International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE) Vol 2, Issue 4, April 2015

Electricity generation using piezo-road with automatic traffic light and street light control

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Abstract: **Electricity has become a major need of present day civilization and its demand is increasing rapidly. Hence we need a non-conventional method of power generation. This paper emphasis one of the promising electricity generation method using piezoelectric material. Vibration energy that is generated by vehicle movement on the road converted to electrical energy by piezoelectric effect. Instead of considering traffic as a problem we can take it as an opportunity to produce energy. And the generated energy effectively utilized for the automatic control of traffic light and street light. Here, a solar panel is also used as an alternative energy source. Hence by all means a piezo-smart road can be developed.**

***Index Terms*— Automatic traffic light and street light control, Energy conservation, Vibration energy, Non-conventional energy, Piezoelectric crystal.**

INTRODUCTION

NOW a days, energy is an essential need for human life and for the development in all the sectors of economy. The drastic increase in population and rapidly decreasing conventional energy sources force us to think on promising way of non-conventional energy harvesting methods. When vehicles move, a large amount of kinetic energy is getting dissipated on roads. Hence, we make use of the vibration energy generated by the moving vehicles into a useable form of energy. Using the principle of piezoelectric effect the vibrational energy is converted into electrical form and stored as a backup source. A solar panel is also used as an alternative energy source. This stored energy is used as a power source for the functioning of traffic lights and street lights. The status of the battery charging is also indicated and this information is also sent to the nearby traffic control room.

I. THEORETICAL REVIEW

The scarcity of energy which inversely affects the development of an economy lead us to think about the modern methods of energy harvesting like piezoelectric energy producing techniques. The energy crisis experienced in various countries made them to implement this type of energy harvesting techniques to overcome these kinds of situations. Firstly, we analyzed a paper that pointed out the crisis of electricity faced in California was solved to a great extent by the method of piezoelectric effect. They made use

of the vibrational energy of vehicles over the piezoelectric sensors placed beneath the road to supply power to various houses near the highway. It could generate around 44 megawatts of electricity over a 1km stretch. Another paper explained an innovative method to harvest energy from piezo-shoes. The piezoelectric sensors placed in the sole of the shoes converts the mechanical motion of our feet into an electrical energy and stores in a rechargeable battery. It also explained about a bag which has straps with piezoelectric sensors bound with it that could also generate small amounts of electricity due to the axial motion of the straps which can create vibrational forces on the piezoelectric crystal. The next paper described about the vibrational energy obtained from an Inter-city125 train. The piezoelectric sensors are placed on the railway track. When the wheels of the train exerts a mechanical force on these sensors, electrical energy is produced. And this energy is used to operate various electrical circuits inside the train itself. These helped us to develop ideas of energy harvesting and its effective utilization.

Our paper emphasize on the technique of energy harvesting using the piezoelectric sensors embedded beneath a four-way junctioned road and that energy is stored in a rechargeable battery. Solar energy is used as an alternative source of energy and also stored as a backup. The battery

may switch to either of these sources according to their availabilities. And these sources of power is used for the operation of traffic light and street light control.

II. Future Scope of The Paper

As years pass by, need for electricity is increasing. For a better future, we need to eliminate the scarcity of energy that we may be forced to face. So we need a better plan that works when such situations arise. The non-conventional method of energy harvesting which is emphasized in this paper is one of such hopeful methods.

The energy production using piezoelectric method will be a revolutionary change that helps in an economy's development. This technique of electricity generation can be made possible through various other ways also. For example, piezoelectric sensors can be embedded on the footpaths where people walk, jog etc. These sensors can also be placed on the tread mills on which people exercise or on a dancing floor where the vibrational energy can be made use of to generate and store power. Airport runways are also such platforms for this. All these ideas will help us to generate electricity at a low cost and made available without any difficulty.

III. Principle of Working

The basic principle which we use to generate electricity is the piezoelectric effect. A piezoelectric material is that one which converts mechanical energy or vibrational energy that is experienced on it, to a charge which can be stored. When a force or pressure is exerted on the elastic piezoelectric crystal material, the crystal gets deformed and this causes it to develop charge between them and the crystal goes back to its original state. This charge flow is converted to a voltage that can be stored in a battery. We explain about a disc shaped piezoelectric buffer plate in our paper. Since the power obtained from a few of them will be in a very small amount, we use voltage amplifying circuits here. As the size and number of piezoelectric crystals increase, the energy obtained from them also increases.

Fig. 1 A disc shaped piezoelectric buffer plate

The power from this source is effectively supplied for the functioning of traffic lights and street lights. The traffic and street lights are automatically controlled. The street light is controlled automatically by Light Dependent Resistors (LDRs). With the help of LDRs the street lights are automatically switched off during day time and switched off during night time. The automatic traffic light control is made possible by two pair of IR transceivers placed on each road of the four-way junction. Each transceiver pairs are kept face to face width-wise on each road. When the IR signals between each of the transmitter and receiver pair gets cut proportionally according to the traffic density on each road, the traffic lights are controlled. This functions with the help of a program stored in a microcontroller. Besides all these, the charging condition of the battery is sent and indicated every second to the nearest traffic control room.

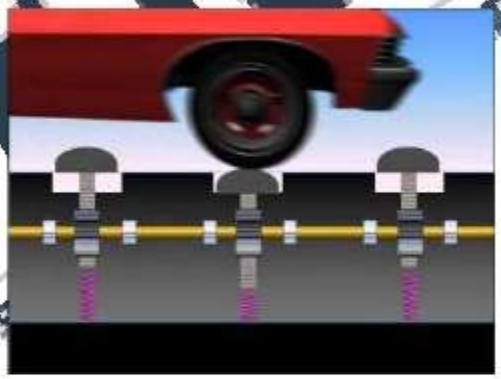

Fig. 2 The mechanical force exerted by wheel of a vehicle over piezoelectric sensor on embedded on road

Block Diagram

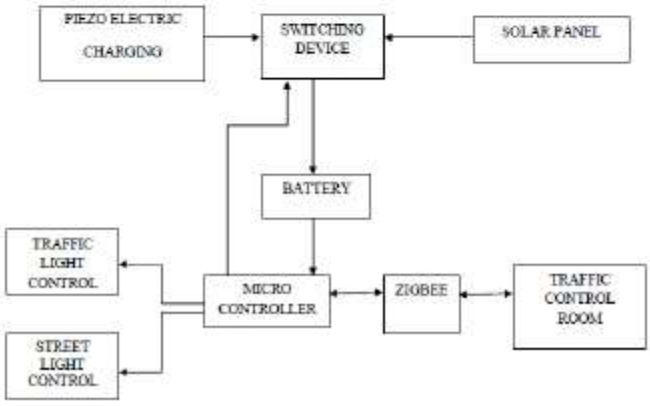

Fig. 1 Block Diagram

The vibrational energy to useable electrical energy conversion is made possible by the help of piezoelectric sensors embedded beneath the asphalt which is the main aim of this project. The mechanical force exerted by the vehicles over the sensors will create a proportional vibrational motion of the sensors. The charge proportionally produced in a sensor as a result of this vibrational motion is converted

to useful voltage or current by an external circuit and is stored in a rechargeable battery.The piezoelectric crystal we use in this project is a disc shaped piezoelectric buffer plate. Around 20 of such piezoelectric sensors may be placed in series together at a depth of 10 cm beneath the asphalt of the road for a demonstration and so as to get a sufficient amount of charge from it to be stored in a battery simultaneously. And this is used for the controlling of traffic lights and street lights. Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. The solar panel converts the solar energy to electrical voltage and this is also got stored in the battery. And this is used as an alternative source of energy to control traffic lights and street lights, when the energy from the piezoelectric charging block is unavailable.

In our project, the battery mainly stores the voltage that comes from the help of piezoelectric sensors. But if the source of energy from the sensors due to vehicle movement is unavailable for the battery, then it has the option to switch on to an alternative source from a solar tracking system.

So, there are two energy sources available for the battery. The power to the traffic signals and the street lights is supplied from this battery itself. A switching circuit helps the battery to switch on to either of the sources when one is unavailable or as per the need. For this purpose, a programmed microcontroller helps the switching circuit to perform this action as per its instructions. In the demonstration of our project, since the power from the battery is of low range, we are using amplification circuits to increase the voltage up to a sufficient level. The unavailability of any of the two sources is known to the microcontroller and it sends signals to the switching circuit and at the same time informs to the nearest traffic control station to take necessary action. And also if the battery is not properly working, this also is checked by the microcontroller and informs the traffic control station. The microcontroller we use in this project is MSP430F249 of MSP(Mixed Signal Processor)430 series. Micro-controller works according to the program written in it. The microcontroller here is used to control the whole system including traffic signal control, battery power switching. It sends control signals to the switching device to help the battery for switching to either of the power sources (solar panel or piezoelectric sensors) and getting charged. When the battery has any problem in charging or it doesn't have any power left, the microcontroller automatically senses it and sends the information via zigbee to nearest traffic control station. The microcontroller also automatically controls the traffic signals. And the µc operates using a separate power supply.

EXPERIMENTAL OBSERVATIONS

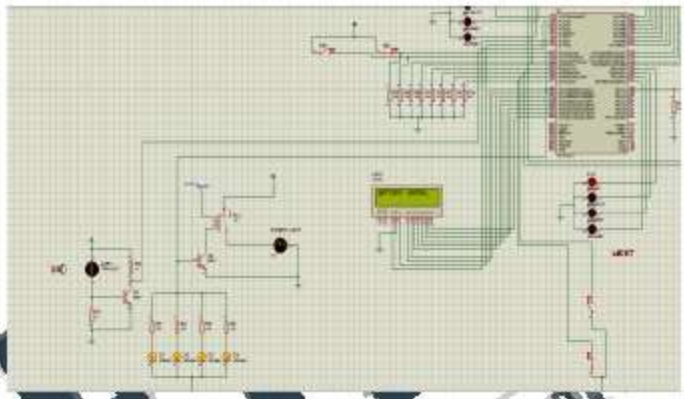

Fig. 2 Charging indication of battery and street light on condition

In fig. 2 an LCD display is there that shows 'battery normal'. This indicates the normal charging of the battery. Along with this a LDR is placed near the street light. When torch is away from the LDR (i.e. the sunlight is less) the street lights D1, D2, D3 and D4 will be in on condition.

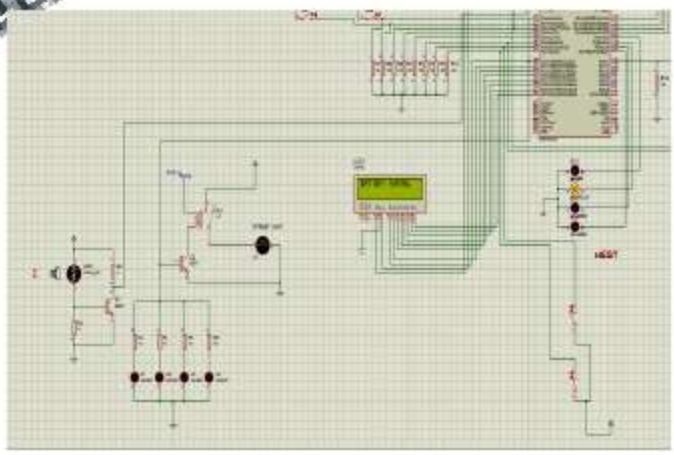

Fig. 3 Street light off condition

In this fig 3 the torch is coming closer to the LDR. As it comes closer (i.e, sunlight is more) the street light turned off.

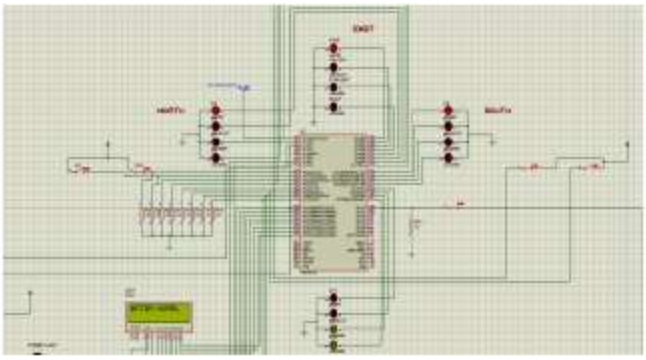

Fig. 4 Operation of traffic signal in a four-way junction

In fig. 4 its shows the traffic signal in a four way junction. In each direction there is a red, yellow and two red light. Here in this figure in west side the signal shows green and all other direction it shows red. Similarly all other combination are possible.

CONCLUSION

Vibrational energy harvesting technology is highlighted as a permanent power source of portable electronic devices and wireless sensor network. There have been many novel ideas for vibration-based piezoelectric energy harvesters.

Industrial and manufacturing units are the largest application market, for piezoelectric devices, followed by the automotive industry. There is also high demand from medical instruments as well as information in telecommunication.

The largest material group for piezoelectric device is piezocrystal and piezopolymer due to its low weight and small size. Piezoelectric crystals are now used in buzzer, solar system also. This technique can solve the problem of electricity to road lighting system, and without the need of kilo meters of electrical wire which runs along the side of the road. It is more efficient operation techniques with cost effective device.

Piezoelectric materials are capable of carrying high load and operating very high frequencies. It requires no maintenance as there are no moving parts. It acts as a capacitor and therefore requires very little power. Piezo-smart road is a promising future for a power generation and utilising system without any separate inputs for the operation and control of various other systems. However, protection of sensitive piezoelectric devices is required against harsh weather condition, and strong electric fields (200-500V/mm) can break down dipoles and depolarize a piezoelectric material.

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