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Enhancement of Quality in a Transmission Grid using UPQC with Fuzzy and Neuron Fuzzy Logic Controller

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ABSTRACT

Non-linear tons are normally affected by power quality (PQ) problems. Harmonic currents make system resonance, capacitor overloading, and decrease in efficiency. Voltage sags are usually happening power quality difficulties in electrical systems. The unified power quality conditioner (UPQC) is one of the FACTS controllers used for modifying the effect of voltage sags. The series compensator in the UPQC is for quadrature type of voltage inoculation. So that at steady state the series compensator not ever ingests active power. The proposed method introduces a low power rating series compensator that injects the voltage which perfectly recompenses the power quality problem of the system. The addition of fuzzy logic controller with the conservative UPQC decreases the voltage sag levels in the output voltage and also develops the power factor. The control circuit is aimed using fuzzy logic controller and simulated using MATLAB/SIMULINK.

Keywords: Minimum active power injection, unified power quality conditioner (UPQC), power quality (PQ) and voltage sag.

1. INTRODUCTION

In the present generation, PQ has become one of the most significant problems. Due to the use of different types of sensitive electronic equipments, PQ issues have drawn substantial attention from both utilities and users. The main PQ deviations are happened by short-circuits, harmonic distortions, notching, voltage sags, voltage flickers, voltages wells and transients due to switching of load.

The Unified Power Quality Conditioner (UPQC) is one of the FACTS devices used for mitigating the effect of voltage sags [I].Unified Power Quality Conditioner (UPQC) is a device expected to solve almost all power problems that is similar to a Unified Power Flow Conditioner (UPFC). It consists of both series and shunt active power filters which compensate the distortions of both source voltages and load currents. UPQC is used for harmonic elimination and simultaneous compensation of voltage and current, and it improves the power quality offered by the harmonic sensitive loads The UPQC employing this type of quadrature voltage injection in series is termed as UPQC-Q.

2. POWER QUALITY ISSUES

When we are using a non-linear bulk in a power system, the fundamental sinusoidal waveform of current will change. Due to this non-sinusoidal voltage drop occur across the various network foundations connected to the system resulting in partial waveform spread throughout the system.

There are different types of PQ disturbances in an electrical power system. A recent research by PQ experts found that 50% of all PQ problems are related to grounding, ground bonds, and impartial to ground voltages, ground loops, ground current or other ground related issues. Some of the power quality issues are voltage sag, voltage swell, harmonics, voltage flicker etc.

3. POWER QUALITY IMPROVEMENT

The FACTS devices are power electronic based controllers. FACTS devices are mainly used for regulating the voltage and schedule power flow through the lines. The harmonic currents in the power networks are mainly caused by non-linear loads used in that power networks and decreases the PQ. Thus voltage distortions are caused due to these harmonic currents at the Point of Common Coupling (PCC).This results the malfunctioning of equipments in the system. To eliminate such problems, passive power filters have been used. Passive power filters can cause annoying resonance and amplify harmonic currents.

To daze the drawback of passive power filters, active power filters has been used [5].According to their system configuration, active power filters can be classified as series and parallel active power filters [6]. The combination of series and parallel active power filters are called the Unified Power Quality Compensator (UPQC) [7]. In addition with harmonic elimination, UPQCs are used for compensation of the reactive power, unbalanced load current, source voltage sags, source voltage unbalance, and power factor correction [4]. The UPQC-Q introduces a quadrature injection method which controls voltage sags and offers economical compensation.

This paper proposed a new minimum active power injection method that can overcome the limitations of the conventional UPQC scheme [3]. The proposed method allows the low power rating series compensator that injects the deficient voltage, which allows economical compensation. If voltage sags cannot be fully compensated by reactive power injection because of limitations in the series compensator rating and the phase difference between the input and output voltage, economical compensation is possible by using the proposed minimum active power injection scheme.

4. UNIFIED POWER QUALITY COMPENSATOR

The Unified Power Quality Compensator (UPQC) consists of two Voltage Source Converters (VSC), one is shunt connected to the power system, and another is series connected to the load. The two converters are connected by common DC bus, as shown in Fig.1. [9].During the voltage dip, the controllable voltage, both magnitude and phase angle, is injected by the UPQC to keep the load terminal voltage and the required energy at the DC bus is delivered by the shunt connected VSC, which excerpts the energy from the power system. As the power drawn by the shunt connected VSC is kept equal to the power delivered to the series connected Scathe energy storage device at the DC bus is not necessary in the UPQC. The power coming from the power system will be greatly reduced during the voltage dip. The shunt connected VSC must be designed to operate correctly with reduced or even unbalanced input voltage.

The block diagram of UPQC is shown in Fig.2. A source gives the AC supply to the rectifier. The input side having one inductive filters. It is used to improve the input power factor. Inverter is used to convert DC voltage to AC voltage. Transformer is used for step down/step up purpose. It is also used for isolation. Rectifier converts AC supply to DC supply. DC supply having some ripples. It is filtered with the help of capacitor filter. Multi-level inverter generates AC output voltage. The control of output voltage is done using pulse width modulation.

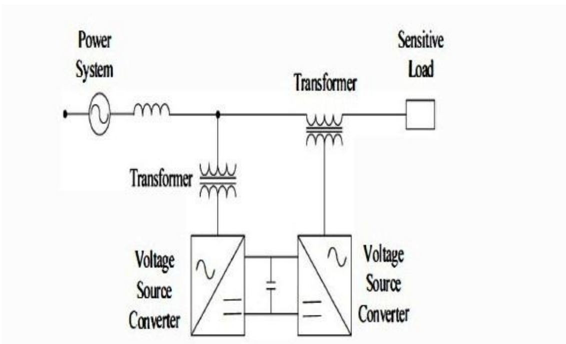

Fig.1. Unified Power Quality Compensator

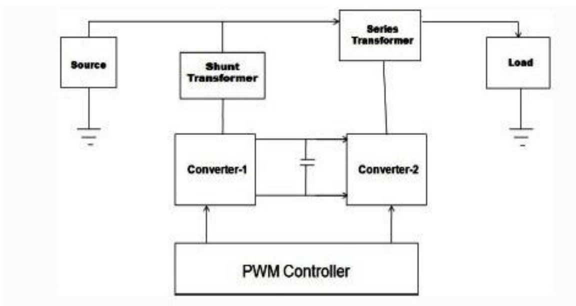

Fig.2. Block diagram of UPQC

5. FUZZY LOGIC CONTROLLER

Fuzzy logic is the portion of artificial intelligence or machine learning which interprets the human act. Computers can interpret only true or false values but a human being can reason the grade of truthiness or degree of wrongness. Fuzzy models interpret the human actions and are also called intelligent systems. Fuzzification is the process of changing areal scalar value into a fuzzy value. This is achieved with the different types of fusiliers. Fuzzy logic is a rule-based system. These rules are stored in the knowledge base of the system. The input to the fuzzy system is a scalar value that is fuzzified.

6. SIMULATION RESULTS

Simulations of the proposed method have been carried out by using the simulation tool MATLAB/SIMULINK. The simulation is done without and with Fuzzy logic controller. The output wave forms without fuzzy logic controller and with fuzzy logic controller are compared and the results are discussed. The addition of fuzzy logic controller with the conventional UPQC reduces the voltage sag levels in the output voltage.

6.1 Without Fuzzy Logic Controller

The output voltage and output current with interruption is shown in Fig.4. Here the interruption occurs for a period 0.05 sec. After that, due to the power quality disturbances, the output waveforms have been distorted. The circuit diagram of UPQC without fuzzy logic controller is shown in Fig.3.

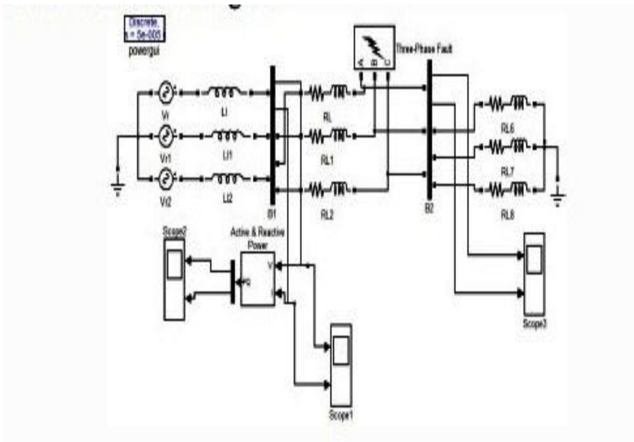

Fig.3. Circuit diagram without fuzzy logic controller

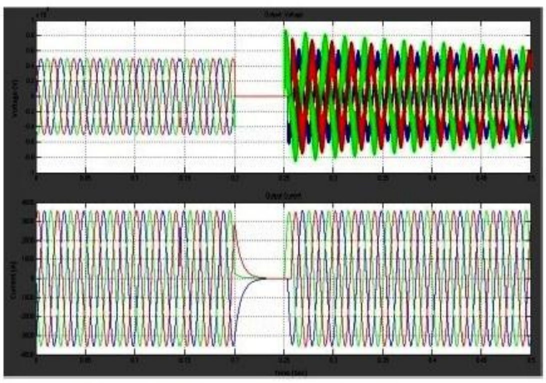

Fig.4. Output voltage and output current with interruption

The occurrence of PQ disturbances was shown in Fig.5, which exits for a duration of 0.05 sec before the introduction of UP QC. The harmonic waveforms of voltage and current due to the usage of non-linear loads are shown in Fig. 5.

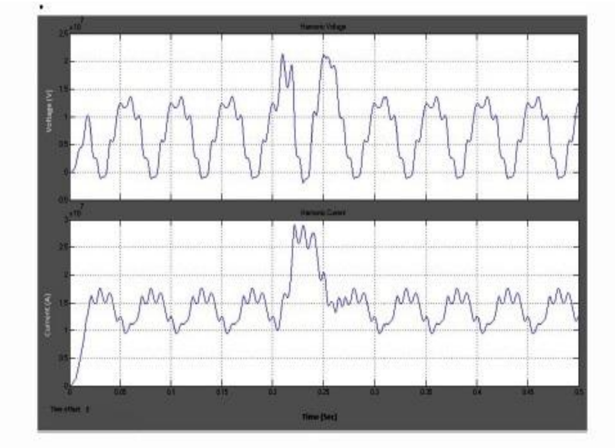

Fig.5. Harmonic waveforms of voltage and current

6.2 With Fuzzy Logic Controller

The circuit diagram of UP QC with the addition of fuzzy logic controller is shown in Fig. 6 and Fig. 7 shows a subsystem for the fuzzy logic controller.

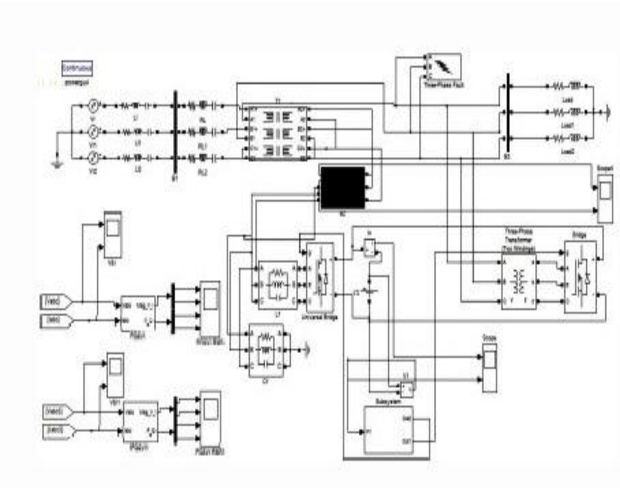

Fig.6. Circuit diagram with fuzzy logic controller

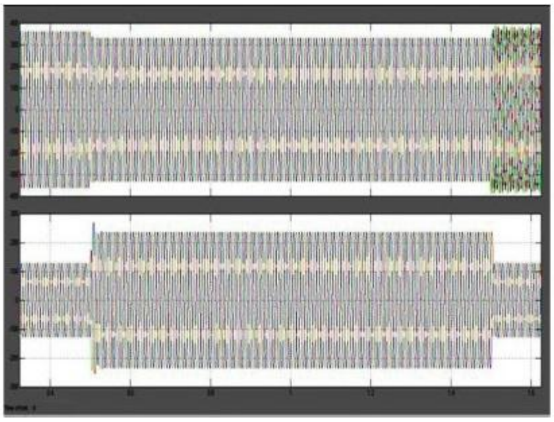

Fig.7. Output waveform without UPQC

6.3 Fuzzy Logic Controller/Subsystem

Fig. 6 Circuit diagram with fuzzy logic controller/subsystem. The output waveform without UPQC is shown in Fig. 7. Here the power quality disturbances occur for a period of 1sec. before the implementation of UP QC.

When we have introduced UPQC and fuzzy, here the power quality disturbances have been mitigated and the output waveforms obtained is shown in Fig. 7.

7. CONCLUSION

This paper has presented a new control method for UPQC using minimum active power injection technique. The conventional UPQC cannot mitigate the voltage sag effectively. The limitations of the conventional UPQC are rectified by the proposed minimum active power injection method. A new control technique and mathematical models were framed and then simulated by MA TLAB/SIMULINK. The experimental results were presented using fuzzy logic controller to verify the performance of the proposed new control technique.

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