Thermal Optimized Operation of the Single-Phase Full-Bridge PV Inverter under Low Voltage Ride-Through Mode

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Published in:
Proceedings of PCIM Europe 2013

Publication date:
2013

Document Version
Accepted author manuscript, peer reviewed version

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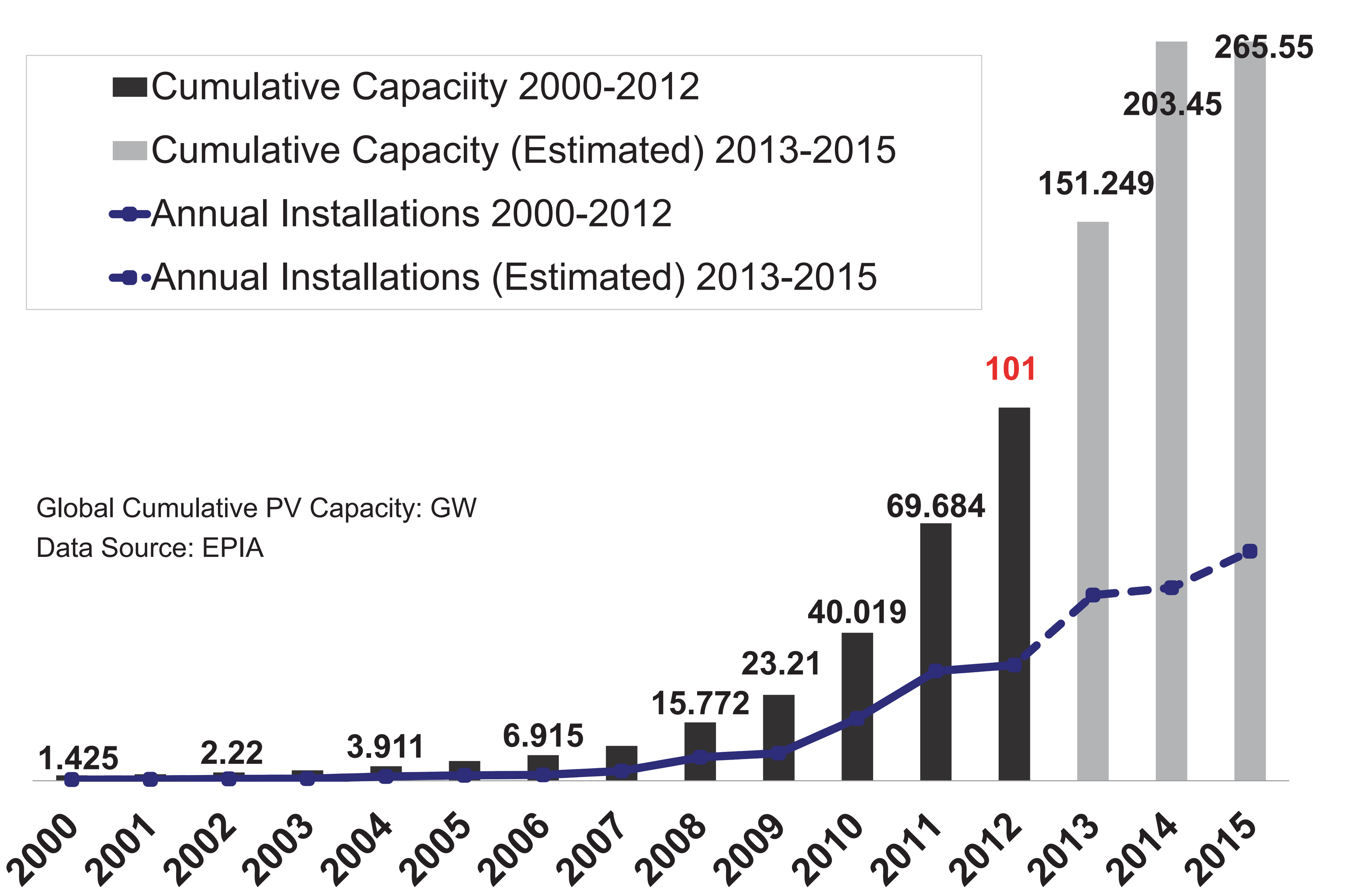
PCIM EUROPE
Nuremberg, 14 – 16 May 2013

Abstract- The efficiency of 98% has been reported on transformer-less photovoltaic (PV) inverters and the penetration of grid-connected PV systems is booming as well. In the future, the PV systems are expected to contribute to the grid stability by means of low voltage ride-through operation and grid support. At the same time, the target of a long service time (25 years or more) imposes new challenges to grid-connected transformer-less PV systems. Achieving more reliable PV inverters is of intense interest in recent research. As one of the most critical stresses that induce failures, the thermal stresses on the power devices of a single-phase full-bridge PV inverter are analyzed in different operational modes in this paper. The low voltage grid condition is specially taken into account in this paper. The analysis is demonstrated by a 3 kW single-phase full-bridge grid-connected PV system by simulations. **The mean junction temperature and the junction temperature fluctuation of the power devices can be reduced by properly injecting reactive current into the grid under grid faults, and consequently, the overall lifetime of the entire PV system is improved.**

Introduction

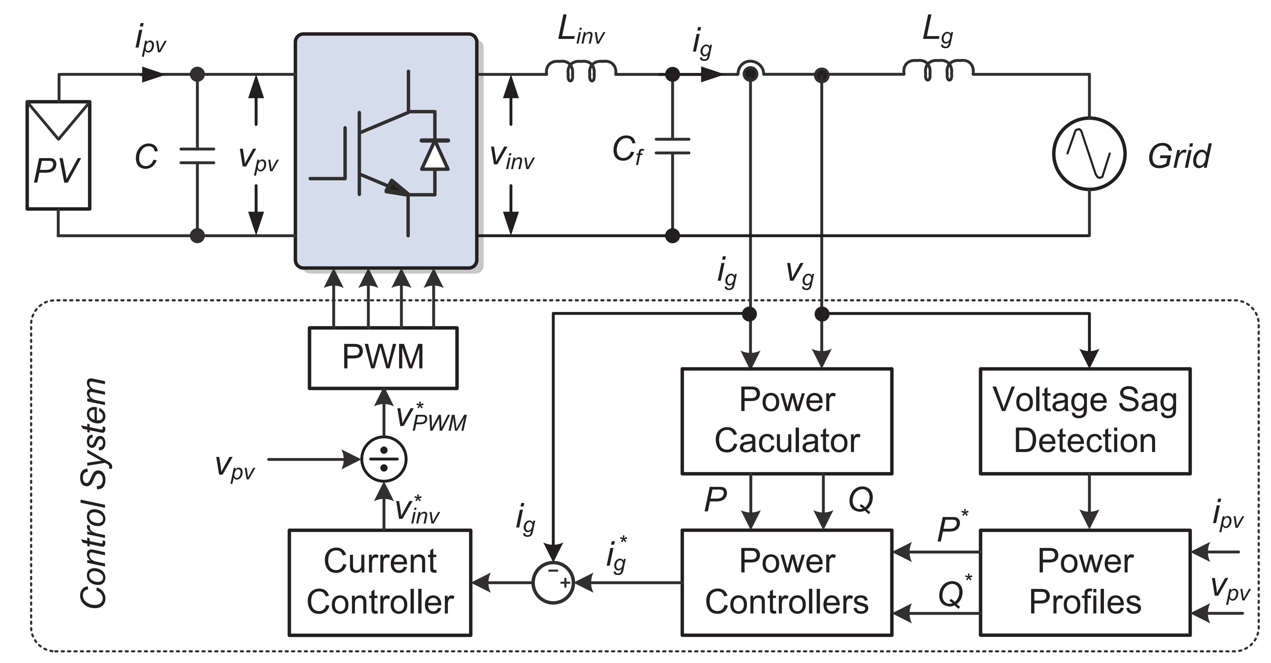


Highly Penetrated PV Systems in the Grid in the Future:

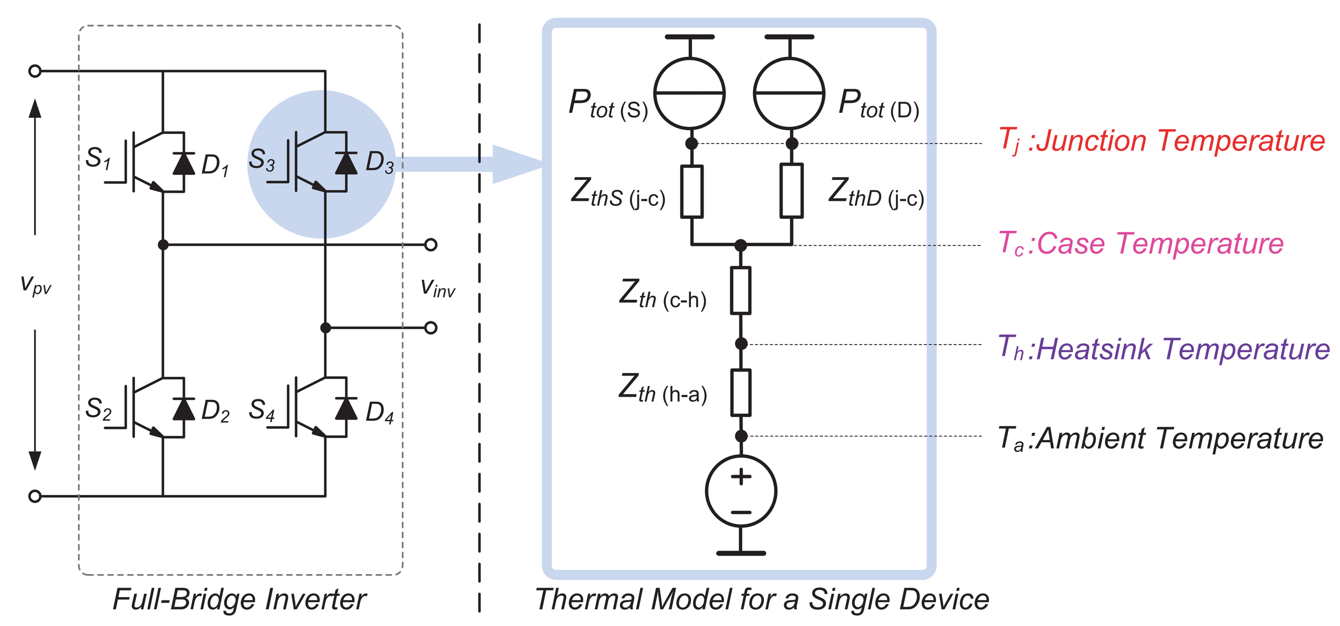
- ❖ More Stringent Grid Requirements
- ❖ Ancillary Services (Grid Support, Reactive Power Compensation)
- ❖ Dynamic Grid Support (**Low Voltage Ride-Through**)
- ❖ High Efficiency and **High Reliability**

Thermal Models of the Full-Bridge PV Inverter

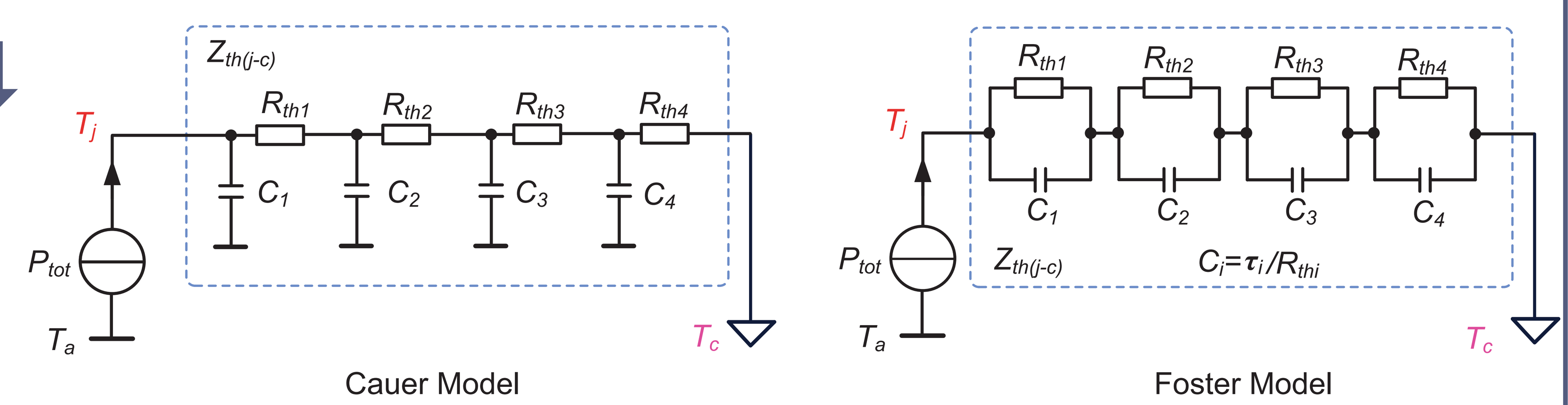
Typical Single-Phase PV System with Low Voltage Ride-Through Capability



Thermal Model of an IGBT Module

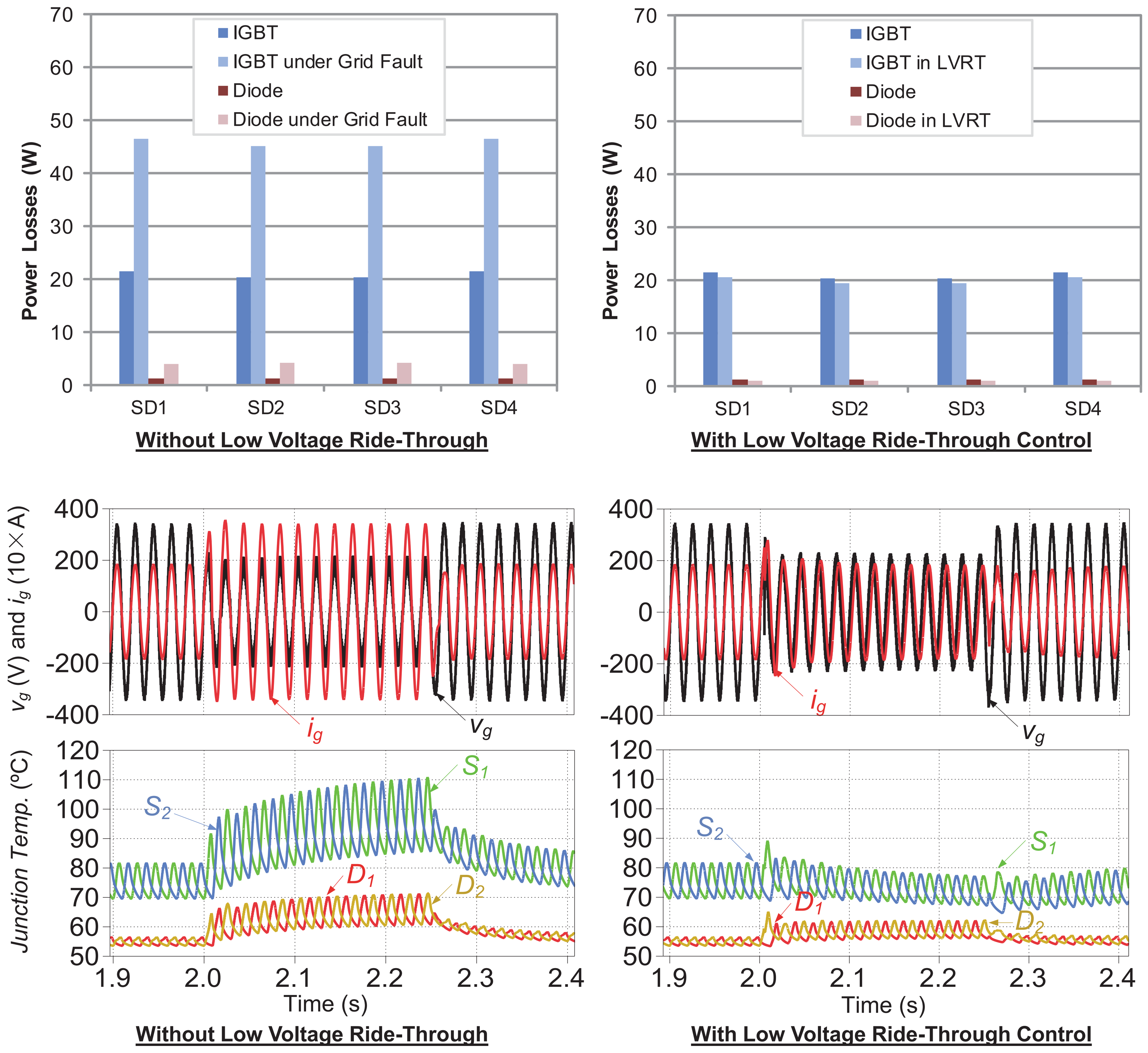


Thermal Model of the Thermal Impedance



Thermal Optimized Operation Mode

Operation Condition: Solar Irradiance: 1000 W/m², Ambient Temperature: 50 ℃

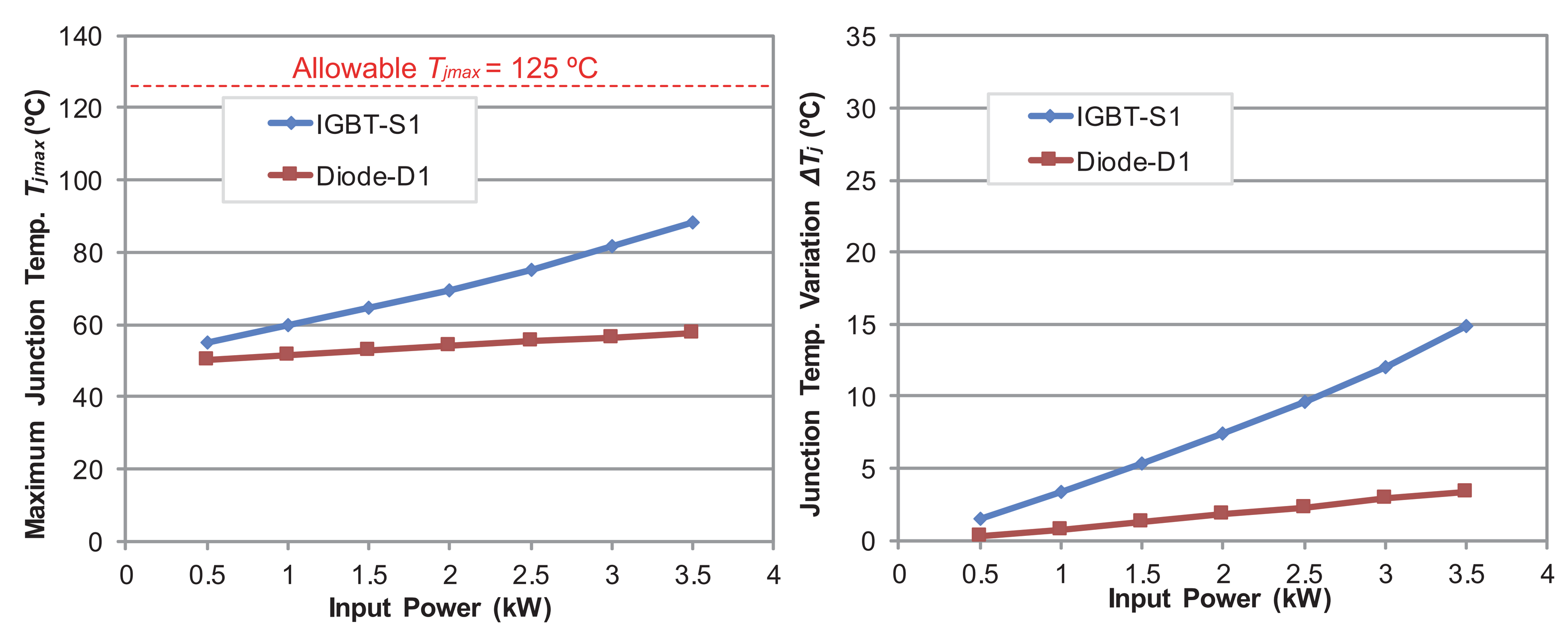


With Thermal Optimized Operation Control:

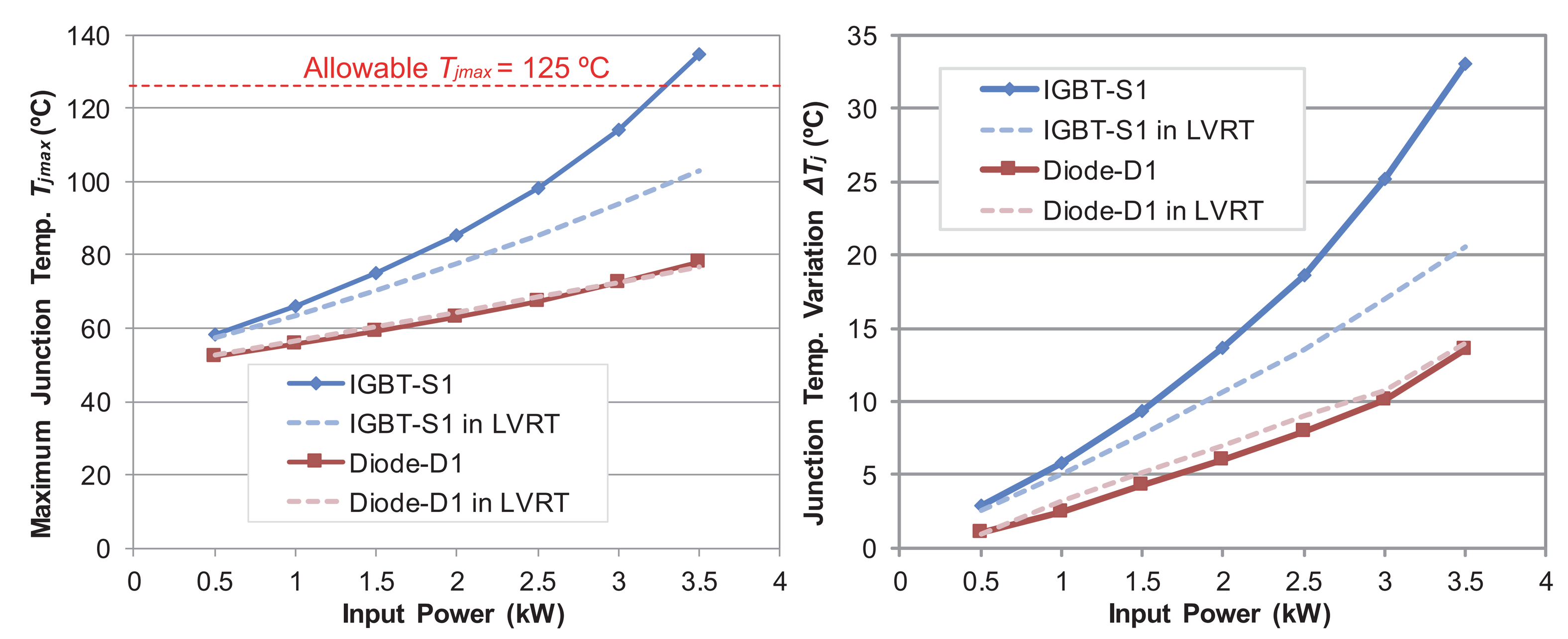
- ✓ Reduction of Power Losses under Grid Faults and Low Junction Temperature
- ✓ Reduced Junction Temperature Variation from 24 ℃ to 10 ℃

System Operation under Different Power Levels

In Normal Operation Mode



Under Grid Fault (0.45 p.u. Voltage Sag)



With Thermal Optimized Operation Control:

- ✓ Maximum Junction Temperature below the Allowable Value