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Pavement Pressure Sensor Based Battery Charging and Street Lightning System

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***Abstract* - In this paper the design and development of pavement pressure sensor-based energy for street lights. The main aim of this paper is to generate the energy through the pressure generated by footsteps. Piezoelectric materials produce electric charge when a stress is applied on it. This phenomenon is known as piezoelectric effect. This effect takes place only in crystals that have no centre of symmetry. The charge produced by the application of stress can be can be manipulated as per our need. This micro controller setup is placed at foot path when a person walking along the foot path the footsteps of the person generate some pressure and that pressure generated by the person is noted down by the pressure transducer connected to the micro controller the pressure generated at the transducer is converted into the electrical energy and that energy is stored into the battery connected to it. This energy can be used to the street light to turn it on during night times the street light can be switch on automatically without any human effort by simply setting on and off time in RTC. By using this we can develop extra energy without wasting the other resources. Lot of energy is wasted for the street lights as they don't switch off at the right time and if this project is implemented in areas where there is lot of pedestrian floating in busy areas and railway stations, power is cost effectively saved as there will be no need of separate power supply from the power stations to the street.**

Keywords: Piezoelectric Sensors, Street Lights Automation, Battery, Micro controller, energy harvesting.

I. INTRODUCTION

India is the third largest producer of electricity in the world. Electricity has become a need of our present-day civilization and thus its demand is growing steadily. There seems no end to the different ways one can generate pollution free electricity. At one hand, rising concern about the gap between demand and supply of electricity for masses has highlighted the exploration of alternate sources of energy and its sustainable use.

Walking is that the commonest activity in day-to-day life. Once an individual walks, he loses energy to the paved surface within the sort of impact, vibration, sound etc, as a result of the transfer of his weight on to the paved surface, through foot falls on the bottom throughout each step. This energy may be tapped and regenerate within the usable type like in electrical type. The utilization of waste energy of foot power with human locomotion is implausibly abounding relevant and necessary. Man has needed and used energy produced degree increasing rate for his sustenance and well-being ever since he came on the world several million years gone. Once the people start the walking on the platform where the piezoelectric sensor is placed the current is produced to charge.

1. Piezoelectric Effect

The piezoelectric effect refers to a change in electric polarization that is produced in certain materials when they are subjected to mechanical stresses. This stress-dependent change in polarization provides a measurable potential difference across the material. Referred to as the direct piezoelectric effect, this phenomenon is observable in many naturally available crystalline materials, including quartz, Rochelle salt, and even human bone. Engineered material, such as lithium niobate and lead zirconate titanate (PZT), exhibit a more pronounced piezoelectric effect. An important feature to note about this phenomenon is that the process is reversible.

The inverse piezoelectric effect refers to a deformation of these materials those results from the application of an electric field. The deformation could lead to either tensile or compressive strains and stresses in the material depending upon the direction of the electric field, the preferred direction of polarization in the material, and how the material is connected to other adjacent structures. A piezoelectric substance is one that produces an electric charge when a mechanical stress is applied Non-centrosymmetric materials are materials lacking a center of inversion. There are 32 crystal classes of which 20 possess direct piezoelectricity, and 10 of these are polar crystals. These polar crystals will show pyroelectricity - in the presence of an oscillating thermal gradient, they will generate a charge. Moreover, the materials are ferroelectric if the dipole moment is reversible when a sufficiently large electric field is applied. Therefore, ferroelectric materials are also piezoelectric, but they exhibit

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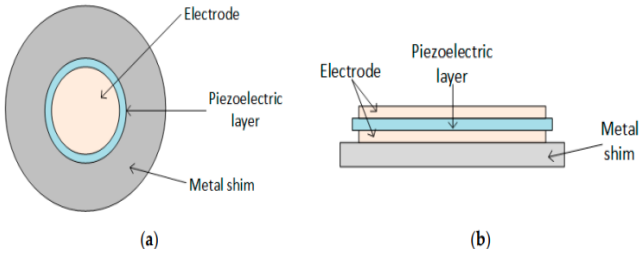
semiconductor properties that are similar to the properties found in mechanically stressed piezoelectric materials. There are around 200 piezoelectric materials used in energy harvesting applications, found in four main categories:

- Single crystals (Rochelle salt, lithium niobite, quartz crystals);
- Ceramics (barium titanate (BaTiO3), lead-zirconate-titanate (PZT), potassium niobate (KNbO3));
- Polymers (polylactic acid (PLA), polyvinylidene fluoride (PVDF), co-polymers, cellulose and derivatives);
- Polymer composites or nanocomposites (polyvinylidene fluoride-zinc oxide (PVDF-ZnO), cellulose BaTiO3, polyimides-PZT).
- Naturally occurring: Quartz, Rochelle salt, Topaz, Tourmaline group;
- Synthetic: Barium titanate, lead titanate, lithium niobite, lead zirconate titanate.

Types of Transducers can be used in different shapes:

- Cantilever beam
- Circular Diaphragm
- Cymbal type
- Stack type

For our project we have choose the circular diaphgram sensors:



The circular diaphragm structure consists of a thin disk-shaped piezoelectric layer attached to a metal shim fixed on the edges of the clamping ring, as shown in Figure a and b. At the core of the diaphragm is attached a proof mass to intensify the performance under low-frequency operation and to improve the power output.

Features of circular diaphragm sensors are:

- Compatible with pressure mode operation
- Resonance Frequency: 4.6 Khz +/- 0.5 Khz
- Resonance Impedance: 200 Ohms
- Capacitance: 20nF +/- 30% at 1 kHz
- Operating Temperature -20 to +70 C
- Storage Temperature -3 to +80 C
- Metal Material Brass

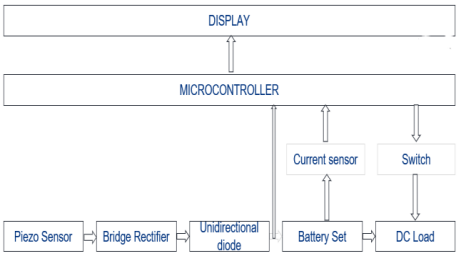
2. Architecture and Components used

Mainly the block diagram consists of following parts:

1. LCD Display
2. Bridge Rectifier
3. Unidirectional Diode
4. Generic Piezoelectric Sensor
5. Charging Module
6. Arduino Uno Microcontroller
7. Current Sensor ACS712
8. MT3608 Boost Converter

Other Components

1. LEDs
2. Rechargeable Li-ion Battery (3.7v 2500mAh model)



1. LCD Display

This is a basic 16 character by 2 lines alphanumeric display. Black text on Green background. Utilizes the extremely common HD44780 parallel interface chipset. Interface code is freely available. You will need Minimum 6 general I/O pins to interface to this LCD screen. Includes LED backlight. Works in 4-bit and 8-bit Mode. Whenever we work with an embedded system we need a reliable output device with the help of which we get the required information, now this problem is solved with the introduction of 16 characters by 2 (16X2) LCD.

2. Bridge Rectifier

The 1.5 Amp Full Wave Bridge Rectifier (W10M) is a single phase Bridge Rectifier. Voltage Range is 50 to 1000

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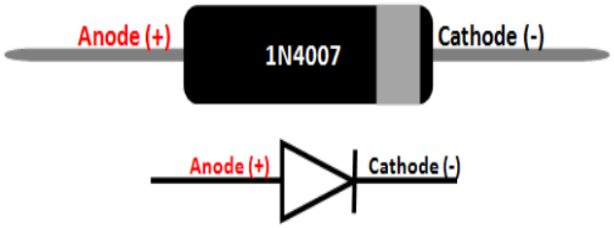
Volts and Current is 1.5 Amperes. A Full-wave rectifier is a circuit arrangement that makes use of both half cycles of input alternating current (AC) and converts them to direct current (DC).

3. Diode



The 1N4007 diode is a standard recovery rectifier with a molded plastic case. The maximum current carrying capacity is 1A and it withstands peak up to 30A. So we can use this diode in circuits that are designed for less than 1A.

4. Piezoelectric sensors

Piezo Electric Sensor /Buzzer/Transducer- (we are using a sensor with 35mm diameter) is a device that uses the piezoelectric effect, it is basically a device that converts voltage to vibration and vibration to voltage. It normally comes in handy to measure knock (knock sensor) or vibration (vibration sensor). Nowadays it is also used extensively in power generation projects e.g. Foot Step Power Generation.

5. Charging Module

TP4056 1A Li-Ion Lithium Battery Charging Module is a complete constant-current/constant-voltage linear charger for single-cell lithium-ion batteries. Its SOP package and low external component count make the TP4056 ideally suited for portable applications. Furthermore, the TP4056 can work within USB. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor

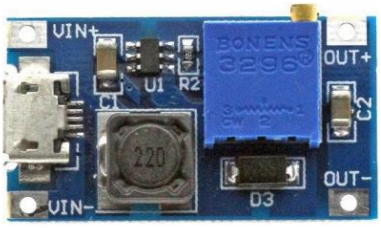
6. Microcontroller

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

7. Current Sensor Module

ACS712 is used in solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage

8. MT3608 Boost Converter



The MT3608 2A Max DC-DC Step Up Power Module Booster Power Module is a low-cost module that can step up a 2 to 24V input voltage up to a 5 to 28V output at up to 2A.DC-DC boost converters step up the input voltage to a higher voltage while also stepping down the available current

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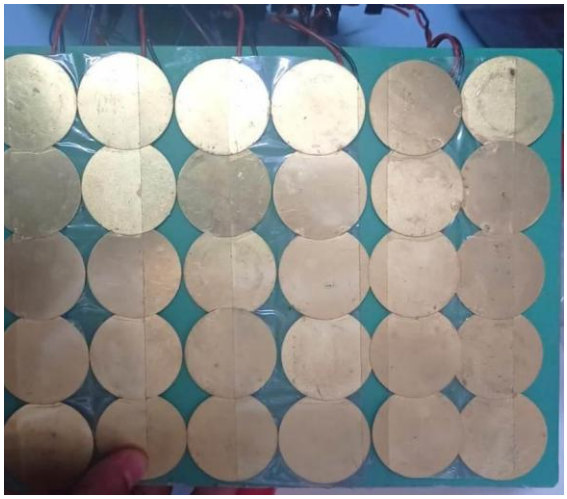
since the module can't output more power than its inputs. The MT3608 features automatic shifting to pulse frequency modulation mode at light loads. The MT3608 includes under-voltage lockout, current limiting, and thermal overload protection to prevent damage in the event of an output overload.

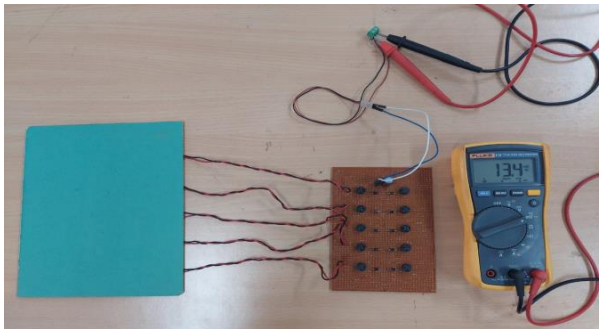
II. METHODOLOGY

- Firstly the main chip controlling the microcontroller and containing all other sensors should be protected from outside factors. All the data from sensor should be display on the display.
- Matrix of the sensors should be implemented in such a way that current generation should be more.
- Sensor should be placed sensibly under the pavement so that proper pressure can be applied on the sensors.
- The following model should take power from battery itself to power the microcontroller so no external power source is needed.
- Followings research paper and paperwork are ideas, information from various journals, papers and, internet.

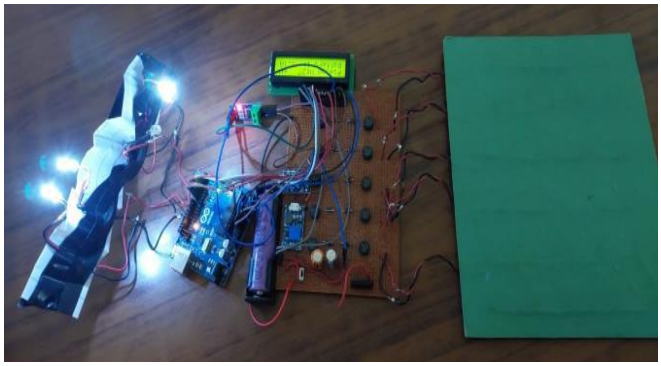
III. WORKING PRINCIPLE



Some voltages readings



When the pressure is applied on the piezo sensor matrix. The applied pressure is changed into electrical energy. We have created a matrix of piezo sensor which is connected in parallel so that we can get load current. The matrix consist of five sensor connected in series in 6 columns and then connected in parallel to rectifier This matrix is connected to the rectifier and diode circuitry because the output voltage generated by piezo plates is in AC and we need DC . The voltage and current generated is stored in the capacitor so that we can get constant voltage. This data which is being generated by the sensor. When the pressure is applied on the piezo sensor the applied pressure is changed into electrical energy.



Current sensor and voltage sensor are used to detect the voltage and current. We have used 3.7V lithium-ion battery. A boost converter module is used to boost the voltage up to 6 to7 V because microcontroller requires 5V constant voltage to operate. This module is used because the battery generates voltage up to 3.7 to 4.1V max. Then the battery is connected to the LED lights to power it. Finally, a switch is use in between battery and circuit to cut power on or off.

IV. ADVANTAGES

- This is a non-conventional energy system.
- Power is generated by simply walking or running.
- No fuel input or external power required.
- Easily applicable at places experiencing pressure.
- Easy maintenance.
- Less moving parts hence long service life.
- Generated electricity can be stored in a battery.

V. APPLICATIONS

Foot step power generation system has many applications, but some of them are given below:

- Mobile charging
- Street lighting
- Bus station lighting
- Emergency power failure stations
- Rural areas etc

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VI. CONCLUSION

This project is based on the principle of piezo electric effect and to produce non-conventional form of energy. The implementation in this system is a way of generating source of renewable energy and power generation it is environmentally friendly but also safe. Sustainable development is possible by adopting this technology. It tackles two problems that world is facing today, saving of fossil fuel and coal which are conventional source of energy.

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