Design of UPQC with constant frequency controlled scheme for removal of Total Harmonic Distortion

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ABSTRACT

Harmonics presence is one of the major power quality problems in the today's power system. It is regarded that the utility should ideally provide a balanced and pure sinusoidal three-phase voltage of constant amplitude to the loads. But with the great use of nonlinear. Loads power distribution system is getting polluted by harmonic distortion and reactive power disturbances. There are various topologies of APFs, one of them is Unified power Quality Conditioner which has two inverters that uses same dc link. In this work a three-phase-three wire UPQC, is proposed for harmonic compensation at point of common coupling (PCC) which are present due to the presence of generated signal produced using synchronous reference frame theory. While the gating signals were generated using Adaptive Hysteresis Band Current Controller. Conventionally hysteresis band current controller was used for generating the gating signal, for its improved stability, fast transient response, simple implementation & higher accuracy in current tracking of non-linear load. But with the limitation of fixed hysteresis band, made the switching frequency varying which caused acoustic noise and difficulty in designing input power filters generated using synchronous reference frame theory. In this work, an Adaptive Hysteresis band Current Controller (AHCC) has been proposed which maintains the switching frequency approximately constant.

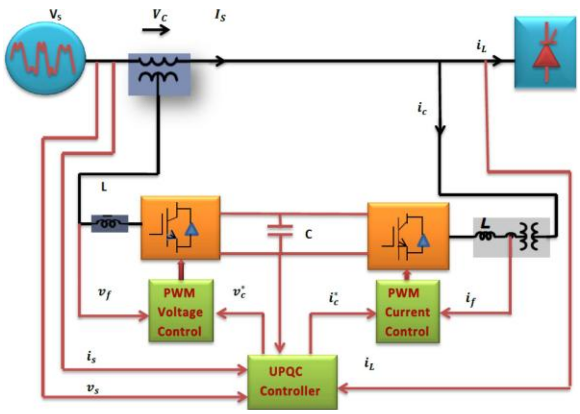
Keywords- *Active power filter (APF), harmonics, power quality (PQ), synchronous reference,adaptive hysteresis band current controller frame (SRF),THD, point of common coupling.*

I. INTRODUCTION

The reliability of the power supply delivered by the utilities varies considerably, and depend on a number of factor like lightning, large switching load, nonlinear load stresses or accident can disrupt the electric power grid. Primarily the infrastructure of grid was designed to serve "analog electric device" like lights or motors. Passive filter have been conventionally used to eliminate current harmonics and improve the power factor, but not without their disadvantages. The filtering characteristic of the passive filter is strongly affected by the system impedance that may create series or parallel resonance causing amplification of harmonic voltage or current at a specific frequency. They have the limitations of fixed compensation and large size. In this work SRF based controller for the UPQC, which mainly compensate the reactive power along with voltage and current harmonics of a nonlinear load is implemented. Conventional methods require the measurement of load current, source current, DC link voltage and filter current for shunt APF and source and injection transformer voltage for the series APF. The proposed control strategy based on sensing source current, source voltage, DC link voltage and voltage across PCC, so that the numbers of current measurements are reduced and the system performance is improved. This design may be best and unified and controlled approach for the power quality improvement.

II. DESIGN OF SERIES ACTIVE POWER FILTER

In designed UPQC configuration, instability problems due to resonance phenomena may occur. In order to enhance the overall system stability, an auxiliary circuit can be added tothe controller of the series active filter. The basic idea consists in increasing harmonic damping, as a series resistance, but effective only in harmonic frequencies, others than the fundamental one. This damping principle was first proposed by Peng in terms of components defined in the pq theory.The damping control algorithm, now developed in tenns of abc variables (in the phase mode).The inputs to the damping circuit are the source currents ias, ibs, ics (compensated currents), which are flowing through the series transformers of the UPQC, and the voltages detennined by the V+l voltage detector val, vbl, vel. The active and non-active instantaneous powers are determined by using the equations.



GENERAL CONFIGURATION OF UPQC (UNIFIEDPOWERQUALITYCONDITIONER)

As is clear from the figure it is series combination of series active power filter and shunt active power filter and one compensating capacitor is used between them.PWM controlled algorithm is used in this specified model scheme.

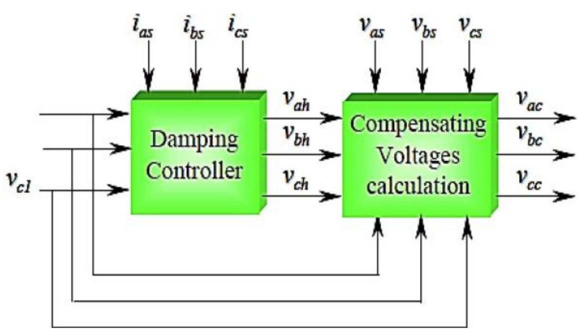


FIG. 2: BLOCK DIAGRAM OF SERIES ACTIVE FILTER

This figure explains the number of blocks will get required in proper configuration of series active power filter.There are two important blocks used in this configuration these are damping controller bock and compensating voltage calculation block.At first signal will go through the damping controller then from this block it will go to the compensating block.

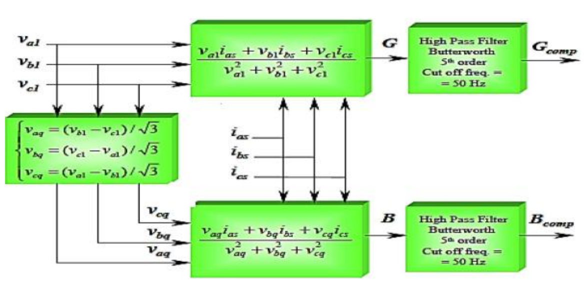
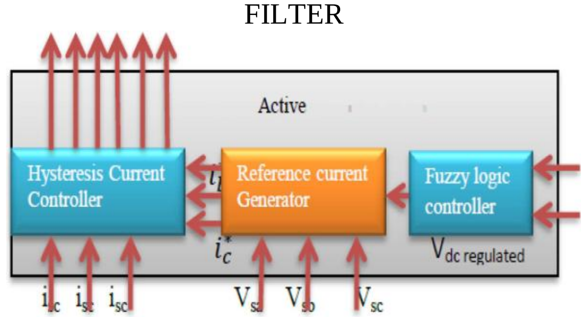


FIG. 3: DAMPING CONTROL ALGORITHM IN TERMS OF ABC VARIABLES

III. DESIGN OF SHUNT ACTIVE POWER FILTER

The active power filter comprises of six power transistors (lGBT), six power diodes, a dc capacitor(C de) , three filter inductor (L e) and reference value of DC side capacitor voltage (V dc, ref) . The filter capacitors and reactors have the function of suppressing the hannonic currents caused by the switching operation of the power transistors. Reduction of current harmonics is achieved by injecting equal but opposite current harmonic components at the point of common coupling (PCC), there by cancelling the original distortion and improving the power quality on the connected power system.This arrangement has unique filtration characterstics.

FIG. 5: BLOCK DIAGRAM OF SHUNT ACTIVE FILTER

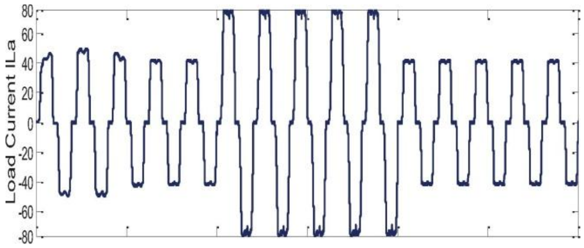


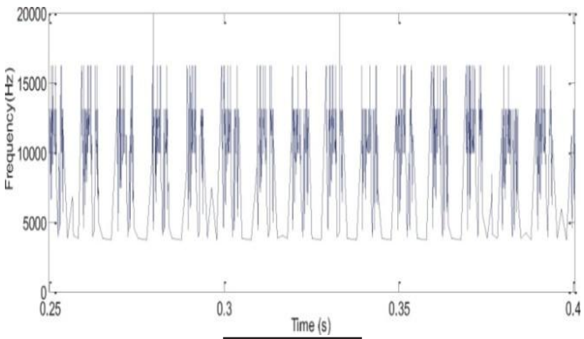
IV. HYSTERESIS CONTROL METHOD WITH CONSTANT SWITCHING FREQUENCY BASED ON VOLTAGE SPACE VECTOR

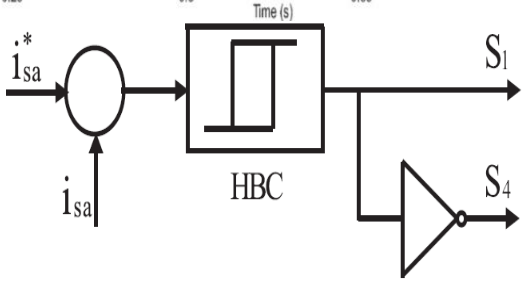
(A)Hysteresis tracking control method Conventionally Hysteresis band current control method is used for its improved stability, fast transient response, simple implementation & higher accuracy tracking. Hysteresis band current control schemes are based on two levels of comparators.Switching frequency as a function of time in hysteresis band current controllershown in figure.Switching signal gets generated on turn on and turn of principle of comparators. Since switching frequency varies over wide variety of range therefore the chances of acoustic noise may get increased.Therefore another method is proposed which makes switching frequency constant called adaptive hysteresis band current controller.

(B)FET ANANLYSIS:

THD=24.74% This explains the total harmonic distortion comes in FET analysis.





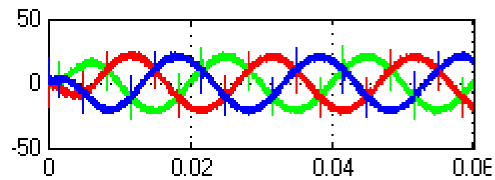


Block diagram of Hysteresis band current controller.

The outputs of the controller are the gating signals to the devices of PWM converter. Development of compensating signals either in terms of voltages or currents is the important part of AF control and affects their rating and transient, as well as steady-state performance. Control strategies to generate compensation commands are based on frequency-domain, time-domain correction techniques. This was finest approach earlier bt now it has been got replaced adaptive hysteresis band current controller.

VI. ADAPTIVE HYSTERESIS BAND CURRENT CONTROLLER

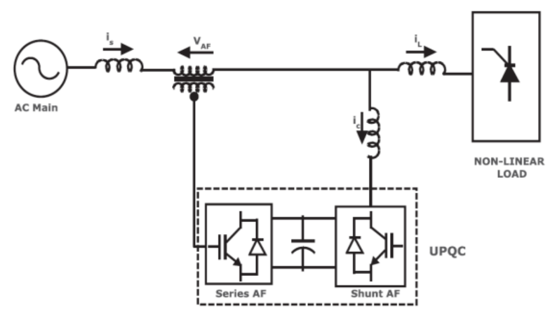
As is clear from the name of this controller that it has got a unique property of frequency adaption according to our own frequency requirement, this is the frequency at which gating signal will get generated. This controller has solved the frequency variation problem of fixed hysteresis band current controller in good extent.

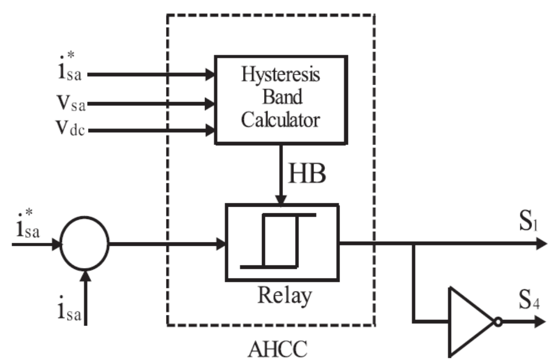


Supply current controlled by hysteresis band current control mechanism.

V. PROPOSED UNIFIED POWER QUALITY CONDITIONER DESIGN

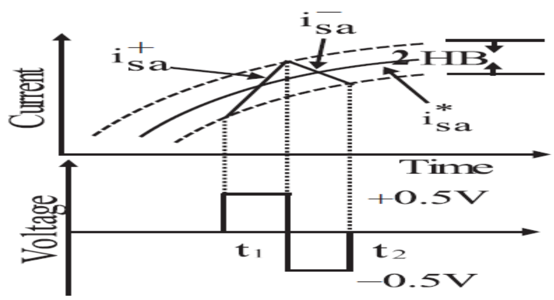
The control scheme is based up on indirect current control technique. The inputs to the control block are dc-link capacitor voltagevdcref three phase source currents (isa, isb ,iSc) three phase voltages (vsa, vsb, vsc) and voltage across point of common coupling is defined clearly in figure.





ADAPTIVE HYSTERESIS BAND CURRENT CONTROLLER

Conventionally Hysteresis band current control method was used for its improved stability, fast transient response, simple implementation and higher accuracy in current tracking. Apart from it there is some drawback of fixed hysteresis band current controller like uneven switching frequency, as a result acoustic noise is produced and difficulty in designing input filters. But for practical application, it is necessary to keep switching frequency within certain limit. To overcome the drawbacks of HBC with fixed hysteresis band an Adaptive Hysteresis Band Current Controller (AHCC) proposed by B.K Bose is used, which maintains the switching frequency nearly constant, by changing the hysteresis band according to system parameters (reference current, source Voltage & dc capacitorvoltage



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rrent and voltage waveform

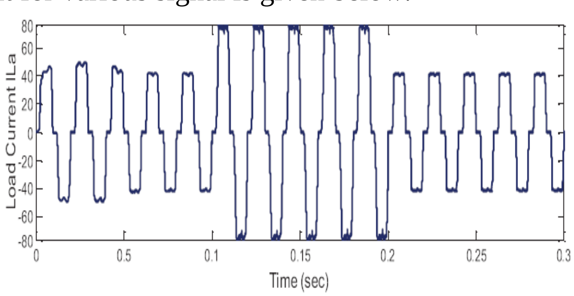
VII. TOTAL HARMONIC DISTORTION CALCULATION

$$THD = \sqrt{\frac{\text{Sum of all squares of amplitude of all harmonic voltages}}{\text{square of the amplitude of the fundamental voltage}}} \times 100$$

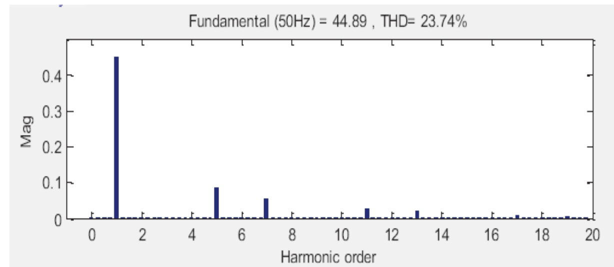
$$THD = \frac{\sqrt{\sum_{h=2}^{h_{max}} M_h^{\,2}}}{M_1}$$

VIII. SIMULATION RESULT

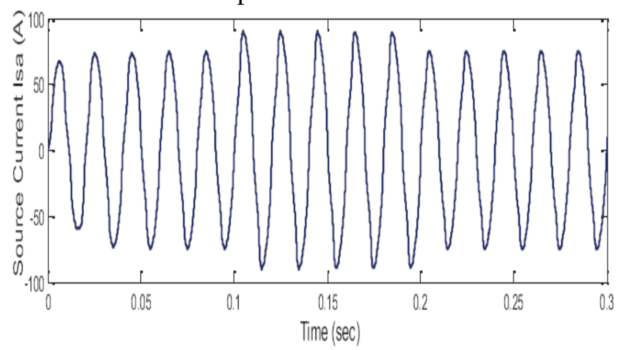
The Matlab/Simulink simulation tool earlier used to project a model that allowed the simulation and testing of the SRF generation method for UPQC, which were implemented in the controller of the unified power quality conditioner for three-phase , three wire system.Simulation result for various signal is given below.



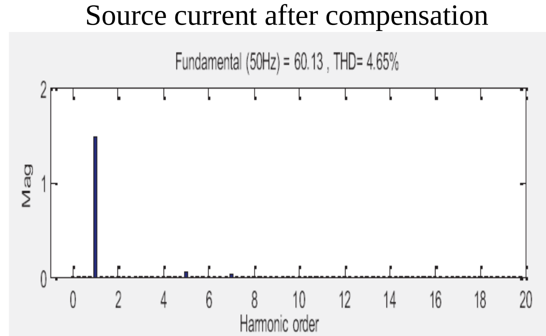
Load current variation with time in UPQC



Harmonc spectrum of nonlinear load



Source current after compensation



Harmonic spectrum of source current

IX. CONCLUSION

This part of work describes SRF-based controller for the Unified power quality conditioner, which mainly nullify the reactive power along with voltage and current harmonics. The proposed control strategy makes use of only source current, source voltage, DC link voltage and voltage across PCC, whereas Conventional methods require the measurement of load current, source current, DC link voltage and filter current for shunt APF and source and injection transformer voltage for the series APF so that the numbers of current measurements are getting reduced and the system performance is improved. To overcome the draw- back of fixed hysteresis band current controller an adaptive hysteresis band current controller has been implemented. The simulation results shows that on nonlinear load, the control algorithm reduces the current as well as voltage harmonics and keeping the utility supply line current sinusoidal. While

AHCC successfully maintains the switching frequency almost constant.

X. SCOPE FOR THE FUTURE WORK

Real time implementation of the suggested control schemes for UPQC using OPAL-RT to validate the simulation result and experimental investigation can be done on unified quality conditioner by developing a prototype model in the laboratory to verify the simulation results for synchronous reference frame method with both hysteresis band current controller and adaptive hysteresis band current controller.

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