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# A Novel Approach For Compensation Of Voltage Fluctuation Using D-STATCOM

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**ABSTRACT :** *Continuity of supply along with power quality is a technical challenge for electrical researchers. Load characterstics on power system are dynamic in nature. Motor starting and short circuit faults are the two main causes of voltage sag. Conventional flywheel system are capable of storing energy but not suitable for high speed energy storage. In this paper D-STATCOM is proposed for compensating voltage fluctuations in distribution system. This paper deals with the modeling and control of an STATCOM system with self controlled DC bus. This model is used to design an efficient control strategy based on the control of the Magnitude and phase angle of the switching pattern. Simulated results obtained with MATLAB are also presented and discussed to validate the model.*

***Keywords:-*** *Modeling, power quality, D-STATCOM, voltage compensation, voltage sag*

## I. INTRODUCTION

A voltage sag is an rms reduction in the AC voltage, at the power frequency, for durations from a half-cycle to a few seconds .Magnitude and duration are its two most important characteristics. It has recently been realized that the phase-angle jump in the sagged voltage is another important characteristic of voltage sags [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 [3], and may cost industries billions of dollars a year. With the increasing use of electronics-based devices, customers' equipment has become more sensitive to voltage sags. Because voltage sags have become a major power quality concern, investigations of techniques of mitigating voltage sags have received a lot of attention. Some conventional devices are able to mitigate voltage sags in some cases, such as uninterruptible power supplies, ferro-resonant transformers, and motor generator sets. However they have their limitations, and can only be used, economically, at low power ratings. So-called superconducting magnetic energy storage(SMES) systems [4] are becoming more attractive and competitive in taking over the role of power conditioning for large sensitive loads, especially with the rapid reduction in the cost of their power conversion units which mainly consist of power electronic components. The use of devices installed for other purposes to offer some extra assistance during voltage sags is also of great importance, as this is the cheapest way to lessen voltage sags. D-STATCOM is a typical example of such devices.

The STATCOM was originally called as advanced SVC and then labeled as STATCON . The advanced static VAR compensator (STATCOM) is based on the principle that a self-commutating static inverter can be connected between three-phase AC power lines and an 2 energy-storage device, such as an inductor or capacitor and controlled to draw mainly reactive current from the lines. This capability is analogous to that of the rotating synchronous condenser and it can be used in a similar way for the dynamic compensation of power transmission systems, providing voltage support, increased transient stability and improved damping . The STATCOM inverter requires gate-controlled power switching device such as GTO thyristors. GTOs are now available with ratings that are sufficiently high to make transmission line applications feasible. Consequently the STATCOM has become an important part of the flexible AC transmission system (FACTS), introduced by Hingorani and presently being promoted by the Electric Power Research Institute. In such cases, STATCOM has the ability to exchange active power with power system in a short period and STATCOM is not a VAR compensator any more, but a four-quadrant power converter . In recent years, the rapid growth of power semiconductor switching devices with high power capabilities and turn off ability has made it possible to use forced Commutation converters for reactive power compensation.

These devices have been successfully applied to power factor correction, improvement of voltage regulation, and increasing transient stability margin. During the last decades, there has been a great demand of controllable reactive power sources. The advantageous use of force commutated converters in reactive power compensation has been well established. Such compensators have also the advantages of reduced size and weight, precise control and very fast responses. The STATCON converter is a voltage source inverter which can provide or absorb reactive power.

## II. STATCOM

Basically, STATCOM is comprised of three main parts ,a voltage source inverter (VSI), a step-up coupling
transformer, and a controller. In a very-high-voltage system, the leakage inductances of the step-up power transformers can function as coupling reactors. The main purpose of the coupling inductors is to filter out the current harmonic components that are generated mainly by the pulsating output voltage of the power converters.

### *2*.1 Voltage Source Converter *(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.

### *2.2* A Controller

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system only measures the rms voltage at the load point, i.e., no reactive power measurements are required. The VSC switching strategy is based on a sinusoidal PWM technique which offers simplicity and good response. Since custom power is a relatively low-power application, PWM methods offer a more flexible option than the Fundamental Frequency Switching (FFS) methods favored in FACTS applications. Besides, high switching frequencies can be used to improve on the efficiency of the converter, without incurring significant switching losses. The controller input is an error signal obtained from the reference voltage and the value rms of the terminal voltage measured. Such error is processed by a PI controller the output is the angle δ, which is provided to the PWM signal generator. It is important to note that in this case, indirectly controlled converter, there is active and reactive power exchange with the network simultaneously: an error signal is obtained by comparing the reference voltage with the rms voltage measured at the load point. The PI controller process the error signal generates the required angle to drive the error to zero, i.e., the load rms voltage is brought back to the reference.

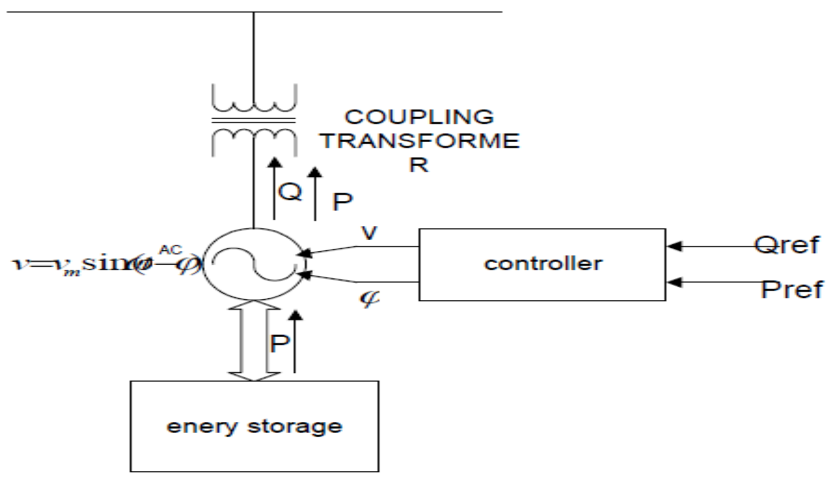



**Fig.1 Block diagram representation of STATCOM**

**2.3 Principle of Operation**

The D-STATCOM is a three phase and shunt connected power electronics based reactive power Compensation equipment, which generates and /or absorbs the reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system.

The AC voltage difference across the leakage reactance power exchange between the D-STATCOM and the Power system, such that the AC voltages at the busbar can be regulated to improve the voltage profile of the power system, which is primary duty of the D-STATCOM. The D-STATCOM employs and inverter to convert the DC link voltage Vdc on the capacitor to a voltage source of adjustable magnitude and phase. Therefore the D-STATCOM can be treated as a voltage controlled source. The D-STATCOM can also be seen as a current controlled source. The basic objective of a VSI is to produce a sinusoidal AC voltage with minimal harmonic distortion from a DC voltage. The operation of the D-STATCOM is as follows: The voltage is compared with the AC bus voltage system (Vs).

- When the AC bus voltage magnitude is above that of the VSI magnitude (Vc); the AC system sees the D-STATCOM as inductance connected to its terminals.

- Otherwise if the VSI voltage magnitude is above that of the AC bus voltage magnitude, the AC system sees the D-STATCOM as capacitance to its terminals.

- If the voltage magnitudes are equal, the reactive power exchange is zero.

If the D-STATCOM has a DC source or energy storage device on its DC side, it can supply real power to the power system. This can be achieved by adjusting the phase angle of the D-STATCOM terminals and the phase angle of the AC power system. When phase angle of the AC power system leads the VSI phase angle, the DSTATCOM absorbs the real power from the AC system, if the phase angle of the AC power system lags the VSI phase angle, the D-STATCOM supplies real power to AC system

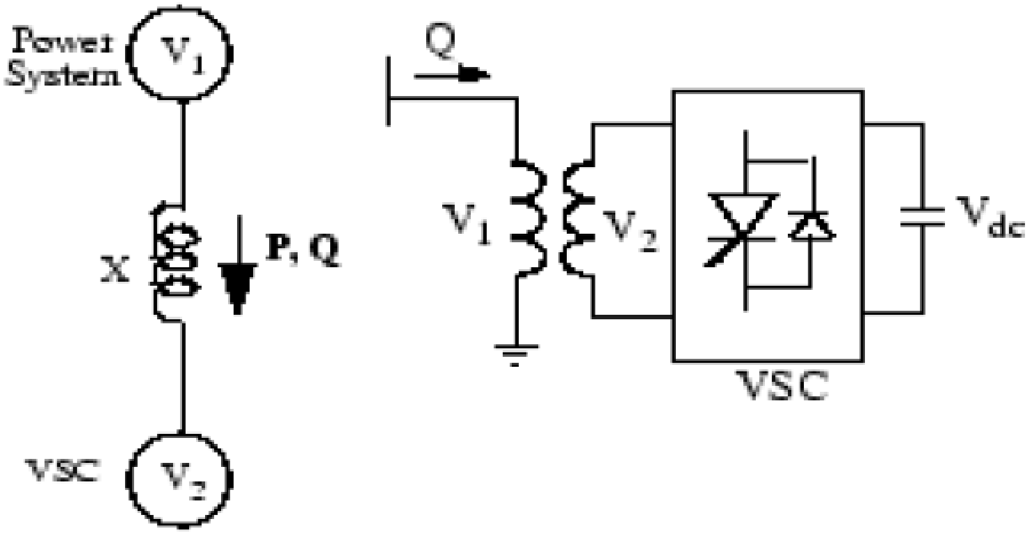



**Fig.2 Operating Principle of the STATCOM**

## III. COMPENSATION SCHEMES

A shunt-connected solid-state synchronous voltage source, composed of a six-pulse/five level, voltage sourced inverter and a dc energy storage device, is shown schematically in Figure . As explained in the previous section, it can be considered as a perfect sinusoidal synchronous voltage source behind a coupling. reactance provided by the leakage inductance of the coupling transformer. If the energy storage is of suitable rating, the STATCOM can exchange both reactive and real power with the ac system. The reactive and real power, generated or absorbed by the STATCOM, can be controlled independently of each other, and any combination of real power generation/absorption With var generation/absorption is possible, as illustrated in Figure 7b. The real power that the STATCOM exchanges at its ac terminals with the ac system must, of course, be supplied to, or absorbed from, its dc terminals by the energy storage device. By contrast, the reactive power exchanged is internally generated by the STATCOM, without the dc energy storage device playing any significant part in it.

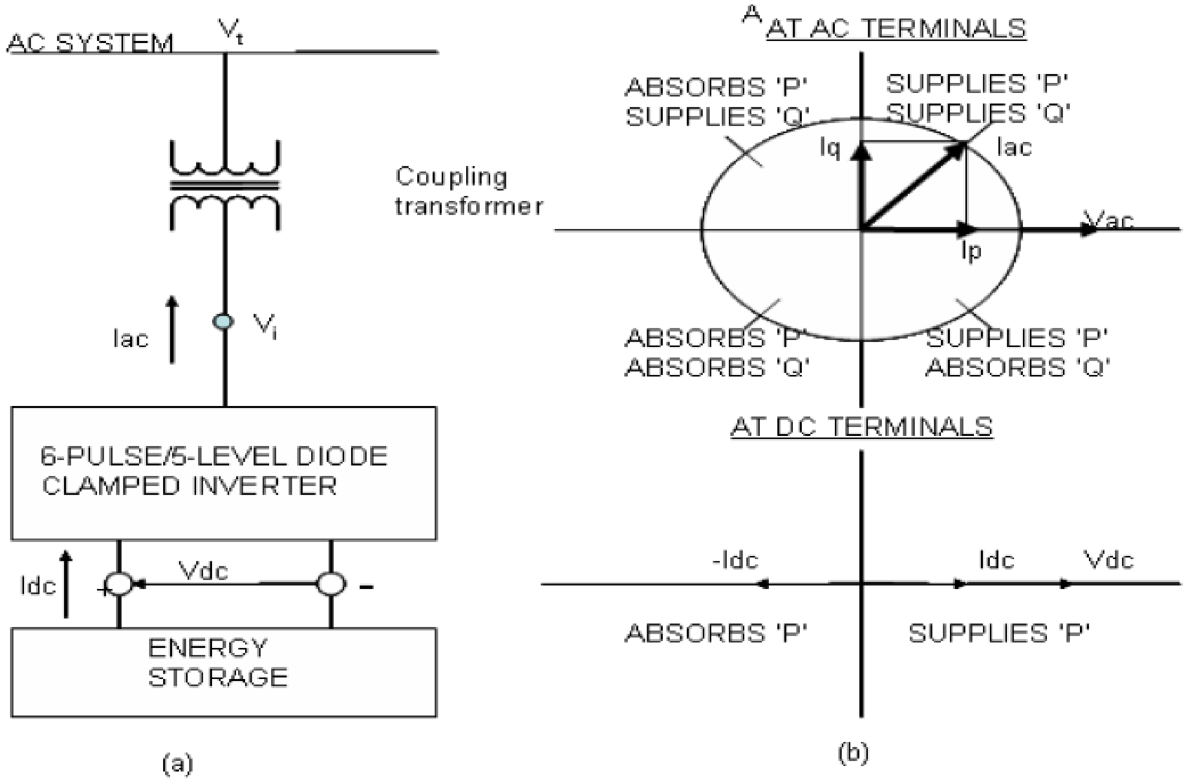



**Fig..3 a) Shunt Connected Synchronous Voltage Source**
**b) Possible Operating Modes for Real and Reactive Power Generation**

## IV. PROPOSED WORK

The MATLAB simulink model is shown in fig 1 and specification of all parameters are given in table below.

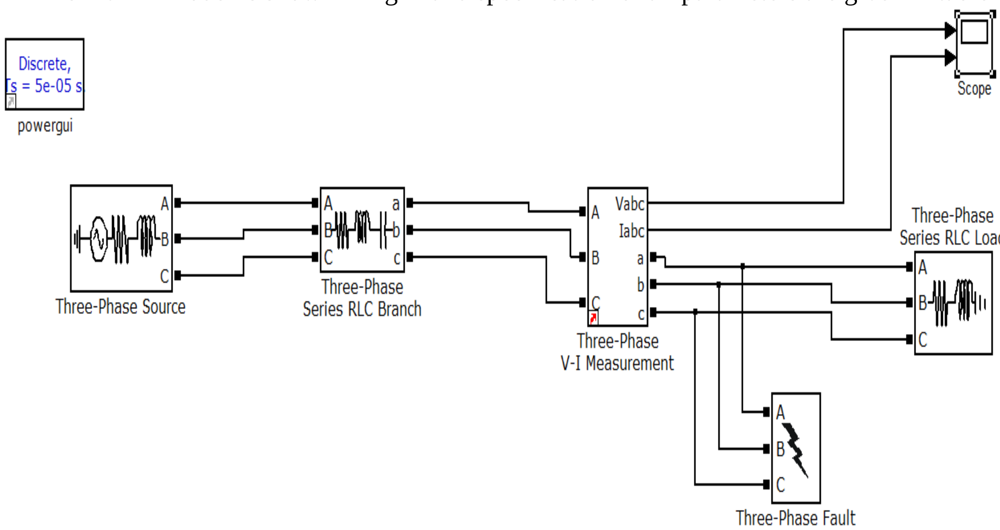
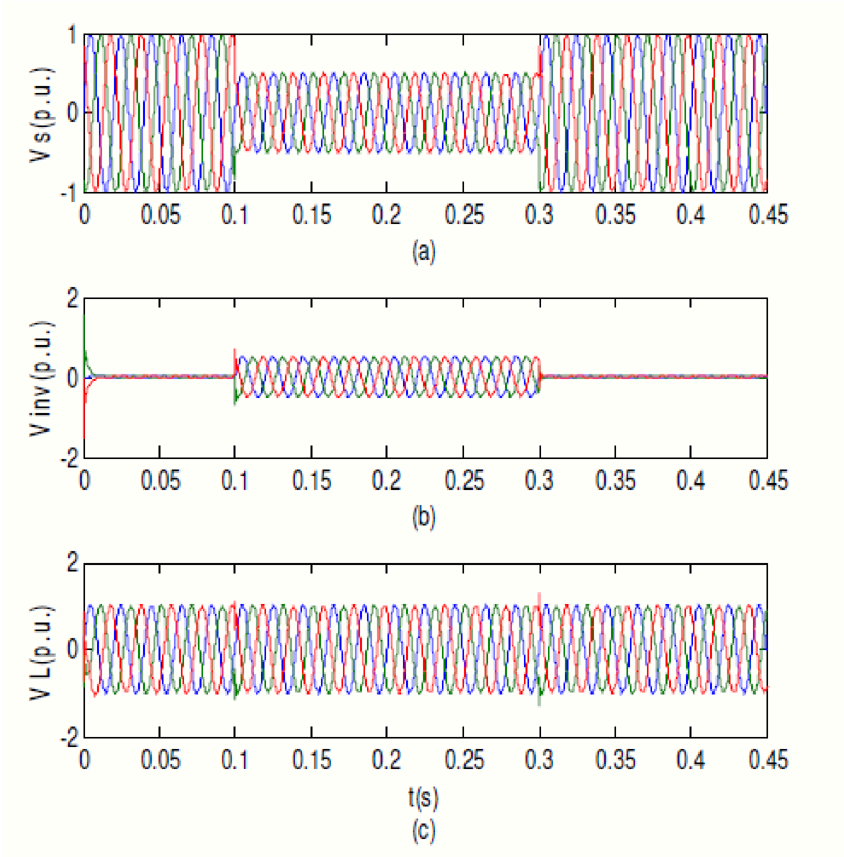



**Fig. 4 Power System with Fault**

**TABLE 1 : CONTROL PARAMETERS**

| Sr. No. | Equipments | Rating |
|---|---|---|
| 1) | Inverter | 8KVA |
| 2) | Coupling transformer | 415/208V,Δ/Δ,1 winding |
| 3) | Inverter series inductance | 9.67mH |
| 4) | Inverter dc bus voltage | 400v |
| 5) | Inverter dc bus capacitance | 1750μF |
| 6) | Dc bus capacitor time constant | 105s |
| 7) | Inverter switching frequency | 5kHz |
| 8) | Supply line inductance | 9mH |
| 9) | Supply line resistance | 0.3Ω |
| 10) | Controller parameters $K_{p}$,$K_I$,$T_F$ | 0.5,320,24ms |

Fig 2. Three-phase voltage sag




**(a):Source voltages (b): Injected voltages; (c): Load voltages**

## V. CONCLUSION

To maintain the standards of power quality mitigating voltage sag is very important. Fig 2(a) shows the voltage sag present in the power system, Fig2(b) shows the injected voltage through the STATCOM and Fig2(c) shows the compensated waveform of the power system voltage. The above results shows that the proposed D-STATCOM can improve the load voltage during a voltage sag by 4% to 21% depending on it's initial operating point .It was observed that the power compensation and voltage regulation depends mainly on two factors, one is rating of dc storage device and another is characteristics of coupling transformer. These two factors determine the maximum value of voltage sag mitigation that D-STATCOM can provide. The size of the DC capacitor does not have significant influence on the mitigation effect. But a small DC capacitance will lead to high peak DC voltage. Therefore, the selection of the DC capacitor should also be influenced by the values of the voltage and current in voltage sag conditions.

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