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# Stand-Alone Wind Power System Operating with a Specific Storage Structure

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**Abstract.** In this paper we analyze a low power wind system operating in autonomous mode. We present a control structure that ensures the maximization of wind energy conversion and the balance between required and produced power. We have studied two stand alone wind system structures based on the capacitor voltage control and the buffer battery operation. The simulation results have been obtained in Matlab/Simulink environment, using PowerSim toolbox.

## Key words

Stand-alone wind system, control, storage energy, local power network, wind energy conversion.

## 1. Introduction

Nowadays, electrical energy savings at residential level, production closer to the habitation places, have become a topic of lively debates for the energy demand satisfaction. Therefore, study of the wind energy like a principal source for isolated sites has become a promising research way[1-4].

The present paper examines specific control methods related to a low power autonomous wind system conceived to run on an isolated site. The different stages of these control methods are analyzed. Starting from the method principles and the system structural elements, we develop a stand-alone wind power system with a synchronous permanent magnet generator. Using Matlab/Simulink environment, simulations have been performed in order to analyze the operating behavior of the considered system.

## 2. The structure of a low power wind system

This paper is focused on low power wind system operating on an isolated site. The energy storage is realized with battery designed to operate in conjunction with a controlled load.

The subsystems involved in the energy transfer which takes place from the turbine to the local network are illustrated synthetically in Fig. 1.

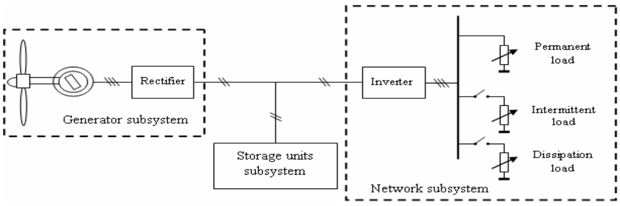


Fig. 1. Energy transfer subsystems

Three components of the stand alone wind system are presented in Fig. 1, which are: wind generator subsystem, local network subsystem (controlled loads) and energy storage subsystem.

### A. *Wind Generator subsystem*

The optimality of the whole system is defined in relation with the wind energy conversion maximization.

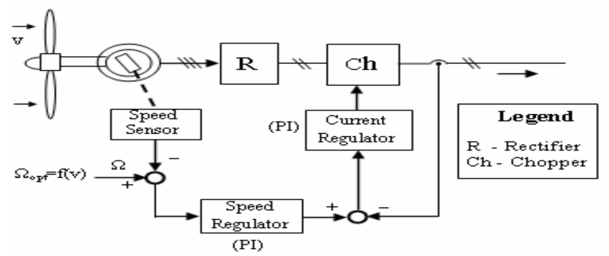


Fig. 2. Wind Generator subsystem structural schema

As shown in Fig.2, we have adopted a cascade control loop. The chopper control being carried out by a current loop, the wind generator subsystem could be considered as a controlled current source.

*B. Local Network subsystem*

This subsystem realizes the load control using specific network switches (states ON-OFF). This local network is associated to a local control loop for AC bus voltage control.

*C. Energy Storage subsystem*

Two solutions for the energy storage subsystem were studied: electrostatic energy accumulation realized with a super capacitor storage and electrochemical energy accumulation (batteries). The last solution presents two operating alternatives: buffer battery or capacitor voltage control.

## 3. Modeling methodologies

Two solutions have been mentioned previously, concerning the energy storage subsystem.
The first solution consists of using a super capacitor on the DC Bus. Capacitor voltage is sensitive to the imbalance between produced power and consumption. To achieve the balance between these two powers, a charge regulator is employed. The capacitor voltage is maintained constant by modifying the power of several receivers connected to the local network and operating as controlled loads, through continuous or discrete actions (switch ON/OFF).
In order to eliminate drawbacks of the first solution related to the continuity of energy supply during periods of wind deficit, a battery was introduced. Firstly, the battery is associated to the capacitor voltage control structure. The simulation was made using the structural schema given in Fig.3 A. Secondly, the battery is working in the intermediary DC circuit (buffer battery operation mode). The structural schema is showed in Fig.3B.

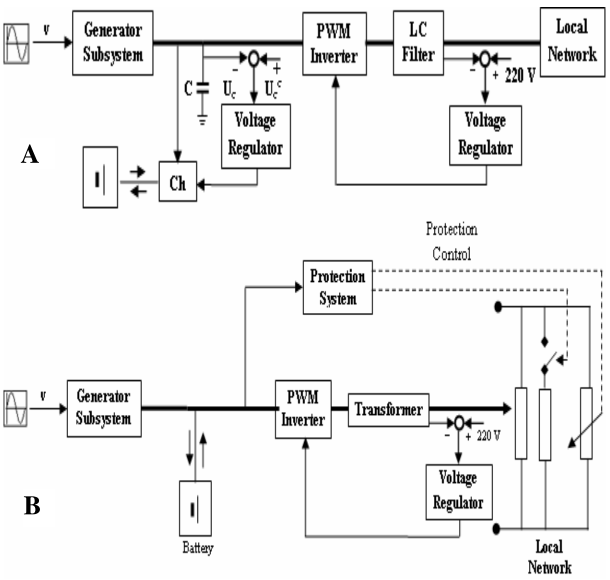


Fig. 3. Energy Storage subsystem structural schema: A) Capacitor and battery. B) Buffer battery.

## 4. Simulation results

We present the simulation results when the energy storage subsystem is based on capacitor storage and battery energy accumulation (second solution).
The local power network is composed by receivers that must be supplied in priority, by auxiliary loads handled by continuous or discrete commands and by dissipation loads. In Fig.4 A. we present the functioning diagram (local network coupling) of controlled receivers, during 5 seconds. In Fig.4 B. we present RMS variations of the load current and the active power generated on the local network.

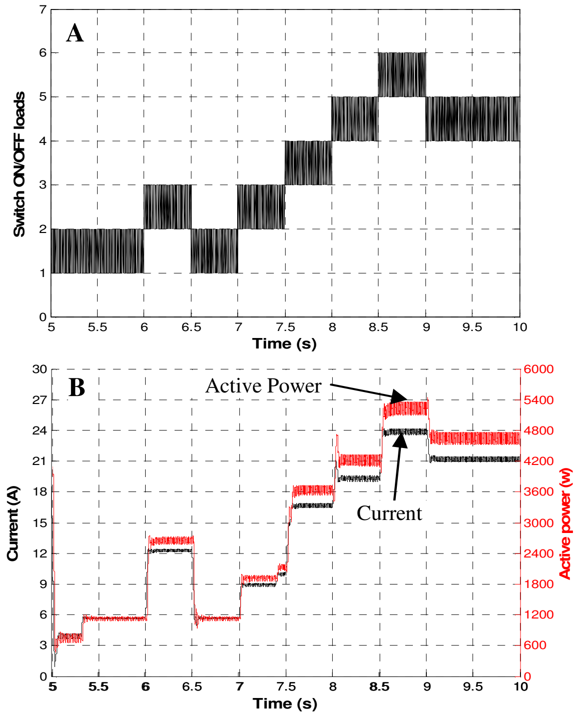


Fig.4. Simulation results for the storage structure based on capacitor and battery:
A) Local loads - Connected/Disconnected.
B) Load current (black), Output active power (red).

It appears that the system provides a convenient balance between consumption and production of the electric energy. This performance is achieved through a controlled operation of the battery, shown in Fig.5, for a nominal battery voltage level of 96 V.

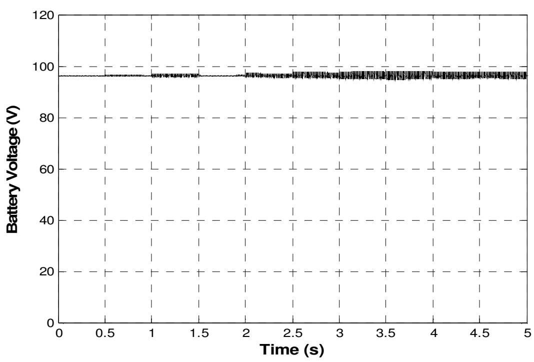


Fig. 5. Battery voltage evolution in buffer operating mode

## 5. Conclusion

Herein we present a specific structure of the storage energy subsystem based on capacitor voltage control. In this case, the system operating mode without battery is allowed for short time periods. The energy storage subsystem with a buffer battery requires a permanent presence of the battery in the system. The advantages of this solution are the equipment simplicity and the reduced voltage level in the intermediary DC circuit.

We intend for our future development to use the results of this work in order to minimize the global cost of the proposed Low Power Wind System designed to operate in stand alone applications.

## References


[1] R. Belfkira, C. Nichita, P. Reghem, and G. Barakat, "Modeling and optimal sizing of hybrid energy system", in *Proc. EPE-PEMC,* Poland, 2008.

[2] I. Munteanu, A.I. Bratcu, N.-A. Cutululis, and E. Ceanga, "Optimal Control of Wind Energy Systems", *Springer*, 2008.

[3] J. Martinez, A. Morales, O. Probst, A. Llamas, and C. Rodriguez, "Analysis and simulation of a wind-electric battery charging system", *International Journal of Energy Research*, vol. 30, 2006.

[4] M. Arifujjaman, M.T. Iqbal, and J.E. Quaicoe, "Energy capture by a small wind-energy conversion system", *Applied Energy*, vol. 85, pp. 41-51, 2008.