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# Performance of STATCOM Incorporating Supercapacitor

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***Abstract: Power system consist of three different processes i.e. generation, transmission and distribution. In this system the important factor is efficiency as well as reactive power improvement. Reactive power is required to maintain the voltage in the structure or system to deliver the active power. Loads require reactive power for their effective operation. To improve the performance of AC power systems, we need to maintain this reactive power is known as reactive power compensation. In recent years, static VAR compensators like STATCOM have been developed. This paper describes how STATCOM plus supercapacitor as an energy storage can deliver significant amounts of real and reactive power to the system using MATLAB software.***
***Index Terms : Power System Stability; reactive power; Transient Stability; STATCOMs; Supercapacitor.***

## I. INTRODUCTION

STATCOMs are used for grid voltage support to improve power quality. Their dynamic response is an order of magnitude faster than conventional synchronous generators or thyristor based static compensators. STATCOMs, however, are limited in their ability to improve system stability due to their limited capability for delivering real power [1]**. v**oltage-source converters (VSCs) are widely used for reactive power compensation, an application referred to as static synchronous compensator (StatCom). In the future,Smart Grid StatComs will probably become one of the most important components for flexible control of power systems on the transmission level and in distribution systems[2]. Transmission providers will be forced to seek means of local control to address a number of potential problems, such as uneven power flow through the system (loopflows), transient and dynamic instability, overvoltages and undervoltages. Flexible ac transmission system (FACTS) power-electronics-based controllers can potentially provide a solution to these potential problems. In recent years, several FACTS topologies have been proposed to solve problems in existing power networks the majority of these topologies are designed to mitigate problems by controlling a reactive power through a transmission and distribution[3]. In recent years, the STATCOM (Synchronous Static Compensator) based on voltage source converter (VSC) is used for voltage regulation in transmission and distribution systems. The STATCOM can rapidly supply dynamic VARs required during system disturbances and faults for voltage support. However, strict requirements of STATCOM losses and total system loss penaulty preclude the use of high frequency PWM (Pulse-Width Modulation) for VSC based STATCOM applications.[4]. This constraint of implementing VSC either without PWM or with low switching frequency PWM functionality, results in VSC DC voltage dip, overcurrents and trips of the STATCOM during and after system disturbances and faults, when its VAR support functionality is most required. In this paper, we studied the performance of statcom with supercapacitor as a energy storage system.

## II. NEED OF COMPENSATION

The main reason for reactive power compensation in a system is:

*A.* The voltage regulation;
*B.* Increased system stability;
*C.* Better utilization of machines connected to the system;
*D.* Reducing losses associated with the system; and
*E.* To prevent voltage collapse as well as voltage sag.

## III. BASICS OF STATCOM AND SUPERCAPACITOR

STATCOM is a FACTS device used for the compensation, it is also called as compensating device. The STATCOM is arrangement of voltage source converter in parallel with the capacitor which acts as a DC energy source link knotted to the transmission line. Almost sinusoidal current of variable magnitude at the point of connection is injected by the STATCOM. This injected current is almost in 90 degree phase with the line voltage, which helps in outdoing an inductive or a capacitive reactance at PCC with transmission line. But there are certain limitations of the STATCOM i.e ability for transporting actual power is insignificant which bounds their capability to increase the structure constancy boundary. Hence there is a SUPERCAPACITOR which is an energy storage element. Energy storage consists of dc-dc converter in parallel with the dc link capacitor of a static synchronous compensator and then supercapacitor.This paper gives idea about the system that how supercapacitor interfaced with synchronous static compensator and provides actual and reactive power to the system. Simulations are carried out using MATLAB/Simulink. STATCOM has the limitation it can diminish higher order harmonics or ripple but their is no way of rejecting lower order harmonics. Hence supercapacitor is used along with the STATCOM in order to improve voltage stability.

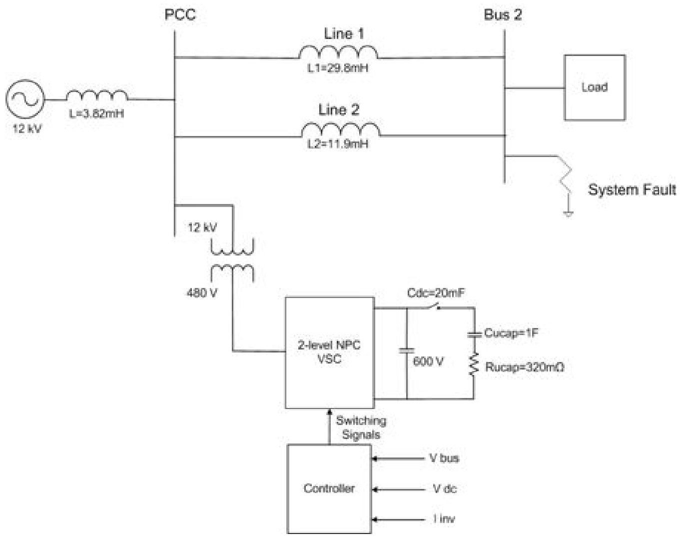


Fig.1.basic structure of STATCOM

## IV. PWM TECHNIQUE USED IN STATCOM

We use sinusoidal PWM technique to control the fundamental line to-line converter voltage. By comparing the three sinusoidal voltage waveforms with the triangular voltage waveform, the three phase converter voltages can be obtained.

The fundamental frequency of the converter voltage i.e. f1, modulation frequency, is determined by the frequency of the control voltages, whereas the converter switching frequency is determined by the frequency of the triangular voltage i.e. fs, carrier frequency. Thus, the modulating frequency f1 is equal to the supply frequency in STATCOM.. The magnitude of triangular voltage is maintained constant and the Vcontrol is allowed to vary.

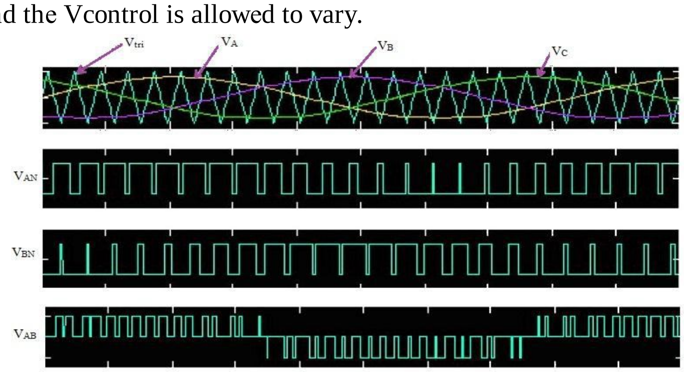


Fig.2. PWM technique

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The objective of any load-flow analysis is to produce the following information: Voltage magnitude and phase angle at each bus. Real and reactive power flowing in each element. Reactive power loading on each generator.

## VI. SYSTEM CONFIGURATION AND MODEL OF STATIC SYNCHRONOUS COMPENSATOR

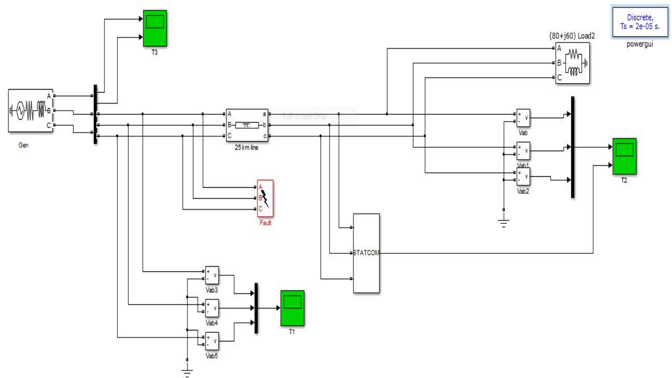

Figure.3. System configuration and control structure of STATCOM without supercapacitor

Fig.3. shows the configuration diagram for STATCOM ,it can be a healthy system or fault can be occure by selecting any type of fault from fault block..Fig.4. shows the simulating diagram for statcom plus supercapacitor where supercapacitor is connected to the sstatcom by DC-DC converter.

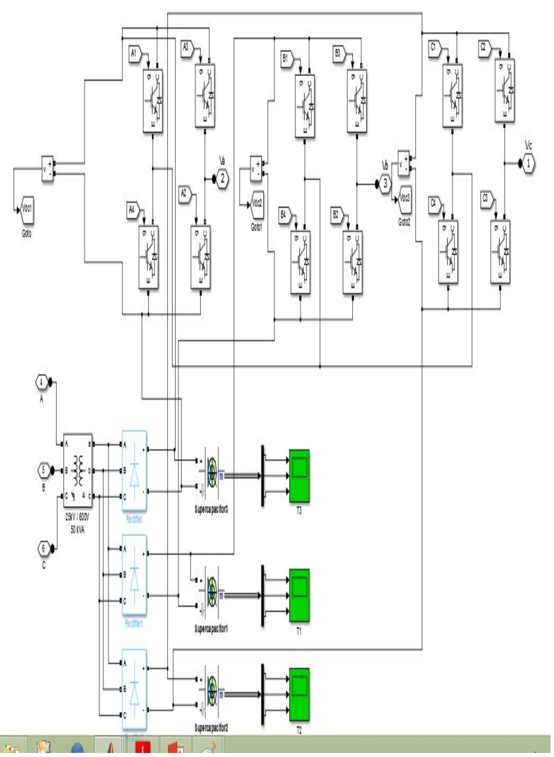

Fig.4.simulation diagram with statcom plus supercapacitor

## VII. SIMULATION RESULTS

From this figure.5. it is clear that voltage of all the phases is balanced when their is no fault in the system that time all three phases of voltage and current are in phase with each other.

From fig.6.it is seen that the Vpcc voltage, Id and Iq current components are regulated, and Vdc is kept constant.

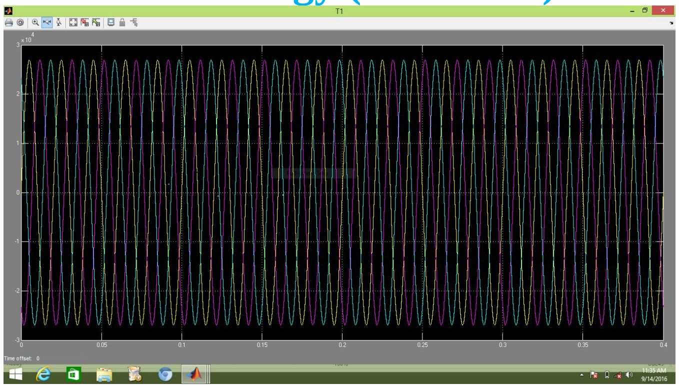

Fig.5. simulation result of voltage at normal condition

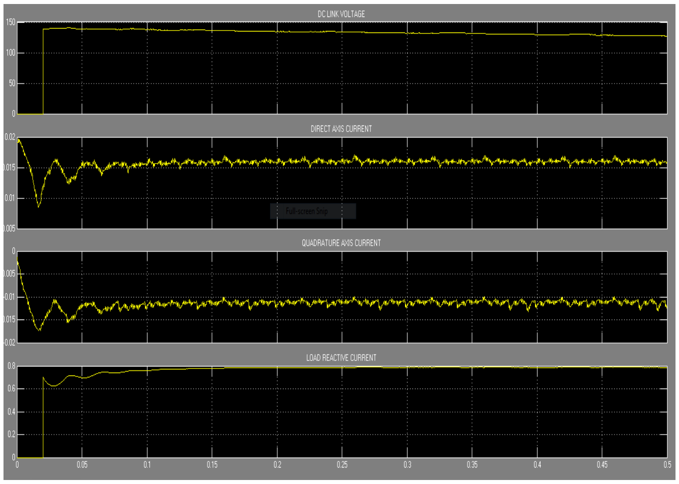


Fig.6. simulation result of voltage,direct axis current,quadrature axis current at normal system condition.

From fig.7. it is clear that when any type of fault occurs then system voltage get disturb.

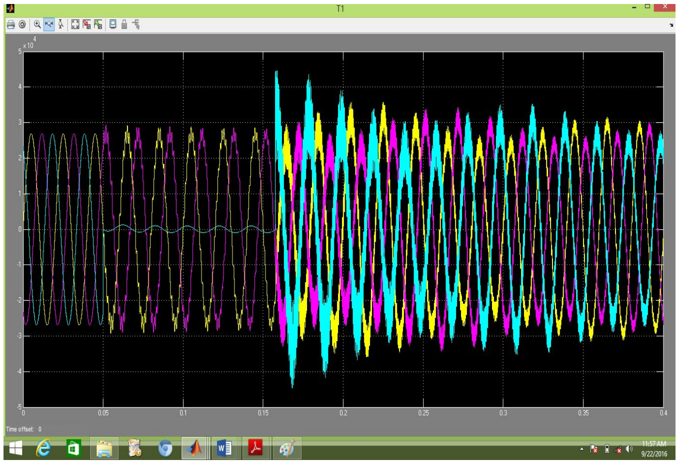

Fig.7. voltage disturbance at faulty condition

The D-STATCOM is commanded to deliver Iq to regulate Vpcc, and Iq increases to around 100A. During the SLG fault, the DC bus voltage is not regulated and has large voltage ripple. This results in the D-STATCOM to supply Id current component, which limits D-STATCOM reactive power/current rating during fault or system disturbances, when it is required the most.

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From fig.8. it is clear that by using STATCOM the voltage profile get improved and hence the reactive power .

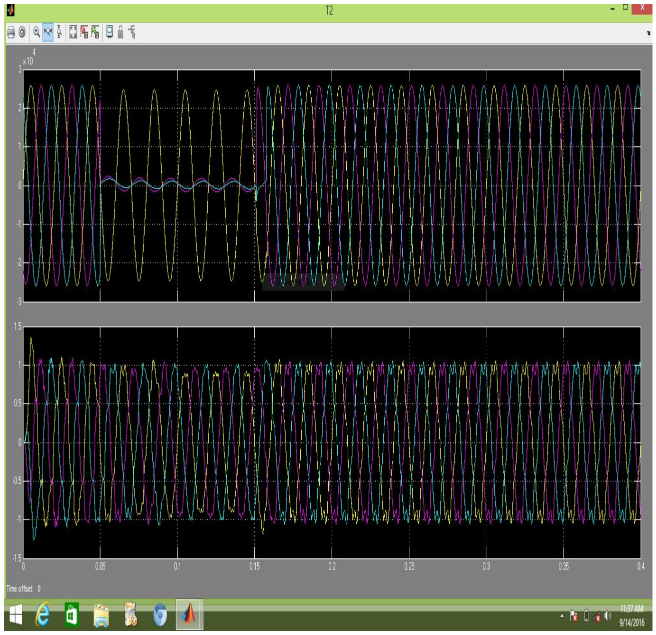

Fig.8. voltage improvement with statcom

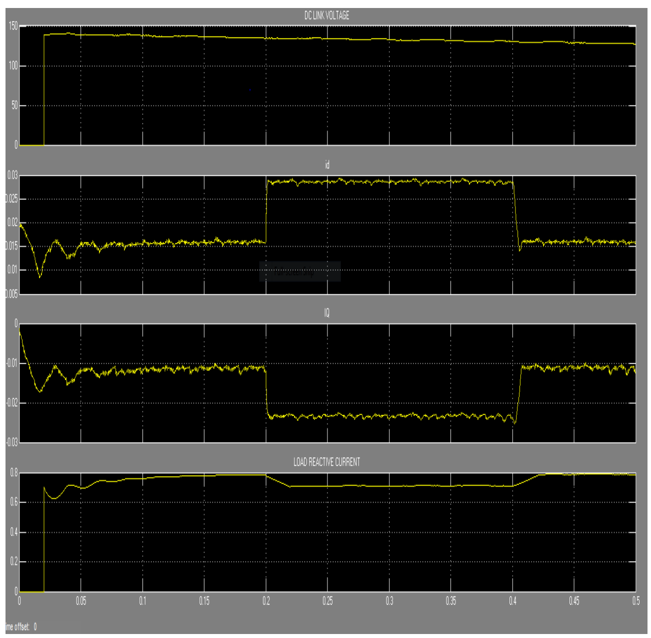

Fig.9. Improvement of voltage,Id,Iq by statcom

This gives the Id, Iq and voltage of bus system.When fault occurs statcom delivers Iq to regulate Vpcc, and Vbus having many more ripples hence statcom delivers Id current component**.** Id limits to statcoms active and reactive current rating.

Fig.10.. shows results of the integrated D-STATCOM with UCAP system operation under SLG fault conditions – the SLG fault is on the load bus as shown in Figure above. The Vpcc voltage dips during the fault and D-STATCOM delivers Iq current component to regulate Vpcc.

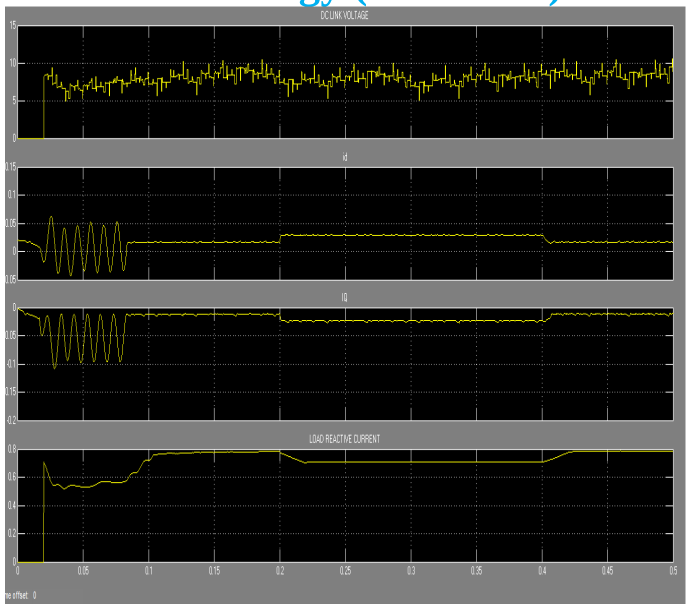


Fig.10. Integration of STATCOM and SUPERCAPACITOR

## VII. CONCLUSION

The D-STATCOM integrated with UCAP is suited for distribution system voltage regulation and voltage sag mitigation. When there is fault in the system, the UCAP can keep the DC bus voltage almost constant and avoid over-current in the system, and even trips of the D-STATCOM. This paper develops the control concepts to charge/discharge the UCAP by the D-STATCOM, and validate the performance for an integrated D-STATCOM/UCAP system under all types

of system related disturbances and system faults – such as single-line to ground fault, line-line fault and 3-phase system faults. simulation results are obtained with the help of MATLAB software.

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