ISSN: 0974-5823 Vol. 6 No. 3 December, 2021

International Journal of Mechanical Engineering

REAL TIME MONITORING OF ENERGY HARVESTING FIELDS WITH BATTERY MANAGEMENT SYSTEM THROUGH SMART WEB

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Abstract

The paper described here deals the energy management system for energy harvesting in Internet of Things (IOT). The simulation of energy management circuits such as power converters, storage elements and energy harvesting sources are done and their results are discussed. This paper describes about the boost converter with energy management system structured for low-voltage and low power energy harvesting system. Also, this paper reviews the power management solutions for energy harvesting system used in Internet of Things (IOT). As the paper deals with the IOT based monitoring of EH field where the data can be stored in the cloud storage which can be efficient to viewed at any of the emergency conditions or for any future reference. The power converter analyzed here was step up converter with MPPT algorithm. Here the project simulation done through Proteus Software where a variable generating solar panel was used as source, irradiation technique also used in MPPT, the algorithm was coded in Arduino microcontroller. The process was simulated and arrived results were further analyzed.

Keywords: Harvesting energy; Boost converter; Power management; Arduino; Internet of things (IOT).

1. Introduction

In the recent times, energy harvesting plays an important role in the development of smart structures for the fully and essential development of completely automated smart buildings. In the case of automated buildings, for the case of autonomous power sources the energy harvesters can be utilized for a vast area of applications in various fields with the significant of harvesting energy which is being well approved for both the domestic and industrial structures [1]. In specific, because of the compact design, the small power sources give a significant solution when comparable to the battery powered solutions. Because of this reason, for recently trending IOT applications such as smart structures and compact sensors, the Energy Harvesting (EH) sources can be designed effectively [2]. Similarly, energy harvesters can be utilized in commercial/domestic structures to enhance automated control structures. But, in IOT applications, the major challenge is to enable an individual and selective source for each separate sensor for the energy harvesters [3]. Thus, when compare to non-EH source powered techniques, a separate circuit and power management solutions are implemented for the energy harvesting source due to the less voltage/power nature of low power EH sources and the voltage imbalance between the load and source.

Because of such reasons, this paper shows the effective boost converter and power management system that is structured for less voltage/power energy harvesting powered dc applications. To enable the Internet of Things the future predictions of energy harvester sources show a tremendous increase that result in effectively greater demand of reliable power sources for about vast smaller applications [4]. As the low power factor energy harvesting sources attain the energy from thermoelectricity [5] and also abstract power from the surrounding outdoor and indoor sources such as solar panel [6] and from solar cells [7]. But not only abstract energy from these sources but also implies a wide energy source that can be attain either from any of the commercial sources or from human [8]. But the power/voltage levels from energy harvesting sources are frequently less to low volts that can be respectively designed for compact sized dc applications.

On reviewing the Energy Harvesting sources, it can be applicable to a vast area of locations but the major challenge is to carefully manage the energy because of the low voltage system of the Energy Harvesting source. Prior to the energy management solution in energy harvesting field, the various components utilized for a IOT powered energy harvesting system are the sensors, a microcontroller and an IOT module. This paper focused on the energy harvesting system using less power components along with the power management solution for an efficient IoT application. Also, this paper deals with the additional components needed to empower a fully completed energy harvesting system that includes storage of energy along with the effective Maximum Power Point Technique (MPPT) for the efficient energy extraction from the energy harvesting source.

2. Energy Harvesting Requirements

Before reviewing the power management in energy harvesting, the requirements of the system are discussed here. The different components utilized in this paper for the energy harvesting system are a microcontroller which is the Arduino, the current and voltage sensors and an IOT module, a wireless data transmitter.

3. Boost Converter

This section reviews the boost converter which is utilized here to ensure that power was supplied at the correct voltage, in order to overcome the voltage imbalance between the energy harvesting source and the dc load. In IoT applications, by considering the low power nature of the energy harvesting source, the power saving techniques are increasingly essential to enhance sufficient supply of energy to the load [9]. For low power energy harvesting applications there are different converter topologies that can be utilized in the energy harvesting fields. To the low voltage energy harvesting sources, many authors have described a detailed review of DC-DC step-up converters which includes inductive based converters and also about hybrid converters, but the main focus of the converters is on the operation principles [10]. When comparing the dc to dc converter topologies, the performance and efficiency of the boost converter is very much suitable and applicable for the efficient function of the EH source. The boost converter would provide voltage step up function which is very much applicable for the low power generating energy harvesters IOT application.

4. Energy Management

Duz to the low power nature of the energy harvesters the energy saving was an important consideration along with the maximum energy abstraction from the source. This energy management section includes boost converter accompanying energy storage along with maximum power point tracking, needed to develop a fully automated energy harvesting system.

A. MPPT Control

For the case of low power voltage sources gaining the maximum power is challenge for enable the system to become accuracy automated as well as functionality. There are wide range of methods to obtain the maximum power from the source [11] however, in order to abstract the maximum amount of energy from the energy harvesting source, in this paper, Maximum power point tracking method is used. MPPT techniques are often digitally implemented and thus it requires a microcontroller to empower the MPPT functionality. Also there are some low voltage MPPT techniques that have been embedded on some of the effective controllers [12] but that have utilized very low range energy about in milli amps to micro amps respectively, [13] and [14].For this reason in this paper for some improved range of energy extraction from the energy harvesting sources, the MPPT is embedded in the controller system for providing enhanced performance.

B. Energy Saving

In the low voltage energy harvesting system, storage of energy is the most significant tool to become fully automated by overcoming the current and power imbalance between the source and the load. However, there are various storage elements that can utilized for EH sources. Most of the battery review is focused on the batteries that are lithium-based [15]-[19], that are viewed to have high voltage density and have greatest energy among battery specifications. Also, in this work battery is considered as the storage element, the life cycle and power density values, energy as well as charge/discharge efficiency are analyzed [21]. When compared to electrolytic and super capacitor leakage, the leakage in battery was less. So, in this paper, lithium ion battery is used which has the greatest energy and voltage density values among the common battery specifications.

5. Energy Harvesting Demonstration

In this proposed system, we used IOT servers for data acquisition and real time monitoring system.

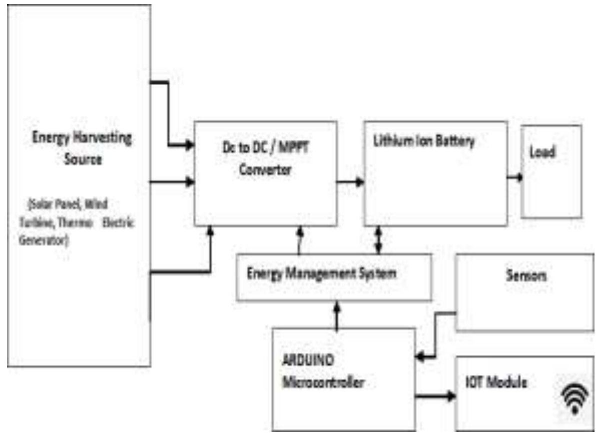

Fig.1 Block diagram of system

The figure 1 represents the proposed block diagram, where the source is from any renewable source. The energy management system includes DC to DC converter simulated along with MPPT algorithm and lithium ion battery for energy storage that could be utilized for future purpose. And finally, the energy was given to the load with minimum difference between the source and load. The current and the voltage in the system was monitored by the sensors such as current and voltage sensor. The all over process in the system was controlled by the Arduino board. Energy transfer could be viewed through the IOT server. As the incorporation of PV source to the grid, this system provides a long-lasting power quality, consistent and reliable power to the load [20].

6. Simulation of proposed system

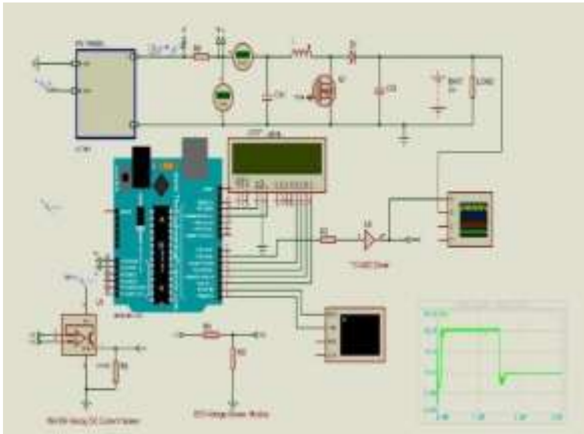

Fig.2 Simulation diagram

In figure 2 a constant supply of 12 volt was given to the Dc boost converter which was simulated along with MPPT algorithm. Dc supply of 12v was given to the voltage regulator to provide a supply of 5v to the Arduino microcontroller. And also, a current sensor module is pinned in the circuit. The power was then conditioned and stored within newly developed thin film battery for future use and given to the DC load. PWM pulse also given from the Arduino board to the converter circuit and finally the power generated was displayed through the LCD display in the circuit. The Arduino microcontroller would control the energy transfer process and the energy transfer could be viewed via the IOT module in the circuit.

7. Result and Discussion

The figure 3 review all components required to create a complete energy harvesting powered sensor system. These include DC-DC step-up converter, Maximum Power Point Tracking embedded in the Arduino board and energy storage tool to supply energy to the load when there is no power from the harvester source. The results of power, voltage and current generated was displayed on the LCD.

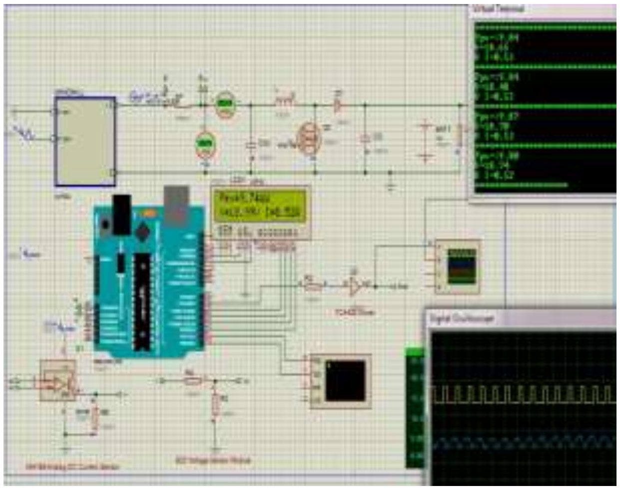

Fig.3 Simulation result with values

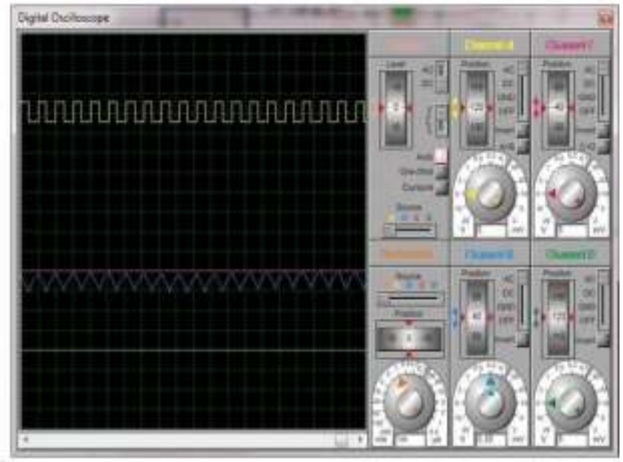

Fig.4 Simulation output waveform

The figure 4 represented the simulation output waveform that shows the waveform of pulse width modulation and saw tooth waveform indicates the energy storing in the battery.
The table 1 shows the performance of the proposed system in comparative to the existing method. Also based on input and output topologies, this shows the enhanced performance of an effective system.

Table 1 Proposed system results

Energy Harvester Parameters	Proposed System (MPPT Control)
Maximum Solar Panel Output Power(P)	12 volts
Average Converter Output Voltage(V)	17.5 volts
Average Converter Output Current(I)	0.53 A
Converter Output Power	9.27 watts
MOSFET Switching Loss	2 mw
Harvester System Efficiency (%)	96.06%

8. Conclusion and Future Scope

The simulation discussed here showed the optimized energy harvesting systems by selecting a unique step-up boost converter with the efficient energy management system which specifies the constant power source for the low power system with the increasing applications of IoT systems. This work reviewed the significant of DC – DC step up boost converter based on low voltage, step-up voltage and power provide to the load with improved performance, effective energy management system and maximum power extraction from the EH source along with the IOT server cloud storage for future reference.

In future, the simulation can be done for different EH sources such as wind, thermal energy etc. and also this could be implemented in hardware for real time IOT applications. In future development the simulation could be incorporated for multiple energy harvesting sources. Also, the further improvement of step- up converters may result in increased output power levels. In addition to this, switched capacitor circuit design might result in greater performance that will improves the energy harvesting and also create a fully automated power IoT applications.

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