Modeling simulation and performance analysis of D-STATCOM at the time of voltage sag

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Abstract: - The project focuses on the behavior of power system when we apply facts devices in the system .We finding out how the quality of power corrects by using facts devices. The power system getting overloaded due to increasing load demand, steep growth of national economics and restructuring of power system .This naturally demands more optimal and profitable operation of the power system with respect to generation, transmission, and distribution. To achieve both operational reliability and financial profitability, it has become necessary to utilize and control the existing transmission system more efficiently.

The development of the modern power system has led to an increasing complexity in the study of power systems, and also presents new challenges to power system stability, and in particular, to the aspects of transient stability and small-signal stability. Transient stability control plays a significant role in ensuring the stable operation of power systems in the event of large disturbances and faults, and is thus a significant area of research.

I.INTRODUCTION

It became clear in the early eighties that apart from the mundane job of pumping lagging/leading VARs into the power system at chosen points ,VAR generators can assist in enhancing stability of the power system during large signal and small signal disturbances if only they were faster in the time domain. Also ,they can provide reactive support against a fluctuating load to maintain the bus voltage regulation and to reduce flicker problems, provide reactive support to control bus voltages against sag and swell conditions and provide reactive support to correct the voltage unbalance in the source – if only they were fast enough High Power FACTS devices of this type essentially consist of a three phase PWM Inverter using GTOs, Thyristors or IGBTs, a D.C. side capacitor which provides the D.C. voltage required by the inverter, filter components to filter out the high frequency components of inverter output voltage, a link inductor which links the inverter output to the AC supply side, interface magnetic (if required) and the related control blocks. The Inverter generates a three-phase voltage, which is synchronized with the AC supply, from the DC side capacitor and the link inductance links up this voltage to the AC source. The current drawn by the Inverter from the AC supply is controlled to be mainly reactive (leading or lagging as per requirement) witha smallactive component needed to supply the losses in the Inverter and Link Inductor (and in the magnetic, if any).The D.C. side capacitor voltage is maintained constant (or allowed to vary with a definite relationship maintained betweenits value and the reactive power to be delivered by the Inverter) by controlling this small active current component. The currents are controlled indirectly by controlling the phase angleof Inverter output Voltage with respect to the AC side source voltage in the "Synchronous Link Based Control Scheme" whereas they are controlled directly by current feedback in the case of "Current Controlled Scheme". In the latter case the Inverter will be a Current Regulated one ,i.e. its switches are controlled in such a way that the Inverter delivers a commanded current at its output

rather than a commanded voltage (the voltage required to see that the commanded current flows out of Inverter will automatically be synthesized by the Inverter).

II. MAJOR POWER QUALITY ISSUES

Methods for improving power factor like

- Shunt capacitor method
- Synchronous condenser method

Causes of low power factor:-

- Induction motor
- Transformer magnetizing current
- Arc lamp and welding equipment
- Effect of low power factor
- At low power factor capacity of plant, transmission and distribution equipment increase to meet load demand.
- At same active power due to low power factor their overloading of equipment
- At same active power due to low power factor high energy losses because the value of current drawn increase
- Low power factor causes poor regulation.

One or two specific harmonic of current distortion can easily remove by passive filter or active filter. The active filter is more costly and complex as compare to passive filter but the active filter is work much better than passive filter. Star-delta or zigzag transformer also used to reduce zero sequence current.

Transient mean surge or spikes in the system voltage or current. Current transient is for very short duration of time like 1/16 of voltage cycle. If we talking about the Indian supply frequency one cycle is of 1/50=1.2 millisecond so the distortion for a duration of 0.0192 second is enough to produce transient. Line can carry Voltage transient for 50 microseconds and current is for 20 microseconds only.

For small scale industries those who have a element creating problem to power quality should provide an external supply to these of loads. Ups is one example of external power supply. Recently this type of event occurs in India at mid night on 30 July on that day the whole northern grid is blacked out and many types of problem is faced by the consumers and on next day at 1 PM on 31 July five out of three grid of India is blacked out.

The dip in a supply voltage for a more than pre-specified time is called voltage sag. The supply frequency in India is 50 Hz so at this frequency sag for 0.5 cycles to 1 minute is known as voltage sag. These dips in supply voltage depend upon the supply voltage and the distance of fault from the consumer. High supply voltage means large sag effect. This sag should be compensating as soon as possible by applying appropriate method.

Factors affecting the sag magnitude due to faults at a certain point in the system are:

- Distance to the fault
- Fault impedance
- Type of fault
- Pre-sag voltage level
- System configuration

III. ROLE OF FACTS

Mainly voltage fluctuation due to voltage drop in line impedance transformer or generator and this is easily eliminated by FACTS (Flexible Alternating Current Transmission System) in series. Device can control voltage in series harmonic voltage, sub-synchronous frequency and main frequency or the combination of these. Series controller has overall control and any type of dip, sag or damp oscillation easily mitigate by injecting voltage to the line. This type of controller is less costly.

Shunt controller is used to maintain voltage at junction point by injecting current into the line by current source. Both active and reactive current injection is possible by alone or in a combination to achieve voltage control

at junction point. These types of controller are more effective at sub-

Benefits of facts controllers

- Increase the loading capability of lines to their thermal capabilities.
- Increase the system security through raising the transient stability limit.
- Control of power flow as ordered.
- Provide secure tie line connections.
- Provide greater flexibility in setting new generation.
- Reduce loop flows.
- Reduce reactive power flows

IV. D-STATCOM MODELING

The best method of reactive power compensation is to add capacitor or inductor to the line. Reactive current is depending upon change of reactive power. Reactive current loaded the system in steps. The switching time of capacitor is lintel complexes and there is chance of occurrence of transient so there is need of some solution. D-SATATCOM is a device which cannot only compensate the reactive power but also reduce the system transient. D-STATCOM is used to protect the system from various types of stability problems. Disturbance in system voltage whether it is sag or swells it is directly proportional to the change in load when there is any change in load due to fault or any other reason than D-STATCOM can protect the system from instability and various types of power quality problem. By changing the phase angle or by varying the amplitude it can exchange both active and reactive power from the system.

The control scheme is to maintain constant voltage at the point of connection where current injected to the system. The VSC switching is based uponvoltage transformation. The reference of voltage magnitude is compare at the controller so there is no need of measurement of reactive power. Basically this type of transformation is commonly used in three-phase electric machine models, where it is known as a Park transformation. By using this transformation we easily eliminate time-varying inductances by referring the stator and rotor quantities to a fixed or rotating reference frame.

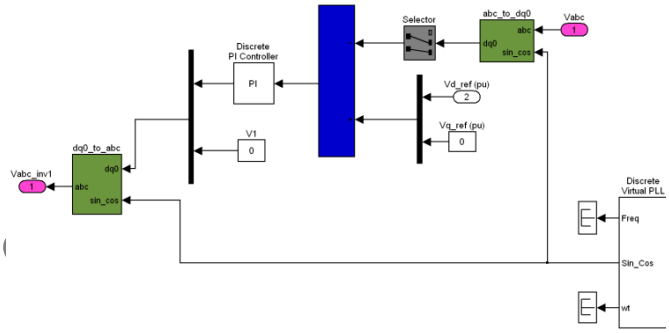

Fig. 1 Triggering circuit of D-STATCOM

The controller is compare two quantity reference voltage and root mean square voltage. The error developed by the controller is send to the pulse width modulation generator so by the difference of these two quantities can control both active and reactive power.

$$V_a = \frac{2}{3}(V_d \sin\omega t + V_q \cos\omega t + V_0)$$

$$V_b = \frac{2}{3}(V_d \sin(\omega t - \frac{2\pi}{3}) + V_q \cos(\omega t - \frac{2\pi}{3}) + V_0)$$

$$V_c = \frac{2}{3}(V_d \sin(\omega t + \frac{2\pi}{3}) + V_q \cos(\omega t + \frac{2\pi}{3}) + V_0)$$

Frequency modulation index of triangular signal and the amplitude modulation index of signal are the main parameter of PWM. Triangle signal and modulation signal compared to generate the switching signal for voltage source converter valve. For obtaining higher fundamental voltage component the amplitude index of controller is set to 1 pu. Output of controller is given by

$$m = \frac{V_{control}}{V_{triangle}} = 1pu$$

Here is peak amplitude of control signal and is peak amplitude of triangular signal There is no need of creating phase difference because the value of all three phase

A,B and C are already at a phase difference of 120 degree from each other. This controller is very fast and gives robust response due to simple controlling of voltage

V. MATLAB SIMULATION OF D-STATCOM

Matlab is designed to solve problems numerically, that is, in finite-precision arithmetic. Therefore it produces approximate rather than exact solutions, and should not be confused with a symbolic computation system (SCS) such as Mathematical or Maple. MATLAB is developed by The Math Works, MATLAB allows creation of user interfaces, plotting of functions and data, matrix manipulation, interfacing with programs in other languages and implementation of algorithms. Although it is numeric only, an optional toolbox uses the Mu PAD symbolic engine, allowing access to computer algebra capabilities. An additional package, Simulink, adds graphical multi domain simulation and Model-Based Design for dynamic and embedded systems it is a tool designed for different tasks and is therefore not directly comparable.

Here the proposed model of D-STATCOM is shown in above figure. The alternator is supplied a power to the system by a three phase three winding transformer. One winding of this transformer is connected to the alternator second winding is with the load and third winding is connected via voltage source convertor ofD-STATCOM. Here we considering two loads connected to a line via circuit breaker in a proper arrangement.

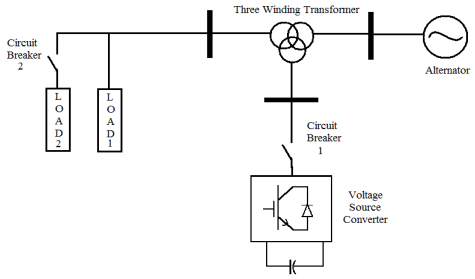

Fig. 2 Basic scheme

For a pre-specified time load 2 connect or disconnect to the system and the effect of this on a system is a part of study. The voltage source convertor of D-STATCOM also connected via circuit breaker so we can connect it according to the requirement.

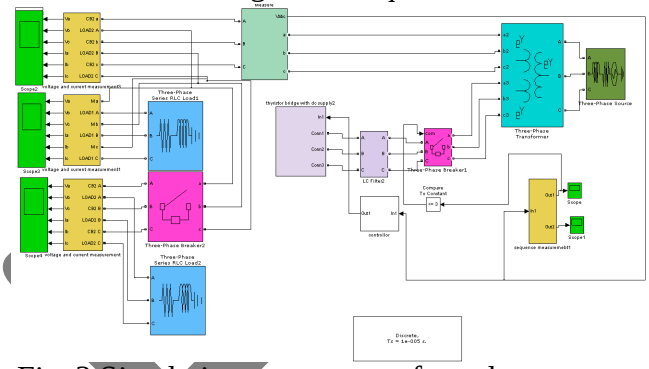

Fig. 3 Simulation arrangement for voltage sag

VI. RESULTS ANALYSIS

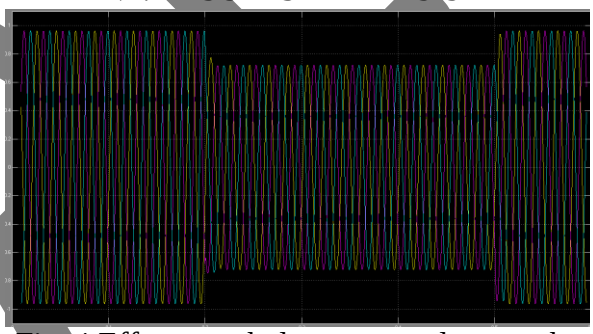

Fig. 4 Effect on whole system voltage at the time of voltage sag

If we concentrate on the all three phase voltage of the system at the time of voltage sag it is clear that all three phase A, B and C voltage are decrease from their per unit value (1 to 0.8) due to extra burden of Three phase series RLC load 2 on to the system.

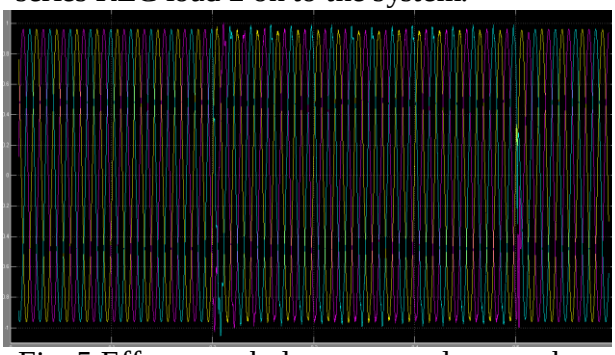

Fig. 5 Effect on whole system voltage at the time of voltage sag removal

If we concentrate on the all three phase

voltage of the system at the time of voltage sag when D-STATCOM is connected to the system it is clear that all three phase A, B and C voltage are unaffected from their per unit value because to extra burden of Three phase series RLC load 2 on to the system is eliminated by D-STATCOM.

VII. CONCLUSION AND FUTURE WORK

From the results it is clear that sag formulation for a pre-specified time or any instant is easily eliminated with very less transition time and with least distortion in system voltage. As we discussed before that main reason of voltage sag are due to flow of high velocity may damage the conductor, substation disconnection, Lightning, fault like line to ground double line to ground, line to line fault, formation of ice on the conductor, circuit breaker operation etc. and this sag may creates problem like failure of sensitive loads, industrial and commercial loads, semiconductor industries and all the loads connected to the system. So any type of voltage sag can easily eliminated by this proposed model and helps to protect the system connected loads.

By applying different type of controller scheme the transition time of D-STATCOM and post fault recovery response should also be improved as here seen in results D-STATCOM take few milliseconds to recover the system and the output voltage waveform distorted for small time period. By applying any different control strategies or different triggering of bridges other voltage problems of system like voltage swell and interruption also be removed. As here we studying it for small distribution system but we can also applying it in large system for observing behavior of system.

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