Remote Vibration FFT Analyzer –Using Mobile App IOT and MATLAB Application

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Abstract - A new system to check machine vibrations from far away has been created. It uses sensor and IoT technology and MATLAB to show data. It's better than old ways because it uses new technology to watch things right away. Here's how it works: M5StickC device on the machine. This thing has a 3-axis IMU digital sensor that measures the acceleration. Then, it sends this info to phones using Bluetooth. This makes it a small, flexible IoT platform that collects reliable data. After that, an app sends this stuff to a cloud platform. There, a MATLAB program does something called Fast Fourier Transform (FFT) analysis. This gives you pictures of the signals in remotely showing how they change over time and how often they happen.

Methods like remote vibration tests can spot equipment problems such as unbalance, gears and bearing issues on. This real-time data review and evaluation boost productivity and make things more accurate while cutting down on repair costs and time when machines aren't working. It allows factories to use predictive upkeep, which makes equipment more reliable and accurate. This means less downtime and cheaper maintenance overall.

***Key Words*:** IoT (Internet of Things), Fast Fourier Transform (FFT), Predictive maintenance,

1.INTRODUCTION

In the evolving field of industrial maintenance, the fusion with cutting-edge technologies has an impact on how we keep an eye on and maintain machinery. This project aims to set up a groundbreaking remote vibration analysis system by using both IoT technology and MATLAB's data visualization tools, addressing these three key needs of today's industry:

1. Remote analysis: The ability to analyze vibration data from anywhere in the world at any time can transform how a company reacts to market shifts and meets customer needs. This allows the business to act in real time monitoring and making decisions right where it matters.

2. Zero Cloud Infrastructure: No-cost cloud-based answers enable businesses to gather, store, and examine vibration data from multiple sites without extra infrastructure expenses. This makes advanced analytical tools accessible to companies of all sizes, at no cost.

3.Triaxial Measurement: The M5StickC device has a 3-axial IMU digital sensor. This 3D measurement ability captures data from all angles. It considers vibrations in every direction to give a complete picture of how well the machine is doing.

The system uses real-time and cheap methods to shake up all the old ways of checking and figuring out mechanical vibration. It picks up on how fast the machine is moving and sends this info to cloud computing. There, a MATLAB program does some tricky math called Fast Fourier Transformation. This lets people see what's going on with the machine right away.

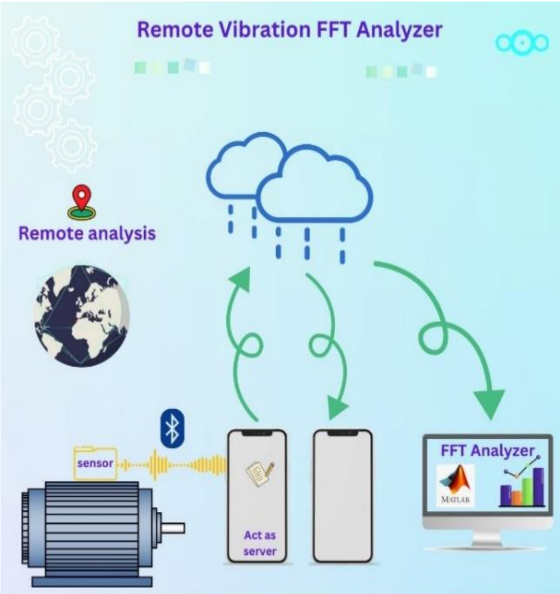
This helps big factories spot machine problems, like when things are unbalance gears and bearings are acting up. Our setup makes machines more reliable cuts the time they're not working and helps save a bunch of money on fixing stuff by letting people fix things before they break.

As we dig into how this thing works, we'll talk about how it might shake up how factories take care of their machines. It could give them some sweet chances to make everything run smoother and save some serious cash in the long run.

2. System Architecture

The system uses an M5StickC device with an IMU sensor to get data from the accelerometer on the X, Y, and Z axes. It also records timestamps for each reading. The device sends vibration data and timestamps through Bluetooth Low Energy to a mobile app that acts as a server. The mobile app then connects to upload the entire dataset to the cloud for storage and processing. MATLAB collects this real-time data to analyze FFT and create visuals giving a complete picture of the captured data, including how measurements relate to each other over time. This setup also allows for remote analysis in the cloud making vibration data easy to access from anywhere. As a result, people can make quick decisions about predictive maintenance strategies.

Fig -1: functional diagram



3. Sensor and Programming

The M5StickCPlus2 has an MPU6886 embedded Inertial Measurement Unit within it, which is used as the central device to host the system. ESP32-PICO-V3-02240MHz dual core Inbuilt connectivity- Wi-Fi, - Bluetooth Memory: 2 MB SPI PSRAM, 8 MB SPI flash LCD Screen- 1.14 inch, 135*240 Colorful TFT LCD Key Features: Due to its small size, M5StickCPlus2 will easily fit into many applications without making them bulky. It uses low power, which proves very essential for applications requiring continuous monitoring in that the low power provides operation time with long durations before recharging. It performs highly in providing the best acceleration data of high accuracy essential for the best vibration analysis. Sensor Specifications Range: The IMU can detect many measurements usually ±2g, ±4g, ±8g, or ±16g. Higher the sensitivity, the sensor can easily pick up on even the slightest vibration, very important for the detection of incipient faults. This sensor normally supports high sampling rates to catch the fast nature of vibration change, normally up to 1000 Hz and above, giving a high-resolution data set for analysis. Battery: Type: Rechargeable lithium-polymer battery Capacity: 200mAh Charging Method: USB-C

Accelerometer Data Acquisition A special programming code is provided for the collection of time-synchronized tri-axial acceleration measurements from the sensor; therefore, it allows for exact time correlation needed in the application of vibration analysis methods that include frequency analysis. The system can download and log tri-axial acceleration measurements every 72 milliseconds. (0.072 second) (100 ms = 0.1 sec)

Battery Monitoring is Multitasking Code. A separate task is created which will monitor the battery level after every 60 sec and update the battery indicator without any disturbance to the main acceleration data capture code. Display and User Interaction Real-time display of accelerometer data, battery level and Bluetooth connection status of the device Button A to start/stop reading accelerometer data. Button B exits the mode.

Fig -2: Sensor

4. Mobile Application Function

The use of the MIT App Inventor is very essential in the development of the mobile app and this specifically performs the function of a server. The mobile application helps to bridge the gap of the vibration sensor to the cloud for efficient data logging. Mobile app gets the data from the vibration sensor through Bluetooth connection, then it gets the data and pass it through the cloud thru internet connection. The functionality of the application is described as When the Bluetooth button is enabled, the list of the detected Bluetooth devices is shown, and you can choose “vibsen-40eb-42”. when the device is chosen, the Bluetooth status is displayed as connected, and a message informs to ready to start the device is displayed. Press the sensor button A to switch to the values of acceleration data, time, and logs on the mobile device. When we hold the sensor button A until it further, the reading stops. Clicking on the “save to cloud” creates the Log Data Sent to the Cloud status that change to “Sending the data” when the process is going on and to “Success” when the process is done, Likewise, pressing the “Erase cloud” icon creates the Log Data

Erase from the Cloud status that change to "Clearing" when the process is going on and to "Cleared Successfully" when the process is complete. The log data is stored in a Google Cloud spreadsheet, with each log entry occupying a separate row.

Fig -3: Mobile App

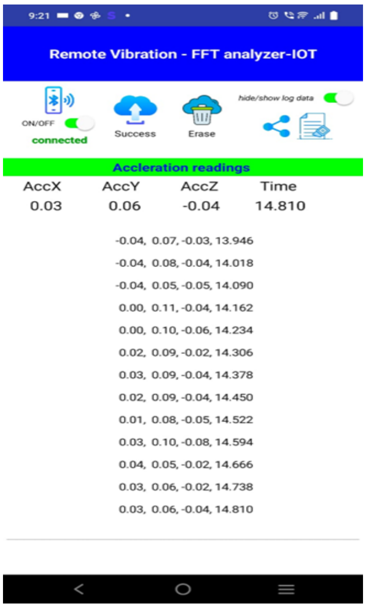
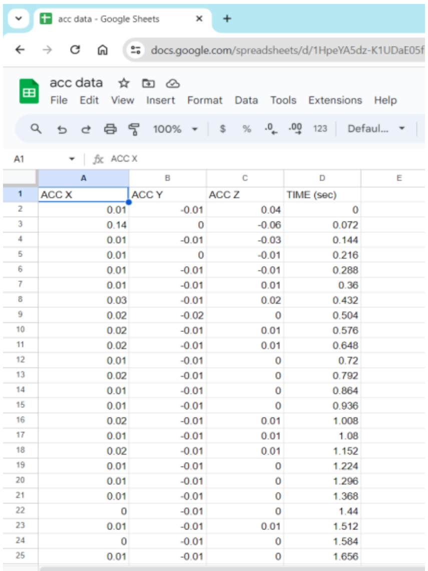


Fig -4: Cloud – Spread sheet



	A	B	C	D	E
1	ACC X	ACC Y	ACC Z	TIME (sec)	
2	0.01	-0.01	0.04	0	
3	0.14	0	-0.06	0.072	
4	0.01	-0.01	-0.03	0.144	
5	0.01	0	-0.01	0.216	
6	0.01	-0.01	-0.01	0.288	
7	0.01	-0.01	0.01	0.36	
8	0.03	-0.01	0.02	0.432	
9	0.02	-0.02	0	0.504	
10	0.02	-0.01	0.01	0.576	
11	0.02	-0.01	0.01	0.648	
12	0.01	-0.01	0	0.72	
13	0.02	-0.01	0	0.792	
14	0.01	-0.01	0	0.864	
15	0.01	-0.01	0	0.936	
16	0.02	-0.01	0.01	1.008	
17	0.01	-0.01	0.01	1.08	
18	0.02	-0.01	0.01	1.152	
19	0.01	-0.01	0	1.224	
20	0.01	-0.01	0	1.296	
21	0.01	-0.01	0	1.368	
22	0	-0.01	0	1.44	
23	0.01	-0.01	0.01	1.512	
24	0	-0.01	0	1.584	
25	0.01	-0.01	0	1.656	

4. MATLAB Application Function

The Windows desktop application uses the MATLAB code provided in this project to analyze vibration data imported from a Google Sheets CSV cloud file. This application was formerly employed to gain access to the data from any place at any given time once the data are saved in the cloud it is simple to illustrate the defect of the component. The structure of the application begins by pulling out all the data involved such as time, X-axis, Y-axis and the Z-axis data and store it in different arrays. It then derives the Fast Fourier Transform (FFT) for each axis, which contains the necessary information to discuss the frequency characteristics of the vibration signals.

The Windows application creates an interactive figure with two buttons: Here, the given Division of plots is "Static Plots" and "Animated Plots". The static plot function creates subplots for time domain signals and frequency spectrum for each axis. The animated plot function is a guided animation of the user through a step-by-step process of the problem where they can observe how the time domain signals and frequency spectra will look like at different stages. This feature also the ability to show important frequencies for appearance, like pinion, gear, or gear meshing, which is crucial for vibration analysis in mechanical systems.

Being a MATLAB-based Windows application, this tool is quite useful for the researchers and engineers who are focusing on the analysis of vibrations, allowing them to pay necessary attention to the vibration characteristics of the systems.

Fig -5: MAT LAB -Window Application

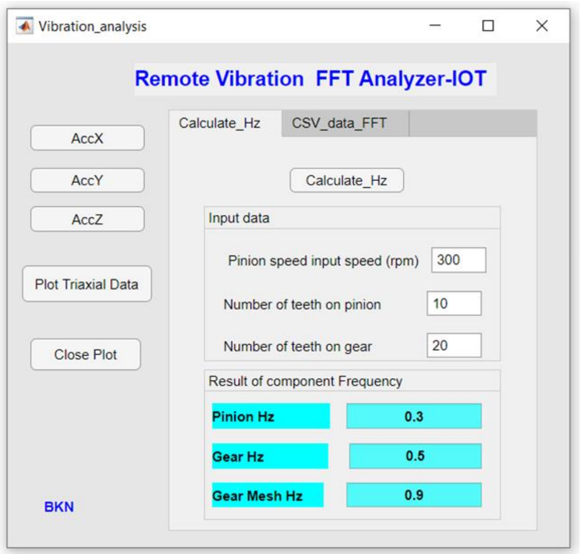


Fig -6: X- axis analysis

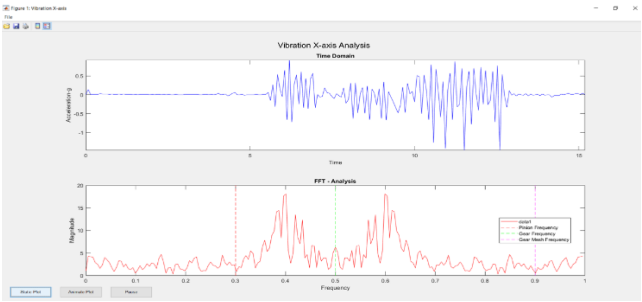


Fig -7: Y- axis analysis

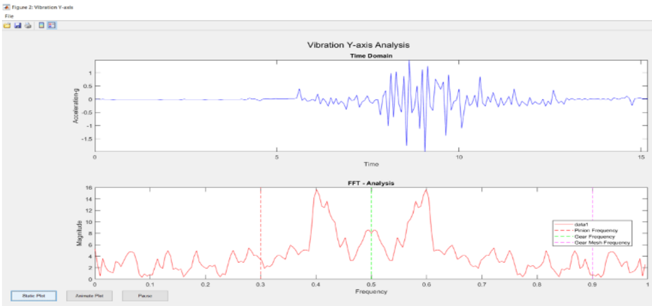


Fig -8: Z- axis analysis

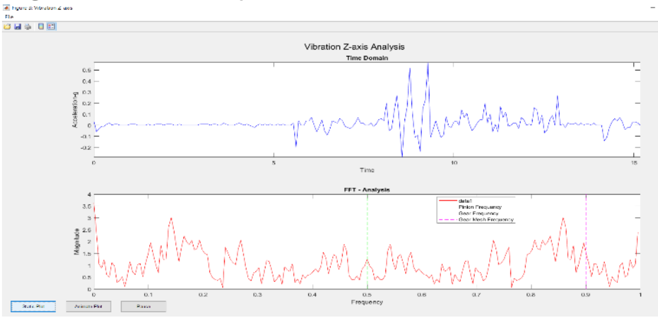
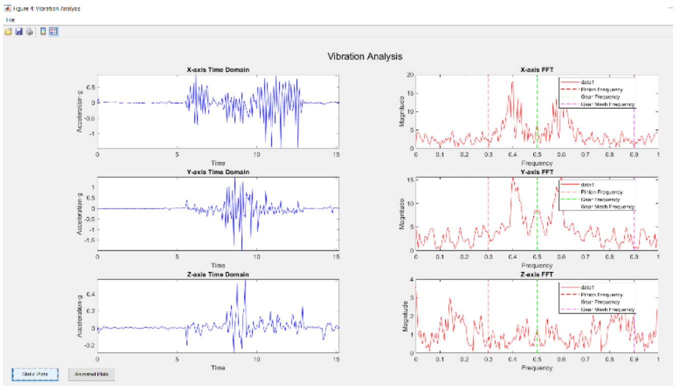


Fig -9: X,Y,Z- axis analysis



5. CONCLUSIONS

The Remote Vibration FFT Analyzer is a Mobile App, IoT, and MATLAB application that is aimed at transforming the field of industrial maintenance. With the help of IoT technology and MATLAB's strong data analysis capabilities, this system allows for real-time remote monitoring and analyzing the machine vibrations. It contributes to reduced downtime and maintenance costs by enhancing predictive maintenance strategies.

Utilization of the M5StickC device with a 3-axis IMU sensor gives accurate and complete vibration data, while the integration with mobile and cloud technologies ensures its accessibility and user-friendly nature. This innovative approach has been accomplished successfully, showcasing the system's potential to transform traditional maintenance practices into a more efficient and cost-effective solution for industrial applications.

The modular and scalable design of the Remote Vibration FFT Analyzer enables easy deployment and integration across various industrial settings, making it accessible to companies of all sizes. This flexibility, coupled with the power of real-time data collection, cloud-based processing, and advanced analytics, empowers industries to make informed decisions, optimize equipment performance, and minimize costly downtime.

Furthermore, the system's combination of cutting-edge technologies, including IoT, mobile apps, and MATLAB, provides a comprehensive and versatile solution for vibration analysis and predictive maintenance. By leveraging these capabilities, the Remote Vibration FFT Analyzer contributes to a more reliable and sustainable manufacturing environment, ultimately leading to increased productivity and cost savings for industrial enterprises.

ACKNOWLEDGEMENT

This is entire experimentation was performed in testing laboratory of gearbox at Flender drive Ltd Chennai, India.

This research has not received any kind of external funding.

This self-funded research work.

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BIOGRAPHIES

Author1 has 19 years of experience in the design of automated products, especially in innovative solutions in the area. The author works presently as a Manager of Design with Flender and leads projects at the edge of automation. His area of research expertise is in vibration analysis, and he makes very useful contributions to the engineering community.