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A REVIEW ON THREE PHASE GRID CONNECTED PV SYSTEM USING THREE LEVEL CASCADED H BRIDGE MULTILEVEL INVERTER

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ABSTRACT
In the recent trend of using green energy, grid connected Photovoltaic (PV) systems are getting more popular. This paper aim to review on, multilevel inverter based single-stage grid connected photovoltaic system based on cascaded three-level inverter is carried out using MATLAB/Simulink. The inverters are controlled using hysteresis current controller for which the synchronizing reference currents are generated using d-q theory. The maximum power is extracted from the PV array under varying environmental condition. The cascaded three-level inverter based grid connected PV system is simulated for injecting active power produced by the PV array under varying solar insolation.

Keywords: Photovoltaic (PV) system; multilevel inverter; cascaded three-level inverter, Individual maximum power point tracking.

INTRODUCTION
Nowadays, the major worldwide problem is of pollution control and energy crisis. The grid connected Photovoltaic (PV) system is one of the promising alternative for sustainable and independent energy resource. The power electronic technology plays an important role in distributed generation and in integration of renewable energy sources to the electrical grid, and it is widely used and rapidly expanding [5]. Single-stage and two-stage grid-connected systems are commonly used topologies in PV applications [6], [8]. Two-stage system, has some disadvantages what are less efficient, being larger and more costly disadvantage. Therefore single-stage structure is widely used today due to small size, low cost, high efficiency and high reliability. Higher power equipments require higher voltages, which limit the maximum DC voltage level. Therefore a new family of multilevel inverters has emerged as the solution for solar applications, as the PV array is directly connected to each level of the DC link.The Cascaded three level inverter based grid connected PV system is a single-stage system in which the MPP tracking is achieved by the control of inverter. The Cascaded three level inverter based grid connected PV system uses only one power processing stage and hence reduces the components and cost.

MULTI-LEVEL TOPOLOGY
A. General Description
In this paper operation of three-phase, three-level cascade H bridge inverter for the grid-connected PV system. Conventional diagram of the proposed system is shown in figure 1. DQ control technique has been used for PV system active power injection as well as harmonics free current injection the grid. Hysteresis PWM technique has been used for switching of the inverter.

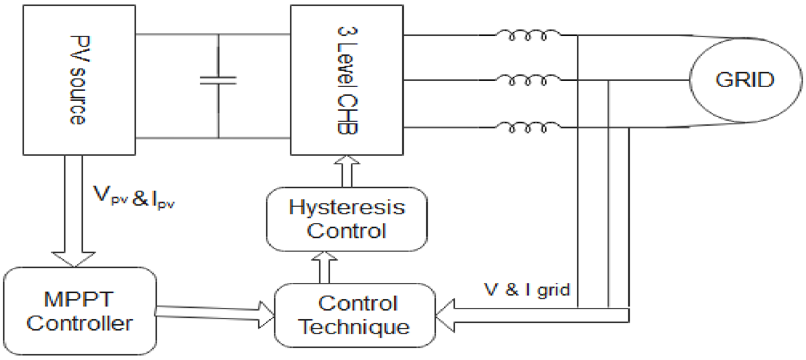


Fig. 1. Block diagram of proposed Scheme

Perturb & Observe method is used for MPPT. Model is simulated for both equal and unequal irradiance values.

B. CASCADED H-BRIDGE MULTILEVEL INVERTER

The multilevel inverter using with separate DC source, that DC source may be obtain from batteries, fuel cell and solar cell. Nowadays this topology becomes very popular in high power supply and adjustable speed drive application. When two or more H-Bridge connecting in series their output voltage can be combine to form different output levels, increasing total output voltage and its rated power also increases. In general term when n number of H-Bridge connected in series 2n+1 different voltage level is obtained. If we connect one H-Bridge in series then three level output voltage is obtain.

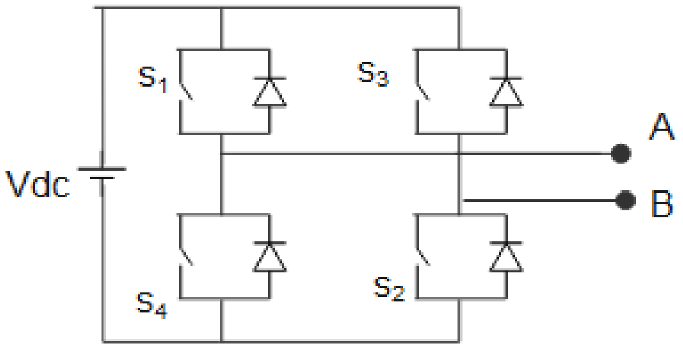


Fig.2 H-bridge cell of CHB Multilevel Inverter

C.PV Array

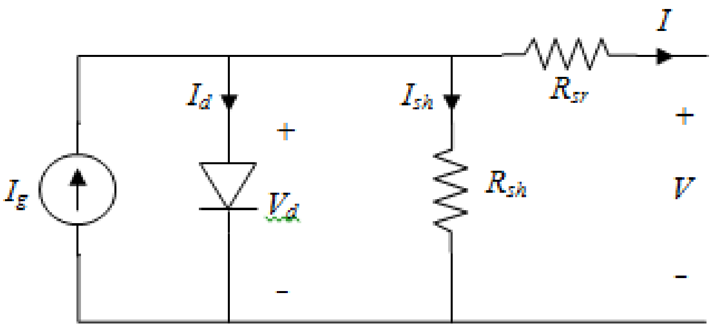


Fig.3 Single Diode model of PV cell[5]

$$I_0 = I_0 R \left(\frac{T_c^3}{T_{CR}^3}\right) exp\left[\left(\frac{1}{T_{CR}} - \frac{1}{T_c}\right)\frac{qe_g}{nk}\right] \ldots(1)$$

I_{oR} is the reference dark current. The other parameters are the electron charge q, the Boltzman constant k, the band-gap energy of the PV cell e_g, and the diode Ideality factor n which is used to adjust the characteristic I − V curves.

Perturb & Observe Method

The Proposed P&O method for single stage multilevel inverter topology is used to produce reference output power.In this method the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be. the core idea of the MPPT technique is to automatically adjust its output voltage and current in terms of V_{MPP} and I_{MPP} under which the PV array can output the maximum power. A flowchart of this method is shown in fig.4

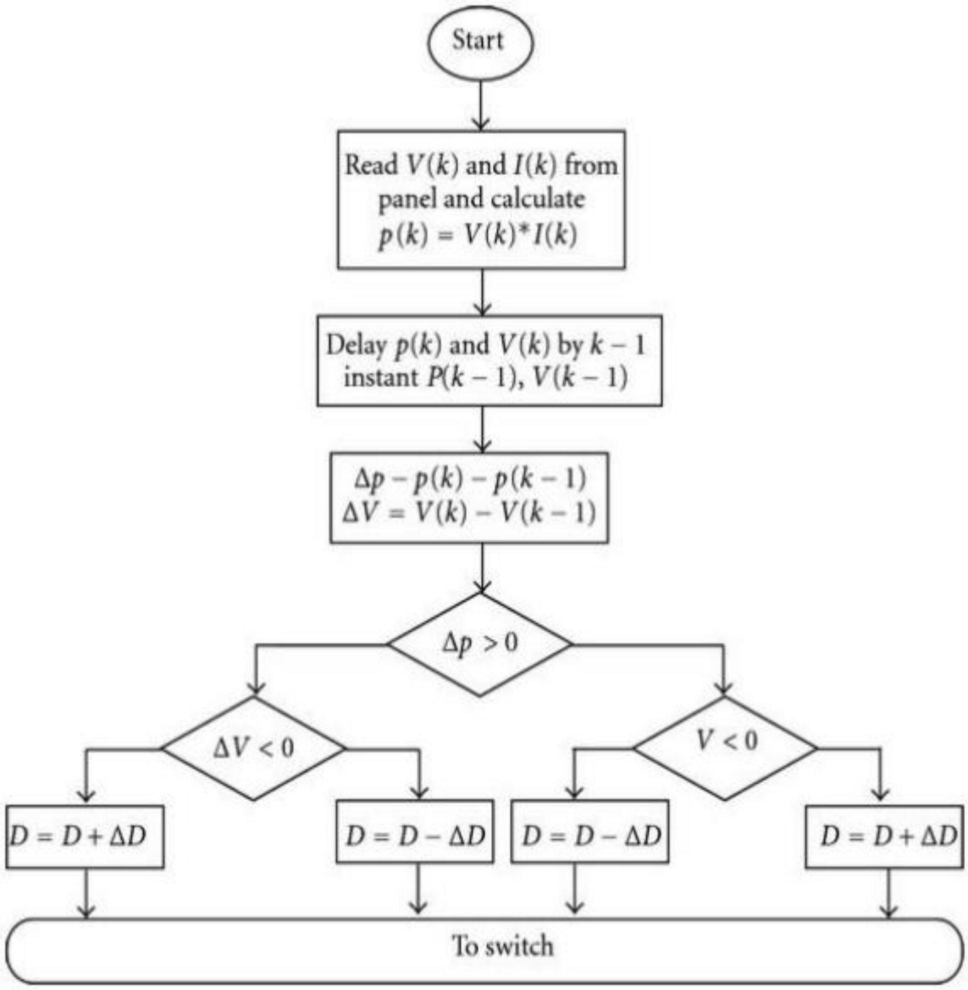


Fig.4 Flow chart of Perturb & Observe Methhod[4]

CONTROL SCHEME OF CASCADED THREE-LEVEL INVERTER

The control scheme of cascaded three-level inverter based single-stage grid connected PV system consists of three parts:

(i) The maximum power point tracking (P&O) technique to extract maximum power from each of the PV array under varying environmental conditions and generate active power reference for the control of inverter.

(ii) The control of the cascaded three level inverter is based on (d-q) theory [6] that generates the reference current to be injected in the grid.

(iii) The switching pulses for the inverter are generated based on comparison of reference current with the sensed inverter current using hysteresis current controller.

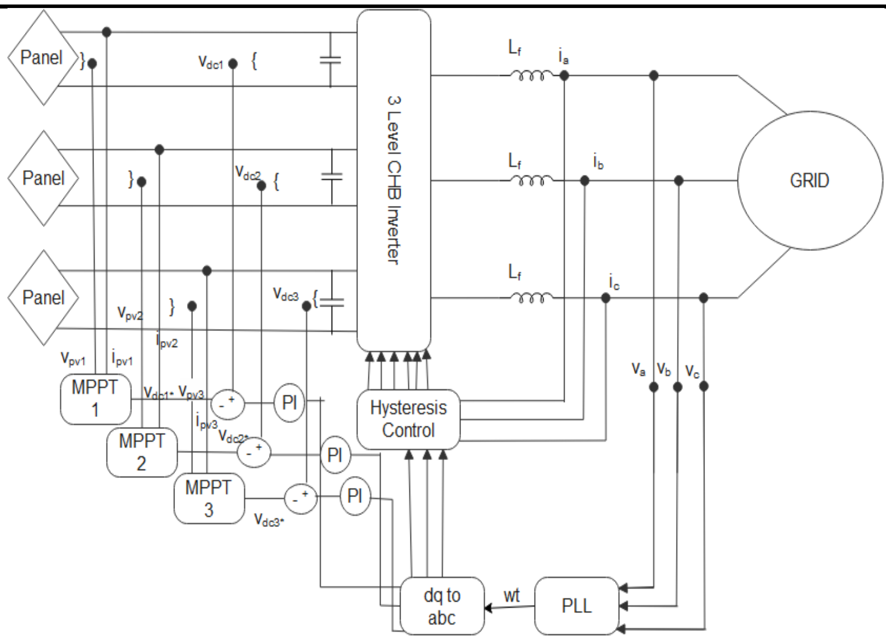


Fig. 5. Control Scheme Block Diagram of single stage grid connected PV system[6]

The grid-connected PV system and its topology and control strategy. The system can supply active power as well as current harmonics when irradiation is enough. In this study, the MPPT system is integrated with the DC-link controller so that a DC–DC converter is not needed and the output shows accurate and fast response. Fig. 5 shows the control block diagram of the single-stage grid-connected PV system.In the control structure of the combined system one of active current reference components id_vdc* is provided for active power injection, the dc-link voltage is set by a PI controller that compares the actual dc-link voltage and the reference generated by the P&O MPPT method

Individual MPPT Control

In order to eliminate the adverse effect of the mismatches and increase the efficiency of the PV system, the PV modules need to operate at different voltages to improve the utilization per PV module. The separate DC links in the cascaded H-bridge multilevel inverter make independent voltage control possible. To realize individual MPPT control in each PV module, the control scheme proposed in [7] is updated for this application. The distributed MPPT control of the three-phase cascaded H-bridge inverter is shown in Fig. 3. In each H bridge module, an MPPT controller is added to generate the dc-link voltage reference. Each dc-link voltage is compared to the corresponding voltage reference, and the sum of all the errors is controlled through a total voltage controller that determines. the current reference Idref. The reactive current reference Iqref can be set to zero. The Synchronous Reference Frame Phase-locked Loop (SRF-PLL) has been used to find the phase angle of the grid voltage. As the classic control scheme in three-phase systems, the grid currents in abc coordinates are converted to dq coordinates, and regulated through PI controllers. which is dq coordinates converted back to three-phase.

Table I Simulation Parameters

PV array Parameters	**Value**
Nominal Maximum Power (P_m)	150 Watt
Open Circuit Voltage (V_{oc})	44.30 Volt
Short Circuit Current (I_{sc})	4.51 Amp
Voltage at Maximum Power (V_{mp})	36.10 Volt
Current at Maximum Power (I_{mp})	4.16Amp
Grid Parameter	**Value**
Voltage	400Vrms(L-N)
Frequency	50Hz
DC link Voltage	350 Volt

Simulations Results

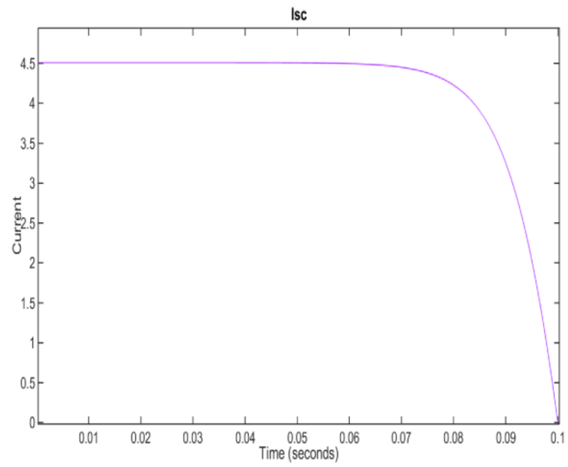


Fig.6 Current of PV Panel

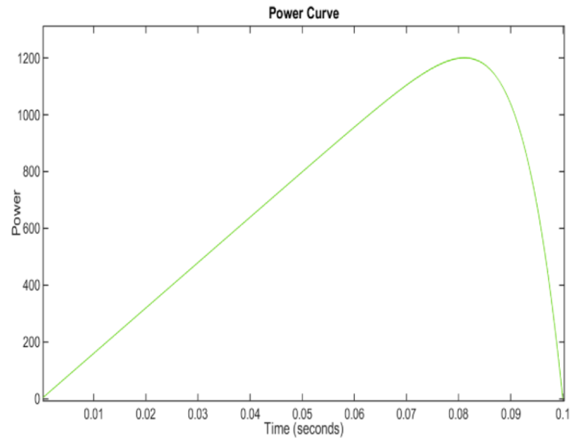
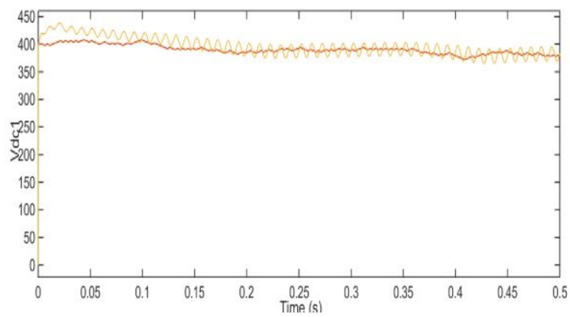
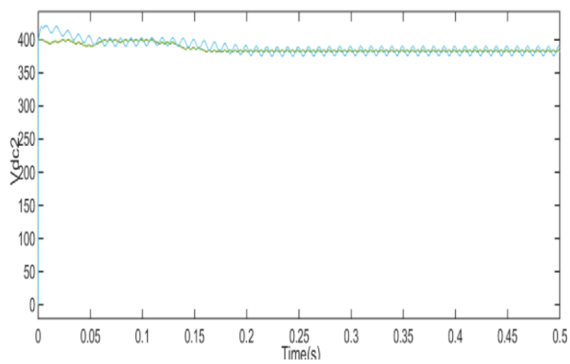


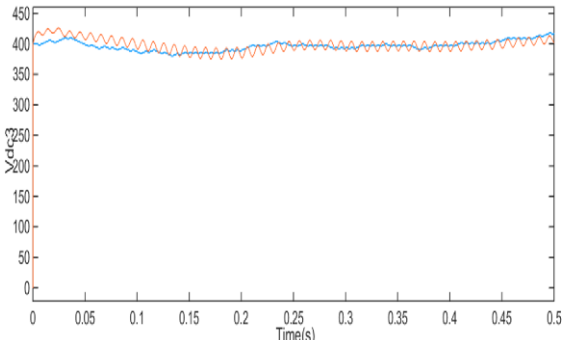
Fig.7 Power extracted from PV panels



(a)



(b)



(c)

Fig.8 DC Link Voltage (a) Phase A (b) Phase B (c) Phase C

To verify the proposed control scheme, the three-phase grid-connected PV inverter is simulated in two different conditions. First, all PV panels are operated under the same irradiance S=1000 W/m2 and temperature T=25 ˚C. the solar irradiance on the panels of phase a 1000 W/m2 , and that for the phase b panels decreases to 600 W/m2 phase c panel 750W/m2 The dc-link voltages of phase a are shown in Fig. 8(a). At the beginning, all PV panels are operated at the MPP voltage 350 V. As the irradiance changes, the dc-link voltages decrease and track the new MPP voltage of 350V, while the third panel is still operated at 350.4 V. The PV current waveforms are shown in Fig.12.The currents of the first and second PV panels are much smaller due to the low irradiance, and the lower ripple of the dc-link voltage can be found in Fig. 8(a). The dc-link voltages of phase b are shown in Fig.8(b). The dc-link voltages of phase c are shown in Fig.8(c). All phase b panels track the MPP voltage of 350 V, which shows that they are not influenced by other phases. With the distributed MPPT control, the dc-link voltage of each H bridge can be controlled independently. In the other words, the connected PV panel of each H-bridge can be operated at its own MPP voltage and will not be influenced by the panels connected to other H- bridges. Thus, more solar energy can be extracted, and the efficiency of the overall PV system will be increased.

The grid current has the same phase as the grid voltage and has unity power factor. The THD of the grid current is 4.38%, as shown in Fig. 13, which is less than 5% and meets the power quality standards.

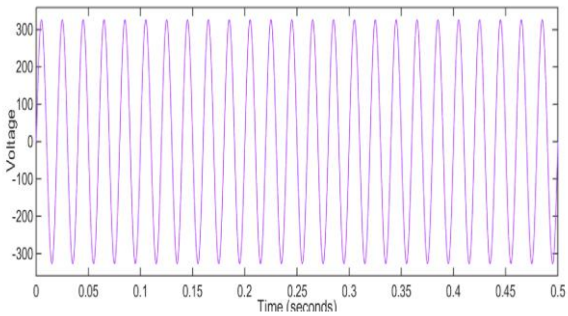


Fig.9 Grid Voltage Waveform

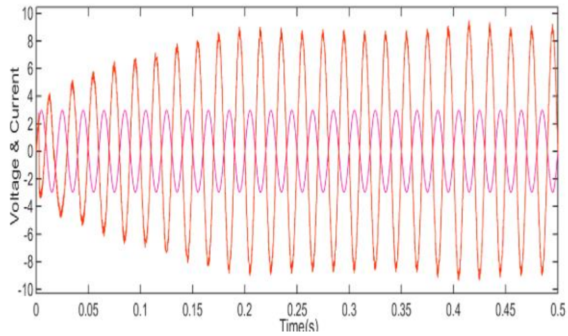


Fig.10 Voltage and current waveforms of grid

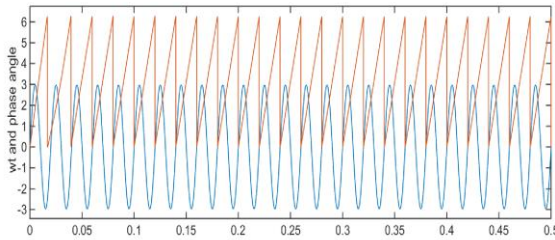


Fig.11 Phase angle of grid Voltage

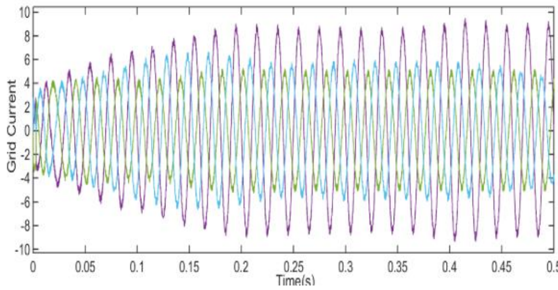


Fig.12 Grid current of different irradiance

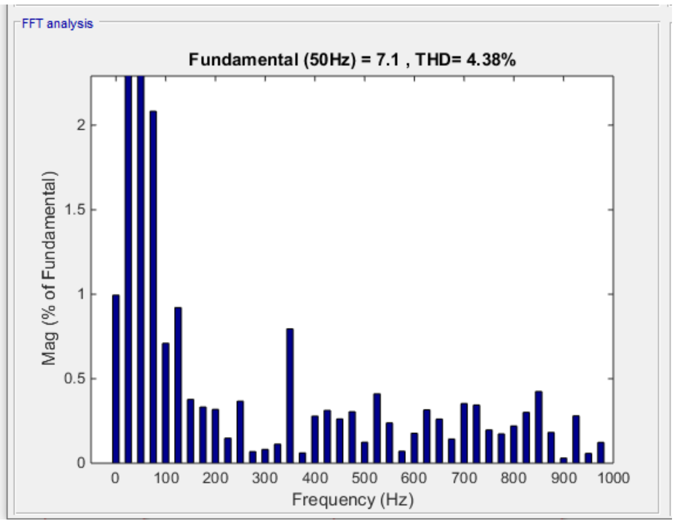


Fig.13 THD of the grid current

CONCLUSION

In this paper, a cascaded H-bridge multilevel inverter for grid-connected PV applications has been presented. The multilevel inverter topology will help to improve the utilization of connected PV modules if the voltages of the separate DC links are controlled independently. Thus, a Individual MPPT control scheme for three-phase PV systems has been applied to increase the overall efficiency of PV systems.

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