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Comparison of thyristor controlled series capacitor and discrete PWM generator six pulses in the reduction of voltage sag

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Abstract: Power quality is the main problem that the industry is facing today. In this paper, an issue i.e. voltage sag of power quality in an isolated power system is considered. The series compensator device thyristor controlled series capacitor is used for improving power quality of isolated power system. The role of the compensator is to mitigate the effects of voltage sag. A control strategy for the SC is developed to regulate power flow and minimize the losses in the power system. 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 across a nonlinear load with PWM Generator controller and with Thyristor controlled series capacitor Series Compensation. This method of reducing the voltage sag by voltage injection using Series Compensation and PWM Generator for the reduction of voltage sag in transmission line. Simulation results using MATLAB/Simulink have been presented. In this paper simulation results showed and comparative study and simulation of thyristor controlled series capacitor and PWM Generator in the reduction of voltage sag and find out which controller is more effective in this system. The simulation results showed that the proposed series compensator was efficient in mitigating voltage sags and improve the power quality of isolated power system. this approach is different from conventional methods and provide effective solution. If this method is enhanced in future it could provide much more improved power quality.

Keywords: Power Quality Problems, Thyristor controller series capacitor, PWM Generator, Voltage Sag, MATLAB.

I. INTRODUCTION

Modern electric power utilities are facing many challenges due to ever-increasing complexity in their operation and structure. In the recent past, one of the problems that got wide attention is the power system instabilities. With the lack of new generation and transmission facilities and over exploitation of the existing facilities geared by increase in load demand make these types of problems more imminent in modern power systems. Demand of electrical power is continuously rising at a very high rate due to rapid industrial development. To meet this demand, it is essential to raise the transmitted power along with the existing transmission facilities. Flexible AC Transmission Systems controllers are used to control various power system problems. 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, voltage swells, voltage 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 voltage sag in the system can cause excessive losses and heavy loading ,nonlinear load. To avoid those undesirable affects the proposed method mitigates the problems caused by voltage sag. System, followed Simulink model and comparative study of output across nonlinear load with PWM Generator and with thyristor controlled series capacitor applied to the transmission system. It is followed by control of voltage sag and finally simulation results are shown. This paper analysis the key issues in the voltage sag problem and power quality using series compensator type of TCSC device. Voltage sag occurs due controlled series capacitor to the connection of the main drive load (non linear load). All these factors affect the nonlinear load which is connected in parallel to the main drive load. So the proposed system protects the nonlinear load by mitigating the voltage sags using thyristor controlled series capacitor device technique.

II. 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 TCSC is introduced recently. The function of series compensation, the FACTS is connected in series with the power system. It works as a controllable voltage. 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. The

simple power system model shown in Figure 1 is used to explain the principle of the proposed represents the equivalent source impedance. Pulse-width modulation (PWM) is a technique where the duty ratio of a pulsating waveform is controlled by another input waveform. The intersections between the reference voltage waveform and the carrier waveform give the opening and closing times of the switches.

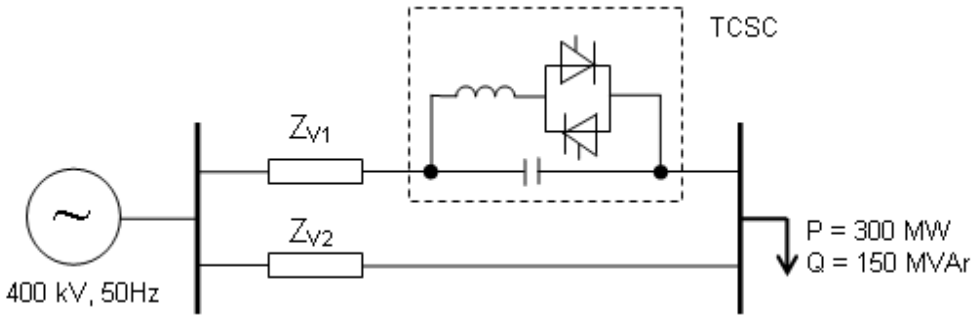

Fig. 1: Block diagram of the model of electrical network with TCSC

1. POWER QUALITY PARAMETERS

Even the best distribution systems are subject to changes in system voltage from time-to-time. Voltage changes can range from small voltage fluctuations of short duration to a complete outage for an extended period of time. The following industry terms can be used to describe given voltage conditions.

(a) Voltage dip: A voltage dip is used to refer to short-term reduction in voltage of less than half a second.

(b) Voltage sag: Voltage sag is used to relate long-term reduction in voltage. A voltage sag is a brief decreased in the rms voltage at power frequency of 0.1 to 0.9 per unit of the nominal voltage value. The duration of a voltage sag is 0.5 cycle to 1 minute. voltage sag obtained in the system when low voltage (less than 80%),for more than one period.

(c) Voltage swell: Voltage swell is an increase in voltage outside normal rated tolerance of an equipment.

(d) Voltage ‘spikes’, ‘impulses‘ or ‘surges’: These are terms used to describe abrupt, very brief increases in voltage value.

(e) Voltage transients: They are temporary, undesirable voltages that appear on the power supply line. Transients are high over-voltage disturbances (up to 20KV) that last for a very short time (milliseconds or nanoseconds). Hence, the term ‘spike’ can also be used.

(f) Harmonics: The fundamental frequency of the AC electric power distribution system is 50 Hz. A harmonic frequency is any sinusoidal frequency, which is a multiple of the fundamental frequency. Harmonic frequencies can be even or odd multiples of the sinusoidal fundamental frequency. The following sections will discuss the causes and symptoms of each power disturbance parameter and themethods of preventing/minimizing their effects on power equipment.

(g) Voltage dips, sags and surges: Most electrical power generating authorities have an obligation to supply consumers from the grid at a constant voltage (typically within +/- 6% of nominal). However, sometimes this is not practical, particularly in rural locations. Sometimes voltage sags are caused by the power supplier during times of heavy demand, while dips are often caused by auto closers, operating within one second of fault detection. It is also possible for heavy plant to pull down the supply voltage during start-up. Compressors and pumps are good examples of loads, which require a high start-up current and switch in and out on a frequent basis, causing the supply voltage to dip. A dip is used to refer to a short term reduction of less than half a second, whilst sag relates to a long-term voltage reduction.

2. CAUSES OF DIPS, SAGS AND SURGES

1. Rural location remote from power source
2. Long distance from a distribution transformer with interposed loads
3. Switching of heavy loads and nonlinear load.
4. Unbalanced load on a three phase system

3. IMPLICATIONS OF POOR POWER QUALITY

Some of the implications of power quality especially related to power factor and harmonics are:

1. Increase in line & equipment current leading to additional ohmic losses.
2. Increase in line & equipment current leading to blocked capacity and/or increased capital investment.

4. GENERAL BENEFITS OF POWER QUALITY IMPROVEMENT

1. Reduction in line & equipment currents and losses and hence lower energy bills
2. Release of blocked capacity and consequent avoided cost of capital investment
3. Improvement in power factor and avoided penalty for low power factor or incentive for high power factor.
4. Reduction in maximum demand and reduction in demand charges.
5. Tax benefits such as accelerated depreciation benefits for installation of power conditioning /energy saving devices.
6. Improvement in voltage profile and consequent efficient operation of power equipment.

5. THYRISTOR CONTROLLED SERIES COMPENSATOR

It is obvious that power transfer between areas can be affected by adjusting the net series impedance. One such conventional and established method of increasing transmission line capability is to install a series capacitor, which reduces the net series impedance, thus allowing additional power to be transferred. Although this method s well known, slow switching times is the limitation of its use. Thyristor controllers, on the other hand, are able to rapidly and continuously control the line compensation over a continuous range with resulting flexibility. Controller used for series compensation is the Thyristor Controlled Series Compensator (TCSC).

1. TCSC controllers use thyristor-controlled reactor (TCR) in parallel with capacitor segments of series capacitor bank (Figure 1). The combination of TCR and capacitor allow the capacitive reactance to be smoothly controlled over a wide range and switched upon command to a condition where the bi-directional thyristor pairs conduct continuously and insert an inductive reactance into the line.

2. TCSC is an effective and economical means of solving problems of transient stability, dynamic stability, steady state stability and voltage stability in transmission lines. TCSC, the first generation of FACTS, can control the line impedance through the introduction of a thyristor controlled capacitor in series with the transmission line.

6. COMPARATIVE PERFORMANCE OF CONTROL SYSTEM OF THYRISTOR CONTROLLED SERIES CAPACITOR BY USING MATLAB SIMPOWER SYSTEM

The model of electrical network with TCSC device was prepared and simulated in Simulink For demonstration of action TCSC device, from the viewpoint of voltage sag control has been created a simple model of electrical network, in which was subsequently implemented TCSC device. The model of simple electrical network consists of a voltage source, load, two parallel lines and units for measuring and displaying measured electric variables. In this paper Comparative performance of thyristor controlled series capacitor with firing angle control system and TCSC device with Discrete PWM Generator six pulses controller for the mitigation of voltage sag in transmission system.

The parameters of the model are as follows:

- Ideal Three-Phase Voltage Source
  - Line to-line voltage *U*N = 400 kV,
  - Phase angle L1 _ = 0°,
  - Frequency *f* = 50 Hz,
- Three-Phase RL Load
  - Active power *P* = 300 MW,
  - Reactive power *Q* = 150 MVAr,
  - Configuration Y (grounded),
- Three-Phase transmission line
  - Line resistance *R* = 0.028 _/km,
  - Line inductance *L* = 0.904 mH/km,

This TCSC device are designed in Matlab Simulink, firstly design the three phase voltage source 400 Kv voltage are consider in this system than transmission line design with R L parameter are taken in the system. TCSC device design in Matlab two anti parallel connection thyristor with series connection of inductance and capacitor connected in parallel of the thyristor and inductance. Then connection of the nonlinear load three phase bridge rectifier are parallel connected of R L load and series connection of R L load in the transmission system. After that measure the transmission line voltage through the discrete PWM generator 6 pulses and firing angle through TCSC control system ,are observed voltage sag reduction in the power system .check the effect of nonlinear load then voltage sag and losses occur in the system and the reduction of voltage sag. Then Comparative effect are observed in system. It is observed that voltage across the nonlinear load are pure sinusoidal. Fig. 3 shows the matlab simulink model of power system with series

compensator thyristor controlled series capacitor for reduction voltage sag is to connected at the nonlinear load terminals. The challenge is to regulated the nonlinear load terminal voltage so that magnitude is increase and voltage sag is reduced to an acceptable level. Simulink model are given below:

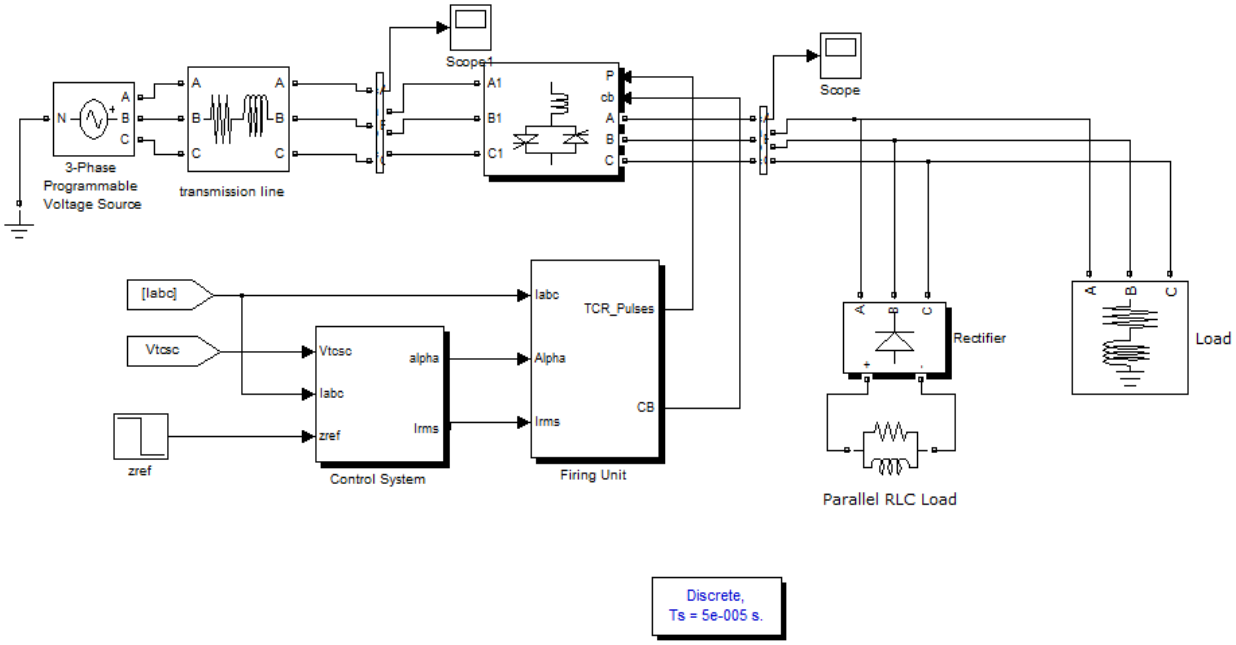

Fig. 2: Simulink diagram of isolated power system with firing angle thyristor controlled series capacitor series compensator

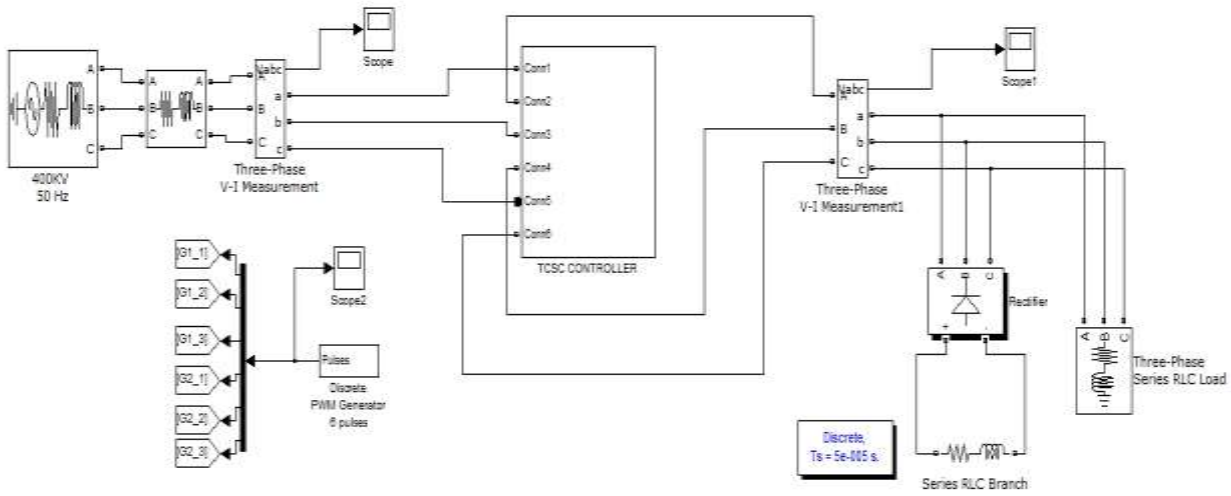

Fig. 3 Simulink diagram of isolated power system with discrete PWM Generator 6 pulses thyristor controlled series capacitor series compensator

III. EXPERIMENTAL RESULTS

The waveforms of the voltage in 400 kv transmission line using thyristor controlled series capacitor for reduction of voltage sag. In this paper discuss in matlab designing of thyristor controlled series capacitor device to reduction of voltage sag using PWM Generator six pulse controller. TCSC controller through reduction of voltage sag in the system and minimize system losses. This Paper present an work on matlab simulink model of TCSC firing angle controller and discrete PWM generator six pluses controller for the comparison of the both controller performance in matlab simulink for reduction of voltage sag in transmission line system. The result waveform are given below this paper discuss design and simulation of transmission system in use in power electronics switching device series compensator in thyristor controlled series capacitor for reduction of voltage sags issues due to the presence of nonlinear loads and heavy load condition and the output results waveform in Comparative performance of firing angle TCSC controller and Discrete PWM Generator six pluses controller. output results waveform are below:

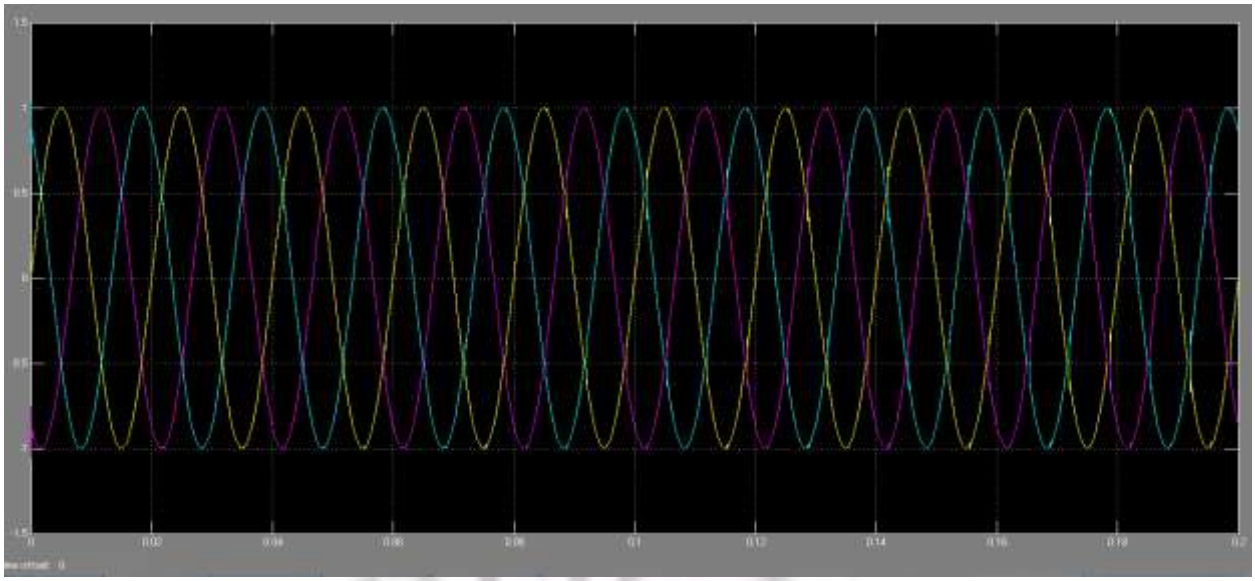

Fig.4 (a): Three phase voltage sag reduction through the firing angle thyristor controlled series capacitor series compensator

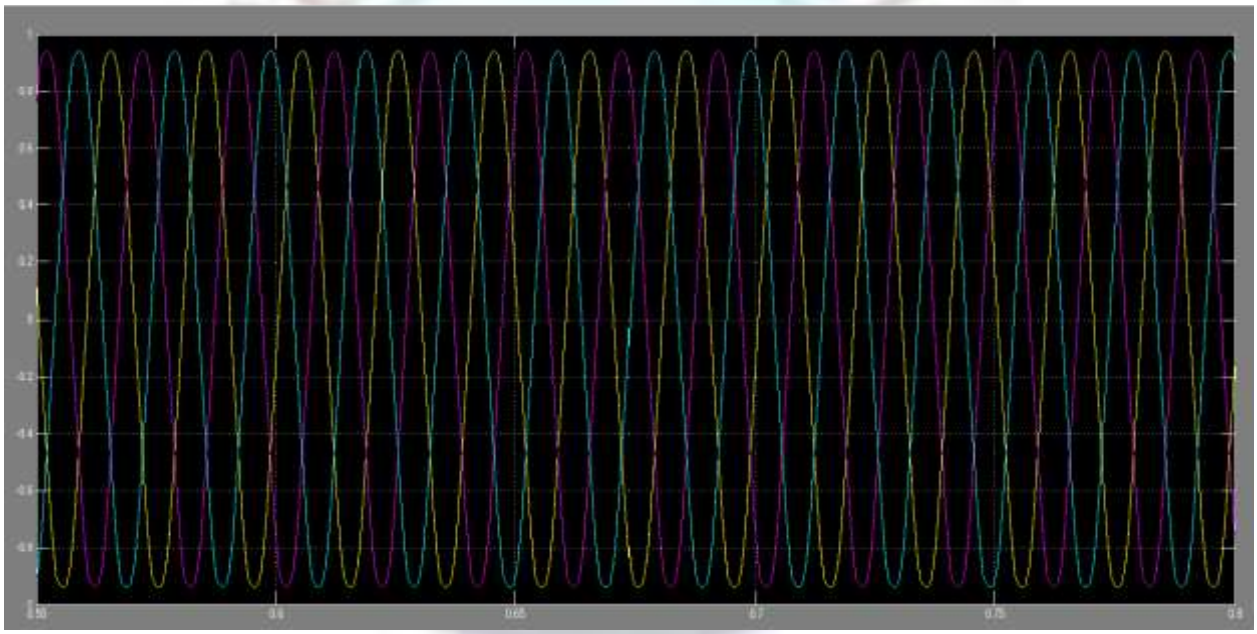

Fig.4 (b): Three phase voltage sag reduction through the Discrete PWM Generator six pluses thyristor controlled series capacitor series compensator

CONCLUSION

Voltage quality improvement in an isolated power system through thyristor controlled series capacitor is a series compensation has been investigated .voltage sag produced by the nonlinear load .In this paper a method to reduce voltage sag & increase voltage quality using series compensation is considered, Discrete PWM Generator six pulses based TCSC series Compensator and Firing angle through TCSC controller system is used to reduce the voltage sag 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 voltage quality. The proposed system performs better than the traditional methods in Mitigating voltage sags. This paper present only for the comparative performance of voltage sag reduction in firing angle TCSC control system and discrete PWM Generator six pulses. Then find out the results in simulink output waveform in firing angle TCSC control system is more effective compare to PWM Generator six pulses control system. This paper is presented for improvement for voltage quality in transmission system.

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