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MITIGATION OF UNBALANCED FAULTS IN DISTRIBUTION SYSTEM USING FD-STATCOM WITH SCESS.

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Abstract: Power quality is certainly a major concern in the present era.This paper proposes a flexible D-STATCOM with a new controller scheme. And it supplies power to sensitive loads under Islanding conditions. This paper introduce the performance of FD-STATCOM system to mitigate power quality problems under all types of system related disturbances such as L-L &DLG faults. A 12 pulse IGBT based D-STATCOM is designed using MATLAB.Here the super capacitor is used as the storage device.The realibility of the control scheme in the system response to the voltage disturbances caused by LL&DLG faults and Islanded operating conditions are obviously proved in the simulation results.

Keywords: FD-statcom,voltage sags,super capacitor,Islanding conditions,Energy storage system**.**

I. INTRODUCTION

The modern power distribution network is constantly being faced with an ever growing load demand.Many loads at various distribution ends like domestic utilities, computers ,adjustable speed drives etc have become intolerant to voltage fluctuations.The power losses in electric power system corresponds to about 70% of total loss of the power system. One of the most severe problems faced in distribution networks operators is voltage drip along distribution feeders,which is caused by real and reactive power flow.Voltage can be improved and power losses can be reduced by installing custom power devices at suitable location.These devices are aimed at enhancing the realibility and quality of power flows in low voltage distribution networks.

Custom power devices includes static switches,inverters,converters,injectiontransformers,micro processor based devices have the ability to perform current interruption and voltage regulation functions with in a distribution system.

There is a high demand for utility DG installations due to their advantage of upgrading the distribution system.Most of the DG units are connected to the system through a shunt nonlinear link sush as a VSI or CSI.There are many types of DG.Among them are wind,biogas,fuel cells&solar cells. Generally these sources are connected to grid through inverters and their main function is to deliver active power to the grid.They are designed to supply both active and reactive power.Flexible DG systems are indeed possible to implement integrated functions like harmonic mitigation,unbalance mitigation,zero sequence component suppression schemes etc…A DG is islanded when it supplies power to some loads while the main utility sources is disconnected islanding detection of DGs is considered as one of the most important aspects when interconnecting DGs to the distribution system.

This paper proposes a flexible D-statcom designed to operate in two different modes.Initially it can mitigate voltage sags caused by LL and DLG faults.Then It can mitigate voltage sags caused by three phase open circuit fault by opening the circuit breaker and disconnecting the main utility source.

Reactive power compensation is an important issue in distribution system.If the reactive current increases,the system losses also increases.Various methods have been applied to mitigate voltage sags.For voltage sag mitigation we generally use capacitor banks,parrel feeders etc..But the power quality problems are not completely solved by using these devices.

Conventionally SVC has been used in conjuction with passive filters at distribution system for mitigating power quality problems.It provide reactive power compensation at transmission level.There are certain disadvantages for SVC,they have limited bandwidth, higher passive element count that increases size and losses. They have slow response also. These characters make them inapt for modern day distribution requirement.

The D-STATCOM is a promising devices to provide not only for voltage sag mitigation but also for a host of other power quality solutions such as voltage stabilization,flicker suppression and power factor correction etc..It is a controlled reactive source which include voltage source converter and DC link capacitor arrays.They are capable of generating or absorbing reactive power.The terminals of VSC are connected to the point of common coupling.

Depending upon the power rating of the statcom,different technologies are used for power converter.High power stations normally use GTO-based square wave voltage source converter.Lower power statcoms use IGBT based PWM(VSC).The reactive power output of the D-STATCOM inductive or capacitive depending can be either on the operation mode of the D-STATCOM.

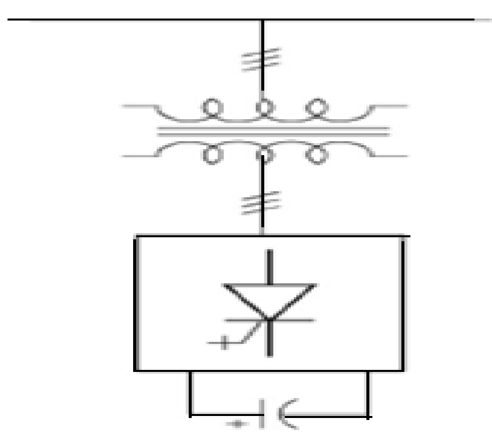

Fig 1 Schematic diagram of Statcom

DC side of the converter is connected to DC capacitor,carries the input ripple current of the converter and is the main energy storage element. The capacitor is charged by a battery source,or precharged by the converter.If the output voltage of VSC is equal to the AC terminal voltage,no reactive power is delivered to the system.If the output voltage greater than AC terminal voltage D-STATCOM is the capacitive mode of operation.The quantity of the reactive power is proportional to the voltage difference.

2. PROPOSED SYSTEM

In this paper we use a 6 pulse IGBT based D-STATCOM for mitigation of unbalanced faults in distribution system.An appropriate controller scheme is used here.

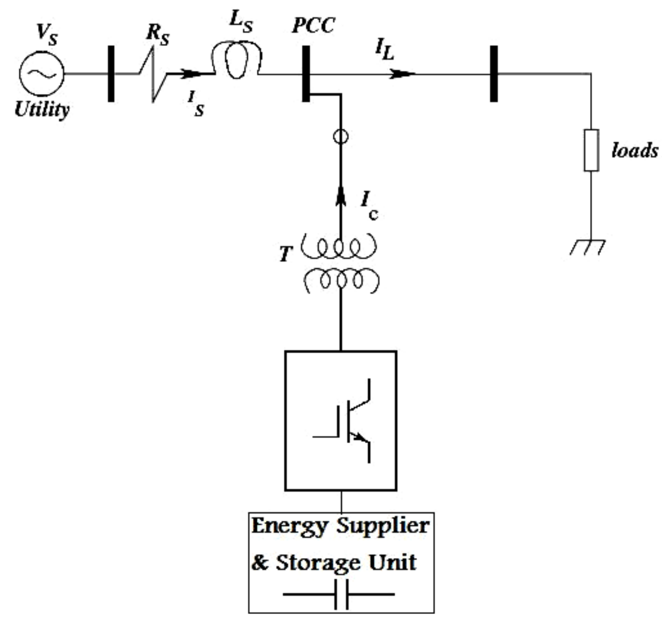

Fig 2 Schematic diagram of FD-STATCOM

The basic block of the FD-STATCOM is the voltage source inverter that converts an input dc voltage into three phase output voltage at fundamental frequency. FD-STATCOM which works flexibly on both voltage control mode and current control mode. Unlike the Unified Power Flow Controller (UPFC) which consist from two parts, series and shunt, to manage the flow of active power from one part to the other, FDG consist of one part only, because it has a supply of the active power from DGsystem. Fig. 2 shows the schematic representation of the FD STATCOM.

The basic electronic block of the FD-STATCOM is the voltage source inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency.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 FD-STATCOM output voltages allows effective control of active and reactive power exchanges between the FD-STATCOM and the ac system.[1]

3. CONTROL STRATEGY.

The control block diagram contains many signal processing blocks.

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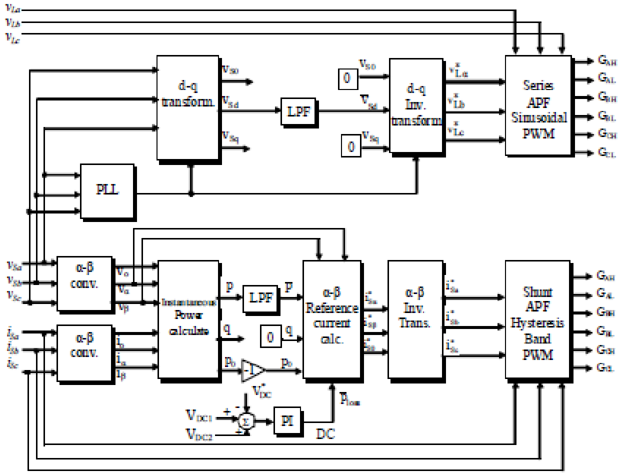

Fig 3 controller blockdiagram

The control strategies of D-STATCOM are mainly implemented in the following steps.

1. Measurements of system variables and signal conditioning.
2. Extraction of reference compensating signals.
3. Generation of firing angles for switching devices.

A few control techniques have been direct implemented to D-STATCOM in corporating PWM switching rather than fundamental frequency switching.

A synchronous reference frame based controller is used in this paper.Here the voltage and current are transferred from ABC reference frame to alpha-beta reference frame.Then the power is calculated.The control signal is given by hysteresis controller.In this controller the required current and measured current are compared.And the difference in two values are given as the gate signal to the inverter.

The control system task to increase or decrease the capacitor DC voltage.So that the AC voltage has correct amplitude for the reactive power.The control system must also keep the AC generated voltage in phase with the system voltage.

1. Initially have no integral gain .
2. Increase KP until get satisfactory response.

3.ANALYSIS OF UNBALANCED FAULTS

The most common types of faults are single line-ground (SLG) and line-line (LL). Other types are double line-ground (DLG), open conductor, and balanced three phase faults.The easiest method to analyze unbalanced system operation due to faults is through the use of symmetrical components

The most common fault is line-to-line, which occurs when two of the conductors come in contact with each other. with out loss of generality we'll assume phases b and c. With a double line-to-ground (DLG) fault two line conductors come in contact both with each other and ground.

SLG: Sequence networks are connected in series, parallel to three times the fault impedance.
LL: Positive and negative sequence networks are connected in parallel; zero sequence network is not included since there is no path to ground.
DLG: Positive, negative and zero sequence networks are connected in parallel, with the zero sequence network including
Three times the fault impedence.

Super capacitor is a new energy device emerged in recent years. It is also known as double-layer capacitor. The electrical double-layer capacitor is a novel energy storagecomponent developed in 1970s. Its pole boards are made ofactivated carbon, which have huge effective surface so thecapacitance could attain several farad even thousands farad.
When it is charged, the electric charges are spontaneously distributed negative and positive ion layers on the interface between pole boards and electrolyte, so the super capacitor does not have electrochemical reaction and only have electriccharges adsorption and desorption when it is charged anddischarged. It has many merits such as high charge/discharge current, less maintenance, long life and some other perfectperformance. At the same time, its small leakage currentenables it has long time of energy storage and the efficiencycould exceed 95% [1].

The structure of SCESS is shown in Fig. 4. Its circuit is mainly composed of three parts: rectifier unit, energy storageunit, and inverter unit. Rectifier unit adopts three phase full bridgerectifier to charge super capacitor and supply dc power energy to inverter unit. Inverter unit adopts three phase voltage inverter composed of IGBTs, it connects to power grid via transformer. When SCESS works normally, voltage at dc side is converted into ac voltage with the same frequency as power grid through IGBT inverter. When only considering fundamental frequency, SCESS can be equivalent to ac synchronizing voltage source with controllable magnitude and phase.Energy storage unit i.e. super capacitor energy storage arrays are composed of many monolithic super capacitors. If a large number of super capacitors be in parallel, at the same time improving capacity of power electronics devices in power conversion system can be easily composed of more large capacity SCESS, but operational reliability and control flexibility will not be

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affected. Super capacitor is very easilymodularized, when required, and it is very convenient incapacity expansion.SCESS stores energy in the form of electric field energy using super capacitor arrays. At the lack of energy emergenc orwhen energy needed, the stored energy is released through control system, rapidly and accurately compensating system.active and reactive power, so as to achieve the balance of power energy and stability control.Determining the number of energy storage module can save super capacitors, and further reducing volume, quality and cost of the energy storage unit.It is assumed that each super capacitor is represented as anequivalent resistance req and equivalent ideal capacitor ce inseries. R and C of super capacitor bank are R=ns.req/np and C=np.ce/ns, respectively; that ns and np are the number of monolithic super capacitors connected in series and parallel for constituting storage energy module [16]. In this paper, SCESS is made of 10 arrays in parallel with ce=3 (mF) and req=1 (Ω) for every array, as shown in Fig. 4.

Fig. 5 shows a typical distribution system controlled by this method. Also, when Timed Fault Logic operates LL and DLG faults are exerted, therefore, the FD-STATCOM supplies reactive power to the system. In this method, the proportional gain is 300. The speed of response and robustness of the control scheme are clearly shown in the simulation results.[1]

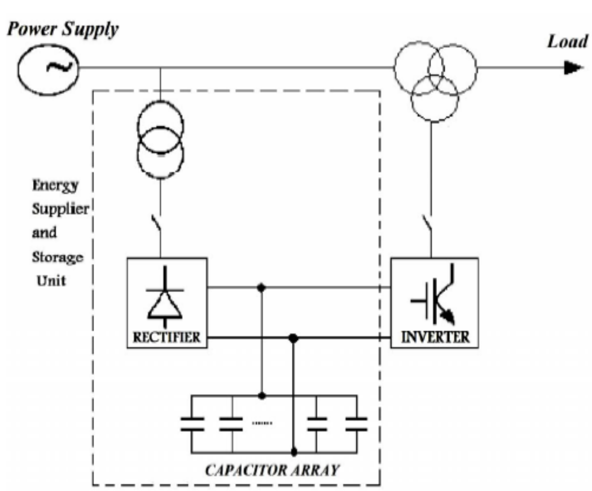

Fig 4 . structure of SCESS

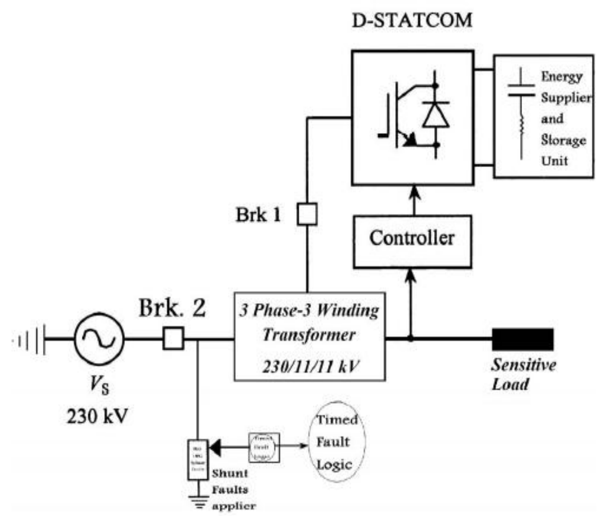

Fig5.Distribution system with statcom

SIMULATION RESULTS

The simulations of the FD-STATCOM in fault condition are done using LL and DLG faults and under islanded operating condition. In LL and DLG faults the faulted phases are phases A and B while in islanded operating condition.

In this paper, the FD-STATCOM uses the proposed control method to mitigate the load voltage sags due to all types of faults. The simulations are done for all types of faults introduced in the 230 V distribution systems as follows

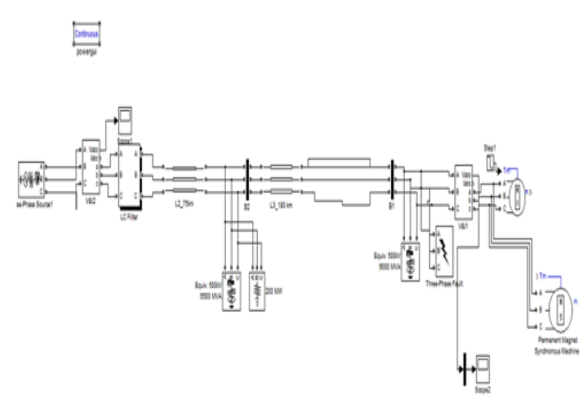

Fig 6 simulink diagram without statcom

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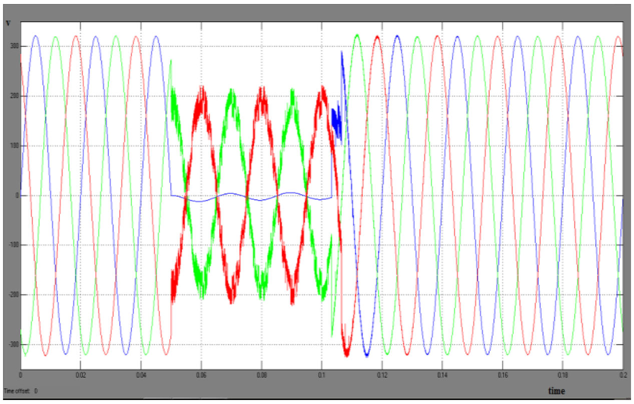

Fig 5 Voltage during DLG fault with out statcom

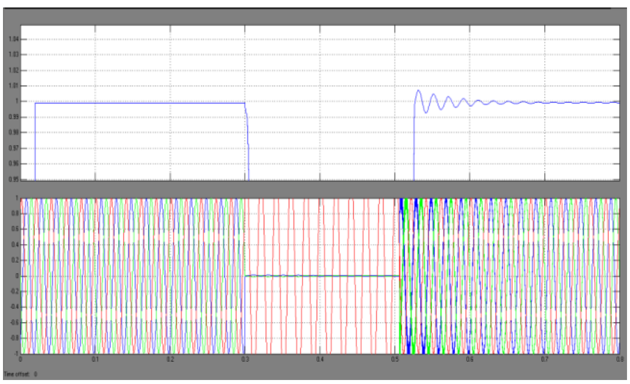

Fig 6 Voltage during SLG fault

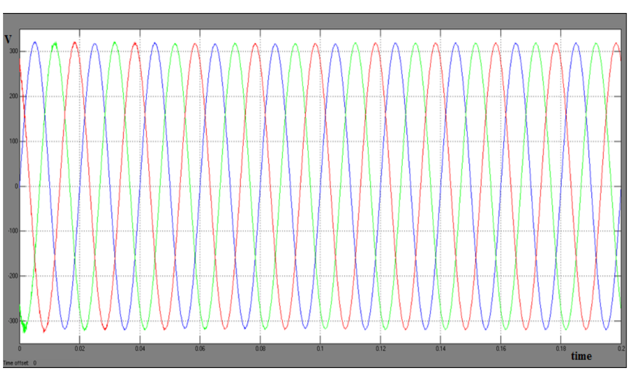

Fig 7 Compensated voltage under Islanding condition

The proposed method merits with respect to the classic methods are simplicity and control convenience and being flexible, i.e. it can mitigate voltage distortions caused by both LL/DLG faults and islanded operating condition only with the same control system setting.The presented results show that the proposed FDSTATCOM and its controller system not only can mitigate voltage distortions caused by the faults but also have a suitable performance under the islanded operating condition as a FDG.

CONCLUSION

In this paper, a flexible D-STATCOM is proposed that mitigate unbalanced faults (such as LL and DLG faults) and operate as a DG, when it supplies power to sensitive loads while the main utility source is disconnected. As a result, D-STATCOM operates same as a FDG and consequently, it is called FD-STATCOM. In addition, this paper has proposed a new control method for mitigating the voltage sags, caused by unbalanced faults and islanding condition, at the PCC. The proposed method is based on integrating FD-STATCOM and SCESS. This proposed control scheme was tested under a wide range of operating conditions (under unbalanced faults and islanded operating condition), and it was observed that the proposed method is very robust in every case. In addition, the regulated V_{RMS} voltage showed . It was observed that the load voltage is very close to the reference value. Moreover, the simulation results were shown that the charge/discharge of the capacitor is rapid through this new method (due to using SCESS) and hence the response of the FD-STATCOM is fast.

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BIOGRAPHY

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