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Piezoelectric Electricity Generator Using Footsteps

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Abstract: The growing demand for sustainable and decentralized energysources has encouraged the exploration of energy harvesting fromeveryday human activities. This project focuses on the design anddevelopment of a piezoelectric electricity generator that convertsmechanical energy from human footsteps into usable electricalenergy. When pressure is applied to piezoelectric materials embedded beneath a walking surface, they generate an electric charge due to the piezoelectric effect. The produced alternating voltage is conditioned using rectification and energy storage circuits to obtain stable electrical output. The harvested energy can be used to power low-energy devices such as LED lighting,sensors, or charging units in public areas. This system is particularly suitable for high-footfall locations like railway stations, shopping malls, and sidewalks, offering a clean,renewable, and cost- effective supplementary power source. The proposed approach demonstrates the potential of piezoelectric technology in promoting energy efficiency and sustainability through smart infrastructure integration.

INTRODUCTION

The Piezoelectric Electricity Generator Using Footsteps is an innovative project that focuses on generating electrical energy from human movement.In today's world, where energy demand is continuously increasing, there is a growing need for alternative and renewable energy sources. This project utilizes the concept of the Piezoelectric Effect to convert mechanical energy produced by footsteps into electrical energy. When a person walks over a surface embedded with piezoelectric sensors, mechanical pressure is applied to these sensors. This pressure generates a small amount of electrical voltage, which can be collected, stored, and used for low-power applications such as lighting, sensors, or charging small electronic devices. This system is especially useful in high-footfall areas like railway stations, shopping malls, and public walkways, where large amounts of energy can be harvested efficiently. The project aims to demonstrate a sustainable, ecofriendly, and cost-effective method of energy generation that can contribute to reducing dependency on conventional energy sources.

The renewable energy industry has traditionally focused on large-scale solutions such as solar, wind, and hydroelectric power. While effective, these sources are not always suitable for indoor environments or locations with space, weather, or installation constraints.
This creates a gap for micro- energy harvesting technologies that can operate continuously and independently of environmental conditions.

EXISTING SYSTEM AND ITS LIMITATION

At present, electricity is mainly generated using conventional and renewable energy sources.Conventional methods include fossil fuel-based power plants that use coal, oil, or natural gas, which are widely used but contribute significantly to environmental pollution and depletion of natural resources. Renewable energy methods such as solar, wind, and hydropower are cleaner alternatives; however, they depend heavily on environmental conditions like sunlight, wind speed, and water availability. In addition to these, modern energy harvesting techniques such as electromagnetic and thermoelectric generators are used to produce electricity from motion and heat. Piezoelectric technology is also an existing method, where mechanical pressure or vibrations are converted into electrical energy, but its application is currently limited to low-power devices and small-scale systems. These limitations highlight the need for more efficient and practical solutions like footstep-based energy generation.

PROBLEM STATEMENT

The continuous rise in global energy demand and the depletion of conventional energy resources have created an urgent need for alternative and renewable energy sources. Conventional power generation methods rely heavily on fossil fuels, which cause environmental pollution, greenhouse gas emissions, and increased operational costs. At the same time, a significant amount of mechanical energy generated by human movement, especially in crowded public places such as railway stations, shopping malls, college campuses, and footpaths, remains unused and wasted.In high footfall areas, thousands of people walk daily, producing mechanical pressure that is dissipated without being harnessed for any useful purpose. Although this energy per individual step is small, the cumulative effect of continuous footsteps can be substantial if efficiently captured. Existing renewable energy systems like solar and wind are location- and weather- dependent, limiting their reliability in certain environments. Therefore, there is a need to design and develop a system that can convert mechanical energy from human footsteps into electrical energy using piezoelectric

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technology. The generated energy should be efficiently stored and utilized for low-power applications such as lighting,mobile charging, and sensor operation.

SCOPE OF PROJECT

Furthermore, the scope extends to improving the efficiency of the system by connecting multiple piezoelectric sensors in series and parallel combinations to increase voltage and current output. It also includes optimizing the mechanical design to ensure maximum pressure transfer to the sensors and minimal energy loss. Although the current implementation is limited to small-scale power generation, the concept has significant potential for future expansion. With advancements in materials,sensor technology, and energy storage systems, this method can be scaled up for larger applications. Integration with smart technologies such as IoT (Internet of Things) can enable realtime monitoring and efficient energy management in smart city infrastructure. In addition, this project contributes to the development of eco- friendly and renewable energy solutions by utilizing human- generated kinetic energy that would otherwise go to waste. It promotes awareness about sustainable energy practices and encourages innovation in alternative energy sources. However, the scope is currently limited by factors such as low power output, high cost of piezoelectric materials, and dependency on consistent foot traffic. Despite these limitations,the project serves as a foundation for further research and development in the field of energy harvesting.

SCHEMATIC DIAGRAM:

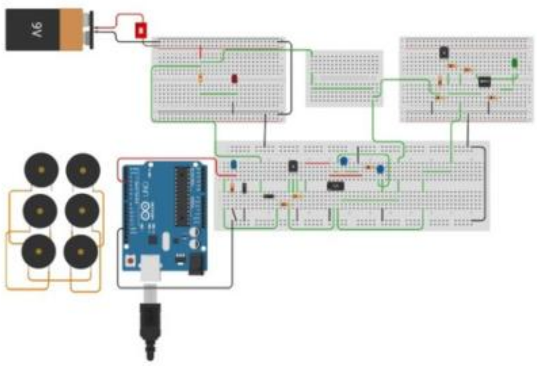

Fig - Connection Diagram

FLOW CHART:

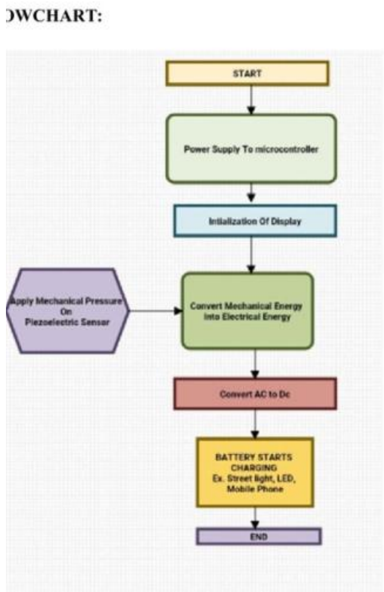

Fig - Flowchart

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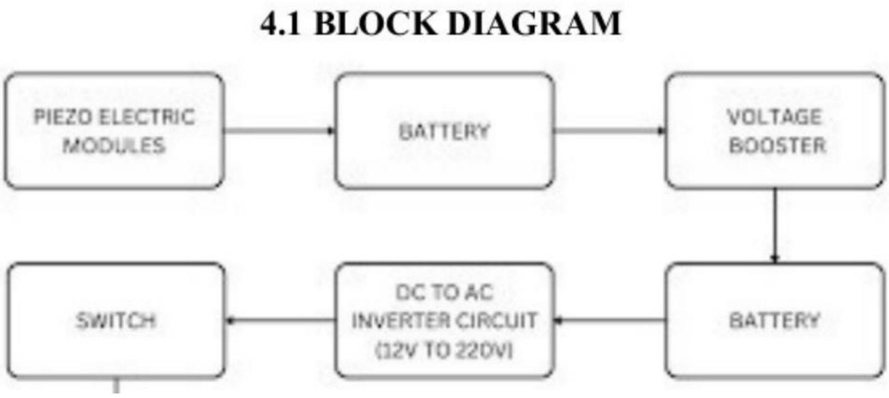
BLOCK DAIGRAM OF AI BASED AUDIO SURVEILLANCE SYSTEM:



WORKING

After setting up the Smart Dustbin and making all the necessary connections, upload the code to Node MCU and provide 5V power supply to the circuit. Once the system is powered ON, Node MCU keeps monitoring for any object near the Ultrasonic Sensor. If the Ultrasonic Sensor detects any object like a hand for example,Node MCU calculates its distance and if it less than a certain predefined value, Node MCU will activate the Servo Motor and with the support of the extended arm, it will list the lid open. After certain time, the lid is automatically closed.

A. Hardware Components Description :
Piezoelectric Sensors
Function: Converts mechanical energy (footsteps) into electrical energy. Working Principle: When pressure is applied to the piezoelectric material, it produces a small voltage due to the piezoelectric effect. Usage in Project: Placed under the footstep platform to generate voltage whenever someone steps on it. Specifications (Example): Can generate 10–20 volts per step,depending on pressure and material.

2. Diodes (Example: 1N4007)
Function: Allows current to flow in only one direction.
Working Principle: Converts alternating current (AC) produced by piezo sensors into direct current (DC) when used in a bridge rectifier. Usage in Project: Four diodes are connected in a bridge configuration to rectify AC voltage from the piezo sensors. Specifications: Maximum repetitive peak reverse voltage: 1000 volts, maximum forward current: 1 ampere.

3. Rechargeable Battery
Function: Stores the electrical energy generated by thepiezo sensors for later use. Working Principle: Receives DC voltage from the rectifier and stores it chemically to supply power when needed. Usage in Project: Powers LEDs or small devices using the stored energy from footsteps. Specifications (Example): 9V or 12V rechargeable battery; capacity depends on size and output requirements.

4. Arduino Uno Microcontroller Board
Function: Reads sensor output, counts footsteps, calculates voltage, and displays data.
Working Principle: Processes analog input from the piezo sensors, converts it to digital values, and controls outputs such as LEDs or LCD display. Usage in Project: Monitors voltage, counts number of footsteps, calculates energy generated, and shows results on the LCD. Specifications: ATmega328P microcontroller, 14 digital input/output pins, 6 analog input pins, USB interface for programming

5. Liquid Crystal Display (16×2 Characters)
Function: Displays voltage, number of footsteps, and energy generated in real-time. Working Principle: Uses liquid crystals that change orientation with electric current to display characters on the screen. Usage in Project: Shows information such as voltage output, step count, and energy stored. Specifications: 16 characters per row, 2 rows, uses 5V power supply.

6. Connecting Wires
Function: Provides electrical connections between all components in the circuit. Usage in Project: Connects piezo sensors, diodes, Arduino, LCD, and battery for proper functioning. Specifications: Copper wires,insulated, standard length depending on setup.

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7. Acrylic Board
Function: Serves as the base platform to mount piezo sensors and other components. Usage in Project: Provides structural support and distributes foot pressure evenly on the piezo sensors.Specifications: Transparent or colored acrylic sheet, thickness 3–5 mm, size depending on project design.

```
#include <LiquidCrystal.h> // Include LCD library
// Initialize LCD pins: RS, E, D4, D5, D6, D7
Liquid Crystal lcd(7, 6, 5, 4, 3, 2);
// Pin definitions const int Piezo pin = A0; // Piezo sensor connected to
analog pin A0 const int led Pin = 13; // LED pin const int buzzer Pin =
8; // Buzzer pin
// Variables int sensor Value = 0; // Raw piezo sensor
reading float voltage = 0.0; // Calculated voltage int
step Count = 0; // Number of footsteps float total Energy
= 0.0; // Energy generated (Joules) float peak Voltage =
0.0; // Highest voltage recorded
// Threshold for detecting a step const int threshold = 50;
unsigned long lastStep Time = 0; const unsigned long
debounce Delay = 200; // milliseconds
// Variables for averaging
const int sample Size = 10;
int samples [sample Size];
int index = 0;
void setup() { pinMode(ledPin,
OUTPUT); pinMode(buzzerPin,
OUTPUT);
Serial.begin(9600); // Start serial communication
lcd.begin(16, 2); // Initialize LCD
lcd.print("Piezo Project");
delay(2000); lcd.clear();
// Initialize sample array for(int i =
0; i < sample Size; i++) { samples[i]
= 0; } }
void loop() { // Read piezo sensor
sensor Value = analog Read(piezo Pin);
// Convert raw value to voltage (0–5V)
voltage = sensor Value * (5.0 / 1023.0);

// Store sample for averaging
samples[index] = sensor Value;
index = (index + 1) % sample Size;
int sum = 0; for(int i = 0; i < sample Size; i++) { sum +=
samples[i]; } float avg Voltage = (sum / sample Size) *
(5.0 / 1023.0);
// Track peak voltage
if(voltage > peak Voltage) {
Peak voltage = voltage; }
// Step detection logic if(sensor Value >
threshold) { if(millis() - last StepTime >
debounce Delay) { step Count++; last Step Time
= millis();
// Energy calculation (approximate)
total Energy += voltage * 0.002; // Joules
// LED and Buzzer indication
digital Write(Led pin,
HIGH);
digital Write(buzzer Pin,
HIGH);
```

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```
delay(50); digital Write(led Pin,
LOW); digital Write(buzzer Pin,
lcd.clear(); if(displayMode
== 0) { lcd.setCursor(0, 0);
lcd.print("V:");
lcd.print(voltage, 2);
lcd.print("P:");
lcd.print(peakVoltage, 2);
lcd.setCursor(0, 1);
lcd.print("Steps:");
lcd.print(stepCount); } else
{ lcd.setCursor(0, 0);

lcd.print("Energy:");
lcd.print(totalEnergy, 2);
lcd.setCursor(0, 1);
lcd.print("Avg V:");
lcd.print(avgVoltage, 2);
}
// Print to Serial Monitor Serial.print("Voltage: "); Serial.print(voltage);
Serial.print(" V | "); Serial.print("Peak: "); Serial.print(peakVoltage);
Serial.print(" V | "); Serial.print("Avg: "); Serial.print(avgVoltage);
Serial.print(" V | "); Serial.print("Steps: "); Serial.print(stepCount);
Serial.print(" | "); Serial.print("Energy: "); Serial.println(total Energy);
delay(200); // Small delay for stability }
```

After that, we define the audio parameters and the GPIO pin for the buzzer alert.

```
BUZZER_PIN = 23                 # GPIO pin for the Active Buzzer
DURATION = 2                    # Audio window size in seconds
ENERGY_THRESHOLD = 0.01         # Minimum energy required for detection
ALERT_SOUNDS = ["gunshot", "shouting", "glass"] # Abnormal sound classes
```

After that, we configure the Twilio settings to send security alerts to the user's mobile through WhatsApp.

```
ACCOUNT_SID = "Your_Account_SID"
AUTH_TOKEN = "Your_Auth_Token"
FROM_WHATSAPP = "whatsapp:+14155238886"
TO_WHATSAPP = "whatsapp:+91XXXXXXXXXX"
client = Client(ACCOUNT_SID, AUTH_TOKEN)
```

Now, to process the audio, we load the trained SVM model. This loads the pre-trained `audio_model.joblib` file into the Raspberry Pi's RAM for high-speed analysis.

```
model = load("audio_model.joblib")
```

Inside the main execution loop, the system captures a 2-second audio buffer from the INMP441 microphone using the ALSA recording utility.

```
subprocess.run([
"arecord",
"-D", "hw:3,0",
"-f", "S32_LE",
"-r", "48000",
"-c", "2",
"-d", str(DURATION),
"live_test.wav"])
```

CONCLUSION

This project work successfully demonstrates the design and implementation of an AI-Powered The Piezoelectric Electricity Generator using Footsteps project demonstrates an innovative and eco-friendly method of generating electrical energy from human movement.
This system uses the principle of the Piezoelectric Effect, where mechanical pressure applied on piezoelectric sensors produces electrical energy. When a person walks over the platform, the pressure exerted on the piezoelectric sensors generates small electrical charges. These charges are collected, stored, and can be used to power low-energy devices such as LED lights, display units, or small electronic circuits. The system is especially useful in crowded places such as railway stations, shopping malls,sidewalks, and public

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pathways where large numbers of footsteps occur daily. This project highlights the importance of utilizing renewable and non-conventional energy sources. It reduces dependency on traditional electricity generation methods and promotes energy conservation. Although the amount of electricity generated from a single step is small, the cumulative energy produced from continuous footsteps can be significant in high-traffic areas. In conclusion, the piezoelectric footstep power generation system is a sustainable and cost-effective solution for producing clean energy.

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