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Research Article

Control techniques for a Three Phase Four Wire (3P4W) Shunt Energetic Power Filter

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ABSTRACT- In this research, we provide a novel model of control for a 3P4W shunt energetic power filter. Typically, a power electronics device's control method will have two control loops: a fast-responding inner current loop and a more gradual-responding outer voltage loop. Because of the dynamic loop of the cirrent, the PI regulator cannot monitor it. The repetitive controllers (RC), which offer excellent gain at all frequencies, are widely recognised for their capacity to follow periodic signals. The higher frequency range's strong gain could cause instability. As a result, the sensitivity function of the regular RC is squared in the proposed study. This project uses a fuzzy logic controller to improve the power quality. This method provides a sensitivity function with a moderate amplitude while giving deep notches at low to medium frequencies and with more frequency low notches. This control approach has been tested and put into practise on the 3P4W SAPF.

Index Terms: Fuzzy logic controller, harmonic compensation, load compensation, non-linear load, balanced load, and repetitive control.

I. INTRODUCTION

There are a lot of problems at the distribution level of the power system network, most of which have to do with load imbalance, reactive power, current harmonics, etc. From the perspective of the operator of the power system, issues of this kind need to be resolved at the distribution level if generation and transmission are to continue running smoothly. Electromechanical devices like tap-changing transformers, passive filters, and synchronous condensers were utilized in the past to address issues with power quality. However, active power filters (APF) and dynamic voltage restorers (DVR) are being used to improve power quality. specialized power devices like static compensators (STATCOM), unified power quality controllers (UPQC), and series or shunt-type devices are just a few that are commonly used today. Depending on the application, a seroes connection is established with the inverter . The SAPF is preferred for resolving grid side current issues due to load adjustment.

Because the SAPF is a device that is regulated by current, creating a controller that responds quickly is typically difficult due to the fact that the inside current loop start before outer current loop. start much earlier than the slow voltage loops outside. In addition, the inner current signals must be transformed from their periodic nature into DC signals in order for a straightforward PI controller to control them. The controller's performance is therefore determined by the transformation's precision, that is extremely variate in all the parameters. Numerous control strategies for the SAPF loop of inside was proposed earlier. Passivity-based control (PBC), proportional resonant (PR), hysteresis, and deadbeat (DB) controllers make up the majority of them. Parameter variations may have a negative impact on the performance of the control; The varying switching frequency may cause resonance issues in the hysteresis controller; Only selective harmonics can be tuned into the PR; An accurate system model is required by the PBC and DB; and so forth. The PI, the simplest of these, is useless for oscillating

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signals as well. Additionally, a small number of regulation strategies based on AI have been described. The main issues with these approaches. Repetitive controllers have an advantage because they can use the periodic nature of the signals used by most power electronics converters to predict the output signal (RC).

The Internal Model Principle Theory (IMPT), which can be used to track numerous harmonic frequencies with zero steady-state error, serves as the foundation for the design of RC. Consequently, RC supposed to be quite successful at mitigating harmonics when SAPF is properly controlled. The conventional digital RC can be constructed by adding n delays. In this case, n is an integer in the basic cycle of the input signal. Making a hearty RC is a troublesome undertaking since any mistakes in math or wrong displaying could drive the regulator into an unsteady region. In addition, the ease with which RC controls are displayed may be compromised by a change in signal frequency. Frequency fluctuations may cause incorrect SAPF operation because the RC is designed to reject integer multiples of the fundamental frequency-related harmonics. The variable sample rate approach to resolving this problem has been the path forward for RC design with proper harmonic rejection. To model the fractional part of n, a similar strategy employing a FIR filter based on Lagrange interpolation is proposed. However, the fractional delay and shifting sample rates imply significant shifts in system dynamics and call for numerous numerical calculations, respectively. The sample points are moved during each cycle to improve stability and compensate for fractional order phase lead in a comparable method that is based on a cycling sampling strategy. Changing examining focuses, however Its ability to follow mistakes in consistent state might be compromised. Multiple authors also presented parallel structure repetitive control (PSRC), which makes use of internal models with multiple orders of harmonics that are suitable for controlling PWM inverters and converters. With PSRC, the most difficult task is determining the gains for numerous parallel loops. Moreover, quicker union requires tuning every symphonious recurrence part separately, which is extraordinarily difficult to do in any certifiable situation. Using a sim power system block set in MATLAB/Simulink, the anticipated control strategy is developed and tested on a four-leg SAPF. The findings of the simulation made use of highly unbalanced non-linear loads, and the SAPF was able to meet these demands while also meeting the demands of the reactive loads. This outcomes in a decent assortment of sinusoidal side flows on the organization.

II. SYSTEM MODELLING AND MANAGEMENT 2.1 is a schematic representation of the proposed system as a whole. By adjusting the switching period of each IGBT during a power frequency cycle, a 4-leg current converter based on IGBTs is managed as a shunt APF to make an unbalanced nonlinear demand and an injected current from the SAPF appear to be good in resistance. A large number of balanced resistive load currents are shown from the grid as a result, allowing a grid with a power factor of one to function automatically.

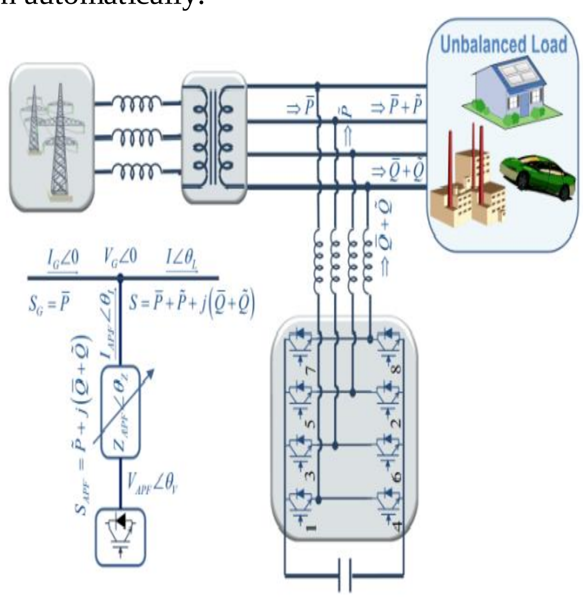

Fig.2.1: Schematic diagram
3P4W Shunt Active Power Filter

The SAPF's impedance, phase angle, and terminal voltage can all be changed to change the injected currents. Resetting load impedance and SAPF impedance become fully resistive loads that can be supplied by the grid is the only way to achieve this difficult goal. Consequently, the numerous switches generates the SAPF operational concept of compressive load. The SAPF's performance can be influenced by utilizing the inner current and outer voltage control loops. Current control loop dynamics are extremely quick in comparison to the lengthy response time of dynamic current. The primary function of the voltage control circle is to keep charge the capacitor with dc-link. This determines how much active power the APF needs to provide to make up for switching losses. The difference between the nominal and effective dc-link voltages (Vdc) is monitored by the PI regulator, which then makes any necessary adjustments. The active current reference (id) is calibrated by the PI regulator's output. The reactive current component (iq) is disabled because the APF is controlled indirectly. The phase lock loop's (PLL) synchronizing angle determines the grid-side reference currents (ia*, ib*, and ic*). For lattice side adjusted activity, the unbiased reference current (in*) is focused out. The suggested iterative controller tracks the error currents until they reach zero and compares both currents. Figure depicts the entire schematic as well as a breakdown of the switches. 2.2.

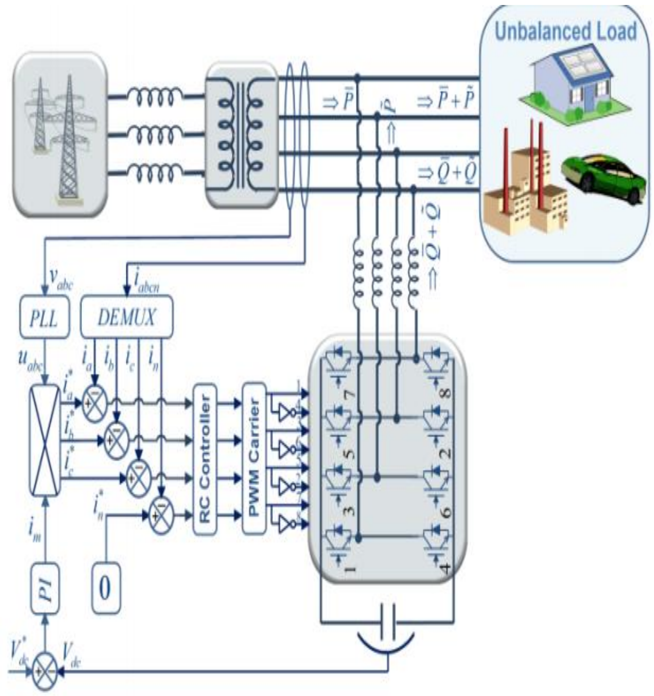

Fig. 2.2. Control Description of 3P4W Shunt Active Power Filter.

II. Control Description:

The abc-dq transformation, is also known as Park's transformation, is used to control power electronic converters that are connected to the grid. The primary advantage of this modification is that it produces easy-to-track quasi-DC signals. A straightforward resistive-inductive load can be controlled using a (PI) controller with a low bandwidth.

III REPETITIVE CONTROLLER DESIGN:

In control situations where various signals to be controlled occur at regular intervals, repetitive controllers are frequently utilized. In order to control the flow to the controller an accurately follow signal is sent to the incerter. (z) reduces gain at frequencies where the system's performance is uncertain. Notably, by reducing the controller's gain to finite values at all frequencies (z, z-1), this FIR low pass filter mimics the design of conventional low pass filters. Figure provides one illustration of a repeating controller. 2.3, which makes use of a zero phase error low pass filter.

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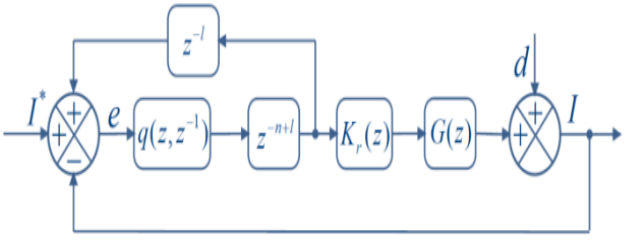

Fig. 2.3. Structure of Typical Repetitive Controller.

The primary purpose of it is to reduce the amplitude of the frequency at the fundamental circuit.

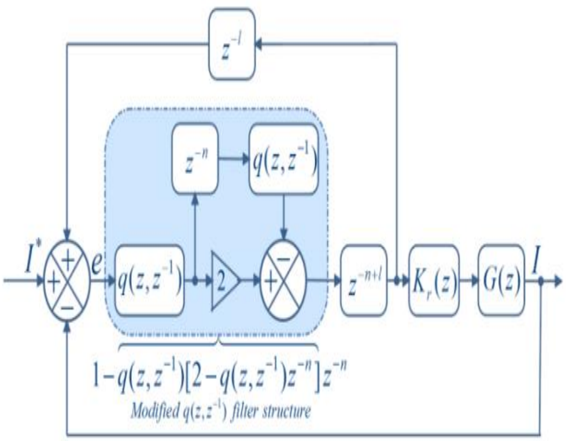

Fig. 2.4 Structure of Modified Repetitive Controller.

IV.FUZZY LOGIC CONTROL

fuzzy controllers convert numerical variables into verbal variables. There are three parts to FLC: an interference engine, a defuzzing process, and a fuzzing process. There are seven fuzzy sets in the fuzzy controller, one for each input and output. To keep things easy, a membership function is triangular. Fuzzy logic makes use of speech's continuous universe. Using the "min" operator from Mamdani has implications. Defuzzification is carried out using the "centroid" method.

IV. Schematic of the Simulation The proposed system is simulated with the help of the MATLAB/Simulink SimPower System toolbox. An easy-to-find 4-leg inverter is not available in the Simulink library. utilizing eight IGBTs as a SAPF to construct a current-controlled voltage source converter. Simulink is used to design all of the IGBT driver circuits as well.

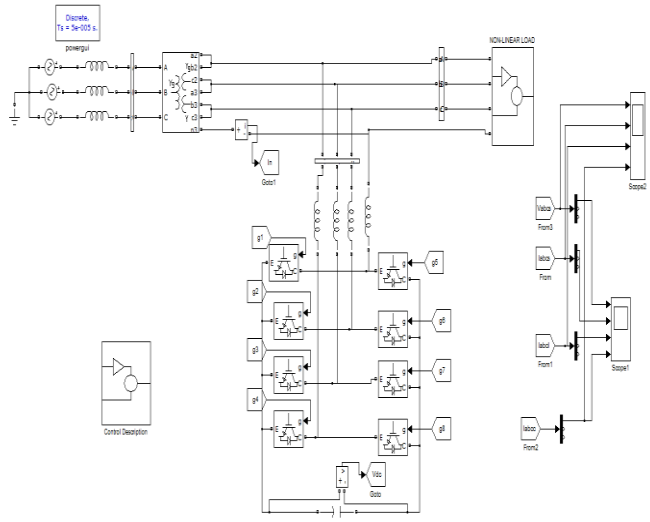

FIG4.1:Simulink Block Diagram

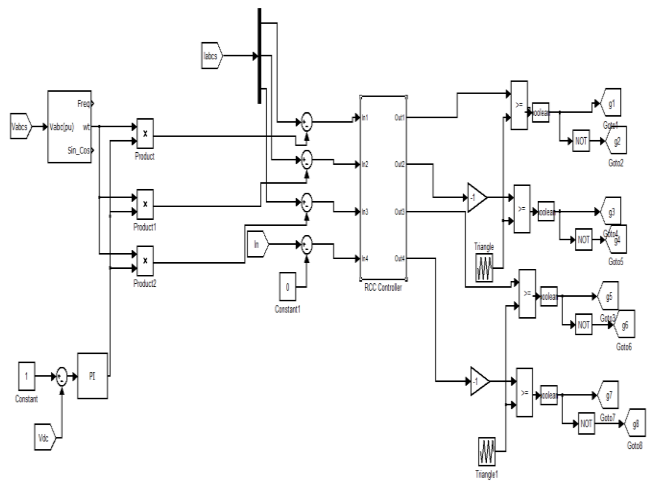

Fig4.2:Control Block Diagram

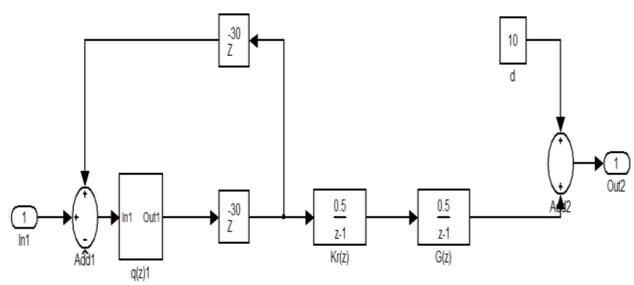

Fig4.3: RC Controller

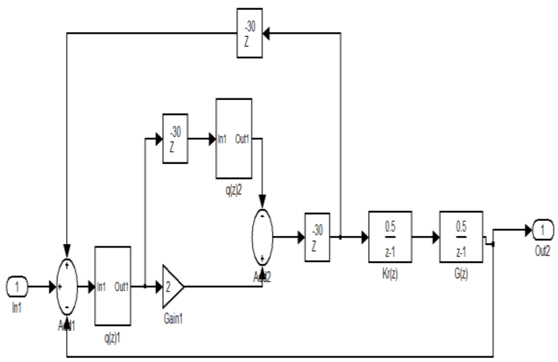

Fig4.4: Modified RC Controller

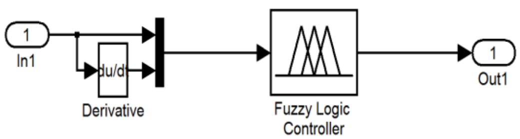

Fig4.5: Fuzzy Logic Controller Controller

Simulation Results:

The grid side voltage (VG), grid side current (IG), unbalanced load side current (IL), and injected SAPF currents (IAPF) are all depicted in Fig.4.7, which is a representation of the outcomes of the simulation. It is essential to emphasize that the simulation research was carried out using two distinct controllers on the same system with identical settings in order to make comparisons. The simulation results from our previous work with the RC controller are shown in Figure 4.6.

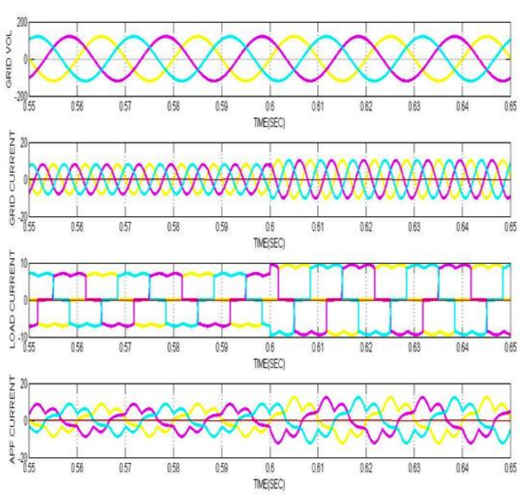

Fig. 4.6 Simulation results

The results of the simulation that were carried out with the RC controller that was suggested are displayed below. The load current waveforms revealed that the system was initially connected to a three-phase balanced nonlinear rectifier load. At time (t) = 0.6 seconds, the non-linear load increases by 75% and returns to its initial value at time (t) = 0.8 seconds. At t = 1.0 seconds in the future, phase A of the power grid's supply is connected to an RL load.

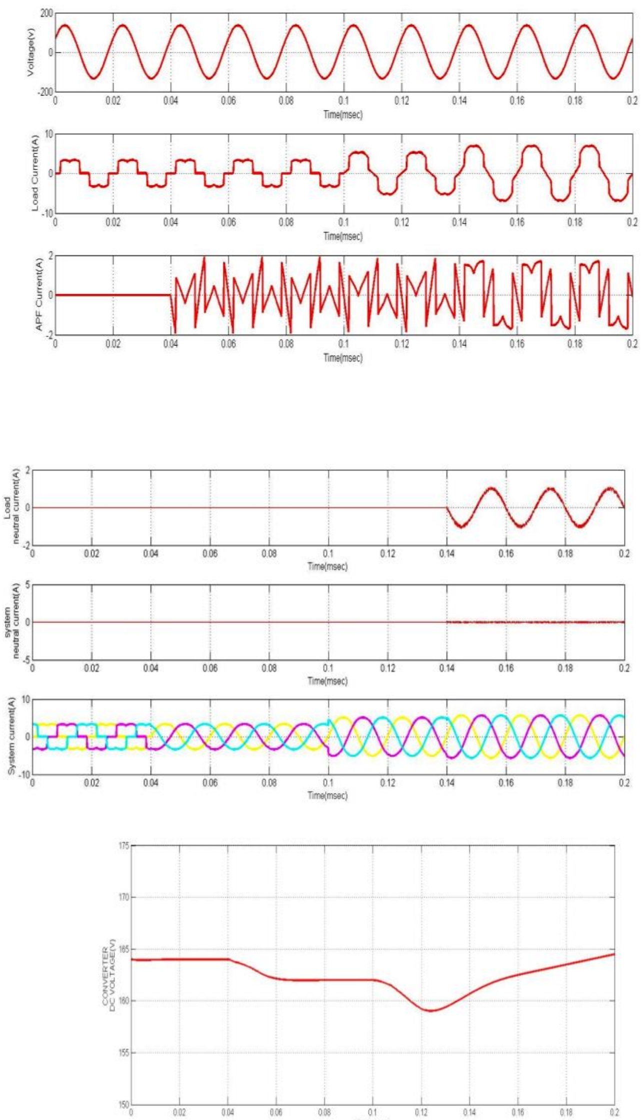

Fig. 4.7. fuzzy control scheme

CONCLUSION

For SAPF control, this study presents a modified RC controller model, design, and simulation. It has been demonstrated that the modified RC controller has a wider control bandwidth than standard RC from a design and modeling perspective.

The proposed controller gives good results in dynamic operating conditions. In addition, it has been demonstrated that the SAPF is capable of controlling non-linear load demand in both balanced and unbalanced conditions. These findings are supported by the simulation results. The fuzzy logic controller is used in this paper. The results of a thorough simulation are also presented to support the assertions. By correcting for current harmonics, current imbalance, and the reactive current demand of the load, the grid side currents at UPF are always maintained as a three-phase balanced set of fundamental currents. In order to eliminate the neutral current on the grid's side, additional demand for load neutral current is generated locally via the fourth leg of SAPF.

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