

## **NEW DSP BASED DEVELOPMENT PLATFORM FOR SOLAR INVERTERS AND WIND POWER GENERATION**

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### **ABSTRACT**

Power electronics plays a key role in electrical renewable energy generation in photovoltaics, fuel cells but also in wind energy. This paper presents a new educational tool designed for motor control that can be also used in wind energy and PV. The platform uses a DC motor to emulate the wind turbine and a permanent magnet synchronous generator, in the case of the wind energy, and a single phase converter connected to the grid for PV.

### **INTRODUCTION**

Renewable energy is the promising energy source to deal with Kyoto and other initiatives to reduce CO<sub>2</sub> emissions. But to integrate this pulsating and not predictable energy sources to today's grid is not an easy task.

Power electronics and digital control is the key enabling technology for the integration of renewables to the grid [1]. Therefore, including power electronics for renewable energy generation is a must in graduate studies, but also in post-graduate and life-long learning.

Digital signal processors have been used over the past 30 years in many areas as multimedia, digital communications, medical imaging and automatic control. Control of power converters is not an exception and there exist in the market a great number of DSP devices oriented for power electronics.

Learning by doing approach is nothing new in electrical engineering education and some practical skills are acquired with this method in higher education. The platform presented here can be used in learning by doing, without any risk for students.

The presented platform is focused on applying theoretical skills acquired during lectures in power electronics applied to renewable energy generation.

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It includes all the necessary hardware to use the TMS320F2812 DSP from Texas Instruments with a permanent magnet synchronous generator (PMSG), a DC motor and a grid connected inverter.

This platform was originally designed for motor control applications [2], showing good results in the teaching process, but with this new approach, flexibility of the platform can be increased. This and new usages can be easily developed.

### WIND ENERGY GENERATION

The platform used in wind generation can be seen in Figure 1. The platform is composed of two electronic boards and two motors. An inductor is used to filter the DC current. The top board includes the DSP and all the necessary hardware for it, and the bottom board includes the power converter and the sensing hardware.

The left motor is the DC motor and at right, the PMSG can be seen. The DC motor and the PMSG are controlled with the same DSP.

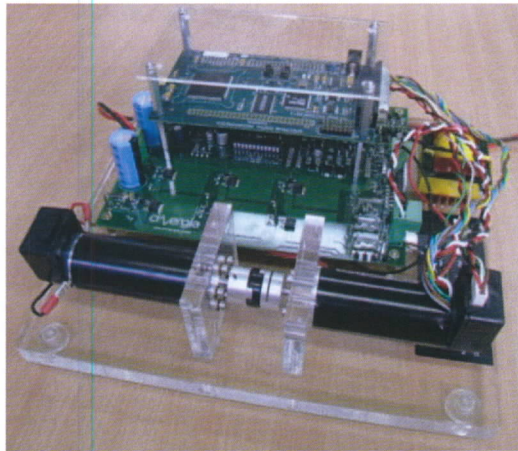


Figure 1. Picture of the platform used in wind generation

The DC motor is used to emulate the mechanical behaviour of a wind turbine. The power generated in a wind turbine can be computed as [3]

$$P_t = c_p P_{wind} = c_p \frac{1}{2} \rho \cdot A \cdot v_{wind}^3$$

where  $c_p$  is a constant that depends on the turbine,  $\rho$  is the air density,  $A$  is the front area of the turbine and  $v_{wind}$  is the wind speed. Fixing all the

parameters for a given wind turbine, the power can be computed for any wind speed, that will be the input of the system. Real series of wind data can be used for emulation.

This wind power is applied in turbine shaft as a torque, so the DC motor has to implement a torque loop. The torque produced in a DC motor is proportional to motor current. To perform the emulation of the wind turbine, the control scheme of is implemented in the DSP.

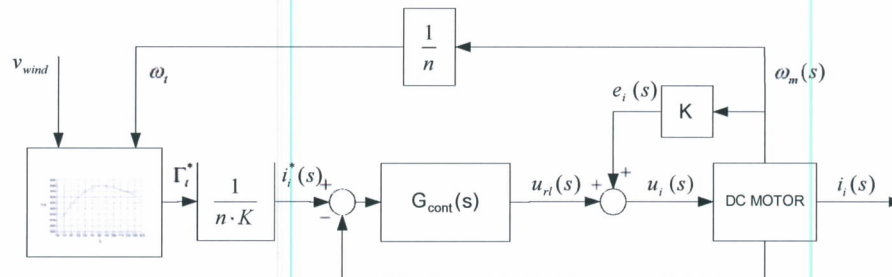


Figure 2. Control scheme for DC motor current control to perform the wind turbine emulation

The wind turbine emulation is implemented as a library function, which the student will use as a part of the platform, but the objective of the student is to program the control of the PMSG.

Using this platform, students can deal with practical issues of vector control of PMSG. The proposed exercises begin with the basic knowledge of DSP and practical implementation of real algorithms. Students are supposed to have some knowledge on C programming, electronics and control. Also knowledge on vector control of AC machines are supposed.

As in DC motor, in a PMSG the torque is proportional to current. Vector current control of PMSG is a topic explained in motor control courses. And using this control technique, the maximum power from rotor shaft can be extracted.

## PV GENERATION

PV inverters obtain the energy from solar panels. These panels transform the light from the sun to electricity, but this electrical energy must be transformed to be injected to the grid.

To transform this energy, PV inverters are used. But, these inverters must fulfil some requirements. The injected power must be AC power, instead of

DC power coming from solar panels. The injected current to the grid must be in phase (power factor of one), and it is obviously desirable that the maximum power is extracted from solar panels (Maximum Power Point Tracking, MPPT)

PV inverters have also some safety issues because they are connected to the public grid. In case of disconnection of the grid, the PV inverter must cease to energize the grid. If not, that can cause damage to other equipment or to maintenance personnel. This is known as anti-islanding mechanism.

All these requirements must be fulfilled by the inverter. As seen, PV inverters are complex systems and teaching must be done in an electrical engineering degree.

Figure 3 shows a block diagram of the control structure of the PV inverter.

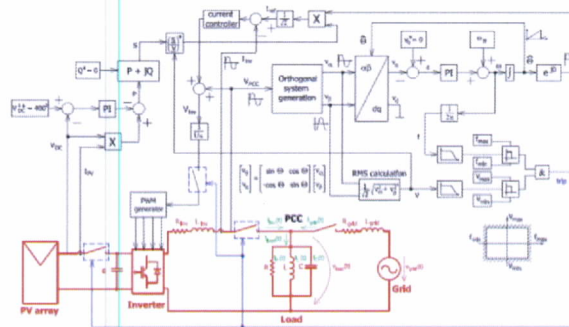


Figure 3. Block diagram of the inverter control structure, including current control and anti-islanding

The proposed platform uses the same control and power electronics hardware and control as the platform for wind energy and motor control presented in previous section, but in this case, new hardware must be added in order to inject the energy from solar panels to the grid. As shown in Figure 3 and Figure 4 an output inductor must be added in order to connect the solar panels to the grid. Also new measurement must be implemented externally in order to measure the grid voltage when the inverter is disconnected, and also, a relay must be also added to disconnect the inverter. A step-down transformer is used to match grid voltage level to the low voltage (24 V) used in the platform. This low voltage level is essential to assure security for students and the low cost of the platform.

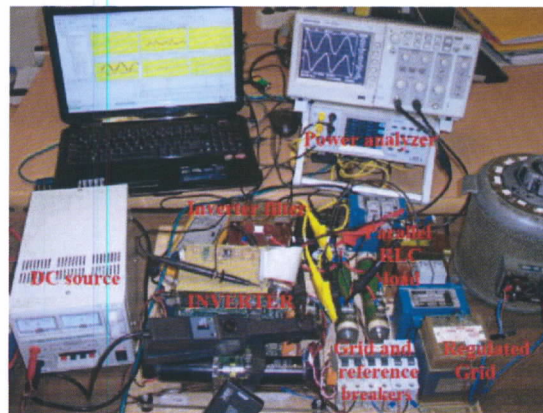


Figure 4. Photography of the proposed platform for PV systems

All the requirements for a PV inverter can be implemented in the presented platform. Also the platform can be used as a test bench for new control methods.

## CONCLUSION

Two new platforms for renewables are presented in this paper. These two new platforms are based on existing DSP control platform designed originally for motor control. The reuse of this platform without or with minimum new hardware is an attractive solution for labs in power electronics and motor control.

The platform on motor control has demonstrated for years to be useful when learning practical implementation of DSP motor control solution. These new platforms are expected to be useful in new applications of power converters in renewables.

This platform has shown flexibility, and with no or minor hardware changes, new applications and educational platforms can be developed. That can helps in the learning process, because the students can learn different topics with the same programming environment and hardware.

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