Advance Devices Using Piezoelectric Harvesting Energy

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***Abstract*—In this paper, an innovative method of energy harvesting sliding door design and develop a piezoelectric device in working with Programmable Interface Controller. The devices arranged in series connection and equipped in a sliding door hinges. The PIC microcontroller system modified by Proteus software which is a software tool used to simulate the programming source code, electronic circuits and mechanical systems to compare their performance with actual hardware system.To complete energy harvesting system, the microcontroller used to monitor system performance in terms of simulation input trigger.**

Keywords—harvesting energy; piezoelectric; microcontroller; proteus; sustainability energy; renewable energy.

I. INTRODUCTION

Ambient energy is abundantly available within our natural surroundings in diverse forms such as thermal energy, solar energy, mechanical energy, etc. With the upcoming energy crisis, techniques pertaining to ambient energy harvesting will be of extreme importance and valued. Piezoelectricity is electrical energy produced from piezoelectric effect enables the conversion of mechanical strain(including motions such as walking or force) to electric voltage which can be either stored or directly utilized. This mechanical strain can come from various sources and so piezoelectric elements can be embedded into various articles of our daily lives to harvest the mechanical strain into piezoelectricity. Once the pressure is relieved it may caused the electrical current flows across the material. Piezoelectric materials are being more and more studies as they turn out to be very unusual material with very specific and interesting properties. In fact in these materials have the ability to produce electrical energy from mechanical energy, for example they can convert mechanical behavior like vibrations into electricity application of stress. Conversely, it is development of an induced strain which is directly proportional to an applied electrical field. Another method of energy harvesting is performed using piezo-composite generating element (PCGE) [1-2] which can exchanged mechanical energy into electrical energy.

Previous result proved that the thicknesses of piezoelectric element are the fact that will increased the output energy during triggered stress [3]. The most criteria to maximize the output power are to match the load of the converter circuit [4]. The output power of the piezoelectric devices also depends on the load connected when simple rectifier is used which has been investigated by many researchers. The equivalent circuit techniques have been used as modeling work energy harvester [5, 6, 7]. Renewable energy is one of the sustainable energy that going on focusing in global issue. In future, conventional energy sources should be reduced then alternative ways to replace the power is come from renewable energy, an approach will be introduced in generating the amount of power from human being's interactions.

Interested research in piezoelectric harvesting energy has seen growing. Software tools simulation was established (ECM) by using combination of FEA and SPICE simulation software [8]. An approached Rayleigh-Ritz theoretically of piezoelectric harvesting energy to investigated the power around single vibration mode [9]. The idea was proposed of performing numerical simulation of suppression the vibration and investigation how the system works when energy supplied regularly from outside [10]. However some researcher focused about the use of transducer voice or pneumatic tools that could be collecting a waste energy from vibration material [11-13]. Although this method could effectively suppress vibration, it was designed suppression by external force.

Piezoelectric Stacked Generator shown that the piezoelectric generator produces electrical power with higher efficiency, and energy harvesting circuit can harvest energy from the piezoelectric generator effectively [14]. A modeling and simulation of piezoelectric power supply LTC 3588-1 of linear technology by using simulink simulation [15].based on above method an optimal rapid energy store using LTC 3588 for the stackable piezoelectric was proposed to obtain 15mAH Ni-MH battery could be fully charge within two hours [16]. However the infinite software is great powerful tools, the system not appropriate with the easier monitoring output display in digital number

Storage circuit and energy harnessing were not interacted between each other. Among of the researcher were established of many combination interface circuit to obtain maximum output power from the devices [17]. Introducing the regulation circuit using rectifier [18], however this connection not successfully because the characteristics of rectifier and the storage system are simplified pure resistance. Although the rectification's nonlinearity was not fully explored recently, thus an optimization method were structure the energy storage circuit and approached the method including difference mechanical structure, the inspection have been made to increase the output power [19]. This paper proposes

an advance piezoelectric harvesting energy system that enhances suppression input stress from external force by opening a sliding door.

II. EXPERIMENTAL PROCEDURE

A. Specification Piezoelectric

Table 1 shows the properties of piezoelectric ceramics transducer. In this experiment piezoelectric ceramic transducer with dimension of 5mm x 0.4mm were chosen. The resonant frequency of piezoelectric ceramic transducer is 450 kHz +-10 kHz

Table 1. PIEZOELECTRIC MATERIAL PROPERTIES

Electromechanical coupling coefficient		K_p	0.58
		K_t	0.45
		K_{31}	0.34
Frequency constant	Hz ● m	N_p	2200
		N_t	2070
		N_{31}	1680
Piezoelectric constant	$\times 10^{-12}$m/v	d_{33}	320
		d_{31}	-140
	$\times 10^{-3}$Vm/N	g_{33}	25
		g_{31}	-11
Elastic Constant	$\times 10^{10}$N/m^2	Y_{33}	7.3
		Y_{11}	8.6
Mechanical Quality Factor	-----	Q_m	1800
Dielectric Constant	@1KHz	□$T_{33/□0}$	1400
Dissipation Factor	%@1KHz	tan δ	0.4
Curie Temperature	°C	T_c	320
Density	g/cm^3	□	7.9

B. Scale of mini structure of sliding door.

The source of force shows in table 2, which are the features of the miniature design of sliding door. At one end of the door vertical ledge, the series of piezo discs will be arranged in a line and similarly, at the end of moveable door that is in opposite position of the door ledge was lined with rubber stoppers. With the door in open position, the series stoppers will put pressure force on the series discs. The amount of voltage will be produced according to the amount of force and the weight of load factors are applied to the discs. Then, the force can be adjusted by manually opening the door. An elevator of high performance sliding door system should fulfill different requirements of harvester design by concerning the opening/closing time

Table 2. SIZE OF THE SCALE MODEL

Input Stress	Material	Mass (Kg)	force (N)
Sliding Door	Aluminium + Mirror	15kg	147.11N
F=ma	Newton Second Law; ; a= standard gravitational force value=9.80665m/s2		

C. System Sliding Door Harvesting Energy Using Piezoelectric

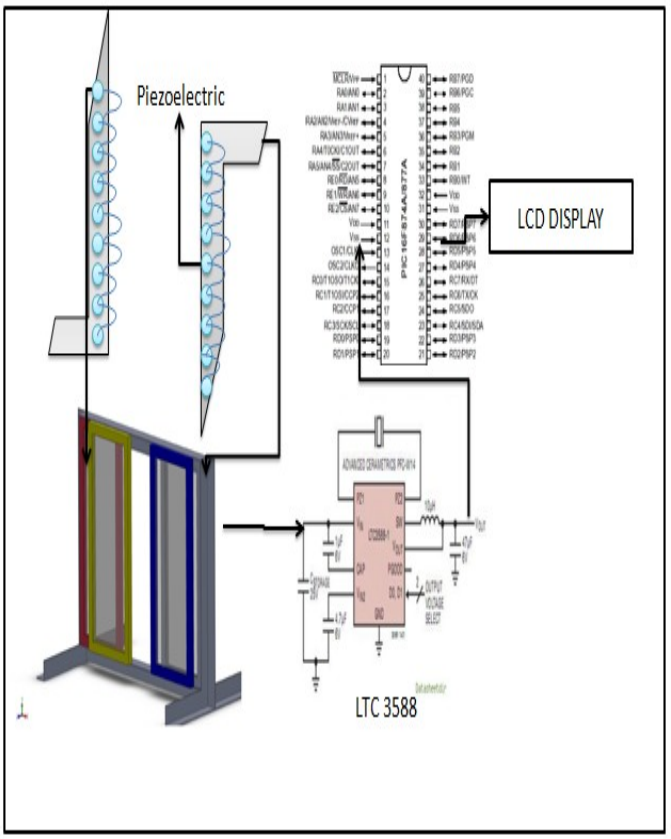

Fig. 1. Modelling schematic diagram

Fig. 1 shows a schematic diagram of experimental apparatus the experiment setup constitutes the mechanical part and the electric/electronic part. Sliding door mechanism as a mechanical structure is used to apply pressure force on the surface of the piezoelectric disc. Sequent pressure forces are required to produce a certain value of voltage from a series of piezoelectric disc so that the process able to store the energy in the storage capacitor (harvester energy circuit).

D. Block Diagram for Processing Energy Harvesting

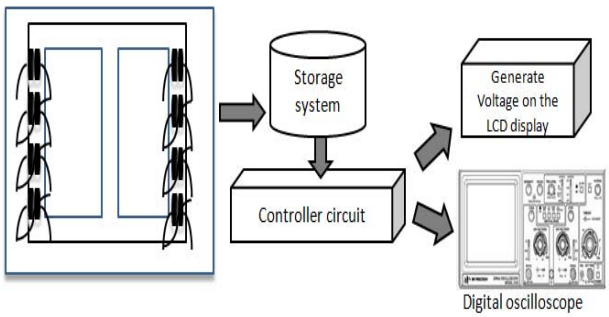

Fig. 2. Process of energy harvesting.

Analyzing and evaluating the performance of energy harvesting devices are depend on the type of selected piezoelectric material and characteristic on the level of surface sensitivity. As shown in Fig. 2, there are three main parts in designing an energy harvesting process. The devices are equipped with a series connection system on the sliding door hinge. Whereas the mechanical and electrical systems harness wasted manpower will be allocated at output side of the devices. A series of piezoelectric are connected to improve the voltage generated when mechanical force applied by closing the door. Meanwhile, storage system is equipped with super capacitor in harvester circuit that serves to store energy before the LCD display shows the amount of generated voltage. A control circuit is used to simulate the system and display the amount of voltage generated. This circuit is a key part of this research because it looks at the voltage that can be generated from a piezoelectric from time to time. Generated voltage will be displayed in integer voltage value, so the proposed system is easy to monitor the produced voltage.

E. Controller and Storage Schematic Diagram

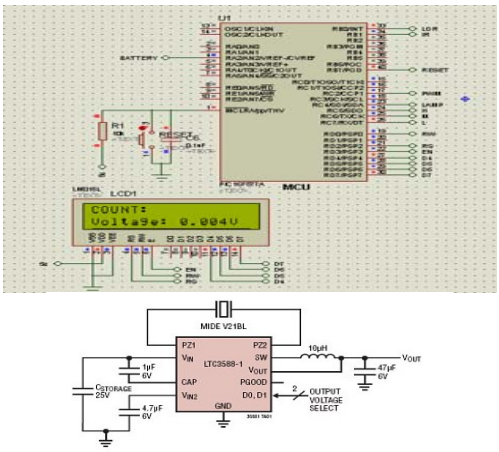

Fig. 3. Microcontroller design by Proteus VSM simulation

To complete this system of harvesting energy, microcontrollers are used to monitoring the system to show the performance of input trigger simulation. Proteus Vsm software designs the system with appropriate programming source code to observe the compatibility chips in this experiment, after all fixed and appropriate with programming ,it will imbedded the source code to the hardware implementation. This source code as well as computer programming, this is the comprehensive process that leads from an original formulation of computing problem to executable programs. The source code in this project was written in programming language C. The purpose of programming is to find a sequence instruction that will automate performing a specific task, as a main of controller part to show the output voltage, signal voltage level indicator and monitoring ease inAs mentioned, energy harvesting needs to be stored in super capacitors.

This project used a Linear Technologies LTC 3588-1 chip integrated, necessary blocks for implementing the piezoelectric energy harvesting as shown in Fig. 3. LTC-3588 is very suitable for piezoelectric energy harvesting applications. The LTC 3588 integrated low-loss full-wave bridge rectifier with high efficiency converter to obtain optimized energy harvesting solution for high output impedance energy sources such as piezoelectric transducers. The LTC 3588 was designed to interface directly to a set of piezoelectric elements. It can correct voltage waveform and store harvested energy in an external capacitor and also control and clamp any generated voltage by an internal voltage regulator.

F. Generated Output Voltage

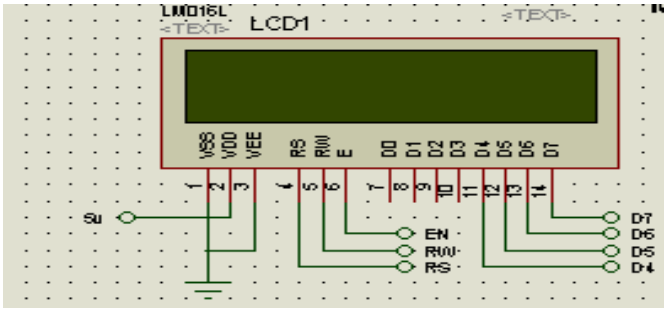

Fig. 4. LCD display

The total amount of energy that generated by sliding door is accumulated and show on the LCD display as shown in Fig. 4. Meanwhile a digital oscilloscope is used to show the voltage waveform.

III. PRELIMINARY RESULT AND DISCUSSION

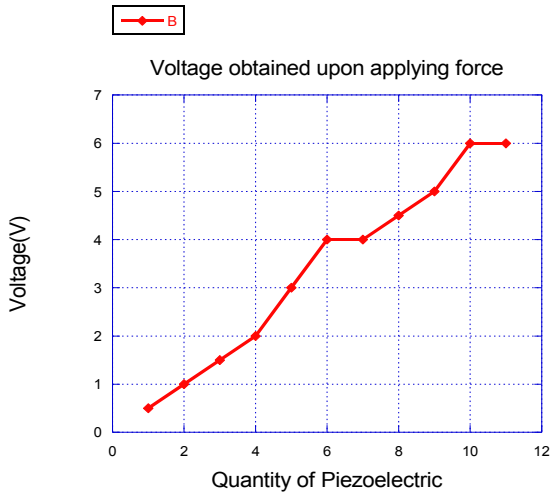

Fig. 5. Correlation Between Voltage and the Number of Piezoelectric Discs Connected in Series.

The above graph illustrates the variation in voltage measured upon application of force for an increasing number of piezoelectric discs connected in series. As is evident the correlation between voltage obtained and the number of piezoelectric discs connected in series is linear as show in Fig.5. Ranging from 1 to 12 piezoelectric discs connected in series it obtained output approximately 0.5volt to a maximum of 6.0volt respectively. During the constant output voltage that show above, the charging system which is the super capacitor circuit was working to boost up the energy storage until it reached maximum voltage approximately 6volt. However the voltage should be more captured for the series connection but due to non-simultaneous pressure force, therefore the output is less than respected one.

IV. CONCLUSION

In summary, types of piezoelectric transducers are used to energize the energy harvesting. Furthermore, an optimal micro power energy storage method was proposed, which utilized buck converter IC (LTC 3588) as energy storage system. The results will help to find the proper load stress and optimal performance of a piezoelectric energy harvester. This proposed project will prove the wide application of piezoelectric disc in the future and encourage the power utilities to develop renewable energy system in grid power system.

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