ISSN: 0975-833X

Available online at http://www.journalcra.com

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 13, Issue, 11, pp.19724-19727, November, 2021

DOI: https://doi.org/10.24941/ijcr.42660.11.2021

RESEARCH ARTICLE

A STATIC SYNCHRONOUS SERIES COMPENSATOR CONNECTED TO INFINITE BUS FOR POWER QUALITY IMPROVEMENT AND PHANTOM POWER CONTROL

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ARTICLE INFO

Article History:
Received 15th August, 2021
Received in revised form
29th September, 2021
Accepted 18th October, 2021
Published online 30th November, 2021

Keywords:

Reactive Power, SSSC,
Matlab Simulink.

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ABSTRACT

The new inventions in technology lead to more power consumption by more number of nonlinear loads, which in turn effecting the quality of power transmitted. The power transmitted in a line is needed to be of high quality. The flow of power basically depends on the line impedance, sending end and receiving end voltage magnitudes. Nonlinear loads create harmonic currents which in turn creates system resonance, capacitor overloading, decrease in efficiency, voltage magnitude changes. The simulation results show that FACTS devices improve the system stability; furthermore, the SSSC-based stabilizer provides a better effectiveness on damping power system oscillation.

Citation: Namburi Nireekshana, Sravan Kumar, K., Vijayakar, N. and Teja, K. "A Static Synchronous Series Compensator Connected to Infinite Bus for Power Quality Improvement and Phantom Power Control", *2021. International Journal of Current Research, 13, (11), 19724-19727.*

INTRODUCTION

What is Reactive Power?

It is the quantity that has become a fundamental concept to the analysis and understanding of AC electric power systems. In general, this quantity is only defined for Alternating Current (AC) electric systems. Reactive power control has been the subject of a systematic study as it plays an important role in maintaining a secure voltage profile in a large-scale transmission system. Though it is a byproduct of alternating current systems, it is needed for the acceptable functioning of various electrical systems such as transmission lines, motors, transformers, etc. It is essential for the operation of all most all of the electromagnetic energy devices for producing the magnetic field. In some cases it is forcefully injected into the power system network to maintain higher node voltage.

Reactive power is both the problem and solution to the power system network for several reasons. It plays an important role in the electrical power system for various functions such as satisfying the reactive power requirement, improving the voltage profiles, decreasing the network loss, providing sufficient reserve to ensure system security in emergencies, and other several functions.

Proposed technology: An SSSC is used to investigate the effect of this device in controlling active and reactive powers as well as damping power system oscillations in transient mode. The SSSC equipped with a source of energy in the DC link can supply or absorb the reactive and active power to or from the line. The SSSC offers an alternative to conventional series capacitive line compensation. It is a solid-state voltage source that internally generates the desired compensating voltage independent of the line current. The voltage source nature of the SSSC provides the basis for its superior operating and performance characteristics not achievable by series capacitor type compensator: Internal reactive power generation and absorption without ac capacitors or reactors: control of reactive compensating voltage independent of the magnitude of the line current. An SSSC is a member of FACTS family, which is connected in series with a power system, consisting of a solid state voltage source converter that generates a controllable alternating current voltage at fundamental frequency. When the injected voltage is kept in quadrature with the line current, it can be emulated as inductive or capacitive reactance – so as to influence the power flow through the transmission line. Primary purpose of an SSSC is to control power flow in steady state; it can also improve transient stability of a power system. SSSC controller provides efficient damping to power system oscillations and greatly improves the system voltage profile. The inter-area and local modes of power system oscillations are effectively damped by using this proposed SSSC controller. The proposed stabilizers have been applied and tested on power systems under severe disturbance and different loading conditions. It is also FACTS-based stabilizer provides great damping characteristics and enhances significantly the system stability compared to individual designs.

Working: SSSC is a modern power quality FACTS device that employs a voltage source converter connected in series to a transmission line through a transformer. The SSSC operates like a controllable series capacitor and series inductor. The primary difference is that its injected voltage is not related to the line intensity and can be managed independently. This feature allows the SSSC to work satisfactorily with high loads as well as with lower loads.

The Static Synchronous Series Compensator has three basic components:

- Voltage Source Converter (VSC) – the main component
- Transformer – couples the SSSC to the transmission line
- Energy Source – provides voltage across the DC capacitor and compensate for device losses

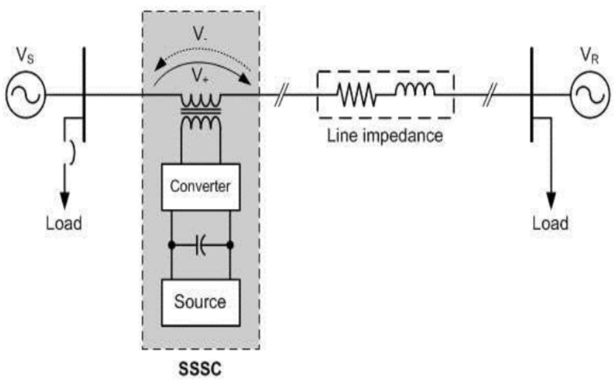

Figure 3.1. Structure of SSSC

Operation and Capabilities: Static synchronous series compensator works like the STATCOM, except that it is serially connected instead of a shunt. It can transfer both active and reactive power to the system, permitting it to compensate for the resistive voltage drops – maintaining high effective X/R that is independent of the degree of series compensation. However, this is costly as a relatively large energy source is required. On the other hand, if control is limited to reactive compensation then a smaller supply should be enough.

In this case, only the voltage is controllable because the voltage vector forms 90º with the line intensity. Subsequently, the serial injected voltage can advance or delay the line current, meaning, the SSSC can be uniformly controlled in any value. The SSSC when operated with the proper energy supply can inject a voltage component, which is of the same magnitude but opposite in phase angle with the voltage developed across the line. As a result, the effect of the voltage drop on power transmission is offset. In addition, the static synchronous series compensator provides fast control and is inherently neutral to sub-synchronous resonance.

Modes of Operation: Generally, the line reactance is constant but its net effect can be controlled through voltage injection. For instance, the line current decreases as the inductive reactance compensation level increases from 0% to 100%. Meanwhile, the line current increases with the capacitive reactance compensation level from 0% to 33%.

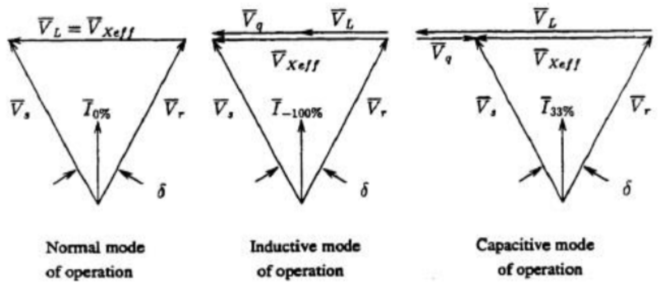

Figure 4.1. SSSC Modes of Operation

It can be noted that the static synchronous series compensator does not only increase the transferable power but it can also decrease it, by simply reversing the polarity of the injected voltage. This reversed polarity voltage is fed directly to the line voltage drop as if the line impedance was increased. In short, the effects of reactance compensation on normalized power flow in the transmission line are as follows:

- When the emulated reactance is capacitive, the active and reactive power flow increases, and the effective reactance decreases as the reactance compensation increases in the positive direction.
- , When the emulated reactance is inductive, the active and reactive power flow decrease, and the effective reactance increases as the reactance compensation increases in the negative direction.

Advantages: Compared to other FACTS controllers, SSSCs are superior due to the following advantages

- They eliminate bulky passive components such as capacitors and inductors.
- They can supply or absorb reactive power. The ability to offer inductive and capacitive operating modes symmetrically is also a benefit.
- When connected with a DC power source on the DC side of an SSSC, they can exchange real power to the power system.
- SSSCs can also connect to other renewable sources such as wind or any AC source. In such cases, an extra converter is included to convert AC to DC, which precedes the DC-link capacitor in an SSSC's structure.

- The power electronic converter (which, in most cases, is a DC-AC converter or inverter) is the heart of an SSSC. Cadence's software is a popular tool for simulating different topologies of power electronic inverters, and is not limited to circuits ranging from rectifiers, choppers, and cyclo converters.

Applications

The main role of SSSC is controlling the active and reactive powers; besides these – it could fairly improve the transient oscillations of the system.

- SSSC is capable of controlling the flow of power at a desired point on the transmission line. It injects a fast changing voltage in series with the line irrespective of the magnitude and phase of the current.
- The capability of SSSC to exchange both reactive and active power makes it possible to compensate both the reactive and resistive line voltage drops and there by maintain a high effective X/R ratio for the line independently of the degree of series compensation. Thus, optimal power transmission (high active to reactive power ratio) can be attained even at a high degree of series compensation.
- The reactive shunt compensation is highly effective in maintaining the desired voltage profile along the transmission line interconnecting two busses of the AC system and providing support to the end voltage of radial lines in the face of increasing power demand.
- The Total Harmonic Distortion studies – performed under both the conditions keeping SSSC on and off – shows that the harmonic content introduced to the line current is very low, due to the utilization of a multi-pulse inverter in the construction of the device, which inherently filters harmonics up to certain levels and thus enhances the output waveform quality.
- Controllable series line compensation is applied to achieve full utilization of transmission assets by controlling the power flow in the lines, preventing loop.
- With the use of fast controls, minimizing the effect of system disturbances, thereby reducing traditional stability margin requirements.
- The non-capacitor like nature, the superior operating characteristics and application flexibility that SSSC offers effectively is a compensation for power flow control and system stability improvement

RESULTS

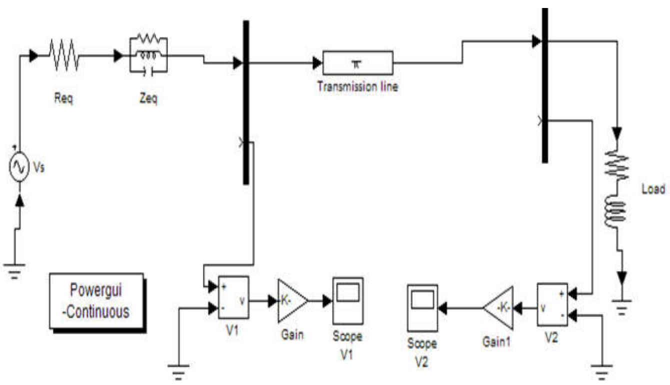

Fig.7.1. Circuit of a transmission line

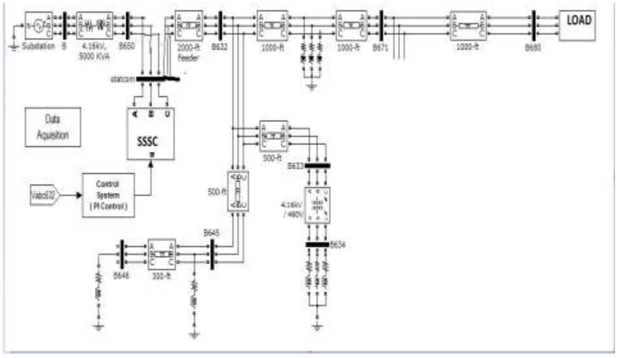

Figure.7.2. Simulation diagram

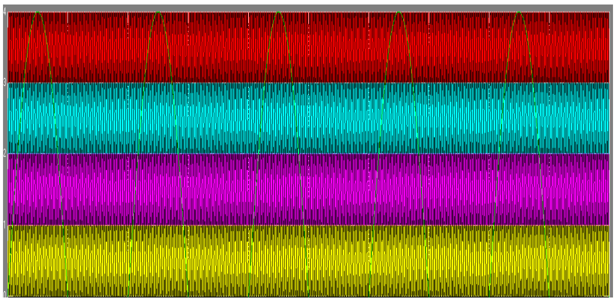

Figure.7.3. Voltage wave form

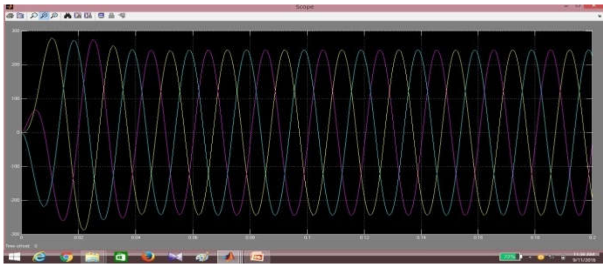

Figure.7.4. Source voltage wave form

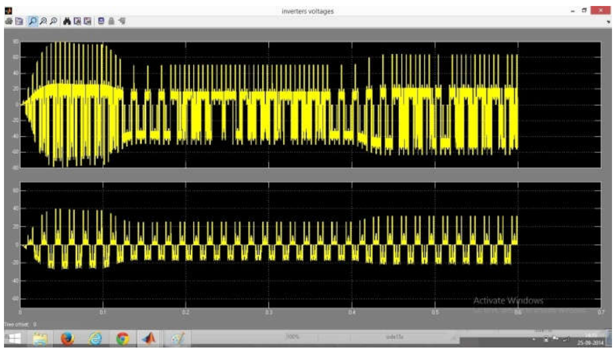

Figure 7.5. Inverter voltages

CONCLUSION

The proposed method introduces low cost low power rating SSSC in Single Machine Connected to infinite Bus system which improves the power quality.

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