

EXPERIENTIAL LEARNING REPORT

Innovative Learning Techniques

Theme: Energy

**Topic: Generation of Electricity from
Acoustic Energy**

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INTRODUCTION

In the modern era, the quest for energy has predominantly been fulfilled by fossil fuels. However, the environmental and geopolitical consequences of this dependence have led to a global realization: the **transition to renewable energy is not just beneficial, it is essential**.

The importance and necessity of using renewable energy sources are becoming increasingly evident as we face the challenges of climate change, environmental degradation, and the finite nature of fossil fuels.

As we know, **sustainability** refers to the ability to meet the needs of the present without compromising the needs of the future generations. In this view, utilization of renewable energy sources instead of energy from fossil fuels is the key idea of our project.

The world relies heavily on electricity, with 75% of it being generated from fossil fuels and nuclear power plants, which harm the environment. While meeting the electricity demand is essential, there are ways to reduce this dependency by using environmentally friendly energy sources. Renewable energy, such as solar, wind, and hydro power, can help decrease reliance on fossil fuels, though they currently only make a small impact on overall energy production.

A proposed solution is to harness energy from sound or noise. Sound is a form of mechanical energy that travels as waves, creating pressure that can be converted into other forms of energy, including electricity. According to the law of thermodynamics, mechanical energy can be transformed into electrical energy. Piezoelectric materials, which convert mechanical strain into electrical energy, can be used to create devices that convert sound energy into electricity.

Sound energy is abundant, free, and sustainable, making it a valuable source of energy if it can be efficiently extracted and converted. Sound waves carry energy that can cause materials to vibrate. The "law of conservation of energy" states that energy cannot be created or destroyed, only transformed. This principle has led to the discovery of various energy sources that can be used for practical purposes.

Renewable energy sources, such as solar power, have become widely used due to their ease of implementation and broad range of applications, like solar heaters and cookers. Other renewable sources include wind and biomass. While these sources require significant financial investment and produce lower power output relative to their cost, they offer a more sustainable alternative to fossil fuels. Nuclear power also provides substantial energy but has high setup and maintenance costs compared to other renewable sources.

Recently, there has been increased interest in generating electricity from mechanical vibrations and pressure using piezoelectric materials. These materials can produce power ranging from microwatts to milliwatts, making them an intriguing method for capturing ambient energy and converting it into usable electricity.

LITERATURE SURVEY

| AUTHOR | PAPER TITLE | ABSTRACT | PUBLICATION DETAILS |
|---|---|--|---|
| Alankrit Gupta, Vivek Goel, Vivek Yadav | Conversion of Sound to Electric Energy | Sound energy is an untapped resource with tremendous potential to meet future electricity demands in an eco-friendly and renewable way. Although the technology to harness sound energy is not yet practical due to efficiency issues, ongoing research in this field holds a promising future. | International Journal of Scientific & Engineering Research, Volume 5, Issue 1, January-2014 ISSN 2229-5518 |
| A.Subramaniya Siva , N.Vinothini , S.Sathieshkumar | Piezoelectric Based Electric Energy Generation From Sound Energy | This paper proposes a method to convert sound into electrical energy for various applications. We use a piezoelectric transducer to achieve this conversion, leveraging the piezoelectric effect. When electrical energy is applied to a piezoelectric crystal, it vibrates. Similarly, when the crystal is subjected to vibrations from sound or mechanical energy, it generates electricity. | INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 9, ISSUE 04, APRIL 2020 |
| Yuan Wang, Xin Zhu, Tingsheng Zhang, Shehar Bano, Hongye Pan, Lingfei Qi, Zutao Zhang ,Yanping Yuan | A renewable low-frequency acoustic energy harvesting noise barrier for high-speed railways using a Helmholtz resonator and a PVDF film | This paper proposes a new type of noise barrier that reduces noise and generates electricity at the same time. The barrier uses a Helmholtz resonator to amplify low-frequency noise from trains, which is then | School of Mechanical Engineering, Southwest Jiaotong University, Chengdu 610031, PR China |

| | | | |
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| | | converted into electricity by a PVDF film. This electricity can power small devices like railway monitors. Tests showed the system can generate electricity, making it a promising approach for reducing noise pollution and generating renewable energy. | |
|--|--|---|--|

1. <https://www.sciencedirect.com/science/article/abs/pii/S2211285520305139>
2. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9000626/>
3. [https://www.sciencedirect.com/topics/materials-science/piezoelectric-material#:~:text=Piezoelectric%20materials%20can%20be%20classified,piezoelectric%20composites%2C%20and%20\(6\)](https://www.sciencedirect.com/topics/materials-science/piezoelectric-material#:~:text=Piezoelectric%20materials%20can%20be%20classified,piezoelectric%20composites%2C%20and%20(6))
4. <https://www.sciencedirect.com/science/article/abs/pii/S0255270122003361>

GAP ANALYSIS

Problem Statement:

“Depletion of non-renewable sources of energy due to increase in energy consumption has created the need to find alternative sources of renewable energy like generating electricity from unwanted noise.”

Objectives:

1. To investigate various innovative methods to generate electrical energy from acoustic sources.
2. To implement and generate electricity from acoustic sources of energy.
3. To increase the efficiency of generating electricity from acoustic sources.

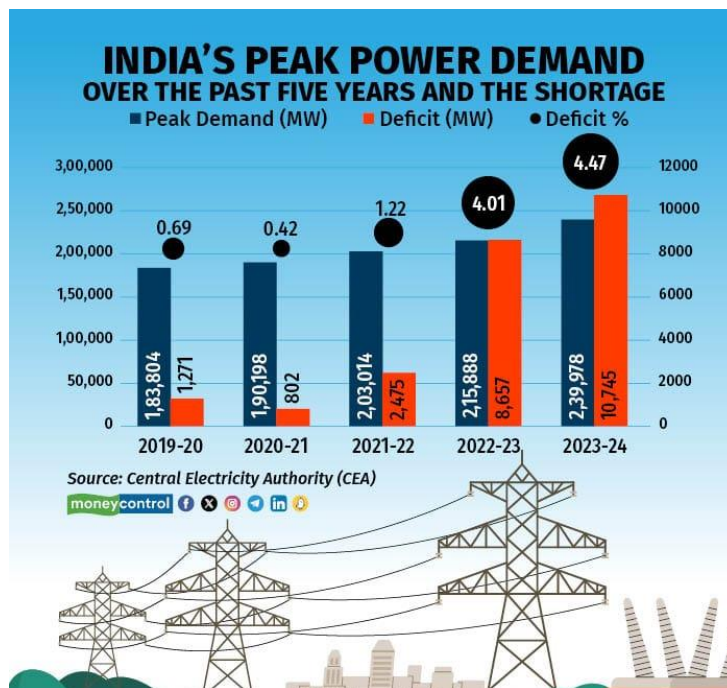


Figure 1: India's peak power demand and corresponding shortage over the past five years

The graph illustrates India's peak power demand and the corresponding shortage over the past five years. Here are the key observations:

1. **Increasing Peak Demand:** India's peak power demand has consistently risen each year from 183,804 MW in 2019-20 to 239,978 MW in 2023-24. This indicates a growing need for electricity, likely driven by economic growth and increased industrial and residential consumption.
2. **Deficit Fluctuations:**
 - **2019-20:** The deficit was 1,271 MW (0.69% of demand).
 - **2020-21:** The deficit reduced to 819 MW (0.42% of demand).
 - **2021-22:** There was a noticeable increase in the deficit to 2,475 MW (1.22% of demand).
 - **2022-23:** The deficit surged significantly to 8,657 MW (4.01% of demand).

- **2023-24:** The deficit further increased to 10,745 MW (4.47% of demand).
- 3. **Growing Shortage:** The percentage deficit has increased from 0.69% in 2019-20 to 4.47% in 2023-24, showing that the power supply has not kept pace with the rising demand. The highest deficit was observed in 2023-24, highlighting a significant shortfall in meeting peak power requirements.
- 4. **Implications:** The increasing deficit suggests challenges in power generation, transmission, or distribution. This could result in power outages, affecting industries, services, and residential areas. Addressing this deficit is crucial for economic stability and growth.

In conclusion, the graph underscores the urgent need for enhancing India's power infrastructure, investing in new generation capacities (including renewable energy sources), and improving efficiency in the power sector to bridge the growing gap between demand and supply.

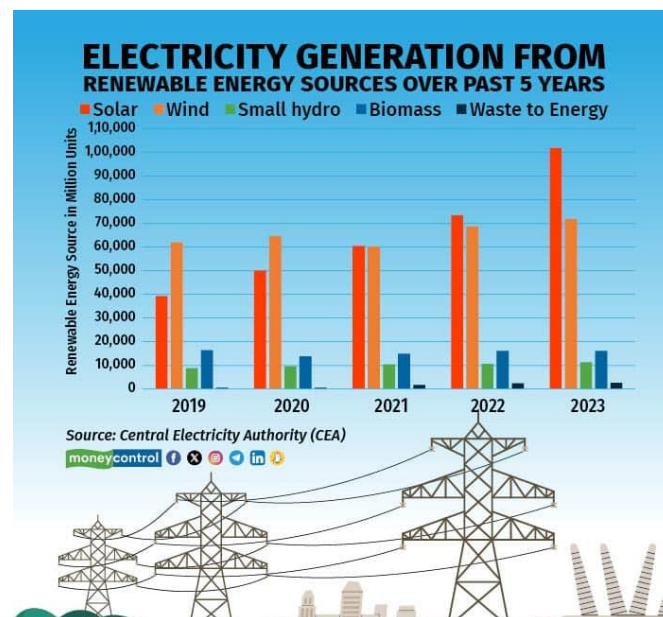


Figure 2: Electricity generation from renewable energy sources over past 5 years

The graph presents data on electricity generation from various renewable energy sources in India over the past five years, categorized into solar, wind, small hydro, biomass, and waste to energy. Here are the key observations and analysis:

1. Dominance of Solar Energy:

- Solar energy is the most significant contributor among the renewable sources, with a noticeable increase in generation from 2019 to 2023.
- The generation from solar energy experienced a substantial rise, especially evident in 2023 where it reached nearly 100,000 million units.

2. Steady Wind Energy Generation:

- Wind energy has remained relatively stable over the five-year period, maintaining a consistent level of electricity generation.
- There is a slight increase from 2019 to 2023, but it does not exhibit the same rapid growth as solar energy.

3. Consistent but Smaller Contributions from Other Sources:

- Small hydro, biomass, and waste to energy sources have contributed steadily but remain much smaller in scale compared to solar and wind energy.
- These sources show minimal growth and relatively low generation levels, consistently contributing around the same amount each year.

4. Year-on-Year Analysis:

- 2019: Solar energy started strong, with wind energy following. Small hydro, biomass, and waste to energy had minimal contributions.
- 2020: There was a significant increase in solar energy generation, while other sources remained stable.
- 2021: Solar energy continued its upward trend, with slight increases in wind energy. Other sources remained consistent.
- 2022: A continued increase in solar energy, with minor growth in wind energy. Small hydro, biomass, and waste to energy maintained their steady contributions.
- 2023: Solar energy saw a substantial surge, becoming the dominant renewable source. Wind energy remained stable, while other sources contributed marginally.

5. Implications:

- The strong growth in solar energy generation reflects India's strategic focus on expanding its solar capacity to meet growing energy demands sustainably.
- The stable contributions from wind energy indicate its established role in the renewable energy mix, although there is potential for further development.
- The relatively small but steady contributions from small hydro, biomass, and waste to energy suggest these sources are supplementary rather than primary contributors to the renewable energy landscape.

In conclusion, the graph highlights the significant rise in solar energy generation as the primary driver of growth in India's renewable energy sector over the past five years. Wind energy remains a steady contributor, while other renewable sources play a minor yet consistent role. This trend underscores the importance of continued investment in solar energy to meet future energy demands and reduce dependence on non-renewable sources.

METHODOLOGY

COMPONENTS USED:

- 1) Honeycomb structured Resonator
- 2) Piezoelectric Sensor
- 3) Full wave bridge rectifier
- 4) Boost Converter

- 5) Switching Voltage Regulator
- 6) Load (Bulb)
- 7) Battery/ Super-capacitor
- 8) Sound Sensor
- 9) Multimeter
- 10) Arduino Board

HONEY COMB STRUCTURED HELMHOLTZ RESONATORS

Acoustic resonators are devices or structures that naturally amplify sound waves at certain frequencies, known as their resonant frequencies. These devices exploit the principles of resonance, where sound waves are reinforced through constructive interference, leading to a significant increase in the amplitude of specific frequencies.

Need of Acoustic Resonator:

1. Amplification of Sound Waves: Sound waves are typically weak in energy. An acoustic resonator can amplify specific frequencies of sound waves, increasing the energy available for conversion into electrical energy. By resonating at the natural frequencies of the sound source, the resonator amplifies these sound waves, making the harvesting process more efficient.

2. Enhanced Energy Capture: Resonators help focus and concentrate sound energy at specific points. This concentration of energy allows the energy harvesting device (such as a piezoelectric transducer) to capture more sound energy than it would from ambient sound alone. This leads to a more efficient conversion process, as more sound energy is funneled into the transducer.

3. Selective Frequency Response: Acoustic resonators can be designed to resonate at specific frequencies. This selectivity is crucial when dealing with sound sources that have a wide range of frequencies. By tuning the resonator to the most dominant or useful frequencies, the system can maximize the energy harvested from these frequencies while ignoring less useful ones.

4. Improved Signal-to-Noise Ratio: In an environment with a lot of background noise, it can be challenging to capture useful sound energy efficiently. Acoustic resonators help by amplifying desired sound frequencies and filtering out the noise. This improves the signal-to-noise ratio, ensuring that the energy harvesting system captures and converts the most relevant sound energy.

5. Mechanical to Electrical Conversion: Acoustic resonators often work in conjunction with piezoelectric materials, which convert mechanical vibrations (sound waves) into electrical energy. By enhancing the vibrations through resonance, the mechanical deformation of piezoelectric materials is maximized, leading to greater electrical output.

Physics Behind Acoustic Resonators

The operation of an acoustic resonator is governed by the principles of wave interference and resonance. When sound waves enter a resonator, they reflect off the surfaces within the structure. At certain frequencies, these reflections interfere constructively, creating standing waves that amplify the sound. The specific frequencies at which this occurs are determined by the geometry and material properties of the resonator.

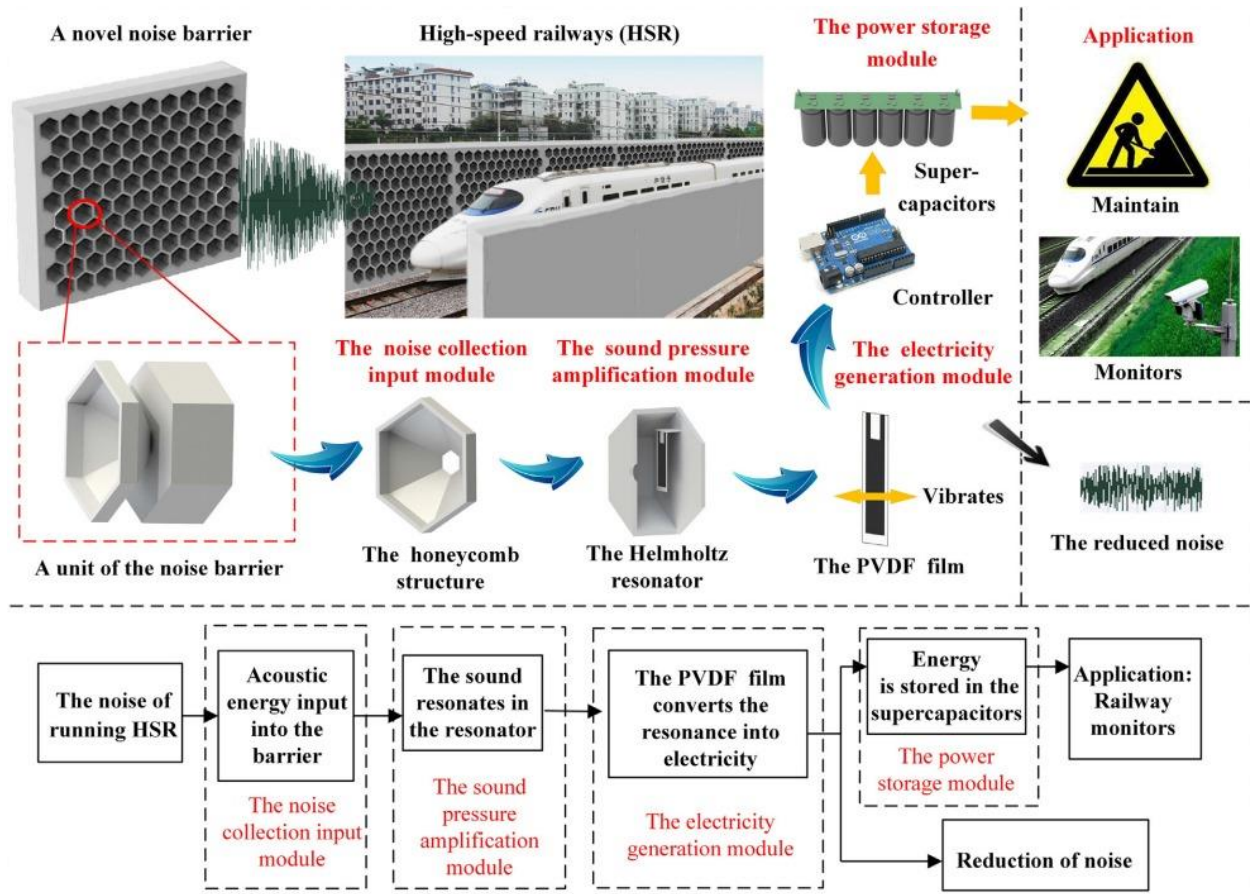


Figure 3: Architecture of the acoustic energy harvesting noise barrier

Working Principle:

The working of a Helmholtz resonator can be understood through the following key components and processes:

Resonance: When sound waves at the resonator's specific frequency enter the cavity through the neck, they cause the air inside the cavity to oscillate. This creates a resonance effect, amplifying the sound wave at that particular frequency.

Air Mass and Stiffness: The mass of the air in the neck and the stiffness of the air inside the cavity determine the resonant frequency. The oscillation of the air mass in the neck against the stiffness of the air inside the cavity creates a standing wave, leading to resonance.

Frequency Determination: The resonant frequency of a Helmholtz resonator is governed by a well-established equation:

$$f = c / (2\pi) * \sqrt{(A / (V * L))}$$

where:

f = resonant frequency

c = speed of sound in air (approximately 343 m/s at room temperature)

A = cross-sectional area of the neck

V = volume of the cavity

L = length of the neck

This formula shows that the resonant frequency can be adjusted by changing the dimensions of the neck and cavity.

Energy Absorption: At the resonant frequency, the resonator absorbs a significant amount of sound energy, converting it into heat within the walls of the cavity, thereby reducing the sound level.

Reasons for using Honey-comb Structure

Acoustic Performance

Broadband Noise Absorption: The honeycomb structure can be tailored to absorb a broad range of frequencies by adjusting the size and depth of the individual cells. This makes the resonator effective in capturing and converting noise from diverse sources.

Enhanced Resonance Properties: The geometric configuration of the honeycomb structure can enhance the resonance properties of the Helmholtz resonator. Multiple cells can resonate simultaneously, increasing the overall efficiency of noise collection.

Structural Strength and Stability

High Strength-to-Weight Ratio: The honeycomb structure provides exceptional strength and rigidity while maintaining a low weight. This makes the resonator both robust and lightweight, which is essential for practical applications where both durability and portability are required.

Formulation

The basic resonance frequency of the HR in response to the incident sound pressure crossing the neck is given by

$$f = \frac{c}{2\pi} \times \sqrt{\frac{S_n}{VL_n}}$$

$$S_n = \pi R_n^2$$

$$V = \left(\frac{3\sqrt{3}}{2} \right) l^2 h$$

where f is the basic resonance frequency of the HR, c is the speed of sound in the air, S_n is the cross-section area of the neck, V is the volume of cavity, L_n is the effective length of neck, R_n is the radius of the neck, h is the height of the hexagonal prisms cavity and l is the side length value of the regular hexagon.

The HR in the system is utilized to amplify the sound pressure with the proximity of noise at the resonance frequency. When the HR is excited at the resonance frequency, the incident sound pressure is amplified resonantly to obtain the peak value of the sound pressure output in the cavity. The pressure amplification factor A stands for the ratio of the sound pressure in the cavity to the incident sound pressure, which is represented as

$$A = \frac{P_{cavity}}{P_{incident}} = 2\pi \sqrt{\frac{(L_n V)^3}{S_n^3}}$$

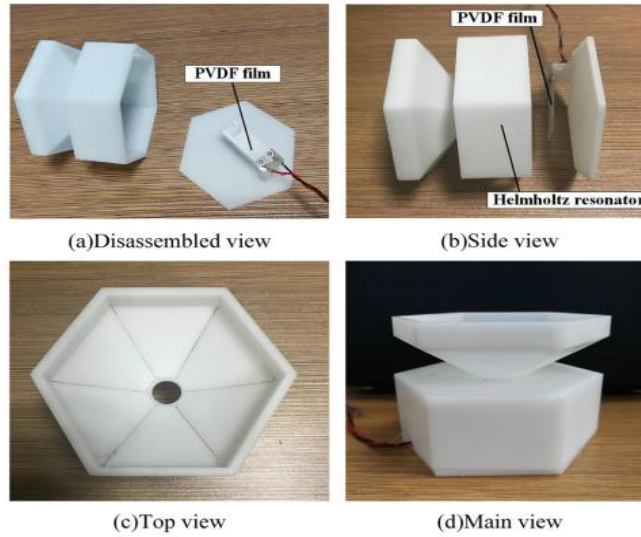


Fig. 2. Prototype of the AEHU.

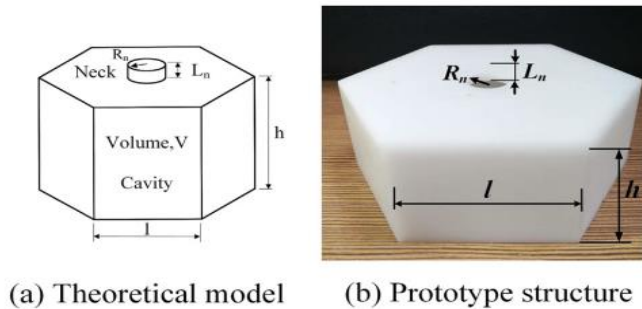


Figure 4: Model of Helmholtz Resonator

PIEZO ELECTRIC SENSOR MATERIAL

Efficient conversion of sound noise into electric energy using electrospun polyacrylonitrile membranes

A novel application for electrospun polyacrylonitrile (PAN) nanofibrous membranes has been identified. Research papers demonstrate their ability to convert low-to-mid frequency noise pollution into electricity, achieving high voltage outputs. The acoustoelectric device is fabricated by simply sandwiching a thin PAN nanofiber membrane between electrodes made from metal-coated plastic film. Notably, under exposure to 117 dB sound at frequencies between 100-500 Hz, the device generates peak electrical outputs exceeding 58 V and 12 μA . This translates to a maximum power output of 210.3 μW , with an areal power density of 17.53 $\mu\text{W}/\text{cm}^2$. These values significantly surpass those reported for previous acoustoelectric devices. Furthermore, the generated electrical energy can be rectified and directly used to power commercial electronic devices like LEDs. Alternatively, it can be stored in a power bank for later utilization. This research suggests that electrospun PAN nanofibers hold promise as a viable method for harvesting usable electrical energy from unwanted noise pollution, offering a potential solution to transform environmental waste into a valuable resource.

Existing acoustoelectric conversion devices employing conventional piezoelectric materials such as PZT and PVDF face two primary limitations. Firstly, their output voltages are intrinsically low, typically ranging from 1 mV to 2 V, attributable to the limited vibration amplitude response of these materials. Secondly, research efforts have predominantly concentrated on optimizing device design to enhance sound input density through the use of acoustic resonators or metamaterials, with less emphasis placed on the development of inherently high-output piezoelectric materials. The exploration of electrospun PAN nanofibers, as demonstrated in one of the research papers, presents a novel avenue for addressing these limitations. This approach offers the potential to overcome the inherent limitations of conventional materials and pave the way for the creation of high-performance acoustoelectric devices with significantly improved output characteristics.

Working Mechanism of Piezoelectric Sensor

Piezoelectric sensor's function based on the piezoelectric effect, which derives from the Greek word "piezein," meaning to squeeze or press. This principle involves generating an electric voltage by applying mechanical pressure to quartz crystals.

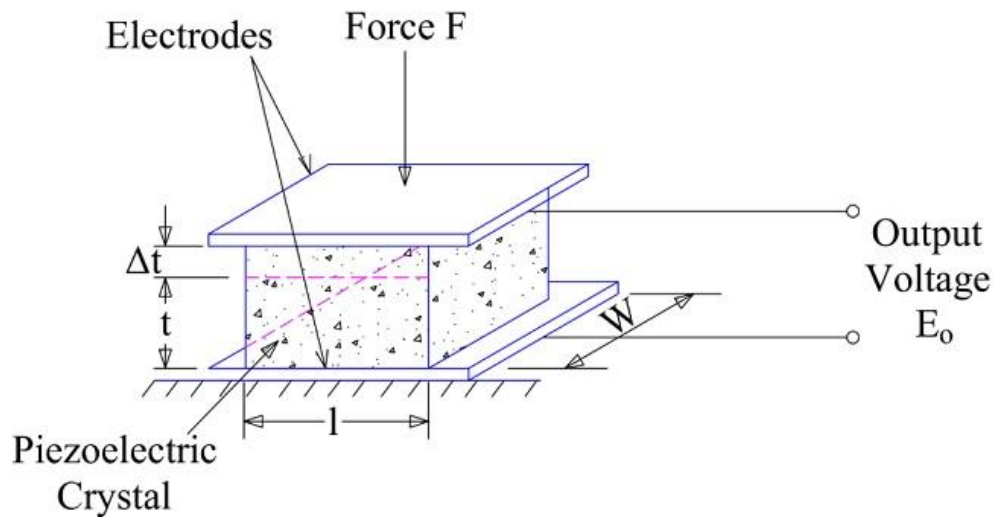


Figure 5: Cross-section of Piezoelectric Sensor

Here's how piezoelectric sensors work:

1. **Crystal and Metal Plates Setup:** A piezoelectric crystal is positioned between two metal plates. Initially, the crystal and plates are in a state of perfect balance and do not conduct electric current.
2. **Application of Mechanical Force:** When mechanical stress or force is applied to the crystal through the metal plates, the crystal's internal structure is disrupted. This force causes an imbalance in the distribution of electric charges within the crystal.
3. **Generation of Electric Charges:** As a result of this imbalance, positive and negative charges appear on opposite faces of the crystal.
4. **Voltage Production:** The metal plates then collect these charges, generating a voltage. This voltage creates an electric current that flows through a connected circuit, producing what is known as piezoelectricity.

PRECISION FULL WAVE BRIDGE RECTIFIER

Operation:

1. During the positive half-cycle of the input signal, the op-amp and diode D1 work together to pass the positive signal to the output.
2. The op-amp compensates for the diode's forward voltage drop, ensuring that even small input signals are rectified accurately.

1. During the negative half-cycle, the op-amp and diode D2 work to pass the negative signal as a positive output.
2. Again, the op-amp ensures that the small signals are accurately rectified.

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1. The signals from both half-cycles are combined in the summing stage, producing a full-wave rectified output.
2. Additional filtering can be applied to smooth the rectified signal.

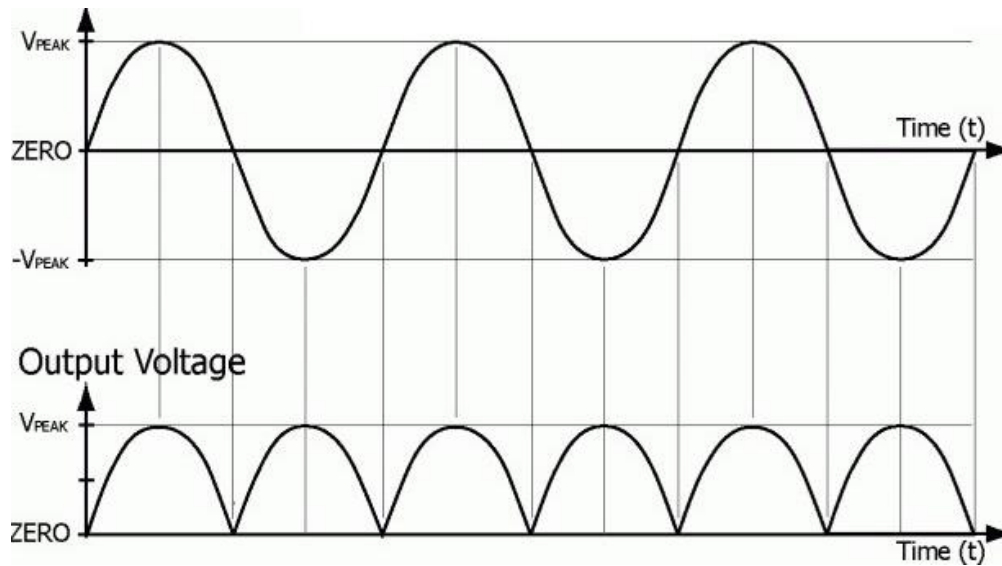


Figure 7: Input and Output Waveforms

Advantages for Piezo Sensor Applications:

- **High Sensitivity:** Precision rectifiers can handle very small signals generated by piezo sensors without significant loss.
- **Accuracy:** The op-amp compensates for the diode's forward voltage drop, providing accurate rectification even for low voltage signals.
- **Linearity:** Precision rectifiers maintain the linearity of the signal, which is crucial for accurately capturing the sensor's response.

Summary:

Using a precision full-wave bridge rectifier for piezo sensor signals ensures high accuracy and sensitivity, making it an ideal choice for applications requiring precise and reliable signal rectification from low-level AC signals.

BOOST CONVERTOR

A boost converter is a type of DC-DC converter that steps up (increases) the input voltage to a higher output voltage. It is widely used in power supply circuits where the input voltage is lower than the required output voltage.

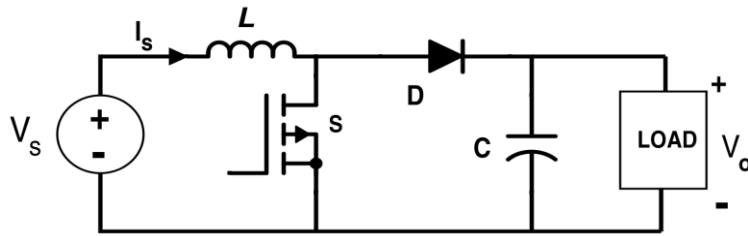


Figure 8: Boost Convertor - Circuit Diagram



Figure 9: Boost Convertor

Basic Operation:

1. **Switch On (Charging Phase):** When the switch is closed, current flows from the input supply through the inductor, causing the inductor to store energy in its magnetic field. During this phase, the diode is reverse-biased, and the capacitor supplies energy to the load.
2. **Switch Off (Discharging Phase):** When the switch is opened, the inductor resists the sudden drop in current by releasing its stored energy. This energy flows through the diode to the output capacitor and load, resulting in an increased output voltage.

The control circuit adjusts the duty cycle (the ratio of the on-time to the total switching period) of the switch to regulate the output voltage.

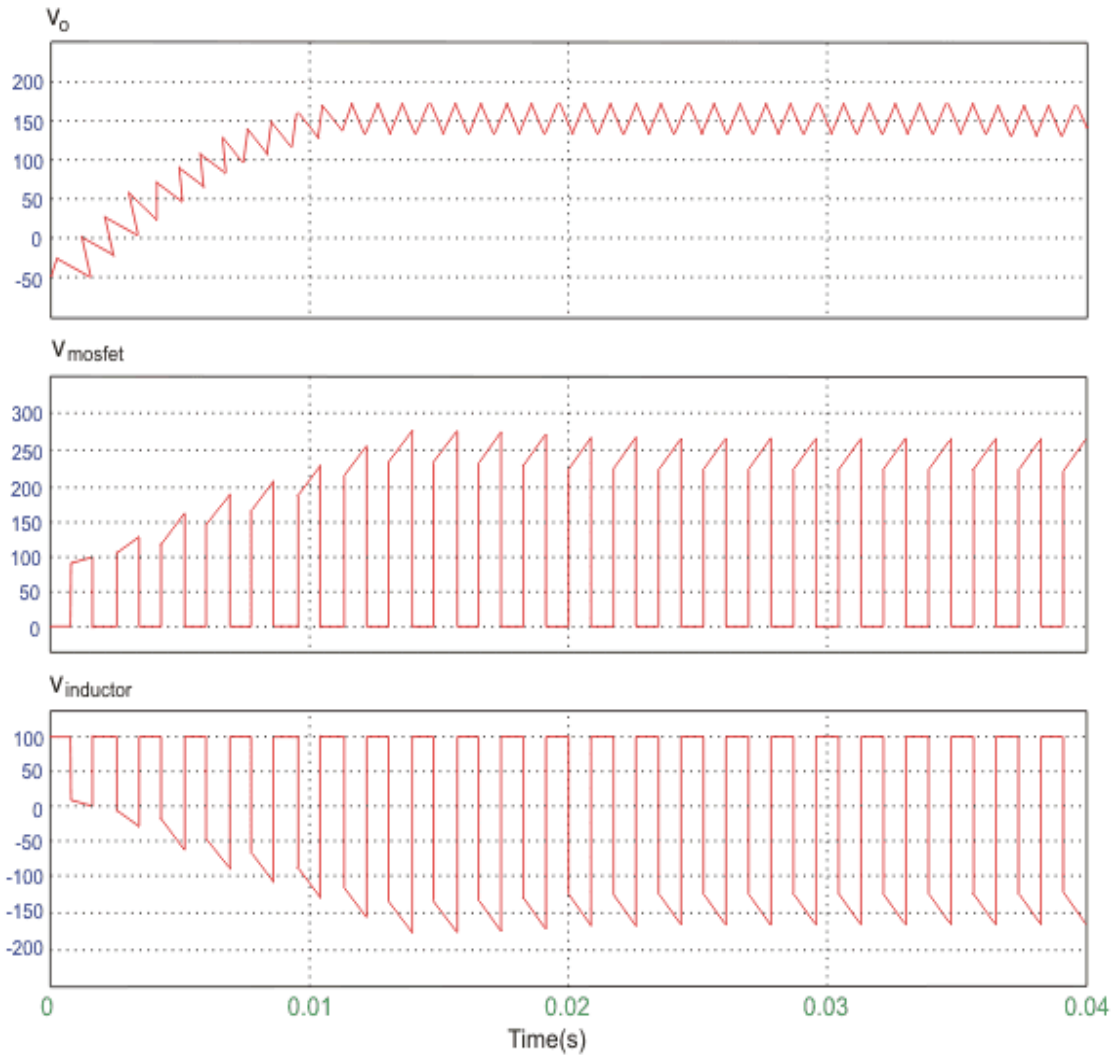


Figure 10: Voltage-Time graph across each component

Advantages of using Simple Boost Converter

1. Inductor-Based Energy Storage:

1. **Component:** An inductor is used to store energy when current flows through it.
2. **Function:** The inductor accumulates energy when the switch (typically a transistor) is closed and releases it to the output when the switch is open.

2. Switching Mechanism:

1. **Component:** A switch, usually a transistor (MOSFET), is used to alternately connect and disconnect the inductor from the input voltage.
2. **Function:** Controls the charging and discharging cycles of the inductor, essential

for stepping up the voltage.

3. Diode for Directional Current Flow:

1. **Component:** A diode is placed between the inductor and the output capacitor.
2. **Function:** Ensures that current flows in the correct direction, preventing backflow from the output to the inductor.

4. Output Capacitor:

1. **Component:** A capacitor is placed at the output of the converter.
2. **Function:** Smooths out the output voltage by storing and releasing energy, reducing voltage ripple.

5. Efficiency:

- a. **Typical Efficiency:** Generally, ranges from 70% to 90%, depending on the design and components used.
- b. **Influence:** Efficiency can be affected by the quality of the inductor, diode, and switching frequency.

6. Voltage Gain:

1. **Characteristic:** The output voltage (V_{out}) is higher than the input voltage (V_{in}).
2. **Relationship:** $V_{out}=V_{in}/[1-D]$, where D is the duty cycle ($0 < D < 1$).

7. PWM Control (Pulse Width Modulation):

1. **Function:** The duty cycle of the switch (the ratio of on-time to the total switching period) is controlled via PWM, determining the output voltage level.
2. **Benefit:** Allows precise control over the output voltage.

Conclusion:

In summary, a simple boost converter is often the best choice for small signal step-up applications because of its simplicity, cost-effectiveness, efficiency, compact size, flexibility, and fast response time. These attributes make it an ideal solution for efficiently increasing small input voltages to the required higher output voltages in various low-power electronic applications.

VOLTAGE REGULATOR

A voltage regulator is a circuit that creates and maintains a fixed output voltage, irrespective of changes to the input voltage or load conditions.

Voltage regulators (VRs) keep the voltages from a power supply within a range that is compatible with the other electrical components. While voltage regulators are most commonly used for DC/DC power conversion, some can perform AC/AC or AC/DC power conversion as well.

Types of Voltage Regulators: Linear vs. Switching

There are two main types of voltage regulators: linear and switching. Both types regulate a system's voltage, but linear regulators operate with low efficiency and switching regulators operate with high efficiency. In high-efficiency switching regulators, most of the input power is transferred to the output without dissipation.

Reasons for not choosing Linear Voltage Regulators

One of the main disadvantages for linear regulators is that they can be inefficient, as they dissipate large amounts of power in certain use cases. The voltage drop of a linear regulator is comparable to a voltage drop across a resistor. For instance, with a 5V input voltage and a 3V output voltage, there is a 2V drop between the terminals, and the efficiency is limited to $3V/5V$ (60%). This means linear regulators are best suited for applications with lower V_{IN} / V_{OUT} differentials.

It is important to consider the estimated power dissipation of a linear regulator in application, since using larger input voltages results in high power dissipation that can overheat and damage components.

Another limitation of linear voltage regulators is that they are only capable of buck (step-down) conversion, in contrast to switching regulators, which also offer boost (step-up) and buck-boost conversion.

Switching Voltage Regulator

A switching regulator circuit is generally more complicated to design than a linear regulator, and requires selecting external component values, tuning control loops for stability, and careful layout design.

Switching regulators can be step-down convertors, step-up convertors, or a combination of the two, which makes them more versatile than a linear regulator.

Advantages of switching regulators include that they are highly efficient, have better thermal performance, and can support higher current and wider V_{IN} / V_{OUT} applications. They can achieve greater than 95% efficiency depending on the application requirements. Unlike linear regulators, a switching power supply system may require additional external components, such as inductors, capacitors, FETs, or feedback resistors. The HF920 is an example of a switching regulator that offers high reliability and efficient power regulation

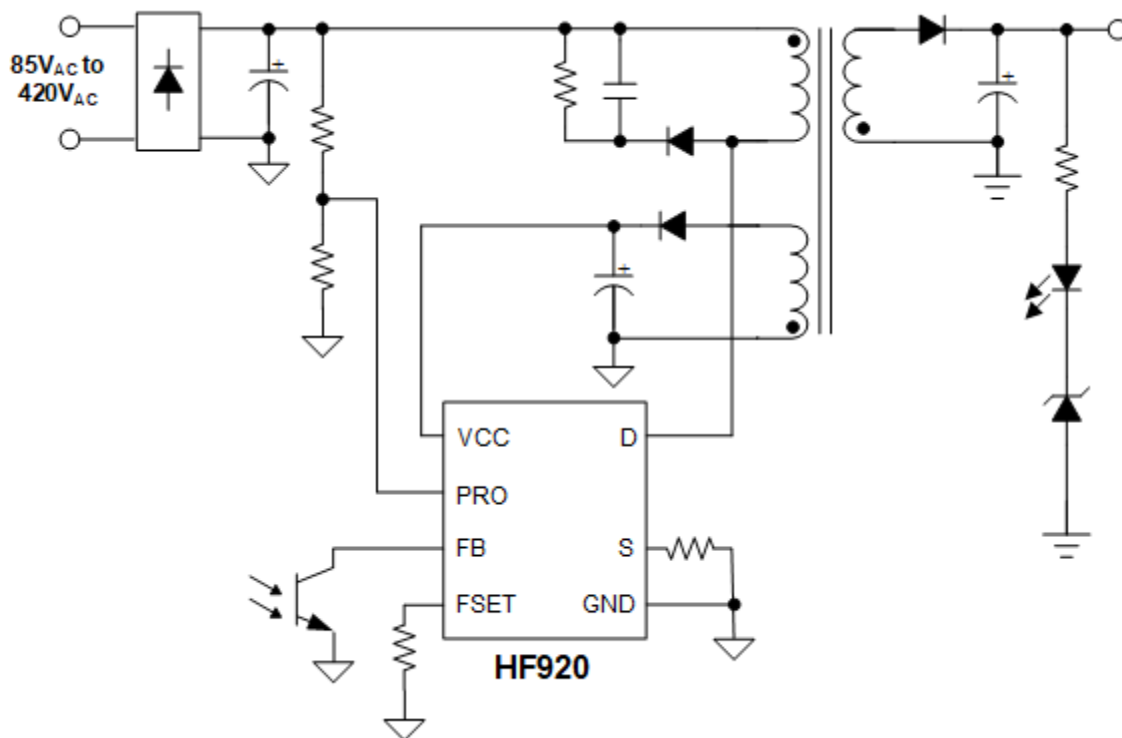


Figure 11: HF920 Switching Regulator

Switching Regulator Topologies:

For switching regulators, there are three common topologies: step-down converters, step-up converters, and buck-boost converters. Each topology is described below:

Step-Down and Step-Up Converters

Step-down converters (also called buck converters) take a larger input voltage and produce a lower output voltage. Conversely, step-up converters (also called boost converters) take a lower input voltage and produce a higher output voltage.

Buck-Boost Converters

A buck-boost converter is a single-stage converter that combines the functions of a buck and a boost converter to regulate the output over a wide range of input voltages that can be greater or less than the output voltage.

Voltage Regulator Control

a switching regulator requires more components to create the circuit. The power stage switches between VIN and ground to create charge packets to deliver to the output. Similar to a linear regulator, there is an operational amplifier that samples the DC output voltage from the feedback network and compares it to an internal voltage reference. Then the error signal is amplified, compensated, and filtered. This signal is used to modulate the PWM duty cycle to pull the output back into regulation. For example, if the load current increases rapidly and causes an output voltage droop, the control loop increases the PWM duty cycle to supply more charge to the load and bring the rail back into regulation.

Switching Regulator Applications

Switching regulators are beneficial for more general applications, and are especially useful in applications that need efficiency and performance, such as consumer, industrial, enterprise, and automotive applications. For example, if the application requires a large step-down solution, a switching regulator is better suited, since a linear regulator could create high power dissipation that would damage other electrical components.

SOUND SENSOR

A **sound sensor** is a device that detects and measures sound waves, typically converting them into an electrical signal.

The sound sensor detects ambient sound waves and measures their properties, such as amplitude and frequency.

The FC-04 sound sensor module is a very sensitive sound detection module. The sound sensor is

one type of module used to notice the sound. This sensor is capable to determine noise levels within DB's or decibels at 3 kHz to 6 kHz frequencies.



Figure 12: Sound Sensor

COSTINGS

| Component | Quantity | Cost per unit |
|----------------------|----------|---------------|
| Resonator | | |
| Piezoelectric Sensor | 1 | 89 |
| Arduino UNO Board | 1 | 253 |
| Bridge Rectifier | 1 | 270 |
| Amplifier | 1 | 4374 |
| Voltage Regulator | 1 | 350 |
| Battery | 2 | 170 |
| Load | 1 | 8 |
| Sound Sensor | 1 | 229 |
| Total | | 5743 |

FUTURE SCOPE

In the near future, harnessing energy from piezoelectric sensors could revolutionize renewable energy sources. By developing innovative methods to capture energy from everyday sounds, we could address electricity shortages, particularly in developing countries.

Imagine a world where your mobile phone charges itself just by making a call and talking to a friend. This advancement would truly make mobile devices "mobile," eliminating constant concerns about battery life. The implications extend beyond personal devices to public infrastructure. For example, street lamps and traffic lights could be powered by converting the sound energy from vehicle noise into electricity. This approach not only helps in reducing noise pollution but also utilizes it as a practical source of energy.

In industrial settings, where heavy machinery generates significant noise, the sound energy can be captured and repurposed. This captured energy could then power smaller, low-energy machines involved in the production process. By doing so, industries could significantly reduce their reliance on conventional energy sources, enhancing energy efficiency and sustainability.

These advancements in piezoelectric technology represent a major step forward in renewable energy, potentially transforming how we power devices and infrastructure by making efficient use of sound energy.

CONCLUSION

Using this proposed method, we can generate green energy efficiently, without the environmental impact associated with fossil fuels. This method effectively harnesses random ambient sound using sound collectors, thereby increasing the generated output voltage by adding more units. By combining a condenser microphone in series with a piezoelectric transducer, we create a hybrid system that improves overall output.

This approach can be particularly effective in busy areas such as railway stations, highways, and other high-traffic locations. Here, well-designed sound collectors and high-sensitivity piezoelectric transducers capture and convert sound energy into electricity efficiently.

The proposed method involves a honeycomb resonator and electrospun polyacrylonitrile nanofibers to enhance efficiency. The concentrated sound waves cause the transducer to vibrate intensely, generating more electricity compared to conventional methods.

By optimizing the design of the sound collectors and using highly sensitive piezoelectric transducers, we can effectively capture and convert ambient sound energy into a reliable source of green energy. This innovative approach offers a sustainable solution for generating electricity in various high-noise environments, contributing to a reduction in reliance on fossil fuels and helping to mitigate environmental impact.