Optimizing Power Supply by Pwm Converter Based Shunt Connected Power Conditioners –Distribution Static Compensator

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Abstract

Increasing automation in modern industry and deregulation has changed the requirements on Power Quality. Computer and process control equipment as well as drive converters are sensitive to deviations of the line voltage from the ideal sinusoidal. Voltage sags, harmonic distortion, flicker and interruption of power supply are the most common problems. In an increasing number of cases, where conventional equipment cannot solve these problems, PWM converter-based shunt connected Power Conditioners named DSTATCOM (Distribution Static Compensator) have been introduced. Energy storage added to the Power Conditioner provides even more flexibility in system operation and planning for utilities and industry. Here Simulink model of test system is analyzed and test model of two similar loads with different feeders are considered. One of the feeders is connected to DSTATCOM and the other is kept as it is. This test system is analyzed under different fault conditions. The control technique implements a PI controller which starts from the difference between the injected current (DSTATCOM current) and reference current (identified current) that determines the reference voltage of the inverter (modulating reference signal).

Index Terms: Power quality,SVC,Voltage Sag,Voltage swell.

I. INTRODUCTION

***Introduction*:-** In 1999 the first SVC with Voltage SourceConverter called D-STATCOM (DISTRIBUTION STATIC COMPENSATOR) went into operation. The characteristics of D-STATCOM are similar to the synchronous condenser, the difference is that it is an electronic device, due to that it has no inertia and it is superior to the synchronous condenser in so many ways, such as better dynamics, a lower investment cost and lower operating and maintenance cost.

Principle of D-STATCOM

A one-line diagram of a static compensator (D-STATCOM) is shown in Figure-1 The D-STATCOM shown in this figure consists of self-commutated converters using Gate Turn off (GTO) Thyristors, a dc voltage source, a converter transformer, a step-up transformer, and a controller. Note that the step-up transformer is not normally necessary for the lower system voltage applications.[1][2]

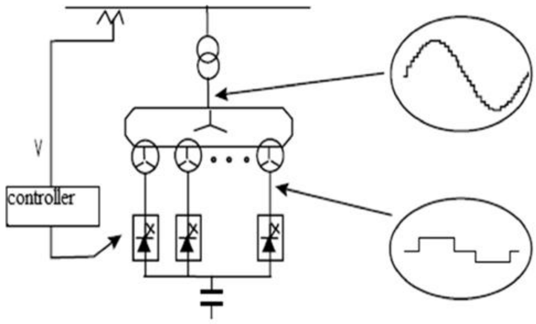

Fig.1 Single Line diagram of D-STATCOM

The basic electronic block of the D-STATCOM is the voltage Source Converter (VSC) that converts an input DC voltage into a three phase output voltage at fundamental frequency. In its most basic form, the D-STATCOM configuration consists of a Voltage Source Converter (VSC), a DC capacitor for energy storage; a coupling transformer connected in shunt with the AC system, and associated control circuits. In this arrangement, the steady-state power exchange between the device and the AC system is mainly reactive. Fig..2. shows the schematic representation of the D-STATCOM.[3][4]

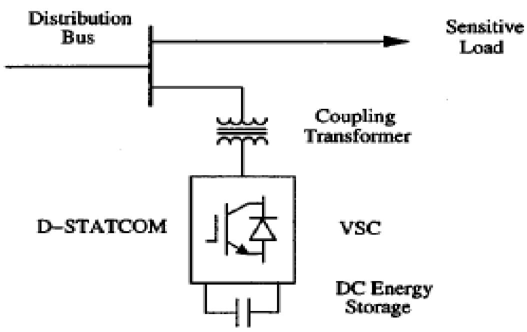

Fig.2 Schematic representation of the D-STATCOM

II. POWER QUALITY PROBLEMS

A. Power Quality

Power Quality is a term that means different to different people. Institute of Electrical and

Electronic Engineers (IEEE) standard IEEE 1100 defines power quality as "the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment." In simple words, Power quality is a set of electrical boundaries that allow a piece of equipment to function in its intended manner without significant loss of performance or life expectancy. This definition embraces two things that we demand from an electrical device which are performance and life expectancy.

B. Problems Regarding Power Quality [6][7]

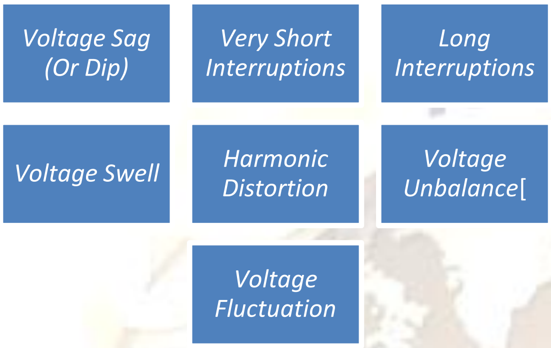

Fig.3 Power Quality Problems

III. DISTRIBUTION STATCOM

A. Principle of Reactive Power Control

The principle of reactive power control via D-STATCOM is well known that the amount of type (capacitive or inductive) of reactive power exchange between the D-STATCOM and the system can be adjusted by controlling the magnitude of D-STATCOM output voltage with respect to that of system voltage. The reactive power supplied by the D-STATCOM is given by-

$$Q= (V_i-V_S)/X * V_s$$

Where,
Q is the reactive power.
V_i is the magnitude of D-STATCOM output voltage.
V_S is the magnitude of system voltage.
X is the equivalent impedance between D-STATCOM and the system.

When Q is positive the D-STATCOM supplies reactive power to the system. Otherwise, the D-STATCOM absorbs reactive power from the system.

B. Load Compensation using D-STATCOM

The schematic diagram of a distribution system compensated by an ideal shunt compensator (D-STATCOM) is shown in Figure 4. In this, it is assumed that the D-STATCOM is operating in current control mode. Therefore its ideal behaviour is represented by the current source I_f. It is assumed that Load-1 is reactive, nonlinear and unbalanced. In the absence of the compensator, the current I_s flowing through the feeder will also be unbalanced and distorted and, as a consequence, so will be Bus-I voltage.

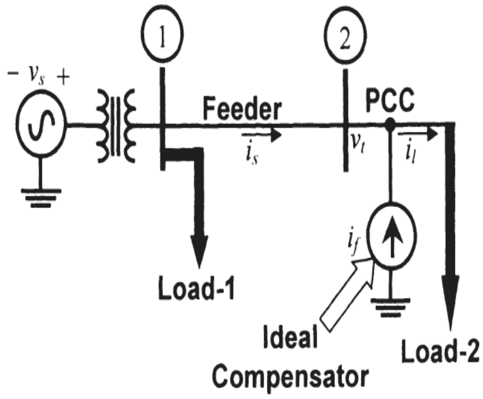

Fig.4 Schematic diagram of ideal load compensation

To alleviate this problem, the compensator must inject current such that the current I_s, becomes fundamental and positive sequence. In addition, the compensator can also force the current I_s to be in phase with the Bus-1 voltage. This fashion of operating the D-STATCOM is also called load compensation since in this connection the D-STATCOM is compensating the load current. From the utility point of view, it will look as if the compensated load is drawing a unity power factor, fundamental and strictly positive sequence current.
The point at which the compensator is connected is called the utility customer point of common coupling (PCC). Denoting the load current by I_L, the KCL at the PCC yields-

$$I_s + I_f = I_L \rightarrow I_s = I_L - I_f$$

The desired performance from the compensator is that it generates a current I_f that it cancels the reactive component, harmonic component and unbalance of the load current.[8][9]

Test System Parameters-. The system is employed with three phase generation source with configuration of 11KV, 50 Hz. This voltage is stepped up to 132KV with the help of three phase transformer connected in Y/Δand transmitted. At transmission receiving end this voltage is stepped down to 11KV with the help of three phase transformer connected inΔ/Y. Then 11KV is given to three phase, three windings transformer with power rating 250MVA, 50 Hz which is feeding two distribution lines.

1. Winding 1: V1rms (ph-ph) = 11 KV, R1 = .002 (pu), L1 = .08002 (pu).
2. Winding 2: V2rms (ph-ph) = 440 KV, R2 = .002 (pu), L2 = .08002 (pu).
3. Winding 3: V3rms (ph-ph) = 440 KV, R3 = .002 (pu), L3 = .08002 (pu).

A two-level DSTATCOM is connected to the 440V tertiary winding to provide instantaneous current support at load point. A 750μF capacitor on the dc side provides the DSTATCOM energy storage capabilities.

IV. IV.IMPLEMENTATION

Simulink model of the test system is given in Figure-5. The system consists of two parallel feeders with similar loads of same rating. Here static linear load is taken. One of the line is connected to DSTATCOM and the other line is kept as it is. This system is analyzed under different fault conditions.

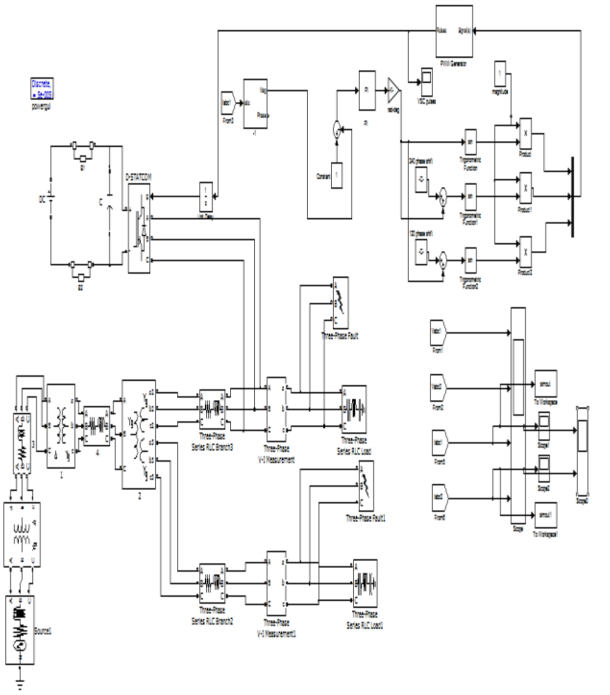

Fig 5:Simulink model of test system with linear load.

CASE 1. Single Line to Ground Fault Condition

In this case, a single line to ground fault is considered for both the feeders. Here the fault resistance is 0.001 ohm and the ground resistance is 0.001 ohm. The fault is created for the duration of 0.2s to 0.3s. The output wave for the load current with compensation and without compensation is shown in Figure-5.1and Figure-5.2respectively.

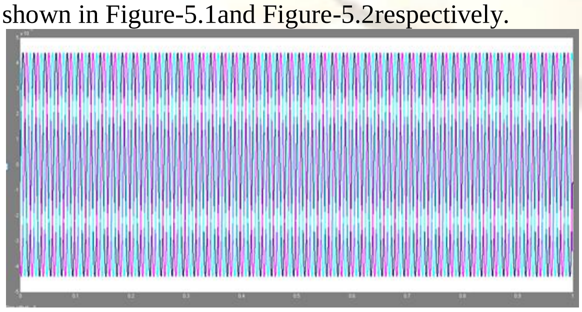

Figure-5.1: Load current (with compensation)

The output wave shapes clear that the current in the phase where fault is created is increasing during the fault duration in the uncompensated feeder,but in system where the DSTATCOM is connected unbalancing is reduced clearly.

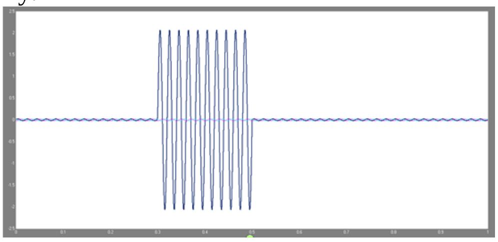

Figure-5.2: Load current (without compensation)

CASE 2. Double Line to Ground Fault Condition

In this case, a Double line to ground fault is considered for both the feeders. Here the fault resistance is 0.001 ohm and the ground resistance is 0.001 ohm. The fault is created for the duration of 0.2s to 0.3s. The output wave for the load current with compensation and without compensation is shown in Figure-5.3andFigure-5.4 respectively.

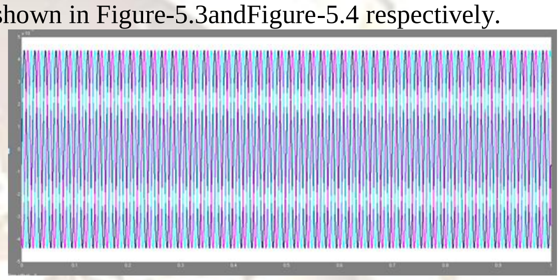

Figure-5.3: Load current (with compensation)

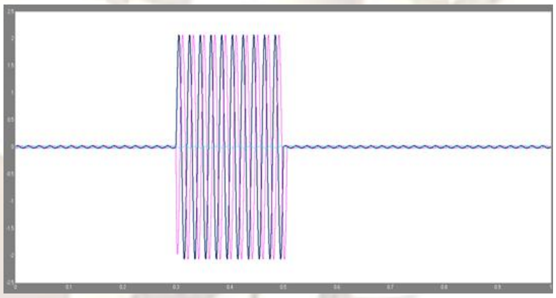

Figure-5.4: Load current (without compensation).

V. CONCLUSION

The results give the satisfactory applications of DSTATCOM in the distribution networks under different fault conditions and it can be concluded that DSTATCOM effectively improves the power quality in distribution networks with static non-linear loads.

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