Performance Evaluation of D-Statcom for Voltage Fluctuations in Power Distribution System

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Abstract— As demand of quality and reliability of electric power is continuously increasing, Power Quality has now become a important aspect in the current power scenario. Power quality determines quality and ability of electric power available at the consumer end. Maintaining voltage, frequency and phase to desired level allows electrical systems to provide quality and reliability of power without considerable loss of performance or life. poor power quality can be caused due to failure of loads and sudden switching of heavy electrical loads in the network, which mainly result in voltage sag and swell , disturbances in loads may also results in voltage fluctuation. However voltage flicker and interruptions are the most common problem which effects power quality.

Voltage fluctuation is considered one of the most important power quality disturbances due to its greater frequency of occurrence as compared with other power quality problem. This problem can be compensated to greater extend by using Flexible AC Transmission Systems (FACTS) like STATCOM, UPFC , DVR etc. Out of which STATCOM also known as a "static synchronous condenser" ("STATCON"), gives better performance than SVC. It is based on a power electronics voltage-source converter VSC it can supply or absorb reactive power to the electrical network. If it is connected to a source of power it can also provide active power. If this stat com is used in distribution network it can be called as D-Stat com (Distribution Static Compensator). D-STATCOM is a shunt device which is generally used to solve power quality problems in distribution systems by injecting current. It is used to improve power factor, maintain constant distribution voltage and eliminate harmonics in a distribution network.

In addition to this a case study is planned taking the parameter of industrial load. This work describes the working of STATCOM to provides voltage support to sensitive loads and will be simulated by using MATLAB/SIMULINK. The control approach presented will be able to compensate for any type of voltage sags and swells

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Keywords –STATCOM, MATLAB, VOLTAGE SAG, VOLTAGE SWELL, SPVM

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i . Introduction

The D-STATCOM is a power electronic device that is used to inject 3-phase voltage in series and in synchronism with the distribution feeder voltages in order to compensate voltage fluctuation. The principal component of the STATCOM is a voltage source inverter that generates three phase voltages and provides the voltage support to sensitive load fluctuations [1].

Voltage sag has been defined as a reduction in the voltage magnitude from its nominal value for a duration ranging from a few milliseconds to one minute. The load comprises an induction motor which is started Direct on Line (DOL). The resulting heavy starting current initiates a sag. The STATCOM is expected to reduce the intensity of the sag. [2]

Motor starting and short-circuit faults in power systems are the two main causes of voltage sags. The first only produces shallow sags, but of longer duration. The second one can cause severe voltage sags, and has a major impact on customers' power quality. Surveys have shown that voltage sags are considered as the dominant factor affecting power quality , increasing use of electronics-based devices, customers' equipment has become more sensitive to voltage sags. [3]

In recent years, there has been an increased emphasis and concern for the quality of power delivered to factories, commercial establishments and residences . The most common problem in power quality today is voltage sag. Power engineers are increasingly concerned over the electrical power quality [4].

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 [6].

When used in low-voltage distribution systems the STATCOM is normally identified as Distribution STATCOM (D-STATCOM). It operates in a similar manner as the STATCOM (FACTS controller), with the active power flow controlled by the angle between the AC system and VSC voltages and the reactive power flow controlled by

the difference between the magnitudes of these voltages. As with the STATCOM, the capacitor acts as the energy storage device and its size is chosen based on power ratings, control and harmonics considerations. The D-STATCOM controller continuously monitors the load voltages and currents and determines the amount of compensation required by the AC system for a variety of disturbances [9].

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In this work, the operation of D-STATCOM is presented and PWM- based control scheme has been implemented to control the electronic valves in the DSTATCOM. The D-STATCOM has additional capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. D-STATCOM injects a current into the system to correct the voltage sag and swell. These power quality devices are power electronic converters connected in parallel or series with the lines and the operation is controlled by a digital controllers. The modeling of these complex systems that contains both power circuits and control systems can be done different bases. One of those power electronic solutions to the voltage regulation is the use of a Distribution STATCOM (DSTATCOM). D-STATCOM is a class of custom power devices for providing reliable distribution power quality. They employ a shunt of voltage boost technology using solid state switches for compensating voltage sags and swells. The DSTATCOM applications are mainly for sensitive loads that may be drastically affected by fluctuations in the system voltage.

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The D-STATCOM employs an inverter to convert the DC link. Therefore the DSTATCOM can be treated as a voltage-controlled source. The D-STATCOM can also be seen as a current controlled source. Fig 1.2 shows the inductance L and resistance R which represent the equivalent circuit elements of the step-down transformer and the inverter will is the main component of the D-STATCOM. 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 inductive or capacitive depending can be either on the operation mode of the D-STATCOM. Referring to fig 1, 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. The phase of the output voltage of the thyristor-based inverter, Vi, is controlled in the same way as the distribution system voltage, Vs.

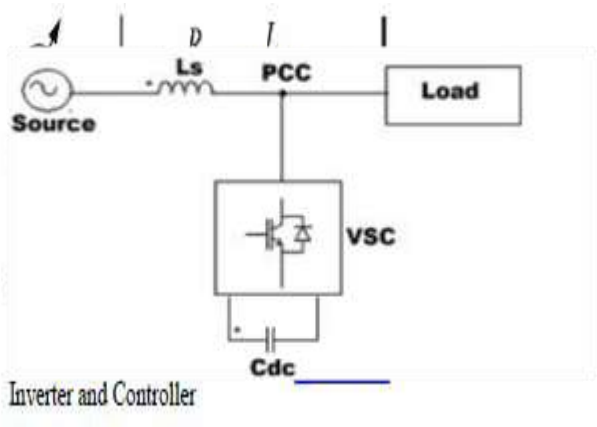

Fig:- Basic Building Blocks of the D-STATCOM.

II.LITERATURE SURVEY

Simulation of D-STATCOM for Voltage Fluctuation Singh R ;Vadodra Inst of Engg, IEEE Second International Conference on Advanced Computing & Communication Technologies (ACCT), 2012
This paper deals with control strategies for DSTATCOM (Distribution Static Compensator) for power quality improvement for a three-phase, three-wire distribution system. A three-leg voltage source inverter (VSI) configuration with a dc bus capacitor is employed as DSTATCOM. The PWM current controllers are designed analyzed and compare for PI controller.
"Unified Approach for Mitigating Voltage Sag and Voltage Flicker Using D-STATCOM" A. Elnady, Student Member, IEEE, and Magdy M. A. Salama, Fellow, IEEE, IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 20, NO. 2, APRIL 2005
This paper introduces a novel method for the mitigation of the voltage sag and voltage flicker by using Kalman filter and its derivatives (adaptive, and extended). The Kalman filter is used as a tool to extract both the instantaneous envelope of the voltage sags, and to extract the instantaneous Flicker Level (IFL) of the voltage flicker. Also, this paper demonstrates the advantages of using the Kalman filter instead of the existing tools for tracking and extracting voltage disturbances.
"Analysis and Performance Evaluation of a Distribution STATCOM for compensating Voltage Fluctuations" P. S. Sensarma, Student Member, IEEE, K. R. Padiyar, Senior Member, IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 16, NO. 2, APRIL 2001
Controller design of a STAT COM-based voltage compensator requires a valid analytical model of the system. If phaser algebra is used for modeling, it is difficult to accurately describe the STATCOM behavior during compensation of sub cycle transients in the PCC voltage. In this paper, a small-signal model of the system, with a distribution line, is derived. Predictions based on frequency-domain analysis are made, which are validated by experimental results. This model, therefore, can be used for controller design where sub cycle voltage transients are to be compensated.

"Experimental Investigation Of Voltage Sag Mitigation by An Advanced Static Var Compensator" P. Wang Student Member IEEE ,N. Jenkins Senior Member IEEE, M.H.J. Bollen Senior Member IEEE, IEEE Transactions on Power Delivery, Vol. 13, No. 4, October 1998

A laboratory model of an advanced var compensator (ASVC) was constructed to examine its capability for voltage sag mitigation. In this paper, the main structure of the laboratory ASVC is described briefly. Its mitigation effect on voltage sags of different magnitude is then demonstrated. The influences of its initial operation point, system impedance, and DC capacitance are considered. The behavior of this laboratory ASVC during a phase-angle jump associated with a voltage sag is examined.

" Mitigate Voltage Sag/Swell Condition and Power Quality improvement in Distribution Line Using D-STATCOM" Pragti Jyotishi et al Int. Journal of Engineering Research and Applications, ISSN : 2248-9622, Vol. 3, Issue 6, , pp.667-674, Nov-Dec 2013

In this paper "Mitigate voltage sag/swell condition and power quality improvement in distribution line using D-STATCOM". In power quality problems accuse many types of disturbance in voltage, current or frequency failure in distribution networks, sensitive industrial loads. This paper shows the techniques of correcting the supply voltage sag, swell and interruption in a distributed system power electronics, based equipment called Distribution Static Compensator (D-STATCOM).A D-STATCOM injects a current into the system to correct the voltage sag, swell and interruption. Distribution STATCOM (D-STATCOM) exhibits high speed control of reactive power to provide voltage stabilization, protects distribution system from voltage sag and /or flicker caused by rapidly varying reactive current demand. During the transient conditions the D-STATCOM provides leading or lagging reactive power to active system stability, power factor correction and load balancing

"Digital Simulation Of D-Statcom For Voltage Fluctuations" G.Sundar S.RamaReddy Research Scholar Professor Bharath University Jerusalam College of Engg., Chennai Chennai, G.Sundar et. al. / International Journal of Engineering Science and Technology Vol. 2(5), , 1131-1135, 2010.

This paper deals with simulation of D-STATCOM used for voltage fluctuations with the help of multilevel 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 STATCOM is performed in the Simulink environment and the results are presented.

"VSC Based DSTATCOM & Pulse-width modulation for Power Quality Improvement" Rodda Shobha Rani1, B. Jyothi2 1M.Tech, Dept. of EEE, Nimra College of Engineering & Technology, A.P., India. 2Assoc.Professor, Dept. of EEE, Nimra College of Engineering & Technology, A.P., India. Volume2Issue2- 2011

This paper proposed voltage-sourced converter (VSC) with Pulse-width modulation (PWM) provides a faster control that is required for flicker mitigation purpose. The voltage regulation in the distribution feeder is improved by installing a shunt compensator. The proposed DSTATCOM is modeled and its performance is simulated and verified for power factor correction and voltage regulation along with neutral current compensation. The three phase three wire Distribution Static Compensator (DSTATCOM) is proposed for power quality improvement. DSTATCOM is based on a three leg VSC and is controlled to compensate reactive power, harmonic current and unbalances in the load.

"Application of DSTATCOM for Improvement of Power Quality using MATLAB Simulation" Archana M. Kadam, Satyen Dhamdhere, D.S.Bankar, International Journal of Science and Modern Engineering (IJISME) ISSN: 2319-6386,Volume-1, Issue-1, December 2012

An increasing demand for high quality, reliable electrical power and increasing number of distorting loads may leads to an increased awareness of power quality both by customers and utilities. The most common power quality problems today are voltage sags, harmonic distortion and low power factor. This paper presents the reduction of voltage sags, using Distribution Static Compensator (D-STATCOM) with LCL Passive Filter in Distribution system. The model is based on the Voltage Source Converter (VSC) principle. D-STATCOM can use with different types of controllers. The D-STATCOM injects a current into the system to mitigate the voltage sags.LCL Passive Filter Was then added to D-STATCOM to improve harmonic distortion and low power factor. The simulations were performed using MATLAB SIMULINK.

"Operation of D-STATCOM for Voltage Control in Distribution Networks with a New Control Strategy" 1Dipesh. M .Patel, Asst. Professor & Head, Dept. of Electrical Engg., Babaria Institute of Tech.-Varnama, Vadodara, Gujarat, Dattesh Y. Joshi,& Sameer H. Patel, Lecturer, Department of Electrical Engineering, Babaria Institute of Technology -Varnama, Vadodara, National Conference on Recent Trends in Engineering & Technology 2011

DSTATCOM (Distribution Static Compensator) is used for compensation of reactive power and unbalance caused by various loads in distribution system. This paper addresses the modelling and analysis of custom power controllers, power electronic-based equipment aimed at enhancing the reliability and quality of power flows in low voltage distribution networks using DSTATCOM. A new PWM-based control scheme has been proposed that only requires voltage measurements and no reactive power measurements are required. The operation of the proposed control method is presented for D-STATCOM. Simulations and analysis are carried out in PSCAD with this control method for two proposed systems.

" Applications of DSTATCOM Using MATLAB/Simulation in Power System" Bhattacharya Sourabh NIIIST Bhopal, MP, INDIA, Research Journal of Recent Sciences, ISSN 2277 - 2502 Vol. 1(ISC-2011), 430-433 (2012)

D-STATCOM (Distribution Static Compensator) is a shunt device which is generally used to solve power quality

problems in distribution systems. D-STATCOM is a shunt device used in correcting power factor, maintaining constant distribution voltage and mitigating harmonics in a distribution network. D-STATCOM is used for Grid Connected Power System, for Voltage Fluctuation, for Wind Power Smoothening and Hydrogen Generation etc. This paper D-STATCOM is used in Marine Power System for Power Quality Improvement. In this paper we are concluding the result of software parts only. The performance of the proposed DSTATCOM system is validated through simulations using MATLAB software with its Simulink and Power System Block set (PSB) toolboxes.

III. RESEARCH OBJECTIVE

To study the operation of D-STATCOM.
To simulate mitigation of voltage sag/swell in the distribution system by D-STATCOM system using MATAB SIMULINK software.
To analyze the voltage sag/swell problems and solve it using D-STATCOM.
In addition to this a case study is planned taking the parameter of industrial load.

IV .CONCLUSION

After doing the literature survey it has been concluded that,
In order to improve the survivability of a navy ship in battle condition, DSTATCOM or Distribution Static Compensator can be used, which reduces the impact of pulsed loads on the bus voltage and thus keeps the bus voltage at desired level.
DSTATCOM is a voltage-source inverter (VSI) based shunt device generally used in distribution system to improve power quality. The main advantage of DSTATCOM is that, it has a very sophisticated power electronics based control which can efficiently regulate the current injection into the distribution bus. The second advantage is that, it has multifarious applications like Can celling the effect of poor load power factor,Suppressing the effect of harmonic content in load currents, Regulating the voltage of distribution bus against sag/swell Compensating the reactive power requirement of load and so on. The performance of the DSTATCOM is very much dependent on the DSTATCOM controller.

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