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Voltage Control Strategy Using SVC with Energy Storage

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Abstract: ***The power generated is usually delivered to the load terminals. But large amount of power is wasted in the form of heat, line losses. In order to balance the sending end power and receiving end power svc is used to overcome the losses. Thus, svc should be added at the dynamic position to improve the bus voltage. Here in my project different generators such as wind, thermal, hydro stations are being connected to the 14 bus system in which the loads are also connected to that bus system. When the loads are on, the voltage gets dipped at the particular bus. So, in that bus the svc should be added to improve the bus voltage. By, this voltage sag, and harmonics can be reduced. The combination of facts devices such as FC-TCR is used to get the better results in maintaining voltage profile.***

Keywords: SVC, FC-TCR, Voltage Sag, Real power, Reactive power

1. Introduction

The power generated is being transmitted to the distribution area for consumers. But, the power generated is wasted due to several losses due to voltage sag, swell. In order to reduce the losses the facts devices are used to balance the losses. So, here svc is used to control the power. Facts devices are defined by the IEEE as "a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability." In series compensation, the FACTS is connected in series with the power system. It works as a controllable voltage source. Series inductance exists in all AC transmission lines. In shunt compensation, power system is connected in shunt (parallel) with the FACTS. It works as a controllable current source. Thus with these devices the combination of different svc's are used such as FC-TCR, TSC-TCR. In my project the combination of Fixed Capacitor-Thyristor Controlled Reactor (FC-TCR).FACTS are a family of devices which can be inserted into power grids in series, in shunt, and in some cases, both in shunt and series. FACTS mainly find applications in the following areas: - Power transmission - Power quality - Railway grid connection - Wind power grid connection - Cable systems With FACTS, the following benefits can be attained in AC systems: - Improved power transmission capability - Improved system stability and availability - Improved power quality – Minimized environmental impact - Minimized transmission losses FACTS are a family of devices which can be inserted into power grids in series, in shunt, and in some cases, both in shunt and series.

2. Voltage control by FACTS Device

A STATCOM is a flexible AC transmission systems (FACTS) device, it is a voltage-source converter based device which converts a DC input voltage into an AC output voltage in order to compensate the reactive power of the system. Usually the reactive output of a STATCOM is regulated to maintain the desired AC voltage at the bus, to which a STATCOM is connected. It can provide voltage control in either transmission or distribution system with a fast control response. The function is similar to reactive power control of the generation, except that a STATCOM provides a solution that is independent of the generator. Currently, the deployment of STATCOM is restricted by high costs. Due to the fast response of STATCOM, modern control strategies, such as linear quadratic regulator (LQR), can be provided for voltage control. Rao et al. (2000) implemented PI, pole-placement and LQR controllers on the STATCOM respectively; the performances were compared in terms of response profile and control effort. The simulation results showed that the PI and LQR controller exhibited comparable responses. At extreme loading cases, however, the LQR controller had superior robustness. The proposed control methodologies were applied on a STATCOM in a traditional radial feeder, they can be easily extended to a network connected with multiple DGs. Today's changing electric power systems create a growing need for flexibility, reliability, fast response and accuracy in the fields of electric power generation, transmission, distribution and consumption. Flexible Alternating Current Transmission Systems (FACTS) are new devices emanating from recent innovative technologies that are capable of altering voltage, phase angle and impedance at particular points in power systems. Their fast response offers a high potential for power system stability enhancement apart from steady state flow control. Static Var Compensator (SVC) provides more effective for providing fast-acting reactive power compensation. SVC also used for voltage regulation as well as reactive power compensation, dampen power swings and reduce system losses by optimized reactive power control. SVC is a shunt-connected static source or sink of reactive power.

3. Voltage Profile Improvement

Let the sending and receiving voltages be given by $V\angle\delta$ and $V\angle 0^{\circ}$ respectively. The ideal shunt compensator is expected to regulate the midpoint voltage to against any variation in the compensator current. The voltage current characteristic of the compensator is shown in Figure.1. This ideal behaviour however is not feasible in practical systems where we get a slight drop in the voltage characteristic. This will be discussed later.

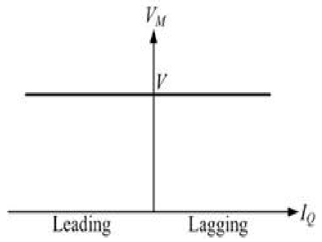

Figure 1: Voltage-current characteristic of an ideal shunt compensator.

Thus, by using the svc and fc-tcr at the dynamic position it improves the voltage profile in the system. Improves and stabilizes the voltage supplied to the load, thereby minimizing heat generation, resulting in energy savings, improved production, and increased equipment efficiency and longevity.

4. Results and Discussion

Here the 14 bus system is considered for the simulation of with and without compensation using svc and FC-TCR. This is the IEEE standard 14 bus system.

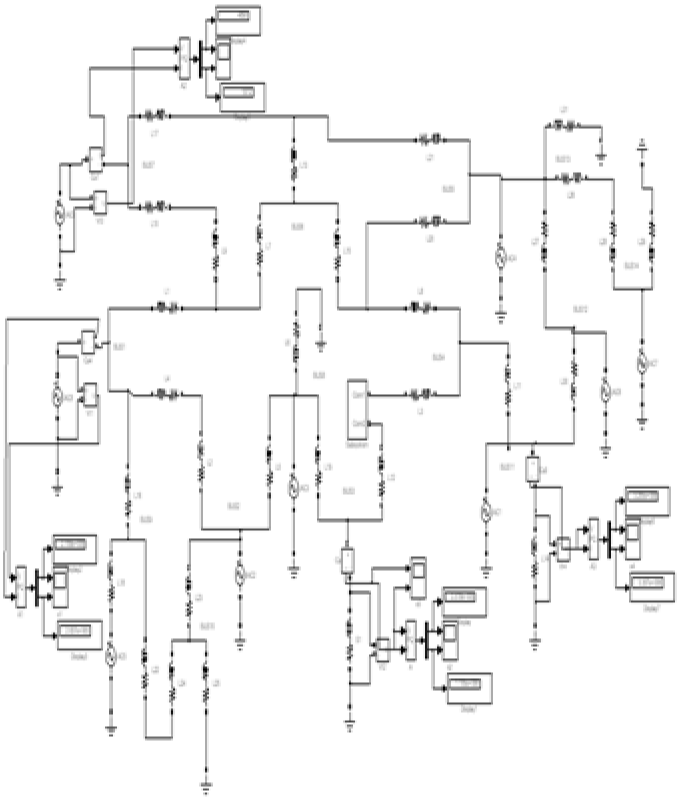

Figure 2: 14 bus system without svc compensator

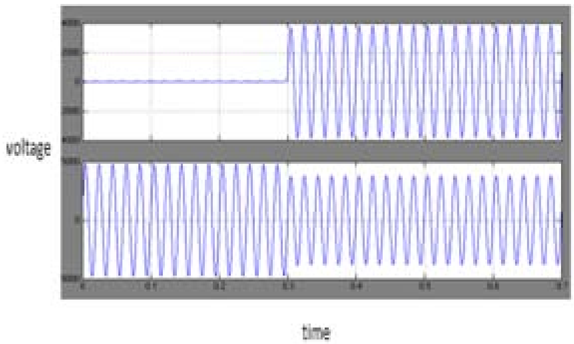

Figure 3: Voltage across load 2 and load 1

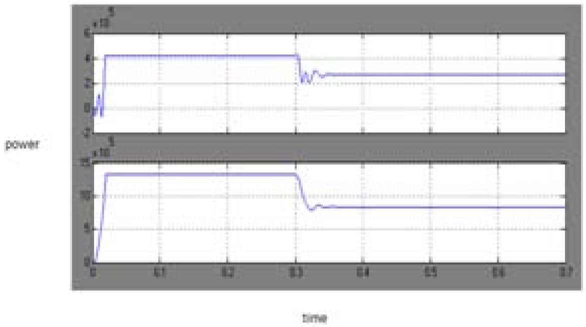

Figure 4: Real and Reactive power across bus-3

Thus, without the svc the real and reactive power gets decreased in the particular bus.

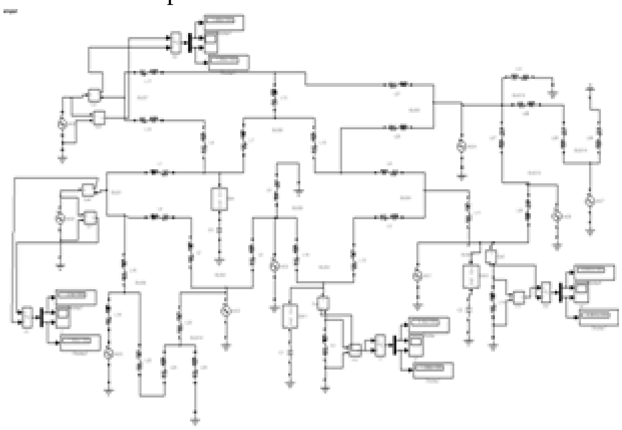

Figure 5: 14 bus system with svc

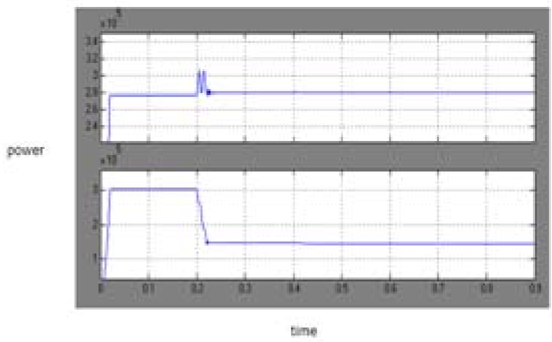

Figure 6: Real and Reactive power across bus1

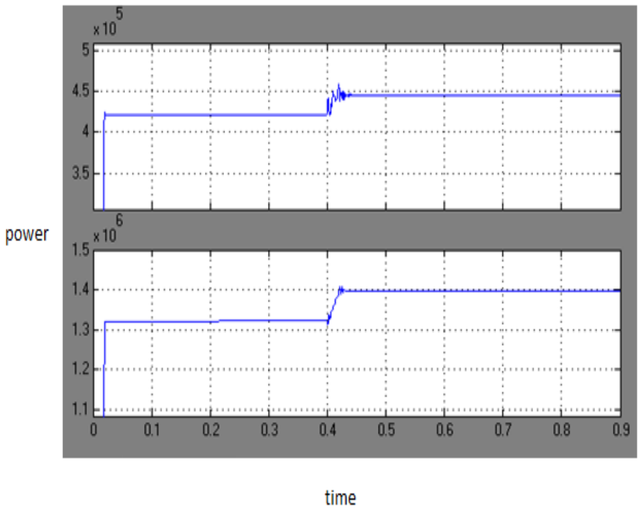

Figure 7: Real and reactive power across bus-3

This, is the simulation results of the 14 bus system with svc. At, bus 1 the voltage gets dropped due to the load. So, in bus 3 the svc is added and then the voltage gets improved at the place where the svc gets on.

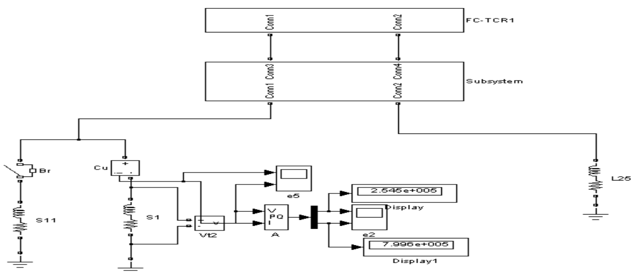

Figure 8: Simulation model of FC-TC

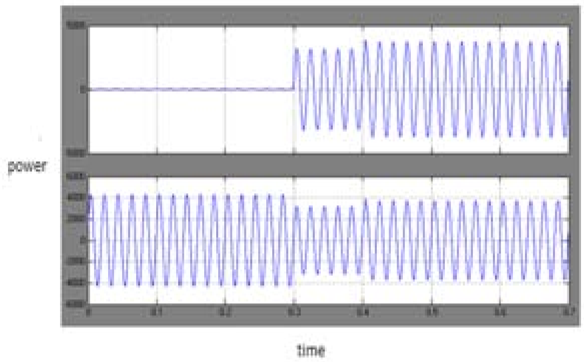

Figure 9: Voltage across Load-1 and Load-2

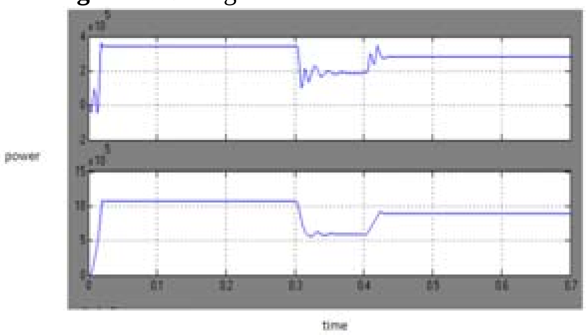

Figure 10: Real and Reactive Power across bus-3

When the load gets on the voltage gets decreased. So, in order to improve the voltage profile the FC-TCR is added on the weak buses. Thus by adding the voltage gets improved in the weak buses. The real and reactive power gets improved. Thus, comparing the performance of SVC and FC-TCR. but svc improves the voltage profile lot.

5. Conclusion

This chapter deals with the simulation results of 14 bus system with and without svc and also the combination of FC-TCR. Normally, the power is wasted during transmission through the heat and line losses. So, in order to overcome this voltage imbalance, FACTS devices such as SVC is added at the weak buses to improve the voltage profile. Thus, by adding the SVC and FC-TCR voltage gets improved in the particular bus.In FC-TCR, it controls the firing angle of TCR and so delivering the stable real and reactive power. In the 14 bus system with svc, if
the svc is added at the 3 bus, then from that the bus that there will be only slight variation in real and reactive power when compared with the bus 1.

The purpose of adding FC-TCR is to give the varying performance in controlling the real and reactive power.

Bus No	*Real Power With Out Compen Sation (MW)*	*Real Power With Compen Sation (MW)*	*Reactive Power Compen Sation (MVA)*	*Reactive Power Compen Sation (MVA)*
BUS-7	0.0246	0.0183	0.0241	0.0451
BUS-1	0.0274	0.0227	0.0274	0.0672
BUS-3	0.266	0.284	0.838	0.892
BUS-11	3.205	3.206	3.341	3.336

Reference

[1] N. G. Hingorani and L. Gyugyi, *Understanding FACTS. Concepts andTechnology of Flexible AC Transmission Systems*. NewYork,NY, USA: IEEE, 2006.

[2] G. Cao, Z. Y. Dong, Y. Wang, P. Zhang, and Y. T. Oh, "VSC based STATCOM controller for damping multi-mode oscillations," in *Proc. IEEE Power and Energy Soc. General Meeting—Conversion and Delivery of Electrical Energy in the 21st Century*, Jul. 2008, pp. 1–8.

[3] M. Zarghami and M. L. Crow, "Damping inter-area oscillations in power systems by STATCOMs," in *Proc. 40th North Amer. Power Symp*., Sep. 2010, pp. 1–6.

[4] Z. Yang, C. Shen, L. Zhang,M. L. Crow, and S. Atcitty, "Integration of a statcom and battery energy storage," *IEEE Trans. Power Syst*., vol. 16, no. 2, pp. 254–260, May 2008.

[5] A. Arulampalam, J. B. Ekanayake, and N. Jenkins, "Application study of a STATCOM with energy storage," *Proc. Inst. Electr. Eng.—Gener., Transm. and Distrib*., vol. 150, pp. 373–384, July 2011.

[6] P. Thakur · A. K. Singh, *"A novel way to quantify the magnitude of voltage sag,"* Electr Eng, DOI 10.1007/s00202-012-0268-0, © Springer-Verlag Berlin Heidelberg 2012.

[7] S. A. Rahman, R. K. Varma, and W. H. Litzenberger, "Bibliography of FACTS applications for grid integration of wind and PV solar power systems: 1995–2010 IEEE working group report," in *Proc. IEEE*

Power Energy Soc. General Meeting, Jul. 2011, pp. 1–17.

[8] Z. Yang, C. Shen, L. Zhang, M. L. Crow, and S. Atcitty, "Integration of a STATCOM and battery energy storage," *IEEE Trans. Power Syst.*, vol. 16, no. 2, pp. 254–260, May 2001.

[9] Mohsen GITIZADEH, Mohsen KALANTAR, Optimum allocation of FACTS devices in Fars Regional Electric Network using genetic algorithm based goal attainment', Gitizadeh et al. / J Zhejiang Univ Sci A 2009 10(4):478-487, ISSN 1673-565X (Print); ISSN 1862-1775 (Online).

[10] Zhengyu Huang, Yixin Ni, C. M. Shen, Felix F. Wu, Shousun Chen, and Baolin Zhang, Application of Unified Power Flow Controller in Interconnected Power Systems—Modeling, Interface, Control Strategy, and Case Study, IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 15, NO. 2, MAY 2000.

[11] D.Murali, Dr. M. Rajaram, N. Reka, Comparison of FACTS Devices for Power System Stability Enhancement, International Journal of Computer Applications (0975 – 8887) Volume 8– No.4, October 2010.

[12] K.R.Padiyar, FACTS Controllers in Power Transmission and Distribution, Copyright © 2007, New Age International (P) Ltd., Publishers, ISBN (13): 978-81-224-2541-3.

[13] Champa Nandi, Sumita Deb, Minakshi Deb Barma, and A.K. Chakraborty, Study and Simulation of the SVC and STATCOM Effect on Voltage Collapse and Critical Fault Clearing Time, International Journal of Modeling and Optimization, Vol. 2, No. 4, August 2012.

[14] R.Mohan Mathur and Rajib K. Varma, Thyristor_based FACTS Controllers for Electrical Transmission Systems, IEEE press 2002, A JOHN WILEY & SONS, INC. PUBLICATION, ISBN 0-471-20643-1.

[15] Enrique Acha,Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pe´rez, Ce´sar Angeles-Camacho, FACTS Modelling and Simulation in Power Networks, Copyright ©2004 John Wiley & Sons Ltd, ISBN 0-470-85271-2.

[16] A. R. Hason, T. S. Martis, and A. H. M. Sadrul, "Design and implementation of fuzzy controller based automatic voltage regulator for a synchronous generation," IEEE Transaction on Energy Conversion, vol. 9, no. 3, Sept. 1994.

[17] P. Chiradeja, R. Ramakumar, "An approach to quantify the technical benefits of distributed generation," IEEE Trans Energy Conversion, vol.19, no. 4, pp. 764-773, 2004.

[18] H. A. Gil and G. Joos, "Models for quantifying the economic benefits of distributed generation," IEEE Transaction on Power Systems, vol. 23, no. 2, pp. 327-335, May. 2008.

[19] Z. Dong, et al., "Capacitor switching and network reconfiguration for loss reduction in distribution system," in Proc Power Engineering Society General Meeting Conf., pp. 1-6, 2006.

[20] J. Kondoh, I. Ishii, H. Yamaguchi, A. Murata, K. Otani,K. Sakuta, N. Higuchi, S. Sekine, and M. Kamimoto.Electrical energy storage systems for energy networks. Energy Conversion and Management, (41):1863–1874,2000.

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