SPRING SEMESTER 2021-22

Section 12

Sub-Section 2

Group 3

INDIAN INSTITUTE OF TECHNOLOGY

KHARAGPUR

[DIY GROUP PROJECT]

Section-12

Sub-Section 2

Group-3

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TOPIC

Energy Harvesting Through Roads/Footpaths

ACKNOWLEDGEMENT

I take this opportunity to express my profound gratitude and deep regards to my teachers **Prof**. **Poulomi Ganguli Ma'am**, and **Prof**. **Manjunatha Mahadevappa Sir** & our **T.A Aparna Raut Ma'am** for their exemplary guidance, monitoring, and constant encouragement throughout the course of this project. The blessing, help, and guidance given by them from time to time shall carry me a long way in the journey of life on which I am about to embark.

CONTENTS

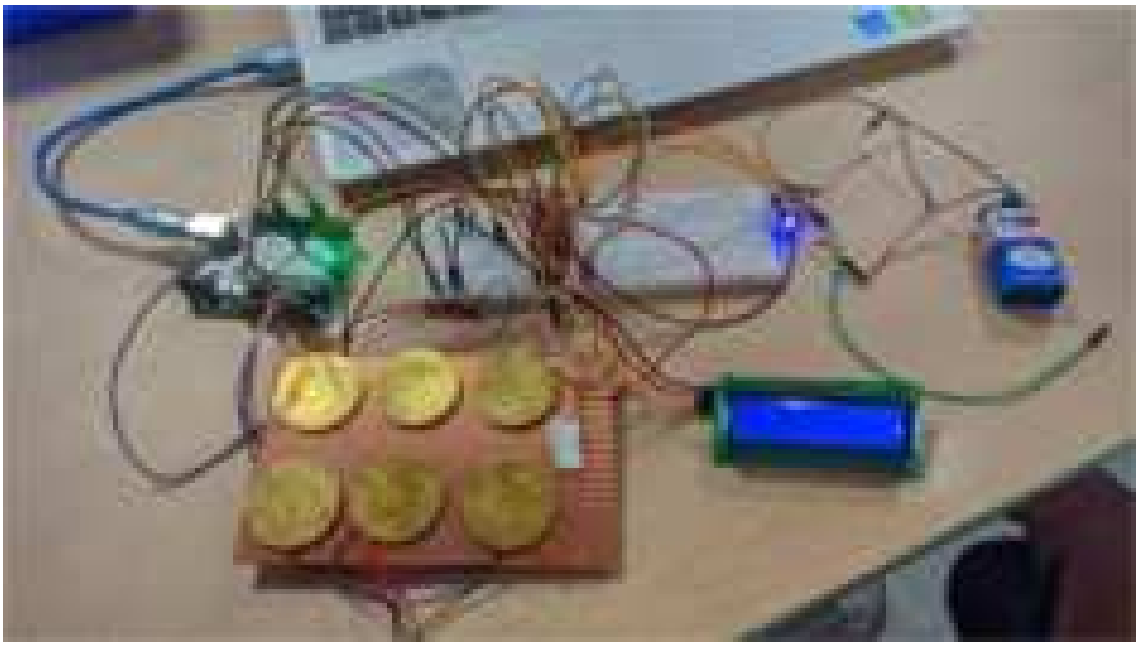
INTRODUCTION

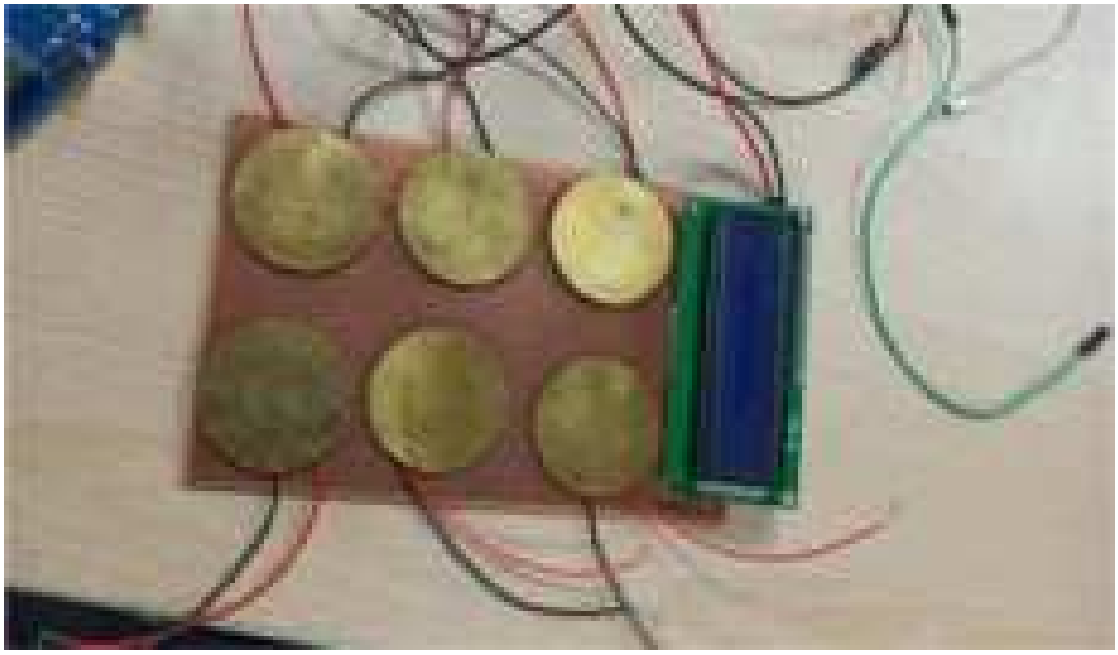
At present, electricity is the necessary part of the human life in daily activities and demand of electricity is increasing exponentially day by day. Modern technology requires a vast amount of power in the form of electricity for its different operations. Worldwide electricity generation contributes maximum in pollution as the single largest source. Also, exponential increasing demands of electricity creating a large gap between demand and supply. Due to this, researcher and innovators working in the field of energy harvesting are trying to explore the alternate sources of energy and its feasible use. Accordingly, main objective of present day technology is to invent and provide a pollution free method of electricity from the growing human population that does not negatively impact the environment. In this technology, piezoelectric effect is used to generate the electricity. When pressure and strain are applied to a material which shows piezoelectric effect have the capability to build up an electrical charge. Piezoelectric sensors generate electricity when we apply pressure on the sensors as shown in figure below.

Piezoelectric materials act as a transducers and pressure exerted by the moving people transformed into electric current. This paper presents the design of power generation using footstep based on piezoelectric sensors with detailed study of their merits, demerits, the sub equipment and their requirements. Many Research groups are actively working in the area of footstep power generation using piezoelectric methodology.

MOTIVATION

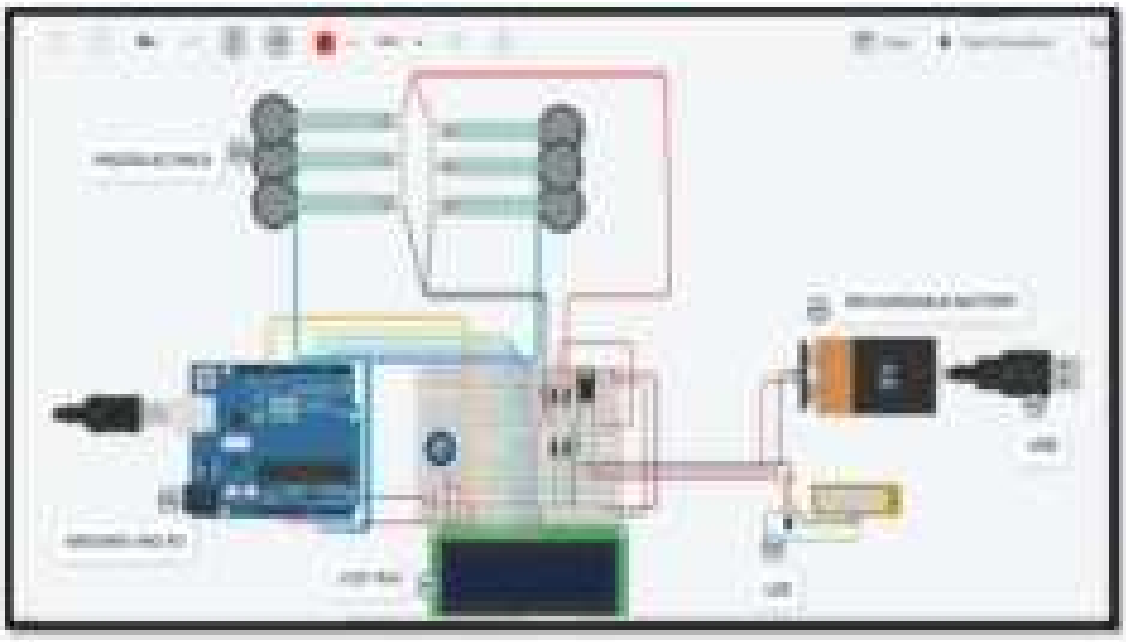
- This project serves a solution to the problem of **'Power Crisis'**.
- Our own country is itself facing a power crisis as of now.
- This method of energy harvesting can replace Thermal Energy.
- Doesn't emits pollutants, **Green solution** for power generation.
- As of now, whole world depends majorly on **coal** for Electricity which has **High Carbon Emissions**, contributes to **Climate Change**.
- The average steps per day over 200 men and women are around **7,192** steps and **5,210 steps** respectively.





WORKING

Piezoelectric ceramics fit to the group of ferroelectric materials. The piezoelectric effect is common in piezo ceramics like PbTiO3, PbZrO3, and PZT. Heart of the present footstep power generator is the piezoelectric sensor which works as shown in Figure.

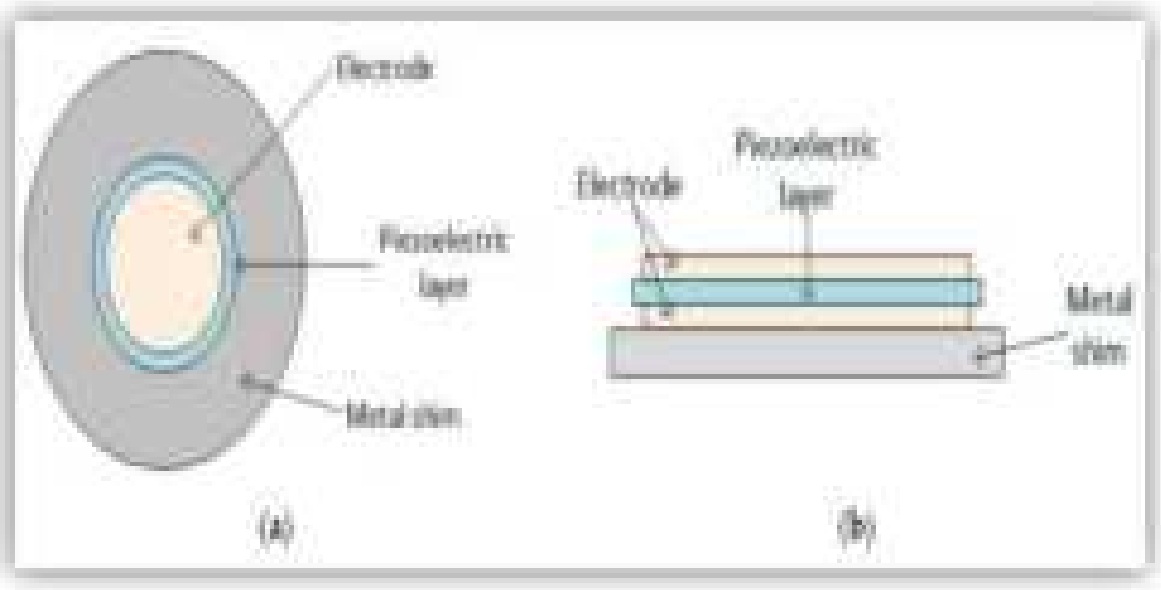


In this present footstep power generator, the piezoelectric material plays a great role so its choice is of great importance. PZT and PVDF are the two most commonly available piezoelectric materials, so an analysis on these two materials was carried out, to chose the most suitable material. The basis for selection was better output voltage for various pressures applied.

As Shown in Figure, The physical foot interface is layed on chain sprocket arrangement and spring which is connected to the piezoelectric sensors. The sensors generate AC voltage which is converted to DC supply using DC generators; the DC outputs will be stored in two (six volt each) batteries that are connected to an inverter which will convert 12V to 220V AC. The AC output power will used in running of load.

Piezoelectric sensors are the sensors that will be producing AC voltage so in order to convert the AC voltage into DC we will be using general purpose diode i.e.1N4001 series. This is followed by a capacitor, and the capacitor charged by the rectifier. Charging threshold voltage of this capacitor is pre-decided and at this voltage the switch closes and discharging of capacitor takes place through the device.

INTERNAL STRUCTURE OF PIEZOELECTRICS



COMPONENTS

S.No	Part Name	Quantity	Technical specifications	Cost
1.	**Arduino Uno R3**	**1**	**Dig. Pins - 14 Analog Pins - 6**	**₹998**
2.	**Breadboard**	**1**	**840 Tie Points**	**₹91**
3.	**Piezo Electric Sensor**	**6**	**Imped. ≤ 500Ω Voltage ≤ 30V**	**₹50x4**
4.	**LCD display**	**1**	**16x2 Display**	**₹229**
5.	**LEDs**	**2**	**-**	**₹3**
6.	**Resistors**	**2**	**1kΩ**	**₹2 each**
7.	**Capacitors**	**1**	**25V, 100uF**	**₹20**
8.	**Diodes**	**4**	**1N4007**	**₹3**
9.	**Battery**	**1**	**Rechargable**	**₹500**
10.	**Wires**	**-**	**Multi-thread**	**₹100**
TOTAL COST-1700 Rs.				

Arduino Uno

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc.The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced with various expansion boards (shields) and other circuits. [1] The board has 14 digital I/O pins (six capable of PWM output), and 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. [4] It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. [5][6] The hardware reference design is distributed under a Creative Commons Attribution-Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available.

The word "uno" means "one" in Italian and was chosen to mark the initial release of Arduino Software. [1] The Uno board is the first in a series of USB-based Arduino boards; version 1.0 of the Arduino IDE was the reference version of Arduino, which has now evolved to newer releases.

The ATmega328 on the board comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. While the Uno communicates using the original STK500 protocol, [1] it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Jumper Wires

A jump wire (also known as jumper, jumper wire, jumper cable, DuPont wire, or cable) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is usually used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

CAPACITOR

ZENER DIODE

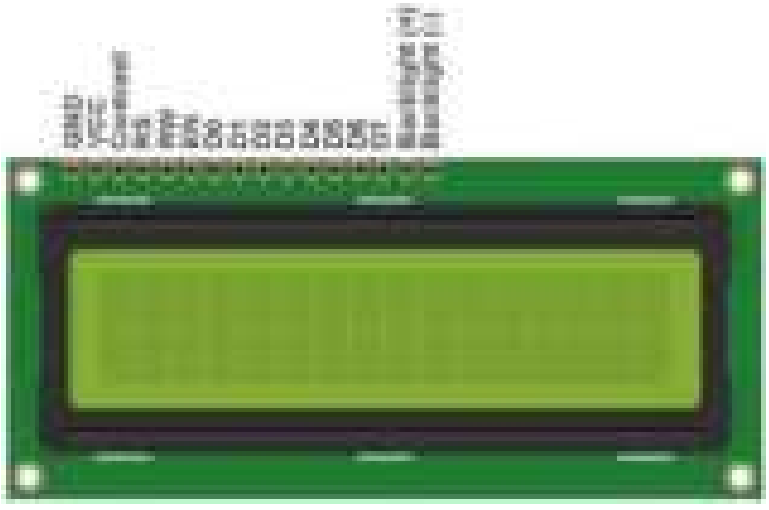
BREADBOARD

PIEZOELECTRIC SENSORS

Piezoelectric products known as piezo sensors detect changes in the environment and convert them into electrical energy. A piezoelectric sensor senses mechanical changes in the environment and produces a useable electrical signal output, which can be used to measure the mechanical changes or generate displacement with the electrical output. Piezo sensors take on two forms to accomplish this: active and passive. Active PZT sensors use a transmitter-receiver system releasing intermittent ultrasonic pulses to gauge the environment. Passive PZT sensors, as the name implies, wait for a signal, like a microphone, and convert that into output. These piezo sensors operate below their resonant frequency for maximized range. Piezoelectric sensors are mostly used in measuring vibrations, acceleration, strain, force, and movement. They are utilized for infinite applications across a broad range of industries due to their ability to both operate in confined spaces and high temperatures, and yield high frequency response.

LCD

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even.



ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. [3] It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. [4] The source code for the IDE is released under the GNU General Public License, version 2. [5] The Arduino IDE supports the DIY PROJECT REPORT | SECTION 17 | TEAM 17 | PAGE 15 OF 22 languages C and C++ using special rules of code structuring. [6] The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, which is compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. [7] The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. [8] By default, avrdude is used as the uploading tool to flash the user code onto official Arduino boards. [9] Arduino IDE is a derivative of the Processing IDE, [10] however as of version 2.0, the Processing IDE will be replaced with the Visual Studio Code-based Eclipse Theia IDE framework. [2] Arduino Pro IDE Developer(s) Arduino Software Preview release v0.1.2 / 14 September 2020; 9 months ago [11] Repository github.com/arduino/Arduino Written in C, C++ Operating system Windows, macOS, Linux Platform IA-32, x86-

64, ARM Type Integrated development environment License LGPL or GPL license Website blog.arduino.cc/2020/08/24/cli-and-ide - get-better-together/ With the rising popularity of Arduino as a software platform, other vendors started to implement custom open-source compilers and tools (cores) that can build and upload sketches to other microcontrollers that are not supported by Arduino's official line of microcontrollers

CHALLENGES FACED BY TEAM

- **Unavailability of certain materials (of exact specifications)**

Material	Req. Specification	Replacement
Diode	1N4007	3V
Capacitor	25V, 100uF	100uF

- **Debugging Code**

- **Adjusting data acquisition softwares with PC was a bit difficult.**

- **Controlling higher voltage(>5V) generation.**

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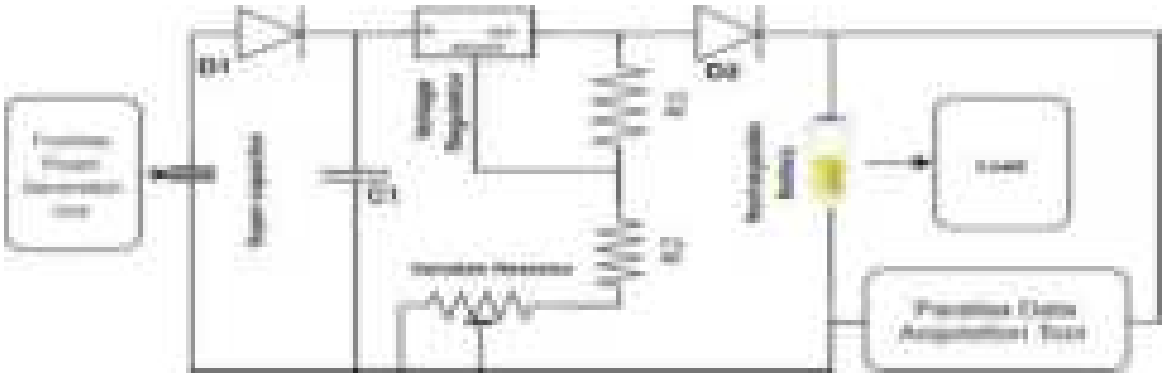
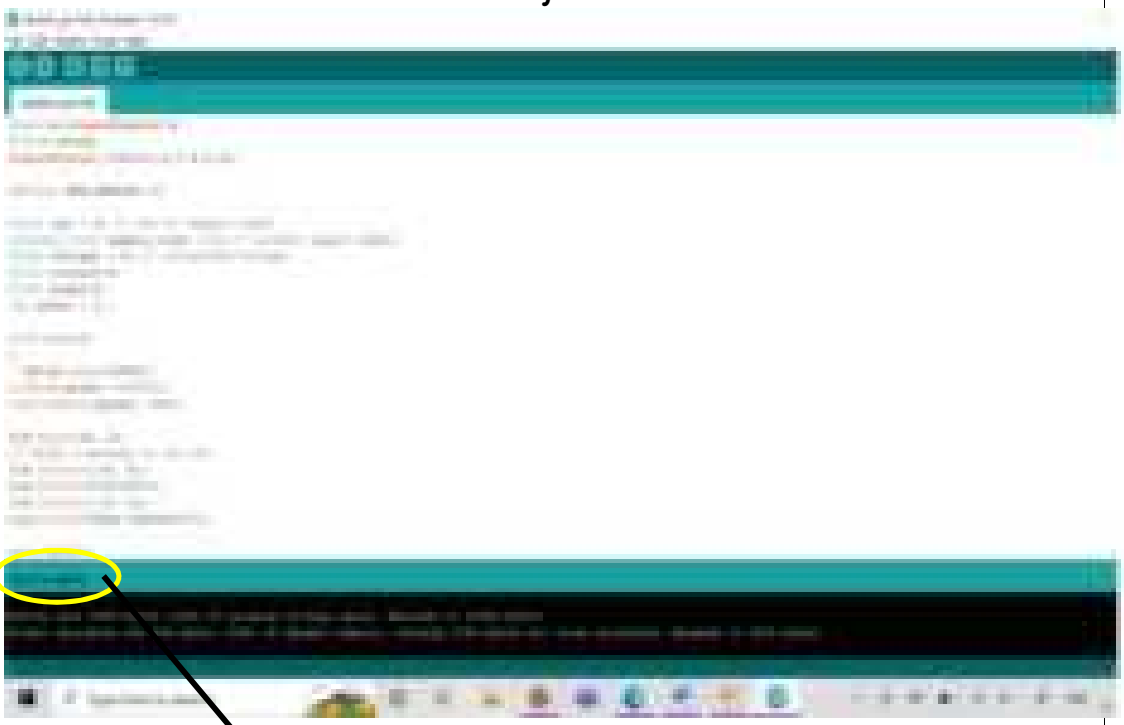
CIRCUIT DIAGRAM



CODE

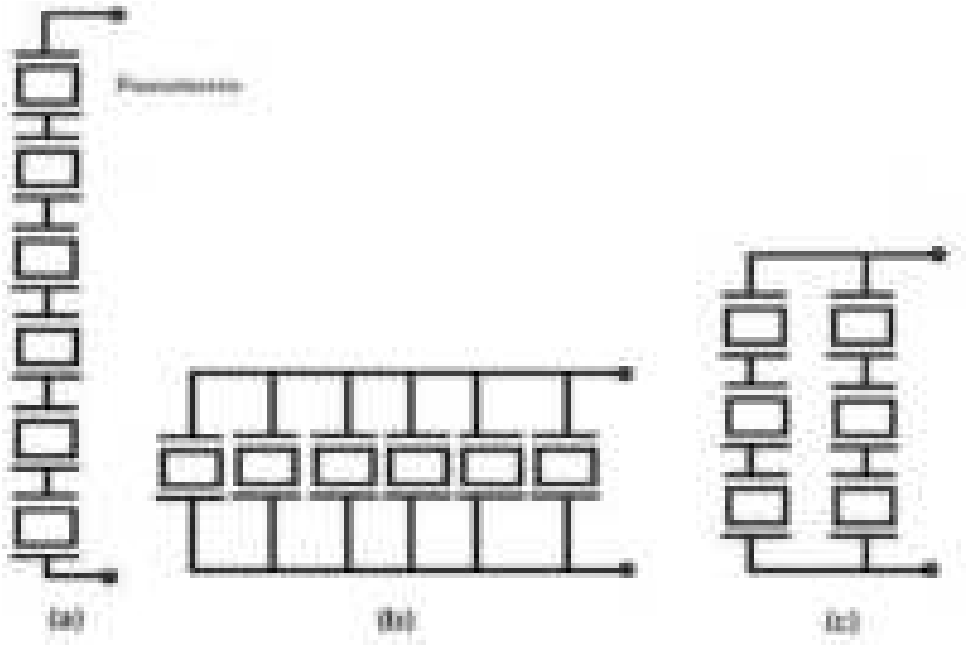
```
#include &lt;LiquidCrystal.h&gt;
LiquidCrystal lcd(3, 5, 9, 10, 11, 12);
#define NUM_SAMPLES 10
int sum = 0; // sum of samples taken
unsigned char sample_count = 0; // current sample number
float voltage = 0.0; // calculated voltage
int green = 2 ;
void setup()
{
pinMode(green, OUTPUT);
digitalWrite(green, LOW);
lcd.begin(16, 2);
// Print a message to the LCD.
lcd.print(&quot;FOOT STEP&quot;);
lcd.setCursor(0, 1);
lcd.print(&quot;POWER GENERATION&quot;);
delay(4000);
//Serial.begin(9600);
lcd.clear();
lcd.print(&quot;Volt Generated:-&quot;);
}
void loop()
{
// take a number of analog samples and add them up
/*
while (sample_count &lt; NUM_SAMPLES)
{
sum += analogRead(A0);
sample_count++;
delay(10);
}
*/
// calculate the voltage
// use 5.0 for a 5.0V ADC reference voltage
// 5.015V is the calibrated reference voltage
sum = analogRead(A0)
if(sum&gt;=180)
{
digitalWrite(green, HIGH);
}
voltage = ((float)sum * 5.015) / 1024.0;
```

```
// send voltage for display on Serial Monitor
// voltage multiplied by 11 when using voltage divider that
// divides by 11. 11.132 is the calibrated voltage divide
/* Serial.print(voltage * 11.132);
Serial.println (&amp;quot; Voltage&amp;quot;);
*/
voltage = ((float)voltage * 11.132);
lcd.setCursor(0, 1);
lcd.print(voltage);
delay(400);
sample_count = 0;
sum = 0;
digitalWrite(green, LOW);
}
```



CODE COMPILES SUCCESSFULLY

ANALYSIS



Across 3 possible circuit connections, we determined the Average Power generated as:

a) **Series Connection- 2.78W**

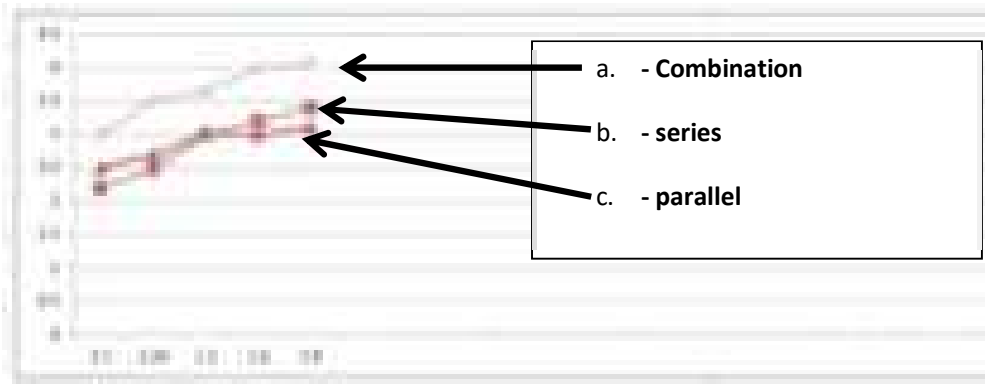
b) **Parallel Connection- 1.85W**

c) **Combination Connection-4.13W**

After analysis, we have connected the final circuit as combination connection, which gives us an Average Voltage of V=4.13 Volts & an Average current as I=1 Ampere (approx..)

GRAPH PLOTTING

Based on results obtained we can plot V vs I graph for all the 3 possible connections. Graph has been pasted below:



Based on observation, we can now comment that combination circuit generates maximum output power across load, whereas the parallel connection generates lowest among all.

Note-The Experimental readings are there in Final presentation (Already Submitted)

ERROR ANALYSIS

Output Voltage Generated in COMBINATION connection is:

4.13 Volts

Current Generated across output (LED):

1 Ampere (approx.)

Average Power Generated

= (Average Voltage) x (Average Current) Watt

= (4.13) x (1) W

= **4.13 W**

The Power Generated by ideal charger across output is 5 W.

Accuracy

=(Power Generated experimentally / Power (ideal source))x100

= (4.13/5) x 100

= **82.6 %**

WORK DISTRIBUTION

Prabhat Kumar	**Coding & debugging** **Final PPT presentation** **Video Editing**
Manish Kumar	**Worked on Physical Assembly** **Video Making & Editing**
Suraj Kumar	**Worked on Physical Assembly** **Gathered experimental data using PLX DAQ**
Saransh Yadav	**TinkerCAD circuit** **Coding** **PPT & report making**

WEEKLY WORK ANALYSIS

WEEK 1:

Finalized Project topic

Distributed Work accordingly

Laid a schematic work plan that was followed by everyone

WEEK 2:

Completed TinkerCAD Circuit

Procured parts which weren't available in DIY Lab

Downloaded softwares that were required (Arduino IDE, PLX-DAQ)

WEEK 3:

90% physical assembly work completed

Formulated plans to carry out Mathematical analysis of Project.

Completed Coding & ensured that it executes successfully.

WEEK 4:

Accessorized the final model

Ensured that it worked properly, Prepared Final Video & PPT.

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[3] Taghavi, Majid, Andrew Stinchcombe, John Greenman, Virgilio Mattoli, Lucia Beccai, Barbara Mazzolai, Chris Melhuish, and I.A. Ieropoulos "Self sufficient wireless transmitter powered by foot-pumped urine operating wearable MFC," Bioinspiration & biomimetics 11, no. 1, pp. 016001, 2015.

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[5] Meier, Rich, Nicholas Kelly, Omri Almog, and Patrick Chiang. "A piezoelectric energy- harvesting shoe system for podiatric sensing," Proceedings of IEEE 36th Annual International Conference of Engineering in Medicine and Biology Society (EMBC 2014), pp. 622-625., 2014.

[6] Pal, Prabir K., Vivek Mahadev, and K. Jayarajan. "Gait generation for a sixlegged walking machine through graph search," Proceedings of IEEE

[7] Wikipedia & Youtube


THANK
YOU