Machine Monitoring in the IME Lab

Computer Engineering Capstone 2025

Project Overview

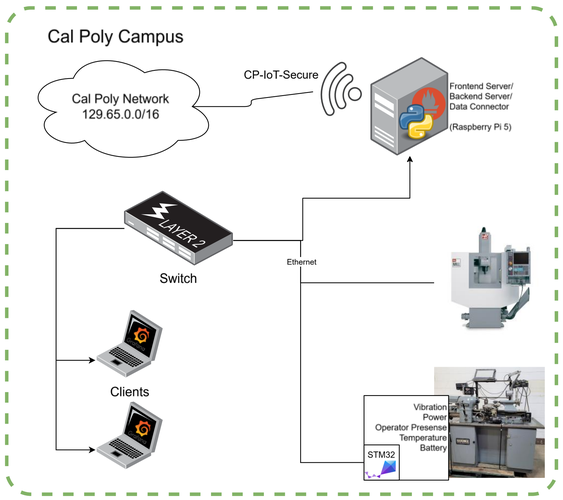
Purpose

The primary purpose of our project is to establish a robust, permanent digital infrastructure within the IME lab that enables real-time monitoring of machine tools. This infrastructure is designed to enhance operational efficiency, improve safety, and support proactive maintenance by providing instantaneous access to critical performance data.

Objectives

- Sensor Integration
- Data Transmission & Processing
- User Interface Development
- Scalability & Future-proofing

System Architecture



Learnings and Future Work

Learnings:

- Researching of certain systems during firmware development took a long time
- During PCB design research of standards and components was a significant time strain.

Future Work:

- Testing of firmware and hardware integration
- Testing of firmware and Grafana/Prometheus integration

Requirements

Value to Customer	Description
Enable real-time monitoring of machine status and performance metrics	Remotely accessible, graphical representation of lab room
Infrastructure is thoroughly documented and designed for long-term sustainability	Develop an infrastructure plan to ensure long-term maintainability of the project
Provide enhanced visibility in non-networked, older machines	Custom hardware devices for capturing and transmitting sensor data
New machines are added to the infrastructure as they are acquired	Easily expandable to new hardware

Hardware Design

Power

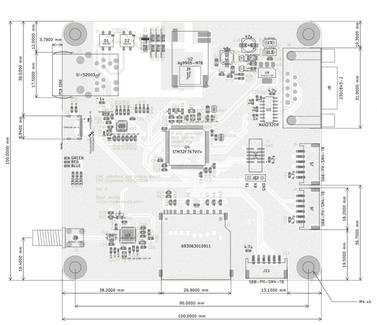
Power can be provided through Ethernet (PoE), or USB-C through wall adapter or battery. The higher voltage supply will be voted through a PFET high-side switch to power 3.3 V regulator.

Sensing

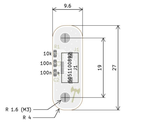
The hardware includes vibration and temperature sensing using the IIS3DWB MEMS vibration sensor, held on a breakout board below the main PCB. Operator presence sensing can be done using a pre-made LD2401C breakout board.

Connectivity

The hardware networks over Ethernet, WiFi, and could also log data over USB. An SD card is provided for offline logging. Older CNC machines can interface through the RS-232 port on the hardware. Further custom sensor boards to measure ways temperature, power consumption, or other metrics can easily be added through the two I2C expansion ports.

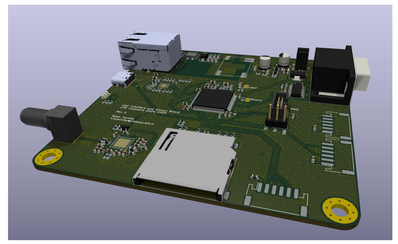


Main PCB Top Fab Print



IIS3DWB Breakout Fab Print, Top and Bottom (Left)

Main PCB 3D Render (Below)



Sensor-to-Dashboard Integration

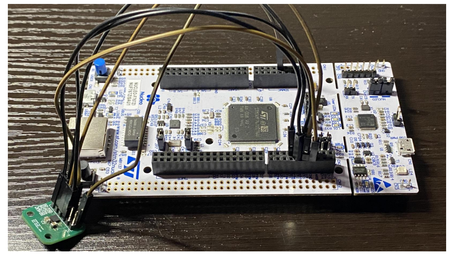
Sensor

Sensor data is collected via the STM32 running Zephyr RTOS over SPI from the II3WDWB sensor and currently outputting to the onboard UART terminal.

Dashboard

The dashboard collects data from the Haas machines and stores it in the Prometheus data base and visualized on the Grafana dashboard.

```
*** Booting Zephyr OS build v4.0.0-4074-ge3a4a16594ff ***
[00:00:00.005,000] <inf> tass: Correct WHO_AM_I: 0x7b
[00:00:00.010,000] <inf> tass: Initializing IIS3DWB sensor
[00:00:00.026,000] <dbg> tass: SENS_INIT: BDU mode verified: 0x40
[00:00:00.033,000] <inf> tass: Register 0x10 set to 0xa0
[00:00:00.038,000] <inf> tass: IIS3DWB initialization complete
[00:00:00.045,000] <inf> main: Temperature: 74.602344 F
[00:00:00.050,000] <inf> main: Acceleration (g):
[00:00:00.055,000] <inf> main: X=-1.912655
[00:00:00.060,000] <inf> main: Y=-0.054351
[00:00:00.064,000] <inf> main: Z=-0.047092
[00:00:01.069,000] <inf> main: Temperature: 74.616406 F
[00:00:01.075,000] <inf> main: Acceleration (g):
[00:00:01.080,000] <inf> main: X=-1.175836
[00:00:01.084,000] <inf> main: Y=0.830881
[00:00:01.089,000] <inf> main: Z=0.003233
[00:00:02.093,000] <inf> main: Temperature: 74.686719 F
[00:00:02.099,000] <inf> main: Acceleration (g):
[00:00:02.104,000] <inf> main: X=0.893589
[00:00:02.108,000] <inf> main: Y=-1.323883
[00:00:02.113,000] <inf> main: Z=-1.316929
```



Verification Plans

Specification	Description
Data Collection Timing	Run firmware under simulated operational conditions. Log sampling intervals and compare against nominal values.
Error Handling	Inject various error conditions and monitor the firmware's logging and exception handling mechanisms.
Data Visualization	Query large quantities of data. Check for freeing or outdated information.
Concurrent Users	Have multiple users access the website at the same time. Monitor the performance and stability during heavy loads.

Team

Ryan Jacoby Nash Segovia
Cameron Bracken Noa Johnson

Project/Product Results

Demonstrated innovative, hands-on solutions to real-world challenges at Cal Poly San Luis Obispo.

Client

Dan Waldorf
Cal Poly IME Dept.