IXYS UK WESTCODE

Date: 1st August 2017

Issue: 3

Application note for the use of a rectifier diode above $T_{j(max)}$ with a short term overload

Introduction

In many applications, semiconductor converters are subject to infrequent short-term overload periods. In order to make efficient use of the semiconductor device it is possible to consider a short term increase in junction temperature above $T_{j(max)}$ but at a reduced voltage.

Rectifier diode operation at an elevated temperature

Silicon rectifier diode characteristics are temperature dependant to some degree. For a modest increase in junction temperature many of these characteristics are of little consequence in line frequency converters.

Above the rated maximum junction temperature, $T_{j(max)}$ the reverse leakage current, I_{RRM} will approximately double for every 10°C rise above $T_{j(max)}$ as shown in figure 1. As the leakage current increases the power dissipation within the diode will increase and the potential for hot spots to form in the silicon could increase significantly. This mechanism could ultimately lead to component failure.

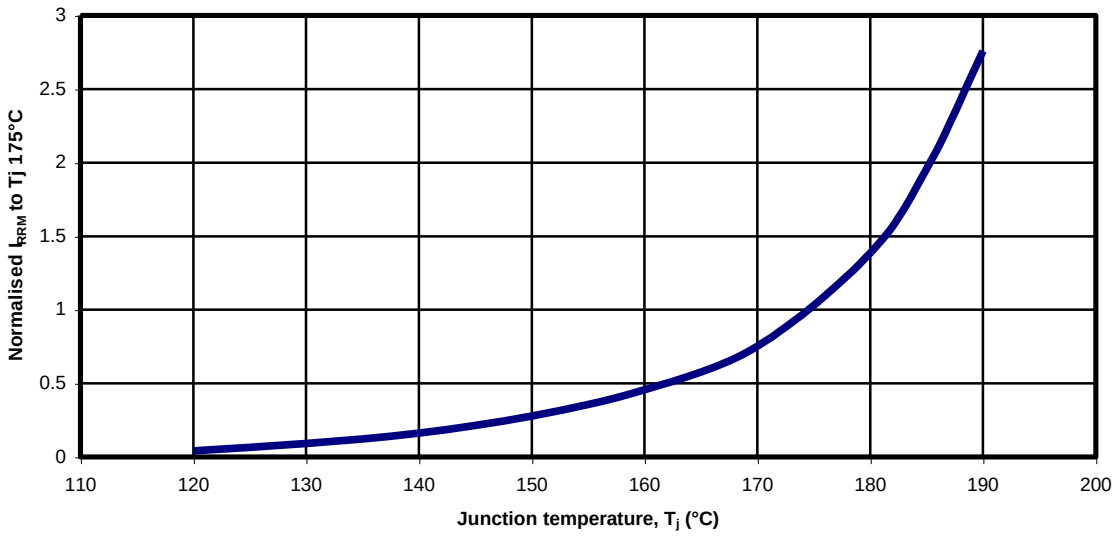

Figure 1: Normalised I_{RRM} vs Tj

In the majority of applications however there is a significant margin between the device rating and the applied working voltage. This is required to allow for transients induced by commutation and network disturbances.

It can be seen in figure 2 that the leakage current typically halves for a 20% drop in the applied voltage.

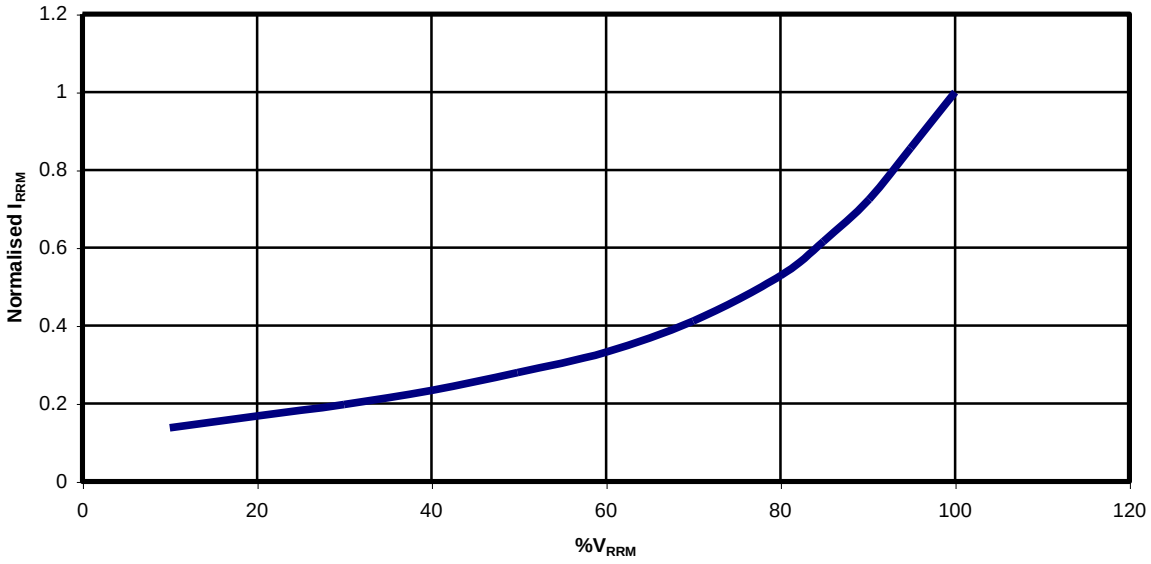

Figure 2: Normalised I_{RRM} vs % applied voltage

It is therefore reasonable to assume that in such applications it may be permissible to operate at an elevated junction temperature for a short period of time.

Designs in which the junction temperature of up to 15°C beyond the maximum rated value of T_j for transient operation with a maximum working peak voltage of 60% of the device rating have been successfully implemented. The transient overload period is limited by the thermal stability of the blocking junction and will vary according to cooling conditions and individual device geometry. Typically overloads up to 60 seconds are acceptable for all IXYS UK Westcode line frequency rectifiers.

It should be noted that during an overload period it may be appropriate to use the transient thermal impedance curve to calculate the increase in junction temperature. To demonstrate a graph of forward current and junction temperature vs time is shown in figure 3. The diode is conducting 5000A DC and the junction temperature is calculated at $T_{j(max)}$ using the steady state thermal resistance value. During this time a series of overload events takes place and the temperature increase is reflected using the transient thermal impedance curve. Information relating to the transient thermal impedances can be found in the data sheets.

For very short overload periods a much higher junction temperature is possible. Under typical limit surge conditions the device junction temperature may exceed 350°C. Please refer to the individual device data sheets for more information relating to surge events.

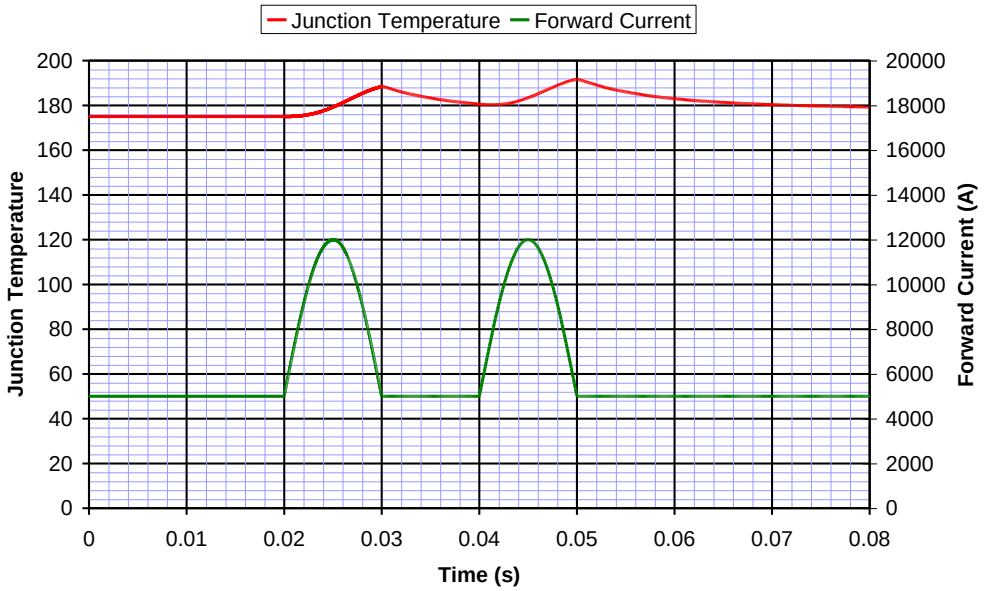

Figure 3: Forward current, junction temperature vs time under overload conditions

Precautions

Other device characteristics will be affected by increasing the T_j beyond that specified in the datasheet, in particular:

1. Increased recovered charge of typically 10% of Q_{rr} per 15°C. This increase must be factored into any snubber design.
2. A shift in the on state characteristics, specifically a small reduction in V_{T0} and a small increase in R_T. This shift could be as much as 5% per 15°C.

Other characteristics such a forward recovery voltage, V_{FR} could be affected but these parameters are less likely to be significant in typical rectifier applications.

One final point to consider is that of thermal cycling load. Operation of a diode with a large temperature deviation (ΔT) is likely to accelerate the mechanical wear out of the internal components and could lead to a reduction in the useful life of the diode. Again it is unlikely that this will present as an issue, but it may warrant investigation.

Summary

The application of rectifier diodes with a junction temperature of 15°C beyond the maximum rated value for transient operation of with an upper limit working peak voltage of 60% of rating has been successfully achieved. The transient overload period is limited by the thermal stability of the blocking junction and will vary according to cooling conditions and individual device geometry. Typically overloads up to 60 seconds are acceptable for all IXYS UK Westcode line frequency rectifiers.

The effects of the increased temperature on the various parameters have been briefly outlined.

It should be noted that the customer must be satisfied as to the suitability of this approach in the specific application.

Disclaimer

The guidance given herein is provided for information only and IXYS UK Westcode in no way implies any warranty for devices operated outside of the maximum ratings as specified in the datasheet.

Any application of devices beyond maximum ratings should be thoroughly qualified and validated on an individual basis.

IXYS Semiconductor GmbH
Edisonstraße 15
D-68623 Lampertheim
Tel: +49 6206 503-0
Fax: +49 6206 503-627
E-mail: marcom@ixys.de

IXYS UK Westcode Ltd
Langley Park Way, Langley Park,
Chippenham, Wiltshire, SN15 1GE.
Tel: +44 (0) 1249 444524
Fax: +44 (0) 1249 659448
E-mail: sales@ixysuk,com

IXYS Corporation
1590 Buckeye Drive
Milpitas CA 95035-7418 USA
Tel: +1 (408) 457 9000
Fax: +1 (408) 496 0670
E-mail: sales@ixys.net

IXYS Long Beach
2500 Mira Mar Avenue
Long Beach CA 90815 USA
Tel: +1 (562) 296 6584
Fax: +1 (562) 296 6585
E-mail: service@ixyslongbeach.com

www.ixysuk.com

www.ixys.com