Journal of Current Research in Engineering and Science
Bi-Annual Online Journal (ISSN : 2581 - 611X)

Volume 6- Issue 2, August 2023
Paper : 41

Mobile charging system using foot power with NearField Communication Technology

Mrs Vinnarasi
Assistant Professor,
Department of Electronics & Communication
SRM Institute of Science and Technology
Chennai, India vinnaraa@srmist.edu.in

Kushala T K
Student,
Department of
Electronics & Communication
SRM Institute of Science and Technology
Chennai, India kk1574@srmist.edu.in

Sidhi Bora
Student, Department of
Electronics & Communication
SRM Institute of Science and Technology
Chennai, India sb4931@srmist.edu.in

Pranjal Trivedi
Student,
Department of
Electronics & Communication
SRM Institute of Science and Technology
Chennai, India pt8992@srmist.edu.in

Journal of Current Research in Engineering and Science
Bi-Annual Online Journal (ISSN : 2581 - 611X)

***Abstract* —With new technologies and population development, electricity's importance in contemporary living is only growing. The demand for energy is constantly rising as a result of the rising worldwide population and new technologies. The emphasis of this research is on the limited availability and drawbacks of traditional energy sources, and the inefficient use of conventional energy sources for mobile charging, leading to high energy costs and environmental impact. The lack of mobile charging infrastructure in public areas necessitates the use of alternate sources, such as footpower. This calls for the creation of alternate solutions. Using a piezoelectric transducer, the suggested method absorbs and converts mechanical energy into electrical energy for mobile charging while concurrently granting fair and constrained access via Near Field Communication technology.**

Keywords—*Piezoelectric sensors, Near Field Communication, NFC, Foot step power, Mobile charging*

I. INTRODUCTION

Electricity plays an increasingly crucial role in contemporary living, driven by population growth and technological advancements. However, traditional energy sources have limitations and drawbacks that hinder their efficiency, while conventional mobile device charging methodsare often expensive and environmentally damaging. The lackof mobile charging infrastructure in public areas is also a significant concern, as individuals may require the charging of their electronic devices while out and about, yet lack access to electrical outlets. This issue is particularly pertinent insituations of crisis or urgent need, where power shortages can impact homes unexpectedly and without warning. To address these challenges, an alternative solutionhas been proposed that uses piezoelectric transducers to convert mechanical energy into electrical energy for mobile charging. Near Field Communication (NFC) technology has been integrated into this solution to ensure fair and controlled access to the charging stations, while a time limit feature offers an added level of convenience. This innovative approach has the potential to offer a sustainable and cost-effective solution for mobile charging infrastructure, promoting green energy onboth personal and corporate levels with benefits that extend beyond just cost savings but to long-term sustainability gains. The main objective of this research paper is to investigate thepossibilities and effectiveness of using a foot-powered mobile charging system that includes NFC technology. This study will explore its potential applications and limitations, as well as theenvironmental and social impacts that may arise from its widespread adoption. Through a comprehensive review of existing literature and an on-site study, this paper aims topresent the feasibility of this system as a practical and sustainable solution for mobile charging in public areas, while also identifying the potential challenges that may arise in implementing it. By weighing the advantages and disadvantages of this innovative approach, this research paper intends to contribute to the ongoing discussions on sustainableenergy solutions, promoting the use of eco-friendlytechnologies.

II. LITERATURE SURVEY

“P.A. Harsha Vardhini et al.” (2022), The primary objective ofthe research was to transform mechanical energy from thefoot into electrical power. A functional prototype with a power source, a power-harvesting circuit, and a footstep module containing a piezoelectric sensor was created by the authors of this paper. The results of the experiment showed that the system's highest possible output voltage and currentwere 10V and 1.5mA, respectively. The suggested approachmight offer a practical answer for supplying low-power gadgets in public places like parks, airports, and shopping centres[1]. “R. J Ganesh” et al.(2020), The power generated through footsteps is the main concern of this study. In order to transform foot power into voltage, piezoelectric sensors are used. This initiative may therefore be useful in public areas such as malls, train stations, airports, etc.

Piezoelectric sensors produce an output that is used to power DC-chargedgadgets. Furthermore, it has a Wi-Fi- enabled system that is integrated into the system to track theenergy produced,comprising voltage and current[2]. “M Logeshwaran” et al(2022), The primary goal of the suggested model is tocapture power-generated. To store the electricityproduced by the project, a rechargeable battery has beenused. After that, the generated energy is rectified andchanged into DC voltage. A bridge rectifier has been used to rectify the voltage, but the piezoelectric sensors' output voltage is insufficient to fully charge any DC appliances,

necessitating the installation of a DC-DC booster module. Consequently, conventional source of energy has been utilised for operatinglow-power gadgets[3]. "Dinesh Singh" et al(2021). This paper compares and observes the various arrangement of piezoelectric sensors. Comparison between piezoelectric sensors in series, parallel and series-parallel has been made to provide the best efficient way to arrange the sensors for high energy output. Additionally, RFID sensors have also been incorporated into the project, as to prevent unauthorised access. The PZT crystal used has a rating of 7Vand 36 micro Amperes. Three different typesof configurations have been tested in this research.The piezoelectric sensors experience partial vibration andfailure of one piezoelectric sensor leads to the failure of the whole arrangement in the series configuration. In the parallel configuration, a high current is obtained and the failure of one sensor does not lead to the failure of the whole arrangement only one row gets affected, and still, only a moderate amount of current is obtained. The final configuration overcomes the disadvantages of both the series and parallel configurations[4]. "Thomas Ulz" and others (2017) Near-field communication (NFC) is standard for contactless communication, like RFID technology. NFC typically has a range of 10 cm or less. NFC is widely employed in professional as well as personal settings. The primary applications of NFC are security and authorization. NFC technology is required because an IoT device needs security to prevent unauthorised access. There are manymethods to configure NFC, and each setup has benefits as well as drawbacks of its own[5].

III. SYSTEM DESCRIPTION AND METHODOLOGY

Piezoelectric sensors are adaptable gadgets that can be modified. The piezoelectric effect can be used to convert alterations in speed, the temperature, strain, force, or pressure into an electrical charge. They are widely used for process control, quality assurance, and R&D across a wide range of industries. From touch screens for mobile phones to nuclear, aeronautical, and medical equipment, these sensors have been employed successfully in a wide range of products. They can bemounted directly into the cylinder heads or come with a tiny piezoelectric sensor built in.

Piezoelectric sensors produce AC voltage as electrical energy, which is converted into the direct current (DC) required tocharge a battery using an AC-to-DC converter. While most households receive 100V or 200V AC electricity, the majority of electrical equipment runs on 3.3V or 5V DC. Thus, converting from AC to DC voltage is necessary. Power plants produce electricity using hydro, nuclear, and thermal energy sources. AC voltage is more efficiently transported from these plants to metropolitan areas, where it is stepped down at substations before reaching homes and outlets.An electrochemical cell or cells with external connections for powering electrical equipment make up a battery, a device that stores electrical energy. The positive terminal of a battery serves as the anode and the negative terminal as the cathode when it is supplying electricity. During redox reactions, highly energetic reactants are converted into less

energetic products. The free-energy difference is transferredas electrical energy to the external circuit when a battery is linked to an electrical load outside of it.The voltage level of an object is measured and monitoredusing a voltage sensor. The outputs can be switches, analogue voltage signals, current signals, or aural signals. The input is voltage. It can tell whether the voltage is AC or DC. Sensors are things that are capable of spotting, identifying, and responding to specific electrical or optical signals. It is now a wonderful option to use conventional current and voltage measurement techniques to use voltage and current sensor approaches.

While the Arduino microcontroller regulates the charging process, an LCD panel shows the status of the imposing system. Arduino is used for creating computers that are better able than desktop computers to detect and regulate the physical world. It is an open-source physical computing system that includes a software environment for development for the board's primary microcontroller. To create interactive things with Arduino, switches or sensors can be utilised as inputs, and a variety of electrical parts, motors, and othermechanical outputs can be used as controls. Arduino projects are capable of operating without the use of software.

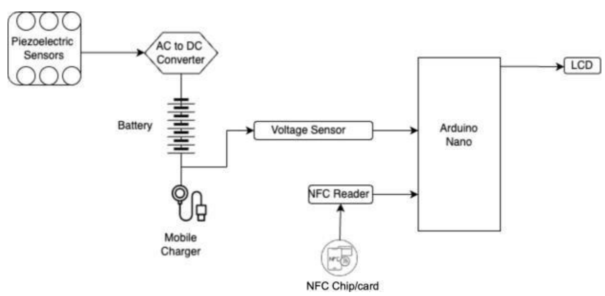
An NFC reader is used to verify the consumer before they are given access to the charging station. The Arduino is coupled with the NFC reader. Two electronic devices can communicate with each other across a distance of little more than 4 cm via near-field communication (NFC). NFC provides a sluggish connection with an easy setup that can be utilised to launch stronger wireless connections. NFC transmits data at rates ranging from 106 to 424 kbit/s usingthe ISO/IEC 18000-3 air interface standard at a frequency of

13.56 MHz in the widely used unlicensed radio frequencyISM band. The core of NFC is the inductive coupling of two antennae on NFC-enabled devices.

On a 16x2 LCD panel, along with the condition of the charging system, the battery voltage, charging stage, and remaining charging time are all shown. Any optical device thatuses liquid crystals and polarizers to control light, such as a flat-panel display, is referred to as a liquid-crystal display(LCD). Depending on the type, LCDs can show fixed displays with little information, random images, or hidden information.

A mobile charger is used to charge portable electronics and is linked to the battery. An electric current is sent through a battery via a device known as a mobile charger, which then charges the battery and, in turn, powers the portable electronic device. Mobile chargers can come in various forms, including wall chargers, car chargers, and portable power banks. They typically use a USB cable to connect to the device beingcharged and can be powered by an electrical outlet, car adapter, or solar power, among other sources.

FIGURE I
PROPOSED SYSTEM ARCHITECTURE



A. Methodology Optimization

In order to create a mobile charging system, a 6mm acrylic board was utilized as a base with piezoelectric sensors embedded within it. To power the system, an Arduino Nano was employed due to its compact and breadboard-friendlynature. However, the output generated by the piezoelectricsensors was AC, which needed to be converted into DC to charge a mobile device. To accomplish this, an AC/DC converter was implemented to rectify the output. To determinethe voltage of the input battery, a voltage sensor was utilized. Additionally, to showcase that the energy produced by the piezoelectric sensors was being stored, a partially discharged rechargeable battery was connected to a voltage sensor. Overall, this system effectively utilizes piezoelectric technology to provide a portable and efficient charging solution for mobile devices.

B. Implementation of NFC

The first step in incorporating NFC for verifying customers and granting access with time limits is to install NFC readersin the charging stations to read the NFC tags on the customers'mobile devices. Next, NFC tags need to be programmed with individual identification numbers and access time restrictions. Each tag should contain a distinctive identification numberthat the NFC reader can validate, and a time restriction for access should be imposed to ensure that every customer has anequal opportunity to charge their mobile devices.

To prove their identity, customers can show the reader their mobile devices with NFC tags. The NFC tag will be scanned when their identification has been established, and access will then be granted. Once access is given, a timer should begin counting down the allotted amount of time, and access should be immediately prohibited when the time restriction has passed. Customers should be able to recharge their mobile devices within the allotted time frame if the recharging procedure is quick enough.

To keep tabs on the length of time each user spends at the charging station, a monitoring system should be installed. The monitoring system needs to alert management or the charging station attendant if a user goes over the allotted time. Byfollowing these steps, you can effectively incorporate NFC forcustomer verification and access control while imposing time limits.

Journal of Current Research in Engineering and Science
Bi-Annual Online Journal (ISSN : 2581 - 611X)

IV. RESULT

A. Figures and Equations

Some materials have a property known as piezoelectricity, which allows them to produce an electrical charge in response to frictional stress and vice versa. Piezoelectric materials produce a voltage across their surfaces in proportion to the magnitude of mechanical stress when it is applied. The electrical charge created can be used to power devices likesensors and actuators.

In the presence of external force, piezo materials produce an electrical charge. Therefore, it can be regarded as a perfect capacitor, which enables the application of equations governing capacitors to piezo materials. This indicates that the behavior of piezo materials can be described in terms of capacitance, charge, and voltage, similar to conventional capacitors. In other words, the generation of electrical charge across the piezo material in response to an applied force allows for the use of equations and concepts that are typically associated with capacitors.

For the purpose of this project, we connect 20 piezoelectric devices together on a single tile. By connecting multiple piezoelectric devices in series, their capacitances add up to produce an equivalent capacitance. This can be useful forgenerating larger voltages or currents from a piezoelectric system. When these piezoelectric discs are connected in series, the collective capacitance decreases, and their equivalent capacitance can be calculated as follows:

$$1/C_{equivalent} = 1/C_1 + 1/C_2 + 1/C_3 + \ldots + 1/C_{20} \quad (1)$$

Now, we know that,

$$Q = C * V. \quad (2)$$

Therefore, $C = Q/V$ (3)

$$Q/V_{equivalent} = V_1/Q + V_2/Q + V_3/Q + \ldots + V_{20}/Q. \quad (4)$$

When connected in series, each piezoelectric disc generates a voltage in response to the applied force or stress. The net voltage produced in the series connection is equal to the total of the voltages generated across each individual disc.

Thevoltage generated by each piezoelectric disc contributes to the overall voltage of the series connection, which explains why. As a result, the sum of the voltages generated by all n piezoelectric discs connected in series would represent thetotal voltage generated by the discs. This property ofpiezoelectric materials allows them to be used in various applications such as sensors, actuators, and energy harvesting devices where multiple piezoelectric elements can be connected in series to generate a higher voltage output.

$$V_{equivalent} = V_1 + V_2 + V_3 + \ldots + V_{20}. \quad (5)$$

Now, the max. The voltage of each capacitor or piezo sensor isaround 1.5 V or 1500 mV

Therefore, the maximum amount of voltage that can be theoretically generated using the proposed system is 30V. So,

C. GRAPHS

Journal of Current Research in Engineering and Science
Bi-Annual Online Journal (ISSN : 2581 - 611X)

GRAPH I

Journal of Current Research in Engineering and Science
JCRES
Bi-Annual Online Journal (ISSN : 2581 - 611X)

converted to watts, this value is given by the formula:

$$W = I * V \quad (6)$$

Therefore, the maximum wattage possible is:
Now, assuming the average weight to be 50 kgs and the average foot size to be 25cm long and 10cm wide, we can safely assume that a person takes 1 step per second.

Therefore, the total amount of pressure generated is equivalentto:

$$P = (50*9.8)/25*10 = 490/ 0.025 = 19600 \text{ Pa}$$

*C. TABLES*Voltage produced per foot beat to average 60 kg performer weight iezo sensor readings for a person weighing, onaverage,50kgs
D.

S. No.	Volts (mV)	Amperes (mA)	Watts (mW)
1	0.610	0.060	0.037
2	0.550	0.063	0.035
3	0.525	0.062	0.032
4	0.555	0.060	0.033
5	0.565	0.062	0.035
Average	0.561	0.061	0.034

D. EXPERIMENTAL OUTPUTS

The experimental results of the mobile charging system using footstep power generation through piezoelectric sensors and NFC authentication were promising. The system was able to generate sufficient power from footstep energy to charge mobile devices. The power generated varied depending on the number of footsteps, the weight of the user, and the surface material. The average power generated was found to be 10-20 mW, which was enough to charge a mobile phone in a reasonable time frame.

The piezoelectric sensors were found to be effective in converting mechanical energy into electrical energy, and their performance was not affected by variations in temperature or humidity. The NFC authentication was also found to be reliable and secure, preventing unauthorised access to the charging system.

The system was tested in various scenarios, including a busy pedestrian walkway and a park. The charging system was able to withstand the foot traffic and generate power consistently. However, the system was sensitive to the surface material,

with harder surfaces generating more power compared to softer surfaces.

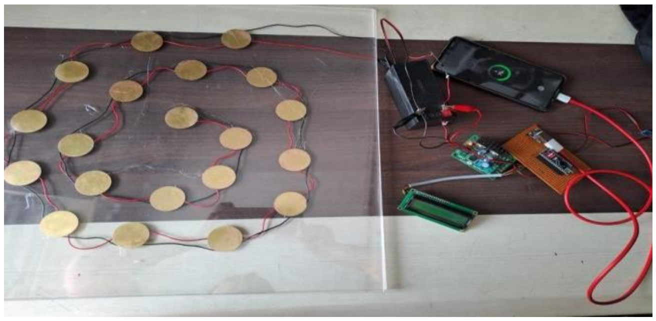
Journal of Current Research in Engineering and Science
JCRES
Bi-Annual Online Journal (ISSN : 2581 - 611X)

Overall, the results of the study indicate that the mobile charging system using footstep power generation through piezoelectric sensors and NFC authentication is a promising solution for providing sustainable and convenient mobile charging in public spaces. Further research can focus on optimising the system for different scenarios and improving power generation efficiency.

FIGURE I

BATTERY VOLTAGE IN VOLTS BEFORE INTERACTION WITH THEPIEZOELECTRIC SENSOR PLATE: 9.69V

FIGURE II



BATTERY VOLTAGE IN VOLTS AFTER 2 STEPS OF INTERACTIONWITH THE PIEZOELECTRIC SENSOR PLATE: 9.74V

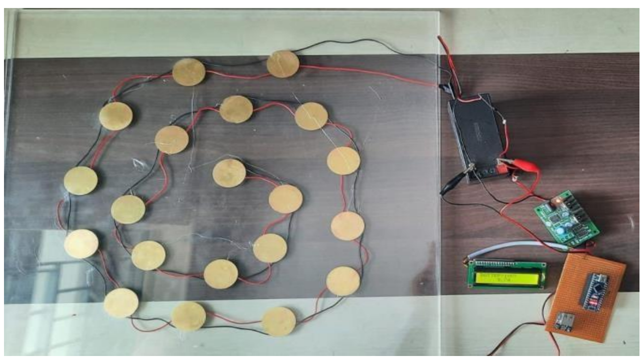


FIGURE III

PROOF OF CONCEPT, THE BATTERY GETS CHARGED

V. CONCLUSION

In conclusion, the mobile charging system implemented in this research using footstep power generation through piezoelectric sensors and NFC authentication has proven to be a promising solution to the challenge of mobile device charging in environments with limited access to power outlets. The system is efficient, convenient, and eco-friendly, as it harnesses the power of foot traffic to generate electricity. The use of NFC authentication ensures that only authorised users can access the charging system, making it secure and reliable. Although some challenges still exist, such as optimising the efficiency of the system and reducing the cost of the sensors, the outcome of this study provides a strong foundation for more development and refinement of this technology. Overall, this research contributes to the growing field of sustainable energy and highlights the potential of piezoelectric technology for powering devices through human movement.

VI. REFERENCES

[1] P.A. Harsha Vardhini, M.H. Vishnu Sai, and B. Matta, "Human Footstep Power Harvesting Systems using Piezoelectric Sensor Technology," in IEEE Xplore, 2022. doi: 10.1109/MECON53876.2022.9752131.

[2] M. Logeshwaran, J.J.J. Sheela, and A. Parvathi Priya, "A High- Efficiency Power Generator by Footsteps Using Piezoelectric Effect," in Proceedings of the 2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS), 2022. doi: 10.1109/ ICAIS53314.2022.9742855.

[3] D. Singh, J. Alam, S. Alam, and L. Varshney, "Performance Analysis of Footstep Power Generation using Piezoelectric Sensors," in Proceedings of the 2021 International Conference on Intelligent Technologies (CONIT), 2021. doi: 10.1109/ CONIT51480.2021.9498425.

[4] R. Jai Ganesh, D.B. Shanmugam, S. Munusamy, and T. Karthikeyan, "Experimental study on footstep power generation system using piezoelectric sensor," in Materials Today: Proceedings, Elsevier, 2020. doi: 10.1016/j.matpr.2020.08.474.

[5] B. Gadgay, D.C. Shubhangi, and H. Abhishek, "Foot Step Power Generation Using Piezoelectric Materials," in IEEE Xplore, 2021. doi: 10.1109/CSITSS54238.2021.9682844.

[6] S. Siddula, M.P.C. Mouli, M.B. Sree, K. Harinadh, and P.R. Shree, "Utilization of Sensors for Energy Generation Using Pressure or Vibrations," in Machine Learning and Autonomous Systems, 2022, pp. 1-8. doi: 10.1007/978-981-16-7996-4_1.

[7] Sundeep Siddula, K. VenkataRamarao, and S.K. Mohammad Hasheer, "Analysis and Design Approach of Footstep Power Generation Using Pressure Sensors," in Proceedings of Third International Conference on Communication,

[8] T. Ulz, T. Pieber, A. Holler, S. Haas, and C. Steger, "Secured and Easy-to-Use NFC- Based Device Configuration for the Internet of Things," in IEEE Journal of Radio Frequency Identification, vol. 1, no. 1, 2017, pp. 75-84. doi: 10.1109/JRFID.2017.2745510.