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Power Quality Improvement of Grid Connected Wind Energy System with STATCOM

[1]Revti Yadav, [2]Dr. Durga Sharma, [3]Vishwanath Prasad Kurmi

[1]M.Tech. Scholar , [2]Associate Professor , Dr. C. V. Raman University , Kota , Bilaspur, [3]Assistant Professor, Dr. C. V. Raman University , Kota , Bilaspur,
[1]Electrical & Electronics Engineering Department
[1]Dr. C. V. Raman University , Kota , Bilaspur (C.G.) India

Abstract :- Injection of the wind power into an electric grid affects the strength exceptional. The overall performance of the wind turbine and thereby electricity nice are determined on the basis of measurements and the norms observed according to the rule specified in International Electro-technical Commission trendy, IEC-61400. The have an impact on of the wind turbine within the grid gadget concerning the electricity pleasant measurements are-the active strength, reactive power, variation of voltage, flicker, harmonics, and electrical conduct of switching operation and these are measured consistent with national/global suggestions. The electricity exceptional problem mainly due to set up of wind turbine with the grid. In this proposed scheme STATIC COMPENSATOR (STATCOM) is attached at a factor of common coupling with a battery electricity storage machine (BESS) to mitigate the energy first-class problems. The battery strength garage is included to sustain the actual strength source below fluctuating wind power. The STATCOM manipulate scheme for the grid linked wind electricity era machine for power excellent development is simulated the usage of MATLAB/SIMULINK in power system block set. The effectiveness of the proposed scheme relives the primary deliver source from the reactive power demand of the burden and the induction generator. The improvement of the grid co-ordination rule and the scheme for improvement in energy excellent norms as according to IEC-preferred at the grid has been supplied.

Keywords; — International electro-technical commission (IEC), Power quality, Wind generating system (WGS).

I. INTRODUCTION

Today, modern energy industry faces a growing awareness regarding the impact of conventional power generation on the environment. Issues such as limited fossil fuel reserves, climate change due to $CO2$ emissions, bring to attention alternative technologies to generate electricity in a more sustainable manner. The intermittency of wind seldom creates insurmountable problems when using wind power to supply a low proportion of total demand, but it presents extra costs when wind is to be used for a large fraction of demand. The latest technological advancements in wind energy conversion and an increased support from governmental and private institutions have led to increased wind power generation in recent years. Wind power is the fastest growing renewable source of electrical energy [1].

The wind power has increased in the past few years, hence it has become necessary to address problems associated with maintaining a stable electric power system that contains different sources of energy including hydro, thermal, coal, nuclear, wind, and solar. In the past, the total installed wind power capacity was a small fraction of the power system and continuous connection of the wind farm to the grid was not a major concern. The wind farm capacity is being continuously increased through the installation of more and larger wind turbines. Voltage stability and an efficient fault ride through capability are the basic requirements for higher penetration. Wind turbines have to be able to continue uninterrupted operation under transient voltage conditions to be in accordance with the grid codes [1]. Grid codes are certain standards set by regulating agencies. Wind power systems should meet these requirements for interconnection to the grid. Different grid code standards are established by different regulating bodies, but Nordic grid codes are becoming increasingly popular [2]

One of the major issues concerning a wind farm interconnection to a power grid concerns its dynamic stability on the power system [3]. Voltage instability problems occur in a power system that is not able to meet the reactive power demand during faults and heavy loading conditions. Stand alone systems are easier to model, analyze, and control than large power systems in simulation studies. A wind farm is usually spread over a wide area and has many wind generators, which produce different amounts of power as they are exposed to different wind patterns.

Flexible AC Transmission Systems (FACTS) such as the Static Synchronous Compensator (STATCOM) are used in power systems because of their ability to provide flexible power flow control. The main aim for choosing STATCOM in wind farms is its ability to provide bus bar system voltage support either by supplying and/or absorbing reactive power into the system. The STATCOM in wind farms has been investigated and indicate that it is able to supply reactive power requirements of the wind farm under various operating conditions, thereby improving the steady-state stability limit of the network [4]. The methods used to develop an equivalence of a collector system in a large wind power plant are described in [5]. The requirements, assumptions and structure of an aggregate model of a wind park with constant speed turbine and variable speed turbines are discussed in [6].

II. OBJECTIVE OF RESEARCH

The causes of power quality problems are generally complex and difficult to detect when we integrate a wind turbine to the grid. The ideal AC line supply by the utility system should be a pure sine wave of fundamental frequency (50/60Hz). We can therefore conclude that the lack of quality power can cause loss of production, damage of equipment or appliances or can even be detrimental to human health. This paper presents the power electronic based power conditioning using custom power devices like STATCOM can be effectively utilized to improve the quality of power supplied to the customers.

III. REQUIREMENTS OF STATCOM

The main functional requirements of the STATCOM in this thesis are to provide shunt compensation, operating in capacitive mode only, in terms of the following.[11]

- Voltage stability control in a power system, as to compensate the loss voltage along transmission.
- This compensation of voltage has to be in synchronism with the AC system regardless of disturbances or change of load.
- Transient stability during disturbances in a system or a change of load.
- Reactive power injection by STATCOM into the system.

IV. CONTROL FOR REAL AND REACTIVE POWER

Basic operating principle of a SATCOM is similar to that of synchronous machine. The synchronous machine will provide lagging current when under excited and leading current when over excited. STATCOM can generate and absorb reactive power similar to that of synchronous machine and it can also exchange real power if provided with an external device DC source.

Reactive Power Exchange:-

If the output voltage of the voltage source converter is greater than the system voltage then the SATCOM will act as capacitor and generate reactive power (i.e. provide lagging current to the system).

Real Power Exchange:-

As the switching devices is not loss less there is a need for the DC capacitor to provide the required real power to the switches. For long duration of real power requirement even after the primary supply failed back up energy storage system (BESS) is used. Hence there is a need for real power exchange with an AC system to make the capacitor voltage constant in case of direct voltage control. There is also a real power exchange with the AC system if STATCOM is provided with an external DC source to regulate the voltage in case of very low voltage in the distribution system or in case of faults. And if the VSC output voltage leads the system voltage then the real power from the capacitor or the DC source will be supplied to the AC system to regulate the system voltage to the equal per unit or to make the capacitor voltage constant [12].

Hence the exchange of real power and reactive power of the voltage source converter with AC system is the major required phenomenon for the regulation in the transmission as well as in the distribution system.

V. MODELING OF POWER QUALITY IMPROVEMENT

The STATCOM based current control voltage source inverter injects the current into the grid in such a way that the source current are harmonic free and their phase-angle with respect to source voltage has a desired value. The injected current will cancel out the reactive part and harmonic part of the load and induction generator current, thus it improves the power factor and the power quality. To accomplish these goals, the grid voltages are sensed and are synchronized in generating the current command for the inverter. The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC), the grid connected system in Fig.1, consists of wind energy generation system and battery energy storage system with STATCOM. [29]

Wind Energy Generating System:- In this configuration, wind generations are based on constant speed topologies with pitch control turbine. The induction generator is used in the proposed scheme because of its simplicity, it does not require a separate field circuit, it can accept constant and variable loads, and has natural protection against short circuit. The power of wind energy system is

$$P_{wind} = \frac{1}{2}\rho A V^3{}_{wind}$$

$$P_{mech} = C_P \; P_{wind}$$

Where C_p is the power coefficient, depends on type and operating condition of wind turbine. This coefficient can be express as a function of tip speed ratio and pitch angle. The mechanical power produce by wind turbine is.

$$P_{mech} = \frac{1}{2}\rho\pi R^2 V^3{}_{wind} \; C_p$$

Where R is the radius of the blade (m).

VI. SYSTEM OPERATION

The shunt connected STATCOM with battery energy storage is connected with the interface of the induction generator and non-linear load at the PCC in the grid system. The STATCOM compensator output is varied according to the controlled strategy, so as to maintain the power quality norms in the grid system. The current control strategy is included in the control scheme that defines the functional operation of the STATCOM compensator in the power system. A single STATCOM using insulated gate bipolar transistor is proposed to have a reactive power support, to the induction generator and to the nonlinear load in the grid system. The main block diagram of the system operational scheme is shown in Fig.1

Simulation model

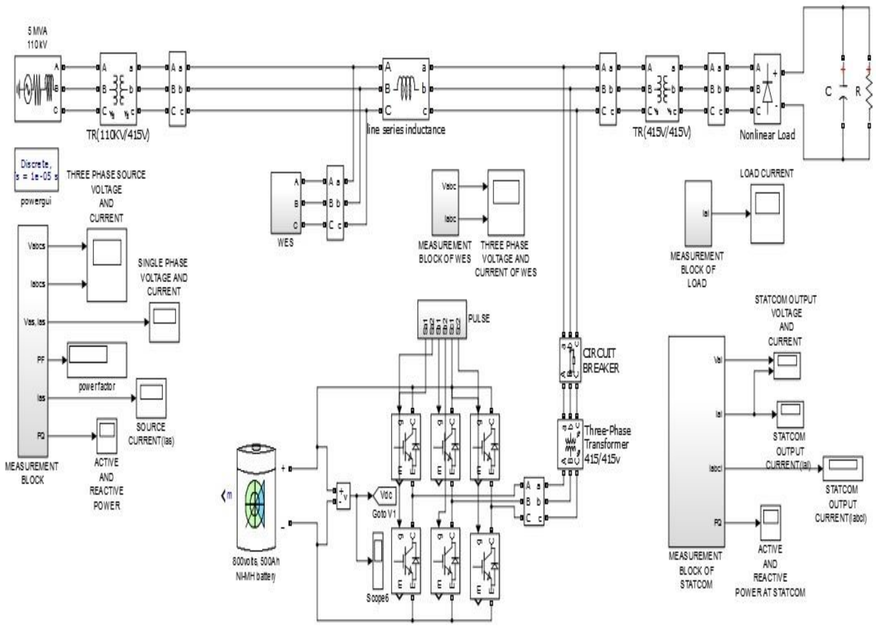

Fig 1. Simulation model for statcom control grid connected wind energy system for power quality improvement

VII. RESULT & DISCUSSION

The wind electricity generating machine is connected with grid having the nonlinear load. The performance of the device is measured by means of switching the STATCOM at time s inside the device and how the STATCOM responds to the step change command for increase in extra load at zero.22s is proven in the simulation. When STATCOM controller is made ON, without alternate in every other load situation parameters, it starts off evolved to mitigate for reactive call for in addition to harmonic modern. The dynamic performance is likewise done via step alternate in a load, whilst applied at zero.22 s. This extra demand is satisfy by STATCOM compensator. Thus, STATCOM can alter the available real electricity from supply. The simulation consequences are shown in the figures beneath.

FFT ANALYSIS

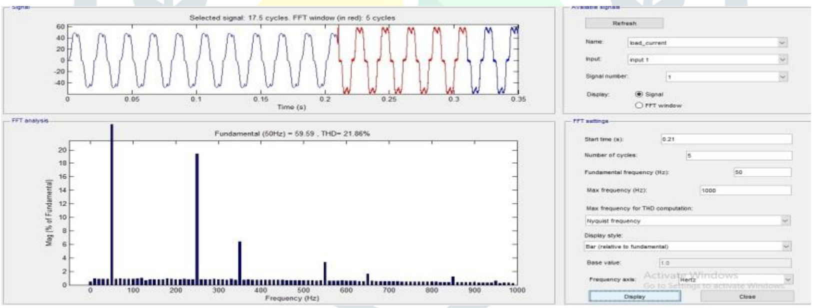

Fig 2. FFT analsysis of without STATCOM

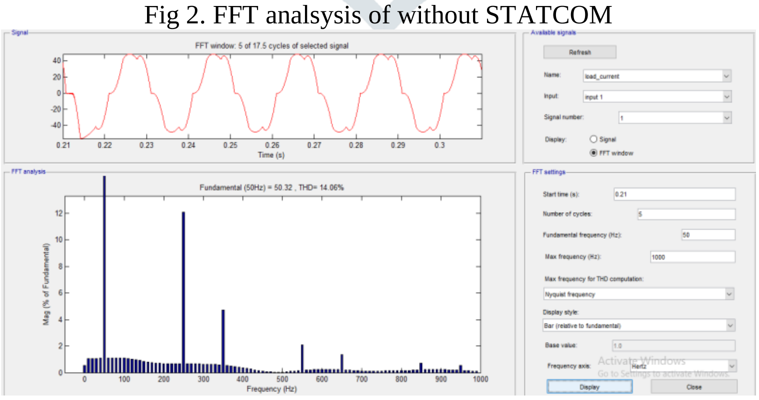

Fig 3. FFT analysis of with STATCOM

According to FFT analysis without STATCOM it is very dip sag and swell in waveform there is lot of harmonics in spectrum the analysis value approximately THD is 21.86 % , 5 of 17.5 cycle instead of with STATCOM it is very clear to obtain clear spectrum is very smooth and optimistic in nature value that is approximately THD is 14.06 % .

ACTIVE & RACTIVE POWER

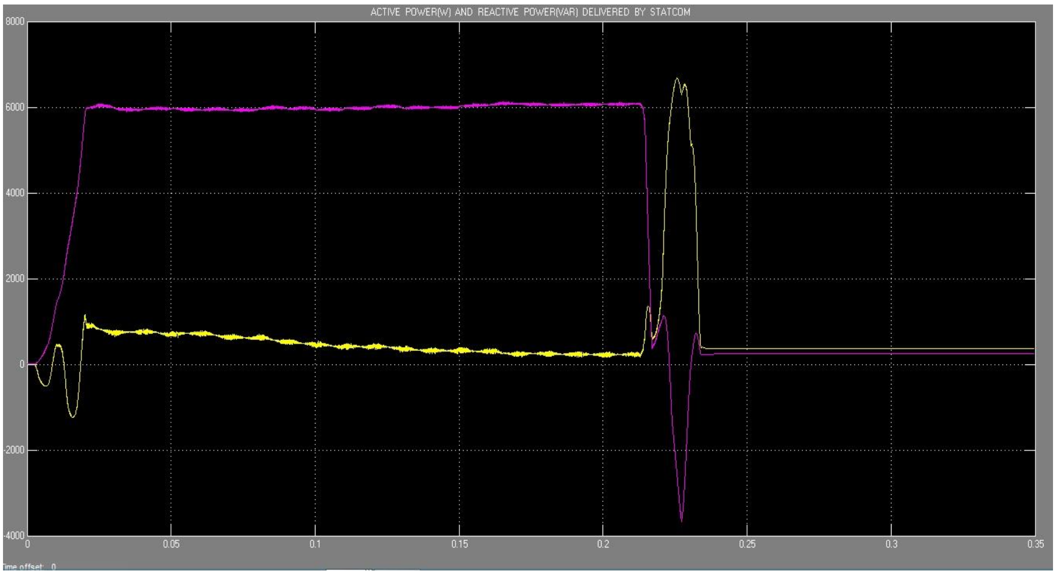

Fig no 4. active and reactive power output

The exchange of real power and reactive power of the voltage source converter with AC system is the major required phenomenon for the regulation in the transmission as well as in the distribution system.

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