Dwight Look College of ENGINEERING
TEXAS A&M UNIVERSITY

ECEN 403 Final Presentation

Sandia Resilient Lidar
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Michael Yoon

TA: Vishwam Raval
Sponsor: Sandia National Labs

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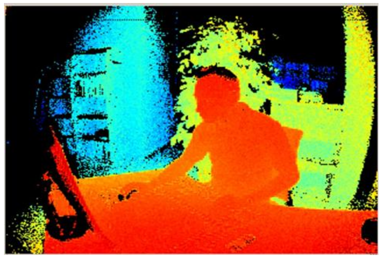
Project Summary

Problem statement:

- Existing physical security cameras each have their own weaknesses

  - RGB Cameras -> Struggle in the dark
  - IR Cameras -> heat shielding
  - Passive IR Motion Detection -> move slowly

- Our sponsor desires a reliable, accurate, and configurable sensing solution that doesn’t suffer from these weaknesses.



Reference: ESPROS, DME660 datasheet

Our Solution:

- Use 3D indirect Time-of-Flight LiDAR
  - Works in complete darkness
  - Detects all motion including depth
  - Configurable for diverse applications
  - Not intended for streaming footage

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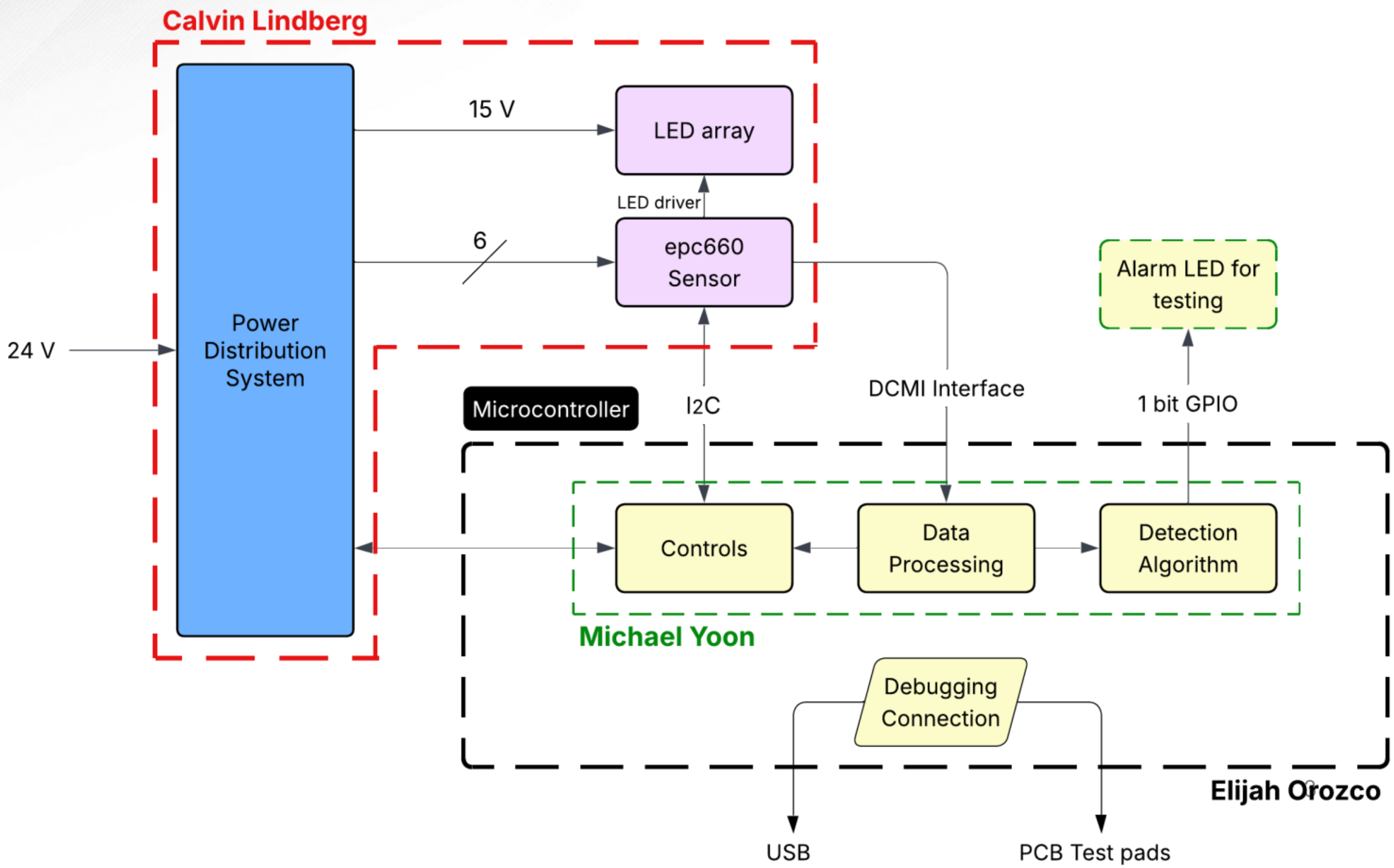
Subsystem Overview



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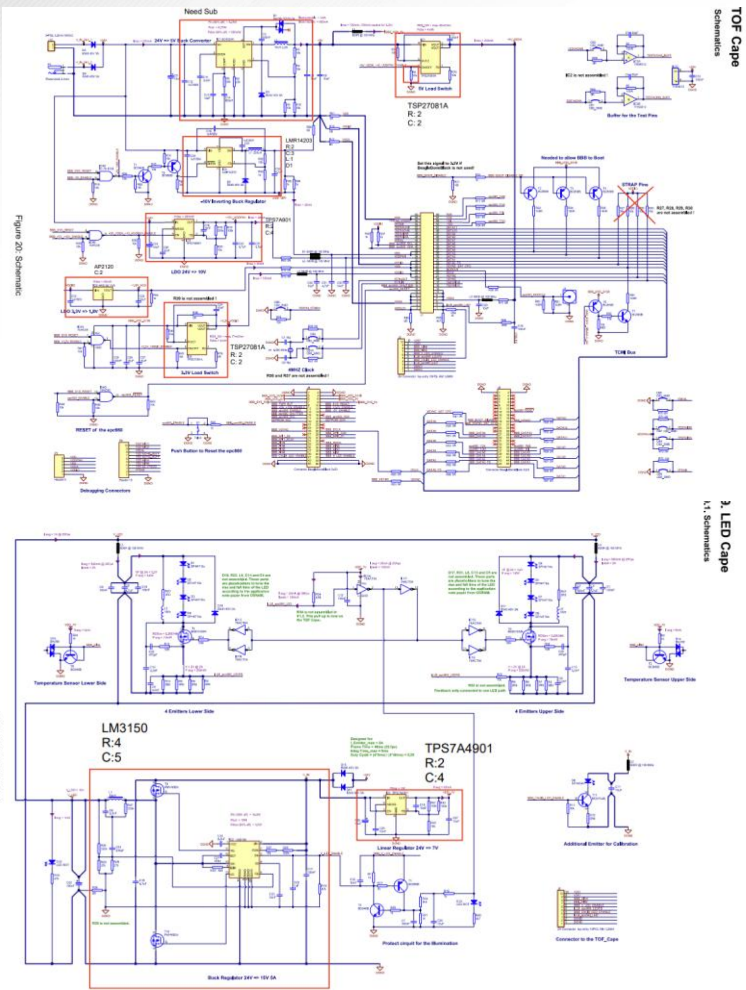
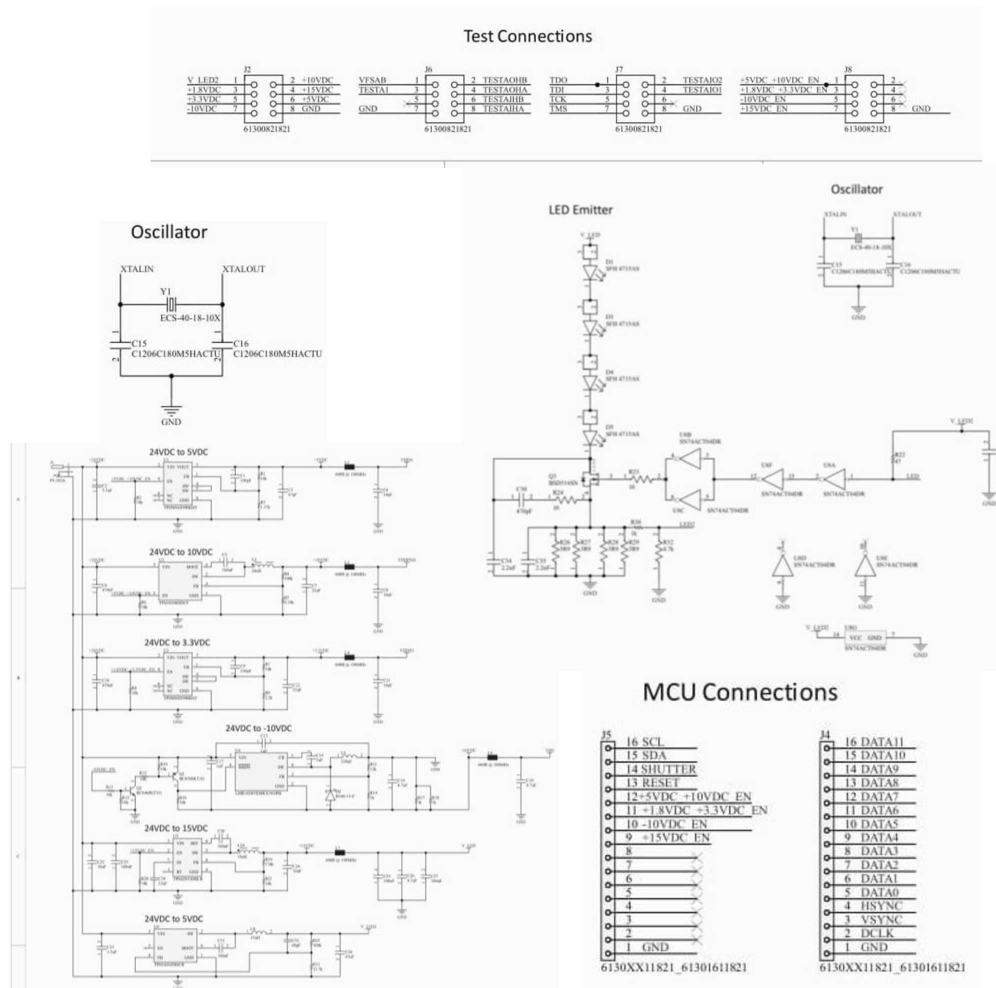
Power and LED Subsystem

Calvin Lindberg

DME660:

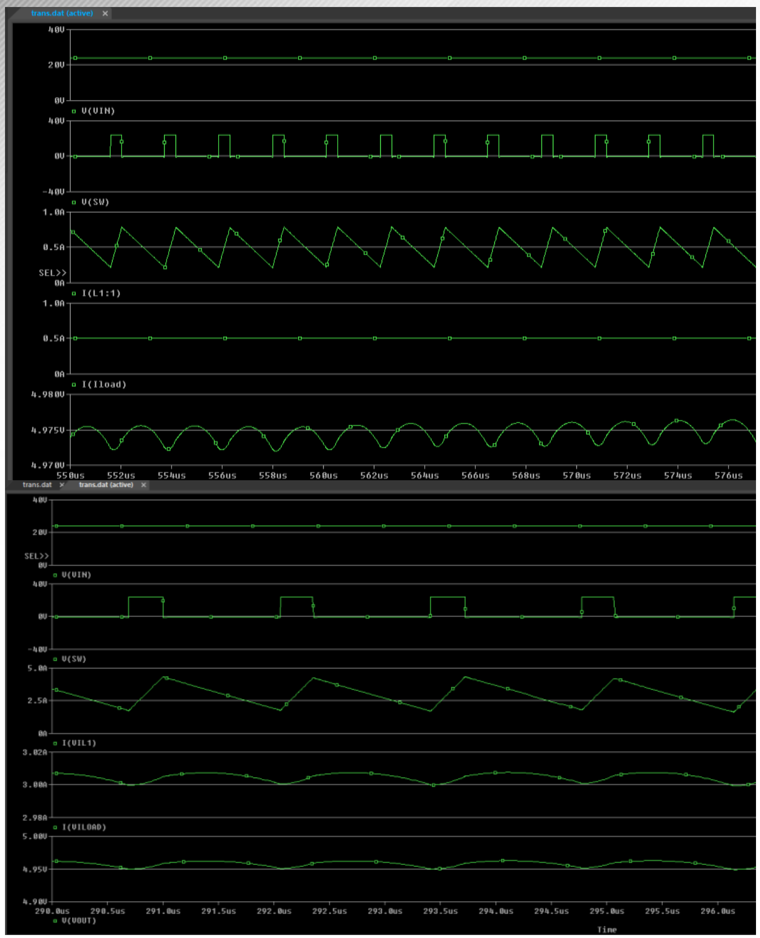


Our Design:



Power and LED Subsystem

Calvin Lindberg

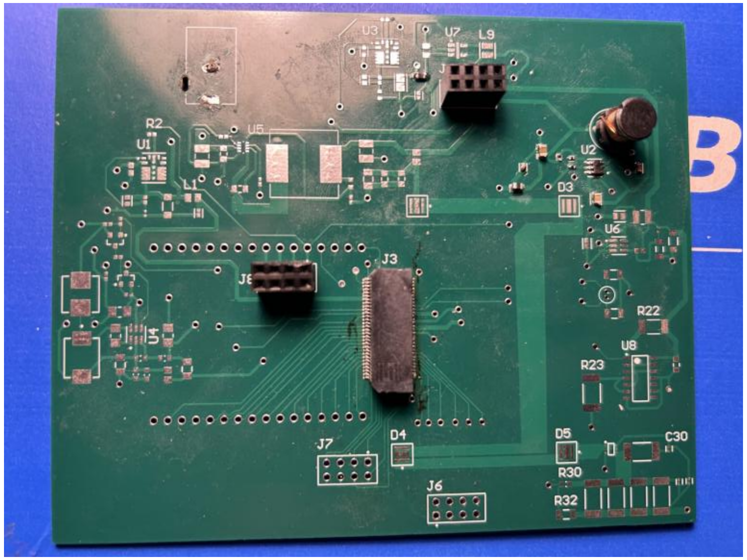


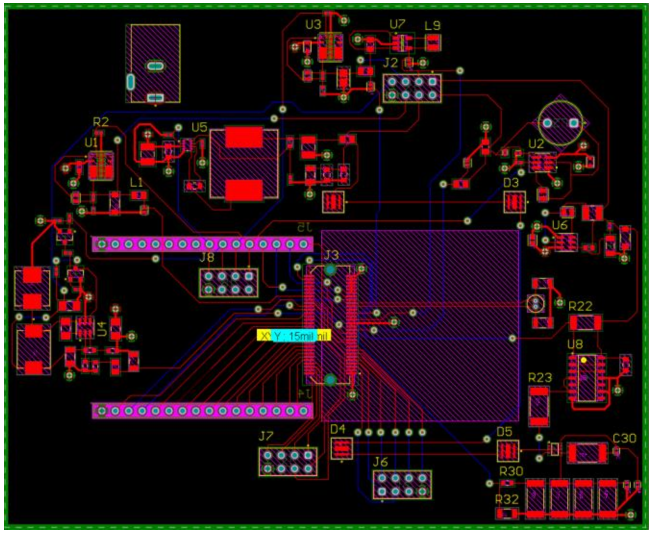
Voltage	Epc660 Ripple	Max Current	Acceptable Ripple	Voltage Maintained Under Load
-10V	≤50mV	17mA		
1.8V	≤20mV	24mA		
3.3V	≤50mV	8mA		
5V	≤50mV	356mA		
5V (LED)	NA	150mA		
10V	≤20mV	13mA		
15V	NA	200mA		

- All Simulated converters had acceptable ripple and maintained correct voltage level under load

Power and LED Subsystem

Calvin Lindberg





- Able to Validate 10v Converter

Power and LED Subsystem

Calvin Lindberg

Test Name	Success Criteria	Methodology	Status	Responsible Engineers
Voltage Spikes in Power Supplies	The Vout stays constant over a a range of input values	Use a signal generator to create a voltage sweep or spike and measure outputs	PARTIALY TESTED	Calvin Lindberg
Voltage Level and Enable Signal	The output voltage levels stay within an acceptable range during steady state and enable	Using the test headers and benchtop multimeters/power supply test all power output and enable signals	PARTIALY TESTED	Calvin Lindberg

- Board was originally going to be preassembled due to time constrains

Power and LED Subsystem

Calvin Lindberg

Catch up:

- Test and Validate other converters
- Redesign board for easier soldering

ECEN 404:

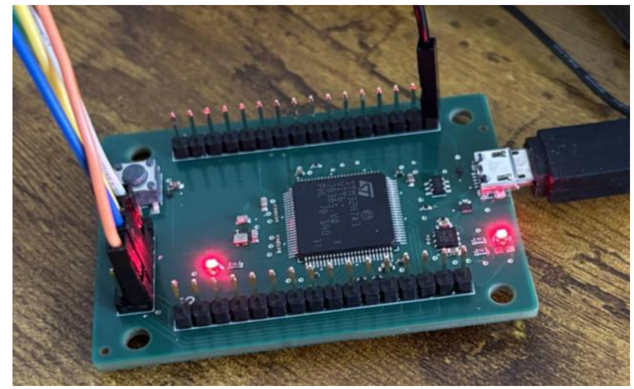
- Further validation using EPC660 and MCU connections
- Create Separate board for LED emitter circuit

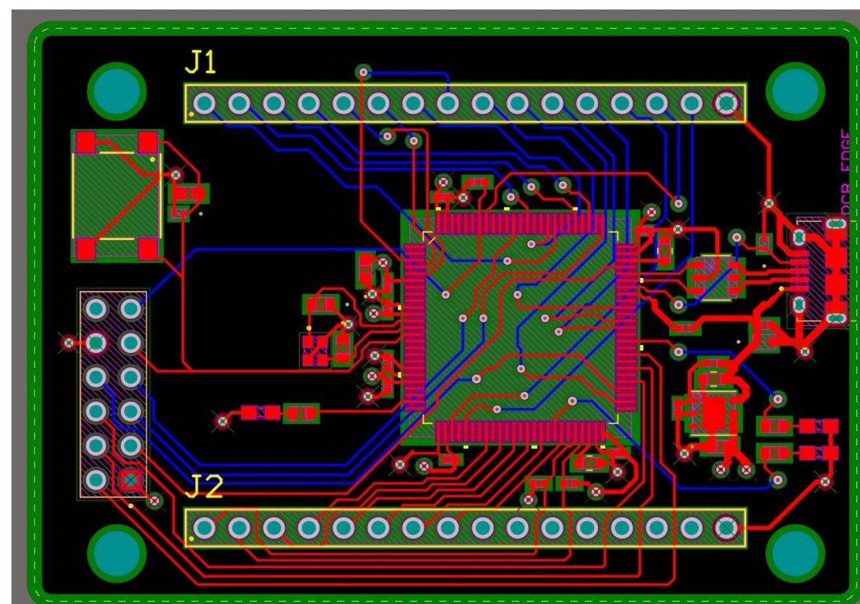
MCU Subsystem

Elijah Orozco

- The MCU board has been designed and fabricated
- The MCU has passed some testing, but more is required

Test Point	Valid
Power	
Reset	
GPIO 1-4	
CC Pins	
I2C	
DCMI	

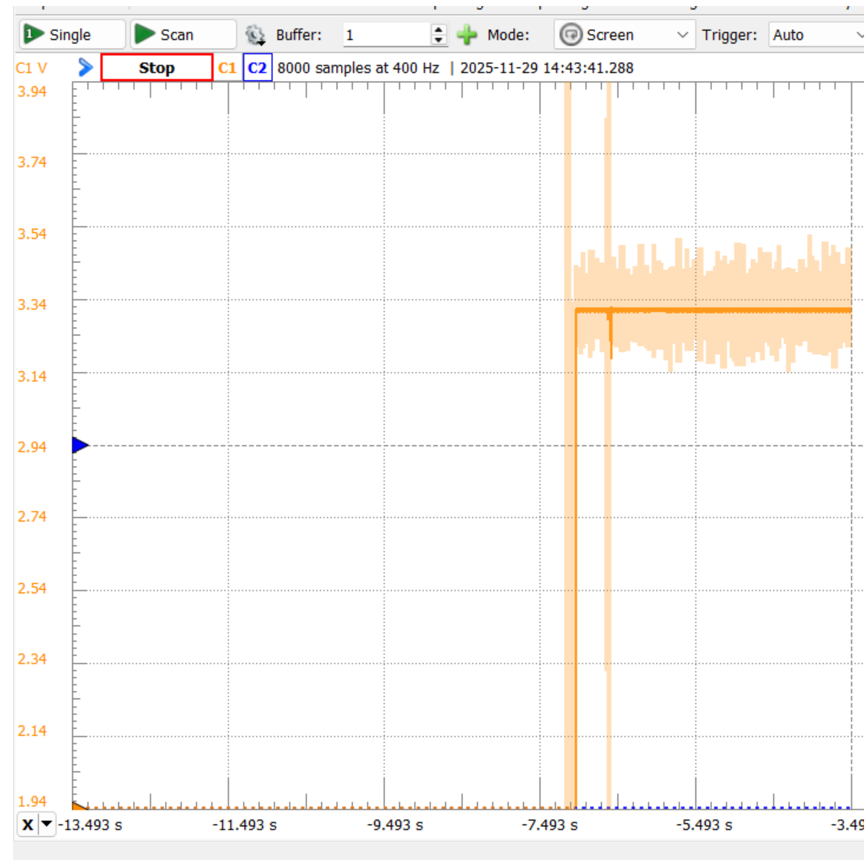




MCU Subsystem Results

Elijah Orozco

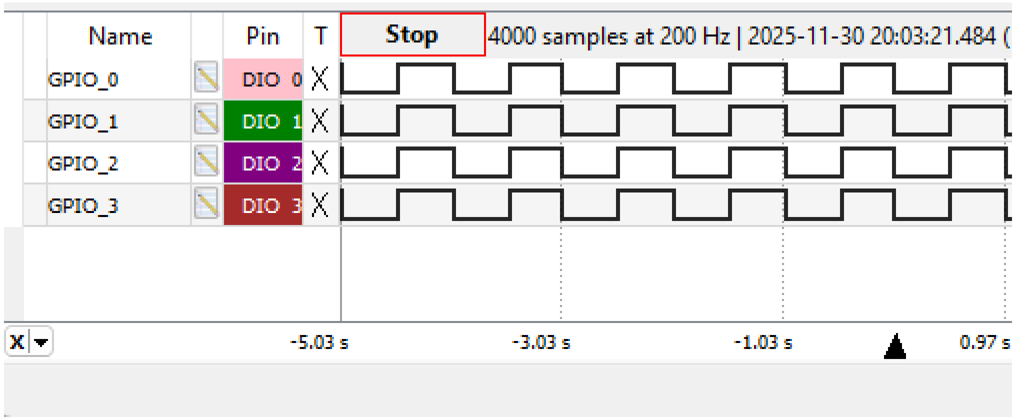
- The MCU is supplied by a 3.3V line coming from an LDO
- The LDO provides the correct voltage from the 5V supplied by the micro USB cable

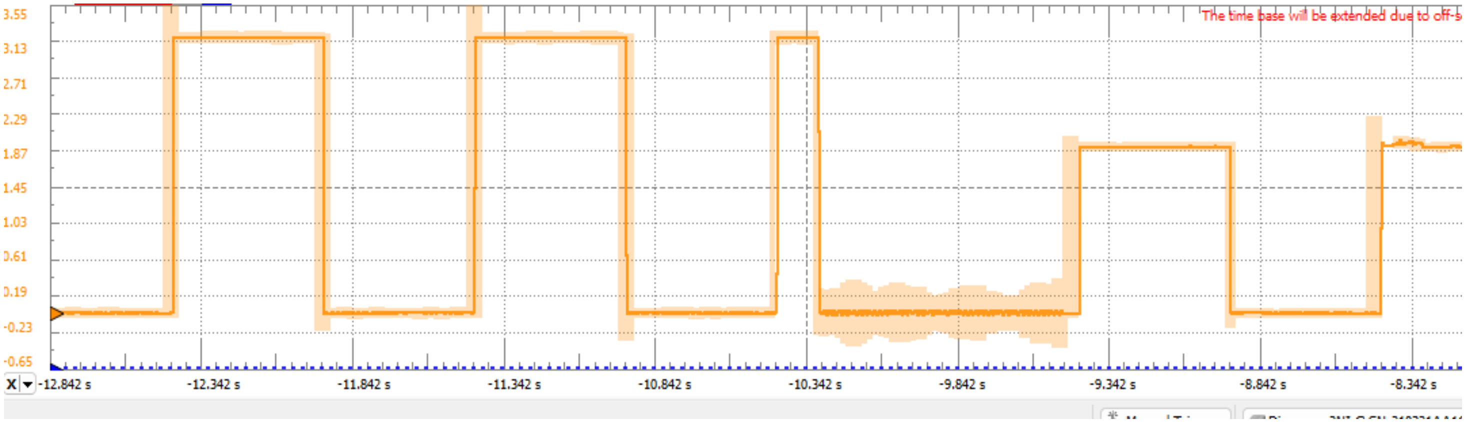


MCU Subsystem Results

Elijah Orozco

- GPIO pins are able to toggle and provide the correct power





MCU Subsystem Validation

Elijah Orozco

Test Name	Success Criteria	Methodology	Status	Responsible Engineers
MCU Voltage spikes	MCU remains functional after power is removed	Unplug the MCU from the USB power supply	Succes	Elijah Orozco
MCU output signals	Output signals for data lines match the dev board	Measure the output signals with an oscilloscope and compare.	Partial Succes	Elijah Orozco

- The MCU works when the USB power is disconnected and reconnected
- The output signals for GPIOs work but I2C and DCMI still need to be tested

MCU Subsystem Remaining Task

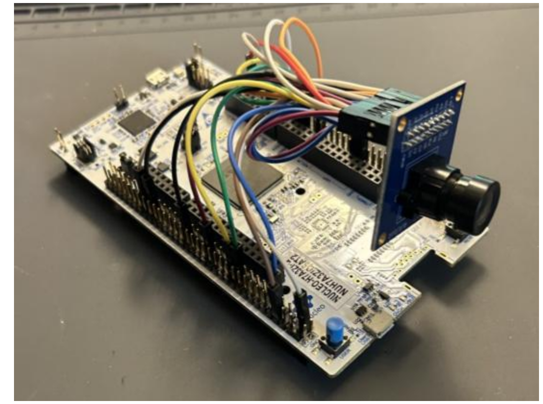
Elijah Orozco

- The DCMI and I2C communication need to be tested and verified
- A redesign of the MCU board so that fabrication is easier. This includes bigger parts and more board space.
- Potential addition of flash storage and ethernet

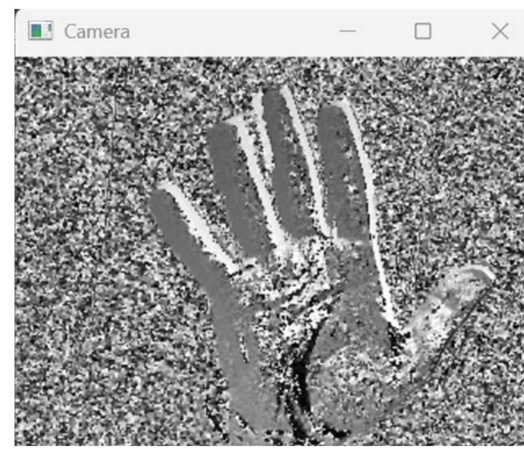
Software Subsystem

Michael Yoon

- Completed software
  - Raw 4-Frame acquisition
  - Memory allocation (>0.9 out of 1MB of RAM used)
  - Depth processing calculations
  - Motion (intruder) detection
  - Frame transmission to host PC
  - Simulated LiDAR data
  - Debugging “command line” interface via serial communication



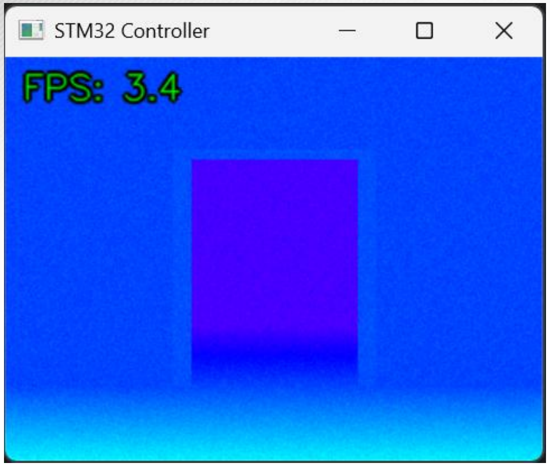
STM32 with OV7670 Camera Module



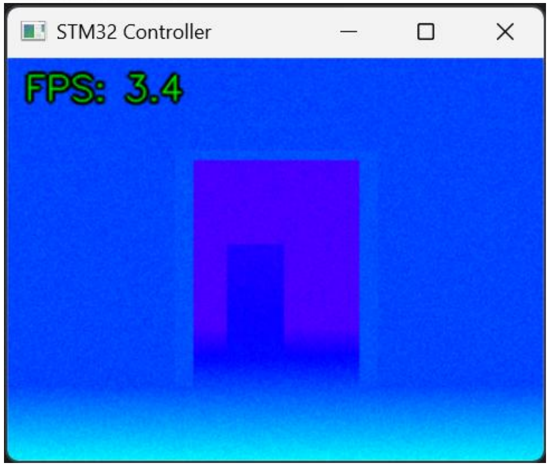
Acquisition, depth processing, and transmission performed on junk data

Software Subsystem

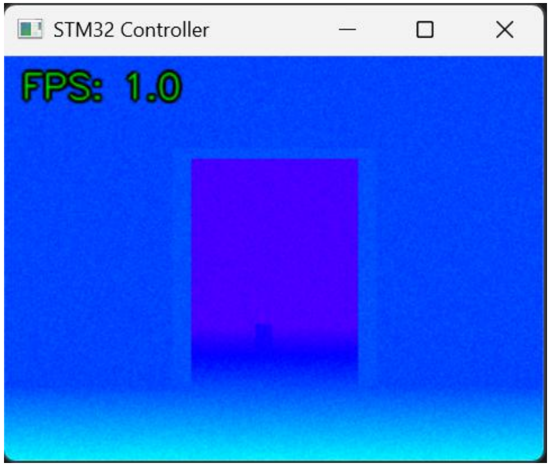
Michael Yoon



Simulated scene – depth is mapped to color

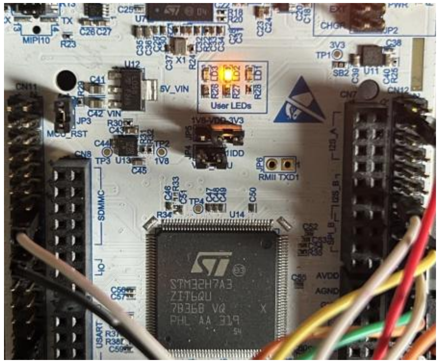


Simulated scene – with “intruder”



Simulated scene – small “intruder”

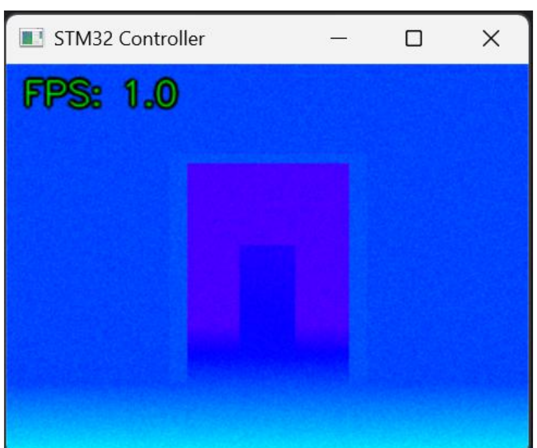
- Includes simulated noise
- An “intruder” crosses the scene and is detected, causing a light to turn on.



- Example commands
  - Calibrate: sets reference frame
  - MAX_FRAMERATE
  - DISPLACED_THRESHOLD: Sets the number of pixels that must be displaced to trigger the alarm
  - DATA_LOG: Displays useful debugging and timing info
- Settings are stored in non-volatile FLASH memory

```
--- TYPE COMMANDS BELOW AND HIT ENTER ---
>> MODE_CAPTURE
[STM32]: Command: MODE_CAPTURE
[STM32]: Switched to MODE_CAPTURE
>> CALIBRATE
[STM32]: Command: CALIBRATE
[STM32]: Calibration request queued
[STM32]: Reference frame CALIBRATED.
>> MAX_FRAMERATE=1
[STM32]: Command: MAX_FRAMERATE=1
[STM32]: MAX_FRAMERATE set to 1
>> DISPLACED_THRESHOLD=100
[STM32]: Command: DISPLACED_THRESHOLD=100
[STM32]: DISPLACED_THRESHOLD set to 100
>> DATA_LOG
[STM32]: Command: DATA_LOG
[STM32]: Avg DCMI capture (10 frames): 1210095.375 ms
[STM32]: Avg depth calc (10 frames): 75498.742 ms
[STM32]: Avg USB TX (10 frames): 137416.484 ms
[STM32]: Avg displaced pixels (10 frames): 72338.6
>> |
```

Fixed a bug where the first command didn't register



This window was captured after resetting the STM32. It still maintains framerate settings.

Software Subsystem Validation

Michael Yoon

Test Name	Success Criteria	Methodology	Status	Responsible Engineers
Robustness to disconnects	The STM32 and sensor continue to function despite unexpected disconnects	The reset button will be rapidly pressed and USB power rapidly switched	TESTED (not on epc660)	Michael Yoon
Important configurations are permanently stored in non-volatile memory	Framerate, mode, and error threshold settings persist despite losing power	Apply specific settings such as a max framerate of 2, then disconnect and reconnect power. Check whether the framerate continues to be set to 2.	TESTED	Michael Yoon
At least 1 FPS during full 4 DCS capture.	When capturing 4 DCS frames for maximum accuracy, the sensor should record at least 1 frame per second.	The sensor will be configured to capture 4 DCS frames and the framerate will be measured	TESTED (not on epc660)	Michael Yoon
Intruder detection	Motion and displacement within the frame immediately trigger the sensor	Map the alarm signal to an LED. Simulate motion with reference to the calibration frame, and make sure the LED turns on.	TESTED	Michael Yoon
Resilience to noise	The STM32 when properly calibrated will not report false alarms due to noise	Apply moderate artificial noise (test different levels). Calibrate the STM32, then make sure that intruders are still detected whilst the noise doesn't trigger the sensor by itself.	TESTED	Michael Yoon
Robustness to incomplete frames	The STM32 continues to function if the epc660 gets interrupted during frame transfer	Manually force the sensor to stop sending data mid frame and ensure that the software handles it gracefully	UNTESTED (partially implemented)	Michael Yoon
Software compensation of temperature drift	The epc660 accurately measures depth accurate to 1cm in a wide temperature operating range	Capture distance measurements in the freezer and in the oven (set to ~150 degrees Fahrenheit)	UNTESTED	Michael Yoon

Remaining Tasks

Michael Yoon

- Hardware integration
  - Boot-up code
  - Debugging
  - Calibration

- Full system testing
  - Able to detect intruders of different speeds
  - No false alarms due to noise

Execution Plan

Week of:	8/24	8/31	9/7	9/14	9/21	9/28	10/5	10/12	10/19	10/26	11/2	11/9	11/16	11/23	11/30
TASK															
Project/Team Assignment												**Status:**			
Brainstorming												Completed			
ToF Sensing Module Selection												Delayed			
CONOPS Report												In Progress			
MCU Selection/Order															
ToF Module Study															
PCB Design Study															
Midterm Report															
Midterm Presentation															
Order DMCI Test Module and PCB Components															
Configure DCS Acquisition and processing															
ToF PCB Board Design/Order															
MCU PCB Board Design/Order															
Status Update Presentation															
Build MCU PCB															
Build ToF PCB															
Write debug code for the STM32															
Begin Debugging/Iterating PCB Designs for ECEN 404															
Tune epc660 to Optimize Performance															
Validation and Final Demo of Subsystems															
Final Presentation															
Final Report															

Thank you!

Team 9: Sandia Resilient Lidar