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Changed Piezoelectric Design Regarding High Electric Power Growing Employing MEMS

R. Udayakumar and M. Masthan

Department of Information Technology,
Bharath University, Tagore Engineering College, India

Abstract: Depending on Conventional energy sources will no longer applies as an excellent decision. Whereas, innovating new methods of power generation has a much scope for research and development. By all these importance of power generation we propose a new method of highly efficient power generation. MEMS are already proven to be cost and power economic circuitry for various micromechanical and electrical application. Thus, it would be very interesting to have a model of the entire harvesting system (the MEMS piezoelectric micro generator cascaded with the electronic circuit) to perform efficient optimization. Some features like damping effects and process fluctuations have considerable impact on the performance of MEMS, especially the resonant structures. A method of integrating such features is proposed early in the design flow, while keeping the simulation time reasonable. It has been tried to modify an existing structure of piezo electric circuitry to generate more power than the existing structure. By modifying the exiting MEMS piezo electric structure in such a way, that the crystal cells are closely packed. So that according to Kirchhoffs law it can deliver ample power when a simple pressure is applied. The modeling of the structure of the MEMS Piezoelectric structure is done by using VHDL AMS Scripting tool.

Key words: Energy harvesting devices · Microelectromechanical systems (MEMS) · Multidomain modeling · Physical modeling · Scavengers · VHDL-AMS

INTRODUCTION

Energy harvesting is the process by which energy is derived from external sources (e.g., solar power, thermal energy, wind energy, salinity gradients and kinetic energy), captured and stored for small, wireless autonomous devices, like those used in wearable electronics and wireless sensor networks. Energy harvesters provide a very small amount of power for low-energy electronics. While the input fuel to some large-scale generation costs money, the energy source for energy harvesters is present as ambient background and is free. For example there is a large amount of electromagnetic energy in the environment because of radio and television broadcasting. Computer-Aided Design (CAD) for Microelectromechanical Systems (MEMS) has been associated with Finite-Element Analysis (FEA). In spite of great improvements made in this area, a designer using this methodology has to separate the simulation of mechanical and electrical parts of his design. VHDL-AMS is a best model for MEMS design because physical and geometric constrain are very important since a small variation can play a vital and major role in the output. Our goal in this paper is to demonstrate a method of producing a predictable and reusable model that contains all design parameters including geometrical dimensions of the device and physical properties of materials.

MEMS: Microelectromechanical system (MEMS) is the technology of very small mechanical devices driven by electricity. It merges at the nano-scale into nanoelectromechanical systems (NEMS) and nanotechnology. MEMS are made up of components between 1 to 100 micrometers in size (i.e. 0.001 to 0.1mm) and MEMS devices generally range in size from 20 micrometers to a millimeter. They usually consist of a central unit that processes data, the microprocessor and

Corresponding Author: R. Udayakumar, Department of Information Technology,
Bharath University, Tagore Engineering College, India.

several components that interact with the outside such as micro sensors. At these size scales, the standard constructs of classical physics are not always useful.

Micro-ElectroMechanical 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 microfabrication. The types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move.

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

Piezoelectricmaterials: The piezoelectric effect describes the relation between a mechanical stress and an electrical voltage in solids. It is reversible. An applied mechanical stress will generate a voltage and an applied voltage will change the shape of the solid by a small amount (up to a 4% change in volume). Piezoelectricity is the property of nearly all materials that have a non-centro symetric crystal structure.

Whypiezoelectric Is Preferred for Mems: Piezoelectric materials can be used as a means of transforming ambient vibrations into electrical energy that can then be stored and used to power other devices. Piezoelectric material is very small and capable of generating up to 85uW of power. It also has a large energy conservation capacity than magnetic materials.

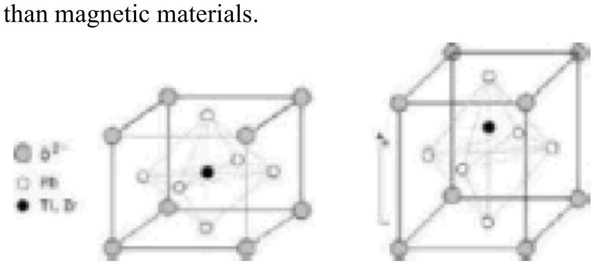

Fig. 1: Structure of piezoelectric

When we use electro-magnetic, scaling is very difficult. With the recent surge of microscale devices, piezoelectric power generation can provide a convenient alternative to traditional power sources used to operate certain types of sensors/actuators, telemetry and MEMS devices. The energy produced by these materials is in many cases far too small to directly power an electrical device. The three types of piezoelectric devices tested are the commonly used lead-zirconate-titanate (PZT) and the monolithic piezo-ceramic materials are the bimorph Quick Pack (QP) actuator and the macro-fiber composite (MFC)[7]. The experimental results estimate the efficiency of the three devices tested and identify the feasibility of their use in practical applications. Different capacity batteries are recharged using each device, to determine the charge time and maximum capacity battery that can be charged.

Simulationtool: In order to support the modeling of non electrical systems, several modeling methods using energy equivalences between electrical and mechanical domains were proposed [19]. Nevertheless, such a way can lead to neglect interaction effects or cross coupling between parts fromdifferent energy domains. This issue may affect the final design in terms of decreasing performances or increasing design time. Signal flow approaches using tools like MATLABTM / SimulinkTM from MathWorks allows only unidirectional quantities, whereas there are bidirectional ones in Kirchhoff networks. Another approach consists in using high accuracy models based on partial equations solved with finite elements tools. Such approaches present two limitations in the case of multidomain simulations. The first one is the cost in terms of time because of very slow simulations. The second limitation is it's incompatibly with circuit based modeling. Analog languages like VHDL-AMS or VERILOG-AMS provide powerful capabilities for modeling components and their interactions in multiple energy domains. In this work, VHDL-AMS is used because it can operate a wide range.

In the following part, the VHDL-AMS modeling approach of a MEMS generator is described. It is started from one dimensional system where only the general behavior of such transducer is presented. Then, an enhanced model of the piezoelectric generator is introduced in order to better predict the real behavior of such system. The simulation of mixed-signal models requires in addition mechanisms to convert between discrete and continuous representations of time and signal values and a synchronization mechanism between the discrete-time and the continuous-time simulation kernels to handle mixed-signal interactions, such as threshold crossings. A consistent quiescent operating point, this time possibly involving some discrete-time signals as well, is still required.

HDL is a programming language for developing executable simulation models of hardware systems. In this paper, the considered hardware systems are not only electrical or electronic systems, but more generally heterogeneous systems. HDL that can be used to describe models in several domains is said to be multidiscipline or mixed-disciplines. VHDL-AMS is the result of an IEEE effort to extend the VHDL language to support the modeling and the simulation of analog and mixed-signal systems. The effort culminated in 1999 with the release of the IEEE Standard 1076.1-1999 [4]. Verilog-AMS, on the other hand, is intended to be an extension of the Verilog HDL language to also support the modeling and the simulation of analog and mixed-signal systems. Verilog is a digital HDL that had first been released in 1995 as 50. IEEE Standard 1365-1995. The Verilog-AMS language reference manual is currently being completed under the auspices of the Accellera consortium [11]. It has not been submitted yet to the IEEE for whatever the state of the language, standard or not, all-defined mixed-signal capabilities are not yet implemented or still subject to interpretation. We hope that tool limitations will be progressively removed so the model writer has access to the real expressive powers of both languages. Therefore, the choice of the language is mostly guided by the idiosyncrasies of the developing team, the EDA tool suite available and commercial and time to market issues. VHDL-AMS can operate at various levels of abstraction. Both VHDL-AMS and Verilog-AMS prove their efficiency at the circuit-level. At this level, however, solid knowledge on analogies between physical theories is required. As systems on chips more and more include analog, RF and nonelectrical parts, it is possible that models written in VHDL-AMS or Verilog-AMS become too low-level and their relative simulators too slow for validating a complete system. An ongoing effort is, for example, intending to enhance SystemC to support the description and the simulation of continuous-time and a fortiori mixed-signal and multidiscipline, systems. Regardless, a seamless path to VHDL-AMS or Verilog-AMS modeling levels will have to be provided to keep a link tomore physical design aspects.

Proposedwork

Introduction: Now a day's energy harvesting is very important. For MEMS device we can generate energy by using piezoelectric microgenerator. In MEMS, physical and geometric constrains are very important because a very small change can produce a very big effect in the resulting output. A simulation method is proposed which will act as a bridge between design and specification. VHDL-AMS is the simulation tool used for implementing physical model of MEMS device.

Principle: Depending on how a piezoelectric material is cut, three main modes of operation can be distinguished: transverse, longitudinal and shear. Vibration sensors can be used to harvest energy from mechanical vibrations. This is accomplished by using piezoelectric materials to convert mechanical strain into usable electrical energy. Piezoelectric technology is insensitive to electromagnetic fields and radiation, enabling measurements under harsh conditions. This is the ability to generate an electrical signal when the temperature of the crystal changes.

This effect is also common to piezoceramic materials. Piezoelectric follows the principle of Hook's Law it states that:

Strain = Compliance x Stress.

Since piezoelectric materials are concerned with electrical properties too, we must also consider the constitutive equation for common dielectrics.

Charge Density = Permittivity x Electric Field.

Due to the applied stress or pressure the whole structure will start vibrate due to this cell will be energized in the electrode which will be collected as electric power.

Pizoelectric Structure: A cantilever beam configuration was chosen for its simplicity, compatibility with MEMS manufacturing processes and its low structural stiffness. The beam configuration is a unimorph structure consisting of a structural layer, a single piezoelectric element/layer and a top and bottom interdigitated electrode. MEMS fabrication process for manufacture imposes definite limits on the size of the device: as size scales down, the resonance frequency of the device scales up. A low resonant frequency is desired since ambient vibration sources have significant vibration components in the frequency range below300 Hz. However, designing a MEMS device with the resonant frequency below 100 Hz can be problematic. For these reasons, a target frequency range of 100-300 Hz was chosen.

Available MEMS manufacturing limits the beam length to around 1 mm, Such that a proof mass is needed to reduce the natural frequency of the device. Modifying the structure of piezoelectric for high power harvesting can be achieved by packing the cell tightly.

Three Dimensional Structure of Piezoelectricmicrogenerator: MEMS fabrication process for manufacture imposes definite limits on the size of the device: as size scales down, the resonance frequency of the device scales up. A low resonant frequency is desired since ambient vibration sources have significant vibration components in the frequency range below300 Hz. However, designing a MEMS device with the resonant frequency below 100 Hz can be problematic. For these reasons, a target frequency range of 100-300 Hz was chosen. Available MEMS manufacturing limits the beam length to around 1 mm, Such that a proof mass is needed to reduce the natural frequency of the device. Modifying the structure of piezoelectric for high power harvesting can be achieved by packing the cell tightly.

Three Dimensional Structure of Piezoelectricmicrogenerator

Operation: It consists of a cantilever beam. A seismic mass is attached at the end of the multilayer beam. When sinusoidal signal is applied a force is generated, due to this force the beam will move up and down so the piezolayer starts vibrating. Due to this cells are energized this makes the cells in the electrode also energized. This energy is collected in the electrode which can be used for charging other devices.

Piezoelectric Layer: It is a nxn matric layer. When there is a pressure the cells in the layer will be compressed due to the applied bias. If the pressure is released the cell will come to normal condition..Due to this effect the cell in the electrode will energies. The generated electrical charges are collected in the electrode. To output voltage produced by this process is very small. To enhance the output a cantilever beam structure is used.

Cantilever: Based on the applied pressure an 'S' bend shape will be formed in the cantilever. This 'S' bend will tight the piezoelectric layer. Since cantilever is present with a small vibration the tension level is increased so the output will also increase up to 4times of the output generated. This output will be collected in the electrode.

CONCLUSION

In this paper, we have proposed a piezo-electric structure for high power harvesting by changing the internal cell structure and we also concluded that VHDL-AMS is the best tool for modeling MEMS device. The efficiency of this method was demonstrated through a study case: a MEMS piezoelectric micro generator. A complete VHDL-AMS physical model is presented. This model is reusable for other piezoelectric materials just by changing material properties and for other piezoelectric micro generator structures just by tuning geometric parameters in the generic interface.

We demonstrate as well the possibility of taking into account different types of losses in compact VHDLAMS models.

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