International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 10, October 2015
Available at http://internationaljournalofresearch.org

# Damping Control Using Sub-Synchronous Current Suppressor with SSSC for DFIG Wind Turbine

[1]Koripelli Sagar Rao & [2]S.Harinath
1.M.tech,KBR Engineering College,Pagidipally, Bibi Nagar, Hyderabad. pincode: 508126
2.Assistant professor,KBR Engineering College,Pagidipally, Bibi Nagar, Hyderabad. pincode: 508126

**Abstract:**
*The paper describes the engineering and design of a doubly fed induction generator (DFIG), using back-to-back PWM voltage-source converters in the rotor circuit. A vector-control scheme for the supply-side PWM converter results in independent control of active and reactive power drawn from the supply, while ensuring sinusoidal supply currents. Vector control of the rotor-connected converter provides for wide speed-range operation; the vector scheme is embedded in control loops which enable optimal speed tracking for maximum energy capture from the wind. An experimental rig, which represents a 1.5 kW variable speed wind energy generation system is described, and experimental results are given that illustrate the excellent performance characteristics of the system. The paper considers a grid-connected system; a further paper will describe a stand-alone system. This paper presents a introduction and use of facts controller in wind power station for improve voltage profile damping oscillations, load ability, reduce active and reactive power losses, sub-state-of-the-art on enhancement of different performance parameters of power systems such as voltage profile, sub-synchronous resonance (SSR) problems, transient stability, and dynamic performance, by optimally placed of FACTS controllers such as TCSC, SVC, STATCOM, SSSC, UPFC, IPFC, HPFC in wind power Systems. Also this paper presents the current status on enhancement of different performance parameters of power systems by optimally placed of FACTS controllers in wind power Systems. Authors strongly believe that this survey article will be very much useful to the researchers for finding out the relevant references in the field of the enhancement of different performance parameters of power systems such as voltage profile, damping of oscillations, load ability, reduce the active and reactive power losses, sub synchronous resonance (SSR) problems, transient stability, and dynamic performance, by optimally placed of FACTS controllers in wind power Systems*

## Introduction:

The worldwide concern about environmental pollution and a possible energy shortage has led to increasing interest in technologies for the generation of renewable electrical energy. Among various renewable energy sources, wind power is the most rapidly growing one in Europe and the United States. With the recent progress in modern power electronics, the concept of a variable-speed wind turbine (VSWT) equipped with a doubly fed induction generator (DFIG) is receiving increasing attention because of its advantages over other wind turbine generator concepts. In the DFIG concept, the induction generator is grid-connected at the stator terminals; the rotor is connected to the utility grid via a partially rated variable frequency ac/dc/ac converter (VFC), which only needs to handle a fraction (25%–30%) of the total DFIG power to achieve full control of the generator. The VFC consists of a rotor-side converter (RSC) and a grid-side converter (GSC) connected back-to-back by a dc-link capacitor. When connected to the grid and during a grid fault, the RSC of the DFIG may be blocked to protect it from over current in the rotor circuit. The wind turbine typically trips shortly after the converter has blocked and automatically reconnects to the power network after the fault has cleared and the normal operation has been restored. The author proposed an uninterrupted operation feature of a DFIG wind turbine during grid faults. In this feature, the RSC is blocked, and the rotor circuit is short-circuited through a crowbar circuit (an external resistor); the DFIG becomes a conventional induction generator and starts to absorb reactive power. The wind turbine continues its operation to produce some active power, and the GSC can be set to control the reactive power and voltage at the grid connection. The pitch angle controller might be activated to prevent the wind turbine from fatal over speeding. When the fault has cleared and when the voltage and the frequency in the utility grid have been reestablished, the RSC will restart, and the wind turbine will return to normal operation. However, in the case of a weak power network and during a grid fault, the GSC cannot provide sufficient reactive power and voltage support due to its small power capacity, and there can be a risk of voltage instability. As a result, utilities, typically, immediately disconnect the wind turbines from the grid to prevent such a contingency and reconnect them when normal operation has been restored. Therefore, voltage stability is the crucial issue in maintaining uninterrupted operation of wind turbines equipped with DFIGs. With the rapid increase in penetration of wind power in power systems, tripping of many wind turbines in a large wind farm during grid faults may begin to influence the overall power system stability. It has been reported recently that integration of wind farms into the East Danish power system could cause severe voltage recovery problems following a three-phase fault on that network. The problem of voltage instability can be solved by using dynamic reactive compensation. Shunt flexible ac transmission system (FACTS) devices, such as the SVC, TCPAR, TCSC, SSSC, UPFC, IFPC, GUPFC, HPFC, and the STATCOM, have been widely used to provide high-performance steady state and transient voltage control at the point of common coupling (PCC). The application of an SVC or a STATCOM to a wind farm equipped with fixed-speed wind turbines (FSWTs) and squirrel-cage induction generators (SCIGs) has been reported in open literatures for steady-state voltage regulation and in [1] and [8] for short-term transient voltage stability. However, compared with the FSWT with a SCIG, the operation of the VSWT with a DIFG, particularly during grid faults, is more complicated due to the use of power electronic converters, and it has not yet been studied with the use of dynamic reactive compensation. Nowadays wind as a significant proportion of non-pollutant energy generation, is widely used. If a large wind farm, which electrically is far away from its connection point to power system, is not fed by adequate reactive power, it present major instability problem. Various methods to analyze and improve wind farm stability have been discussed in open literatures. The increasing power demand has led to the growth of new technologies that play an integral role in shaping the future energy market. Keeping in view the environmental constraints, grid connected wind parks are a promising aspect in increasing system reliability and congestion relief. Wind farms are either connected to the grids or a stand-alone operation. With the ever changing wind patterns, it is not feasible to connect wind farms directly to the grids. Certain conditions have to be met before wind farms start operating in conjunction with the main power network. The succeeding sections of this paper present the problems related with the reliable and secure operation of Wind Energy Conversion Systems (WECS) and the possible solutions. Though

Doubly-Fed Induction Generators (DFIGs), which have the feature of regulating the reactive power demand, have emerged but most of the wind farms worldwide employ either squirrel-cage induction generators or rotor wound induction generators. These induction generators draw reactive power from the main power grid and hence might result in voltage drops at the Point of Common Coupling (PCC). Moreover, the input power to these induction machines is variable in nature and hence the output voltages are unacceptably fluctuating. To address these problems FACTS Controllers are being encouraged. FACTS Controllers provide the necessary dynamic reactive power support and the voltage regulation. Herein these Controllers and their applications to wind farms are discussed. On the other hand there exist instruments like Flexible AC Transmission Systems (FACTS), which were developed in order to dynamically control and enhance power system performance. Stability is the key aspect for introducing FACTS devices. Therefore, is seems quite natural, that one of the today„s research topics is employment of FACTS devices for enhancing wind farm performance with respect to the grid codes and power system stability. FACTs are an acronym which stands for Flexible AC Transmission System.

**Basic Structure of the DFIG Wind Power Generation System:** The term ‗doubly fed„ refers to the fact that the voltage on the stator is applied from the grid and the voltage on the rotor is induced by the rotor-side converter. This system allows a variable-speed operation over a large, but restricted, range. The converter compensates the difference between the mechanical and electrical frequency by injecting a rotor current with a variable frequency. The behavior of the DFIG is controlled by the converter and its controller in both normal and fault condition operation. Figure 6 shows the basic structure of the DFIG wind power generation system. Back-to-back PWM converters consist of two converters, the stator-side converter and rotor-side converter, which are controlled independently of each other. The main idea is that the rotor-side converter controls the active and reactive power by controlling the rotor current components, while the stator-side converter controls the DC-link voltages and ensures a converter operation at unity power factor (zero reactive power). Depending on the operating condition of the rotor, the power is fed into or out of the rotor. In an over synchronous condition, power flows from the rotor via the converter to the grid, whereas power flows in the opposite direction in a sub-synchronous condition. In both cases, the stator feeds power into the grid.

Static Var Compensator(SVC) SVC„s being dated from early 70„s, have the largest share among FACTS devices. They consist of conventional thyristors which have a faster control over the bus voltage and require more sophisticated controllers compared to the mechanical switched conventional devices. SVC„s are shunt connected devices capable of generating or absorbing reactive power. By having a controlled output of capacitive or inductive current, they can maintain voltage stability at the connected bus. Figure 9 shows these configurations: the Thyristor Controlled Reactor (TCR), the Thyristor Switched Reactor (TSR) and the Thyristor Switched Capacitor (TSC) or a combination of all three in parallel configurations. The TCR uses firing angle control to continuously increase/decrease the inductive current whereas in the TSR the inductors connected are switched in and out stepwise, thus with no continuous control of firing angle. Usually SVC„s are connected to the transmission lines, thus having high voltage ratings. Therefore the SVC systems have a modular design with more thyristor valves connected in series/ parallel for extended voltage level capability to provide the needed reactive power generation/consumption in the network SVC„s adjust the conduction periods of each thyristor valve. For an SVC consisting of one TCR and one TSC, assuming that both reactor and capacitor have same pu. Ratings then the following scenarios can occur: • Reactive power is absorbed when the thyristor valve on the reactor leg is partially or fully conducting and the capacitor leg switch is off. • Reactive power is generated when the thyristor valve on the reactor leg is in partial or no conduction mode and the capacitor leg switch is on. • No reactive power is generated/absorbed if both the thyristor valve is not conducting and the capacitor switch is off.

**Static Synchronous Compensation (STATCOM)**:

Another way to enhance a Wind Power Plant with ability to deliver or absorb reactive power from the grid is to use Static Synchronous Compensation. STATCOM can be treated as a solid state synchronous condenser connected in shunt with the AC system. The output current of this controller is adjusted to control either the nodal voltage magnitude or reactive power injected at the bus. STATCOM is a new breed of reactive power compensators based on VSC. It has a characteristic similar to a synchronous condenser, but because it is an electrical device it has no inertia and it is superior to the synchronous condenser in several ways. Lower investment cost, lower operating and maintenance costs and better dynamics are big advantages of this technology [8]. STATCOM consists of one VSC with a capacitor on a DC side of the converter and one shunt connected transformer. Voltage Source Converter is usually built with Thyristors with turn-off capability like Gate Turn Off (GTO) or today Integrated Gate Commutated Thyristors (IGCT) or with Insulated Gate Bipolar Transistors (IGBT) based converter.

**Reactive power:** This type of control strategy focuses on reactive power injection to the local bus, to which the STATCOM is connected, according to a reference from the wind park controller. Voltages droop characteristic: In this type of operation STATCOM works in a way to fulfill a voltage/reactive power slope characteristics. This is done by setting a target voltage accepted from wind park controller at the PCC.

**Power factor:** The following table summarizes the main characteristics of the most important shunt Var compensators. The significant improvements observed in the STATCOM devices, makes them a first choice for improving the performances in AC power systems.

**Voltage Source Converter-Based FACTS Devices** Power-electronics-based FACTS devices has been widely recognized as powerful controllers to enhance the controllability of the ac transmission systems. Among various FACTS devices, those based on the VSC concept have some attractive features [8], such as rapid and continuous response characteristics for smooth dynamic control, allowing advanced control methodologies for high-performance operation, elimination or reduced requirements for harmonic filtering, ability to add energy storage devices, allowing simultaneous active and reactive power exchange with the ac system, etc. The VSC based FACTS devices include the static synchronous compensator (STATCOM), the static synchronous series compensator (SSSC), and the unified power flow controller (UPFC). A STATCOM [7], [9], [10] is a shunt FACTS device. The basic configuration of a STATCOM is shown in Figure 1.1. It consists of a gate turn-off (GTO), insulated gate bipolar transistor (IGBT), or integrated gated commutated thyristor (IGCT)-based VSC that uses charged capacitors as the dc source. The converter is connected in shunt to a bus through a coupling transformer. The STATCOM generates a set of balanced three phase sinusoidal voltages in synchronism with the ac system, with rapidly controllable amplitude and phase angle. A typical application of the STATCOM is to provide smooth and rapid steady-state and transient voltage control at the point of common coupling (PCC) in the power network. An SSSC is a series FACTS device, which uses a VSC to inject a controllable voltage in quadrature with the line current of the power network through a series connected transformer, as shown in Figure 1.2. This is equivalent to providing a controllable capacitive or inductive impedance compensation which is independent of the line current [11]-[13]. A typical application of the SSSC is for power flow control. In addition, with a suitably designed damping controller, the SSSC has an excellent performance in damping low frequency power oscillations in a power network [14]. By coupling an additional energy storage system to the dc terminal, the SSSC can also provide simultaneous active power compensation, which further enhances its capability in power flow control, power oscillation damping, and improving transient stability [7]

## Conclusion:

Different type of FACTS device was proposed in for FRT of FSWTs – SDBR. Authors claim that 0.05p.u. SDBR is equivalent of 0.4p.u. dynamic reactive power compensation device. Totally different approach to FRT of FS- and DFIG-WTs was proposed by Gamesa in. Instead of shunt compensation DVR was used. This device, by exchanging active power with the grid, injects series voltage between PCC and wind farm terminals to cover voltage reduction caused by grid fault In such a way fault is not seen from the wind turbine point of view. Thus, it might continue its operation uninterrupted. FRT concepts for DFIG-WTs are also discussed

## REFERENCES

[1.] EWEA, “Wind energy statistics”, 2008,

[2.] EWEA, “Pure Power – Wind Energy Scenarios up to 2030”, 2008

[3.] I. Erlich, F. Shewarega “Insert Impact of Large-Scale Wind Power Generation on the Dynamic Behaviour of Intrerconnected Systems”, iREP Symposium, 2007

[4.] I. Erlich, F. Shewarega, M. Wilch “Interaction of Large Offshore Wind Parks with the Electrical Grid”, DRPT, 2008

[5.] I. Erlich, F. Shewarega, J.L. Rueda “Impact of Large Offshore Wind Farms on Power System Transient Stability”, PSCE, 2009

[6.] B. Singh, S.N. Singh “Wind Power Interconnection into the Power System: A Review of Grid Code Requirements”, The Electricity Journal, 2009