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Research Paper

Compensation of voltage Sag using STATCOM

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Abstract

Due to unpredicted non-linear loads, power quality problems, a raise in the transmission system. One such problem is voltage sag. Voltage sag is caused by the non-linear load which demands reactive power, but the balanced 3Φ source provides required reactive power of the load with reduced voltage at the receiving end. In this paper, simulation study has been performed to reducethe voltage sag issue. A transmission system with generation source with different loading conditions is considered and study has been done. A 3Φ medium Π model transmission line is designed with a power source of 11kV. A shunt connected compensation unit called Static Synchronous Compensator (STATCOM) reduces the voltage sag in the transmission line. STATCOM provides the required reactive power demanded by the non-linear load along with the source for compensation of voltage sag. The STATCOM circuit comprises of Voltage source converter(VSC) unit and a DC source. Reactive power compensation is done by VSC unit firing angle control. The source of the STATCOM can also be from renewable energy system. This AC source is converted by a AC-DC-AC converter unit.The firing angle is controlled by the control unit which ensures the continuous and balanced power flow even under sudden change in load conditions. The simulation results depict the characteristics of the developed STATCOM.

Keywords: *Power quality, Voltage Source Converter, Static Synchronous Compensator, Voltage Sag, Non-linear load.*

1. Introduction

In India, in the distribution system either no device is employed to alleviate the effects such as voltage drop caused due to higher R/X ratio. The conventional devices which are used have many limitations[22]. The transmission system transmits electrical energy, the losses produced in the transmission system makes the magnitude of sending end voltage not to appear completely in receiving end. The major causes for the losses are the resistance of the conductor and the reactive power needed by the load is beyond the limit generated by the source. [1] This leads to the deterioration of PQ standards of the transmission system and it affect the operation of certain electronic gadgets [2] This power loss can be minimized by providing the required reactive power using the compensators.

The compensator chosen in the paper is STATCOM[4] as it has a faster response of the order of ½ cycle and has better V-I characteristics when compared to SVCs.[3]STATCOM is shunt connected power electronic device which is connected at the mid-point of the transmission line through coupling transformer[5] The STATCOM can provide required reactive power support to the transmission system and to some extend can also compensate real power.[7]The transmission line voltage is reduced to 415 volts and is connected with non-linear loads are considered for analysis.[21] The STATCOM generates an AC voltage, due to which a current of variable magnitude flows at the point of common coupling(PCC) in the transmission system. This current is nearly quadrature with the line voltage, thus at PCC an inductive or a capacitive reactance is connected in the transmission system[6] and provides the required real power and reactive power compensation [8].This method can be used to reduce the power quality issues and improve fault ride-through capability of a wind farm[20][22]. Controller design for dc-dc converters [23-25]

2. Block Diagram

Fig.1shows the block diagram of the system with STATCOM circuit which is the 3ϕ inverter and a DC source which is connected with the transmission system wherethe voltage has to be compensated. The DC source can also bea renewable energy conversion system.

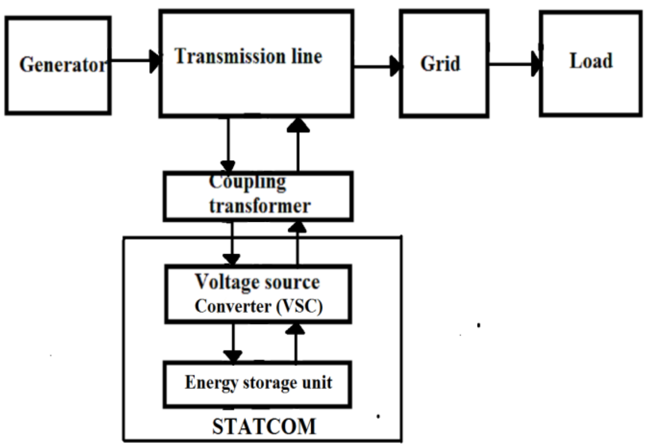


Fig. 1: Block diagram of transmission system with STATCOM

3. System Description

As shown in Fig.2 A11kVgeneration source is connected with the R load of 100 KWthrough a medium π transmission line of length 100km. The transmission line parameters are R=2Ω and L=20mH.The transmission is connected with a second load of same rating throughcircuit breaker for short duration of 0.2 to 0.4sec.

Source	11kV
Supplyfrequency	50 Hz
Grid reactive power	Zero
Load	100KW
Transmission line length	100km
DC link voltage	Vdc = 5kV

An extra load of the same rating is added in parallel with the load that is already present as depicted in Fig.3 The extra load is connected in the line through a circuit breaker. The breaker

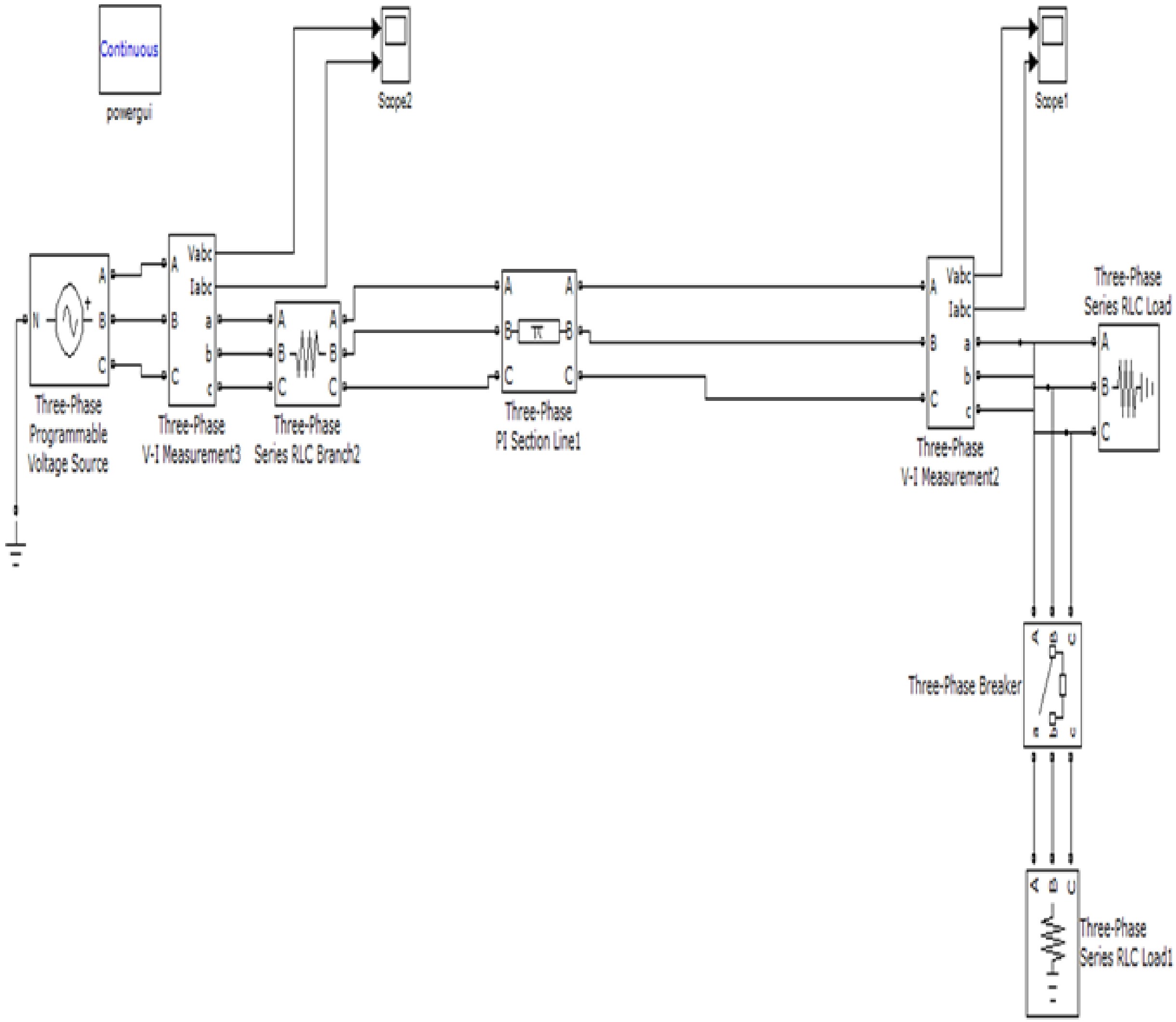


Fig. 2: Simulink model of power system

condition is initially open and the closing period of the circuit breaker is given between 0.2 to 0.4 seconds, so only during that time the extra load will be added to the circuit. Due to the addition of the extra load the current drawn by the load will be more, so voltage sag occurs only at the time between 0.2 to 0.4
seconds which is observed in the waveform shown in Fig.5.
The circuit for sag compensation using STATCOM consists of AC-DC-AC converter. The AC-DC-AC converter output is connected to the transmission line and the operation of the STATCOM is regulated.

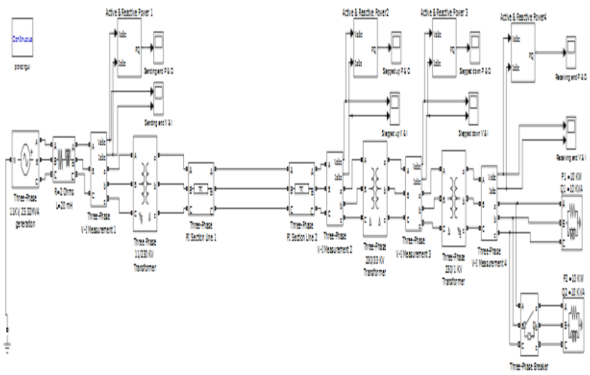


Fig. 3: Simulation diagram of transmission line with voltage sag condition

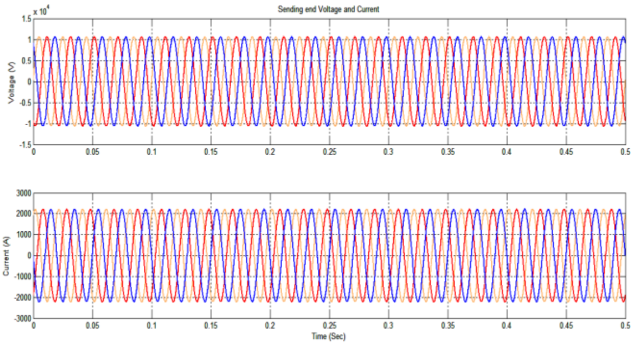


Fig. 4: Sending end voltage and current of transmission line

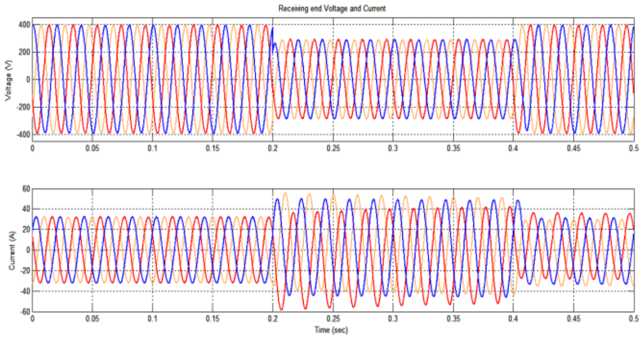
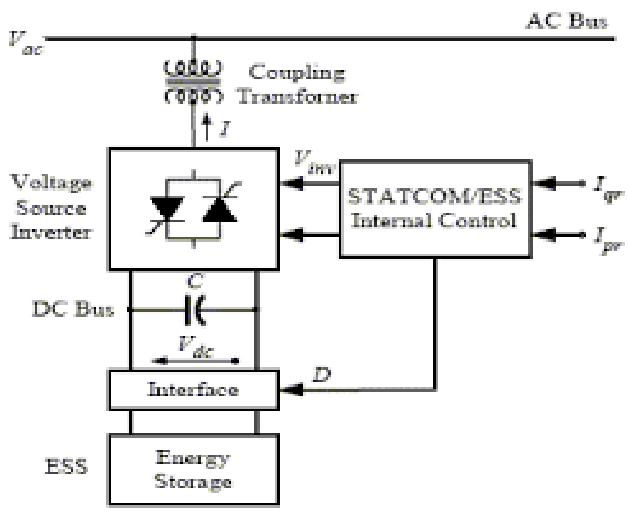


Fig. 5: Receiving end voltage and current with voltage sag in transmission line

STATCOM is a reactive-power compensation device which is capable of generating or absorbing reactive power. It is a general solid-state switching converter capable of injecting or consuming independently controllable real and reactive power at its output terminals. Specially, the STATCOM considered is a VSC that forms the given input of DC voltage, produces a set of 3 phase AC system output voltages, each in phase with the corresponding AC system voltage and coupled with itthrough a relatively small reactance. The DC voltage source is an energy-storage capacitor.



4. Simulation

The AC-DC-AC converter circuit shown in Fig.7hasa AC source which can be renewable energy source like wind farm. Variable AC source is converted in to DC by a rectifier circuit and The DC source is Inverted into grid frequency AC Source by 3ϕ inverter circuit and it is connectedto the transmission line in order to compensate the sag.

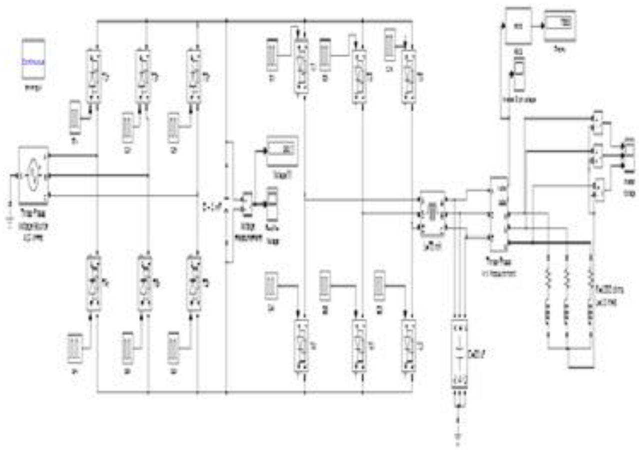


Fig. 7: Simulink model of AC-DC-AC converter

Fig.8 shows the output of rectifier phase of AC-DC-AC converter circuit and the inverter phase output of AC-DC-AC converter circuitis shown in Fig.9

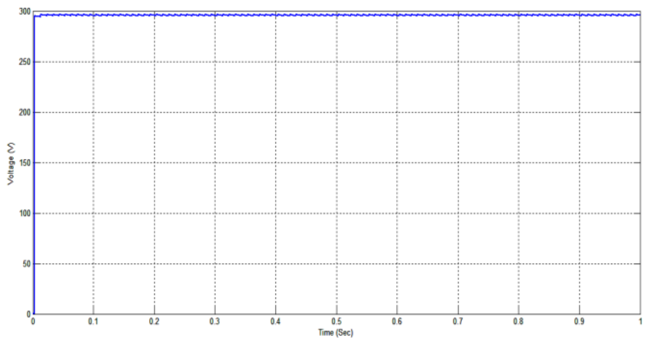


Fig. 8: Output waveforms of rectifier phase of AC-DC-AC converter

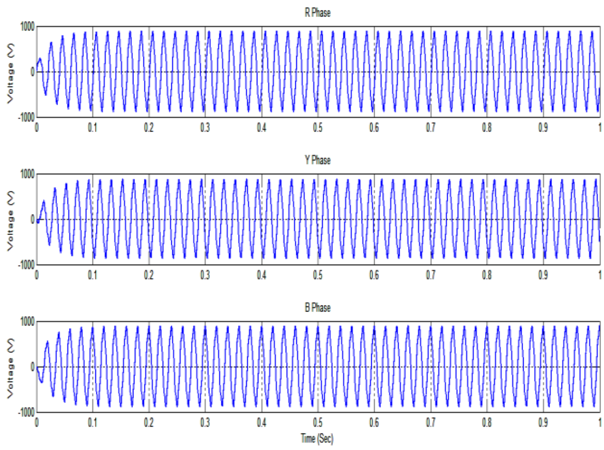


Fig. 9: Output waveforms of inverter phase of AC-DC-AC converter

Since they have a control unit the STATCOM circuit will be added to the circuit only if voltage sag occurs. So STATCOM provides shunt compensation for the sag only at the time it occurs. The DC source used for 3ϕ inverter is a 415V source.
Fig.5 shows the load voltage of the system. It can be seen that during the sag period, the voltage compensation has been performed by the STATCOM.The circuit diagram in Fig.11 shows that the addition of STATCOM for voltage sag compensation. It consists of normal transmission line circuit with sag condition in it and a STATCOM circuit for the automatic sag compensation.

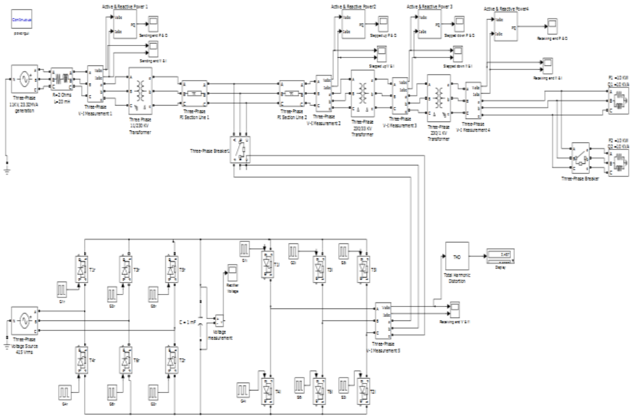


Fig. 10: Simulink model of transmission system with STATCOM

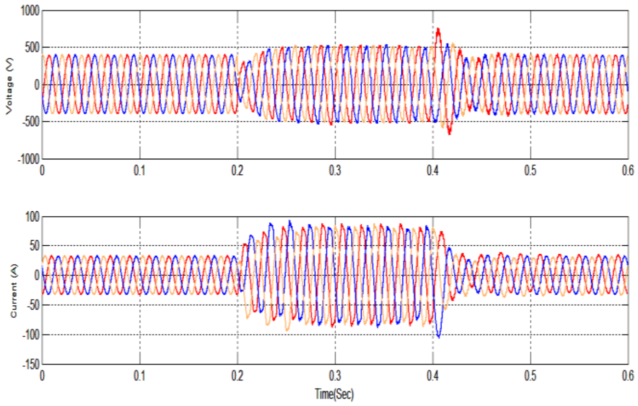


Fig. 11: Compensated waveforms at the receiving of transmission system

5. Conclusion

In this paper, study of compensation of the transmission line is done and injection of the real or reactive power when requiredusing STATCOM has been performed. It has been observed that STATCOM ensures the continuous supply of constant voltage from the source to the receiver throughout the transmission line. A suitable control unit can be implemented which acts as a feedback mechanism has been designed to ensure the proper operation of STATCOM to compensate the voltage sag created due to the sudden addition of an extra load.

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