

# Multisource Energy Harvesting System

Mr. Aditya Dhanvijay

Assistant Professor

Department of Electronics & Telecommunication Engineering  
Rajiv Gandhi College of Engg. and Research, Nagpur

## Abstract

The harvesting of ambient energy to power small electronic components has received tremendous attention over the last decade. The research goal in this field is to enable self-powered electronic components for use particularly in wireless sensing and measurement. Thermal energy due to temperature gradients, solar energy and ambient vibrations constitute some of the major sources of energy that can be harvested. The process of extracting energy from the surrounding environment is termed as energy harvesting. There are various forms of energy that can be scavenged, like thermal, mechanical, solar, acoustic, wind, and RF-wave.

**Keywords-** Photovoltaic cells, piezo electric, Peltier cells, boost converter, Thermo-Electric Generator

## I. INTRODUCTION

Energy harvesting refers to the process by which energy is derived, captured and stored from external sources. Energy has been harvested from several external sources such as thermal, mechanical, optical, RF signals and salinity gradient. Some of the energy harvesting techniques include RF energy, piezoelectric, pyro electric, electrostatic, photovoltaic, Biomechanical, magneto static and thermoelectric. The basic structure of an energy harvester includes harvesting element, a conditioning circuit and a means of storing or using the harvested energy. Now with computing requirements in the fields of embedded systems, wireless sensor networks and low power electronic devices an alternative source of energy is required. To aid this situation we propose multisource energy harvesting system. The process of extracting energy from the surrounding environment is termed as energy harvesting or energy scavenging. Over the years, batteries have been the source of energy for small scale electronics applications.

### A. Solar Energy

The flexible self-charging cantilever described in section 2.2 is located under a solar spectrum light (6500 K—Hamilton Technology) while an irradiance sensor (SRS-100—Pace Scientific, Inc.) records the level of irradiance near the cantilever (located on the shaker). The focus is placed on the outermost solar layer on the upper surface as it is directly exposed to the incident light. The irradiance reading depends on the proximity of the solar layer from the solar spectrum light. This distance is altered to achieve three levels of irradiance (124, 311 and 437 W m<sup>-2</sup>) in order to determine the electrical output over a range of solar input conditions, and resistor sweep tests are run to obtain the maximum electrical power output of a single layer. The matched resistance of the solar layer depends dramatically on the irradiance level. An irradiance level of 437 W m<sup>-2</sup> results in a raw DC power output of 30 mW from the top solar panel of the self-charging structure. The open-circuit voltage output of the solar layer changes from 3.8 to 4 V as the irradiance level changes from 124 to 437 W m<sup>-2</sup>. A photovoltaic cell is a device that converts light energy into electrical energy. The form of energy exploited is typically light energy obtained usually from sunlight. For locations where the availability of light is guaranteed and usage of batteries and other means of power supply are not feasible or expensive, usage of photovoltaic cells is a convenient solution.



Fig. 1.1: solar plate

A few examples of such locations are marine locations and roadway signs. While designing sources which scavenge solar energy, factors such as availability of day light, periods of dense cloud and snow cover, effects of operation at higher latitudes, characteristics of the photovoltaic cell used, the intensity of the incident light, power supply requirements are to be considered [9]. Lee, et al. [2] implement a project where an array of 100 solar cells is used to produce power to supply MEMs electrostatic actuators. The project could successfully produce voltage of about 150V. Studies on delivering power to a remote system with an optical fibre are discussed Here, a photocell is used to convert the light energy into electrical power.

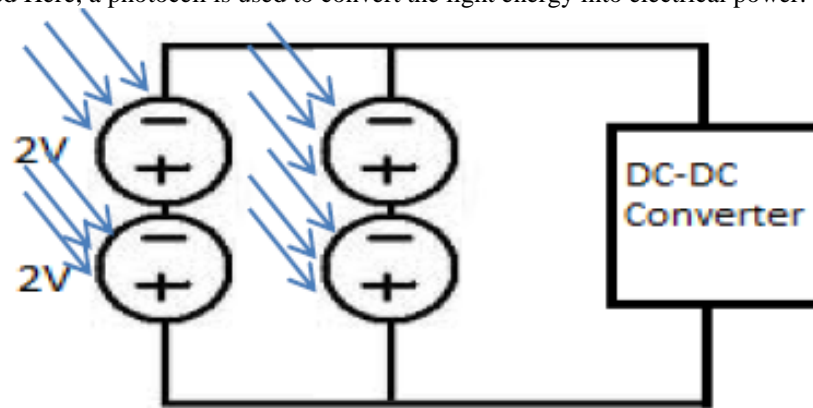


Fig. 1.2: solar plate connection

### B. Piezoelectric Materials

These materials convert mechanical energy from pressure vibrations or force into electricity. They are capable of generating electrical charge when a mechanical load is applied on them. This property of piezoelectric materials is considered by the researchers to develop various piezoelectric harvesters in order to power different applications [2, 10]. Due to their inherent ability to detect vibrations, piezoelectric materials have become a viable energy scavenging source. Currently a wide variety of piezoelectric materials are available and the appropriate choice for sensing, actuating, or harvesting energy depends on their characteristics. Some are naturally occurring materials such as quartz. Polycrystalline ceramic is a common piezoelectric material. Lead Zirconate Titanate (PZT) is being considered since it shows a high efficiency of mechanical to electrical energy conversion. With their anisotropic characteristics, the properties of the piezoelectric material differ depending upon the direction of forces and orientation of the polarization and electrodes [8]. Using piezoelectric materials to harvest energy requires a mode of storing the energy generated. This means they can either implement a circuit used to store the energy harvested or a circuit developed to utilize the energy harvested in producing excess energy. The energy harvested can be stored in rechargeable batteries instead of using capacitors to store the energy. The attribute of common capacitors to discharge quickly makes them unsuitable as energy storage devices in computational electronics. Umeda, et al. [6] used a piezo-generator made of a bridge rectifier and a capacitor to store the energy. This resulted in achieving a maximum efficiency of 35% that is three times that of the energy harvested from a solar cell [7]. A self-powered mechanical strain energy sensor designed by Elvin, et al. [6] illustrates a simple beam bending experiment conducted to produce electrical energy from the mechanical stress applied. Here a piezo film sensor attached to a beam is used to generate the electrical signal. According to Glynne-Jones, et al. [9, 2] an energy harvesting device is being developed where a thick film of piezoelectric layer is deposited on to a thin steel beam. When the beam is resonated, the piezoelectric material is deformed and electrical energy is generated. By changing the material used, the magnitude of power generated can be improved. This group continues to research in this area and is currently preparing a detailed study to evaluate both piezoelectric and magnet-coil based generators and their possible useful applications. Maintaining the Integrity of tThe earliest example for extracting electrical energy from piezoelectric material is from the impact of dropping a steel ball bearing onto a piezoelectric transducer [8,]. This energy was then stored in a capacitor or a battery [6]. The recent work by Cavallier, explored the amount of energy generated when a nickel package is used to couple the mechanical impact on to a piezoelectric plate. The properties of piezoelectric materials vary with age, stress and temperature. The possible advantages of using piezoelectric materials are the direct generation of desired voltage since they do not need a separate voltage source and additional components. These generators are compatible with the MEMs. These generators are the simplest and can be used in force and impact-coupled harvesting applications [8,]. Some disadvantages are that piezoelectric materials are brittle in nature and sometimes allow the leakage of charge.

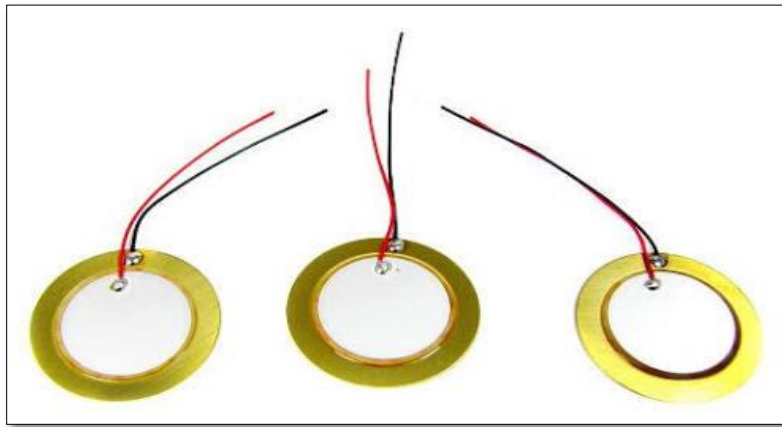


Fig. 1.3: Piezoelectric Cells

### C. Thermal Energy

Another source of energy used in this senior project is the excess heat emitted to the surrounding from cooking and thermal emitting devices. To utilize this heat, a Peltier cell is used. Most common application of Peltier cells is for cooling purposes such as wine cooler. If you apply a temperature difference across the plates of a Peltier cell, it produces Seebeck voltage due to Seebeck effect. To create a constant heat, source the hot side of TEG is attached to oil filled Altoids container, in which oil absorbs and retain the heat for longer time. The colder side of the Peltier is connected to a heat sink to dissipate heat to the surrounding so that way the colder side will remain cold and a temperature difference will be maintained. In this senior project the Peltier cell used is TEC1-12706.

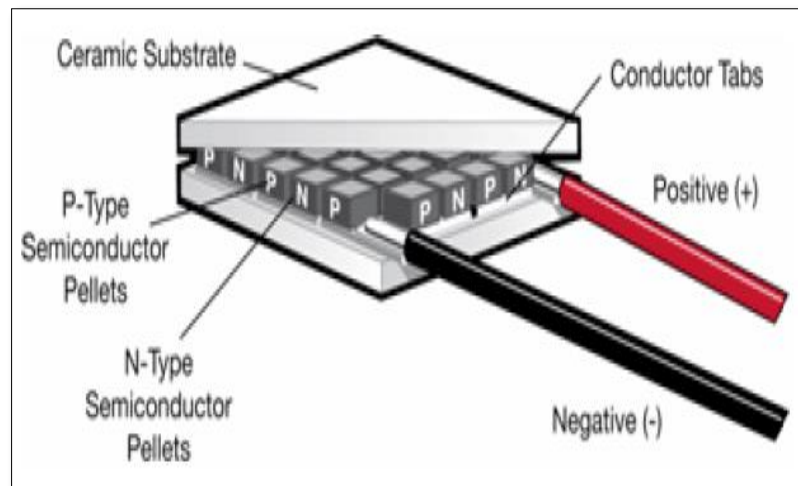


Fig. 1.4: Basic structure of Peltier cell

Hot side Temperature (°C)	25°C	50°C
$Q_{max}$ (Watts)	50	57
$\Delta T_{max}$ (°C)	66	75
$I_{max}$ (Amps)	6.4	6.4
$V_{max}$ (Volts)	14.4	16.4
Modules Resistance (Ohms)	1.98	2.30

Fig. 1.5: Performance specifications

### D. RF Radiation Harvesting

A novel 900MHz RF energy harvesting system for powering low power sensors has been analysed, discussed, designed, and tested. The novelty lies in the partial ground plane in the antenna structure which resulted in maximizing the energy captured and generating a higher DC output voltage that can power low power devices. [1] A study of feasibility to harvesting the ambient RF energy. The measurement of the RF power density available in urban environment shows the RF power is very low and is distributed in a large wide band frequency. To scavenge a maximum of DC power, a wideband system when able to deliver a DC

power around 12.5pW. A narrowband system is given. The first study for this system show the attended DC power can be about a 400pW.[2]

## II. PROPOSED METHODOLOGY

In that project we performing energy harvesting form multiple energy sources. With help of boost converter, we boost up voltage 1.5 -2 times its input voltage. Input voltage is taken from the multiple sources like thermal, RF wave, piezoelectric material and thermal.

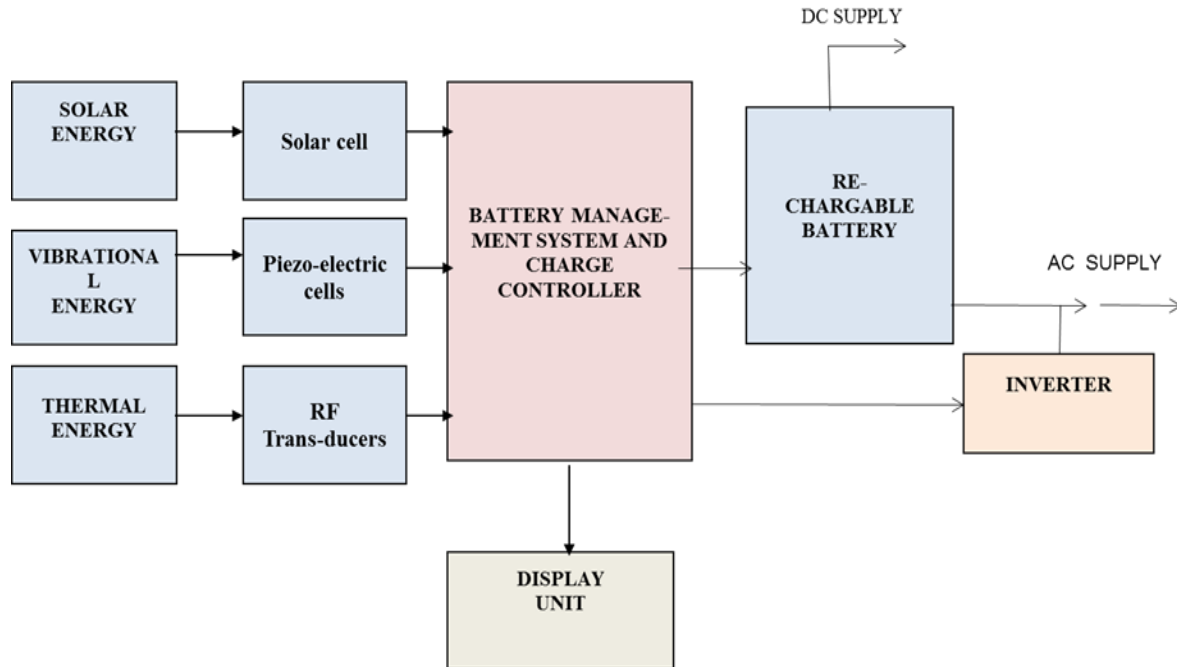


Fig. 2.1: Proposed Block Diagram of Multisource Energy Harvesting System

### A. Sources

In that project various energy sources are used for energy harvesting from multiple sources which is explain above.

### B. Boost Converter

The DC- DC converter used in this project is a simple Boost converter available in the market. The picture of one used in this senior project is displayed below. The main advantages of this boost converter are its compact size and prize. The specifications of the boost converter are shown in the table 3-3. The output voltage of solar panel set-up displayed in figure 3-2 is 4.75 to 4 V which falls under the input range of this converter, which also has required current rating. The 5V output is the required voltage to charge the battery pack, which makes this converter preferable than others available now. The compact size of this is another reason to select this prefer to LT3652 from linear technology. For different energy sources having different boost converter. Because each sources having its own particular power range.

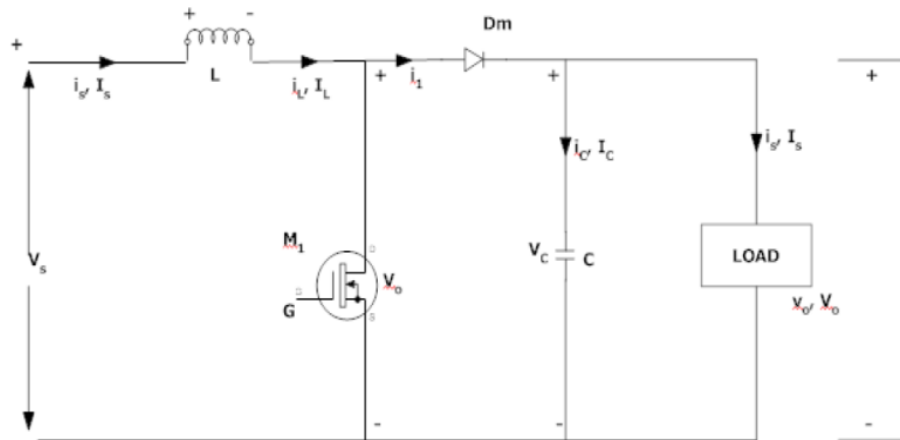


Fig. 2.2: Circuit Diagram of Boost Converter

### C. Battery Management System

Battery management system are used to receive the power from the boost converter and manage the DC voltage directly to the load, if we want to converted in AC voltage for glowing CFL light. Then BMS connected to the inverter for AC voltage purpose.

### D. Inverter

Inverter is used for invert the DC voltage into AC voltage. In this project inverter use for the AC devices like CFL light etc. After inverter AC device is connected as load.

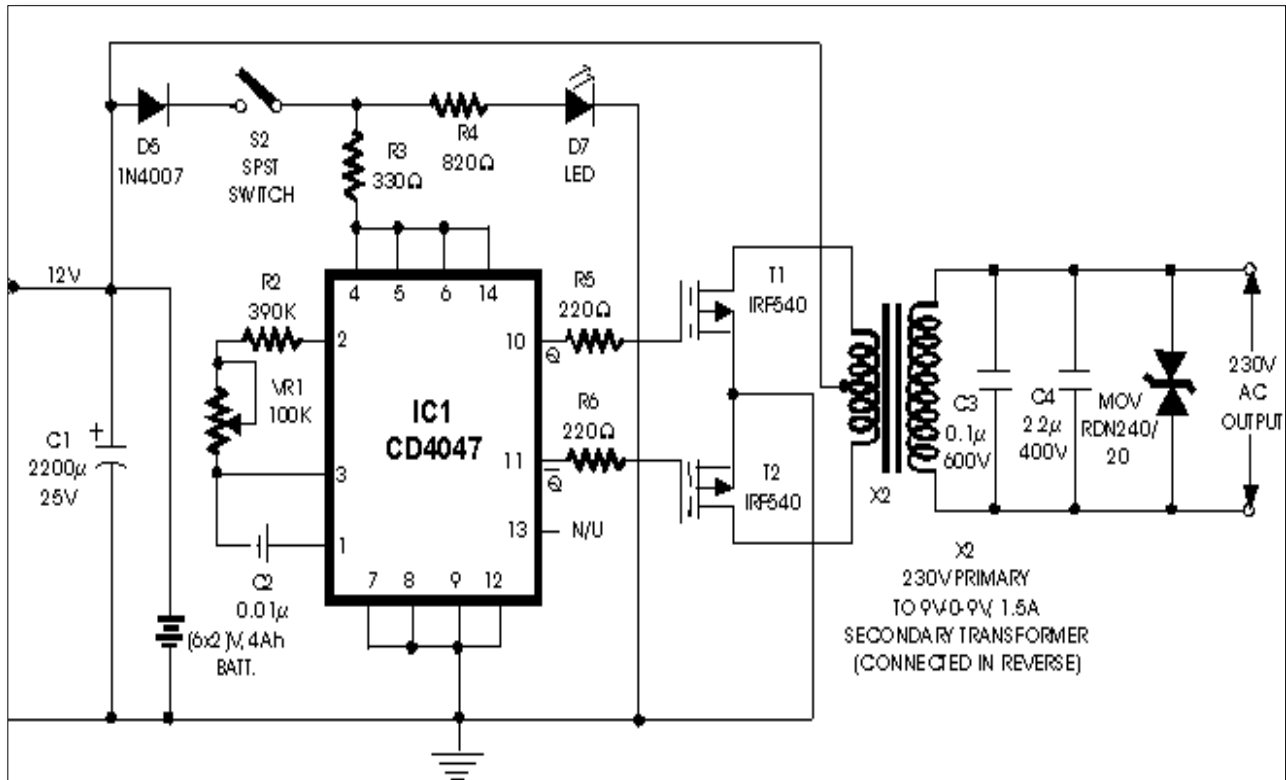


Fig. 2.3: Circuit diagram of inverter

## III. CONCLUSION

The construction of this multisource energy harvesting system with the sources was a gradual process from gathering of materials to testing of components. It is to be noted that the efficiency of this project depends on the power generation of sources connected to the input and on the total power of the load connected to its output terminals. Thus, the system could deliver constant power for a calculated number of hours. It is noiseless, harmless, and cost effective. It is also a preferred power backup to charging a battery and other low power appliances because it switches automatically to the battery charging as per as the specific source is not available. Thus reduce system breakdown, prevent hard disk damages and data loss. In addition, the life span of the battery and other low power devices connected to either a standby or a continuous system is prolonged.

## IV. FUTURE SCOPE

- That concept is very beneficial for rural areas peoples where most of the time electricity is not sufficient for day to day life.
- Solar module is used extracting the energy from day time and other sources like piezo, thermal and RF waves at the night as well as day. This sources are charges the battery.
- When we connect the thermal module to hot area of vehicles then also produces some amount of energy. That also behaves like secondary source of energy.

## REFERENCES

- [1] Amirtharajah R and Chandrakasan A P, "Self-powered low power signal processing," IEEE Symposium, VLSI Circuit Digest of Technical Papers, 1997, pp. 25–26.
- [2] N. M. Din, C. K. Chakrabarty, A. Bin Ismail, K. K. A. Devi and W.Y. Chen, "Design of RF Energy Harvesting System for Energizing Low Power Devices", Progress in Electromagnetics Research, Vol. 132, 49{69, 2012

- [3] D. Bouchouicha, F. Dupont, M. Latrach, L. Ventura, "Ambient RF Energy Harvesting", International Conference on Renewable Energies and Power Quality (ICREPQ'10) Granada (Spain), 23th to 25th March, 2010
- [4] Abdul Fathah, "Design of a Boost Converter", National Institute of Technology Rourkela-769008 (ODISHA) June-2013
- [5] Yamuna. M. B, K. Shanmukha Sundar, "Design of Piezoelectric Energy Harvesting and Storage Devices", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering an ISO 3297: 2007 Certified Organization) Vol. 3, Issue 8, August 2014
- [6] A. Jacks deligtus peter, Balaji.D, D.Gowrishankar Waste heat energy harvesting using thermo electric generator IOSR Journal of Engineering(IOSRJEN) e-ISSN: 2250-3021, p-ISSN: 2278-8719 Vol. 3, Issue 7 (July. 2013), ||V2 || PP 01-04
- [7] Arrawatia, M., Kumar, M., Kumar, G., —RF Energy Harvesting System from Cell Towers in Mumbai. Indian Institute of Technology, Mumbai, 2008
- [8] Miles R W, Hynes K M and Forbes I 2005 Photovoltaic solar Cells: an overview of state-of-the-art cell development and environmental issues Prog. Cryst. Growth Charact. Mater.
- [9] H-Y. Tang et. al., " A Fully Electrical Startup Battery-less Boost Converter withz 50mV Input Voltage for Thermoelectric Energy Harvesting," IEEE Symp. VLSI, pp. 196-197, June 2012.
- [10] Y. K. Ramadass and A. P. Chandrakasan, "A Battery less Energy-Harvesting Interface Circuit with 35mV Startup Voltage," IEEE ISSCC Dig. Tech. Papers, pp. 486-487, Feb 2010.