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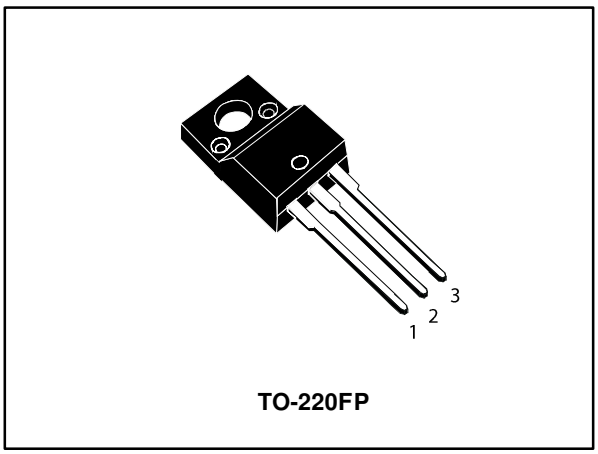
Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

# STGF15M65DF2

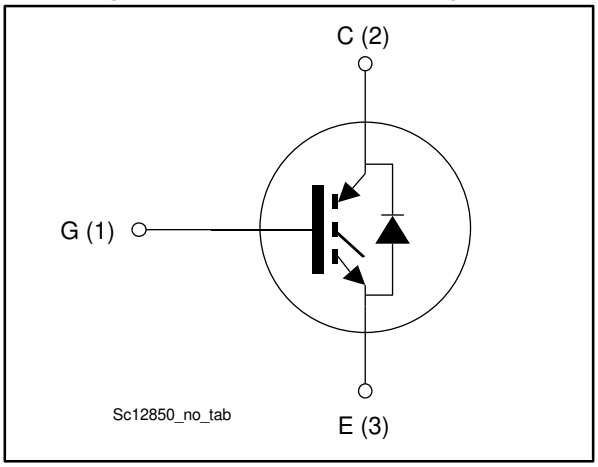
## Trench gate field-stop IGBT M series, 650 V, 15 A low-loss

Datasheet - production data




**TO-220FP**

**Figure 1: Internal schematic diagram**




## Features

- 6 µs of short-circuit withstand time
- $V_{CE(sat)}$ = 1.55 V (typ.) @ $I_C$ = 15 A
- Tight parameter distribution
- Safer paralleling
- Low thermal resistance
- Soft and very fast recovery antiparallel diode

## Applications

- Motor control
- UPS
- PFC

## Description

This device is an IGBT developed using an advanced proprietary trench gate field-stop structure. The device is part of the M series IGBTs, which represent an optimal balance between inverter system performance and efficiency where low-loss and short-circuit functionality are essential. Furthermore, the positive $V_{CE(sat)}$ temperature coefficient and tight parameter distribution result in safer paralleling operation.

**Table 1: Device summary**

| Order code | Marking | Package | Packing |
|---|---|---|---|
| STGF15M65DF2 | G15M65DF2 | TO-220FP | Tube |

# Contents

# 1 Electrical ratings

**Table 2: Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-emitter voltage ($V_{GE}$ = 0 V) | 650 | V |
| $I_C$(1) | Continuous collector current at $T_C$ = 25 °C | 30 | A |
| | Continuous collector current at $T_C$ = 100 °C | 15 | A |
| $I_{CP}$(2) | Pulsed collector current | 60 | A |
| $V_{GE}$ | Gate-emitter voltage | ±20 | V |
| $I_F$(1) | Continuous forward current at $T_C$ = 25 °C | 30 | A |
| | Continuous forward current at $T_C$ = 100 °C | 15 | A |
| $I_{FP}$(2) | Pulsed forward current | 60 | A |
| $V_{ISO}$ | Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s, $T_C$ = 25 °C) | 2.5 | kV |
| $P_{TOT}$ | Total dissipation at $T_C$ = 25 °C | 31 | W |
| $T_{STG}$ | Storage temperature range | - 55 to 150 | °C |
| $T_J$ | Operating junction temperature range | - 55 to 175 | °C |

**Notes:**

(1)Limited by maximum junction temperature.

(2)Pulse width limited by maximum junction temperature.

**Table 3: Thermal data**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{thJC}$ | Thermal resistance junction-case IGBT | 4.8 | °C/W |
| $R_{thJC}$ | Thermal resistance junction-case diode | 6.25 | °C/W |
| $R_{thJA}$ | Thermal resistance junction-ambient | 62.5 | °C/W |

# 2 Electrical characteristics

$T_C$ = 25 °C unless otherwise specified

**Table 4: Static characteristics**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage | $V_{GE}$ = 0 V, $I_C$ = 2 mA | 650 | | | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE}$ = 15 V, $I_C$ = 15 A | | 1.55 | 2.0 | V |
| | | $V_{GE}$ = 15 V, $I_C$ = 15 A, $T_J$ = 125 °C | | 1.9 | | |
| | | $V_{GE}$ = 15 V, $I_C$ = 15 A, $T_J$ = 175 °C | | 2.1 | | |
| $V_F$ | Forward on-voltage | $I_F$ = 15 A | | 1.7 | | V |
| | | $I_F$ = 15 A, $T_J$ = 125 °C | | 1.5 | | |
| | | $I_F$ = 15 A, $T_J$ = 175 °C | | 1.4 | | |
| $V_{GE(th)}$ | Gate threshold voltage | $V_{CE}$ = $V_{GE}$, $I_C$ = 500 µA | 5 | 6 | 7 | V |
| $I_{CES}$ | Collector cut-off current | $V_{GE}$ = 0 V, $V_{CE}$ = 650 V | | | 25 | µA |
| $I_{GES}$ | Gate-emitter leakage current | $V_{CE}$ = 0 V, $V_{GE}$ = ± 20 V | | | 250 | µA |

**Table 5: Dynamic characteristics**

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $C_{ies}$ | Input capacitance | $V_{CE}$ = 25 V, f = 1 MHz, $V_{GE}$ = 0 V | - | 1250 | - | pF |
| $C_{oes}$ | Output capacitance | | - | 80 | - | |
| $C_{res}$ | Reverse transfer capacitance | | - | 25 | - | |
| $Q_g$ | Total gate charge | $V_{CC}$ = 520 V, $I_C$ = 15 A, $V_{GE}$ = 15 V (see *Figure 30: " Gate charge test circuit"*) | - | 45 | - | nC |
| $Q_{ge}$ | Gate-emitter charge | | - | 11 | - | |
| $Q_{gc}$ | Gate-collector charge | | - | 15 | - | |

Table 6: IGBT switching characteristics (inductive load)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 15 A, $V_{GE}$ = 15 V, $R_G$ = 12 Ω (see *Figure 29: " Test circuit for inductive load switching"*) | - | 24 | - | ns |
| $t_r$ | Current rise time | | - | 7.8 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | - | 1570 | - | A/µs |
| $t_{d(off)}$ | Turn-off-delay time | | - | 93 | - | ns |
| $t_f$ | Current fall time | | - | 106 | - | ns |
| $E_{on}$(1) | Turn-on switching energy | | - | 0.09 | - | mJ |
| $E_{off}$(2) | Turn-off switching energy | | - | 0.45 | - | mJ |
| $E_{ts}$ | Total switching energy | | - | 0.54 | - | mJ |
| $t_{d(on)}$ | Turn-on delay time | $V_{CE}$ = 400 V, $I_C$ = 15 A, $V_{GE}$ = 15 V, $R_G$ = 12 Ω $T_J$ = 175 °C (see *Figure 29: " Test circuit for inductive load switching"*) | - | 24.8 | - | ns |
| $t_r$ | Current rise time | | - | 9.2 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | - | 1300 | - | A/µs |
| $t_{d(off)}$ | Turn-off-delay time | | - | 96 | - | ns |
| $t_f$ | Current fall time | | - | 169 | - | ns |
| $E_{on}$ | Turn-on switching energy | | - | 0.22 | - | mJ |
| $E_{off}$ | Turn-off switching energy | | - | 0.61 | - | mJ |
| $E_{ts}$ | Total switching energy | | - | 0.83 | - | mJ |
| $t_{sc}$ | Short-circuit withstand time | $V_{CC}$ ≤ 400 V, $V_{GE}$ = 15 V, $T_{Jstart}$ = 150 °C | 6 | | - | µs |
| | | $V_{CC}$ ≤ 400 V, $V_{GE}$ = 13 V, $T_{Jstart}$ = 150 °C | 10 | | | |

**Notes:**

(1)Including the reverse recovery of the diode.

(2)Including the tail of the collector current.

Table 7: Diode switching characteristics (inductive load)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $t_{rr}$ | Reverse recovery time | $I_F$ = 15 A, $V_R$ = 400 V, $V_{GE}$ = 15 V (see *Figure 29: " Test circuit for inductive load switching"*) di/dt = 1000 A/µs | - | 142 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 525 | | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 13.4 | | A |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ | | - | 790 | | A/µs |
| $E_{rr}$ | Reverse recovery energy | | - | 64 | | µJ |
| $t_{rr}$ | Reverse recovery time | $I_F$ = 15 A, $V_R$ = 400 V, $V_{GE}$ = 15 V $T_J$ = 175 °C (see *Figure 29: " Test circuit for inductive load switching"*) di/dt = 1000 A/µs | - | 241 | | ns |
| $Q_{rr}$ | Reverse recovery charge | | - | 1690 | | nC |
| $I_{rrm}$ | Reverse recovery current | | - | 20 | | A |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ | | - | 420 | | A/µs |
| $E_{rr}$ | Reverse recovery energy | | - | 176 | | µJ |

## 2.1 Electrical characteristics (curves)

**Figure 2: Power dissipation vs. case temperature**

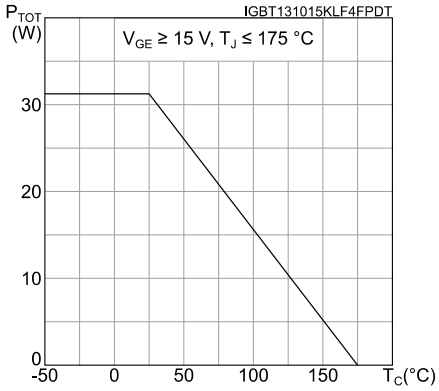



**Figure 3: Collector current vs. case temperature**

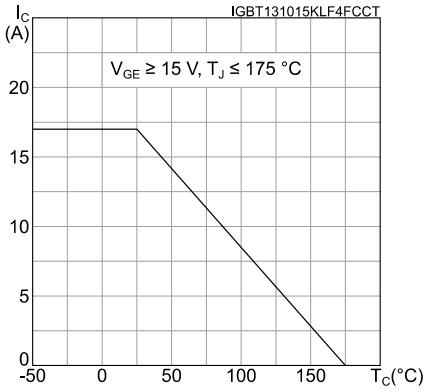



**Figure 4: Output characteristics ($T_J$ = 25 °C)**

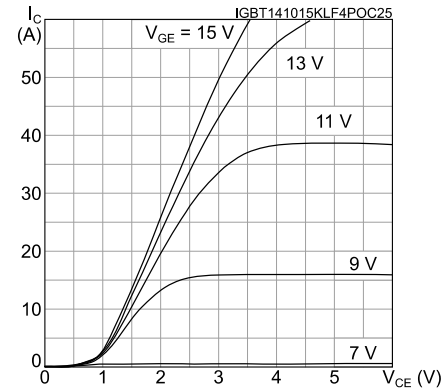



**Figure 5: Output characteristics ($T_J$ = 175 °C)**

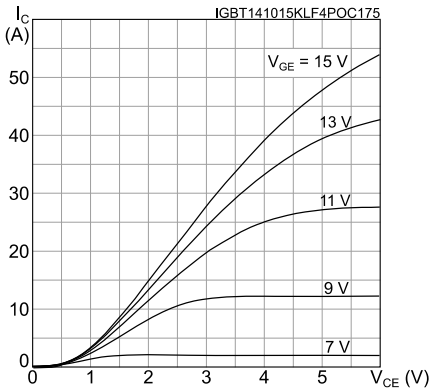



**Figure 6: $V_{CE(sat)}$ vs. junction temperature**

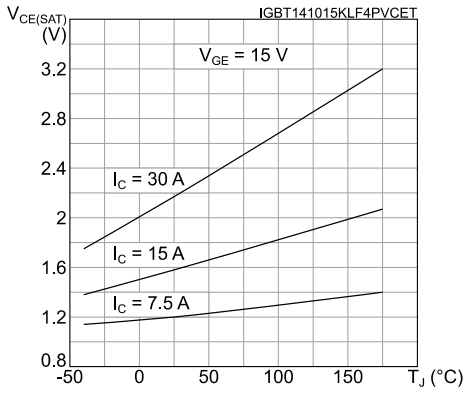



**Figure 7: $V_{CE(sat)}$ vs. collector current**

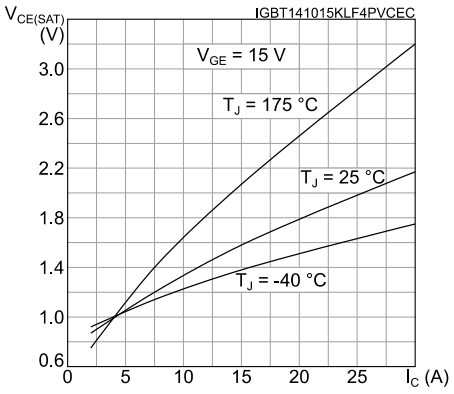


**Figure 8: Collector current vs. switching frequency**

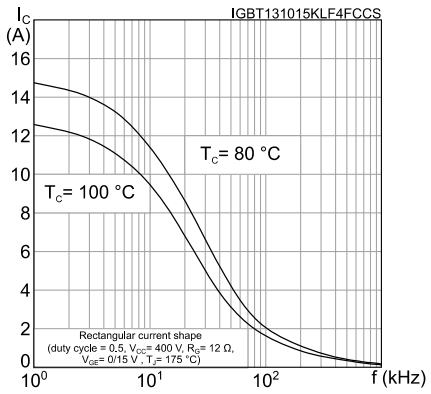



**Figure 9: Forward bias safe operating area**

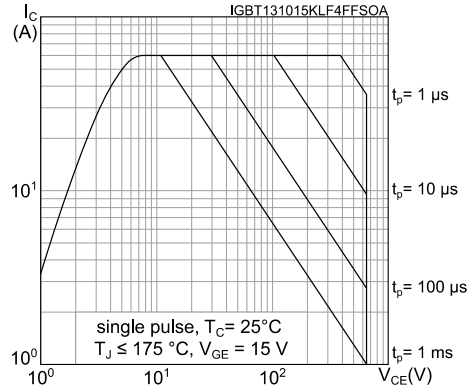



**Figure 10: Transfer characteristics**

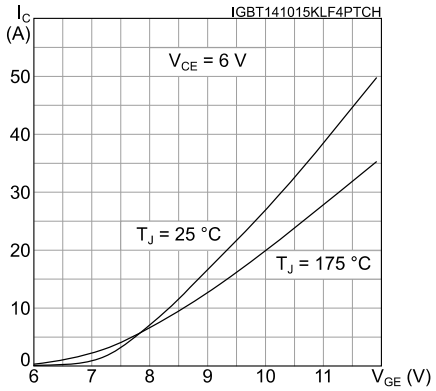



**Figure 11: Diode $V_F$ vs. forward current**

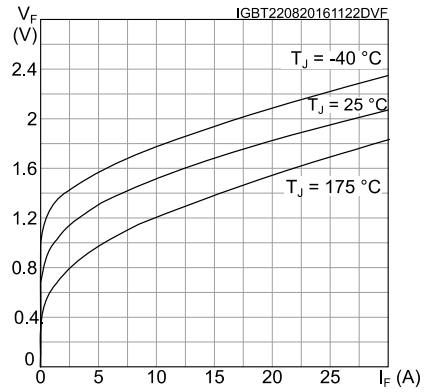



**Figure 12: Normalized $V_{GE(th)}$ vs. junction temperature**

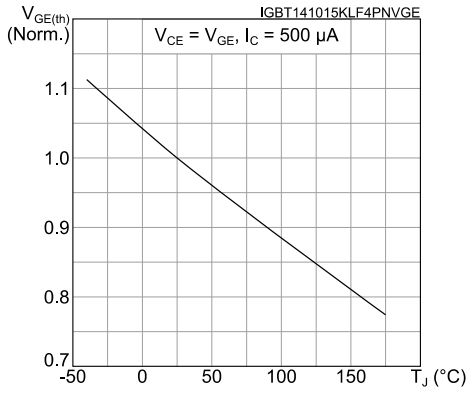



**Figure 13: Normalized $V_{(BR)CES}$ vs. junction temperature**

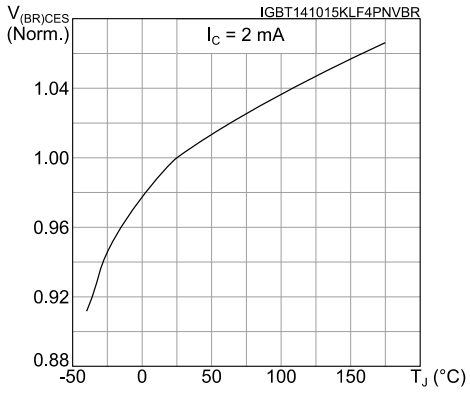


**Figure 14: Capacitance variations**

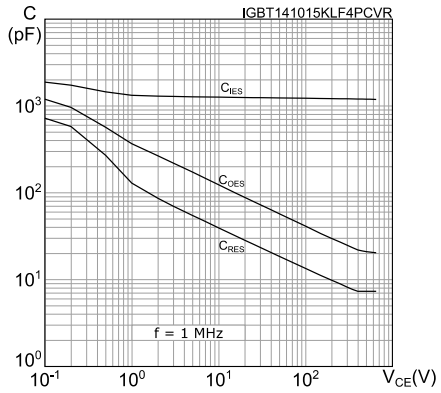



**Figure 15: Gate charge vs. gate-emitter voltage**

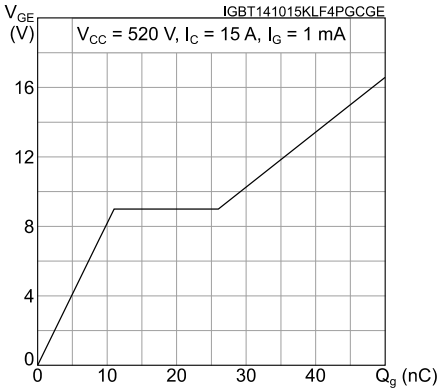



**Figure 16: Switching energy vs. collector current**

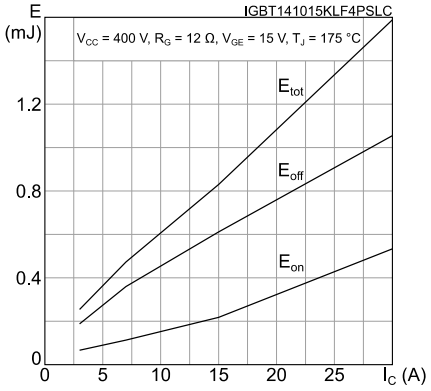



**Figure 17: Switching energy vs. gate resistance**

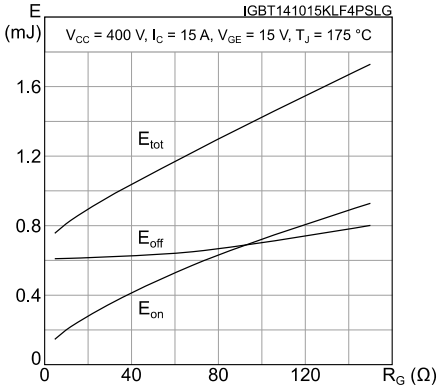



**Figure 18: Switching energy vs. temperature**

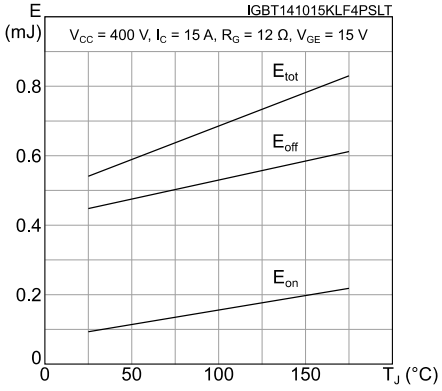



**Figure 19: Switching energy vs. collector emitter voltage**

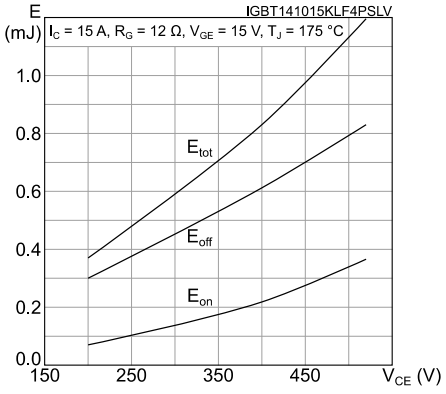


**Figure 20: Short-circuit time and current vs. $V_{GE}$**

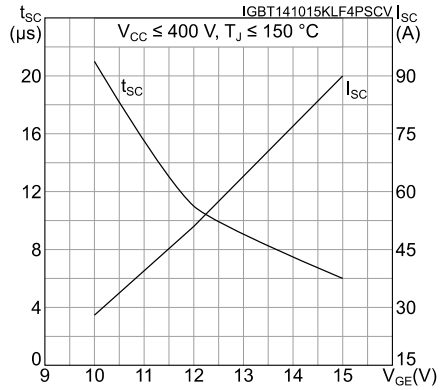



**Figure 21: Switching times vs. collector current**

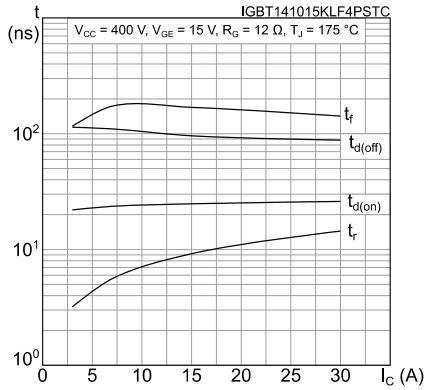



**Figure 22: Switching times vs. gate resistance**

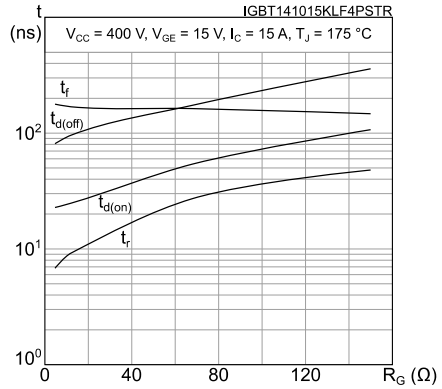



**Figure 23: Reverse recovery current vs. diode current slope**

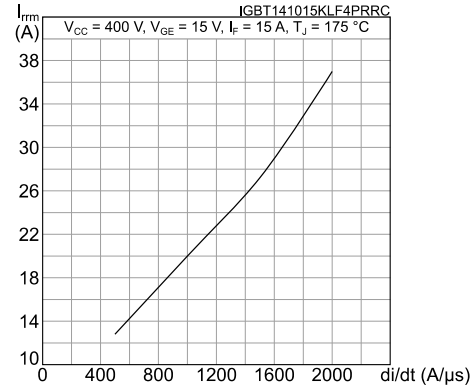



**Figure 24: Reverse recovery time vs. diode current slope**

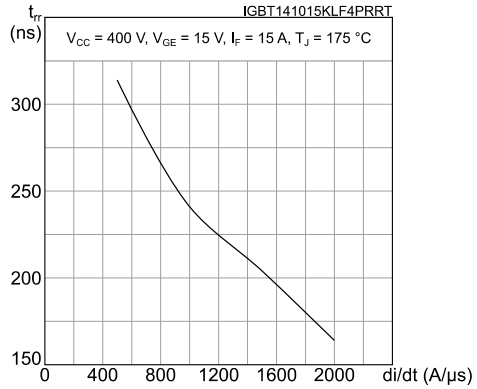



**Figure 25: Reverse recovery charge vs. diode current slope**

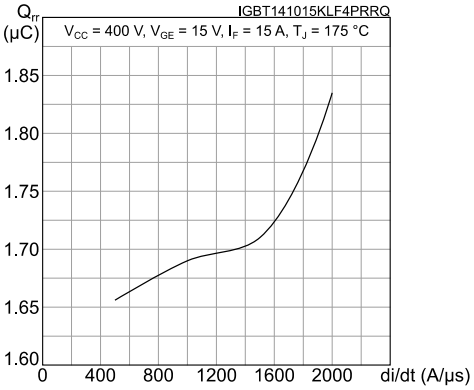


**Figure 26: Reverse recovery energy vs. diode current slope**

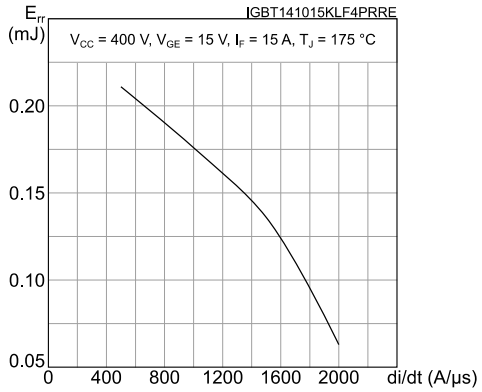



**Figure 27: Thermal impedance for IGBT**

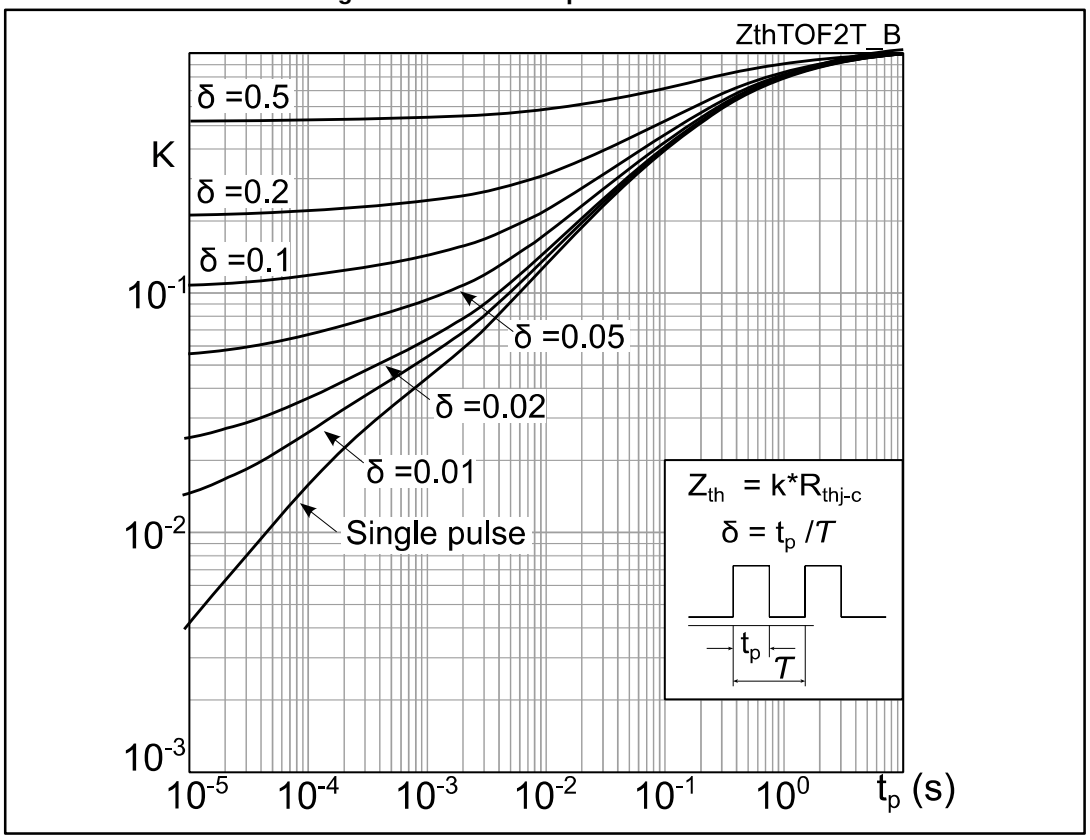
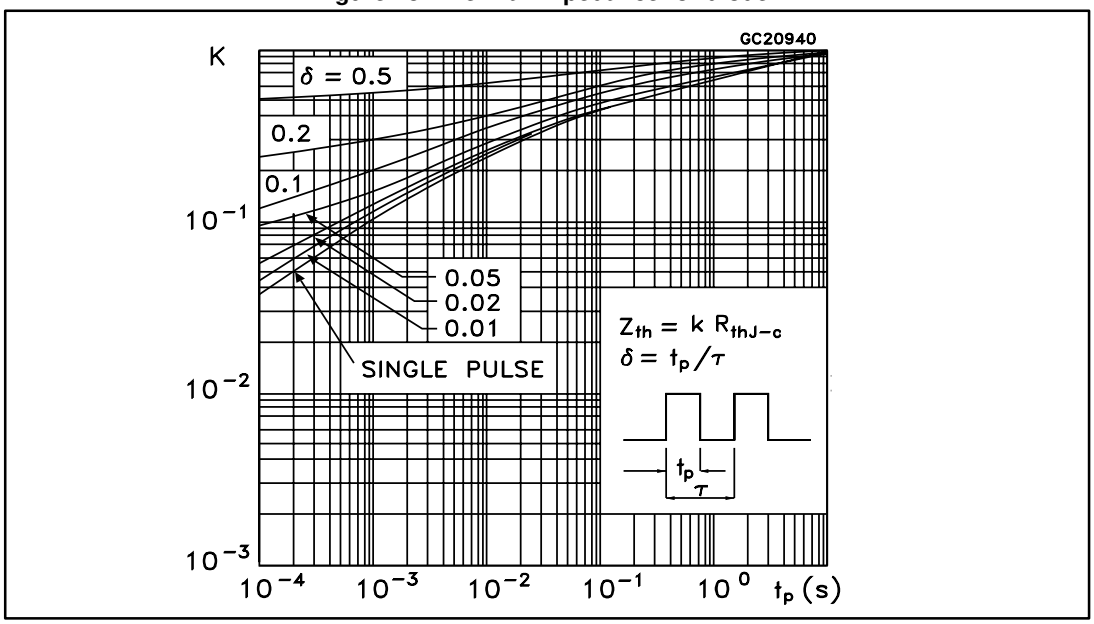


Figure 28: Thermal impedance for diode



# 3 Test circuits

**Figure 29: Test circuit for inductive load switching**

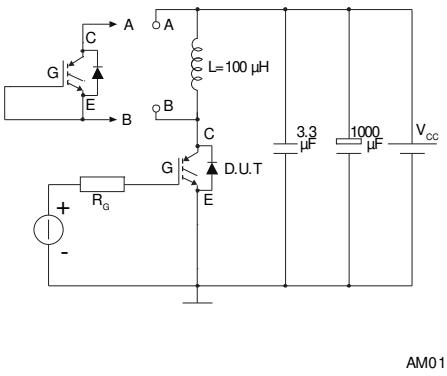



**Figure 30: Gate charge test circuit**

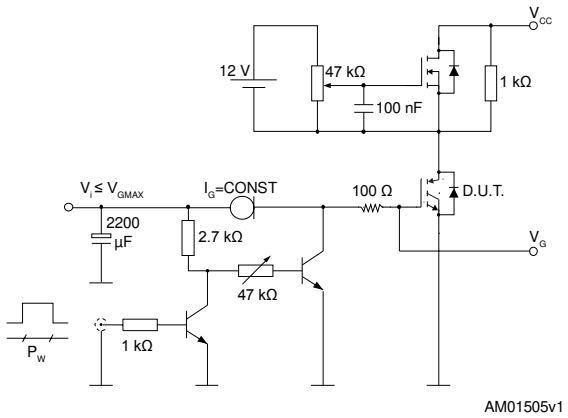



**Figure 31: Switching waveform**

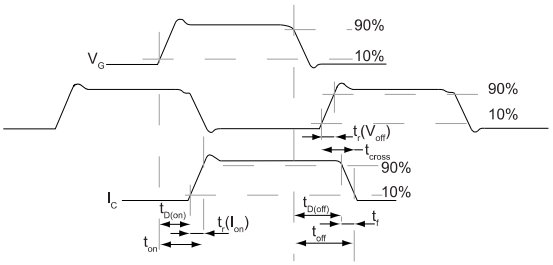
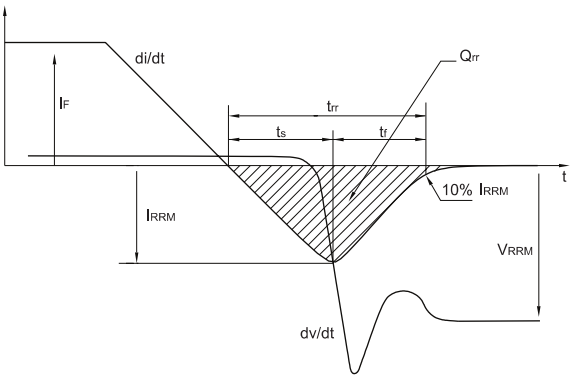



**Figure 32: Diode reverse recovery waveform**



# 4 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: ***www.st.com***. ECOPACK® is an ST trademark.

## 4.1 TO-220FP package information

Figure 33: TO-220FP package outline

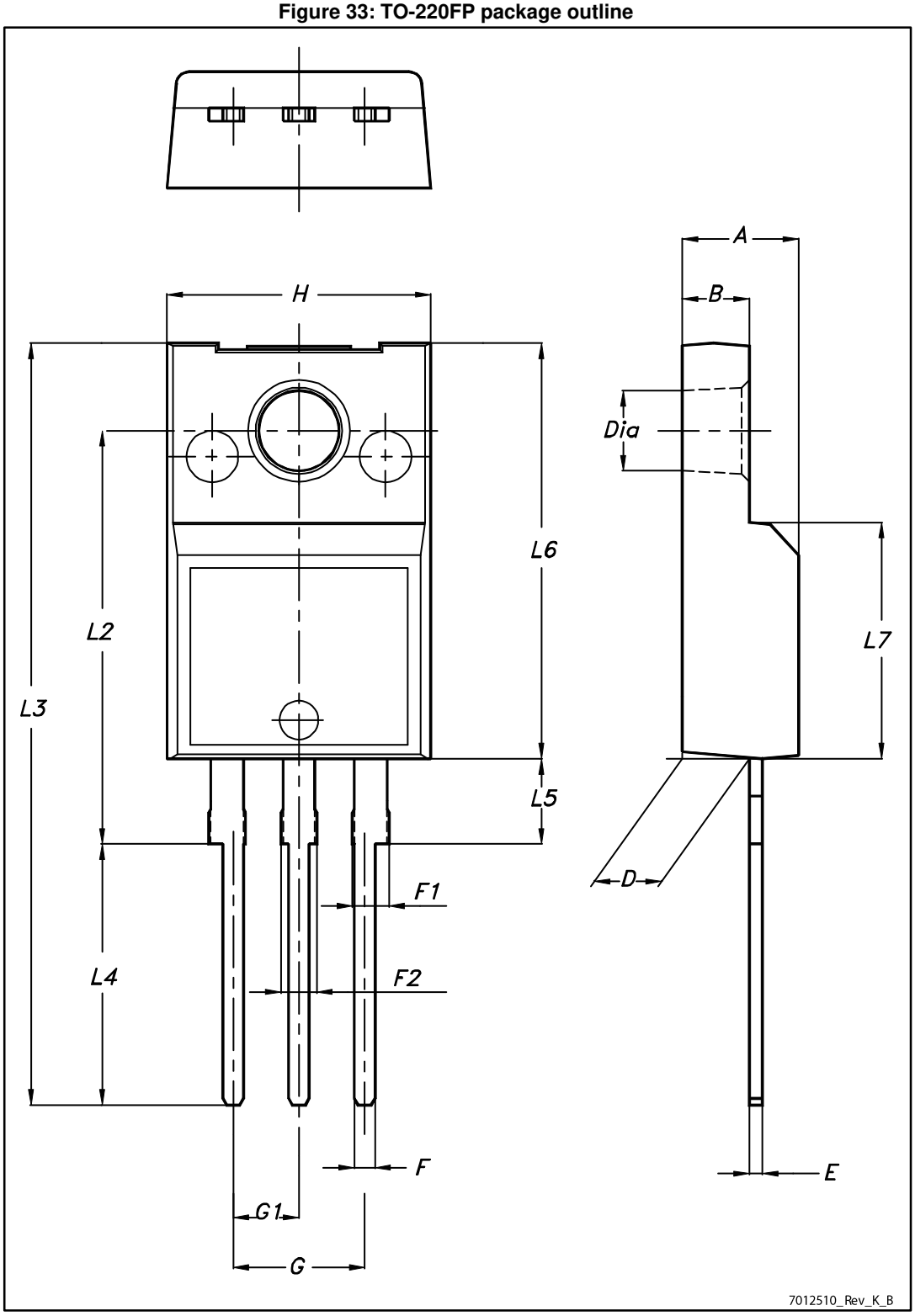


Table 8: TO-220FP package mechanical data

| Dim. | mm | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 4.4 | | 4.6 |
| B | 2.5 | | 2.7 |
| D | 2.5 | | 2.75 |
| E | 0.45 | | 0.7 |
| F | 0.75 | | 1 |
| F1 | 1.15 | | 1.70 |
| F2 | 1.15 | | 1.70 |
| G | 4.95 | | 5.2 |
| G1 | 2.4 | | 2.7 |
| H | 10 | | 10.4 |
| L2 | | 16 | |
| L3 | 28.6 | | 30.6 |
| L4 | 9.8 | | 10.6 |
| L5 | 2.9 | | 3.6 |
| L6 | 15.9 | | 16.4 |
| L7 | 9 | | 9.3 |
| Dia | 3 | | 3.2 |

# 5 Revision history

Table 9: Document revision history

| Date | Revision | Changes |
|---|---|---|
| 14-Oct-2015 | 1 | First release. |
| 22-Aug-2016 | 2 | Datasheet promoted from preliminary data to production data.<br>Changed *Figure 11: "Diode VF vs. forward current"*.<br>Updated: *Table 2: "Absolute maximum ratings"* and *Table 6: "IGBT switching characteristics (inductive load)"*.<br>Updated: *Figure 16: "Switching energy vs. collector current"*, *Figure 17: "Switching energy vs. gate resistance"*, *Figure 18: "Switching energy vs. temperature"* and *Figure 19: "Switching energy vs. collector emitter voltage"*. |

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