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Voltage Quality Enhancement In An Isolated Power System Through Series Compensation

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Abstract: Power quality is the main problem that the industry is facing today. In this paper, an issue of power quality in an isolated power system is considered. The used of series compensators in improving power quality of isolated power system. 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. A control strategy for the SC is developed to regulate power flow. This is achieved through phase adjustment of load terminal voltage. It leads to an increase in the ride through capability of loads to the voltage sags/swells. In this paper Simulation results shows a comparative study of output voltage and current across a sensitive load without and with Series Compensation. This method of reducing the harmonics by voltage injection using Series Compensation is more effective. Simulation results using MATLAB/Simulink have been presented.

Keywords: Power Quality Problems; Series Compensator; ESS; VSI; Harmonics; Voltage Sag; MATLAB.

I. INTRODUCTION

Power quality in electric network is one of today's most concerned areas of electric power system. Power quality is the combination of voltage quality and current quality. Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The electrical power quality is more concerned issue. The main problems are stationary and transient distortions in the line voltage such as harmonics, flicker, swells, sags and voltage asymmetric. Among power system disturbances, voltage sags, swells and harmonics are some of the severe problems to the sensitive loads, because the occurrence of voltage sag in the system can cause devices/process down time, effect on product quality, failure/malfunction of equipments etc., the occurrence of harmonics in the system can cause excessive losses and heating in motors, capacitors and transformers connected to the system. To avoid those undesirable affects the proposed method mitigates the problems caused by voltage sag and harmonic [3]. System, followed Simulink model and comparative study of output across sensitive load without and with Series Compensation applied to the power system. It is followed by control of harmonic distortion and finally simulation results are shown. This paper analyses the key issues in the Harmonics problem and power quality improvement using series compensator. Harmonics occurs due to the connection of the main drive load (non linear load). 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 harmonics and voltage sags using series compensator technique[5].

II. PROBLEM ASSOCIATED WITH POWER QUALITY PROBLEM

A. Transients

These are undesirable but decay with time and hence not a steady state problem. A broad definition is that a transient is that part of the change in a variable that disappears during transition from one steady state operating condition to the other. Another synonymous term is `surge'. Transients are classified into two categories, [4]

(a) Impulsive
(b) Oscillatory

B. Long Duration Voltage Variations

A long-duration variation means rms deviation at power frequencies for longer than 1 minute. A voltage variation is considered to be long duration when the ANSI limits are exceeded for greater than 1minute. Long duration variation can be sustained interruptions over voltage or under voltage and are generally caused by load variations on the system and switching operations.

Sustained Interruptions: If the supply voltage becomes zero for a period of time which is than one minute, then we can say that it is a sustained interruption ,Normally ,voltage interruption lasting for more than one minute is often unending and requires human intervention to restore the supply. The term "outage" is also used for long interruption. However it

does not bring out the true impact of the power interruption. Even an interruption of half a cycle can be disastrous for a customer with a sensitive load.

C. Short Duration Voltage Variations:

Short duration variations are deviations at power frequency for less than 1 minute. The short duration voltage variations are generally caused by fault conditions like single line ground or double line to ground and starting of large induction motors. This voltage variation can be instantaneous, momentary or temporary depending on its duration.

a. Voltage Sags

Voltage sag is a brief decrease in the rms voltage at power frequency of 1 to 0.9pu of the nominal voltage value. The duration of voltage sag is 0.5 to 1 minute. Voltage sags as a voltage dip. Voltage sags are mainly due to system faults and last for durations ranging from 3 cycles to 30 cycles depending on the fault clearing time. The magnitudes of the voltages sags caused by faults depend upon the distance of the fault location from the bus where the sag is measured. Starting of large induction motors can result in voltage sags as the motor draws a current up to 10 times the full load current during the starting. Also, the power factor of the starting current is generally poor.

b. Voltage Swells

A voltage swell is opposite to the sag**.** A voltage swell is defined as an increase to between 1.1 and 1.8 p.u.in RMS voltage at the power frequency for duration between 0.5 cycles to 1minute. But voltage swell are not as common as voltage sags. A swell can occur on the healthy phases during a single line ground fault. A voltage swell caused by an SLG fault. Swell can also be caused by switching off large load, energizing a large capacitor bank, incorrect setting of tap changer etc. Swell are characterized by their magnitude and duration which depends in the fault location, system impendence and grounding. How-ever in a grounded system, there will be negligible voltage rise on the un-faulted phases close to a substation where the delta connected windings of the transformer (usually connected delta-wye) provide low impendence paths for the zero sequence current during the SLG fault.

c. Interruption

If the supply voltage or load current decrease to less than .1 p.u for a period of time not more than one minute is known as interruption .Interruption can be caused either by system faults, equipment failures or control malfunction .The interruption are measured by their duration alone. The duration due to a fault is determined by the operating time of the protective devices. Duration of an interruption due to equipment malfunction can be irregular. Some interruption may also be caused by voltage sag conditions when there are faults in the source side.

D. Steady State Phenomena

Waveform Distortion
This is defined as steady state deviations from an ideal sine wave of power frequency. There are five type of waveform distortion.

a. DC offset
b. Harmonic
c. Inter harmonics
d. Notching
e. Noise

Voltage imbalance can be defined using symmetrical components. The ratio of the negative sequence or zero sequence components to the positive sequence component is a measure of unbalance. The main cause of voltage unbalance is single phase loads on a three phase circuit which resulting in load imbalance .Sever imbalance can be caused by single phasing conditions in the system.

E. Voltage Fluctuations and Flicker

Voltage fluctuations are systematic variations of the voltage envelope or a series of random changes in the voltage magnitude (which lies in the range of 0.9 to 1.1 p. u.)High power loads that draw fluctuating current, such as large motor drives and arc furnaces, cause low frequency cyclic voltage variations that result in flickering of light sources (incandescent and fluorescent lamps) which can cause significant physiological discomfort or irritation in human beings.

The voltage flicker can also stable operation of electrical and electronic devices such as motors and CRT devices. The typical frequency spectrum of voltage flicker lies in the range from 1 Hz to 30 Hz.

III. MODELING OF SERIES COMPENSATOR

The simple isolated power system model shown in Fig.1 is used to explain the principle of the proposed harmonics compensation method of the SC. Vs represents an idle voltages source and Zs represent the equivalent source impendence [1].

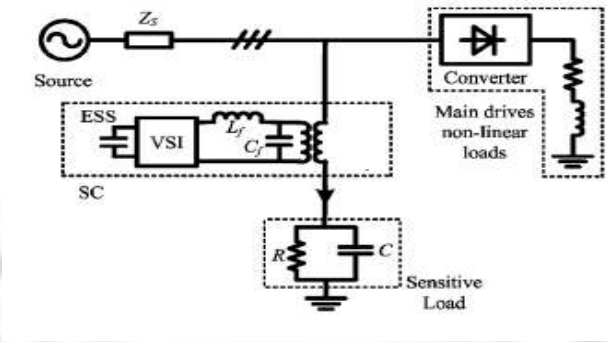

Figure 1: Basic Structure of Series Compensator

The main drives or machinery loads are modeled as a lumped RL load connected to the source through a power converter which is 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 Series compensator is connected to the transmission line using injection transformer. The function of series compensator is to protect sensitive load from the harmonics generated by the nonlinear load. The central part of SC is the energy storage system and VSI[6].PWM switching scheme is used in the VSI. Due to the switching, harmonics are generated and filtering is required, Lf, and Cf are the filter inductance and capacitance. Fig. 2 shows the matlab simulink model of power system without series compensator. In this power system model with sensitive load and non-linear loads is considered. Series Compensator is absent.

It is observed that voltage and current across the sensitive load are not pure sinusoidal waveform as it contains harmonics. Fig.3 shows the main drives or machinery loads are modeled as a lumped RL load connected to the source through a power converter which is 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 Series compensator is connected to the transmission line using injection transformer [1]. The function of series compensator is to protect sensitive load from the harmonics generated by the nonlinear load. The central part of SC is the energy storage system and VSI. PWM switching scheme is used in the VSI. Due to the switching, harmonics are generated and filtering is required, Lf and Cf are the filter inductance and capacitance. Fig. 2 shows the mat lab simulink model of power system without series compensator. In this power system model with sensitive load and non-linear loads is considered.

Series Compensator is absent .It is observed that voltage and current across the sensitive load are not pure sinusoidal waveform as it contains harmonics. Fig. 3 shows the matlab simulink model of power system with series compensator. To improve power quality is to use passive filters connected at the sensitive load terminals. The challenge is to regulated the sensitive load terminal voltage so that magnitude remains constant and any harmonic distortion is reduced to an acceptable level. This practice has some or load condition changes; it can lead to resonance between the filter and the source impedance. 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. Then a simple control based PWM method is used to compensate Harmonics, Voltage sags. . Pulse width Modulation (PWM) control technique is applied for inverter switching so as to produce a three phase 50 Hz sinusoidal voltage at the load terminals. Chopping frequency is in the range of few KHz. The IGBT inverter is controlled with PI controller in order to maintain 1 per unit voltage at the load terminals [2].

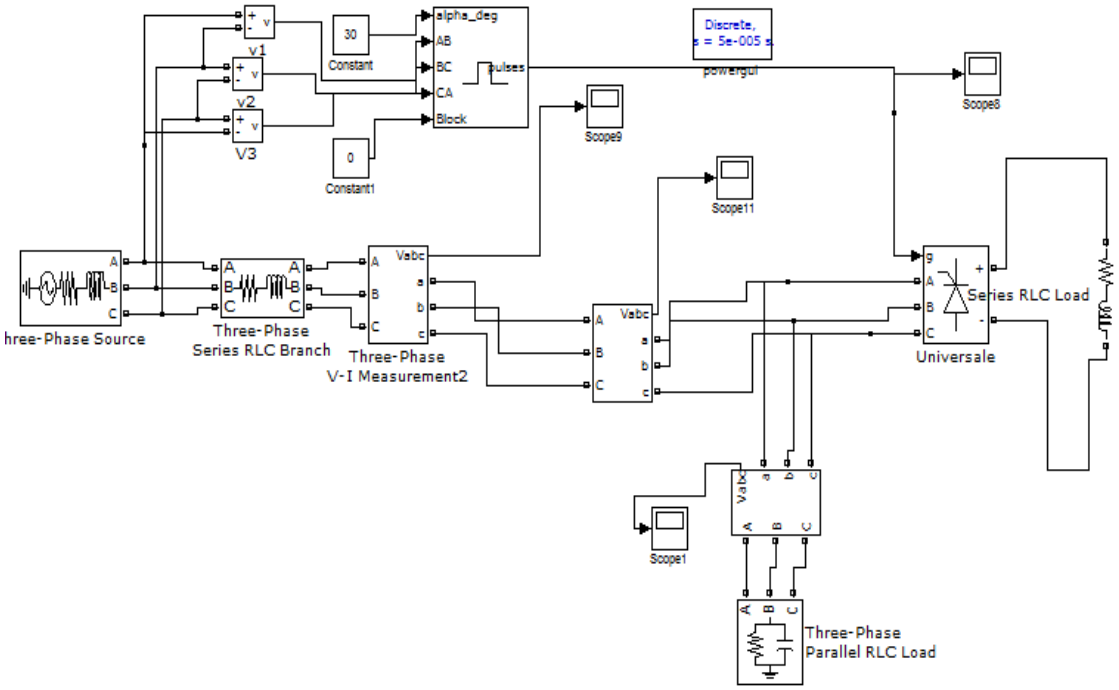

Fig. 2: Simulink diagram of isolated power system without series compensator

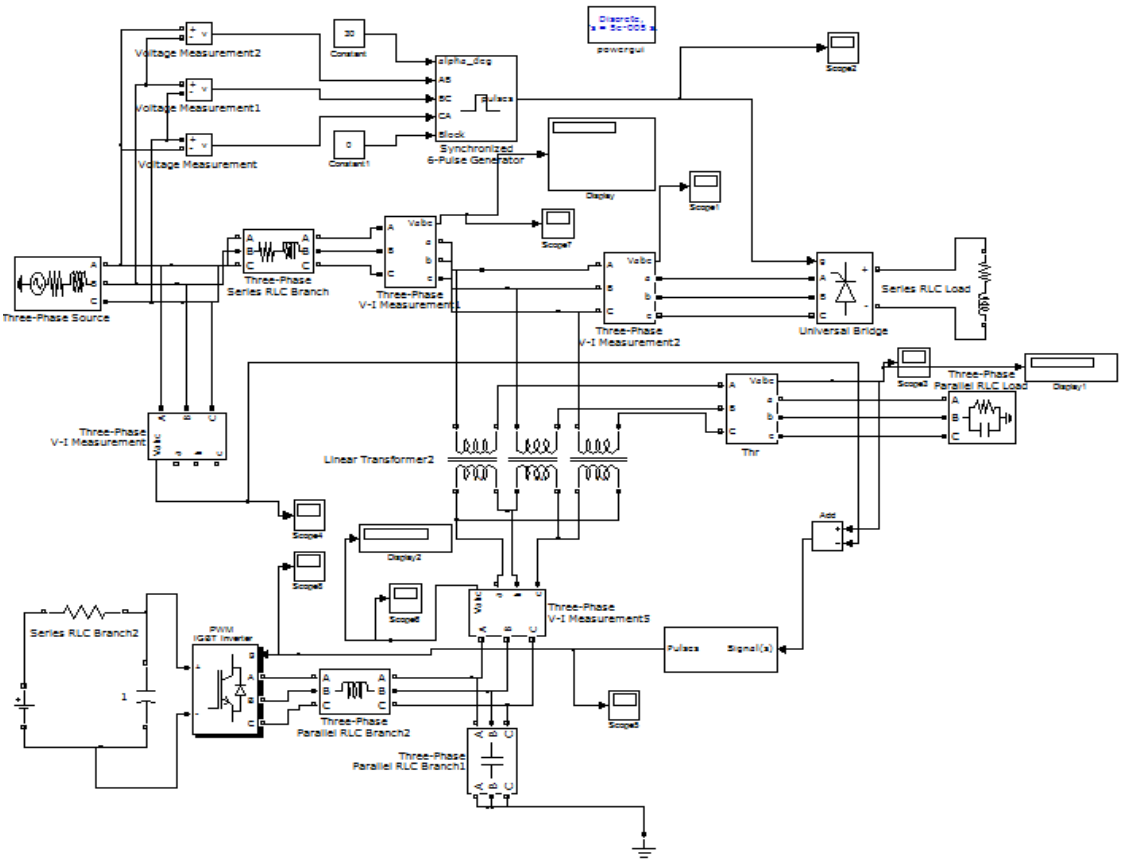

Fig. 3: Simulink diagram of isolated power system with series compensator

CONCLUSION

In this paper Simulation results shows a comparative study of output voltage and current across a sensitive load without and with Series Compensation The use of compensators in improving power quality of isolated power systems is considered The proposed series compensator consists of Energy Storage System (ESS) and Voltage Source Inverter (VSI), Injection Transformer. ESS would act as a buffer and generally provides the energy needed for load ride-through during voltage sag. Injection Transformer is used to inject the voltage in transmission line in appropriate level. In this way the terminal voltage of the protected sensitive load can be regulated to maintain a constant level. At the end MATLAB SIMULINK model based simulated results were presented to validate the effectiveness of the proposed control method of Series Compensation.

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