 0.072	\$ 0.22
	62K	Resistor	1	\$ 0.072	\$ 0.07
	510 0.5W Resistor		2	\$ 0.460	\$ 0.92
Voltage Regulators					\$ 2.48
		Voltage Regulator	1	\$ 0.83	\$ 0.83
	3.3V	Voltage Regulator	1	\$ 0.73	\$ 0.73
	5V Reg.	Voltage Regulator	1	\$ 0.92	\$ 0.92
ADXL345 - Digital 3-Axis Accelerometer (I2C/SPI)					\$12.32
		ADXL345 - Digital 3-Axis Accelerometer (I2C/SPI)	1	\$ 12.32	\$ 12.32
OBD Connector					\$ 1.11
	Male OBD2		1	\$ 7.99	\$ 7.99
Crystals					\$ 1.32
	16MHz	Crystals	1	\$ 1.32	\$ 1.32
MOSFET					\$ 2.73
	BSS138	MOSFET	4	\$ 0.45	\$ 1.80
	ZXMP6A	MOSFET	1	\$ 0.93	\$ 0.93
Raspberry Pi Zero					\$35.03
	RPI-ZERO	Raspberry Pi Zero W	1	\$ 35.03	\$35.03
					Grand total
					\$75.07

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		SCANTOOL STN1110 - OBD II to UART Interpreter, QFN-28-S	1	\$ 7.65	\$ 7.65	ZXMP6A13F MOSFET TA
Quad Differential Comparators					\$ 1.16	Raspber ry Pi Zero
	LM339PWR	Quad Differential Comparators	2	\$ 0.58	\$ 1.16	RPI-ZERO Raspberry Pi Zero W
CAN Driver					\$ 1.86	
	MCP2551	CAN Driver	1	\$ 1.86	\$ 1.86	Resistor s
Header					\$ 2.00	100 Resistor
	DNP	Header	1			240 Resistor
		Header	1			330 Resistor
LEDs					\$ 4.38	374 Resistor
	RED	LED	3	\$ 0.32	\$ 0.96	866 Resistor
	YELLOW	LED	2	\$ 0.39	\$ 0.78	1.2k Resistor
	GREEN	LED	3	\$ 0.88	\$ 2.64	1.5k Resistor
Transistors NPN					\$ 0.66	10k Resistor
	MMBT2222	Transistor NPN	3	\$ 0.22	\$ 0.66	1k Resistor
Voltage Regulators					\$ 2.48	4.7k Resistor
		Voltage Regulator	1	\$ 0.83	\$ 0.83	62K Resistor
	3.3V	Voltage Regulator	1	\$ 0.73	\$ 0.73	510 0.5W Resistor
	5V Reg.	Voltage Regulator	1	\$ 0.92	\$ 0.92	
ADXL345 - Digital 3-Axis Accelerometer (I2C/SPI)					\$12.32	
		ADXL345 - Digital 3-Axis Accelerometer (I2C/SPI)	1	\$ 12.32	\$12.32	
						Grand total \$75.07

APPENDIX – FULL GANTT CHART

