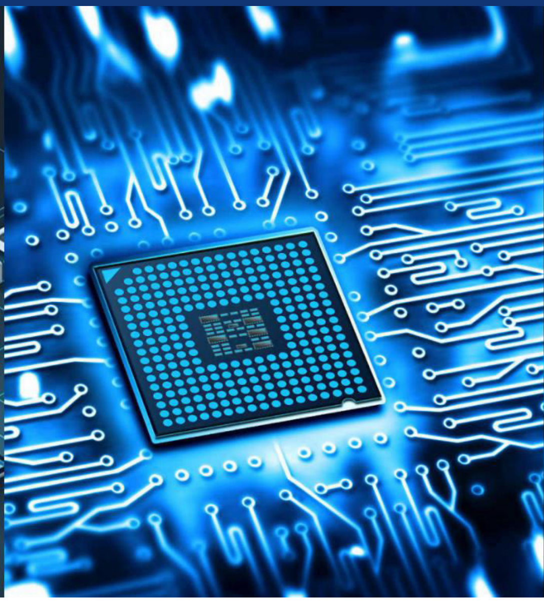
ISSN(O): 2320-9801
ISSN(P): 2320-9798


International Journal of Innovative Research in Computer and Communication Engineering

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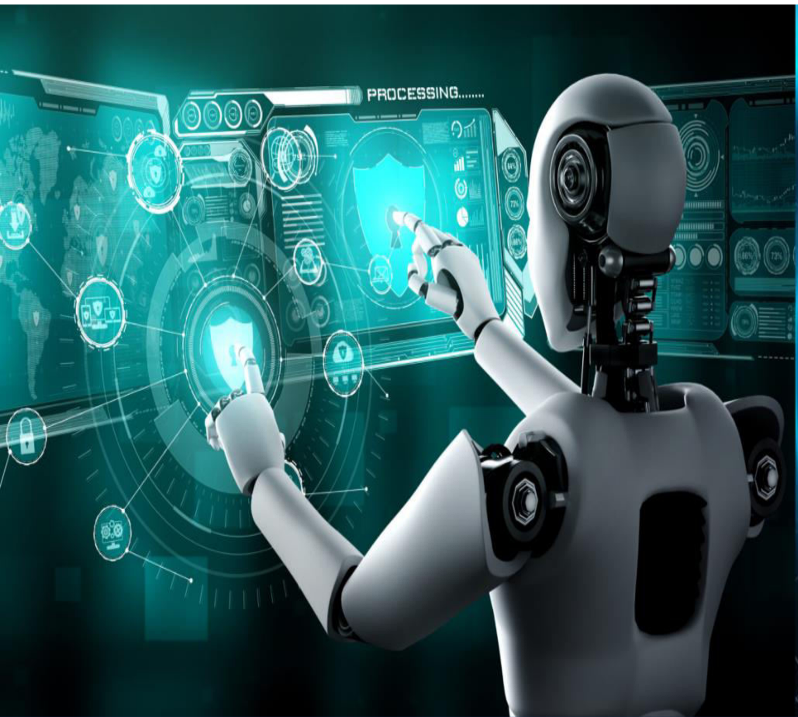

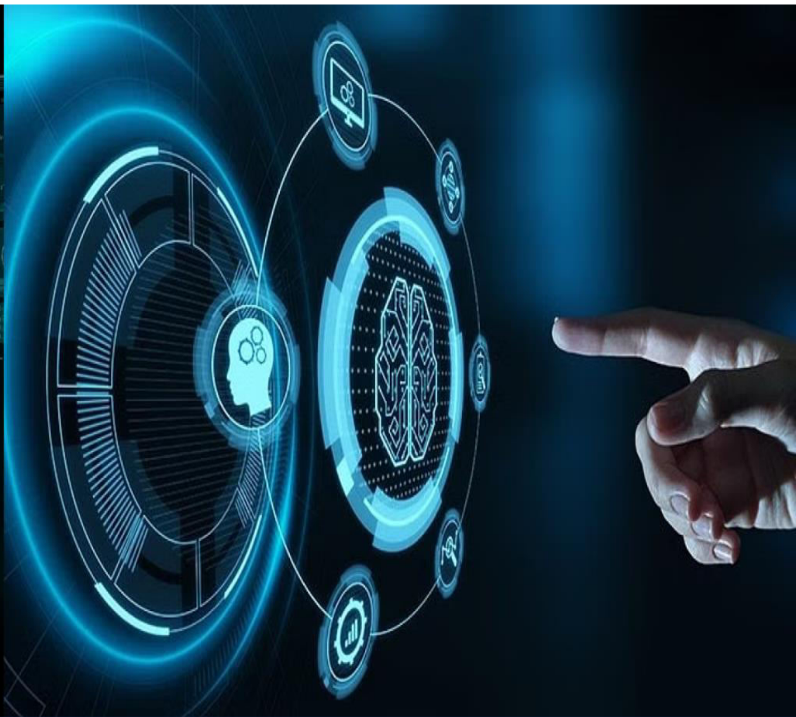

Impact Factor: 8.771

Volume 14, Issue 3, March 2026

www.ijircce.com ijircce@gmail.com +91-9940572462 +91 63819 07438

© 2026 IJIRCCE | Volume 14, Issue 3, March 2026 DOI: 10.15680/IJIRCCE.2026.1403007

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Noise and Vibration Analyser

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ABSTRACT: Noise and Vibration Analyser is essential in predictive maintenance and quality control almost in all industries. Noise and vibration analyser is used for real-time monitoring and fault detection.
This results in improving machinery reliability and reducing downtime. Utilizing sensors like microphones, these instruments employ FFT (Fast Fourier Transform) algorithms to separate signals into frequency components, enabling precise fault detection. They are critical for optimizing performance, ensuring structural integrity, and reducing operational noise in systems.

KEYWORDS: Atmega328P, OLED display, sound sensor module, USB cable, universal PCB board, 16x2 LCD display, ESP32 development board, tap sensor, jumper wire, power bank.

I. INTRODUCTION

In signal processing, noise is a general term for unwanted (and, in general, unknown) modifications that a signal may suffer during capture, storage, transmission, processing, or conversion. Sometimes the word is also used to mean signals that are random (unpredictable) and carry no useful information; even if they are not interfering with other signals or may have been introduced intentionally, as in comfort noise.

Noise and vibration analysis is a critical aspect of predictive maintenance and quality control in various industries, including aerospace, automotive, and manufacturing. Excessive noise and vibration can indicate machinery faults, leading to downtime, reduced efficiency, and increased maintenance costs. Traditional analysis methods often rely on manual data collection and offline processing, limiting their effectiveness. This paper introduces a real-time noise and vibration analyser leveraging advanced signal processing and IoT technologies to address these limitations.

It's Purpose To monitor machinery health, diagnose faults (e.g., loose parts, gear mesh issues), and ensure product quality. Piezoelectric are commonly used to measure acceleration, velocity, or displacement. Analyser includes detecting noise up to 20 dB and measuring vibration amplitude, frequency, and phase.

II. RELATED WORK

Noise and vibration analyzers are essential tools for measuring, analyzing, and mitigating unwanted acoustic and mechanical oscillations in engineering and industrial applications.

The deployment of these models relies heavily on sensor data, with vibration and temperature sensors being the most widely utilized, accounting for 46.42% and 60.71% of applications respectively (Samatas et al., 2021). However, a growing area of research focuses on "Green AI" or low-power implementations. Traditional deep learning relies on power hungry cloud computing, but recent surveys suggest that Spiking Neural Networks (SNNs) and optimized ANNs can enable on device processing of vibration data, significantly reducing energy consumption and latency (Vasilache et al., 2024).

Noise and analyser work includes predictive maintenance systems, condition monitoring of machinery, structural health monitoring, sound quality analysis and industrial IoT solutions for machinery monitoring.

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III. PROPOSED SYSTEM A.

- ATmega 328P: Microcontroller for processing vibration data and controlling the system.
- OLED Display: Shows vibration data, alerts, and system status.
- Sound Sensor Module: Detects sound waves or vibrations (often used for knock/tap detection).
- USB Cable: For programming the microcontroller and powering the system.
- Universal PCB Board: Base for assembling and connecting components.
- 16×2 LCD Display: Alternative display for showing vibration data and alerts.
- ESP32 Development Board: Optional Wi-Fi/Bluetooth enabled microcontroller for IoT connectivity and data transmission.
- KY 031 Knock/Tap Sensor: Detects vibrations or knocks, used for specific vibration detection tasks.
- Jumper Wire: Connects components on the PCB or breadboard.
- Power Bank: Portable power source for the noise and vibration analyser.

IV. SYSTEM WORKING

Noise Analyser:
Step 1: Connect the power bank to the Noise analyser using the USB cable.
Step 2: Sensor detect noise signals.
Step 3: Signals are processed by the Atmega328p microcontroller/PCB.
Step 4: Data is displayed on the LCD.
Step 5: Analysis for fault detection or monitoring.

Vibration Analyser:
Step 1: Connect the power bank to the vibration analyer using USB cable.
Step 2: The sensor like buzzer captures mechanical vibrations and converts them into electrical signals.
Step 3: The microcontroller processes these analog signals often using ADC to analyze amplitude and frequency. Step 4: Processed data is shown on the LCD, indicating vibration levels.

V. EXPERIMENTAL RESULTS AND TESTING

Noise Analyser:
We propose an interpretable method for noise monitoring in specific scenarios like industries. Our approach has two configurations that summarize the profiles into several features and classify the acoustic events. Our method adapts to environments with different background noises through a novel data augmentation policy from clean scenarios.

Our approach has reduced computational and economic costs, being implementable into the sound analyzer or portable devices.

This study applied Machine Learning Algorithms to classify the traffic-noise annoyance perceived by the population in urban cities. In this sense, this research presents an alternative methodology to evaluate the relationship between subjective variables such as perceived loudness and self-reported annoyance.

Vibration Analyser:
Vibration testing is accomplished by introducing a forcing function into a structure, usually with some type of shaker. Alternately, a DUT (device under test) is attached to the "table" of a shaker. Vibration testing is performed to examine the response of a device under test (DUT) to a defined vibration environment. The measured response may be ability to function in the vibration environment, fatigue life, resonant frequencies or squeak and rattle sound output (NVH). Squeak and rattle testing is performed with a special type of *quiet shaker* that produces very low sound levels while under operation.

Vibration analysis, applied in an industrial or maintenance environment aims to reduce maintenance costs and equipment downtime by detecting equipment faults.VA is a key component of a condition monitoring (CM) program, and is often referred to as predictive maintenance (PDM). Most commonly VA is used to detect faults in rotating

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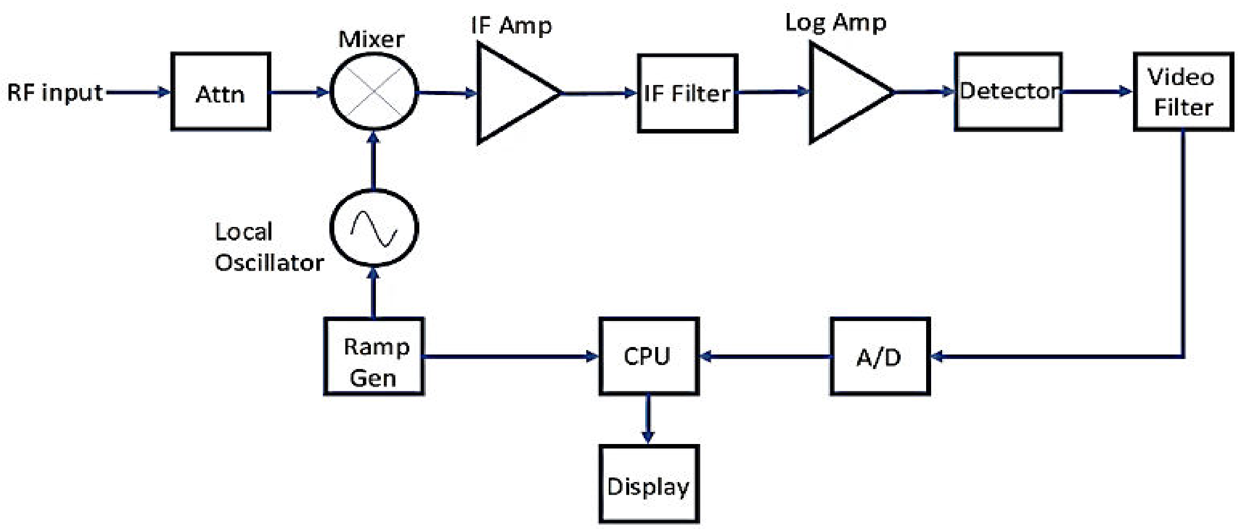
equipment (Fans, Motors, Pumps, and Gearboxes etc.) such as imbalance, misalignment, rolling element bearing faults and resonance conditions.

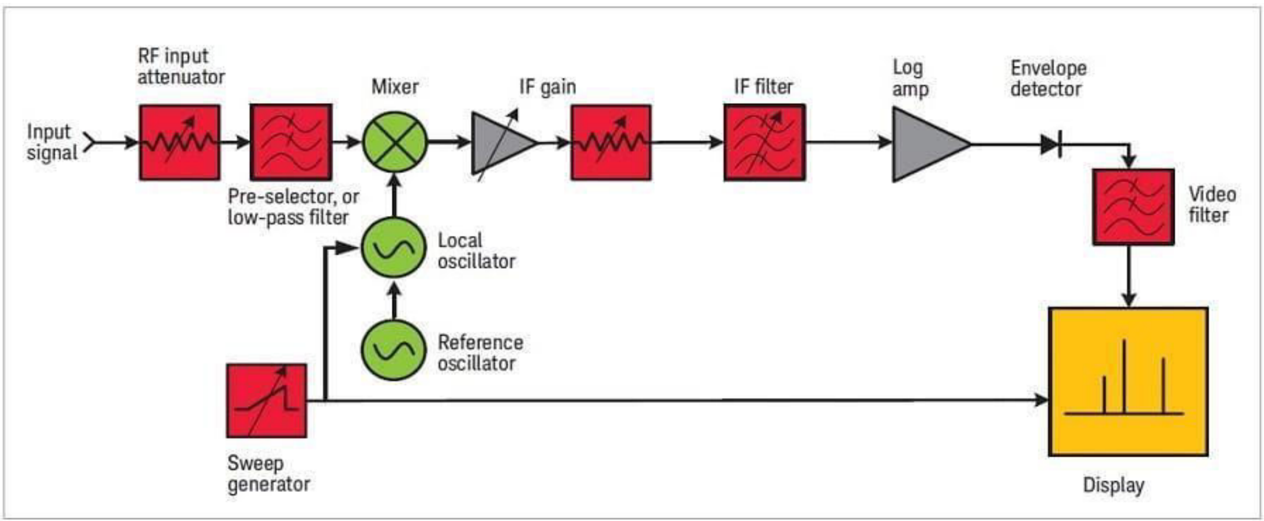
The studies of sound and vibration are closely related (both fall under acoustics). Sound, or pressure waves, are generated by vibrating structures (e.g. vocal cords); these pressure waves can also induce the vibration of structures (e.g. ear drum). Hence, attempts to reduce noise are often related to issues of vibration.

This paper investigates the potential of neural networks for low-power on-device computation of vibration sensor data for predictive maintenance.

Block diagram of Noise Analyser:



Block diagram of Vibration Analyser:



VI. CONCLUSION AND FUTURE WORK

Noise and vibration analyser remains a vital diagnostic capability for ensuring the performance, safety, and comfort of modern systems. This paper has highlighted that while the physical principles of vibration measurement remain

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constant, the methods for interpreting this data are undergoing a fundamental transformation through AI and IoT. We demonstrated that traditional limitations regarding data scarcity and economic alignment can be addressed through the use of generative diffusion models and cost-sensitive learning frameworks. However, challenges regarding model adaptability and explainability must be resolved to fully realize the potential of these technologies. Ultimately, the successful convergence of physical analysis and artificial intelligence provides the foundation for a safer, more efficient, and economically optimized industrial future.

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