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Modelling And Simulation Of STATCOM For Compensation Of Reactive Power To Improving The Power Quality By Using PI With Fuzzy Logic Controller

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Abstract- *Static Synchronous Compensator (STATCOM) regulates the voltage and corrects the power factor at the point of common coupling (PCC) by injecting reactive power. Also, this device plays a vital role as a stability aid for small and large transient disturbances in an interconnected power system. This paper deals only with power-factor correction mode and show the Total Harmonic Distortion (THD) in source current is drastically reduced fuzzy controller is included in the STATCOM control circuit..The use of STATCOM a FACTS device is increasing in the power system for enhancing power transfer capability and dynamic reactive power support in power system. In this paper a Fuzzy logic new control method for STATCOM is proposed and applied for damping oscillations. Simulations using MATLAB / SIMULINK are carried out to verify the performance of the proposed controller. Significant improvement of damping oscillations has been achieved with the proposed fuzzy logic supplementary controller. The results of these studies show that the designed controller has an excellent capability in damping power system oscillations.*

Keywords- *STATCOM; Fuzzy logic Controller; Power-Factor Correction, power system, Total Harmonic Distortion (THD)*

I. INTRODUCTION

The rapid development of the high-power electronics industry has made Flexible AC Transmission System (FACTS) devices practical and attractive for utility applications.

1] FengLiua, ShengweiMeia, QiangLua, Yixin Nib, Felix F. Wub, Akihiko Yokoyama "The nonlinear internal control of STATCOM: theory and application" Electrical Power and Energy Systems 25 (2003) 421–430

As one kind of the typical FACTS devices, the static synchronous compensator (STATCOM) is playing more and more important roles in reactive power provision, voltage regulation support and even in the improvement of the transient stability of power systems; because of its attractive steady state performance and operating characteristics, which have been well studied in the past years STATCOM is connected in parallel to the power network devices and it is based on the principle that a voltage source inverter generates a controllable AC voltage source behind a transformer-leakage reactance so that the voltage difference across the reactance produces active and reactive power exchange between the STATCOM and the transmission network.

Proper control strategies corresponding to the control objectives are necessary in order to achieve efficient utilization of STATCOM. Most of the controllers used for this device are based on the PI controller [4]. Although the PI controllers are simple and easy to design, their performance deteriorates when disturbances occur. Unlike the PI controllers, fuzzy logic controllers (FLCs) are capable of tolerating uncertainty and imprecision to a greater extent. So, they produce good results under changing operating conditions and uncertainties in system parameters. During the past few decades, there are many successful applications with Fuzzy Logic Controllers (FLCs) in industry. It has been reported that they are successfully used in a number of complex and non-linear processes. Moreover, the experience has shown that fuzzy controls are often a favored method of designing controllers for dynamic systems even if traditional methods can be used.

In this paper, a fuzzy logic controller (FLC) is proposed for controlling the STATCOM controller under steady and transient conditions. A Fuzzy logic new control method for STATCOM is proposed and applied for damping oscillations. Simulations using MATLAB / SIMULINK are carried out to verify the performance of the proposed controller. Significant improvement of damping oscillations has been achieved with the proposed fuzzy logic supplementary controller. The results of these studies show that the designed controller has an excellent capability in damping power system oscillations. This paper deals only with power-factor correction mode and show the Total Harmonic Distortion.

II.SYSTEM CONFIGURATION AND THE BASIC OPERATION

Figure 1 shows the proposed STATCOM system configuration. In its simplest form, The STATCOM consists of a coupling transformer, a voltage-sourced inverter, a control system and a dc capacitor. STATCOM is a primary shunt device of the FACTS family, which uses power electronics to control power flow and improve transient stability on power grids. The STATCOM regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. For purely reactive power flow the three phase voltages of the STATCOM must be maintained in phase with the system voltages. The variation of reactive power is performed by means of a VSC connected through a coupling transformer. The VSC uses forced commutated power electronics devices (GTO's or IGBT's) to synthesize the voltage from a dc voltage source. The operating principle of STATACOM is explained. It can be seen that if V2> VI then the reactive current Iq flows from the converter to the ac system through the coupling transformer by injecting reactive power to the ac system. On the other hand, if V2< VI then current Iq flows from ac system to the converter by absorbing reactive power from the system. Finally, if V2= VI then there is no exchange of reactive power. The amount of reactive power exchange is given by:

$$Q = \frac{V_1(V_1 - V_2)}{X_s}$$

Where,
VI: Magnitude of system Voltage.
V2: Magnitude of ST A TCOM output voltage.
Xs: Equivalent impedance between STATCOM and the system.

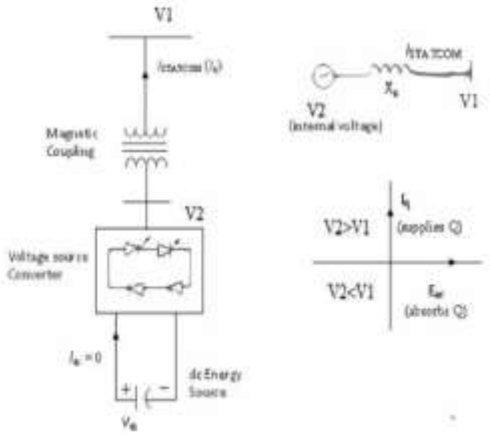

Fig 1: Schematic Configuration of STATCOM

A capacitor connected on the DC side of the VSC acts as a dc voltage source.

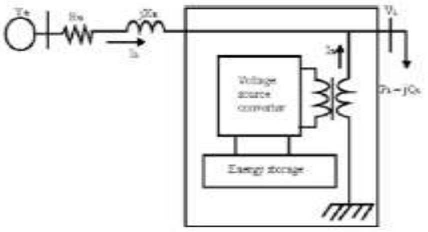

Fig. 2 Schematic Diagram of a STATCOM

A STATCOM can improve power-system Performance like:
1. The dynamic voltage control in transmission and distribution systems,
2. The power-oscillation damping in power- transmission systems,
3. The transient stability;
4. The voltage flicker control; and
5. The control of not only reactive power but also (if needed) active power in the connected line, requiring a dc energy source. Furthermore, a STATCOM.

Reactive Power Control

There is a strong relationship between voltage and reactive power flow. The voltage in a distribution system and to the consumers must be maintained within a certain range around the rated equipment. Sudden load impacts or load demands under contingency operating conditions, when one or more tie line circuits may be out of service, result in short time or prolonged voltage dips.

$$\frac{\Delta Vs}{V} \approx \frac{\Delta Vr}{V} = \frac{\Delta Q}{Ssc}$$

Where, Vs =Sending end voltage,
Vr = Receiving end voltage,
Q =Reactive Power,
Ssc =Short circuit level of system

This means that the voltage regulation is equal to the ratio of reactive power change to the short circuit level. This gives the obvious result that the receiving end voltage falls with the decrease in system short circuit capacity or increase in system reactance. STATCOM is able to provide rated reactive current under reduced voltage conditions. The ability to produce full capacitive current at low voltage makes it ideally suited for improving the transient stability.

Sag Mitigation

The application of a shunt device such as a

STATCOM for mitigation of voltage sag has some advantages when compared with a series device, as a shunt devices can simultaneously be used for steady state voltage control, load power oscillation damping and as a backup power source. Some applications of STATCOM for voltage sag mitigation are presented.

III. Fuzzy logic controller

Fuzzy logic control essentially involves the derivation of a control law from heuristic and imprecise (fuzzy) rules. The configuration of the Fuzzy logic control system that is employed for designing the Fuzzy supplementary controller is shown in Fig.4. The FLC contains four main components, the fuzzification interface (FUZZIFICA TION), the knowledge base (FUZZY RULE BASE), the decision making logic (FUZZY INFERENCE ENGINE)and the defuzzification interface DEFUZZIFICATION). A Mamdani type double input single output (DISO) FLC has been designed.

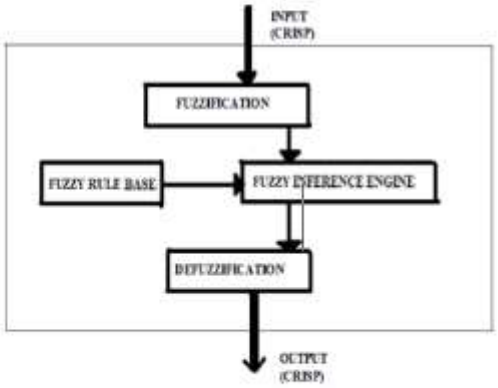

Fig. 3. Fuzzy logic control

The following steps are involved in the designing fuzzy logic controller.

1). Choose the inputs to FLC (INPUT-CRISP): The inputs to FLC used in this study are generator terminal voltage deviation and generator speed deviation which are given

$$\Delta V_t(pu) = V_{ref} - V_t$$
$$\Delta\omega(pu) = \omega - \omega_0$$

Where

Vt= generator terminal voltage;
VreFReference voltage;

ω_o =synchronous speed of generator;
ω = speed of generator;

2). Choose membership functions to represent the inputs and outputs in fuzzy set notation (FUZZIFICATION): Triangular membership functions were selected for this study as shown in
Fig.5 with five linguistic variables chosen as Large positive (LP), Small positive (SP), Very small (VS), Small negative (SN), Large Negative (LN) for both inputs and outputs. The values of the axes are given in Appendix

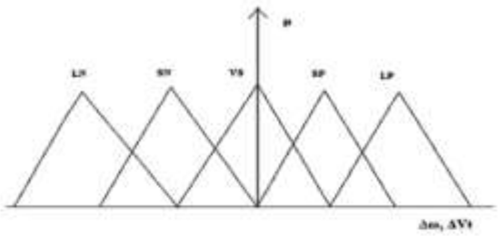

Fig. 4. Triangular member ship functions for speed deviation and voltage deviation

3). Develop fuzzy rules (FUZZY RULE BASE): A set of decision rules relating the inputs to the controller with the output are compiled and stored in the memory in the form of decision table. Twenty five rules for the present study are developed as follows.
Rulel: If (O is LN and □Vt is LN, then change in susceptance of SVS should be SN. The remaining

twenty four rules are formed in the same way as shown in the Table I.

TABLE I. FUZZY RULE TABLE

$\Delta\omega\rightarrow$ $\Delta V_t\downarrow$	LN	SN	VS	SP	LP
LN	SN	SN	LN	LN	LN
SN	SN	SN	SN	LN	SN
VS	SP	SP	VS	SN	SN
SP	LP	SP	SP	SP	SP
LP	LP	LP	LP	SP	SP

4). Since there are N (five) membership functions for each input, there are N2 (twenty five) possible combinations resulting in M (five) values for the decision variable u. All the possible combinations of inputs, called states, and the resulting control are arranged in a (N2xM) fuzzy relationship matrix. The membership values for the output characterized by the M linguistic variables are then obtained from the intersection of N2 values of membership function /l(x) with the corresponding values of each decision variables in the fuzzy relationship matrix.

5).Defuzzy to obtain crisp output (DEFUZZIFICATION):

The output FLC is converted to crisp value by Centre or Gravity (COG) method in this study. The crisp value of FLC in COG is expressed.

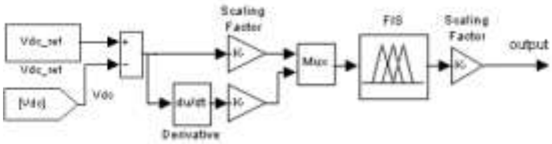

Figure.5 . SIMULINK model of the fuzzy logic controller (FLC)

V. SIMULATION RESULTS

During the past few decades, there are many successful applications with Fuzzy Logic Controllers (FLCs) in industry. It has been reported that they are successfully used in a number of complex and non-linear processes. Moreover, the experience has shown that fuzzy controls are often a favored method of designing controllers for dynamic systems even if traditional methods can be used. The effectiveness of the F-statcom controller is been observed in comparison with the system implemented with the conventional SVC controller. The F-statcommodelled in Simulink/MATLAB. After the fault occurred, the SVC will try to support the voltage by injecting reactive power on the line when the voltage is lower than the reference voltage.

A Fuzzy logic new control method for STATCOM is proposed and applied for damping oscillations. Simulations using MATLAB / SIMULINK are carried out to verify the performance of the proposed controller. The proposed fuzzy logic supplementary controller.The results of these studies show that the designed controller has an excellent capability in damping power system oscillations. This paper deals only with power-factor correction mode and show the Total Harmonic Distortion.

Simulation circuit

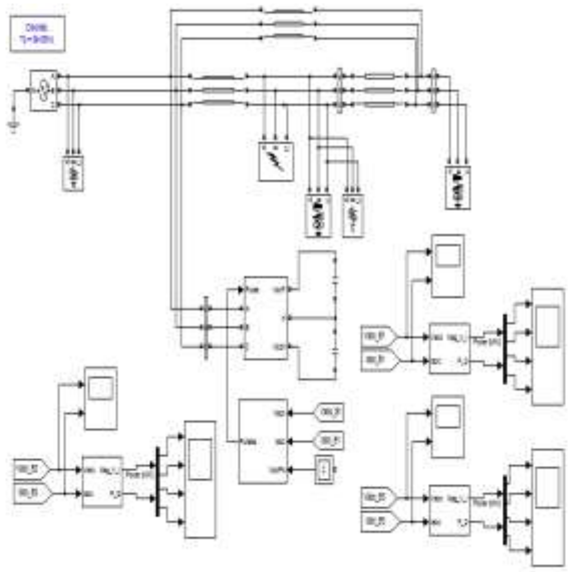

Fig .6, Matlab implementation STATCOM with fuzzy logic controller.

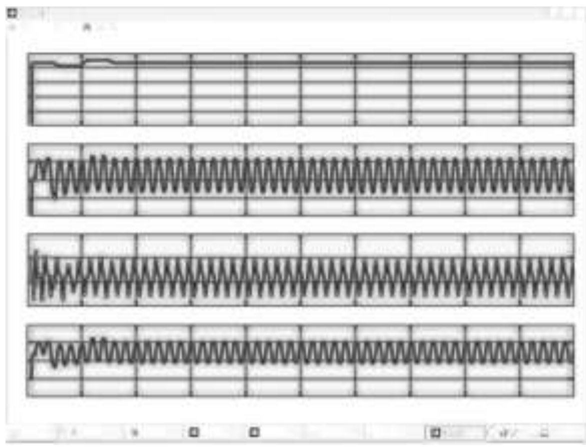

Fig.7 Scope 1: magnitude of voltage and current wave forms and active and reactive power at bus 1

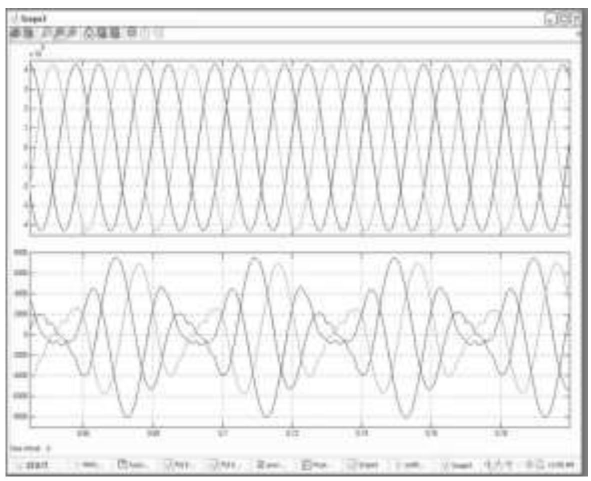

Fig.8 voltage and current waveforms at bus1

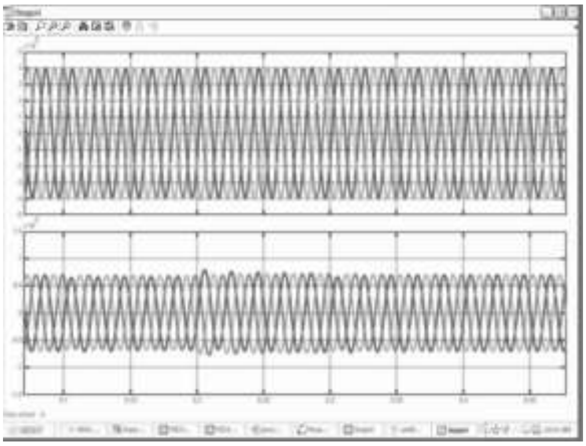

Fig.9 Voltage and current wave forms at bus3

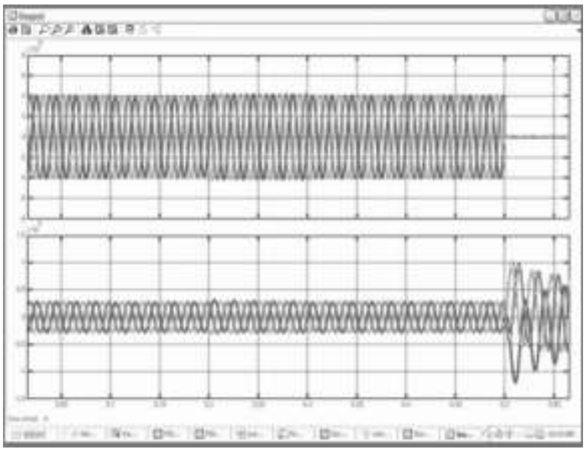

Fig.10 Voltage and current wave forms at bus2

VI CONCLUSION:

In this paper, we are using fuzzy logic for statcom controller. This paper deals only with power-factor correction mode and show the Total Harmonic Distortion (THD) in source current is drastically reduced by fuzzy logic controller is included in the STATCOM control circuit.

In this paper a Fuzzy logic new control method for STATCOM is proposed and applied for damping oscillations. Significant improvement of damping oscillations has been achieved with the proposed fuzzy logic supplementary controller. The results of these studies show that the designed controller has an excellent capability in damping power system oscillations. This paper deals only with power-factor correction mode and show the Total Harmonic Distortion.

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