

da_Mushroom_25-05-08_0326-no_simulation2

May 14, 2025

```
[33]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import os

# Set file path
file_path = '../data/Mushroom_25-05-08_0326.lvm'

# Check if file exists
if not os.path.exists(file_path):
    print(f"Error: File {file_path} does not exist")
else:
    # Read LVM file
    # LVM files are tab-separated text files without header
    data = pd.read_csv(file_path, sep='\t', header=None)

    # Display basic information about the data
    print(f"Data shape: {data.shape}")
    print("\nFirst 5 rows of data:")
    print(data.head())

    # Based on file content, we need to name the columns
    # Assuming first column is timestamp, others are sensor data
    columns = ['Timestamp'] + [f'Sensor_{i}' for i in range(1, data.shape[1])]
    data.columns = columns

    print("\nData after renaming columns:")
    print(data.head())
```

Data shape: (1084420, 10)

First 5 rows of data:

	0	1	2	3	4	5	6	\
0	120386.537600	-0.017416	-0.015052	-0.035177	-0.024526	-0.022283	-0.014307	
1	120386.714606	-0.017413	-0.015028	-0.035177	-0.024510	-0.022269	-0.014292	
2	120386.889620	-0.017420	-0.015043	-0.035157	-0.024524	-0.022270	-0.014293	
3	120387.088626	-0.017404	-0.015036	-0.035172	-0.024527	-0.022294	-0.014290	
4	120387.273636	-0.017437	-0.015036	-0.035183	-0.024523	-0.022269	-0.014280	

	7	8	9
0	-0.035494	0.001486	NaN
1	-0.035491	0.001480	NaN
2	-0.035494	0.001500	NaN
3	-0.035498	0.001483	NaN
4	-0.035490	0.001495	NaN

Data after renaming columns:

	Timestamp	Sensor_1	Sensor_2	Sensor_3	Sensor_4	Sensor_5	Sensor_6	\
0	120386.537600	-0.017416	-0.015052	-0.035177	-0.024526	-0.022283	-0.014307	
1	120386.714606	-0.017413	-0.015028	-0.035177	-0.024510	-0.022269	-0.014292	
2	120386.889620	-0.017420	-0.015043	-0.035157	-0.024524	-0.022270	-0.014293	
3	120387.088626	-0.017404	-0.015036	-0.035172	-0.024527	-0.022294	-0.014290	
4	120387.273636	-0.017437	-0.015036	-0.035183	-0.024523	-0.022269	-0.014280	

	Sensor_7	Sensor_8	Sensor_9
0	-0.035494	0.001486	NaN
1	-0.035491	0.001480	NaN
2	-0.035494	0.001500	NaN
3	-0.035498	0.001483	NaN
4	-0.035490	0.001495	NaN

```
[34]: # Extract date and time information from the filename
file_name = os.path.basename(file_path) # Get the filename
date_time_str = file_name.split('_')[1:3] # Extract date and time parts
date_str = date_time_str[0].replace('-', '/') # Format date
time_str = date_time_str[1].replace('.lvm', '') # Format time
# Parse time string, first two digits are hours, last two are minutes
hour = time_str[:2]
minute = time_str[2:]
formatted_time = f"{hour}:{minute}"

# Use actual timestamps and convert to specific times
actual_time = data['Timestamp']
# Calculate seconds relative to start time
start_time = actual_time.iloc[0]
relative_seconds = actual_time - start_time

# Create specific time labels
from datetime import datetime, timedelta
# Assume data recording started at the date and time specified in the filename
base_time = datetime(2025, 5, 12, int(hour), int(minute)) # Date and time
# parsed from filename
time_labels = [base_time + timedelta(seconds=s) for s in relative_seconds]

# Determine the number of sensors in the dataset
```

```

num_sensors = len([col for col in data.columns if 'Sensor_' in col]) - 1

# Create a figure with subplots for all sensors
plt.figure(figsize=(15, 10))

# Plot data for all sensors
for i in range(1, num_sensors + 1):
    sensor_name = f'Sensor_{i}'
    plt.subplot(num_sensors, 1, i)
    plt.plot(time_labels, data[sensor_name], linewidth=1)
    plt.title(f'{sensor_name} Data')
    plt.ylabel(f'{sensor_name} Value')
    plt.grid(True)

    # Only add x-label for the bottom subplot
    if i == num_sensors:
        plt.xlabel('Time')

plt.gcf().autofmt_xdate() # Automatically format x-axis date labels

# Add a main title for the entire figure
plt.suptitle(f'Sensor Data - {date_str} {formatted_time}', fontsize=16)

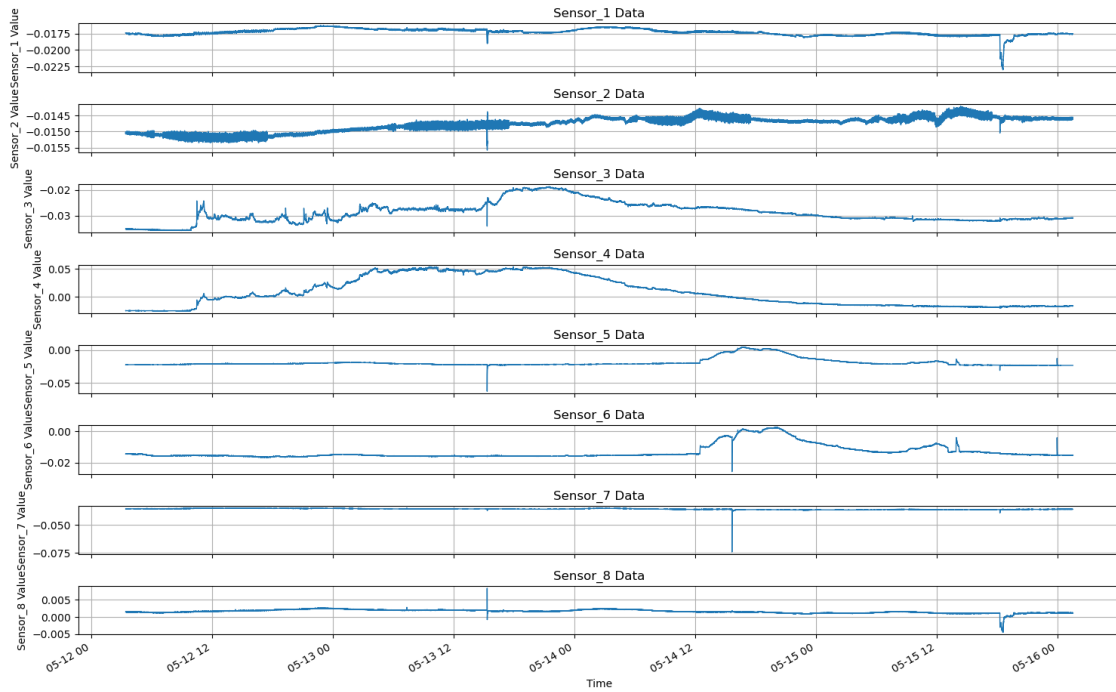
# Adjust layout
plt.tight_layout(rect=[0, 0, 1, 0.97]) # Make room for the supitle

# Display the figure
plt.show()

# Print basic statistics for all sensors
print("Sensor Statistics:")
for i in range(1, num_sensors):
    sensor_name = f'Sensor_{i}'
    print(f"\n{sensor_name}:\n{data[sensor_name].describe()}")

```

Sensor Data - 25/05/08 03:26



Sensor Statistics:

Sensor_1:

```
count    1.084420e+06
mean     -1.727884e-02
std       5.048720e-04
min      -2.300700e-02
25%      -1.762500e-02
50%      -1.728600e-02
75%      -1.690600e-02
max       -1.632500e-02
Name: Sensor_1, dtype: float64
```

Sensor_2:

```
count    1.084420e+06
mean     -1.481143e-02
std       2.283351e-04
min      -1.557400e-02
25%      -1.504800e-02
50%      -1.476700e-02
75%      -1.461900e-02
max       -1.421000e-02
Name: Sensor_2, dtype: float64
```

Sensor_3:
count 1.084420e+06
mean -2.902471e-02
std 4.014688e-03
min -3.576500e-02
25% -3.148200e-02
50% -2.978400e-02
75% -2.700600e-02
max -1.869200e-02
Name: Sensor_3, dtype: float64

Sensor_4:
count 1.084420e+06
mean 9.146397e-03
std 2.632990e-02
min -2.506200e-02
25% -1.520400e-02
50% 2.054000e-03
75% 3.857700e-02
max 5.387100e-02
Name: Sensor_4, dtype: float64

Sensor_5:
count 1.084420e+06
mean -1.927404e-02
std 5.577440e-03
min -6.273700e-02
25% -2.202700e-02
50% -2.094700e-02
75% -1.956500e-02
max 4.554000e-03
Name: Sensor_5, dtype: float64

Sensor_6:
count 1.084420e+06
mean -1.349133e-02
std 4.149826e-03
min -2.560900e-02
25% -1.566500e-02
50% -1.521000e-02
75% -1.375100e-02
max 2.503000e-03
Name: Sensor_6, dtype: float64

Sensor_7:
count 1.084420e+06
mean -3.571238e-02
std 5.212150e-04

```

min      -7.406800e-02
25%      -3.605700e-02
50%      -3.561300e-02
75%      -3.531600e-02
max      -3.472400e-02
Name: Sensor_7, dtype: float64

```

```

[35]: # Perform Short-Time Fourier Transform (STFT) analysis
from scipy import signal
import matplotlib.pyplot as plt
import numpy as np

# Create a new figure for STFT analysis
plt.figure(figsize=(15, 10))

# Perform STFT on all sensor data
for i in range(1, 9): # Assuming 8 sensors
    sensor_name = f'Sensor_{i}'

    # Get sensor data
    sensor_data = data[sensor_name].values

    # Calculate sampling rate (based on timestamp differences)
    sampling_rate = 1.0 / np.mean(np.diff(data['Timestamp']))

    # Perform STFT
    f, t, Zxx = signal.stft(sensor_data, fs=sampling_rate, nperseg=256)

    # Plot STFT results
    plt.subplot(4, 2, i)

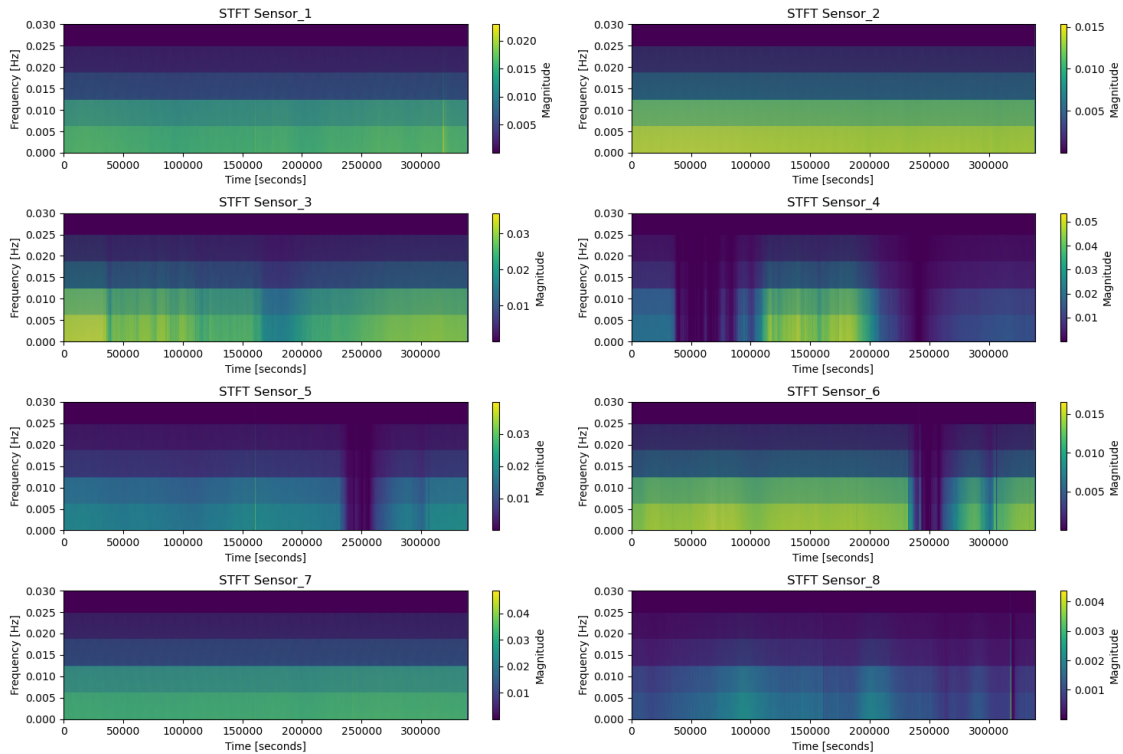
    plt.pcolormesh(t, f, np.abs(Zxx), shading='gouraud')

    plt.title(f'STFT {sensor_name}')
    plt.ylabel('Frequency [Hz]')
    plt.xlabel('Time [seconds]')
    plt.colorbar(label='Magnitude')
    plt.ylim(0, 0.03) # Limit y-axis to 0.03Hz

plt.tight_layout()
plt.show()

# Print basic information about the STFT analysis
print(f"STFT analysis completed")
print(f"Sampling rate: {sampling_rate:.2f} Hz")
print(f"Frequency resolution: {f[1]-f[0]:.4f} Hz")
print(f"Time resolution: {t[1]-t[0]:.4f} seconds")

```



STFT analysis completed
Sampling rate: 3.20 Hz
Frequency resolution: 0.0125 Hz
Time resolution: 39.9933 seconds

```
[36]: # Calculate the recording end time based on the timestamp
import datetime
# Extract start time from the filename (Mushroom_25-05-08_0326)
filename = file_path.split('/')[-1]
date_part = filename.split('_')[1] # '25-05-08'
time_part = filename.split('_')[2] # '0326'

# Handle potential file extension in time_part
if '.' in time_part:
    time_part = time_part.split('.')[0] # Remove file extension if present

year = 2000 + int(date_part.split('-')[0]) # '25' -> 2025
month = int(date_part.split('-')[1]) # '05' -> 5
day = int(date_part.split('-')[2]) # '08' -> 8
hour = int(time_part[:2]) # '03' -> 3
minute = int(time_part[2:]) # '26' -> 26

start_time = datetime.datetime(year, month, day, hour, minute)
```

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# Get the first and last timestamp
first_timestamp = data['Timestamp'].iloc[0]
last_timestamp = data['Timestamp'].iloc[-1]

# Calculate the duration in seconds
duration_seconds = last_timestamp - first_timestamp

# Calculate the end time
end_time = start_time + datetime.timedelta(seconds=duration_seconds)

# Format and print the results
print(f"Recording start time: {start_time.strftime('%Y-%m-%d %H:%M:%S')}")
print(f"Recording end time: {end_time.strftime('%Y-%m-%d %H:%M:%S')}")
print(f"Total recording duration: {duration_seconds:.2f} seconds_
↳({duration_seconds/60:.2f} minutes)")

```

Recording start time: 2025-05-08 03:26:00
Recording end time: 2025-05-12 01:33:04
Total recording duration: 338824.48 seconds (5647.07 minutes)

```

[37]: # Function to find the closest timestamp in the data to a given event time
import pytz
import datetime

# Parse the event time string
event_time_str = "2025-05-10T20:26:00.669Z"
event_time = datetime.datetime.strptime(event_time_str, "%Y-%m-%dT%H:%M:%S.%fZ")
event_time = event_time.replace(tzinfo=pytz.UTC) # Make it timezone-aware

# Make start_time timezone-aware as well
start_time = start_time.replace(tzinfo=pytz.UTC)

# Calculate seconds elapsed since recording start
elapsed_seconds = (event_time - start_time).total_seconds()

print(f"Event time: {event_time_str}")
print(f"Recording start time: {start_time.strftime('%Y-%m-%d %H:%M:%S %Z')}")
print(f"Seconds elapsed since recording start: {elapsed_seconds:.2f} seconds")

# Get the first timestamp from the data
first_timestamp = data['Timestamp'].iloc[0]

# Calculate the target timestamp by adding elapsed seconds to the first_
↳timestamp
target_timestamp = first_timestamp + elapsed_seconds

```



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# Find the closest timestamp in the data
closest_idx = (data['Timestamp'] - target_timestamp).abs().idxmin()
closest_timestamp = data['Timestamp'].iloc[closest_idx]
closest_time_diff = abs(closest_timestamp - target_timestamp)

print(f"First data timestamp: {first_timestamp:.2f} seconds")
print(f"Target timestamp: {target_timestamp:.2f} seconds")
print(f"Closest data timestamp: {closest_timestamp:.2f} seconds")
print(f"Difference from target: {closest_time_diff:.2f} seconds")

# Extract the data at the closest timestamp
event_data = data.iloc[closest_idx]
print("\nSensor readings at event time:")
for column in data.columns:
    if column != 'Timestamp':
        print(f"{column}: {event_data[column]}")

```

Event time: 2025-05-10T20:26:00.669Z
 Recording start time: 2025-05-08 03:26:00 UTC
 Seconds elapsed since recording start: 234000.67 seconds
 First data timestamp: 120386.54 seconds
 Target timestamp: 354387.21 seconds
 Closest data timestamp: 354387.38 seconds
 Difference from target: 0.17 seconds

Sensor readings at event time:

Sensor_1:	-0.01767
Sensor_2:	-0.014673
Sensor_3:	-0.028876
Sensor_4:	-0.008457
Sensor_5:	-0.000789
Sensor_6:	0.001774
Sensor_7:	-0.036359
Sensor_8:	0.00121
Sensor_9:	nan

```

[38]: # Plot voltage data for 10 minutes before and after the event time
import matplotlib.pyplot as plt
import numpy as np

# Define the time window (10 minutes before and after the event)
window_minutes = 10
window_seconds = window_minutes * 60 # Convert minutes to seconds
event_idx = closest_idx
start_idx = max(0, event_idx - int(window_seconds * data['Timestamp'].diff().
    ↪median() ** -1))

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end_idx = min(len(data) - 1, event_idx + int(window_seconds * data['Timestamp'].
↳diff().median() ** -1))

# Extract the data for the time window
window_data = data.iloc[start_idx:end_idx+1]

# Calculate time relative to the event (in seconds)
relative_time = window_data['Timestamp'] - closest_timestamp

# Create a figure with subplots for each voltage channel
plt.figure(figsize=(15, 10))
voltage_columns = [col for col in data.columns if col != 'Timestamp']

for i, column in enumerate(voltage_columns):
    plt.subplot(3, 3, i+1)

    # Convert voltage to millivolts
    voltage_mv = window_data[column] * 1000 # Convert to mV

    plt.plot(relative_time, voltage_mv)
    plt.axvline(x=0, color='r', linestyle='--', label='Event time')
    plt.title(f'{column} (mV)')
    plt.xlabel('Time relative to event (seconds)')
    plt.ylabel('Voltage (mV)')
    plt.grid(True)

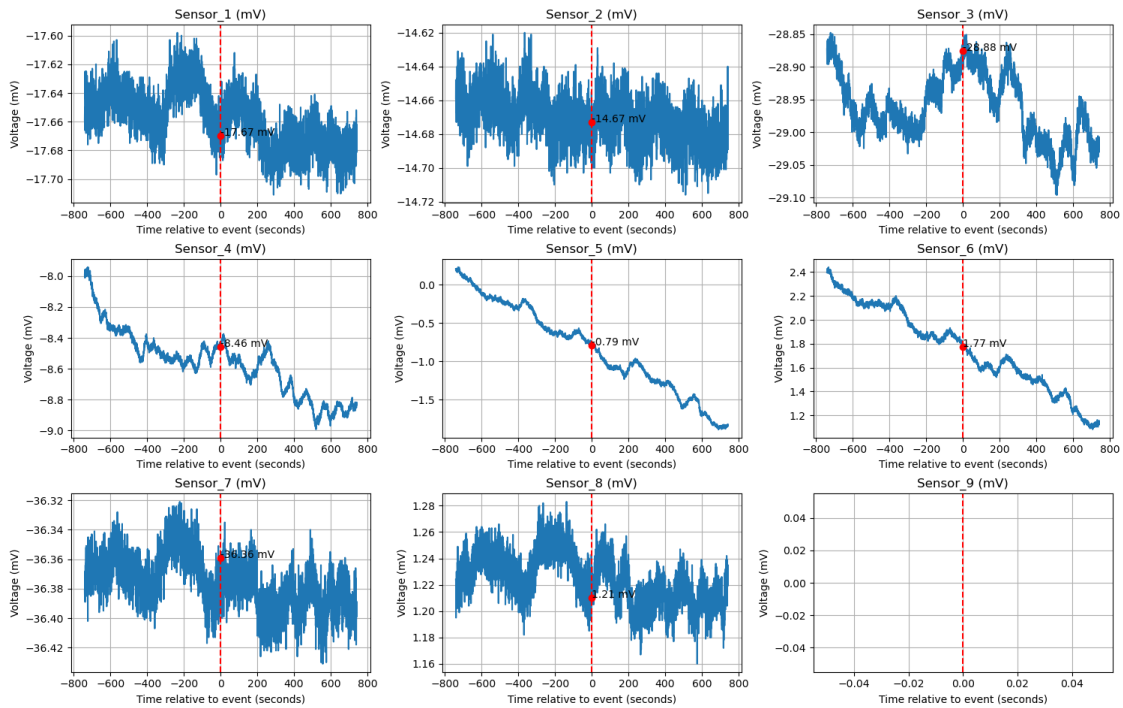
    # Add a red dot at the event time point
    event_value_mv = event_data[column] * 1000 # Convert to mV
    plt.plot(0, event_value_mv, 'ro', markersize=6) # Red dot at event time
    plt.text(1, event_value_mv, f'{event_value_mv:.2f} mV') # Text label
↳without arrow

plt.tight_layout()
plt.suptitle('Voltage Readings ±10 minutes from Event Time', fontsize=16)
plt.subplots_adjust(top=0.92)
plt.show()

```

posx and posy should be finite values
posx and posy should be finite values

Voltage Readings ± 10 minutes from Event Time



```
[39]: # Perform Short-Time Fourier Transform (STFT) analysis for each voltage channel
import matplotlib.pyplot as plt
from scipy import signal
import numpy as np

# Create a figure with subplots for STFT of each voltage channel
plt.figure(figsize=(15, 10))
voltage_columns = [col for col in data.columns if col != 'Timestamp']

# Calculate sampling frequency
sampling_freq = 1.0 / data['Timestamp'].diff().median()

for i, column in enumerate(voltage_columns):
    plt.subplot(3, 3, i+1)

    # Get voltage data for this channel
    voltage_data = window_data[column].values

    # Perform STFT
    f, t, Zxx = signal.stft(voltage_data, fs=sampling_freq, nperseg=256)

    # Plot the STFT magnitude (in dB)
    plt.pcolormesh(t, f, np.abs(Zxx), shading='gouraud')
```

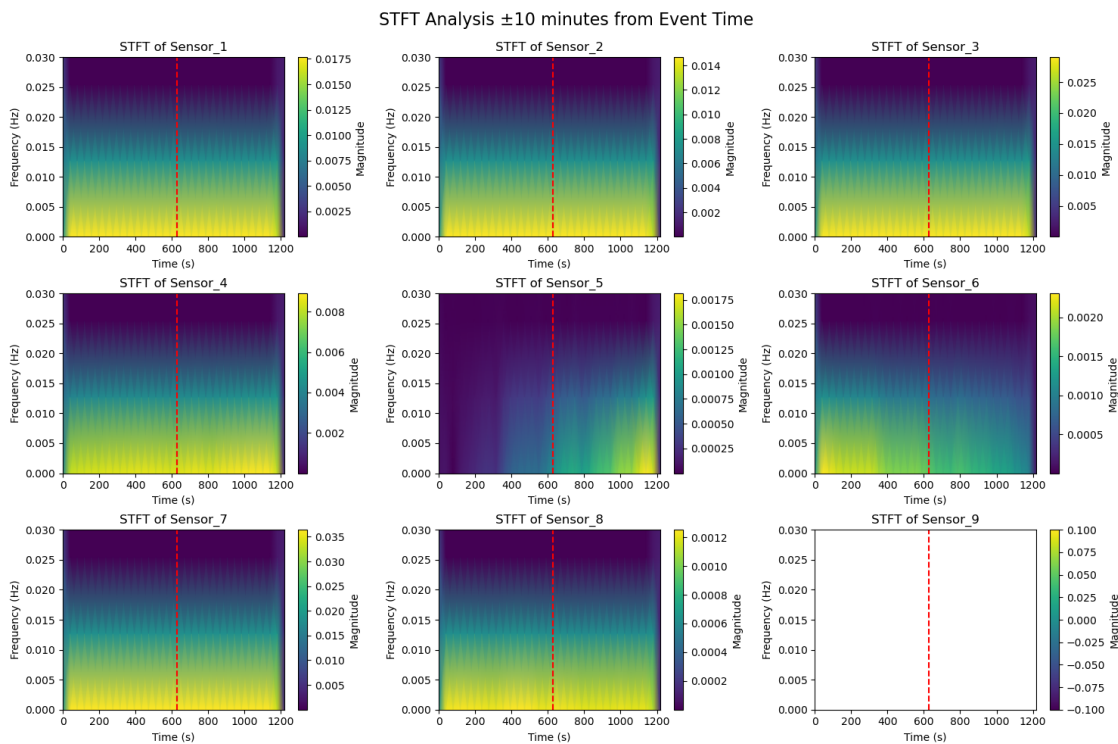
```

# Mark the event time
plt.axvline(x=t[len(t)//2], color='r', linestyle='--', label='Event time')

plt.title(f'STFT of {column}')
plt.ylabel('Frequency (Hz)')
plt.xlabel('Time (s)')
plt.colorbar(label='Magnitude')
plt.ylim(0, 0.03)

plt.tight_layout()
plt.suptitle('STFT Analysis ±10 minutes from Event Time', fontsize=16)
plt.subplots_adjust(top=0.92)
plt.show()

```



```

[40]: # Analyze the 0.02Hz frequency band before and after event for each sensor
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import os
import datetime

# Get dataset name from the notebook filename

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notebook_name = os.path.basename(__file__) if '__file__' in globals() else_
↳ 'Mushroom_25-05-08_0326'
if notebook_name.endswith('.ipynb'):
    notebook_name = notebook_name[:-6] # Remove .ipynb extension
if notebook_name.startswith('da_'):
    notebook_name = notebook_name[3:] # Remove da_ prefix

# Create a directory to save CSV files with dataset name
csv_dir = f"significant_changes_csv_{notebook_name}"
if not os.path.exists(csv_dir):
    os.makedirs(csv_dir)
    print(f"Created directory: {csv_dir}")

# Calculate sampling frequency
sampling_freq = 1.0 / data['Timestamp'].diff().median()

# Find the event time (assuming it's at the center of the filtered data)
event_time = window_data['Timestamp'].mean()

# Loop through each voltage channel
for channel_to_analyze in voltage_columns:
    print(f"\n=== Analysis for {channel_to_analyze} ===")
    voltage_data = window_data[channel_to_analyze].values

    # Perform STFT for the selected channel
    f, t, Zxx = signal.stft(voltage_data, fs=sampling_freq, nperseg=256)

    # Find the closest frequency to 0.02Hz in the STFT results
    target_freq = 0.02
    freq_idx = np.argmin(np.abs(f - target_freq))
    actual_freq = f[freq_idx]
    print(f"Analyzing frequency: {actual_freq:.4f} Hz (closest to 0.02 Hz)")

    # Extract the magnitude data for this frequency
    freq_magnitude = np.abs(Zxx[freq_idx, :])

    # Create a time axis in minutes for better visualization
    time_min = t / 60

    # Plot the magnitude of the 0.02Hz component over time
    plt.figure(figsize=(15, 6))

    # Plot the magnitude
    plt.plot(time_min, freq_magnitude, 'b-', linewidth=2, label=f'{actual_freq:.
↳ 4f} Hz Component')

    # Convert event time to minutes

```

```

event_time_min = t.mean() / 60
plt.axvline(x=event_time_min, color='r', linestyle='--', label='Event Time_
↳(estimated)')

# Calculate average magnitude before and after event
before_mask = t < t.mean()
after_mask = t >= t.mean()

avg_before = np.mean(freq_magnitude[before_mask])
avg_after = np.mean(freq_magnitude[after_mask])

print(f"Average magnitude before event: {avg_before:.4f}")
print(f"Average magnitude after event: {avg_after:.4f}")
print(f"Change: {(avg_after - avg_before):.4f} ({(avg_after - avg_before)/
↳avg_before*100:.2f}%)")

# Add horizontal lines showing the average values
plt.axhline(y=avg_before, color='g', linestyle=':', label=f'Avg Before:
↳{avg_before:.4f}')
plt.axhline(y=avg_after, color='m', linestyle=':', label=f'Avg After:
↳{avg_after:.4f}')

# Add annotations
plt.annotate(f"Avg: {avg_before:.4f}", xy=(time_min[len(time_min)//4],
↳avg_before),
            xytext=(time_min[len(time_min)//4], avg_before*1.1), color='g')
plt.annotate(f"Avg: {avg_after:.4f}", xy=(time_min[3*len(time_min)//4],
↳avg_after),
            xytext=(time_min[3*len(time_min)//4], avg_after*1.1),
↳color='m')

# Set axis labels and title
plt.xlabel('Time (min)')
plt.ylabel('Magnitude')
plt.title(f'Magnitude of {actual_freq:.4f} Hz Component Before and After_
↳Event - {channel_to_analyze}')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()

# Calculate energy (integral of magnitude squared) before and after event
energy_before = np.sum(freq_magnitude[before_mask]**2)
energy_after = np.sum(freq_magnitude[after_mask]**2)

# Normalize by the number of samples to get average energy

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num_samples_before = np.sum(before_mask)
num_samples_after = np.sum(after_mask)
avg_energy_before = energy_before / num_samples_before
avg_energy_after = energy_after / num_samples_after

print("\nEnergy Analysis:")
print(f"Total energy before event: {energy_before:.4f}")
print(f"Total energy after event: {energy_after:.4f}")
print(f"Average energy before event: {avg_energy_before:.4f}")
print(f"Average energy after event: {avg_energy_after:.4f}")
print(f"Energy change: {(avg_energy_after - avg_energy_before):.4f}␣
↪({(avg_energy_after - avg_energy_before)/avg_energy_before*100:.2f}%)")

# Power Spectral Density (PSD) Analysis
# Calculate power (magnitude squared)
power_matrix = np.abs(Zxx) ** 2

# Convert time to minutes for consistency with previous plots
time_min = t / 60

# Define the event time point (assuming same as before)
event_time_min = time_min[len(time_min) // 2] # Middle point as event time

# Create masks for before and after event
before_mask_time = time_min < event_time_min
after_mask_time = time_min > event_time_min

# Calculate average PSD before and after event
avg_psd_before = np.mean(power_matrix[:, before_mask_time], axis=1)
avg_psd_after = np.mean(power_matrix[:, after_mask_time], axis=1)

# Plot the power spectral density comparison
plt.figure(figsize=(15, 6))
plt.plot(f, avg_psd_before, 'g-', label='Before Event')
plt.plot(f, avg_psd_after, 'm-', label='After Event')

# Calculate and display the difference
psd_diff = avg_psd_after - avg_psd_before
plt.plot(f, psd_diff, 'b--', label='Difference (After - Before)')

# Set axis labels and title
plt.xlabel('Frequency (Hz)')
plt.xlim(0, 0.2) # Limit x-axis to show only frequencies below 0.2 Hz
plt.ylabel('Power Spectral Density')
plt.title(f'Power Spectral Density Comparison Before and After Event -␣
↪{channel_to_analyze}')
plt.grid(True)

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```

plt.legend()

# Add text box with summary statistics
total_power_before = np.sum(avg_psd_before)
total_power_after = np.sum(avg_psd_after)
power_change = (total_power_after - total_power_before) /
↳total_power_before * 100

stats_text = f"Total Power Before: {total_power_before:.2f}\n"
stats_text += f"Total Power After: {total_power_after:.2f}\n"
stats_text += f"Change: {power_change:.2f}%"

plt.annotate(stats_text, xy=(0.02, 0.95), xycoords='axes fraction',
             bbox=dict(boxstyle="round,pad=0.5", fc="white", alpha=0.8))

plt.tight_layout()
plt.show()

# Print detailed statistics
print("\nPower Spectral Density Analysis:")
print(f"Total power before event: {total_power_before:.4f}")
print(f"Total power after event: {total_power_after:.4f}")
print(f"Absolute power change: {total_power_after - total_power_before:.
↳4f}")
print(f"Relative power change: {power_change:.2f}%")

# Find frequency bands with the most significant changes
freq_change_percent = (avg_psd_after - avg_psd_before) / (avg_psd_before +
↳1e-10) * 100 # Avoid division by zero
significant_changes = pd.DataFrame({
    'Frequency': f,
    'Before': avg_psd_before,
    'After': avg_psd_after,
    'Absolute_Change': avg_psd_after - avg_psd_before,
    'Percent_Change': freq_change_percent
})

# Save the significant_changes DataFrame to CSV
csv_filename = os.path.join(csv_dir,
↳f"{channel_to_analyze}_significant_changes.csv")
significant_changes.to_csv(csv_filename, index=False)
print(f"Saved significant changes data to: {csv_filename}")

# Display top 5 frequencies with largest increase and decrease
print("\nTop 5 frequencies with largest power increase:")
print(significant_changes.sort_values('Percent_Change', ascending=False).
↳head(5))

```



```

print("\nTop 5 frequencies with largest power decrease:")
print(significant_changes.sort_values('Percent_Change', ascending=True).
↳head(5))

```

Created directory: significant_changes_csv_Mushroom_25-05-08_0326

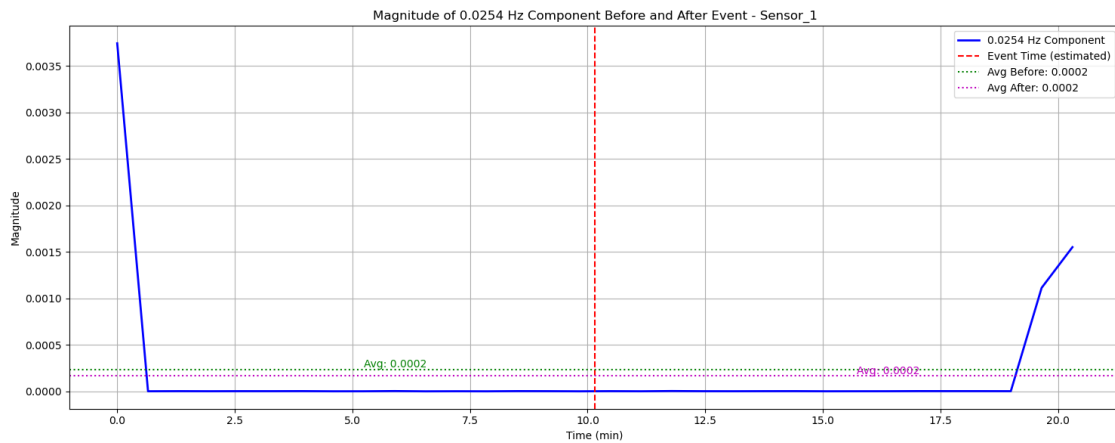
=== Analysis for Sensor_1 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0002

Average magnitude after event: 0.0002

Change: -0.0001 (-28.56%)



Energy Analysis:

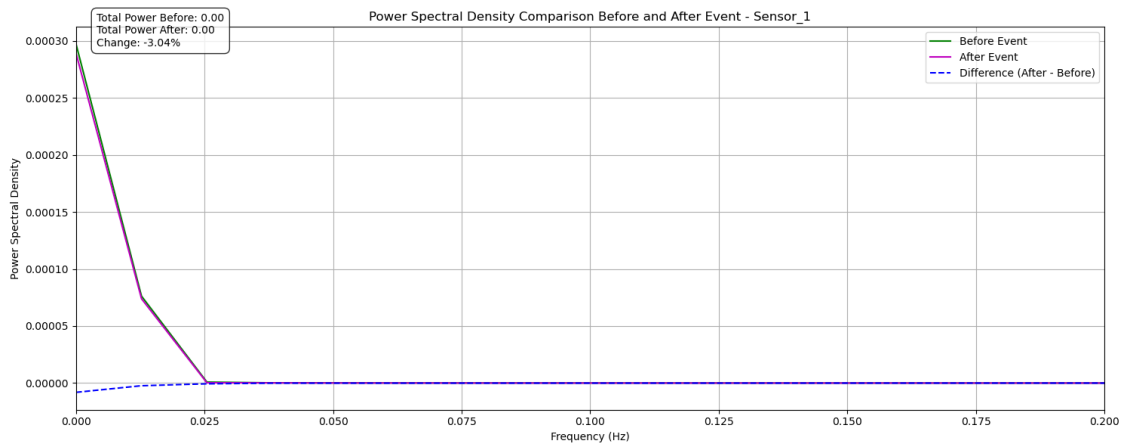
Total energy before event: 0.0000

Total energy after event: 0.0000

Average energy before event: 0.0000

Average energy after event: 0.0000

Energy change: -0.0000 (-73.99%)



Power Spectral Density Analysis:

Total power before event: 0.0004

Total power after event: 0.0004

Absolute power change: -0.0000

Relative power change: -3.04%

Saved significant changes data to:

significant_changes_csv_Mushroom_25-05-08_0326\Sensor_1_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	2.968583e-04	2.887490e-04	-8.109248e-06	-2.731689
1	0.012722	7.620873e-05	7.389340e-05	-2.315325e-06	-3.038132
3	0.038165	2.191682e-07	1.488597e-07	-7.030846e-08	-32.065051
110	1.399401	3.099989e-10	1.748798e-10	-1.351190e-10	-32.955949
122	1.552063	2.971577e-10	1.662093e-10	-1.309484e-10	-32.971389

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	8.764387e-07	2.431797e-07	-6.332589e-07	-72.245409
6	0.076331	5.802607e-08	2.924027e-08	-2.878580e-08	-49.523052
10	0.127218	2.020418e-08	1.073879e-08	-9.465381e-09	-46.617904
14	0.178106	1.029429e-08	5.510975e-09	-4.783313e-09	-46.018666
12	0.152662	1.397502e-08	7.515429e-09	-6.459590e-09	-45.894004

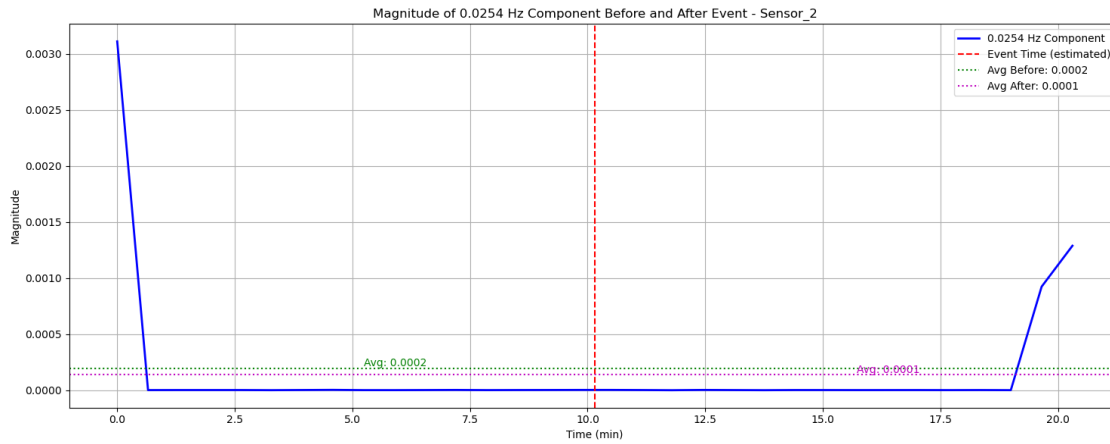
=== Analysis for Sensor_2 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0002

Average magnitude after event: 0.0001

Change: -0.0001 (-28.80%)



Energy Analysis:

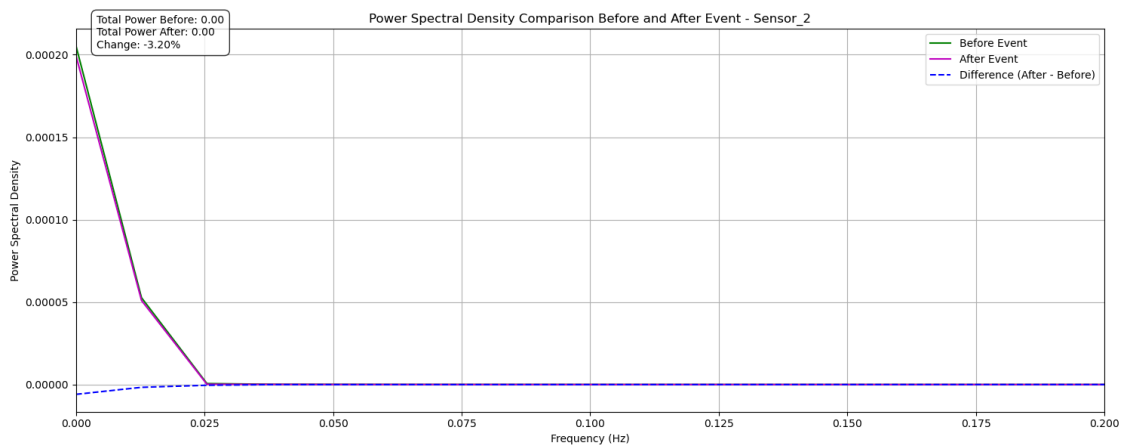
Total energy before event: 0.0000

Total energy after event: 0.0000

Average energy before event: 0.0000

Average energy after event: 0.0000

Energy change: -0.0000 (-74.02%)



Power Spectral Density Analysis:

Total power before event: 0.0003

Total power after event: 0.0003

Absolute power change: -0.0000

Relative power change: -3.20%

Saved significant changes data to:

significant_changes_csv_Mushroom_25-05-08_0326\Sensor_2_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	2.050875e-04	1.991528e-04	-5.934664e-06	-2.893722
1	0.012722	5.264655e-05	5.096375e-05	-1.682802e-06	-3.196408
122	1.552063	2.052025e-10	1.191341e-10	-8.606839e-11	-28.200423
126	1.602950	2.050034e-10	1.138201e-10	-9.118334e-11	-29.895844
114	1.450288	2.069731e-10	1.150783e-10	-9.189479e-11	-29.935781

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	6.044278e-07	1.674976e-07	-4.369303e-07	-72.276288
6	0.076331	4.010620e-08	2.018996e-08	-1.991624e-08	-49.535251
10	0.127218	1.397468e-08	7.411883e-09	-6.562793e-09	-46.628377
16	0.203549	5.435949e-09	2.895233e-09	-2.540715e-09	-45.894849
12	0.152662	9.640142e-09	5.190336e-09	-4.449806e-09	-45.685227

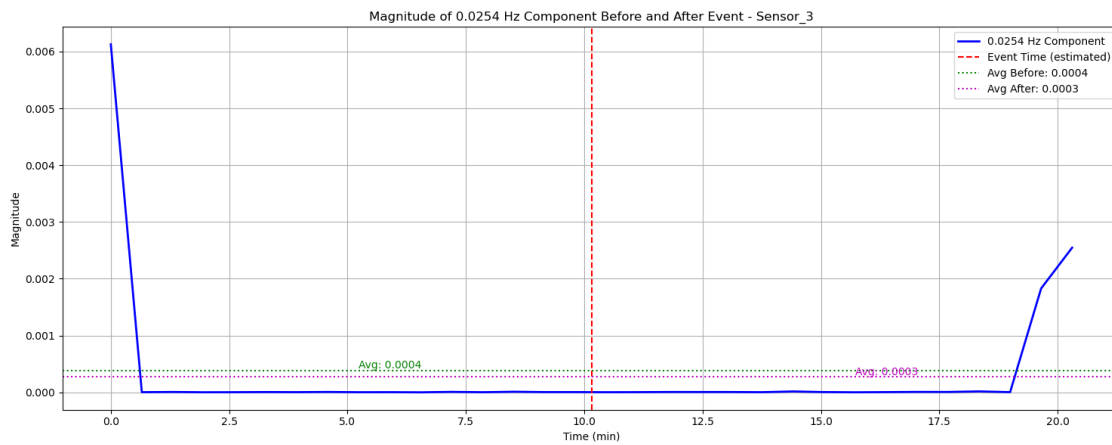
=== Analysis for Sensor_3 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0004

Average magnitude after event: 0.0003

Change: -0.0001 (-27.90%)



Energy Analysis:

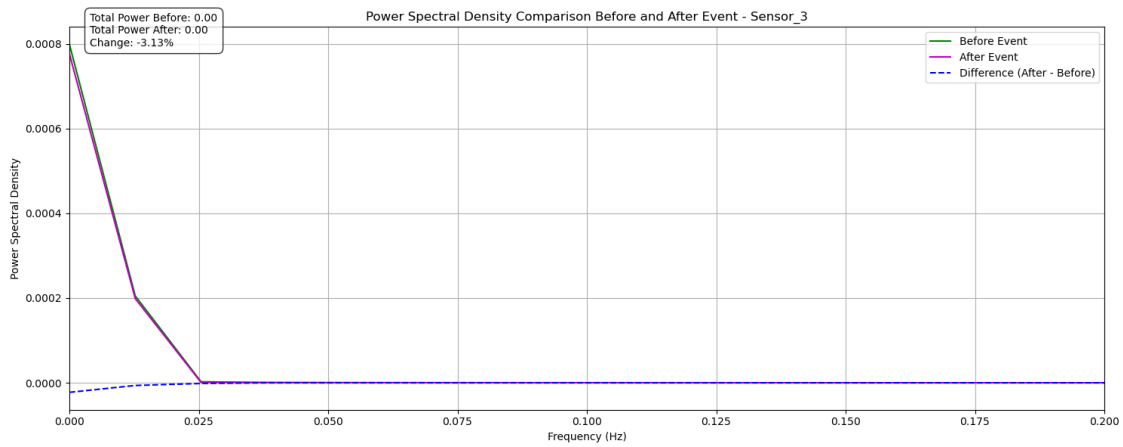
Total energy before event: 0.0000

Total energy after event: 0.0000

Average energy before event: 0.0000

Average energy after event: 0.0000

Energy change: -0.0000 (-73.80%)



Power Spectral Density Analysis:

Total power before event: 0.0010

Total power after event: 0.0010

Absolute power change: -0.0000

Relative power change: -3.13%

Saved significant changes data to:

significant_changes_csv_Mushroom_25-05-08_0326\Sensor_3_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	7.990619e-04	7.764624e-04	-2.259948e-05	-2.828252
1	0.012722	2.051075e-04	1.987153e-04	-6.392224e-06	-3.116522
3	0.038165	5.873626e-07	4.010315e-07	-1.863311e-07	-31.717954
108	1.373957	8.305876e-10	4.674738e-10	-3.631139e-10	-39.019845
117	1.488454	8.020849e-10	4.444660e-10	-3.576189e-10	-39.643599

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	2.346565e-06	6.557414e-07	-1.690824e-06	-72.052196
6	0.076331	1.553858e-07	7.894813e-08	-7.643764e-08	-49.160537
10	0.127218	5.409620e-08	2.899554e-08	-2.510066e-08	-46.314427
14	0.178106	2.754315e-08	1.486458e-08	-1.267858e-08	-45.865162
20	0.254437	1.358104e-08	7.317137e-09	-6.263903e-09	-45.785283

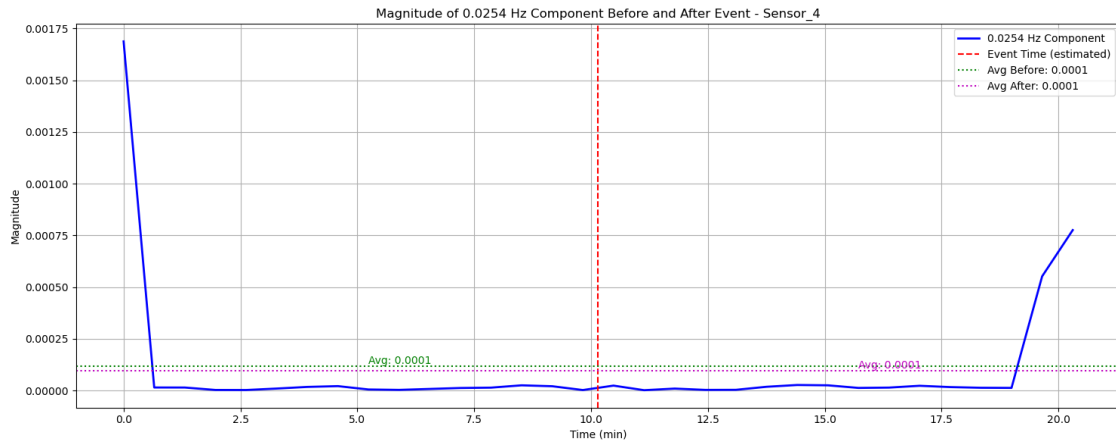
=== Analysis for Sensor_4 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0001

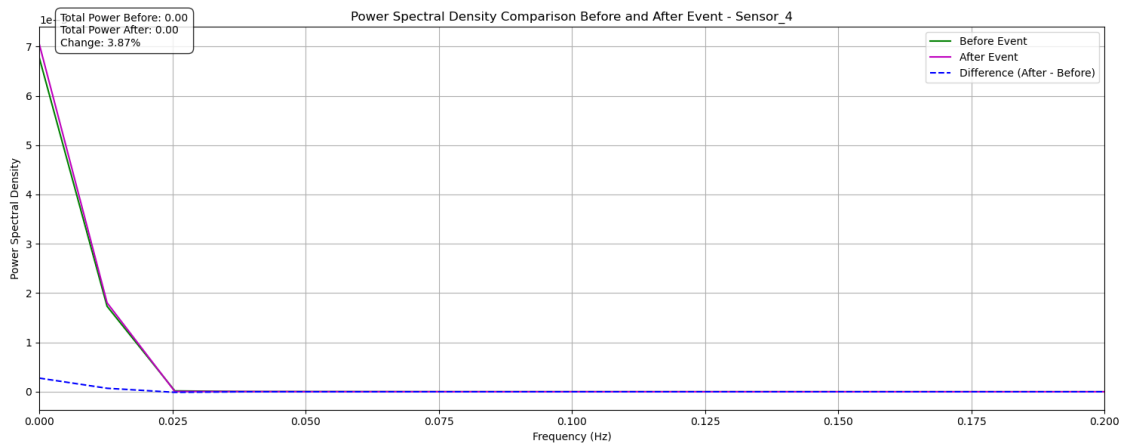
Average magnitude after event: 0.0001

Change: -0.0000 (-17.63%)



Energy Analysis:

Total energy before event: 0.0000
 Total energy after event: 0.0000
 Average energy before event: 0.0000
 Average energy after event: 0.0000
 Energy change: -0.0000 (-68.05%)



Power Spectral Density Analysis:

Total power before event: 0.0001
 Total power after event: 0.0001
 Absolute power change: 0.0000
 Relative power change: 3.87%
 Saved significant changes data to:
 significant_changes_csv_Mushroom_25-05-08_0326\Sensor_4_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	6.768243e-05	7.044645e-05	2.764022e-06	4.083805
1	0.012722	1.733313e-05	1.803929e-05	7.061624e-07	4.074039
101	1.284905	6.461699e-11	4.693797e-11	-1.767902e-11	-10.739487
117	1.488454	6.210609e-11	4.426067e-11	-1.784541e-11	-11.008478
111	1.412123	6.035043e-11	4.253414e-11	-1.781629e-11	-11.110844

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	1.783122e-07	6.073798e-08	-1.175743e-07	-65.900332
6	0.076331	1.188320e-08	7.394090e-09	-4.489113e-09	-37.461710
10	0.127218	4.160037e-09	2.688039e-09	-1.471998e-09	-34.553649
12	0.152662	2.872541e-09	1.867244e-09	-1.005297e-09	-33.819450
9	0.114496	5.055652e-09	3.323014e-09	-1.732639e-09	-33.606581

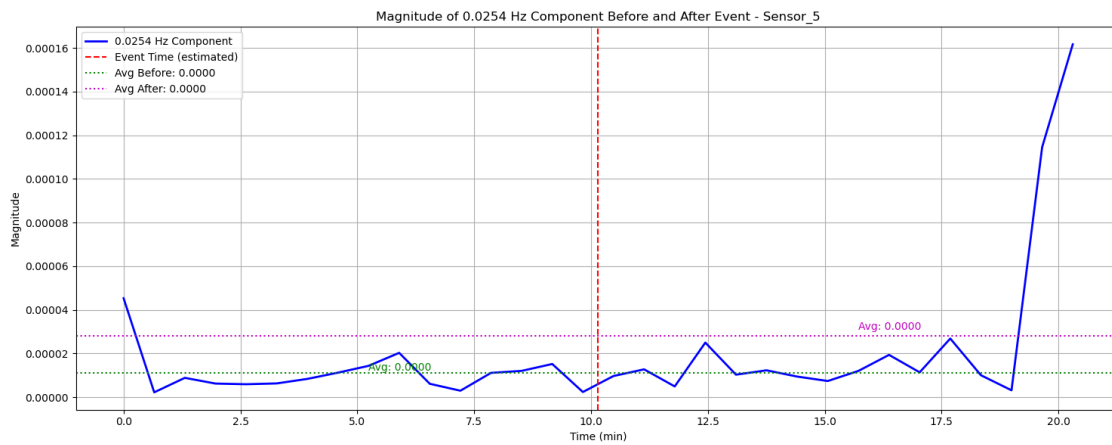
=== Analysis for Sensor_5 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0000

Average magnitude after event: 0.0000

Change: 0.0000 (152.21%)



Energy Analysis:

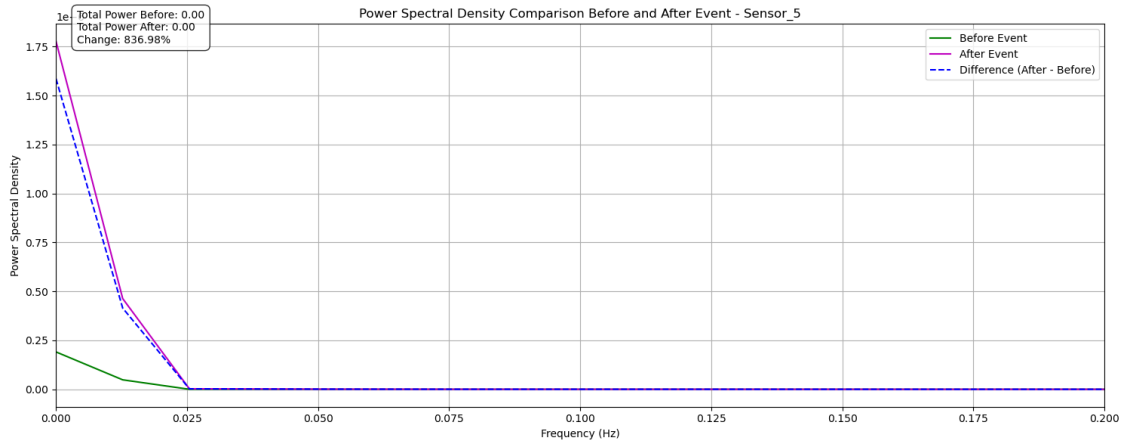
Total energy before event: 0.0000

Total energy after event: 0.0000

Average energy before event: 0.0000

Average energy after event: 0.0000

Energy change: 0.0000 (1063.74%)



Power Spectral Density Analysis:

Total power before event: 0.0000

Total power after event: 0.0000

Absolute power change: 0.0000

Relative power change: 836.98%

Saved significant changes data to:

significant_changes_csv_Mushroom_25-05-08_0326\Sensor_5_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
3	0.038165	5.249916e-11	1.652344e-09	1.599845e-09	1049.084323
1	0.012722	4.850303e-08	4.633636e-07	4.148606e-07	853.569381
0	0.000000	1.909802e-07	1.777128e-06	1.586148e-06	830.095016
2	0.025444	2.258227e-10	2.796950e-09	2.571127e-09	789.118673
4	0.050887	2.458312e-11	8.900787e-10	8.654955e-10	694.713302

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
103	1.310348	9.520205e-13	1.900682e-12	9.486610e-13	0.939715
126	1.602950	5.975665e-13	1.980901e-12	1.383335e-12	1.375117
119	1.513898	7.564051e-13	2.143271e-12	1.386866e-12	1.376454
107	1.361236	6.951328e-13	2.097510e-12	1.402377e-12	1.392696
100	1.272183	4.941462e-13	1.967097e-12	1.472951e-12	1.465708

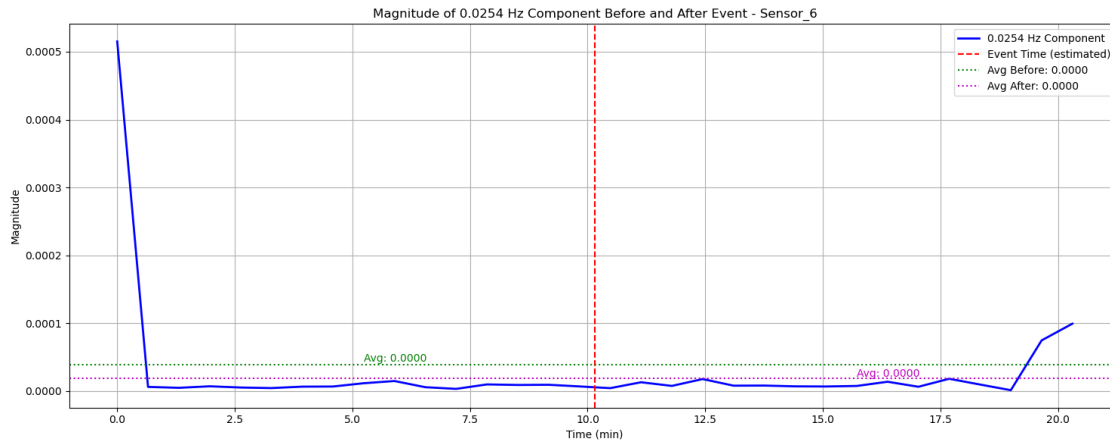
=== Analysis for Sensor_6 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0000

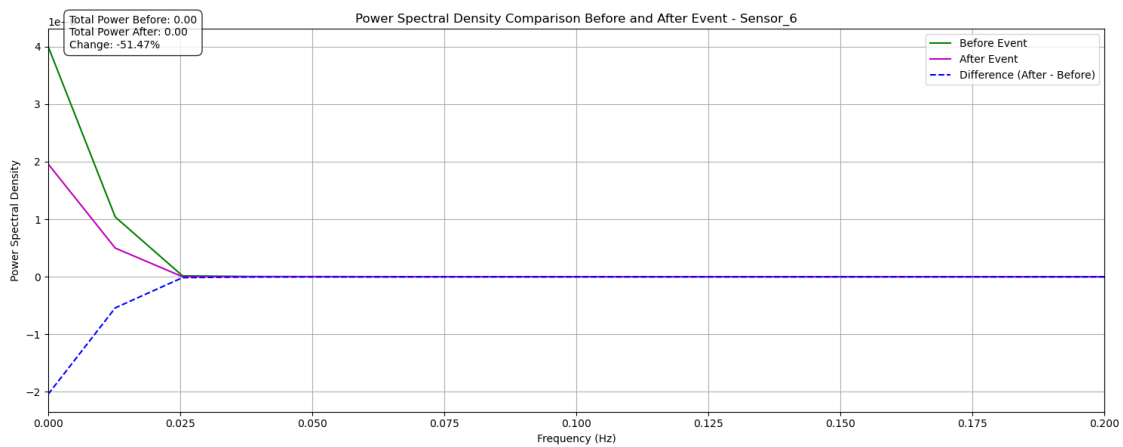
Average magnitude after event: 0.0000

Change: -0.0000 (-51.74%)



Energy Analysis:

Total energy before event: 0.0000
 Total energy after event: 0.0000
 Average energy before event: 0.0000
 Average energy after event: 0.0000
 Energy change: -0.0000 (-93.66%)



Power Spectral Density Analysis:

Total power before event: 0.0000
 Total power after event: 0.0000
 Absolute power change: -0.0000
 Relative power change: -51.47%
 Saved significant changes data to:
 significant_changes_csv_Mushroom_25-05-08_0326\Sensor_6_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
116	1.475732	5.713501e-12	1.469335e-12	-4.244166e-12	-4.014781
118	1.501176	5.328932e-12	9.631812e-13	-4.365751e-12	-4.144874
115	1.463010	5.684343e-12	1.302219e-12	-4.382124e-12	-4.146427
128	1.628394	5.558178e-12	9.246618e-13	-4.633516e-12	-4.389537
114	1.450288	5.816099e-12	1.093789e-12	-4.722309e-12	-4.462751

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	1.664633e-08	1.124199e-09	-1.552213e-08	-92.689750
4	0.050887	2.608361e-09	3.290712e-10	-2.279289e-09	-84.157531
3	0.038165	4.198735e-09	6.078158e-10	-3.590919e-09	-83.534324
6	0.076331	1.095456e-09	1.209318e-10	-9.745243e-10	-81.519039
5	0.063609	1.478673e-09	1.919108e-10	-1.286762e-09	-81.509095

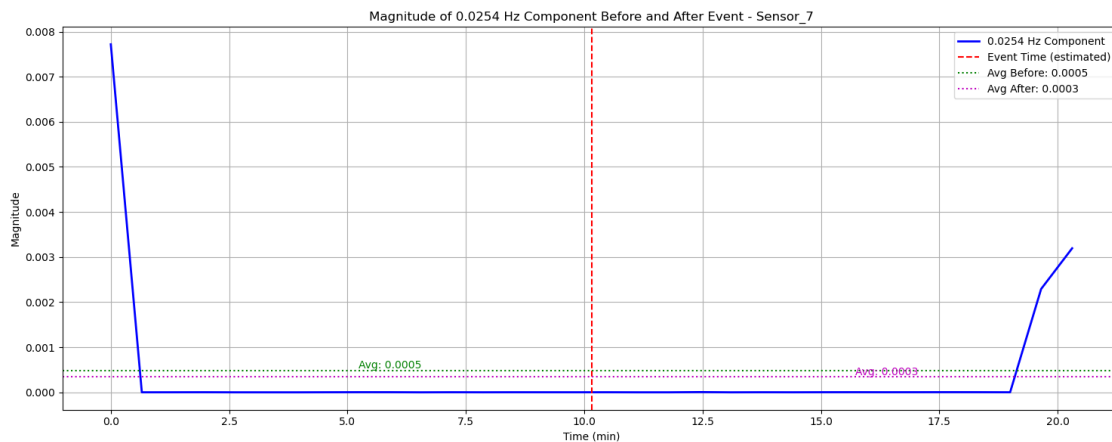
=== Analysis for Sensor_7 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0005

Average magnitude after event: 0.0003

Change: -0.0001 (-28.71%)



Energy Analysis:

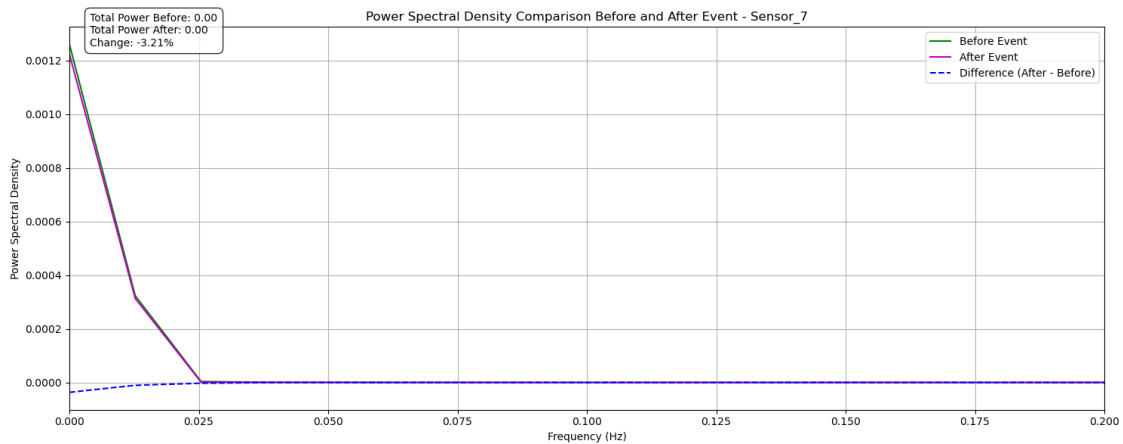
Total energy before event: 0.0001

Total energy after event: 0.0000

Average energy before event: 0.0000

Average energy after event: 0.0000

Energy change: -0.0000 (-74.05%)



Power Spectral Density Analysis:

Total power before event: 0.0016

Total power after event: 0.0015

Absolute power change: -0.0001

Relative power change: -3.21%

Saved significant changes data to:

significant_changes_csv_Mushroom_25-05-08_0326\Sensor_7_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	1.260792e-03	1.224150e-03	-3.664175e-05	-2.906248
1	0.012722	3.236504e-04	3.132586e-04	-1.039175e-05	-3.210794
3	0.038165	9.311271e-07	6.305541e-07	-3.005730e-07	-32.277086
126	1.602950	1.252598e-09	6.835875e-10	-5.690103e-10	-42.067959
111	1.412123	1.318686e-09	7.217872e-10	-5.968992e-10	-42.074074

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	3.722770e-06	1.030549e-06	-2.692221e-06	-72.315741
6	0.076331	2.466253e-07	1.240796e-07	-1.225457e-07	-49.668876
10	0.127218	8.594318e-08	4.556326e-08	-4.037992e-08	-46.929833
24	0.305324	1.506858e-08	8.053006e-09	-7.015578e-09	-46.250710
16	0.203549	3.343455e-08	1.796288e-08	-1.547167e-08	-46.136513

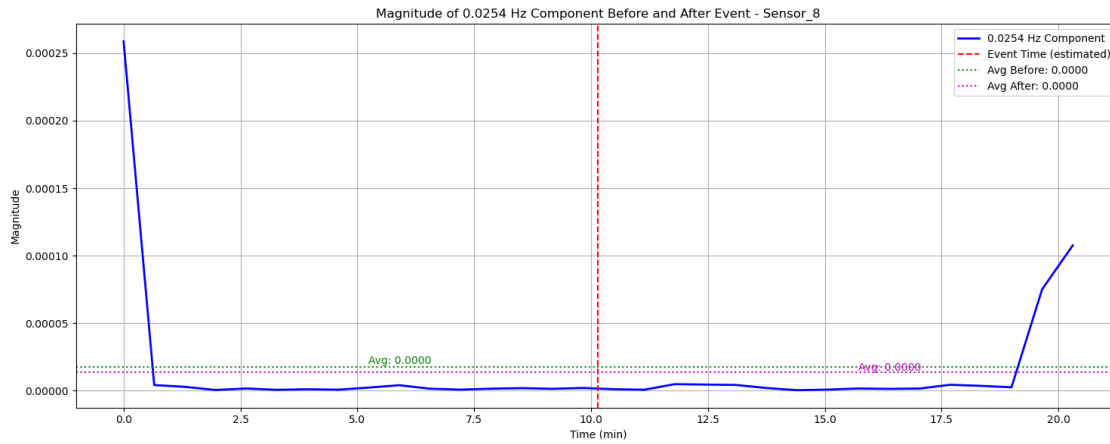
=== Analysis for Sensor_8 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: 0.0000

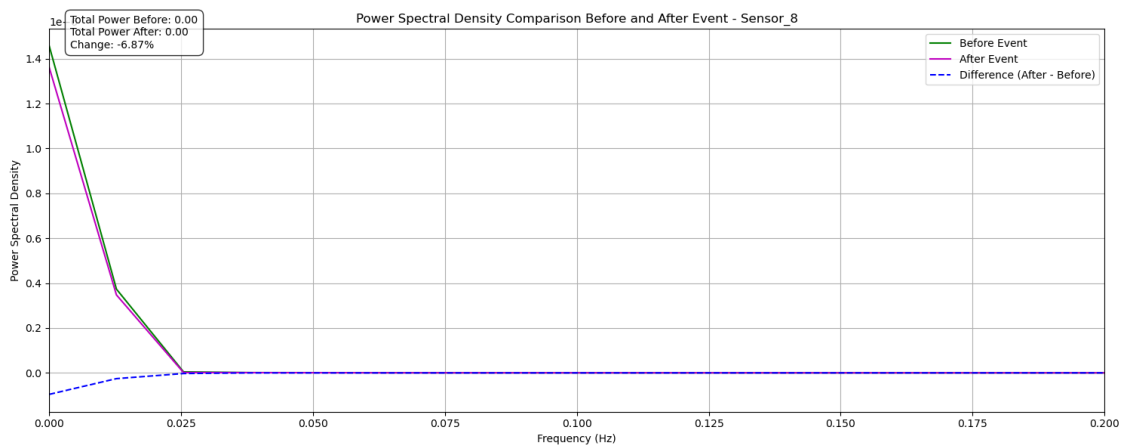
Average magnitude after event: 0.0000

Change: -0.0000 (-24.46%)



Energy Analysis:

Total energy before event: 0.0000
 Total energy after event: 0.0000
 Average energy before event: 0.0000
 Average energy after event: 0.0000
 Energy change: -0.0000 (-74.18%)



Power Spectral Density Analysis:

Total power before event: 0.0000
 Total power after event: 0.0000
 Absolute power change: -0.0000
 Relative power change: -6.87%
 Saved significant changes data to:
 significant_changes_csv_Mushroom_25-05-08_0326\Sensor_8_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
98	1.246739	1.746126e-12	1.739261e-12	-6.865117e-15	-0.006747
123	1.564785	1.749248e-12	1.740373e-12	-8.875565e-15	-0.008723
110	1.399401	1.436612e-12	1.419493e-12	-1.711848e-14	-0.016876
111	1.412123	1.525424e-12	1.478100e-12	-4.732491e-14	-0.046614
124	1.577507	1.888741e-12	1.577261e-12	-3.114798e-13	-0.305706

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
2	0.025444	4.188243e-09	1.153365e-09	-3.034878e-09	-70.772059
4	0.050887	6.713963e-10	3.863197e-10	-2.850766e-10	-36.955917
5	0.063609	3.753800e-10	2.054697e-10	-1.699103e-10	-35.742000
6	0.076331	2.716959e-10	1.415131e-10	-1.301827e-10	-35.023993
7	0.089053	1.837440e-10	1.068023e-10	-7.694173e-11	-27.116600

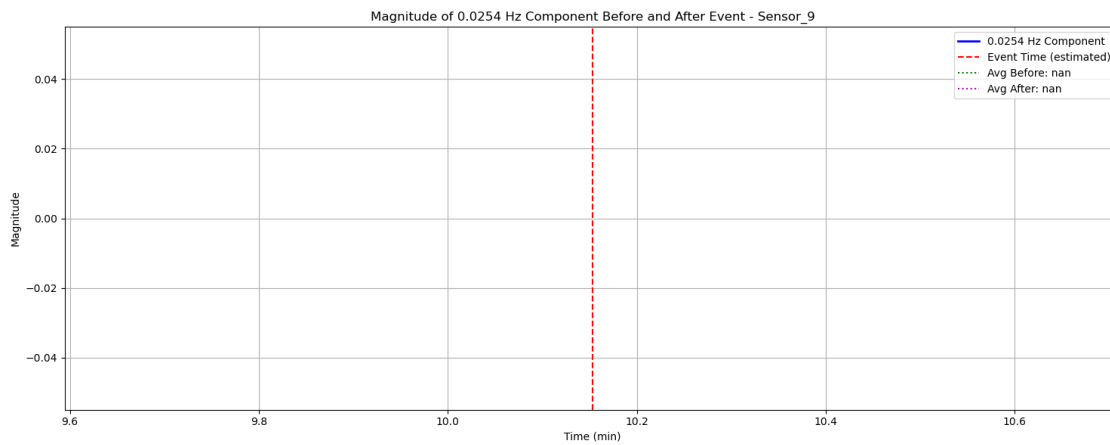
=== Analysis for Sensor_9 ===

Analyzing frequency: 0.0254 Hz (closest to 0.02 Hz)

Average magnitude before event: nan

Average magnitude after event: nan

Change: nan (nan%)



Energy Analysis:

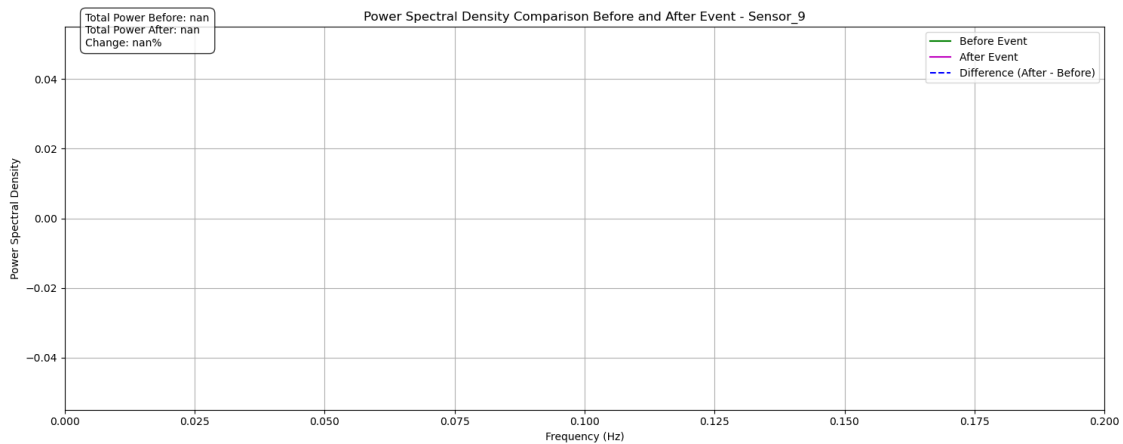
Total energy before event: nan

Total energy after event: nan

Average energy before event: nan

Average energy after event: nan

Energy change: nan (nan%)



Power Spectral Density Analysis:

Total power before event: nan

Total power after event: nan

Absolute power change: nan

Relative power change: nan%

Saved significant changes data to:

significant_changes_csv_Mushroom_25-05-08_0326\Sensor_9_significant_changes.csv

Top 5 frequencies with largest power increase:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	NaN	NaN	NaN	NaN
1	0.012722	NaN	NaN	NaN	NaN
2	0.025444	NaN	NaN	NaN	NaN
3	0.038165	NaN	NaN	NaN	NaN
4	0.050887	NaN	NaN	NaN	NaN

Top 5 frequencies with largest power decrease:

	Frequency	Before	After	Absolute_Change	Percent_Change
0	0.000000	NaN	NaN	NaN	NaN
1	0.012722	NaN	NaN	NaN	NaN
2	0.025444	NaN	NaN	NaN	NaN
3	0.038165	NaN	NaN	NaN	NaN
4	0.050887	NaN	NaN	NaN	NaN

```
[41]: # Delete data for the 9th sensor in the
      ↪significant_changes_csv_Mushroom_25-05-08_0326 directory

import os
import shutil

# Define the directory containing the CSV files
```

```

csv_dir_path = "significant_changes_csv_Mushroom_25-05-08_0326"

# Get all CSV files in the directory
csv_files = [f for f in os.listdir(csv_dir_path) if f.
    ↪endswith('_significant_changes.csv')]

# Sort the files to ensure consistent ordering
csv_files.sort()

# Check if we have at least 9 sensors
if len(csv_files) >= 9:
    # Get the 9th sensor's filename (index 8 since zero-based)
    ninth_sensor_file = csv_files[8]
    ninth_sensor_path = os.path.join(csv_dir_path, ninth_sensor_file)

    # Print information about the file being deleted
    print(f"Deleting data for the 9th sensor: {ninth_sensor_file}")

    # Option 1: Delete the file
    os.remove(ninth_sensor_path)
    print(f"File {ninth_sensor_file} has been deleted.")

    # Alternative option (commented out): Create a backup instead of deleting
    # backup_path = ninth_sensor_path + ".backup"
    # shutil.copy2(ninth_sensor_path, backup_path)
    # os.remove(ninth_sensor_path)
    # print(f"File {ninth_sensor_file} has been deleted. Backup created at ↵
    ↪{backup_path}")
else:
    print(f"There are only {len(csv_files)} sensor files in the directory, ↵
    ↪cannot delete the 9th sensor.")

```

Deleting data for the 9th sensor: Sensor_9_significant_changes.csv
File Sensor_9_significant_changes.csv has been deleted.

```

[42]: import seaborn as sns

# Analyze significant changes across all sensors
print("\nAnalyzing significant changes across all sensors...")

# Define the directory containing the CSV files
csv_dir_path = "significant_changes_csv_Mushroom_25-05-08_0326"

# Get all CSV files in the directory
csv_files = [f for f in os.listdir(csv_dir_path) if f.
    ↪endswith('_significant_changes.csv')]

```

```

# Initialize lists to store summary data
sensor_names = []
top_increase_freqs = []
top_decrease_freqs = []
all_sensor_data = {}

# Create a figure for comparing all sensors
plt.figure(figsize=(15, 6))

# Process each sensor's data
for csv_file in csv_files:
    # Extract sensor name from filename
    sensor_name = csv_file.split('_significant_changes.csv')[0]
    sensor_names.append(sensor_name)

    # Load the CSV data
    csv_path = os.path.join(csv_dir_path, csv_file)
    sensor_data = pd.read_csv(csv_path)
    all_sensor_data[sensor_name] = sensor_data

    # Sort by absolute percent change
    sensor_data['Abs_Percent_Change'] = np.abs(sensor_data['Percent_Change'])

    # Get top increases and decreases
    top_increases = sensor_data.sort_values('Percent_Change', ascending=False).
    ↪head(20)
    top_increase_freqs.append(top_increases['Frequency'].tolist())

    top_decreases = sensor_data.sort_values('Percent_Change', ascending=True).
    ↪head(20)
    top_decrease_freqs.append(top_decreases['Frequency'].tolist())

    # Plot frequency vs percent change for this sensor
    plt.scatter(sensor_data['Frequency'], sensor_data['Percent_Change'],
                alpha=0.3, label=sensor_name)

# Add plot details
plt.axhline(y=0, color='k', linestyle='--', alpha=0.3)
plt.xlabel('Frequency (Hz)')
plt.ylabel('Percent Change (%)')
plt.title('Frequency Distribution of Power Changes - All Sensors')
plt.legend()
plt.grid(True, alpha=0.3)
plt.tight_layout()
plt.show()

# Analyze patterns in top increases and decreases

```



```

print("\nAnalyzing patterns in top increases and decreases...")

# Create figures for top increases and decreases
plt.figure(figsize=(15, 6))
plt.subplot(1, 2, 1)
for i, sensor_name in enumerate(sensor_names):
    sensor_data = all_sensor_data[sensor_name]
    top_increases = sensor_data.sort_values('Percent_Change', ascending=False).
    ↪head(10)
    plt.scatter(top_increases['Frequency'], top_increases['Percent_Change'],
                label=sensor_name, s=100, alpha=0.7)

    # Removed annotation of frequencies to avoid overlapping text

plt.title('Top 10 Frequencies with Largest Increases')
plt.xlabel('Frequency (Hz)')
plt.ylabel('Percent Change (%)')
plt.legend()
plt.grid(True, alpha=0.3)

plt.subplot(1, 2, 2)
for i, sensor_name in enumerate(sensor_names):
    sensor_data = all_sensor_data[sensor_name]
    top_decreases = sensor_data.sort_values('Percent_Change', ascending=True).
    ↪head(10)
    plt.scatter(top_decreases['Frequency'], top_decreases['Percent_Change'],
                label=sensor_name, s=100, alpha=0.7)

    # Removed annotation of frequencies to avoid overlapping text

plt.title('Top 10 Frequencies with Largest Decreases')
plt.xlabel('Frequency (Hz)')
plt.ylabel('Percent Change (%)')
plt.legend()
plt.grid(True, alpha=0.3)

plt.tight_layout()
plt.show()

# Analyze frequency overlap between sensors for top increases and decreases
print("\nAnalyzing frequency overlap between sensors...")

# For increases
increase_overlap = set(top_increase_freqs[0])
for freqs in top_increase_freqs[1:]:
    increase_overlap = increase_overlap.intersection(set(freqs))

```

```

# For decreases
decrease_overlap = set(top_decrease_freqs[0])
for freqs in top_decrease_freqs[1:]:
    decrease_overlap = decrease_overlap.intersection(set(freqs))

print(f"Common frequencies showing increases across all sensors:␣
↪{sorted(list(increase_overlap))}")
print(f"Common frequencies showing decreases across all sensors:␣
↪{sorted(list(decrease_overlap))}")

# Analyze the distribution of top changes by frequency range
for sensor_name in sensor_names:
    sensor_data = all_sensor_data[sensor_name]

    # Define frequency bands
    sensor_data['Frequency_Band'] = pd.cut(sensor_data['Frequency'],
                                             bins=[0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.
↪6, 0.7],
                                             labels=['0-0.1', '0.1-0.2', '0.2-0.
↪3', '0.3-0.4', '0.4-0.5', '0.5-0.6', '0.6-0.7'])

    # Count top increases and decreases by frequency band
    top_increases = sensor_data.sort_values('Percent_Change', ascending=False).
↪head(20)
    top_decreases = sensor_data.sort_values('Percent_Change', ascending=True).
↪head(20)

    increase_band_counts = top_increases['Frequency_Band'].value_counts().
↪sort_index()
    decrease_band_counts = top_decreases['Frequency_Band'].value_counts().
↪sort_index()

    # Plot distribution of top changes by frequency band
    plt.figure(figsize=(15, 6))
    plt.subplot(1, 2, 1)
    increase_band_counts.plot(kind='bar', color='green', alpha=0.7)
    plt.title(f'{sensor_name}: Distribution of Top 20 Increases by Frequency␣
↪Band')
    plt.xlabel('Frequency Band (Hz)')
    plt.ylabel('Count')
    plt.grid(True, alpha=0.3)

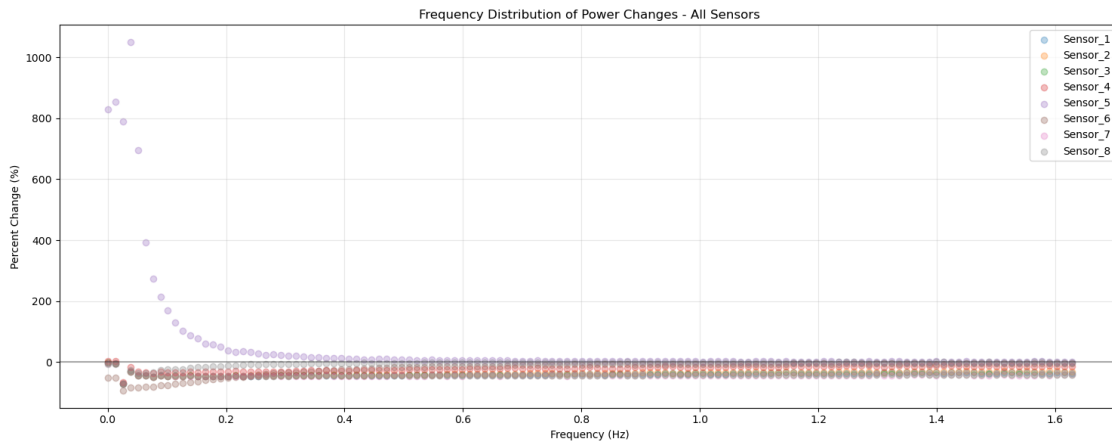
    plt.subplot(1, 2, 2)
    decrease_band_counts.plot(kind='bar', color='red', alpha=0.7)
    plt.title(f'{sensor_name}: Distribution of Top 20 Decreases by Frequency␣
↪Band')

```

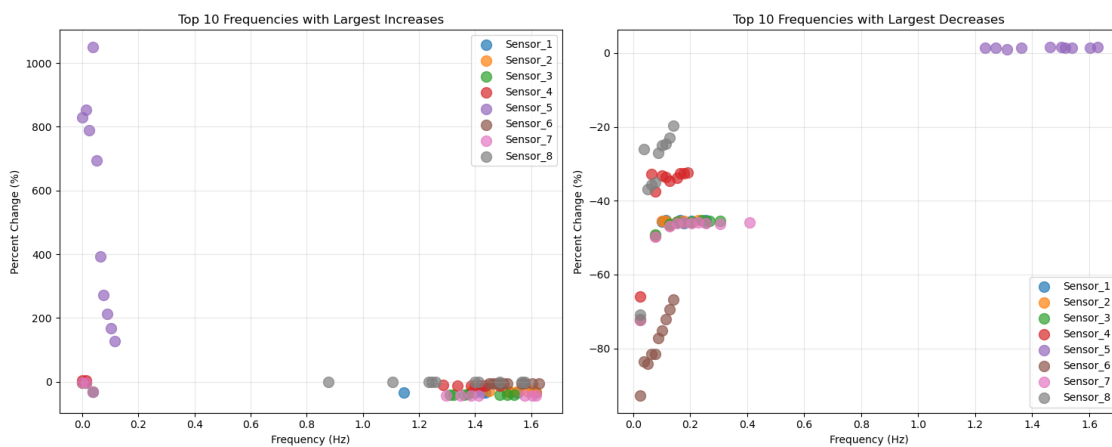
```
plt.xlabel('Frequency Band (Hz)')
plt.ylabel('Count')
plt.grid(True, alpha=0.3)

plt.tight_layout()
plt.show()
```

Analyzing significant changes across all sensors...



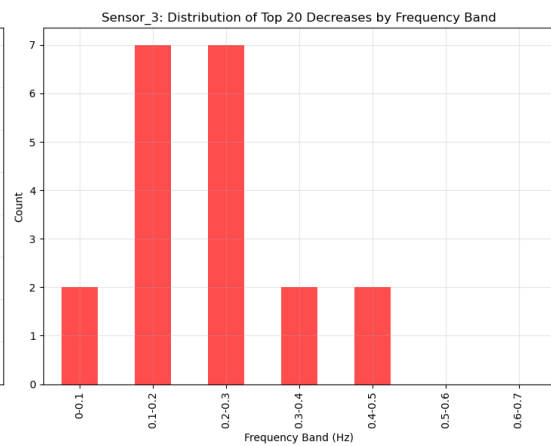
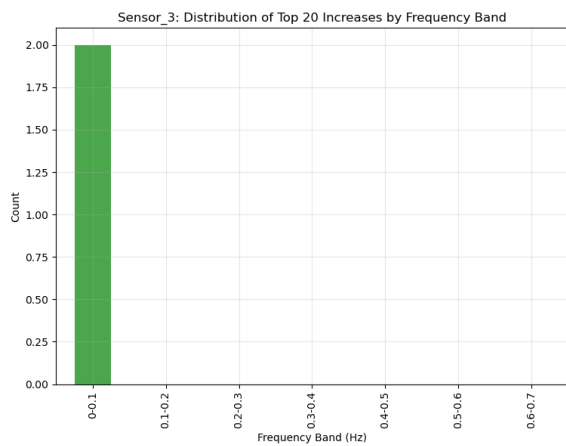
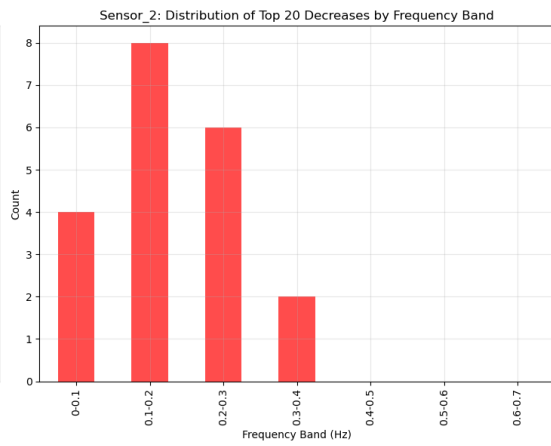
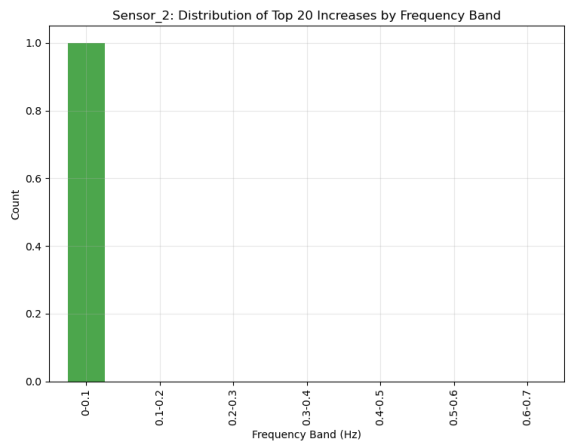
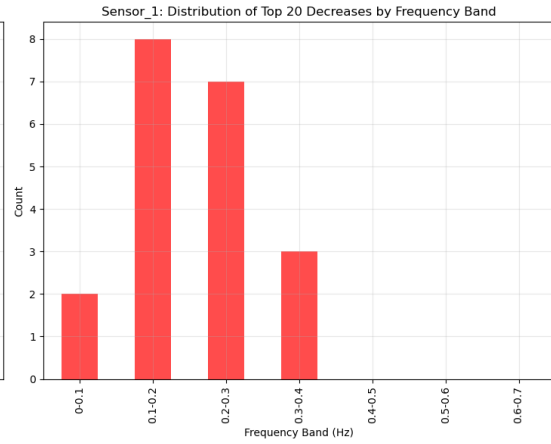
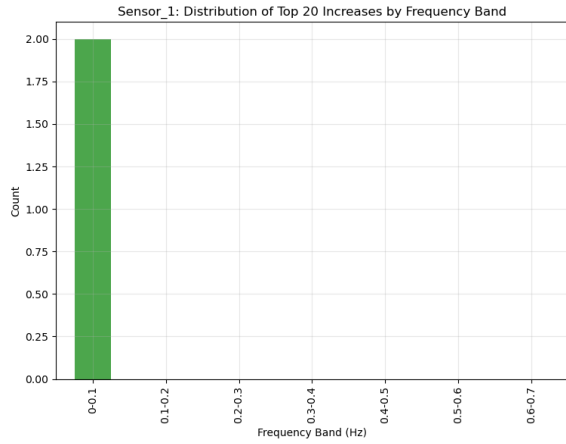
Analyzing patterns in top increases and decreases...

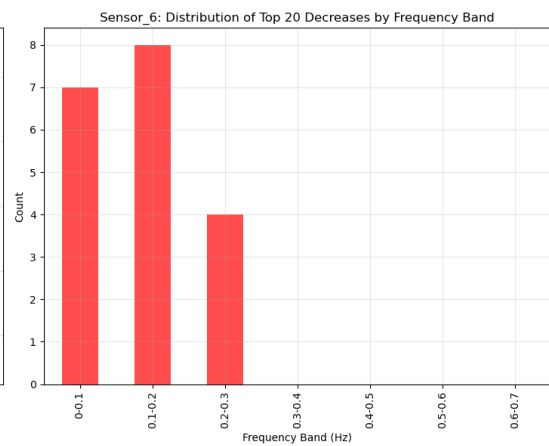
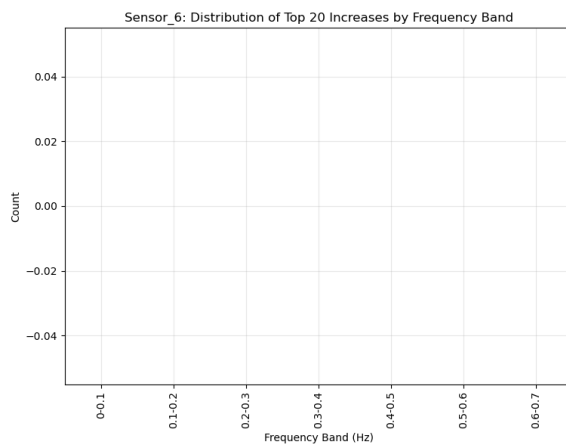
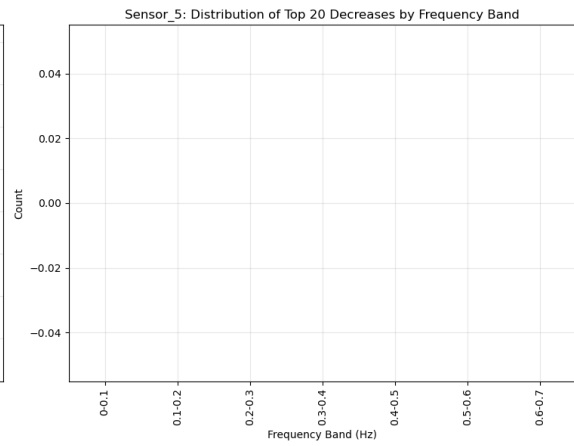
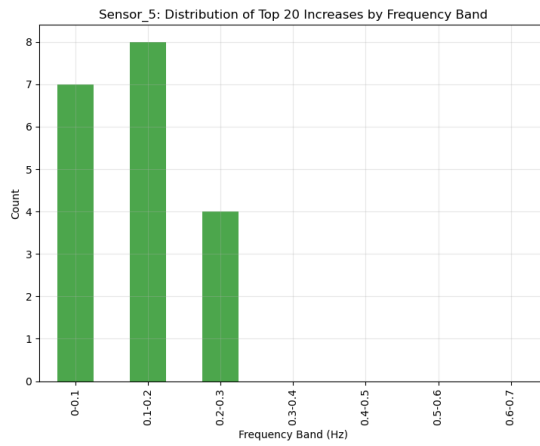
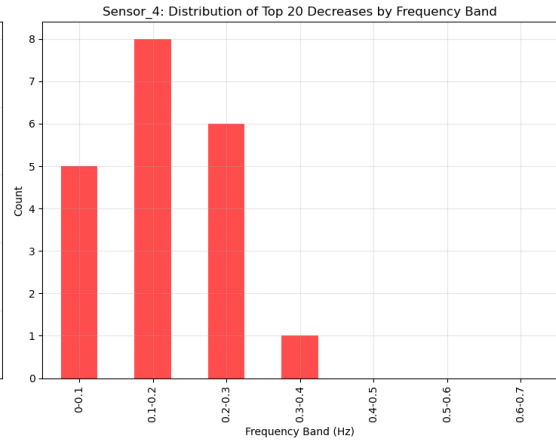
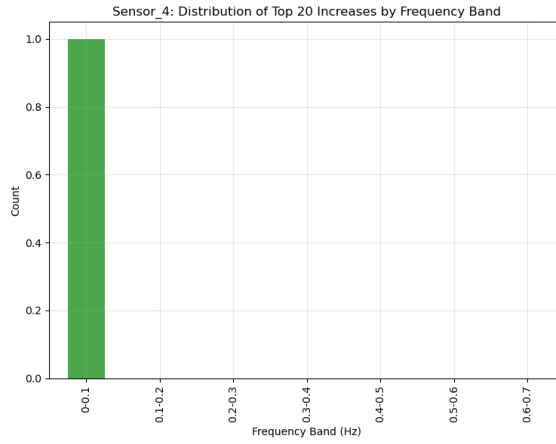


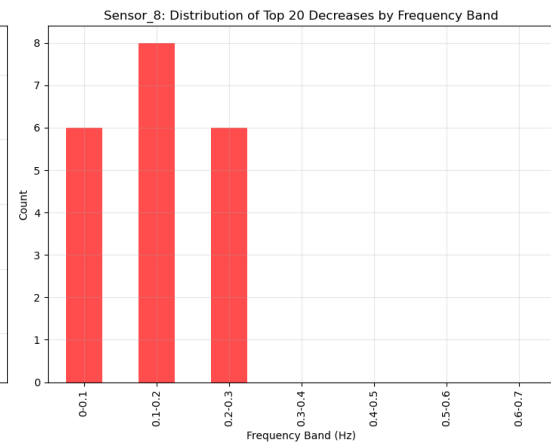
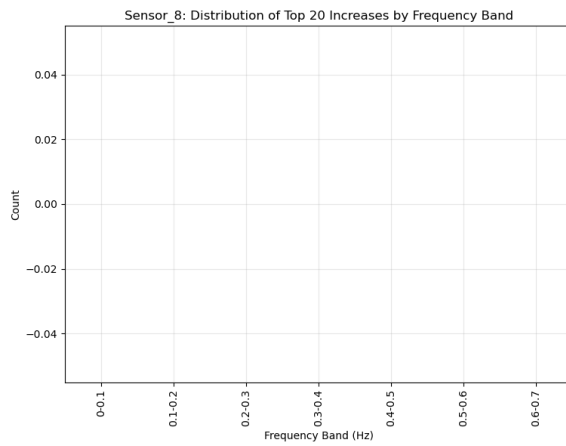
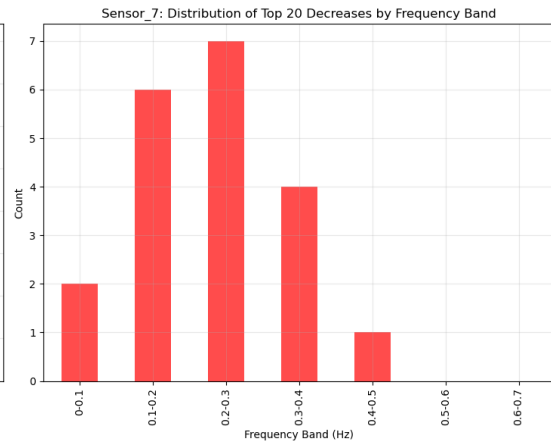
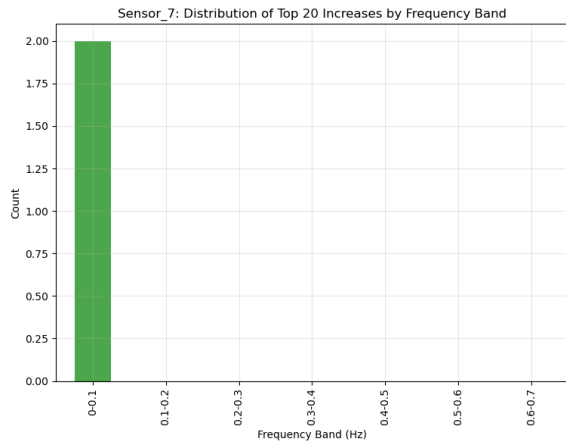
Analyzing frequency overlap between sensors...

Common frequencies showing increases across all sensors: []

Common frequencies showing decreases across all sensors: []







[]: