International Journal of Research in Engineering, Science and Management
Volume 4, Issue 8, August 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

An Efficient Solar Energy Harvesting Management with MPPT for WSN

M. Anand[1], N. Anusha[2*], P. Anitha[3], G. Chaitanyalaksmi[4], J. K. Divyashree[5]
[1]*Associate Professor, Department of Electronics and Communication Engineering, East West Institute of Technology, Bangalore, India*
[2,3,4,5]*Student, Department of Electronics and Communication Engineering, East West Institute of Technology, Bangalore, India*

***Abstract*: Wireless Sensor Networks (WSNs) are the fundamental building blocks of today's contemporary Internet of Things, with applications ranging from smart agriculture to smart cities to online industrial monitoring. The battery energy of WSN nodes is restricted, which is a key design restriction. The objectives of this paper are to use a solar energy harvesting technology to extend the lifetime of a WSN network. An iterative re-enactment was performed in MATLAB/SIMULINK for solar powered DC-DC converters with Maximum Control Point Tracking (MPPT) to attain ideal results. From the re-enactment results, it is proved that our outlined solar energy harvesting system has accomplished 98% proficiency.**

***Keywords*: solar energy harvesting, DC-DC converters, MPPT, wireless sensor nodes.**

1. Introduction

Due to the rise in global warming and other environmental concerns, the development of renewable energy harvesting systems is the most significant technical design challenge of the twenty-first century. Commercial firms like as Texas Instruments, ST Microelectronics, and Linear Technology in the United States are now presenting renewable energy harvesting-based power management solutions for wireless sensor networks. The plan of a proficient sun-based vitality gathering frameworks is fundamental for long arrange lifetime sun powered vitality gathering remote sensor systems. The harvester mechanism in SEH-WSN nodes takes solar photovoltaic energy and transforms it to electrical energy. The electrical energy is then utilized to charge the WSN node battery and provide the working voltage to the sensor hub.

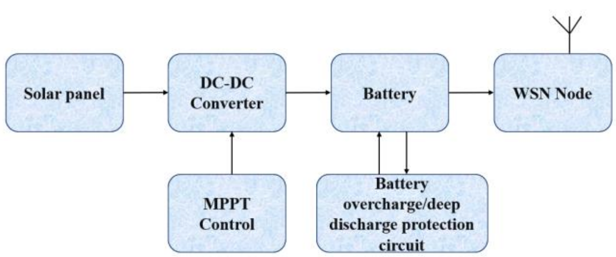

Fig. 1. Block diagram of solar energy harvesting system using MPPT control

The advantage of utilizing energy harvesting in WSN nodes is that it decreases the human endeavors required to supplant the battery of hundreds or thousands of sensor hubs by going out into inaccessible regions for well of lava checking, glacier checking, timberland checking and war zone observing applications. The energy harvesting technology increases the total sensor network operating lifespan by enabling WSN nodes. In this paper, the re-enactment results show that by utilizing effective solar energy harvester circuits the sensor network lifetime can be expanded from few days to 20-30 a long time and higher. Section 2 provides an operation of SHE-WSN node. Section 3 provides working of solar energy harvesting system. Section 4 provides re-enactment parameters and its test setup. section 5 provides results of recreation experiment. section 6 gives the proficiency for the system outlined and section 7 concludes the discussion.

2. Operation of an SEH-WSN Node

The block diagram of an SEH-WSN node is shown in Figure 1. The solar energy-harvesting system gives a DC control supply to the WSN node. This voltage is harvested from the encompassing sunlight by utilizing the solar panels. The solar panel converts light energy specifically into the DC electrical energy. The DC-DC converter directs this DC voltage to charge the battery. The rechargeable battery powers the WSN node. The WSN node measures the required physical amount (e.g., temp., light, humidity, and pressure) by utilizing the sensor estimation unit. A microcontroller in computation unit processes this detected information. The measured or detected information is sent to the adjacent network node wirelessly, within the frame of data packets by utilizing the transmitter unit. The data is sent to the USB gateway node through cluster head nodes [2]. Finally, the client can remotely monitor & control the application process e.g., temperature checking, control of a mechanical boiler plant, well of lava checking, glacier checking, timberland observing, battlefield checking applications, air conditioner cooling system control, activity light administration in a smart city.

*Corresponding author: anugowda2706@gmail.com

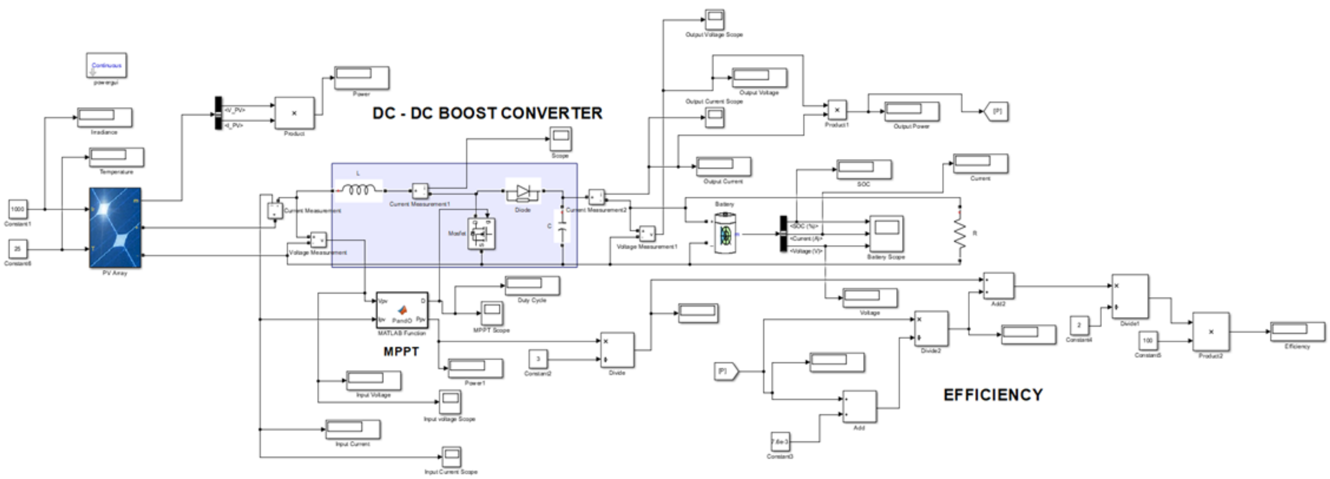

Fig. 2. MATLAB/SIMULINK model for MPPT controlled SEH system for WSN Node

Table 1
Re-enactment parameters

Parameters	value	Parameters	value
Irradiance (W/m^2)	1000 Watts/m^2	Capacitor (C)	100uF
Temperature (T)	25 degree Celsius	Inductor (L)	200uH
DC-DC Converter	Boost Converter	MOSFET Switching Frequency (f)	5KHz
Max. Solar Panel output voltage (V_m)	6 volts	Initial duty Cycle	0.75
Max. Solar Panel output current (I_m)	500mA	MOSFET Switching Power Losses (P_{sw})	4.48mW
Max. Power from Solar Cell (P_m)	3 watts	Switching Voltage Loss (V_{sw})	0.2volts
Rechargeable Battery Type	Li-ion	WSN Load Model	100-ohm resistor
Battery Voltage	5 volts	Inductor conduction Power Loss (P_L)	2.59mW

3. Solar Energy Harvesting System

A block schematic of a maximum power point tracking (MPPT) controlled solar energy harvester (SEH) system is shown in Figure 1. The SEH system comprises of a solar panel, a DC-DC boost converter, a rechargeable battery, a maximum power point (MPPT) controller, and a WSN sensor node connected as a dc load. The encompassing solar light energy is harvested utilizing the solar panel and changed over into the electrical energy. The DC-DC boost converter steps ups and directs the magnitude of this harvested voltage, and supplies it to the rechargeable battery. The MPPT controller tracks the voltage and current from the solar panel and alters the duty cycle appropriately for the MOSFET of DC-DC Boost converter [3]. Finally, the battery voltage is utilized to function the wireless sensor node. The WSN performs the function of detecting, computation, and communication with other comparable characteristics nodes. Hence, independent operation of monitoring and control of any physical phenomenon such as temperature, humidity, pressure or acceleration can be accomplished utilizing the SEH-WSN nodes. In this entire situation, the proficiency of solar energy harvester circuit plays a very vital role. In case the proficiency of solar energy harvester system is destitute, then the battery will not get recharge appropriately and consequently the wireless sensor network lifetime will reduce.

4. Experiment

Figure 2 shows MATLAB Simulink model of solar energy harvester system utilizing MPPT control. The solar irradiance of 1000 watts/cm^2 is incident on the solar panel with a steady temperature of 25 degree Celsius [4]. The Solar panel can extract only this solar energy into 15 mW/cm^2 with 15% proficiency [5]. For full irradiance on the re-enacted solar panel, the output voltage of solar panel is 6 volts, 500mA, and 3 watts. Presently, this electrical vitality from the solar cell is fed to the DC- DC boost converter which increments the output voltage [6]. The Boost converter output voltage is utilized to charge the rechargeable battery. The rechargeable battery is utilized to function the WSN node. Here, the WSN load is demonstrated as output dc load resistance of 100 ohms. The re-enactment parameters for a solar energy harvesting framework are shown in Table 1.

5. Results

The re-enactment results for the Battery State of Charge (SoC), battery Current (IB) and battery voltage (VB) as a function of time 10 seconds are shown in figure 3 to figure 5. In figure 3 battery SOC reaches from 84.49 to 85% for 10sec of re-enactment time. In figure 4 and 5 the obtained battery current is of -0.5063 and the voltage obtained is of 5.106 for the system outlined. In this way, the battery charging time is dynamically expanded by utilizing MPPT controlled solar energy harvesting systems for WSN nodes. Table 2 shows the re-enactment results for MPPT Control SEH System.

Table 2
Re-enactment results for MPPT control SEH system

Parameters	Value
Max. Solar Panel output Power (Pm)	2.9 watts
Boost Converter Output Current (Im)	506.8 mA
Boost Converter Output Voltage (Vm)	5.106 volts
Boost Converter Output Power (P_O)	2.58watts
Harvester System Efficiency(ηsys)	98.19%

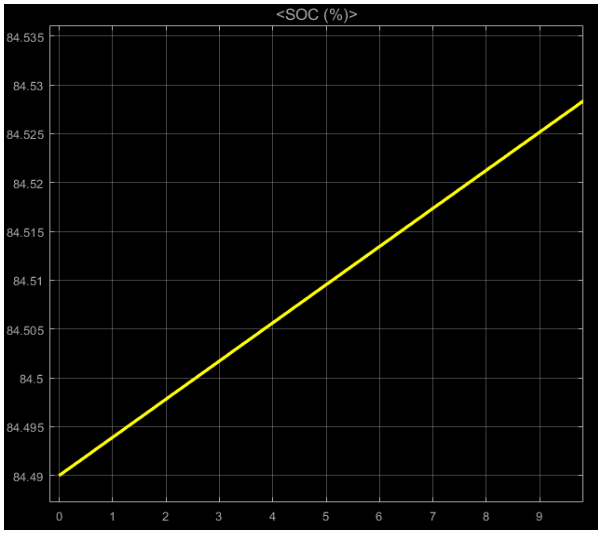

Fig. 3. MPPT controlled SEH system battery SOC for 10 sec

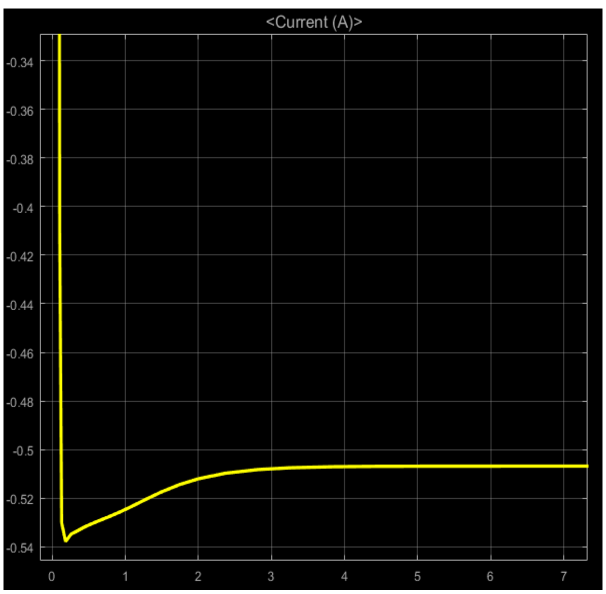

Fig. 4. MPPT controlled SEH system battery current for 10 sec

6. Efficiency of the Energy Harvester System (η_{sys})

The energy harvester system proficiency is calculated for MPPT control methods. By utilizing P&O MPPT the maximum Power available from the solar panel is 2.9 watts. The MPPT proficiency is calculated as [7]:

$$\text{MPPT Efficiency}(\eta_{MPP}) = P_{MPP} \div P_m \quad (1)$$

From the re-enactment parameters the obtained solar panel output power (PMPP) is 2.9 watts and the maximum theoretical control (Pm) is 3 watts. Hence, MPPT proficiency is calculated as 2.9w / 3w = 96.66%. Here, the Ploss too changes due to MPPT in DC-DC Boost Converter. The Ploss is the sum of MOSFET switching loss (Psw) and Inductor conduction loss (PL). From the re-enactment results table, the output control (Po) is 2.58 W and MOSFET switching losses are 4.48mW and inductor power loss is 2.59mW. Thus, boost converter efficiency is calculated as 2.58W /2.58 W+ 7.07mW = 99.72%. The overall energy harvester system proficiency (ηsys) is the average of boost converter proficiency and MPPT efficiency. Harvester system efficiency:

$$(\eta_{sys}) = (\eta_{boost}) + (\eta_{MPP}) \div 2 \quad (2)$$

From, equation (2), (ηsys) = 96.66%+99.72% / 2 = 98.19%.

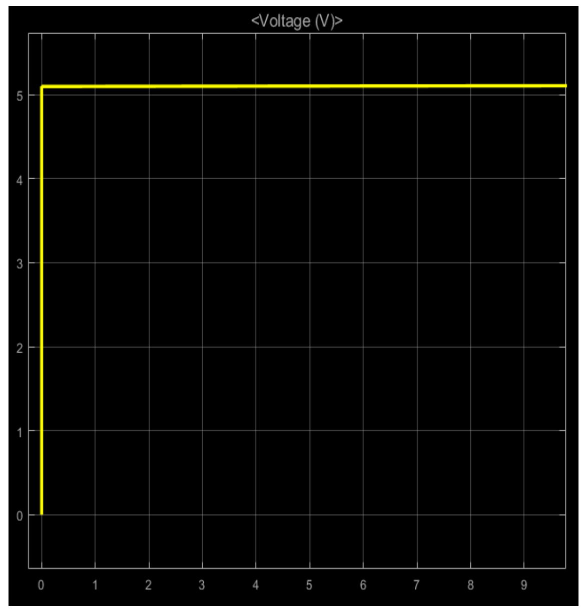

Fig. 5. MPPT controlled SEH system battery voltage for 10 sec

7. Conclusion

In this Project, we have modelled an efficient solar energy harvesting system for WSN nodes with Maximum Power Point Tracking (MPPT) is designed and analyzed using MATLAB /SIMULINK. The proficiency of the overall system is upgraded up to 98.19%. The system guarantees the battery with an extremely long life with a suitable charging strategy.

References

[1] Himanshu Sharma, Ahteshamul Haque, Zainul Abdin Jaffery, “Maximization of wireless sensor network lifetime using solar energy harvesting for smart agriculture monitoring,” Ad Hoc Networks, July 2019.

[2] X. Liu and E. Sanchez-Sinencio, “A highly efficient ultralow photovoltaic power harvesting system with MPPT for internet of things smart nodes,” IEEE Transactions on VLSI System, vol. 23(12), pp. 3065–3075, 2015.

[3] Jaw-Kuen Shiau and Chien-Wei Ma, “Li-Ion Battery Charging with a Buck-Boost Power Converter for a Solar Powered Battery Management System,” Energies Journal, vol. 6, MDPI, pp. 1669-1699, 2013.

[4] S. Sivakumar et al., “An assessment on performance of DCDC converters for renewable energy applications,” Renewable Sustainable Energy Reviews, Springer, Elsevier, vol. 58, pp. 1475–1485, 2016.

[5] Minchul Shin, Inwhee Joe, “Energy management algorithm for solar-powered energy harvesting wireless sensor node for Internet of Things,” IEEE- IET Communications Journal, vol. 10, no. 12, pp.1508-1521, 2016.

[6] Himanshu Sharma, Ahteshamul Haque, and Zainul A. Jaffery, “Solar energy harvesting wireless sensor network nodes: A survey”, Journal of Renewable and Sustainable Energy, American Institute of Physics (AIP), USA, vol. 10, no. 2, pp. 1-33, March 2018.

[7] Himanshu Sharma, Ahteshamul Haque, and Zainul A. Jaffery, “Modeling and Optimisation of a Solar Energy Harvesting System for Wireless Sensor Network Nodes”, Journal of Sensor and Actuator Networks, MDPI, vol. 7, no. 40, pp. 1-19, Sept. 2018.