

Rol de la Electrónica de Potencia en las Energías Renovables y la Calidad de Red

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1er Seminario de Sistemas de Potencia y Energía (SISPOE)



RAMA ESTUDIANTIL
UNA



Laboratory of Power and
Control Systems

San Lorenzo – Paraguay
December 15th, 2017



UNIVERSIDAD NACIONAL DE ASUNCIÓN
FACULTAD DE INGENIERÍA

Content Index

1. Introduction
2. Power Electronic applications
 - Electric drives
 - Power quality
3. Laboratory of Power and Control Systems

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PARAGUAY IN FIGURES

General Info about Paraguay

Formal Name: Republic of Paraguay - República del Paraguay (Spanish) - Tetã Paraguái (Guarani)

Short Name: Paraguay

Capital: Asuncion

Major Cities: Asuncion, San Lorenzo, Ciudad del Este

Geography: landlocked; lies among Argentina, Bolivia, and Brazil; population concentrated in southern part of country



People

Population: 6.672.631 (2012)

Total Area: 406,752 km²

Official Language: Spanish, Guaraní

Ethnic Groups: mestizo (mixed Spanish and Amerindian) 95%, other 5%

Religion: Roman Catholic 89.6%, Protestant 6.2%, other Christian 1.1%, other or unspecified 1.9%, none 1.1% (2002)



Government

Government Type: constitutional republic

President: Horacio Cartes (2013-2018)

Legal System: Civil law system with influences from Argentine, Spanish, Roman, and French civil law models; judicial review of legislative acts in Supreme Court of Justice

Economy

GDP (purchasing power parity): \$41.1 billion (2012 est.)

GDP - PER CAPITA (PPP): \$6,100 (2012 est.)

1 US\$ = 4500 Gs.

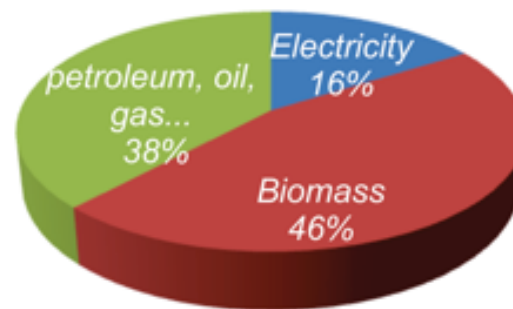
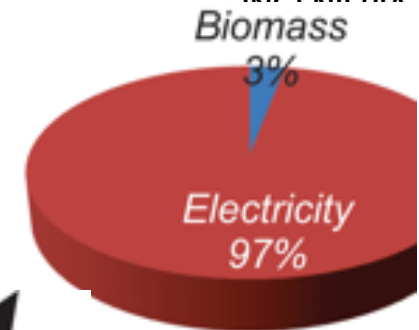
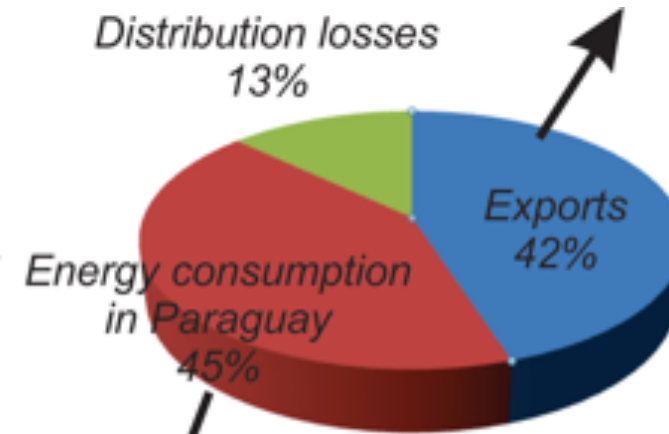
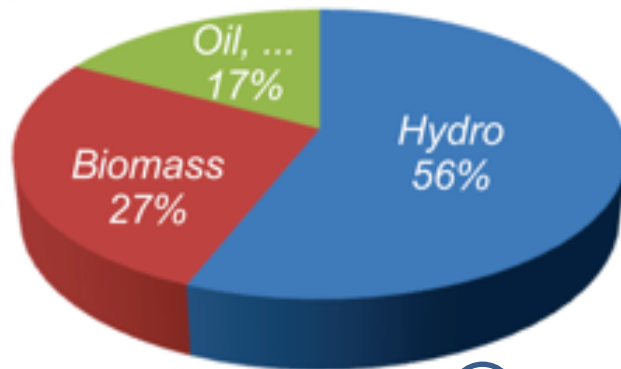
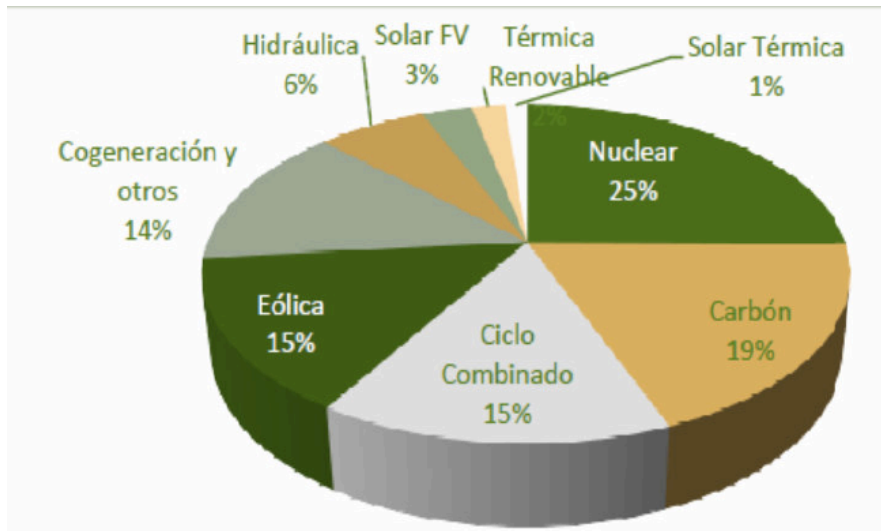
Unemployment rate: 6.6%

Imports: road vehicles, consumer goods, tobacco, petroleum products, electrical machinery, tractors, chemicals, vehicle parts

Exports: soybeans, cotton, meat, wood, leather, electricity



ENERGY MATRIX STRUCTURE IN PARAGUAY



Wind farms ✘

Solar plants ✘

Distributed generation ✘

Source: Vice Ministry of mines and energy
"National energy balance 2012"

ELECTRICITY GENERATION IN PARAGUAY



ANDE: 2.302 MW, que supera el anterior, de 18/10/2017.



...
17, registramos un nuevo
779 MW. Este suministro
ma Interconectado
.928 MW.
tica a nivel nacional y la
n para el Paraguay

...
anzó a las 21:00 horas del
l-Paraguay fue de 2.951

14,000 MW installed power
103.098.366 MWh (103 million MWh)



30-nov-2017

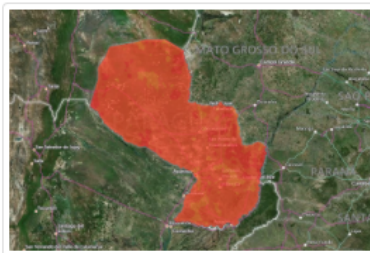
#Temporal Desde la Administración Nacional de Electricidad (ANDE) informaron que 60.000 usuarios amanecieron sin servicio de energía eléctrica en todo el país.

En total, 26 líneas quedaron fuera de servicio. De estas, 15 ya están de nuevo en funcionamiento, y las restantes serán restablecidas en el transcurso del día, informaron en Radio Monumental. Además, oyentes de la AM están reportando la falta de agua potable en sus viviendas.

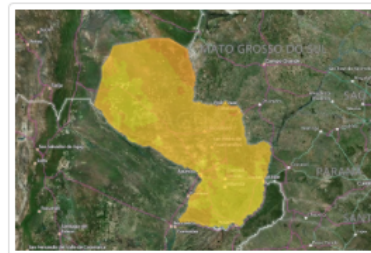
SOLAR & EOLIC ENERGY IN PARAGUAY

ITAIPU BINACIONAL PTI Parque Tecnológico Itaipu Inicio Mapas Recursos Ayuda Buscar Ingresar

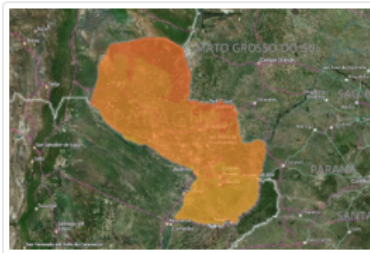
Mapa de Energía Solar



Energía Solar Estacional - Verano



Energía Solar Estacional - Otoño



Energía Solar Estacional - Invierno



Energía Solar Estacional - Primavera

Mapa de Energía Eólica



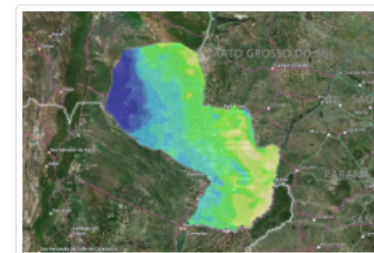
Energía Eólica Estacional a 80mts. - Verano



Energía Eólica Estacional a 80mts. - Otoño



Energía Eólica Estacional a 80mts. - Invierno



Energía Eólica Estacional a 80mts. - Primavera

Acerca de PESE PTI Parque Tecnológico Itaipu CITE PTI Parque Tecnológico Itaipu CIIG INTN Personal Español

Advantges in PV and/or Eolic?

RENEWABLES: PROS & CONT

Ventajas de la utilización de fuentes de energía renovables

- Contribuye a la mejora del medio ambiente.
- Evita las grandes emisiones de CO₂.
- Aumenta la independencia energética.
- Reduce el consumo de petróleo y otros tipos de combustibles no disponibles en nuestro país.
- Puede generarla cualquier persona u empresa.
- Producción de energía de forma descentralizada.



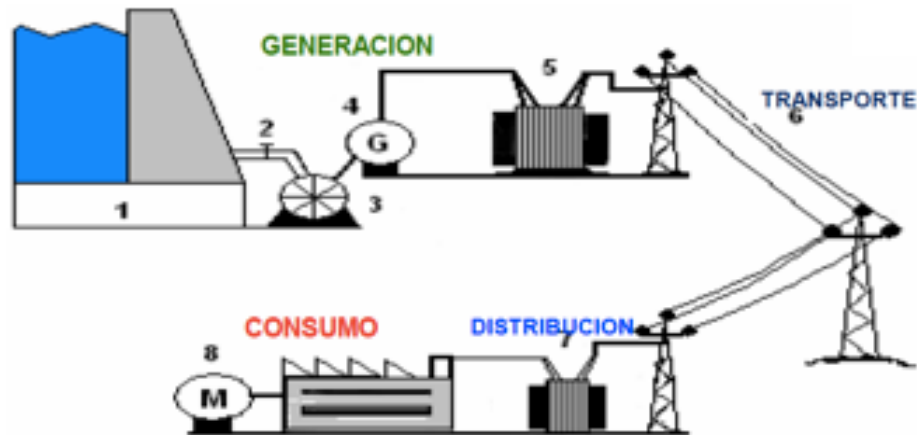
Problemática de las energías renovables:

La disponibilidad temporal de los recursos renovables no suele coincidir con las necesidades de consumo de la energía demandada por los usos residenciales e industriales. (*Necesidad de Sistemas Predecibles*).

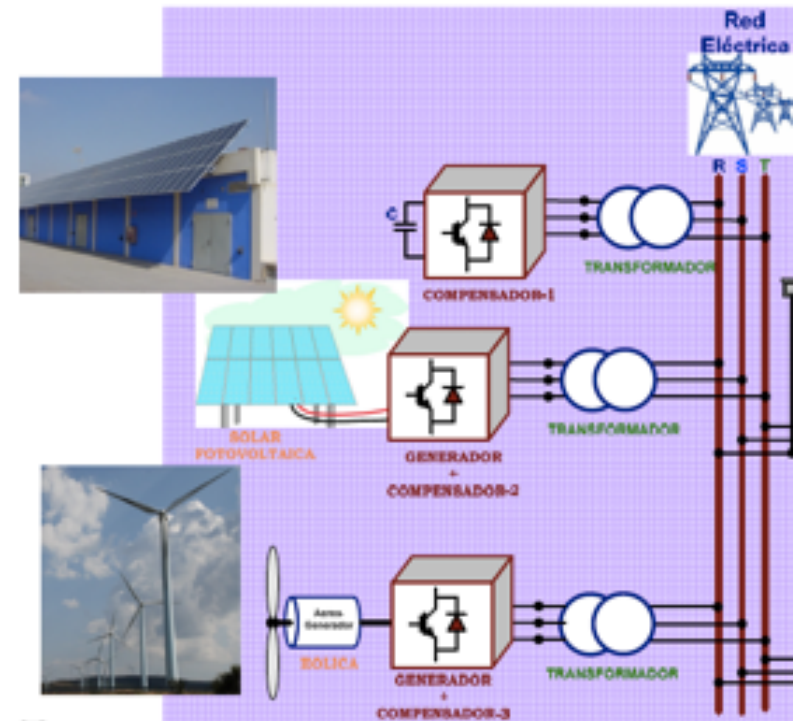
Solución: Almacenamiento de la energía (excedentes).

RENEWABLES & DISTRIBUTED GENERATION

Yesterday Centralized Power

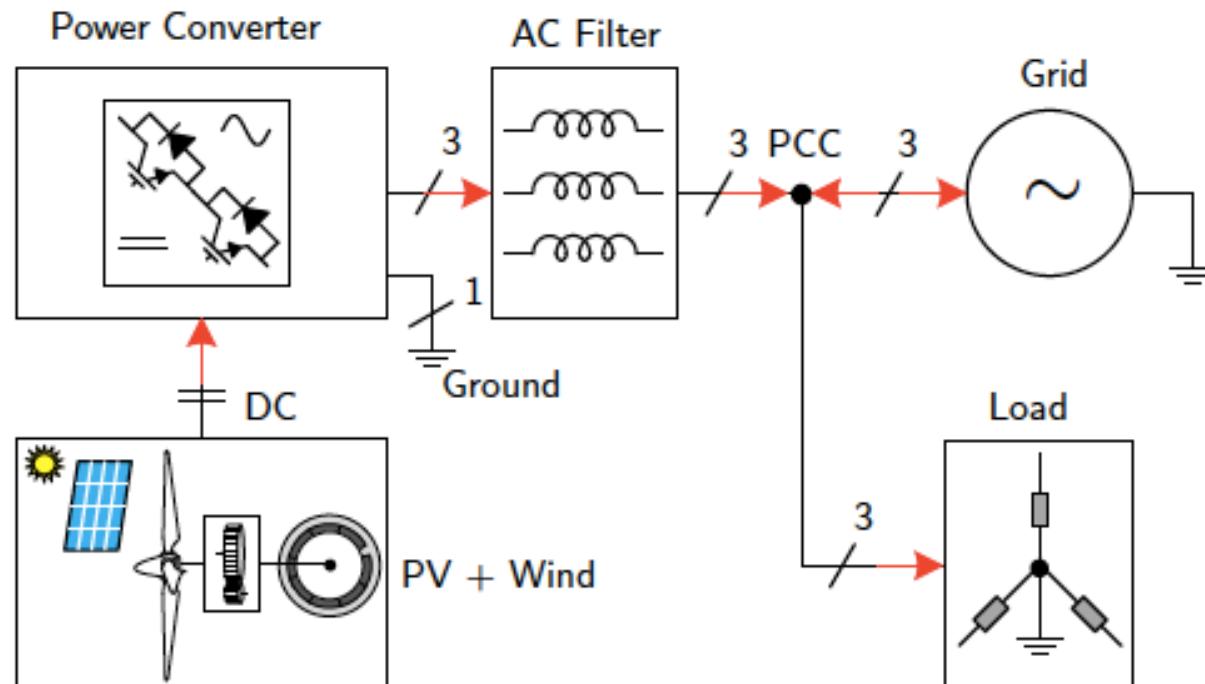


Tomorrow Clean, local power



Role of Power Electronics & Control in Renewables?

POWER ELECTRONICS IN RENEWABLES

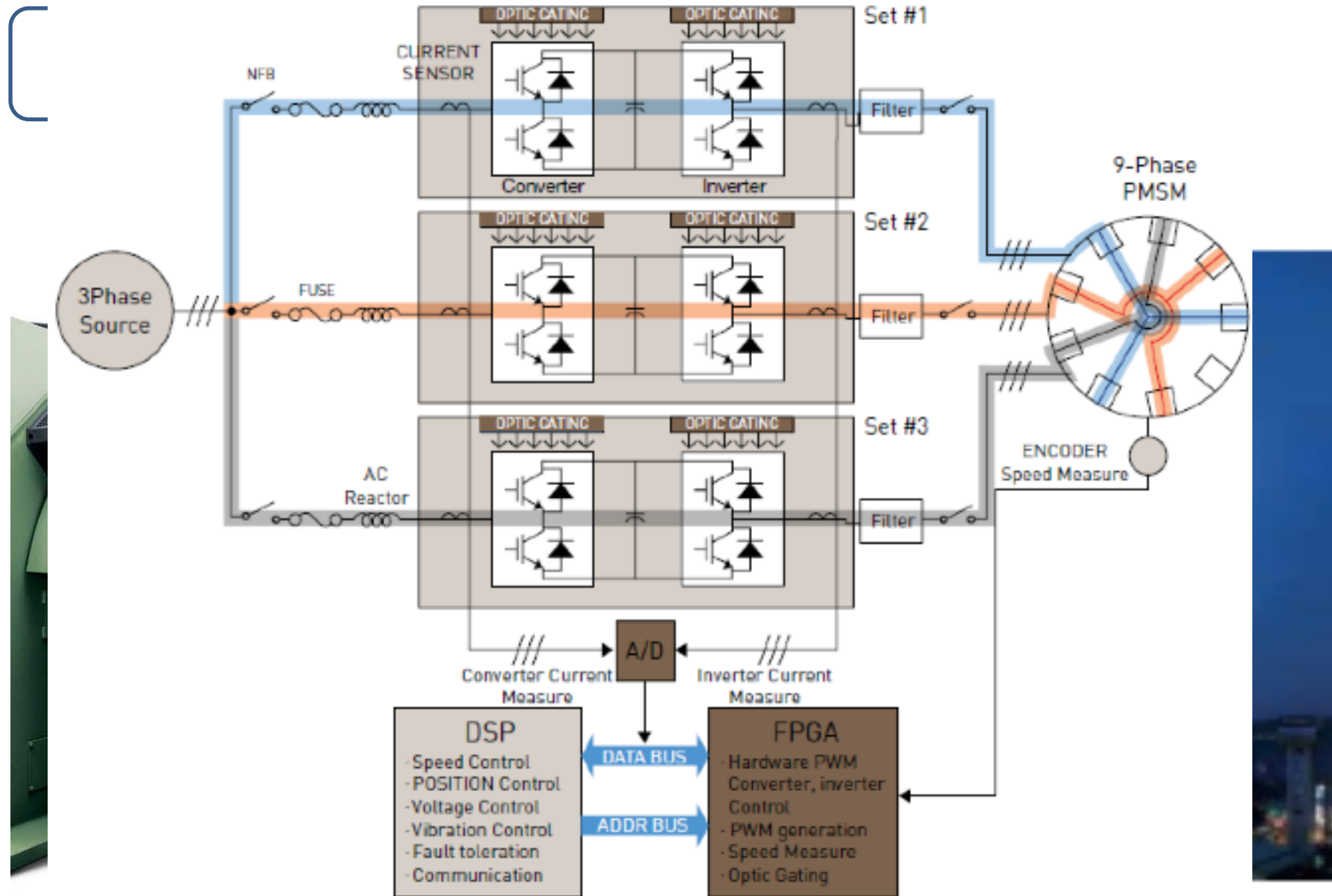


They play an important role for the management of electrical energy

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MULTIPHASE DRIVES: APPLICATIONS (1)

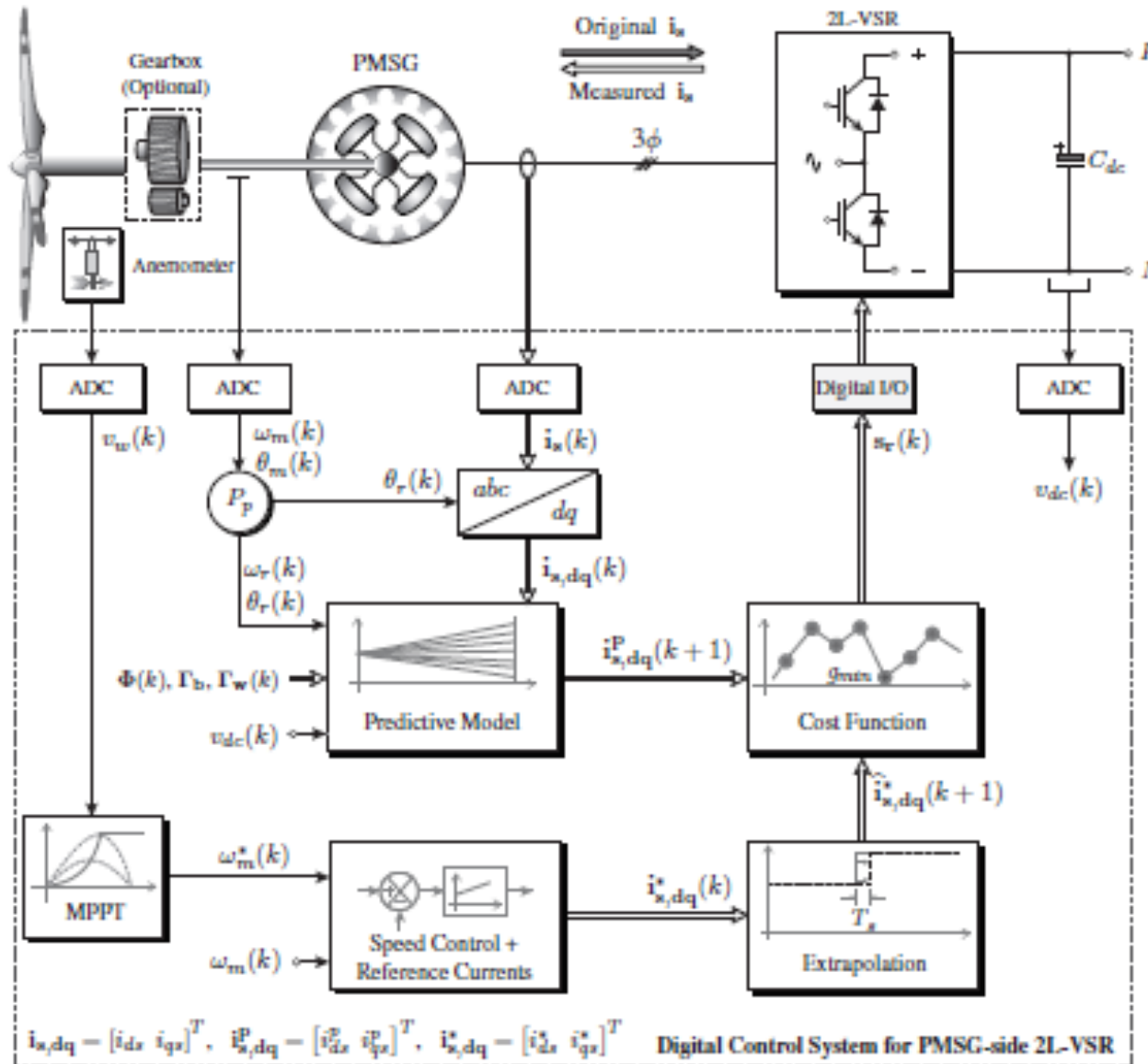
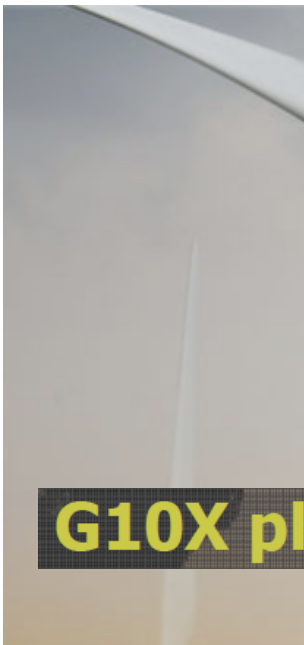


MULTIPHASE DRIVES: APPLICATIONS (1)

Industry

W

- 18-P
- 4.5 N



MULTIPHASE DRIVES: APPLICATIONS (2)

Industry Applications

Two propeller shafts (each with two Alstom **15-phase** electric motors (150 rpm), 80MW total power consumption, output – 95,000 SHP.



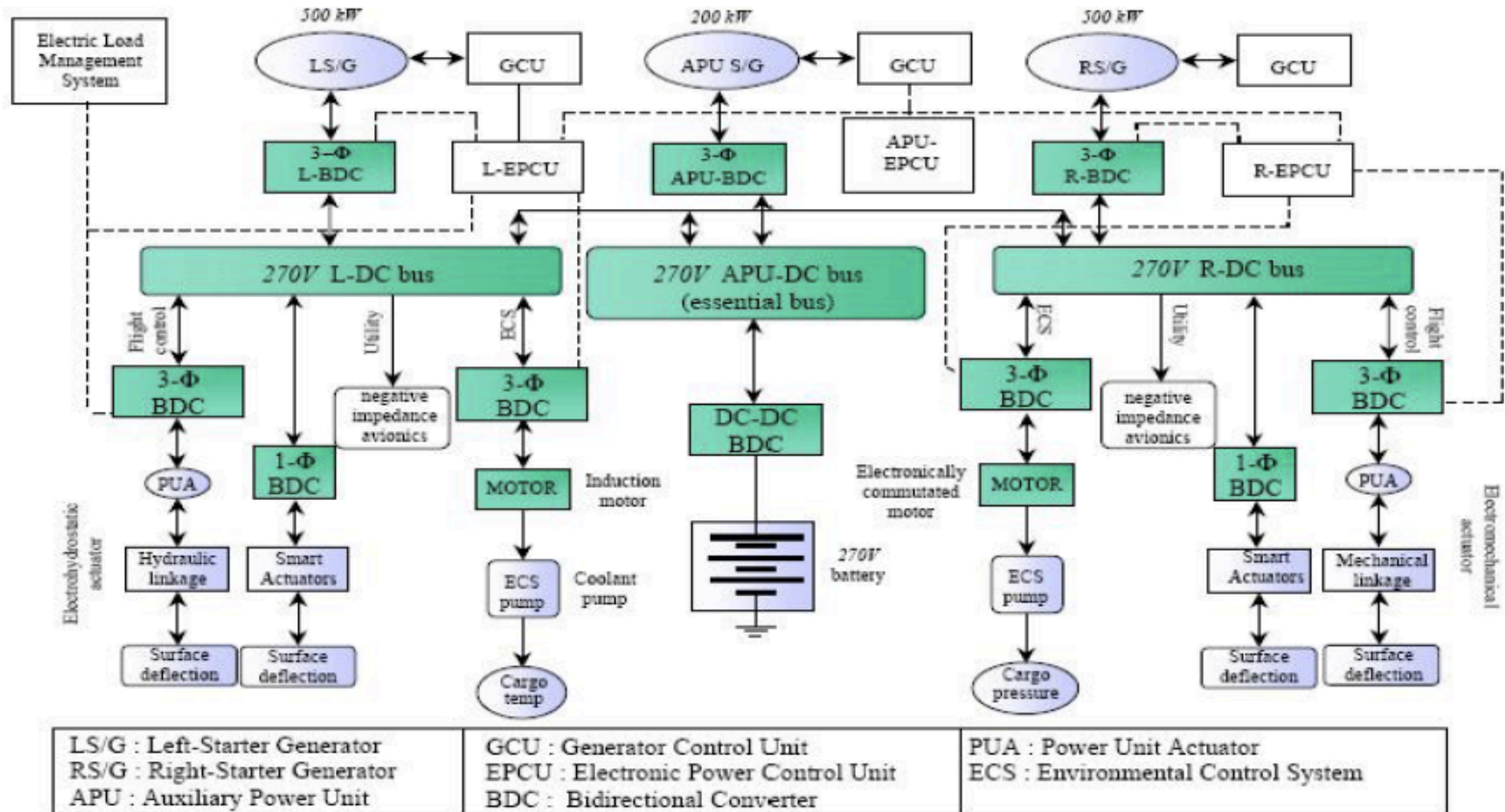
QUEEN ELIZABETH AIRCRAFT CARRIERS

HMS QUEEN ELIZABETH AND HMS PRINCE OF WALES

THE NATION'S FLAGSHIPS



MULTIPHASE DRIVES: APPLICATIONS (3)



A Possible MEA DC Power System Layout

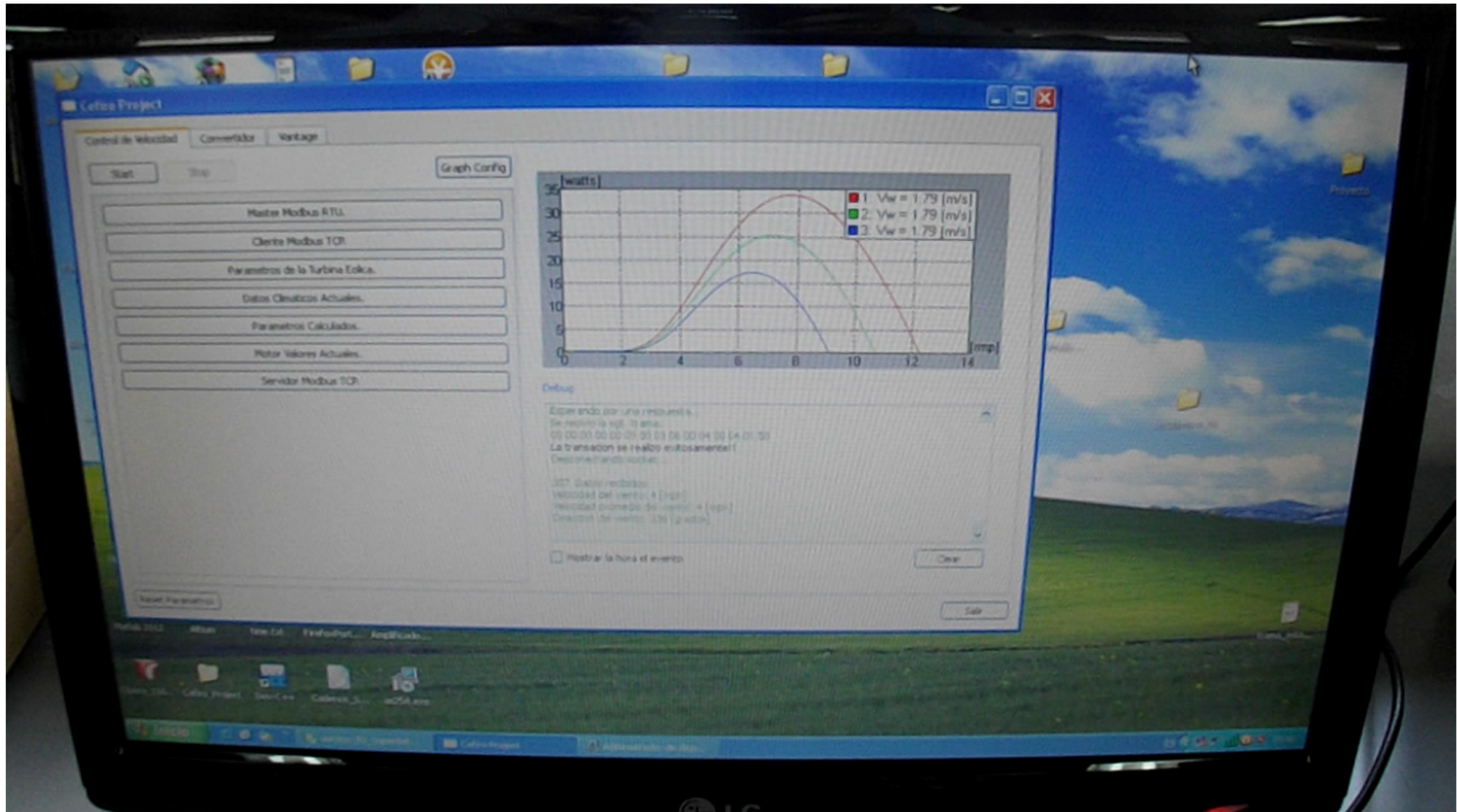
MULTIPHASE DRIVES: APPLICATIONS (4)



WIND ENERGY EMULATOR AT LSPyC

Project
(2011-2013)

Análisis y evaluación de accionamientos multifásicos orientado a la generación de energía eléctrica basada en fuentes potenciales de energías renovables en Paraguay

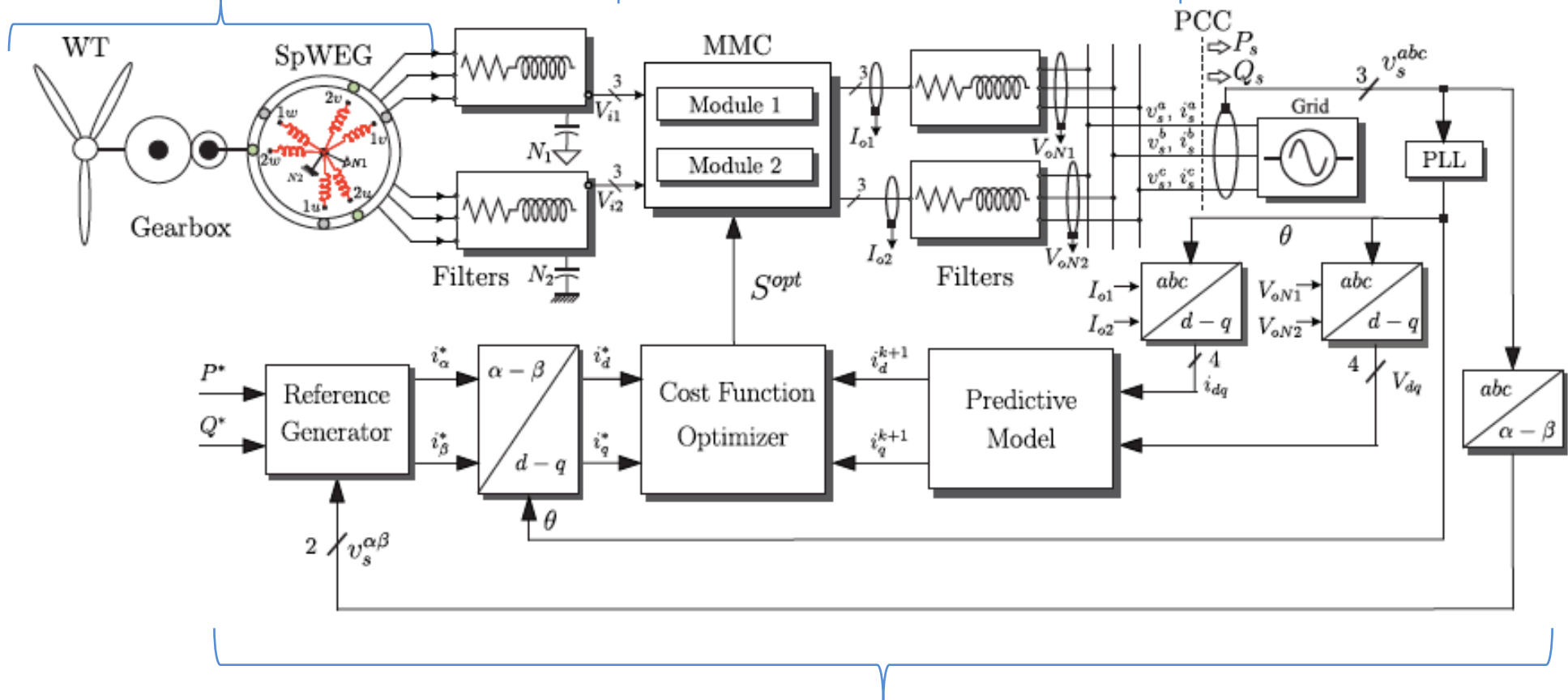


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Project #1: Real Multiphase-based Wind Turbine

Project #2: Multi-modular matrix converter

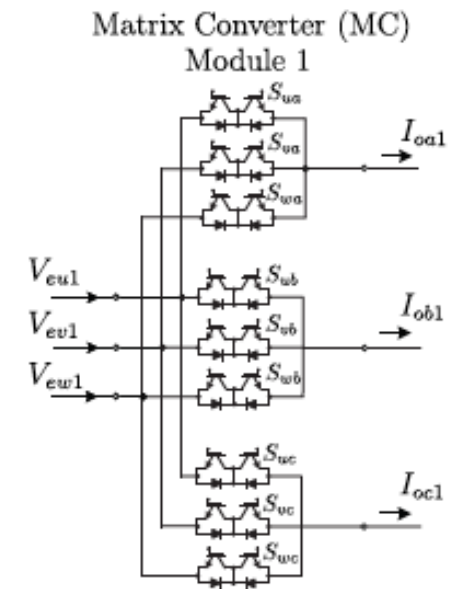
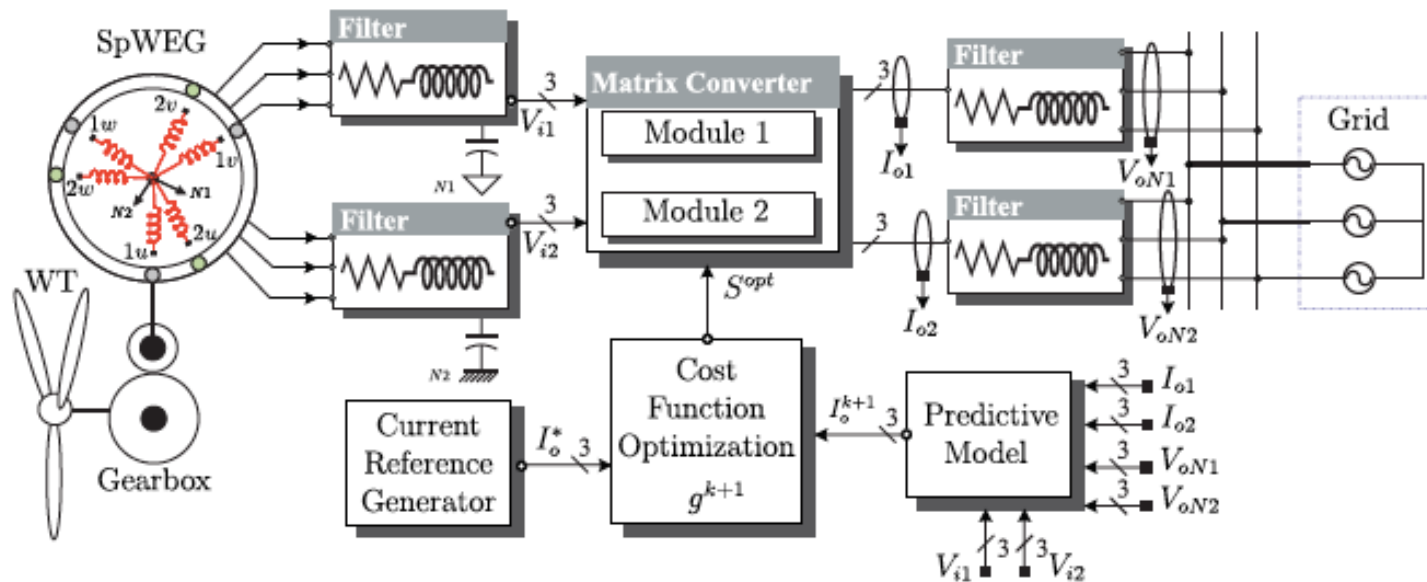



MPC applied to power converters


MATRIX CONVERTERS

Proposed multi-modular matrix converter topology applied to the SpWEG.

Matrix converter topology.



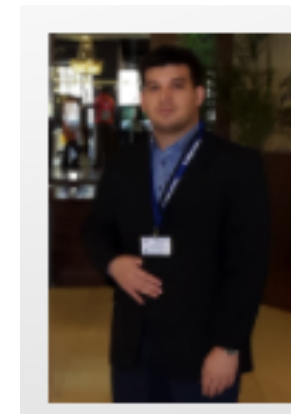
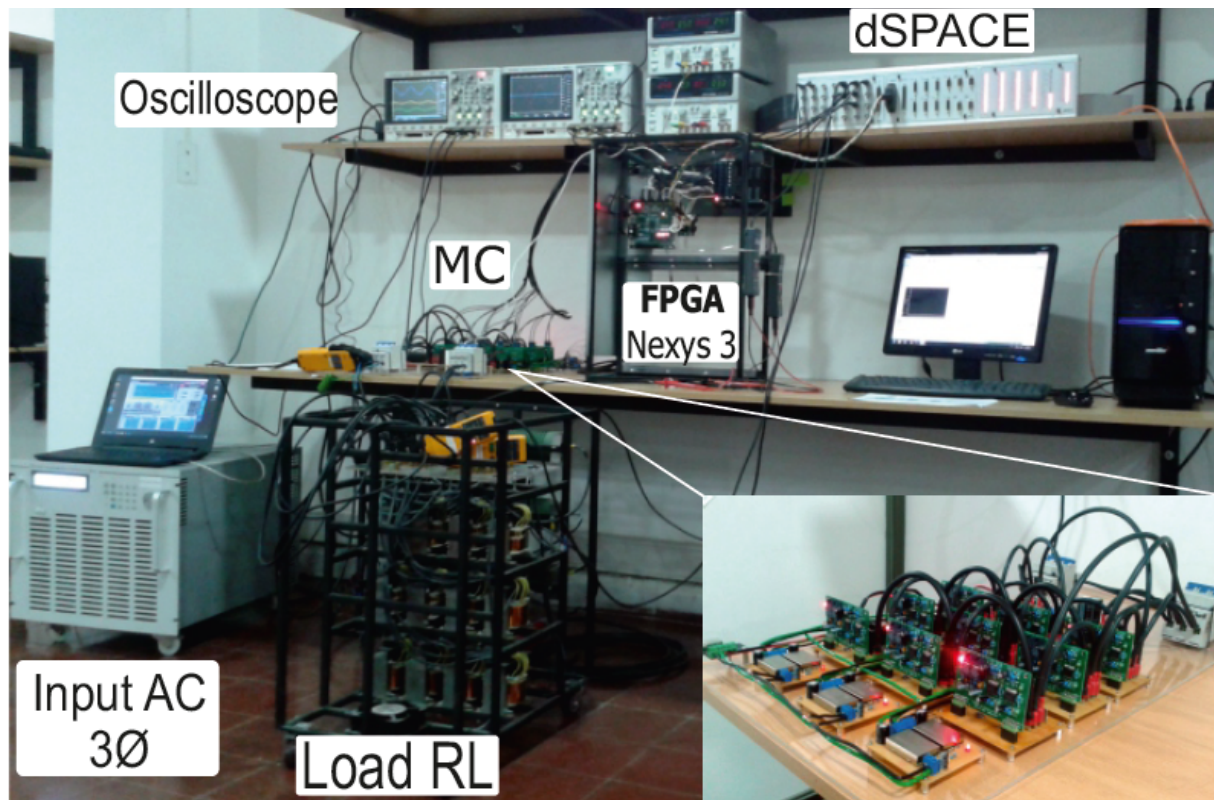
 D. Caballero, F. Gavilan, E. Maqueda, R. Gregor, S. Toledo, J. Rodas, D. Gregor, "Active and Reactive Power Control Strategy for Grid-Connected Six-Phase Generator by Using Multi-Modular Matrix Converters," *Journal on Systemics, Cybernetics and Informatics*, vol. 14, no. 6, pp. 57–61, 2016.

 S. Toledo, R. Gregor, M. Rivera, J. Rodas, D. Gregor, D. Caballero, F. Gavilan, E. Maqueda, P. Wheler, "Multi-Modular Matrix Converter Topology applied to Distributed Generation Systems," *The 8th IET International Conference on Power Electronics, Machines and Drives: PEMD 2016, Glasgow, Scotland, Apr. 19-21, 2016*.

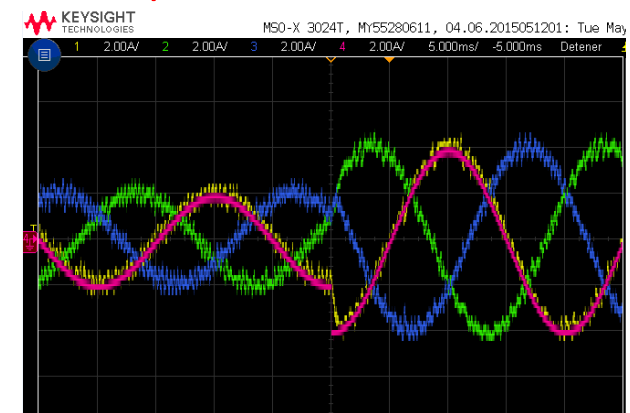
MATRIX CONVERTERS: EXPERIMENTAL SETUP

13:40 a 14:10

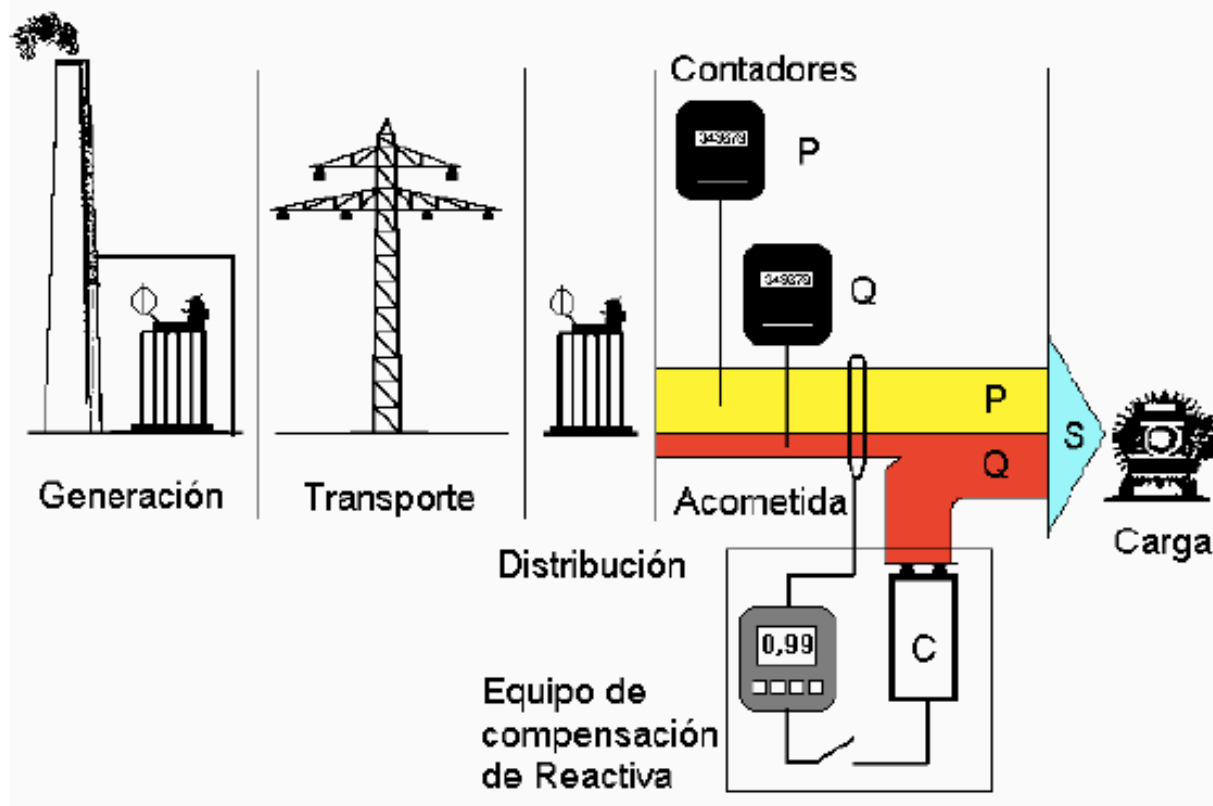
Nuevos Esquemas de Conversión para la Generación Distribuida.
Disertante: Prof. MSc. Sergio Toledo y Prof. MSc. David Caballero, LSPyC-FIUNA.



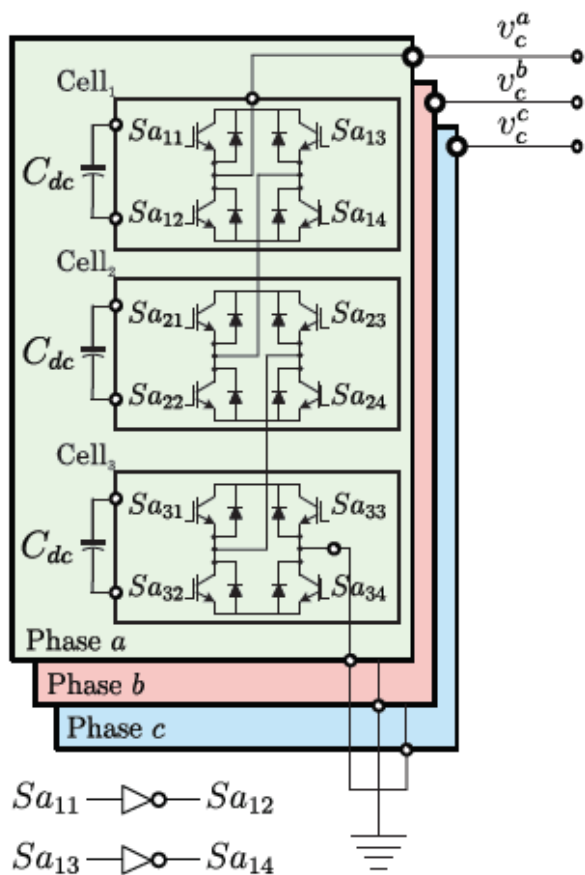
Experimental Results



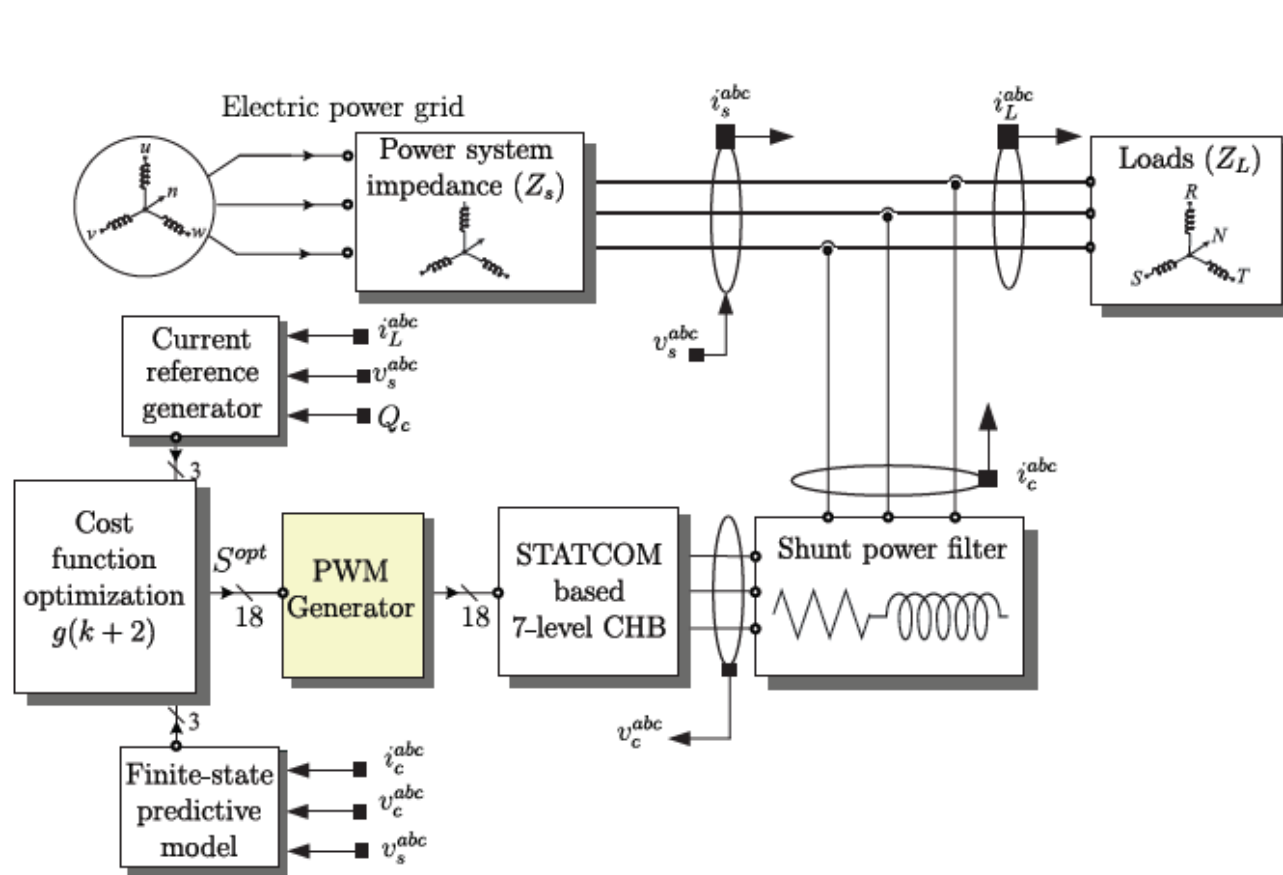
REACTIVE POWER COMPENSATION



ACTIVE POWER FILTER



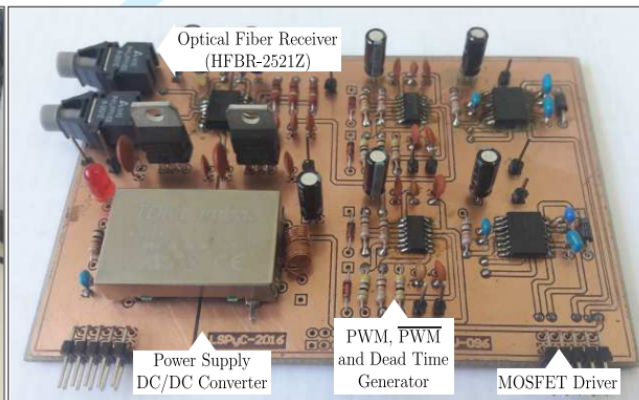
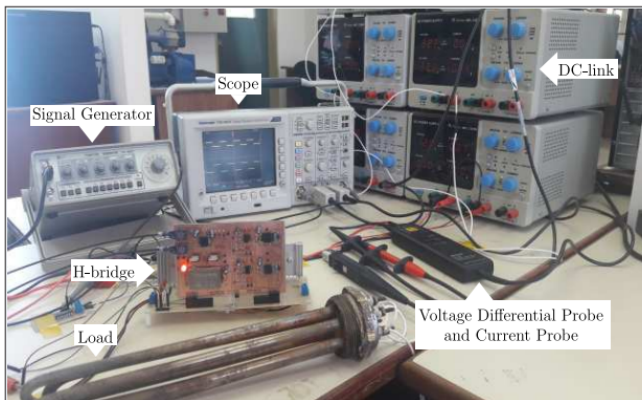
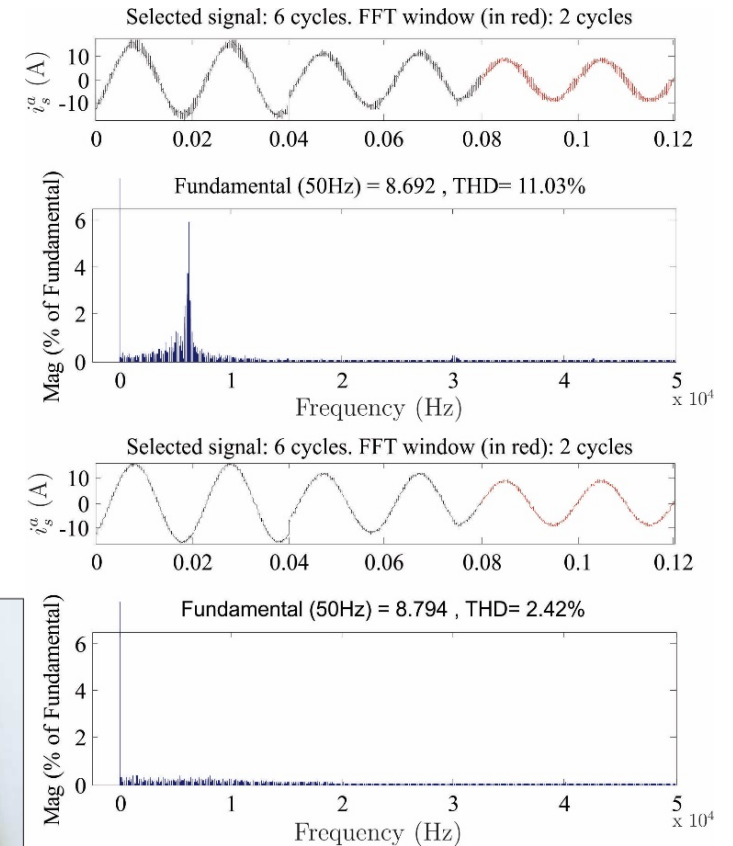
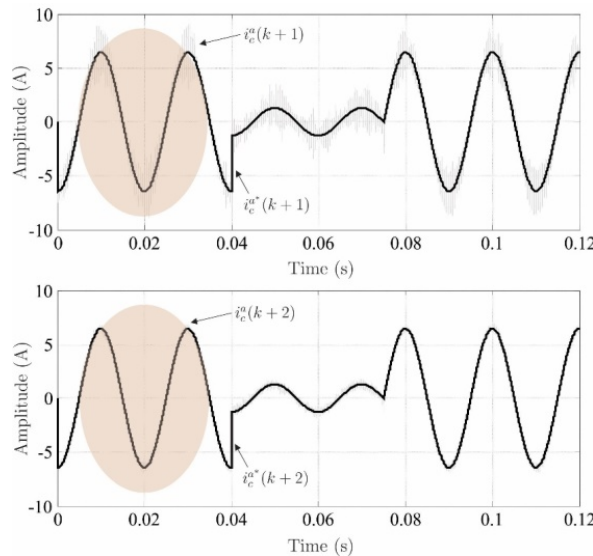
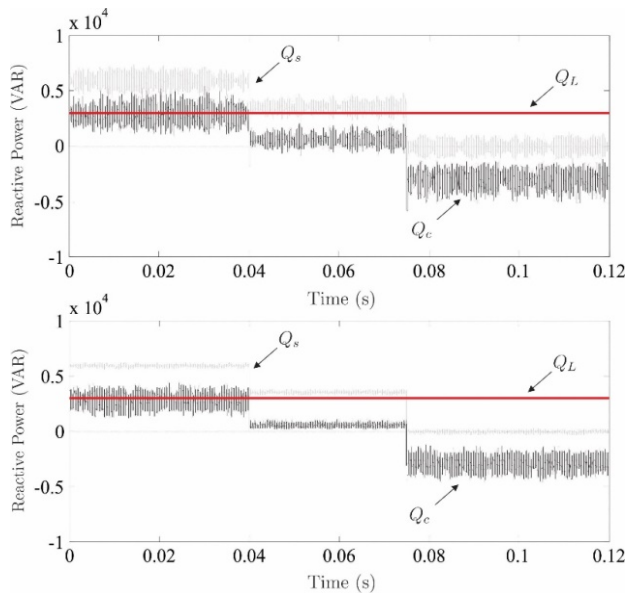
(a) Three-phase 7-level CHB converter.



(b) Proposed finite-fixed predictive control technique scheme.

L. Comparatore, J. Rodas, R. Gregor, M. Rivera, "Model Based Predictive Current Control for a Three-Phase Cascade H-Bridge Multilevel STATCOM Operating at Fixed Switching Frequency" *IEEE 8th International Symposium on Power Electronics for Distributed Generation Systems: PEDG, Florianopolis, Brazil, April 17-20, 2017.*

FCS-MPC IN MULTILEVEL/2L CHB APF



L. Comparatore, J. Rodas, R. Gregor, M. Rivera, "Modulated Model Based Predictive Control with Switcher of Redundant States for a Three-Phase Cascade H-Bridge Multilevel STATCOM," *The 18th IEEE Workshop on Control and Modeling for Power Electronics: IEEE COMPEL 2017, Stanford, California, USA, July 9-12, 2017.*

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LABORATORY OF POWER AND CONTROL SYSTEMS

- ✓ Created in 2009.
- ✓ **Staff**
 - 2 full time professors.
 - 11 part-time professors (PhD students).
 - 1 post-doctoral researcher.
 - 10 junior researchers (B. Eng. students).
 - 1 administrative.

Funds

- 1 PhD program (1st Ed. 2017): **200,000 US\$**
- 1 MSc program (1st Ed. 2015-2017): **200,000 US\$**
- 7 Research projects: **1,750,000 US\$**



PROGRAMA DE APOYO A LA FORMACIÓN DE DOCENTES-INVESTIGADORES



DOCTORADO EN INGENIERÍA ELECTRÓNICA con énfasis en Electrónica de Potencia

Importante: Este programa de posgrado es **GRATUITO** para todos sus estudiantes gracias al apoyo del CONACYT en el marco del Programa PROCIENCIA – Convocatoria 2016.

LABORATORY OF POWER AND CONTROL SYSTEMS

Contributions:

- > 20 Journal papers (>7 in IEEE-TIE).
- > 70 Conference papers (IECON, PEMD, ...)
- > 3 book's chapters



IET AWARDS
The Institution of
Engineering and Technology

TIE Best Paper Awards

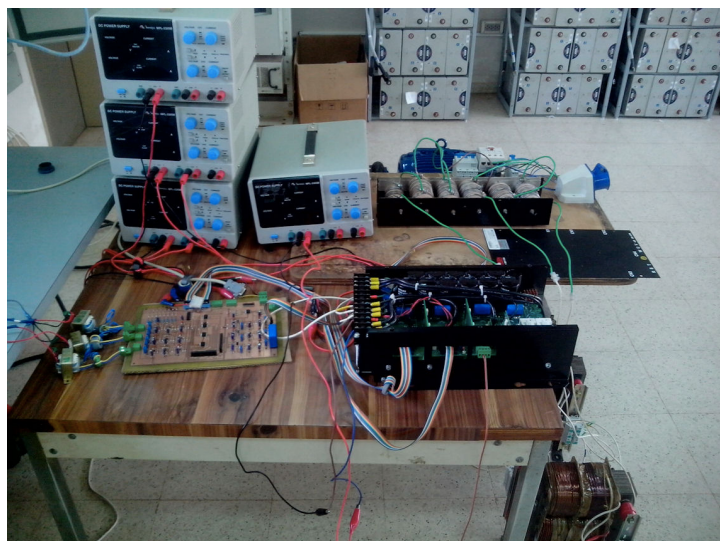
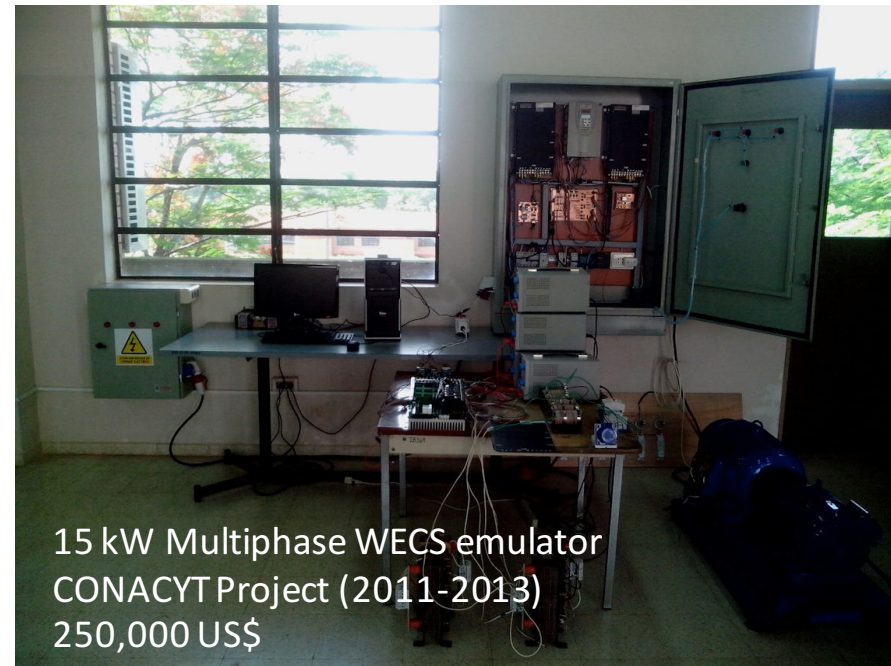
Best Paper Award for the Trans. on Industrial Electronics.

LABORATORY OF POWER AND CONTROL SYSTEMS

> 20 partners in 15 countries



CONCLUDED PROJECTS



Undergraduate projects (B.Eng.)

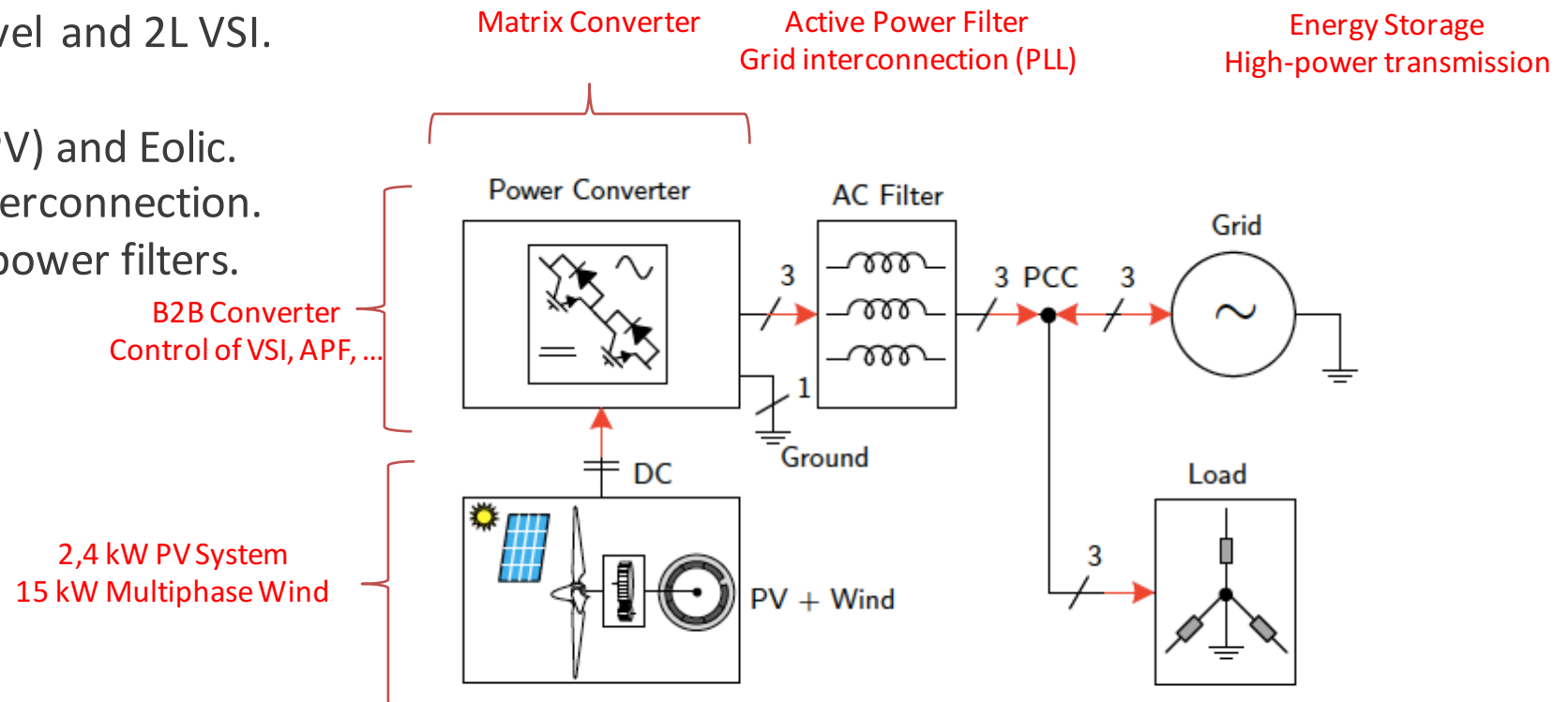
- Grid interconnection
- Bi-directional meter
- Concentrated solar collector
- Ultrasonic anemometer
- Active filter
- Three-phase IM control
- UAV

...



Summary

- Advanced Control of power converters for renewable energy applications and machines and drives:
 - FCS-MPC, parameter estimation, modelling, fault tolerant control.
 - Sensorless control.
 - Nonlinear control.
- Electric Machines and Drives and Power Converters:
 - Multiphase machines: IM and PM.
 - Matrix converters.
 - Multilevel and 2L VSI.
- Renewables:
 - Solar (PV) and Eolic.
 - Grid interconnection.
 - Active power filters.



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