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Stand alone electric power generation for roadways lighting

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Abstract—Energy harvesting technologies refer to applications that capture and exploit the unused and depleted energy so as to convert it to a more usable form. There are many different types of kinetic energy (natural or man- made) can be harvested and converted to electrical energy. Piezoelectric generators convert mechanical strain into electrical energy. They can be inserted into shoes, in walkway pavers or roadway to harvest the energy of walking, jumping or vehicles movement. This research presents a standalone - powered system generation using Piezoelectric based energy harvesting technology in roadways applications

Index Terms— **Arduino Uno microcontroller, energy harvesting, piezoelectric converter, pollution-free technology, renewable energy, roadway lighting.**

I. INTRODUCTION

Highlight solar cells and wind turbines are rapidly becoming an inexpensive, pollution-free technology to harness renewable energy from the sun and wind [1]. Energy harvesting may or may not capture renewable.

In the case of sunlight, the energy is renewable because it is sourced from the sun, a source of nearly infinite energy for the planet and the solar system.

Vibration in industries, roadways or any where may not be renewable since the processes generating of the vibration may not be renewable, however, vibration may be a significant source of energy to be harvested.

Piezoelectric materials fall within a class of multiple solid state materials that can generate electricity with the application of stress [2]. Piezoelectric materials are widely available in many forms including single crystal (e.g.quartz), piezoceramic (e.g. lead zirconate titanate or PZT), thin film (e.g. sputtered zinc oxide), screen printable thick-films based upon piezoceramic powders and polymeric materials such as polyvinylidene fluoride (PVDF) [3]. Piezoelectricity is found in useful applications such as the production and detection of sound, generation of high voltages, sensors, actuators, frequency standard, piezoelectric motors, reduction of vibrations and noise, electronic frequency generation, microbalances, ultrafine focusing of optical assemblies and piezo-smart roads [4].

Using piezoelectric to harvest vibration energy from humans walking, machinery vibrating, or cars moving on roadway is an area of great interest, because this vibration energy is otherwise untapped.

Since movement is everywhere, the ability to capture this energy cheaply would be a significant advancement toward greater efficiency and cleaner energy production[2]. For example, London Club Surya and Rotterdam Watt have piezo floors to harvest energy from dancers. The floor system is engineered with springs and a series of crystal and ceramic blocks and ceramic blocks. In the clubs, this can supply up to 60 percent of the club's energy needs. Each person can produce between 5 to 20W [2].

The hierarchy at the stand alone electric power generation procedure is; firstly, the harvesting of energy; secondly, the storage of energy that includes its condition before its final use as shown in Fig.1[3].

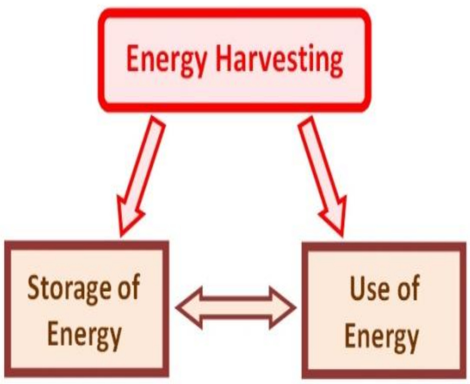

Fig. 1: Stand alone electric power generation principle [3].

II. PRACTICAL CONCEPT

This research presents a standalone-powered system generation pollution-free technology; using Piezoelectric based energy-harvesting technology in roadways application.

This energy is produced by consumers' participation without requiring any kind of input energy. The waste vibration and compression under the vehicle tires are converted to electric energy. Parallel rows of energy harvesters, each row contains large number of piezoelectric units, are embedded in roadway. Each of them when compressed generates electric power. The electric load, such as roadways lighting, traffic indicating signals, roadside advertising and other local services consume the harvested energy. Rechargeable batteries have been traditionally used to store excess electric energy in standalone power systems. The system has been suggested to be used any where, especially in remote areas, where no electric grid is available and in the cities where the period of day light is insufficient to use the solar cell system or any other renewable energy system which is not available as a source of energy.

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III. SYSTEM WORKING

Fig.2 shows the block diagram of the proposed stand alone electric power generation for roadways lighting, traffic indicating signals, roadside advertising and other local services. The first block represents energy harvester modules, which consist of piezoelectric devices embedded in roadways to recapture energy in the form of vibration and compression under the vehicle tires and convert it to electric energy. The output electric signal of the piezoelectric devices is fed to a conditioning and shaping circuit, and the output of the conditioning and shaping circuit is fed to a microcontroller. The microcontroller is used to control the functions of energy storage and energy consume of roadway lighting, traffic singles, roadside advertising and other local services. Also a light sensor and car movement sensor are connected to the microcontroller. The microcontroller provides control signals to relays, the relays are used to provide isolation between low voltage circuitry and high voltage circuitry.

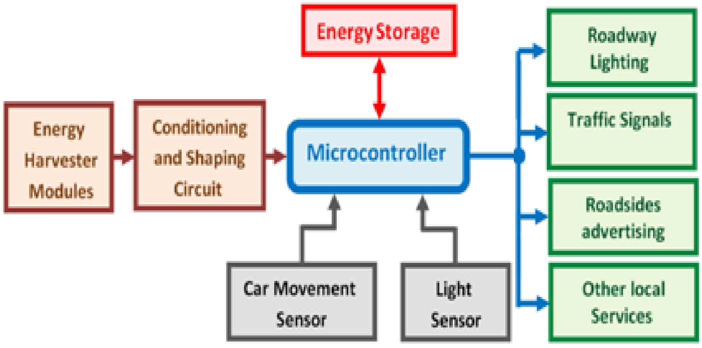

Fig. 2. Block diagram of the proposed system.

IV. PRACTICAL APPLICATION AND ARRANGEMENT

A prototype system, of the stand alone electric power generation for roadways lighting and other local services consume energy, has been constructed as shown in fig. 2:-

(I) Energy harvester modules:-

The main source of energy in a piezoelectric roadway ener gy harvesting event is the impact of the vehicle tire (and the weight it bears) as it transitions over a piezoelectric device. This energy is kinetic energy that goes otherwise unused, a nd is an accepted inefficiency that comes with the use of vehicle as a transportation mode. Harvesting a fraction of this energy may be a source for increasing the overall efficiency of transportation infrastructure [2]. Reference [5] provides a detailed list of novel piezoelectric devices, along with their application, power, voltage, and current data, it can be seen that the devices have ranged in scale from micro to macro, with output power values that range from 1 μW to 25kW [5].

The piezoelectric materials relevant to this application are design for low frequency vibration harvesting in the range of 100 to 120 Hz [2]. A piezoelectric material generates energy when it is stressed and strained. This primary Mechanical stress generates a voltage and current pulse, the product of which is power. There are two technologies reviewed in this research that harvest energy in two different ways, but both rely on stressing a piezoelectric element. In the first case, a stack of piezoelectric material is compressed to generate energy and a pulse of power is registered with each compression cycle (such as the passage of a vehicle tire over the stack). In the second case– based on what can be simplified and inferred from product literature the energy harvesting mechanism appears to be an array of cantilever or bent beam piezoelectric energy harvesters vibrating as a result of external stimulus (such as the passage of a vehicle tire overhead). The power profile continues to generate power for a longer duration as the vibrations decay. An example of a vibrating device is shown in Fig. 3 [2] in comparison to a compression based energy harvesting device. An array of many devices within a small volume leads to to higher energy or power density. However, the array configuration and duration of output will determine these properties [2].

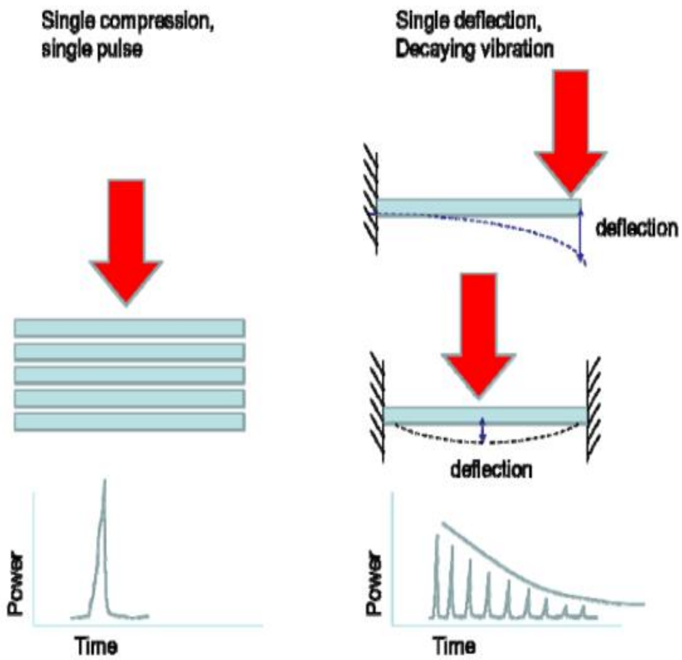

Fig.3: Difference in performance characteristics of compression-based energy harvesters and cantilever energy harvesters [2].

The roadway piezoelectric units are installed in the road bed and epoxy is used as a filler to permanently affix the units in place, such as what was demonstrated by Virginia Tech.

Approximately 5 cm (2”) of asphalt is overlaid as shown in Fig.4 [2]. Also in this configuration, a less efficient transformer is used which may lead to 30 percent losses (70 percent pass through efficiency) in conversion of the power signal to usable power [2].

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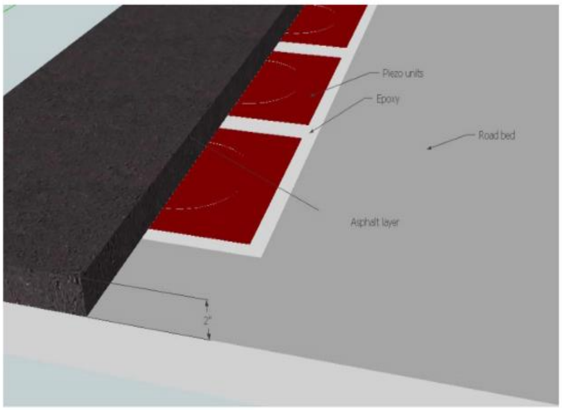

Fig. 4. Cross-sectional diagram of roadway installation of piezoelectric energy harvesters [2].

(II) Conditioning and shaping circuit

The output of the piezoelectric devices is randomly alternating. Multiple piezoelectric devices are connected inside modules. Modules are wired together to form arrays, then tied to the conditioning and shaping circuit, which produces power at the desired ac voltage, and the desired frequency/phase. The conditioning and shaping circuit design depends on the output waveforms properties of the voltage and current of the piezoelectric devices.

(III) Energy storage

Since the proposed system does not produce consistent power twenty-four hours a day, it is important to select techniques of accumulate and store of energy for later use, such as rechargeable batteries [6].

(IV) The microcontroller board

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as pulse width modulated PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, it has other pins for specialized functions. The Arduino Uno can be programmed with the Arduino software.

Select "Arduino Uno w/ ATmega328" from the Tools Board menu (according to the microcontroller on your board). For details, see the reference and tutorials. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing).

Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP) [7]. The Arduino UNO is a popular microcontroller which comes on a development board to accelerate programming, provides simple interfacing with peripheral devices and connection with computers. The Arduino UNO chip is programmed with the Arduino programming language and Arduinio 1.0 software through a USB port on the board which plugs into a computer's USB port. The Arduino 1.0 software writes code from the software to the chip by uploading the file containing the desired code to the board. Once the chip has been programmed with the desired code, the chip can be removed from the development board and connected to any circuit.

(V) Light sensor

Light sensor and roadway light control using Arduino is designed to measure intensity of light or amount of light. Roadway light is controlled automatically with the help of intensity of light and Arduino. Light dependent resistor is used for detection of light. Relay is used to provide isolation between Arduino and 220 volt ac roadway light. For more details and circuit diagram and Arduino programming, refer to [6].

(VI) The vehicle movement sensor

The ultrasonic sensor hc-sr04, which shown in Fig. 2, is used as speed sensor to measure the vehicles speed. This sensor is adapted through the microcontroller to be used as speed sensor to measure the vehicles speed [8].

V. RESULTS AND CONCLUSIONS

A prototype model of standalone electric power generation for roadways lighting has been proposed. The waste vibration and compression under the moving vehicle tires are converted to electric energy using piezoelectric devices to use for roadways lighting, traffic indicating signals, roadside advertising and other local services. As a result, greater labor costs are required for installation, and greater difficulties are encountered with maintenance. On the other hand power generated from 'Piezo-smart roads' concept is green power and no harm to the environment. This energy is produced by consumers' participation without requiring any kind of input energy. The actual model can be performed practically in future and its results will indicate a demonstration and further evaluation of the technology should attempt to quantify the power output, durability, and lifetime of the system in addition to its performance as a function of traffic volume is warranted, The benefits to the cities and countries could be studied. Future development enhancement improves the quality of life by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace. The research can be extended. With grid-connected the proposed power system, excess electric energy can be sent to the electrical grid.

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REFERENCES

[1] httpsen.wikipedia.orgwikiSolar_power.

[2] DNV KEMA Energy & Sustainability,"Assessment of piezoelectric materials for roadway energy harvesting", January 2014 CEC-500-2013-007.

[3] Andriopoulou Symeoni, " A review on energy harvesting from roads", MSc Environmental Engineering & Sustainable Infrastructure, [TSC-MT 12-017].

[4] Priyanshu Kumar, "Piezo-Smart Roads", International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463, Vol. 2 Issue 6, June-2013, pp: (65-70).

[5] Kimberly Ann Cook-Chennault, Nithya Thambi, Mary Anne Bitetto and E.B. Hameyie, "Piesoelectric energy harvesting", Bulletin of Science, Technology & Society, Vol.28, No.6, Dec 2008 pp496-509.

[6] Bilal Malik, "light sensor and street light control using Arduino", October 1, 2014 http://microcontrollerslab.com/light-sensor-street-light-control-using-arduino.

[7] RS Radiospares Radionics, "Technical specifications and how to use Arduino Uno". http://www.oz1edr.dk/Arduino%20Uno/Arduino%20UNO.pdf.

[8] ELEC Freaks, "Ultrasonic Ranging Module HC - SR04, Tech Support". http://www.micropik.com/PDF/HCSR04.pdf.