International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

HARMONIC DISTORTION REDUCTION OF ISLANDED MICROGRID

V SANDEEP

Assistant Professor, Department of Electrical and Electronics Engineering, Siddhartha Institute of Technology and Sciences, Narapally, Hyderabad, Telangana, India

ABSTRACT: In this project the Harmonic analysis and mitigation of Islanded microgrid with nonlinear loads are presented. This paper mainly focuses the concentration on power quality enhancement in an autonomous microgrid along with the nonlinear load. When the loads are made to transfer from grid connected to islanded, there arises power quality problems. This ability of islanding the generation and load has the potential of high reliability of the main grid. The nonlinear loads in microgrids are due to the switching converters and consequent current interruptions. These distortions produce different components of current that are multiples of the fundamental frequency of the system nominal frequency which are called harmonics. Harmonic producing loads are distributed in the building low voltage network. Voltage could possibly be distorted due to increased loading level and cable harmonic voltage drop. Due to increase in the number of distributed renewable sources facilitate reduction in total harmonic distortion (THD) in buses by adding an active filter. The microgrid operation with nonlinear loads is presented by using MATLAB and SIMULINK software.

KEYWORDS-Microgrid, power quality, harmonics, Active Power Filter(AP)

I. INTRODUCTION

Nowadays there is a worldwide need for renewable and clean energy. Because of this urge and thanks to technological improvements during the last decades, a lot of renewable energy generators have been introduced throughout the world, capable of mitigating most technical challenges created by those intermitted energy sources. The great potential of such resources for green energy production has led the technological society to the implementation of a new type of distribution system, the microgrid [1-3].

The utilization of such technologies may have a lot of advantages such as improved efficiency, infinite and free raw materials and almost no environmental impact, but there are some drawbacks too. The integration of these Renewable Energy Source (RES) to the grid would not be possible without the use of power electronics devices [4-6]. Specifically, harmonic distortion occurs due to loads supplied by converters as well as to RES interfaced to the grid through inverters. Harmonic distortion leads to poor power quality to the end user of the distribution system, as well as to increased value of line current.For this reason a lot of

active filters and power conditioners have been proposed in order to alleviate the distribution system problems from both current and voltage high-order harmonics point of view and improve power quality. Only a few of these proposals deal with grid's power quality improvement [7]. Instead, the majority of them focus in the harmonic cancellation and power quality improvement of critical loads against the high-order harmonic distortion of the grid that they are connected to.The integration of these renewable resources utilizing Sun and wind sources in the distribution system can be defined as distribution generation systems. The penetration of these resources is limited by the supply of percentage to load demanded. The system is said to be 100% penetrated when the total load is supplied by the renewable sources. Due to the integration of these renewable sources into the grid with power electronic devices may deteriorate the power quality. We need to compensate the quality with FACTs devices [8] in a combination of passive filters.The grid system contain linear and non-linear loads, the effect of non-linear loads is higher than the linear loads. As the non-linear load works on DC an AC to DC converter is used with the help of power electronic switches. Load is only inductors or resistors, we do not have any capacitor loads. The total impedance of the load connected to the AC to DC converter introducing [9] harmonics in the system creating a severe problem of PQ balancing. These load current harmonics caused by the power electronic devices can be compensated through the APF (Active Power Filter) with RES by injecting required active and reactive power. The compensation reduces emphasize on main source increasing the power factor and improving the power quality. The operational cost of the APF is very less as RES is interconnected for the compensation to the grid [10].In the three phase microgrid there will be different types of loads such as balanced, unbalanced and non-linear loads. When the system is isolated from the main utility grid, then it loss the control of voltage and frequency which is being supported by the grid due to which unbalanced and non-linear loads leads to degrade the power quality and produce harmonics. The distorted voltage due to unbalanced loads and harmonics cause severe problems on equipments such as, [11] over-heat, over-voltage, vibration etc. In [12], a new improved control strategy of microgrid is being presented in which APF is used to control the unbalanced voltage and frequency and to make it constant voltage profile and proper frequency. And then also a proper control technique used which restore the disturbed voltage and frequency to the normal values in an islanded mode of operation of microgrid.Different types of filters are being utilized to compensate such problems. In [13] comparing active and passive filter, active filter is mostly used to improve the power quality issues. Unbalanced voltage and harmonics are compensated by using series active filters by injecting negative sequence and harmonic voltage. But we cannot install active filters [14] for each microgrid since it becomes uneconomical.APF helps in improving the power quality and also fulfills the demand at the time of requirement and also it helps in maintaining the stability. But due to the fluctuation in the output of renewable source of energy leads to create problem for the battery storage because due to this the charging and discharging problem in the battery occurs and which leads to early damage of battery life. Also using and maintaining of different types of batteries according to use is very difficult. So APF [15] leads to disadvantageous in use in microgrid.

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

II. MICROGRIDS WITH NONLINEAR LOADS

When power can be fully supplied by local renewable power sources, long distance transmission is no longer necessary. AC microgrids are utilized to facilitate the connection of renewable power sources to conventional AC systems. Numerous countries are in the way for transforming their power grid to smart power grids incorporated with microgrids and distributed generators. India has initiated researches and practical projects for developing indigenous microgrid Systems. However, dc power form photovoltaic (PV) panels or fuel cell has to be converted into AC using dc/dc boosters and dc/ac inverters for AC grid interconnection. On other hand, more and more dc loads such as light-emitting diode (LED) lights, electronic devices and electric vehicles (EVs) operated in battery/DC supply are emerging. Therefore, power electronic converters such as ac/dc or ac/dc/dc are required. The switching operations within these converters result in current discontinuities or distortions. Power quality issues resulting from these distortions are described in the following section.

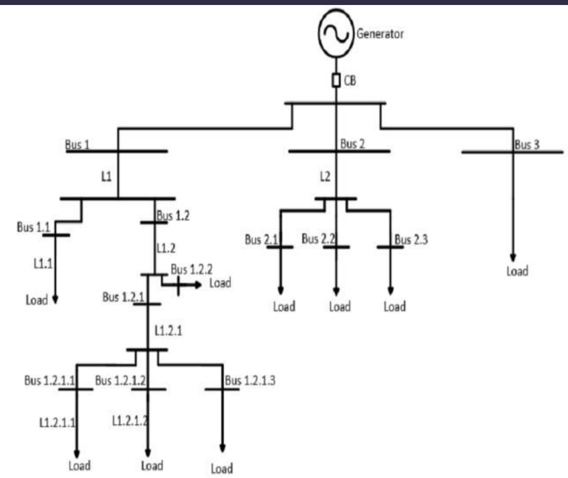

Fig.1. Single line diagram of 18-bus microgrid in islanded mode

III. POWER QUALITY

As described in the preceding section, converters adopted within microgrid produces current distortion. This current distortion produces current harmonics. When these current harmonics flow through various elements in a microgrid, results in harmonic voltage drops. These harmonic voltage drops result in voltage profile distortion. Since majority of the consumer loads are connected in parallel, the voltages are equal to all. Hence, distorted voltage will be available for all loads within the microgrid that include sensitive loads. Harmonic components produce overheating and vibration in electrical machines and maloperation of electronic components. Hence analysis of impact of nonlinear loads on voltage profile in a microgrid is of great importance. This paper studies the same in a model microgrid during islanded mode of operation.

IV. ACTIVE POWER FILTER (APF)

In a modern power system, increasing of loads and nonlinear equipment’s have been demanding the compensation of the disturbances caused for them. These non-linear loads may cause poor power factor and high degree of harmonics. Active power filter (APF) can solve problems of harmonic and reactive power simultaneously. APF's consisting of voltage source inverters and a dc capacitor have been researched and developed for improving the power factor and stability of transmission systems. APF have the ability to adjust the amplitude of the synthesized ac voltage of the inverters by means of pulse width modulation or by control of the dc-link voltage, thus drawing either leading or lagging reactive power from the supply. APF's are an up-to-date solution to power quality problems. Shunt APF's allow the compensation of current harmonics and unbalance, together with power factor correction, and can be a much better solution than conventional approach (capacitors and passive filters). The simplest method of eliminating line current harmonics and improving the system power factor is to use passive LC filters. However, bulk passive components, series and parallel resonance and a fixed compensation characteristic are the main drawbacks of passive LC filters.Harmonic compensations have become increasingly important in power systems due to the widespread use of adjustable-speed drives, arc furnace, switched-mode power Supply, uninterruptible power supply, etc. Harmonics not only Increase the losses but also produce unwanted disturbance To the communication network, more voltage and/or current Stress, etc. Different mitigation solutions, e.g., passive filter, Active power line conditioner, and also hybrid filter, have been Proposed and used. Recent technological advancement of switching devices and availability of cheaper controlling devices, E.g., DSP-/field-programmable-gate-array-based system, Make active power line conditioner a natural choice to compensate For harmonics. Shunt-type active power filter (APF) is used to eliminate the current harmonics. The dynamic performance of an APF is mainly dependent on how quickly and how accurately the harmonic components are extracted from the load current. Many harmonic extraction Techniques are available, and their responses have been explored. In this project a new concept is proposed that is FBD algorithm in three-phase four-wire shunt active power filter to compensate the harmonics. In APF design and control, instantaneous reactive power theory was often served as the basis for the calculation of compensation current. In this theory, the mains voltage was assumed to be an ideal source in the calculation process. However, in most of time and most of industry power systems, mains voltage may be unbalanced and/or distorted. Under such scenarios, this theory may not be valid for application. The *p–q* theory, since its proposal, has been applied in the control of three-phase active power filters. However, power system voltages being often non-ideal, in distorted voltage systems the control using the *p–q* theory does not provide good performance. For improving APF performance under non-ideal mains voltages, new control methods are proposed by Komatsu and Kawabata and Huang and Chen and Hsu. In this paper, the proposed control algorithm.Gives adequate compensating current reference even for non ideal voltage system. Consequently, it is primarily concerned with the development of APF performance under non-ideal or distorted mains voltage conditions. Performance of the proposed scheme has been found feasible and excellent to that of the instantaneous reactive

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

power algorithms under various non-ideal mains test scenarios.

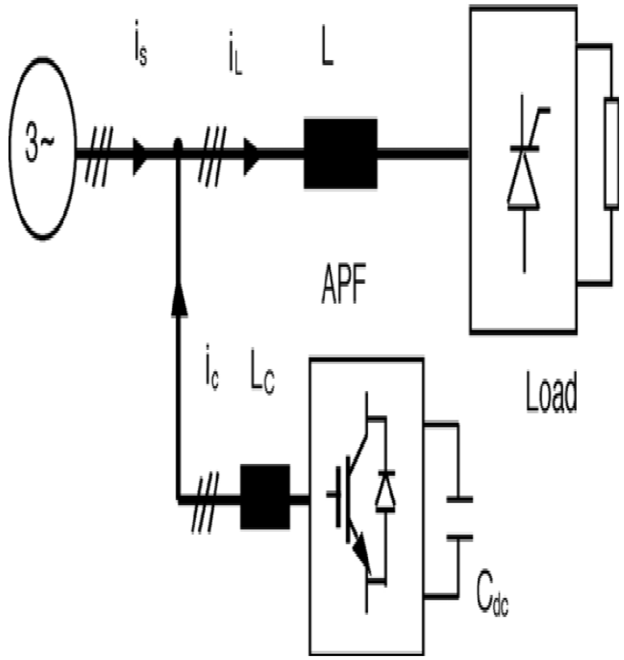

Fig.2 Block diagram of APF

a) Active power filter

Fig. 2 shows basic APF block diagram including non-linear load on three-phase supply condition. In this study, three-phase controlled thyristor bridge rectifier with ohmic–inductive loading are considered as a non-linear load on three-phase ac mains. This load draws non-sinusoidal currents from ac mains and can be controlled by changing its firing angle. APF overcome the drawbacks of passive filters by using the switching mode power converter to perform the harmonic current elimination. Shunt active power filters are developed to suppress the harmonic currents and compensate reactive power simultaneously. The shunt active power filters are operated as a current source parallel with the non-linear load. The power converter of active power filter is controlled to generate a compensation current, which is equal but opposite the harmonic and reactive currents generated from the nonlinear load. In this situation, the mains current is sinusoidal and in phase with mains voltage. A voltage-source inverter having IGBT switches and an energy storage capacitor on dc bus is implemented as a shunt APF. The main aim of the APF is to compensate harmonics, reactive power and to eliminate the unwanted effects of non ideal ac mains supplies only unity power factor sinusoidal balanced three-phase currents. Shunt active filters are designed to compensate for harmonic currents, reactive power and neutral current by injecting filtering currents into the electric grid. These can be considered as a controlled current source and prove to be particularly effective when their control system provides a good reference tracking. The simplest control technique for current controlled PWM inverters, used as an APF, is hysteresis control. However, at critical points, where changes of reference waveform slope are unpredictable, hysteresis control causes a dangerous increase in switching frequency which cannot be justified, even if it has the advantage of not exceeding the designed error band. The proposed current control, on the other hand, aims to reduce tracking error, by means of a fixed frequency driving signal. During the switching period in each inverter leg, the control allows the proper state for a longer interval resulting in the quickest possible error reduction. The effectiveness of the proposed active filter control was proved in a simulation, where the compensation of the harmonic pollution caused by a hard distorting and unbalanced load is carried out, and is evaluated by means of a performance index. Harmonic compensation as well as reactive power reduction and line neutral current reduction are achieved by using 10 kHz inverter switching signals.

V. MATLAB/SIMULINK RESULTS

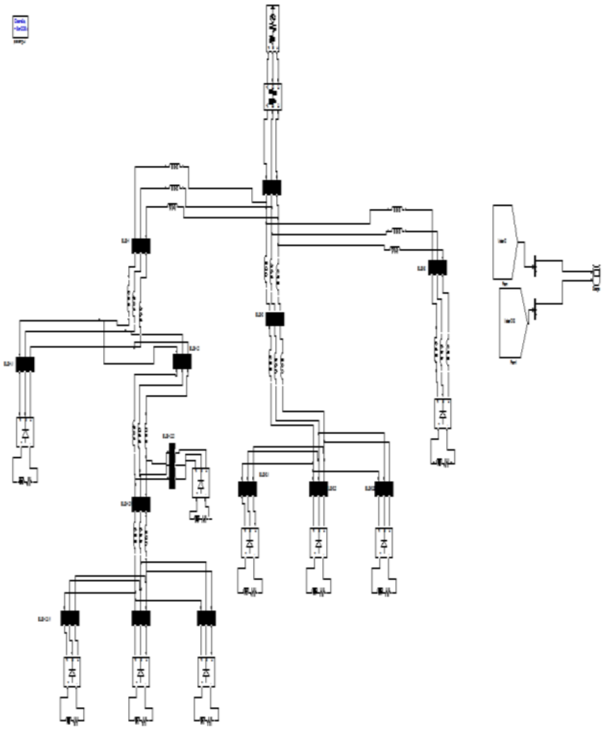

Fig.3. MATLAB/SIMULINK circuit for Single line diagram of 18-bus microgrid in islanded mode

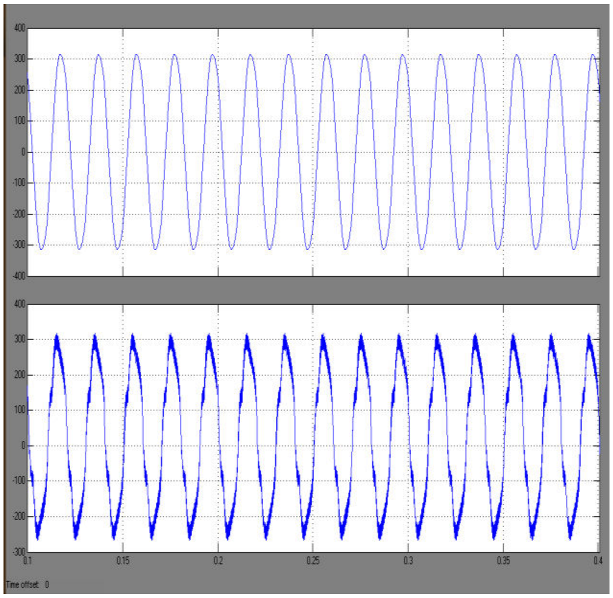

Fig.4.R-phase voltage waveforms at bus-1.2 and bus-1.2.1.3 (test case-1)

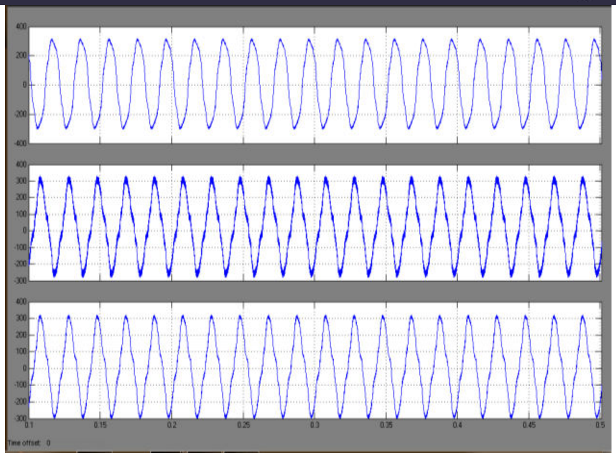

Fig.5. R-phase voltage waveforms at bus-1, bus-2 and bus-3 (test case-II)

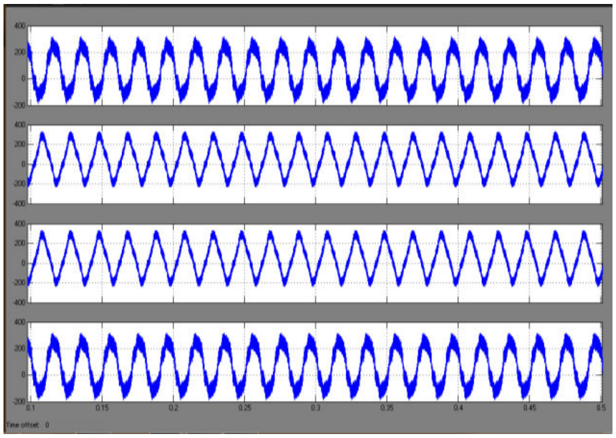

Fig.6. R-phase voltage waveforms at bus-1, bus-2, bus-3
and bus-1.2 (test case-III)

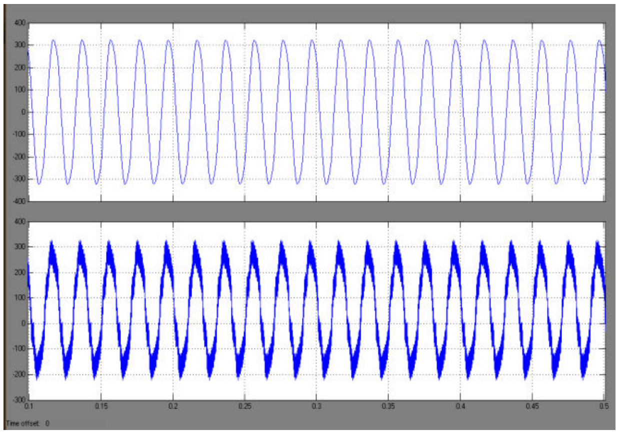

Fig.7. R-phase voltage waveforms at bus-1.2 and bus-1.2.1.3 when total distributed generation in test case-I is increased by 20%

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

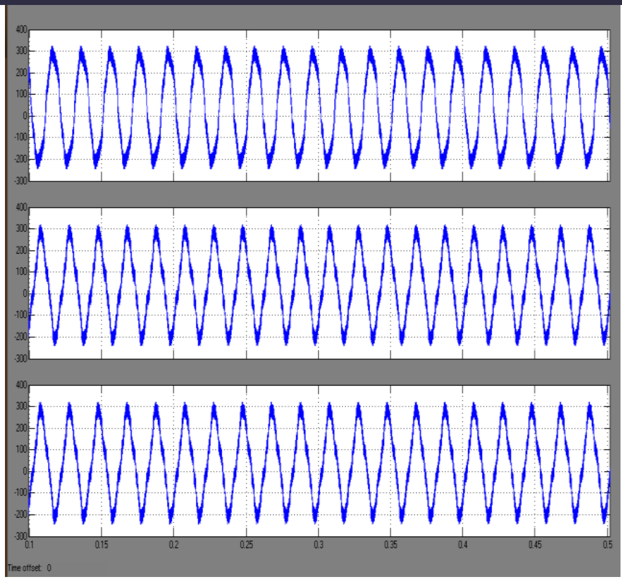

Fig.8. R-phase voltage waveforms at bus-1, bus-2 and bus-3 in test case-II when total distributed generation in test case-I is increased by 40%

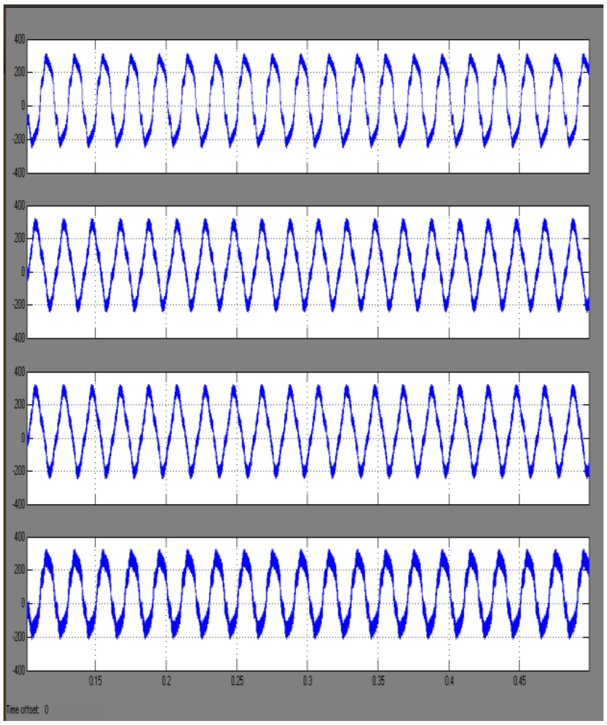

Fig.9. R-phase voltage waveforms at bus-1, bus-2, bus-3
and bus-1.2 in test case-III when total distributed generation in test case-I is increased by 60%

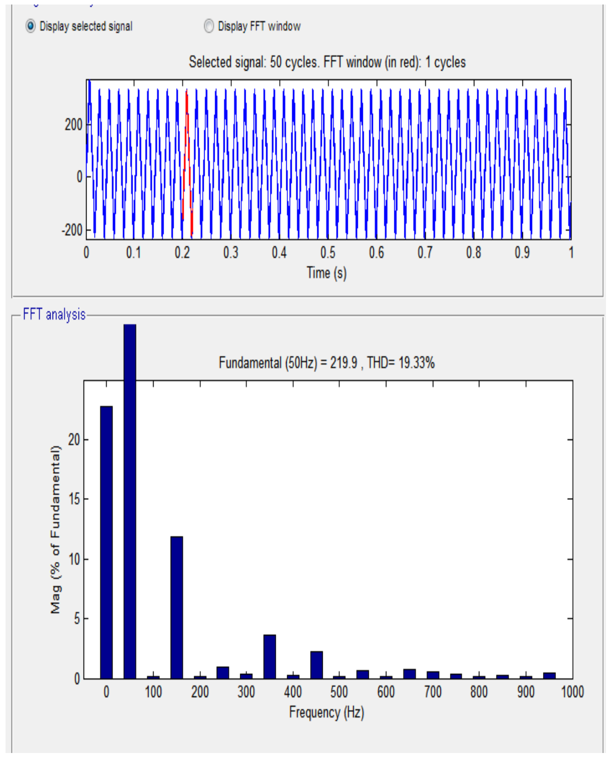

Fig.10. FFT spectrum of bus-3 voltage for Case III with
90% of nonlinear loads

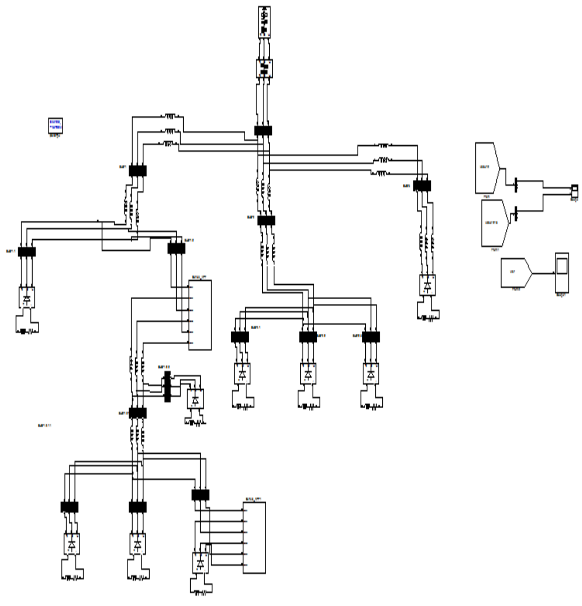

Fig.11. MATLAB/SIMULINK circuit for Single line diagram of 18-bus microgrid in islanded mode with APF

International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

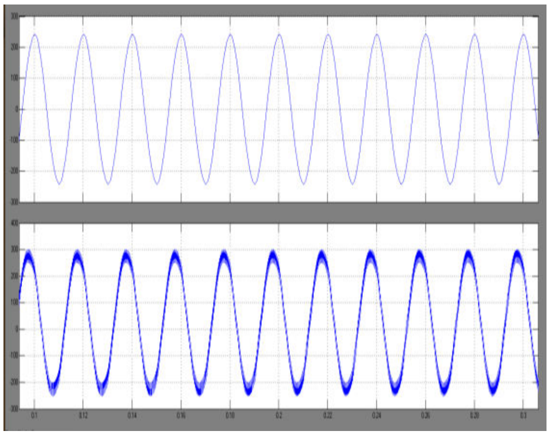

Fig.12.R-phase voltage waveforms at bus-1.2 and bus-1.2.1.3

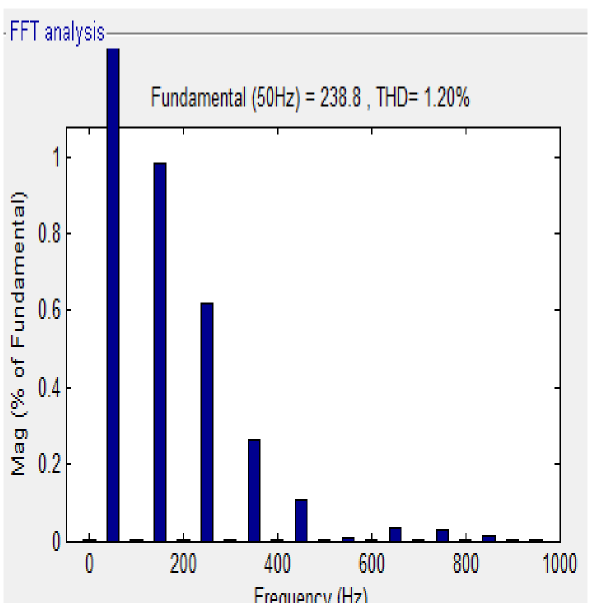

Fig.13. FFT spectrum of bus-3 voltage for Case III with
90% of nonlinear loads with APF

VI. CONCLUSION

One of the important challenges in microgrid is to maintain constant voltage and frequency, especially during the switching between islanded mode and grid connected mode of operation. A coordinated control scheme for the control of a microgrid system in both islanded and grid connected mode is implemented in Matlab/Simulink environment in this paper. This control scheme improves performance of microgrid system with respect to voltage and frequency during its operation. The voltage and frequency has to be controlled to maintain smooth power flow and power quality in microgrid system. This control strategy provides coordination between islanded mode and grid connected mode of operation of microgrid system. An active filter topology proposed in this paper for current harmonic reduction in a distribution system (i.e. microgrid). The main advantages of the proposed topology are its robustness; its converter's low switching losses and the simplicity of its harmonic control. it can be concluded that the proposed topology can provide both voltage and current harmonic reduction in microgrids (or generally in distribution systems), depending on which kind of distortion exists. Finally, the above mentioned theory and simulation results were experimentally confirmed. The THD is reduced below the 5% threshold imposed by the existing standards.

REFERENCES

[1] A. Micallef, M. Apap, C. Spiteri-Staines, J. M. Guerrero, and J. C. Vasquez, "Reactive Power Sharing and Voltage Harmonic Distortion Compensation of Droop Controlled Single Phase Islanded Microgrids," IEEE Trans. Smart Grid, vol. 5, no. 3, pp. 1149–1158, May 2014.

[2] T.-L. Lee and P.-T. Cheng, "Design of a New Cooperative Harmonic Filtering Strategy for Distributed Generation Interface Converters in an Islanding Network," IEEE Trans. Power Electron., vol. 22, no. 5, pp. 1919–1927, Sep. 2007.

[3] "IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems," IEEE 1547-2003, 2003.

[4] "Characteristics of the utility interface for photovoltaic systems," IEC 61727 , 2004

[5] J. Miret, M. Castilla, J. Matas, J. Guerrero, and J. Vasquez, "Selective Harmonic-Compensation Control for Single-Phase Active Power Filter With High Harmonic Rejection," IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 3117–3127, Aug. 2009.

[6] S. Chakraborty and M. Simoes, "Experimental Evaluation of Active Filtering in a Single-Phase High-Frequency AC Microgrid," IEEE Trans. Energy Convers., vol. 24, no. 3, pp. 673–682, Sep. 2009.

[7] J. M. Guerrero, P. C. Loh, T.-l. Lee, and M. Chandorkar, "Advanced Control Architectures for Intelligent MicrogridsâA˘TPart II: Power Quality, ˘ Energy Storage, and AC/DC Microgrids," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1263–1270, Apr. 2013.

[8] Akagi, H.: 'Active Harmonic Filters', Proceedings of the IEEE, 2005, 93, (12), pp. 2128-2141

[9] Quanwei, L., Yan, D. and Xiangning, H.: 'A novel AC-AC shunt active power filter without large energy storage elements'. Power Electronics and Applications (EPE 2011), Proceedings of the 2011-14th European Conference on, 2011, pp. 1-9

[10] Hamad, M., Masoud, M. and Wayne Williams, B.: 'Medium-Voltage 12-pulse Converter: Output Voltage Harmonic Compensation using a Series APF', Industrial Electronics, IEEE Transactions on, 2013, PP, (99), pp. 1

[11] Erickson, M. J. and Lasseter, R. H.: 'Integration of battery energy storage element in a CERTS microgrid'. Energy Conversion Congress and Exposition (ECCE), 2010 IEEE, 2010, pp. 2570-2577

[12] Y. W. Li, D. M. Vilathgamuwa, and P. C. Loh, "Design, analysis and realtime testing of controllers for multi-bus micro grid system," IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1195–1204, Sep. 2004. [13] Tahri A.; et al, "A Fast Current Control Strategy of a PWM Inverter used for Static VAr Compensation", Industrial Electronics Society Conference, Vol: 1, Aug 1998.

[14] Jang S.-I.; Kim K.-H., "An Islanding Detection Method for Distributed Generations using Voltage Unbalance and Total Harmonic Distortion of Current", IEEE Transactions on Power Delivery, Vol: 19, Issue: 2, April 2004.

[15] F. Magueed, and J. Daalder, "Operation of Distributed Generation in Weak Grids with Local Critical Load," accepted to be published in the 32nd Annual Conference of the IEEE Industrial Electronics Society (IECON'06), Paris, France, and 7-10 November 2006.