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HYBRID SERIES ACTIVE POWER FILTER FOR POWER QUALITY IMPROVEMENT

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Abstract - In this work, a hybrid active power filter with sources and loads is introduced for harmonic filtering in a gearbox system. The harmonics generated by non-linear loads (such diode bridge rectifiers) may also inject the source voltage and currents into other loads linked to the system. By severing the harmonics from the source voltage and currents, a series active power filter linked to the transmission line via series transformers attenuates them. In addition to the series active power filter, a passive filter is added to eliminate lower order harmonics. This allows the passive filter to react faster to transients produced by the recommended system. A fuzzy logic controller has been added to the series active power filter's controller. The MATLAB Simulink software's FFT analysis tool is used to compare the harmonics of the source current utilising fuzzy logic controllers and PI. The table displays the comparative results of the THD values.

***Key Words*: Active Power filter, Power Quality, THD**

1.INTRODUCTION

When nonlinear loads proliferate, line losses, instability, and voltage distortion significantly rise, raising questions about the quality of electrical power. These nonlinear loads also drive the system's low electricity component with the introduction of harmonic current. Each element inside the energy system and equipment is negatively impacted by the resulting imbalanced current. This had horrible power consequences, more losses, too many neutral currents, and decreased standard efficiency. To compensate for the damage caused by persistent non-straight loads, passive power filters have been used as a compensating device. These filters [2] are designed to provide harmonics with a low impedance path while maintaining excellent power quality with the utmost simplicity and ease. Notwithstanding, Latent filters suffer from a number of drawbacks, including mistuning, reverberation, dependence on the status of the power supply system, and significant estimates of detachable section, which make use of them difficult. When active filters, such as APF, are connected in series or parallel to nonlinear loads in order to improve voltage or current bending, these topologies are referred to as shunt active filters or arrangement active filters. These filters are the most widely used configuration because they effectively get rid of current distortion and the reactive power generated by irregular loads.This document shows the suggested format and appearance of a manuscript prepared for SPIE journals. Accepted papers will be professionally typeset. This template is intended to be a tool to improve manuscript clarity for the reviewers. The final layout of the typeset paper will not match this template layout.

2. Proposed Methodology

The schematic diagram of the 3-stage HSAPF's control and power circuit is shown in Fig. 2.1. The SAPF is made up of a three-stage direct transformer and an LC filter connected to the matrix by the voltage source inverter.

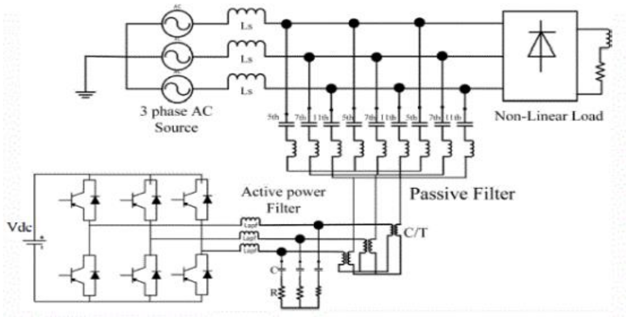

Fig 2.1: Bolock diagram of Hybrid Sesies Active Power Filter

An arrangement-associated active power filter (SAPF) and a shunt-associated latent power filter make up the topology of HSAPF (PPF). PPF linked to the load in parallel. For the purpose of paying consonant current on the load side, the PPF consists of a fifth and seventh tuned LC filter with ratings of (Lpf= 1.86mH and Cpf= 60F). To ensure galvanic seclusion, the SAPF was connected to the source through a coordinating transformer with a turn ratio of 1:2. Three separate components make up the SAPF, such as a three-stage IGBT-based SEMIKRON inverter, a 2200-F DC-connect capacitor, and a three-stage high-recurrence LC filter with impedances (Cf=60F, Lf=1.35mH). To exclude high recurrence changing swells from the compensating voltage supplied by the inverter, a high recurrence LC filter is connected. A three stage diode connect rectifier (ABC 100V 100A) with a non-direct load (i.e., a resistor of 8.5A, 100 and an inductor of 40mH) is taken into consideration.

3. TEST SYSTEM WITH STATCOM DEVICE

The inductors' arrangement obstacle is disregarded. Where ua, ub, and uc represent the duty cycle of the inverter legs during an exchange period, while Ica, Icb, and Icc represent the three-stage active filter current yield, VaN, VbN, and VcN represent the three-stage stage voltages, Isa, Isb, and Isc represent the three-stage source current, and VnN represents the unbiased voltage, are shown in Fig. 2.2. As shown in Fig. 2.3, the whole model [13] of the inverter's middle value was identified and acquired in three steps. The dynamic model of the HSAPF under a synchronous reference frame can be described by the following differential equations from this circuit diagram:

$d\ icddt = VcdLf + w\ icq - ud\ VdcLf$ (2.1)

$d\ icqdt = VcqLf + w\ icd - uq\ VdcLf$ (2.2)

$d\ Vcddt = w\ Vcq - icdCf + isdCf$ (2.3)

$d\ Vcqdt = -\ w\ Vcd - icqCf + isqCf$ (2.4)

$d\ Vdcdt = 23Cdc\ (ud\ icd + uqicq)$ (2.5)

Where ud and uq are the dq-axis obligation proportion and Vcd and Vcq are the dq-axis compensating voltages.

The HSAPF system model can be defined as pursuing the following in order to support the controller plan:

x = f (x) + g (x) + u (2.6),

and

y = h (x) (2.7)

Where vector u = [ud, uq]T represents system control factors, vector y = [y1, y2]T = [Vcd, Vcq]T provides the system yields, and vector x = [icd, icq, Vcd, Vcq, Vdc]T is defined as the state vector. It must be noted that the multi-input, multi-output (MIMO) system is not straight because state factors and control factors are present as augmentation terms. Moreover, there is a high correlation between the state components. The sliding mode controller's strategy can precisely limit these two challenges.

The synchronous reference outline strategy-based half-and-half control approach's reference pay voltage for the HSAPF system is transmitted

as Vc=K Ish VLh (2.8)

This half-and-half control strategy identifies the source current Is as well as the load voltage VL at the same time to obtain their consonant components. The age of the synchronous reference outline strategy for the HSAPF system using the combined load voltage and source current identification method and receiving cross breed control approach is obtained as (8) and (9). Fig. 3.2 depicts the acknowledgment circuit for making vc.

Fig. 2 depicts the reference repayment signal's age using the combined load voltage and source current recognition scheme. The error between the reference and the actual DC-connect voltage of the DC-interface capacitor of the three-stage PWM inverter fed by the air conditioner system is first processed through a PI controller, and it is subsequently deducted from the oscillatory component of the d-pivot. owing to the unique insertion of new essential symphonic components. In keeping with this, the reference compensating voltages are also communicated as:

$Vca* = \text{K}\ Isah - VLah + \Delta\ Vcaf$ (2.11)

$Vcb* = \text{K}\ Isbh - VLbh + \Delta\ Vcbf$ (2.12)

$Vcc* = \text{K}\ Isch - VLch + \Delta\ Vccf$ (2.13)

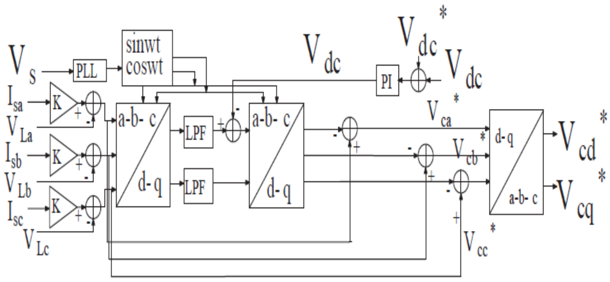

Fig.3.2: Reference Generation Scheme (HSRF)

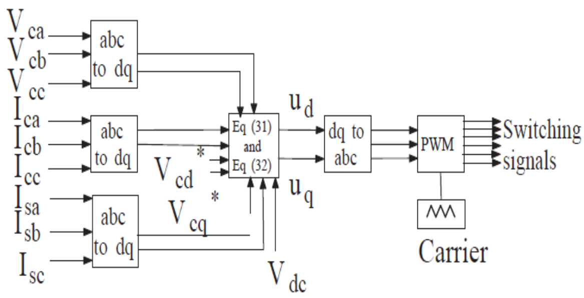

Fig.3.3: Pulse Generation from Controller

In this proposed control approach the control signal satisfies all the above conditions, with the goal that the state directions are moved towards the exchanging surface. Consequently, amid the activity of this proposed controller, the HSAPF system accomplishes quick reaction, great power and disposable aggravations successfully.

3.3 Design of Fuzzy Control Rules

The fuzzy control rule design involves defining rules that relate the input variables to the output model properties. As fuzzy logic controller is independent of system modal, the design is mainly based on the intuitive feeling for, and experience of, the process. The rules are expressed in English like language with syntax such as If {error e is A and change of error Δe is B} then {control output is C}For better control performance finer fuzzy petitioned subspaces(NL, NM, NS, ZE, PS, PM, PB) are used, and summarized in table 5.1. These seven membership functions are same for input and output and characterized using triangular membership functions.

3.4 Advantages of Fuzzy Control

The advantages of fuzzy control over the adaptive control can be summarized as follows the linguistic, not numerical; variables make the process similar to that of human think process. It relates output to input, without understanding all the variables, permitting the design of system more accurate and stable than the conventional control system. The fuzzy controller uses two input membership variables error E and change in error dE. There is only one output for the fuzzy function. The function considered is 'mamdani' function with seven membership functions in each variable. The input membership functions have gauss format and are shown below.

Fig. : 3.4 Error input membership function

4. SIMULALTION RESULT AND DISCUSSION

4.1 INTRODUCTION

In this paper, various waveforms of fuzzy logic controller model are simulated in MATLAB Simulink and various input and output waveforms for the different conditions are shown below.

4.2 PROPOSED SIMULATION MATLAB MODEL

Case: 1 Improvement of Power Quality by using Hybrid Series Active Power Filter using conventional pi controller. The proposed simulation model is shown in fig. no. 4.1

Fig. No. 4.1 show the Matlab/Simulink power circuit model of HAPF. It consists of five blocks named as Ac source block, nonlinear load block, control block, HSAPF block and measurements block.

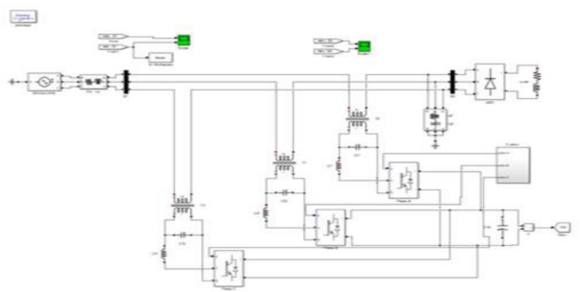

Fig. 4.1 Simulink model of test system PI Model with HSAPF

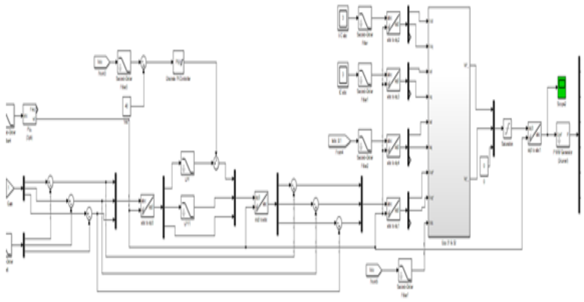

Fig. 4.2: Internal sub system of SM- PI controller

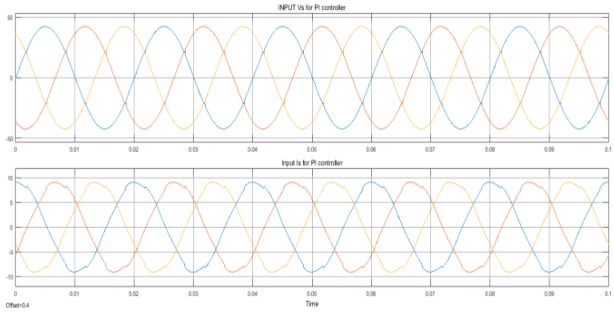

Fig 4.3: Input Waveforms, Vs and Is for PI controller

4.3 Harmonics analysis of Hybrid Series Active Power Filter using conventional pi Controller.FFT Analysis:

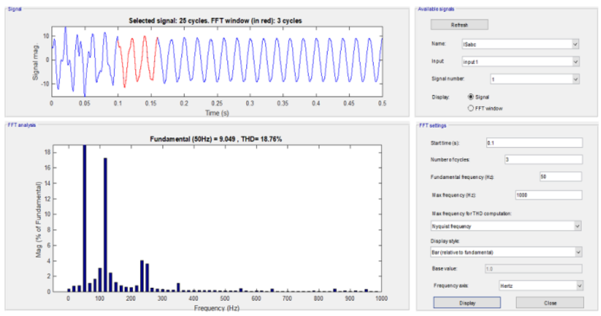

Fig. 4.4 THD analysis of source current at 0.1sec with PI controller

Case ii: Improvement of Power Quality by using Hybrid Series Active Power Filter using conventional fuzzy controller. The proposed simulation model is shown in fig. no. 4.4

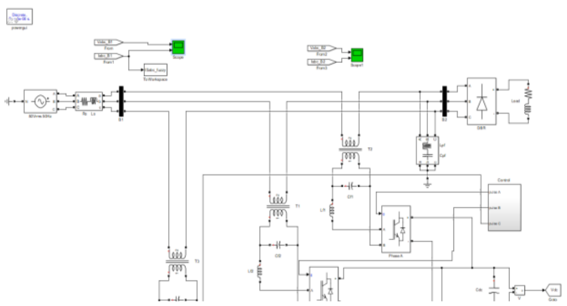

Fig.4.5: Simulink model testsystem Fuzzy controller with HSAPF

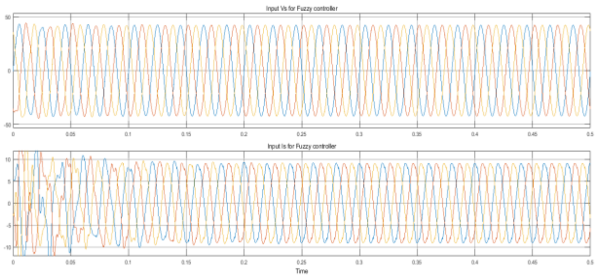

Fig 4.5: Input Waveforms, Vs and Is for Fuzzy controller

4.3 Harmonics analysis of Hybrid Series Active Power Filter using conventional Fuzzy Controller.

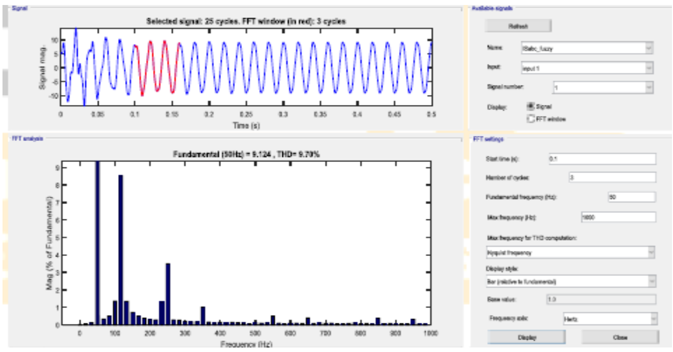

Fig. 4.6 THD analysis of source current at 0.1sec with Fuzzy controller

5. CONCLUSIONS

With the comparison of the above given results the THD of the source current is less at transient state when the controller of the series active power filter is updated with fuzzy logic controller. The THD reduction is done at transient state when the active power filter is connected to the test system. A comparison table is given with THD percentage at different intervals of time with simulation run for 0.5 sec.

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