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Power Quality Improvement in Power Distribution System using D-STATCOM

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Abstract:
The STATCOM is the shunt connected FACTS devices that are useful for reactive power compensation and mitigation of power quality problems in transmission and distribution system particularly in smart grid environment. This paper has dealed with performance analysis of D-STATCOM that is used for voltage flicker control. The D-STATCOM has been used to regulate voltage on a 33-kV distribution network for the plant absorbing continuously changing currents, like an arc furnace, that produces voltage flicker. The variable load current magnitude has been modulated at a frequency of 5 Hz so that its apparent power varies significantly and fast. It will be observed the ability of the D-STATCOM to mitigate voltage flicker.

IndexTerm: D-STATCOM, distribution system, line voltage, voltage stability, Power Quality, voltage source converter.

I. INTRODUCTION

Power Transmission and distribution is a complex process, requiring the working of many factors of the power system in order to maximize the output. One of the major factors is to maintain the reactive power in the system. Following are the requirements of reactive power compensation: (1) It is required to supply/absorb reactive power to maintain the rated voltage to deliver the active power through the long transmission lines. This Voltage support helps in (a) reduction of voltage fluctuation at a given terminal of the long transmission line. (b) An increase in transfer of active power through a long transmission line (c) increases the stability. (2) Many Loads like motor loads require reactive power for their proper operation. This Load compensation helps in (a) improvement of power factor (b) balancing of real power drawn from the supply (c) better voltage regulation due to large fluctuating loads. (3) The modern industries use electronic controllers which are sensitive to poor voltage quality and will shut down if the supply voltage is depressed and may mal-operate in other ways if changes of the supply voltage is excessive. Many of these modern load equipments itself uses electronic switching devices which then can contribute to poor network voltage quality [5]. With power quality problem utility distribution networks, industrial loads, sensitive load etc. are suffered. (4) Along with advance technology, the organization of the worldwide economy has evolved towards globalization and the profit margins of many activities tend to decrease. The increased sensitivity of the vast majority of processes like (industrial services and even residential) to Power quality problems turns the availability of electric power with quality a crucial factor for competitiveness in every activity sector. The continuous process industry and the information technology services are most critical area due to disturbance a huge amount of financial losses may happen with the consequent loss of productivity and competitiveness. (5) With the trend towards distributed and dispersed generation, the issue of power quality is going to take newer dimensions. (6) The introduction of competition into electrical energy supply has created greater commercial awareness of the issues of power quality while equipment is now readily available to measure the quality of the voltage waveform and so quantify the problem [1-3]. This implies that some measures must be taken in order to achieve higher level of power quality and power transfer capability [3]. STATCOM can do these jobs of absorbing or generating reactive power with a faster time response compare to SVC and capacitor banks. (1) The maximum capacitive power generated by a SVC is proportional to the square of the system voltage (constant susceptance) while the maximum capacitive power generated by a DSTATCOM decreases linearly with voltage decrease (constant current). (2) This ability to provide more capacitive power during a fault is one important advantage of the DSTATCOM over the SVC. (3) The DSTATCOM will normally exhibit a faster response than the SVC because with the voltage sourced converter, the DSTATCOM has no delay associated with the thyristor firing (in the order of 4 ms for a SVC). (4) DSTATCOM provides fast acting dynamic reactive compensation for voltage support during contingency events which would otherwise depress the voltage for a significant length of time [2, 3]. (7) The fast response of the distribution static compensator (DSTATCOM) makes it the efficient solution for improving power quality in distribution systems [3-5].

II. DSTATCOM

The STATCOM mainly consists of DC
voltage source behind IGBT based current controlled voltage source inverter. STATCOM has no long term energy support in the DC Side and cannot exchange real power with the ac system; however it can exchange reactive power. Also, in principle, it can exchange harmonic power too. But when a STATCOM is designed to handle reactive power and harmonic currents together it is Shunt Active Power Filter but the STATCOM

handles only fundamental reactive power exchange with the ac system. DSTATCOM controller is highly effective in improving the power quality at the distribution level by making the voltage stable. It is the shunt connected var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage).

III. STATIC OF ART

The D-STATCOM is three phase shunt

connected power electronics based device. It is connected near the load at the distribution system as shown in fig 1. It is also a one type of the voltage source converter, which converts a DC input voltage into AC output voltage in order to compensate the active and reactive power needed by the system.

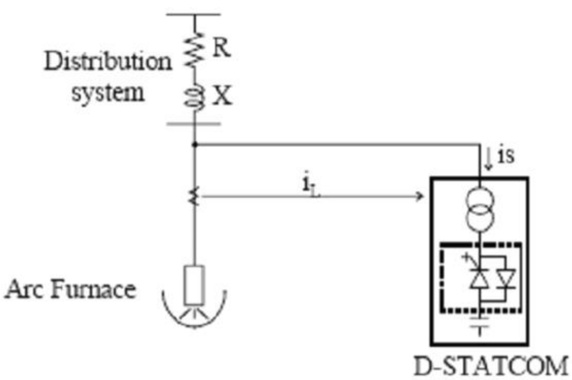

Figure. 1. system configuration of DSTATCOM

A voltage Source converter is connected to bus via three phase transformer. A voltage source converter is a power electronics device, which can generate sinusoidal voltage with required magnitude frequency and phase angle. A 5000 □F capacitor is used as a dc voltage source for the inverter. PCC is the point of common coupling at which the generation or absorption of reactive Power takes Place to and from the system and the device. At the distribution voltage level, the switching device is generally the IGBT due to its lower switching losses and reduced size. Figure 2 shows a simplified diagram of a STATCOM connected to a typical distribution network represented by an equivalent network.**2**

1) Control System Block Diagram of DSTATCOM

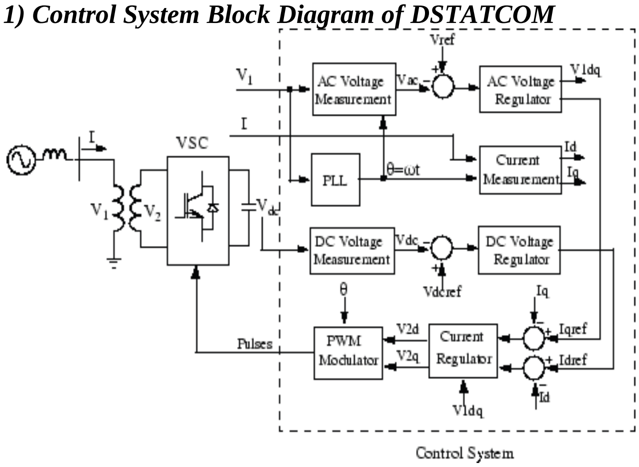

Figure.2. Control System Block Diagram of DSTATCOM

The control system consists of:

a) A phase-locked loop (PLL) which synchronizes on the positive-sequence component of the three-phase primary voltage V1. The output of the PLL is used to compute the direct-axis and quadrature-axis components of the AC three-phase voltage and currents (labelled as Vd, Vq or Id, Iq on the diagram).

b) Measurement systems measuring the d and q components of AC positive sequence voltage and currents to be controlled as well as the DC voltage Vdc.

c) An outer regulation loop consisting of an AC voltage regulator and a DC voltage regulator. The output of the AC voltage regulator is the reference current Iqref for the current regulator (Iq = current in quadrature with voltage which controls reactive power flow). The output of the DC voltage regulator is the reference current Idref for the current regulator (Id = current in phase with voltage which controls active power flow).

d) An inner current regulation loop consisting of a current regulator. The current regulatory controls the magnitude and phase of the voltage generated by the PWM converter (V2d V2q)from the Idref and Iqref reference currents produced respectively by the DC voltage regulator and the AC voltage regulator (in voltage control mode). The current regulator is assisted by a feed forward type regulator which predicts the V2 voltage output (V2d V2q) from the V1 measurement (V1d V1q) and the transformer leakage reactance.

IV. SIMULATION RESULTS AND DISCUSSION

A Distribution Static Synchronous Compensator (D-STATCOM) is used to regulate voltage on a 33-kV distribution network.

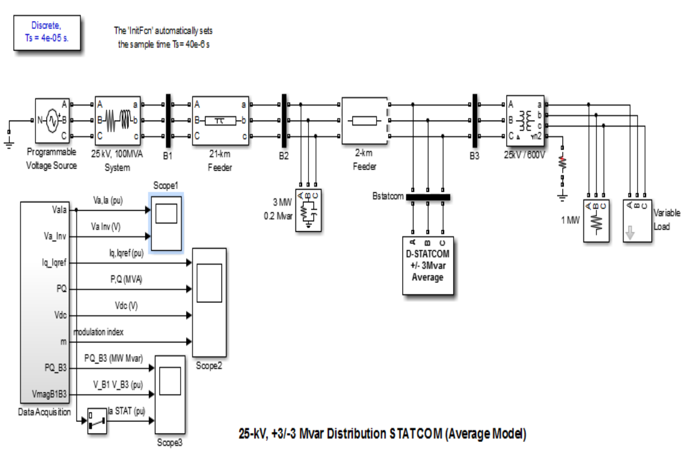

Figure. 3. Overall Simulation Block

The D-STATCOM is three phase shunt connected power electronics based device. It is connected near the load at the distribution system as shown in fig . It is also a one type of the voltage source converter, which converts a DC input voltage into AC output voltage in order to compensate the active and reactive power needed by the system. A voltage Source converter is connected to bus via three phase transformer. A voltage source converter is a power electronics device, which can generate sinusoidal voltage with required magnitude frequency and phase angle. A 5000 uF capacitor is used as a dc voltage source for the inverter. PCC is the point of common coupling at which the generation or absorption of reactive Power takes Place to and from the system and the device. At the distribution voltage level, the switching device is generally the IGBT due to its lower switching losses and reduced size. Figure 2 shows a simplified diagram of a STATCOM connected to a typical distribution network represented by an equivalent network.

The D-STATCOM consists of the following components:

- **25kV/1.25kV coupling transformer** which ensures coupling between the PWM inverter and the network.

- **Voltage-sourced PWM inverter**. In this example, the PWM inverter is replaced on the AC side with three equivalent voltage sources averaged over one cycle of the switching frequency (1.68 kHz). Harmonics generated by the inverter are therefore not visible with this average model. On the DC side, the inverter is modeled by a current source charging the DC capacitor. The DC current Idc is computed so that the instantaneous power at the AC inputs of the inverter remains equal the instantaneous power at the DC output (Va*Ia + Vb*Ib + Vc*Ic = Vdc*Idc).

- **LC damped filters connected** at the inverter output. Resistances connected in series with capacitors provide a quality factor of 40 at 60 Hz.

- **A 10000-microfarad capacitor** acting as a DC voltage source for the inverter

- **A voltage regulator** that controls voltage at bus B3

- **Anti-aliasing filters** used for voltage and current acquisition.

The D-STATCOM controller consists of several functional blocks:

- **A Phase Locked Loop (PLL)**. The PLL is synchronized to the fundamental of the transformer primary voltages.

- **Two measurement systems**. Vmeas and Imeas blocks compute the d-axis and q-axis components of the voltages and currents by executing an abc-dq transformation in the synchronous reference determined by sin(wt) and cos(wt) provided by the PLL.

- **An inner current regulation loop**. This loop consists of two proportional-integral (PI) controllers that control the d-axis and q-axis currents. The controllers outputs are the Vd and Vq voltages that the PWM inverter has to generate. The Vd and Vq voltages are converted into phase voltages Va, Vb, Vc which are used to synthesize the PWM voltages. The Iq reference comes from the outer voltage regulation loop (in automatic mode) or from a reference imposed by Qref (in manual mode). The Id reference comes from the DC-link voltage regulator.

- **An outer voltage regulation loop**. In automatic mode (regulated voltage), a PI controller maintains the primary voltage equal to the reference value defined in the control system dialog box. **A DC voltage controller** which keeps the DC link voltage constant to its nominal value (Vdc=2.4 kV).The electrical circuit is discretized using a sample time Ts=40 microseconds. The controller uses a larger sample time (4*Ts=160 microseconds).

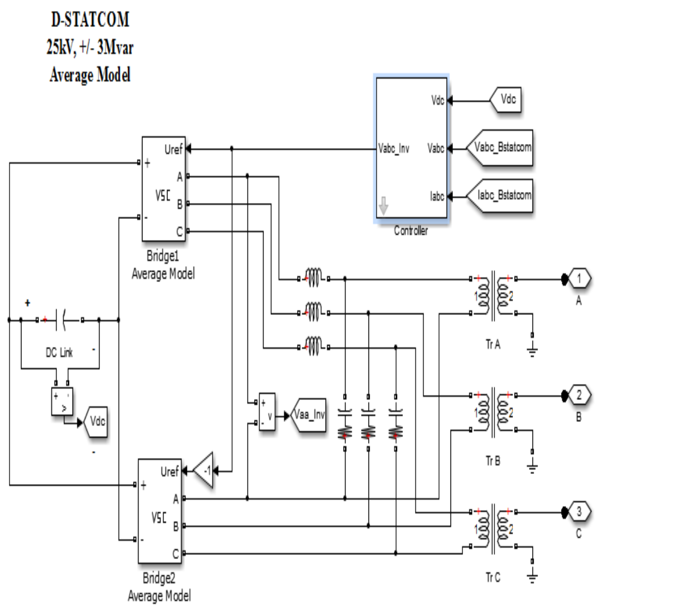

Figure. 4. DSTATCOM Model

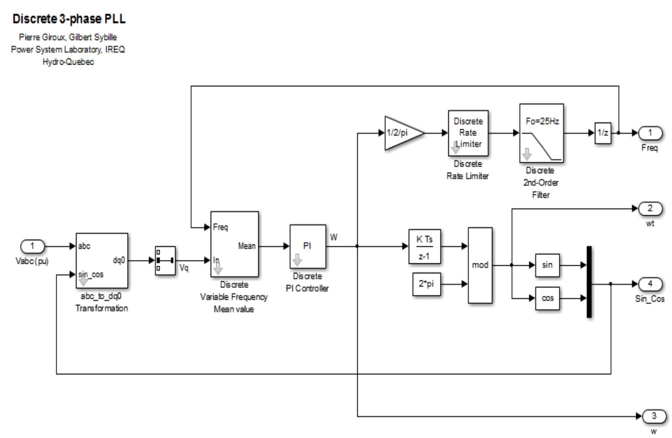

Figure. 5. Three Phase PLL

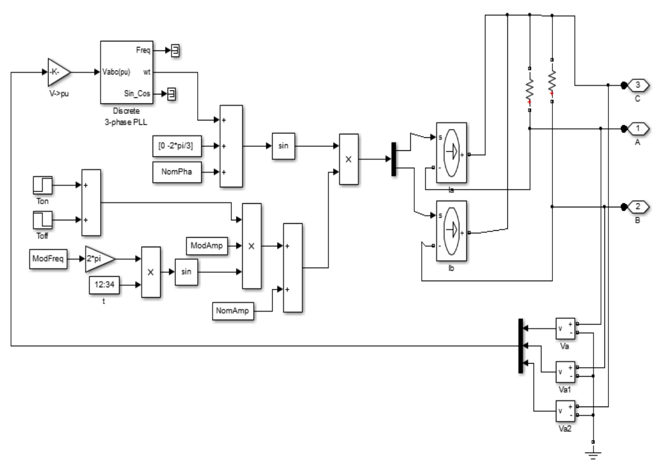

Figure. 6. Variable Load

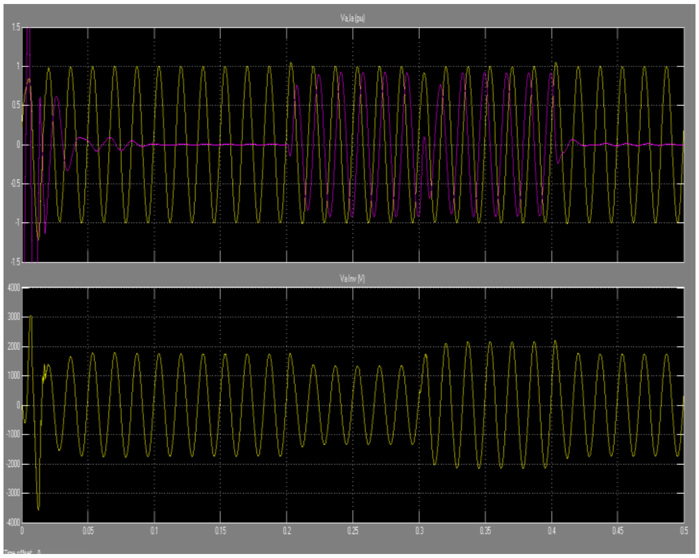

Figure.7. Input Voltage, Input Current and Inverting Voltage V/S Time

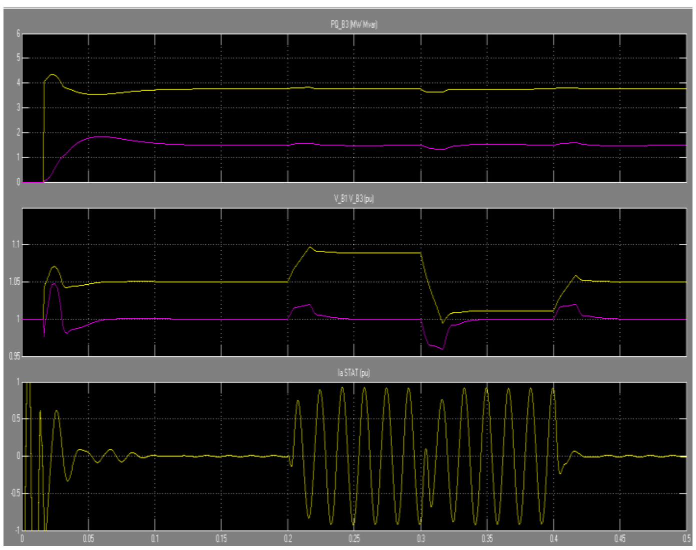

Figure.8. Real and Reactive Power, Bus1 and Bus3 Voltage and Statcom Current V/S Time

During this test, the variable load will be kept constant and you will observe the dynamic response of a D-STATCOM to step changes in source voltage. Check that the modulation of the Variable Load is not in service (Modulation Timing [Ton Toff]= [0.15 1]*100 > Simulation Stop time). The Programmable Voltage Source block is used to modulate the internal voltage of the 25-kV equivalent. The voltage is first programmed at 1.077 pu in order to keep the D-STATCOM initially floating (B3 voltage=1 pu and reference voltage Vref=1 pu). Three steps are programmed at 0.2 s, 0.3 s, and 0.4 s to successively increase the source voltage by 6%, decrease it by 6% and bring it back to its initial value (1.077 pu). Then voltage of the Programmable Voltage Source will be kept constant and you will enable modulation of the Variable Loadso that you can observe how the D-STATCOM can mitigate voltage flicker. In the Programmable Voltage Source block menu, change the "Time Variation of" parameter to "None". In the Variable Load block menu, set the Modulation Timing parameter to [Ton Toff]= [0.15 1] (remove the 100 multiplication factor). Finally, in the D-STATCOM Controller, change the "Mode of operation" parameter to "Q regulation" and make sure that the reactive power reference value Qref (2nd line of parameters) is set to zero. In this mode, the D-STATCOM is floating and performs no voltage correction. Initially, the source voltage is such that the DSTATCOM is inactive. It does not absorb nor provide reactive power to the network. At t = 0.2 s, the source voltage is increased by 10%. The D-STATCOM compensates for this voltage increase by absorbing reactive power from the network (Q=+3 Mvar on trace 2 of Scope2). • At t = 0.3 s, the source voltage is decreased by 10% from the value corresponding to Q = 0. The D-STATCOM must generate reactive power to maintain a 1 pu voltage (Q changes from +3 MVAR to -3.1 MVAR). • When the D-STATCOM changes from inductive to capacitive operation, the modulation index of the PWM inverter is increased from 0.6 to 0.92 it is due to a proportional increase in inverter voltage. Reversing of reactive power is very fast, about one cycle.

V. CONCLUSION

The power quality improvement by using DSTATCOM has been presented in this paper. The model of a D-STATCOM has been analyzed and developed for use in simulink environment with power system block sets. Here a control system is designed in MATLAB simulink. So DSTATCOM provides fast acting dynamic reactive compensation for voltage support during voltage flicker events.

VI. REFERENCES

[1]. IJESIT, “A STATCOM-Control Scheme for Power Quality Improvement of Grid Connected Wind Energy System” by B.T.RAMAKRISHNARAO.

[2]. IJERT “Enhancement in Voltage Stability and Reactive Power Compensation Using D-STATCOM” Vol. 1 Issue 7, September – 2012.

[3]. Pierre Giroux, Gilbert Sybille, Hoang Le-Huy “Modeling and simulation of distribution STATCOM using Simulink power system blockset”IECON’01: the 27th annual conference of the IEEE industrial electronics society.

[4]. G.sundar, S.Ramareddy, ”digital simulation of DSTATCOM for voltage fluctuations” Inter National journal of engineering science and technology Vol.2 (5), 2010, 1131-1135.

[5]. M. G. Molina, P. E. Mercado “Control Design and Simulation of DSTATCOM with Energy Storage for Power Quality Improvements” 2006 IEEE PES Transmission and Distribution Conference and Exposition Latin America, Venezuela.

[6] Bhim singh, Alka Adya, A P Mittal and J R P Gupta, “Modeling of DSTATCOM for distribution system”, Int. J. energy technology and policy, Vol. 4, no.1/2, 2006, pages: 142-160.

[7] R.Meinski, R.Pawelek and I.Wasiak, “Shunt Compensation For Power Quality Improvement Using a STATCOM controller Modelling and Simulation”, IEEE Proce, Volume 151, No. 2, March 2004.

[8] S.V Ravi Kumar and S. Siva Nagaraju, "Simulation of D-STATCOM and DVR in Power Systems", Conference on ARPN Journal of Engineering and Applied Sciences vol. 2, No 3, 2007.

[9] Wei-Neng Chang and Kuan-Dih Yeh, "Design and Implementation of DSTATCOM for Fast Load Compensation of Unbalanced Loads", Conference on Journal of Marine Science and Technology, vol. 17, No. 4, pp. 257-263, 2009.

[10] M. G. Molina and P. E. Mercado, "Dynamic Modeling and Control Design of DSTATCOM with Ultra-Capacitor Energy Storage for Power Quality Improvements", Conference on Transmission and Distribution conference and Exposition: Latin America, IEEE/PES, pp. 1 – 8, 2008.

[11] P. M. Meshram, B.Y.Bagde, R.N.Nagpure, "A Novel DFACTS Device for the Improvement of Power Quality of the Supply", Conference on 2th International Conference on Electrical Engineering and Electronics, Computer, Telecommunications and Information Technology, vol.1, pp. 775- 778,2005.