Fuzzy Logic Controller for Static Synchronous Series Compensator with Line Power Transient Stability Analysis

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Abstract: **This paper investigates the problem of controlling and modulating power flow in a transmission line using a Synchronous Static Series Compensator (SSSC). The studies, which include detailed PWM techniques controlled for SSSC, are conducted and the control circuits are presented. In this study, a static synchronous series compensator (SSSC) is used to investigate the effect of this device in controlling active and reactive powers as well as damping power system oscillations in transient mode. The SSSC equipped with a source of energy in the DC link can supply or absorb the reactive and active power to or from the line. Simulations have been done in MATLAB/SIMULINK environment. Simulation results obtained for selected bus-2 in two machine power system shows the efficacy of this compensator as one of the FACTS devices member in controlling power flows, achieving the desired value for active and reactive powers, and damping oscillations appropriately.**

Keywords: **static synchronous series compensator (SSSC), FACTS, Two machine power system, active and reactive powers.**

1. INTRODUCTION

Static Synchronous Series Compensation represent a work of fiction approach, and an substitute to series line compensation, in which a synchronous voltage source, implemented by a thyristor based voltage source inverter (VSI), is used to provide controllable series compensation. This compensator is, in general, a solid-state switching converter which is able to exchange active and reactive power at its output terminals with an ac power system, when operated with an appropriate dc power supply at its input Terminals. When coupled to an energy storage capacitor, an SSSC can only produce or absorb reactive power from the system. The SSSC considered 3 levels VSI connected in series with a three phase transmission line through a coupling transformer. The power flow on a line can be increased by inserting an additional capacitive reactance in series with the transmission line, thus decreasing the effective line impedance. The power flow can also be decreased by adding an additional inductive reactance, that's why increasing the effective reactance. The SSSC is a static, synchronous generator operated as a series compensator without an external electric energy source, whose output voltage is controllable and is in quadrature with the line current. It is employed for increasing or decreasing the overall reactive voltage drop across the line, thus modelling an inductive or a capacitive reactance in series with the transmission Line.

The transmitted real power becomes a parametric function of the injected voltage *(Vq)* and can be expressed as follows:

$$Pq = \frac{V2}{XL - Xq} sin\delta$$

$$Xq = \frac{Vq}{I}$$

1.1. Operating principle:

A SSSC operated without an external electric energy source as a series compensator whose output voltage is in quadrature with, and controllable independently of, the line current for the purpose of increasing or decreasing the overall reactive voltage drop across the line and thereby controlling the transmitted active power. The SSSC may include transiently rated energy storage or energy absorbing devices to enhance the dynamic behaviour of the power system by additional temporary real power compensation, to increase or decrease momentarily, the overall resistive voltage drop across the line. Static synchronous

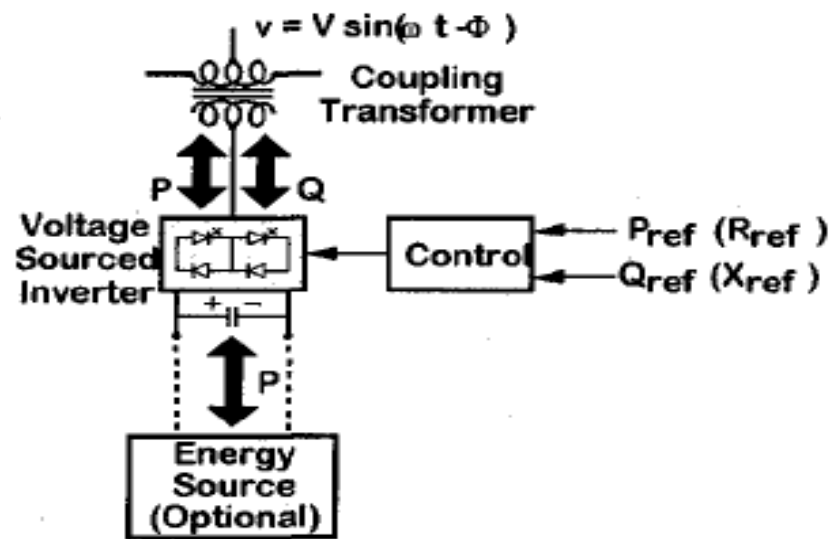Fig.1 Symbol of SSSC series compensator shown in below fig

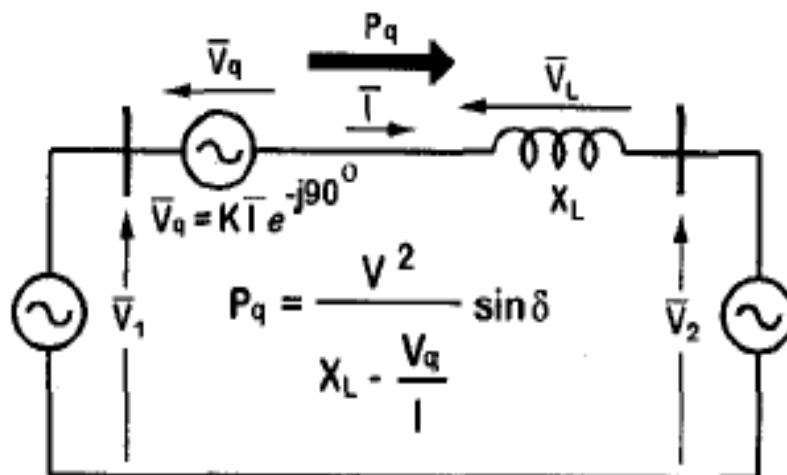

Figure.1: Control System Block Diagram of a SSSC.

Fig.2: equivalent circuit of SSSC

2. FUZZY LOGY SYSTEM

fuzzy logic controller is used for voltage control. Fuzzy logic is based on the statement of fuzzy sets, A fuzzy logic interfacing system (FIS) can be defend as the nonlinear mapping of an input data set to a scalar output data. Fuzzy Logic controller (FLC) procedures the mathematical model of the system without the need for complex transactions. Classical numerical (0-1) is an approach goes in advance of the logic of fuzzy logic multi-level values between the two values as a result of the production control to better decision, thus provided that increased performance and efficiency. The fuzzy logic control unit showed the basic block structure. A fuzzy logy system consists of four different rules:
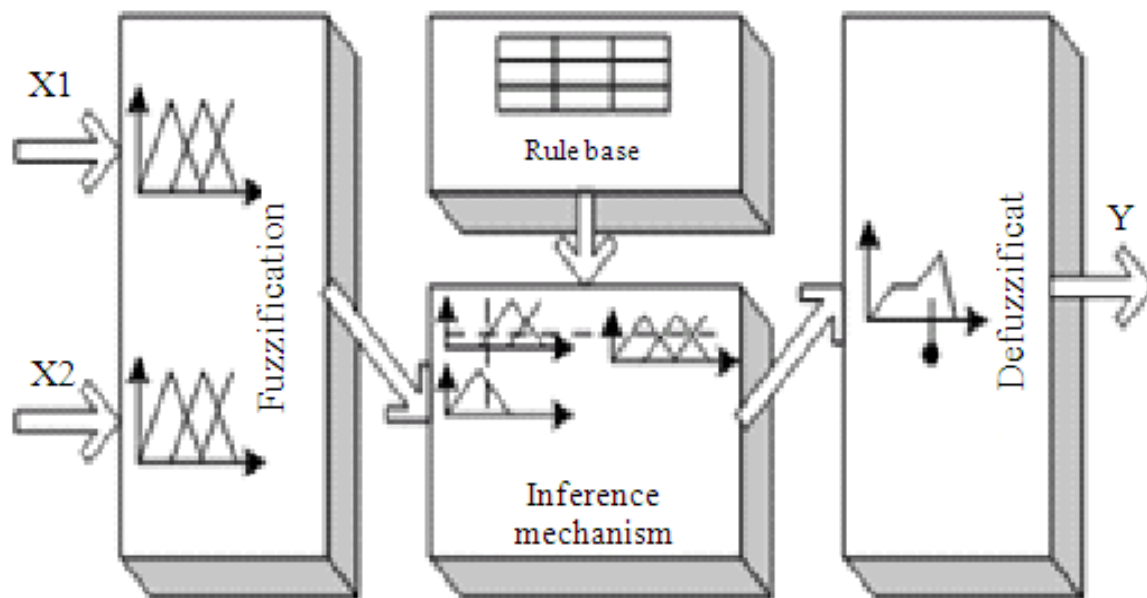
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Fig.3: Structure of Fuzzy

2.1 Fuzzification unit:

creation the task of making the final fuzzy input information Fuzzy values and sent to the rule base unit. Convert standard data or crisp data into fuzzy data or Membership Functions (MFs). Both the input and the output must also be converted from standard data to fuzzy data both the input and the output must also be converted from standard data.

2.2 Defuzzification Unit:

Defuzzyfication is the development of producing a experimental result in fuzzy logic. The fuzzy inference will output a fuzzy result, described in terms of degrees of membership of the fuzzy sets into a specific action or real-value. Their many methods for defuzzification like First of maximum, Middle of maximum, Last of maximum, Mean of maxima, Random choice of maximum.

2.3 Membership Functions:

Membership functions are used in the fuzzification and defuzzification steps of a FLS, to record the non-fuzzy input values to fuzzy linguistic value and vice versa. A membership function is used to calculate a linguistic value. For instance, in Fig., membership functions for SSSC control. The important characteristic of fuzzy logic is that a numerical value does not have to be fuzzed using only one membership function. There are different forms of membership functions such as triangular, trape- zoidal, piecewise linear, Gaussian, or singleton. That is mostly types of membership functions are triangular, trapezoidal, and Gaussian shapes. The types of the membership function depend on the nature of function and that can be genrateded. Firing Unit consists of three independent subsystems, one for each phase (AB, BC and CA). Each subsystem consists of a PLL synchronized on line-to-line secondary voltage and a pulse generator for each of the TCR and TSC branches. The pulse generator uses the firing angle α and the TSC status coming from the Distribution Unit to generate pulses. The firing of TSC branches can be synchronized (one pulse is sent at positive and negative thyristors at every cycle) or continuous. The synchronized firing mode is usually the preferred method because it reduces harmonics faster.

2.4 Simulation Model:

In this thesis the two machine model has been used. And using SSSC with fuzzy logy for voltage stability improvement and reducing the oscillation damping of two machine system. Their two generation substations and one load centre. The generation substation (M 1) has a rating of 2100 MVA and the other substation (M2) which has a rating of 1400 MV A. The transmission lines are used to connect the load connected in the system. Simulation is performed under single phase fault condition. The SSSC connected the near bus B2. In this system three buses are connected B1,B2 B3 and B4

connected through the three line L1, L2-1,L2-2 and L3. Their three lines are located in 280km, 150km, 150km, and 50km respectively
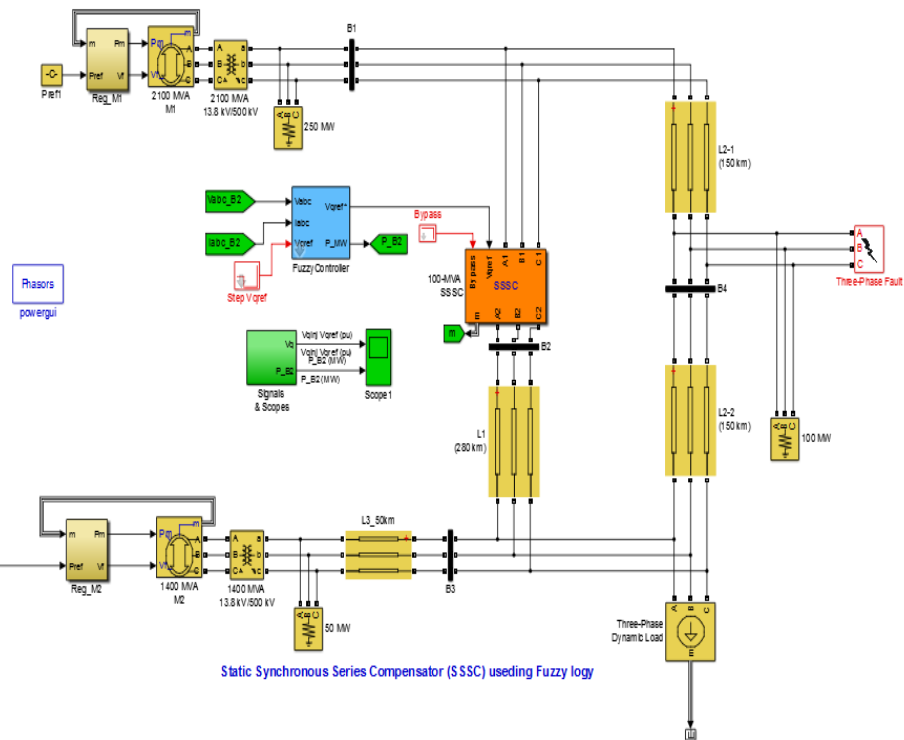

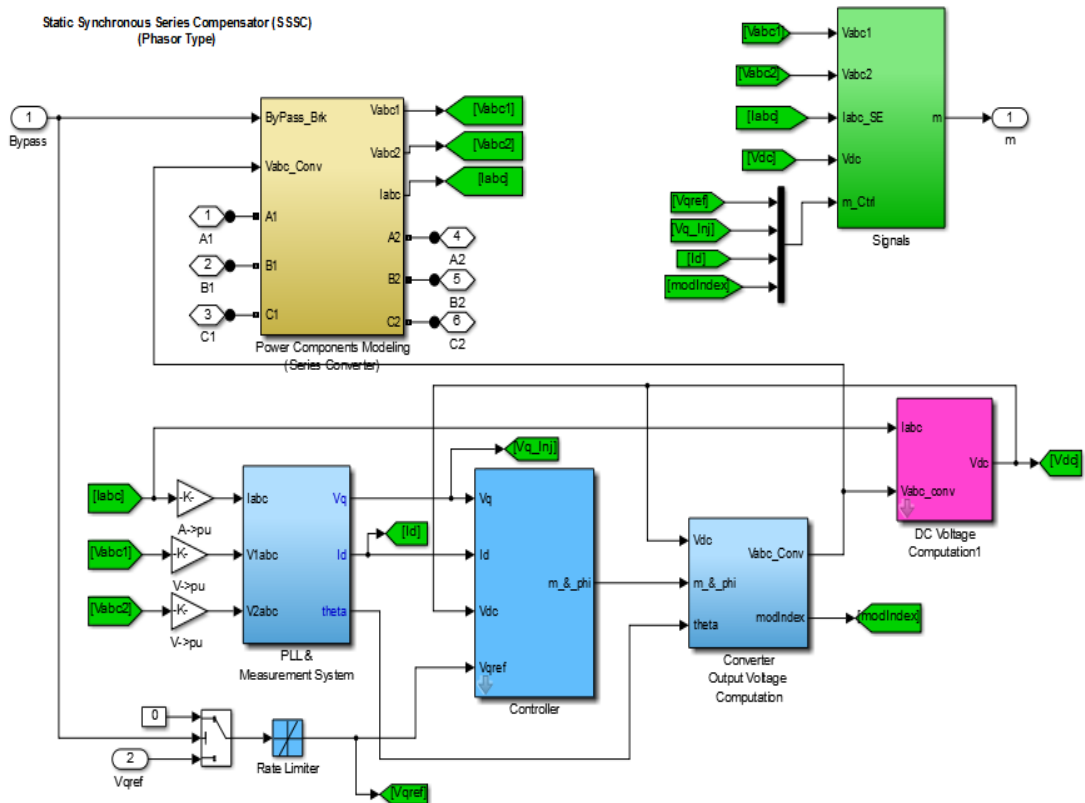**Fig.4: Simulink diagram representation of proposed work.**
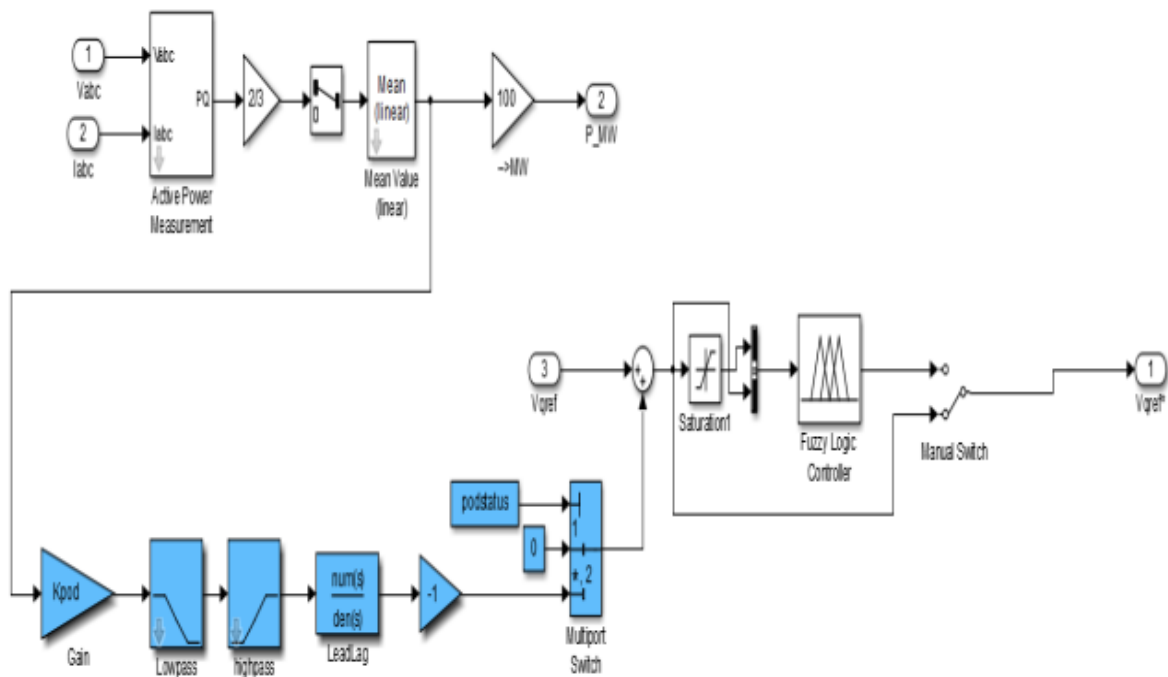

Fig.5: SSSC Subsystem

Fig.6: Subsystem Fuzzy Logic

3.   RESULT AND DISCUSSION

Let us first take the phase voltage transmission line system Figure illustrates, the KW Voltage obtained at bus B1 and B3 without SSSC. Obtained the voltage at bus B2 with SSSC and Fuzzy controller voltage.
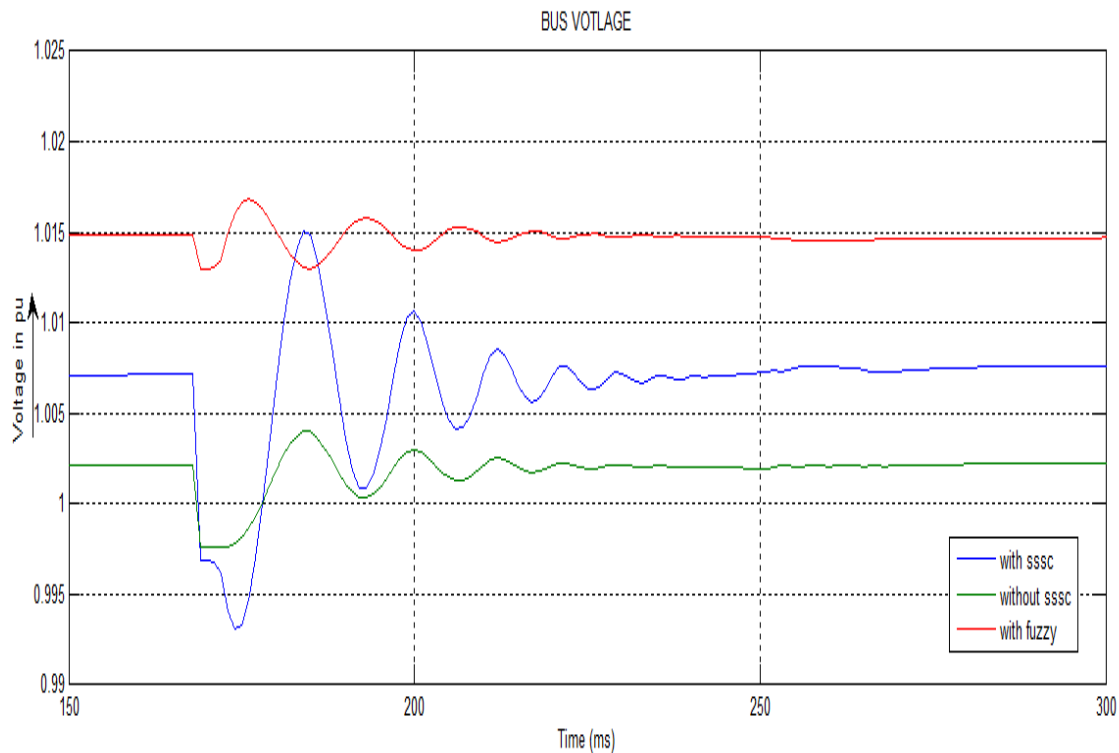

Figure.7: B1 B2 B3 BUS voltage

Now take the active power transmission line system Figure illustrates, the MW Power obtained at bus B1 and B3 without SSSC. Obtained at all the bus B2 with SSSC and With Fuzzy controller.
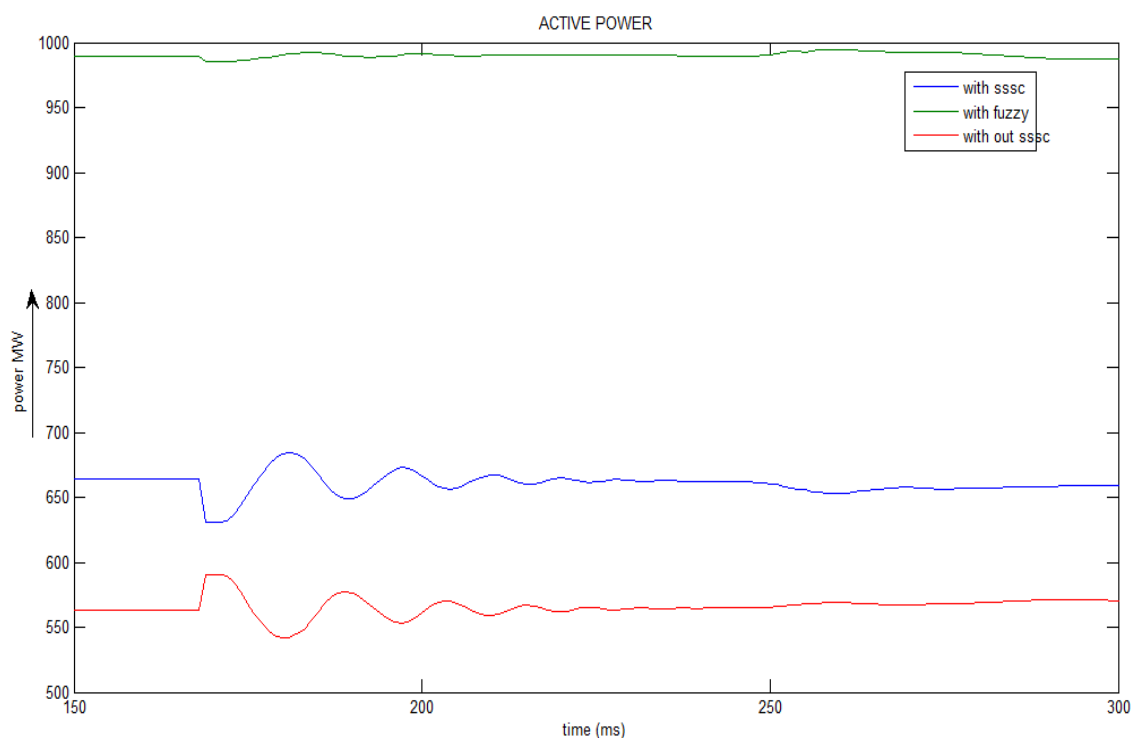

Fig.8: Buses Active Power

Table.1: Comparison Line Voltage, Active Power And Reactive Power

Parameters	Without SSSC	With SSSC	With Fuzzy
Voltage p.u. KV	1.002	1.007	1.015
Active Power MW	570	660	980
Reactive Power MVar	250	120	50

Table.2: Stability and damping analysis

Parameters	Stability Time msec		
	Without SSSC	With SSSC	With Fuzzy
Voltage	100	75	50
Active Power	103	73	48
Reactive Power	103	73	48

Table.3: damping analysis

Parameters	Damping		
	Without SSSC	With SSSC	With Fuzzy
Voltage	100	60	30
Active Power	110	55	50
Reactive Power	100	53	55

4. CONCLUSION

Multi area system is analysed with SSSC and fuzzy logic controller for SSSC integrated with energy storage system. Here the Superconducting Magnetic Energy Storage system is taken for the voltage source inverter is used for the generation of injected voltage. Two quadrant three phase choppers, is connected for the interfacing of the voltage source inverter and the energy storage device. Three phase fault is simulated in the system near the SSSC in line 2. It is inferred from the results, that improvement stability of two machine systems and maintaining the damping of rotor angle oscillations for the system with SMES using Fuzzy logic controller is better than SSSC.

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