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Implementation of Three-phase Inverter for Micro Grid Application with Fuzzy Controller Technique

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Abstract:

A power distribution system with distributed generations can operate as a micro grid under specific conditions. A micro grid can be operated under grid-connected and islanded modes seamlessly without disrupting the loads within the micro grid. This study analyzes the intelligent control of a micro grid with a pulse-width modulation-controlled voltage source inverter. Switching patterns are generated through a fuzzy proportional-integral (PI) controller. This study aims to develop a fuzzy-PI controller and compare its performance with that of a PI controller in controlling the voltage and frequency of a micro grid under disturbances in a Matlab/Simulink environment. The inverter is regulated as a current source just by the inner inductor current loop in grid-tied operation, and the voltage controller is automatically activated to regulate the load voltage upon the occurrence of islanding. This paper mainly depends on PI and fuzzy controller by using fuzzy controller to improve the power quality compare to PI controller.

Index Terms:

Unified Power Quality Conditioner, Three Phase Inverter, Distributed generation (DG), islanding, load current, seamless transfer.

I. INTRODUCTION:

A micro grid installed with distributed generations (DGs) is a new type of power system [1]. DGs, which include micro turbines, photovoltaic's, wind cells, and fuel cells, are small generation units of less than 100 kW. At present, power systems are experiencing a rapid growth in the connection of DG units. Integrating DGs in a distribution system offers technical, environmental, and economic benefits.

Moreover, such integration allows distribution utilities to improve system performance by reducing power losses [2]. Electric energy market reforms and developments in electronics and communication technology enable the advanced control of DGs [3]. DG units can be integrated and efficiently operated as a micro grid in grid-connected and islanded modes [4]. A micro grid system can strategically be placed on any site in a power system for grid reinforcement, thereby deferring or eliminating the need for system upgrades and improving system integrity, reliability, and efficiency of the existing power system [5,6]. Therefore, many efforts have been exerted to control power electronic converters and thus allow the grid connection of micro grids in a distribution system. This technique is necessary to maximize the potential of DGs to enhance power quality and reliability and provide auxiliary services, such as active reserve, load following, interruptible loads, reactive reserve, and restoration [7].The fuzzy logic controller has two input signals, and the output signal of the fuzzy logic controller is the input signal to the conventional PI controller.

The control performance of the fuzzy-PI controller is tested under load conditions using the MATLAB/SIMULINK simulation platform. In this study, fuzzy-PI controller algorithm, strategies, and modeling are developed and simulated in MATLAB/SIMULINK to develop an intelligent control technique for a micro grid in grid-connected and islanding modes. The main objective of the inverter control system is to generate and stabilize the 50 Hz sinusoidal-shape AC (alternating current) output voltage and frequency. With the grid synchronization algorithm, we can interconnect the inverter to the utility grid. The proposed fuzzy-PI control strategy has better robustness and adaptability with respect to the different parameters than the conventional strategy.The simulation results demonstrate that the model is potentially useful in studying the micro grid system. It is especially suitable for a micro grid operated in both grid connected and islanded modes.

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The micro grid system simulation model is built in the MATLAB/Simulink environment and implemented using the Sim Power System toolbox. Fig. 1 illustrates a block diagram of the proposed micro grid system with VSI. As illustrated, this system consists of the control system and an inverter with filter that interfaces the DGs with the grid. The DGs generally used in a micro grid are photovoltaic, fuel cell, and micro turbine generators. The configuration and utilization of a set of DGs usually depend on customer needs and load criticality. The DC power sources can either be directly interfaced to the AC system through an inverter or be first set to an inverter compatible DC voltage level using a DC–DC converter and then converted into three phases using an inverter. AC power sources (e.g., micro turbines) that produce power a high frequencies are first rectified and then converted to three-phase.

The loads within a micro grid can either be electrical and/or thermal in nature. They can be further classified into critical and non-critical loads. During islanding, load shedding of non-critical loads can be performed to maintain the power balance and hence stability of the micro grid system. Therefore, the critical loads can be continued to operate in a normal manner through load shedding. The control system shown in Fig. 1 consists of several subsystems, including voltage and current control functions, grid synchronization function, and a pulse-width modulation (PWM) generator.

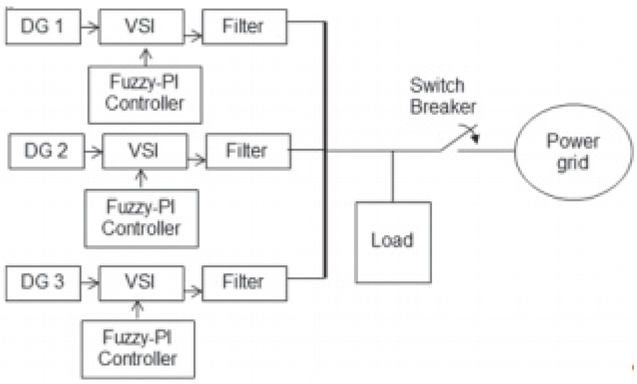

Fig.1. Block Diagram of the Micro Grid System.

A. Passive methods:

This method is fast to detect the islanding. But it has large non detection zone and it need special care to set the thresholds for it is parameters. Passive method can classified into: Rate of change of output power, Rate of change of frequency, rate of change of frequency over power, Change of impedance, voltage unbalance, and harmonic distortion B.Active MethodsActive method tries to overcome the shortcomings of passive methods by introducing perturbations in the inverter output. Active method can detect the islanding even under the perfect match of generation and load, which is not possible in case of the passive detection schemes but it caused degradation of power quality. Active method can be classified into: Reactive power export error detection , Impedance measurement method, Phase (or frequency) shift methods , Active Frequency Drift ,Active Frequency Drift with Positive Feedback Method , Adaptive Logic Phase Shift ,Current injection with positive feedback.

II. PROPOSED CONTROL STRATEGY

A. Power Stage:

This paper presents a unified control strategy for a three phase inverter in DG to operate in both islanded and grid-tied modes. The DG is equipped with a three-phase interface inverter terminated with a LC filter. The primary energy is converted to the electrical energy, which is then converted to dc by the front-end power converter, and the output dc voltage is regulated by it. In the ac side of inverter, the local critical load is connected directly. and their functions are different [1]-[5]. The inverter transfer switch Si is controlled by the DG, and the utility protection switch Su is governed by the utility. When the utility is normal, both switches Si and Su are ON, and the DG in the grid-tied mode injects power to the utility. When the utility is in fault, the switch Su is tripped by the utility instantly, and then the islanding is formed.After the islanding has been confirmed by the DG with the islanding detection scheme [6]–[10], the switch Si is disconnected, and the DG is transferred from the grid-tied mode to the islanded mode. When the utility is restored, the DG should be resynchronized with the utility first, and then the switch S I is turned ON to connect the DG with the grid.

B. Basic Idea :

With the hybrid voltage and current mode control, the inverter is controlled as a current source to generate the reference power PDG+jQDG in the grid-tied mode. And its output power PDG+jQDG should be the sum of the power injected to the grid Pg +jQg and the load demand P load + jQ load, which can be expressed as follows by assuming that the load is represented as a parallel RLC circuit:

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$$P_{\text{load}} = \frac{3}{2} \cdot \frac{V_m^2}{R} \tag{1}$$

$$Q_{\text{load}} = \frac{3}{2} \cdot V_m^2 \cdot \left(\frac{1}{\omega L} - \omega C\right) \tag{2}$$

In (1) and (2), Vman dω represent the amplitude and frequency of the load voltage, respectively. When the nonlinear local load is fed, it can still be equivalent to the parallel RLC circuit by just taking account of the fundamental component.

During the time interval from the instant of islanding happening to the moment of switching the control system to voltage mode control, the load voltage is neither fixed by the utility nor regulated by the inverter, so the load voltage may drift from the normal range [6].

And this phenomenon can be explained as below by the power relationship. When the islanding happens, the magnitude and frequency of the load voltage may drift from the normal range, and then they are controlled to recover to the normal range automatically by regulating the output power of the inverter.

C. Control Scheme:

Fig. 2 describes the overall block diagram for the proposed unified control strategy, where the inductor current iLabc ,the utility voltage vg abc, the load voltage vCabc, and the load current iLLabc are sensed. And the three-phase inverter is controlled in the SRF, in which, three phase variable will be represented by dc quantity.

The control diagram is mainly composed by the inductor current loop, the PLL, and the current reference generation module. In the inductor current loop, the PI compensator is employed in both D- and Q-axes, and a decoupling of the cross coupling denoted byω0Lf/k PWM is implemented in order to mitigate the couplings due to the inductor.

The output of the inner current loop dd q , together with the decoupling of the capacitor voltage denoted by 1/k PWM, sets the reference for the standard space vector modulation that controls the switches of the three-phase inverter. It should be noted that k PWM denotes the voltage gain of the inverter, which equals to half of the dc voltage in this paper.

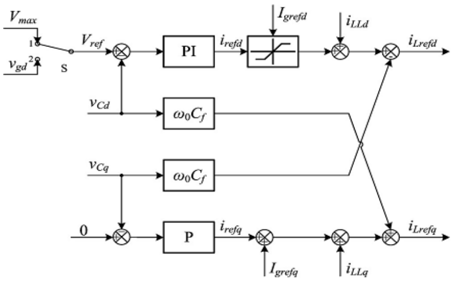

Fig.2 Block Diagram of the Current Reference Generation Module.

The PLL in the proposed control strategy is based on the SRF PLL, which is widely used in the three-phase power converter to estimate the utility [8] frequency and phase. Furthermore, a limiter is inserted between the PI compensator GPL Land the integrator, in order to hold the frequency of the load voltage within the normal range in the islanded operation. In Fig. 2, it can be found that the inductor current is regulated to follow the current reference iLrefdq, and the phase of the current is synchronized to the grid voltage vgabc.

If the current reference is constant, the inverter is just controlled to be a current source, which is the same with the traditional grid-tied inverter. The new part in this paper is the current reference generation module shown in Fig. 2, which regulates the current reference to guarantee the power match between the DG and the local load and enables the DG to operate in the islanded mode. Moreover, the unified load current feed forward, to deal with the nonlinear local load, is also implemented in this module.

The block diagram of the proposed current reference generation module is shown in Fig. 3, which provides the current reference for the inner current loop in both grid-tied and islanded modes. In this module, it can be found that an unsymmetrical structure is used in D- and Q-axes. The PI compensator is adopted in D-axes, while the P compensator is employed in Q-axis. Besides, an extra limiter is added in the D-axis.

Moreover, the load current feed forward is implemented by adding the load current iLL dq to the final inductor current reference iLref dq. The benefit brought by the unique structure in Fig. 3 can be represented by two parts: 1) seamless transfer capability without critical islanding detection; and 2) power quality improvement in both grid-tied and islanded operations. The current reference iLre dq composes of four parts in D-and Q-axes respectively:

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1) the output of voltage controller iref dq; 2) the grid current reference Igref dq; 3) the load current iLLdq; and 4) the current flowing through the filter capacitor Cf. In the grid-tied mode, the load voltage vC dq is clamped by the utility. The current reference is irrelevant to the load voltage, due to the saturation of the PI compensator in D-axis, and the output of the P compensator being zero in Q-axis, and thus, the inverter operates as a current source. Upon occurrence of islanding, the e voltage by regulating the current reference, and the inverter acts as a voltage source to supply stable voltage to the local load; this relieves the need for switching between different controls architectures. Another distinguished function of the current reference generation module is the load current feed forward. The sensed load current is added as a part of the inductor current reference iLref dq to compensate the harmonic component in the grid current under nonlinear local load. In the islanded mode, the load current feed forward operates still, and the disturbance from the load current, caused by the nonlinear load, can be suppressed by the fast inner inductor current loop, and thus, the quality of the load voltage is improved [9]-[13].The inductor current control in Fig. 2 was proposed in previous publications for grid-tied operation of DG, and the motivation of this paper is to propose a unified control strategy for DG in both grid-tied and islanded modes, which is represented by the current reference generation module in Fig. 3. The contribution of this module can be summarized in two aspects. First, by introducing PI compensator and P compensator in D-axis and Q-axis respectively, the voltage controller is in activated in the grid-tied mode and can be automatically activated upon occurrence of islanding.

III. OPERATING PRINCIPLE OF DG:

The operation principle of DG with the proposed unified control strategy will be illustrated in detail in this section, and there are in total four states for the DG, including the grid-tied mode, transition from the grid-tied mode to the islanded mode, the islanded mode, and transition from the islanded mode to the grid-tied mode.

A. Grid-Tied Mode:

When the utility is normal, the DG is controlled as a current source to supply given active and reactive power by the inductor current loop, and the active and reactive power can be given by the current reference of D- and Q-axis independently.

First, the phase angle of the utility voltage is obtained by the PLL, which consists of a Park transformation expressed by (3), a PI compensator, a limiter, and an integrator

$$\begin{pmatrix} x_d \\ x_q \end{pmatrix} = \frac{2}{3}\begin{pmatrix} \cos\theta & \cos\left(\theta - \frac{2}{3}\pi\right) & \cos\left(\theta + \frac{2}{3}\pi\right) \\ -\sin\theta & -\sin\left(\theta - \frac{2}{3}\pi\right) & -\sin\left(\theta + \frac{2}{3}\pi\right) \end{pmatrix} \times \begin{pmatrix} x_a \\ x_b \\ x_c \end{pmatrix} \tag{3}$$

Second, the filter inductor current, which has been transformed into SRF by the Park transformation, is fed back and compared with the inductor current reference iLref dq, and the inductor current is regulated to track the reference iLref dq by the PI compensator GI. The reference of the inductor current loop iLref dq seems complex and it is explained as below. It is assumed that the utility is stiff, and the three-phase utility voltage can be expressed as

$$\begin{cases} v_{ga} = V_g \cos\theta^* \\ v_{gb} = V_g \cos\left(\theta^* - \frac{2\pi}{3}\right) \\ v_{gc} = V_g \cos\left(\theta^* + \frac{2\pi}{3}\right) \end{cases} \tag{4}$$

Where Vg is the magnitude of the grid voltage, and θ∗ is the actual phase angle. By the Park transformation, the utility voltage is transformed into the SRF, which is shown as

$$\begin{cases} v_{gd} = V_g \cos(\theta^* - \theta) \\ v_{gq} = V_g \sin(\theta^* - \theta). \end{cases} \tag{5}$$

vgq is regulated to zero by the PLL, so vgd equals the magnitude of the utility voltage Vg. As the filter capacitor voltage equals the utility voltage in the gird-tied mode,vCd equals the magnitude of the utility voltage Vg, and vCq equals zero, too. In the D-axis, the inductor current reference iLref d can be expressed by (6) according to Fig. 3

$$i_{Lrefd} = I_{grefd} + i_{LLd} - \omega_0 C_f \cdot v_{Cq}. \tag{6}$$

The first part is the output of the limiter. It is assumed that the given voltage reference Vmaxis larger than the magnitude of the utility voltage vCd in steady state, so the PI compensator, denoted by GVDn the following part, will saturate, and the limiter outputs its upper value Igref d. In theQ-axis, the inductor current reference i Lref q consists of four parts as

$$i_{Lrefq} = v_{Cq} \cdot k_{Gvq} + I_{grefq} + i_{LLq} + \omega_0 C_f \cdot v_{Cd} \tag{7}$$

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Where k Gvq is the parameter of the P compensator, denoted by GVQ in the following part. The first part is the output of GVQ which is zero as the vCq has been regulated to zero by the PLL. The second part is the given current reference Igref q, and the third part represents the load current in Q-axis. The final part is the proportional part−ω0Cf •vCd, which is fixed since vCd depends on the utility voltage. Therefore, the current reference ILr efq cannot be influenced by the external voltage loop and is determined by the given reference Igref q and the load current iLLq.

B. Transition from the Grid-Tied Mode:

To the Islanded Mode When the utility switch Suspense, the islanding happens, and the amplitude and frequency of the load voltage will drift due to the active and reactive power mismatch between the DG and the load demand. while the load voltage and current are varying dramatically, the angle frequency of the load voltage can be considered to be not varied. The dynamic process in this time interval can be described by Fig. 4, and it is illustrated later.

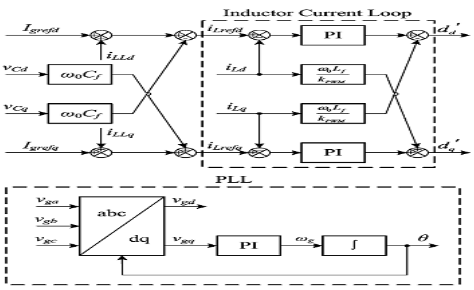

Fig.3 Simplified Block Diagram Of The Unified Control Strategy When DG Operates In The Grid-Tied Mode.

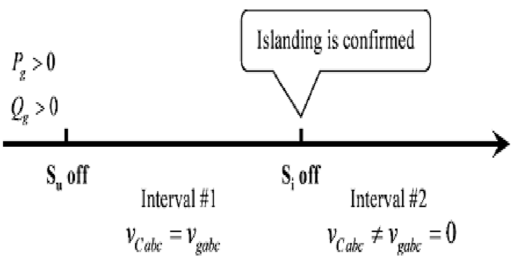

Fig.4 Operation Sequence During The Transition From The Grid-Tied Mode To The Islanded Mode.

In the grid-tied mode, it is assumed that the DG injects active and reactive power into the utility, which can be expressed by (8) and (9), and that the local critical load, shown in (10), represented by a series connected RLC circuit with the lagging power factor.

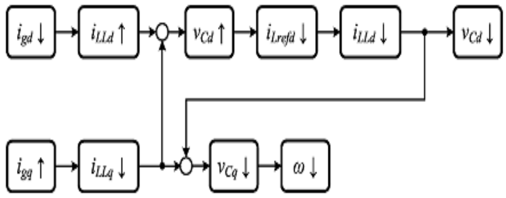

Fig.5 Transient process of the voltage and current when the islanding happens.

$$P_g = \frac{3}{2}\cdot(v_{Cd}i_{gd} + v_{Cq}i_{gq}) = \frac{3}{2}v_{Cd}i_{gd} \tag{8}$$

$$Q_g = \frac{3}{2}\cdot(v_{Cq}i_{gd} - v_{Cd}i_{gq}) = -\frac{3}{2}v_{Cd}i_{gq} \tag{9}$$

$$Z_{sload} = R_s + j\omega L_s + \frac{1}{j\omega C_s} = R_s + j\left(\omega L_s - \frac{1}{\omega C_s}\right) = R_s + jX_s. \tag{10}$$

When islanding happens, igd will decrease from positive to zero, and igq will increase from negative to zero. At the same time, the load current will vary in the opposite direction. The load voltage in D- and Q-axes is shown by (11) and (12), and each of them consists of two terms. It can be found that the load voltage in D-axis vCd will increase as both terms increase. However, the trend of the load voltage in Q-axis vCq is uncertain because the first term decreases and the second term increases, and it is not concerned for a while

$$v_{Cd} = i_{LLd}\cdot R_s - i_{LLq}\cdot X_s \tag{11}$$

$$v_{Cq} = i_{LLq}\cdot R_s + i_{LLd}\cdot X_s. \tag{12}$$

With the increase of the load voltage in D-axis VCd, when it reaches and exceeds Vmax, the input of the PI compensator GVD will become negative, so its output will decrease. Then, the output of limiter will not imposed to Igref dany longer, and the current reference iLref dwill drop. With the regulation of the inductor current loop, the load current in D-axis iLLd will decrease. As a result, the load voltage inD-axis VCd will drop and recover to Vmax. After iLLd has almost fallen to the normal value, the load voltage in Q-axis VCqwill drop according to (12). As VCq is decreased from zero to negative, then the input of the PI compensator GPLL will be negative, and its output will drop.

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In other words, the angle frequency ω will be reduced. If it falls to the lower value of the limiter ω min, then the angle frequency will be fixed a tω min

C. Islanded Mode:

In the islanded mode, switching Si and Su are both in OFF state. The PLL cannot track the utility voltage normally, and the angle frequency is fixed. In this situation, the DG is controlled as a voltage source, because voltage compensator GVD and GVQ can regulate the load voltage vCdq. The voltage references in D and Q-axis are Vmax and zero, respectively. And the magnitude of the load voltage equals to Vmax approximately, which will be analyzed in Section IV. Consequently, the control diagram of the three-phase inverter in the islanded mode can be simplified as shown in Fig. 6. In Fig. 6, the load current iLLdq is partial reference of the inductor current loop. So, if there is disturbance in the load current, it will be suppressed quickly by the inductor current loop, and a stiff load voltage can be achieved.

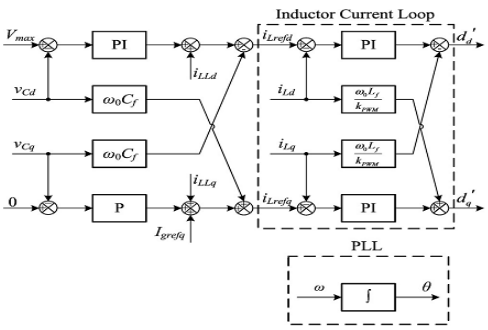

Fig.6. Simplified Block Diagram Of The Unified Control Strategy When DG Operates In The Islanded Mode.

D. Transition from the Islanded Mode :

To the Grid-Tied Mode If the utility is restored and the utility switch Su is ON, the DG should be connected with utility by turning on switch Si. However, several preparation steps should be performed before turning on switch S First, as soon as utility voltage is restored, the PLL will track the phase of the utility voltage. Third, the switch Si is turned on, and the selector S is reset to terminal 1. In this situation, the load voltage will be held by the utility. As the voltage reference Vref equals Vmax, which PI compensator GVD will saturate, and the limiter outputs its upper value Igref d.

At the same time, vCq is regulated to zero by the PLL according to (5), so the output of GVQ will be zero. Consequently, the voltage regulators GVD and GVQ are inactivated, and the DG is controlled as a current source just by the inductor current loop.

IV. FUZZY LOGIC CONTROLLER:

A new language was developed to describe the fuzzy properties of reality, which are very difficult and sometime even impossible to be described using conventional methods. Fuzzy set theory has been widely used in the control area with some application to dc-to-dc converter system. A simple fuzzy logic control is built up by a group of rules based on the human knowledge of system behavior. Matlab/Simulink simulation model is built to study the dynamic behavior of dc-to-dc converter and performance of proposed controllers. Furthermore, design of fuzzy logic controller can provide desirable both small signal and large signal dynamic performance at same time, which is not possible with linear control technique. Thus, fuzzy logic controller has been potential ability to improve the robustness of dc-to-dc converters. The basic scheme of a fuzzy logic controller is shown in Fig 7 and consists of four principal components such as: a fuzzy fication interface, which converts input data into suitable linguistic values; a knowledge base, which consists of a data base with the necessary linguistic definitions and the control rule set; a decision-making logic which, simulating a human decision process, infer the fuzzy control action from the knowledge of the control rules and linguistic variable definitions; a de-fuzzification interface which yields non fuzzy control action from an inferred fuzzy control action [10].

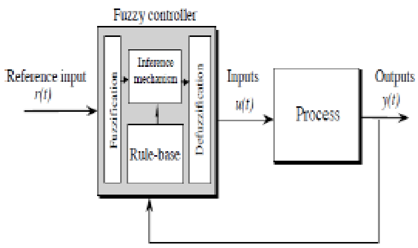

Fig.7. General structure of the fuzzy logic controller on closed-loop system

The fuzzy control systems are based on expert knowledge that converts the human linguistic concepts into an automatic control strategy without any complicated mathematical model [10]. Simulation is performed in buck converter to verify the proposed fuzzy logic controllers.

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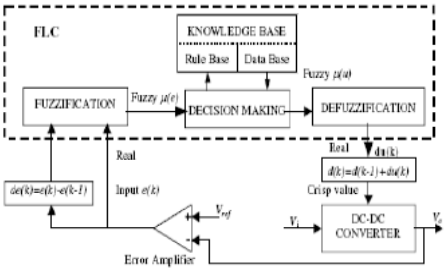

Fig.8 Block diagram of the Fuzzy Logic Controller (FLC) for dc-dc converters

V.MATLAB/MODELING & RESULTS:

Here simulation is carried out in different cases, in that 1). Proposed Three Phase Three level Inverter Fed Distributed Generation Scheme using Unified Control Scheme. 2). Proposed converter with fuzzy logic controller

Case 1: Proposed Three Phase Three level Inverter Fed Distributed Generation Scheme using Unified Control Scheme

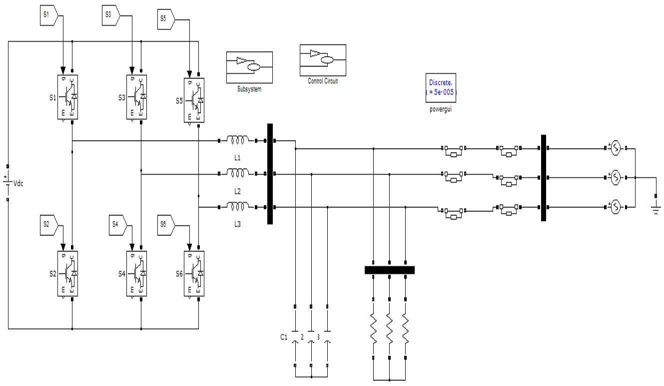

Fig.9 Matlab/Simulink Model of Proposed Three Phase Three level Inverter Fed Distributed Generation Scheme using Unified Control Scheme

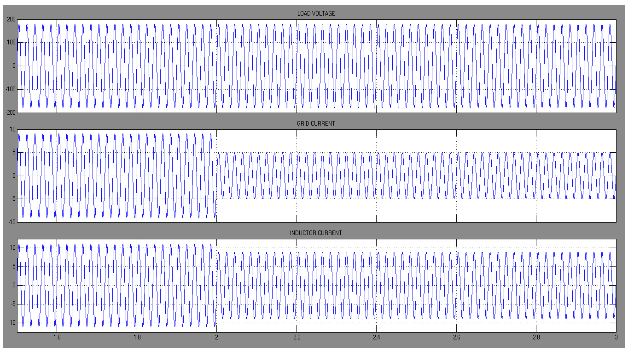

Fig.10 Simulation waveforms of load voltage vC a , grid current iga, and inductor current iLa when DG is in the grid-tied mode under condition of the step down of the grid current reference from 9 A to 5 A with proposed unified control strategy.

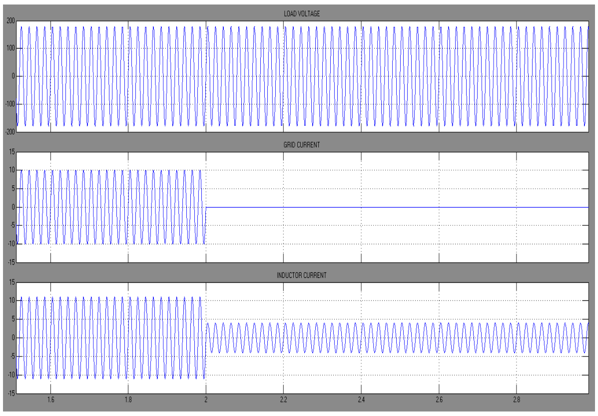

Fig.11 Simulation waveforms of load voltage vCa, grid current iga, and inductor current iLa when DG is transferred from the grid-tied mode to the islanded mode with proposed unified control strategy.

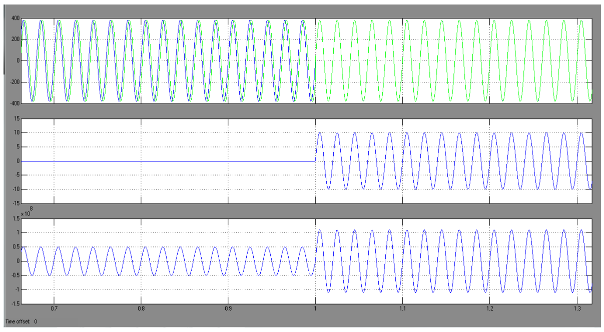

Fig. 12 simulation waveforms when DG is transferred from the islanded mode to the grid-tied mode.

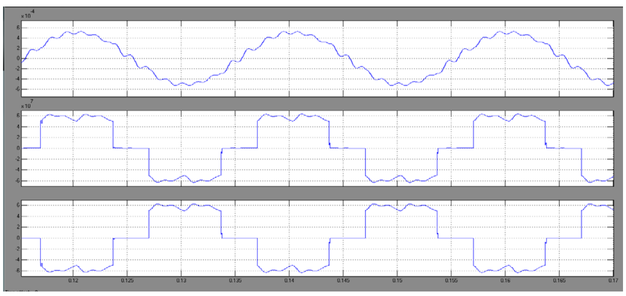

Fig. 13 simulation waveform when DG feeds nonlinear load in islanded mode with load current feed-forward and

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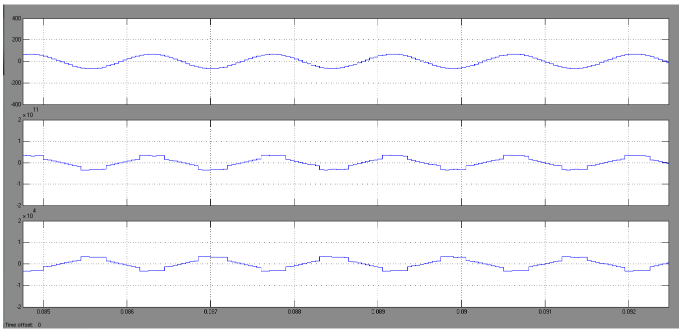

Fig. 14 simulation waveform when DG feeds nonlinear load in islanded mode without load current feed-forward

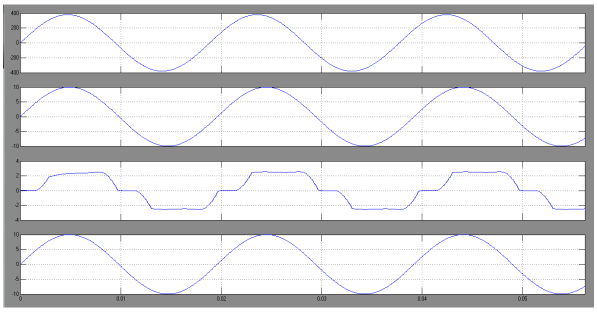

Fig.15 simulation waveforms when DG feeds nonlinear load in the grid tied mode with load current feed-forward

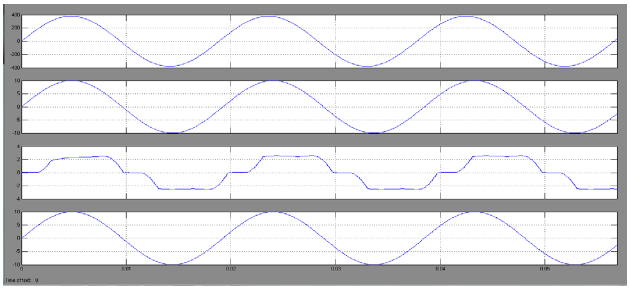

Fig.16 simulation waveforms when DG feeds nonlinear load in the grid tied mode without load current feed-forward

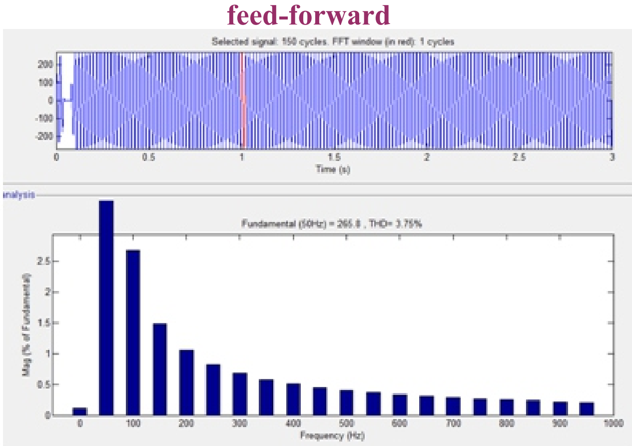

Fig.17 FFT analysis with PI controller without filter THD 3.75%

Case 2: Proposed converter with fuzzy logic controller

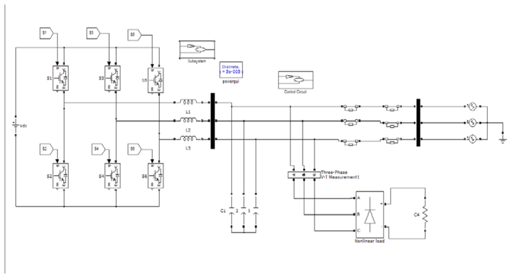

Fig.18 matlab/simulink model of proposed converter with fuzzy logic controller

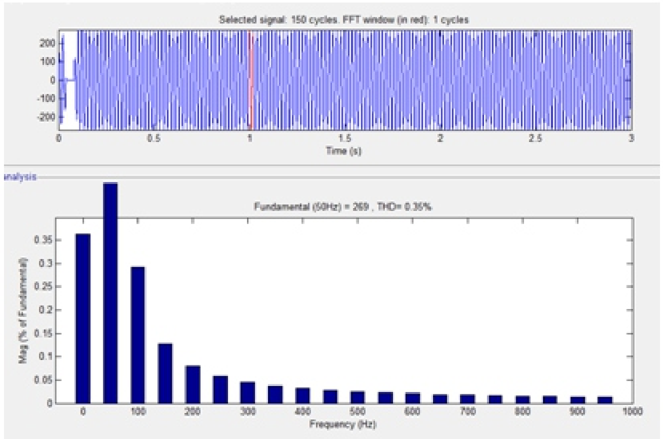

Fig.19 FFT analysis with fuzzy controller without filter THD 0.35%

VI.CONCLUSION:

In this concept PI and fuzzy based control strategy for 3-phase inverter in micro grid applications in this PI controller THD value is 3.75% and by using fuzzy controller THD is 0.35%. A unified control strategy was proposed for three-phase inverter in DG to operate in both islanded and grid-tied modes, with no need for switching between two different control architectures or critical islanding detection. It is inactivated in the grid-tied mode, and the DG operates as a current source with fast dynamic performance. Upon the utility outage, the voltage controller can automatically be activated to regulate the load voltage. Moreover, a novel load current feed forward was proposed, and it can improve the waveform quality of both the grid current in the grid-tied mode and the load voltage in the islanded mode. A advanced control strategy was proposed for three-phase inverter in DG to operate in both islanded and grid-tied modes, with no need for switching between two different control architectures or critical islanding detection. The above all simulation results are verified through Matlab/simulink software

REFERENCES:

[1] R. C. Dugan and T. E. McDermott, "Distributed generation," IEEE Ind. Appl. Mag., vol. 8, no. 2, pp. 19–25, Mar./Apr. 2002.

[2] R. H. Lasseter, "Microgrids and distributed generation," J. Energy Eng., vol. 133, no. 3, pp. 144–149, Sep. 2007.

[3] C. Mozina, "Impact of green power distributed generation," IEEE Ind. Appl. Mag., vol. 16, no. 4, pp. 55–62, Jul./Aug. 2010.

[4] IEEE Recommended Practice for Utility Interface of Photovoltaic(PV) Systems, IEEE Standard 929-2000, 2000.

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

[6] J. Stevens, R. Bonn, J. Ginn, and S. Gonzalez, Development and Testing of an Approach to Anti-Islanding in Utility-Interconnected Photovoltaic Systems. Livermore, CA, USA: Sandia National Laboratories, 2000.

[7] A. M. Massoud, K. H. Ahmed, S. J. Finney, and B. W. Williams, "Harmonic distortion based island detection technique for inverter-based distributed generation," IET Renewable Power Gener., vol. 3, no. 4, pp. 493– 507, Dec. 2009.

[8] T. Thacker, R. Burgos, F. Wang, and D. Boroyevich, "Single-phase islanding detection based on phase-locked loop stability," inProc. 1st IEEE Energy Convers. Congr. Expo., San Jose, CA, USA, 2009, pp. 3371–3377.

[9] S.-K. Kim, J.-H. Jeon, J.-B. Ahn, B. Lee, and S.-H. Kwon, "Frequency shift acceleration control for anti-islanding of a distributed-generation inverter," IEEE Trans. Ind. Electron., vol. 57, no. 2, pp. 494–504, Feb. 2010.

[10] A. Yafaoui, B. Wu, and S. Kouro, "Improved active frequency drift anti islanding detection method for grid connected photovoltaic systems," IEEE Trans. Power Electron., vol. 27, no. 5, pp. 2367–2375, May 2012.

[11] J. M. Guerrero, L. Hang, and J. Uceda, "Control of distributed uninterruptible power supply systems," IEEE Trans. Ind. Electron., vol. 55, no. 8, pp. 2845–2859, Aug. 2008.

[12] M. C. Chandorkar, D. M. Divan, and R. Adapa, "Control of parallel connected inverters in standalone AC supply systems, "IEEE Trans. Ind. Appl., vol. 29, no. 1, pp. 136–143, Jan./Feb. 1993.

[13] Y. Li, D. M. Vilathgamuwa, and P. C. Loh, "Design, analysis, and real time testing of a controller for multibus microgrid system," IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1195–1204, Sep. 2004.