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Technique of Controlling the Cascaded H-Bridge SSSC using Zero-Sequence Voltage and Negative-Sequence Current

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Abstract **- This paper presents a control scheme of cascaded H-bridge SSSC in three-phase power systems. By this method, the SSSC can control output current almost freely. But it needs wide margin of dc voltage under large power system voltage unbalance. To avoid this, we exclusively use the two methods depending on the extent of voltage unbalance. Solving this problem, a technique using zero sequence voltage and negative-sequence current is proposed. By this scheme, the SSSC is allowed to operate under asymmetrical conditions by power system faults. The validity is examined by digital simulation under one line and two-lines fault circuit condition.**

Keywords: Cascaded H-bridge, Static Series Synchronous Compensator, FACTS.

I. INTRODUCTION

Recently, several methods of voltage balancing between phase clusters are proposed. One method is based on zero-sequence voltage injection. However it needs wide margin of dc capacitor voltage compared with rated power system voltage when the unbalance of power system voltage is large. The other method handles the capacitor voltage unbalance by independently controlling active power of individual phase cluster, but unbalance of power system voltage is not considered. By these reasons, the circuit condition in which these methods are effective is considered to be limited in practical use. We also had proposed a capacitor voltage balancing method using negative-sequence current. It does not need wide margin of dc capacitor voltage and can handle large unbalance of power system voltage.

However the output current of the SSSC using the method is uniquely determined by the unbalance of power system voltage and function of the SSSC is limited. So we introduce a different control method using zero-sequence voltage in this paper. By this method, the SSSC can control output current almost freely. But it needs wide margin of dc voltage under large power system voltage unbalance. To avoid this, we exclusively use the two methods depending on the extent of voltage unbalance. Solving this problem, a technique using zero sequence voltage and negative-sequence current is proposed. By this scheme, the SSSC is allowed to operate under asymmetrical conditions by power system faults. The validity is examined by digital simulation under one line and two-lines fault circuit condition.

II. EXISTING TECHNIQUES

Static Series Synchronous Compensator (SSSC) is a voltage sourced converter based series FACTS controller. It provides capacitive or inductive compensation independent of line current. The power electronics topology of SSC is similar to that of SSSC. It is incorporated into the ac power system through a series coupling transformer which injects an independently controlled voltage in quadrature with the line current for controlling the transmitted power. Thus, it can be considered to be controllable effective line impedance. Another control technique has described the development of a control scheme suitable for practical implementation of the inverter based compensator. Practical results are presented demonstrating the ability of the compensator to provide a rapidly controllable magnitude of compensating reactance in the transmission line. Comparisons of the performance of four different controllers on laboratory prototype of UPFC are also described.

They have shown that the performance of the system with cross-coupling and H -∞ controllers are better when the exact value of the power transmission parameters is unknown. Two novel control schemes namely the indirect control and direct control using pulse width modulation (PWM) switching techniques are discussed for a 48 pulse VSC model of SSSC for a grid connected SSSC in both capacitive and inductive modes of operation through a simulation study. The constant reactance control shows a superior performance than constant voltage control for voltage regulation and damping oscillation in a weak power system.

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A novel technique have investigated the influence of the two modes of SSSC viz. constant reactance mode and constant quadrature voltage mode on the damping power, synchronizing power and transient stability limit of a radial power system. It is also shown that the inherent delay of a phase locked loop (PLL) has an effect on the dynamic operation of the SSSC; and the authors have proposed a new auxiliary regulator to enhance the dynamic performance of the SSSC which is validated by simulation. Another control strategy described the loading margin in voltage stability assessment on the modified IEEE-14 bus system with different FACTS controllers, SSSC being one of them. Two control schemes have been proposed by the authors where one is the conventional coordination scheme and the other is a modified control scheme wherein the performance of the FACTS devices especially SSSC is improved. The schemes have been verified experimentally and their feasibility is established. The conventional cascaded H - bridge converters suffers with demerits like more switching losses as it consists of series H-bridge cells. Moreover, the output voltage contains harmonics and often these, are beyond the acceptable limits.

We have analyzed various methods are available on zero sequence voltage and these techniques requires a large capacitor to inject voltage such capacitors are required whenever the unbalanced voltages appears in the system. The cause for unbalanced voltages is faults in the networks. It also suffers with practical issues with capacitor size. Similarly, the negative sequence voltage injection also suffers with handling issues and hence SSSC is limited to certain range of capacitors only.

This makes us to propose a new control technique to overcome such limitations. A combination of both zero sequence voltage and negative sequence currents are used to operate SSSC. These techniques can handles the consequences due to unsymmetrical conditions arise from various system faults. This control technique is also used in cascaded H-bridge in SSSC topology to improve the performance. MATLAB is used to test the effectiveness of the proposed method.

III. PROPOSED SYSTEM

The proposed system mainly used the Static Synchronous Series Compensator (SSSC) is a solid-state voltage source inverter that injects variable magnitude sinusoidal voltage in series with the line, which is almost in phase with the line current that in turn, emulates an inductive or a capacitive reactance in series with the transmission line. This variable reactance influences the electric power flow through the transmission line. A portion of injected voltage provides the inverter loss thereby increasing the efficiency.

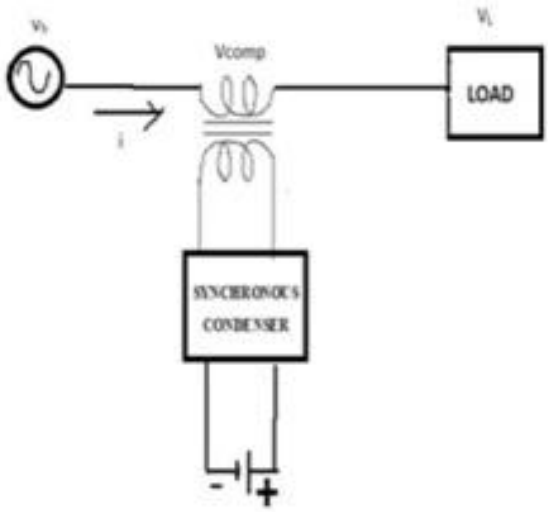

Figure 1: Static Synchronous Compensator

A SSSC can operate as a series compensator without external supply whose output voltage is in phase with, and controllable independently of, the line current for increasing or decreasing the overall reactive voltage drop across the line to control the active power transmission. This series compensator includes transiently rated energy storage and energy absorbing devices in order to enhance fluctuations in the power system by temporary real power compensation. This is achieved by adjusting the resistive voltage drop across the line, thereby controlling the power flow effectively for both low and high load conditions.

IV. SYSTEM MODEL & OUTPUT

The simulink model of the proposed system is shown and the output of the system also given below.

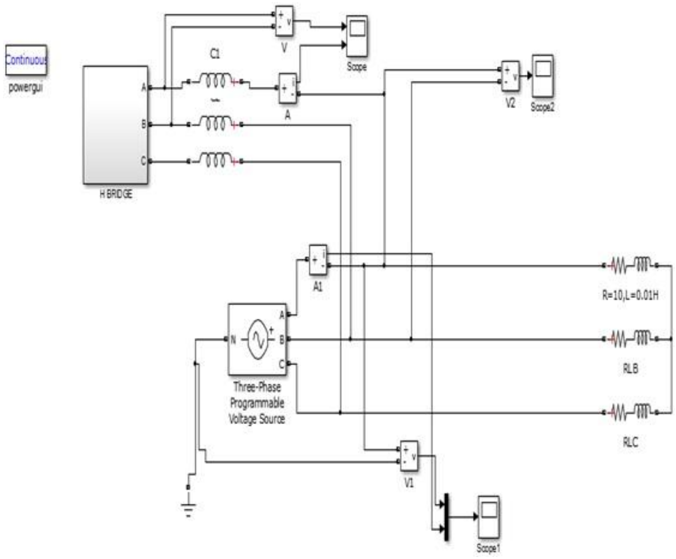

Figure 2: Simulink model of proposed system

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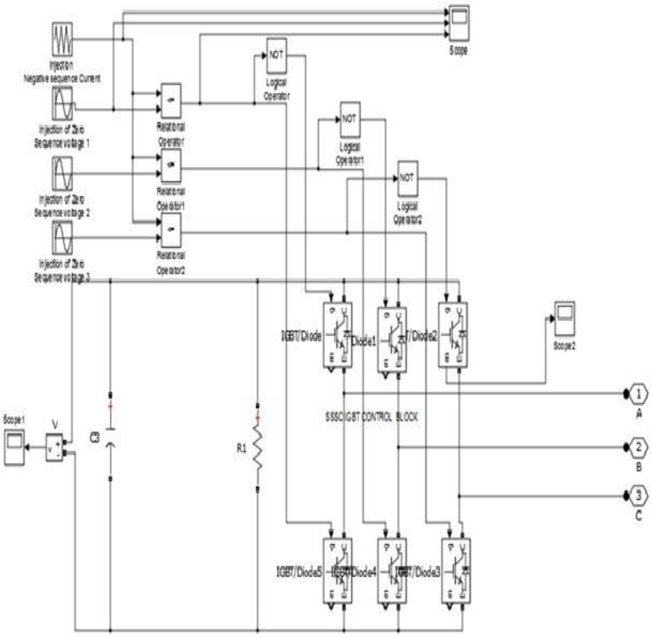

Figure 3: Subsystem

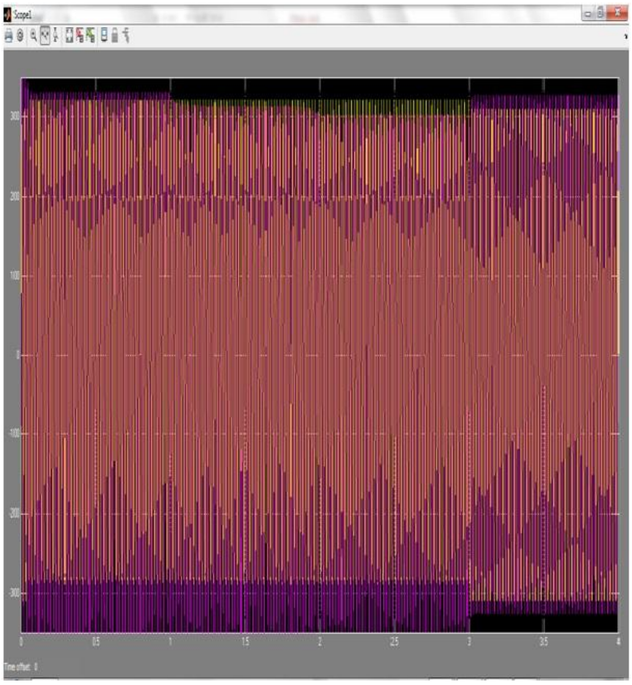

Figure 4: Scope1 output

The simulation result of power system voltage and is shown in Fig. 4. The SSSC compensates power system voltage. As a result, grid connection voltage is 263 V higher than source voltage during 1LG and 2LS. Before 1LG (t<2s), the capacitor voltages of phase clusters are balanced and the voltage ratio of H-bridge cells is controlled to 1:2:4.

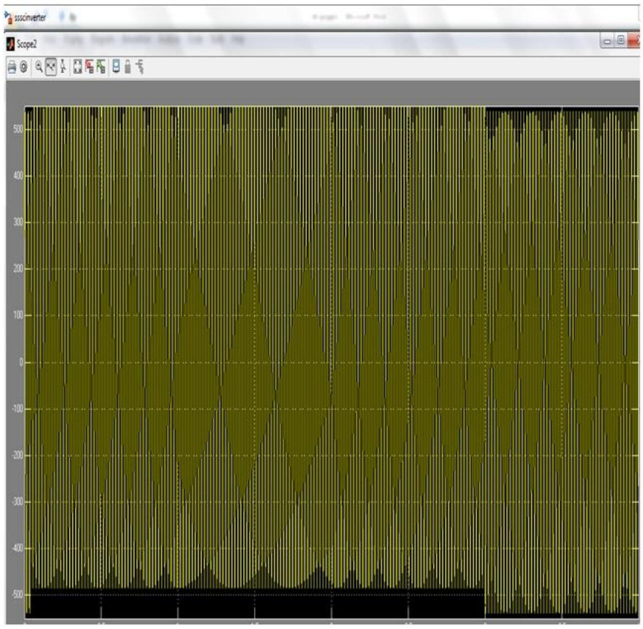

Figure 5: Scope2 output

If the zero-sequence voltage method was used under 2LS, the SSSC outputs balanced current, as shown in Fig. 5. But the peak value of the SSSC output voltage is about 6000 V. Thus, the SSSC had to output high voltage and a wide margin of dc capacitor voltage was need.

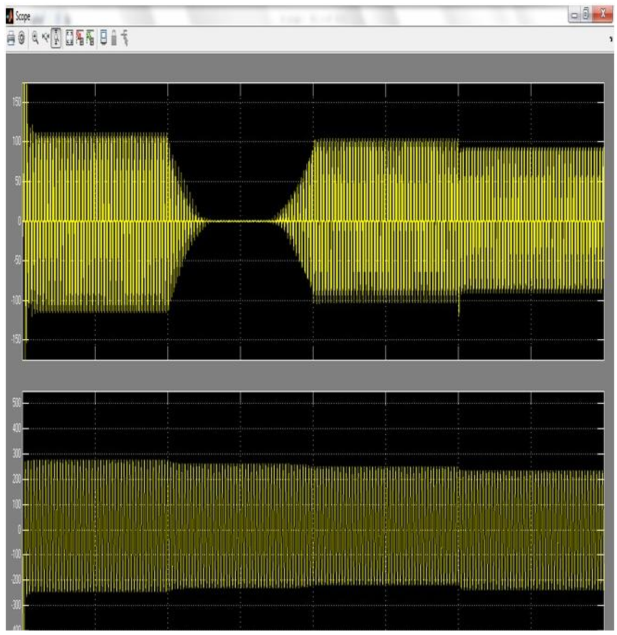

Figure 6: Scope output

Fig. 6 shows the power system voltage, STATCOM output voltage and SSSC output current. Under normal condition or 1LG (t<4s), the zero-sequence voltage method is used and balanced current are output, as shown in Figure. The peak value of the currents is about 120 A.

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V. CONCLUSION

In this paper an effective configuration and control method is presented for a cascaded H-bridge SSSC in three-phase power system. The proposed control method is based on the zero-sequence voltage and negative-sequence current, which is used exclusively depending on the extent of voltage unbalance. By this method, SSSC can operate flexibly under normal power system condition and does not need wide margin of dc capacitor voltage under large asymmetrical condition. The validity is examined by digital simulation under one line and two-lines fault conditions. The simulation results show the effectiveness of proposed SSSC.

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