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POWER QUALITY IMPROVEMENT USING ACTIVE POWER FILTER BASED ON FUZZY LOGIC CONTROLLER

Pramesh Choudhary[1], Nitin Gupta[2]

[1]M.Tech. Scholar, School of Instrumentation
Devi Ahilya University, Indore (MP), India
prmesh89@gmail.com

[2]M.Tech. Scholar, School of Instrumentation
[1]M.Tech. Scholar, School of Instrumentation
Devi Ahilya University, Indore (MP), India
nitin_gupta24420@yahoo.com

Abstract- A fuzzy logic controller (FLC) with fast reference voltage generation with active power filter to correct and regulate unbalance voltage in three-phase system is proposed to improvement in power quality. The compensation algorithm is not based on three symmetrical components decomposition so the controller can yield a fast response that is essential in such a critical real time control work. The reference voltage is fed to the FLC, which is a robust closed loop controller. The proposed algorithm and control scheme of active power filter may correct and regulate unbalance voltage in three-phase system under different conditions of the utility of supply.

Keywords: Power Quality Improvement, Active Power Filter, Fuzzy Logic Controller, Power Unbalance.

1. Introduction

Power quality in ac three-phase systems could be analyzed by; Voltage unbalance, Voltage sags, Voltage swells, partial or total loss of one or more phases. A major cause of voltage unbalances is the uneven distribution of single-phase loads, which may be continuously changing across a three phase power system. Additional causes of power system voltage unbalances can be asymmetrical transformer winding impedances, open delta transformer banks and asymmetrical transmission impedances. Voltage unbalance causes a lot of ill effects on induction motors. The adverse effects of voltage unbalance in induction motors are overheating, line-current unbalance, de-rating, torque pulsation and inefficiency. The overheating leads to winding insulation degradation.

The poor power quality can degrade or damage the electrical equipment connected to the system. Improving the power quality may be provided using a three-phase active power filter, active filter may correct the voltage unbalances and regulate it to the desired level. This study proposes a compensation algorithm using a active filter associated with the fuzzy logic controller to correct and regulate the unbalance voltage in three-phase system.

The proposed APF is composed of a three-phase PWM voltage source inverter injecting compensation voltage through three separate 1-Ø transformers. The output of inverter is connected to a second order filter to eliminate high frequency caused by the switching action of the inverter. The secondary winding of each transformer is connected in series with each phase of the power supply as shown in Fig. 1.

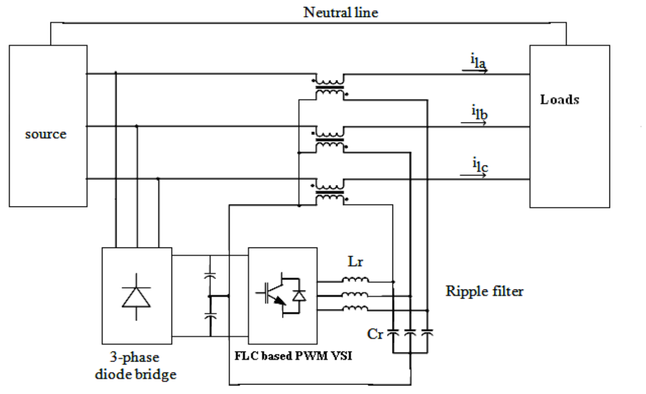


Figure 1:-Diagram of proposed APF

ACTIVE POWER FILTER principle and topology

2.1 PRINCIPLE

An APF is capable of solving many problems occurring in power system feeders.

2. Harmonic distortion.
3. Fundamental frequency reactive power.
4. Unbalanced sequence components.
5. Neutral line components.

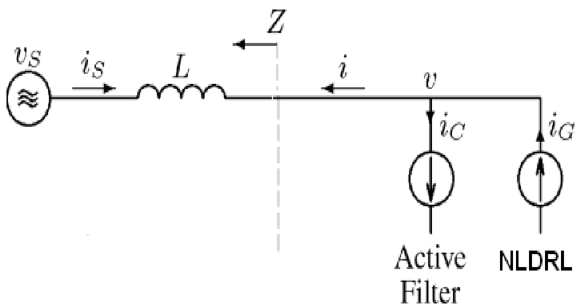


Figure 2:-Simplified circuit of distribution system with APF

2.2 TOPOLOGY DESCRIPTION

The APF is based on a 3-phase voltage inverter. Each arm consist of two pairs of insulated gate bipolar transistors with anti-parallel diodes.

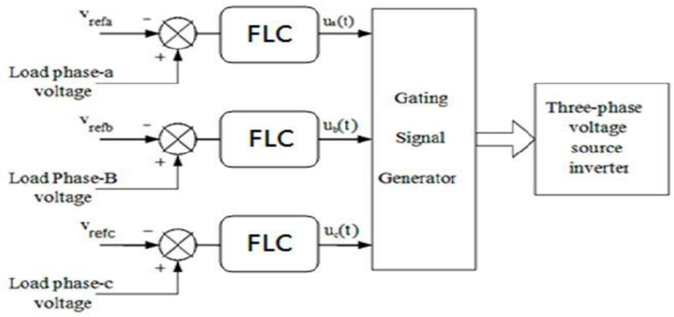


Figure 3:-Topology of APF in system

The APF performance depends on power semiconductor devices design, switches modeling techniques and coupling element design.

FUZZY LOGIC CONTROLLER

3.1 PROPOSED CONTROL SCHEME OF APF WITH FLC

The performance of the active filter mainly depends on the methodology adopted to generate the reference current and the control strategy adopted to generate the gate pulses. The block diagram representation of the proposed control technique for the APF is shown in Fig .The control strategy is implemented in three stages. In the first stage, the essential voltage signals are measured to gather accurate system information. In the second stage, compensating currents are derived based on synchronous reference D-Q theory. In the third stage, the gating signals for the solid state devices are generated using HCPWM control method.

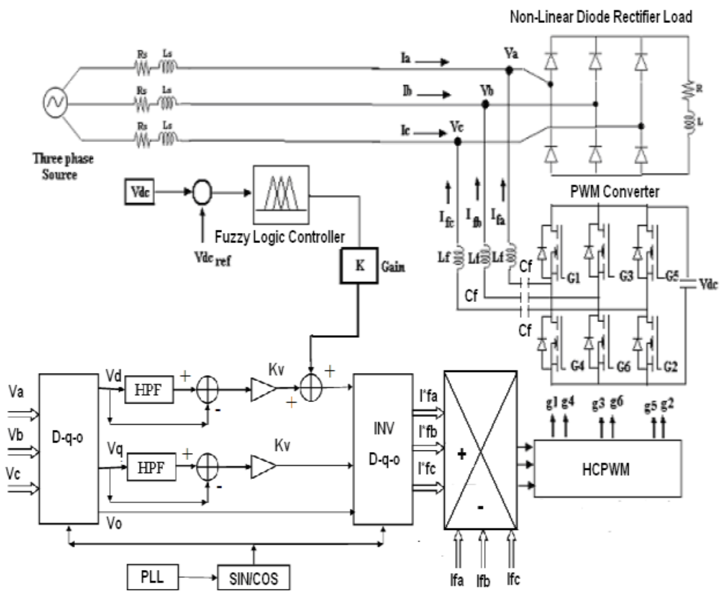


Figure 4:-Control structure of APF with FLC

3.2 PROPOSED FUZZY CONTROLLED SCHEME

The fuzzy control algorithm is implemented to control the load phase voltage based on processing of the voltage error e(t) and its variation Δe (t) in order to improve the dynamic of APF.

A fuzzy logic controller is consisting of four stages: fuzzification, knowledge base, inference mechanism and defuzzification. The knowledge base is composed of a data base and rule base and is designed to obtain good dynamic response under uncertainty in process parameters and external disturbances. The data base consisting of input and output membership functions provides information for the appropriate fuzzificztion operations, the inference mechanism and defuzzification. The inference mechanism uses a collection of linguistic rules to convert the input conditions into a fuzzified output. Finally, defuzzification is used to convert he fuzzy outputs into control signals. In designing of a fuzzy control system, the formulation of its rule set plays a key role in improvement of the system performance.

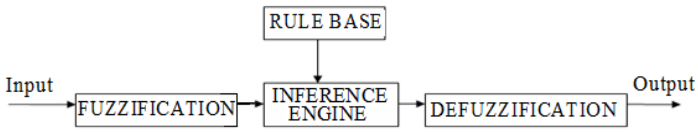


Figure 5:- Fuzzy controlled scheme

3.3 BASIC FUZZY ALGORITHAM

The fuzzy logic is characterized as follows in five categories:-

i. Seven fuzzy set for each input and output: NB (negative big), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium), PB (positive big).

ii. Triangular membership functions for simplicity.

iii. Fuzzification using continuous universe of discourse.

iv. Implication using madman's 'min' operator.

v. Defuzzification using the 'height' method.

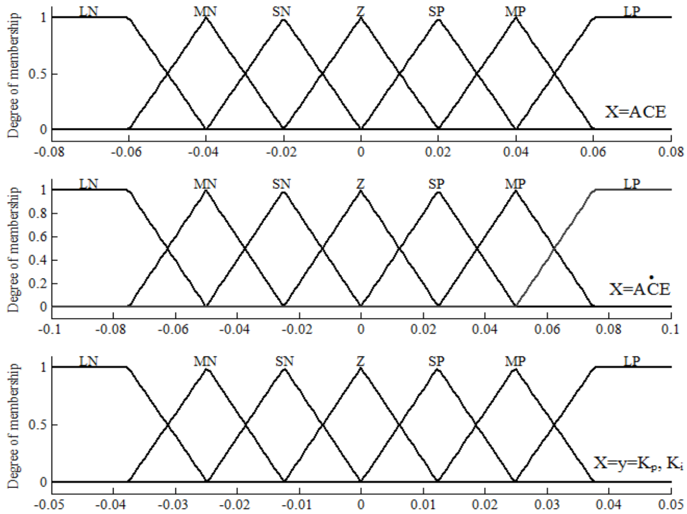


Figure 6:-Membership function for input and output variables.

3.4 DESIGN OF CONTROL RULES

	Error(e)							
Change In error		NB	NM	NS	ZE	PS	PB	PM
	NB	NB	NB	NB	NB	NM	NS	ZE
	NS	NB	NB	NB	NM	NS	ZE	PS
	NS	NB	NB	NM	NS	ZE	PS	PM
	ZE	NB	NM	NS	ZE	PS	PM	PB
	PS	NM	NS	ZE	PS	PM	PB	PB
	PB	NS	ZE	PS	PM	PB	PB	PB
	PM	ZE	PS	PM	PB	PB	PB	PB

The fuzzy control rule design involves defining rules that relate the input variables to the output model properties. As both inputs have seven subsets, a fuzzy rule base formulated for the present application is given in Table 1.

Table 1:-control rule table

4. SIMULATION AND RESULT

This section presents the details of the simulation carried out to demonstrate the effectiveness of the proposed control strategy for the APF to reduce the harmonics. Fig. shows the test system used to carry out the analysis. The test system consists of a three phase voltage source, and an uncontrolled rectifier with RL load. The active filter is connected to the test system through an inductor Lf and Capacitor CF.

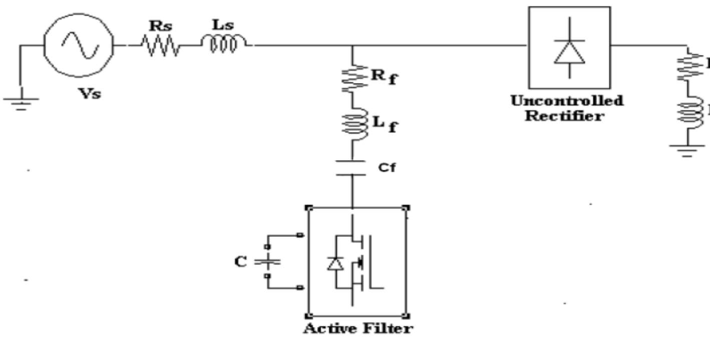
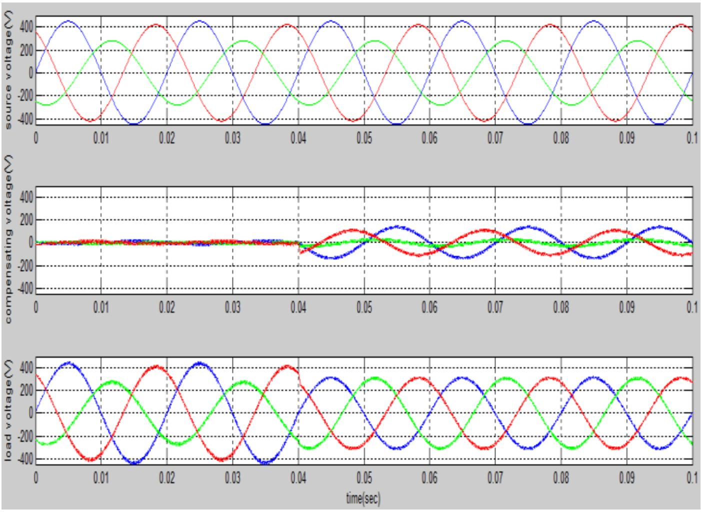
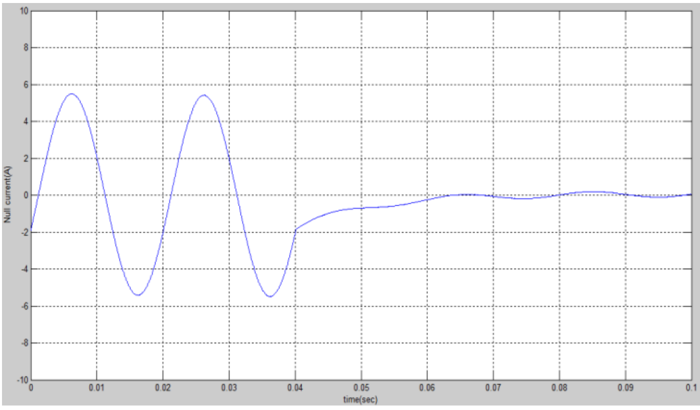


Figure 7:-Test power system for simulation.

4.1 CASE STUDY



(a)



(b)

Figure 8 (a):-Source phase voltage, compensating voltage and load phase voltage in case of balance voltage swells. (b):-Null current in this case

In each of different simulation study, magnitude and unbalance factors are calculated and given with each figure. It is clear that proposed filter has been able to bring the load phase voltages to their normal condition by inserting compensation voltages to the system. It also causes the null current approaches to zero.

5. CONCLUSION

In this study, a fuzzy controller with active power filter to regulate Unbalance voltage in three-phase system is presented and analyzed. The algorithm avoids the computational load by symmetrical components decomposition.

The simulation results show a very good performance of the proposed algorithm and control scheme under arbitrary fault conditions of the utility supply hence power quality is improved.

6. REFERENCES

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