DESIGN AND SIMULATION OF SOLAR PV SYSTEM BY USING MLI-MPPT CONTROL

Arth Patel
Dept. of Electrical Engineering
Ganpat University, Mahesana, India
abp05@ganpatuniversity.ac.in

Shakti Thakkar
Dept. of Electrical Engineering
Ganpat University, Mahesana, India
srt01@ganpatuniversity.ac.in

Rajendra V. Patel
Dept. of Electrical Engineering
Ganpat University, Mahesana, India
rajendra.v.patel@ganpatuniversity.ac.in

***Abstract*—** Nowadays, renewable energy resources play a very vital role in replacing with the conventional fossil fuel energy resources. Photovoltaic energy is very beneficial renewable energy resources which grew rapidly in the past few years and still growing. Photovoltaics has one of the major problems and which is that with the variation of the operating conditions of the array affects the voltage at which maximum power can be obtained from it also changes. A PV model is used to simulate actual PV arrays behavior, and then a Maximum Power Point tracking method using P&O and MLI are proposed in order to control the DC-DC converter. An inverter scheme is also developed to maintain the DC-link voltage at a constant value which facilitates the maximum power point tracking process. Furthermore, the conventional perturb and observe maximum power point tracking method and MLI are simulated. A grid-connected complete photovoltaic model is generated to simulate the actual life

Keywords— PV array, DC-DC converter, P&O and MLI technique.

I. INTRODUCTION

The power delivered by a PV system of one or more photovoltaic cells is dependent on the radiance, temperature, and the current drawn from the cells. Maximum Power Point Tracking (MPPT) is used to obtain the maximum power from these systems. Such applications as putting power on the grid, charging batteries, or powering an electric motor benefit from MPPT. In these applications, the load can demand more power than the PV system can deliver power conversion system is used to maximize the power from the PV system. There are many different approaches to maximizing the power from a PV system, these range from using simple voltage relationships to more complex multiple sample-based analysis. Depending on the end application and the dynamics of the irradiance, the power conversion engineer needs to evaluate the various options.

II. MAXIMUM POWER POINT TRACKING

The maximum power point (MPP) of any PV varies with the variation of the atmospheric conditions (solar irradiance and temperature). This means there is always one optimum terminal voltage for PV array to operate at with each condition which is shown in figure, to obtain the maximum power out of it i.e., Increase the array's efficiency overcoming thermal resistance. DC-DC converter plays very important role in the MPPT process by connecting the array's output terminals with the DC-DC converter's input terminals, the array voltage can be controlled by varying the duty cycle of the converter and the voltage at which maximum power is obtained can be maintained. DC-AC inverter's main task is to convert from DC Power to AC and hence it could be tied to the grid. The inverter has also played a very important role in the MPPT process which is fixing the DC-link voltage at certain value. By the variations of the duty cycle of the DC-DC converter will change the array's terminal voltage only in case of fixing the output voltage of the DC-DC converter at the certain value, a control schemes for the DC-AC inverter are used to keep the DC link voltage constant (which is the DC-DC output voltage also) and thus, varying the duty cycle of the DC-DC converter varies the array's terminal voltage.

III. MPPT METHODS & MLI

A. Perturbation and Observation (P & O) Method

The P & O algorithm as shown below it operates by increasing or decreasing the array terminal voltage, or current, at regular intervals and then by comparing the PV output power with that of the previous sample. If the PV array operating voltage changed and power increases

(dP/dV PV > 0), the control system adjusts the PV array operating point in that same direction; otherwise, the operating point is moves in the opposite direction. At each perturbation point, the algorithm will continue to operate in the same manners. The main advantages of this approach the simplicity of the techniques. And further, previous knowledge of the PV panel characteristics is not required. its simplest form, this method generally exhibits good performance which is provided the solar irradiation does not vary too quick. The algorithm operates by increasing the duty cycles until the PV output voltage is close to the open circuit voltage of the panel (VOC), this and after that is used as the initial conditions for the MPP tracker.

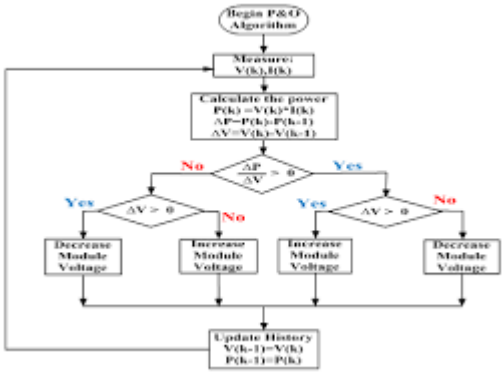

Fig.1 Flow Chart of P&O

Method Simulation results in demonstrate that overall greater energy can be extracted from PV panel. Efficiency levels of the 95% to 99% are quoted over a wide irradiation range.

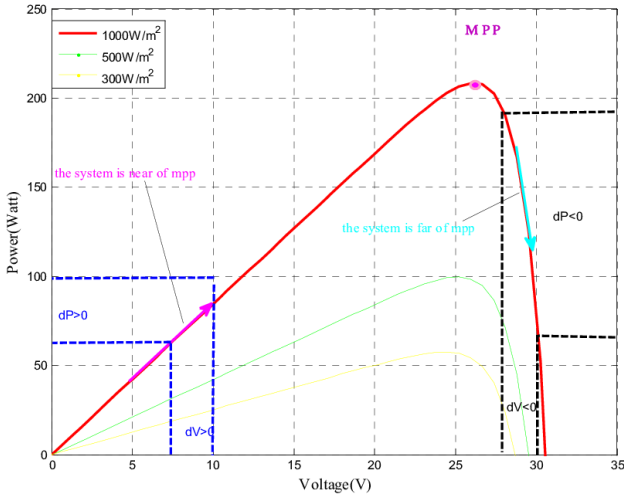

Fig. 2 Graph Power versus Voltage for Perturb and Observe Algorithm

B. MLI Method

The term SPWM stands for “Sinusoidal pulse width modulation” is a technique of pulse width modulation used in inverters. An inverter generates an output of AC voltage from an input of DC with the help of switching circuits to reproduce a sine wave by generating one or more square pulses of voltage per half cycle. If the size of the pulses is adjusted, the output is said to be pulse width modulated. With this modulation, some pulses are produced per half cycle. The pulses close to the ends of the half cycle are constantly narrower than the pulses close to the center of the half cycle such that the pulse widths are comparative to the equivalent amplitude of a sine wave at that part of the cycle. To change the efficient output voltage, the widths of all pulses are amplified or reduced while keeping the sinusoidal proportionality. With PWM (pulse width modulation), only the on-time of the pulses are changed during the amplitudes.

A. Inverter

The Inverter is an electrical device that converts direct current (DC) to alternate current (AC). The inverter is used for emergency backup power in a home. The inverter is used in some aircraft systems to convert a portion of the aircraft DC power to AC. The AC power is used mainly for electrical devices like lights, radar, radio, motor, and other devices.

B. Multilevel Inverter

Now a day’s many industrial applications have begun to require high power. Some appliances in the industries, however, require medium or low power for their operation. Using a high-power source for all industrial loads may prove beneficial to some motors requiring high power, while it may damage the other loads. Some medium voltage motor drives and utility applications require medium voltage. The multi-level inverter has been introduced since 1975 as an alternative in high power and medium voltage situations. The Multilevel inverter is like an inverter and it is used for industrial applications as an alternative in high power and medium voltage situations.

C. General DC-AC Inverter Circuit

The need for the multilevel converter is to give high output power from the medium voltage source. Sources like

batteries, supercapacitors, the solar panel are medium voltage sources. The multi-level inverter consists of several switches. In the multi-level inverter, the arrangement switches' angles are very important. There are 3 types of MLI.

- Diode clamped multilevel inverter
- Flying capacitors multilevel inverter
- Cascaded H- bridge multilevel inverter

Among that all inverter we are using Diode clamped multilevel inverter.

I. Diode Clamped Multilevel Inverter.

The main concept of this inverter is to use diodes and provides the multiple voltage levels through the different phases to the capacitor banks which are in series. A diode transfers a limited amount of voltage, thereby reducing the stress on other electrical devices. The maximum output voltage is half of the input DC voltage. It is the main drawback of the diode clamped multilevel inverter. This problem can be solved by increasing the switches, diodes, capacitors. Due to the capacitor balancing issues, these are limited to the three levels. This type of inverters provides high efficiency because of the fundamental frequency used for all the switching devices and it is a simple method of the back-to-back power transfer systems. The 5- level diode clamped multilevel inverter uses switches, diodes; a single capacitor is used, so the output voltage is half of the input DC.

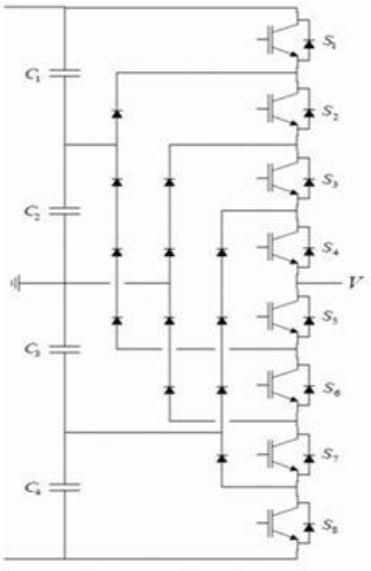

Fig.4 (5-Levael Diode Clamped Multilevel Inverter)

IV. Model and Simulation

A. MPPT system

The model shown in Fig. represents a block diagram of a PV array connected to a resistive load through a dc/dc (boost) converter with MPPT controller.

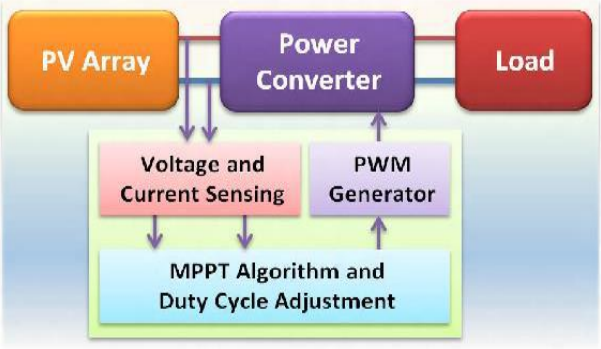

Fig. 5 Block diagram of a PV array connected to the load

In the model of PV panel as a constant dc source created using the subsystem block from Simulink library browser, which included all functions of PV panel. The model has three inputs irradiance, temperature and voltage input that is coming as feedback from the system and the output of the block gives the current. This model generates current and receives voltage back from the circuit.

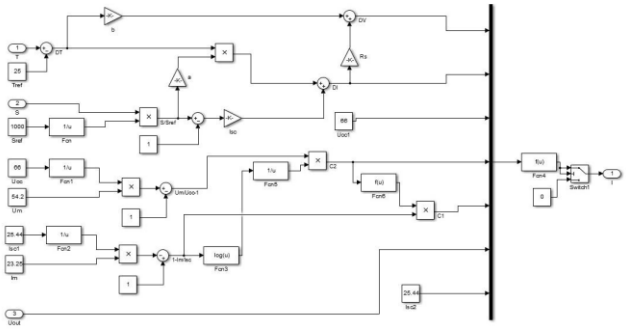

Fig. 6 PV subsystem

B. Boost Converter

DC-DC boost power converters play vital role in solar power systems: they step up the input voltage of solar array for given set of condition. Each boost converter is evaluated on its capability to operate efficient, size, and cost implementation. Model (Perturb & Observe).

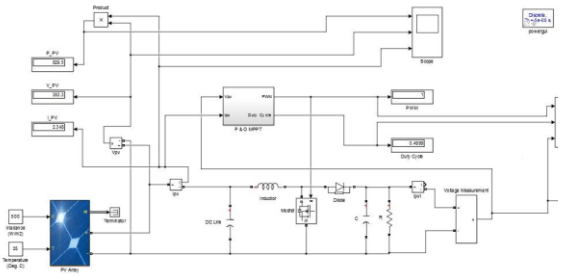

Fig. 6 Boost Converter with Perturb & Observe Method

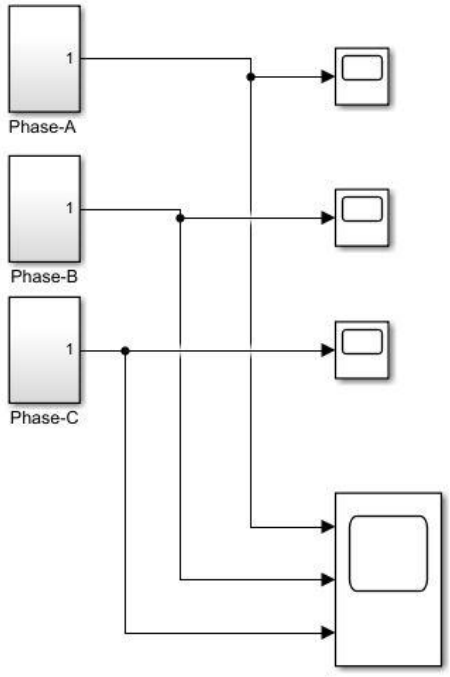

Fig.7 MLI 3-phase system

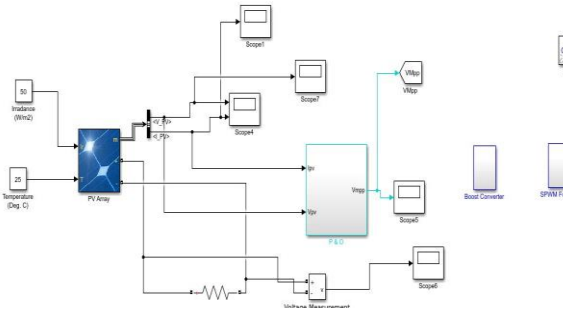

Fig.8 P&O connected with MLI system

Simulations Results

DC-DC boost power converters play vital role in solar power systems they step up the input voltage of solar array for given set of condition.

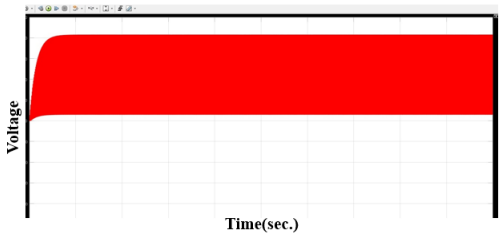

Fig.9 Boost converter Voltage vs time(sec) without MLI

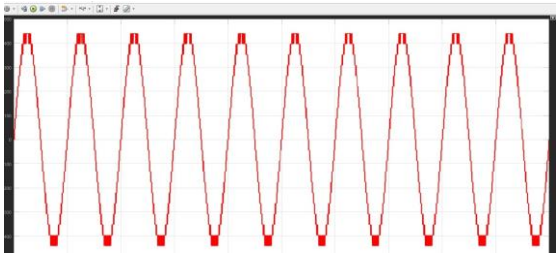

Fig.10 1- Phase P&O Voltage with MLI

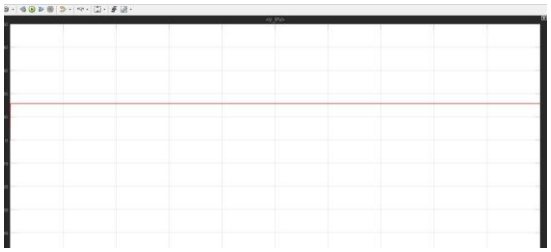

Fig.11 <V_PV> With MLI

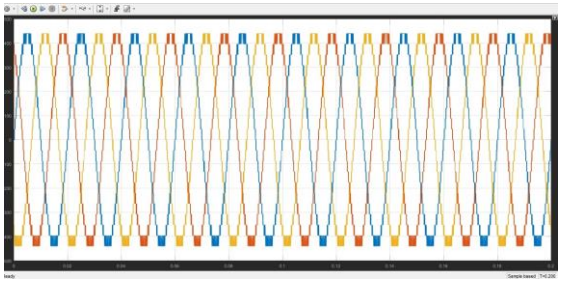

Fig.12 3-Phase P&O Voltage with MLI

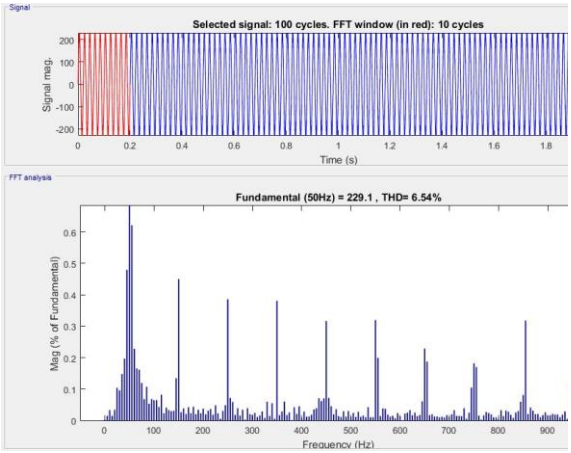

Fig.13 FFT analysis result

The simulation result at constant temperature (T=25 degree) with changes in the insolation (S=1000 w/m²) From Fig. the results below including current, voltage and power as below.

Parameters	Value
V_P_v	15 V
O\P Voltage (V Boost)	40 V
THD	6.54
3-Phase Voltage	440 V
1-Phase Voltage	440 V
F_s	5 KHz

V. CONCLUSION

We had simulated the converters by using MPPT so by this MPP changes with the change in external environment quickly. Boost converter has succeeded to track MPP. And the technique used is P&O and MLI method the advantageous method is MLI method because it can determine when you reach the MPP without having to oscillate around this value which rapidly increase and decrease irradiance condition with high accuracy than P&O method. The only advantage of MLI is that when we applied output voltage of solar PV to 3-Phase MLI then we get sinusoidal output voltage with low THD. And due to Low THD design of L-C filter is easy and economical.

VII. REFERENCES

1. Literature survey on maximum power point tracking (MPPT) technique for photovoltaic (PV) system, Umesh T. Kute, Preeti S. Ratnaparkhi, IJAREAS Vol. 2 No. 12 December 2013.
2. Modeling of Maximum Power Point Tracking Algorithm for Photovoltaic Systems, Ioan Viorel Banu,Marcel Istrate "Gheorghe Asachi" Technical University of Iasi.
3. Modeling and Simulation of PV Array and its Performance Enhancement Using MPPT (P&O) Technique, T.Chaitanya, Ch.Saibabu, International Journal of Computer Science & Communication Networks,Vol 1(1),September-October 2011.
4. H.Knopf, "Analysis, Simulation, and Evaluation of Maximum Power Point Tracking (MPPT) Methods for a Solar Power Vehicle," in Electrical and Computer Engineering, Master Thesis in Electrical and Computer Engineering: Portland State University 1999.
5. Yen-Jung M. Tung, A.P. Hu and N.K. Nair "Evaluation of Micro Controller Based Maximum Power Point Tracking Methods Using DSPACE Platform" Australian University Power Engineering Conference, 2006.