

Trench gate field-stop IGBT, M series 650 V, 4 A low loss

Datasheet - production data

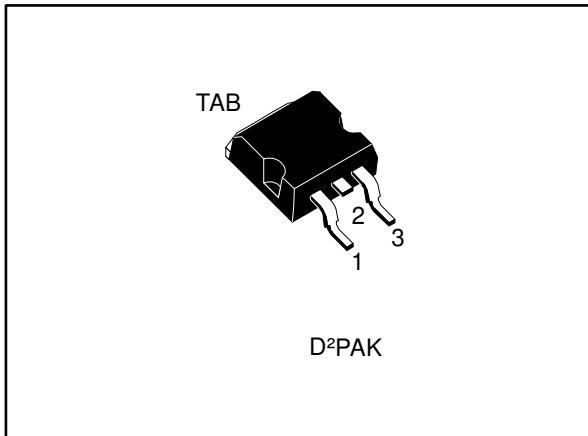
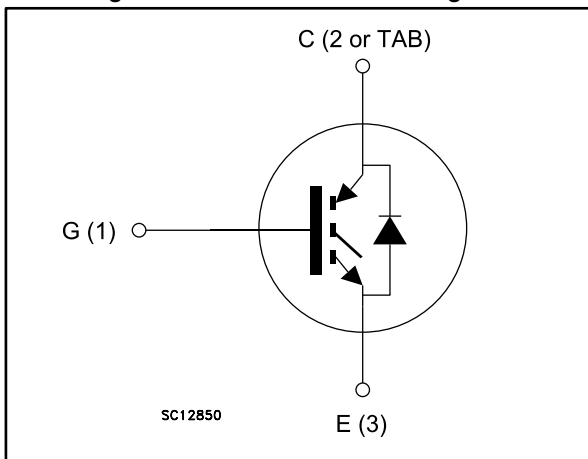


Figure 1: Internal schematic diagram



Features

- 6 μ s of short-circuit withstand time
- $V_{CE(sat)} = 1.6$ V (typ.) @ $I_C = 4$ 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 |
|-------------|----------|--------------------|---------------|
| STGB4M65DF2 | G4M65DF2 | D ² PAK | Tape and reel |

Contents

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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 | Continuous collector current at $T_C = 25$ °C | 8 | A |
| | Continuous collector current at $T_C = 100$ °C | 4 | A |
| $I_{CP}^{(1)}$ | Pulsed collector current | 16 | A |
| V_{GE} | Gate-emitter voltage | ± 20 | V |
| I_F | Continuous forward current at $T_C = 25$ °C | 8 | A |
| | Continuous forward current at $T_C = 100$ °C | 4 | A |
| $I_{FP}^{(1)}$ | Pulsed forward current | 16 | A |
| P_{TOT} | Total dissipation at $T_C = 25$ °C | 68 | W |
| T_{STG} | Storage temperature range | - 55 to 150 | °C |
| T_J | Operating junction temperature range | - 55 to 175 | °C |

Notes:

⁽¹⁾Pulse width limited by maximum junction temperature.

Table 3: Thermal data

| Symbol | Parameter | Value | Unit |
|------------|--|-------|------|
| R_{thJC} | Thermal resistance junction-case IGBT | 2.2 | °C/W |
| R_{thJC} | Thermal resistance junction-case diode | 5 | °C/W |
| R_{thJA} | Thermal resistance junction-ambient | 62.5 | °C/W |

2 Electrical characteristics

$T_C = 25\text{ °C}$ unless otherwise specified

Table 4: Static characteristics

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---------------|--------------------------------------|--|------|------|-----------|---------------|
| $V_{(BR)CES}$ | Collector-emitter breakdown voltage | $V_{GE} = 0\text{ V}$, $I_C = 250\text{ }\mu\text{A}$ | 650 | | | V |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}$, $I_C = 4\text{ A}$ | | 1.6 | 2.1 | V |
| | | $V_{GE} = 15\text{ V}$, $I_C = 4\text{ A}$, $T_J = 125\text{ °C}$ | | 1.9 | | |
| | | $V_{GE} = 15\text{ V}$, $I_C = 4\text{ A}$, $T_J = 175\text{ °C}$ | | 2.1 | | |
| V_F | Forward on-voltage | $I_F = 4\text{ A}$ | | 1.9 | | V |
| | | $I_F = 4\text{ A}$, $T_J = 125\text{ °C}$ | | 1.7 | | |
| | | $I_F = 4\text{ A}$, $T_J = 175\text{ °C}$ | | 1.6 | | |
| $V_{GE(th)}$ | Gate threshold voltage | $V_{CE} = V_{GE}$, $I_C = 250\text{ }\mu\text{A}$ | 5 | 6 | 7 | V |
| I_{CES} | Collector cut-off current | $V_{GE} = 0\text{ V}$, $V_{CE} = 650\text{ V}$ | | | 25 | μA |
| I_{GES} | Gate-emitter leakage current | $V_{CE} = 0\text{ V}$, $V_{GE} = \pm 20\text{ V}$ | | | ± 250 | μA |

Table 5: Dynamic characteristics

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|--|------|------|------|------|
| C_{ies} | Input capacitance | $V_{CE} = 25\text{ V}$, $f = 1\text{ MHz}$, $V_{GE} = 0\text{ V}$ | - | 369 | - | pF |
| C_{oes} | Output capacitance | | - | 24.8 | - | |
| C_{res} | Reverse transfer capacitance | | - | 8 | - | |
| Q_g | Total gate charge | $V_{CC} = 520\text{ V}$, $I_C = 4\text{ A}$, $V_{GE} = 15\text{ V}$ (see Figure 30: "Gate charge test circuit") | - | 15.2 | - | nC |
| Q_{ge} | Gate-emitter charge | | - | 3 | - | |
| Q_{gc} | Gate-collector charge | | - | 7 | - | |

Table 6: IGBT switching characteristics (inductive load)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|------------------------------|---|------|-------|------|------------|
| $t_{d(on)}$ | Turn-on delay time | $V_{CE} = 400\text{ V}$, $I_C = 4\text{ A}$, $V_{GE} = 15\text{ V}$, $R_G = 47\ \Omega$ (see Figure 29: "Test circuit for inductive load switching") | | 12 | - | ns |
| t_r | Current rise time | | | 6.9 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | | 480 | - | A/ μ s |
| $t_{d(off)}$ | Turn-off-delay time | | | 86 | - | ns |
| t_f | Current fall time | | | 120 | - | ns |
| $E_{on}^{(1)}$ | Turn-on switching energy | | | 0.040 | - | mJ |
| $E_{off}^{(2)}$ | Turn-off switching energy | | | 0.136 | - | mJ |
| E_{ts} | Total switching energy | | | 0.176 | - | mJ |
| $t_{d(on)}$ | Turn-on delay time | $V_{CE} = 400\text{ V}$, $I_C = 4\text{ A}$, $V_{GE} = 15\text{ V}$, $R_G = 47\ \Omega$, $T_J = 175\text{ }^\circ\text{C}$ (see Figure 29: "Test circuit for inductive load switching") | | 11.6 | - | ns |
| t_r | Current rise time | | | 8 | - | ns |
| $(di/dt)_{on}$ | Turn-on current slope | | | 410 | - | A/ μ s |
| $t_{d(off)}$ | Turn-off-delay time | | | 85 | - | ns |
| t_f | Current fall time | | | 211 | - | ns |
| $E_{on}^{(1)}$ | Turn-on switching energy | | | 0.067 | - | mJ |
| $E_{off}^{(2)}$ | Turn-off switching energy | | | 0.210 | - | mJ |
| E_{ts} | Total switching energy | | | 0.277 | - | mJ |
| t_{sc} | Short-circuit withstand time | $V_{CC} \leq 400\text{ V}$, $V_{GE} = 15\text{ V}$, $T_{Jstart} = 150\text{ }^\circ\text{C}$ | 6 | | - | μ s |
| | | $V_{CC} \leq 400\text{ V}$, $V_{GE} = 13\text{ V}$, $T_{Jstart} = 150\text{ }^\circ\text{C}$ | 10 | | - | μ s |

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 | $I_F = 4\text{ A}$, $V_R = 400\text{ V}$, $V_{GE} = 15\text{ V}$, $di/dt = 800\text{ A}/\mu\text{s}$ (see Figure 29: "Test circuit for inductive load switching") | - | 133 | - | ns |
| Q_{rr} | Reverse recovery charge | | - | 140 | - | nC |
| I_{rrm} | Reverse recovery current | | - | 5 | - | A |
| dl_{rr}/dt | Peak rate of fall of reverse recovery current during t_b | | - | 520 | - | A/ μ s |
| E_{rr} | Reverse recovery energy | | - | 15 | - | μ J |
| t_{rr} | Reverse recovery time | $I_F = 4\text{ A}$, $V_R = 400\text{ V}$, $V_{GE} = 15\text{ V}$, $T_J = 175\text{ }^\circ\text{C}$, $di/dt = 800\text{ A}/\mu\text{s}$ (see Figure 29: "Test circuit for inductive load switching") | - | 236 | - | ns |
| Q_{rr} | Reverse recovery charge | | - | 370 | - | nC |
| I_{rrm} | Reverse recovery current | | - | 6.6 | - | A |
| dl_{rr}/dt | Peak rate of fall of reverse recovery current during t_b | | - | 378 | - | A/ μ s |
| E_{rr} | Reverse recovery energy | | - | 32 | - | μ J |

2.1 Electrical characteristics (curves)

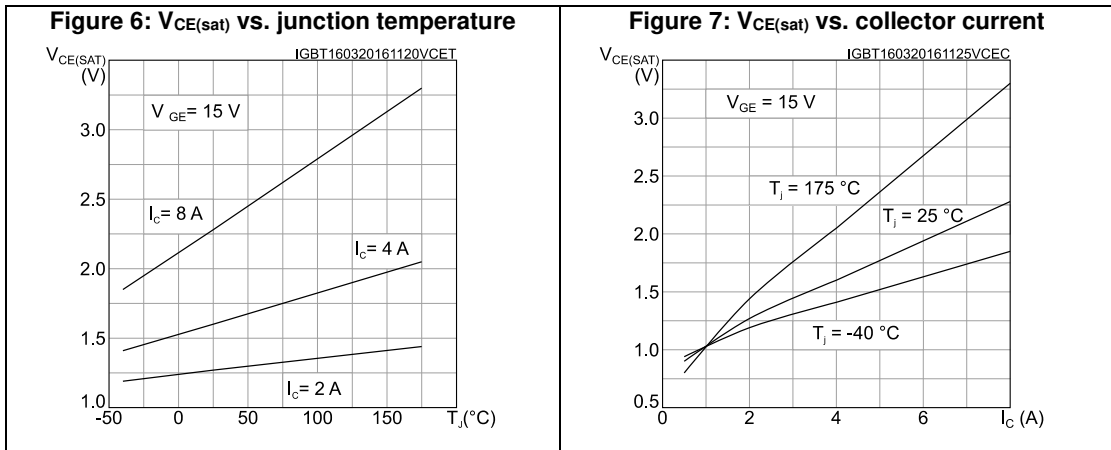
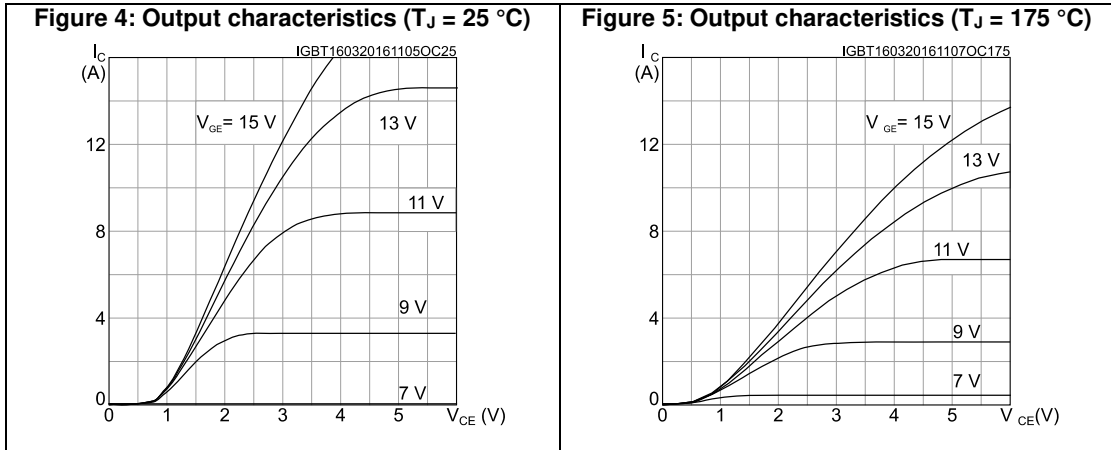
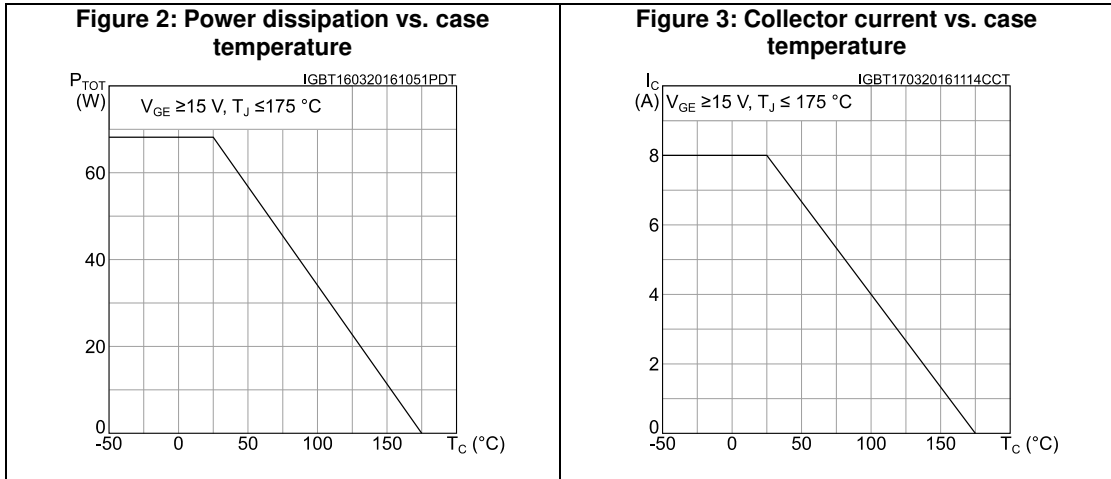


Figure 8: Collector current vs. switching frequency

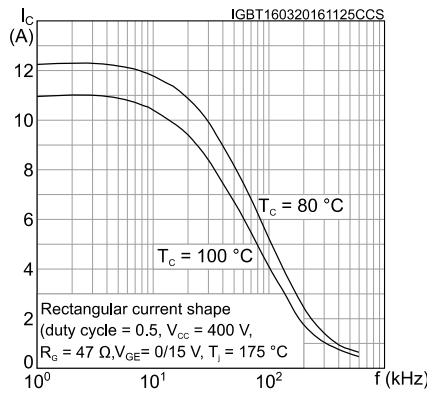


Figure 9: Forward bias safe operating area

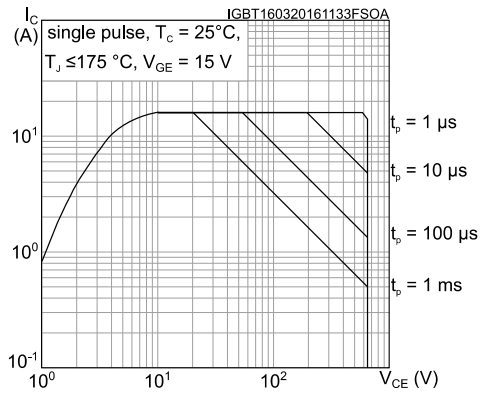


Figure 10: Transfer characteristics

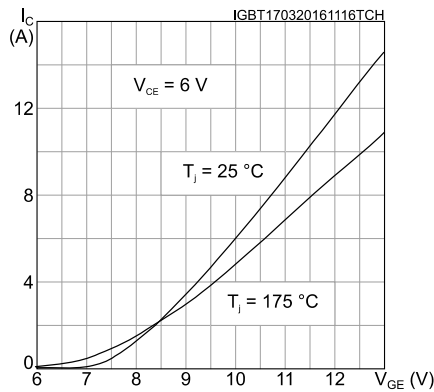


Figure 11: Diode VF vs. forward current

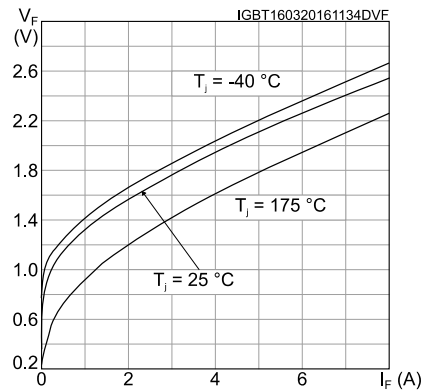


Figure 12: Normalized V_GE(th) vs. junction temperature

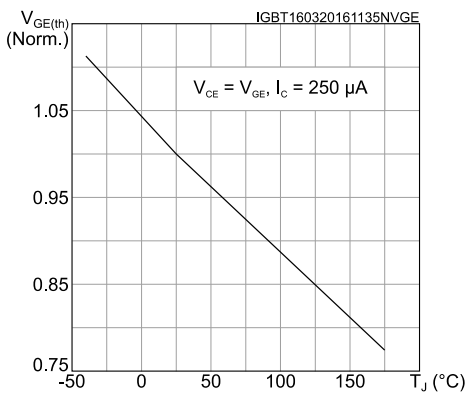
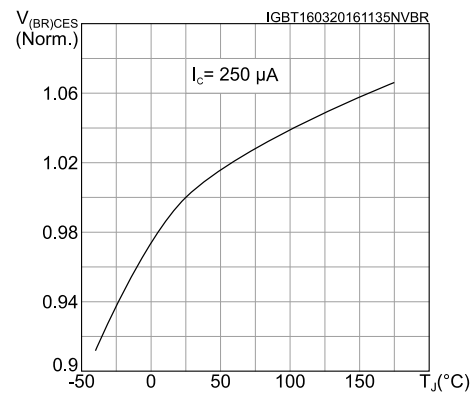


Figure 13: Normalized V_(BR)CES vs. junction temperature



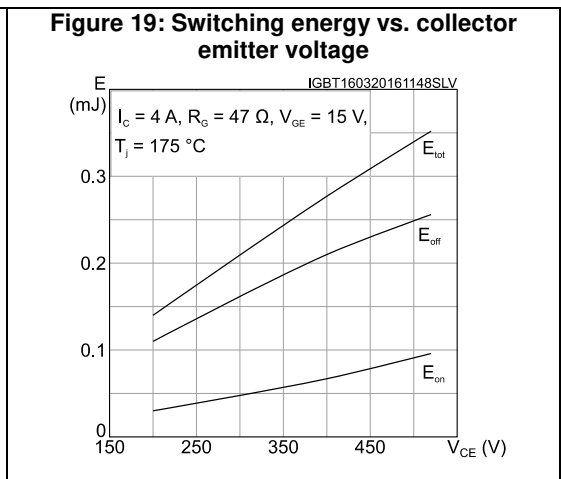
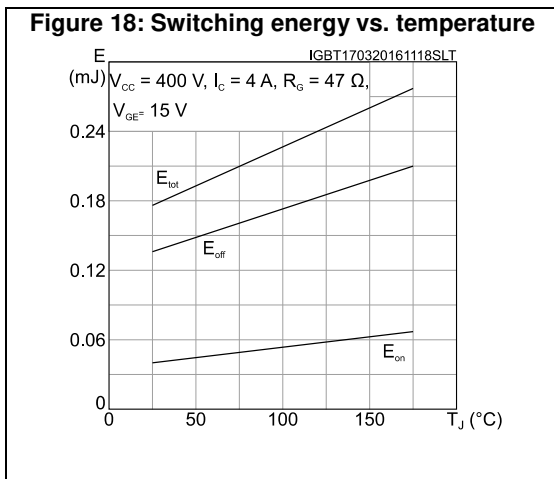
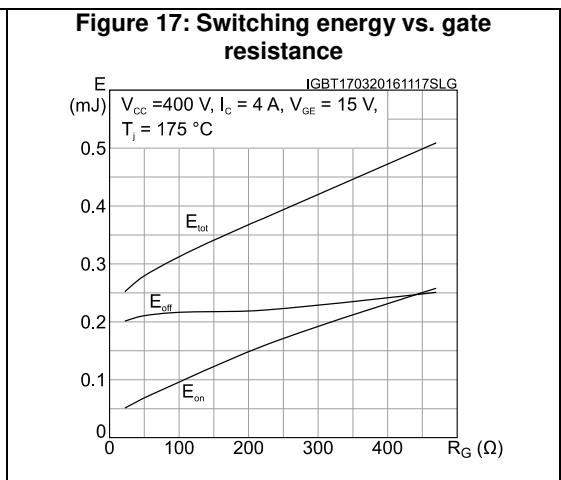
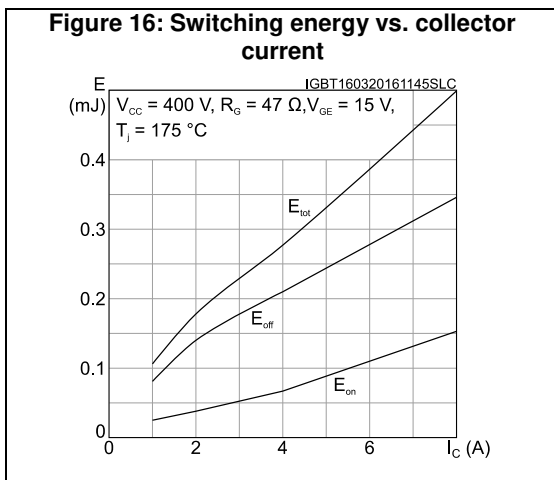
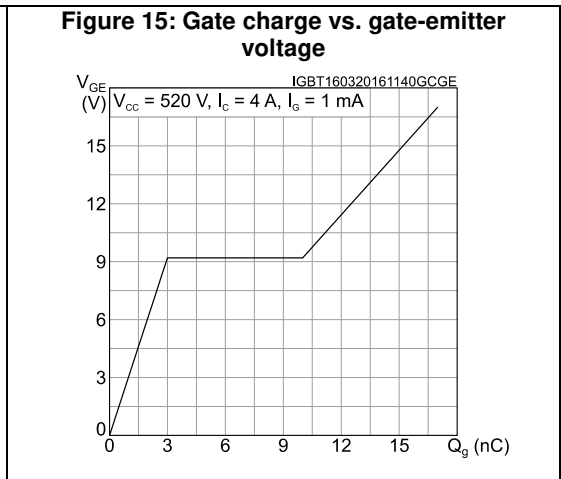
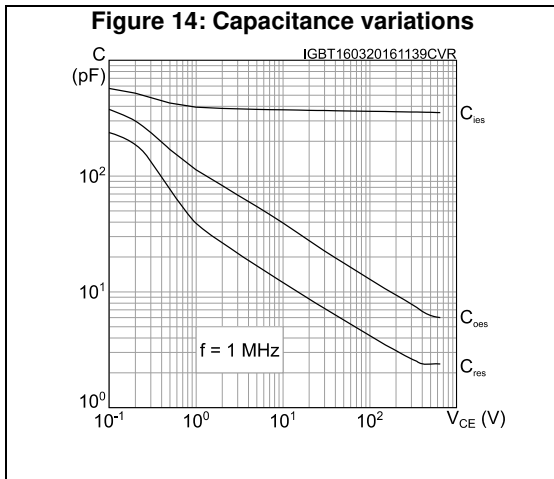


Figure 20: Short-circuit time and current vs. V_{GE}

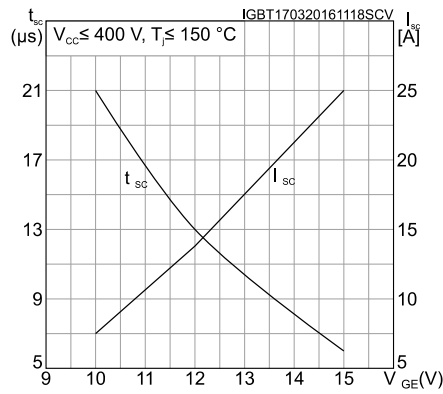


Figure 21: Switching times vs. collector current

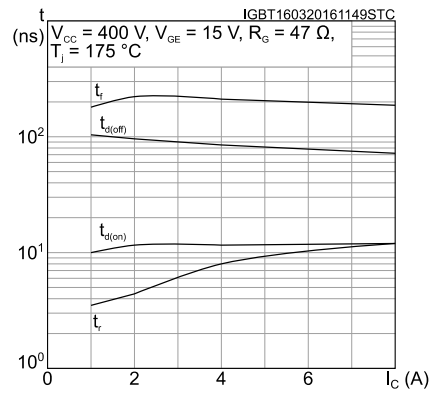


Figure 22: Switching times vs. gate resistance

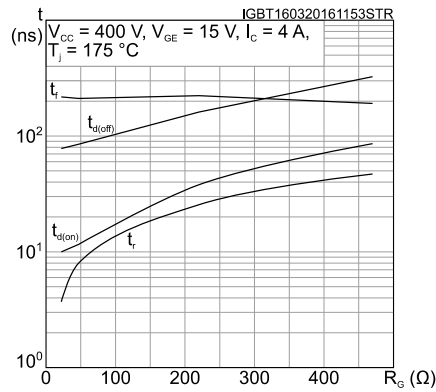


Figure 23: Reverse recovery current vs. diode current slope

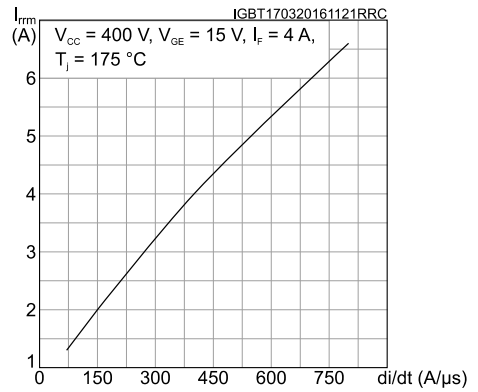


Figure 24: Reverse recovery time vs. diode current slope

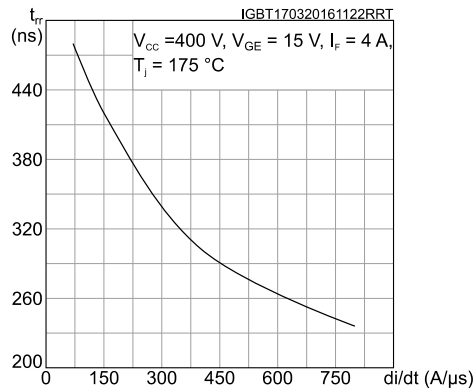


Figure 25: Reverse recovery charge vs. diode current slope

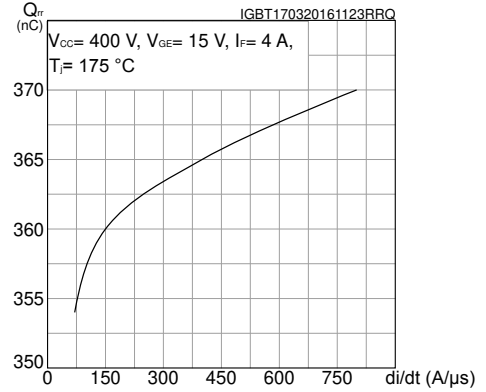


Figure 26: Reverse recovery energy vs. diode current slope

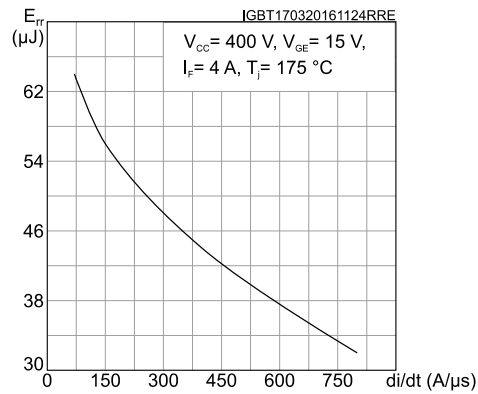


Figure 27: Thermal impedance for IGBT

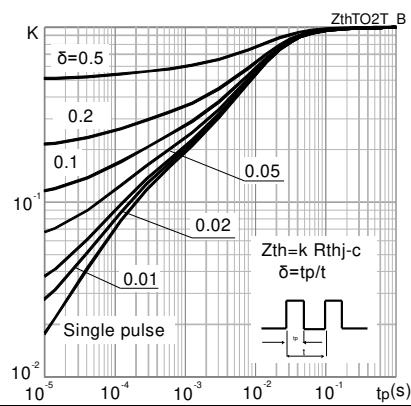
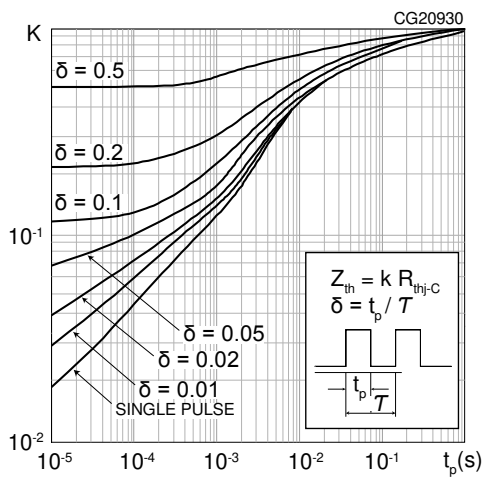
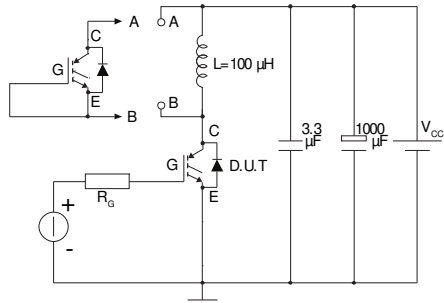


Figure 28: Thermal impedance for diode



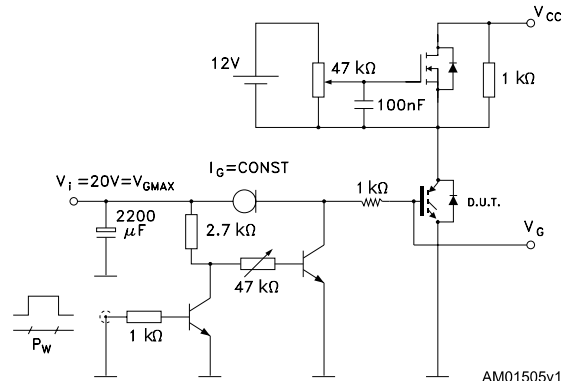
3 Test circuits

Figure 29: Test circuit for inductive load switching



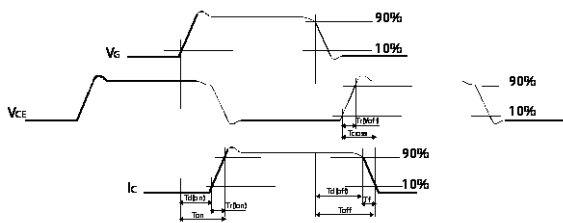
AM01504v1

Figure 30: Gate charge test circuit



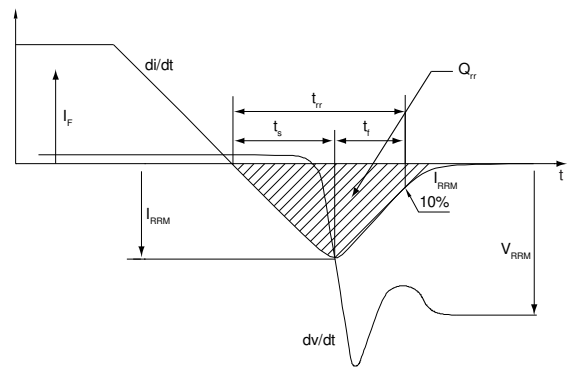
AM01505v1

Figure 31: Switching waveform



AM01506v1

Figure 32: Diode reverse recovery waveform



AM01507v1

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 D²PAK (TO-263) type A package information

Figure 33: D²PAK (TO-263) type A package outline

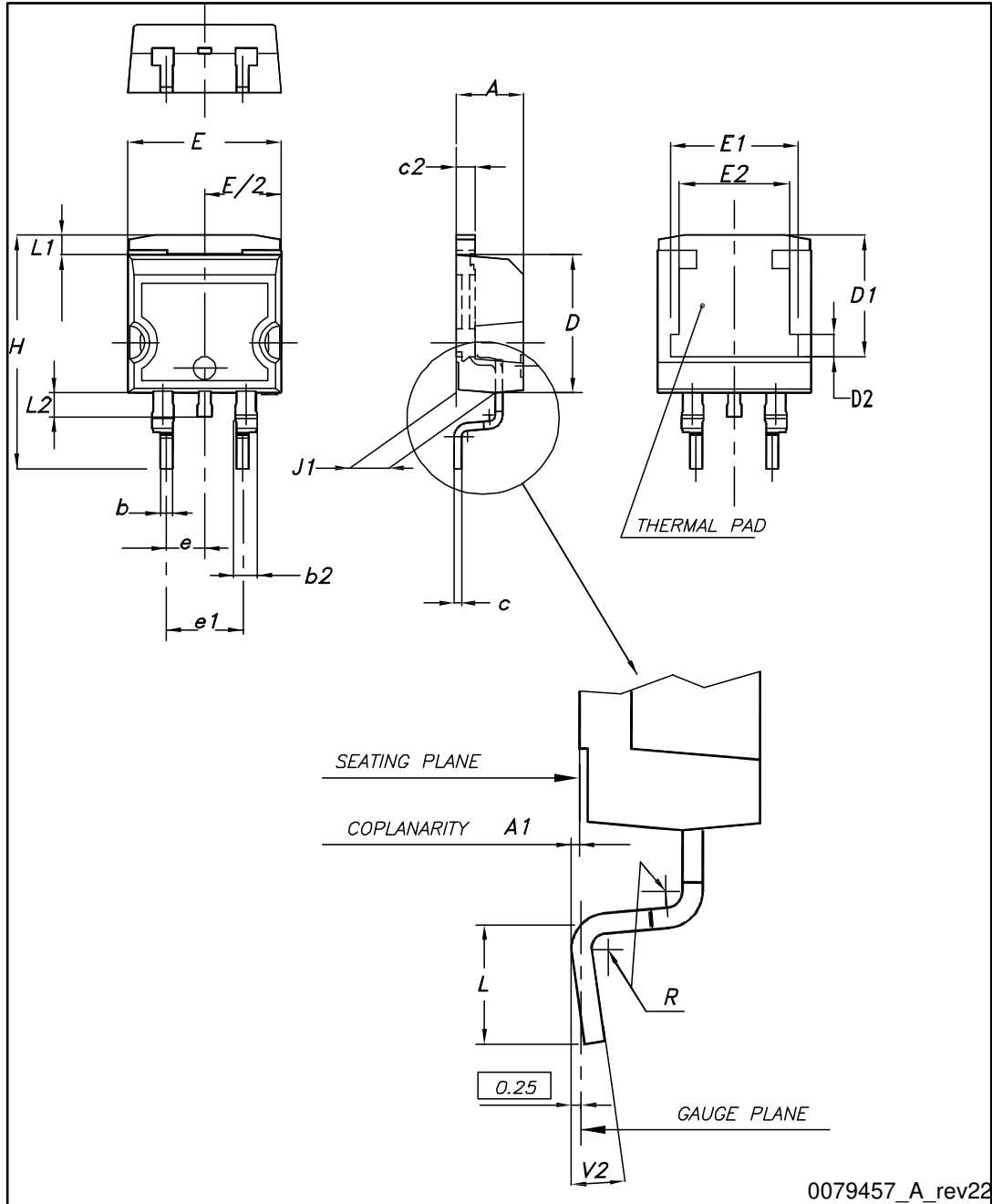
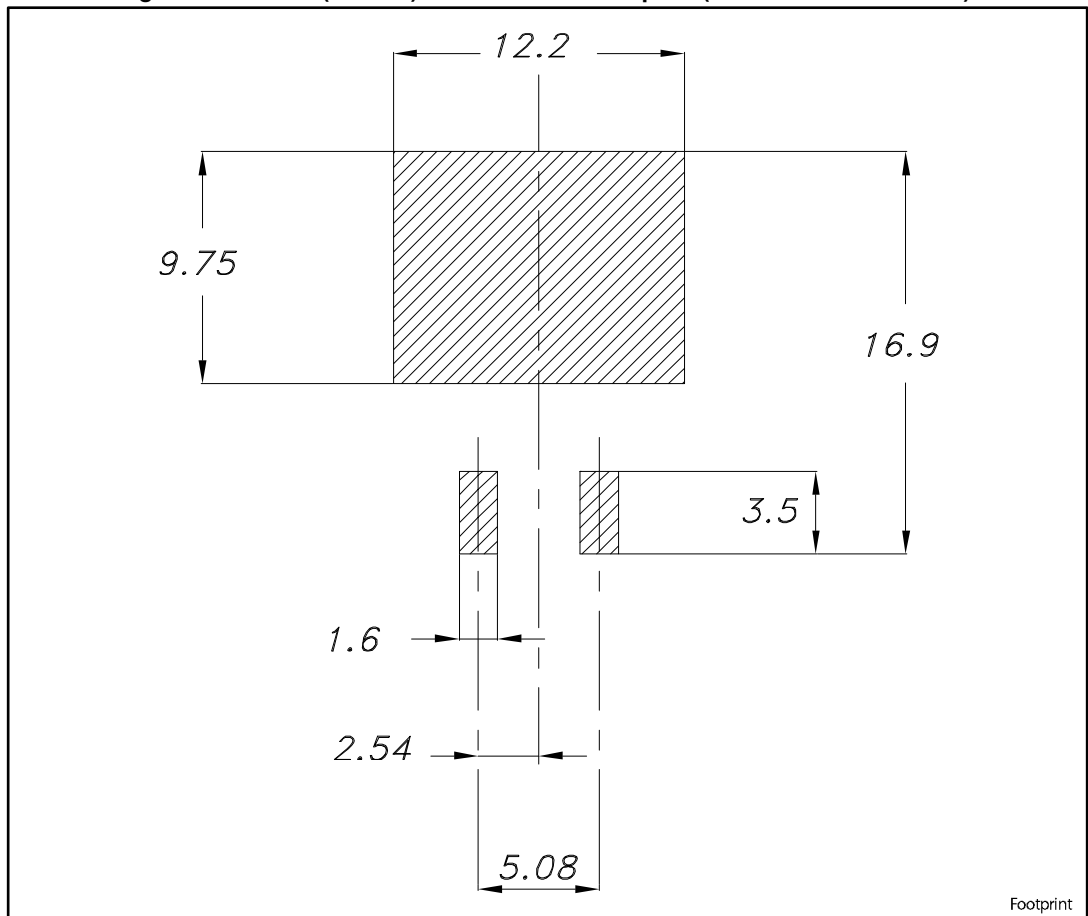


Table 8: D²PAK (TO-263) type A package mechanical data

| Dim. | mm | | |
|------|------|------|-------|
| | Min. | Typ. | Max. |
| A | 4.40 | | 4.60 |
| A1 | 0.03 | | 0.23 |
| b | 0.70 | | 0.93 |
| b2 | 1.14 | | 1.70 |
| c | 0.45 | | 0.60 |
| c2 | 1.23 | | 1.36 |
| D | 8.95 | | 9.35 |
| D1 | 7.50 | 7.75 | 8.00 |
| D2 | 1.10 | 1.30 | 1.50 |
| E | 10 | | 10.40 |
| E1 | 8.50 | 8.70 | 8.90 |
| E2 | 6.85 | 7.05 | 7.25 |
| e | | 2.54 | |
| e1 | 4.88 | | 5.28 |
| H | 15 | | 15.85 |
| J1 | 2.49 | | 2.69 |
| L | 2.29 | | 2.79 |
| L1 | 1.27 | | 1.40 |
| L2 | 1.30 | | 1.75 |
| R | | 0.4 | |
| V2 | 0° | | 8° |

Figure 34: D²PAK (TO-263) recommended footprint (dimensions are in mm)



4.2 Packing information

Figure 35: Tape outline

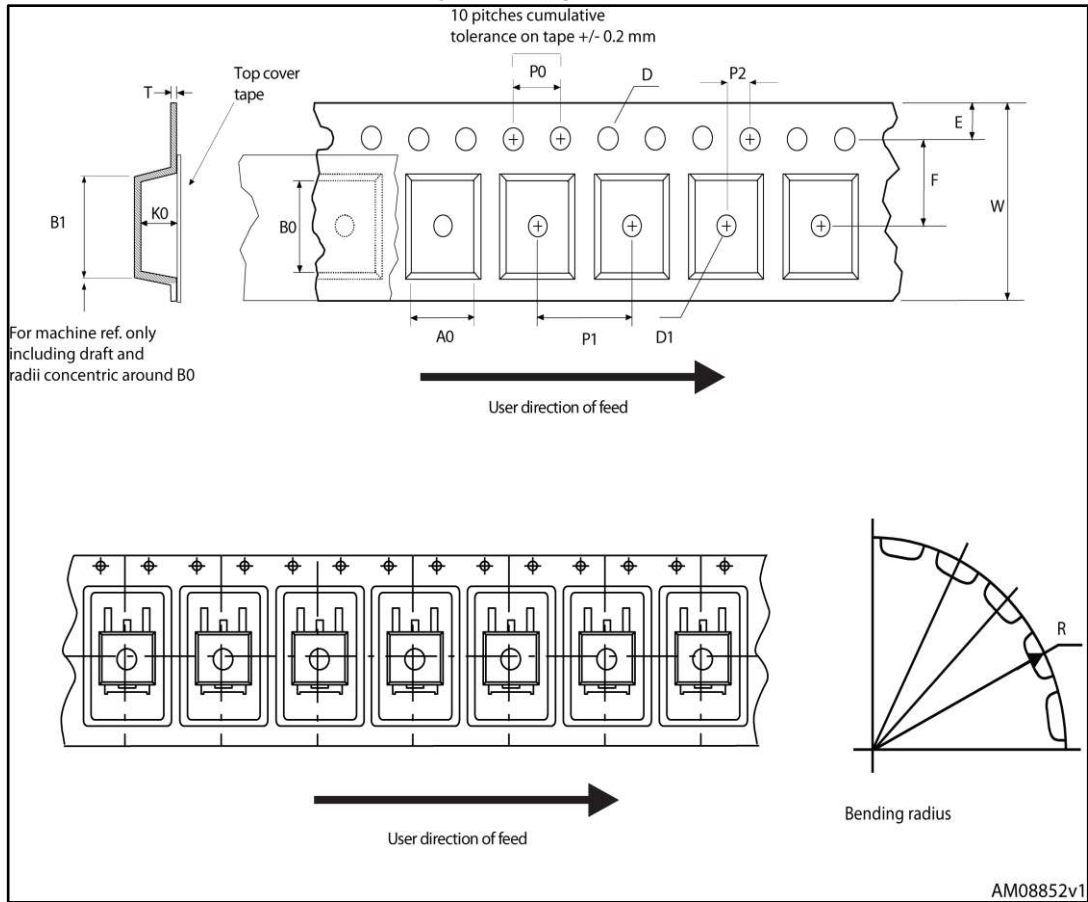
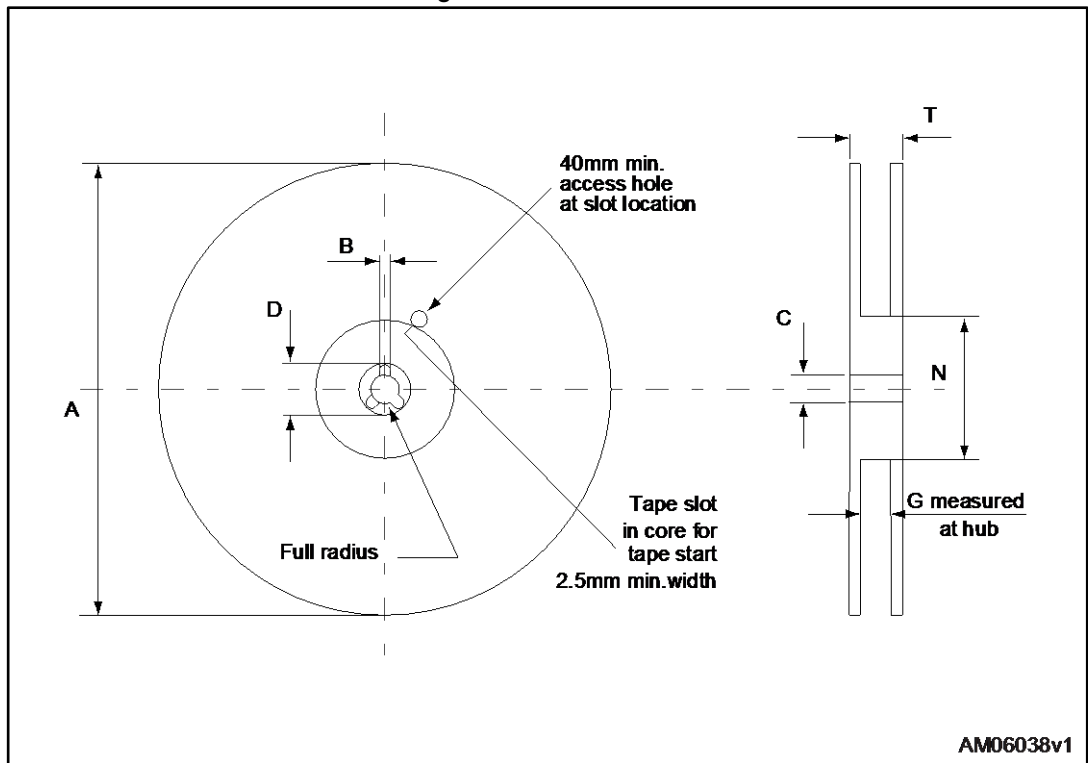


Figure 36: Reel outline



AM06038v1

Table 9: D²PAK tape and reel mechanical data

| Tape | | | Reel | | |
|------|------|------|---------------|------|------|
| Dim. | mm | | Dim. | mm | |
| | Min. | Max. | | Min. | Max. |
| A0 | 10.5 | 10.7 | A | | 330 |
| B0 | 15.7 | 15.9 | B | 1.5 | |
| D | 1.5 | 1.6 | C | 12.8 | 13.2 |
| D1 | 1.59 | 1.61 | D | 20.2 | |
| E | 1.65 | 1.85 | G | 24.4 | 26.4 |
| F | 11.4 | 11.6 | N | 100 | |
| K0 | 4.8 | 5.0 | T | | 30.4 |
| P0 | 3.9 | 4.1 | | | |
| P1 | 11.9 | 12.1 | Base quantity | | 1000 |
| P2 | 1.9 | 2.1 | Bulk quantity | | 1000 |
| R | 50 | | | | |
| T | 0.25 | 0.35 | | | |
| W | 23.7 | 24.3 | | | |

5 Revision history

Table 10: Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 23-Nov-2015 | 1 | First release. |
| 17-Mar-2016 | 2 | Modified: features in cover page Modified: Table 2: " <i>Absolute maximum ratings</i> ", Table 4: " <i>Static characteristics</i> ", Table 5: " <i>Dynamic characteristics</i> ", Table 6: " <i>IGBT switching characteristics (inductive load)</i> " and Table 7: " <i>Diode switching characteristics (inductive load)</i> " Added: Section 2: " <i>Electrical characteristics</i> " Minor text changes |
| 21-Mar-2016 | 3 | Modified: schematic in cover page Datasheet promoted from preliminary data to production data Minor text changes |
| 21-Nov-2016 | 4 | Updated Table 2: "Absolute maximum ratings" Updated Figure 25: "Reverse recovery charge vs. diode current slope" Updated Figure 32: "Diode reverse recovery waveform" |

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