CENELEC TC 8X/WG 06 System Aspects of HVDC Grids

Best Paths Dissemination Event

Paris, 5 November 2015

Frank Schettler (Siemens, Convenor)

Overview

- ► **Introduction to CLC TC 8X/WG 06**
- ► **Scope and present status of work**
- ► **Examples of topics in discussion**
  - ▷ Coordination of HVDC Grid System and AC systems
  - ▷ HVDC Grid Control
  - ▷ Models and Validation
  - ▷ HVDC Grid System Integration Tests

CENELEC

CLC/TC 8X/WG 06
Key Figures

- 1st Meeting: 11th April 2013 (Kick-Off)
- 14 regular Working Group meetings until today (6 Meetings in 2015)
- 5 Sub Groups dealing with different technological aspects:
  - Coordination of HVDC Grid and AC Systems
  - HVDC Grid Control
  - HVDC Grid Protection
  - HVDC Grid System Characteristics and HVDC Grid Equipment
  - Models and Validation, HVDC Grid System Integration Tests
- 43 registered members (October 2015)
  - 10 of Manufacturers (ABB, ALSTOM, DIgSILENT, Siemens)
  - 12 of TSOs (ENEL, REE, RTE, Terna, 50Hertz)
  - 15 of Universities (Imperial Collage London, HS Karlsruhe, TU Clausthal, TU Darmstadt, TU Ilmenau, RWTH Aachen, UPM Madrid)
  - 7 of other Organisations/Institutions (Arup, ECOS, DKE, ObjectFarm)

Team Goals (excerpt)

The CENELEC TC 8X Working Group 06 elaborates
standards for HVDC Grid Systems on a European level.

The Working Group focuses first on **preparing the ground for a competitive supply chain of HVDC Grid System components and solutions.**

The work builds on the findings of the European HVDC Grid Study Group (2010 to 2012) with the following objectives in chronological order:

- **Elaborating technical Guidelines and Functional Specifications for:**
  - **Radial HVDC Grid Systems** (Radial systems are characterized by having exactly one electrical connection between any two converter stations)
  - **Applications in meshed HVDC Grid Systems**
- Identification of items for HVDC Grid System standardisation
- **Elaboration of the HVDC Grid System standards**

Aiming at providing best benefit to the technological development, the Working Group **liaises with other organizations working in the same field or actively contributes to their work as appropriate**.

HVDC Grid Systems - Guidelines and Parameter Lists for Functional Specifications

Outline

1 Scope
2 Normative references
3 Terms, definitions and abbreviations
4 Coordination of HVDC Grid and AC systems
5 HVDC Grid System characteristics
6 HVDC Grid control
7 HVDC Grid System protection
8 AC/DC converter stations
9 HVDC Grid System equipment (requirements)
10 Models and validation
11 HVDC Grid System integration tests
12 Bibliography

The specifications shall cover all HVDC Grid specific topics

A Set of Two Complementing Documents

Title	**HVDC Grid Systems – Guidelines and Parameter Lists for Functional Specifications**		
Sub Title	**Part 1 Concepts and Guidelines**	**Part 2 Operating Conditions and Performance Requirements**	
Working Title	(Background)	(Parameter List)	
		Grid Characteristics (Operating Conditions)	Performance Requirements
Example: Harmonic voltage distortion	Explaining backgrounds like: - How to obtain „pre-existing harmonic voltage levels“ - How to calculate harmonic voltage distortions - How to demonstrate compliance with requirements - …	Listing: Pre-existing harmonic voltage levels DC network harmonic impedances	Listing: Maximum permissible harmonic voltage distorions due to converter operation (considering converter self generated harmonics and possible magnification of pre-existing harmonics.)

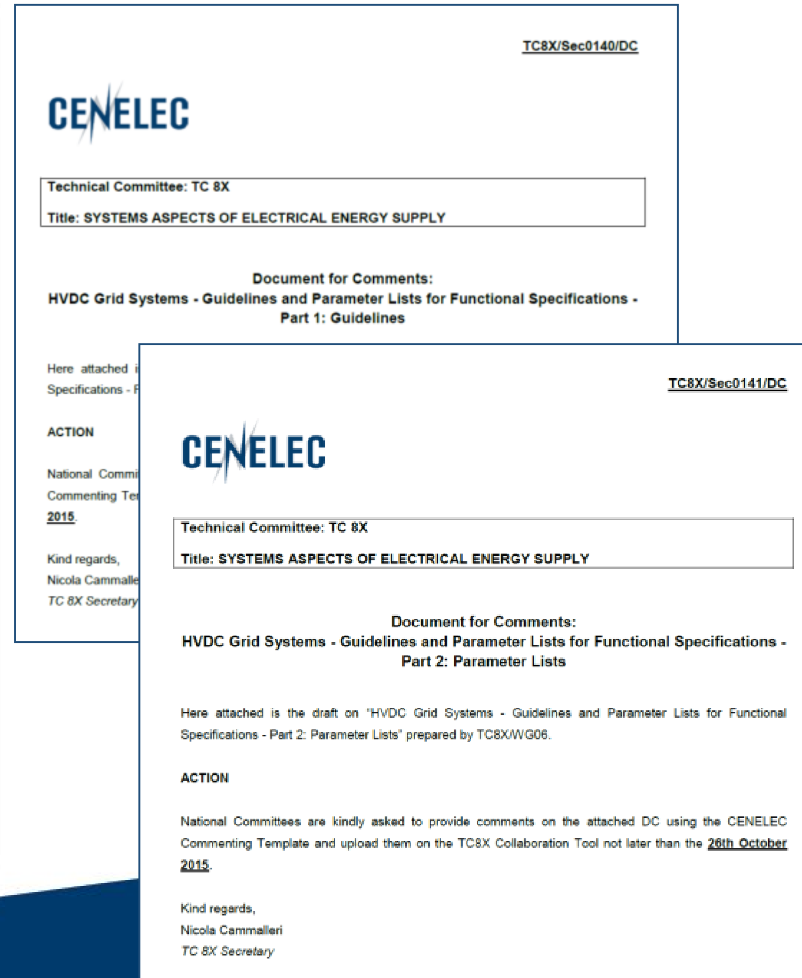
Approaching a New Technology
From System Function to Specification

- Establish structure of Part 2 (Parameter Lists)
- Define Parameters and Requirements of Part 2
  - focus on system functions (assure technology independence)
  - categorise and develop systematics of functions and technical principles
  - define parameters, assure completeness in addressing all relevant physical effects
- Elaborate Part 1 (Guidelines)
  - make reference to publications and work of other Working Groups, e.g. CENELEC and CIGRÉ
  - elaborate principles as appropriate
- Recommend Parameter Values
  - investigate applications
  - define scenarios where appropriate
  - derive parameter values and describe reasoning
  - standardise values

HVDC Grid Systems – Guidelines and Parameter Lists for Functional Specifications

- First Draft of Documents circulated as **TC8X/Sec0140/DC and TC8X/Sec0141/DC**
  more than 80 comments received, mainly by NCs of France and Germany, currently under investigation

- Scope
  - Radial topologies, open for extension to meshed ones
  - Symmetrical Monopoles, Monopoles, Bipoles, combinations thereof



TC8X/Sec0140/DC

CENELEC

Technical Committee: TC 8X

Title: SYSTEMS ASPECTS OF ELECTRICAL ENERGY SUPPLY

Document for Comments:
HVDC Grid Systems - Guidelines and Parameter Lists for Functional Specifications - Part 1: Guidelines

Here attached i…
Specifications - P…

ACTION

National Commi…
Commenting Te…
2015.

Kind regards,
Nicola Cammalle…
TC 8X Secretary

TC8X/Sec0141/DC

CENELEC

Technical Committee: TC 8X

Title: SYSTEMS ASPECTS OF ELECTRICAL ENERGY SUPPLY

Document for Comments:
HVDC Grid Systems - Guidelines and Parameter Lists for Functional Specifications - Part 2: Parameter Lists

Here attached is the draft on "HVDC Grid Systems - Guidelines and Parameter Lists for Functional Specifications - Part 2: Parameter Lists" prepared by TC8X/WG06.

ACTION

National Committees are kindly asked to provide comments on the attached DC using the CENELEC Commenting Template and upload them on the TC8X Collaboration Tool not later than the 26th October 2015.

Kind regards,
Nicola Cammalleri
TC 8X Secretary

Coordination of HVDC Grid System and AC systems (I)

Target: Provide guidelines for specifying functional requirements for HVDC Grid Systems from an AC system's perspective

HVDC grid functions for AC systems

Basic operating functions:

- Main purpose of the HVDC Grid System,
  design and optimization criteria
- Static power flow
- Main active power controls

Ancillary services:

- Energy balancing
- Power modulations
- Voltage services
- System restoration
- Stabilizing functions

Boundary conditions: Network Code requirements

Coordination of HVDC Grid System and AC systems (II) Basic Operating Functions for AC systems

Example: Static power flow optimization – What to specify?

a) Conditions and capabilities

- ▷ DC line ampacities (normal, overload)
- ▷ voltage and power ratings of converters
- ▷ DC line resistances

b) Optimization criteria

- ▷ reserve capacity, e.g. to cover n-1 contingencies
- ▷ overall minimization of power losses

Samuel Nguefeu (RTE, Lead Subgroup 1)

Coordination of HVDC Grid System and AC systems (III) Ancillary services for AC systems

Example: Energy balancing

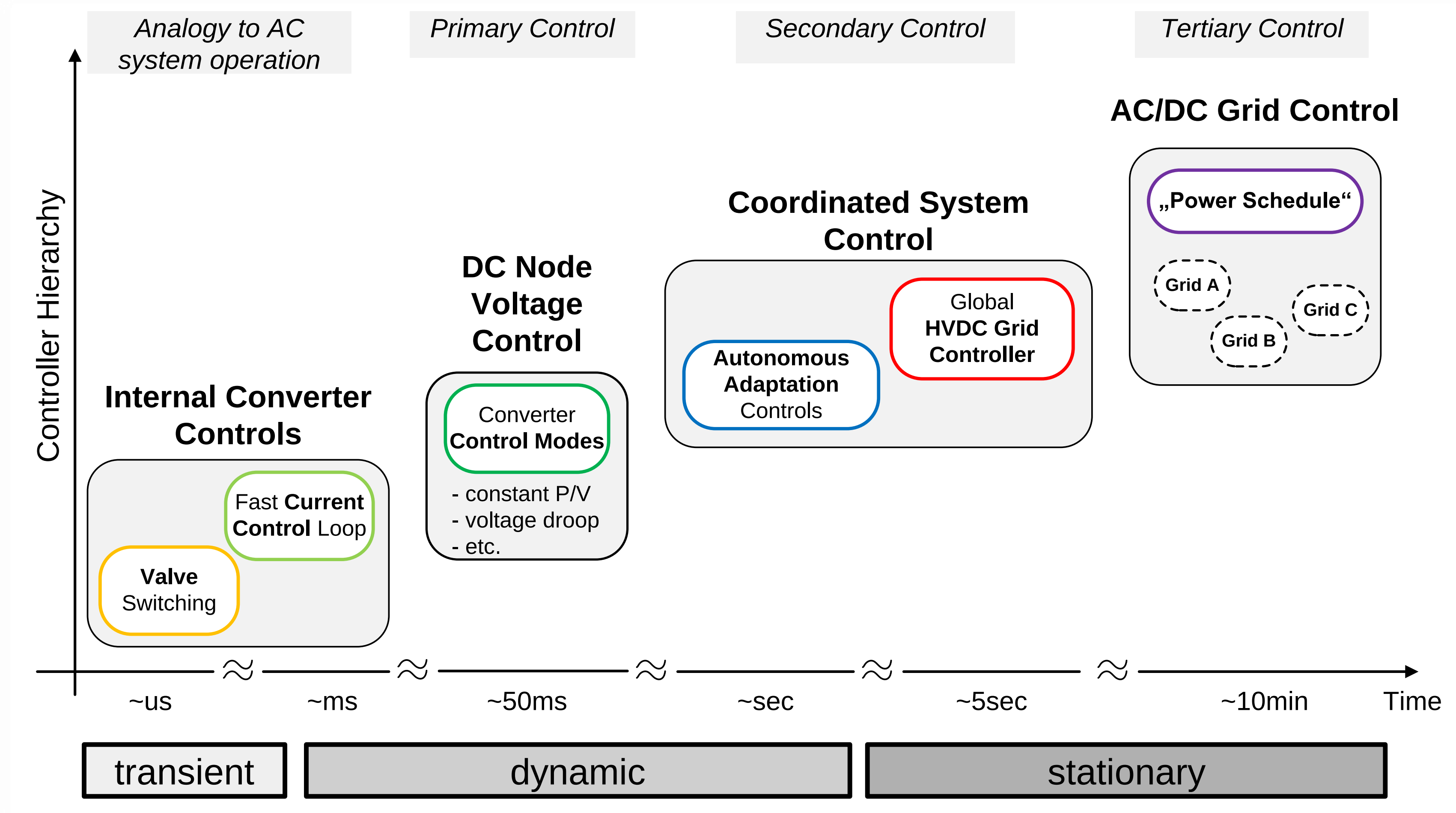
- Frequency containment control (primary frequency control)
- Frequency restoration (secondary and tertiary frequency control)
- participation in unplanned AC power flow changes
  (e.g. in response to tripping)
- Synthetic inertia
  (faster response time than automatic frequency control)

Example: Power modulations

- Inter-area oscillations
- Power oscillation damping
- Subsynchronous torsional interactions

HVDC Grid Control (I)

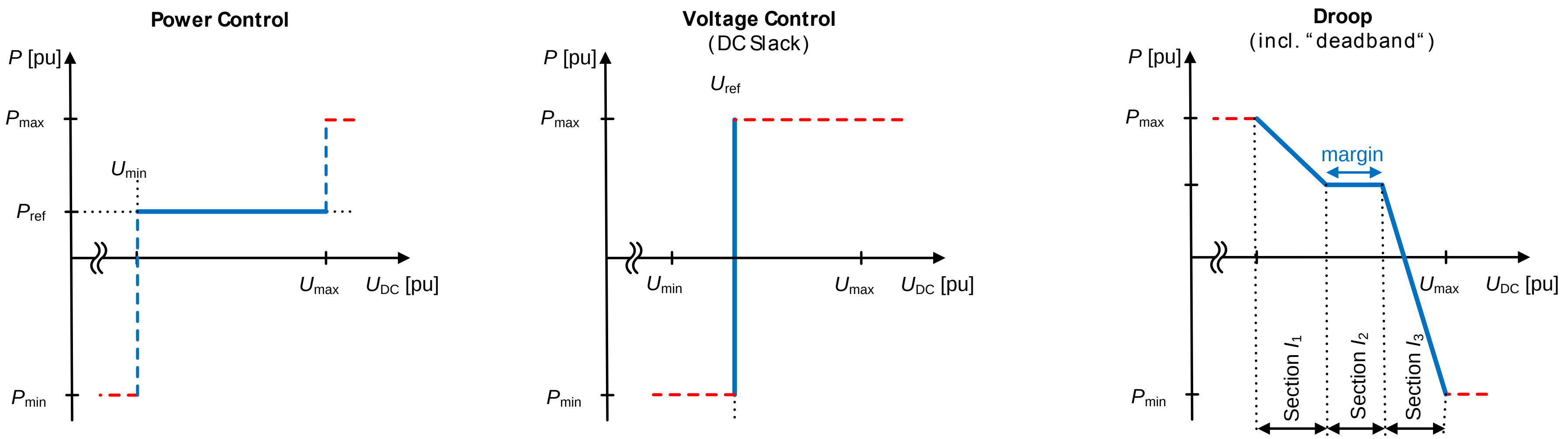
Target: Describe principles of HVDC Grid controls and provide guidelines for specification of grid control functions and interfaces



Marcus Zeller (Siemens, Lead Subgroup 2)

HVDC Grid Control (II)

Characteristics for DC Node Voltage Control



HVDC Grid Control (III)

Coordinated System Control

- Intermediate-term modification of set values
  - Response to fluctuating injection / contingencies etc.
  - Faster than “Power Schedule”
- Station-autonomous mechanisms (no communication)
  - Set of rules (staggered in location & time)
  - Robust, but prior definition required
- Elaborate schemes via “HVDC Grid Controller”
  - Communication required, but…
  - …optimisation due to “global” grid knowledge!

CENELEC

Models and Validation (I)

Target: Provide guidelines to the design and validation of simulation models needed for studies in various phases of a project

Scope: models, control replicas, real time simulation, offline simulation.

Examples:

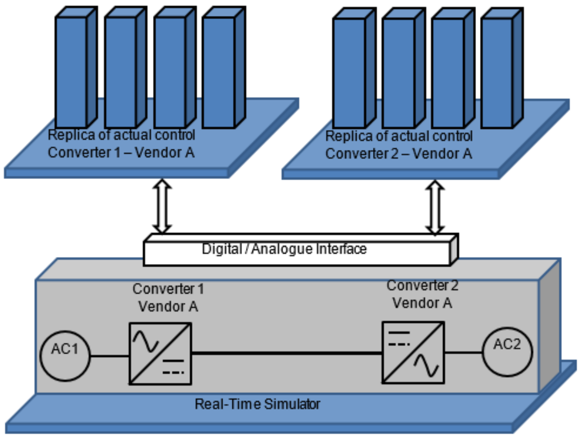
- ► Contingency analysis
  → concern on the reconfiguration and automatic adaptation of the DC system and converter controllers following a disturbance.
- ► Harmonic analysis
  → concern on AC and DC system models and methods, testing is needed.
- ► Small-signal Stability studies
  → concern on modal analysis.

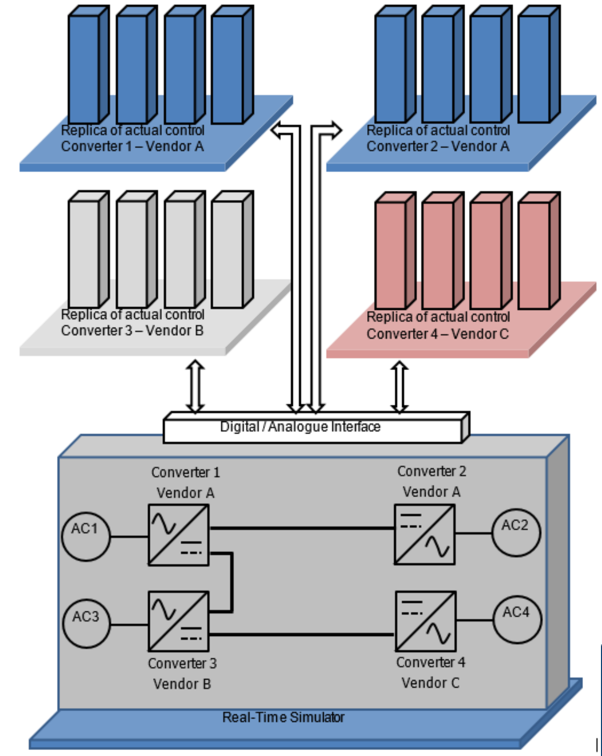
Ana Morales (DIgSILENT, Lead Subgroup 5)

Models and Validation (II)

Guidelines for modelling and model validation:

- Multi-vendor systems: many involved actors (manufacturers, TSOs, HVDC Grid System owners and operators…)





How can models be specified and qualified for multivendor systems?

HVDC Grid System Integration Tests

Target: Provide guidelines to the specification of system integration tests

System integration tests

- Factory Acceptance Tests: single-vendor.
- Laboratory Acceptance Tests: multi-vendor.
- Commissioning Tests: on site.
- Compliance tests and simulations: steady state calculations, dynamic simulations.

How can tests be specified and qualified for multivendor systems?

- Independent laboratory?
- Every TSO or HVDC Grid System operator?

Summary

- **Introduction to CLC TC 8X/WG 06**
- **Scope and present status of work**
- **Examples of topics in discussion**
  - Coordination of HVDC Grid System and AC systems
  - HVDC Grid Control
  - Models and Validation
  - HVDC Grid System Integration Tests

Looking forward to a fruitful collaboration !

Contact: Frank Schettler, Siemens AG
frank.schettler@siemens.com