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HARMONIC MITIAGATION USING GSC ANDEXTRACTING MAXIMUN POWER USING RSC FOR WIND ENERGY CONVERSION

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ABSTRACT

This paper gives the operation of doubly fed induction generator with an integrated active filter capabilities using grid-side converter (GSC).The main work of this paper lies in the control of GSC for supplying harmonics with addition to its slip power transfer. Maximum power extraction is attaining by rotor-side converter. This Wind energy conversion system (WECS) works as a static compensator (STATCOM) and work for supplying harmonics even when the wind turbine is in off condition. Control strategies of both GSC and RSC are presented .The suggested DFIG-based WECS is simulated using MATLAB/Simulink. DFIG based WECS is developed using a digital signal processor (DSP). Simulated results are validated with test results of the developed DFIG for different practical conditions.

***keywords:wind energy conversion system (WECS).Doubly fed induction generator (DFIG), integrated active filter, nonlinear load, power quality*.**

I. INTRODUCTION

Due to growth in population and industrialization, the energy demand has increased in large amount. We know that the conventional energy sources such as coal, oil, and gas are limited in nature. So there is a need for renewable energy sources for fulfill future energy demand. Renewable source are in more amount and eco-friendly also cost of the wind power produced is comparable to that of conventional power plants. So, the wind energy is the most preferred compare to all other renewable energy source. In starting days, wind turbines used as fixed speed wind turbines with squirrel cage induction generator along with capacitor banks. For simplicity and low cost most of the wind turbines are fixed speed, but for extracting maximum power, the machine should run at varying rotor speeds at different speed of wind. Now a day by using modern power electronic converters, the machine is able to run at adjustable speeds. So there is improvement in the wind energy production .Among all variable speed wind turbines, doubly fed induction generators (DFIGs) are preferred because of their low cost and higher energy output, lower converter rating, and better utilization of generators. DFIGs provide good damping performance for the weak grid. Independent control of active and reactive power is achieved by the decoupled vector control algorithm presented in and this vector control of such system is usually realized in synchronously rotating reference frame oriented in either voltage axis or flux axis. In this work, the control of rotor-side converter (RSC) is implemented in voltage-oriented reference frame.

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Grid code requirements for the grid connection and operation of wind farms are discussed. Response of DFIG-based. As the wind penetration in the grid becomes significant, the use of variable speed WECS for supplementary jobs such as power smoothening and harmonic mitigation are compulsory in addition to its power generation.

II. SYSTEM MODEL AND ASSUMPTIONS

Figure.1.Shows a schematic diagram of the suggested DFIG based WECS with integrated active filter capabilities. In figure it is shown that the stator is directly connected to the grid as shown. Two back-to-back connected voltage source converters (VSCs) are position in between the rotor and the grid. Nonlinear load is connected at PCC which is shown in Fig. 1. The suggested DFIG works as an active filter in addition to the active power generation similar to normal DFIG. Harmonics generated by the nonlinear load connected at the PCC affect and distort the voltage at PCC.GSC controls these nonlinear load harmonic currents, so that the stator and grid currents are harmonic-free. Maximum power point tracking (MPPT) is achieved by RSC,and RSC also help for making unity power factor at the stator side using voltage oriented reference frame. Synchronous reference frame (SRF) control method is used for extracting the fundamental component of load currents for the GSC control.

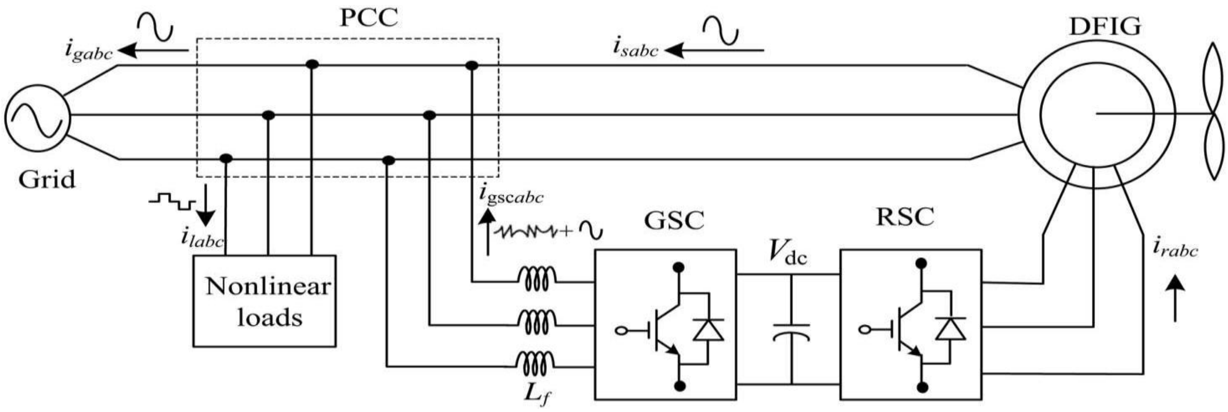

Fig.1. schematic diagram of the suggested DFIG

III. DESIGN OF DFIG-BASED WECS

The rating of VSCs and dc-link voltage is very much important for the successful operation of WECS Selection. Appendix shows the ratings of DFIG and dc machine used in this experimental system. In this part, a detailed design of VSCs and dc-link voltage is discussed for the experimental system.

Table 1. System Parameters

Sr.No.	Parameters	Ratings
1.	Grid voltage	3-phase,415V,50Hz
2.	Induction Generator	3.35 KVA,415V,50Hz,P=4, Rs=0.01Ω, Rr=0.015 Ω, Ls=0.06H,Lr=0.06H.
3.	Inverter Parameters	DC link Voltage=800V, DC link Capacitance=100µF Switching frequency =2kHz
4.	IGBT rating	Collector Voltage =1200V, Forward Current =50A,

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		Gate voltage=20V Power dissipation =310W
5.	Load Parameter	Non-Linear Load 25kW,50kVAR

IV. CONTROL STRATEGY

The control scheme approach is based on injecting the currents into the grid using “bang-bang controller.” The controller uses a hysteresis current controlled technique. Using such technique, the controller keeps the control system variable between boundaries of hysteresis area and gives correct switching signals for GSC & RSC operation.

The control system scheme for generating the switching signals to the GSC & RSC is shown in Fig. 3. The control algorithm needs the measurements of several variables such as three-phase source current i_{Sabc}, DC voltage V_{dc}, inverter current i_{iabc} with the help of sensor. The current control block, receives an input of reference current i^*_{Sabc} and actual current i_{Sabc} are subtracted so as to activate the operation of GSC & RSC in current control mode.

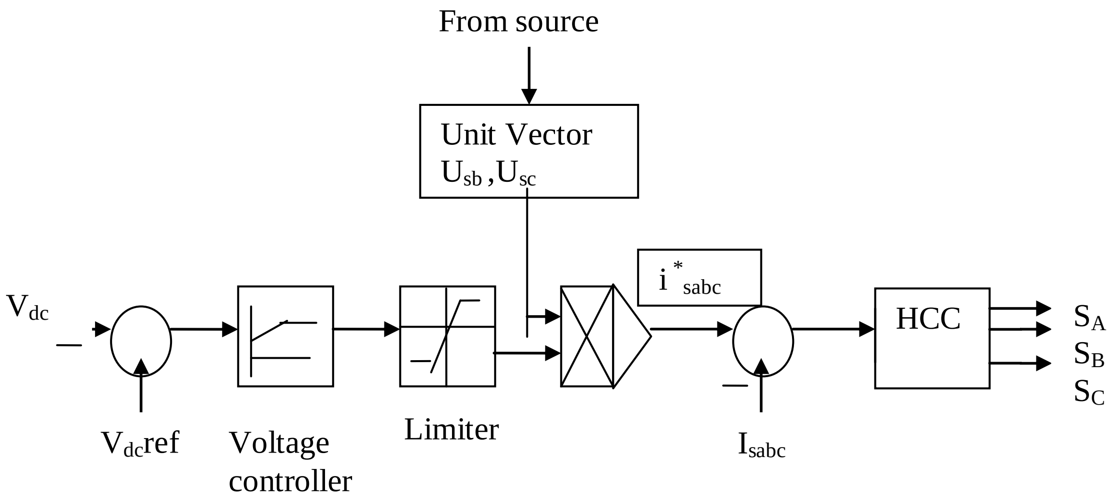

Figure 2. Control System Scheme

The control of power flow between a grid-connected power converter and the ac mains requires an online tracking of the fundamental component voltage (or current) phase angle. Due to this switching function, the inverter injects the current into the grid in such a way that the source current is harmonic free. The injected current will cancel out the reactive and harmonic part of the load current and thus improve the power factor. To accomplish these goals, the grid voltages are sensed and synchronized in generating the current command for the inverter.

The wind energy generating system is connected with grid having the nonlinear load. The performance of the system is measured by switching the GSC & RSC at time t = 0.3 s in the system and how the GSC & RSC responds to the step change command for increase in additional load at 1.0 s is shown in the simulation. When GSC & RSC controller is made ON, without change in any other load condition parameters, it starts to mitigate for reactive demand as well as harmonic current. The dynamic performance is also carried out by step change in

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a load, when applied at 1.0 s. This additional demand is fulfill by GSC & RSC compensator. Thus, GSC & RSC can regulate the available real power from source

Bang-Bang Current Controller-Bang-Bang current controller is implemented in the current control scheme. The reference current is generated and actual current are detected by current sensors and are subtracted for obtaining a current error for a hysteresis based bang-bang controller. Thus the ON/OFF switching signals for IGBT ofGSC & RSC are derived from hysteresis controller.

The switching function $S_A$for phase 'a' is expressed as (1) & (2).

$$i_{sa} < (i^*_{sa} - HB) \rightarrow S_A = 0 \quad (1)$$

$$i_{sa} > (i^*_{sa} - HB) \rightarrow S_A = 1 \quad (2)$$

Where,

HB is a hysteresis current-band, similarly the switching function S_B, S_C can be derived for phases "b" and "c". A controlled current inverter is required to generate this compensating current. Hysteresis current control is a method of controlling a voltage source inverter so that an output current is generated which follows a reference current waveform. This method controls the switches in an inverter asynchronously to ramp the current through an inductor up and down so that it tracks a reference current signal. Hysteresis current control is the easiest control method to implement. One disadvantage is that there is no limit to the switching frequency, but additional circuitry can be used to limit the maximum switching frequency. A hysteresis current controller is implemented with a closed loop control system. An error signal is used to control the switches in an inverter. This error signal is the difference between the desired current, i_{sa}^*, and the current being injected by the inverter, i_{sa}. When the error reaches an upper limit, the transistors are switched to force the current down. When the error reaches a lower limit the current is forced to increase. The range of the error signal directly controls the amount of ripple in the output current from the inverter and this is called the Hysteresis Band. The hysteresis limits error and relates directly to an offset from the reference signal and is referred to as the Lower Hysteresis Limit and the Upper Hysteresis Limit. The current is forced to stay within these limits even while the reference current is changing. The ramping of the current between the two limits.A method to reduce the low-order harmonic content of the GSC & RSC output current is to use hysteresis current control. Under hysteresis control, rapid switching of each switch according to the continuous measurement of the difference between the GSC & RSC supply current and reference sinusoidal current. The basic principle of current hysteresis control technique is that the switching signals are derived from the comparison of the current error signal with a fixed width hysteresis band. With simple, extreme robustness, good stability, fast dynamic, this current control technique exhibits some unsatisfactory features.

For hysteresis control the phase output current is fed back to compared with the reference current I_{ref}. An upper tolerance band and a lower tolerance band, taken as ±2% of, are also assigned in order to define an acceptable current ripple level. Whenever the phase current exceeds the upper band, the upper switch of that leg will be turned ON while the lower switch will be turned OFF. If phase current falls below the lower band, the upper switch will be turned OFF whereas the lower switch will be turned ON.

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IV. SIMULATION AND RESULTS

Results obtained without using GSC & RSC up to 0.3s

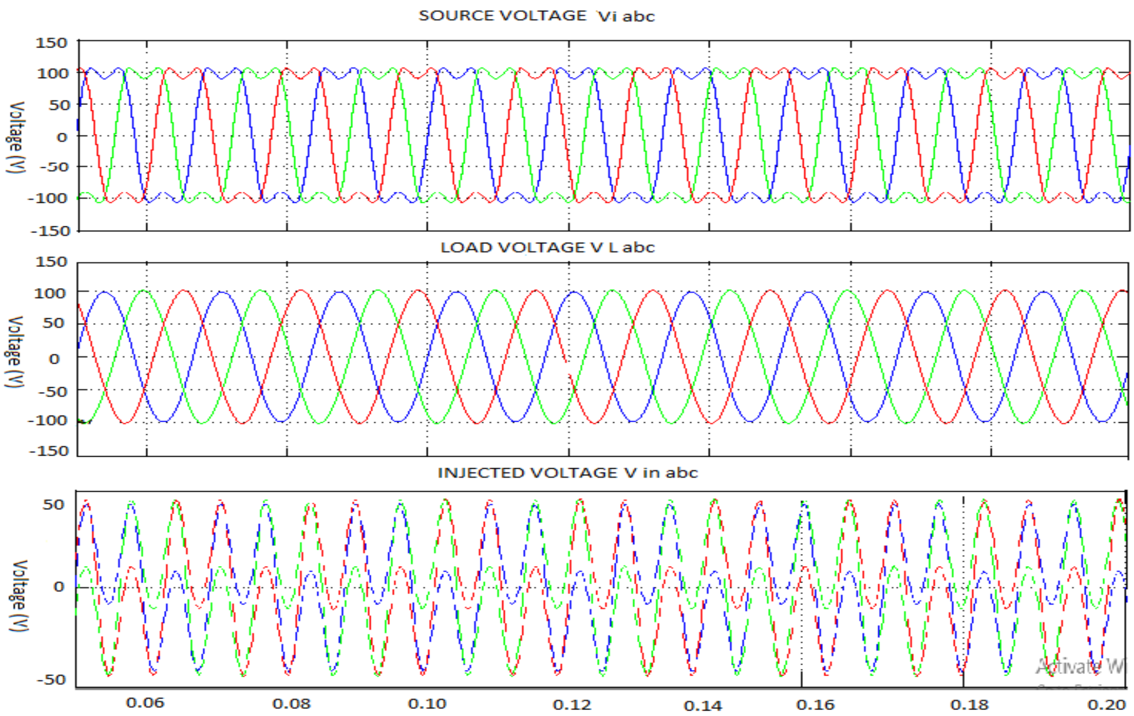

Fig. 3 voltage difference between source and load with injected voltage

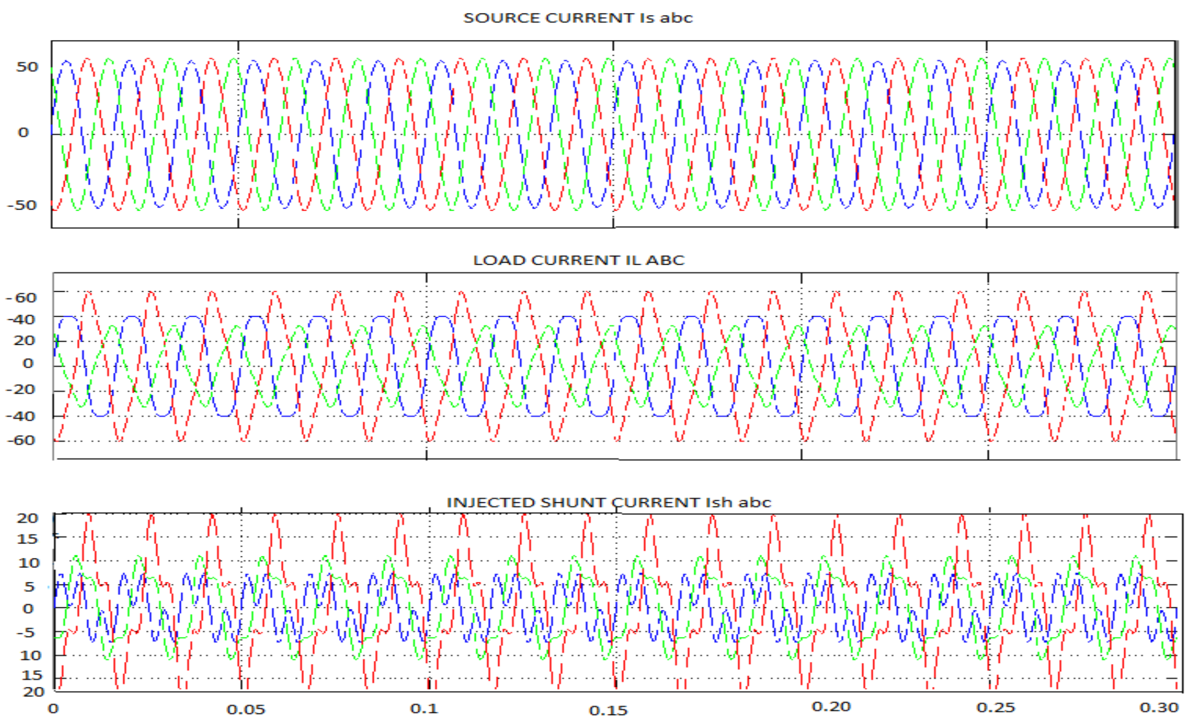

Fig. 4 current difference between source and load with injected current

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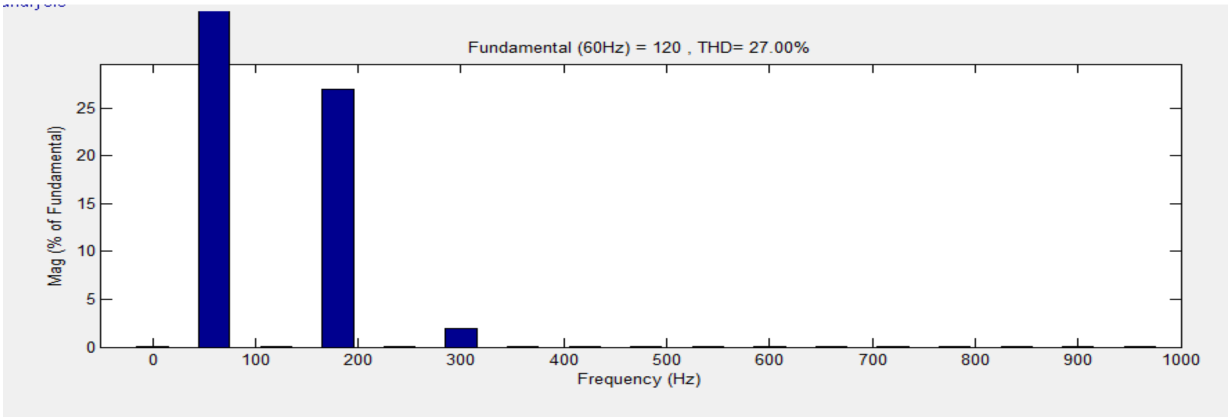
Harmonics obtained without using GSC & RSC up 0.3s:



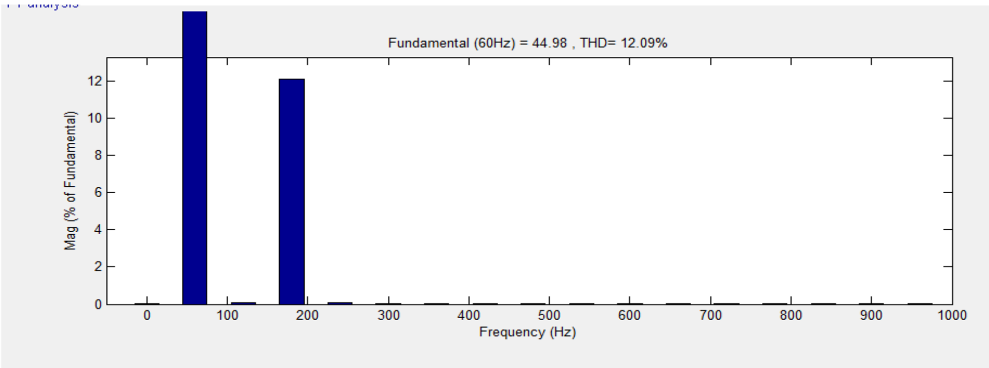
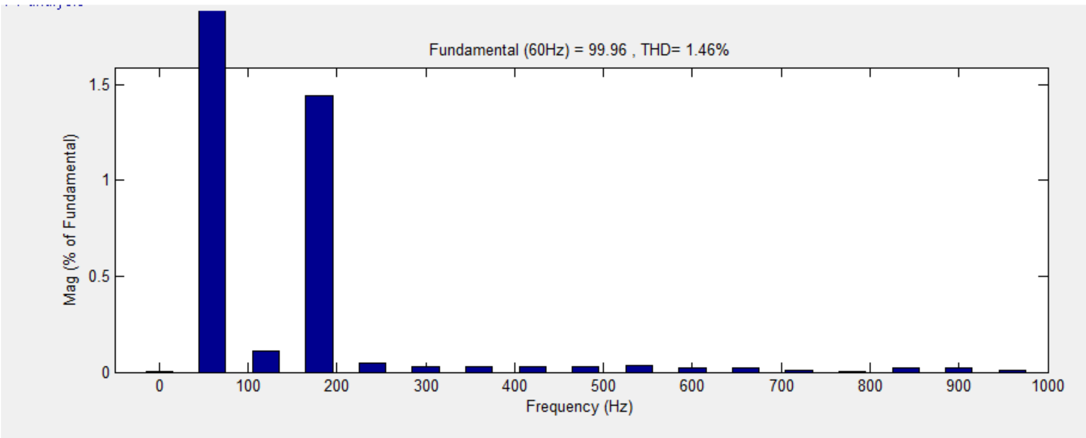


Fig.5 FFT Analysis for voltage and current without using GSC & RSC up 0.3s for 60Hz

Harmonics obtained using GSC & RSC after 0.3s :



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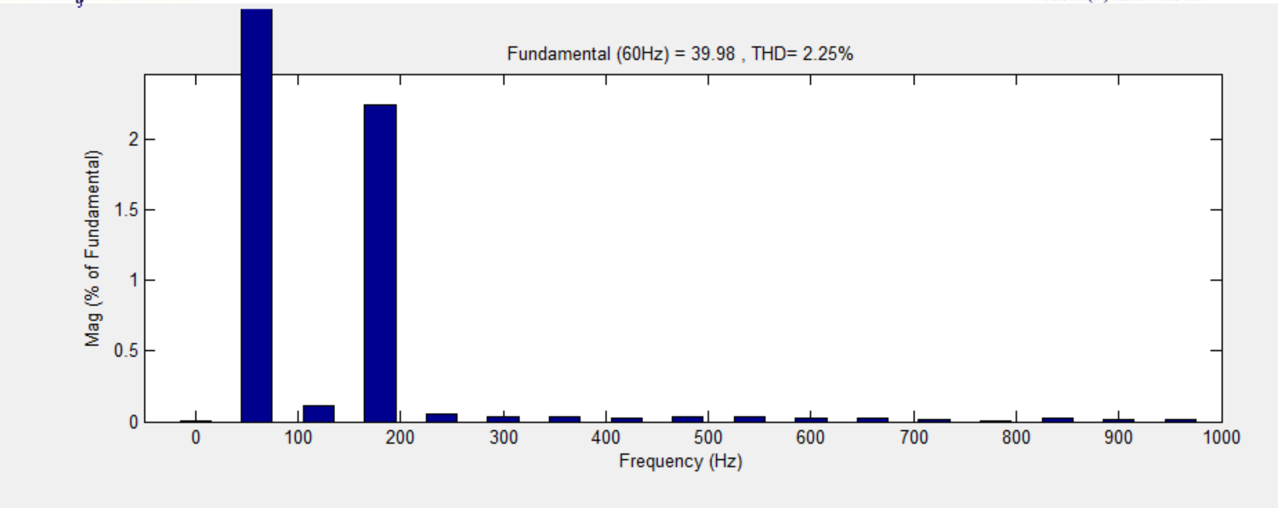

Fig.6 FFT Analysis for voltage and current with using GSC & RSC after 0.3s for 60Hz

V. CONCLUSION

This system presents the control scheme for power quality improvement in grid connected wind generating system with non-linear load. The power quality issues and its consequences on the consumer and electric utility are presented. GSC & RSC based SIMULINK MODEL for grid connected wind energy system is also proposed. It has the capability to cancel out the harmonic parts of the load current. It maintains the source voltage and current in phase and supports the reactive power demand for the wind generator and load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of the transmission line. The integrated wind generation and GSC & RSC have the outstanding performance. In addition, since the GSC & RSC suppresses the voltage fluctuation, it is apparent that, compared to the case without GSC & RSC.

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