A PROJECT REPORT
on

” Advanced footstep power generation system using RFID for charging”

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SAVITRIBAI PHULE PUNE UNIVERISTY

In Partial Fulfillment of the Requirement for the Award of

BACHELOR’S DEGREE IN INSTRUMENTATION & CONTROL ENGINEERING

by

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DEPARTMENT OF INSTRUMENTATION & CONTROL

D.Y. PATIL COLLEGE OF ENGINEERING AKURDI, PUNE - 411044
2024 - 2025

Affiliated to
SAVITRIBAI PHULE PUNE UNIVERISTY

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CERTIFICATE

This is to certify that the project entitled "Advanced footstep power generation system using RFID for charging"
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is a record of bonafide work carried out by them, in the partial fulfillment of the requirement for the award of **Degree of Bachelor** in instrumentation and control during year 2024 – 2025, under the guidance of.

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ABSTRACT

Power utilization turns out to be necessary for every work in today's world. To ease our daily routines the devices are used in large numbers. An advanced footstep power generation system proposed here uses the piezoelectric sensors. To generate a voltage from footsteps, the piezoelectric sensors are mounted below the platform. To generate maximum output voltage the sensors are placed in series arrangement. The circuit is the microcontroller-based monitoring circuit that allows users to monitor the charges and voltage of a battery connected to it and this power source has many applications like mobile charging or to charge e vehicles.

It consists of a USB mobile phone charging point where a user can connect a cable to charge the mobile from the charge stored in the battery. The current is distributed using RFID (radio-frequency identification) cards so that only an authorized person can use the generator for charging. Thus, we charge a battery using power from footsteps, display it on LCD using a microcontroller circuit and allow mobile charging through the setup. Our project model is cost effective and easy to implement and also it is green and not hurtful to the environment.

Contents

1. INTRODUCTION

The demand for electricity is increasing day by day and its use has become so advanced and applicable in the present lifeline of a human being. The arising value of the latest technology every day demands more power from electricity because the population of citizens is increasing day by day and hence the energy demand is increasing linearly. This technology is simply based on a principle called the piezoelectric effect, in which certain materials have the ability to build up an electric charge from having pressure applied to them. Now, piezoelectricity is generally referred to as having the ability of some materials to generate voltage in response to the pressure applied on them. So, the piezoelectric material can convert the exerted pressure into electric current. The piezoelectricity is known because of the linear interaction between the mechanical and therefore the electrical state in crystalline materials with no inversion symmetry. The system generates voltage using footstep pressure. The system serves as a medium to generate electricity using non conventional sources i.e., force and store it. The project is meant to be useful at public places like railway stations where tons of individuals keep walking through all day. At such places these systems are to be placed at any entry points where people travel through entrances or exits and that they need to tread on this device to urge through. These devices may then generate a voltage on every footstep and when mounted in series, they're going to produce a large Advanced Footstep Power Generation System using RFID for Charging

1.1 BACKGROUND:

The "Advanced Footstep Power Generation System using RFID for Charging" is an innovative approach aimed at addressing the growing demand for electrical energy by utilizing non-conventional energy sources, specifically the mechanical energy from human footsteps. The core idea is to harvest energy generated from foot pressure using piezoelectric materials—materials that produce an electric charge when subjected to mechanical stress. This energy is stored in a battery and later used for practical applications like mobile charging.

As the global energy demand escalates, traditional power generation methods struggle to keep up, especially in rural or underdeveloped regions where grid electricity is unreliable or absent. Hence, there’s a need for alternative energy solutions that are sustainable, eco-friendly, and accessible. This project provides one such solution by converting mechanical energy, an abundant and often wasted resource, into electrical energy.

The technology leverages the piezoelectric effect—a phenomenon discovered by Pierre and Paul-Jacques Curie in 1880—where specific crystals generate voltage upon application of pressure. The system is designed to generate electricity at places with high human foot traffic, such as railway stations, airports, shopping malls, and walkways. By installing piezoelectric tiles at such locations, the energy from each footstep can be harnessed effectively.

An additional innovation in this project is the integration of RFID (Radio Frequency Identification) technology. The RFID system ensures controlled and authorized usage of the generated power. Users with registered RFID cards can access the stored energy for charging purposes, ensuring fair usage and preventing misuse.

The generated voltage from the footstep energy is processed using a microcontroller (ATmega328P) that manages the system, displays the voltage and system status on an LCD screen, and controls the charging mechanism. This solution is not only cost-effective but also green and environmentally safe, as it relies purely on human activity without the need for external fuels.

Thus, the project aims to create a self-sustaining energy system for small-scale applications, providing an eco-friendly alternative to traditional power sources and promoting energy conservation and environmental awareness.

1.2 Motivation:

The motivation behind developing the Advanced Footstep Power Generation System using RFID for Charging stems from the growing global energy demands, the limited availability of conventional power sources, and the urgent need for sustainable energy solutions. In today's world, electricity is indispensable—every aspect of human life, from basic amenities to advanced technologies, relies on a continuous power supply. However, traditional methods of power generation, such as fossil fuels, contribute significantly to environmental degradation, greenhouse gas emissions, and climate change. Furthermore, with the ever-increasing population and technological advancements, the demand for energy is outpacing the available supply, leading to energy crises, particularly in developing regions and rural areas where access to the electrical grid is often limited or absent.

The core motivation of this project is to tap into the underutilized, renewable, and sustainable energy available from human movement—specifically, footsteps. Every day, millions of people move across spaces like railway stations, airports, malls, and public pathways, generating mechanical energy that is typically wasted. The idea is to capture this mechanical energy using piezoelectric sensors embedded in walkways and convert it into usable electrical energy. By harvesting energy from footsteps, the system presents a unique, eco-friendly, and innovative solution to contribute to the energy grid or provide localized power for essential applications like mobile charging stations, LED lighting, or small electronic devices.

In addition to energy generation, the system integrates RFID-based authorization to ensure controlled and secure usage of the generated power. This feature ensures that only authorized users can access the charging functionality, promoting fair distribution and responsible utilization of the limited energy resources.

The motivation also lies in making such systems cost-effective, easy to implement, and environmentally safe. The project encourages a shift towards green energy practices, reduces dependency on non-renewable energy sources, and inspires further innovation in the field of energy harvesting.

2. LITERATURE SURVEY

Research / work done in the past

The growing need for sustainable and renewable energy has led researchers to investigate innovative methods of energy harvesting. One promising technique is the conversion of mechanical energy from footsteps into electrical energy. This approach is particularly useful in crowded areas where thousands of people walk daily. The energy generated through footstep pressure can be stored and used for low-power applications such as mobile charging, LED lighting, and small electronic devices. Various energy harvesting techniques have been studied, including piezoelectric, electromagnetic, and triboelectric methods. Among these, piezoelectric materials are most commonly used in footstep power generation systems. These materials produce electrical voltage when subjected to mechanical stress, such as the pressure of a footstep. Their compact size, reliability, and ability to generate electricity without external power make them ideal for such applications. Several, researchers have developed systems that use footpaths and tiles embedded with piezoelectric sensors. These sensors generate power as people walk over them. For instance, a study conducted by Kiran et al. (2018) showed that placing piezoelectric plates beneath a wooden tile could generate enough energy to power street lights and charge mobile phones when combined with a battery and voltage regulation system.

The electrical energy generated from footsteps is typically stored in rechargeable batteries or supercapacitors. To ensure safe charging, a voltage regulation module is used to maintain a steady output suitable for mobile devices. Arduino or other microcontroller-based systems are often integrated to monitor voltage levels, power output, and charging status. These systems help optimize performance and add smart features to the energy harvesting unit. Advanced footstep power generation systems are also being integrated with mobile charging ports. Some models include RFID or smart card modules, allowing only authorized users to access the charging feature. Additional features like LCD screens can display information such as battery levels, energy generated, or number of users. This adds convenience and enhances the system's functionality. Real-world applications of footstep power generation have been seen in public places like railway stations, airports, shopping malls, and educational institutions. These systems offer an eco-friendly and innovative way to harness energy while promoting awareness of renewable energy sources among the public. They not only provide practical benefits but also help encourage the use of clean technology in daily life. Despite the benefits, this technology still faces some challenges. The amount of energy generated depends heavily on foot traffic, and the overall efficiency is relatively low. The high cost of piezoelectric materials also limits large-scale implementation. As a solution, researchers are working on hybrid systems that combine piezoelectric and electromagnetic generators to improve power output and reduce costs.

AIM AND OBJECTIVES

AIM:

The primary aim of the project is to develop an advanced footstep power generation system that harnesses mechanical energy generated from human footsteps using piezoelectric sensors and converts it into electrical energy for practical use. The system further integrates RFID technology to control access and ensure secure usage for charging purposes, making the solution cost-effective, user-friendly, and eco-friendly.

The goal is to provide an alternative power source, especially for public areas with high foot traffic, such as railway stations, bus stands, airports, and shopping malls, where the energy generated from footsteps can be stored and utilized for applications like mobile charging or small-scale energy needs.

"Advanced Footsteps Power Generation Using RFID for Charging," is to design and develop an innovative, eco-friendly energy harvesting system that utilizes the mechanical energy generated by human footsteps to produce electrical energy. This energy is then stored and made available for charging electronic devices, particularly through RFID-based user authentication. The primary objective is to harness renewable energy from foot traffic in public or high-density areas such as railway stations, malls, airports, and educational institutions, where a large number of people walk regularly. By converting the kinetic energy of footsteps into electrical energy using piezoelectric sensors or pressure transducers, the system promotes the use of clean and sustainable energy sources.

In addition to power generation, the integration of RFID (Radio Frequency Identification) technology introduces a smart access and monitoring mechanism. Each user is provided with a unique RFID tag, which, when scanned, allows the system to authenticate the user and enable controlled access to the stored energy for charging portable electronic devices like mobile phones, power banks, or emergency lights. This smart feature helps in tracking energy usage per user, ensuring efficient distribution of the harvested energy, and avoiding unauthorized access. Furthermore, the system includes real-time energy storage monitoring and display, making it user-friendly and interactive.

The ultimate goal of this project is to demonstrate a self-sustaining, intelligent energy harvesting solution that not only addresses the growing demand for alternative energy sources but also integrates modern identification and access control systems for practical utility. It combines principles of mechanical-to-electrical energy conversion, embedded systems, and RFID technology, making it an ideal project for educational, commercial, and environmental applications.

Objectives:

1. Harness Human Footsteps for Energy:
Design a system to convert mechanical pressure from footsteps into electrical energy using piezoelectric sensors.
Arrange sensors in a way (series/parallel) to maximize the output voltage and current.

2. Energy Storage and Monitoring:
Store the generated energy in a rechargeable battery for later use.
Monitor the battery's charge and voltage status using a microcontroller-based system.

3. Controlled Access through RFID Integration:
Incorporate an RFID module for secure charging access, ensuring that only authorized users (with RFID cards) can utilize the stored energy for charging their devices.
Enable RFID-based user authentication and balance management system.

4. User Interface Design:
Use an LCD to provide visual feedback to users, such as system status, voltage levels, or instructions.

5. Efficient Power Utilization:
Design the system to power small-scale applications like mobile charging, with USB ports connected to the stored energy source.

6. Sustainability and Green Energy Focus:
Ensure the system is eco-friendly, cost-effective, and promotes the use of renewable energy sources without relying on conventional fuels.

7. Future Scalability:
Explore possibilities of scaling the system for larger implementations in public spaces such as airports, bus stations, shopping malls, etc.

Purpose system:

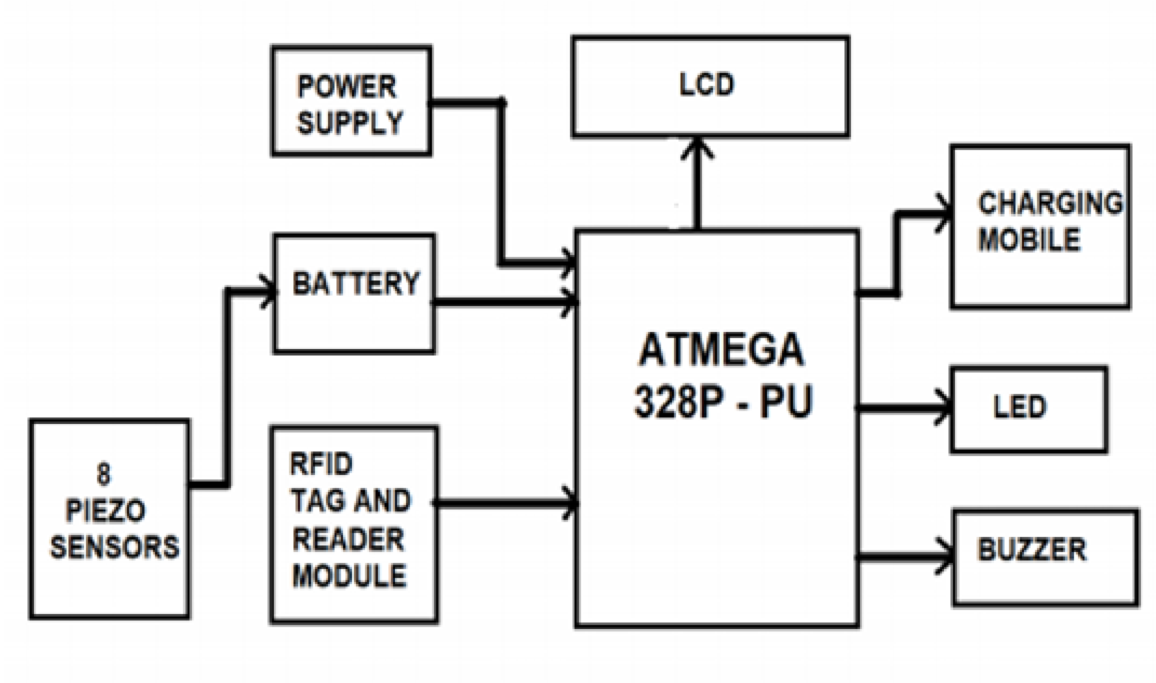

Fig no. 1

•Piezoelectric Sensors: We have used 8 piezoelectric sensors in series combination that generate the voltage corresponding to the pressure applied on it.

•Battery: The voltage generated by the piezoelectric sensors is then used to store the charge in the battery.

•Power Supply: It is used as the power input for the ATmega328P-PU.

•RFID tags: Tags are used for storing the user information. These tags transmit this information to the RFID reader using Radio Waves.

•RFID Reader (Module): The signal coming from the tag through the antenna of the RFID reader is fed to the demodulator and decoder (present in the reader) to obtain the data. This data is then further processed by the Microcontroller.

•LCD: LCD is used to display the instructions to be followed by the user i.e., put your card to the reader, connect the charger, put your card to recharge. It also displays the status of mobile charging.

•ATmega328P-PU: According to the inputs to the ATmega i.e., the RFID and battery, the message is displayed on the LCD and controls the mobile charging.

•LED: These are used to indicate if the pressure is applied to the sensor or not. One LED is used to indicate mobile charging.

•BUZZER: It is used to indicate the communication between RFID tag and Reader

This block diagram represents the working of the Advanced Footsteps Power Generation System using RFID for Charging, which is controlled by the ATmega328P-PU microcontroller. The system begins with 8 piezoelectric sensors that are embedded in the floor or walkway to capture mechanical energy from human footsteps. This kinetic energy is converted into electrical energy and is used to charge a battery via a power supply module, which conditions the voltage to appropriate levels. The stored energy can later be used for powering other modules in the system. An RFID tag and reader module is also integrated with the microcontroller to authenticate users. When a registered RFID tag is scanned, the microcontroller allows access to the charging function or triggers specific outputs.

The ATmega328P-PU acts as the central processing unit of the system. It receives input from the RFID reader and manages the outputs accordingly. Once a user is authenticated, the microcontroller enables mobile charging by releasing the stored power through a designated port. The system also includes LED indicators and a buzzer, which provide visual and audio feedback during operations such as successful user authentication or power access. Additionally, an LCD display is connected to show relevant information like user ID, charging status, or available power. This setup not only generates green energy through footsteps but also intelligently manages its use using RFID authentication for secure and monitored access.

3. Circuit Diagram

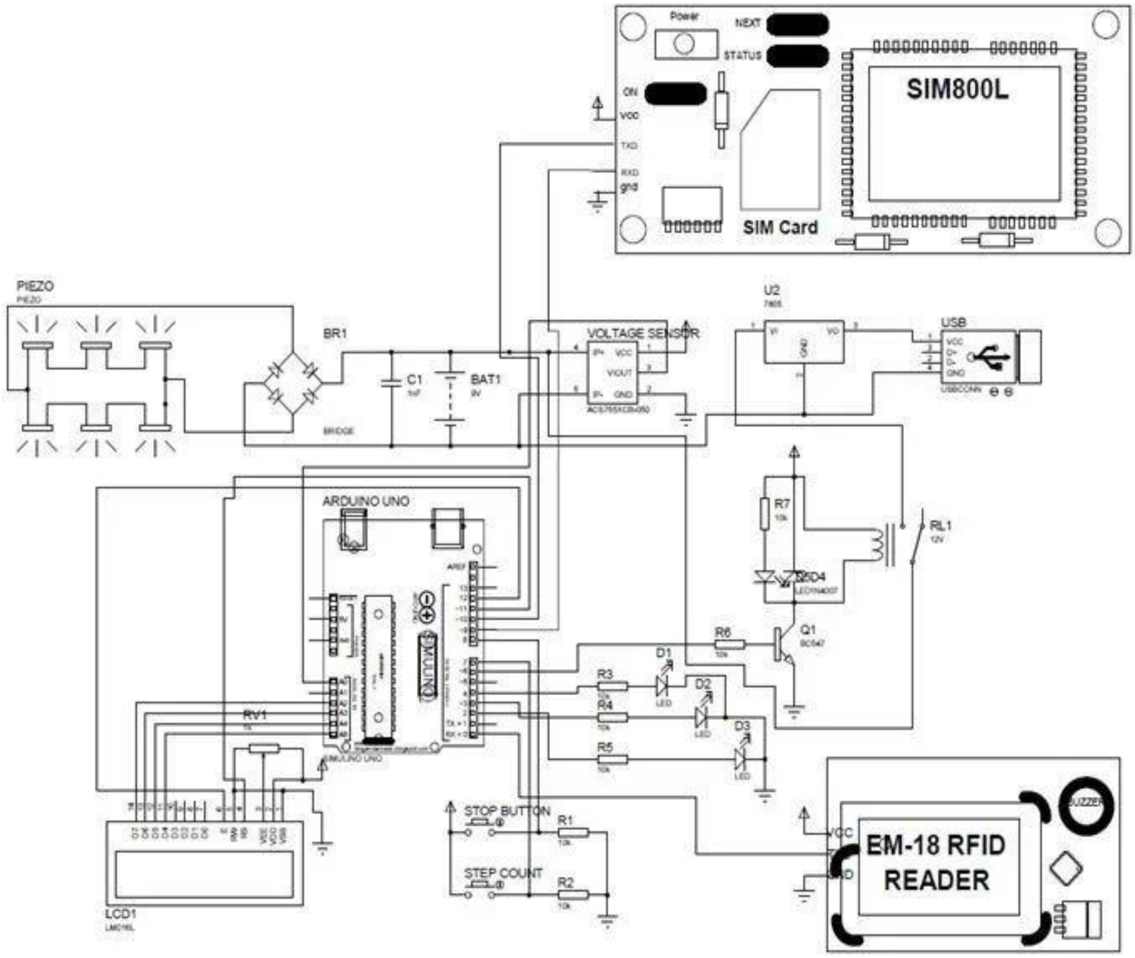

Fig no 2

This circuit diagram illustrates a sophisticated Arduino-based embedded system meticulously designed to handle access control, remote communication, and real-time monitoring through the integration of various hardware modules and components. At the heart of the system lies the Arduino UNO, a versatile and widely-used microcontroller board based on the ATmega328P, which functions as the central processing unit responsible for managing inputs, processing data, and controlling outputs based on the logic encoded into its firmware. The Arduino acts as the main controller that interfaces with all the peripheral devices and ensures the seamless operation of the system.

A critical component of the system is the EM-18 RFID Reader, a 125kHz module used for reading passive RFID tags. This reader plays a vital role in user identification and authentication. When an RFID tag is brought within range of the reader, it captures the unique identification number stored in the tag and transmits it to the Arduino through a serial interface. The microcontroller then compares this ID against a list of authorized users or pre-defined conditions stored in its memory. If the ID is recognized as valid, the Arduino executes specific actions such as activating a relay to unlock a door, sending a notification, or triggering a status indicator. If the ID is invalid, it may deny access and initiate an alert through visual or audible means. This approach allows for contactless authentication, enhancing both security and convenience.

To enable remote communication and notification capabilities, the system incorporates the SIM800L GSM module, a compact and efficient GSM/GPRS module that connects to the Arduino via serial communication. This module allows the system to send and receive SMS messages or communicate over a mobile network. In an access control scenario, for instance, the Arduino can be programmed to send an SMS notification to an administrator whenever an RFID tag is scanned—whether the scan is successful or unauthorized. This feature is particularly useful for real-time monitoring of access events, ensuring that stakeholders are immediately informed of any activity. The SIM800L also provides potential for remote command execution, where authorized users can send SMS commands to control the system or retrieve status updates.

The power supply section of the circuit is robust and well-structured to support all the connected modules and ensure reliable performance. It includes a bridge rectifier (BR1), which converts AC voltage from an external power adapter into DC voltage suitable for electronic circuits. Following the rectifier is a voltage regulator (typically a 7805 or 7812 IC labeled U2), which stabilizes the output voltage to either 5V or 12V depending on the requirements of the connected devices. Many components such as the Arduino, RFID reader, and SIM800L operate at 5V, while other peripheral devices like relays might require 12V. To prevent data loss and maintain system functionality during power outages or fluctuations, a battery backup system is integrated, ensuring that the system continues to operate without interruption. This is especially critical in security and monitoring applications where downtime can result in vulnerabilities or data gaps.

The circuit diagram also includes a USB port, which serves multiple purposes. Primarily, it allows for serial communication between the Arduino and a computer, facilitating programming, debugging, and data logging. Additionally, it can be used as an alternative power input, enabling flexibility in deployment. During development and testing, the USB interface is particularly valuable for uploading code to the Arduino and observing serial output data in real-time via the Arduino IDE or other terminal software.

For manual interaction and control, the system includes push buttons labeled "STOP BUTTON" and "STEP COUNT". These buttons can be programmed to execute specific commands when pressed. For example, the STOP BUTTON could be used as an emergency override to halt all operations, while the STEP COUNT button might increment a counter displayed on an external interface or log steps in a sequential process. These buttons enhance the system's interactivity and allow users to intervene or interact with the process directly.

To provide audible feedback, a piezo buzzer is connected to the Arduino. This buzzer can be triggered to emit sounds for various events, such as successful RFID scans, unauthorized access attempts, or system alerts. Different tones or beep patterns can be programmed to represent different statuses, offering an intuitive and immediate way to understand system responses without needing to view a display.

The circuit also features LED indicators and relay-controlled outputs, which are managed through transistors. Since the Arduino's digital output pins can only supply a limited amount of current (typically 20–40mA), transistors are used as switching devices to drive higher-power components such as relays, motors, or high-brightness LEDs. These transistors act as intermediaries, allowing the Arduino to control devices that require more current than it can supply directly. In a real-world setup, these outputs could be used to activate a door lock, turn on lights, sound alarms, or control industrial equipment. The relays provide electrical isolation between the Arduino and high-voltage devices, ensuring safety and preventing damage.

This Arduino-based circuit diagram outlines a powerful and flexible embedded system designed for real-time access control and remote communication. By combining RFID-based user identification, GSM-based SMS alert capabilities, manual controls, visual and audible feedback, and robust power management, the system is well-suited for applications such as automated attendance systems, secure entry solutions, industrial process tracking, remote asset monitoring, and other IoT-based applications. Its modular design allows for easy customization and scalability, making it a reliable choice for developers, engineers, and system integrators looking to implement intelligent, connected embedded systems.

4.Components

Piezoelectric sensor:

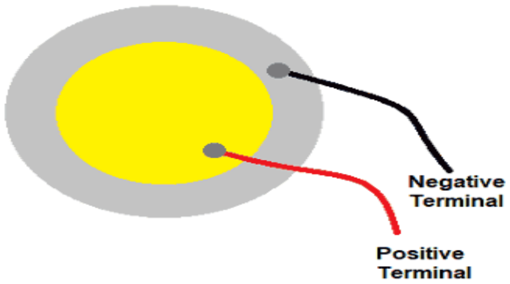

Fig no 3

Piezoelectric Sensors + Weighting Machine

These are placed beneath a platform where people step. When someone steps on it, pressure is exerted. The piezoelectric effect converts this mechanical pressure into electrical energy. A piezoelectric sensor is a special type of sensor that works based on the piezoelectric effect, which is the ability of certain materials to generate an electrical charge when they are subjected to mechanical stress. This means when pressure, force, vibration, or even a small deformation is applied to a piezoelectric material such as quartz, lead zirconate titanate (PZT), or certain types of ceramics and crystals, it produces a voltage that is proportional to the amount of force applied. This unique characteristic allows piezoelectric sensors to act as transducers, effectively converting mechanical energy into electrical signals that can be measured and analyzed. The piezoelectric effect was discovered in the 1880s by French physicists Jacques and Pierre Curie, and since then, it has been widely applied in many modern technologies. Piezoelectric sensors are known for their high sensitivity, fast response time, and ability to operate without the need for an external power source. Because of these advantages, they are used in a broad range of applications. For example, in the automotive industry, piezoelectric sensors are used in airbag systems to detect sudden impacts. In medical devices, they are used in ultrasound imaging to generate and receive sound waves. In consumer electronics, they are used in microphones, touch sensors, and even electronic drum pads. They are also commonly used in vibration and pressure monitoring systems in industrial environments to ensure machine health and safety.

One of the growing areas of interest for piezoelectric sensors is in the field of energy harvesting. These sensors can be integrated into systems where mechanical movements, such as footsteps or machine vibrations, are converted into electrical energy to power small devices. This is particularly useful in remote or wireless sensor systems where changing batteries frequently is not practical. In footstep power generation systems, piezoelectric sensors are placed beneath walking surfaces to capture the mechanical energy produced by people walking, which is then stored or used to power nearby devices like lights or displays.

Furthermore, piezoelectric sensors are extremely reliable and durable because they have no moving parts, making them less prone to wear and tear over time. They also perform well in harsh environmental conditions such as high temperatures or strong vibrations, which makes them ideal for use in aerospace, military, and heavy-duty industrial applications.

Buzzer:

Fig no 4

A buzzer is an audio signaling device, often used in electronic products like alarms, timers, and computers to produce a buzzing or beeping sound. It converts electrical signals into audible sounds, typically by rapidly moving a diaphragm or using a piezoelectric element. A buzzer is an electronic audio signaling device that produces sound when an electric signal is applied. It is widely used in embedded systems, electronic circuits, and various consumer and industrial applications to provide audible alerts, warnings, and notifications. Buzzers are simple to use, compact, and cost-effective, making them an essential component in systems where sound feedback is required. Buzzers operate by converting electrical energy into mechanical vibrations, which in turn produce sound. The most common types of buzzers are active and passive. An active buzzer has a built-in oscillator and generates sound as soon as a DC voltage is applied, making it easy to interface with microcontrollers using just a digital HIGH signal. In contrast, a passive buzzer requires an external frequency signal, typically a square wave generated by a microcontroller using PWM (Pulse Width Modulation), which makes it suitable for producing tones of varying frequency and melody.

The buzzer operates either on the piezoelectric principle or through electromechanical action. Piezo buzzers use a piezoelectric crystal that vibrates when voltage is applied, producing sound waves. Electromechanical buzzers, on the other hand, consist of a coil and a magnetic diaphragm; when current flows through the coil, the magnetic field moves the diaphragm back and forth, producing sound. Most buzzers operate at voltages between 3V to 12V and consume very little current, typically in the range of a few milliamps. Their sound output is usually around 70 to 90 decibels, and the frequency range is typically between 2 kHz to 4 kHz, which is easily audible to the human ear.

Buzzers are frequently used in alarm systems, timers, home appliances (like microwave ovens and washing machines), automotive electronics (seat belt reminder, key-in ignition alert), and embedded microcontroller-based systems such as Arduino or ATmega-based projects. When used with microcontrollers, a simple circuit involving a transistor may be used to drive the buzzer if higher current is required. Buzzers offer several advantages: they are easy to use, lightweight, durable, and require minimal interfacing. However, they are limited in the complexity of sound they can produce—especially active buzzers which are restricted to one tone. Despite this, their reliability and simplicity make buzzers a preferred choice in many electronic designs that require audio signaling.

ATmega328 microcontroller:

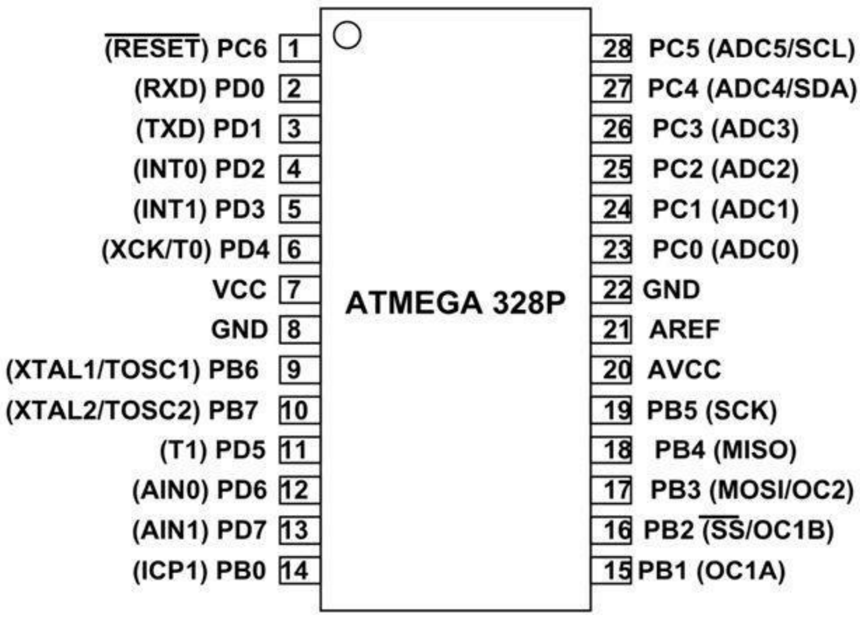

Fig no 5

The ATmega microcontroller is a widely used 8-bit microcontroller developed by Atmel, which is now a part of Microchip Technology. It is based on the efficient

AVR RISC architecture, allowing most instructions to execute in a single clock cycle. This architecture makes the ATmega both powerful and energy-efficient, which is why it is commonly used in embedded systems, robotics, consumer electronics, and educational tools.One of the most well-known models in this family is the ATmega328P, which powers the popular Arduino Uno development board. ATmega microcontrollers feature various built-in peripherals and memory types, including Flash memory (up to 256 KB), SRAM for temporary data storage, and EEPROM for non-volatile memory storage. They also provide multiple general-purpose I/O ports, timers/counters for precise timing and PWM generation, and a built-in analog-to-digital converter (ADC) for interfacing with analog sensors.For communication, ATmega microcontrollers support common serial protocols like USART, SPI, and I2C, making them versatile in connecting with other devices and sensors. They support both external and internal interrupts, making them responsive to real-time events. Operating voltages typically range from 1.8V to 5.5V, and various low power modes are available to optimize power consumption in battery-operated systems. Additionally, they can be easily programmed using In-System Programming (ISP) or through a bootloader, which simplifies firmware updates.

Due to their flexibility, low cost, and strong community support, ATmega microcontrollers are ideal for use in Arduino-based projects, embedded control systems, home automation, industrial electronics, and educational applications.

RFID module:

Fig no 6

An RFID (Radio-Frequency Identification) system uses radio waves to identify and track objects without line-of-sight. It consists of two main components: an RFID tag (or transponder) and an RFID reader. The tag contains a microchip that stores data and an antenna to transmit it, while the reader emits radio waves to activate the tag and receive the data. An RFID (Radio Frequency Identification) module is an electronic device used to identify and track objects wirelessly using radio waves. It plays a key role in automatic identification and data capture (AIDC) systems. The RFID system consists of three main components: an RFID tag (or transponder), an RFID reader (or interrogator), and an antenna. The RFID module generally refers to the reader unit, which communicates with RFID tags to read or write data.The RFID tags contain a microchip and an antenna. The microchip stores a unique identification number or other data related to the item it is attached to. When the tag comes into the electromagnetic field generated by the RFID reader’s antenna, it receives energy from the reader and transmits its stored information back to the reader. The reader then sends this data to a microcontroller or computer for further processing. There are two types of RFID tags: passive and active. Passive tags do not have a power source and rely on the reader’s energy to operate, whereas active tags have an internal battery and can transmit data over longer distances. RFID modules come in various frequency ranges – low frequency (LF), high frequency (HF), and ultra-high frequency (UHF). The most commonly used modules in small-scale projects or academic experiments operate at 13.56 MHz, which is part of the HF band. One popular example is the RC522 RFID module, which is widely used with Arduino and other microcontroller platforms. This module supports MIFARE RFID cards and uses the SPI (Serial Peripheral Interface) protocol for communication, allowing fast and secure data exchange. RFID technology is widely used in applications such as access control systems, contactless payments, inventory management, asset tracking, library systems, public transport ticketing, and attendance monitoring. The main advantages of RFID modules include fast scanning, non-contact operation, the ability to read multiple tags at once, and long service life. However, they also face challenges such as signal interference, privacy concerns, and high implementation costs in large-scale deployments. In modern embedded systems and IoT (Internet of Things) projects, RFID modules are increasingly integrated for smart automation and security purposes. Their ability to communicate wirelessly and uniquely identify objects makes them highly valuable in various industries, including healthcare, logistics, manufacturing, and retail.

Power Supply:

Operates from 1.8V to 5.5V, making it suitable for battery- operated devices. It has various power-saving modes to reduce power consumption.

LCD Display:

Fig no 7

A 16x2 LCD display, also known as a 16x2 character LCD (Liquid Crystal Display), is a common type of alphanumeric display used in various electronic devices and project.

- Size: The display has 16 columns and 2 rows, meaning it can display up to 16 characters per row.

- Technology: It uses liquid crystal technology to display characters by selectively blocking light.

- Interface: Typically, these displays are interfaced with microcontrollers or other
- control circuitry using parallel or serial communication protocols.

- Backlight: Many 16x2 LCDs come with an optional backlight for improved visibility in low-light

- Features:

- Readable Characters: Can display alphanumeric characters, symbols, and custom characters.

- Adjustable Contrast: Some displays allow adjusting the contrast of the characters for better visibility.

- Low Power Consumption: Consumes minimal power, making it suitable for battery-powered devices.

- Easy to Use: Relatively easy to interface with microcontrollers and program to display desired information.

Battery:

Fig no 8

A battery is an electrical storage device that converts chemical energy into electrical energy. It consists of one or more electrochemical cells that can supply power to various electrical and electronic systems. Batteries come in different sizes and capacities depending on their application. In our project, Advanced Footstep Power Generation System, we are using a rechargeable battery to store the electricity generated from human footsteps. As people walk over the specially designed platform, their foot pressure is converted into electrical energy, which is stored in the battery for later use. This stored power can be used to charge mobile devices, light up LEDs, or support small loads, making the system an effective solution for renewable and sustainable energy harvesting.

4. Program

```
#include <SPI.h>
#include <MFRC522.h>
#include <LiquidCrystal.h>

#define SS_PIN 10
#define RST_PIN 9
MFRC522 rfid(SS_PIN, RST_PIN);

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

#define RELAY_PIN 7
#define BUZZER_PIN 8
#define FOOTSTEP_PIN A0
#define BUTTON_PIN 6

byte allowedUID[4] = {0xDE, 0xAD, 0xBE, 0xEF};

bool isCharging = false;
unsigned long chargeStartTime = 0;
const unsigned long CHARGE_DURATION = 2 * 60 * 1000;

void setup() {
  Serial.begin(9600);
  SPI.begin();
  rfid.PCD_Init();

  pinMode(RELAY_PIN, OUTPUT);
  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(BUTTON_PIN, INPUT_PULLUP);
  digitalWrite(RELAY_PIN, LOW);
  digitalWrite(BUZZER_PIN, LOW);

  lcd.begin(16, 2);
  lcd.setCursor(0, 0);
  lcd.print("Footstep Power");
  lcd.setCursor(0, 1);
  lcd.print("Generation");
  delay(2000);
  lcd.clear();
```

```
}


void loop() {
  if (!isCharging) {
    lcd.setCursor(0, 0);
    lcd.print("Connect Charger ");
    lcd.setCursor(0, 1);
    lcd.print("And Swipe Card ");
  }

  checkFootstep();
  checkRFID();
  handleCharging();
  checkStopButton();
}

void checkFootstep() {
  int val = analogRead(FOOTSTEP_PIN);
  if (val > 100) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Power Generated");
    lcd.setCursor(0, 1);
    lcd.print("V = 1V         ");
    delay(1000);
    lcd.clear();
  }
}

void checkRFID() {
  if (!rfid.PICC_IsNewCardPresent() || !rfid.PICC_ReadCardSerial()) return;

  if (isCardAuthorized(rfid.uid.uidByte)) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("User 1 Reg.");
    lcd.setCursor(0, 1);
    lcd.print("Bal: 2 Min");
    delay(2000);

    lcd.clear();
```

```
    lcd.setCursor(0, 0);
    lcd.print("Payment Done");
    lcd.setCursor(0, 1);
    lcd.print("Bal: 0 Min");
    delay(2000);

    startCharging();
  } else {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Invalid Card");
    delay(1500);
    lcd.clear();
  }

  rfid.PICC_HaltA();
  rfid.PCD_StopCrypto1();
}

bool isCardAuthorized(byte *uid) {
  for (byte i = 0; i < 4; i++) {
    if (uid[i] != allowedUID[i]) return false;
  }
  return true;
}

void startCharging() {
  digitalWrite(RELAY_PIN, HIGH);
  isCharging = true;
  chargeStartTime = millis();
  lcd.clear();
}

void stopCharging() {
  digitalWrite(RELAY_PIN, LOW);
  isCharging = false;

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Charging Done");
  tone(BUZZER_PIN, 1000);
  delay(2000);
```

```
  noTone(BUZZER_PIN);
  lcd.clear();
}

void handleCharging() {
  if (isCharging) {
    unsigned long timeLeft = CHARGE_DURATION - (millis() -
chargeStartTime);

    lcd.setCursor(0, 0);
    lcd.print("Charging...     ");
    lcd.setCursor(0, 1);
    lcd.print("Time: ");
    lcd.print(timeLeft / 1000);
    lcd.print("s    ");

    if (millis() - chargeStartTime >= CHARGE_DURATION) {
      stopCharging();
    }
  }
}

void checkStopButton() {
  static bool prevButton = HIGH;
  bool currButton = digitalRead(BUTTON_PIN);

  if (prevButton == HIGH && currButton == LOW && isCharging) {
    stopCharging();
  }

  prevButton = currButton;
}}
```

5. Applications

- Public Charging Stations in High-Traffic Areas
    - Railway stations, bus stands, airports, and shopping malls where thousands of people walk daily can be equipped with these systems.
    - Footsteps generate electricity, which can be stored in a battery and used for charging mobile phones and electronic devices via USB points.
    - RFID authentication ensures controlled and secure access to the generated energy.

- Charging for Electric Vehicles (EVs)
    - The system can generate enough power (in combination with storage) to charge small electric vehicles like e-bikes, scooters, or light-duty EVs. Ideal for parking lots or pathways where people naturally walk.

- Energy Harvesting in Remote and Rural Areas
    - Especially useful where grid electricity is unavailable or unreliable.
    - Can be installed in rural schools, clinics, village centers, or pathways to provide basic charging needs and small-scale lighting.

- Integration with Street Lighting Systems
    - The system can power LED street lights, reducing dependence on conventional power grids.
    - Especially helpful in rainy seasons where solar power is unreliable.

- Disaster Relief Zones & Emergency Situations
    - Can provide temporary charging solutions in areas affected by natural disasters or power outages.
    - Ensures basic communication devices like mobile phones can be charged for emergency calls and updates.

- Educational Demonstration & Awareness
    - Can be used in schools, colleges, and science centers to demonstrate principles of piezoelectricity, energy harvesting, and sustainable energy.
    - Promotes awareness among students and communities about renewable energy.

- Powering Small Electronic Systems
    - The generated power can also be used to run microcontrollers, sensors, IoT devices, or low-power electronics in public areas.

6. References

[1] Prabaharan R, Jayramaprakash A, Vijay Anand. “Power Harvesting by Using Human Foot Step”- International Journal of Innovative Research in Science Engineering and Technology, vol.2, issue 7, July 2013.

[2] Tanvi Dikshit, Dhawal Shrivastava, Abhijeet Gorey, Ashish Gupta, Parag Parandkar, Sumant Katiyal, “Energy Harvesting via Piezoelectricity”, BVICAM’s International Journal of Information Technology 2010.

[3] Jose Ananth Vino, AP.”Power Generation Using Footstep”- International Journal of Engineering Trends and Technology, vol.1, Issue 2, May 2011.

[4]Umeda, M., Nakamura, K., and Ueha, S. Energy Storage Characteristics of a Piezo Generator Using Impact Vibration. Japan Journal of Applied Physics, Vol. 36, Part 1, No. 5b, May 1997, pp.3146-3151.

[5]Ramesh Raja R, Sherin Mathew.”Power Generation from Staircase (steps)”- International Journal of Innovative Research in Science Engineering and Technology, vol.3, Issue 1, February 2014.

[6] C. Nithiyeshkumar, K. Gowtham, M. Manikandan, P. Bharathkanna, T. ManojKumar, IJLTET, “Power Generation in Automobile Suspension System” – January2015.

[7] Md.Azhar,ZitenderRajpurohit,Abdul Saif,NallaAbhinay,P.SaiChandu,IJMETMR “Generation of Electrical Energy from Footstep Using Rackand PinionMechanism”– June2017.

[8] KunalSoni,NikhilJha,JaiPadamwar,DevanandBhonsle,TanuRizvi,

IRJMETS,“FootstepPowerGenerationUsingPiezoelectricPlate”–March2022

[9] RameshRajaR,SherinMathew“PowerGenerationfromSteps”–July2018

[10] ManishaB.Kanawade1,AmrutaN.Jadhav2,RohiniB.Jadhav3,Prof.KalpeshKBamb

“FootstepPowerGeneration UsingPIC Microcontroller”

[11] JithaVarghese1andPaulKarikotti“FootstepPowerGenerationUsingPiezoelectricS

ensors”

[12] Mr.A.Adhithan,K.Vignesh,M.Manikandan „Proposed Method Of Foot Step

PowerGeneration Using Piezo Electric Sensor” International Advanced Research

Journal InScience,Engineering AndTechnologyVol.2,Issue4,April 2015

[13] MonikaJain,Mohitdev

Sharma‟VIDYUT

GenerationViaWalking:Analysis

“InternationalJournal of EngineeringScience andResearchTechnology-2014

[14] V.Joseananthvino,AP,BharathUniversity,„PowerGenerationUsingFootStep‟International Journal Of Engineering Trends And Technology (IJETT) – Volume1Issue2–

May2011.