Micro Grid Based MPPT Technique for Renewable Energy Source

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Abstract— **Era of renewable energy plays a vital role in reduction of carbon foot print on global scale; the renewable energy upholds the fidelity. Generation of renewable energy at a concentrated point is not feasible; the distributed generation is the key to unravel the shortage of energy source in future of power grid. Concretion goes on to solar based energy source which is low power density source, to squeeze maximum out of these power source, use very old technique that track the maximum power point. Various methods are available to achieve the same. In this paper, discussion of the maximum power point tracking with various methods were empirically analyzed using Simulink® simulation tool; proposed a hybrid combination of these method that relax the computation burden on the controller; in turn increase the power tracking ability and response. Power circuit has been validated found active time of the photovoltaic module was increased with the implement of proposed method.**

Keywords— **Maximum power point tracking (MPPT), Maximum power point (MPP), interleaved dc/dc converter, perturb and observe tracking algorithm, Constant voltage tracking algorithm.**

I. INTRODUCTION

Due to abundant need for energy, world energy requirement are fed form the fossil fuels like coal, petroleum products etc [1], which is polluting the earth with green house gases and global warming. The alternative source is renewable energy like solar energy is becoming a very crucial energy source for it advantage such as running fuel cost is nil, no green house effects, environmental friendly. These advantages have driven research and development of renewable energy sources. Among the other renewable energy resource electric energy for Photovoltaic is presently considered as the natural energy source, since it's free, abundant, clean, distributed over the Earth and participates as a primary factor of all other processes of energy production on Earth [2].

A wonderful fact about the Photovoltaic energy generation is the reduction of carbon dioxide emissions. Within the year 2030, the yearly reduction rate of CO_2 due to the usage of Photovoltaic's may around 1 billion tons/year, which is equaling to India's total emissions in 2004 [3]. In this context the amount of the power feed in by distributed energy resources is growing; the conventional grid with centralized power stations are to be replace gradually with the distributed energy resource mainly powered by the Photovoltaic energy which form a micro grid; which could operated stand-a-lone or can synchronize with the main power grid to supply power [4].

With the Photovoltaic energy source two major disadvantages:

- Very low conversion efficiency in range of (9-16)%;
- Panel output power variation with the ambient condition.

This in turn require to incorporate the maximum power point (MPPT) for the Photovoltaic array to maximize the active period of power generation and absorb the power at its peak irrespective of variation in ambient condition. The amount of energy generated by a photovoltaic depends on the solar insulation that falls on the panel surface and its current operating temperature, directly influence the operating power of a panel as shown in Fig. 1 which shows the power delivery of the panel to the supply voltage since the photovoltaic panel are consider to be constant current source the output power purely depend upon the terminal voltage Fig. 2 shows the current of a typical solar module vs. terminal voltage of the solar module.

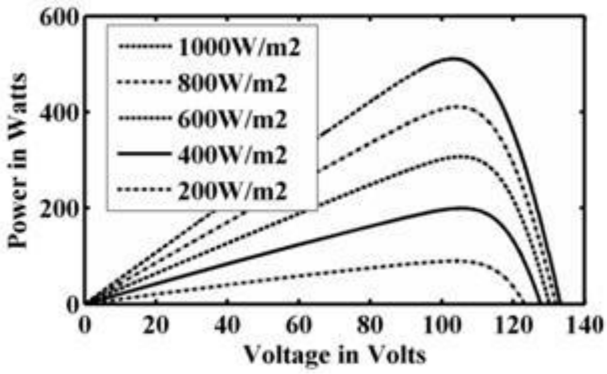

Fig. 1. P – V Characteristics of a Typical 500Wp Solar Module.

Characteristics show the nonlinearity of the solar module; which in turn gives a better understanding of its unique operating point for maximum possible power delivery. For making the solar module to operate at its maximum power delivery point; many methods of tracking this power point is developed by the various researchers. Still numerous soft computing techniques are proposed with heavy computational requirement, most practical and easy to implement algorithm to determine the maximum power point is employed through look up table on a microcontroller to track maximum power point. Here the real time system dynamics are not considered, the data is semi real time variation based on the pervious experimental results; which could not adapt to its present environment at same instant. Appling a dynamic Maximum power point tracker to solar module is the concept of perturb and observe (P&O) method, where in the real time sensor data are acquired and new reference point is set based on the change in the ambient condition [5]. To date many alternatives for fetching the Maximum power point is proposed like Incremental conductance technique (Inc Cond) [6], fuzzy logic control approach for hill-climbing method [7], through particle swarm optimization various steady state oscillation that will be present in other algorithm is avoided to proved maximum power [8].

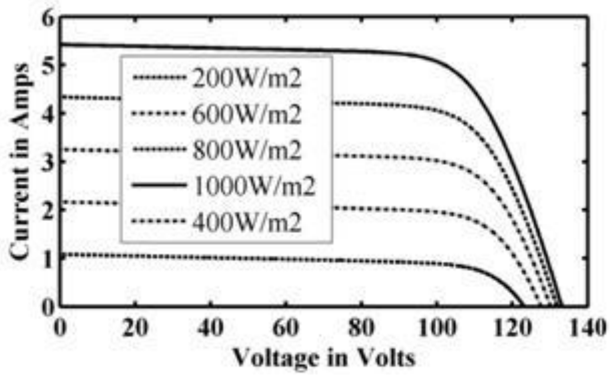

Fig. 2. I – V Characteristics of a Typical 500Wp Solar Module.

As far as the practical implementation of maximum power point tracking is concern P&O technique is favorite due to its simplicity and ease of implementation on a simple low end controller, with ruggedness that required in field. But the main disadvantage of P&O technique is the oscillation in the steady state due to constant increase and decrease of the reference value form the sample point. If the ambient condition various quickly like passing of cloud formation in atmosphere or any other sudden disturbances there will be oscillation in the power deliver in turn create a huge stress on the dc/dc converter that interfaced with the solar module. This creates a considerable amount of power transfer loss which is unavoidable. This triggered research and development to extended P&O technique a three point weight comparison method based on 8 bit single chip control unit by utilizing a boost converter to adjust the output of solar module for taking maximum power point algorithm [9]. The dc/dc converter charges the inductor sufficient enough, respect to the reference of generated by the algorithm. The time take to charge the inductor & discharge the inductor create a ripple which is normally been taken care by a bulky capacitor. Size of the capacitor depend upon the ripple value, here a hybrid method introduced; two different solar module coupled together to single DC bus with separate inductor, sensing circuit & controlling circuit been put together to evaluated its performance.

This paper is organized as follow next section with mathematical modeling of solar module, then followed by the traditional P&O and modified scheme for proposed system, the followed by simulation of the proposed system with result discussion finally the conclusion with further scope.

II. MATHEMATICAL MODELING

Solar modules use the light energy (i.e. insolation) from the sun to generate electricity through the photovoltaic effect that transforming the sun rays or photons directly into electric power. Solar module is made up of various series and parallel combination of solar cell which is PN union, whose electrical characteristic differ a very little form a normal PN diode, which in turn represented using a Shockley diode model equation give in Equation. For designing/modeling the solar cell which could be developed with easy based on following equation suggested [10].

$$I_d = I_{SAT} * \left(e^{\left[\frac{qV_{pv}}{AKT_{pv}}\right]} - 1 \right) \qquad (1)$$

where

- I_d is dark Current in Amps,
- I_{SAT} is saturation current of the Diode in Amps,
- V_{pv} is cell voltage in Voltage,
- q is Charge of an electron in Coulomb [$q = 1.602*10^{-19}$ Coulomb],
- A is diode ideality constant depend on the band gap of the material type [1.2 to 1.3 Si, 1.42 GaAs, 1.5 CdTe & 1.75 amorphous silicon],
- K is Boltzmann's constant [$K = 1.3806*10^{-23} J.K^{-1}$],

T_p is Cell Temperature in Kelvin.

To determine the gross output current from the cell, will be the difference of the photo current Ip; which current is generated by the isolation, and Id the normal diode current, as represented in Eq. (2).

$$I = I_p - I_d \qquad (2)$$

Substitution the Eq. (1) in Eq. (2) then the net output current from the solar cell, can be given as stated in Eq. (3)

$$I = I_p - I_{SAT} * \left(e^{\left[\frac{q(V_{pv} + I_{pv}R_s)}{AKT_{pv}}\right]} - 1 \right) \qquad (3)$$

From the work presented by J.A. Gow; were above equation presents the simplified model, which the ideal solar cell, theoretically be modeled as a current source with an anti-parallel diode shown (Fig 1). Eq. (3) does not represent the I-V characteristics of a practical PV module, to achieve more of a realistic model of the PV module; series and shunt resistance are added to the model. In the real operation of the solar cell some losses exit, these resistances is added into the model as a resistance in series R_s which is an intrinsic series resistance of the diode and another shunt resistance R_{sh} [11]. Remodeling the Eq. (3) with newly added resistance which gives you the realistic value of I-V characteristics of practical PV module is given in Eq. (4).

$$I = I_p - I_{SAT} * \left(e^{\left[\frac{q(V_{pv} + I_{pv} R_s)}{AKT_{pv}}\right]} - 1 \right) - \frac{(V + IR_s)}{R_{sh}} \quad (4)$$

Eq. (4) can be re-modified to obtain the value in term of terminal voltage as given in Eq. (5).

$$V_c = \frac{AKT_{pv}}{q} \ln \left[\frac{I_{pv} + I_{sat} - I}{I_{sat}}\right] - R_s I \quad (5)$$

The PV panel here considered is a typical 205Wp PV model composed of 60 multi crystalline cells in 10x6 cell configuration. Its main specification is shown in Table 1, with STC = 1000W/m^2; Temp=25C; A.M = 1.5. I-V characteristic is shown in (Fig. 1) and P-V characteristics is shown in (Fig. 2) these figure show the power output of PV module is the function of irradiance and temperature respectively. These curves are nonlinear and are crucially influenced by isolation and ambient temperature.

TABLE I
Specifications for the Solar Module 205 Wp [KOTAKURJA PANELS]

Terms	Quantity	Rating values
Voc	Open Circuit voltage	36.12 Volts
Isc	Short circuit current	7.62 Amps
Vmp	Max Voltage @ load	29.63 Volts
Imp	Max Current @ load	6.92 Amps
Pmax	Max Power	205Wp
Operating Temp	Operation temp range	-40 C to +85 C
NOCT	Normal operating cell temp	48 C +/- 2 C
Tsc	Temp Co-efficient of Current Isc	0.09%/C
Toc	Temp Co-efficient of voltage Voc	-0.34%/C

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III. SIMULATIONS AND RESULTS

The 205Wp PV module selected for modeling due to its avaliablity and cost factor. This panel deliver a 205W at standard test condition with a nominal maximum power and it has 60 multi crystalline cells in 10x6 cell configuration the specification are shown in Table 1.

Simulink modeling of the panel was implemented in Matlab environment, the proposed dc/dc converter topology is shown in Fig. 3. Block diagram shows the two independent source of panel unlike the normal scheme were two dc/dc converters is connected to single source. These two panels is feed with two different type of isolation to simulate the practical scenario. To maintain the maximum power point the two individual MPPT point is computed form the individual sensor data. Depend upon the computed MPPT point the S1 & S2 of the converter is triggered in a toggle action.

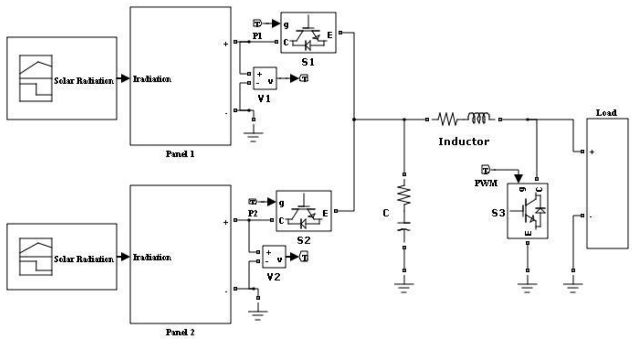

Fig. 3. Block Diagram of the system.

Data used for simulating the solar insolation, is taken from the daily isolation over the campus as shown in Fig 4 & 5.

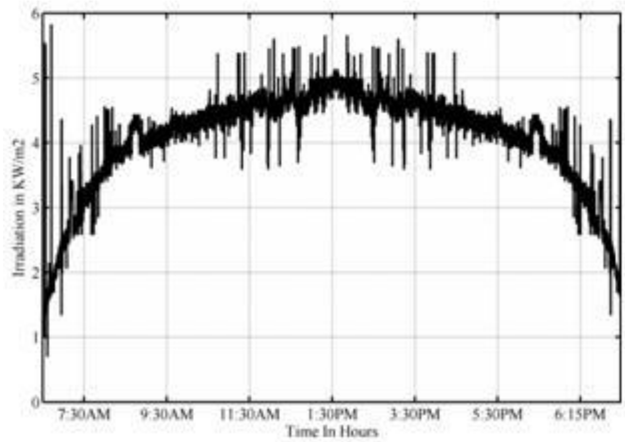

Fig. 4. Data Acquired on 2nd March 2012.

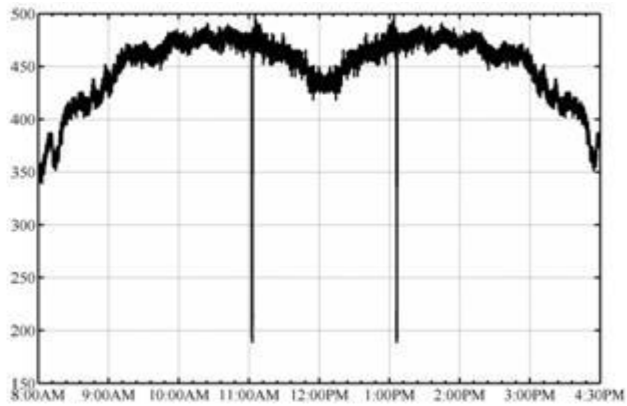

Fig. 5. Data Acquired on 25th June 2012.

Fig.4 shows a clear sky on that day with the maximum irradiation on the panel. Fig. 5 shows a semi cloudy day were clouds passing by. These two data are been used to simulated the proposed interleave scheme of the DC/DC system.

Output of the simulated system is shown in Fig.6. The output sine wave is supplied to the grid the source supplying the harvested energy from the solar to power grid.

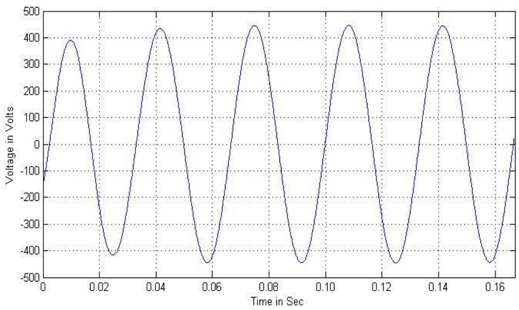

Fig. 6. Load Waveform of 3phase supply.

IV. CONCLUSIONS

In this manuscript the proposed technique provides a high superior method to track the maximum power point, with low computational requirement and sensing the real time voltage and current achieved quickly & easily for measurement of the pannel performance to its ambient condition. Methodologies employed here could be adapted for small power scale panel, with a help of sample and hold circuit, while the measuremnt of voltage & current are done.

Stability and avaliability of the power deliver to the load is increased by 6% than woithout maximum power point technique in the solar module. Modular design of this alogrithm with low rate microcontroller will help to provide a reliable power to DC rail even when there is a passing of cloud or other kind of natural & artifical phenomenon.

This work could be extented by employing the various softcomputing techniques for inverter topologies at the load side of the converter to interface with the AC power grid with improving power quality.

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