600 V TRENCHSTOP™ Performance versus TRENCHSTOP™

Discrete IGBT

About this document

Scope and purpose

This Application Note provides an explanation of the new 600 V TRENCHSTOP™ Performance technology, abbr. 60 TP, and to provide a comparison to the 600 V TRENCHSTOP™ technology, abbr. 60 T. The main differences of products in those two technologies are given.

We demonstrate how the design-in of the new 600 V TRENCHSTOP™ Performance IGBTs can be easily achieved. Existing applications which currently use 60 T IGBTs do not need a re-design to make use of TRENCHSTOP™ Performance IGBTs.

Attention: ***The information given in this document is only to be regarded as a hint for the utilization of the IGBT device and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.***

Intended audience

This application note addresses engineers designing-in the products in their applications. It is intended to be a guide to reduce the design-in effort into existing applications using TRENCHSTOP™ IGBTs.

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1 Introduction

The 600 V TRENCHSTOP™ IGBTs are well established products on the power electronics market within a big field of hard switching applications such as industrial and consumer drives, uninterruptible power supplies, air conditioning, major home appliances, solar inverters, and automotive drives.

With the new 600 V TRENCHSTOP™ Performance technology, Infineon combines the latest IGBT and diode technologies to provide a competitive solution especially for industrial and consumer drives and major home appliance applications. The target for this technology is to improve system efficiency over the existing 60 T products, without needing to invest time and effort re-designing in the driver circuit and EMI filters.

The 60 TP technology is realized as Non-Punch-Through-IGBT with a state-of-the-art fieldstop and a trench gate concept. This enables low collector-emitter saturation voltage $V_{CE(sat)}$ and low switching losses at compact dimensions.

The 60 TP IGBTs are offered with and without copacked Rapid 1 diodes. Infineon's Rapid 1 diode family, with temperature-stable forward voltage V_F, ensures the lowest conduction losses and soft recovery.

1.1 Product portfolio

The initial product portfolio consists of six products in the TO-247 package. The IGBT is available as single IGBT, but also as DuoPack copacked with a half rated Rapid 1 diode.

A further portfolio extension is possible.

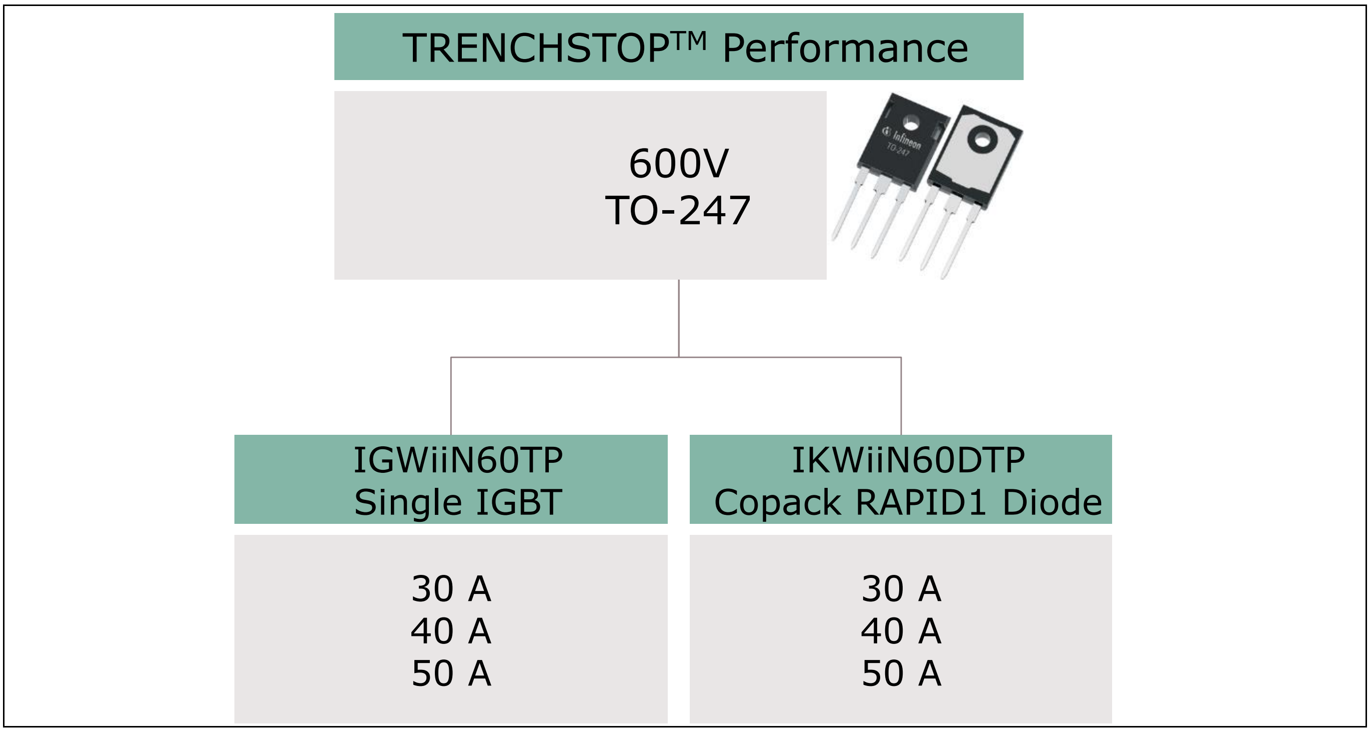

Figure 1 Portfolio overview

1.2 Type designation

IGBTs are marked with a part number label identifying the main information related to the part. Products of the new 600 V TRENCHSTOP™ Performance technology can be identified via the last two digits of the part number:

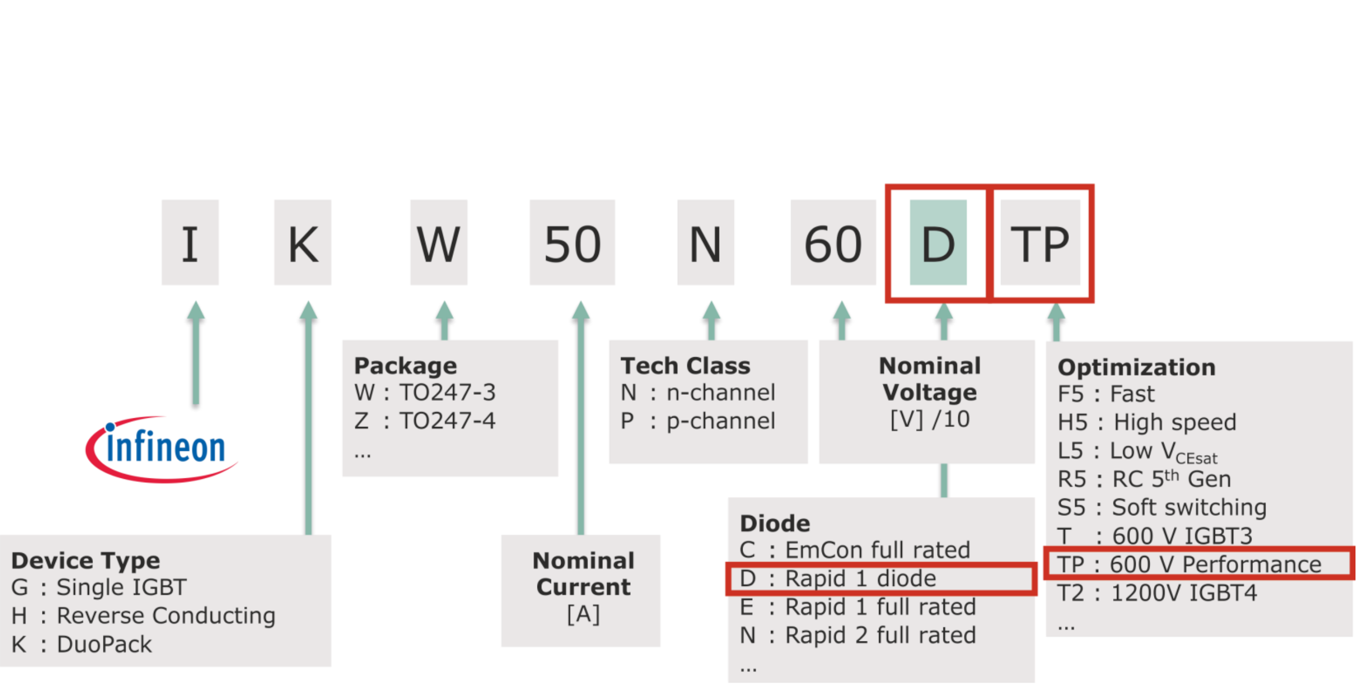

Figure 2 Designation of IGBT part number

2 TRENCHSTOP™ Performance characteristics

This section is dedicated to the 60 TP IGBTs electrical performance compared to the existing 60 T IGBTs.

Note: Details about electrical parameters can be found in the related application note [1]

The data reflects the typical device behavior. It does not represent the maximum or minimum characteristics, which are possible. For details about minimum and maximum parameter values please refer to the data sheet for the particular device of interest. To provide an example, the products IKW50N60T (TRENCHSTOP™ technology) and the IKW50N60DTP (TRENCHSTOP™ Performance technology) are compared.

2.1 Application measurement test

To assess the performance of the IKW50N60DTP under application conditions, an application test in an internal motor test bench was performed. The IGBTs were mounted in a two level 3-phase B6 inverter.

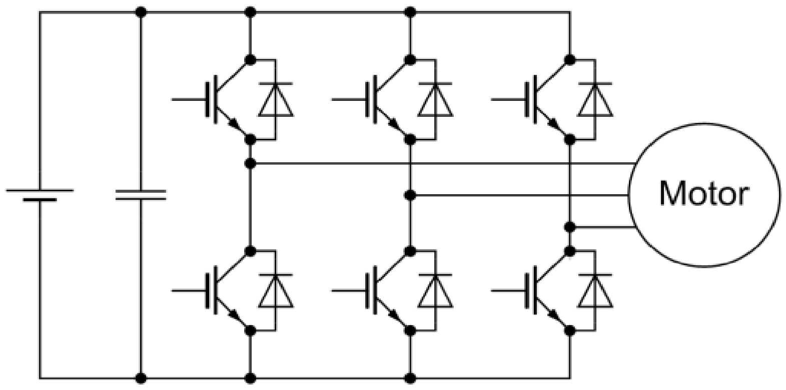

Figure 3 Simplified B6 inverter schematic for application test

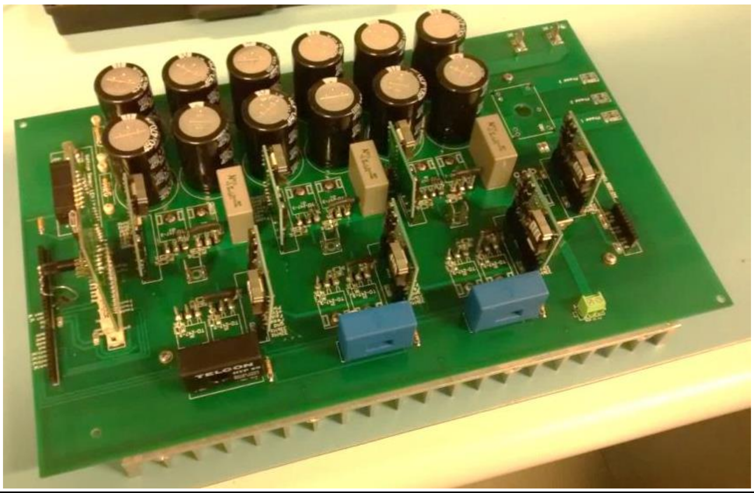

Figure 4 B6 inverter

Test conditions

- V_{BUS} = 400 V
- f_{SW} = 15 kHz

- P_{OUT} = 2.2 and 5 kW
- 3-phase motor with generator as break
- Dead time = 1 µs
- Modulation index = 99%
- IGBTs fixed on common heat sink

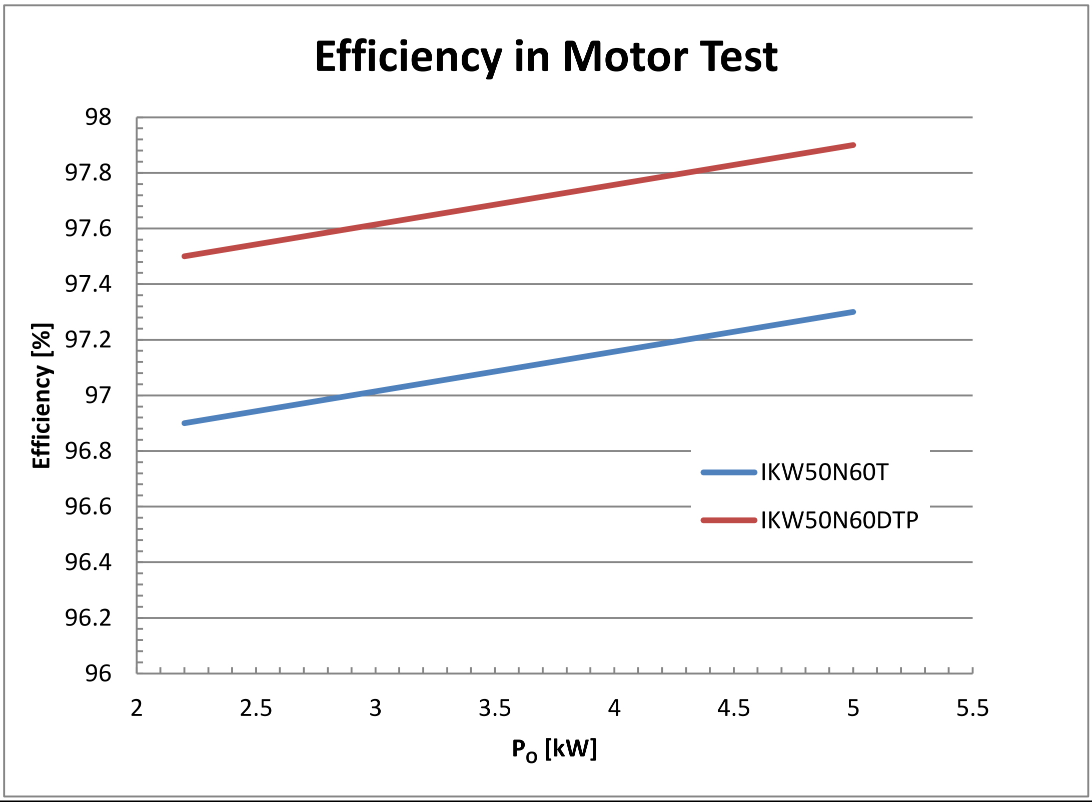

Figure 5 Inverter efficiency comparison

Result

The TRENCHSTOP™ Performance IGBT shows a 0.6 % improved efficiency compared to the IKW50N60T in this application test thanks to the lower switching losses. The test results shows that even without changing any hardware of the system, the TRENCHSTOP™ Performance IGBT can replace former products and improve efficiency at the same time.

2.2 Electromagnetic interference (EMI) test

Due to the slightly different switching behavior an EMI test has been performed to verify if a different EMI protection network is required or not. The test has been performed with the inverter shown in Figure 4 and a motor load. Conducted and radiated emissions have been measured.

Test conditions

- V_{BUS} = 400 V
- R_{Gon} = 16 Ω
- R_{Goff} = 15 Ω
- Load: 3-phase motor (750 W)
- I_{sup} ≈ 1.6 A (phase frequency = 25 Hz)
- f_{sw} = 15 kHz
- Dead time = 1µs
- Modulation index = 99%
- Conducted emissions measured according to EN55011 A CE voltage with 2-line-LISN ESH3-Z5, with 80 cm distance between device under test and the measurement device.
- Radiated emission measurement according to EN55011 A radiated emissions between 30 MHz-1 GHz. 3 m distance between device under test and antenna. Only the device under test was in the chamber. The motor was outside of the chamber.

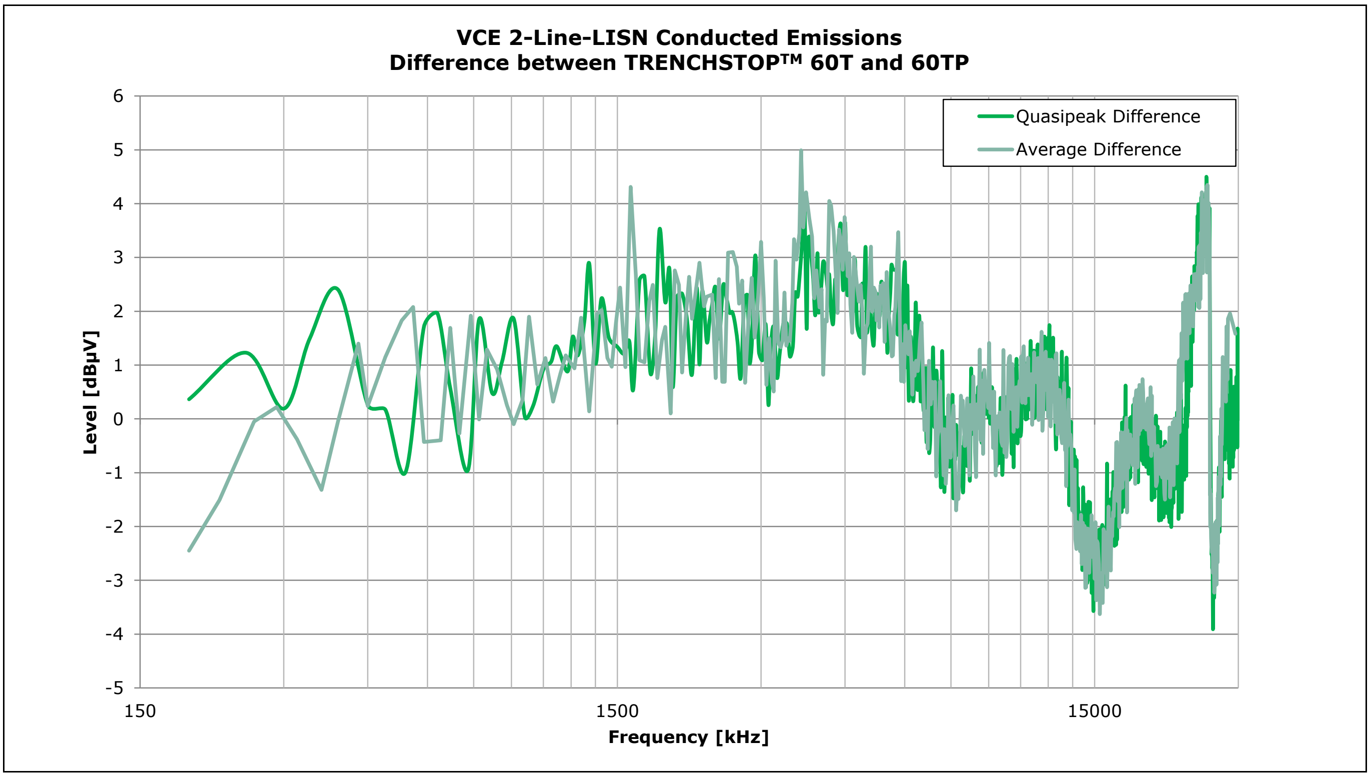

Figure 6 Conducted emission measurements; Differences between IKW50N60T and IKW50N60DTP

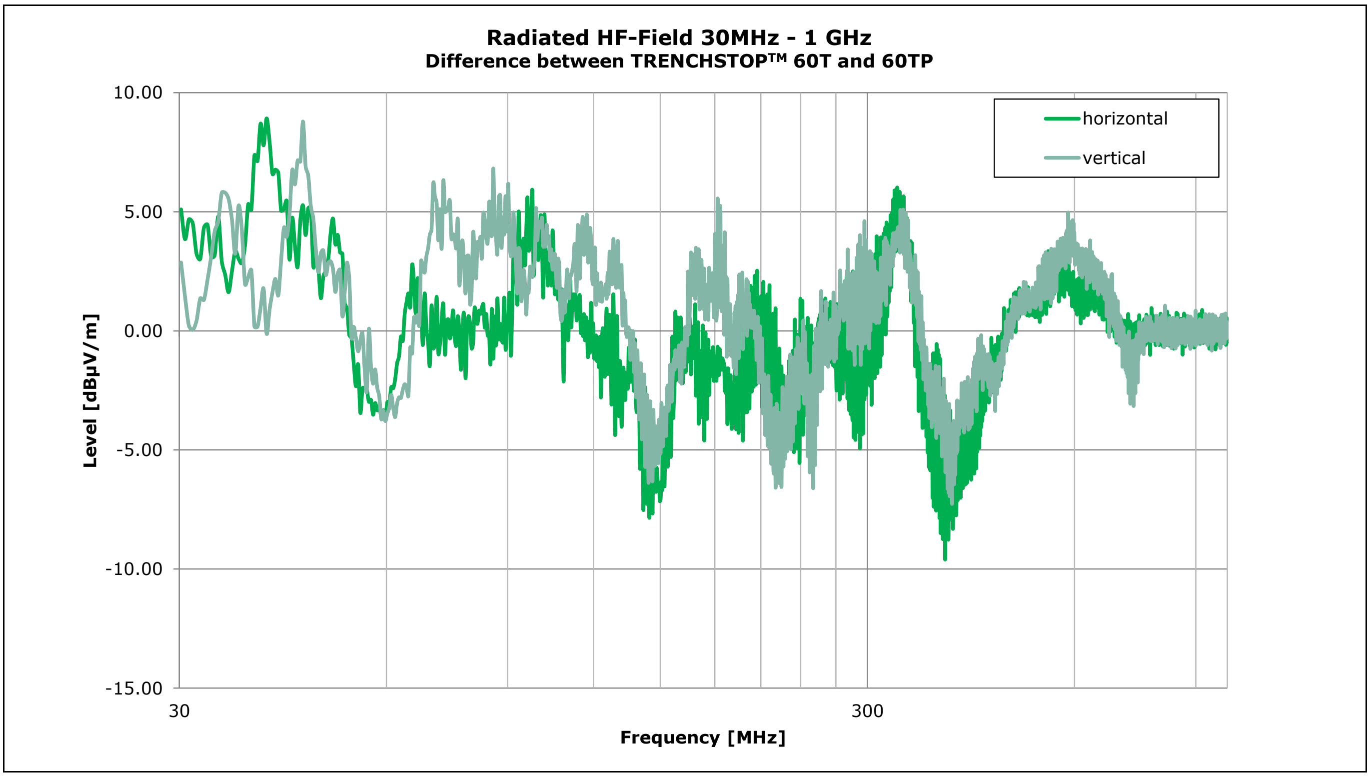

Figure 7 Radiated emission measurements; Differences between IKW50N60T and IKW50N60DTP

Results

The measurements showed that no new emission frequency spots occurred for IKW50N60DTP. Only small differences in the absolute values are observed. Therefore, existing EMI circuits used in applications using the TRENCHSTOP™ IGBTs may be used for the TRENCHSTOP™ Performance IGBTs without modifications (although the final decision would depend on the specific application requirements).

2.3 Static characteristics

The 600 V TRENCHSTOP™ Performance technology has slightly higher static losses than the original 60T products.

The following figure shows the collector-emitter saturation voltage $V_{CE(sat)}$ as a function of the junction temperature T_j. The temperature gradient of the IKW50N60DTP is positive allowing a paralleling of device.

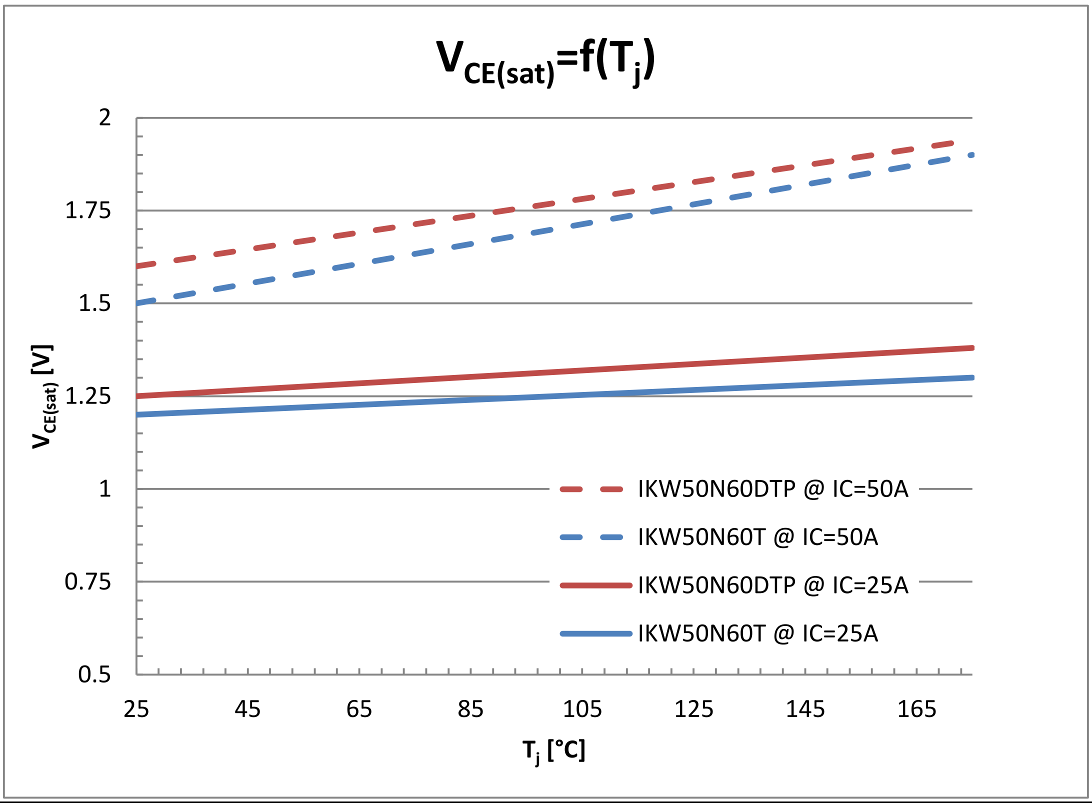

Figure 8 **$V_{CE(sat)}$ as a function of the T_j for two currents**

Figure 4 highlights the static diode losses versus junction temperature. The IKW50N60T uses a full rated emitter controlled diode, with 20 mV lower forward voltage V_F than Rapid 1 diode used in the IKW50N60DTP at T_j = 25°C.

Note: The temperature characteristic shown in Figure 9 is a simplification. For more details please refer to the appropriate datasheets.

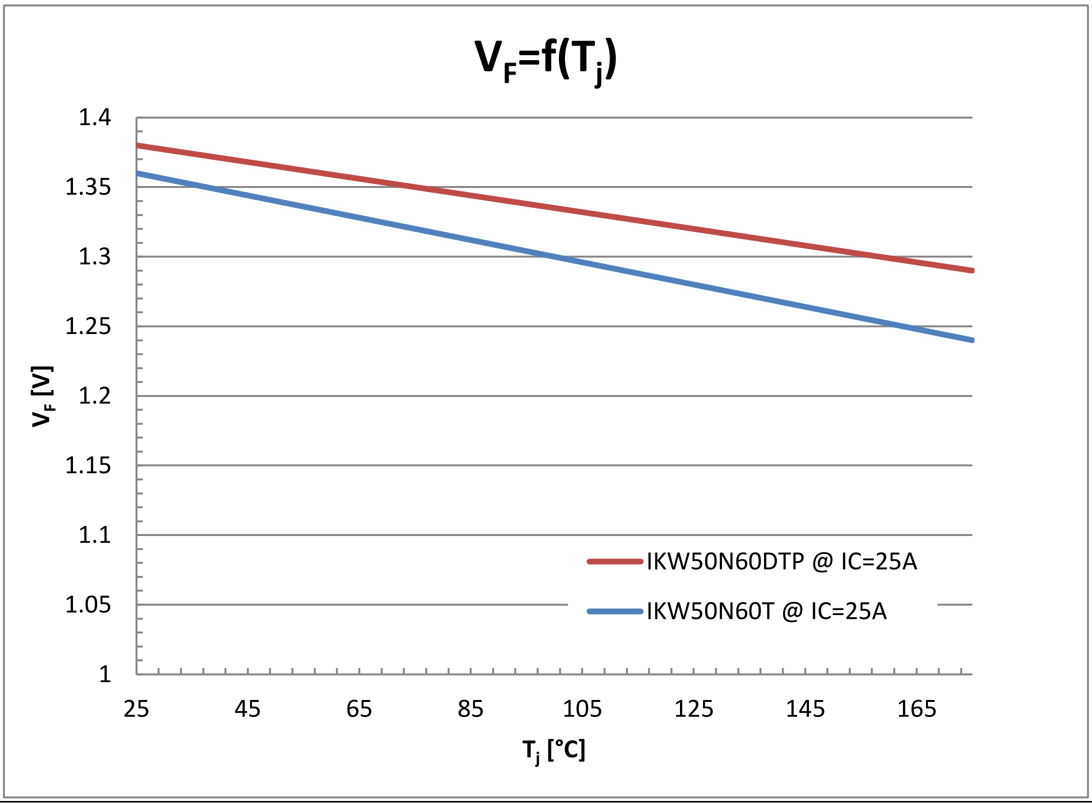

Figure 9 V_F as a function of the T_j

2.4 Dynamic characteristics

The IKW50N60DTP has lower total switching losses compared to the IKW50N60T thanks to lower diode reverse recovery losses and a strongly reduced current tail. The higher the switching frequency in the application is, the bigger the efficiency improvement of the TRENCHSTOP™ Performance technology is.

Figure 9 to Figure 14 show the switching behavior of both technologies in a double-pulse test setup for the following conditions:

- Hard switching condition
- T_j = 100 °C
- I_C = 25 A
- R_G = 14.6 Ω
- The high and low side IGBTs are always of the same product type

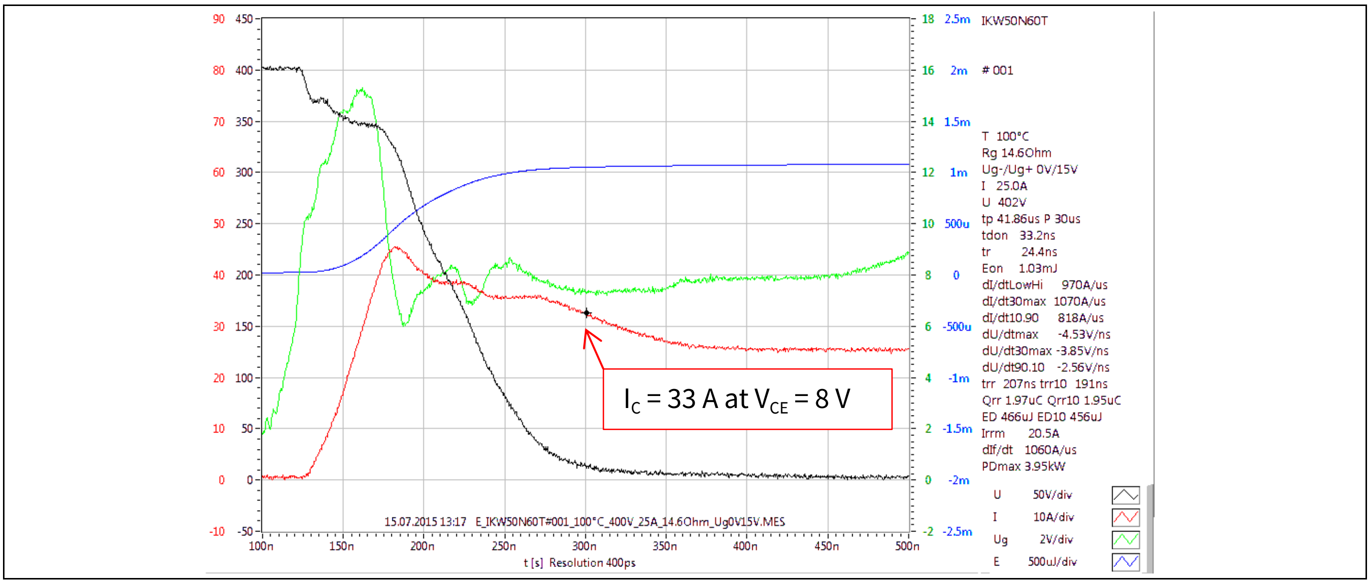

Figure 10 Turn on of IKW50N60T

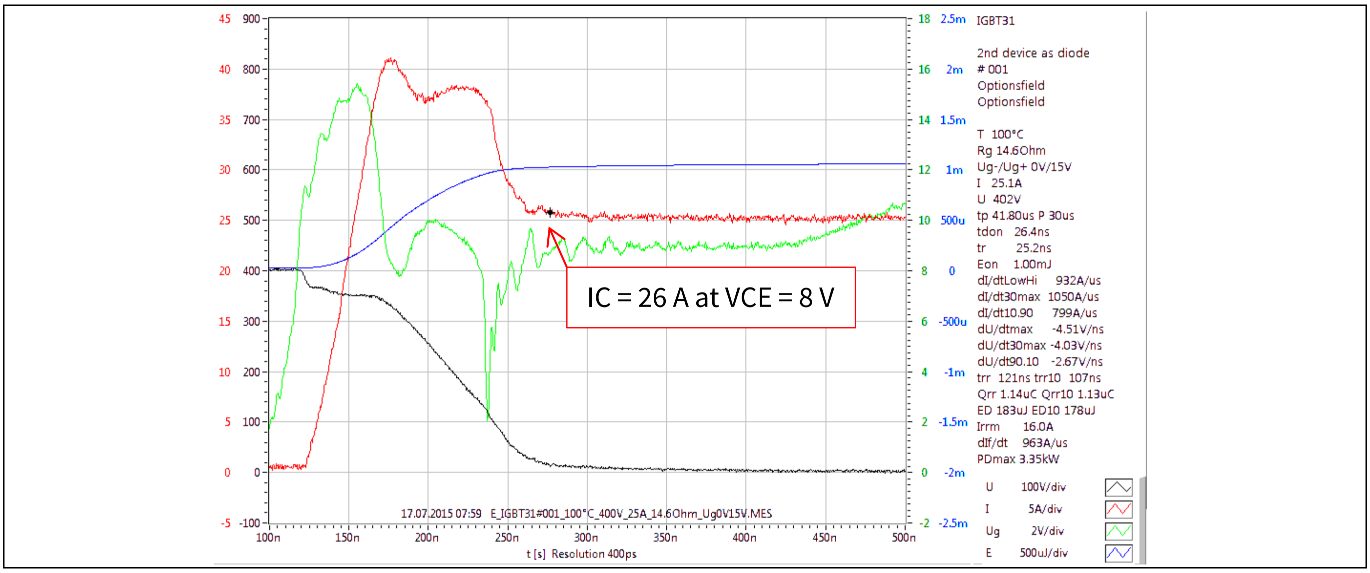

Figure 11 Turn on of IKW50N60DTP

IKW50N60DTP has a significant lower reverse recovery charge Q_{rr} due to the use of the latest Rapid diode technology.

Note: *The turn on energy is calculated as shown in Figure 12 between the points V_{GE} = 10 % V_{GEon} and V_{CE} = 2 % V_{CEoff}. The collector current at the voltage V_{CE} = 8 V (2 % V_{CEoff}) is I_C = 26 A for the IKW50N60DTP, but I_C = 33 A for the IKW50N60T. Therefore the total IKW50N60T's turn on losses are slightly higher than the measured ones in this document, if the losses after V_{CE} = 2 % V_{CEoff} until I_C reaches I_C = 26 A are considered too. For the example shown in Figure 10 the turn on losses increase by ≈1.3 %, if the energy is calculated until the collector current I_C reaches the value I_C = 26 A.*

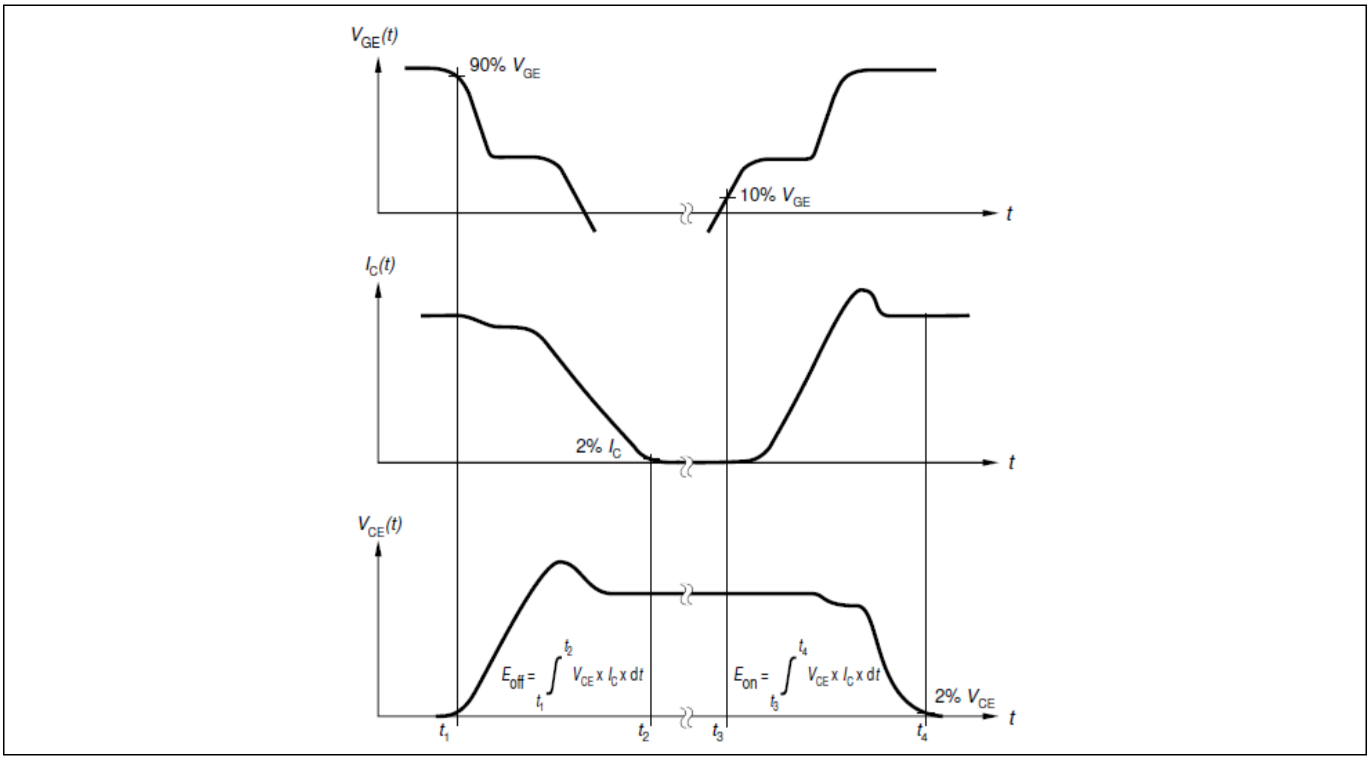

Figure 12 Definition of switching losses according datasheet

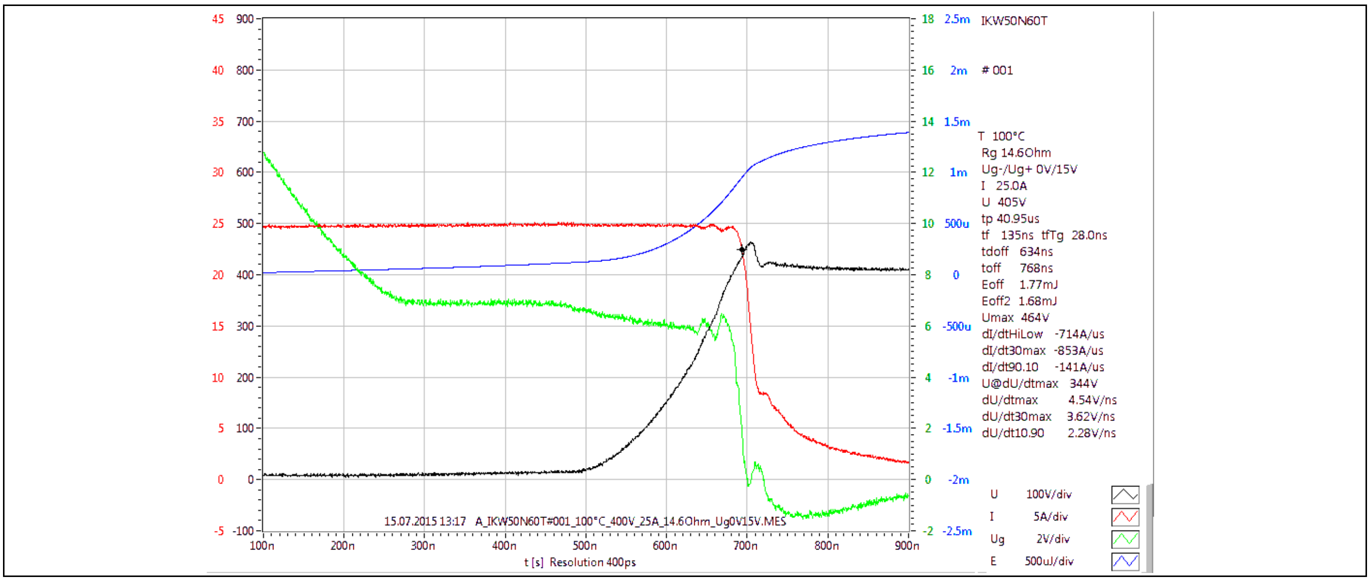

Figure 13 Turn off of IKW50N60T

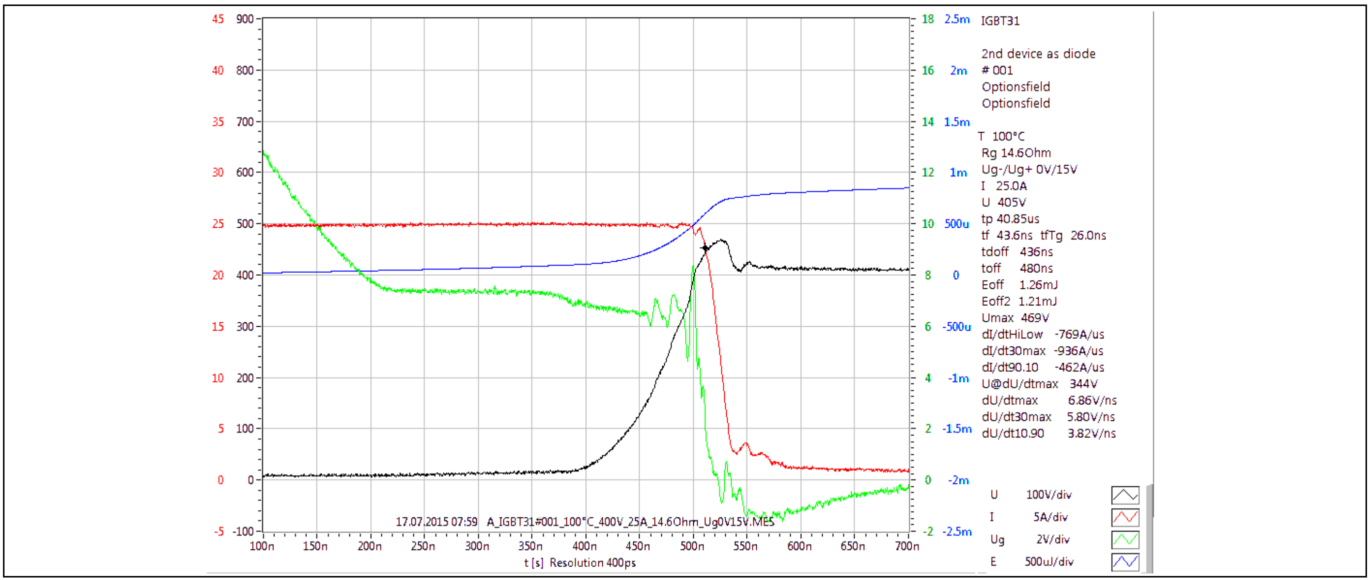

Figure 14 Turn off of IKW50N60DTP

The IKW50N60DTP has a significantly reduced current tail, which leads to a 30% lower turn off energy at the same voltage overshoot compared to IKW50N60T.

Figure 15 gives the switching losses' comparisons for $I_C = 25$ A.

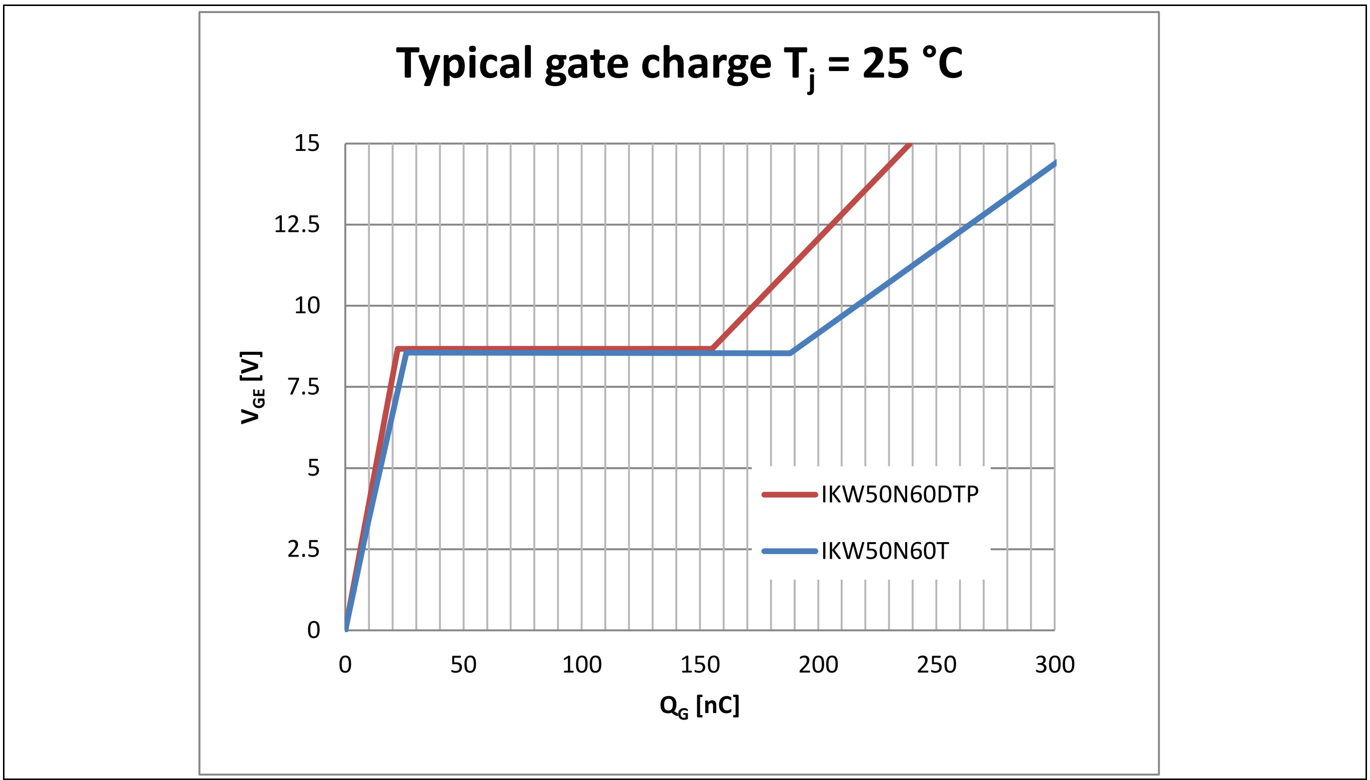

Figure 15 Switching energies as a function of T_j for $I_C = 25$ A

The turn-on energies are comparable for both products, but the turn-off energy of the IKW50N60DTP is, thanks to the low current tail, significantly lower. As a result the total switching losses are significantly lower. The total switching losses of the IKW50N60DTP at T_j = 100 °C are about 19 % lower compared to the IKW50N60T. This allows improved application efficiencies as shown in chapter 2.1.

2.5 Gate charge

The IGBT's gate charge determines the gate driver output power capabilities. The TRENCHSTOP™ Performance technology offers a 20 % reduced gate charge at V_{GE} = 15 V compared to the existing TRENCHSTOP™ IGBTs.

Figure 16 provides the typical gate charge Q_G comparison for I_C = 50 A.

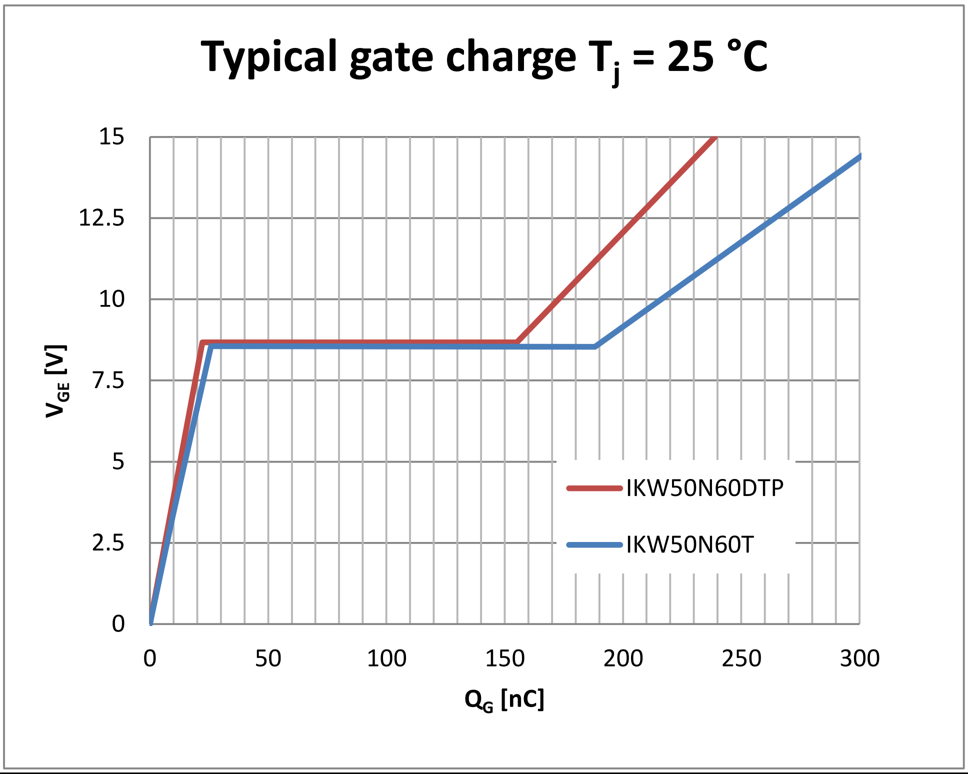

Figure 16 Gate charge for V_{CC} = 480 V, I_C = 50 A and T_j = 25 °C

2.6 Summary

In this application note, the comparison of the static and dynamic characteristics of the new TRENCHSTOP™ Performance IGBTs gave a view of the improved performance in comparison to the existing TRENCHSTOP™ IGBTs. The proof has been done by an application test on a motor test bench. At 15 kHz, an improved efficiency of 0.6 % has been observed.

The EMI investigation has shown a marginal change in radiated and conducted emission of the 60 TP, with no new frequency spots being observed.

As a result, the TRENCHSTOP™ Performance family can replace the 60 T family in most applications with no or very little redesign effort. Furthermore, it offers a perfect fit for applications requiring short circuit robustness at high efficiency and superior EMI performance.

3 Symbols and terms

A	Anode
C	Collector, capacitance
di_F/dt	Rate of diode current raise
di_{rr}/dt	Peak rate of diode current fall during recovery process
E	Emitter, energy
E_{off}	Turn-off loss energy
E_{on}	Turn-on loss energy
f	Frequency
G	Gate
I	Current
I_C	Collector current
I_F	Diode forward current
Q_{rr}	Reverse recovery charge
Q_G	Gate charge
R_G	Gate resistance
$R_{th(j-c)}$, R_{thjc}	Thermal resistance junction to case
T_c	Case temperature
t	Time
T_j	Junction temperature
T_{vj}	Operation junction temperature
V	Voltage
V_{bus}	Bus voltage
V_{CEsat}	Collector-emitter saturation voltage
V_F	Diode forward voltage
V_{GE}	Gate-emitter voltage

4 References

[1] Infineon Application note AN2015-13 V1.0 'Explanation of discrete IGBTs' datasheets', September 2015 http://www.infineon.com/dgdl/Infineon-ApplicationNote_DiscreteIGBT_DatasheetExplanation-AN-v01_00-EN.pdf?fileId=5546d462501ee6fd015023070b8b306d

Revision history

Major changes since the last revision

Page or Reference	Description of change
--	First release

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