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Energy Harvesting using Novel Technique: Walk & Charge

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Abstract— Increase in energy consumption of portable electronic devices and the concept of harvesting renewable energy in human surrounding arouse a renewed interest. This technical paper focuses on one such advanced method of energy harvesting using piezoelectric material. Piezoelectric materials can be used as mechanisms to transfer mechanical energy, usually ambient vibration, into electrical energy that can be stored and used to power other devices. A piezoelectric substance is one that produces an electric charge when a mechanical stress is applied. Conversely, a mechanical deformation is produced when an electric field is applied. Piezo-film can generate enough electrical density that can be stored in a rechargeable battery for later use. Piezoelectric materials have a vast application in real fields. Some of the latest applications are mentioned below. Currently, there is a need to utilize alternative forms of energy at passenger terminals like airports and railways across the world. Cleaner, more sustainable forms of electrical power are needed in order to keep costs lower, to maintain positive and productive relationships with neighbors and to insure a healthier environment for future generations. The use of piezoelectric devices installed in terminals will enable the capturing of kinetic energy from foot traffic. This energy can then be used to offset some of the power coming from the main grid. Such a source of power can then be used to operate lighting systems. The increasing prevalence and portability of compact, low power electronics requires reliable power sources. Compared to batteries, ambient energy harvesting devices show much potential as power sources. A piezoelectric generator can be developed that harvests mechanical vibrations energy available on a bicycle. The electrical energy thus produced can be used to power devices aboard the bike, or other portable devices that the cyclist uses. Electrical energy can also be generated from traffic vibrations (vibrations in the road surface) using piezoelectric material.

Keywords: Energy Harvesting, Power consumption, Piezo electric material

INTRODUCTION

1.1 Overview

In today's hectic lifestyle, health has been seriously hampered due to sedentary work. This project represents an idea of walking based wearable piezoelectric device that provides an alternate means for powering mobile phone batteries. Since, the mechanism of the device is based on walking; the device promotes human metabolism as well as physical fitness. Hence, it can be seen as an e-health gadget that encourages walking exercise as a means to charge mobile phone batteries. Walking is the best and common activity in day to day life. As per the study of Biomechanics, the ground reaction force, GRF is the force exerted by the ground on the body in contact with it. For example A person standing motionless on the ground exerts a contact on it which is equal to the person's weight and at the same time an equal and opposite GRF is exerted by the ground on the person .Thus, as the human starts walking, this GRF increases which generates power in greater amount, so why to waste this power?

The world's energy consumption is all the time high with the demand continuously increasing. With the advent use of portable machines in this technological world; it has become a major issue of power source. The situation brings up several challenges that need to be addressed. [1]

1.) Power supply.

2.) Battery discharging.

3.) Availability of power source.

Our project represents an idea of walking based wearable piezoelectric device that provides an alternate means for powering mobile phone batteries.

1.2 Objective

Human walking carries a lot of energy, Theoretical estimates show that it can produce up to 10 watts per shoe, and that energy is just wasted as heat. A total of 20 watts from walking is not a small thing, especially compared to the power requirements of the majority of modern mobile devices.

Primary objective of this project is to make an ultra portable charging solution which nullifies dependencies on charging ports on the go. Moreover, the energy is clean and free of cost. Essential goal of this project is to make an ultra compact charging arrangement which invalidates conditions on charging ports in a hurry. Additionally, the vitality is spotless and free of cost.

This project has been chosen because it will help us to enhance with the present footwear innovation shown in the market. This is an exceptionally powerful approach to actualize innovation in footwear at a shabby cost.[2]

1.3 Scope

Nike Hyper Adapt 1.0 is a self lacing shoe. It needs to be charged once the battery is depleted. When this circuit is implemented in this shoe, this will eliminate the need to charge the shoe.

The shoe translates deep research in digital, electrical and mechanical engineering into a product designed for movement. It challenges traditional understanding of fit, proposing an ultimate solution to individual idiosyncrasies in lacing and tension preference. Functional simplicity reduces a typical athlete concern, distraction. “When you step in, your heel will hit a sensor and the system will automatically tighten,” explains Tiffany Beers, Senior Innovator, NIKE, Inc., and the project’s technical lead. “Then there are two buttons on the side to tighten and loosen. You can adjust it until it’s perfect.” [3]

Fig 1.1 Nike HyperAdapt 1.0

Nike HyperAdapt 1.0 is the first step into the future of adaptive performance. It’s currently manual (i.e., athlete controlled) but it makes feasible the once-fantastic concept of an automated, nearly symbiotic relationship between the foot and shoe.

Nike HyperAdapt 1.0

In future, it could be more beneficial for a lot of applications especially for consumer electronic devices. The energy scavenging from man’s temperature has been studied and it was shown that it is capable to produce a very limited amount of energy that cannot charge any device properly. Thus, the energy harvesting with biological sources like walking is our main goal.[5]

Don’ts:- Battery can’t be connected directly as the voltage fluctuations are frequent. So there are chances of battery getting damaged.

II PROJECT MANAGEMENT

2.1 Project Planning

Project planning was divided into three phases.

Understanding the Hardware components,

Implementing the circuitry

To bring the complete module in working state.

Understanding the hardware components:

The first half month was dealt with the understanding of the hardware components. Our project being a part of embedded systems, our first task was to get an idea of embedded systems.

Embedded Systems:

Embedded systems are always designed to do some specific task.

Embedded System reflects the facts that they are integral parts of the system. An embedded system is designed to run on its own without human intervention, and may be required to respond to events in real-time.[4]

It is a computer system that is built to control one or few dedicated functions, and is not designed to be programmed by the end user, in the same way, that a desktop computer is.

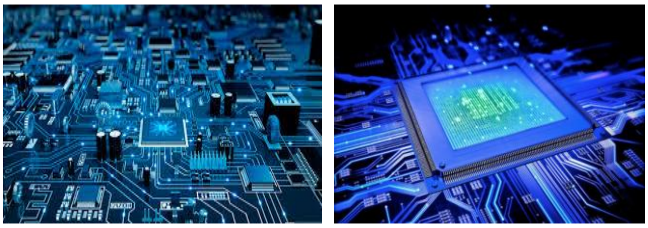

Fig 2.1 & 2.2 Embedded Systems

Advantages of Embedded Systems:

Easy to design and use.

Design time and cost is thus low.

Having understood the basic idea behind embedded systems our main target was to understand components briefly that are being used in our project.

Major components in our project included piezoelectric disk, Rectifier Diode, Voltage Regulator, Step-up Convertor and Lithium Charger Board which were studied in brief before implementing the circuitry

Implementing the Circuitry:

After understanding the working of all the components briefly, second task was to implement the circuitry.

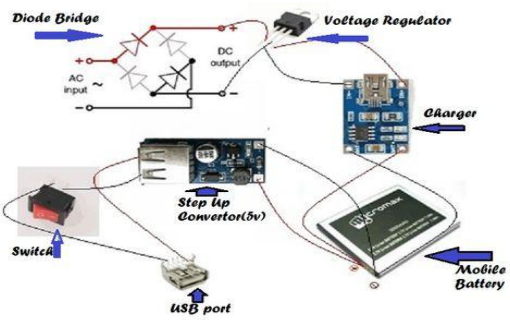

Fig 2.3 Circuit Implementation

Connections were made as observed in the above circuit diagram.

Second half of the month was carried out with the learning of the soldering, to check how much voltage is produced from each piezoelectric disk in order to get a rough idea that how much total voltage would be needed to charge a battery completely, also how long a person needs to walk to completely charge a 3.7 voltage battery.[1,2]

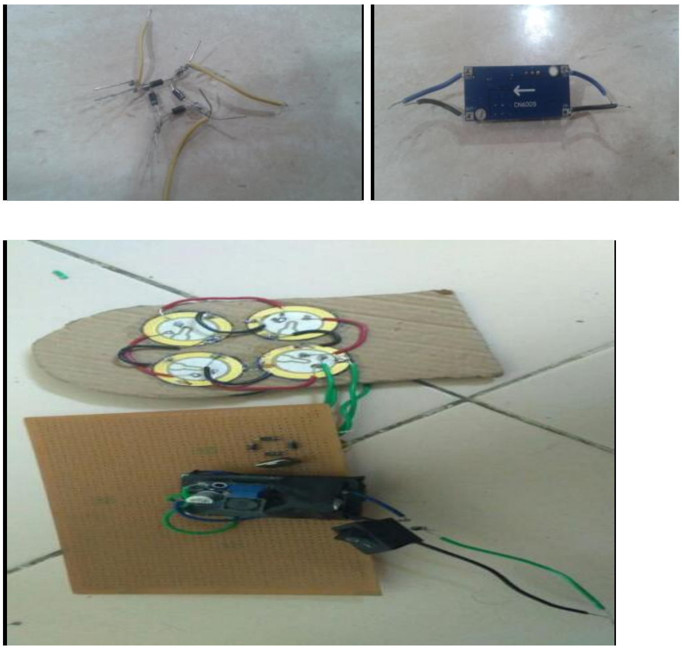

Fig 2.4 Complete Circuit

Above are few snapshots taken while implementing the circuitry.

Circuit Diagram:

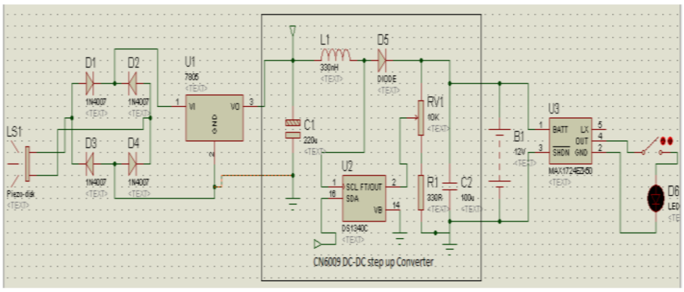

Fig 1.7 Circuit Diagram

Fig.1.7 illustrates the overall circuit diagram of the entire process. The rectifier shown in the Fig. 1.7 maybe either a fullwave rectification circuit or a half wave rectification circuit based on the combination of diodes or a voltage double rectifier. Since a diode is being used in the rectifier, a p-n junction diode or a Schottky diode can be used. The Schottky diode has a threshold voltage which is smaller thanthat of a p-n junction diode. For example, if the diode isformed on a silicon substrate, a p-n diode may have athreshold voltage of approximately 0.065 volts while the threshold voltage of a Schottky diode is approximately 0.30 volts. Accordingly, the uses of Schottky diode instead of p-ndiode will reduce the power consumption required fo rrectification and will effectively increase the electrical charge available for accumulation by the capacitor. When the electromotive force in the piezoelectricity generation section is small, a Schottky diode having a low rising voltage is more preferable.The bridge rectifier section provides rectification of the AC voltage generated by the piezoelectric section. By arranging the rectification section on a monolithic n-Sisubstrate, it is possible to form a very compact rectification section. A typical diode can rectify an alternating currentthat is, it is able to block part of the current so that it will pass through the diode in only one direction. However, in blocking part of the current, the diode reduces the amount of electric power the current can provide.A full-wave rectifier is able to rectify an alternating current without blocking any part of it. The voltage between two points in an AC circuit regularly changes from positive to negative and back again. In the full-wave rectifier shown in Fig. 1.7, the positive and negative halves of the current arehandled by different pairs of diodes.The output signal produced by the full-wave rectifier is a DC voltage, but it pulsates. To be useful, this signal must be smoothed out to produce a constant voltage at the output. A simple circuit for filtering the signal is one in which a capacitor is in parallel with the output. With this arrangement, the capacitor becomes charged as the voltage of the signal produced by the rectifier increases. As soon as the voltage begins to drop, the capacitor begins to discharge, maintaining the current in the output. This discharge continues until the increasing voltage of the next pulse again equals the voltage across the capacitor. The rectified voltage is stored into a storage capacitor as shown in Fig. 1.7, which gets charged up to a pre-decided value, at which the switch closes and the capacitor discharges through the storage device or the battery. In this way the energy can be stored inthe capacitor, and can be discharged when required.

To bring the complete module in working state:[6]

It took almost one and a half month to implement the complete circuitry and bring the module in working state though many problems were encountered. Walk and Charge was an idea born out of need to find renewable/alternate sources of energy. The aim was to find a clean energy that doesn't affect our environment, but being IT students we only had basic idea about the working of these individual modules, never had any practical implementation, so it took sufficient amount of time to bring the module in working state with proper readings where it can produce enough power and charge the battery completely.

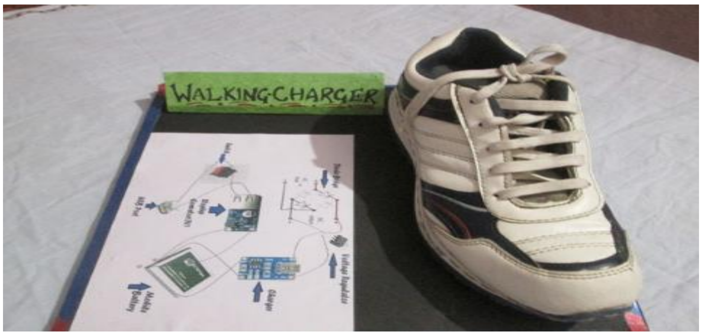

Fig 2.5 Implementation in shoe

III SYSTEM REQUIREMENTS

3.1 User Characteristics:

Walk and Charge is designed considering the daily power consumption of a human being. Also the goal of this project is to give people motivation to walk for their health. Thus the end users of this product are a common man who might not be technologically sound.[7]

Use Case Diagram: UML Use Case Diagrams. Use case diagrams are usually referred to as behaviour diagrams used to describe a set of actions (use cases) that some system or systems (subject) should or can perform in collaboration with one or more external users of the system

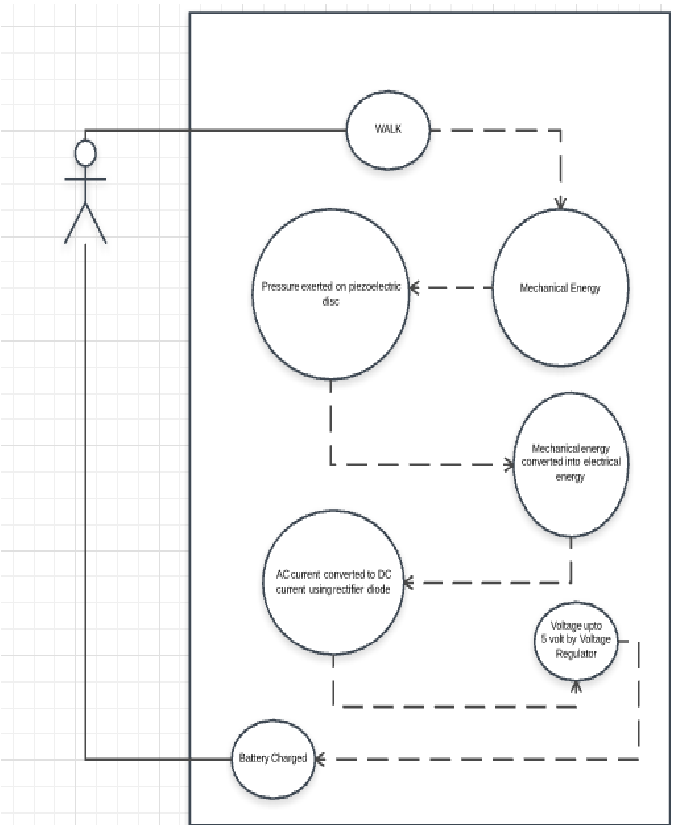

Fig 3.1 Use Case Diagram

IV SYSTEM ANALYSIS

System analysis is "the process of studying a procedure or business in order to identify its goals and purposes and create systems and procedures that will achieve them in an efficient way". Another view sees system analysis as a problem-solving technique that decomposes a system into its component pieces for the purpose of the studying how well those component parts work and interact to accomplish their purpose. Analysis and synthesis, as scientific methods, always go hand in hand; they complement one another. Every synthesis builds upon the results of a preceding analysis, and every analysis requires a subsequent synthesis in order to verify and correct its results.[8]

The field of system analysis relates closely to requirements analysis or to operations research. It is also "an explicit formal inquiry carried out to help a decision maker identify a better course of action and make a better decision than she might otherwise have made."

The development of a computer-based information system includes a system analysis phase. This helps produce the data model, a precursor to creating or enhancing a database. There are a number of different approaches to system analysis. When a computer-based information system is developed, system analysis (according to the Waterfall model) would constitute the following steps:

The development of a feasibility study: determining whether a project is economically, socially, technologically and organizationally feasible Fact-finding measures, designed to ascertain the requirements of the system's end-users.

Gauging how the end-users would operate the system, what the system would be used for and so on another view outlines a phased approach to the process. This approach breaks system analysis into 5 phases:

Scope Definition: denoting an instrument for observing, viewing, or examining Problem analysis: analyzing the problem that arises Requirements analysis: determining the conditions that need to be met Logical design: looking at the logical relationship among the objects Decision analysis: making a final decision

V SYSTEM IMPLEMENTATION & TESTING

System Design and Implementation:

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development. There is some overlap with the disciplines of systems analysis, systems architecture and systems engineering.

The physical design relates to the actual input and output processes of the system. This is explained in terms of how data is input into a system, how it is verified/authenticated, how it is processed, and how it is displayed. In physical design, the following requirements about the system are decided.

Input requirement, Output requirements, Storage requirements, Processing requirements and System control and backup or recovery.

User Interface Design is concerned with how users add information to the system and with how the system presents information back to them. Data Design is concerned with how the data is represented and stored within the system. Finally, **Process Design** is concerned with how data moves through the system, and with how and where it is validated, secured and/or transformed as it flows into, through and out of the system. At the end of the system design phase, documentation describing the three sub-tasks is produced and made available for use in the next phase.

Physical design, in this context, does not refer to the tangible physical design of an information system. To use an analogy, a personal computer's physical design involves input via a keyboard, processing within the CPU, and output via a monitor, printer, etc. It would not concern the actual layout of the tangible hardware, which for a PC would be a monitor, CPU, motherboard, hard drive, modems, video/graphics cards, USB slots, etc. It involves a detailed design of a user and a product database structure processor and a control processor. The H/S personal specification is developed for the proposed system.

Systems implementation is the process of:

1. Defining how the information system should be built (i.e. physical system design),
2. Ensuring that the information system is operational and used,
3. Ensuring that the information system meets quality standard (i.e., quality assurance).

There are different methods that can be used for software testing. Here, white-box and black box are used for testing methods to test software.[9]

VI CONCLUSION AND FUTURE ENHANCEMENT

This system can be used to charge any gadget which supports rechargeable battery. It is not confined to only mobile phones.

Future scope of our project is it can be applied in any place wherever there is mechanical stress is in the picture. Few examples are as shown.

Piezo electric system employed under the railway tracks.

Fig 6.1 Piezoelectric system under the railway tracks

This piezoelectric system can be employed under the railway tracks so as when the train passes over it, it will lead to the generation electric power. The power generated by this system will be very large as the force applied by the trains would be very high.[10]

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