Performance Improvement of Constant Current Controller Based T-type DVR Multilevel Inverter for Solar PV Integrated with Grid

T. Dinesh[a], Deepika Koppolu[b], Dr. T. Anil kumar[c]

[a] Assistant Professor, [b] PG Scholar, [c] Professor
[a,c] Department of Electrical and Electronics Engineering, Anurag University, Venkatapur, Ghatkesar, Medchal–Malkajgiri district, Hyderabad, Telangana, India. 500 088.
[c] Department of Electrical and Electronics Engineering, Anurag Group of Institutions(now Anurag University)
[a] dinesheee@cvsr.ac.in, [b] saideepikakoppolu@gmail.com, [c] thalluruanil@gmail.com

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Abstract: The performance improvement of the T-type DVR Multilevel Inverter for Solar PV Integrated with Grid based Constant Current Controller is defined in this paper. The T-type DVR Multilevel Inverter has decreased the number of switches here. The Controller used for the DVR based T-type MLI is Constant Current Controller which is in cooperated to the solar PV Power Generator with integration to the Grid. A 3 Phase PLL is used in Constant Current Controller for utility grid phase angle tracking and this mechanism will react fast enough to the load changes or different states of Grid connection. This result is supplying constant voltage without any phase jump to the load. Results are discussed for load currents for supplying 2mw load and even a load about 30Mw, 2MVAR. By using Matlab/Simulink, the overall framework is planned and modeled.

Keywords: Constant Current Controller, DVR, MLI, Phase Locked Loop, Solar PV System.

1. Introduction

The decentralized development of renewable energy systems is now becoming popular for its environmentally friendly production and the production of electrical energy continues to increase. The best way to solve issues such as unclean electricity, etc., is to decentralize the RES, and this can be built into the power grid to make it renewable energy. The cost of solar PV modules has been lowered and this is a positive indication that more solar power will be incorporated into the utility grid. However, solar energy is only usable during the day, which can be solved by combining both solar and wind energy.

The PWM techniques are commonly used for solar inverter control, but there are some interference problems with this technique. The prototype of the new controlled power conditioning system has been constructed and tested. This configuration produces 20KW of energy from a solar PV array with the largest control point of electricity. These are the key inverters, string inverters, used for the Solar Photo Voltaic Inverters with module orientation, Multi string PV inverter and integrated module. The merits and demerits of the regulated single-phase grid connected to Photo Voltaic inverters have been clarified. With the disruption of the sensed line voltage, the fasting sensing techniques of the 3-phase PV power conditioning system with line link have been suggested. The solar inverter system was operated by an electronic power system at the interface of the solar power generation system. The local load was supplied for modeling and designing by the developed grid linked photovoltaic system.

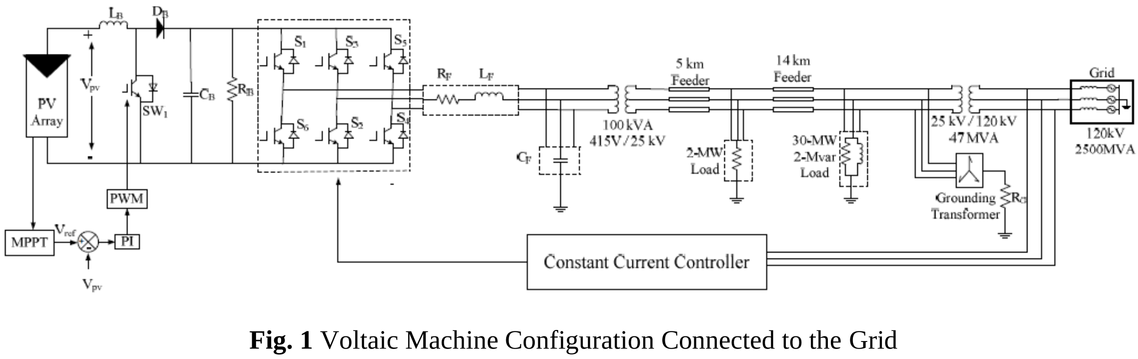

Fig. 1 Voltaic Machine Configuration Connected to the Grid

This paper proposes a constant current controller for modeling the Photo Voltaic grid-connected system that regulates the grid-interfacing solar inverter. The PV array raises the boost converter and produces the DC voltage and then applies it to the 3-phase 2 stage solar PV inverter. The solar inverter control is given by the Constant Current Controller. In the CCC, the PLL and PI controllers are used. The proposed models given by the 30MW, 2MVAr loads that are applicable to the 2MW resistive loads are described in this paper.

2. Constant Current Control Proposed MPPT Technique

Fig 1, displays the planned solar PV system incorporated into the grid and its configuration. The PV module is connected in series to create an array depending on the voltage requirement of the PV cell and it is connected in series to create a Photo Voltaic module. The PV module is joined in series or in parallel to make an array. From the PV array the maximum power point will be extracted by using different Maximum Power Point Technique techniques. The input for the MPPT technique is voltage and current derived out of solar PV array.

In general, the MPPT approach is used to interrupt and observe, in which the desired voltage of the PV array is compared to the voltage of the Solar PV array and any controller further processes this mistake. Here, the PI controller is used to minimize errors in this article. The 415V sinusoidal AC signal is reversed by a 2-level inverter with a DC voltage of 600V DC. The CCC is supplied with inverter switching pulses. The distorted phase angle is tracked by the constant current controller when there is phase distortion in the grid voltage to give the same output. The 3-Phase LC filter is reduced its harmonics generated by the inverter. Hence, the 100KVA, 415/25KV transformer is used.

Load current waveform is shown in fig 11, which is supplying for a load of 2MW. The 2MW load is considered to be connected to a transmission line of 5KM length. Here, the inverter voltage level of 415V has to be raised to the voltage level of 25KV, so that the solar PV generation system is connected to the grid.

3. Constant Current Control Based T-type DVR MLI

The PV range electricity is converted using medium-sized solar cells to transform the solar energy, the solar cell is made of semiconducers, the electricity is produced when the sun's power is absorbed by the semi-conductive junction, the electron emitts and releases the current. Figure 2 illustrates the V-I properties and analogous circuit of the photovoltaic cells.

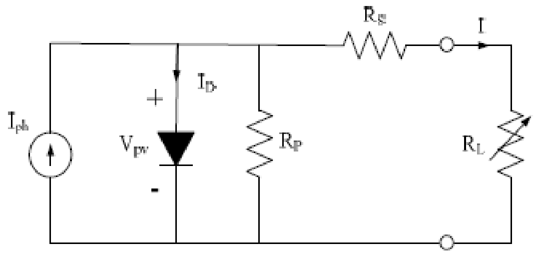

Fig. 2 Equivalent PV Cell Circuit

Solar cells are connected in series and in parallel, to achieve the preferred high power numbers. Solar PV cells are interconnected in sequence for high voltage needs, and PV cells are interconnected parallel to high-current applications. Sets of PV panels are known as PV arrays. It can be written in mathematical form below the solar photo voltaic array.

$$I = N_P I_{ph} - N_P I_D \left[\exp\left(\frac{q}{kTA} * \frac{V_{pv}}{N_S}\right) - 1\right]$$

The temperature varies according to the following equation with the diode reverse saturation current I_D

$$I_D = I_{rr}\left[\frac{T}{T_r}\right]^3 \exp\left(\frac{qE_G}{kA}\left[\frac{1}{T_r} - \frac{1}{T}\right]\right)$$

The power difference of the semiconductors in the CCC is dependent on the PV cell. Solar radiation and temperature play an important role in predicting the behavior of the P cell and in the configuration of the PV system the influence of both variables must be considered. The output of solar irradiation determines the temperature of the terminal voltage of the constant current controller.

Boost Converter Controllers

The applications of the Photo Voltaic cells are very limited to the output voltage. The desired output voltage is not provided by the combination of parallel and series, Hence, the PV array is enabled by the necessary condition of the boost converters. A capacitor is linked between them in order to decrease the high frequency harmonics between the PV array and the Boost converter. Fig 3 displays the closed loop controller for the boost converter.

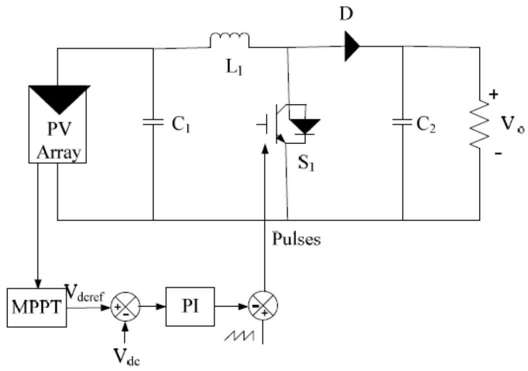

Fig. 3 Loop Controller Closed for Boost Converter.

The boost converter is powered by the PWM signal. The filter output is the control signal in comparison to the reference voltage. The PI controller tries to minimize the malfunction by adjusting the process control inputs. The PWM signal, which the IGBT switch provides as the gate signal, is then matched to the saw-tooth waveform.

4. Solar Photo Voltaic Integrated With Grid

The solar Photo Voltaic Inverter is used to transform the DC output voltage obtained from the solar Photo Voltaic array into an alternating current at the frequency of the utility grid, so that it can be integrated into the grid. Since it has to balance the grid frequency, the solar PV inverter plays and important role. The control aspects of it are therefore essential, divided into two type; CCC & CPC respectively. 3-phase PLL is used a long with CCC in this article. The models of solar inverter switching shown in fig 4 are used to power both reference gird current and inverter output currents using CCC.

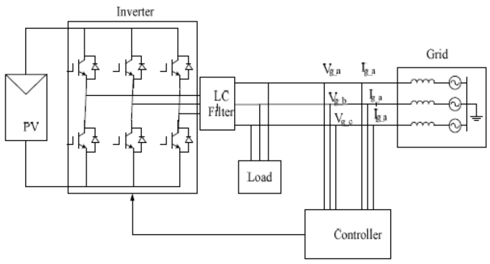

Fig. 4 Solar Inverter Switching Model.

The controlled switching pulses were produced by the solar inverter constant current controller which id capable of interfacing the grid with the output voltage shown in fig 5. The 3-phase PLL measures the Phase angle of the utility grid, which provides precise details about the frequency variations. The solar inverter switching pulses are produced by the CCC for the monitoring of the grid voltage process by the utility grid voltage. The dq variables are changed into αβ variables. To minimize the errors in the CCC the PI controller is used by comparing the currents I_d, I_q vs I_{dref} and I_{dref}.. The expected DC voltage of Photo Voltaic Array and the DC connection voltage of the Photo Voltaic array is V_{dc} and V_{dref}

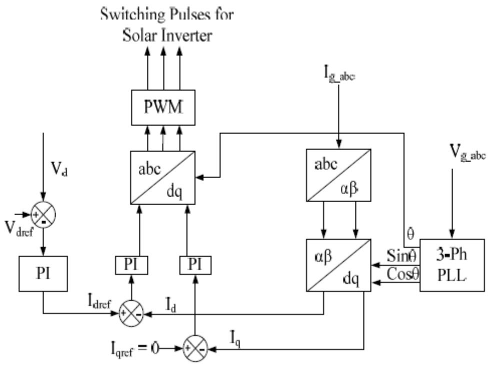

Fig. 5 Constant Current Controller Block diagram

5. Results and Discussion

The simulation modeling of the proposed grid-integrated solar PV system is considered at 120KV and 2500MVA voltage and apparent power levels, respectively. The power generated by the solar PV array for various solar irradiance values is shown in fig 6. At standard temperature condition of solar PV array, the array is generating 100KW of power and the voltage generator is 321V shown in fig 7. Here, the solar PV system is considered is solar PV Module consisting of 96 solar cells, 5 PV modules are linked in series to construct an array and total 66 parallel strings are there and V_{oc} = 64.2V & I_{sc} = 5.96A, V_{mp} = 54.7V & I_{mp}= 5.58V. Fig 6 & 7 shows the IV and PV curves of the proposed system considered.

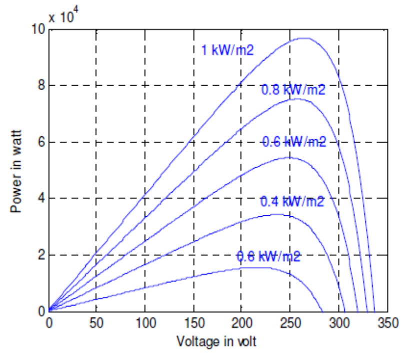

Fig. 6 Solar Array's PV Curve

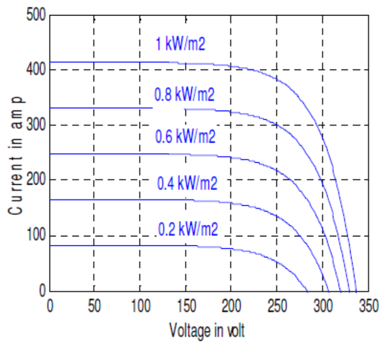

Fig . 7 Solar array's V-I Curve

The natural voltage of the solar Photo Voltaic has been enhanced to 600V DC voltage by its Converter. The PI controllers switching service cycle is optimized according to the load variations by the closed loop controller fig 8 displays the DC converter supplied with DC voltage.

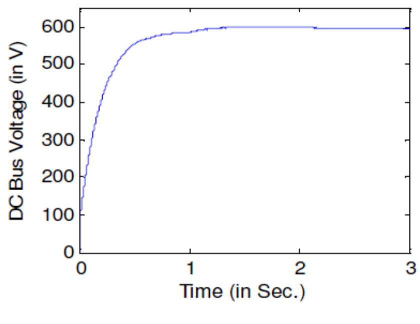

Fig. 8 Boost converter is delivering the DC Voltage

Sinusoidal AC voltage has been transformed using a 2-level 3-phase voltage source inverter by boosted DC voltage. With help of the 250 μH series inductance branch consisting of internal resistance of 0.002Ω and 10KVAr capacitor bank using LC filter, the VSC generates the harmonics or filters. The 600V DC voltage was converted to 415V pure sinusoidal AC voltage with the combination of LC & VSC filters. The output voltage of inverter filtering without using the filter and vice versa is clearly shown in Fig 9 and Fig 10.

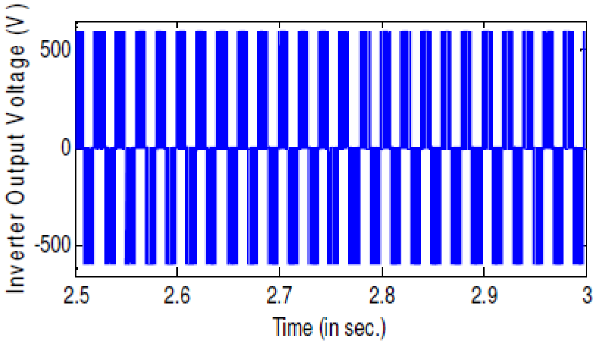

Fig . 9 Voltage Inverter output voltage before filtering

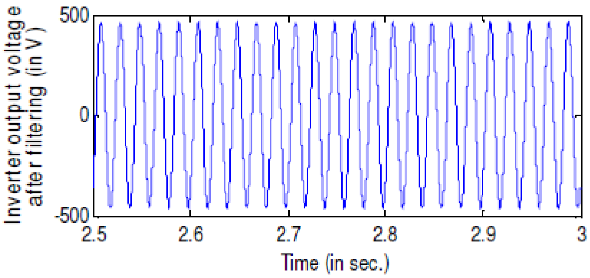

Fig. 10 Output Voltage of an Inverter after Filtering

Load current waveform is shown in fig 11, which is supplying for a load of 2MW. The 2MW load is considered to be connected to a transmission line of 5KM length. Here, the inverter voltage level of 415V has to be raised to the voltage level of 25KV, so that the solar PV generation system is connected to the grid.

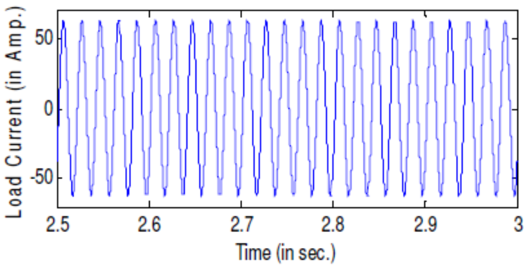

Fig. 11 Load Current Depicting for 2MW Load.

Similarly, a 30MW, 2MVAr load is deemed to be linked to a 14KM long transmission line. Load current to be supplied for the above mentioned load is shown in fig 12. Here, for protection against faults, the grounded transformer is utilized and the grid voltage level from 120KV to 25KV stepped down. The considered level of grounding resistance is 3.3Ω.

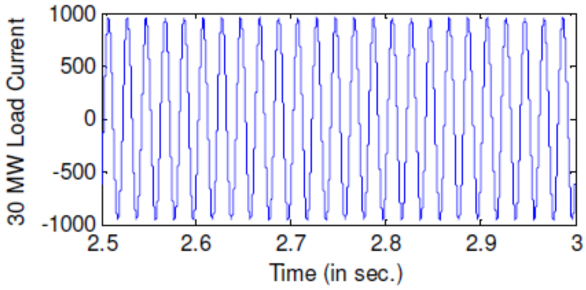

Fig. 12 Load Current Depicting for 30MW, 2MVAr Load

6. Conclusion

In this paper for the T-type multi-level inverter-based DVR, engineered and built with a reduced switch count in Matlab/Simulink, we are using the power grid solar photovoltaic system and continuous current controller. This system is used in the grid. The PLL system allows a steady current controller to monitor and produce switching pulses for the proposed inverter, the voltage stage in the utilities grid and the Frequency. The Because of the PLL system, the solar inverter's power voltage and the grid voltage are in line with one another, making the PV system grid-compatible. The results demonstrate that the proposed system is suitable for different load conditions..

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