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Modeling and Simulation of Unified Power Quality Conditioner to Improve Power Quality

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ABSTRACT: The power system network is a combination of complex networks, within which many generating units and load centers are interconnected together through long transmission and distribution lines. Customer's distribution networks, significant commercial operations, and susceptible industrial loads all suffer from various sorts of outages and interruptions which can result in considerable financial loss, loss of manufacturing of idle workforces, etc. Now a day due to the changing trends and reformation of power systems, the tip users are concentrating on the standard and reliability of power supply at the load points. A power quality problem is an incidental claim as an irregular voltage, current, or frequency that fails end-use equipment. With shifting this trend towards distributed and isolated generation, the difficulty of power quality will take a replacement magnitude. The concept of customary power is going to be introduced to the distribution network for the advance of system performance. The motto then lies, in this work is to clarify the most important concerns within the area and from there to recommend measuring the enhancement of power quality, by considering the economic capability and technical cost. The unified power quality conditioner (UPQC) is an inefficient traditional power electronics device for the improvement of power quality due to its quick response, high consistency, and insignificant value. A Unified power quality conditioner is employed to suppress misrepresentation, unstable voltage, and current situation. It's capably accomplished of defending perceptive loads against the voltage turbulence. UPQC uses two converters that are connected to a common DC link with an energy storage condenser. The main components of UPQC are series & shunt converters, capacitors, low pass, and high pass filters, series and shunt transformers.

KEYWORDS: UPQC, Power Quality, faults, DSTATCOM, PI Controller.

I. INTRODUCTION

In present years, Electrical Power system engineers are mainly concerned with the power quality of the utility systems. In industries, Electrical Machine uses electronic-based Controllers which are very sensitive to unstable voltage and will be off. If the supply voltage is decreased it misoperates due to harmonic distortion in the supply voltage. Most of the load equipment utilizes electronic-based switching devices which contribute to weak network voltage quality.

The electrical energy market competition in electrical supply has shaped greater commercial alertness of the issues of power quality while equipment is willingly available to measure the quality of the voltage waveform and so quantify the problem. With advanced technology, the association of the world economy has been analyzed globally and the income limits of many activities are likely to be decreased. The augmented compassion of the huge mainstream of processes like (industrial and residential services) to power quality problems turned to the availability of electric power with the quality a critical factor competitively in every sector. The continuous process of services to industry and information technology is the most significant area. Due to interruption, a vast amount of economic losses may happen, with the consequential loss of production and competition. Many pains have been taken by utilities to complete consumer obligation, some customers require a higher level of power quality than the level provided by existing networks. This implies that some actions must be taken so that upper levels of Power Quality can be obtained.



The FACTS devices and traditional power electronics devices are introduced to the power system for the improvement of the power quality of the electrical power system. DVR, D-STATCOM, ACTIVE power FILTERs and UPQC, etc. are few devices that are used to improve the quality of voltage and current. With the support of such devices, we can accomplish the reduction of power quality issues related. Though all devices can improve the power quality, this paper is focused on UPQC, because it is a device that consists of both DVR and D-STATCOM, Previously it was connected in series and then in parallel to protect the sensitive load from all disturbances.

II. UPQC SYSTEM

The major parts of a UPQC are a series power converter, shunt power converter, capacitors, low-pass & high-pass passive filters, series and shunt transformers, etc.

- A. Series converter referred to as a voltage-source converter connected serial with the AC path and acts as a line voltage source to compensate voltage disruptions. It helps to minimize line voltage fluctuations from the load supply voltage and feeds to a parallel branch of the device to consume current harmonics produced by unbalancing load. The pulse-width modulation (SPWM) is employed to manage the series converter output voltage. The gate pulses required for the converter are produced by comparing the fundamental voltage and also the reference signal voltage with a high-frequency triangular waveform.
- B. A shunt converter is a voltage-source converter (VSC) that is connected in parallel with the same AC supply line and acts as a current source to eliminate the current disruption and mitigates the reactive current in the load circuit and enhances the load power factor. It also acts as a DC-link voltage regulator for the reduction of the DC capacitor rating. The resultant current of the shunt converter can be separated by the application of dynamic hysteresis band (DHB) based on the status semiconductor switches control so that the resultant current follows the reference signal and remains in the predicted hysteresis band (PHB).
- C. The DC capacitor bank connected between Midpoint-to-ground is divided into two parts, which are arranged in series together. The neutral point's secondary transformer is connected to the DC-link midpoint directly. Since both three-phase transformers are connected in Y/Yo form, therefore the zero-sequence voltage will appear in the primary winding of the transformer which is connected in series to mitigate the zero-sequence voltage of the supply power system. There would not be any zero-sequence current flow in the primary side of both transformers. This assures the balancing of system current when the voltage disturbance occurs.
- D. The Low-pass filter (LPF) is made use to get high attenuation in high-frequency components at the output side of the series converter which is produced by a high-frequency switching mode.
- E. A high-pass filter (HPF) can be applied at the output of the shunt converter to consume the ripples produced while in current switching mode.
- F. Series and shunt transformers are used to inject the mitigating voltages and currents for the electrical separation of UPQC converters. The UPQC is very useful for steady-state analysis and dynamic control of series and shunts active and reactive power mitigation at fundamental as well as harmonic frequencies. Anyhow the UPQC is concerned about the good quality load voltage and the line current at the point of its application, but it does not enhance the quality of power for the entire power system unit.

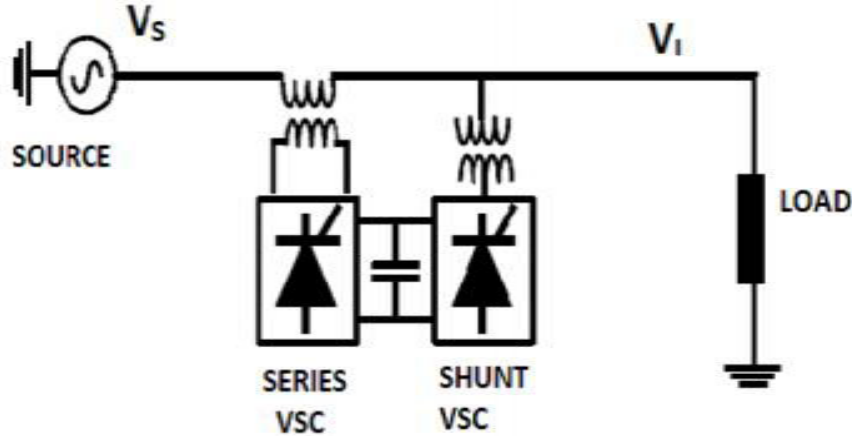


Figure 1: Block diagram of UPQC

III. SYSTEM CONFIGURATION

There are two ways of connecting the UPQC unit to the terminal voltage (V_t) at PCC:

Right-shunt UPQC (figure2), where the shunt compensator (i_c) is placed at the right side of the series compensator (V_c).

Left-shunt UPQC (figure3), where the shunt compensator (i_c) is placed at the left side of the series compensator (V_c).

These two structures will have similar features; however the overall characteristics of the right shunt UPQC is superior (e.g. operation at zero power injection/consumption mode, which achieves the unity power factor at load terminals, and full reactive power mitigation).

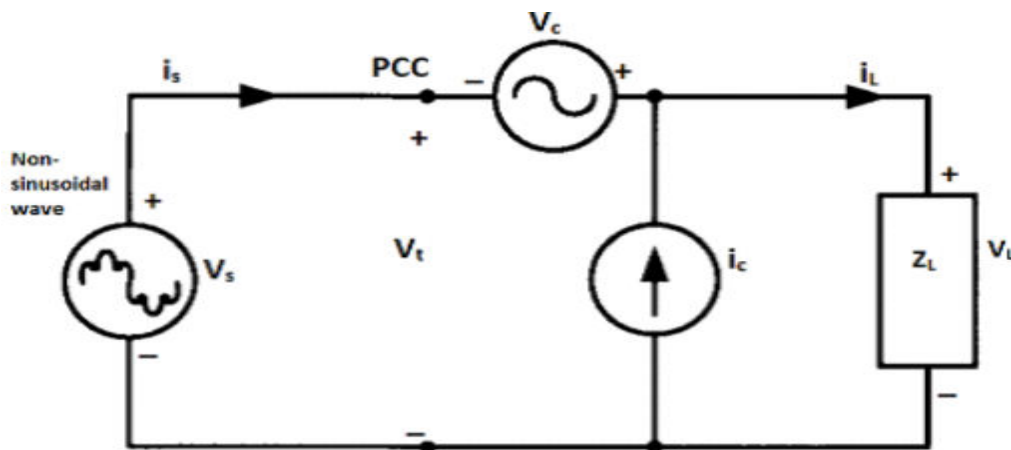


Figure 2: Right shunt UPQC compensation configuration

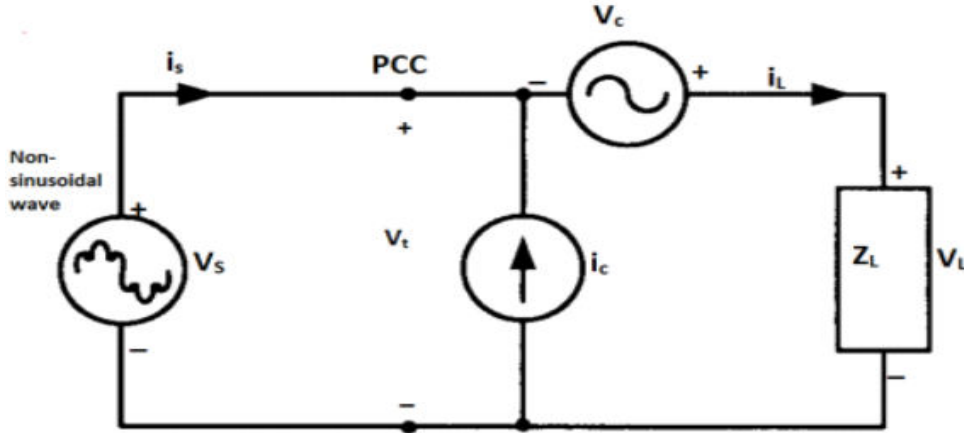
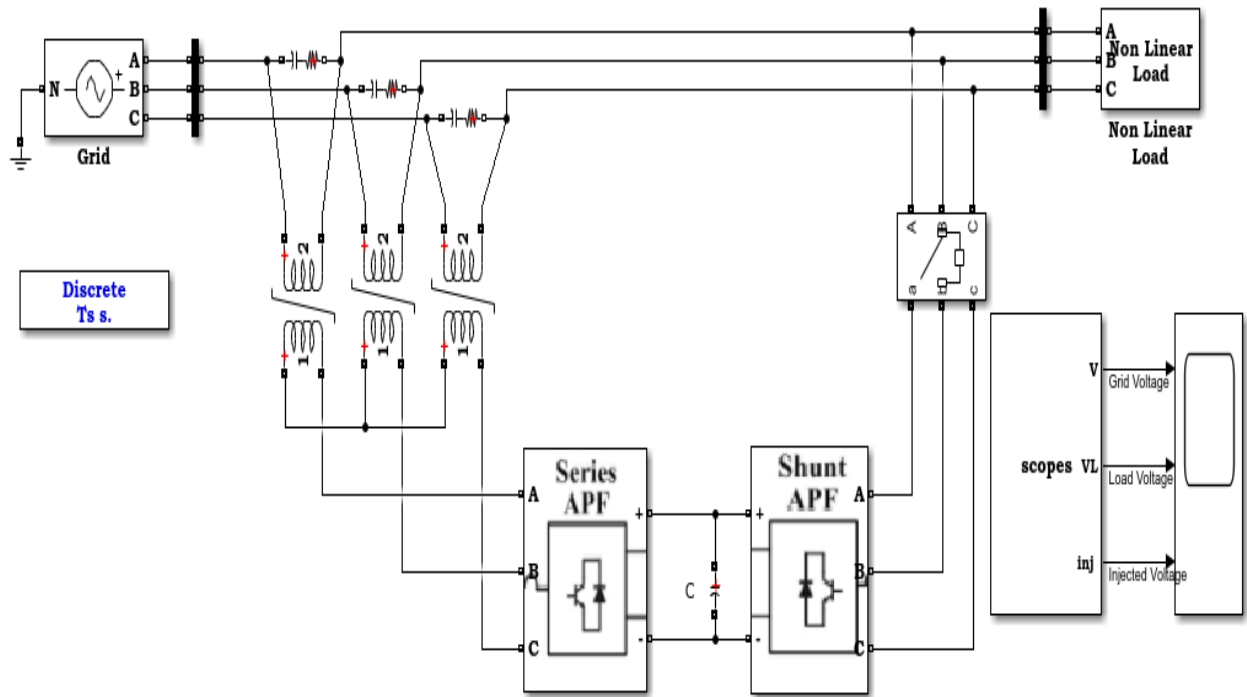


Figure 3: Left shunt UPQC compensation configuration

IV. MATLAB SIMULINK MODEL





V. SIMULATION RESULT AND DISCUSSION

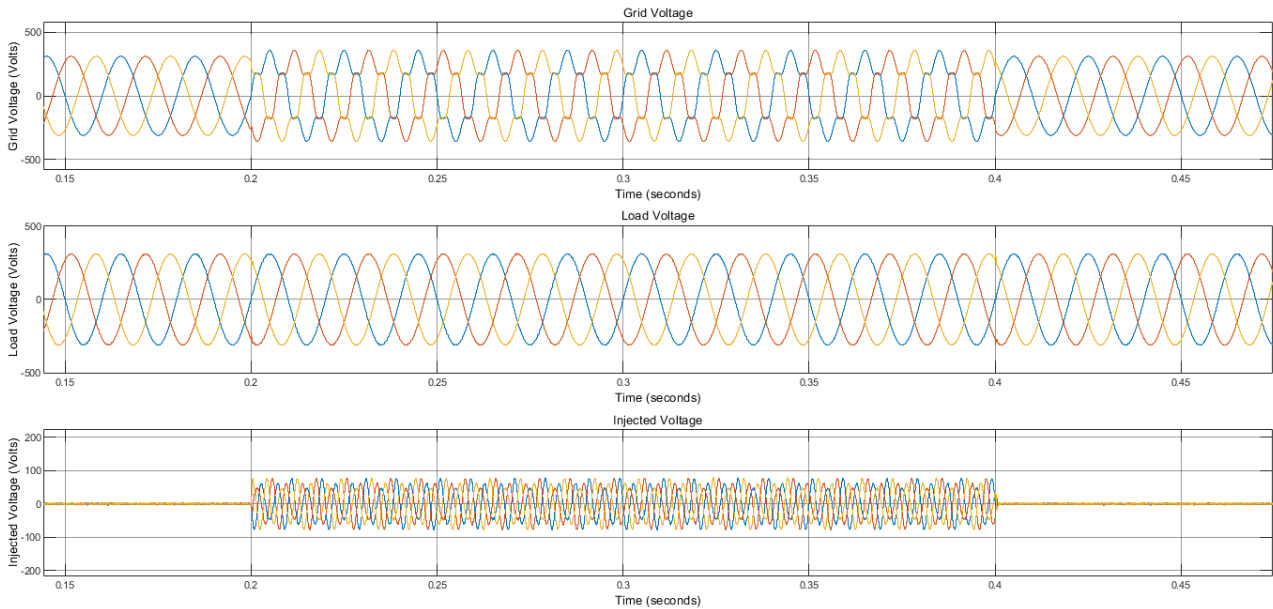


Figure 4: Harmonics Compensation

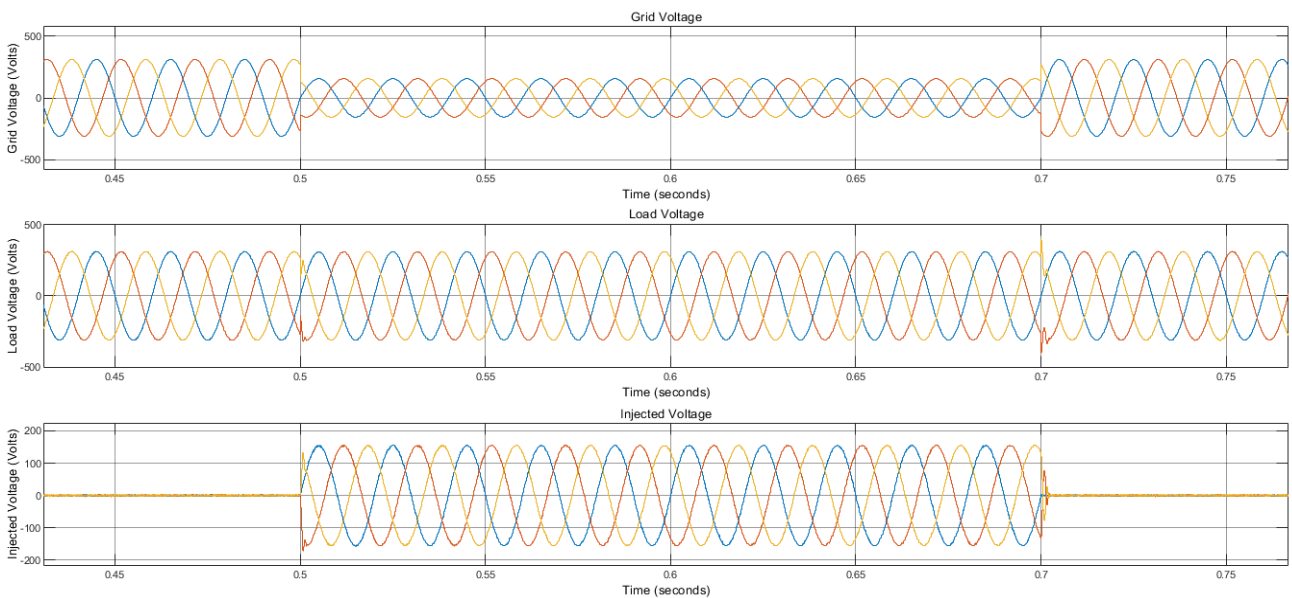


Figure 5: Voltage Sag Compensation

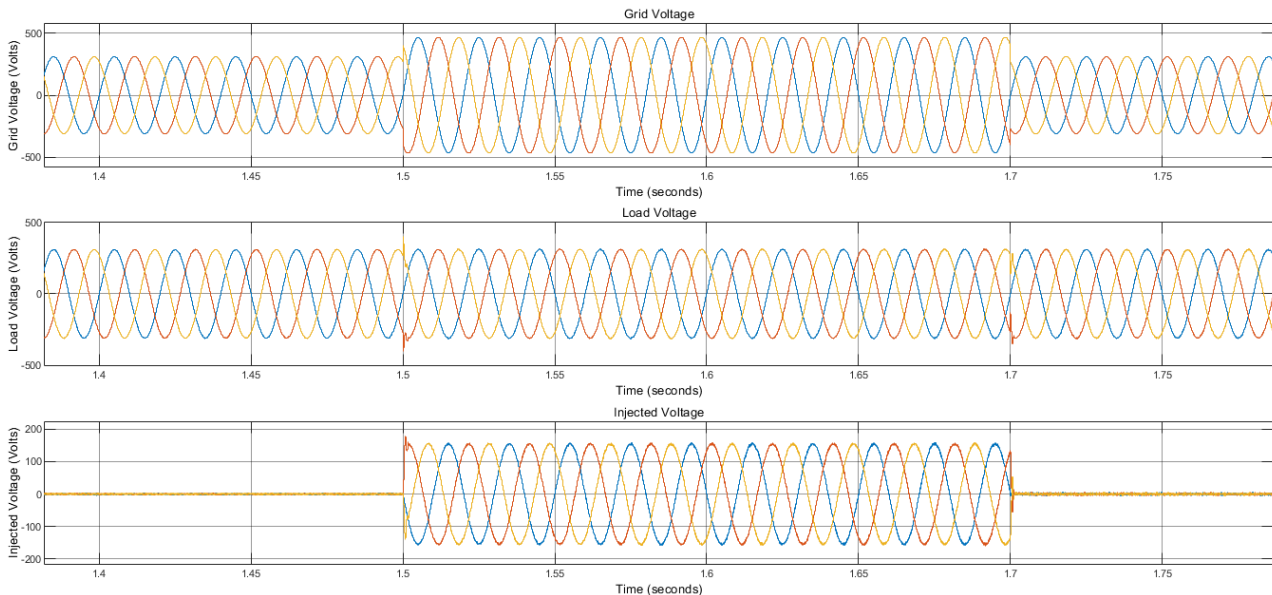


Figure 6: Voltage Swell Compensation

In this part, a Simulink model is designed to validate the functions of UPQC. In this model, the UPQC is attached to the distribution system to improve the power quality and feeds it to the consumer side. To validate this model three cases are considered which consist of harmonic compensation, voltage sag compensation, voltage swell compensation. When the UPQC starts functioning, it mitigates the voltage sag, voltage swell, and harmonics problems.

VI. CONCLUSION

The main objectives of this work are to reduce the disruption occurring in the case of the harmonics produced in the loads connected to the distribution networks by using custom power electronics devices. There will be a high improvement in the power quality of the system. To protect critical loads from more harmonics in voltage and current of the distributed network, the UPQC is recommended in the form of a series-connected voltage-source converter called Dynamic Voltage Restorer and shunt connected voltage-source converter called D-STATCOM. UPQC gives the optimal solution for the mitigation of voltage and current harmonics as well as the other PQ issues. In this work, the UPQC is only simulated for minimizing the voltage sag, voltage swell, and harmonics. The above simulation results show the UPQC can be used for effectively improving the power quality of an electrical power system.

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