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Improving Power Quality by Usingmc-Upqc

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ABSTRACT

This paper presents a new Unified PowerQuality Conditioning System (MCUPQC),capable of simultaneous compensation for voltage and current in multi-bus/multi-feeder systems. By using one shunt Voltage-Source Converter(VSC) and two or more series VSCs the configuration is made. The system can be applied to adjacent feeders to compensate for supplyvoltage and load current imperfections on the main feeder and full compensation of supply voltage imperfections on the other feeders. The configuration will be designed as all converters are connected back to back on the dc side and share a common dc-link capacitor. Therefore, power can be transferred from one feeder to adjacent feeders to compensate for sag/swell and interruption. The proposed topology can be used for simultaneous compensation of voltage and current imperfections in both feeders by sharing power compensation capabilities between two adjacent feeders which are not connected. The system is also capable of compensating for interruptions without the need for a battery storage system and consequently without storage capacity limitations. By the simulation the performance of MC-UPQC as well as the adopted control algorithm will be illustrated.

Index terms: Voltage-Source Converter(VSC), Interline Power Flow Controller (IPFC),Unified Power-Quality Conditioning System (UPQC),

I. INTRODUCTION When the power flows of two lines starting in one substation need to be controlled, an Interline Power Flow Controller (IPFC) can be used. An IPFC consists of two series VSCs whose dc capacitors are coupled. This allows active power to circulate between the VSCs. With this configuration, two lines can be controlled simultaneously to optimize the network utilization. The GUPFC combines three or more shunt and series converters. It extends the concept of voltage and power-flow control beyond what is achievable with the known two-converter UPFC. The simplest GUPFC consists of three converters—one connected in shunt and the other two in series with two transmission lines in a substation. The basic GUPFC can control total five power system quantities, such as a bus voltage and independent active and reactive power flows of two lines. The concept of GUPFC can be extended for more lines if necessary. The device may be installed in some central substations to manage power flows of multilines or a group of lines and provide voltage support as well. By using GUPFC devices, the transfer capability of transmission lines can be increased significantly. Furthermore, by using the multilinemanagement capability of the GUPFC, active power flow on lines cannot only be increased, but also be decreased with respect to operating and market transaction requirements. In general, the GUPFC can be used to increase the transfer capability and relieve congestions in a flexible way. This concept can be extended to design multiconverter configurations for PQ improvement in adjacent feeders. For example, the interline unified power-quality conditioner (IUPQC), which is the extension of the IPFC concept at the distribution level, has been proposed in the IUPQC consists of one series and one shunt converter. It is connected between two feeders to regulate the bus voltage of one of the feeders, while regulating the voltage across a sensitive load in the other feeder. In this configuration, the voltage regulation in one of the feeders is performed by the shunt-VSC. However, since the source impedance is very low, a high amount of current would be needed to boost the bus voltage in case of a voltage sag/swell which is not feasible. It also has low dynamic performance because the dc-link capacitor voltage is not regulated. In this paper, a new configuration of a UPQC called the multiconverter unified powerquality conditioner (MC-UPQC) is presented. The system is extended by adding a series-VSC in an adjacent feeder. The proposed topology can be used for simultaneous compensation of voltage and current imperfections in both feeders by sharing power compensation capabilities between two adjacent feeders which are not connected. The system is also capable of compensating for interruptions without the need for a battery storage system and consequently without storage capacity limitations.

II. PROPOSED MC-UPQC SYSTEM A. Circuit Configuration The single-line

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diagram of a distribution system with an MC-UPQC is shown in Fig.1

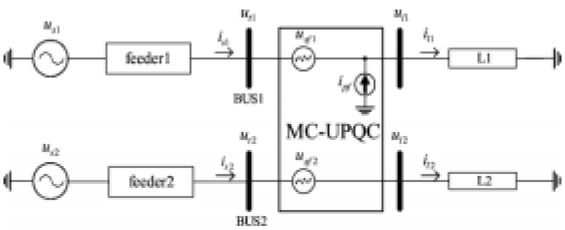

Fig.1 Single-line diagram of a distribution system with an MC-UPQC

As shown in this fig.1., two feeders connected to two different substations supply the loads L1 and L2. The MC-UPQC is connected to two buses BUS1 and BUS2 with voltages of ut1 and ut2, respectively. The shunt part of the MC-UPQC is also connected to load L1 with a current of il1. Supply voltages are denoted by us1 and us2 while load voltages are ul1 and ul2 Finally, feeder currents are denoted by is1 and is2 load currents are il1 and il2 Bus voltages ut1 and ut2 are distorted and may be subjected to sag/swell. The load L1 is a nonlinear/sensitive load which needs a pure sinusoidal voltage for proper operation while its current is non-sinusoidal and contains harmonics. The load L2 is a sensitive/critical load which needs a purely sinusoidal voltage and must be fully protected against distortion, sag/swell, and interruption. These types of loads primarily include production industries and critical service providers, such as medical centers, airports, or broadcasting centers where voltage interruption can result in severe economical losses or human damages.

B. MC–UPQC Structure

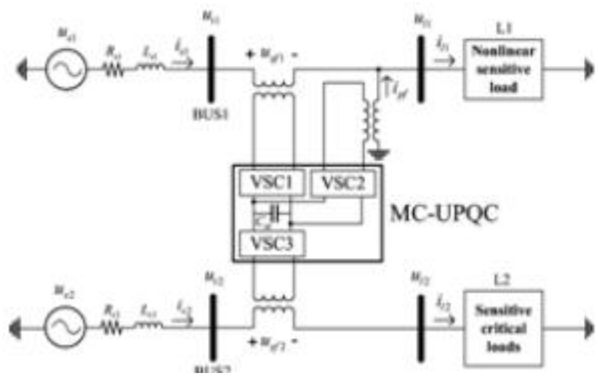

Fig.2 Typical MC-UPQC used in a distribution system

The internal structure of the MC–UPQC is shown in Fig.2. It consists of three VSCs (VSC1, VSC2, and VSC3) which are connected back to back through a common dc-link capacitor. In the proposed configuration, VSC1 is connected in series with BUS1 and VSC2 is connected in parallel with load L1 at the end of Feeder1. VSC3 is connected in series with BUS2 at the Feeder2 end. Each of the three VSCs in Fig.3 is realized by a three-phase converter with a commutation reactor and high-pass output filter as shown in Fig.3.

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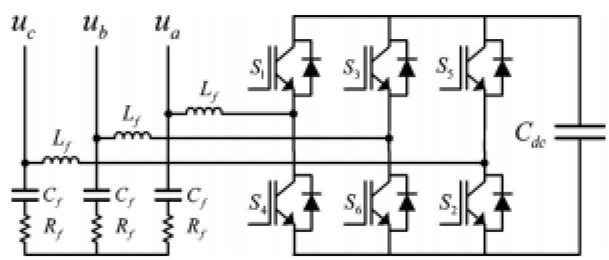


Fig 3 Schematic structure of a VSC

The commutation reactor (Lf)and high- pass output filter (Rf , Cf) connected to prevent the flow of switching harmonics into the power supply. As shown in Fig, all converters are supplied from a common dc-link capacitor and connected to the distribution system through a transformer. Secondary (distribution) sides of the series-connected transformers are directly connected in series with BUS1 and BUS2, and the secondary (distribution) side of the shunt-connected transformer is connected in parallel with load L1.

The aims of the MC-UPQC shown in Fig are:

1) To regulate the load voltage (ul1) against sag/swell and disturbances in the system to protect the nonlinear/sensitive load L1;

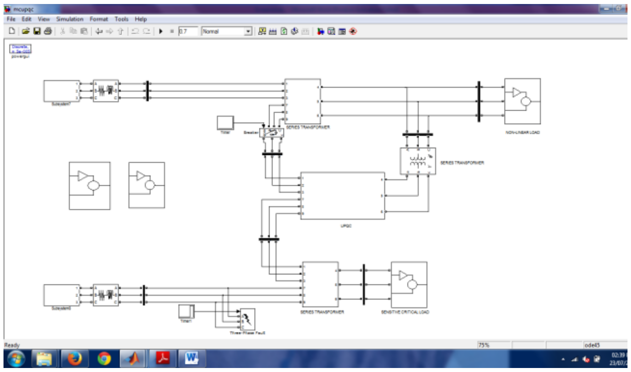
2) To regulate the load voltage ul2 against sag/swell, interruption, and disturbances in the system to protect the sensitive/ critical load L2;

3) To compensate for the reactive and harmonic components of nonlinear load current (il1). In order to achieve these goals, series VSCs (i.e., VSC1 and VSC3) operate as voltage controllers while the shunt VSC (i.e., VSC2) operates as a current controller.

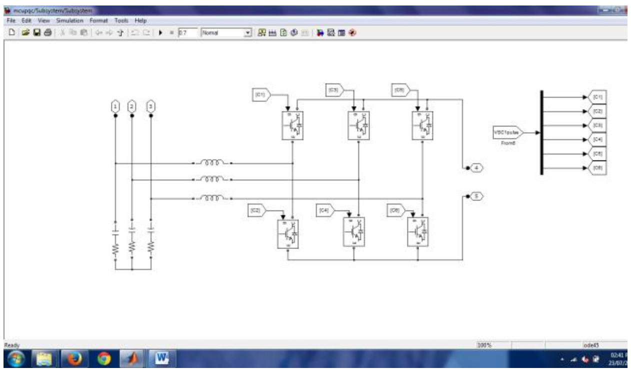
C. Control Strategy

As shown in Fig.4, the MC-UPQC consists of two series VSCs and one shunt VSC which are controlled independently. The switching control strategy for series VSCs and the shunt VSC are selected to be sinusoidal pulse width-modulation (SPWM) voltage control and hysteresis current control, respectively. Details of the control algorithm, which are based on the d–q method, will be discussed later. Shunt-VSC: Functions of the shunt-VSC are: 1) To compensate for the reactive component of load L1 current; 2) To compensate for the harmonic components of load L1 current; 3) To regulate the voltage of the common dc-link capacitor.

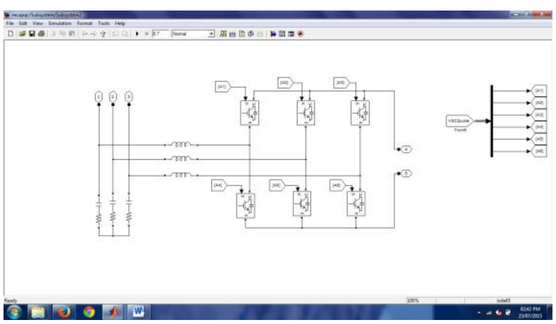
MULTI CONVERTER UNIFIED POWER QUALITY CONDITIONER



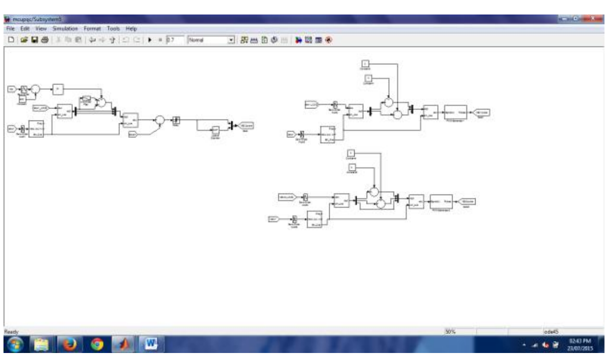
Shunt Converter



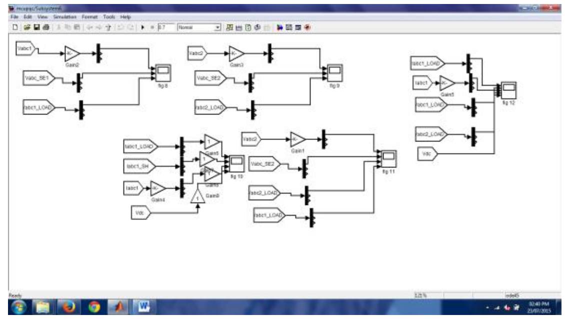
Series Converter



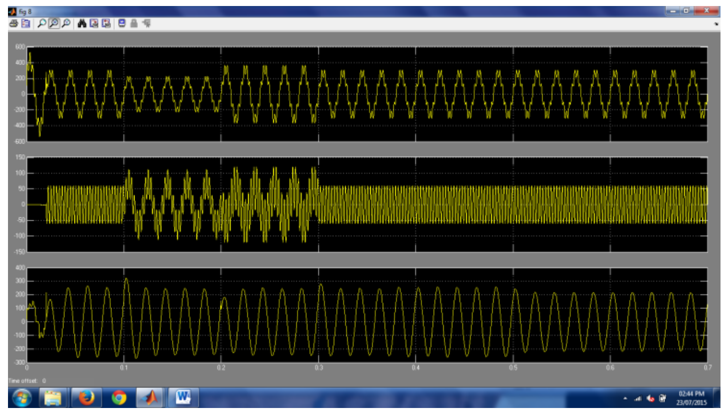
Controller



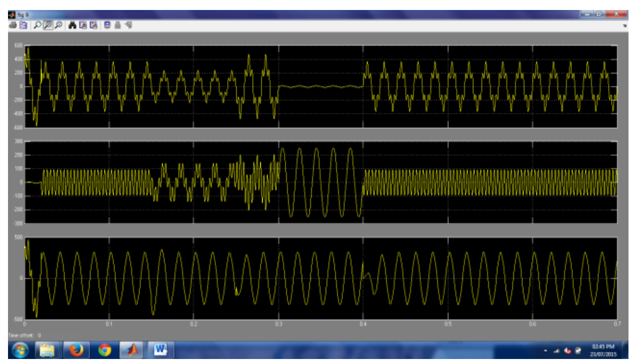
Output Subsystem



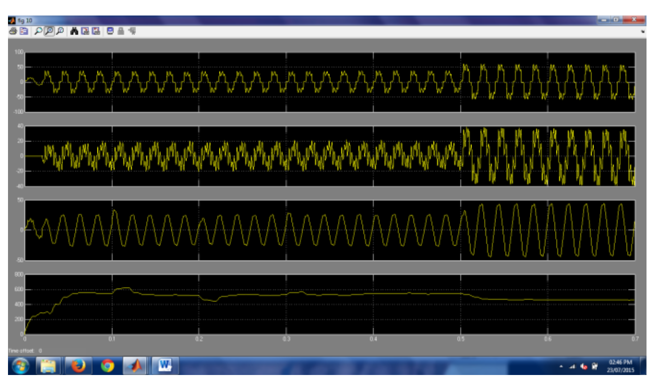
Input, Injected and Output Voltages at Bus-1



Input, Injected and Load Voltages at Bus-2



Input, Injected and Load Currents at Shunt Converter



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CONCLUSION

In this paper, a new configuration for simultaneous compensation of voltage and current in adjacent feeders has been proposed. The new configuration is named multi-converter unified power-quality conditioner (MC-UPQC). Compared to a conventional UPQC, the proposed topology is capable of fully protecting critical and sensitive loads against distortions, sags/swell, and interruption in two-feeder systems. The idea can be theoretically extended to multibus / multifeeder systems by adding more series VSCs. The performance of the MCUPQC is evaluated under various disturbance conditions and it is shown that the proposed MCUPQC offers the following advantages: 1) Power transfer between two adjacent feeders for sag/swell and interruption compensation; 2) Compensation for interruptions without the need for a battery storage system. 3) Sharing power compensation capabilities between two adjacent feeders which are not connected.

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