1. General info

Person in charge: Carlos Amin Mendez

Campo	Description
Project	*Multi-system sensor for predictive maintenance*
Equipment / target machine	The device will be integrated into the motor responsible for adjusting the height of a pneumatic arm within a storage system, and into the motor that regulates the conveyor's motion.
Responsible	*Professor Raquel Tejeda Alejandre*
Start date	*22/09/2025*
Version of the design	*1.0*
Location / laboratory	*LD 306M*

2. Objective

Present the design, characterization, and initial testing of a multifunctional sensor that measures vibration, noise, and temperature, developed to support predictive maintenance in industrial systems.

3. General description of the system

Person in charge: Fernando Saldana Jasso

Component	Description	Model / Specifications	Manufacturer	Notes
Vibration sensor	MEMS Accelerometer (Micro-Electro-Mechanical System)	ADXL355	Analog Devices	
Noise sensor	Digital MEMS Microphone	ICS-43434	**InvenSense**	
Temperature sensor	Infrared Thermometer (Non-Contact)	MLX90614	Melexis	
Microcontroller / Acquisition circuit	Low-power Wi-Fi/Bluetooth module based on the ESP32 chip.	ESP32-WROOM-DA	Espressif Systems	
Housing or case	*PLA*			

4. Housing Design and Circuit Assembly

Person in charge: Carlos Amin Mendez

Element	Description
CAD / 3D Design	Case Assembly V3.SLDASM
Manufacturing Materials	*PLA, screws and Velcro*
External Dimensions (mm)	*75 x 44 x 78 mm*
Internal Circuit Layout	Case Assembly V3.SLDDRW
Implemented Protections	*None*

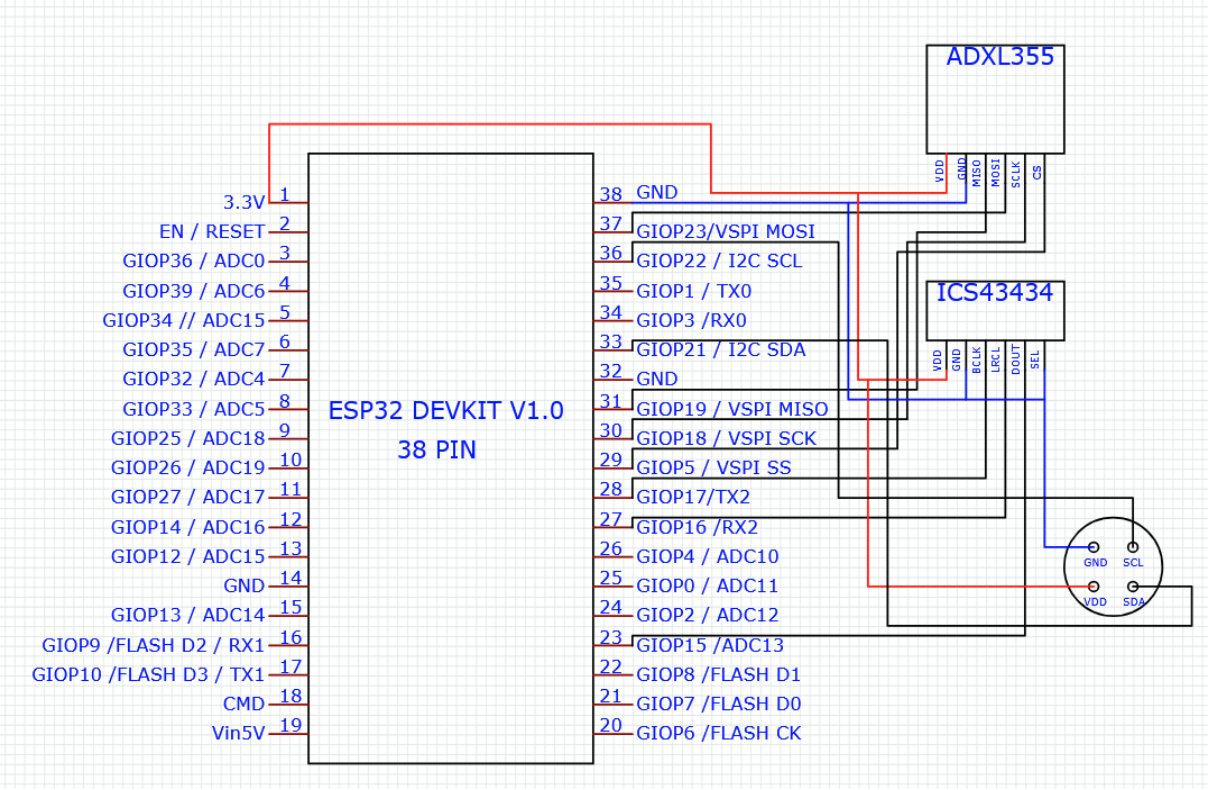
5. Sensor Characterization

Sensor	Measuring Range	Sensitivity	Accuracy	Sampling Rate	Recommended Conditions
Vibration Datasheet:adxl354_adxl355.pdf	**±2g,±4g,±8g** (selectable)	**±2g: 80µg/LSB** (≈256 LSB/g)	Zero-g Offset:±24 mg (Max)	**3.906 Hz** to **4000 Hz** (Output Data Rate)	**Operating Temperature:** −40∘C to +125∘C. **Supply Voltage:** 2.0 V to 3.6 V.
Noise Datasheet:DS-000069-ICS-43434-v1.2.pdf	Sound Pressure Level (SPL) range up to **120 dB** (Max)	**−26 dBFS** (Typ) at 1 kHz and 94 dB SPL	Signal-to-Noise Ratio (SNR): 64 dBA	**48 kHz** (Default Sampling Rate)	**Operating Temperature:** −40∘C to +85∘C. **Supply Voltage:** 1.62 V to 3.6 V.
Temperature Datasheet:MLX90614-Datasheet-Melexis-1.pdf	**Object:** −70∘C to 380∘C (TA =25∘C)	Not applicable (Measures absolute temperature)	**0.5∘C** (Typ) in the range of **0∘C to +50∘C**	Not specified (It's an IR sensor communicating via SMBus/I2C)	**Ambient (Operating) Temperature:** −40∘C to +125∘C. **Supply Voltage:** 4.5 V to 5.5 V.

6. Circuit and Connections

Person in charge: Fernando Saldana Jasso

Element	Connection pin	Signal type	Operating voltage	Notes
Sensor de vibración	pin conection.xlsx	SPI	3v	
Sensor de ruido		I2S	3v	
Sensor de temperatura		IS2	3v	
Microcontrolador			5v	



Software development as advance till having proper data from the sensors with the motors working

Some software has been developed to begin as a demo of how to approach data analytics, data visualization, and planning. (Why demo? Because the sensors haven't been connected to a motor,

and the data has been extracted in normal environments with moves and irregularities, that is why so many data deviations will be seen for now in the next steps)

Person in charge: Diego Armando Salinas

Software Used: Cursor

Works being done in: Jupyter Notebooks for better data readability and efficient workflow

Programming Language: Python

Data Collection Format
- Column 1: Accelerometer X (g)
- Column 2: Accelerometer Y (g)
- Column 3: Accelerometer Z (g)
- Column 4: Microphone (raw amplitude)
- Column 5: Temperature (°C)

📊 Data Summary
==
Total readings: 126
Columns: ['ax_g', 'ay_g', 'az_g', 'mic_raw', 'temp_C', 'reading_num']
==

	ax_g	ay_g	az_g	mic_raw	temp_C	reading_num
0	-0.07	0.55	0.84	41036	25.01	1
1	-0.07	0.54	0.85	42004	24.97	2
2	-0.06	0.55	0.85	22548	25.01	3
3	-0.06	0.55	0.85	20030	24.97	4
4	-0.06	0.55	0.85	36974	25.11	5
5	-0.06	0.56	0.84	18142	25.11	6
6	-0.07	0.55	0.83	22624	25.19	7
7	-0.07	0.55	0.86	20032	25.19	8
8	-0.06	0.55	0.85	20508	25.09	9
9	-0.07	0.55	0.85	26800	24.91	10

...

	ax_g	ay_g	az_g	mic_raw	temp_C	reading_num
121	-0.20	0.14	0.94	99146	24.07	122
122	-0.20	0.15	0.98	61048	24.49	123
123	-0.20	0.15	0.98	54222	24.57	124
124	-0.21	0.15	0.98	49726	24.59	125
125	-0.20	0.16	0.98	30960	24.53	126

Data Quality and Statistics

```
Missing Values:
ax_g          0
ay_g          0
az_g          0
mic_raw       0
temp_C        0
reading_num   0
dtype: int64

============================================================

Statistical Summary:
```

	ax_g	ay_g	az_g	mic_raw	temp_C	reading_num
count	126.000000	126.000000	126.000000	1.260000e+02	126.000000	126.000000
mean	-0.072222	0.411111	0.865952	1.225071e+05	26.994286	63.500000
std	0.141652	0.254540	0.287837	5.774671e+05	2.746309	36.517119
min	-1.010000	-0.660000	-1.260000	1.733000e+04	24.070000	1.000000
25%	-0.135000	0.190000	0.850000	2.483750e+04	24.955000	32.250000
50%	-0.040000	0.510000	0.870000	4.494900e+04	25.280000	63.500000
75%	-0.022500	0.540000	0.957500	8.644400e+04	28.730000	94.750000
max	0.430000	1.440000	2.040000	6.496218e+06	33.830000	126.000000

🚨 Potential Anomalies (based on extreme values):

⚠️ High Vibration Readings (9 occurrences):

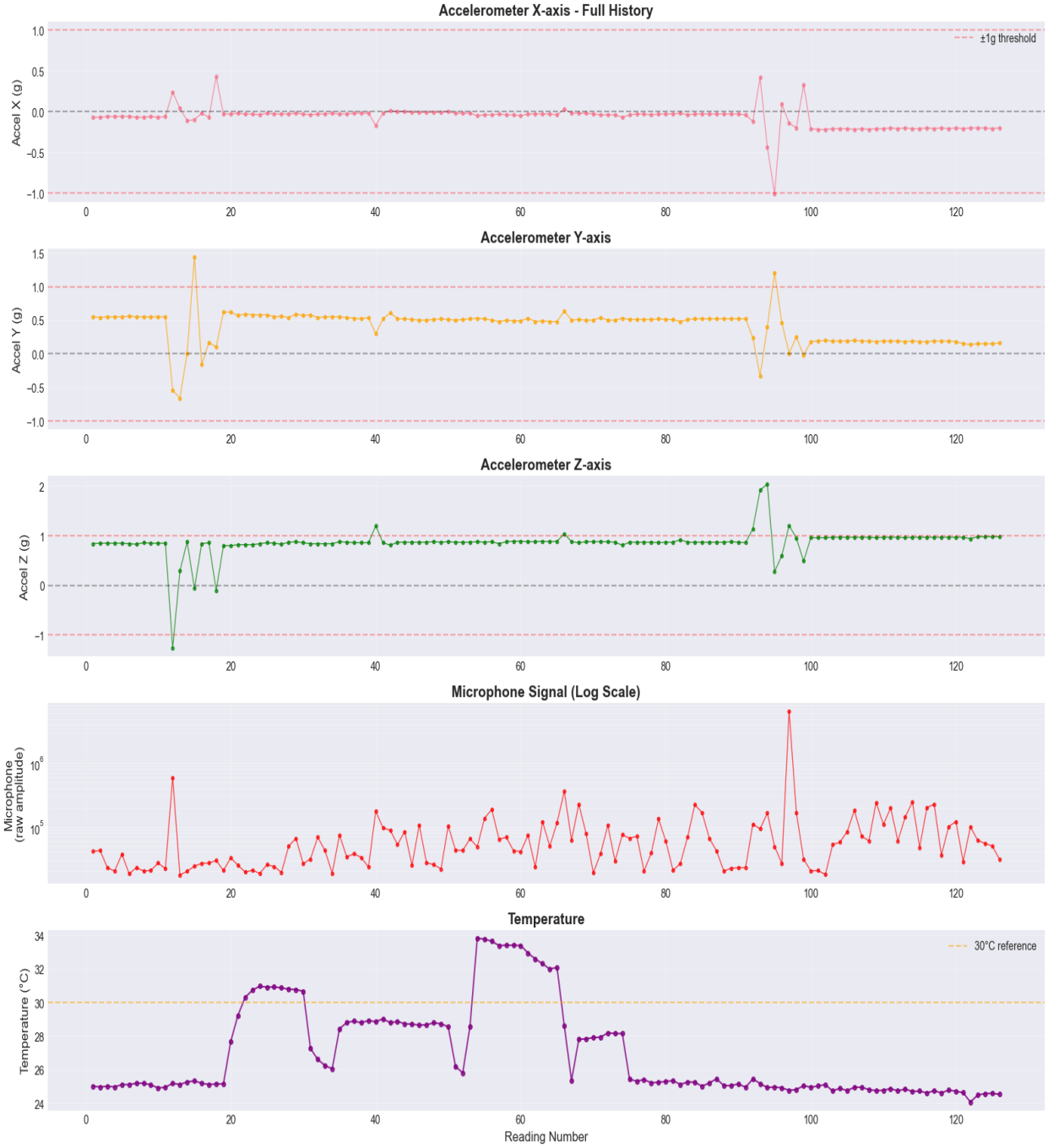
	reading_num	ax_g	ay_g	az_g	temp_C
11	12	0.24	-0.54	-1.26	25.19
14	15	-0.10	1.44	-0.06	25.33
39	40	-0.17	0.30	1.20	28.85
65	66	0.03	0.64	1.04	28.61
91	92	-0.12	0.24	1.14	25.45
92	93	0.42	-0.33	1.92	25.17
93	94	-0.44	0.40	2.04	24.93
94	95	-1.01	1.21	0.28	24.97
96	97	-0.14	0.01	1.21	24.77

⚠️ Unusual Microphone Readings (12 occurrences):

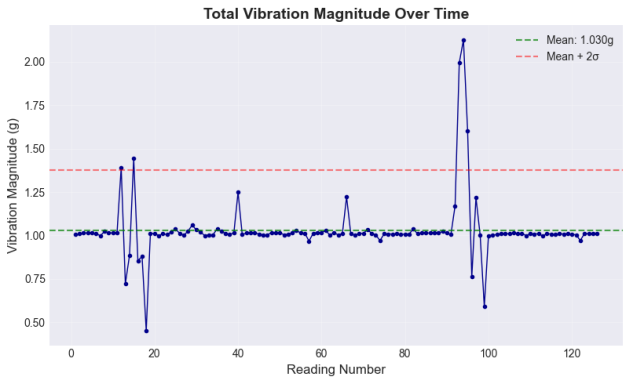
	reading_num	mic_raw	temp_C	ax_g	ay_g	az_g
96	97	6496218	24.77	-0.14	0.01	1.21
11	12	591314	25.19	0.24	-0.54	-1.26
65	66	358670	28.61	0.03	0.64	1.04
113	114	243662	24.69	-0.21	0.19	0.97
108	109	239538	24.75	-0.21	0.18	0.96
67	68	225578	27.81	-0.02	0.51	0.86
116	117	223820	24.75	-0.21	0.19	0.97
83	84	220140	25.25	-0.03	0.52	0.87
115	116	198176	24.61	-0.20	0.18	0.97
110	111	195878	24.87	-0.20	0.19	0.97
55	56	185882	33.65	-0.04	0.50	0.88
105	106	179312	24.95	-0.22	0.20	0.97

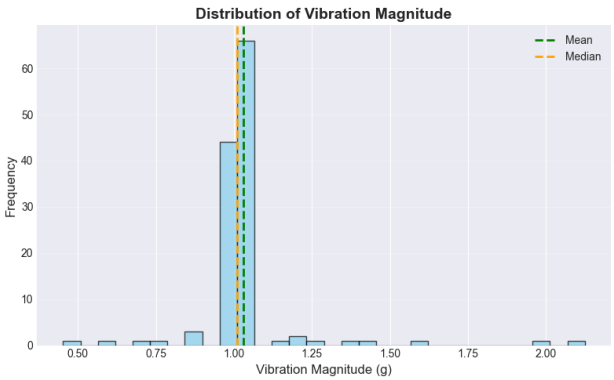
🌡️ High Temperature Readings (>32°C): 11 occurrences
Max temp: 33.83°C at reading #54

Series Visualization



Vibration Magnitude Analysis





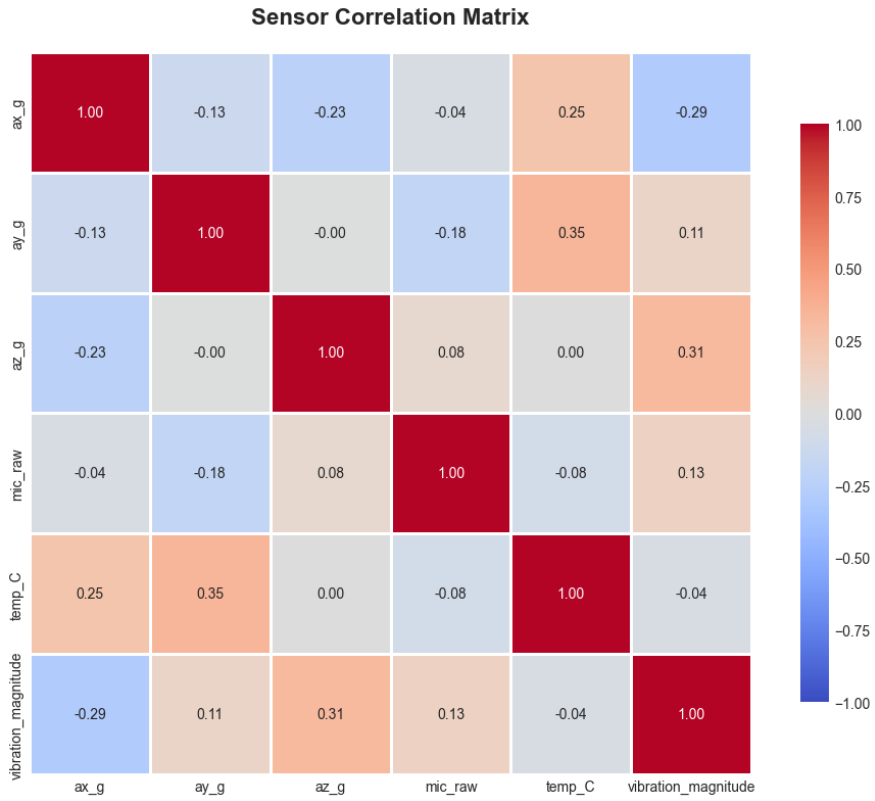
Vibration Statistics:

Mean: 1.0300g

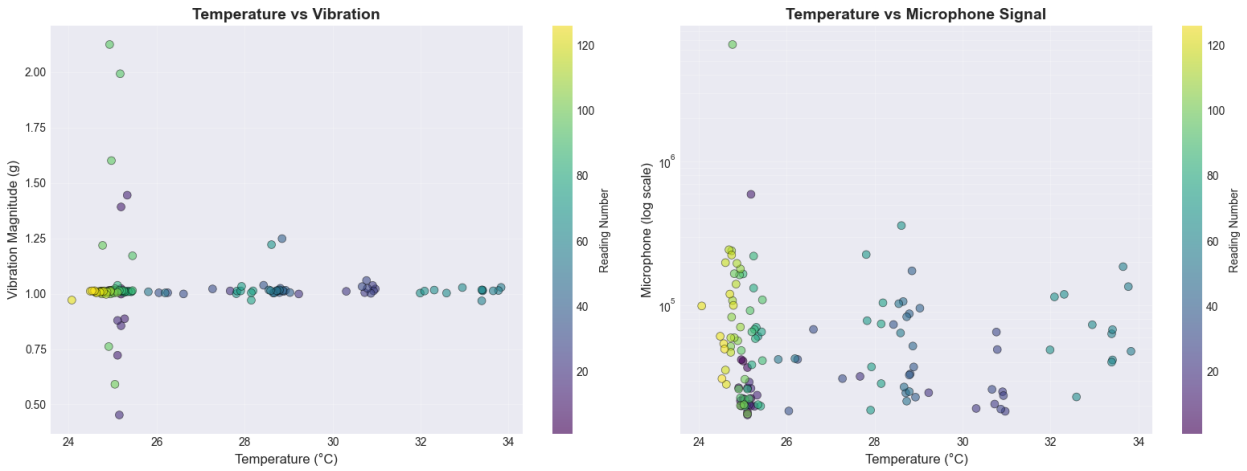
Std: 0.1724g

Max: 2.1249g (reading #94)

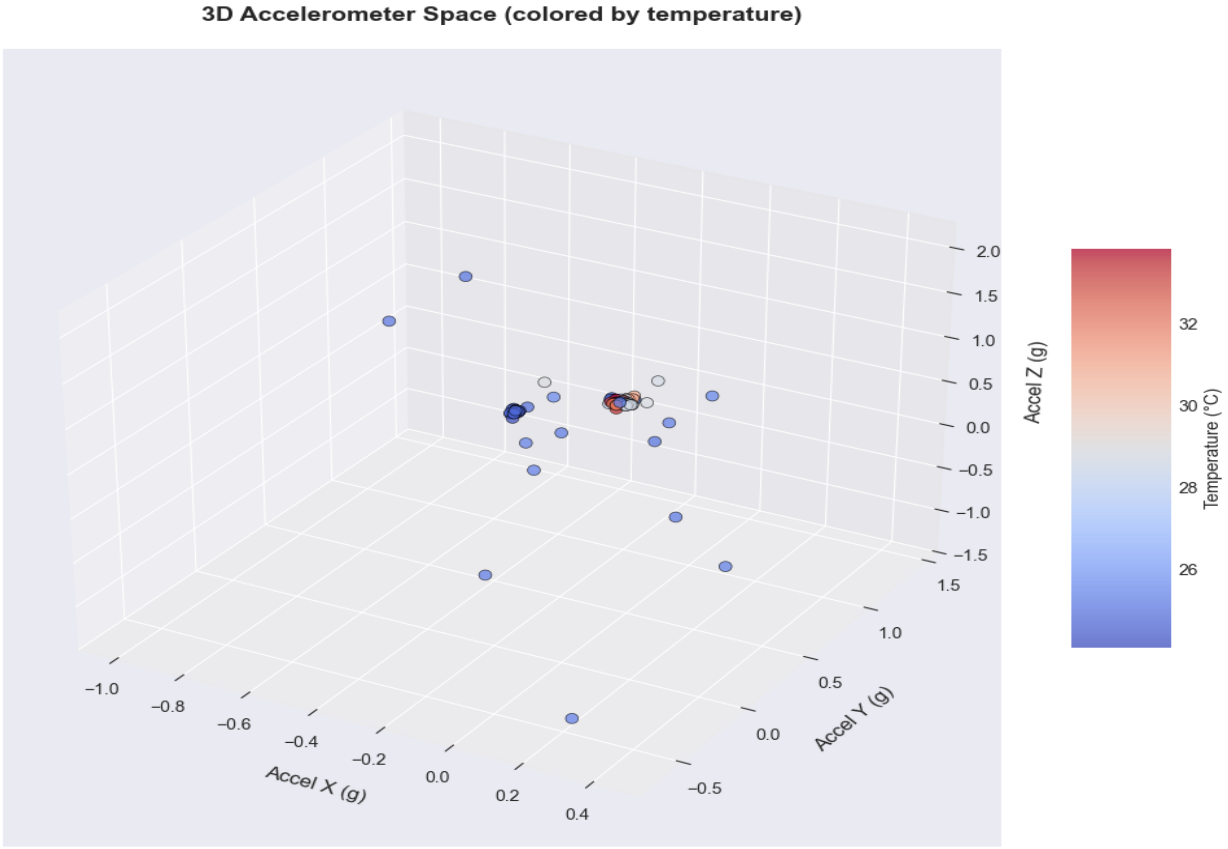
Correlation Analysis (sensors)



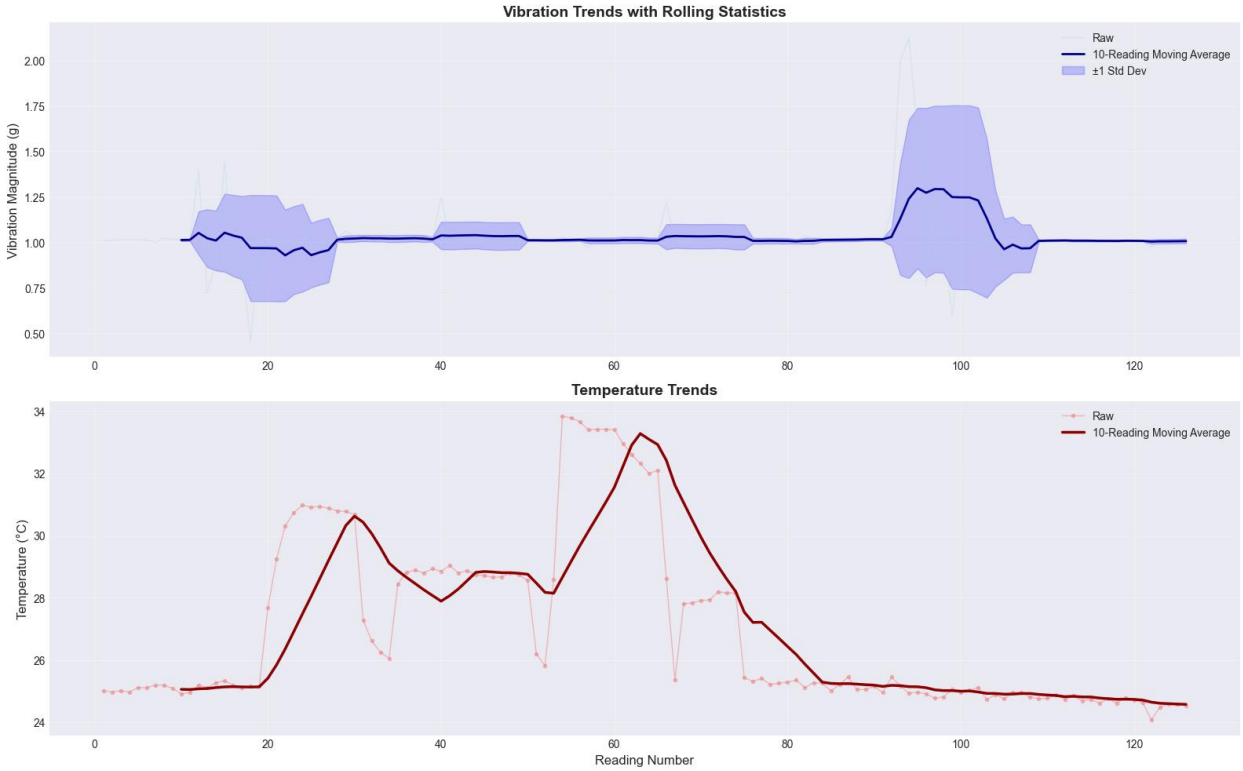
Scatterplots: Relationships Analysis



Accelerometer Visualization



Rolling Statistics



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MOTOR HEALTH SUMMARY REPORT

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📊 **Dataset Overview:**

Total Readings: 126

Data Collection: Without motors working, just the sensors moved drastically (that is why the anomalies)

🔧 **Vibration Analysis:**

Mean Magnitude: 1.0300g

Std Deviation: 0.1724g

Max Observed: 2.1249g

High Vibration Events (>1.5g): 3 (2.4%)

🌡️ **Temperature Analysis:**

Current: 24.53°C

Mean: 26.99°C

Range: 24.07°C - 33.83°C

Trend: ↓ Falling

🎤 Microphone Analysis:

Median: 44949

Max Peak: 6496218

Outliers Detected: 12

⚠️ Anomaly Detection:

🔴 9 High Vibration Anomalies Detected

🟡 Temperature exceeded 32°C (33.8°C max)

💡 Recommendations:

- Monitor temperature trends closely

- Ensure adequate cooling

- Sufficient data for initial baseline analysis

- Ready for anomaly detection model training

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To have a better approach, another .py file was created which will be able to extract and register the timestamps to have better traceability of the sensors reading and therefore more accurate analysis when working with the motors. This led to creating another .ipynb (jupyter file) which will make it possible to deep the analysis in a more complete manner because now a time feature will be present.

All the codes and outputs are in the following github repository created for this project:
https://github.com/DArmandoSalinas/Motor-performance-prediction

And also in this folder where this file is placed:

https://tecmx-my.sharepoint.com/personal/raquel_tejeda_tec_mx/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fraquel%5Ftejeda%5Ftec%5Fmx%2FDocuments%2FFiles%20Raquel%20Tejeda%2FMR3002B%2E602%20Proyectos%2FReto%2011%2E%20Proyecto%20Sensor%20Mannto%20IA%2FPrediction&viewid=7f8f7a8c%2D3e14%2D4555%2Da53a%2D1014b4d65ba5&csf=1&web=1&e=UCfqjg&CID=68062894%2D370d%2D442f%2Db8dc%2Dbdd5f00bcfd0&FolderCTID=0x01200030AF4C85E95D31439CF2301BFA5FF24D&view=0