International Journal of Innovative Trends in Engineering (IJITE)
Volume-01, Number-01, 2014

Fuzzy Based SVPWM Technique for Connecting DG to Grid

Lalahmed Mohammad[1], **U Chandra Rao**[2], **Ch Rambabu**[3]
[1]PG Scholar, [2]Associate Professor, [3]Professor & Head,
Department of Electrical and Electronics Engineering
Sri Vasavi Engineering College, Tadepalligudem, Andhra Pradesh, India

Abstract

This paper presents a fuzzy logic controller (FLC) based SVPWM technique for autonomous operation of an electronically interfaced distributed generation unit and its load. This proposed system which can compensate for active, reactive, and harmonics load current components during connection of grid to the DG link. In the grid connection mode, the voltage-source converter is operated in the active and reactive power (PQ) control mode. In this paper, a fuzzy logic based SVPWM technique is employed to generate the switching pulses for the switches in voltage source converter due to its fast dynamic response and better DC-link voltage utilization. In this proposed system fuzzy controller also reduces the Total Harmonic Distortion (THD) in the grid current. The overall system with the proposed control strategy is developed and simulated in MATLAB/SIMULINK environment.

Keywords

Distributed Generation (DG), Fuzzy Logic Controller (FLC), Total Harmonic Distortion (THD),Voltage Source Converter (VSC).

1. Introduction

Fuzzy is a rule based controller which has multiple inputs and uni-output. We should have to specific values for both input and output. It has separate inference with the control technique which will have best functions to the environment. We can get the values between the range by using the Fuzzy interfacing system with the fuzzy logic toolbox. It has been shown that the grid-interfacing inverter can be effectively utilized for power conditioning without affecting its normal operation of real power transfer. The importance of using a fast and accurate method for detection of sequence components of the grid voltage affected by a fault is emphasized. From this we can observe the grid-side converter with different fault conditions, particularly at low, medium and high voltages, to provide proper synchronization for the power electronics apparatus. After synchronization we can get a clearly get an overview of grid strategies and fault conditions. Fuzzy control method is supported to the system which can divide linear and nonlinear loads. It fact's that grids are facing many troubles with unwanted disturbances and uncertainties complicates while the designing of practical converters connected to DG system. The power electronic devices plays a important role to match the characteristics of the distributed generation units and the required of the grid connections, including control of active and reactive power, voltage, frequency, harmonic load current components etc.

A current controller with time-delay compensation is used to control the grid current with high-bandwidth to eliminate the higher band width disturbance with the control at higher frequencies. From past years it is very difficult to increase the reliability to the customers, to reduce the cost of small scale generation, so for that cause DG technology is proposed to domestic and industrial purposes. The main concept of DG system is to provide natural power o the consumers without any effect to the grid with proper protection between the load. The main importance of in this system is voltage source converter which is connected between the utility grid and DG resources. By this we can compensate the current references to the load currents of active, reactive , DG and harmonics minimization.

The controller of the currents synchronized with the grid voltage, without any dedicated synchronization. Very different current strategies are realizable with the same controller, constant and maximum instantaneous active power injection, balanced current injection At this position grid should provide continues power to the load. Under normal condition DG inverter works as constant current control mode in the grid. When the grid is disconnected from the main grid, the DG inverter system will provide constant voltage to the load.

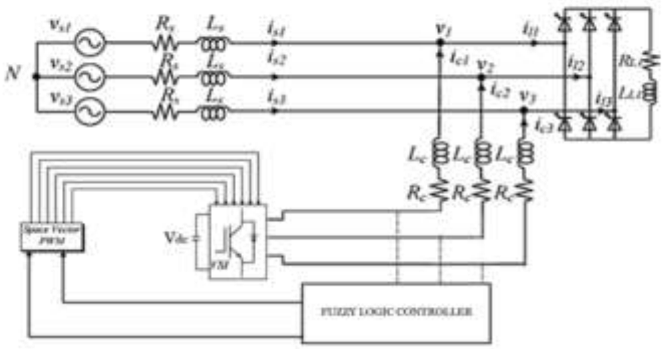

Fig. 1. Schematic diagram of the Proposed System

The converter, which can control by the guarantees balanced overall supply currents, described control strategy, unity displacement power issue, and compact harmonic currents in the point of common coupling. In today's life Distributed Generations (DG's) has become an important role of electrical generation in many countries to decrease the cost of residential and industrial loads with their business. DG system which can supply the power to the load when grid is low balanced power to the customers. If the load side is consumption is low the DG system will acts as a rectifier and load side required more power than grid side the DG system acts as a inverter. For this propose we are controlling with fuzzy logic controller. Therefore, the applications of DG's, to increase the power factor of the grid and reduces the harmonic distortion of the grid.

2. Proposed DG System

Fig.1. shows the schematic diagram of the proposed system. The voltages and currents components are also indicated proposed system, where *Rc* and *Lc* represent the equivalent resistance and inductance connected between the inverter and point of common coupling (PCC) with link cables. *Rs* and *Ls* signify the grid conflict and inductance up to the PCC, respectively. *Vl* (l = 1, 2, 3) is the supply voltage components at the PCC; *Vsg* is the grid voltage components; *Vdc* is the dc-link voltage; and *isg*, *icd and iln*, are grid, DG, and load current components, respectively. In addition, the DG resources represent's as a dc current source which is connected to the dc side of the converter and the firing pulses for this converter are generated by using fuzzy controller based SVPWM technique.

3. Current and Voltage Components in The Special Reference Frames

The control technique is developed based on the analysis of current and voltage vector components in the special reference frames such as *'a-b-c* to *α-β'* and '*α-β* to *d-q'* transformation. The Clarke transformation maps the three phase instantaneous voltages and currents in the *a-b-c* phases into the instantaneous voltages and currents on the *α-β*-axes.

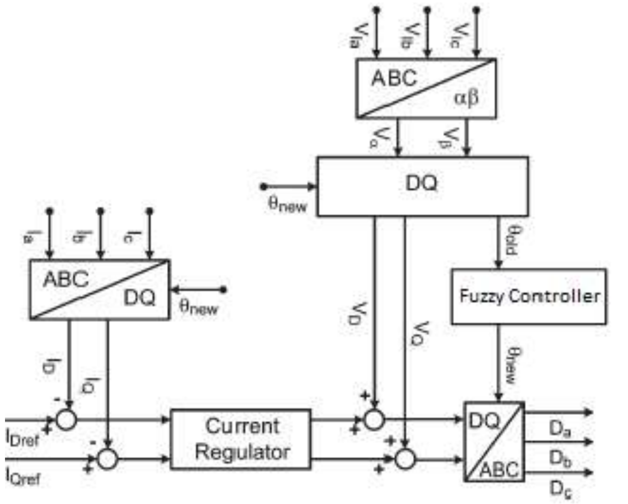

Fig.2. Block diagram of current controller for grid connected

The angle of reference frames with grid voltage be calculated as

$$\emptyset = \tan^{-1}\frac{V_\alpha}{V_\beta} \tag{1}$$

The reference voltages in dc quantities *Vdqref* are transformed into a stationary frame by the Park's transformation and are utilized as

$$v_a = v\cos(\emptyset) \tag{2}$$

$$v_b = v\cos(\emptyset - 2\pi/3) \tag{3}$$

$$v_c = v\cos(\emptyset - 4\pi/3) \tag{4}$$

From the Park's transformation the references voltage's *a-b-c* to *α-β and d-q* to *α-β* is given by

$$\begin{bmatrix} V_D \\ V_Q \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos\emptyset & \cos(\emptyset-\gamma) & \cos(\emptyset+\gamma) \\ -\sin\emptyset & -\sin(\emptyset-\gamma) & -\sin(\emptyset+\gamma) \end{bmatrix}\begin{bmatrix} V_a \\ V_d \\ V_c \end{bmatrix} \tag{5}$$

$$\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} = 2\big/3\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix}\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \tag{6}$$

$$\begin{bmatrix} V_D \\ V_Q \end{bmatrix} = \begin{bmatrix} -\cos\emptyset & \sin\emptyset \\ \sin\emptyset & \cos\emptyset \end{bmatrix}\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} \tag{7}$$

From the above equation, we can calculate the voltages of special reference frames.

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} \cos\emptyset & -\sin\emptyset \\ \cos(\emptyset - 2\pi/3) & -\sin(\emptyset - 2\pi/3) \\ \cos(\emptyset + 2\pi/3) & -\sin(\emptyset + 2\pi/3) \end{bmatrix} \begin{bmatrix} V_d \\ V_q \end{bmatrix} \tag{8}$$

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -1/2 & \sqrt{3}/2 \\ -1/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} \tag{9}$$

where $\gamma = 2\pi/3$
$\emptyset$ is angle between dq and αβ reference frames.

The voltages of special reference frames, we can obtain that parameters of *α-β and d-q* axis with respect to the a-b-c.

4. Simulation Results

In order to get the high performance of the proposed control technique, the complete system was simulated using the "Power System Blockset" simulator operating under the Matlab/Simulink environment. Fig 3 shows the simulation diagram for proposed DG system. In addition, the simulation results has used to analyze the total harmonic distortion (THD) of the utility grid current with various load conditions. To simulate a real ac grid, the load is connected and disconnected to the grid wise versa. The grid current can be compared at different loads conditions. By this we can get the particular values of load, grid and DG currents at various conditions. The SVPWM technique will used to give pulses to DG source which can reduce the harmonic distortion.

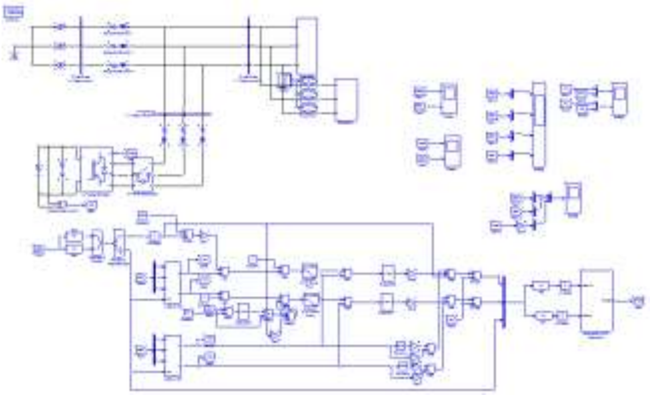

Fig 3. Simulation diagram of proposed DG System

Let us consider in DG source Constant dc voltage is taken in simulation process. The active power delivered from DG link to the grid is taken as constant. During the simulation the load operated at different conditions in a real ac grid.

Fig.4. Shows that Load Voltage is constant. Load Current may be vary before and after connection of loads from t=0.1s to t=0.2s in to the grid. When grid is connected to DG link at t=0.1s the grid current is zero up to t=0.2s at this moment the full-wave thyristor connected at this level we will get the sinusoidal wave till t=0.35s.Initially the DG current will be zero up to t=0.1s after this the system is connected to grid up to t=0.2s from that position additional load is connected up to t=0.35s from that it can disconnected the extra load

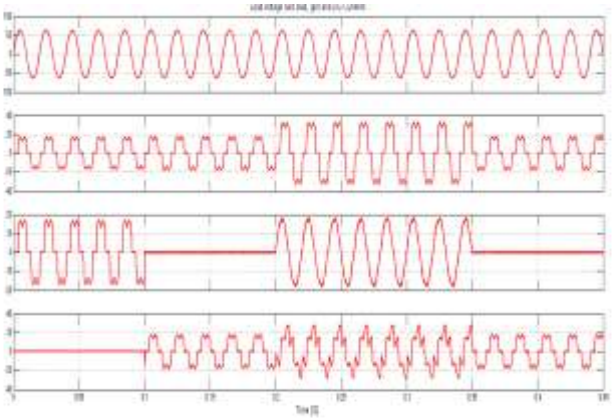

Fig.4. Load Voltage and Load, Grid & DG Currents.

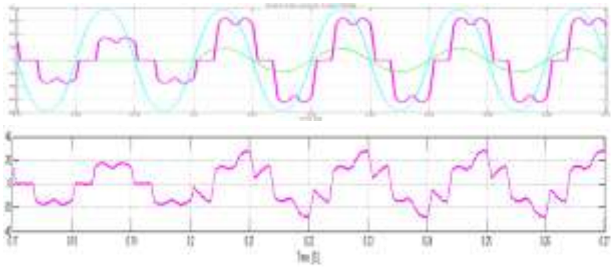

Fig.5.(a) Grid Current, load Current, DG Current and Load Voltage before and after connection of additional load.

Fig.5.(a) shows that, the DG source connected after additional load to the grid at t=0.2s, system gets the maximum active and reactive power to the grid.

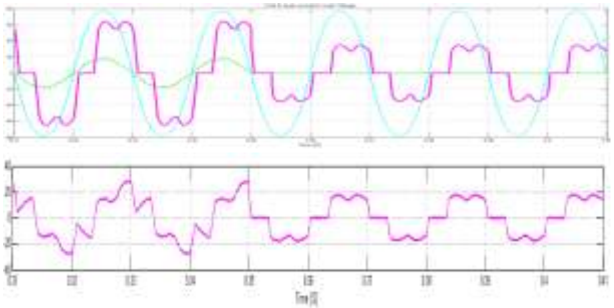

Fig.5.(b) Grid Current, load Current, DG Current and Load Voltage before and after disconnection of additional load.

Fig.5.(b) shows that, at t=0.35s the injected current from grid to the load become zero it passes the transient time. At this condition additional load is removed delay as before.

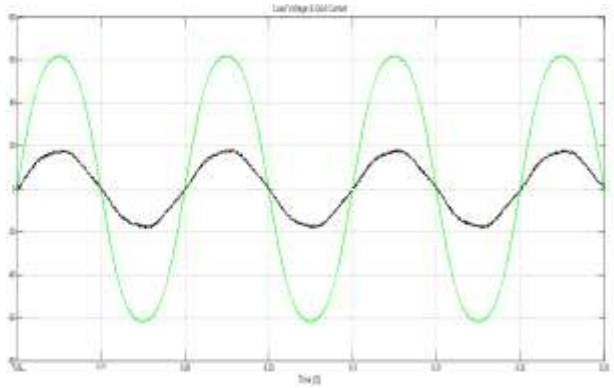

Fig.6. Phase-to-neutral Voltage and grid current for Phase (a).

Fig.6. shows that, during additional load connected to the main grid after the transient times, the grid current load voltage are in phase, and the grid need not to provide harmonic currents and reactive to the load.

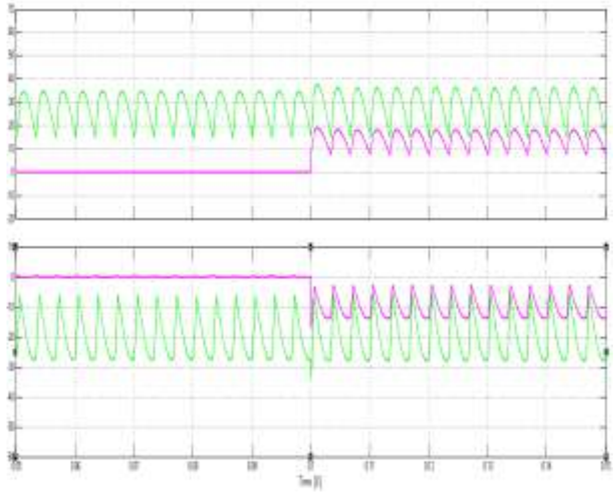

Fig.7.(a).Reference Currents track the load current before connection of additional load.

Fig.7.(a) shows that, the additional load is connected to the grid, the DG's control loop track their references before the actual *d-q*-axis current components.

Fig.7.(b).shows that, after additional load is connected to the grid, the *d-q* axis current component of DG tracks half of its reference trajectory which is equal to its maximum active power and all the reference trajectories of reactive current change.

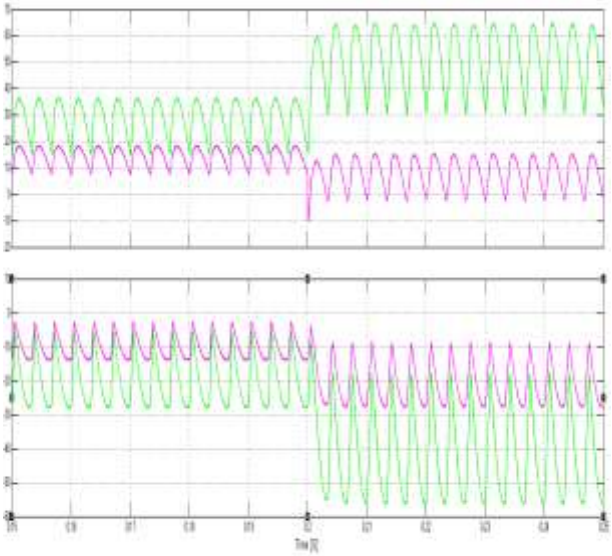

Fig.7.(b).Reference Currents track the load current after connection of additional load.

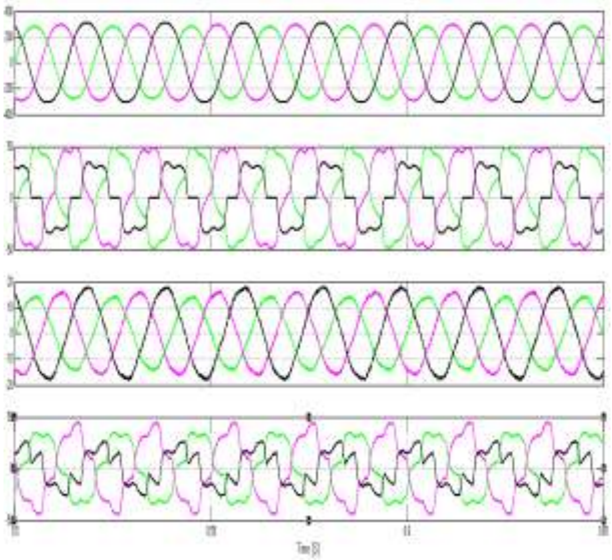

Fig.8. load, grid and DG Currents/ load Voltage.

Fig. 8. shows that, Load Voltage and grid current are in phase with up to the time interval t=0.45s. At this mode of operation the load voltage purely sinusoidal with balanced and unbalanced conditions.. The grid current having minute non-linear at maximum current reach. The load current and DG current has unbalanced after at t=0.55s. The grid current and load voltage must be phase .The proposed system will provide balanced current to the DG system. An unbalanced grid voltage and load current are present which causes the grid current will be unbalanced. Depending upon the electronics devices the current and voltages ratings are unbalance which can compensates the grid current will be unbalance by inserting the unbalanced DG currents links. By

this unbalanced system we cannot m propose at present conditions.

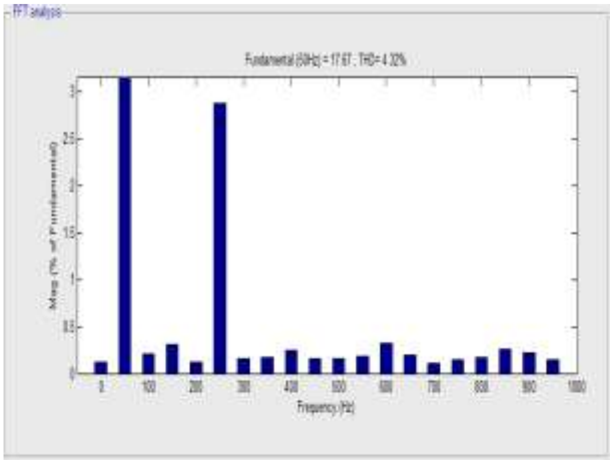

Fig. 9. THD with PI Controller

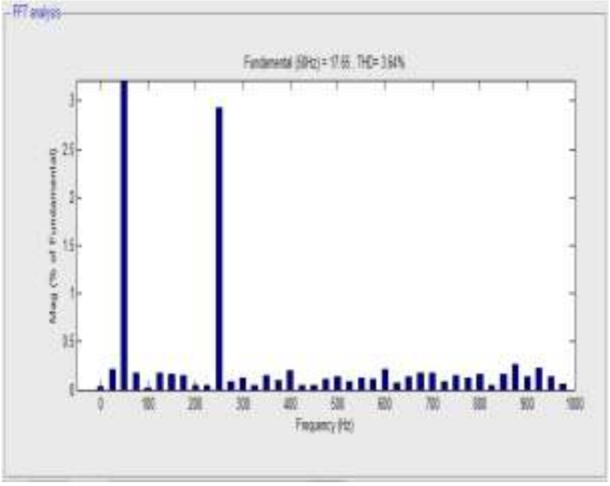

Fig. 10. THD with Fuzzy Controller

Fig.9 and Fig.10 presents the FFT analysis of source output current with PI and FUZZY controller respectively. The first Fourier transform ensures that proposed sources output THD of 4.32% but with Fuzzy controller output THD of only 3.64%.

6. Conclusion

In this paper, a Fuzzy Based SVPWM (FB-SVPWM) technique is proposed for the converter connected from DG to the grid. The proposed control technique has the better performance than PI controller with the injection of maximum available power to grid from DG link, reduced total harmonic distortion of the grid and increased power factor of the utility grid. From the simulation results the source current and load voltage are in phase so that power factor is improved near PCC. The results identify the proposed DG system with FB-SVPWM technique can provide harmonic load currents in all conditions. From this FB-SVPWM technique we can use multiple types of DG sources as best improvement in power quality in power distribution system. The proposed DG system is more flexible at both transient and steady state conditions. By the use of FB-SVPWM technique, THD is reduced from 4.32% to 3.64%. Hence this system has better performance than conventional PI controller.

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Author's Profile

Lalahmed Mohammad has received his Bachelor of Engineering degree in Electrical & Electronics Engineering from S R K R Engineering College, Bhimavaram in the year 2011. At present he is pursuing M.Tech. with the specialization of Power Electronics in Sri Vasavi Engineering College. His area of interest Control system, Power electronics, Renewable energy sources, Signal and Systems.

U Chandra Rao has received his Diploma in Electronics & Communication Engineering from SBTET, Hyd. in the year 1999 and B. Tech. degree in Electrical and Electronics Engineering from JNTU, Hyd. in the year 2004 and Master's degree with the specialization of High Voltage Engineering from JNTUK, Kakinada in the year 2010. Currently he is pursuing Ph.D. in JNTUK, Kakinada. At present he is working as an Associate Professor at Sri Vasavi Engineering College, Tadepalligudem. His areas of interests are Power electronics, Electrical Drives, Power Systems, Renewable Energy Sources and Custom Power Devices.

CH Rambabu has received his Bachelor of Engineering degree in Electrical & Electronics Engineering from Madras University, in 2000 and Master's degree from JNTU Anantapur in 2005. He is pursuing Ph.D. in JNTUK, Kakinada. Currently, he is a Professor at Sri Vasavi Engineering College, Tadepalligudem. His areas of interests are power system control, Optimization techniques and FACTS.