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Challenges in Integration of Wind Power in Main Grid and There Mitigation Techniques

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Abstract- **Wind energy has experienced remarkable growth over the last decade. This was possible because of renewed public support and maturing turbine technologies. The wind generated power is always fluctuating due to its time varying nature and causing stability problems. This weak interconnection of wind generating source in the electrical network affects the power quality and reliability. The influence of wind turbine in the grid system concerning the power quality measurement are the variation voltage, flicker and harmonics. The integration of wind power in the power system is now an issue in order to optimize the utilization of the resource and to continue the high rate of necessary to achieve the goals of sustainability and security of supply. Smart grids promise to facilitate the performance of grid system. The power industry has adopted smart grids the difficulties and challenges associated with introducing a new technology into an older electrical system is explained in this report.**

Key Words – STATCOM, static synchronous series compensator, unified power flow controller

I. INTRODUCTION

Wind Energy Conversion Systems (WECSs) exhibit variability in their output power as a result of change in their prime movers (wind speed). This introduces a new factor of uncertainty on the grid and poses a lot of challenges to the power system planners and the utility operators in terms of the power system grid integrity *i.e.* power system security, power system stability and power quality. This report discusses the various challenges of wind power when integrated into the grid and identifies different mitigating strategies for its smooth integration.

Many early wind turbines utilized a squirrel-cage or wound-rotor induction generator to produce electricity. These generators allowed small variations in rotor speed thus improving energy capture and reducing torque shocks caused by wind gusts. However, they absorbed large amounts of reactive power and sometimes caused severe voltage stability problems on the grid. Hence various techniques for reactive power control (FACTS) are discussed in this report.

II. LITERATURE SURVEY

Wind power injection into an grid affects the power quality due to the fluctuation of wind and comparatively new type of its generators. the power arising out of the wind turbine when connected to grid system generates power quality problem. Normally static var compensator can be used to improve the power quality by reducing harmonics in the grid. the static compensator will reduces harmonics in grid by injecting superior reactive power into the grid .this is because of reactive power drops off static compensator is linear with voltage. Wind energy has become one of the most acceptable solution among the different renewable energy sources because of application based power electronic controller that allows wind energy conversion system to generate quality electric power irrespective of variable wind profile. the continuous flow of quality power from wind conversion system to grid is insured for wider range of speed. Double feed induction generator used in wind energy conversion system having power electronic convertor which requires very small friction of power in comparison to the total generation capacity.

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III. PROBLEMS IN WIND GENERATION

A. Power imbalance

The security of a power system is regarded as the ability of the system to withstand disturbances without causing a breakdown of the power system . For wind power generators to contribute to the security of a power system they must have the ability to contribute to both the voltage and frequency control in stabilizing the power system following a disturbance, they must be able to ramp up or down to avoid insecure power system operation, they must be able to ride through disturbances emanating from the power system, they must be able to avoid excess fault levels while still contributing to fault identification and clearance.

B. Impact on power system voltage control

The nodal voltage distribution on a power system network must not be less than an acceptable limit. The reactive power contribution capability of a power plant determines its nodal voltage control. A conventional generator has a way of controlling the reactive power to ensure a proper voltage distribution at the different nodes of the network. Most WECS make use of induction generators which are not capable of injecting reactive power to the grid This often forms one of the limitations of wind power integration.

C. Power Quality is affected due to Harmonics

Harmonics can be injected both at the generation and the consumer end. At the consumer end, harmonics are caused by non -linear loads such as television, personal computers, compact fluorescent lamps, and so forth. At the generation level, sources of harmonics include the Flexible Alternating Current Transmission System (FACTS) such as reactive power compensators and power electronics devices. Others include adjustable speed drives, generator speed controls, HVDC installations, and underground and submarine cable installations. Most of these are found in the power conditioning devices of integrating WECS into the grid. They could cause distortion to the voltage and current waveform of a power system. Also, the power electronic converters in use by the variable speed WECS such as DFIG are sources of harmonic

Flickers

Flickers are the periodic voltage frequency variations typically between 0.5 and 25Hz that cause annoyance from the incandescent bulb The wind generators sometimes produce oscillatory output power, which could cause flickers in the power system network. The fluctuation caused by the tower shadow. The effects of flickers are generally not severe in variable speed wind turbines unlike in fixed speed wind turbines. This is because the variable speed wind turbines have the ability to provide speed controls to damp the fluctuations of the aerodynamic torque emanating from switching operations or changes in wind speed therefore mitigating flickers.

Voltage dip

Voltage dip also called voltage sag, is a momentary reduction in the rms voltage value beyond a specified threshold for a short duration of time Voltage dip as a power quality component could extend to stability studies for wind turbines; the limit of voltage dip is given as 70% rms voltage reduction in 1s duration, whereas the limit for many electronic devices is 85% for 40ms.

D. System stability is affected

"When power system maintains a state of equilibrium during normal operating condition or returns to acceptable state of equilibrium after being subjected to a disturbance, then the system is said to be stable". A disturbance could be disconnection of generators, load, lines, transformers or a fault. The stability where a generator remains in synchronism in order to deliver power is known as angular stability and is governed by the relationship between the generator rotor angle and power angle. Before the advent of wind power plants, power systems mainly consisted of synchronous generators for electricity production. The behaviour and control of these generators following a disturbance are well understood by the utility operators due to their experiences thereof over the years. The advent of wind power introduces induction generators into the power system for electricity generation because they are cheap, robust and support variable speed operations. At the earlier stage of wind power integration, there was little concern about its influence on the overall stability of a power grid.

E. Impact on reserve management

Electrical power is expensive to store. Hence, the power produced at the generating station must be consumed by the load. Therefore, there must be a power balance between all the generating plant and the load demand. Any imbalance would affect the frequency of the system which could lead to loss of synchronism in certain cases . The accomplishment of a power balance between the load and the generating plants is more challenging in the case of wind power generation due to its unpredictable nature especially when the generating ratio is high. A system of high wind power integration would expand the reserve capacity due to the variability of the primary resources. A conventional power plant is expected to provide for this variability. This has an effect on both the operational costs and the ancillary service costs of the power system.

IV. MITIGATION TECHNIQUES TO INCREASE THE POWER QUALITY.

A. Static synchronous compensator

STATCOM is a static synchronous compensator operated as shunt connected static VAR compensator whose inductive or capacitive output current can be controlled independent of AC system voltage.

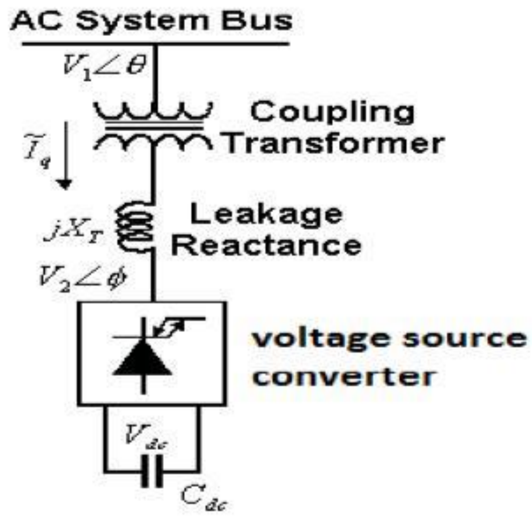

Fig 1: A functional model of STATCOM

The STATCOM is having higher dynamic response than the SVC and no additional filter network is needed for STATCOM like SVC. In SVC we have to use capacitor banks to generate capacitive current and inductive banks to generate current, where a STATCOM will alone generate capacitive and inductive current. Under light load conditions, the controller is used to minimize or completely diminish line overvoltage; on the other hand, it can also used to maintain certain voltage levels under heavy loading conditions. The results under three phase to ground fault condition for 200ms at PCC with and without STATCOM is shown here.

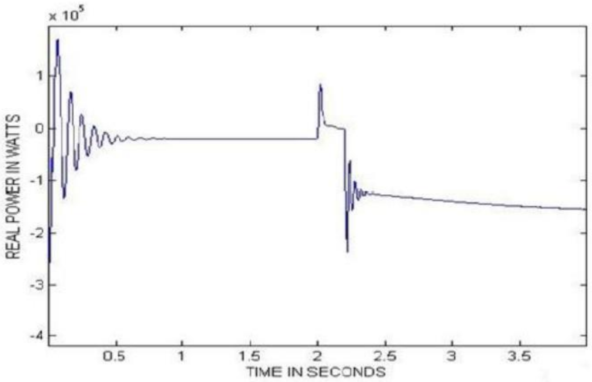

Fig 2: Without STATCOM

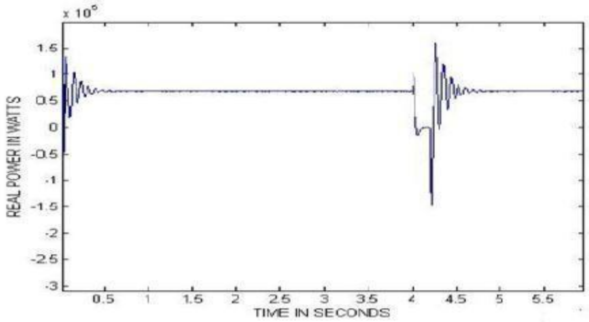

Fig 3: With STATCOM

STATCOM has been proposed for the improvement of transient response of SCWEG under different types of fault conditions and thereby improves the fault ride through capability of WEG. From the simulation results we can conclude that, for all types of faults, the real and reactive power variations are identified with and without STATCOM, and hence stability margin can be increased to a great extended by the usage of STATCOM.

A. Static synchronous series compensator

SSSC is one of the most important and popular facts controllers which is used for series compensation of power. SSSC controllers are the third generation FACTS controller devices. It is a solid state VSI (voltage source inverter)/VSC (voltage source convertor), which is inject sinusoidal voltage of variable magnitude and in series with the transmission line. The line currents in quadrature with the injected voltage.

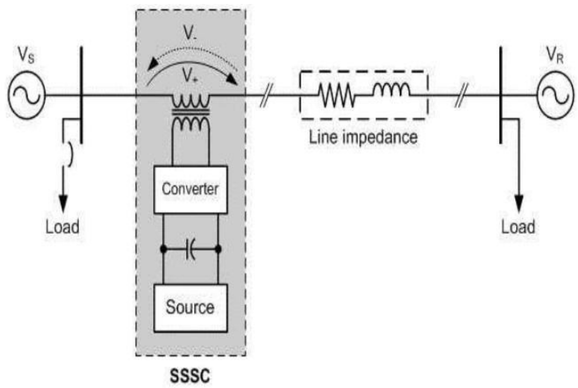

Fig 4:.Block Diagram of static series compensator

The line current and SSSC output voltage is in quadrature. The voltage across series capacitor is –jXcI (where Xc is the capacitive reactance of the series capacitor) and voltage drop across line inductance (XL) is + JX_LI cancel each other thus reducing the effect of line inductance. Due to this, power transfer capability is increased. The basic representation of SSSC using voltage source converter is shown in Fig.7the SSSC operates as a series inductor and controllable series capacitor. The basic difference is that SSSCs injected voltage is not related to the line intensity and it can be managed independently. For this feature, the SSSC works satisfactorily with lower load as well as high loads. The SSSC has several advantages over the SVC and STATCOM.

B. Unified power flow controller

System stability loss is the major issues where capability and utilization of FACTS are noticed. Representative of the last generation of FACTS devices is the Unified Power Flow Controller (UPFC). The UPFC is a device which can control simultaneously all three parameters of line power flow (line impedance, voltage and phase angle). Such new FACTS device combines together the features of two old FACTS devices: the Static Synchronous Compensator (STATCOM) and the Static Synchronous Series Compensator (SSSC).

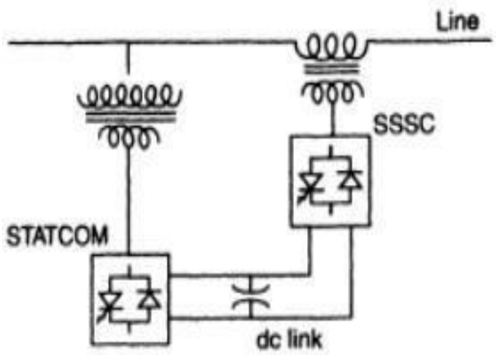

Fig 5: Block Diagram of unified power flow controller

The UPFC is a device which controls simultaneously all three parameters of line power flow: line impedance, Voltage, Phase angle. The shunt inverter is used for voltage regulation at the point of connection injecting an opportune reactive power flow into the line and to balance the real power flow exchanged between the series inverter and the transmission line. The series inverter can be used to control the real and reactive line power flow inserting an opportune voltage with controllable magnitude and phase in series with the transmission line.

Parameters	STATCOM	SSSC	UPFC
Connection in power line	Shunt	Series	Shunt and Series as well
Transmission circuit overload problem	No	Yes	Yes
Mode of operation	1	1	3
Settling time in post fault period	7 Sec	11 Sec	0.6 Sec
Cost	Cheap	Moderate	Costly

Table no 1: Comparison With other parameters

IV. ROLE OF SMART GRID IN INTEGRATION OF WIND POWER

An advanced EMS in a smart grid extracts maximum power from RE sources when they are available. During periods of fluctuations the back-up generator sets are used. To maintain reliability of the grid, smart grid includes the facility of interfacing the information obtained from advanced weather forecast into the system. Hence the reliability of the system can be increased.

V. CONCLUSION

We have studied various challenges that occur in integration of wind power in main grid. Today the worldwide trend of wind power penetration has increased. The integration of high penetration level of wind power into existing power system has significant impact on the power system operation. The wind turbines connected to weak grids have an important influence on power system. The weak grid has characterized by large voltage and frequency variations, which affects wind turbines regarding their power performance, safety and allied electrical components .The strength of the distribution system has been important from the point of power quality. Some techniques which can be improve for the power quality improvement.

VI. FUTURE SCOPE

Use of Unified Power Flow Controller over STATCOM and SSSC will have more advantages. As UPFC system contains both series and shunt filter hence it can provide better protection to the integration of wind power in main grid. Even though UPFC is costly but looking at its advantages it should be taken into consideration.

In response to the energy needs and environmental concerns, electricity from wind generators is considered as one of the future solutions. It will not only enhance integration of wind power in main grid but also provide a platform for advance services.

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