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Performance Analysis of Diode Clamped Five-Level Inverter integrated PV Grid system using Soft computing based MPPT Scheme

M. Eswara Prasad[1], Mrs. Nirmaladevi[2]
[1]M.Tech Student, [2]Associate Professor, EEE Dept. Dr. KVSRIT, Kurnool

Abstract: ***This paper focuses on diode clamped five-level inverter for the application of PV system. Carrier based phase disposition method is adopted for control of inverter switches. The five-level diode clamped integrated to grid connected PV system is considered for the performance evaluation. The PI controller is adopted for the regulation of DC voltage. The Fuzzy Logic Control (FLC) based MPPT scheme is used to track the maximum power from the PV panel. The performance indices including PV current, DC link voltage and %THD of diode clamped inverter based grid connected PV system is compared with conventional two-level Inverter. The proposed work is carried out in the environment of Matlab/Simulink.***
Keywords: Diode clamped five-level inverter, FLC MPPT, Two-level voltage source inverter, PWM, THD, PV, Grid.

I. INTRODUCTION

Alternative energy sources such as photovoltaic (PV) installations are becoming increasingly popular, and they're being used in a wide range of settings, including both distributed and standalone systems. Utilizing photovoltaic (PV) energy is difficult because of the nonlinear output characteristics that change with temperature and solar insolation. There are multiple peaks in the output when the Array is partially clouded (shaded) because of the lack of uniform light exposure. MPPT schemes [1–3] are less effective when multiple peaks are present due to their inability to distinguish between local and global peaks. It has also been used in conjunction with an electricity grid, where an individual PV system injects current directly into the power grid. With a grid-connected system, the ability to sell excess energy generated is a significant advantage.

Control objectives are met in a grid-connected PV system by employing a pulse-width modulation (PWM) scheme based on two cascaded control loops [7]. Because of the feed-in-tariff and lower battery costs, grid-connected PV systems have grown in popularity. In contrast, intermittent PV generation varies with changes in atmospheric conditions. Maximum power point tacking (MPPT) techniques are used to deliver maximum power into the grid [2].

To operate with environmental changes and extract the maximum power from PV units, efficient control schemes are required. The controllers of a grid-connected PV system keep the system running stable in the face of disturbances such as changes in atmospheric conditions, changes in load demands, or external faults within the system. This is accomplished by regulating the switching signal via the inverter, i.e., the desired performance is obtained if a proper controller is applied via the system's inverter. MPPT has a substantial body of literature [3].

In the field of photovoltaic systems, perturb and observe (PO) [4] and incremental conductance methods are widely used. The importance of dc voltage control for a grid-connected PV system can be seen in [5-7], which proposes a model-prediction-based voltage controller to improve inverter reliability and lifetime, as well as MPPT performance by reducing dc-link capacitance. An improved MPPT method based on voltage oriented control, employing a proportional-integral (PI) controller in the outer dc-link voltage loop, was recently proposed [8].

Because they can regulate the current to follow the reference current, current controllers are used to keep grid-connected PV systems running smoothly. Various techniques for controlling current are available, including the PI controller, hysteresis controller, predictive controller, sliding mode controller, and so on. [9] Proposes the PI current control scheme to keep the output current sinusoidal, to have fast dynamic responses under rapidly changing atmospheric conditions, and to keep the power factor at unity. The difficulty in employing a PI controller stems from the requirement to adjust the gain in response to changes in atmospheric conditions. To overcome the disadvantages in conventional MPPT methods an advanced FLC based MPPT scheme is adopted for tracking of maximum power from the panel.

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II. DIODE CLAMPED FIVE LEVEL INVERTER

Voltage source inverters produce output voltages or currents with 0 or Vdc voltages or currents. Two-level inverters are the technical term for them. High switching frequencies and various pulse-width modulation (PWM) strategies are required to produce a high-quality output voltage or current waveform with minimal ripple content. There are some drawbacks to using two-level inverters in high power and high voltage applications because of switching losses and device rating constraints. In addition, problems with series-parallel combinations, which are necessary to handle high voltages and currents, should be avoided when using semiconductor switching devices.

Interest in multi-level inverters in the power industry has risen significantly in the last few years. Reactive power compensation can benefit from a new set of features presented here. A high-power, high-voltage inverter with a multilevel structure may be easier to manufacture. The inverter's power rating can be increased by adding more voltage levels without increasing the individual devices' ratings. High voltage and low harmonics can be achieved without the use of transformers or series-connected synchronised switching devices thanks to multilevel voltage source inverters' unique structure. Output waveform harmonic content decreases dramatically as the number of voltage levels is increased. Different renewable energy sources, such as fuel cells, photovoltaics, and biomass, work well with the structure of dc sources.

Diode-clamped multilevel (m-level) inverters (DCMLI) use (m-1) capacitors on the dc bus to generate m levels of output on the phase. A full-bridge five-level diode-clamped converter is illustrated in Fig.1. The numbering order of the switches is S_{a1}, S_{a2}, S_{a3}, S_{a4}, S'_{a1}, S'_{a2}, S'_{a3}, and S'_{a4}.

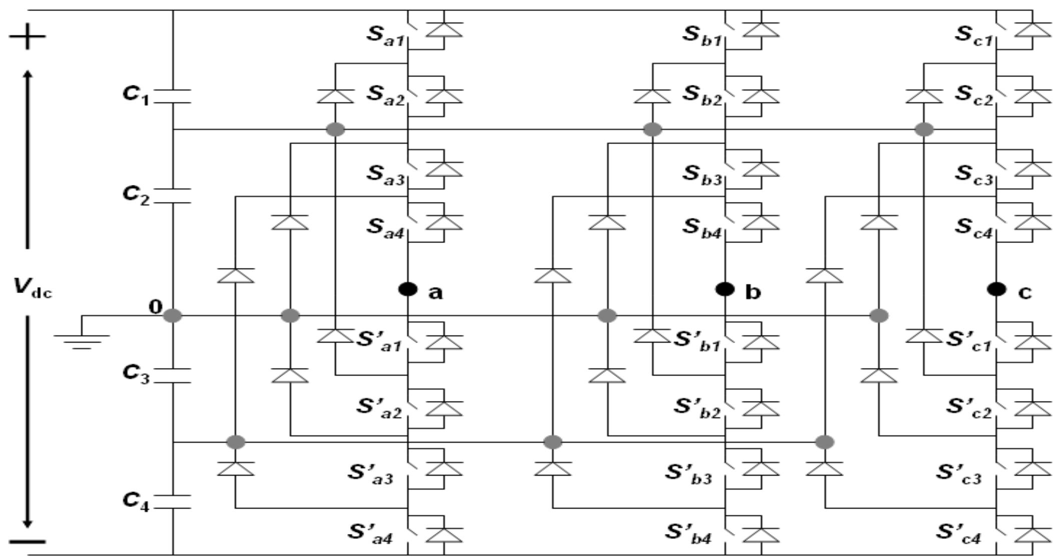

Fig. 1: A 3-phase 3 leg Five-level diode clamped inverter

Table I shows the voltage levels and their corresponding switch states. State condition1 means the switch is on, and state 0 means the switch is off. Figure 2 shows the typical output voltage of a five-level inverter.

Table I
Diode-clamped voltage levels and their switch states

Output V_{ao}	Switch State							
	S_{a1}	S_{a2}	S_{a3}	S_{a4}	S'_{a1}	S'_{a2}	S'_{a3}	S'_{a4}
$V_5 = V_{dc}$	1	1	1	1	0	0	0	0
$V_4 = 3V_{dc}/4$	0	1	1	1	1	0	0	0
$V_3 = V_{dc}/2$	0	0	1	1	1	1	0	0
$V_2 = V_{dc}/4$	0	0	0	1	1	1	1	0
$V_1 = 0$	0	0	0	0	1	1	1	1

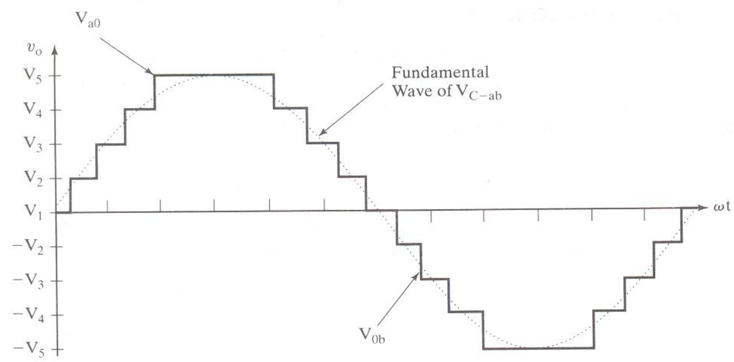

Fig.2: Typical output voltage of a five-level inverter

III. GRID CONNECTED PV SYSTEM

Figure 3 shows system integration of PV inverter system which comprises of a PV panel, associated with a dc-dc converter and a widely used dc-ac pulse width modulation (PWM) inverter connected to the utility grid.

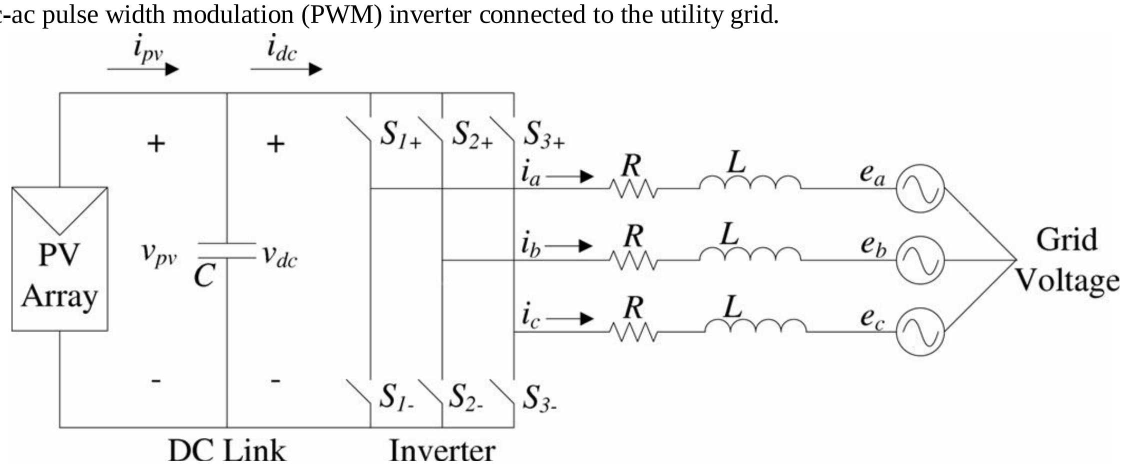

Fig.3: Grid-connected PV system [10]

The waveforms generated by grid-connected inverters are controlled by voltage and current control schemes. PV inverters, as power sources, deliver "constant" power to the utility grid with a power factor close to unity. Control systems monitor and adjust the power output of your photovoltaic (PV) array on a continuous basis in either voltage control mode or current control mode, respectively. The grid connected PV system is shown in Fig.3 consists inverter for conversion of DC to AC voltage. The diode clamped five-level inverter is used for this purpose in this paper.

A three-phase grid-connected PV system is shown in Fig.3, where the PV array consists of a number of PV cells in a series and parallel combination to achieve the desired output voltage. The output voltage of the PV array (v_{pv}) is a dc voltage (v_{dc}) and, thus, the output dc power (P_{pv}) is stored in the dc-link capacitor (C). The output current of the PV array (i_{pv}) is and that of the dc-link capacitor is i_{dc}.

IV. SIMULATION RESULTS

In order to demonstrate the efficacy of the FLC-based MPPT system, a three-phase grid-connected multilevel inverter is analyzed. Matlab/Simulink simulations are used to verify the proposed topology. Three-phase grid-connected PV systems are tested using a PV array containing 20 strings each rated at 5.36A in order to evaluate the FLC controller's performance. Linked in series, each string is divided into 18 modules, each with a rated voltage of 43.5 volts. The PV array's total output voltage is 770V. There is an inductance of 4.5 mH in the line capacitance. It has 660 V and 50 Hz grid voltage and 50 Hz. The inverter's switching frequency is referred to as 5 kHz. Tracking of maximum power from the PV panel is done using FLC based MPPT. The dc link voltage is controlled by the PI control.

Various operating conditions were considered to validate the feasibility of the proposed controller. The controller's performance is evaluated in the following scenarios: 1) constant atmospheric conditions, and 2) changing atmospheric conditions.

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A. Case 1: Controller Performance under Standard Atmospheric Conditions

The standard values of solar irradiation (1 kW-2) and environmental temperature (298 K) are taken into account in this case study. In the first case, as shown in Fig. 4, the standard atmospheric condition is taken into account.

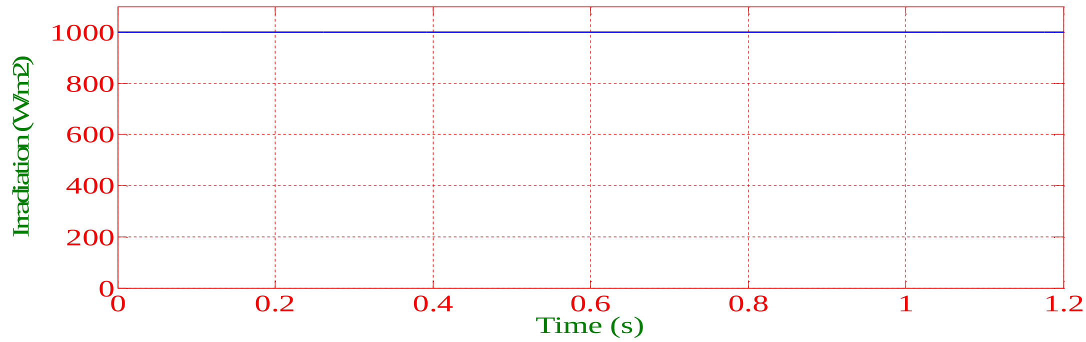
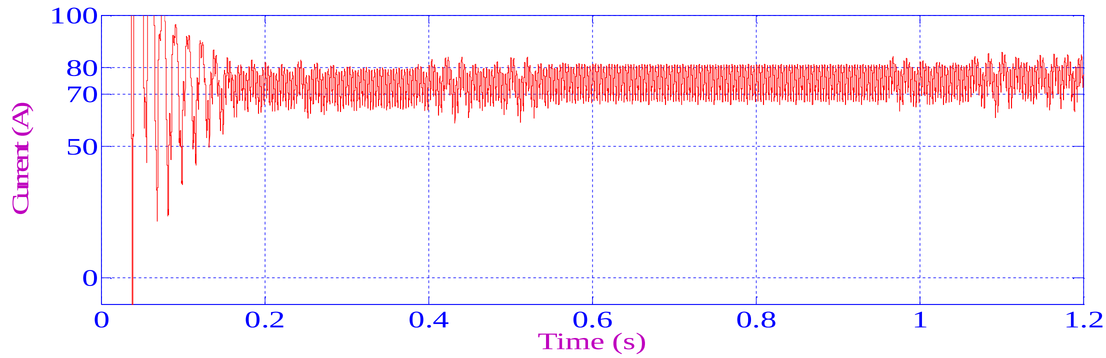
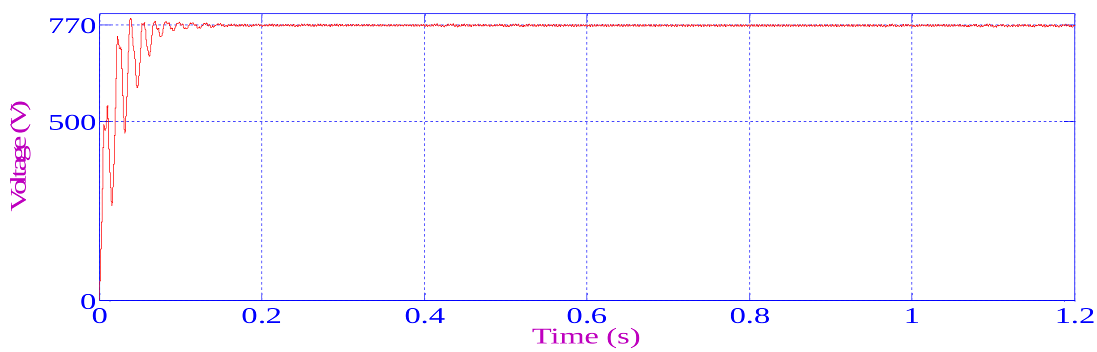


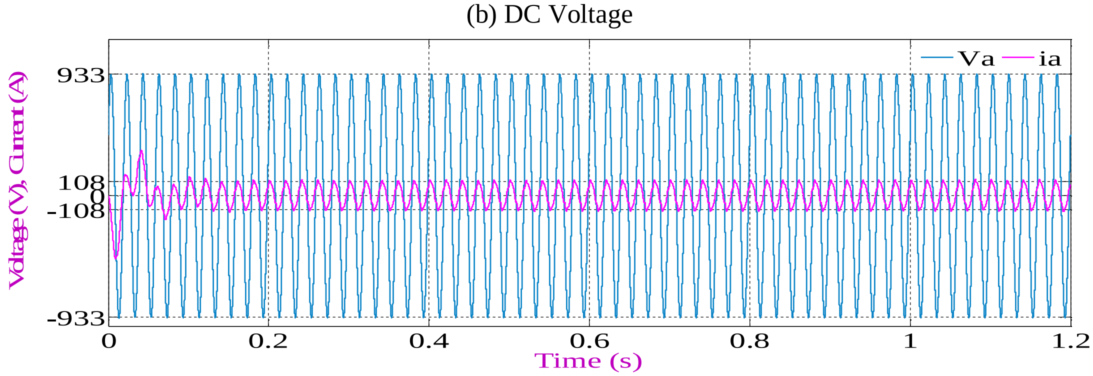
Fig.4: Standard irradiation



(a) PV current



(b) DC Voltage



(c) Grid voltage and current

Fig.5: Performance curves at standard atmospheric conditions using two- level inverter

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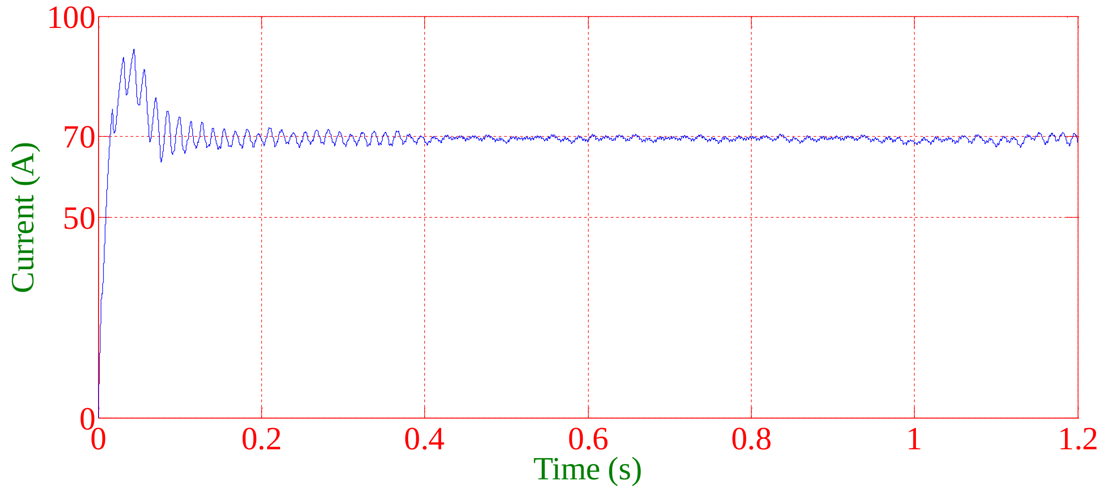
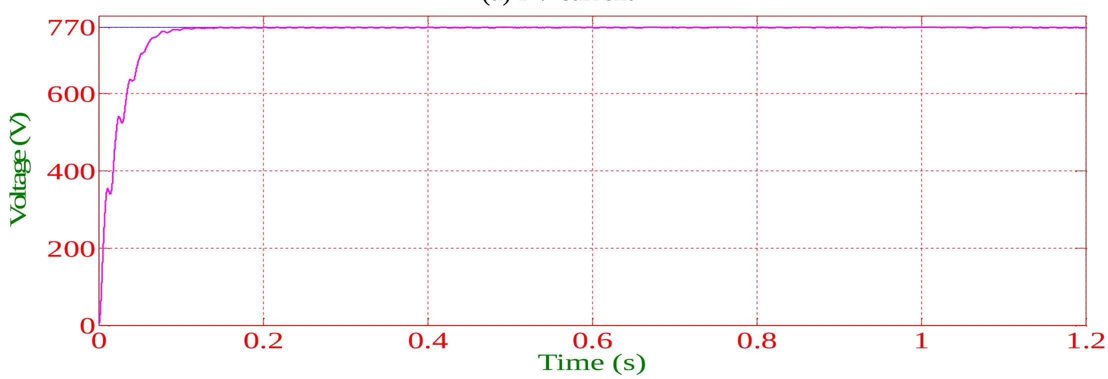
The response curves including the PV current, DC link Voltage, the grid current and voltage are shown in Fig. 5 using two-level converter. The PV current is oscillating from 70A to 80A as shown in Fig.5 (a). The two-level inverter dc link voltage is regulated and reached the steady state after t=0.1sec. The grid voltage and current is illustrated in Fig. 5(c) and it shows that in line displacement.

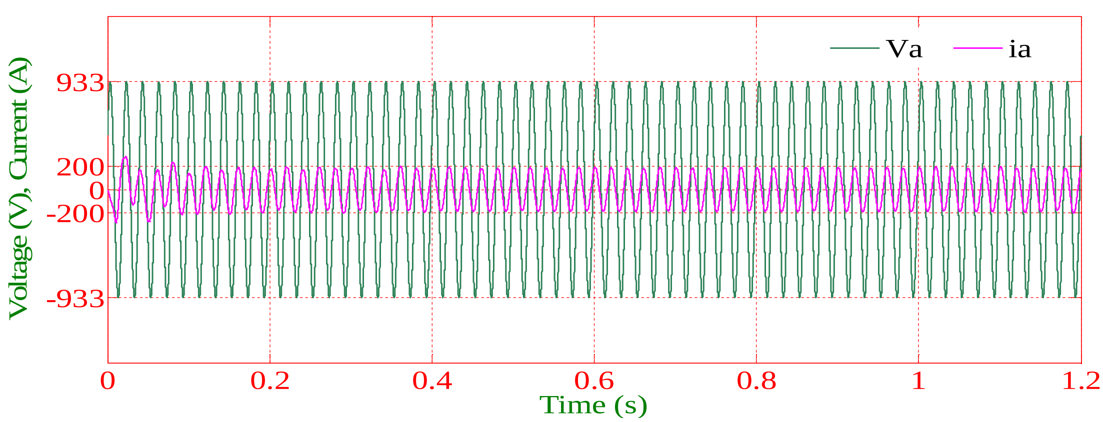
The response curves including the PV current, DC link Voltage, the grid current and voltage are shown in Fig. 6 using five-level diode clamped inverter. The PV current is not oscillating and it is observed that 70A as shown in Fig.6 (a). The five-level diode clamped inverter dc link voltage is regulated and reached the steady state at t=0.1sec. The grid voltage and current is illustrated in Fig. 6 (c) and it shows that in line displacement. The PV current and DC voltage curves follows the stable condition for all the time as shown in Fig.6 (a) and (b).



(a) PV current



(b) DC Voltage



(c) Grid voltage and current

Fig.6: Performance curves at standard atmospheric conditions using diode clamped five-level inverter

B. Case 2: Controller Performance under Changing Atmospheric Conditions

At this stage, it is considered that the PV unit operates under standard atmospheric conditions until 0.5 s. At t = 0.5 s, the atmospheric condition changes in such a way that the solar irradiation of the PV unit reduces to 70% from the standard value as shown in Fig.7. Under this situation though, the controller is able to maintain the stability of the system. Thus, the designed controller performs satisfactory in changing condition which is shown in Fig.5.8 using two level inverter and five-level diode clamped inverter as shown in Fig.5.9, from which it can be seen that the PV unit operates under the standard atmospheric condition up to 0.5s and changing atmospheric conditions up to 0.8s. After that, it operates under standard conditions, and the designed controller maintains the operation of the system at near unity power factor.

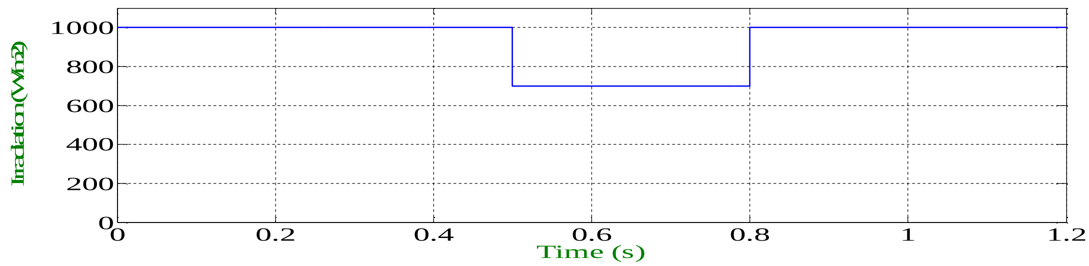
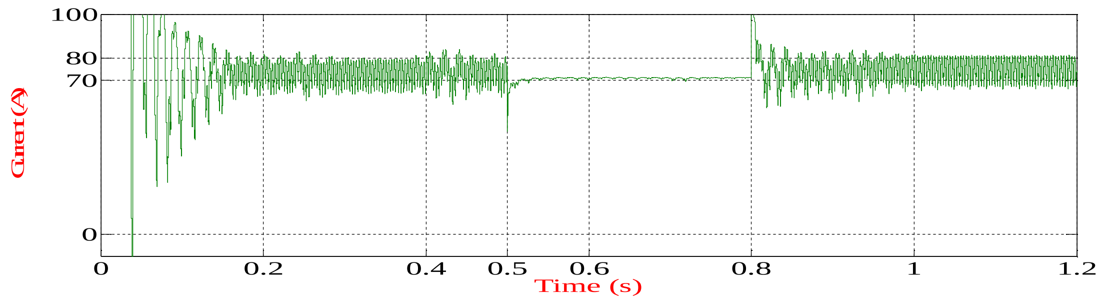
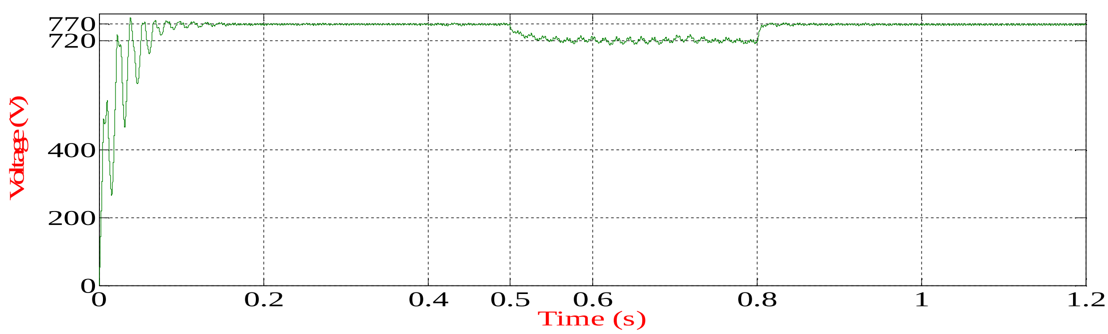


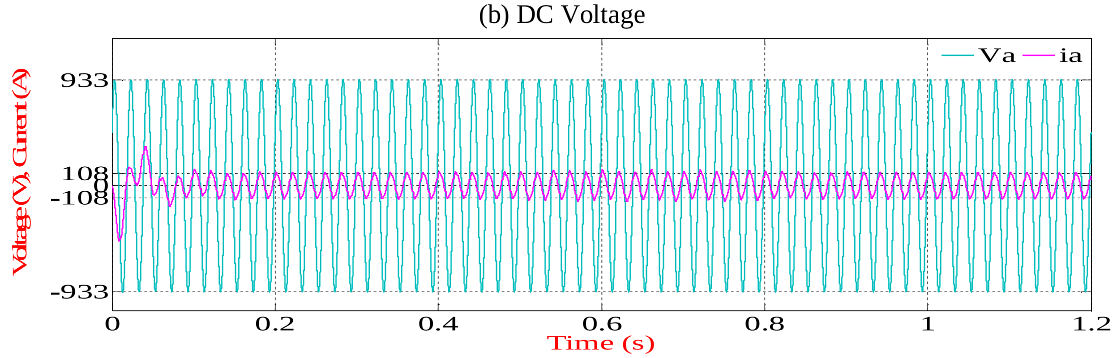
Fig.7: Change of irradiation



(a) PV current



(b) DC Voltage



(c) Grid voltage and current

Fig.8: Performance curves at changing atmospheric conditions using two-level inverter

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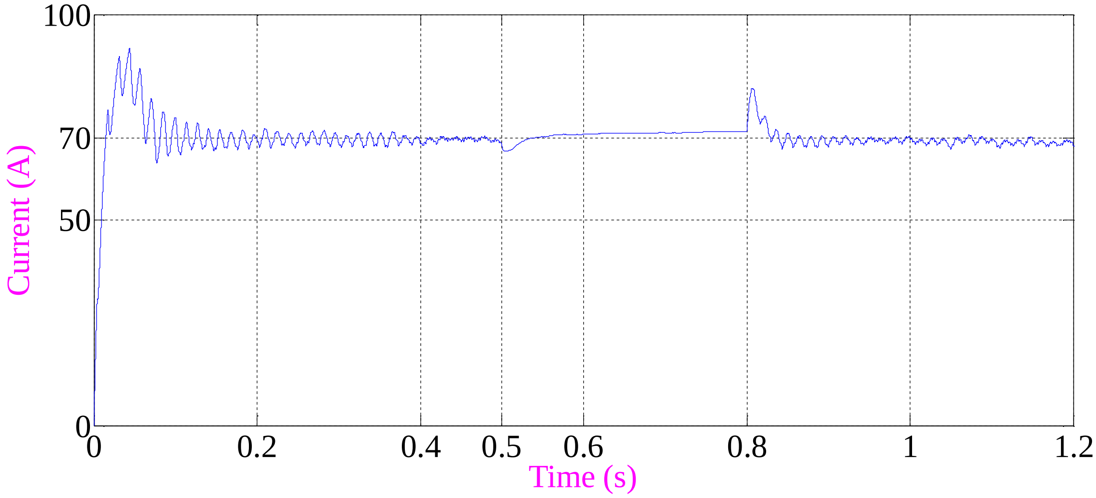
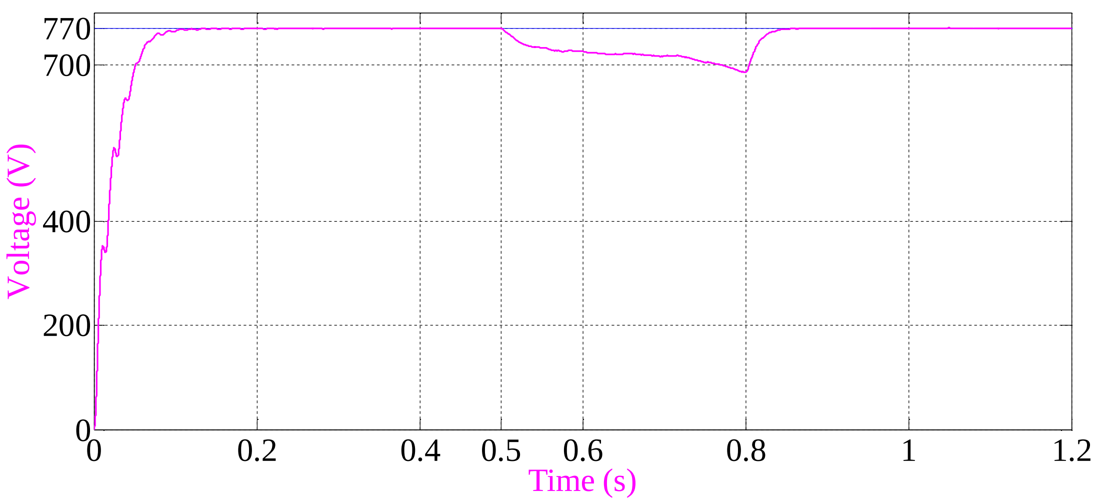
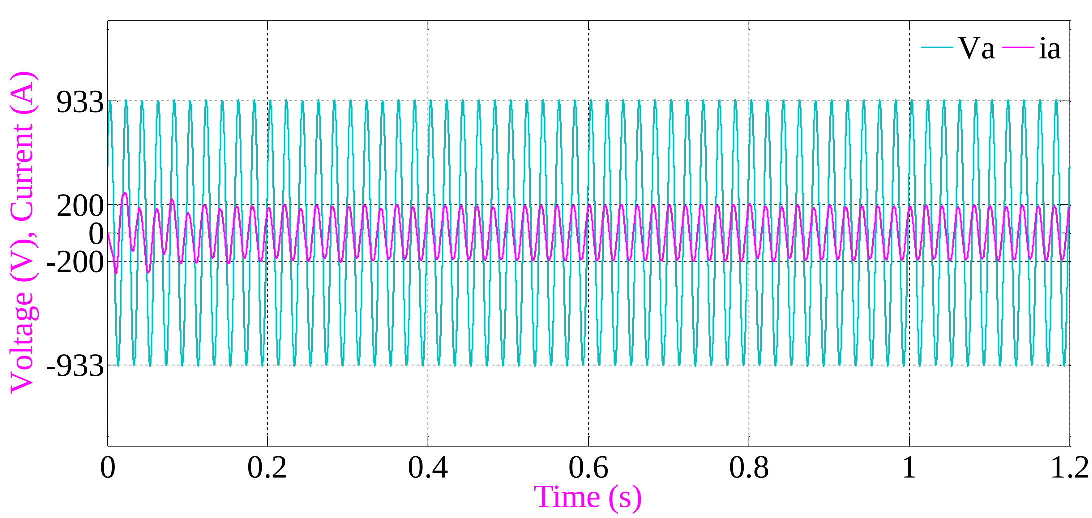


(a) PV current

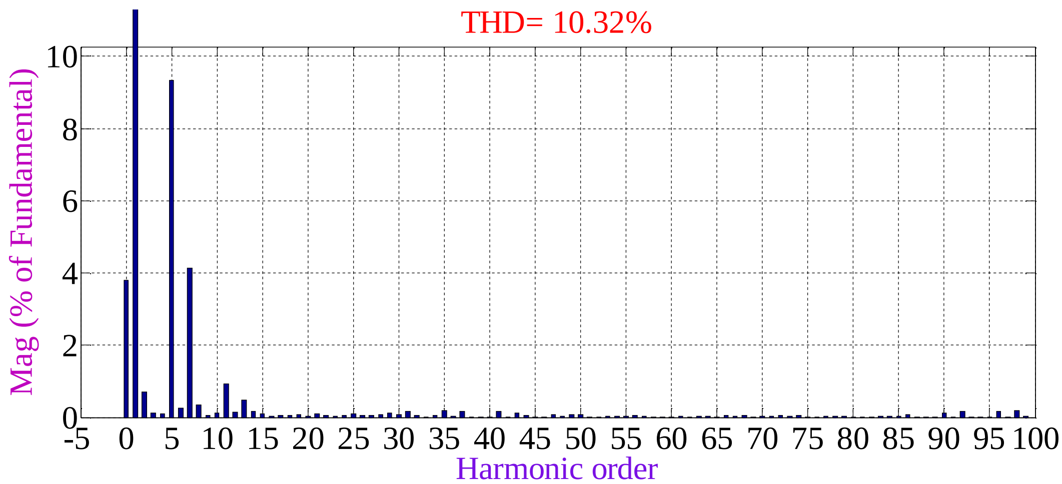


(b) DC Voltage

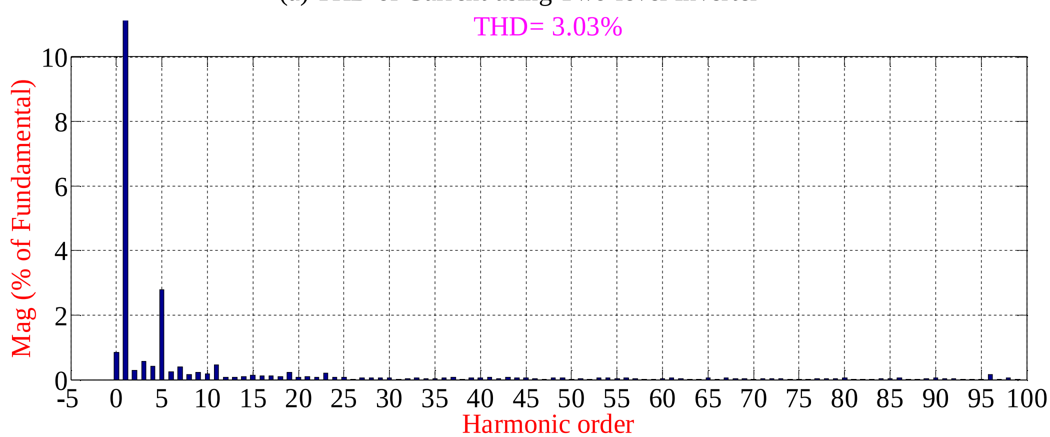


(c) Grid voltage and current

Fig.9: Performance curves at changing atmospheric conditions using diode clamped five-level inverter



(a) THD of Current using Two-level Inverter



(b) THD of Current using diode clamped five-level Inverter

Fig.10: THD comparison

Further, the %THD comparison has made for both two-level and five-level diode clamped inverter. The diode clamped five-level inverter based grid connected PV system has produced less THD of 3.03% compared to two-level inverter (10.32%) based system.

V. CONCLUSIONS

In this paper, FLC is designed by structuredly modelling the uncertainties of a three-phase grid-connected PV system using a diode clamped five-level inverter based on the satisfaction of matching conditions. The control scheme is used to obtain the robust control law, and with the designed control scheme, only the upper bounds of the PV system parameters and states, rather than network parameters and system operating points, are required to be known. As a result, regardless of network parameters and configuration, this controller has good robustness against parameter changes and variations in atmospheric conditions.

REFERENCES

[1] Y. T. Tan, D. S. Kirschen, and N. Jenkins, "Impact of a large penetration of photovoltaics on the power system," in Proc. CIRED 17th Int. Conf. Elect. Distrib., 2003, pp. 1–5.

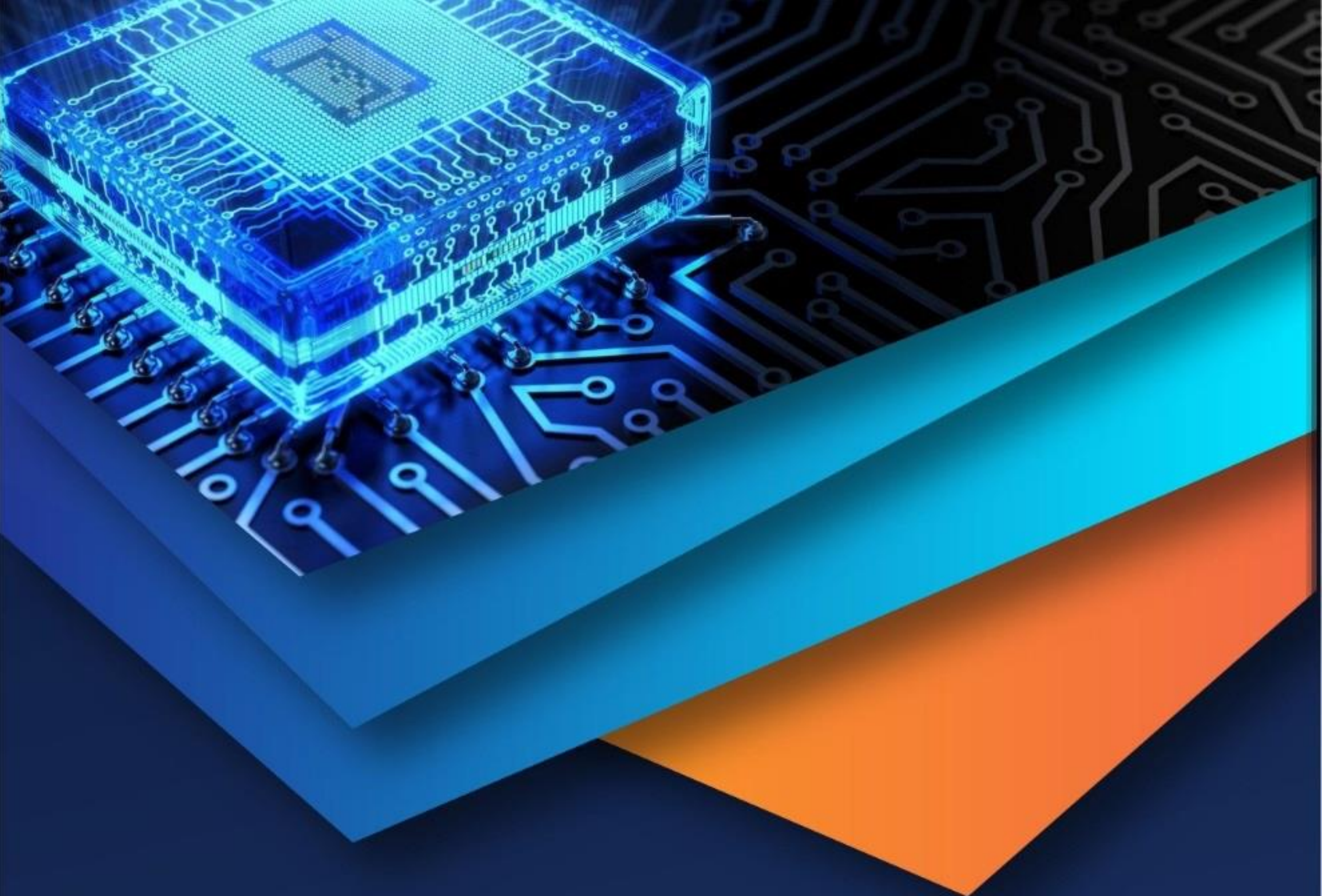
[2] I. Houssamo, F. Locment, and M. Sechilariu, "Maximum power point tracking for photovoltaic power system: Development and experimental comparison of two algorithms," Renewable Energy, vol. 35, no. 10, pp. 2381–2387, 2010.

[3] T. Esram and P. L.Chapman, "Comparison of photovoltaic array maximum power point tracking techniques," IEEE Trans. Energy Convers., vol. 22, no. 2, pp. 439–449, Jun. 2007.

[4] A. Mellit, H. Rezzouk, A. Messai, and B. Medjahed, "FPGA-based real time implementation of MPPT controller for photovoltaic systems," Renewable Energy, vol. 36, no. 5, pp. 1652–1661, 2011.

[5] L. Chun-Xia and L. Li-Qun, "An improved perturbation and observation MPPT method of photovoltaic generates system," in Proc. 4th IEEE Conf. Ind. Electron. Appl., 2009, pp. 2966–2970.

[6] B. Liu, S. Duan, F. Liu, and P. Xu, "Analysis and improvement of maximum power point tracking algorithm based on incremental conductance method for photovoltaic array," in Proc. IEEE Int. Conf. Power Electron. Drive Syst., 2007, pp. 637–641.
[7] F. He, Z. Zhao, T. Lu, and L. Yuan, "Predictive DC voltage control for three-phase grid-connected PV inverters based on energy balance modeling," in Proc. 2nd IEEE Int. Symp. Power Electron. Distrib. Generat. Syst., Jun. 2010, pp. 516–519.
[8] R. Kadri, J. P. Gaubert, and G. Champenois, "An improved maximum power point tracking for photovoltaic grid-connected inverter based on voltage-oriented control," IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 66–75, Jan. 2011.
[9] J. Selvaraj and N. A. Rahim, "Multilevel inverter for grid-connected PV system employing digital PI controller," IEEE Trans. Ind. Electron.,vol. 56, no. 1, pp. 149–158, Jan. 2009.
[10] M. A. Mahmud, et al., "Dynamic Stability of Three-Phase Grid-Connected Photovoltaic System Using Zero Dynamic Design Approach", IEEE JOURNAL OF PHOTOVOLTAICS, VOL. 2, NO. 4, OCTOBER 2012.



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