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A D-STATCOM Scheme using Power Quality Improvement in Power System

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Abstract - D-STATCOM (Distribution Static Compensator) is a play vary vital role in a Distribution system. D-STATCOM used for reactive power compensation and load balancing and it's including power factor (PF) correction, voltage regulation, and harmonic filtering in distribution network. This paper present the analysis of reactive power compensate, D-STATCOM is based on power electronic equipment at the reliable operation and power quality improving with power flows in large voltage distribution system using D-STATCOM. An electronics -based PWM inverter control operation has been developed the voltage and current measurements and reactive power measurements are required. The operation of the reactive power control is presented for D-STATCOM.

Keywords: *D-STATCOM, PWM Inverter, SVC, Power Quality.*

I. INTRODUCTION

Electrical supply's nowadays concerned about quality of power a delivered to customers. With a developments of power electronics several solution have been proposed to compensated to power fluctuation observed in the Distribution network in order to ensure to highest power quality of customers. This Power Quality Device is Power electronic converters in concerned with parallel or in series with the lines and the operation is controlled by digital controller.

D-STATCOM is often used in transmission system. When it is used in distribution system, it is called D-STATCOM (STATCOM in Distribution system). D-STATCOM is a key FACTS controller and it utilizes power electronics to solve many power quality problems commonly faced by distribution systems. Potential applications of D-STATCOM include power factor correction, voltage regulation, load balancing and harmonic reduction. Comparing with the SVC, the D-STATCOM has quicker response time and compact structure. It is expected that the D-STATCOM will replace the roles of SVC in nearly future. D-STATCOM and STATCOM are different in both structure and function, while the choice of control strategy is related to the main-circuit structure and main function of compensators, so D-STATCOM and STATCOM adopt different control strategy.

II. DISTRIBUTION STATIC COMPENSATOR (D-STATCOM)

a) Principle of DSTATCOM

A D-STATCOM is simplified Fig.1. It's consists of a two-level Voltage Source Converter (VSC), a dc energy storage device, a coupling transformer (CT) connected in shunt to the distribution network through a coupling transformer (CT). The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power.

The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to *three* quite distinct purposes:

1. *Voltage regulation and compensation of reactive power;*
2. *Correction of power factor; and*
3. *Elimination of current harmonics.*

Here, such device is employed to provide voltage regulation using an indirectly controlled converter.

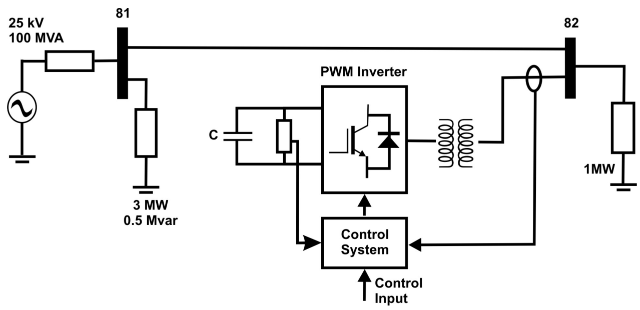
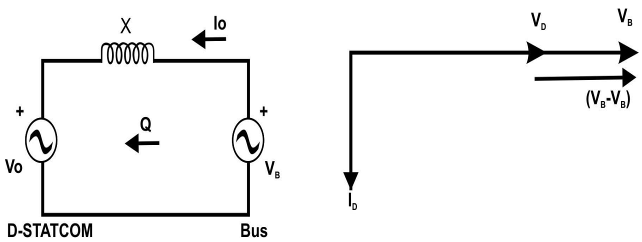


Figure.1 Simplified Diagram of a D-STATCOM

The STATCOM consisting of PWM inverter connected to the network in the transformer. The DC link voltage delivered by capacitive C which is charged with taken from the network. The control system ensures the regulation of bus voltage and the DC link voltage. The D-STATCOM is to regulate the bus voltage with the absorbing or generating reactive power to the network, similar a thyristor static compensator. The reactive power is transfer is leakage reactance of the coupling transformer (CT) in this network secondary voltage in phase and the primary voltage in network side. This voltage is given by a voltage source PWM inverter. The D-STATCOM operation is illustrated by a phase Diagrams fig. (2)



(a) Inductive mode

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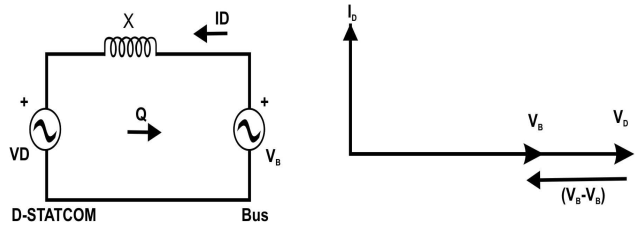

b) Capacitive mode

Figure 2 D-STATCOM Operation (a) Inductive mode (b) Capacitive mode

When the secondary voltage (V_D) is lower than the bus voltage (V_B), the D-STATCOM acts like an inductance because absorbing reactive power from the bus voltage .When the secondary voltage (V_D) is higher than the bus voltage (V_B), The D-STATCOM acts like a capacitor generating reactive power to the bus. In study state operation, due to inverter losses the bus voltage always leads the inverter voltage by a small angle to supply a small active power.

III. MATAB/SIMULINK MODELING OF D-STATCOM

a) Modeling of Power Circuit

A D-STATCOM is used to regulate voltage on a 25-kV distribution network. Two feeders (21 km and 2 km) transmit power to loads connected at buses B2 and B3. A shunt capacitor is used for power factor correction at bus B2. The 600V load connected to bus B3 through a 25kV/600V transformer represents a plant absorbing changing currents, similar to an arc furnace, thus producing voltage flicker. The variable load current magnitude is modulated at a frequency of 5 Hz so that its apparent power varies approximately between 1 MVA and 5.2 MVA, while keeping a 0.9 lagging power factor. This load variation will allow you to observe the ability of the D-STATCOM to mitigate voltage flicker. The D-STATCOM regulates bus B3 voltage by absorbing or generating reactive power. This reactive power transfer is done through the leakage reactance of the coupling transformer by generating a secondary voltage in phase with the primary voltage (network side). This voltage is provided by a voltage-sourced PWM inverter. When the secondary voltage is lower than the bus voltage, the D-STATCOM acts like an inductance absorbing reactive power. When the secondary voltage is higher than the bus voltage, the D-STATCOM acts like a capacitor generating reactive power.

b) The D-STATCOM and distribution network consists of the following components

1. A 25kV/1.25kV coupling transformer which ensures coupling between the PWM inverter and the network.
2. A voltage-sourced PWM inverter. 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 their fore 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 ($V_a \times I_a + V_b \times I_b + V_c \times I_c = V_{dc} \times I_{dc}$).
3. LC damped filters connected at the inverter output. Resistance connected in series with capacitors provides a quality factor of 40 at 60 Hz.
4. A 10000-microfarad capacitor acting as a DC voltage source for the inverter.
5. A voltage regulator that controls voltage at bus B3.
6. Anti-aliasing filters used for voltage and current acquisition.

c) The D-STATCOM controller consists of several functional blocks

1. A Phase Locked Loop (PLL). The PLL is synchronized to the fundamental of the transformer primary voltages.
2. Two measurement systems. V_{meas} and I_{meas} 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(ωt) and cos (ωt) provided by the PLL.
3. An inner current regulation loop. This loop consists of two proportional-integral (PI) controllers that control the d-axis and q-axis currents. The controller's outputs are the V_d and V_q voltages that the PWM inverter has to generate. The V_d and V_q voltages are converted into phase voltages V_a, V_b, V_c 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 Q_{ref} (in manual mode). The I_d reference comes from the DC-link voltage regulator.
4. DC voltage controller which keeps the DC link voltage constant to its nominal value (V_{dc}=2.4 kV).

IV. SIMULATING THE D-STATCOM OPERATION

The Operation of the D-STATCOM in it static form. The simulation of distribution network taking a discrete step time (T_s=5μs). The Programmable voltage source (PVS) block is using to the modulate in voltage of the 25-kv. The 25-kv source voltage is the D-STATCOM is inactive. It does not absorbing to the network and not delivering reactive power to the network. In operation at t=0.124s, the 25-kv source volt-

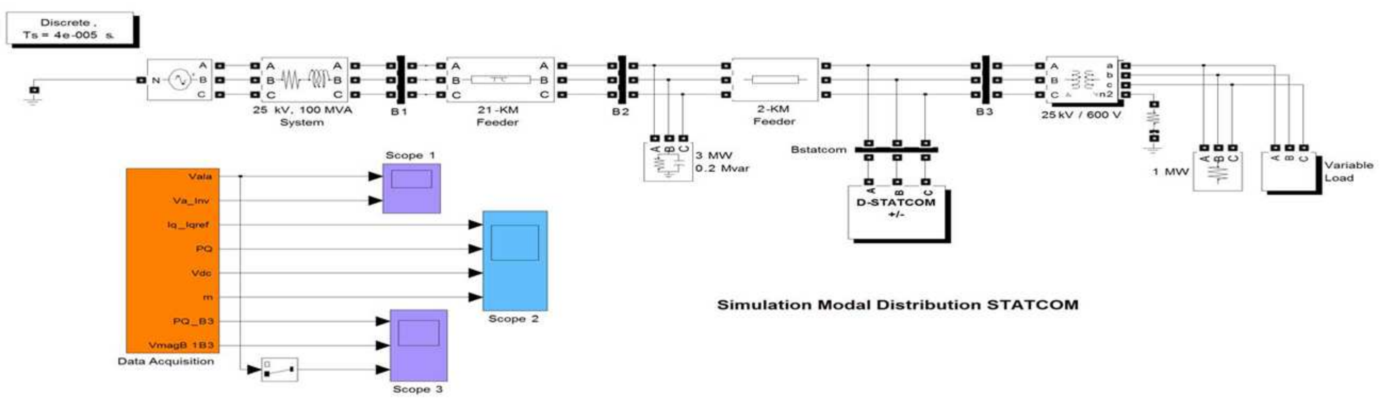

Figure 3 The D-STATCOM and the distribution network

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age is increased by 6% to the distribution network. When the Distribution network absorbing reactive power the D-STATCOM compensates for the voltage increased in system. Again at t=0.2s, the 25-kv source voltage is decreased by 6% from the value is Q= 0. The D-STATCOM is deserved to generating reactive power to balancing a 1 pu value in voltage Q changing in distributing network from +2.7M_{var} to -2.8M_{var}. In this method the D-STATCOM changing from inductive to capacitive operation so in this process modulation index m is increased from 0.45 to 0.85 and which increased in inverter voltage. In the reversing process of reactive power flow is very fast and the instantaneous power must be the same on the DC side and the AC side of the inverter.

$$V_{dc}\times I_{dc}= V_a\times I_a + V_b\times I_b + V_c\times I_c \qquad (a)$$

The DC current in the DC-link capacitor can be then computed from the AC instantaneous power and the DC Link voltage V_{dc} as:

$$I_{dc}= (V_a\times I_a + V_b\times I_b + V_c\times I_c)/V_{dc} \qquad (b)$$

The PWM inverter side is three controlled sources which are determined by three voltages V_{abc} from the system on the DC link side from the D-STATCOM network.

V. SIMULATION RESULT

Initially the programmable voltage source is set at 1.0491 pu voltages at bus B1 when the D-STATCOM is out of service. In the reference voltage V_{ref} is set to 1.0 pu, the D-STSTCOM is initially zero current. The DC voltage is 19.3 kV. At t=0 is 1st voltage is suddenly decreased by 4.5% in 0.955pu of nominal voltage. The D-STATCOM reacts by generating power is Q=+70M_{var} to keep voltage at 0.979 pu. The 95% settling time approximately 47 ms. In this time the DC voltage has increased to 24.2 kv. Then, at t=0.2s the source voltage is increased to 1.045 pu of its nominal value. The D-STATCOM operating point from capacitive to inductive to keep voltage at 1.021pu. In this point the D-STATCOM absorbed 72 M_{var} and the DC voltage has been lowered to 18.2 kV. Observed on the first trace showing the D-STATCOM primary voltage and current that current the current is changing from capacitive to inductive in one cycle. In the finally, at t=0.3s the source voltage in set back to its nominal value and the D-STATCOM operation come back to zero M_{var}.

VI. CONCLUSION

A model of a D-STATCOM has been developed for using power quality improvement with the Power System in distribution network. Model of distribution network and control system have been developed in the Simulink diagram provide smooth modulation have been presented. D-STATCOM connected to a 25-kv Distribution network it provides reactive power compensation. The Obtained simulation result have demonstrated of power quality the developed model. We can also that the Dynamic of the current response is presented by the D-STATCOM and the distribution network model.

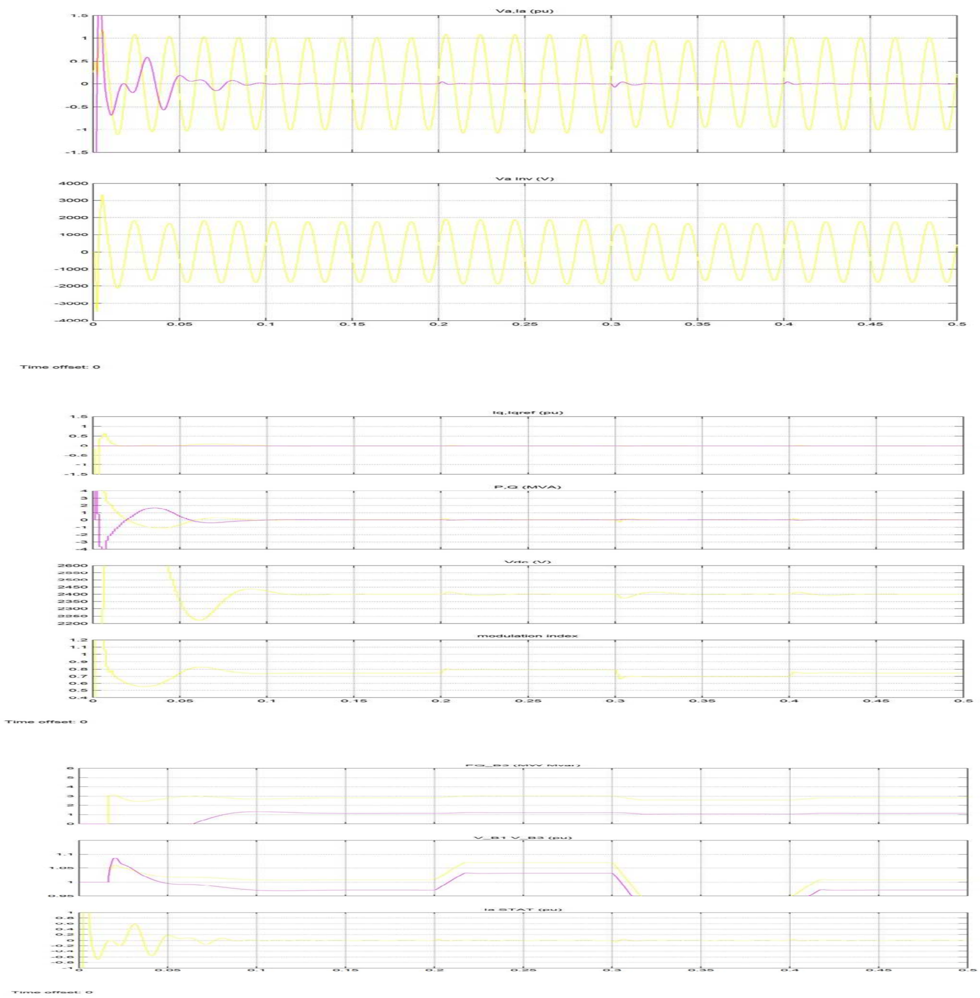

Fig. 5 Waveforms Illustrating the D-STATCOM Performance

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