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Design and Implementation of Energy Generation System Using Solar and Vibration on Road

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Abstract: — **The growing demands of human needs have increased the utilization of conventional energy enormously. Consequently environmental issues like global warming, drought, famine etc. and other political issue due to its after effect have risen. Keeping these facts in view this project has been prepared to present an model on how the daily energy requirement can be fulfilled in a more practical, feasible and economical way. Solar energy is the viable source of renewable energy over the last two-three decades. It is now used in variety of fields such as industries, domestic purpose. Solar energy system is designed to collect maximum power from sun and to convert into electrical power. Another form of energy is Vibration energy (mechanical energy) that is generated by vibration or pressure applied on it is converted into electric energy by piezoelectric effect. Piezoelectricity is the electric charge that accumulates in certain solid material such as crystal, certain ceramic and biological matter such as bone, DNA and various proteins in response to applied mechanical stress. The aim of this work is to make power generation more sustainable, economical and ecological by utilizing the advancement in the technology. Environmentally friendly solutions are becoming more prominent than ever as a result of concern regarding the state of our deteriorating planet. This project presents a new system configuration of the stage for a hybrid energy system which uses solar power and vibration. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. This projects aims to design and construct optimized charging system for hybrid vibration/photovoltaic energy system**

Keywords: **photo electricity, Piezoelectric generator, Megawatt (MW)**

I. INTRODUCTION

Demand for power is growing exponentially. Electricity demand increasing at 5%, Supply demand gap increasing at 7.5 to 10 %. Industry and agriculture sectors are severely affected on account of power shortage. In the short run it will be difficult to meet the energy demand through already stressed out grid power. The need is therefore promote off-grid and renewable energy so as to take power to remote areas. Even in electrified areas, frequent power outrages; suggest use of more renewable energy. Renewable energy presents a better alternative to fossil fuels with greener impact on environment. Though hydroelectricity offers a potential amount of renewable energy to the world, yet it is not available to all the places of the globe. Solar energy on the other hand has all the opportunity to take over the existing power generation system.

Solar energy is a very large, inexhaustible source of energy. The power from the sun intercepted by the earth is approximately 1.8*1011 MW which is much thousands of times larger than the present consumption rate on the earth of all commercial energy source [1]. Thus, in principle, solar energy could supply all the present and future energy needs of the world on a continuing basis. This makes it one of the most promising of the nonconventional energy sources. Renewable energy presents a better alternative to fossil fuels with greener impact on environment. Though hydroelectricity offers a potential amount of renewable energy to the world, yet it is not available to all the places of the globe. Solar energy on the other hand has all the opportunity to take over the existing power generation system.

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Piezoelectric effect displayed by specific materials having the ability to build up an electrical charge from pressure or strain applied to them. What's the reason for piezoelectric materials to be applicable so abundantly? Well, it's the nature of the material itself: it has the ability to convert mechanical energy into electric energy and vice versa [2]. The property of Piezoelectricity in piezoelectric materials causes generation of voltage on application of stress leading to change in polarization depending upon the two famous phenomenon as direct and indirect piezoelectricity.

II. METHODOLGY

A little device called a solar cell can make electricity right from sunlight ("solar" means having to do with the Sun). A solar cell doesn't give off any gases. It doesn't even make any noise. A solar panel is a group of solar cells that work together. The cells are made of a type of material known as a semiconductor [3]. They are made up of pure silicon. When exposed to sunlight they generate electricity. The technology behind solar is relatively old, despite their futuristic appeal, but while the basics are the same the efficiency of solar panels has improved greatly in recent years. Solar panels usually have a 25-year manufacturers' performance guarantee and you should get another 10 to 15 years of use beyond this.

Piezoelectricity, also called the piezoelectric effect, is the ability of certain materials to generate an AC (alternating current) voltage when subjected to mechanical stress or vibration, or to vibrate when subjected to an AC voltage, or both. A piezoelectric transducer comprises a "crystal" sandwiched between two metal plates. When a sound wave strikes one or both of the plates, the plates vibrate. The crystal picks up this vibration, which it translates into a weak AC voltage. Therefore, an AC voltage arises between the two metal plates, with a waveform similar to that of the sound waves. Conversely, if an AC signal is applied to the plates, it causes the crystal to vibrate in sync with the signal voltage. As a result, the metal plates vibrate also, producing an acoustic disturbance [4].

The piezoelectric effect is a special material property that exists in many single crystalline materials. Quartz, Rochelle salt, topaz, tourmaline, sugar cane, Berlinite ($AlPO_4$), bone, tendon, silk, enamel, dentin, Barium Titanate ($BaTiO_3$), Lead Titanate ($PbTiO_3$), Potassium Niobate ($KNbO_3$), Lithium Niobate ($LiNbO_3$), Lead Zirconium Titanate (PZT) etc. are examples of such crystalline structure. PZT is well known energy converting source because it has high electro mechanical coupling coefficient [5].

III. SYSTEM DESIGN

The project is hybrid generator of energy which uses two sources namely: solar and piezo sensor. When sun light is present the solar panel absorb light and generate electricity which is stored in battery. The series as well as parallel connected number of piezosensor generate electric charge when a vehicle passes above it.

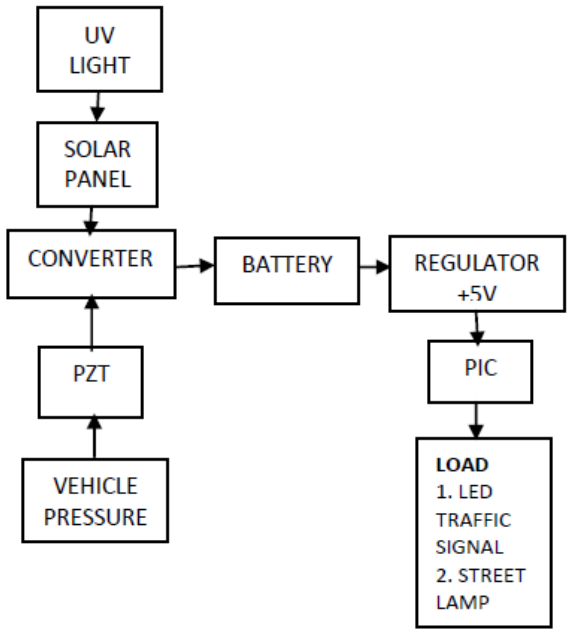

Fig. 1: Block Diagram

Energy regeneration by PZT device is very much related to the stress that can be generated by the PZT device where we know that deflection is the source for the stress. An increment in the deflection simply can be done by increasing the concentrated load. It provide energy whenever an object apply pressure on it thus it is independent of weather. This system ensure that no use of fossil used. This system have high life cycle because there are no mechanical part in the sensor.

In the utilization part, we have made a PIC controller to operate a smart. Our project can be extended by using number of generation source that is by increasing the solar panel and piezo sensor used.

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IV. SYSTEM COMPONENT

A. Piezoelectric generator

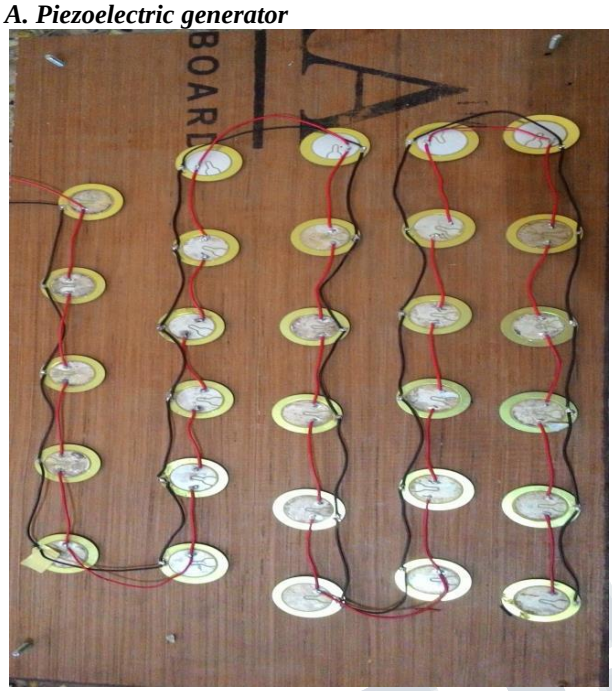

Fig. 1 Ceramic Piezo-electric element connected in parallel

Kinetic energy can be converted into electrical energy by means of the piezoelectric effect: Piezo elements convert the kinetic energy from vibrations or shocks into electrical energy. The conversion chain starts with a mechanical energy source from vibration. The vibrations are converted into electricity via piezoelectric element. The electricity produced is thereafter formatted by a static converter before supplying a storage system or the load (electrical device). Piezoelectric generators work due to the piezoelectric effect. This is the ability of certain materials to create electrical potential when responding to mechanical changes. To put it more simply, when compressed or expanded or otherwise changing shape a piezoelectric material will output some voltage. Solar cells or photovoltaic cells are semiconductor diodes that convert available sunlight (at least a portion) into electrical power.

Piezoelectric materials have the unique and useful property of being able to transform mechanical energy into electrical energy, and vice versa. This gives piezoelectric materials a wide range of potential applications from sensors and actuators to artificial muscles. One of the most interesting applications is in the field of energy harvesting, where piezoelectric materials are used to convert mechanical energy that is typically wasted into a source of electrical energy. However, the technology of currently available piezoelectric materials and methods is unable to produce a sufficient amount of energy, so engineers are researching how to improve piezoelectric energy harvesting devices. Energy regeneration by PZT device is very much related to the stress that can be generated by the PZT device where we know that deflection is the source for the stress. An increment in the deflection simply can be done by increasing the concentrated load.

B. Solar panel

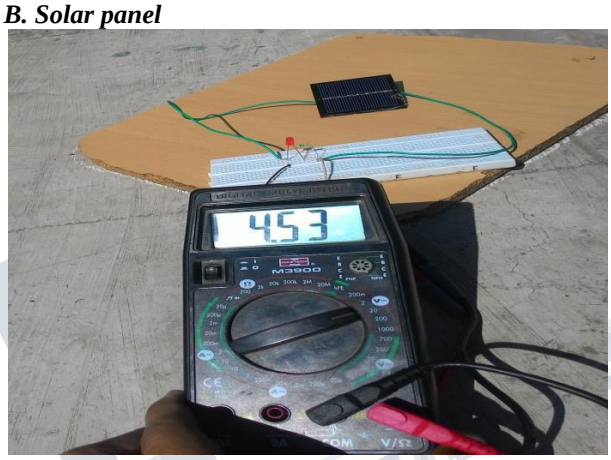

Fig. 2 System Implementation

Solar energy is unsurpassed by any other form of energy. Solar energy was originally coming from sun. Solar cells convert this solar radiation into useful electrical energy and store them in storage such as batteries, but in these cases, it will directly converted to be used for competition. Solar radiation strikes the earth surface and creates the paramount source of alternative energy. Solar panels help to harvest this energy and convert it into usable energy.

Solar is an intermittent power source that functions only when the sun is shining. Solar cells or photovoltaic cells are arranged in a grid like pattern on the surface of the solar panel. These solar voltaic cells collect sunlight during the daylight hours and convert it into electricity.

In traditional solar modules (polycrystalline and monocrystalline), silicon wafers are impregnated with impurities to create a semiconductor that converts sunlight into electric current. Electrical contacts are then created to join one solar cell to another. As silicon reflects, an anti-reflective coating is placed on top of the silicon wafers, usually titanium dioxide or silicon oxide. The solar cells are laid between a superstrate layer on the

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top and a backsheet layer on the bottom. The superstrate is usually glass, and the backsheet is plastic. This is then placed inside an aluminium frame to create a finished solar panel.In thin film solar panels, it's a different process. It begins with a thin layer of flexible substrate such as coated glass, stainless steel or plastic and metal contact, and the solar cell is then built up in a series of layers. An oxide layer is then applied at the end to form the electrical contact of the cell. The cell is then laminated with a weather resistant superstrate material. Simply put, a solar panel works by allowing photons, or particles of light, to knock electrons free from atoms, generating a flow of electricity. Solar panels actually comprise many, smaller units called photovoltaic cells.

Table I: Material used in solar cell

MATERIAL	MARKET EFFICIECY (%)
Monocrystalline	12-15
Polycrystalline	11-14
CdTe	7-10
CIS	11-12

C. Microcontroller

Application of energy must be done, so to utilize this energy we have designed a traffic control system. This is small scale implementation of the project. The street light turn ON and OFF according to the program feed in the controller. Generally PIC controller are used because of their in-built feature which provide user to interface with them easily [6].

The designed smart traffic light control system corresponds to a junction of 4 mono directional roads in the form of "+". We aim in the first place to investigate the technologies of the existing systems and seek the most appropriate employed devices. We try also to test the proposed integrated design as architecture, hardware, and software. Next step will be an extension of the suggested traffic light system to a bidirectional "+" junction with various routing configurations. Our research target involves the management of traffic light systems for multiple adjacent bidirectional roads [7].

D. Lamp

Lamp or street light are number of LEDs connected along the road. They are used to illuminate the path. They are powered by the battery and turned ON-OFF by microcontroller. An extra pair of LED bulb is used because they operate on DC voltage and hence can be directly connected to the battery. This further increases efficient energy utilization.

E. Battery

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices. Battery is used to store the energy generated and use it after some time. It provide the system with power when both sources are disabled to produce electricity. They are various type of battery available in market some are given below:

- Lead acid battery
- Nickel cadmium
- Lithium Ion battery
- Lithium Ion polymer

From the charging characteristics of lead-acid battery, lead-acid battery can accept different currents at different rechargeable stages. Especially in the end of charge, if its charge current is too large, the battery will gas seriously and its temperature rises rapidly, seriously affecting battery life or even battery explosion [8]. Battery life can be extended by storing the batteries at a low temperature, as in a refrigerator or freezer, which slows the side reactions. Such storage can extend the life of alkaline batteries by about 5%; rechargeable batteries can hold their charge much longer, depending upon type. Rechargeable batteries typically initially cost more than disposable batteries, but have a much lower total cost of ownership and environmental impact, as they can be recharged inexpensively many times before they need replacing. Some rechargeable battery types are available in the same sizes and voltages as disposable types, and can be used interchangeably with them. Lithium iron phosphate batteries reach according to the manufacturer more than 5000 cycles at respective depth of discharge of 70%. After 7500 cycles with discharge of 85% this still have a spare capacity of at least 80% at a rate of 1 C; which corresponds with a full cycle per day to a lifetime of min. 20.5 years.

F. Charging Circuit

Usually, in real-world application of vibration power harvesting, a rectifier circuit is necessary to convert AC to DC in order to charge a battery or to feed directly an electronic device. A very simple and common non-controlled rectifier circuit is the full-wave rectifier with Diode Bridge. A schematic diagram is shown below.

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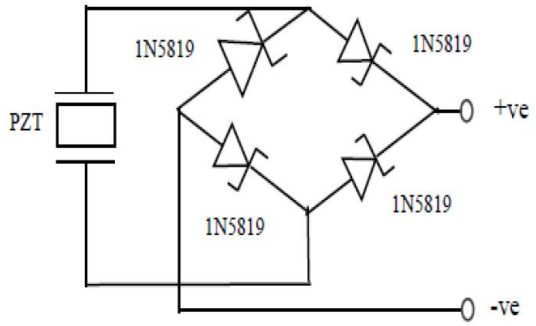

Fig. PZT rectifier circuit

PZT set produces energy for every pressure on it and this PZT AC signal is converted into DC signal after rectification. The charging circuit for 20 PZT plates.Capacitor is used to store DC voltage in battery.

V. MODEL

Fig System Implemented

In this project we have a model for lighting the streets of city which is cost-effective and self-sufficient. Instead of using electricity from poles, we have used solar panels and piezo sensor. We have also an efficient traffic management and street light system. This model when implemented will be used for wide application which will further enhance the cultivation of energy.

Urban area are suitable for this type of purpose hence enhancing the energy efficiency of the system. This type of prototype will ensure that the energy is used fully and no wastage take place**.**

VI. EXPERIMENTAL DATA ANALYSIS

In the project the single solar module of 4V, 100mA is tested by taking reading from morning to evening. The graph below shows the power generated P=V*I

Fig. 3 Solar module readings

VII. ADVANTAGES

The following advantages can be observed after implanting following system

- Conservation and Utilization of Natural Resources.
- This present model ensures the reduction in the use of coal and other sources of energy.
- By the reduction in the consumption of coal, its reserves will last for a longer time in earth and will give service to mankind for a longer time.
- This will save a huge amount of money which the government spends for purchasing power for street
- No fuel transportation problem
- Energy available all the year round light.
- Life time expected system is around 15 years
- Require led cost in maintaining the system.
- Various government scheme are available for developing such system

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CONCLUSION

In this study, we have investigated the feasibility of applying piezoelectricity to convert the mechanical vibrations of roadway to useful electricity. We have also investigated the practicability of employing solar concentrators to enhance the output power of the solar panel to a considerable level. We hope that our project will help to reduce pressure on conventional power use and current generation. This model is simple and less complex as compared to others and it has very vast future development scope.

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