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Portable Engine Vibration Analyser

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Abstract –This document reports on a system designed to maintain the aircraft engines and optimize the aircraft's up-time. Vibration measurements are taken within the defined limits of and by the requirements of the engine builder. The system enables the raw data gathered at the service site to be analysed by the team. The system uses piezoelectric modules to detect engine vibrations, with the data processed through an Arduino and displaced on an LCD. A BLDC motor drives the engine and vibrations are monitored in real-time through sensors placed between the engine and its pylon.

***Key Words*:** Piezoelectric Sensor, Vibration Monitoring, Arduino Uno, BLDC Motor, Embedded Systems, Engine Health Monitoring, Real-time Data Acquisition.

1. INTRODUCTION

When it comes to testing vibrations in aircraft, the most commonly used method is Ground Vibration Testing (GVT). This technique is great for keeping an eye on overall vibration levels, especially in the 10Hz to 100Hz range, which is crucial for construction assessments. For engine monitoring, though, we need to pay attention to higher frequencies. In this paper, we delve into how we built an engine vibration analyser that uses a BLDC motor, piezoelectric sensors, and an Arduino-powered graphical display. This setup allows us to quickly and easily tackle any issues related to engine vibrations.

2. SYSTEM DESIGN AND METHODOLOGY

In various industries, you'll find a range of vibration analysers, but most of them depend on accelerometers and expensive signal-processing units. Consider the Brüel and Kjaer vibration analysers, for instance - they work really well, but they are not the most appropriate for portable or small-scale applications.
This particular project goes one step further in that it involves piezoelectric modules to detect vibrations in real-time and does so all under the Arduino control of handling the display of data.

A. System Architecture

The portable engine vibration analyzer compromises the following components:

1) *Engine with a BLDC motor*: The motor works as a power source for the rotating engine.

2) *Pylon and Airframe*: The engine is mounted on a pylon attached to an airframe to simulate the actual conditions of flight or operation.

3) *Piezoelectric Sensors*: These sensors are placed between the engine and the pylon to detect vibrations during operation.

4) *Arduino Microcontroller*: Arduino processes sensor data and sends it to LCD for display.

5) *LCD Display*: Displays vibration metrics in real-time.

3. WORKING PRINCIPLE

During engine operation, mechanical vibrations travel from the pylon to the piezoelectric sensor, which emit electrical pulses corresponding to the levels of vibration. These pulses are processed by an Arduino microcontroller and displayed as vibration levels on the LCD. The analog signal is converted into digital signal using an Analog-to-Digital Converter (ADC), which can then be examined. The observation of a disruption in the level of vibration enables a diagnosis to be made. Unusual frequencies suggest possible faults such as imbalance, misalignment, and structural issues. This enables operators to monitor the engine's vibration in real-time and provides scope for taking corrective actions well in advance.

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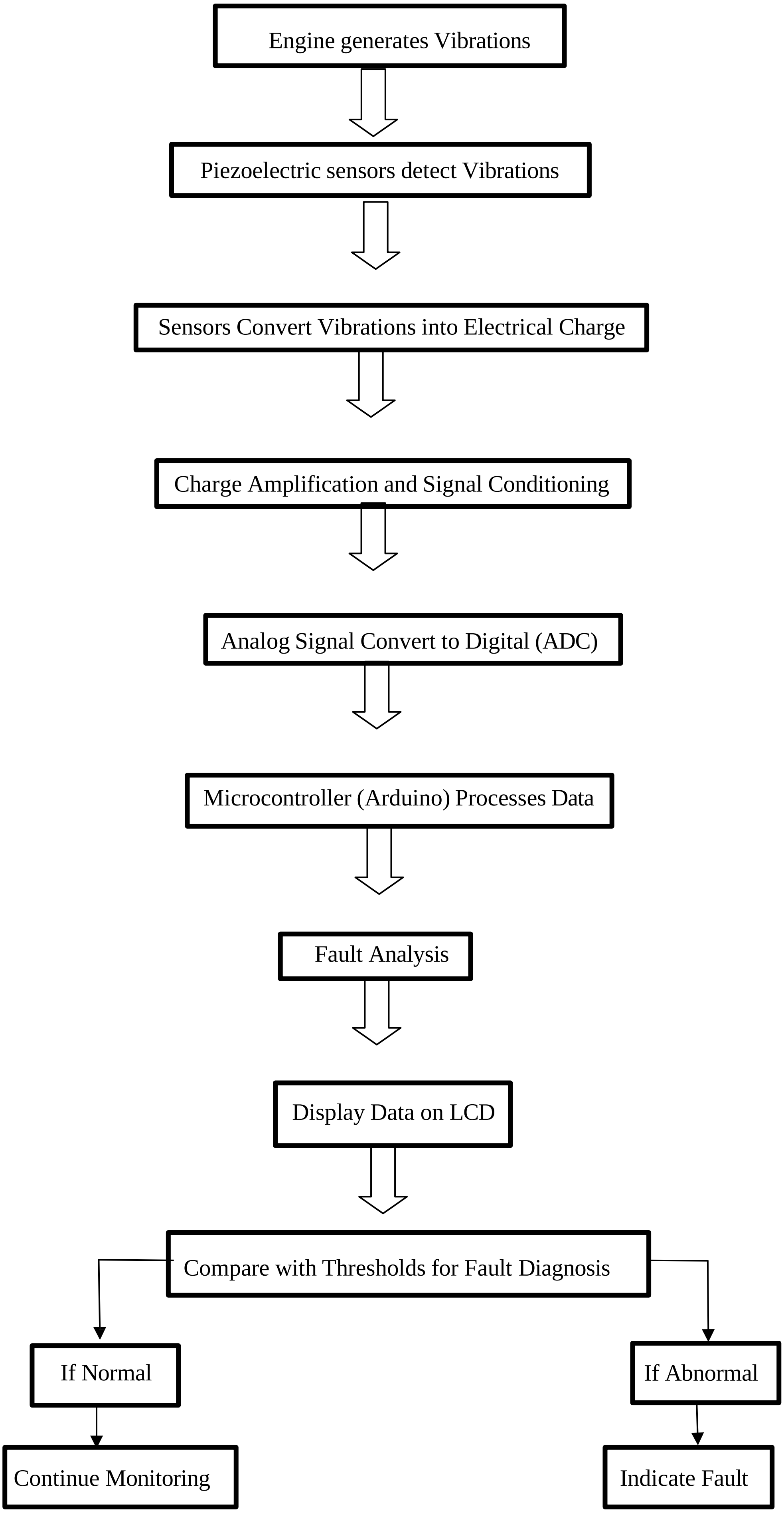

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4. IMPLEMENTATION AND TESTING

A. Hardware Assembly

The engine, powered by a BLDC motor, is mounted on the airframe via a pylon. Piezoelectric sensors are placed between the engine and the pylon to measure vibrations. The Arduino microcontroller processes the electrical signals from these sensors and continuously updates the LCD display with the real-time data.

ENGINE RPM	VIBRATIONS VALUE (ARDUINO UNITS)	OBSERVATION
1000 RPM	120	LOW VALUE
3000 RPM	320	MODERATE VALUE
5000 RPM	540	HIGH VALUE

B. Software Assembly

The Arduino is configured to capture analog signals from the piezoelectric sensors and translate them into vibrations metrics. Below is code

```
#include <LiquidCrystal.h>
LiquidCrystal lcd (12, 11, 5, 4, 3, 2);
const int sensorPin = A0;
int vibrationValue = 0;
int rpm = 1000;
String observation = "";
void setup() {
   lcd.begin (16, 2);
   pinMode (sensorPin, INPUT);
}
 void loop(){
    vibrationValue = analogRead
(sensorPin);
 if(vibrationValue < 200){
   rpm = 1000;
   observation = "LOW VALUE";
 } else if(vibrationValue < 450) {
   rpm = 3000;
   observation = "MODERATE VALUE";
 } else {
   rpm = 5000;
   observation = "HIGH VALUE";
 }
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("RPM: ");
 lcd.print(rpm);
 lcd.print("V: ");
 lcd.print(vibrationValue);

 lcd.setCursor(0, 1);
 lcd.print(observation);

 delay(1000);
}
```

5. OBSERVATION

Different engine speeds and load conditions were used to evaluate the vibration analyzer's performance. It was found that the piezoelectric sensors continuously picked up an increase in vibration intensity in tandem with an increase in engine RPM. As a result, sensor output values increased steadily, showing a direct relationship between vibration levels and engine speed. The information gathered shows that the system can accurately track variations in engine vibration in response to variations in RPM. It is crucial to remember that uncalibrated raw data is currently reflected in the sensor outputs. The lack of calibration reduces the accuracy of quantitative analysis, even though the system is good at detecting relative vibration changes. A suitable calibration procedure would greatly increase the measurements precision and dependability, allowing the system to deliver more meaningful and precise vibration readings.

6. PERFORMANCE ANALYSIS

Throughout testing, the system continuously delivered reliable and consistent sensor readings under various engine conditions and trials. This attests to the piezoelectric-based vibration monitoring system's dependability. However, minor changes in sensor output were noted at higher engine speeds. As the engine runs at higher RPM, mechanical effects or high-frequency noise are probably to blame for these variations. Although these differences had no discernible effect on the data's general trend, they might have an effect on accurate analysis in more delicate applications. This implies that there is room for improvement in the signal processing of the system. Simple digital filtering techniques, like smoothing algorithms or moving averages, could be used in later iterations to help lower noise and enhance data clarity. These enhancements would increase the accuracy of the system.

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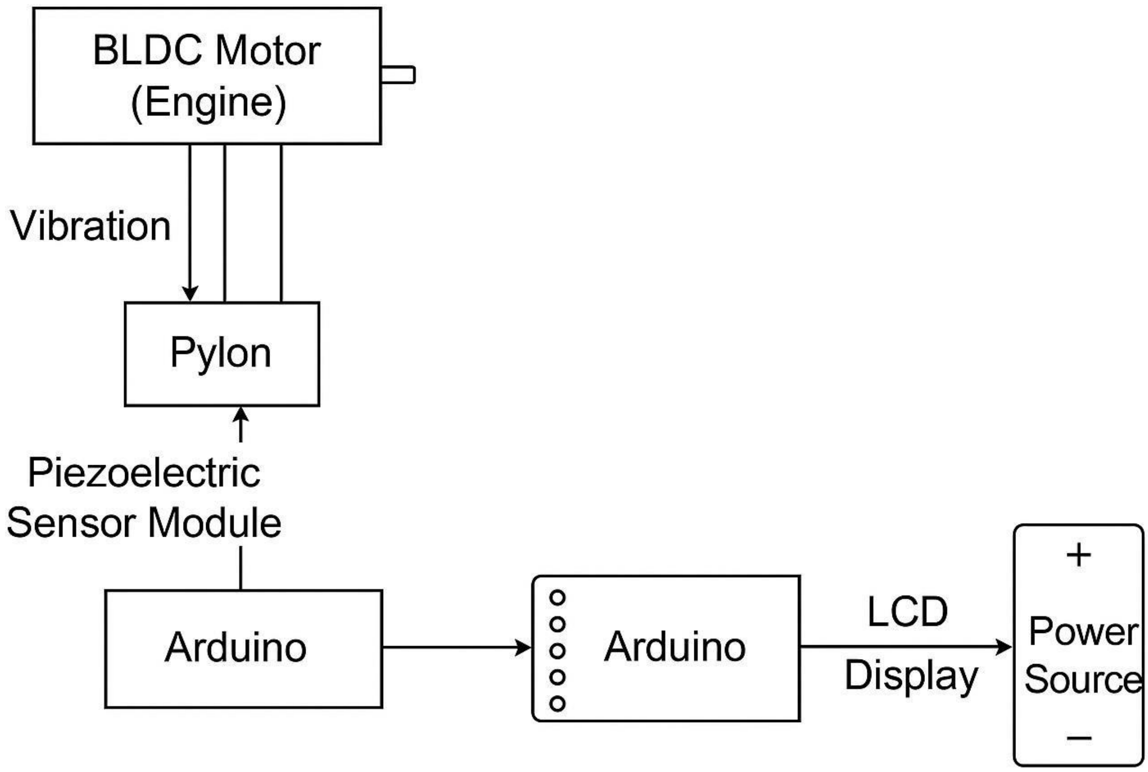
BLOCK DIAGRAM



7. LIMITATIONS

One of the primary limitations of the current system is that the vibration readings are uncalibrated and expressed as raw analog values rather than in standardized physical units such as g-force. This restricts the system's ability to deliver quantifiable and comparable data, which is essential for detailed analysis and diagnostics. Additionally, at higher engine speeds, the presence of noise adversely affects the stability of sensor output. These fluctuations are likely caused by high-frequency disturbances and electromagnetic interference, which become more prominent at elevated RPMs. This results in occasional instability in the readings, especially during rapid changes in engine speed. Furthermore, the piezoelectric sensors employed in this setup, while cost-effective and suitable for basic detection, have limited sensitivity compared to industrial-grade accelerometers. This reduced sensitivity may affect the precision of the measurements, particularly when capturing subtle vibration changes. These challenges point to important areas for future enhancement. Calibrating the sensor output to real-world vibration units, improving noise isolation, and possibly upgrading to more sensitive sensors could significantly improve the system's performance, accuracy, and suitability for professional diagnostic applications.

8. APPLICATIONS

The compact and low-cost design of the proposed vibration analyzer enables its use across a variety of practical domains. Its versatility makes it suitable for real-time monitoring and early fault detection in multiple mechanical systems. Notable application areas include:

- Unmanned Aerial Vehicles (UAVs): Monitoring motor vibrations during flight to detect abnormalities that could affect stability or performance.
- Automotive Engines: Identifying early signs of mechanical issues such as imbalance, misalignment, or wear in internal combustion engines.
- Industrial Machinery: Supporting condition-based maintenance strategies for small-scale machines by enabling early detection of irregular vibration patterns.

These applications highlight the system's potential as a diagnostic tool for lightweight, mobile, or cost-sensitive platforms where traditional monitoring solutions may not be feasible.

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9. CONCLUSION

The developed portable engine vibration analyzer successfully detects and displays real-time engine vibrations using piezoelectric sensors, an Arduino microcontroller, and an LCD interface. Its lightweight and cost-effective design makes it a practical solution for small-scale or resource-constrained applications where conventional industrial-grade analyzers may be impractical.

Looking ahead, future iterations of the system could benefit from the integration of wireless data transmission for remote monitoring, as well as the implementation of advanced digital filtering techniques to enhance measurement accuracy and reduce signal noise. These improvements would further expand the system's utility in real-world diagnostic and predictive maintenance applications.

10. REFERENCES

1. Fraden, J. (2010). Handbook of Modern Sensors: Physics, Designs, and Applications (4th ed.). Springer.

https://link.springer.com/book/10.1007/978-1-4419-6466-3

2. Doebelin, E. O., & Manik, D. N. (2011). Measurement Systems: Application and Design (6th ed.). McGraw-Hill Education.

https://archive.org/details/measurementsyste00doeb

3. Brüel & Kjær. (n.d.). Machine-Condition Monitoring using Vibration Analysis. Retrieved from

https://www.bksv.com/doc/bo0253.pdf

4. Ali, M., & Mahmood, A. (2020). Vibration monitoring of rotating machines using piezoelectric sensors and Arduino. International Journal of Engineering Research and Technology, 9(4), 184–188.

https://www.researchgate.net/publication/371890784_A_Review_on_Vibration_Monitoring_Techniques_for_Predictive_Maintenance_of_Rotating_Machinery

5. Arduino. (n.d.). Arduino Uno Rev3. Retrieved from

https://docs.arduino.cc/hardware/uno-rev3

6. Sze, S. M., & Ng, K. K. (2006). Physics of Semiconductor Devices (3rd ed.). Wiley-Interscience. https://onlinelibrary.wiley.com/doi/book/10.1002/0470068329

7. Tandon, N., & Choudhury, A. (1999). A review of vibration and acoustic measurement methods for the detection of defects in rolling element bearings. Tribology International, 32(8), 469–480. \

https://www.sciencedirect.com/science/article/abs/pii/S0301679X99000547

8. Krishnan, R. (2009). Permanent Magnet Synchronous and Brushless DC Motor Drives. CRC Press.

https://www.taylorfrancis.com/books/mono/10.1201/9781420014235/permanent-magnet-synchronous-brushless-dc-motor-drives-ramu-krishnan