Junction Temperature Estimation Technology Demonstrator

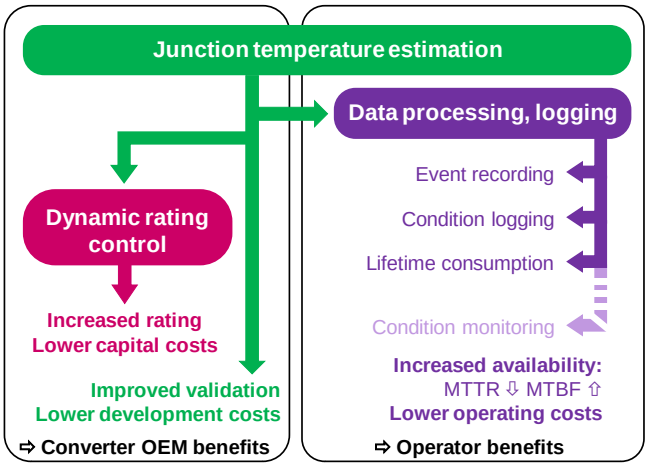
An intelligent gate drive can deliver significant benefits to the whole converter – not just the power devices – and reduce both capital and operating costs through improved rating and condition monitoring. Estimation of IGBT and diode junction temperature and accurate measurement of on-state voltage are two of the enabling technologies to achieve this so-called "silicon squeeze". This technology demonstrator is a showcase for junction temperature estimation, which is targeted at commercial deployment.

Why junction temperature?

Junction temperature estimation enables the following features in power converters:

- Detection of device exceeding maximum temperature threshold (e.g. 125 °C).
- Validation of converter stack design during converter type testing.
- Dynamic rating control, i.e. intelligent over-rate and de-rate, both dynamic and steady-state.
- Temperature cycle counting, for recording the thermal cycling history and lifetime consumption estimation.

Closely related to this is on-state voltage measurement, which is a key enabler for **condition monitoring**. This allows detection of thermo-mechanical wear-out of packaging, notably bond wire lift-off and solder fatigue.



Converter and End User Benefits

- **Converter design and test:**
  Improved converter stack validation is possible, particularly at the type testing stage, reducing development costs and increasing confidence in the design.
- **Optimised converter cost and performance:**
  "Dynamic Rating Control" (DRC) can be achieved with greater confidence using junction temperature estimation. This enables converter stack over-rating when the ambient temperature is low, or the correct de-rating above the nominal rated temperature. This can result in smaller converter; for example, in wind turbine applications where higher ratings are required in winter but the ambient temperatures are lower:
- **End user operating costs:**
  Junction temperature estimation and on-state voltage drop measurement both enable condition monitoring (CM) of IGBT and diode modules. This gives warning of abnormal operation, and potential reductions in operating and maintenance costs if failure is prevented by CM. The payback can be less than 1 year in high-availability applications.

What is being demonstrated?

- **Junction temperature estimation** for both IGBT and anti-parallel diode
- On-board collector current measurement
- On-board voltage measurement: accurate **on-state voltage drop** for both IGBT and anti-parallel diode, and off-state (DC link) voltage.

Summary of Results

The junction temperature estimates are compared with IR temperature sensors and an IR camera with an open IGBT module. A 3-phase inverter with inductive load is driven by a simple mission profile of rms current to generate dynamic loading.

Matching of the estimated junction temperature is accurate to within ±5 °C for both the IGBT and diode.


Medium voltage motor drives


Locomotive traction & marine drives


Wind turbine & solar inverters


High voltage DC infrastructure

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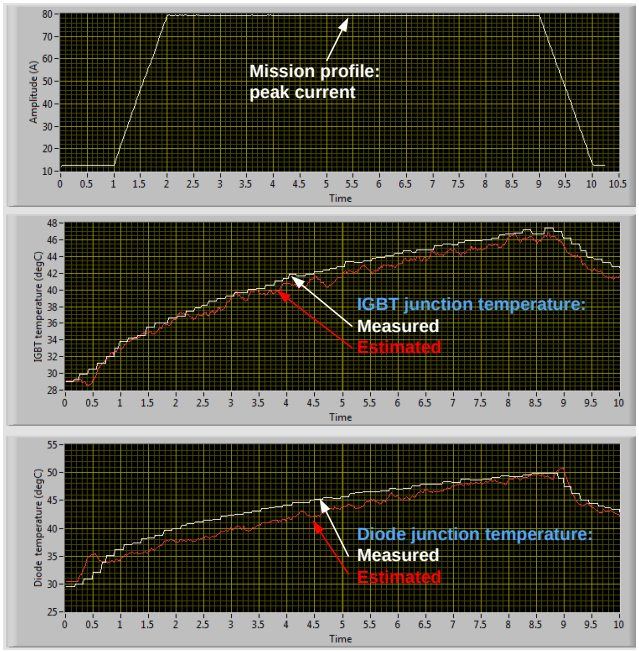
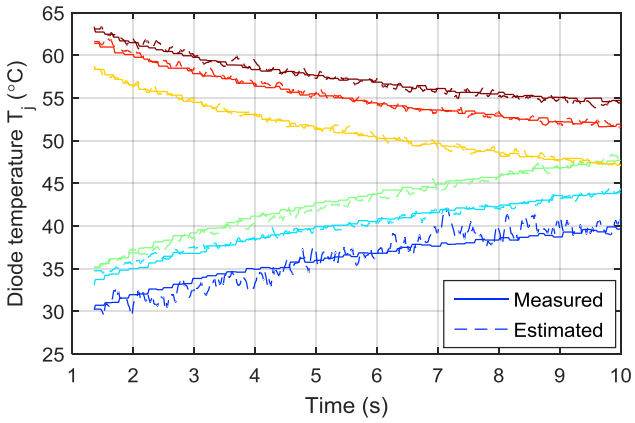
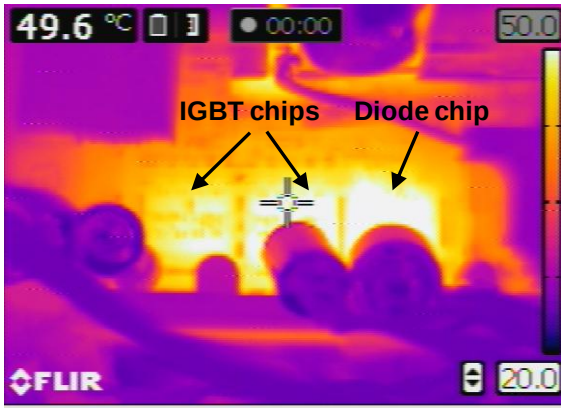


Matching of junction temperature estimation with temperatures measured by IR sensors.



Matching of diode junction temperature estimate for both heating and cooling mission profiles.



Chip temperature measurement with IR camera.

Supporting Technology

Amantys Power Insight™ technology provides two-way communication between the central controller and the gate drive. This includes remote configuration of the gate drive, and streaming of data in real time from IGBT and diode measurements.

It allows both real-time monitoring and periodic download of key device parameters, including **junction temperature and on-state voltage drop**, during the converter operation.

Application of the Technology

The technology demonstrated here is suitable for all high power converter applications. In particular, the technology has the following features:

- Measurement techniques compatible with any voltage and current rating, and SiC devices
- Compatible with all high-power device modules, including next generation half-bridge modules ($_n$HPD^2, LinPak, XHP, etc)
- Simple integration into a converter.
- Estimation techniques designed for ease of use and calibration in future products.

Typical uses include:

- HVDC voltage source converters
- Rail traction converters
- Medium- and low-voltage converters and drives:
  - Industrial drives
  - Mining applications
  - Construction and agricultural vehicle traction
  - Oil and gas applications
  - Marine and offshore applications
  - Solar converters
  - Wind turbine converters

Want to know more…?

Our engineers would be delighted to discuss your requirements for junction temperature estimation and condition monitoring.

For more information, please contact us at info@amantys.co.uk.

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