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A Review on Improvement of Power Quality using D-STATCOM

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Abstract - Maximum AC loads consumes reactivepower, it causes poor power quality in power system. In this paper an attempts has been to analyses the role of D-statcom (Distribution static compensator) andlocated at load side in the distribution system, which can to eliminating or overcome the problems of source side likevoltage sag and interruption etc. In order to maintain the power system quality the D-statcom will absorb and providereactive power to mitigate voltage sag, swell, interruption and improve powerfacor in various conditions.

D-statcom used to supply thereactive power and absorb the real power to maintain power quality as well. The detailed modeling and simulations of different control strategies are presented and implemented along with the necessary equations in the MATLAB simulink using the simpower systems tool boxes

Index terms - D-statcom, Voltage source converter, Voltage sag, Interruption, Voltage swell, power control and power quality

1. INTRODUCTION

Electricity supply plays an important role in the economic development and technology advancement throughout the world. Total quality and reliability of power supplies relates closely to the economic growth of a country. However, power quality disturbances such as sags, swells, flicker, harmonics, voltage imbalance etc. These power quality problems are very common in the electrical distribution systems .Power quality concerns the factors affecting, and the standard of, the received electrical power supply .increasingly concerned about the quality of electric power. There are four major reasons for the growing concern which are described as follows.

1) Load equipment is more sensitive to power quality variations than equipment applied in the past. Many new load devices contain microprocessor-based controls and power electronic device s that are sensitive to many types of disturbances.

2) The increasing emphasis on overall power system efficiency has resulted in a continued growth in the application of devices such as high-efficiency, speed motor drives and shunt capacitors for power factor correction to reduce losses. Thus concerned about the future impact on system capabilities.

3) Increased awareness of power quality issues by the end users. Utility customers are becoming better informed about power quality problems.

4) Many things are now interconnected in a network. Integratedprocesses means that the failure of any component has much more economic consequences. From the four major reasons stated above it can be deduced that the responsibilities and challenge of the utility sector are great in providing quality, supply to the end users such as factories, quality is ultimately a customer-driven issue and the customer's point of reference takes precedence.

The increased awareness in power quality Issues has brought tremendous changes and Improvements in power electronics devices. Different circuit topologies, control techniques and strategies are created aimed at mitigating power quality problems. The Custom Power concept is one of technological responses to the poor power quality presently surfacing in factories, offices and homes. Custom Power is dedicated to maintaining and improving the quality and reliability of distribution level power received and to protect customers against disturbances generated by other users on the network. This is to offer a 'Total Solution' package to the customer. The Custom Power concept is to providecustomer's solution by the utilities sector. Utility participation occurs at the distribution substation and/or at the front end of power supply.

There is also Flexible AC Transmission System (FACTS) devices that are concerned with improving power in the transmission system. The Custom Power offers the customer no power interruptions, tight voltage regulation, low harmonic voltage and acceptance of fluctuating and non-linear loads without affecting the terminal voltage.The Custom Power family includes Dynamic Voltage Restorer (DVR), Distribution Static Compensator (DSTATCOM), Solid State Fault Current Limiter (SSFCL), Solid State Transfer Switch (SSTS) and Active Power Filter CAPP).

The aim of this work is to investigate the applications that are enabled by equipping STATCOM with energy storage. With energy storage devices are able to exchange both active and reactive power, compared to only reactive power without storage. This gives an increased controllability and some additional uses. Furthermore, the studied applications concern power quality improvements which demand fast response times. Hence, uses which utilize slower response times, for example energy trading or deferring of grid reinforcements, are not treated. Additionally, this work examines the impact from dynamic loads on power system performance when compensators with and without energy storage, respectively, is used. In particular system damping and stability are investigated when the dynamic properties of the loads vary

2. D-STATCOM (DISTRIBUTION STATIC COMPENSATOR)

It is a FACTS device which is installed for the support of electricity networks which have poor power factor and voltage regulation also, commonly it is use for the stabilization of voltage and to improve power factor of that network. It is a voltage source converter based device, which can work as reactive power source. The D-STATCOM, in which the dc storage battery also connected with the device to charge in case of over voltage and to discharge in case of under voltage in this way by withdrawing and supplying the reactive power it can compensate the reactive power. Therefore it can improve the power factor and reduce the harmonics in the system. The D-STATCOM proposed here maintains the voltage magnitude within the limits by eliminating the voltage sags and swells in the system.

There are different components used in D-STATCOM i.e. Voltage Source Converter (VSC), Controller, Energy Storage Circuit, LCL Passive Filter

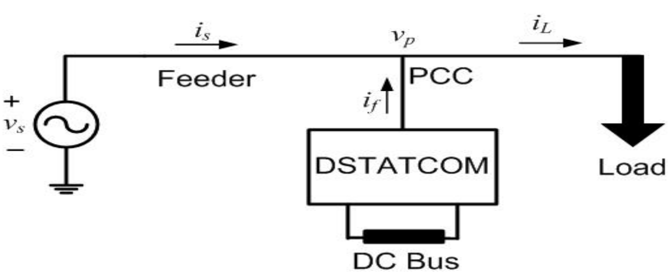

Fig. 2.1: D-STATCOM Components

2.1: Voltage Source Converter (VSC)

A voltage-source converter is a power electronic device that connected in shunt or parallel to the system. It 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. It also converts the DC voltage across storage devices into a set of three phase AC output voltages.

In addition, D-STATCOM is also capable to generate or absorbs reactive power. If the output voltage of the VSC is greater than AC bus terminal voltages, D-STATCOM is said to be in capacitive mode. So, it will compensate the reactive power through AC system and regulates missing voltages. These voltages are in phase and coupled with the AC system through the reactance of coupling transformers.

Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effectives control of active and reactive power exchanges between D-STATCOM and AC system. In addition, the converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The voltage source rectifier operates by keeping the requirements. Addition, the ac current waveforms can be maintained as almost sinusoidal, which reduces dc link voltage at a desired reference value, using a feedback control loop. To accomplish this task, the dc link voltage is measured and compared with a reference v_{ref}. The error signal generated from this comparison is used to switch the six valves of the rectifier ON and OFF. In this way, power can come or return to the ac source according to dc link voltage harmoniccontamination to the mains supply.Thesolid-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. VSC is a bidirectional component. As per the requirement this device converts the AC voltage to DC or DC voltage to AC voltage as per the requirement. It consists of diode, op-amp, and transistor circuit. VSC designed for this model works in two cases

2.2: D-STATCOM Controller

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is linked, under system disturbances. The control system only measures the RMS voltage at the load terminal i.e.no reactive power measurements are requisite. The VSC switching approach is based on a sinusoidal PWM technique which offers simplicity and good result. 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. Moreover, without incurring significant switching losses, high switching frequencies can be used to improve on the efficiency of the converter. The input of the controller is an error signal which is obtained from the reference voltage and the value RMS of the terminal voltage measured. Now Proportional-Integral (PI) controller will process this error signal and then the output is the angle δ, which is provides to the PWM signal generator. In this case converter is exchange active and reactive power exchange with the network simultaneously. Such error is deal with a PI controller the output is δ angle, which is providing to the PWM signal generator. It is vital to note that here, indirectly controlled converter, there is reactive and active power exchange with the network simultaneously. Proportional-integral controller (PI Controller) is a feedback controller which drives the system to becontrolled with a weighted sum of the error signal (difference between the output and desired set point) and the integral of that value. In an error signal is obtained by comparing the reference voltage with the RMS voltage measured at the load terminal. The PI controller processing the error signal generates the required angle to drive the error to zero, The RMS value of load voltage is took back to the reference voltage.

The sinusoidal signal V control is phase-modulated by means of the angle δ. i.e.

$$VA = \sin(\omega t + \delta) \text{ ----------------(a)}$$

$$VB = \sin(\omega t + \delta - 120^\circ) \text{ -------(b)}$$

$$VC = \sin(\omega t + \delta + 120^\circ) \text{ -------(c)}$$

Now in order to generate the switching signals for the VSC valves, the modulated signal V control is compared with a triangular signal. The main parameters of the sinusoidal PWM scheme are the amplitude modulation index of signal and the frequency index of the triangular signal. The amplitude index is kept fixed at 1 p.u, in order to obtain the highest fundamental voltage component at the controller output. Where V control is the peak amplitude of the control signal.

V is the peak amplitude of the triangular signal.

PWM generator is the device that generates the Sinusoidal PWM waveform or signal. To operate PWM generator, the angle is summed with the phase angle of the balance supply voltages equally at 120 degrees. Therefore, it can produce the desired synchronizing signal that required. PWM generator also received the error signal angle from PI controller. The modulated signal is compared against a triangle signal in order to generate the switching signals for VSC valves.

2.3 : Energy Storage Circuit

DC source is connected in parallel with the DC capacitor. It carries the input ripple current of the converter, ripple current is a rms value of alternating current flowing through a capacitor. This causes an internal temperature rise due to power losses within the capacitor, the rms effect on capacitor and it is the main reactive energy storage element. This DC capacitor could be charged by a battery source or could be recharged by the converter itself.

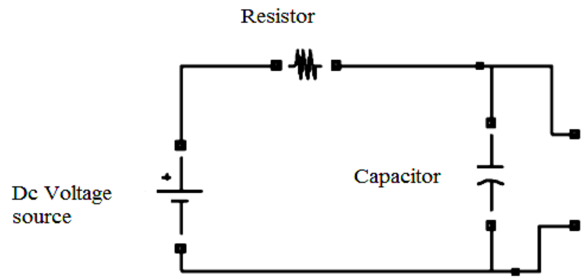

Fig. 2.3 : Circuit diagram of energy storage

2.4: LCL Passive Filter

There is used of inductor and capacitor so it is called passive filter .Commonly a high-order LCL filter has been used in place of the conventional L-filter for smoothing the output currents from a VSC. The LCL filter achieves a higher attenuation along with cost savings, given the overall weight and size reduction of the components. LCL filters have been used in grid-connected inverters and pulse-width modulated active rectifiers because they minimize the amount of current distortion injected into the utility grid, Good performance can be obtained in the range of power levels up to hundreds of kW, with the use of small values of inductors and capacitors. The LCL filter model is for reduction of harmonic distortion LCL filters are very effective. The main drawback with this is that the LCL-filter will introduce a resonance frequency in the system. Harmonic components in the output voltage can lead to resonance oscillations and instability problems unless they are properly handled. One way of reducing the resonance current is by adding a passive damping circuit to the filter. This damping circuit can be purely resistive, causing relatively high losses, or a more complex solutions consisting of a combination of resistors, capacitors and inductors. To design it following equations are required,

The LCL filter model is shown below

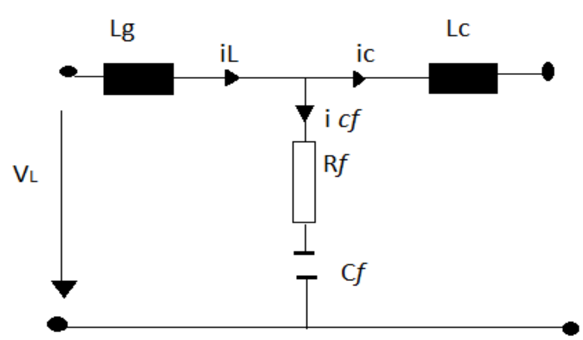

Fig. 2.3.4**:** LCL Passive Filter

3. RESULTS AND DISCCUSION

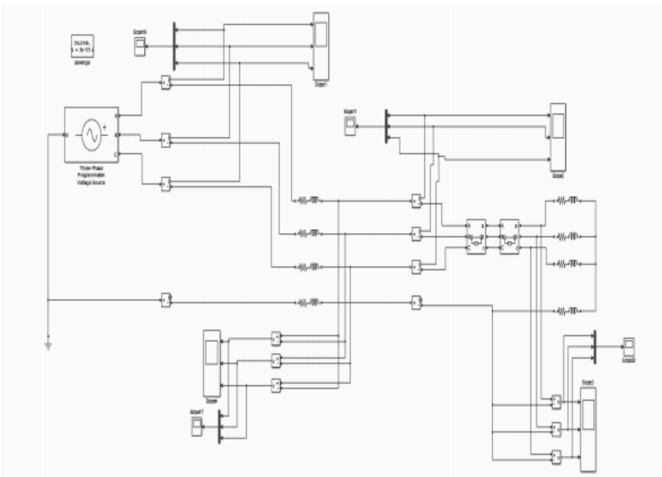

Fig Simulation model without D-statcom

MATLAB/SIMULINK modeling of three phase loads without D-statcom as shown in Fig.2. The fault is created in source side, the corresponding waveform as shown in Fig.3. and fault time is mentioned as given below,

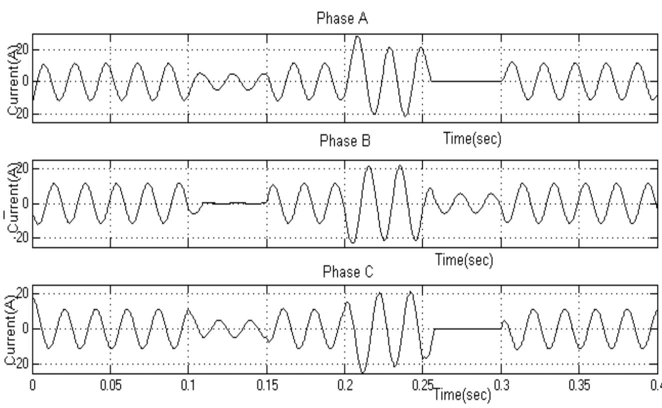

Fig. 3 Current waveform without D-statcom

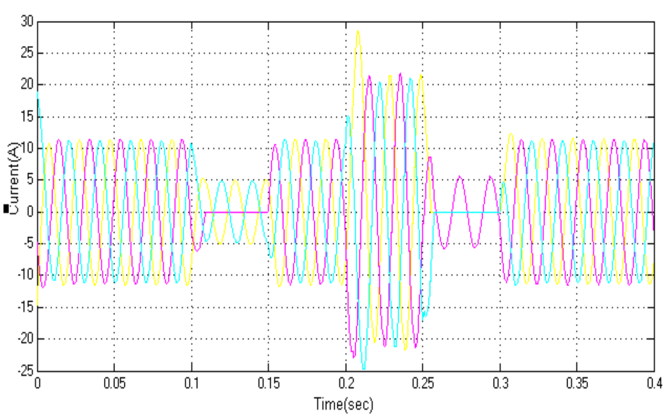

Fig .4.Three phase Current waveform without D-statcom

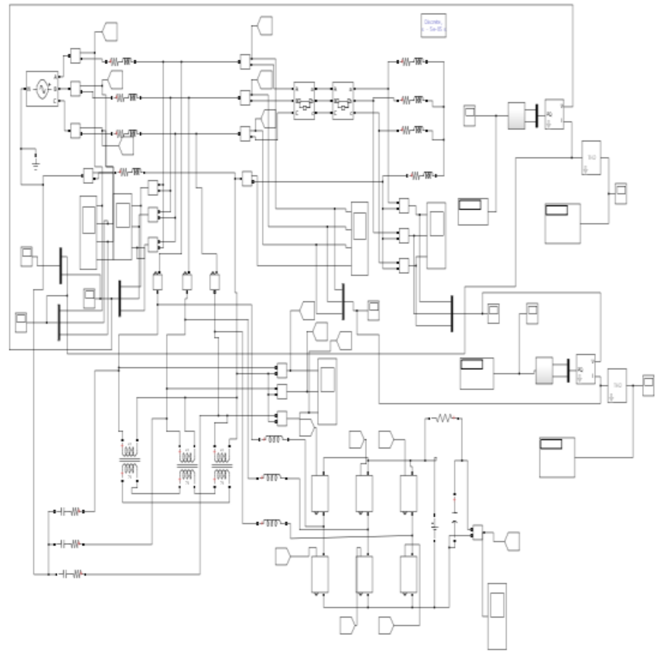

Fig.5 Simulation model with D-statcom

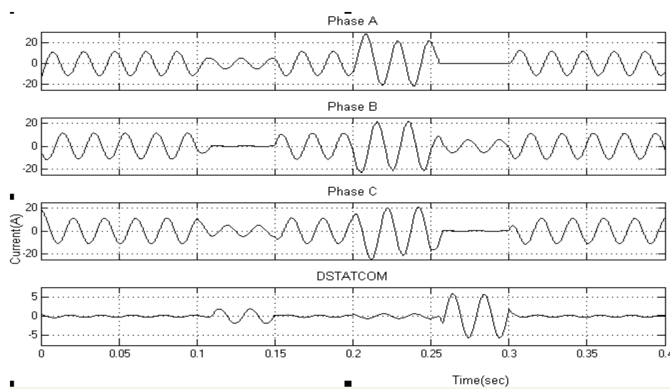

Fig.6 Current waveform with D-statcom

The three phase current waveform as shown in Fig.4. The three single phase signals are combined by using multiplexer to create the three phase signal as mentioned above

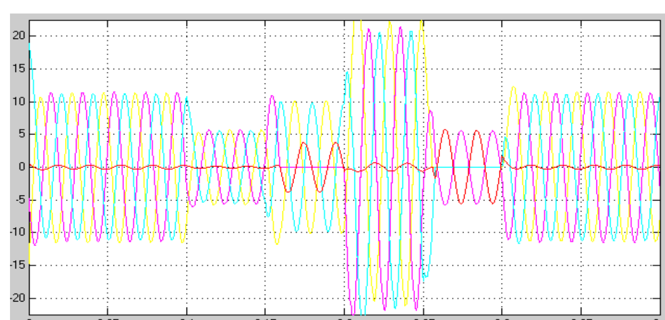

Fig.7 Three phase Current waveform with D-statcom

The faults time periods like sag from 0.1 to 0.15 sec, swell from 0.2 to 0.25 sec and interruption from 0.25 to 0.3 sec. These above faulting periods to damage utility side loads, Hence to compensate these problems, we are used in Dstatcom. The corresponding three phase loads with D statcom as mentioned above Fig.7. In transient condition fault current is produced, that fault current to affect or damage the voltage source converter. Hence to product the voltage source converter in D-statcom by using space vector pulse width modulation (PWM). The three phase current waveform as shown in Fig.7.

4. POWER FACTOR COMPARISION

Power factor comparison of source side and load sides as shown in Fig.8.The power factor level to improve in load side or utility side by using the D-statcom as mentioned the above figure. The directly source signal is supplying through the load to affect the sensitive loads and linear loads. These above problems to overcome by using D-statcom to improve the power factor in load side level. Similarly, it is also reducing the Total Harmonic Distortion (THD).

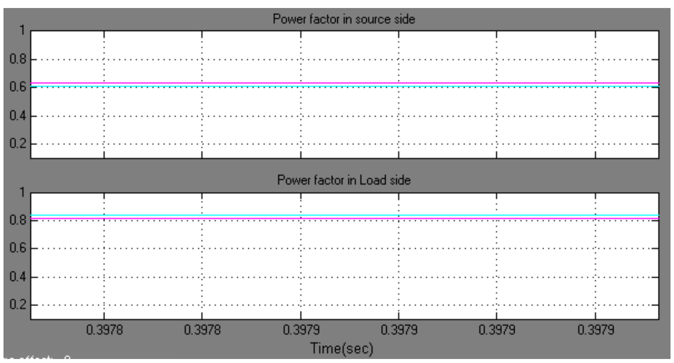

Fig .8.Power factor comparison for source and load side

5. CONCLUSION

D-STATCOM in system the power quality and voltage profile is improved. The power factors also increase close to unity. Thus by adding D-STATCOM with LCL filter the power quality is improved. Thus, it can be concluded that by adding D-STATCOM the voltage and current are improved that in addition to complete reactive power compensation, power factor correction and voltage regulation the harmonics are also checked, and for achieving improved power quality levels at the distribution end. By adding LCL passive filter with D-STATCOM, the THD is reduced. The custom power device D-STATCOM is connected in shunt with distribution system to improve the power quality. The voltage sag can be mitigated by connecting D-STATCOM to the distribution system. It can be concluded that D-STATCOM improves the power quality and remove the voltage sag condition in distribution network.

Thus, it can be concluded that by adding D-STATCOM with LCL filter the power quality is improved.

REFERENCES

[1] E. Hammad, "Comparing the voltage source capability of present and future var compensation techniques in transmis, July/August, PP. 682-688, 1999.*ery. Volume1. No.1 Jan 1995.*

[2] Anaya-Lara O, Acha E.,**"** Modelling and analysis of Custom Power Systems by PSCAD/EMTDC **",** *IEEE Trans on power Delivery , Volume 17, Isuue:2002, Pages: 266-272.*

[3] C. Han, A. Q. Huang, M. Baran, S. Bhattacharya, and W. Litzenberger, "STATCOM impact study on the integration of a large wind farm into a weak loop power system," *IEEE Trans. Energy Conv., vol. 23, no. 1, pp. 226–232, Mar. 2008.*

[4] D. L. Yao, S. S. Choi, K. J. Tseng, and T. T. Lie,"A statistical approach to the design of a dispatchable wind power—Battery energy storage system," *IEEE Trans. Energy Conv., vol. 24, no. 4, Dec. 2009*.

[5] G. Yalienkaya, M.H.J Bollen, P.A. Crossley, "Characterization of voltage sags in industrial distribution system" ,*IEEE* Trans *on industry applications, volume 34, No , July/August, PP.682-688, 1999.*

[6] H. Akagi, E. H. Watanabe and M. Aredes, **"**Instantaneous Power theory and Application to power conditioning", *Hoboken, NJ: Wiley, 2007.*

[7] Haque , M.H.," Compensation of Distribution Systems Voltage sags by DVR and D-STATCOM", *Power Tech Proceedings,2001 IEEE Porto, Volume 1, PP. 10-13, September 2001.*

[8] J. J. Gutierrez, J. Ruiz, L. Leturiondo, and A. Lazkano, "Flicker measurement system for wind turbine certification," *IEEE Trans.Instrum. Meas., vol. 58, no. 2, pp. 375–382, Feb. 2009.*

[9] K. Somsai and T. Kulworawanichpong , **"** Instantaneous Power control of D-STATCOM with consideration of power factor correction", *IEEE International conf. on* May 2010, PP. 1186-1190.