

Proyectos Coordinados con el Proyecto de Centro: IE 10050048

## **ADAPTACION DE LAS ASIGNATURAS "AEROGENERADORES Y PARQUES EÓLICOS CONECTADOS A REDES ELÉCTRICAS DE DISTRIBUCIÓN Y TRANSPORTE" Y "CONTROL DE ACCIONAMIENTOS" AL CONTEXTO DEL E.E.E.S.**

### **Objetivos**

- Introducir las **nuevas demandas tecnológicas de la sociedad** en la universidad.
- Construir nuevas sistemas que permitan abordar el estudio de las **ENERGÍAS RENOVABLES** a los alumnos.

### **Metodología:**

- A través del **trabajo en equipo**.
- Fomentando la **habilidad para la búsqueda y la gestión de la información**.
- Reforzando en los alumnos la **adquisición de competencias transversales**.

### **Se necesita:**

- Generar un **nuevo material docente**: sistemas de realización de prácticas de generación eólica, extracción de energía de las olas, etc.

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### **Actuaciones realizadas en el marco del proyecto**

- Realización de diversas interfaces de control tanto en **Matlab** como en **LabView** para realización de prácticas de control de aerogeneradores.

Estas interfaces permiten:

- Visualización de datos procedentes del microprocesador de control del aerogenerador en tiempo real.
- Control de las consignas de potencia activa y reactiva en tiempo real.
- Exportación de los gráficos de resultados de los experimentos a Excel.

### **Dificultades encontradas**

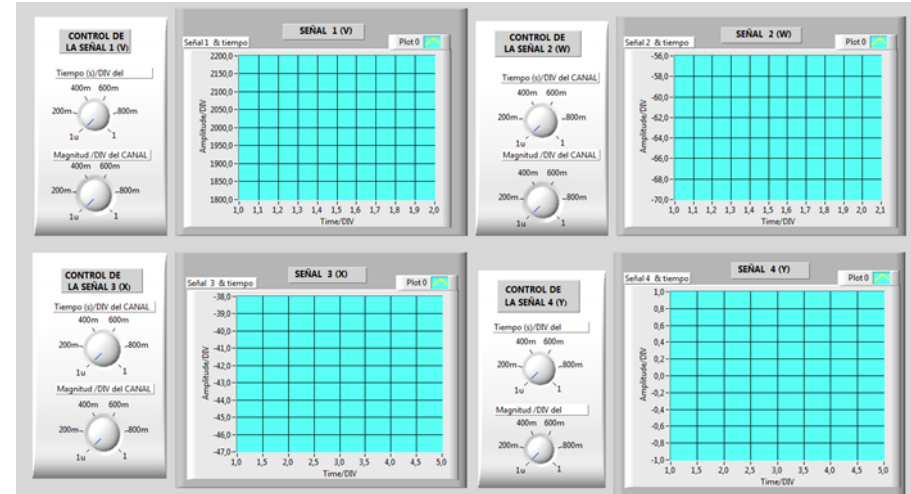
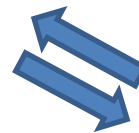
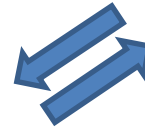
- Únicamente de carácter técnico.

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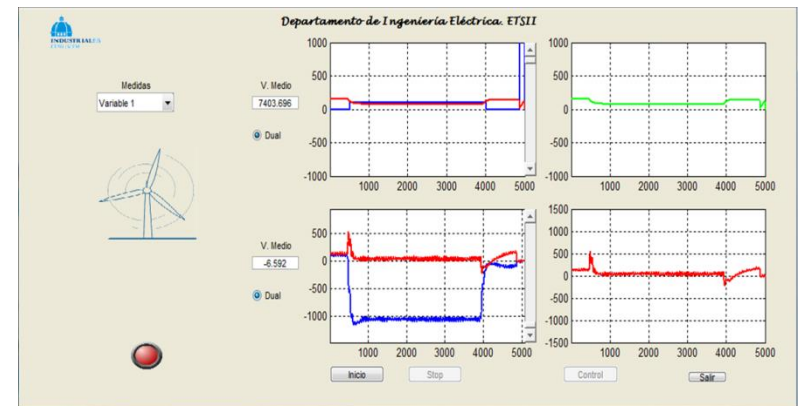
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## RESULTADOS

### Práctica de Control de Aerogeneradores



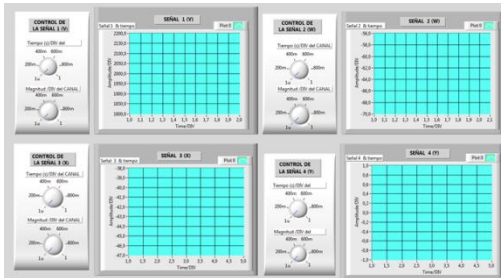
Interface de control realizada en LabView



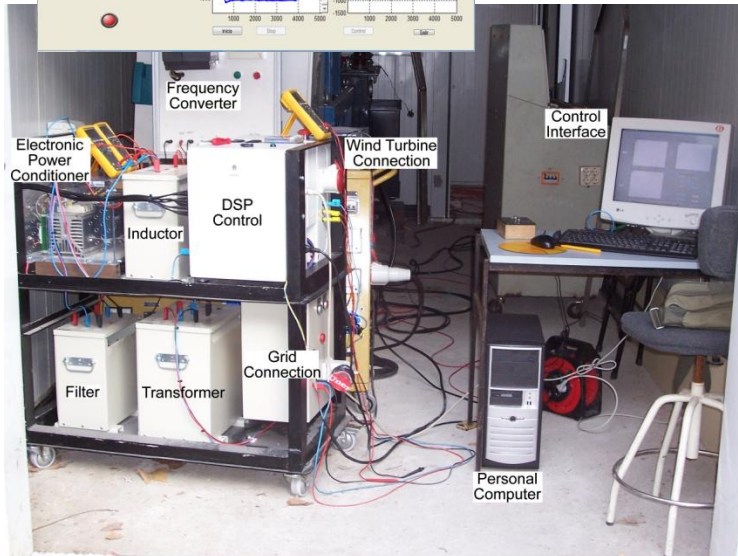
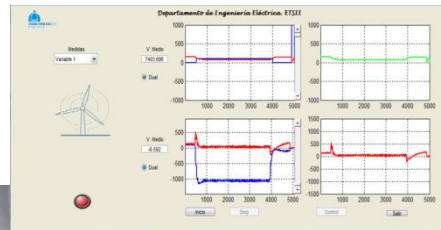
Interface de control realizada en Matlab

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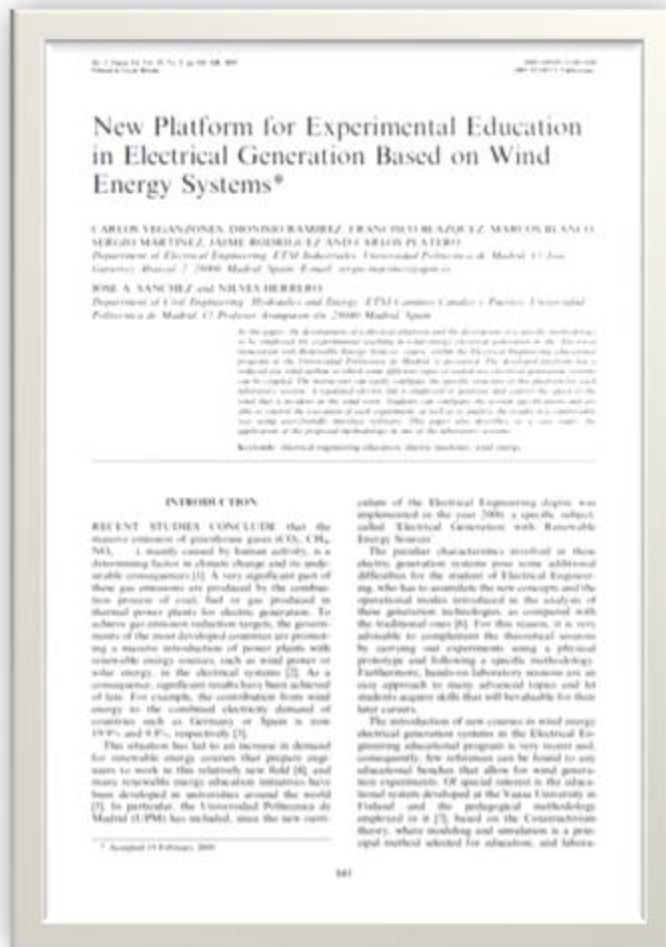
## Práctica de Control de Aerogeneradores



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Dos publicaciones sobre esta línea en la revista:  
*International Journal of Engineering Education*



**INTRODUCTION**

RECENT STUDIES CONCLUDE that the massive emission of greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O), ... (1 month caused by human activity is a determining factor in climate change and its undesirable consequences) [1]. A very significant part of these gas emissions are produced by the combustion process of coal, fuel oil or gas produced in thermal power plants for electric generation. To achieve gas emission reduction targets, the governments of the most developed countries are promoting a massive introduction of power plants with renewable energy sources, such as wind power or solar energy, in the electrical systems [2]. As a consequence, significant results have been achieved of late. For example, the contribution from wind energy to the combined electricity demand of countries such as Germany or Spain is now 10.9% and 9.6%, respectively [3].

This situation has led to an increase in demand for renewable energy sources that require engineers to work in this relatively new field [4] and many renewable energy education initiatives have been developed in universities around the world [5]. In particular, the Universidad Politécnica de Madrid (UPM) has included, since the new curriculum of the Electrical Engineering degree, was implemented in the year 2000 a specific subject, called 'Electrical Generation with Renewable Energy Sources'.

The peculiar characteristics involved in these electric generation systems pose some additional difficulties for the student of Electrical Engineering, who has to assimilate the new concepts and the operational modes introduced in the analysis of these generation technologies, as compared with the traditional ones [6]. For this reason, it is very advisable to complement the theoretical lessons by carrying out experiments using a physical prototype and following a specific methodology. Furthermore, hands-on laboratory sessions are an easy approach to many advanced topics and let students acquire skills that will be valuable for their later careers.

The introduction of new systems in wind energy electrical generation systems in the Electrical Engineering educational programs is very recent and, consequently, few references can be found in any educational benches that allow for wind generation experiments. The special interest in the educational systems developed at the Vassar University in Hartford and the pedagogical methodology employed in it [7], based on the Constructivism theory, where modeling and simulation is a principal method selected for education, and labora-

**INTRODUCTION**

IN THE context of electric drives there are very often abstract and difficult to understand, as well as many aspects of control electronics. To help the students to understand them better, it is necessary to carry out laboratory sessions with real electrical machines and control systems. The control requirements call for the algorithms to be implemented using high-capacity microprocessors so that they can be processed in short cycle times, thus improving the system's overall behavior. These microprocessors are usually Digital Signal Processors (DSP) because their architecture is designed to maximize the mathematical performance and data throughput.

Industrial systems like the development of control software use multiprocessor techniques of the master-slave type, where the processing board is plugged into a personal computer [1-5]. These systems have a very high processing capability, which makes it possible to use high-level programming languages with very short cycle times. Nevertheless, they do not reflect the limitations of a real control system, since they do not work with an industrial controller board; they tend not to be extremely costly and do not allow students to familiarize themselves with the electronics associated with the DSP, such as sensor interfaces, multiprocessor port configurations, signal generators, interrupters and outputs such as the position coder of the different tasks in the master program task, etc. [6].

Commercial development systems allow the hands-on experiments on the lab to focus on the drive control strategies, but the system presented here also lets the professor teach control electronics, including the programming of the DSP and its peripherals, which in a three modules task and exposes the student to the way in which these control systems are actually implemented in industry.

The main objectives of the work presented in this paper are as follows:

- The first is to develop a learning tool for laboratory sessions on the control of electric drives using a DSP originally designed for this type of industrial application. In this way, in contrast to other systems obtained to the top layer of the control system (i.e., the algorithm [1]), the students become familiar with the real problems of a control system, such as the limitations on computing time, cycle time, arithmetic precision, depending on data type chosen in floating-point configuration of control electronics, memory availability, etc. [6].
- The second objective is to facilitate the rating and debugging of the control algorithms when they have been implemented in the DSP. This is

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**Continuación de la línea de Proyectos de Innovación Educativa (2011/12):**  
*Sistemas extracción de la energía de las olas*



(Inaugurado en Motrico en 2011)