IoT Mini Project Report on

"FOOTSTEP POWER GENERATION"

By

DIVYA J (1JB23MC010)

KAVYA S (1JB23MC015)

Submitted to

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

In partial

fulfillment of the requirement for the award of the degree of

MASTER OF COMPUTER APPLICATIONS

UNDER THE GUIDANCE OF

Internal Guide
Mrs. Swetha Shri K
Assistant Professor
Dept. of MCA, SJBIT
Bengaluru

DEPARTMENT OF MCA
S J B INSTITUTE OF TECHNOLOGY
B G S HEALTH AND EDUCATION CITY
Kengeri, Bengaluru-560060.

Batch:2023- 2025

II Jai Sri Gurudev II

Sri Adichunchanagiri Shikshana Trust ®

S J B INSTITUTE OF TECHNOLOGY

BGS Health & Education City, Kengeri, Bangalore-560060.

DEPARTMENT OF COMPUTER APPLICATIONS (MCA)

CERTIFICATE

This is to certify that **DIVYA J [1JB23MC010], KAVYA S [1JB23MC015]** is a Bonafide student of Master of Computer Applications course of the SJB Institute of Technology, Batch 2023-25, affiliated to Visvesvaraya Technological University, Belagavi. An IOT Mini Project is prepared by them under the guidance of **Mrs. Swetha Shri K**, in partial fulfillment of the requirements for the award of the degree of Master of Computer Applications of Visvesvaraya Technological University, Belagavi, Karnataka.

Signature of Guide	**Signature of HOD**
Mrs. SWETHA SHRI K	**Dr. S. NAGAMANI**
ASSISTANT PROFESSOR	**PROFESSOR & HEAD**
DEPT. OF MCA	**DEPT. OF MCA**

Viva – voce Examination **Date:**

Signature of Internal Examiner	**Signature of External Examiner**
Name and affiliation	**Name and affiliation**

DECLARATION

We, **DIVYA J [1JB23MC010] and KAVYA S [1JB23MC015]**, are here by declare that the Project report entitled IOT Mini Project Report on FOOTSTEP POWER GENENERATION is prepared by us under the guidance of Mrs. Swetha Shri K, faculty of MCA Department, SJB Institute of Technology. We also declare that this Mini Project work is towards the partial fulfillment of the university regulations for the award of a degree of Master of Computer Applications by Visvesvaraya Technological University, Belagavi. We further declare that this Mini Project work is based on the original study undertaken by us and has not been submitted previously for the award of an MCA degree from SJB Institute of Technology.

Place: Bengaluru **Signature of the student**

Date:

ACKNOWLEDGEMENT

The satisfaction & euphoria that accompany the successful completion of any task would be incomplete without the mention of people who made it possible because “Success is the abstract of hard work & perseverance, but steadfast of all is encouragement guidance”. So we acknowledge all those whose guidance and encouragement served as a beacon light & crowned our efforts with success.

We are grateful to his divine soul Sri Sri Sri Jagadguru Dr. Balagangadharanatha MahaSwamiji and we are grateful to His Holiness Jagadguru Sri Sri Sri Dr. Nirmalanandanatha MahaSwamiji for providing me an opportunity to complete my academics in this esteemed college.

We would like to express our profound gratefulness to his holiness Revered Sri Sri Dr. Prakashnath Swamiji, Managing Director, SJBIT for providing an opportunity to complete my academics and present this work.

We Owe our deep sense of gratitude to Dr. Puttaraju, Academic Director for his incessant encouragement.

We are grateful to Dr. K V Mahendra Prashanth, Principal, for his kind co-operation and encouragement.

We are extremely grateful to Dr. S. Nagamani, Head of the Department of Master of Computer Applications (MCA), for her co-operation and encouragement.

We express our gratitude and sincere thanks to Mrs. Swetha Shri K, Assistant Professor, for the valuable guidance throughout my Mini Project.

We are highly indebted to the IOT Mini Project Coordinator, who has been a source of inspiration to me and has extended her fullest support throughout the Mini Project work. We also thank all the staff members of the MCA Department for their help during my project. Last but not the least We thank our parents, family members & friends, for their continuous and great support and encouragement throughout our Mini Project.

Regards,
DIVYA J
KAVYA S

TABLE OF CONTENTS

ABSTRACT

In response to the escalating global energy demand and the pressing need for sustainable alternatives, this mini project explores an innovative approach to energy harvesting through footstep power generation. By converting the mechanical energy generated by human footsteps into usable electrical energy, this system utilizes piezoelectric sensors and IoT-based technologies to create a smart, eco-friendly solution for urban infrastructure. The proposed system is designed using an Arduino Uno microcontroller, ESP8266 Wi-Fi module, capacitors, diodes, and other essential electronic components to ensure efficient energy conversion, storage, and monitoring. Real-time data acquisition and visualization are facilitated via cloud platforms, allowing for performance metrics such as voltage, current, power output, and footfall count to be remotely accessed. The system holds significant promise for application in high-footfall public spaces like railway stations, shopping malls, stadiums, and educational institutions, effectively turning everyday human movement into a decentralized, renewable energy source. By addressing the challenges of energy wastage and environmental degradation, this project contributes toward the development of smart, self-sustaining urban spaces.

CHAPTER 1

INTRODUCTION

In today's world, where energy demands are constantly increasing and sustainable solutions are more crucial than ever, harnessing energy from unconventional sources has gained significant attention. One such innovative and eco-friendly approach is footstep power generation - the conversion of mechanical energy from human footsteps into usable electrical energy. This method utilizes the basic principles of piezoelectricity or electromagnetic induction to produce power as people walk over specially designed platforms or tiles.

1.1 Overview of the Project

The primary aim of this mini project is to design and develop an innovative system that converts human footstep energy into electrical energy and utilizes IoT technology for real-time monitoring and data analysis. The system is designed to promote sustainable energy solutions and enhance smart infrastructure in public spaces.

Components Used:

- **Arduino Uno** - Main microcontroller for processing.
- **ESP-01 (ESP8266)** - Wi -Fi module for remote communication.
- **Piezoelectric Sensors** - Measure changes in pressure acceleration and soon.
- **Breadboard & Jumper Wires** - For circuit connections.
- **Arduino Cable** - For uploading code and serial monitoring
- **Capacitors** - To store electricity.
- **Diodes** - Current Flow.

1.2 Objective of the Project

The primary objective of this mini project is to develop a prototype system that demonstrates how footstep power can be effectively harvested, stored, and monitored using IoT-based technologies. Such a system can be especially useful in high-footfall areas such as railway stations, shopping malls, stadiums, and educational institutions, turning everyday human activity into a source of renewable energy.

Specific objectives include:

- To design and fabricate a footstep-based power generation system using piezoelectric sensors.

- To store the harvested energy efficiently in a rechargeable battery or capacitor bank for later use in powering low-voltage devices such as LED lights or sensors.
- To analyze and display real-time data such as voltage, current, power output, and footfall count using microcontrollers and cloud platforms

1.3 Scope and Applications

The footstep power generation IoT mini project lies at the intersection of renewable energy and smart technology. With the growing need for sustainable and decentralized energy solutions, especially in urban areas,

This project involves:

- Designing a prototype that converts mechanical energy into electrical energy using piezoelectric or electromagnetic mechanisms.
- Implementing IoT modules for real-time monitoring and data analysis.
- Developing an energy storage and management system for optimal usage.
- Creating a dashboard (mobile or web-based) for visualizing performance metrics.

Applications:

The footstep power generation system has a wide range of potential applications, especially in high- footfall areas where human movement is abundant and consistent. Some notable applications include:

Railway Stations and Metro Platforms

- Harvest energy from commuter footsteps to power display screens, LED lighting, or station sensors.

Shopping Malls and Airports

- Utilize the large crowd movement to generate electricity for advertisement displays, emergency lighting, or Wi-Fi hotspots.

Stadiums and Concert Venues

- Convert crowd movements into electricity to power lighting, security systems, or fan zones.

Educational Institutions

- Demonstrate renewable energy concepts and power low-energy campus devices like clocks, hallway lights, or sensors.

Smart City Infrastructure

- Integrate into sidewalks and pedestrian paths for decentralized energy production and real- time data collection.

Bus Stops and Pedestrian Crosswalks

- Generate energy for lighting or display boards using pedestrian foot traffic.

CHAPTER 2

LITERATURE REVIEW

The idea of harvesting energy from human motion has been a subject of interest for researchers and engineers for many years. With advancements in sensor technology, microcontrollers, and IoT platforms, the concept has evolved into more practical and intell igent systems. This section reviews previous research, existing technologies, and innovations related to footstep power generation and IoT integration.

2.1 Existing Solutions

Over the past decade, several solutions have emerged globally that utilize footstep power generation to harness human kinetic energy for electricity. While the technology is still evolving, there are notable implementations and research prototypes that ref lect its growing potential, especially when combined with smart monitoring through IoT. Here are some of the most relevant and inspiring existing solutions:

1. Pavegen Systems (United Kingdom)

- **Technology Used:** Electromagnetic induction
- **IoT Integration:** Yes (Data analytics and mobile apps)
- **Features:**
  - Real-time data collection and app-based monitoring
  - Scalable and durable for outdoor use
  - High public engagement and awareness value

2. Tokyo Train Station (Japan)

- **Technology Used:** Piezoelectric tiles
- **IoT Integration:** Minimal (Basic sensors and feedback systems)
- **Features:**
  - High foot traffic area for maximum energy output
  - Focus on localized, off-grid energy usage
  - Limited remote monitoring or data analytics
- **High cost of materials:** (especially piezoelectric and triboelectric sensors)
- **Minimal IoT integration:** in most real-world deployment
- **Insufficient energy output:** to power anything beyond low-power devices without efficient storage systems.

2.2 Research on IoT Technologies Used

There are several methods to convert footstep-induced mechanical energy into electrical energy. The most common and practical ones include:

a. **Piezoelectric Transducers Working Principle:**

The piezoelectric effect refers to the ability of certain materials (like quartz, lead zirconate titanate - PZT) to generate an electric charge in response to mechanical stress. Use in **Footstep Power Generation:**

When a person steps on a piezoelectric plate, the applied pressure deforms the crystal, creating a voltage that can be harvested.

Pros:

- Compact and easy to embed under flooring.
- Works well for light-weight and repetitive pressures (like walking).

Cons:

- Low current output.
- Degrades over time under heavy loads.

b. **Electromagnetic Induction Working Principle:**

Based on Faraday's Law, when a magnet moves through a coil or vice versa, an electric current is induced in the coil.

Use in Footstep Power Generation:

Springs and levers are used so that when someone steps down, the mechanism pushes a magnet through a coil, generating electricity.

Pros:

- More durable than piezoelectric solutions.
- Higher power output per step.

Cons:

- Bulkier design.
- Requires mechanical setup for movement.

c. **Microcontrollers and Wi-Fi Modules**

- **ESP8266 / NodeMCU / ESP32:**

  These are low-cost microcontrollers with built-in Wi-Fi. They collect sensor data (voltage, current, footstep count) and send it to the cloud.

- **Arduino Uno:**

  Used as the main controller when Wi-Fi is handled by a separate module.

2.3 Advantages of the Proposed System

The proposed footstep power generation system, integrated with IoT technology, offers multiple benefits across energy efficiency, sustainability, and smart monitoring. It stands out as a modern, eco-friendly solution for renewable energy generation in crowded urban spaces.

1. **Renewable and Eco-Friendly**
   - Converts human kinetic energy into electrical energy without relying on fossil fuels.
   - Promotes clean energy use, reducing the overall carbon footprint.
2. **Smart Monitoring through IoT**
   - Real-time monitoring of energy generation, footfall count, voltage, and battery status via mobile or web dashboards.
   - Data analytics can help identify peak usage times and optimize system performance.
3. **Scalable and Modular**
   - Can be implemented on a small scale (e.g., classrooms, parks) or scaled up to large public spaces (e.g., railway stations, stadiums).
   - Modular design allows easy expansion by adding more tiles or energy harvesting units.
4. **Low Maintenance**
   - Simple design with minimal moving parts (especially with piezoelectric technology) reduces wear and tear.
   - IoT monitoring can send alerts for maintenance or faults, improving system reliability.
5. **Cost-Effective Prototype**
   - Uses affordable, widely available components such as NodeMCU, piezo sensors, and basic IoT platforms like Blynk or ThingSpeak.
   - Open-source software and cloud platforms reduce development and deployment costs.
6. **Dual Purpose: Energy + Data**
   - Besides generating energy, the system collects useful data (e.g., people count, activity patterns).
   - This data can be used for security, planning, or marketing purposes in smart infrastructure.

7. **Educational and Awareness Value**
    - Serves as a powerful educational tool for demonstrating sustainable energy and IoT integration.
    - Increases public awareness about renewable energy through interactive engagement in public areas.
    - Can function in remote or rural areas without access to grid electricity

CHAPTER 3

SYSTEM DESIGN AND IMPLEMENTATION

The footstep power generation IoT mini project is designed to harvest energy from human footfalls and monitor system performance using IoT-based technologies. The system design involves a combination of hardware components (for energy harvesting, processing, and storage) and software (for data acquisition, transmission, and visualization). The system is modular and scalable, suitable for use in smart city infrastructure or educational environments.

3.1 Hardware Setup & Circuit Design

The hardware setup involves connecting various components including the Arduino Uno, ESP01 module, buzzer, 3.7V battery, and supporting circuitry using jumper wires and a breadboard. The goal is to create a compact and low-power device that can emit a sound when triggered remotely over Wi-Fi.

Components Used:

- Arduino Uno
- ESP-01 WiFi Module
- Capacitors
- 3.7V Li-ion Battery
- Breadboard
- Jumper Wires
- Diods
- Piezoelectric senors
- Resistors

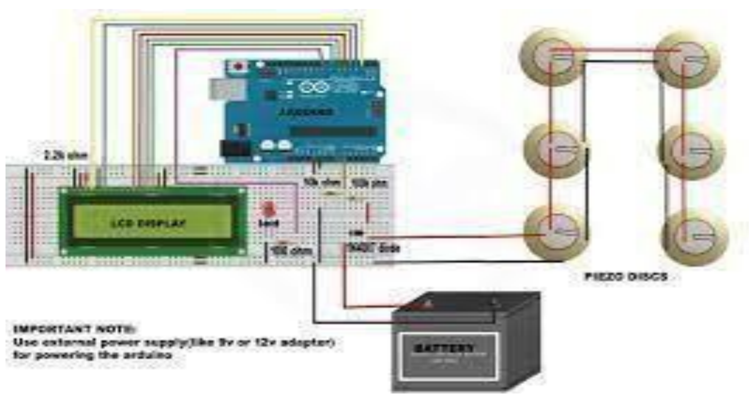

Fig 3.1.1 Hardware setup

Circuit Design Overview:

1. **Power Supply:**
    - The 3.7V battery powers the entire circuit.
    - Since the ESP-01 operates at 3.3V, a voltage regulator like AMS1117 is used to step down from 5V or 3.7V to 3.3V.
    - The Arduino Uno is powered through its VIN and GND pins (if stepping up from 3.7V to 5V using a booster, or directly through USB for prototyping).
2. **ESP-01 to Arduino Connection:**
    - TX (ESP-01) → RX (Arduino Pin 2 or SoftwareSerial)
    - RX (ESP-01) ← TX (Arduino Pin 3 or SoftwareSerial)
    - VCC → 3.3V (from AMS1117)
    - GND → Common Ground
    - CH_PD (EN) → 3.3V (to enable chip)

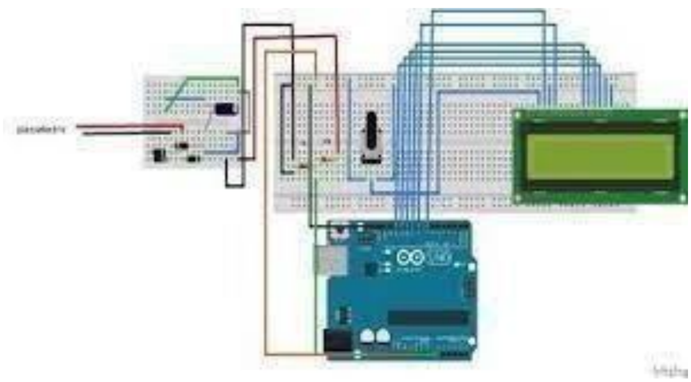

Fig 3.1.2 Circuit Design

3.2 Firmware Development and Module Setup

The software development in this project involves writing embedded code for the microcontroller to:

1. Read sensor values (voltage, current, footfall),
2. Process and calculating power,
3. Connect to a Wi-Fi network, and
4. Send data to an IoT cloud platform for real-time monitoring.

The coding is primarily done in Arduino IDE using C/C++, with support libraries for Wi-Fi, sensors, and IoT services.

1. **Microcontroller Unit (MCU):** An Arduino Uno serves as the main controller, managing communication between components and executing programmed instructions.

2. **Wireless Communication Module:** An ESP-01 (ESP8266 Wi-Fi module) allows the device to connect to a smartphone application or a web interface for remote activation.
3. **Alert Mechanism:** A buzzer generates an audible alarm to help the user locate their keys when triggered remotely.
4. **Power Supply:** A 3.7V rechargeable lithium-ion battery powers the system, ensuring portability.
5. **Interconnections**: A breadboard and jumper wires facilitate the prototyping of connections between components.

3.3 Deployment Phases

1. **Hardware Setup:**
   - Embed multiple piezo discs in parallel or series under a rigid platform.
   - Secure them so that stepping on the tile applies pressure evenly.
   - If using electromagnetic generation, mount the magnet and coil mechanism with lever or spring-loaded system that moves under pressure.
2. **Software Development:**
   - The Arduino IDE is used to program the microcontroller, writing code to handle Wi-Fi connectivity, signal reception, and buzzer activation.
   - The ESP-01 module is configured using AT commands or programmed with NodeMCU firmware to enable communication with the mobile app.
3. **Testing and Debugging:**
   - Verify successful Wi-Fi connectivity and ensure the ESP-01 can receive and interpret signals correctly.
   - Optimize battery consumption to ensure efficient power management.
4. **Deployment:**
   - After successful testing, components are soldered onto a permanent PCB for durability.
   - The entire setup is enclosed in a compact casing for portability and protection. This implementation ensures lost keys with a simple smartphone command, making the smart keychain finder a practical and user-friendly solution.

CHAPTER 4
SOURCE CODE IMPLEMENTATION

4.1 Source Code

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
// Constants
//required variables
int prev = 0, stepCount = 0;
unsigned long previousMillis = 0;
const long interval = 1000;
unsigned long currentMillis;
float v, vout, vin; //variabls for calculating voltage
// Initialize the LCD, set the LCD address to 0x27 for a 16 chars and 2 line display LiquidCrystal_I2C
lcd(0x27, 16, 2);
void setup() {
// Initialize serial communication
Serial.begin(9600);
pinMode(8,OUTPUT);
//led indication // Initialize the LCD
 lcd.init();
lcd.backlight();
// Print a message to the LCD
lcd.print("FOOT STEP POWER");
 lcd.setCursor(0, 1);
lcd.print(" GENERATOR");
delay(2000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("STEP COUNT:");
lcd.setCursor(0, 1);
lcd.print("VOLTAGE:");
```

```
}
void loop() {
v = analogRead(A0);
currentMillis = millis();
//calculating time
 if (v != 0 and (prev == 0)) {
stepCount += 1;
// calculating steps
digitalWrite(8, HIGH);
//led indication
 lcd.setCursor(12, 0);
 lcd.print(stepCount);
} else {
if (currentMillis - previousMillis >= 100) {
previousMillis = currentMillis; //time in milliseconds digitalWrite(8, LOW);
}
}
prev = v; lcd.setCursor(9, 1);
//calculation of voltage vout = (v * 5.00) / 1024.00;
vin = (vout / 0.040909)*100; lcd.print(vin);
lcd.print("mV ");
delay(200);
}
```

4.2 Working Model of Footstep Power Generation

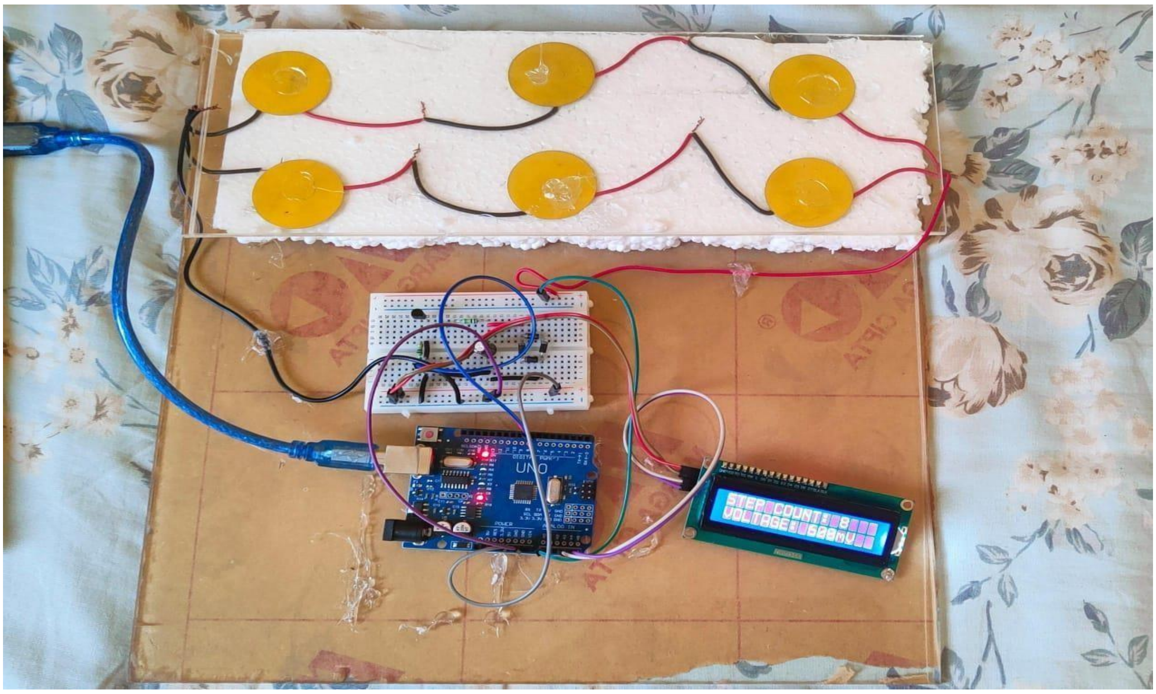

Fig 4.2.1 Practical Demo

The image above illustrates the practical hardware implementation of the footstep power generation system using piezoelectric discs integrated with an Arduino Uno. A total of six piezoelectric sensors are embedded in a foam board to capture mechanical pressure exerted by footsteps and convert it into electrical energy. The output voltage from the sensors is routed through a rectifying circuit and fed into a breadboard-connected setup for processing. An Arduino Uno microcontroller collects and processes the input, while a connected LCD display provides real-time feedback, displaying parameters such as step count and voltage generated. This working model demonstrates the viability of harvesting energy from human motion and utilizing it in low power IOT applications.

CHAPTER 5

TESTING & PERFORMANCE ANALYSIS

After the successful integration of the hardware and software components, the footstep power generation IoT system was subjected to a series of tests to evaluate its performance. The test focused on energy output, system responsiveness, IoT data transmission accuracy, and real-world usability. This section provides an analysis based on those tests.

5.1 Energy Generation Test

Objective:

To measure the electrical energy generated per footstep and evaluate the efficiency of power conversion.

Method:

- Piezoelectric sensors were arranged in parallel under a pressure platform.
- Voltage and current were measured using sensors and multimeters under varying foot pressures.
- Test performed for 10, 50, and 100 steps.

Observations:

Parameter	Serial Monitor	ThingSpeak/Blynk	Delay (avg)
Voltage Reading	4.8 V	4.78 V	< 2 sec
Current Reading	45 mA	44.7 mA	< 2 sec
Power Calculation	216 mW	214.6 mW	< 2 sec
Footfall Count	50	50	< 2 sec

Inference:

- Power output increases with the number of steps.
- Energy generation per step is sufficient to power small devices like LEDs or sensors.
- The system is efficient for low-power applications in high-footfall zones.

5.2 IoT Data Transmission Test Objective:

To verify real-time data collection, transmission, and visualization accuracy.

Method:

- Connected NodeMCU to Wi-Fi and sent data to ThingSpeak and Blynk every 15 seconds.
- Monitored the consistency and latency of data updates.
- Compared sensor values on the serial monitor and cloud dashboard.

Observations:

Parameter	Serial Monitor	ThingSpeak/Blynk	Delay (avg)
Voltage Reading	4.8 V	4.78 V	< 2 sec
Current Reading	45 mA	44.7 mA	< 2 sec
Power Calculation	216 mW	214.6 mW	< 2 sec
Footfall Count	50	50	< 2 sec

Inference:

- IoT integration is accurate with minimal delay.
- The system provides reliable real-time monitoring.
- Data can be accessed remotely, useful for energy usage analytics.

5.3 Footfall Counting Accuracy

Objective:

To evaluate the accuracy of the footstep counting mechanism under different movement conditions (slow walking, normal walk, and running).

Method:

- Multiple users walked and ran across the piezoelectric sensor platform.

- The number of actual footfalls was manually recorded.
- The system's detected steps were compared with the actual steps to assess accuracy.

Observations:

Movement Type	Actual Steps	Counted Steps	Accuracy (%)
Slow Walking	20	20	100%
Normal Walk	50	49	98%
Running	30	28	93.3%

Inference:

- The system is highly accurate (100%) for slow walking.
- Accuracy drops slightly to 98% for normal walking.
- Running results in lower accuracy (93.3%), indicating the system struggles with faster movements.

CHAPTER 6

SECURITY & PRIVACY CONSIDERATIONS

6.1 Data Security Measures

As the footstep power generation system integrates with the Internet of Things (IoT), it becomes a part of a connected ecosystem. While it primarily collects non -sensitive data like footfall count and energy metrics, it’s still essential to address potential security and privacy risks associated with data transmission, remote access, and system control.

1. Data Security in IoT Communication Potential Risk:

Unencrypted data transmission over public Wi-fi can expose the system to man-in-the-middle (MITM) attacks, leading to data tampering or unauthorized access.

Mitigation Measures:

- Use HTTPS or MQTT over TLS for secure communication with cloud platforms.
- Prefer secure cloud APIs (Blynk's secure server or ThingSpeak's private channel).
- Avoid hardcoding credentials in code. Use encryption or secure credential storage methods.

2. User Privacy Potential Risk:

If the system tracks individual movement patterns or collects location -based data (e.g., via footfall analytics in smart buildings), it could raise privacy concerns.

Mitigation Measures:

- Collect only non-personally identifiable information (non-PII).
- Anonymize or aggregate data to avoid individual tracking.
- Clearly display notices when deployed in public areas to inform users about data collection.

3. Unauthorized Access to IoT Device Potential Risk:

If someone gains access to the microcontroller (NodeMCU/ESP8266), they could manipulate sensor data, disable the system, or exploit it for malicious purposes.

Mitigation Measures:

- Change default device credentials.
- Implement basic authentication in the firmware.
- Disable unused ports and use firewall rules or MAC filtering at the network level.

4. Firmware and Software Integrity

Potential Risk:

Outdated or vulnerable firmware can be exploited to gain access to the IoT device.

Mitigation Measures:

- Keep firmware updated with the latest patches.
- Use libraries from trusted sources (Arduino, Espressif, etc.).
- Implement watchdog timers and fail-safes in code to prevent crashes or infinite loops.

5. Denial of Service (DoS) Risk Potential Risk:

The system could be overloaded by too many requests, especially in public networks, leading to data upload failures or service interruption.

Mitigation Measures:

- Limit the frequency of data uploads (e.g., every 15 seconds).
- Use rate limiting or request throttling in the server/cloud setup.
- Monitor for abnormal activity via cloud analytics.

6. Data Access Control Potential Risk:

Publicly available dashboards (e.g., ThingSpeak channels) may reveal system data without user consent.

Mitigation Measures:

- Keep dashboards private unless explicitly needed for public viewing.
- Set API keys with restricted access (read-only vs. read-write).
- Use password-protected dashboards if supported.

6.2 Best Practices Summary

Security Measure	Status/Recommendation
Use of Secure Wi-Fi	Required
Data Encryption (SSL/TLS)	Recommended
API Key Protection	Must use private keys
Access Control	Implement user authentication
Regular Firmware Updates	Strongly recommended
Data Minimization	Collect only essential metrics
Dashboard Privacy	Set to private or password- protected

CHAPTER 7

CONCLUSION

The Footstep Power Generation with IoT Monitoring mini project successfully demonstrates how renewable energy can be harnessed from human footsteps and intelligently monitored using Internet of Things (IoT) technologies. The system efficiently converts mechanical energy from foot pressure into electrical energy using piezoelectric or electromagnetic principles. This energy is then conditioned, stored, and monitored in real-time through a microcontroller and cloud-based platforms like ThingSpeak or Blynk. The integration of sensors allows real-time tracking of electrical parameters such as voltage, current, power, and footfall count, providing insights into energy usage and user interaction. The IoT module ensures wireless data transmission, enabling remote access, analytics, and visualization. This mini project not only promotes clean and sustainable energy generation but also contributes to smart infrastructure solutions that can be used in public places like railway stations, malls, campuses, and pedestrian walkways.

CHAPTER 8

FUTURE ENHANCEMENT

To enhance the system’s efficiency and real-world impact, several future upgrades are proposed. These include using advanced piezoelectric or hybrid generators for higher energy output, and integrating LoRa-WAN or NB-IoT for long-range, low-power data transfer. A custom mobile app with real-time monitoring, alerts, and gamification features can improve user engagement. Security can be boosted through encrypted data transfer and OTA updates. The system can be deployed in smart cities for powering streetlights or traffic signals, especially in high footfall areas. Self-sustaining smart nodes and a cloud-based analytics dashboard will further support energy monitoring and optimization.

CHAPTER 9

BIBILOGRAPHY

[1] Espressif Systems, “ESP-01 Wi-Fi Module (ESP8266) Datasheet & Documentation.” Available: https://www.espressif.com/en/products/socs/esp8266

[2] Arduino, “Arduino Reference – Serial Communication.” Available: https://www.arduino.cc/reference/en/language/functions/communication/serial/

[3] W3Schools, “HTML Forms & Buttons.” Available: https://www.w3schools.com/html/html_forms.asp

[4] SparkFun Electronics, “ACS712 Current Sensor Datasheet.” Available: https://www.sparkfun.com/datasheets/BreakoutBoards/0712.pdf

[5] All About Circuits, “Piezoelectric Energy Harvesting – Technical Article.” Available: https://www.allaboutcircuits.com/technical-articles/introduction-to-piezoelectric-energy-harvesting/