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A Comparison of Power Quality Improvement based on Controls of UPQC

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Abstract - *This paper proposes compare and analysis of ANN based unified power quality controller (UPQC) and IRPT for power quality improvement. The UPQC is the combination of shunt and series APF. The series APFs are used to compensate voltage related problems and the shunt APFs are used to compensate current related problems. The unified power quality conditioner (UPQC) integrates both shunt and series APFs through a common DC link capacitor. The UPFC is employed in power transmission system, and the primary objective of UPFC is to control the flow of power at, fundamental frequency. Whereas the UPQC is employed in a power transmission system. It controls distortion due to harmonics and unbalance in voltage in addition to control of flow of power at the fundamental frequency. In this work, the results obtained through the ANN and IRPT are good in terms of dynamic response. Simulations are verified by using of MATLAB/Simulink.*

Key Words*: *Artificial neural network (ANN), Current Source Inverter (CSI),* Instaneous Reactive Power Theory (IRPT),*proportional integral (PI), unified powerquality conditioner (UPQC), Voltage Source Inverter (VSI).

1. INTRODUCTION

Power quality is one of the major challenges of grid [1]. The term electric power quality (PQ) is generally used to assess and to maintain the good quality of puissance at the caliber of generation, transmission, distribution, and utilization of AC electrical potency. Since the pollution of electric power supply systems is much astringent at the utilization level, it is paramount to study at the terminals of end users in distribution systems. There are a number of reasons for the pollution of the AC supply systems, including natural ones such as lightening, flashover, equipment failure, and faults (around 60%) and coerced ones such as voltage distortions and notches (about 40%). A number of customer's equipment additionally pollute the supply system as they draw non sinusoidal current and comport as nonlinear loads. Ergo power quality is quantified terms of voltage, current or frequency deviation of the supply system, which may result in failure or mal-operation of customer's equipment. Typically, some power quality quandaries cognate to the voltage at the point of prevalent coupling (PCC) [2] where sundry loads are connected are the presence of voltage harmonics, surge, spikes, notches, sag/dip, swell, unbalance, fluctuations, glitches, flickers, outages, and so on. These quandaries are present in the supply system due to sundry perturbances in the system or due to the presence of sundry nonlinear loads such as furnaces, uninterruptible power supplies (UPSs), and adjustable speed drives (ASDs). However, some power quality quandaries cognate to the current drawn from the AC mains are impecunious power factor, reactive power burden, harmonic currents, unbalanced currents, and an exorbitant neutral current in polyphase systems due to unbalancing and harmonic currents engendered by some nonlinear loads. Electrical equipment susceptible to power quality or more congruously to lack of potency quality would fall within a ostensibly abysmal domain. Mundane issues cognate to power quality are such as voltage sag, voltage swell, voltage unbalance, harmonics, voltage fluctuations. General issues cognate to power quality are such as voltage sag, voltage swell, voltage unbalance, harmonics, voltage fluctuations. In this paper, the instantaneous reactive power theory is presented, and its emolument strategy is applied to a three phase three-wire power system.

2. UNIFIED POWER QUALITY CONDITIONER

UPQC is a coalescence of a shunt active power filter and series active power filter. here shunt active power filter (APF) is utilized to compensate for load current harmonics and make the source current thoroughly sinusoidal and liberate from harmonics and distortions. Shunt APF is connected parallel to transmission line. Here series APF is utilized to mitigate for voltage distortions and unbalance which is present in supply side and make the voltage at load side impeccably balanced, regulated and sinusoidal. Series APF is connected in series with transmission line.

2.1 CONFIGURATION OF UPQC

The configuration of UPQC is shown in Figure 1 in general UPQC is a power conditioner device which consists of two voltage source inverters (VSI) connected through a prevalent dc-link capacitor

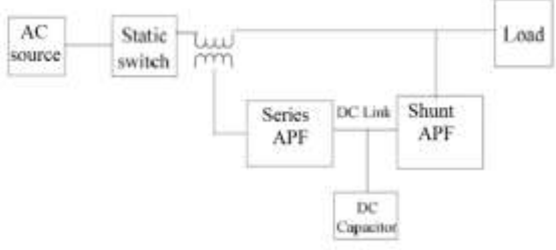

Fig-1: Configuration of UPQC

It is utilized to mitigate both load current as well as supply voltage imperfections. The main components of a UPQC are series converter and shunt converter, dc capacitors, lowpass and high-pass passive filters, and series and shunt injecting transformers. The purport of a UPQC is to compensate for supply voltage power quality issues, such as sags, swells, unbalance, flicker and harmonics.

3. REFERENCE SIGNAL GENARTION FOR UPQC

In this work two controls for Unified Power Quality Conditioner has been implemented and detailed study has been carried based on the compensation of voltage, current and harmonics

3.1 INSTANTANEOUS REACTIVE POWER THEORY

The instantaneous reactive power theory, withal designated p–q formulation is predicated on the Clarke coordinates transformation, which, applied to the voltage and current vectors in phase coordinates, gives those vectors in 0αβ coordinates In instantaneous power theory, the instantaneous three phase currents and voltages are calculated as given in following equations 3 and 4

$$\begin{bmatrix} V_0 \\ V_\alpha \\ V_\beta \end{bmatrix} = \frac{\sqrt{2}}{3} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \quad \text{………………3}$$

$$\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = \frac{\sqrt{2}}{3} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad \text{………………4}$$

The $\alpha - \beta$ theory is one of several methods that can be utilized in the control active filters. It presents some intriguing features, namely,

• It is inherently a three-phase system theory

•It predicates the instantaneous values, sanctioning excellent dynamic replication

• It can be applied to any three-phase system (balanced or unbalanced, with or without harmonics in both voltages and currents)

The instantaneous active and reactive power in the $\alpha - \beta - 0$ coordinates are calculated with the following expressions

$$P_0 = V_0 * I_0 \quad \text{………………5}$$

$$P = V\alpha * I\alpha + V\beta * I\beta \quad \text{………………6}$$

$$Q = V\alpha * I\alpha - V\beta * I\beta \quad \text{………………7}$$

Where the P_0, P, Q are the instantaneous zero sequence power, instantaneous real power, instantaneous imaginary power.

3.2 ARTIFICIAL NEURAL NETWORK

The detection of the disturbance signal in a rapid way with high accuracy, fast processing of the reference signal, and high dynamic response of the controller are the prime requirements for desired compensation in case of UPQC. The traditional controller neglects to perform agreeably under parameter varieties nonlinearity load aggravation, and so forth. An ongoing report demonstrates that NN-based controllers give quick unique reaction while keeping up steadiness of the converter framework over wide working. Neural systems are models of natural neural structures. The beginning stage for most neural systems is a model neuron, as in Figure 2. This neuron comprises of various information sources and a solitary output. Each information is changed by a weight, which increases with the info esteem. The neuron will join these weighted sources of info and, with reference to an edge esteem and actuation work, utilize these to decide its output. The conduct pursues intently our comprehension of how genuine neurons work. ANN benefits include massive parallelism, learning faculty, generalisation faculty, adaptivity, expeditious convergence and robustness. Fundamental ANN architecture has 3 layers and is shown in Fig. 2. Contextual information processing, Fault tolerance, low energy consumption, tracking faculty

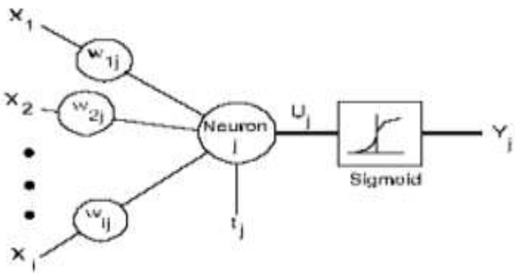

Fig-2: Basic structure of ANN

1. Input layer — stores input data and withal inputs to be given to the system are provided through this layer.
2. Hidden layer — inputs provided by input layer are processed in this layer depending on weights of connection between layers, partialness if any and activation function.
3. Output layer — results of the computations are stored.

ANN is one of the AI techniques which find very opportune application to power electronic system control. Recent study denotes controllers designed predicated on ANN provides more expeditious dynamic replication and ameliorated stability of converter systems over wide range of operating conditions.

4. SIMULATION WORK AND RESULT

The system is simulated based on following parameter as shown in table 1

Table -1: System parameter

Types	Range
Three phase source	110Kv
Three phase transformer	110/33 Kv
Inductor	4e-3H
Series transformer	250e-6KVA
Non liner RL load	--

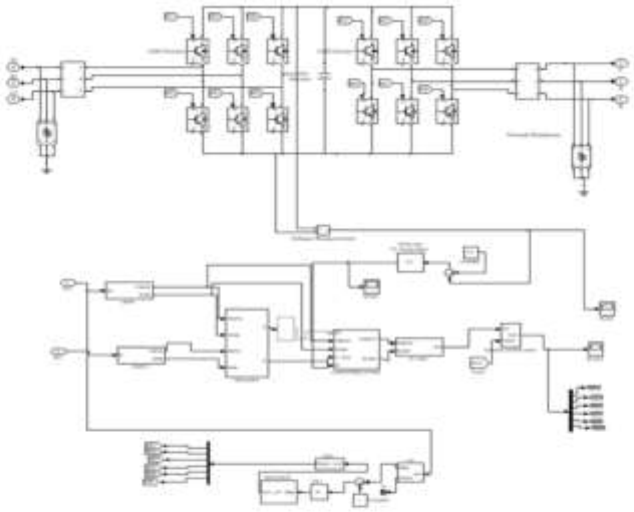

Fig-3: Simulink Model of UPQC

MATLAB is an interactive system for numerical computation. The simulation diagram of unified Power Quality Conditioner is shown below in fig 3 The system has been simulated based on flowing parameter shown in table 1for both IRPT and ANN controller. The system is simulated at the intervals of 0.8 to 1.6 during this sag and swell are crated and waveforms are obtained which have been shown on table 2

Table -2: output values

Terms	Without UPQC	With IRPT	With ANN
Voltage	0.8 to 1.6	Reduce upto 0.85	Reduce upto 0.87
Current	0.8 to 1.6	Reduced upto 0.85	Reduced upto 0.88
Harmonics	9.56%	0.4%	0.41%

Here from above table 2 we have obtained that upqc with IRPT has the best output compared with ANN controller and without conditioner.

4.1 Voltage Waveform

Before connecting UPQC:

Here the voltage wave form is obtained and it has been simulated in time interval 0.8 to 1.6 sec as shown in fig 4

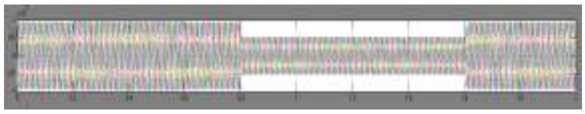

Fig-4: voltage wave before connecting UPQC

After connecting UPQC(IRPT):

Here the voltage wave form is obtained the distoritaion is reduced upto 0.85sec from 1.6 sec by implementing IRPT as shown in fig 5

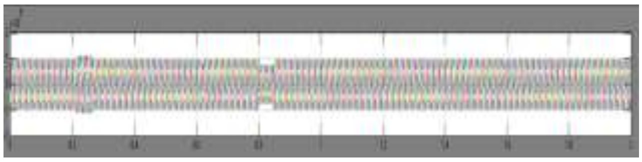

Fig-5: voltage wave after connecting UPQC

After connecting UPQC(ANN):

Here the voltage wave form is obtained the distoritaion is reduced upto 0.87sec from 1.6 sec by implementing IRPT as shown in fig 6

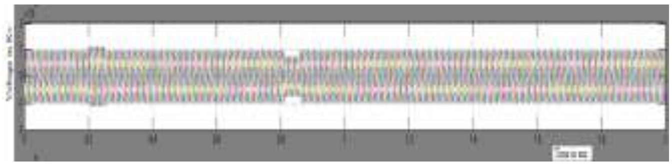

Fig-6: voltage wave after connecting UPQC

4.2 Current Waveform

Before connecting UPQC:

Here the current wave form is obtained swell are present in the time interval of 0.8 to 1.6 sec as shown in fig 7

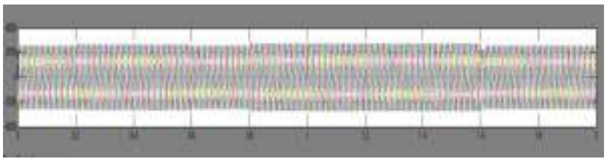

Fig-7: current wave before connecting UPQC

B After connecting UPQC(IRPT):

Here the current wave form is obtained swell are reduce upto 0.85sec from 1.6 as shown in fig 8

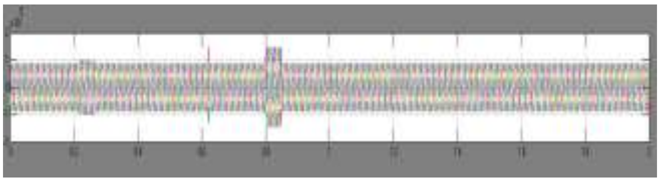

Fig-8: current wave after connecting UPQC

C After connecting UPQC(ANN):

Here the current wave form is obtained swell are reduce upto 0.88 sec from 1.6 by implementing ANN control as shown in fig 9

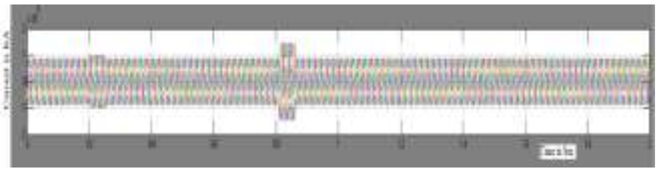

Fig-9: current wave after connecting UPQC

4.3 Harmonic Distortion

The Harmonic distortion in the system is analysed in source side. The THD in source side before connecting UPQC is9.56% at the time of 0.84 sec and THD is analysed in source side after connecting UPQC(IRPT) is 0.4% at the time of 0.86 sec as shown below fig 10 ,fig 11 and THD is analysed in source side after connecting UPQC(ANN) is 0.41% at the time of 0.86 sec

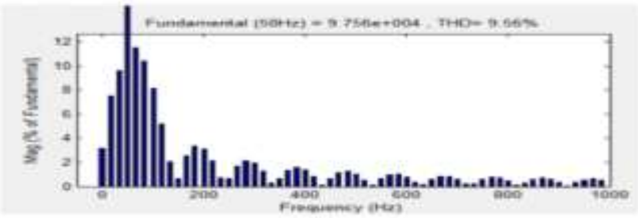

Fig-10: THD Without UPQC

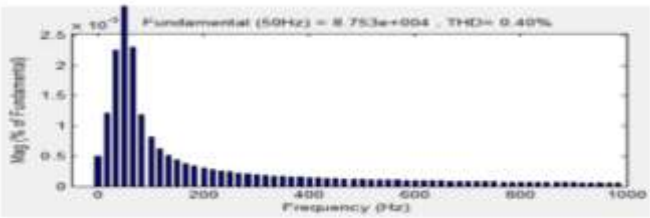

Fig-11: THD With UPQC(IRPT)

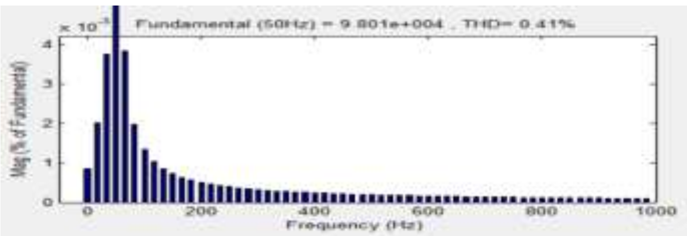

Fig-12: with UPQC(ANN)

5. CONCLUSION AND FEATURE SCOPE

In this paper the incrementation in commercial and industrial load has results in rigorous power quality quandary in the transmission and distribution side. The major perturbance in the distribution side cause losses of equipment, damage equipment. To solve these quandaries several solutions have been developed and cumulated power quality conditioner is the one of the most popular solution used nowadays. In these work it has been conclude that ,both ANN control and IRPT control strategy have been used which results reduction of harmonics and power disturbance etc for the operation of Power system out of both IRPT has the better result compared with other controller . Furtherly this work can be elongate in the controller performance of active filter may further be specified by other perspicacious control techniques like Genetic algorithm. These control techniques which reduce the uncompensated part and improve the power quality compared with previous control techniques

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