POWER QUALITY IMPROVEMENT USING FUZZY LOGIC BASED UPQC

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ABSTRACT

Here in this paper a unified power quality conditioner (UPQC) utilizing a fuzzy logic controller (FLC) has been suggested. The response accomplished through the FLC is better in terms of dynamic response because of the fact that the fuzzy logic controller is based on linguistic variable set theory and a mechanical model is also does not required.The results obtained through the FLC are very good in terms of dynamic response and harmonic elimination, because of the fact that the FLC is based on linguistic variable set theory, tuning the PI controller and does not require a mathematical model of the system. Here in this paper we can enhance by improving the power quality of the system.Though the tedious approach of varying the PI controller is not desired in this case of FLC. Simulations are verified using MATLAB/Simulink to validating the theoretical evaluation findings.

Keywords: FLC, Harmonic Ripples, PI Controller, Reactive Power, Unified Power Quality Controller, Total Harmonic Distortion.

I. INTRODUCTION

There has been a rapid rise of nonlinear loads over the years due to the intensive usage of power electronic devices in industry as well as by domestic consumers of electric source. The utility providing these nonlinear loads has to huge reactive power. Even though, the harmonics produced by the nonlinear loads contaminate the utility. The foremost requirements for compensation technique involve precise and continuous VAR control with quick dynamic response and online mitigation 0f load harmonics. In order to satisfy this principle, the conventional methods of VAR compensation using switched capacitor and thyristor controlled inductor integrated with passive filters are increasingly replaced by active powerfilters (APFs).

The current related problems are compensated generally by using the shunt type APFs, flowing of reactive power balance, filtering of harmonics, unbalancing of load compensation. The voltage related problembalanced by using the series APFs like voltage harmonics, voltage sag, voltage swell, voltage rapid variations called flicker etc. The unified power quality conditioner (UPQC) is aims at coupling both shunt and series APFs through a common DC link capacitor. The UPQC is as same in construction to a unified power flow controller (UPFC). The UPFC is selected in power transmission system, whereas in power distribution system the UPQC is selected. The main objective of UPFC is to maintain the flow of power at, essential frequency. On the other hand the distortion due to harmonics can be compensated by UPQC and also maintain the power flow at the fundamental frequency.

The schematic block diagram of UPQC is illustrated in figure 1. It integrates of two voltage source inverters (VSIs) integrated back to back, sharing a common DC link in between. In these two voltages source inverters one can act as a shunt type APF, and another can perform as a series type APF. The operating performance of UPQC primarily depends on how quickly and accurately compensation signals are established. The control strategy of UPQC depends on PI controller has been majorly reported. The PI control dependent control techniques are simple and very effective. Even though the maintaining the PI controller values is a tedious method.

The control of UPQC based on the traditional PI control is flat to serious dynamic interaction between active and reactive powerflow. Here in this paper the traditional PI controller has been replaced by a fuzzy controller. The FC has been utilized in APFs in place of traditional PI controller for increasing the dynamic operating performance. The FC is generally a nonlinear and adaptive in nature.

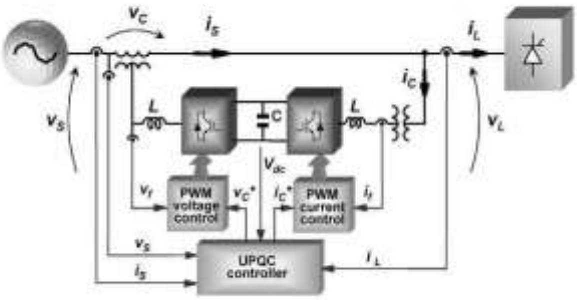

Fig1. Schematic Block Diagram of UPQC

The suitable reference signal in phase with the supply voltage is multiplied with the output of the PI controller to produce the reference current. The main function series APF calculate the reference voltage magnitude to be injected by the series APF by comparing the terminal voltage with a reference value of voltage magnitude.

II. CONTROL STRATEGY OF UPQC

The sensed DC link voltage Vdc is compared with a reference voltage V*dc. The error signal obtained is processed in Fuzzy Logic controller. The output response of the Fuzzy controller $i * sb$ is considered as the magnitude of three phase reference supply currents. The three phase unit current vectors ($u_{sa}, u_b, and\ u_{sc}$) are derived in phase with the supply voltage in terms of three phases $(Vsa, Vsb, and\ Vsc)$.The unit current vectors from the three phase of applied current. The unit vectors reference supply current can be represented by($i_{sa}, i_{sb}, and\ i_{sc}$). These references current values are compared with the actual shunt balancing currents which are flowing in the line is represented by$(i^*_{sha}, i^*_{shb}, and\ i^*_{shc})$ and the sensed error signal is converted into PWM triggering pulses, the shunt APF delivered harmonic currents and reactive power demand of the load.

The magnitude of the supply voltage is calculate from the three phase sensed values of voltages as

$$v_{sm} = \left[\sqrt{\left[\frac{2}{3}(v_{sa}^2 + v_{sb}^2 + v_{sc}^2)\right]}\right] \quad (1)$$

The three phase unit current vectors are calculated as

$$u_{sa} = (\frac{v_{sa}}{v_m}), u_{sb} = (\frac{v_{sb}}{v_m}),\ u_{sc} = (\frac{v_{sc}}{v_m}) \quad (2)$$

To accomplish reference currents, three phase currents at the load are subtracted from three phase supply

$$i_{sha} = a_1 \ , i_{shb} = b_1 \ and i_{shc} = c_1 \qquad (3)$$

Where

$a_1 = (i_{sa}^* - i_{la})$,$(b_1 = i_{sb}^* - i_{lb})$,and$(c_1 = i_{sc}^* - i_{lc})$,

2.1 Principle of Control of Series APF

In the series APF, the three load voltages (v_{la}, v_{lb} and v_{lc}) are subtracted from three supply voltagesv_{sa}, v_{sb} and v_{sc}) resulting into three phase reference voltages (v_{la}^*, v_{lb}^* and i_{lc}^*)tp be injected in series with the load side of the network. The required injected voltage is given as

$$V_{inj} = V_s - V_l \qquad (4)$$

$$V_{ia}^* = \sqrt{2} V_{inj} \ \sin(\omega t + \delta_{inj}) \qquad (5)$$

$$V_{ib}^* = \sqrt{2} V_{inj} \ \sin(\omega t + \frac{2\pi}{3} + \delta_{inj}) \qquad (6)$$

$$V_{ic}^* = \sqrt{2} V_{inj} \ \sin(\omega t - \frac{2\pi}{3} + \delta_{inj}) \qquad (7)$$

$$i_{sea} = \left[\frac{V_{ia}^*}{Z_{se}}\right], i_{seb} = \left[\frac{V_{ib}^*}{Z_{se}}\right], i_{sec} = \left[\frac{V_{ic}^*}{Z_{se}}\right] \qquad (8)$$

Where δ_{inj} is indicate the phase angle of the injected voltage

III. FUZZY LOGIC CONTROLLER

In FLC, basic control action is evaluated by a set of linguistic rules. These rules are calculated by the system. Since the numerical variables are changed into linguistic variables sets, mathematical structure of the system is not desired in Fuzzy Controller. The FLC compose of three parts, those are fuzzification, interference engine and defuzzification. The Fuzzy Controller is characterized as a) seven fuzzy sets for every input and output. B) Triangular membership functions for simplicity. C) Fuzzification using continuous universe of discourse. D) Implecation using Mamdani's 'min' operator. E) Defuzzification using the 'height' method.

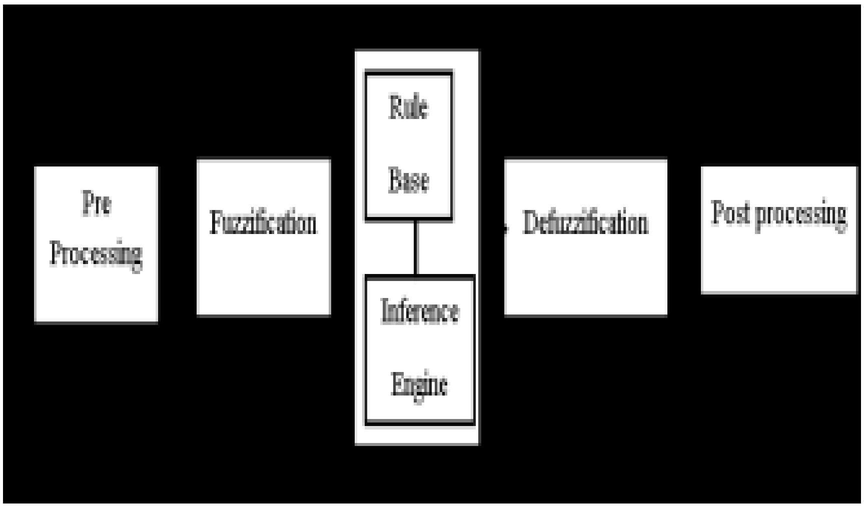

Fig2. Fuzzy Logic Controller

3.1 Fuzzification

Membership function values are applied to the linguistic variables using seven fuzzy subsets those are 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 structure of membership function adapt the structure up to suitable system. The value of supply magnitude error $E(k)$ and change in error $CE(k)$ are normalized by an input scaling factor illustrated 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

Table1. Fuzzy Rules

In this system the input scaling phenomenon has been developed so that input supply values boundary between -1 and +1. The triangular control structure of the membership function of this preparation presumes that for any particular input there is only one effective fuzzy subset. The input error E(k) for the FLC is explained.

3.2 Interface Procedure

Certain composition approach such as Max-Min and Max-Dot has been suggested in the literature. Here in this paper Min method is used. The output membership function of every rule is given by the minimum operator and maximum operator. Table 1 illustrates the rule base of the FLC.

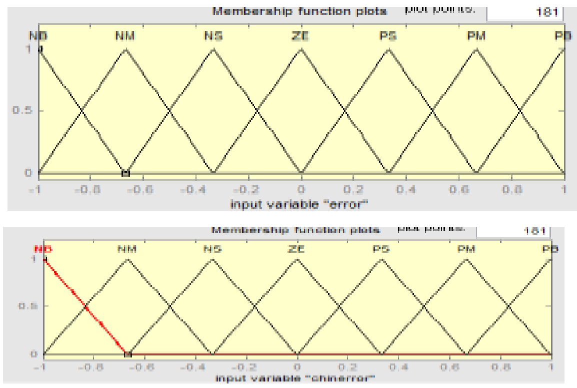

Fig3. Membership Functions

3.3 Defuzzification

As a plant usually requires a non-fuzzy value of control, a defuzzificationlevel is required. To compute the output of the FLC, the method called height is used and the FLC output changes the control output. In addition all the inverter switches are controlled by the output of FLC. In the UPQC the terminal voltage magnitude, the availability of active power, the flow of reactive power and the voltage across the capacitor are required to be controlled. For this controlling these parameters, they are detected and compared with the desired parameters.

To switch on this, the membership functions of FC are, obtained error, variation in error, and output as illustrated in the figure 3. Here in this paper investigatedfuzzification, nonuniformfuzzifier has been applied. If the accurate error values and change in error are small, they are divided contrary and if the parameter values are big, they are divided coarsely. The set of FC rules are derived from following expression.

$$u = [\alpha E + (1 - \alpha) * C] \quad (9)$$

Where α is factor of self-adjustable which can control the total operation, E is the error value of the system, C is the variation in the error and u is the control variable.A huge value of error express that given system is not in symmetrical state. If the system is unsymmetrical state, the controller should extend its control variables to be control the system as soon as possible. Here the overshoot plays a key role in the system stability.

Less overshoot is desired for system stability and in confining oscillations. The optimization is done by α. During the operating process it is assumed that neither the UPQC absorbs the Active power nor it delivers active power during the normal conditions.Hence the active power flowing through the UPQC is assumed to be continuous. The fuzzy rule set is made by using the values given in Table.

In order to test the operating performance of the UPQC using the recommended FLC, it has been simulated for a 400V, 50Hz, three phase AC supply using MATLAB/Simulink platform. A nonlinear load in this paper is considered as a three phase diode reciter feeding an RL load. To test the working of the UPQC under the sag and swell conditions, 20 percent voltage sag has been created.

The UPQC simulated by using the suggested FC. The source current signal before and after integrating the UPQC as discussed. It observed that the source current is distorted before connecting the UPQC and it becomes sinusoidal after integrating the UPQC at 0.1s.

The THD of the source current before integrating the UPQC is 24.54%. Harmonic spectrum of the source current after integrating the UPQC. The THD of the source current is reduced after integrating of the UPQC isn0.13s. The DC link capacitor is kept constant at its reference vale by the FLC. To examine the operating performance of the suggested UPQC using FLC, under voltage sag condition, already 20% sag has been created in the all the phases of the supply voltage.

IV. CONCLUSION

UPQC using FC has been examined for balancing reactive power and harmonics. It is evident from the simulation results that the UPQC using FC is simple and is depend on sensing the line currents only. The THD content of the source side current using the recommended FLC is well below 5%, the harmonic limit can be decided.

By implementing this suggested method that integrating the fuzzy controller to the system which is the combination of two different kinds of controllers those series type APF and shunt type APF with taking the help of DC link. This DC link voltage is plays a crucial role that can capable of balancing the active and reactive power flowing in the power system and improves the power quality of the power system.

Here in this paper we observed that the harmonic component was reduced to a very low values and the THD value also calculated in this paper. The results obtained through the FLC are very good in terms of dynamic response and harmonic elimination, because of the fact that the FLC is based on linguistic variable set theory, tuning the PI controller and does not require a mathematical model of the system. Here in this paper by calculating the mathematical sets by utilizing the Fuzzy controller the power factor is improved an the total harmonic distortion also reduced to lower values. That is the FLC which reduced the THD value below 5%.

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