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Static Synchronous Series Compensator: Series compensator for better transmission of power in long transmission line

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Abstract — This paper describes an approach to series line compensation in which MOSFET based voltage source inverter is used for series compensation. This compensator called Static Synchronous Series Compensator is compensate reactive power and give batter reduction in harmonic components for identical resistive load connected to transmission line. Also give better voltage profile of transmission line. Here simulation is carried out on single phase 500KM long transmission line with ideal resistive load where series compensation introduced in middle of line.

Keywords- Multilevel Inverter, PLL, Static Synchronous Series Compensator, Transmission Line, Transformer

I. INTRODUCTION

Some of the major issues that are involved in high power transmission are to enhance the level of power transfer capability and give a flexible control of power flow through the line. To achieve these**,** mostly we are using solid state devices for faster control and reliable operation. The initial investment of installing any of these devices is high, primary studies shows that in many times the installation cost is paid back by the savings and get benefits within a few months. Power electronic devices, which are used for power flow control, are categorized under the name of flexible ac transmission systems (FACTS). There are three major facets of FACTS. They are shunt compensation, series compensation and phase angle regulation.

The shunt compensation is mostly used in short distance lines where series compensation can be used for long transmission line. The series compensation has received much attention. Series capacitor compensation is an excellent method to relieve power congestion in the lines.

Sub synchronous resonance (SSR) is a dynamic phenomenon that denotes an energy exchange between a generating thermal power plant and a closely connected transmission system. In particular, the problem of SSR is related to the interaction between a series-compensated transmission line and the mechanical system in the generator unit. The series compensation also gives nearer to sinusoidal waveforms.

FACTS technologies offer competitive solutions to today's power systems in terms of increased power flow transfer capability, enhancing continuous control over the voltage profile, improving system damping, minimizing losses, etc. FACTS technology consists of high power electronics based equipment with its real-time operating control. [3,4]

AC transmission systems (FACTS) devices are installed in power systems to increase the power flow transfer capability of the transmission systems, to enhance continuous control over the voltage profile and/or to damp power system oscillations. The ability to control power rapidly can increase stability margins as well as the damping of the power system, to minimize losses, to work within the thermal limits range, etc.

TYPES OF THE FACTS CONTROLLER: [1] In general, FACTS controllers can be divided into four categories:

1. Series controllers
2. Shunt controllers
3. Combine series-series controllers
4. Combine series-shunt controllers

From this four controllers mostly series and shunt controllers are used.

II. APPLICATION OF SERIES COMPENSATION [4,5,7]

High power quality is becoming desirable for industrial factories and commercial building. The use of electronic devices has improved the manufacturing process by providing a means for automated production. Automated production processes are particularly sensitive to electrical disturbances such as voltage sags and swells, voltage flicker, and harmonic interference. Voltage sags that last for only a few milliseconds can cause entire production processes to stop. The applications for a SSSC are the same as for traditional controllable series capacitors. The SSSC can be used for power flow control, voltage stability, and phase angle stability. The benefit of the SSSC over the conventional controllable series capacitor is that the SSSC can induce both capacitive and inductive series voltages on a line. In other words, the SSSC has a wider range of operation compared with the traditional series capacitors. A SSSC can increase or decrease the power flow in a transmission line. Since power system stability is crucial, the SSSC has better possibilities for damping electromechanical oscillations compared to fixed capacitors. The primary reason that the converter type SSSC is not frequently used for series compensation is that the SSSC requires an interfacing transformer to the power system. The interfacing transformer is a big cost disadvantage to traditional series capacitors. In other words, performance is sacrificed for cost.

or a similar sans-serif font). Callouts should be 9-point non-boldface Helvetica. Initially capitalize only the first word of each figure caption and table title. Figures and tables must be numbered separately. For example: “***Figure 1. Database contexts” , “Table 1. Input data***”. Figure captions are to be centered *below* the figures. Table titles are to be centered *above* the tables.

III. BASIC PRINCIPLE OF SSSC

Due to numerous advantages of SSSC nowadays it is used as series compensator in the transmission line. It injects nearly sinusoidal voltage in series with transmission voltage. It can provide compensating voltage independent to magnitude of line current [4]. As other series compensator ideally SSSC injects pure sine wave at the fundamental frequency. The output of SSSC is ideally near to zero at other frequency. So it is not resonant with line impedance to create a sub synchronous oscillation in the line.[5]

The SSSC, as a series compensator, has two modes of operation: 1) the constant reactance mode, in which the SSSC voltage is proportional to the line current, and 2) the constant quadrature voltage mode, in which the SSSC voltage is constant quadrature voltage independent of the line current[4].The heart of the SSSC is a voltage source inverter (VSI) that is supplied by a dc storage capacitor or battery. The VSI is mainly multilevel inverter [5].

An SSSC comprises a voltage source inverter and a coupling transformer that is used to insert the ac output voltage of the inverter in series with the transmission line.[1,6]

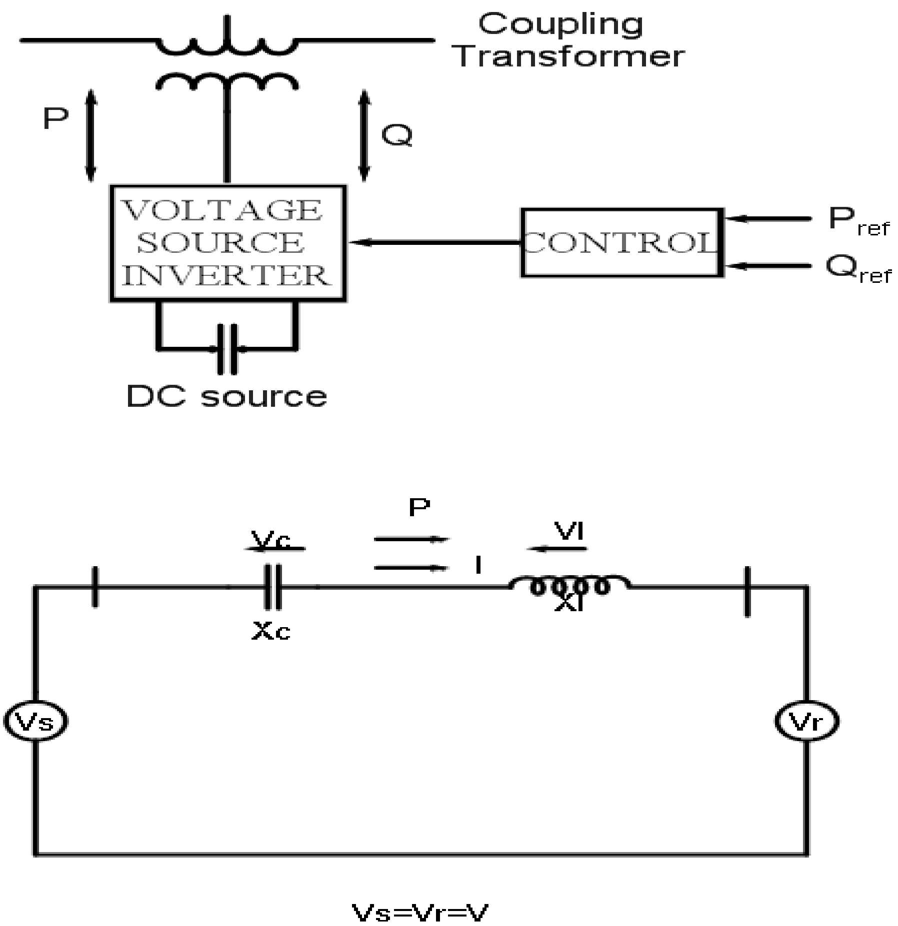


Figure 1

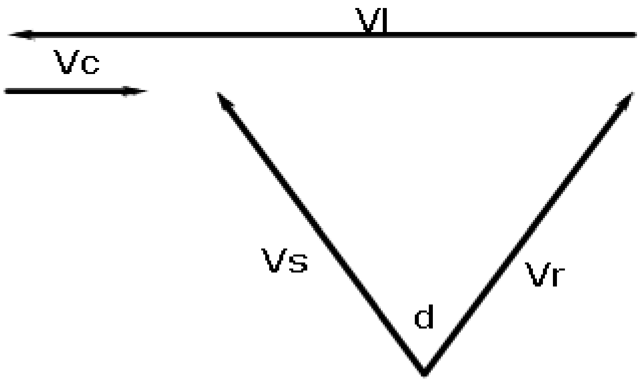


Figure 2

The SSSC injects the compensating voltage in series with the line irrespective of the line current. The transmitted power Pq, therefore becomes a parametric function of the injected voltage, and can be expressed as follows:

$$V q = \pm jVq\ (\zeta)\ I/I$$

The SSSC, therefore can increase the transmittable power, and also decrease it, simply by reversing the polarity of the injected ac voltage. Also if the injected voltage is larger than the line voltage (V_1-V_2) then the power flow can be reverse.

3.1 Power Topology

Multilevel Inverter:

The concept of multilevel converters has been introduced since two decades. The term multilevel began with the three-level converter. However, the elementary concept of a multilevel converter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. It gives almost sinusoidal wave with low harmonic distortion.[2]

The multilevel topology can be classified in three ways:

1. Diode clamp multilevel inverter (DCMLI)
2. Flying capacitor clamp multilevel inverter (FCMLI)
3. Cascade (H Bridge) clamp multilevel inverter

Among these are DCMLI and FCMLI has some drawbacks, it is placed by H bridge inverter. In recent application of power inverter mostly H Bridge is used as it gives numerous advantages. In H bridge MLI we can control on real power flow also.

3.2 Simulation Work:

For simulation of SSSC, thirteen level cascade H Bridge multilevel topology is used. This consist six series single H Bridge inverter units. Each Bridge generates different voltage levels as its source connected. Here all Bridges are connected with different DC source as an input of the inverter. In this model as a power electronic device MOSFET is used. For switching of the MLI fundamental frequency switching and PWM switching is used. Figure shows the single phase transmission line with R load, which is series compensate by 2 level pwm inverter. The inverter voltage is the reference voltage of the transmission line which is given by feedback loop which consists PLL circuit as shown. It also shows the two level inverter circuit, output voltage and current waveforms, THD analysis. This system has the THD value of 14.04%.

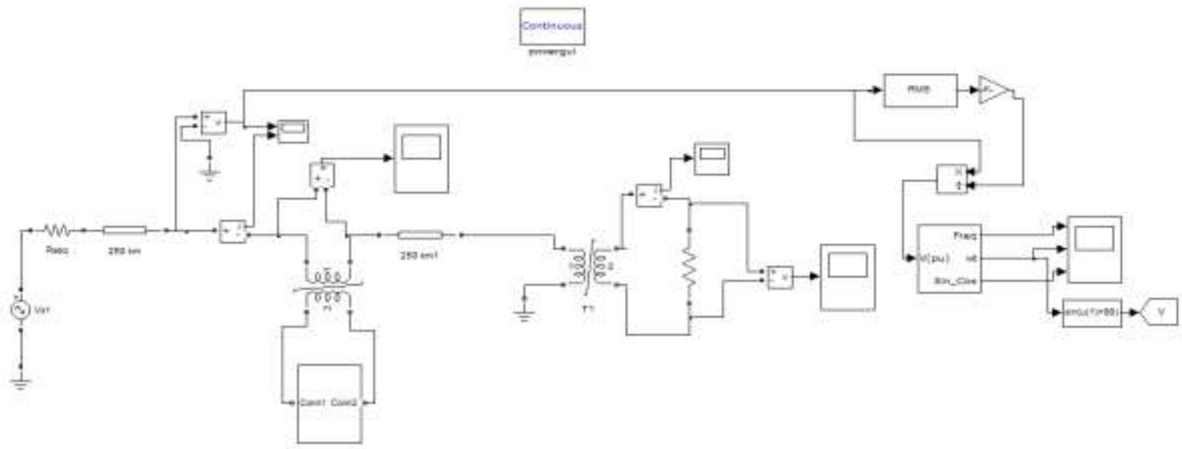
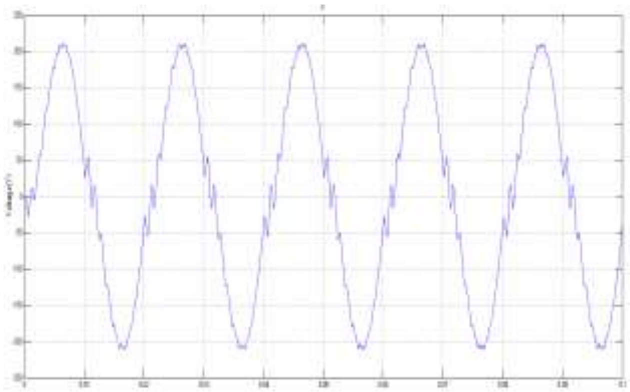
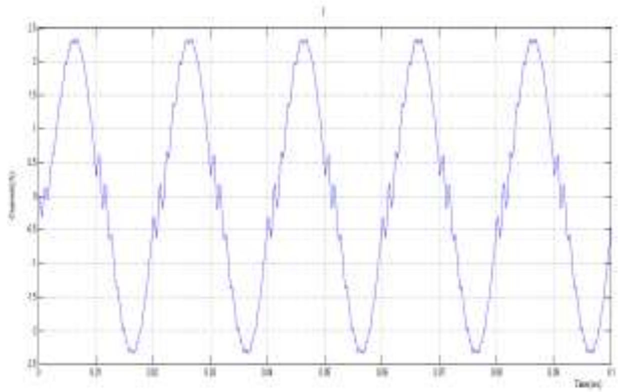


Figure 3



Voltage Waveform



Current Waveform

THD Analysis:

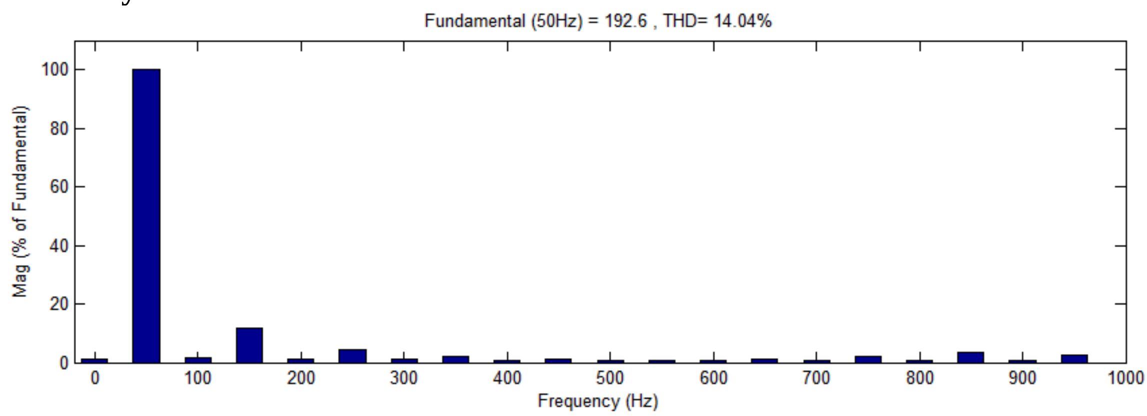


Figure shows the single phase transmission line with R load, which is series compensate by 13 level pwm inverter. The inverter voltage is the reference voltage of the transmission line which is given by feedback loop which consists PLL circuit as shown. It also shows the two level inverter circuit, output voltage and current waveforms, THD analysis. This system has the THD value of 10.16%.

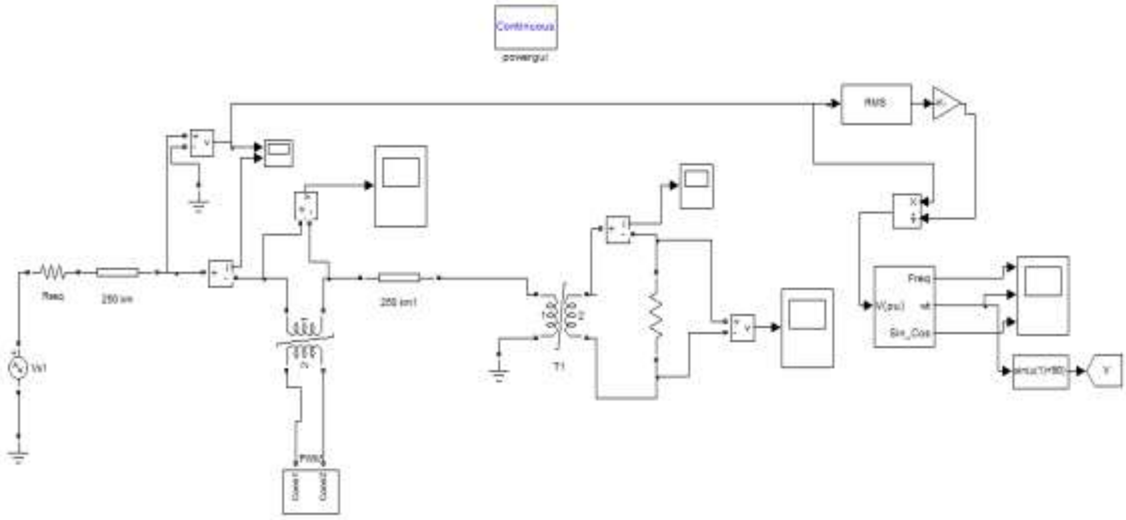
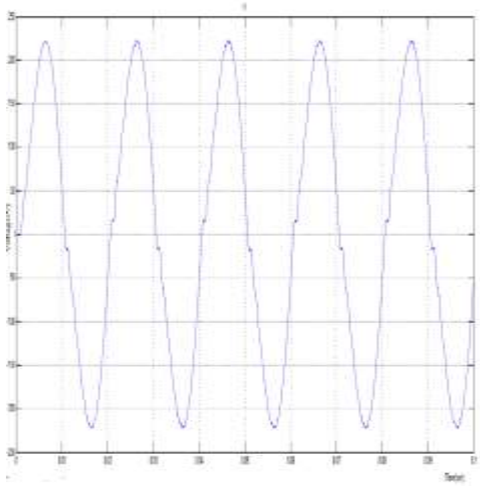
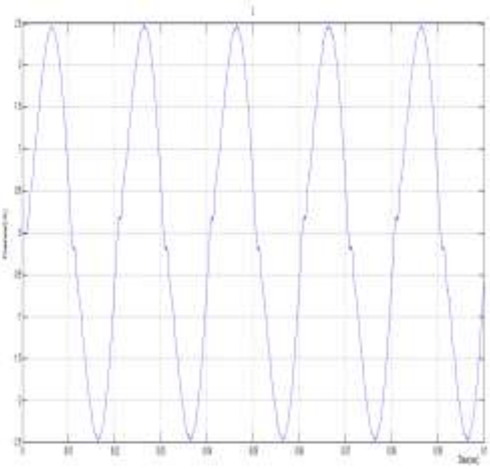


Figure 4

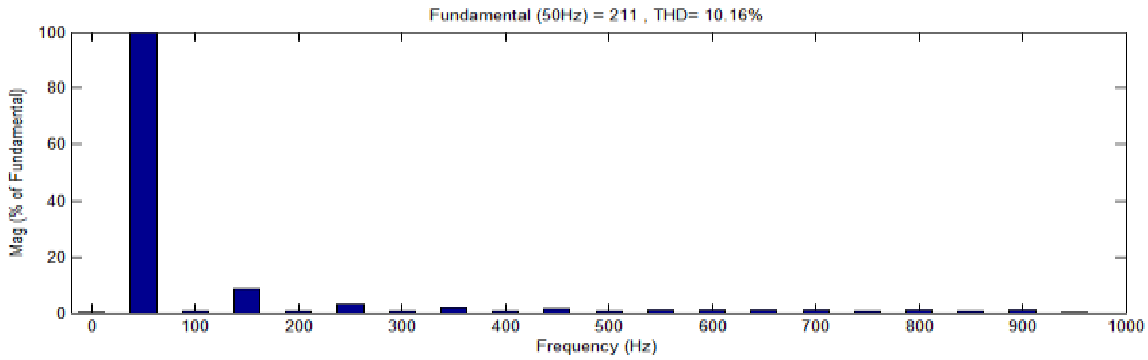


Voltage Waveform



Current Waveform

THD Analysis:



IV. CONCLUSION

As the demand of power is increased we need high power transmission with better power transfer capability and flexible control. The series FACTS device are used for long transmission line, is connected series in transmission line to increase power transfer capability and compensate reactive power flow through the line. Whereas shunt FACTS device is used for short transmission line.

In this paper, 2 level and 13 level inverter connected in series with single phase transmission line have been simulated and the output results are shown. It was found from the simulation that THD of 2 level inverter is around to 15% and whereas 13 level inverter is 10%. Hence it can be concluded that 13 level MLI gives less THD compare to 2 level inverter.

REFERENCES

[1] Narain G. Hingorani and Laszlo Gyugyi," Understanding FACTS, Concepts and Technology of Flexible AC Transmission Systems."

[2] Muhammad H. Rashid, "POWER ELECTRONICS, CIRCUITS, DEVICES AND APPLICATION".

[3] L, Sunil Kumar and Arindam Ghosh, "Modeling and Control Design of a Static Synchronous Series Compensator", IEEE Transactions on Power Delivery, Vol. 14, No. 4, October 1999.

[4] Fawzi A. L. Jowder, Member, IEEE, "Influence of Mode of Operation of the SSSC on the Small Disturbance and Transient Stability of a Radial Power System", IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 20, NO. 2, MAY 2005.

[5] L, Sunil Kumar and Arindam Ghosh, "Modeling and Control Design of a Static Synchronous Series Compensator", IEEE Transactions on Power Delivery, Vol. 14, No. 4, October 1999.

[6] Zhong Du, Member, IEEE, Leon M. Tolbert, Senior Member, IEEE, Burak Ozpineci, Senior Member, IEEE,and John N. Chiasson, Senior Member, IEEE ," Fundamental Frequency Switching Strategies of a Seven-Level Hybrid Cascaded H-Bridge Multilevel Inverter", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 24, NO. 1, JANUARY 2009.

[7] Fang Zheng Peng, Senior Member, IEEE, John W. McKeever, and Donald J. Adams," A Power Line Conditioner Using Cascade Multilevel Inverters for Distribution Systems", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 34, NO. 6, NOV/DEC 1998.