Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

ECEN 404 Final Presentation
Team 28: Livestock Gas Monitor

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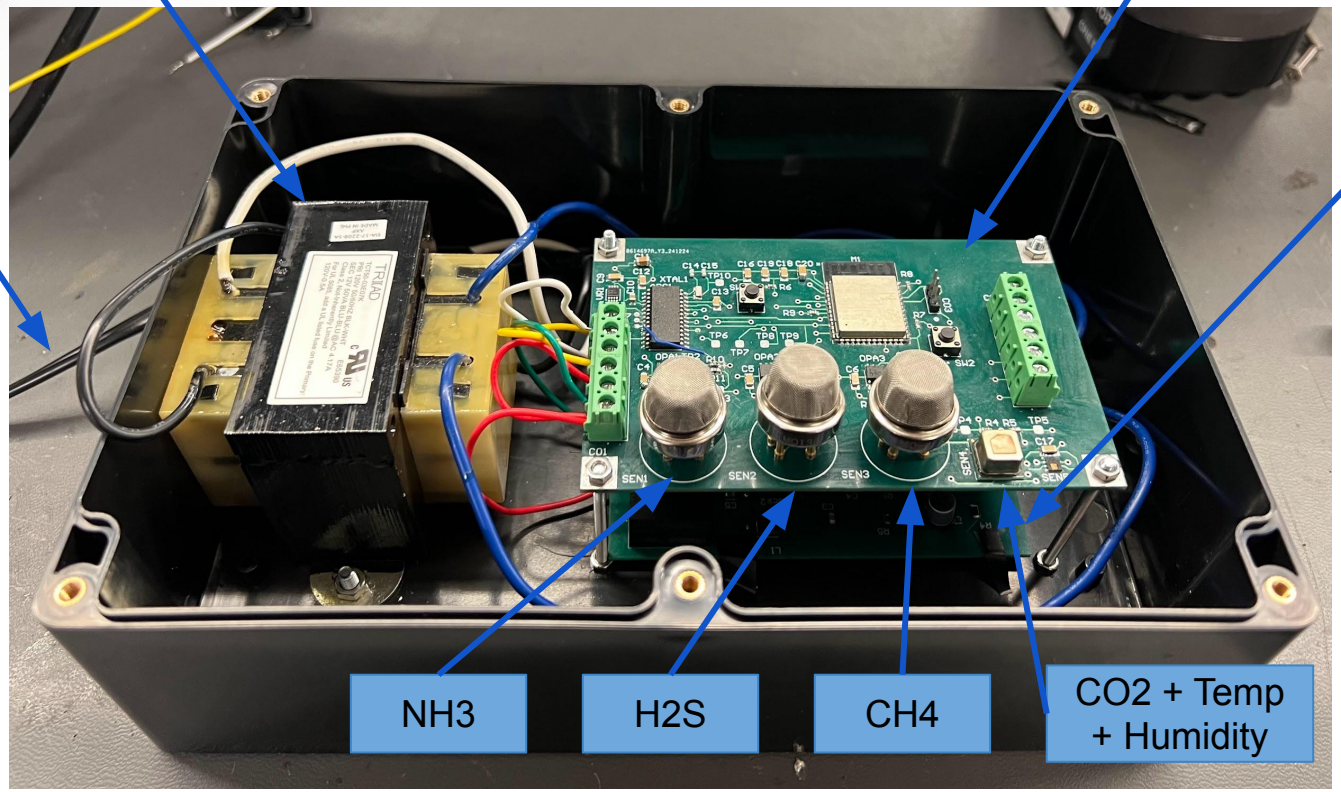
TA: Vishwam Raval

Problem Overview

- Monitoring environmental conditions in animal farms.
- To design and implement a durable, real-time gas monitoring system that can track harmful gases in animal farms.

Integrated Project Diagram



User Interface

Gas Monitoring System

Temperature (°C)

Average: , Min: , Max:

Humidity (%)

Average: , Min: , Max:

CO_2 (ppm)

Average: , Min: , Max:

ID	Temperature (°C)	Humidity (%)	CO2 (ppm)	CH4 (ppm)	NH3 (ppm)	H2S (ppm)	Timestamp
3278	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:38:03
3277	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:58
3276	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:53
3275	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:48
3274	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:43
3273	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:38
3272	25	50	400	0.123456	0.234567	0.345678	2025-03-15 20:37:33

Engineering Design Accomplishments
Blake

- Designed 2 iterations of the sensor pcb that takes measurements of CH4, H2S, NH3, CO2, Temperature, and humidity in the air.
  - PCB consisted of 3 analog sensors, 2 digital I2C sensors, unity gain op amps, ADC, and microcontroller.
- Created equations to convert the voltage level detected to the gas concentration in parts per million.

Challenges	Solutions
Voltage divider for ain1 not working.	Ain1 input on ADC broken, rerouted to ain4.
Analog sensors heating up the board and causing skewed temperature measurements.	External sensor in the housing unit routed to the microcontroller.
Inaccuracy in voltage to ppm calculations.	Looked over datasheet again and fixed the equations.

Engineering Design Accomplishments
Blake

NH3 (ppm)	H2S (ppm)	CH4 (ppm)
27.5278	0.1324	0.336903
37.7256	0.135651	0.330812
602.433	0.113883	0.255422
37.541	0.172677	0.462406
37.6081	0.169129	0.382718
27.3617	0.104913	0.492009
28.5659	0.113744	0.398275

Temp with sensors (F)	Temp without sensors (F)
88.71	75.77
89.11	75.73
86.37	75.74
86.63	75.69
86.85	75.68
87.06	75.71
87.28	75.72

Engineering Design Accomplishments
Blake

Input Value	Output Value	Corrected Value	Error (%)
0.25	0.272611	0.24996	0.00016
0.3	0.3214	0.299959	0.00014
0.35	0.370206	0.349975	0.00007
0.4	0.419002	0.399982	0.00005
0.45	0.467812	0.450002	0.00000
0.5	0.516805	0.500005	0.00001
0.55	0.565394	0.550004	0.00001
0.6	0.614412	0.599039	0.00160
0.65	0.6629	0.649928	0.00011
0.7	0.710648	0.699913	0.00012
0.75	0.760481	0.749993	0.00001
0.85	0.858065	0.849934	0.00008
0.95	0.955856	0.949924	0.00008
1	1.00447	1.00046	0.00046
1.25	1.24846	1.250016	0.00001
1.5	1.429238	1.499936	0.00004
1.75	1.736281	1.749929	0.00004
2	1.980254	1.999953	0.00002

Sent voltages to the ADC and then to microcontroller.

Corrected error and calibrated the ADC.

Engineering Design Accomplishments Matthew

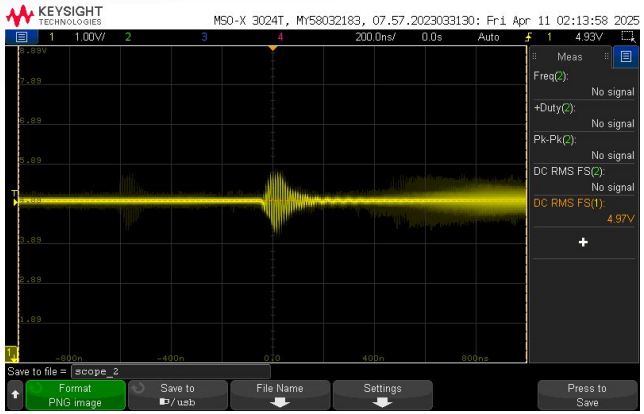
- Designed multiple iterations of power PCB to provide 5,3.3,-8 V under max current of 1A to sensor subsystem
  - PCB consisted of buck boost converters, AC-DC rectifiers, inverters, and filtering circuits
- Fabricated a custom housing unit that securely mounted PCBs and the transformer. Wired all components in a way that protected both the parts and the connections

Challenges	Solutions
Power subsystem not handling load from sensors subsystem	Redesign pcb by removing overloaded capacitors and make changes to resistor values
Negative voltage not working	Identify and order new parts that were better suited to handle the amount of load necessary for project and revising the pcb to correct the input voltages of the inverter
Unreliable power for long periods over long periods of time	Rewired transformer and corrected all sloppy soldering points

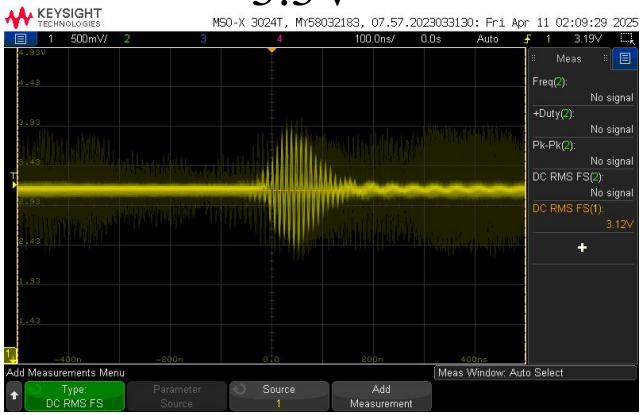
Engineering Design Accomplishments
Matthew

- Voltages under full load conditions have been tested and validated

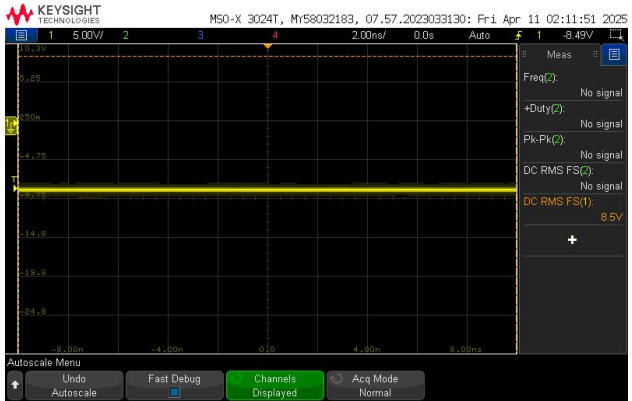
5V



3.3V



-8.5V



Engineering Design Accomplishments - Joaquin

- Programmed ESP32-S3 in ESP-IDF (C):
  - Several GPIO, Built in Wi-Fi/Bluetooth, low-level control, managing tasks
- Integrated sensors:
  - I2C: HDC1000 (Temp/Humidity), SCD41 (CO_2 + Temp/Humidity)
  - Analog: MQ-4, MQ-136, MQ-137 via AD7718 Analog-Digital Converter
- Developed Wi-Fi/MQTT transmission to AWS IoT for real time data visualization

Challenges	Solutions
Interfacing and calibrating AD7718 ADC	Referencing spec sheet to find setup processes, read/write/reset register. Improved voltage measurement with a linear calibration equation.
Wi-Fi connectivity and flexibility (no hard-coded credentials)	Integrated Wi-Fi provisioning. Added error-handling and reconnection logic to always stay online.
Replica/Repeated Data Transmissions	Implemented a mutex (semaphore) to protect shared sensor data during updates, preventing repeated or stale values from being transmitted.

Engineering Design Accomplishments - Joaquin

Requirement	Target Spec	Result
Read Analog Sensor Data	±1% error max across 0-2.5V	Minimum Error: 0.000001% Maximum Error: 0.00160% Average Error: 0.00017%
Read Digital Sensor Data	Digital sensor initializes and reports valid CO_2, temperature, and humidity values	Successful sensor initialization and realistic environmental readings under test conditions
Transmit Sensor Data	Send all sensor values every 5s to AWS MQTT broker without data loss	0 data loss, corrupted data, repeated data
Wi-Fi Range and Stability	Maintain stable transmission over extended time periods (30 min, 1 hr, 2 hrs, 3 hrs)	Successful under ideal Wi-Fi. Under busy Wi-Fi network/weak signal: Wi-Fi reconnects every 5-20 data transmissions.

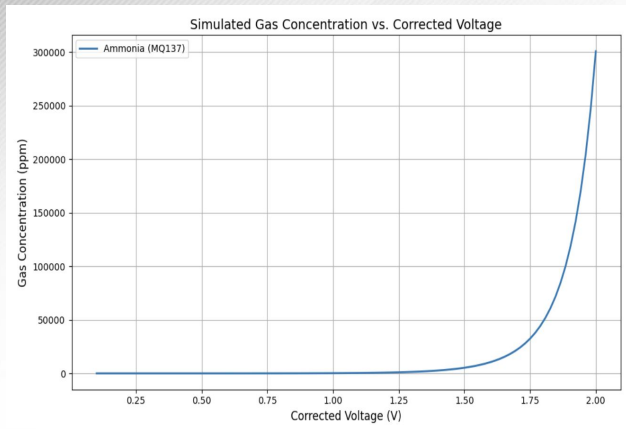
	Temp (°F)	Humidity (%)	CO_2 (ppm)
min	76.85	51.55	390.0
max	87.06	60.45	764.0
mean	84.88	56.81	475.85

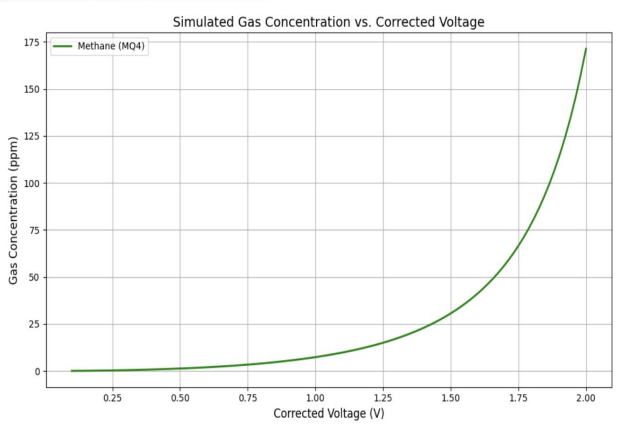
From 11:00 AM to 2:00 PM on April 3rd:

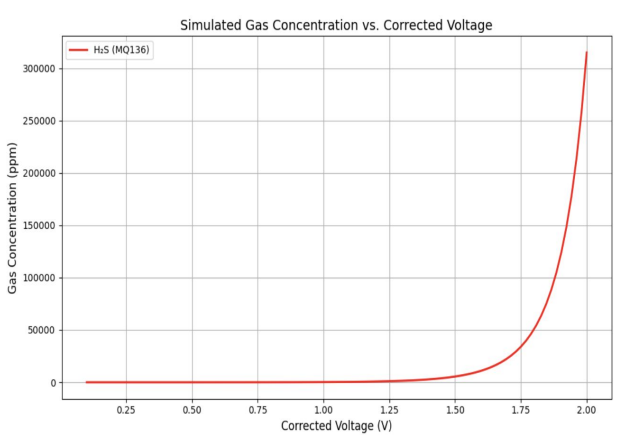
Temp (°F): Min = 81°F, Max = 88°F, Average = 85.25°F

Humidity (%): Min = 61%, Max = 79%, Average = 68%

Engineering Design Accomplishments - Joaquin





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I (2940) gasmonitor: TLS connection successful
I (3610) coreMQTT: MQTT connection established with the broker.
I (3610) gasmonitor: MQTT connection successful
I (4110) gasmonitor: mqtt_process_task started
I (4620) AD7718: AD7718 initialized!
I (5110) main_task: Returned from app_main()
I (9630) SCD41: Sensor initialized!
I (9820) AD7718: AIN1 Voltage: 0.484118 V
I (10020) AD7718: AIN2 Voltage: 0.485083 V
I (10220) AD7718: AIN3 Voltage: 0.319086 V
I (15420) AD7718: AIN1 Voltage: 0.483310 V
I (15620) AD7718: AIN2 Voltage: 0.484435 V
I (15820) AD7718: AIN3 Voltage: 0.319314 V
I (19640) gasmonitor: Publishing: {"temperature":91.98, "humidity":43.32, "co2":
558.00, "NH3":4.513113, "H2S":0.556384, "CH4":1.663040}
I (21020) AD7718: AIN1 Voltage: 0.482838 V
I (21220) AD7718: AIN2 Voltage: 0.483742 V
I (21420) AD7718: AIN3 Voltage: 0.319410 V
I (25660) gasmonitor: Publishing: {"temperature":91.50, "humidity":43.94, "co2":
564.00, "NH3":4.480154, "H2S":0.557184, "CH4":1.659512}
I (26620) AD7718: AIN1 Voltage: 0.509980 V
I (26820) AD7718: AIN2 Voltage: 0.572995 V
I (27020) AD7718: AIN3 Voltage: 0.532796 V
I (30670) gasmonitor: Publishing: {"temperature":91.08, "humidity":44.54, "co2":
619.00, "NH3":10.875322, "H2S":7.065025, "CH4":1.870822}
I (32220) AD7718: AIN1 Voltage: 0.540971 V
I (32420) AD7718: AIN2 Voltage: 0.568763 V
I (32620) AD7718: AIN3 Voltage: 0.413384 V
```

Above: Equations used for calibrating gas sensors

Example Equation: Ammonia (NH_3) — MQ137 (AIN4)

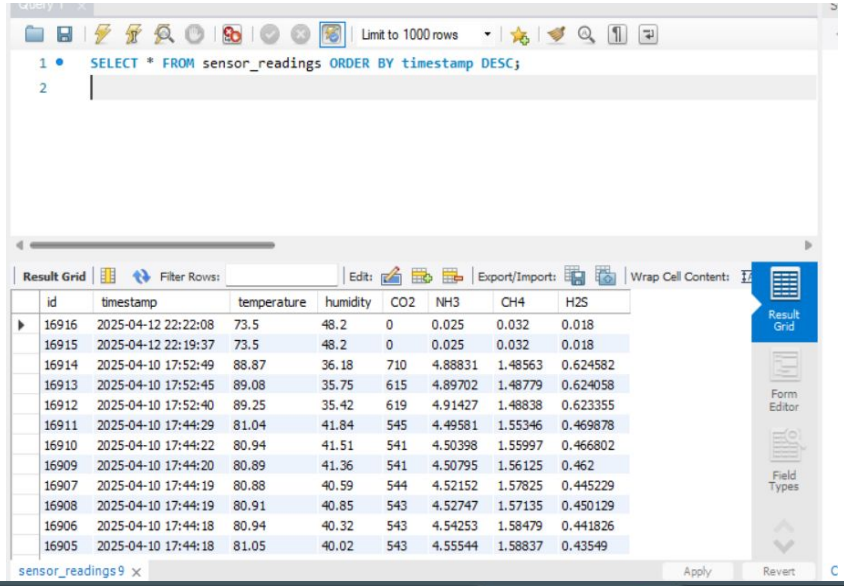
PPM = 1264.231 × *(Rs / 10064)^(-4.1325)*

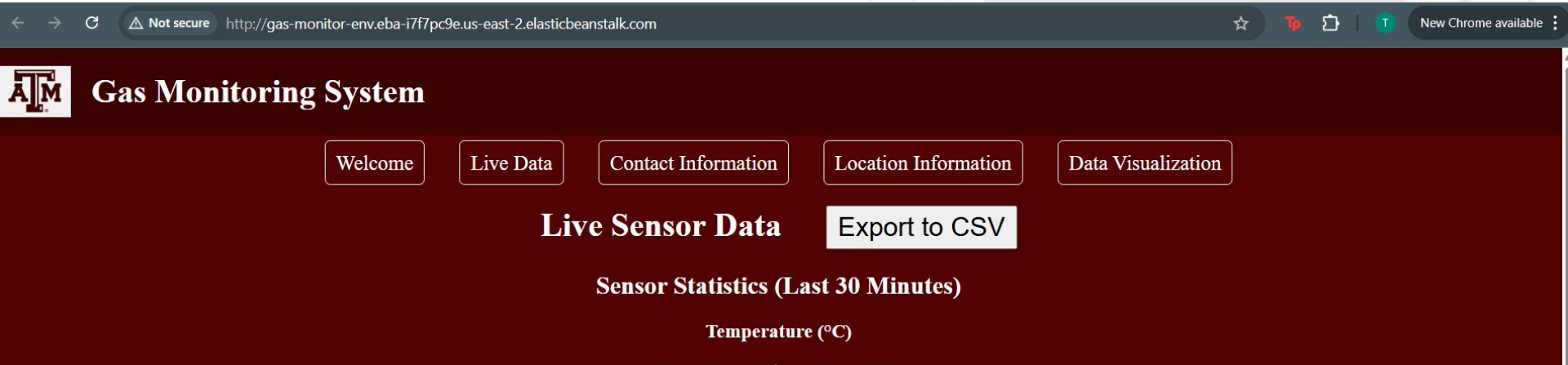
Rs = *(5 − 2 × Vout) × 10000 ÷ (2 × Vout)*

To the left: Gas Monitoring system fully functional

Engineering Design Accomplishments
Tanmay Sarkar

- Created a realistic auto-generating database which went into a locally hosted web application.
  - This was used for testing/validation
  - Gradually increasing rate/volume of data to test the efficiency of the website/database.
- Integrated real time data from AWS which was fed from an ESP32 Microcontroller





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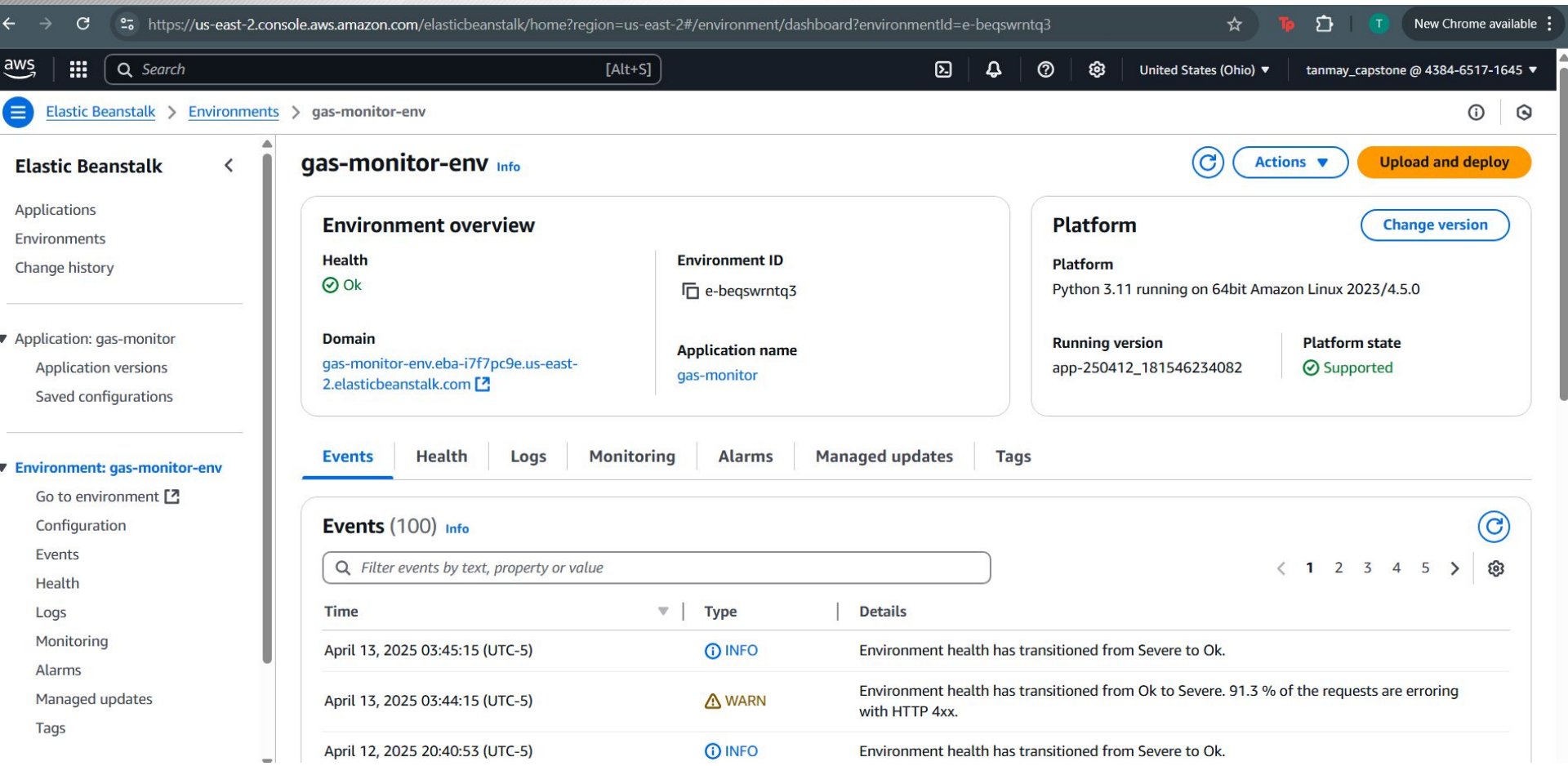


Engineering Design Accomplishments
Tanmay Sarkar

- Built a MySQL Database hosted by AWS (Relational Database Services)
  - Managed by MySQL Workbench.
- Flask web application with real time data updating and CSV export capabilities
- Link

Challenges	Solutions
Connection of AWS Lambda to MySQL Database	Debugging python script that was being uploaded to Lambda by breaking it down part by part.
Keeping website updated as more sensors were added on and the JSON text format was changing	Keeping track of the order of the sensors and updating each part of the software flow one at a time.
Website deployment	Debugging the folder structure of my project and reading the EB (elastic beanstalk) logs

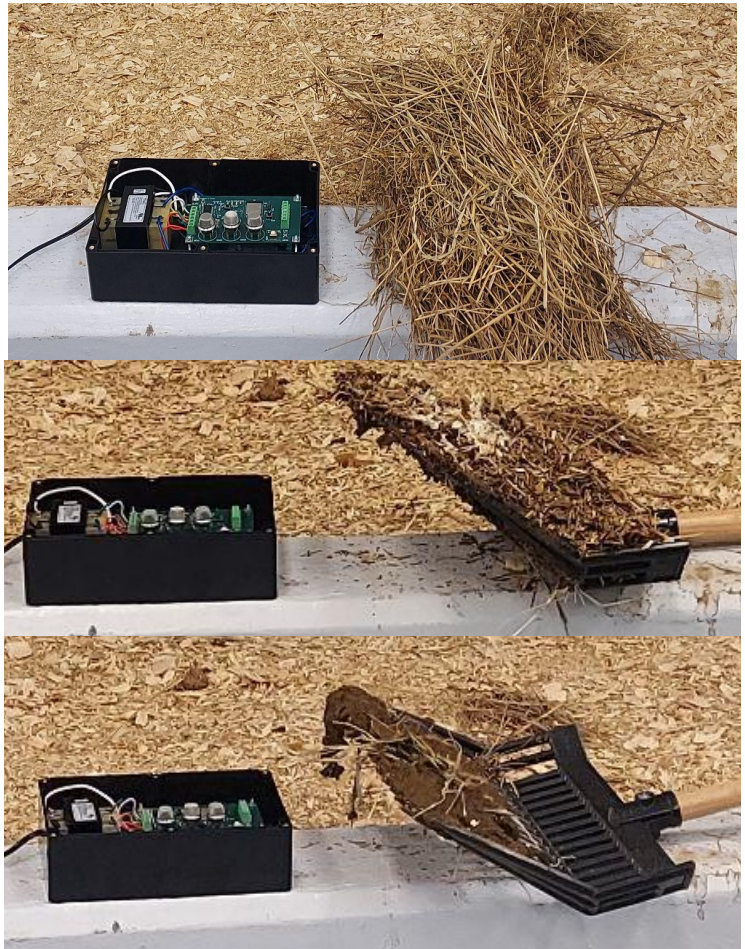
Integrated System Results

Farm Visit #1 with Sponsor Justin Houck:

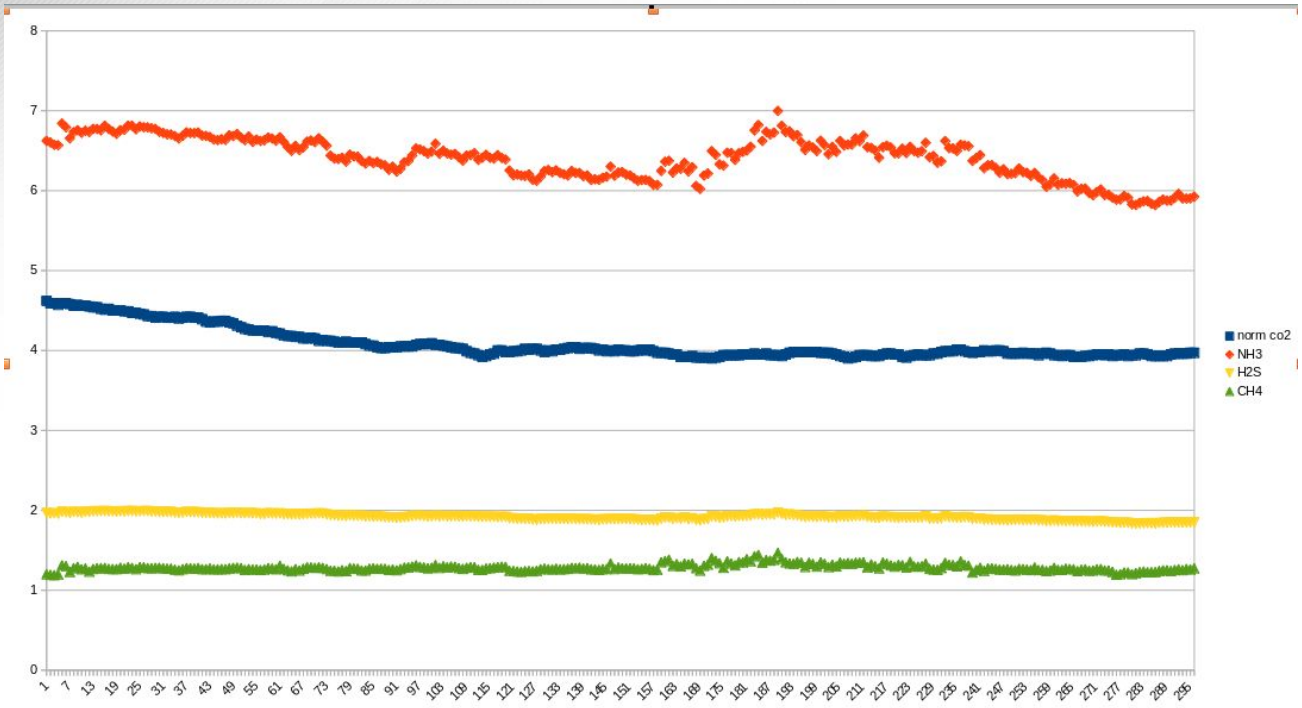
- Met sponsors expectations
- Collected an hours worth of data
- Data sent to sponsor for analysis
- Farm Visit #2 on Thursday, April 17th

Integrated System Results

Test 1	Room State	11:46
Test 2	Cow Patty	11:55
Test 3	Damp Cattle Bedding	12:06



Integrated System Results



Red: NH3
Blue: CO2
Yellow: H2S
Green: CH4

Most significant detection in NH3 and CO2. H2S and CH4 detection less present.

Conclusions

- Moved from LoRaWAN to Wi-Fi due to ease of use, cost, and requirements
- Temperature reads higher due to system heat
- Current status:

  Integration, Test, and Validation Complete

  Second field test April 17th to collect more data with highly detailed experimental plan