Transient Stability Improvement in Transmission System Using SVC with fuzzy logic Control

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Abstract - *In power system the transmission line are becoming more advanced and stressed due the increase in load. The new technology which is known as Flexible AC transmission system (FACTS) devices, are found very extensively to reduce this stress without disturbing the desired stability margin. In this paper, a fuzzy logic based supplementary controller for Static Var Compensator (SVC). Flexible AC Transmission System (FACTS) controllers, such as Static VAR Compensator (SVC) and Static Synchronous Compensator uses the latest technology of power electronic switching devices in electric power transmission systems to control voltage and power flow, The stability enhancement can be done by using FACTS controllers. In this paper, a fuzzy logic based supplementary controller for Static Var Compensator (SVC) is developed which is used for improve the power quality of generated and distributed power. The designed model has been tested in a 2 machine 3 bus test system using MATLAB software. The simulation results show that the new controller logic gives better and quick performance compared to the other types*

Key Words: **SVC, compensator, Fuzzy logic, MATLAB.**

1. INTRODUCTION

In power system the transmission line are becoming more advanced and stressed due the increase in load. The new technology which is known as Flexible AC transmission system (FACTS) devices, are found very extensively to reduce this stress without disturbing the desired stability margin. In this paper, a fuzzy logic based supplementary controller for Static Var Compensator (SVC) [1]. Flexible AC Transmission System (FACTS) controllers, such as Static VAR Compensator (SVC) and Static Synchronous Compensator use the latest technology of power electronic switching devices in electric power transmission systems to control voltage and power flow. The stability enhancement can be done by using FACTS controllers [2]. In this paper, a fuzzy logic based supplementary controller for Static Var Compensator (SVC) is developed which is used for improve the power quality of generated and distributed power [3]. The designed model has been tested in a 2 machine 3 bus test system using MATLAB software. The simulation results show that the new controller logic gives better and quick performance compared to the other types [4].

Static Var Compensator (SVC) is a shunt type FACTS which is used in power system primarily for the purpose of voltage and reactive power control in the power system network [5]. The optimal location and design of two kinds of FACTS, namely the SVC and the TCSC. The SVC is defined as a shunt connected static Var generator or consumer whose output is adjusted to exchange capacitive or inductive so as to maintain or control specific parameters of electrical power system, typically a bus voltage [6]-[8]. Combines a series capacitor bank shunted by thyristor controlled reactor. Then, the SVC can be considered as a synchronous compensator modeled as bus, with Q limits designed by its rated size Qsvc.

In this paper, a new model is proposed to incorporate the advantages of both PI and Fuzzy Controller, thereby improving the performance of SVC. The model is tested using a 2 machines 3 bus test system and MATLAB software is used to perform the simulation studies. The performance analysis of the new controller is done by subjecting the system to a three phase fault. The results obtained shows that the proposed controller gives better performance in damping the oscillations during the disturbances and also in regulating other parameters like terminal voltage and transmission line reactive power[10]-[12].

1.1 SVC Operation

SVC is a shunt connected static var generator or consumer whose output is adjusted to exchange capacitive or inductive so as to maintain or control specific parameters of electrical power system, typically, a bus voltage. The voltage can be regulated by controlling its equivalent reactance. SVC is built of reactors and capacitors, controlled by thyristor controlled reactors (TCR) which are parallel with capacitor bank as shown in fig. 1.1.

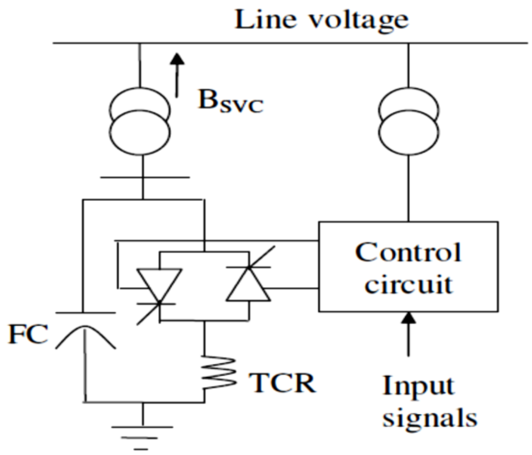

Fig -1.1 SVC shunt with the transmission line

This SVC is a controllable reactive admittance which, when connected to the ac system, faithfully follows (within a given frequency band and within the specified capacitive and inductive ratings) an arbitrary input (reactive admittance or current) reference signal. Figure 1.2 shows the V-I characteristics of the SVC.

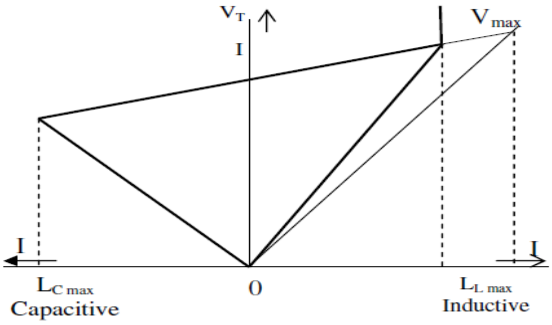

Fig -1.2 V-I characteristics of the SVC

In the active control range, current/susceptance and reactive power is varied to regulate voltage according to a slope (droop) characteristic. The slope value depends on the desired sharing of reactive power production between different sources, and other parts of the system. The slope is typically 1-5 percent. At the capacitive limit, the SVC becomes a shunt capacitor.

1.2 SVC Control and Modeling

As shown in Fig. 1.3, a typical SVC comprises one or more banks of fixed or switched shunt capacitive reactance; switched by thyristors at least one must be operated. The reactive power variation can be achieved by switching the capacitor banks and inductor banks. The capacitors are switched ON and OFF by Thyristors Switched Capacitor (TSC) and the reactors are controlled by Thyristors Controlled Reactor (TCR).

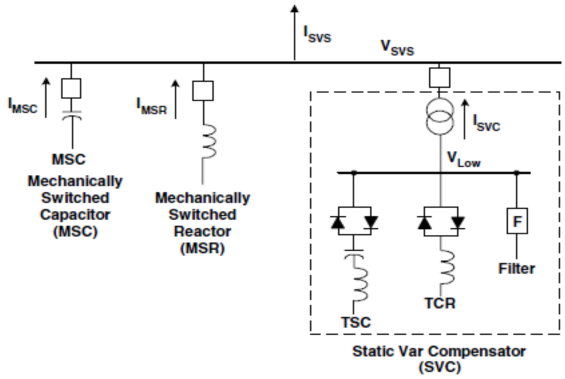

Fig- 1.3 SVC arrangement with transmission line

The reactive power control achieved by switching the capacitor banks and inductor banks. The capacitors are switched ON and OFF by Thyristor Switched Capacitor (TSC) and the reactors are controlled by Thyristor Controlled Reactor (TCR). The current in the reactor can be varied using Firing delay angle control method, which is shown in fig. 1.4 and operating waveform in fig. 1.5.

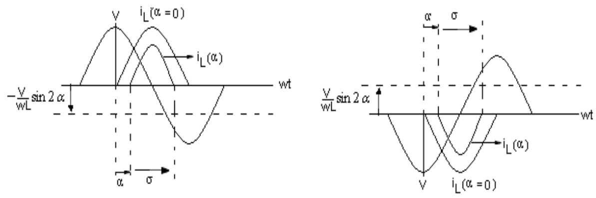

Fig. 1.4 Firing Delay Angle Control

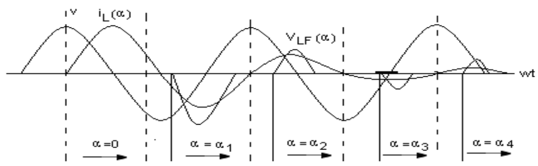

Fig -1.5 SVC Operating Waveforms

Fig. 1.6 shows the basic architecture of SVC Control scheme. This model is known as Phasor type in MATLAB, which can be used for transient stability studies and to observe the impact of SVC on electromechanical oscillations and transmission capacity.

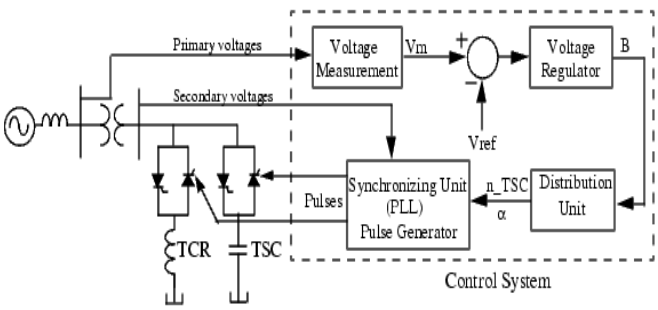

Fig. 1.6 Basic configuration of SVC Control Scheme

2. FUZZY LOGIC CONTROL

Fuzzy Inference system With cause effect relationship expressed as a collection of fuzzy if – then rules , in which the preconditions uses linguistic variables and the consequent have to perform the qualitative result. In this model Mamdani inference system with product t-norm and max t-co norm is used. Here, the set of sensor input is matched against the part of each if – then rule, and the response of each rule is obtained through fuzzy. The response of each rule is weighted according to the extent to which each rule fires. The result of fuzzy rules for a particular output class is combined to obtain the confidence with which the sensor input is classified to that fault class. [27]

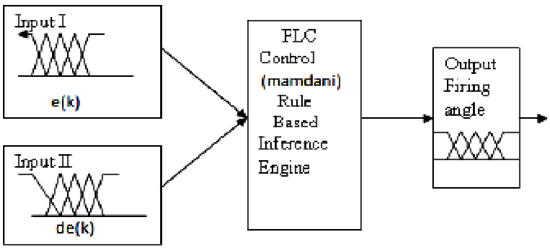

Fig.-1.7 DWT Decomposition model

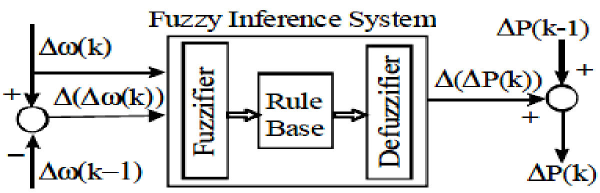

Fig.-1.8 Basic Structure of fuzzy logic controller

As been told, the results shown in both Figure 1.7 and 1.8 can be useful to construct the rule table. The values we read on this graphics will be used to define the first fuzzy set intervals. By applying trial-and-error in order to achieve improved results with the FLC, these intervals may change.

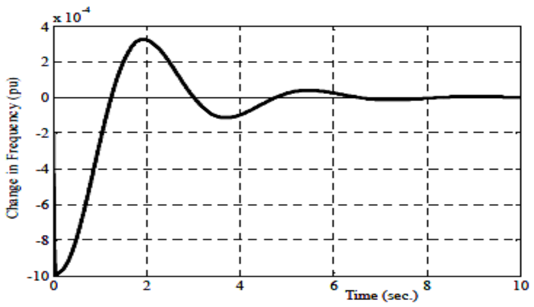

Fig- 1.7 Impulse response of the system without any controller

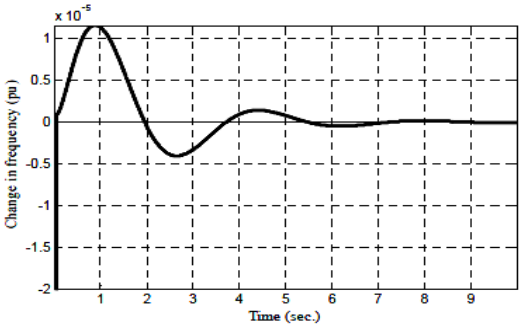

Fig-1.8 Classical controller impulse response signal's derivative

We first try to develop an initial rule base (with only 3 fuzzy sets), which we will extend to a 5 fuzzy sets base. According to the signs of Δω and Δ(Δω). We decide whether the sign of Δ (Δ P) has to be positive or negative. A summary of all possible situations, or so called operation regions, is given in Table 1.

Table: 1 Output decision making table

	Operating Regions								
$\Delta\omega$	+	0	-	-	0	+	-	+	0
$\Delta(\Delta\omega)$	-	-	-	+	+	+	0	0	0
$\Delta(\Delta P)$	+	-	-	-	+	+	-	+	0

The sign of Δ (Δ P) should be positive if Δ P has to be increased and it should be negative otherwise. This simple rule is applied as in Table 1 to determine the sign of Δ (ΔP).

2.1 Stability Control Circuit Using Fuzzy Logic Controller

The MATLAB Simulink model of the test system is shown in Figure 1.9. A three phase fault is made to occur

at Bus 1 for 2 sec. The effectiveness of the SVC with the newly designed controller and that with conventional controller are observed and compared. As soon as the fault occurs, the SVC will try to inject reactive power into the line when the voltage goes below the reference value, in order to regulate the voltage.

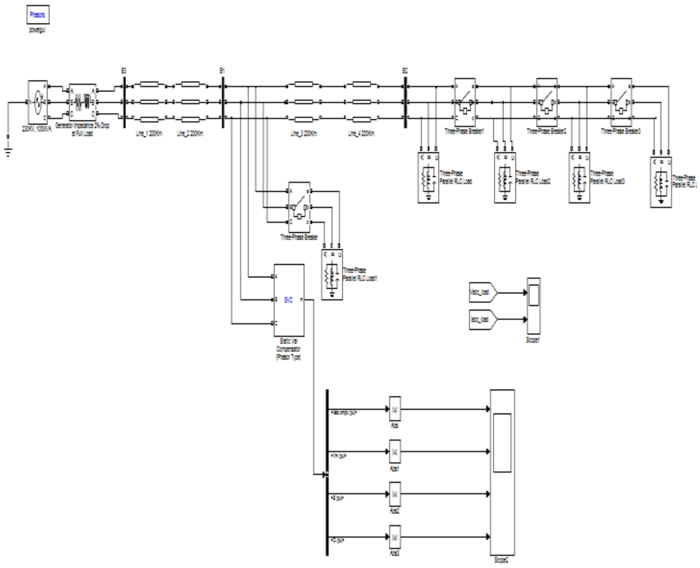

Fig- 1.9 A power transmission system modeled in Simulink/MATLAB

3. EXPERIMENT AND RESULTS

3.1 Output Voltage Waveform from Scope 1

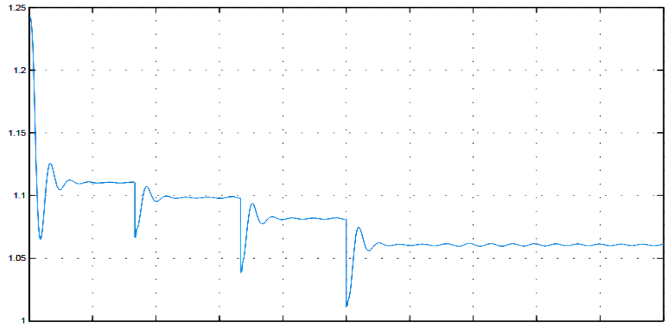

Fig-1.10 a)

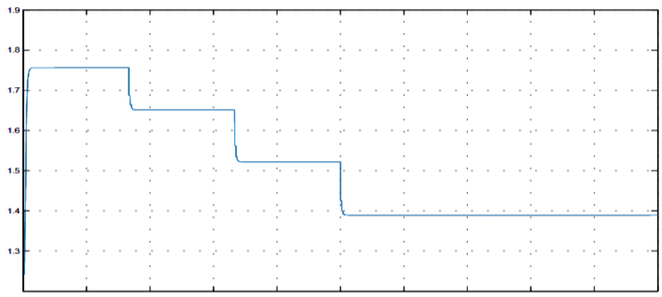

Fig-1.10 (b)

It is observed from the output waveform without fuzzy logic from waveform fig. 1.10 (a) that the voltage at t = 0 sec is 1.25 volt and as we move on next second seen that at t = 0.2 sec voltage reduces to 1.12 volt.

Now at t = 1.4 sec the voltage again reduces to 1.11 volt and so on After long time at t = 5 sec oscillations are settle down, but when we are performing the same simulation with fuzzy logic from fig. 1.10 (b) we observed that the output wave form at t = 0 sec is 1.75 volt which is better than the previous result, and at last oscillations are almost goes to zero.

3.2 Output Current Waveform from Scope 2

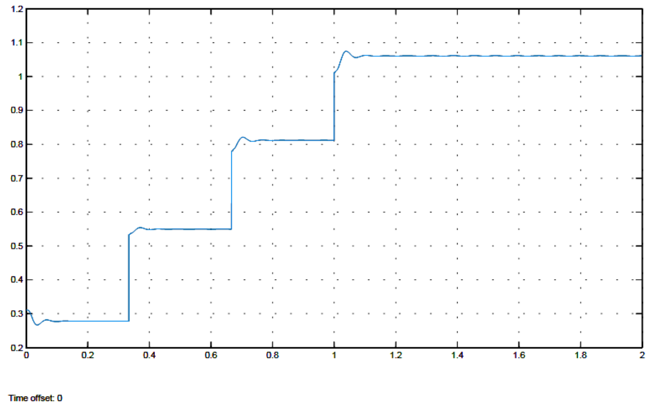

Fig-1.11 (a)

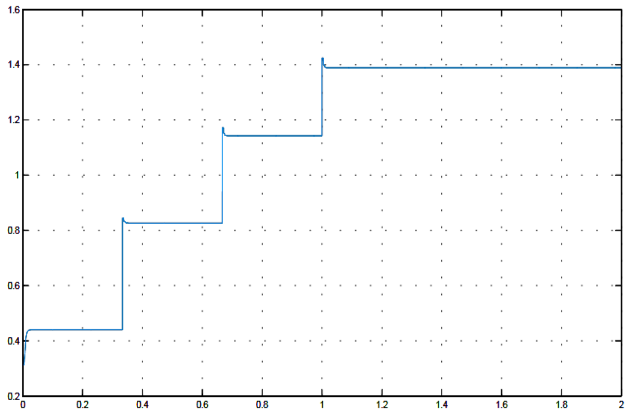

Fig-1.11 (b)

It is observed from the output waveform fig. 1.11 (a) without fuzzy logic that the current at t = 0 sec is 0.31 ampere only and as we move on next second seen that at t = 0.37 sec current suddenly reaches to .55 ampere and it is constant up to t = .67 sec. after long time at t = 1.1 sec it is observed that the current reaches to its maximum value 1.05 ampere, here we observed that from fig. 1.11 (b) as the switching instant changes, the spikes are appeared on the scope, but if we perform the same simulation with fuzzy logic application the spikes are reduces and we get smooth response.

3.3 Output Power Waveform from Scope 2

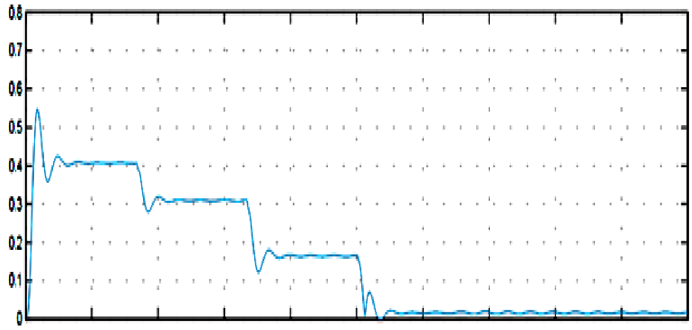

Fig-1.12 (a)

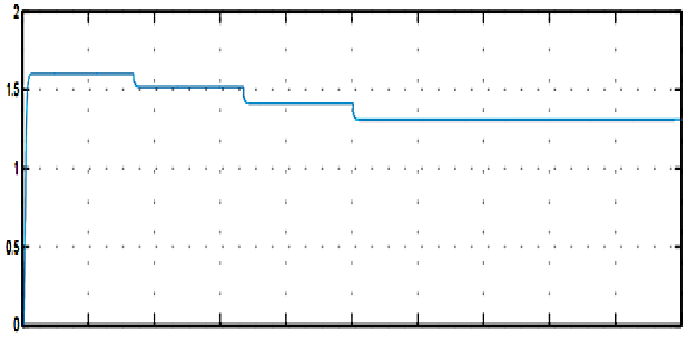

Fig-1.12 (b)

It is observed from the output waveform fig. 1.12 (a) without fuzzy logic that the power at t = 0 sec shows the transient response and the value of power is .55watt and it decreases as the time increases. At t = 5.5 sec the power reaches to zero value. It is improved by fuzzy logic in fig. 1.12 (b) and at t = 0 sec power is 1.52 watt, after some time at t = 6 sec it becomes constant and we got smooth performance.

4. CONCLUSIONS

A Fuzzy controller combined with a PI controller for SVC mechanism is discussed in this paper. The idea is to combine the advantages of both the controllers to derive a better performance out of SVC. Mamdani based Fuzzy logic is employed in the proposed multi machine model and the design is tested on transmission line in power system. The simulation is done using MATLAB software. The simulation studies are carried out on various parameters like improve transmission line economics and system losses by resolving dynamic voltage problems and reactive power control. The controller performance of both types are also compared in above areas and it is observed that the combined PI and Fuzzy based SVC controller gives enhanced performance in terms of stability and reliability of the system during the disturbances.

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