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Piezoelectric Transduction Based Power Generation System

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Abstract: Now a days we are facing a lot of power problems. In many countries these power sources are depending upon non-renewable energy resources such as natural gases, coal and etc. many countries noticed that due to the lack of fuels further we will face a lot of power problems. So we need to move for renewable energy resources such as solar, wind, geo-thermal. Many countries are already started to use these sources for power generation. These all are very expensive and depending upon their only respective sources. In my project I am introducing the one more energy source which is depending upon vibrations. In this project we used one cantilever. This cantilever works with the principle of piezoelectric transduction mechanism, and also it acts as a source for vibrations. This cantilever will produce mechanical beam. When a MEMS sensor is placed on the beam, it converts the mechanical energy generated from the movement of the beam into electrical energy. The output of MEMS is given to the ADC for analog to digital conversion and then to microcontroller in order to monitor the value of energy generated. The output of MEMS is also given to boost controller. The obtained energy is boosted up using Boost Controller and given to DC-DC converter. The output of the DC-DC converter is stored in a storage device. The stored energy is inverted to AC voltage and is given to the relay and is utilized for purposes like lighting lamps, powering a remote sensor, extending the rechargeable battery lifetime etc.

Keywords: Piezoelectric Transduction, Vibratory Cantilever, MEMS, Boost converter.

I. INTROCUTION

For a long time, the human race has relied on fossil fuels as their primary source of energy. Fossil fuels heat our homes; provide gas for our cars and electricity for our everyday appliances. In the 21st century, we are using non-renewable energy sources more than ever, but our ravenous power consumption comes with a cost. Over time, we are depleting the Earth's resources and slowly killing our planet. There is still hope for the Earth. If we change our ways now and shift our focus to green energy sources, the planet will survive for generations to come. The power to make the world a better place for the future is in our hands. [1]. Green energy sources are the solution to the environmental, political and social problems of this lifetime. By spending more on these technologies, no country will have to depend on another or even a corporation for their power needs because green energy sources are self-dependent and free [2]. The biggest advantage of green energy is that we will never run out of it. Everyone is aware of the impending crisis we will be facing when the world's non-renewable energy sources run out. This isn't the case with green energy where we will always have the sources to draw power from. Green energy sources are not maintenance free. However, compared to fossil fuels, they don't cost that much to maintain. Although plants that produce green energy are more expensive to construct and setup, they are less expensive in the long run due to the decreased operating costs.

II. EXISTING SYSTEM

Energy harvesting sources including solar, wind and thermal each with a different optimal size. They either waste much available energy due to impedance mismatch, or they require active digital control that incurs overhead, or they work with only one specific type of source. No more research on the vibration domain.

Disadvantages:

- Construction cost is high in normal energy harvesting like wind, solar.
- Not will be compact.
- More storage device required.

III. PROPOSED SYSTEM

This paper has investigated the optimal power that can be extracted from human gait over a wide speed range using electromechanical vibration conversion from human movement as shown in Fig.1. Driven by the potential to power small portable electronic devices, more recent research in energy harvesting from gait has focused on 1) increasing the power output 2) energy harvesting from the motion of backpacks during walking, and 3) minimizing energy expenditure by controlling the breaking force.

Advantages:

- Good output power.
- Renewable energy facilities generally require less maintenance.
- Renewable energy produces little or no waste products.
- Easy Method.
- Portable Technologies.
- Boost level increased.

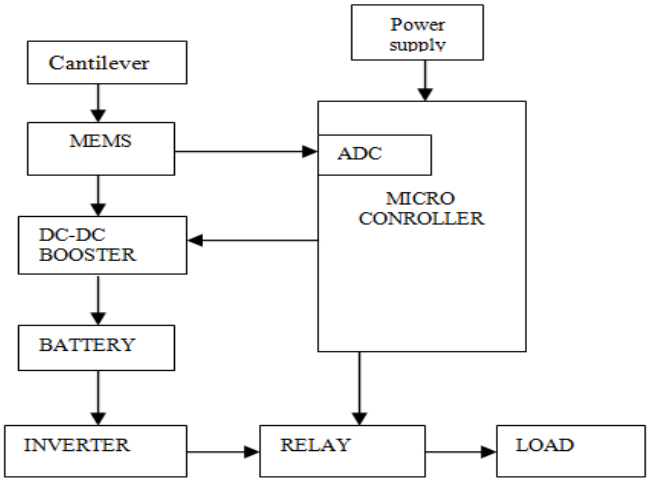

Fig.1. Block diagram.

The main theme of this project is to generate the power from the vibrations(not only from vibrations but also from acceleration and force) . Here the cantilever acts as a source of vibrations. The main working principle of this project is piezoelectric transduction principle. When the vibrations produced, the cantilever will generate mechanical beam. If we place the MEMS sensor on the mechanical beam, this sensor will produce electrical energy. The amount of electrical energy is depends upon the amount of vibrations. The output of MEMS is given to the dc-dc boost converter and also the microcontroller in order to monitor the generated values. The boost controller will increase the generated electrical energy into higher amount. This will be stored into the battery. This dc voltage will be converted into high amount of ac power. Here the relay is used as an electric switch.

A. Cantilever

A cantilever beam is anchored at only one end. The beam carries the load to the support where it is resisted by moment and shear stress. It is a projecting structure which is supported at one end and carries a load at the other end or along its length. A cantilever is a beam that projects beyond a fulcrum and is supported by a balancing member or a downward force behind the fulcrum as shown in Fig.2.

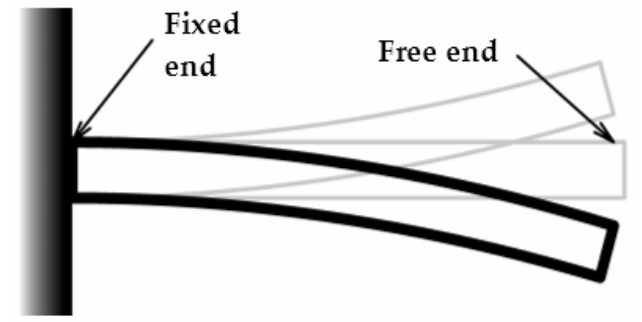

Fig.2. Prototype of a cantilever.

A linear structural member supported both transversely and rotationally at one end only; the other end of the member is free to deflect and rotate. Cantilevers are common throughout nature and engineered structures. Examples are a bird's wing, an airplane wing, a roof overhang etc. The working principle of this element is piezoelectric transduction principle. This principle states that whenever an external force like movement, pressure, and force applied on the piezoelectric element then that element will give response in terms of electric energy.

B. MEMS

Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements that are made using the techniques of micro fabrication as shown in Fig.3. MEMS are an electrostatic transducer used for harvesting and converting the energy of vibrations into electrical energy.

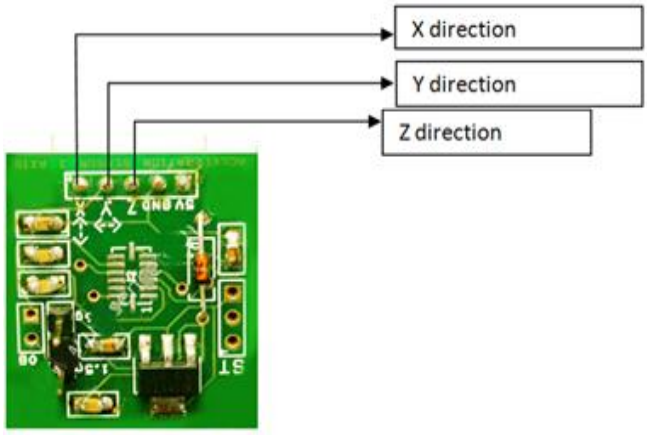

Fig.3. MEMS IC.

While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable and perhaps the most interesting elements are the micro sensors and micro actuators. Micro sensors and micro actuators are appropriately categorized as 'transducers', which are defined as devices that convert energy from one form to another. In the case of micro sensors, the device typically converts a measured mechanical signal into an electrical signal.

C. DC-DC Boost Converter

A boost converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. Power comes from DC sources such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion. A boost converter is a DC to DC converter with an output voltage greater than the source voltage as shown in Fig.4. A boost converter is sometimes called a step-up converter since it "steps up" the source voltage. The DC-DC Switching Boost Converter is designed to provide an efficient method of taking a given DC voltage supply and boosting it to a desired value.

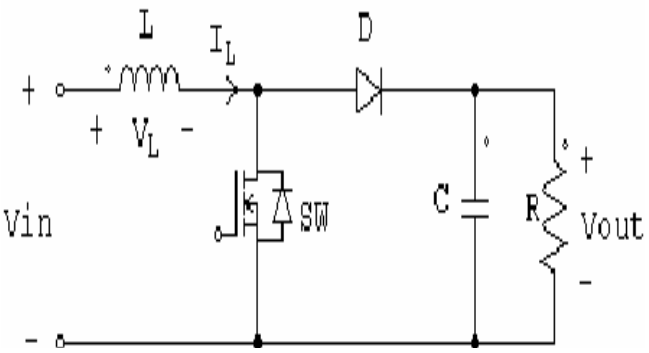

Fig.4. Boost Converter Circuit Diagram.

The dc-dc boost converters are used to convert the unregulated dc input to a controlled dc output at a desired voltage level. They generally perform the conversion by applying a dc voltage across an inductor or transformer for a period of time (usually in the 20 kHz to 5 MHz range) which causes current to flow through it and store energy magnetically, then switching this voltage off and causing the stored energy to be transferred to the voltage output in a controlled manner as shown in Fig.5. The output voltage is regulated by adjusting the ratio of on/off time. The basic principle of step-up (boost) DC-DC converter is as follows. When switch SW is closed for the time t_1, inductor current rises and energy is stored in inductor L. If switch is opened for time t_2, energy stored in the inductor is transferred to load through diode D_1 and the inductor current falls. For a continuous current flow, waveform for the inductor current is as in figure. If large capacitor C is connected across the load, output voltage is continuous and becomes average value. Voltage across the load can be stepped up by varying duty cycle and the minimum output voltage is V_i when k = 0.

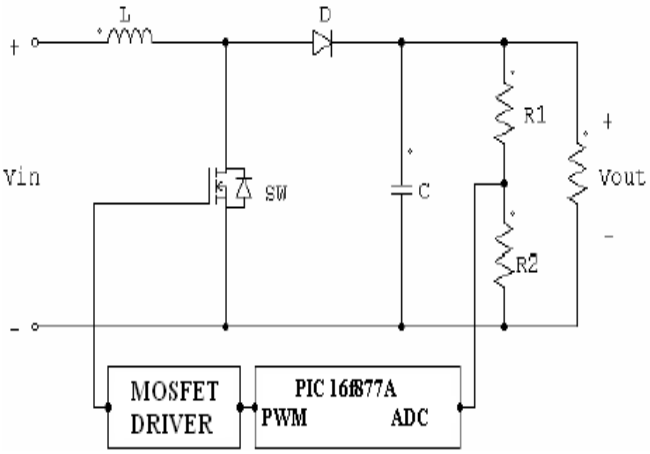

Fig.5. Embedded Boost Converter.

D. Relay

A relay is an electro-magnetic switch which is useful if you want to use a low voltage circuit to switch on and off a light bulb (or anything else) connected to the 220v mains supply. The Fig.6 below shows a typical relay (with "normally-open" contacts).

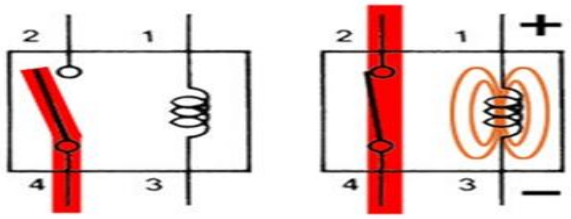

Fig.6. working of relay.

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions. When no voltage is applied to pin 1, there is no current flow through the coil. No current means no magnetic field is developed, and the switch is open. When voltage is supplied to pin 1, current flow though the coil creates the magnetic field needed to close the switch allowing continuity between pins 2 and 4.

E. Inverter

In the world today there are currently two forms of electrical transmission, Direct Current (DC) and Alternating Current (AC), each with its own advantages and disadvantages. DC power is simply the application of a steady constant voltage across a circuit resulting in a constant current. A battery is the most common source of DC transmission as current flows from one end of a circuit to the other. Most digital circuitry today is run off of DC power as it carries the ability to provide either a constant high or constant low voltage, enabling digital logic to process code executions. Historically, electricity was first commercially transmitted by Thomas Edison, and was a DC power line. However, this electricity was low voltage, due to the inability to step up DC voltage at the time, and thus it was not capable of transmitting power over long distances. The basic inverter circuit has shown below Fig.7.

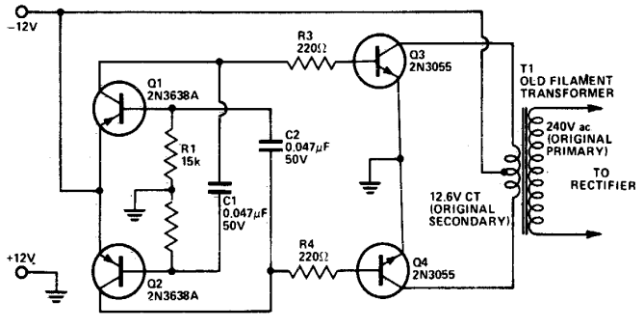

Fig.7. Basic inverter circuit.

Power inverters are devices which can convert electrical energy of DC form into that of AC. They come in all shapes and sizes, from low power functions such as powering a car

radio to that of backing up a building in case of power outage. Inverters can come in many different varieties, differing in price, power, efficiency and purpose. The purpose of a DC/AC power inverter is typically to take DC power supplied by a battery, such as a 12 volt car battery, and transform it into a 120 volt AC power source operating at 60 Hz, emulating the power available at an ordinary household electrical outlet. Power inverters are used today for many tasks like powering appliances in a car such as cell phones, radios and televisions. They also come in handy for consumers who own camping vehicles, boats and at construction sites where an electric grid may not be as accessible to hook into. Inverters allow the user to provide AC power in areas where only batteries can be made available, allowing portability and freeing the user of long power cords. On the market today are two different types of power inverters, modified sine wave and pure sine wave generators. These inverters differ in their outputs, providing varying levels of efficiency and distortion that can affect electronic devices in different ways.

IV. EXPERIMENTAL RESULT

The setup of the hardware section is shown below Fig.8:

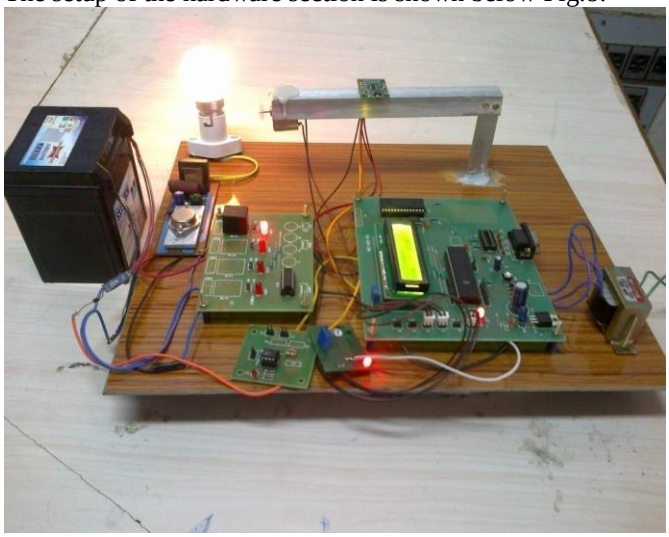

Fig.8. Hardware implementation.

V. APPLICATIONS

There are several sources of vibration present in the environment. A few of them are listed below.

- Cantilever beam, when placed on speed breakers can generate high power because heavy trucks may cross over by applying full pressure of tyres on the speed breakers thus making the beam to vibrate for longer duration.
- Green energy can be generated in many industries where there is continuous source of vibration such as sugar factory, automobile manufacturing companies etc. The fact is, in all these concerns, the vibrations generated by the motor is continuous.
- By employing proper mechanisms, we can harvest energy from the railway tracks since it vibrates every time a train passes by.
- Vibrations are also produced in our day-to-day activities like walking, typing etc.
- For e-vehicles we can use this project by adding some more mechanisms.

VI. FUTURE SCOPE

Energy harvesting is, in itself, an energy resource. Most of the human work is done by machines and most of the machines, needless to say, vibrate. These ambient vibrations can be used in an effective way by converting them to electrical energy. In future, miniature version of our whole setup can be pre-installed in all the machines that vibrate. The MEMS sensor along with the microcontroller would only add a very minimum to the actual cost of the machine. In the long run, the users of those machines will be able to generate enough power to at least provide lighting system in vicinity of those machines. Also, some techniques need to be developed to install our setup in the railway tracks and speed breakers. A large amount of vibrations are produced every time a train or a vehicle passes the track or speed breaker. With appropriate development of technology, the electrical energy generated from these vibrations, can be used to power the traffic-signal or at least can be used to provide lighting.

VII. COUNCLUSION

The need of the hour is to save power. Green energy sources are the solution to the environmental, political and social problems of this lifetime. By spending more on these technologies, no country will have to depend on another or even a corporation for their power needs because green energy sources are self-dependent and free. Thus, a highly reliable and versatile system has been designed and developed to convert vibrations into electrical energy. Green energy harvesting is encouraged because it causes no negative impact to the environment. Also, this method of power generation saves the cost spent for other renewable sources of energy and the biggest advantage of green energy is that we will never run out of it. Ambient vibrations are converted to electrical energy with the help of MEMS sensor. The sensor used is very sensitive and can sense the slightest of motion. Thus, energy is conserved effectively.

VIII. REFERENCES

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