

MICROGRID TEST BED USING BACK TO BACK CONVERTERS

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Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research



**DERlab – PhD and researchers seminar on
“Distributed Generation and Renewable Energy Sources”**

National Technical University of Athens, Greece, 3rd – 4th November 2009

PRESENTATION OUTLINE

1. Context

1.1 Entities involved

1.2 The project

2. Microgrid overview

2.1 System description

2.2 Electrical design

2.3 Control Architecture

2.4 Communications

3. Power system

3.1 Hardware specifications

3.2 Software specifications



1. Context





Institut de Recerca en Energia de Catalunya
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The Institute's **reference** technological line of action:

Energy Efficiency and Conservation

Technological lines of action **complementary** to the reference line:

**Electricity
Grids**

**CO2
capture &
storage CCS**

Biofuels

**Off-shore
Wind Energy**

With the following **transversal** activities:

Power Electronics Laboratory

Advanced Materials for Energy Applications

Socio-technical Research



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ELECTRICAL ENGINEERING AREA

- Renewable energy: wind and photovoltaic
- Distributed generation
- Microgrids and microgeneration
- Energy storage systems
- Energy management
- Energy industry markets and regulation
- Demand management
- Electricity generation, transport and distribution
- Supply quality
- Energy management in buildings
- Electromagnetic compatibility
- Intelligent control gear and equipment
- Energy intensive industrial processes
- Static converters
- Superconductivity
- Rail transport
- Electric cars

SMART CITY

AIM

To develop a model of the new generation of power distribution grids whereby customers and electricity companies work together to increase the use of renewable energy sources by matching generation to consumption and by promoting a more efficient consumption management model.

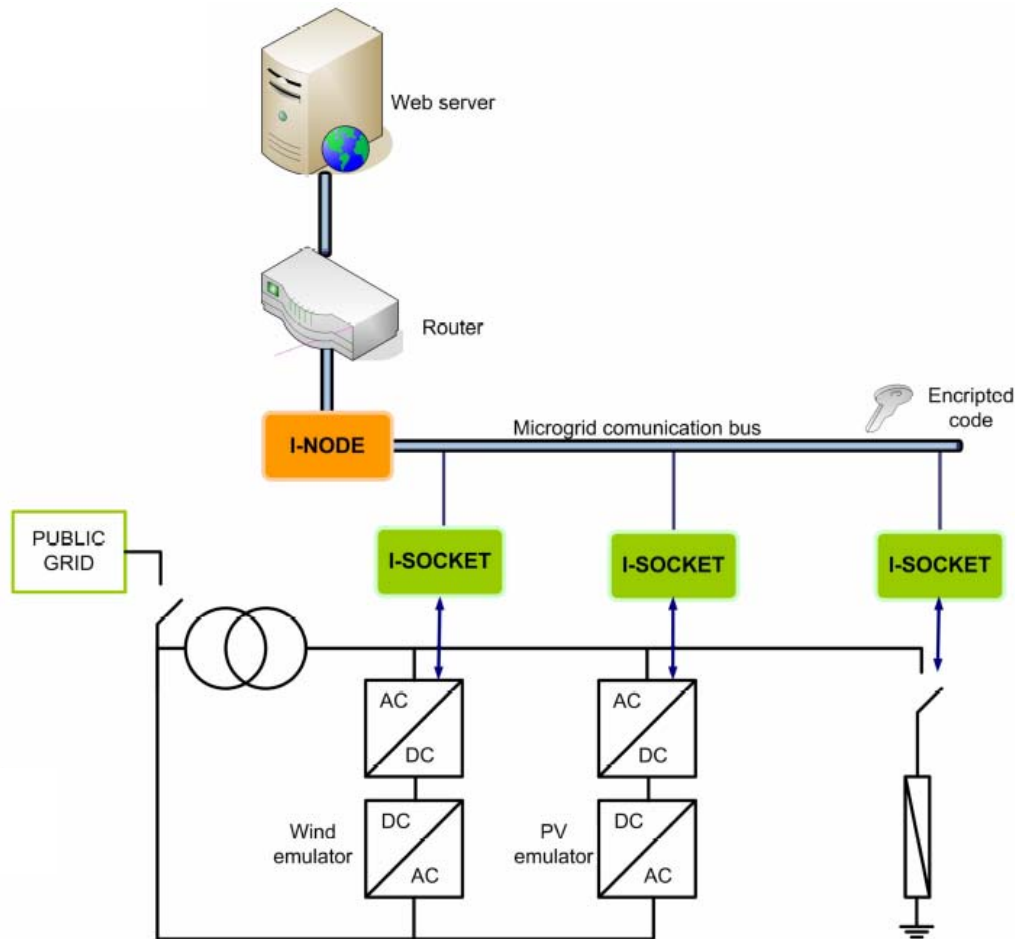


2. Microgrid overview



MICROGRID OVERVIEW

SYSTEM DESCRIPTION



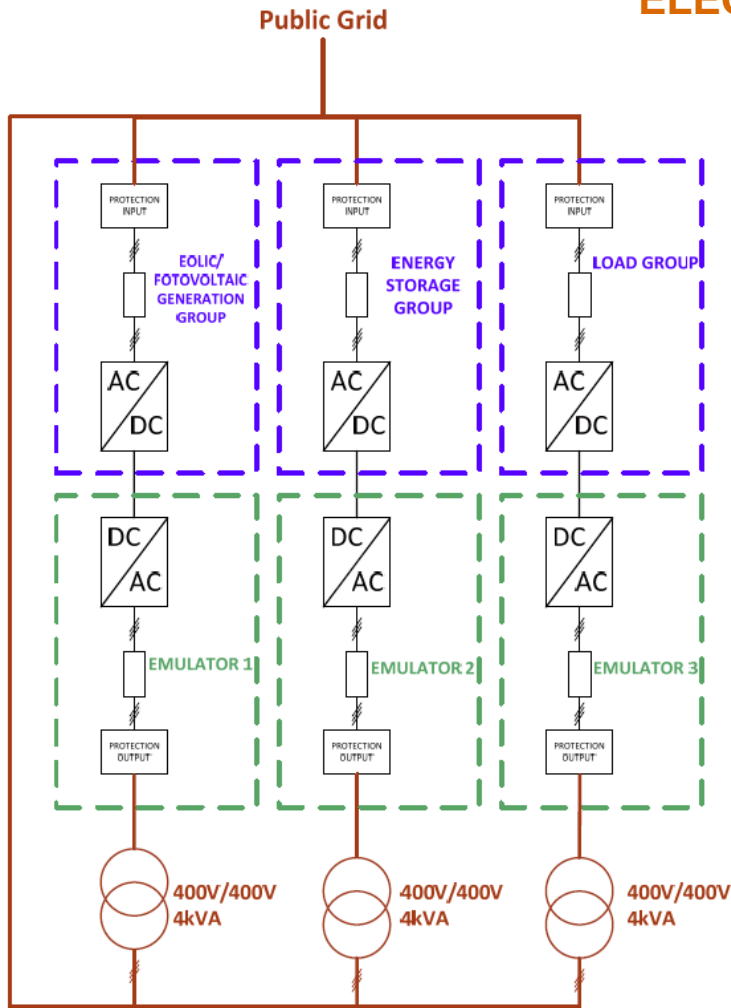
Composition:

- **Remote Monitoring System and control system**
- **Power system:**
 1. **Production Unit:** Renewable energy. PV panel or wind turbine.
 2. **Storage system:** Battery bank.
 3. **Consumption Unit:** Controllable load.



MICROGRID OVERVIEW

ELECTRICAL DESIGN



➤ **Each VSC (Voltage Source Converter) is composed of:**

- 1 Converter
- Sensors
- Protective devices

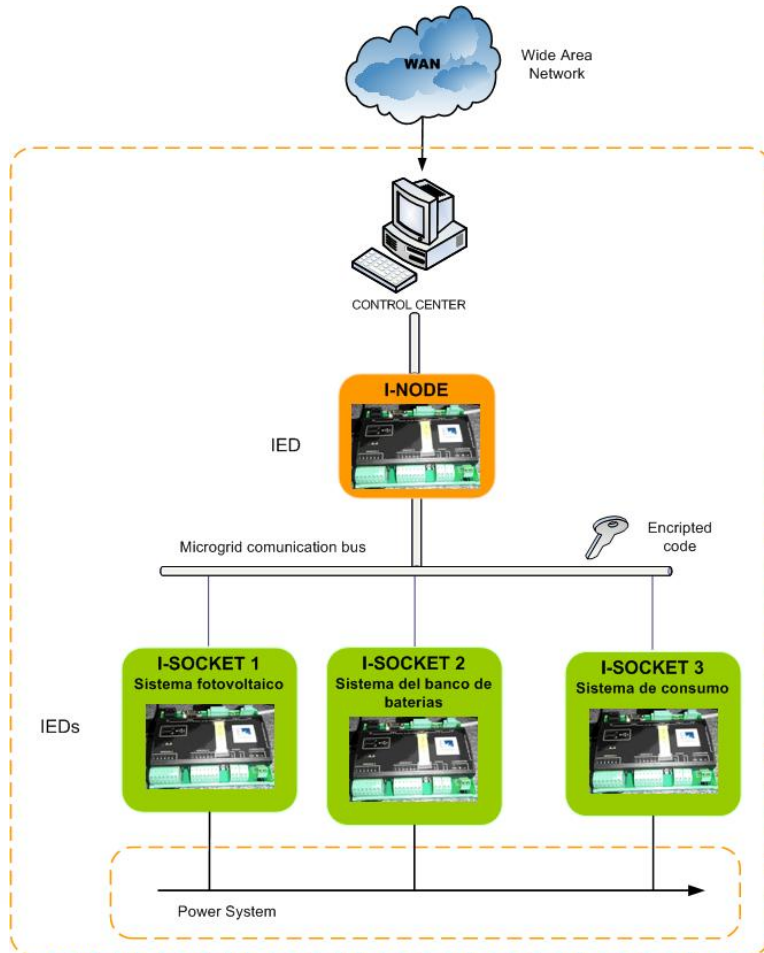
➤ **Converters (3 converters and 3 emulators)**

- Same hardware
- Different software
- Different connection to the network:
 - Through an inductance (converters)
 - Using a transformer (emulators).



MICROGRID OVERVIEW

CONTROL ARCHITECTURE



➤ Basic elements of control:

- **iNode:** global management of microgrid tasks
- **iSockets:** one source operation (generation, storage or loading)

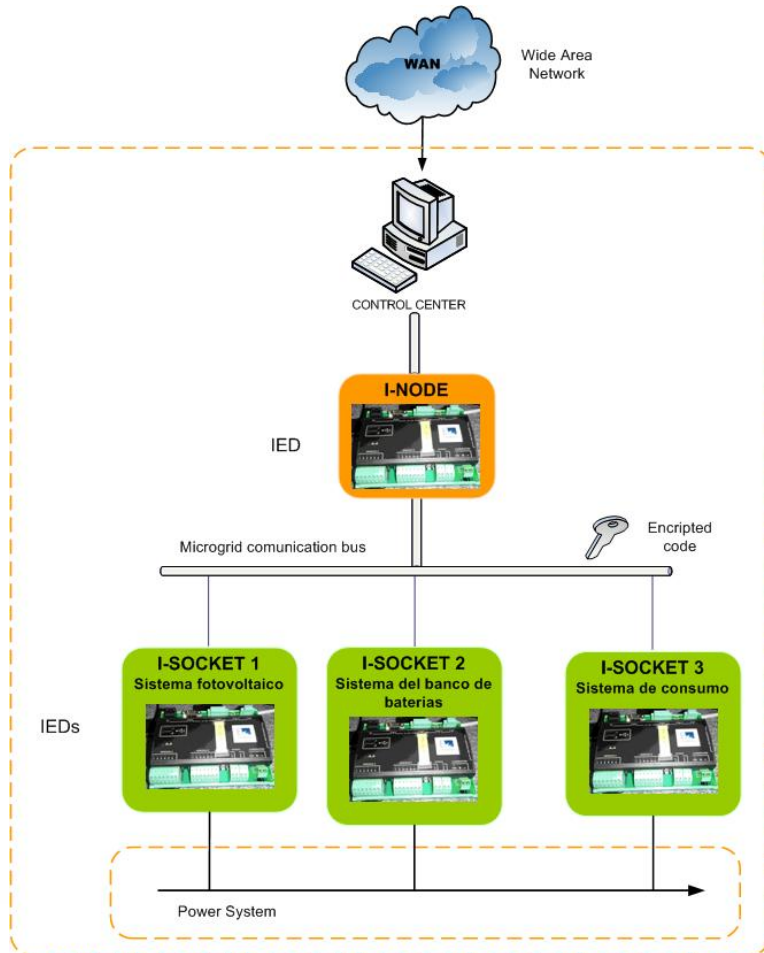
➤ Elements specifications:

- **Regulation:** generation and consumption.
- **Pricing:** energy measurements and real-time pricing.
- **Maintenance**
- **Monitoring**
- **Security**



MICROGRID OVERVIEW

CONTROL ARCHITECTURE



➤ Control structures:

Various structures using centralized and distributed control

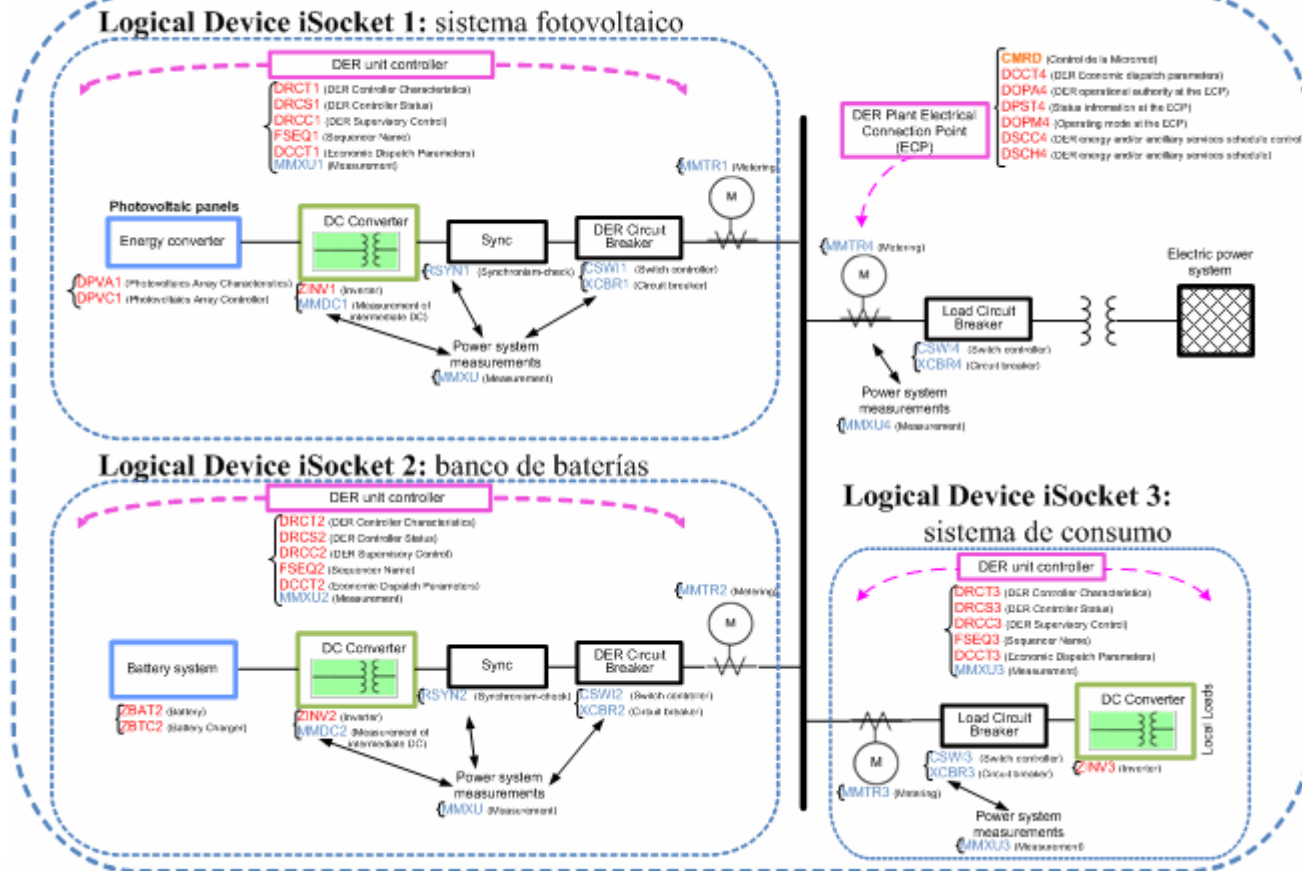
- **Centralized control**, P_{total} Q_{total} tracking
- **Autonomous centralized control** (uses a energy price reference value)
- **Distributed Control**, specific PQ for each iSocket
- **Autonomous Distributed Control** specific energy prices and electrical measurements for each iSocket, the iNode forwards this information and iSockets manage themselves..
- **Fault control**



MICROGRID OVERVIEW

COMMUNICATION SPECIFICATION

Logical Device iNode



IEC 61850 Standards



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3. Power system



Power system



Membre de:



CITCEA-UPC is a technological research and development centre born in 2001 inside the Technical University of Catalonia (UPC) with the support from CIDEM of the Government of Catalonia.

The group mainly works in two areas:

- Mechatronics
- Enertronics

Our objective is to generate knowledge in the above areas and to transfer it to the industry by developing equipments, by training high qualified personnel and by offering a wide range of education and training activities in the above areas.



Power system

CINERGIA is a technology-based company spin-off of CITCEA-UPC. Our objective is to promote the use of digital control and power electronics for conversion of electrical energy, energy efficiency and energy saving by:

- Developing tailored equipments and solutions in collaboration with R+D centres, specially, CITCEA-UPC
- Offering products for Industry, R+D labs, Education and Training
- Offering engineering services for mechatronic and electronic applications:
 - Industrialization, commissioning, technical assistance
 - Industrial automation and communications
 - Energy efficiency and saving



Power system

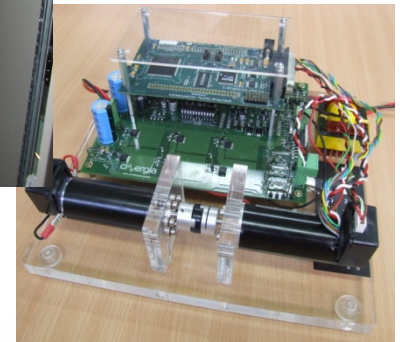
Some examples of this collaboration between CITCEA-UPC and CiNERGIA in previous projects are:



Battery charger for electric trucks (700V/20A)



200kW plasma torch power supply



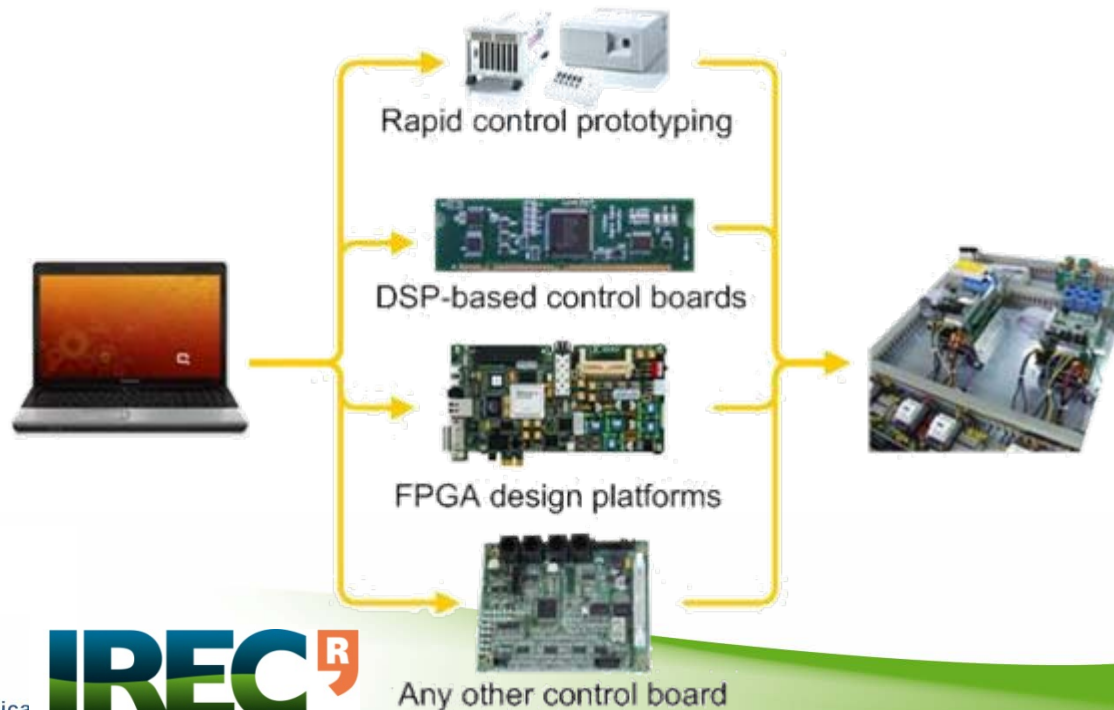
DSP-based motor control educational and training platform



Power system

Converter design and implementation:

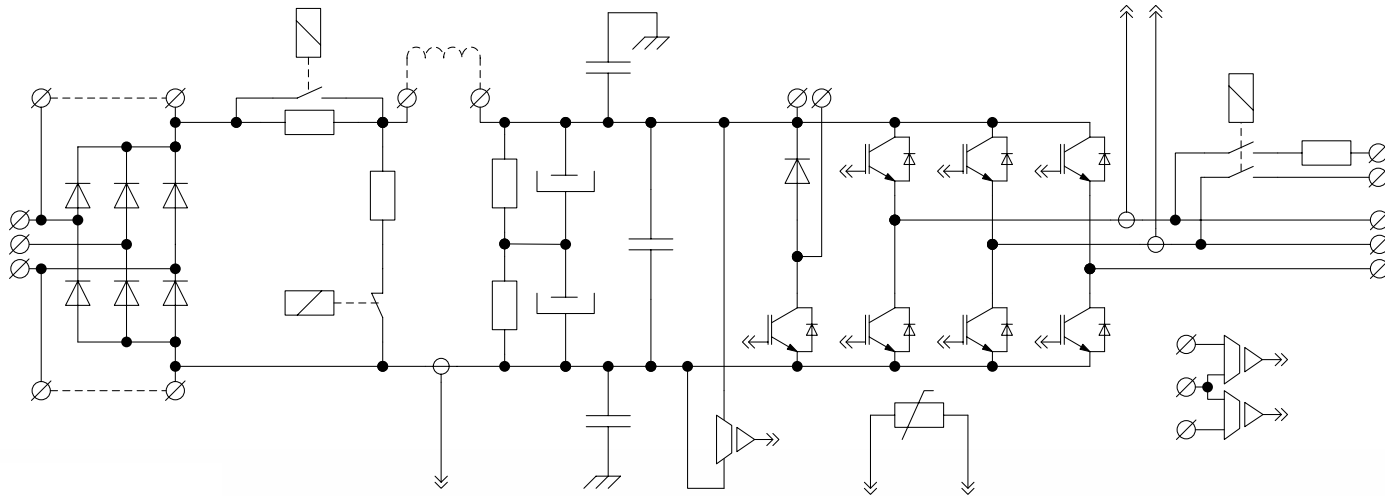
- **This hardware was designed with the aim of create a safe structure to implement new control algorithms. It is self-protected against overcurrent, overvoltage and overheating failures.**
- **Between other electrical characteristics, it was designed for 10kVA applications, up to 800V in the DC link and 25A peak on each phase.**
- **It is designed to be used with any control board, including dSpace platforms, DSP or FPGA based control boards, etc.**



Power system

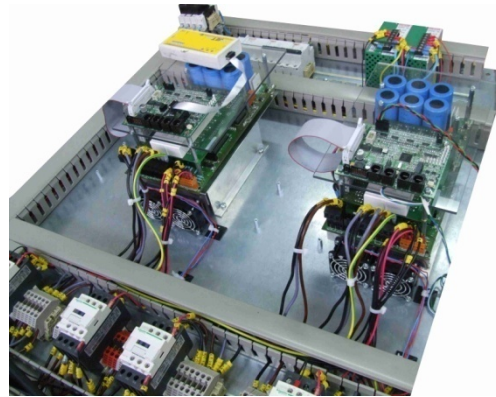
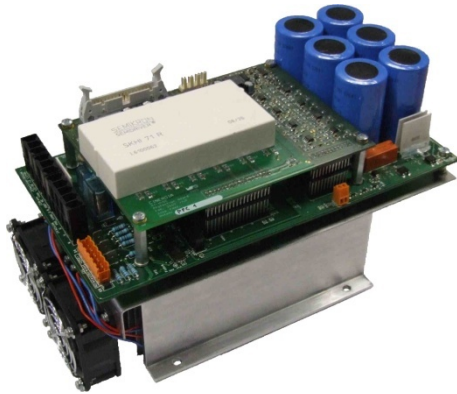
More about the converter, special features:

- It is a 3 phase inverter based in one IGBTs module with an optional diodes rectifier.
- It has 3 current and 3 voltage transducers (2 in phases and 1 in the DC link).
- In order to improve the functionality of the converter the precharge can be made from de DC link or from the AC side, depending on the application where used.



Power system

Some images of the platform implemented:



Power system

Overview of software implemented:

The control of the converter is made using a DSP from Texas Instruments. One of the converter acts like a bidirectional boost-rectifier, rectifying and rising the voltage of the DC link; and the other one transfers power to the grid according to the set point given by an external user.



THANKS FOR YOUR ATTENTION

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