CITCEA-UPC

Electrical Machines & Inductive Components

www.citcea.upc.edu

Technology and Knowledge transferred from University to Industry
CITCEA-UPC is a centre for research and technology innovation born in 2001 inside the Technical University of Catalonia (UPC) supported by the Government of Catalonia.

13 years' experience, 60 people, 110 customers, 200 projects, 9 M€ turnover, 10 patents, 1 spin-off (teknoCEA), more than 200 conference papers; more than 100 journal paper.

ACTIVITY FIELDS

MECHATRONICS:
Power electronics and electrical drives. Automation, industrial ICTs.

ENERTRONICS:
Generation, transmission and distribution of electrical energy. Economics, market and regulation of electrical energy.

LIFE LONG LEARNING:
LLL Masters in Mechatronics and Enertronics. Courses and Seminars for professionals.

MECHATRONICS
Power electronics and converters, special for applications in wind and PV
Digital control with DSP
Industrial communications
Data acquisition and signal processing
Process automation and Motion control
Electric vehicles and battery chargers
Design of electrical machines

ENERTRONICS
Electrical generation from renewable and distributed generation
Wind generator design
Distribution and transmission grids
Control of wind generators and wind farms
Offshore wind farms and HVDC
Microgrids and smart grids
Condition monitoring and PQ
CITCEA-UPC Spin-off company

Custom power electronics systems for research labs

• Power converters from **10 kW to 120 kW**
• Control cards based on **TI DSP**
• PC embedded based **HMI**. Industrial **Communications**
• Application oriented **DSP starter kits**
• Educational test-benches

• Application examples:
  • **Emulators**: energy resources (Grid, PV, Wind, Diesel, Fuel-cell), storage and loads. Ready to be used.
  • Research and educational AC and DC **microgrids**
  • Battery and electrical vehicle chargers/dischargers. V2G

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DESIGN OF ELECTRIC MACHINES

TYPES OF WORK
- Analytic design
- FEM analysis
- Optimization ($\eta$, P, Noise, Vol., €, …)
- Creation of tools for automatic optimization

TYPES OF MACHINES
- Inductances & Transformers (Hz … kHz)
- Motors/Generators:
  - Permanent magnet / Wound rotor
  - Brushless DC/AC
  - Superficial / Interior Permanent Magnet
- Other devices

AREAS OF KNOWLEDGE
- Multipolar machines (Direct-Drive)
- Multiphase machines (5, 7, 9… phases)
- Wide power range (100 W … 15 MW)
- Interior / Exterior rotor
- Ferrite / Neodymium
- Machines optimized for the application
  - Sensorless control
    - Initial position detection
    - Open loop operation
  - Flux weakening
  - Others
PROJECT CHARLIE

- Design of high efficiency motor for home appliance and its power electronics
  - 400 W
  - Brushless DC
  - Flat design

![Motor Image]

![Graph Image]

<table>
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<th>RPM</th>
<th>15000</th>
<th>P. Output (W)</th>
<th>500</th>
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<td>1000</td>
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<tr>
<td>I (A)</td>
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PROJECT NET

Motor for industrial washing machine (3 kW)
Direct-Drive (24 poles)
↓ maintenance  
↑ mounting easiness

Two very different working zones:
- Washing (low $\omega$ & high $\Gamma$)
- Spin (high $\omega$ & low $\Gamma$)

Designed for high Flux Weakening
($\omega_{\text{max}} = 4.5 \times \omega_{\text{nom}}$)

Interior Permanent Magnet Synchronous Motor (IPMSM)
PROJECT AZIMUT

- <15 MW wind turbine generator design
  - 9 phases: 3 x 3 phase converter
  - Direct-Drive (100…200 poles, D = 5…8 m):
    - Reliability
    - For: high off-time cost
- Design of tools
  - Automated design
  - Automated simulation
    - Thermal (Lumped parameter)
    - Electromagnetic (FEM)
    - Result analysis
    - Cost calculation
- Synchronous machines:
  - SPM-SM (Superficial Permanent Magnets)
  - IPM-SM (Interior Permanent Magnets)
  - WR-SM (Wound Rotor)
PROJECT MARACA

- Design of micro wind turbine generator (7,5 kW)
  - Permanent Magnet Synchronous Machine (NdFeB)
  - Direct-Drive (10 poles)
  - Partial reuse of customers machine (cost reduction)
PROJECT NOSTRUM

- Design of 70 kW motor
  - Permanent Magnet Synchronous Motor
  - 5 phases:
    - ↑ Reliability
    - ↓ Iphase
    - ↑ torque (by adding harmonics)
    - ↓ torque ripple
  - Interior Permanent Magnets: easy of production
  - Compact: Dext < 0,5 m
  - Water cooled
- Design, construction and programming of 5 phase converter
  - Open loop control
  - Initial position detection
  - Torque with 3rd harmonic
  - Complex control & modulation:
    - 3 virtual machines (D/Q, X/Y, homopolar)
    - 32 vectors SVPWM
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No fun, no innovation
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