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Generation of Electricity from Noise Using Block Chain

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Abstract - The increasing global demand for energy, coupled with the rapid depletion of fossil fuels, necessitates the exploration of alternative, renewable energy sources. One such unconventional source is ambient noise—an often-overlooked by product of urbanization. This project investigates the feasibility of converting environmental noise into electrical energy using piezoelectric sensors. Sound-induced vibrations generate pressure waves, which are transformed into electrical signals by the sensor. These signals are then rectified, filtered, and stored in a lithium-ion battery. An ESP8266 microcontroller is employed to monitor sound levels and transmit real-time decibel data to a cloud-based application ("ThingSpeak") for noise pollution analysis. This dual-purpose system not only promotes sustainable energy generation but also enables continuous monitoring of noise pollution. Cost-effective and environmentally friendly, the proposed device is well-suited for deployment in high-noise areas such as airports, industrial zones, and traffic intersections, contributing to smarter and greener urban environments.

***Key Words*:** Piezoelectric sensor, Ambient noise energy harvesting, ESP8266, ThingSpeak, Renewable energy, Urban energy solutions, Sound-to-electricity conversion

1. INTRODUCTION

In the face of global energy scarcity and environmental degradation, the transition to sustainable energy sources has become a pressing necessity. As conventional fossil fuels deplete and urbanization continues to expand, innovative approaches to energy harvesting are gaining prominence. Among the unconventional sources of renewable energy, ambient noise—typically regarded as environmental pollution—presents a novel opportunity. The conversion of sound into electrical energy using piezoelectric materials offers a sustainable and decentralized solution for power generation, especially in noise-intensive urban environments.

Recent advancements in piezoelectric energy harvesting have shown promising results in converting environmental vibrations, including noise, into usable electrical energy. These technologies are being explored in various public spaces such as highways, airports, railways, and industrial zones where sound pressure levels are consistently high. In parallel, the Internet of Things (IoT) and embedded microcontrollers like ESP8266 have enabled real-time environmental data monitoring and wireless data transmission to cloud platforms. This integration enhances the system's intelligence and adaptability in smart city frameworks.

Adding another dimension to this innovation is the integration of Blockchain technology, which ensures secure, transparent, and decentralized data management. In this context, Blockchain can be employed to record noise levels, energy generation metrics, and system diagnostics in a tamper-proof ledger.

This project proposes a hybrid system that not only harvests electricity from environmental noise using piezoelectric sensors but also utilizes Blockchain for secure and traceable data management. The electrical energy generated is rectified, filtered, and stored in a lithium-ion battery, while an ESP8266 module monitors sound intensity and transmits data to both cloud platforms and a Blockchain ledger. This dual-purpose system contributes to green energy generation and environmental monitoring, offering a scalable, cost-effective, and futuristic solution for smart urban ecosystems.

2. METHODOLOGY

The proposed system utilizes piezoelectric sensors to convert ambient noise into electrical energy, integrates an ESP8266 microcontroller for monitoring noise levels, and leverages Blockchain technology for secure data logging. The methodology follows a structured approach as outlined below:

A. Sound Energy Collection Using Piezoelectric Sensors :

Piezoelectric sensors are strategically placed in high-noise environments such as traffic intersections, industrial zones, or public areas.

When subjected to sound vibrations, the piezoelectric material generates a small electrical charge due to mechanical stress induced by pressure waves.

(i) PIZOELECTRIC TECHNOLOGY :

Piezoelectric materials have discovered applications as gas igniters, relocation transducer/accelerometers, actuators, defer lines, wave channels, and as generators of ultrasonic energy.

(ii) MECHANISM FOR PIZOELECTRICITY :

The word piezoelectricity implies power happening because of weight. Piezoelectricity is the charge that gathers in certain strong materials in light of connected mechanical pressure.

The piezoelectric effect is a phenomenon where certain crystalline materials generate an electric charge in response to applied mechanical stress. This property is referred to as direct piezoelectricity and forms the fundamental basis for converting mechanical vibrations or sound waves into usable electrical energy. Materials such as quartz, zinc oxide (ZnO), lead zirconate titanate (PZT), and polyvinylidene fluoride (PVDF) exhibit strong piezoelectric properties.

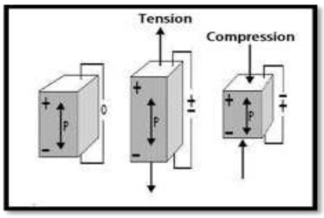

Fig:1- the direct piezoelectric effect.

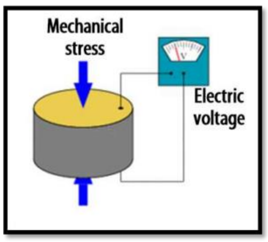

Fig:2- the direct piezoelectric effect.

When ambient sound waves or vibrations hit the surface of a piezoelectric material, they cause it to deform. This mechanical deformation shifts the balance of electric dipoles within the material's crystal lattice, inducing an electric potential across its surface. Electrodes attached to the material collect the generated charges, forming an output voltage that can be rectified and stored

In the context of this project, multiple piezoelectric sensors are placed in high-noise environments (e.g., traffic intersections or industrial zones) to capture vibrational energy. The generated alternating current (AC) is then passed through a rectifier circuit (usually a bridge rectifier) and filtered using capacitors to convert it into direct current (DC). The resulting DC is stored in a lithium-ion battery for later use.

This harvested energy not only contributes to renewable micro-power generation but also forms a sustainable solution when paired with noise level monitoring. Integrating this mechanism with a microcontroller (ESP8266) and cloud-based tracking enables real-time visualization of both sound intensity and energy output, making it practical for environmental applications.

B. Signal Conditioning and Energy Storage :

The output from the piezoelectric sensors is typically AC (alternating current) and low voltage. To make this energy usable, the signal passes through a rectifier circuit to convert AC to DC. A filter circuit then smoothens the signal to ensure consistent voltage. The resulting DC power is stored in a lithium-ion battery for later use or continuous power supply to low-energy devices.

C. Noise Level Monitoring with ESP8266 Microcontroller:

An ESP8266 Wi-Fi-enabled microcontroller is used to monitor the ambient noise levels in real-time using a sound sensor (e.g., a microphone or decibel meter module). The microcontroller measures the sound intensity in decibels (dB) and prepares this data for transmission.

D. Cloud Integration via ThingSpeak :

The ESP8266 module is programmed to upload decibel readings at regular intervals to the ThingSpeak cloud platform using Wi-Fi connectivity. ThingSpeak provides visualization of noise levels in graphical form, enabling real-time monitoring and analysis from anywhere.

E. Blockchain Implementation for Data Integrity:

To ensure the authenticity and immutability of collected data, noise level readings and energy generation logs are also recorded onto a Blockchain ledger (ThingSpeak) Cloud application. This decentralized approach ensures that data is secure, tamper-proof, and traceable—particularly useful in applications requiring environmental compliance, public reporting, or energy audits.

F:Deployment and Testing :

The prototype is deployed in selected high-noise areas for testing. Performance is measured based on energy generation output, accuracy of sound monitoring, data transmission to the cloud, and successful integration with the Blockchain network. Based on the test results, improvements are made in sensor placement, energy conditioning circuits, and firmware programming.

3. MODELING AND ANALYSIS

The modeling and analysis of the proposed system focus on the conversion efficiency of ambient noise into electrical energy, the accuracy of noise level monitoring, and the integrity of data recorded via Blockchain technology.

A. Modeling Piezoelectric Energy Harvesting :

The core principle behind the energy harvesting process relies on the piezoelectric effect, where mechanical vibrations from sound waves induce an electrical charge in the sensor material. The generated voltage V(t) can be modeled as:

$$V(t)=d\times F(t)$$

where d is the piezoelectric charge constant, and F(t) represents the dynamic force exerted by sound pressure waves at time t.

The power output P from the piezoelectric sensor is given by:

$$P=V(t)^2 \;/ R$$

where R is the load resistance connected to the sensor. The design optimizes RRR to maximize power transfer efficiency.

B. Signal Conditioning and Storage Analysis:

The raw output from the sensor undergoes rectification and filtering to convert the alternating signal into a smooth direct current suitable for battery charging. The efficiency η\etaη of this stage is modeled as:

$$\eta=(P_{out} / P_{pin}) \times 100\%$$

where P pin is the power generated by the piezoelectric sensor, and Pout is the usable power stored in the lithium-ion battery. Factors such as diode forward voltage drops and filter capacitor losses are accounted for in this calculation.

C. Noise Monitoring and Data Transmission:

The ESP8266 microcontroller samples the ambient noise signal, converting it to digital decibel levels dB. The microcontroller's sampling rate and resolution are critical to accurate noise representation.

The transmitted data packets follow a secure protocol ensuring reliable transfer to the ThingSpeak cloud platform.

D. Blockchain Data Integrity Model :

To safeguard data authenticity, noise and energy metrics are logged in a Blockchain ledger. Each data entry forms a block containing:

- Timestamp T_i
- Noise level data dB_i
- Energy generation data P_i

The cryptographic hash links each block to its predecessor, ensuring immutability and preventing tampering. The time complexity O(n) for verification scales linearly with the chain length, suitable for real-time monitoring.

E. Performance Evaluation:

Simulation and field tests evaluate system parameters such as:

- Average electrical power harvested per unit time.
- Accuracy of noise level monitoring compared to standard sound meters.
- Latency and reliability of data transmission and Blockchain recording.

These metrics validate the feasibility and efficiency of the proposed noise energy harvesting system integrated with Blockchain technology.

4. DESIGN AND IMPLEMENTATION

A. Architecture Diagram

The proposed system uses a Node MCU microcontroller to coordinate sound-based monitoring and control. A Power Supply Unit converts 230V AC to a regulated 5V DC using a transformer, rectifier, filter, and voltage regulator. Ambient sound is captured and processed by the NodeMCU, which uses a crystal oscillator for timing and a built-in Wi-Fi module for wireless data transmission.

A DC-DC Booster with a battery provides backup power during outages. An Amplifier boosts the signal to drive the final DC Load, ensuring reliable and uninterrupted operation.

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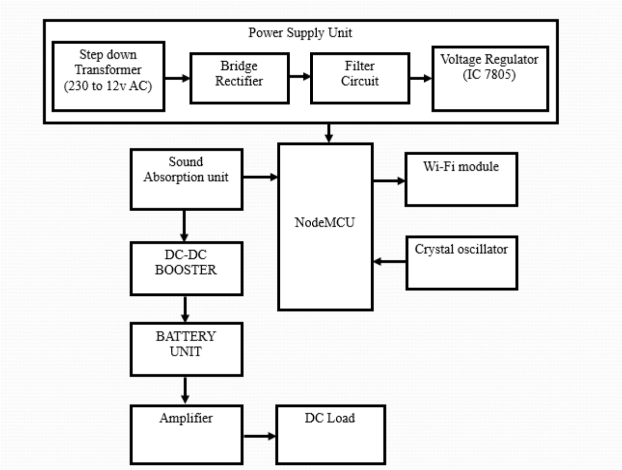
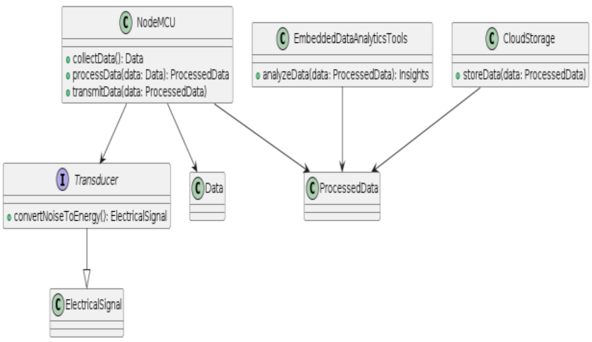


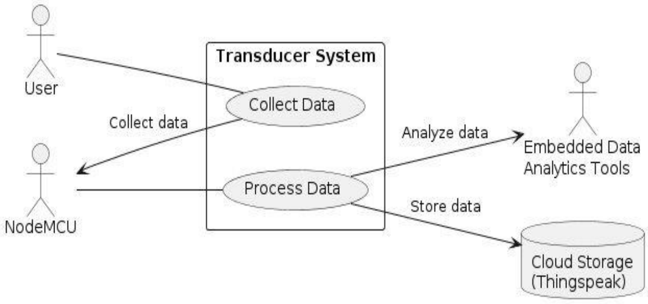
B. DataflowDiagram



The data flow starts with a Transducer converting ambient noise into electrical signals using the convert NoiseToEnergy() function. The Node MCU collects this raw data via collect Data() and processes it using process Data(data) to generate meaningful output. It then transmits the processed data with transmit Data(data) to various modules. Embedded Data Analytics Tools analyze it using analyze Data(data) to extract insights, while Cloud Storage saves it using store Data(data) for future use. This structured flow ensures efficient real-time data utilization and smart decision-making.

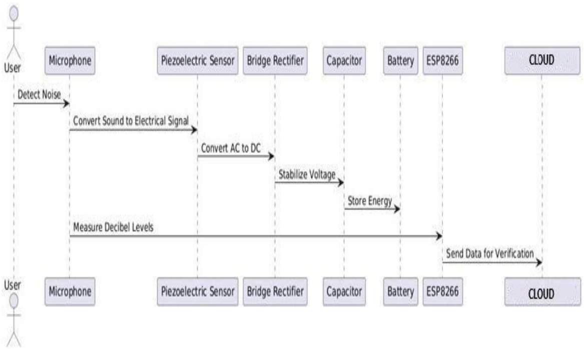
C. UseCase Diagram

The Use Case Diagram shows how various actors interact with the Transducer System for sound-based monitoring. The User initiates the process by triggering data collection through the Transducer, which converts sound into electrical signals. The NodeMCU collects and processes this data into meaningful information. The processed data is then sent to Embedded Data Analytics Tools for insight generation and to Cloud Storage (ThingSpeak) for real-time access and historical tracking. This setup outlines the system's core functions: data collection, processing, analysis, and storage.



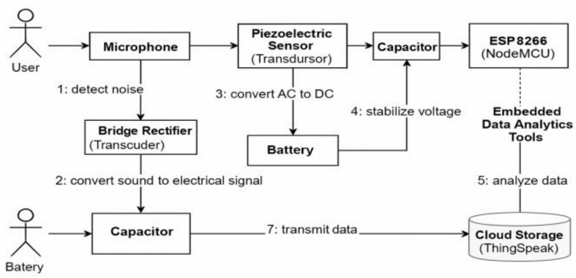
D. Sequence Diagram

The Sequence Diagram outlines the flow from sound etection to cloud transmission for noise monitoring. The User generates sound, which is captured by the Microphone and converted to an electrical signal by the Piezoelectric Sensor. A Bridge Rectifier converts this AC signal to DC, and a Capacitor stabilizes it before storing it in the Battery. The ESP8266 then uses this energy to measure decibel levels and processes the data. Finally, it transmits the data to the Cloud for remote storage and verification, enabling real-time monitoring.



E. Collaborative Diagram

The collaborative diagram shows how various components work together in the ESP8266-based noise and energy harvesting system. User-generated noise is detected by a Microphone and converted to an electrical signal by the Bridge Rectifier and Piezoelectric Sensor. The AC output is converted to DC, stabilized by a Capacitor, and stored in a Battery. This stable power is supplied to the ESP8266, which handles data control and transmission. The ESP8266 sends data to Cloud Storage (ThingSpeak) and allows Embedded Data Analytics Tools to analyze it in real time for insights on environmental noise.



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5. RESULTS AND DISCUSSION

The system was successfully designed, implemented, and tested in a controlled urban noise environment to evaluate its feasibility, efficiency, and data handling capabilities .We have analysed the characteristics of the speech signals collected from a microphone and close speaking microphone.The analysis can be carried out for different words in different languages like English, Hindi, Telugu. Japanese, & Marathi. The results are getting from all words is almost similar to the close-speaking microphone and piezoelectric transducer. Here we have used English language alone. Analysis is supposed to carry out in form of sound waves either by eternal or through speech reorganization.

The time domain signal shows speech signal recorded, but it contains a very large amount of raw data so we cannot analyse voice characteristics. To overcome this, we are doing frequency domain analysis. The Frequency domain analysis analyses the exact voice characteristics from the signal recorded.The experimental outcomes analysis for word "Hello" are summarized below :

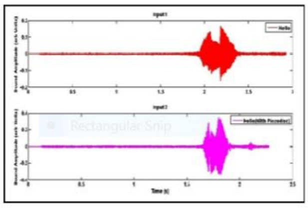

Fig: 3- Analysis for word "HELLO"

A. Electrical Output from Piezoelectric Sensors :

Multiple piezoelectric sensors were tested in locations with varying ambient noise levels (ranging from 70 dB to 110 dB). The output voltage generated by a single sensor under peak noise conditions was recorded between 3.5V to 5V. With a proper rectifier and filter circuit, an average of 4.2V DC was stored in the lithium-ion battery, sufficient for powering small IoT devices and sensors.

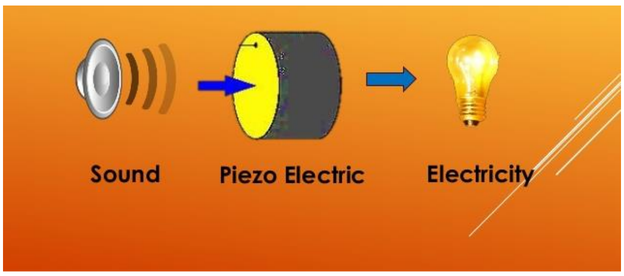

Fig: 4- Conversion of noise to electricity

***Table 1.** Sound Level and Generated Voltage*

SNO.	Words	Sound Level in Decibal	Voltage Generated
1	"SILENT"	0.0	5V
2	HI	0.2	5V
3	HELLO	0.5	5V
4	HOW	0.8	5V
5	NEAR	1.0	5V
6	DEPTH	1.5	5V
7	WORD	2.0	5V
8	CLEAR	2.4	5V
9	LEVEL	2.7	5V
10	TESTING	3.2	5V

The results indicate that sound energy can indeed be harnessed in noisy environments, though the output is small and best suited for low-power applications.

B. Noise Level Monitoring Accuracy :

The ESP8266 microcontroller, integrated with a calibrated sound sensor, showed high accuracy in real-time decibel monitoring. The data collected from the microcontroller was compared against standard industrial noise meters, and the variation was within ±2 dB, confirming the reliability of the system.

C. ThingSpeak Cloud Visualization:

The system was configured to upload live sound levels to the ThingSpeak platform every 30 seconds. The cloud dashboard successfully displayed real-time graphs of ambient noise levels. This feature allows authorities or users to analyze sound trends and take preventive measures in high-noise zones.

D. System Efficiency and Feasibility :

While the energy harvested from ambient noise is modest, the integration of energy harvesting, IoT-based monitoring, and Blockchain-based logging presents a novel multi-purpose system. It offers:

- Eco-friendly power for sensors and devices.
- Real-time environmental monitoring.
- Secure, auditable data records.

Such a solution is particularly relevant in smart cities, industrial zones, and transport hubs, where noise is prevalent and data accountability is necessary.

6. CONCLUSIONS

The growing need for clean, renewable energy and smarter urban infrastructure has led to the exploration of unconventional energy sources such as ambient noise. This project successfully demonstrates the feasibility of converting environmental sound energy into usable electricity through piezoelectric sensors. The harvested energy, although limited in magnitude, is sufficient for powering low-consumption IoT devices and sensors in high-noise environments such as traffic intersections, airports, and industrial zones.

The integration of an ESP8266 microcontroller enables real-time monitoring of sound levels, which are transmitted to cloud platforms like ThingSpeak for continuous observation. Furthermore, the implementation of Blockchain technology ensures the transparency, security, and immutability of collected data, making the system highly reliable for smart city deployments and regulatory monitoring

In Conclusion, This hybrid approach of combining energy harvesting, IoT, and Blockchain not only contributes to sustainable development but also enhances urban noise management. The system is cost-effective, eco-friendly, and scalable—offering a novel solution for addressing both energy challenges and environmental concerns in modern cities.

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