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

Integration of Energy Storage systems in Microgrids

Barcelona, 8 de gener de 2014

Jordi Pegueroles Queralt

INDEX

- **Motivation**
  - Microgrid description
  - Hierarchical Control and Management of Microgrids
- **Storage integration in Microgrids**
  - Low level storage management
    - Droop control
  - Power electronics interface
    - Control implementation
  - Storage technologies
    - Different technologies for different purposes
- **Conclusions**

Motivation, microgrid description

The microgrid is a paradigm proposed for the large scale integration of renewable sources.

The microgrid can be thought as a small power system which can operate in two different modes:

- **Grid connected** and
- **Islandend mode**
  - Need to maintain voltage and frequency of the island
    - Low inertia → low stability margins
  - Need of robustness to achieve high power quality
    - Low level decentralized control without communications

Motivation, microgrid description

The microgrid is a paradigm proposed for the large scale integration of renewable sources.

The goal is to **substitute** the **mechanical intertia** of synchronous generation **for virtual inertia** from electrical storage units

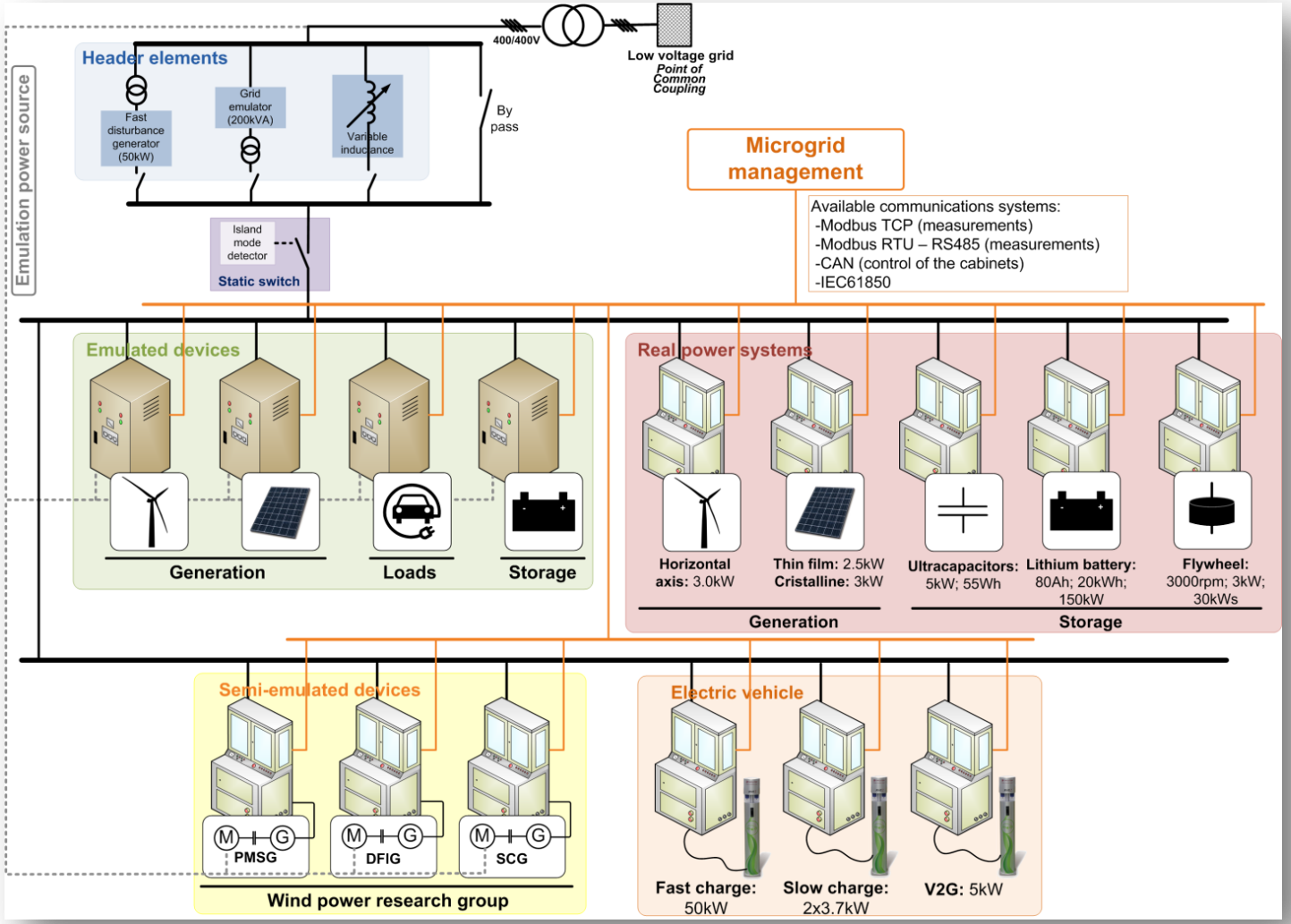
- Need to maintain voltage and frequency of the island
  - Low inertia → low stability margins
- Need of robustness to achieve high power quality
  - Low level decentralized control without communications

Motivation, microgrid description

The **IREC microgrid** is an **experimental platform** ideal for **the validation of new control strategies** for the inegration of electrical energy **storage systems**

The **IREC microgrid** is formed by emulated and real devices

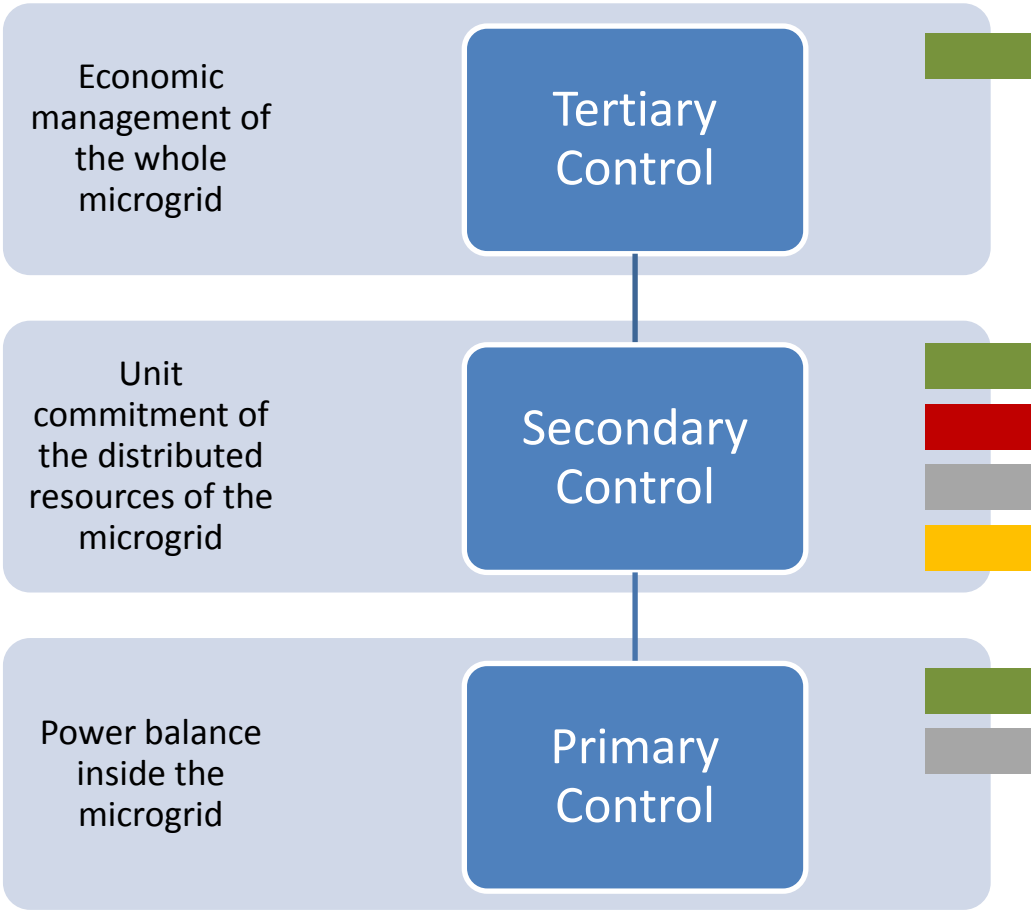
Motivation, microgrid description



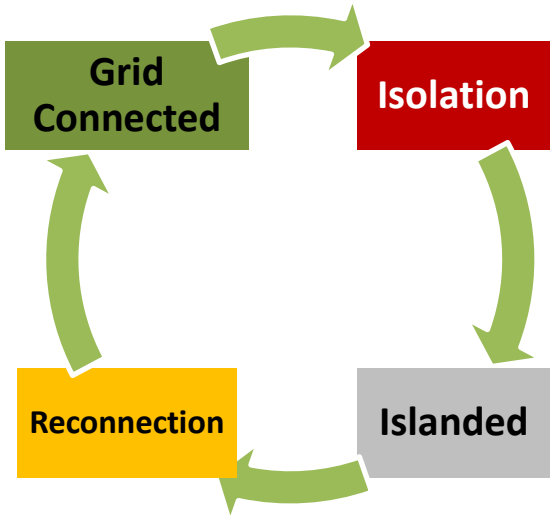
Motivation, microgrid description

Motivation, Hierarchical Control and Management of Microgrids

Microgrid has 3 control levels



Four Operational States



The transition from **Grid Connected** to **Isolation** can be motivated by:

- **fault** in the grid
- **economic** and
- **technical reasons.**

In either case, the **Isolation** is triggered by the **secondary control**

INDEX

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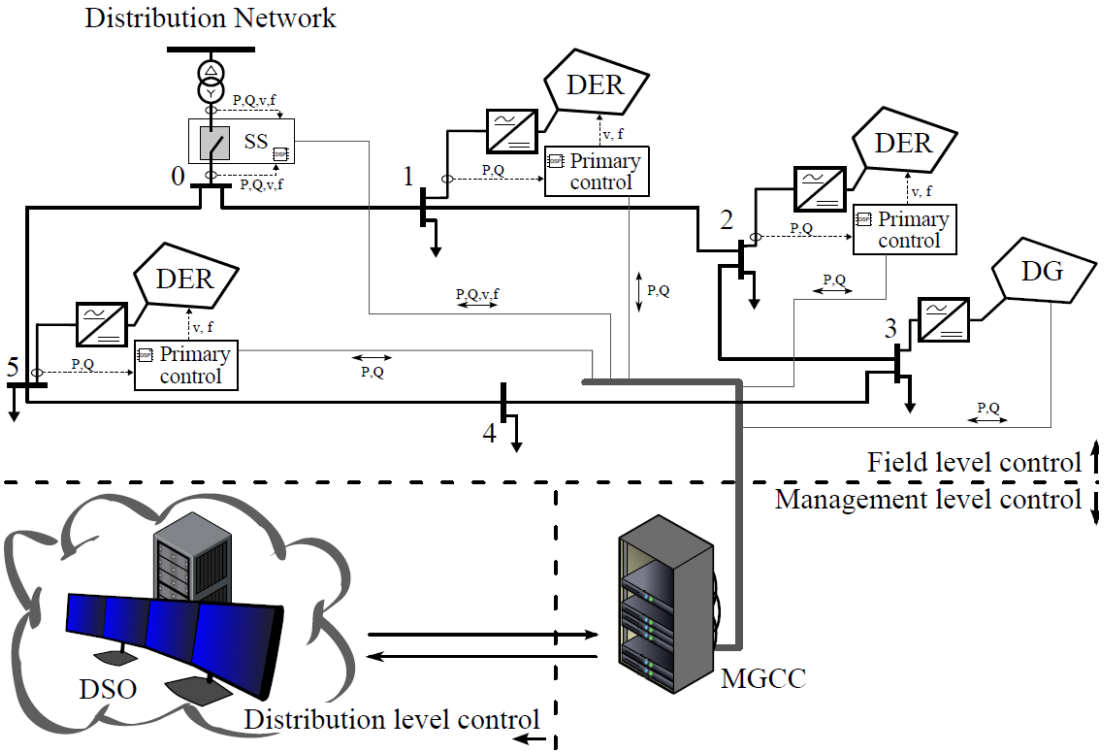
Low level storage management

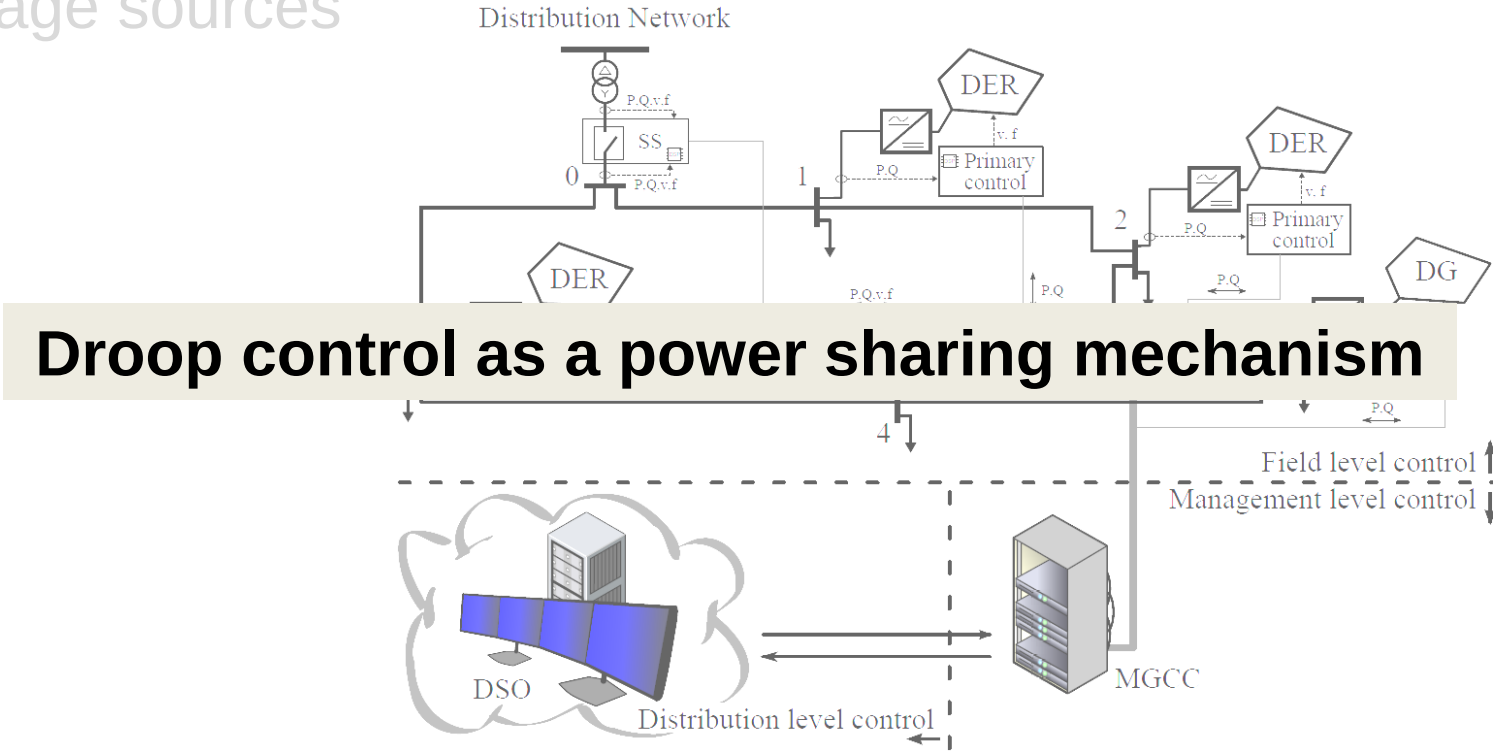
In islanded mode, electrical energy storage systems acts as a voltage sources



Interactions among paralleled units must be regulated to ensure a desired power sharing

Low level storage management

In islanded mode, electrical energy storage systems acts as a voltage sources



Droop control as a power sharing mechanism

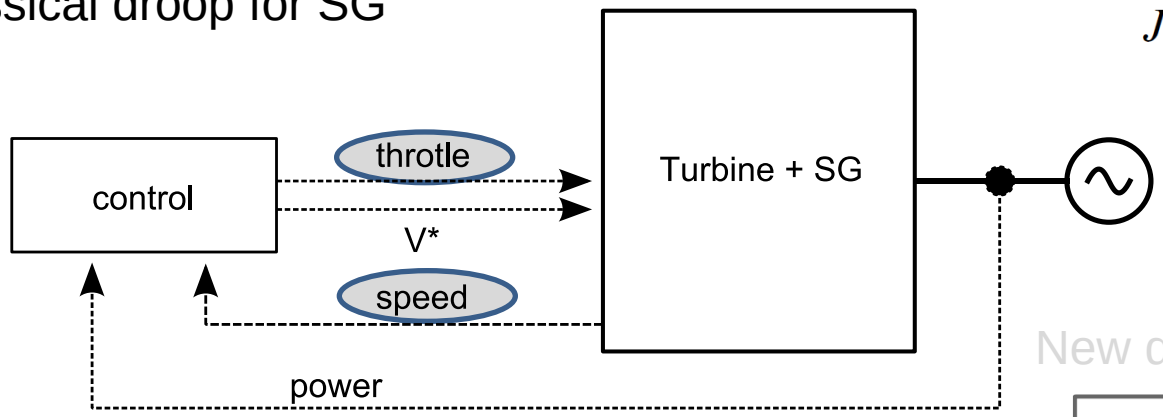
Interactions among paralleled units must be regulated to ensure a desired power sharing

Low level storage management, droop control

Droop control comparison

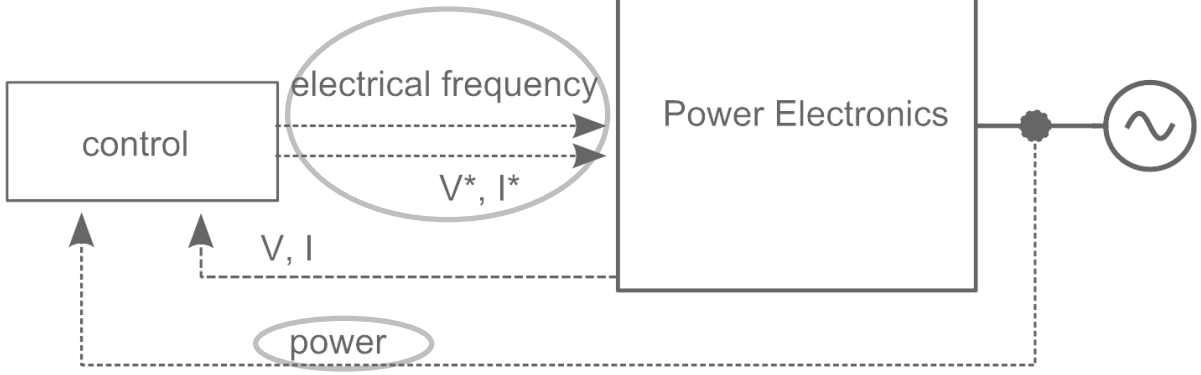
Classical droop for SG

$$J\frac{\mathrm{d}\omega_\mathrm{m}}{\mathrm{d}t} + D_\mathrm{d}\,\omega_\mathrm{m} = \tau_\mathrm{t} - \tau_\mathrm{e},$$



New droop for power electronics

$$\omega - \omega_0 = -k_\omega(P' - P'_0)$$
$$V - V_0 = -k_v(Q' - Q'_0)$$



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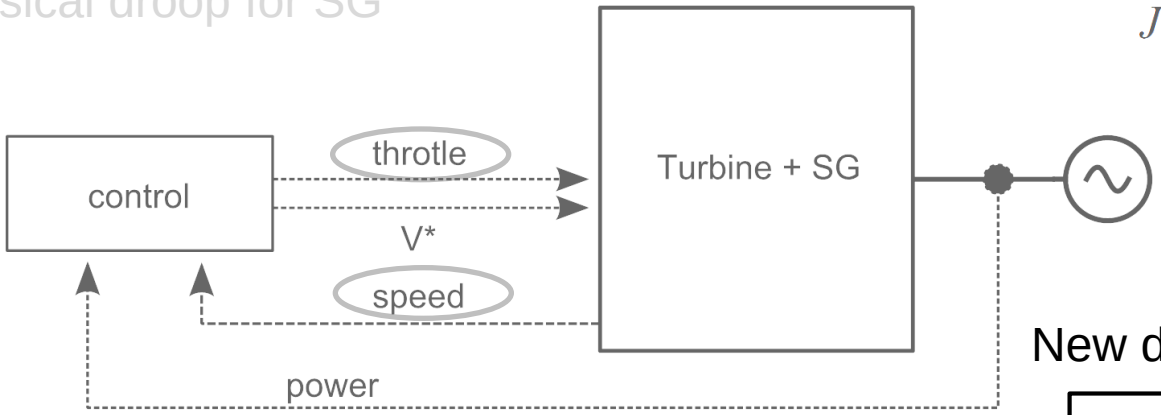

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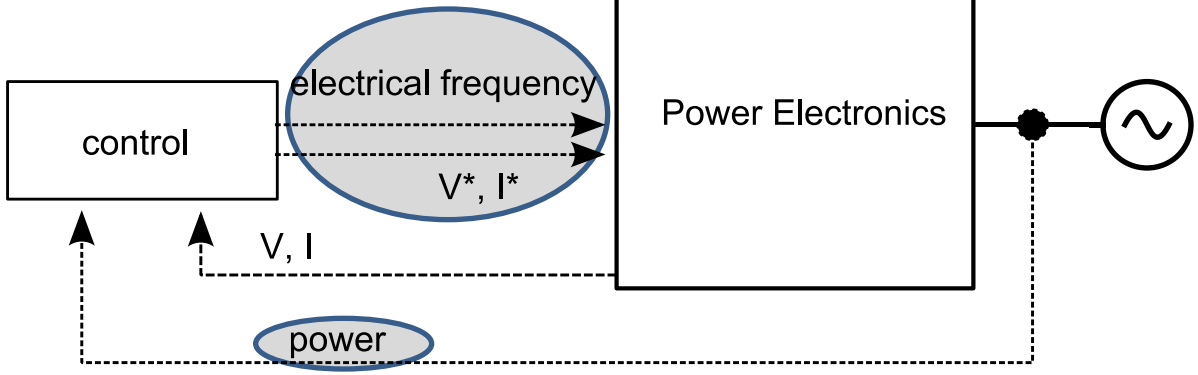
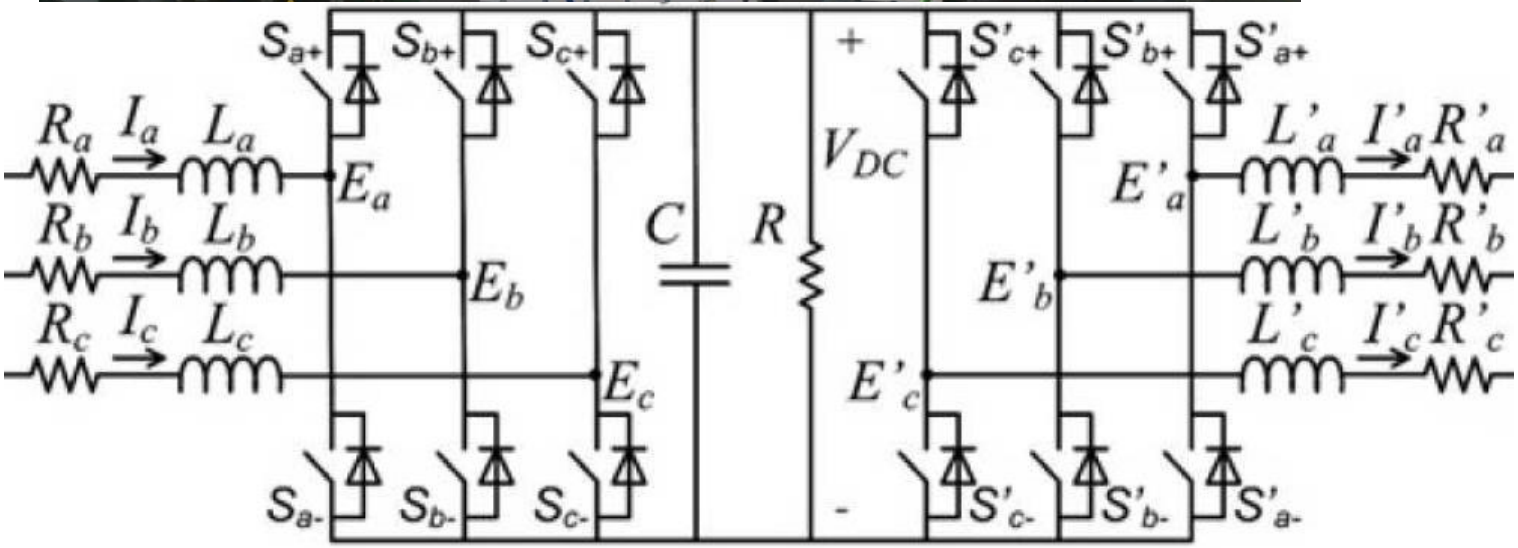
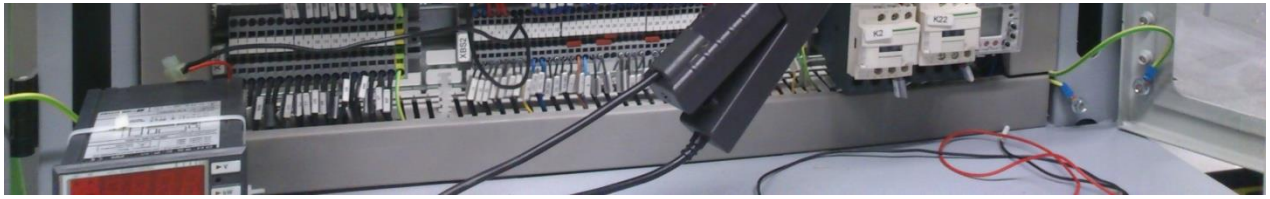


Power electronics interface





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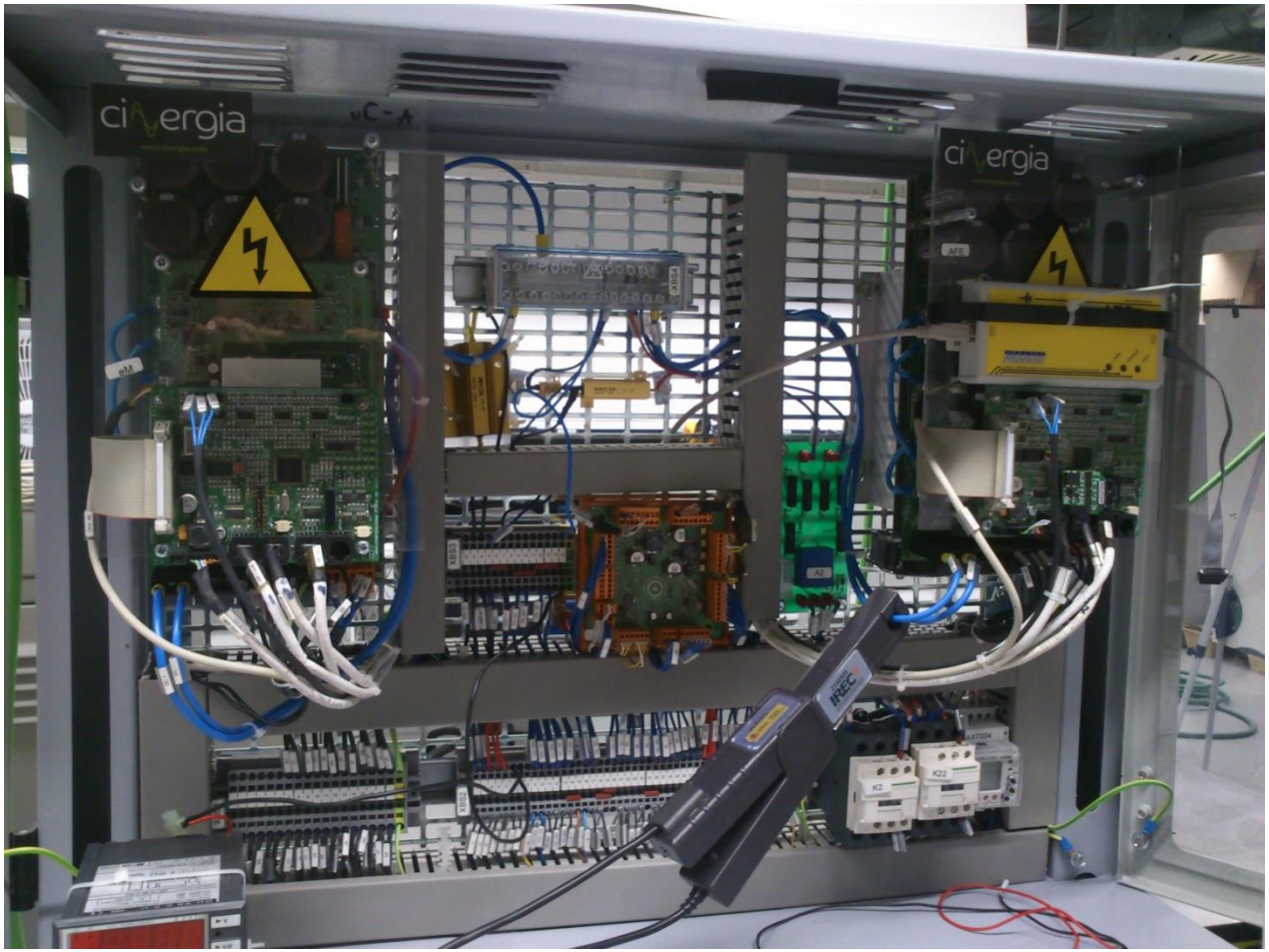
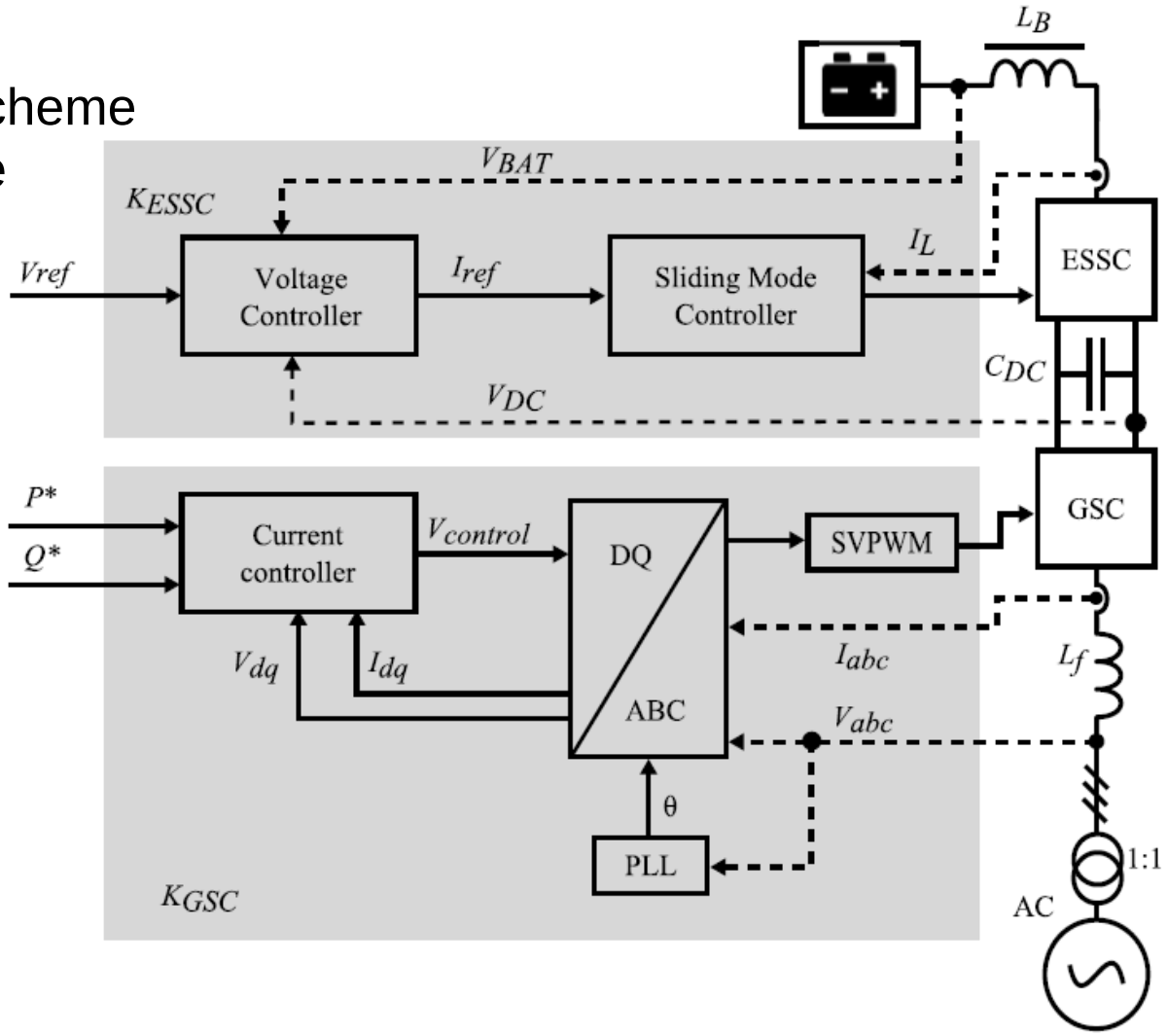


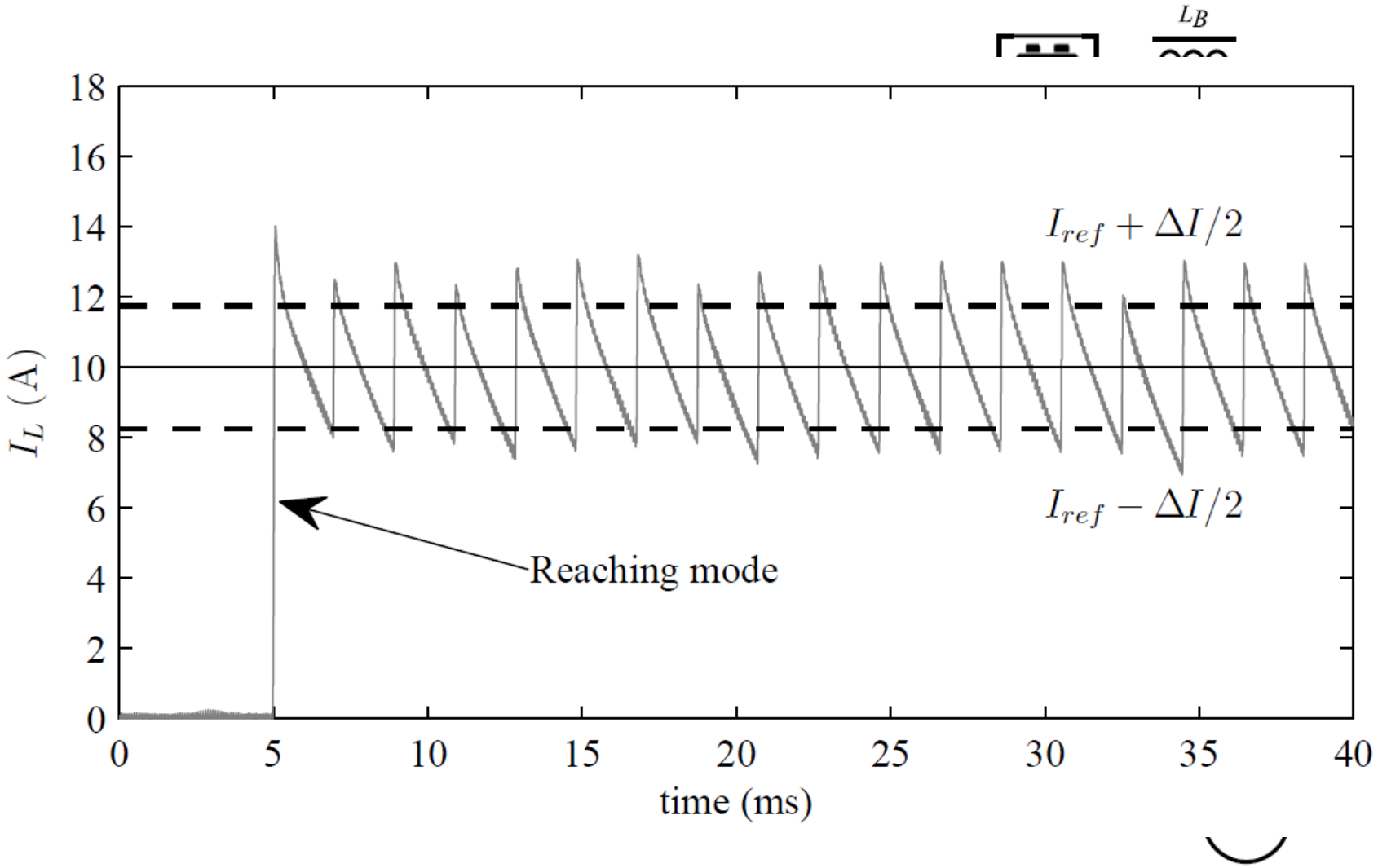
Rated power:
10 kVA
Rated DC link:
750 Vdc
Rated AC volt.
400 Vac
Switching Freq.
20 kHz

Power electronics interface, control implementation

General control scheme for energy storage systems



Power electronics interface, control implementation



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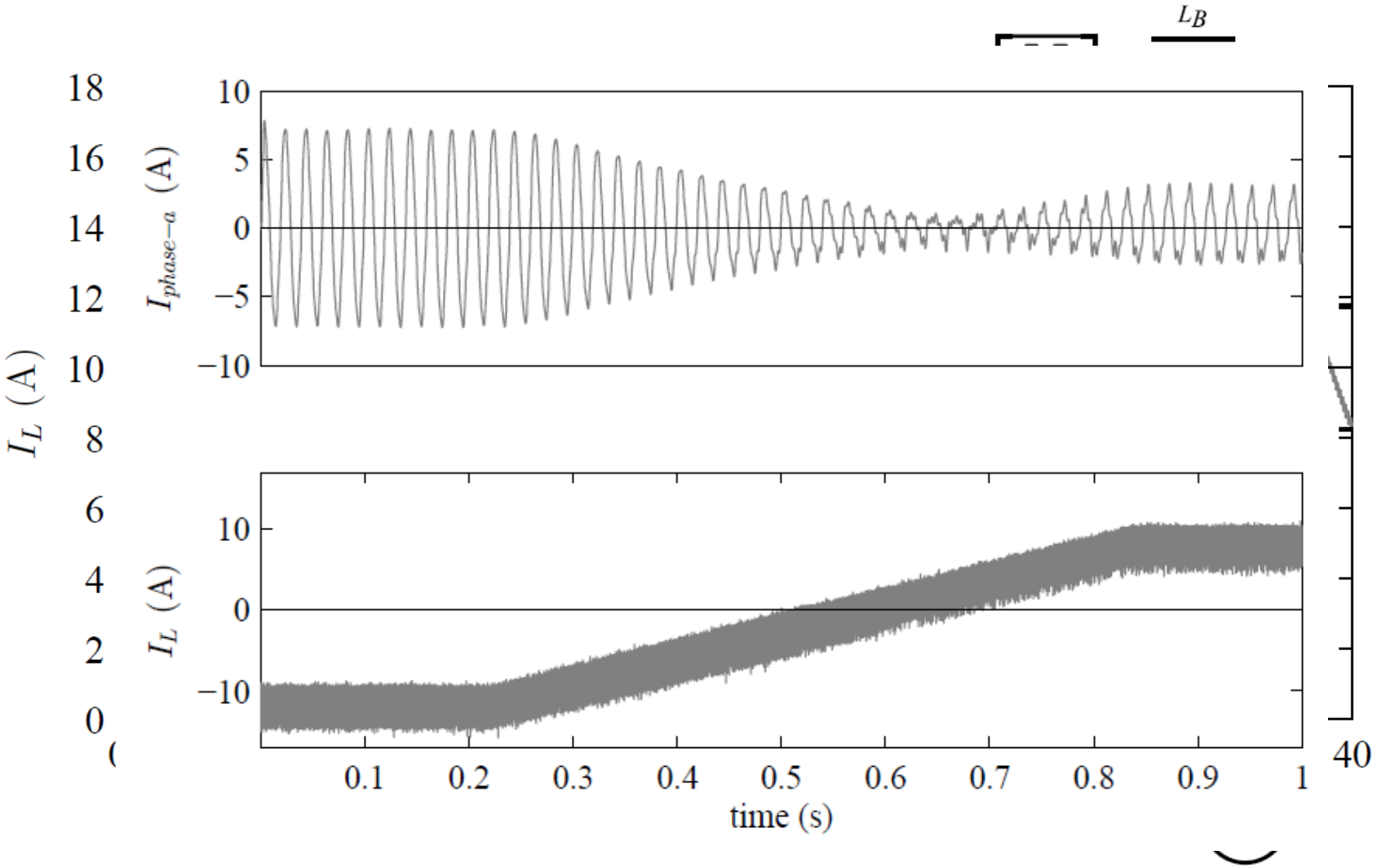
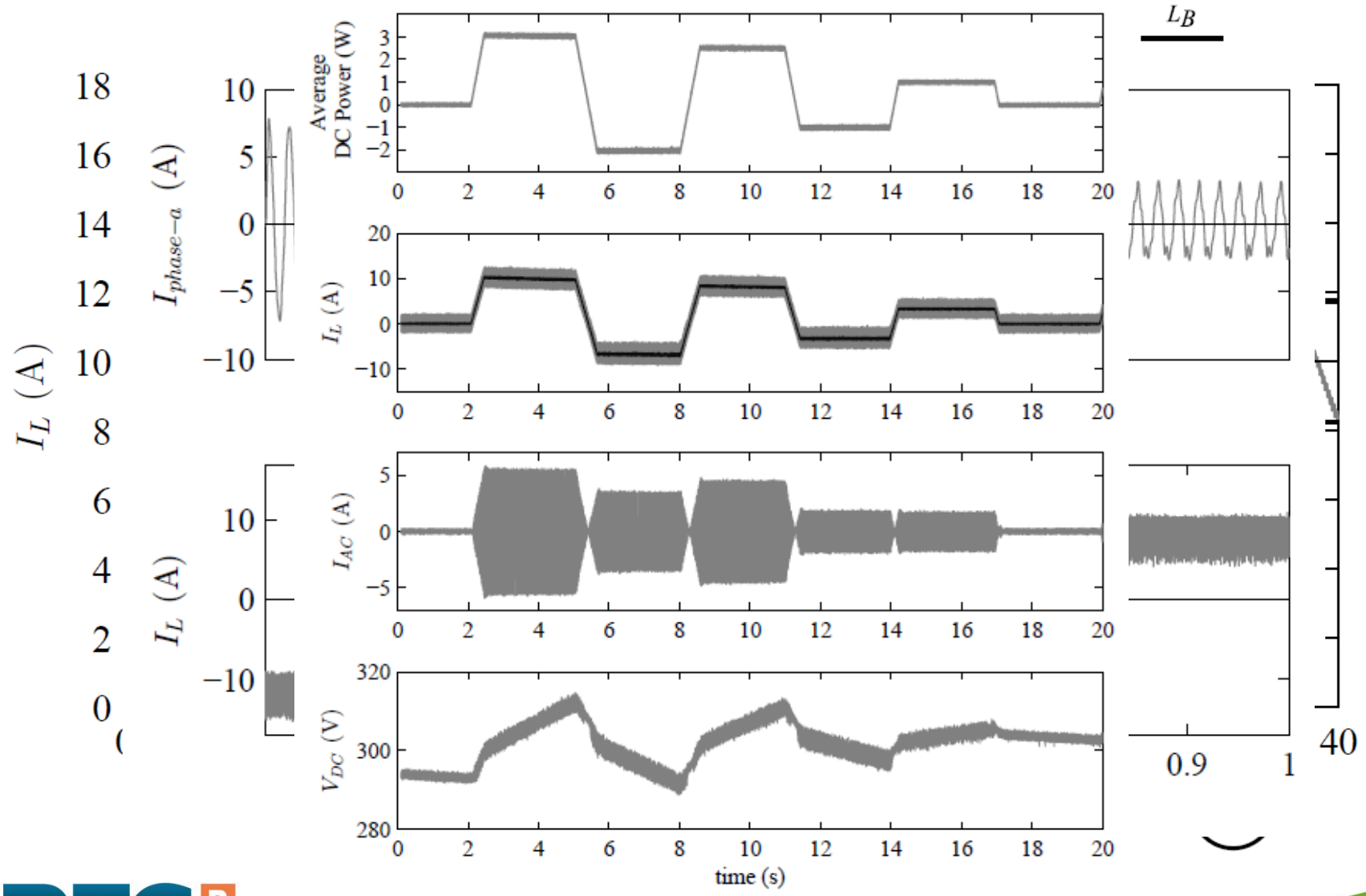


Power electronics interface, control implementation



Storage technologies, Different technologies for different purposes

Long term. storage

Bad cyclability
High energy stored

Io-Li Batery
5 kW & 20 kWh

Fly Wheel5 kW

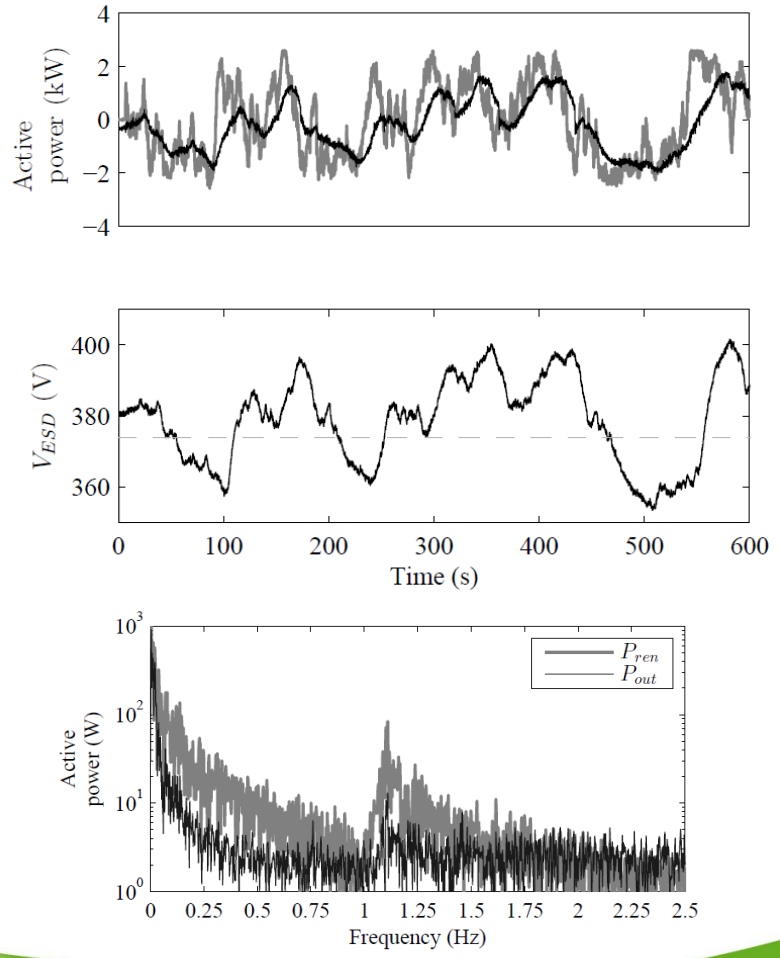
Ultracaps 5 kVA & 55 Wh @ 400V

Good cyclability
Low energy stored

Short term. storage

Storage technologies, Different technologies for different purposes

SuperCapacitors: fast power compensation, **NOT** for freq. restoration



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Storage technologies, Different technologies for different purposes

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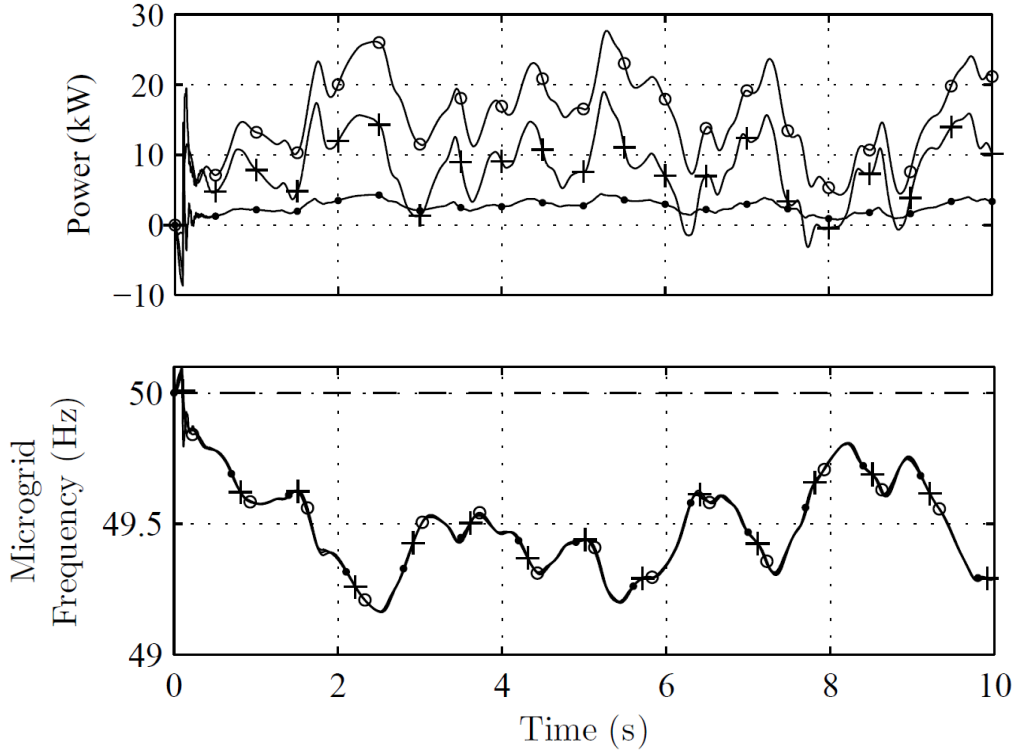
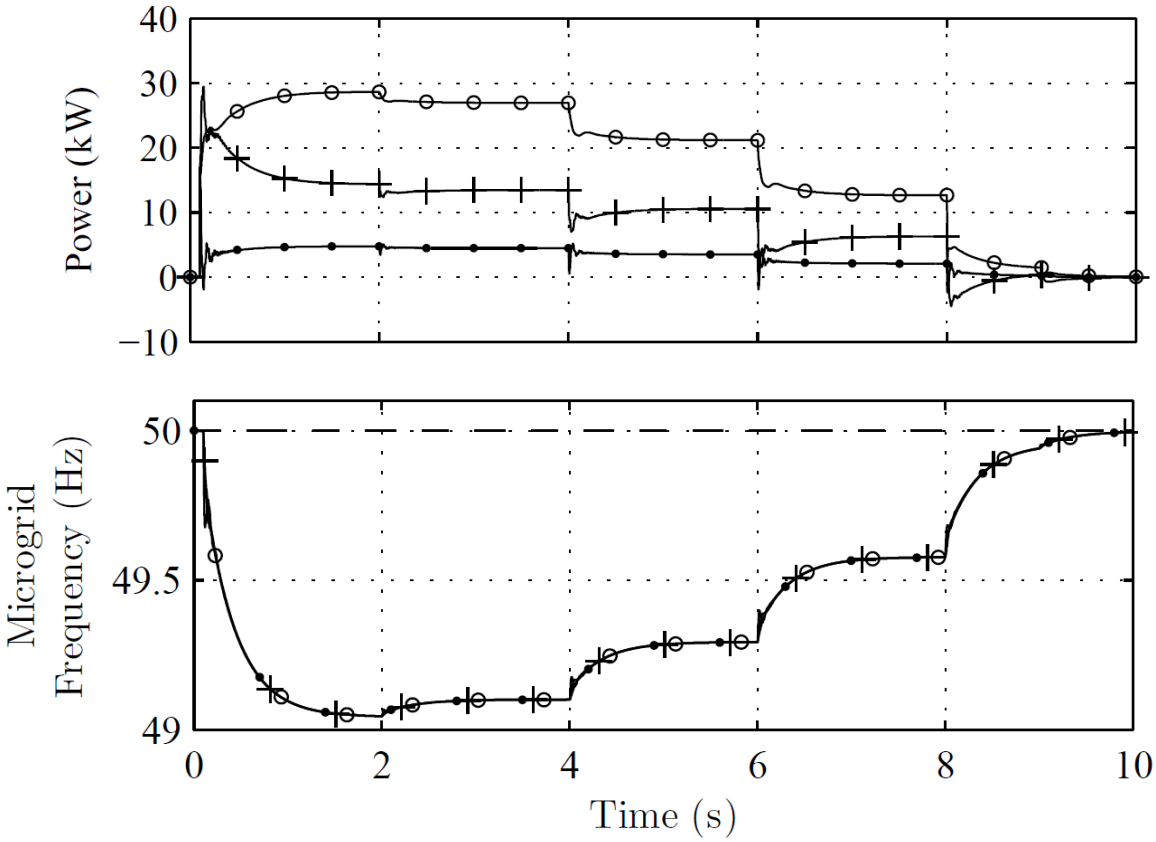


Storage technologies, Different technologies for different purposes

Li-ion batteries: slow power compensation, freq. restoration



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Conclusions

- IREC has facilities for testing storage integration
- Fast storage devices can smooth variable power generation
- Li-ion batteries can be used to restore microgrid frequency when working in islanded mode
- Modified droop strategies offers good performance for the regulation of islanded microgrids.

Conclusions

Thanks for your attention!