IGBT

Maximum junction temperature (Tjmax185℃)

Introduction

This application note explains the maximum junction temperature (Tjmax) of 185℃ for Renesas Electronics IGBT products.

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1. IGBT Junction Temperature

When an IGBT is used in an inverter or other device, energy is consumed, and heat is generated during switching and conduction. Operations exceeding the maximum junction temperature (Tjmax) can damage the product and run the risk of causing a fire. Caution must be taken when determining the operating conditions. Users also face the risk of a vicious cycle in which heat generation leads to increased losses due to high-temperature operation, further worsening energy efficiency. Using products with a high Tjmax helps to reduce these risks.

Also, products with a high Tjmax can increase the maximum output current, allowing operations in harsher conditions.

The Renesas IGBT AE5 achieves a Tjmax of 185℃. Figure 1-1 shows the output current during 3-phase inverter operations at Tjmax 175℃ and 185℃. The 185℃ operation can increase output current by about 7% compared to the 175℃ operation. Using a higher Tjmax increases the likelihood of the product being suitable for the user's target operating conditions.

*Note that Figure 1-1 shows the calculated results based on a simulation. The Tjmax rating must not be exceeded even momentarily. The product must not be used under conditions where Tjmax may be exceeded. Before using the product in actual conditions, always evaluate and verify under worst-case conditions after setting a sufficiently verified design margin.

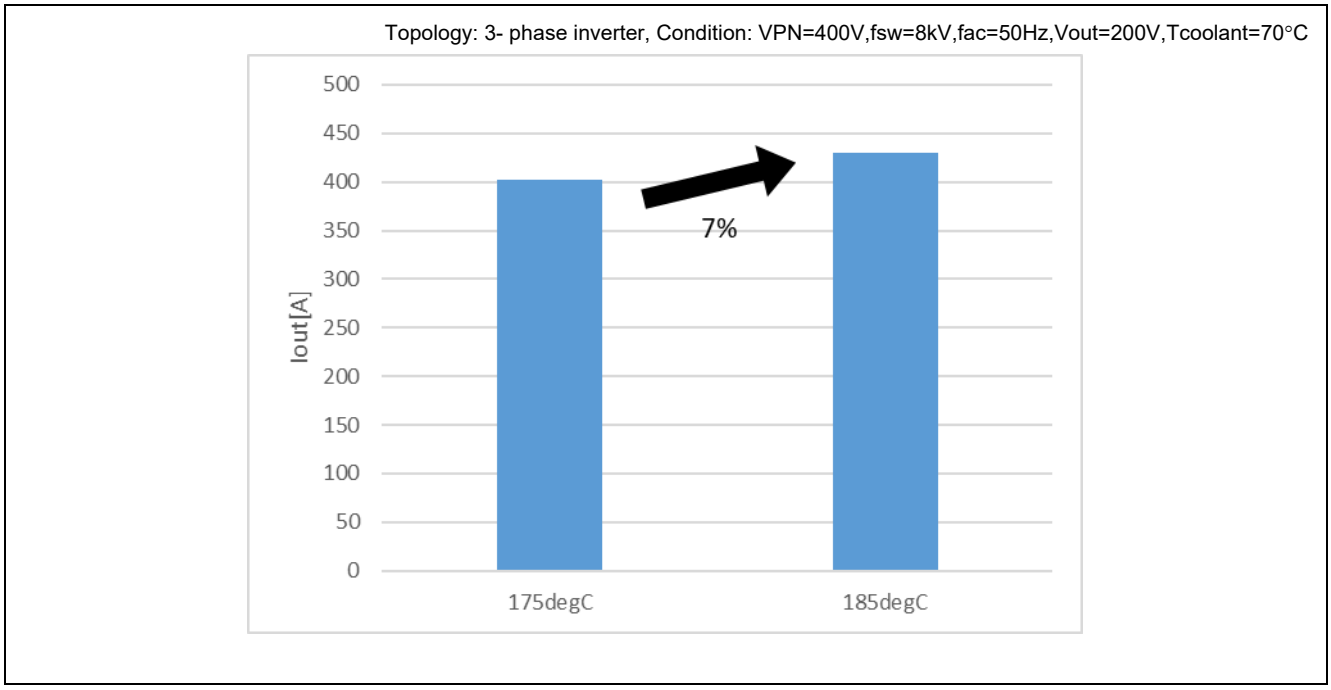

Figure 1-1 Output Current Value During Inverter Operations (AE5 175°C vs. 185°C)

2. Tjmax 185℃ Point of Realization

Recently, the market has been trending toward ultra-high temperature compatibility. Most IGBTs have a Tjmax of 150℃ to 175℃, but our IGBT AE5 exceeds this by supporting 185℃.

Leakage current ICES can lead to thermal runaway when high voltage is applied, and is a good indicator of device quality and reliability; ICES is an important design item for clearing the HTRB test.

As shown in Figure 2-1, the leakage current of the IGBT AE5 is about 3mA at 185℃, which is less than 1/3 that of competitors' products (A and B in the figure). Since leakage current increases exponentially with temperature, the risk of thermal runaway due to leakage current is higher at high temperatures. In this respect, AE5 can be expected to reduce the risk at high temperatures compared to competitors A and B.

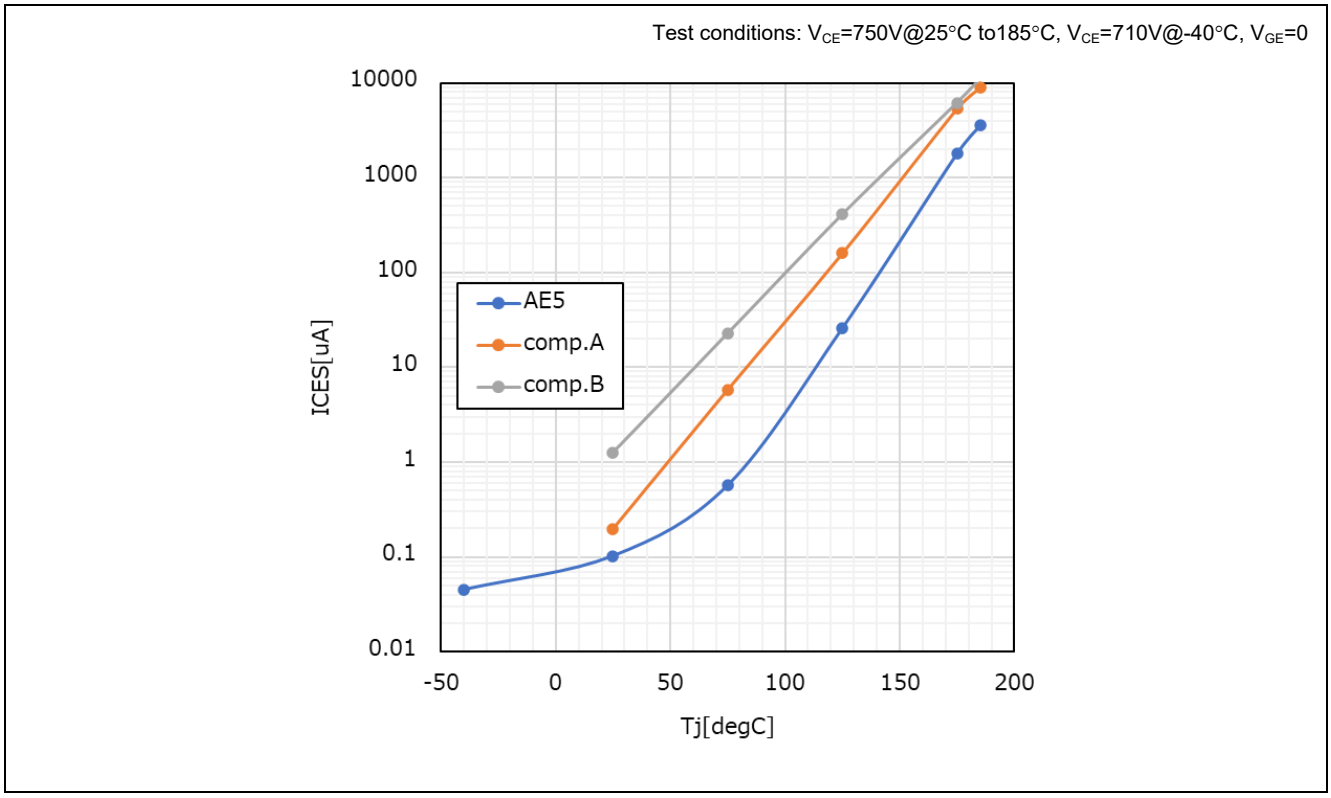

Figure 2-1 I_{CES} - Tj (Renesas IGBT AE5 vs. Competitors)

3. 185℃ Results for Automotive IGBT AE5.

Normal operation was confirmed for ICES, VCE(sat) and SW electrical characteristics tested at 185℃, as shown in Figures 3-1 to 3-3. And, as shown in Figures 3-4 and 3-5, RBSOA and load short circuit tested at 185℃ confirmed that the device is robust enough for this application's operations.

Note that Tjmax is not a temperature rating defined for continuous operation, but a rated value that must not be exceeded even momentarily. Although the values shown in this section are the results of operation confirmed at 185℃, we do not recommend operating a device at this temperature. For maximum ratings including Tjmax, check individual reliability information based on operating conditions and design reliability considering appropriate derating.

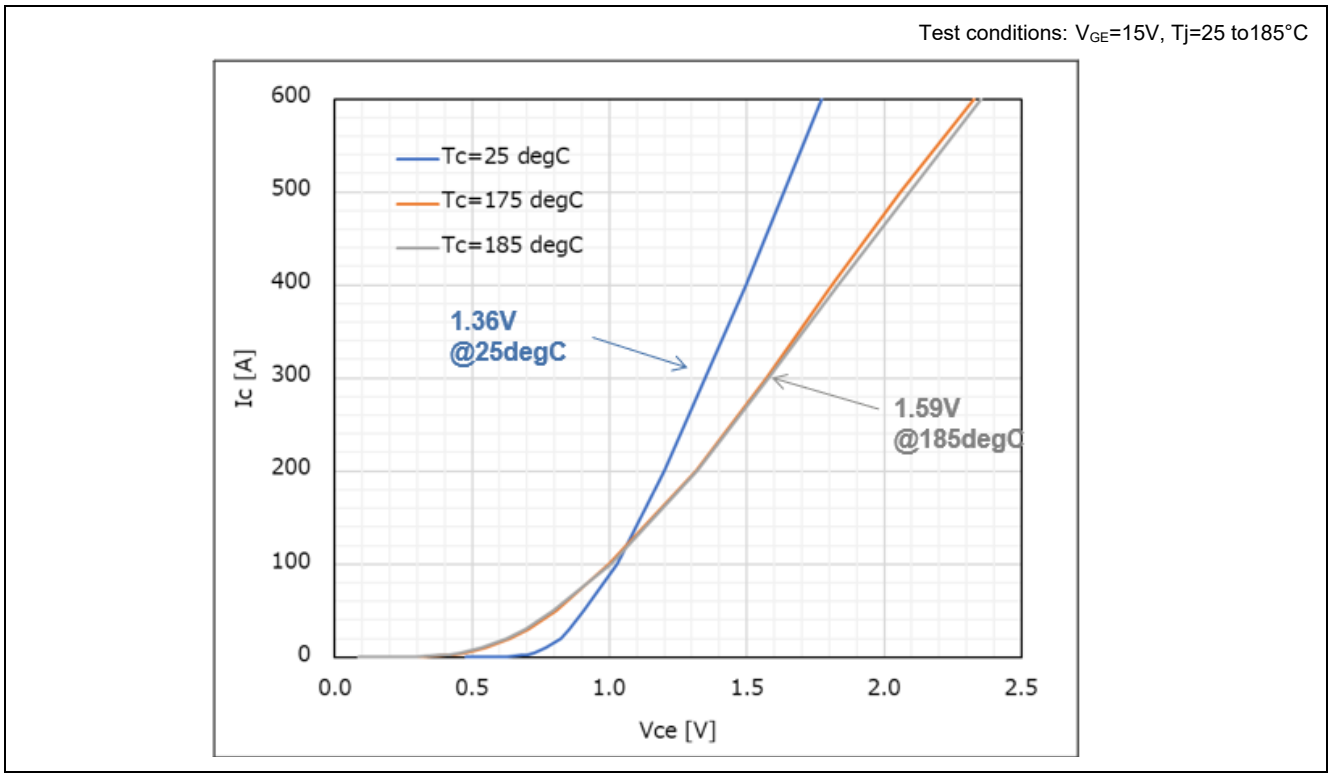

Figure 3-1 V_{CE} - I_C Characteristics (AE5)

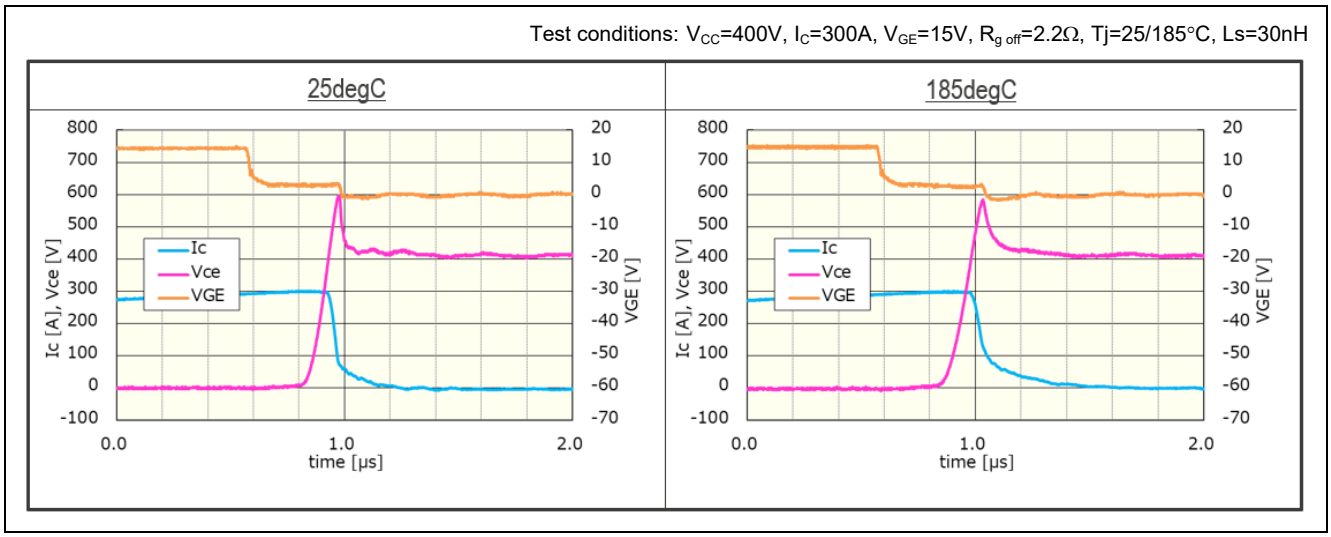

Figure 3-2 Turn-off Waveform (AE5)

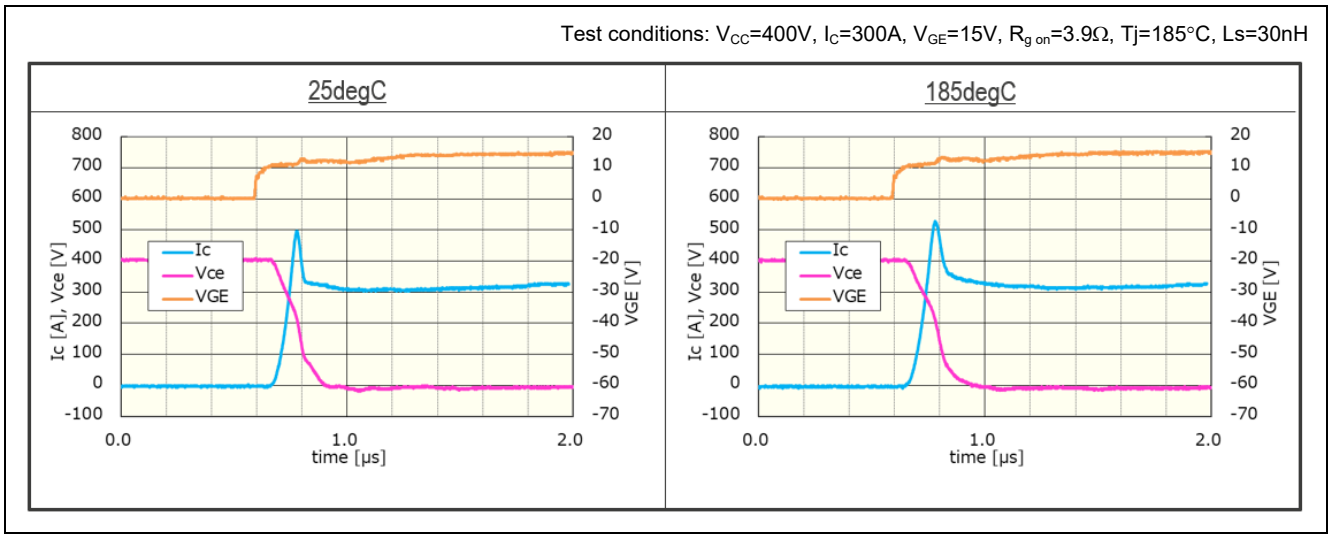

Figure 3-3 Turn-on Waveform (AE5)

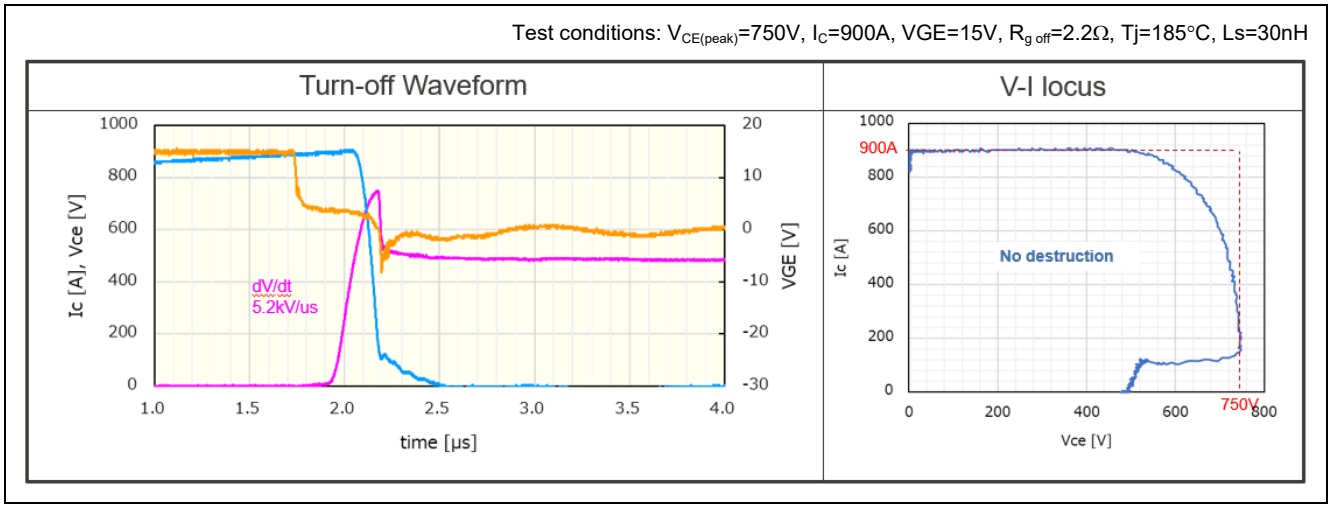

Figure 3-4 RBSOA (AE5)

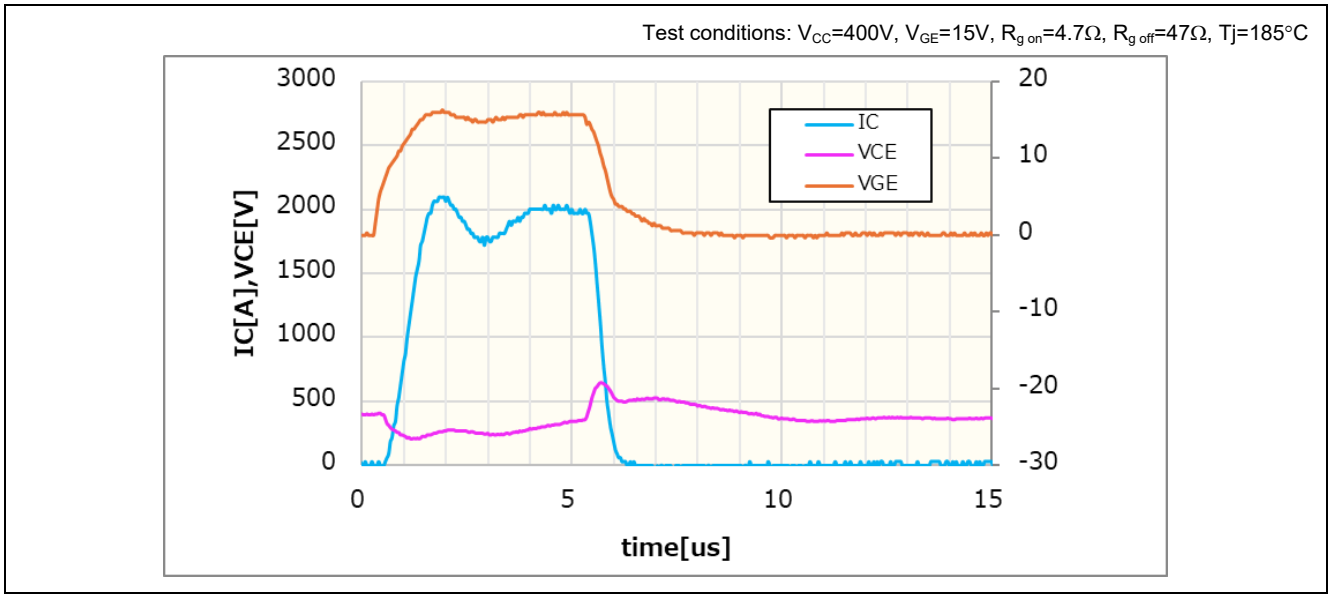

Figure 3-5 Short-circuit Waveform (AE5)

4. Reliability Test Results

The reliability level at high temperatures is checked by performing the HTRB test, in which the maximum rated voltage is applied for a long period, such as 1000 hours, and leakage current is monitored. As shown in Table 4-1, the AE5 passed the reliability test at 185°C, complying with the AEC automotive standard. After testing HTRB/HTGB at 185°C, we checked the quality of the device and were able to confirm that the AE5 can withstand 185°C.

Table 4-1 Reliability Test Results

Product		Test item (*1)	Sample size	Test result
process	PN			
AE5	750V/300A IGBT	HTRB@VCE=750V, **185degC**, 1kh	77pcs x 3lot (*1,2)	**Pass**
	RBN300N75A5	HTGB@VGE=+/-30V, **185degC**, 1kh	77pcs x 3lot (*1,2)	**Pass**
	750V/220A IGBT	HTRB@VC=750V, **185degC**, 1kh	77pcs x 3lot (*1,2)	**Pass**
	RBN220N75A5	HTGB@VGE=+/-30V, **185degC**, 1kh	77pcs x 3lot (*1,2)	**Pass**

*1. AEC Q101 Compliant
*2. Reliability test results include data for representative products of the process family.

5. Summary

Extending Tjmax makes it possible to reduce risks during high temperature operation and to cover a wider range of operating conditions.

The Renesas IGBT AE5 achieves a Tjmax of 185℃. Stable operation and sufficient robustness were verified at 185℃ for various electrical characteristics, SW, RBSOA, and load short circuit.

The AE5 also undergoes reliability testing in accordance with the AEC automotive standard. AE5 cleared HTRB and HTGB for 1000 hours at 185℃, confirming the quality and safety of the product.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.26.2024	-	First edition

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(Rev.5.0-1 October 2020)

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