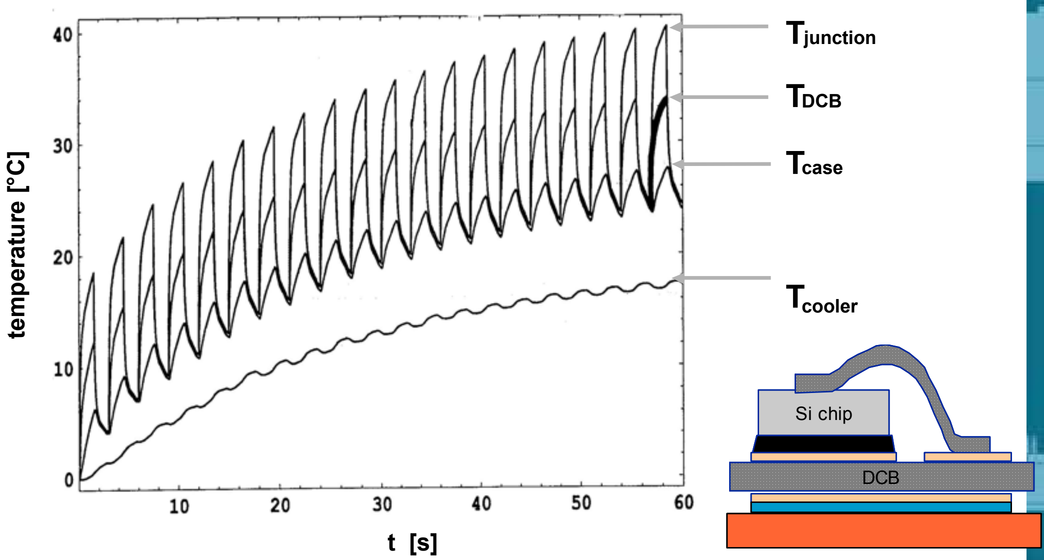
APPLICATION NOTE

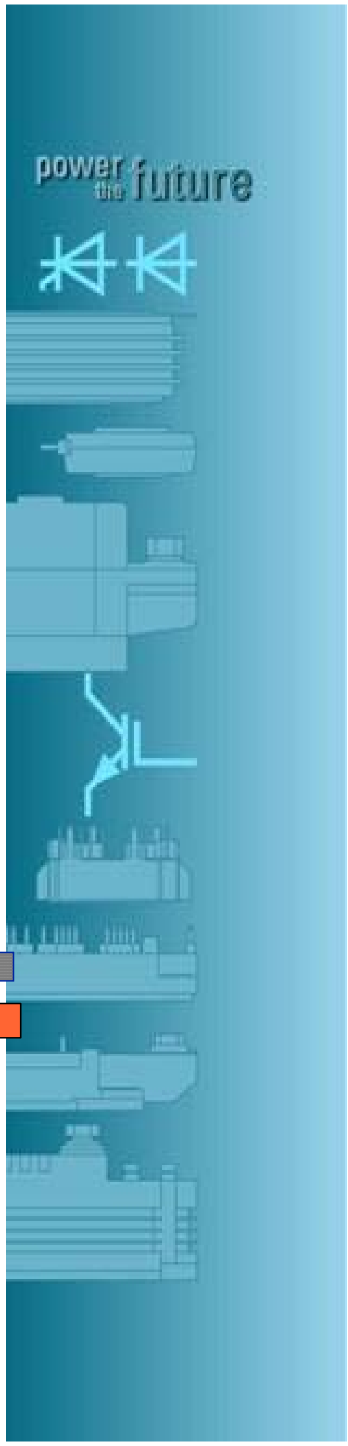
AN-Number: AN2003-x04

This application note will summarize the power and thermal cycling capability of eupec high power IGBT modules.

Standard modules are designed for the needs of general industrial applications while **traction modules** feature specific measures for increased reliability. They are fulfilling even the severest specifications commonly required by traction or industrial applications with heavy load cycles.
Traction modules are available in the voltage classes from 1700V up to 6500V.



The **power cycling** capability**,** given by the temperature excursions of the junction, depicts the quality of the bond wires while the **thermal cycling** capability specifies the material matching between base plate and substrate in regard to their capability to sustain thermal stress. For more details on this, see the PCIM 2002 paper “The new 6.5kV IGBT module: a reliable device for medium voltage applications”, available on eupec´s hompage (editorials).



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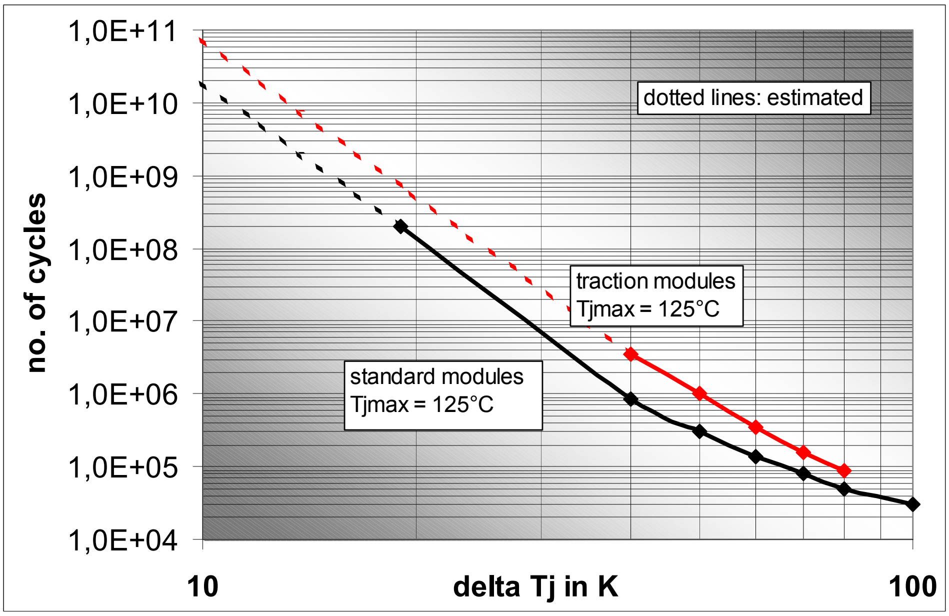
The power cycling diagram

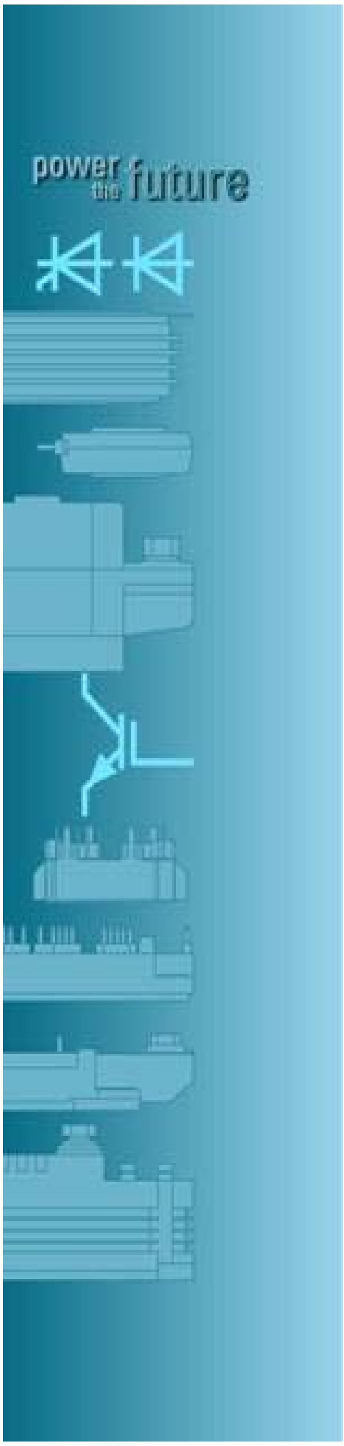
Tests are performed by temperature swings which commonly reach a T_{jmax} of 125°C (e.g. the value for ΔT_j = 40K is derived from cycles between 85°C and 125°C). Failure indicator is an increase of the forward voltage by 5%. With this, the parameters are still within the limits of the data sheet and the switching characteristics are within the specification !



Power cycling capability of standard and traction modules at 125°C

Against formerly published diagrams, the standard curve is now extended widely into the direction of lower ΔT_j. Actual measurements confirm 200Mio. cycles at 19K. The above failure criteria was still not reached when stopping the test due to material fatigue in the test stand.

Considering the gain of reliabilty between standard and traction technology, predictions into the range of low temperature excursions at high number of cycles could be done for traction modules as well. These values are marked as estimated in the above diagram.



Power and Thermal Cycling Capability

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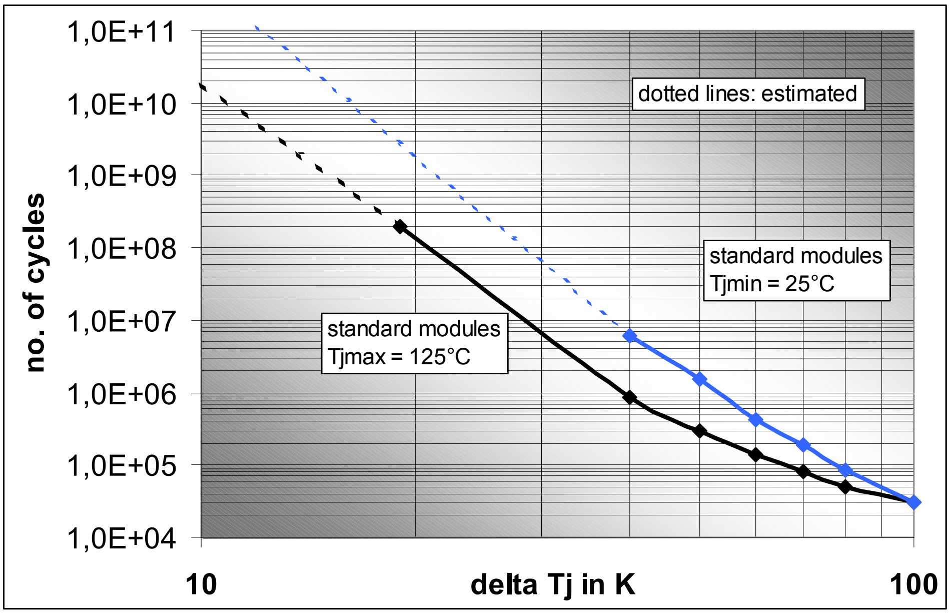
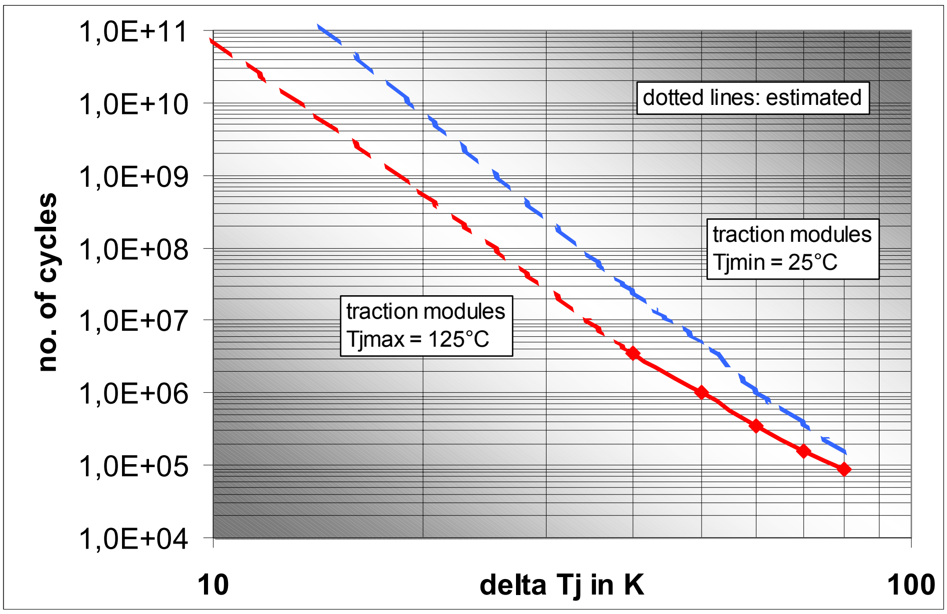
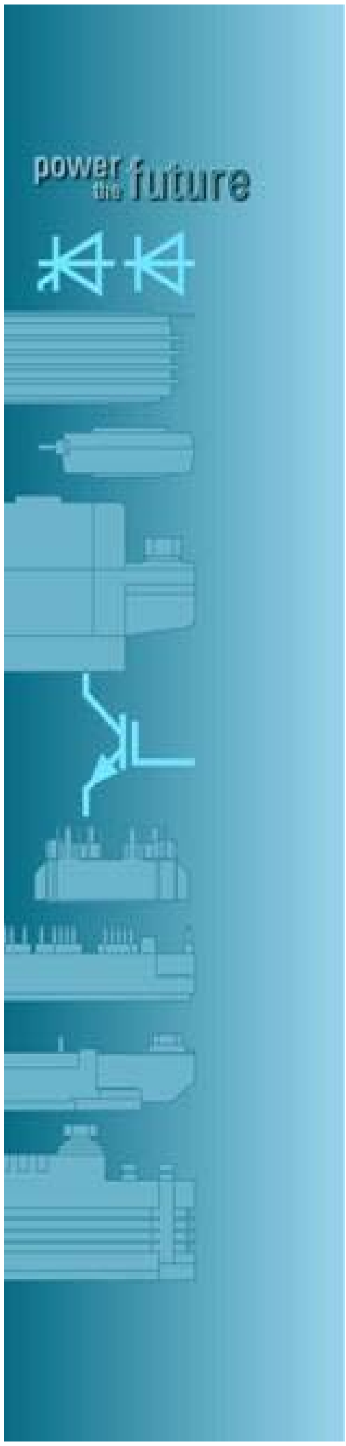
For applications which do not reach the temperature level of 125°C, the diagram only allows a worst case estimation. To allow also calculations for temperatures below this level, a second set of measurements was performed, now testing temperature swings starting at a T_{jmin} of 25°C.



Power cycling of standard modules in dependency of the temperature



Power cycling of traction modules in dependency of the temperature



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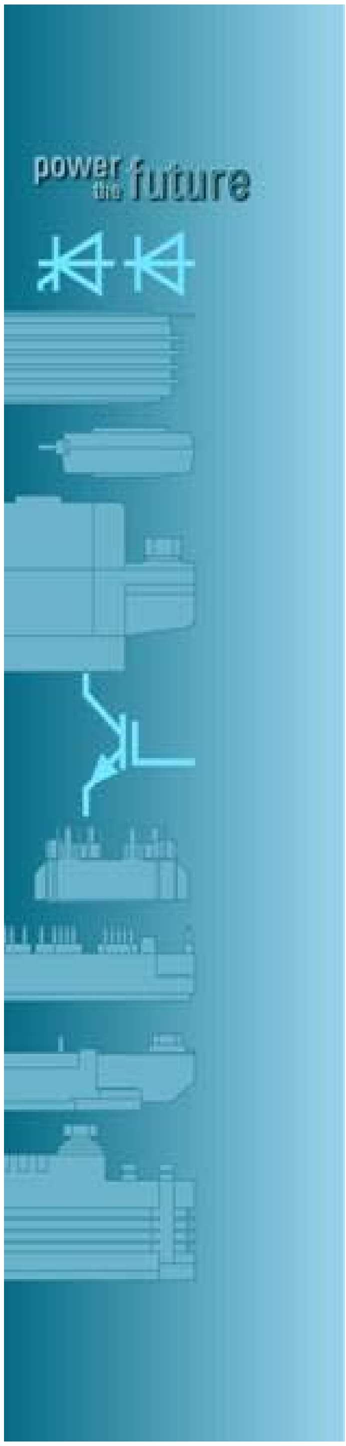
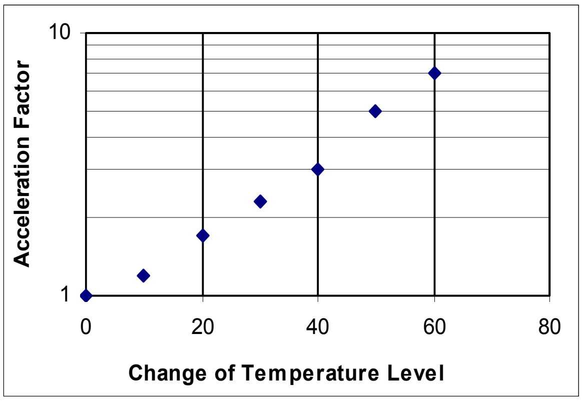


Further temperature levels in-between the range of T_{jmin}=25°C and T_{jmax}=125°C can be evaluated with the help of acceleration factors:



Example: what is the power cycling capability of a traction module for repetitive cycles of ΔT_j = 50K from T_{jmin} = 50°C to T_{jmax} = 100°C ?

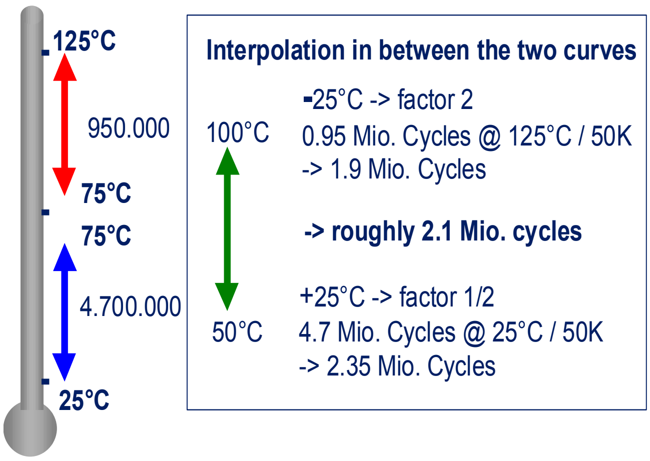
Acceleration factors for power cycling

The power cycling diagram for traction modules in combination with above accelating factors give the following numbers:

0.95Mio cycles for ΔT_j = 50K and T_{jmax} = 125°C → operation at 100°C instead of 125°C (-25K) gives a deceleration by a factor of approximately two, resulting in 1.9Mio cycles.

4.7Mio cycles for ΔT_j = 50K and T_{jmin} = 25°C → operation at 50°C instead of 25°C (+25K) gives an acceleration by a factor of 2 resulting in 2.35Mio cycles.

Interpolation between the two results finally allows a prediction of roughly 2.1Mio cycles.



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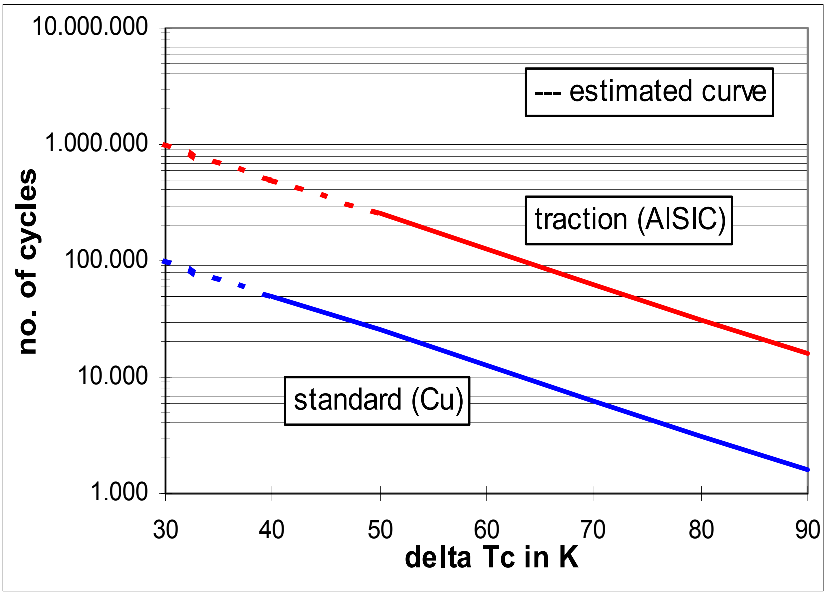
The thermal cycling diagram

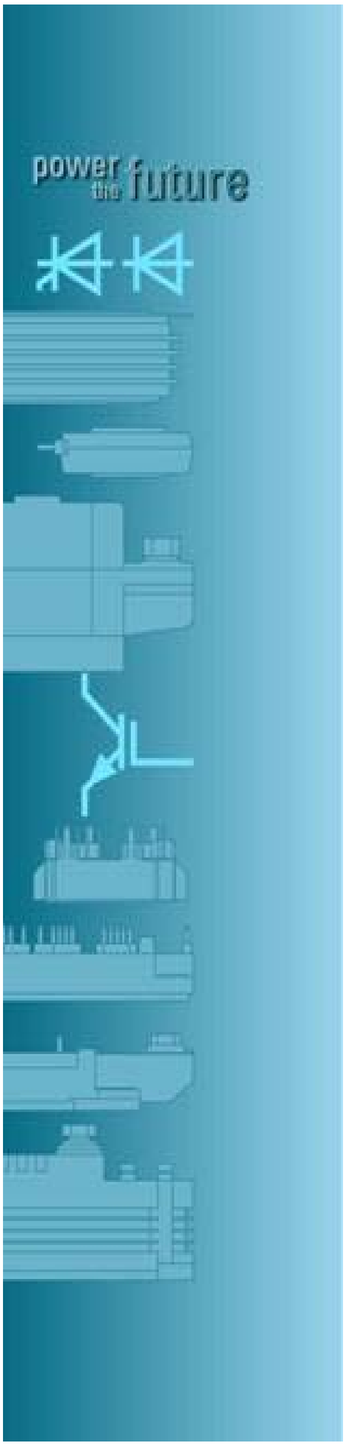
Thermal cycling means driving the case (base plate) at two different case temperatures, e.g. testpoints: ΔT_c = 80K: T_{c1} = 20°C T_{c2} = 100°C

Failure indicator is an increase of the thermal resistance of 20%. With this, the parameters are still within the limits of the data sheet and the switching characteristics are within the specification !

The improvements, receivable by changing the base plate material from Cu (standard) to AlSiC (traction), are documented in the following figure.



Thermal cycling capability for standard (Cu) and traction (AlSiC) modules



The thermal cycling capability can be substantially increased, whereby Al-SiC shows absolutely no indications of delamination or weakening of the solder structure.

Example for standard and traction modules:

	standard e.g. ..R17KE3	traction e.g. ..R17KE3_B2
☞ Baseplate	copper	AlSiC
☞ Chip bonding	standard bond process	special coating
☞ Reliability	standard	very high
☞ Insulation	$Al_2 0_3$	AlN