FUZZY LOGIC BASED DC-LINK VOLTAGE CONTROLLER USING THREE PHASE D-STATCOM TO COMPENSATE NON LINEAR UNBALANCED LOADS

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Abstract: ***To*** **compensate hastily varying non-linear & un-balanced loads, the transient response of the DSTATCOM (distribution static compensator) is much important. Due to any change in load, it will directly affect the dc-link voltage. When the load is removed abruptly it will result in an increasing the dc-link voltage above the reference value, where as there is a sudden increase in load will reduce the dc-link voltage below its reference value. For smooth operation of DSTATCOM the dc-link voltage should be wide-ranging within the prescribed limits. In this paper I am proposed a fast acting fuzzy logic based dc-link voltage controller which will achieve the quick transient response. Simulation results have done using Matlab/Simulink.**

Index Terms— **DSTATCOM, Power Quality, DC-link voltage controller, Fuzzy Logic based DSTATCOM, harmonics.**

I. INTRODUCTION

Now a days, Power Quality problems are more common in distribution power system network. This leads to excessive heating of electrical apparatus, neutral currents, distortion in voltage and poor-power factor. Maintaining quality of power in a power system is very vital in today's scenario because of increase in various loads which litter the power system. Power Quality maintenance is very important for this type of problems facing in power distribution network. To improve power quality the FACTS devices has been proposed for fast dynamic voltage, impedance, phase angle control on high voltage ac lines [1]. There are so many FACT controllers are available to minimise power quality problems but DSTATCOM [2] is the best key fact controller that utilizes power electronics for solving power quality problems especially in DS (distribution system) [3].

DSTATCOM is a device connected in parallel which contains a voltage source converter (VSC) and a shunt capacitor which has capability of generating and observing reactive power.

II. COMPENSATION of AC AND DC LOAD with DSTATCOM

To compensate the non-linear and unbalanced load conditions using DSTATCOM various Voltage Source Inverter topologies are there out of which here we considered a H-bridge Voltage Source Inverter(VSI) topology [2] due to its simple characteristics. In this DSTATCOM is connected in parallel, between the three-phase four wire source and the un balanced and non-linear ac load [4]. DC load is connected across the dc link. under normal condition the source is going to generate balanced and sinusoidal voltage. When there is an unexpected decrease/increase of the unbalanced & nonlinear load in this type of system, causes unbalance and harmonics in the load current [5], [6]. These currents are going to be inject at the Point of Common Coupling (PCC) with the help of DSTATCOM. The operation of the compensator is supported by the dc capacitor and this supplies the required dc load [7] [8].

III. DESIGNING OF A FUZZY LOGIC CONTROLLER

Using Fuzzy Logic tool box in MATLAB, Mamdani type Fuzzy PD controller is demonstrated [9]. The membership functions of input (error and rate of change of error) and output variables (control action) and rules are defined in the tool box. The DSTATCOM control scheme is designed using Fuzzy Inference System (FIS). The DSTATCOM was simulated for the same load with all other parameters maintaining the same.

Control Scheme for Fuzzy logic based DSTATCOM

Fuzzy logic (FL) controller [10] [11] is the heart of fuzzy control set; the most important features of this is, we are using linguistic variables instead of numeric variables. This control technique is based on human capability, i.e. how to understand the systems behavior based on rules of quality control. Fuzzy Logic provides a trouble-free way to arrive a specific conclusion based on ambiguous, vague, noisy, imprecise and missed input information. The composition of an FLC is represented in Figure 2 and comprises with four principal components:

- The Fuzzyfication *interface* will converts the input data into suitable linguistic values[2].
- The Knowledge Base consists of a data base with the necessary linguistic definitions and control rule set.
- A Decision Making Logic will, simulating a human decision process, and interface the fuzzy control action from the knowledge of the control rules and the linguistic variable definitions.

Defuzzyfication interface yields a non-fuzzy control action from an inferred fuzzy control action.

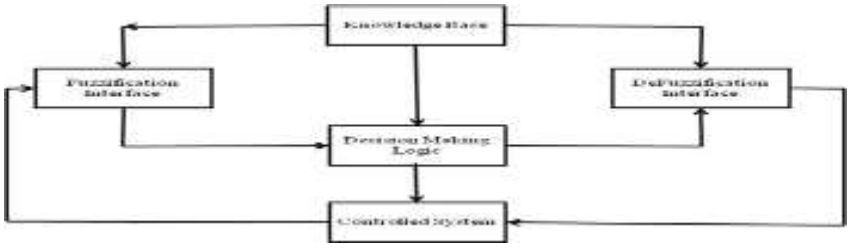


Fig.1: Basic structure of Fuzzy Logic Controller.

The input, output membership functions and the rule base of FLC are shown as below

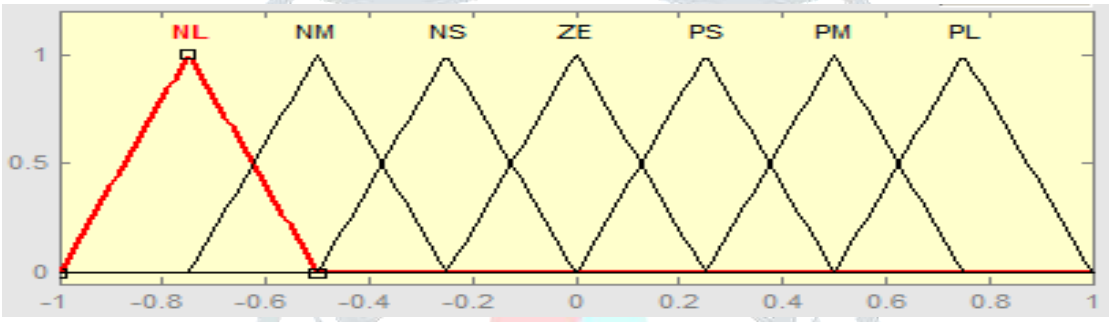


Fig. 2: Error as input

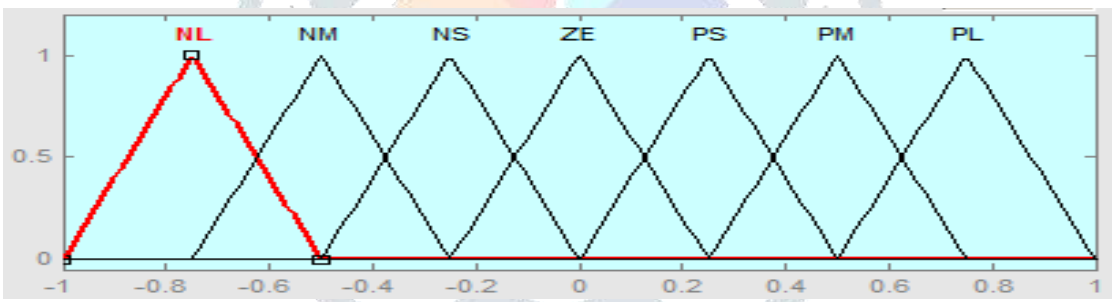


Fig. 3: Change in error as output

In the decision-making process, there is rule base which is linking between input signal (error) and output signal (Change in error). Table 1 show the rule base used in this Fuzzy Logic controller(FLC).

TABLE1: FUZZY RULE BASE

C.E / E	NL	NM	NS	ZE	PS	PM	PL
NL	NL	NL	NL	NM	NM	NS	ZE
NM	NL	NL	NM	NS	NS	ZE	PS
NS	NL	NM	NS	NS	ZE	PS	PM
ZE	NM	NS	NS	ZE	PS	PM	PL
PS	NM	NS	ZE	PS	PS	PM	PL
PM	NS	ZE	PS	PS	PM	PL	PL
PL	ZE	PS	PM	PM	PL	PL	PL

IV. SIMULATION RESULTS

To analyze the performance of system we have designed a Matlab/Simulink model as shown in the fig. Here is a three phase source which is connected to the unbalanced load & non- linear load, the DSTATCOM is connected in parallel at the PCC. The main intention here is to control the dc-link voltage. Whenever there is a change in load, this causes the variation in the dc-link voltage from its reference value. In order to get the dc-link voltage to its reference value here we are considering, Fuzzy Logic controller to control DC-link voltage. The explanation of control circuit and the simulation results are as follows.

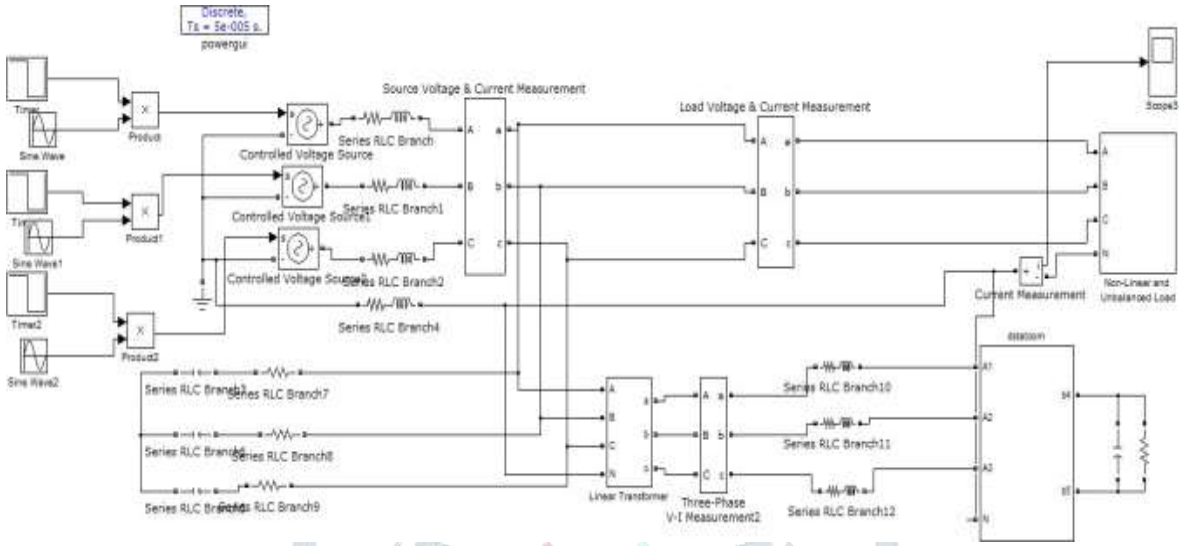
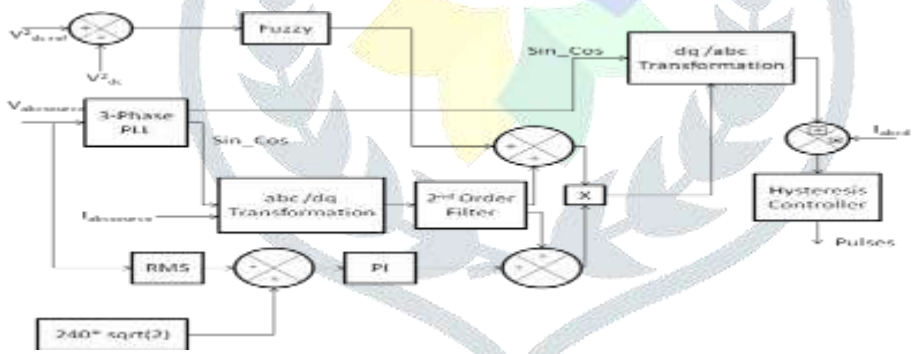


Fig. 4: Simulation diagram of the system with D-STATCOM

DC-Link voltage control using Fuzzy controller:

The controlling circuit with Fuzzy controller is shown below.

Fig. 5: Simulation diagram of the system with Energy based Fuzzy logic Controller



Using Fuzzy controller the changes in load, the small spike which was there in the below result is controlled in 0.002 sec only.

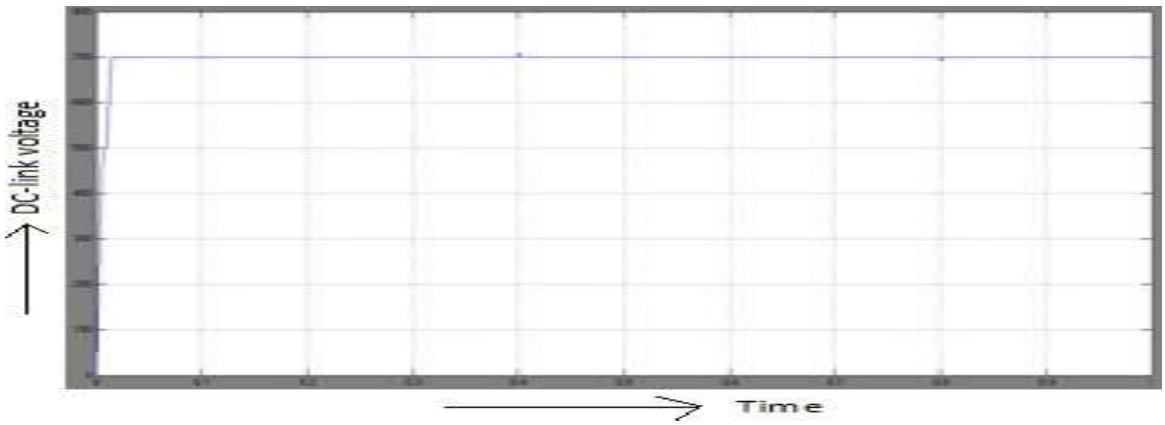


Fig. 6: DC-link voltage with fuzzy logic controller, improvement in transient response t=0.002 sec

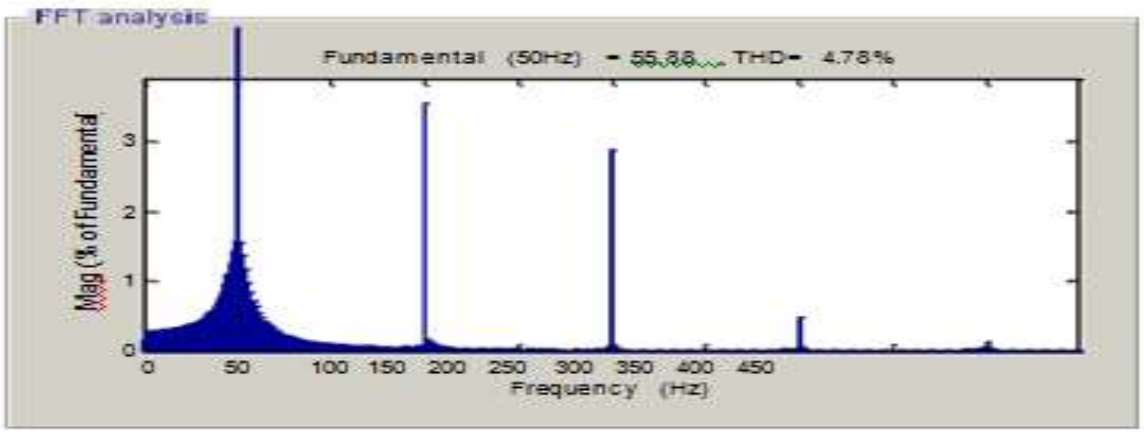


Fig.7 shows the FFT analysis of the load voltage for Fuzzy Logic controller.

Total Harmonic Distortion is only 4.78%

V. CONCLUSION

Utilities are finding difficult to maintain the power quality at the consumer end, and consumers are paying the penalties indirectly in terms of increased plant downtimes, etc. Parallel connected Custom Power device like DSTATCOM can compensate for unbalanced and non-linear load currents. An energy based d.c link voltage controller is very efficient in improving the Power Quality. A fuzzy logic controller with fast reference voltage generation is used to regulate unbalanced voltage in three-phase system improves the Power Quality problem further. One of the main advantages of Fuzzy logic control is the inaccuracies of the sensors on the system performance can be reduced by adding some additional rules, which reduces the costly sensors and also the cost of the control system is reduced without compromise in the performance. The rule base and membership function of input and output variables can be obtained easily if we have expert knowledge of the system.

The simulation result shows a superior performance of this method and the control scheme of arbitrary fault conditions of the utility supply. Simulation results show that the system limits the Total Harmonic Distortion percentage of source current is within the limits of IEEE-519 standard (5%) and also observed that there is an improvement in Power factor.

VI. References

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