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Mitigating Voltage Sags and Faults Using STATCOM in Power System

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***Abstract*—** Voltage instability problems are attracting more and more attention in the areas of power system operation, planning and control. These problems are becoming a more serious concern with the ever-increasing utilization and higher loading of existing transmission systems, particularly with increasing power demands, and competitive generation and supply requirements. As the power demand increases different techniques are being introduced in order to improve the power quality issues. In this paper, a FACTS controller, Static Compensator (STATCOM) is being used in the power system in order to mitigate the common power quality issues like voltage sags. STATCOM is also used to overcome various faults. The simulations were performed using *MATLAB/SIMULINK.*

Keywords*-STATCOM, Voltage Sag, Faults, power quality issues*

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I. INTRODUCTION

In recent years Electrical Power Quality had obtained more attention in power engineering. In present day, power distribution systems are suffering from severe power quality problems. Under heavy load conditions, voltage sag or swell may occur in the system. Of course the industry would consider power outage to be serious than small voltage sags and swells, but voltage instabilities occurring more often can cause severe problems and economic losses. So to overcome these issues Flexible AC Transmission System (FACTS) controllers are used. As the power wheeling has become increasingly prevalent, the power electronic devices are utilized more frequently to ensure reliability and stability and to increase maximum power transmission.

The static synchronous compensator, or STATCOM, is a shunt connected FACTS device. It generates a balanced set of three phase sinusoidal voltages at the fundamental frequency, with rapidly controllable amplitude and phase angle. It consists of a dc capacitor, three-phase inverter, coupling transformer and a control strategy [1].

According to IEEE Standard 1159-1995, a voltage sag is defined as the decrease in the RMS voltage level to 0.1 – 0.9 p.u. of the nominal voltage, at power frequency for durations of half cycle to 1 minute.

II. STATIC COMPENSATOR

STATCOM is controlled reactive source with the same operating principle as that of a conventional synchronous compensator [1]. It includes a voltage source converter and a DC link capacitor connected in parallel to generate or absorb the reactive power

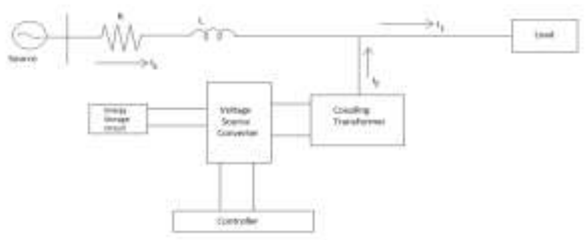

Figure.1. Block diagram of STATCOM in shunt with the transmission line

A. Modelling

The Voltage source converter based STATCOM is the dominant topology. Figure.2. shows the equivalent circuit of the STATCOM [2]. Applying KCL we get the following circuit equations.

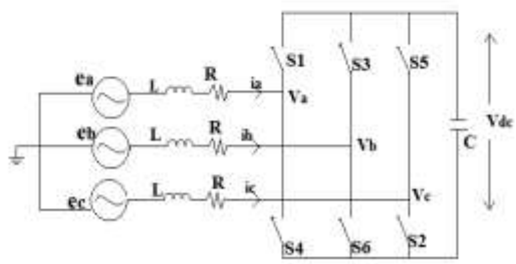

Figure.2. Equivalent circuit of STATCOM

$$\frac{di_a}{dt} = \frac{R}{L}i_a + \frac{1}{L}(e_a - V_a) \quad \text{.................(1)}$$

$$\frac{di_b}{dt} = \frac{R}{L}i_b + \frac{1}{L}(e_b - V_b) \quad \text{.................(2)}$$

$$\frac{di_c}{dt} = \frac{R}{L}i_c + \frac{1}{L}(e_c - V_c) \quad \text{.................(3)}$$

B. Voltage Source Inverter

The conventional voltage source inverters give a two level AC output for DC input. Inverters are chosen based on their applicability on its efficiency and simplicity. Even though the two level inverter is of low cost the progress in multilevel inverters field is increasing due to their many applications. As this is a well known and established system it is used frequently.

Voltage source inverter is connected in parallel to the transmission system. It can produce sinusoidal voltage of any magnitude, phase angle and frequency. It converts the DC voltage into three phase AC voltage [3].

Adjusting the magnitude and phase angle, the active and reactive power flow between the STATCOM and the system can be controlled.

C. Energy Storage Circuit

DC source is connected in parallel with the DC capacitor. It is the main reactive energy storage element. It carries the input ripple current. Numbers of energy storage systems are available; the simpler one is the DC capacitor. This capacitor can be charged by any battery source or by the inverter itself as shown in figure 1 [4,5,6].

D. Controller

A proportional-integral controller (PI controller) is a control loop feedback mechanism (controller) widely used in industries. It drives the system to be controlled by the error which is the difference between a measured process variable and a desired set point.

The positive sequence of the feedback voltage from the STATCOM is given to the PI controller whose output is compared to the triangular sequence for obtaining the synchronized gate pulses [4]. The control block is shown in figure.3.

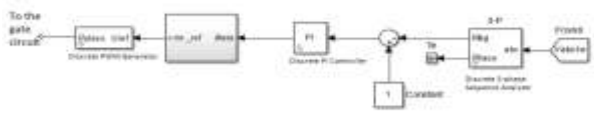

Figure.3. Control Block

III. SIMULATION CIRCUIT AND RESULTS

The three phase six pulse converter with MOSFET as the switching device is designed and simulated with an energy storage system and control block

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TABLE I. SIMULATION PARAMETERS

Simulated parameter	Value
Source Voltage	120 KV
Transmission Line Length	30 Km
DC Capacitor	750µF
DC Source	5 KV

The simulation circuit is as shown in the figure.4. and figure.5

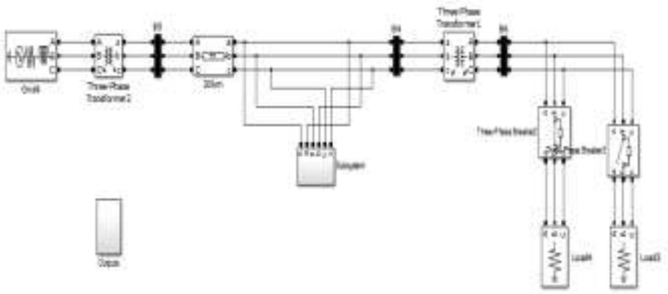

Figure.4. Simulation circuit for Voltage Sag and Swell Condition

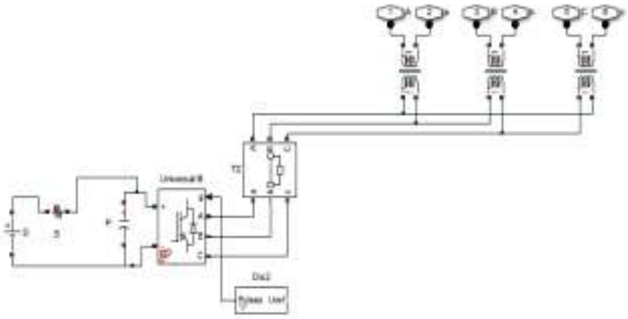

Figure.5. Subsystem including energy storage system, voltage source inverter and coupling transformers

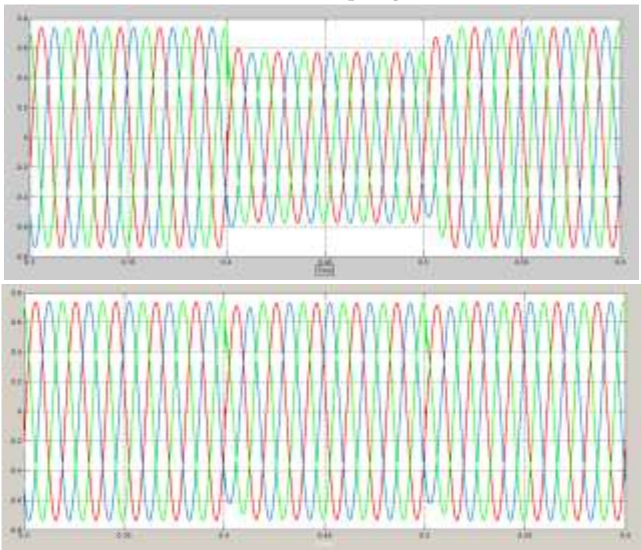

Figure.6. Voltage waveforms under Sag condition without and with STATCOM

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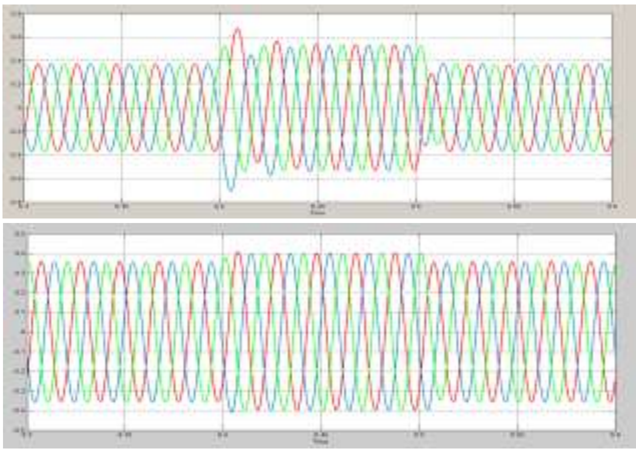

Figure.8. Current waveforms under Three-phase to ground fault without and with STATCOM

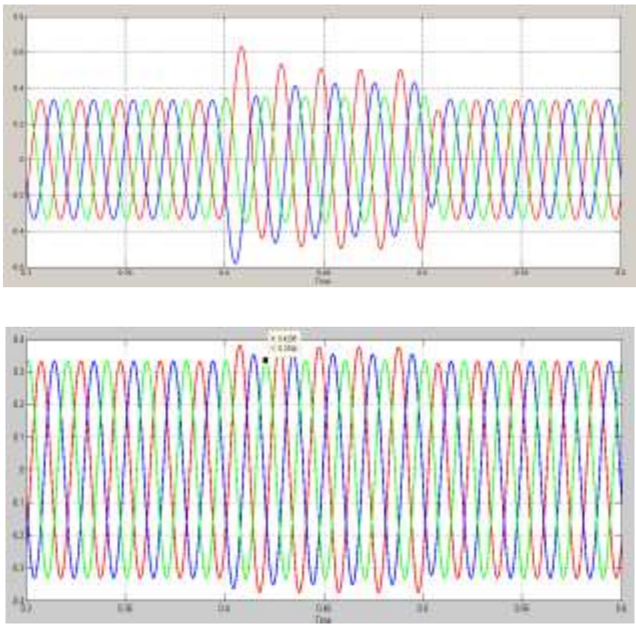

Figure.9. current waveforms under double line to ground fault without and with STATCOM

IV. CONCLUSION

The circuit with STATCOM was simulated using ***MATLAB/SIMULINK.*** The simulation results obtained show that the power quality issues like Sag and Swell can be overcome by using Static Compensator. The fault currents were also reduced using STATCOM.

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