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Fuzzy Logic Based DSTATCOM Control for Power Quality Enhancement

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Abstract- **This paper presents the optimized fuzzy logic control of dstatcom for power quality improvement. Power quality improvement refers to the improvement in the magnitude of voltage during voltage sag. As most of the practical systems are non linear systems intelligent control systems perform much better than conventional control techniques. In this paper fuzzy logic technique can be used to implement a controller for controlling the output of dstatcom. The test system with and without dstatcom is simulated using MATLAB for various fault conditions. The performance of fuzzy controlled dstatcom is analysed and the test results are compared with PI controlled dstatcom. In the further stage the if–then rules of the fuzzy logic controller is optimized by using genetic algorithm technique.**

Keywords: Voltage sag, dstatcom, Fuzzy Logic, PI Controller, Fuzzy Logic Controller

I. INTRODUCTION

Power quality is a set of electrical boundaries that allows an equipment to perform in its specified manner. Voltage sag and voltage swell are the common power quality issues. Voltage sag is defined as a decrease in voltage to between 0.1 and 0.9 pu in rms voltage for a duration of 0.5 cycle to 1 minute[2]. Voltage sag occurs mainly due to faults and the short circuit current results in decrease of voltage[6]. In this paper we consider voltage sag due to three types of faults namely single line to ground fault (SLG), double line to ground fault (DLG), and three phase fault.

As the demand of electric power is increasing day by day, the transmission networks are found to be very weak so that they cannot supply unreliable supply with good quality. Flexible A transmission systems(FACTS) is an idea developed based on power electronic controllers, which controls the values of different electrical parameters. FACTS technology makes use of high speed thyristors for switching in or out transmission line components for the required performance of the system. There are different types of FACTS devices namely shunt connected devices and series connected devices[1].

Dstatcom is a shunt connected FACTS device. It is a reactive source that can be controlled and it is capable of absorbing or generating reactive power. Dstatcom consists of coupling transformer, voltage source converter, DC energy storage device and necessary control circuits[8].During voltage sag dstatcom supplies the required voltage and during voltage swell dstatcom limits the voltage magnitude with in a particular value. A proper control technique is essential for the effective working of the dstatcom.

The dstatcom can provide compensation in both inductive and capacitive mode. The V-I characteristic of dstatcom is shown in figure. By using dstatcom we can control the effect of voltage sag also.

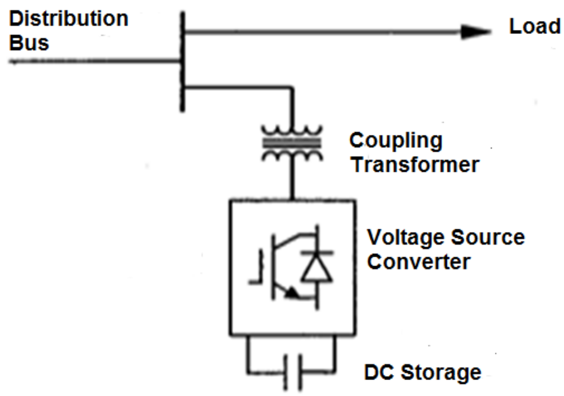

Fig. 1. Block Diagram of Dstatcom

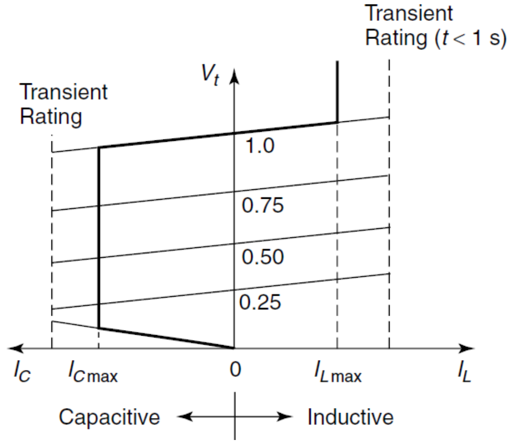

Fig. 2. V-I characteristics of Dstatcom

Intelligent control techniques provide a method of approximate reasoning that is similar to human decision making process. They have fast response time and high range of operating conditions. Fuzzy logic provides a formal idea for presenting and implementing human knowledge about how to control a system[3]. The fuzzy logic controller is shown below.

Fuzzification part converts crisp input values into fuzzy values. The knowledge base consists of a database of the plant. It gives all the required definitions for the fuzzification process .Rule base represents the controlling system of the network. It is represented as a set of if-then rules. Inference applies fuzzy reason to rule base to obtain the output. Defuzzification process converts fuzzy output to crisp values.

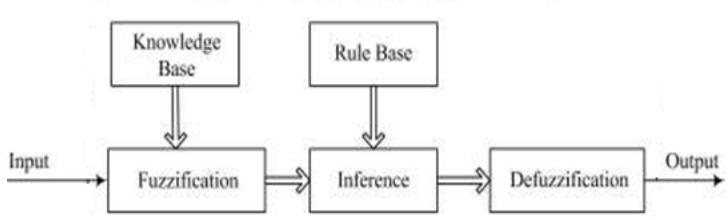

Fig. 3. Fuzzy Logic Controller

2. DSTATCOM CONTROL SCHEME

Dstatcom is controlled by means of PWM generator. The test system output is compared in an error detector and its output is fed to a fuzzy logic controller. The controller will take necessary control actions and the controller will output an angle δ which Is phase modulated by the following equations[5].

$$V_A = \text{Sin}(\omega t + \delta)$$

$$V_B = \text{Sin}(\omega t + \delta - 2\pi/3)$$

$$V_C = \text{Sin}(\omega t + \delta + \pi/3)$$

The phase modulated signals are fed to PWM generator and the pulses from PWM generator will control the operation of DSTATCOM during voltage sag.

3. DESIGN of FUZZY LOGIC CONTROLLER

The fuzzy logic controller designed here consists of two inputs, namely error and change in error, and an output. Seven linguistic variables are selected. The linguistic variables are NEB, NEM, NES, ZE, POS, POM and POB. Triangular shaped membership functions are chosen for the inputs and output .A rule base with a strength of forty nine rules is created by interconnecting different variables. Fuzzy logic controller is implemented by using fuzzy logic toolbox of Matlab Simulink..The rule base for inpiuts and output using different linguistic variables are given in the table below

de / e	NEB	NEM	NES	ZE	POS	POM	POB
NEB	NEB	NEB	NEB	NEB	NEM	NES	ZE
NEM	NEB	NEB	NEB	NEM	NES	ZE	POS
NES	NEB	NEB	NEM	NES	ZE	POS	POM
ZE	NEB	NEM	NES	ZE	POS	POM	POB
POS	NEM	NES	ZE	POS	POM	POB	POB
POM	NES	ZE	POS	POM	POB	POB	POB
POB	ZE	POS	POM	POB	POB	POB	POB

Fig. 4. Fuzzy Logic Rulebase

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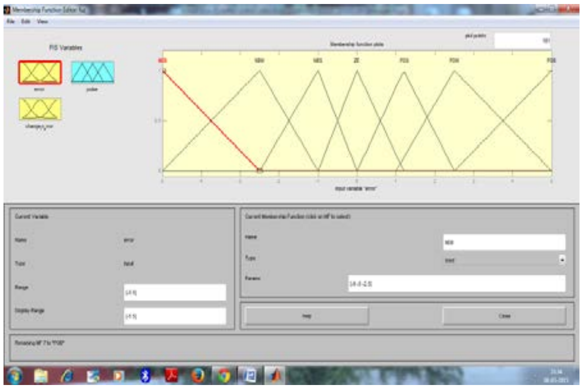

Fig. 5. Membership function for input

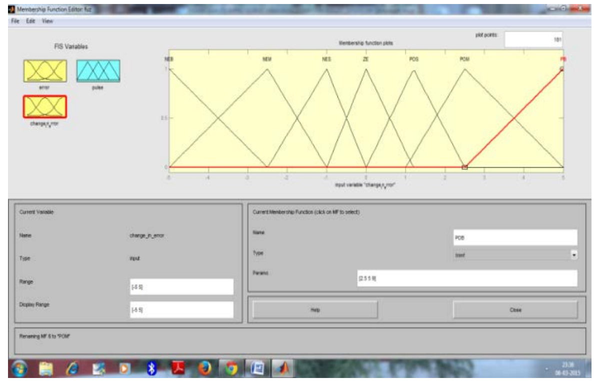

Fig. 6. Membership function for input2

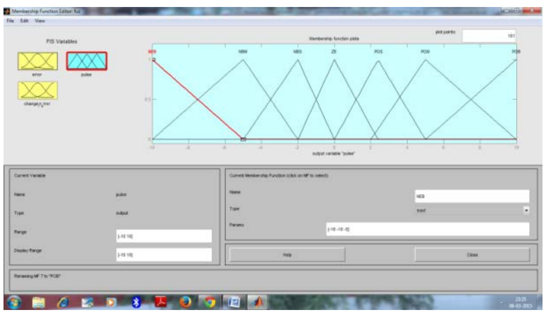

Fig. 7. Membership function for output

4. TEST SYSTEM

Test system consists of a 250kv source which is connected to the input of a three phase three winding transformer. The output terminals of three phase tree winding transformer are fed to two branches of 11kv each..In one of the branches Dstatcom is connected for the compensation of voltage sag is connected. In the second feeder we connected linear and varying loads. Different faults are introduced into this branch and the test results are analysed.

5. SIMULATION RESULTS

The system is simulated using Matlab Simulink Sim Power Systems toolbox.

A three phase fault is applied for a time range 0.85s-0.9s with a fault resistance of 0.66Ω..The system is simulated for 1s.In the first case no DSTATCOM is placed for the compensation of voltage sag. In the second case DSTATCOM with PI controller is introduced in the system. In the third case fuzzy controlled DSTATCOM is operated during the time of fault. A subsystem block is also provided in simulink model to generate the PWM control signals. Matlab Simulink test model and the simulation results are shown below. During fault in the system without dstatcom a voltage sag occurs and there is no control over the system.When PI controlled dstatcom is placed in the system voltage sag is mitigated. Fuzzy controlled dstatcom provides much more improvement in voltage sag mitigation.From the various figures given below we can analyse the performance of different controllers.

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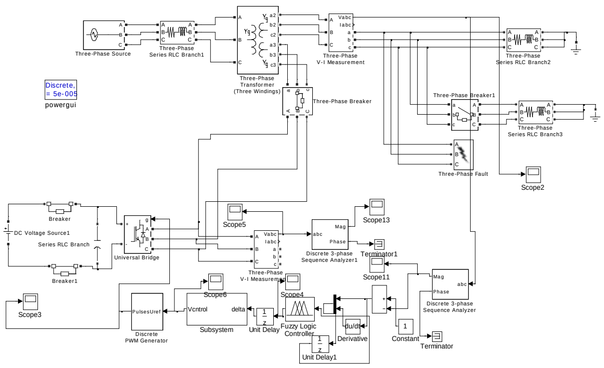

Fig. 8. Simulink Model of the Test System

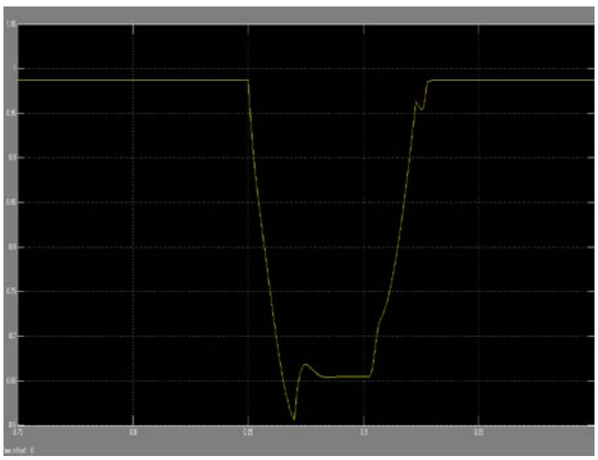

Fig. 9. Output of the System without Dstatcom

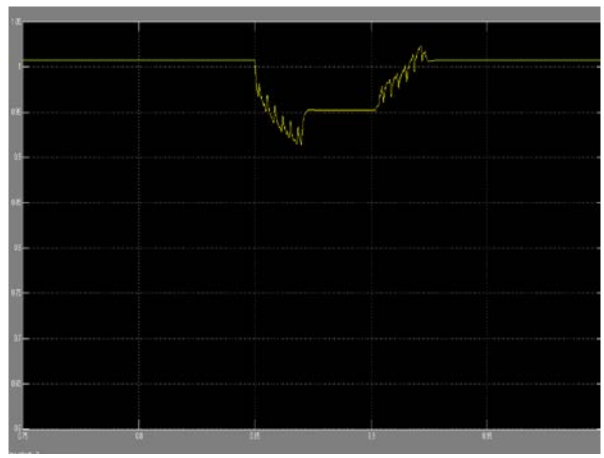

Fig. 10. Output of the System with PI Controlled Dstatcom

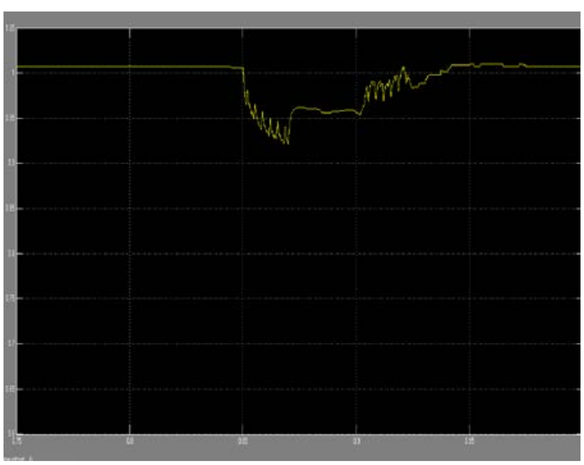

Fig. 11. Output of the System with Fuzzy Controlled Dstatcom

6. CONCLUSION

From the test results we can see the performance of fuzzy controlled DSTATCOM is better than the performance of PI controlled Dstatcom..With suitable controllers Dstatcom can perform well in voltage sag mitigation. A combination of different intelligent control techniques can be applied for the control of Dstatcom. The performance of DSTATCOM can be further improved by the application of different optimization techniques like genetic algorithm.

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