International Journal of Electrical Electronics Computers & Mechanical Engineering (IJEECM)
ISSN: 2278-2808
www.ijeecm.org Volume 8 Issue 5 ǁ May. 2018
IJEECM journal of Electrical and Electronics Engineering (ijeecm-jee)

PV system integration with grid using fuzzy based H-Bridge multilevel inverter

Hasen Ali[1], Dr.T Srinivasa Rao[2], R Ganesh[3]
[1,2] *Electrical and Electronics Engineering Department,*
[1,2,3] , Avanthi Institute of Engg & Technology, Narsipatnam, Visakhapatnam (Dt), A.P., India

Abstract: **This paper characterizes another fuzzy based controller based measured fell H-bridge multilevel photovoltaic (PV) inverter for single-or three-phase grid-associated applications. The particular fell multilevel topology enhances the proficiency and adaptability of PV systems. To acknowledge better use of PV modules and maximize the sun based vitality extraction, a disseminated most extreme power point tracking control plan is connected to both single-and three-phase multilevel inverters, which permits free control of each dc-connection voltage. For three-stage network associated applications, PV mismatches may present uneven provided control, leading to lopsided framework current. To unravel this issue, a control scheme with tweak remuneration is likewise proposed. An experimental three-stage seven-level fell H-connect inverter has been built utilizing nine H-connect modules (three modules for every stage). Each H-connect module is associated with a 185-W sun oriented board. Simulation and test results are exhibited to check the possibility of the proposed approach.**

Index Terms— Fuzzy, **Cascaded multilevel inverter, distributed maximum power point (MPP) tracking (MPPT), modular, modulation compensation, photovoltaic (PV).**

I. INTRODUCTION

Because of the lack of fossil fills and natural issues brought about by ordinary power era, renewable energy, especially sunlight based vitality, has progressed toward becoming very popular. Sun based electric-vitality request has developed consistently by 20%–25% for every annum in the course of recent years [1], and the growth is for the most part in lattice associated applications. With the extra ordinary market development in network associated photovoltaic (PV)systems, there are expanding premiums in matrix associated PV configurations .Five inverter families can be characterized, which are connected to different setups of the PV framework: 1) focal inverters; 2) string inverters; 3) multi string inverters; 4) air conditioning module inverters ;and 5) fell inverters [2]–[7]. The designs of PV systems are appeared in Fig. 1.Cascaded inverters comprise of a few converters connected in arrangement; consequently, the high power as well as high voltage from the combination of the different modules would support this topology in medium and extensive matrix associated PV frameworks [8]–[10].There are two sorts of fell inverters. Fig. 1(e) indicates a cascaded dc/dc converter association of PV modules [11], [12].Each PV module has its own dc/dc converter, and the modules with their related converters are as yet associated in arrangement to create a high dc voltage, which is given to a rearranged dc/ac inverter. This approach consolidates parts of string inverters and ac-module inverters and offers the upsides of individual module most extreme power point (MPP) following (MPPT), but it is not so much expensive but rather more effective than air conditioning module inverters. However, there are two power transformation organizes in this configuration .Another fell inverter is appeared in Fig. 1(f), where each PV board is associated with its own particular dc/air conditioning inverter, and those inverters are then put in arrangement to achieve a high-voltage level[13]–[16]. This fell inverter would keep up the benefits of "one converter for each board, for example, better usage per PV module, ability of blending distinctive sources, and redundancy of the framework. Also, this dc/air conditioning fell inverter removes the requirement for the per-string dc transport and the focal dc/air conditioning inverter, which additionally enhances the general efficiency. The particular fell H-connect multilevel inverter, which requires a secluded dc hotspot for every H-scaffold, is one dc/ac cascaded inverter topology. The different dc interfaces in the multilevel inverter make autonomous voltage control conceivable. As a result, individual MPPT control in each PV module can be accomplished, and the vitality collected from PV boards can be augmented. In the meantime, the measured quality and low cost of

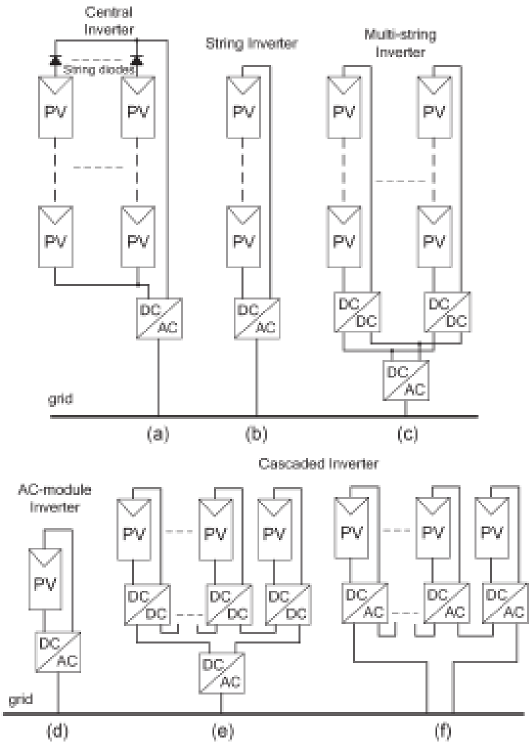

Fig. 1.Configurations of PV frameworks. (a) Central inverter. (b) String inverter.(c) Multi string inverter. (d) AC-module inverter. (e) Cascaded dc/dc converter.(f) Cascaded dc/air conditioning inverter.

multilevel converters would position them as a prime candidate for the up and coming era of effective, vigorous, and solid grid connected solar control electronics .A secluded fell H-connect multilevel inverter topology for single-or three-stage network associated PV frameworks is presented in this paper. The board befuddle issues are addressed to demonstrate the need of individual MPPT control, and a control scheme with appropriated MPPT control is then proposed. The

distributed MPPT control plan can be connected to both single and three-stage systems. In expansion, for the exhibited three-stage lattice associated PV system, if each PV module is worked at its own MPP, PV mismatches may acquaint unequal power provided with the three-stage multilevel inverter, prompting uneven injected grid current. To adjust the three-stage framework current, modulation compensation is additionally added to the control system .A three-stage secluded fell multilevel inverter proto type has been constructed. Every H-extension is associated with a 185-Wsolar board. The secluded plan will build the flexibilityof the framework and lessen the cost also. Reenactment and experimental results are given to exhibit the developed control plot.

II. FRAMEWORK DESCRIPTION

Measured fell H-connect multilevel inverters for single and three-stage framework associated PV frameworks are appeared in Fig. 2.Each stage comprises of nH-scaffold converters associated in series, and the dc connection of every H-extension can be sustained by a PV panel or a short string of PV boards. The fell multilevel inverter is associated with the lattice through L channels, which are used to lessen the exchanging sounds in the current .By distinctive blends of the four switches in each H-connect module, three yield voltage levels can be generated:−vdc, 0, or +vdc. A fell multilevel inverter with ninput sources will give 2n + 1 levels to combine the air conditioner output waveform. This (2n + 1)- level voltage waveform empowers the reduction of sounds in the incorporated current, reducing the size of the required yield channels. Multilevel inverters also have different focal points, for example, lessened voltage stresses on the semiconductor switches and having higher effectiveness when compared to other converter topologies [17].

III. BOARD MISMATCHES

PV befuddle is a vital issue in the PV framework. Due to the unequal got irradiance, distinctive temperatures, and aging of the PV boards, the MPP of each PV module may be different. In the event that each PV module is not controlled independently, the productivity of the general PV framework will be decreased. To demonstrate the need of individual MPPT control, a five-level two-H-connect single-stage inverter is mimicked in MATLAB/SIMULINK. Every H-connect has its own particular 185-W PV panel associated as a secluded dc source. The PV board is modeled as per the determination of the business PV panel from Astrometry CHSM-5612M.Consider a working condition that each board has a different irradiation from the sun; board 1 has irradiance S =1000 W/m2, and board 2 has S = 600 W/m2. On the off chance that exclusive board 1 is tracked and its MPPT controller decides the normal voltage of the two boards, the power extricated from board 1 would be133 W, and the power from board 2 would be 70 W, as can be found in Fig. 3. Without individual MPPT control, the total power collected from the PV framework is 203 W. However, Fig. 4 demonstrates the MPPs of the PV boards under the different irradiance. The most extreme yield control qualities will be185 and 108.5 W when the S qualities are 1000 and 600 W/m2,respectively, which implies that the aggregate power reaped from the PV framework would be 293.5 W if individual MPPT can be accomplished. This higher esteem is around 1.45 circumstances of the one before. In this way, individual MPPT control in each PV module is required to expand the effectiveness of the PV system .In a three-stage framework associated PV framework, a PV mismatch may cause more issues. Beside diminishing the overall efficiency, this could even present unequal power supplied to the three-stage framework associated framework. In the event that there are PV mismatches between stages, the information force of each stage would be distinctive. Since the lattice voltage is adjusted, this difference in input power will make unequal current the framework, which is not permitted by matrix norms. For instance, to unbalance the current per stage over 10% is not took into consideration some utilities, where the rate lopsidedness is ascertained by taking the most extreme deviation from the normal current and dividing it by the normal current [18].

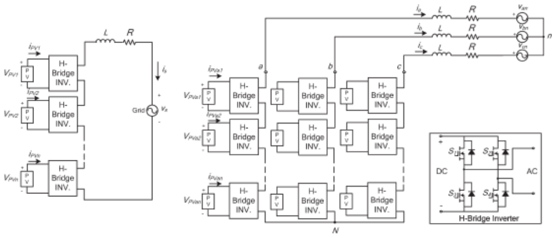

Fig.2. Topology of the modular cascaded H-bridge multilevel inverter for grid-connected PV systems.

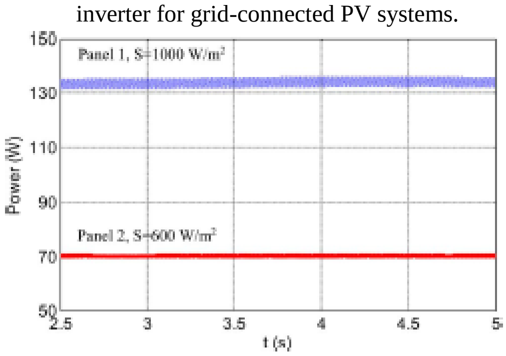

Fig. 3. Power extracted from two PV panels.

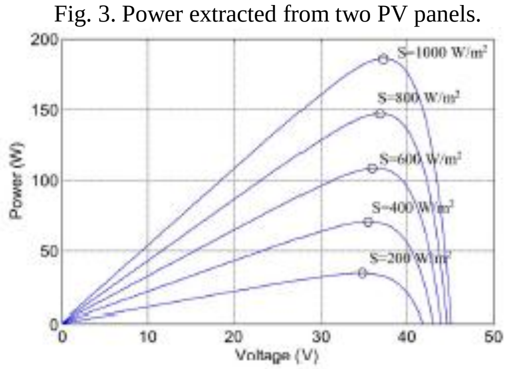

Fig. 4.*P–V* characteristic under the different irradiance.

To illuminate the PV crisscross issue, a control plot with individual MPPT control and balance remuneration is proposed .The points of interest of the control plan will be talked about in the next area.

IV. CONTROL SCHEME

A. Conveyed MPPT Control

With a specific end goal to take out the unfavorable impact of the confounds and increase the effectiveness of the PV framework, the PV modules need to work at various voltages to enhance the use per PV module. The isolate dc connects in the fell H-connect multi level inverter make autonomous voltage control conceivable. To realize individual MPPT control in each PV module, the control scheme proposed in [19] is refreshed for this application. The conveyed MPPT control of the three-stage cascaded H-connect inverter is appeared in Fig. 5. In every H-connect module ,an MPPT controller is added to produce the dc-interface voltage reference. Every dc-interface voltage is contrasted with the corresponding voltage reference, and the whole of all mistakes is controlled through an aggregate voltage controller that decides the current reference Idref . The responsive current reference Iqref can be set to zero, or if receptive power remuneration is required, Iqref can also be given by a responsive current adding machine [20], [21]. The synchronous reference outline stage bolted circle (PLL) has be ensued to discover the stage edge of the network voltage [22]. As the classic control conspire in three-stage frameworks, the lattice currents in abc coordinates are changed over to dq coordinates and regulated through proportional–integral (PI) controllers to produce the modulation list in the dq coordinates, which is then changed over back to three phases. The disseminated MPPT control conspire for the single-phase system is about the same. The aggregate voltage controller gives the magnitude of the dynamic current reference, and a PLL provides the recurrence and stage point of the dynamic current reference. The current circle then gives the adjustment index. To make each PV module work at its claim MPP, take phase a for instance; the voltages vdca2 to vd can are controlled individually through n − 1 circles. Every voltage controller gives the regulation record extent of one H-bridge module in stage a. After increased by the regulation index of phase *a*, *n* − 1 modulation indices can be obtained. Also, the modulation index for the first H-bridge can be obtained by subtraction. The control schemes in phases band *c* are almost the same. The only difference is that all dc-link voltages are regulated through PI controllers, and *m*odulation index proportions are obtained for each phase.

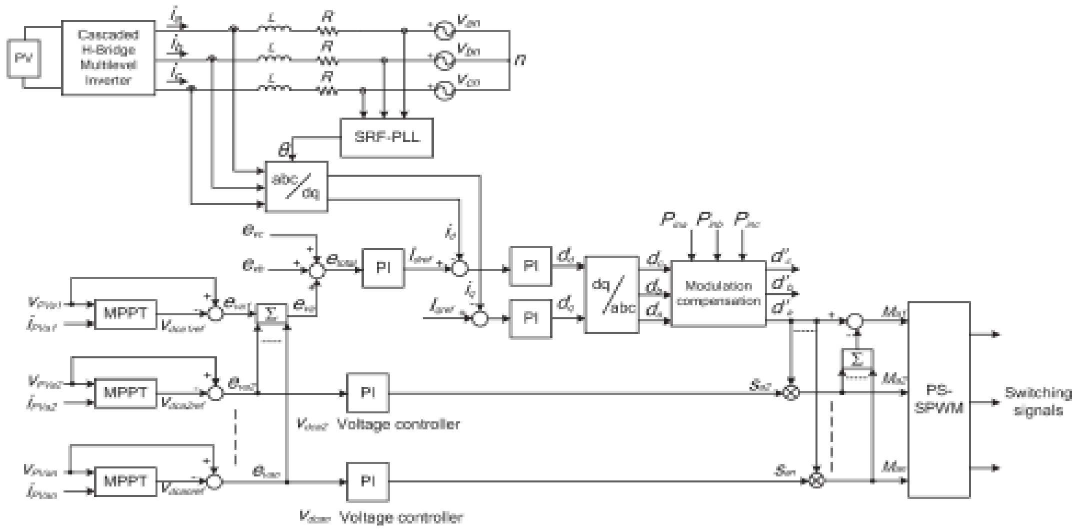

Fig. 5. Control scheme for three-phase modular cascaded H-bridge multilevel PV inverter.

A stage moved sinusoidal heartbeat width balance switching scheme is then connected to control the exchanging gadgets of each H-bridge .It can be seen that there is one H-connect module out of N modules whose adjustment list is gotten by subtraction. For single-stage frameworks, N = n, and for three-stage systems, N = 3n, where n is the quantity of H-extension modules per phase. The reason is that N voltage circles are important to manage diverse voltage levels on N H-scaffolds, and one is the total voltage circle, which gives the present reference. Along these lines, only N − 1 adjustment lists can be controlled by the keep going N – 1voltage circles, and one tweak record must be acquired by subtraction. Many MPPT techniques have been produced and implemented[23], [24]. The incremental conductance technique has been used in this paper. It loans itself well to advanced control, which can easily monitor past estimations of voltage and current and make all choices.

B. Adjustment Compensation

As specified before, a PV confuse may bring about more problems to a three-stage particular fell H-connect multilevel lPV inverter. With the individual MPPT control in each H-connect module, the info sun oriented force of each stage would be different, which acquaints uneven current with the matrix. To solve the issue, a zero grouping voltage can be forced up on the stage legs keeping in mind the end goal to influence the present streaming into each phase [25], [26]. On the off chance that the refreshed inverter yield stage voltage is corresponding to the uneven power, the present will be balanced. Thus, the balance remuneration obstruct, as indicated in Fig. 6, is added to the control arrangement of three-stage modular cascaded multilevel PV inverters. The key is the means by which to update the regulation list of each stage without expanding the

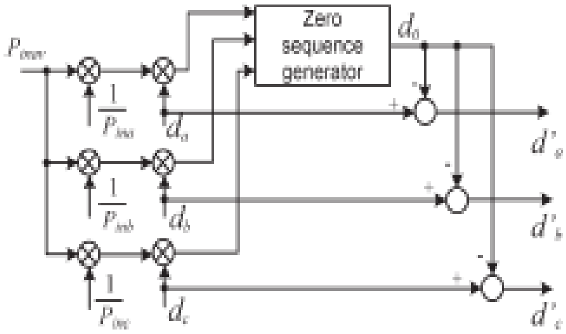

Fig. 6.Modulation compensation scheme.

complexity of the control system. First, the unbalanced power is weighted by ratio rj, which is calculated as

$$r_j = \frac{P_{in\,av}}{P_{inj}} \quad (1)$$

Where Pinj is the information force of stage (j = a, b, c), and Pinav is the normal info power. Then, the infused zero grouping balance record can be generated as

$$d_0 = \frac{1}{2}[min(r_a . d_a, r_b . d_b, r_c . d_c) + max(r_a . d_a, r_b . d_b, r_c . d_c)] \quad (2)$$

Where dj is the adjustment list of stage (j = a, b, c) and is determined by the present circle controller.

The adjustment list of each stage is refreshed by

$$d'_j = d_j - d_0 \quad (3)$$

Just straightforward counts are required in the plan, which will not build the unpredictability of the control framework. An example is exhibited to demonstrate the adjustment compensation scheme all the more unmistakably. Accept that the info force of each phase is unequal

$$P_{ina} = 0.8 \qquad P_{inb} = 1 \qquad P_{inc} = 1. \qquad (4)$$

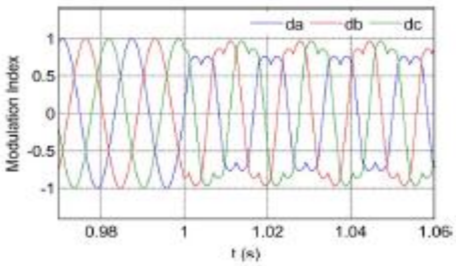

Fig.7.Modulation indices before and after modulation compensation.

TABLE I
SYSTEM PARAMETERS

parameters	value
DC-link capacitor	3600μF
Connection inductor L	2.5 mH
Grid resistor R	0.1ohm
Grid rated phase voltage	60 Vrms
Switching frequency	1.5 kHz

By infusing a zero succession adjustment record at t = 1 s, the adjusted regulation list will be refreshed, as indicated in Fig. 7. It can be seen that, with the remuneration, the updated modulation record is uneven corresponding to the power, which implies that the yield voltage of the three-phase inverter is lopsided, however this creates the coveted balanced grid current.

IV. SIMULATION RESULTS

Reproduction and trial tests are completed to validate the proposed thoughts. A measured fell multilevel inverter prototype has been implicit the research facility. The MOSFETIRFSL4127 is chosen as inverter switches working at1.5 kHz. The control signs to the H-connect inverters are sent by a d SPACE ds1103 controller .A three-stage seven-level fell H-connect inverter is simulated and tried. Every H-connect has its own particular 185-W PV panel (Astrometry CHSM-5612M) associated as an independent source. The inverter is associated with the lattice through a transformer, and the stage voltage of the auxiliary side is 60Vrms. The framework parameters are appeared in Table I.

A. Reenactment Results

To confirm the proposed control plot, the three-stage grid connected PV inverter is mimicked in two distinctive conditions .First, all PV boards are worked under a similar irradiance S = 1000 W/m2 and temperature T = 25 ◦C. At t = 0.8 s, the sun oriented irradiance on the first and second boards of stage a reductions to 600 W/m2, and that for alternate boards stays the same. The dc-connect voltages of stage aare appeared in Fig. 8. At the starting, all PV boards are worked at a MPP voltage of 36.4 V. As the irradiance changes, the first and second dc-

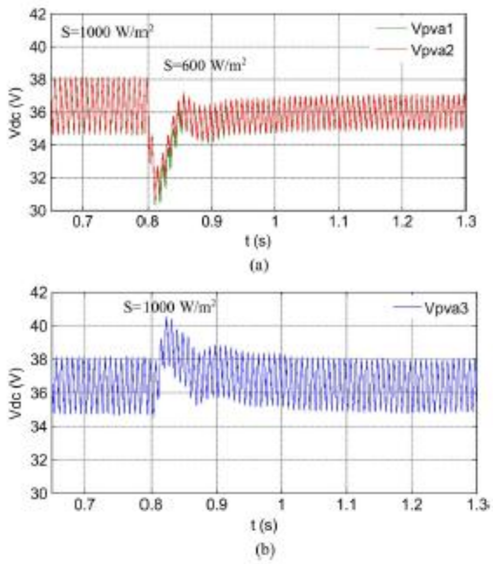

Fig. 8. DC-link voltages of phase *a* with distributed MPPT (*T* = 25 ◦C).(a) DC-link voltage of modules 1 and 2. (b) DC-link voltage of module 3.

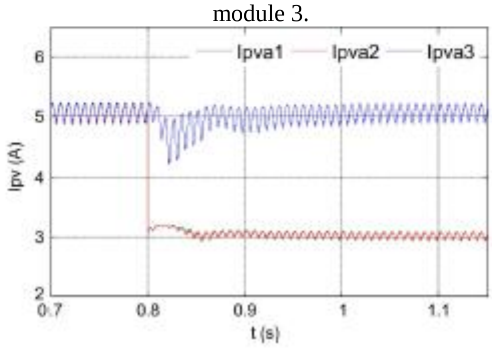

Fig. 9. PV currents of phase *a* with distributed MPPT (*T* = 25 ◦C).

interface voltages reduction and track the new MPP voltage of 36V, while the third board is still worked at 36.4 V. The PV current waveforms of stage a are appeared in Fig. 9. After t = 0.8 s, the currents of the first and second PV boards are substantially littler due to the low irradiance, and the lower swell of the dc-interface voltage can be found in Fig. 8(a).The dc-connect voltages of stage b are appeared in Fig. 10. All phase-b boards track the MPP voltage of 36.4 V, which appears that they are not impacted by other phases .With the distributed MPPT control, the dc-connect voltage of every H-scaffold can be controlled freely. At the end of the day, the associated PV panel of every H-extension can be worked at its own MPP voltage and won't be affected by the boards associated with other H-spans. Hence, more sun oriented vitality can be extricated, and the efficiency of the general PV framework will be increased .Fig. 11 demonstrates the power extricated from each phase .At the starting, all boards are worked under irradiance

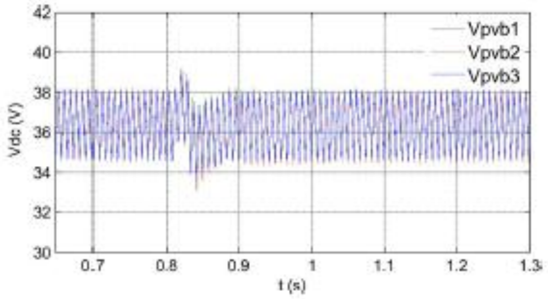

Fig. 10. DC-link voltages of phase *b* with distributed MPPT (T = 25 ◦C).

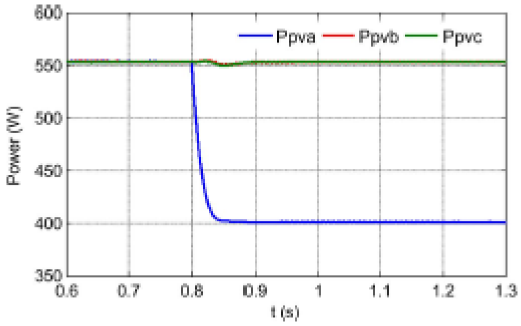

Fig.11. Power extracted from PV panels with distributed MPPT.

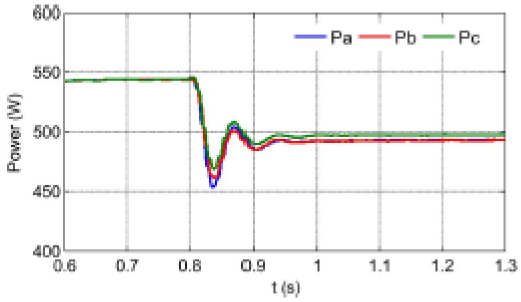

Fig. 12. Power injected to the grid with modulation compensation.

S = 1000 W/m2, and every phase is generating a maximum power of 555 W. After t = 0.8 s, the power harvested from phase a decreases to 400 W, and those from the other two phases stay the same. Obviously, the power supplied to the three-phase grid-connected inverter is unbalanced. However, by applying the modulation compensation scheme, the power injected to the grid is still balanced, as shown in Fig. 12. In addition, by comparing the total power extracted from the PV panels with the total power injected to the grid, it can be seen that there is no extra power loss caused by the modulation compensation scheme. Fig. 13 shows the output voltages of the three-phase inverter. Due to the injected zero sequence component, they are unbalanced after t = 0.8 s, which help to balance the grid current shown in Fig. 14.

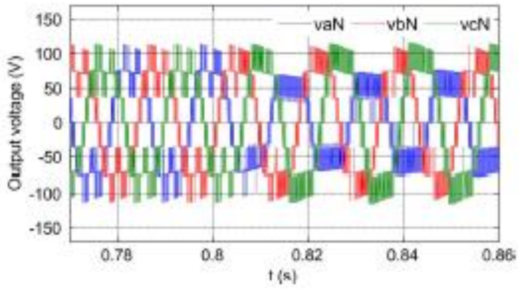

Fig.13. Three-phase inverter output voltage waveforms with modulation compensation.

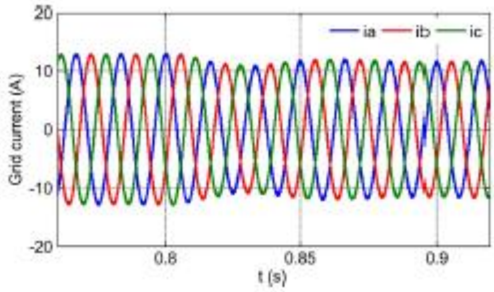

Fig.14.Three-phase grid current waveforms with modulation compensation.

V. CONCLUSION

In this paper, a secluded fell H-connect multilevel inverter for network associated PV applications has been presented. The multilevel inverter topology will enhance the utilization of associated PV modules if the voltages of the separate dc connections are controlled autonomously. In this way, a distributed MPPT control conspire for both single-and three-stage PV frameworks has been connected to expand the general productivity of PV systems .For the three-stage network associated PV framework, PV mismatches may present lopsided provided control, bringing about unbalanced injected lattice current. A balance compensation scheme, which won't build the unpredictability of the control system or cause additional power misfortune, is added to adjust the network Current. A secluded three-stage seven-level fell H-connect inverter has been inherent the research facility and tried with PV panels under various halfway shading conditions. With the proposed control plot, each PV module can be worked at its claim MPP to expand the sun oriented vitality extraction, and the three-stage framework current is adjusted even with the unbalanced supplied sun oriented power.

REFERENCES

[1] J. M. Carrasco *et al.*, “Power-electronic systems for the grid integration of renewable energy sources: A survey,” *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1002–1016, Jun. 2006.

[2] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, “A review of single-phase grid connected inverters for photovoltaic modules,” *IEEE Trans. Ind. Appl.*, vol. 41, no. 5, pp. 1292–1306, Sep./Oct. 2005.
[3] M. Meinhardt and G. Cramer, “Past, present and future of grid connected photovoltaic- and hybrid power-systems,” in *Proc. IEEE PES Summer Meet.*, 2000, vol. 2, pp. 1283–1288.
[4] M. Calais, J. Myrzik, T. Spooner, and V. G. Agelidis, “Inverter for singlephase grid connected photovoltaic systems—An overview,” in *Proc. IEEE PESC*, 2002, vol. 2, pp. 1995–2000.
[5] J.M. A.Myrzik andM. Calais, “String and module integrated inverters for single-phase grid connected photovoltaic systems—A review,” in *Proc. IEEE Bologna Power Tech Conf.*, 2003, vol. 2, pp. 1–8.
[6] F. Schimpf and L. Norum, “Grid connected converters for photovoltaic, state of the art, ideas for improvement of transformerless inverters,” in
Proc. NORPIE, Espoo, Finland, Jun. 2008, pp. 1–6.
[7] B. Liu, S. Duan, and T. Cai, “Photovoltaic DC-building-module-based BIPV system—Concept and design considerations,” *IEEE Trans. Power Electron.*, vol. 26, no. 5, pp. 1418–1429, May 2011.
[8] L. M. Tolbert and F. Z. Peng, “Multilevel converters as a utility interface for renewable energy systems,” in *Proc. IEEE Power Eng. Soc. Summer Meet.*, Seattle, WA, USA, Jul. 2000, pp. 1271–1274.
[9] H. Ertl, J. Kolar, and F. Zach, “A novel multicell DC–AC converter for applications in renewable energy systems,” *IEEE Trans. Ind. Electron.*, vol. 49, no. 5, pp. 1048–1057, Oct. 2002.
[10] S. Daher, J. Schmid, and F. L. M. Antunes, “Multilevel inverter topologies for stand-alone PV systems,” *IEEE Trans. Ind. Electron.*, vol. 55, no. 7, pp. 2703–2712, Jul. 2008.
[11] G. R. Walker and P. C. Sernia, “Cascaded DC–DC converter connection of photovoltaic modules,” *IEEE Trans. Power Electron.*, vol. 19, no. 4, pp. 1130–1139, Jul. 2004.
[12] E. Roman, R. Alonso, P. Ibanez, S. Elorduizapatarietxe, and D. Goitia, “Intelligent PV module for grid-connected PV systems,” *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1066–1073, Jun. 2006.
[13] F. Filho, Y. Cao, and L. M. Tolbert, “11-level cascaded H-bridge gridtied inverter interface with solar panels,” in *Proc. IEEE APEC Expo.*, Feb. 2010, pp. 968–972.
[14] C. D. Townsend, T. J. Summers, and R. E. Betz, “Control and modulation scheme for a cascaded H-bridge multi-level converter in large scale photovoltaic systems,” in *Proc. IEEE ECCE*, Sep. 2012, pp. 3707–3714.
[15] B. Xiao, L. Hang, and L. M. Tolbert, “Control of three-phase cascaded voltage source inverter for grid-connected photovoltaic systems,” in *Proc. IEEE APEC Expo.*, Mar. 2013, pp. 291–296.
[16] Y. Zhou, L. Liu, and H. Li, “A high-performance photovoltaic moduleintegrated converter (MIC) based on cascaded quasi-Z-source inverters (qZSI) using eGaN FETs,” *IEEE Trans. Power Electron.*, vol. 28, no. 6, pp. 2727–2738, Jun. 2013.
[17] J. Rodriguez, J. S. Lai, and F. Z. Peng, “Multilevel inverters: A survey of topologies, controls, and applications,” *IEEE Trans. Ind. Electron.*, vol. 49, no. 4, pp. 724–738, Aug. 2002.
[18] Standard for Electric Installation and Use. [Online]. Available: https:// www.xcelenergy.com/ [19] A. Dell’Aquila, M. Liserre, V. Monopoli, and P. Rotondo, “Overview of PI-based solutions for the control of DC buses of a single-phase H-bridge multilevel active rectifier,” *IEEE Trans. Ind. Appl.*, vol. 44, no. 3, pp. 857– 866, May/Jun. 2008.
[20] B. Xiao, K. Shen, J. Mei, F. Filho, and L.M. Tolbert, “Control of cascaded H-bridge multilevel inverter with individual MPPT for grid-connected photovoltaic generators,” in *Proc. IEEE ECCE*, Sep. 2012, pp. 3715–3721.