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ENHANCEMENT OF WECS VOLTAGE PROFILE USING STATCOM

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ABSTRACT:- *Renewable energy, also called non-conventional sources of energy, is a kind of natural resource of energy. Sunlight, Wind, Water, Geothermal Heat, and Biomass are the natural sources of energy capable of generating electrical energy. Renewable energy shares 18 % of the world's total electrical energy generation and is increasing day by day as it is a clean source of energy and gives no harmful effect to the atmosphere. In this work, wind energy integration with the utility is discussed. This work focuses on absolute power control and frequency control using a Wind Energy Conversion System, consisting of a Three–Phase Induction Generator and Static Compensator.*

INTRODUCTION

Energy is considered to be the key input for development. Due to the depletion of available conventional resources and concern regarding environmental degradation, renewable sources are being utilized to meet the ever-increasing energy demand. Due to the relatively low cost of electricity production, wind energy is considered one of the potential clean energy sources for the future. But the nature of wind flow is stochastic. So rigorous testing is to be carried out in the laboratory to develop an efficient control strategy for wind energy conversion system (WECS)[1]. The study of WECS and the associated controllers are, thus, becoming more and more significant with each passing day. Nowadays, many asynchronous machines are that the variable speed operation allows extracting maximum power from WECS and reducing the torque fluctuations. An induction generator with a lower unit cost, inherent robustness, and operational simplicity is considered the most viable option as a wind turbine generator (WTG) for off-grid applications. However, the induction generator requires capacitor banks for excitation at isolated locations. The excitation phenomenon of a self-excited induction generator (SEIG) is explained as the power output of the SEIG depending on the wind flow, which by nature is erratic. Both amplitude and frequency of the SEIG voltage vary with wind speed. Such arbitrarily varying voltage when interfaced directly with the load can give rise to flicker and instability at the load end. So, the WECS is integrated with the load by power electronic converters to ensure a regulated load voltage. Again, due to the intermittent characteristics of wind power, a WECS needs to have an energy storage system. An analysis of the available storage technologies for wind power applications is made[2-3]. The advantage of battery energy storage for an isolated WECS is discussed. With battery energy storage, it is possible to capture maximum power from the available wind. A comparison of several maximum power point tracking (MPPT) algorithms is compared for small wind turbine (WT).

WECS

The wind turbine converts the wind's kinetic energy into rotational energy; this rotational energy rotates the generator. The winding nature is either constant speed or variable speed. The power fluctuation is caused by the variable wind speed, which can be reduced by using power electronic equipment such as converters with BESS (Battery Energy Storage System)

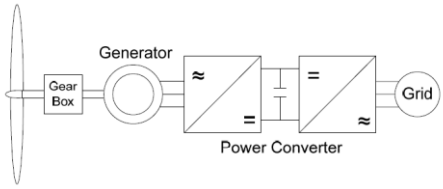

Figure 1 Wind Turbine with Induction Generator

Figure 1 shows the constant speed wind turbine, which consists of an induction generator. The wind turbine is connected to the induction generator through the gearbox, and the pitch control technique is used to maintain the maximum speed[4]. Pitch control in a wind turbine can change the incidence of the wind blades according to the speed of wind blowing, and this leads to maximum speed for the wind turbine rotor at a particular velocity of the wind.

Technical challenges in the integration of WECS and STATCOM

Inherent characteristics of wind energy cause technical challenges that are not present with conventional (non-renewable) sources of energy, i.e., thermal, hydro, or nuclear power. The issues arise in the integration of wind energy systems to the grid. Among all issues, one important issue is how to integrate this wind energy system into the grid. Although the traditional approach during the last decade has been used was power convertor control of renewable energy system. There is a critical need to develop new, improved power converted control technologies for the following reason[5].

1. The performance of existing power convertor control technologies was not well.

2. Unbalance & very high harmonic distortion have been formed, stabilizing the grid system and affecting the renewable energy source.
3. The power quality issues are not considered in the existing controller design for the power converter control system. However, the power quality should be the critical factor in the power system & which has to be improved.
4. The existing power convertor control mechanism without BESS can cause malfunction of the system, for example, abnormal DC capacitor voltage, Active power, and Reactive power.

STATCOM

A Distribution Static Compensator is, in short, known as D-STATCOM. It is a power electronic converter-based device used to protect the distribution bus from voltage unbalances. It is connected in shunt to the distribution bus generally at the PCC[6].

Basic Structure

STATCOM is a shunt-connected device designed to regulate the voltage either by generating or absorbing the reactive power. The schematic diagram of a D-STATCOM is as shown in Figure 2, contains-

- DC Capacitor
- Voltage Source Inverter (VSI)
- Coupling Transformer
- Reactor

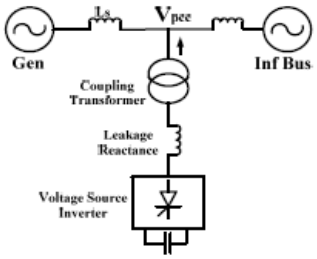

Figure 2 Schematic Diagram of STATCOM

Operating Principle of STATCOM

A STATCOM is capable of compensating either bus voltage or line current. It can operate in two modes based on the parameter which it regulates given below.

- Voltage Mode Operation: This mode can make the bus voltage to which it is connected a sinusoid. It can be achieved irrespective of the unbalance or distortion in the supply voltage.
- Current Mode Operation: In this mode of operation, the D-STATCOM forces the source current to be a balanced sinusoid irrespective of the load current harmonics.

The basic operating principle of a D-STATCOM in voltage sag mitigation is to regulate the bus voltage by generating or absorbing the reactive power. Therefore, the STATCOM operates either as an inductor or a capacitor based on the bus voltage magnitude [7-8].

Inductive operation:- If the bus voltage magnitude (VB) is more than the rated voltage, then the D-STATCOM acts as an inductor absorbing the reactive power from the system. The circuit and phasor diagram is shown in Fig.3

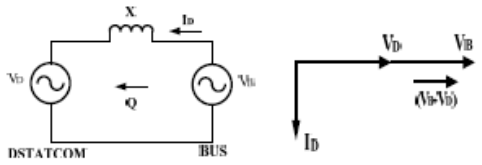

Figure 4 Inductive Mode of Operation

Capacitive operation:- If the bus voltage magnitude (VB) is less than the rated voltage, the D-STATCOM acts as a capacitor generating the reactive power to the system. The circuit and phasor diagram of this mode of operation is shown in Fig.4

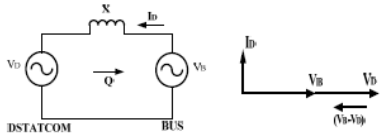

Figure 4 Capacitive Mode of Operation

SIMULINK MODEL AND RESULT

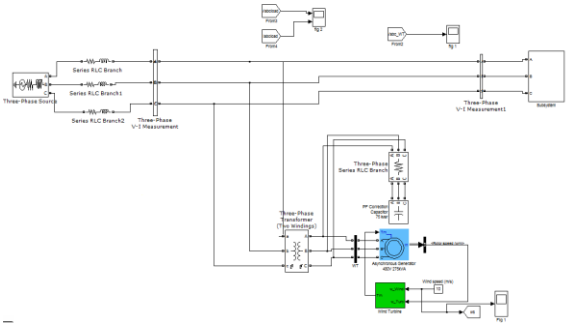

Figure 5 Simulation of wind generator without any battery storage

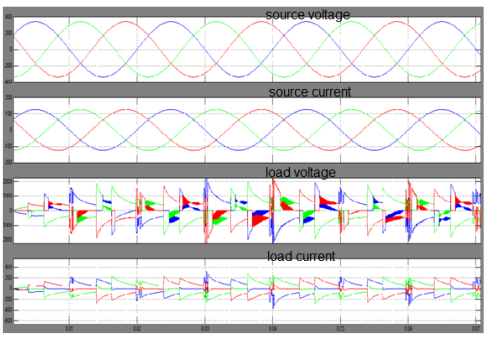

Figure 6 shows (a) source voltage (b) source current (c) load voltage (d) Load current

CONCLUSION

FACTS (Flexible AC Transmission System) devices are introduced in the present power system. STATCOM (Static Compensator) is a member of the FACTS devices. For maintaining the stability and voltage of the power system under the integration of wind energy generation, the STATCOM plays an essential role in providing reactive power support. The power quality issues and problems in an integrated wind energy system into the grid are explained, and the STATCOM is proposed to improve power quality is given below.

- STATCOM Helps reduce the harmonic parts of the load current. Hence the THD of the load current is reduced to a permissible level.
- Source voltage and the source current are both maintained in the same phase.
- STATCOM is useful for providing the reactive power demand for wind energy generation and a nonlinear load at PCC (point of common coupling) in the grid system.

So, STATCOM helps in many ways to improve the power quality and maintain the system's stability; STATCOM acts as a current-controlled voltage source (CCVS) inverter, consisting of six IGBTs triggered by the control strategy, i.e., fuzzy logic control.

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