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Unified Power Quality Conditioner: A Review

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ABSTRACT

During Last decade power quality problems has become more complex at all level of power system. Recently, the Power electronics controllers are gaining concern to provide the quality of power for both power suppliers and consumers. Various power filtering technology i.e. passive filters, active power filters, hybrid filters have applied from time to time for giving the solution of power quality problems to users, But could not fully satisfied them. Now day's a new concept of custom power is used for customers' satisfaction. The aim of a unified power quality conditioner (UPQC) that consists of series active and shunt active filters is to compensate for supply voltage flicker/imbalance, reactive power, negative sequence current and harmonics.

Keywords: Unified Power Quality Conditioner (UPQC)

I. INTRODUCTION

The UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. The UPQC, therefore, is expected to be one of the most powerful solutions to large capacity loads sensitive to supply voltage flicker/imbalance The UPQC can be divided into two parts i.e. general UPQC, for power distribution systems and industrial power systems; and specific UPQC for a supply voltage flicker/imbalance sensitive load, which is installed by electric power consumers on their own premises.[1] . In UPQC the series active power filter |eliminates supply voltage flicker/imbalance from the load terminal voltage and forces an existing shunt passive filter to absorb all the current harmonics produced by a nonlinear load. Elimination of supply voltage flicker, however, is accompanied by low frequency fluctuation of active power flowing into or out of series active filter. As the name suggests, the series-shunt active filter is a combination of series active filter and shunt active filter. The topology is shown in Fig 1. The shunt-active filter is located at the load side and can be used to compensate for the load harmonics. On the other hand, the series portion is at the source side and can act as a harmonic blocking filter[2]. This topology is called as Unified Power Quality Conditioner. The series portion compensates for supply voltage harmonics and voltage unbalances, acts as a harmonic blocking filter and damps power system oscillations. The shunt portion compensates load current harmonics, reactive power and load current unbalances.

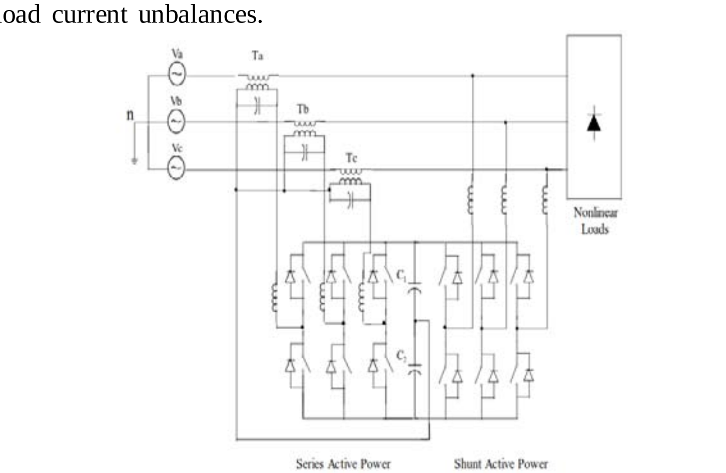

Fig-1 Unified Power Quality Conditioner Topology

II. SPECIFIC UPQC

Fig 3. shows the configuration of a specific UPQC. The aim of specific UPQC is not only to compensate for the current harmonics, but also to eliminate the voltage flicker/imbalance contained in the receiving terminal voltage V_R from the load terminal voltage VL.

The receiving terminal in fig 2. is often corresponding to the utility-consumer point of common coupling in high power applications. The operation of series active filter greatly forces all the current harmonics produced by the load into an existing shunt passive filter. It also has the capability of damping series/parallel resonance between the supply impedance and the shunt passive filter.

The shunt active filter is connected in parallel to the supply by the step up transformer. The only objective of the shunt active filter is to regulate the dc link voltage between both active filters.[3]

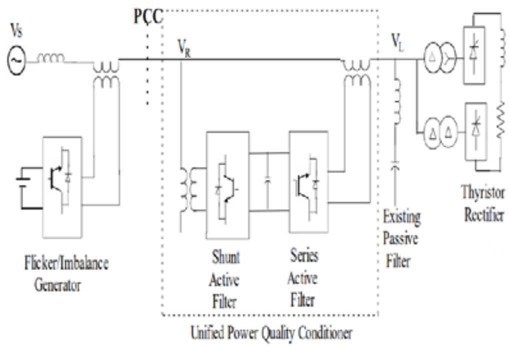

Fig-2 specific UPQC

Thus, the dc link is kept at a constant voltage even when a large amount of active power is flowing into or out of the series active filter during the flicker compensation. Although the shunt active filter has the capability of reactive power compensation, the shunt active filter in fig 3 provides no reactive power compensation in order to achieve the minimum required rating of the shunt active filter[3]. There is noticeable difference in the installation point of shunt active filters of figures 1. and 3. The reason is as follows: In fig 1., the shunt active filter compensates for all the current harmonics produced by nonlinear loads downstream of the PCC. Therefore, it should be connected downstream of the series active filter acting as a high resistor for harmonic frequencies. In fig 3., the shunt active filter draws or injects the active power fluctuating at a low frequency from or into the supply, while the existing shunt passive filter absorbs the current harmonics. To avoid the interference between the shunt active and passive filters, the shunt active filter should be connected upstream of the series active filter.

III. BASIC CONFIGURATION OF UPQC

Fig 3. shows the basic configuration of a general UPQC consisting of the combination of a series active and shunt active filter. The main purpose of the series active filter is harmonic isolation between a sub transmission system and a distribution system. In addition the series active filter has the capability of voltage flicker/imbalance compensation as well as voltage regulation and

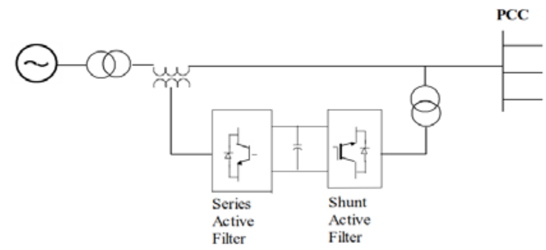

Fig-3 General UPQC

Harmonic compensation at the utility-consumer point of common coupling (PCC). The main purpose of the shunt active filter is to absorb current harmonics, compensate for reactive power and negative sequence current, and regulate the dc link voltage between both active filters.

IV. PROPOSED UPQC OPERATING PRINCIPLE

Distorted voltages in a 3-phase system may contain negative phase sequence, zero phase sequence as well as harmonic components. The voltage of phase "a" can be expressed as,in general

$$v_a = v_{1pa} + v_{1na} + v_{1oa} + \sum V_{ka}\sin(kwt + \theta_{ka})$$

Where, v_{1pa} is the fundamental frequency‘s positive sequence component while v_{1na} and v_{1oa} is the negative and zero sequence components.

V. MATHEMATICAL MODELING UPQC

In this study, the power supply is assumed to be a three-phase, three-wire system. The two active filters are composed of two 3-leg voltage source inverters (VSI). Functionally, the series filter is used to compensate for the voltage distortions while the shunt filter is needed to provide reactive power and counteract the harmonic current injected by the load. Also, the voltage of the DC link capacitor is controlled to a desired value by the shunt active filter. There can be negative and zero sequence components in the supply when a voltage disturbance occurs. The DC link capacitor bank is divided into two groups connected in series. The neutrals of the secondary of both transformers are directly connected to the dc link midpoint. In this way, as the connection of both three- phase transformers is Y/Yo, zero sequence voltage appears in the primary winding of the series connected transformer in order to compensate for the zero sequence voltage of the supply system. No zero sequence current flows in the primary side of both transformers. It ensures the system current to be balanced when the voltage disturbance occurs[5]. Assuming that the load is non-linear, the power system model considered can be divided into following units: the power supply system, series active filter and shunt active filter. These constituent members of the UPQC are modeled separately in this section. These constituent members of the UPQC are modeled separately in this section. First consider the power supply system. By Kirchhoff‘s law.

$$v_{if} = e_i - L_s \frac{di_{is}}{dt} - R_s i_{is} - v_{sh}$$

$$i_{is} = i_{iL} - i_{ih}$$

Where, subscript i refers to a, b and c phases in the power system; L_s and R_s are the inductance and resistance of the transmission line; e_i is source voltage; v_{ih} is the output voltage of the series active filter; i_{is} is the line current; i_{iL} is the load current and i_{is} is the output current of the shunt of the shunt active filter respectively[6].

VI. DESIGN OF DC-LINK BUS CAPACITOR VOLTAGE

The dc-link capacitor is divided into two units connected in series, c_l and c_2. The voltages v_{cl} and v_{c2} are such that v_{cl} = -v_{c2} under balanced operating conditions. Usually, the DC link voltage is maintained at a desired value under all operating conditions. It can be shown that apart from the power loss due to line and winding resistances, a certain amount of power needs to be supplied to or absorbed by the capacitor to restore a voltage during a voltage disturbance For example, if voltage sag occurs in phase "a", v_{ah} is higher than the normal value; the dc-link capacitors will supply the power through the series active filter. In the proposed scheme, a PI controller is used to control the capacitor voltage[8].

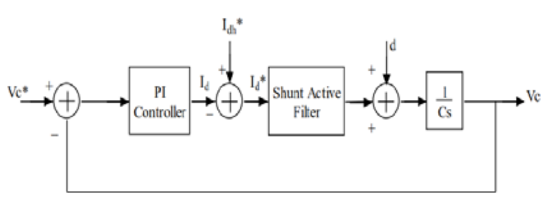

Fig. 5 Control scheme of Vc

Fig 5. shows the basic control scheme. The input to the PI controller is the error between the actual capacitor voltage and its desired value. The output of the PI controller is added to the reference current component in the d axis, i_d; to form the new reference current i_d*. It means that the power needed to charge the two capacitors comes from the active power of the power supply system. The shunt active filter acts like a regulator. Its currents are used to adjust the capacitor voltages to within a certain range. Here only one PI controller is used to control the two capacitor voltages. Although these voltages will not be symmetrical when the system is unbalanced, this is caused by the zero sequence current in the UPQC.

VII. IMPLEMENTATION OF THE PROPOSED UPQC ALGORITHM

The realization of the UPQC can be divided into two parts: circuit realization and control strategy. The topology circuit was shown in fig 3. The flow chart of control strategy is shown in fig 4.

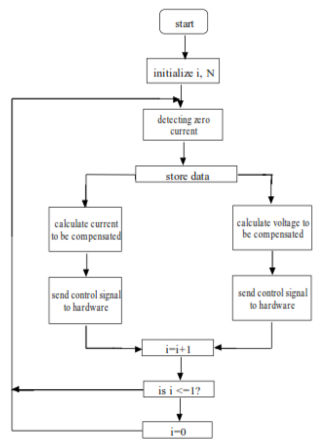

Fig. 4 Flow chart for control strategy of UPQC

VIII. APPLICATIONS

- Voltage sag and swell correction
- Voltage balancing
- Voltage regulation
- Flicker attenuation
- VAR compensation
- Harmonic suppression
- Current balancing
- Active and reactive power control[7]

IX. CONCLUSION

In this chapter the unified power conditioner (UPQC) has been discussed in detail. In this the Mathematical Modeling, Operating Principle and Control scheme of the UPQC have been discussed in detail. The simulation blocks and their respective results of shunt and series active power filters and unified power quality conditioner have been shown. A very simple hysteresis current controller based control technique with help of unit vector template is proposed for STATCOM. DVR is simulated with abc to dq0 base new control algorithm to generate the pulse Phase Locked Loop (PLL) is used to generate unit sinusoidal wave in phase with main voltage. The combination of shunt and series Fact devices test on the RL load and DC machine.

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