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A Modified iUPQC Controller to Increase Power Quality of Power Distribution System

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***Abstract-* This paper deals with an improved Unified Power Quality Conditioner (iUPQC), for power factor compensation, voltage and current harmonics compensation, voltage sag and swell compensation, grid side bus voltage regulation and load bus voltage regulation for the combinations of linear and non-linear loads. The iUPQC will work as both STATCOM and conventional UPQC compensation, at the grid side and at the load side respectively. The iUPQC controller composes of PLL and PWM controller which is used for generating reference signal for shunt converter and also the Proportional Integral Derivative controller (PID) which is used for generating reference signal for series converter.**

***Keywords-* iUPQC, Microgrids, Power quality, STATCOM, Unified Power Quality Conditioner (UPQC), PID**

INTRODUCTION

CERTAINLY, power-electronics devices have caused great technological enhancements. However, the increasing variety of power-electronics driven loads used generally within the industry has caused uncommon power quality problems. In distinction, power-electronics driven loads generally need ideal sinusoidal supply voltage so as to function properly, whereas they are the foremost responsible ones for abnormal harmonic currents level within the distribution system. In this situation, devices that may mitigate these drawbacks are developed over the years. The number of the solutions involve a versatile compensator, known as the Unified power quality conditioner (UPQC) and the static synchronous compensator(STATCOM).

The power circuit of a UPQC consists of a compound of a shunt active filter and a series active filter connected in a back-to-back configuration. this combination permits the simultaneous compensation of the load current and the supply voltage, in order that the balanced and sinusoidal compensated current drawn from the grid and the compensated supply voltage delivered to the load. The dual topology of the Unified Power Quality Conditioner, the shunt active filter behaves as an ac-voltage source and the series one as an ac-current source, both at the fundamental frequency.

This is for the better design the control gains, as well as to optimize the LCL filter of the power converters, which permits improving significantly the overall performance of the compensator. The Static Synchronous Compensator (STATCOM) has been widely used in transmission networks to control the voltage by means of dynamic reactive-power compensation. Nowadays, the STATCOM is basically used for voltage regulation, whereas the UPQC and the iUPQC are selected as solution for a lot of specific applications. By connection of the extra functionality like a STATCOM within the iUPQC device, a wider state of affairs of applications will be reached, significantly in case of distributed generation in smart grids and as the coupling device in grid-tied microgrids.

The main difference between the iUPQC and UPQC is that the kind of source emulated by the series and shunt power converters. within the UPQC approach, the series converter is controlled as a non sinusoidal voltage source and therefore the shunt one as a non sinusoidal current source. On the other hand, in the iUPQC approach the series converter behaves as controlled, sinusoidal, current source and the shunt converter as a controlled, sinusoidal, voltage source. This means it's not necessary to work out the harmonic voltage and current to be compensated, since the harmonic voltages seem naturally across the series current source and also the harmonic currents flow naturally into the shunt voltage source.

When the switching frequency increases in actual power converters, the power rate capability is reduced. Therefore the iUPQC offers better solutions compared to the UPQC in case of high power applications. Since the iUPQC compensating references are pure sinusoidal waveforms at the fundamental frequency. Furthermore, the UPQC has higher switching losses due to its higher switching frequency. This improved version of iUPQC controller includes all functionalities of UPQC including the voltage regulation at the load side bus, and also providing voltage regulation at the grid side bus, like a STATCOM to the grid.

METHODOLOGY

For understanding the applicability of the improved iUPQC controller. An electrical system with two buses, bus A and bus B. Bus A of the power system, supplies sensitive loads and serve up point of coupling of a microgrid. At bus B non- linear loads are connected, which requires premium quality power supply, is a bus of the microgrid. The voltages at bus A and bus B should be regulated in order to supply properly the sensitive loads and the non-linear loads. If using a STATCOM, it gives only voltage regulation at bus A not mitigate harmonic currents drawn by the non-linear loads. On the other hand, if using UPQC between bus A and bus B, it can only compensate the harmonic currents of the non-linear loads and compensate the voltage at bus B, but it cannot regulate the voltage at bus A. Hence, to accomplish all the desired goals, a STATCOM at bus A and a UPQC between bus A and B should be employed. However the cost of this solution would be excessive.

An attractive solution is the use of a modified iUPQC controller to provide beside all those functionalities of this equipment and also reactive power support to the bus A. The modified iUPQC can provide the following functionalities:-

a) It controls the energy and power flow between the grid and the microgrid.
b) It provides voltage/frequency support at bus B of the microgrid.
c) It provides reactive power support at bus A of the power system.
d) It provides harmonic voltage and current isolation between bus A and bus B.

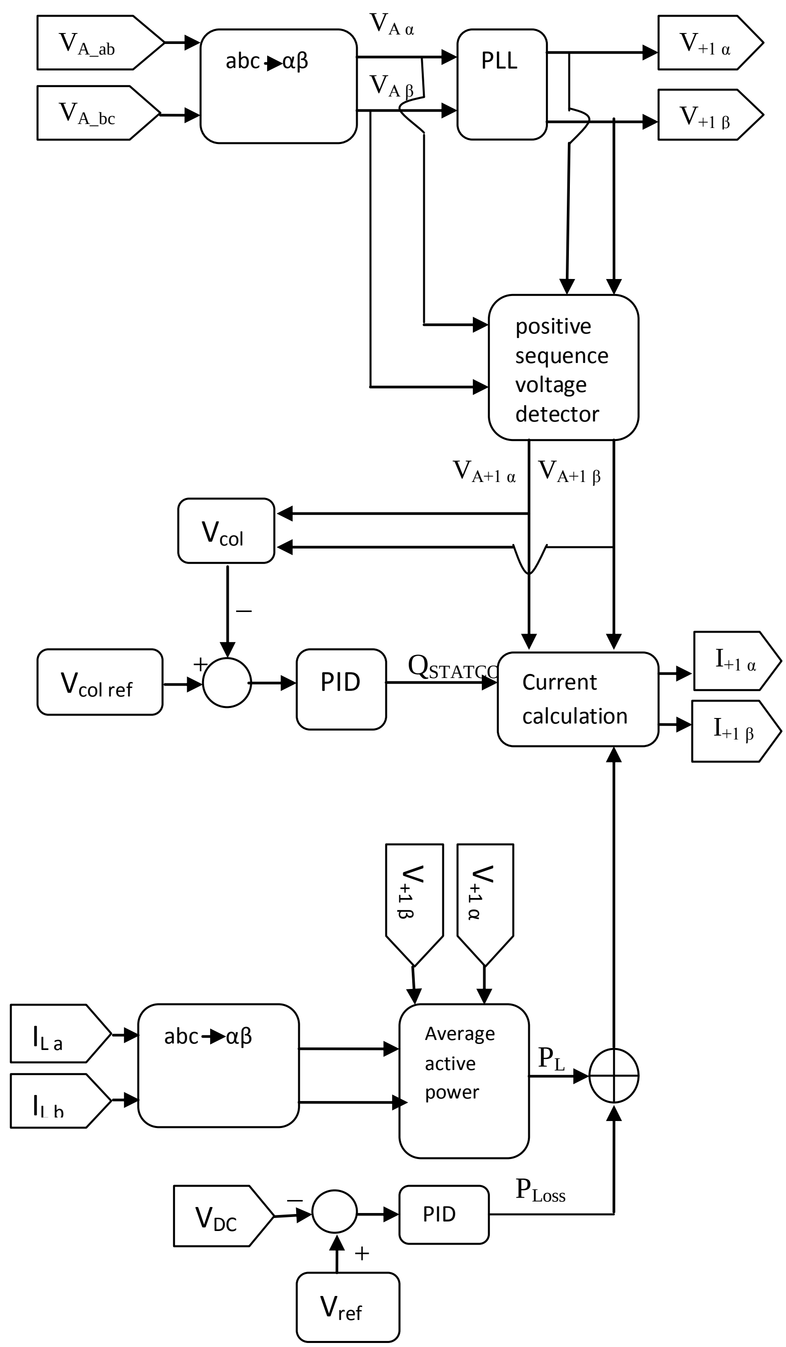

Fig 1: iUPQC Controller

e) It provides "smart" circuit breaker as an intertie between the grid and the microgrid.

f) It provides voltage and current imbalance compensation.

The shunt converter inflicts a controlled, sinusoidal voltage at bus B, which represents the above mentioned functionality (b). Whereas, the series converter of a conventional iUPQC uses only an active power control variable , p, for synthesize a fundamental, sinusoidal current drawn from the bus A, compatible with the active power demanded by bus B. In the case of the DC link of the iUPQC has no large energy storage system, the control variable p also attend as an additional active power reference to the series converter to maintain the energy inside the dc link of the iUPQC balanced. The voltages at bus A and B, the current demanded by bus B, I_L and the voltage V_{DC} of the common dc link are the inputs of the controller. The shunt voltage reference and the series current reference are the outputs of the controller.

The clark transformation is used to the measured variables for calculating the grid voltage in αβ-reference frame. The Phase-Locked-Loop (PLL) outputs sent to the PWM controller. Since the modified iUPQC can regulate the grid voltage, therefore both the buses will be regulated independently to obtain their reference values. The current drawn from the grid bus is synthesized by the series converter. In the iUPQC approach, this current is calculated by adding the average active power required by the loads P_L, and the power loss $P_{Loss.}$ The load active power can be calculated by:

$$P_L = V_{+1\,\alpha} * i_{L\,\alpha} + V_{+1\,\beta} * i_{L\,\beta}$$

Where $i_{L\,\alpha}$, $i_{L\,\beta}$ are the load currents and $V_{+1\,\alpha}$, $V_{+1\,\beta}$ are the voltage references for the shunt converter. The average active power (P_L) is obtained by a low pass filter.

For determining the power loss signal P_{Loss} , a PID controller is used. It gives signal P_{Loss} by comparing the measured dc voltage V_{DC} with its reference value. An additional control loop is used to provide the voltage regulation at the grid bus like a STATCOM. It is represented by the control signal $Q_{STATCOM}$. This control signal is obtained by the PID controller. The input of this controller is the error between the reference value and actual aggregate voltage of the grid bus. Fig.1 represents the iUPQC controller, which shows the working of iUPQC.

CONCLUSION

The main advantages of the iUPQC are power quality improvements like power factor correction, voltage and current harmonics mitigation, voltage sag and swell compensation, voltage regulation. The iUPQC keeps clear the disturbances which affects the system, by natural disturbance mitigation. Since the iUPQC provides grid voltage regulation, therefore it reduces the inner loop circulating power inside the iUPQC, this is another power quality compensation feature. The performance of iUPQC can be further improved by using better controller in place of PID controller.

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