IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Fuzzy Control Based SAPF for Power Quality Improvement in Industrial Applications

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Abstract: In an AC power system, presence of non-linear loads such as compact fluorescent lamps, switching mode power suppliers, adjustable speed drives, uninterruptible power supplies etc. causes current waveform as non-sinusoidal which affects the efficient power supplies. These harmonics causes voltage sag, voltage swell, voltage distortion also affects the system power quality. In the proposed work a FLC based SAPF is designed to compensate the harmonic current along with reactive power. Instantaneous P-q power theory (Active-Reactive Power Theory) along with hysteresis controller is used to control the SAPF and also to give the gate pulses to filter switches. The Fuzzy logic controller with SAPF is designed and simulated using software simulation tool MATLAB/Simulink.

Index Terms **- THD- total harmonic distortion, SAPF- shunt active power filter, FLC- fuzzy logic controller.**

I. INTRODUCTION

AC generating systems are facing more PQ problems. The presence of Non-linear loads namely adjustable speed motor drives, UPS, compact fluorescent lamps etc. are the reason for power quality problems. Traditional compensation techniques namely series filters, passive filters or combination of both series and parallel filters are in practice to indemnify the reactive power factor and to conquer the harmonic issues [6][7]. The drawbacks of passive LC filters are resonance, overloading, detuning and finite for some harmonics. The current waveform is maintained sinusoidal and balanced by SAPF using compensation technique. Active-Reactive (P-q Power theory) theory along with hysteresis controller is used to control the SAPF and also to give the gate pulses to filter switches. (SAPF) [1].

II. BLOCK DIAGRAM

Block diagram consists of three phase AC system, three leg voltage source inverter, three phases Rectifier with RL load and FLC controller [2]. Non- linear load is connected in parallel for a 3-phase Voltage Source Inverter. Due to the appearance of nonlinear loads, there will be current harmonics at the source side and these are to be suppressed to IEEE standard. These harmonics are eliminated by SAPF with PI based Fuzzy logic controller [9]. P-q theory is used for the current control SAPF. The compensated harmonic current by SAPF is equal in magnitude and in opposite direction with the generated harmonic current. [8].

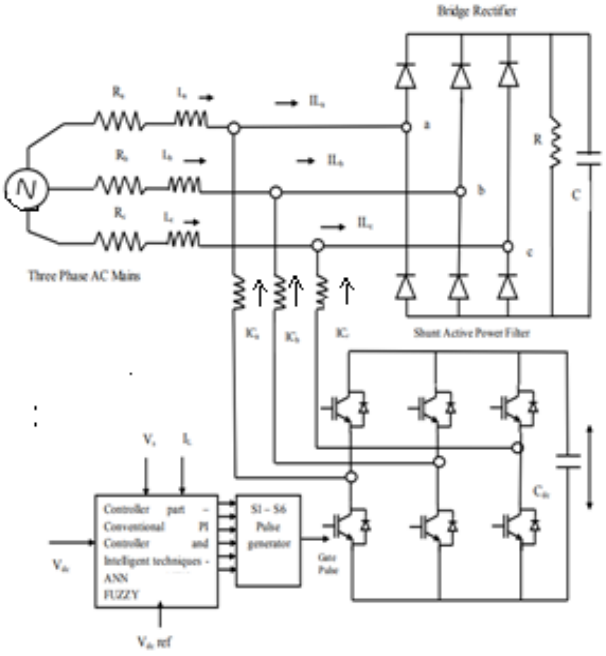

Fig 1: Block Diagram of Proposed System.

III. An Overview On FLC (Fuzzy Logic Controller)

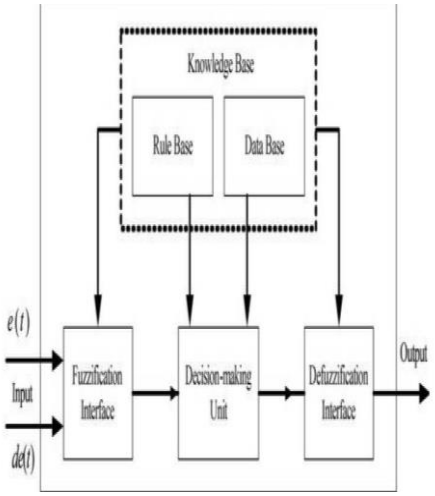

Fig 2: FLC Architecture

FL (Fuzzy- Logic) architecture consists of 4 Blocks, they are: Fuzzifier, database, Fuzzy inference engine, and Defuzzifier [10].

Fuzzifier: Fuzzy system operates with Linguistic variable rather than numerical variables. The error among input and output are divided into seven fuzzy rules are mentioned in table. Triangular membership function is applied for Fuzzification. Fuzzification means transforming the crisp data into linguistic data/rule with the purpose that the error should be equal to fuzzy rules.

Rule Base: The Fuzzy rules are held by Rule Base in the form of linguistic variables thus it helps in Decision making. Fuzzy controller output calculates the peak current thereby it is multiplied by PLL to get the required reference current.

Database: The Database block consists of a triangular membership functional block which is much advantageous for the Fuzzification process and Defuzzification.

Fuzzy Inference Engine: Here mamdani inference system is used. This process consists of three steps they are: 1) Fuzzy rules have to be decided. 2) With the help of input membership function the crisp input is converted into fuzzy.3) generating the fuzzy output according to the fuzzy rules.

Defuzzifier: Defuzzification process is converting the fuzzy output into numerical crisp output.

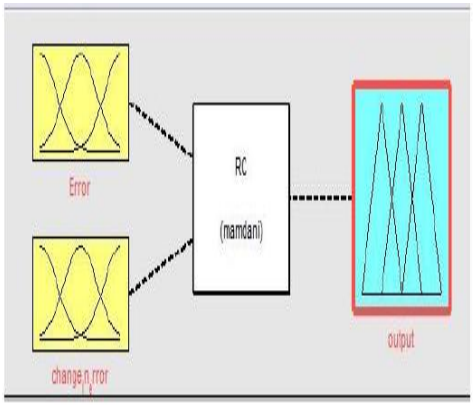

Fig 3: Fuzzy logic Implementation

Table 1: Mamdani fuzzy rules

E CE	NB	NM	NS	Z	PS	PM	PB
PB	Z	PS	PM	PB	PB	PB	PB
PM	NS	Z	PS	PM	PB	PB	PB
PS	NM	NS	Z	PS	PM	PB	PB
Z	NB	NM	NS	Z	PS	PM	PB

A FLC system is a set of linguistic rules which uses linguistic type of variables rather than numerical type of variables by choosing seven fuzzy sets such as NB (–ve big), NM (-ve medium), NS(-ve Small), Zero(Z), PS(+ve small), PM(+ve Medium) and PB(+ve

big)are the linguistic variables for every input and output. Fuzzification uses Triangular membership function [1]. In this proposed system mamdani inference system with the set of fuzzy rules is used to suppress the harmonics.

IV. SIMULATION RESULTS

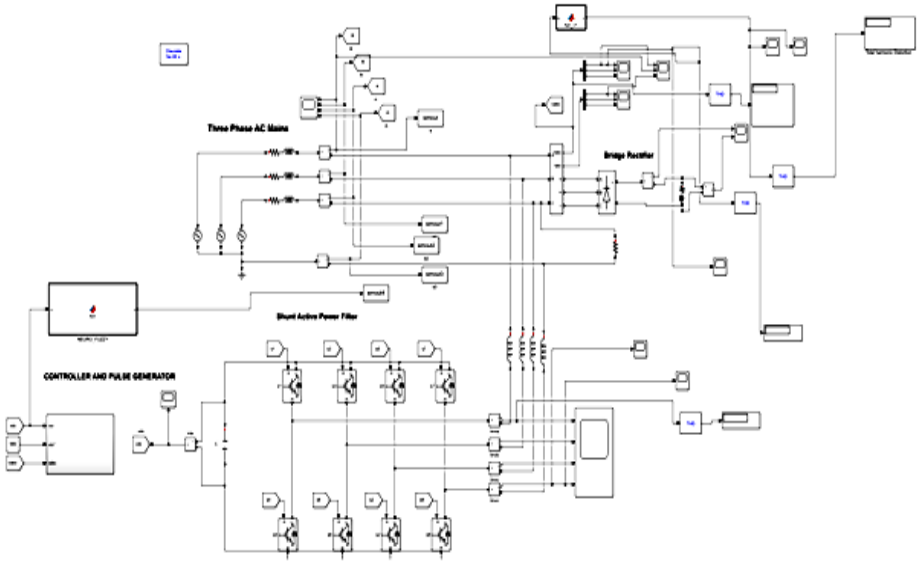

Fig 4: Simulation Circuit

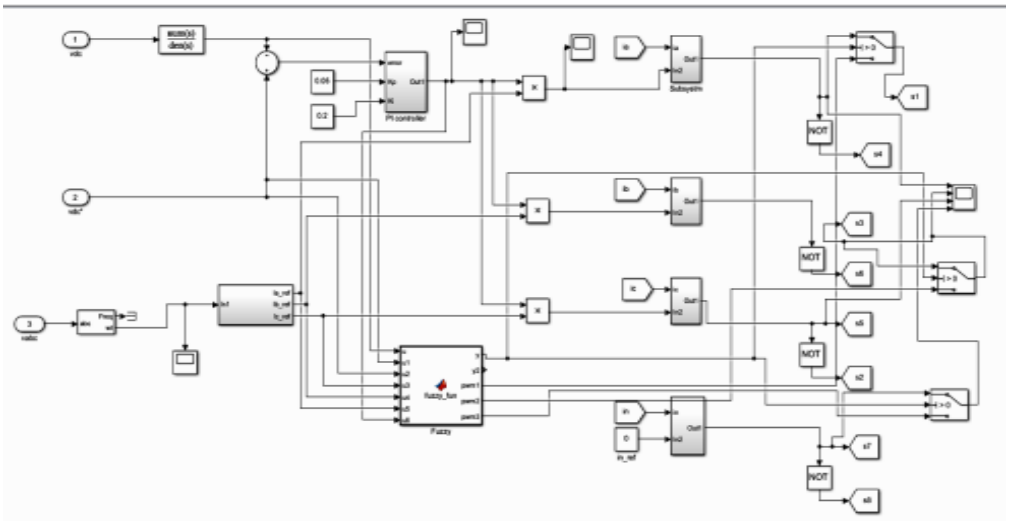

Fig 5: Simulation circuit of FLC

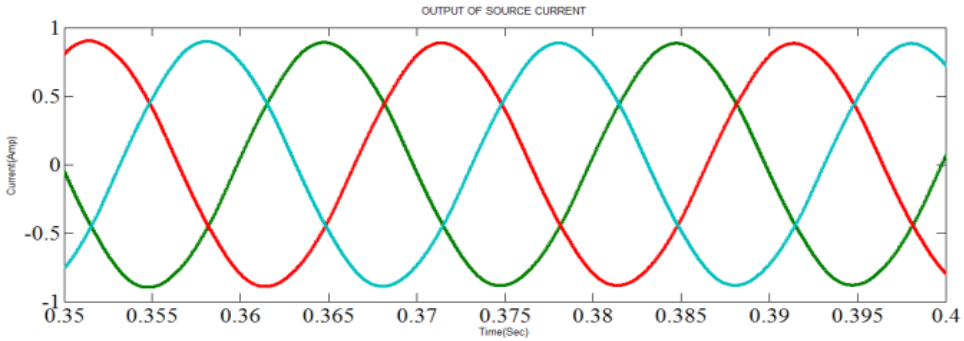

Fig 6: Simulation output- FLC based SAPF

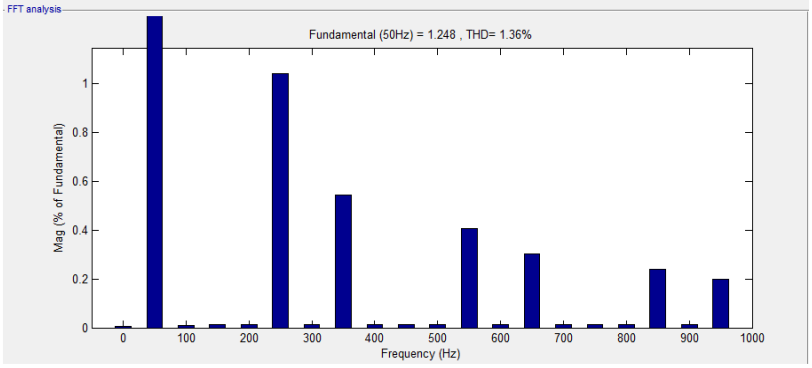

Fig 7: FFT analysis of FLC based SAPF

V. CONCLUSION

Proportional integral along with Fuzzy Logic Controller [4] based SAPF is proposed to mitigate the current harmonics by injecting the compensation current in opposite to that of harmonic current. Shunt active power filter with PI based FLC having THD less than 5% which is IEEE standard. These indemnification techniques are used in industrial applications data storage and computer systems, induction heating etc.

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