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HEALTH MONITORING MACHINE USING A NOVEL MECHANICAL APPROACH

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Abstract

In the modern period, machines have become an essential component of daily life. Taking care of numerous machines and maintaining their efficiency and safety has become essential. Various tools have been developed to assess the health of these equipment. This monitors power usage, temperature, noise level, vibrations, and noise level. Unusual behaviour in the aforementioned parameters can be used to diagnose any machine defects. Machine vibrations are measured using FFT analyzers. However, FFT analyzers are quite expensive, making them unaffordable for small-scale enterprises. Rarely do they offer a way to gauge the machine's speed, temperature, or power usage. The objective of the current project is to design a low-cost substitute for the existing health monitoring systems that can also measure a wide variety of additional parameters, such as vibrations, noise, temperature, rotational speed, and power consumption. A cheap Arduino Mega 2560 controller is connected to many sensors and integrated into the MATLAB GUI to store and show the collected data. It was found that there was good agreement between the planned device and the systems being used. Small firms may use this device as a monitoring tool as they cannot afford pricy FFT analyzers.

Keywords : Fast Fourier Transform, Arduino, Vibration & MATLAB

1. Introduction:

The vast array of personal electronic devices on the market today includes a significant number of inertial microelectromechanical systems (MEMS) sensors. These components' small size, low power consumption, ease of assembly, great usability, and high performance enable and inspire devices like cell phones, gaming devices, tracking motions, and cutting-edge picture frames. MEMS sensors may already be found in many automobiles thanks to significant cost and reliability reductions in automotive safety systems [1]. A complicated signal's basic pieces are broken down into separate frequencies as part of frequency analysis. To achieve this, the engineers have to be deciphered spectrum measurement data and be conversant with frequency analysis parameters. [2]. MEMS accelerometers have begun to find their way into numerous industrial systems thanks to ongoing improvements in performance and practical integration. While some of these applications separate the inertial transducer activity in novel and distinctive ways, others provide more affordable substitutes for the current goods and services. Recent developments in the field of vibration sensing have determined that integrated MEMS devices should be appreciated for their rapid distribution and affordable purchase costs. A wide spectrum of users are increasingly using the use of vibration monitoring. Devices that monitor the health of machines are frequently made with piezoelectric technology for maintenance and safety. A high speed automation instrument is

used to measure the vibration to obtain feedback of lubrication, speed, belt tension or to turn the instrument off in order to call the operating staff's urgent attention [3-5].
MEMS accelerometers can be swiftly, efficiently, and economically integrated by an increasing number of new users. One device that gains from this improved practical integration is the digital MEMS vibration detecting element with integrated RF transmitter and receiver (ADIS16229) [6, 7]. Signal processing and transmission are combined to offer a comprehensive resolution. Periodically waking up, this type of device will record time-domain vibration information data, perform a fast Fourier transform (FFT) on the data, apply user-configurable spectral analysis to the result, provide clear pass/fail results over affordable wireless transmission, provide access to that information and results, and then return to hibernate or sleep mode [8]. Thanks to integrated MEMS-based sensors, real-time vibration data for instruments is now more practicable and affordable.

2 Domain Analysis for Time and Frequency

A typical spring-mass-damper system is shown in Figure 1 together with its time-domain responses. When taken as a whole, these opposing viewpoints offer a complete and precise knowledge of the behaviour of dynamic engineering systems. In general, we seek for duration in the time domain, whereas we hunt for a system's response time in the frequency domain. The output of a dynamic system is represented as a time-dependent observable parameter in the time domain data. This might be a common approach to evaluating the output of a dynamic system [9].

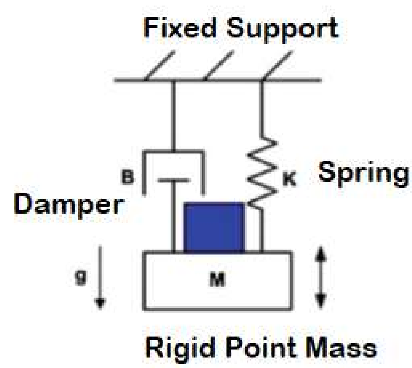

Fig 1: Spring Mass Damper System

A temporal reaction is demonstrated in Fig. 1 by the displacement of the mass of the spring-mass damper system over time as a result of the rapid addition of additional mass to the linked mass. Step reactions illustrate the output response of the system to the abrupt impact force. After examining how a dynamic system functions, we frequently use the input to the system as step input [10].

3 Mechatronic Integration with Design Control

The goals of the application are taken into consideration while selecting the sensing device and signal-processing approach. Figure 2 displays a schematic of the sensors attached to the microcontroller.

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The Arduino is powered by an outside power source. The machine health monitoring system utilizes various sensors including the K-type thermocouple, MAX6675 temperature sensor, ADXL335 accelerometer, AC712 current sensor, MAX4466 noise sensor, and a voltage divider circuit. In Figure 3, the implementation showcases the utilization of an analog tri-axial vibration sensor element, an Arduino Mega 2560 microcontroller, and an ADXL335 accelerometer to observe the vibration spectrum of a device, perform FFT analysis, and log the outcomes

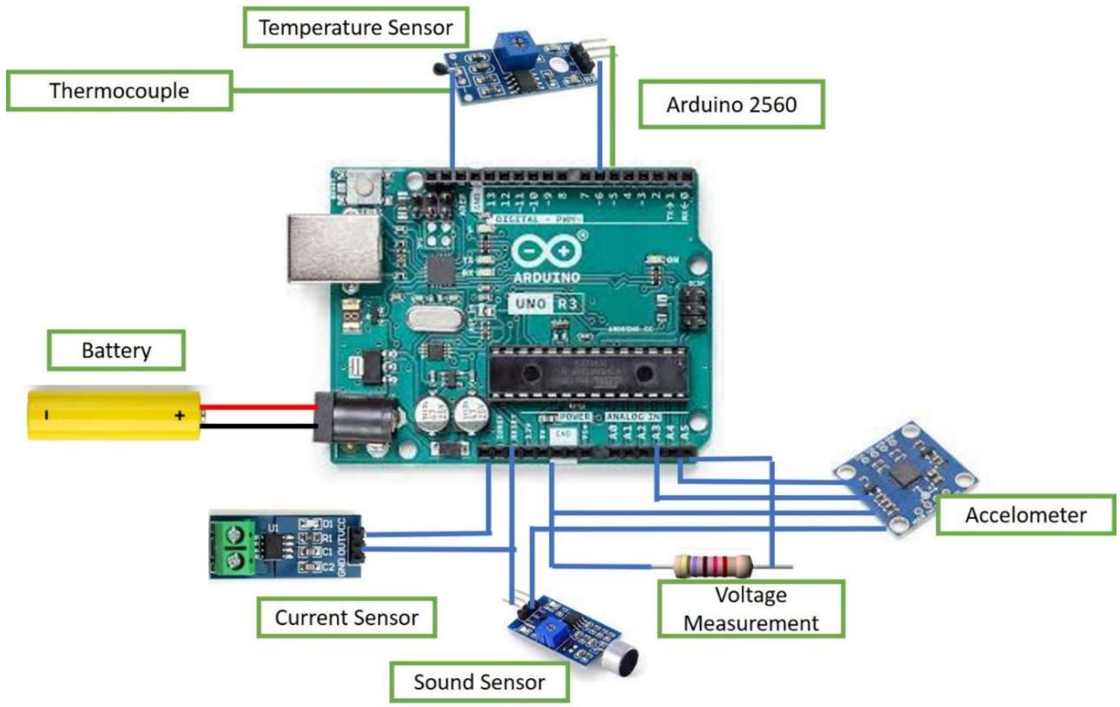

Fig. 2 Combination of Sensors and Controller

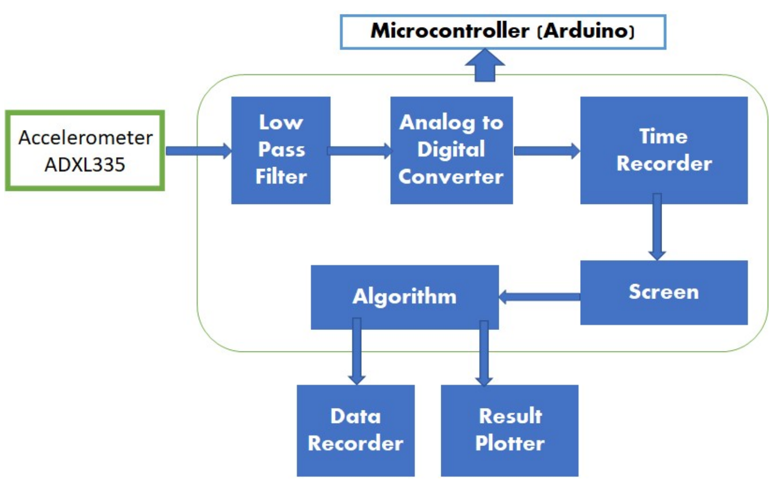

Fig. 3 Vibration analysis using Control System

3.1 Sensor ADXL335

In either strategy, a MEMS accelerometer frequently serves as the primary sensor component.

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The most crucial elements to take into account when choosing a core sensing device are the number of axes, package/assembly requirements, electrical interface (analog/digital), frequency response (bandwidth), measurement range, noise, and linearity [11]. Using the silicon on insulator (SOI) MEMS method, the ADXL335 accelerometer in this study benefits from differential sensor cells that are electrically distinct yet automatically connected.As the detector frame travels, the differential capacitance modifies. The change in capacitance is detected by an electrical circuit on the chip, which converts it to an output voltage [12].

3.2 Low-Pass Analogue type filter

The analogue filter in the example system only permits the signal content to exceed half the sample rates or one Nyquist zone. Even when the filter cut-off frequency is close to intervals of the Nyquist zone, higher-frequency components may still enter the pass band, making indefinite rejection of such components impossible [15].

3.3 Windowing

Time-coherent sampling is often not feasible in vibration sensing applications due to the significant spectrum discharge and decreased FFT accuracy that might result from nonzero sample values at the start and end of the time record. To stop the spectrum leak, use a window operation before performing the FFT [13].

3.4 FFT Analysis

An economical computational method FFT is used for assessing types of temporal data.

Each sample represents a distinctive frequency area of the Nyquist zone as a result of the procedure, which transforms a temporal record into a discrete spectral record [14]. The main premise of this method is that a collection of N points' DFT may be appropriately represented by two DFTs of length N/2. Therefore, it is easy to repeat this method several times until we know DFT of a single point [15] if N is a power of 2. The mathematical analysis software MATLAB was used to create the approach. Figure 4 displays the method's flowchart. The connection to the ARDUINO Mega 2560 is made easier and more flexible by using MATLAB, which also makes it possible to develop a GUI. The axis along which we want the data on time acceleration can also be chosen. The outcomes can also be saved in.mat file format for subsequent use. The extremely highest and lowest frequency values may be displayed with a broad enough frequency range.

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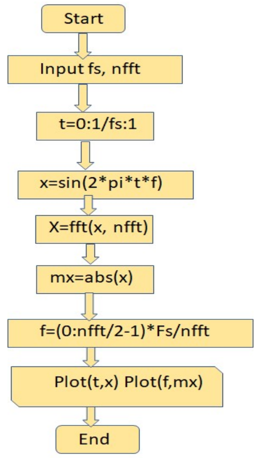
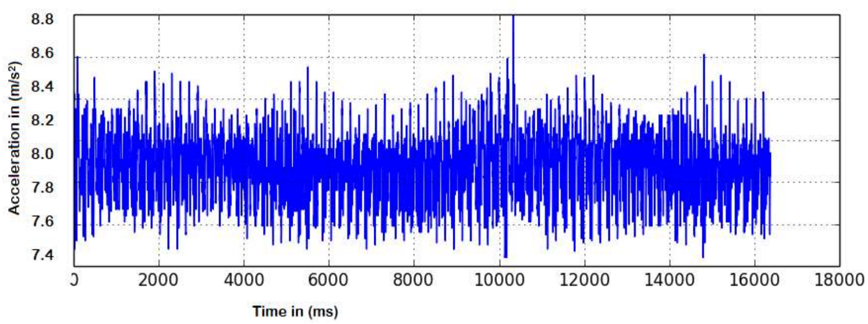


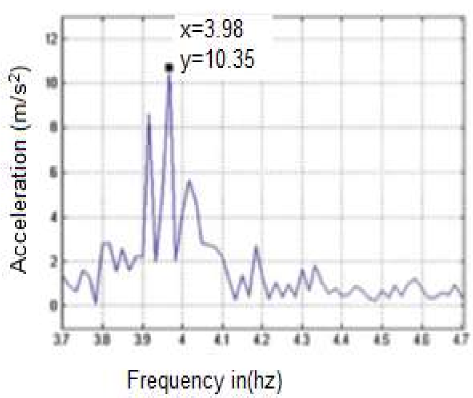
Fig. 4 Process flow of FFT algorithm

4 Results

Using a cam follower device with an involute cam profile, which caused the follower to vibrate at a single frequency and constant speed, the aforementioned technique was tested experimentally. The formula $\frac{2\pi n}{60}$ =20.13 rad/sec= 3 Hz may be used to get the analytical frequency of the cam at 200 rpm. The statistics in Figure 5a make this clear. A peak at 4.397 Hz can be seen on the graph in Figure 5b, which exhibits good agreement with the analytical frequency. The forced frequency and amplitude of the system are in very excellent agreement, as shown in Figure. 5c, when these findings are compared to those from the ADASH manufacture A4400-VA4 FFT Analyzer.



(a)Plot of Time



(b)Plot of Frequency **(c)FFT Analyzer Reader**

Fig. 5 Plot at 300rpm of Time and frequency

Using the graph in Figure. 6, the developed gadget is compared to a readily available analyzer. A system's time reaction does not provide a lot of insightful data. We may associate the various frequency components with particular system elements, since the dynamic attributes of each individual system component are typically known. The position of the energy concentration close to the peak frequency is determined by the variable motor's rotational speed when it is coupled to the cam jump apparatus. The created system achieved exceptional accuracy of up to 99.175% using a commercially available Adash 4400-VA4 analyzer.

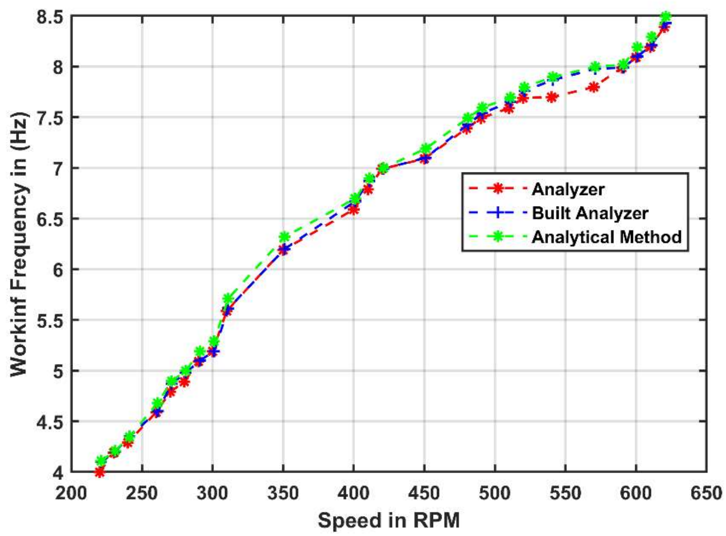


Fig. 6 Evaluation of frequency obtained by built analyser and commercial analyser

5 Conclusion

Using inexpensive controllers like the Arduino mega, a revolutionary health monitoring system was created. The sensors were initially found to measure a variety of machine health-related information. Additionally, these sensors were combined with microcontroller built together in the real-time data from various sensors. In order to study vibrations, a system was created to change time domain information into frequency domain area. To arrange, assess, show, and retain actual on going input data from sensors was obtained on the developed GUI. After extensive testing, this cutting-edge technique showed outstanding accuracy up to 98.275 as with the traditional FFT analyzer. It is possible to raise this device's accuracy even more by increasing the initial port and controller resolution. This device can offer additional input channels for more sensors.

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