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Robust Repetitive Control Design for 3-Phase 4-Wire Distribution System by using Shunt Active Power Filter

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ABSTRACT

In general, with the increasing demand of electrical power, the reliability has to be decrease due to its general power quality issues like harmonics or current unbalances. In order to improve its quality and reliability generally we need a common LC filter. For this, this paper proposes a concept of hybrid cascaded shunt active filter-based Thyristor Controlled Reactor. Current tracking and voltage regulations was done in this a nonlinear control strategy of SPF The small-rating APF is used to improve the filtering characteristics of SPF and to suppress the Possibility of resonance between the SPF and line inductances. The reference for inner current loop is periodic in nature and cannot be easily tracked by PI regulator. The repetitive controllers (RC) are well known for their tracking ability of periodic signals and offers high gain at all the frequencies. The high gain in higher frequency range may leads towards instability. Therefore, in proposed work, the regular RC is modified by squaring its sensitivity function. This approach results in low amplitude of sensitivity function while offering deep notches at low to mid frequencies range and smaller notches at higher frequencies.

KEY WORDS: Harmonics, Shunt Active Filter, PI controller, Total Harmonic Distortion and repetitive controllers.

1.INTRODUCTION:

Advanced power systems demand is increasing with the large usage of electrical power. This implies an increase of the electrical load and power electronic equipment, higher consumption of electrical energy, more demand for generated power, power quality, and stability problems [1]. The concept of multilevel inverters, introduced to performing power conversion in multiple voltage steps by this we are improving power quality and high voltage capacity. In all topologies of multilevel inverters, the most popular is cascaded H-bridge because of it has capability to use variable dc voltages on individual H-bridge cells it causes the splitting of power conversion among higher-voltage lower-frequency and lower-voltage [2] higher-frequency inverters. Without using PWM techniques the total harmonic distortion (THD) is reduced with more number of steps in output voltage. A topology is proposed in this paper to get high 31 levels.

Recently non-linear loads usage is increasing mostly the power electronic equipment's [3] which effects the voltage waveforms quality at PCC. The harmonic pollution has been reduced by using Active power Filter (APF) in electrical networks. Ideal current source is nothing but an APF here, by selective harmonic compensation it inserts the compensating current into the ac lines to cancel the Harmonics of line current. To improve the power quality APF has more advantages over the traditional compensation methods like passive filters. The APF have better compensation for voltage and current disturbances in distribution systems [4]-[5].

APFs has two fundamental configurations, either active or passive i.e series or the shunt filter. The shunt active filter shown in Figure1. For harmonic compensation in low and medium power systems shunt active filter has a cost effective solution [6]. To the line a dc link capacitor which is large is connected, same structure and construction for both PWM voltage source inverter and APF [7]

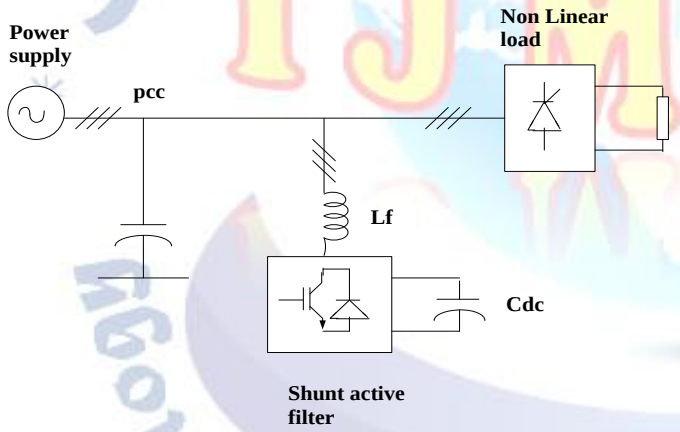

Figure 1 Block diagram of shunt active power filter

Reduction of current distortion for power quality improvement is affectively done by harmonic current compensation in APF. The load current harmonic components harmonic are drawn from shunt compensator which acts as a controlled current source. APFs are also applicable in the line current compensation, harmonic damping and power flow control.

In this a proposed new combination of a shunt hybrid power filter (SHPF) [8] [9] and a TCR (SHPF-TCR compensator) for suppress current harmonics and mitigating the reactive power problems generated from the load. The hybrid filter consists of a series connection of a small-rated active filter and a fifth-tuned LC passive filter.

In the proposed topology, the major part of the compensation is supported by the passive filter and the TCR while the APF is meant to improve the filtering characteristics and damps the resonance, which can occur between the passive filter, the TCR, and the source [10] impedance. The shunt APF when used alone suffers from the high kilovolt ampere rating of the inverter, which requires a lot of energy stored at high dc-link voltage.

2. CONTROL STRATEGY FOR APF

In the control of APF, the approaches are fully depending on feed forward open loop control and it is sensitive to the parameter mismatches so it effects the ability to accurate prediction of the current reference of voltage-source inverter and its performance [11] controllability. The close-loop control has detection and the source current is controlling target.

We known that closed loop control is feedback control so it is having the following benefits: Disturbances to the output to transfer function is reduces [12].

Figure 2 shows the method of synchronous reference frame used to extract the reference current in closed loop control scheme for using. Figure 3 shows the harmonic detection bloc function. In the SRF method using Park's transformation [13] the 3-phase line currents are transformed into 2-phase quantities.

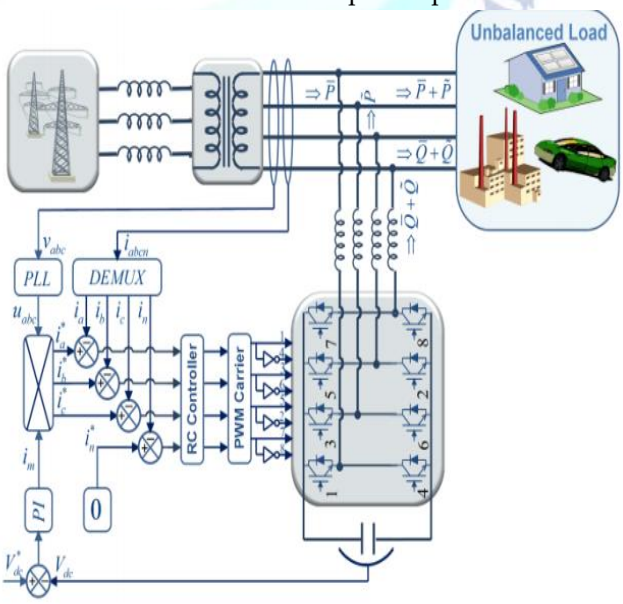

Figure 2 Proposed SHPF compensator

Positive and negative sequence components are two main blocks corresponded, transformation of de–qe axes by generating positive sequence phase information +_ from PLL circuit was done in positive sequence component of load current. All harmonic components [14]-[15] are included in AC quantities of positive sequence waveform while the fundamental line current component is dc quantity. The negative sequence component of the current is same but from the PLL it generates negative sequence phase information. If the voltages and currents are balanced in 3-ϕ system then the oututt signal is '0' for the block. The dominant harmonic component is the output from the comparison of the positive and negative sequence controller. To convert 3-ϕ components in to 2- ϕ components inverse transformation is applied [16].

Both the currents from the harmonic component and dc voltage control block is compared and signal is send.

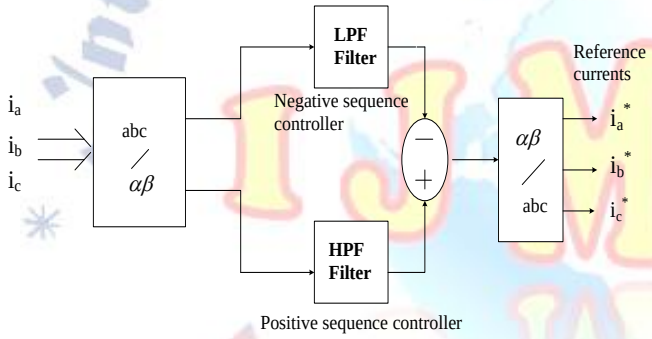

Figure 3 Scheme of harmonic detection

The control target is determined by summing the capacitor voltages at every cluster. The voltage reference is taken from the dc capacitor is used for generating u-phase overall voltage signal and is divided into V1, V2. In feature this control strategy is extended to N-phase H-bridge cascaded inverter [17].

With the usage of the one or more cascade converters the compensation performance was better.

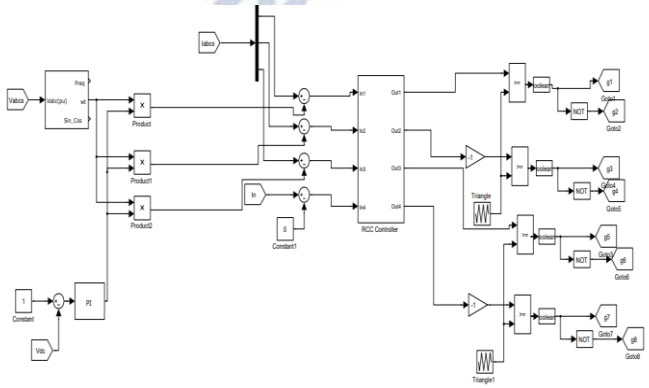

Figure 4 Control Diagram

The Figure 4 show the whole control diagram for phase-u of the proposed u AAPF is given in [17], which contains the source current direct control, load current feed forward compensation, voltage-balance control and voltage control.

RC Controller:

The repetitive controllers are mainly used to solve those control problems where the disturbances or signals to be controlled are periodic with defined time intervals.

- According to IMPT, a generator with periodic signal must be included in controller feedback loop to track the periodic reference signal.
- The periodic signal generator uses large time delay terms corresponding to periods of reference signal. In actual practice, a zero-phase FIR low pass filter H(z) is used to reduce the gain of those frequencies where the behavior of system is not well defined.
- Here, it is pertinent to mention that this FIR low pass filter decreases the gain of controller to finite values for all the frequencies and thus takes the shape of typical lowpass filter q(z, z-1). A typical repetitive controller with zero-phase error low pass filter

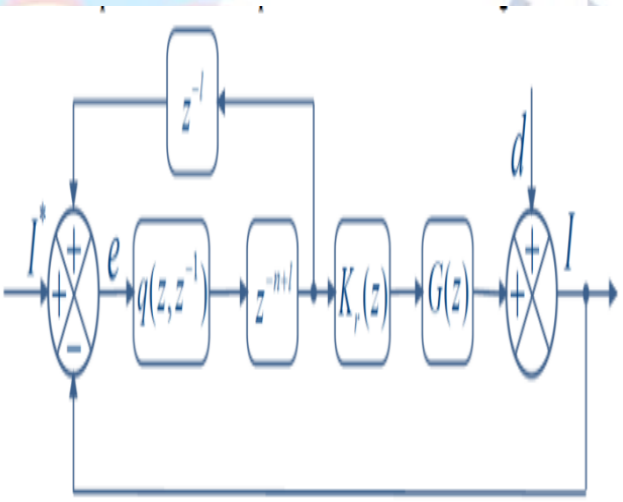

Figure 5: Structure of Typical Repetitive Controller

3. SIMULATION RESULTS

The compensation performance of APF is verified by simulink results. Figure 6 shows the simulated results for the 400-Hz EPS SW with inductive load. Nonlinear loads start to work from 0 to 1.5s.

Case 1: Simulation Results without RC controller:

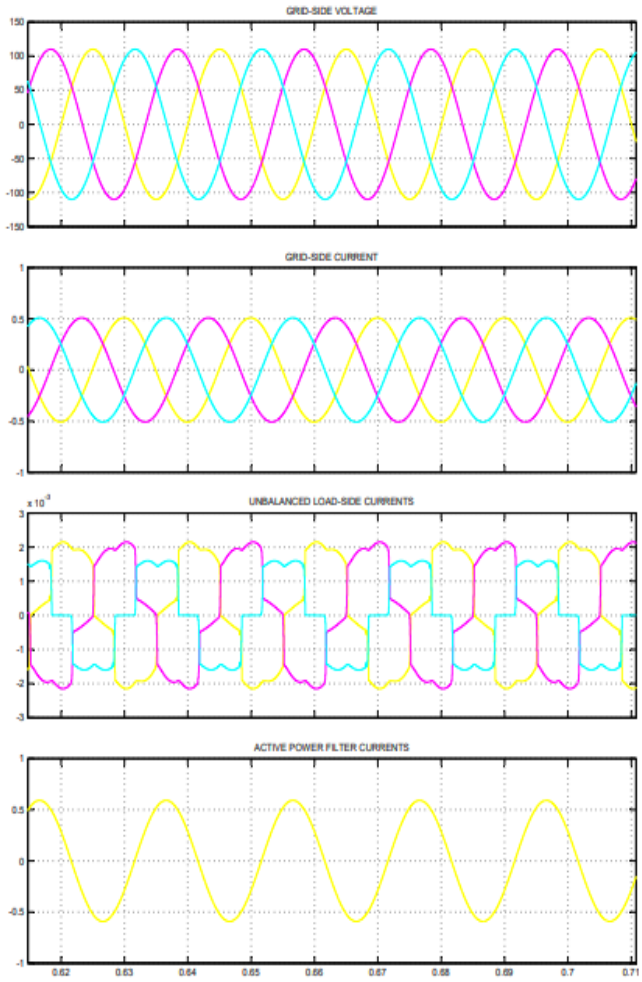

Figure 6: Simulation results without RC: (a) Grid side voltages, (b) Grid side currents, (c) Unbalanced load side currents, (d) APF currents

As in Figure 6 the first waveform shows the result of source voltage, second one is compensated source current and finally third waveform is the load current waveform which is effected by the non-linear load.

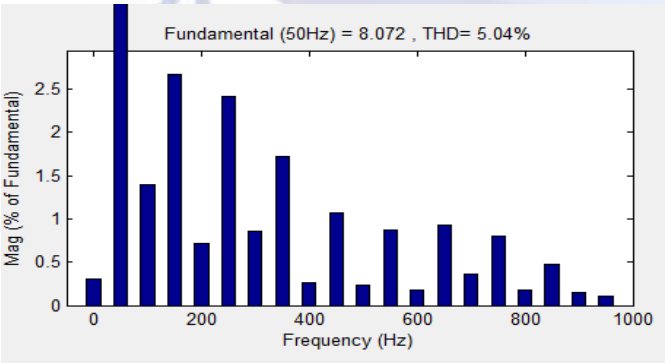

Figure 7: simulation result show for THD of Source Current

Case 2: Simulation Result with RC Controller:

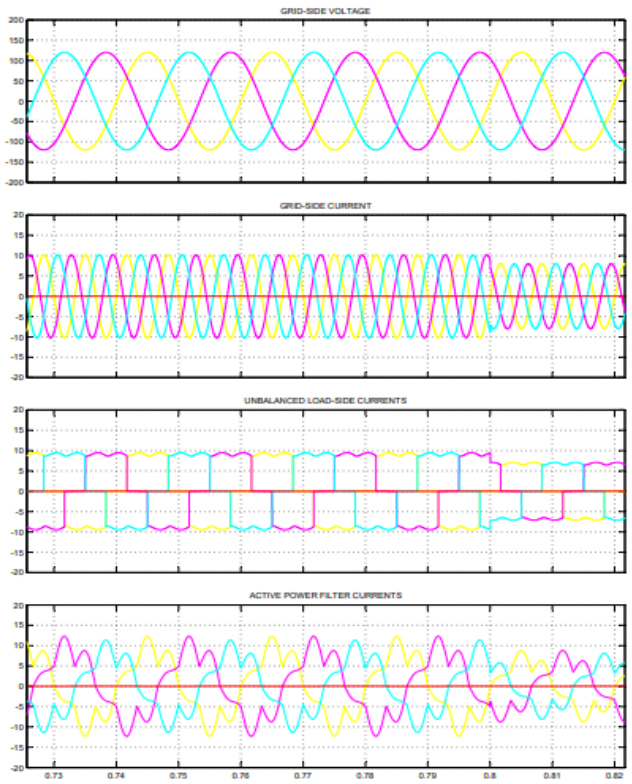

Figure 8: Simulation results with RC: (a) Grid side voltages, (b) Grid side currents, (c) Unbalanced load side currents, (d) APF currents

As in Figure 8 the first waveform shows the result of source voltage, second one is compensated source current and finally third waveform is the load current waveform which is affected by the non-linear load. And figure 9 shows the simulation result for THD of current.

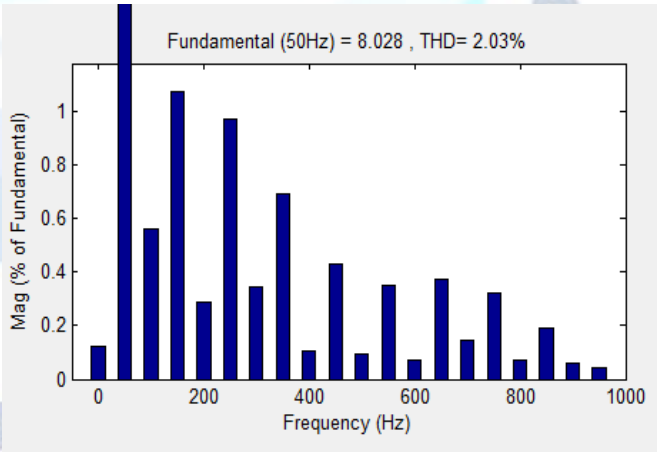

Figure 9: simulation result show for THD of Source Current

4. CONCLUSION

This exploration work can be reached to the research areas like: Power systems have advanced from isolated generators taking care of own loads to huge interconnected systems which are spread across the

nation. Interconnected systems are more reliable, because in case of interruption in one part of the system, power can be taken care of from interchange ways and thus can maintain continuity of the system. However, harmonic distortions introduced by the nonlinear loads will propagate throughout the system. This issue might be solved by installing filters of suitably designed ratings at optimal locations in the interconnected power system. The optimal allocation and rating of these filters can be resolved with help of evolutionary algorithms for example Genetic Algorithm.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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