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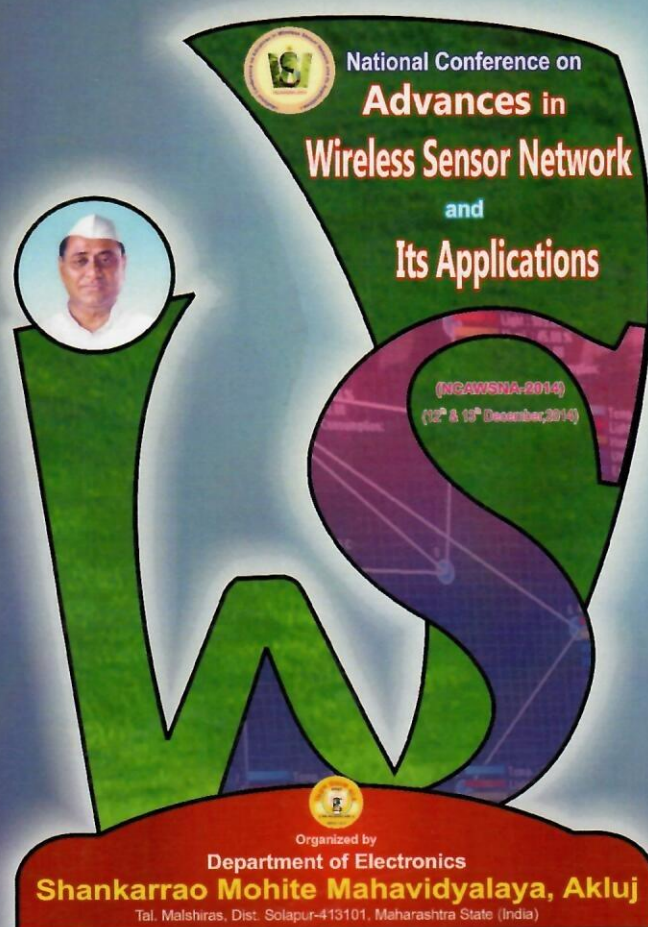
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## Development of Energy Harvesting System for Wearable Electronics

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**ABSTRACT:** Wearable Electronic is a new field of research. The term wearable electronics is a working electronics small circuit into new innovative gadgets or smart wearable cloths which is suitable for everybody everywhere. These gadgets work in coordination with each other with Wireless Sensor Network (WSN). Wearable electronic technologies is an emerging trend and are expected to be revolutionary in many applications like Smart health monitoring, fashion and designing, sports etc. All wearable electronics gadgets require energy. This Energy is either generated or captured. Energy requirement of this devices depend on number their mode of operation. The energy harvesting from human body has been provided to be an effective alternative for wearable electronic technology. Human body activities are used as a source of energy for implantable for biomedical devices

In this research work, the main focus is on converting mechanical energy into electrical energy. An effort is made to generate electrical energy from the movement of human body or part of it. The human hand moves like a pendulum and generate small amount of electrical energy. The shaft of electromagnetic generator attach to human hand. The movement of human hand moves electromagnetic generator and generator generate energy. This generated energy further charges the rechargeable batteries or super capacitor used for wearable electronic. The rechargeable battery or super capacitor is a source of power for different nodes of wireless sensor on human body. An effort is made to analysis the electrical energy from the movement of pendulum with the help of MATLAB. And these results are verified experimentally.

**Keywords:** Electromagnetic Generator, Energy Harvesting System, Rechargeable battery, Wearable Electronics, Wireless Sensor Network

### I. INTRODUCTION

Wearable electronic systems are modern era and an emerging trend and are expected to be revolutionary in many applications. Wearable electronics technology constitutes very strong growth in electronic technology. Wearable electronic technology devices are widely used by consumers and often many applications. The most important trend in the wearable electronic technology from its beginning is portable electronics devices [1].

A mainly wearable electronic device contains small sensors for sensing a data and communicates wirelessly. All wearable electronic gadgets require electrical energy. This energy is either generated or captured. Energy requirement and consumption of such devices depend on number of devices as well as their mode of operation. Energy harvesting is the process by which energy is derived from environment, captured and stored. Conversion of ambient energy into electrical energy has attracted much interest in both the communication and commercial sectors. Energy harvesters provide a very small amount of power for electronics devices. [2].

The world going through the energy crises. There is need to search alternative energy source like renewable energy source to generate electrical energy. The renewable energy can be obtained from different sources like radiant energy harvesting, Mechanical energy harvesting or thermal energy harvesting. Alternative energy generation have rapid development due to crises of energy and industrial demand.

Mechanical energy harvesting is one in which mechanical energy is convert into electrical energy. Mechanical energy is generated through the motion of objects. It can be either kinetic energy (energy of motion) or potential energy (stored energy of position) [3]. Objects have mechanical energy if they are in motion and/or if they are at some position relative to a zero potential energy. In mechanical energy harvesting system mainly Electromagnetic, Electrostatics/ Capacitive or piezoelectric energy harvesting technique are used.

### II. SYSTEM UNDER STUDY

In the present research work, efforts are made to design electromagnetic generator which generate electrical energy from mechanical energy. Here electric energy is generated from movement of human hand. The human hand work like pendulum and generate electrical energy.

Following Figure 1 shows the block diagram of experimental setup. The human hand is work like pendulum. Movement of human hand generates mechanical energy. The shaft of electromagnetic generator is connected to pendulum

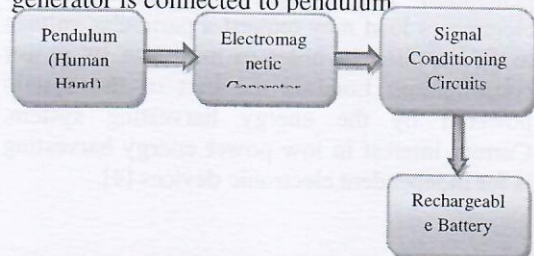


Figure 1: Block diagram of experimental setup of Electromagnetic energy harvesting system



The following Figures 2 show the human hand work as pendulum

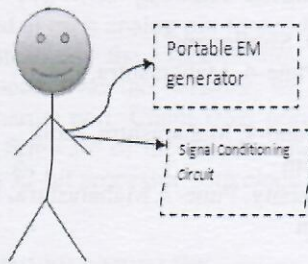


Figure 2: Human hand work as Pendulum

While moving a pendulum moves a shaft of electromagnetic generator. The electromagnetic generator generates electrical energy from mechanical energy. The electrical energy converted is mainly depends upon movement of pendulum, efficiency of electromagnetic generator and power dissipation of circuits. This energy need to amplify by using signal conditioning circuits.

Following Figure 3 shows an Experimental setup of pendulum as energy generator.

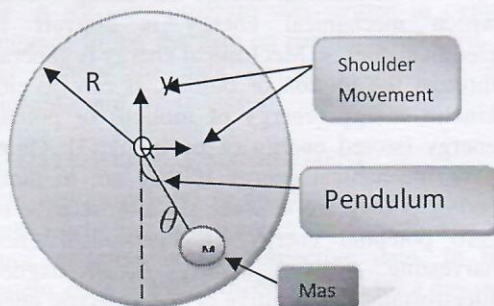


Figure 3: Movement of pendulum as energy generator

The generated energy can be stored in a capacitor/super capacitor or battery or combination of both. Capacitor is used when the application needs to provide huge energy spikes. Batteries leak less energy and therefore used when the device needs to provide a steady flow of energy. In future Regulator is required for two reasons: the voltage on the storage element may change dependency on the rate of power generation and usage. In addition, the electronics load may request a particular voltage to be supplied in order to minimize its power consumption. Load is the part of the system powered by the energy harvesting system. Current interest in low power energy harvesting is for independent electronic devices [4].

**Designing of Pendulum**

A pendulum is one which can be considered to be a point mass suspended from string of negligible mass [4].

Consider mass of object connected to a pendulum is 'm' and length of string 'L'. The motion of the pendulum can be completely described by coordinate θ. The angle θ measured from y axes.

For a small angle

$$\theta = \theta_{max} \sin(\sqrt{g/L} t)$$

The period of the motion, the total time for a complete oscillation (outward and return) is

$$T = 2\pi\sqrt{L/g}$$

**Designing of power generator**

The energy generated of pendulum is depends upon periods of pendulum. The pendulum period is initially depends upon length of pendulum and gravitational fields strength g.

Velocity at the bottom of the swing

$$v = \sqrt{2g * L * (1 - \cos(\theta))}$$

The maximum height of pendulum is

$$h = L - L * \cos(\theta)$$

The total energy is

$$E = m * v^2 / 2$$



### III. EXPERIMENTAL RESULTS

For calculating the energy generated from pendulum need to calculate or identify the angle of the pendulum. By using a simulation tool like MATLAB can be easily find out the position of pendulum and angle of pendulum. That angle  $\theta$  is used to find out the energy

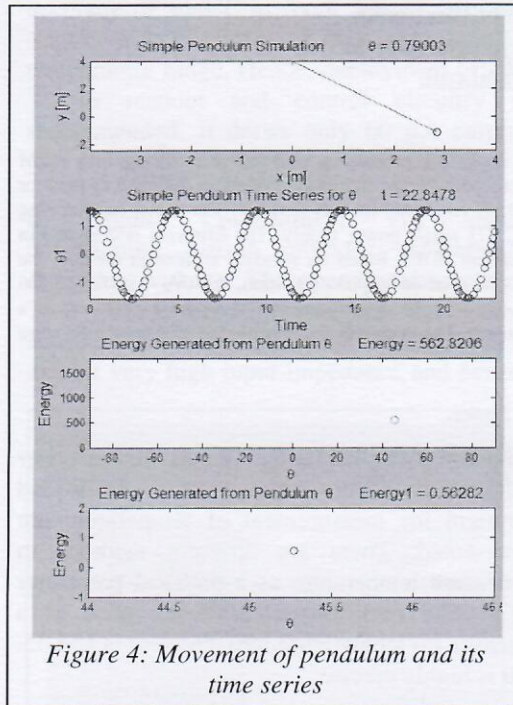


Figure 4: Movement of pendulum and its time series

generated from pendulum. The figure 4 and figure 5 shows the simulation results of movement of pendulum and its time series for different angle.

The generated energy by using different formulae and its simulation are shown in below. The generated energy is very low. The generated energy is need to store in either rechargeable battery or super capacitor.

### IV. CONCLUSION

In Wearable Electronics technology energy generation is new era of research. Human hand work like pendulum and generate Energy from its motion. There are several alternative energy sources which can be used for the same purpose. When the angle of pendulum oscillation increased, the generated electric energy also increases. As per above discussed the system designed for energy generator using a Pendulum which is used in Wearable Electronics devices. The generated power is in mill watt range. In future generated power will be amplify and stored in rechargeable battery or super capacitor.

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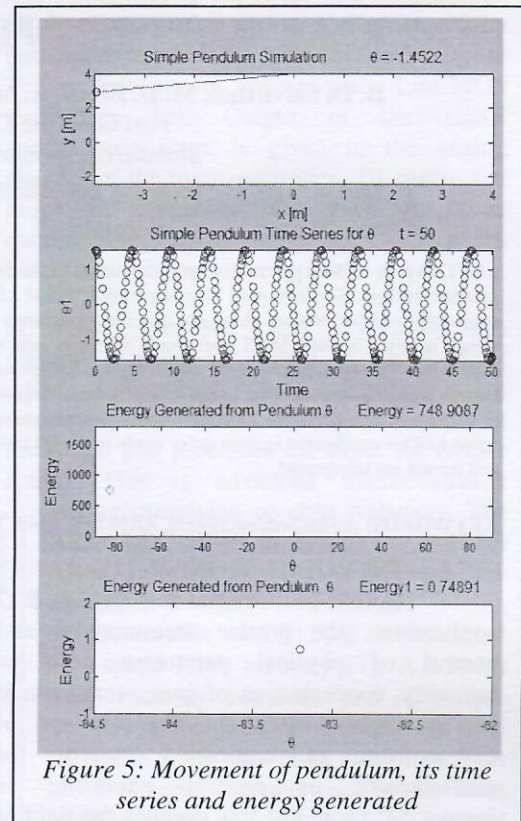


Figure 5: Movement of pendulum, its time series and energy generated

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