SINTEF FACTS

April 2012

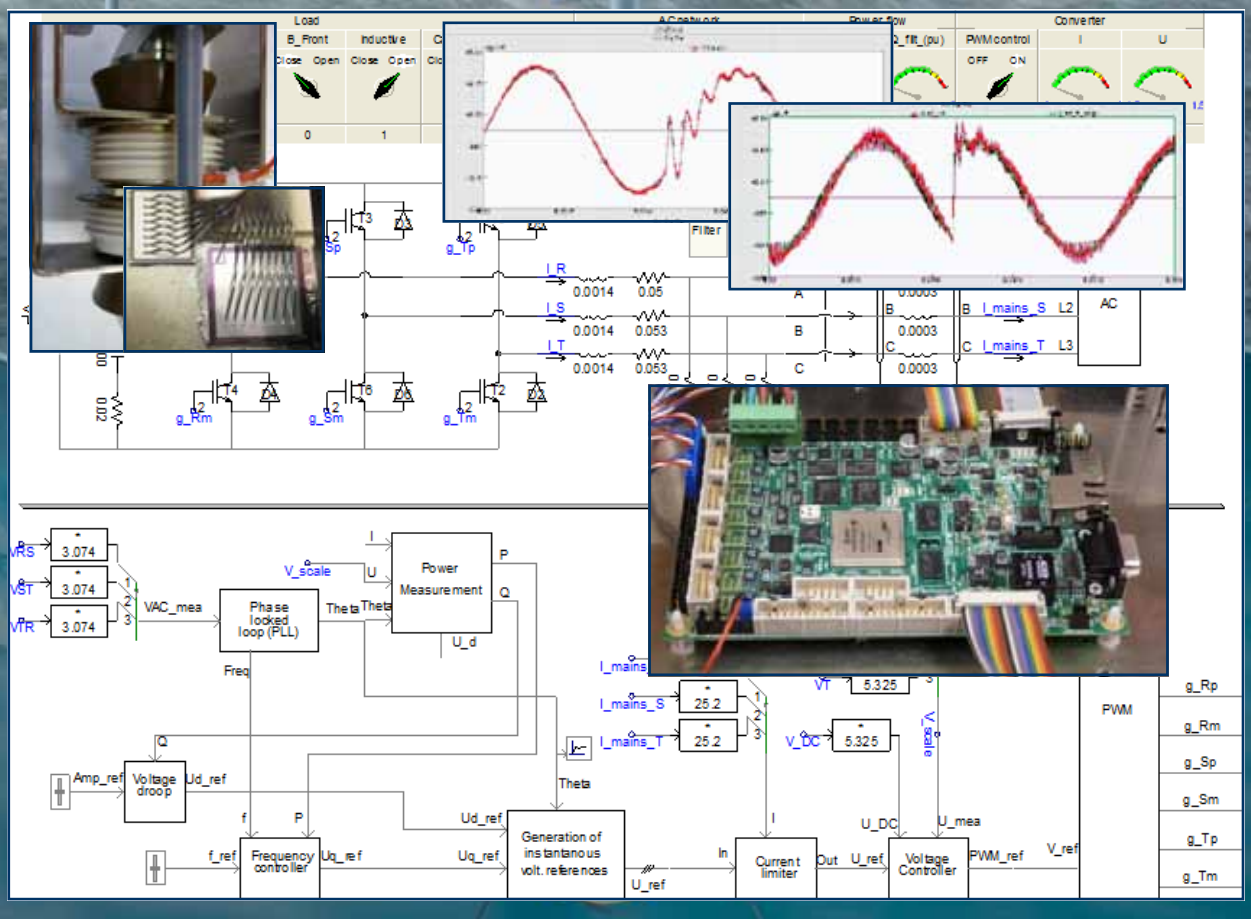
Reliable and Energy Efficient Power Electronics

- for Renewable Energy Systems

The main focus of this project is on reliability and energy efficiency of future offshore wind park systems, dominated by power electronic converters.

Project principal objective:
Provide competence and decision basis for enabling reliable and energy efficient power electronic components and systems for renewable power generation in harsh offshore environments, with focus on future hybrid ac/dc distribution networks for offshore wind parks.

Illustration: CeSOS, Bjarne Stenberg



Background

With large scale offshore power generation high voltage DC is expected to be used for transmission of power to the main land ac grid. Different AC- and DC- distribution systems may be used to connect the individual generators (wind turbines) to the high voltage DC transmission line.

Power electronic converters will be important components in offshore distribution systems. All power generated offshore will pass through two or more power electronic converters on its way to the consumers, thus high efficient converters are needed as well as strategies for efficient power flow in case of meshed networks. Grids dominated by converters increase system complexity and call for new skill and tools especially for fault handling. Because of long distances to shore and inaccessibility of the equipment, long repair times must be expected. At the same time the offshore environment is extremely harsh. Thus, high reliability is required for the converters and the system must be capable of handling faults in a way that does not cause unnecessary damages.

Research tasks and activities

Energy efficient conversion
- alternative topologies for medium voltage, medium power converters
- topology related losses considering switching frequency, filters, additional high frequency losses etc.

Energy efficiency of alternative system solutions
- different distribution network design alternatives
- different options for optimizing plant efficiency by utilizing advanced converter control options
- oscillations in a DC system and study of active damping alternatives

Reliable power electronic devices and converters
- semiconductor failure mechanisms, safety margins and aging effects
- redundancy and considerations regarding series and parallel connection of semiconductors

Reliability of complex power electronic grids
- reliability of different topology alternatives
- converter and system response to faults and operational disturbances
- fault handling in networks with several converters and especially with converters from different vendors

Analysis of advanced hybrid AC-DC grids
- focusing on both reliability and efficiency issues

Laboratory experiments to
- establish input for analysing plant efficiency, e.g. loss data from converter components
- study reliability issues, e.g. power cycling testing

Advanced control strategies for grid connected converters
- provide suitable control strategies for grid connected converters

Development of new models for numerical simulation
- models for numerical transient analysis for electrical and thermal phenomena in complex power grids, including detailed switching
- new models based on emerging needs in the project

Demonstrations by simulations and laboratory experiments

Education

- PhD study (Tilo Poller) on fault mechanisms and design measures to increase reliability and ruggedness of converters
- Post doc (Salvatore D'Arco) work within topologies and control strategies for medium voltage, high power converters

Research approach

The research in this project is performed through:

- Collection and compilation of relevant information from literature, partners, and international contacts
- Numerical analyses of various wind park grid architectures
- Laboratory measurements for component characterisation as input to simulations
- Laboratory testing of power semiconductor reliability and aging affects
- Development of dedicated models to be used with existing software
- Laboratory testing of converter control schemes

Project results:

The project provides knowledge and analysis tools applicable for designing offshore distribution systems, as well as for designing converters for offshore wind parks.

- Knowledge basis supporting technology selection
- Knowledge basis for designing reliable power electronic converters
  - redundancy and considerations regarding series and parallel connection of semiconductors, semiconductor failure mechanisms, safety margins and aging effects
- Knowledge basis and tools for designing medium voltage, medium power converters
  - interface between wind park grids and HVDC transmission systems
  - analysis of topologies for medium voltage, medium power converters
  - tools for calculating power losses and considering energy efficiency
- Analysis examples and simulation models for evaluating complex wind park structures
  - failure mechanisms, failure consequences and fault handling
  - characteristics of different network design alternatives
  - interaction between different converters in the same network
  - interface between wind park grid and HVDC transmission systems

A competence building project with user involvement, funded by the Research Council of Norway and industry partners.

Project responsible:	SINTEF Energy Research
Duration:	2009 – 2013
Total budget:	19 mill. NOK. Funded 70 % from the Norwegian Research Councils RENERGI programme
Partners:	Wärtsilä Norway, Statkraft, GE Wind Energy and The Norwegian University of Science and Technology
Sponsor:	Westcode Semiconductors Ltd
Project manager:	Magnar Hernes, SINTEF Energy Research
Project homepage:	www.sintef.no/OPE

SINTEF

SINTEF Energi AS (SINTEF Energy Research)
Phone: + 47 73 59 72 00, energy.research@sintef.no
www.sintef.no/energy

CONTACT
Senior Research Scientist Magnar Hernes,
e-mail: Magnar.Hernes@sintef.no