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Fuzzy Logic Controller based Shunt Active Filter

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Abstract- In this analysis Shunt Active Power Filter (APF) is proposed for the compensation of harmonic currents and reactive power. For this purpose, a fuzzy logic controller is developed to adjust the energy storage of the dc voltage. The reference current computation of the shunt APF is based on the instantaneous reactive power (p-q) theory. MATLAB/SIMULINK power system toolbox is used to simulate the proposed system. With this controller we are able to compensate the harmonic current and reactive power within limits by making an improvement in conventional triangularization current control loop by eliminating current controller from feedback control system.

Keywords-APF, PQ, FLC

1. INTRODUCTION

The power quality (PQ) problems in power utility distribution systems are not new, but only recently their effects have gained public awareness. Advances in semiconductor device technology have fuelled a revolution in power electronics over the past decade, and there are indications that this trend will continue. However the power electronics based equipments which include adjustable-speed motor drives, electronic power supplies, DC motor drives, battery chargers, electronic ballasts are responsible for the rise in reactive power problems. These nonlinear loads appear to be prime sources of harmonic distortion in a power distribution system. Harmonic currents produced by nonlinear loads are injected back into power distribution systems. These perturbations are the origin of many problems and affect electrical equipments connected to the power supply. In this analysis, we will use a Fuzzy logic controller based shunt active filter to compensate the harmonic content and reactive power within limits by making an improvement in conventional triangularization current control loop by eliminating current controller from feedback control system.

2. FUZZY LOGIC CONTROLLER

Fuzzy logic controller (FLC) is an attractive choice when precise mathematical formulations are not possible. In fuzzy logic controller, fuzzy code is designed to control something; they can be in software or hardware and can be anything from small circuits to large mainframes. It can also be used to generate the peak value of the reference current of supply. It consists of two main blocks:

2.1 REFERENCE CURRENT GENERATOR

It generates the reference current, I_{ref}, for the PWM pulse generator block. The reference current is the product of the synchronized unit sine wave and the value of I_{sp}^*. Fuzzy PI controller generate I_{sp}^* based on the value of input variables, error (e_v) and rate of change of error (de_v/dt).

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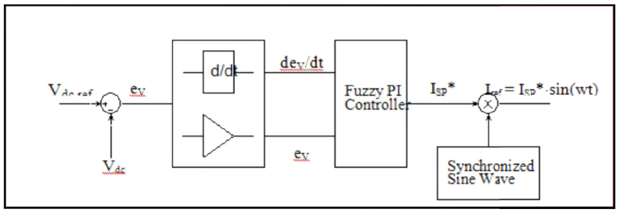
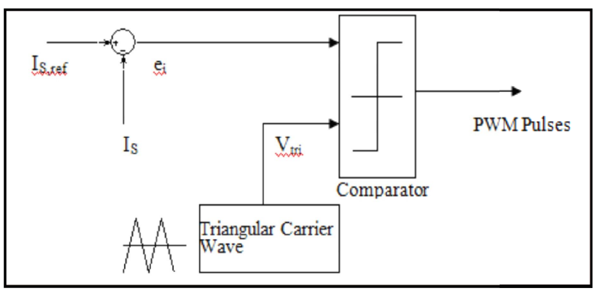


Internal structure of Reference current generator

2.2 PWM PULSE GENERATOR

It generates the switching pulses for converter switches. Pulses are generated by the comparison of the supply current error i.e. difference of supply current and reference current, with the triangular carrier waveform current controller is removed from the control system, which is an improvement on the conventional methods.



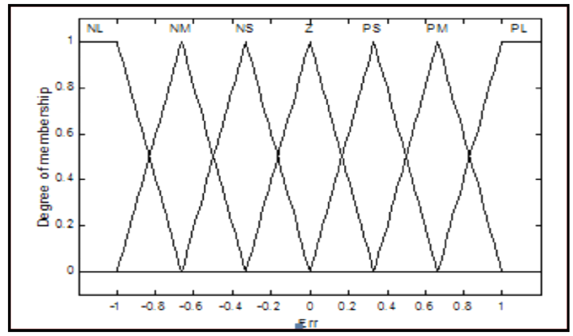
3. TUNNING OF FUZZY PI CONTROLLER

It requires two inputs and one output variable for the controller. The two inputs are:

- error ($e_V = V_{dc,ref} - V_{dc}$)
- rate change of error (de_V/dt)

The output is incremental peak value of reference supply current. The error and rate of change of error are determined at every zero crossing of the supply waveform. Thus fuzzy controller output is refreshed at every 10 msec. The fuzzy PI controller is characterized using seven triangle membership functions:

NL(Negative Large), NM(Negative Medium), NS(Negative Small, Z(Zero), PS(Positive Small), PM(Positive Medium), PL(Positive Large).



Membership Function of Input/ Output Variable

4. CONTROL RULE BASE OF FUZZY LOGIC CONTROLLER

The control rule base is constructed using the three meta rules defined for the sign and value of the error ($e_V = V_{dc,ref} - V_{dc}$) and rate of change of error (de_V/dt)

(de/dt) \ e	NL	NM	NS	Z	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	Z
NM	NL	NL	NL	NM	NS	Z	PS
NS	NL	NL	NM	NS	Z	PS	PM
Z	NL	NM	NS	Z	PS	PM	PL
PS	NM	NS	Z	PS	PM	PL	PL
PM	NS	Z	PS	PM	PL	PL	PL
PL	Z	PS	PM	PL	PL	PL	PL

Control Rule Base of Fuzzy Logic Controller

5.1 SIMULATION PARAMETERS

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Parameters	Values
AC source	230 V, 50 Hz
Source impedance:	0.628 ohm
Source resistance, R_S	0.001 ohm
Source inductance, L_S	2 mH
Active Filter:	
Filter inductance, L_f	1 mH
DC link capacitance, C_{dc}	5000 µF
Equivalent circuit parameters of dc link capacitor:	
Series Resistance, ESR	0.009 ohm
Series inductance, L	15 µH

Design Specific and Circuit Parameters

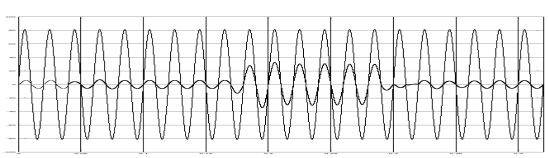
Load parameter:	
Nonlinear load:	
- Diode bridge rectifier with RC load:	
Resistance, R	10 and 30 ohm
Capacitance (Electrolytic), C	2000 µF
Equivalent circuit parameters of electrolytic capacitor:	
Series resistance, ESR	0.176 ohm
Series inductance, L	3.51 mH
Diode bridge rectifier with RL load -	
Resistance, R	10 and 30 ohm
Inductance, L	100 mH
Linear RL load:	pf. = 0.37
Resistance, R	27 ohm
Inductance, L	35 mH

Load parameters

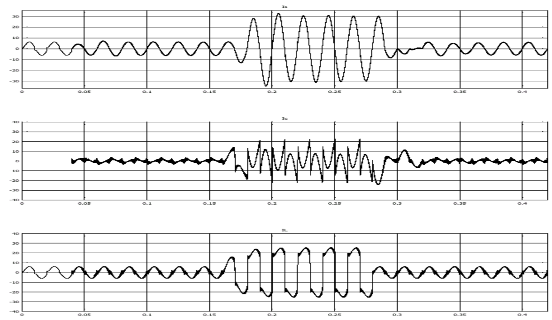
5.2 Simulink Result of

5.2.1 Diode Bridge with RL load

5.2.1.1Voltage Waveform



5.2.1.2 Current Waveform

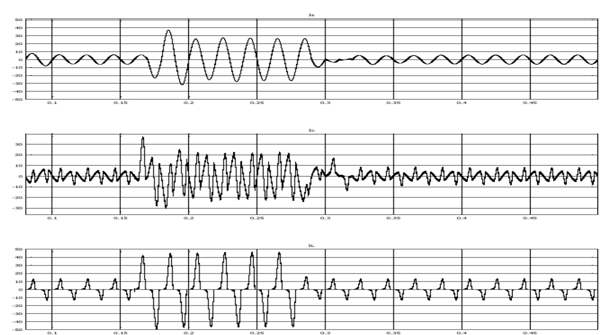


a) Supply current b) Filter current and c) Load current waveform

5.2.2Diode Bridge with RC load

5.2.2.1 Voltage waveform

5.2.2.2 Current Waveform



a) Supply current b) filter current and c) load current

6. CONCLUSION

With the help of modified fuzzy PI controller, improvement is made in conventional triangularization current control loop *by eliminating current controller from feedback control system. The simulation results show that the shunt active filter with proposed fuzzy controller is able to compensate the harmonic current and reactive power within the limits.The proposed controller is simple to implement compared to the reported fuzzy controller.*

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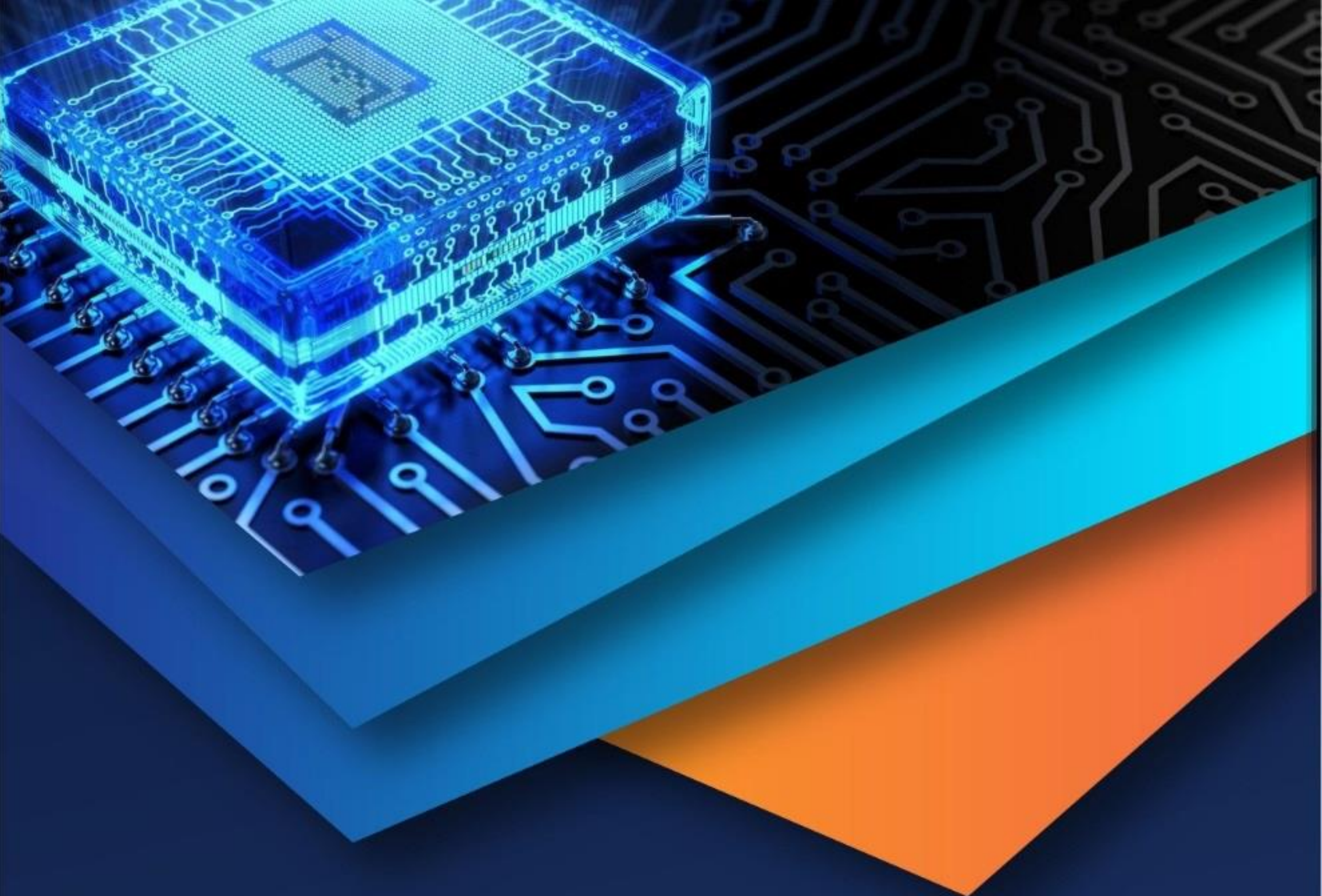

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