Comparative Analysis of Piezoelectric Energy Harvester using Rotary Motion Application

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Abstract—This Project investigates the analysis and design of a vibration-based energy harvester for rotary motion applications. The energy harvester consists of a cantilever beam with a tip mass and a piezoelectric ceramic attached with the beam that is mounted on a rotating shaft. Using this system, mechanical vibration energy is produced in the flexible beam due to the gravitational force applied to the tip mass when the hub is rotating. A piezoelectric transducer is used to convert the induced mechanical vibration energy into the electricity. The equations of the motion of the flexible structure are used along with the physical characteristics of the piezoelectric transducer to derive expressions for the electrical power. The expressions for the optimum load resistance and maximum output power are obtained and validated experimentally using PVDF and PZT transducers. The results indicate that a maximum power can be extracted by using a PZT transducer in the system. The amount of power is sufficient to supply power for typical wireless sensors such as accelerometers and strain gauges.

Keywords—Piezoelectricity, Vibration energy, Cantilever beam

II. LITERATURE SURVEY

The piezoelectric materials, in special PZTs, have been largely used as mechanisms to convert ambient motion, usually vibration, into electrical energy that may be stored or used directly to provide power to other devices, e.g. mobiles, portable electronics or wireless sensors networks. These examples characterize a huge potential for commercial applications in different areas as presented in recent market researches. Structural health monitoring applications are one of the most benefited areas with devices for power harvesting. An interesting application is given by Starner and Paradiso (2004), who discuss the possibility of using alternative sources of vibration, such as the vibration of human breath captured through PZT in the human upper body, and even recovery energy of blood pressure or provided by vibration when a person walks with shoes bonded with PZTs patches. Another very interesting study is the use of mechanical vibration caused by machine.

An important stage to develop a practical design in an energy harvesting device is to model correctly the dynamical actions of the integrated system composed of mechanical structure, in general a cantilever beam, electromechanical coupling between the PZTs and the mechanical system, and, finally, the electrical load attached to the device. However, the multidisciplinary nature of this field has caused some modelling problems. Erturk and Inman (2008) presented some considerations about the oversimplified, incorrect physical assumptions and mistakes in analytical modelling of piezoelectric energy harvesters.

The authors clarified through improved models with lumped and distributed parameters, besides presenting a good overview of the numerical and analytical modelling of
electromechanical systems for power harvesting. The spot light in this strand of papers about piezoelectric energy harvesting models to study the maximum power that can be dissipated in a simple resistor or combination of linear electrical elements. The most part of these models focused on simplifying the energy harvesting circuit by a simple resistive load, but in the real-world applications, the energy harvesting circuit attached is more complex than a simple resistor. Thus, few in sequence about the interface between practical rectifiers circuits, used to transform alternating current (AC) into direct current (DC), and the electromechanical devices attached are discussed clearly.

On the other hand, the members of the research community in power electronics focus on the developing non-linear electronic models by using diodes, transistors, synchronized switch, etc. Provided an analytical and graphical analysis equation related to the output power with the efficiency of the rectifier circuit, which shows the important of the step of rectifying and storing the electrical charge. Wickenheiser and Garcia observed that the full-wave rectifier has a smooth capacitor to provide a tension approximately constant over the load. A Synchronized Switch Harvesting (SSH) has been analyzed in the area of energy harvesting with the PZT sensors. Also, a Synchronized Switch Harvesting on Inductor (SSHI) has been developed, taking up to 160% efficiency above standard rectifier. Other studies show the possibility of using inductors for switching. This techniques of circuit switched consider that the frequency is constant on the sinusoidal signal. However, there is deficient in studies concerning circuit switched with the electrical noise, where the non-controlled rectifier circuits have advantages.

The target, in general, is to study the optimal conditions to control the power flow and to charge an electrochemical battery or supercapacitors or directly feed an electronic system. The most part of these papers employed simplest models of mechanical resonator (spring, mass, damper) coupled with the electrical circuit, normally, with a single degree of freedom. The simplicity of the mechanical model can provide good results close to the resonance frequencies. However, it is well known in the literature that to predict accurately the electromechanical performance of piezoelectric energy harvester it is necessary to use a distributed parameter model so that considers multiple vibration modes.

III. MATERIAL AND METHOD

A. Block Diagram

B. Functions

- **Piezoelectric transducer**
  Piezoelectric transducers are a type of electroacoustic transducer that convert the electrical charges produced by some forms of solid materials into electrical energy.

- **Bridge rectifier**
  A Bridge rectifier is an Alternating Current to Direct Current converter that rectifies mains AC input to DC output.

- **Boost converter**
  A Boost converter is a switch mode DC to DC converter in which the output voltage is greater than the input voltage.

- **Storage capacitor**
  Storage capacitors are devices which store electrical energy in the form of electrical charge.

- **Load**
  An electrical load is an electrical component or portion of a circuit that consumes electric power.

IV. Expected Outcome

Flexible piezoelectric materials are attractive for the power harvesting applications because of their ability to withstand the large amounts of strain. PZT materials that can change
the ambient vibration energy surrounding them into electrical energy. The electrical energy can be used to power other devices or stored for later use. This equipment has gained an increasing notice due to the recent advances in wireless and MEMS technology, allowing sensors to be placed in remote locations and operate at very low power. The need for power harvesting devices is cause by the use batteries as power supplies for these wireless electronics. The output voltage can be generated up to 5v to 12v.

**Advantage**

- Easy to operators.
- Much more reliable for operator's.
- Simple operation.
- Low cost.
- Time saving.
- Self generating, no need external source.
- Very high frequency response.

**V. Conclusion**

The project deals with the method finding for the generation of the power from the vibration created by the harvesting. By using this project. We can drive D.C loads according to the force we applied on the piezoelectric sensor. Similar results will be encountered when one examines the energy transferred from side to side the series switch and inductor in the buck converter. In addition, based on the results gather in this analysis, the final prototype will be designed to fulfill the objective of generating electricity from piezoelectric disk.

**VI. References**


2. Filippo Ambroglini “Energy Harvesting application” , CTO, NiPS Summer School 2017


4. Farbod Khameneifar “Vibration-Based Piezoelectric Energy Harvesting System For Rotary Motion Applications” 2011