Electrical design of a smart control and monitoring system for small horizontal-axis wind turbines

J. Vilà[1,4], N. Luo[1], L. Pacheco[3], T. Pujol[2], J.R. Gonzalez[2], I. Ferrer[1], A. Massaguer[2], E. Massaguer[2]

[1] Department of Electrical Engineering, Electronics and Automation, University of Girona, Campus Montilivi, 17003 Girona (Spain)
[2] Department of Mechanical Engineering and Industrial Construction, University of Girona, Campus Montilivi, 17003 Girona (Span)
[3] Department of Computer Architecture and Technology, Polytechnic School, University of Girona, 17003 Girona (Spain)
[4] AULA ECOGranja Vilà, sustainable engineering, Camí Vell de Figueres a Olot S/N, Veïnat de Pols, 17772, Girona (Spain)
Phone number:+0034 686 750 724, e-mail: joaquim.vilab@udg.edu; ningsu.luo@udg.edu

1. Introduction

- Climate change threat demands actions towards new energy models.
- State-of-the-art micro-wind turbines (< 5 kWp) use passive pitch control technologies.
- Active pitch control and electronic brake are proposed as a technological advance for energy generation at micro scale.
- The electric system for monitoring and control of active pitch and brake systems is depicted.

2. The mechanical active pitch system

- Lab experiments were carried out in order to validate the proof-of-concept under steady aerodynamic loads of laminar winds [1].
- The results of output power for different resistance loads are shown in Fig. 1.
- From Fig. 1, we can see that the pitch angle has a strong influence on the extracted output power.

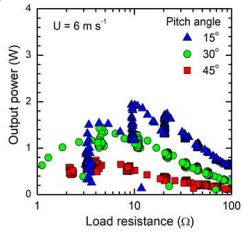

Fig. 1. Output power as function of load resistance for different values of pitch angle. Inlet mean wind velocity equals to 6 m/s.

3. Test on field and electrical system

- At 2017, an agreement between Eco-farm Vilà and the Polytechnic School of the University of Girona started.
- Tramuntana wind is an important source of natural energy that is present at Eco-farm Vilà.
- Figure 3 shows the self consumption system implemented at Eco-farm Vilà.

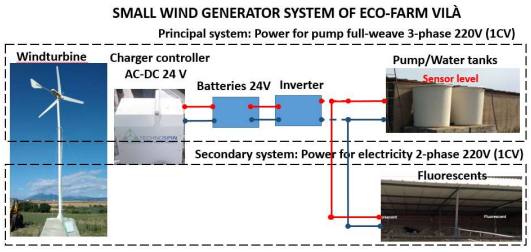

Fig. 2. Self Consumption scheme for the small horizontal axis wind turbine placed at Eco-farm Vilà.

- Fig. 3 shows the designed electronic system consisting of a PLC (Programmable Logic Control) unit that acts as master, and three 8 bits microcontrollers units that are used as slaves.
- Slave 1 controls the active pitch of the system.
- Slave 2 is used for monitoring different parameters (Vibrations, wind forces, wind orientation and speed.
- Slave 3 is designed for controlling and monitoring the power of the system.

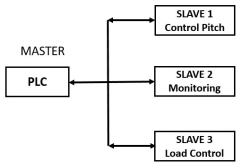

Fig. 3. Block diagram corresponding to different units of the electronic System developed

4. Monitoring and control electronic systems

- The different actions are done by different slave subsystems
- Slave 1 controls the active pitch implementing a PID controller that modules a PWM signal.
- Slave 2 is focused on monitoring tasks such as wind speed and orientation, tower structure deformations, and vibrations of the generator.
- Slave 3 monitors and controls the power generated.

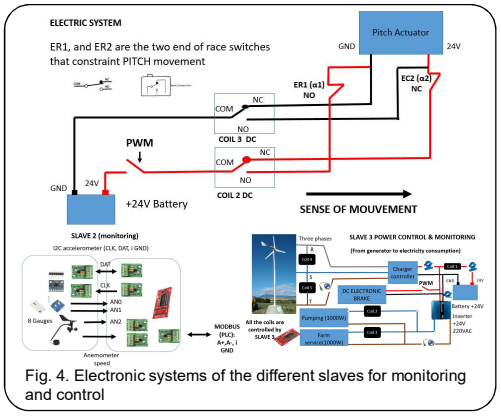

Fig. 4. Electronic systems of the different slaves for monitoring and control

5. Networks and communications

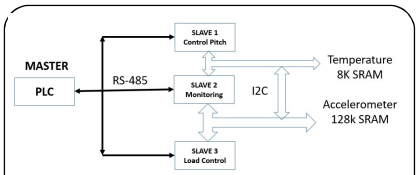

Fig. 5. Electrical design based on the use of RS485 and I2C networks.

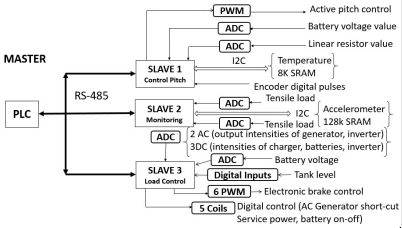

Fig. 6. **Different signals that can be controlled or monitored by PLC using the RS-485 communication line.**.

- Fig. 5 shows the block diagram corresponding to the RS485 and I2C networks used in this work.
- The flexibility of the multi master I2C network proposed may allow the system to work without the need of PLC.
- The RS-485 network is the backbone of this proposal. It allows the PLC to work in two modes (monitoring and control). Fig. 6 summarizes the signals used in this work.
- Under monitor mode the PLC read the meaningful data acquired by the slaves. When PLC is in control mode, reading or writing can be done in any parameter of slaves.

6 Conclusions

- The electronic system, that allows smart control and monitoring for a horizontal-axis micro-wind turbine with the purposes of increasing its performance and of making the device more robust against gust and high winds, is presented.
- The main control system consists in the combination of an active pitch control and an electronic brake that reduces the generator speed by increasing the electric load.
- Wind gust and turbulences are strongly related to territory and characterize the different regions.

References:

[1] J. Vilà, N. Luo, L. Pacheco, T. Pujol, J. R. Gonzalez, I. Ferrer, A. Massaguer, E. Massaguer, "Design of an active pitch control for small horizontal-axis wind turbine", Renewable Energy and Power Quality Journal, (2021). Vol. 19, pp. 195-198.

Acknowledgments: This work has been cofunded by the European Union through the European Regional Development Funds (FEDER). It has also been cofounded by the Secretaria d'Universitats I Recerca del Departament d'Empresa i Coneixement de la Generalitat de Catalunya through the Agència de Gestió d'Ajuts Universitaris i de Recerca under contract Ajut Llavor – 2019 LLAV 00003.Aula Ecogranja Vilà also supported the project.

Generalitat de Catalunya
Departament d'Empresa i Coneixement
Secretaria d'Universitats i Recerca

Unió Europea
Fons europeu
de desenvolupament regional