Hybrid human powered power generating unit by using multiple transducers

Avanish Gautam Singh and B Ravi Subrahmanyam

1,2Department of Electrical and Electronics Engineering, GCET (Dr. A.P. J. AKTU)
Greater Noida, Uttar Pradesh-201306 India
E-mail: avanish.g.s@ieee.org

Abstract. This paper provides concept of capturing the different kinds of energy conversions that can be in form of motion, physical force, heat energy and solar energy and converting all form of energy into useful electrical energy. It can provide endless supply of energy to electronic device also has attracted large number of researchers and has bought a growing amount of attention to energy harvesting. The hybrid human powered power generating unit is an electronic device, purpose of proposed model is to supply electricity for charging devices when the user is out of reach to the charger or charging port. This device basically transforms many different kind of energies to electricity (direct current) example piezoelectric plate produces electrical energy when mechanical force is applied on it and another we have Peltier plate (thermal electric generator) which transforms temperature differences into electrical energy. The proposed model is very much portable, so any individual easily can carry with them. This device does not need any external power supply to charge it, because this device made up of four energy inducing elements or can say transducers and one buck booster which step up the output voltage of the energy produced or induced by the generating elements assembled with a super-capacitor. This device is very useful in the situation where the person doesn’t have power source around and need to charge any electronic device. This device can replace your heavy power bank with this light weighted device. Anyone can easily use this electronic device simply by squeezing it and shaking horizontally, these all physical movements induces electrical energy and got stored in super capacitor and further consume by the charging devices.

1. Introduction
Electronic wireless communication devices play a vital role in today’s era. These devices majorly consist of microprocessor, sensors, transducers, screen, etc. [1], these kinds of elements connected in a systematic pattern to run the device for performing a specific task. To run any electronics device, it needs a specified or rated quantity of power supply (generally rated 3.7V) and required current according to device load demand [2]. The above literature shows that battery is one of the basic components of any device and if the battery dies or the state of charge become “0” unfortunately, the device will die and it will stop working completely, this situation leads any individual barring from intercellular communication, world wide web or internet and many other important applications which may cause anyone heavy loses. So it is necessary for electronics or smart electronics devices to work uninterruptedly. The uninterrupted supply from the battery is little difficult task because it is always possible that there might occur few situations when battery’s state of charge is near to zero and the person is out of reach to the power supply, currently most of the people carries power bank, this may be the liable solution for the above stated problem, but there are also some demerits of power bank like power bank needs to charged again and again, so with time power bank’s capacity degrades. Another demerit is that it is heavy in weight. And yet another demerit is that power bank can only supply limited capacity of charge once it is fully charged. So this paper provides smart solution for the electronic device’s batteries, which encounters all the above stated problems. The proposed model is of hybrid human power generating unit using multiple transducers, the device consists of five kinds of energy converting elements like Piezoelectric Plates, Peltier Module (thermal electric generators),
Solar Panel (5w), small DC generator (dynamo) and a coil with permanent magnet. These elements are connected to a boost converter (XL6009-module) which is further connected to super-capacitor and then to IC-78S05 and at the output, a constant 5-voltage and current not more than 2A is obtained.

Here, we investigate a complete design and construction for an electronic circuit that will be used for charging electronic devices. The paper is organized in four different sections. The first section consists of introduction. The second section consists of description of all the elements present in the proposed model. Third section consists of working and the last and forth section consist of results and discussion.

2. Technical Studies
This section includes different units of the device explained individually along with their fundamental mathematical output expressions.

2.1. Piezoelectric Plates
The piezoelectric plates are used in the proposed model in a particular pattern as shown in Fig. 1. The piezoelectric means the electricity generated with the help of pressure, the Quartz crystal is one of the example of natural piezoelectric crystal, where the Rochelle salt, lithium sulphate, dipotassium tartrate are the example of manmade crystal. Piezoelectric is a kind of energy converting element which converts pressure and vibration into electric energy. The piezoelectric effect is due to the presence of electric dipole moments in solid materials. The induced ions on crystal lattice sites with different kinds of charge surroundings like BaTi03 and PZTs or may be directly carried with molecular groups. The dipole density can easily be calculated for crystal by adding the dipoles per volume of crystallographic unit cell [3]. As dipoles are vector quantity, dipole density is vector field. The dipoles those are nearer to each other having the tendency to align in a regions known as Weiss domains. The domains are generally having the random orientations. But with the help of poling (process by which a strong electric field is applied across material, at elevated temperature. And not all piezoelectric materials can be polarized. The different piezoelectric material has different piezoelectric constant like PZT-5H has D31 of -274 PM/V that means if you applied a Voltage of 1V it will produce a charge of 1 Pica Meter. Negative sign depends upon its direction [4]. Output voltage of piezoelectric crystal can be calculated by using formula:

\[ V = P \times g \times t \]  

where \( P \) is the pressure applied in N/(sq.m)  
\( g \) is the sensitivity of the material  
\( t \) is the thickness of the material  
\( V \) is output voltages like quartz crystal

![Fig. 1. Piezoelectric plates pattern](image)

2.2. Dynamo
The dynamo is a small electric generator. It works on the principle that if the coil is rotating in the presence of electric field then the electricity induced in the coil, which is proportional to the flux density and number of turns. So that it converts the mechanical rotations into direct electric current. Dynamos were the first large scale generators available for transferring power for industrial complex
power supply. Regardless of size, dynamo generators obey ohms’ law (V=IR), where V is voltage, I is current and R is resistance respectively. For this reason, lap-wound armatures used in dc generators require several pairs of poles and brushes. Wave Winding is used in dc generators employed in high-voltage applications. So the proposed model consists of lap winding dc dynamo generator. The e.m.f. output equation of dynamo generator is- 

\[ E = \frac{\alpha PNZ}{(60 A)} \]  

(2)

Let, \( \alpha \) = flux/pole in Wb (weber)
\( Z \) = Total number of conductors.
\( P \) = Total number of generator poles.
\( A \) = Total number of armature poles in generator.
\( N \) = Rotational speed of armature in revolution per minutes (rpm).
\( E \) = E.M.F. induced in parallel path.

[Fig. 2. Dynamo is physically coupled with teeth of the movable part in the device.]

2.3. Photovoltaic panel
Photovoltaic effect, phenomenon used to produce electricity from the photos or light energy from the sun. There are some diodes (photosensitive) which are sensitive to the sunlight and make electrons move, when the beam of light falls on it. Several such diodes combined as a cell and several such cells put together called modules. Generally, the modules are made up of wafer based crystalline silicon or thin-film cells, and are connected in series (electrically) with one-another, so to obtain the desired output. The output of the panel is in the form of electric current and given below is a formula regarding-

\[ E_a = S_a \times Y \times R_{av} \times pr \]  

(3)

\( E_a \) is the Energy generated (kWh)
\( S_a \) represents Total area of solar panel (in m²)
\( Y \), represents Yield (%) of solar panel
\( R_{av} \) is Average radiation on panels per annum (without shadings on panel)
\( pr \) represents Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)
\( Y \) is the yield of solar panel given by the ratio of electrical power (in KW) to the area of one solar panel.

2.4. Linear Alternator
According to Faraday’s law change in magnetic flux of a coil will cause e.m.f. to be induced in the coil, i.e. there should be a relative movement between the coil and the magnet in order to change the magnetic flux linkage of the coil. Proposed model deals with a moving magnet within a coil of conducting wire (as shown in Fig. 3), hence flux linkage between the magnet and the coil will change causing e.m.f. induction within the coil. The e.m.f. induced can be given according to Faraday’s law as,

\[ E.m.f. = -N(\Delta(BA))/\Delta t \]  

(4)
Where E.m.f. denotes the voltage induced, N denotes the number of turns in the coil, B is the magnetic field of the coil, A is the Area and t is time.

![Linear Alternator](image)

**Fig. 3.** Linear Alternator

As shown in Fig. 3 the magnet is kept in between the coil (kept inside a hollow non-ferrous and non-conducting cylindrical tube and the coil is wound around it [5]). As soon as the magnet is made to move within the coil, e.m.f. induces in the coil.

### 2.5. Peltier Plate

Peltier Plate (also called as thermoelectric generator (TEG), seebeck generator), is a solid state device that converts heat energy directly into electrical energy through a phenomenon called the seebeck effect [6]. Peltier Plates are used to convert electrical energy into a temperature difference between both sides of plates and vice-versa.

The relation between heat and current can be given through the formula below,

\[ Q = P \times I \times t \]  

(5)

Where \( Q \) denotes the amount of heat, \( P \) is the Peltier coefficient (depends on the material used), \( I \) is the current and \( t \) is time.

![Peltier Plate](image)

**Fig. 4.** Peltier Plates

Peltier Plates are used in the proposed model at the top of the device as shown in the Fig. 4.

### 2.6. IC 78S05

IC 78S05 belongs to family of linear voltage regulator integrated circuits i.e. 78XX, and is used as a voltage regulator to regulate the output voltage to 5V, 2A. In the proposed model the IC has been used at output end, so as to obtain the desired output of 5V, 2A. The circuit diagram of the model has been shown in Fig. 5,
2.7. XL6009 Module
XL6009 is used as a boost converter in the model. Boost converter is a step up DC-DC power converter used to step up the voltage from its input side to its output side. In the proposed model the module has been used after all the power producing transducers to obtain desired output.

3. Methodology
This section consists of working of proposed model, explanation of flow chart and physical appearance of model.

3.1. Flow chart
Fig. 7 shows flow chart, where the proposed model consists of five power generating elements those are connected in parallel and combined output of these five elements provide input to the boost
converter, boost converter step ups the input and the output energy get stored in the super capacitor. The stored energy is made to release through IC-78S05, which provides the desirable output for the electronic devices.

3.2. Circuit diagram and Outer model

Fig. 8 shows circuit diagram of each and every element present in the proposed model including the required diodes and bridge rectifiers with labeling.

![Circuit Diagram](image)

**Fig. 8. Circuit Diagram**

4. Conclusion

Portable wireless electronic devices generally consist of a battery for required power, and thus counter the problems associated. The device proposed in this paper thus provides with respective solutions. Hybrid human powered power generating unit consists of five different transducers used to convert different forms (heat, solar, rectilinear motion and pressure) of physical energy into electrical energy. The output of individual transducers is obtained as per the energy equations given, and thus output power obtained by the device is sum of the outputs of individual transducers. And thus obtaining required output power for charging wireless electronic devices.
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