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"Simulation of Unified Series- Shunt Compensator for Power Quality Improvement"

Reshmi Bhagwat, Asst. Prof. Vaishali Malekar
PG Student, Dept. Of Electrical Engineering *Asst. Professor, Dept. Of Electrical Engineering*
Tulsiraamji Gaikwad Patil College of Engineering *Tulsiramji Gaikwad Patil College of Engineering*
& Technology , Nagpur& Technology , Nagpur

Abstract: *This paper deals with the simulation of a unified series shunt compensator aimed at examining its capability in improving power quality in a power distribution systems. The USSC simulation comprises of two 12- pulse inverters which are connectedin series and in shunt to the system.A generalized sinusoidal pulse width modulation switching technique is developed in the proposed controller design for fast control action of the USSC. Simulations were carried out using the UPQC to examine the performance of the USSC model. The power quality problems are many as voltage sag and voltage swell exist in the system so in this project we are going to design unified series shunt compensator for number of issue such as harmonic elimination, voltage flicker, voltage sag , voltage unbalance mitigation. The USSC has moderated a few power quality issues giving better execution.*

Keywords: *unified series-shunt compensator, power quality mitigation,modeling , simulation*

I. Introduction

Power Quality issues have been attracting the attention of researches for decade. An increasing demand for high quality, reliable electrical power , and an increasing number of distorting loads have led an increased awarness of power quality both by customer and utilities. For power quality improvement, the development of power electronic devices such as flexible ac transmission system(FACTS) and custom power device, it hasbecome possible to play an important role in emerging deregulated power system with versatile new control capabilities.FACTS devices are used in transmission control whereas custom power devices are used for distribution control.Since the introduction of FACTS and custom power devices such as unified power –flow controller(UPFC), synchronous static compensator (STATCOM), dynamic voltage restorer(DVR),solid -state transfer switch, and solid –state fault current limiter are developed for improving power qualityand reliability of a system.

These devices have been developed for mitigating specific power –quality problems.Foe example, UPFC works well for power –flow control. DVR which act as a series compensator, is used for voltage sag compensation.STATCOM which is a shunt compensator, is used for reactive power and voltage sag compensation.The STATCOM and DVR are only useful for compensating a particular type of power quality problem and therefore, it is necessary to develop a new kind of unified series shunt compensator(USSC) which can mitigate a wider range of power quality problems. By using a unified approach of series shunt compensators it is possible to compensate for a varity of power quality problems in a distribution system.

The objective of this paper is to explore the capabilites of a USSC in mitigating power-quality problems. The modeling and simulation of the USSC has been carried out using the well known UPQC.

II. Configuration of Unified Series Shunt Compensator

The USSC is a combination of series and shunt voltage source inverter and its basic configuration is shown in fig. 1. The basic components of the USSC are two 12 –pulse voltage source nverters composed of forced commutated power semiconductor switches, typically Gate Turn Off (GTO) thyristor valves.One voltage source inverter is connected in series with the line through a set of series injection transformers, while the other is connected in shunt with the line through a set of shunt transformers. The dc terminals of the two inverters are connected together and their common dc voltage is supported by a capacitor bank.

The USSC is almost similar to the UPFC , but the only differences are that the UPFC inverters are in shunt-series connection and it is used in transmission systems whereas the USSC inverters in series-shunt connection and it is used in distribution systems.

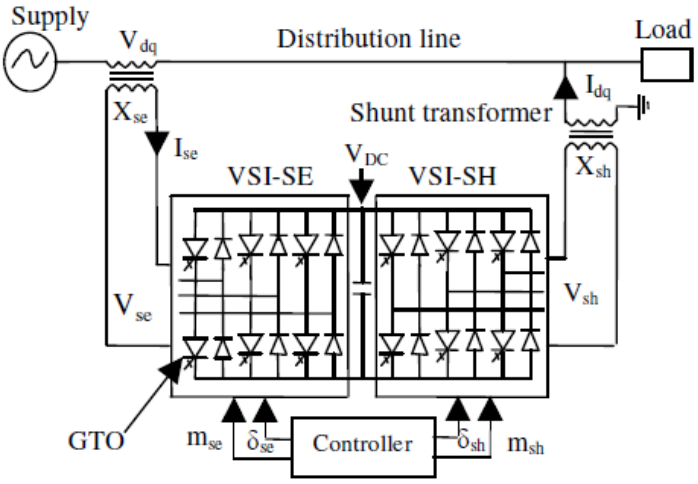


Fig. 1- Basic configuration of USSC

III. Principle Operation Of Ussc

The principle operation of USSC is described by first referring to the model shown in fig 2 As mentioned earlier, the USSC consists of a shunt connected inverter and a series connected inverter. The series connected inveter injects a voltage V_{dq} in series with the distribution line, which in turn changes the voltage V_x across the distribution line reactance X_L ,hence changing the current and the power flow through the distribution line. The exchange of real power P_{inv} and reactive power Q_{inv} can be written in terms of phase angle ,the injected voltage V_{dq} and the line current I ,as

$P_{inv} = V_{dq}$ Icos ⍉ (1)
$Q_{inv} = V_{dq}$ Isin ⍉ (2)

The current injected by the shunt inverter has a real or direct component I_d ,which can be in phase or in opposite phase with the line and a reactive or quadrature component I_q , which is in quadrature with the line voltage, thereby emulating an inductive or a capacitive reactance at the point of connection with the distribution line. The reactive current can be independently controlled which in turn will regulate the line voltage.

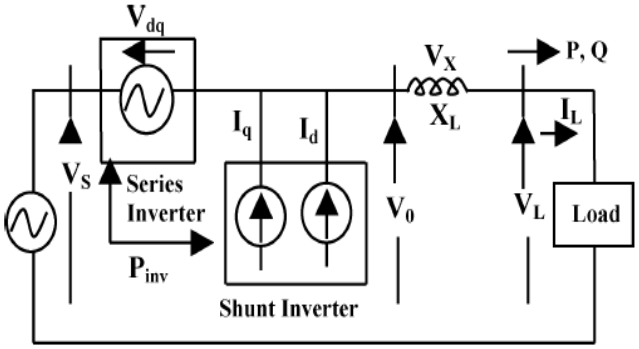


Fig. 2- Principle operation of USSC

The USSC behave as an ideal ac to ac inverter, in which the exchange of real power t the terminal of one inverter to the terminal of the other inverter is through the commom dc link capacitor. It should be noted that the shunt inverter iscontrolled in such away as to provide precisely the right amount of real powerat its dc terminal to meet the real power needs of the series inverter and to regulate the dc voltage of the dc bus. Thus, real power is absorbed from or delivered to the distribution line through the shunt connected inverter, which injects a current at the point of connection.

Thus, USSC includes the functions of both series and shunt connected inverters which generates or absorbes reactive power to regulate voltage magnitude and current flow at the ac terminal, respectively.

IV. Concept Of The System

Active power filter that have been explored in shunt , series and combination of shunt and series configurations to compensate for current and voltage based distortion. It will play an important rple for better quality solutions. Conventional power quality mitigation equipment is proving to be inaqequate for applications, and this fact has attracted the attention of power to develope dynamic and adjustable solutions to power quality problems. Thus between the different technical options available to improve power quality, Active Power Filters hav proved to be an important alternative to minize the financial impacts of PQ problems Unified power quality conditioner is one of the modern and very promising PQ improvingdevice , which of two APFs connected back to back on the DC side and deals with both load current and supply voltage imperfections.

The main purpose of a UPQC is to compensate for voltage flicker/ imbalance, reactive power, negative sequence current and harmonics. UPQC has the capability of improving power quality at the point of installation on the power distribution systems.

UPQC consist of two voltage source converte. They are operated from a common dc link provided by a dc storage capacitor. One converter is connected across the line referred as shunt converter and the other which is connected in series with the line reffered as series converter. Shunt coupling inductor LSh is used to interface the shunt inverter to the network.It also helps in smoothing the current wave shape.A series injection transformer is used to connect the series inverter to the network. A suitable turn ratio is often considered to reduce the current or voltage rating of the series inverter. UPQC is an integration of shunt series APFs with a common self supporting dc bus. The shunt inverter in UPQC is controlled in current control mode such that it delivers a current which is equal to the set value of the reference current as governed by the UPQC control algorithum. The shunt inverter plays an important role in achieving required performance from a UPQC system by maintaining the dc bus voltage at a set reference value. In order to cancel the harmonics generated by a nonlinear.

V. Model Of USSC

In the proposed series shunt compensator the shunt compensator is designed and controlled to active power factor correction and to regulate dc bus voltage. The series connector is used to make load voltage at the desired value so that load voltage in insensitive to utility voltage variation.

A series shunt compensator is presented to improve power quality for nonlinear and voltage sensitive load. The single phase neutral point clamp topology is used in proposed system to generate unipolar voltge waveform on the AC side of the inverters. The series compensator connected between the AC source and non linear load will improve the voltage quality due to abnormal voltage sag and swell.

The shunt compensator will generate the nessary comppensating crrent to improve the system curent quality including haronic and reactive currents and to regulate the DC link voltage . The proposed compensator can make the load voltage insensitive to source voltage disturbance and increase the input power factor to be unity.

VI. Simulation Model Of Generation

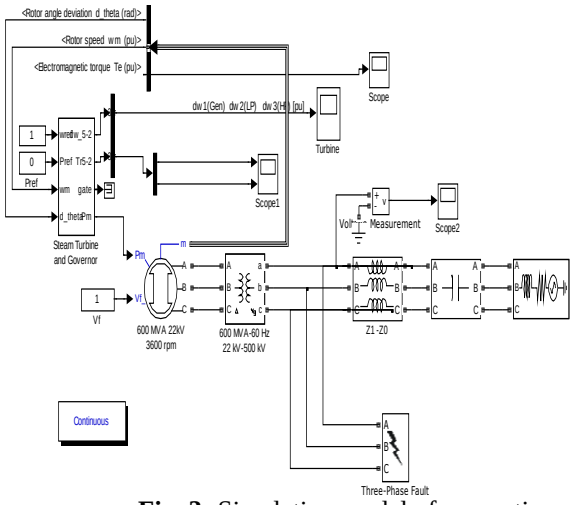
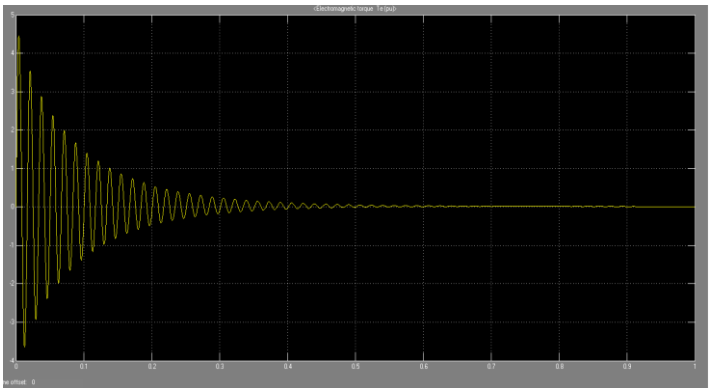


Fig. 3- Simulation model of generation

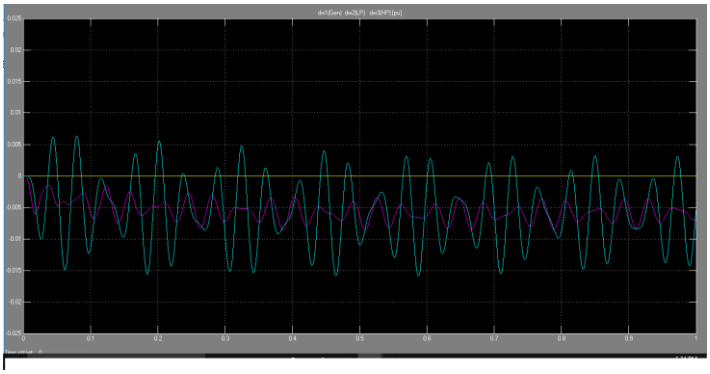
SYSTEM PARAMETER

Sr. No.	System Quantity	Specification
1.	Supply voltage	22 KVA, 60 Hz, 3- phase
2.	Synchronous Machine	600MVA,22KV, 3600rpm
3.	3-phase transformer	600MVA-50Hz, 22KV-500KV
4.	3- phase Mutual Inductance	R=0.007Ω ,L=0.080H
5.	Capicatance	0.55 F, 500KV
6.	3- phase source	500KV, 3333MVA, 60Hz
7.	Steam Turbine	Kp=1, Rp=0.05,Dz=0

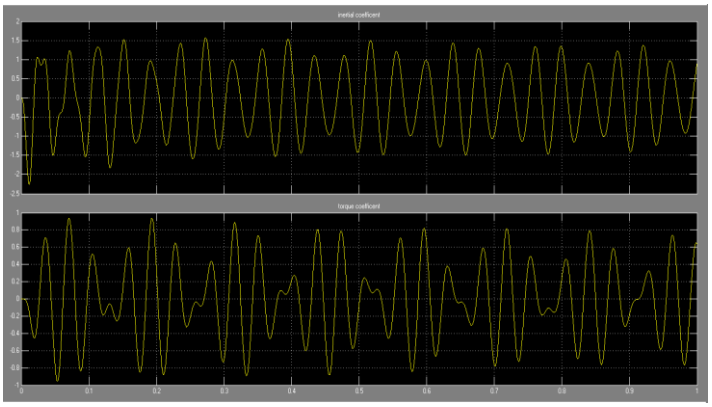
VII. Result Of The Simulation



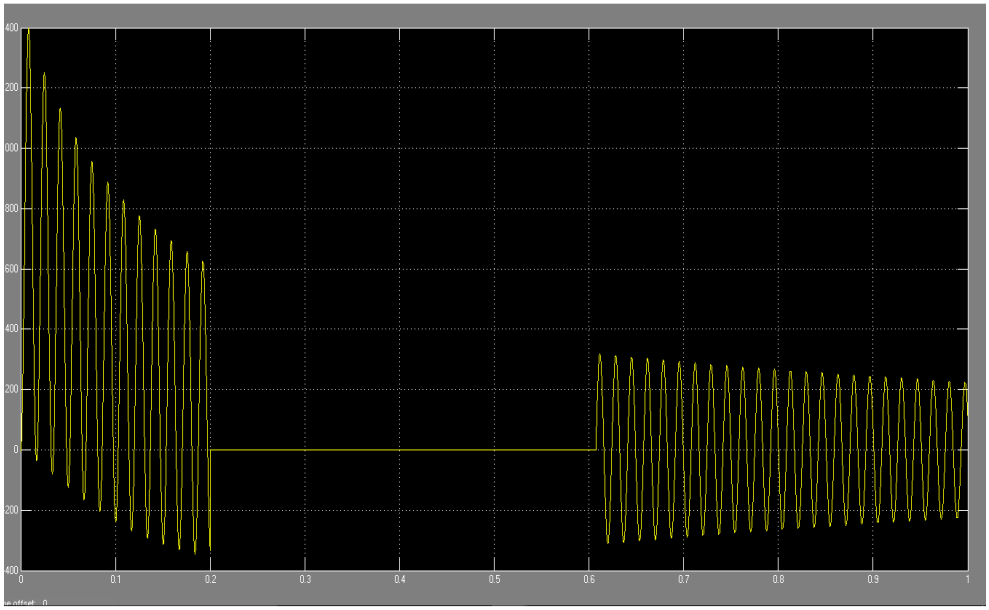
Fig(a)



Fig(b)



Fig(c)



Fig(d)

VIII. Simulation Of UPQC

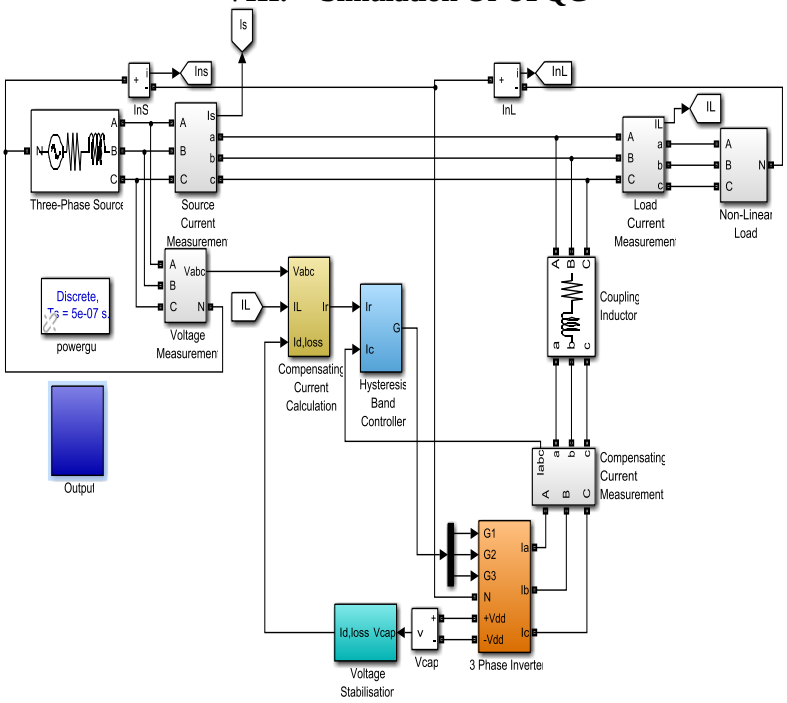
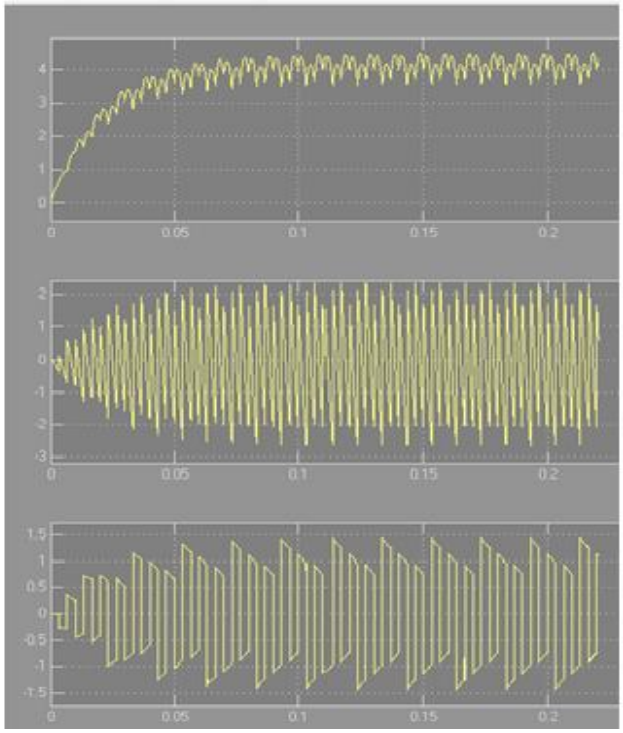
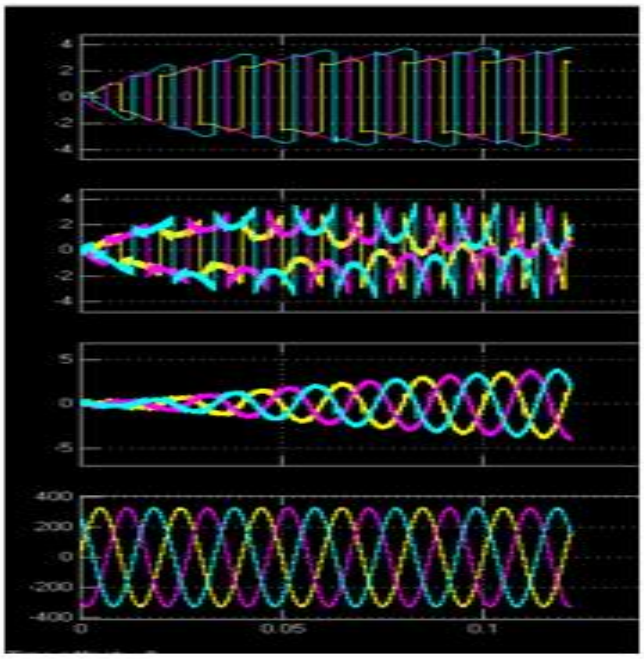


Fig. 4- Simulation model of UPQC

IX. Result Of UPQC





X. Conclusion

The mitigation of a number of power quality problems have been investigated by using USSC. The two dimension USSC fusing 12- beat arrangement and shunt associated inverters has been demonstrated in MATLAB program and another SPWM- based control plot has been executed to control the GTOs of the inverters.Simulations have been carried out to evaluate the performance of the USSC under various operating conditions and power quality disturbances.The USSC gives a better performance in power quality mitigation especially in voltage sag compensation and power flow control and also provide more power quality solutions as compared to the D-STATCOM and DVR.

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