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Enhancement of transmission capability of long transmission line by Fuzzy controlled SVC

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ABSTRACT

As the technology is advancing, day by day demand of electricity is increasing and hence the consumption is also increasing. Due to restrictions on extension of transmission lines it is necessary to enhance transmission capabilities of existing lines to meet the demand. Among various means of enhancement, reactive power compensation is effective one.

In the paper a simulated system is applied with a fuzzy controlled SVC, at one of the buses to study the effects on the voltage and power at buses. Analysis shows that there is considerable increase in the voltage and power at that bus which helps to improve the transmission capability of the system.

Keywords: Reactive power compensation, SVC, Transmission capability, fuzzy logic.

1. INTRODUCTION

Every year requirement of power is increasing considerably. Reason is continuous load growth because of vast advancements in technologies. This causes disturbance between generation and transmission of the power. System becomes congested [3].This increases the prices of electricity also. In order to fulfill the demands new lines should be installed .But because of ROW (right of way) it is difficult to get permission for new lines and lack of investors who are interested in financing for such transmission projects. Then to fulfill the demands only option left is to enhance the transmission capability of existing transmission system.

Various transmission capability enhancement techniques are available for the transmission lines till date. Now a days modern practice is to use FACTS devices [1] [3].

Flexible AC transmission system (FACTS) can supply or absorb the reactive power at the bus where it is applied in transmission system, which helps in achieving better economy in power transfer. Reduces transmission losses and increases transmission capability within same degree of stability and thermal limits [4]. They are very well recognized to give solutions for voltage and power flow control.

In this paper 2 machine 4 bus system with the different loads at different buses is considered and is simulated with and without SVC connected at one of the buses. Then the same system is simulated with fuzzy controlled SVC and the change in the power flow and voltage at SVC implemented bus is observed. Then analysis is done. It is observed that there is considerable increase of power and voltage in the system.

2. FACTS DEVICE IN THE SYSTEM

Static Var Compensators are shunt connected static generators, absorbers whose outputs are varied to control voltage of the electric power systems [11]. SVC (static Var Compensator) helps the system by giving stabilized voltage support by providing reactive power compensation at the point of implementation. It exchanges capacitive or inductive current to maintain or control specific power system variables.

In this paper phasor type of SVC is considered and the components of Control system of SVC are as shown in the figure. Their function is as follows.

1. A measurement system used to measure the positive sequence voltage to be controlled.

2. A voltage regulator that uses the difference between the measured voltage Vm and the reference voltage Vref to determine the SVC susceptance which is required to keep the system voltage constant.

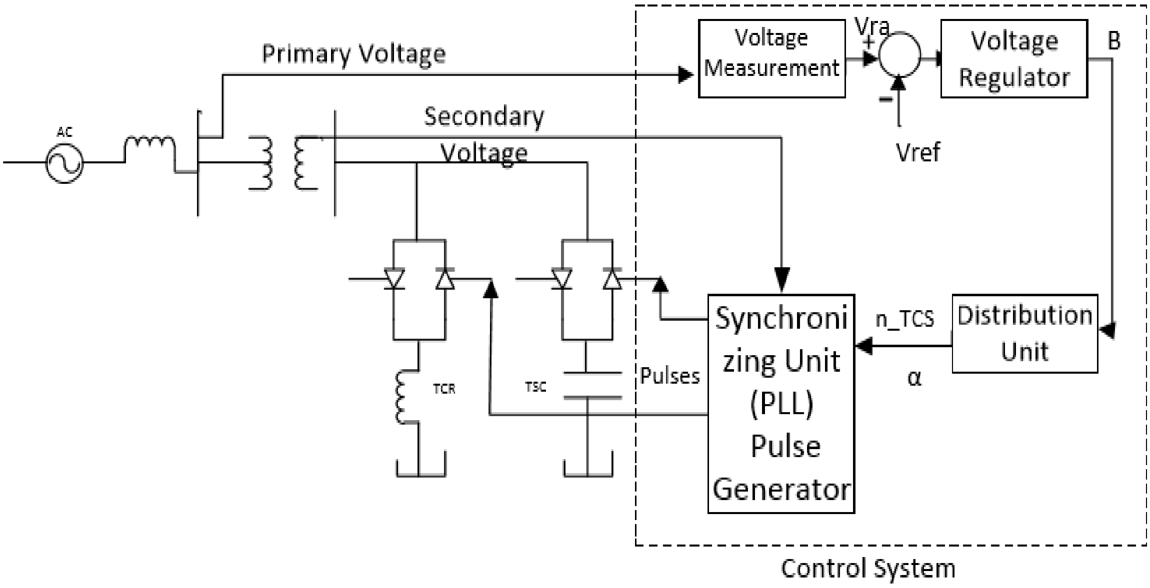


Figure 1 Single-line diagram of a svc and its control system block diagram

3. A pulse generator that sends appropriate pulses to the thyristors

4. A distribution unit which determines the Thyristor Switched Capacitors (TSCs) that must be switched in and out, and computes the firing angle of Thyristor Controlled Reactors (TCRs) [6][4].

3. FUZZY LOGIC CONTROLLER

Fuzzy logic idea is similar to human beings feeling and inference process. It is range to point or range to range control. Fuzzy logic control system is the mathematical system which analyzes the analog values in terms of logical variables which takes values between 0 and 1. It is a collection of logic rules in the form of IF-THEN statements, where the IF part is called the "antecedent" and THEN part is called the "consequent" [7]. Fuzzy logic deals with uncertainty in engineering by attaching degrees of certainty to the answer to a logical question which is commercial and practical.[8] Fuzzy logic is a new control approach with great potential for real time applications.
To implement fuzzy logic technique to a real application following steps is taken into consideration. These are the main components of Fuzzy logic system.

1. Fuzzification interface
2. Knowledge base
3. decision–making logic
4. Defuzzification

Fuzzification interface: It measures the values of input variable. Performs a scale mapping that transfer the range of input variables. Knowledge base consists of knowledge of application domain. It consists of data base and fuzzy control rule base. Decision-making logic is a pointer of FLC. It has a capability of simulating human decision making based on fuzzy concept and of inferring fuzzy control actions employing fuzzy implication and rules of inference in fuzzy logic. Defuzzification in fuzzy logic system is turning the fuzzy variables generated by the fuzzy logic rules into a real signal again. It combines the fuzzy variables to give a corresponding real signal which can then be used to perform some action [8] [9].

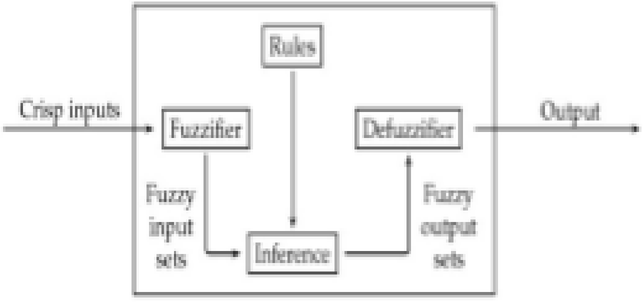


Figure 2 block diagram of fuzzy logic controller

Regulator is the component of control system of the SVC. Here voltage error and derivative of voltage error are used as input to fuzzy logic and output is suseptance (B) and rules are set as shown in the table. This fuzzy logic is then applied to the phasor SVC [10].

Table 1: Rules for the fuzzy controller

Voltage error	*Derivative of voltage error*		
	N	Z	P
N	N	N	Z
Z	N	Z	P
P	Z	P	P

4. TEST SYSTEM

In this paper a simple 400 Kv 2 machine 4 bus system is used .A single line diagram is as shown in the figure. It is formed in ring mode with buses(B1 to B4) which are connected to each other with three phase transmission line L1, L2-1, L2-2 and L3 having lengths 280km,150km, 150km and 150km respectively. The static loads of 250MW, 100MW, 50MW and a dynamic load of 2500+j1000 MVA is connected on the system as shown.

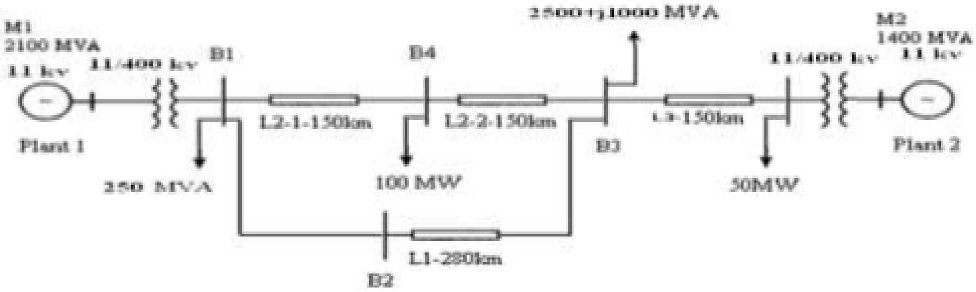


Figure 3 the single line diagram 2 Bus 4-bus 400 kV transmission system

Two power plants of phase to phase 11KV give supply to system. The two machines have a hydraulic turbine and governor (HTG), excitation system, and power system stabilizer (PSS).To resume the simulation in steady state load flow analysis is done at the start of the system. The reference mechanical powers and reference voltages for the two machines have been automatically updated in the two constant blocks connected at the HTG and excitation system inputs: Pref1=0.761905 Pu (1600 MW), Vref1=1.0 Pu; Pref2=0.750827 Pu (1051 MW), Vref2=1.01 Pu. [4].

5. SIMULATION RESUTS AND ANALYSIS

First test system is simulated without SVC mounted over it then the same system is simulated with SVC and fuzzy controlled SVC mounted on bus B3 results obtained are tabulated as follows.

A. System simulation without Facts device mounted on it

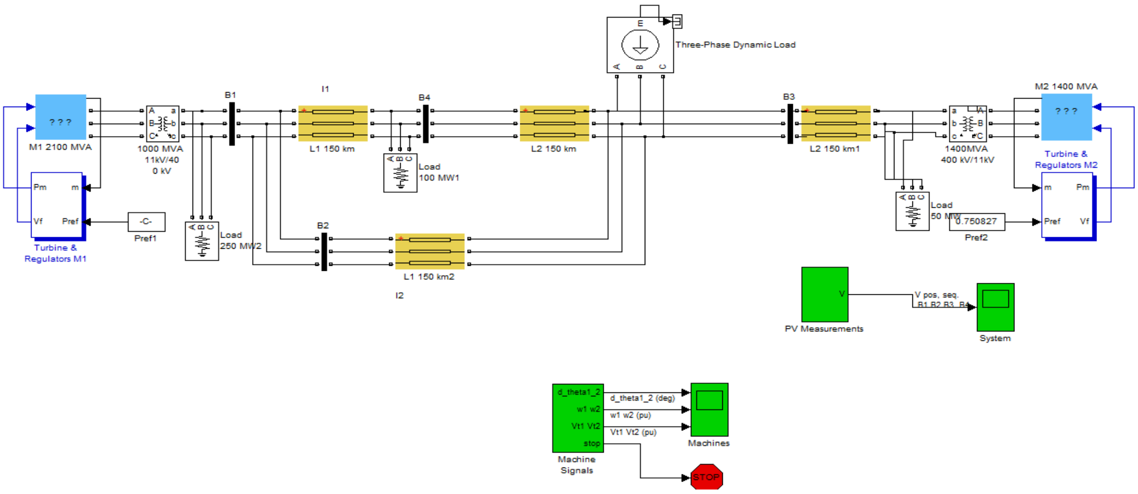
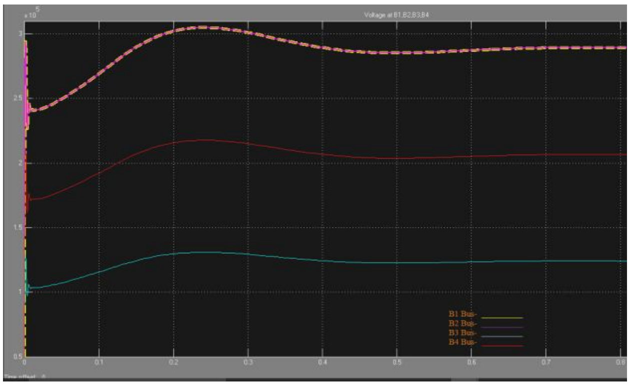


Figure 4 Simulation model of 2 machine 4 bus system without SVC

Table 2: Profile voltage and powers at respective buses

Buses	Real Power(MW)	Reactive Power(Mvar)	Apparent power (MVA)	Voltage(Kv)
B1	614.4	1719	1825.5	288.4
B2	303	891.6	941.68	288.4
B3	35.66	550.7	551.83	123.7
B4	254	607.9	658.83	203.9

Apparent power at B3 is 551.83 MW and real power at B3 bus is 35.66 MW.



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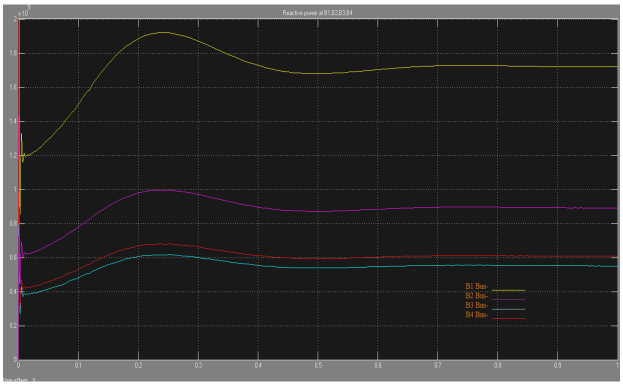
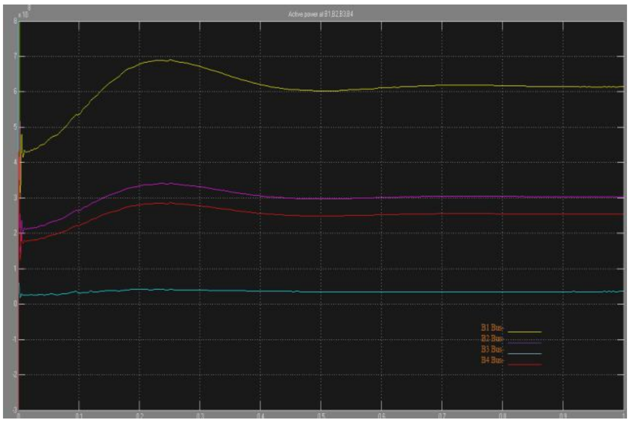


"(b)"



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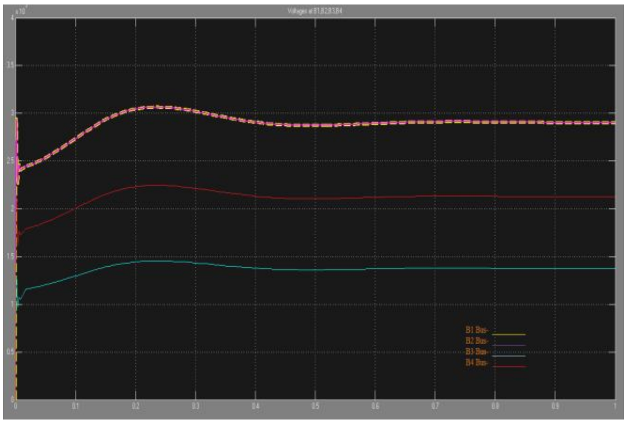

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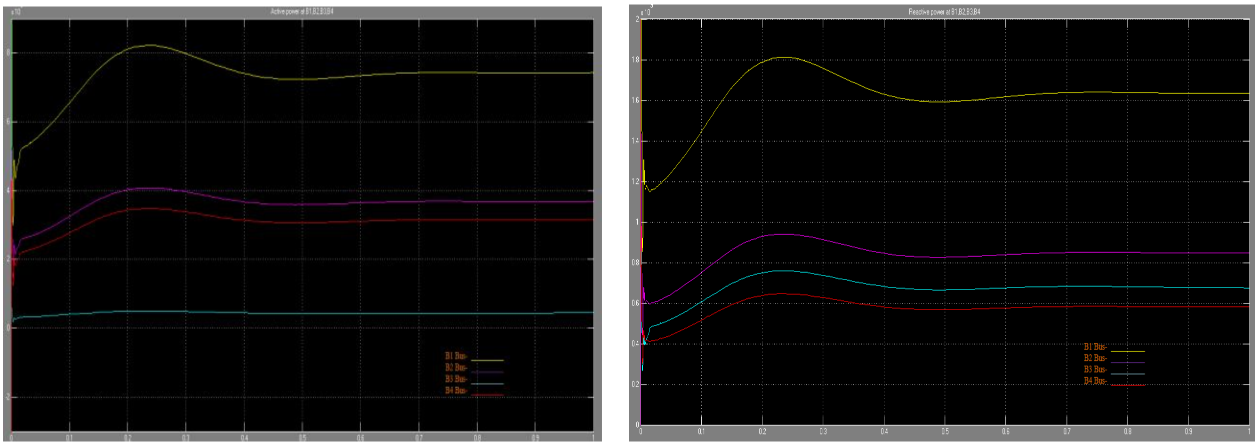

“(e)” “(f)”

Figure 5 (a) Voltage, (b) Reactive power, (c) Active power profile without SVC
Figure 6 (a) Voltage, (b) Active power, (c) Reactive power profile with fuzzy controlled SVC

B. System simulation with fuzzy controlled Facts device mounted on it.

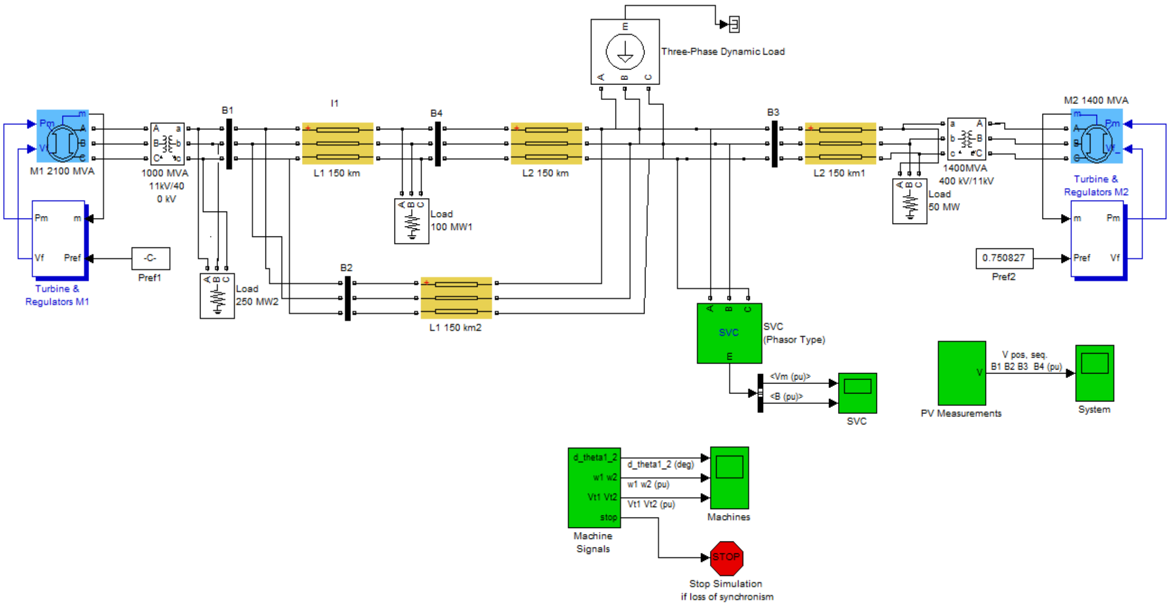

Figure 7 Simulation model of 2 machine 4 bus system with fuzzy controlled SVC

Table 3: Voltage real and reactive power at buses when SVC mounted

Buses	Real Power(MW)	Reactive Power(Mvar)	Apparent power (MVA)	Voltage(Kv)
B1	742.6	1634	1794.82	290.3
B2	368.7	847.5	924.23	290.3
B3	44.74	675.2	676.68	137
B4	314.6	580.8	660.53	212.4

Apparent power at B3 Bus is 676.68 MVA. Real power at the Bus B3 is 44.74 MW.

6. CONCLUSION

A fuzzy controlled SVC technique is used in this paper to enhance the power transmission capability of the system. The given technique is applied to the power system and its results obtained are as follows.
1. Real power flow has increased considerably from 35.66 MW at the B3 bus (SVC was not there) to 44.74MW when fuzzy controlled SVC was applied.

2. It was seen that power losses were more without SVC and got reduced when fuzzy controlled SVC was applied.
3. Voltage at Bus B3 was improved from 123.7 Kv (with out SVC) to 137 Kv (Fuzzy controlled SVC).
4. Loading capacity of the system with fuzzy controlled SVC has improved. FACTS device SVC improves the transmission capability of the given 2 machine 4 bus system at the bus B3 from 551.83 MVA (without SVC) to 676.68 MVA (with SVC)

From the above we can conclude that System performance can be improved by installing fuzzy controlled SVC at one of the buses of the given system and the transmission capability of the system is enhanced.

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