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Study of Constant Power Strategy for Series Controller and Sinusoidal Current Strategy for Shunt Controller in UPQC.

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Abstract:- In this paper a Unified Power Quality Conditioner(UPQC) has been presented for a non linear load in the distribution network. This UPQC is capable of compensating the constant active power requirement and sinusoidal source current requirements. In this topology one series and one shunt Voltage Source converter(VSC) are present. The performance and proposed control algorithm is being validated in MATLAB/SimPowerSystem toolbox.

Keywords:- Power Quality, UPQC, Shunt VSC, Series VSC

I. INTRODUCTION

The power transfer capability of the transmission line is generally constrained by the line impedances, operating voltages and currents. Now a days a change in power quality is affected by non linear loads and electronically switched devices is also a constraint. This has led evolvement of new technologies namely Flexible AC Transmission System and custom power devices.

The custom power device is collection of controllers, which when applied in the distribution network can control one or more interested parameters. They enable the transmission system to operate a little more optimally. The idea of FACTS or custom power device is to use power electronics for controlling the power flow in the transmission system.[1][2][3]

A. Unified Power Quality Conditioner

Active Power Filters(APF) such as shunt APF, series APF, hybrid APF unified power quality conditioner have made it possible to mitigate some of the power quality problems. The concept of shunt active filtering was first introduced by Gyugyi and Strycula 1976. Their controllers determine in real time the compensating current reference and force a power converter to synthesize it properly.

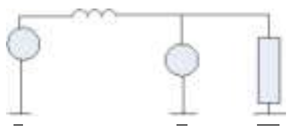

Fig.1 Basic Shunt Converter/Filter

Fig 1 summarizes the basic concept of shunt active filter. A non linear load draws a fundamental current I_{LF} and a harmonic curent I_{LH}. A shunt active filter can compensate the both harmonic current source and load. But for shunt connection the primary function is filtering the load harmonic current.

In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. Therefore, the UPQC is expected to be one of the most powerful solutions to large capacity loads sensitive to supply voltage flicker / imbalance. The UPQC consisting of the combination of a series active power filter (APF) and shunt APF can also compensate the voltage interruption if it has some energy storage or battery in the DC link. The shunt APF is usually connected across the loads to compensate for all current-related problems such as the reactive power compensation, power factor improvement, current harmonic, compensation, and load unbalance compensation, whereas the series APF is connected in a series with the line through series transformers. It acts as controlled voltage source and can compensate all voltage sources and can compensate all voltage related problems, such as voltage harmonics, voltage sag, voltage swell, flicker, etc. [3][4]

II. CONTROL STRATEGY

The UPQC consists of the two VSCs one connected in series and other connected in shunt which are controlled independently. The switching control strategy used for both is the sinusoidal pulse width modulation .

1. To have a constant active power to the load
2. To have sinusoidal source current.

A. Sinusoidal Current Strategy for Shunt Converter

The sinusoidal current control strategy is a compensation method that makes the active filter compensate the current of a non linear load to force the compensated source current to be sinusoidal and balanced. In order to make the compensated current to be sinusoidal and balanced, the shunt active filter should compensate all the harmonic components as well as fundamental component that differs from fundamental positive sequence current. The shunt control strategy is implemented with PWM current controlled voltage source inverter and connected to the point of common coupling for eliminate the current harmonic and make sinusoidal current to the source. The reference current(s) are extracted from sinusoidal current controller algorithm and PWM-VSI gate control signals are generated.

The block contains the Positive sequence voltage detector, PI controller, Clarke transformation, Instantaneous power calculation, Low pass filter (LPF), current calculation and Inverse Clarke transformation. The distorted or imbalanced voltage sources involved the fundamental positive sequence voltage detector which uses a PLL circuit locked to the fundamental frequency of the system voltages. It should synchronizing angle to generate unitary and balanced sinusoidal voltage signals. These instantaneous 3-phase coordinate voltages are transformed into the coordinates by using the Clarke transformation.

The instantaneous current on the coordinates of are divided into two kinds of instantaneous current components; first is real power loss and second is reactive power loss, this controller computed only the real power losses. The coordinate currents are calculated from the voltages with instantaneous real power and reactive power assume as zero. This approach is reduced the calculations and different from the conventional methods. The references of the compensating currents are calculated instantaneously without any time delay by using the instantaneous -coordinate currents. The desired references current derivate from the inverse Clarke transformation.[3][5][6]

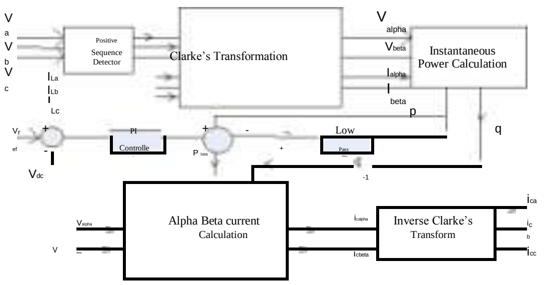

Fig..2 Overall Block Diagram for Shunt Converter

B. Equations Used in Shunt Converter

The pq theory can be thought as the projection of the phase quantities onto a stationary two-axis reference frame. The equations changes the quantities onto two axes separated 90 degrees apart. By applying Clarke's transform on the positive sequence components

$$\begin{bmatrix} u_0 \\ u_\alpha \\ u_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \cdot \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \cdot \begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} \quad ......(1)$$

$$p = v_{\alpha} i_{\alpha} + v_{\beta} i_{\beta} \quad ....(2)$$

$$q = v_{\alpha} i_{\beta} \quad ....(3)$$

C. Constant Power Strategy for Series Converter

Considering duality of its circuit a series active filter should be power electronics device that, in principle would block harmonic voltages in the load from appearing from source. In fact, this would be a dual device of a shunt active filter, the source is represented by a voltage source and load by a current source, including harmonic current that have to be compensated for the load current. Series active filter should generate harmonic voltage to cancel load harmonic voltages to cancel load harmonic voltages.

The series active filter power loss, includes the switching loss in the inverters and the copper loss in the coupling transformers. When there is voltage flicker, or the voltage is below the rated voltage, ac and dc active power is needed to draw from the series inverter to the load. The series inverter control calculates the reference voltage to be injected by the series inverter, comparing the positive-sequence component V_{abc} ' with the disturbed source voltage V_{sabc}.

The voltage compensation may involves supplying / absorbing real power from the supply line, so there must be real power balance between series and shunt inverters . The instantaneous real power absorbed/ delivered by the series inverter must be equal to the real power delivered / absorbed by the shunt inverter so as to maintain DC link capacitor voltage constant.

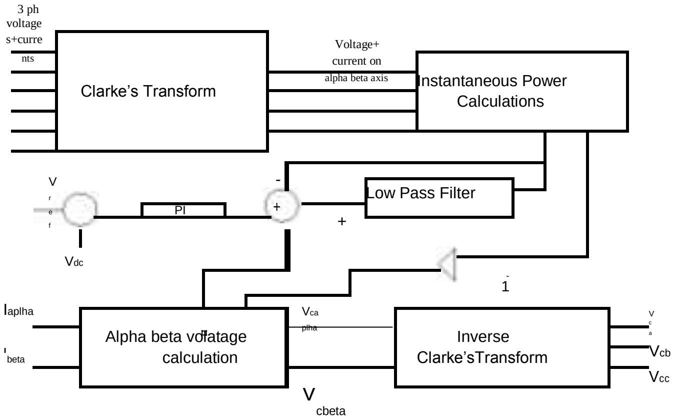

Fig.3 Series Converter Control

D. Equations Involved

By the duality of the pq theory the compensating reference signals for the series converter are generated by the following equations:

The relation between the load source and compensating voltages which governs all the control strategy the dual relation for the power calculations:

III. SIMULATION AND RESULTS

In the MATLAB simulation a 415 V three phase programmable AC voltage source has been used, wherein 3rd order harmonics are also being introduced. There are four voltage and current measurement tool boxes from Sim Power System library. The series converter has been applied with constant power control and shunt with sinusoidal source current strategy. The non linear load has been realised through the inbuilt universal bridge acting as thyristor rectifier gated through the synchronised 6 pulse generator with a firing angle of 30 degrees.

The instantaneous oscillating active and reactive powers needs to be compensated for the source current to become sinusoidal. Along with these compensation reactive power also needs to be compensated for a constant active power supply to the load.[3]

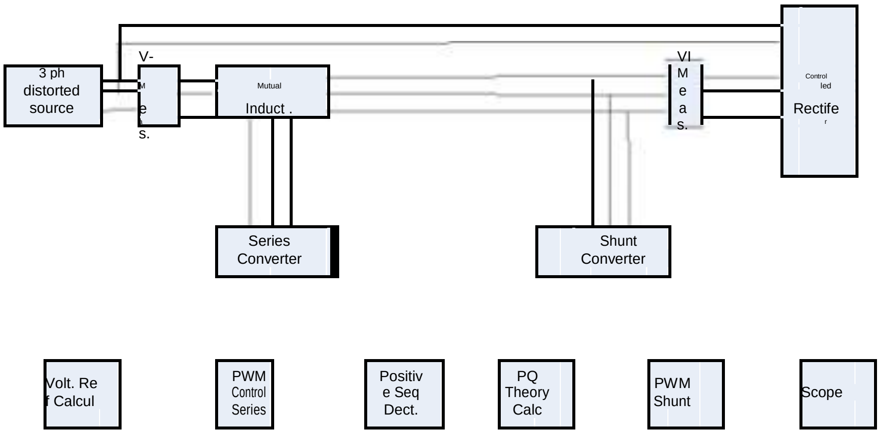

Fig.4 MATLAB model

The preliminary results obtained are shown in the graphs below through saving them in the workspace and then plotted in the workspace.

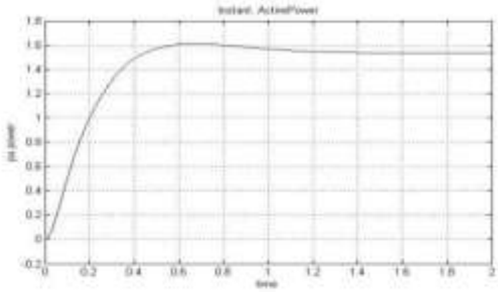

Fig. 5 Constant Instantaneous Active Power

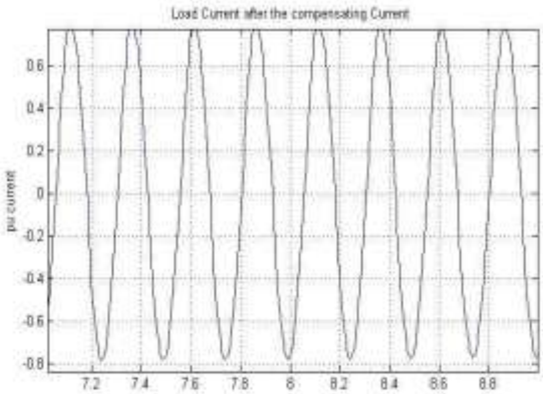

Fig. 6 Load current free from harmonics

IV. CONCLUSIONS

Through the compensation of the oscillating components of the active and reactive power the two objective of constant power and sinusoidal current are achieved fairly. The issue of voltage sag needs to be addressed with minor changes in the series control strategy.

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REFERENCES

[1]. Sankaran, C. Power quality. CRC press, 2001.

[2]. Dugan, Roger C., Mark F. McGranaghan, and H. Wayne Beaty. "Electrical power systems quality." New York, NY: McGraw-Hill,| c1996 1 (1996).

[3]. Akagi, Hirofumi, Edson Hirokazu Watanabe, and Mauricio Aredes. Instantaneous power theory and applications to power conditioning. Vol. 31. John Wiley & Sons, 2007.

[4]. Fuchs, Ewald, and Mohammad AS Masoum. Power quality in power systems and electrical machines. Academic press, 2011.

[5]. Khadkikar, Vinod. "Enhancing electric power quality using UPQC: a comprehensive overview." Power Electronics, IEEE Transactions on 27.5 (2012): 2284-2297.

[6]. Khadkikar, Vinod, and Ambrish Chandra. "Control of single-phase UPQC in synchronous dq reference frame." Harmonics and Quality of Power (ICHQP), 2012 IEEE 15th International Conference on. IEEE, 2012.