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Solar-Piezo Hybrid Power Generation Based Charging System

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Abstract: **The use of renewable resources like the solar energy and various other clean sources of energy have been on an increase in demand in the recent years due to their ease in availability and low and cost. This project demonstrates how to use the solar energy and the kinetic energy from footsteps of people walking over piezo based footboard. The Solar Panel is used to harness the solar power. It converts the solar power into voltage, which when more than the voltage in the battery is able to charge the battery. The power available through the solar panel is sensed by an Atmega family microcontroller which it displays on the LCD. Similarly, the power generated through footsteps over Piezo Footboard is shown on the LCD. In this case, the footstep count is also displayed on the LCD along with the voltage generated by that particular footstep. In this way one can charge the battery through solar and footstep energies while simultaneously also monitoring of how much is getting generated with the use of Solar Piezo Hybrid Power Charging System.**

INTRODUCTION

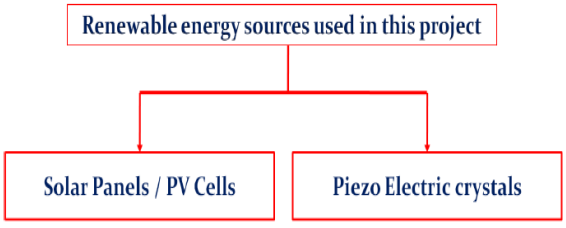
Energy is essential to everyone's life no matter when and where they are. This is especially true in this new century, where people keep pursuing higher quality of life. Among different types of energy, electric energy is one of the most important that people need every day. It is now a globally accepted reality that electrical energy is fundamental for social and economic development. Unfortunately still one third of the world's population lives in developing and threshold countries and have no access to electricity [1]. It has been estimated that the world population will reach 8 billion by 2020 [2]. The statistic shows that the population growth is mostly in developing countries where most of the people live in remote and rural areas. So, to supply the electricity requirements for them, the extension of utility grid is complicated and expensive due to

geographical, economical and social barriers. Up to now, mostly diesel generator sets are used for rural electrification. This is not a good solution since, the fuel, maintenance cost is expensive, and it is also

not environment friendly.In such circumstances, an alternative is to use locally available renewable energy sources (e.g. PV, wind, hydrogen, and etc..,) and implement modular, expandable and task-oriented systems that guarantee cost-effective and sustainable resources of energy, especially for remote and rural areas. At the world engineering convention in 2000, it has been mentioned that the energy needed will be provided, distributed, and consumed in a suitable way. Keeping this promise in mind, many decentralized Hybrid Power Systems have been installed worldwide.

Multi-source alternative energy systems with proper control have great potential to provide higher quality and more reliable power to customers than a system based on a single resource. However, the issues on optimal system configuration, proper power electronic interfaces and power management among different energy sources are not resolved yet. Therefore, more research work is needed on new alternative energy systems and their corresponding control strategies.

In this chapter, an overview is given on the Indian energy demand, present existing solutions for the



crisis, the constraints in their development for future scenario. Furthermore, the scope of the technical, commercial issues coverage and typical applications

is addressed. Finally, the organization of the dissertation is also defined.

DESCRIPION OF HPS

Combining several different types of power sources will forms a system, which is known as "Hybrid Power System". As mentioned earlier, HPS combines two or more energy conversion devices, or two or more fuels for the same device, that when integrated, overcome limitations inherent in either.

.Fig.1 Different renewable energy sources used in the proposed HPS

HPS is available in two modes; namely islanding and grid connected modes. In general, a hybrid power system might contain AC diesel generators-diesel system, an AC or DC distribution system, renewable power sources, energy storage, power converters, dump loads, load management options, or a supervisory. The proposed HPS in this paper focuses on the combination of renewable energy sources as shown in Figure 1, such as Photovoltaic cells, Piezo electric crystals and Batteries. These are clean and abundantly available in nature, offers many advantages over conventional coal based power system, such as low pollution, high efficiency, diversity of fuels, reusability of exhausts, and onsite installation.

Importance of combined plants/HPS

In the present day everybody is looking towards renewable energy sources for their growing energy needs. In a single renewable power plant there are many difficulties in operating satisfactorily because, they are nature dependent sources. The output of these sources is not constant and varies with atmospheric conditions and needs a back-up such as batteries to take over the fluctuations of the system which is not economical. If a single source is operated, fluctuations in the output will affect the usage of that source. For example, if the generated power doesn't meet the fluctuations in load requirement then we cannot use that source and that amount of power generated is mere waste. So, to eliminate such drawbacks and utilize the generated power to its full extent, now the system is moved to Hybrid renewable system, where more than one energy sources are integrated and can take up the load fluctuations effectively with proper control strategies.

HPS are classified in two categories:

- Grid connected HPS, which are connected in parallel with the central utility power grid and can be used at any location; and
- Stand alone/off grid/Islanding HPS, which are independent of the utility grid, used to meet the load demands especially at remote places.

Stand alone/off grid/Islanding HPS

Stand Alone HPS are designed and sized to attend specific loads. The power units commonly used are photovoltaic panels (DC source), piezo turbines and Diesel Generators (AC sources); batteries are often used for backup power. Other power electronics components like rectifiers, converters, and inverters are used to match the ac and dc generation source with the voltage and frequency requirements of the load. The control system for HPS. configurations should minimize fuel consumption by maximizing power from the renewable sources. However, there are power fluctuations by the variability of the renewable energy, which cause disturbances that can affect the quality of the power delivered to the load.

Grid connected HPS

Many different types of grid connected HPS architecture have been practiced. The possible different architectures are shown. Each system has its own advantages and disadvantages. The choice of the layout for particular location depends upon geographical, economical and technical factors. These are available in three modes namely centralized AC-bus architecture, distributed AC-bus architecture, and centralized DC-bus architecture.

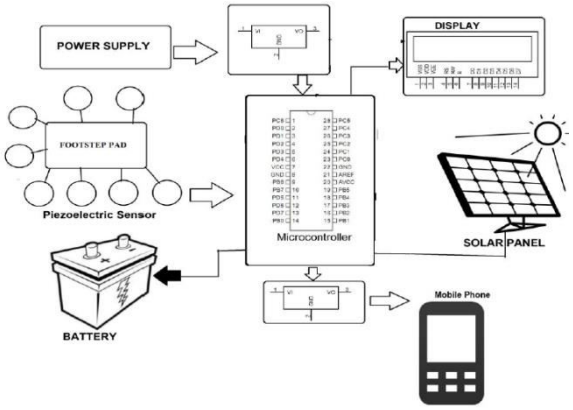
In the centralized AC-bus architecture, the sources and the battery are all installed in one place and are connected to a main AC bus bar before being connected to the grid. This system is centralized in the sense that the power delivered by all the energy conversion systems and the battery is fed to the grid through a single point. In this case, the power produced by the PV system and the battery is inverted into AC before being connected to the main AC bus.

Piezo-electric crystals

Piezoelectric materials belong to a broader class called ferroelectrics. One of the defining traits of a ferroelectric material is that the molecular structure is oriented such that the material has local charge separations, known as electric dipoles. Piezoelectric materials have two main functions. The first function is the direct piezoelectric effect, which is the transformation of mechanical strain into electrical charge. The second function, called the converse piezoelectric effect, takes an applied electrical

potential and converts to mechanical strain. Therefore, an electric field can be applied to induce an expansion or contraction of the material and vice versa.

The mechanical vibrations which are produced by the automobiles can be utilized as a source of energy for generating electrical energy that can be utilized by this electronic equipment to operate. These vibrations are produced by different vehicles around us which are going as a waste. Piezoelectric materials is used by this technique, where deformations done by the vibrations are directly converted into the electrical charge via piezoelectric effect and principle of electromagnetic induction between coil and magnetic field that produces Electromotive force (EMF) in the



coil and so it provides displacement to the performance magnet by the vibrations. All the piezoelectric materials and magnets are used as the energy conversion devices for converting mechanical vibrations into electrical energy. In this context, we introduced two methods and considered its output performance provided input vibrations, by using piezoelectric materials such as piezoelectric for electromechanically conversion using Mass- spring system as medium of conversion of force from vibrations applied on piezoelectric materials and by using spring-magnet system where relative displacement of magnet with respect to coil, provided input vibrations generates Electromotive force in coil.

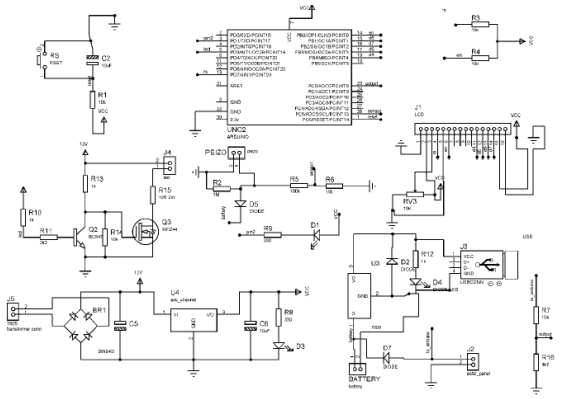
HARDWARE DESIGN

The block diagram of the proposed charging system is shown in Fig.2

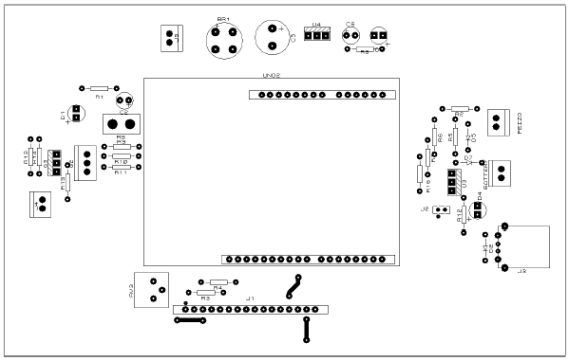
Fig.2 Block Diagram of Proposed charging system

Arduino

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions



to the microcontroller on the board. To do so you use the Arduino programming language (based on



Wiring), and the Arduino Software (IDE), based on Processing. Over the years, Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike. The most common version of Arduino is the Arduino Uno. This board is what most people are talking about when they refer to an Arduino. In the next step, there is a more complete rundown of its features. Arduino NG, Diecimila, and the Duemilanove (Legacy Versions).Legacy versions of the Arduino Uno product line consist of the NG, Diecimila, and the Duemilanove.

Fig.3 Connection diagram for various components

Fig.4 PCB layout used for Hardware Design

Working of the Hardware unit

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The Footstep power generator works on the principle of piezoelectric effect. Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress. Thus, squeeze certain crystals (such as quartz) and you can make electricity flow through them.

In most crystals (such as metals), the unit cell (the basic repeating unit) is symmetrical; in piezoelectric crystals. Normally, piezoelectric crystals are electrically neutral: the atoms inside them may not be symmetrically arranged, but their electrical charges are perfectly balanced: a positive charge in one place cancels out a negative charge nearby. However, if you squeeze or stretch a piezoelectric crystal, you deform the structure, pushing some of the atoms closer together or further apart, upsetting the balance of positive and negative, and causing net electrical charges to appear. This effect carries through the whole structure so net positive and negative charges appear on opposite, outer faces of the crystal. Normally, the charges in a piezoelectric crystal are exactly balanced, even if they're not symmetrically arranged. If you squeeze the crystal, you force the charges out of balance.

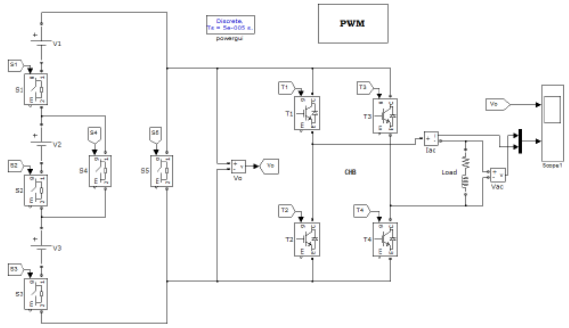
Now the effects of the charges (their dipole moments) no longer cancel one another out and net positive and negative charges appear on opposite crystal faces. By squeezing the crystal, you've produced a voltage across its opposite faces and that's piezoelectricity. In this paper, the same phenomenon of producing piezoelectricity from piezoelectric crystal in the form of coin shaped disc has been used. When one steps on the weighing machine the piezoelectric disc gets compressed. After the leg is lifted the crystal is decompressed. Thus a full vibration is sensed by the crystal disc and a voltage across it is produced. This voltage is sensed by the voltmeter and displayed on its display. Also, at the same time this voltage is used to charge the 12VDC Battery. LED‟s have been mounted under the weighing machine that is switched on by relay through 555 timers IC whenever a voltage is generated. This event is notified by a glowing LED on the PCB. (Also one can hear the switching sound of the relay). Thus, whenever a person walks though the weighing machine the battery gets charged due to the voltage which is also displayed on the voltmeter. This event is notified by glowing LED‟s beneath the weighing machine.

Continuity Test:

In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open". Devices that can be used to perform continuity tests include multi meters which measure current and specialized continuity testers which are cheaper, more basic devices, generally with a simple light bulb that lights up when current flows.

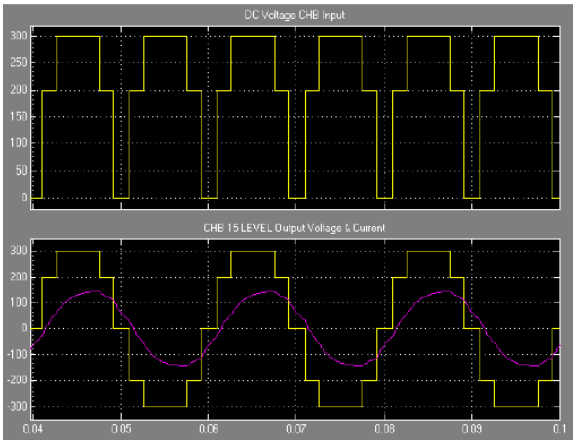
Power on Test:

This test is performed to check whether the voltage at different terminals is according to the requirement or not. A multi meter can be taken and put it in voltage mode Firstly, we check the output of the transformer,



whether we get the required 12 v AC voltage.

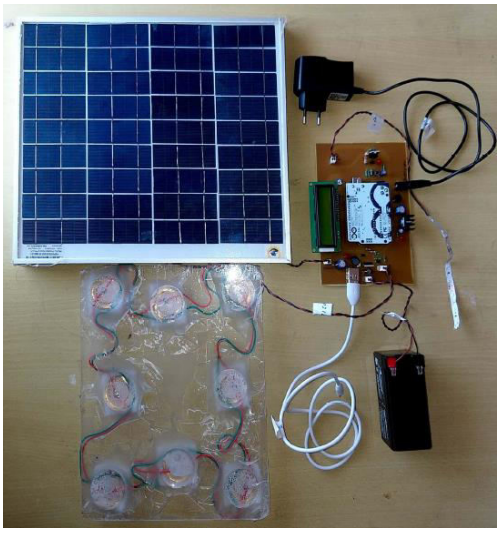
Then we apply this voltage to the power supply



circuit. Note that we do this test without microcontroller because if there is any excessive voltage, this may lead to damaging the controller. We check for the input to the voltage regulator i.e., are we getting an input of 12v. and an output of 5v. This 5v output is given to the microcontrollers‟ 40th pin. Hence we check for the voltage level at 40th pin. Similarly, we check for the other terminals for the required voltage. In this way we can assure that the voltage at all the terminals is as per the requirement.

SIMULATION RESULTS

In order to clarify the correct performance of the developed proposed inverter in generating the desired output voltage levels, the experimental results have been used. The number of required power electronic devices in the proposed inverter is completely based on the selected algorithm to determine the magnitude of the dc voltage sources. The proposed concept has been implemented in MATLAB/SIMULINK and the



results have been observed.

Fig.5 Simulation circuit of Proposed Charging System

Fig.6 Proposed basic unit output waveform

The first proposed algorithm is considered to determine the magnitude of the dc voltage sources with *V*dc = 20 V. According to (5), this inverter is able to generate 15 levels (seven positive levels, seven negative levels, and one zero level) with the maximum amplitude of 140 V at the output. It is important to note that the used IGBTs on the prototype are BUP306D (with an internal anti parallel diode). The 89C52 microcontroller by ATMEL Company has been used to generate all switching patterns. In all processes of the experimental performance, the load is assumed as a resistive–inductive (*R*−*L*) load, with *R* = 70 Ω, and *L* = 55 mH. It is important to point out that the used control method in this inverter. is the fundamental control method. The main reason to select this control method is its low switching frequency compared with other control methods that leads to reduction in switching losses.

Fig.7 Hardware Circuit of Proposed Charging system

CONCLUSION

The proposed charging system is successfully tested and implemented which is the best economical, affordable energy solution to common people. This can be used for many applications in rural areas where power availability is less or totally absence. The prototype demonstrates that a floor generator can be done. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant and important for highly populated countries like India and China. The whole human/ bio-energy being wasted if can be made possible for utilization, it will be great invention and crowd energy farms will be very useful energy sources in crowded countries.

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