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Modeling and Simulation of Hybrid Active Wind Generator Fuel Cell and Supercapacitor Distributed Power Generation System with Grid Integration

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***Abstract*: The unstable wind conditions the network essential made force not depends. This paper describes the dc wind /electrolysers/super capacitor/fuel cell hybrid power system and the inspiration driving the control structure is to arrange these different sources. Fundamentally their power exchange, to make the controllable the generated power. A functioning wind generator can be attempted to offer some subordinate sorts of help to the framework are the results in this paper. The control system should be changed incorporate the force the board methodologies. The power management system is shown and simulated by MATLAB/SIMULINK. We executed that the source following approach has better execution on the network power guideline than the lattice following technique.**

***Keywords*: Distributed power, energy management, hybrid power system (HPS), power control, wind generator (WG).**

1. Introduction

The fast expansion in the interest for electric energy requires more installation of energy capacities. The energy capacities from fossil fuels have been incredibly devoured and their reserves have been quickly drained contrasted with different assets. Thus, there is as of late an attention on renewable energy usage and improvement as appropriate alternative energy. Among the renewable resources wind, solar oriented and fuel cells are filling in significance and gain the interest of energy researches.

After 1980s, the cost of power given by wind energy has been radically dropping. These cost decreases are because of new advances, more effective and more reliable wind turbines. Renewable energy sources (RES) have been attracting in unique consideration all around the world since many years due to the following reasons:

1. Reduces dependency on imported fossil fuels.
2. Reduction of emission of the greenhouse gases.
3. Secured energy supply at all the times. The low efficiency and high cost are the main drawbacks of RES.

There will be no legal order on the power generated in the event of a generator, fuel cells. If installed without proper control techniques, it can lead to grid instability or grid failure, which can ultimately lead to a complete breakdown of the system. After that it is important to achieve stable operating power, which responds to the generators. The electrical framework should provide less services when connected to a smaller grid. A hybrid power system with a power saving system and great power management techniques can be the solution.

Energy-saving systems are used to compensate or maintain the difference between the wind power generated by the grid power so that the active, active energy is controlled. These are long-term energy storage systems for combining fuel cells (FCs) and electrolysis (EL). Energy management strategies are developed to control the exchange of energy between different sources and to provide several types of grid support. They also offer auxiliary types of services on the grid. According to researchers, wind electrolysis is a unique attraction of an economically viable production system. Hydrogen, as an energy carrier, contributes directly to reducing dependence on fossil fuels. Flywheel systems are also ready to store fast power with energy.

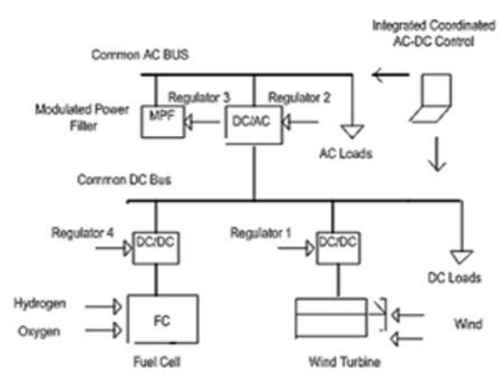

Fig. 1. Integrated (Wind-FC) green energy utilization scheme for village electricity

However, this mechanical framework is at present hampered

*Corresponding author: gadgesonam12@gmail.com by the risk 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 issues. The plan of the examined framework with normal common DC/ common AC collection buses interface. The plan utilizes an essential common DC bus collection with a secondary common AC bus for taking care of any AC loads and public grid interface. The proposed hybrid green energy scheme is digitally simulated for different operation conditions and load excursions. The developed control scheme comprises novel multi-loop coordinated dynamic. error driven controllers with supplementary regulation loops to control the different subsystems.

2. Literature Review

"Energy Management and Power Control of a Hybrid Active Wind Generator for Distributed Power Generation and Grid Integration" By Tao Zhou and Bruno François in IEEE Transactions On Industrial Electronics, Vol. 58, No. 1, January 2011. In this paper they discussed about Classical wind energy conversion systems are usually passive generators. The generated power does not depend on the grid requirement but entirely on the fluctuant wind condition. A dc-coupled wind/hydrogen/supercapacitor hybrid power system is studied in this paper. The purpose of the control system is to coordinate these different sources, particularly their power exchange, in order to make controllable the generated power. As a result, an active wind generator can be built to provide some ancillary services to the grid. The control system should be adapted to integrate the power management strategies. Two power management strategies are presented and compared experimentally. We found that the "source-following" strategy has better performances on the grid power regulation than the "grid-following" strategy.

"Real-Time Simulation of a Wind Turbine Generator Coupled with a Battery Supercapacitor Energy Storage System" by Wei Li, Géza Joós and Jean Bélanger in IEEE Transactions On Industrial Electronics, Vol. 57, No. 4, April 2010. In this paper they discussed about that the Wind power generation studies of slow phenomena using a detailed model can be difficult to perform with a conventional offline simulation program. Due to the computational power and high-speed input and output, a real-time simulator is capabl of conducting repetitive simulations of wind profiles in a short tim with detailed models of critical components and allows testing of prototype controllers through hardware-in-the-loop (HIL). This paper discusses methods to overcome the challenges of real-time simulation of wind systems, characterized by their complexity and high-frequency switching. A hybrid flow-battery supercapacitor energy storage system (ESS), coupled in a wind turbine generator to smooth wind power, is studied by real-time HIL simulation. The prototype controller is embedded in one real-time simulator, while the rest of the system is implemented in another independent simulator. The simulation results of the detailed wind system model show that the hybrid ESS has a lower battery cost, higher batter longevity, and improved overall efficiency over its reference ESS.

3. Hybrid Power System (HPS) and Control System

A. Structure of 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 in vertex. 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.

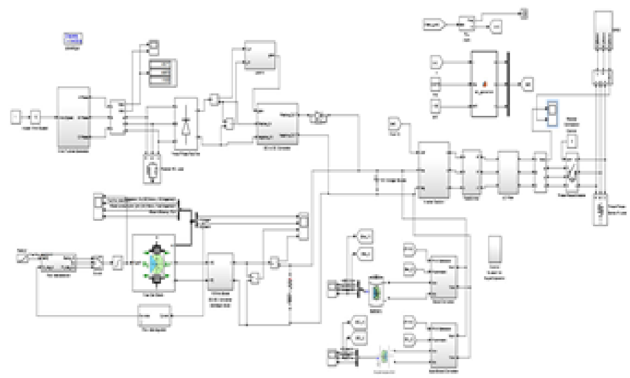

Fig. 2. Simulation of system

B. 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.

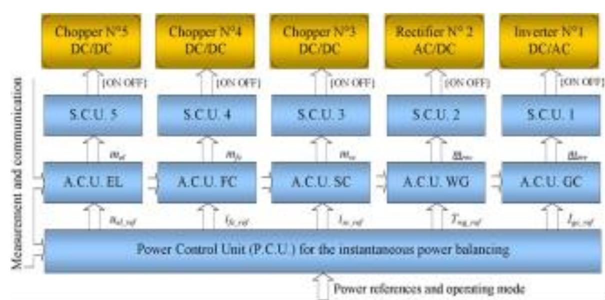

Fig. 3. Hierarchical control structure of the HPS

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 control schemes in the ACUs are shown in Fig. 4 with block diagrams.

1) The EL power conversion system is controlled by setting the terminal voltage equal to a prescribed reference through the dc chopper N◦5. The EL stack is considered as an equivalent current source.
2) The FC power conversion system is controlled with a reference of the FC current through the dc chopper N◦4. The FC stack is considered as an equivalent voltage source.
3) The SC power conversion system is controlled with a current reference through the dc chopper N◦3. The SC bank is considered as an equivalent voltage source.
4) The wind energy conversion system is controlled with a reference of the gear torque by the three phase rectifier N◦2.
5) The grid connection system consists of a dc-bus capacitor and a grid power conversion system. The grid power conversion system is controlled with line-current references by the three-phase inverter N◦1, because the grid transformer is considered as an equivalent voltage source.

C. PCU

The PCU is further divided into two levels: the power control level and the power sharing level (Figure 5). The power-sharing level connects the energy exchange between different energy sources with different energy measurement techniques.

1) Power Control Level

To achieve the maximum amount of power from the wind power conversion system, the most widely used energy tracking system is widely used.

The maximal-power-point-tracking (MPPT) strategy Output the maximum wind power available depending on the aspect of the speed limit. In this air / hydrogen / SC HPS, five power converters are used to control the transmission of energy through each source. Depending on the power flow selected, the following two power measurement techniques can be implemented.

1. The grid-following strategy uses the line-current loop to regulate the dc-bus voltage.
2. The source-following strategy uses the line-current loop to control the grid active power, and the dc-bus voltage is regulated with the WG and storage units.

2) Grid-Following Strategy

With the grid tracking device, the DC-bus voltage is controlled by adjusting the power provided by the grid, while the WG operates with MPPT techniques. In the fixed case, the DC-bus voltage is controlled, and the power exchange rate with the dc-bus capacitor can be considered as zero. Therefore, in a stable case, the power of the grid (pg) is equal to the total energy from the sources (psour).

To help the wind energy conversion system respect the energy-efficient requirement, energy storage systems must be aligned to provide or absorb the difference between this power requirement (pgc_ref) and the changing wind power (pwg).

4. Results

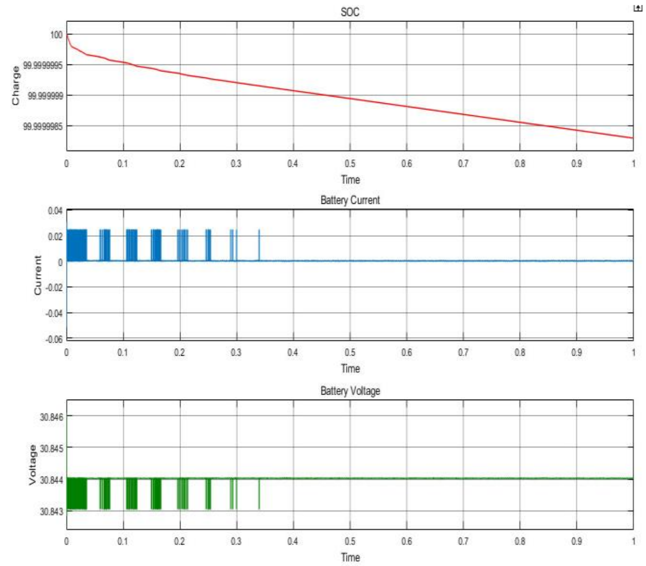

Fig. 4. Battery parameter

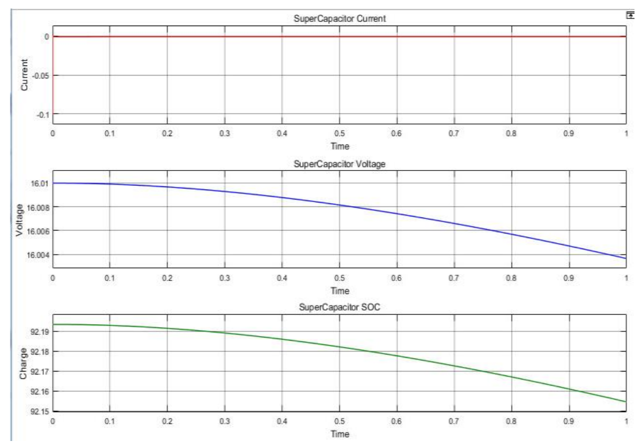

Fig. 5. Super-Capacitor parameter

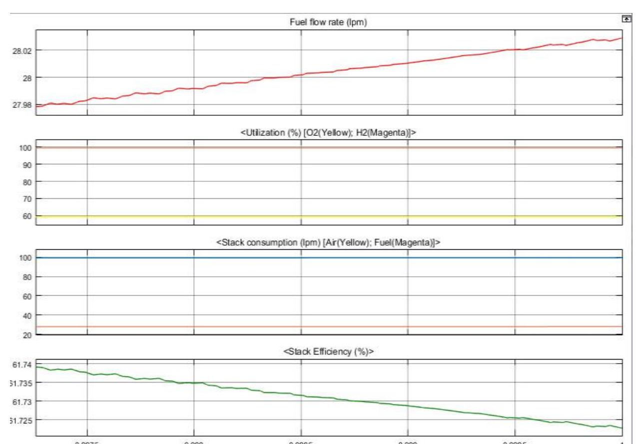

Fig. 6. Fuel cell input parameter

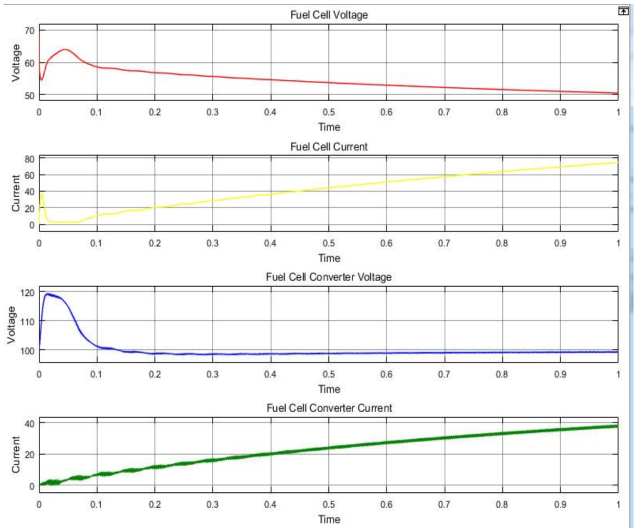

Fig. 7. Fuel cell output parameter

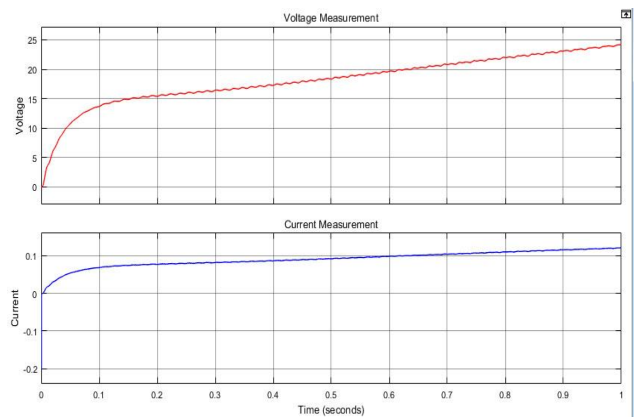

Fig. 8. Wind converter output

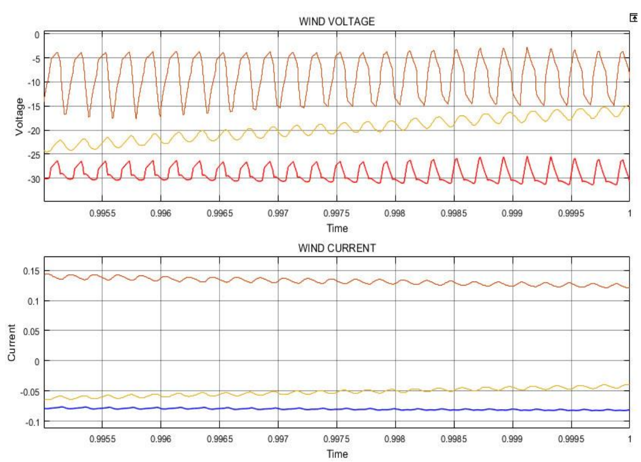

Fig. 9. Wind ac output

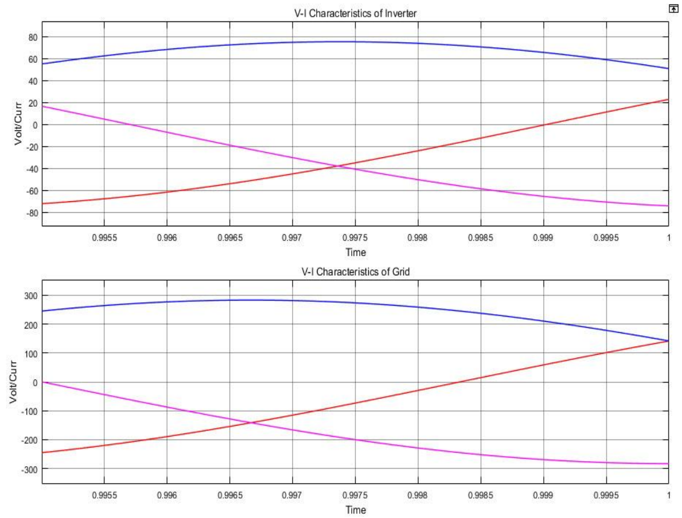

Fig. 10. Inverter and Grid output

5. Conclusion

The next two grid power management methods and the next source are introduced by the system. Dc bus voltage is well controlled by the following source process. Imitation results indicate that the introduction of an energy saving system, a better instruction for effective and efficient energy. With the effect of enabling compatible grid resources, unconventional power sources will be used more frequently. Therefore, with appropriate power adjustments and power control methods a grid tracking or source tracking techniques can be used. With more advances in technology, SCs can be made more sensitive to operating temperatures than batteries and have no safety issues. With the advancement of technology, super capacitors (SCs) can become the best choice for fast-moving dynamic energy storage devices, especially for smooth fluid power generation, such as a wind power generator.

References

[1] J. M. Guerrero, J. C. Vasquez, J. Matas, M. Castilla, and L. G. de Vicuna, "Control Strategy for flexible micro grid based on parallel line interactive UPS systems," in *IEEE Trans. Ind. Electron*, vol. 56, no. 3, pp. 726–736, Feb. 2009.

[2] C. Sudipta, D. W. Manoja, and M. G. Simoes, "Distributed intelligent energy Management system for a single-phase high-frequency AC micro grid," in *IEEE Trans. Ind. Electron*, vol. 54, no.1, pp. 97–109, Feb. 2007.

[3] D. M. Vilathgamuwa, C. L. Poh, and Y. Li, "Protection of micro grids during utility voltage sags," in *IEEE Trans. Ind. Electron*., vol. 53, no. 5, pp. 1427–1436, Oct. 2006.

[4] M. Prodanovic and T. C. Green, "High-quality power generation through distributed control of a power park micro grid," in *IEEE Trans. Ind. Electron.*, vol. 53, no. 5, pp. 1427–1436, Oct. 2006.

[5] R. M. Dell and D. A. J. Rand, "Energy storage-A key technology for global energy sustainability," in *Power Sources*, vol. 100, no. 1/2, pp. 2–17, Nov. 2001.

[6] Mohamed A. H. El-Sayed, Adel M. Sharaf, "An Efficient Hybrid Wave/Photovoltaic Scheme for Energy Supply in Remote Areas," accepted for publication in international journal of Renewable Energy Technology.

[7] H. Fargali, F. Fahmy, M. A. El-Sayed, "Control and optimal sizing of PV-Wind powered rural zone in Egypt," Al-Azhar Engineering 10th International conference, Cairo, Dec. 24-26, 2008.

[8] M. Lebbal, T. Zhou, B. Francois, and S. Lecoeuche, "Dynamically electrical modeling of electrolyze sand hydrogen production regulation," in *Proc Int. Hydrogen Energy Congr. Exhib*., Istanbul, Turkey, Jul. 2007.