CSS: CAR SENTRY SYSTEM

Group 38

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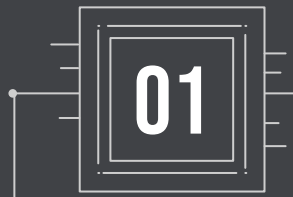

PROJECT OVERVIEW

Motivation, Project Goals/Objectives, Specifications & Requirements

COMPUTER VISION & MOBILE APPLICATION

CV/App Flow & Design, Physical Components Used, & Software Technologies Used

FIRMWARE & MODULES

Firmware Flow & Design, Components Implemented with Firmware

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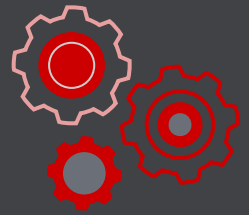
PROJECT OVERVIEW



MOTIVATION

- Driving is a dangerous activity
  - Hit & Run/Reckless Driving
- Difficulty in Memorization
- Wide range of applications
  - Parking
  - Tolls
  - Grounds Management

GOALS AND OBJECTIVES

GOAL:
Produce a low-cost, portable license plate scanner for the average day-to-day driver

OBJECTIVES:

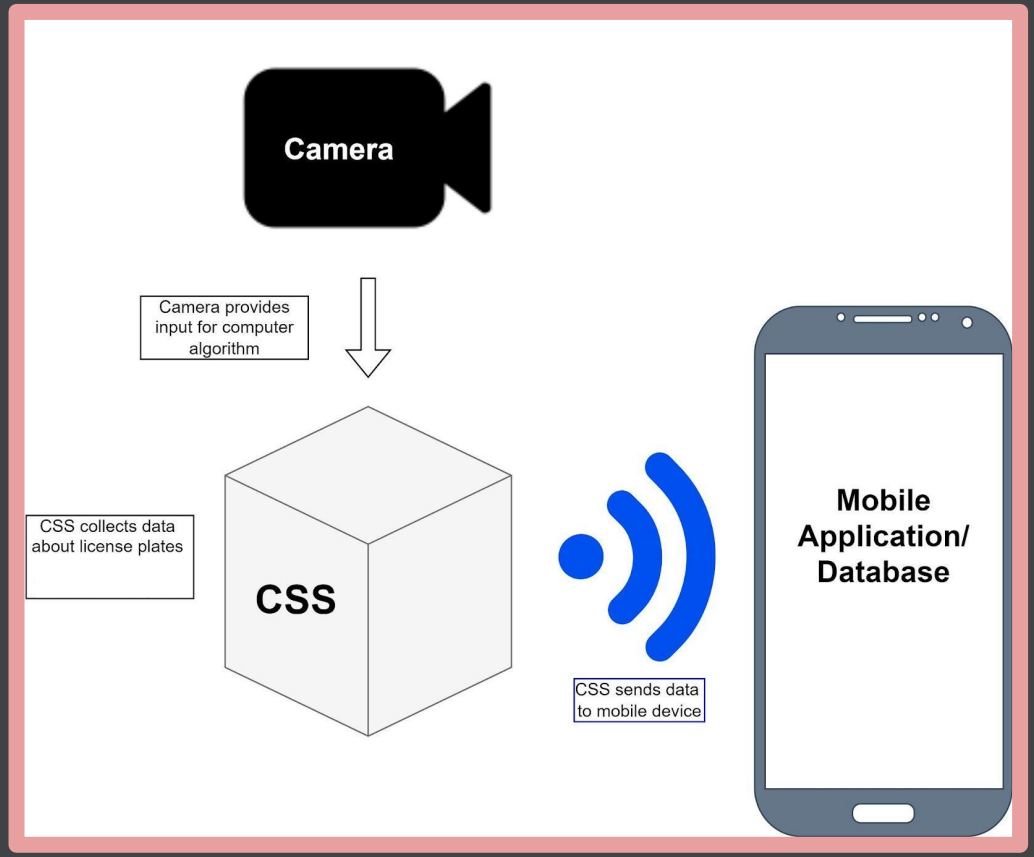
- Scan license plate information for enclosed, 4-wheel civilian vehicles
- Plug-and-Play functionality
- Lightweight & Portable Design
- Crash Survivability
- Prevent Obstruction in Driver View
- Build to IEEE/IEC/UL Standards
- Modular codebase
- Accessible and Convenient to Users (Mobile Application)

SPECIFICATIONS

Demonstrable

Component	Parameter	Design Specification
Battery	Discharge Life	3-5 days (Avg. 40-60 mins/day)
Camera	Resolution	1080p with accuracy of ≥ 90%
Camera	Frame Rate	Process video feed ≥ 20 fps
System	Dimensions	Will not exceed 5"x4"x4"
System	Weight	< 2lb
Enclosure	Survivability	Readable storage after 2-story drop

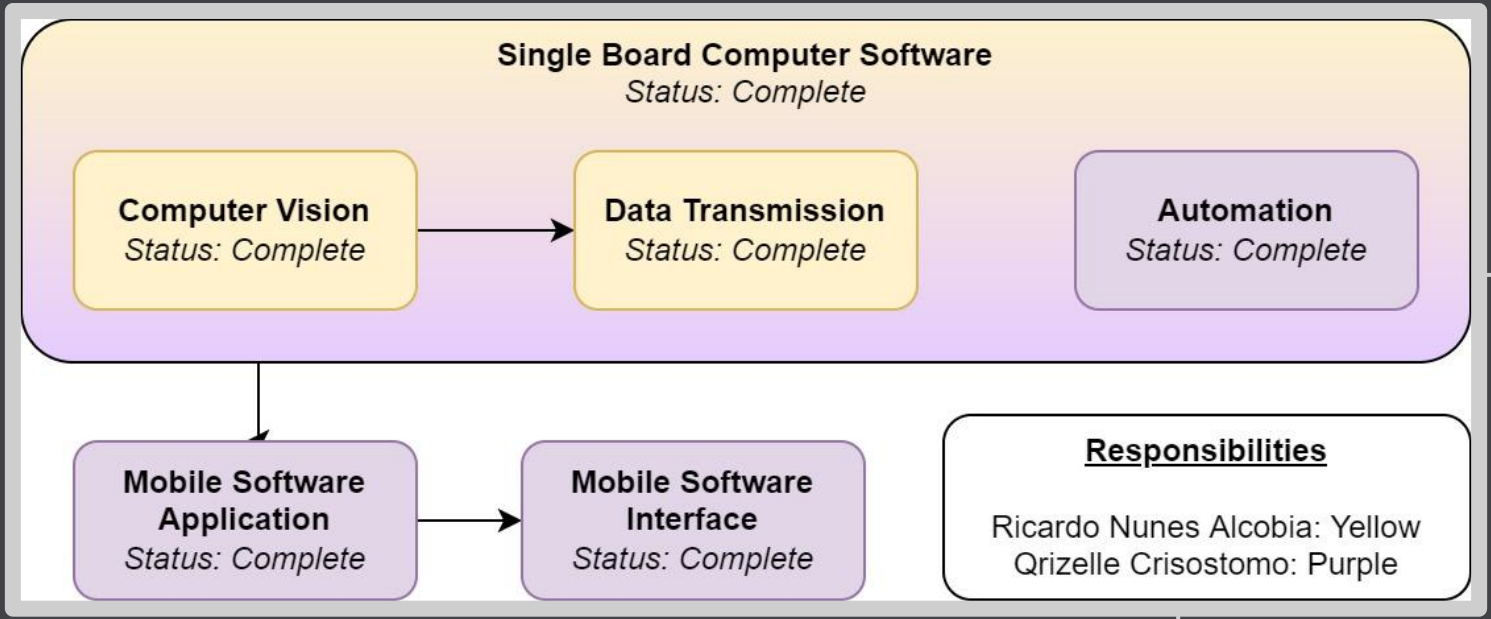
HIGH-LEVEL OVERVIEW



02

COMPUTER VISION & MOBILE APPLICATION

SOFTWARE BLOCK DIAGRAM



SBC ANALYSIS

PROCESSING POWER

Single Board Computer	CPU Clock Frequency (MHz)	GPU Clock Frequency (MHz)
Arduino Nano 33 BLE Sense	64 MHz	N/A
Asus Tinker Board S	1800 MHz	600 MHz
NVIDIA Jetson Nano	1430 MHz	640 MHz
Raspberry Pi 4 Model B	1500 MHz	N/A

ENERGY CONSUMPTION

Single Board Computer	Operating Voltage (V)	DC Current Min - Max (mA)	Power Consumption Min - Max (mW)
Arduino Nano 33 BLE Sense	3.3V	15 - 330 mA	49.5 - 1089 mW
Asus Tinker Board S	5 V	500 - 1000 mA	2500 - 5000 mW
NVIDIA Jetson Nano	5 V	1000 - 2000 mA	5000 - 10000 mW
Raspberry Pi 4 Model B	5 V	540 - 1280 mA	2700 - 6400 mW

MEMORY SIZE

Single Board Computer	Memory (GB)
Arduino Nano 33 BLE Sense	0.001 GB FLASH | 0.000256 GB SRAM
Asus Tinker Board S	2GB Dual Channel DDR3
NVIDIA Jetson Nano	2 GB LPDDR4
Raspberry Pi 4 Model B	2 GB LPDDR4

COST ANALYSIS

Single Board Computer	Board Price ($)	Percentage of System Cost (%)
Arduino Nano 33 BLE Sense	$22.50	4.5%
Asus Tinker Board S	$199.99	40%
NVIDIA Jetson Nano	$62.84	12.6%
Raspberry Pi 4 Model B	$83.95	16.9%

SINGLE-BOARD COMPUTER (SBC)

FEATURES

Powerful GPU in a compact form factor

OVERALL VALUE

Great Value Proposition

WEALTH OF KNOWLEDGE

Extensive Developer Community and Resources

COSTS

Cheaper than comparable alternatives

JETSON NANO

CAMERA

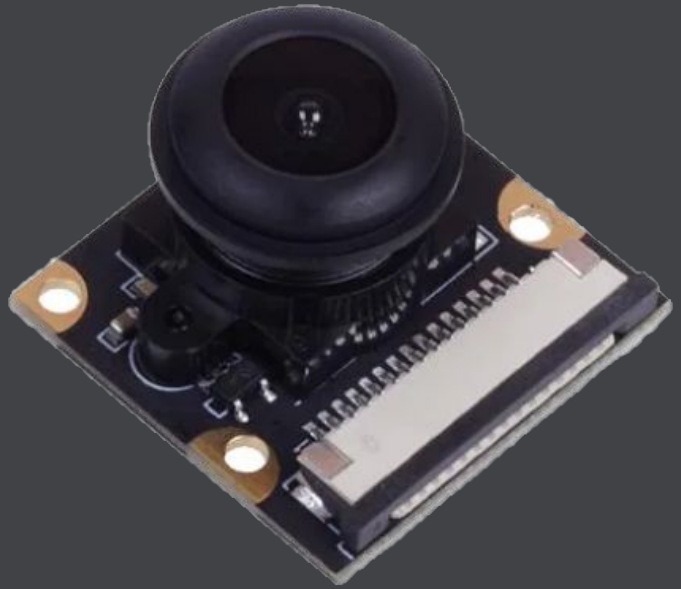
IMX219-130 SEEED STUDIO 114992262

8 MEGAPIXELS

Exceeds 1080p Requirements

130° FIELD OF VIEW

Allows for little distortion



MADE FOR US

Designed specifically to interface with Jetson

COMPUTER VISION

OPENALPR

Supports license plates for over 70 countries
Model trained with a significantly larger dataset

OPENCV

Large library of APIs for object detection
Powerful pretrained models

TESSERACT FOR OPTICAL CHARACTER RECOGNITION (OCR)

To recognize characters

OBJECT DETECTION

Identify and isolate license plate area

TENSORRT

Used for training
Optimized for Nvidia GPUs

EDGE DETECTION

To isolate characters

GRAPHICAL USER INTERFACE & FEATURES

Users are able to create their own accounts and access License Plate data.

MOBILE APPLICATION DEVELOPMENT

FERN STACK

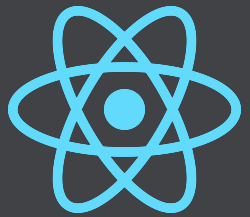
FIREBASE

Robust and scalable database system

EXPRESS

Framework for APIs

Tried and true technology stack.
Facilitates faster development



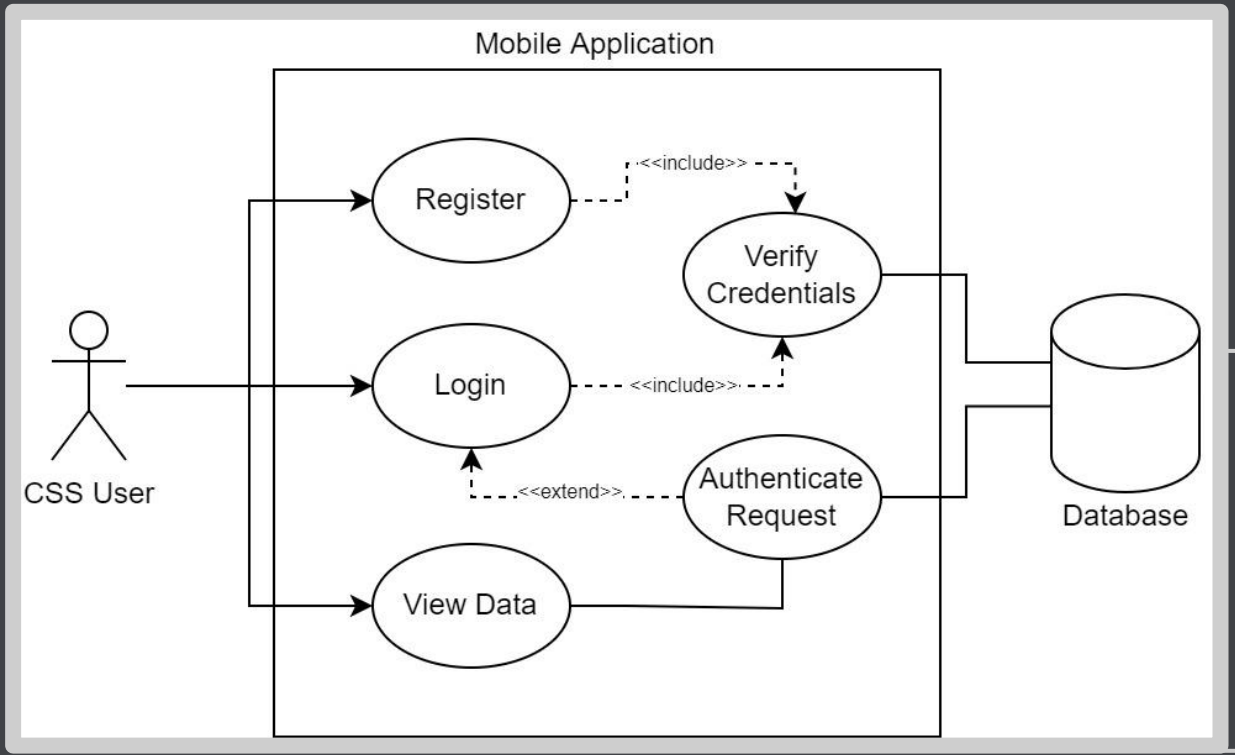
REACT

Team members have experience with REACT frontend dev.

NODE.JS

Backend environment

MOBILE APPLICATION USE CASE DIAGRAM



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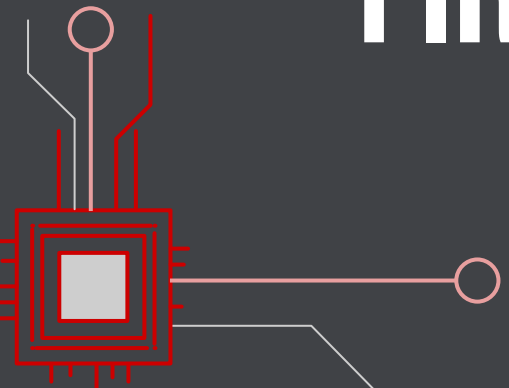
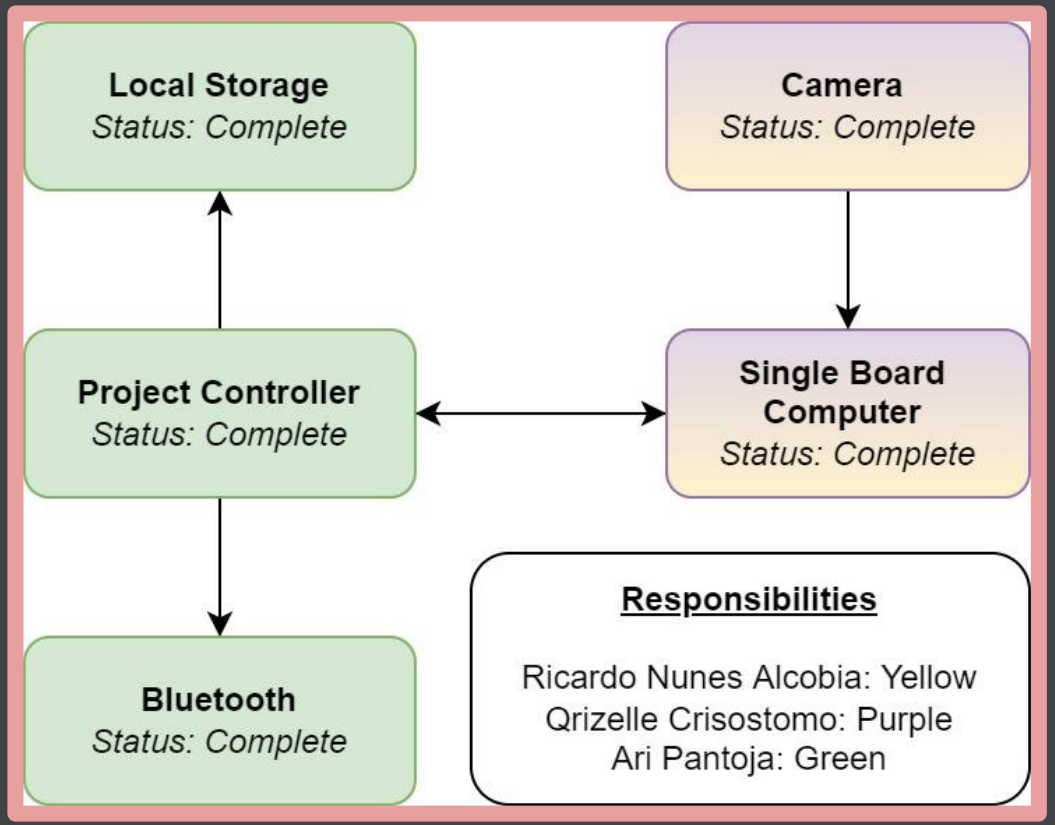
FIRMWARE & MODULES



ELECTRONICS BLOCK DIAGRAM



PROJECT CONTROLLER
TI MSP430FR6989

CONVENIENCE

Familiar and Previously Acquired

CAPABLE

Enough channels to run all communications

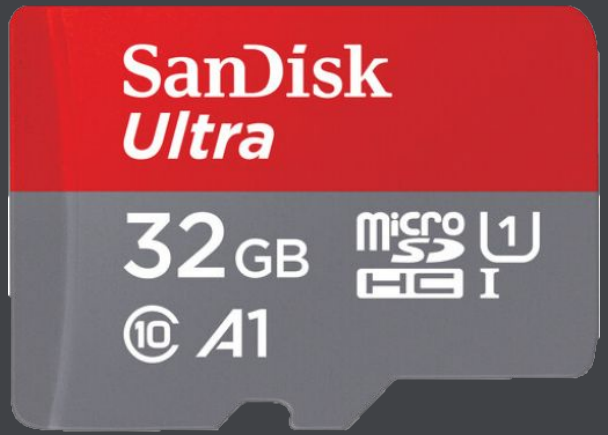
STORAGE UNIT

MORE PERMANENT

Less risk of data loss than BT

PORTABILITY

Can be removed and read in any device that can access uSD Card



RELIABLE

Shown to consistently store .txt files

EASILY ACCESSIBLE

Large variety of uSD Card compatible with FatFs Library

MICRO SD CARD

BLUETOOTH

RAYTAC MDBT42Q-P192

AVAILABILITY

Readily available on many online retailers

USER SUPPORT

Plenty of examples to work with

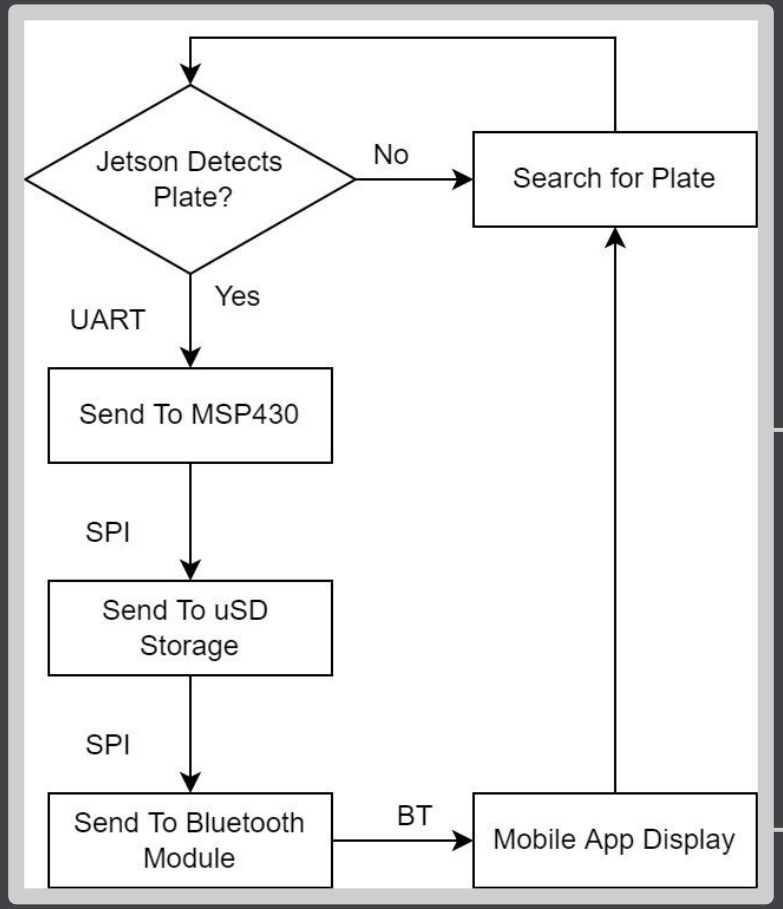
BLUETOOTH 5.0

Fits our Bluetooth 5.0 requirement

EASILY PROGRAMMABLE

J-Link via Nordic Dev Kit

FIRMWARE DATAFLOW



FIRMWARE DEVELOPMENT

Keil
uVision
5

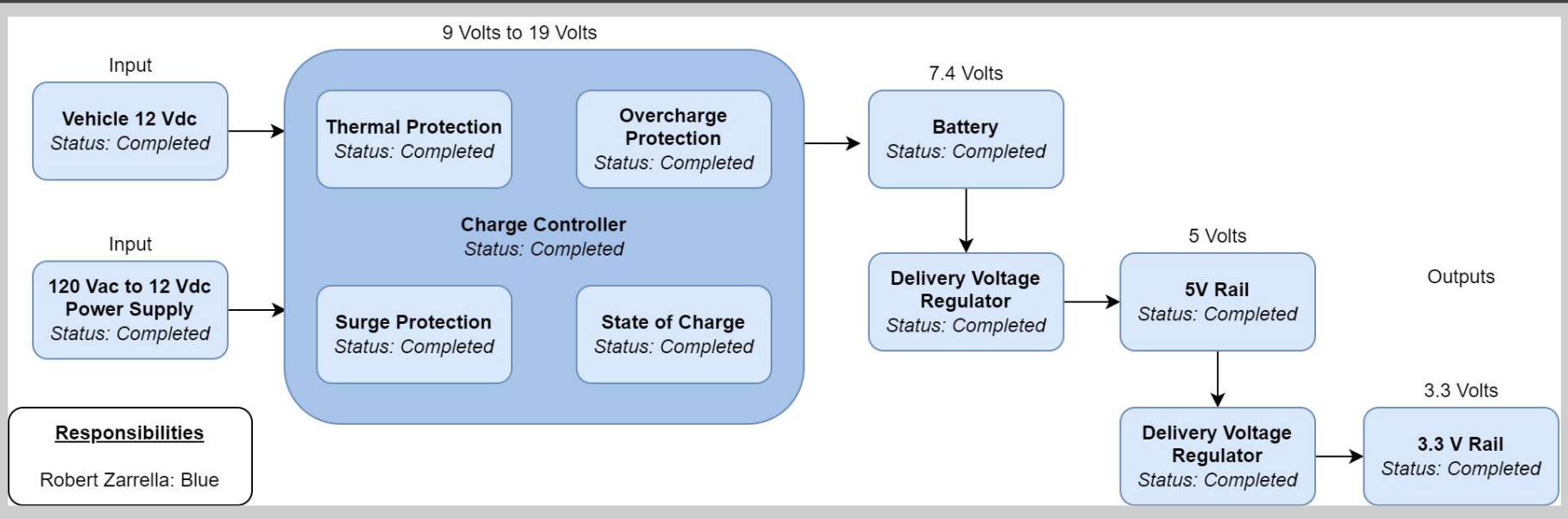
TI CODE
COMPOSER
STUDIO

NORDIC®
SEMICONDUCTOR

04

POWER & PCB

POWER BLOCK DIAGRAM



BATTERY
MAKERFOCUS 9065115

LITHIUM POLYMER
Low Self-Discharge
Resilient to High Temperatures

PROTECTION CIRCUIT MODULE
Thermal Protection
Overcurrent Protection
Short-Circuit Protection

HIGH CAPACITY
10,000 mAh
74 Wh = 8.8 Hrs of CSS operation

STANDARD ADHERENCE
IEEE 1725-2021
IEC/UL 62133

5 VOLT REGULATOR

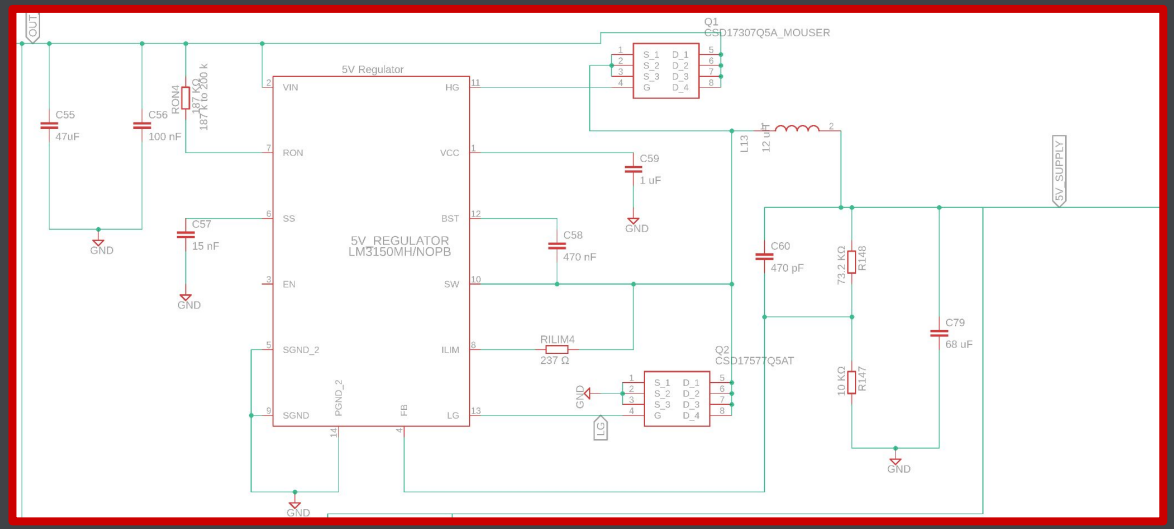
TEXAS INSTRUMENTS LM3150

HIGH EFFICIENCY

96.3%
Drives high efficiency external MOSFETs

OVERCURRENT PROTECTION

Feedback network monitors current



LOW COST

Only 61% cost of comparably efficient topologies

ADDITIONAL PROTECTION

Short Circuit
Soft Start
Thermal

3.3 VOLT REGULATOR

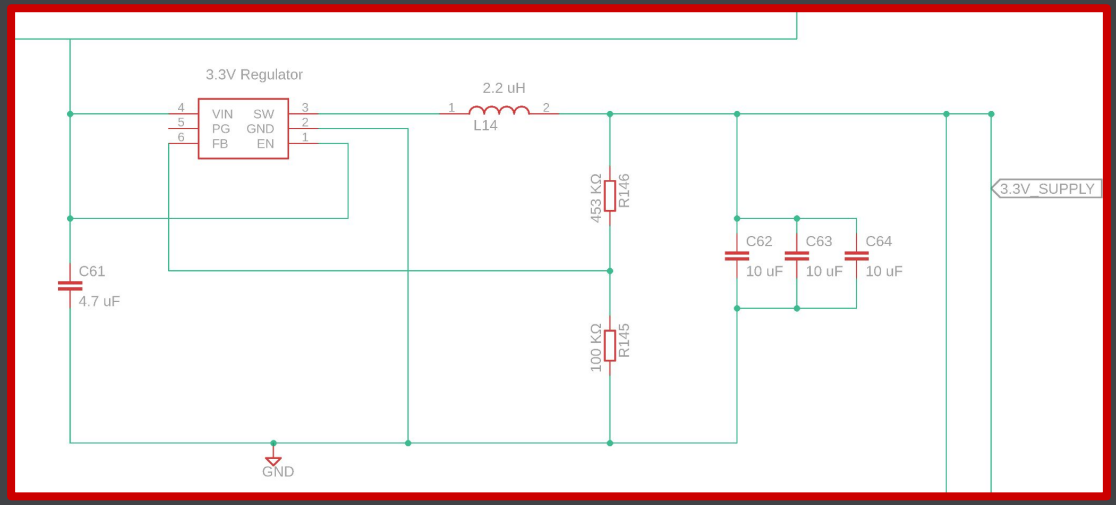
TEXAS INSTRUMENTS TLV62568

HIGH EFFICIENCY

96.26 %
With Minimal
PCB Area and Cost

OVERCURRENT PROTECTION

Integral current detection with auto shut-off and restart



SOFT START

Limits dV/dT to protect sensitive downstream devices

DYNAMIC FREQUENCY

Provides additional efficiency under low load

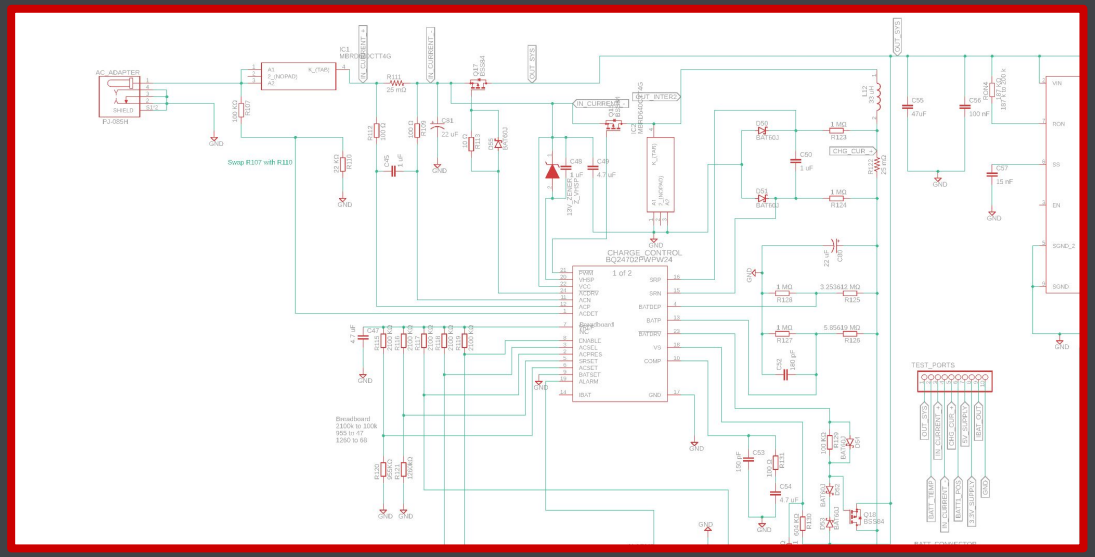
CHARGE CONTROLLER

HIGH EFFICIENCY

Low quiescent power consumption when on battery power

CONCURRENT LOAD/CHARGE

Provides system power from AC while simultaneously charging the batteries



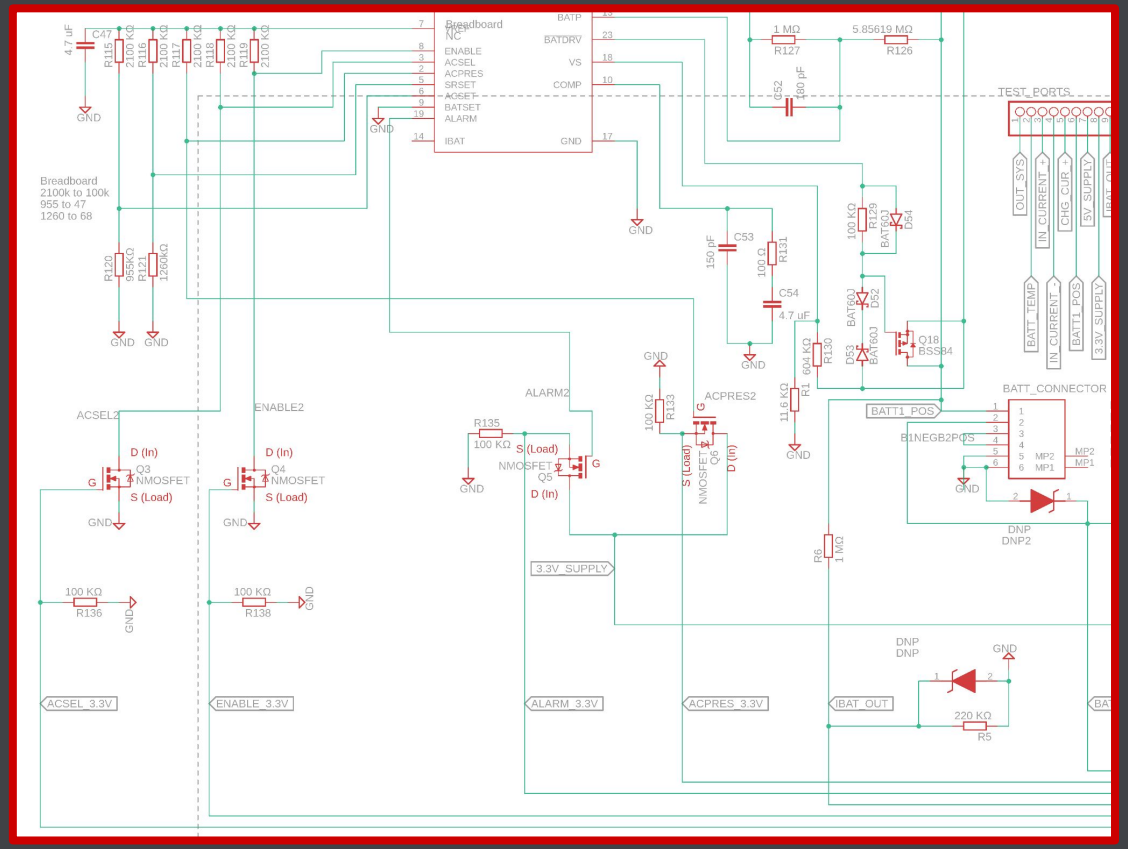
DYNAMIC SOURCE SWITCHING

Seamlessly changes from AC supply to battery supply without interruption

PROTECTION

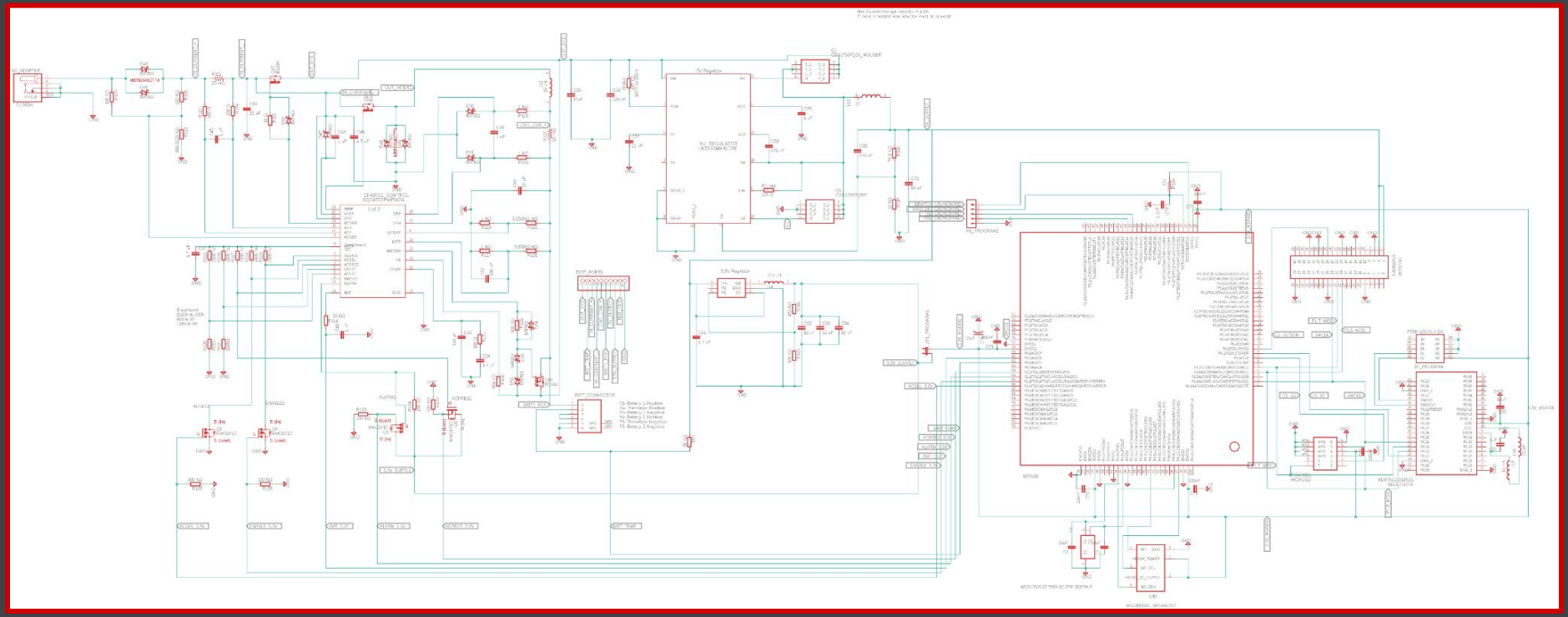
Overcurrent
Undervoltage
Thermal
Short Circuit

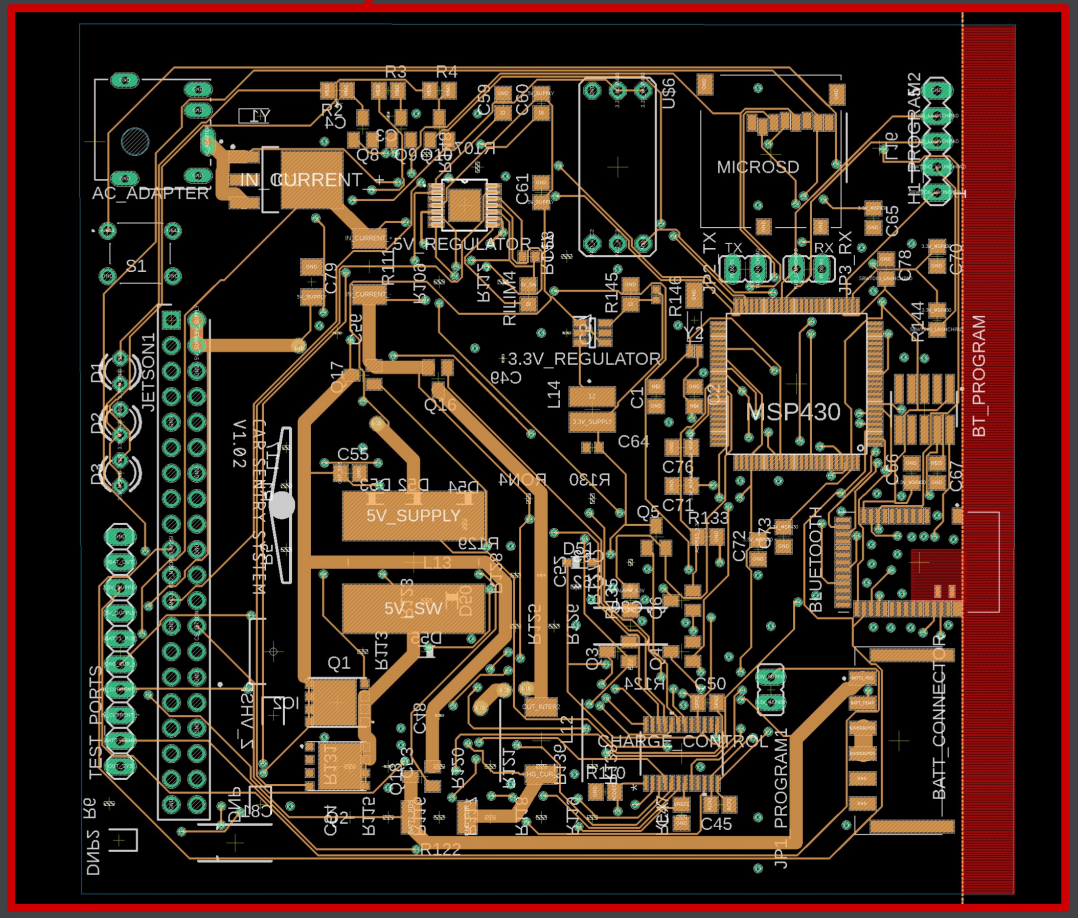
TEXAS INSTRUMENTS BQ24703



CHARGE CONTROLLER TO SYSTEM CONTROLLER COMMUNICATION

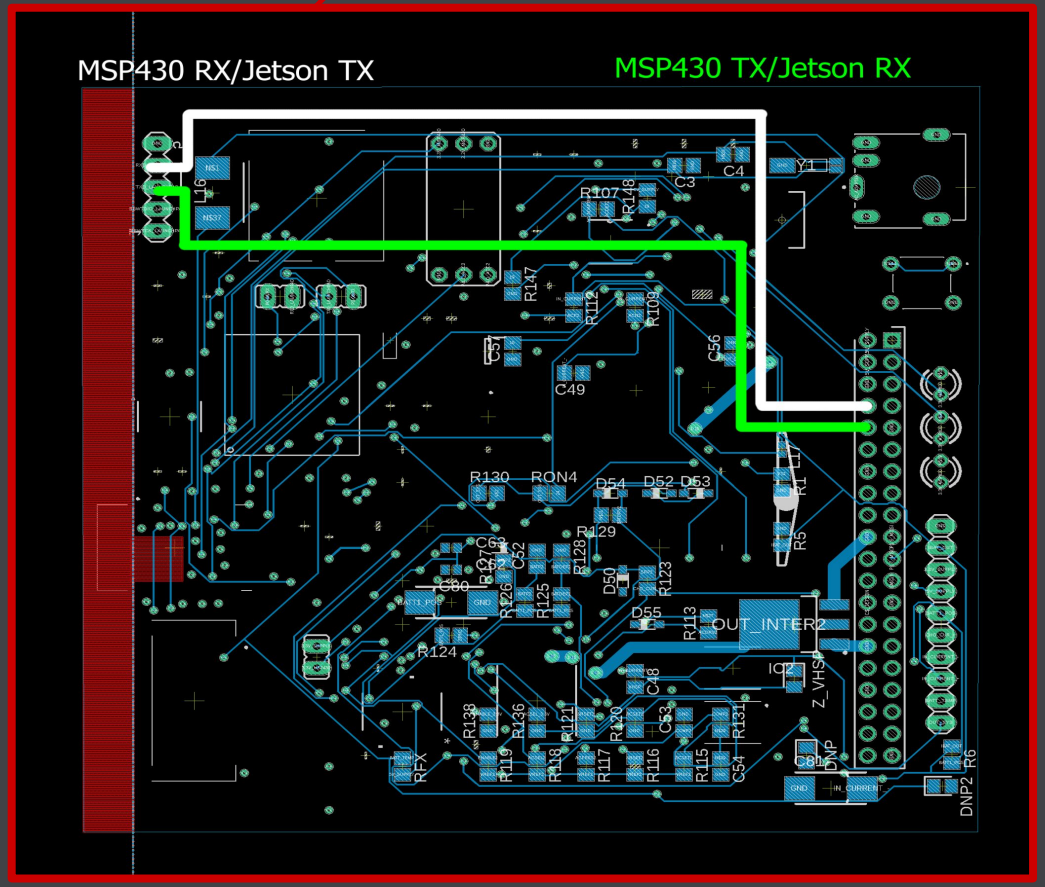
INTEGRATED SCHEMATIC





PCB LAYOUT:

TOP LAYER



PCB LAYOUT:

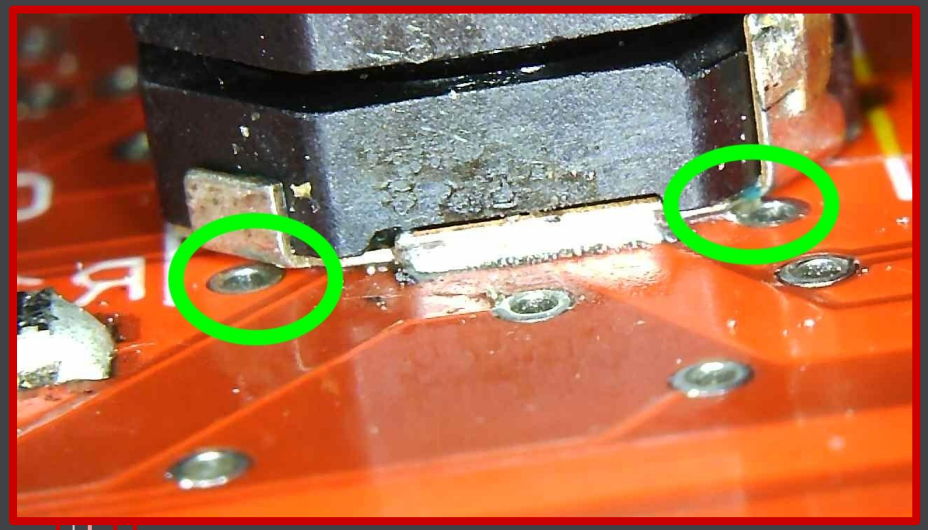
BOTTOM LAYER

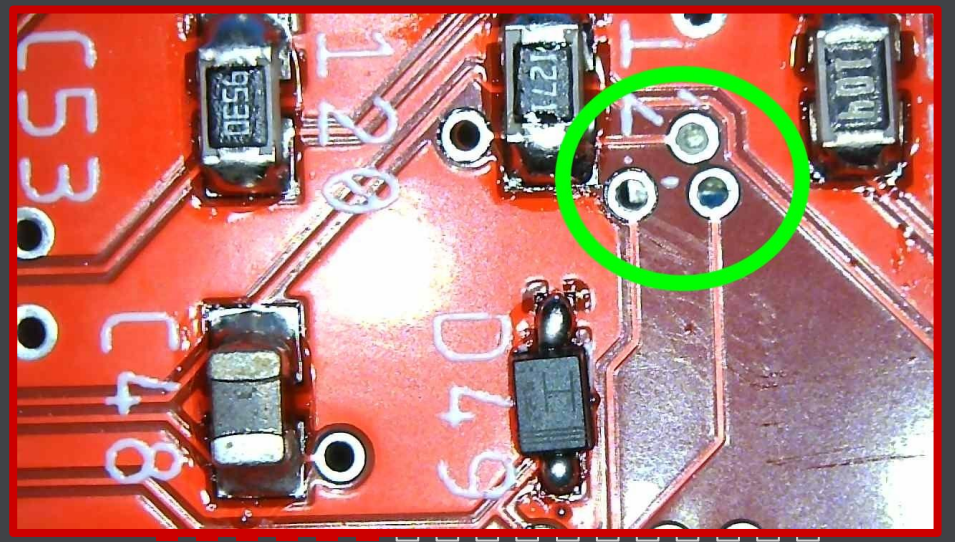
PCB ASSEMBLY WITH NEODEN REFLOW OVEN

Special Thanks to

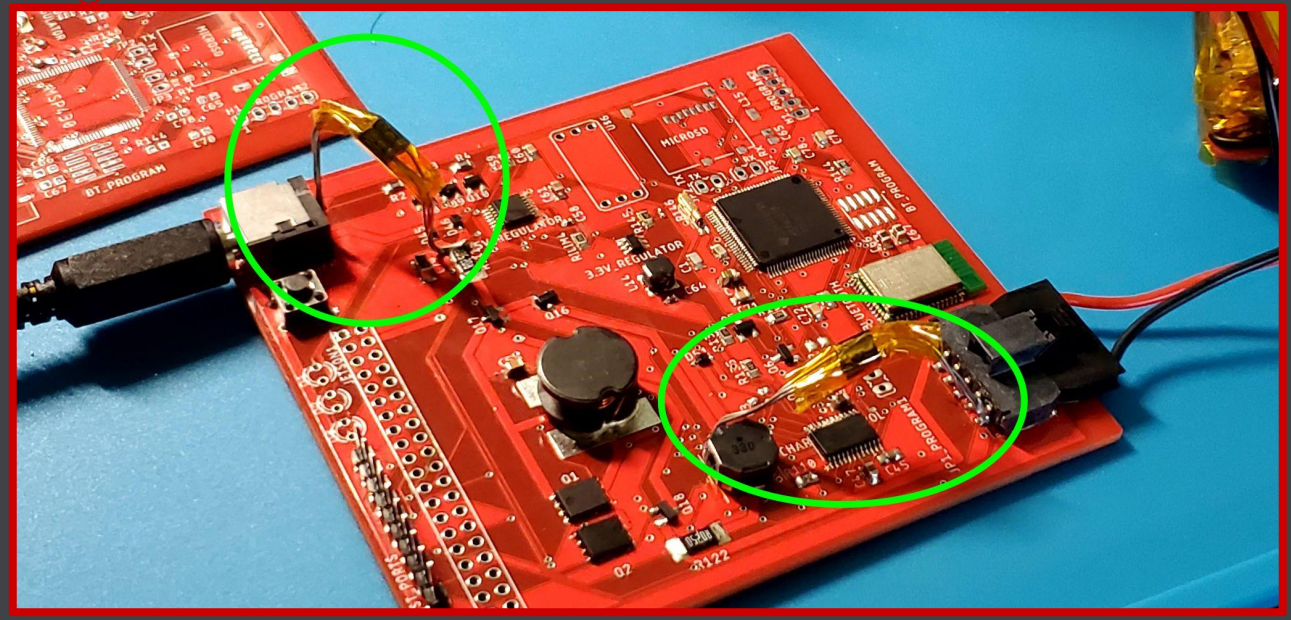
Dr. Avra Kundu
Lab Specialist Zhou

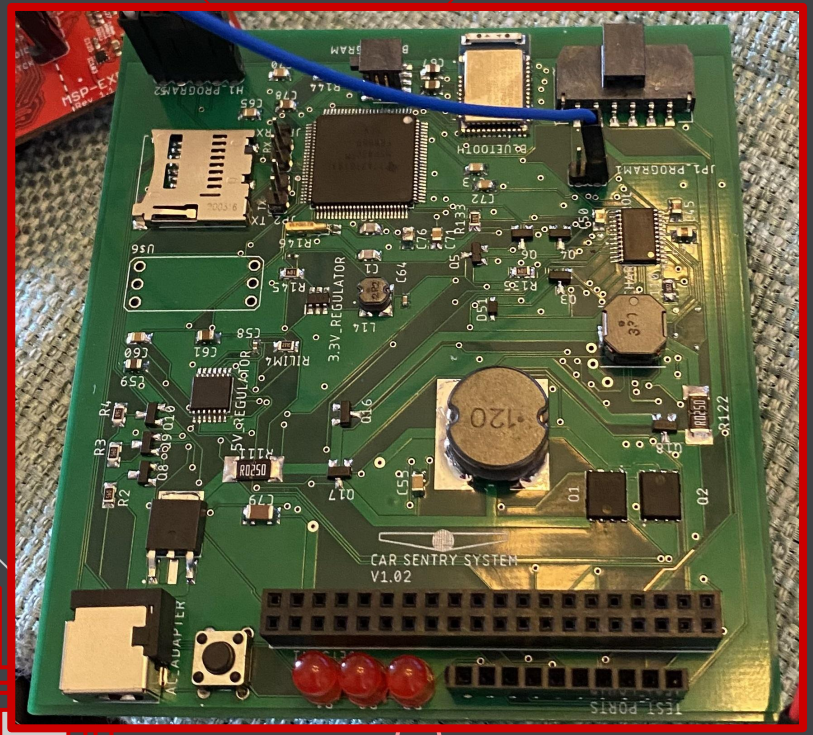
PCB TESTING





PCB TESTING




CAR SENTRY SYSTEM
V1.02
3.3V_REGULATOR
5V_REGULATOR
BLUETOOTH
JP1_PROGRAM1
JP2_PROGRAM2
TEST_PORTS
AC_ADAPTER

FINAL PCB

SYSTEM INTEGRATION

- Four distinct subsystems:
  - Power System
  - System Controller and System Modules
  - Single board computer
  - Mobile Application
- Tested independently before integrating and performing system tests

05

ENCLOSURE

ENCLOSURE

3D PRINTED

ABS Filament for added strength

PCB SLIDE SHELVING

PCB will slide and lock into place

HIGH GRADE SUCTION CUPS

Affixed to Windshield

SLIDE DOOR

Inaccessible while installed

06

CONCLUSION

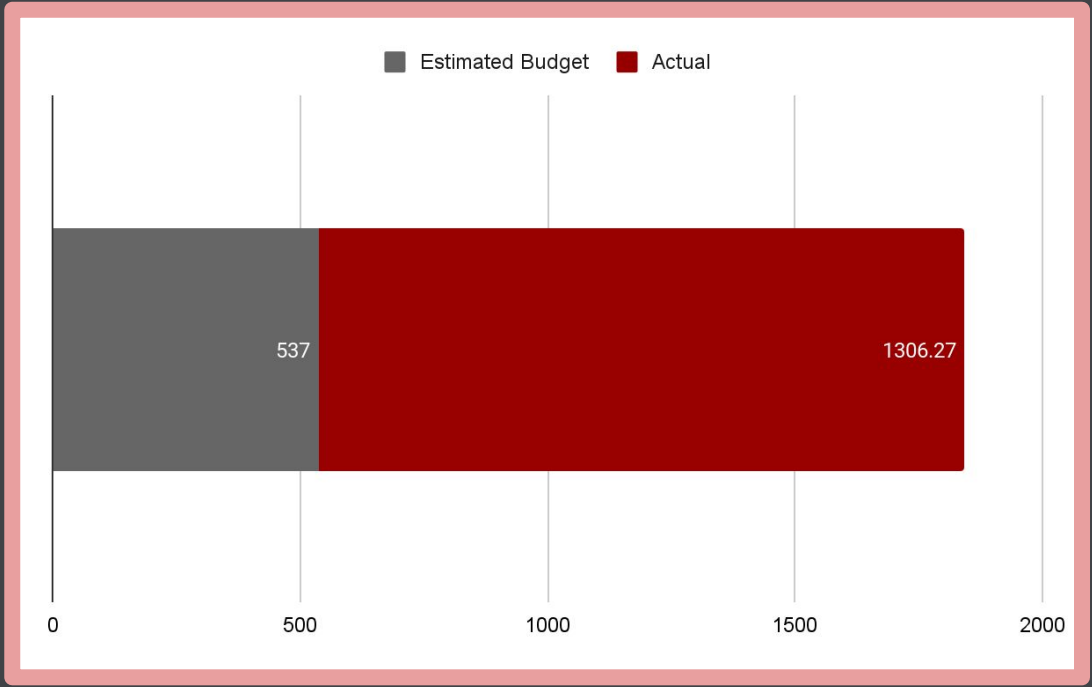
SUCCESSES

- Getting the Nano to read a license plate
- Seamless transition from different power sources
- Data Transmission Across All Modules
- CSS automation

CHALLENGES

- Automation of CV/ML on Jetson
- Data transmission across all components
- Specced some parts too small to solder by hand
- Nordic Software Bugs

BUDGET & FINANCING



BOUGHT TWO JETSON NANO DEV. KITS FOR TESTING

MISC COMPONENTS WERE ANOTHER MAJOR EXPENSE

SECOND VERSION OF PCB HAD TO BE REORDERED

COST OF COMPONENTS

Item	Price	Quantity	Shipping Cost	FL Tax	Total
Example	$0.00	0.00	$0.00	1.07	$0.00
MSP430FR6989	$10.10	2.00	$0.00	1.07	$29.50
NVIDIA Jetson Nano	$59.00	1.00	$0.00	1.065	$62.84
5V 4A Power Supply	$12.59	2.00	$0.00	1.065	$26.82
2.5 to 2.1mm Adapter	$8.96	2.00	$0.00	1.065	$19.08
4GB NVIDIA Jetson Nano	$169.95	1.00	$0.00	1.065	$181.00
GY-521 MPU-6050 MPU6050 Module 3 Axis analog gyro sensors	$2.64	1.00	$0.00	1	$2.64
WAVGAT Micro SD Storage Expansion Board	$1.83	1.00	$0.00	1	$1.83
Accelerometer & uSD expansion	$3.25	1.00	$0.00	1	$3.25
10000mAh LiPo Batteries	$12.00	2.00	$0.00	1	$24.00
Cooling Unit	$24.38	2.00	$1.50	1	$50.26
uSD Module	$0.20	1.00	$1.80	1	$2.00
GPS Module	$2.60	1.00	$1.65	1	$4.25
Camera Module	$19.90	1.00	$0.00	1.07	$21.29
Accelerometers	$1.49	2.00	$0.00	1.07	$3.19
Mouser Shipping	$7.99	1.00	$0.00	1	$7.99
10000mAh LiPo Battery	$13.82	2.00	$0.99	1.07	$30.56
BL651/BL652 Breakout PCB	$8.00	2.00	$9.98	1.065	$27.02
128GB uSD Cards	$17.99	2.00	$0.00	1.07	$38.50
438-MXC4005XC-B Accelerometer Board	$19.94	1.00	$5.99	1.07	$27.33
MSP430FR6989 to Solder Test and LFC Oscillators	$34.98	1.00	$0.00	1	$34.98
nRF52 Dev Kit	$39.00	1.00	$0.00	1	$39.00
Black ABS Enclosure Filament	$18.09	1.00	$0.00	1	$18.09
Misc. Connectors and SMD Components	$54.70	1.00	$7.99	1.065	$66.25
JLCPCB Order	$37.93	1.00	$42.68	1	$80.61
Enclosure Suction Cups	$15.97	1.00	$0.00	1.065	$17.01
Noctua 40mm Fan 5V	$13.95	1.00	$0.00	1.065	$14.86
8MP IMX219-77 Camera		1.00			25.2
Arducam 5MP Camera and supplies		1.00			34.03
PCB (less what is already on here) Components Lump Sum	314.66				314.66
	36	10.00	62.24		98.24
Grand Total					$1,306.27

WORK DISTRIBUTION

	ROLES	RESPONSIBILITY
QRIZELLE C.	Lead Mobile Developer	Computer Vision and Mobile Application
RICARDO N.	Lead Computer Vision Developer	Computer Vision and Mobile Application
ARI P.	Lead Firmware Developer	Hardware (PCB) and Firmware Development
ROBERT Z.	Lead Power Systems and PCB Design Engineer	Hardware (PCB) and Schematic Integration

FINAL THOUGHTS

COLLABORATION

Two online meetings weekly

Working in the senior design lab

Almost always had a team member in the lab

FEEDBACK

Storing images as an added backup on the Nano

Streamlined wireless connectivity

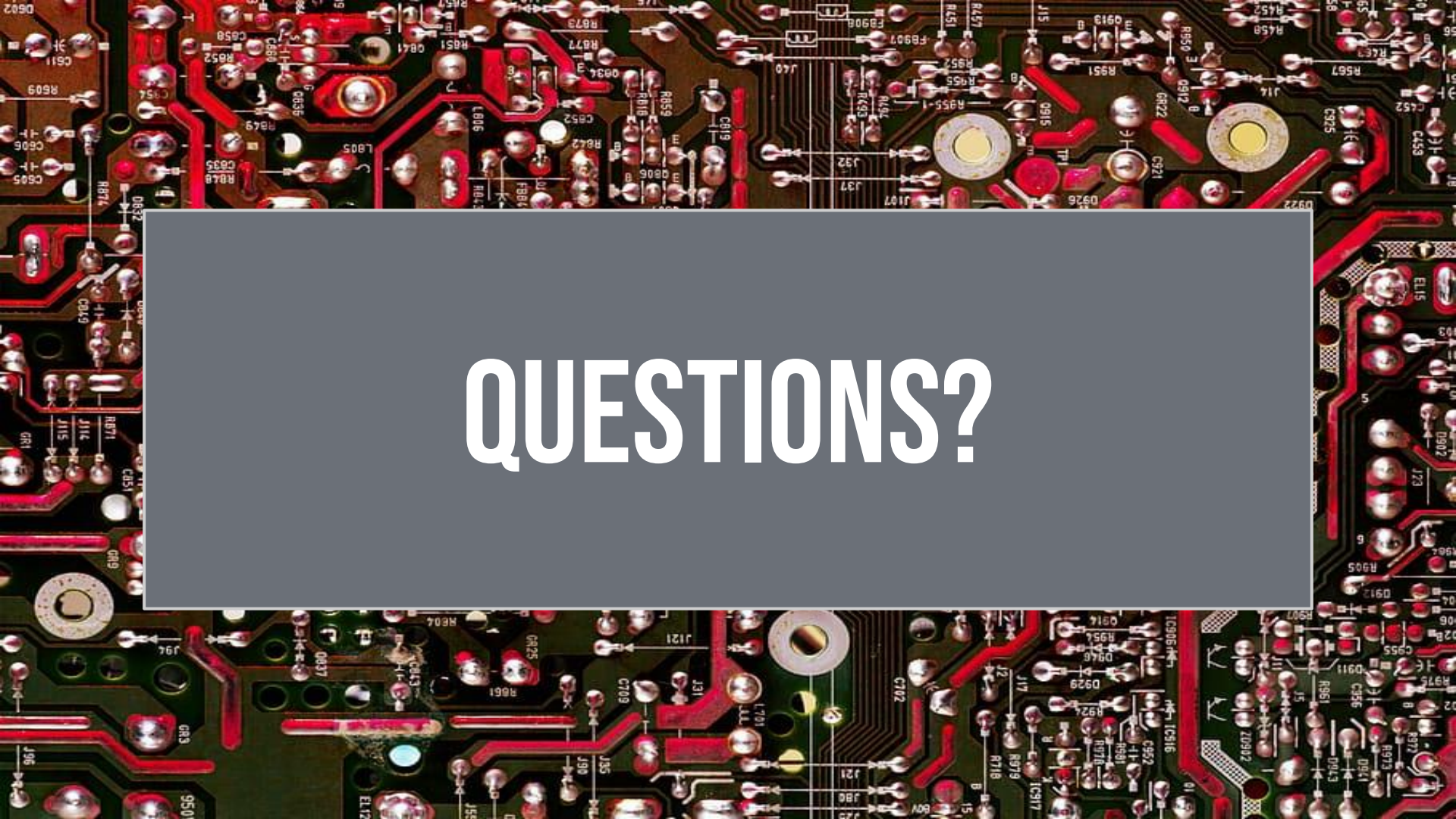
Built in suction cup

BIGGEST LESSONS LEARNED

Communication is key

Start early on all components to get a better scope of the work required

Online forums are not the most reliable resource


QUESTIONS?