

Architecture of Low Power Energy Harvester Using Hybrid Input Solar, Peltier Thermo Electric and Vibrational Generation

¹G. Ramya, ²R. Sivakumar, ³Dr. G. Prabhakar, ⁴Dr. K. Umamaheswari, ⁵K. Karthi

¹M.E Scholar, Power System Engineering, VSB Engineering College, Karur, Tamilnadu, India

^{2,3,4}Associate Professor, Dept. of EEE, VSB Engineering College, Karur, Tamilnadu, India

⁵Assistant Professor, Dept. of EEE, VSB Engineering College, Karur, Tamilnadu, India

Abstract - This project presents the efficient design and development of ambient energy harvesting system based wireless sensor networks (WSN). In this system Super capacitor is used as storage device instead of batteries, which eliminate the complication of replacing the batteries at regular intervals thus developing sustainable and self-powered wireless sensor nodes. This project utilizes photovoltaic cells to sustain energy buffers in the form of super capacitors instead of batteries. Combined with power efficient algorithms, we can increase the lifetime of sensor network nodes using charging mechanisms. In the hybrid architecture, three input sources (PV, thermal and vibration) are combined in parallel to solve the limitation issue of a single source energy harvester and to improve the system performance.

Energy will be scavenged from the environment for thermal and vibration sources by converting directly temperature difference and vibrational movement to electrical energy. Vibration produces AC input and will be converted to DC using a rectifier. A converter is used to boost the two sources (thermal and vibration) and DC-DC converter is proposed to step-up these small input sources. Here also proposed a frequency regulation technique to provide constant efficiency at all loads because of the incessant problems of using a Pulse Width Modulation pump with fixed frequency that leads to low efficiency at low load conditions. The team presented a wireless energy harvesting unit in the first instance that uses only a single stage voltage multiplier which they extended to three stages in order to harvest energy much more efficiently with a Low-dropout regulator that cannot boost the rectified voltage. But with a regulated Charge pump they were able to boost the battery voltage up to 3.7 times the input DC Voltage.

Keywords: Peltier, Thermo Electric Generator, TEG, Hybrid Power Generation, Energy Harvesting, WSN.

I. INTRODUCTION

Wireless sensor networks are composed of hundreds and thousands of low cost, low power and miniaturized sensor nodes, which are densely deployed in target areas and cooperate to complete complicated tasks. These networks have been used in many applications such as environmental monitoring, structural monitoring and home automation. Typically, wireless sensor nodes are powered by batteries with limited amount of energy. In certain cases, it is infeasible or even impossible to replace batteries for so many nodes. As a result, lifetime becomes one of the most critical challenges in wireless sensor networks. Due to the power limited nature of each sensor node, power efficiency is one of the major merit factors for commercially available devices as well as for wireless communication standards. Also for some applications, the location of the sensors, as well as the method of deployment, would make it hard to replace power sources each time a node loses power.

II. PROPOSED SYSTEM

We propose a new architecture of Ultra Low Power Hybrid Energy Harvester that can be employed in wireless sensor networks. The proposed architecture is utilizing three hybrid sources which are:

1. Thermoelectric Generator (TEG)
2. Vibration Energy Harvesting
3. And PV cell for Solar Energy Harvesting

In this project, we present a novel energy aware adaptive approach that combines with an energy management technique optimized for energy harvesting WSN. The main goal of this work is to show that combining energy harvesting from the environment and effectively managing node activity (i.e., the sampling rate of the sensors) according to the energy levels and the dynamics of the phenomenon observed can ensure an enhanced lifespan of the nodes in the network, thereby achieving self-sustainability.

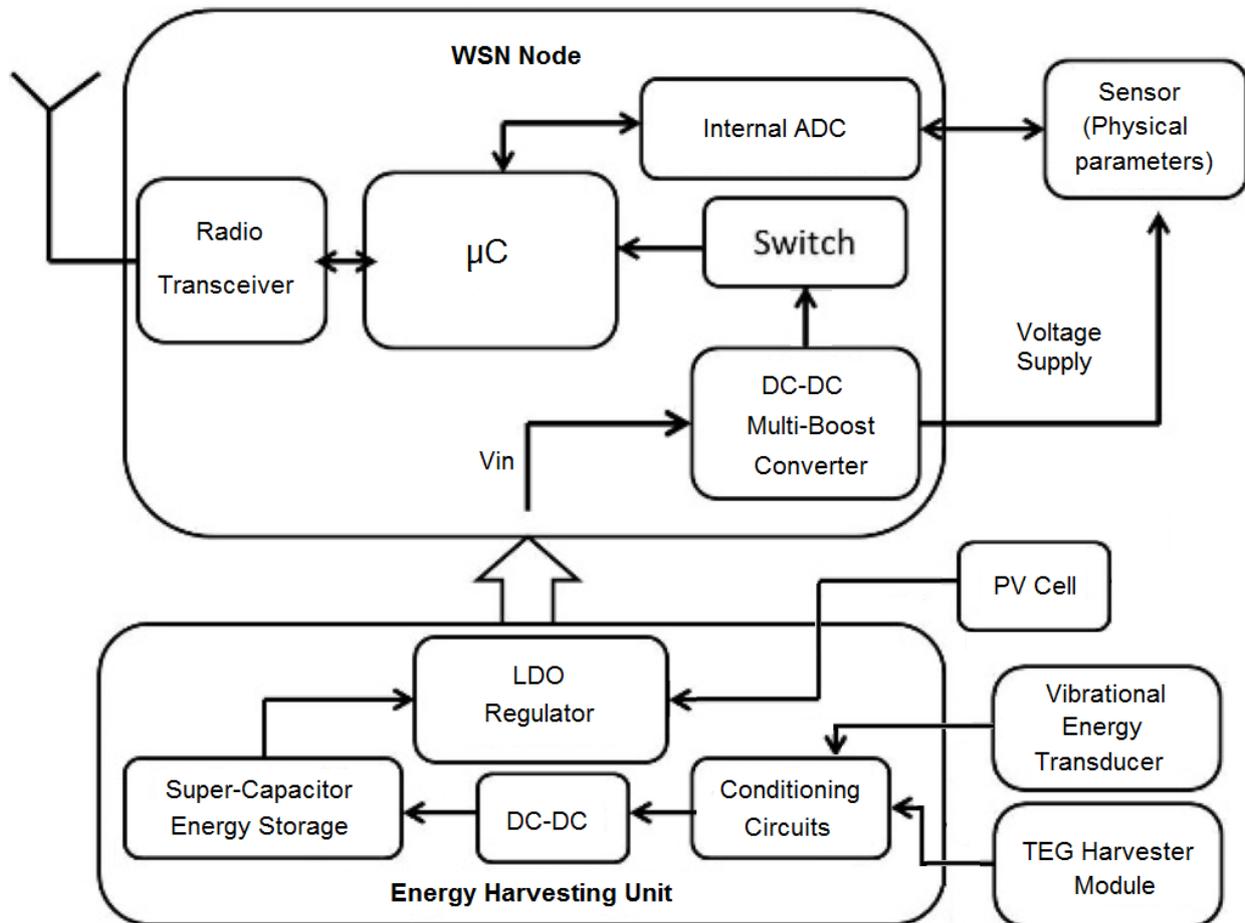


Figure 1: Block Diagram of Proposed System

III. PROPOSED METHODOLOGY

TEG is depending on the variance of temperature between the surrounding environment and the heat resulting from the power losses in the device to convert thermal power to electrical power. Vibration energy transducer produces power from the vibrating sources from shaking of the device and other environmental vibrations. Here we use an electromagnetic type vibrational energy harvester for harnessing energy from mechanical vibrations. Solar harvesting is done by micro-PV cell from the day light available.

Conditioning circuit provides isolation between the source and the converter circuit. Basically it provides impedance matching between source and the converter. DC-DC circuit provides necessary voltage boost for charging the super-capacitor using passive voltage multiplier. Super-Capacitor Energy Storage is used to store the harvested energy from the multiple transducer sources.

LDO Regulator is a low-dropout or LDO regulator which is a DC linear voltage regulator that can regulate the output voltage even when the supply voltage is very close to the output voltage.

DC-DC Multi-Boost Converter is a pulse-width modulation (PWM)-based DC-DC converter, which combines the boost converter and the switched capacitor function to provide different output voltages and a self-balanced voltage using only one driven switch, one inductor and a HF rectifier.

Sensor Module converts any physical parameters to a proportional electrical output. μC is the microcontroller unit which reads the physical parameters from the sensor, process and calculate the readings and send the data to a wireless communication unit. Radio Transceiver module transmits the sensor data to a nearby base station receiver unit.

The proposed of hybrid architecture consists of a control manager to grab the proper input value, a rectification to convert vibration input from AC to DC, a start-up to initialize the desired input, a Maximum Power Point Tracking (MPPT) to achieve maximum power extraction, a boost converter to boost up the input voltage, energy storage to keep the energy and voltage regulator to fix or produce the desired output voltage. A single power management circuit is used to reduce the number of components used and power losses.

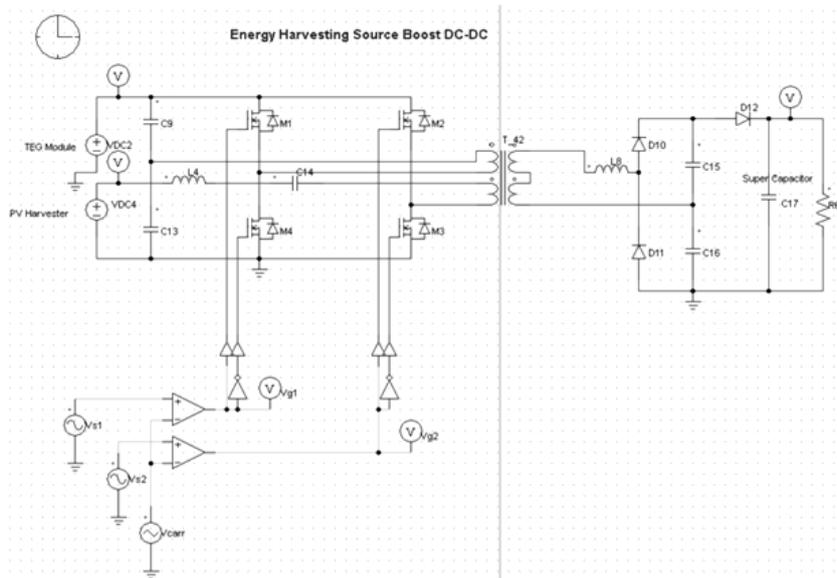


Figure 2: Circuit Diagram of Proposed System

The power used from the control mechanism will reduce the total of usable electrical power. Hybrid Micro Energy Harvester is suggested to produce a suitable input that can be implemented to micro biomedical devices.

Hybrid energy harvester combines input sources into a single system to enhance system reliability and functionality. It provides more and enough power delivery for variety environmental conditions. When using hybrid inputs system, the amount of required components will increase in terms of cost and volume specifically for the passive component like inductor. Tan and Panda (2011) have presented the idea of energy harvesting from ambient thermal and light to solve the

limitation of the single source. They used one power management circuit to prolong the lifespan of the wireless sensor node besides reduce the power losses and cost.

IV. RESULT AND DISCUSSIONS

The system hardware presents a hybrid energy harvesting system employing thermoelectric generators integrated with solar panel. The designed system is able to harness both light as well as thermal energy. The thermoelectric generators are employed at the rear side of the solar panel so as to protect the solar panel from getting heated up and at the same time harvesting the wasted thermal energy.

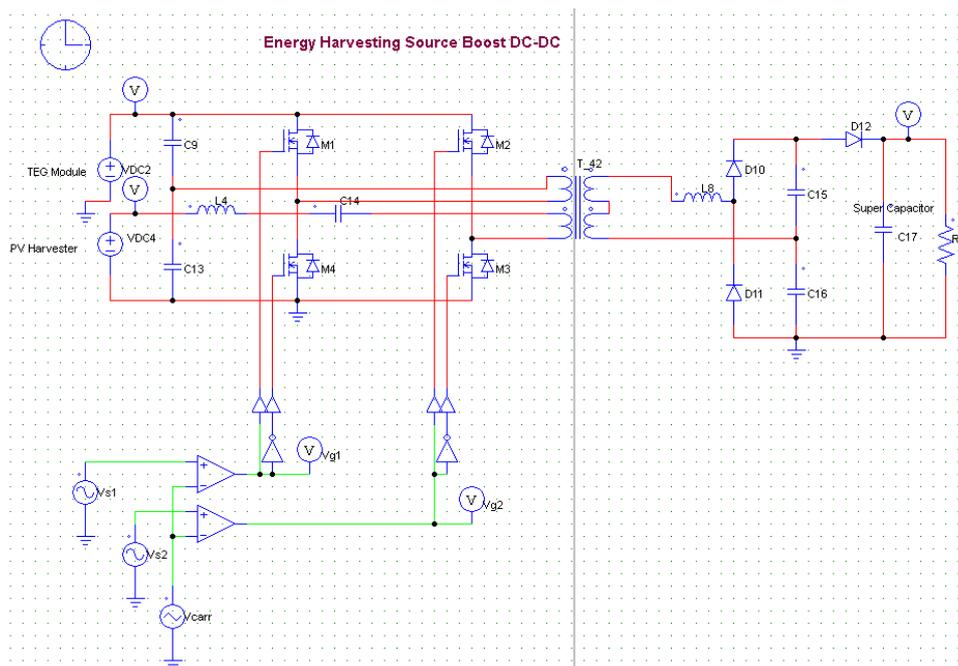


Figure 3: Hybrid Source DC-DC Boost Converter

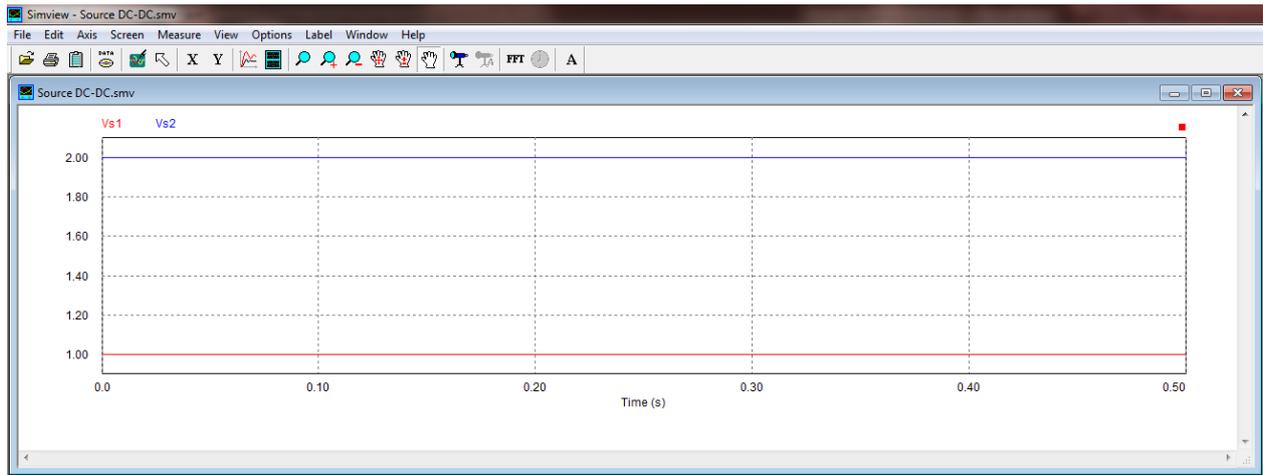


Figure 4: Source Inputs

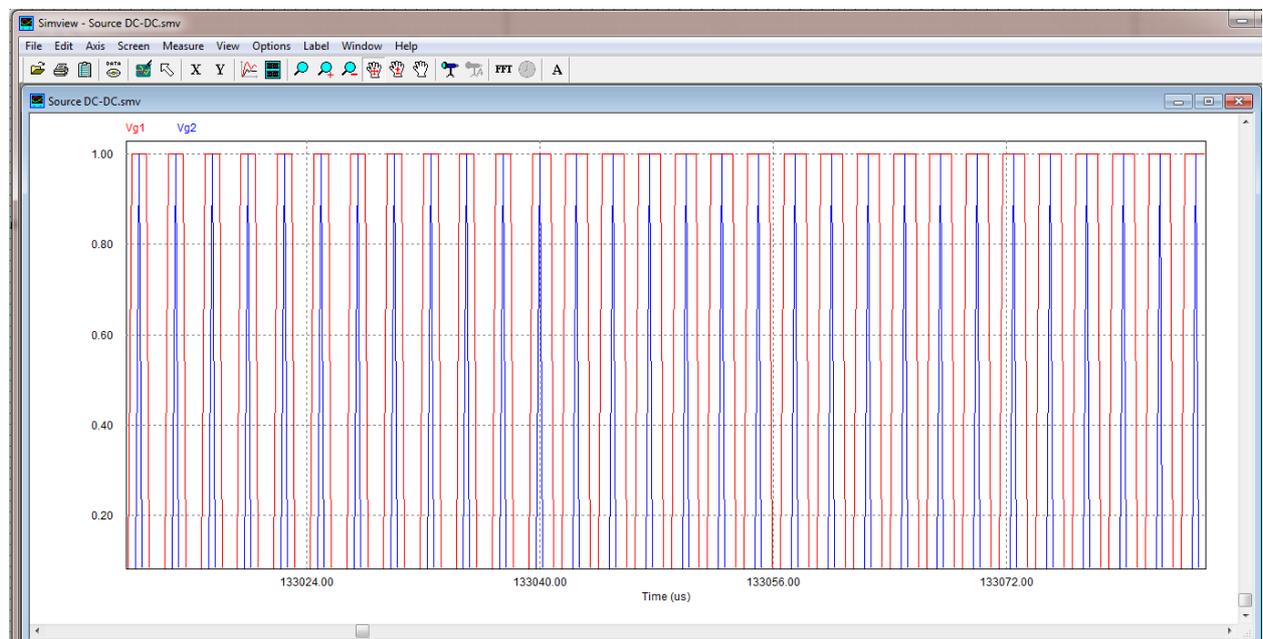


Figure 5: PWM Trigger Pulses

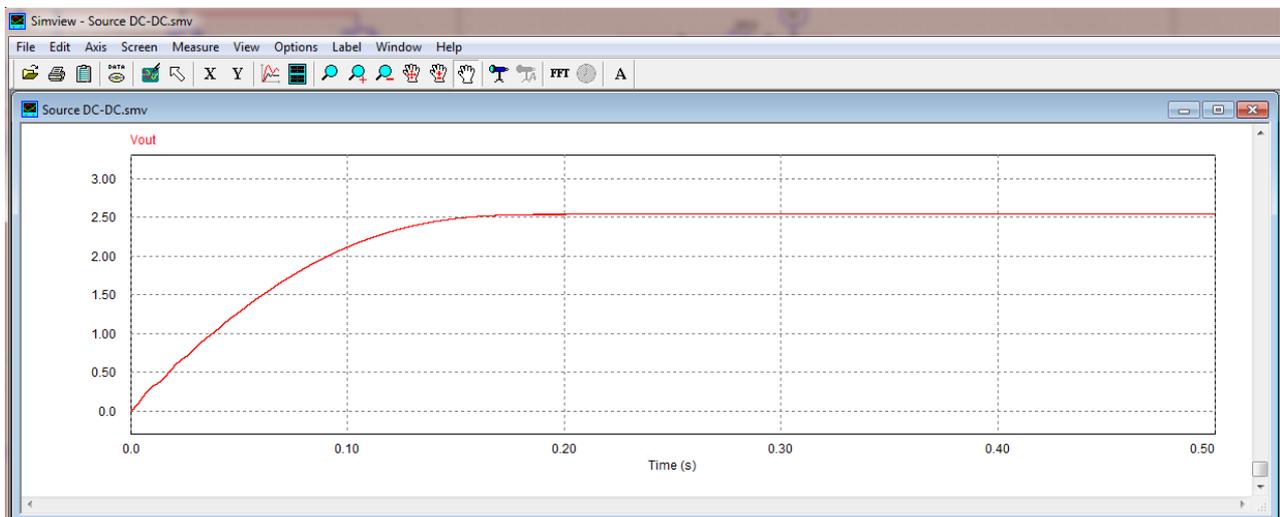


Figure 6: Converter Output

4.1 DC-DC Multi Boost Converter Schematic

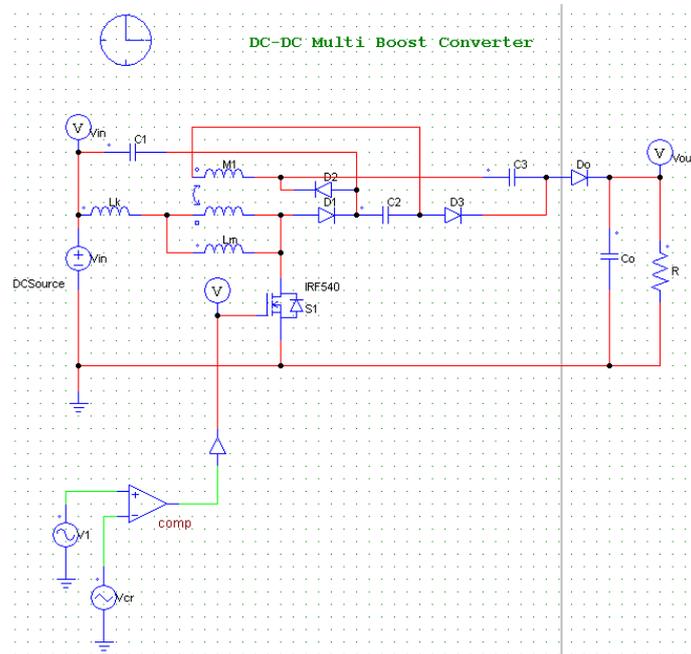


Figure 7: DC-DC Multi Boost Converter Schematic

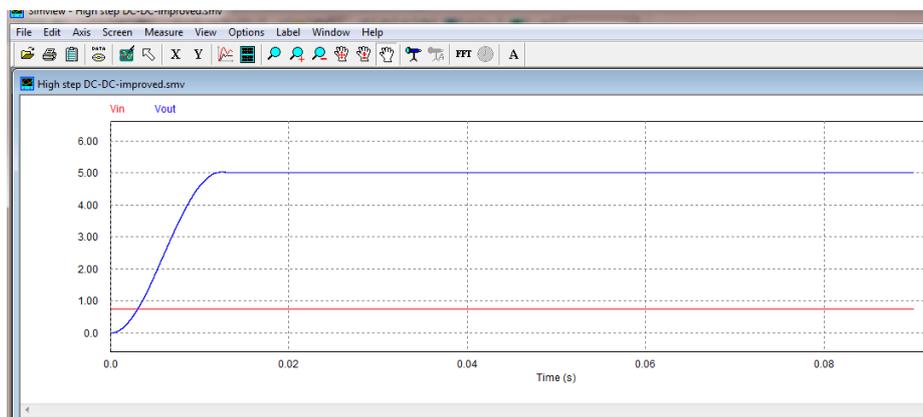


Figure 8: Input – Output Voltages

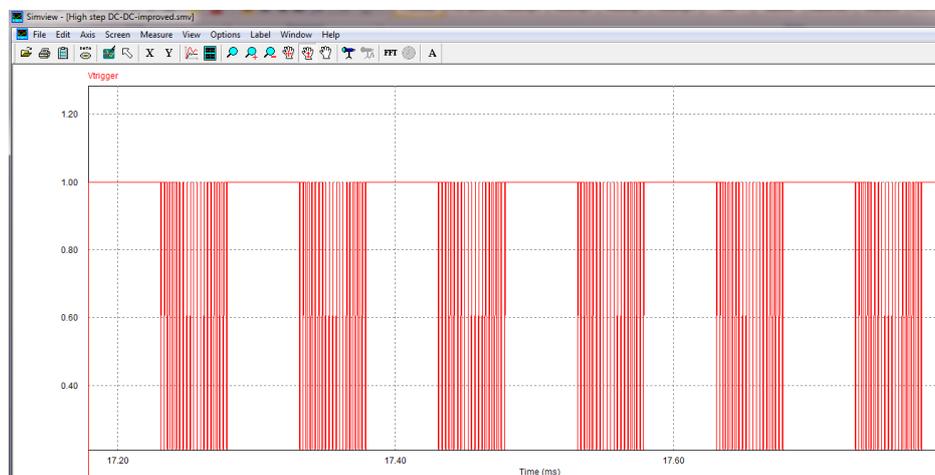


Figure 9: PWM Switching Pulses

The proposed system has been successfully designed, implemented and experimentally tested for the results. The hybrid energy harvesting system can be employed in dams for keeping check on water levels and generation of electricity for far away areas. The proposed energy harvesting system is able to harness an electrical output which is effective enough to charge a +12 Volt rechargeable battery.

V. CONCLUSION

The hardware for Ultra Low Power Hybrid Energy Harvester has been designed and implemented with the sources from TEG, PV and vibration. The inputs from the three sources are tested separately and corresponding output voltages from boost converter are observed. With an input voltage of ranges between 20 mV to 500mV an output voltage of 5.1V is produced at an efficiency of 85%- 94% is obtained and stored in a battery bank, which can be utilized for any WSN Applications.

The designed hardware of DC-DC boost converter produces required operating voltage for WSN with maximum efficiency. The proposed energy harvesting system consists of a solar panel with thermoelectric generators being placed at its rear side. In this proposed research work, the EH system is simultaneously harvesting both solar energy as well as thermal energy, making it suitable to be termed as a hybrid system.

REFERENCES

- [1] S. Chalasani and J. M. Conrad, "A survey of energy harvesting sources for embedded systems," in *Southeastcon*, 2008. IEEE, 2008, pp. 442-447.
- [2] M. R. Shokrani, M. Khoddam, M. N. B. Hamidon, N. A. Kamsani, F. Z. Rokhani, and S. B. Shafie, "An RF Energy Harvester System Using UHF Micropower CMOS Rectifier Based on a Diode Connected CMOS Transistor," *The Scientific World Journal*, vol. 2014, 2014.
- [3] Y. K. Tan and S. K. Panda, "Energy Harvesting From Hybrid Indoor Ambient Light and Thermal Energy Sources for Enhanced Performance of Wireless Sensor Nodes," *IEEE Transactions on Industrial Electronics*, vol. 58, pp. 4424-4435, 2011.
- [4] S. Bandyopadhyay and A. P. Chandrakasan, "Platform architecture for solar, thermal, and vibration energy combining with MPPT and single inductor," *IEEE Journal of Solid-State Circuits*, vol. 47, pp. 2199-2215, 2012.
- [5] N. A. A. Semsudin, J. Sampe, M. S. Islam, A.R. M. Zain, and D. D. Berhanuddin, "Designing a boost converter of micro energy harvester using thermal and vibration input for biomedical devices," in *Micro and Nanoelectronics (RSM)*, 2015.
- [6] A.P.Chandrakasan, D. C. Daly, J. Kwong, and Y. K. Ramadass, "Next generation micro power systems," in *VLSI Circuits, 2008 IEEE Symposium*, 2008, pp. 2-5.

Citation of this Article:

G. Ramya, R. Sivakumar, Dr. G. Prabhakar, Dr. K. Umamaheswari, K. Karthi, "Architecture of Low Power Energy Harvester Using Hybrid Input Solar, Peltier Thermo Electric and Vibrational Generation" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 5, Issue 4, pp 68-73, April 2021. Article DOI <https://doi.org/10.47001/IRJIET/2021.504010>
