Characteristic differences between 1200V IGBT^3 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 (IGBT^3) – 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 IGBT^3 can be found in the application note AN2003-03)

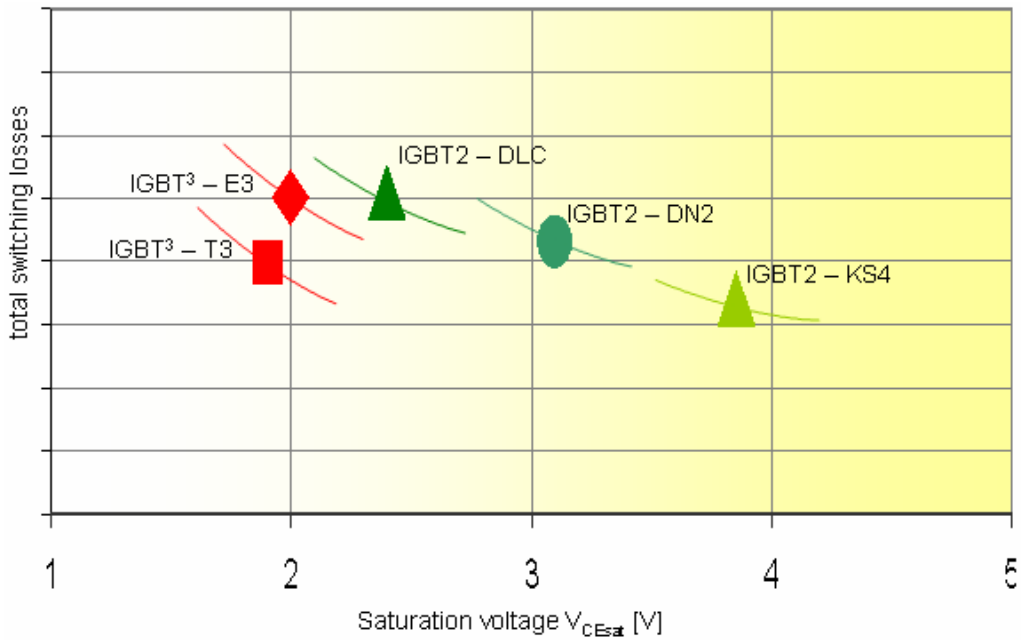


Figure 1.1. Total switching losses vs. Saturation voltage of all 1200V IGBT generations.

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 IGBT^3 modules.

eupec GmbH
Max-Planck-Straße
D-59581 Warstein
Tel. +49 (0) 29 02 7 64-0
Fax + 49 (0) 29 02 7 64-12 56
info@eupec.com
www.eupec.com
Author: Wilhem Rusche

2. Output Characteristic

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

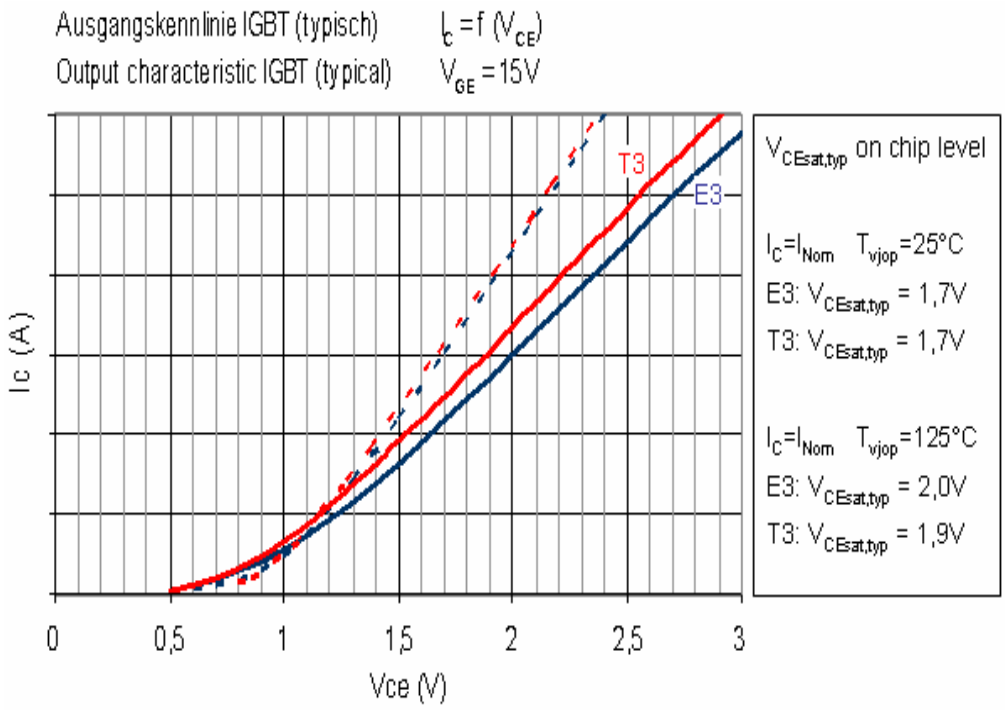


Figure 2.1 Output Characteristic (typical)

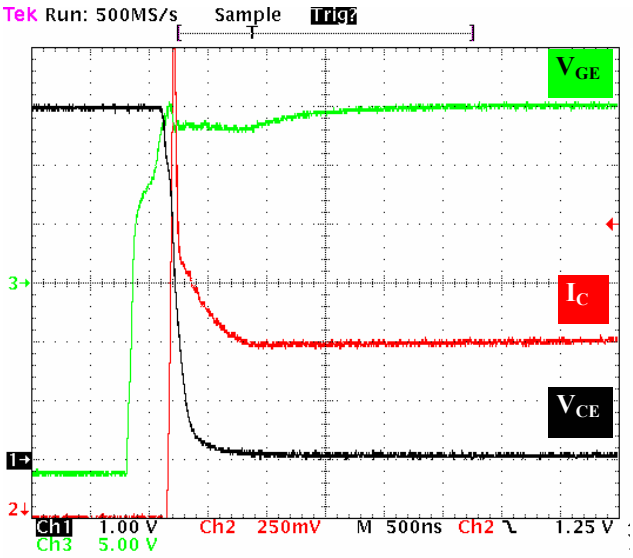
The (typical) Collector-Emitter saturation voltage (V_{CEsat}) of both IGBT[3] generations are shown with the value of V_{CEsat}=1,7V. There are no differences between the E3 & T3 at a junction temperature of T_{vj}=25°C.
The output characteristic diagram of the T3 IGBT at the max. junction temperature T_{vjop}=125°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.

eupec GmbH
Max-Planck-Straße
D-59581 Warstein
Tel. +49 (0) 29 02 7 64-0
Fax + 49 (0) 29 02 7 64-12 56
info@eupec.com
www.eupec.com
Author: Wilhem Rusche

3. Switching Behavior

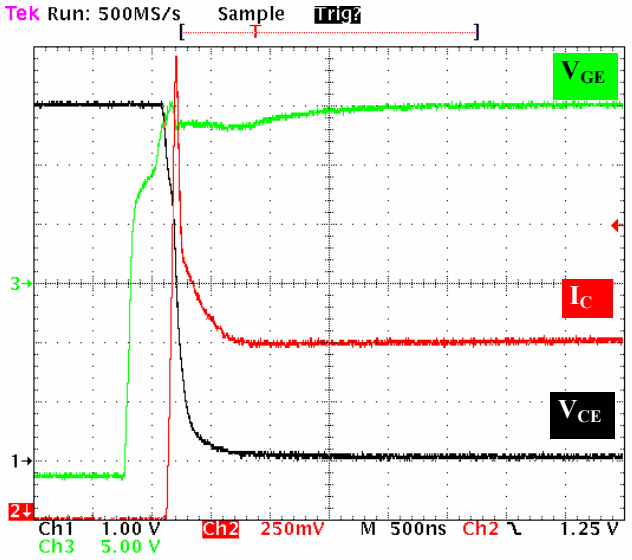
3.1. Turn-On

The typical turn-on switching behavior of both IGBT^3 generations are given in the figures 3.1.1. and 3.1.2.



IGBT3 - T3
FS75R12KT3
T_{vjop} = 125°C
I_C = 75A
V_{DC} = 600V
R_g=$R_{g\ nom}$= 4,7Ω
Eon = 6,2mJ
di/dt = 3,6kA/µs
dv/dt = -2,9kV/µs

Figure 3.1.1. turn-on (typical) FS75R12KT3



IGBT3 - E3
FS75R12KE3
T_{vjop} = 125°C
I_C = 75A
V_{DC} = 600V
R_g=$R_{g\ nom}$= 4,7Ω
Eon = 6,3mJ
di/dt = 2,4kA/µs
dv/dt = -2,8kV/µs

Figure 3.1.2. turn-on (typical) FS75R12KE3

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

eupec GmbH
Max-Planck-Straße
D-59581 Warstein
Tel. +49 (0) 29 02 7 64-0
Fax + 49 (0) 29 02 7 64-12 56
info@eupec.com
www.eupec.com
Author: Wilhem Rusche

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. $E_{on} = f(IC)$ in figure 3.2.1..

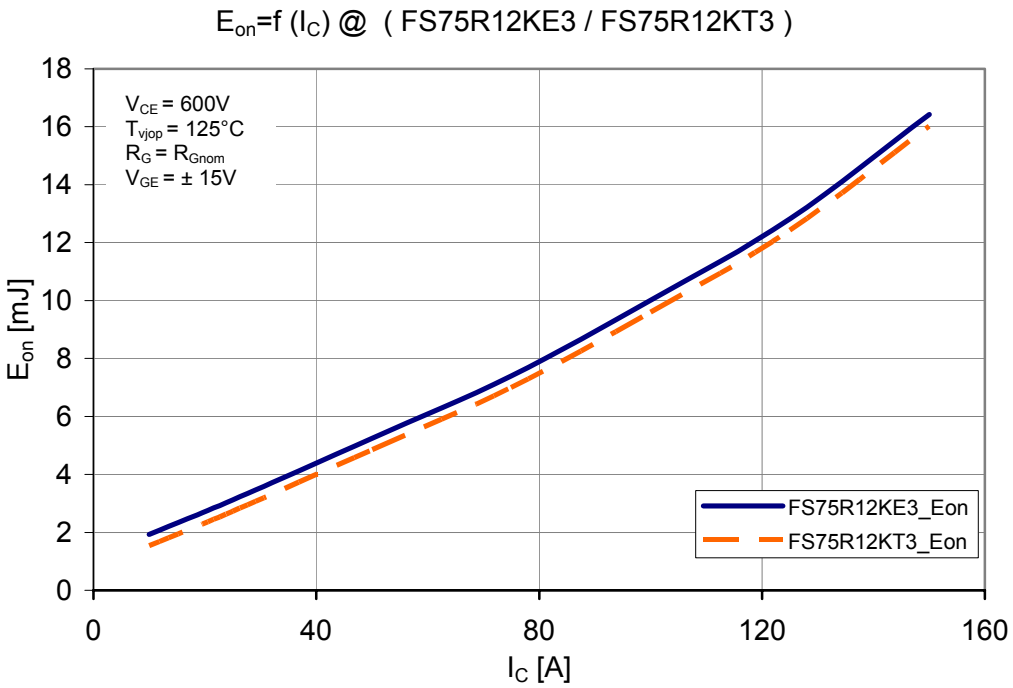


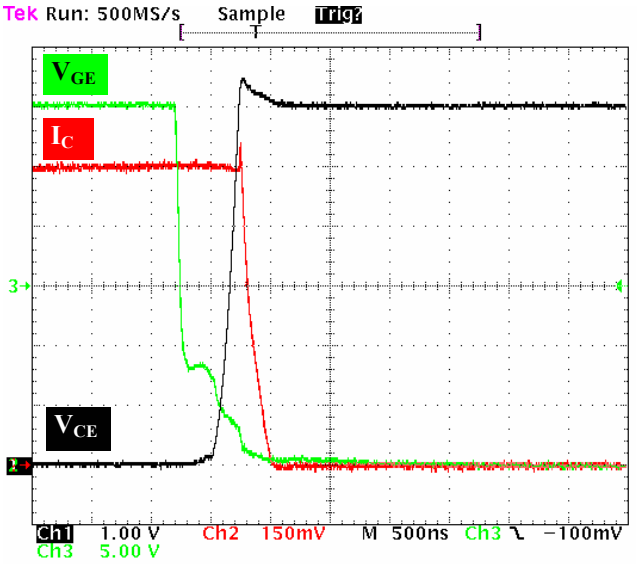
Figure 3.2.1. turn-on losses (typical) E3 vs. T3

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

eupec GmbH
Max-Planck-Straße
D-59581 Warstein
Tel. +49 (0) 29 02 7 64-0
Fax + 49 (0) 29 02 7 64-12 56
info@eupec.com
www.eupec.com
Author: Wilhem Rusche

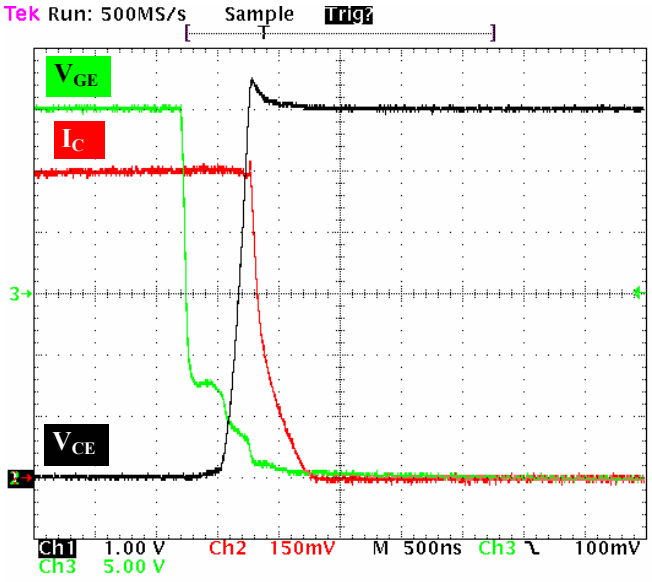
3.3. Turn-off behavior

The typical turn-off behavior of both IGBT^3 generations is given in the figures 3.3.1. and 3.3.2..



IGBT^3 - T3
FS75R12KT3
T_{vjop} = 125°C
I_C = 75A
V_{DC} = 600V
R_g=$R_{g\ nom}$= 4,7Ω
Eoff = 8mJ
di/dt = -0,45kA/µs
dv/dt = 3,2kV/µs

Figure 3.3.1. turn-off (typical) FS75R12KT3



IGBT^3 - E3
FS75R12KE3
T_{vjop} = 125°C
I_C = 75A
V_{DC} = 600V
R_g=$R_{g\ nom}$= 4,7Ω
Eoff = 11mJ
di/dt = -0,39kA/µs
dv/dt = 3,1kV/µs

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.

eupec GmbH
Max-Planck-Straße
D-59581 Warstein
Tel. +49 (0) 29 02 7 64-0
Fax + 49 (0) 29 02 7 64-12 56
info@eupec.com
www.eupec.com
Author: Wilhem Rusche

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.

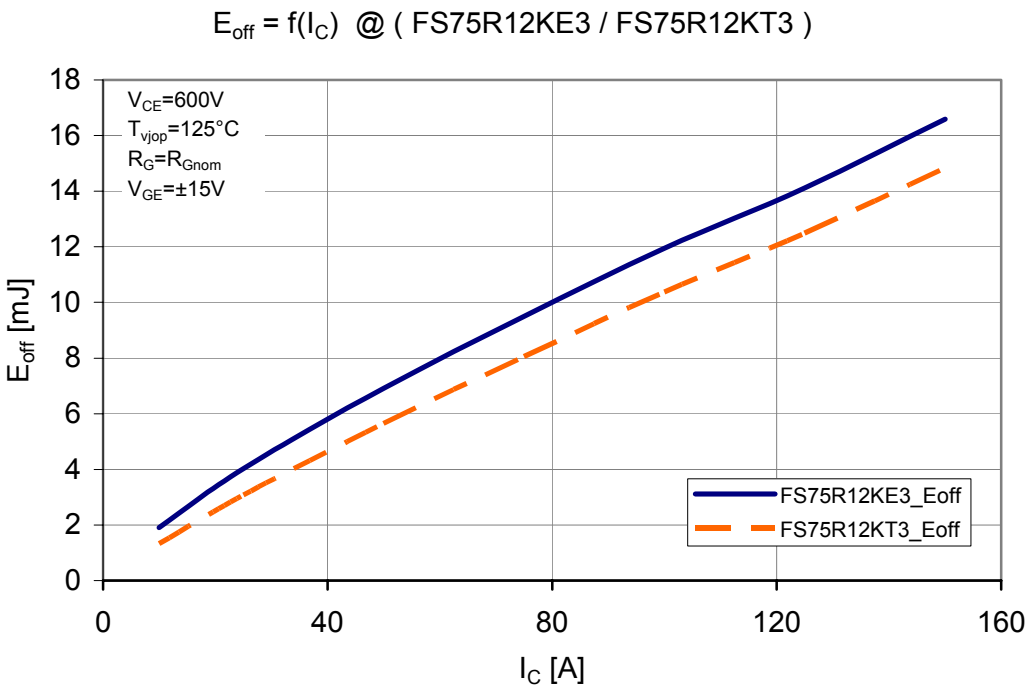


Bild 3.4.1 Abschaltverluste (typisch) E3 vs. T3

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

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}).

eupec GmbH
Max-Planck-Straße
D-59581 Warstein
Tel. +49 (0) 29 02 7 64-0
Fax + 49 (0) 29 02 7 64-12 56
info@eupec.com
www.eupec.com
Author: Wilhem Rusche