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Efficiency Analysis Of Perturb and Observe Maximum Power Point Tracking Method with Open Loop Boost Convertor and Closed Loop Boost Convertor

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Abstract— As the research on the renewable sources has been increasing day by advancing to new materials and techniques required to achieve maximum efficiency of the circuit so that production of the energy in that country can be managed and stabilized well. Solar is the best renewable form of the energy with high capital cost issue and changing weather conditions. If we can concentrate more on to stabilize output voltage at maximum power point then our work is done. In this paper overview of maximum power point tracking techniques with concentration on perturb and observe method with boost convertor is analyzed. If we can neatly implement feedback controls on the boost convertor MPPT system then its output is easily boosted by using amplification of error signal with PI controller.

Keywords- *boost convertor, MPPT, P & O, closed loop control, PI controller*

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I. INTRODUCTION

Current globe of world scenario about energy is changing day by day making a huge competition in the countries for development and implementation of renewable sources. If we will concentrate on fig. 1 it shows numerical values of the conventional sources energy production of the world in the comparison with the renewable energy production.

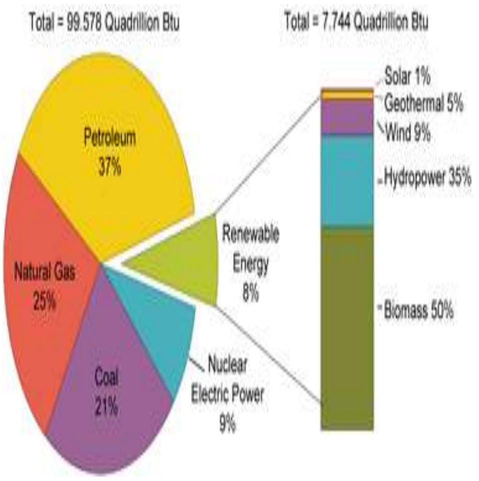

Fig. 1 global energy scenario

Only 8% of the total generation is from renewables which needs to be extended for saving the world from problem of energy crisis. Main target behind using renewables is to reduce global warming increasing continuously due to use of fossil fuels and to reduce consumption of that so. Now if we will have a look over India's energy scenario our country is in fully plan to concentrate on renewables. Current production which is near about 1891 MW that is to be developed up to 20000 MW which is very important target for overall growth of the country. 2013 renewable total generation was 29591 MW which is planned to boost up to 106530 MW which is needed and desirable if we forecast the future demand.

Fig. 2 shows installed capacity of the world by the end of 2014 in which countries from Europe continent are very much ahead and developed. Germany having 38 GW, Italy having 19 and rest of the Europe 32 GW, now if we concentrate on Asian countries China is far ahead which is generating 28 GW followed by Japan 23 GW and least by India 3 GW out of total 178 GW worldwide. Globe has already forecasting the demand and according to that they in way to develop new techniques for maximum output extraction. Boost convertor is implementing in this paper for perturb and observe method of MPPT and it is been compared with its closed loop control by using PI control.

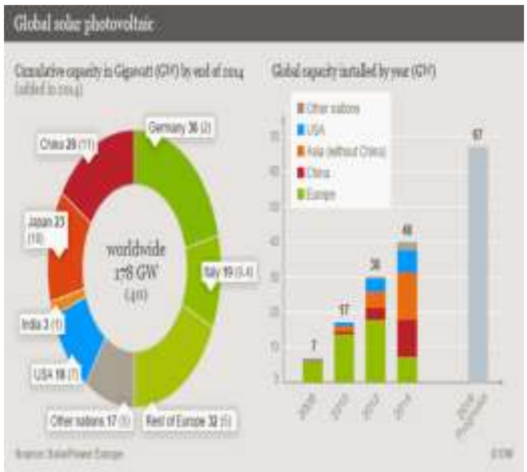

Fig. 2 global solar energy production scenario 2014

II. BASIC PV MODULE DESIGN

Solar energy is accessible in abundance in most components of the planet approximately 1.5 x 1018 kWh/year is the quantity of solar power incident on the earth's surface that is concerning 10,000 times the present annual energy consumption of the whole world. The density of power

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radiated from the sun (referred to as solar power constant) is 1.373 kW/m2. Photovoltaic cell is a device that converts photons in solar rays to direct-current (DC) and voltage. The associated technology is termed solar photovoltaic (SPV). A typical semiconducting material PV cell is a slim wafer consisting of a very thin layer of phosphorous-doped (N-type) Si on top of a thicker layer of boron-doped (P-type) Si. An electrical field is formed close to the top surface of the cell where these both materials are in contact (the P-N junction). When the daylight hits the semiconductor surface, an electron springs up and is attracted towards the n-type semiconductor material. This will cause additional negatives within the n-type and additional positives within the P-type semiconductors, generating a better flow of electricity. this is often referred to as photovoltaic effect. Figure 1 below shows the operating mechanism of a Si photovoltaic cell.

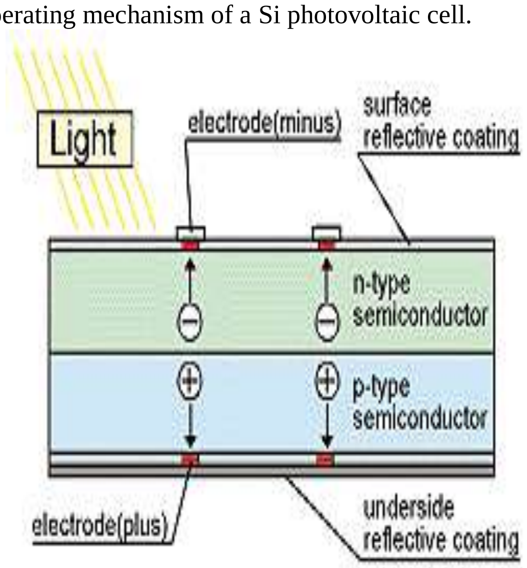

Figure 3: Silicon Solar Cell and its working mechanism (*Source: global.kyocera.com)*

The amount of current generated by a PV cell depends on its potency, its size (surface area) and also the intensity of daylight striking the surface. for example, under peak daylight conditions a typical industrial PV cell with a surface area of about twenty five sq. inches can produce about two watts peak power.

III. MAXIMUM POWER POINT TRACKING TECHNIQUES

A typical solar panel converts solely thirty to forty % of the incident star irradiation into voltage. Maximum power point chase technique is employed to boost the potency of the solar battery. in line with most Power Transfer theorem, the facility output of a circuit is most once the Thevenin resistance of the circuit (source impedance) matches with the load impedance. Therefore our drawback of tracking the maximum power point reduces to an resistance matching drawback. Within the supply aspect we tend to are employing a boost converter connected to a solar battery so as to reinforce the output voltage so it is used for various applications like motor load. By dynamical the duty cycle of the boost convertor suitably we will match the source impedance therewith of the load impedance. Necessary methods that are studied are P & O, incremental conductance, fuzzy logic controller and neural networks.

- **Perturb & Observe technique (Hill climbing method):**

Perturb & Observe (P & O) is that the simplest methodology. during this we tend to use only 1 sensing element, that's the voltage sensing element, to sense the PV array voltage then the value of implementation is a smaller amount and therefore simple to implement. The time quality of this algorithmic program terribly is less however on reaching very near the MPP it doesn’t stop at the MPP and keeps on perturbing on each the directions. Once this happens the algorithmic program has reached terribly near the MPP and that we will set an applicable error limit or will use a wait operate that lands up increasing the time quality of the algorithmic program.

The Perturb & Observe algorithmic program states that once the operational voltage of the PV panel is hot and bothered by a small increment, if the ensuing modification in power displaced person is positive, then we tend to are stepping into the direction of MPP and that we continue worrying within the same direction. If dP is negative, we tend to are leaving from the direction of MPP and therefore the sign of perturbation equipped must be modified. Figure 4.1 shows the plot of module output power versus module voltage for a solar battery at a given irradiation. The purpose marked as MPP is that the most wall plug, the theoretical most output procurable from the PV panel Take into account A and B as 2 in operation points. As shown within the figure on top of, the purpose A is on the paw aspect of the MPP. Therefore, we will move towards the MPP by providing a positive perturbation to the voltage. On the opposite hand, purpose B is on the proper hand aspect of the MPP.

After we provide a positive perturbation, the worth of displaced person becomes negative; therefore it's imperative to vary the direction of perturbation to attain MPP. The flow chart for the P & O algorithmic program is shown in Figure.

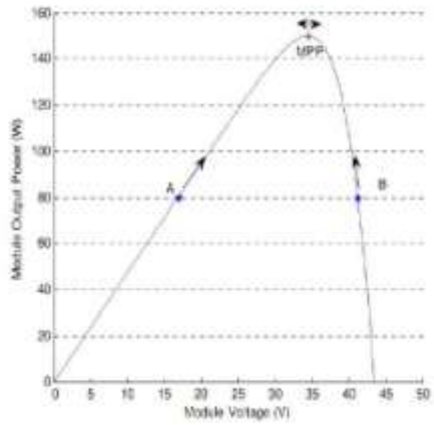

Fig. 4 module voltage versus module output power

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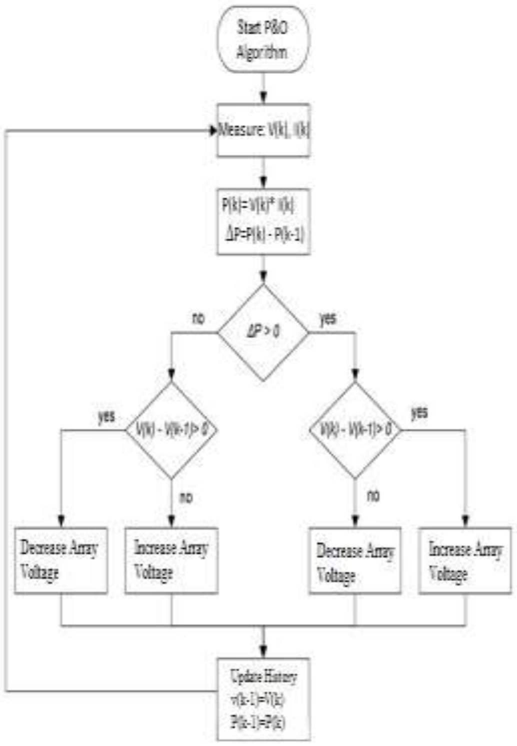

Fig. 5 algorithmic program of P & O

Limitations of Perturb & Observe algorithm:

During a scenario wherever the irradiance changes speedily, the MPP conjointly moves on the proper hand aspect of the curve. The algorithmic program takes it as a modification owing to perturbation and within the next iteration it changes the direction of perturbation and therefore goes far from the MPP as shown within the figure. However, during this algorithmic program we tend to use only 1 sensing element, that's the voltage sensing element, to sense the PV array voltage then the value of implementation is a smaller amount and therefore simple to implement. The time quality of this algorithmic program terribly is extremely is incredibly} less however on reaching very near the MPP it doesn't stop at the MPP and keeps on worrying in each the directions. Once this happens the algorithmic program has reached terribly near the MPP and that we will set an applicable error limit or will use a wait operate that lands up increasing the time quality of the algorithmic program but the strategy doesn't appreciate of the speedy modification of irradiation level (due to that MPPT modifications) and considers it as a change in MPP owing to perturbation and lands up calculative the incorrect MPP. To avoid this drawback we will use incremental conductance method.

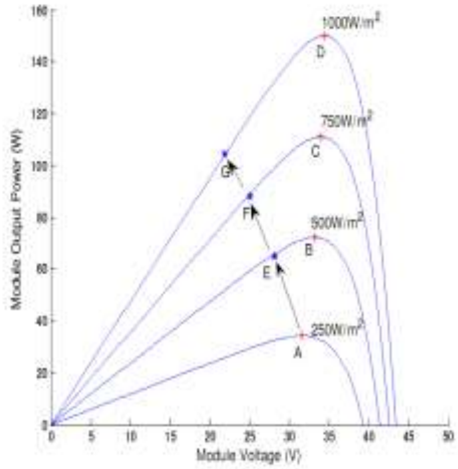

Fig. 6 module voltage versus power at 2d condition

IV. CONVERTOR CIRCUIT

As we all know analysis of star PV modules depends on cell, MPPT and device circuit thus here during this analysis I actually have used a normal boost convertor for P & O and with same parameter values made another model by using a feedback component to improve output. PI controller is used as a feedback circuit in which it is compared and boosted in comparison with the output voltage.

a) Open loop Boost Converter:

Once the switch S_1 is closed for time length t_1, the electrical device current rises and also the energy is keep within the electrical device. If the switch S_1 is opened for time length t_2, the energy keep within the electrical device is transferred to the load via the diode D_1 and also the electrical device current falls. The wave of the electrical device current is shown in fig.

Following observations are often made:

• The voltage across the load is often stepped up by variable the duty ratio D.

• The minimum output voltage is Vs and is obtained when D=zero

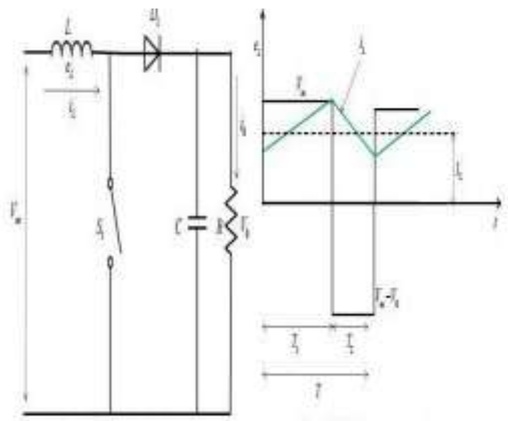

Fig. 7 Boost converter & its inductor current waveform

- The device cannot be switched on unendingly specified D=1. For values of D tending to unity, the output becomes terribly sensitive to changes in D For values of D tending to unity; the output becomes terribly sensitive to changes in fig.

b) Closed loop boost convertor:

Construction and working is same as normal boost convertor but here by using PI controller as a feedback circuit error signal is triggered so the output voltage is boosted which is nearly 45 % more than the boost with more soft output voltage. Fig shows the block structure of closed loop boost convertor connected to MPPT controller. The values that are set of PI are mentioned in data table.

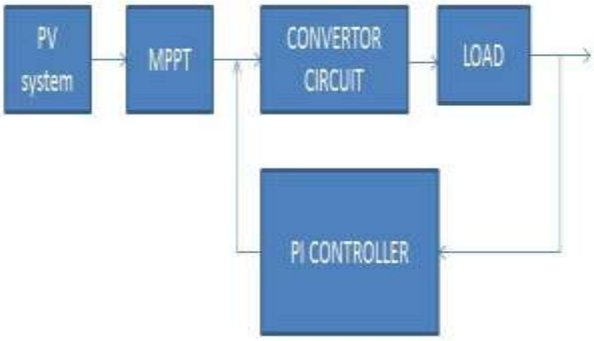

Fig. 8 closed loop boost convertor

V. SIMULATION AND RESULTS

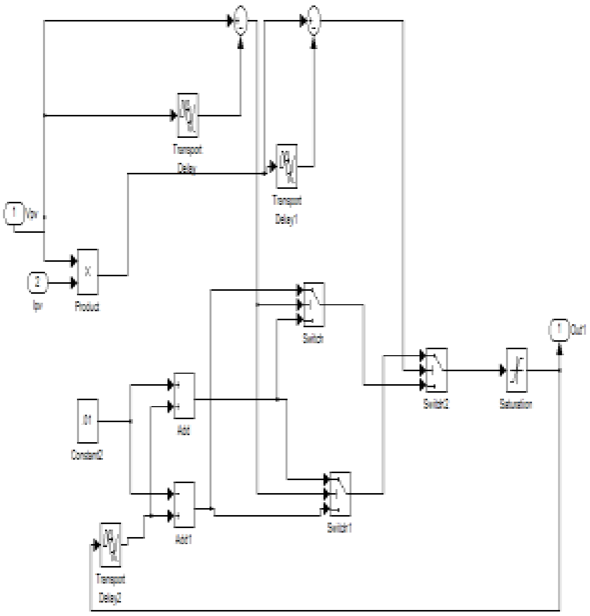

Fig. 9 Subsystem of P & O:

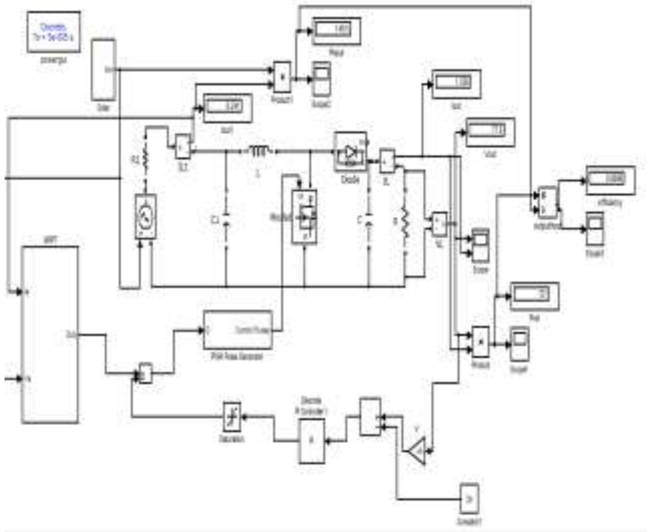

Fig. 10 Closed loop boost convertor:

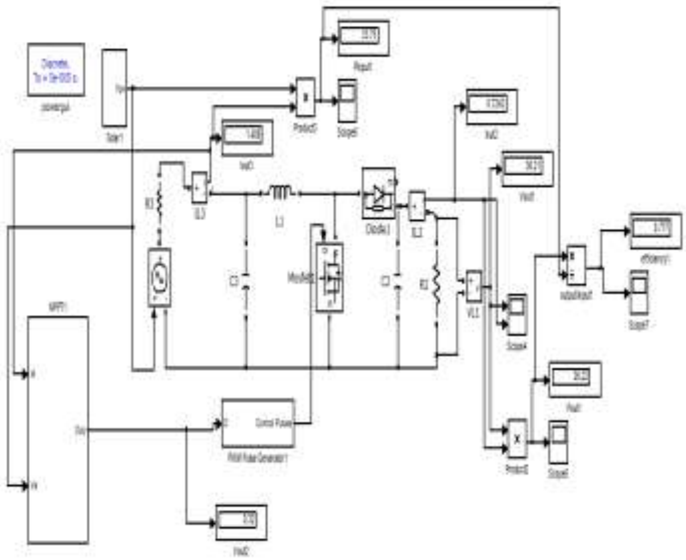

Fig. 11 Open loop boost convertor:

VI. RESULTS

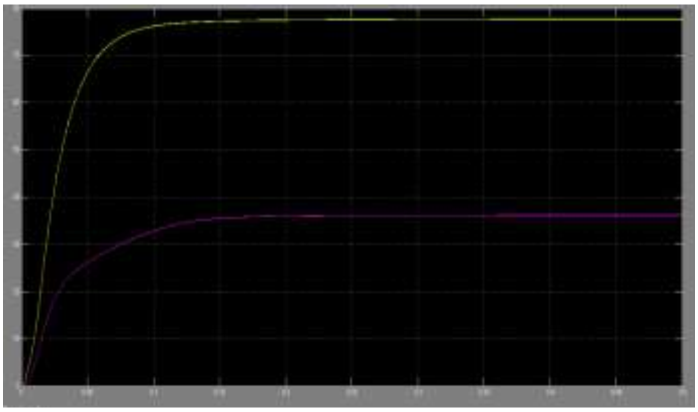

Fig. 12 Output voltage comparison:

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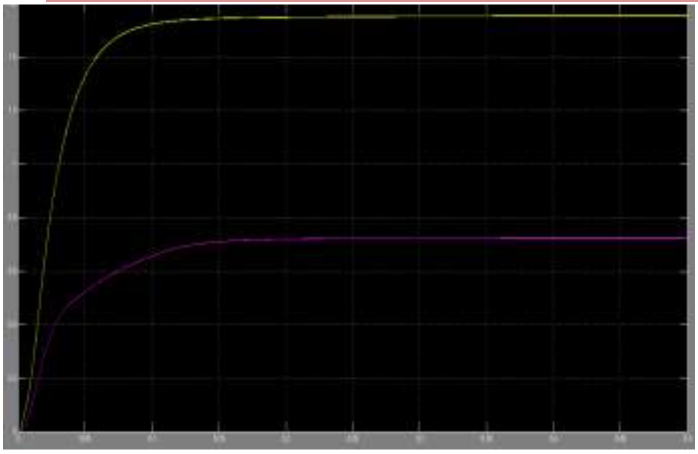

Fig.13 Output current comparison:

Simulation data:

Open Loop Boost Convertor	Closed Loop Boost Convertor
L=0.25 mH	L=0.25 mH
C_1= 220 µF	C_1= 220 µF
C_{out}= 2200 µF	C_{out}= 2200 µF
R_{load}= 50 Ω	R_{load}= 50 Ω
R_s=3.5 Ω	Rs=0.6 Ω Kp=0.6, K_i=80

Calculated results:

Parameter\Convertor	Open Loop	Closed Loop
Input Current (A)	1.409	6.427
Input Power (W)	33.75	154
Output Voltage(V)	36.21	82.14
Output Current (A)	0.7242	1.664
Output Power (W)	26.22	135.2
Efficiency (%)	77.78	87.79

VII. CONCLUSION

From these results we can conclude that if we can modify this system practically on hand with neat safe design specifications then the closed loop control will be in fame for solar for each and every method of maximum power point tracking techniques. For further research this feedback system can be developed for IDB, CUK, Buck Boost and SEPIC convertor for further research analysis.

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