Smart Grids Measurement Needs

- Early warning of instability – Identify areas of the grid where demand exceeds supply – avoids blackouts.
- A "life support monitor" for Smart Grids - Phasor Measurement Units (PMU), in multiple locations to manage stability.
- Power Quality (PQ) Disturbances – understand the impact of disturbing connections to the grid.
- PQ Disturbance "radar" – locate major sources of poor PQ for mitigation and enforcement.
- Grid topology and impedance - for grid planning, analysis and mitigate of disturbances.
- Transducers – Accurate level transformation, essential for the PMU measurement chain.

Power Quality Propagation and Source Location

Problem
- How does a new load/generator disturb the grid?
- In a given network do these disturbances decay or resonate?
- Can an unknown disturbance be located?

Solution
- Use multiple GPS synchronized digitizers at locations in a grid.
- Reconcile PQ results with network impedance and topology.
- Investigate source location triangulation technique from GPS synchronized measurements.

PMUs in Distribution Networks

Problem
- Critical decisions to manage grid stability are based on PMU outputs.
- PMUs in distribution grids require: 1) improved phase discrimination, 2) higher PQ immunity 3) response to dynamic signals.

Solution
- Dynamic Performance of PMUs
  - Compare new PMU algorithms with signals of varying frequency, magnitude and phase.
  - Modify existing PMU calibrator to generate dynamic signals.
  - Test new algorithms on-site.
- Calibrating "PMU Calibrators"
  - Commercial PMU calibrators need traceability.
  - Characterize the waveform output of the calibrator.
  - Improve NMI capability by a factor 10.

Network Impedance Measurements

Proposed work
- Measure impedance using 2 PMUs either end of a grid section.
- Impedance is low, so a small voltage difference must be measured.
- Extend to harmonic impedances

PMU/PQ Transducer Measurements

Problem
- Transducers are a vital part of the PMU measurement chain.
- Frequency response errors will distort captured waveforms.
- Non-invasive CTs have positional and rotational repeatability issues.

Solution
- Characterize the frequency response of VTs using distorted voltages.
- Optimize the design and use of non-invasive CTs.
- DSP techniques to correct digitized waveforms.

Smart Grid Test Sites

- Bornholm Island Test Site
  - 28,000 customers
  - Wind Power 36 MW
  - CHP (biomass) 16 MW
  - PV 2 MW
  - Biogas Plant 2 MW
  - 5 District Heating Plants

- EDF Concept Test Site
  - 3 km of MV grid, 7 km of LV grid,
  - 2 secondary substations,
  - A residential area with 5 smart houses

- Power Networks Demonstration Centre
  - Typical 11kV and 400V networks
  - replica primary substation

- Oosterschelde Ring
  - 6 PMUs in 50 kV ring with 5 substations and 40 km cables
  - Significant RES generation