Study of UPQC using Fuzzy Logic Controller

Rasika Linge[1], Rashmi Phasate[2]

[1]*Student, Department Of Electrical Engg, G.H Raisoni Institute Of Engg & Tech,Nagpur.*

[2]*Asst Prof, Department Of Electrical Engg, G.H Raisoni Institute of Engg &Tech,Nagpur.*

[1]rasika.linge@gmail.com Cell-9970588503

[2]rashmi.phasate@raisoni.net Cell-8793872984

Abstract **–A Unified Power Quality Conditioner (UPQC) using Fuzzy Logic Controller (FLC) is proposed. Since FLC is based on linguistic variable theory and does not require any mathematical model, the results obtained through are good in terms of dynamic response. Tuning of PI Controller is not required in case of FLC. Simulation is carried out using MATLAB/Simulink to validate the results.**

Index Terms **– UPQC, Fuzzy Logic Controller, PI controller, reactive power, harmonic distortion.**

I. INTRODUCTION

Now a days, power electronics devices has brought about great technological improvements. However, the increasing number of power electronics driven loads used generally in the industry has brought about uncommon power quality problems. These devices are mostly responsible for generating harmonics. Hence the devices that can mitigate these drawbacks are developed one of which is-UPQC. The basic requirements for compensation process involve precise and continuous VAR control with fast dynamic response and on line elimination of load harmonics. Hence Active power filters (APF) has been used. The APFs are of two types; the shunt APF and the series APF. The shunt APFs are used to compensate current related problems, such as reactive power compensation, current harmonic filtering, load unbalance compensation, etc. The series APFs are used to compensate voltage related problems, such as voltage harmonics, voltage sag, voltage swell, voltage flicker, etc. The UPQC is formed by integrating both these APFs.

The UPQC controls the flow of power at fundamental frequency. Also it controls distortion due to harmonics and unbalance in voltage in addition with control of flow of power at fundamental frequency.

The schematic diagram of UPQC is shown in fig 1. It consists of two voltage source inverters (VSIs) connected back to back, sharing a common DC link in between. One of the VSI acts as shunt APF, whereas the other act as series APF. The performance of UPQC is based on how quickly and accurately compensation signals are derived. The Control scheme of UPQC using pi controller is tedious and is prone to severe dynamic interaction between active and reactive power flow.

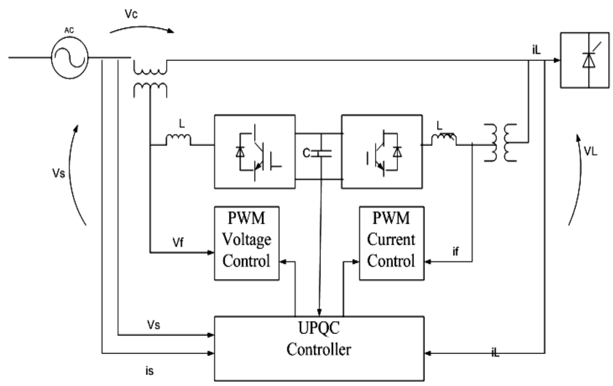

Fig 1.Schematic diagram of UPQC

In this paper, a Fuzzy logic Controller based UPQC is proposed. The dynamic response of FLC based UPQC is better in dynamic response and THD values can also be kept within limits.

II. LITERATURE REVIEW

Possible methods of VAR generation and control by static thyristor circuits are reviewed, and new approaches are described in which power frequency changers (cycloconverters) are employed. Oscillographic recordings illustrate the operation and performance of practical systems, including a 35-Mvar arc furnace compensator. [1]

A quasi-passive filter (QPF) has been proposed to overcome the limitations of conventional shunt passive filters, which are invariably used for harmonic filtering. With certain modifications in the QPF, a modified quasi-passive filter (MQPF) has been proposed, which can be used for reactive power compensation in addition to harmonic filtering. The proposed QPF and MQPF have been verified through analysis and simulation. Experiments are carried out to verify the validity of the QPF. [2]

A shunt active power filter (APF) based on unified constant frequency integration or one-cycle control for compensating unbalanced loads in a three-phase four-wire system is explored. The scheme neither requires the service of a phase-locked loop nor requires to sense the utility voltages. This makes the scheme insensitive to the distortions that are generally present in the utility voltages. First, the one-cycle control technique is applied to a topology involving a four-leg converter for the proof of concept. Then it is utilized to control a conventional three-leg converter having a split-capacitor dc link. The effectiveness and the viability of the schemes are demonstrated through detailed simulation and experimental verification. [3]

The possible calculation methodologies when designing a selective shunt active filter are presented. To accomplish selective extraction of harmonic sequences, the modulation-filter-demodulation technique is used. The fundamental equations of this method are based on pq theory. Its equivalence with the SRF (synchronous reference frame) method is shown. In order to validate the proposed calculation methods, measured currents from an arc furnace, showing high harmonic distortion, are used. The obtained results show the effectiveness of the proposed method for selective filtering of the undesired current harmonics in a controlled way. [4]

Two control scheme models for UPQC, for enhancing PQ of sensitive non-linear loads has been described. Based on two different kinds of voltage compensation strategy, two control schemes have been designed, which are termed as UPQC-Q and UPQC-P. A comparative loading analysis has developed useful insight in finding the typical application of the two different control schemes. The effectiveness of the two control schemes is verified through extensive simulation using the software SABER. As the power circuit configuration of UPQC remains same for both the models, with modification of control scheme only, the utility of UPQC can be optimized depending upon the application requirement. [6]

III.FUZZY LOGIC CONTROLLER

FLC, basic control action is determined by a set of linguistic rules. These rules are determined by the system. Since the numerical variables are converted into linguistic variables, mathematical modeling of the system is not required in FC. The FLC comprises of three parts: fuzzification, interference engine and defuzzification. The FC is haracterized as; i. seven fuzzy sets for each input and output. ii. Triangular membership functions for simplicity. iii. Fuzzification using continuous universe of discourse. iv. Implication using Mamdani"s „min" operator. v. Defuzzification using the „height" method.

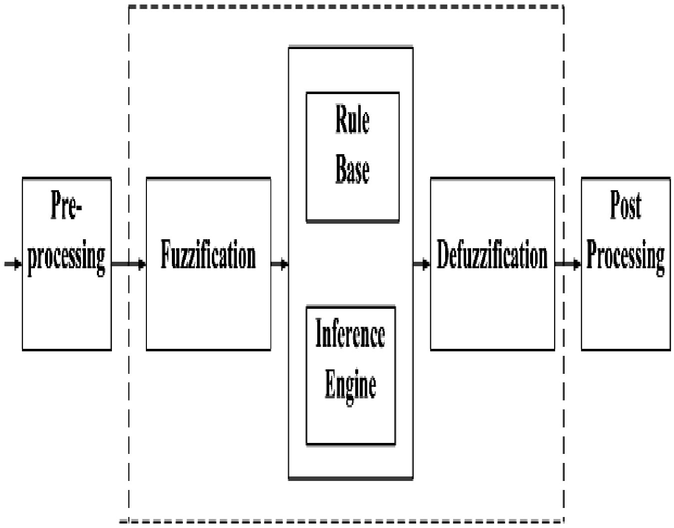

Fig 2.Fuzzy Logic Controller

Fuzzification:

Membership function values are assigned to the linguistic variables, using seven fuzzy subsets: NB (Negative Big), NM (Negative Medium), NS (Negative Small), ZE (Zero), PS (Positive Small), PM (Positive Medium), and PB (Positive Big). The partition of fuzzy subsets and the shape of membership function adapt the shape up to appropriate system. The value of input error E(k) and change in error CE(k) are normalized by an input scaling factor shown in Fig 2

CHANGE IN ERROR	ERROR						
	NB	**NM**	**NS**	**Z**	**PS**	**PM**	**PB**
NB	PB	PB	PB	PM	PM	PS	Z
NM	PB	PB	PM	PM	PS	Z	Z
NS	PB	PM	PS	PS	Z	NM	NB
Z	PB	PM	PS	Z	NS	NM	NB
PS	PM	PS	Z	NS	NM	NB	NB
PM	PS	Z	NS	NM	NM	NB	NB
PB	Z	NS	NM	NM	NB	NB	NB

TABLE 1: Fuzzy rules

Interference Method:

Several composition methods such as Max–Min and Max-Dot have been proposed in the literature. In this paper Min method is used. The output membership function of each rule is given by the minimum operator and maximum operator. Table 1 shows rule base of the FLC.

Defuzzification:

As a plant usually requires a non-fuzzy value of control, a defuzzification stage is needed. To compute the output of the FLC, „height" method is used and the FLC output modifies the control output. Further, the output of FLC controls the switch in the inverter. In UPQC, the active power, reactive power, terminal voltage of the line and capacitor voltage are required to be maintained. In order to control these parameters, they are sensed and compared with the reference values. To achieve this, the membership functions of FC are: error, change in error and output. In the present work, for fuzzification, non-uniform fuzzifier has been used. If the exact values of error and change in error are small, they are divided conversely and if the values are large, they are divided coarsely. The set of FC rules are derived from (1).

$$u=-[\alpha E + (1-\alpha)*C] \qquad (1)$$

Where α is self-adjustable factor which can regulate the whole operation. E is the error of the system, C is the change in error and u is the control variable. A large value of error E indicates that given system is not in the balanced state. If the system is unbalanced, the controller should enlarge its control variables to balance the system as early as possible.During the process, it is assumed that neither the UPQC absorbs active power nor it supplies active power during normal conditions. So the active power flowing through the UPQC is assumed to be constant.

IV. CONCLUSION

It is concluded that a UPQC using Fuzzy Logic Controller can be investigated for compensating reactive power and harmonics and that the UPQC so designed will be simple and will be based on sensing the line currents only.It is to ensure that the fuzzy logic controller limits the THD of the source current well below 5% which is the harmonic limit imposed by IEEE-519 standard.

REFERENCES

[1]. Gyugyi L., “Reactive power generation and control by thyristor circuits,” *IEEE Trans. Ind. Appl.*, vol. 15, no. 5, pp. 521-532, 1979.

[2]. Mahanty R., “Large value AC capacitor for harmonic filtering and reactive power compensation,” *IET Gen. Transm. Distrib.*, vol. 2, no. 6, pp. 876-891, 2008.

[3]. Hirve [S., Chatterjee K., Fernandes B. G., Imayavaramban M. and Dwari S., “PLL-less power filter based on one-cycle control for compensating unbalanced loads in three-phase four-wire system,” *IEEE Trans. Power Deliv.*, vol. 22, no.4, pp. 2457-2465, 2007.

[4]. Casaravilla G., Salvia A., Briozzo C. and Watanabe E., “Control strategies of selective harmonic current shunt active filter,” *IEE Proc. Gener. Transm. Distrib.*, vol. 149, no. 6, pp. 689-694, 2002.

[5]. Gyugi L., “Unified power-flow control concept for flexible AC transmission systems,” *IEE Proc. C Gener. Transm. Distrib.,* vol. 139, no. 4, pp. 323-331, 1992.

[6]. Basu M., Das S. P. and Dubey G. K., “Comparative evaluation of two models of UPQC for suitable interface to enhance power quality,” *Elect. Power Syst. Res.*, vol. 77, no. 7, pp. 821- 830, 2007.

[7]. Jain S. K., Agrawal P. and Gupta H. O., “Fuzzy logic controlled shunt active power filter for power quality improvement,” *IEE Proc. Electr. Power Appl.*, vol. 149, no. 5, pp. 317-328, 2002.