

Power Quality Improvement in Micro Grid System using Fuzzy - UPQC Controller

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Abstract

Generally, the power systems are mainly affected by the continuous changes in operational requirement and increasing amount of distribution energy systems due to because of this causes the effect of deregulation. This paper proposes a new concept i.e. power-control strategies for a micro grid generation system for better transferring of power. So that these micro grids are obtained with the general renewable energy sources and this concept provides the maximum utilization of power at environmental free conditions with low losses, then the system efficiency is also improved

This paper proposes a single stage converter based micro grid to reduce the number of converters in an individual ac or dc grid. The proposed micro grid concept can work in both stand-alone mode and also in grid interfaced mode. The distortions occurred in power system due to changes in load or because of usage of non-linear loads, can be eliminated by using control strategies designed for shunt active hybrid filters such as series and shunt converters. A conventional Proportional Integral (PI) and Fuzzy Logic Controllers are used for power quality enhancement by reducing the distortions in the output power. The simulation results were compared among the two control strategies with fuzzy logic controller and pi controller.

Keywords: Grid Control; Micro-grid; Wind power generation; Fuzzy Controller; UPQC.

1. Introduction

Over the past few years, the growth in the use of nonlinear loads has caused many power quality problems like high current harmonics, low power factor and excessive neutral current. Nonlinear loads appear to be current sources injecting harmonic currents into the supply network through the utility's Point of Common Coupling (PCC). This results in distorted voltage drop across the source impedance, which causes voltage distortion at the PCC. Other customers at the same PCC will receive distorted supply voltage, which may cause overheating of power factor correction capacitors, motors, transformers and cables, and mal-operation of some protection devices [12].

The Distributed Energy Resources are one of the power generations systems in small scale range such as renewable energy resources examples of photovoltaic cell, wind energy generation system or hydro energy. Placing the microgrid concept near to the load centers has the advantage of improving efficiency by reducing the transmission line losses or voltage drops.

By increasing the domestic and commercial appliances and increasing demand of critical or sensitive loads causes the growing electricity consumption. In this paper a micro grid concept based single stage AC-DC converter is proposed for reducing processes of multiple reverse conversions in an individual ac or dc grid and to facilitate the connection of various renewable sources and loads to power system. The coordination control scheme such as maximum power point tracking converters are proposed for obtaining maximum power from the renewable energy sources under variations in input or any demand conditions [1 - 9]. This type of microgrid systems are even generated electrical power under normal abnormal conditions such as if it is solar it operate at room

temperature or if it generates energy at normal speed i.e in plain surface area. However, power electronic based converters are proposed in this paper for controlling purpose.

Generally, harmonics and reactive power are two of the serious problems associated with the grid. They are caused by nonlinear loads, including saturated transformers, arc furnaces, and semiconductor switches. The presence of harmonics and reactive power in the grid is harmful, because it will cause additional power losses and malfunctions of the grid components [1 - 5]. To prevent the inflow of harmonic and reactive currents and to improve the operating ability of the transmission systems, a kind of Flexible AC Transmission System (FACTS) has been proposed [6 - 10]. The static var compensator (SVC) is an important component of FACTS.

2. Grid Interfacing System

In the present scenario, the integration of grid with the renewable energy sources such as photovoltaic system is the most important application. These advantages include the favorable incentives in many countries that impact straight forwardly on the commercial acceptance of grid connected PV systems. This condition imposes the necessity of having good quality designing tools and a way to accurately predict the dynamic performance of three-phase grid-connected PV systems under different operating conditions in order to make a sound decision on whether or not to incorporate this technology into the electric utility grid.

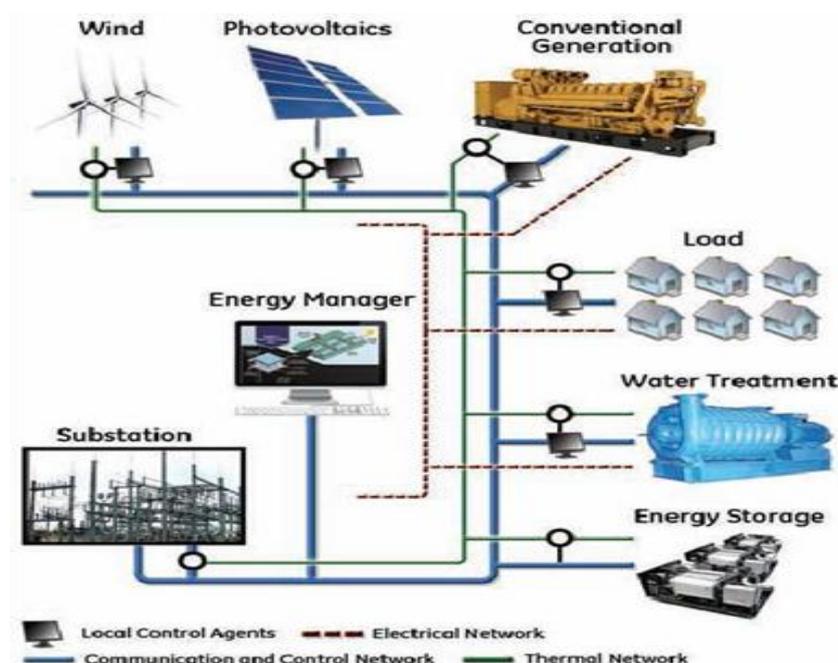


Figure 1: Microgrid power system

2.1 Photovoltaic Cell:

Photovoltaic energy system is one of method for generating electrical power by the direct conversion of solar irradiation into electrical energy using power semiconductor devices. This photovoltaic power generation system consists

of series and parallel connected solar cells. The power generated from the photovoltaic system is varied as changes occur in the input of solar panel i.e. sun radiation, in order to get maximum output at any instant of time irrespective of time we are going to use maximum power point tracking controller.

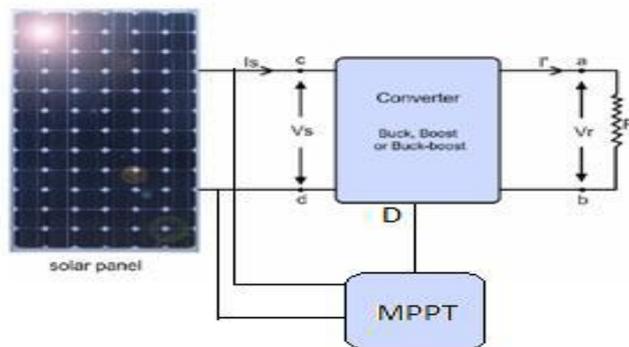


Figure 2: PV System with Power Converter

With increasing commercial or domestic appliances such as sensitive or non-linear loads they causes the changes in the transmission system parameters such as voltage or current unbalances or harmonics in current and other power quality problems. In order to meet the requirement of power quality standards, it is necessary to use some sort of compensating techniques. Basically, from the first generation the reactive elements are used for compensating purposes. Later on a power electronics control based devices are implemented and also called as flexible AC transmission systems.

3. Unified Power Quality Controller

One of the compensating device form the FACTS family called as Unified Power Quality Conditioner is the efficient method improving for the power quality [4]. The Unified power quality controller is a combination of series and shunt controller separated by a common dc-link for exchanging reactive power.

A shunt device is a one of the compensated equipment which is connected at the transmission system. This shunt compensated system has the capability of either absorb or generate active power at the point of connection thereby controlling the voltage magnitude. Because the bus voltage magnitude can only be varied within certain limits, controlling the power flow in this way is limited and shunt devices mainly serve other purposes. A device that is connected in series with the transmission line is referred to as a 'series device'. Series devices influence the impedance of transmission lines. The principle is to change (reduce or increase) the line impedance by inserting a reactor or capacitor. To compensate for the inductive voltage drop, a capacitor can be inserted in the line to reduce the line impedance.

The series compensated device is connected in series with the line for controlling the transmission parameters such as transmission impedance by controlling reactance, fluctuations in system voltage.

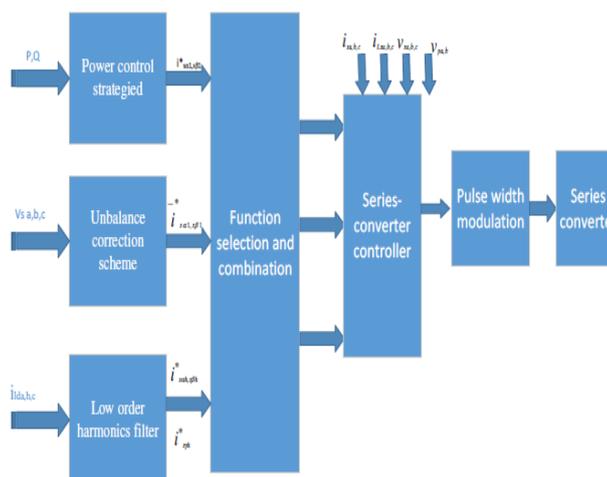


Figure 3: Block diagram of overall control structure with Series converter

The series controller which is explained in the previous section is used for compensating the power quality problems. It is controller with help of three phase converter. The gate pulse for this series converter is generated with the help of closed loop control diagram as shown in Figure 4. In

this control technique first the voltages are compared and the error obtained for this is converted to two phase orthogonal vectors. With the help of these vectors the pulses for the series converter is calculated.

3.1 Closed Loop Control Diagram for Shunt Converter

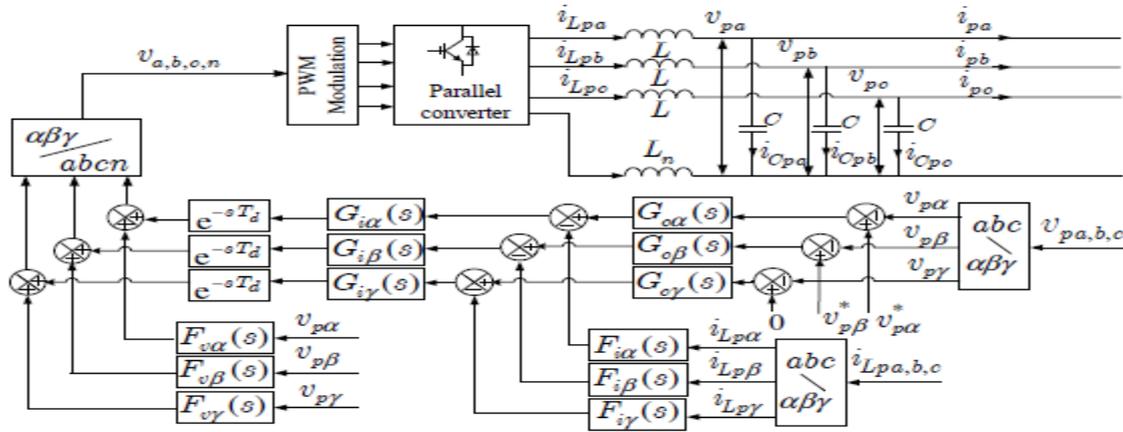


Figure 4: Closed loop control Diagram for shunt converter.

The closed loop control circuit of the shunt converter which is used for generating gate pulses for three phase voltage source converter is as shown in Figure 4 [6]. From this figure the reference vector currents are obtained by

comparing the actual currents with normal currents which are obtained from the PQ theory concept. Based on this error obtained from this concept the gate triggering pulses are generated are given to the VSC of shunt converter.

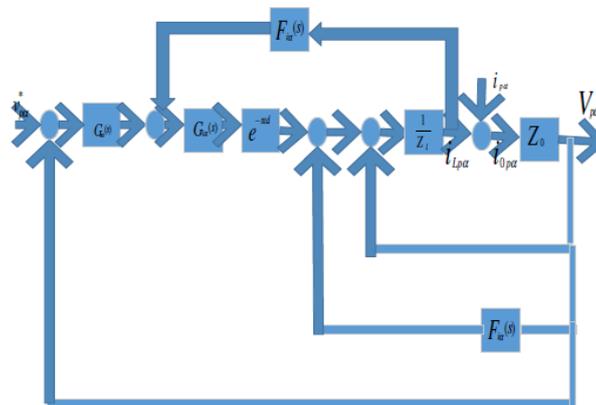


Figure 5: Closed loop block diagram for α

Fuzzy Inference System:

The fuzzy logic controller is one of the advanced soft computing controllers which are used for controlling the system output. As compared with the other conventional controllers, fuzzy logic controller has the advantage of fast

computing, better response, low settling time and high running response. The fuzzy logic controller operation can be explained in mainly four ways i.e 1. Fuzzification, 2. Membership function, 3. Rule-base formation and 4. Defuzzification.

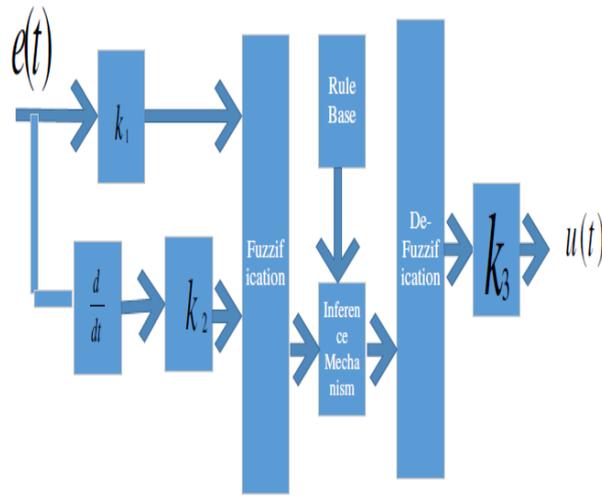


Figure 6: Block diagram of Fuzzy Logic Controller

The basic block diagram for the fuzzy logic controller as shown in Figure 6. The rules taken for this system is shown in below table. The input variables such as error and error rate are expressed in terms of fuzzy set with the linguistic

terms VN, N, Z, P, and VP. In this type of mamdani fuzzy inference system the linguistic terms are expressed using triangular membership functions.

$$L(e, ce) = \{VN, N, Z, P, VP\}$$

e/ce	VN	N	Z	P	VP
VN	VN	N	Z	P	VP
N	VP	P	Z	N	VN
Z	N	Z	P	VP	VN
P	N	N	VN	P	P
VP	N	Z	P	P	VP

Table 1: Seven variable rule base

Ex: let us choose one rule with the terms for error and error rate as Zero and Zero. In this the rules are formed with the help of if-then rule base formation. For this examples these two inputs are related with the logical operator AND (means Min value) and then the output is derived.

If input 1 e is Z AND input 2 ce is Z then the output is Z.

The membership function for the input error is as shown below.

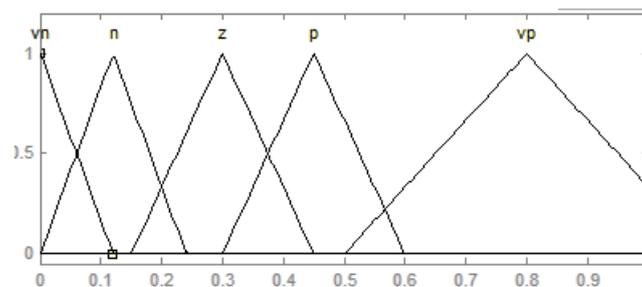


Figure 7: Membership function representation for input 1

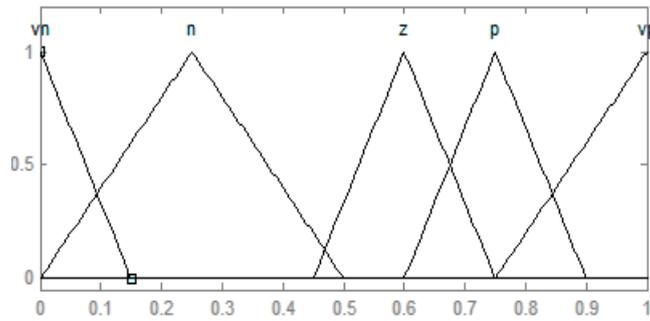


Figure 8: Membership function representation for input 2

The type membership functions here used are Triangular type and the membership function range is -1 to 1 i.e., universe of discourse. The defuzzification is done by

using Centroid method. The seven variable rule base consisting of 49 rules and are If-Then type.

4. Simulation and Results

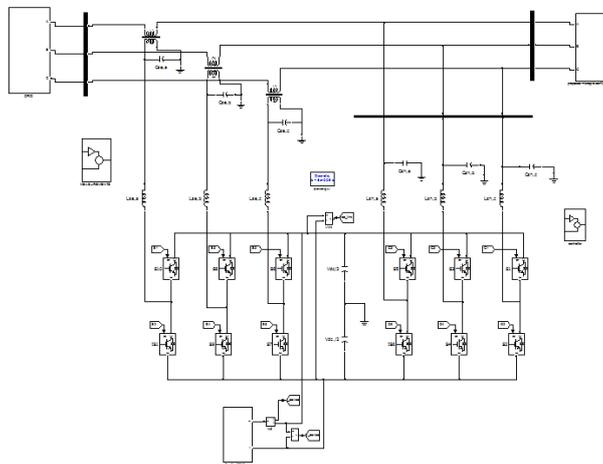


Figure 9: Simulation implementation of Micro Grid with and without fuzzy controller.

In this paper the simulation is done for micro grid and the results are compared with two cases.

Case 1: with PI Controller

In this the conventional PI controller is used for series and shunt controllers. The obtained results are shown in below figures.

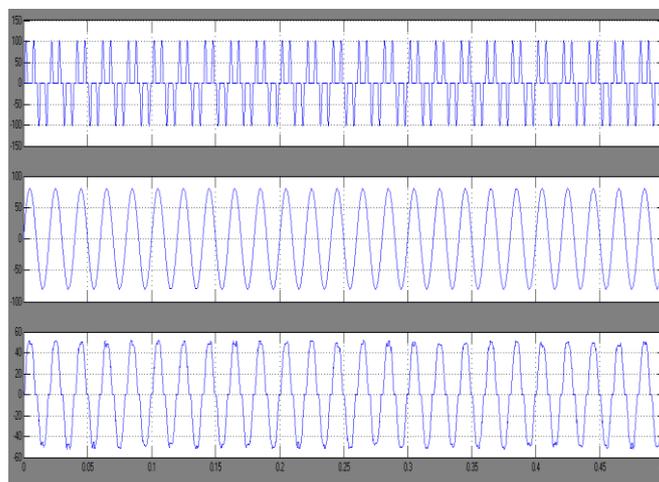


Figure 10: Simulation result for Feeder currents 1, 2 and 3

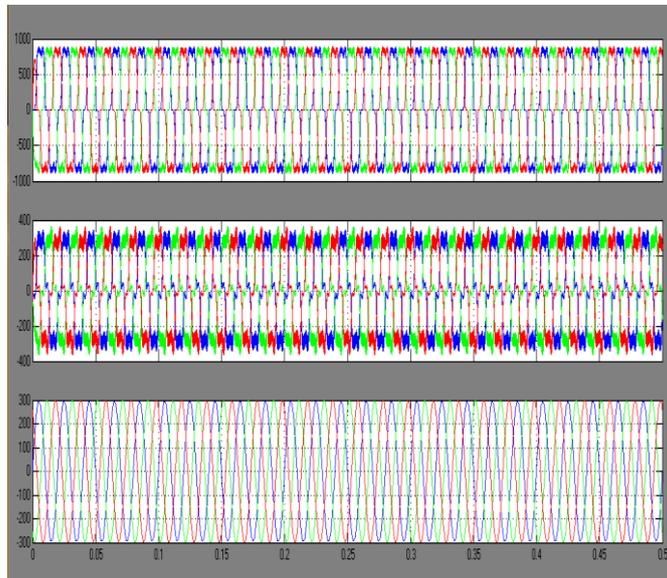


Figure 11: Simulation result for Grid, Series Converter and Micro-Grid Voltage

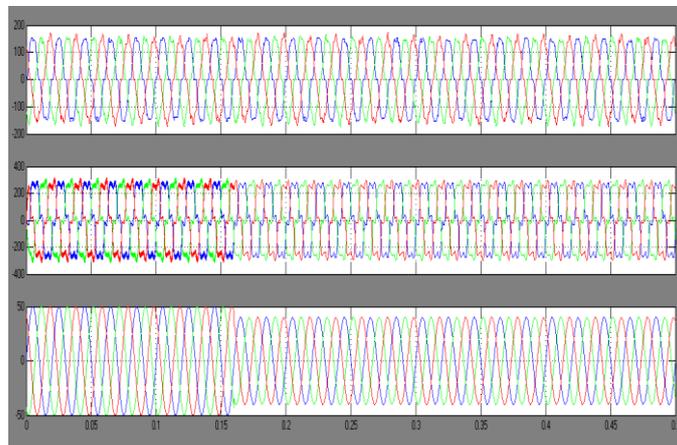


Figure 12: Simulation result for Grid, Series Converter and Micro-Grid Current

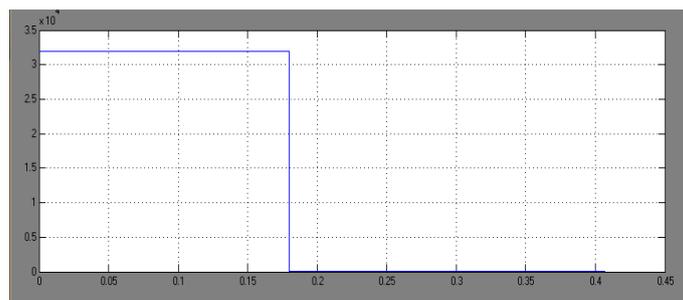


Figure 13: Simulation result for Active Power under Islanded condition

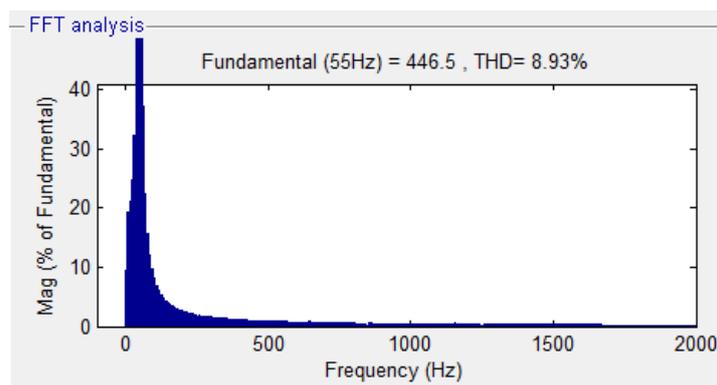


Figure 14: FFT Analysis

Case 2: with Fuzzy controller:

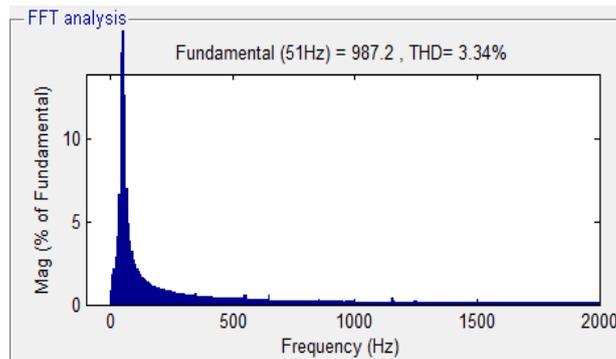


Figure 15: FFT Analysis

5. Conclusion

This paper has successfully implemented the microgrid based unified power quality conditioner along with the fuzzy logic controller. Generally, the micro grid concept mainly concentrates on the reduction of transmission losses and the power quality problems occurred in the system is compensated by unified power quality conditioner. The fuzzy logic controller is used for getting better performance by the reduction of total harmonic distortion in the system.

The simulation results obtained for the Grid interfacing using series and parallel converter system with conventional PI controller and Fuzzy logic controller. Due to the presence of non-linearity in the system, harmonics will produce which leads to voltage distortions. By using conventional PI controller in the system we can reduce these distortions. This drawback can be overcome by adopting fuzzy set theory.

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