Step2Power

A Footstep Energy Generator and Harvesting System

Sirajum Munir (22-48549-3), Turjo Das Dip (22-48558-3), Ashfaqur Rahman Chowdhury (22-48532-3), Nusrat Faraezi Ivy (22-48608-3)

Abstract

Step2Power is a Footstep Energy Generator and Harvesting System that converts human walking pressure into electrical energy using piezoelectric transducers. The generated electrical pulses are converted into DC using a rectifier circuit (1N4007 diodes) and filtered using a capacitor to reduce fluctuations. The harvested energy is temporarily stored in a small capacitor for monitoring and demonstration. An Arduino Uno measures the generated voltage and provides real-time feedback through an I2C LCD display, while a transistor-controlled LED demonstrates usable output. **Step2Power** promotes renewable micro-energy harvesting for low-power applications in high-traffic public spaces.

Introduction

➢ Problem

- A large amount of mechanical energy from walking in public places is wasted every day.
- At the same time, many low-power devices require small but continuous energy sources.

➢ Solution

- This project captures footstep energy using piezoelectric sensors and converts it into electrical energy that is rectified, filtered and temporarily stored in a capacitor to power small loads and provide monitoring feedback .

➢ Key Innovations

- Uses multiple piezo disks in series for higher voltage output.
- Provides real-time feedback using Arduino + LCD.
- Provides a complete energy harvesting pipeline: generation → rectification → filtering → capacitor storage → output.

Background and Motivation

Piezoelectric materials generate electrical voltage when mechanical pressure is applied. This property makes piezoelectric sensors suitable for harvesting energy from repeated human actions such as footsteps. The motivation of this project is to develop a low-cost, compact and interactive energy harvesting prototype that can demonstrate sustainable energy generation in every day environments like corridors, staircases and walkways.

Objective

The objectives of this project are:

- To generate electrical energy from footsteps using piezoelectric disks.
- To convert unstable piezo output into usable DC using a rectifier circuit.
- To filter and temporarily store the generated energy in a capacitor.
- To display real-time output information on a LCD.
- To power a small load (LED) as proof of usability.

System Architecture

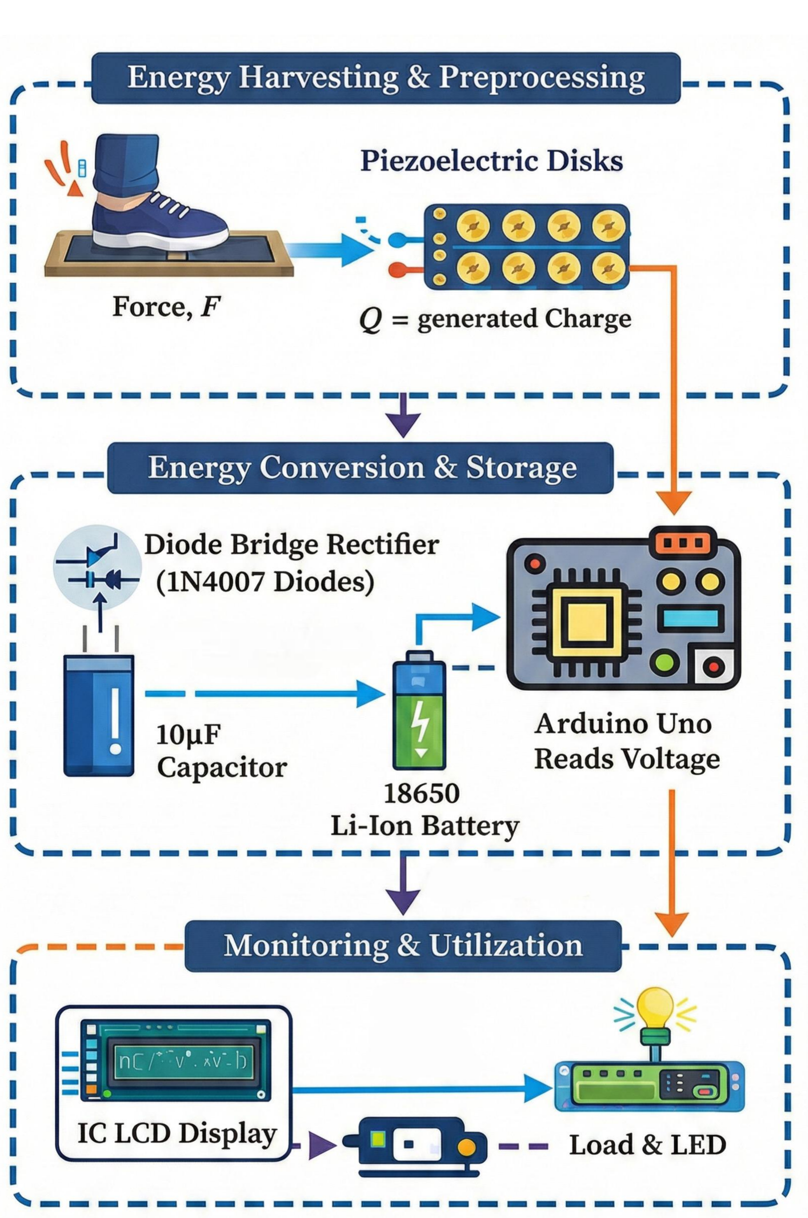

Figure 1: System Architecture of The Step2Power

Methodology

The **Step2Power** system follows a step-by-step process to convert footstep pressure into usable electrical energy. First, the user steps on the tile, creating mechanical force that is applied to the piezoelectric disks. These disks generate electrical voltage pulses from the applied pressure. Next, the generated output is passed through a 1N4007 diode rectifier to convert the alternating piezoelectric pulses into DC. A capacitor filter is then used to smooth the DC output and reduce fluctuations. The filtered energy is temporarily stored in a capacitor for monitoring and demonstration. The Arduino Uno measures the generated voltage through its analog input and provides real-time system status on an I2C LCD display. The overall system (Arduino and display) is powered using an 18650 Li-ion battery, while a BC547 transistor-controlled LED is used as a load to demonstrate practical energy output.

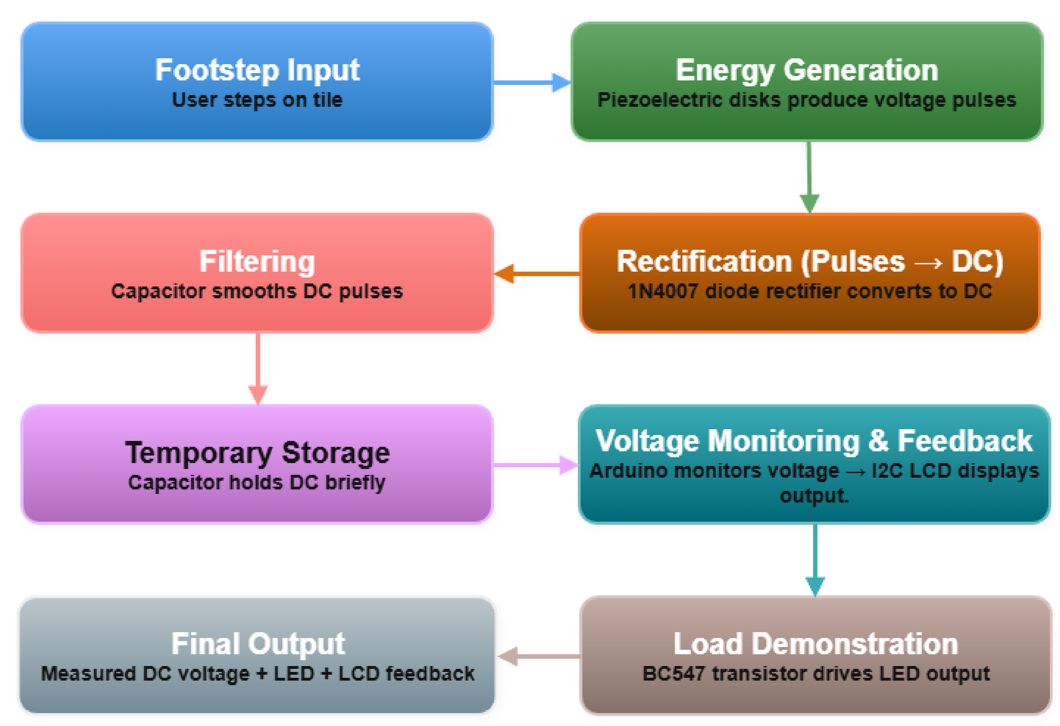

Figure 2: Workflow of The Step2Power

Components

Table I: Table of Components

Name	Model	Feature	Qty
Microcontroller Board	Arduino Uno	Controls system, reads voltage, drives LCD/LED	1
Piezoelectric Transducers	27mm Piezo Disk	Converts footstep pressure to electrical pulses	7
LCD Display	I2C 16×2 LCD	Displays voltage/output in real-time	1
Diode	1N4007	Rectifies AC pulses into DC	4
Resistor	220-330Ω, 10kΩ 100kΩ	Limits LED current for protection, Base control / voltage divider support, Voltage sensing / circuit biasing	4
Capacitor	10µF	temporary storage/filter	1
Transistor	BC547	Acts as switch to drive LED load	1
Battery	18650 Li-ion	Powerup the whole system	2
Breadboard	400-point Mini	Circuit prototyping platform	1
Switch	KCD11	On/Off the prototype	1
Jumper Wires	Male - Male, Male - Female	Connects components and Arduino pins	As needed

Experimental Setup

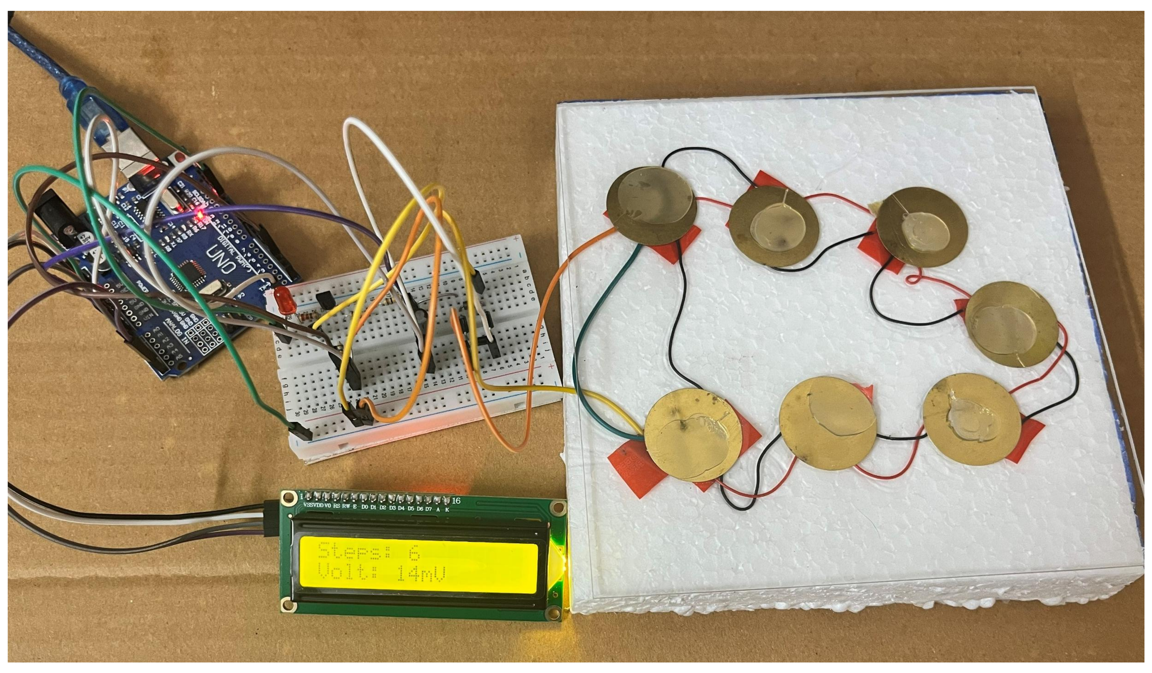

Figure 3: Experimental Setup of The Step2Power

Simulation Setup

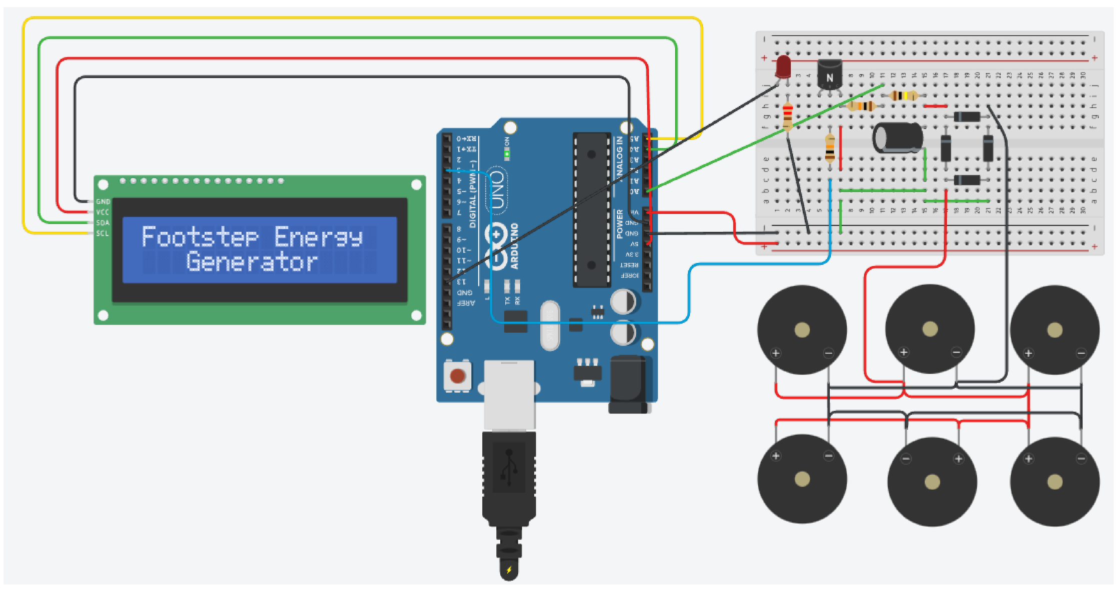

Figure 4: Simulation of The Step2Power

Result

The **Step2Power** prototype successfully generated electrical energy from footsteps using seven piezoelectric disks. The output voltage pulses were rectified using bridge rectifier using 1N4007 diodes and filtered using a 10µF capacitor to reduce fluctuations and obtain a smoother DC level. Higher footstep force and frequency produced higher voltage peaks, which was reflected in the LCD readings and LED demonstration.

Table II: Experimental Result

No. of Footsteps	Peak Voltage (V)	Average Voltage (V)	Output Strength
5	1.8V	0.6V	Very Low
10	2.6V	1.1V	Low
20	3.4V	1.8V	Medium
30	4.2V	2.5V	High
50	5.0V	3.2V	Very High

Simulation of the rectifier and capacitor filter showed successful conversion of piezoelectric pulses into DC output. The capacitor reduced voltage fluctuations and produced a smoother, more smoother DC level. The simulated trend matched the experimental results, where stronger input produced higher output voltage.

Table III: Simulated Result

Input Condition	Rectified Output (V)	Filtered Output Stability	Output Type
Low Footstep Force	~1.0V–2.0V	Low (high ripple)	Unstable DC
Medium Footstep Force	~2.0V–3.5V	Medium	Semi-stable DC
High Footstep Force	~3.5V–5.0V	High (low ripple)	Stable DC

Applications

This system can be applied in:

- Smart floors in shopping malls.
- Energy harvesting tiles in university corridors.
- Public transport stations and terminals.
- Staircases and walkways with heavy foot traffic.
- Powering low-power IoT sensors.

Future Improvements

- Improve mechanical design using stronger pressure plates and better force distribution.
- Use supercapacitors for faster and higher-capacity energy storage.
- Increase rectification efficiency using Schottky diodes (lower voltage drop).
- Add Bluetooth/Wi-Fi monitoring for mobile or cloud-based display.
- Build a durable tile-based enclosure for long-term real-world deployment.

Conclusion

This project demonstrates a working prototype of a Footstep Energy Generator and Harvesting System using piezoelectric transducers. The system successfully converts mechanical footstep energy into electrical energy, rectifies and filters the output using a diode bridge and capacitor, and provides real-time user feedback through an I2C LCD display. It is a promising step toward sustainable micro-energy harvesting for low-power applications in high-traffic areas.

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Acknowledgement

We gratefully acknowledge our supervisor Prof. Dr. M. F. Mridha and for his invaluable guidance. This work was conducted with dedication from all team members.

Department of Computer Science, Faculty of Science and Technology.
American International University-Bangladesh (AIUB)