OPTIMIZATION OF SOLAR ENERGY HARVESTER SYSTEM FOR WIRELESS SENSOR NETWORKS

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***Abstract*— This project presents closed loop maximum power point tracking for photo voltaic panels used in wireless sensor networks. Perturb and observe (P & O) algorithm is used to track the maximum possible output power from solar at every instant of time. Solar power is affected by the temperature and insulation, due to the environmental conditions it changes at every instant of time. Irrespective of temperature and insulation variation, P & O algorithm compares the instantaneous power from solar and reference power that we have been chosen.**

The output power from photo voltaic cell is used in low-power indoor devices such as remote sensors, supervisory and alarm systems, distributed controls and data transfer systems. The Design and characteristics of PV cell, Maximum power point tracking are analysed with the help of MATLAB Simulation diagram.

***Index Terms*— Photo Voltaic Array, Power Converter, MPPT(P&O Algorithm),**

I. INTRODUCTION

Solar energy has offered promising results in the quest of finding the solution to the problem. It is also gratifying to lose reliance on conventional electricity generated by burning coal and natural gas. Regarding the endless aspect of solar energy, it is worth saying that solar energy is a unique prospective solution for energy crisis. However, despite all the aforementioned advantages of solar power systems, they have two inherent major problems. The first is low conversion efficiency and second is presence of highly nonlinear I-V characteristics. The problem gets worse because the efficiency of solar cells mainly depends on factors such as temperature and irradiance. Varying environmental conditions along with the changing irradiance greatly affects the photovoltaic array output power. This paper mainly focuses on developing an efficient converter topology along with maximum power extraction. It involves the performance analysis of higher converters such as Cuk Converter and Positive Output Super-Lift Luo Converter along with the two most popular MPPT methods such as Perturb & Observe method and Incremental Conductance method. Few Comparisons such as voltage, current, voltage gain for each combination has been recorded and the MPPT methods are also compared and their analysis are performed for improved efficiency.

II. PV ARRAY

The basic structural unit of a solar module is the PV cells. A solar cell converts energy in the photons of sunlight into electricity by means of the photoelectric phenomenon. The equivalent circuit model of a solar cell is shown in Fig. 1. It is modeled by utilizing a current source, a diode and two resistors. The diode is connected in parallel to current source; the photon energy incident on the PV cell generates current. The current source (I_{SC}) is proportional to the amount of energy incident on PV cell.

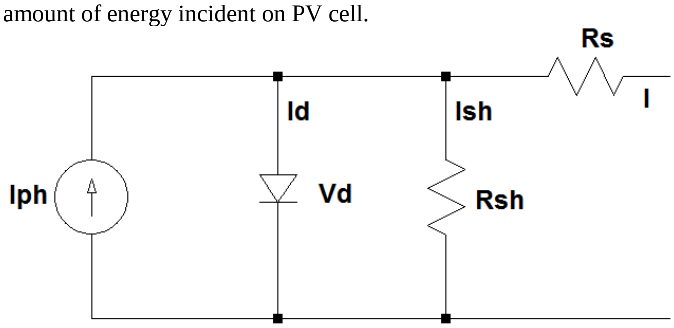

Fig. 1 Equivalent Circuit Model of a Solar Cell.

The I-V characteristics of the equivalent solar cell model can be determined by following equations.The current through diode is given by:

$$I_D = I_O\,[\exp(q\,(V + I\,R_S)/KT) - 1] \quad (1)$$

While, the solar cell output current is given by:

$$I = I_L - I_D - I_{sh} \quad (2)$$

And,

$$I = I_L - I_O\,[\exp(q\,(V + I\,R_S)/KT) - 1] - (V + IR_S)/\,R_{sh} \quad (3)$$

Where:
I: Solar cell current (A)
I: Light generated current (A) [Short circuit value assuming no series/ shunt resistance]
I_O: Diode saturation current (A)
q: Electron charge (1.6×10-19 C)
K: Boltzmann constant (1.38×10-23 J/K)
T: Cell temperature in Kelvin (K)
V: Solar cell output voltage (V)

R_s: Solar cell series resistance (Ω)
R_{sh}: Solar cell shunt resistance (Ω)

III. POWER CONVERTER

A DC-to-DC converter is an electronic circuit which converts a source of direct current from one voltage level to another. There are several different types of dc-dc converters, buck, boost, buck-boost and cuk topologies, have been developed to meet variety of application specific demands. The important requirement of any DC–DC converter used in the MPPT scheme is that it should have a low input current ripple. Buck converters will produce ripples on the PV module side currents and thus require a larger value of input capacitance on the module side. On the other hand, boost converters will present low ripple on the PV module side, so here in this experimental work, boost converter is used to verify the output power results.

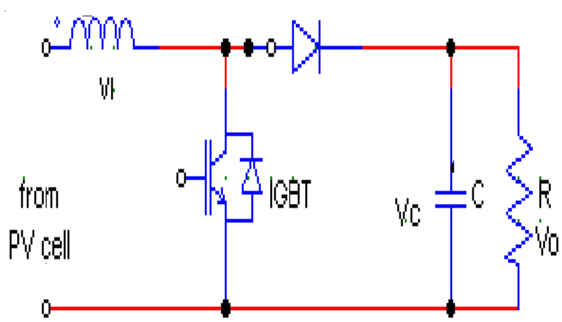

Fig. 2 Boost converter representation.

The output voltage equation is given as follows
Output voltage [Vo] = Vin / (1-D) volts.
Where,
Vin- Input voltage applied from PV cell
D-Duty cycle.

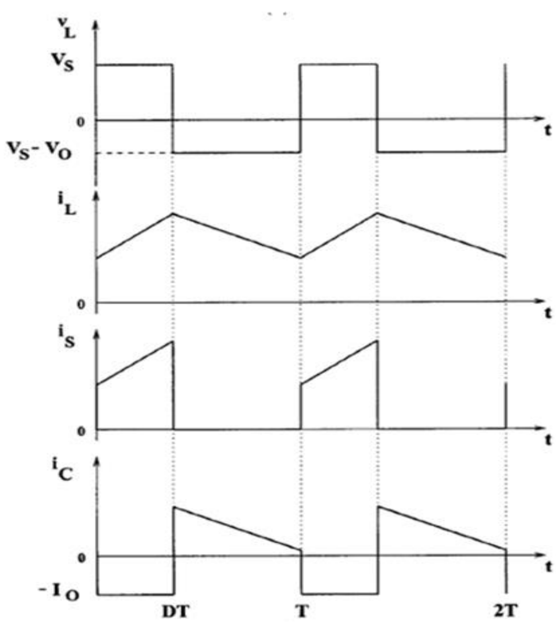

Fig. 3 Boost Converter Waveform.

IV. MPPT ALGORITHM

The problem considered by MPPT techniques is to automatically find the voltage v_{mpp} or current i_{mpp} at which a pv array should operate to obtain the maximum power output p_{mpp} under a given temperature and irradiance. It is noted that under partial shading conditions, in some cases it is possible to have multiple local maxima, but overall there is still only one true MPP. The maximum power is generated by the solar cell at a point of the current-voltage characteristic where the product *vi* is maximum. Most techniques respond to changes in both irradiance and temperature, but some are specifically more useful if temperature is approximately constant. Most techniques would automatically respond to changes in the array due to aging, though some are open-loop and would require periodic fine-tuning.

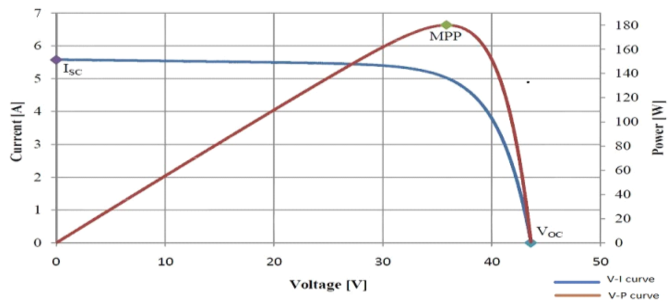

Fig. 4 Characteristics of PV array curve.

A. Perturb & Observe (P&O) Method:

The P&O method is perturbation in the operating voltage of the PV array. If the power increases due to the perturbation then the perturbation is continued in that direction [9]. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses.

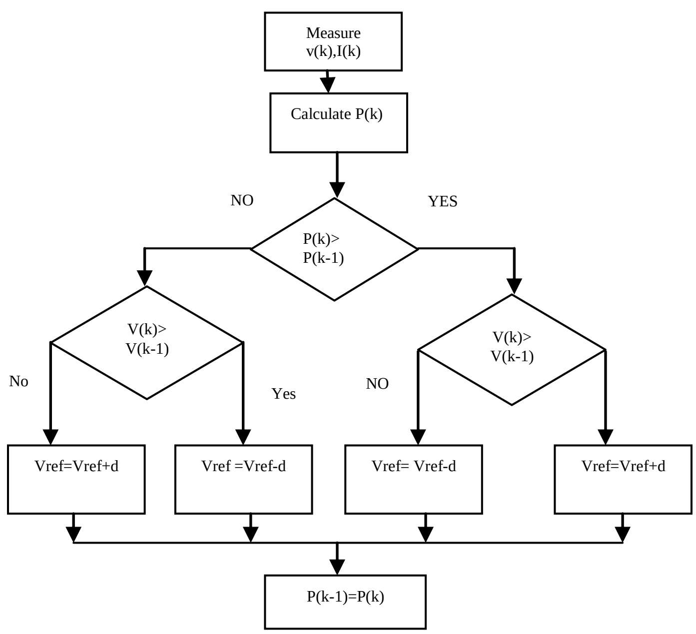

Fig. 5 P & O Algorithm.

V. WIRELESS NETWORKS

These sensor networks have applications in military monitoring, health, industrial control, weather monitoring, commodity tracking, home control ,etc. As promising as this technology seems, many design issues must yet be resolved before Wireless Sensor Networks become fully functional. A critical constraint on sensors networks is that sensor nodes employ batteries. A second constraint is that sensors will be deployed unattended and in large numbers, so that it will be difficult to change or recharge batteries in the sensors. Therefore, all systems, processes and communication protocols for sensors and sensor networks must minimize power consumption. The existing research on energy consumption of sensors is usually based on either theoretical models or computer simulations.

VI. MATLAB SIMULATION

The MATLAB® is a high-performance technical computing language in an interactive environment for algorithm development, data visualization, data analysis, and numeric computation.It offers variety of tools for computation, visualization, programming and graphical analysis. Among which Simulink® tool is used to model, simulate, and analyze the dynamic systems in a real time environment.

A. Solar Panel design

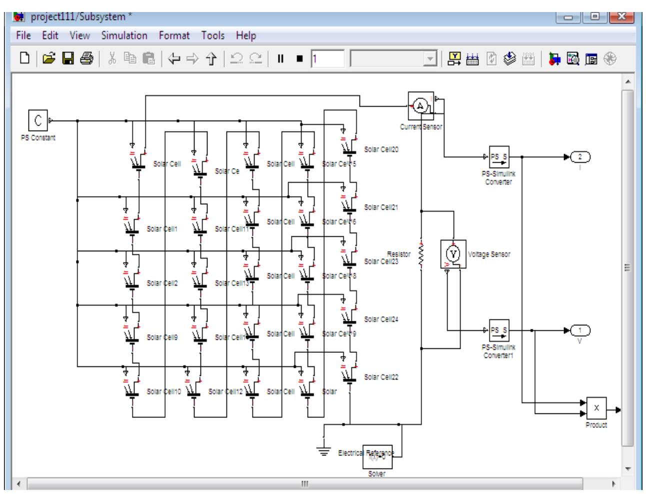

Fig. 6 Solar Panel Design.

In proposed converter matlab simulink diagram is shown in figs this circuit main parts are solar panel, MPPT P&O algorithm technique, boost converter. The solar panel input voltage is applied to the boost converter then the boost converter gate signal applied to using the MPPT algorithm. Then the converter output voltage is connected to the sensor circuit.

B. MPPT Design

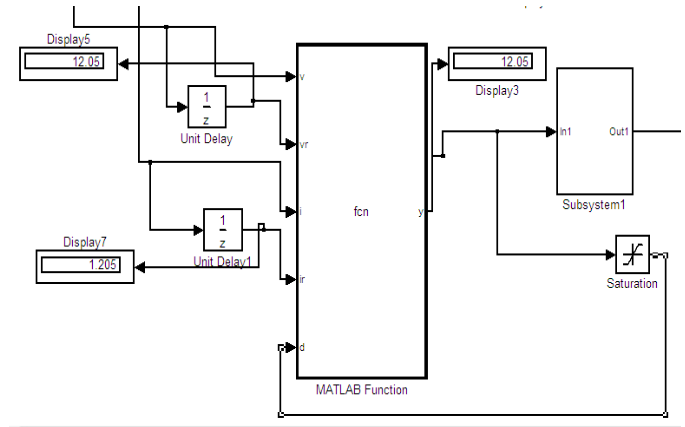

Fig. 7 MPPT Simulation.

C. MPPT P & O Coding

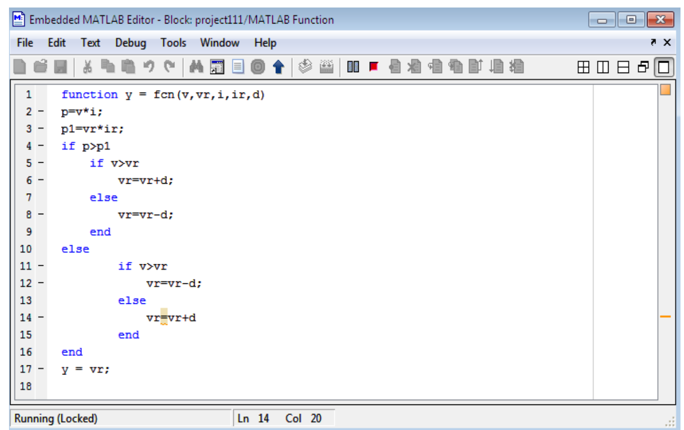

Fig. 8 MPPT Coding.

D. SIMULATION DIAGRAM

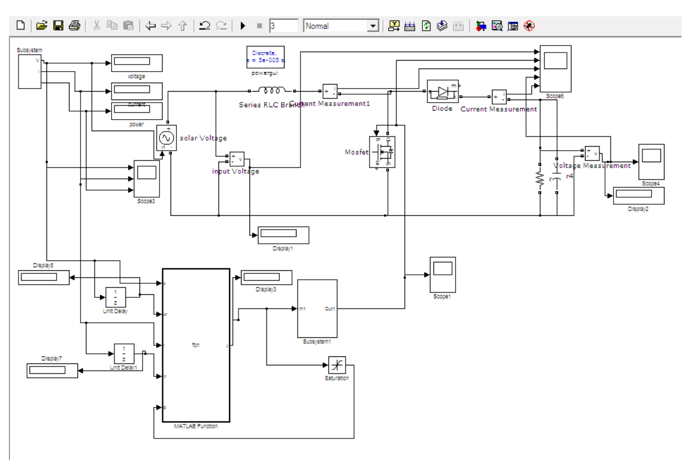

Fig. 9 Simulation.

VII. SIMULATION RESULTS

All simulation and result for every converter have been recorded to make sure the comparison of the circuit can be determined more accurately. The input, output voltage and current are the main comparison taken into consideration.

A. Solar Panel Output waveform

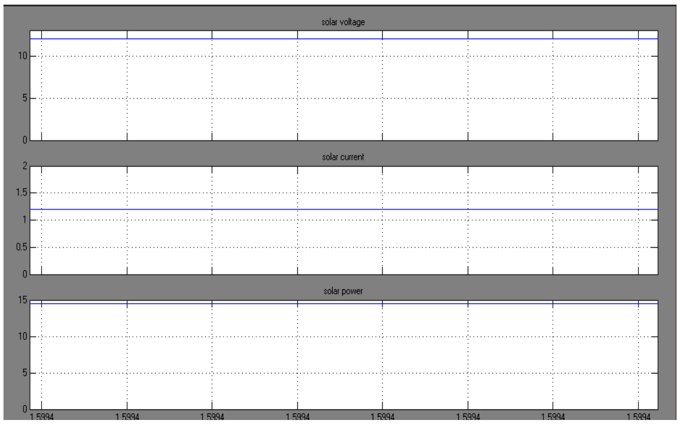

Fig. 10 Solar panel Output.

B. MPPT Pulse generation

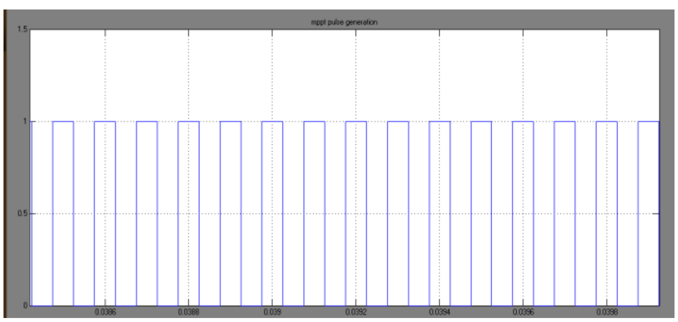

Fig. 11 MPPT Pulse generation.

C. MPPT Waveform

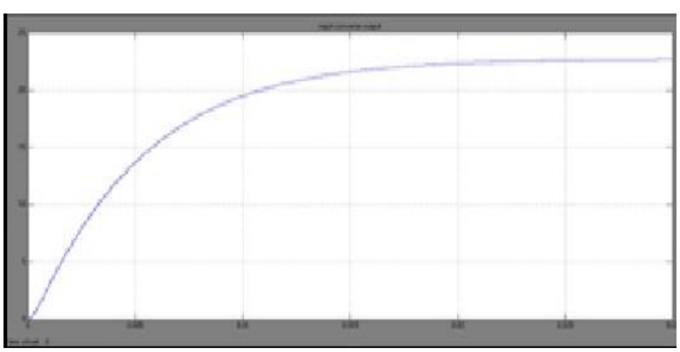

Fig. 12 MPPT waveform.

D. Boost Converter Waveform

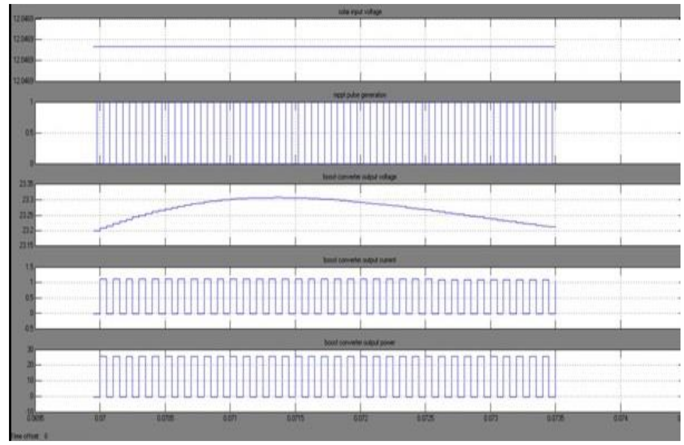

Fig. 13 Boost converter Output waveform.

TABLE I

COMPARISON TABLE

S.NO	IRRADIANS(w/m2)	OUTPUT POWER	
		WITHOUT MPPT	WITH MPPT
1	1000	14.5	24.5
2	800	14.02	23.5
3	500	12.92	21.6
4	200	10.11	16.74
5	100	5.8	8.27

VIII. CONCLUSION

The output power of solar is improved by Perturb and observe (P & O) algorithm. Fuzzy controller controls the pulses given to the buck converter, it regulates the voltage applied to the sensor circuit. Simulation results are verified the output power of solar with and without MPPT. Perturb and Observe control algorithm works under Hill Climbing technology. But it can't properly work in partial shading condition. However it can fail under rapidly changing atmospheric condition.

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