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Effect of Carrier Frequency in Grid Inter Connected Wind System with SSFC Controller

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ABSTRACT

In this paper a grid interconnected system with wind energy source linked with a FACTs based SSFC device (Static switched filter compensator) at load for enhancing power quality is considered .Analysis is done for the proposed system by varying Carrier frequency over a wide range and observed system performance at all 3 busses wise Grid bus, Generator Bus and Load Bus. Two regulators are used to organize the FACTS SSFC-device, these are based on a tri-loop dynamic error obsessed inter-coupled input to VSC controller. Investigation is made in MATLAB/SIMULINK Environment for the proposed system ,it is observed that system performance in terms of percentage Total harmonic Distortion is satisfactory along with the Enhanced Power Quality.

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1. INTRODUCTION

Renewable Energy sources such as Wind ,Solar ,Biomass etc are way out for the present day rising demand for electricity consumption with sustainable intensification and societal development. The green energy on conventional plant is minimized by the incorporation of the renewable energy resource akin to wind energy into power system [1]. This incorporation presents methodological challenges for which voltage regulation and power quality problems are to be measured. The power quality is a fundamental customer-central assess which is greatly affected by the distribution and transmission network's operation. The power quality issue is of great significance to the wind turbine. There has been an extended growth and fast development in using wind energy in the present day scenario. Wind energy conversion systems (WECS) are a outline of practicable and valuable renewable energy source that translate the wind kinetic energy to the mechanical energy [2]. This energy can be used to drive unalike AC and DC type generators. Generally, the WECS consists of a wind turbine, generator and its associated equipment, and the crucial control systems.

The WECS can be allied as either standalone or associated to the electric grid system, in the standalone connection the power is supplied to local isolated loads in isolated areas. It is required to endow with economical and effective technical solutions for both power quality and security issues anxious to the electric grid with schemes such as scattered and isolated wind energy schemes. Satisfyingly, the new arising FACTS technologies can act upon stabilization and power control functions by rapidly switching solid-state devices. Mostly FACTs devices are implemented for transmission control and Custom power devices for distribution control [3].

UPFC and STATCOM are custom power devices. Solid-state fault current limiters and Dynamic voltage Restorers are Apt for enhancing reliability and power quality of a system. The progress of these devices such as FACTS and custom power are for reducing definite power quality problems. For example, UPFC works most excellent for control of power flow, DVR as a series compensator is new for voltage sag compensation and STATCOM as a shunt compensator is in use for compensation of both reactive power and voltage sag[4] - [6]. Therefore different kinds of FACTS devices as STATCOM, DVR and UPS are functional for compensating a thorough kind of power quality problems.

This paper presents Effect of carrier frequency in the proposed FACTS based Static Switched Filter Compensator (SSFC) scheme incorporated wind energy system with efficient power quality enrichment[7]-[9]. Carrier frequencies are varied over range of 500 Hz to 10,000Hz and observed variations in % Total Harmonic Distortions[10],[11] at different busses in FACTS-SSFC scheme , it is satisfactory as per IEEE Standards[12] .This System is validated for well-organized precision of power quality, power losses reduction, voltage stabilization, and power factor improvement by means of Matlab/Simulink environment.

The above literature does not deal with Effect of variation of carrier frequency in the Grid Interconnected Wind System with FACTs-SSFC used for Improving Power Quality by Diminishing Total harmonic Distortion. This Paper presents that analysis. This paper is organized as follows: Section II describes the proposed system Section III explains about controller. Section IV Provides Simulation results and analysis. conclusion is given in Section V.

2.THE STATIC SWITCHED FILTER COMPENSATOR

Figure 1 depicts the FACTS SSFC scheme in which the series capacitor Cs1 is in series with the line conductors in order to reimburse part of the feeder inductance vigorously. Such fall enhances the power flow and mitigates the feeder reactive power loss. The two three phase shunt capacitor banks Cf1 and Cf2 are connected with the two series capacitor terminals in parallel. The shunt capacitor banks contribute reactive power compensation and as well get better the regulation of distribution feeder.

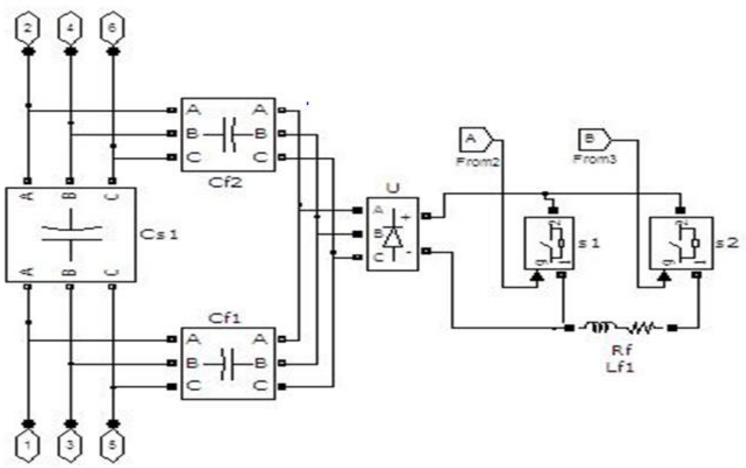

Figure 1. The FACTS Static Switched Filter Compensator scheme

The series capacitor bank operates as a dynamic voltage booster and inflow current preventive device. For the capacitor, the energy discharge path is formed by the six pulses diode rectifier including the resistance (R_f) and inductance (L_f) branch which forms a tuned arm filter at the DC side of the rectifier. The two complementary switching pulses P1 and P2 controls the two IGBT switches S1 and S2. The pulses are generated by the modified VSC controller. The fluctuating topology of the FACTS-SSFC can be varied by the complementary PWM pulses as follow:

Case 1: If P1 is high and P2 is low, the resistor and inductor will be fully shorted and the combined shunt andseries capacitors will provide the required shunt and series capacitive compensation to the AC distribution system.

Case 2: If P1 is low and then P2 is high, the resistor and inductor will be connected into the circuit as a tunedarm filter.

3. CONTROLLER DESIGN

Inter-coupled dynamic control depending on two regulators A and B are anticipated to moderate the harmonics, stabilize the buses voltage and develop the power factor by means of the FACTS SSFC. To regulate the switched filter compensator the tri-loop error driven dynamic controller is worn which is a dual action control. The global error is the totting up of the output of the two inter-coupled regulators. The input of the VSC controller is the global error signal which regulates the modulating control signal to the PWM switching block as depicted in Figure 2.

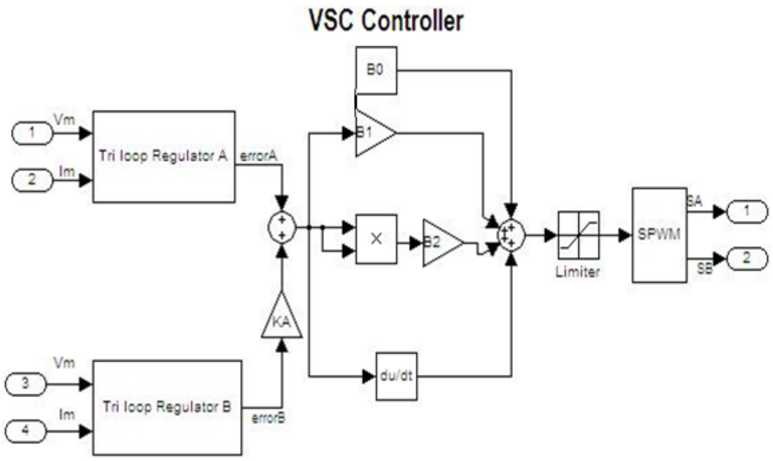

Figure 2. The VSC control of the FACTS SSFC scheme

The function of the Regulator A is to furnish a stable voltage at all busses and progress the power factor. This is achieved by modulating the SSFC admittance. The purpose of the regulator B is to repress harmonics in voltage and current waveforms.

4. SIMULATION RESULTS AND ANALYSIS

4.1. AC system configuration

The proposed AC system is 11 kV distribution network with a renewable wind energy source which is associated to AC grid of 138 kV via step up transformer which is of 11/138kV. A hybrid load consisting of a linear, nonlinear and an induction motor load is connected to the distribution network via 11/4.16kV step down transformer. Figure.3 shows Block Diagram of proposed Grid connected wind system With FACTs-SSFC.

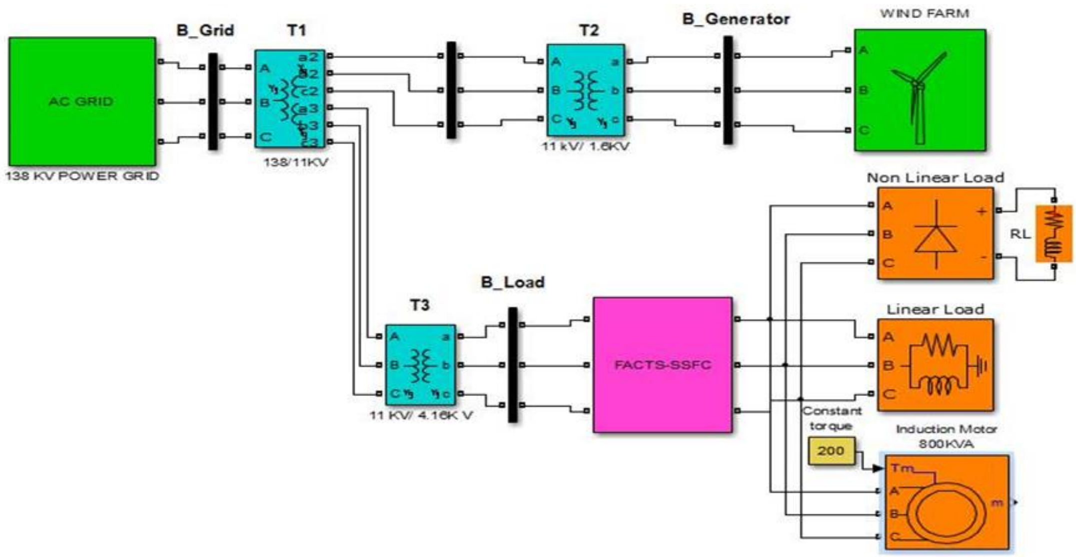

Figure 3. Block diagram of proposed grid connected wind system with FACTs-SSFC

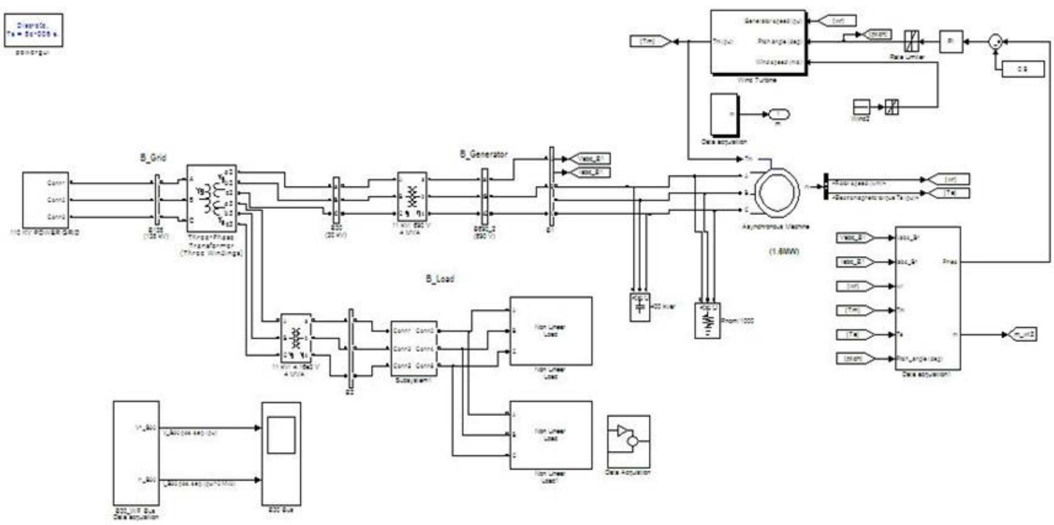

Figure 4. Simulation diagram of proposed grid connected wind system with FACTs –SSFC

Table 1. IEEE-519 Voltage Distortion Limits

	Maximum Individual Harmonic component,%	Maximum THD ,%
69KV and below	3.0	5.0
69 KV to 161 KV	1.5	2.5
Above 161 KV	1.0	1.5

In this paper analysis is done for different carrier frequencies at busses wise Grid bus Generator Bus ,Load Bus of the proposed Grid connected wind system with FACTs –SSFC and it is observed in the range of 500Hz to 10000Hz.From the analysis it is observed that the Percentage voltage THD is almost zero through out ,its value is minimum 0.18 to 0.3 maximum for Generator bus ,for load bus its value is 0.02 through out. All these are with in the limits specified by IEEE-519 Voltage Distortion Limits as mentioned in Table 1.

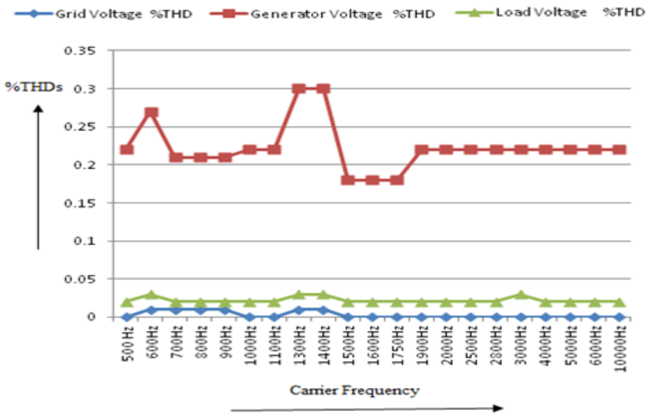

Figure 5.Variation of % voltage THDs of different busses with variation of carrier frequencies

Similarly analysis is done for different carrier frequencies at busses wise Grid bus, Generator Bus ,and Load Bus of the proposed Grid connected wind system with FACTs –SSFC and it is observed for the range 500Hz to 10000Hz.From the analysis it is observed that the Percentage current THDs is 0.73 throughout Grid Bus ,its value is 0.74 at Generator bus ,but at load bus its value varies from 0.61to 1.11.

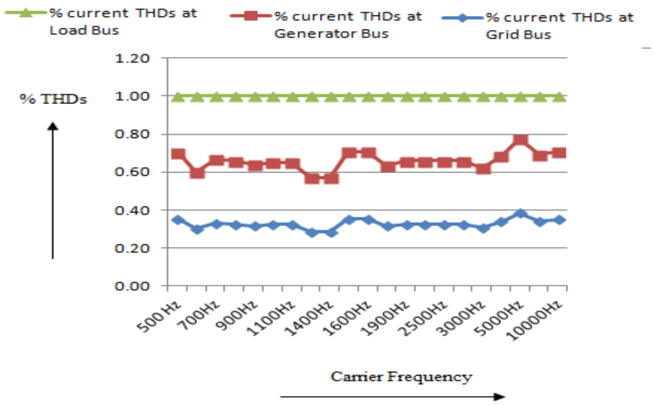

Figure 6. Variation of % Current THDs of different busses with variation of carrier frequencies

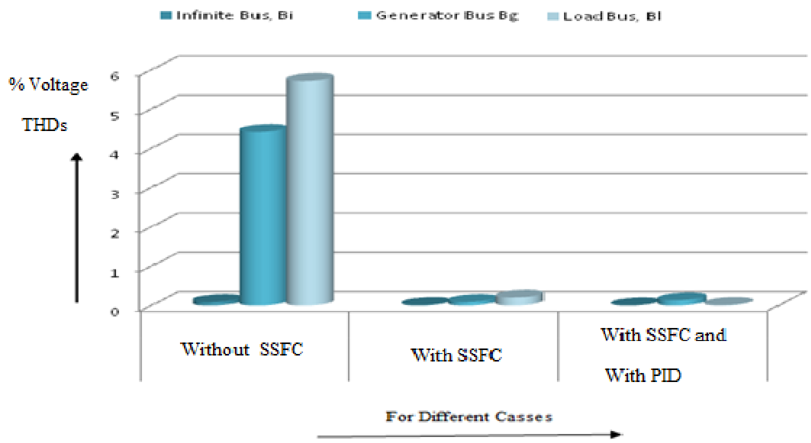

Figure 7. Percentage THDs for voltages at Different busses for different cases

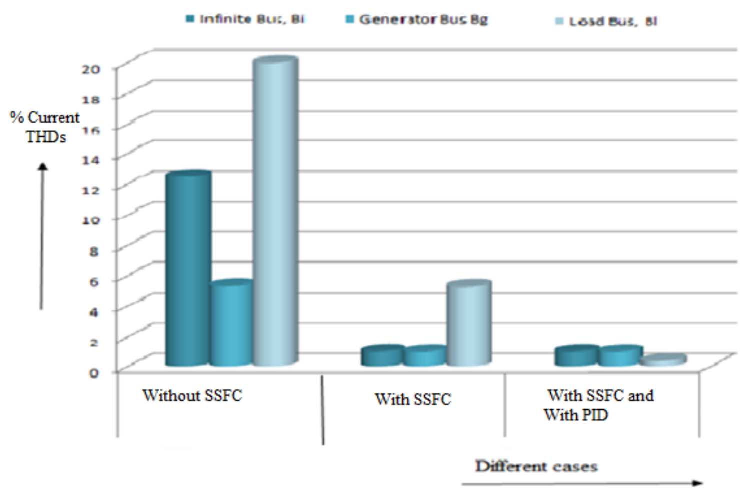

Figure 8. Percentage THDs for currents at Different busses for different cases

Percentage THDs for Voltages and Currents atdifferent bussesas Infinite bus,Generator bus and Load bus for different cases as Without SSFC ,With SSFC and With SSFC and With PID are is shown in Figures 7 and 8 respectively .It is Observed that Percentage Total Harmonic Distortions Minimised and it is within the limits as per IEEE Standards.

5. CONCLUSION

This paper provides a concise investigation of effect of carrier frequency on the proposed grid interconnected wind energy system with FACTs-SSFC at different busses as Grid bus, Generator bus and Load buseinterms of percentage Total Harmonic Distortion.of voltages and currents. It is clear from the analysis that carrier frequency is varied from 500Hz to 10,000Hz.There is very less variation in voltages and currents percentage THDs at all busses expect at load buses that too for current THDs. For thisreason the power lines besides communication lines are not affected by the noise signals and hence Power Quality is Improved. The current THD is fluctuating around 1% while minimum being 0.61% at 500Hz.and maximum being 1.11% at 1400Hz at Load bus. Similarly voltage THD is fluctuating around 0.3%.It is observed that THDs are well below 2.5% as specified by IEEE standards.

REFERENCES

[1]. J. M. Carrasco, and etc," Power-Electronic Systems for the Grid Integration of Renewable Energy Sources: A Survey", *IEEE Transactions on Industrial Electronics*, vol. 53, no. 4, pp 1002-1016, August 2006.

[2]. S.Sarita, H. Prakash Kumar, "Power Quality Improvement by Solar Photo-voltaic/Wind Energy Integrated System Using Unified Power Quality Conditioner," *International Journal of Power Electronics and Drive Systems (IJPEDS)*, Vol. 8,pp.1416-1426, 2017.

[3]. Narain G. Hingorani and Laszlo Gyugyi, Understanding FACTS: concepts and technology of flexible AC transmission system, *Institute of Electrical and Electronics Engineers*, Inc. 2000.

[4]. S. Deepa, S. Praba, V. Deepalakshmi, L. Jayaprakash, M. Manimurugan, "A Fuzzy GA Based STATCOM for Power Quality Improvement", *International Journal of Power Electronics and Drive System (IJPEDS)*, Vol. 8,, No. 1 pp. 483-491, 2017.

[5]. K. Rabyi , M.Hassane , " Analysis and Impact of D-STATCOM ,Static Var Compensator, Fuzzy Based SVC Controller on the Stability of a Wind Farm," *International Journal of Power Electronics and Drive Systems(IJPEDS)*, Vol. 8,pp.935-944, 2017.

[6]. G.Stayanarayana, G. Ravi Kumar, "Harmonic Elimination Using STATCOM for SEIG Fed Induction Motor Load," *International Journal of Power Electronics and Drive Systems (IJPEDS)*, Vol. 8, pp.1026-1034, 2017.

[7]. M. Sharaf, A. A. Abdelsalam, "A novel switched filter compensation scheme for power quality enhancement and loss reduction," International *Symposium on Innovations in Intelligent Systems and Applications ,INISTA* 2011, Turkey, pp 398- 403.

[8]. M. Sharaf, A. A. Abdelsalam, A. A. Eldesouky, A.A. Sallam, " A novel FACTS based modulated power filter compensation scheme for smart electric grid stabilization and efficient utilization, " *International Journal of Distributed Energy Resources*, vol. 7, no. 4, pp 311-327, 2011.
[9]. M. Sharaf, A. A. Abdelsalam, "A novel facts based dynamic voltage compensation scheme for smart electric grid stabilization and efficient utilization," IEEE Proceedings of the *24th Canadian Conference on Electrical and Computer Engineering (CCECE)*,Canada, May 2011, pp.000042-000047.
[10]. M.V.Subramanyam, S.Mani.Kuchibhatla, P.V.N.Prasad, " Effect of carrier frequency on THD in – closed loop control of 5 Level Multi –level inverter fed 3 phase Induction motor drive," *International Journal of Scientific & Engineering Research,*Vol.4 , pp.804-809, 2013
[11]. D.Stepins, Jin. Huang, "Effects of Switching Frequency Modulation on Input Power Quality of Boost Power Factor Correction Converter," *International Journal of Power Electronics and Drive Systems (IJPEDS)*, Vol. 8,pp.882-899, 2017.
[12]. IEEE Std 519-1992, "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems", 1992.

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