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RESEARCH ARTICLE

DESIGN A HYBRID WIND GENERATOR FOR GRID INTEGRATION AND MEMORY MANAGEMENT

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***Abstract:** Wind energy is the world's fastest growing energy source. The amount of power generated by wind energy depends on the speed of the wind. Because of the intermittent and fluctuating wind speed they are not suitable to micro grid applications unless proper power and energy management strategies are available. Hence a Suitable method of giving stable active, reactive power is required. Hybrid power systems are proposed to overcome the problems with energy storage and power management strategies. Fuel cells (FCs) and electrolyzers (ELs) have high energy storage density. This paper also proposes a hybrid energy system consisting of a wind turbine, a photovoltaic source, and a fuel cell unit designed to supply continuous power to the load. A simple and economic control with dc-dc converter is used for maximum power extraction from the wind turbine and photovoltaic array. Due to the intermittent nature of both the wind and photovoltaic energy sources, a fuel cell unit is added to the system for the purpose of ensuring continuous power flow.*

***Keywords:** wind energy, micro grid, hybrid power systems, fuel cells, electrolyzers, closed loop control*

I. INTRODUCTION

The standalone solar photovoltaic and wind systems have been promoted around the globe on a comparatively larger scale. These independent systems cannot provide continuous source of energy, as they are seasonal. For example, standalone solar photovoltaic energy system cannot provide reliable power during non-sunny days. The standalone wind system cannot satisfy constant load demands due to significant fluctuations in the magnitude of wind speeds from hour to hour throughout the year. Therefore, energy storage systems will be required for each of these systems in order to satisfy the power demands. Usually storage system is expensive and the size has to be reduced to a minimum possible for the renewable energy system to be cost effective. The power generated from both wind and solar components is stored in a battery bank for use whenever required. A hybrid renewable energy system utilizes two or more energy production methods, usually solar and wind power. The other advantage of solar / wind hybrid system is that when solar and wind power production is used together, the reliability of the system is enhanced. Additionally, the size of battery storage can be reduced slightly as there is less reliance on one method of power production. Often, when there is no sun, there is plenty of wind. The low efficiency and high cost are the main drawbacks of RES. There is no proper control over the produced electrical power in case of Wind generators, Photovoltaic panels. If they are integrated without proper control strategies, they may lead to grid instability or even failure of grid, which ultimately may lead to total collapse of the system.Hence it is necessary to achieve stable active, reacting power at the generators. The electrical system must provide some ancillary service when connected to a micro grid. A hybrid power system with energy storage system and good power management strategies can be a solution [1-4].

1) Energy storage systems are used to compensate or absorb the difference between the generated wind power and the required grid power so that active, reactive powers are controlled. These are long term Energy storage systems including Hydrogen technologies, combining fuel cells (FCs) and electrolyzers (ELs).

2) Power management strategies are implemented to control the power exchange among different sources and to provide some services to the grid. They also provide ancillary services to the grid.

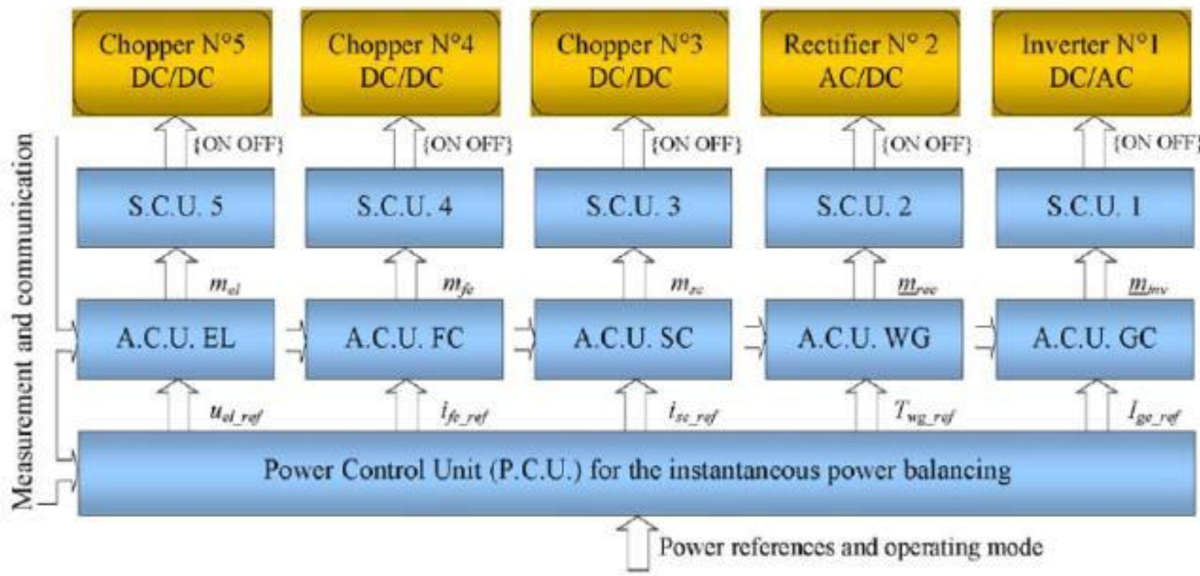
According to researchers, wind electrolysis is a very attractive candidate for an economically viable renewable hydrogen production system [5], [6]. Hydrogen, as an energy carrier, contributes directly to the reduction of dependence on imported fossil fuel [7], [8]. Flywheel systems are also suitable for fast-dynamic energy storage. However, this mechanical system is currently hampered by the danger of ―explosive‖ shattering of the massive wheel due to overload (tensile strength because of high weight and high velocity). SCs are less sensitive in operating temperature than batteries and have no mechanical security problems.This paper develops a wind generator (WG), including three kinds of sources: they are A RES: WG; 2) a fast-dynamic storage: SCs; and 3) a long-term storage: FC, EL, and H2 tank. Energy management strategies are implemented in the control system to satisfy the requirements while maximizing the benefits of RES and optimizing the operation of each energy unit.The power management strategies of the HPS control the DC bus voltage and also satisfying micro grid power requirements. These requirements are formulated as active, reactive power and calculated by a centralized secondary control unit in order to co-ordinate power dispatch of several power plants in a control area.The high reliability and high efficiency achieved with high reliable communication systems in the micro gird.In Sections II and III, the studied HPS structure is presented.

II. HYBRID POWER SYSTEM (HPS)

In this paper a DC coupled structure is use to decouple the grid voltages and frequencies from other sources. All sources are connected to main DC bus before being connected to the main grid inverter (fig1).Every source is electrically connected with a power electronic converter to get the best possible power control actions. The HPS structure and its global control system can be used for various combinations of sources.

A)Structure of control system

Power converters introduce some control inputs for power conversion. In this paper, the structure of the control system can be divided into different levels. The switching control unit (SCU) is designed for each power converter. In an SCU, the drivers with opto couplers generate the transistor’s ON/OFF signals from the ideal states of the switching function {0, 1}, and the modulation technique (e.g., pulse width modulation) determines the switching functions from the modulation functions (m). The automatic control unit (ACU) is designed for each energy source and its power conversion system. The ACU consists of control algorithms to calculate the modulation functions (m) for each power converter according to their reference values.The power control unit (PCU) is designed to perform the instantaneous power balancing of the entire HPS in order to satisfy the grid requirements. These requirements are real- and reactive-power references, which are obtained from the secondary control center and from references of droop controllers. In a PCU, some power-balancing algorithms are implemented to coordinate the power flows of different energy sources. The different power-balancing algorithms correspond to a number of possible operating modes of the HPS and can be gathered.The purpose of this Paper is to present the power-balancing strategies in the PCU. In order to focus on the power-balancing strategies of the HPS, the control schemes of the power conversion systems through different power converters are not detailed. However, some explanations of the ACUs are given in the following paragraphs in order to make the controllable variables of the power conversion systems appear.



III. POWER BALANCING STRATAGIES

Grid-Following Strategy: With the grid-following strategy, the dc-bus voltage is regulated by adjusting the exchanged power with the grid, while the WG works in MPPT strategies . In Fig. 6, the dc-bus voltage control is shown by a closed loop (pdc_ref → pg_ref → pg → pdc). Thus, the required power for the dc-bus voltage regulation (pdc_ref) is used to estimate the grid power reference (pg_ref).

POW 1E: Pg-ref = psource - Pdc-ref …………(7)

The source total power (psour) is a disturbance and should also be taken into account with the estimated wind power and the sensed total storage power

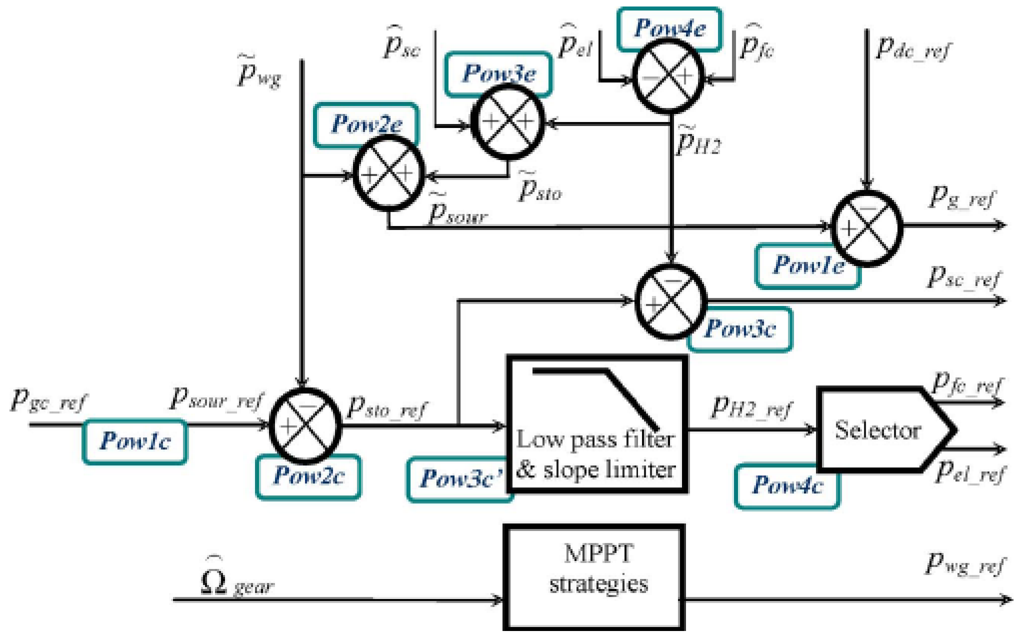
Pow 2E: psource = Pwg+Psto…………………. (8)

The energy storage systems help the wind energy conversion system satisfy the power references, which are asked by the microgrid operator

POW 3E: Psto = Psc+Ph2……………… (9)

POW 4E: Ph2 = Pfc - Pel………………… (10)

In steady state, the dc-bus voltage is regulated, and the averaged power exchange with the dc-bus capacitor can be considered as zero in (3). Hence, in steady state, the grid power (pg) is equal to the total power from the sources (psour). If the microgrid system operator sets a power requirement (pgc_ref), it must be equal to the sources' power reference (psour_ref),as shown inFig6 . POW 1 C: Psource-ref = pg-ref = pgc-ref … (11)

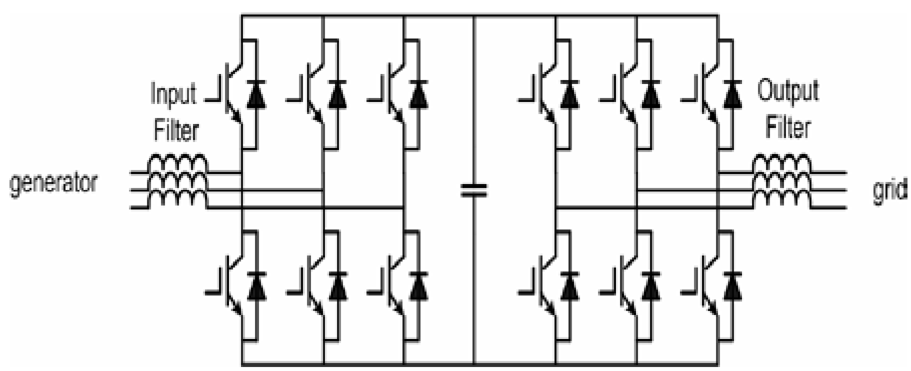


IV. POWER CONVERTER TOPOLOGIES FOR WIND TURBINES

Basically two power converter topologies with full controllability of the generated power are currently used in the commercial wind turbine systems. These power converters are related to the partial-rating power converter wind turbine and the full-rating one. However, other topologies have been proposed in the last years.

A. Bi-directional back-to-back two-level power converter

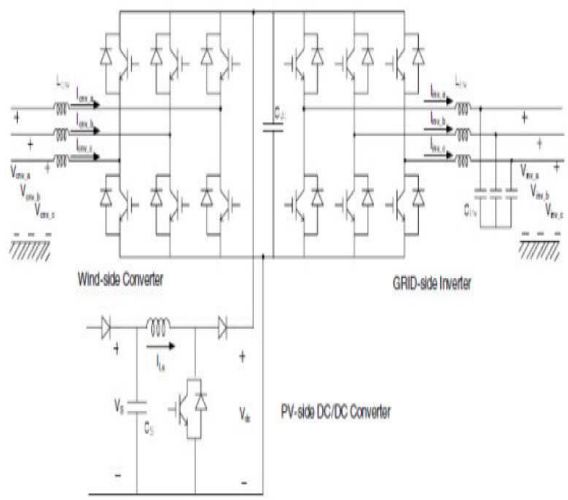
The back-to-back Pulse Width Modulation-Voltage Source Converter (PWM-VSC) is a bi-directional power converter consisting of two conventional PWM-VSCs. This topology is shown in Figure 6.



The PWM-VSC is the most frequently used three-phase frequency converter. As a consequence of this, the knowledge available in the field is extensive and very well established. Furthermore, many manufacturers produce components especially designed for use in this type of converter (e.g., a transistor-pack comprising six bridge coupled transistors and anti-paralleled diodes). Therefore, the component costs can be low compared to converters requiring components designed for a niche production. A technical advantage of the PWM-VSC is the capacitor decoupling between the grid inverter and the generator inverter.

V. POWER ELECTRINICS INTERFACE OF THE HYBRID SYSTEM

In many small-scale systems, the dc system is set at a constant dc voltage and is usually comprised of a battery bank which energy storage, a controller to keep the batteries from overcharging; and a load. The load may be dc or may include an inverter to an ac system. Connecting a wind generator to a constant dc voltage has significant problems due to the mismatching the poor impedance matching between the generator and the constant dc voltage (battery), which will limit power transfer to the dc system. In response to these problems, researchers have investigated incorporating a dc–dc converter in the dc link.



VI. RESULTS

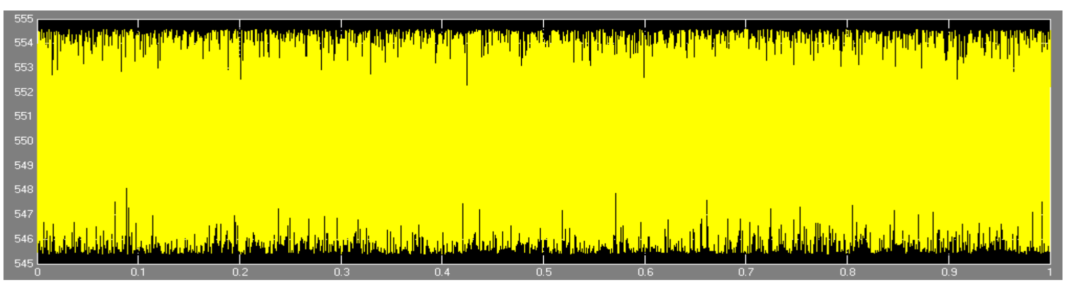


Fig 6.0 Grid Active power

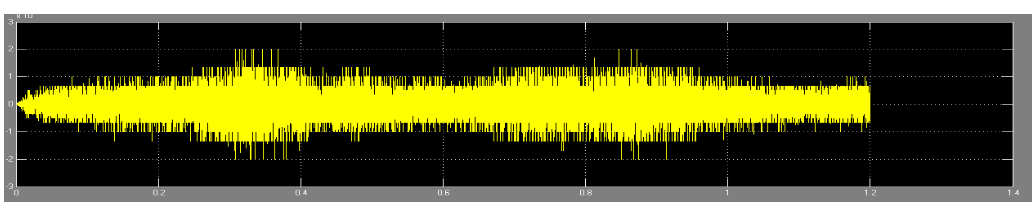


Fig 6.1 grid reactive power(normal mode)

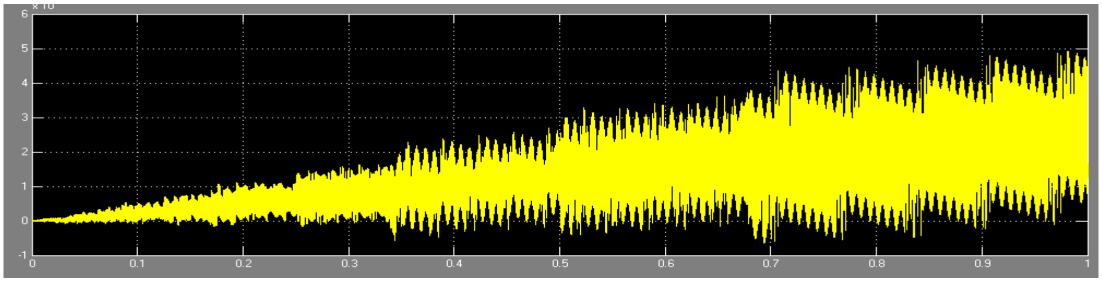


Fig 6.2 grid reactive power during transients

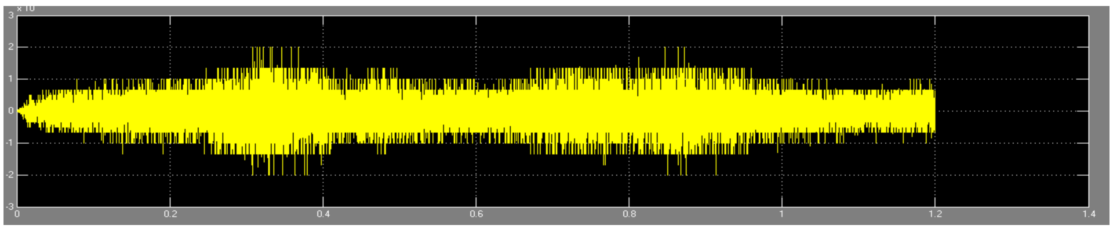


Fig 6.3 grid reactive power after stabilization

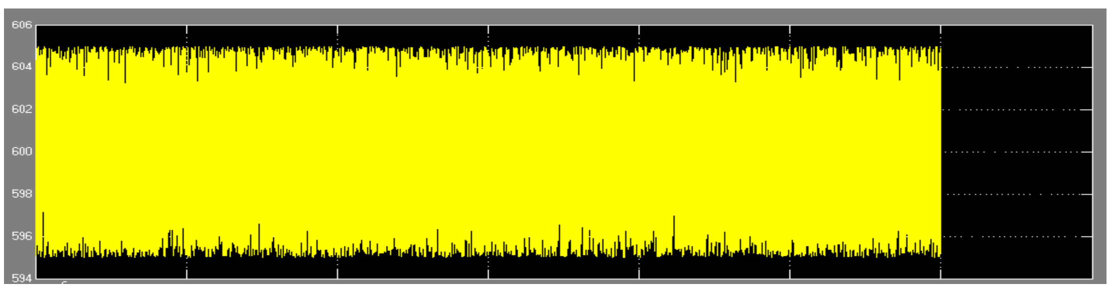


Fig 6.4 grid reactive power

VII. CONCLUSIONS

The proposed model takes sunlight irradiance and cell temperature as input parameters and outputs the I-V and P-V characteristics under various conditions. This paper describes renewable energy hybrid Wind-PV with battery energy storage system. In Hybrid Wind-PV System, PV system acts as a main source. The power fluctuation of the hybrid system is less dependent on the environmental conditions as compared to the power generated of individual PV and WG systems. This power fluctuation has been suppressed using a battery in this project and it will be the subject of future work.

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