Behavior study of D-STATCOM with Load Variation

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Abstract: Multi-level power conversion is playing a big role for high power applications. The multi-level Voltage Source Converter (VSC) allows to reach the goal with low Harmonics and high voltage. A three-phase insulated gate bipolar transistor (IGBT)-based distribution static VAR compensator (D-STATCOM) is used for voltage unbalance compensation. Multi-level VSC with diode have simple configuration and very easy controlling. This device improves the quality and reliability of voltage distribution and power flow into the networks. It reduces the effect of voltage sags, swells and interruption in the distribution system. Multi-level D-STATCOM configuration shown here with a three level voltage source converter. Main Objective here to increase the DC voltage to compensate the sag or swell which create voltage interruption during these conditions in the load voltage. The DC voltage controlled by the inverter switching. Reliability and robustness of the control scheme in the system response to the voltage disturbances due to load variations is shown in simulation results. The simulation and experimental results show that the control schemes can compensate the unbalance in the voltage source.

I. INTRODUCTION

A distribution static VAR compensator (D-STATCOM) is eliminate or mitigate the harmonics and unbalance in current. Diode clamped M.I. scheme is proposed here to take advantage of the M.I. like to minimize utilization of switch and the switching duty ratio among its various levels. M.I reduces the voltage stress on each power device of power system. This device focuses on low voltage distribution and is a more cost-effective when it comes to the large power users like industries commercial buildings etc. With custom power solutions in place, the end-user sees better. The mitigation equipments relies on the power electronic switches and the contribution of power electronic switches to power system has lead to vast developments in the area of power quality. Power quality problems like voltage sag/swell, voltage flicker and harmonics, unbalance, were investigated separately. Combination of parallel and series active filters may be necessary for harmonic compensation in some special cases. The wide range of power quality disturbances covers sudden, short duration deviations, voltage dips, short interruptions. The compensation of voltage unbalance, an active filter for voltage regulation, together with passive filters harmonics compensation. Series active filter and a parallel active filter are connected to perform both voltage and current compensation. Voltage quality is worsened due to Voltage dips and interruptions caused by faults. These disturbances cause tripping of sensitive electronic equipments, damage the plants and also completely stop the production. Distribution Synchronous Compensator (D-STATCOM) is one of the qualitatively superior FACTS devices used to control the power flow through an electrical transmission/distribution line.

II. DESCRIPTION OF D-STATCOM OPERATION

A D-STATCOM is a shunt device that regulates the system voltage by absorbing or generating reactive power at a point of coupling connection. The D-STATCOM is a solid state DC/AC power switching converter that consists mainly of a three-phase PWM voltage source converter (VSC) bridge having six IGBTs with associated anti-parallel diodes. It is connected to the distribution network via the impedance of the coupling transformer. A DC-link capacitor

provides constant DC link voltage. The output provides constant DC link voltage.

III. FEATURES

1) High-level language for technical computing
2) Development environment for managing code, files, and data
3) Interactive tools for iterative exploration, design, and problem solving
4) Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, and numerical integration.
5) 2-D and 3-D graphics functions for visualizing data
6) Tools for building custom graphical user interfaces
7) Functions for integrating MATLAB based algorithms with external applications and languages, such as C, C++, FORTRAN, Java, COM, and Microsoft Excel.

B. Modeling

The D-STATCOM was simulated for bus voltage regulation mode using the Simulink environment ofMATLAB. The switching frequency is 1080 Hz and the sampling time Ts= 1e-05 sec. The step change on source voltage is shown. The D-STATCOM tries to maintain the bus voltage 1pu where it is connected byabsorbing or supplying the required reactive power. The dynamic response of 20kV,+/-3Mvar DSTATCOM is obtained for step change on source voltage which is shown.The source voltage is maintained initially at 1pu after transient lasting approximately t=0.4 sec. Proportional increase in VSC voltage. During the compensation the inverter voltage and current variations are shown in Fig.6.which indicates that the inverter voltage remains constant and the current is injected in shunt for compensation.

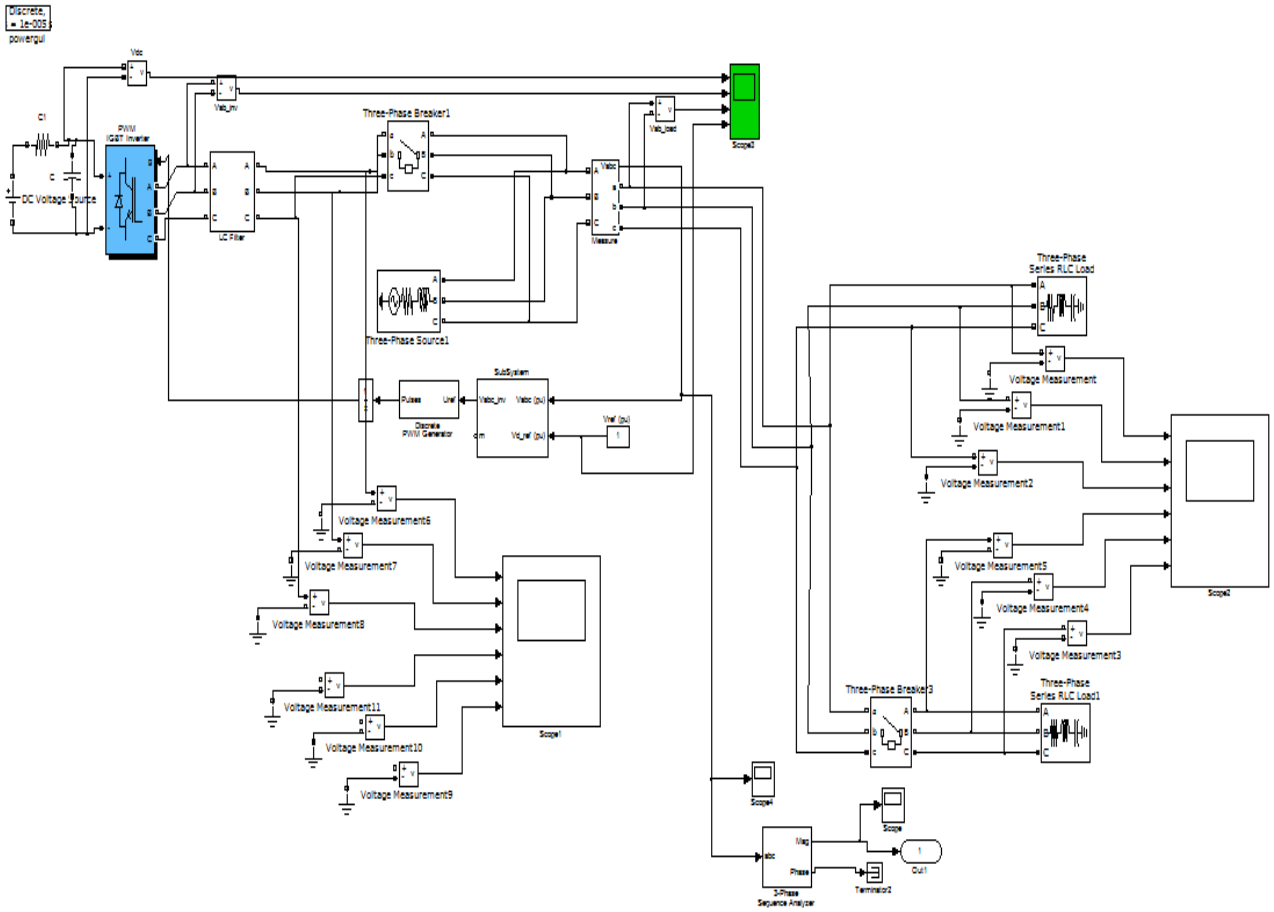

Fig.1 D-statcom model

C. Results

The first simulation simulation contains no D-STATCOM and three phase fault is applied via fault resistance of 0.001 OHM, during the period 500-900ms. Result for Sag and swell formation and voltage intrupption at the load point with or without DSTATCOM shown below.

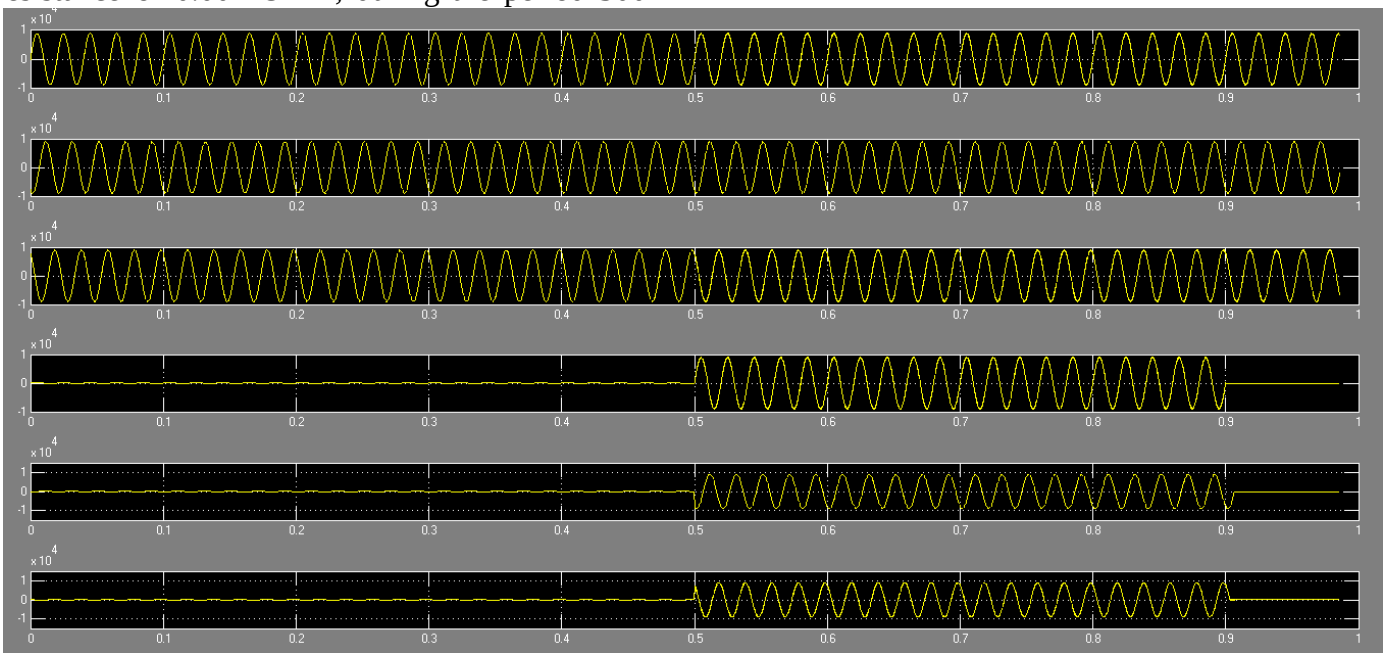

Fig. 2 Load output Improved Voltage From 0.5 to 0.9 sec

IV. Conclusion

A three-phase IGBT-based D-STATCOM is proposed for voltage compensation. Modeling of D-STATCOM using two-level and three level VSC are modeled and simulated. PWM based control scheme proposed here to control the two and three level VSC in the D-STATCOM. PI control scheme used for voltage regulation requires only voltage measurements at the load point. The highly developed observational facilities available in MATLAB are used for all aspects of model realization and to carry out extensive simulation studies This characteristic ideally suitable for low voltage custom power applications. The control scheme is tested under a wide range of operating conditions with various connecting loads. Simulation studies are referred to the impact of three level D-STATCOM for voltage sag/swell elimination, harmonic suppression, speed of response of the PWM control and transient overshooting. It is observed that for increased number of levels of VSC the output voltage and current waveforms approaches a sinusoidal nature with minimum harmonics D-STATCOM brings flexibility to the compensation system and reduces capital costs. In practice, because of the limited DC link voltage, sometimes the D-STATCOM cannot achieve 100% compensation.

REFERENCES

[1] H. Akagi, *Instantaneous Power Theory and Applications to Power Conditioning*, New Jersey, USA.: Wiley, 2007.

[2] J. A. Momoh, *Electric Power Distribution, Automation, Protection and Control*, New York, USA: CRC Press, 2008.

[3] N. G. Hingorani and L. GyuGyi, *Understanding FACTS Concept and Technology of Flexible AC ransmission System*, New York, USA.:IEEE Press, 2000.

[4] N. G. Hingorani, "Introducing custom power", *IEEE Spectrum*, June 1995, pp. 41 – 48.

[5] A. Ghosh and G. Ledwich, *Power quality enhancement using custom power devices*, Massachusetts, USA.: Kluwer Academic Publishers, 2002.

[6] A.L. Olimpo and E. Acha, "Modeling and analysis of custom power systems by PSCAD/EMTDC," *IEEE Trans. Power Delivery*, vol. 17, no. 1, pp. 266-272, Jan. 2002.

[7] P. Pohjanheimo and E. Lakervi, "Steady state modeling of custom power components in power distribution networks," *in Proc. IEEE Power Engineering Society winter Meeting*, vol. 4, Jan. 2000, pp. 2949- 2954.

[8] A. Adya, "Application of D-STATCOM for isolated systems", *IEEE Region 10 Conference (TENCOM)*, Vol. 3, Nov. 2004, pp. 351-354.

[9] K. Somsai and T. Kulworawanichpong, "Modeling, simulation and control of D-STATCOM using ATP/EMTP," *In Harmonics and Quality of Power, 2008. ICHQP 2008. 13th International Conference on*. pp. 1- 4, 2008.

[10] C. Sumpavakup, and T. Kulworawanichpong, "Distribution Voltage Regulation Under Three-Phase Fault By Using D-STATCOM", *TheInternational Conference on Electric Power and Energy Systems (EPES2008)*, pp.855-859, July 2008.

[11] E. Acha, *Electronic Control in Electrical Power Systems*, London, UK.: Butter-Worth-Heinemann, 2001.

[12] P. Giroux, G. Sybille, H. Le-Huy, "Modeling and Simulation of a Distribution STATCOM using Simulink's Power System Blockset," *IEEE Industrial Electronics Society*, pp.990-994, Nov 2001.

[13] H. Akagi, *Instantaneous Power Theory and Applications to Power Conditioning*, New Jersey, USA.: Wiley, 2007.

[14] J. A. Momoh, *Electric Power Distribution, Automation, Protection and Control*, New York, USA: CRC Press, 2008.

[15] N. G. Hingorani and L. GyuGyi, *Understanding FACTS Concept and Technology of Flexible AC ransmission System*, New York, USA.:IEEE Press, 2000.

[16] N. G. Hingorani, "Introducing custom power", *IEEE Spectrum*, June 1995, pp. 41 – 48.

[17] A. Ghosh and G. Ledwich, *Power quality enhancement using custom power devices*, Massachusetts, USA.: Kluwer Academic Publishers, 2002.

[18] A.L. Olimpo and E. Acha, "Modeling and analysis of custom power systems by PSCAD/EMTDC," *IEEE Trans. Power Delivery*, vol. 17, no. 1, pp. 266-272, Jan. 2002.

[19] P. Pohjanheimo and E. Lakervi, "Steady state modeling of custom power components in power distribution networks," *in Proc. IEEE Power Engineering Society winter Meeting*, vol. 4, Jan. 2000, pp. 2949- 2954.

[20] A. Adya, "Application of D-STATCOM for isolated systems", *IEEE Region 10 Conference (TENCOM)*, Vol. 3, Nov. 2004, pp. 351-354.

[21] K. Somsai and T. Kulworawanichpong, "Modeling, simulation and control of D-STATCOM using ATP/EMTP," *In Harmonics and Quality of Power, 2008. ICHQP 2008. 13th International Conference on*. pp. 1-4, 2008.

[22] C. Sumpavakup, and T. Kulworawanichpong, Distribution Voltage Regulation Under Three-Phase Fault By Using D-STATCOM", *TheInternational Conference on Electric Power and Energy Systems (EPES2008)*, pp.855-859, July 2008.

[23] E. Acha, *Electronic Control in Electrical Power Systems*, London, UK.: Butter-Worth-H