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Review on comparative analysis of VSI and CSI configuration based UPQC device

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Abstract: Varieties of power conditioning techniques are in use starting from passive filtering to active power conditioning to improve the power quality. Among different new technical options available to improve power quality, Unified Power Quality Conditioner (UPQC) has found to be more promising. It provides an important and flexible alternative to compensate both current as well as voltage disturbances simultaneously by a single unit. It is generally configured with two bi-directional converters connected back to back through an energy storage device. Since its development VSI based UPQC was in use due to its compact size, flexibility to extend multilevel. Different configuration principle of operation and control of VSI based UPQC is discussed in this project. With the availability of new IGBT with reverse blocking capability the use of current source active filters is increasing due to its inbuilt short circuit protection capability, higher efficiency at low power loads, simple open loop current control and effective filtering of harmonics. A configuration and control aspect of current source active power filter is also discussed in this paper. Performance of CSI based UPQC is also presented to achieve the above objectives. In recent years Unified Power Quality conditioner (UPQC) is being used as universal active power conditioning device to mitigate both current as well as voltage harmonics in a polluted power system network. Both voltage source and current source inverter are in use for fabrication of UPQC. Current source UPQC has unique advantages over generalized voltage source UPQC. This paper presents a comparative analysis of voltage source and current source UPQC. A simple PI controller and robust hysteresis band PWM technique is used for derivation of reference and switching signals respectively. The resultant compensation system eliminates voltage as well as current harmonics with good dynamic response.

I. INTRODUCTION

The recent development in power electronics led to development of solid-state controllers, which are in use with industry, commercial and domestic sectors extensively. The quality of power is being deteriorated due to use of these electronic controllers, which in turn demands quality power from source. Varieties of power conditioning techniques are in use starting from passive filtering to active power conditioning. Among different new technical options available to improve power quality, Unified Power Quality Conditioner (UPQC) has found to be more promising. It provides an important and flexible alternative to compensate both current as well as voltage disturbances simultaneously

by a single unit. It is generally configured with two bi-directional converters connected back to back through an energy storage device. A configuration and control aspect of current source active power filter is also discussed in this paper. Performance of CSI based UPQC is also presented to achieve the above objectives. In recent years Unified Power Quality conditioner (UPQC) is being used as universal active power conditioning device to mitigate both current as well as voltage harmonics in a polluted power system network. Both voltage source and current source inverter are in use for fabrication of UPQC. Current source UPQC has unique advantages over generalized voltage source UPQC. This project presents a comparative analysis of voltage source and current source UPQC. With the availability of new IGBT with reverse blocking capability, the use of current source active filters is increasing due to its inbuilt short circuit protection capability, higher efficiency at low power loads, simple open loop current control and effective filtering of harmonics A simple PI controller and robust hysteresis band PWM technique is used for derivation of reference and switching signals respectively. The resultant compensation system eliminates voltage as well as current harmonics with good dynamic response.

II. UPQC WORKING

Unified Power Quality Conditioner comprises of two bidirectional converters connected back to back through an energy storage element as shown in fig.1. The generalized UPQC consists of both series and shunt (Voltage /Current) compensation elements. Each element consists of a bidirectional switch to accommodate for voltage or current conversion as per requirement. One of bidirectional converter is connected to system bus in series through a transformer termed as series active filter. It is controlled as voltage generator.

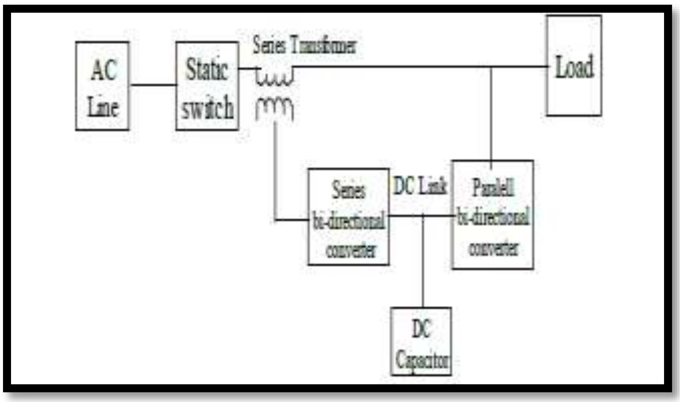

Fig.1. Conceptual diagram of UPQC [1]

It has capability of voltage imbalance compensation, voltage regulation and harmonic compensation at the utility-consumer point of common coupling (PCC). In addition to this, it provides harmonic isolation between a sub transmission system and a distribution system. Another bidirectional converter is connected in parallel with load to the system bus called shunt active filter. It is controlled as a current generator. It absorb current harmonics, compensate for reactive power and negative sequence current injected by the load. Third element of this power line conditioner is an energy storage device. These bidirectional switches may be of Voltage Source Inverter (VSI) based or Current Source Inverter (CSI) based. Each type of switch is having its own merits and demerits. In current source based UPQC a large inductor is used as a DC link. This dc link will function as DC sources and hence does not demand any external power source. However in order to maintain constant DC current/ voltage in the energy storage element a small fundamental current is drawn to compensate active filter losses.

III. VSI BASED UPQC

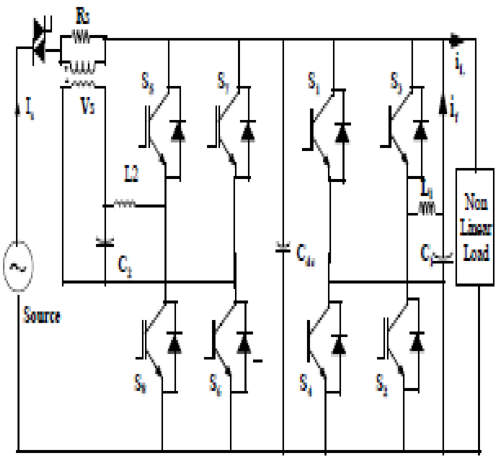

Fig.2. Schematic diagram of VSI based UPQC

A VSI based UPQC is built with two bridges of IGBT switches with anti parallel diode connected back to back with a dc capacitor as energy storage device as shown in fig 2. The inductor Lf through which the inverter is connected to power supply network via series transformer, ensures firstly the controllability of the active filter currents and secondly act as first order passive filter attenuating the high frequency ripples generated by the inverter. This filter may also be formed with third order (LCL) type. The voltage of dc capacitor used as energy storage device should be so high that the filter currents can be controlled to draw the load current harmonics through the supply filter. The theoretical minimum value for the voltage is the peak of the supply line-to-line voltage.

IV. CSI BASED UPQC

A CSI based UPQC is built with two bridges of IGBT switches connected back to back through an inductor of sufficiently large value as shown in fig.3. The series filter is connected to AC mains supply through a series transformer of suitable rating and a second order low pass filter formed by Cf and Lf. The size of filter capacitor must be selected carefully to make sure that no low-order harmonics are close to the resonant frequency of the LC tank circuit.

The switches are under bidirectional voltage stress and maximum values of these are the peak value of the supply line –to-line voltage. A Fast Recovery Diode of similar rating is required to connect in series with each switch as to limit reverse voltage blocking. The use of series diode can be avoided by using reverse blocking IGBT.

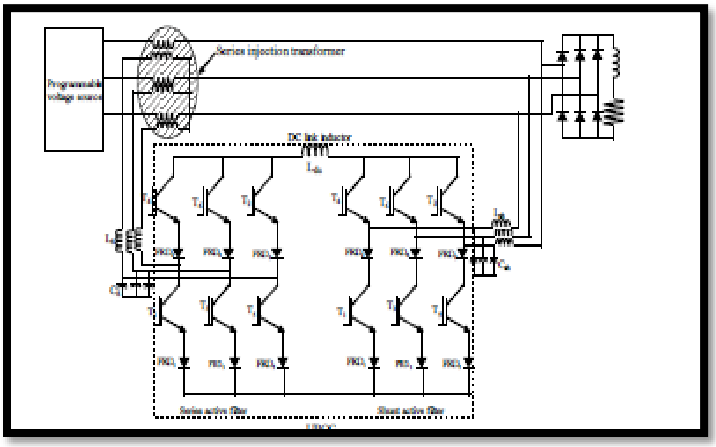

Fig. 3 Schematic diagram of CSI based UPQC

V. MATLAB SIMULATION AND RESULTS

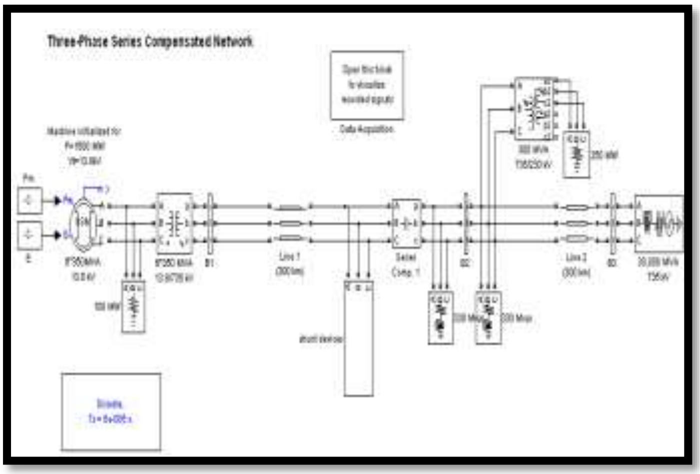

Fig 4-matlab model of three phase series compensated network

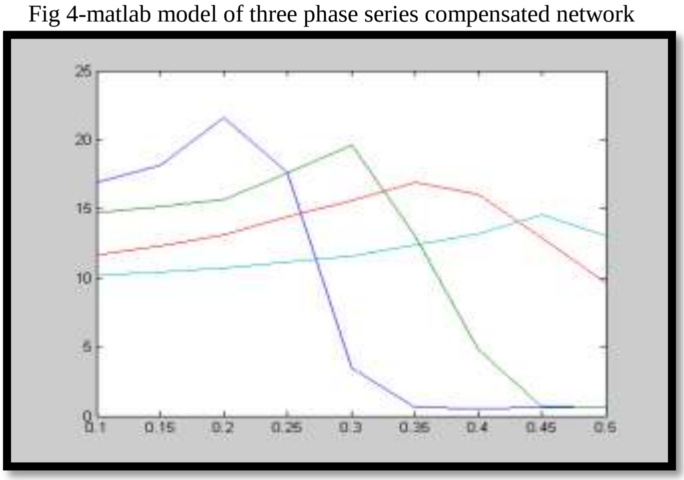

Fig.5- Variation in maximum RE power for diff. value of %S

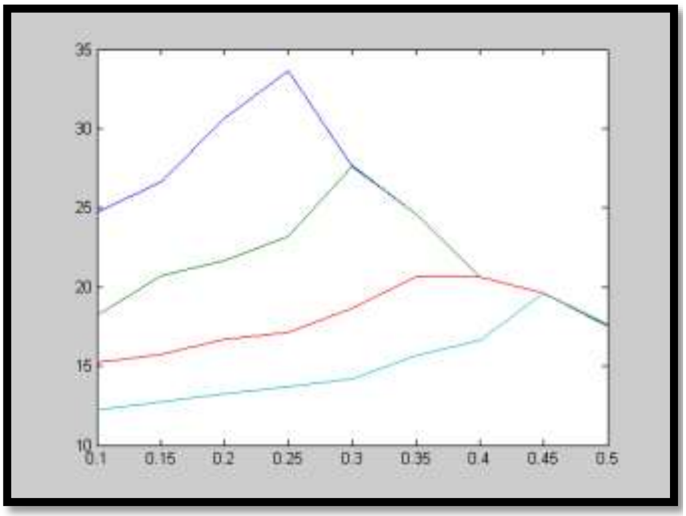

Fig.6- Variation in maximum SE power for diff. value of %S

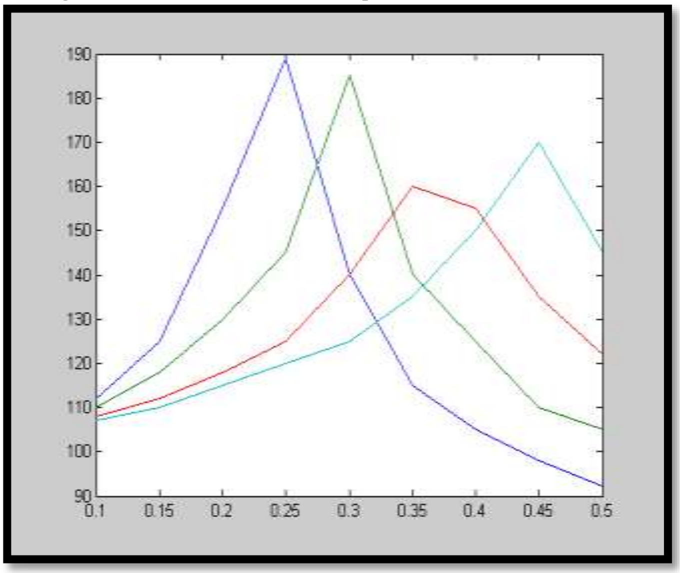

Fig.7- Variation in transmission angle at the max. SE power for diff. %S

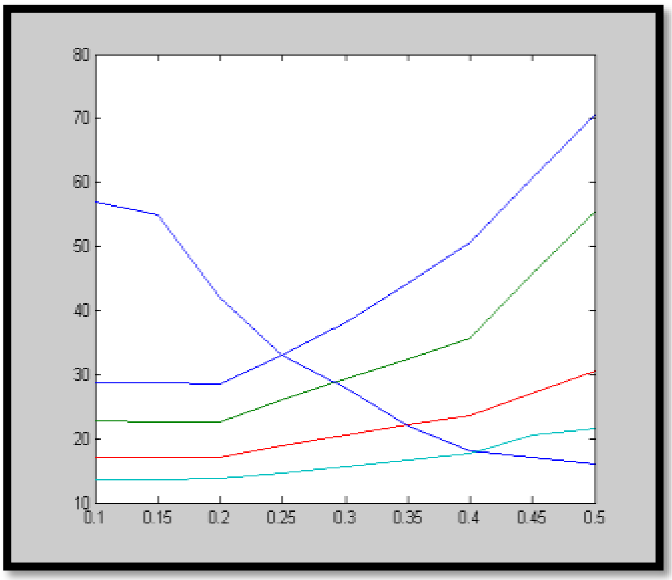

Fig.8-Variation in the maximum RE power of section-1 and SE power of section-2 against k for diff. value of %S

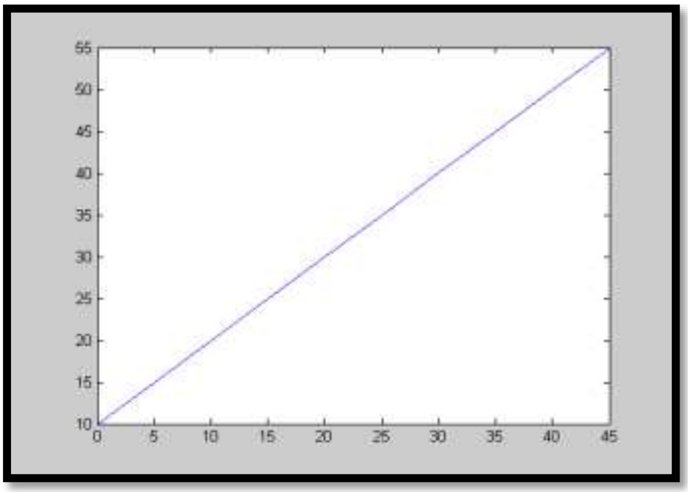

Fig.9- Variation in the optimal off-center location of shunt FACTS device against degree of compensation of line (%S)

Simulation Results

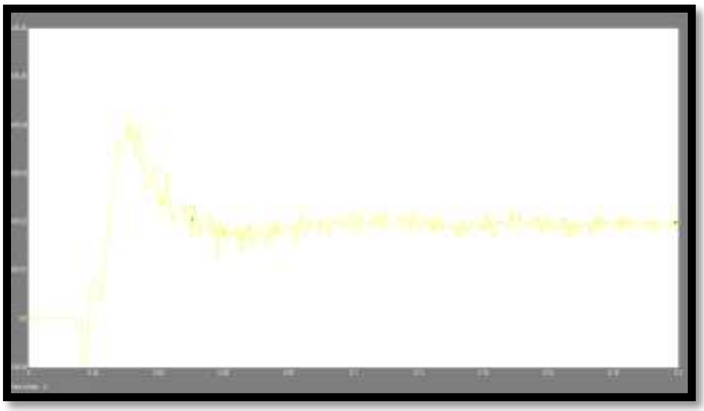

Fig 10- Simulation Results of 3-phase voltage Vabc

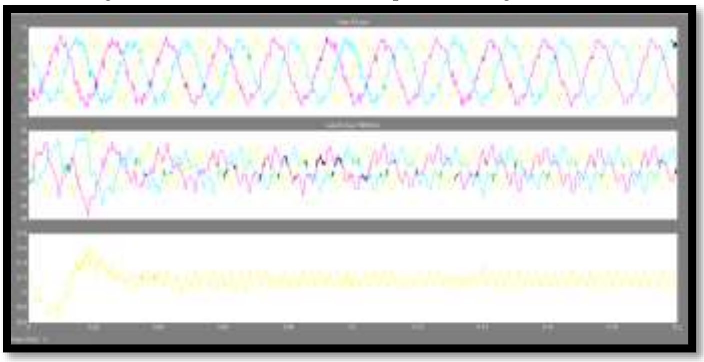

Fig 11 -Vabc, Iabc, Real and Reactive power (Case-I)

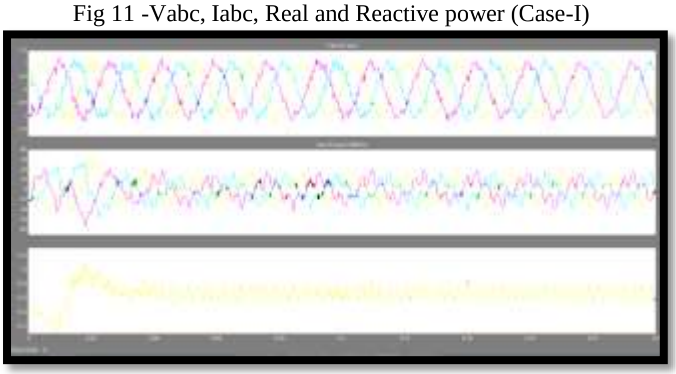

Fig 12-Vabc, Iabc, Real and Reactive power (Case-II)

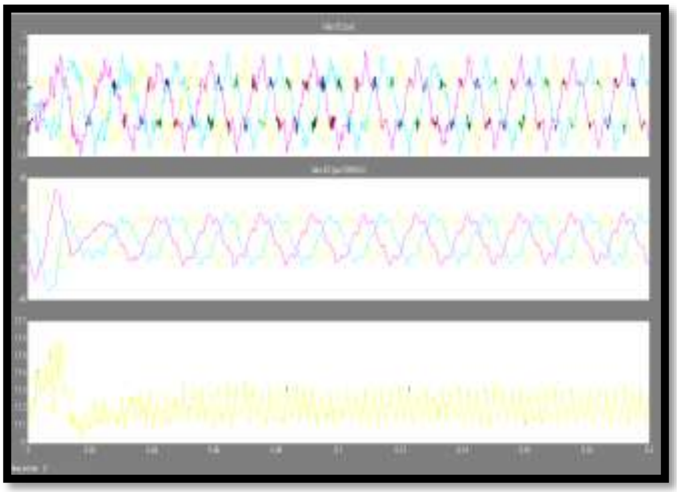

Fig 13-Vabc, Iabc, Real and Reactive power (Case-III)

VI. CONCLUSIONS

In this paper a UPQC configuration employing an LCL input filter at the front end of shunt VSI and CSI has been proposed to mitigate voltage and current related PQ problems. Performance of the proposed UPQC, with the detailed design procedure for the series and shunt passive filter, has been compared with the conventional UPQC. Proposed UPQC has provided better current and voltage compensation with improved ripple attenuation capability while using reduced passive components. Moreover, appropriate reduction in common dc link voltage is also achieved. The three phase system with UPQC and distortion in waveform has been shown in the Matlab simulation results.

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