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Implementation of Fuzzy Based UPQC Controller for Microgrid Power Quality

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***Abstract**: Generally speaking, the growing number of distributed energy systems and ongoing changes in operating requirements have the biggest effects on power systems. In order to improve power transfer, this research suggests a novel idea for power-control strategies for a micro grid generation system. In order to maximize power usage under environmentally free conditions with minimal losses, micro grids are created using general renewable energy sources. This also improves system efficiency. To lower the number of converters used in a grid, this study recommends a single stage micro-grid to do the job. According to the idea, both operating solo or with the main grid are possible for the micro grid. The unwanted influence of load changes or non-linear devices on power systems can be eliminated using control techniques for shunt active hybrid filters. Power quality is increased by using fuzzy logic controllers with a PI traditional control which helps control output power distortions. The simulation results are used to examine the differences between the fuzzy logic controller and the pi controller.*

***Keywords**: Fuzzy controller, Grid control, Wind power generation, Micro-grid, UPQC*

I. Introduction

In recent years, more nonlinear loads have led to power system problems such as high current harmonics, low power factor and higher neutral current. In the utility's Point of Common Coupling (PCC), nonlinear loads behave as current generators that add harmonic currents to the system's power. Voltage distortions take place at the point where the source taps the network because of uneven voltage drop across the source's internal resistance. Affected consumers in the same PCC may encounter incorrect supply voltage which might cause some protection devices to fail and motors, power factor correction capacitors, transformers and cables to heat up [2].

One of the small-scale power generation systems is the Distributed Energy Resources (DES). Examples of renewable energy resources include solar cells, wind energy systems, and hydro energy. One benefit of positioning the microgrid idea close to load centers is that it can increase efficiency by lowering voltage drops or transmission line losses. Electricity consumption rises as a result of rising load demands from household and commercial appliances and loads. This study suggests the idea of micro grids as a solution to these issues. These micro grids are often dispersed energy sources. In essence, these DES sources are renewable energy sources like wind or solar power plants.

These microgrid systems produce electricity in both typical and unusual circumstances. However, this article proposes power electronic-based converters for controlling purposes. Reactive power and harmonics are typically two of the major issues with the grid. They are brought on by nonlinear loads, such as semiconductor switches, arc furnaces, and saturation transformers. Reactive power and harmonics are detrimental to the grid since they will result in more power losses and component failures [1]. A type of FACTs has been proposed to enhance the transmission systems' working capability and stop the intake of reactive and harmonic currents [6]. One crucial element of FACTS is the static var compensator.

II. Grid Interfacing System

Currently, the main role of the grid is to combine with clean energy sources, like photovoltaic power. Part of these benefits are the interesting perks available in many places which play a big role in driving companies to adopt grid-connected photovoltaic systems. To make a confident decision about including this technology in the electric utility network, we need reliable design software and ways to precisely predict how three-phase PV systems will behave under different conditions.

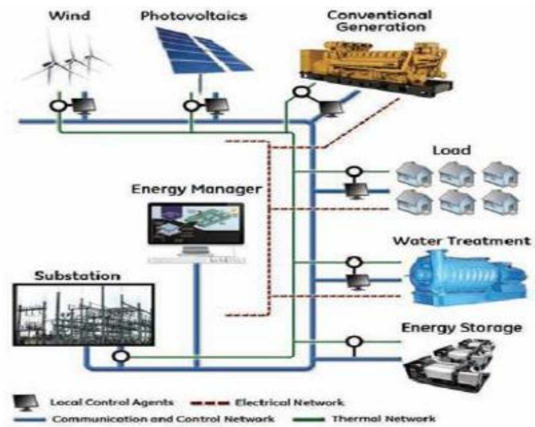

Fig 1: Microgrid Power System

The photovoltaic energy system is a technique used to create electricity by directly transforming sunlight with power semiconductors. In these solar-powered systems, you connect solar cells in groups, both in series and in parallel. Any time there is a change in the sunlight getting to the solar cells, the amount of electricity the system generates is automatically changed.

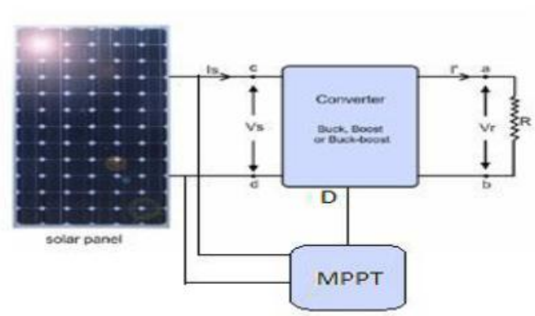

Fig 2: PV System with Power Converter

Increased sensitive or non-linear loads from home or business appliances can alter transmission system parameters, resulting in power quality issues like current harmonics or imbalances in voltage or current. Some kind of compensating procedures must be used in order to meet the requirements of power quality standards. Reactive elements have essentially been employed for compensatory purposes since the first generation. Later, gadgets based on power electronics control are used.

III. UPQC

A UPQC, a FACTS device, is an effective tool to improve how power is supplied and used [4]. The unified power quality controller loops reactive power between shunt and series controllers via their common dc-link. An example of compensated equipment connected to the transmission system is a shunt device. The shunt compensated system can control voltage magnitude by supplying or removing power from the grid at the connection point. The method is limited since bus voltage cannot be adjusted too much and mainly shunt devices have other functions.

A series device is one which runs parallel to the transmission line. Transmission line impedance can be changed by series devices. We modify line impedance by means of a reactor or capacitor. Placed on the line, a capacitor can reduce the line impedance and solve the problem with inductive voltage loss. The purpose of the series compensated device is to control gearbox impedance and stabilize system voltage fluctuations by means of series with the line.

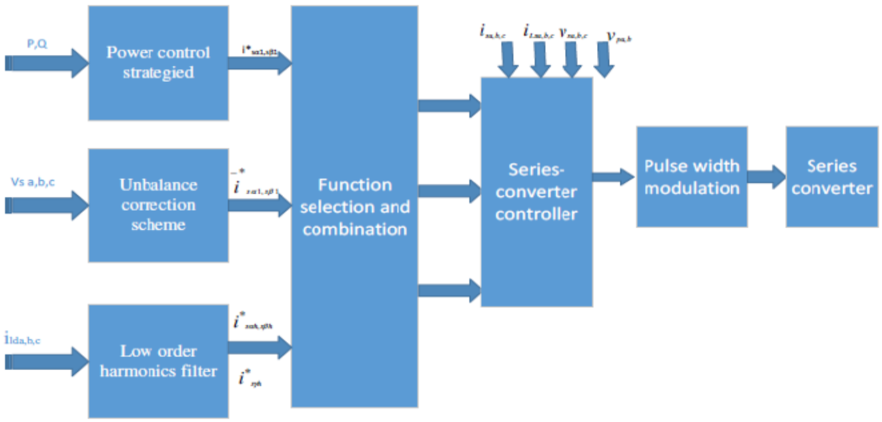

Fig 3: Block Diagram of Series Converter

The power quality issues are compensated for using the series controller that was described in the preceding section. A three-phase converter is used to regulate it. As seen in Figure 4, the closed loop control circuit is used to create the gate pulses for this series converter. The voltages are first compared in this control method, and the error that results is then transformed into two-phase orthogonal vectors. These vectors are used to calculate the series converter's pulses.

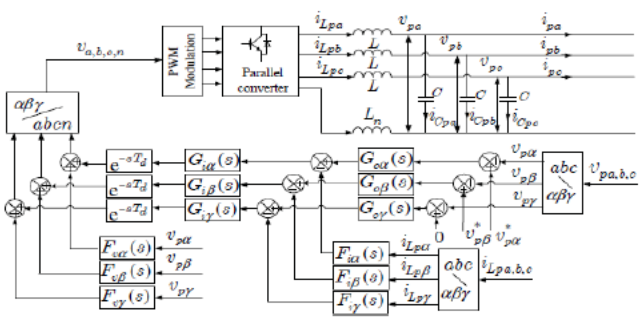

Fig 4: Shunt Converter closed loop

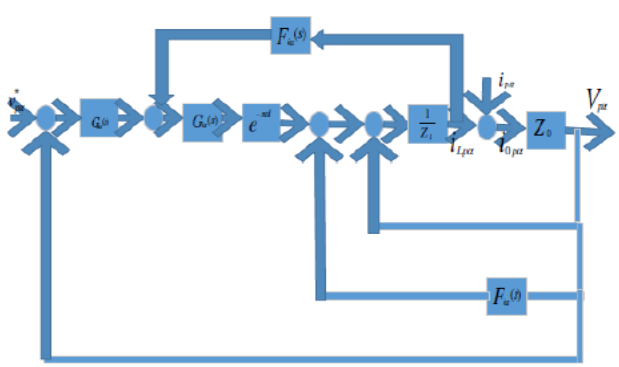

Fig 5: Closed Loop Block Diagram for α

One of the more sophisticated soft computing controllers for managing system output is the fuzzy logic controller. Fuzzy logic controllers provide the advantages of quick computation, superior reaction, low settling time, and high running response when compared to other traditional controllers.

IV. Simulation Results

Micro Grid simulation implementation using and without fuzzy controller

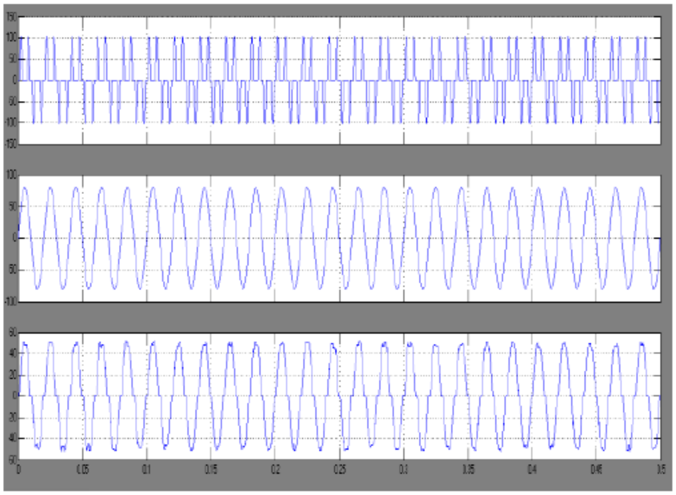

Fig 6: Simulation result for Feeder currents 1, 2 and 3

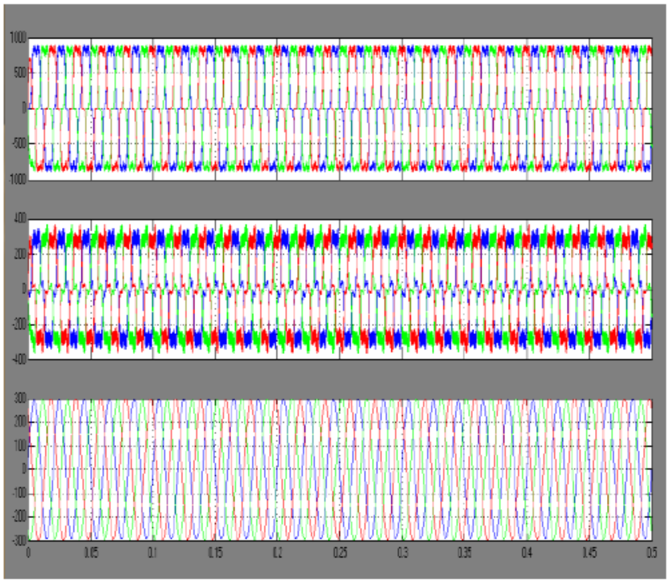

Fig 7: Simulation result for Grid

V. Conclusion

The fuzzy logic controller and microgrid-based unified power quality conditioner have been effectively built in this work. Generally speaking, the microgrid concept focuses primarily on reducing transmission losses and the system's power quality issues, which are addressed by a single power quality controller.

By lowering the system's overall harmonic distortion, the fuzzy logic controller improves performance. Using a series and parallel converter system with a traditional PI controller and a fuzzy logic controller, the simulation results are obtained for the Grid interfacing. The system's non-linearity causes harmonics to be created, which in turn causes distortions in the voltage. We can lessen these distortions in the system by utilizing a traditional PI controller.

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