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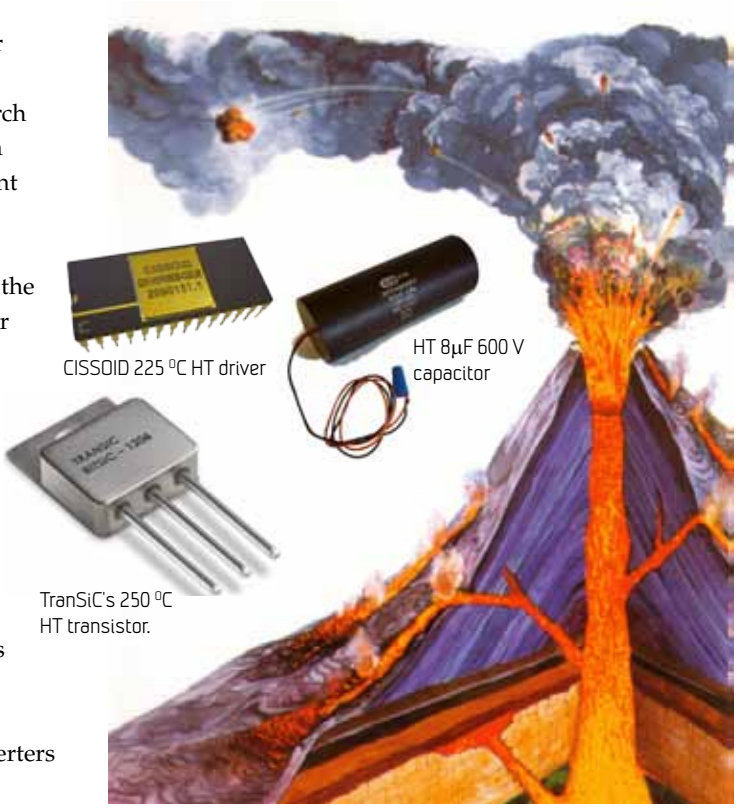
High Temperature Power Electronics
for downhole exploration

SINTEF Energy Research has started exploiting advances optained ?? for High Temperature Power Electronics (HTPE) medium-power converters for operation up to ambient temperatures in the range 200-250 °C for downhole, automotive and aerospace applications.

There is demand for increasing productivity and exploitation of oil and gas wells. As the well depth increases, the operating temperature for deep well tools and instruments increases. The today's downhole actuator technology is primarily based on hydraulic systems. Electronics has been limited to monitoring and logging functions. Electric drives operating at high temperatures would enable new concepts for designing new technologies for oil and gas exploration and processing. Power electronics is one of the triggering factors in these applications.

Downhole subsea exploration and processing, courtesy of Roxar AS

The demand for increased power density, improved reliability, higher operating voltage and operating temperature are encouraging research on new materials. Advanced silicon technology (e.g. SOI) could represent a solution for control electronics. Widebangap materials represent interesting candidates for avoiding the silicon physical limitations in power device technology (thermal limit, voltage breakdown, etc). Silicon Carbide (SiC) and Gallium Nitride (GaN) are two candidates for new power semiconductor technology.



CISSOID 225 °C HT driver

HT 8µF 600 V capacitor

TranSiC's 250 °C HT transistor.

Today SiC power devices are on the market, but unfortunately the commercial available products are limited to a few types of devices (Schottky diodes, VJFET and SiC BJT). Typical applications for high temperature power electronic converters are oil and gas exploration and processing, drive trains, electric vehicles and aerospace applications.

Newsletter from SINTEF Energy Research

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SINTEF Energy Research is investigating the feasibility of this emerging technology for downhole power supplies where the ambient temperatures may increase above 200 °C (deep wells). Our background is experience from research and development of power electronics for special applications, such as hyperbaric welding equipment and pressure tolerant power electronics.

In an ongoing internal project at SINTEF Energy Research we have mapped the availability for high-temperature power electronic components, and based on this information we are currently investigating suitable converter topologies that can be candidates for prototypes aimed for reliable operation above 200 °C ambient.

Design Challenges

Downhole exploration and oil and gas processing give new challenges to power electronics. Operability in ambient temperatures up to 250 °C is demanded.

- Operability in harsh environment
- Adaptation to space limitations
- High temperature stability and reliability
- Acceptable costs

Standard components are designed for absolute maximum temperatures up to 125-175 °C, but will not fulfil long-term reliability requirements under these conditions. E.g. power capacitors are often rated up to 80 °C and for commercial ICs the temperature limit is 125 °C. For short lifetime applications standard components are used at their maximum absolute ratings.

The investigations at SINTEF Energy Research has shown that a limited number of components capable of operating at high temperatures are available and that they represent a starting point for further work on design and development of prototypes.

Possible future downhole and automotive applications enabled by high temperature Power Electronics

- Motor drivers for downhole exploration
- Power electronics embedded on drivetrain
- Downhole equipment for inspection and repair
- Power supplies for well monitoring and control equipment
- Engine monitoring and control

Further work

Tasks on High Temperature

- Device characterization
- Failure mechanisms and device reliability
- Packaging
- Driver topologies and other components
- Mapping of applications including technical and economical potentials
- Converter topology investigations
- Design of HT converter modules

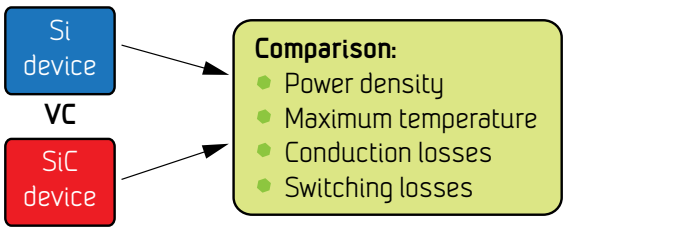
Scope

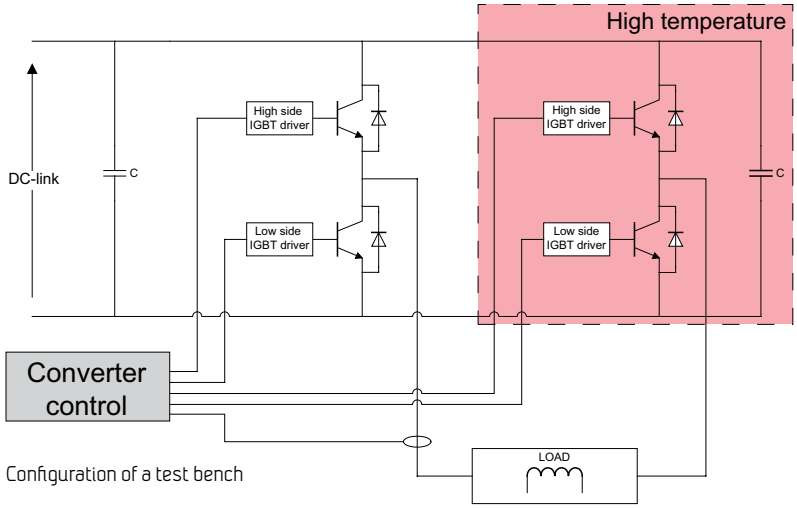
Realize reliable HT converter test objects. Several components will be subject to tests:

- Power switching devices
- HT power capacitors for DC-link and filter
- HT control electronics
- Components and circuit design

Testing methodologies

- Component parameter characterization f(T)
- Passive testing of packages, terminations etc
- Power pulse testing
- Continuous testing at HT and rated V&I





Configuration of a test bench

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