<u>SMART ENERGY AMASSMENT</u>:

USING PIEZOELECTRIC SENSORS AND PHOTOVOLTAIC CELLS WITH TWO-SIDED MIRROR TECHNIQUE

A PROJECT REPORT

Submitted

by

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BONAFIDE CERTIFICATE

Certified that this project report "SMART ENERGY AMASSMENT" is the bonafide work of "Aman Pandey (16SECE103041), Sarsij Mishra (16SECE103020) " who carried out the project work under my supervision.

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ABSTRACT

To be able to yield energy from the usual day-to-day human activities like walking and running is only a very noble way of fighting environmental crisis and the least of a contribution from the society; this project focusing precisely on the same. Piezo Sensor is attached to a doormat/tile like structure to generate current when pressure is applied externally. The system is capable of producing voltage of 80-100V which could be stored with the help of capacitors or super capacitors or rechargeable battery. Also, the Photovoltaic cells complement in power generation using sun rays with the added two-sided mirror technique, increasing device efficiency with better output. Inclining more towards resources like "solar energy", which is present in abundance, must be the primary agenda of sustainable development. This project proposes an intelligible and judicious way of escalating the statistics of power generation of India and provides an eco-friendly and cost-effective method of helping the large population of the country or even world out of the darkness.

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CHAPTER -1

INTRODUCTION

INTRODUCTION

The idea of over-consumption and perennial shortage of energy resources in accordance with human needs has become synonymous to the reality of contemporary lifestyle. When the tragedy of over-population stares directly at our faces, even the slightest exhibition of ignorance on our part is only very irresponsible and morally unacceptable. Therefore, a re-thinking of our day-to-day lifestyle in this mechanical era is vital. Since every scientific experiment is essentially premised on the singular aim of social amelioration, likewise this project aims to address immediate social concerns by putting forward methods of sustainable development and harnessing of energy.

This project focuses on generating energy this energy to be stored in capacitors/super capacitors or rechargeable battery(s) which can be used in variety of applications. Even we could convert DC to AC with the help of an inverter circuit for its use in AC appliances. The energy produced can be used in low-power-consumption devices like emergency lamps, portable speakers/device charging station, etc. To bring to notice is the fact that the project does not use any conventional energy resource; rather energy from fundamental human activities like walking or running can be channelled to generate electricity using the device/setup.

Propounding this idea, this project uses "Piezoelectric Sensors" to generate electricity. An external pressure on the piezo sensor is converted into electricity. This does not require use of any other equipment/material. The increase (or decrease) of the current and voltage required is regulated through parallel and series connections of the piezo respectively. A mat/tile structure, for example, could be designed with 12 piezo plates in a matrix of 4X3 or with 20 such plates in 4X5 matrix, wherein four piezos would be in series with five other such connections in parallel.

Fig.1 Piezo matrix arrangement

The range is in micro ampere of current generated by one piezo sensor. Since the current generated by piezo sensors is feeble enough to not cater to the desired range, "Solar Panels" are used to accentuate the current generation. Voltage generated is in the range of 7-12V/piezosensor. Photovoltaic cells are used to increase the device efficiency at lower costs. An approach to increase the efficiency of it has been done. Two mirrors are placed at such an angle along the breadth of the panel so as to concentrate even more solar rays onto the panels, thus enabling an increased output than the normal mark. These mats/tiles can be placed in shopping malls, hospitals, universities, railway stations, airports and many such public places where heavy commuters are expected. The constant pressure on the mats/tiles will enable current generation in continuity and more power could be conserved. Not only as mats, but the setup which is easy-to-handle and quite convenient, can be installed in public footpaths, cross-over bridges, even in dance academies where excessive physical movement and footwork is a usual thing. The concept of this project is outlined with the need to target the collective conscience of the society, unfortunately becoming apathetic to the alarming environmental situation. This aims to make the society at large, conscious of its role in not only judiciously conserving energy but also creating it. The existence of human species is intricately interlaced and greatly dependent on nature and its resources. As experts agree, the global trend of accelerated depletion of non-renewable resources like coal for example, has created an alarming situation. Zooming into the national circumstances, an estimate of 319.02 billion tonnes of Geological resource of coal has been recorded as of April 2018. Comparing it to the essential factors, like national population, which is palpably exploding and the many industries predominantly based on coal as their raw material only gives us a rather unnerving picture of threat out society faces. Also, to inform the citizen of its responsibility to adopt judicious ways of consuming energy resources over exploitative manners of overuse and thus protect the human species from the dangers of shrinking options of resources. Therefore, a rethinking of developmental processes on global level is necessary. Scientific endeavours along with governmental policies have to focus on bringing non-conventional energy resources to the centre-stage; to identify the wealth that could be generated from resources discarded away as wastes and put them into use is the need of the hour. This energy harnessed can be used to light up houses of those eighty million people still having to live in darkness in our country. This eco-friendly method of harvesting energy can help in making India a hundred percent electrified nation.

CHAPTER-2

SYSTEM DESCRIPTION

SYSTEM DESCRIPTION

2.1 Piezo Sensor

The word Piezo finds its origin in Greek and essentially means "press" or "squeeze". This meaning gets translated into the basic working of what is known as a Piezoelectric Sensor. An external pressure applied on a piezo sensor acts as the necessary stimulus for it to convert mechanical stress/energy into electrical charge. This effect is called Photoelectric effect and is used to measure anomalies in pressure, temperature, acceleration, force or strain. The primary rule that guides the working of a piezoelectric sensor is that the generated piezoelectricity is relative to the pressure applied to the solid piezoelectric crystal material.

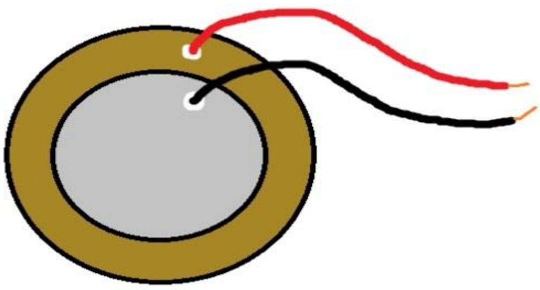

Fig.2: Piezo Plate

A piezo sensor generates AC or Sinusoidal wave, which gets converted into pulsating DC when passed through a bridge rectifier circuit. The resultant DC is fed into a capacitor to smoothen the signal which is finally channelled into a rechargeable battery and stored. Piezo Sensors have a high internal resistance, an impedance value of <500 ohm and generally operate in a temperature range of -20°C to +60°C [1].

There is an increase in voltage with the rise in temperature but the current produced is feeble. Piezoelectric sensors cannot be used for truly static measurements because the energy so produced would last for only a fraction of seconds and the current reading would glide down to 0 the moment external stimulus is removed. A better storage circuit, capacitor for instance, can be used for a continuous current production. A Piezo Sensor can be made using various materials but, owing to its higher flexibility and abundant availability, Quartz is preferred to any other material. This project uses PZT piezo plates.

Observations table of characteristics of piezo sensor element vs separate varieties:

Standard	**Strain sensitivity [V/με](Apprx.)**	**Threshold [με](Apprx.)**	**Span to Threshold ratio (Apprx.)**
Piezoelectric	5.1	0.00002	100,000,000
Piezoresistive	0.0002	0.0003	2,600,000
Inductive	0.003	0.0004	2,000,000
Capacitive	0.004	0.0002	740,000
Resistive	0.000006	0.02	50,000

Sensor Design:

Based on piezoelectric equipment various physical quantity can be calculated the most frequent of them are pressure and acceleration. For the pressure sensors, a slight membrane and a vast base is used, assure that a concerned pressure especially loads the components in the one direction. For accelerometers, a seismic mass is appended to the crystal rudiments. When the accelerometer encounters a motion, the inconvertible seismic bulk load the components according to the Second law of motion (F=m.a).

Piezoelectric Sensor Specifications:

Some of the fundamental features of piezoelectric sensors are:

- **The sort of measurement:** This sort is subject to quantity limits.
- **Sensitivity S:** Ratio of change in output signal Δy to the signal that caused the change Δx. $S = \Delta y/\Delta x$.
- **Reliability:** This account to the sensors potency to keep characteristics in definite limit under set running condition.
- These sensors have very lower Soldering temperature.
- Due to its soaring ductility Quartz is the most major material as a piezoelectric sensor.

Senstivity of Piezo sensors:

The output is linear over a broad spectrum, on average 0.8 KPa to 71 MPa (0.2 to 10000 psi) with an exactitude of about 1%. There might also be a small loss in sensitivity when foremost exposed to higher pressure and temperature. The impact of this is able to stave off by cycling the sensor through the most essential pressure and temperature by extending them. The frequency impedance of a piezoelectric sensor drop off at small frequencies as the propagate charge cannot be reserved. At large frequencies, there is a steeple concordant to the reverberating frequency of the piezoelectric component. The sensor is generally used in the flat region of the response curve among these two utmost.

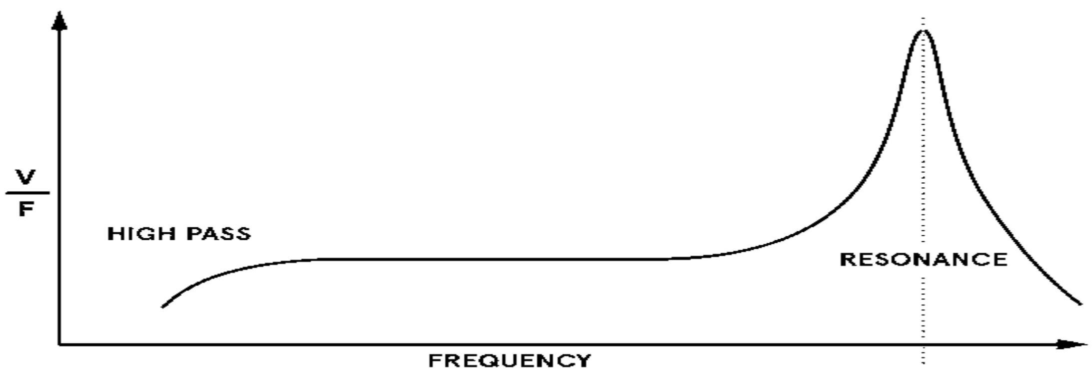

Fig.3: The rate of recurrence response of a piezoelectric sensor

Applications:

- The insistence high frequency and quick response time of piezoelectric pressure sensors means they can be employed in a broad range of industrial and aerospace application where they'll be unveil to high temperature as well as pressure.
- They are frequently employed for measuring movable pressure, for example in turbulence, blast, and engine ignition. These all demand fast reaction ruggedness and a broad variety of manipulation.
- Their sensitivity as well as low power circulation also makes them useable for a number of medical application. For example, a thin-film synthetic sensor can be attach to the skin and consumed for real-time monitoring of the major pulse.

Advantages and Disadvantages of Piezo sensors:

- One of the major benefit of piezoelectric load sensors is their ruggedness. This make them appropriate for utilize in a diversification of harsh environment.
- Distant from the related electronics, piezoelectric sensors be capable of used at high temperature. Several material will work at up to 1,000ºC. The sensitivity might shift with temperature but this can be minimised with suitable variety of material.
- The yield signal is engraft with the piezoelectric element itself, hence they are naturally low-power device.
- The sensing component itself is not sensitive to electromagnetic intervention and radiation. The charge amplifier and other electronics want to be sharply designed and placed as close as possible to the sensor to decrease noise and other signal fault.

- Piezoelectric sensor can be easily prepared using low-priced material (for example quartz or tourmaline), therefore they can supply a low cost solution for industrial pressure measurement.

2.2 Photovoltaic Cell:

A Photovoltaic Cell is a widget efficient in harvesting energy by converting solar energy into electricity. A multitude variety of photovoltaic cells are available, all of which make use of semiconductors to trap the arriving photons from the sun's rays and convert it to electric current through the procedure called photovoltaic effect. The ratio of useful electrical energy produced to the total amount of solar rays incident on the panel under standardised testing conditions gives us the rate of efficiency of the photovoltaic cell. Most PV cells in commercial use have efficiency of 30% though some experimental solar cells have achieved efficiency of 40-50% [2]. A solar panel of 10W/ 12V and of the dimensions 28.5 x 35 x 2.2 cm is used. The efficiency rating of the solar panel used is 10%.

Fig:4 A solar panel, consisting of several photovoltaic cells

Functioning of PV Cells:

A photovoltaic cell is developed of semiconductor material to imbibe the photons emitted via the sun and engraft a stream of electron. Photons are primal particle to facilitate solar radiation at a speed of 300,000 kilometer per second. In the 1920s, Albert Einstein describe them as “grain of light”. Once the photons hit a semiconductor material similar to silicon , they release the electron from its atom, leaving behind a empty space. The unplaced electrons move around at random looking for an additional hole to fill up.

To out-turn an electric current, however, the electrons want to flow in the same side. This is cognizable using two type of silicon. The silicon layer that is unveiled to the sun is doped by atoms of phosphorus, which have one more electron than silicon, as the other side is doped by atoms of boron , which has one less electron. The resultant sandwich work greatly similar to a battery: the layer that has additional electrons become the negative terminal (n) and the side that has a lack of electrons become the positive terminal (p). An electric field is produced at the junction among the two layer.

Once the electrons are agitated by the photons, they are swept to the n-side with an electric field, at the same time the holes drift to the p-side. The electron and holes are convened towards the electrical contact functional to both sides with flowing to the outer circuit in the outward appearance of electrical energy. This produce direct current. An anti-reflective covering is combined to the apex of the cell to subact photon failure due to surface reflection.

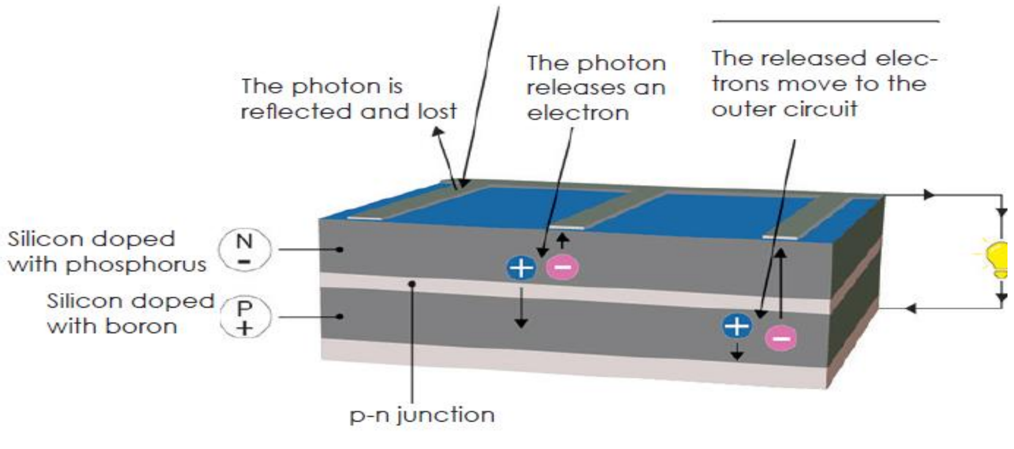

Fig:5 Working of Photovoltaic cells

Photovoltaic Cell Efficiency:

Efficiency is the fraction of electrical power created by the cell to the mass of sunlight it achieved. To calculate efficiency, the cells can be mixed into modules, which are in turn compiled into arrays. The resultant panels be then installed in front of a solar simulator to mimics perfect sunlight conditions: 1,000 watt (W) of light per cubic meter at an extensive temperature of 25°C. The electrical power formed in the system, is a percentage of the inward solar energy. But a panel measuring one square meter reproduce 200W of electrical power, it has an efficiency of 20%. The utmost theoretical efficiency of a Photovoltaic cell is around 33%. This is indicated towards the Shockley-Queisser limit.

Layers of a PV Cell:

The photovoltaic cell is built-in of several layers of materials, each one with a specific objective. The most key layer of a photovoltaic cell is the especially treated semiconductor layer. It is comprises of two separate layers (p-type and n-type), and is what actually convert the Sun's energy into helpful electricity by a procedure called the photovoltaic effect. On the either part of the semiconductor a layer of conducting material which "hoard" the electricity created. Note down that backside or shaded part of the cell can put to be completely enclosed in the conductor, while the front or illuminated part should use the conductors scarcely to stay away from blocking too much of the Sun's radiation as of reaching the semiconductor. The ultimate layer which is applied simply to the illuminated part of the cell is the anti-reflection covering. While all semiconductors are naturally reflective, reflection failure can be substantial. The key is to use one or various layers of an anti-reflection covering (alike to those use for eyeglasses and cameras) to decrease the quantity of solar radiation that is reflected off the surface of the cell.

Two mirror Techniques (Double sun Technology):

The mass of radiation to fall upon the modules in this system is generally mark by the concentration factor. The most general definition is the geometric concentration factor(C), which intended for this system is calculated by ratio among the effective area(the area seen by the sun) and the dynamic cell area as clear by the following equations:

C= Aeff/Amodule = Amirrors + Amodule/ Amodule = 1+ Amirror/Amodule

Fig.6: Solar Panel with two-side mirror

2.3 Arduino:

Arduino is an open-source electronics platform based on easy-to-use hardware and software Arduino board is of three types:

i. Arduino UNO
ii. Arduino MICRO
iii. Arduino MEGA

In this project we have used Arduino Uno board because the requirement of memory and space was less.

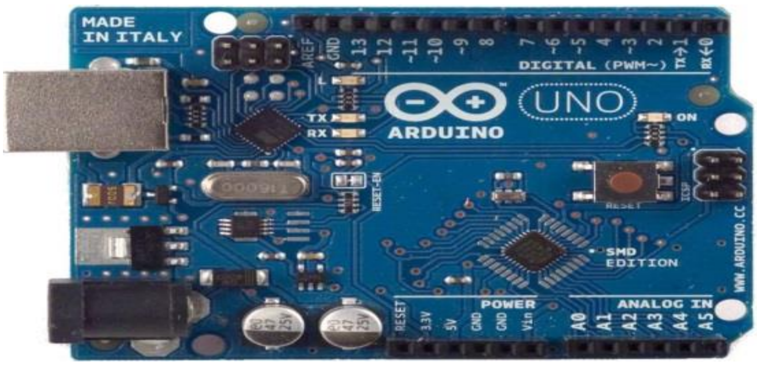

Fig.7: Arduino UNO

Technical specifications:

- Microcontroller: Microchip ATmega328P
- Effective Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts
- Digital Input/Output Pins: 14 (of which 6 can be used for PWM output).
- UART: 1
- I2C: 1
- SPPI: 1
- Analog Input Pin: 6
- DC Current per Input/Output Pin: 20 mA
- DC Current intended for 3.3V Pin: 50 mA
- SRAM: 2KB
- EEPROM: 1KB
- Clock pace :16MHZ

General pin functions:

- **LED:** There is a built-in LED driven by digital pin 13. As the pin is high value, the LED is ONN, while the pin is low, it is OFF.
- **VIN:** The input voltage to the Arduino board when it is with an exterior power source .You can be able to supply voltage through this pin, or, if supplying voltage by the power jack, right to use it through this pin.
- **5V**: This pin outputs a synchronized 5V from the regulator on the board. The board can be give power either from the DC power jack (8 - 20V), the USB connector (5V), or the VIN pin in the board (8-20V). Provide voltage through the 5V or 3.1V pins bypass the regulator, and can harm the board.
- **GND**: Earthing pin.
- **IOREF**: This pin on the Arduino board provide the voltage indication with which the microcontroller works. A well configured shield can read the IOREF pin voltage and choose the proper power source, or allow voltage translators on the outputs to work with the 5V or 3.1V.
- **Reset**: Normally used to connect a reset button to shield that log(block) the one lying on the board.

2.4 Relay:

A relay is an electrically operated switch. It comprises of a set of input terminals for a single or multiple control signals, and a set of working contact terminals. The switch may have many number of contacts in multiple contact forms, such as make contacts, split contacts, or combination thereof.

Fig.8: Relay

Working of Relays:

Relays differ in their shape, efficiency, and corresponding uses. However, although they may differ in these respects, all relay function in essentially the same way: one circuit is used to power another.

The special manner in which this occurs depend on whether the relay is generically open (NO) or generically closed (NC).

- **Generically Open Relays:**

  Most relays are generically open; i.e, the second, larger circuit is in the off position by default.

  In a generically open relay, power stream through an input circuit, activating an electromagnet. This procreate a magnetic field that exerts a contact to join with the second, larger circuit, permitting current to flow through. When the origin of power is removed, a spring draws the contact away from the second circuit, block the flow of electricity and turning off the end device.

- **Generically Closed Relays:**

  The fundamentals of an GC relay are the same as an GO relay: there are two circuits, with the second being larger, and an electromagnet move a physical contact between two position.

But in the case of an GC relay, the default states are inverted. When the first circuit is activated, the electromagnet draw-up the contact away from the second circuit. As such, GC relays keep the larger circuit in the ON position by default.

Types of relays:

- **Coaxial relay**: Where radio transmitters and receivers allocate one antenna, regularly a coaxial relay is used as a TR (transmit-receive) relay, which switch the antenna from the receiver to the transmitter. This shield the receiver from the high power of the transmitter.
- **Contactor:** A contactor is a durable relay with advanced current ratings, in use for switching electric motors and lighting loads. Constant current ratings for general contactors range from 10 amps to some hundred amps.
- **Mercury relay:** A mercury relay is a relay that uses mercury as switching component. They are used where contact erosion would be a trouble for conventional relay contact. Due to environmental thought about precious quantity of mercury used and modern alternative, they are now relatively uncommon.
- **Overload protection relay:** Electric motors need overcurrent protection to obstruct damage from over-loading the motor, or to guard against short circuits in between cables or internal fault in the motor windings.
- **Polarized relay:** A polarized relay place the armature along with the poles of a permanent magnet to amplify sensitivity. Polarized relay were used in middle 20th Century telephone exchanges to stumble on out faint pulses and correct telegraphic deformation.

- **Static relay:** A static relay comprise of electronic circuitry to imitate all those characteristics which are achieve by motile parts in an electro-magnetic relay.
- **Vacuum relays:** A vacuum relay is a susceptive relay having its contacts mounted in an exiled glass housing, to permit handling radio-frequency voltages as high as 20,000 volts without flashover between contacts even though contact spacing is as low as a few hundredths of an inch when open.

Advantages of Relay:

- Confer physical isolation between circuits.
- Can usually withstand high voltage.
- Can bear short term overloads, often with little ill effects - transient effects can often impracticably damage solid state relays / electronic switch.\

Disadvantages of Relay:

- Mechanical character of the relay means it is slow when collate to semiconductor switch.
- Has a finite lifetime due to the mechanical character of the relay. Solid state switch tend to have a greater level of credibility provided they are not subject to transients that fall outside their ratings.
- Suffers from contact bounce as the contacts start to make contact and then physically bounce, making and breaking the contact and cause some arcing to a greater or lesser degree.

2.5 LCD (16X2)

An LCD is an electronic display unit which uses liquid crystal to generate a visible image. The 16X2 LCD display is a very necessary module which is commonly used.

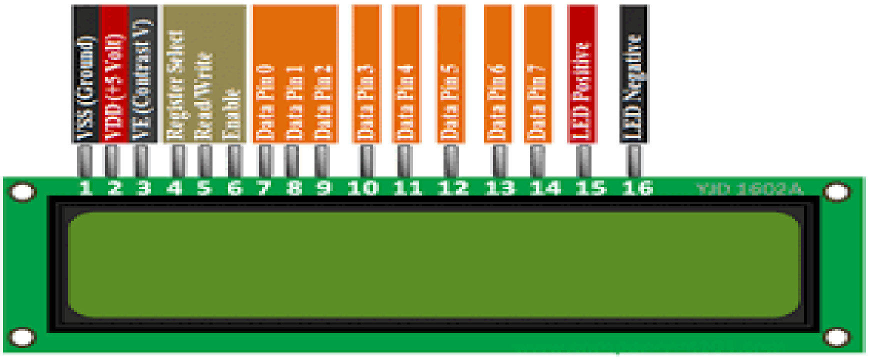

Fig.9: LCD (16X2)

Pin No.	Function	Name
1.	Ground (0V)	Ground
2.	Provided voltage; 5V (4.6V – 5.4V)	Vcc
3.	Gap adjustment; the best way is to use a variable resistor such as a potentiometer. The generated output of the potentiometer is appended to this pin. Rotate the potentiometer knob forward and backwards to change the LCD contrast.	Vo/VEE
4.	Choose command register as low, and data register as high.	RS (Register Select)
5.	Low to write to the register; High to read from the register.	Read/write
6.	Send data to data pins as a high to low pulse is given; Extra voltage flip is necessary to execute the instruction and EN(enable) signal is used for this purpose. Generally we make it en=0 and when we want to execute the instruction we make it high en=1 for a few milliseconds. After this, once more make it ground that is, en=0.	Enable

7.	8-bit data pin	DB0
8.		DB1
9.		DB2
10.		DB3
11.		DB4
12.		DB5
13.		DB6
14.		DB7
15.	Backlight VCC (5V)	Led+
16.	Backlight Ground (0V)	Led-

RS (Register select):

A 16X2 LCD have two registers, that is, command and data. The register select is applied to switch as of one register to other. RS =0 for command register, and RS =1 for data register.

Command Register:

The command register store up the command instruction given to the LCD. A command is an instruction given to LCD to do a predefined action. Examples like initializing it, clearing the screen, setting the cursor place, controlling display etc. Processing for commands happen in the command register.

Data Register:

The data register stores the data headed for to articulate on the LCD. The data is the ASCII value of the character to be articulate on the LCD. When we convey data to the LCD it go to the data register and is processed there. When RS=1, data register is selected.

CHAPTER-3
LITERATURE REVIEW

LITERATURE REVIEW

3.1 [3] In this paper, the authors have presented a design in which they have used wooden board as base to generate power using piezo. According to their table, the output so produced is very feeble. Hard foam could've been a better base to provide more stress for the piezo plates to generate more power as the external force is directly relative to power produced in the case of piezo sensors.

3.2 [4] The authors have used rubber to protect plates, which actually absorbs shocks hence providing lesser stress over the piezo plates and consequently lesser amount of power is generated. Also, no storage circuitry like capacitor has been discussed to shift its non-static nature of output to static. More parallel connections would add up to more amount of current generation for wider use. Bridge rectifier would've been a better replacement than normal diode for appropriate DC output.

3.3 [5] The authors have considered a surface to provide appropriate amount of stress for piezo to produce better output but clearly have missed a factor that the surface above it should allow uniform pressure over the plates to generate effective results. This could be done by applying a hot glue over the centre of every piezo plate as the efficiency is maximum at the centre and place a hard surface above it for uniform pressure at each and every plate.

3.4 [6] The output produced with the help of the proposed model will provide feeble energy generation. A hard foam base is required to provide more stress for the piezo plates in order to generate more power. Also, full-wave bridge rectifier using Schottky diode would provide better DC output with low voltage drop than simple diode. A capacitor in parallel to the rectified will help in smoothening of the signal as well as provide better static output.

3.5 [7] In this paper, a storage circuitry isn't mentioned which is essential to provide a static output in order to be further utilised by device like LTC3588. Without it, it won't be possible to provide a static input to the buck converter, resulting in no output. The current produced by piezo sensor is in the range of micro-milli amperes and also is only for a fraction of second, momentarily. A storage unit with capacitor or battery is required before giving the output out of diode directly to any load or module for further enhancement of the power produced.

CHAPTER-4

METHODOLOGY

METHODOLOGY

This project of harvesting energy is based on two systems which is piezo sensor and solar energy based system. The more focused source of conserving energy in this project is piezo sensor which when supplied with external pressure generates AC signal. This AC signal is then transformed into pulsating DC signal by passing it through a Full Wave Bridge Rectifier. This is made using four schottky diode because it provides low voltage drop. The DC signal produced after having it pass through the bridge rectifier is, however, for a fraction of second and not enough to influence even a reasonable energy generation. Thus, this output is fed into a capacitor. A capacitor not only smoothens the resultant DC signal, but is also conducive to generate a current production in continuity.

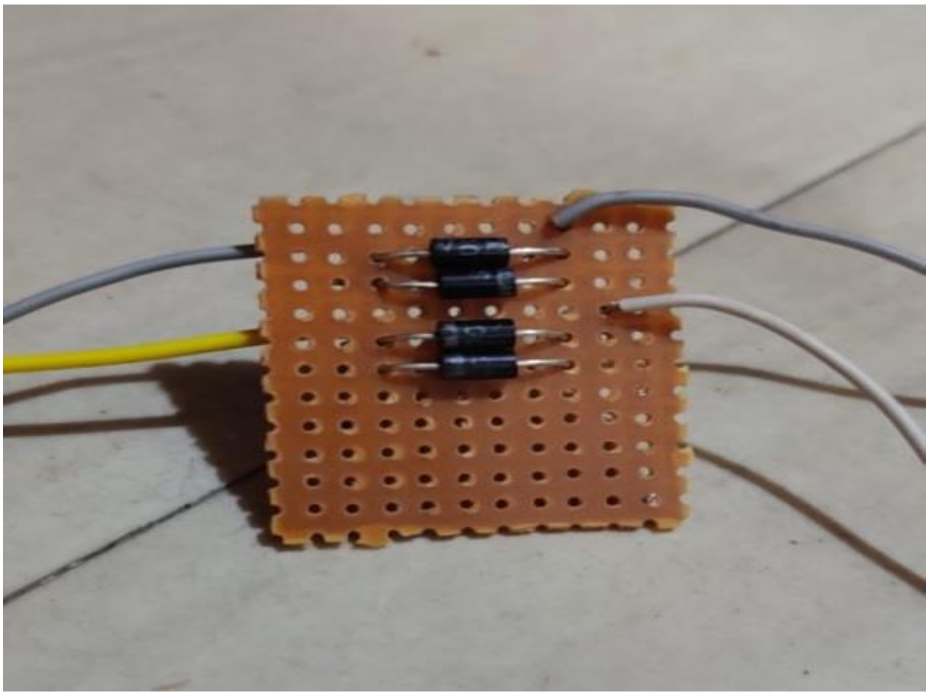

Fig.10: Full-Wave Bridge Rectifier

This project includes the usage of two capacitors of different values of capacitance, for a comparative analysis; one with a capacitance of 470 μF and the other of 1000 μF. The comparison of the respective readings of the two capacitors creates a space for comparative performance analysis.

Full-wave bridge rectifier: To adjust both alternating cycles of a sine wave, the bridge rectifier adopts four diodes, conjoin together in a “bridge” formation. The secondary winding of the transformer is appended on one side of the diode bridge network and the load on the previous side.

Subsequent image shows a bridge rectifier circuit:

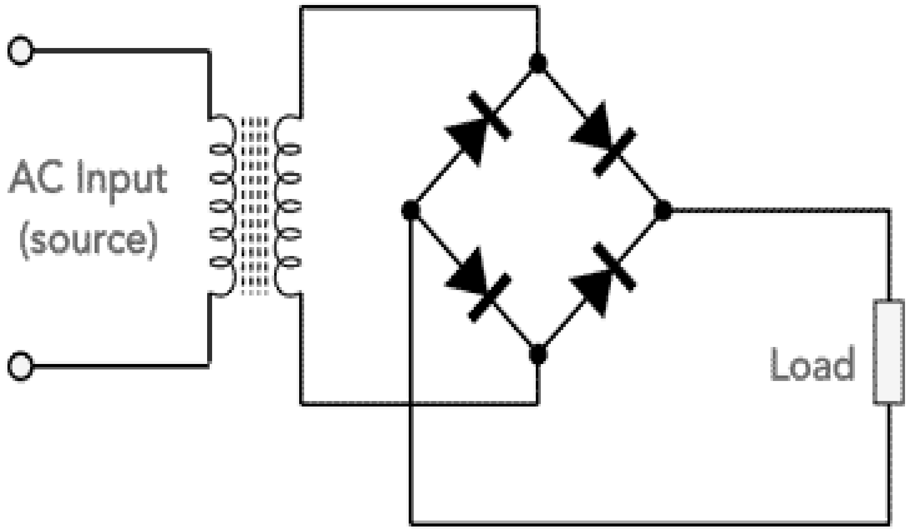

Fig:11 Bridge rectifier circuit Diagram

Working:

The functioning of a bridge rectifier is manageable. The circuit diagram of the bridge rectifier is shown above. The auxiliary winding of the transformer is affixed towards the two diametrically opposite points of the bridge. Suppose that a load is appended at the output. The load RLoad is attached to bridge.

In the first half cycle of the AC input, the upper part of the transformer secondary winding is positive concerning the lower portion. Therefore during the first half cycle diodes D1 and D4 are forward biased. Current flows through, enter into the load RL. It returns, In this half input cycle, the diodes D2 and D3 are reverse biased. Hence there is no current stream through the path.

In the next cycle lower part of the transformer is positive by means of reverence to the upper portion. Hence in this cycle diodes D2 and D3 are forward biased. Current flows through the path and flows back through the path.The diodes D1 and D4 are reverse biased. So there is no current flow in the course of the path. Thus negative cycle is rectified and it appear across the load.

Peak Inverse Voltage of Full Wave Bridge Rectifier:

Once the secondary voltage receive its utmost positive value and the terminus A is positive, and B is negative as shown in the circuit diagram below.

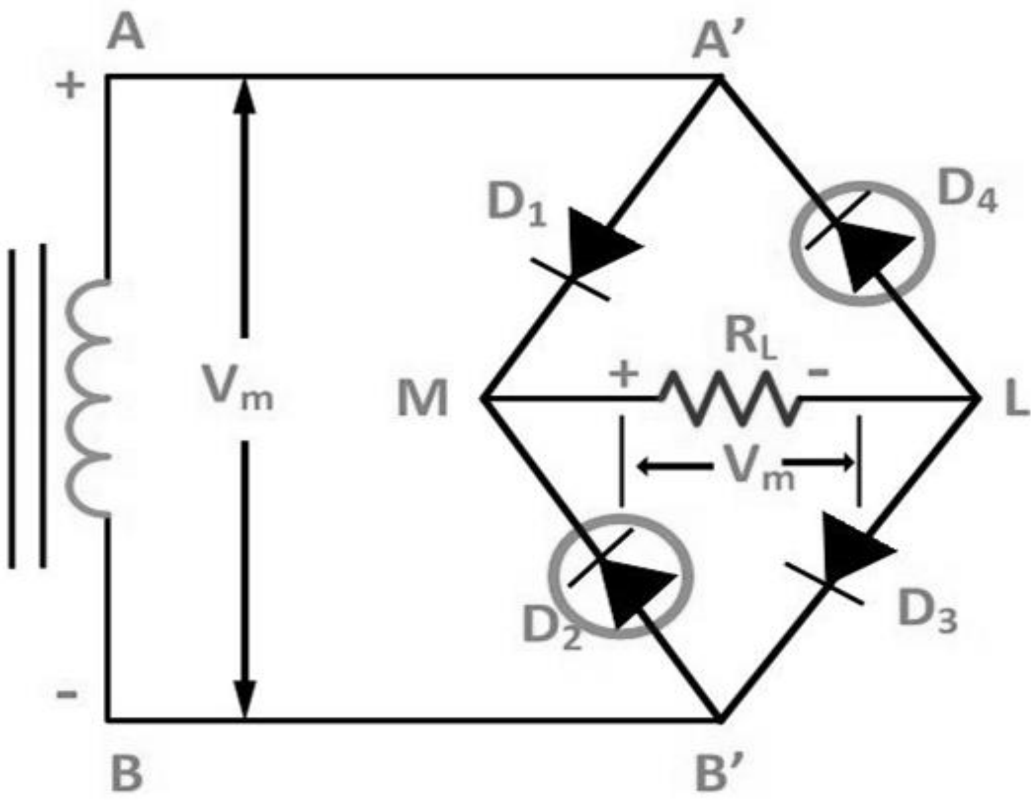

Fig: 12.Peak inverse Voltage FWBR

At this right off diode, D1 and D3 are forward biased and direct current. Therefore, terminus M receive the same voltage as that A' or A, while the terminus L receives the same voltage as that of B' or B. Hence the diode D2 and D4 are reversed biased and the PIV across both of them is Vm.

Therefore,

$$PIV = V_m$$

Advantages of Full Wave Bridge Rectifier:

- The center tap transformer is disconnected.
- The output is two-ply to that of the center tapped full wave rectifier used for the same secondary voltage.
- The peak inverse voltage across each diode is one-half of the center tap circuit of the diode.

Disadvantages of Full Wave Bridge Rectifier:

- It desires four diodes.
- The circuit is not suitable when a small voltage is requisite to be revised. It is for the reason that in this case, the two diodes are appended in series and offer double voltage drop due to their internal resistance.

4.1 Block Diagram

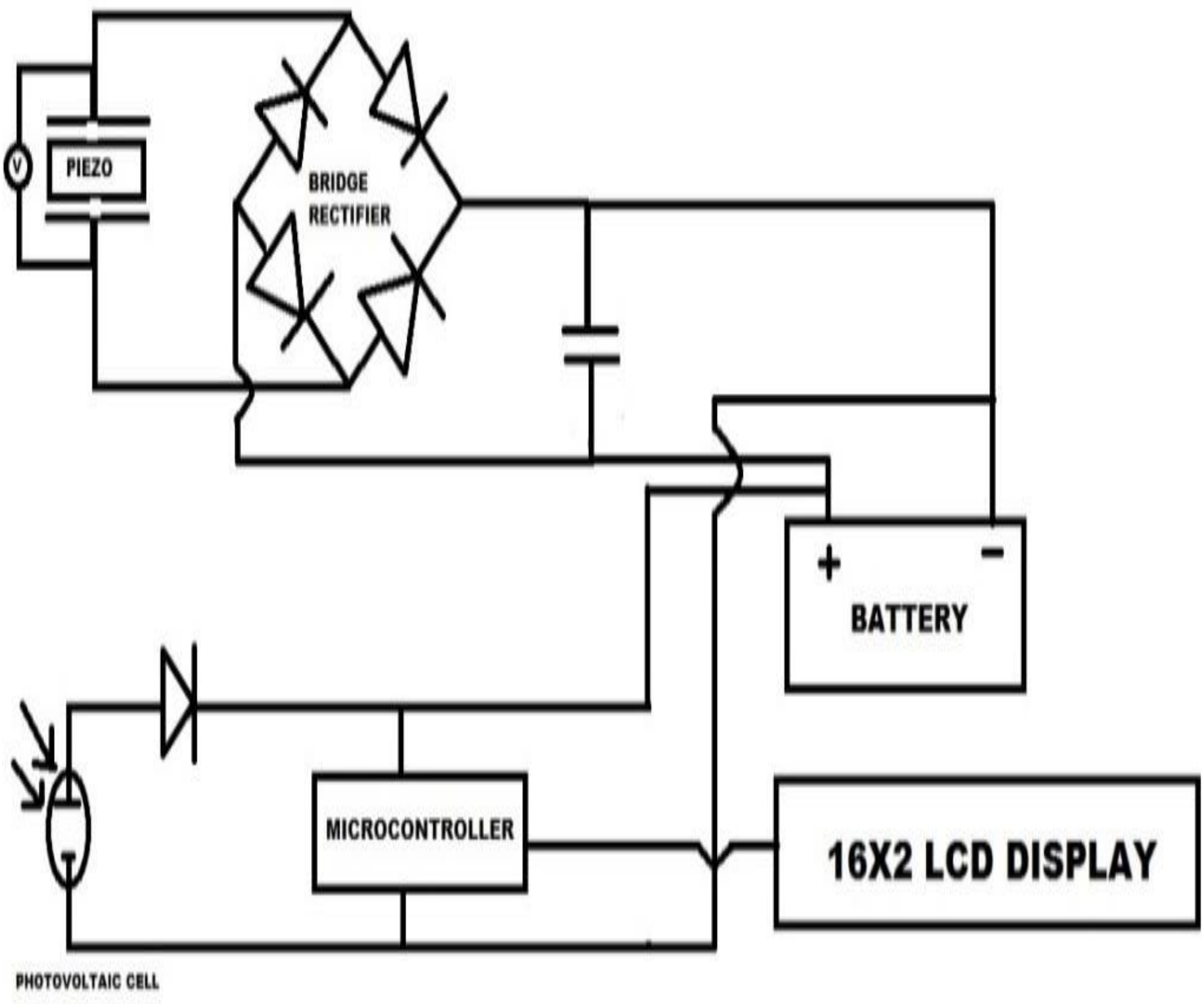

Fig.13: Block Diagram

A piezo sensor operates through external pressure application so the type of material that is used as the base of the sensor is decisive of the efficiency output of the whole device. It is through a series of experimentation that "hard foam" as the most appropriate material for the base of the piezo has been included in this project.

Fig.14: Piezo-plates matrix setup over a hard foam surface

With wooden board as the base was recorded to generate output of a rather lower reading than desired. To check for any difference in the reading of current generation, the wooden base was then replaced with rubber. But since the insulation of a material like rubber is high enough to absorb all the shock/suspension, it did not create the stress between the plates and the surface to generate required output. Hence, a material like "hard foam" which absorbs the external pressure in the right amount, enabling a stress between the surface and piezo and consequently producing desired output is used. This reading when juxtaposed with the readings of the previous two cases- wooden board and rubber- is higher.

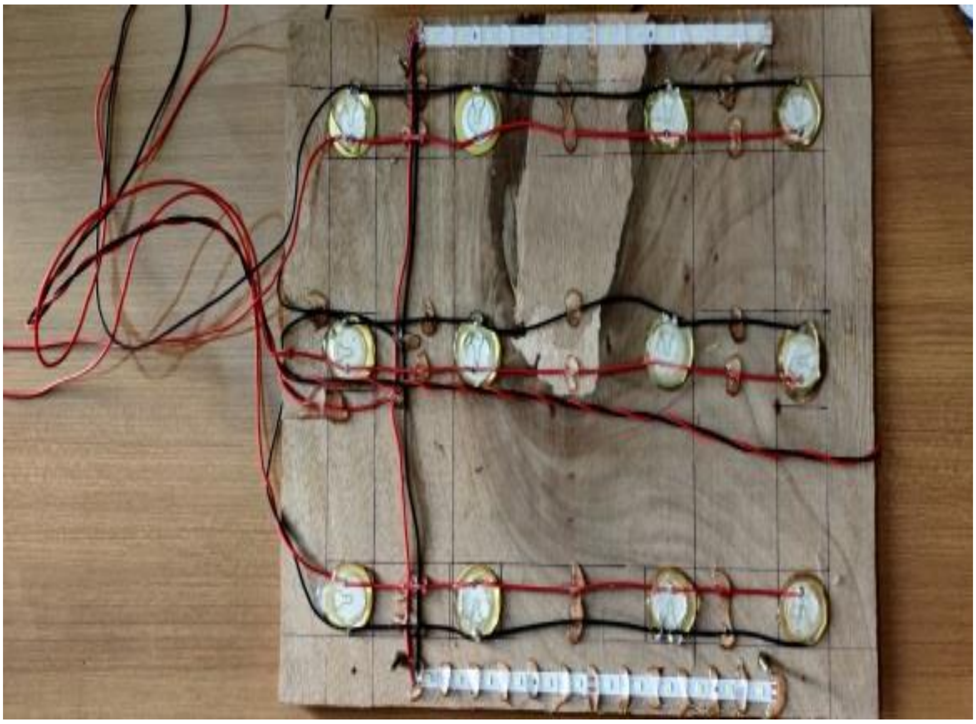

Fig.15: Piezo-plates matrix setup over a wooden base

The piezo itself acts as a parallel plate capacitor[8][9] and has an internal resistance which plays against the motive of maximum current generation. To counter this internal resistance, the piezo has been put together in a matrix of more parallel connections. To enable more current generation, the matrix has more parallel connections than series connections because series connection contributes to more voltage generation and not current production. The piezo design that this project is based on is put into a matrix of 6x9. This model of it being only a prototype and caught within the limitation of academic exhibition has the potential to be further developed into a larger system with a larger matrix, which can even touch the mark of unit Ampere. To extract the maximum efficiency from the piezo sensor, hot glue is fixed at the centre of every piezo which is producing maximum output when stimulated with external pressure than the peripheral regions of the sensor[10].

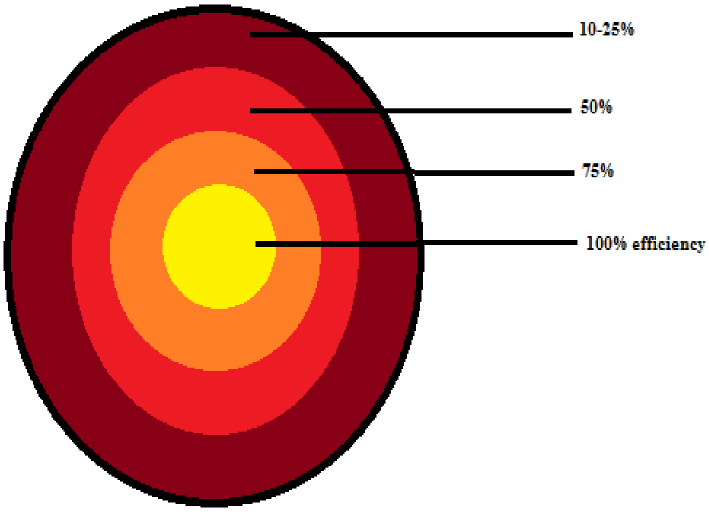

Fig.16: Maximum efficiency point on a piezo plate

However, a factor that poses challenge to the idea of consumer-friendly model is the cost of the piezo sensor. Developing this prototype into a larger system with a larger matrix, for example, 6x100 or 6x200, although produces higher reading of current but would also be very expensive and inaccessible to the larger mass. Therefore, a “Solar energy” based system as a more consumer-friendly source of energy has been incorporated into this project. Not only does this complement in sourcing current generation but also takes forward the imperative notion of sustainable energy harvesting. In times of shrinking options of energy production due to the overuse of the limited conventional resources, solar energy is the solution to proceed with a sustainable scientific development; solar is the future.

Including it as one of the sources to compensate with the current generation, reduces the production cost of the system to a palpable extent. However, losses in the energy production of solar panels are bound to happen. Wherein the efficiency of solar panel in lab is recorded around 40%, it can barely touch the range of 25% in normal environmental conditions (usually between 10-25%)[2].

But there are various techniques to curb this loss of energy, like Solar Tracker, Solar Concentrator, Panel Orientation, etc. The technique of Solar Concentrator conventionally uses ‘Fresnel lens’, which again are expensive. Deriving from this very technique but using mirrors instead of Fresnel lens, the loss of energy in solar panels is compensated for, here. Based on “double sun technique” the effective area or the area exposed to the sun is increased. This is done by placing two mirrors along the sides of the solar panel, thus enabling more solar rays to be concentrated on the larger area. It is intended by the ratio among the effective area (the area seen by the sun) and the active cell area as defined by the following equation[11] :

$C = A_{eff} A_{module};$

where, A_{eff} *is the effective area (the area seen by the sun)*

$= A_{mirrors} + A_{module} A_{module}$

where, $A_{mirrors}$ *is the area of the mirrors that is seen by the sun and* A_{module} *is the total area of the modules.*

$= 1 + A_{mirrors} A_{module}$

This increases the ‘geometric concentration factor’ and pushes the efficiency of the solar panel by 10-15% than usual.

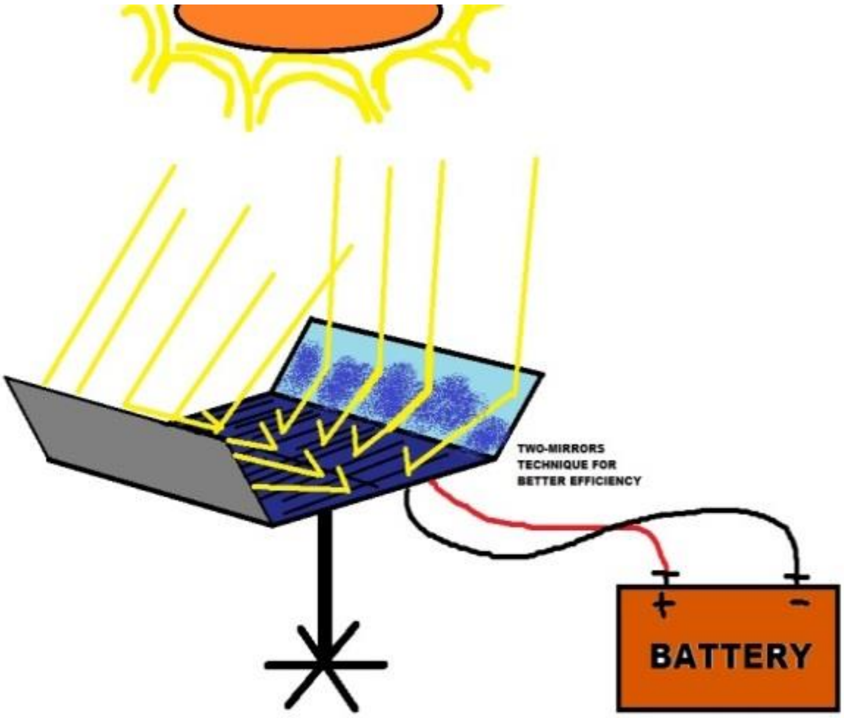

Fig.17: Solar Panel with two-sided mirror technique also known as double sun technique

Microcontroller:

A microcontroller is a rigorous integrated circuit designed to oversee a particular operation in an embedded system. A typical microcontroller comprise a processor, memory and input/output (I/O) peripheral on a single chip.

Sometimes described to as an microcontroller unit (MCU), microcontroller are set up in vehicle, robot, office machine, medical device, mobile radio transceiver, vending machine and home appliance, among other device. They are effectively simple small personal computer (PCs) designed to manage small feature of a larger component, without a complicated front-end operating system (OS).

Working:

A microcontroller is set in inside of a system to control a single function in a device. It does this by interpreting data it obtain from its I/O peripheral using its central processor. The variable information that the microcontroller obtain is stored in the data memory, where the processor approaches it and uses instructions stored in its program memory to interpret and apply the arriving data. It then uses its I/O peripherals to communicate and pass the appropriate action.

Core Elements of a Microcontroller:

- **Central Processing Unit:** A processor can be intellect of as the brain of the device. It processes and responds to various instructions that direct the microcontroller's function. This involves performing necessary arithmetic, logic and I/O operation. It also perform data transfer operation, which communicate mandate to other component in the larger embedded systems.

- **Memory:** A microcontroller memory is used to store up the data that the processor obtain and uses to respond to instruction that it is been programmed to carry out. A microcontroller has two major memory types:

  - Program memory, which stores prolonged information about the instructions that the CPU carries out. Program memory is non-volatile memory, meaning it hold information more time without needing a power source.

- Data memory, which is expected for short-term data storage while the instruction are being executed. Data memory is interconvertible, meaning the data it hold is temporary and is only maintained if the device is appended to a power source

- **I/O peripherals:** The I/O devices are the line for the processor to the outside world. The input ports obtain information and convey it to the processor in the form of binary data. The processor obtains that data and sends the necessary instructions to output devices that carry out task external to the microcontrollers.

Applications of Microcontrollers:

- Light sensing and controlling device like LED.
- Temperature sensing and controlling device like microwave oven, chimney, etc.
- Fire detector and safety device like Fire alarm.
- Measuring device like ammeter.

Advantages of Microcontroller:

- Low time requisite for performing operation.
- The processor chip are very small and ductility occurs.
- Once microcontroller are programmed then they cannot be reconfigured.
- It is convenient to use, troubleshooting and systems maintain is simple.

Disadvantages of Microcontroller:

- The microcontroller can not interface advanced power device directly.
- It has more difficult structure as collated to microprocessor.
- It only performed fixed number of execution cumulatively.
- It is normally used in micro tools.

CHAPTER-5

PERFORMANCE ANALYSIS

PERFORMANCE ANALYSIS

<u>*5.1 Power generated at different voltage-current level reached*</u>

At different stages in this project, variable voltage-current generation took place ranging from 20-100V and 0.05-0.25 milli amperes respectively.

Taking five different readings into account, power generated at different stages has been calculated using the formula:

P=V.I

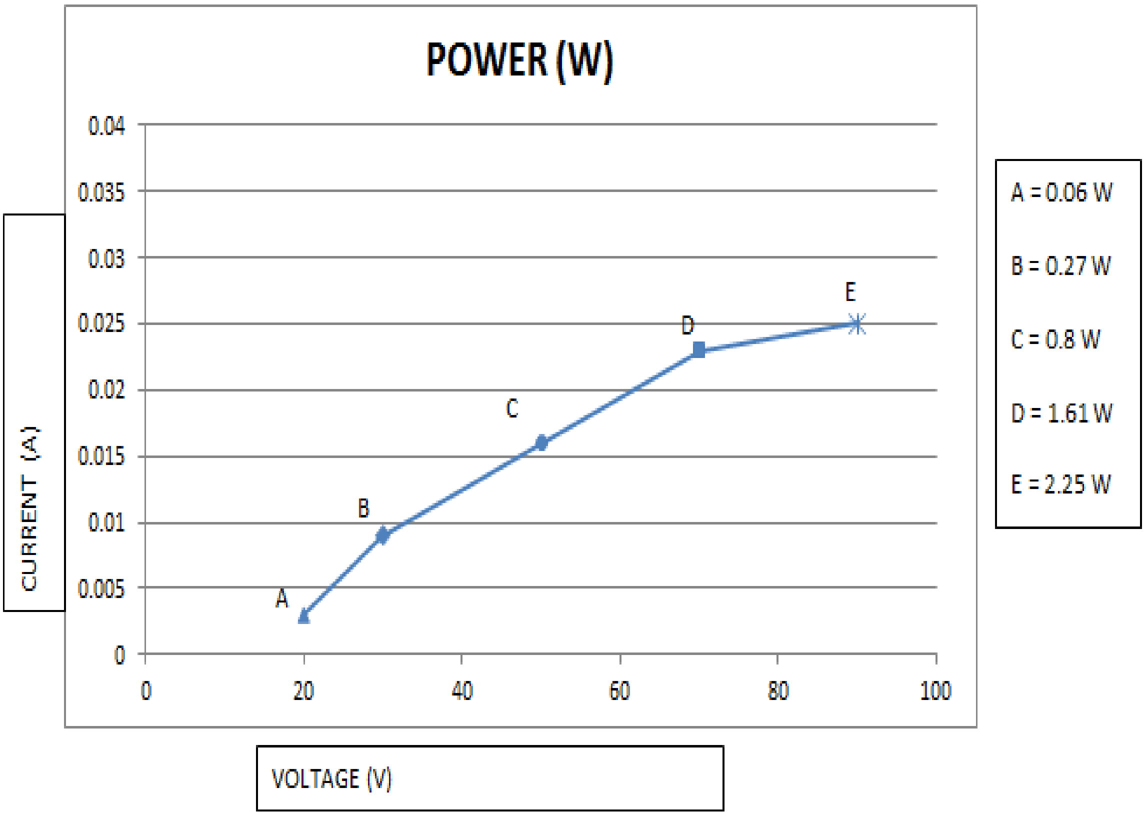

Fig.18: Power generated at different voltage-current produced

5.2 Time required to charge a super capacitor with the help of this system

It took 4 steps (approx.) to fully charge a 470µF capacitor.

470µF ***= 0.00047F***

Multiplying this capacitance with the factor of 10,000 gives:

*0.00047F * 10000 =* ***4.7F***

Similarly, multiplying the steps count with the same factor we get:

*4 * 10000 =* ***40,000 steps***

The result shows that it will take 40,000 steps (approx.) to fully charge a 4.7F super capacitor. The other case study showed that it took 20 steps approx. to fully charge a 1000µF capacitor.

1000µF = ***0.001F***

Multiplying this capacitance with the factor of 1000 gives:

*0.001F * 10000 =* ***1F***

Similarly, multiplying the steps count with the same factor we get:

*20 * 1000 =* ***20,000 steps***

Hence, this result shows that it will take 20,000 steps approx. to fully charge a unit F super capacitor.

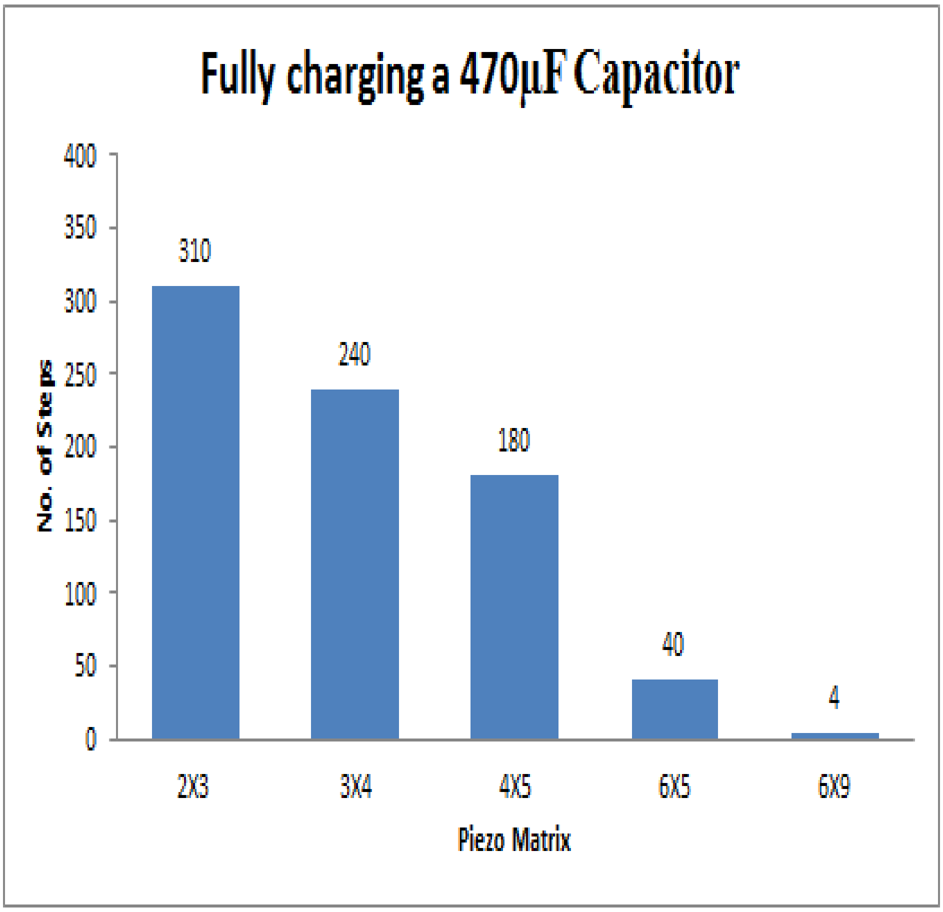

Fig.19: Complete charging of a 470µF capacitor with different piezo matrices design

Studying both the results we can say that on steps count in the range of 20-50K, the piezo sensors will be able to successfully charge a super capacitor of 1-5F value. For the first case study let us consider that;

1 sec = ***2 steps***

therefore, *40,000 steps =* ***20,000 seconds***

This time in hours will be 5.5 hrs. Approximating the hours taken to 6-7 hours, we can say that, the time required to charge a super capacitor of 1-5F is 6-7 hrs.

5.3 Unit Farad supercapacitor discharging time with a resistive load of a 10W LED bulb

It took 50-60 seconds for this system with capacitance of 1000µF to reach 5V mark.

if, 1 sec = 2 steps, therefore, it took 100-120 steps to reach 5V mark in 1000µF capacitor.

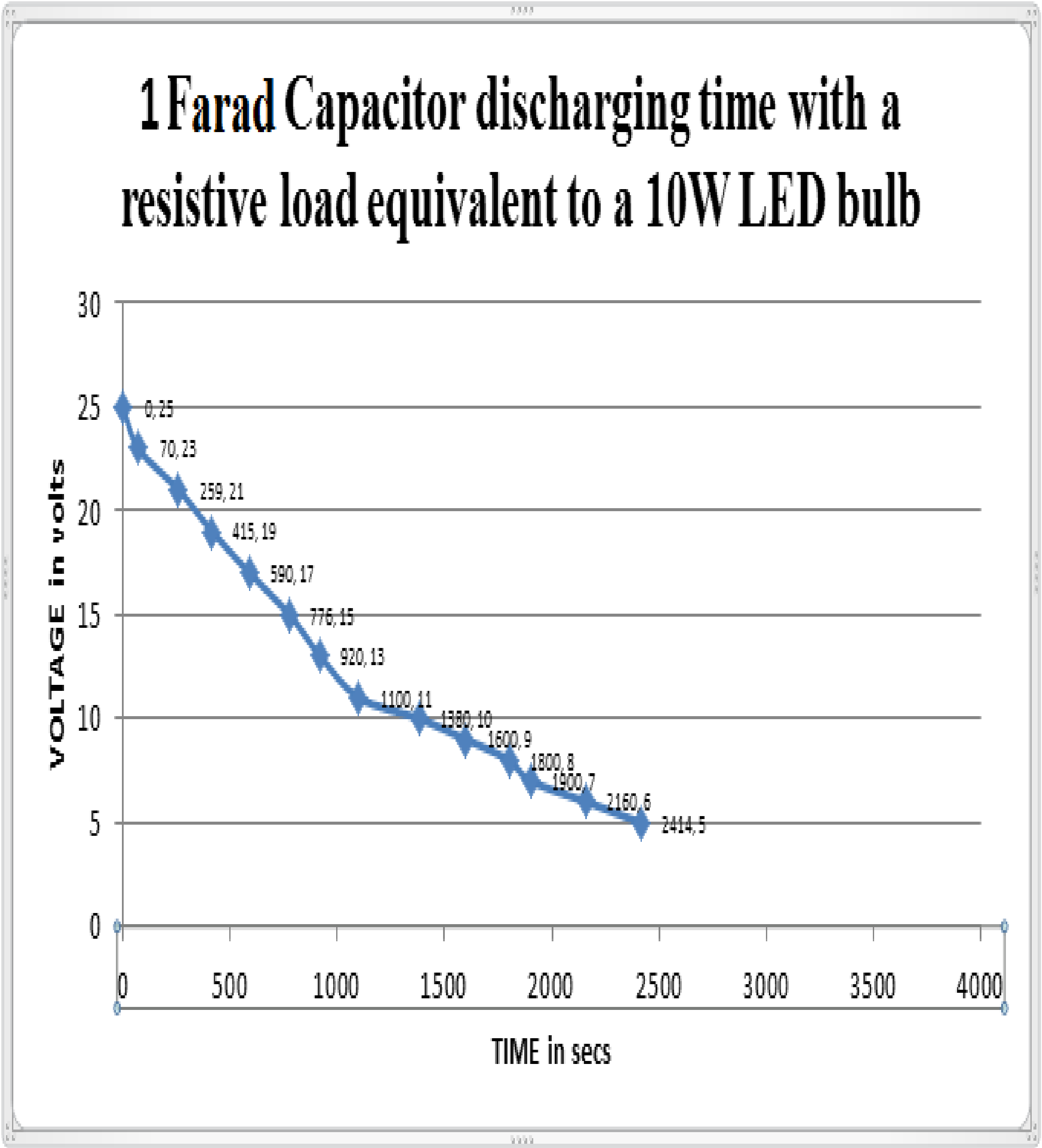

Fig.20: Unit Farad capacitor discharging time with a resistive load equivalent to a 10W LED bulb

The initial voltage considered is 25V and the safety threshold voltage is 5V. The resistive load of a 10W LED bulb is equivalent to 1500 Ω.

Formula used for calculation of this graph is:

$$\mathbf{V_C=V_0e^{-t/RC}}$$

where V_c*=voltage across capacitor,* V_0*=initial voltage, t=time elapsed, R=resistance, C=capacitance*

The time taken by the load to discharge capacitor to threshold voltage is 2414 seconds which is approximately 40 minutes. Hence, we can conclude this study by saying that within 6-7 hours of placing this system in active mode one can conserve the amount of energy which is sufficient to light a 10W LED bulb for good 40 minutes.

5.4 Piezoelectric Energy Calculation

Considering 1000μF capacitor into account with the system working for 1 minute, it will be able to reach up to the mark of 5V (as per previous case study).

So, piezoelectric energy of the system would be calculated using the same formula as that of capacitance energy in low frequency condition, due to its working in such conditions is similar to that of a parallel-plate capacitor;

$$\boldsymbol{U = \frac{1}{2}CV^2}$$

where, C=Capacitance, V=Voltage, U=Piezoelectric Energy

Using this formula, we get:

U = 12.5mJ

CHAPTER-6

CONCLUSION

CONCLUSION

This paper positions itself around the notion of development through non-conventional and renewable energy resources. Piezoelectric Sensor provides an intelligible alternative to the declining reserves of non-renewable resources like coal. Piezo has the potential to furnish a better energy-storage-module by amassing energy from regular human activities like walking and running. The installation of piezo sensors in heavy commuting spaces like railway stations, bus stands, gyms, malls, shopping complexes will create an energy reservoir, much needed to meet the ever-growing demands. As proposed, developing the prototypical piezo model with increased number of parallel connections will lessen the internal resistance of the device and make it more widely accessible. The piezoelectric system paired with photovoltaic cell which harvests solar energy using the technique of solar concentration is a better substitute for pollution-inducing coal and challenges its popularity as a cheap energy resource. This piezoelectric system apart from being a cleaner, noiseless and eco-friendly means of energy production can be made even more economical than coal. As official news release states that, India's electricity consumption would increase upto 4 trillion units by 2030[12]. To secure the future and to be able to meet the enormous demands, adoption of non-conventional methods of energy production, like piezoelectric System, is essential. With collating the harvesting energy technologies vested on the body and footpaths, it is obvious that for body vested harvester the power output depend on the physiological constraint. So, it is preferable to put into practice the harvester within the footpaths to gain a appropriate output. Moreover, in collate among the different type of transduction used in the equipped footpaths, while, the output current of the electromagnetic mechanism is high, the piezoelectric technology with the simple configuration, ductility of the design and geometry, small size of the sensor, the potential of easily meshing into hybrid material has made the piezoelectric transduction favoured. Furthermore, four introduced interconnected conditions , play a major role in achieving the favoured results. It is understandable that the number of pedestrian is the major factor when choosing the type of technology and can be leading on the generated power output. In the other word, the type of transduction has to be selected in pursuance to the number of footsteps and the necessary services. The study solicits for more study on the piezoelectric properties to optimize the power output in order to use the technology for the footpaths in apart applications.

CHAPTER-7

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