Application of phasor measurement units and wide-area measurement systems in Finland

Katariina Saarinen, Fingrid

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- Short introduction to the Nordic Power System
- Background for the Wide Area Measurement System project in Finland
- Structure of Finnish WAMS
- Application of WAMS and PMUs in Finland

The Nordic Power System

2008	Consumption TWh	Generation TWh	Maximum system load MWh/h
Denmark	36.1	34.6	6.4
Finland	87.0	74.1	13.8
Iceland	16.6	16.6	2.1
Norway	128.9	142.7	21.6
Sweden	144.1	146.0	24.5
Nordel total	412.7	414.0	63.1 [1]

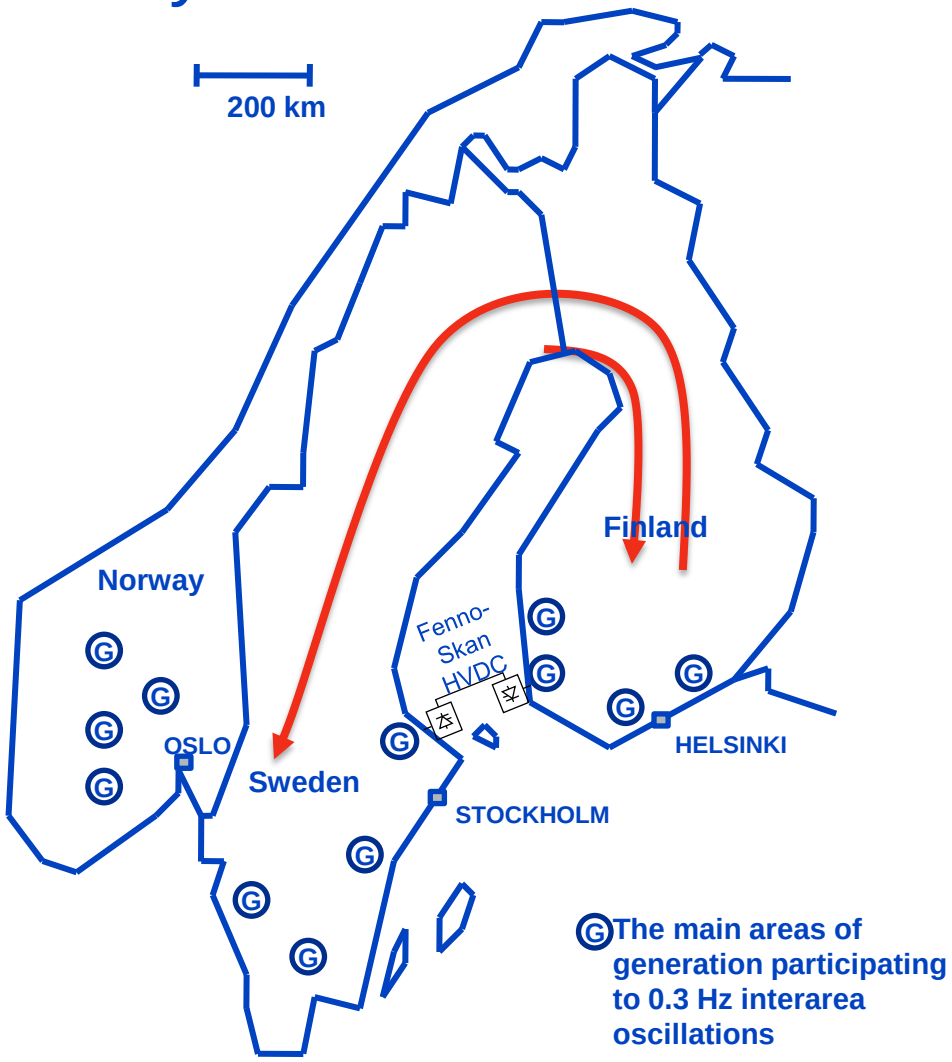
[1] simultaneous maximum

Source: Nordel Annual Report 2008

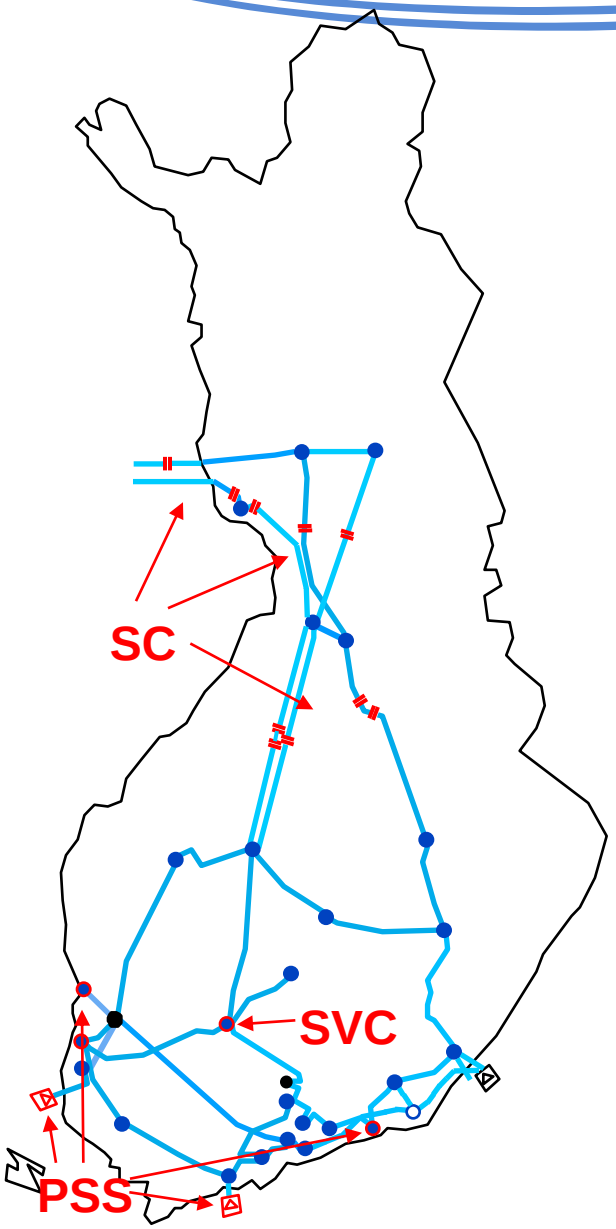
Nordic network and nature of dynamics from the Finnish point of view

- voltage stability limits power import from Sweden
- damping of 0.3 Hz interarea electromechanical oscillations limits power export to Sweden

→ normal operation within N-1 margin from stability limits



Increasing the capacity of the Finnish 400 kV grid



Measures taken to increase the capacity of the existing grid **with 50...100%**:

- Proper tuning of power system stabilizers (PSS) on large generators and HVDC links
  - ✓ **7 generators and 2 links tuned**
- Series compensation (SC) of critical transmission corridors
  - ✓**9 capacitor banks installed**
- Installing an SVC close to the strongly oscillating generators
  - ✓ **SVC installed and POD in use**

Next step: Power oscillation monitoring

Vision in 2005:

"Traffic lights in the control room to tell if damping is insufficient."

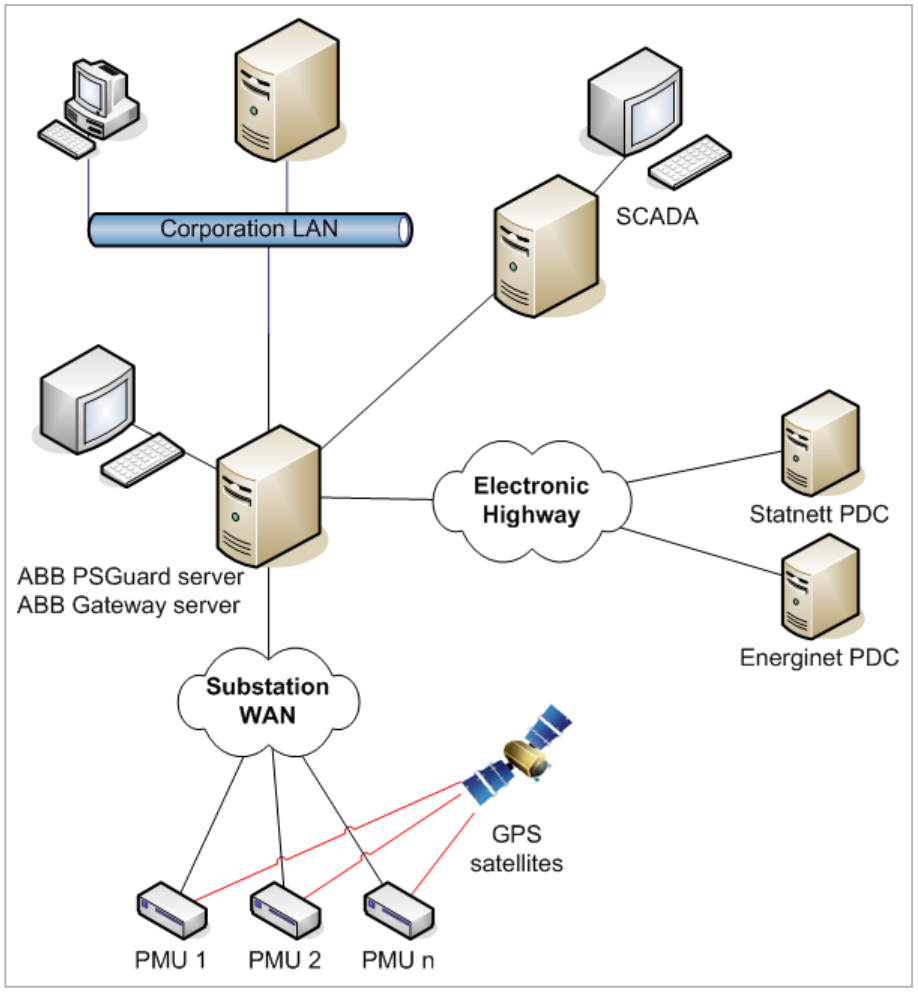
Nordic WAMS

In June 2006 the Nordic TSO's agreed to develop and implement a Nordic WAMS.

Status in 2010:

- Over 20 PMU's installed
- Three Phasor Data Concentrators
- PDC data streaming:
  - Norway ↔ Finland
  - Denmark ↔ Finland
- IEEE 1344-1995 and C37.118 protocols in use

Fingrid WAMS



12 Phasor measurement units

- 5 x ABB RES521
- 7 x SEL-451
- sampling rate: 50 samples/s

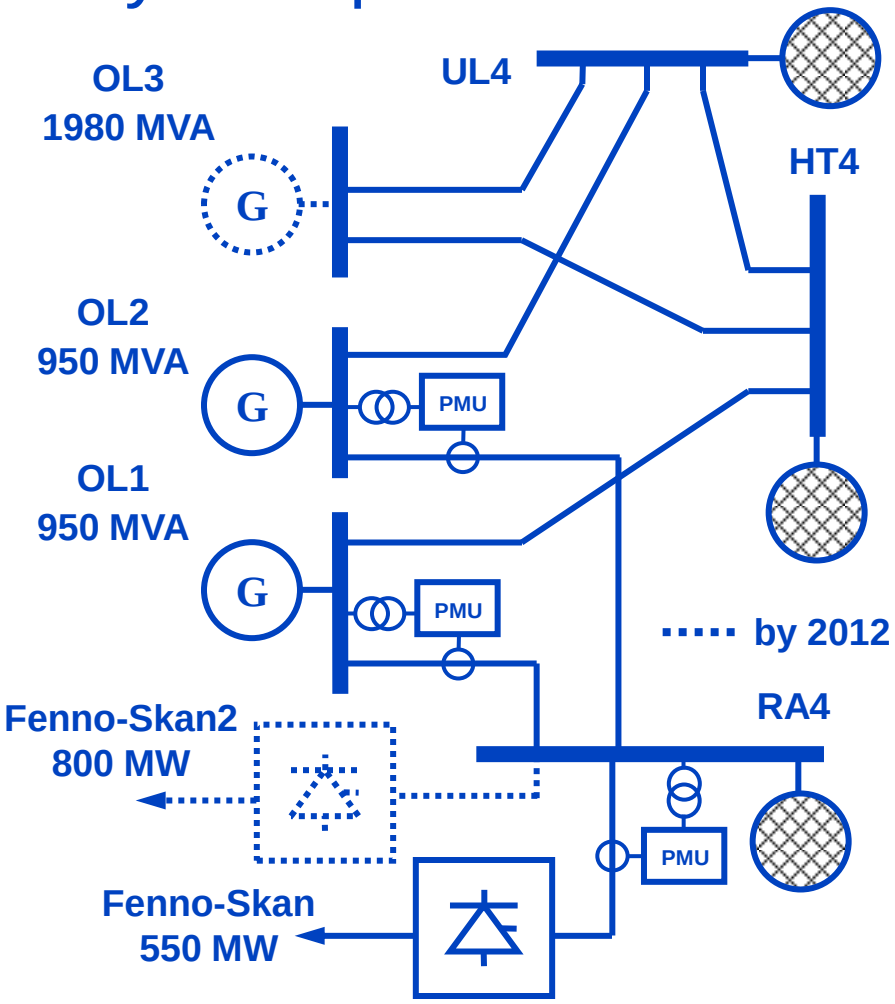
ABB PSGuard system

- Power Oscillation Monitoring
- Phase Angle Monitoring
- Gateway server for data streaming in/out
- Continuous and event based archiving of selected signals

Applications on PMU's & WAMS in Fingrid

- Power oscillation monitoring
- Post-disturbance analysis and model verification
- Application of synchrophasors for power oscillation damping controls
- Analysis of damping of subsynchronous oscillations

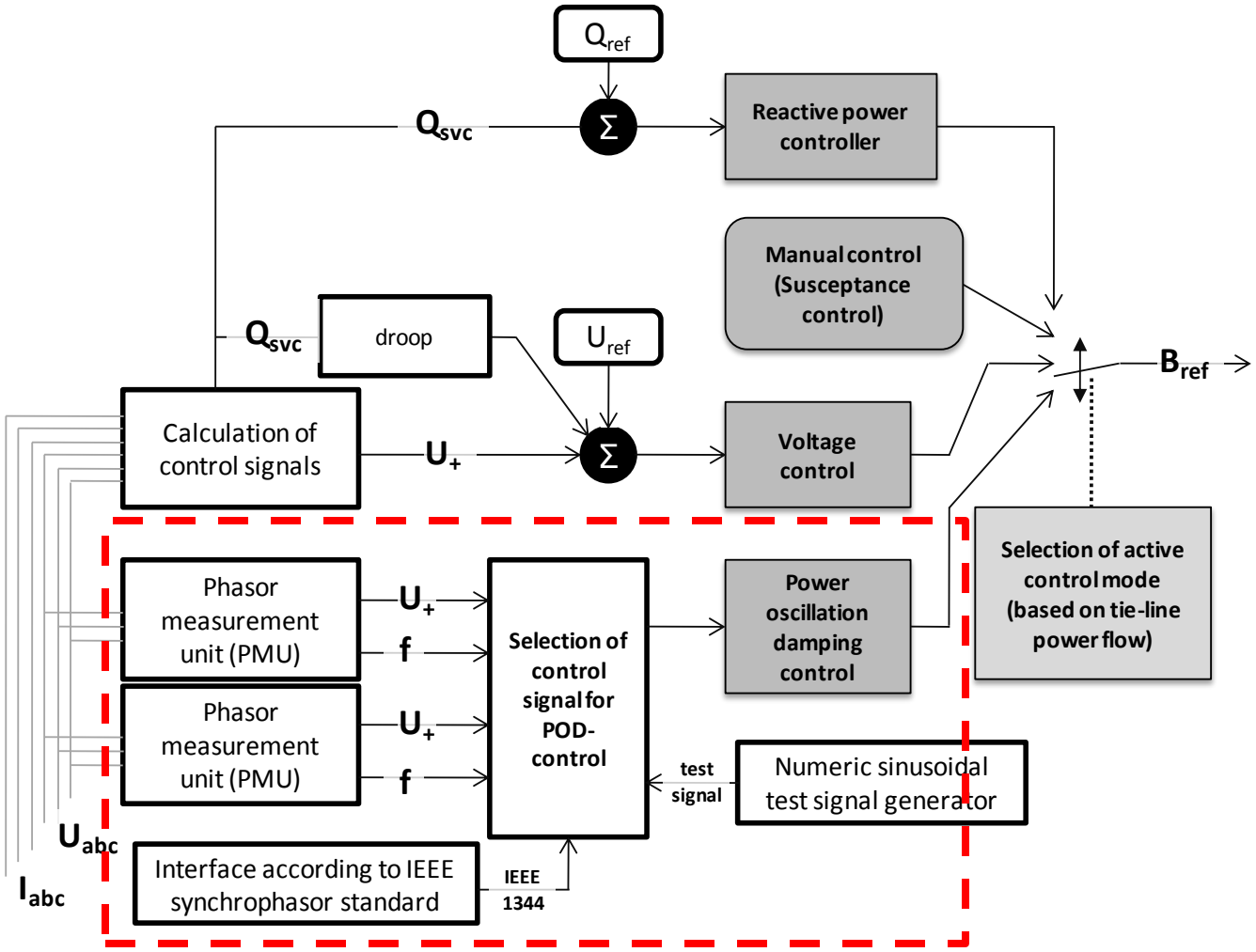
Estimation of subsynchronous damping using synchrophasor measurement

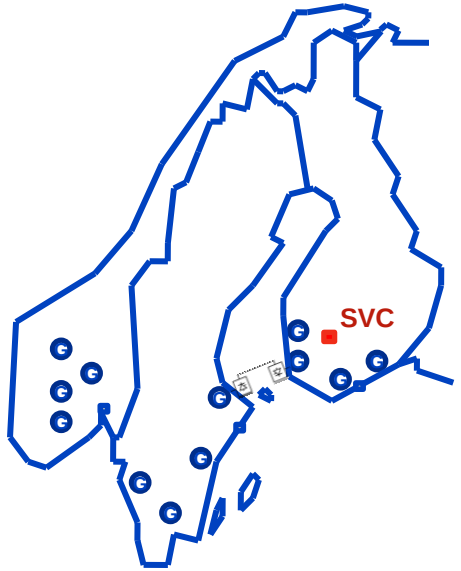


- at planning stage risk related to damping of subsynchronous oscillations must be evaluated
  - however, no torsional measurement system available
- PMUs allows detection of subsynchronous oscillations up to 20 Hz (acc. Nyqvist up to 25 Hz)
  - damping estimation using analysis of post-disturbance recordings

→ level of total subsynchronous damping can be evaluated

PMU-based POD control of Kangasala SVC

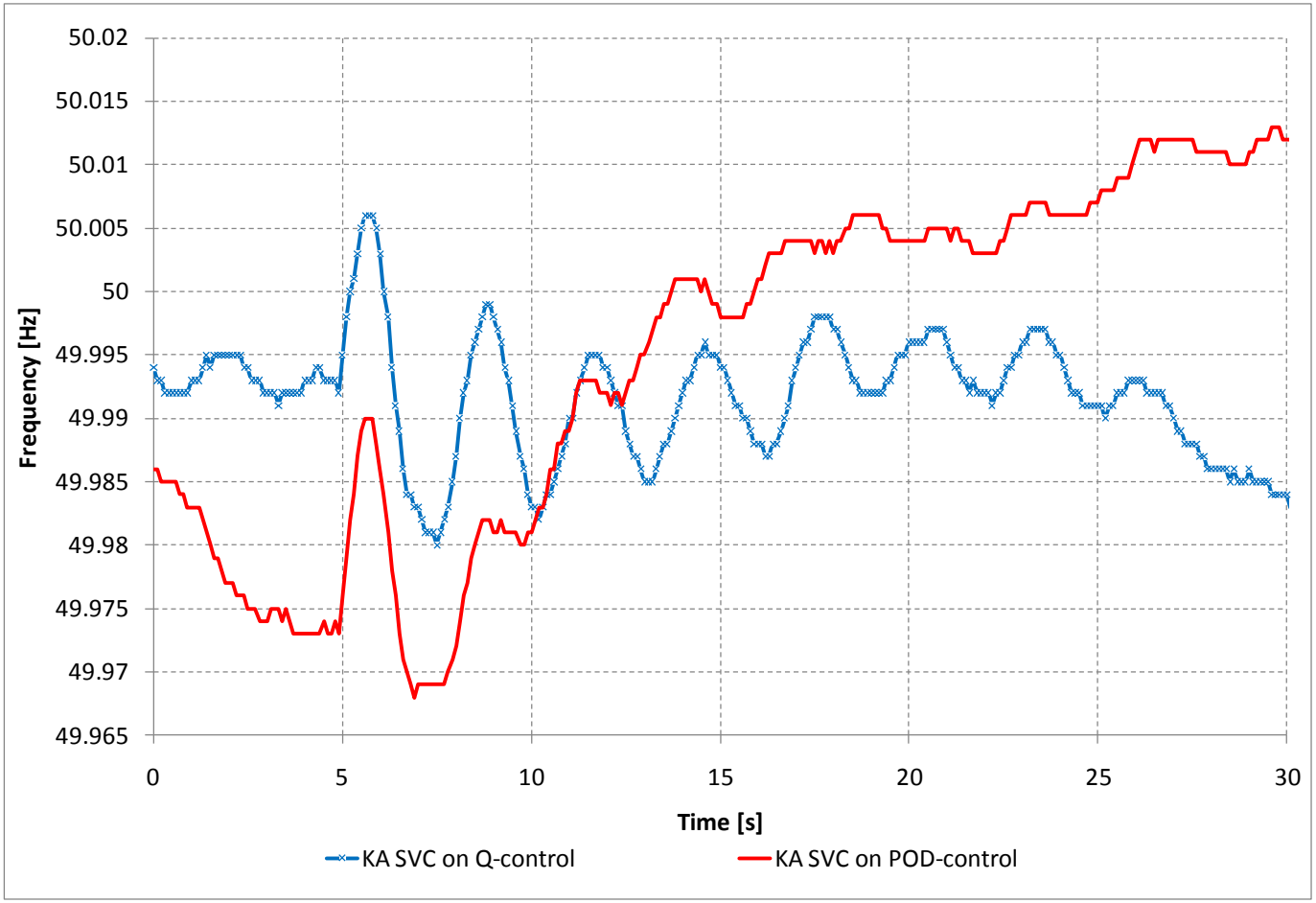




Local PMU measuments so far, possibility for wide-area POD in the future

Staged tests to verify the performance of PMU-based POD

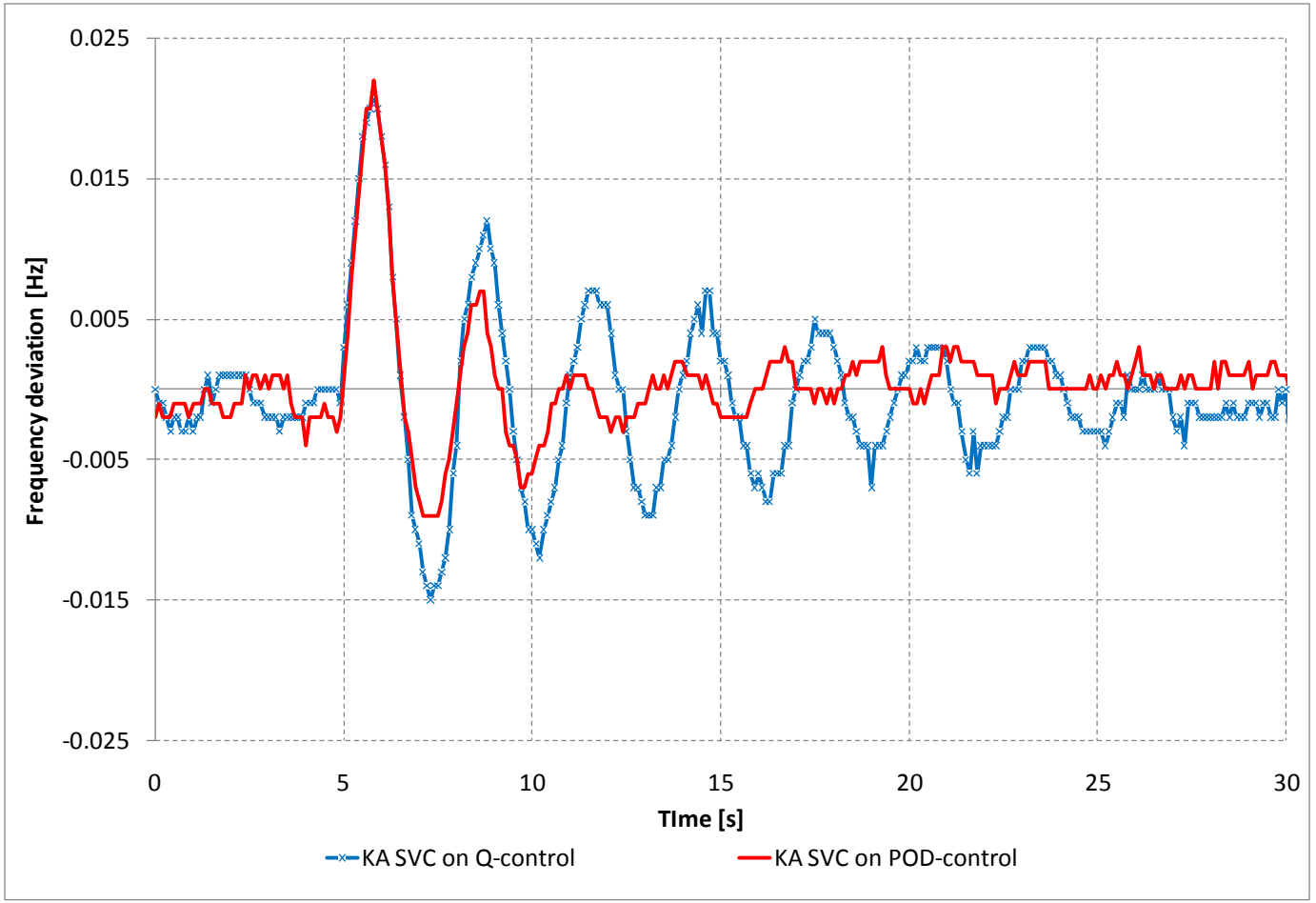
Damping in local frequency measurements (Finland)



Staged tests to verify the performance of PMU-based POD

Damping based on WAMS-signal

("Helsinki - Oslo" - frequency)



R&D in power oscillation monitoring

- Evaluation of feasibility of on-line damping estimation methods in 2005
- Development of wavelet-based real-time estimation method since 2006 in close co-operation with Helsinki University of Technology, TKK
- Benchmarking of different methods with TKK, ABB and London Imperial College since 2007

What is difficult in power oscillation damping estimation?

- ambient vs. transient oscillations
- accuracy
- variation in results
- length of the time window
- implementation of a commercial method may be unknown
- parametrization of the algorithm

Vision for power oscillation monitoring at the moment?

Lesson learned: It's a lot more than just bringing the signal in to the control room....

Damping estimation method must be absolutely reliable.

Challenges:

- need for extensive testing and evaluation of damping estimation methods
- feasibility of the estimation methods in different situations
- combination of input signals and estimation methods will be needed
- simple but informative visualization

More information

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