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ANFIS based Custom Power Devices to Improve the Power Quality in Distribution System

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ABSTRACT

In present scenario power quality is the major concern for electrical power system. In order compensate these problems lot of methods available in the market. This project proposes application of custom power devices to power system. For achieving better power quality an UPQC and IUPQC is provided in this paper. Both UPQC and IUPQC is a structure of two filters such as, series and shunt filters. The causes for poor power quality of system is due to harmonics, power factor variations and changes in system voltage. The purpose of these converters is to mitigate the PQ issues. The reference signals required for series and shunt converters of CPD system is generated with the help of conventional controllers and PWM controllers. The PLL used to match the phase sequence of converters. For obtaining better improvement in Power Quality this paper is implemented with one of the AI technique such as neuro-fuzzy controller. The purpose of anfis is used to control the DC Link Voltage of CPD. With the help of this anfis technique, the variations in voltage and current are reduced to enhance the power quality. The effectiveness of this proposed system with anfis technique is tested and verified using Matlab/Simulink environment.

KEY WORDS: Interline Unified Power Quality Conditioner (IUPQC), ANFIS, UPQC, Power Quality, THD.

1. INTRODUCTION

The latest power distribution system is fetching very susceptible to the various PQ (Power-Quality) problems [1]. PQ in distribution systems is a focal concern for industrial, commercial and residential purposes. Increased affair above this matter has run to quantifying PQ variations, reviewing the features of power disturbances and specifying solutions to these power quality problems. PQ is mostly exaggerated by the increased usage of non-linear loads such as powered electronic equipment, variable speed drives, and electronic control gears. Indigent power quality can disturb the security, reliability, and efficiency of several categories of equipment. Many parts of PQ are harmonics; flicker and imbalance have turn out to be stern concerns. Furthermore, lightning strikes on transmission lines, switching of capacitor banks and several network faults can too instigate PQ problems [2].

In consequence of the growth of powered electronic devices such as Flexible AC Transmission System (FACTS) and custom power devices, deregulated power systems with multipurpose new-fangled control abilities have performed. Reasonably slight concentration, however, has been fervent to system sag enhancement [3]. It is recognised that FACTS-based devices, viz., SVC, STATCOM, and DVR can deliver an effectual solution to voltage sag difficulties. Therefore, a recent distribution system needs a better steadiness of voltage being provided and the current drawn which is an elemental viewpoint to the end user. One latest and the very assuring solution is UPQC (Unified Power-Quality Conditioner). UPQC is a custom power device that contains shunt and series converters linked back to back on the dc side and distributes with load current and supply-voltage insufficiencies. The shunt inverter delivers reactive power and harmonic rewards by injecting a shunt current to the load. The series inverter is used in the compensation of voltage related problems, for example, sag and fabulous in source voltage by interleaving a controllable series voltage.

Conveniently, UPQC has been ultimate solution to progress the PQ in the electrical distribution system. The control method is not suitable for UPQC system for the motive that the dc sources are exchanged by capacitors in the UPQC system [4]. Accordingly, there is a requirement to consider several PQ mitigation procedures to convalesce the quality of power supplied. This shortage can be overwhelmed by unique intelligent optimization algorithms known as heuristic approaches are executed to solve PQ distributions. Some sounds regarded optimization systems are Evolutionary Programming (EP), Genetic Algorithm (GA), Simulated Annealing (SA), Differential Evolution (DE), Particle Swarm Optimization (PSO) and Artificial Bee Colony (ABC), etc. The improvement of UPQC PQ problem in a viable environment includes in the minimization of power losses [5].

2. PROPOSED METHODOLOGY

The structure of Interline power flow controller is shown in figure 1. It consists of two back to back converters with a common dc link capacitor. These two converters are connected to two feeders of distribution system for maintain system conditions. In this case we consider two feeder system. The shunt vsc converter of system is connected to feeder-1 and series vsc converter is connected to feeder-2. There is a boosting transformer is connected between series converter and transmission system to maintain the voltage levels. IUPQC can act as a (a) smart circuit breaker, (b) also acts as power flow controller between grid and microgrid to repay the active and reactive power references of the series converter [6].

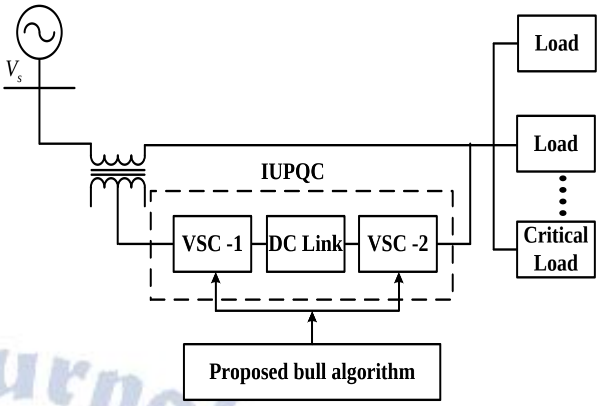


Figure 1: Structure of the proposed method

In the proposed method, the IUPQC is used to compensate the PQ issues with the help of the bull algorithm. The power sharing between the sources to the load is by achieves through maintain the dc link voltage. Initially, the normal voltage and current characteristics are analyzed, and then the PQ issues are created using the non-linear load, unbalanced load or critical load. The PQ issues are mitigated in the use of IUPQC device and bull algorithm is assist to the mitigation process via power sharing, dc link voltage regulation. The connected structure of IUPQC with distribution system is shown in figure 2.

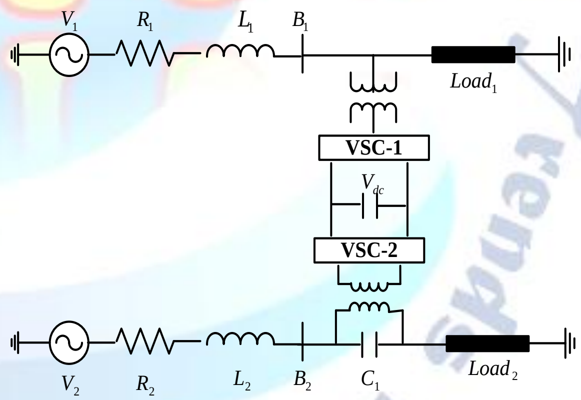


Figure 2: IUPQC structure in the distribution system

Incidentally, the IUPQC exemplify a traditional power device that is effusively in employment in the distribution scheme to restrict the conflict that has an actual impact on the efficiency in function of the non-linear or critical load. Dependably, the IUPQC concealments the sequences active power filter (APF) over and above the shunt APF. The sequence APF effectual provides the compensation amongst the distribution scheme and the sub-transmission scheme affecting to the harmonics [7]. Into the bargain, the BOA algorithm assistance the regulation of voltage from the

DC link capacitor. The power that the shunt section distributes or suck up, relaxes on the power conditions of the sequences compensator and the power mandatory to strip the losses. The detailed control process of the PAC control, series and shunt control techniques are described in the following sections.

3.IUPQC CONTROL TECHNIQUES

A. Control Diagram of the Series APF controller

The gate pulses required for series VSC is obtained by general PWM controller. And the reference voltage signals are obtained by controlling of dc bus and line voltage parameters. The magnitude required for reference signal is obtained with dc link voltage controller and required phase angle is to get with phase angle controller. The control diagram for series converter is shown in figure 4.

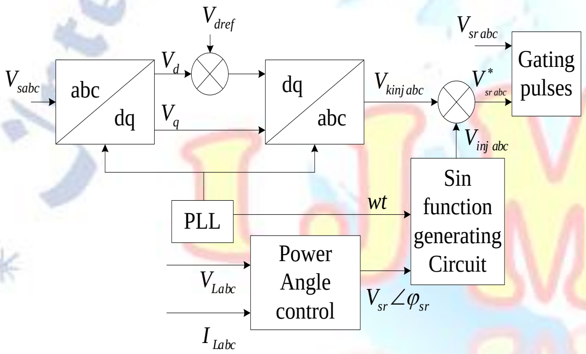


Figure 3: control structure of the series inverter

In this APF controller, the source voltage is transformed into dq-axis and that component is compared with reference direct voltage. Again, this error component converted to 3-phase components. The combined value of error component and phase angle control value is applied to PWM controller for generating gate signals required for VSC.

B. Controlling of the Shunt APF controller

Here, PQ-theory method is used to generate reference current signals required for shunt apf controller. In this case, the actual load voltage and currents are converted into αβ-coordinates. Form these coordinates, the active and reactive powers are to be calculated. These reference powers are compared with rated power and then converted to reference currents with the help of conventional PI controllers [9]. And Inverse Park's transformation is used for getting general abc components and applied to PWM controller to get gate signals.

The expressions for calculating powers using currents are shown below.

$$p = v_\alpha \cdot i_\alpha + v_\beta \cdot i_\beta = \bar{p} + \tilde{p}$$

$$q = v_\beta \cdot i_\alpha - v_\alpha \cdot i_\beta = \bar{q} + \tilde{q}$$

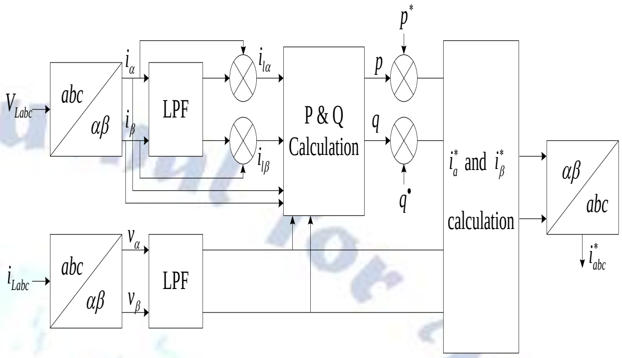


Figure 4: control structure of the shunt inverter

4.ANFIS CONTROLLER

Fuzzy Logic Controller:

The major complexity in conventional PID controller is mathematical analysis with multiple variables and constant interfacing. The major three issues with conventional PID controller is (a) time delay, (b) step function response and (c) ramp or soak function response.

In order to overcome these issues, this paper is implemented with soft computing controller called as Fuzzy logic Controller. Fuzzy Logic is one type in artificial intelligence and it is based on the information which is either true or false. FLC is a function or group of flexible set of if-then rules.

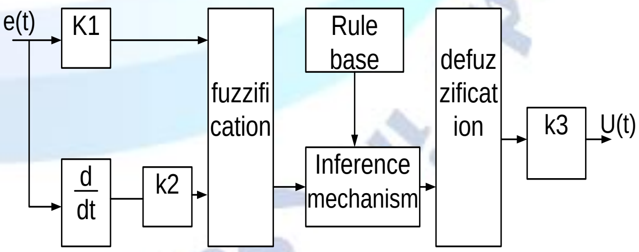


Figure 5: Architecture of FLC system

Figure 5, shows the basic structure of fuzzy logic controller with two inputs namely error of dc link voltage and change in error. Each input of FLC is a set of 5 memberships (i.e MS, S, Z, H, VH). The minimum of the two inputs of Medium small, small, zero, high and medium high are chosen which ultimately try to fire the set of IF-THEN rules. If error input is Z AND change in error input is H then the output is MH.

e/ce	MS	S	Z	H	MH
MS	MS	S	Z	H	MH
S	MH	H	Z	S	MS
Z	S	Z	H	MH	MS
H	S	S	MS	H	H
MH	S	Z	H	H	MH

Table 1 Rule-Base formation for 5*5 input FLC

ANN Controller:

Figure 6 shows the basic architecture of artificial neural network, in which a 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.

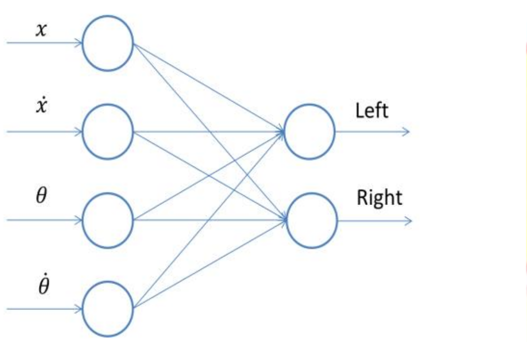


Figure 7: ANN architecture for a two-input multi-layer network

5. RESULTS AND DISCUSSIONS

The proposed method can be executed in MATLAB/Simulink working platform. At this point, the proposed method is actually based on CPD which is assisting the control for generating reference signals of the system. With this proposed method, voltage sag and swell problems tend to be compensating the sag appearance all the way through PAC control signals in distribution systems. Afterwards the controlled signals are produced from the proposed method that pulses can compensate the PQ issues in the utilization of the CPD. For that reason, the proposed method is also employed to enhance the performance of CPD not counting compensate the voltage sag and swell issues. The proposed method is experimented and its performance analysed. The performance analysis of the planned method is computed and explained in the following section.

Case 1: Proposed System with UPQC Controller

Unified power quality conditioning system (UPQC) consists of three VSCs in which two VSCs are connected in series to the two feeders and one VSC is connected in parallel to load end of the first feeder. These three VSCs connected back to back through a common dc-link capacitor. Each of the VSCs in Figure 8, is realized by a three-phase converter with a commutation reactor and high-pass output filter. The commutation reactor and high-pass output filter are connected to prevent the flow of switching harmonics into the power supply.

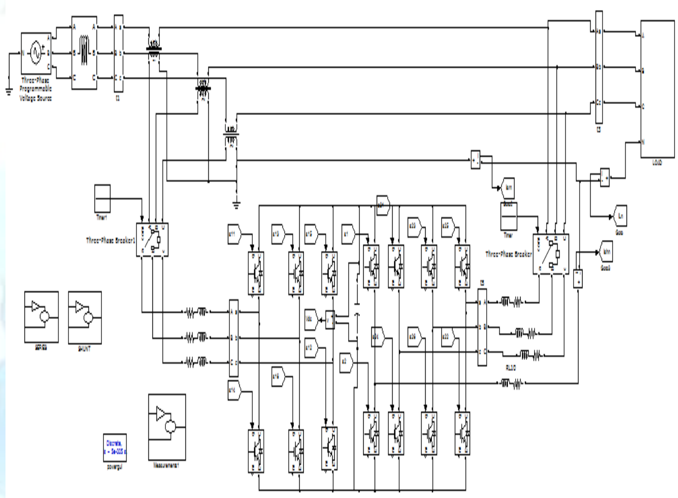


Figure 8: Simulink block diagram of UPQC

The purpose of UPQC is to regulate the load voltages against voltage sags, voltage swells and disturbances in the in the system and to compensate the reactive and harmonic components of nonlinear load currents.

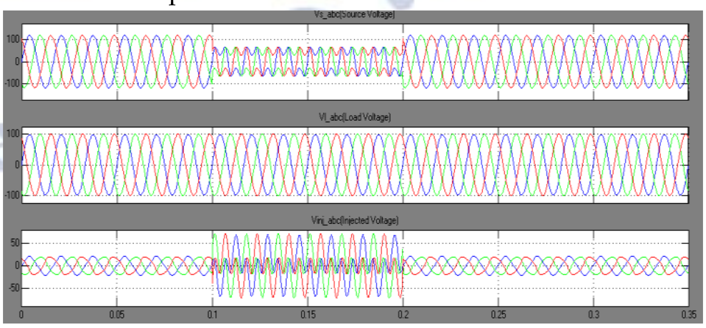


Figure 9: Simulation results using conventional topology. Terminal voltages with sag, UPQC-injected voltages, and load voltages after compensation.

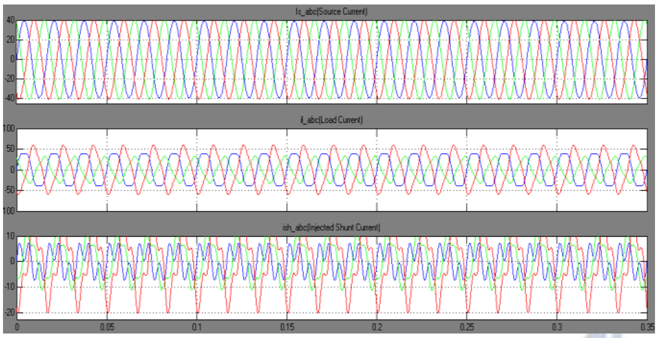


Figure 10: Simulation results using conventional topology. Shunt active filter currents

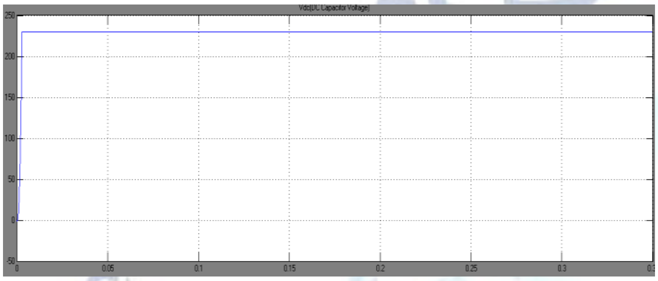


Figure 11: Simulation results using conventional topology. DC capacitor voltage

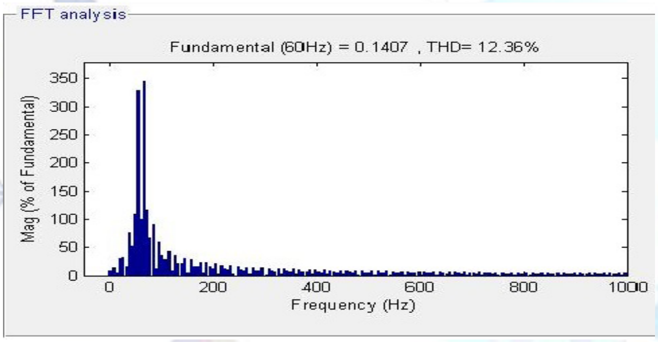


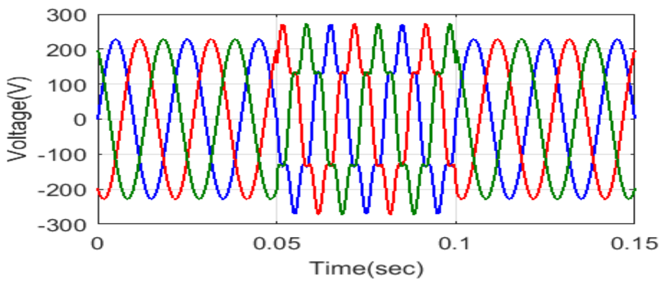
Figure 12: Total Harmonics Distortion for Grid Current

A. *Performance Analysis*

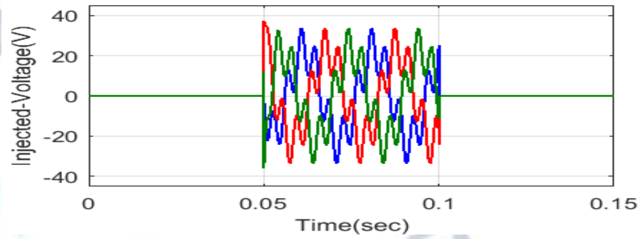
Figure 13 presents the normal behaviour of the distribution system current and voltage in the feeders 1 and 2. The PQ of the system along with non-linear load is enhanced because of the help of a proposed control technique based IUPQC.

Case A: Swell at feeders 1 and 2

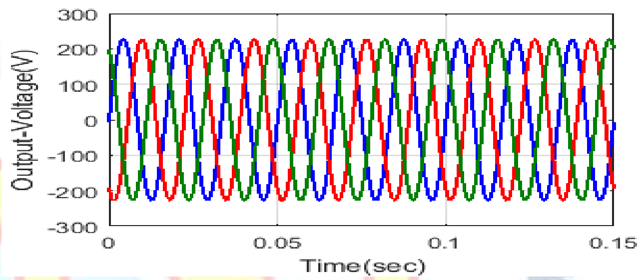
The swell is initiated in the system use of the non-linear load, unbalanced load or critical load in the load side. The voltage swell signal is shown in Figure 13. The mitigation is achieved through the use of proposed controller.



(a)



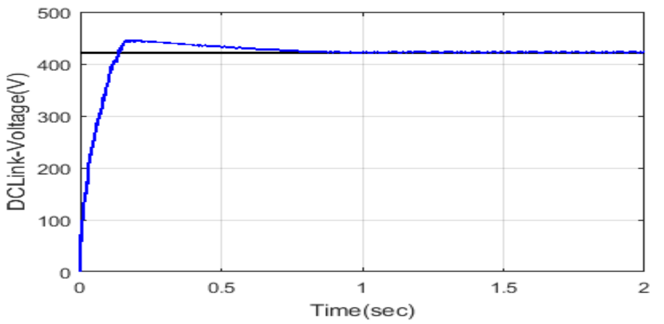
(b)



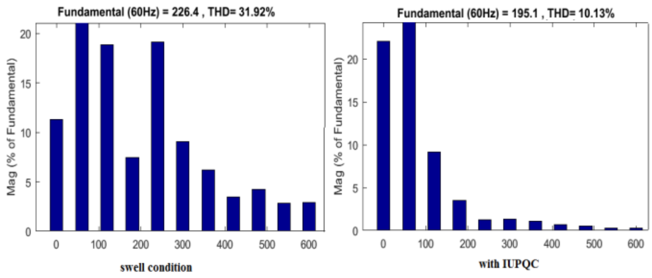
(c)

Figure 13: Analysis of the (a) Voltage swell, (b) Injected voltage and (c) Output voltage

Figure 13(a) illustrates the disturbance voltage. Initially, 230V is maintained in the constant level to at 0-0.05s, then it is increased the voltage to 30V (i.e. 260V) at 0.05s-0.1s due to the load variation. The increased voltage is compensated with the help of the IUPQC device through the series filter. The injected voltage from the series filter is 30V, it is compensated the voltage swell and the excess voltage is stored in the capacitor of the IUPQC is presented figure 13(b).



(a)



(b)

Figure 14: Analysis of the (a) dc link voltage and (b) THD ratio

Table-2 THD Analysis for Load Voltage

S.No	Type of Problem	THD (%)		
		Without Controller	With UPQC	With IUPQC-ANFIS
1	Swell at feeders 1 and 2	29.92%	19.12%	6.72%

The THD is analyzed for the load voltage under three different cases with UPQC and with IUPQC controllers. The comparative analysis for harmonic distortion is shown in table-2. From the table, it conclude that UPQC based IUPQC controller provides better harmonic distortion as compared with convention controllers.

Table-3 THD Analysis for Current

S.No	Type of Problem	THD (%)		
		Without IUPQC	With UPQC	With IUPQC-ANFIS
1	Load Current	**22.34%**	**21.24%**	**20.08%**
2	Source Current	**22.34%**	**12.56%**	**9.4%**

6.CONCLUSION

This paper has proposed the PQ improvement with the help of CPD, which has employed ANFIS based controller. The proposed controller is executed in the MATLAB/Simulink platform. The proposed method positions the optimal control pulses of the series and shunt APF depend on the source side and load side parameters through the phase angle. In the proposed method, different source side parameters, load side parameters are analyzed to calculate the phase angle for provided control signals for UPQC & IUPQC. After that, the proposed ANFIS based controller has maintained the dc-link voltage. The control signals of the CPD are compensate the voltage variations and the current perturbations. The gain of the proposed manage technique is the robustness, the reliability and the adaptability for diverse forms of problems. The proposed technique has been carried out and the overall performance has been evaluated below exceptional kinds of pq problems including voltage sag and voltage swell.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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