International Journal of Applied Engineering & Technology

MODELLING AND SIMULATION OF ADVANCE COMPOSITE MATERIAL PROCESSING USED IN SMIB SYSTEM

Seema Bai Meena*[1], Lokesh Meena[2] and M.L. Meena[3]
[1]Department of Electrical Engineering, Rajasthan Technical University Kota, Rajasthan
[2]Department of Electrical Engineering, Govt. Engineering College, Baran, Rajasthan,India
[3]Department of Electronics Engineering, Rajasthan Technical University, Kota
smeena@rtu.ac.in*

ABSTRACT

Composite materials have gained significant popularity within the vehicle industry due to its advantageous characteristics such as lightweight nature, extended lifespan, improved physical and mechanical properties, and their ability to be easily molded into various shapes, surpassing the capabilities of traditional metals. The non-linear simulation studies have been carried out for SMIB system without any FACTS device. The models of SMIB system have been developed in the MATLAB/SIMULINK software. Results are demonstrated and are found satisfactory. Firstly, the modeling of SMIB system without any device has been carried out successfully. Thereafter eigen values of SMIB system have been calculated with the help of load flow results. Thereafter Simulink model of SMIB system has been created in MATLAB software and results are demonstrated satisfactorily with and without fault.

Keywords: Advance composite material, Simulation, Modelling, SMIB system

1. INTRODUCTION

In the earlier few decades, the power flow control is highly demanding and is the main concerning aspect of power utilities. The consumer side demands and number of loads are increasing day by day and hence the electrical power system is becoming too complex and is the challenge for electrical engineers to handle the system with different kinds of loads and to supply them reliable and uninterrupted power supply. In the literature it is found that the UPFC is ultimate & versatile FACT device but costlier. In recent papers new low-cost device namely, DPFC is discussed as alternative of UPFC FACT device. In this chapter rigorous literature survey has been carried out regarding DPFC & UPFC, their modelling with SMIB system, State Space model, mitigation of power oscillations using DPFC & UPFC FACTS devices and their simulation studies. In the last few decades, power demand grows tremendously. This Growing trend requires transmission networks and generation plants to support this growth. But new transmission lines and generation are restricted due to environmental issues and less availability of resources, which compel the power system to be operated near to the stability margin. It is known that the transmission line network is expensive due to complex electrical circuits. Power flow controlling is also a typical task from generation side to consumer side. In present scenario the consumer side demand is increasing day by day across the world. Low frequency oscillations may arise due to the interconnected power system which is in the range of 0.2-3 Hz. These oscillations may constrain the power transfer capability of the line and the system may lose the synchronism, if these oscillations are not damp out smartly. In the past, it has been customary to construct automobiles using a range of materials including glass, plastic composites, and metals. In the field of automation, the utilization of aluminum and magnesium alloys has emerged as a viable alternative to steel in order to achieve weight reduction. The utilization of novel composite materials in the pursuit of reducing the weight of modern cars has been made possible through recent breakthroughs in this field. The aerospace and automotive sectors are employing recently developed composite materials in order to achieve enhanced levels of strength and rigidity.

2. BACKGROUND OF STUDY

Francisco P. Demello et al. [1] deals with phenomena of stability of synchronous machines under small disturbances for SMIB system connected to a large system. Stability aspects are discussed through external impedance. Frequency response analysis has been done to see the effect on system parameters voltage regulator gain. The study also explored at different machine loadings, machine inertias and system external impedances to determine oscillations and damping characteristics. Stabilizing Signals are obtained from speed. Magdy E.Aboul-Ela et al. [2] investigated global control signals through two separate control strategies. In first strategy two level PSS controller is developed. For first level control is obtained from local signals to deal with local modes and for second level control selected global states are used to deal poorly damped inter area modes of oscillations. For the second strategy SVC is used for damping of inter area modes of oscillations. The effectiveness and robustness of the two control strategies are tested on a 19- generator system. Papic, P. zunko, et al. [3] investigated the basic control for UPFC in which the change in reference values of the active and reactive power is supplied from other outer system controller. Hence the analysis is based on the analysis is done on the basis of transformation of 3-phase system into the rotating reference frame. The new approach is cable to provide better stability and transient response as compare to classical decoupled approach. The derived control is tested on the NETOMAC program system. K.S. Smith et al. [4] describes the Dynamic modeling of a unified power flow controller UPFC which is a combination of STATCOM and SSSC is coupled via common dc link to allow bidirectional flow of real power between the series output terminals of the SSSC and the shunt output terminals of the STATCOM and is controlled to provide simulations. Control of real and reactive power is without any external energy storage device. K.R. Padiyar et al. [5] developed the control strategy and found that UPFC can simultaneously or selectively can control the transmission line voltage, impedance and angle or the real and reactive power flow in the line through angularly unconstrained series voltage injection. It may also provide independent controllable shunt reactive compensation. Simulation studies have been carried out to check the efficiency of control design strategy. L.Gyugyi et al. [6] Investigates new approach for power transmission control with UPFC. Approach is based on generalized real and reactive power flow controller to maintain the prescribed P & Q at a desired bus. For that simulation studies have been carried out by considering the broad range of P & Q and are found that response of the control is very fast and device is effectively capable in handling the dynamics system disturbances. M. Noroozian et al. [7] presented optimal power flow control of electrical power system using UPFC. Various examples are coded to verify the application. Performance of phase shifting transformer is also discussed and is compared with UPFC. Steady state mathematical model is also discussed of UPFC. Kalyan K. Sen et al. [8] presented detailed information in terms of theory, modeling and applications. EMTP simulation package is used to validate the application model by connecting the model to a simple transmission line. H. F. Wang [9] established non-linear model of Multimachine power system for UPFC and then derived linearized Phillip's Heffron model to study the oscillation stability. Care study have been carried out on 3 machine 9 bus system after incorporating UPFC.PSS is also studied and is found that the voltage control of the dc link capacitor inside the UPFC interacts negatively with the PSS. To avoid this situation damping controlled is designed to improve damping oscillations. A. J. F Keri et al. [10] proposed the MATLAB modeling tool to evaluate and understand the total behavior and impact of UPFC incorporated on a power system network. MATLAB code is developed to perform fast parametric studies of the UPFC in terms of applications. To confirm the validity of the developed technique; study has been performed on TNA. B. A. Benz et al. [11] discussed the installation of the world's First Unified Power flow controller and various tests performed during installation process at the Inez Substation of AEP in eastern Kentucky. The various test verifies the versality of UPFC. Presented challenge to utility system planners that now and where to install FACTS devices and how to develop and carry out feasible model and studies. N. Tambey et al. [12] investigated the damping of power system oscillation by using UPFC which is the ultimate device. For that simulation studies have been carried out by incorporating UPFC in multi-machine system and results are validated and are found satisfactory. Sayed Ali et al. [13] investigated the Non-linearity effects of UPFC in load flow study on the power system. Also investigated, the ability of UPFC to control the tie line power flow, by visualize the effects of different control parameters. The phase angle of parallel voltage is set to regulate the dc link capacitor voltage.

S.A. Al-Mawsawi [14] proposed, a PWM based UPFC used as a voltage regulator and is simulated and analyzed to obtain its optimal position in the transmission line and compared with shunt connected device. The simulation results determine the performance of UPFC in steady state and demonstrate that by changing the modulation index of two devices, they can control the distribution of active and reactive power flows. Besides this, the optimal performance of two devices and their comparison have been done. Li-Jun Cai et al. [15] described the simultaneous coordinated control of PSS and FACTS based damping controllers for large power systems. For that linearized system models are created and parameter constrained nonlinear optimization algorithm is used. Simulation studies have been carried out to check the efficiency of the damping controllers and method is found effective for the tuning of multi controllers in large power systems U. P. Mhaskar et al. [16] described the properties of local Zeros and investigated the use of modal controllability and observability in the selection of local signals for FACTS based damping controllers. These signals are identified for various FACTS devices. Many case studies have been performed to validate the results. For that detailed model is used. Arup Ratan Bhowmik et al. [17] investigated the performance of UPFC in controlling the power flow in the transmission line. The simulation studies have been carried out on IEEE-14 bus system by incorporating UPFC at the sending end to improve the real and reactive power flow control in transmission line. Simulation results of the developed models are compared with and without UPFC FACT device on the basis of active and reactive power transfer in the transmission line to check the performance of UPFC. Surjan et al. [18] described the linearized modeling of SMIB system for small signal stability improvement. The paper also presented the comparative analysis of PID, PSS and TCBR Controllers which are designed for small signals stability improvement SMIB system and modeled through six k constants. Sapna Khanchi et al.[19] presented the brief study of Unified Power Flow Controller focused on the role of UPFC device in electrical power system and current status of power system network. Budi Srinivasrao et al. [20] described the comparison of different types of FACTS devices for different problems in power system and observed the performance. Compared the operation and mitigated the power quality issues by using DPFC and UPQC in MATLAB software. Ismail Musirin et al. [21] discussed the voltage profile enhancement using UPFC via AIS. Programming codes for AIS optimization technique is developed to determine the optimal value of UPFC. Tests are performed on IEEE- 30 bus Reliability test system. Implementation in a large system can realize the robustness of the developed technique in solving more complex problems.

3. MODELLING OF SMIB SYSTEM

In this study modeling of SMIB system without any FACTS device has been developed. Load flow study with SMIB system has been performed to calculate the initial operating conditions. Eigen values have been calculated of SMIB system at different loadings. Nonlinear simulation studies of SMIB system have been carried out and result are demonstrated.

3.1Single Machine Infinite Bus System

The model of SMIB test system without any FACTS device is shown in Fig. 1

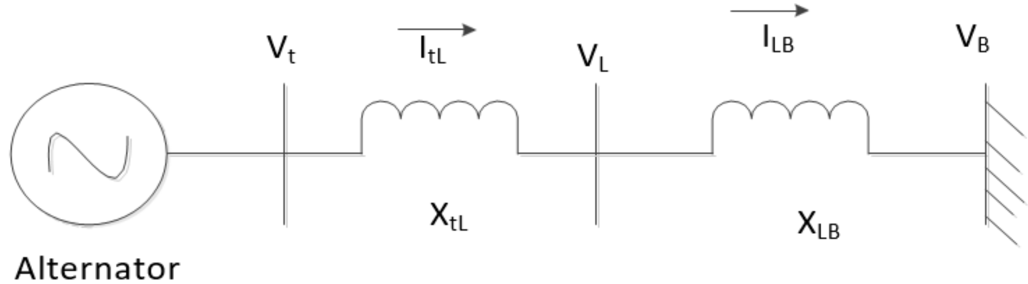

Fig.1 Single machine infinite bus System

The synchronous generator is delivering power to the infinite-bus through transmission lines. V_t and V_B are the generator terminal voltage and infinite bus voltage respectively. X_{tL} and X_{LB} are transmission line reactances respectively as shown in Fig 3.1

3.2 Dynamic Model of SMIB System

3.2.1 Non-linear Dynamic Model

The dynamic model of the system is non-linear model. For the calculation of the rotor speed, power angle delta, and electrical power output, model based on Phillips & Heffron is used. Now, from Fig 1

$$I_{tl} = I_{lb} \quad (3.1)$$

$$V_t = V_d + jV_q$$

$$I_{tl} = I_{tld} + jI_{tlq}$$

and terminal voltage is given as follows:

$$V_t = jX_{tl}I_{tl} + jX_{lb}I_{lb} + jV_b \square 0^0 \quad (3.2)$$

The value of generator current corresponds to the d-q axis is obtained after equating imaginary and real parts of the equation (3.2) as follows:

$$I_{tld} = \frac{E_q' - V_b \cos\delta}{(X_{tl} + X_{lb} + X_{dd}')} \quad (3.3)$$

$$I_{tlq} = \frac{V_b \sin\delta}{(X_{tl} + X_{lb} + X_q)} \quad (3.4)$$

3.2.2 Dynamics of generator and the Excitation System

In this work, a third order model of the generator has been adopted and a simple, first order excitation system for the generator has been chosen. Therefore, the dynamics of the generator and the excitation system are expressed through a fourth order model of the power system as follows:

$$\delta = \omega_b \omega \quad (3.5)$$

$$\dot{\omega} = \frac{p_m - p_e - D\omega}{M} \quad (3.6)$$

$$E_q' = \frac{(-E_q + E_{fd})}{T'_{d0}} \quad (3.7)$$

$$E_{fd}' = -\frac{1}{T_a}E_{fd} + \frac{Ka}{T_a}(V_{ref} - V_t) \quad (3.8)$$

Moreover, the expressions of power output and terminal voltage of generator expressed in the d- q axis are as follows:

$$p_e = E'_q I_{tlq} + (X_q - X'_d)_{ld} I_{tlq} \quad (3.9)$$

$$E_q = E'_q + (X_d - X'_{d\,d}))_{ld} \quad (3.10)$$

$$V_t^2 = (E'_q - X'_d I_{tld})^2 + (X_q I_{tlq})^2 \quad (3.11)$$

By linearising the equations (3.5), (3.6), (3.7), (3.8) following equations are obtained:

$$\Delta\delta = w_b \Delta w \quad (3.12)$$

$$\Delta \dot{w} = \frac{-\Delta P_e - D\Delta w}{M} \quad (3.13)$$

$$\Delta E_q' = \frac{\left(-\Delta E_q + \Delta E_{fd}\right)}{T_{do}'} \quad (3.14)$$

3.3 Simulation Studies and Results of SMIB System

Load flow results at different loadings along with Eigen value analysis have been presented. Eigen values are found to ensure the stability of the system. The mathematical model of SMIB system has been developed in MATLAB.

3.3.1 Load Flow Study with SMIB System

For calculating the initial operating conditions of the SMIB system as shown in the Fig.1, the load flow study has been carried out and the results are shown in Table1 at different loading conditions i.e. at 80%, 90% and 100% loadings.

Table 1: Load flow results of SMIB at different loadings

Loadings	Vt∠θ	It∠θ	□o
80%	1∠66.45	0.57∠52.30	51.7988
90%	1∠63.96	0.61∠48.58	57.6777
100%	1∠63.25	0.74∠45.12	61.9759

3.3.2 Calculation of Eigen values

Eigen values are calculated as shown in Table2 to ensure the stability of the system. The K constants are functions of the infinite bus voltage and branch impedance. Eigen values are obtained at different loadings i.e. at 80%, 90% and 100%.

Table 2: Eigen values of SMIB at different loadings

Loading	80%	90%	100%
Values of SMIBSystem	-98.7639 612 ± 6.4834i08 -1.7110	-98.7815 96 ± 6.3548i 11 -1.7500	-98.7935 61 ± 6.2246i -1.7911

4. SIMULATION RESULTS

The Figs 2 & 3 shows the simulink models of SMIB system developed in MATLAB environment without & with fault respectively. Simulation results without & with fault have been demonstrated.

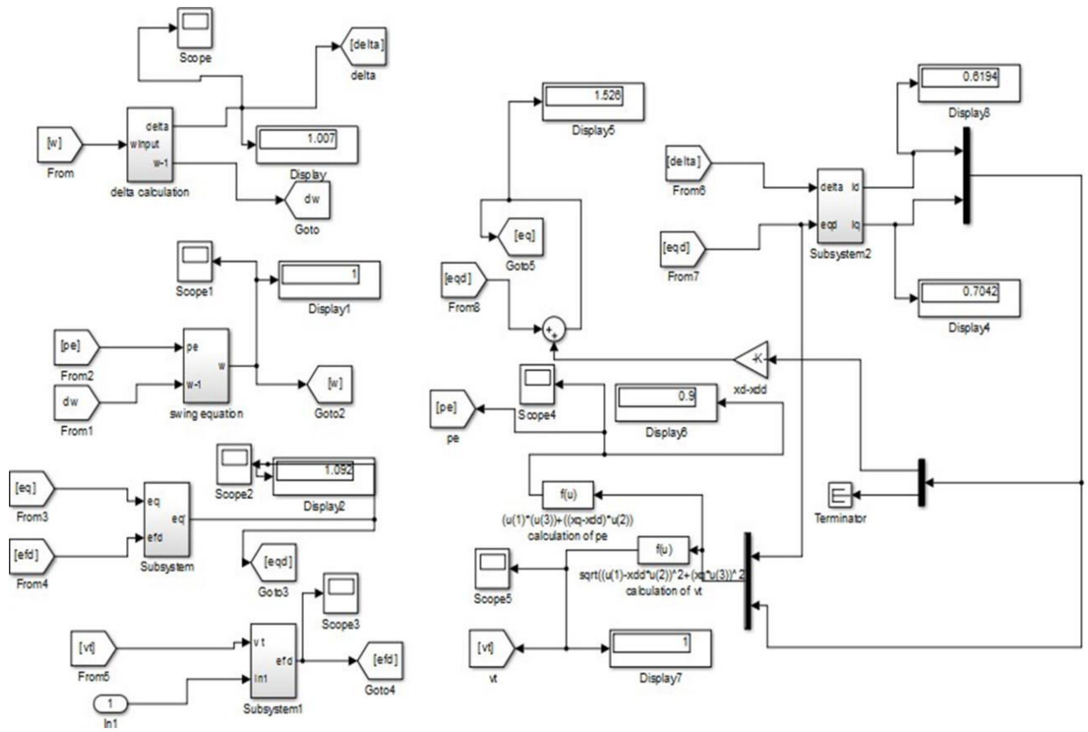

Fig.2 Simulink Model of SMIB System without fault

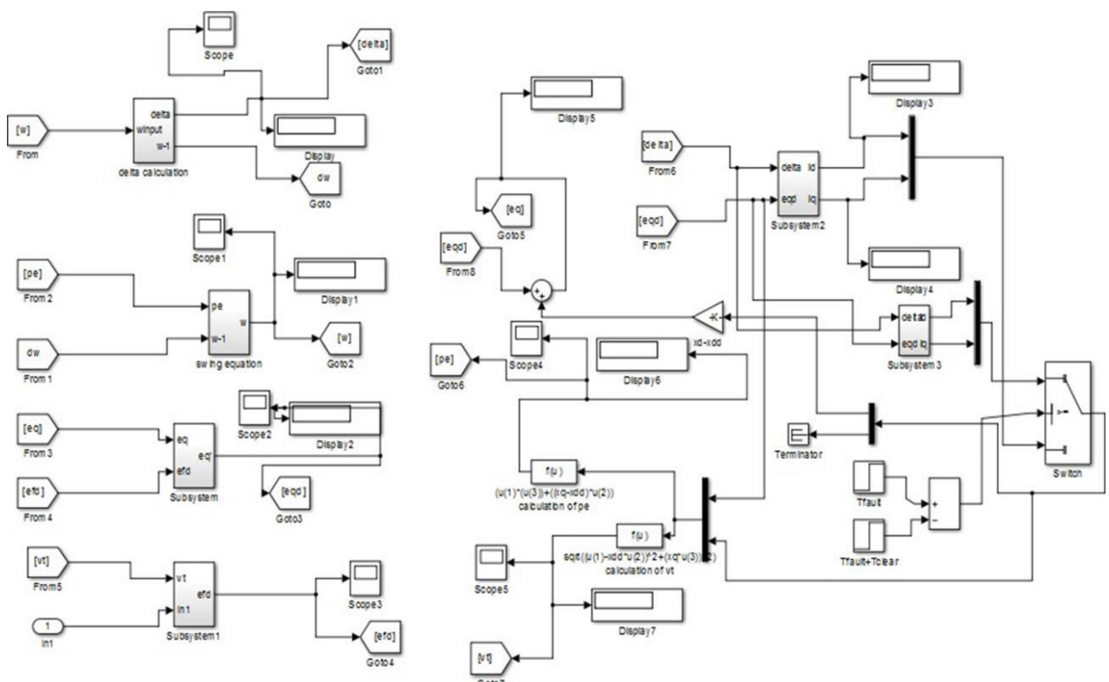

Fig. 3 Simulink Model of SMIB System with Fault

5. CONCLUSION

The non-linear simulation studies have been carried out for SMIB system without & with fault and without any FACTS device. The models of SMIB system have been developed in the MATLAB/SIMULINK software. Results are demonstrated and are found satisfactory. Firstly, the modeling of SMIB system without any device has been carried out successfully. Thereafter eigen values of SMIB system have been calculated with the help of load flow results. Thereafter simulink model of SMIB system has been created in MATLAB software and results are demonstrated satisfactorily with and without fault.

REFERENCE

1. Francisco P. Demello, Charles Concordia,"Concepts of Synchronous Machine Stability as Affected by Excitation Control", IEEE Transactions on Power Apparatus and systems, Vol. pas-88, No. 4, April 1969.
2. Magdy E.Aboul-Ela, A.Sallam,James D.Mc Calley, A.Fouad, "Damping Design For Power System Oscillations Using Global Signals", IEEE Transactions on Power Systems, vol. 11, no. 2, may 1996.
3. Papic, P. zunko, D. Povh, "Basic Control of Unified Power Flow Controller" IEEE Transactions on Power Systems, vol. 12, no. 4, november 1997.
4. K.S. Smith , L.Ran & J. Penman, "Dynamic modeling of a unified power flow controller". IEE Proc. Gener. Transm. Distrib., Vol 144, No.1, January 1997.
5. K.R. Padiyar and A.M. Kulkarni, "Control design and simulation of unified power flow controller". IEEE Trans .Power Delivery, Vol.13, No.4,October 1998.
6. L.Gyugyi,T. R.Rietman,A. Edris,"The Unified Power Flow Controller: A New Approach To Power Transmission Control", IEEE Transactions on Power Delivery,Vol. 10, No. 2, April 1995.
7. M. Noroozian, L.Angquist, M. Ghandhari, G. Anderson, "Use of UPFC for Optimal Power Flow Control",IEEE Transactions on Power Delivery,Vol. 12,No. 4, October 1997.
8. Kalyan K. Sen, Eric J. Stacey, "UPFC - Unified Power Flow Controller: Theory and Applications", IEEE Transactions on Power Delivery, Vol. 13, no. 4, October 1998.
9. H. F. Wang, "Applications of Modelling UPFC Into Multi-Machine Power Systems", IEEE Proc.-Gener. Transm. Distrib., Vol. 146, no. 3, May I999.
10. A. J. F Keri, AS. Mehraban, A. Elriachy, X. Lombard, A. A. Edris, "Unified Power Flow Controller (UPFC): Modeling and analysis", IEEE Transaction on Power Delivery , Vol. 14, No. 2, April 1999.
11. B. A. Benz, A. Keri, C. Schauder, E. Stacey, A. S. Mehraban, L. Kovalsky, L.Gyugyi, A. Edris, "Aep Unified Power Flow Controller Performance", IEEE Transactions on Power Delivery, Vol. 14, no. 4, October 1999.
12. N. Tambey, M.L Kothari, —"Damping of Power System Oscillations with Unified Power Flow Controller (UPFC)", IEE Proc. Gener. Trans. Distrib., Vol. 150, No. 2, pp. 129-140, 2003.
13. Sayed Ali Nabavi-Niaki, M. R.Iravani, "Visualization and Investigation of Unified Power Flow Controller (UPFC) Non-linearity in Power Flow", IEEE, 2003.
14. S.A. Al-Mawsawi, "Comparing and evaluating the voltage regulation of a UPFC and STATCOM" Elsevier Science Ltd. All rights reserved, Electrical Power and Energy Systems 25,735–740,2003.
15. Li-Jun Cai and István Erlich, "Simultaneous Coordinated Tuning of PSS and FACTS Damping Controllers in Large Power Systems", IEEE Transactions on Power Systems, Vol. 20, no.1, February 2005.
16. U. P. Mhaskar and A. M. Kulkarni, "Power Oscillation Damping Using FACTS Devices: Modal Controllability, Observability in Local Signals, and Location of Transfer Function Zeros", IEEE Transactions on Power Systems, Vol. 21, no. 1, February 2006.

17. Arup Ratan Bhowmik, Champa Nandi, “Implementation of Unified Power Flow Controller (UPFC) for Power Quality Improvement in IEEE 14-Bus System”, Int. J. Comp. Tech. Appl., ISSN: 2229-6093, Vol. 2, Dec 2011.

18. Balwinder Singh Surjan, “Linearized Modeling of SMIB bus power system and controllersfor small signal stability Investigation and Enhancement”, IJARCET, Vol.-1, Issue.8, Oct. 2012.

19. Sapna Khanchi,Vijay Kumar Garg, “Unified Power Flow Controller (FACT Device): Review Paper”, IJERA, Vol. 3, Issue 4, August 2013.

20. Budi Srinivasrao, G.Sreenivasan, Swathi Sharma, “Comparison of Facts Controller for power quality Problems in power system”, IJST, Vol. 8, Nov. 2015.

21. Ismail Musirin, Nur Dianah Mohd. Radzi, “Voltage Profile Improvement using Unified Power Flow Controller via Artificial Immune System”, Vol. 3, Issue 4, April 2008.