POWER QUALITY IMPROVEMENT IN A GRID CONNECTED RENEWABLE ENERGY SYSTEM

Mr. Anantrao V. Patil
Department of Electrical Engineering,
Annasaheb Dange College of Engineering and Technology, Ashta, Sangli, India
Email: anantpatil17@gmail.com

Dr. Anwar M. Mulla
Department of Electrical Engineering,
Annasaheb Dange College of Engineering and Technology, Ashta, Sangli, India
Email: ammaitp@rediffmail.com

Mr. Swapnil D. Patil
Department of Electrical Engineering,
Annasaheb Dange College of Engineering and Technology, Ashta, Sangli, India
Email: sdp_ele@adcet.in

Mr. Ajit B. Jadhav
Department of Electrical Engineering,
Annasaheb Dange College of Engineering and Technology, Ashta, Sangli, India
Email: abj_ele@adcet.in

ABSTRACT

In distributed system, renewable energy resources (RES) are progressively incorporated using power electronics interfaces. Extensive use of power electronics devices produce harmonic current and may reduce quality of power. In this paper, renewable energy resources (RES) is linked to the grid through a grid interfacing inverter for power quality improvement. The grid interfacing inverter is linked to a 3- phase 4-wire system and hysteresis current control method is used to generate gate pulses. Here renewable energy resource (RES) is represented as a dc source. The grid interfacing inverter has the capability of injecting RES power to the grid and also reduces load unbalance, load harmonics and reactive power demand is compensated. Total Harmonic Distortion (THD) of the grid connected system is analyzed. The simulation has been carried out in MATLAB/Simulink.

Keywords: Grid interfacing inverter, Hysteresis Current control, Power Quality Improvement, Renewable Energy Resources (RES).

INTRODUCTION

In three phase systems, balanced and unbalanced systems are the commonly used terms. Here the load in the system determines whether it is balanced or unbalanced one. In a 3 phase system, the three voltages or current phasor are placed at 120° apart from each other. The flow of current starts in the system as soon as the load is connected to it. The system is said to be balanced one if the neutral current is seen to be zero. Otherwise the system is said to be unbalanced.

For a balanced three phase system, waveform. Is smoothly sinusoidal i.e. in terms of magnitude and phase shift of 120°, current passing through all phases is identical, no current through the neutral and losses are very less or absent. The unbalanced .system causes heating of 3-ϕ machines decreased whole life of machine, increased I^2R losses, tripping of variable frequency induction motor drives. In unbalanced .system the waveforms are distressed in magnitude & phase angle, current through phases is not equal, a neutral terminal in required and more power losses are present.

The 3 phase 4 wire system has the benefit of neutral line. This neutral wire offers the route for current when the load on the system is not balanced. Also single phase loads can be safely connected to three phase system with neutral wire. Industrial consumers require 3 phase connection for high power appliances as well as single phase connection for low power appliances where as domestic consumers require only single phase connection. This leads to creation of unbalance in the system. The main reasons for adopting 3-ϕ, 4 wire power supply are: it is generally suitable for single-phase loads such as power and lighting to facilitate the mixed use of electricity. Three-phase motors are symmetrical three-phase loads and require three-phase power, while three-phase four-wires are used the system is as if there are three separate power supplies (each phase power supply can supply power to each phase load separately). When a 1-ϕ load is associated to a 3-ϕ circuit, although each phase strives to be evenly distributed, it cannot be carried out at the same time in actual use, which in fact becomes a three-phase asymmetrical circuit. The voltage is basically unchanged, and it is necessary to have a neutral wire as a loop for normal operation to flow an unbalanced current. In order to prevent the non-grounded two phase grounding from rising to the line voltage when single-phase grounding occurs in the low-voltage power supply, the "high voltage" that endangers personal safety is required.

The inverter design has always remained challenge for unbalanced system. In stand alone micro grid consisting of renewable and distributed energy resources the grid integration can be effectively done by being 3 phase 4 wire inverter. For development of such three phase 4 wire inverter various topologies have been proposed by researchers. The development of neutral is done through split AC source, split capacitor or by introducing another leg of switching devices in the inverter bridge. This research work is proposed to develop 3 phase 4 leg inverter for renewable energy applications.

METHODOLOGY

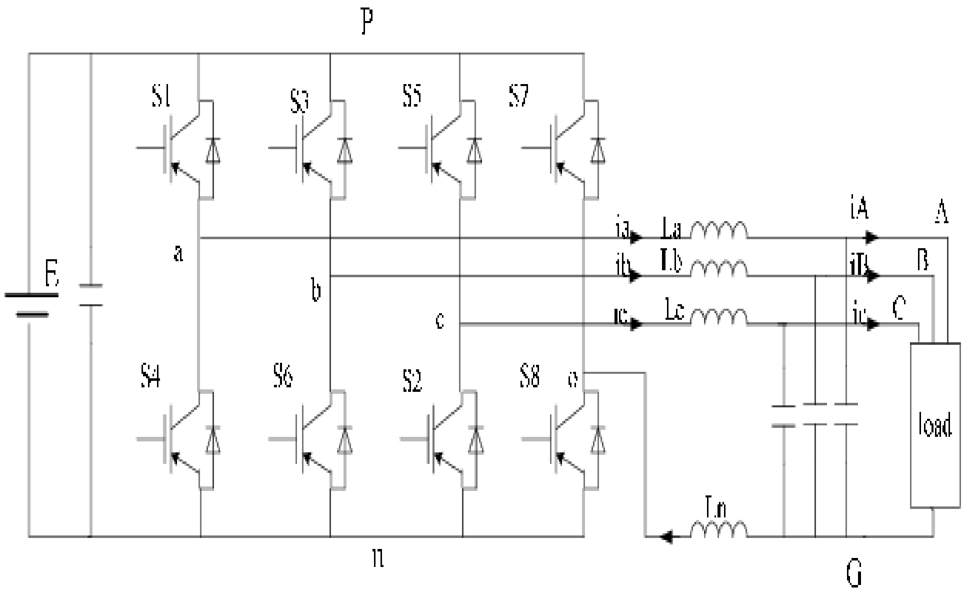

Figure 1. Structure of 3 phase 4 leg inverter

The consumer electricity distribution is accomplished through 3-ϕ , 4 wire distribution system. In India, the secondary winding of distribution transformer is star connected with three phase voltage of 415V and line to neutral voltage of 230V. On basis of number of phases, the electrical loads are categorized into 3-ϕ loads and 1-ϕ loads. The neutral.terminal.for the load is obtained by using star point which is earthed at the substation.

A 3 phase 4 leg inverter is planned to reimburse 3-ϕ unstable currents under unstable load conditions in grid - connected operation. The figure.1 shows circuit scheme of the same where S1 to S8 are the IGBT switches with free wheeling diode. The imbalance compensation method is planned using 3-ϕ, 3 leg voltage source inverter. The negative..-sequence conductance is controlled to compensate for the voltage unbalance.

The idea of the planned inverter approaches.. the unbalance currents as different to the unbalance voltage. In the case of the occurred micro grid, the unbalance currents of the loads is generally supplied.. by the diesel generator, because the 3-ϕ, 3 wire created DGs are incredible to inject unbalance current. The planned scheme directly compensates unbalance currents under unbalanced conditions.

For the control of the grid connected inverter two controls are essential first DC. Link voltage control. Wherein the DC. voltage. supplied to the inverter bridge is maintained constant and the other being triggering of semiconductor switching devices in the inverter bridge. In the proposed research work, the DC link voltage is regulated with Fuzzy PI controller and the triggering of IGBTs in the inverter bridge is controlled by hysteresis controller.

MATLAB Simulation

The system of 3-ϕ , 4 leg VSI is simulated through MATLAB Simulink.

The developed system 3-ϕ, 4 leg VSI is constructed through IGBT inverter switches. A PV panel is taken as renewable energy source whose output.. voltage.. is proportional to solar radiations. The DC voltage.. output is regulated by a FLC. The output of inverter is fed towards the network with appropriate filtering towards LC filter. The triggering of inverter bridge is controlled by hysteresis controller.

The measurements are taken for solar radiations, DC.. link.. voltage.., grid voltage and current,.. load voltage and current,.. printer network voltage and current waveforms and the waveforms of triggering pulses at each of the IGBT inverter bridge. The readings of output of the system are recorded for 3 phase balanced RL load and unbalanced resistive load.

MATLAB Simulation Models

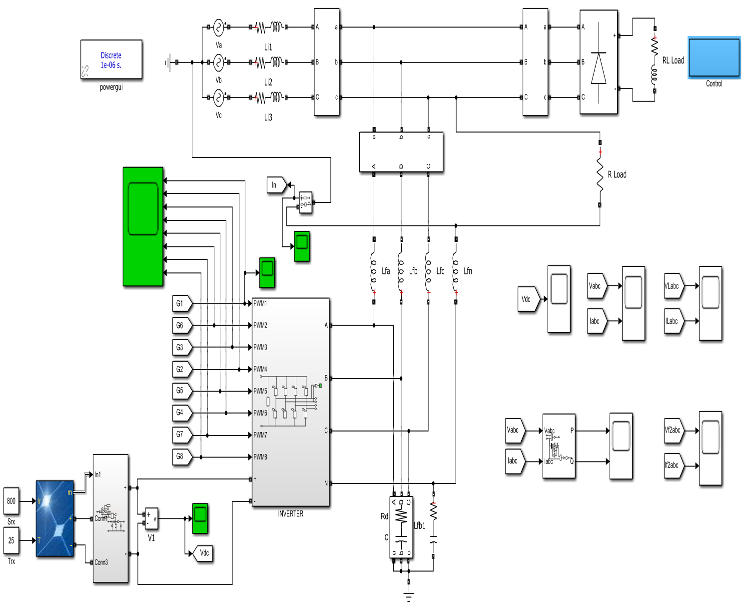

Figure. 2 MATLAB Simulink Model of 3 phase 4 leg inverter

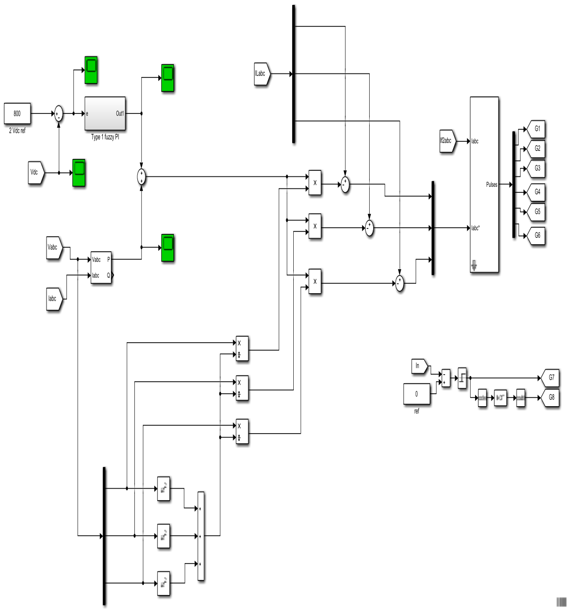

Figure. 3 Control scheme of the inverter based on fuzzy logic controller

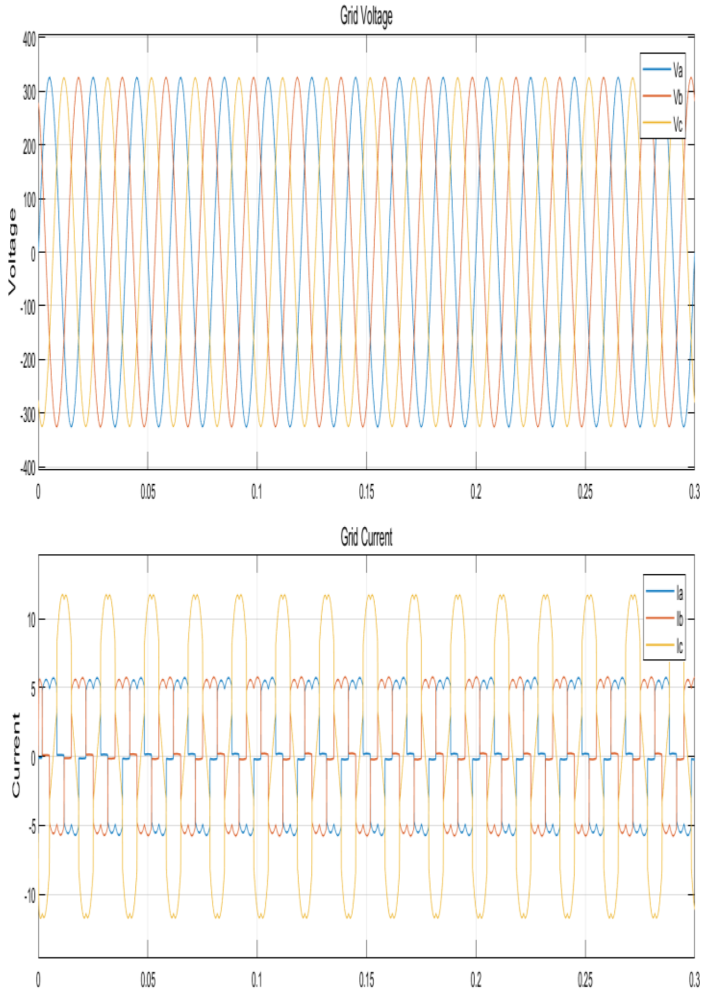

Figure. 4 Waveforms of voltage & current of the grid.

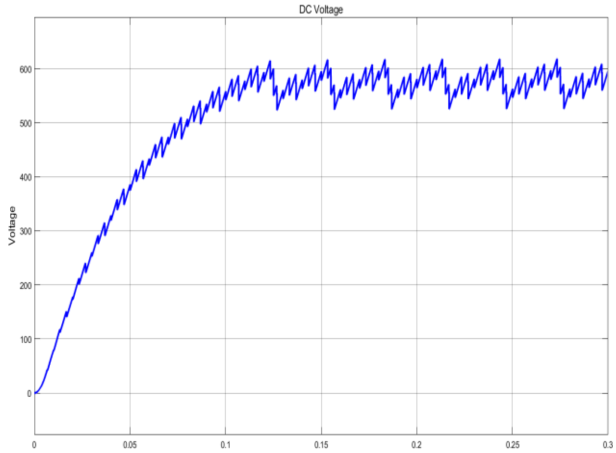

Figure. 5 DC Link voltage of the inverter

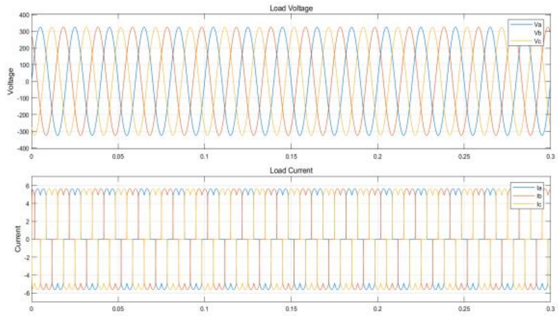

Figure. 6 Voltage & current waveforms of the load.

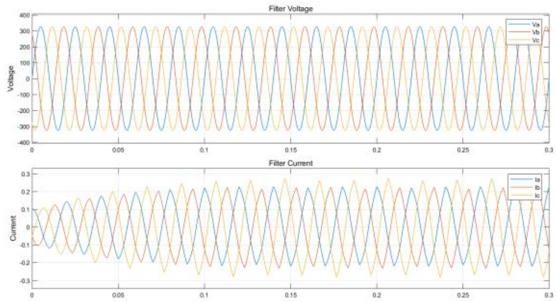

Figure. 7 Voltage & current waveforms at filter network

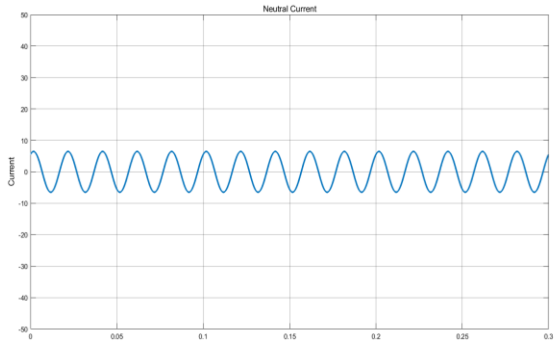

Figure.8 The neutral current waveforms

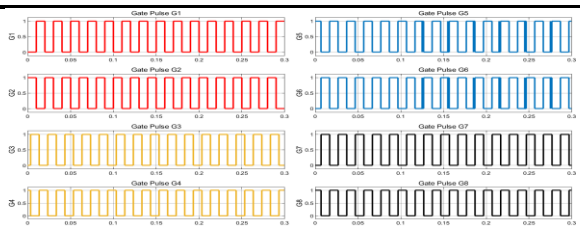

Figure. 9 Gate pulses waveforms for inverter IGBTs

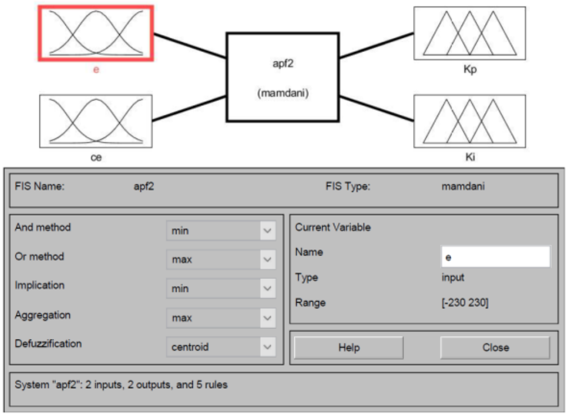

Figure. 10 Fuzzy Logic Controller designer block

Description of Simulation Model Results

The simulation model of proposed 3 phase 4 leg inverter for renewable energy application is shown in figure.. 2 & figure.. 3 The corresponding results.. of simulation results are presented in figure 4 to 9. The figure 4 shows the waveforms for grid voltage and grid current. Figure.. 5 shows.. the.. DC link voltage of the inverter bridge. Figure 6 shows waveforms.. of.. voltage.. & current.. of load. Figure 7 shows waveforms.. of.. voltage and current.. at the filter network whereas the figure 8 shows neutral current waveforms. The triggering pulses for IGBTs in the inverter bridge are shown in figure 9.

It is noted that the triggering pulses for neutral leg of the inverter are generated only when unbalance in the three phase load is present otherwise neutral leg of the inverter remains idle. The triggering of neutral leg is proportional towards the phase angle.. of the unbalanced load current... The unbalance in the load current is identified by increased magnitude of current in the three phase current waveforms of load and filter circuit.

It can be clearly seen that the unbalanced loading conditions are compensated through the proposed 3-ϕ, 4 leg VSI with fuzzy logic controller.

Hardware Implementation

The voltage source inverter is the main component of the Distributed Generation (DG) system as it interfaces the RES to the grid. RES is connected to the dc link of the interfacing inverter as shown in The RES can be represented as a DC source or an AC source with rectifier coupled to dc-link of the inverter. In this paper RES is represented as a DC source

For prototype hardware development, following specification are considered

3 phase 4 leg inverter bridge

Voltage.: 24V

Frequency: 50Hz.

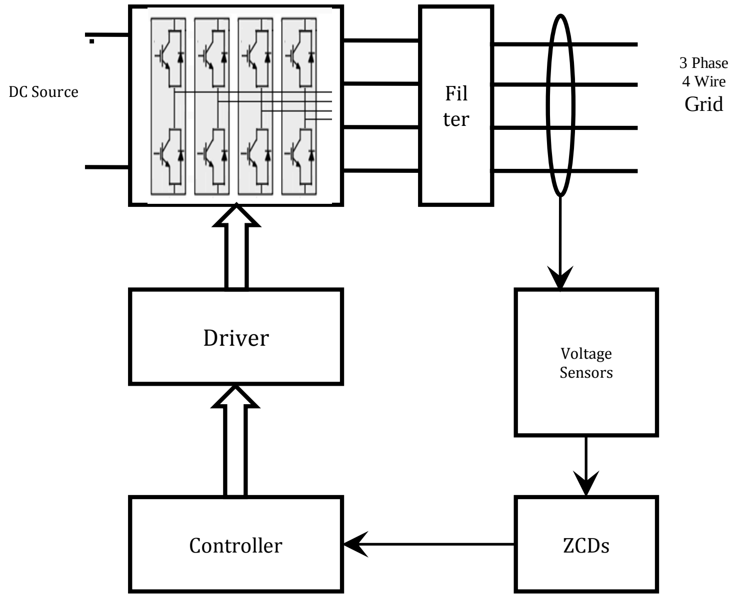

Figure. 11 Basic configuration of the system

RESULTS

The.. results of.. the.. developed.. prototype are recorded as mentioned in.. the following table. Here, the measurement of voltages is done for three phase voltage (line to neutral voltage), DC link voltage and the waveforms of triggering pulses for IGBTs in the inverter bridge are mentioned.

Observation table of voltages

DC Link Voltage	V_R	V_Y	V_B
36	24.8	24.8	24.6

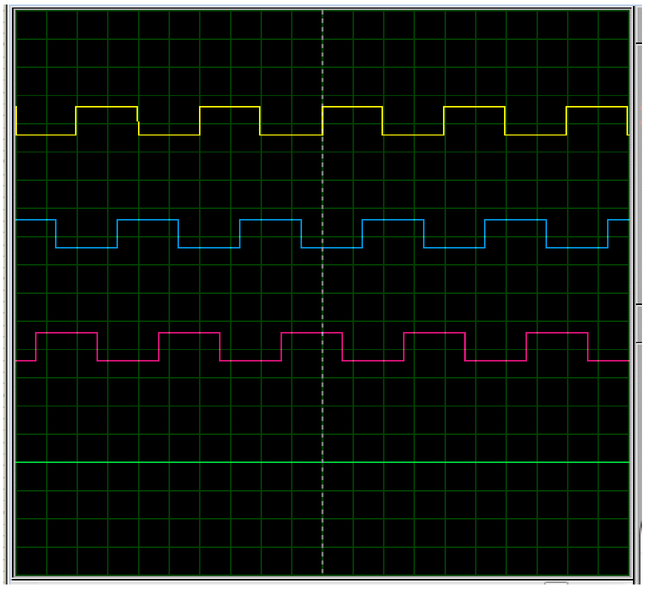

Figure. 12 IGBT triggering waveforms with balanced load

CONCLUSION

This research work discusses development of a 3-ϕ, 4 leg VSI for.. renewable energy application. The.. system.. simulation with MATLAB Simulink is presented and a hardware prototype is developed. In 3-ϕ, 4 wire systems, the unbalanced load forces current.. through the.. neutral wire. This neutral current creates the problems associated with power quality.

From.. the.. simulation.. and experimental results.. it can be concluded.. that.. the.. proposed 3-ϕ, 4 wire inverter is.. able.. to.. compensate.. the.. neutral.. current.. arising due to the.. unbalanced.. load.. Such an inverter is best suited for isolated micro grid systems with renewable energy sources.

APPLICATIONS

The 4 leg Inverter topology offers advantages in.. terms of its capability of handling unbalanced and nonlinear loading conditions, lower.. ripple.. contents on.. DC.. link.. voltage.. and the ability to cope up with.. the.. power.. quality.. requirements. The applications of developed 3 phase 4 leg inverter configuration are listed below

- Grid integration of renewable energy resources
- Active power filters
- Standalone micro grids
- Feeding the unbalanced load
- Power quality improvement devices

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