Design of a Monitoring and Test system for PV Based Renewable Energy Systems

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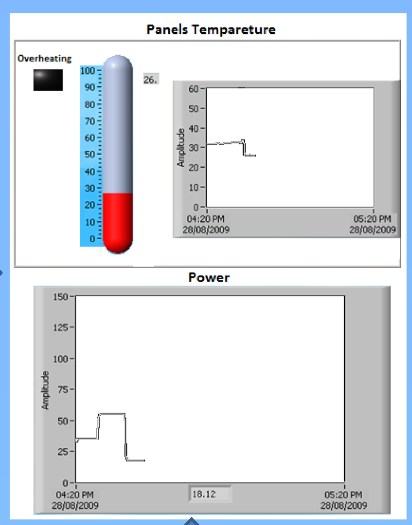
INTRODUCTION

To optimize the energy production and usage, of Renewable Energy Systems (RES), it is essential that an effective monitoring and control strategy is employed. In order to develop new control algorithms the designer needs to evaluate the RES parameters and at the same time simulate real test condition load profiles. The system developed so far is composed of a monitoring tool that measures and displays, in real-time, the parameters of Photovoltaic (PV) solar panels, and of an electronic load that can simulate load profiles such as the averaged domestic or stepped power consumption.

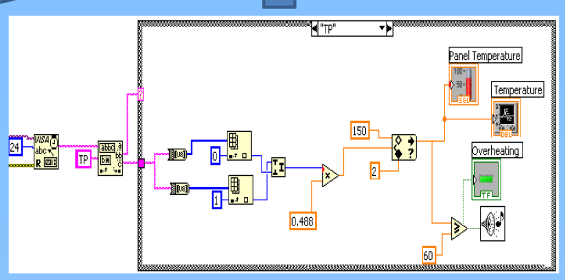
SYSTEM DESCRIPTION

The developed system is composed of three modules; firstly the acquisition module, which is physically connected to the RES under test, through a series of sensors. Once the different sensor signals are digitalized and processed the data is then sent to the PC interface module, in order to be displayed, on a PC, using a LabVIEW graphical user interface. The PC interface module is also fitted with a LCD to allow remote monitoring and data access when the PC is off. The data transition between the two modules is undertaken using IEEE 802.15.4-2003 standard ZigBee devices. Finally, the electronic load is controlled and powered by the acquisition module.

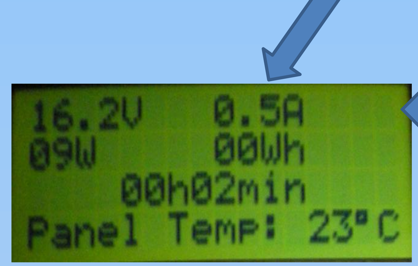
LabVIEW graphic interface



Displays measured parameters on a remote location

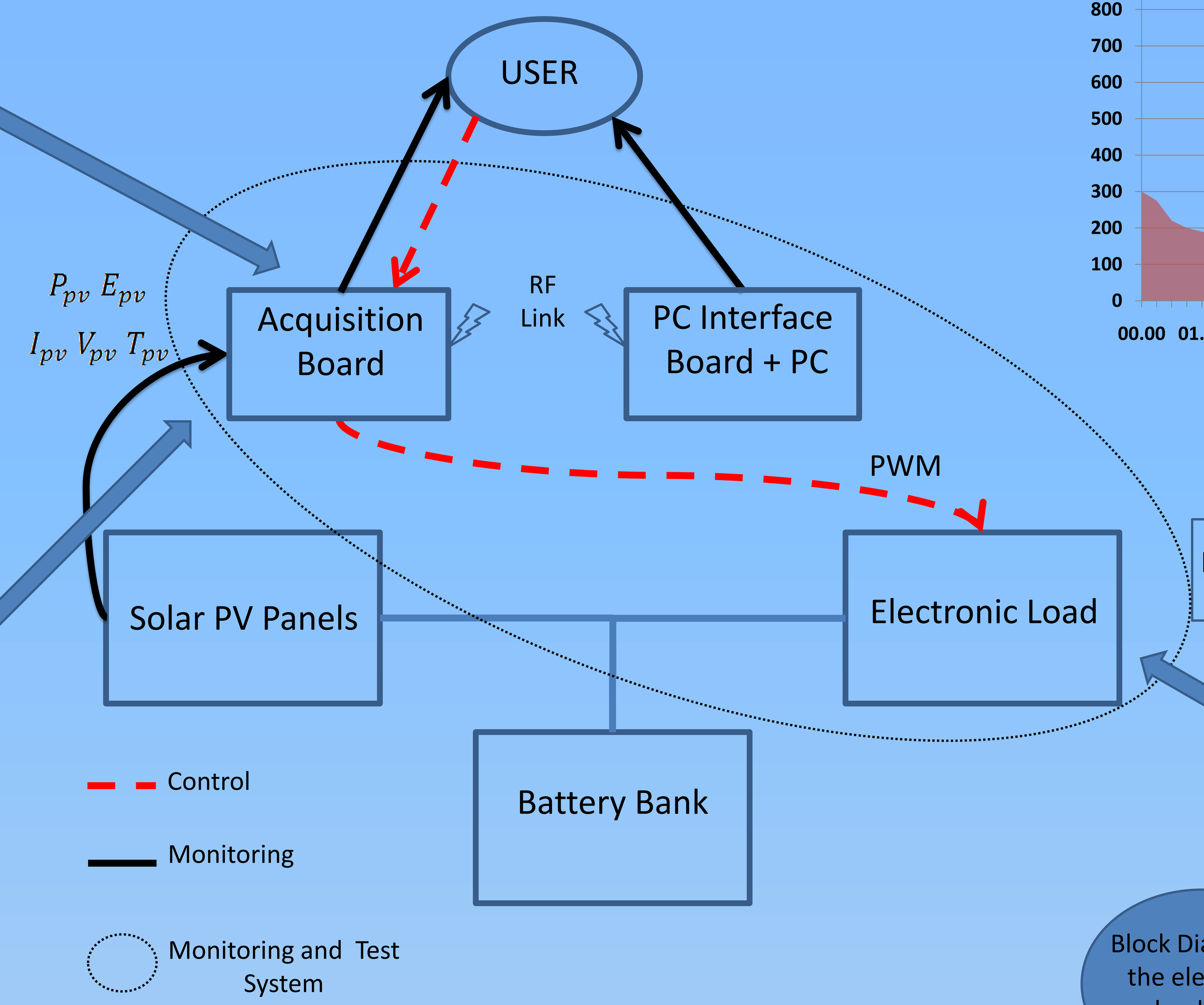


On-site Display: Voltage, Current, Power, Energy, Running Time and Panel Temperature

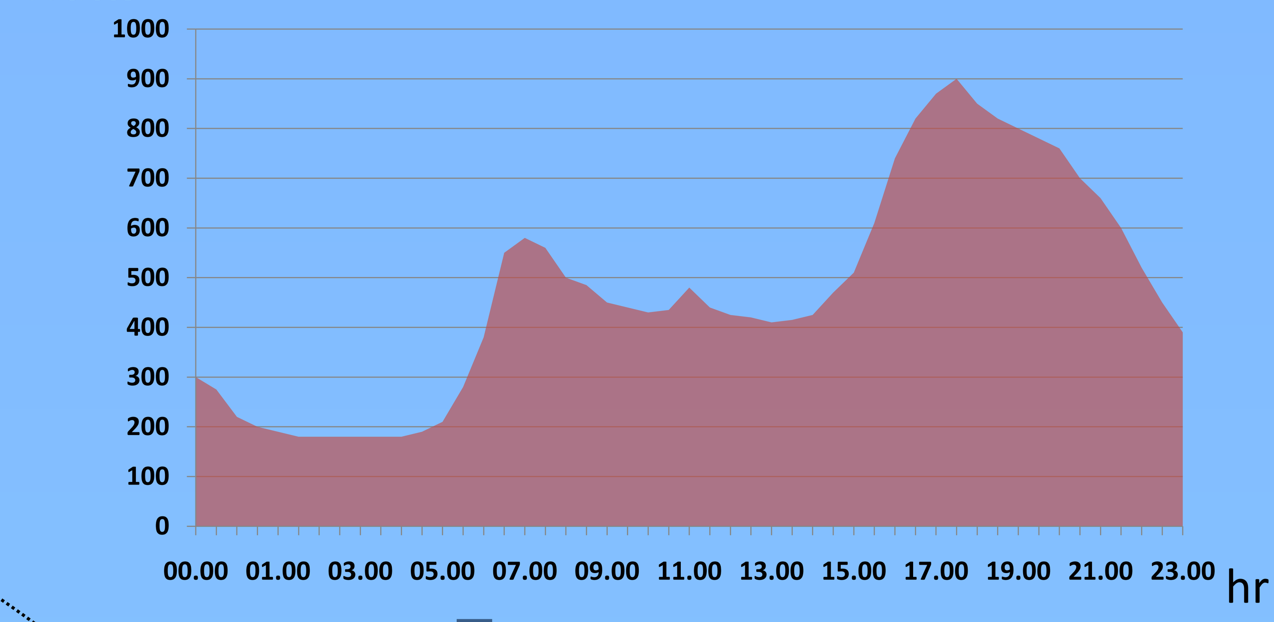


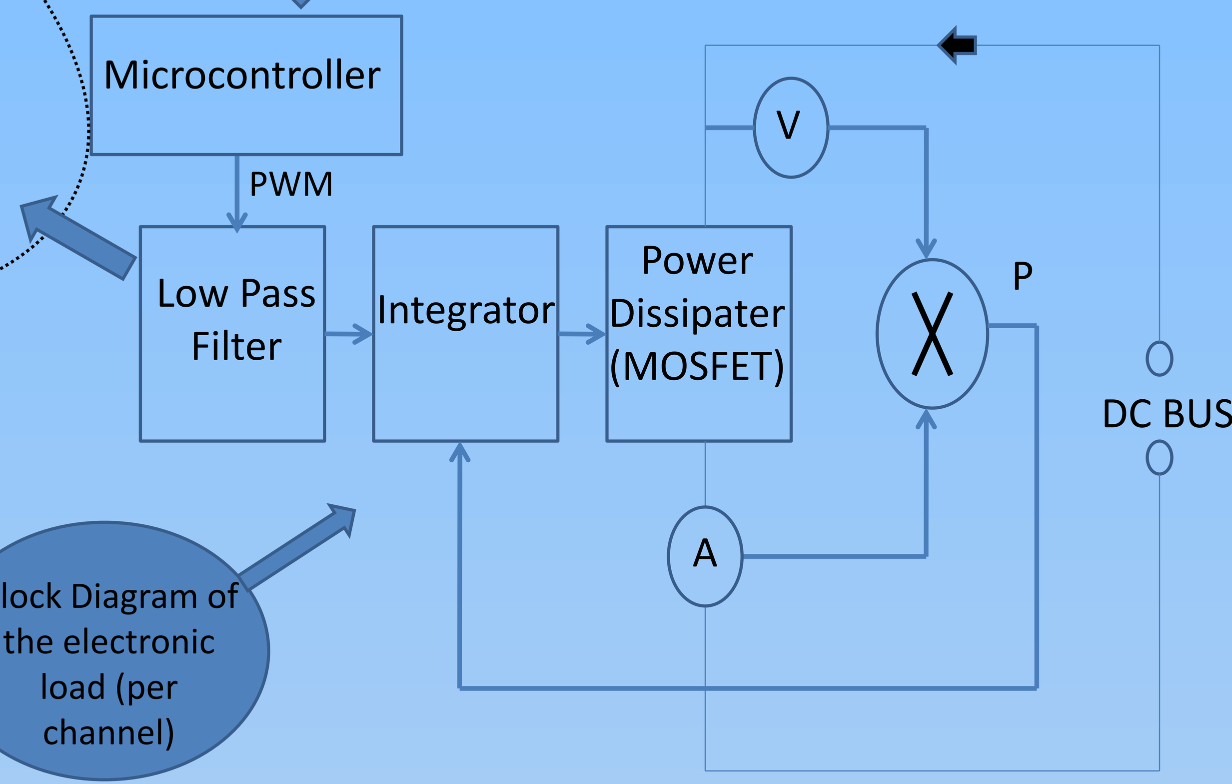
On-Site LCD Display

System Block Diagram



Typical Averaged Winter Domestic Load Profile





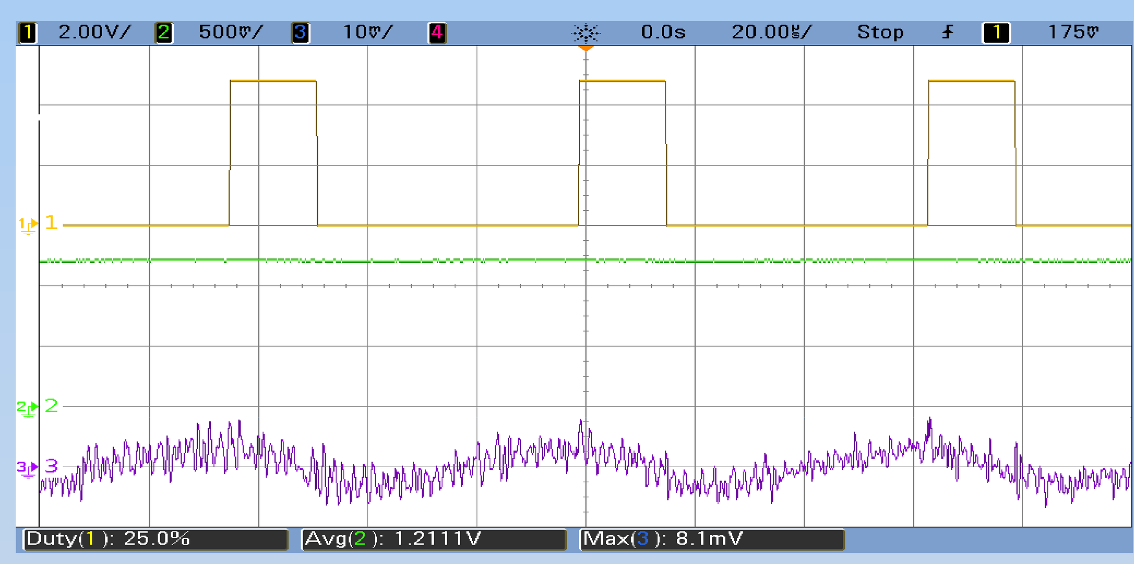
Block Diagram of the electronic load (per channel)

Results

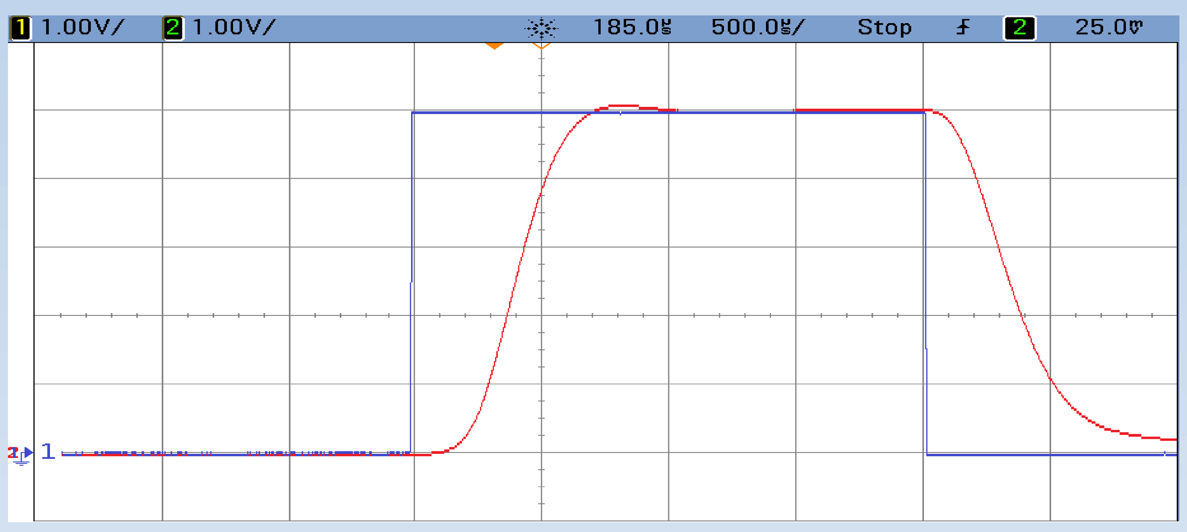
The electronic load was connected to a PSU in order to be tested in the laboratory. The control signal of the acquisition module was set to give a 0 - 100% duty cycle to yield a 0 – 50W step for the power dissipated by the electronic load. The Figure bellow shows the measurements taken during this test. The control signal is displayed in blue and in red is the power dissipated by the electronic load.

-The load response time is approximately 1ms.

-After 1ms the power is stabilised and is equal to the value set by the control signal.



Ripple for a 25% Duty Cycle (12.5W) Represented in Purple. In Yellow is the PWM signal, in Green the Output of the Low-Pass filter.



Load Response Time for 0-50W In Blue the Control Signal, In red the Dissipated Power. 1V = 10W.

The power ripple of the load is represented in the figure above. Displayed in Purple is the dissipated power with AC coupling to allow an easy display of the ripple. The main ripple frequency is approximately 15.5 kHz which is the frequency of the PWM signal. The maximum measured ripple for a 25% duty cycle is 80mW which is ±6% error. This value is acceptable for RES testing.

The monitoring system was successfully tested, all the parameters are accurate. Pictures of the LabView interface as well as the LCD of the acquisition board are shown on the left hand side of the system block diagram.

Conclusion and Further Work

The results demonstrate that the designed system is able to monitor the current, voltage and temperature of PV panels as well as calculate the output power and energy production. These functionalities make the system a valuable tool to ascertain the system efficiency . The electronic load was successfully tested and the performances assessed. The Load has already been improved with dissipation capability of 1.6 kW and new load profiles will be implemented. A picture of the improved circuit is shown on the right hand side.
In the future, new sensors will be added to monitor:

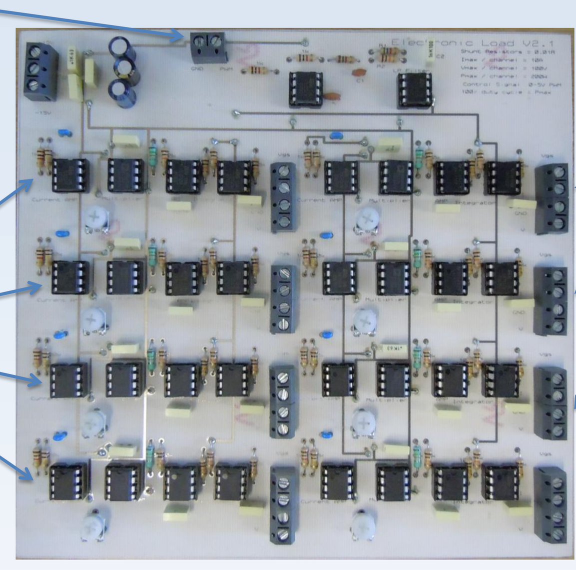
-Fuel cell (temperature, hydrogen pressure…)

-Weather conditions (ambient temperature and irradiance)

The system will then be used to develop new control strategies for hybrid RES.

PWM Input

8 Channels dissipating up to 200W each



Connectors for the MOSFETs, current shunt resistor and voltage measurement

Picture of the improved electronic load control circuitry capable of dissipating 1.6kW

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