Application of ANN Based UPQC for Power Quality Enhancement in Smart Grid

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Abstract:

Electrical distribution system is designed to operate in sinusoidal mode, but the voltage and current waveforms shows distortion compared to the sinusoidal mode. Current technology development, which results in an increasing adoption of the local generation and storage capacities, is pushing towards the adoption of smartgrid paradigm. An effective technical solution for enforce limitation of various types of power quality (PQ) disturbance is based on power electronics in order to increase energy transmission capacity, improve voltage stability and dynamic behaviour, control power flow and ensure a better power quality at distribution inside accepted boundaries. The well-known Flexible AC Transmission System (FACTS) devices like Unified Power Quality Conditioners (UPQC) are usually employed to resolve the issues related to voltage sag, swell, flicker, PQ, and neutral current reduction of distribution systems. An UPQC itself inserts harmonics into the system that affects the system stability for sensitive loads. This project describes artificial neural network with harmonics elimination techniques for modified UPQC connected with SG.

Key Words: *Micro Grid System, FACTS device, ANN Controller.*

INTRODUCTION

Basically, the microgrid system is a combination of loads and different micro sources operating as a single system providing power. The structure of a microgrid system consists of different parts such as interface control, control and protection devices for each micro sources as well as microgrid voltage control, power flow controlling devices, load sharing during islanding conditions, protection and stability [1]. The ability of the Microgrid to operate when connected to the grid, smooth transition to and from the island mode is another important function.

The main consideration for interconnection of microgrid to the distribution system is the impact of power quality problems on the overall power systems. Generally, these power quality problems are classified as voltage and frequency deviations in grid voltage and harmonic contents in load current. In order to overcome these type of power quality problems this paper proposes a concept of flexible ac distribution system for microgrid. This flexible ac distribution system is a combination of series and shunt converters shared by a common dc link capacitor [2]. The proposed dc link source of the FACTS device is obtained by a distributed energy source. This paper also proposes the concept of ANN controller for obtaining better harmonic distortions.

DISCRIPTION OF PROPOSED SYSTEM:

In an electrical power system the microgrid is commonly a group of electrical loads and power generations from different generating sources like solar, wind etc. these microgrid plays an important role to

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enhance the reliability, increasing efficiency and voltage sag correction. The complete structure of the proposedFACTS device and microgrid structure is shown in Figure 1 [3].

Proposed microgridconfiguration

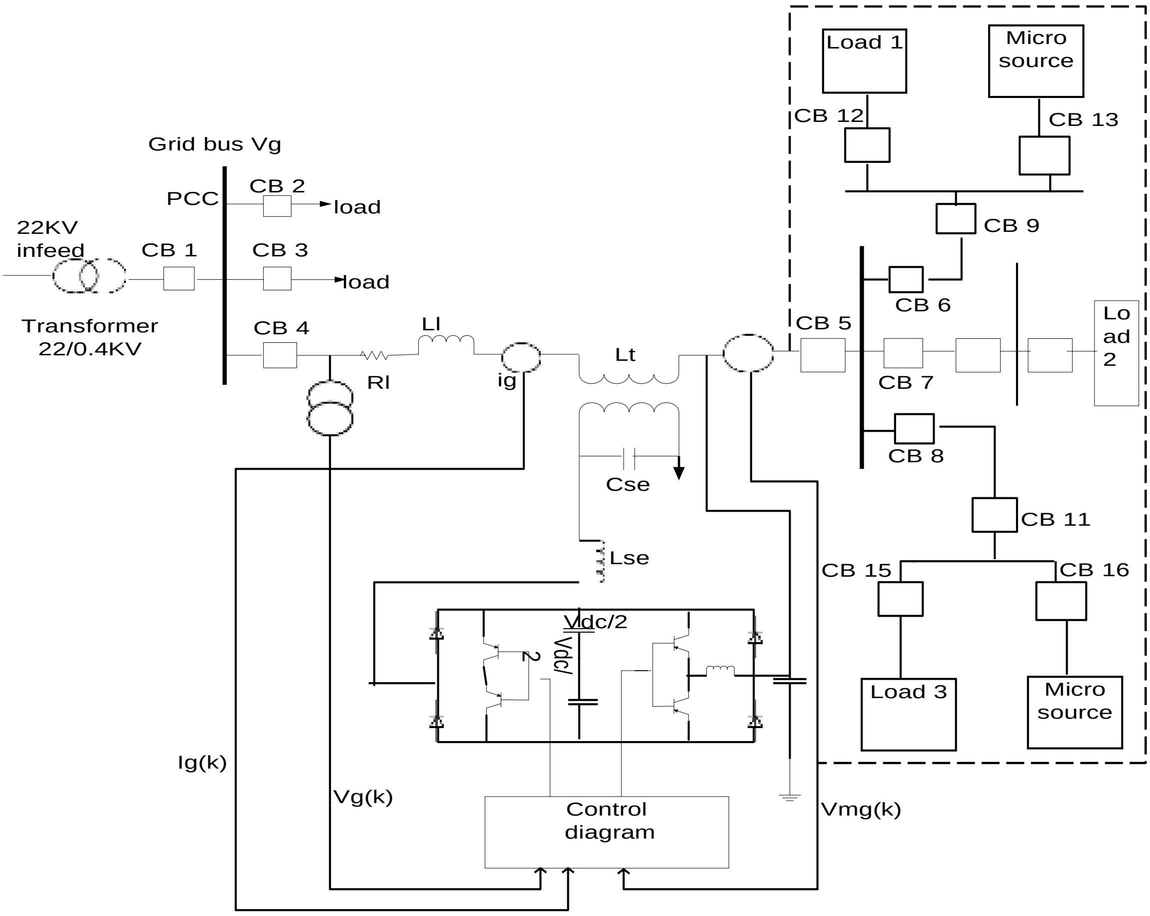

Figure 1 Configuration of Proposed FACTS device based Microgrid system

From this figure 1, the structure of microgrid consists of three feeder terminals. And the flexible ac transmission system is used for power quality compensation. And the device is also used for compensating harmonic content in both gird voltage and load currents [4].

The operation and constructional structure of flexible ac distribution system is explained in the next section.

Unified Power Quality Controller

One of the compensating devices from the FACTS family, called Unified Power Quality Conditioner, is the efficient method to improve power quality [5]. 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 one of the compensated equipment which is connected at the transmission system. This shunt compensated system has the capability of either absorbing or generating active power at the point of connection thereby controlling the voltage magnitude. 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 [6] by controlling reactance, fluctuations in system voltage. The structure of the unified power quality conditioner is shown in figure 2.

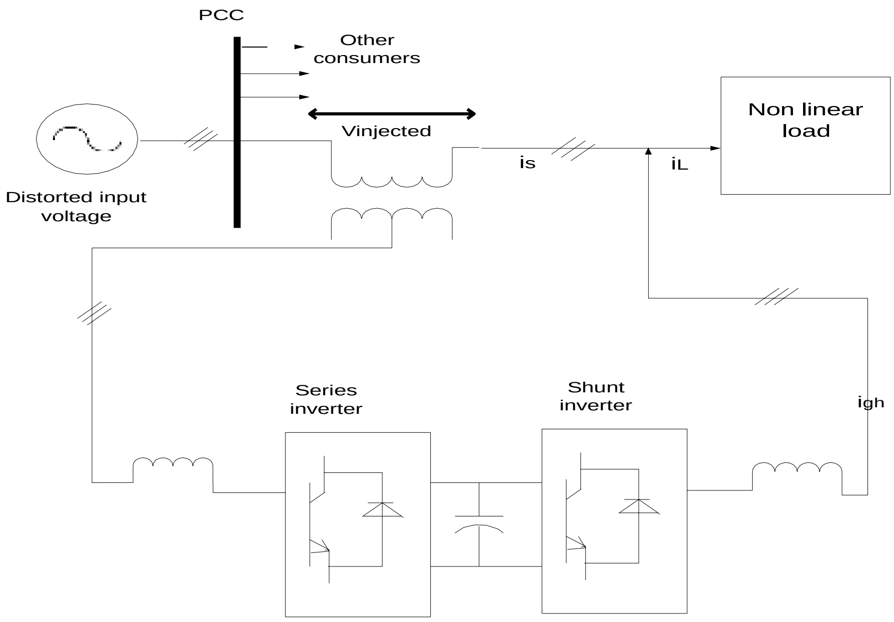

Figure 2 structure of unified power quality conditioner

The series controller which is explained in this section is used for compensating the grid voltage. It is controlled with help of three phase converter. The control diagrams for the both series and shunt converters are shown in figure 3 and figure 4.

Figure 3 shows the closed loop control diagram for the series converter. The active/reactive powers, grid voltages and currents are used as reference signals to control the series converter. In this the grid voltage and load voltages are compared and generate the reference voltage signals [7]. These reference signals are compared with carrier signal in pulse width modulation technique which generates the gate signals to series voltage source converter.

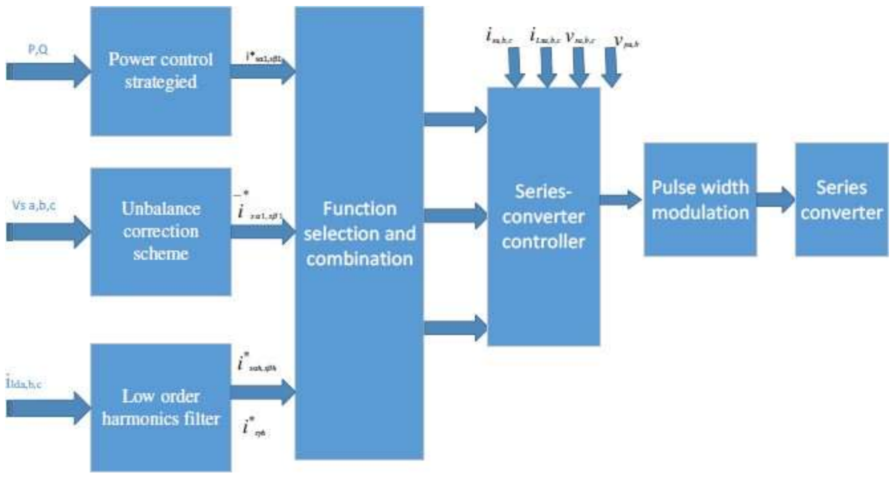

Figure 3 Control Diagram of series converter

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The control structure of the shunt converter is shown in figure 4. The park's transformation technique is used for converting three phase current coordinates to two phase currents commands for calculating the error signals. These reference signals are compared with carrier signal in pulse width modulation technique which generates the gate signals to shunt voltage source converter [8].

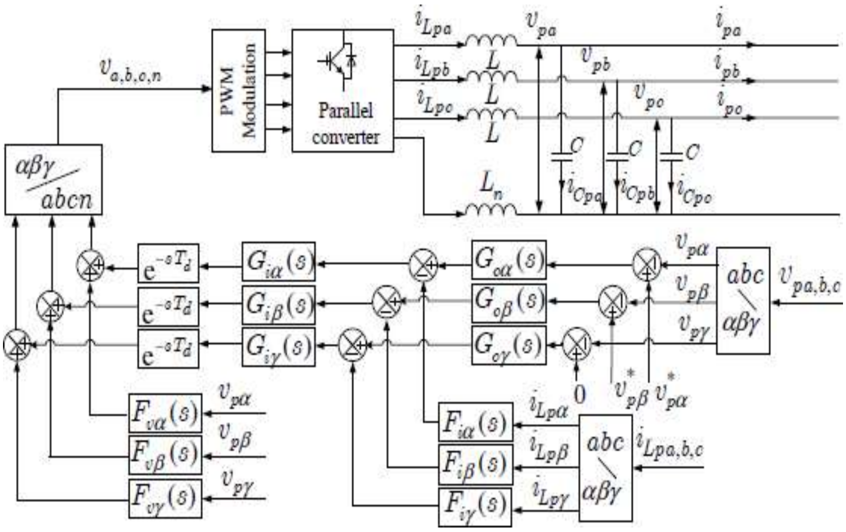

Figure 4 Control Diagram of shunt converter

Basically, the unified power quality conditioner has a capability to compensate harmonics in load current, reactive power, voltage variations and controlling the power flow [9]. But the unified power quality conditioner has no capability in compensating the voltage fluctuations in a system because there is no energy storage. Now, this paper presents a concept of UPQC that is incorporated with distribution, generation system asa dc-link through the rectifier [10].

Therefore, the unified power quality conditioner compensates these voltage fluctuations in the grid, while the distribution generation system supplies power to grid and load. These proposed DG system is operated in two modes. One is DG provides power to load and source called as interconnected mode and second one is DG provides power to load only called as islanding mode. In this paper the photovoltaic generating plant [11] is considered as a one of the distribution generation system. The structure of unified power quality conditioner based distributed generating system is as shown in figure 5.

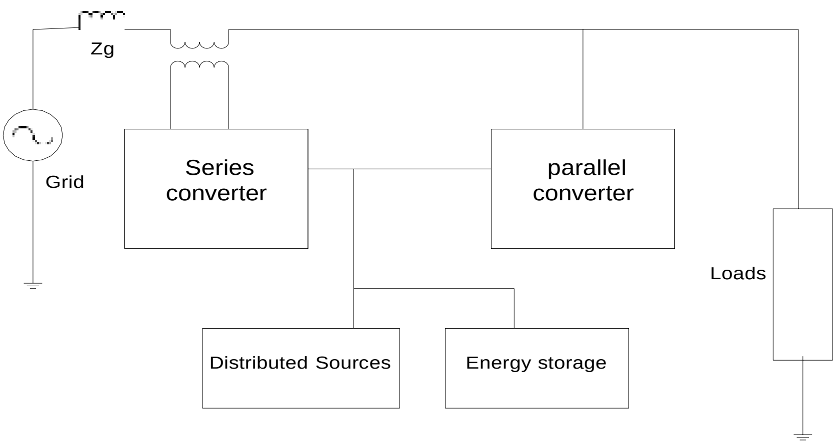

Figure 5: configuration of UPQC system with DG

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Artificial Neural Networks

Figure 6 shows the basic architecture of artificial neural network, in which an hidden layer is indicated by circle, an adaptive node is represented by square. In this structure hidden layers are presented in between input and output layer, these nodes are functioning as membership functions and the rules obtained based on the if-then statements is eliminated. For simplicity, we considering the examined ANN have two inputs and one output. In this network, each neuron and each element of the input vector p are connected with weight matrix W.

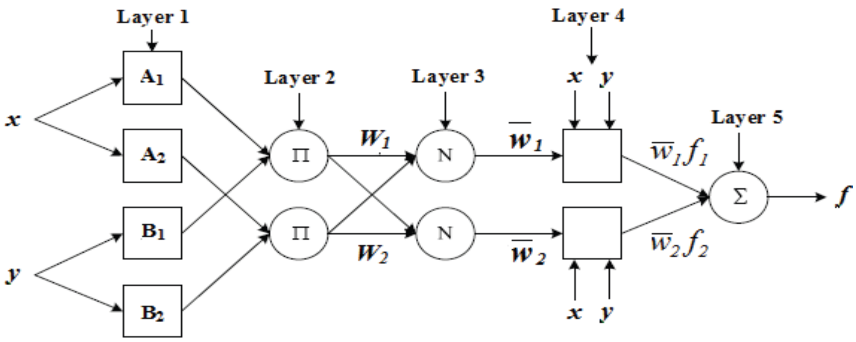

Figure 6: ANN architecture for a two-input multi-layer network

Where the two crisp inputs are x and y, the linguistic variables associated with the node function are Ai and Bi. The system has a total of five layers are shown in Figure 6.

Step by step procedure for implementing ANN:

1. Identify the number of input and outputs in the normalized manner in the range of 0-1.
2. Assume number of input stages.
3. Identify number of hidden layers.
4. By using transig and poslin commands create a feed forward network.
5. Assume the learning rate should be 0.02.
6. Choose the number of iterations.
7. Choose goal and train the system.

9. Generate the simulation block by using ‘genism’ command.

EXPERIMENTAL VERIFICATION:

The experimental verification for the proposed Fuzzy based UPQC micro-grid system is verified inMatlab/Simulink in two cases.

Case 1: with PI Controller

In this case the proposed grid interfaced system is implemented with PI controller and the results areshown below.

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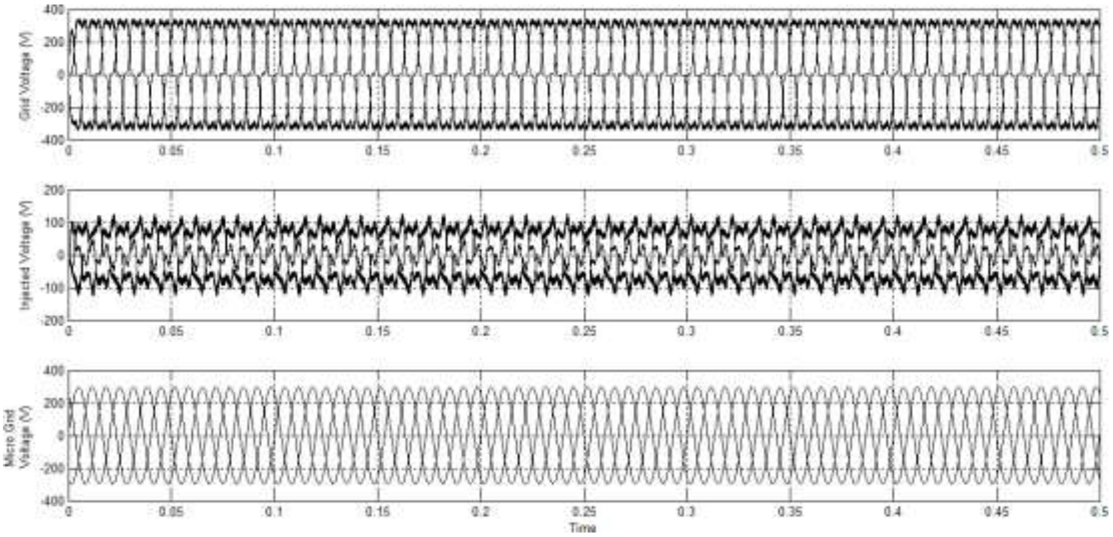

Figure 7. Simulation result for Feeder currents

Figure 7 shows the simulation results for the system feeder currents under without and withcompensation.

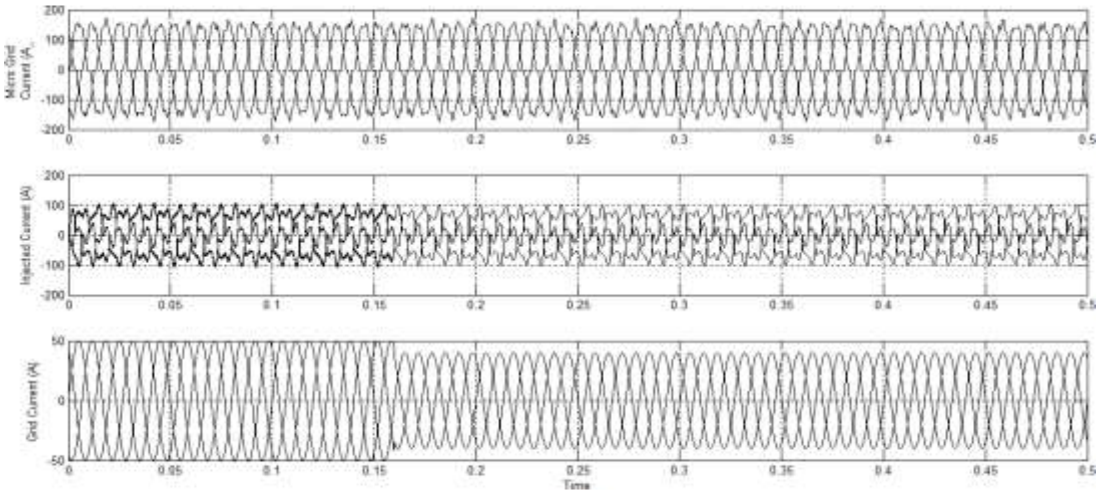

Figure 8 Simulation result for Grid, Series Converter and Micro-Grid Voltage

Figure 8 shows the simulation results for the system micro grid voltage under without and with compensation.

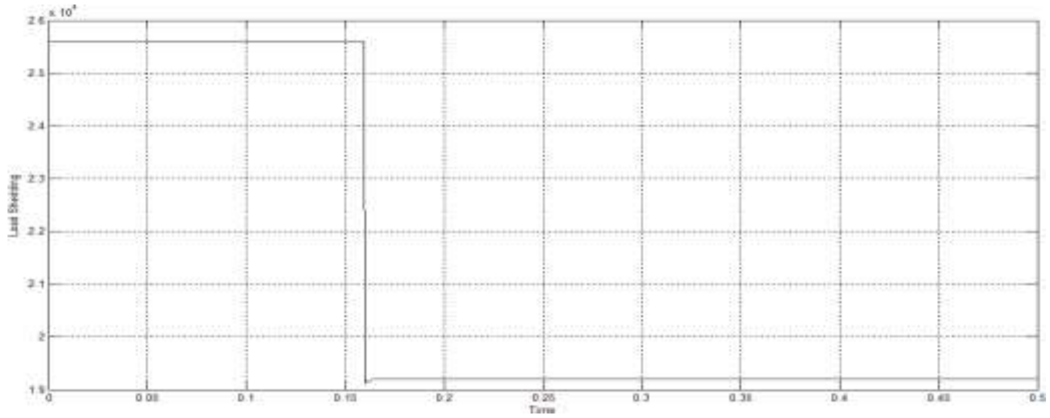

Figure 9 Simulation result for Active Power under Islanded condition

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Figure 9 shows the simulation result for the active and reactive powers under Islanded condition. In thiscase we consider the islanded condition at time t=0.17sec and at that the grid is disconnected from the system.

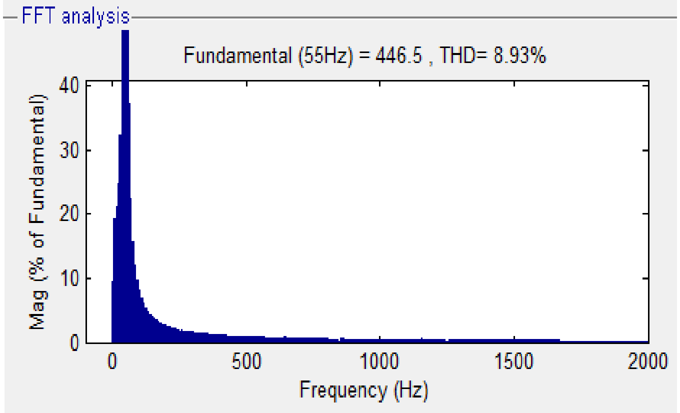

Figure 10 FFT Analysis

Case 2: with ANN controller:

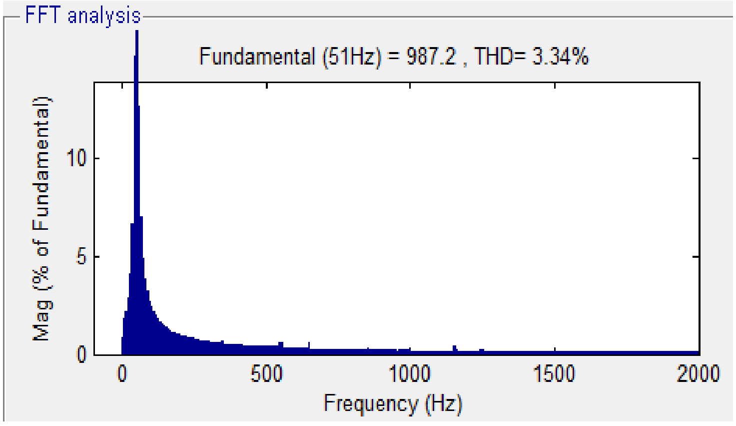

Figure 11 FFT Analysis

Figure 10 and Figure 11 shows the total harmonic distortion values with PI and ANN controllers. From these figure it conclude that the ANN control provide better harmonic distortion factor of load current as compared with conventional PI controller.

CONCLUSION

This paper has successfully implemented the microgrid based unified power quality conditioner along with the ann controller. Generally, the microgrid concept mainly concentrates on the reduction of power quality problems associated with the system, the later are compensated by unified power quality controller. The ANN controller is used for getting better performance by the reduction of total harmonic distortion in the system.

The simulation results are obtained for the Grid interfacing using series and parallel converter system with conventional PI controller and ANN controller. Due to the presence of non-linearity in the system, harmonics are produced which lead to voltage distortions. By using conventional PI controller in the system we can reduce these distortions. However, it is found, through the simulation results, that ANN controller can do better in reducing harmonics & improves THD.

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