International Journal of Advanced Research in
Electrical and Electronics Engineering
Volume: 2 Issue: 1 08-Mar-2014,ISSN_NO: 2321-4775

Fuzzy Logic based DSTATCOM for Voltage Regulation and Harmonic Reduction

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ABSTARCT-*These papers propose the nonlinear control of DSTATCOM (distribution STATCOM) using fuzzy logic based supervision of PI regulator. In this the control methodology of DC capacitor voltage is regulated using a fuzzy PI controller. However during load change, there is considerable variation in DC voltage which might affect compensation. In this work the fuzzy based supervision is proposed to improve transient performance of DC link, which varies the gain of PI regulator to minimize the error in DC link capacitor voltage during the load change is obtained. Additionally the harmonic of the load current is reduced below the standard value.*

Keywords-DC link voltage control, fuzzy supervisor, DSTATCOM, symmetrical PI controller, harmonic analysis, voltage source inverter.

1, INTRODUCTION

The voltage regulation and the power quality in the distribution feeder are improved by shunt compensator called DSTATCOM. DSTATCOM is the shunt connected reactive power compensator in distribution system shown is figure 1. The DSTATCOM is modeled to achieve the power factor correction and voltage regulation along with neutral current compensation, harmonic elimination and load balancing with linear loads and non-linear loads. In DSTATCOM, the dc voltage should to be maintaining constant at reference value, whereas sudden change in load makes the dc voltage to change away from the reference value. The dc voltage in this is controlled by fuzzy logic controller by minimizing its error. The harmonics in the power line produce greater power losses in distribution system, which create inference problem, operation failure of equipment. Additionally harmonic of load current is also reduced in this paper. In this paper the theory of instantaneous symmetrical component is used because of its simplicity in formulation and ease of calculation. The fuzzy logic based supervisor varies the proportional gain and integral gain of the PI controller during the transient period immediately after the load change. This will improve the performance of controller with faster settling time. The efficiency of the proposed strategy is proved using detailed matlab simulation design.

Principle of DSTATCOM

Figure: 1 shows the schematic diagram of DSTATCOM. The basic principle of DSTATCOM in PS is the generation of a AC voltage source by voltage source inverter

(VSI) connected to a DC capacitor (energy storage device).the DSTATCOM is connected to the PS at the PCC, using transformer leakage reactance which gives active and reactive power exchange between PS and the DSTATCOM. Ideally the output voltage of the VSI is in phase

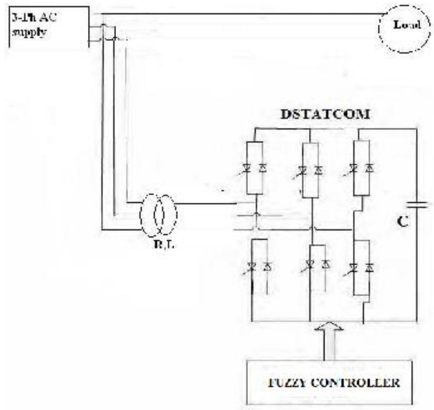

Figure 1: schematic diagram of DSTATCOM

with source voltage. In this the decouple voltage control technique is used as control technique by abc-dqo frame based technique which offer higher accuracy of control. In this technique abc determines the 3-phase vector such as (voltage and current) then dqo determines the direct axis and quadrature 2-phase vector define the real and reactive power transfer between PS and DSTATCOM.

2, FUZZY LOGIC BASED PI CONTROLER

At steady state, the average power is updated at every half cycle which gets the power from DSTATCOM as temporarily. This leads to the decrease dc link voltage, if the load is increased or increase, if the load is decreased respectively. In decoupled technique the PI

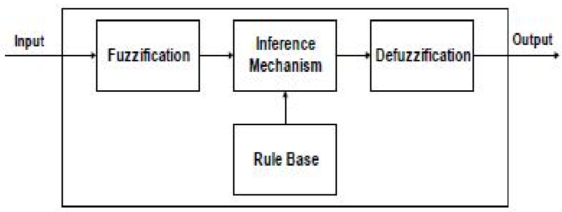

Figure 2: Fuzzy Controller Architecture

controller for dc voltage regulation has the control output is given by (1)

$$P_{loss} = K_P (V_{dc}^{ref} - V_{dc}) + K_i \int (V_{dc}^{ref} - V_{dc})dt \qquad (1)$$

Where, Kp is Proportional gain, Ki is Integral gain, V_{dc}^{ref} is Reference gain, V_{dc} actual DC voltage. For ordinary PI controller after a load change depending on its Kp and Ki value the capacitor voltage takes the 6-8 cycle to settle where as the gain is chosen by trial and error method. In order to perform satisfactory performance for load varying system, further tuning may be necessary for ordinary PI regulator. Since many processes are complicated and nonlinear, fuzzy control seems to be better choice. However instead of modifying the control action it is sufficient to use an additional level of control by supervising the gain of PI regulator for DC voltage regulation. Some of the main aspect of fuzzy controller design are choosing the right inputs and outputs and designing each of the four components of the fuzzy logic controller shown in figure.2.

2.1 Input and Output

The input of the fuzzy supervisor has been chosen as the error in DC voltage and the change in DC voltage.

$$Err(i) = V_{dc}^{ref} - V_{dc}(i) \qquad (2)$$

$$Derr(i) = Err(i) - Err(i-1) \qquad (3)$$

Where, Err(i) is error at i^{th} iteration, Derr(i) is difference of error at i^{th} iteration.

The output of controller has been chosen as the change Kp and Ki value.

$$Kp = K_{pref} + \Delta K_p \qquad (4)$$

$$Ki = K_{iref} + \Delta Ki \qquad (5)$$

Where, $K_{pref,}$ and K_{iref} is Reference Proportional and Integral gain respectively. ΔK_p and ΔK_{iv} is change in Kp and Ki given by fuzzy controller.

2.2 Fuzzification

The fuzzification interface the input(crisp value) to a form in which they can be used for inference mechanism to assign the membership function value[0,1] of triangular, trapezoidal or exponential. After fuzzification, the inference mechanism do the two membership function are a) Based on the active membership function from input, the rule for current situation are determined. b) From the rule, the certainty of the control action is ascertained from the membership values which are called as premise quantification. Thus at the end of the process, we shall have a set of rules each with a certain certainty of being valid. The database containing the rules will determine the output membership function value from the respective rule based system. The common rule based system used here is IF-THEN process of minimum operation is used to determine the certainty $\mu_{premise}$.

2.3 Rule base

The rule based system play an important role in the designing of controller. From the typical DC voltage waveform of figure after an increase in the load without the inherent ripple due to compensation. The waveform has been split into various parts depending on the sign of error and change in error.

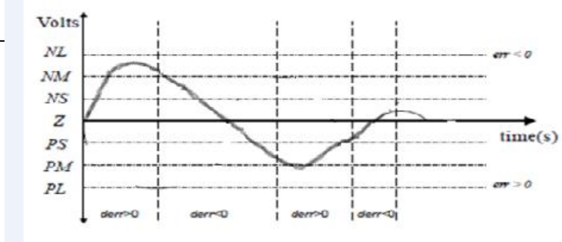

Figure 3: typical DC link voltage after a load change

2.4 Defuzzification

the defuzzyfication mechanism consider the rule from inference mechanism which has set of rules as

Err Vs Derr	NL	NM	NS	Z	PS	PM	PL
NL	L	L	L	M	S	S	Z
NM	L	L	M	S	S	Z	Z
NS	L	M	S	S	Z	Z	Z
Z	M	Z	Z	Z	Z	Z	M
PS	Z	Z	Z	S	S	M	L
PM	Z	Z	S	S	M	L	L
PL	Z	S	S	M	L	L	L

Table 1: Rule base Matrix for change in Kp

ErrVs Derr	NL	NM	NS	Z	PS	PM	PL
NL	SKI	SKI	SKI	Z	Z	Z	Z
NM	SKI	SKI	SKI	Z	Z	Z	Z
NS	LKI	LKI	LKI	Z	Z	Z	Z
Z	LKI	LK	LKI	Z	LKI	LKI	LKI
PS	LKI	LKI	LKI	Z	LKI	LKI	LKI
PM	Z	Z	Z	Z	SKI	SKI	SKI
PL	Z	Z	Z	Z	SKI	SKI	SKI

Table 2: Rule matrix for change in Ki

$\mu_{premise}$. From this the numerical value of output (crisp value) as Kp and Ki which is calculated using 'center of gravity'. If we use this resultant crisp output sensitive to all of the active fuzzy outputs of the inference mechanism.

3, SIMULATION DESIGN OF DSTATCOM

The proposed system shown below is 3-phase system of 415v, 50Hz is connected to a linear(3-phase unbalanced load) and nonlinear load (rectifier with C load).

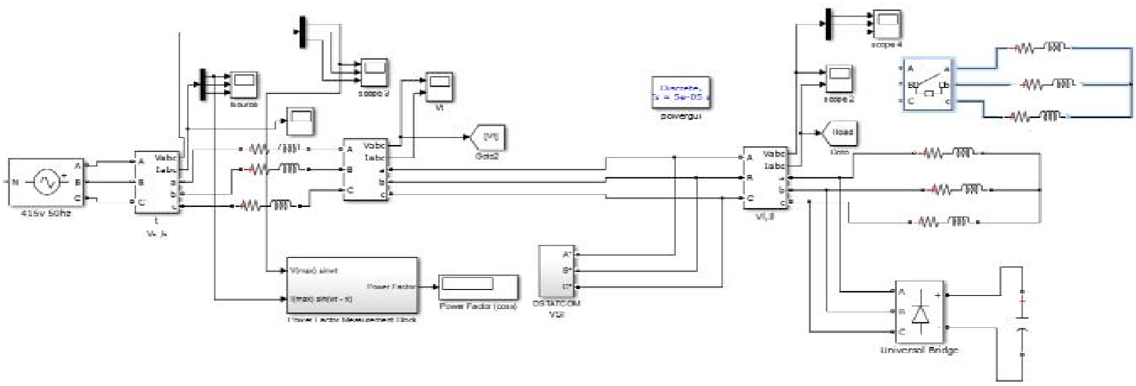

Figure 4: Simulink model with fuzzy controlled DSTATCOM.

The DC voltage regulation using fuzzy logic based system is shown below.

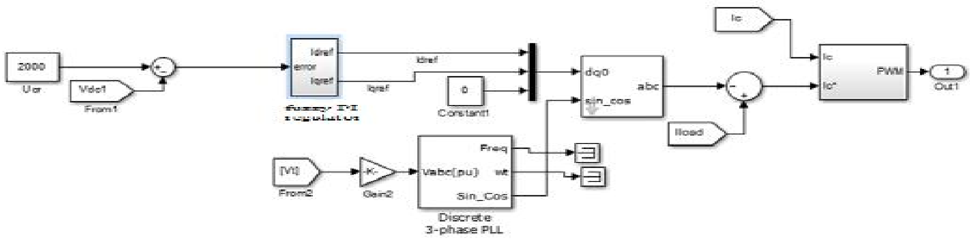

Figure 5: fuzzy logic control implementation of DSTATCOM

The figure shown above gives the control of DC voltage by getting the actual value of dc and

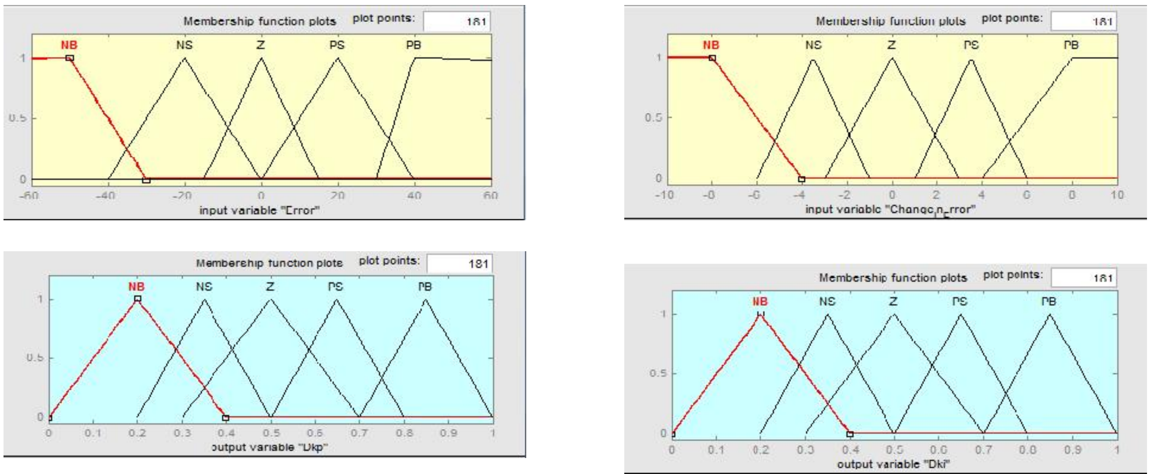

Figure 6 membership function for Input and Output

reference value. In this case the fuzzy logic based supervisor is manipulating the gain of PI controller. The figure.6 shows the fuzzy implemented PI controller deign of input and output are shown.

Then the two input of controller as error of DC voltage and change in error and their output as gain of change in Kp and Ki is shown above.

The output of controller has to be added with actual gain of PI controller. The proposed fuzzy controller is able to compensate the reactive power and suppress the harmonic in load current. Thus the fuzzy logic controller is more effective for DSTATCOM. With the implementation of fuzzy logic supervisor the improvement in DC voltage for change in load is given in figure 7(a). Then output voltage and current for this proposed system is also shown below of figure 7(b).

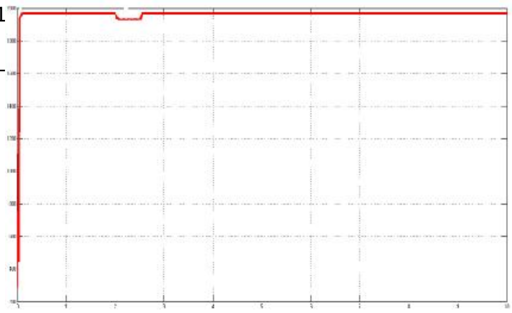

Figure 7(a) fuzzy implemented DC voltage

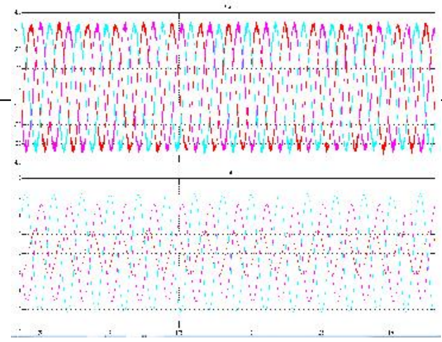

Figure 7(b) load voltage & current

4, CONCLUSION

The fuzzy logic supervisory control to the DC link PI controller in a DSTATCOM has been proposed. during transient period the supervisor varies the gain of the PI controller which improve the performance. The performance of DC voltage is analyzed and well control for change in load. Good compensation has been observed through simulation design. then the load current THD has been observed under the 5.0% for each phase.

5, REFERENCE

[1] Harish suryanarayana and Mahesh k. mishra, “fuzzy logic based control of dc link PI control in a DSTATCOM”, IEEE India conference 2008, volume-2,pages 453-458

[2] J.L aguero, F. Issouribehere, P.E Battaiotto, “STATCOM modeling for mitigation of voltage fluctuations caused by Electric Arc Furnaces” , IEEE Argentina conference 2006, pp: 1-6.

[3] R. Mohan Mathur, Rajiv k. varma, “thyristor based FACTS controller for electrical transmission system”, IEEE press series on power engineering, John Wiley & sons publishers, 2002, pp: 413-457.

[4] A. Ghosh and G.ledWich; “power quality enhancement using custom power devices” kluwer acaremic publisher, boston, 2002.

[5] H. Akagi, Y. Kanazawa, and A. Nabae, “Instantaneous reactive power compensators comprising switching devices without energy storage components,” IEEE Trans. on Ind. Appl. Vol. 20, no. 3, 625-630, 1984.

[6] F. Z. Peng and J. S. Lai, “Generalized instantaneous reactive power theory for three-phase power systems,” IEEE Trans. on Instrumentation and Measurement. Vol. 45, no. 1, 293-297, 1996.

[7] S. Tzafestas and N. P. Papanikolopoulos, “Incremental fuzzy expert PID control,” IEEE Transactions on Industrial Electronics, Vol. 37, pp. 365-371, 1990.

[8] Zhen-Yu Zhao, M. Tomizuka and S. Isaka, “Fuzzy gain scheduling of PID controllers”, IEEE Tran. On Systems, Man and Cybernetics, Vol. 23, pp. 1392-1398, 1993.

[9] A. Ajami and H.S. Hosseini, “Application of a Fuzzy Controller for Transient Stability Enhancement of AC Transmission System by STATCOM,” International Joint Conference SICE-ICASE, pp. 6059-6063, 2006

[10] H.R. Van Lauta Nemke and Wang De-zhao, “Fuzzy PID Supervisor,”24th IEEE Conf. on Decision and Control, Vol. 24, pp 602-608, 1985.

[11] P. Venkata Kishore et. al. “ Voltage sag mitigation in eight bus system using D-STATCOM for power quality improvement” International Journal of Engineering Science and Technology Vol. 2(4), 2010, pp.529-537.

[12] Mahesh K. Mishra, Member, IEEE, and K. Karthikeyan “A Fast-Acting DC-Link Voltage Controller for Three-Phase DSTATCOM to Compensate AC and DC Loads” IEEE Transactions On Power Delivery, VOL. 24, NO. 4, OCTOBER 2009, pp. 2291-2295.