SMART Grids LATVIA

EERA
European Energy Research Alliance

Smart Transmission Grids Operation and Control

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Smart Transmission Grids Operation and Control
KTH - NTNU - AALTO - DTU - UI - TUT - IPE

Dr.sc.ing. Anna Mutule

Timeline and Project Partners

October 2011 – December 2015

Academia

Industry

Project task leaders: NTNU, **Kjetil Uhlen**; KTH, **Luigi Vanfretti**; AALTO University, **Liisa Haarla**; DTU, **Arne Hejde Nilsen**

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Smart Transmission Grids Operation and Control

A project funded by

Sustainable Energy Systems 2050
NORDIC ENERGY RESEARCH PROGRAMME

norden
Nordic Energy Research

– *And co-funded by Nordic TSOs and DSOs*

Objectives

– to support the development of better ***tools for operation and control*** of power grids

– to create innovative ***applications*** that will enable a more reliable operation and control of the Nordic power grid and with better information about security margin

– to increase Nordic collaboration through ***common research platform*** and software interfaces (software and hardware) for application prototyping and testing

Research approach

Evolution of networks **passive** → **active**

- faster and larger changes in operation
- need of advanced and smarter tools to manage the increasing complexity of the grid
- new solutions in ICT and power engineering together will enable more flexible, secure and sustainable energy systems
- main involved aspect is the network monitoring by means of Phasor Measurement Units (PMUs)

PMU definition (as stated in IEEE Std.C37.118-2011):
"A device that produces synchronized measurements of phasor *(i.e., its amplitude and phase),* frequency, ROCOF *(Rate of Change of Frequency) from voltage and/or current signals based on a common time source that typically is the one provided by the* Global Positioning System UTC-GPS.*"*

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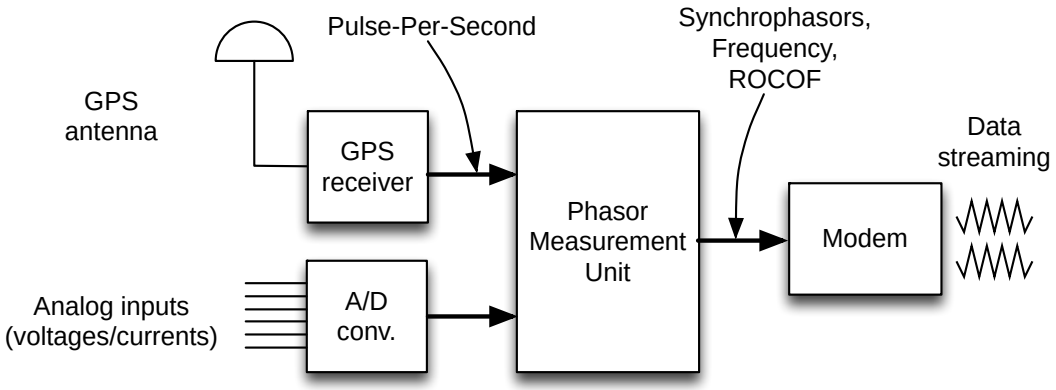
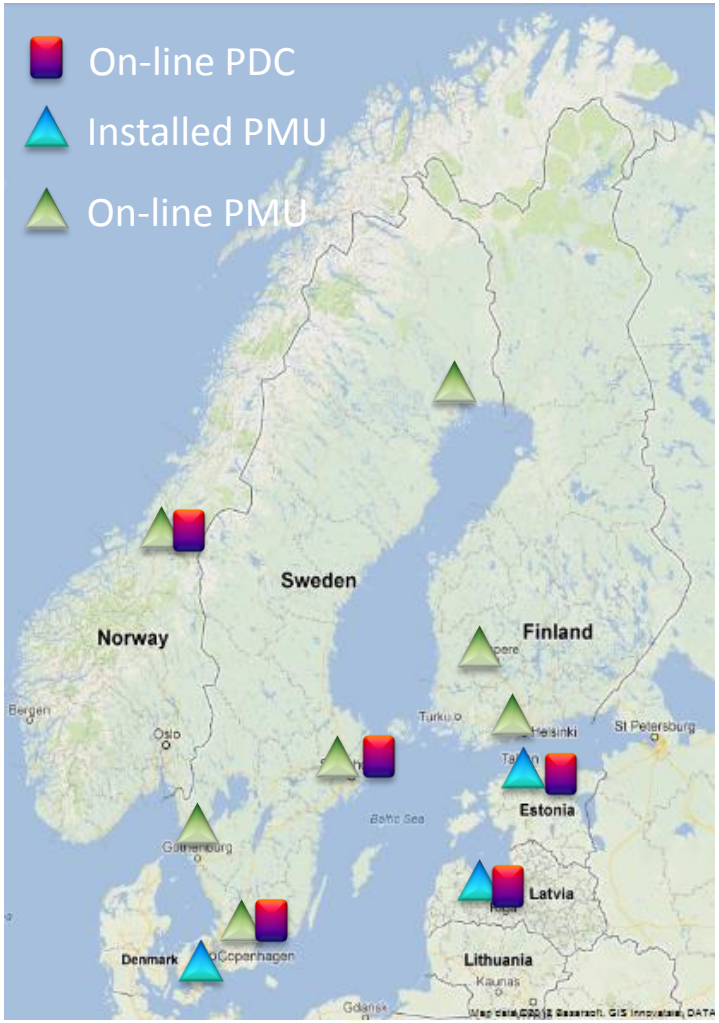
Research Platform: Low voltage PMU Network

- PMUs are connected on the LV networks in our laboratories

PMU typical configuration:





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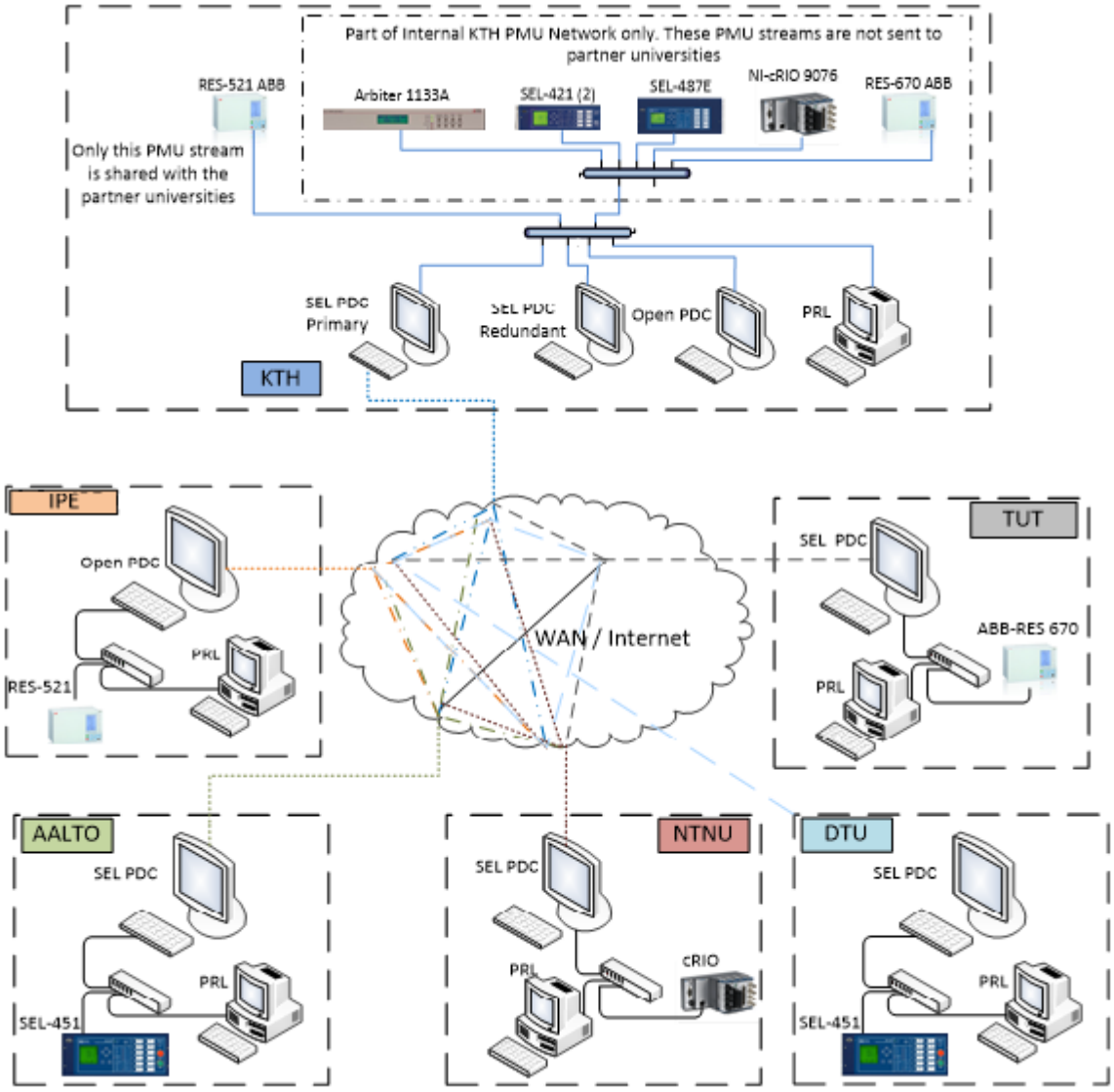
Research Platform:
Real-time PMU Data Exchange

- Each partner (PMUs, PDC) exchanges an Output Stream" with each other partner.
- PDCs installed locally allow data archiving and real-time access for all partners.



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Research facilities, PMU TestLab at IPE

NATIONAL INSTRUMENTS

NI cRIO-9074 Chassis

NI 9467 GPS Time synchronization module

NI 9225 Voltage AI module

NI 9227 Current AI module

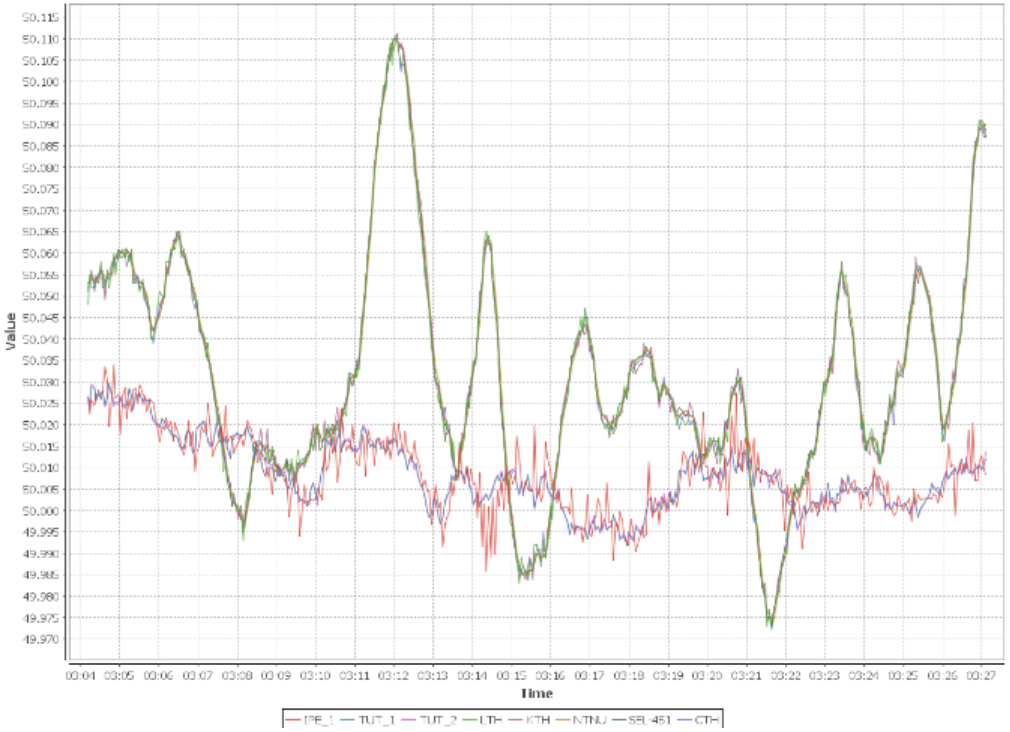
Software:
Edition PDC:Intel Server System R1000RP
Software: SEL-5073 SYNCHROWAVE

APC UPS

ABB

THE UNIVERSITY OF TENNESSEE KNOXVILLE

PMU ABB RES-521, IEEE C37.118
PMU NI cRIO-9074
Frequency Disturbance Recorder- FDR-GI-GSY The University of Tennessee



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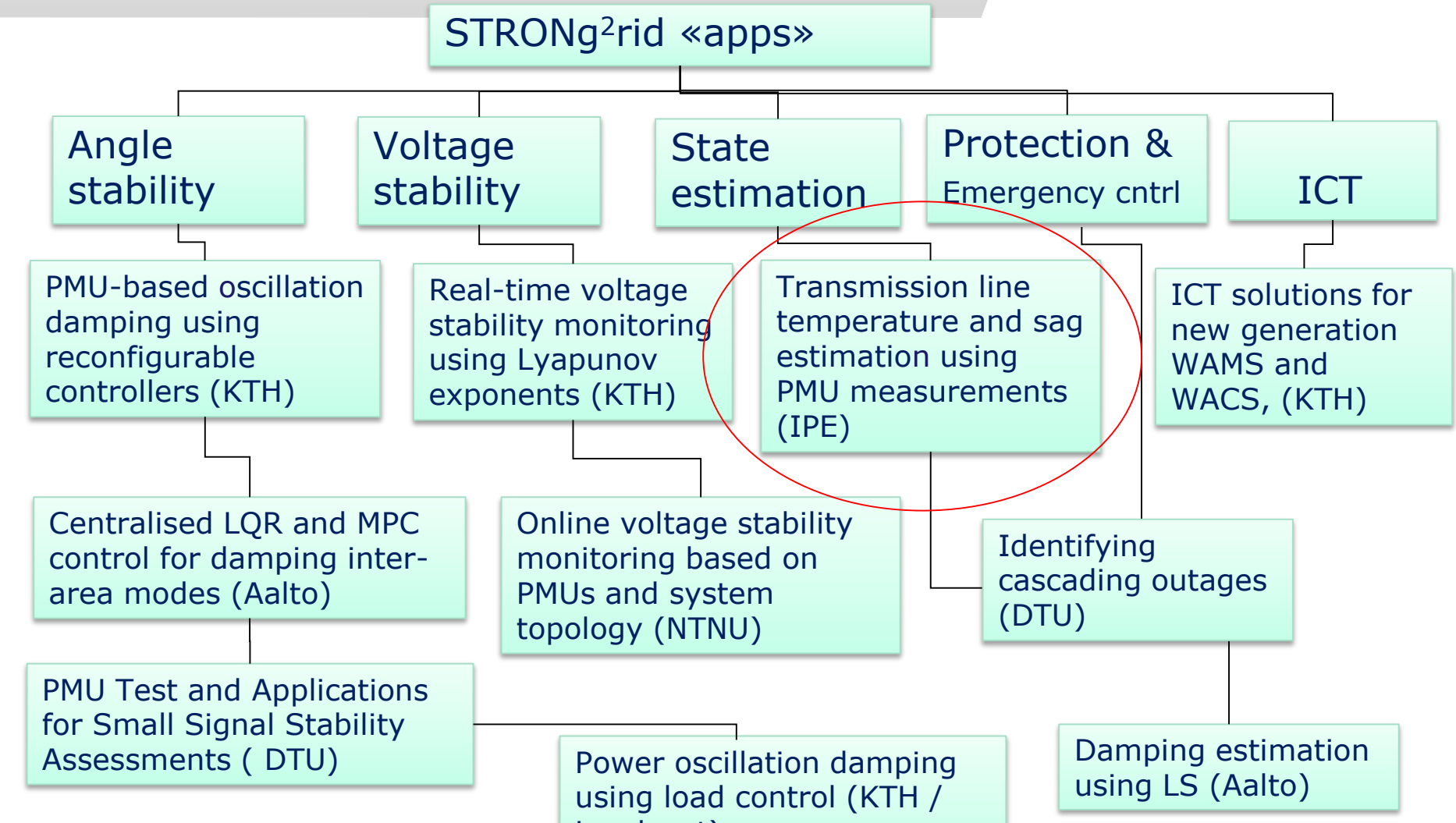
Application developments



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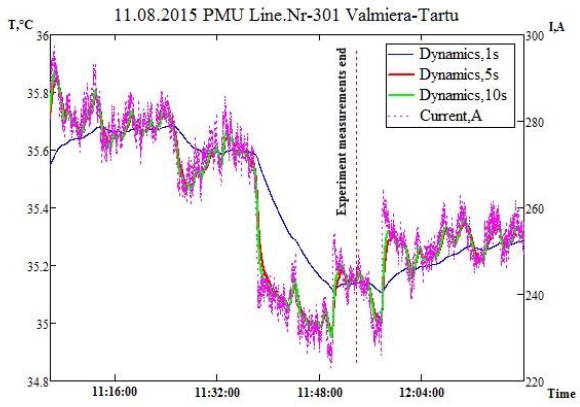
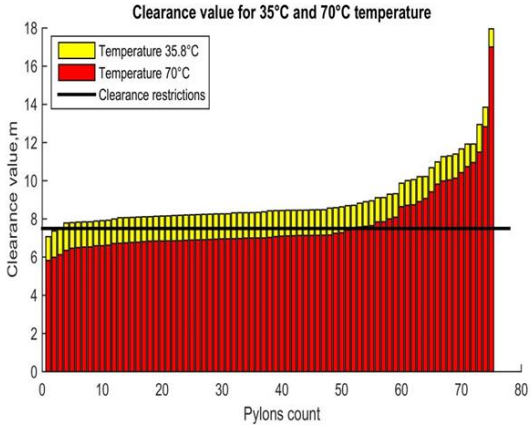
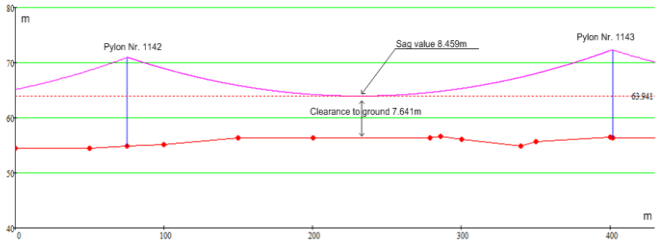
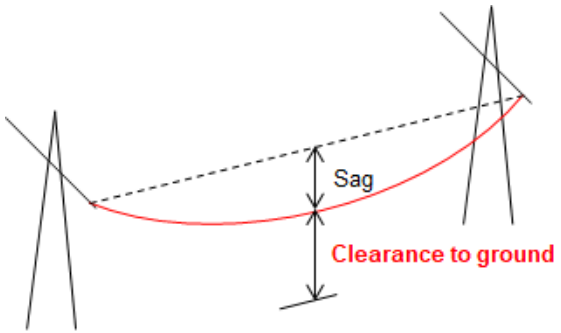
IPE research topics and results

- The objective of IPE task was to apply PMU in transmission line temperature, sag and clearance parameter estimation.
- An algorithm for sag and clearance calculation in overhead power lines was proposed and tested in real-time conditions with a focus on thermodynamics and line mechanics behaviours.
- This research will contribute to real-time operation performance. An exact line sag and clearance calculation will increase potential total transfer capacity (TTC).









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Test in real-time conditions

- On 11.08.2015, an experiment was conducted during two hours in collaboration with Latvian TSO, on line No. 301 Valmiera – Tartu between pylons No. 1123 – 1124. The temperature and sag were measured using
  - clearance to ground measurement unit
  - weather station
  - thermovision camera
- Temperature estimation methods in dynamics have similar answers, with low variations.
- Sag and clearance fluctuations have less than ~ 1cm difference in 15 minutes.

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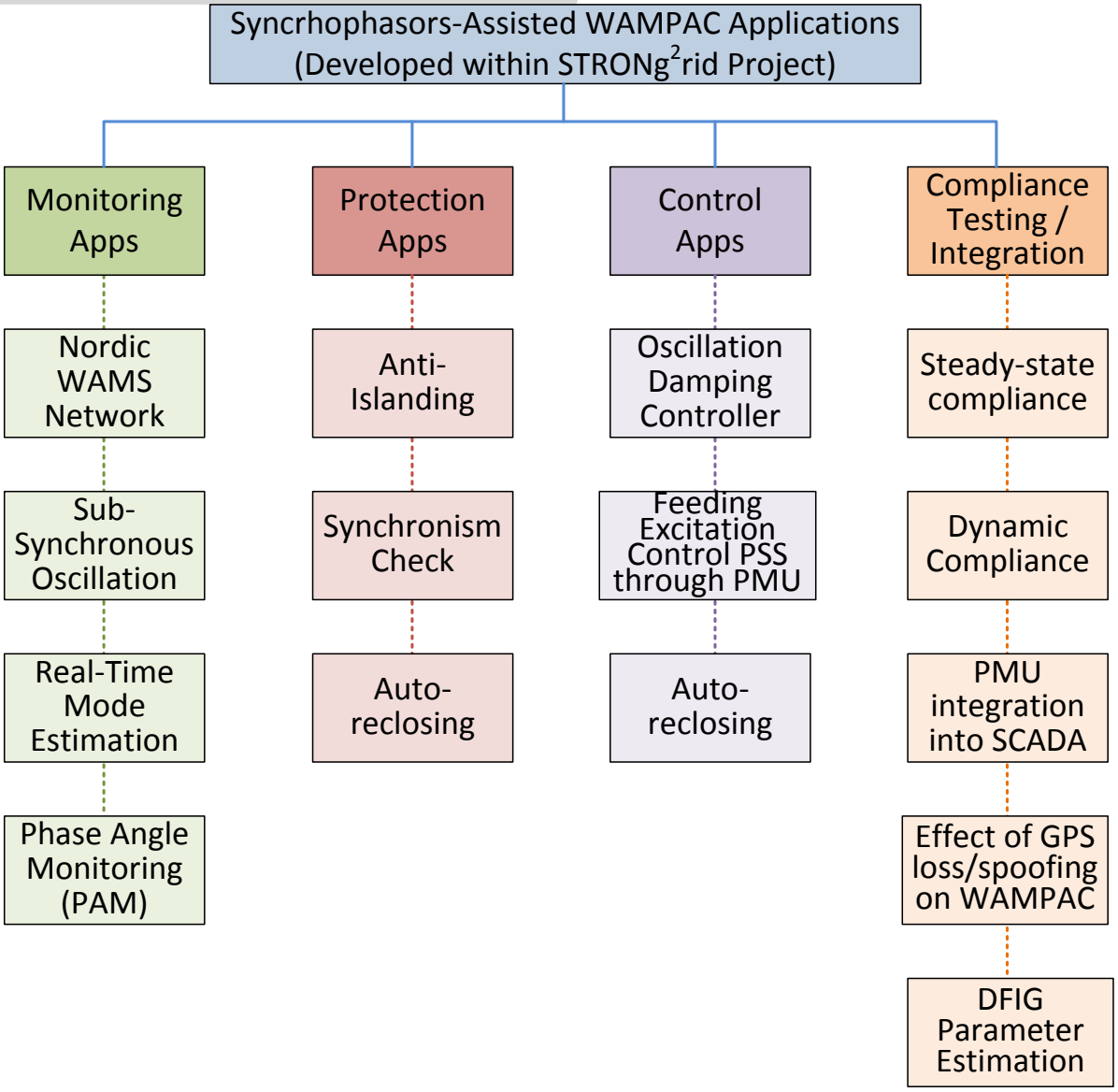
Application developments

- A large number of PMU-assisted WAMPAC applications have been developed within the STRONg^{2}rid project.
- All these applications have been tested using Real-Time Hardware-in-the-loop (RT-HIL) facility at SmarTS-Lab



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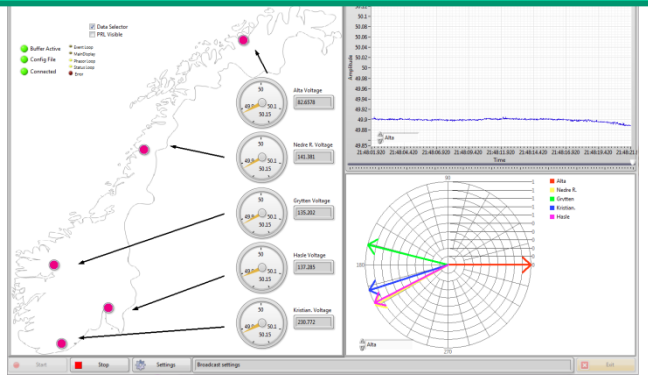
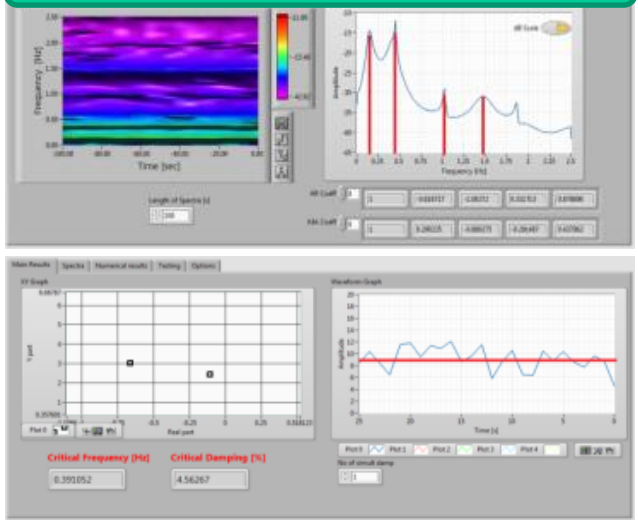
Apps developed in collaboration with KTH

Monitoring & Visualization

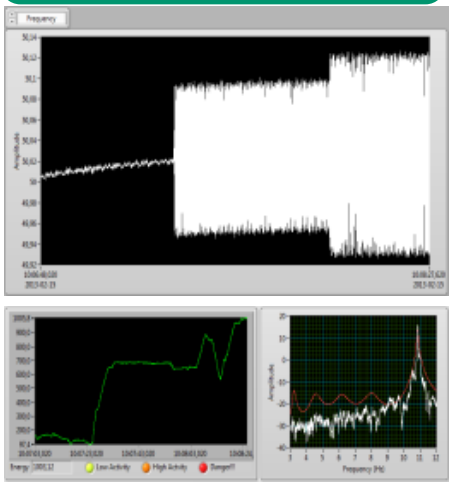


Mobile Apps

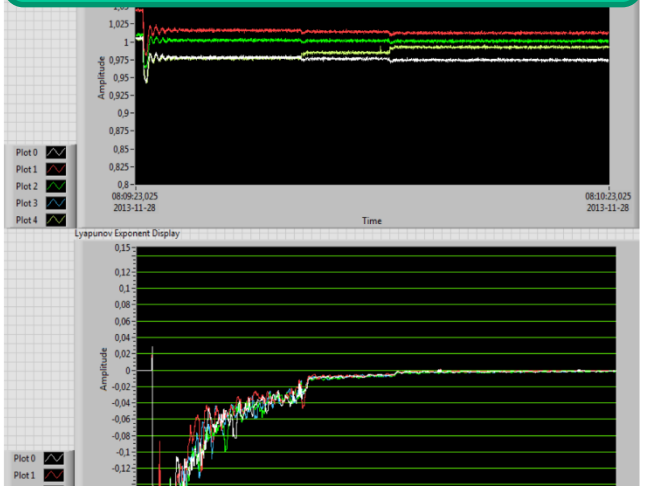
Inter-Area Oscillation Assessment



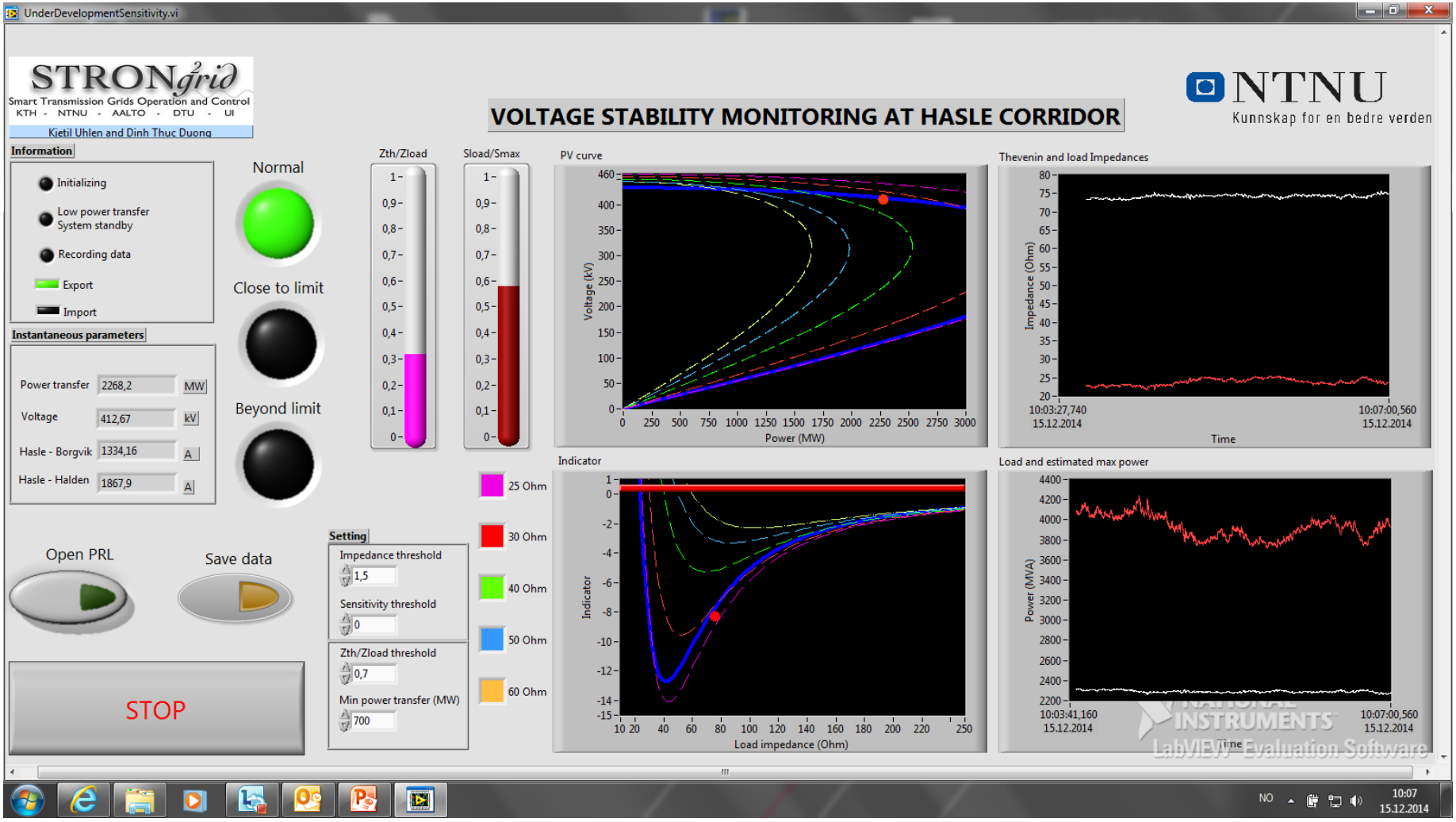
Forced Oscillation Detection



Short-Term Voltage Stability Assessment



Apps developed in collaboration with NTNU

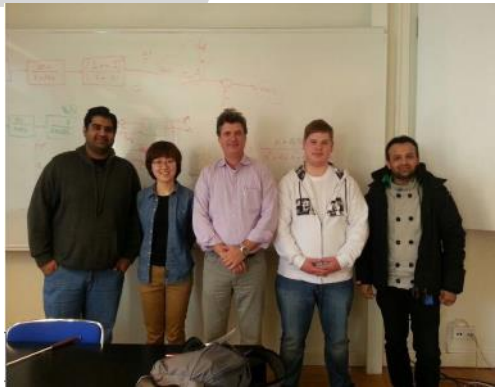


Collaboration

Collaboration with Partner Universities
A. 8 Educational Courses (2 on SmarTS-Lab, 2 on Labview Modules and 4 from International Faculty)

B. Several joint publications

SmarTS-Lab Training Program (Sept 23-October 04, 2013)



Power System Dynamics and Control (Professor Taranto) 22-26 April 2013

TuT-KTH collaboration (PMU compliance Testing)

3-day course on renewable energy integration, 2014

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Concluding remarks

- Increased awareness at the TSOs about the possibilities of utilizing PMU technology in operation and control
  - TSOs are starting deployment and pilot installations
- New competences have been gained at the universities, institutes and at the TSOs through research, PhD education, educational courses and dissemination activities
- STRONG motivation to continue the R&D collaboration at the Nordic/Baltic level

Major challenges while developing WAMPAC applications were mainly technical:

- communication latency
- loss of data / bad data
- GPS vulnerability (Jamming/Spoofing Attack)
- measurement noise due to hardware PMUs
- signal scaling which affects overall SNR

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Key aspects

- For policymakers, there are technologies and methods available or under development that provide totally new system information and control possibilities. This can radically enhance power system operation and the possibility of coping with a changing and less predictable system based on Renewable energy sources.

- There is a need for more research to further develop the methods, as well as to initiate more pilot projects to demonstrate the new solutions in a full-scale environment.

- Increased efforts are required to adopt standards for PMUs, which depends on the strengthening of technical aspects of interoperability of standards for real-time data exchange and of software application systems.

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Thank you for your attention!

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