IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SINGLE-PHASE INVERTER CONTROL TECHNIQUES FOR INTERFACING RENEWABLE ENERGY SOURCES

C.Nallasivam*, V. Rathinavel Subramaniam, S.Ayyubh
[*] Assistant Professor, Dept. of Electrical and Electronics Engineering, Shree Venkateshwara Hi-Tech Engineering College, Anna University,Gobichettipalayam – 638455 Erode District, Tamilnadu, India
Assistant Professor, Dept. of Electrical and Electronics Engineering, Shree Venkateshwara Hi-Tech Engineering College, Anna University,Gobichettipalayam – 638455 Erode District, Tamilnadu, India
Assistant Professor, Dept. of Electrical and Electronics Engineering, Shree Venkateshwara Hi-Tech Engineering College, Anna University,Gobichettipalayam – 638455 Erode District, Tamilnadu, India

ABSTRACT

A novel current control technique is proposed to control power flow from a renewable energy source feeding a microgrid system through a three-phase parallel-connected inverter. The parallel-connected inverter ensures that the power flow from the grid with low-current total harmonic distortion even in the presence of nonlinear load. The renewable energy sources are paralleled, and the average of this constant supply is given to Booster circuit and is used to improve the power level of renewable energy sources. The current controlled voltage source inverter is used to convert DC supply into AC supply. The CCVSI is controlled by PWM techniques and the current flows are controlled. A p–q theory-based approach is used to find the reference current of the parallel-connected converter and the stability of the proposed controller is ensured by direct Lyapunov method. By applying this concept, selected harmonic can be eliminated, and the output voltage THD can be improved. The proposed project is to be simulated by using MATLAB and the results are to be compared with experimental setup. The PIC microcontroller is to be used for generating required pulses to the parallel inverter.

KEYWORDS:.

INTRODUCTION

Nowadays, renewable energy sources are heavily used to reduce the generation of electricity using natural coal and other fossil fuels. Electrical power systems are getting more and more stressed due to the increase in power demand, limitation on power delivery capability of the grid, complications in building new transmission–distribution lines, and leading to blackouts. In this project, a method for the parallel operation of inverters in an ac-distributed system is proposed. This project explores the control of active and reactive power flow through the analysis of the output impedance of the inverters and its impact on the power sharing. The parallel-connected inverter ensures active and reactive power flow from the grid with low-current total harmonic distortion even in the presence of nonlinear load.

Developments of power electronic converters along with its sophisticated high-performance controllers make it possible to integrate different types of renewable energy sources to the microgrid. In this project, it can be seen that extensive research is undertaken to connect renewable energy sources to three-phase grids using three-phase pulse-width-modulation inverters. These grid-connected inverters are extensively used in three phase microgrid to have active, reactive power control as well as used as active filter to minimize the harmonic contents in the grid current. In this mode, the proposed control technique also eliminates the need of external power factor correction circuit as the proposed current control method makes the single inverter to do both power control and local grid current THD control.

GENERAL CONFIGURATION OF THE MICROGRID STRUCTURE

In this method is discussed to control active and reactive power flow for a three-phase grid-connected inverters for islanded application.

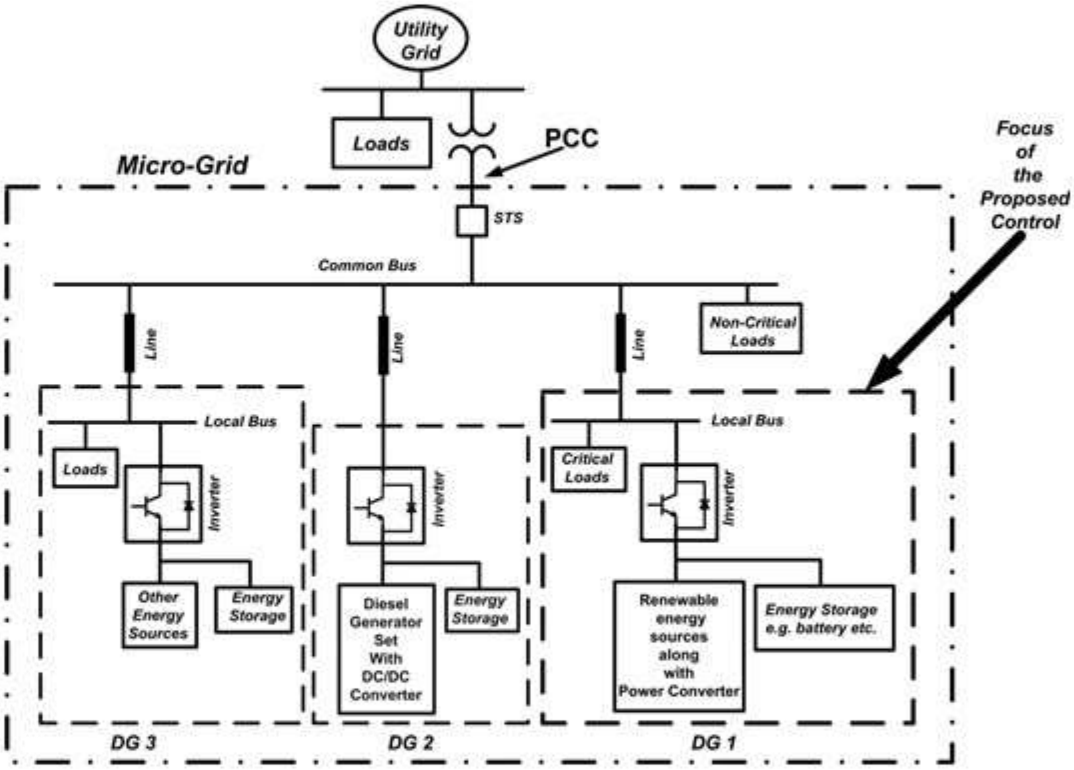
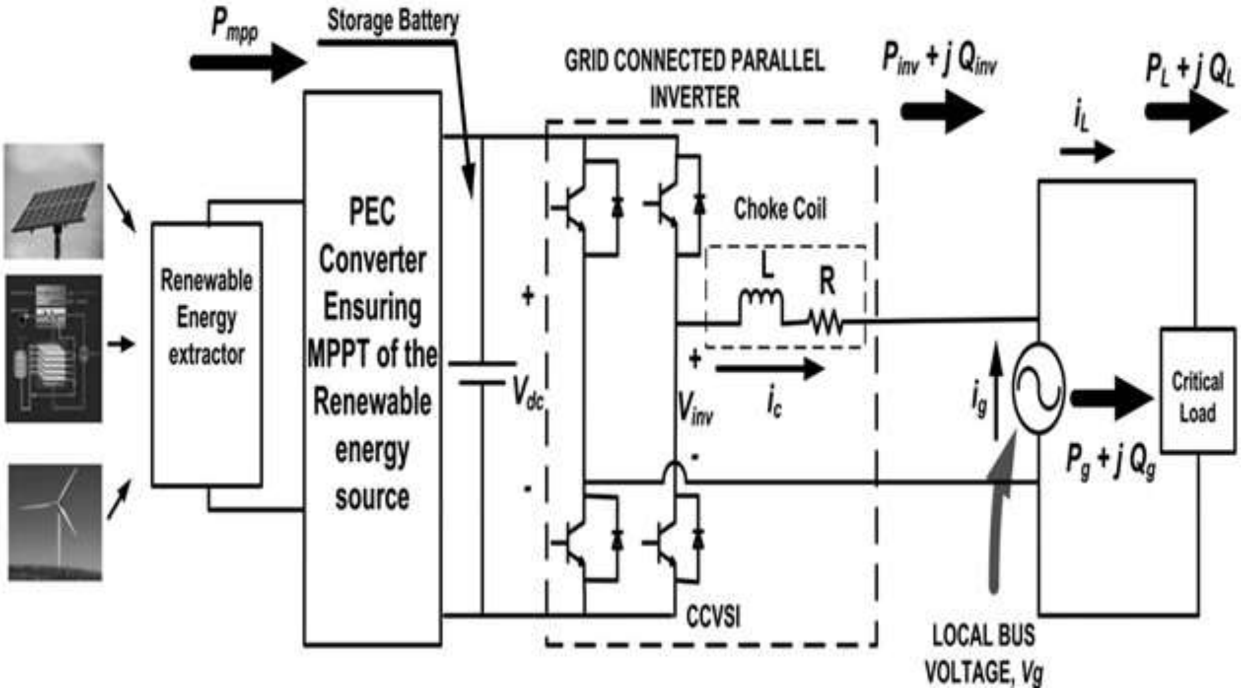
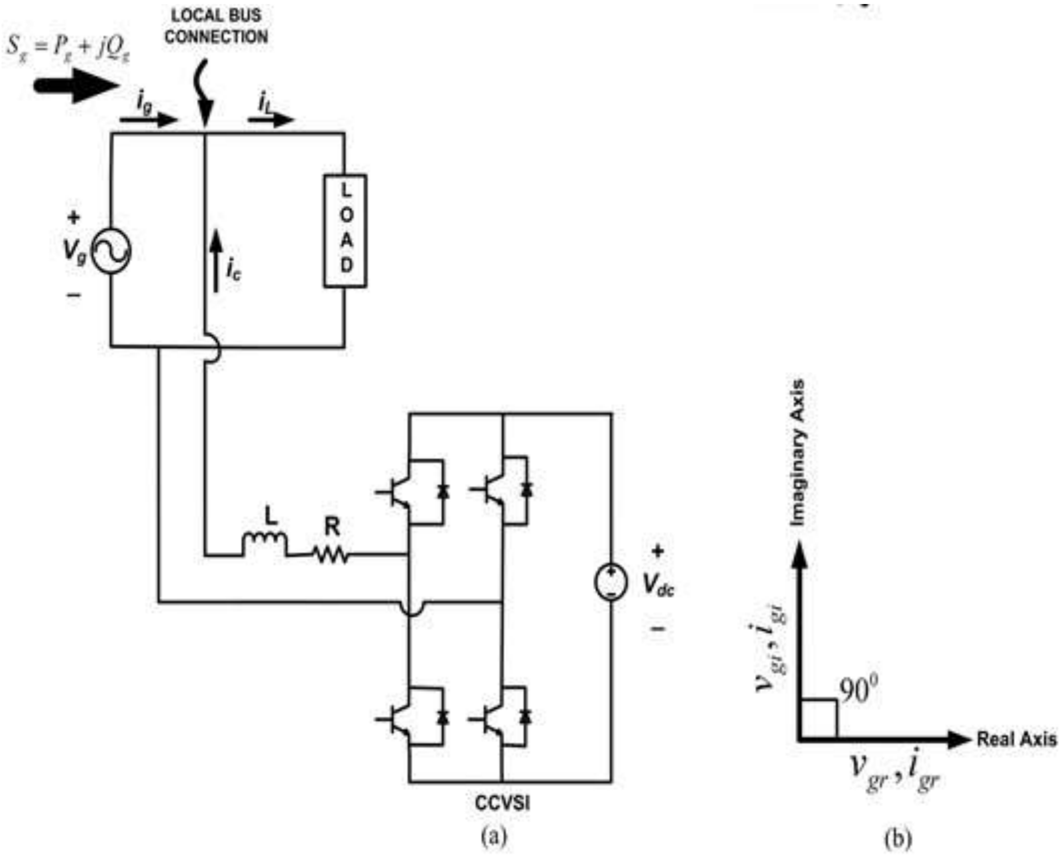


Fig.2. 1 Typical configuration of inverter-based microgrid

Newton–Rapshon repetitive iteration method used to calculate the inverter voltage magnitude and voltage angles to control the power flow. However, because of the repetitive calculation, the control process is slower than the other developed methodologies of grid power control. Besides these, in the case of single-phase grid-connected inverters, the well-known "a–b–c to d–q" transformation concept can not be directly used. An approach is proposed in to facilitate current control of single-phase inverters using "a–b– c to d–q" transformation-based synchronous reference frame controllers by introducing an extra imaginary "q" axis. Some approaches are shown in and where the current of the single-phase grid-connected inverter is directly controlled without using imaginary "q" axis concept. The analysis given in pronounces that the structure of the controllers become more complex with the increase in harmonic contents in the current to be tracked. This controller structure requires the fundamental operating frequency of grid to be constant. The controller proposed in a spatial repetitive controller(SRC) and the dynamic response of this controller is reported to be relatively slowerIn this paper, a Lyapunov-function-based current tracking controller is proposed for the single-phase microgrid-connected renewable energy sources through the inverter. The proposed controller is shown to have fast convergence of the tracking error. The stability of the controller is derived by using the direct method of Lyapunov. A technique of improving the performance of the proposed Lyapunov-function-based controller by estimating the grid and other nonlinear disturbances using SRC is also proposed in this paper. The inverter current reference is derived from the desired inverter output power using single-phase p– q theory. This allows the control of active, reactive, and harmonic power flow through the inverter to the microgrid. The controller also leads to low total harmonic distortion (THD) in grid current even in presence of nonlinear load. Detailed experimental results are provided to show the efficacy of the proposed current controller. The power circuit and its associated control strategy is described to work in such a way that the proposed parallel inverter along with its control methodology can be used to interface loads with any type of renewable energy sources and the microgrid.

POWER CIRCUIT OF SINGLE-PHASE CONNECTED INVERTER





(a) (b)

Fig3.1 Power Circuit of Single-Phase Connected Inverter

Introduction

The renewable sources like solar and wind are connected in parallel for maintaining constant input supply and the output voltage level of these sources are boosted by Boost circuit. The three phase current controlled inverter is used to convert DC into AC supply. The three phase supply is connected to load. The voltage at which PV module and wind module can produce maximum power is called ‘maximum power point’ and the Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

Newton–Rapshon repetitive iteration method used to calculate the inverter voltage magnitude and voltage angles to control the power flow for balanced/unbalanced nonlinear load conditions. It has been observed that the DELC results in a satisfactory performance under different loading conditions along with the frequency and its voltage control, load balancing and harmonic elimination of three-phase consumer loads. This type of control algorithm has been found simple, flexible, easy to control and quick in response. All the characteristics of the generators can also be achieved in case of utility grid-connected mode. In this mode, the proposed control technique also eliminates the need of external power factor correction (PFC) circuit as the proposed current control method makes the single inverter to do both power control and local grid current THD control.

The active and reactive power flow from the renewable energy are measured and controlled. These grid-connected inverters are extensively used in three phase microgrid to have active, reactive power control as well as used as active filter to minimize the harmonic contents in the grid current. In this mode, the proposed control technique also eliminates the need of external power factor correction (PFC) circuit as the proposed current control method makes the single inverter to do both power control and local grid current THD control.

The power system controller FACTS concept is applied to control the flow of active and reactive power from renewable energy sources to load. Based on the load variation, the reactive power is injected to line through PWM controller. So that the active and reactive power is maintained.

The grid current harmonics are reduced and based on nature of load variation, the active and reactive power flow is measured and controlled. When the load low the excess power is stored in battery.

DESCRIPTION OF THE INVERTER CONFIGURATION AND ITS CONTROL

Fig.3.1 shows the schematic diagram of the power circuit of the parallel-connected inverter assembly interconnecting the load and the microgrid. The inverter power circuit is preceded by a set of renewable energy extracting apparatus, as can be seen in Fig. 3.1. Fig. 3.1 also shows that the renewable energy extractor is directly connected to the power electronic converter (PEC). PEC is a typical dc/dc converter if the renewable energy extractor is a photovoltaic (PV) panel system, and a typical ac/dc converter if the renewable energy extractor is a permanent magnet or induction-machine-based wind turbine. The PEC output is connected to the dc link of the PWM voltage source inverter (VSI). At the dc link of the PWM VSI, an energy storage element, battery, is also connected in parallel with the PEC converter output. As depicted in Fig. 3.1, the PWM VSI, is directly connected in parallel with the microgrid, operating in current controlled VSI (CCVSI) mode. The load is directly connected to the microgrid. The PE converter is operated in such a way that the renewable energy source operates in maximum power point (MPP), and MPP active power PMPP is extracted from the renewable energy source.

CONTROL STRATEGY OF THE INVERTER

In Fig.3.1, it is shown that the load requires the active power PL and the reactive power QL (load complex power SL = PL + jQL). If the inverter is not operated, load draws the full complex power SL from the local bus. In reality, the inverter is connected in parallel to the microgrid vg . The current ic of the CCVSI is controlled in such a way that the inverter supplies active power Pinv and reactive power Qinv to the local bus of the microgrid (the local bus is getting complex power Sinv = Pinv + jQinv from the inverter). In normal operating conditions, the active power Pinv supplied by the CCVSI is less than the extracted renewable power PMPP (Pinv ≤ PMPP) and the rest of the renewable power is stored in the battery (Pbat = PMPP − Pinv). The discussions here make it clear that only part of the load power demand: active power Pg = PL − Pinv and reactive power Qg = QL − Qinv is drawn from the local bus connected to the microgrid. Initially, Pinv is controlled in such a way that Pbat is positive to charge the battery. When battery is fully charged, Pinv = PMPP is maintained to transfer the entire extracted renewable power PMPP to the load. The battery energy is used to feed the load if the renewable energy is not sufficient to supply the load during intermittent grid failure condition. In the actual system, the values of Pg and Pinv under different operating condition are to be set by an automatic controller, but in the laboratory prototype, Pg and Pinv are manually changed to test the proposed control strategy in the laboratory environment. The reference of the current drawn from the local bus is derived from Pg and Q using the single-phase p–q theory approach to ensure specific active and reactive power flow (Sg = Pg + jQg) from the local bus connected to the common bus of the microgrid.

EXPERIMENTAL RESULT

ACTIVE AND REACTIVE POWER WAVEFORM

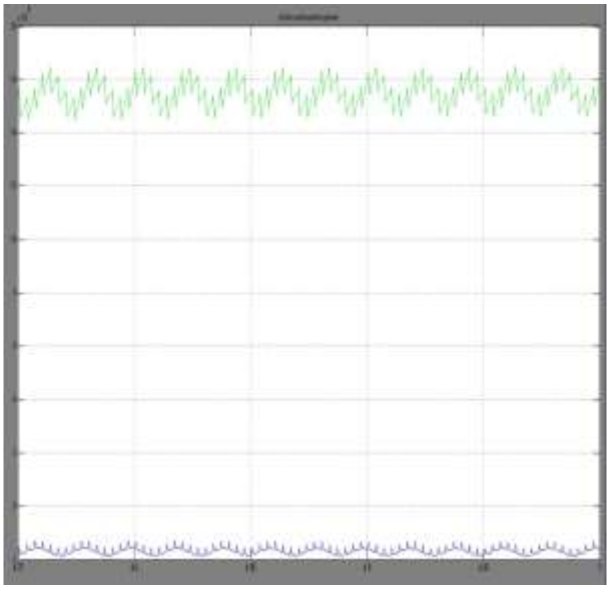


Figure 4.1 Active and reactive power

OUTPUT VOLTAGE WAVEFORM

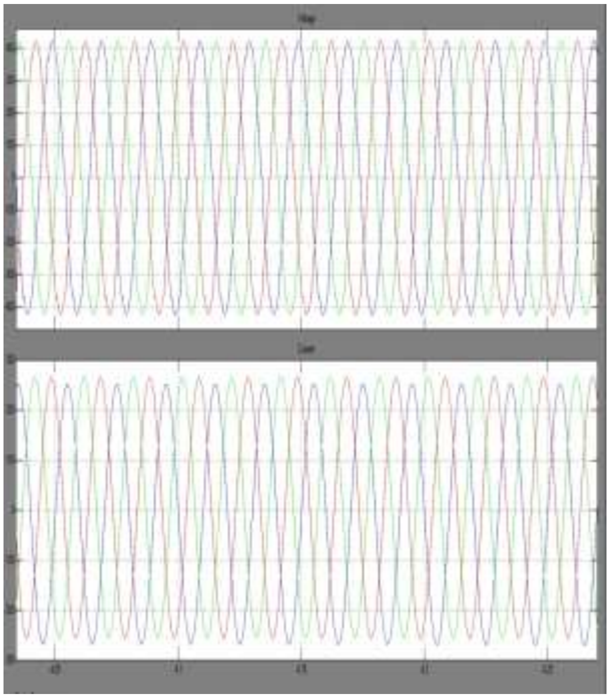


Figure 4.2 Simulation Results of output voltage

MATLAB MODEL

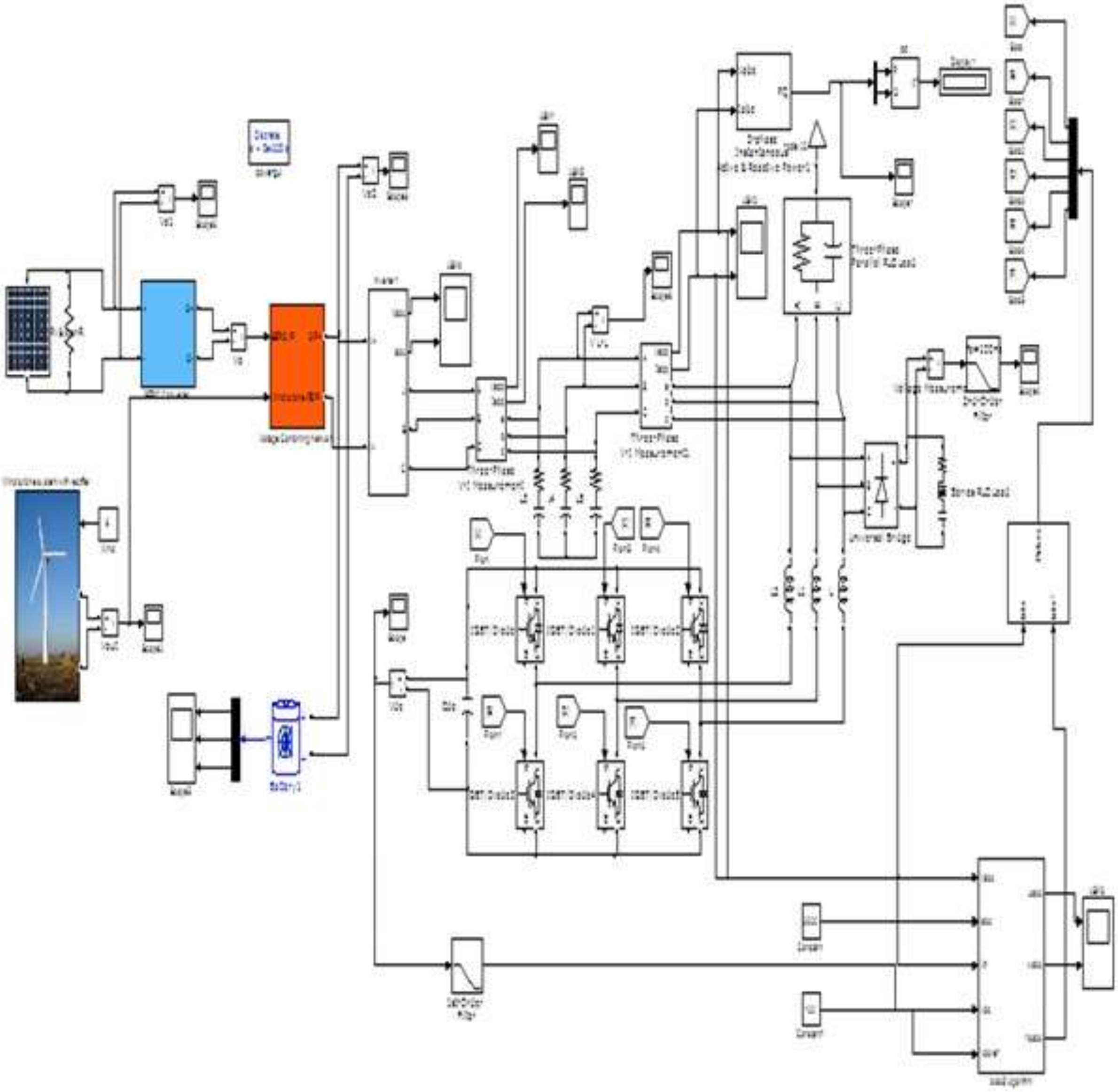


Figure 4.3 MATLAB Model

THD ANALYSIS

Fig 4.4 shows that the output voltage THD analysis for the proposed system with the minimum distortion. The sine wave output current can be obtained with the THD value of 3.50%.

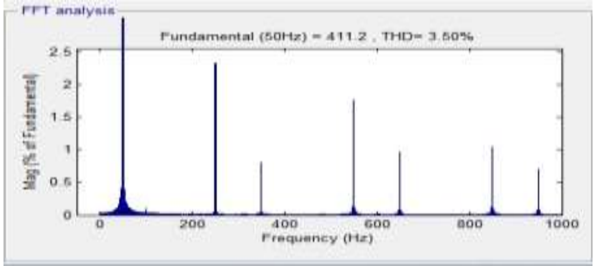


Fig 4.4 FFT analysis of the signal

CONCLUSION

Wind power generation systems, solar PV power generation system have been presented in this project. A Newton Rapshon control algorithm has been used to control the voltage and frequency regulation for balanced/unbalanced nonlinear load conditions. It has been observed that the DELC results in a satisfactory performance under different loading conditions along with the frequency and its voltage control, load balancing and harmonic elimination of three-phase consumer loads. The experimental results show that the proposed controller along with the "p–q" current calculator is capable of controlling the active and reactive power flow from the microgrid in a decoupled manner along with controlling the THD of the grid current.This type of control algorithm has been found simple, flexible, easy to control and quick in response. The THD was reduced to 0.33% and the power factor was maintained at 0.96.

REFERENCES

[1] E. Barklund, N. Pogaku, M. Prodanovic, C. H. Aramburo, and T. C. Green,(Sep. 2008) "Energy management in autonomous microgrid using stabilityconstrained droop control of inverters," IEEE Trans. Power Electron., vol. 23, no. 5, pp. 2346–2352.
[2] F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus, (Oct. 2006) "Overview of control and grid synchronization for distributed power generation systems," IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1398–1409.
[3] Y. M. Chen, H. C. Wu, Y. C. Chen, K. Y. Lee, and S. S. Shyu, "The AC line current regulation strategy for the grid-connected PV system,"(Jan. 2010) IEEE Trans. Power Electron., vol. 25, no. 1, pp. 209–218.
[4] J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. G. Galvan, R. C. P. Guisado, M. A. M. Prats, J. I. Leon, and N. M. Alfonso, (Aug. 2006) Powerelectronic systems for the grid integration of renewable energy sources: A survey," IEEE Trans. Ind. Electron., vol. 33, no. 4, pp. 1002–1016.
[5] J. Dannehl, F. W. Fuchs, and P. B. Thogersen, "PI state space current control of grid-connectedPWMconverterswith LCL filters," IEEE Trans. Power Electron., vol. 25, no. 9, pp. 2320–2330, Sep. 2010.
[6] M. Dai, M. N. Marwali, J. W. Jung, and A. Keyhani, (Jan. 2008) "Power flow control of a single distributed generation unit," IEEE Trans. Power Electron., vol. 23, no. 1, pp. 343–352.
[7] J. M. Guerrero, J. C. Vasquez, J. Matas, L. G. de Vicuna, and M. Castilla, (Jan. 2011) "Hierarchical control of droop-controlledAC andDCmicrogrids—A general approach toward standardization," IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 158–172.
[8] J. M. Guerrero, J. Matas, L. G. de Vicuna, M. Castilla, and J. Miret, (Apr. 2007) "Decentralized control for parallel operation of distributed generation inverters using resistive output impedence," IEEE Trans. Ind. Electron., vol. 54, no. 2, pp. 994–1004.
[9] J. M. Guerrero, J. C. Vasquez, J. Matas, M. Castilla, and L. G. de Vicuna, (Mar. 2009) "Control strategy for flexible microgrid based on parallel line-interactive UPS systems," IEEE Trans. Ind. Electron., vol. 56, no. 3, pp. 726–736.