Metrology for HVDC

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Metrology

• is the science of measurement, embracing all measurements, made at a known level of uncertainty, in any field of human activity

• underpins commercial settlements, legal regulations etc.

“When you can measure what you are speaking about and express it in numbers you know something about it; but when you can not express it in numbers your knowledge is of a meagre and unsatisfactory kind.”

Lord Kelvin, British Scientist (1824 - 1907)
European Metrology Research Programme

• a metrology-focused programme of coordinated R&D
  – facilitates closer integration of national research programmes
  – ensures collaboration between National Measurement Institutes
  – enhances industrial relevance

• EMRP, phase 1 (2007-2011) “IMERA-PLUS”
  – 21 Joint Research Projects, In total 65 M€ (21 M€ from European Commission)

• EMRP, phase 2 (2009-2016)
  – Supported through Article 169 of the European Treaty
  – First call (2009) is about Energy, one is “Metrology for HVDC”
  – In total 400 M€ (200 M€ from European Commission)
Rationale for HVDC

• Small environmental impact
  – Narrow right-of-way for over-head line
  – Cables suitable also for long distance

• Controllable
  – Converters can produce both active and reactive power on demand
  – Stability margin in grids can be made larger

• Support for renewable energy sources
  – Permits connection to weak grids of e.g. wind-farms
  – Permits very long distance transfer, e.g. solar power from north Africa
The grid of today

- 400kV
- 132kV
- 11kV
- 400V
The grid of the future?

Bulk power import using UHVDC

HVDC & FACTS Product Line
Drivers for metrology for HVDC

- Evaluation of losses in HVDC conversion
- D.c. side metering
- Power quality v.s. HVDC
- Very high d.c. voltage measurement
Participants in Metrology for HVDC

- INRiM, National Institute of Metrological Research, Italy
- MIKES, Centre for Metrology and Accreditation, Finland
- NPL, National Physical Laboratory, UK
- PTB, Physikalisch-Technische Bundesanstalt, Germany
- SP, Technical Research Institute of Sweden
- UME, Ulusal Metroloji Enstitüsü, Turkey
- VSL, Dutch Metrology Institute, the Netherlands
WP 1 Losses

- Minimisation of losses in electricity grid is vital
- If you cannot measure it you can not know it!
- Metrology for losses especially in convertor valves is needed
- Challenges are
  - High transients with non-negligible energy
  - Dynamic range is large between conduction losses, switching losses and off-state losses
  - Global loss measurement requires very high accuracy (say 1% of 1%)
- Challenge will be met by two-pronged approach with WP1 providing the metrology and REG 1 providing practical tools, circuit analyses and tests
WP 2 Laboratory references to 1 MV

- Loss measurements on system level and metering require quality assured voltage measurement
- Traceability in Europe for HVDC is limited to 400 kV
- Challenges are:
  - Mastering leakage currents
  - Verification of voltage dependence
- Two dividers will be established as references for 1000 kV
WP 3, On-site calibration of wide-band dividers

- The dividers of WP 2 are not suitable to go on-site
- Need to develop sturdy, transportable divider
- Response should be flat from d.c. to at least kHz range
- Modular design will be preferred

Challenges are:
- Retaining accuracy in the face of transport rigours
- Ensuring wide frequency response without affecting d.c. accuracy
WP 4, Power quality and HVDC

• Interaction between grid and converter must be characterised
• Models are needed
• Measurement techniques must be laid down
• Suitable measurement devices must be found or developed
• Investigation of the suitability of existing PTs and CTs for power quality measurements
• Quality assured power quality measurements will be demonstrated in one HVDC converter station
WP 5, Metering and billing

- Standardisation for d.c. side metering is missing
- Test facilities and agreed test procedures for d.c. electricity meters are missing
- Pre-normative research will be carried out for d.c. electricity meters with analogue input signals and for digital input signals
- Test methods and test requirements will be defined and implemented in a new test facility
- A demonstration of an electricity meter adapted for d.c. metering will be performed
- A system for non-invasive check of a.c. CTs will be built
WP 6, Creating impact

• Ensuring industry relevance through Stakeholder committee
• Promote transfer of knowledge gained in the project
• Provide advise to standardisation bodies relevant to d.c. applications
• Creation of new services:
  – traceable calibration of energy meters for d.c. metering
  – calibration services of wideband d.c. transducers for metering applications
  – Methods and instrumentation for assessment of losses
  – On-site billing and power quality (PQ) measurement capabilities for d.c. installations
• Thus easing the way for expansion of HVDC in the service of a more efficient European electricity grid