

Characteristic differences between 1200V IGBT³ modules of the E3 and T3 series

1. Chip Technology IGBT 1200V

The product range of the existing 1200V IGBT modules of the third generation (IGBT³) – E3 was expanded by a further optimization. The result was the T3 IGBT.

The Collector-Emitter saturation voltage (V_{CEsat}) and the turn-off losses (E_{off}) were reduced with this T3 IGBT. (Further information on the IGBT³ can be found in the application note AN2003-03)

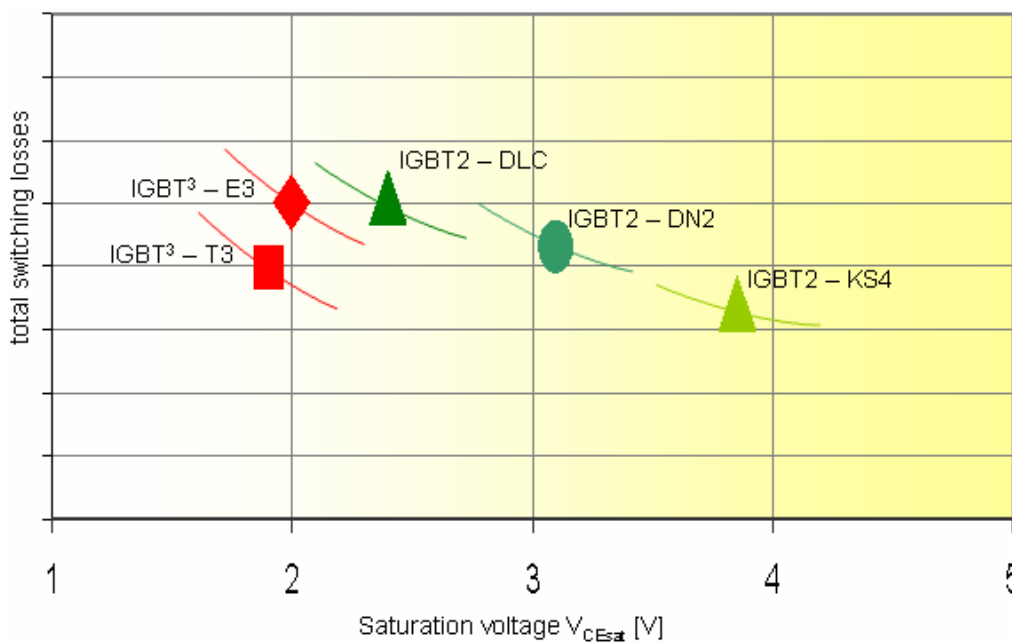


Figure 1.1. Total switching losses vs. Saturation voltage of all 1200V IGBT generations.

This T3 device was optimized at a higher switching frequency. The reduced losses in combination with the higher current density have allowed for the expansion of the product range of the IGBT³ modules.

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2. Output Characteristic

Figure 2.1 shows the typical output characteristic of the T3 and the E3 IGBT.

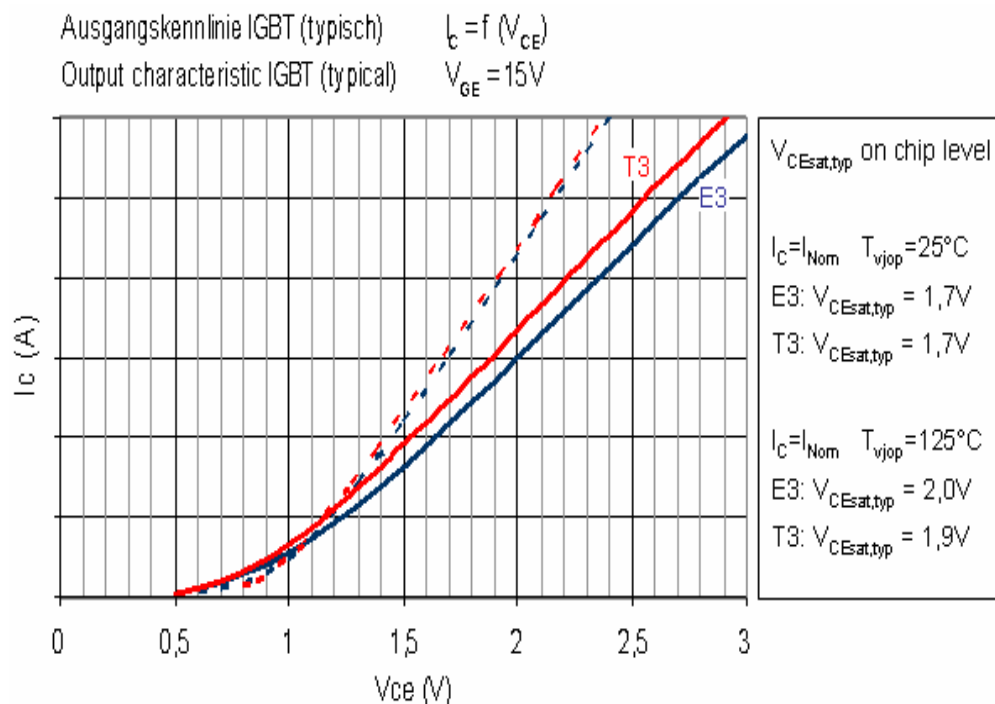


Figure 2.1 Output Characteristic (typical)

The (typical) Collector-Emitter saturation voltage (V_{CEsat}) of both IGBT³ generations are shown with the value of $V_{CEsat} = 1,7V$. There are no differences between the E3 & T3 at a junction temperature of $T_{vj} = 25^\circ C$.

The output characteristic diagram of the T3 IGBT at the max. junction temperature $T_{vjop} = 125^\circ C$ and at nominal rated current (I_{Cnom}) shows a reduction of the Collector-Emitter saturation voltage (V_{CEsat}) by approx. 100mV compared with the E3.

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3. Switching Behavior

3.1. Turn-On

The typical turn-on switching behavior of both IGBT³ generations are given in the figures 3.1.1. and 3.1.2.

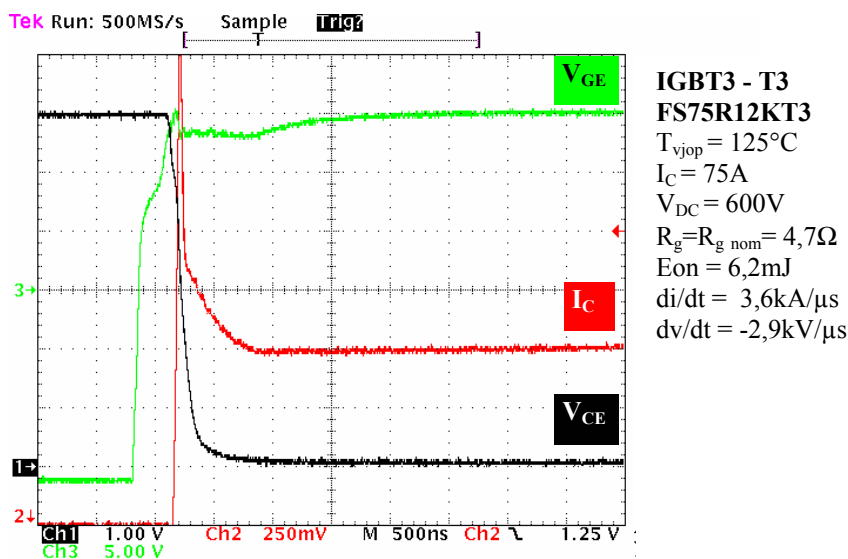


Figure 3.1.1. turn-on (typical) FS75R12KT3

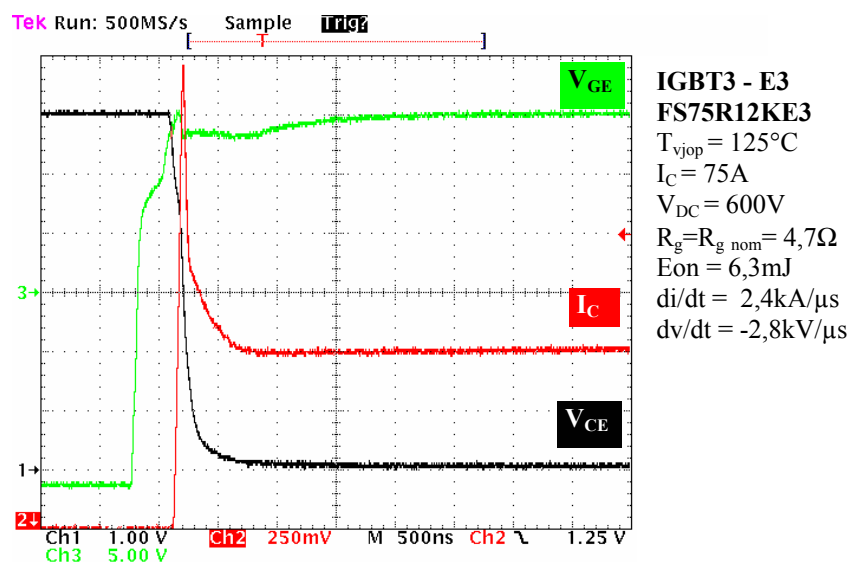


Figure 3.1.2. turn-on (typical) FS75R12KE3

The turn-on switching behavior of both chip types is comparable and shows almost no difference.

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3.2. Turn-On Losses

The typical turn-on losses of the IGBT Module with E3 and T3 IGBTs are given by the example of the IGBT Module FS75R12KE3 and FS75R12KT3 as a function of the collector current. $E_{on} = f(I_C)$ in figure 3.2.1..

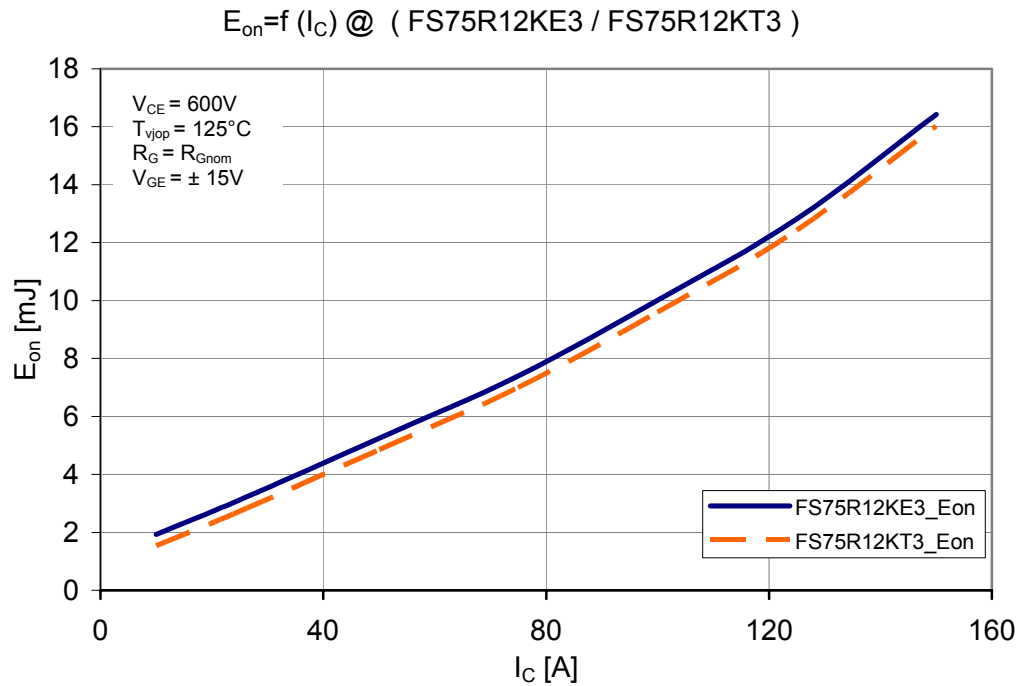


Figure 3.2.1. turn-on losses (typical) E3 vs. T3

The typical turn-on losses of the IGBT modules with E3 and T3 IGBT show almost no differences.

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3.3. Turn-off behavior

The typical turn-off behavior of both IGBT³ generations is given in the figures 3.3.1. and 3.3.2..

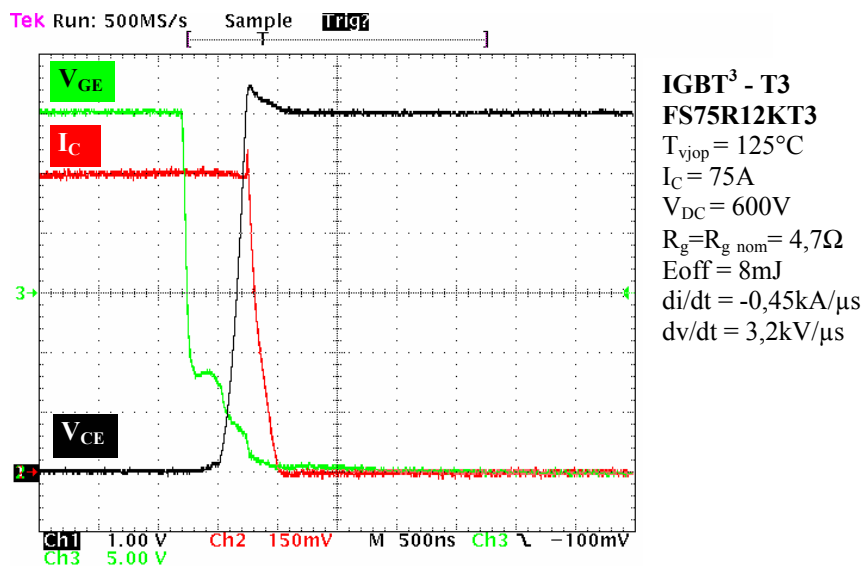


Figure 3.3.1. turn-off (typical) FS75R12KT3

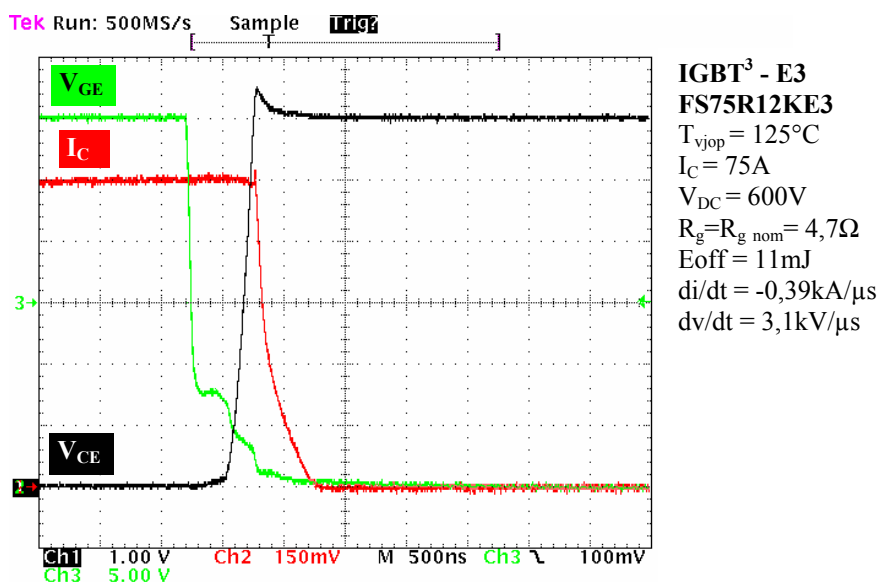


Figure 3.3.2. turn-off (typical) FS75R12KE3

The turn-off process of both chip generation shows for the IGBT3-E3 chip a softer turn-off behavior.

3.4. Total Turn-Off Losses

The total turn-off losses of the T3 IGBT could be reduced in comparison with the E3 IGBT. In figure 3.4.1 the typical characteristic of the total turn-off losses as a function of the collector current is given for the IGBT Modules FS75R12KE3 and FS75R12KT3.

$$E_{\text{off}} = f(I_C) \text{ @ (FS75R12KE3 / FS75R12KT3)}$$

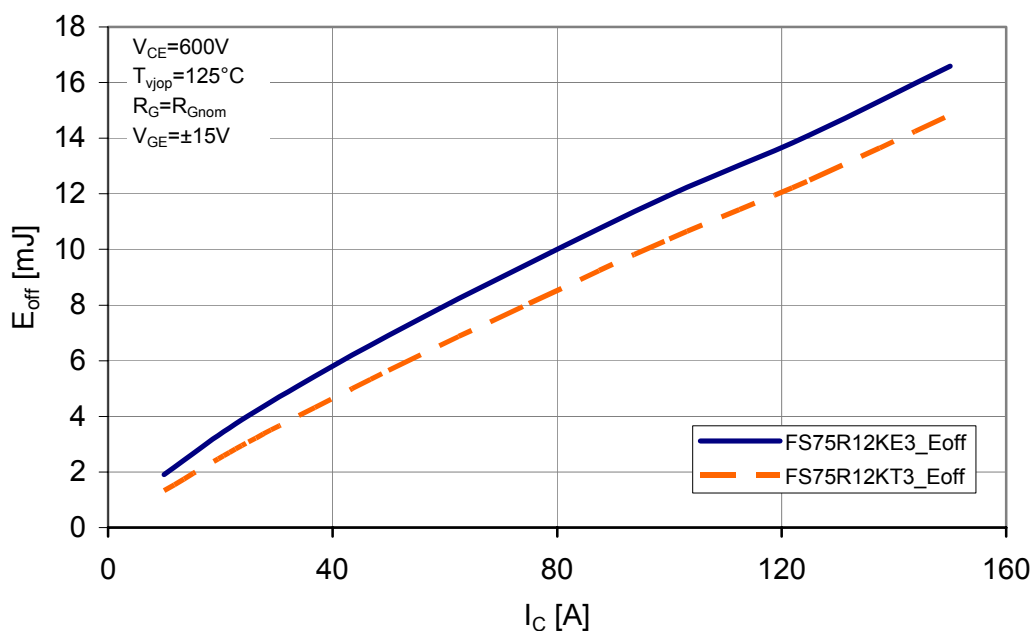


Bild 3.4.1 Abschaltverluste (typisch) E3 vs. T3

The turn-off losses of the T3 IGBT module (FS75R12KT3 $E_{\text{off}}=8,1\text{mJ}$) under nominal conditions are approx. 17% lower in comparison with the E3 IGBT module (FS75R12KE3 $E_{\text{off}}=9,5\text{mJ}$).

To optimally use the advantages of the reduced losses of the IGBT3 - T3 it is required to reduce the stray inductances of the application, because the IGBT3-T3 exhibits a reduced softness during turning off.

The current steepness during the turn-off process produces in combination with the parasitic inductance of the DC link and module inductance, an over voltage at the IGBT: $\Delta V = -L_{\sigma} * \frac{di}{dt}$

Naturally over voltages that occur at the IGBT during the turn-off process must always be limited to the maximum reverse voltage of the module (V_{CES}).