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Analysis of Solar Energy Harvesting using Two different MPPT Method

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***Abstract*—Solar energy is the important source of energy. The demand for utilization of Solar energy is rapidly increasing . To optimize the solar energy is greatest challenge. Here MPPT method is used to extract the maximum power from the sun . In this paper, we have design a DC-DC Converter, as it provides the constant power flow for battery charging for wireless sensor node .The duty cycle of the converter controls charging based on the state of charge of the battery and direction of the current. Here its mainly emphasizes on the battery charging supplied by solar panel PV connected with DC-DC Converter controlled by maximum power point tracking technique . Solar energy system have been developed and simulation was performed in MATLAB/SIMULINK solar powered. DC-DC Converter with MPPT to achieve absolute result.**

***Index Terms*— PV cell, DC-DC Converter , MPPT, Incremental Conductance, Perturb and Observe and Wireless sensor node.**

I. INTRODUCTION

Wireless Sensor network are used in numerous applications like health care, monitoring and controlling system, detecting, industrial monitoring, security and surveillance etc. All of these applications has been developed with a portable battery. One main drawback with wireless sensor network is the battery life [1]. Due to which the lifetime of the wireless sensor node is reduced.

The solution to the problem is to harvest energy from the renewable energy sources. The widely used renewable energy is the solar energy, as it is abundantly available. To harness this energy PV (Photovoltaic) array system is used. There are two different ways to harvest solar energy one is sun tracking and second is Maximum Power Point Tracking [2].

In this proposed work Maximum power point Tracking is being used. As it is known that there are various maximum power point tracking technique ,but here Perturb & Observe and Incremental Conductance technique is used. Although many researches works has been done on [3-6] to increase the efficiency of PV modules. [7-10]Here the comparative study is done on Perturb & Observe and Incremental Conductance on harvesting solar energy for Wireless Sensor Node .

In this work simulation result shows the efficiency of the solar harvesting system and comparison of the two algorithm Section 1. Introduction of the paper, section 2. describe the working of the solar harvesting system section 3. major component used, section 4. Provides the difference between the two MPPT algorithm method. Section 5. gives us the results and finally section 6. is the conclusion.

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II. SOLAR ENERGY HARVESTING MODELLING

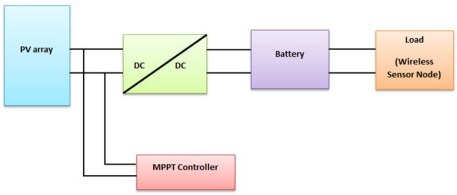

Fig 1. Block diagram of Solar Energy Harvesting

Solar energy produces electricity from the energy of the sun . The block diagram of the solar energy harvesting system for wireless sensor node is shown in the Figure 1. The solar energy consists of the tracking device (Photovoltaic cell) which convert the light energy into electrical energy. This energy is supplied to DC-DC Boost converter. Now the DC-DC Boost converter step up and regulates the harvested voltage. The power is supplied to the battery for charging. The MPPT controller track the maximum voltage and current ,accordingly adjust the duty cycle for IGBT of DC-DC Boost converter [11] . Hence the wireless sensor node is powered.

II. COMPONENT OF PROPOSED WORK

The component used in the solar energy harvesting is described below:

A. PV Cell

PV cell acts as very large area p-n junction diode when such a diode is forming a junction between the n-type and p-type region. As sun ray falls on the PV cell the incident energy is converted directly into the electrical energy. Transmitted light is absorbed within the semiconductor by using energy to excite free electron from the low energy status to an unoccupied higher level. The equivalent circuit of the PV cell is shown in the Fig 2.

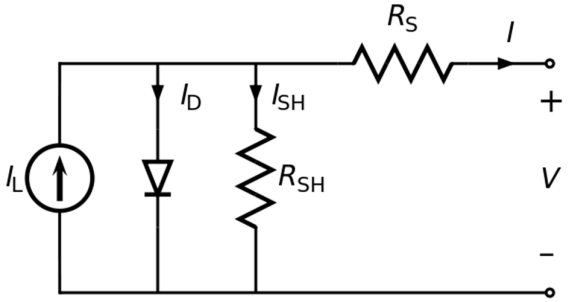

Fig 2. Equivalent circuit of PV cell

The PV and IV characteristics equations of the PV cell can be described from the equation circuit shown in Figure 2. [12]

$$I = Ipv - Io\left[\exp\left(\frac{q(V+IRs)}{KT}\right)-1\right]-\frac{V+IRs}{Rsh} \quad (1)$$

Here the PV cell output current I_{pv} is equal to I_{sc} , I_o is the reverse leakage current, R_s is series resistance, R_{sh} is the parallel resistance , is denoted by R_p, K is the Boltzmann's constant, T is the temperature, q is the charge.

For better performance of the solar cell it is assumed that , R_{sh} approaches to infinity , R_s approaches to zero and

$$\left[\exp\left(\frac{q(V+IRs)}{KT}\right)\right] \gg 1$$

The equation can be written as,

$$I = Isc - Io\left[\exp\left(\frac{qV}{KT}\right)\right] \quad (2)$$

For an open circuit V= $V_{oc,}$ and I=0 from eq.(2)

$$Io = Isc\left[\exp\left(\frac{-qVoc}{KT}\right)\right] \quad (3)$$

From (3) in (2) we get the characteristics of solar cell

$$I = Isc\left[1-\exp\left(\frac{q(V-Voc)}{KT}\right)\right] \quad (4)$$

We know P=VI, the P can be represented as

$$P = V\left[Isc - Isc\exp\left(\frac{q(V-Voc)}{KT}\right)\right] \quad (5)$$

where P is the output power and I is the current .

A. DC-DC Converter

The DC-DC Converter is the necessary part of the solar energy harvesting. It is used to obtain the regulated and DC voltage of the system. In this Boost converter is used, as it step up the voltage . Wireless sensor Node is for low power application.

B. Maximum Power Point Tracking

The energy harvested model is highly efficient with the help of MPPT techniques. A model design with MPPT tracker extract maximum power and delivers to the load and storage devices which is the rechargeable battery in this case. There are various technique use in the MPPT like fuzzy logic control , current sweep , stated based MPPT and neural network but in the proposed work Incremental Conductance [13] and Perturb and Observe [14] is used.

C. Load

The energy which is harvested are storage in the rechargeable battery used to operate the load, which is wireless sensor Node.

IV. MAXIMUM POWER TRACKING ALGORITHM

A. Purturb & Observe Techniue

Perturb and Observe which is also known as Hill Climbing Method, has grasp the attention due its simple and easy working. This algorithm is based on the output power of the PV module. The voltage is increased and decreased by the fixed step size in the direction of the maximum power point .[15] sometimes instead of operating at MPP ,it operate near at MPP because of error process, which exhibits oscillation in the power of PV module. The Fig 3. shows the Flowchart of Perturb & Observe algorithm.

Fig. 3 Flowchart of Perturb & Observe algorithm

B. Incremental Conductance

Incremental Conductance is also a very popular method, the only problem with Incremental Conductance is, its complexity. This method was introduced to overcome the weakness of the Perturb & Observe Method. The P& O method cannot compare any terminal voltage with Maximum power point operating voltage. Incremental conductance has certain advantageous like it has high tracking speed and good efficiency.

The incremental conductance algorithm detects the slope of the PV curve and the MPP is tracked by searching the peak of the PV curve. It uses the instantaneous conductance I/V for MPPT [16]. Depending on the equation,

$$\frac{dP}{dV} = 0 \qquad \text{at MPP} \qquad (6)$$

$$\frac{dP}{dV} > 0 \qquad \text{left of MPP} \qquad (7)$$

$$\frac{dP}{dV} < 0 \qquad \text{right of MPP} \qquad (8)$$

P-V curve,

$$\frac{dP}{dV} = \frac{IV}{dV} = I + \frac{VdI}{dV} I + \frac{V\Delta I}{\Delta V} \qquad (9)$$

Equations (9) can be written as:

$$\frac{\Delta I}{\Delta V} = \frac{-I}{V} \qquad \text{at MPP} \qquad (10)$$

$$\frac{\Delta I}{\Delta V} > \frac{-I}{V} \qquad \text{left at MPP} \qquad (11)$$

$$\frac{\Delta I}{\Delta V} < \frac{-I}{V} \qquad \text{right at MPP} \qquad (12)$$

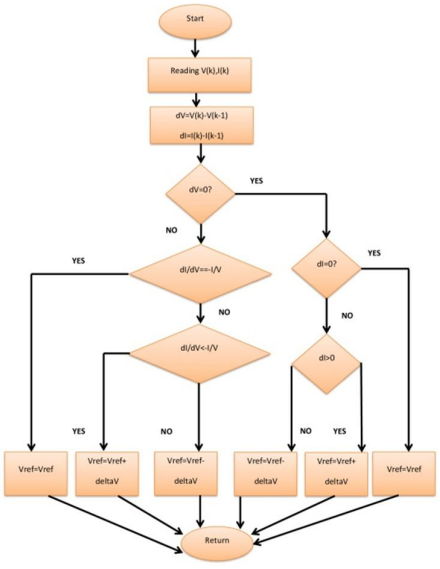

Fig 4. Flowchart of Incremental Conductance algorithm

V. STIMULATED RESULT

The TABLE I., TABLE II., TABLE III. show the design specification of PV solar system, photovoltaic array DC-DC Converter and Battery.

TABLE I. PARAMETER

Parameter	At Values	Parameter	Values
Irradiance(W/m^2)	1000 W/m^2	Input Voltage	250-350 V
Temperature(T)	25 degree Celsius	Voltage at Maximum Power Vmp (V)	29.0
Output Voltage(V_o)	500 V	IGBT Switching Frequency(f)	5KHz
Rated power	100 kW	STC Power Rating Pmp(W)	215
Voltage ripple(V)	1%	PTC/STC Power Rating Pmpp(W)	189.4
Current ripple(I)	5%	PTC/STC Power Ratio	88.1%
Max. Solar Panel output current(Im)	7.35	Open Circuit Voltage V_{oc} (V)	36.3
Short Circuit Current I_{sc} (A)	7.84	Current at Maximum Power Imp (A)	7.35

TABLE II. SHOWS THE DESIGN OF PV SOLAR CONVERTER (BOOST CONVERTER)

PARAMETER	VALUES
OUTPUT CURRENT(A)	200
CURRENT RIPPLE(ΔI)	20
VOLTAGE RIPPLE (ΔV)	5
INDUCTANCE	1.25MH
CAPACITOR	4000μF

TABLE III. SHOWS THE BATTERY VALUES

PARAMETERS	VALUES
BATTERY TYPE	LITHIUM ACID
BATTERY VOLTAGE	7.2
BATTERY CURRENT	5.4

The Fig.5 and Fig. 6 shows the simulink model of Incremental Conductance and Perturb & Observe .

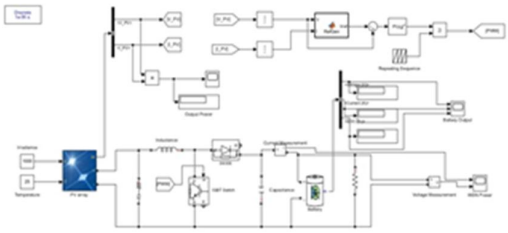

Fig 5. Simulink Model of Solar Harvesting for wireless sensor Node using Incremental Conductance algorithm

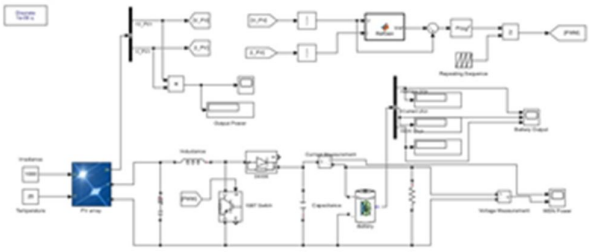

Fig 6. Simulink Model of Solar Harvesting for wireless sensor node using Perturb & observe Algorithm

The simulation results of the battery State of Charge (SOC), Battery Current(I_B) and Battery Voltage (V_B) as a function of time for different MPPT Controlled is shown in Fig 7. And Fig 8.

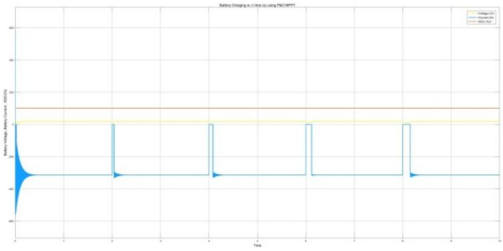

Fig 7. Shows the graph of battery charging InC Method

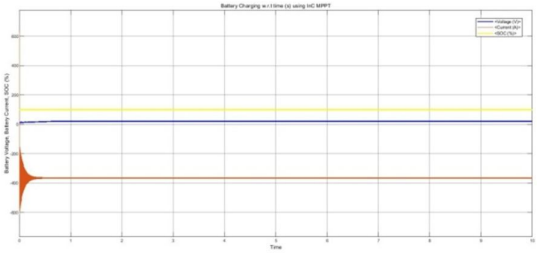

Fig 8. Shows the graph of battery charging P&O Method

VI. CONCLUSIONS

In this paper MATLAB /SIMULINK is performed for solar energy harvesting wireless sensor network , also a comparative study is done between Incremental Conductance and Perturb & Observe . From the result, it is clear that in Perturb & Observe technique oscillations is more as compare to Incremental Conductance. Incremental Conductance showed a better and stable performance.

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