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Grid-Connected Wind Energy System Control Scheme for Power Quality Enhancement

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Abstract

The addition of wind power may have an impact on the quality of the energy generated by a system. The efficiency of wind turbines and, therefore, the quality of the power they generate are assessed using measures and criteria that correspond to the International Electro-technical Commission standard IEC-61400. When a wind turbine is installed on a power grid it affects the quality of energy by influencing voltage fluctuations and flickering as well as harmonics and switching operations. A decline in power quality has been shown to be a consequence of wind turbines being added to the system, according to this report. A battery energy storage system (BESS) is connected to the STAT COMpensator (STATCOM) at one common connection point in order to minimise power quality issues. Battery energy storage is used to sustain the grid's power supply during times of fluctuating wind output. MATLAB/SIMULINK is used to model the grid-connected wind energy producing system's STATCOM control approach for enhancing power quality. The induction generator is utilised as the principal power source in the proposed design because of its efficiency in providing reactive power. Coordination control and a strategy to improve power quality have been shown.

Static command and control, or STATCOM, is a crucial concept. Static quality measure compensator implemented in Matlab and SIMULINK.

INTRODUCTION

The corporation must be successful in all of its markets to guarantee long-term profitability and social progress. Speed wind turbine operations express all variations in renewable energy resources such as wind and biomass as fluctuations in generation in the fixedis necessary to supply the energy demand. Voltage changes in a sustainable energy system are mostly controlled by factors such as mechanical torque, grid power, and the conservation and use of renewable energy sources. As part of everyday activities. Wind turbines generate a fluctuating but constant stream of wind energy, which must be fed into the electrical grid in order to function. In addition to [1] and [2], these power variations are caused by turbulence, wind shear, and tower-shadow effects [1]. Wind power may be integrated into the present power control system. These oscillations must be dealt with in the network's technical features. Wind power generation challenges such as voltage control, stability, and power may be examined in connection to the quality of the power supply. Transmission and distribution networks must include customer-focused voltage quality controls in order to function properly. Several different kinds of transient events have a negative influence on voltage quality and other similar metrics. On the other side, a distribution and transmission network may be powered by wind. Generators cause havoc with distributed generating. The quality of the electricity

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is very important to the system. Using a simple method to run a wind turbine [2]. In the past several years, the induction generator has seen tremendous progress in the use of wind energy directly connected to the grid. The recent introduction of pricing up to 2 MW and feeding the distribution network to the individual units of large capacity generators has fundamental advantages. There are many more benefits to come. However, induction generators need active electricity in order to generate magnetic fields. Following an understanding of wind speed and generator torque Active power may be affected by wind speed, reactive power, and the induction generator's voltage at its terminals due to these factors. Due to the instability of wind turbine production in the event of a grid interruption, batteries for wind energy generating systems are often required. Using a STATCOM-based control approach for commercial wind turbines might hypothetically enhance electrical quality. The following are hoped-for outcomes of the proposed STATCOM control technique for grid-connected wind energy generation.

The source has a power factor of unity.

- Only the STATCOM provides reactive power assistance to the wind generator and the load.
- STATCOM's quick dynamic reaction may be achieved with a simple bang-bang controller.
- Power Quality Standards, Issues And its Consequences
- International Electro Technical Commission Guidelines:

Measurement recommendations for wind turbine power quality are offered. Wind turbine power quality characteristics may be determined using IEC standard 61400-21, which is produced by the Technical Committee-88 of the International Electrotechnical Commission (IEC)[15].

The standards have been established.

• ISO/IEC 61400-21: Wind turbine power quality measurement and evaluation, part 21 turbine
Wind Turbine—Method of assessing how individuals react while under stress. • 61400-13:
IEC standard 61400-3-7: Emission limit evaluation based on shifting weighting IEEE 61400-12: Wind Turbine performance.
The wind turbine's data sheet with electrical characteristics serves as the basis for utility evaluations of grid connections [11-13].
An increase or decrease in Voltage Voltage variation is closely related to changes in both real and reactive power.
Voltage sags/dips, voltage swells, short interruptions, and long-duration voltage fluctuations are all terms used to describe voltage fluctuations.
This issue discusses how wind turbines or variable loads might cause dynamic changes in the network. As a result, the wind turbine's power output fluctuates when it is running continuously. Grid strength, network impedance, and phase-angle and power factor of the wind turbines all influence voltage fluctuations. Voltage fluctuations at a frequency of between 10 and 35 Hz are the most common form of this phenomenon. In order to measure flicker, an IEC 61400-4-15 flicker metre is required.

Harmonics: Related to the functioning of power electronic converters are the harmonic results. At the point of wind turbine connection to the network, the harmonic voltage and current should be limited to the suitable level. Harmonic voltage must be kept within a certain range per the IEC-61400-36 standard, therefore any source of harmonic current may only contribute a limited amount. Even if it is possible to filter out high frequency components, lower order harmonic current is reduced significantly by the fast switching, but this may be done with ease.

Wind Turbine Location in Power Equipment: The manner of connecting the wind producing system into the power system strongly effects the power quality. Thus the operation and its impact on power system rely on the structure of the neighbouring power network [17].

Self Excitation of Wind Turbine Generating System: Theself excitation of wind turbine generating system (WTGS) with an asynchronous generator takes occur after disconnection of wind turbine generating system (WTGS) with local load. The danger of self excitation increases significantly when WTGS is fitted with compensating capacitor. The capacitor attached to induction generator enables reactive power correction. However the voltage and frequency are dictated by the balance of the system. The drawbacks of self excitation include the safety issue and balance between actual and reactive power [5].
Circuit Diagram for Proposed System:

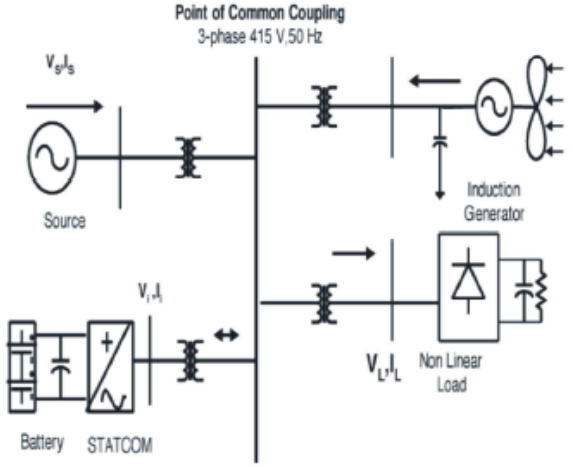


Fig. 1: Grid connected system for power quality improvement

Grid Coordination Rule:

Both the utility grid and the consumer may make use of these grid quality criteria and constraints. Transmission grid operators are responsible for the design, installation, and operation of the linked system in accordance with energy-economic laws.

1.Voltage Increase
2.When the voltage drops, so does the current
3. Flicker
4. Harmonics
Five. Grid Frequency.

Topology for Power Quality Improvement:

An inverter injects current into the grid for harmonic-free and specified phase angles with respect to the STATCOM current control voltage sources' input voltage. [18] The injected current balances out the reactive and harmonic components of the load and induction generator currents. To accomplish these goals, the grid voltages are detected and synchronised to supply the inverter with a current instruction. The grid-connected system aims to improve power quality at the common coupling point (PCC).

Wind Energy Generating System:

Constant speed topologies with pitch control turbines are used to generate wind power in this form. A simple induction generator is utilised because it does not need a separate field circuit, it can handle constant and changing loads, and it provides natural short-circuit safety.

BESS-STATCOM:

The use of a battery energy storage device allows for voltage regulation (BESS). Since it can swiftly inject or absorb reactive power to stabilise the grid, the BESS is well-suited for STATCOM. In addition, it has the ability to rapidly control the distribution and transmission systems. By charging and discharging, the BESS can smooth out the system's power fluctuations. a parallel connection exists between the STATCOM battery and its dc capacitor. This inverter is a three-phase voltage source since the DC link's capacitance is connected at the point of common coupling. The STATCOM injects a compensating current of changing amplitude and frequency into the bus when it is connected together.

System Operation:

STATCOM battery energy storage is coupled by shunt to the PCC's induction generator and non-linear load interface. The output of the STATCOM compensator is regulated to maintain grid quality requirements in a controlled method. STATCOM compensator's functional functioning in the power system is determined by the control strategy, which includes the current control strategy. An insulated gate bipolar transistor-based STATCOM is shown for supplying reactive power to the grid system's induction generator and nonlinear load...

Control Scheme:

Currents may be injected into the grid with the use of a device known as a "bang-bang controller." The controller uses a hysteresis current method to maintain stability. Maintaining the system variable in an intermediate position between hysteresis and STATCOM operation may be achieved using this strategy.

In the power system block set, the proposed control approach is simulated using SIMULINK. Dynamic situations are provided to demonstrate how the proposed system works.

Voltage Source Current Control-Inverter Operation:

With STATCOM's three-phase injected current, nonlinear loads and wind turbines will be eliminated from the grid. The grid is linked to the three-phase

IGBT inverter through the transformer.

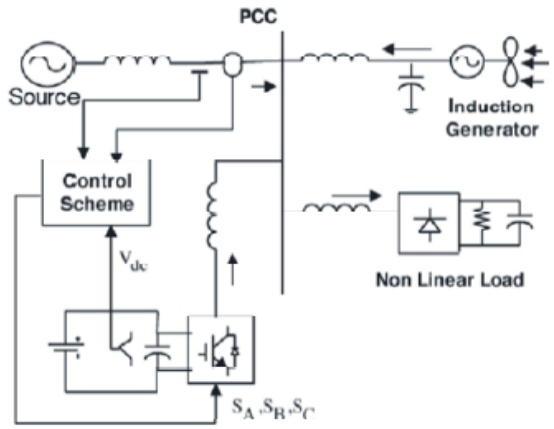


Fig. 2: System operational scheme in grid system

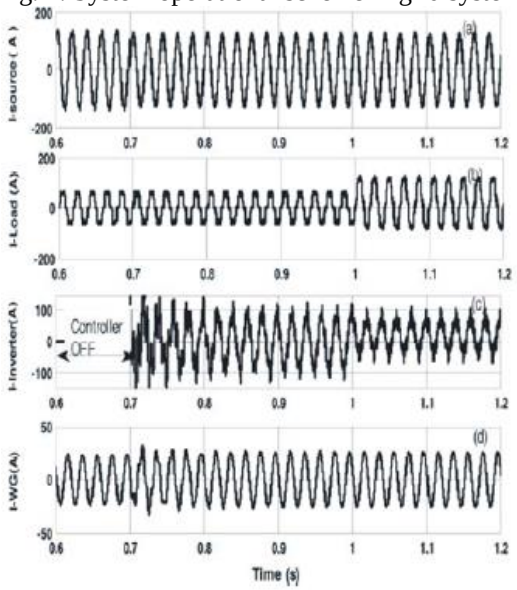


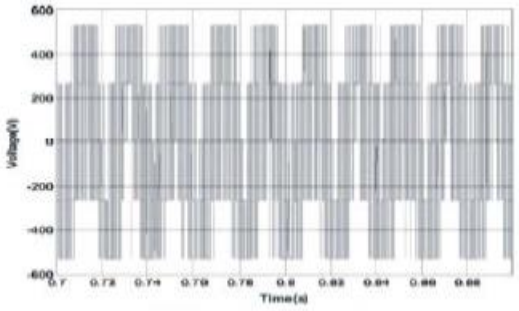
Fig. 3: (a) Source Current. (b) Load Current. (c) Inverter Injected Current. (d) Wind generated (Induction generator) current.

A hysteresis band of 0.08 is used to mimic the creation of switching signals from the reference current. In the existing system, narrow hysteresis band switching has a positive effect on the quality. Operational band for switching frequency controls. The operating voltage and the impedance of the interface transformer determine which current band to choose. The inverter is responsible for supplying the reactive power and compensated current required by the nonlinear load. This inverter's controller is also responsible for the actual transmission of power from the batteries.

Power Quality Improvement:

As a result of the nonlinear load and wind generator affecting grid source current, the waveform purity may be compromised on both sides of the system. Under STATCOM functioning, the inverter's output voltage. When the STATCOM is in use, the supply power maintains a unity power factor. An analysis of the current waveform before and after STATCOM is performed. At PCC without STATCOM, the THD of this source current is 4.71 percent, according to a Fourier Analysis. When the controller is turned on, an improvement in power quality may be seen at the common coupling point.

0.7 s after switching on the STATCOM, the source current waveform is shown on the display screen. The suggested scheme includes not only a power quality enhancement feature, but it also has the potential to maintain the load using the energy storage provided by the batteries in the system.



STATCOM output voltage.

CONCLUSION

Grid-connected wind generating and non-linear loads may benefit from a STATCOM-based control strategy to improve power quality. An overview of power quality issues is presented in this article for the benefit of customers and electric utilities. In this MATLAB/SIMULINK simulation, the STATCOM-BESS power quality control system is shown in action. Removes harmonics from the load current with ease. Thus, the in-phase voltage and current sources, as well as the reactive power needs for the wind generator and the load at PCC, can be maintained, allowing for a greater transmission line utilisation factor. The usage of BESS and STATCOM with wind power has yielded impressive results. For a grid-connected system, IEC 61400-21 [19–23] says the proposed scheme meets the power quality standards.

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