I J C T A, 9(15), 2016, pp. 7145-7150

Power Management System for Wireless Sensor Network

Noushida Noufal and Ramesh P.

ABSTRACT

Solar energy is the most abundant cheap form or renewable source of energy hence it has found to be used in a variety of application. One of such application is to power a sensor, such as ZigBee. ZigBee is a low power device that require only about 50mW of power for its function. This low power requirement can be met by using a single solar cell. We can use Maximum Power Point Tracking (MPPT) techniques to increase the efficiency of the circuit. The sensor node, it can be noted that it has 2 types of operating conditions, they are: maximum power mode (during signal transmission reception) maximum voltage mode(during sensory action idle state). The power requirement during maximum voltage mode is quiet low hence during this mode if we operate at a maximum voltage the additional power can be used for charging a secondary supply like battery [1].

Keywords: Efficient power utilization, Real time power, Wireless sensor network (WSN), Maximum Power Point tracking (MPPT), Constant voltage control scheme (CVC), Mode signal.

1. INTRODUCTION

Sun is not just a heat ball that provides vitamin D. Usages of solar energy are widespread in industry, commercial, and military applications . It will gradually become one of the primary energy supply resources in the future. This paper discusses the design of a real time solar power management system for low power applications such as wireless sensor network. This system, consisting of a solar panel, DC-DC convertor, control unit, low power sensor. The power for the sensor is provided by a solar cell. There are different modes for a wireless sensor node, transmitting mode, receiving mode, sensing mode and idle mode. Power consumption differ for different modes. A control unit that gives appropriate power to the sensor node according to the mode with a mode signal, will provide an intelligent power management for WSN.

Maximum Power Point Tracking is a means of effectively utilizing the source minimize wastage of resources hence it finds its major application in photovoltaic cells. This is done to increase the efficiency of photovoltaic cells, fuel cells, as well as transfer of maximum power to the sensor nodes so that they could effectively transmit or receive signals. In case of solar cells, the solar energy being free-source the MPPT serves the later purpose mentioned above[2].

Constant Voltage Control scheme is used when the load needs a constant voltage rather than power. When the load draws much less power, we can use the power to charge a battery. In such cases, we need constant voltage for better performance. It is to be noted that conventional methods such as perturb observe incremental conductance focuses on finding the point of maximum power by trial error method hence they are applicable for any device i.e. even after replacing the source we need a very little calibration, if any, for the algorithm to work. While the algorithm such as sliding mode algorithm are device specific they are generally designed after knowing the characteristics of the source. Since they work in a sliding region which is source specific we need to recalibrate the system to work when replaced by identical sources.

* College of Engineering Munnar India, *Email: noushidanoufal@gmail.com*

** College of Engineering Munnar India, *Email: rap@ieee.org*

Even then disadvantage is not that big while considering its fast tracking capability as well as its stability. When for other algorithms the efficiency depends on its sampling or processing time, efficiency of SMC is almost independent of the processing time. For other algorithms as they use trial error method blindly select values slowly make the correct tracking value while the sliding surface equation provide as with instantaneous values which is very close to the actual value. They can also respond to fast variations that occur in source as well as in load considering the other algorithms.CVC algorithm is combined along with MPPT algorithm is an effective method in photovoltaic systems when used to low power sensor node[3].

2. OVERALL SYSTEM DESCRIPTION

An intelligent solar energy-harvesting system for supplying a long term and stable power is proposed. The system is comprised of a solar panel, a load, DC-DC convertor, a battery, and a control circuit. Hardware, instead of software, is used for charge management of the battery, which improves the reliability and stability of the system. It prefers to use the solar energy whenever the sunshine is sufficient, and the lithium battery is a complementary power supply for conditions, such as overcast, rain, and night. The system adapts a maximum power point tracking (MPPT) circuit to take full advantage of solar energy, and it ensures the battery an extremely long life with an appropriate charging method, which shortens the frequency of the battery charge-discharge cycle. This system can be implemented with small power equipment which is especially suitable for outdoor-based wireless sensor nodes like zigbee. Block diagram of the proposed system is shown in Fig: 1.

3. CONTROL UNIT

Sensor nodes consists of four modes of operation. Trans-mitting mode, receiving mode, idle mode, and sleep mode. Control unit need to switch according to these operating modes. And square wave with appropriate duty cycle is given to the DC-DC convertor. Operating modes can be informed to the control unit with a mode signal (m). Since there are 4 operating modes, mode signal can be represented with 2 bit. Simulated the control unit for a single bit mode signal using MATLAB. Operating modes corresponding to the maximum power is represented by mode equal to 1. That is m = 1 implies transmitting mode or receiving mode. Similarly idle mode and sensing modes are represented by m = 0.

3.1. Maximum Power Point Tracking (MPPT)

The amount of electrical power generated by a photovoltaic system depends on solar irradiance (solar energy per unit area of the solar panels surface)other conditions such as tempera-ture cloud cover. The

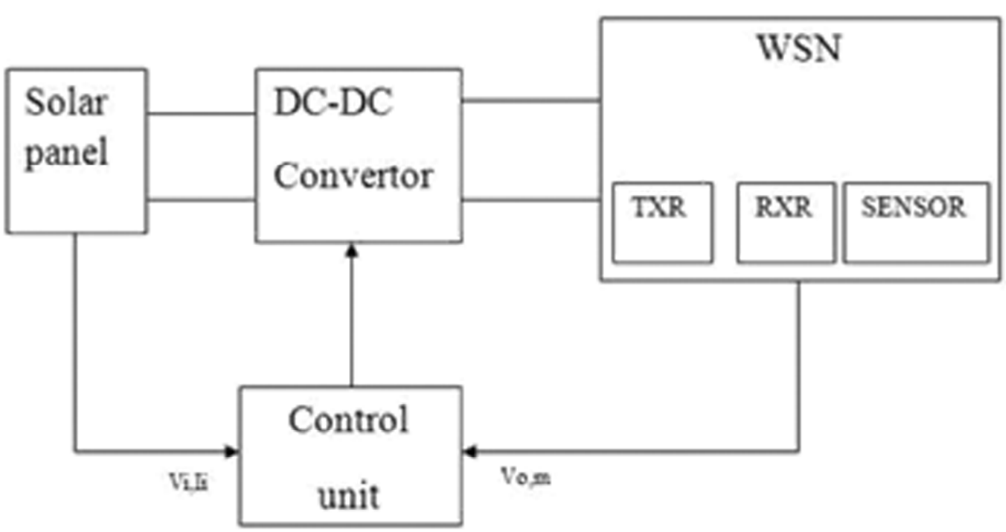

Figure 1: Block diagram of the system

current voltage at which a solar module generates the maximum power is known as the maximum power point. The location of the maximum power point (MPP) is not known in advance[3].

Maximum power point tracking (MPPT) modifies the electrical operating point of a solar energy system to ensure we extract the maximum amount of power. This involves finding the current or voltage of the solar panel at which maximum power can be generated. MPPT improves the electrical efficiency of a solar energy system, thus reducing the number of solar panels or arrays required to generate a desired output. The duty cycle of the boost converter is controlled based on MPPT algorithms[4].

- Sliding mode control: Sliding mode control is a fast unconditionally stable maximum power point tracking scheme with high tracking efficiency used for photovoltaic generators. We are defining a

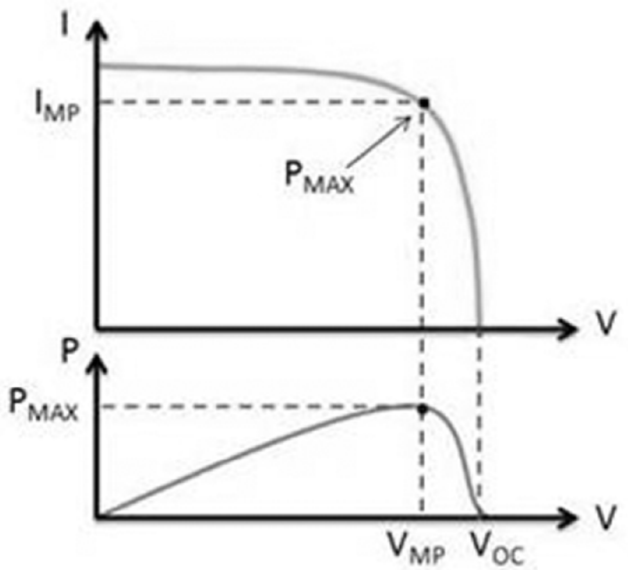

Figure 2: MPP in I-V curve and P-V curve

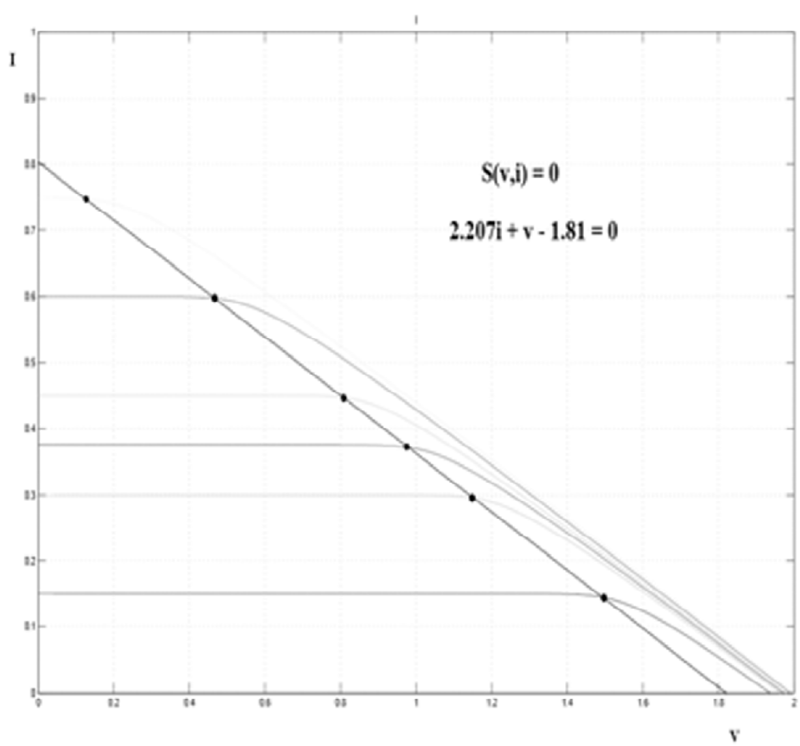

Figure 3: Sliding Mode Control Graph

sliding region on the I-V graph converges the operation into these region. Below graph show the sliding region. Here, unlike conventional methods, instead of tracking to an MPP we track the values to a point anywhere on the slide surface generated that is made by linear approximation of all MPP. By doing so it defines the area of stable operation as the collection of MPP points are never linear. Also defining the sliding surface exclusively based on the characteristics of the particular device hence while using other devices we need to re calibrate the surface to suit its need[5].

3.2. Constant Voltage Control Scheme

Proving a constant voltage at the output of DC-DC conver-tor. To charge a battery which is a secondary source, requires constant voltage. CVC mode is activated during the idle and sensing mode of operation. The power required during these two mode of wireless sensor node is very less compared to the transmitting and receiving mode. The power required for sensor node during idle and sensor node is provided by the solar cell as real time power supply, and extra power is stored in the battery. It can be used when the solar energy available is not sufficient for the proper functioning of sensor node.

4. SIMULATION RESULTS

The circuit consists of a single solar cell as the source. A boost circuit comprising of an input capacitance, an output capacitance, an inductance, a diode a MOSFET which is used as switch. The capacitor at the output section along with the additional inductor placed at output side gives a smoothened output by eliminating the ripples. The MOSFET switch is controlled by the control unit. Based on the signal coming from control unit, the on-off time of MOSFET varies which results in MPPT or CVC as specified by the control circuitry. The load impedance varies according to its operational modes. Also, the power requirement varies. When high power is required, the system will works in MPPT mode while it works in CVC mode if the power requirement is low. In such cases we can use this power to charge batteries.

The first figure denotes the mode. If the mode is zero, then MPPT algorithm is employed. If the mode is one, then CVC will be employed. In the above figures, mode is zero from initial state to 1 second. In this time interval MPPT based on sliding mode control is employed. It catches the maximum power point within 0.25 seconds. Then it is switched to Maximum voltage mode. Then power decreases and the voltage is raised by some value. The initial spike is due to the charge stored in capacitor and inductor. After 2.8 seconds it is then switched again to maximum power point mode. Maximum power point tracking mechanism

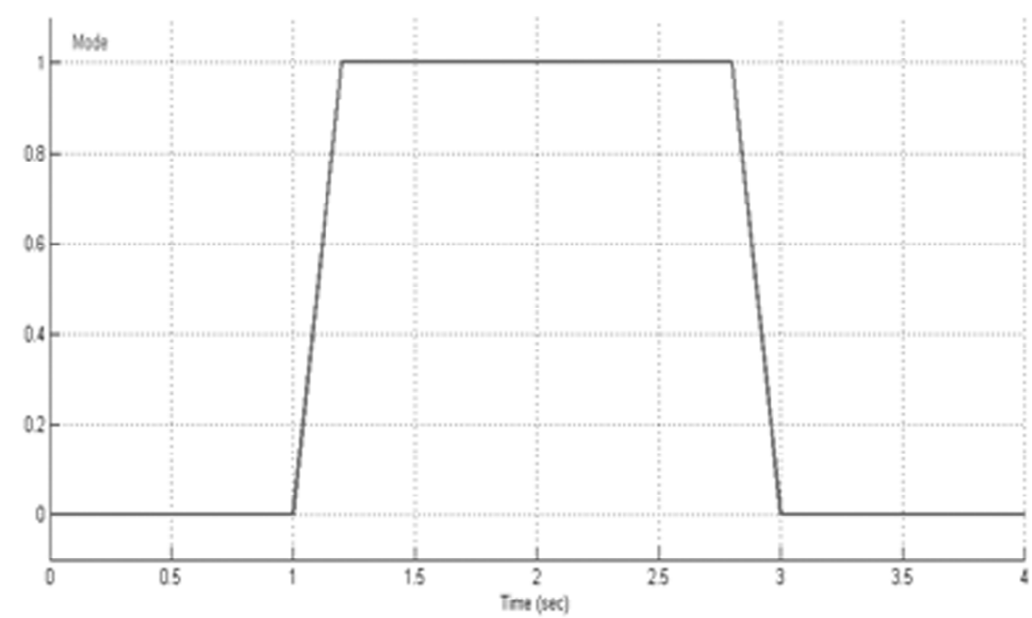

Figure 4: Operation Mode of Load

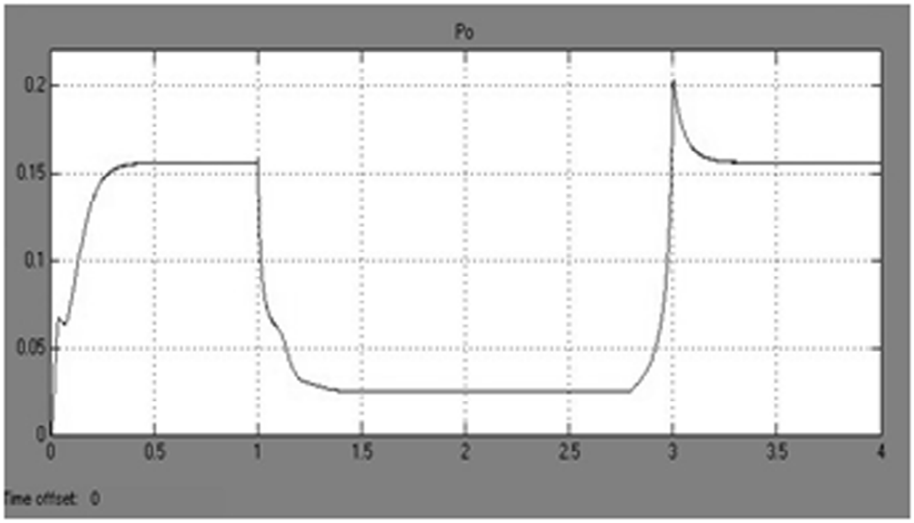

Figure 5: Output Power of Power Management System.

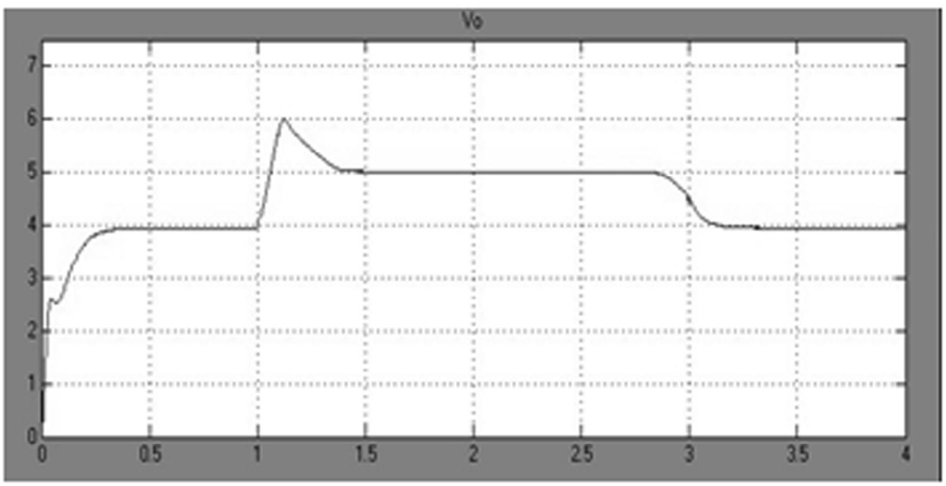

Figure 6: Output Voltage of Power Management System

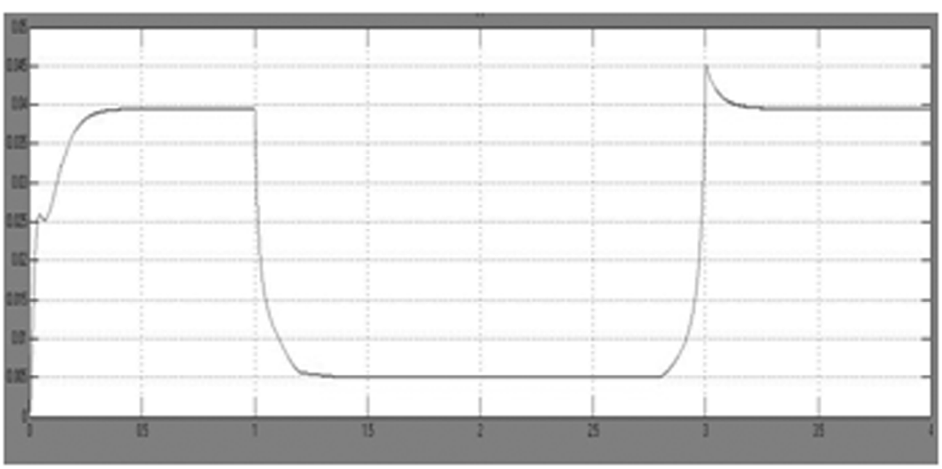

Figure 7: Output Current of Power Management System

based on sliding mode control is the better algorithm for maximum power point tracking. Except the problem that SMC is specific to a device, it is the best method.

The sensor module operates in four modes namely the transmitting mode receiving mode sensing mode and the sensing mode. The sensor requires maximum power to operate in the transmitting and the receiving modes but it requires only very low power to operate in the sensing mode. So the available power can be stored in some secondary storage device. An effective switching mechanism is required to switch between the maximum power point tracking mode and the constant voltage control scheme. The system tracks the maximum power point in the maximum power point tracking mode, the sliding mode control (SMC) method provides the effective algorithm to track the maximum power point, we have proved that the SMC method provides the fastest tracking to the MPP.

Even though we observed some uneven bounces in the output waveform obtained, it can clearly be observed that these spikes are within the allowable limit. The advantage of the system developed is that it insists in obtaining the maximum efficiency from the photovoltaic cell. In case of the sensor module if it is not transmitting or receiving there is a chance that the voltage obtained from the PV cell get wasted. In our system this voltage is stored in to some secondary storage device. To store the energy it requires constant voltage instead of the maximum power. So we need an effective mechanism which switches between the maximum power tracking and the constant voltage control scheme.

5. CONCLUSION

This work introduces a sliding-mode based MPPT method. In comparison to conventional PWM based MPPTs, con-vergence to maximum power is accelerated by an order of magnitude. This is accomplished by an optimal selection of the switching surface. In addition, the controller can operate either as a voltage source or a current source, maintaining stability all across the photo-voltaic curve. SMC is found to be more stable with more fast efficient tracking even at a much faster variation. Using the output voltage from MPPT circuit we will drive ultra-low power devices such as ZigBee. Two modes of operation are required; MPPT mode- during transmission reception, constant voltage mode- during ideal condition. We require boosting techniques to boost the output voltage of the fuel cell. But conventional boost methods including diodes are impractical due to the voltage drop in elements. hence we have to use very little power for controlling circuitry for boosting the output of a single solar cell. It uses the processor supporting the sensor node.

ACKNOWLEDGMENT

I wish to thank Dr. Ramesh P. HOD, ‘College of Engineering Munnar’, India for helpful discussion. Also wish to acknowledge the facilities provided by ‘College of Engineering Munnar’.

REFERENCES

[1] H. Yu, H. Wu, Y. Wen, and P. Li, “Indoor micro-light energy harvesting system for low power wireless sensor node.”

[2] Y. Li and R. Shi, “An intelligent solar energy-harvesting system for wire- less sensor networks,” EURASIP Journal on Wireless Communications and Networking, vol. 2015, no. 1, pp. 1–12, 2015.

[3] K. Hussein, I. Muta, T. Hoshino, and M. Osakada, “Maximum photo- voltaic power tracking: an algorithm for rapidly changing atmospheric conditions,” IEE Proceedings-Generation, Transmission and Distribution, vol. 142, no. 1, pp. 59–64, 1995.

[4] C. Liu, B. Wu, and R. Cheung, “Advanced algorithm for mppt control of photovoltaic systems,” in Canadian solar buildings conference, Montreal, pp. 20–24, 2004.R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[5] Y. Levron and D. Shmilovitz, “Maximum power point tracking employing sliding mode control,” Circuits and Systems I: Regular Papers, IEEE Transactions on, vol. 60, no. 3, pp. 724–732, 2013.