Power electronics for offshore, subsea and down-hole applications

Development of new power electronic converter technology opens up for new solutions for offshore, subsea and downhole power supplies.

Power semiconductors are available with increased power ratings. Ruggedness is improving, switching speed is increasing, control is becoming simpler and production costs are falling.

Installation of converters and power systems on the seabed is becoming more interesting as the ocean depth for oil and gas production increases. E.g. compressor drives, including electric motors and frequency converters for recompression of well stream placed on the seabed are already planned for some deep-water field development projects.

In an ongoing research project at SINTEF Energy Research we are currently doing research on new and pioneering concepts for subsea power electronic converters by enabling pressure tolerant power electronic components.

Design challenges
Designing converters and power systems including converters for seabed and downhole applications will be challenging.

• Satisfactory operating reliability in harsh environments
• Satisfactory accessibility for state monitoring and repair
• Satisfactory solutions for component and converter adaptation to high-pressure environment
• Satisfactory solutions for high ambient temperatures (downhole)
• Adaptation to space limitations (downhole)
• Acceptable costs

When facing high-pressure environments, traditional converter design is not sufficient. New design methods, materials and expertise need to be obtained. E.g. commercial available transistors and capacitors will need special encapsulation solutions to operate successfully in high pressure environments. Research at SINTEF Energy Research has shown that if traditional encapsulations are replaced with special solutions, these components can be exposed to ambient pressure of several hundred bars.
Reliability concerns

Power semiconductors are vulnerable components, in the sense that electric overload capacity (voltage/current) is strictly limited. E.g. in order to avoid breakdown of a transistor as result of a short-circuit, it must be switched off within a microsecond.

Power systems dominated by power electronic converters are also far more complex than traditional systems. The reliability of the converter and the complete system depends on the skills of the converter designer and the power system designer.

The reliability of a converter itself depends very much on built-in robustness:

- Power circuit topology and design
- Reliability and robustness of converter components (power semiconductors, capacitors, transformers, electronic components etc.) with reference to the specifications given by the manufacturer
- Component derating factors (voltage, current, temperature, etc)
- Selection and implementation of control strategies, including state monitoring, local and remote fault handling and self protection

Important issues for a reliable system solution:

- Mapping of worst case converter load conditions including load faults
- Mapping of power system fault scenarios
- Evaluation of risk for interaction between components in the system that may cause operating problems, especially between converter control systems and rotating machineries
- Accuracy and thoroughness in preparation of converter specifications

SINTEF Energy research is prepared and capable of assisting clients in these fields.

R&D projects involving offshore and subsea power electronics:

- “Feasible power electronics for demanding subsea applications”
  - Multi-client research project financed by power electronics industry, oil companies and The Research Council of Norway
- “Electric power systems for subsea processing and transportation of oil and gas”
  - Multi-client research project financed by power electronics industry, oil companies and The Research Council of Norway
- “Simulation of possible VSD and Gas Turbine-Generator interaction at the HAMMERFEST LNG-plant” – Accomplished project for Linde AG, in cooperation with Ødegaard & Danneskiold-Samsøe A/S (ØDS)
- “Clarification of possible network interaction between turbine-generator train and converters in the power network at VISUND” – Accomplished project for Norsk Hydro
- “Power electronics for extreme subsea and down-hole ambient conditions” - Self-financed SINTEF project
- Development of new Hyperbaric Welding Machine for PRS (Pipeline Repair System) - Norsk Hydro, Statoil et al - Working unit in operation since 1996, without any operating problems

Possible future subsea and downhole applications utilizing power electronic converter technology:

- Motor drives for valve actuators, pumps, compressors etc.
- Power supplies for control and monitoring equipment, e.g. well monitoring and reservoir mapping
- Inductive power couplers (to and between subsea modules)
- Solid state power breakers
- Downhole tools for assembling and repair
- Electrical drives for well drilling
- Subsea power distribution systems for offshore wind energy