INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING & APPLIED SCIENCES
TRANSFORMING TECHNOLOGY EXPLORING KNOWLEDGE
Volume 2 Issue 3
July 2014 - September 2014
ISSN: 2322-0821(online)
ISSN: Applied for (Printed)
www.irjeas.com

A fuzzy logic based static synchronous series compensator (SSSC) for enhancement of real power in a transmission line

Sourabh Raghuwanshi[1], A.K. Jhala[2]

[1] *Research Scholar, Department of Electrical and Electronics Engineering, RKDF College of Engg., Bhopal, India*
[2] *Assct. Professor, Department of Electrical and Electronics Engineering, RKDF College of Engg., Bhopal, India*

***Abstract* - In this paper the performance of SSSC (static synchronous series compensator) is reviewed so that the utilization of this FACT device can be carried out. Implementation will be done in a long transmission line for the power transmission enhancement with the sensitivity parameter improvement using the approaches of fuzzy logic based controller. In this paper fuzzy logic implementation will also be reviewed.**

Keywords - SSSC, fuzzy logic controller, transmission line.

I. INTRODUCTION

Electric utilities are Operating in an increasingly competitive environment due to the recent trend of deregulation. At the same time, economic and environmental pressures limit their possibilities to expand their transmission facilities. It thus becomes increasingly important to be able to control power flow on individual transmission lines. In this context, FACTS (flexible a.c. transmission system) devices are becoming increasingly used in high voltage transmission systems. The improvement of voltage and current limits of power electronics devices has led to fast development of FACTS devices in the last decade; for example, the development of high power GTO's led to the development of STATCOM's which offer significant advantages over the thyristor - controlled SVC's in common use. In the not too distant future it is likely that high power IGBT's will make PWM controlled FACTS devices feasible for transmission applications. These devices will offer improved speed of response and cause less waveform distortion on the network. The Static Synchronous Series Compensator (SSSC) is an important FACTS device which can allow rapid and continuous changes in the transmission line impedance so that the active power flow along the compensated transmission line can be maintained within a specified range under a range of operating conditions. Applications *of* SSSC to modem power system are lead to more flexible, secure and economic operation. Previous research has shown that while power system stabilizers (PSS) have been able to provide damping of system oscillations in some cases, they have not been universally successful, and TS devices are being increasingly used for this purpose. However, FACTS devices equipped with conventional controllers which were designed based on a linear system models cannot provide satisfactory performance over a wide range of operating conditions and under large disturbances.

II. LITERATURE SURVEY

Manjup, subbiah v [1] suggested that , To control the power flow, for increasing the transmission capacity and optimizing the stability of the power system, FACTS devices are used. One of the most widely used FACTS devices is Unified Power Flow Controller (UPFC). The controller used in the operation of UPFC has significant effect on power flow control and stability enhancement. Conventional PI regulators are generally used in the control of UPFC. This paper investigates control method, using fuzzy logic, for the unified power flow controller in order to improve the stability of a power system. FLC was developed by taking into consideration Mamdani inference system in the decision process and Mamdani's Centroid method in the defuzzification process.

M.A.abido [2] has explained in his survey papers various generations of FACTS devices and were they can be implemented in power system analysis. Also he explained that power system stability can be enhanced using the power electronic devices that is the FACTS devices and surveyed regarding the work of journals in the different year in his paper

V.K chandrakar and A.G Kothari [3] introduced the concept of transient stability improvement using fuzzy logic based static synchronous series compensator for the transmission line. The main aim of his research was to built the concept of artificial intelligence in real power flow were he used the fuzzy rules based logic control to

International Research Journal of Engineering & Applied Sciences
www.irjeas.com, ISSN: 2322-0821, Volume 2, Issue 3, July 2014 – September 2014, Page 57-60

regulate the power flow and simulated results and improved transient stability

J.jegatheesan, A nazarali [4] applied the concept of neuro-fuzzy logic based control in UPFC were he sorted the problem of centroid variation in mamdani type fuzzy logic control by applying neural networks. Simulation were done in matlab and as UPFC is a combination of STATCOM and SSSC he replaced the PI controller with neuro fuzzy logic control

Ya –chin chang , rung-fang chang [5] found the optimal place for the location of FACTS devices in the transmission line for the power flow in most secure and stable condition. A complete analysis was done were mathematical modeling proved suitable location for different type of FACTS devices for sustain in maximum loadability condition.

M.E.A farrag [6] The UPFC is one of the FACTS device which has the unique capability of controlling the real and reactive power flow at different transmission angles .in this research mathematical analysis of the effects of UPFC's VA rating and the system short circuit level on the power flow are investigated to define the overall feasible operating area. Based on the analysis a new fuzzy logic controller was proposed to improve system performance

V.K chandrakar[8] In this paper, Fuzzy logic based supplementary controller is installed with Interline Power Flow Controller [IPFC] to damp low frequency oscillations. IPFC is a new concept to the Flexible AC Transmission system controller for series compensation with the unique capability of power flow of multiple transmission lines. For the analysis Modified linearized Philips–Heffron model of Single Machine Infinite Bus system is established with a IPFC. The simulation results are presented to show the effectiveness and robustness of the proposed control schemes like Power Oscillation Damping [POD] controller, Power System Stabilizer [PSS] controller and Fuzzy logic controller by selecting effective control signals.

T.Hiyama [9] This research presents a new scheme for switching of FACTS devices such as high speed phase shifter, thyristor controlled series capacitor module, braking resistor and static variable compensator using fuzzy logics to enhance overall stability of electric power system. The real power flow at the location of FACTS devices is utilized to determine thyristor switching

.

T.Lie,G. Shrestha,andA.Ghosh [11] Introduced and Design the Application of Fuzzy Logic Control Scheme for Transient Stability Enhancement in Power Systems. In a mathematical modeling the time response analysis was focused which was improved at various loads disturbances on the application of fuzzy logic controller.

Xiao-Ping Zhang,[12] Performed an Advanced modeling of the Multi-control Functional Static Synchronous Series Compensator (SSSC) in Newton Power Flow

I. N gamrooand W.Kong prawechnon [13] A Robust Controller Design of SSSC for Stabilization of Frequency Oscillations in Interconnected Power Systems

B.N. Singh, A. Chandra, K.Al-Haddad, and B.Singh [14] Performance of Sliding Mode and Fuzzy Controllers for a Static Synchronous Series Compensator

III. FACTS SURVEY

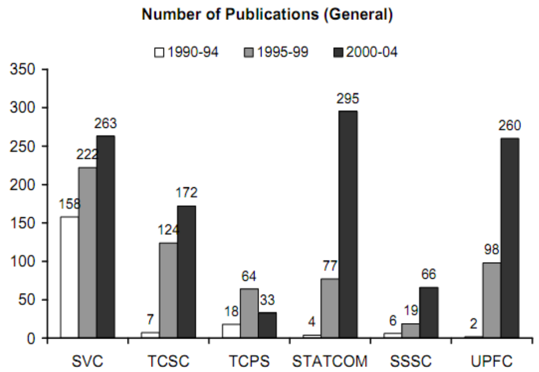

Fig. 3.1 Statistics for FACTS application to different power system studies

IV. SSSC DYNAMICS OVERVIEW

The transfer function of SSSC based controller is:

$$U_{SSSC} = K_S \left(\frac{sT_W}{1+sT_W}\right)\left(\frac{1+sT_{1S}}{1+sT_{2S}}\right)\left(\frac{1+sT_{3S}}{1+sT_{4S}}\right) y,$$

Where, U_{SSSC} and y are the output and input signals of the SSSC-based controller respectively. During steady state conditions ΔV_q and V_{qref} are constant. During dynamic conditions the series injected voltage V_q is modulated to damp system oscillations. The effective V_q in dynamic conditions is given by:

$$V_q = V_{qref} + \Delta V_q.$$

International Research Journal of Engineering & Applied Sciences
www.irjeas.com, ISSN: 2322-0821, Volume 2, Issue 3, July 2014 – September 2014, Page 57-60

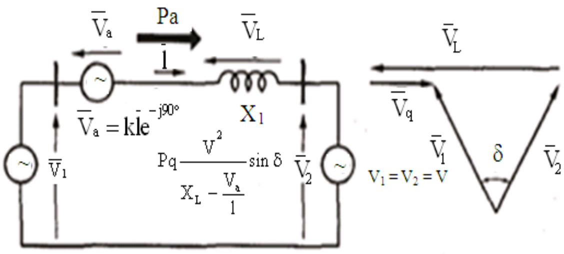

Figure 4.1 - Basic model of the series compensation with a voltage source

V. FUZZY LOGIC CONTROL

Fuzzy control systems are rule-based systems in which a set of so-called fuzzy rules represent a control decision mechanism to adjust the effects of certain system stimuli. The aim of fuzzy control systems is to replace a skilled human operator with a fuzzy rule-based system. The fuzzy logic controller provides an algorithm which can convert the linguistic control strategy based on expert knowledge into an automatic control strategy. The fuzzy logic controller involves four main stages: fuzzification, rule base, inference mechanism and defuzzification (Sivanandam and Deepa, 2009).The structure of the fuzzy logic controller is shown in Fig. 4.1.

The error and change in error are taken as the inputs to the fuzzifier.here the error is between the line voltage and the reference voltage (i.e Vq and Vref) and the change in error is taken by subtracting two consecutive error values by providing a unit step delay and giving the second input to the fuzzifier as shown in the figure . Triangular membership functions are used for the inputs and the output. The universe of discourse for both the inputs is divided into seven partitions (NL - Negative Large, NM - Negative Medium, NS - Negative Small, Z - Zero, PS - Positive Small, PM - Positive Medium, PL - Positive Large). The output is the voltage and again the universe of discourse is divided into seven partitions. Fuzzy rules are if then rules were these are specified by max –min operator functions .the fuzzy rules taken here are of the form:

i) If error is large negative (LN), AND change in error is large negative (LN); THEN output (u) is large positive (LP).

ii) For N linguistic variables for each of error and chage in error there are $N2$ possible combinations resulting into any of M values for the decision variable u. All the possible combinations of inputs, called states, and the resulting control are then arranged in a $NN2\times MM$ 'fuzzy relationship matrix' (FRM).

iii) The membership values for the condition part of each rule are calculated from the composition rule as follows:

μ(Xi) = μ(e is LN, and Δe is LN) = min [μ (Δω is LN), μ (Δω̇ is LN)]; where i=1, 2,…N2 Here, Xi is the i-th value of the N2 possible states (in-put-combinations) in the FRM.

iv)The membership values for the output characterized by the M linguistic variables are then obtained from the inter-section of the N2 values of membership function μ(x) with the corresponding values of each of the decision variables in the FRM. For example, for the decision LN⊂M and for state Xi, we obtain, μu(Xi, LN) = min[μ(Xi, LN), μ(Xi)];

Where i=1, 2, N2 the final value of the stabilizer output 'LP' can be evaluated as the union of all the outputs given by the relationship

μu(LN)= max {μus (Xi, LN)} , for all Xi

The membership values for the other M-1 linguistic variables are generated in a similar manner.

v) The fuzzy outputs μu(LN), μu(LP), etc. are then defuzzified to obtain crisp u. The popular methods of defuzzification are the centroid and the weighted average methods. Using the centroid method, the output of the FLC is then written as

$$u = \frac{\sum_{i=1}^{M} \mu_u(A_i) * A_i}{\sum_{i=1}^{M} \mu_u(A_i)}$$

$$u = \frac{\sum_{i=1}^{M} (\mu_u(A_i) * threshold\ value\ of\ A_i)}{\sum_{i=1}^{M} \mu_u(A_i)}$$

vi) A set of decision rules relating the inputs to the output are compiled and stored in the memory in the form of a 'decision table'. The rules are of the form:

	NL	NM	NS	Z	PS	PM	PL
NS	PS	PL	PL	PS	NM	NS	NM
NM	PM	PL	PL	PM	Z	Z	Z
NL	PL	PL	PL	PL	Z	Z	Z
Z	PS	PM	PL	Z	NS	NM	NL
PS	PS	PS	NM	NS	NS	NL	NL
PM	Z	Z	Z	NM	NM	NL	NL
PL	Z	Z	Z	NL	NL	NL	NL

Table 5.1 – Decision Table

VI. MODEL TO BE PROPOSED

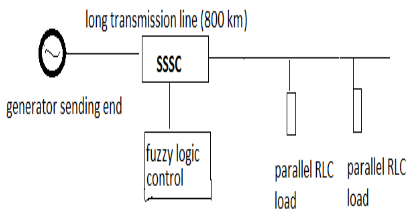

Fig. 6.1 – Model to be proposed

(i) It will be desired that the voltage injection will have a sensitive improvement for the maximum loads changes. The results are explained using graphical analysis through the approaches of MATLAB.

(ii) Total harmonic distortion curves will also be explained through graph of the complete analysis.

(iii) Comparison of results is shown between the PI controller approach and fuzzy logic control approach. and is expected to have improved and enhanced changes

VII. CONCLUSION

In this paper, a fuzzy logic controller based SSSC is reviewed which will inject necessary voltage to the power transmission network at various load changes. Fuzzy logic controller works according to system behavior. Controller input parameters are carefully chosen to provide considerable damping for power system. The range of each controller is determined based on simulation results of the fuzzification process. Simulation results indicate that this controller can inject necessary voltage drop required in the transmission network.

VIII. REFERENCES

[1] N.G. Hingorani and L. Gyugyi, "Understanding FACTS, Concepts and Technology of Flexible AC Transmission System", Wiley-IEEE press, 1ed., Dec.

[2] N.G. Hingorani. "High power electronics and Flexible AC transmission system", IEEE Power Engineering review, Jul. 1988

[3] N.G.Hingoroni, "Flexible AC transmission systems", IEEE spectrum (40-45) April

[4] Kundur P., Klein M., Rogers G.J. and Zywno M.S. "Appli-cation of power system stabilizers for enhancement of overall system stability," IEEE Trans. Power syst., vol.4, pp.614-626, 1989

[5] H.F.Wang, "Applications of damping torque analysis to STATCOM control " , Elsevier, Electrical Power and Energy Systems 22, 2000, 197–204

[6] H.F.Wang, "Phillips-Hefron model of power systems in-stalled with STATCOM and applications", IEE proceedings on generation, transmission and distribution, vol. 146, no.5, September 1999, pp 521-527

[7] Ustun, T.S. and S. Mekhilef, 2010, Effects of a Static Synchronous Series Compensator (SSSC) based on a soft switching 48-pulse pwm inverter on the power demand from the grid. J. Power Elect., 10:85-90.

[8] Panda, S., 2010. Modelling, simulation and optimal tuning of SSSC-based controller in a multi machine power system. World J.Model. Simulation, 6: 110-121

[9] Ustun, T.S. and S. Mekhilef, 2010, Effects of a Static Synchronous Series Compensator (SSSC) based on a soft switching 48-pulse pwm inverter on the power demand from the grid. J. Power Elect., 10: 85-90.

[10] K.R.Padiyar and A.M. Kulkarni, "Analysis and design of voltage control of static condenser", IEEE conference on power electronics, derives and energy systems for industrial growth 1, pp 393-398, 1996

AUTHORS' PROFILE

Sourabh Raghuwanshi is student of M.Tech.(power systems) in RKDF college of engineering, Bhopal. He has completed his B.E. (Electrical and Electronics Engineering) from NRI institute of research and technology, Bhopal.

A.K. Jhala is currently designated as an Associate Professor (Electrical and Electronics Dept.) in RKDF college of engineering, Bhopal.