# POWER QUALITY IMPROVEMENT FOR MICROGRID BASED UPQC SYSTEM WITH FUZZY CONTROLLER

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## ABSTRACT

*THREE PHASE ac power systems have existed for over 100 years due to their efficient transformation of ac power at different voltage levels and over long distance as well as the inherent characteristic from fossil energy driven rotating machines. The proposed system presents power-control strategies of a grid-connected Micro grid generation system with versatile power transfer. This Micro grid system allows maximum utilization of freely available renewable energy sources like wind and photovoltaic energies. For this, an adaptive MPPT P&O Controller along with standard perturbs and observes method will be used for the system.In This paper proposes a ac/dc micro grid to reduce the processes of multiple dc–ac–dc or ac–dc–ac conversions in an individual ac or dc grid. The Micro grid consists of both ac and dc networks connected together by multi-bidirectional converters. AC sources and loads are connected to the ac network whereas dc sources and loads are tied to the dc network. Energy storage systems can be connected to dc or ac links. The proposed Micro grid can operate in a grid-tied or autonomous mode. The coordination control algorithms are proposed for smooth power transfer between ac and dc links and for stable system operation under various generation and load conditions and the output voltage contains harmonics. This distortions can be eliminated by using proper control strategies and filters in both the series and shunt converters. Pulse Width Modulation (PWM) is used in both three phase four leg inverters. 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.*

***Index Terms: Energy Management, Grid Control, Grid Operation, Micro-Grid, Wind Power Generation, Fuzzy Controller.***

## I INTRODUCTION

Power systems currently undergo considerable change in operating requirements mainly as a result of deregulation and due to an increasing amount of distributed energy resources (DER). In many cases DERs include different technologies that allow generation in small scale (microsources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having microsources close to the load has the advantage of reducing transmission losses as well as preventing network congestions. Moreover, the possibility of having a power supply interruption of end-customers connected to a low voltage (LV) distribution grid (in Europe 230 V and in the USA 110 V) is diminished since adjacent microsources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances. This is identified nowadays as a microgrid. Increasing electrification of daily life causes growing electricity consumption, rising number of sensitive/critical loads demand for high-quality electricity, the energy efficiency of the grid is desired to be improved, and considerations on climate change are calling for sustainable energy applications [1][2]. All these factors are driving the conventional electricity grid to the next generation of grid, i.e. smart grid, which is expected to appear and coexist with the existing grid, adding to its capacity, reliability, and functionalities [3].Consequently, the applications of distributed generation(DG) systems are emerging, and most will be interfaced to the grid through power-electronics converters. However, the grid will become much more complex due to the increasing number of DG systems. For instance, the traditional one way power flow is broken by the bidirectional power flow.

An ac/dc microgrid is proposed in this paper to reduce processes of multiple reverse conversions in an individual ac or dc grid and to facilitate the connection of various renewable ac and dc sources and loads to power system. Since energy management, control, and operation of a Micro Grid are more complicated than those of an individual ac or dc grid, different operating modes of a Micro Grid ac/dc grid have been investigated. The coordination control schemes among various converters have been proposed to harness maximum power from renewable power sources, to minimize power transfer between ac and dc networks, and to maintain the stable operation of both ac and dc grids under variable supply and demand conditions when the Micro Grid operates in both grid-tied and islanding modes. The advanced power electronics and control technologies used in this paper will make a future power grid much smarter. The proposed Micro grid can operate in a grid-tied or autonomous mode. The coordination control algorithms are proposed for smooth power transfer between ac and dc links and for stable system operation under various generation and load conditions. This Micro grid system operates under normal conditions which include normal room temperature in the case of solar energy and normal wind speed at plain area in the case of wind energy. The Power Balancing Control simulation results are presented to illustrate the operating principle, feasibility and reliability of Micro grid proposed system. [1]

## II GRID INTERFACING SYSTEM

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peak- shaving technologies must be accommodated [1].


**Fig 2.1 Microgrid power system**

As a basic structure of the smart grid, plug-and-play integration of micro grids is essential, which can function whether they are connected to or separate from the electricity grid. On the right-hand side, a bidirectional series converter, which is supplied with distributed source and energy storage, interfaces the micro grid to a utility grid (can be another micro grid) for exchanging power and isolates grid disturbances from each of the grids. The data bus indicates network-scale communication path for variable collection and exchange in smart grid.

### 2.1 Photovoltaic Cell

DUE to the growing demand on electricity, the limited stock and rising prices of conventional sources (such as coal and petroleum, etc.),photovoltaic (PV) energy becomes a promising alternative as it is omnipresent, freely available, environment friendly, and has less operational and maintenance costs. Therefore, the demand of PV generation systems seems to be increased for both standalone and grid-connected modes of PV systems. Photovoltaic (PV) as a renewable energy resource naturally is not stable by location, time, season and weather and its installation cost is comparatively high. An important consideration in increasing the efficiency of PV systems is to operate the system near maximum power point (MPP) so to obtain the approximately maximum power of PV array. To achieve maximum energy produced by a PV array, maximum power point tracking (MPPT) techniques are used.

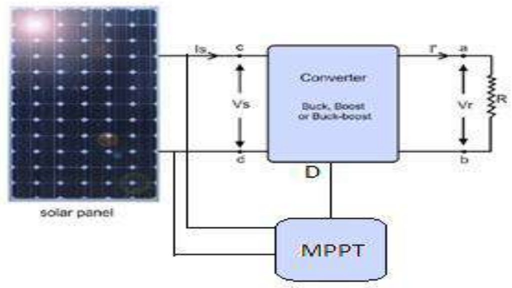


**Fig 2.2 PV System with Power Converter**

### 2.2 Wind Generation System

Wind energy is the leading source of renewable electricity. It is fast becoming an international business sector, spreading beyond its original markets in a few European countries, India and the United States [1]. Whilst the underlying motivation, is wind power being one of the leading carbon-free generation technologies, there are also other economic bonuses. Even without its clean credentials, wind power unaffected by fuel price rises presents an important opportunity to diversify from potentially volatile sources.

Wind, that is moving air, possesses some kinetic energy due to its high speed. The most common application of wind could probably be kite flying or even paragliding, sail boats etc. Well these activities are definitely not possible without wind. Wind energy can be harnessed and used for generating electricity or for other smaller purposes by a windmill. In olden times, windmills were used to draw water out of wells or to grind flour etc. It is the rotator motion of the shaft in a windmill that is used to rotate the turbine. The typical layout of wind power generation as shown below.

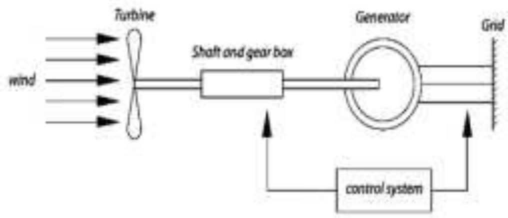


**Fig.2.3 Typical layout of wind power generation**

## III CONTROLLER DESIGN AND IMPLEMENTATION

The various nonlinear loads like Adjustable Speed Drives (ASD's), bulk rectifiers, furnaces, computer supplies, etc. draw non sinusoidal currents containing harmonics from the supply which in turn causes voltage harmonics. Harmonic currents cause increased power system losses, excessive heating in rotating machinery, interference with nearby communication circuits and control circuits, etc.

With increasing applications of nonlinear and electronically switched devices in distribution systems and industries, power-quality (PQ) problems, such as harmonics, flicker, and imbalance have become serious concerns. In addition, lightning strikes on transmission lines, switching of capacitor banks, and various network faults can also cause PQ problems, such as transients, voltage sag/swell, and interruption. In recent years, solutions based on flexible ac transmission systems (FACTS) have appeared. The application of FACTS concepts in distribution systems has resulted in a new generation of compensating devices. A unified power-quality conditioner (UPQC) is the extension of the unified power-flow controller (UPFC) concept at the distribution level is one the best solution to make the overall power distribution system more healthy. It consists of combined series and shunt converters for simultaneous compensation of voltage and current imperfections in a supply feeder.

### 3.1 Unified Power Quality Conditioner

The Unified Power Quality Conditioner (UPQC) is a more complete solution for the power quality problem. The UPQC is an association of a series and shunt active filter based on two converters with common dc link. The series converter has the function to compensate for the harmonic components (Including unbalances) present in the source voltages in such a way that the voltage on the load is sinusoidal and balanced.

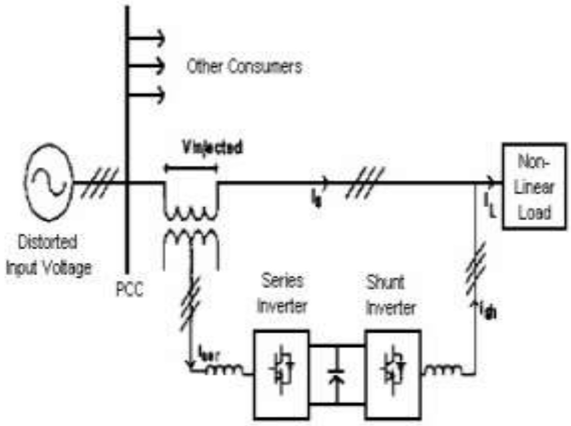


**Fig 3.1: Configuration of UPQC**

### 3.2 Fuzzy Logic Controller

Fuzzy controllers are normally built with the use of fuzzy rules. Fuzzy rules are conditional statement that specifies the relationship among fuzzy variables. These rules help us to describe the control action in quantitative terms and have been obtained by examining the output response to corresponding inputs to the fuzzy controller. The basic block diagram of Fuzzy Logic Controller is shown below.

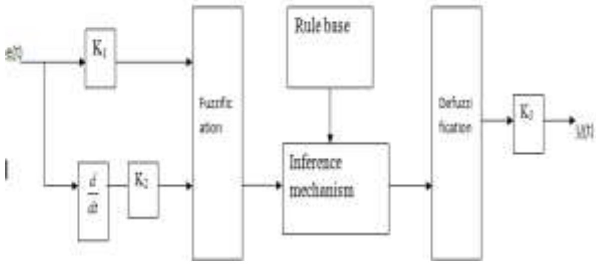


**Fig.3.2 Block diagram of Fuzzy Logic Controller**

The Fuzzy Logic Controller is applied in Load Frequency control of Two area system, this analysis is done using different Fuzzy based rules using Linguistic variable i.e., by considering Three variable and Five variable[4]

| Error rate /Error | LP | MP | SP | VS | SN | MN | LN |
|---|---|---|---|---|---|---|---|
| LP | PB | PB | PB | PM | PM | PS | Z |
| MP | PB | PB | PM | PM | PS | Z | NS |
| SP | PB | PM | PM | PS | Z | NS | NM |
| VS | PM | PM | PS | Z | NS | NM | NM |
| SN | PM | PS | Z | NS | NM | NM | NB |
| MN | PS | Z | NS | NM | NM | NB | NB |
| LN | Z | NS | NM | NM | NB | NB | NB |

**Table 3.1 Seven variable rule base**

### VI. SIMULATION AND RESULTS

The parameters of the system is given in Table 4.1

| Description | Symbol | Value |
|---|---|---|
| Rated grid voltage | $V_{ga,b,c}$ | 230V/50Hz |
| Grid impedance | $Z_g$ | 2 mH (ESR 0.628 Ω) |
| Output inductor | $L$ | 1.8 mH (ESR 0.03 Ω) |
| Output capacitor | $C$ | 5 $\mu$F |
| Neutral inductor | $L_n$ | 0.67 mH (ESR 0.02 Ω) |
| Series transformer | $T_N$ | 1 : 1 |
| dc-link voltage | $V_{dc}$ | 750 V |
| dc-link capacitors | $C_{dc}$ | 4400 $\mu$F |
| Switching frequency | $f_{sw}$ | 16 kHz |
| Sampling frequency | $f_{sp}$ | 8 kHz |

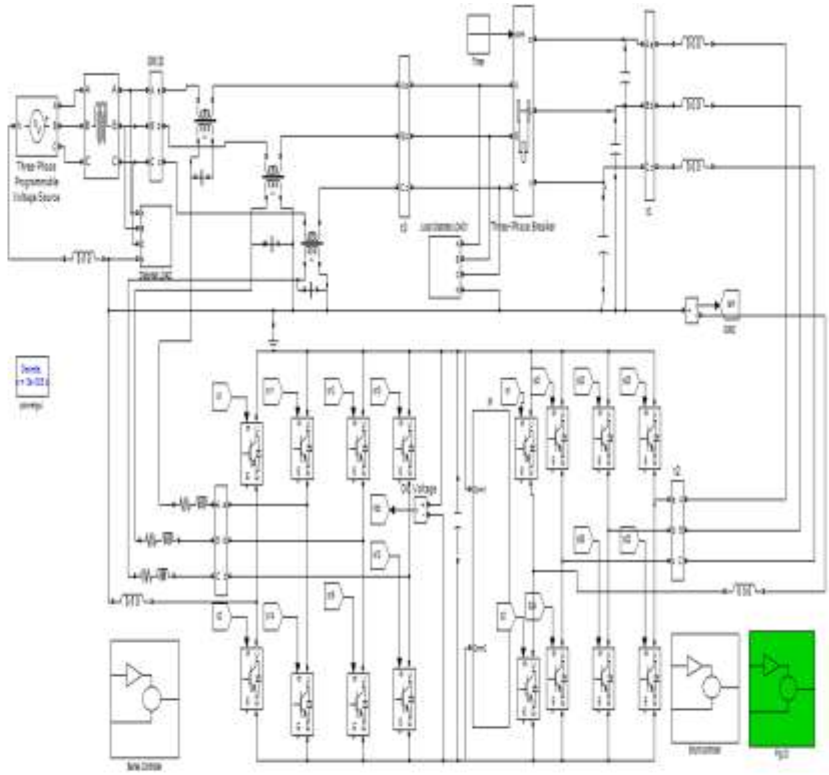

**Fig 4.1Simulation implementation of Micro Grid with and without fuzzy controller.**

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.

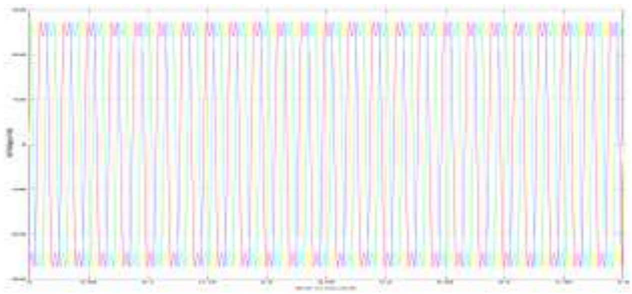

**Fig 4.2 Grid voltages of the series- parallel system**

Fig 4.2 Shows simulation result for Grid voltages w.r.t time from this waveform we conclude that grid voltage is distorted 8% from 0 to 0.5 because of 3$^{rd}$ and 5$^{th}$ harmonics

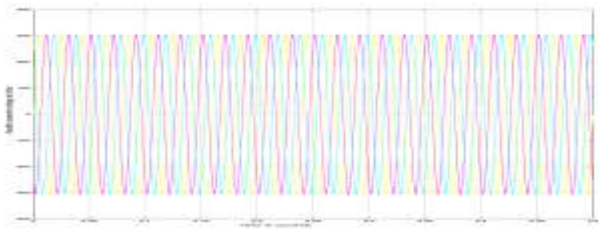

**Fig 4.3output voltage of the parallel converter of the series- parallel system**

Fig 4.3 shows simulation result for output voltage of the parallel converter w.r.t time. In this result the voltage of the series- parallel system under a distorted grid with 2% from 0 to 0.5 sec. with 310v

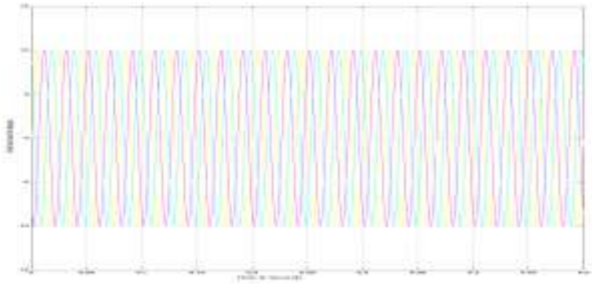

**Fig 4.4 grid current of the series- parallel system**

Fig 4.4 shows simulation result for grid current w.r.t time. From this result the current of the series- parallel system under a distorted grid current is 2% with 10A current

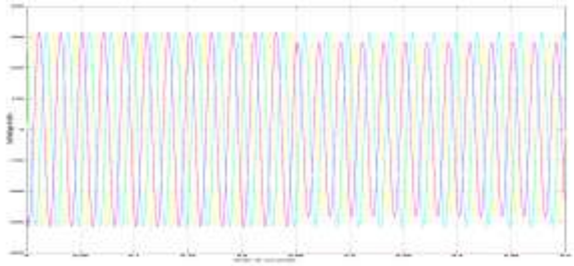

**Fig 4.5 grid voltage of the series-parallel system**

Fig 4.5 Shows simulation result for grid voltage of the series-parallel system w.r.t time. The voltage is causes distortions cause of unbalanced Voltage dips accrued in Phase A and B at 0.25sec to0.5sec with 7% distortion.

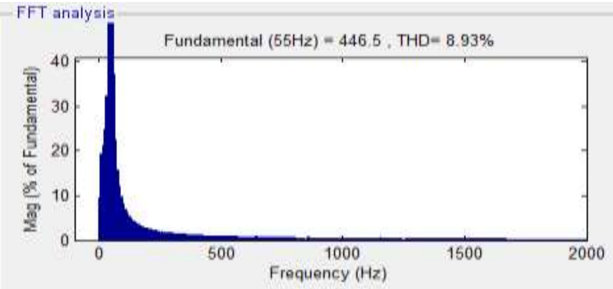


**Fig 4.6 FFT Analysis**

**Case 2: With Fuzzy Controller**

In this fuzzy is designed as mentioned in the above section.

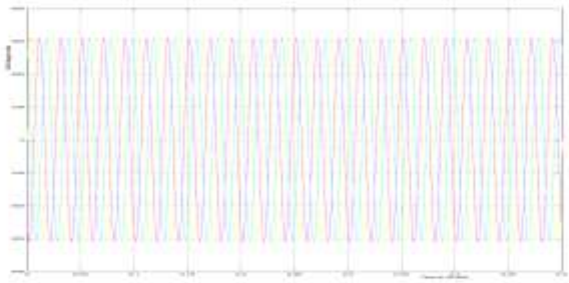

**Fig 4.7 grid voltage of the series-parallel system**

Fig 4.7 Shows simulation result for grid voltage of the series-parallel system w.r.t time. In this due to because of fuzzy controller the dips in voltage is compensated to 2%distrotion

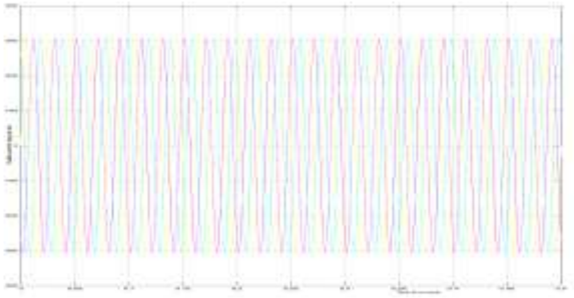

**Fig 4.8 output voltage of the parallel converter of series-parallel system**

Fig 4.8 Shows simulation result for output voltage of the parallel converter of series-parallel system w.r.t time. With the help of fuzzy logic controller the distortions in voltage of parallel converter is compensated to 2%.

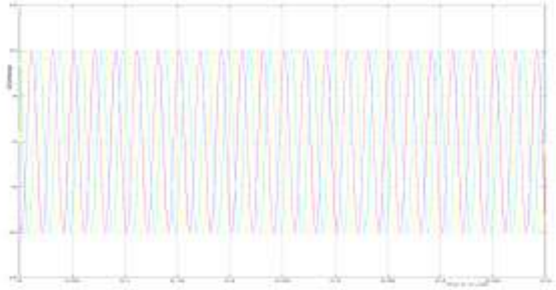

**Fig 4.9 Grid Current of the series-parallel system**

Fig 4.9 shows output waveform for Grid current of the series-parallel system w.r.t to time. The with the help of fuzzy logic e variations in grid current is compensated with fuzzy controller using Pq theory technique with 2.2% distortion.

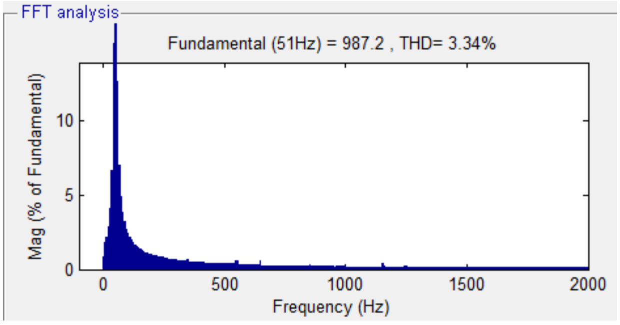


**Fig 4.10 FFT Analysis**

COMPARISON OF PI CONTROLLER AND FUZZY CONTROLLER

Comparison of pi controller and fuzzy controller as show in Table

| S.NO | Description | PI CONTROLLER | FUZZY CONTROLLER |
|---|---|---|---|
| | | | |

| | | | |
|---|---|---|---|
| 1 | Frequency | 55HZ | 55HZ |
| 2 | THD | 8.93% | 3.34% |

From the above table we can conclude that the Total Harmonic Distortion with Fuzzy Logic Controller can be reduced to 3.34%. This is very less as compared with PI controller (i.e 8.93%).

## VI. CONCLUSION

This paper has introduced system-level concept and implementation aspects aiming at grid-interfacing architecture in the future grid with enhanced voltage quality. 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. Since the conventional PI controller has been designed with fixed gains, it failed to provide the best control performance. This drawback can be overcome by adopting fuzzy set theory.

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