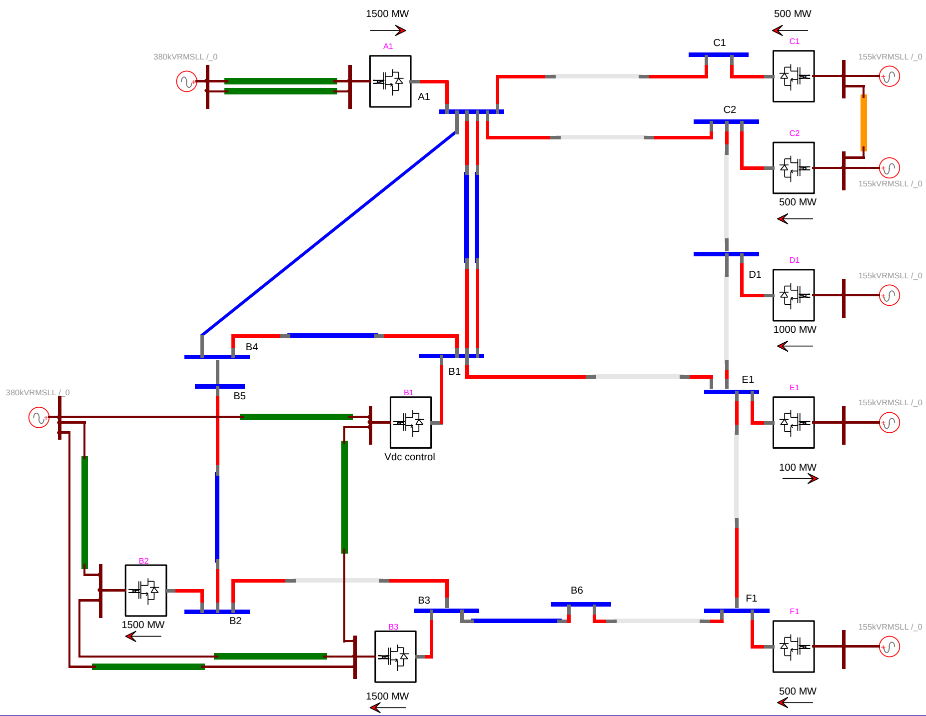
Réseau de transport d'électricité



DC grid modeling with EMTP-RV

Sébastien Dennetière – Rte / National Center for Grid Expertise

EMTP-RV User Group Meeting

April 3, 2012

PRESENTATION LAYOUT

01. HVDC Grid – Context & Requirements
02. Available models in EMTP-RV
03. Next step : HVDC Grid CIGRE Benchmark

01

HVDC Grids
Context and requirements

HVDC Grids

Context

New contraints

- Increase in renewable power generation
- Increase in power trade across national borders
- Impossible to get permission to build new overhead lines

Technologies opportunities

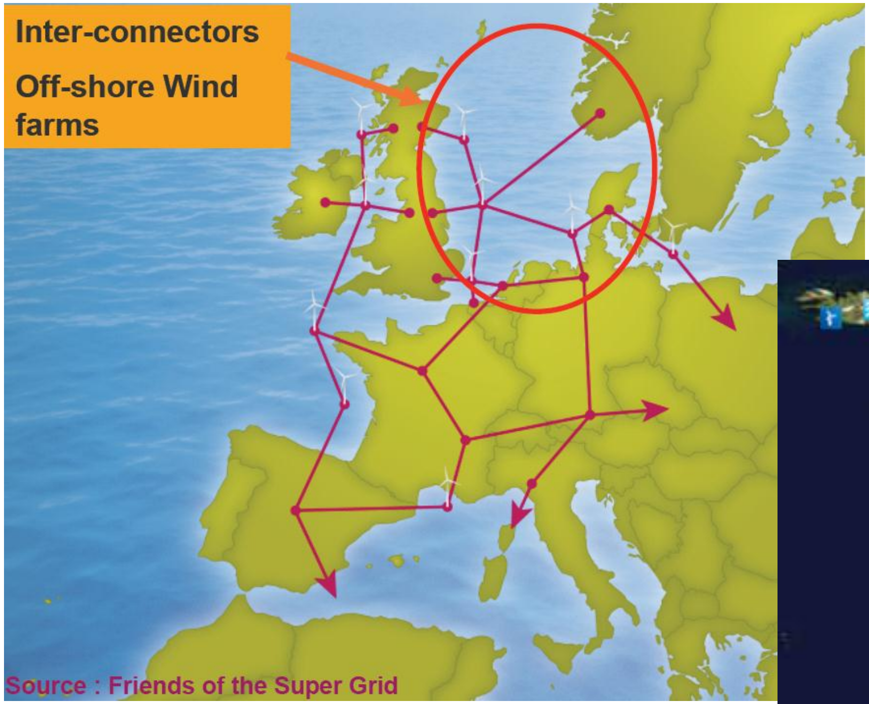
- VSC HVDC Transmission well suited to DC Grid : change of power direction does not require a change of polarity
- Smaller footprint of VSC → well suited to offshore platform

Organisations to support the development of DC grids :

- Friends of SuperGrid
- MedGrid
- TWENTIES
- …

HVDC Grids

Concepts



Rte Réseau de transport d'électricité

HVDC Grids

Main challenges

Power flow control

- Each converter can control on DC side : P or Vdc
- Which converters will act as a slack bus (Vdc control) ?
- Global dispatcher is required

Models for phasor domain studies : load-flow and transient stability

Very fast protections system and DC Circuit Breakers

- DC fault currents : higher magnitudes and steeper derivatives (only R)
- Initial transient mainly consists of capacitive discharging → very high amplitude
- Fast detection and tripping with DC CB(< 5ms)

Detailed models for EMT studies

Need for standardisation and functional specifications

- DC grids will grow organically
- Converters from different manufacturers
- Functional specifications : DC fault withstand requirements
  - Insulation co-ordination on DC side
  - DC Grid master control
- Dynamic Performance Studies with control systems of every manufacturers…

Detailed and protected models for offline and real-time EMT studies

DC Grids modeling

Rte involvement

TWENTIES : European R&D project

- http://www.twenties-project.eu
- Rte proposed and developed in EMTP-RV a HVDC grid model
- A scale-down HVDC grid prototype will be built in 2012 and connected to a real-time simulator

CIGRE B4 Study Committee :

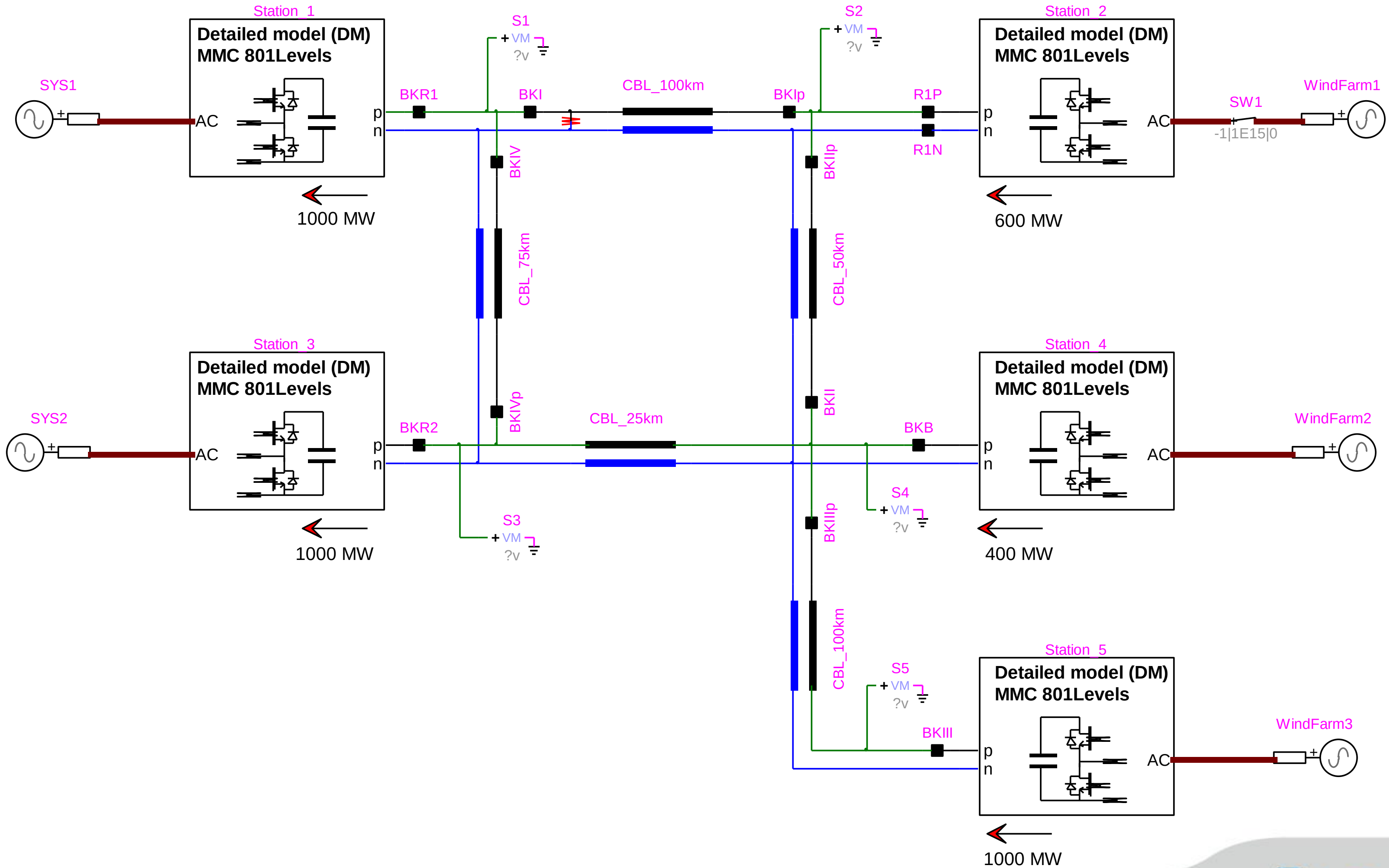
- In 2009 WG B4-52 “HVDC Grid Feasibility Study”
- In 2011 :
  - B4-56: Guidelines for the preparation of “Grid Codes” for HVDC Grids
  - **B4-57**: Guide for the development of models for HVDC converters in a HVDC grid
  - B4-58: Load flow control and direct voltage control in a meshed HVDC Grid
  - B4-59: Protection of HVDC Grids
  - B4-60: Designing HVDC Grids for Optimal Reliability and Availability performance.

02

Available models

HVDC Grid

Test System Description



Rte
Réseau de transport d'électricité

5-node test system

Model description

Converters

- MMC 801 levels (400 Submodules / valves)
- Upper level control system : standard VSC control
- Low level control system :
  - Circulating Current Suppressing control,
  - Modulation techniques (Nearest level control),
  - Capacitor Balancing Control.

Cables

- Frequency dependant cable models (phase domain)

Wind Farms and AC grid

- Models based on Thevenin equivalent
- Detailed models (DFIG and Full converter) will be included in 2012

Available Converters Models

2 EMTP-RV models

First model : Full detailed model (reference model)

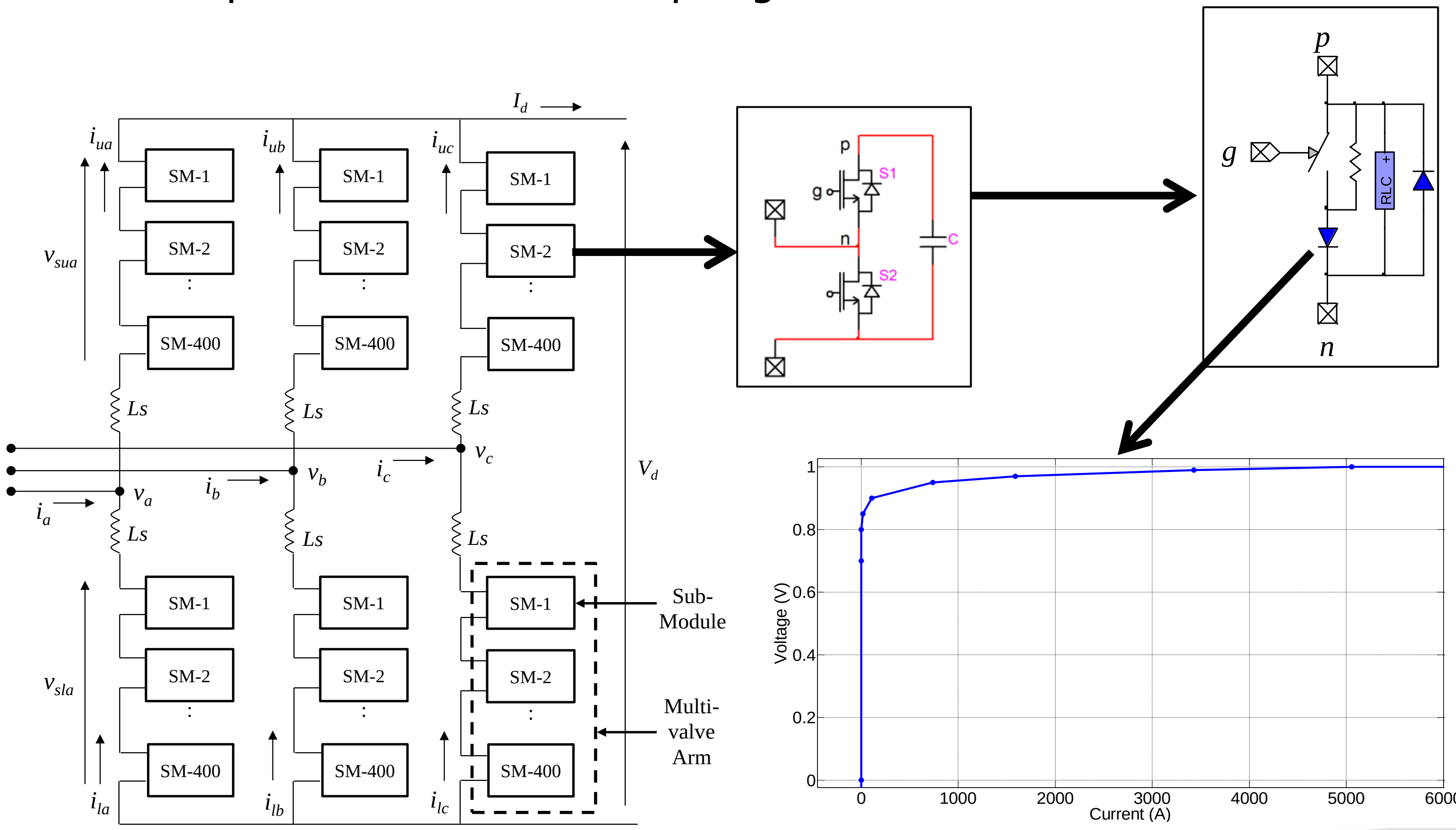
Second model : Detailed equivalent model

Third model : Average value model

Available models

Full detailed model

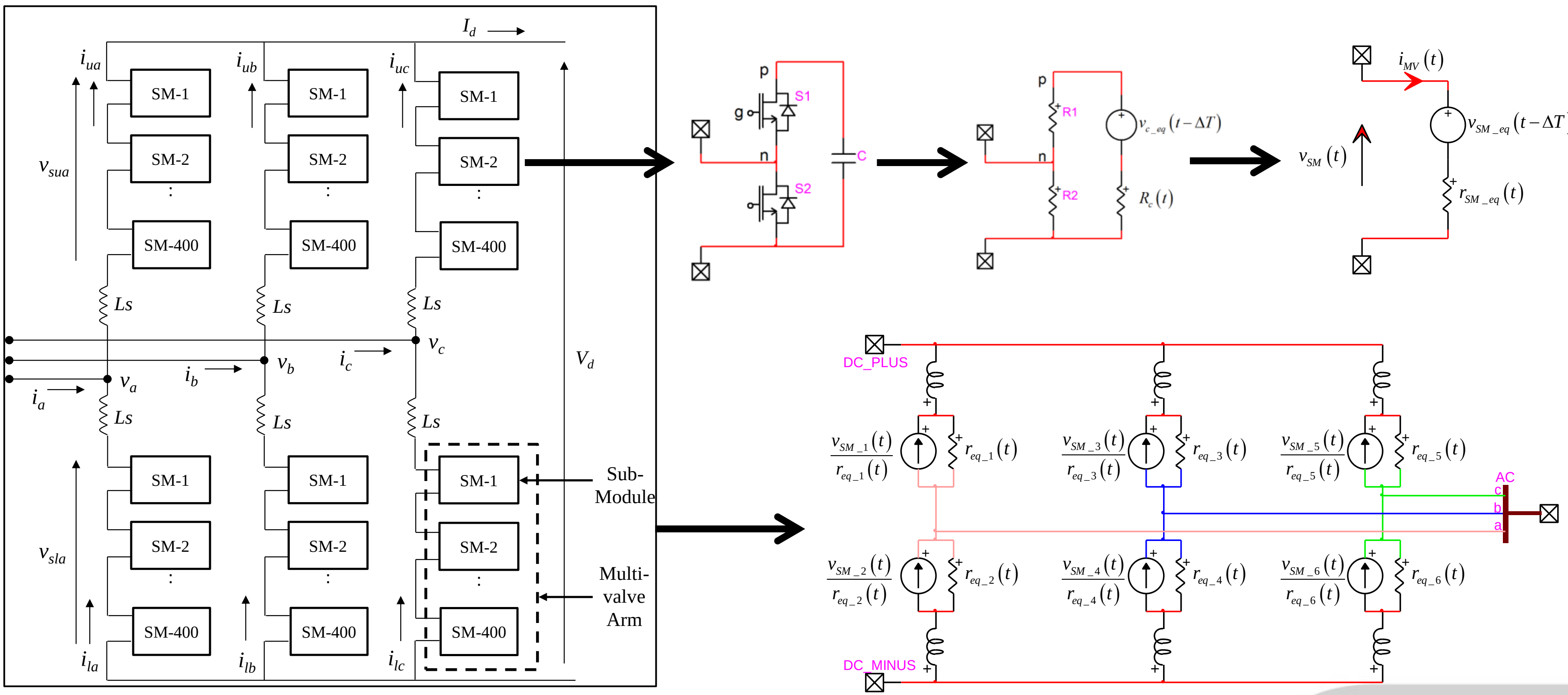
Description from converter topologies to semi conductors



Available models

Detailed equivalent models

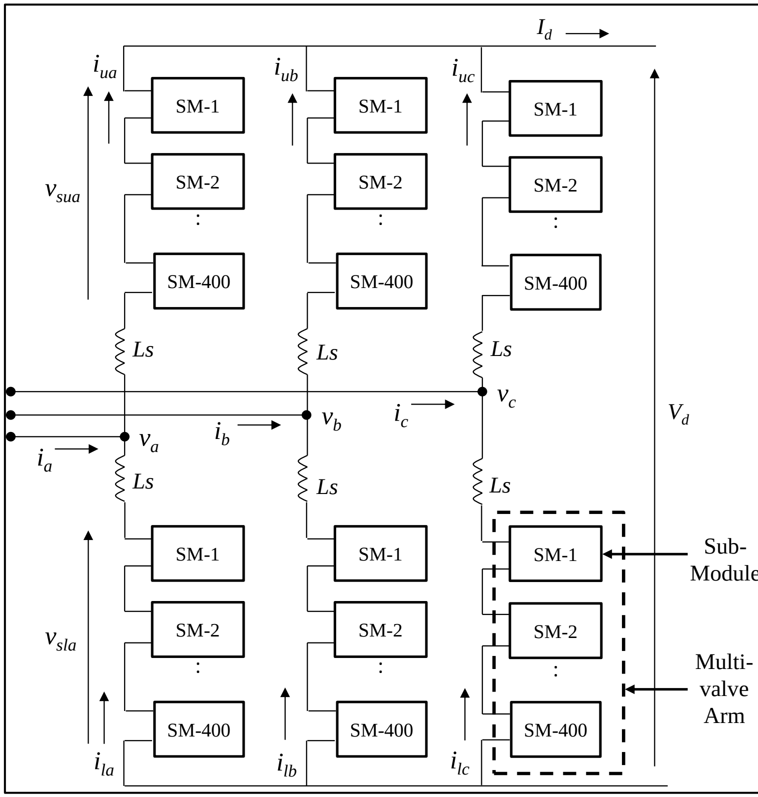
A solution to limit electrical nodes in converter



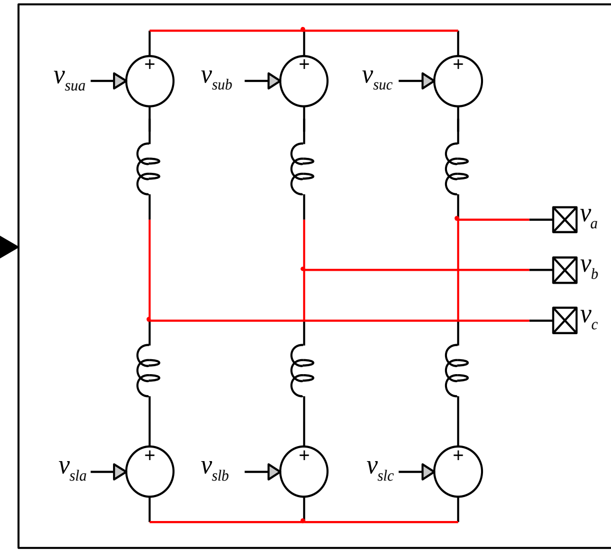
Available models

Average value model

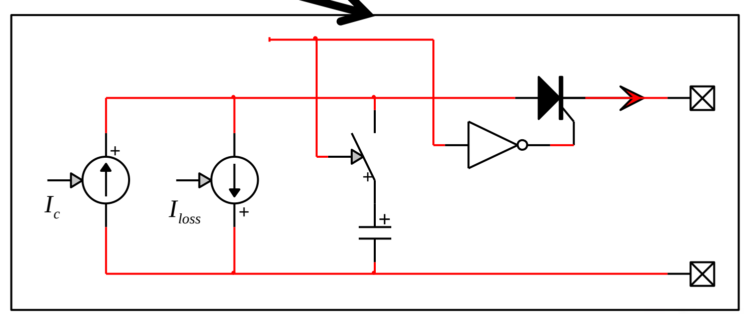
To get a fast solution only valid on AC side



on AC side



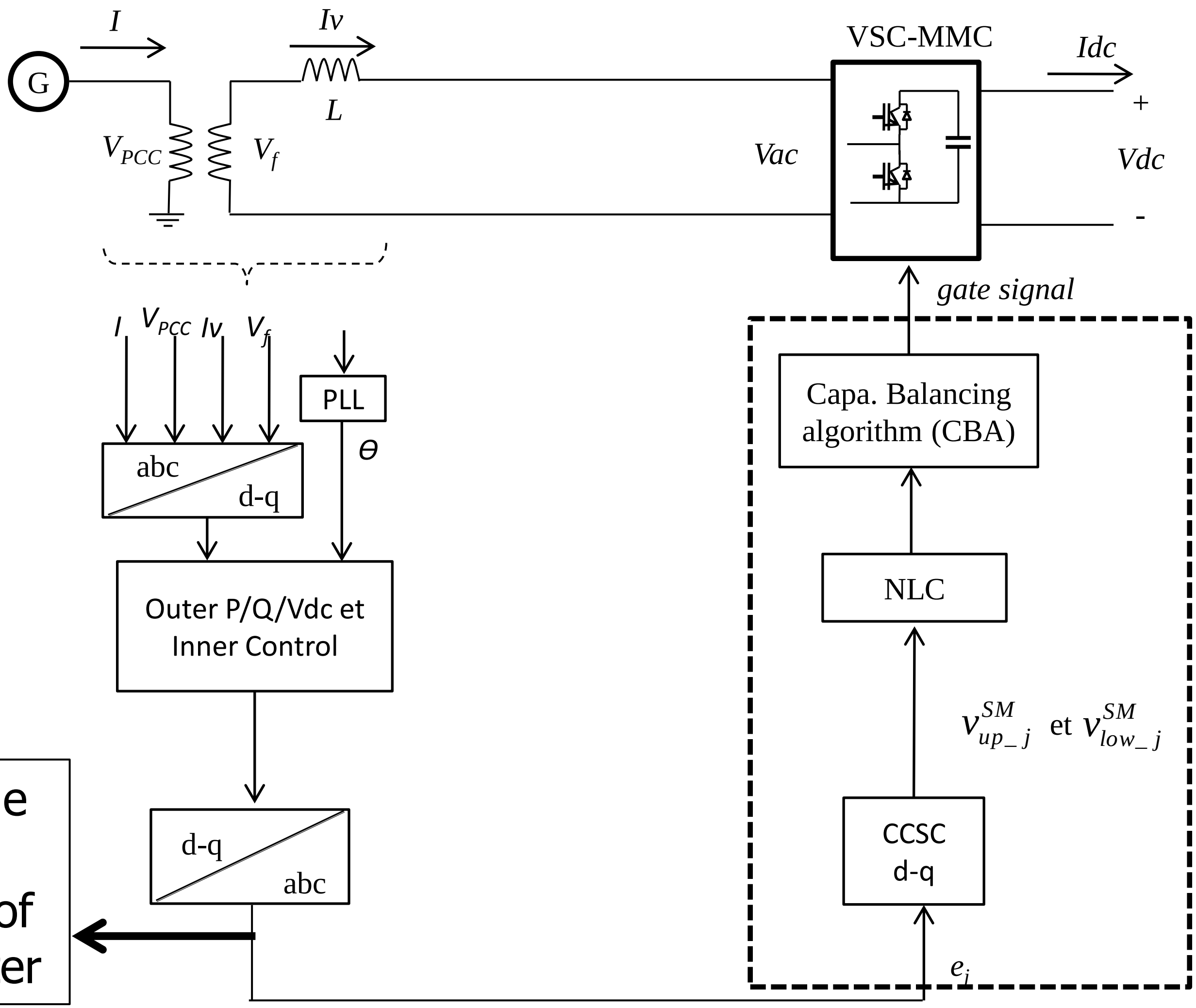
on DC side



Rte Réseau de transport d'électricité

Available models

Same control system for every models



Average Value Model of converter

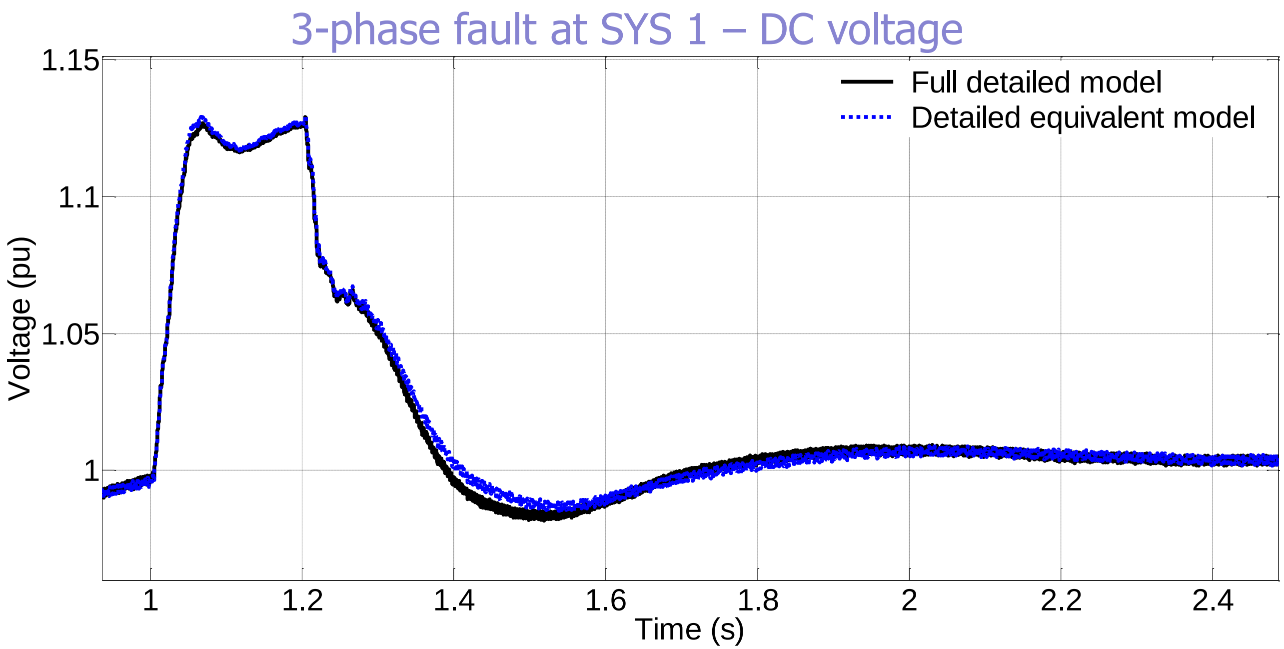
Modeled in Simulink and connected to the EMTP-RV model with the DLL based interface

Models comparisons

Detailed equivalent model vs full detailed model

Simulation timings for a 3 s simulation (Time step : 40µs) :

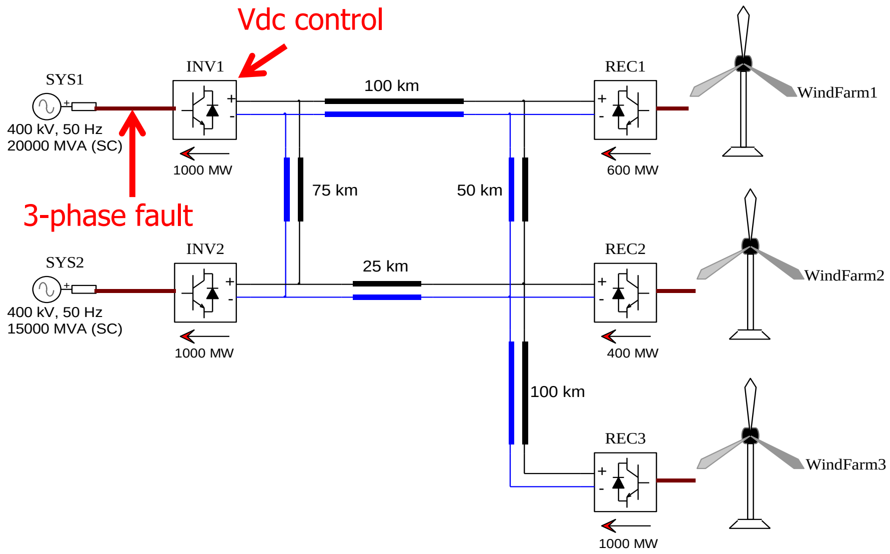
- Detailed equivalent : ~3min
- Full detailed : ~500 min

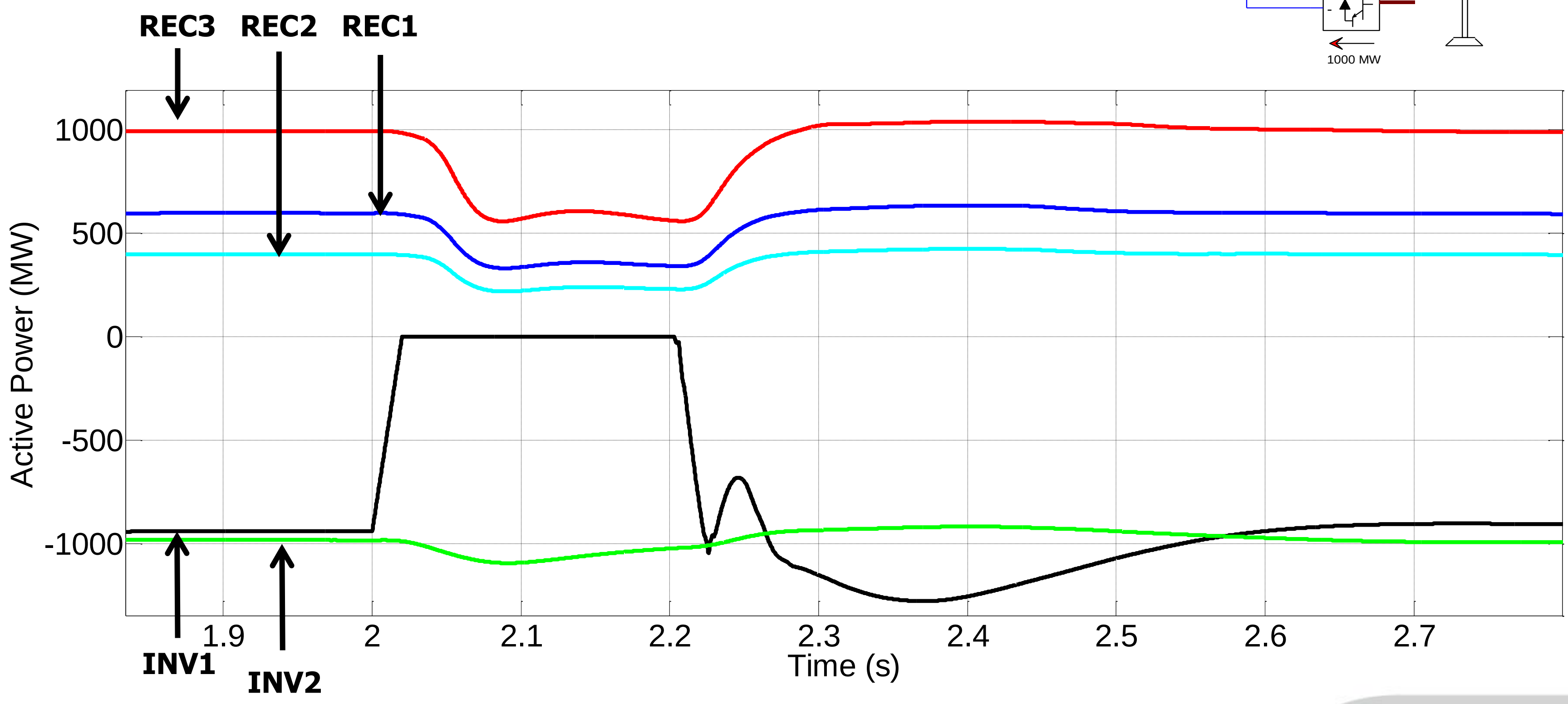


Rte Réseau de transport d'électricité

Simulation results

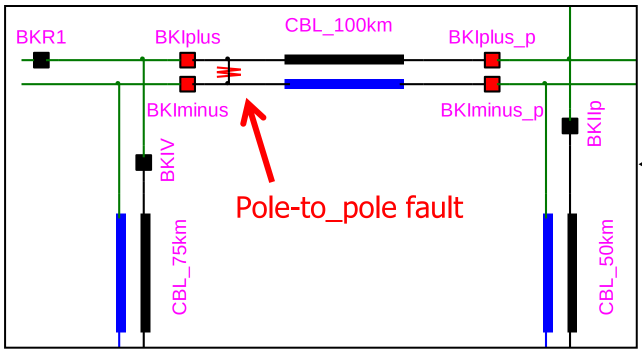
3-phase fault at SYS1

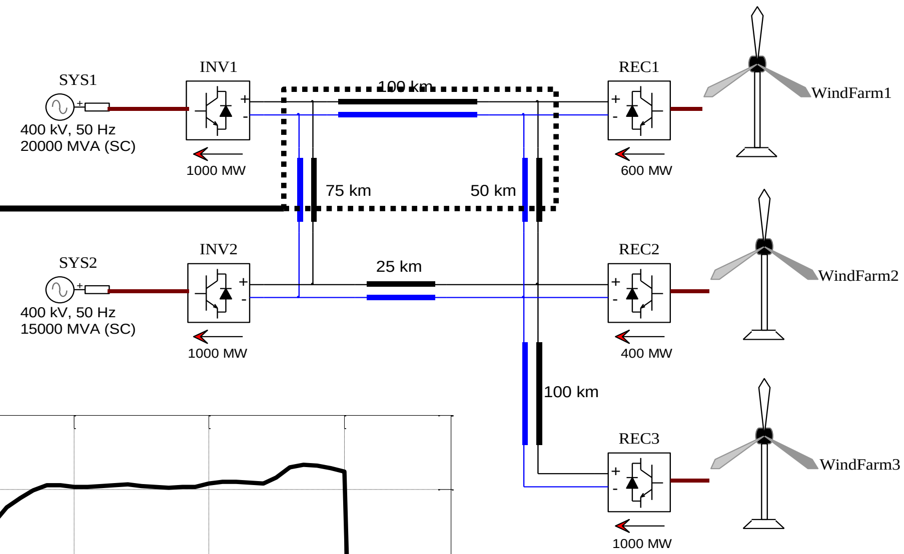


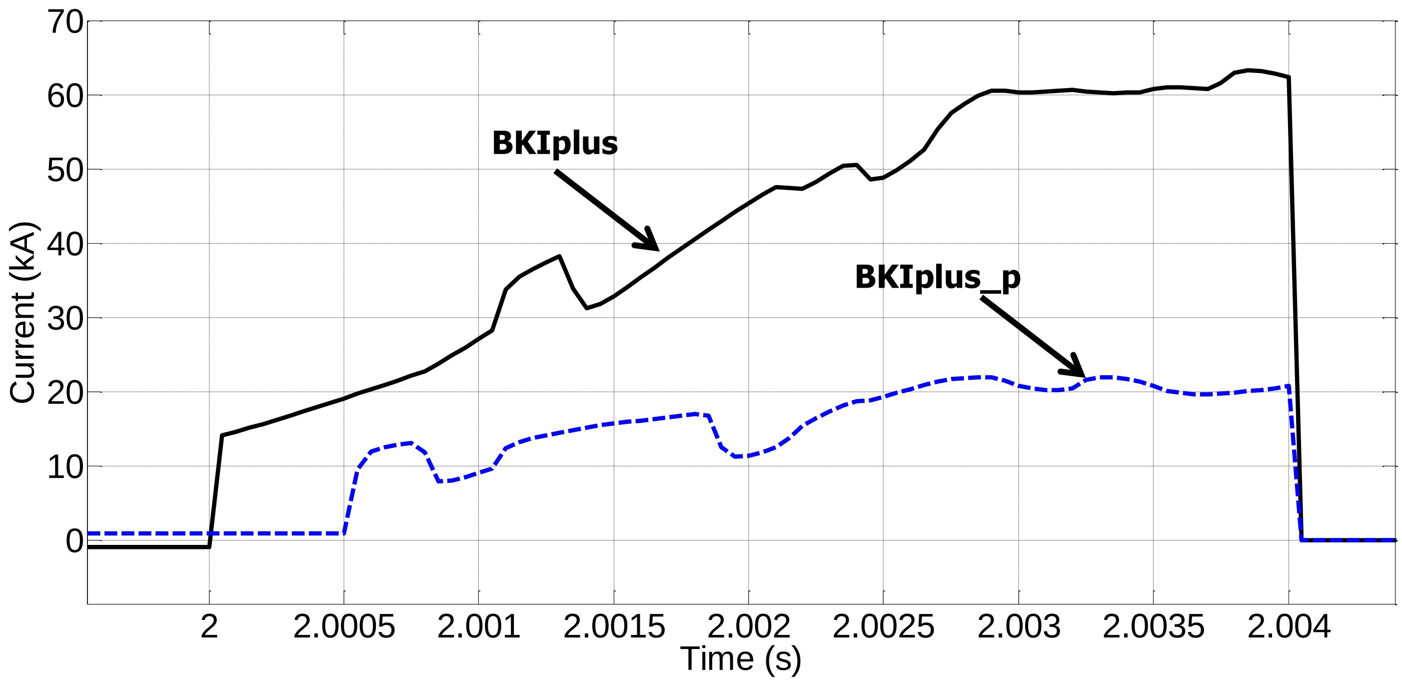


Simulation results

DC fault







DC CB are modeled by ideal switch

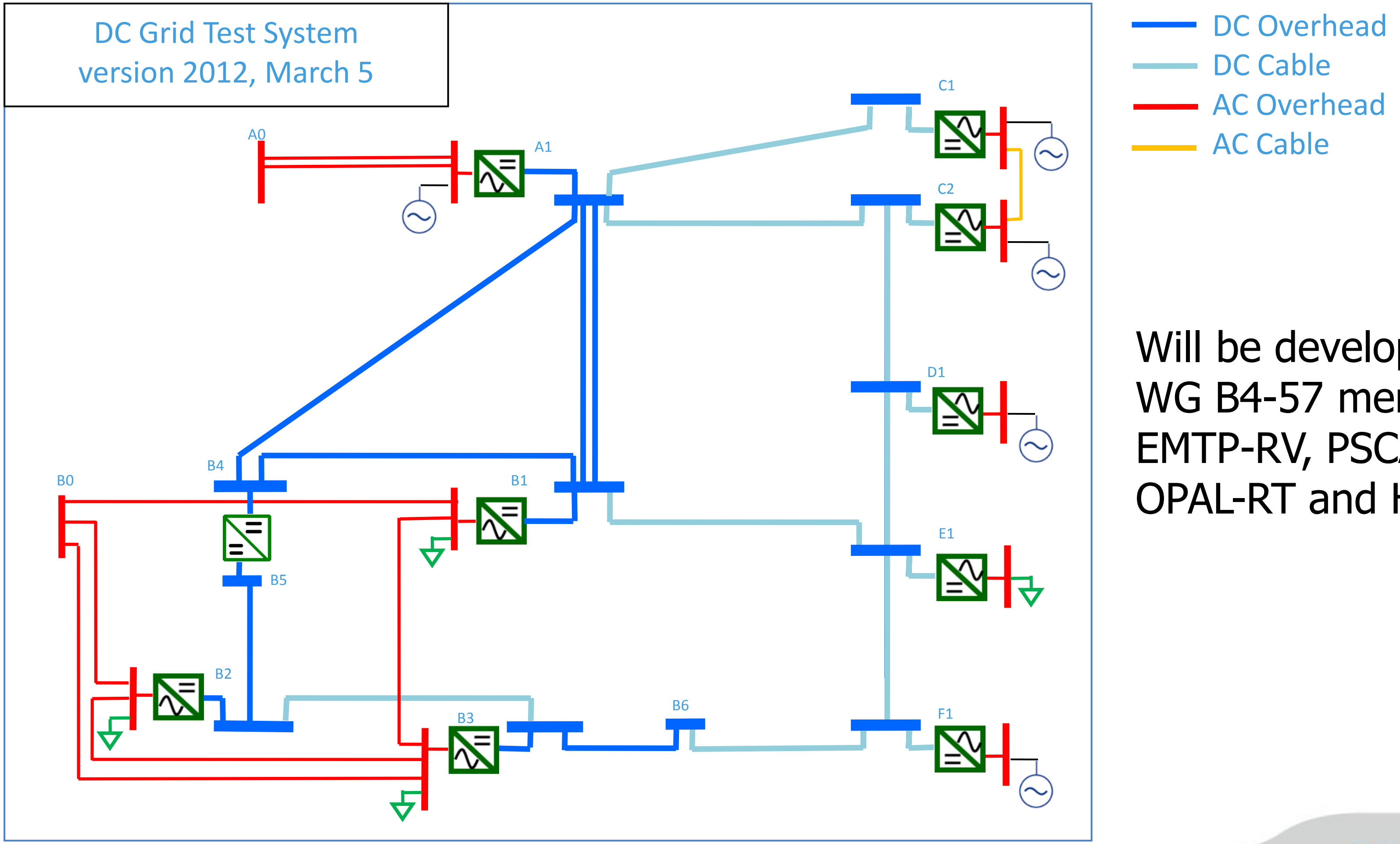
03

Next steps
HVDC Grid CIGRE Benchmark

HVDC grid CIGRE Benchmark

Defined by CIGRE WG B4-58

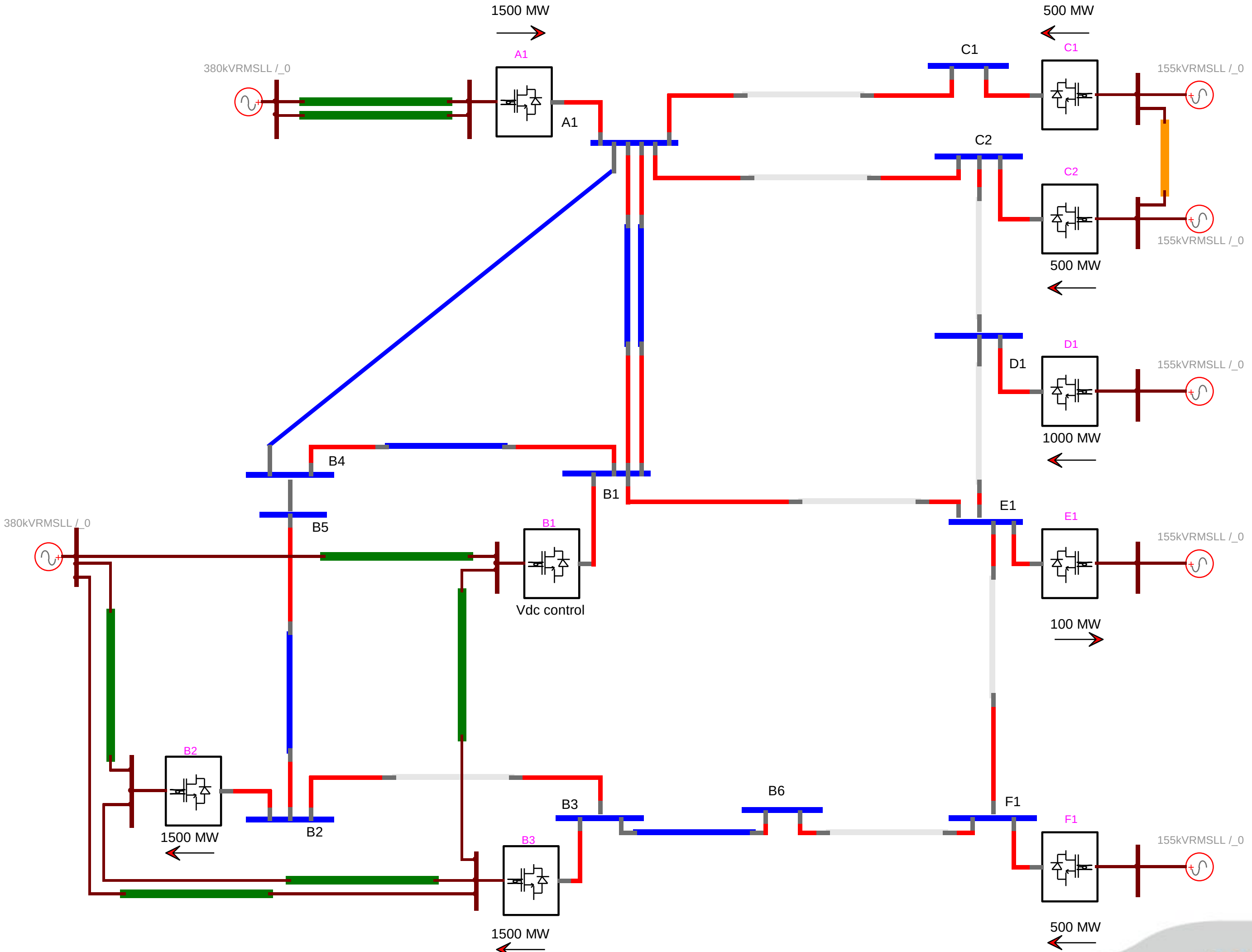
"Load flow control and direct voltage control in a meshed DC Grid"



Will be developed by WG B4-57 members in EMTP-RV, PSCAD, OPAL-RT and Hypersim

HVDC grid CIGRE Benchmark

EMTP-RV preliminary model



Rte Réseau de transport d'électricité

DC Grids modeling

Next steps

CIGRE benchmark

- To be developed in 2012 in EMT tools
- Will be delivered to DC grid WG members to perform transients studies (protection, transient stability,…)
- Detailed data will be available in the B4-57 working document

Special CIGRE session on DC grid modeling in 2012

- Organized by Rte to share experience on DC grid modeling
- People involved in DC grid modeling are encouraged to present their work
- **August 28, 2012** in conjuction with CIGRE general meeting in Paris

- Contribution or information : sebastien.dennetiere@rte-france.com