Research Journal of Recent Sciences ISSN 2277-2502
Vol. **3(7),** 53-57, July **(2014)** *Res.J.Recent Sci.*

Performance improvement of Photovoltaic systems through Harmonics Elimination of system and minimizing of THD

Mohammadamin Heidari and Abdolamir Nekoubin*
Fasa Branch, Islamic Azad University, IRAN

Available online at: www.isca.in, www.isca.me
Received 14th August 2013, revised 13th November 2013, accepted 4th May 2014

Abstract

Multilevel inverters have been extremely applied in industries. A family of optimal pulse width modulation (PWM) methods for multilevel inverters, such as step modulation, can generate output voltage with less harmonic distortion. In grid connected multiple inverter systems, it is normal to synchronize the output voltage of each inverter to the common network voltage. Any controller deficiencies, which result in low order harmonics, are also synchronized to the common network voltage. As a result the harmonics produced by individual converters show a high degree of correlation and tend to be additive. Each controller can be tuned to achieve a different harmonic profile so that harmonic cancellation can take place in the overall system, thus reducing the net t total harmonic distortion level. The simulation results based on MATLAB/Simulink environment shows that the proposed system offers improvement in harmonic elimination and simultaneously inject the maximum power available from PV array into the grid.

Keywords: Low order harmonics, multiple inverter systems, net harmonics.

Introduction

Multiple string inverters are frequently used to connect a PV system to the network[1]. In this approach, each panel is connected through its own inverter, the inverter units being connected in parallel up to the required volt-ampere rating of the system (figure-1). This avoids the need to run long lengths of high current dc cabling, with the attendant problems of expensive circuit breakers. It is normal practice for the output current of each inverter to be controlled to be sinusoidal, with low harmonic levels, and at unity power factor with respect to the network voltage.

Low harmonic levels are desirable since harmonics have long been recognized as causing a number of operational problems to the grid network[2,4]. Some of the major effects caused by harmonics include capacitor bank failure, overvoltage and overcurrent on the network, dielectric breakdown of insulated cables and kWh metering errors. To preserve the quality of the utility current and voltage, set limits are imposed on the current and voltage harmonics that may be injected into the grid[5,6]. However, as more and more distributed generation systems are being interfaced to the network, the problem of harmonic injection into the grid is becoming an increasing problem[7, 8].

For this reason, there is considerable motivation to improve grid connected inverter performance through the reduction, or ideally complete elimination, of the output harmonics. Several techniques aimed at inverter system harmonic improvement have been presented. Holmes and McGrath[9] considered the effect of a number of different PWM strategies in various converter topologies. It was demonstrated that certain PWM strategies and sampling techniques could help eliminate particular side-band switching harmonics. This work also identified further opportunities for harmonic elimination in multilevel cascaded inverter systems. Liang *et al.* [10] described the use of Walsh Functions in a single phase full bridge inverter for the purpose of voltage harmonic elimination at the inverter output.

The Walsh Function technique allowed the harmonic amplitudes of the inverter output voltage to be expressed as functions of the inverter switching angles. A series of linear algebraic equations could then be solved to eliminate unwanted harmonics. Infield[11,12] discussed the manner in which random phase harmonics in multiple inverter systems combined. In particular, the work was applicable to switching harmonics, which are random in phase. Mathematical rules, based on probabilistic integrals, were formulated to help assess the overall degree of harmonic cancellation arising from multiple connection of inverter systems to a common point[13,14].

This paper suggests a new idea to improve the overall current harmonic output of a grid connected multiple inverter system. In particular, the work focuses on reducing low order current harmonics. This is achieved through simple randomization of the inverter current control parameters[15,16]. This technique is shown to significantly reduce the correlation of low order current harmonics between inverters. As a result, on average, the inverter harmonics at the common point of coupling are likely to demonstrate a degree of cancellation, as opposed to harmonic reinforcement when correlated.

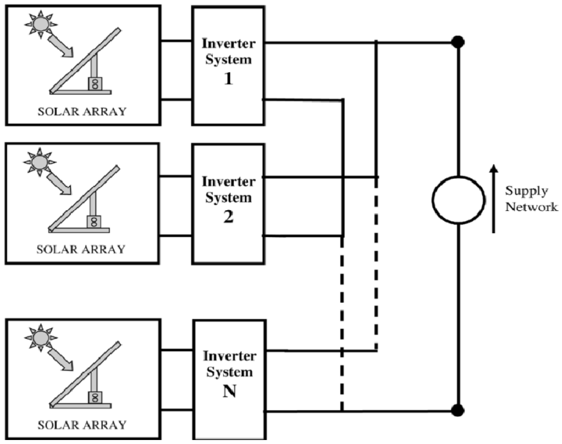

Figure -1
Grid connected, multiple string inverter system

Grid connected inverter harmonics

The harmonics in the output current of an inverter can be grouped according their source: switching harmonics which are related to the PWM circuits in each inverter and lower frequency harmonics which are due to deficiencies in the control of the inverter output current. The majority of the switching harmonics are easily filtered at the inverter output. The low order harmonics, however, are at frequencies much closer to the fundamental. Therefore, it is more difficult to filter these harmonics without impairing the fundamental current waveform. The output current harmonics related to the PWM are synchronized to the clock circuits within the inverter controller and therefore, will not be correlated because the crystal controlled clocks within each inverter are usually independent. A recognized power quality benefit of this arrangement is that the harmonic distortion arising in each inverter is uncorrelated and therefore cancellation will take place in multiple inverters systems. The harmonics due to the current controller performance will, however, behave differently. It is normal to produce a current reference waveform within the inverter, which specifies the magnitude and power factor of the output current in accordance with the active and reactive power generation requirements at a particular time. For a grid connected system, the current reference waveform in each inverter must be synchronized to the common network voltage waveform. Therefore, any low order harmonics resulting from controller deficiencies will also be synchronized to the common network voltage and the harmonics produced by individual converters will have a high degree of correlation. This will mean that the lower order harmonics from each inverter will be additive. The grid-connected inverter has to drive current against the supply voltage and impedance, which are not fixed quantities. Grid connected inverter performance has been shown to be very much dependent on grid operating conditions. Controlling current to be injected into the grid network is, therefore, considerably more difficult than controlling current into fixed loads such as motor windings or isolated consumer load systems. The output current waveform fidelity is dependent on the tuning of the current control loop but changes in the grid supply characteristics mean that it is not possible to achieve an optimally tuned output current loop at all times. Normally the inverter output current is tuned by adjusting settings within the controller while monitoring the low order harmonics. By trial and error, various harmonics can be minimized and total harmonic distortion (THD) can be reduced. A point is normally reached where further tuning does not produce any further improvement in THD. By adjustments to the controller tuning, however, it is possible to alter which harmonics are suppressed while maintaining the total harmonic distortion reasonably constant. This is due to the interaction between the controller dynamics and the dynamics of the supply and line inductance.

Harmonic Cancellation Scheme

In principle, for a multi inverter system, each controller could be tuned to achieve a different harmonic profile. Harmonic cancellation would take place in the overall system and the net THD level would be reduced. To force this to happen, however, inter-inverter communications would be required, a feature which is not desirable on cost grounds. An alternative approach is therefore considered, which is to arrange for the tuning within each inverter to be adjusted automatically with a random component. This will result in a harmonic varies with time but is uncorrelated with the harmonic spectrum of any other inverter in the system. As a consequence, the net harmonics from all the inverters will undergo a degree of cancellation while each individual inverter THD will remain almost constant. Thus, the overall system of inverters yields a net improvement in power quality. One of these inverter modules is shown in figure-2.

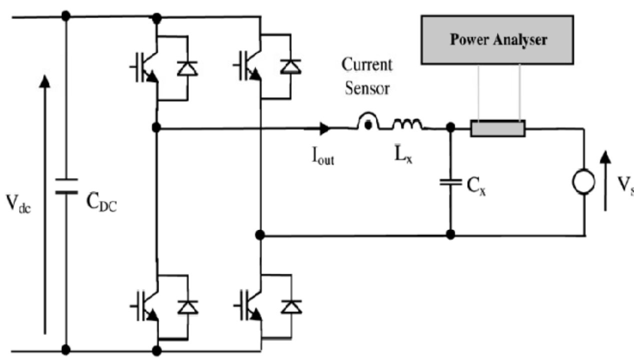

Figure-2
Inverter model

Simulation of photovoltaic system

The Simulator used should be capable of modeling of not only PV cells/modules but as well as possess the ability to simulate connected power electronics so that a simulation of a whole PV system can be carried out.

In this part a photovoltaic system with filter is simulated. Designed system is shown in figure-3. Figures 4-10 shows the results of simulation.

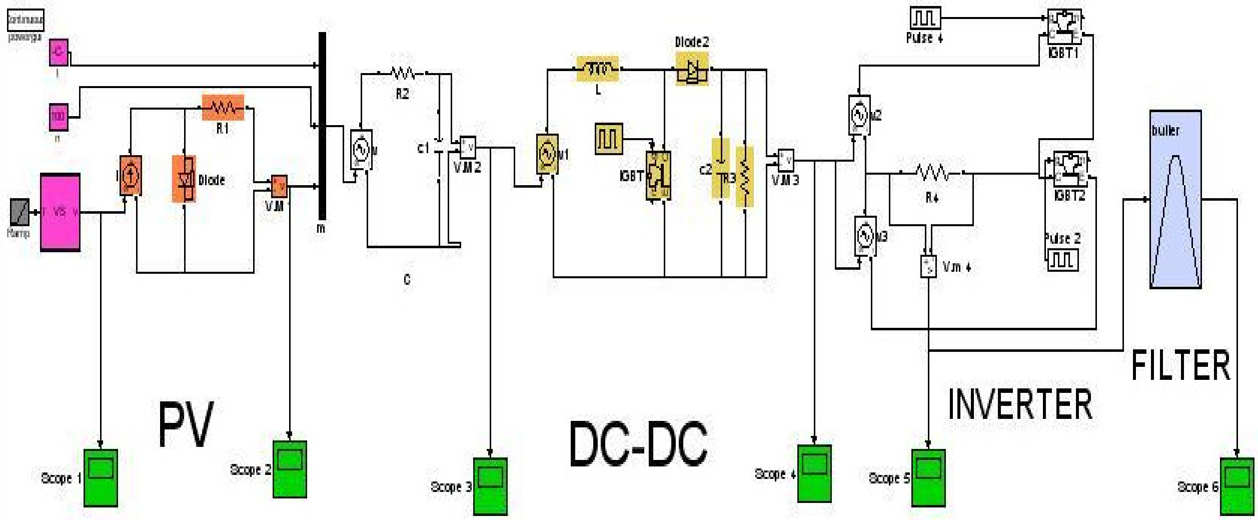

Figure -3
Simulated Network

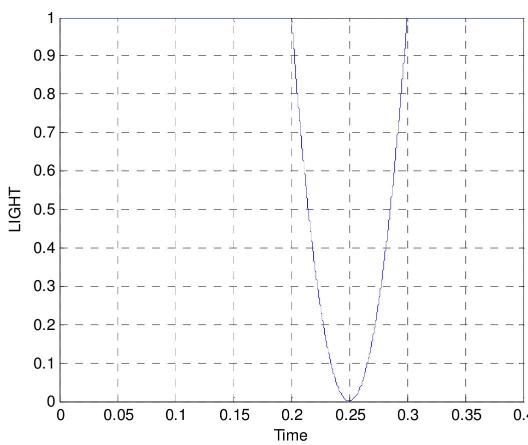

Figure -4
Scheme of light

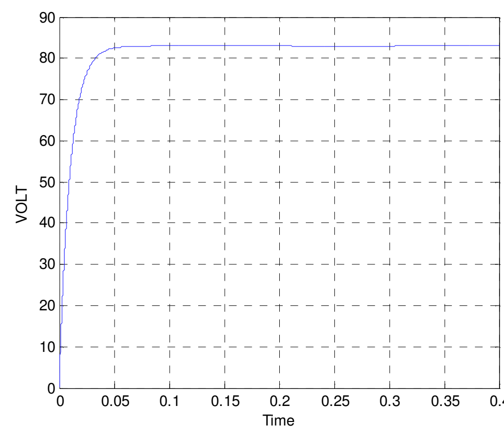

Figure-6
Out put voltage (input of DC-DC convertor)

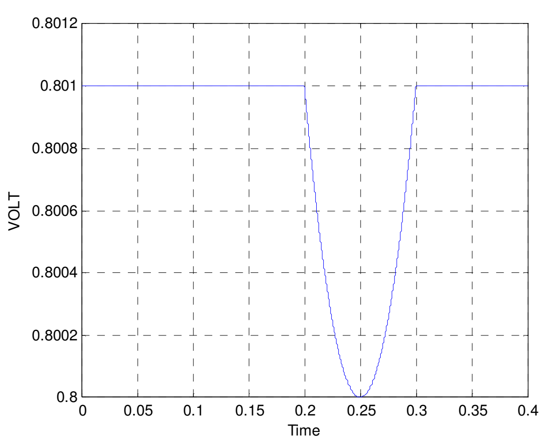

Figure -5
Produced voltage in a cell

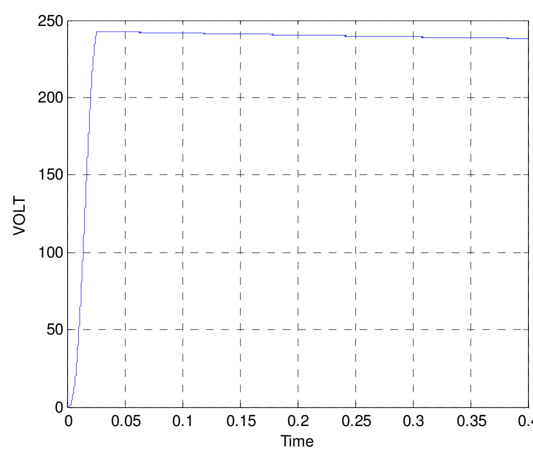

Figure-7
Out put voltage of DC-DC convertor

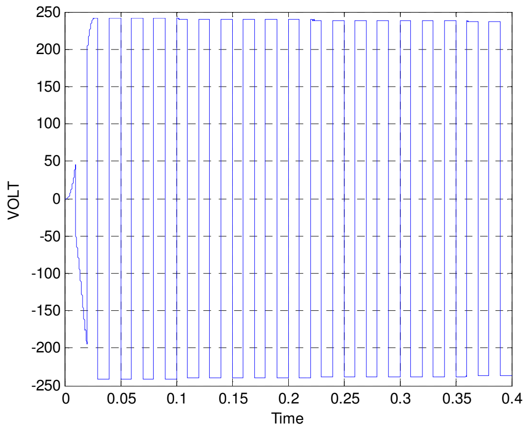

Figure-8
Input voltage of inventor(consist of harmonics)

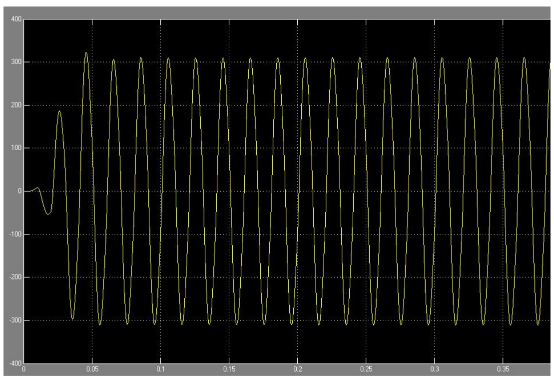

Figure-9
Out put voltage (after filtering)

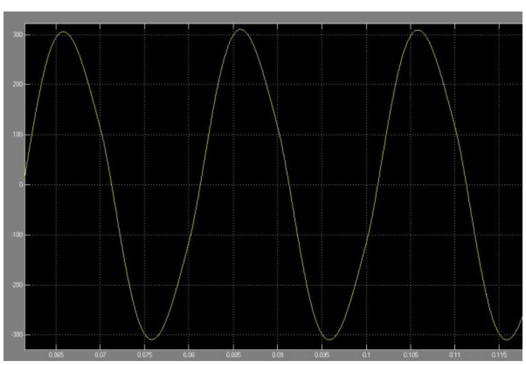

Figure-10
Out put voltage (after filtering in shorter time)

The harmonic mitigation in photovoltaic system with Active Power Filter (APF) has been studied. The proposed system consists of a PV array, a DC–DC boost converter and a DC-AC inverter. It also includes a control strategy, based on instantaneous reactive power theory for the APF. The simulation results based on MATLAB/Simulink environment shows that the proposed system offers improvement in harmonic elimination and simultaneously inject the maximum power available from the PV array into the grid.

Figure-9 shows the compensated source voltage, PV system power to the grid with low harmonics and balanced currents. This verifies the effectiveness of the proposed filter system.

Conclusion

In this paper, an active power filter is included to eliminate the harmonics in photovoltaic system has been discussed. The simulation results, carried out by MATLAB/simulink, show the effectiveness of the suggested control systems in grid-connected mode. Also, it shows that the proposed control system improve the harmonics suppression. MPPT control strategy is also used to extract maximum power from the proposed PV system.

Acknowledgements

This work was supported by Fasa Branch, Islamic Azad University, IRAN

References

1. H. Watanabe T. Shimizu and G. Kimura, A novel utility interactive photovoltaic inverter with generation control circuit, **9(3)**, 72-78 **(2012)**
2. Andersen M. and Alvsten T.B., 200W low cost module integrated wittily interface for modular photovoltaic energy systems, *IEEE Industrial Applications Magazine*, **14,** 57–62 **(2012)**
3. Kim Y.S., Yoo G. and Song J., A Bi functional utility connected photovoltaic systems with power factor correction and U.P.S. facility, *IEEE Trans. on Power System,* **18(1),** 305-312 **(2011)**
4. Hosseini S.H. and Ajami A., Voltage Regulation and Transient Stability Enhancement of a Radial AC Transmission System using UPFC, *IEEE Annual conference Industrial Electronics Society*, **2,** 1150-1154 **(2011)**
5. Quantum Size Effects on Effective Mass and Band gap of Semiconductor Quantum Dots, Changiz Vatankhah and Ali Ebadi, *Res. J. Recent Sci*, **2(1),** 21-24 **(2013)**
6. Oviri O.K. and Ekpunobi A.J., Transmittance and Band Gap Analysis of Dye Sensitized Solar Cell, *Res. J. Recent Sci.,* **2(1),** 25-31 **(2013)**
7. Sallameh Z. and Taylor D., Step-up maximum power point Tracking for photovoltaic Arrays, *IEEE Trans. on Power Electronics*, **1(9),** 36-40 **(2012)**
8. Teulings W., Marpinard J.C., Capel A. and Sullivan D.O., A New maximum power point Tracking system, *IEEE Trans. on Power Delivery*, **10(2)**, 1085-1097 **(1995)**

9. Wagner V.E., Effect of harmonics on equipments (UPFC) for Power System Studies, *IEEE Trans. on Power Systems*, **11(4)**, 1937-1943 **(1996)**

10. Jintakosonwit P., Fujita H. and Akaka H., Control and performance of a fully – Digital - controlled shunt Active filters for installation on a power distribution systems, *IEEE Trans. on Power Systems*, **17(4)**, **(2002)**

11. Ishengoma F.M. and NorAm L.N., Degin and implementation of digitally controlled stand - alone photovoltaic power supply, *Res.J.Recent Sci.,* **1(2),** 97- 99 **(2012)**

12. Masoud K. and Ledwich G., Asperts of grid interfacing: current and voltage controllers, *Res.J.Recent Sci.,* **1(3),** 76-79 **(2012)**

13. Wood A., Qualitative Analysis of Stochastic Operations in Dual Axis Solar Tracking Environment, Fam D.F., Koh S.P., Tiong S.K. and Chong K.H., *Res.J.Recent Sci.,* **1(9),** 74-78 **(2012)**

14. Collins C., Watson N. and Wood A., UPFC Modeling in Harmonic Domain, *IEEE Trans. on Power Delivery*, **21**(**2**), 933-938 **(2006)**

15. Malesani L., Tenti P., Gaia E. and Piovon R., Improved current control technique of VSI PWM Inverters with constant modulating frequency and extended voltage rang, *IEEE Trans. on Power Electronics*, **21(4)**, 1013-1020 **(2006)**

16. Akogi H., Kansawa Y. and Noble A., Instantaneous reactive power compensation comprising switching device swith out energy components, *IEEE Trans. on Power Electronics*, **22(4)**, 1186-1195 **(2007)**