Design and Implementation of Power Generation Utilizing Human as a Source

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ABSTRACT

In this paper, authors present the design and implementation of power generation utilizing human as a source. Designing has two parts electrical and mechanical. Human are rich source of energy. This energy is being dissipated while walking, running and doing other activities. We have designed an apparatus that takes the energy from human during walking and converts it into electrical energy. This apparatus is the foot step module. After converting mechanical energy into electrical, this energy can be stored in battery and used latter. This paper also includes designing and implementation of inverter to convert DC into AC.

Key Words: Power Generation, Energy, Module, Inverters and DC/AC

INTRODUCTION

Humans have a definite amount of energy which can be used to power small devices. An average-sized person stores as much energy in fat as a 1000-kg battery (Brooks, Fahey & Baldwin, 2005). This energy is first converted into useful form and then used. Human use the chemical energy stored in their body to perform different functions like running, walking and even dancing. This chemical energy is converted into mechanical energy by muscles with peak efficiency of 25%. This work can be performed at a high rate, with 100 W easily sustainable (Donelan, Naing, Hoffer, Weber and Kuo, 2008). It is likely that the energy harvesting shoe also increases user's effort because normal shoe soles typically store and return 40-60% of the mechanical energy applied during a typical walking step (Starner, 1996). While walking some of the energy is used for muscle movement and some is lost to overcome friction. The energy used to overcome friction can also compress a spring which in turn could run a generator. The generator in turn produces electrical energy which can be used to power small devices. This method of electricity generation is suitable for small power applications. In case of high power applications, this method is not suitable. Recently, the research on energy harvesting has focused on generating electrical power from the shoe sole, with the best devices generating around 0.8 W (Paradiso & Starner, 2005). Alternatively, a spring-loaded backpack (Rome, Flynn, Goldman & Yoo, 2005). harnesses approximately 7.4 W of power during fast walking using the vertical oscillations of a 38 kg load.

(a)

(b)

Figure 1. Sustainable dance floor at the sustainable club Watt in Rotterdam, The Netherlands .

MOTIVATION FOR IMPLEMENTATION IN CROWDED AREA

Our project is suitable for those areas where intensity of pedestrians is very high. Each individual can contribute to a greater extent to utilize his energy for power generation. Power generation is directly proportional to the number of pedestrians who pass through the specific place where the foot step module is installed. This project has many applications like hospitals, railway plate forms, schools, colleges, universities & public parks etc. These are the places where hundreds of people visit daily. In case of our college almost thousand individuals including students, staff and visitors visit our college on daily basis. If we implement this project at the entrance gate of the college it could generate enough amount of energy. As far as the impact of this project on environment is concerned, there is no fuel consumption and as a result there is no hazardous effects on the environment. We can say that this project is environment friendly. We can also implement this project on busy footpaths where thousands of people walk through. Our project could meet the power requirements of street lights and railway platform etc. Now a days street lights are made up of LED which requires less amount of energy to make this project work efficiently.

ENERGY HARVESTING MODULE

The physical model of the module is shown in the figure 2a. We have just shown a simple structure as a model. This model is used to understand the basic working of the system, basic characteristics of the components, many of the limitations of the system will be remedied and a system optimization can be explored. The top plate is of wood and rest of the structure is of metal. The load of this energy saver is 5 watt. We can also use parallel arrays of LED as a load.

The harvesting part consists of a top wooden plate and a steel structure. Four set of springs are used to support the weight of a person. Steel rods are used for stabilizing the plate. The vertical motion of the plate is converted to rotational motion by a rack and pinion. Rack and pinion is further connected to a gear box which in turn is connected to a DC generator.

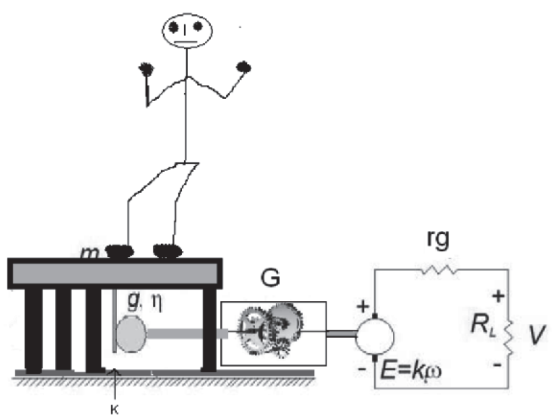
The simplified harvesting model, as shown in Figure 2b consists of a tile supported by four set of springs and steel rods modeled by a simplified mass m. The coefficient of the spring is k. The linear vertical motion of the moving part of the tile is converted to rotary motion by rack and pinion and gear box gear. The DC generator is modeled by its coefficient kg and an armature resistance of rg and load resistance of RL, Lg be the inductance of the generator armature, EA is the armature voltage, Wg is the angular velocity of the armature, ig is the current in the armature, Jg is the moment of inertia of the generator and φ is the flux in the generator . For gear box G is the gear ratio, Jgb is the moment of inertia of the gear box,τingb is the input torque to the gear box and τogb is the output torque of the gear box.The state space model is shown below:

$$\begin{bmatrix} X_1' \\ X_2' \end{bmatrix} = \begin{bmatrix} -r_g+R_L/L_g & K_g/L_g \\ -K_g/\ (J_{gb}+J_g) & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ G/\ (Jgb+Jg) \end{bmatrix} \begin{bmatrix} \tau_{in\,gb} \end{bmatrix}$$

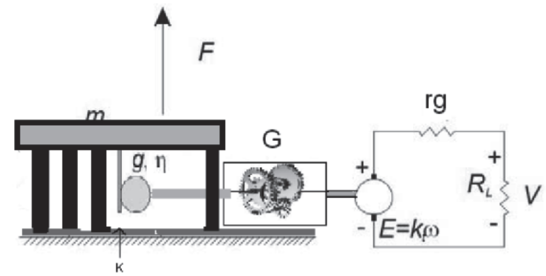
And

$$\begin{bmatrix} V_L \end{bmatrix} = \begin{bmatrix} -rg & Kg\varphi \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \end{bmatrix} \begin{bmatrix} \tau_{ingb} \end{bmatrix}$$

Where X_1 is the rate of change of current in the armature of generator, X_2 is the rate of change of angular velocity of the generator and V_L is the voltage across the load.



(a)



(b)

Figure 2. Physical model of the energy harvesting module.

Figure 3. Mechanical model of energy harvesting module.

PERIPHERAL CIRCUIT BOARDS

After generation of power it can be used by connecting the load to the generator directly. As the generated voltage is DC so only DC operated devices can be used. The power can also be stored for future purpose in the battery. To power AC loads we use inverters. If instead of using DC generator, we use AC generator then we use rectifier before power can be stored to the battery. The basic functions of all the circuits used in this project are

A. INVERTER:

Inverter converts DC into AC. If we want to attach an ac load then we have to convert the battery voltage which is DC into AC with the help of an inverter. Inverter consists of two parts: one is the oscillator which produces 50 Hz frequency and second consists of a number of power transistors which convert DC voltage into ac voltage. A step-up center tapped transformer is used to step-up 12v to 220v.

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B. Constant Voltage Circuit:

A constant voltage circuit provides constant voltage to the battery. The generated voltage varies with the weight of the person, more the weight more will be the generation, so a constant must be supplied to the battery in order to charge the battery properly and to enhance its efficiency and life period. This circuit provides a constant 12v to the battery for a variable voltage between 10 to 30 volts. It also has an additional feature of monitoring the temperature of the battery. During charging the temperature of the battery it will increase so it continuously monitors the temperature and cut off the supply in case when the temperature increases beyond certain limit.

PROTOTYPE:

In order to validate the design and analysis techniques developed, prototypes have been created in order to perform the measurements. The electromechanical model along with the peripheral circuits is integrated within the same module. The steel structure module is 1'x1'feet in size with a height of 1feet. The downwards movement of the tile is about 3inches. The gear box used is of ratio1:20. The steel rods are of an inch in diameter. These bars are of stainless steel. Four sets of spring with spring constant of k are used. Rack and pinion are used to convert the vertical motion into circular motion. In electronics portion, we have a constant voltage circuit that gives a constant 12 v to the battery and an inverter circuit that converts DC into AC and a 100 watt setup transformer.

MEASUREMENT:

Energy is generated when the tile moves downwards due to the force applied by the person and when the tile moves upwards due to the spring, even when the person moves ahead. The measured average output power that can be generated by a single foot step is about 3.5 to 5W. The power that can be generated in a specified interval of time depends upon the frequency of the people and the weight of the person that passes through the module. More the people pass through the module more the power will be generated.

CONCLUSION

In this paper we have presented the design of small size, low power generation system by using human as a power generation source. The energy lost during walking, running and dancing can be converted into electrical form which can be used for other applications. By building an electro-mechanical setup we can convert these energy losses into electrical form. This is a low cost power generation system with acceptable production. To increase the generation we have introduced a gear system to speed up the rotation of the generator so that it can produce more power. By choosing gear system with higher gear ratio we can increase the generation. This system can be implemented at crowded places like airports, railway platform, dance clubs and hospitals where they can meet small power applications.

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