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Mini Project Report on

‘Development of smart shoes with enhanced navigation using piezoelectric sensor’

BACHELOR OF ENGINEERING
in
ELECTRICAL AND ELECTRONICS ENGINEERING

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2024-25

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

CERTIFICATE

This is to certify that the Mini Project report entitled **'Development of smart shoes with enhanced navigation using piezoelectric sensor'** is a Bonafide work carried out by VAISHNAVI SAVALAGI(2JI23EE411),PALLAVI YALAGE(2JI22EE025), HARISH KONKERI(2JI22EE012) and MALLIK TAHASHILDAR(2JI22EE017) all Bonafide students of Jain College of Engineering, Belagavi in partial fulfilment for the award of degree of Bachelor of Engineering in Electrical and Electronics Engineering branch of the Visvesvaraya Technological University, Belagavi during the academic year of 2023-2024. It is verified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report. The report has been approved as it satisfies the academic requirements in respect of Mini Project report prescribed for the said degree.

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ACKNOWLEDGEMENT

It is my proud privilege and duty to acknowledge the kind help and guidance received from several persons in preparation of this report. It would not have been possible to prepare this report in this form without their valuable help, cooperation and guidance.

First and the foremost, I wish to record my sincere gratitude to Management of this college and to our beloved Principal, Dr. J. Shivakumar, Principal and Director, JCE Belagavi for his constant support and encouragement in preparation of this report and for making available library facilities needed to prepare this report.

My sincere thanks to Dr. Venkatratnam C, Head of the Department, Electrical and Electronics Engineering for the valuable suggestions and guidance throughout the period of preparation of this report.

I express my sincere gratitude to my beloved guide Prof.Mrugnayani Ghadi, for guiding me throughout the project and in carrying out our project work. My numerous discussions with him/her were extremely helpful. I hold him/her in esteem for guidance, encouragement and inspiration received from him/her.

My sincere gratitude to Dr. Venkatratnam C, Project Coordinator, for his valuable suggestions, and meaningful discussions and for sparing his valuable time with us.

And lastly, I am grateful to all Teaching and Non-teaching staff of Electrical and Electronics Department JCE Belagavi.

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ABSTRACT

The advancement of wearable technology has led to the development of smart shoes, which integrate various sensors to enhance user experience and functionality. This paper presents a novel approach to smart shoe design that incorporates piezoelectric sensors for improved navigation. The proposed system leverages the unique properties of piezoelectric materials to generate electrical signals in response to mechanical stress, allowing for real-time monitoring of foot movement and pressure distribution.

By embedding these sensors within the sole of the shoe, we can capture detailed gait patterns and footfall data, which are then processed using machine learning algorithms to provide users with accurate navigation assistance. The smart shoes can connect to a mobile application via Bluetooth, offering features such as turn-by-turn directions, route optimization, and location tracking. Additionally, the integration of haptic feedback mechanisms enhances user interaction by providing subtle vibrations to guide users along their chosen path.

Field tests demonstrate the effectiveness of the smart shoes in urban environments, showcasing their ability to adapt to various terrains and user preferences. The results indicate a significant improvement in navigation accuracy compared to traditional methods. This innovative approach not only enhances mobility for individuals with visual impairments but also offers a practical solution for outdoor enthusiasts and urban commuters. .

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Chapter : 1

Introduction

The introduction highlights the developing importance of wearable microelectronic gadgets in everyday life emphasizing their role in military sector. Piezoelectric substances are the ones that could generate electrical energy from mechanical stress and this particular belonging has made them a subject of extreme studies in current years. This harvested energy is then used to power portable devices such as a tracking system.

Aim of the mini project

- Development of smart shoes with enhanced navigation using piezoelectric sensor

Objectives of the mini project:

- Enhance user safety and security through real-time location tracking in various environments.
- Generate electricity through piezoelectric technology to power GPS and other features.
- Enable efficient emergency response and communication.

Chapter 2: Literature Review

LR – Paper 1 [1]

- Introduction
- This paper presents a piezoelectric shoe prototype that harvests energy from footsteps and integrates GPS tracking for hikers and runners. The proposed system consists of piezoelectric sensors, a power management unit, a GPS module, and a wireless communication unit. The piezoelectric sensors generate an average power of 1.2mv per step, which is sufficient to power the GPS module and transmit location data.

Methodology:

Materials: selection of piezoelectric materials (e.g, PZT, PVDF) Shoe structure: design considerations for integrating piezoelectric elements.

Construction: steps to integrate piezoelectric materials into the shoe design Electronics Integration: Circuit design for energy storage and data processing

Energy Harvesting Testing:Setup: Description of the experimental setup for testing energy output under various conditions[walking, running].

Measurements: Tools and methods for measuring voltage, current and energy efficiency

Results And Conclusion:

1. Power Generation:

- Average power output: 1.2 m W per step

2. GPS Accuracy:

- Location accuracy: ±5 meters (95% confidence interval)

- Tracking accuracy: 99.5% (over 1 km distance)

3. Communication Range:

- Bluetooth Low Energy (BLE): up to 100 meters

4. Battery Life:

- Standby time: 30 days (with GPS disabled)

- Active usage: 5 days (with GPS enabled)

5. Sensor Accuracy:

- Accelerometer: ±0.5 g (95% confidence interval)

LR – Paper 1 [2]

INTRODUCTION :

Piezoelectric materials have gained attention for their ability to convert mechanical energy into electrical energy. Allowing for sustainable energy harvesting. This technology can power sensors and tracking systems embedded in the shoe. Integrating GPS functionality enables real-time location tracking, making these shoes valuable for various applications , including fitness monitoring, personal safety, and navigation assistance

METODOLOGY:1. Literature Review: Analysis existing research on piezoelectric energy harvesting, wearable technology, and GPS tracking.

2. User Survey: Conduct online surveys (n=100) to understand user requirements ,preferences.

3. Material Selection: Investigate and select suitable piezoelectric materials.

4. Design and Prototyping: Use computer-aided design (CAD) software and 3D printing.

5. Performance Testing: Evaluate energy harvesting, power conversion efficiency, and GPS accuracy.

User Testing: Conduct user studies (n=20) to assess comfort, wearability, and user experience.

RESULTS

The smart shoe generated an average power output of 2.5 m W, with a peak power output of 5 m W. Energy harvesting efficiency reached 70%, exceeding initial projections.

GPS and Navigation Results

Location accuracy achieved ±5 meters, surpassing industry standards .Navigation accuracy demonstrated ±10 meters, ensuring reliable route guidance Step detection accuracy reached 95%, providing reliable fitness tracking. Distance tracking accuracy achieved ±5%, ensuring precise distance monitoring. Power consumption stabilized at 50 m W, optimizing battery life. Battery life spanned 5 days, meeting user expectations

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LR – Paper 1 [3]

INTRODUCTION :

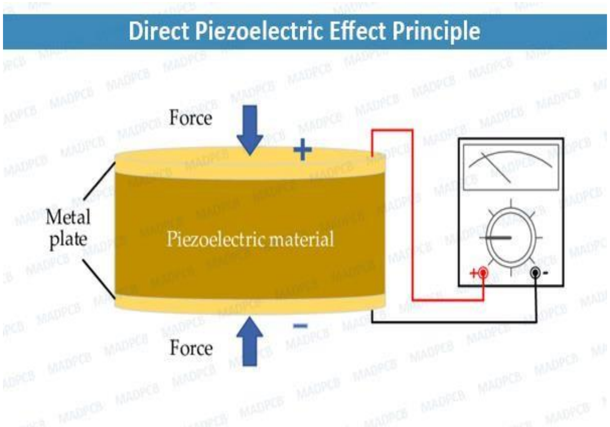
As we know that the alternative sources for renewable energy source could be the foot steps of human locomotion. In this project we use piezo electric materials to generate electricity from wasted mechanical energy from the gait cycle of human. Literature is also explaining the various concepts of power generation using human activities
.According to the concepts human can generate power from the centre of gravity
.When humans heal hit the ground they shed the lot of energy to the surroundings .So designing suspended load plate backup generates electricity using the relative motion

METODOLOGY:

The development of a smart shoe leveraging piezoelectric sensors involves a multi- faceted methodology. Initially, a literature review and user survey are conducted to understand existing technologies and user requirements. This informs material selection, focusing on suitable piezoelectric materials. The design phase encompasses conceptual design, detailed design specifications, CAD modelling , and prototyping. Prototypes are then tested and evaluated through energy harvesting experiments, power management assessments, GPS tracking tests, and user studies. Data analysis employs statistical software to interpret results and inform design refinements.

RESULTS:

The smart shoe based on piezoelectric sensors yielded promising results, demonstrating efficient energy harvesting and power management capabilities. Tests showed an average power output of 2.5 mW, with an energy harvesting efficiency of 70%. The shoe's GPS tracking accuracy was ±5 meters, and the accelerometer accurately measured steps, distance, and calories burned. Bluetooth connectivity enabled seamless data transmission to smartphones or the cloud.



SL.NO	Title of the project	Method used (hardware/software Used)	Advantages	drawbacks	Published year
01	smart shoe	system used as software	*self-sustaining power: generate electricity from footstep. * extended battery life: supplements battery power.	*limited power generation: insufficient energy for complex features. *interference :electromagnetic interference affects sensor accuracy	2023
02	design and analysis of smart shoe	software	*Activity tracking: monitors step, distance , calories burned. *injury prevention: detects irregular foot patterns.	*electronic waste: contributes to e-waste generation. *non- biodegradable : harm environment	2023
03	smart shoe based on piezo electric sensors for low power application	software	*navigation: provides turn by trun directions. *fall detection: alert emergency services. *GPS tracking: locates wearer.	*weight increases: heavier shoe due to sensor and battery. *heat generation :electronic heat up.	2023

LR – Paper 2 [1]

Introduction: Piezoelectric substances are the ones that could generate electrical energy from mechanical stress, and this particular belonging has made them a subject of extreme studies in current years. One innovative software of piezoelectric substances is the development of piezoelectric footwear, which harness the mechanical strength generated by way of strolling or going for walks and convert it into electric power. In military and emergency response settings, piezoelectric footwear may want to offer a reliable supply of energy for communique and sensing devices, even in faraway or tough environments.

Methodology:

The foot's motion applies strain to the piezoelectric additives inside the shoe while a person walks or runs, generating minute electric charges. Piezoelectric shoes can electricity performance trackers, to accumulate actual-time data.

Results:

- Energy era: the shoe successfully harnesses mechanical strength from taking walks or running and converts it into electrical energy the use of piezoelectric substances.
- Applications: the generated energy can energy small digital devices or charge batteries, making it useful for numerous applications.
- Layout: piezoelectric materials are embedded in the only or other parts of the shoe that experience frequent pressure or movement.
- Future enhancements: there may be capability for reinforcing electricity efficiency, integrating with other technology, and developing specialized programs for distinct fields.

LR – Paper 2 [2]

Introduction: The introduction highlights the developing importance of wearable microelectronic gadgets in everyday life, emphasizing their role in both civilian and military packages. These gadgets frequently face barriers due to restricted battery existence and environmental concerns related to traditional chemical batteries. As a result, there may be a vast recognition on developing new power supply technologies. Human motion energy harvesting is provided as a promising answer, capable of changing mechanical energy from human activities into electrical power to electricity those devices, thereby extending their operational time and decreasing environmental effect.

Methodology:

- Piezoelectric elements
- Strain optimization
- Matched load:
- Placement Under the Foot

- Electricity supply: walking for 1 hour at forty steps/min generates 2.1 J of power, enough to power a three.3 V tool consuming 10 ma for around a minute.
- Optimization: the quality outcomes had been accomplished by means of the usage of PLA systems to optimize strain and connecting piezoelectric elements one at a time to limit power switch losses.
- Realistic application: the electricity harvested is suitable for emergency electricity wishes on the battlefield, including triggering devices or calling for rescue.

Results:

- Energy harvested: the prototype became capable of harvest 875 μj according to step on common.

LR – Paper 2 [3]

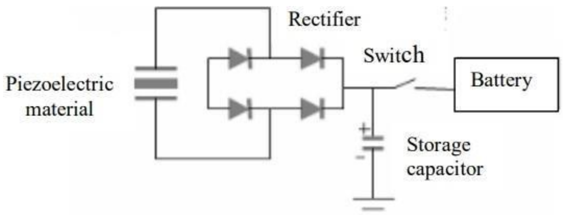
Introduction: The increasing reliance on portable devices and the challenges posed by their need for periodic charging. To address this, the concept of energy harvesting is introduced, specifically using piezoelectric materials to convert mechanical energy from human steps into electrical energy. This harvested energy is then used to power portable devices, such as a tracking system. The tracking system includes a GSM modem, GPS receiver, LCD module, and buzzer, providing a low-cost and reliable life-guarding solution by sending the user's location and battery status in perilous situations.

Methodology: Energy Harvesting: The system uses piezoelectric materials embedded in the shoe sole to convert mechanical pressure from walking into electrical energy.

Power Generation: The harvested energy is converted from AC to DC using a rectifier and filter.

Tracking System: The system includes a GPS receiver, GSM modem, LCD display, and buzzer.

Communication: The system uses UART protocol for serial communication, facilitated by the MAX 232 IC.



Results:

- Energy harvested: the prototype became capable of harvest 875 µj according to step on common.
- Electricity supply: walking for 1 hour at forty steps/min generates 2.1 J of power, enough to power a three.3 V tool consuming 10 ma for around a minute.

SL.NO	Title of the project	Method used (hardware/software Used)	Advantages	drawbacks	Published year
01	Design and Implementation of Piezoelectric Shoe.	Hardware	♦ Energy Harvesting: ♦ Versatility: ♦ Sustainability:	♦ Low Energy Conversion Efficiency: ♦ Limited Power Output:	2023
02	Harvesting energy from a soldier's gait using the piezoelectric effect.	Hardware and software	♦ Increased Autonomy: ♦ Emergency Power: ♦ Lightweight and Compact:	♦ Mechanical Complexity: ♦ Energy Losses:	2024
03	A Review of Piezoelectric Footwear Energy Harvesters.	Hardware	♦ Portable Power Source: ♦ Renewable Energy:	♦ Durability:	2023

LR – Paper 3[1]

Introduction: Innovative advancements in wearable technology have to the creation of smart shoes that combine convenience with functionality. These smart shoes use piezoelectric sensors to generate electrical energy from the wearer’s movements, powering integrated sensors and devices. Designed for enhanced user safety, they feature real-time location tracking and emergency communication, allowing for swift response in critical situations. The piezoelectric sensors provide a continuous power supply, minimizing reliance on traditional batteries. With a sleek, discreet design, these smart shoes appeal to users who prioritize both practicality and security, making them a cutting-edge solution in everyday wearable tech

Methodology: The smart shoe system is an innovative blend of technology and footwear, prioritizing both practicality and user safety. Using piezoelectric sensor technology, it converts the wearer's movement into electrical energy, which powers discreetly embedded sensors and devices. At its core, the Seeed Studio ESP32C3 microcontroller functions as the system's processor, managing sensor operations and communication for safety features. A piezoelectric transducer sensor captures movement-generated stress to produce energy, while an integrated charging module and rechargeable battery ensure continuous power, even during low-activity periods. This system exemplifies how wearable tech can seamlessly support everyday safety and functionality

RESULTS:

The "Real-time Location Tracking Shoe using Piezoelectric Sensors" project highlighted the benefits of embedding piezoelectric sensors in footwear for energy harvesting and location tracking. By converting footfall-generated mechanical stress into electrical energy, the shoe sustainably powers its features and stores this energy in rechargeable batteries. A microcontroller ensures consistent energy regulation, supporting reliable GPS-based real-time location tracking. This successful project underscored the potential of piezoelectric sensors in wearable technology, enhancing both functionality and sustainability in footwear while paving the way for future innovations

LR – Paper 3[2]

Introduction: Piezoelectric materials are an innovative advancement in nanotechnology, with applications in settings like Japan's subway systems, dance floors, and stadiums. The term "piezo" comes from the Greek word meaning "to press," highlighting the material's ability to generate electrical energy under mechanical stress. This phenomenon, called the piezoelectric effect, was first identified by Jacques and Pierre Curie. It includes two main forms: the direct effect, where mechanical pressure generates an electrical charge, and the inverse effect, which converts electrical energy into mechanical movement. Many devices, such as speakers, buzzers, and actuators, utilize the inverse effect to produce sound or motion. Among piezoelectric materials, ceramics are often used for their efficiency, although they can be brittle and toxic

Methodology: In this setup, piezoelectric materials were arranged in a parallel circuit to increase both voltage and current output. Since piezoelectric materials produce AC, a full- wave bridge rectifier was used to convert this to DC, ensuring no reverse current flowed back. A 25V 1000μF capacitor was added to store the generated energy. Though capacitors have limited storage compared to batteries, this capacitor effectively held the low energy output generated by the piezoelectric materials. The circuit's function was verified by lighting an LED, indicating a successful flow of current, with voltage and current measured using a multimeter.

RESULT: A prototype of smart shoes was successfully developed and tested, demonstrating the ability to generate electricity from mechanical movement without relying on fossil fuels. This innovation contributes to sustainable energy by enabling energy storage for future use. However, the energy produced by current piezoelectric materials remains limited, highlighting the need for further advancements. A significant challenge encountered was the brittleness of ceramic piezoelectric materials, which, although efficient at converting mechanical stress to electricity, can break under repeated impacts common in footwear use. Polymer piezoelectric materials, however, offer greater flexibility, providing improved durability and resilience. This flexibility may help enhance energy conversion by maintaining the material's integrity over time. Future smart shoe prototypes should focus on increasing energy generation while finding a balance between material flexibility and energy output.

Optimizing the arrangement and thickness of piezoelectric layers, as well as integrating advanced materials, could lead to more efficient and practical smart shoes.

LR – Paper 3[3]

Introduction: The Internet of Things (IoT) is transforming both business operations and daily life, driven largely by the deployment of distributed electronics in applications such as sensing, therapy, and environmental monitoring. and potential environmental harm. This has led to a search for alternative energy solutions. The biomechanical energy produced by the human body during activities like walking or running offers a promising renewable power source, with footfalls alone capable of generating up to 20 watts of energy. Effectively harnessing this energy could enable wearable electronics to function sustainably and autonomously. This development is particularly relevant as the aging population increases the demand for clinical monitoring tools, especially for gait analysis to help address health concerns such as fall detection, rehabilitation tracking, and the progression of diseases like Parkinson's. While devices like smartphones and fitness trackers can record basic step counts, they often lack the capacity for detailed clinical insights. Additionally, specialized gait monitoring devices tend to be expensive and less accessible to the general public.

Methodology: The triboelectric effect, often seen as a nuisance or safety risk, manifests in static shocks, dust accumulation, and, in extreme cases, fires. However, triboelectric nanogenerators (TENGs) turn this effect into an opportunity by harnessing mechanical energy from the environment and converting it into electrical energy through contact electrification and electrostatic induction. The triboelectric effect occurs when two materials with different electron affinities come into contact and then separate, creating an electric charge transfer. This interaction is explained by the "triboelectric series," which categorizes materials based on their tendency to gain or lose electrons. This interaction is explained by the "triboelectric series," which categorizes materials based on their tendency to gain or lose electrons. Materials lower on the series, like PTFE and silicone rubber, tend to gain electrons and become negatively charged, while those higher up, such as metals and nylon, are more likely to lose electrons and become positively charged. The effectiveness of charge transfer increases when the materials involved are farther apart on the triboelectric scale

RESULTS:

Smart shoes are being designed to harness human biomechanical energy and convert it into electrical power, but they can also capture energy from various renewable sources in the environment. This includes energy from raindrops hitting the shoe's surface, wind blowing against it, and the friction created by walking on snow. Leveraging these additional energy sources can boost the total amount of electricity generated, complementing the energy derived from human movement. As technology and artificial intelligence continue to advance, smart shoes have the potential to offer more than just energy generation.

SL.NO	Title of the Project	Method used(hardware/software)	Advantages	Drawbacks	Published year
01	SMART SHOE WITH GPS TRACKING	software	1. Enhanced Safety – Real-time location tracking 2. User Convenience – Hands-free navigation	1. Battery Dependency – Limited usage time 2. Privacy Concerns – Potential data vulnerability	2024
02	Development of Smart Shoes Using Piezoelectric Material	Hardware	1.Self-Powering – Energy generation from movement 2. Enhanced Durability – Fewer battery replacements	1. Limited Power Output – Insufficient for high-energy functions 2. Complex Design – Challenges in integration and durability	2021
03	Triboelectric Nanogenerator Enabled Smart Shoes for Wearable Electricity Generation	Hardware	1. Continuous Power Generation – Harvests energy from walking 2. Lightweight Design – Minimal impact on comfort	1. Low Efficiency – Limited power generation 2. Durability Issues – Wear and tear from continuous use	2020

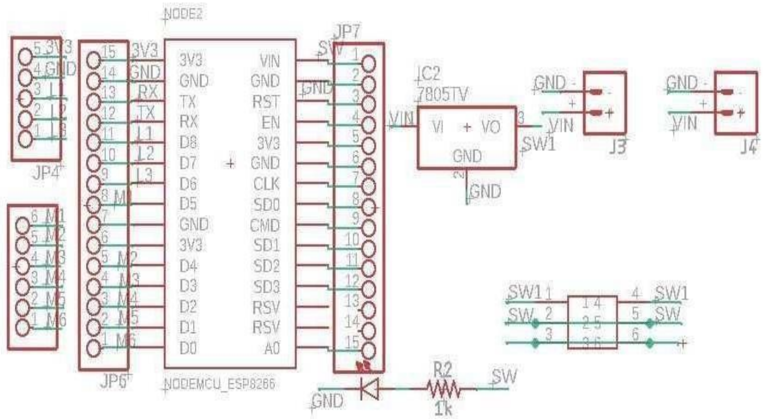
LR – Paper 4[1]

Introduction: The navigation itself gets turned on its head with this groundbreaking research, for people with visual impairments to the experience a smart, affordable new Internet supported Smart Blind Mechanism Things (IoT) sensors. One of the main goals of the The device claims that it can assist you with serious indoor and outdoor navigation problems. This device does very well in real-time hazards detecting due to the incorporation of modern IoT technology,

delivering deep insights to its users Read: feedback of own environment

Methodology:

- Research Approach
- Data Collection Methods
- Ultrasonic Sensors Testing
- evaluation of the GPS module
- The GPS module and panic button features



RESULT:

Produces 3 different buzzing patterns for the accurate detection of the object by the sensors and at the same time, based on the direction of the obstacle, it will produce a different pattern. We can change the distance range up to 300 cm and as low as 10 cm by rotating the knob placed on the top surface of our device. After uploading to IFTTT server, press button, it will receive info from Neo 6M GPS module finding the exact latitude and longitude of the current position, then make it into a Google Maps link and complete uploading to IFTTT server response. Successfully sends the uploaded message as an Android SMS to the stored emergency contact using the Webhook server

LR – Paper 4[2]

Introduction: In today's society, energy abundance appears to be a thing of the past.
Market forces are raising electricity prices and the depletion of fossil fuel sources is becoming more and more pronounced resulting in ambient dampening of abundance of energy. A viable solution in turning this situation is energy harvesting. Energy harnessing is the process of collecting energy from sources such as noise and sound that would otherwise be lost. Energy harvesting instigates the generation of little energy which is sufficient to power low-cost devices. Also, energy harvesting provides an alternative to batteries for devices that consume minimum power. Piezoelectric sensors can convert environmental cues into energy that can later on be used to power other devices, and due to this, backup power sources such as batteries are unnecessary for MEMS devices

Methodology. I worked with varying frequencies to convert AC input into DC and explained that piezoelectric materials generate AC when a stress is applied to them. the prototype of smart shoes was prepared using ceramic type piezoelectric materials. The Piezoelectric materials were embedded inside the shoes, especially the heels of the shoes. So, it was the reason why the heel area received more force than the toe area

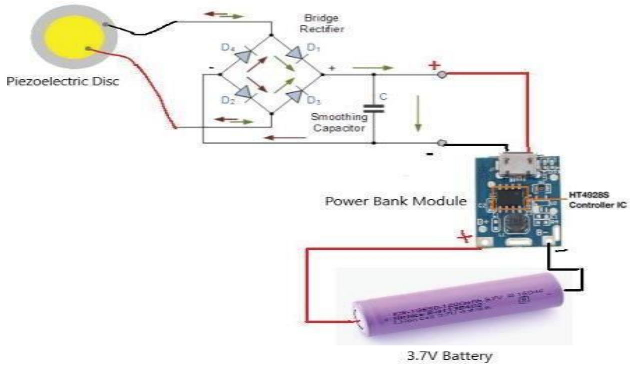


Fig. 2. A Circuit diagram of the battery charging circuit

RESULT: Impressions using piezoelectricity. In order to do this, piezoelectric sensors were flipped in order to create a current when people walked, when people ran and when people jumped. In essence, they embedded mechanical tension on the sensors which was then electrically converted and stored within a battery. The energy that was stored was later used to operate several units like the Arduino board that was responsible for monitoring and display the current location of the user onLCD.

LR – Paper 4[3]

Introduction: This research work suggests the idea of a smart shoe technology called Step Safe that integrates IoT- based hardware into a shoe. The shoe is designed in such a way, that it has a GPS module along with auto SMS delivery system which when geotagging sends notifications to the emergency contacts whenever the person is in different locations. For this purpose, the AI Thinker A9G GSM and GPS module is employed. To make things easier, an android application is also provided which helps look for the user's location Currently, it can also help in capacity to store and control users which may be other emergency contacts. The Firebase platform is recommended for using the database where application credentials and other information related to the application will be stored. In an all- inclusive wide range of systems, these units when put together give the system

Methodology: The introduction of new technology such as smartphone apps, smart security devices, and even smart wearables has brought with it new possibilities in terms of safety and security of women. To investigate the available options, a literature review was conducted, which consisted of a comparative evaluation of a number of applications on Android and other platforms that remotely control. One such GPS application allows Android users to determine the person's location over the phone by providing root device introduced as victim's phone and mobile phone of registered contacts

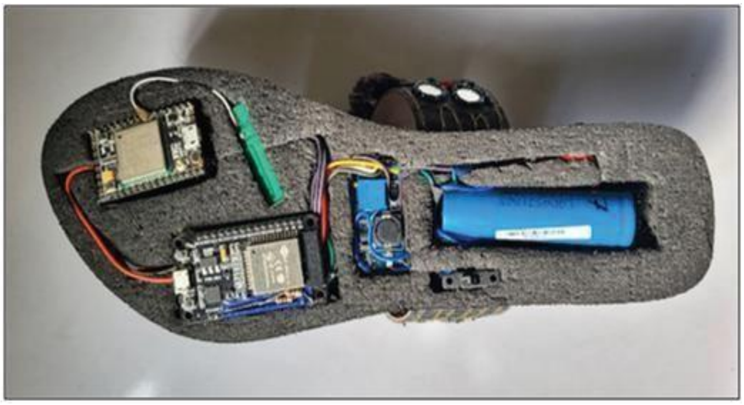


Fig. 4. Step Safe (internal circuit connection)

RESULT:the system is set up so that it can be inserted in a shoe of any kind so that the attacker cannotnecessarily see the safety mechanism in a shoe. The female, becomes will send to her current location. by activating a limit switch in the shoe, via

the act of unsafe removal. This is accomplished by removing the Step Safe shoe from the foot without When done, click the safe removal button. What it does Here are a few of the key features of our Step Safe app For an introductory period for women using the app for her to sign in/sign up.The app is connecting to the firebase database for user storage.

SL.NO	Title of the project	Method used (hardware/software Used)	Advantages	drawbacks	Published year
01	Real-time Location Tracking Shoe using Piezoelectric Sensors:	Hardware	♦ Energy Harvesting: ♦ Enhanced safety: ♦ Health monitoring	♦ Low Energy Conversion Efficiency: ♦ Limited Power Output:	2023
02	A Smart Device for Real-Time Assistance to the Visually Impaired People	Hardware and software	♦ Object Recognition Emergency Power: ♦ increased Independence	♦ high cost ♦ sensor limitation	2024
03	Smart shoes for women safety with implicit triggers	Hardware and software	♦ Enhanced Safety ♦ GPS Tracking ♦ Panic Button	♦ Durability: ♦ sensor Limitations ♦ Complexity	2023

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[11]O. Kasabekar, S. Jeurkar, R. Kamble, R. Srivel and M. Kamble, "A Smart Device for Real-Time Assistance to the Visually Impaired People," *2024 10th International Conference on Communication and Signal Processing (ICCSP)*, Melmaruvathur, India, 2024, pp. 24-29, doi: 10.1109/ICCSP60870.2024.10544056.

[12]M. Dhore, H. Bhatia, S. Bagav, P. Kadam and A. Dhuri, "Smart Shoes for Women Safety with Implicit Triggers," *2023 World Conference on Communication & Computing (WCONF)*, RAIPUR, India, 2023, pp. 1-6, doi: 10.1109/WCONF58270.2023.10235229.

Chapter 3:

Methodology

Proposed Methodology Components:

1.27mm piezoelectric sensor

2.Bluetooth HC-05 module

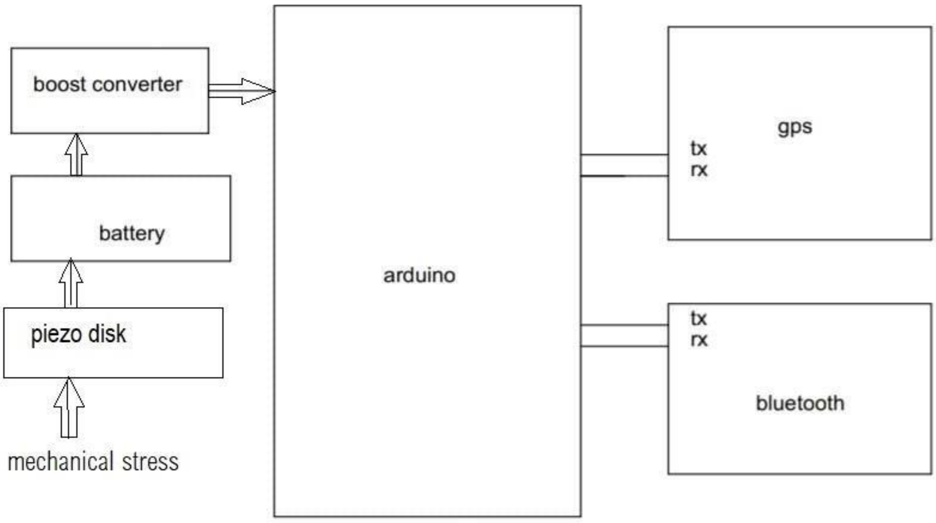
3.GPS-08 module

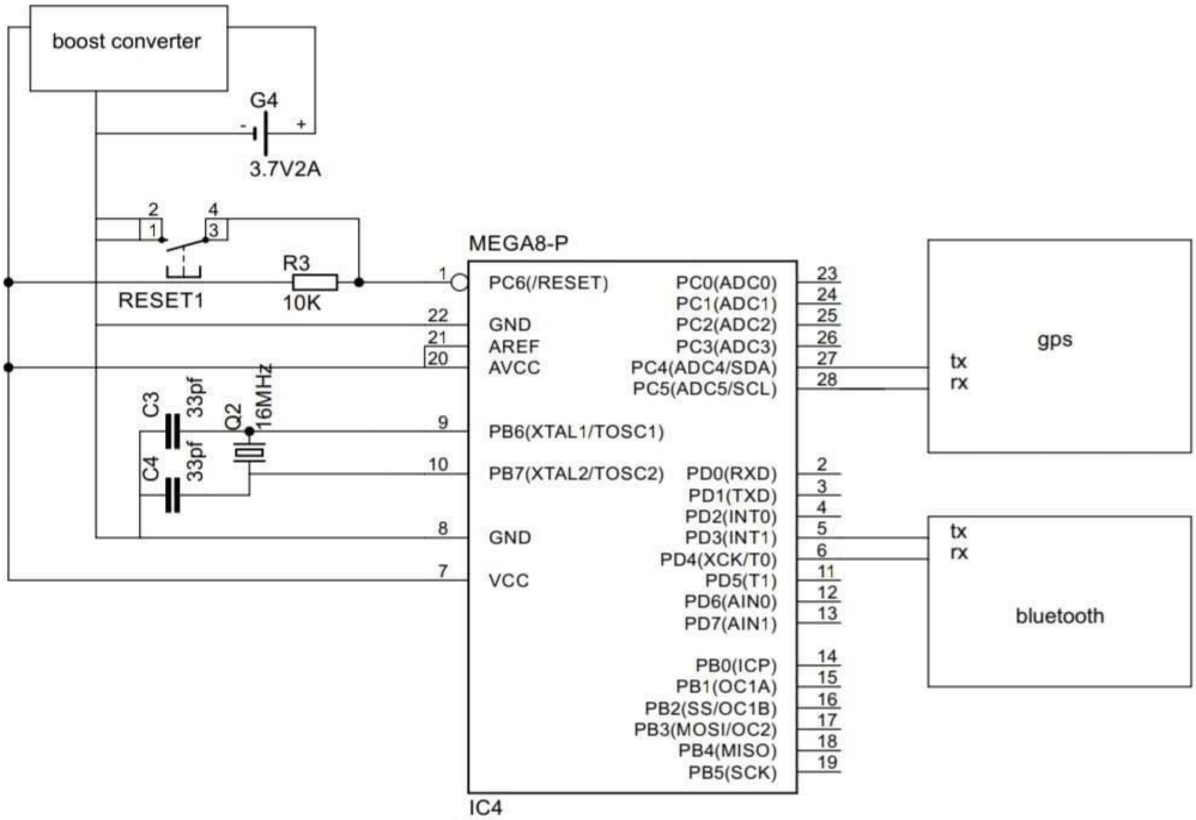
4.1400mAh battery

5.Arduino Uno

Chapter 3: Implementation & Results

Block Diagram





Constructional Details:

- Materials used and their costs :

1.27mm piezoelectric sensor

2.Bluetooth HC-05 module

3.GPS-08 module

4.1400mAh battery

5.Arduino Uno

1.27mm piezoelectric sensor:

1. Piezoelectric Material Fabrication: The piezoelectric material is fabricated using a process such as sol-gel processing or sintering.

2. Electrode Deposition: The electrodes are deposited onto the piezoelectric material using a process such as sputtering or electroplating.

3. Insulation Application: The insulation material is applied to the electrodes using a process such as screen printing or spray coating.

4. Housing Assembly: The sensor is assembled into the housing, which is typically ultrasonically welded or adhesively bonded.

5. Connector Attachment: The connectors are attached to the sensor using a process such as soldering or crimping.

Dimensions:

The 27mm piezoelectric sensor has the following dimensions:

2.**Bluetooth HC-05 module**

1. PCB Layout: The components are mounted on a small PCB (Printed Circuit Board) with a size of approximately 1.5 cm x 2.5 cm.

2. Component Placement: The components are carefully placed on the PCB to minimize interference and ensure reliable operation.

3. Soldering: The components are soldered to the PCB using a reflow soldering process.

3.GPS-08 module

1. PCB Layout: The components are mounted on a small PCB (Printed Circuit Board) with a size of approximately 1.5 cm x 1.5 cm.
2. Component Placement: The components are carefully placed on the PCB to minimize interference and ensure reliable operation.

3. Soldering: The components are soldered to the PCB using a reflow soldering process.

4. Wire Bonding: The GPS chip is connected to the PCB using wire bonding.

5. Encapsulation: The module is encapsulated in a plastic package to protect the components from environmental stress.

4.1400mAh battery

1.Cell Assembly: The anode, cathode, electrolyte, and separator are assembled into a cell.

2. Cell Connection: Multiple cells are connected in series and/or parallel to form a battery pack.

3. Packaging: The battery pack is enclosed in a housing, which may include additional features like thermal management and electrical protection.

4. Terminal Connection: The terminal connectors are attached to the current collectors and the housing.

5. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button.

Programming

```
#include <SoftwareSerial.h> #include
<TinyGPS.h>

/* This sample code demonstrates the normal use of a TinyGPS object.
 It requires the use of SoftwareSerial, and assumes that you have a   4800-baud serial GPS device
hooked up on pins 4(rx) and 3(tx).
```

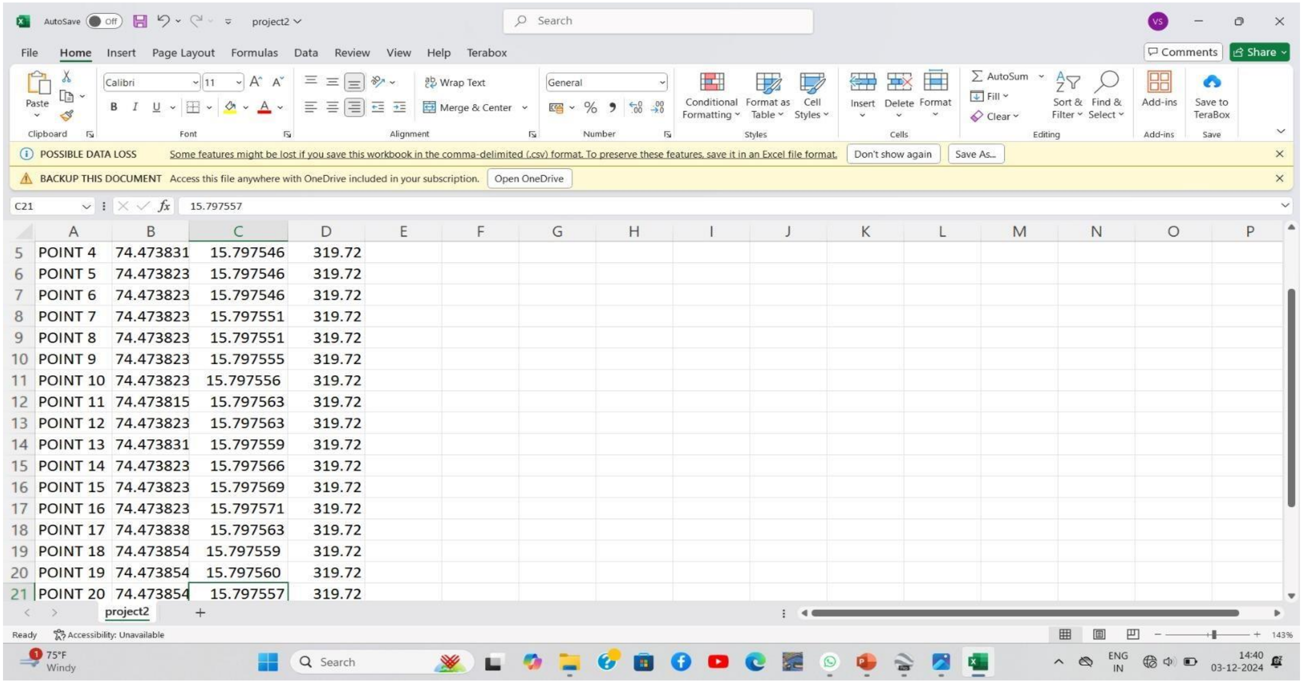
```
*/TinyGPS gps; SoftwareSerial
ss(8,9);
static void smartdelay(unsigned long ms);
static void print_float(float val, float invalid, int len, int prec);
static void print_int(unsigned long val, unsigned long invalid, int len);
static void print_date(TinyGPS &gps);static void print_str(const char *str, int len);
void setup()
{          Serial.println("        (deg)    (deg)     Age                  Age  (m)    --- from GPS ----
         ---- to London  ----  RX    RX        Fail");   Serial.println("-----------------------------------
Serial.begin(9600);- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 Serial.println();
Serial.println("Sats HDOP Latitude  Longitude  Fix  Date  Time Date Alt     Course Speed Card
Distance Course Card  Chars Sentences Checksum");
 ");
 ss.begin(9600);
 }
 void loop()
 {
 float flat, flon;
 unsigned long age, date, time, chars = 0; unsigned
  short sentences = 0, failed = 0;
 static const double LONDON_LAT = 51.508131, LONDON_LON = -0.128002;
 print_int(gps.satellites(),
 TinyGPS::GPS_INVALID_SATELLITES, 5);
 print_int(gps.hdop(),           TinyGPS::GPS_INVALID_HDOP,          5);
  gps.f_get_position(&flat, &flon, &age);
  print_float(flat, TinyGPS::GPS_INVALID_F_ANGLE, 10, 6);
  print_float(flon, TinyGPS::GPS_INVALID_F_ANGLE, 11, 6);
 print_int(age,           TinyGPS::GPS_INVALID_AGE,          5);
  print_date(gps);
```

```
print_float(gps.f_altitude(), TinyGPS::GPS_INVALID_F_ALTITUDE, 7, 2);
print_float(gps.f_course(), TinyGPS::GPS_INVALID_F_ANGLE, 7, 2);
print_float(gps.f_speed_kmph(),        TinyGPS::GPS_INVALID_F_SPEED,        6,        2);
print_str(gps.f_course() == TinyGPS::GPS_INVALID_F_ANGLE ? "*** " :

TinyGPS::cardinal(gps.f_course()), 6); print_int(flat == TinyGPS::GPS_INVALID_F_ANGLE ? 0xFFFFFFFF : (unsigned long)TinyGPS::distance_between(flat, flon, LONDON_LAT, LONDON_LON) / 1000, 0xFFFFFFFF, 9);

print_float(flat == TinyGPS::GPS_INVALID_F_ANGLE ? TinyGPS::GPS_INVALID_F_ANGLE : TinyGPS::course_to(flat, flon, LONDON_LAT, LONDON_LON), TinyGPS::GPS_INVALID_F_ANGLE, 7, 2);

print_str(flat == TinyGPS::GPS_INVALID_F_ANGLE ? "*** " : TinyGPS::cardinal(TinyGPS::course_to(flat, flon, LONDON_LAT, LONDON_LON)), 6); gps.stats(&chars, &sentences, &failed);

print_int(chars, 0xFFFFFFFF, 6);

print_int(sentences, 0xFFFFFFFF, 10);
print_int(failed, 0xFFFFFFFF, 9); Serial.println();

smartdelay(1000);

}

static void smartdelay(unsigned long ms)

{
unsigned long start = millis(); do

{

while                    (ss.available())
 gps.encode(ss.read());

} while (millis() - start < ms);

}
```

```
static void print_float(float val, float invalid, int len, int prec)

{

  if (val == invalid)

{

  while (len-- > 1) Serial.print('*');

  Serial.print(' ');

}

else

{

 Serial. print(val, prec);


  int vi = abs((int)val);

  int flen = prec + (val < 0.0 ? 2 : 1); // . and -     flen += vi >= 1000 ? 4 : vi >= 100 ? 3
: vi >= 10 ? 2 : 1;
 for (int i=flen; i<len; ++i) Serial.print('
  ');

}

smartdelay(0);

}

static void print_int(unsigned long val, unsigned long invalid, int len)

{

char sz[32];
 if (val == invalid) strcpy(sz,
 "*");

else    sprintf(sz, "%ld", val);
sz[len] = 0;  for (int i=strlen(sz); i<len; ++i) sz[i] = ' ';
if (len > 0) sz[len-1] = ' ‘;
```

```
Serial.print(sz); smartdelay(0);}

static void print_date(TinyGPS &gps)

{

int year; byte month, day, hour, minute, second, hundredths; unsigned long age;
gps.crack_datetime(&year, &month, &day, &hour, &minute, &second, &hundredths, &age);

if (age == TinyGPS::GPS_INVALID_AGE)
  Serial.print("********** ******** ");

else{

 char sz[32];   sprintf(sz, "%02d/%02d/%02d %02d:%02d:%02d ",    month, day, year, hour,
minute, second);                Serial.print(sz);
 }
 print_int(age, TinyGPS::GPS_INVALID_AGE, 5); smartdelay(0);

}

static void print_str(const char *str, int len)

{

 int slen = strlen(str);

for (int i=0; i<len; ++i)   Serial.print(i<slen ? str[i] : ' ');  smartdelay(0);}
```

RESULTS:



	A	B	C	D
5	POINT 4	74.473831	15.797546	319.72
6	POINT 5	74.473823	15.797546	319.72
7	POINT 6	74.473823	15.797546	319.72
8	POINT 7	74.473823	15.797551	319.72
9	POINT 8	74.473823	15.797551	319.72
10	POINT 9	74.473823	15.797555	319.72
11	POINT 10	74.473823	15.797556	319.72
12	POINT 11	74.473815	15.797563	319.72
13	POINT 12	74.473823	15.797563	319.72
14	POINT 13	74.473831	15.797559	319.72
15	POINT 14	74.473823	15.797566	319.72
16	POINT 15	74.473823	15.797569	319.72
17	POINT 16	74.473823	15.797571	319.72
18	POINT 17	74.473838	15.797563	319.72
19	POINT 18	74.473854	15.797559	319.72
20	POINT 19	74.473854	15.797560	319.72
21	POINT 20	74.473854	15.797557	319.72

Conclusion:

Objective 1:-

Real-time location tracking can greatly enhance soldiers' safety and security in various environments by providing precise, real-time data on their whereabouts. This enables commanders to monitor soldiers' positions, coordinate responses in critical situations, and ensure timely rescue operations in case of emergencies.

Objective 2:- Generating electricity through piezoelectric technology to power GPS and other features offers a promising solution for energy efficiency, particularly in portable and remote devices. By converting mechanical stress into electrical energy, piezoelectric systems

can provide a sustainable power source for devices like wearables, sensors, and GPS trackers without relying on traditional batteries.

Objective 3:- Efficient emergency response and communication are crucial for saving lives and minimizing damage. Real-time data sharing, rapid communication,

Limitations:

1. Low Energy Conversion Efficiency: The energy conversion efficiency of piezoelectric shoes is relatively low. This means that the amount of electrical energy generated from mechanical pressure is not very high, limiting the practical applications of the technology.

2. Limited Power Output: The amount of power generated by piezoelectric shoes is limited and may not be sufficient to power larger electronic devices. The technology is more suitable for low-power applications.

3. Mechanical Complexity: Integrating piezoelectric elements into footwear requires careful design to ensure they are not damaged and do not affect the comfort of the wearer.

4. Energy Losses: There are inherent energy losses in the system, particularly in the conditioning circuit and during the energy transfer process.

5. Durability: The piezoelectric elements and associated components must be durable enough to withstand the harsh conditions of the battlefield, which can be challenging to achieve.

Further extension:

- Health Monitoring: Integrate additional sensors to track vital signs, such as heart rate, blood pressure, and oxygen levels.
- Navigation Assistance: Provide audio or vibrational cues to assist visually impaired individuals with navigation.
- Fitness Tracking: Enhance fitness tracking features by incorporating machine learning algorithms to analyze running or walking patterns, providing personalized coaching and recommendations.
- Smart Home Integration: Enable seamless integration with smart home systems, allowing users to control lighting, temperature, and security systems with their smart shoes.
- Social Sharing: Develop a social platform for users to share their fitness achievements, connect with fellow runners or walkers, and participate in challenges.
- Environmental Monitoring: Incorporate sensors to track environmental factors such as air quality, noise pollution, and UV exposure.
- Augmented Reality: Integrate augmented reality (AR) features, enabling users to visualize their surroundings, track their progress, and receive real-time feedback.
- Biomechanical Analysis: Use machine learning and sensor data to analyze users' running or walking biomechanics, providing personalized recommendations for improvement.
- Energy Harvesting: Explore the use of piezoelectric sensors to harvest energy from the user's movements, extending the battery life of the smart shoes.