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IMPROVEMENT OF POWER QUALITY IN DISTRIBUTION SYSTEM USING D-STATCOM

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Abstract: This paper deals with simulation of D-STATCOM used for voltage sag mitigation with the help of VSI circuit. A Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end user equipments. This work describes the techniques of correcting the supply voltage sag, swell and interruption in a distributed system. D-STATCOM works based on the VSI principle and injects a current into the system to correct the voltage sag, swell and interruption. The simulation of the D-STATCOM is performed in the Simulink environment and the results are presented.

Keywords: Distribution Static Synchronous Compensator (D-STATCOM), Flexible AC Transmission Systems (FACTS), Power Quality, Reactive Power Control, Voltage Source Converter (VSC).

I. INTRODUCTION

Electric problems always occur regardless of time and place. This cause an impact to the electric supply this may affect the manufacturing industry and affects the economic development in a country. The major electric problems that always occur in power systems are the power quality problems that have been discussed by the electrical engineers around the world, since problems have become a major issue due to the rapid development of sophisticated and sensitive equipment in the manufacturing and production industries. The increased concern for power quality has resulted in measuring power quality variations, studying the characteristics of power disturbances and providing solutions to the power quality problems. In distribution systems, the power quality problems can reduce the power supplied to the customers from its nominal value. Voltage sag, harmonic, transient, overvoltage and under voltage are major impacts to a distribution system. The utility and the users are responsible in polluting the supply network due to operating of large loads. The best equipment to solve this problem at distribution systems at minimum cost is by using Custom Power family of D-STATCOM. Voltage dips are one of the most occurring power quality problems. Off course, for an industry an outage is worse, than a voltage dip, but voltage dips occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems. This is correct for many disturbances, flicker, harmonics, etc., but voltage dips mainly have their origin in the higher voltage levels. Faults due to lightning, is one of the most common causes to voltage dips on overhead lines. If the economical losses due to voltage dips are significant, mitigation actions can be profitable for the customer and even in solution which will work for every site, each mitigation action must be carefully planned and evaluated.

There are different ways to mitigate voltage dips, swell and interruptions in transmission and distribution systems. At present, a wide range of very flexible controllers, which capitalize on newly available power electronics components, are emerging for custom power applications. D-STATCOM is connected in shunt to the distribution system. Passive filters will be employed to reduce the harmonics present in the output of the D-STATCOM. The problem of voltage compensation by reactive current injection is investigated. The capability of the D-STATCOM to mitigate voltage sag is also demonstrated.

II. BASIC CONFIGURATION AND OPERATION OF D-STATCOM

The D-STATCOM is a three-phase, shunt connected power electronics device. It is connected near the load at the distribution systems. The major components of a D-STATCOM are shown in Fig. 1. It consists of a capacitor, three-phase inverter (IGBT, thyristor) module, ac filter, coupling transformer and a control strategy.

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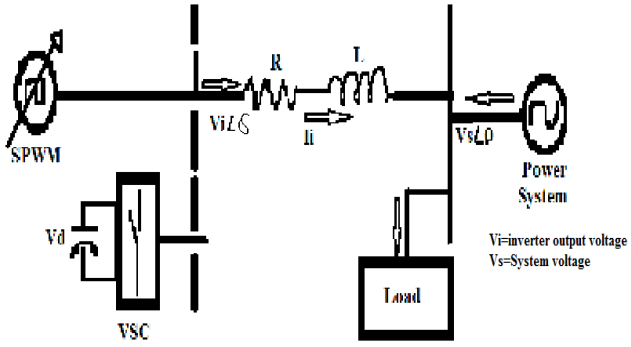


Fig. 1: Basic Building Blocks of the D-STATCOM

The basic electronic block of the D-STATCOM is the voltage-sourced inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency. STACOM employs an inverter to convert the DC link voltage *Vdc* on the capacitor to a voltage source of adjustable magnitude and phase. In Fig. 1 the inductance L and resistance *R* represents the equivalent circuit elements of the step down transformer. The voltage *Vi* is the effective output voltage of the D-STATCOM and δ is the power angle. The reactive power output of the D-STATCOM, either inductive or capacitive depending on the operation mode of the D-STATCOM. The controller of the D-STATCOM is used to operate the inverter in such a way that the phase angle between the inverter voltage and the line voltage is dynamically adjusted so that the D-STATCOM generates or absorbs the desired VAR at the point of connection.

TABLE 1: OPERATION MODES OF D-STATCOM

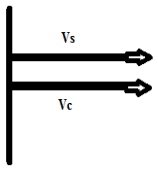
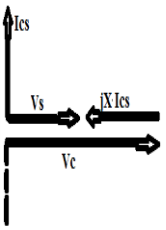
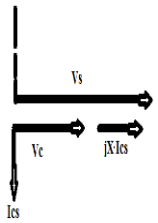
MODE		PHASOR	DESCRIPTION
No Load Mode	Vs=Vc		If Vc=Vs, Ics=0
Capacitive Operation Mode	Vc>Vs Ics-leading current		If Vc>Vs, Ics appears to be leading current.. The STACOM will function as a capacitor .
Inductive Operation Mode	Vc<Vs Ics-lagging current		If Vc<Vs, Ics appears to be lagging current. The D-STATCOM will function as a reactor.

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Table 1 shows the three basic operation modes of the D-STATCOM output current I, which varies depending upon Vi. If Vi is equal to Vs, the reactive power is zero and the D-STATCOM does not generate or absorb reactive power. When Vi is greater than Vs, the D-STATCOM shows an inductive reactance connected at its terminal. The current I, flows through the transformer reactance from the D-STATCOM to the ac system and device generates capacitive reactive power. If Vs is greater than Vi, the D-STATCOM shows the system as a capacitive reactance. Then the current flows from the ac system to the D-STATCOM, resulting in the device absorbing inductive reactive power.

III. VOLTAGE SOURCE CONVERTERS (VSC)

A voltage-source converter is a power electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable-speed drives, but can also be used to mitigate voltage dips. The VSC is used to either completely replace the voltage or to inject the 'missing voltage'. The 'missing voltage' is the difference between the nominal voltage and the actual. The converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the VSC is not only used for voltage dip mitigation, but also for other power quality issues, e.g. flicker and harmonics.

IV. SIMULATON AND RESULTS

A Static Synchronous Compensator (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 600-V load connected to bus B3 through a 25kV/600V transformer represents a plant absorbing continuously 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.

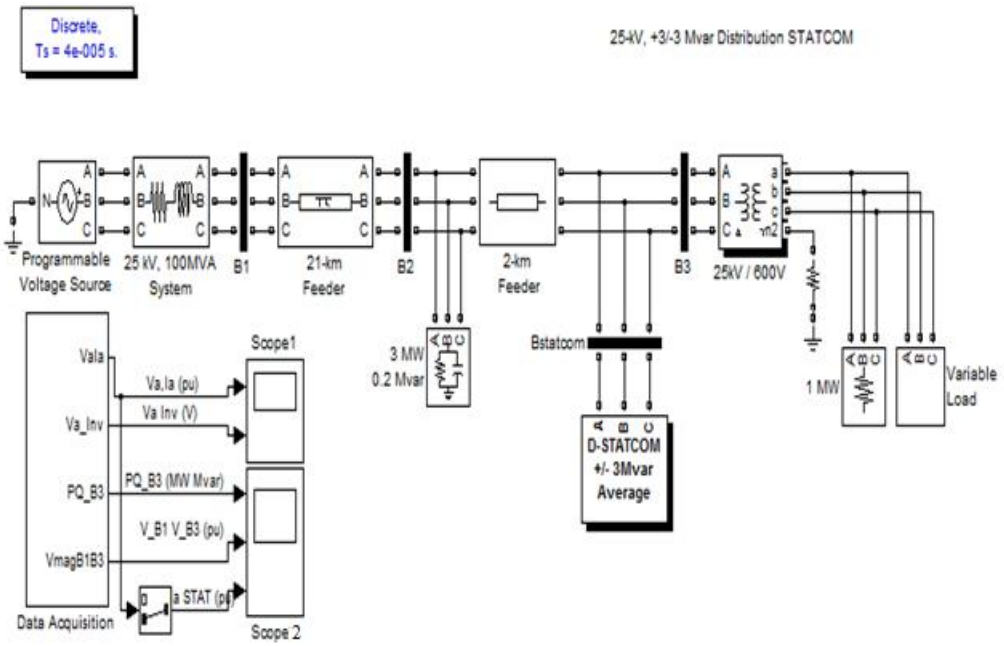

Fig..2- Simulation of D-STATCOM for voltage Mitigation

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In results, Scope 2 shows variations of P and Q at bus B3 (1st trace) as well as voltages at buses B1 and B3 (trace 2). Without D-STATCOM, B3 voltage varies between 0.96 pu and 1.04 pu (+/- 4% variation). Now, in the D-STATCOM Controller, change the "Mode of operation" parameter back to "Voltage regulation" and restart simulation. Observe on Scope 3 that voltage fluctuation at bus B3 is now reduced to +/- 0.7 %. The D-STATCOM compensates voltage by injecting a reactive current modulated at 5 Hz (trace 3 of Scope2) and varying between 0.6 pu capacitive when voltage is low and 0.6 pu inductive when voltage is high.

Scope-1

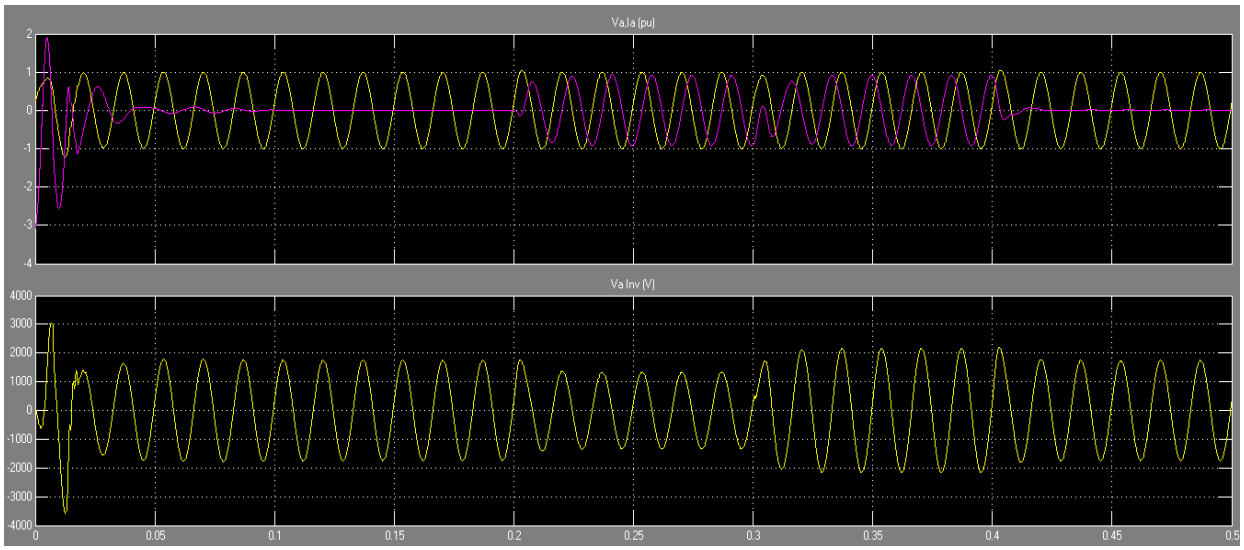

Fig..3- Variation of supply voltage and inverter voltage

Scope-2

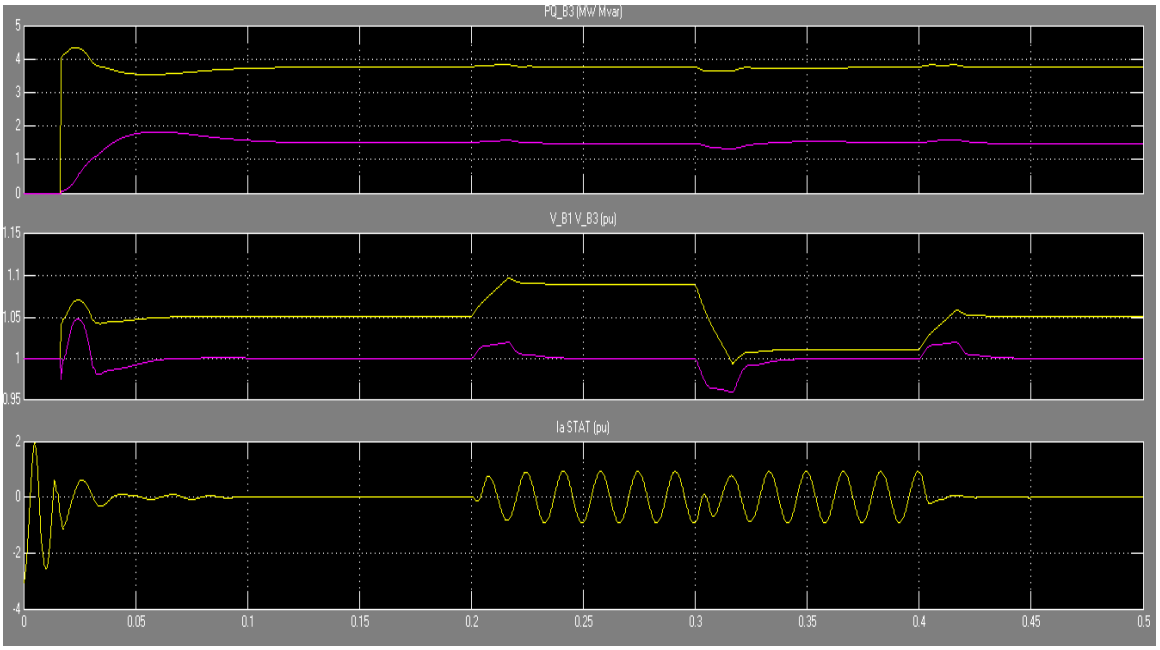

Fig..4- Variation of active –reactive power, voltages and D-STATCOM current

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V. CONCLUSION

D-STATCOM is a one of the key FACTS controller for distribution network. The primary objective of applying a static compensator (D-STATCOM) in a power system is to increase the power transmission capability, with a given transmission network, from the generators to the loads. Output of D-STATCOM is varied to maintain or control specific parameters of Electrical Power System. D-STATCOM provides various benefits, as reactive power compensation, power system stability and voltage control. From the standpoint of physical installation D-STATCOM does not need large reactor or capacitor like SVC this result in reduction of overall size. The reactive and real power exchange between the D-STATCOM and the ac system is controlled independently of each other and any combination of real power generation and absorption with Var generation and absorption is achievable. Voltage source inverter based D-STATCOM is modelled and simulated using the blocks of Simulink. This work has proposed a Voltage source inverter for the voltage fluctuations at the receiving end voltage. The simulation is based on the assumption of balanced load. Three phase circuit model is considered for simulation studies. Simulation results are presented and they are in line with the predictions**.**

REFERENCES

[1] Narain G. Hingorani Laszlo, "Understanding FACTS:Concepts and Technology of Flexible AC Transmission Systems". IEEE Press, Inc, 2000.
[2] Dinavahi, V., Iravani, R., Bonert, R. Design of a real-time digital Simulator for a D-STATCOM system; Industrial Electronics, IEEE Transactions on Volume 51, Issue 5, Oct. 2004 Page(s):1001 – 1008.
[3] G.F. Reed, M. Takeda, I. Iyoda, "Improved power quality solutions using advanced solid-state switching and static compensation technologies". IEEE Power Engineering Society 1999 Winter Meeting, New York, NY, USA, vol. 2, pp: 1132-1137
[4] P.S. Sensarma, K.R. Padiyar, V. Ramanarayanan, "Analysis and Performance Evaluation of a Distribution D-STATCOM for Compensating Voltage Fluctuations", IEEE Transaction on Power Delivery, Vol. 16
[5] M. F. McGranaghan, D. R. Mueller and M. 3. Samotyj, "Voltage Sags in Industrial Systems", IEEE h n s on Industry Applications, Vol. 29, No. 2, Mar/Apr 1993 I