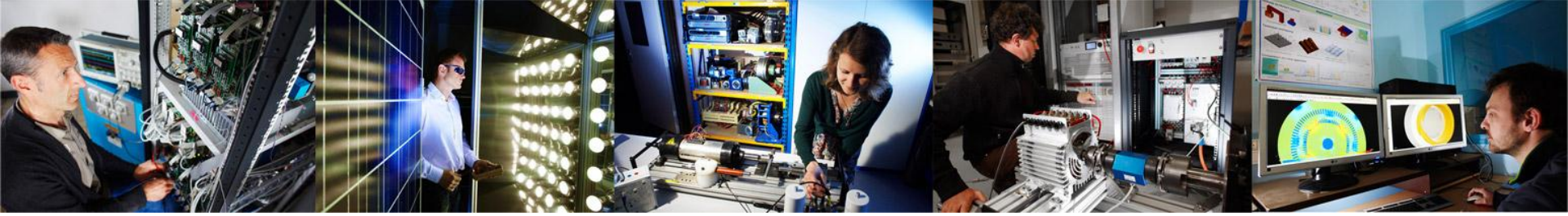


L2EP
Laboratoire d'électrotechnique et d'électronique de puissance de Lille

HIL and PHIL simulation examples in EPMLab

Frédéric Colas

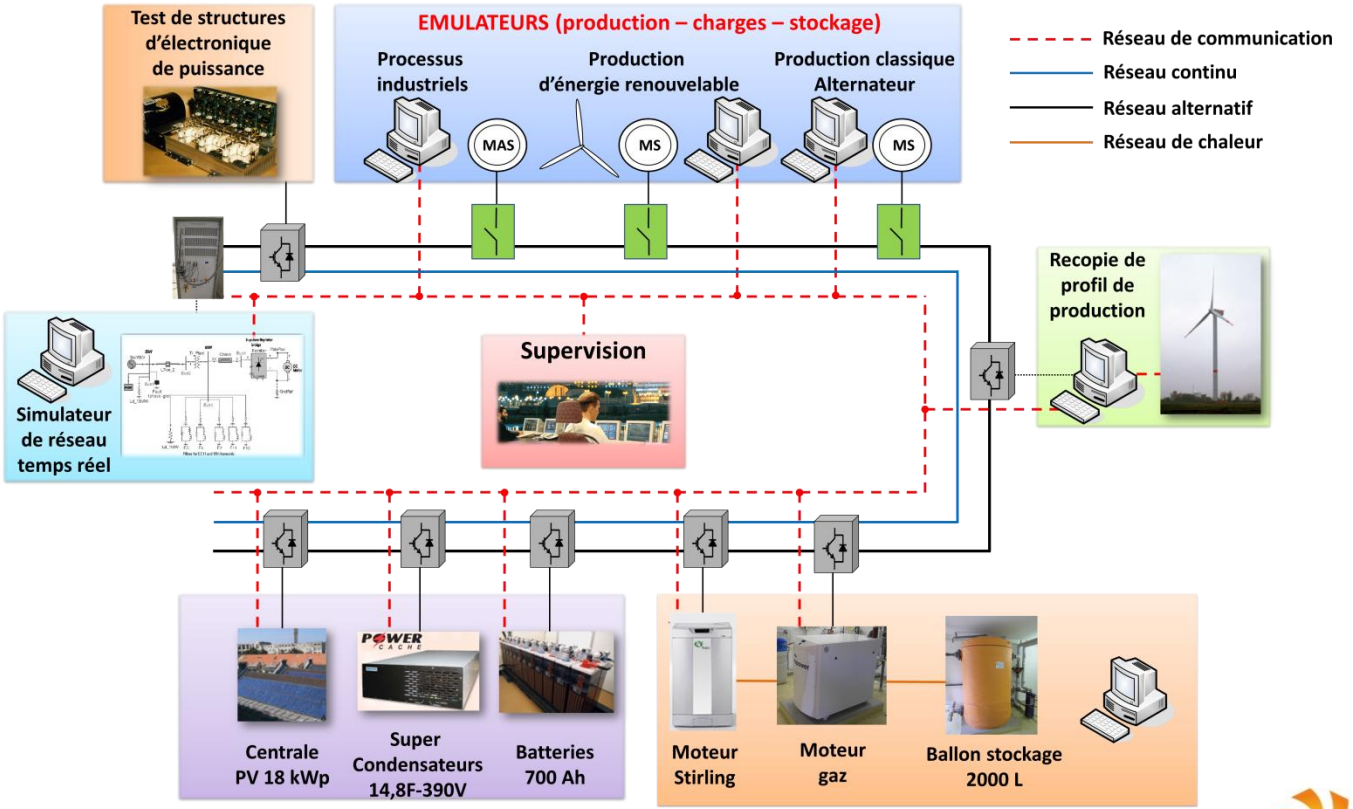
INTERNATIONAL SUMMER SCHOOL HIL 16

Outline

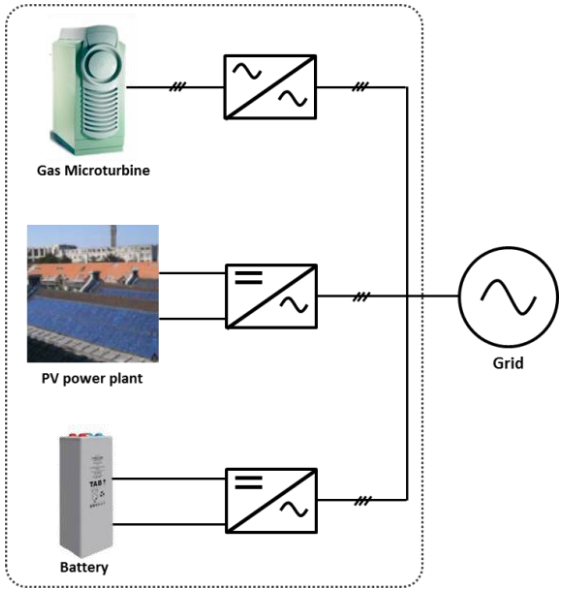
- Introduction – EPMLab short presentation
- Storage integration in island grid (Guadeloupe)
- EV charge control for distribution grid
- experimental MTDC grid

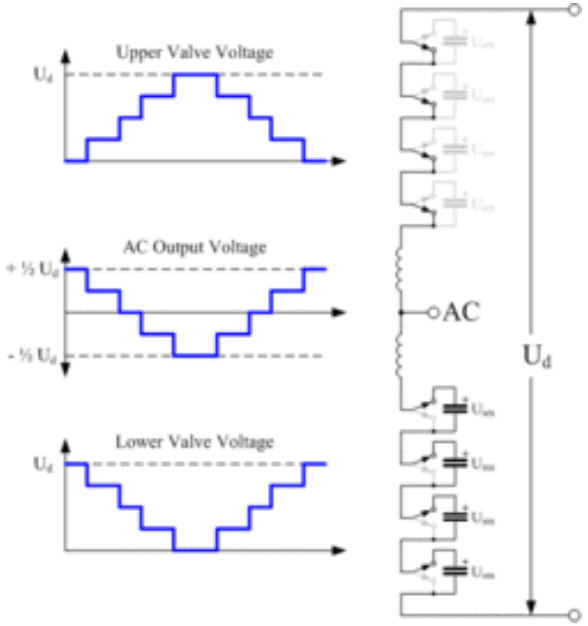
✓ *Description:*

- Open R&D environnement in the field of new types of energy conversion, generation and storage integration in power system based on an experimental grid and real time simulation.



- Hybrib power plant control
- Integration of New types of energy production in power system
- New types of energy conversion (i.e. power electronics)





Examples

=> 3 examples

- ✓ ***Storage integration in island grid (Guadeloupe)***
- ✓ ***EV charge control for distribution grid***
- ✓ ***Experimental Multi-terminal DC grid***

Examples

=> 3 examples

- ✓ ***Storage integration in island grid (Guadeloupe)***
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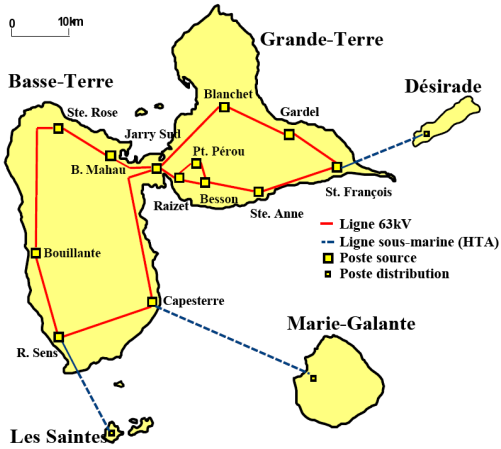
Island Grids :

- Weak Grid
- One grid operator (TSO+DSO)
- Fossil fuel power plant
- Integration of renewable energy distributed generation



Restriction factor to the integration of renewable energy generation

More and more of renewable energy

→ Reduction of the power system inertia

→ Primary reserve allocation problem

→ Fossil fuel Power Plant used on a non-optimal point
=> Pollution increase

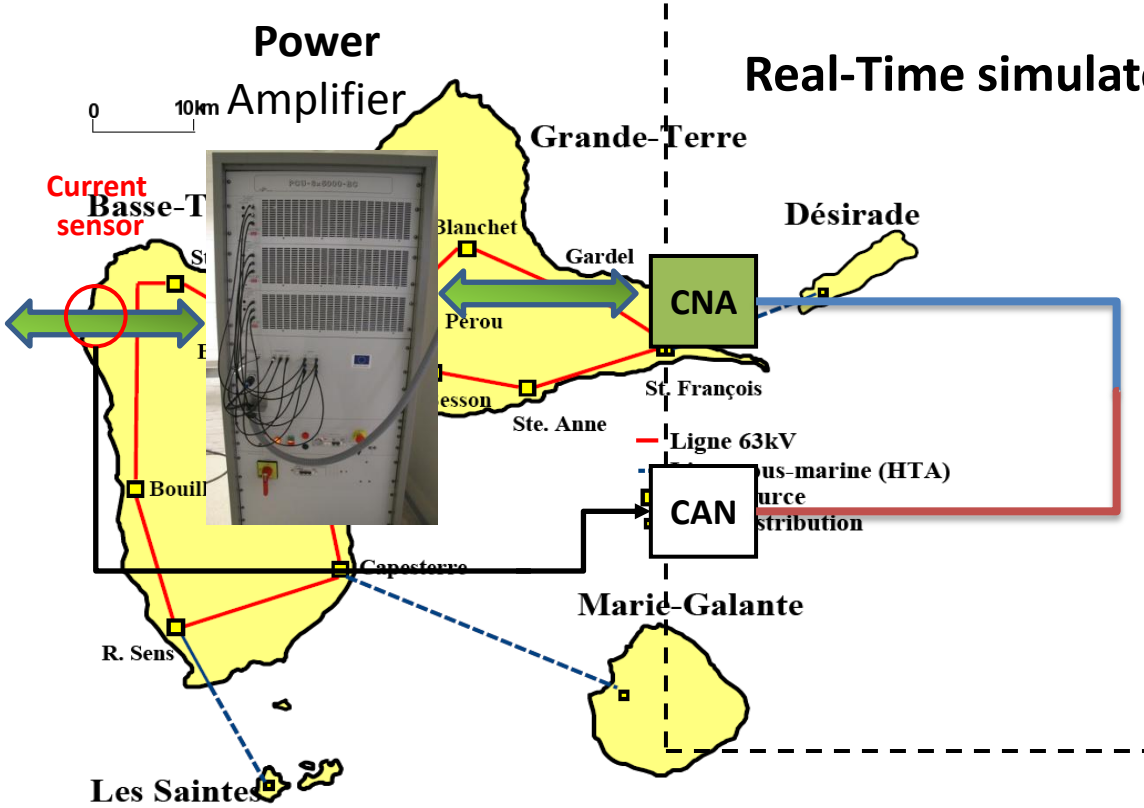
→ One solution : Connect DESS to the island grid

Scenario

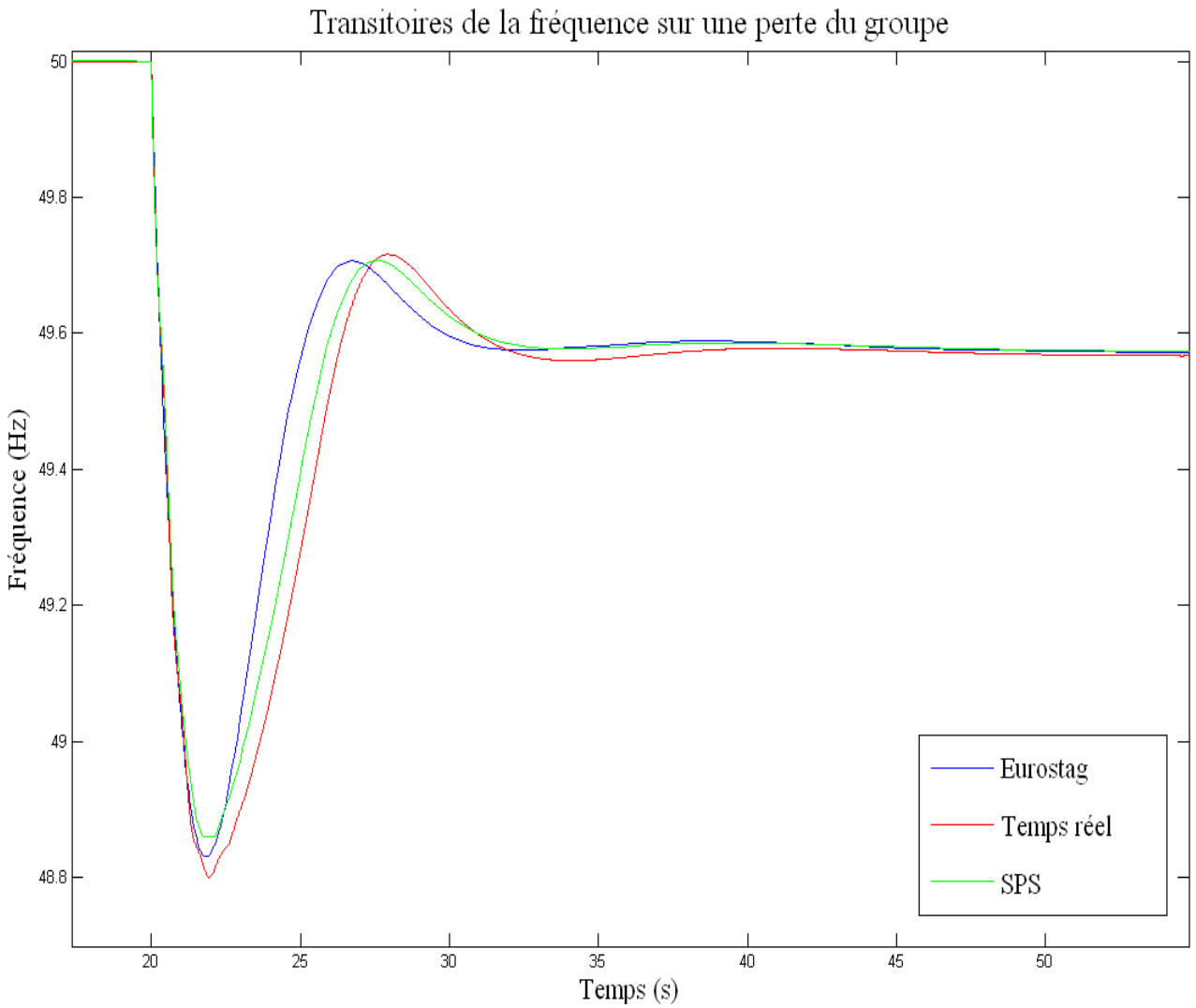
- ✓ Coal Power plant fault producing 22.7MW of a total consumption of 140MW
- ✓ Supercapacitor storage device virtual insertion in Sainte Anne substation

Storage objectives : Peak frequency and dynamic transient settling time reduction

Storage device insertion



Results


Transitoires de la fréquence sur une perte du groupe
Fréquence (Hz)
Temps (s)
50
49.8
49.6
49.4
49.2
49
48.8
20
25
30
35
40
45
50
Eurostag
Temps réel
SPS

Examples

=> 3 examples

- ✓ *Storage integration in island grid (Guadeloupe)*
- ✓ ***EV charge control for distribution grid***
- ✓ *Experimental Multi-terminal DC grid*

IVERD Project - Objectives

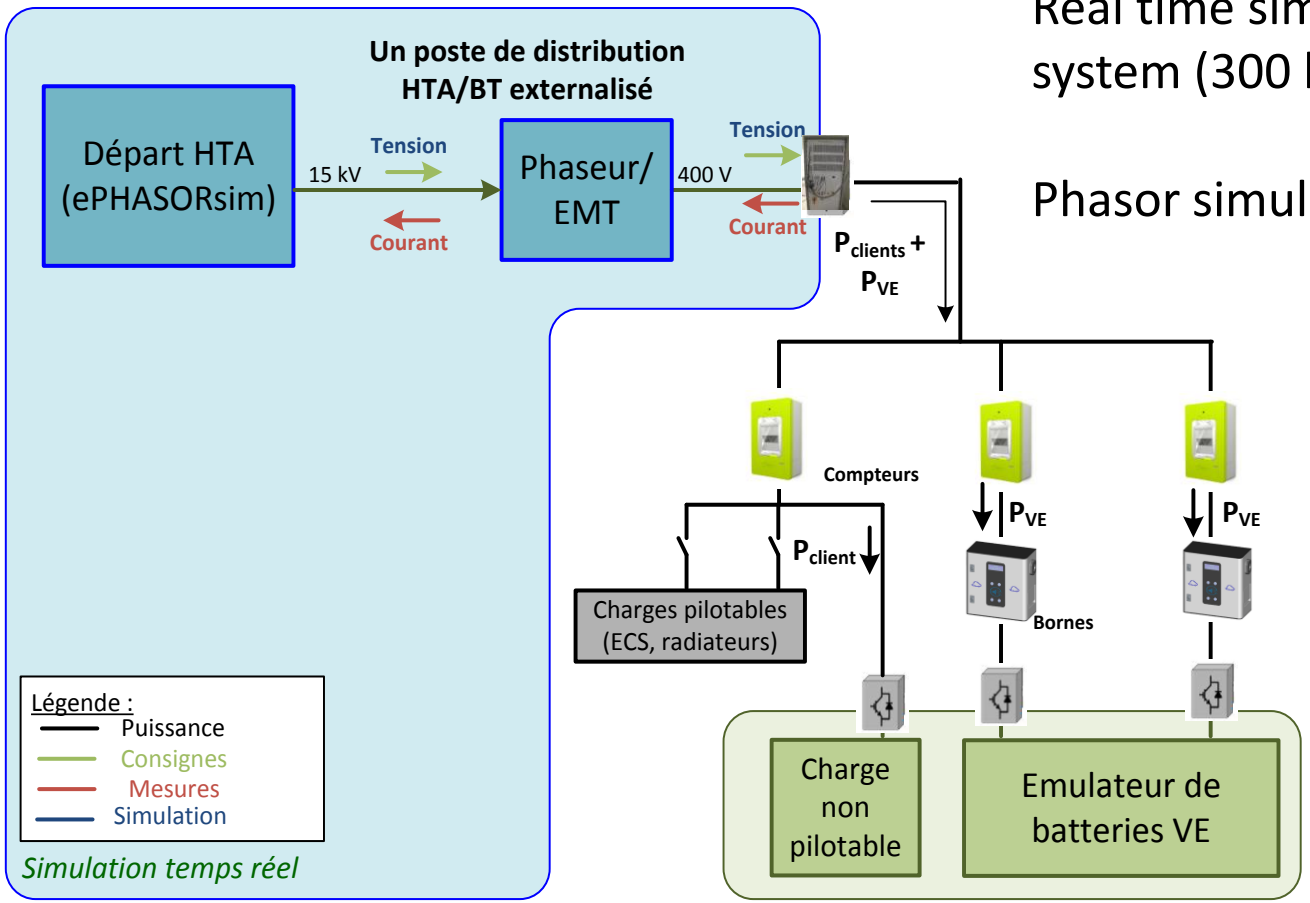
1/ Develop a supervisor for EVs chargers to

- **minimize costs of DSO, energy suppl**
- **Propose some ancillary services for Distribution grids**

2/ Build a demonstrator using PHIL principle and integrating real chargers controlled with smartmeters.

3/ test the proposed supervision strategies

✓ *EV integration in distribution grid (EV charge and load shedding…)*

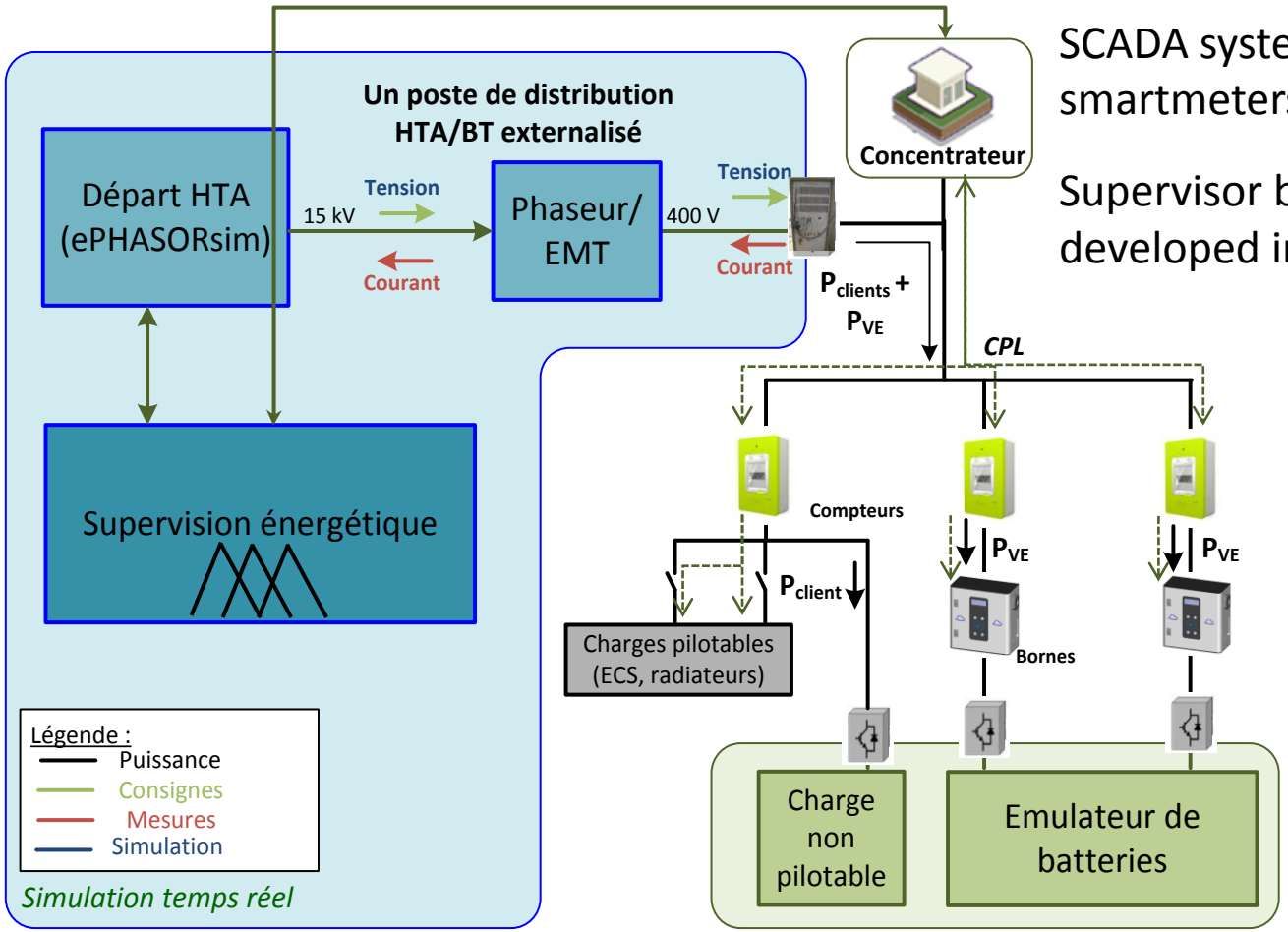


Real time simulation of distribution system (300 bus)

Phasor simulation mandatory

Phasor mode/EMT and Hardware interaction

✓ *EV integration in distribution grid (EV charge and load shedding…)*



SCADA system connected to smartmeters

Supervisor based on theory developed in our laboratory

Examples

=> 3 examples

- ✓ *Storage integration in island grid (Guadeloupe)*
- ✓ *EV charge control for distribution grid*
- ✓ ***Experimental Multi-terminal DC grid***

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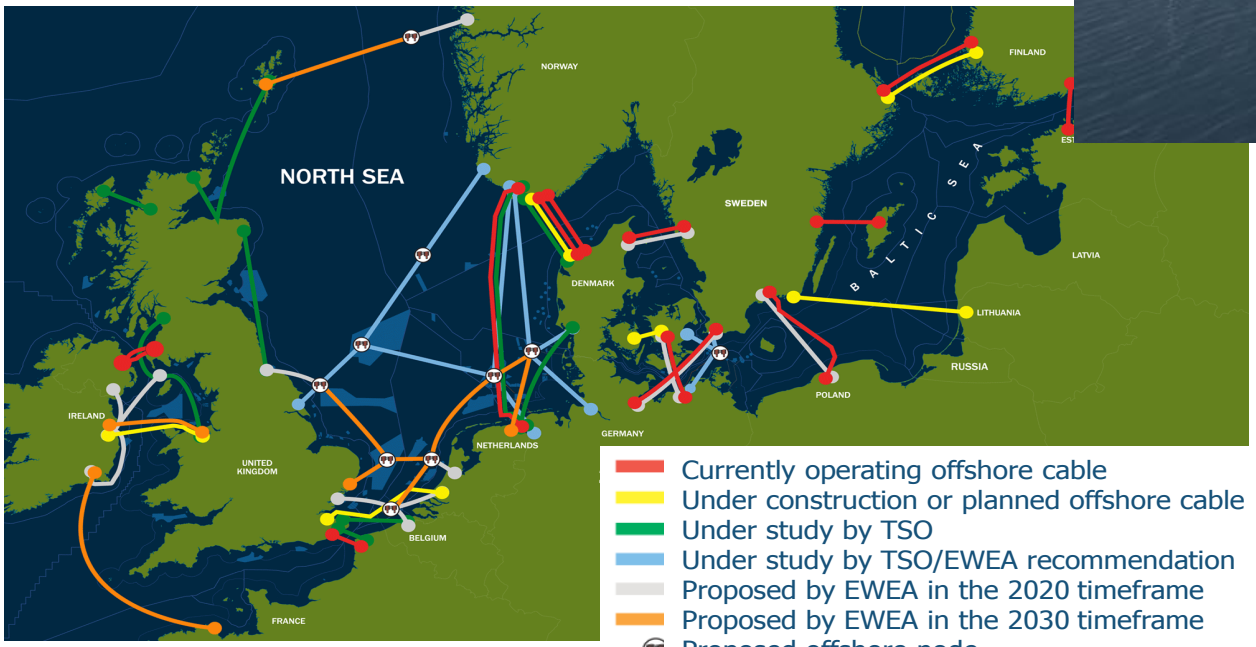
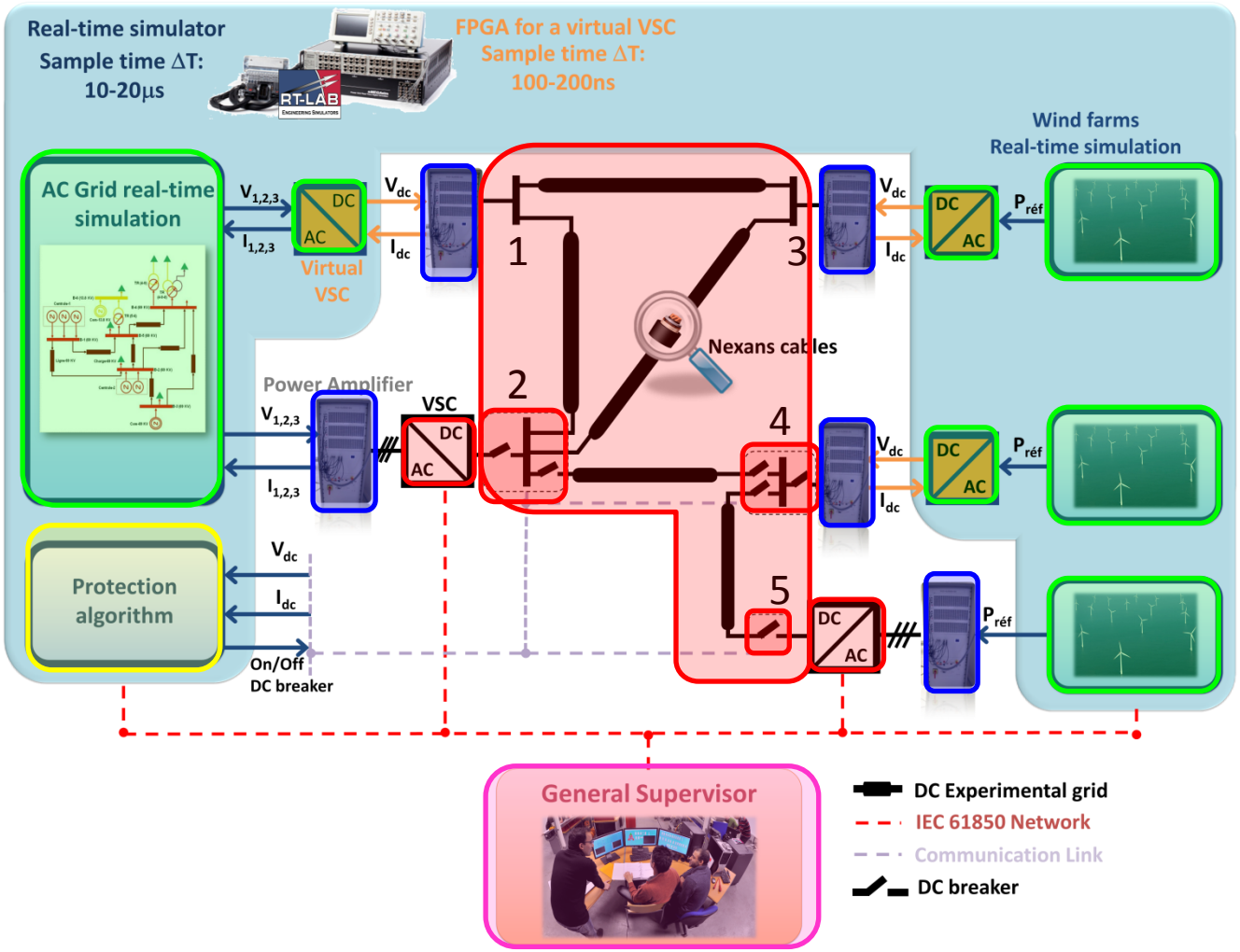
Demo – TWENTIES Mock-up

✓ *Context*



MTDC Mock-up



Characteristics

- Vdc = 250 V
- Idc = 10 A
- Uac = 125 V

Physical elements

- Low voltage DC grid
- Real VSC
- DC breakers

Simulated elements

- RT simulated VSC
- AC grids
- Wind farms

Interface

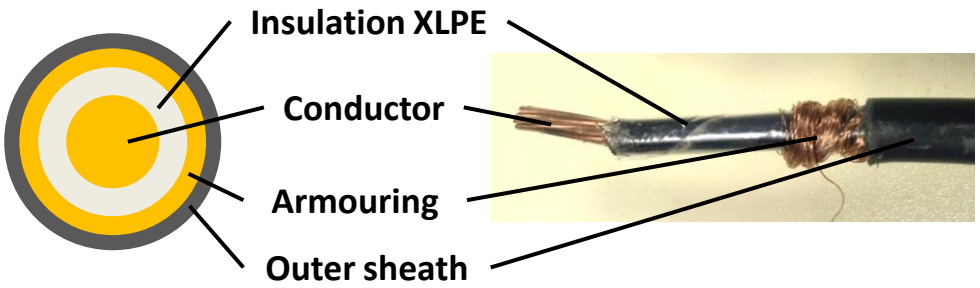
- Power amplifiers

SCADA System

- Coordinated control

Protection algorithm

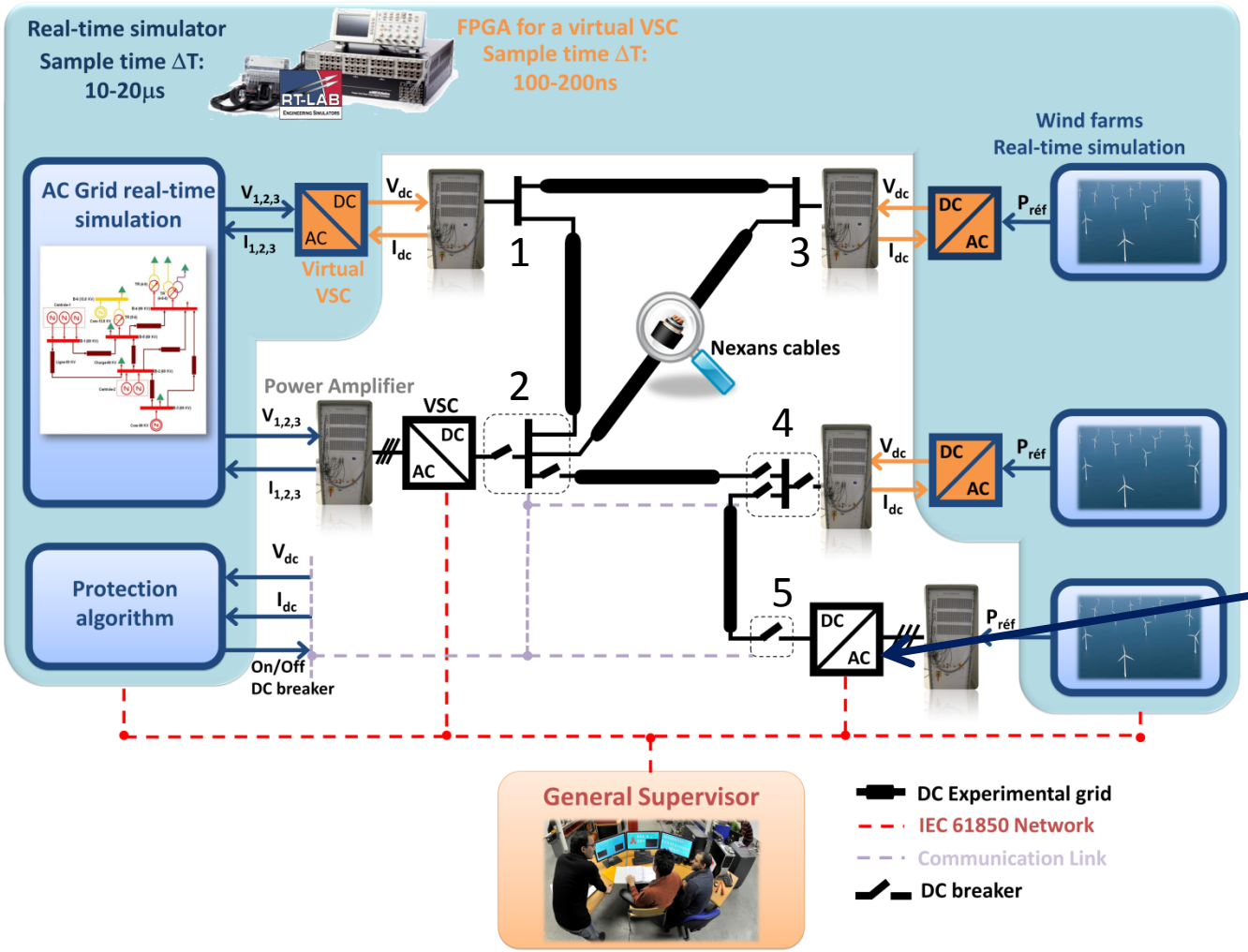
Low scale submarine cable delivered by Nexans
Total length = 15km



Copper Section 10mm²

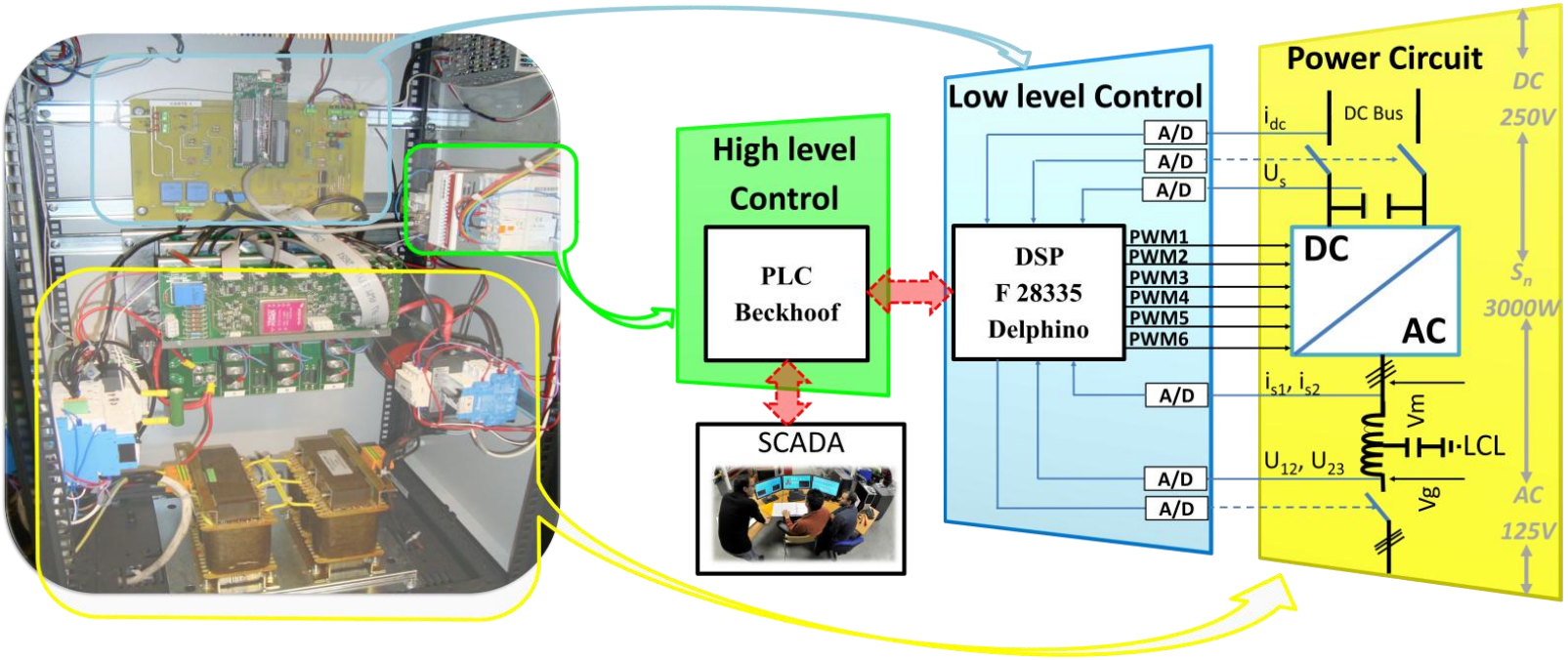
Copper Section 25mm²

General overview



Vdc = 250V, Idc_{nom} = 10A
Uac = 125V

Inverter design – Real VSC



High level control :

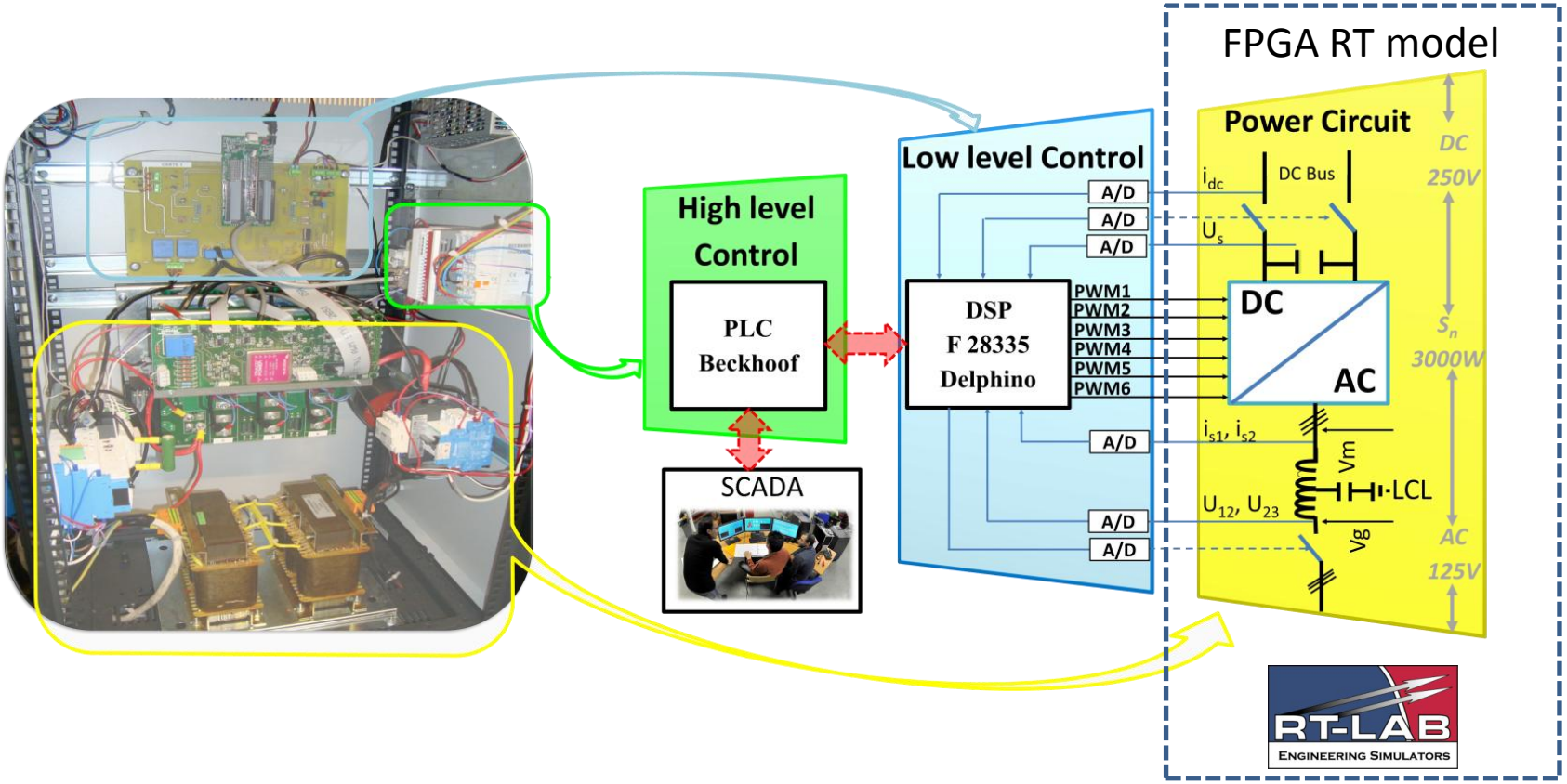
- Gateway to the SCADA system
- Initialization sequence

Low level control :

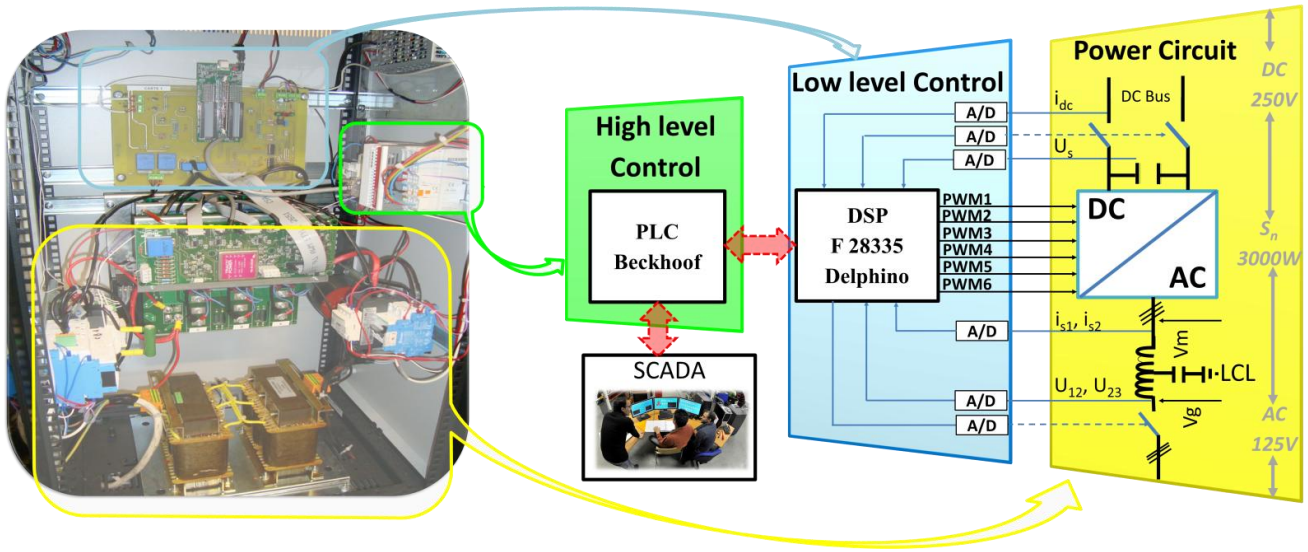
- Voltage and current loops
- PWM generation
- Over current and voltage software protection

Inverter design – Real VSC

Use of real time simulation to design and test the real VSC Control algorithm



Inverter design – Real VSC

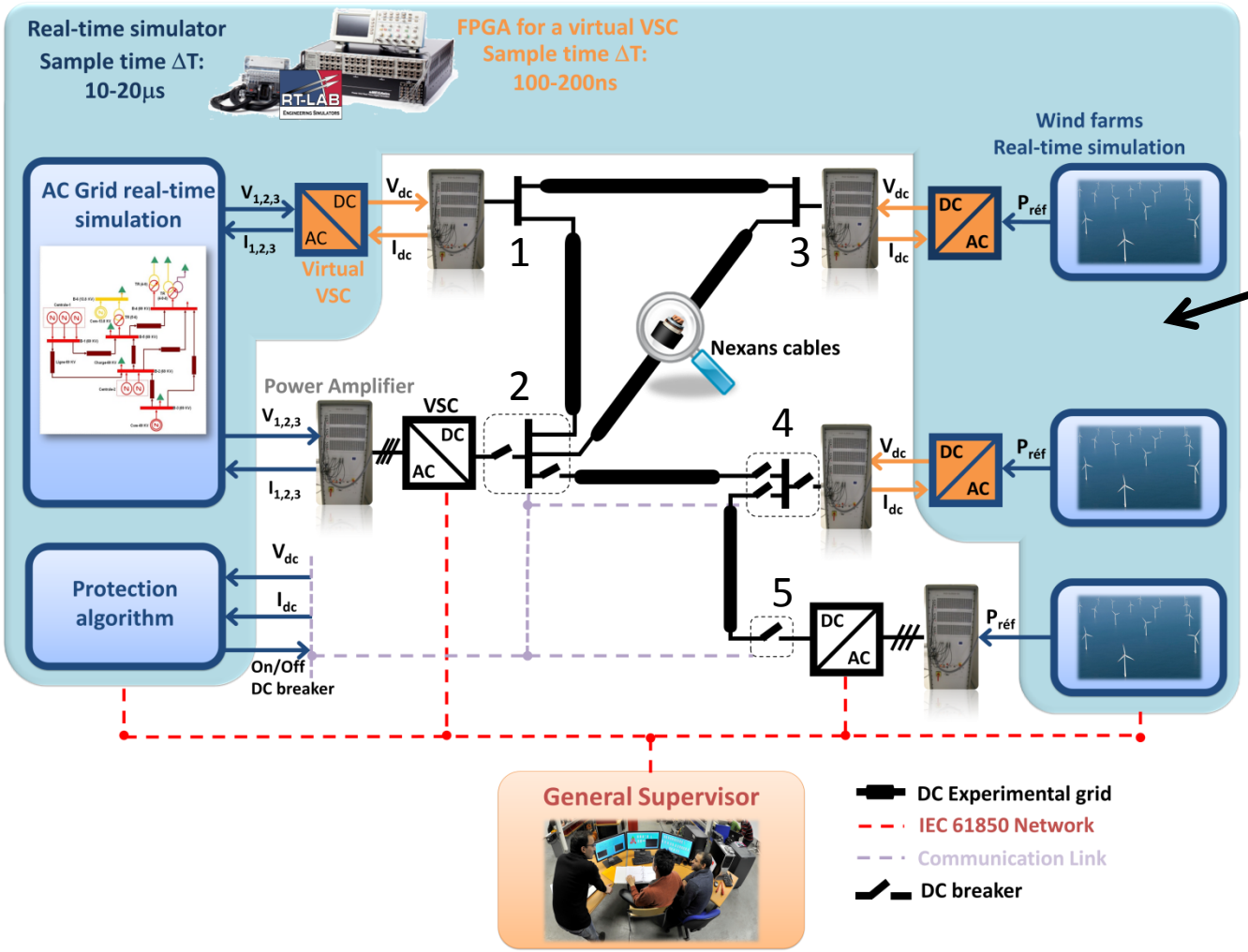


- ✓ Totally homemade and remote controlled

3 Operating Modes:

1- Slave Mode
2- Master Mode
3- Droop Mode

General overview



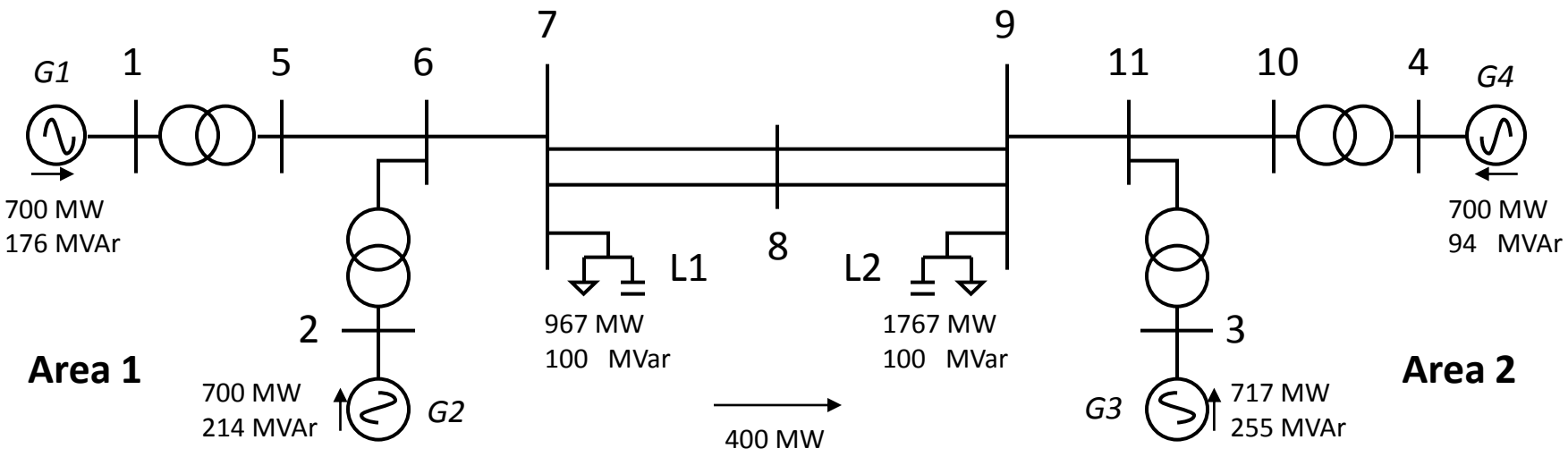
Vdc = 250V, Idc_{nom} = 10A
Uac = 125V

AC Grid And Windfarms simulation

Simulated AC Grid

Kundur power system

- ✓ 2 areas
- ✓ Primary frequency and voltage control
- ✓ Each group has a PSS



Simulated in Real Time
Time step = 25µs

RT-LAB ENGINEERING SIMULATORS

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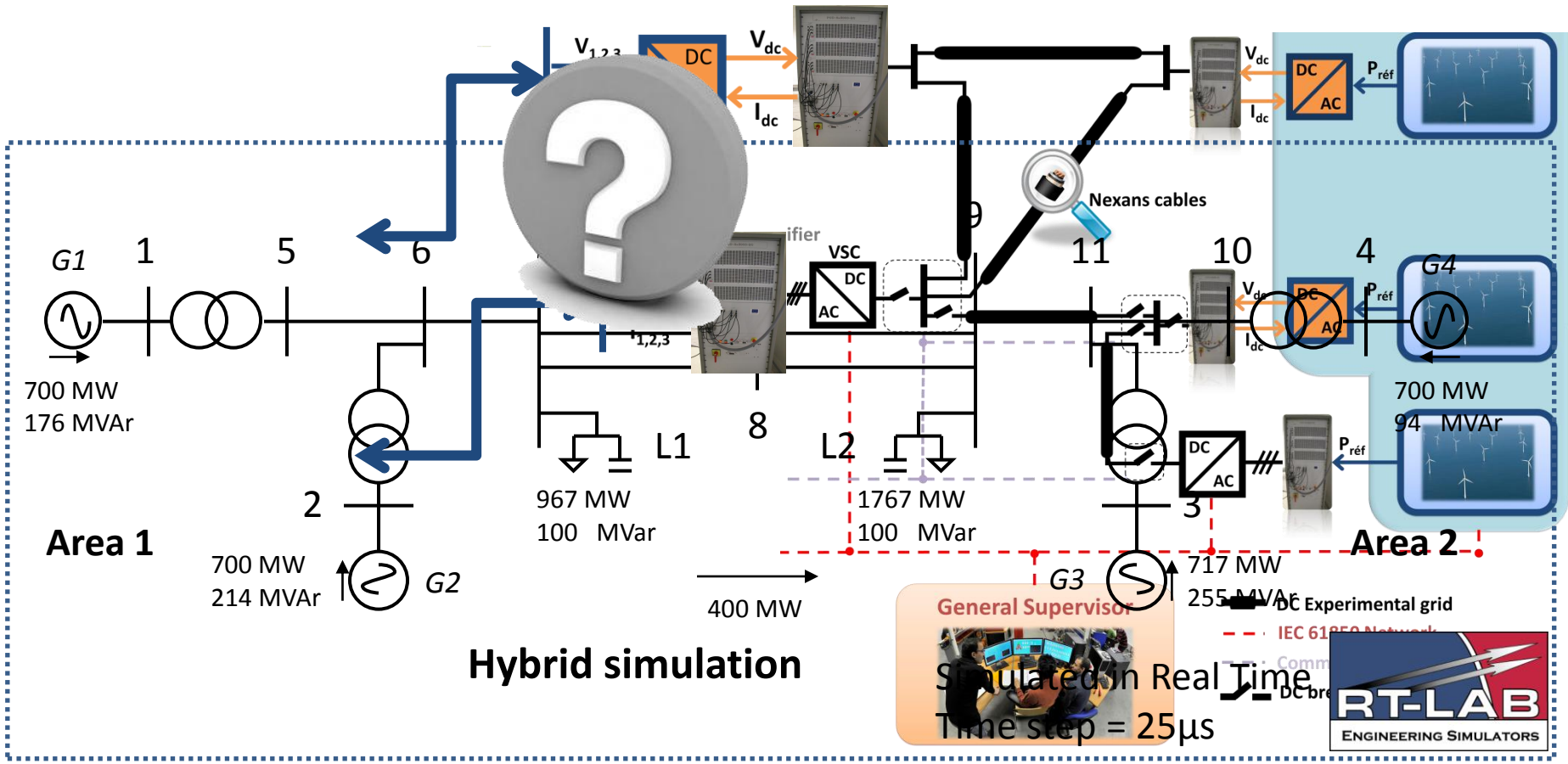
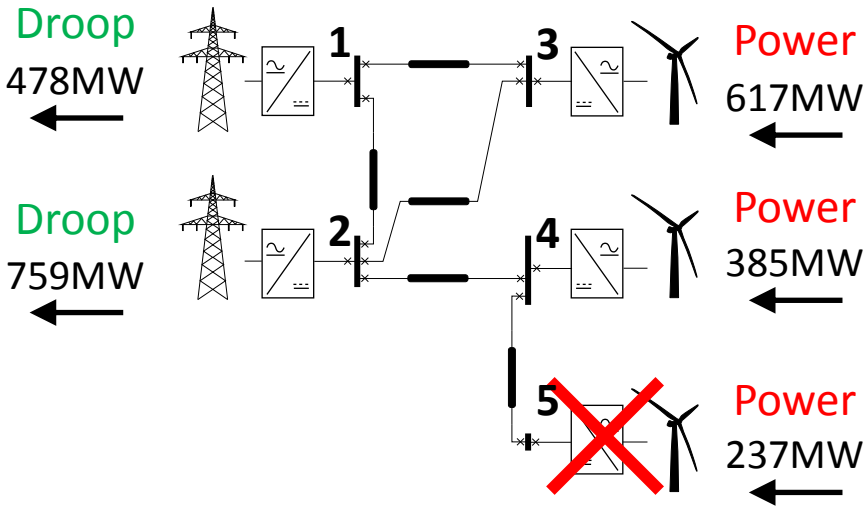
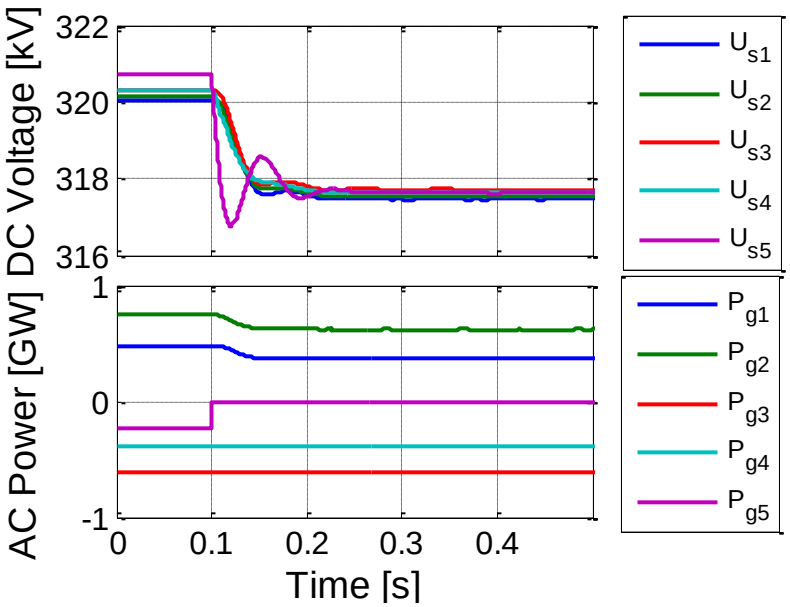
Simulated AC Grid



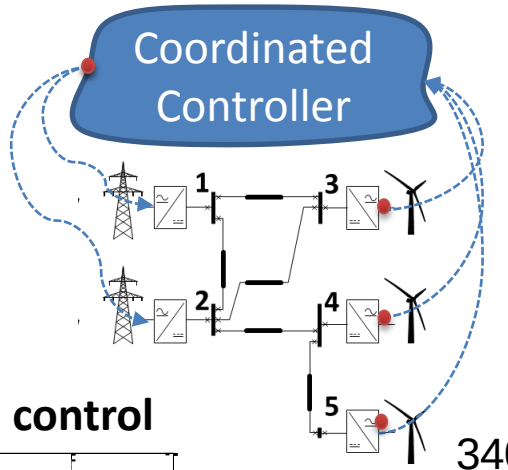
Local control strategy
Ex : Droop Control

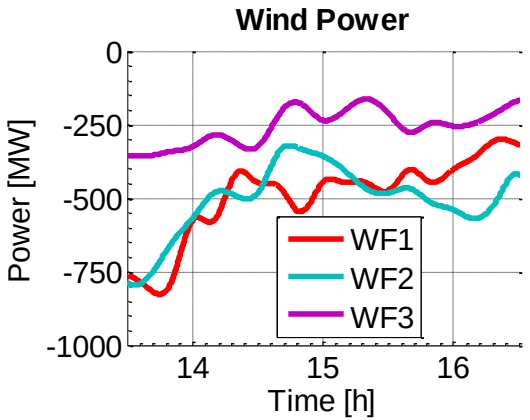
- **DC voltage deviation**
- **Power deviation is shared between 1 & 2**

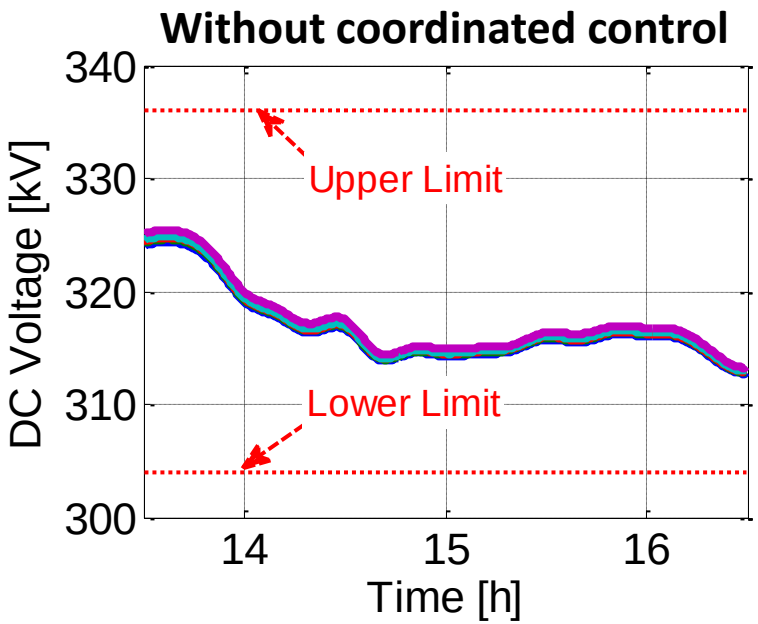


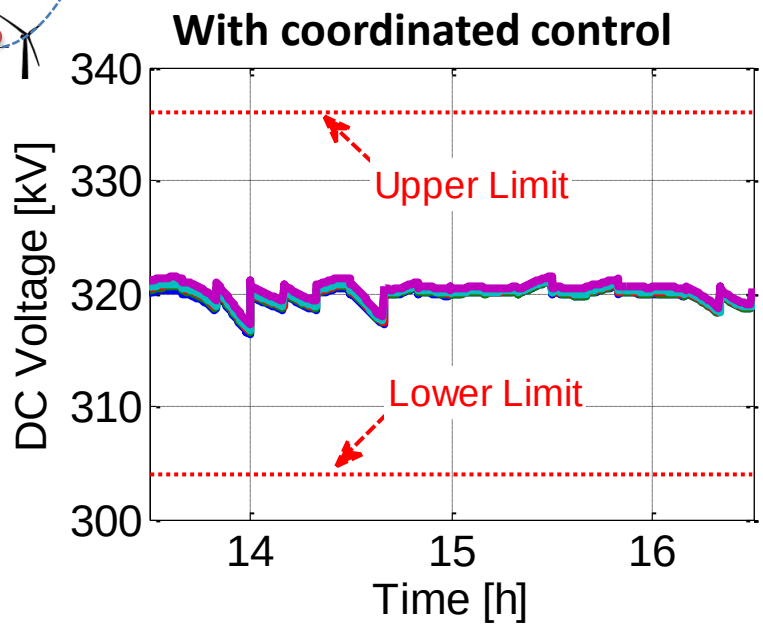


High level control strategy
Ex : Coordinated Control









Perspectives

- Integration of 2 MMC in the MTDC grid

- Integration of a fault tolerant DC/DC converter designed by Aberdeen and Barcelona university

Thank you for your attention

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cinergia

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Rte