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PIEZOELECTRIC BASED AUTOMATIC POWER GENERATION USING IoT

Ambrish R.[1], Ashwini S.[2], Dharun Surya M.K.[3], Karthick M.[4], Dr.T.Kalaikumaran[5]

[1, 2, 3]Student, [4]Assistant Professor, [5]Professor and Head of the Department,
Department of CSE, SNS College of Technology, Coimbatore, Tamilnadu (India)

ABSTRACT

Power is the essential one for human's day-to- life at the same time humans waste the power in various ways. So the main objective of our project is to generate a renewable electric energy to charge a mobile phone wirelessly and also monitor and control the power supply through the mobile application. This paper designed to generate the renewable electric power and reduce the energy wastage. More number of pedestrians pass through the subway, stairs andalso many vehicles pass through the roads which creates the vibration under the floor. These vibration in turn to produces mechanical energy. Piezoelectric sensor is used to convert the mechanical energy into electrical energy and this energy is then used to charge the high capacity battery. Internet of Things (IoT) server connected to a piezoelectric material which monitors the amount of energy generation and control the whole system. IoT server is connected to a Multi Control Unit (MCU) for wireless network to communicate with personal computer (PC) or mobile phone to the piezoelectric material. This technology aim to bring a wireless charger for mobile phones, laptop and etc.

***Keywords*: electrical energy,IoT, MCU, piezoelectric, Wireless charger.**

I. INTRODUCTION

The human life turns into very modern, the electricity plays the vital role of our modern life. Everyone has a smart phones. The mobile phone works by electric power, everyone wants to charge their phone. There are two types of energy available one is renewable and another one is non-renewable. Instead of using non-renewable energy resource, renewable energy reduce our electricity problem. Piezoelectric sensoris the material which gives provide electricity to small electronic gadgets with the help of IoT(Internet of Things) server.IoT is the modern technology to communicate with piezoelectric sensor. This system mainly concentrate on to charge the mobile phone with using wireless system. When the pedestrians pass through the subway or vehicles passes on the road the vibration will be created this vibration is known as mechanical energy. Piezoelectric sensor has the power of converting mechanical energy into electrical energy [3] which is stored in battery. This is connected to MCU(Multi Control Unit) which provide a wireless network like Wi-Fi. This MCU connect IoT server with smart phones to transfer information likes the amount of voltage stored in battery, which device requires

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electricity, and if mobile phone get charged full then gives an intimation message to a battery to stop electric supply. Wireless transmitter[4] used to transfer electronic energy to smart phones for charging purpose.

II.LITRATURE REVIEW

The piezoelectric PZT (Lead Zirconate Titanate)-5A elements are small mechanical devices that when a force is applied or when mechanical action is produced, they can produce electricity[1]. This type of piezoelectric is of low cost. In addition this piezoelectric have great robustness and ease to use, with a vibration or shock and is very sensitive to any pressure or vibration. Quartz is a natural crystal that is used for the manufacture of piezoelectric. Quartz crystal is composed of silicon and oxygen atoms[3]. Where quartz is composed of silicon atoms that have a positive charge and oxygen atoms have a negative charge[3].

Normally, when the crystal is not under any external type of stress, that is to say under pressure, the charges are uniformly dispersed in the molecules through the crystal, but when the quartz is stretched or tight, the order of the atoms changes slightly, this change makes the negative charges to accumulate on one side and positive charges to accumulate on the opposite side.

This potential difference is used to produce current between more pressure on the crystal more intense will be the current electrical. While people walking through stairs the piezoelectric material produce an electric power[5]. An energy efficient power amplifier module for wireless node of cellular IoT[4]. Solar power plant through IoT[2] which control the electric power via IoT server.

III. POWER ANALYSIS

The piezoelectric can ability to harvest energy in the density range of 1 to 200 μW/cm3 from ambient mechanical energy sources [1] (the energy density can be increased by design optimization, and in the future, it can also be increased by using improved piezoelectric materials). To design a harvester with a high energy density, several design approaches have been used to design the PEHs; for example,

- Selection of suitable piezoelectric material properties, i.e., a high piezoelectric strain constant *d*, piezoelectric strain constant $d_{31,}$ a high piezoelectric stress constant $g_,$ piezoelectric stress constant $g_{31}$and a electromechanical coupling coefficient $k_{31,}$ a high electromechanical coupling coefficient *k* for achieving high energy transduction rates of PEH(Piezoelectric Energy Harvesters) [1], relative dielectric constant Σ_{r33}^{T}
- Impedance matching technique for efficient extraction of energy from PEHs [1].
- Optimization design of geometry and parameters of PEHs for effective straining [1].

Associated material properties of the d_{31} x g_{31}called Figure of Merit(FOM). This paper evaluates how piezoelectric material properties influence electrical power output from PEHs with consideration of material selection for design of PEHs with a higher electrical power output. It is well known that the *d* has been used as a parameter to select a suitable piezoelectric material in design of PEHs in the literature. This is because one of the physical meanings of *d* is the short-circuit charge collected on the electrodes of PEHs to a unit applied mechanical stress. It is obvious that the higher the *d*, the higher the possible charge collected in the short circuit.

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Because charge is a quantity related to electrical power, it can be said that the piezoelectric material with a high *d* can potentially produce a higher power. Therefore, a high *d* of material property has been used for selection criteria. Similar to the *d*, the *g* is also used to select a suitable piezoelectric material in design of PEHs in the literature. This is because one of the physical meanings of *g* is the open-circuit voltage produced across the electrodes of PEHs to a unit applied mechanical stress. It is again obvious that the higher the *g*, the higher the electrical voltage produced across the electrode in the open circuit. Because the voltage is also related to the electrical power, piezoelectric material with a high *g* can also potentially lead to a higher power output from PEHs, and therefore it is also used in selection criteria of piezoelectric materials for design of PEHs.

It should be mentioned that, in spite of their different physical meanings, *d* and *g* are related to each other; that is,

$$G=d/\sum^{T,} \quad (1)$$

Where εT is the dielectric constant measured at a constant stress. Higher *d* and *g* constants of a piezoelectric material favor either a larger current in the short circuit or a larger voltage in the open circuit, and therefore they are sought after for design of a higher power output from PEHs. Furthermore, because of the physical meanings of *d* and *g*, the product of *d* and *g*, i.e., $d \times g$, can, in some way, represent the electrical power output from PEHs under an excitation. Thus, $d \times g$ has primarily been used as a figure of merit (FOM) for the selection of piezoelectric material for generating a higher power output from PEHs in the literature, i.e., [1]

$$FOM = g\,.d = d^2/\sum^T \quad (2)$$

From the preceding analyses, it is not difficult to find that the *d*, *g*, and FOM were derived either in the short circuit or in the open circuit, or in mixed open with short circuit conditions, and therefore the FOM doesn't mean the electrical power generated by PEHs. This is because the electrical power generated is the product of the electrical current and the electrical voltage produced in one circuit, not in two different circuits, the open and short circuits, in which the power generated is zero. This raises the basic questions of how these piezoelectric materialproperties relate to the power output from PEHs and what kind of piezoelectric material properties are more effective when be used for power generation. This paper will study these questions.

In addition to *d*, *g*, and FOM, the electromechanical coupling coefficient *k* has also been commonly used for selection of a suitable piezoelectric material in design of PEHs in the literature. This is because *k* is definedas the ratio of the converted energy from mechanical to electrical form, and vice versa; that is, *k*

***k*2=Electrical energy stored/Mechanical energy applied (or)**

***k*2=Mechanical energy stored / *Electrical* energy applied,**

And the relation to the piezoelectric material properties, taking the 31 mode as an example, is

$$k^2_{31} = d^2_{31} / S_{11}{}^E{}_{\sum}{}^T{}_{33} \quad (4)$$

Where *k*31 is the electromechanical coupling coefficient of piezoelectric materials in the 31 mode, *s*11 E is the elastic compliance measured at a constant field and $\sum^T{}_{33}T$ is the dielectric constant measured at a constant stress. Although *k* represents the electromechanical coupling capability between mechanical and electrical and vice versa, how *k*31 is related to the power generation is also a question to be studied.

Several research scientists have carried out research in this area. Bilgen*et al*. did a study based on cantilevered unimorph beams and an experimental approach to investigate the actuation and energy harvesting capability of several different piezoelectric materials, and concluded that, for the same type of materials, the MFC type of unimorph beams has the highest actuation capability but the lowest energy harvesting capability [1]. Piezoelectric composition is better for use in energy harvesting based on similar beams but an analytical approach, which can be used in routine material evaluation [1]. Kim *et al*. used the first physical principle approach to analyze how the electrical power available in piezoelectric transducers is related to piezoelectric material properties of the FOM and *g*, and further based on 5 different materials, including polyvinylidene fluoride (PVDF), PZN-PT, hard PZT and soft PZT, and high *g*, to conclude that a material with a higher FOM and a higher *g* can generate a higher voltage and a higher power when the piezoelectric material is directly used either for energy harvesting or for sensing [1]. It seems that there is a lack of quantitative study on how the piezoelectric material properties are related to energy harvesting capability. With the present progress of the research community in modeling and simulation, this question can be answered by use of a coupled piezoelectric circuit–finite element method (CPC-FEM), proposed in [1]. The CPC-FEM is able to calculate the power output of PEHs directly connected to a load resistor and is used in this paper to evaluate piezoelectric material properties for a higher power output with insight into material selection.

IV.WORKING PRINCIPLE

1. NodeMCU

NodeMCU is an open source IoT platform refers to Lua based firmware developed for ESP8266 Wi-Fi Soc by EspressifSystemand hardware. NodeMCU is based on the ESP-12 module. The firmware uses the Luascripting language Fig 1 represents the nodeMCU, which supports wireless connection like Wi-Fi, Bluetooth.

FEATURES

- Wi-Fi Module – ESP-12E module similar to ESP-12 module but with 6 extra GPIOs.
- USB – micro USB port for power, programming and debugging
- Headers – 2x 2.54mm 15-pin header with access to GPIOs, SPI, UART, ADC, and power pinsMisc – Reset and Flash buttons
- Power – 5V via micro USB port
- Dimensions – 49 x 24.5 x 13mm

Fig 1 nodeMCU

2. Piezoelectric Effect

Piezoelectric material which is used to convert mechanical stress into electrical energy. This piezoelectric material shown in Fig 2 that contains quartz and barium titanate ($BaTiO_3$) crystal placed between two metal plates. When mechanical stress applied to the piezoelectric material the Positive and negative charges starts to move one place to another place. The motion of positive and negative charges it generate the voltage. And the voltage gets stored in the battery. The Piezoelectric material has two properties such has direct effect and converse effect. Direct effect is the property to develop electric change on their surface when mechanical stress is applied on them. Converse effect is the property of some materials to increase a mechanical energy when an electric power is induced.

Fig 2 Piezoelectric Material

Piezoelectric materials placed under the footpath, roads,stairs and roads. When people are passes through these places mechanical stress will be created. Piezoelectric sensor sense this mechanical stress and converted into electrical power. This electrical energy is used to charge the battery. Here, Lithium Polymer (Li-Poly) Batteries is used. Li-Poly is the latest and most advanced technology to save the electric voltage. Li-Poly makes the battery ultra-lightweight. Depending on the design and chemistry of the lithium cell it stores voltage. IoT (Internet ofThings)technology is used here to access this electric power. Fig 3 System Architecture represents the connections of different modules.

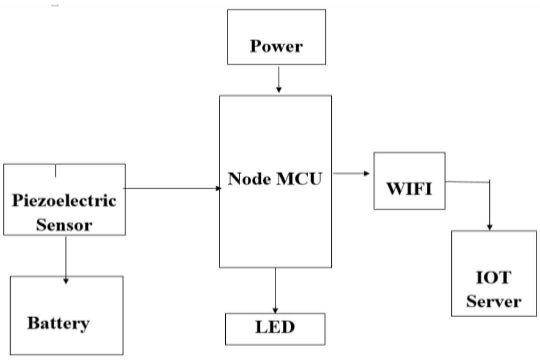

Fig 3 System Architecture

Internet of Things the mechanism of communication via Internet among all devices. The M2M(Machine to Machine) technology provides communication between one machine to another machine without human interaction. By using this mechanism piezoelectric material and particular electronic device can communicate Human can easily access and control the power supply via power control mobile applications. Transmitter is used to transfer electronic data and receives the signal. This wireless transmission mechanism gives an efficient result. Fig 3. Represent the demo model of the power generation.

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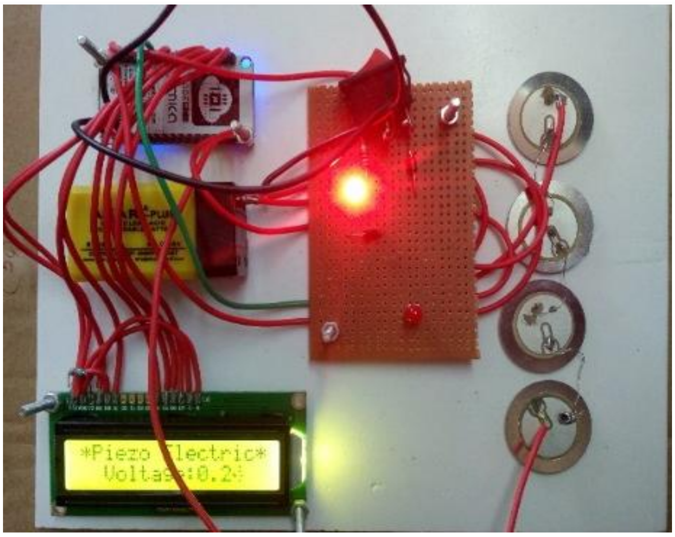

Fig 4 Piezoelectric sensor generate electricity and stores in battery

The mobile application which is used to control and monitor the power generation. This application connected to the IoT server. This mobile application contains login pagewith user name and password, only the administrator the authorities to login the page. Once login it goes to next page which contains energy flow graph that shown in fig.4.

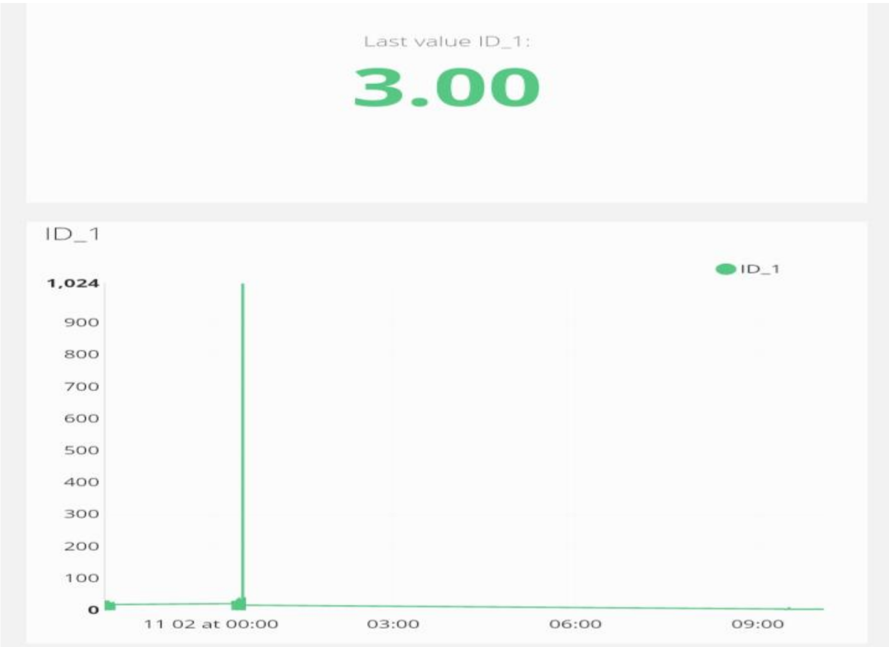

Fig. 5 Energy flow graph

V.CONCLUSION

A piezo can able to generate 40V has been devised. It is easy to construct and implement. This system uses wireless connection with using latest technology IoT. So human can interact with device, monitor the function of the device and control the activities of devise. Renewable power battery used here so easily store the energy

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