

Figure 1: Internal schematic diagram

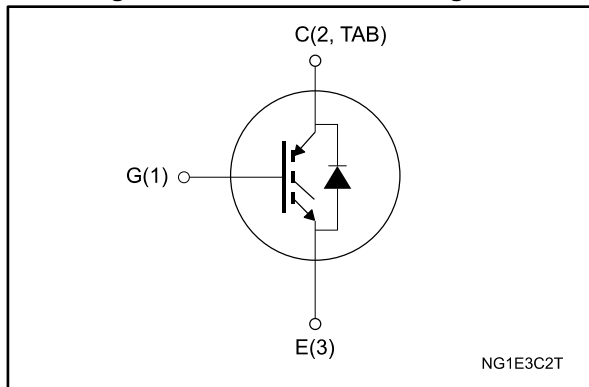


Table 1: Device summary

| Order code     | Marking    | Package            | Packing       |
|----------------|------------|--------------------|---------------|
| STGB10NC60KDT4 | GB10NC60KD | D <sup>2</sup> PAK | Tape and reel |
| STGD10NC60KDT4 | GD10NC60KD | DPAK               |               |
| STGF10NC60KD   | GF10NC60KD | TO-220FP           | Tube          |
| STGP10NC60KD   | GP10NC60KD | TO-220             |               |

### Features

- Lower on voltage drop ( $V_{CE(sat)}$ )
- Lower  $C_{RES} / C_{IES}$  ratio (no cross-conduction susceptibility)
- Very soft ultra fast recovery antiparallel diode
- Short-circuit withstand time 10  $\mu$ s

### Applications

- High frequency motor controls
- SMPS and PFC in both hard switch and resonant topologies
- Motor drives

### Description

These devices are very fast IGBTs developed using advanced PowerMESH™ technology. This process guarantees an excellent trade-off between switching performance and low on-state behavior. These devices are well-suited for resonant or soft-switching applications.

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# 1 Electrical ratings

Table 2: Absolute maximum ratings

| Symbol                         | Parameter  | Value                         |      |          | Unit |
|--------------------------------|--|-------------------------------|------|----------|------|
|                                |  | D <sup>2</sup> PAK,<br>TO-220 | DPAK | TO-220FP |      |
| V <sub>CEs</sub>               | Collector-emitter voltage (V <sub>GE</sub> = 0 V)  | 600                           |      |          | V    |
| I <sub>C</sub> <sup>(1)</sup>  | Continuous collector current at T <sub>C</sub> = 25 °C   | 20                            |      | 9        | A    |
|                                | Continuous collector current at T <sub>C</sub> = 100 °C  | 10                            |      | 6        | A    |
| I <sub>CL</sub> <sup>(2)</sup> | Turn-off latching current  | 30                            |      |          | A    |
| I <sub>CP</sub> <sup>(3)</sup> | Pulsed collector current   | 30                            |      |          | A    |
| V <sub>GE</sub>                | Gate-emitter voltage   | ±20                           |      |          | V    |
| I <sub>F</sub>                 | Diode RMS forward current at T <sub>C</sub> =25°C  | 10                            |      |          | A    |
| I <sub>FSM</sub>               | Surge non repetitive forward current t <sub>p</sub> = 10 ms sinusoidal   | 20                            |      |          | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C  | 65                            | 62   | 25       | W    |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T <sub>C</sub> =25 °C)                                 | 2500                          |      |          | V    |
| t <sub>scw</sub>               | Short-circuit withstand time V <sub>CE</sub> = 0.5 V <sub>CEs</sub> , T <sub>J</sub> = 125 °C, R <sub>G</sub> = 10 Ω, V <sub>GE</sub> = 12 V | 10                            |      |          | µs   |
| T <sub>stg</sub>               | Storage temperature range  | - 55 to 150                   |      |          | °C   |
| T <sub>J</sub>                 | Operating junction temperature range   |                               |      |          |      |

**Notes:**

(1) Calculated according to the iterative formula:

$$I_C(T_C) = \frac{T_{j(max)} - T_C}{R_{thj-c} \times V_{CE(sat)(max)}(T_{j(max)}, I_C(T_C))}$$

(2) V<sub>clamp</sub> = 80 % V<sub>CEs</sub>, V<sub>GE</sub> = 15 V, R<sub>G</sub> = 10 Ω, T<sub>J</sub> = 150 °C.

(3) Pulse width limited by maximum junction temperature and turn-off within RBSOA.

Table 3: Thermal data

| Symbol                | Parameter                              | Value                      |      |          | Unit |
|-----------------------|--|----------------------------|------|----------|------|
|                       |  | TO-220, D <sup>2</sup> PAK | DPAK | TO-220FP |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case IGBT  | 1.9                        | 2    | 5        | °C/W |
| R <sub>thj-case</sub> | Thermal resistance junction-case diode | 4                          | 4.5  | 7        |      |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient    | 62.5                       | 100  | 62.5     |      |

## 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  | $I_C = 1\text{ mA}$ , $V_{GE} = 0\text{ V}$   | 600  |      |           | V             |
| $V_{CE(sat)}$  | Collector-emitter saturation voltage | $V_{GE} = 15\text{ V}$ , $I_C = 5\text{ A}$   |      | 2.2  | 2.5       | V             |
|                |                                      | $V_{GE} = 15\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$T_j = 125\text{ °C}$                    |      | 1.8  |           |               |
| $V_{GE(th)}$   | Gate threshold voltage               | $V_{CE} = V_{GE}$ , $I_C = 250\text{ }\mu\text{A}$  | 4.5  |      | 6.5       | V             |
| $I_{CES}$      | Collector cut-off current            | $V_{CE} = 600\text{ V}$ , $V_{GE} = 0\text{ V}$   |      |      | 150       | $\mu\text{A}$ |
|                |                                      | $V_{CE} = 600\text{ V}$ , $V_{GE} = 0\text{ V}$ ,<br>$T_j = 125\text{ °C}$ <sup>(1)</sup> |      |      | 1         | mA            |
| $I_{GES}$      | Gate-emitter leakage current         | $V_{GE} = \pm 20\text{ V}$  |      |      | $\pm 100$ | nA            |
| $g_{fs}^{(2)}$ | Forward transconductance             | $V_{CE} = 15\text{ V}$ , $I_C = 5\text{ A}$   |      | 15   |           | S             |

**Notes:**

<sup>(1)</sup>Defined by design, not subject to production test.

<sup>(2)</sup>Pulse test: pulse duration < 300  $\mu\text{s}$ , duty cycle < 2 %.

Table 5: Dynamic characteristics

| Symbol    | Parameter                    | Test conditions  | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|--|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GE} = 0\text{ V}$   | -    | 380  | -    | pF   |
| $C_{oes}$ | Output capacitance           |  | -    | 46   | -    |      |
| $C_{res}$ | Reverse transfer capacitance |  | -    | 8.5  | -    |      |
| $Q_g$     | Total gate charge            | $V_{CE} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$V_{GE} = 0\text{ to }15\text{ V}$<br>(see <a href="#">Figure 19: "Gate charge test circuit"</a> ) | -    | 19   | -    | nC   |
| $Q_{ge}$  | Gate-emitter charge          |  | -    | 5    | -    |      |
| $Q_{gc}$  | Gate-collector charge        |  | -    | 9    | -    |      |

Table 6: Switching on/off (inductive load)

| Symbol         | Parameter             | Test conditions  | Min. | Typ. | Max. | Unit       |
|----------------|-----------------------|--|------|------|------|------------|
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$<br>(see <a href="#">Figure 18</a> : "Test circuit for inductive load switching" and <a href="#">Figure 20</a> : "Switching waveform")                                | -    | 17   | -    | ns         |
| $t_r$          | Current rise time     |  | -    | 6    | -    | ns         |
| $(di/dt)_{on}$ | Turn-on current slope |  | -    | 655  | -    | A/ $\mu$ s |
| $t_{d(on)}$    | Turn-on delay time    | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_j = 125^\circ\text{C}$<br>(see <a href="#">Figure 18</a> : "Test circuit for inductive load switching" and <a href="#">Figure 20</a> : "Switching waveform") | -    | 16.5 | -    | ns         |
| $t_r$          | Current rise time     |  | -    | 6.5  | -    | ns         |
| $(di/dt)_{on}$ | Turn-on current slope |  | -    | 575  | -    | A/ $\mu$ s |
| $t_{r(voff)}$  | Off voltage rise time | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$<br>(see <a href="#">Figure 18</a> : "Test circuit for inductive load switching" and <a href="#">Figure 20</a> : "Switching waveform")                                | -    | 33   | -    | ns         |
| $t_{d(off)}$   | Turn-off delay time   |  | -    | 72   | -    | ns         |
| $t_f$          | Current fall time     |  | -    | 82   | -    | ns         |
| $t_{r(voff)}$  | Off voltage rise time | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_j = 125^\circ\text{C}$<br>(see <a href="#">Figure 18</a> : "Test circuit for inductive load switching" and <a href="#">Figure 20</a> : "Switching waveform") | -    | 60   | -    | ns         |
| $t_{d(off)}$   | Turn-off delay time   |  | -    | 106  | -    | ns         |
| $t_f$          | Current fall time     |  | -    | 136  | -    | ns         |

Table 7: Switching energy (inductive load)

| Symbol       | Parameter                 | Test conditions   | Min. | Typ. | Max. | Unit    |
|--------------|---------------------------|---|------|------|------|---------|
| $E_{on(1)}$  | Turn-on switching energy  | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$<br>(see <a href="#">Figure 18</a> : "Test circuit for inductive load switching")                                | -    | 55   | -    | $\mu$ J |
| $E_{off(2)}$ | Turn-off switching energy |   | -    | 85   | -    | $\mu$ J |
| $E_{ts}$     | Total switching energy    |   | -    | 140  | -    | $\mu$ J |
| $E_{on(1)}$  | Turn-on switching energy  | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_j = 125^\circ\text{C}$<br>(see <a href="#">Figure 18</a> : "Test circuit for inductive load switching") | -    | 87   | -    | $\mu$ J |
| $E_{off(2)}$ | Turn-off switching energy |   | -    | 162  | -    | $\mu$ J |
| $E_{ts}$     | Total switching energy    |   | -    | 249  | -    | $\mu$ J |

**Notes:**

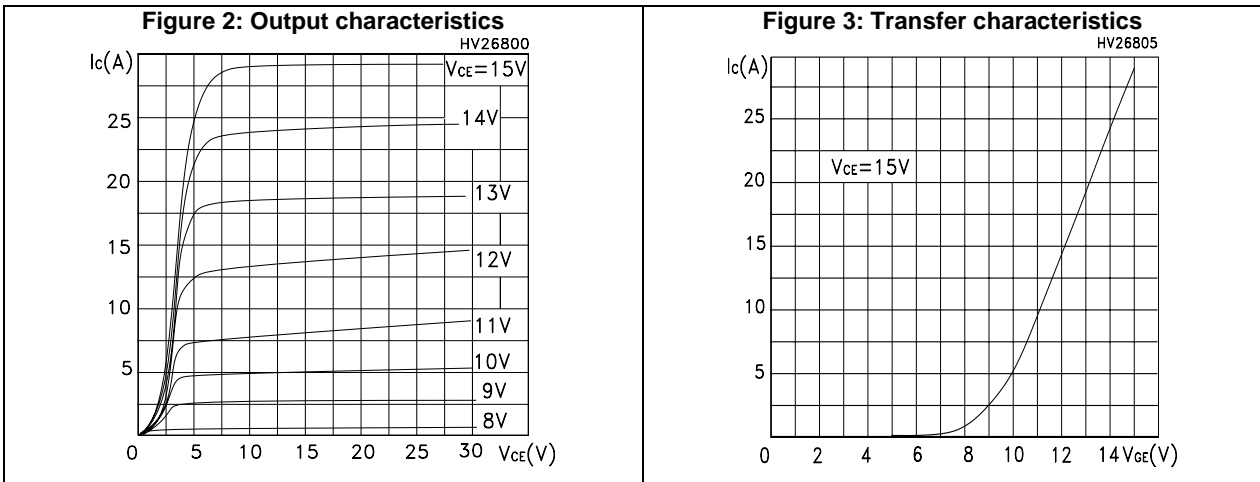
(1)Including the reverse recovery of the diode.

(2)Including the tail of the collector current.

Table 8: Collector-emitter diode

| Symbol    | Parameter                | Test conditions   | Min. | Typ. | Max. | Unit |
|-----------|--------------------------|---|------|------|------|------|
| $V_F$     | Forward on-voltage       | $I_F=5\text{ A}$  | -    | 2    | -    | V    |
|           |                          | $I_F=5\text{ A}$ , $T_j=125\text{ °C}$  | -    | 1.6  | -    | V    |
| $t_{rr}$  | Reverse recovery time    | $I_F=5\text{ A}$ , $V_R=40\text{ V}$ , $di/dt=100\text{ A}/\mu\text{s}$ (see <a href="#">Figure 21: "Diode reverse recovery waveform"</a> )                       | -    | 22   | -    | ns   |
| $Q_{rr}$  | Reverse recovery charge  |   | -    | 14   | -    | nC   |
| $I_{rrm}$ | Reverse recovery current |   | -    | 1.3  | -    | A    |
| $t_{rr}$  | Reverse recovery time    | $I_F=5\text{ A}$ , $V_R=40\text{ V}$ , $T_j=125\text{ °C}$ , $di/dt=100\text{ A}/\mu\text{s}$ (see <a href="#">Figure 21: "Diode reverse recovery waveform"</a> ) | -    | 35   | -    | ns   |
| $Q_{rr}$  | Reverse recovery charge  |   | -    | 40   | -    | nC   |
| $I_{rrm}$ | Reverse recovery current |   | -    | 2.2  | -    | A    |

## 2.1 Electrical characteristics (curves)



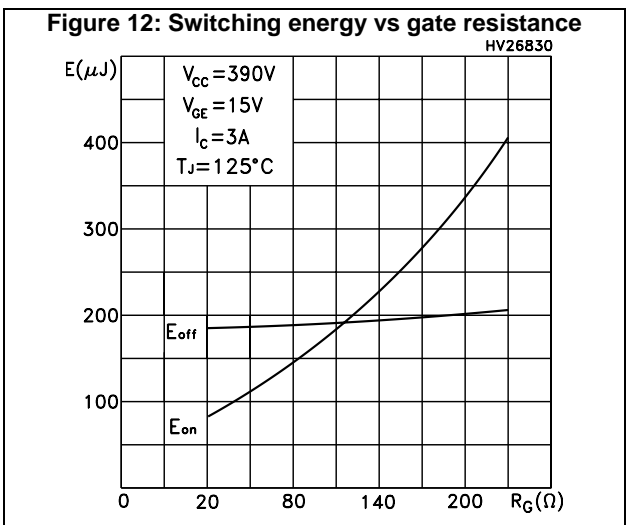
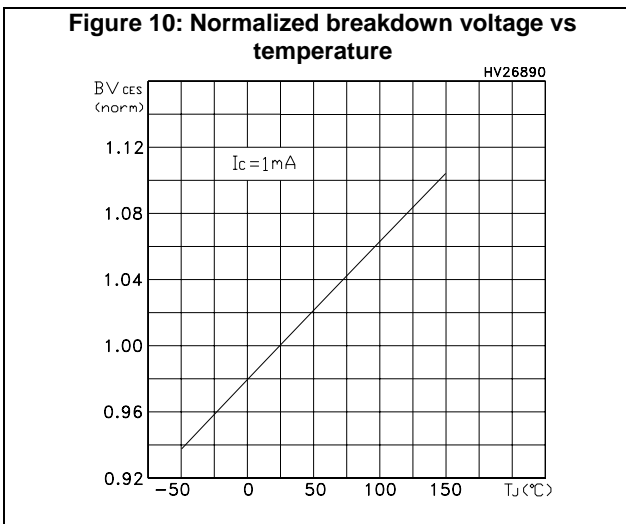
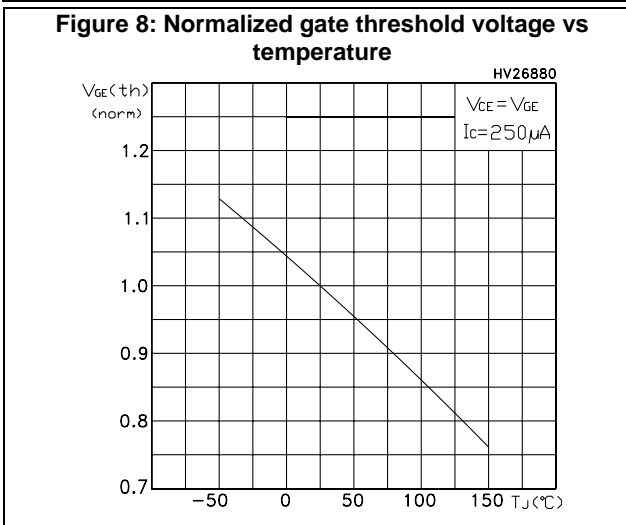




Figure 14: Thermal impedance for D<sup>2</sup>PAK, DPAK and TO-220

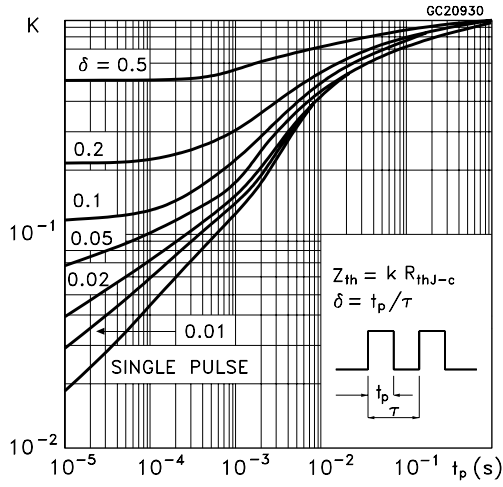


Figure 15: Turn-off SOA

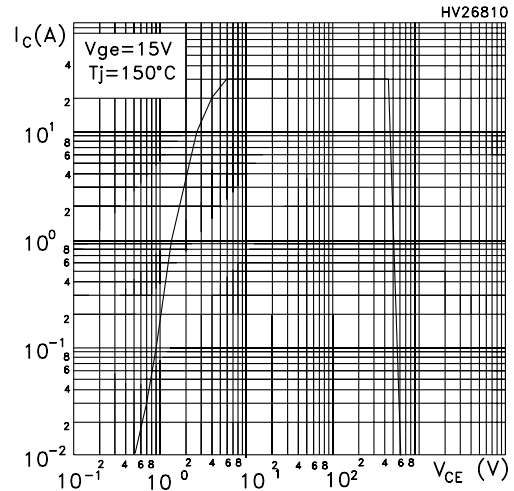


Figure 16: Emitter-collector diode characteristics

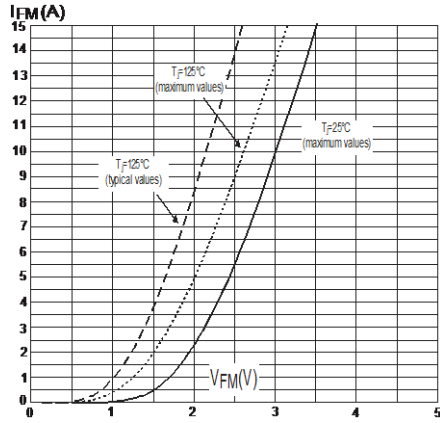
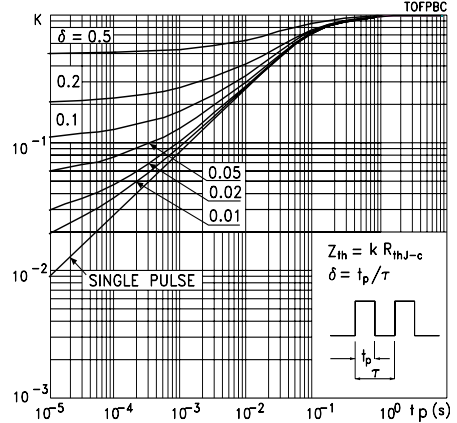
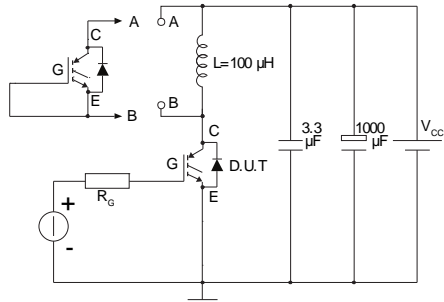


Figure 17: Thermal impedance for TO-220FP



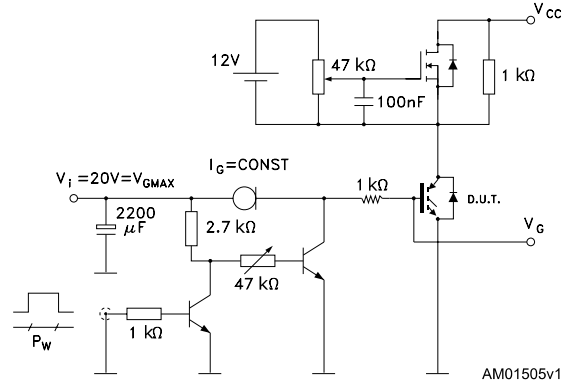
### 3 Test circuits

**Figure 18: Test circuit for inductive load switching**



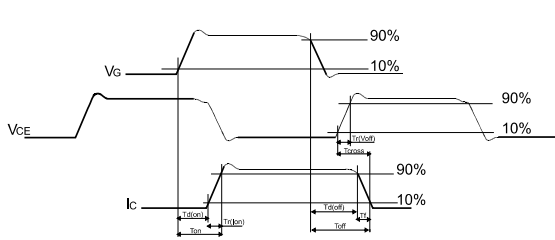
AM01504v1

**Figure 19: Gate charge test circuit**



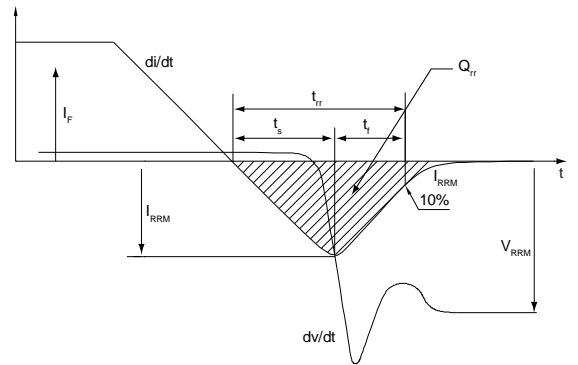
AM01505v1

**Figure 20: Switching waveform**



AM01506v1

**Figure 21: 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](http://www.st.com). ECOPACK® is an ST trademark.

### 4.1 D<sup>2</sup>PAK (TO-263) type A package information

Figure 22: D<sup>2</sup>PAK (TO-263) type A package outline



Table 9: D<sup>2</sup>PAK (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    | 10.00 |      | 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    | 15.00 |      | 15.85 |
| J1   | 2.49  |      | 2.69  |
| L    | 2.29  |      | 2.79  |
| L1   | 1.27  |      | 1.40  |
| L2   | 1.30  |      | 1.75  |
| R    |       | 0.40 |       |
| V2   | 0°    |      | 8°    |

Figure 23: D<sup>2</sup>PAK (TO-263) type A recommended footprint (dimensions are in mm)



### 4.2 D<sup>2</sup>PAK (TO-263) type B package information

Figure 24: D<sup>2</sup>PAK (TO-263) type B package outline



Table 10: D<sup>2</sup>PAK (TO-263) type B mechanical data

| Dim. | mm       |      |       |
|------|----------|------|-------|
|      | Min.     | Typ. | Max.  |
| A    | 4.36     |      | 4.56  |
| A1   | 0        |      | 0.25  |
| b    | 0.70     |      | 0.90  |
| b1   | 0.51     |      | 0.89  |
| b2   | 1.17     |      | 1.37  |
| b3   | 1.36     |      | 1.46  |
| c    | 0.38     |      | 0.694 |
| c1   | 0.38     |      | 0.534 |
| c2   | 1.19     |      | 1.34  |
| D    | 8.60     |      | 9.00  |
| D1   | 6.90     |      | 7.50  |
| E    | 10.15    |      | 10.55 |
| E1   | 8.10     |      | 8.70  |
| e    | 2.54 BSC |      |       |
| H    | 15.00    |      | 15.60 |
| L    | 1.90     |      | 2.50  |
| L1   |          |      | 1.65  |
| L2   |          |      | 1.78  |
| L3   |          | 0.25 |       |
| L4   | 4.78     |      | 5.28  |

Figure 25: D<sup>2</sup>PAK (TO-263) type B recommended footprint (dimensions are in mm)





### 4.3 DPAK (TO-252) type A package information

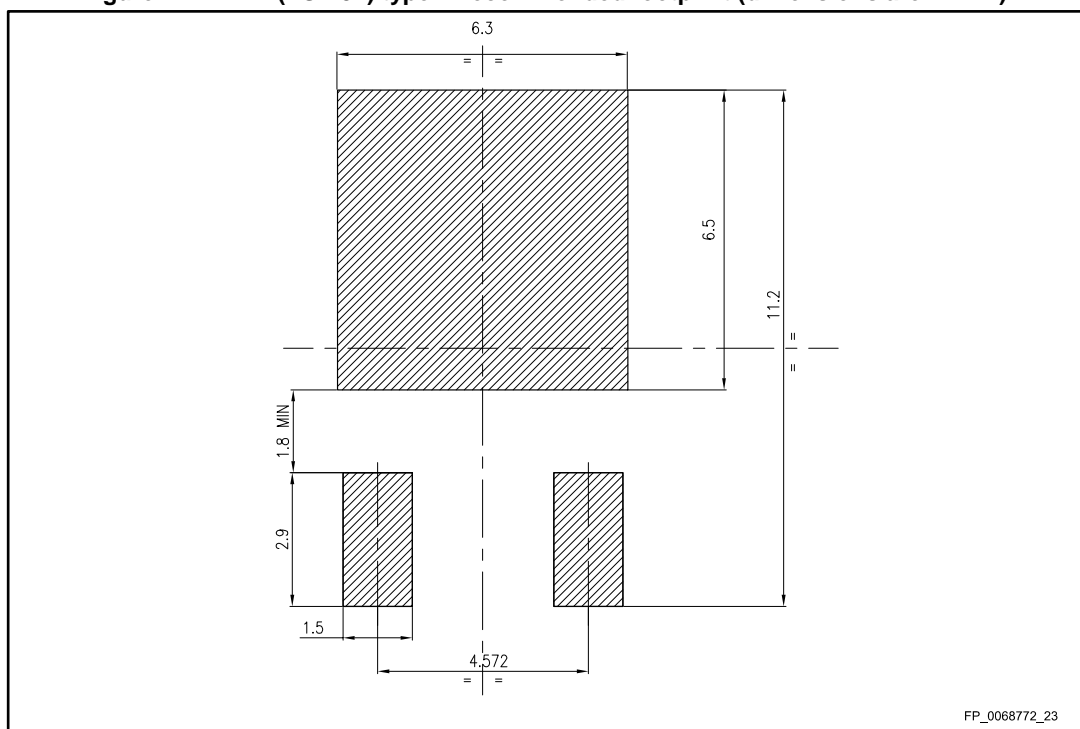
Figure 26: DPAK (TO-252) type A package outline



Table 11: DPAK (TO-252) type A mechanical data

| Dim. | mm   |      |       |
|------|------|------|-------|
|      | Min. | Typ. | Max.  |
| A    | 2.20 |      | 2.40  |
| A1   | 0.90 |      | 1.10  |
| A2   | 0.03 |      | 0.23  |
| b    | 0.64 |      | 0.90  |
| b4   | 5.20 |      | 5.40  |
| c    | 0.45 |      | 0.60  |
| c2   | 0.48 |      | 0.60  |
| D    | 6.00 |      | 6.20  |
| D1   | 4.95 | 5.10 | 5.25  |
| E    | 6.40 |      | 6.60  |
| E1   | 4.60 | 4.70 | 4.80  |
| e    | 2.16 | 2.28 | 2.40  |
| e1   | 4.40 |      | 4.60  |
| H    | 9.35 |      | 10.10 |
| L    | 1.00 |      | 1.50  |
| (L1) | 2.60 | 2.80 | 3.00  |
| L2   | 0.65 | 0.80 | 0.95  |
| L4   | 0.60 |      | 1.00  |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |

Figure 27: DPAK (TO-252) type A recommended footprint (dimensions are in mm)



### 4.4 TO-220FP package information

Figure 28: TO-220FP package outline



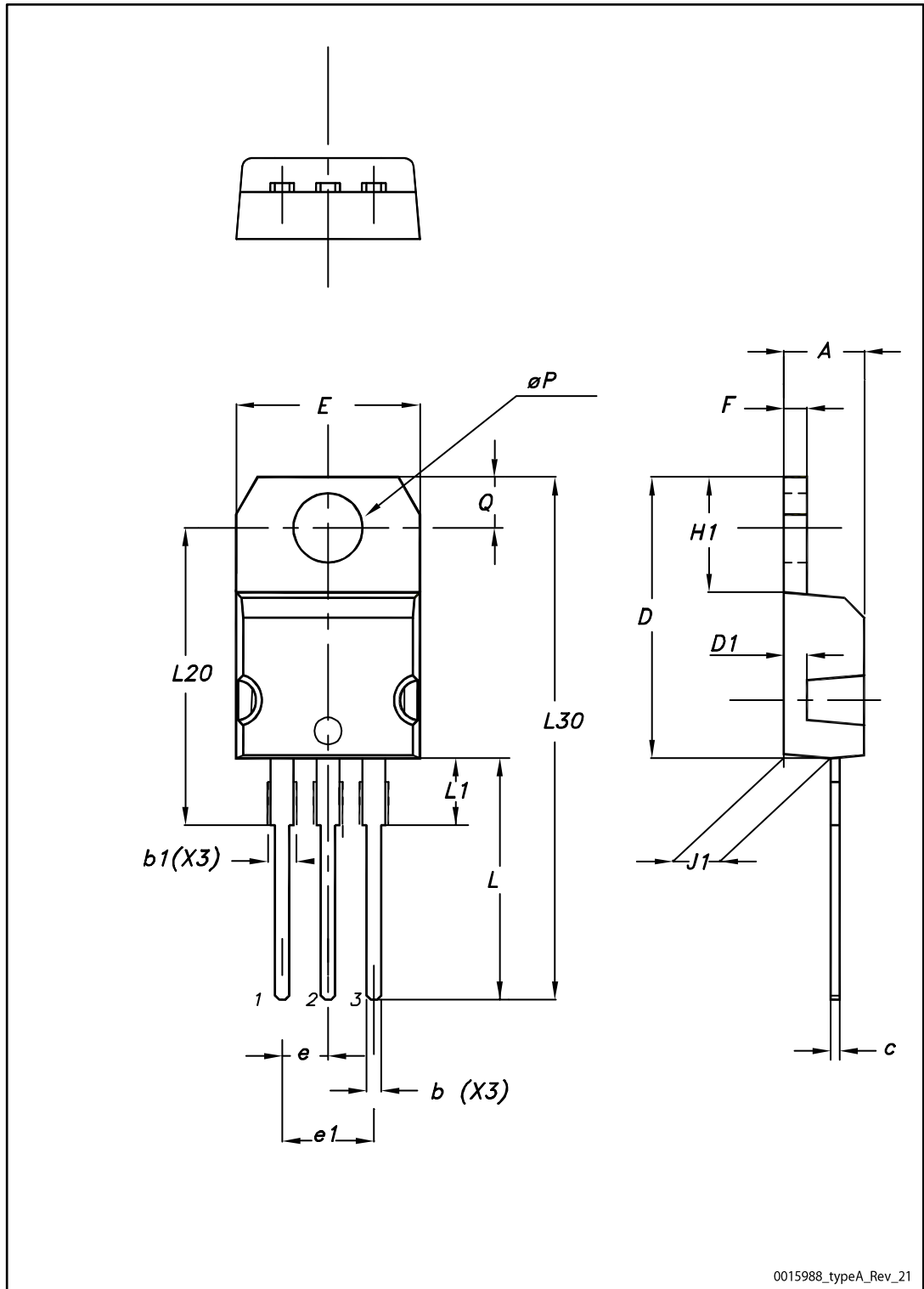
7012510\_Rev\_12\_B

Table 12: 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  |

### 4.5 TO-220 type A package information

Figure 29: TO-220 type A package outline



0015988\_typeA\_Rev\_21

Table 13: TO-220 type A package mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.55  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10.00 |       | 10.40 |
| e    | 2.40  |       | 2.70  |
| e1   | 4.95  |       | 5.15  |
| F    | 1.23  |       | 1.32  |
| H1   | 6.20  |       | 6.60  |
| J1   | 2.40  |       | 2.72  |
| L    | 13.00 |       | 14.00 |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| øP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |

### 4.6 D<sup>2</sup>PAK (TO-263) type A packing information

Figure 30: D<sup>2</sup>PAK type A tape outline





Figure 31: D2PAK type A reel outline

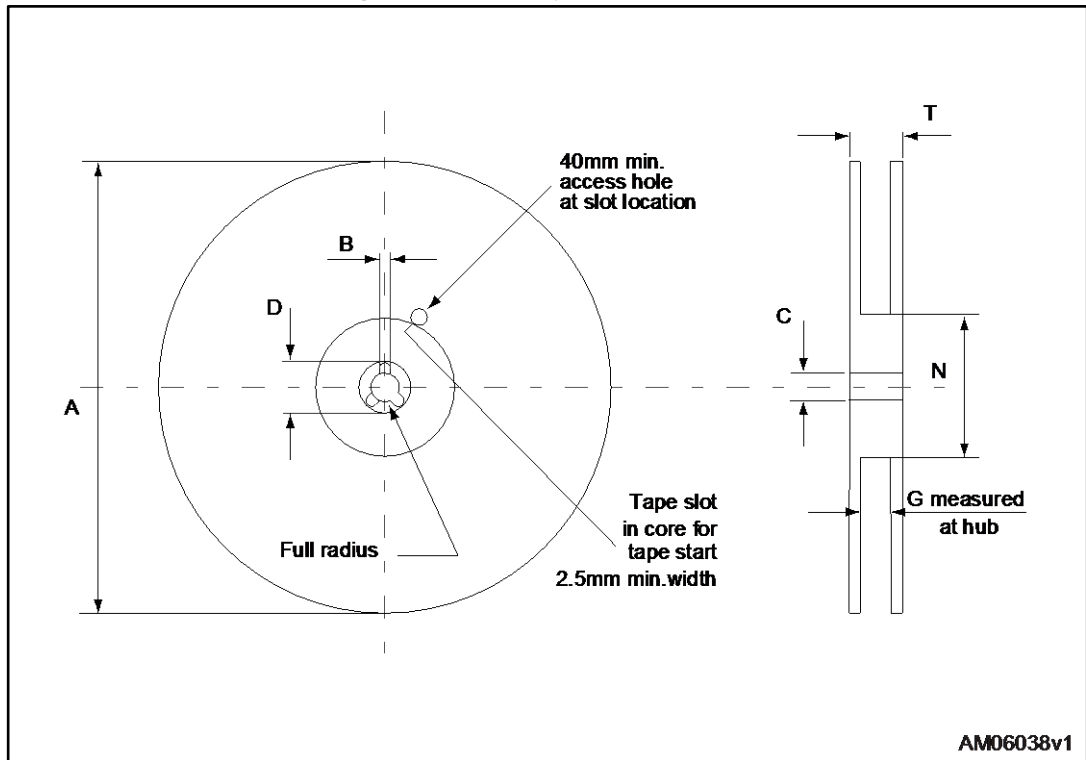


Table 14: D<sup>2</sup>PAK type A tape and reel mechanical data

| 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 |               |      |      |

### 4.7 D<sup>2</sup>PAK (TO-263) type B packing information

Figure 32: D2PAK type B tape outline

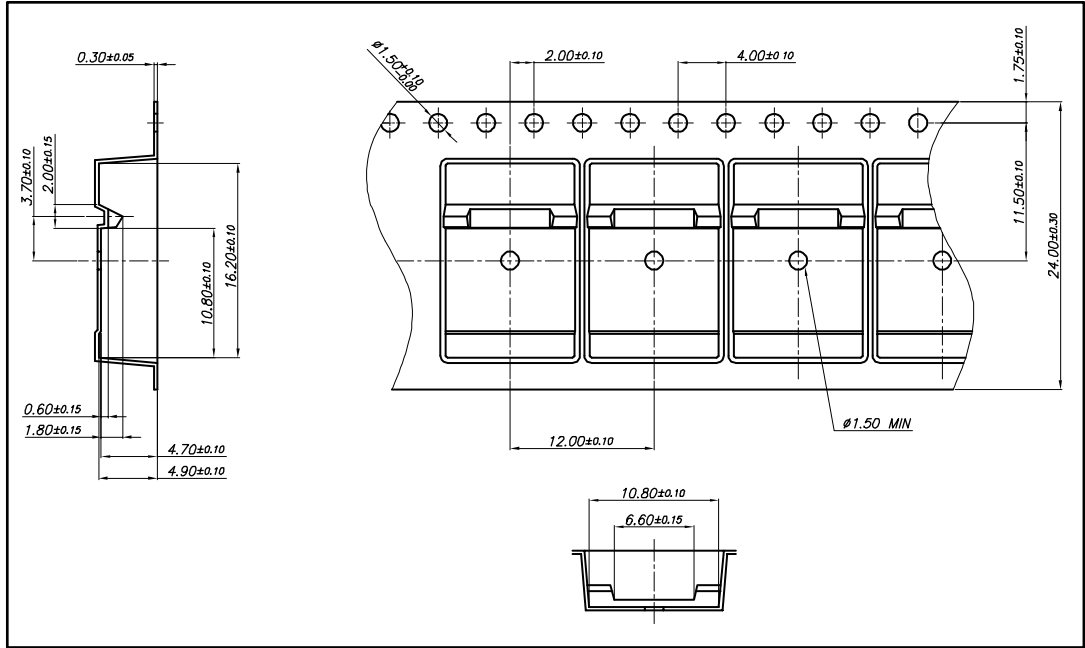


Figure 33: D2PAK type B reel outline

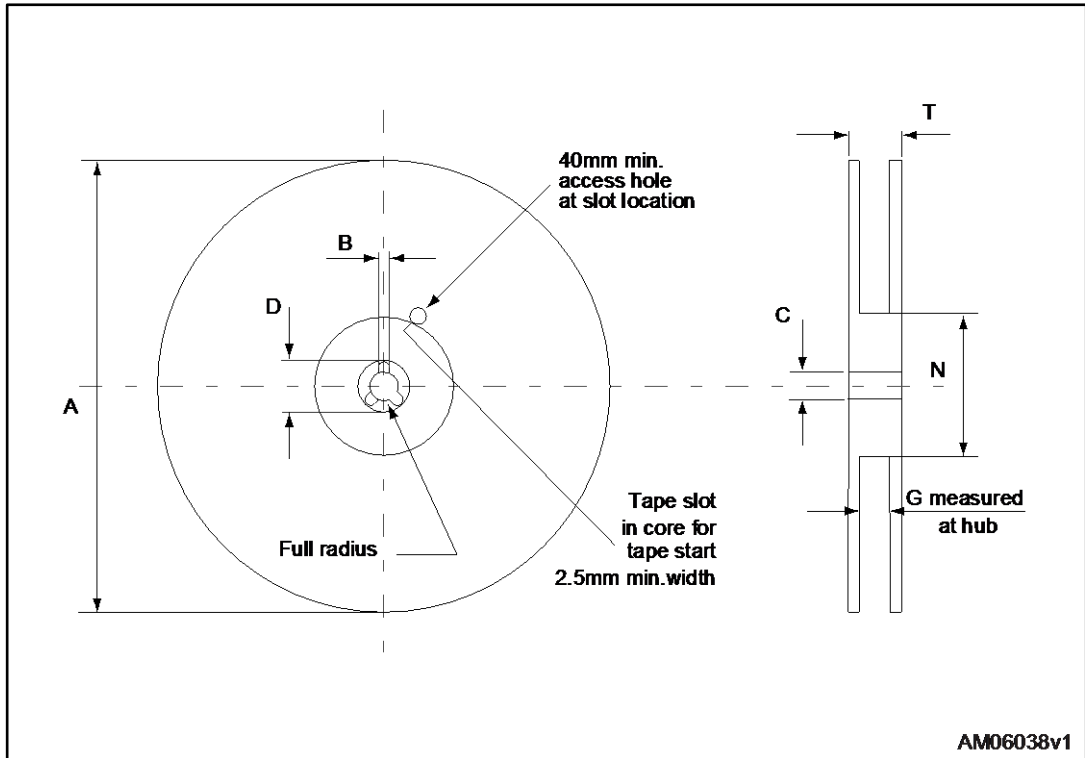


Table 15: D<sup>2</sup>PAK type B reel mechanical data

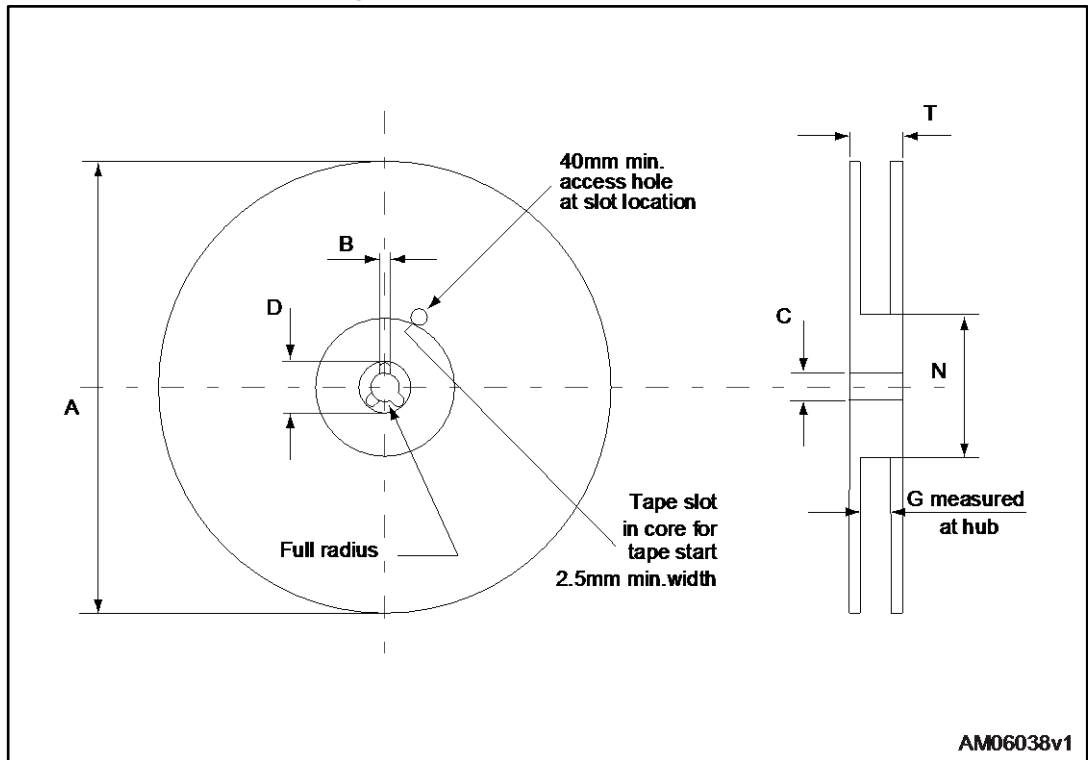
| Dim. | mm   |      |
|------|------|------|
|      | Min. | Max. |
| A    |      | 330  |
| B    | 1.5  |      |
| C    | 12.8 | 13.2 |
| D    | 20.2 |      |
| G    | 24.4 | 26.4 |
| N    | 100  |      |
| T    |      | 30.4 |

### 4.8 DPAK (TO-252) type A tape packing information

Figure 34: DPAK (TO-252) tape outline



Figure 35: DPAK (TO-252) reel outline



AM06038v1

Table 16: 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 |           |      |      |

## 5 Revision history

Table 17: Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 14-Jun-2005 | 1        | First release.  |
| 19-Jul-2005 | 2        | Complete version.   |
| 27-Jan-2006 | 3        | Inserted ecopack indication.  |
| 01-Mar-2006 | 4        | The document has been reformatted.  |
| 08-Feb-2007 | 5        | Modified value on <i>Table 6.: Switching on/off (inductive load)</i> .  |
| 24-Nov-2009 | 6        | Inserted DPAK package option.   |
| 06-Jun-2017 | 7        | Modified part numbers on cover page.<br>Updated <a href="#">Section 4: "Package information"</a> .<br>Minor text changes. |

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