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Improve Power Quality Problem Using Series Compensator

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Abstract

This paper discusses study of design and simulation of series compensator for improving power quality and reduces the harmonic distortion of sensitive load. Electronic device and control technologies have made it possible to mitigate power quality problems &maintain the operation of sensitive load. The use of a series compensator (SC) to improve power quality is an isolated power system is investigated. The role of the compensator is not only to mitigate the effects of voltage sag, but also to reduce the harmonic distortion due to the presence of non linear loads in the network. The series compensator consists of injection transformer, filter, ESS, VSI, & control. In SC LC filter can be achieved by eliminating the unwanted harmonics. The ESS can be a capacitor of suitable capacity. The modelling and simulation of the proposed series compensator was implement in matlab simulink work space .Simulation results verify that the SC is effective in reducing the harmonic distortions and thus improving the supply quality of isolated power system.

Keywords: Harmonics, Power quality problem, isolated transformer, ESS, VSI, Filter, SC.

Introduction

Power Quality (PQ) related issues are of most concern now a day. The widespread use of electronic equipment such as information technology equipment, power electronics such as adjustable speed drives (ASD), programmable logic controllers (PLC), energy-efficient lighting, led to a complete change of electric loads nature [3]. ISOLATED power systems are commonly found in rural and remote areas of the world. These systems represent the alternative to grid connection, where interconnection to a large grid is not viable due to high cost and/or geographical obstacles Power quality problem is an occur as a non-standard voltage, current and frequency. The loads are nonlinear and harmonic currents generated by the loads will cause a voltage drop across source impedance which causes decrease in power quality. Power System may also contain sensitive loads such as computers or electronic controllers which consume less power are connected in parallel with nonlinear loads. The harmonics generated by this nonlinear load may be harmful to sensitive loads and could even damage the sensitive loads. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problem such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipments. Be harmful to sensitive loads and could even damage the sensitive load this paper analyses the key issues in the power quality problems, in the proposed system. Harmonics occurs due to the connection of controlled six pulse converter (rectifier) to the main drive load (non linear load). Voltage sag/Voltage swell occurs due to the three phase fault/ground fault/phase to ground fault in the transmission [7].All these factors affect the sensitive load which is connected in parallel to the main drive load. So the proposed system protects the sensitive load by mitigating the voltage sags and harmonics using series compensation technique

Research Methodology

Among the power quality problems (sags, swells, harmonics) voltage sags are the most severe disturbances. In order to overcome these problems the concept of series compensator devices is introduced recently. The function of series compensation, the FACTS is connected in series with the power system. It works as a controllable voltage source. Series inductance exists in all AC transmission lines. On long lines, when a large current flows, this causes a large voltage drop. To compensate, series capacitors are connected, decreasing the effect of the inductance[4]. The simple power system model shown in Figure 1 is used to explain the principle of the proposed represents the equivalent source impedance. The main drives or machinery loads are modeled as a lumped resistive-inductive load connected to the source through a power converter, assumed to be a six-pulse rectifier .The much smaller capacity sensitive loads are assumed to be supplied through point of common coupling and are modeled by the resistor R in parallel with the capacitor C. The SC is connected upstream from the sensitive capacitor of suitable required It is series connected with the sensitive load. The function of the SC is to ensure that the voltage across the sensitive load terminals is of high quality. The central part of the SC is an energy storage system (ESS) and a VSI where a PWM switching scheme is often used[5]. The ESS can be a capacitor of suitable capacity. Because of the switching, harmonics are generated, and filtering is required. The function of each component of series compensator is as follows:

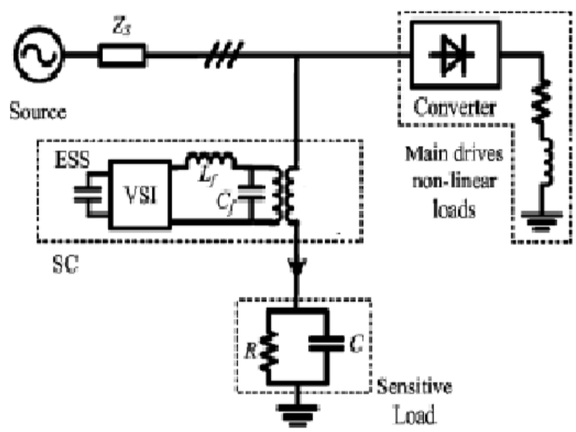

FIG.1 The Basic Structure of series compensator

Basic Configuration of Series Compensation: The general configuration of the SC consists of:

a) An Injection/Isolation transformer
b) A Harmonic filter/Passive filter
c) Storage Devices/ESS
d) A Voltage Source Converter (VSC)/VSI
e) By-pass Switch
f) A Control and Protection system

a. Injection/ Isolation transformer-

In a three phase system, three single-phase transformer units or one three phase transformer unit can be used for voltage injection purpose. In the proposed system Voltage sag occurs due to the three phase fault in the transmission line and harmonics occurs due to the connection of controlled six pulse converter (rectifier) to the main drive load (non linear load). So the proposed system mitigates the voltage sag & harmonics.

b. A Harmonic filter/Passive filter

The passive filters can be placed either on the high voltage side or the converter side of the injection transformers. Filters are used to convert the PWM inverted pulse waveform into a sinusoidal waveform. This is achieved by removing the unnecessary higher order harmonic components generated during the DC to AC conversion in the Voltage Source Inverter (VSI), higher orders harmonic components distort the compensated output voltage.

c. Storage Devices/ESS-

ESS would act as a buffer and generally provides the energy need for load ride-through during voltage sag. In this way the terminal voltage of the protected sensitive load can be regulated to maintain a constant level..

d. A Voltage Source Converter (VSC) /VSI-

A VSC is a power electronic system consists of a storage device and switching devices, which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. This voltage source inverter system is used to convert from dc storage to ac. Rating of the VSI converter is of low voltage and high current type due to injection transformer in the series compensation technique.

e. By-pass switch-

If the voltage sag appear in the power system, By-pass switch is used to protect the inverter from high currents. When the event of a fault or a short circuit on downstream, the series compensator change in to the bypass condition where the VSI inverter is protected against over current flowing through the power semiconductor devices.

f. A Control and Protection system-

The aim of the control system is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The harmonics is generated in the load terminals using six pulse converters with fixed firing angle are connected to the main drive non linear load which is parallel to the sensitive load. Voltage sag is created at load terminals via a three phase fault. The above voltage problems are sensed separately and passed through the sequence analyzer The magnitude component is compared with reference voltage (Vref).Pulse width Modulation (PWM) control technique is applied for inverter switching so as to produce a three phase 50 Hz[6] . Sinusoidal voltage at the load terminals. Chopping frequency is in the range of few KHz. The IGBT inverter Controlled with PI controller in order to maintain 1 per unit voltage at the load terminals. PI controller (Proportional Integral Controller) is a closed loop controller which drives the plant to be controlled with a weighted sum of the error (difference between the output and the desired set point) and the integral of that value .One advantage of a proportional plus integral controller is that the integral term in a PI

controller causes the steady-state error to be zero for a step input. PI controller input is an actuating signal which is the difference between the V_{ref} and V_{in}.
Output of comparator = $V_{ref} - V_{in}$ …… (1)
Where (1p.u. = Base Voltage)
V_{ref} equal to 1p.u. voltage
V_{in} voltage in p.u. at the load terminals. The angle δ is provided to the PWM signal generator to obtain desired firing sequence.

Solution to Improve Power Quality Problem & Reduce Harmonic Distortion

A traditional method to achieve improved PQ is to use passive filters connected at the sensitive load terminals. However, this practice has some shortcomings: the effectiveness of the scheme could deteriorate as the source impedance or load condition changes; it can lead to resonance between the filter and the source impedance. For these reasons, active filters such as that described in may be used. Essentially an active filter, connected at the sensitive load terminal, injects harmonic currents of the same magnitude but of opposite polarity to cancel the harmonics present there[1]. However, as noted earlier, harmonic distortions are only part of the problem faced in such a network,the variations in the drive load would result in voltage sag/swell or flickers appearing in the upstream voltage . Thus, the challenge is to regulate the sensitive load terminal voltage so that its magnitude remains constant and any harmonic distortion is reduced to an acceptable level. In a recent study, proposed a series compensation method to mitigate the harmonics problem for the power system shown in Fig. 1. However, compensation for voltage sag/swell or flicker has not been considered. Series voltage compensation methods have been discussed in for the mitigation of short-duration voltages/swells but the presence of harmonic voltages/current in the networks has been ignored . This paper introduces series compensator and its operating principle. Then a simple control based PWM method is used to compensate Harmonics, Voltage sags. At the end MATLAB SIMULINK model based simulated results were presented to validate the effectiveness of the proposed control method of Series Compensation.

Data Analysis

Illustration of the Series Compensator TestSystem

1S.NO	SYSTEM QUANTITIES	STANDARDS
1.	Main supply voltage per phase	230V
2.	Source impedance	Ls=0.005Mh ,Rs=.0.001ohm
3.	PI Controller	Kp=.5.Ki=50, sample time=50micro sec
4.	Sensitive load	1KW, 20VAR
5.	Inverter	IGBT based, 3 arm, 6pulse,Carrier Frequency=2000 Hz
6.	Main Drive Load	1MW, 100 VAR
7.	Battery Voltage	100V
8.	Injection transformer turn ratio	1:1, 230/230 V
9.	Line frequeccy	50Hz
10.	Fault Resistance	.001ohm

Experimental Results

In simulink model shows the harmonics is generated in the transmission line using six pulse converters connected to the main drive non linear load which is parallel to the sensitive In Matlab simulation is carried out with compensation technique. The simulation results show that the harmonics in the sensitive load side is decreased approximately to 50%. The sensitive load is protected against the distortion introduced by the main drive load and the total harmonic distortion is reduced up to 50%. The simulation results carried out with series compensator generated harmonics are reduced.

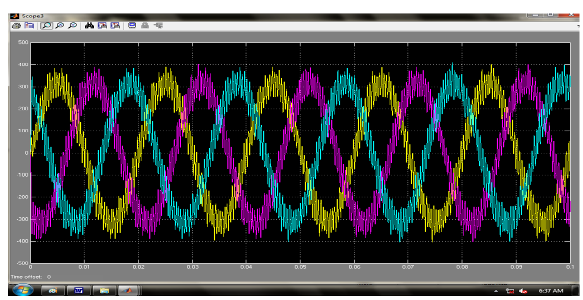

Fig:2 output or three phase harmonics with out series compensator

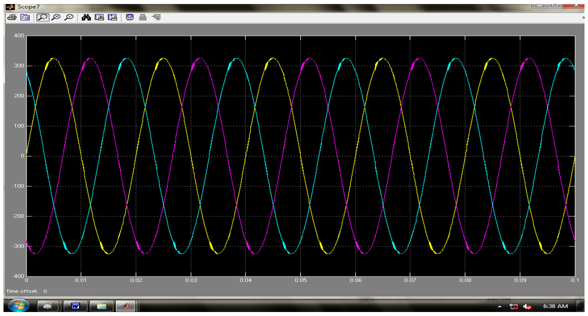

Fig:3 output or three phase harmonics with series compensator

Conclusion

Power quality improvement in an isolated power system through series compensation has been investigated .Harmonic produced by the nonlinear load are harmful to the sensitive load which are connected in parallel with the non linear load .In this paper a method to reduce harmonic & increase power quality using series compensation is considered. VSI based series Compensator is used to reduce the harmonic produced by non linear loads. The SC is also designed to maintain the fundamental frequency component of the terminal voltage of protected sensitive load. In this paper, a complete simulated series compensator system has been developed by using Matlab/ Simulink software. It is shown that the simulated SC developed works successfully to improve power quality. The proposed system performs better than the traditional methods in mitigating harmonics and voltage sags.

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