To Study The MATLAB Simulation Of A Single Phase STATCOM And Transmission Line

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***Abstract*-As an important member of FACTS family, STATCOM (Static Synchronous Compensator) has got more and more widely application. However conventional STATCOM is based on self commutated devices such as GTO, IGBT and MOSFET. This paper reports a development of simulation and laboratory model of single phase voltage source converter based STATCOM as a superior approach to maintain the voltage profile of the AC system and AC transmission line. MATLAB Simulation of STATCOM gives results of power exchange with ac system for different firing angles. This boosts confidence for building the experimental hardware of STATCOM. Sinusoidal Pulse Width Modulation (SPWM) technique is used to trigger the IGBT provides an advantage of simple triggering method and reduced harmonics level. This paper highlights the results obtained from the simulation of STATCOM as well as discussing some of the recommendations for future development.**

Keywords: STATCOM; FACTS; Transmission line; Trigger system; MATLAB Simulation; Converter; IGBT; PWM.

I. INTRODUCTION

With the advent of FACTS technology the power system learner has gained additional opportunity to learn the power transfer phenomenon in different prospective. The literature revels applications and implementation of FACTS devices on many sites throughout the world. Moreover, the mathematical analysis and simulation studies reported in celebrated Journals and books create an interest in the subject. However, implementation of concepts at laboratory is very difficult to realize.

An attempt is made in this dissertation work to develop a laboratory scaled model of STATCOM (Static synchronous compensator) which is one of the FACTS device used for shunt compensation purpose. A suitably scaled laboratory model is first designed and fabricated. The STATCOM is fabricated using IGBTs (Insulated gate bipolar transistor) suitable demonstrating line compensation using FACTS. This dissertation report discusses the work carried out in development, fabrication, testing, simulation and practical implementation of laboratory scaled model of STATCOM. It is expected that, this developed model is very much suitable for undergraduate students in electrical engineering to practically verify the theoretical concepts learned in the classroom.

Static synchronous compensator is used to absorb or supply reactive power into the system thereby providing required reactive power compensation [1]. For doing this single and three phase STATCOM (Static synchronous compensator) is used. A STATCOM consists of a constant dc voltage source capacitor C, solid-state electronic switching devices such as IGBT (Insulated Gate Bipolar Transistor) or GTO (Gate Turn-Off), converter unit, coupling transformer to connect STATCOM with AC system as shown in Figure 1.

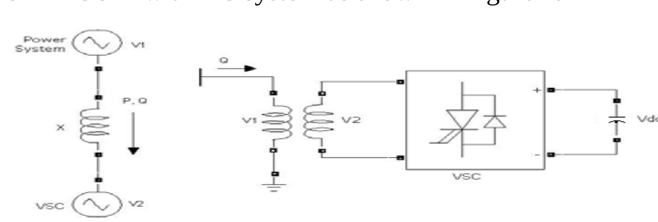


Fig.1. Basic circuit of STATCOM

Now, with the understanding of fundamental principles of FACTS, VAR and concept of STATCOM, next discusses the transmission line theory. Moreover, the MATLAB based simulation of the designed line is presented.The fabricated STATCOM is tested on laboratory model of transmission line.

II. DESIGN OF TRANSMISSION LINE

This paper includes developing a simulation of laboratory scale down model of transmission line. This transmission line model is also useful to perform different power system experiments. In order to analyze transmission line in terms of ac circuit theory, it is necessary first to obtain the equivalent circuit of the line. In this dissertation work the laboratory scales down model of three phase transmission line is developed. This model is scaled down from 173 MVA to 8.66 KVA and 289 KV to 400 Volts. For developing this model the parameters related to transmission line such as series resistance and inductance, shunt capacitance are first designed. Then the Load bank consists of resistive, inductive and capacitive is designed.

III. DESIGN OF LOAD BANK

The load bank of transmission line has been divided into resistive, inductive, and capacitive load. From the transmission line design calculation the phase current is 7.5 A is divided into 4A, 2A, 1A & 0.5A to design the required load.

IV. SIMULATION OF TRANSMISSION LINE

In order to verify the performance of transmission line the SIMULINK model of transmission line is developed as shown in Fig. 2.

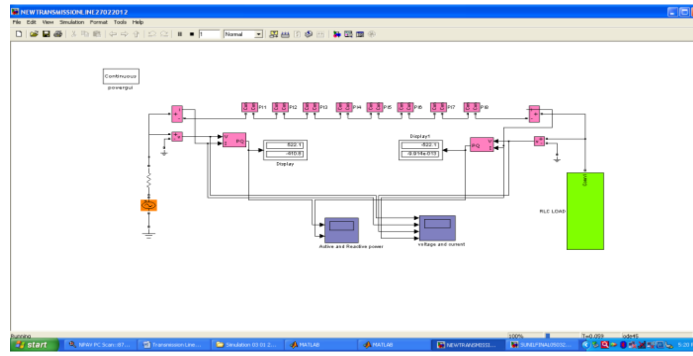


Fig. 2 - Simulation of transmission line

The simulation of transmission line is designed with the help of values of inductor, capacitor & resistor obtained from the calculation of transmission line model. The values are L=5.045mH, C=8.045µF & R=0.24Ω for 50Km transmission line. Simulation of transmission line consists of 8 pi sections each having 50Km length as shown in Figure 2. The SIMULINK model of the load bank is also developed to study active power, reactive power, voltage and current variations for different loading conditions.

The experimental transmission line model build in laboratory is as shown in Figure 3. This gives an opportunity to study the performance of a transmission line.

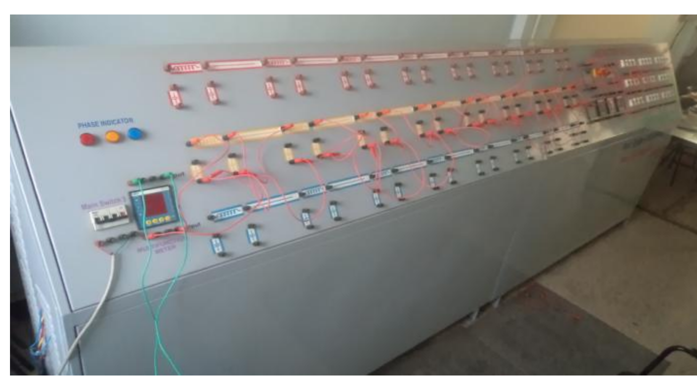


Fig. 3 – Experimental Transmission line Model

The foregoing discussion has elaborated the steps involved in understanding the idea of design, fabrication and simulation of transmission line. The simulation results were compared with practical results on the model transmission line. This line is further compensated by using developed laboratory

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 7, July - 2013

models of STATCOM which help to practically understand line compensation.

V. MATLAB SIMULATION OF STATCOM

MATLAB simulation of a single phase STATCOM is as shown in Figure 4. It consists of single phase IGBT bridge, a constant dc voltage source, shunt transformer and PWM generator to generate the triggering pulses.

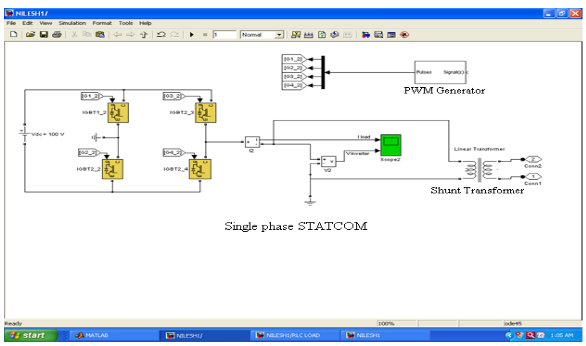


Fig. 4 - MATLAB simulation of a single phase STATCOM

The active and reactive power compensation of single phase transmission line can be study with the help of simulation of single phase STATCOM and transmission line with different firing angles and modulation index for various combinations of resistive, inductive and capacitive load. This provides a better understanding about active and reactive power exchange of STATCOM with ac system for various firing angles. The Figure 4 shows the simulation of single phase STATCOM which consists of a single phase IGBT bridge, PWM pulse generator and shunt transformer.

The triggering PWM pulses are generated from PWM generator. The PWM generator block generates pulses for carrier-based pulse width modulation (PWM) converters using two-level topology. The PWM generator triggers the forced-commutated devices (FETs, GTOs, or IGBTs) of single-phase, two-phase, three-phase, two-level bridges or a combination of two three-phase bridges. In this paper a single phase STATCOM has developed. For triggering the IGBT's PWM signals are used which has carrier frequency equal to 1000Hz with a modulation index of 0.8.

For the simulation, all the output results are taken for the load of **R||L** having values **R= 115Ω** and **L= 1.46H**. The overall Simulink model consists of a single phase STATCOM and transmission line with R-L-C load bank. The transmission line is provided with a single phase 230volt, 50Hz ac supply. The active and reactive power is measured by PQ measurement meter and their values are shown on digital display. This paper deals with the reactive power compensation of transmission line without STATCOM and with STATCOM.

(A) Active and Reactive power compensation of Transmission line without STATCOM-:

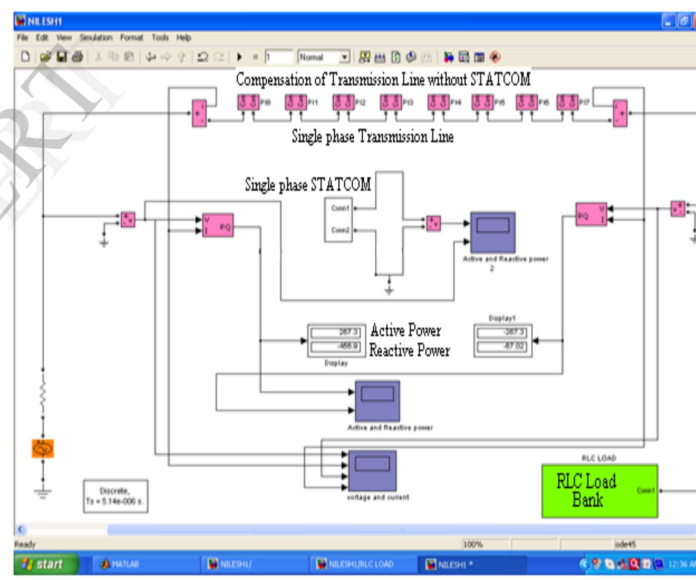


Fig. 5 - Compensation of transmission line without STATCOM

(B) Active and Reactive power compensation of Transmission line with STATCOM-:

ISSN: 2278-0181
Vol. 2 Issue 7, July - 2013

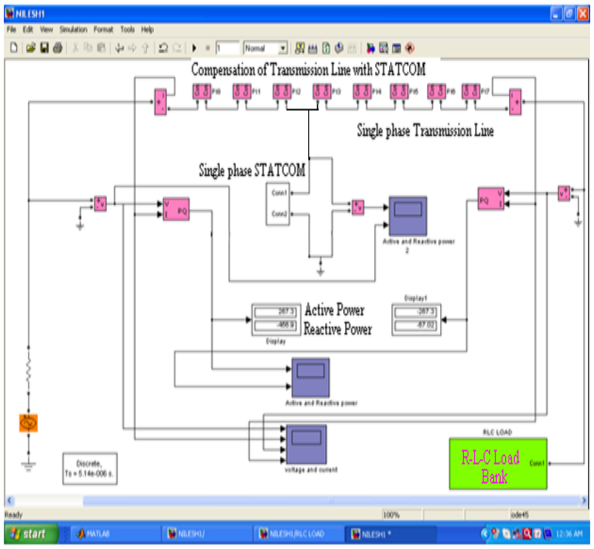


Fig. 6 - Compensation of transmission line with STATCOM

The reactive power compensation of single phase transmission line with STATCOM for different firing angles can be seen with MATLAB simulation.

VI. INVERTING OUTPUT VOLTAGE AT DIFFERENT FIRING ANGLES

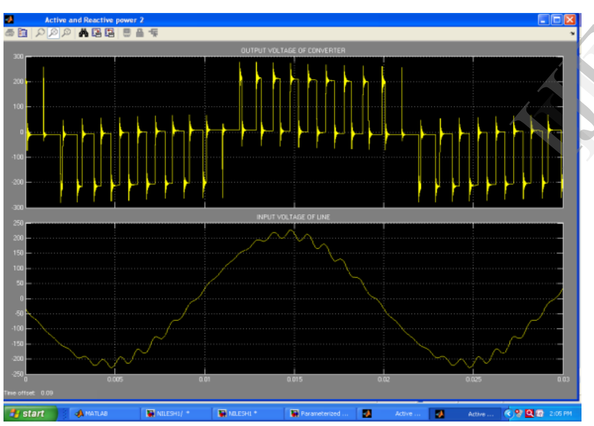


Fig. 7(a) - Inverting output voltage at 20°

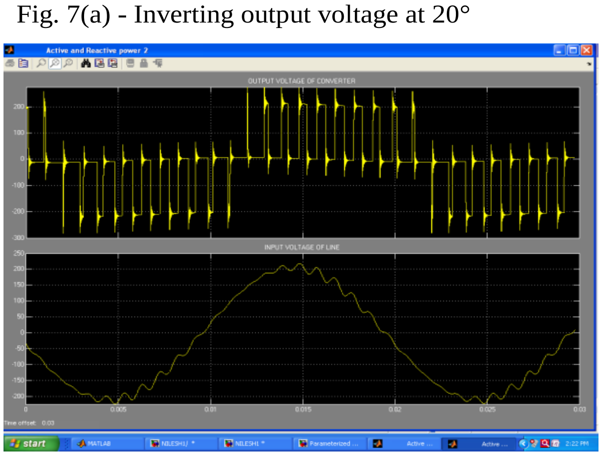


Fig. 7(b) - Inverting output voltage at 30°

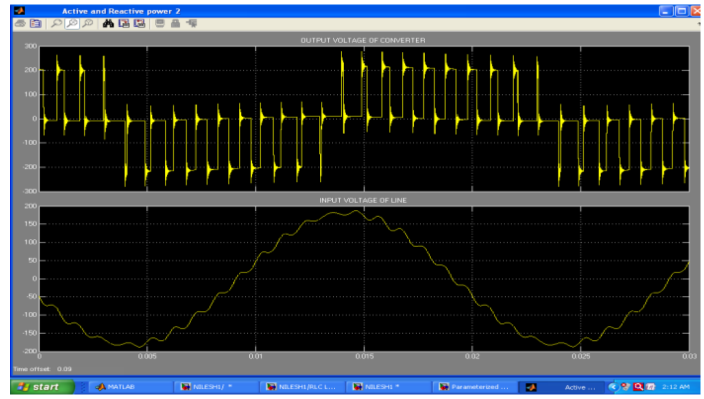
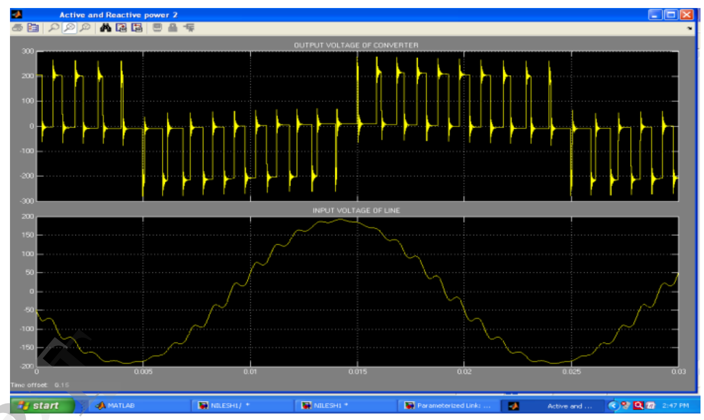


Fig. 7(c) - Inverting output voltage at 60°



VII. OUTPUT SIMULATION RESULTS

Active and reactive power without STATCOM-:

Load = R‖L (R = 115Ω and L = 1.46H)	
P_{ACTIVE} (Watt)	$Q_{REACTIVE}$ (Var)
267..3	-456.9

Table 1 - Active and reactive power without STATCOM

Active and reactive power with STATCOM-:

Load = R‖L (R = 115Ω and L = 1.46H)			
Sr. No.	Firing Angle	P_{ACTIVE} (Watt)	$Q_{REACTIVE}$ (Var)
1	20°	955.2	1942
2	30°	1179	2015
3	60°	1577	2516
4	80°	1569	3059

Table 2 - Active and reactive power with STATCOM

VIII. CONCLUSION

This paper shows the simulation of a single phase voltage source based STATCOM with single phase transmission line. Paper gives output STATCOM voltages at different firing angles. This work has provided a background for devising hardware of single phase STATCOM and to verify its performance with a laboratory scale model.

Fig 7(d) - Inverting output voltage at 80°

IX. REFERENCES

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