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Study on Hybrid Solar Wind Power System with PMSG for Power Enhancement Using Ai Technique

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Abstract: **This paper presents various permanent magnet synchronous generators (PMSG) that operate with wind turbines and solar systems. Over the past five years, a comprehensive study has been conducted on new contributions to harmonic compensation and new efficient topologies to improve the efficiency, reliability, and cost of the wind turbine. Various electronic power converters connected between the generator and the load/network were examined on the basis of harmonic compensation, efficient operation, and conversion of high rated powers. The wind generation system is always a challenge to extract gentle electricity from the wind. To improve the quality of the system's supply, such as island problems and performance fluctuations, various renewable storage systems are discussed and compared. Finally, a discussion is presented on the different controllers to meet load or network requirements.**

Keywords: **solar system, grid, wind, controller.**

I. INTRODUCTION

The Power supply from mere conventional sources cannot satisfy modern electrical needs and therefore poses the problem of reliability and safety of the power supply, while a large amount of pollutants poses serious environmental problems. Over the past two decades, renewable and decentralized energy sources have emerged as a complement to traditional energy sources and are seen by utility engineers as an effective solution to meet load requirements in order to successfully overcome electricity problems. Decentralized generation (DG), which is based on hybrid systems for renewable energy systems, is the most recent trend in the field of renewable energy, as it has been shown to improve overall performance and reliability. Many options have been proposed to efficiently use multiple renewable energy sources to generate electricity. Among all trendy renewable energy sources, wind and solar sources have been used efficiently in various hybrid systems. Hybrid photovoltaic and solar wind systems have recently attracted the attention of public services around the world [1].

Wind and solar systems complement each other in the daily cycle. Solar energy, which is a given region of North Africa can cover four times the total global energy requirement, is available all day, while strong winds generally occur at night. Generally, strong winds and cloudy days are observed at night, while weak winds occur on clear days. Regardless of their intermittent behavior and associated disadvantages, hybrid wind and photovoltaic systems are used to provide energy to the load with greater reliability and continuity of supply.

II. LITERATURE REVIEW

F. Mazouz et al. [1] in this article, we propose a vector control of a dual power induction generator (DFIG) to get wind energy at variable speed. The model is predicated on the double current generator to regulate active and reactive power. Numerous studies are underway to check their functioning in several wind conditions. The results showed that the wind energy conversion system works well with indirect variations of wind control with indirect vector control strategies.

S. Engelhardt et al. [2] this text illustrates the capacity of DFIG-based wind turbines for charging stationary reactive energy, taking under consideration the foremost important physical phenomena that limit the reactive power of DFIG-based WT systems. The active-reactive power diagram is systematically derived, taking under consideration the standard power-speed ratio and therefore the load limits of the converter. The authors also discuss some special modalities that limit reactive power, also as aspects of modeling and control that cause these limitations.

T. Lund et al. [3] the aim of the work is to derive a stationary PQ diagram for a variable speed turbine, which is provided with a dual power induction generator. First, the connection between the optimal rotor speed and therefore the wind speed is illustrated. Secondly, restrictions on reactive power generation caused by rotor current, rotor voltage and stator current are derived. Third, the influence of the transition from the Δ coupling to the stator Y coupling is examined. Finally, an entire PQ diagram is recorded for a turbine. We conclude that the limiting think about terms of reactive power generation is usually the rotor current limit which the reactive power absorption limit is that the stator current limit. It had been also concluded that the rotor voltage features a limiting effect only in high positive and negative sliding points, but near the limit the reactive power is extremely sensitive to small variations in sliding.

D. Santos-Martin et al. [4] during this article, the reactive power of synchronous generators has been discussed intimately within the bibliography. The reactive power of dual-feed asynchronous generators (DFAG) has not yet been studied. This sort of generator is widely utilized in wind energy and its reactive power capacity must be known to plan the reactive power of the wind park consistent with the requirements of the grid codes. The active and reactive output power of the DFAGs are often expressed as a function of the terminal voltage and therefore the internal voltage, which means that the performance limits are often graphically represented during a similar thanks to that of the synchronous generator.

III. Grid Stability Improvement By Reactive Power

Several measures can be taken to improve the static and dynamic reactive power reserves of the electricity grid. Usually this is achieved through the use of reactive power support devices, such as e.g. OLTC transformers (load switching switches), excitation control, switchable and non-switchable shunt capacitors / inductors, synchronous capacitors and FACTS (Flexible AC Transmission System) devices (z synchronous static compensators (STATCOM)). Researchers used various techniques to use these elements to stabilize the network and provide adequate reactive power support to the network. Some wind turbines based on asynchronous machines (e.g. squirrel-cage induction machines (SCIM) in fixed speed wind turbines (FSWG)) cannot contribute to voltage regulation because they absorb reactive power in stationary operation. However, variable speed wind turbines (VSWG) with a PEC interface, such as the dual power induction generator (DFIG), can provide reactive power [5].

Unfortunately, the nominal power of the DFIG rotor converter is limited only to fixed requirements in order to keep this technology within a reasonable cost range. Consequently, the reactive power of DFIG is not sufficient as primary protection in transient conditions. Similar restrictions could apply to full converter wind turbines (FCWG). FACTS devices are therefore used in wind farms to improve voltage stability thanks to their dynamic reactive power. Excitation controllers also play an important role in compensating for reactive power in power systems. However, this type of control system is not precise enough because it is designed with static load patterns in mind. Although VSWG technologies such as DFIG are used more frequently because of their superior control capabilities, they have very limited reactive dynamic power reserve compared to synchronous generators. However, STATCOM devices with a PEC interface could be used to improve the dynamic reactive power of wind farms and to comply with grid codes.

IV. Grid Code Reactive Power Compliance Requirements For REGS

With the growing penetration of renewable energies into electricity grids, grid operators (e.g. transmission system operators (TSO) and distribution system operators (DSO)) have started to establish rigorous network codes for REG for energy management and regulation of the reactive transit voltage. The reactive power mentioned above has a strong influence on the voltage of the stationary network and on the restoration of the voltage during the system quotas. Therefore, the grid codes indicate both stationary and dynamic reactive power capacity for REGs. Grid code specifications for FRT and voltage control are also closely related to static and dynamic reactive power requirements for REGs. Therefore, the requirements for the reactive power network code specified for wind turbines and PEC interface generators (eg solar PV) are discussed in the following subsections [6].

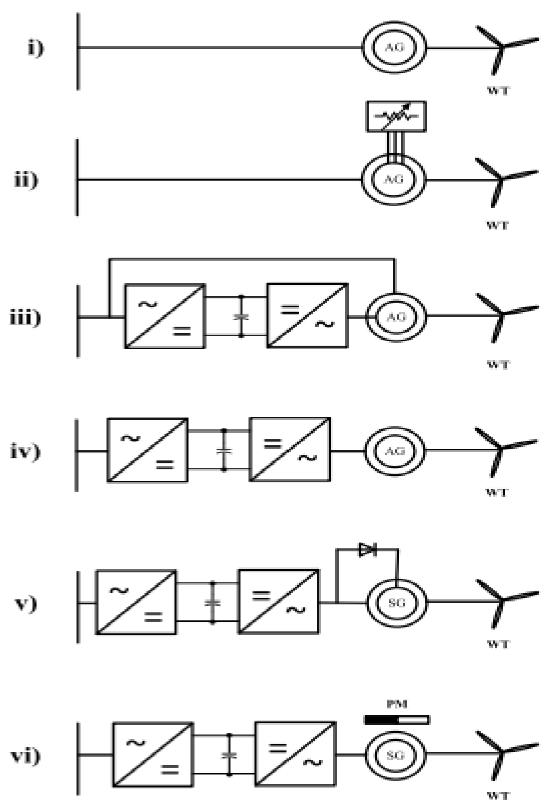

Fig. 1. Typical wind generator configurations: i) Fixed-speed wind generator (FSWG); ii) Limited variable-speed wind generator; iii) Doubly-fed induction generator (DFIG); iv) PEC interfaced fully-fed AG based FCWG; v) Electrically excited synchronous generator based FCWG; and vi) Permanent magnet synchronous generator (PMSG) based FCWG

A. *Reactive Power Capability OF Wind Generator*

Wind turbines are generally divided into four (4) types: 1) Type 1: fixed speed wind generator (FSWG) (based on SCIG), 2) Type 2: limited variable speed wind generator (based on induction of the rotor wound) Generator (WRIG)), 3) Type 3: dual power induction generator (based on WRIG) and 4) Type 4: wind turbine complete converter (FCWG). FCWGs can be divided according to the type of generator (e.g. permanent magnet synchronous generator (PMSG) and electrically excited synchronous generator). Figure 5 shows typical wind turbine configurations. It should be noted that the SCIG and WRIG machines are also called asynchronous generators (AG).

The first and simplest configuration is the FSWG, which connects the SCIG directly to the network and a transmission group is used in the powertrain to keep the speed constant. These types of wind turbines generate active power when the shaft speed is higher than the electrical frequency of the network (i.e. when a negative slip is generated), but these generators consume reactive energy. At a given wind speed, the operating speed of the turbine changes linearly with the torque. The mechanical inertia of the powertrain limits the speed of variation of the electric energy in different wind conditions. This configuration is illustrated in Fig. 1 (i).

There is no active or reactive power control scheme, except that the tilt angle control scheme (PAC) maintains the maximum power point (MPP) and limits the extraction of wind turbine energy at high speed of the wind. To avoid a high transient starting current, a soft start device is used in the FSWG. Figure 1 (ii) shows a limited variable speed wind turbine (type 2) which is almost similar to FSWG. However, variable resistors are connected to the rotor circuit of this type of wind turbine to provide limited speed variability. Variable resistors can control rotor current based on wind gust conditions and also improve dynamic behavior in case of line failure.

Type 3 wind turbines are commonly known as dual power induction generators (DFIG) and the configuration of DFIG is illustrated in Figure 1 (iii). In this type of wind turbine, the stator circuit is connected directly to the network and the rotor is connected via a back-to-back PEC interface, which makes it a dual-power machine. Thanks to the superior controllability of the active and reactive power of DFIG, this type of wind turbine is often used in the wind industry. Therefore, in the last 15 years in-depth studies have been conducted on DFIG to improve their performance [7] - [8].

Type 4 wind turbines (also known as FCWG) use a full nominal PEC interface to connect to the network. Fig. 1 (iv) - (vi) shows three different configurations. Fig. (iv) Shows an AG-based FCWG and WRIG is primarily used as an AG. FCWG configurations based on a synchronous generator can be electrically excited via contact rings as shown in Figure 1 (v) or they can be self-excited permanent magnet synchronous generators (PMSG) as shown in Fig. 1 (vi).

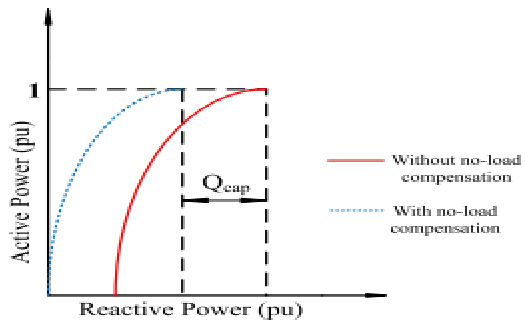

Fig. 2. FSWG reactive power characteristics.

V. Reactive Power Capability of Solar-PV Generators

Having no rotating magnetic field or coil arrangement, photovoltaic solar systems supply electricity via an inverter.

The photovoltaic solar modules themselves do not have reactive power support because they generate electricity with a photovoltaic effect. However, the inverter used for DC / AC conversion can provide significant support for reactive power under normal operating conditions or even in fault conditions [9]. The solar inverter also offers other additional services such as MPPT, LVRT control, etc. Although support for reactive energy for photovoltaic solar systems is not yet mandatory in most grid codes, the level of penetration will increase controllability through active and reactive power. A typical single-phase photovoltaic solar system connected to the grid is shown. There are several reactive power compensation techniques that have been implemented by researchers for photovoltaic solar systems. Traditionally, this is done using a control scheme in the control circuit of the inverter. These techniques and some others are discussed in the following subsections.

VI. STATCOM

Hingoraniare first proposed the STATCOM concept in 1976. A STATCOM is a FACTS device, which normally consists of a VSC, a controller and a step-up transformer or a coupling reactor, as shown in Fig. 3. It is generally used. In the P_{CC} of a wind farm or a photovoltaic solar generator for reactive power compensation and voltage control. By activating and deactivating the STATCOM VSC switches (eg IGBT), the VSC output voltage is adjusted and, therefore, it is possible to control the output current. STATCOM current and power equations are shown in the equation.

$$I = \frac{V_0 - V_{pcc}}{X_S}$$

$$P = \frac{V_0 V_{pcc}}{X} \sin(\alpha\text{-}\theta)$$

$$Q = \frac{V_0 (V_0 - V_{pcc} \cos(\alpha - \theta)}{X}$$

From the above equations, it can be seen that the capacitive or inductive current can be obtained by adjusting the output voltage VSC V_o. For V_o values higher than Vpcc, STATCOM works in capacitive mode, while for Vo values lower than Vpcc, it works in inductive mode. The active and reactive current characteristics of a STATCOM are displayed. STATCOM has been used extensively with REG for reactive power

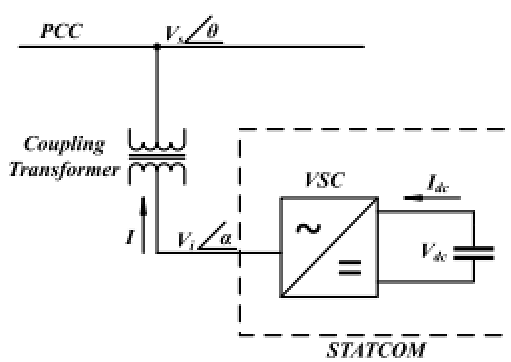

Fig. 3. Schematic diagram of a STATCOM

VII. Artificial Intelligence

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, in particular computer systems. These processes include learning (acquiring information and rules for using information), reasoning (using rules to draw approximate or definitive conclusions) and self-correction. Special AI applications include expert systems, speech recognition and image processing.

Artificial intelligence can be classified as weak or strong. Weak artificial intelligence, also known as narrow artificial intelligence, is an artificial intelligence system designed and trained for a specific task. Virtual PDAs like Apple's Siri are a weak form of AI. Strong artificial intelligence, also known as general artificial intelligence, is an artificial intelligence system with generalized human cognitive abilities. When a powerful artificial intelligence system is faced with an unknown task, it can find a solution without human intervention.

VIII. CONCLUSION

This paper provided a comprehensive overview of recent literature on reactive power management in REG's high penetration power grids. According to the review, many grid codes indicate the stopping reactive power requirements for REGs, but only a few grid codes indicate the dynamic reactive power requirements. With the growing penetration of renewable energies, however, it is becoming necessary for all grid operators to specify the dynamic reactive power requirements for ERW in their grid codes in order to maintain a stable and reliable electricity grid.

Various reactive power support devices are also used in power grids and PEC interface devices (e.g. STATCOM) offer a much better ability to compensate for dynamic reactive power than conventional devices such as capacitor banks. However, control of these devices only depends on some AI-based techniques for a few days, which can be changed for further improvements.

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