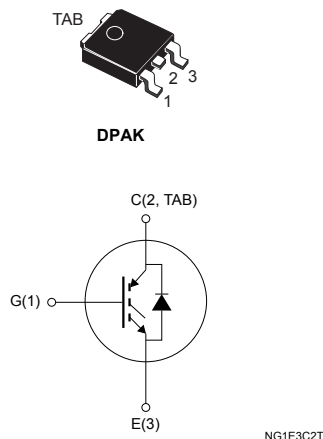


## Trench gate field-stop, 650 V, 6 A, low-loss M series IGBT in a DPAK package



### Product status link

[STGD6M65DF2](#)

### Product summary

|            |               |
|------------|---------------|
| Order code | STGD6M65DF2   |
| Marking    | G6M65DF2      |
| Package    | DPAK          |
| Packing    | Tape and reel |

### Features

- Maximum junction temperature:  $T_J = 175\text{ }^{\circ}\text{C}$
- 6  $\mu\text{s}$  of minimum short-circuit withstand time
- $V_{CE(sat)} = 1.55\text{ V}$  (typ.) at  $I_C = 6\text{ A}$
- Tight parameter distribution
- Safer paralleling
- Positive  $V_{CE(sat)}$  temperature coefficient
- Low thermal resistance
- Soft and very fast-recovery antiparallel diode

### Applications

- Industrial motor control
- PFC converters, single phase input
- Uninterruptable power supplies (UPS)

### 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 the low-loss and the short-circuit functionality is essential. Furthermore, the positive  $V_{CE(sat)}$  temperature coefficient and the tight parameter distribution result in safer paralleling operation.

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol         | Parameter                                             | Value      | Unit |
|----------------|-------------------------------------------------------|------------|------|
| $V_{CES}$      | Collector-emitter voltage ( $V_{GE} = 0\text{ V}$ )   | 650        | V    |
| $I_C$          | Continuous collector current at $T_C = 25\text{ °C}$  | 12         | A    |
|                | Continuous collector current at $T_C = 100\text{ °C}$ | 6          |      |
| $I_{CP}^{(1)}$ | Pulsed collector current                              | 24         | A    |
| $V_{GE}$       | Gate-emitter voltage                                  | $\pm 20$   | V    |
| $I_F$          | Continuous forward current at $T_C = 25\text{ °C}$    | 12         | A    |
|                | Continuous forward current at $T_C = 100\text{ °C}$   | 6          |      |
| $I_{FP}^{(1)}$ | Pulsed forward current                                | 24         | A    |
| $P_{TOT}$      | Total power dissipation at $T_C = 25\text{ °C}$       | 88         | W    |
| $T_{STG}$      | Storage temperature range                             | -55 to 150 | °C   |
| $T_J$          | Operating junction temperature range                  | -55 to 175 | °C   |

1. Pulse width is limited by maximum junction temperature.

**Table 2. Thermal data**

| Symbol     | Parameter                                  | Value | Unit |
|------------|--------------------------------------------|-------|------|
| $R_{thJC}$ | Thermal resistance, junction-to-case IGBT  | 1.7   | °C/W |
|            | Thermal resistance, junction-to-case diode | 5     |      |
| $R_{thJA}$ | Thermal resistance, junction-to-ambient    | 100   | °C/W |

## 2 Electrical characteristics

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

**Table 3. 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 | $V_{GE} = 15\text{ V}$ , $I_C = 6\text{ A}$                         |      | 1.55 | 2.0       | V             |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 6\text{ A}$ , $T_J = 125\text{ °C}$ |      | 1.9  |           |               |
|               |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 6\text{ A}$ , $T_J = 175\text{ °C}$ |      | 2.1  |           |               |
| $V_F$         | Forward on-voltage                   | $I_F = 6\text{ A}$                                                  |      | 2.6  | 3.5       | V             |
|               |                                      | $I_F = 6\text{ A}$ , $T_J = 125\text{ °C}$                          |      | 2.3  |           |               |
|               |                                      | $I_F = 6\text{ A}$ , $T_J = 175\text{ °C}$                          |      | 2.2  |           |               |
| $V_{GE(th)}$  | 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        | $\mu\text{A}$ |
| $I_{GES}$     | Gate-emitter leakage current         | $V_{CE} = 0\text{ V}$ , $V_{GE} = \pm 20\text{ V}$                  |      |      | $\pm 250$ | nA            |

**Table 4. Dynamic characteristics**

| Symbol    | Parameter                    | Test conditions                                                                                                                | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GE} = 0\text{ V}$                                                            | -    | 530  | -    | pF   |
| $C_{oes}$ | Output capacitance           |                                                                                                                                | -    | 31   | -    | pF   |
| $C_{res}$ | Reverse transfer capacitance |                                                                                                                                | -    | 11   | -    | pF   |
| $Q_g$     | Total gate charge            | $V_{CC} = 520\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 0\text{ to }15\text{ V}$<br>(see Figure 28. Gate charge test circuit) | -    | 21.2 | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |                                                                                                                                | -    | 5.2  | -    | nC   |
| $Q_{gc}$  | Gate-collector charge        |                                                                                                                                | -    | 8.8  | -    | nC   |

**Table 5. IGBT switching characteristics (inductive load)**

| Symbol          | Parameter                    | Test conditions                                                                                                                                                                              | Min. | Typ.  | Max. | Unit       |
|-----------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|------|------------|
| $t_{d(on)}$     | Turn-on delay time           | $V_{CE} = 400\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 15\text{ V}$ ,<br>$R_G = 22\ \Omega$ (see Figure 27. Test circuit for inductive load switching)                                     |      | 15    | -    | ns         |
| $t_r$           | Current rise time            |                                                                                                                                                                                              |      | 5.8   | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope        |                                                                                                                                                                                              |      | 828   | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time          |                                                                                                                                                                                              |      | 90    | -    | ns         |
| $t_f$           | Current fall time            |                                                                                                                                                                                              |      | 130   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy     |                                                                                                                                                                                              |      | 0.036 | -    | mJ         |
| $E_{off}^{(2)}$ | Turn-off switching energy    |                                                                                                                                                                                              |      | 0.200 | -    | mJ         |
| $E_{ts}$        | Total switching energy       |                                                                                                                                                                                              |      | 0.236 | -    | mJ         |
| $t_{d(on)}$     | Turn-on delay time           | $V_{CE} = 400\text{ V}$ , $I_C = 6\text{ A}$ , $V_{GE} = 15\text{ V}$ ,<br>$R_G = 22\ \Omega$ , $T_J = 175\text{ }^\circ\text{C}$ (see Figure 27. Test circuit for inductive load switching) |      | 17    | -    | ns         |
| $t_r$           | Current rise time            |                                                                                                                                                                                              |      | 7     | -    | ns         |
| $(di/dt)_{on}$  | Turn-on current slope        |                                                                                                                                                                                              |      | 685   | -    | A/ $\mu$ s |
| $t_{d(off)}$    | Turn-off delay time          |                                                                                                                                                                                              |      | 86    | -    | ns         |
| $t_f$           | Current fall time            |                                                                                                                                                                                              |      | 205   | -    | ns         |
| $E_{on}^{(1)}$  | Turn-on switching energy     |                                                                                                                                                                                              |      | 0.064 | -    | mJ         |
| $E_{off}^{(2)}$ | Turn-off switching energy    |                                                                                                                                                                                              |      | 0.290 | -    | mJ         |
| $E_{ts}$        | Total switching energy       |                                                                                                                                                                                              |      | 0.354 | -    | mJ         |
| $t_{sc}$        | Short-circuit withstand time | $V_{CC} \leq 400\text{ V}$ , $V_{GE} = 15\text{ V}$ , $T_{Jstart} \leq 150\text{ }^\circ\text{C}$                                                                                            | 6    |       | -    | $\mu$ s    |
|                 |                              | $V_{CC} \leq 400\text{ V}$ , $V_{GE} = 13\text{ V}$ , $T_{Jstart} \leq 150\text{ }^\circ\text{C}$                                                                                            | 10   |       | -    |            |

1. Including the reverse recovery of the diode.
2. Including the tail of the collector current.

**Table 6. Diode switching characteristics (inductive load)**

| Symbol       | Parameter                                                  | Test conditions                                                                                                                                                                                               | Min. | Typ. | Max. | Unit       |
|--------------|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------------|
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 6\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$ (see Figure 27. Test circuit for inductive load switching)                                        | -    | 140  | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |                                                                                                                                                                                                               | -    | 210  | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |                                                                                                                                                                                                               | -    | 6.6  | -    | A          |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |                                                                                                                                                                                                               | -    | 430  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |                                                                                                                                                                                                               | -    | 16   | -    | $\mu$ J    |
| $t_{rr}$     | Reverse recovery time                                      | $I_F = 6\text{ A}$ , $V_R = 400\text{ V}$ , $V_{GE} = 15\text{ V}$ ,<br>$di/dt = 1000\text{ A}/\mu\text{s}$ , $T_J = 175\text{ }^\circ\text{C}$<br>(see Figure 27. Test circuit for inductive load switching) | -    | 200  | -    | ns         |
| $Q_{rr}$     | Reverse recovery charge                                    |                                                                                                                                                                                                               | -    | 473  | -    | nC         |
| $I_{rrm}$    | Reverse recovery current                                   |                                                                                                                                                                                                               | -    | 9.6  | -    | A          |
| $dI_{rr}/dt$ | Peak rate of fall of reverse recovery current during $t_b$ |                                                                                                                                                                                                               | -    | 428  | -    | A/ $\mu$ s |
| $E_{rr}$     | Reverse recovery energy                                    |                                                                                                                                                                                                               | -    | 32   | -    | $\mu$ J    |

## 2.1 Electrical characteristics (curves)

**Figure 1. Power dissipation vs. case temperature**

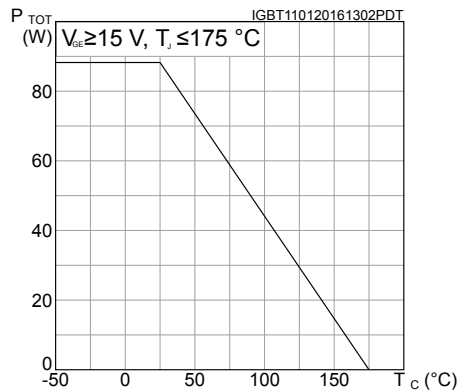


**Figure 2. Collector current vs. case temperature**

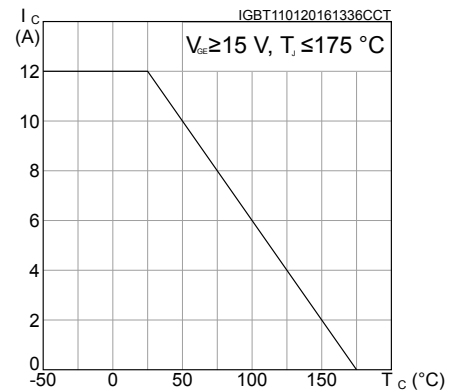


**Figure 3. Output characteristics (T\_J = 25 °C)**

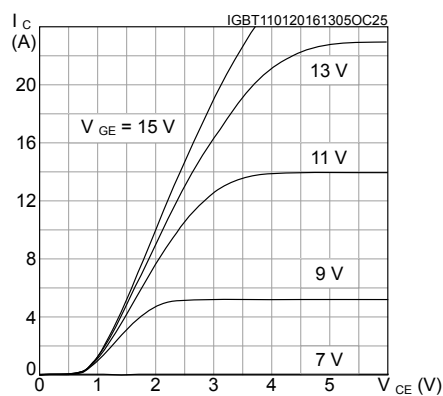


**Figure 4. Output characteristics (T\_J = 175 °C)**

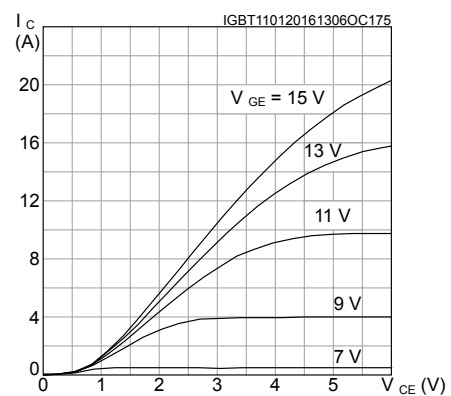


**Figure 5. V\_CE(sat) vs. junction temperature**

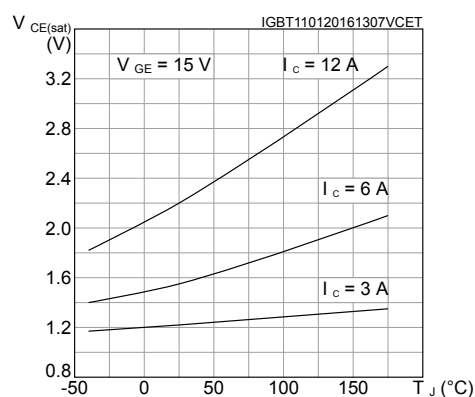


**Figure 6. V\_CE(sat) vs. collector current**

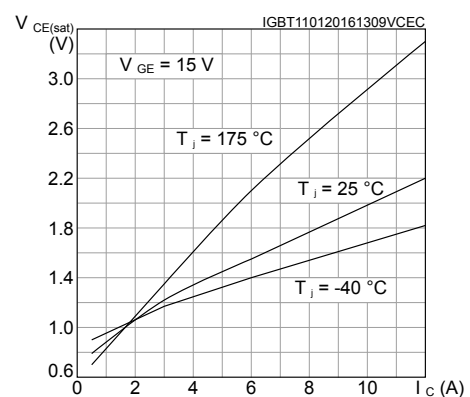


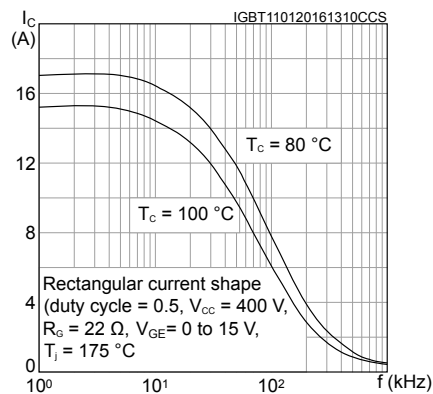
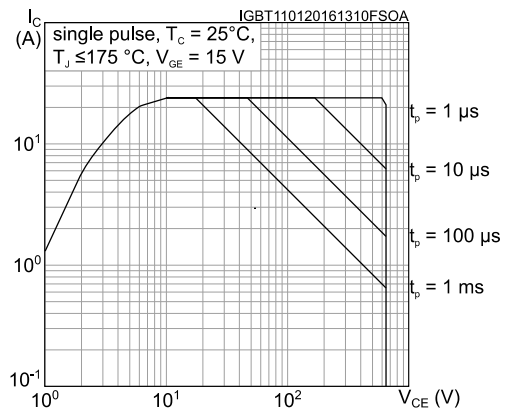
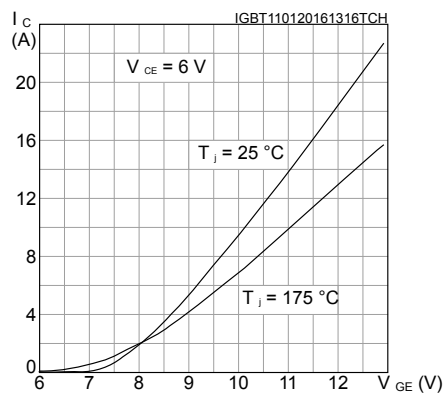
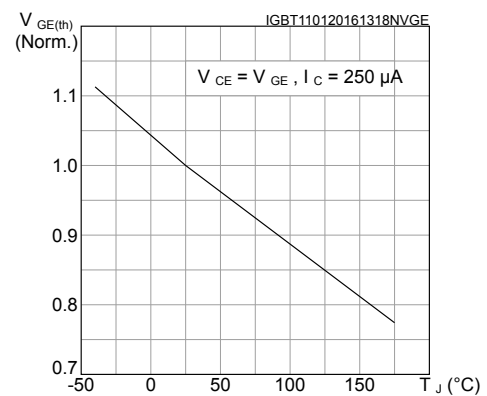
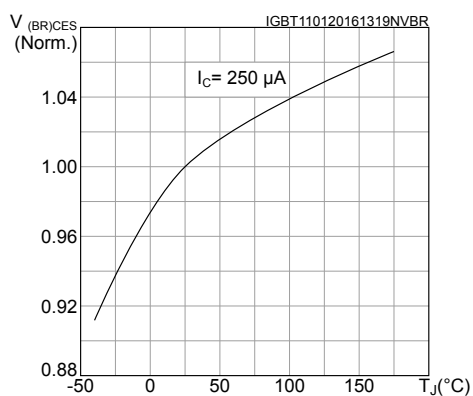
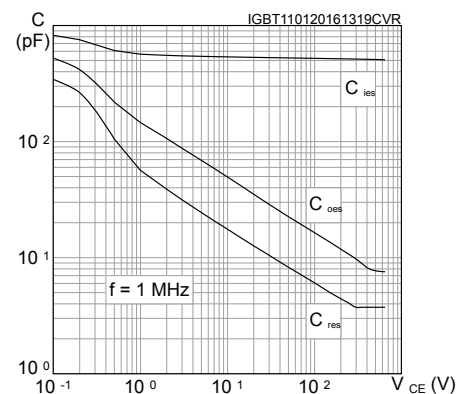
**Figure 7. Collector current vs. switching frequency**

**Figure 8. Forward bias safe operating area**

**Figure 9. Transfer characteristics**

**Figure 10. Normalized  $V_{GE(th)}$  vs. junction temperature**

**Figure 11. Normalized  $V_{(BR)CES}$  vs. junction temperature**

**Figure 12. Capacitance variations**


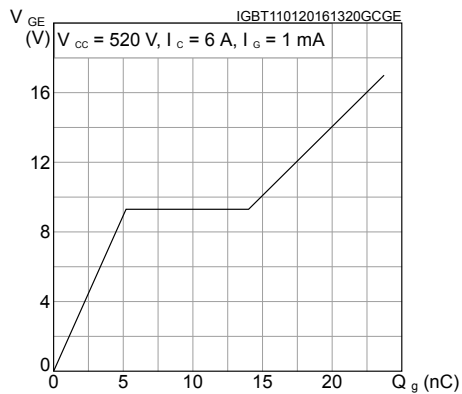
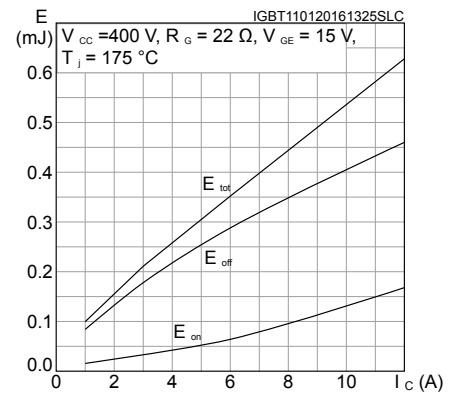
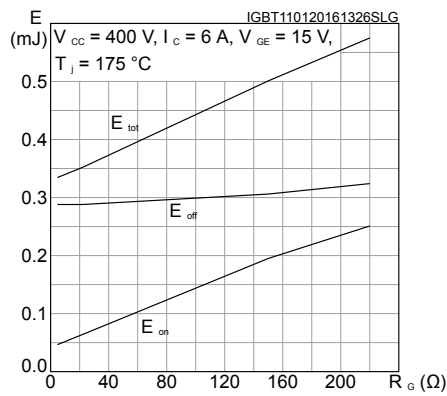
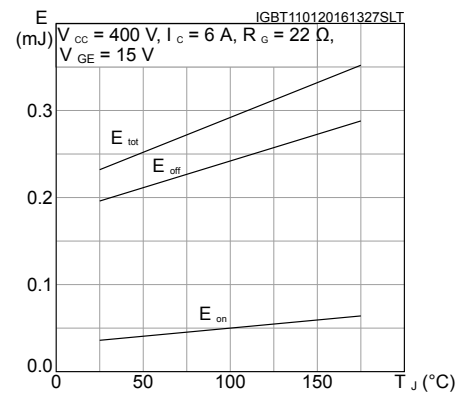
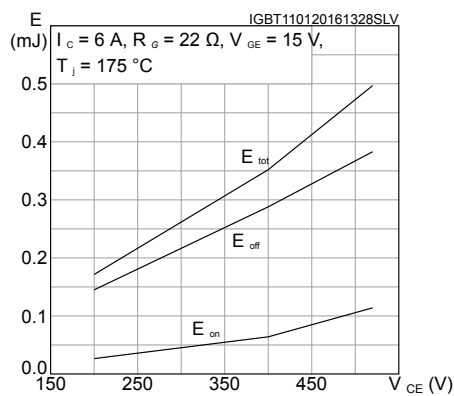
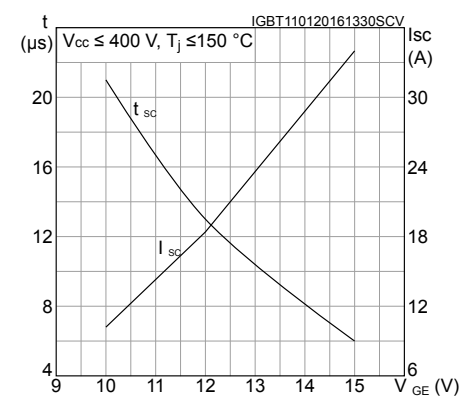
**Figure 13. Gate charge vs. gate-emitter voltage**

**Figure 14. Switching energy vs. collector current**

**Figure 15. Switching energy vs. gate resistance**

**Figure 16. Switching energy vs. temperature**

**Figure 17. Switching energy vs. collector emitter voltage**

**Figure 18. Short-circuit time and current vs. V\_GE**


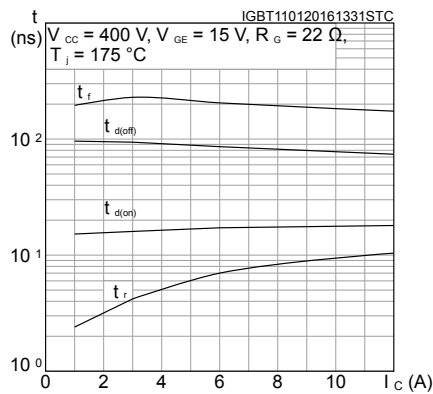
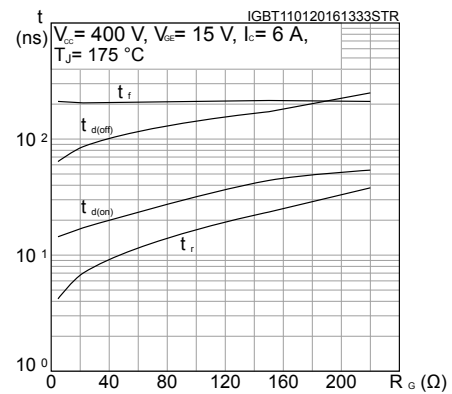
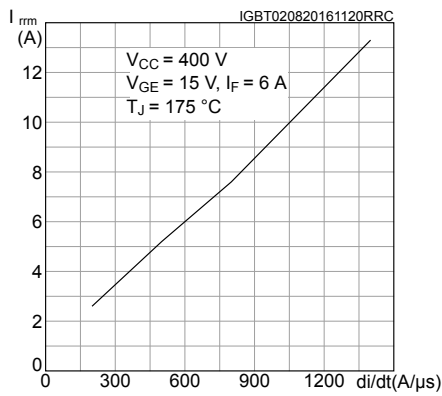
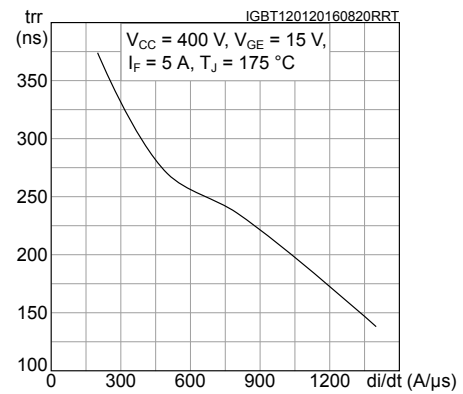
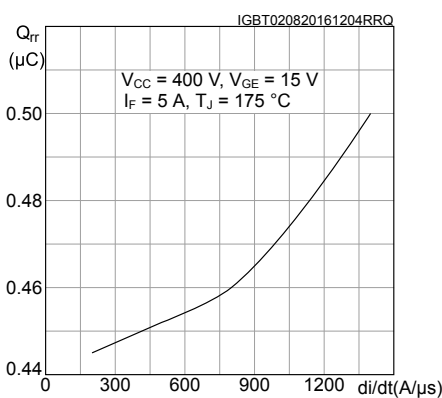
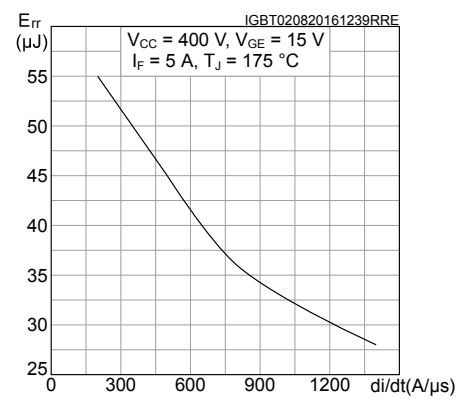
**Figure 19. Switching times vs. collector current**

**Figure 20. Switching times vs. gate resistance**

**Figure 21. Reverse recovery current vs. diode current slope**

**Figure 22. Reverse recovery time vs. diode current slope**

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

**Figure 24. Reverse recovery energy vs. diode current slope**


**Figure 25. Thermal impedance for IGBT**

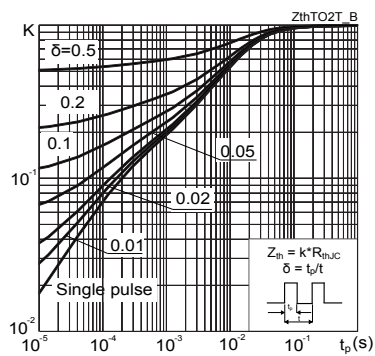
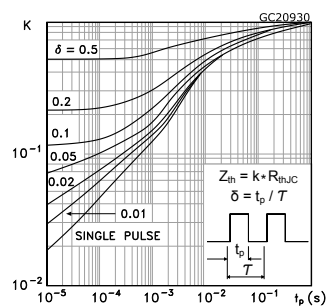


**Figure 26. Thermal impedance for diode**



### 3 Test circuits

**Figure 27. Test circuit for inductive load switching**

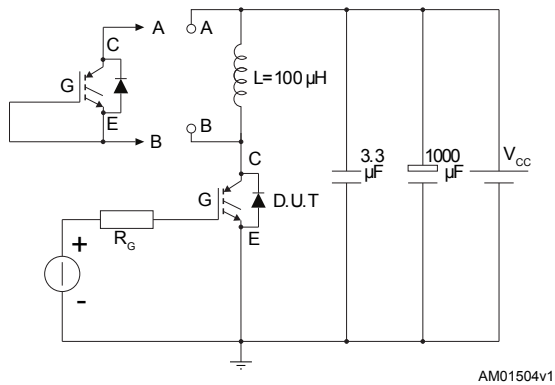


**Figure 28. Gate charge test circuit**

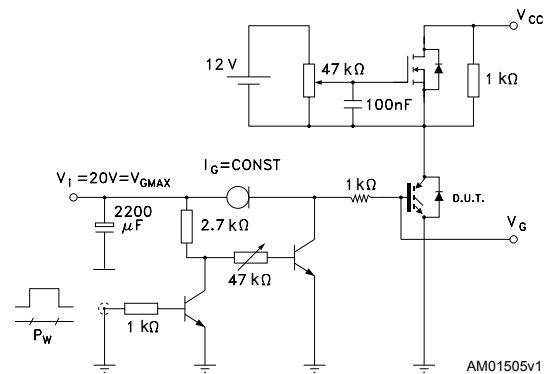


**Figure 29. Switching waveform**

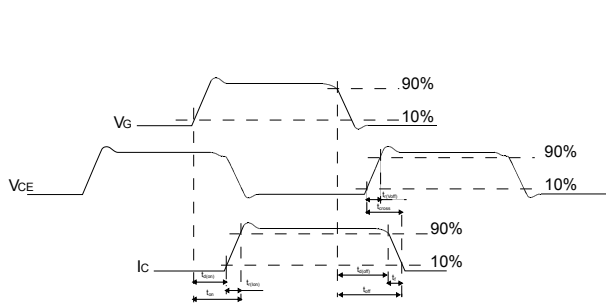
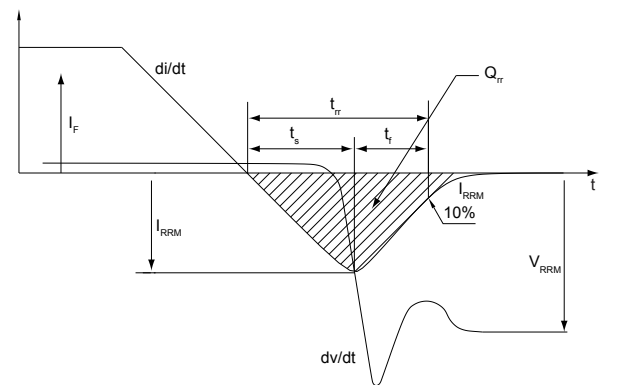


**Figure 30. Diode reverse recovery waveform**

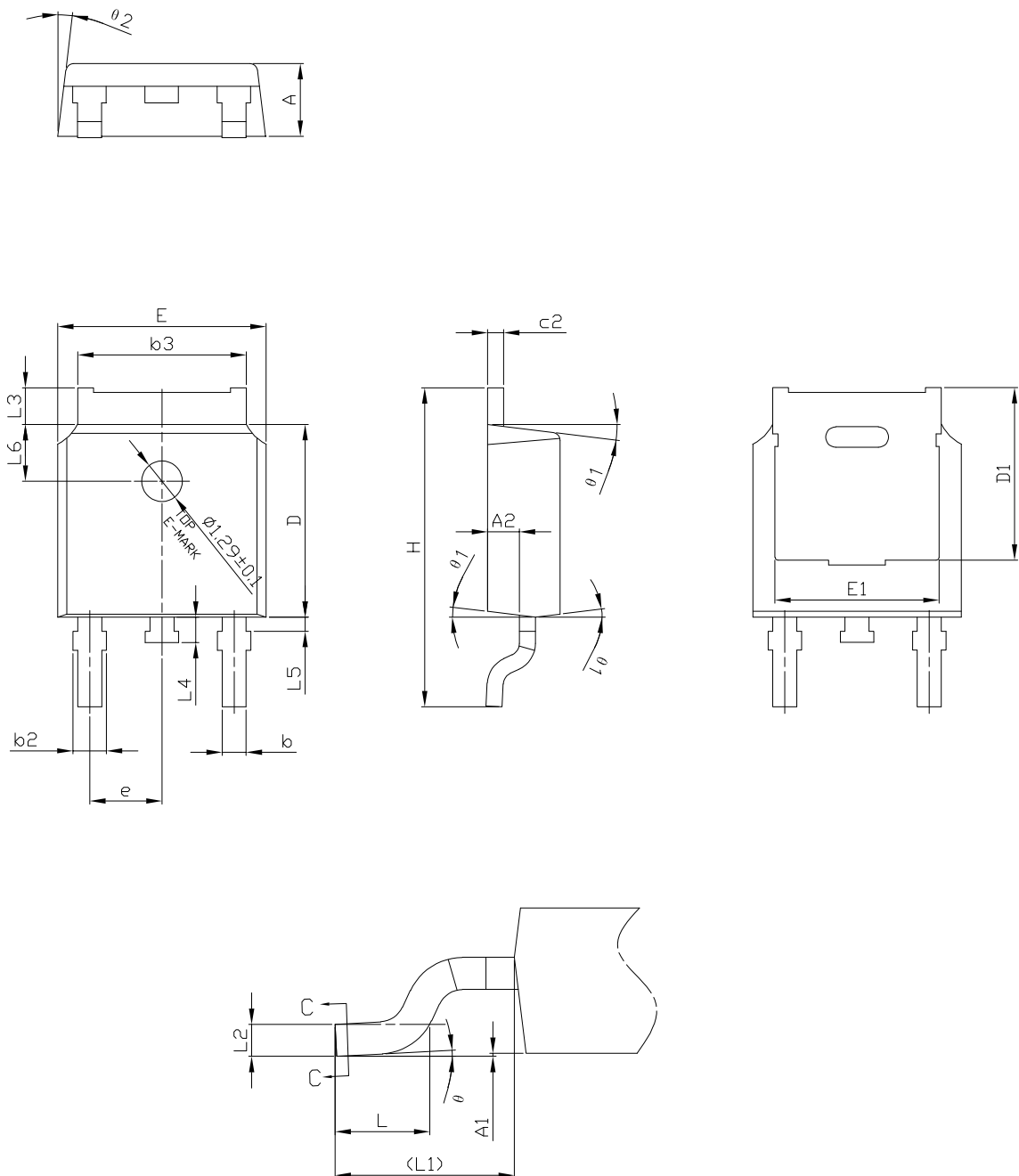


## 4 Package information

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](http://www.st.com). ECOPACK is an ST trademark.

### 4.1 DPAK (TO-252) type C3 package information

**Figure 31. DPAK (TO-252) type C3 package outline**

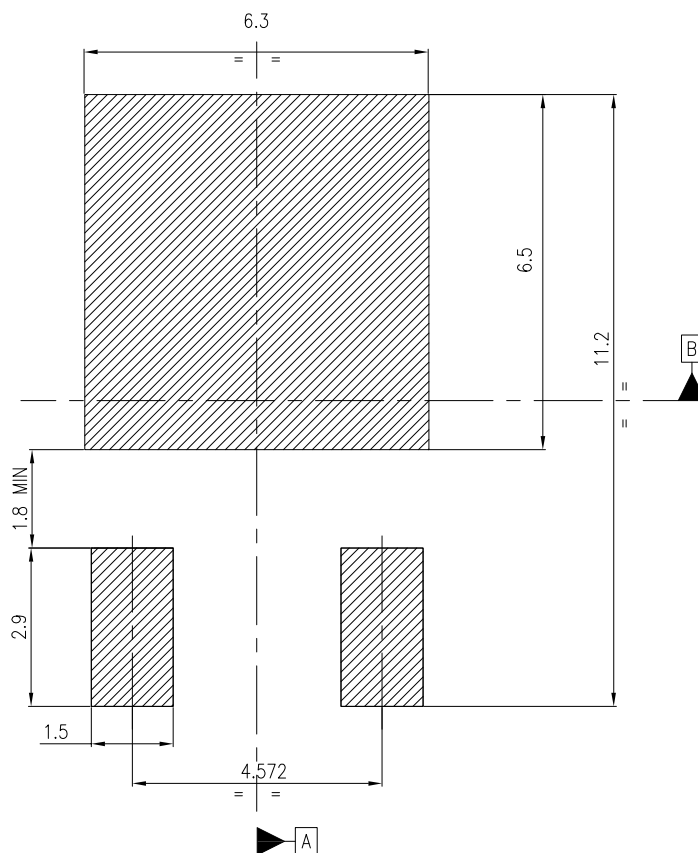


0068772\_type-C3\_rev35

**Table 7. DPAK (TO-252) type C3 mechanical data**

| Dim. | mm       |       |       |
|------|----------|-------|-------|
|      | Min.     | Typ.  | Max.  |
| A    | 2.20     | 2.30  | 2.38  |
| A1   | 0.00     |       | 0.10  |
| A2   | 0.90     | 1.01  | 1.10  |
| b    | 0.72     |       | 0.85  |
| b2   | 0.72     |       | 1.10  |
| b3   | 5.13     | 5.33  | 5.46  |
| c    | 0.47     |       | 0.60  |
| c2   | 0.47     |       | 0.60  |
| D    | 6.00     | 6.10  | 6.20  |
| D1   | 5.20     | 5.45  | 5.70  |
| E    | 6.50     | 6.60  | 6.70  |
| E1   | 5.00     | 5.20  | 5.40  |
| e    | 2.186    | 2.286 | 2.386 |
| H    | 9.80     | 10.10 | 10.40 |
| L    | 1.40     | 1.50  | 1.70  |
| L1   | 2.90 REF |       |       |
| L2   | 0.51 BSC |       |       |
| L3   | 0.90     |       | 1.25  |
| L4   | 0.60     | 0.80  | 1.00  |
| L5   | 0.15     |       | 0.75  |
| L6   | 1.80 REF |       |       |
| θ    | 0°       |       | 8°    |
| θ1   | 5°       | 7°    | 9°    |
| θ2   | 5°       | 7°    | 9°    |

**Figure 32. DPAK (TO-252) recommended footprint (dimensions are in mm)**



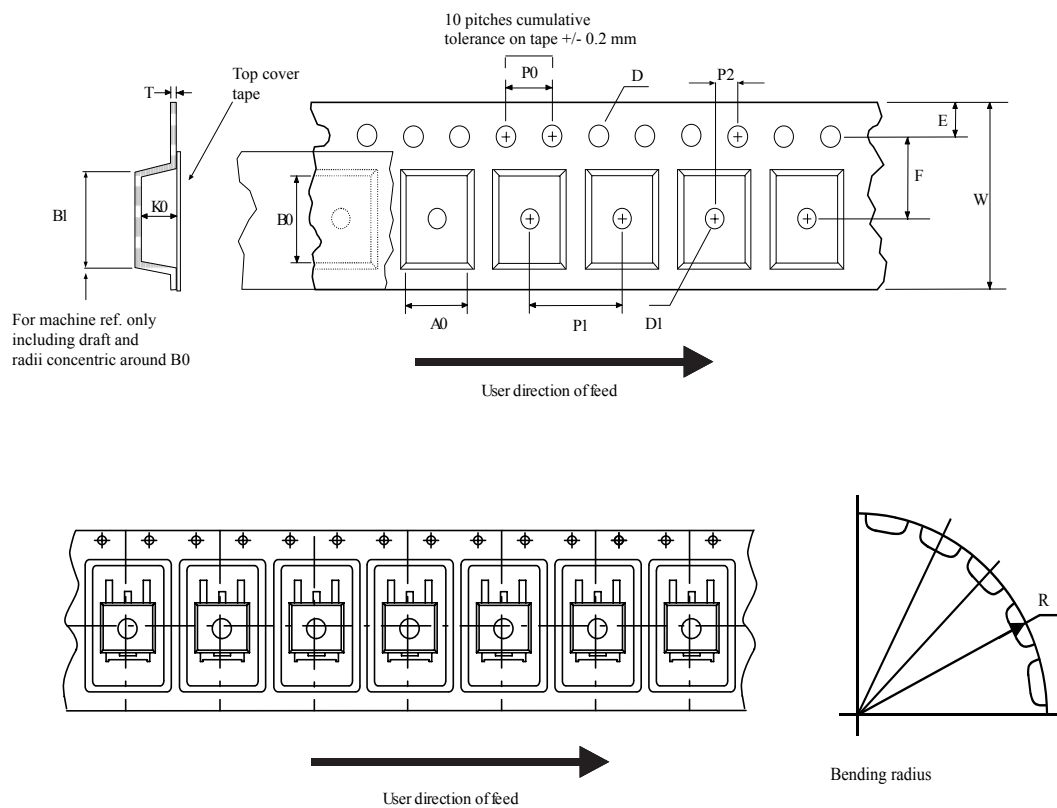
Notes:

- 1) This footprint is able to ensure insulation up to 630 Vrms (according to CEI IEC 664-1)
- 2) The device must be positioned within  $\boxed{\Phi 0.05 \text{ A B}}$

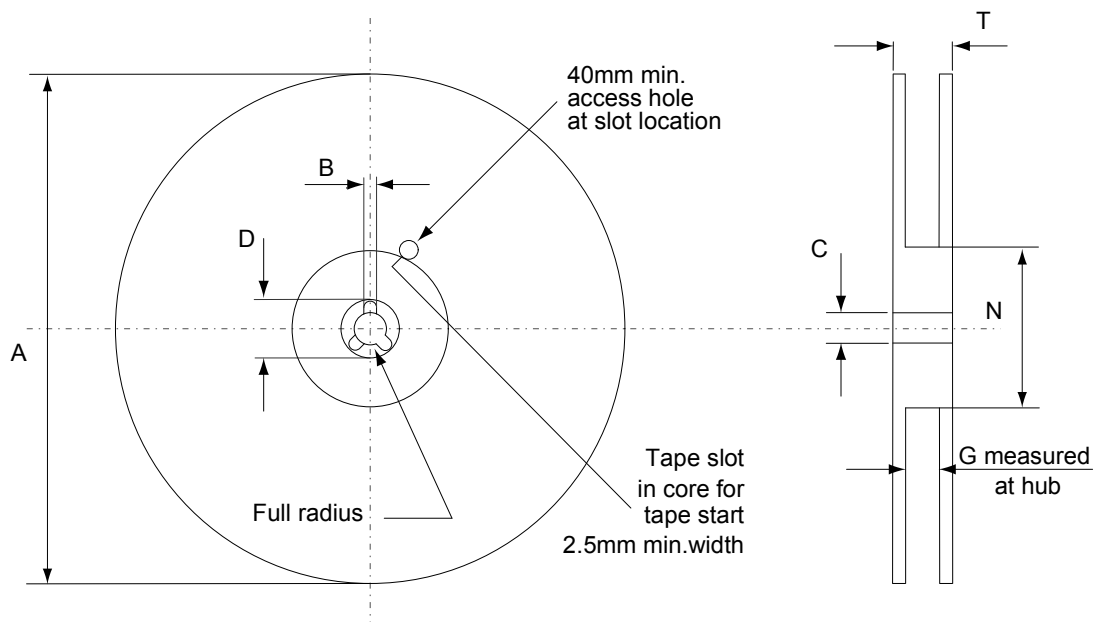
FP\_0068772\_35

## 4.2 DPAK (TO-252) packing information

**Figure 33. DPAK (TO-252) tape outline**



AM08852v1

**Figure 34. DPAK (TO-252) reel outline**


AM06038v1

**Table 8. DPAK (TO-252) tape and reel mechanical data**

| Tape |      |      | Reel      |      |      |
|------|------|------|-----------|------|------|
| Dim. | mm   |      | Dim.      | mm   |      |
|      | Min. | Max. |           | Min. | Max. |
| A0   | 6.8  | 7    | A         |      | 330  |
| B0   | 10.4 | 10.6 | B         | 1.5  |      |
| B1   |      | 12.1 | C         | 12.8 | 13.2 |
| D    | 1.5  | 1.6  | D         | 20.2 |      |
| D1   | 1.5  |      | G         | 16.4 | 18.4 |
| E    | 1.65 | 1.85 | N         | 50   |      |
| F    | 7.4  | 7.6  | T         |      | 22.4 |
| K0   | 2.55 | 2.75 |           |      |      |
| P0   | 3.9  | 4.1  | Base qty. |      | 2500 |
| P1   | 7.9  | 8.1  | Bulk qty. |      | 2500 |
| P2   | 1.9  | 2.1  |           |      |      |
| R    | 40   |      |           |      |      |
| T    | 0.25 | 0.35 |           |      |      |
| W    | 15.7 | 16.3 |           |      |      |

## Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 30-Nov-2015 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 13-Jan-2016 | 2        | Modified: <i>Table 4: "Static characteristics", Table 5: "Dynamic characteristics", Table 6: "IGBT switching characteristics (inductive load)" and Table 7: "Diode switching characteristics (inductive load)"</i><br>Added: <i>Section 2.1: "Electrical characteristics (curves)"</i><br>Minor text changes                                                                                                                                                                                                                                                                                                                                                                                                          |
| 04-Aug-2016 | 3        | Updated: <i>Table 2: "Absolute maximum ratings", Table 4: "Static characteristics", Table 6: "IGBT switching characteristics (inductive load)", Table 7: "Diode switching characteristics (inductive load)"</i> .<br>Updated <i>Figure 9: "Forward bias safe operating area", Figure 12: "Normalized <math>V_{GE(th)}</math> vs. junction temperature", Figure 20: "Short-circuit time and current vs. <math>V_{GE}</math>", Figure 23: "Reverse recovery current vs. diode current slope"</i> .<br>Changed: <i>Figure 25: "Reverse recovery charge vs. diode current slope", and Figure 26: "Reverse recovery energy vs. diode current slope"</i> .<br>Document status promoted from preliminary to production data. |
| 09-Jun-2023 | 4        | Updated the entire Section 4 Package information.<br>Minor text changes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 13-Jul-2023 | 5        | Minor text changes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 14-May-2025 | 6        | Updated <a href="#">Table 3. Static characteristics</a> .<br>Removed <i>Figure 10. Diode <math>V_F</math> vs. forward current</i> .<br>Removed <i>DPAK (TO-252) type A2 package information</i> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

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