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Research Paper

Platform strategy by uniting solar, thermal, vibrational and wind energy with maximum power point tracking system

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ABSTRACT

This paper presents the power generation through multiple sources where maximum power point tracking system is used to achieve maximum efficiency. A platform strategy by uniting different kinds of energies was presented by researchers. The dynamic and static performance is theoretically analyzed and design criteria are provided. Due to variations in Dc voltage, the change in wind speed is detected. DC current is then used as a disturbing variable for WECS in MPPT algorithms. By using this technique, 15 to 20% efficiency of the system is improved. The system consists of specific several inputs and outputs switching matrixes that associate the energy from four discrete systems of energy harvesting sources such as: thermoelectric, wind electric, piezo electric and photovoltaic. The system can hold input voltages from 50 mV to 6 V and is proficient of removing maximum power and efficiency from all individual sources and combines them by using a single inductor and capacitor. A projected time base power monitoring system is used in obtaining MPPT for the photovoltaic harvester. The control circuits and the switch matrix are executed on a 0.36 m CMOS (Complementary metal oxide silicon) process. The peak efficiency of 97% was recorded using maximum power point tracking algorithm.

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Keywords: MPPT, Maximum power point Tracking, efficiency, solar, wind, thermo and piezoelectric harvesters.

INTRODUCTION

The energy from renewable resources was recently industrialized due to the fossil fuel enervation and ecological problems. If we compare different resources of renewable energy such as energy from solar panels and energy from wind turbines which are appropriate for different applications in worldwide due to their low cost. For less developed areas, the small size standalone wind energy systems and solar systems with a multiple battery banks for the energy storage components are common and necessary for providing electricity which is reliable and stable. These energy systems can be installed easily for producing electricity at particular locations with abundant wind energy resources which are more flexibly effective and have low capital cost (Saha, 2010; Dalala et al., 2013). Solar systems are also installed at selected locations by measuring the intensity of light and other factors.

Therefore, researchers proposed to combine multiple renewable energy sources in order to maximize power generation efficiency (Saha, 2010; Gomes, 2013).

In Gomes (2013), researchers proposed to combine wind and solar power. In the areas where several energy sources are merged, the power analyses of the grid combination are done. For example, harmonic analysis and load flow analysis of combining two or more sources together. For multiple standalone or single systems scientists focused mostly on control approaches and maximum power point tracking methods of different

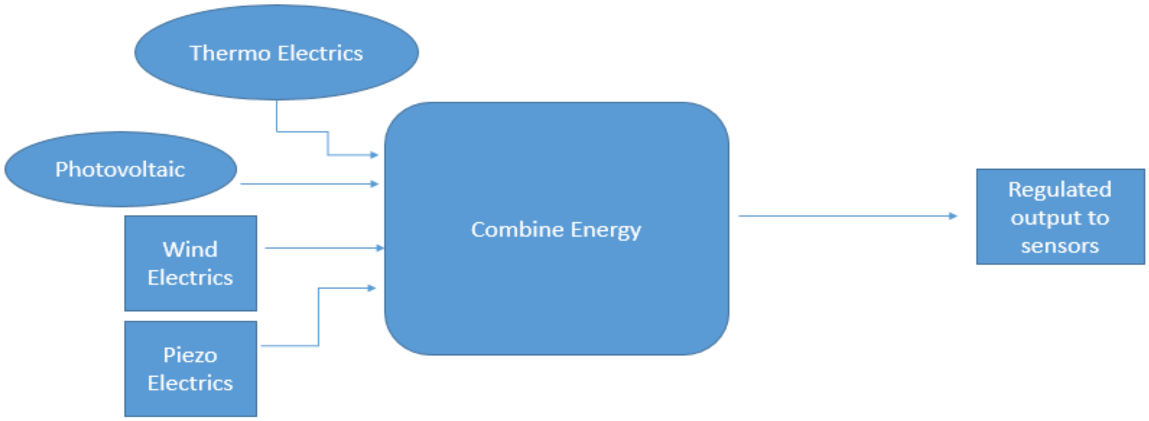

Figure 1: Multi input energy harvesting system and regulated output.

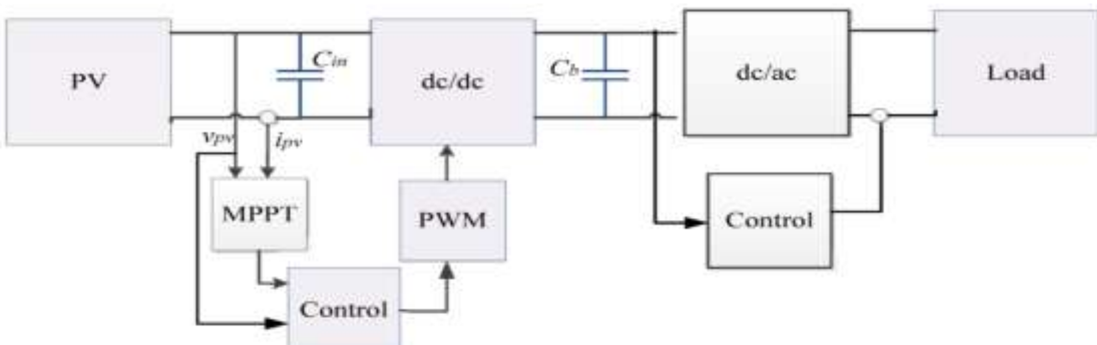

Figure 2: Perturb and observed algorithms.

processes (Saha, 2010; Salas et al., 2006).

Energy harvesting due to environment is periodic and this makes it unreliable for practical systems. It is necessary to increase the complete electrical system reliability by combining energies from multiple sources (Shen and Hua, 1988). For increasing the reliability, reliability indices must also be considered such as customer base, load base reliable indices and power quality indices. It is necessary to have a reconstruct able and general energy harvesting system which can interface or join and can be added to any harvester to improve the efficiency of electrical power systems. Figure 1 shows systems prop which associate energy from wind, thermal, vibration and solar sources.

MAXIMUM POWER POINT TRACKING SYSTEM

MPPT

The MPPT is defined as circuitry related with effectiveness collaborating inverters that constantly adjust the value of Dc operating point to achieve the maximum power available from a PV module or array at any given time. All the advantages are due to the generation of energy through the use of photo voltaic systems. The efficiency of energy transformation is relatively low and the starting cost for its operation is measured high and ad such it is necessary to use different methods to abstract the maximum power from these photo voltaic panels to achieve the maximum efficiency in the process. It should be considered that there is only one maximum power point (MPP) which differs according to atmospheric, climatic and preservation environments.

Perturb and observe algorithms

In perturb and observed technique the controller regulates and processes the voltage to a very small extent from the combination of module or array and amplifies the power. If energy and power increases, necessary changes in a particular direction are used and the procedure is repeated again and again until power no longer increases that is, maximum power is achieved. This method is very common for achieving the maximum efficiency, but there are some oscillations produced in this method. Due to perturb and observed method, very high efficiency is achieved. In order to gain maximum power, hill climbing methodology is commonly implemented. Figure 2 shows perturb and observed algorithm depicted. Hill

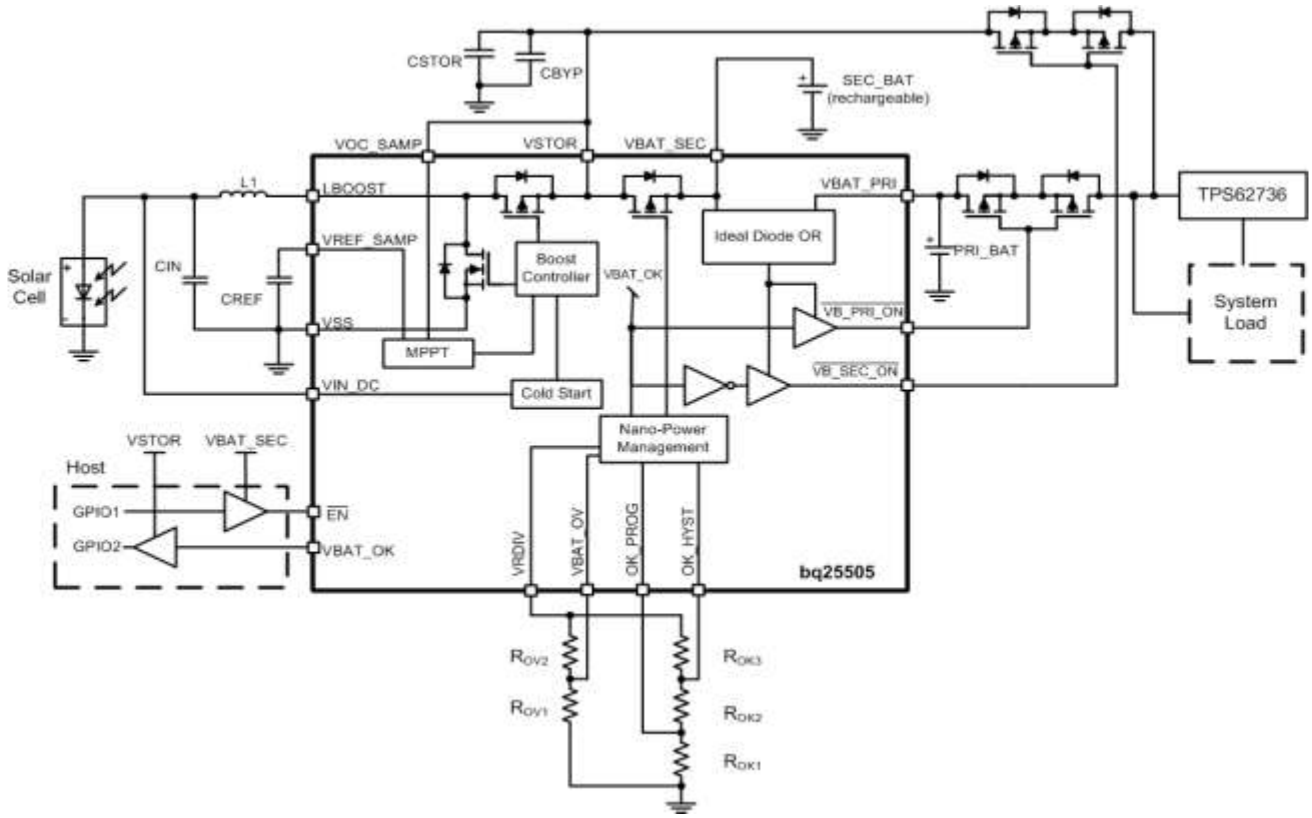

Figure 3: Photovotaic Boost converters.

climbing technique mostly depends on the upsurge of the curve of power in contradiction of voltage below the maximum power point and the fall after that MPPT point. Perturb and observed method is generally used in MPPT method due to ease in implementation.

SYSTEM ARCHITECTURE

There are four power converters used in parallel and synchronizing with each other to achieve the maximum efficiency. The four power boosters are solar boost, thermal boost, piezoelectric buck-boost and wind boost.

Solar boost

Figure 3 shows photovoltaic inputs boost converters. The solar boost converter is used and when it combines in parallel with other three boost converters maximum efficiency is achieved.

Wind boost

The wind boost converters is used in parallel with other boost converters to achieve the maximum efficiency. Figure 4 shows the wind boost converters.

Thermal boost

The thermal boost converters is also used for maximum efficiency when it is connected in parallel with the other boosters (Figure 5).

Piezoelectric buck-boost converters

Figure 6 shows the inverters used for piezoelectric harvester. It is also used in parallel with all three other boost converters. Harvesters are used to maximize the output for increasing efficiency.

ENERGY HARVESTERS

After increasing the energy from all four parallel converters energy harvesters are used, which deliver energy to power management unit. The primary or secondary cell batteries also give the energy to management unit and intermediate energy storage units also deliver the energy to management unit. Thereafter, this energy management unit delivers the power to the sensors, controllers and actuators as (Figure 7). Figure 8a and b shows the simple circuits of solar and thermoelectric harvesters.

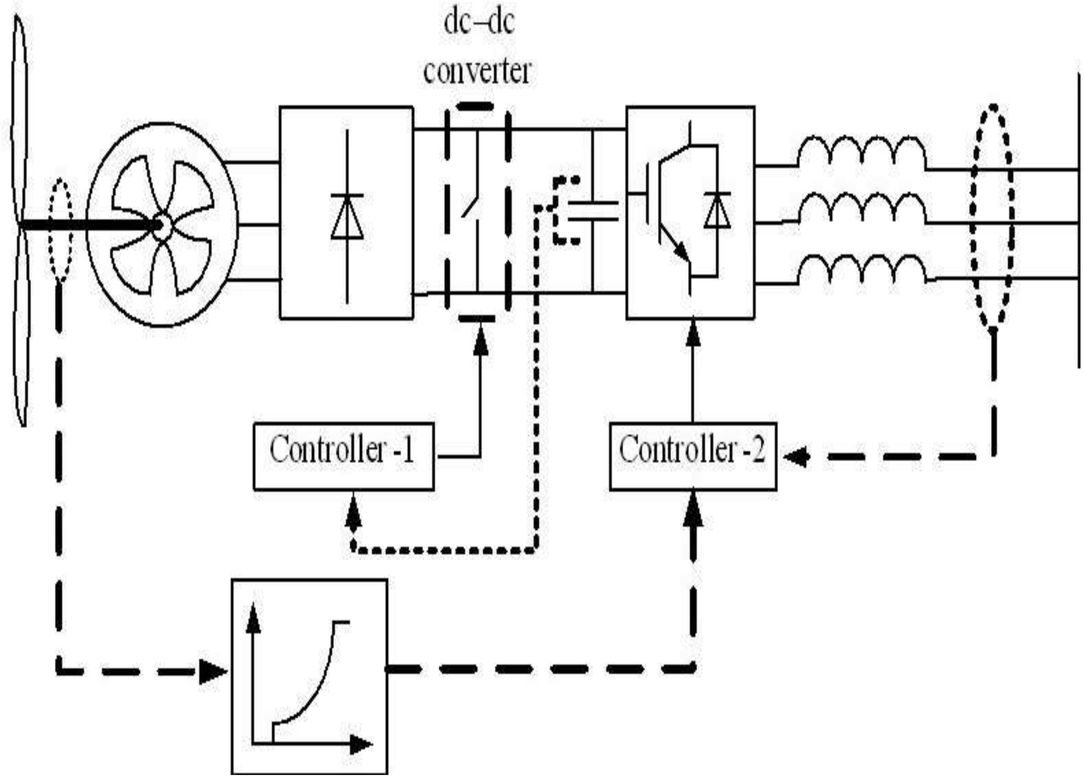

Figure 4: Wind boost converters.

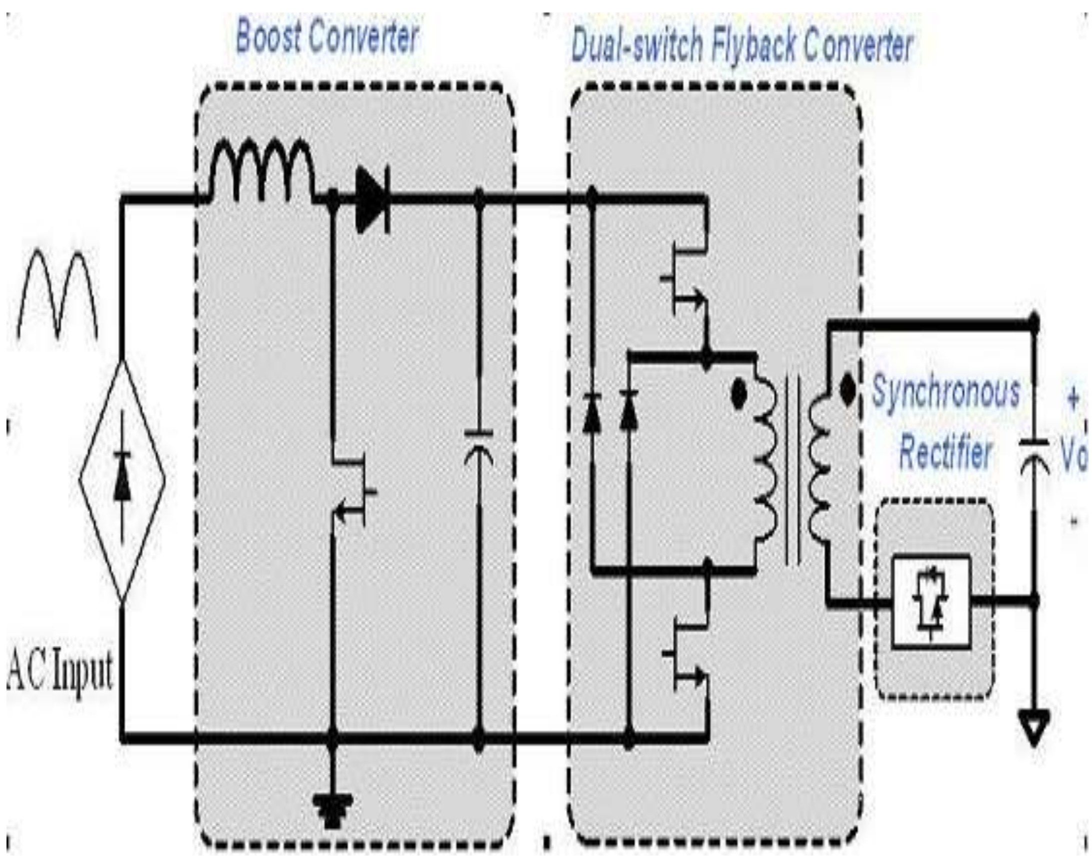

Figure 5: Thermoelectric boost converters.

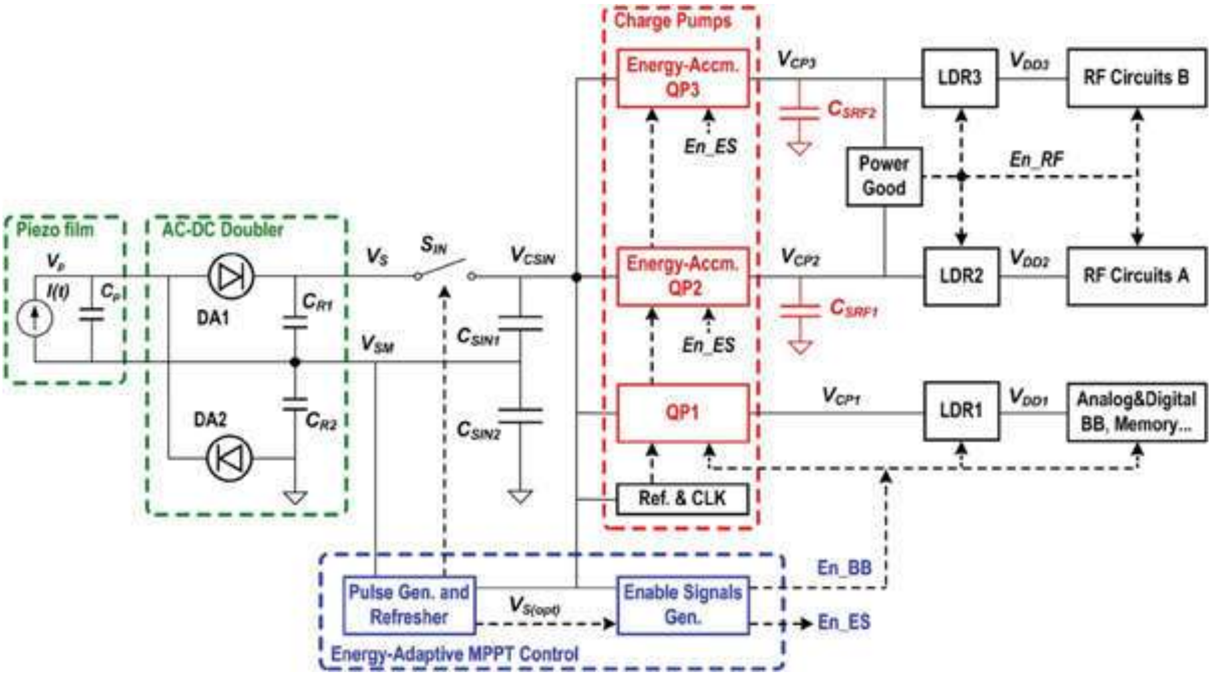

Figure 6: Piezoelectric - Buck Boost Converters for maximum power point tracking system.

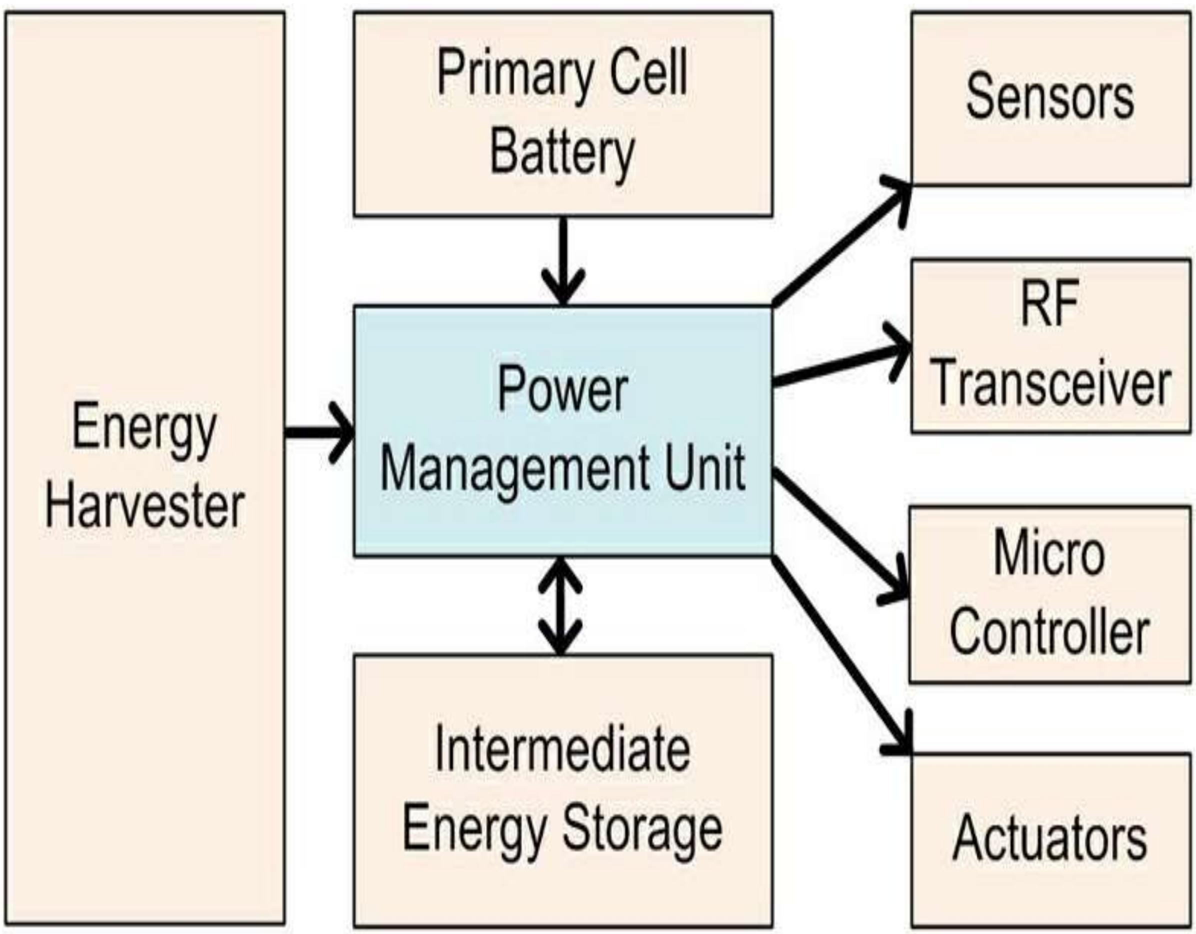

Figure 7: Energy harvester to deliever the energy.

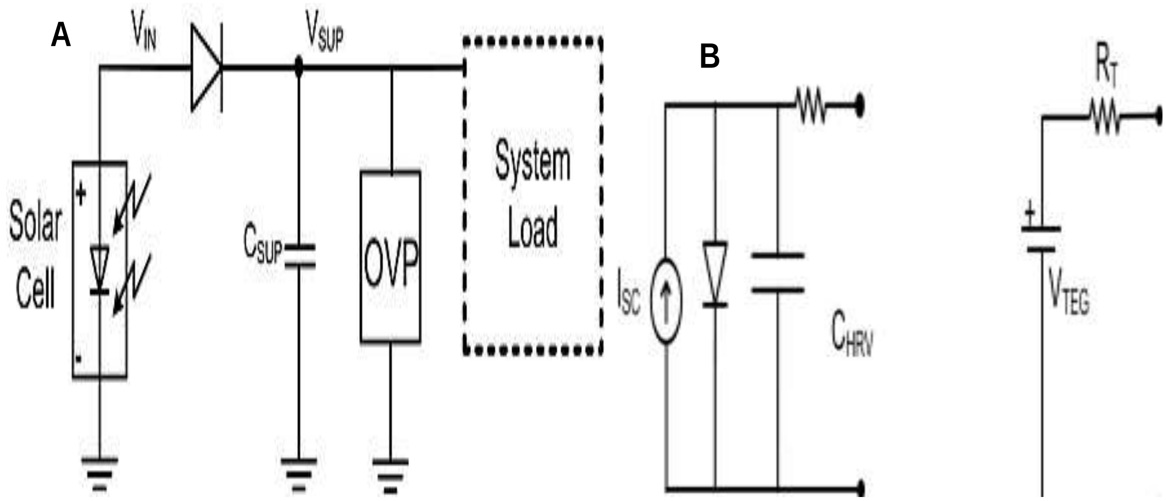

Figure 8: a) Photovoltaic Harvester and b) Thermoelectric harvester.

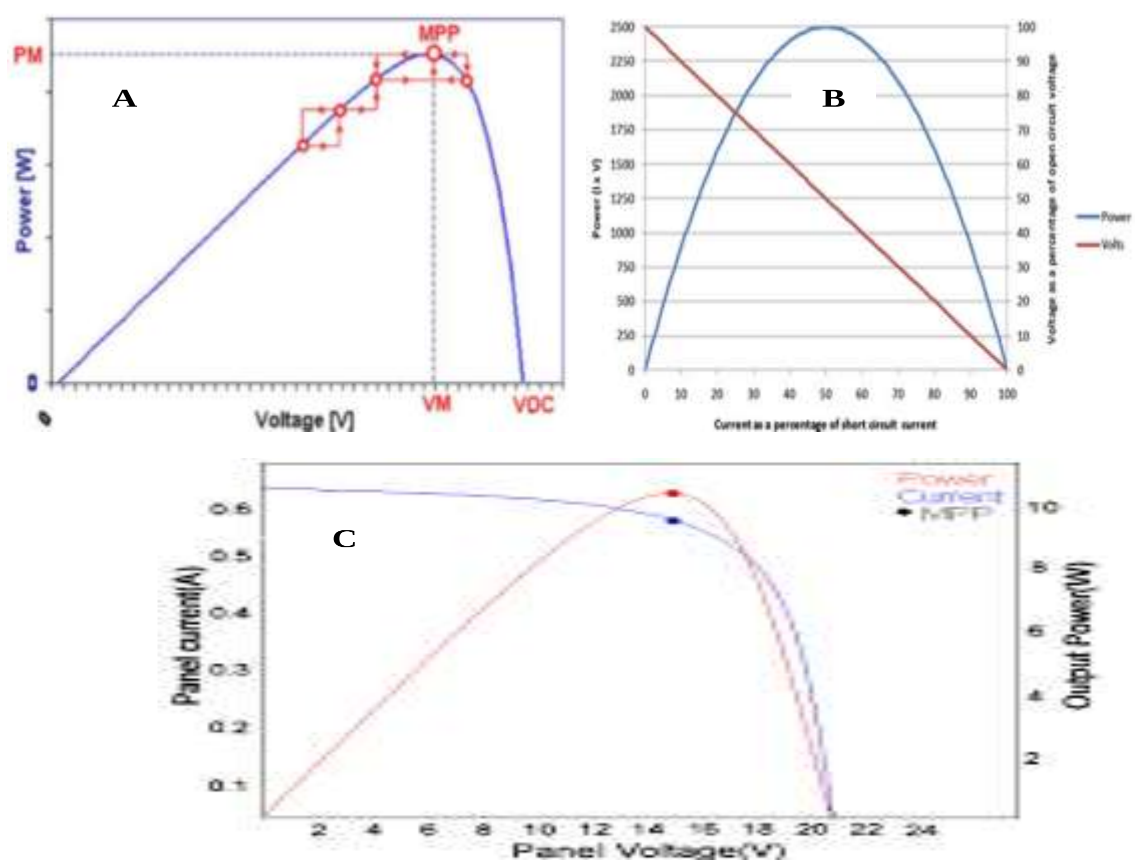

Figure 9: a) MPPT P-V Characteristics; b) MPPT P-I Characteristics and c) MPPT V-I Characteristics.

MPPT CURVES

The MPPT curves results for power and voltage, voltage and current and across power and current are shown in Figure 9a, b and c respectively.

MAXIMUM POWER EXTRACTION

Mostly, harvesters are models either as voltage sources or as a current source. As such, from the harvester a circuit element limits the maximum power extractable. Figure 9a

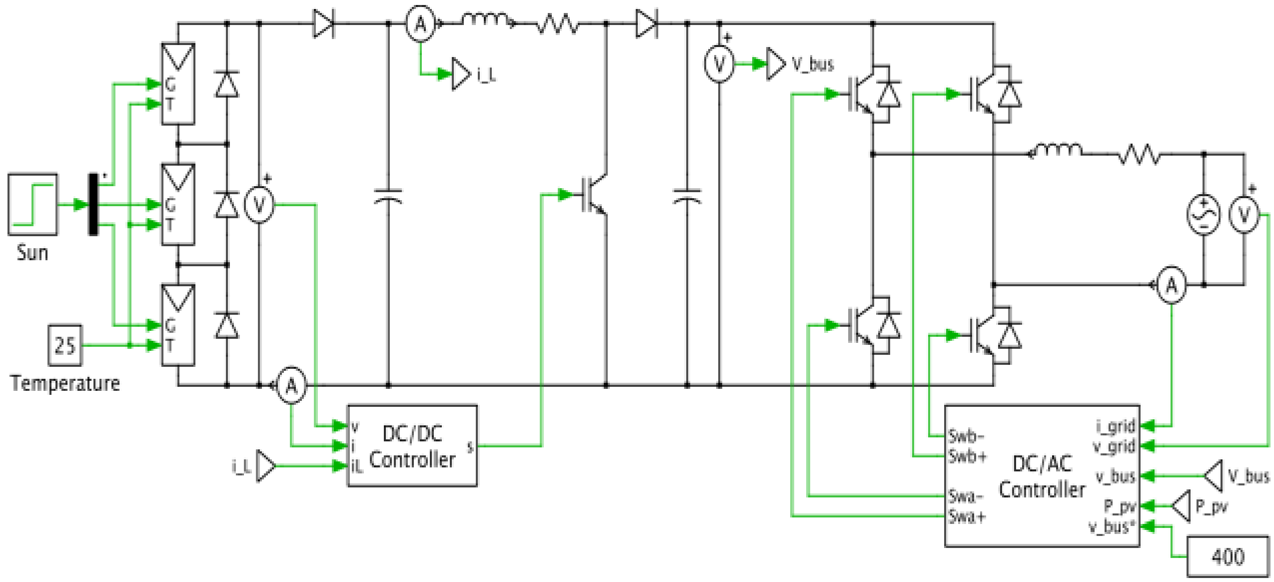

Figure 10: Inductor and Capacitor Sharing Harvester to improve the efficiency of the whole system at room temperature.

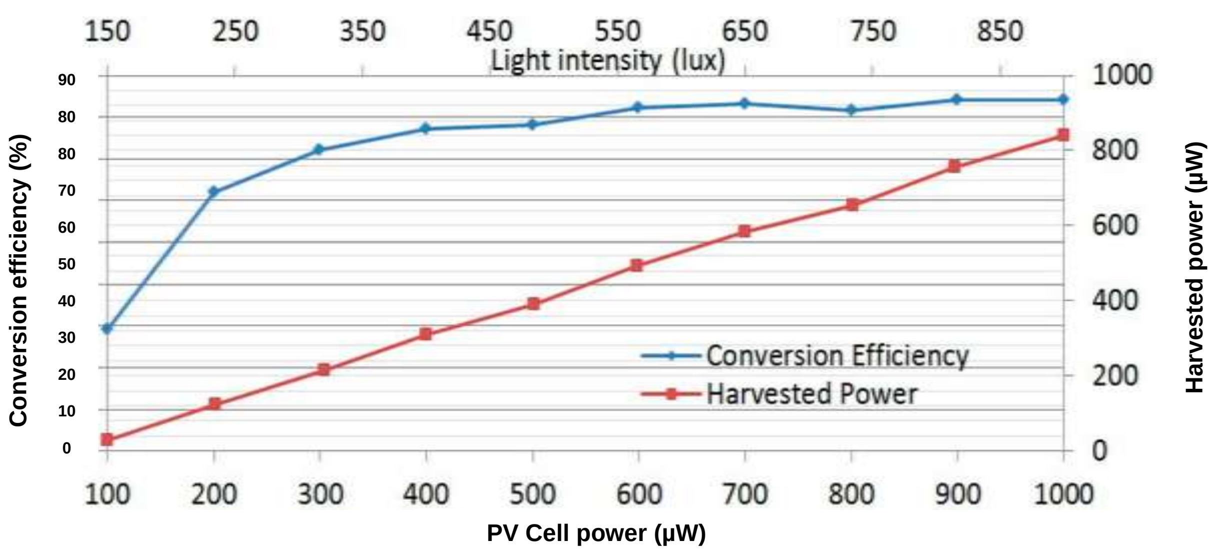

Figure 11: Perturb and observe flow chart.

shows the maximum power point extraction from the voltage source. For photovoltaic cells, the maximum power is dependent on the cell voltage. Figure 7 shows we can also adjust the impedance of the energy harvesters and as such the realization of impedance for maximum power extraction is very necessary for increasing the efficiency of the harvesters.

INDUCTOR AND CAPACITOR SHARING

With the use of inductor and capacitor sharing the efficiency of the harvesters increases (Figure 10). All four converters of photovoltaic, wind, piezoelectric and thermoelectric are arranged in parallel for increasing the efficiency of the harvesters.
Figure 11 shows perturb and observed flow chart. It can be noted that the maximum power point is shown at the peak position in the curve.

RESULTS

With the help of inductor and capacitor sharing we observed that the efficiency of the harvester increased (Figure 12). For photovoltaic cell, the efficiency of the PV cell also increased up to 85% (Figure 12). Table 1 shows the result of standalone systems with this work. We also

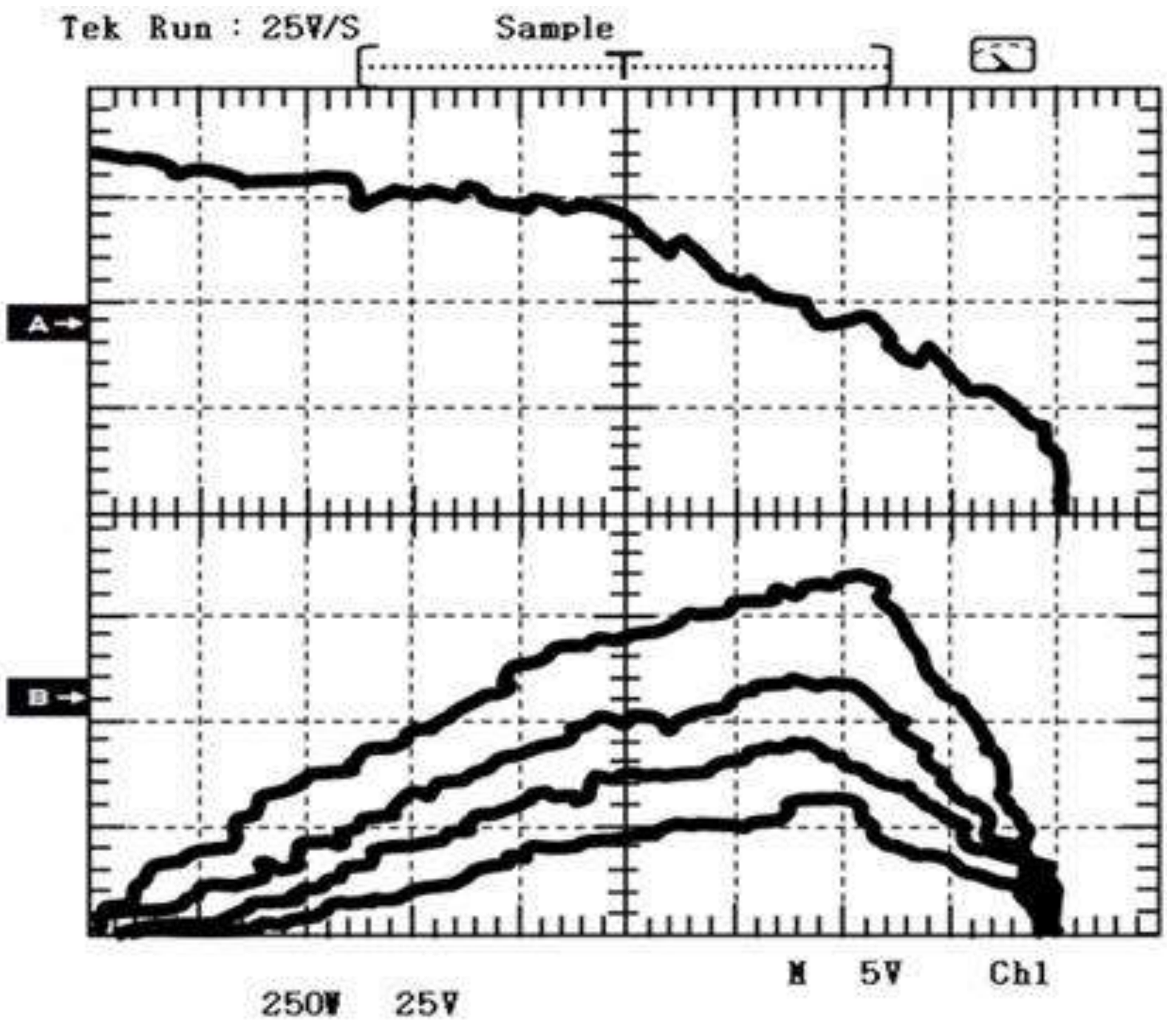

Figure 12: MPPT efficiency with inductor and capacitor sharing.

Table 1: Comparison of different energy sources with this work.

Different parameters	**[13]**	**[14]**	**[24]**	**[10]**	**This paper work**
Source of energy	Thermoelectric	Vibration	Photovoltaic	Wind electric	Combine all four sources
Input voltage to converters	20 mV to 0.5 v	2 to 5 v	0.5 to 2 v	0,5 to 1.5 v	20 mV to 0.1 v 1.5 v 0.5 to 1 v 0.1 to 0.75 v
Construction	Charger	Charger	Charger	Charger	From harvester to charger and from charger to load
Peak tracking efficiency for photovoltaic and wind electric	N/A	N/A	82%	64%	97%
Peak efficiency for power converters	59%	88%	89%	71%	97% without inductor and capacitor sharing 98% with inductor and capacitor sharing

analyzed that the efficiency of the system increased up to 97%.

Conclusion

By combining the energy from photovoltaic, thermoelectric, piezoelectric and wind electric and by using the method of inductor and capacitor sharing, we proved that the efficiency of the combined system increased up to 15%. This work mainly shows the dual path architecture of the energy harvesting systems. The control circuits and the switch matrix are executed on a 0.36 m CMOS (Complementary Metal Oxide Silicon) process. We noticed maximum power point tracking with the help of inductor and capacitor sharing. With the energy harvesting system, the efficiency of the combined system increased up to 15%. In this work, the new idea is about the capacitor sharing and the energy harvesting systems.

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