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# STGB10NC60HD - STGD10NC60HD STGF10NC60HD - STGP10NC60HD

600 V - 10 A - very fast IGBT

## Features

- Low on-voltage drop ( $V_{CE(sat)}$ )
- Low  $C_{RES} / C_{IES}$  ratio (no cross-conduction susceptibility)
- Very soft ultra fast recovery antiparallel diode

## Applications

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

## Description

This IGBT utilizes the advanced PowerMESH™ process resulting in an excellent trade-off between switching performance and low on-state behavior.

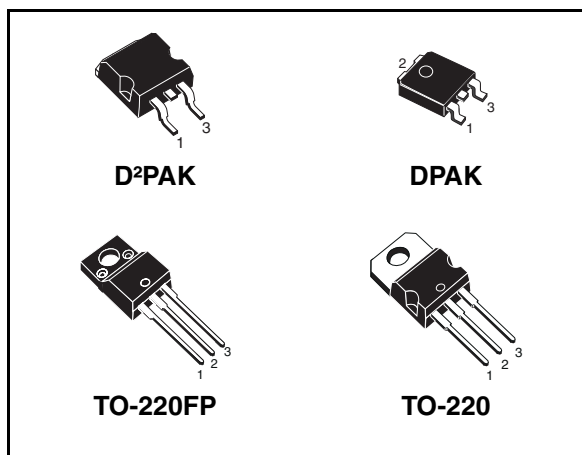


Figure 1. Internal schematic diagram

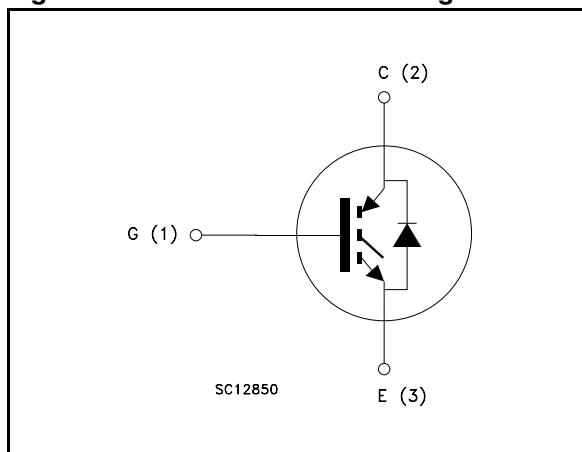


Table 1. Device summary

| Order codes    | Marking    | Package            | Packaging     |
|----------------|------------|--------------------|---------------|
| STGB10NC60HDT4 | GB10NC60HD | D <sup>2</sup> PAK | Tape and reel |
| STGD10NC60HDT4 | GD10NC60HD | DPAK               |               |
| STGF10NC60HD   | GF10NC60HD | TO-220FP           | Tube          |
| STGP10NC60HD   | GP10NC60HD | TO-220             |               |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                         | Parameter  | Value                       |      |          | Unit |
|--------------------------------|--|-----------------------------|------|----------|------|
|                                |  | TO-220 / D <sup>2</sup> PAK | DPAK | TO-220FP |      |
| V <sub>CES</sub>               | Collector-emitter voltage (V <sub>GE</sub> = 0)  | 600                         |      |          | V    |
| I <sub>C</sub> <sup>(1)</sup>  | Collector current (continuous) at T <sub>C</sub> = 25 °C   | 20                          |      | 9        | A    |
| I <sub>C</sub> <sup>(1)</sup>  | Collector current (continuous) 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 not repetitive forward current<br>t <sub>p</sub> = 10 ms sinusoidal  | 20                          |      |          | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C  | 65                          | 62   | 24       | W    |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink<br>(t = 1 s; T <sub>C</sub> = 25 °C) |                             |      | 2500     | V    |
| T <sub>J</sub>                 | Operating junction temperature   | – 55 to 150                 |      |          | °C   |

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 max junction temperature allowed

**Table 3. Thermal resistance**

| Symbol                | Parameter                                   | Value                     |      |          | Unit |
|-----------------------|---|---------------------------|------|----------|------|
|                       |   | D <sup>2</sup> PAK TO-220 | DPAK | TO-220FP |      |
| R <sub>thj-case</sub> | Thermal resistance junction-case IGBT max.  | 1.9                       | 2.0  | 5.1      | °C/W |
| R <sub>thj-case</sub> | Thermal resistance junction-case diode max. | 4                         | 4.5  | 7        | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient max.    | 62.5                      | 100  | 62.5     | °C/W |

## 2 Electrical characteristics

( $T_{CASE} = 25\text{ °C}$  unless otherwise specified)

**Table 4. Static**

| Symbol         | Parameter  | Test conditions   | Min. | Typ. | Max.      | Unit          |
|----------------|--|---|------|------|-----------|---------------|
| $V_{(BR)CES}$  | Collector-emitter breakdown voltage ( $V_{GE} = 0$ ) | $I_C = 1\text{ mA}$   | 600  |      |           | V             |
| $V_{CE(sat)}$  | Collector-emitter saturation voltage                 | $V_{GE} = 15\text{ V}, I_C = 5\text{ A}$                      |      | 1.9  | 2.5       | V             |
|                |  | $V_{GE} = 15\text{ V}, I_C = 5\text{ A}, T_C = 125\text{ °C}$ |      | 1.7  |           | V             |
| $V_{GE(th)}$   | Gate threshold voltage                               | $V_{CE} = V_{GE}, I_C = 250\text{ }\mu\text{A}$               | 3.75 |      | 5.75      | V             |
| $I_{CES}$      | Collector cut-off current ( $V_{GE} = 0$ )           | $V_{CE} = 600\text{ V}$                                       |      |      | 150       | $\mu\text{A}$ |
|                |  | $V_{CE} = 600\text{ V}, T_C = 125\text{ °C}$                  |      |      | 1         | mA            |
| $I_{GES}$      | Gate-emitter leakage current ( $V_{CE} = 0$ )        | $V_{GE} = \pm 20\text{ V}$                                    |      |      | $\pm 100$ | nA            |
| $g_{fs}^{(1)}$ | Forward transconductance                             | $V_{CE} = 15\text{ V}, I_C = 5\text{ A}$                      |      | 3.5  |           | S             |

1. Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %

**Table 5. Dynamic**

| Symbol    | Parameter                    | Test conditions                                      | Min. | Typ. | Max. | Unit |
|-----------|------------------------------|--|------|------|------|------|
| $C_{ies}$ | Input capacitance            | $V_{CE} = 25\text{ V}, f = 1\text{ MHz}, V_{GE} = 0$ |      | 365  |      | pF   |
| $C_{oes}$ | Output capacitance           |  |      | 43   |      | pF   |
| $C_{res}$ | Reverse transfer capacitance |  |      | 8.3  |      | pF   |
| $Q_g$     | Total gate charge            | $V_{CE} = 390\text{ V}, I_C = 5\text{ A},$           |      | 19.2 |      | nC   |
| $Q_{ge}$  | Gate-emitter charge          | $V_{GE} = 15\text{ V}$                               |      | 4.5  |      | nC   |
| $Q_{gc}$  | Gate-collector charge        | (see Figure 19)                                      |      | 7    |      | nC   |

**Table 6. Switching on/off (inductive load)**

| Symbol                                  | Parameter   | Test conditions   | Min. | Typ.              | Max. | Unit                   |
|---|---|---|------|-------------------|------|------------------------|
| $t_{d(on)}$<br>$t_r$<br>$(di/dt)_{on}$  | Turn-on delay time<br>Current rise time<br>Turn-on current slope  | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>(see Figure 18)<br>(see Figure 20)   |      | 14.2<br>5<br>1000 |      | ns<br>ns<br>A/ $\mu$ s |
| $t_{d(on)}$<br>$t_r$<br>$(di/dt)_{on}$  | Turn-on delay time<br>Current rise time<br>Turn-on current slope  | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_C = 125\text{ }^\circ\text{C}$<br>(see Figure 18)<br>(see Figure 20)      |      | 14<br>5<br>920    |      | ns<br>ns<br>A/ $\mu$ s |
| $t_r(V_{off})$<br>$t_{d(off)}$<br>$t_f$ | Off voltage rise time<br>Turn-off delay time<br>Current fall time | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_{GE} = 10\ \Omega$ ,<br>$V_{GE} = 15\text{ V}$<br>(see Figure 18)<br>(see Figure 20)                                     |      | 27<br>72<br>85    |      | ns<br>ns<br>ns         |
| $t_r(V_{off})$<br>$t_{d(off)}$<br>$t_f$ | Off voltage rise time<br>Turn-off delay time<br>Current fall time | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$ ,<br>$R_{GE} = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_C = 125\text{ }^\circ\text{C}$<br>(see Figure 18)<br>(see Figure 20) |      | 50<br>108<br>139  |      | ns<br>ns<br>ns         |

**Table 7. Switching energy (inductive load)**

| Symbol  | Parameter   | Test conditions   | Min. | Typ.                 | Max. | Unit                          |
|---|---|---|------|----------------------|------|-------------------------------|
| $E_{on}^{(1)}$<br>$E_{off}^{(2)}$<br>$E_{ts}$ | Turn-on switching losses<br>Turn-off switching losses<br>Total switching losses | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>(see Figure 18)                                      |      | 31.8<br>95<br>126.8  |      | $\mu$ J<br>$\mu$ J<br>$\mu$ J |
| $E_{on}^{(1)}$<br>$E_{off}^{(2)}$<br>$E_{ts}$ | Turn-on switching losses<br>Turn-off switching losses<br>Total switching losses | $V_{CC} = 390\text{ V}$ , $I_C = 5\text{ A}$<br>$R_G = 10\ \Omega$ , $V_{GE} = 15\text{ V}$ ,<br>$T_C = 125\text{ }^\circ\text{C}$<br>(see Figure 18) |      | 61.8<br>173<br>234.8 |      | $\mu$ J<br>$\mu$ J<br>$\mu$ J |

1.  $E_{on}$  is the turn-on losses when a typical diode is used in the test circuit in Figure 18. If the IGBT is offered in a package with a co-pak diode, the co-pak diode is used as external diode. IGBTs & Diode are at the same temperature (25 °C and 125 °C)
2. Turn-off losses include also 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    | 2.45 | V    |
|           |                          | $I_F = 5 \text{ A}, T_C = 125 \text{ }^\circ\text{C}$   |      | 1.7  |      | V    |
| $t_{rr}$  | Reverse recovery time    | $I_F = 5 \text{ A}, V_R = 40 \text{ V},$<br>$di/dt = 100 \text{ A}/\mu\text{s}$                                   |      | 22   |      | ns   |
| $Q_{rr}$  | Reverse recovery charge  | $di/dt = 100 \text{ A}/\mu\text{s}$   |      | 14   |      | nC   |
| $I_{rrm}$ | Reverse recovery current | (see Figure 21)   |      | 1.3  |      | A    |
| $t_{rr}$  | Reverse recovery time    | $I_F = 5 \text{ A}, V_R = 40 \text{ V},$<br>$T_C = 125 \text{ }^\circ\text{C}, di/dt = 100 \text{ A}/\mu\text{s}$ |      | 33   |      | ns   |
| $Q_{rr}$  | Reverse recovery charge  | $T_C = 125 \text{ }^\circ\text{C}, di/dt = 100 \text{ A}/\mu\text{s}$   |      | 30   |      | nC   |
| $I_{rrm}$ | Reverse recovery current | (see Figure 21)   |      | 1.85 |      | A    |

## 2.1 Electrical characteristics (curves)

Figure 2. Output characteristics

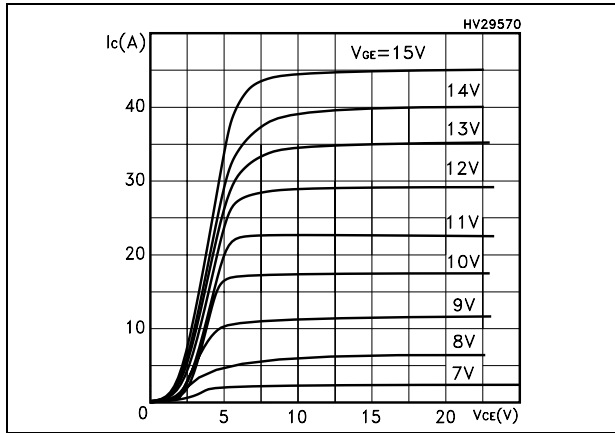


Figure 3. Transfer characteristics

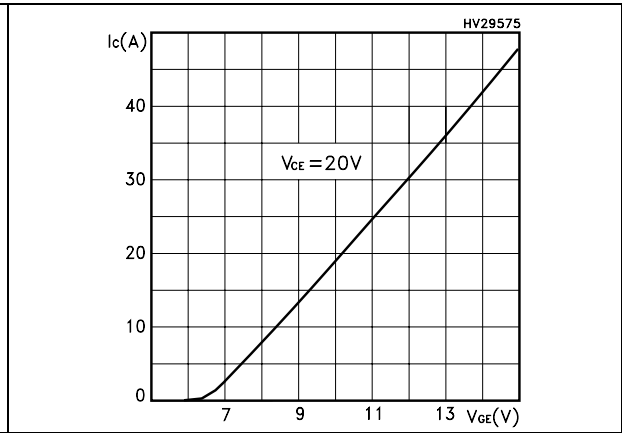


Figure 4. Transconductance

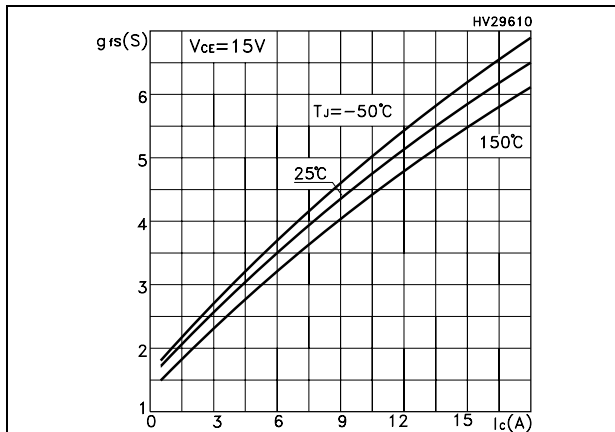


Figure 5. Collector-emitter on voltage vs temperature

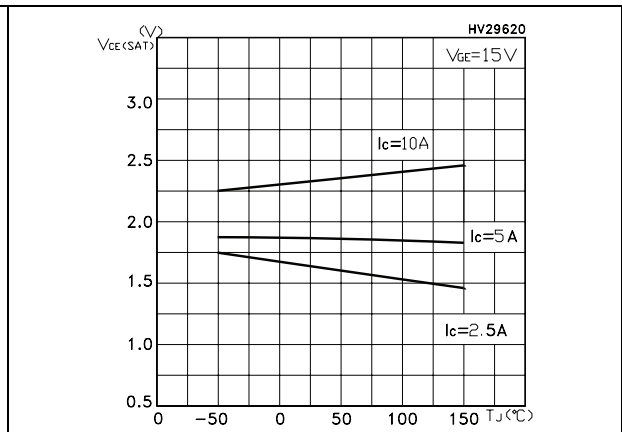


Figure 6. Gate charge vs gate-source voltage Figure 7. Capacitance variations

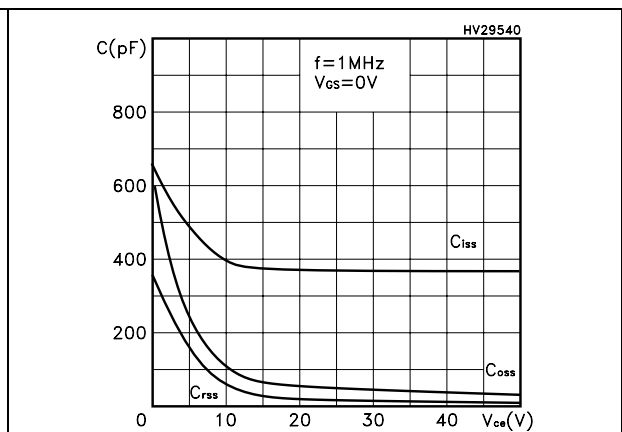
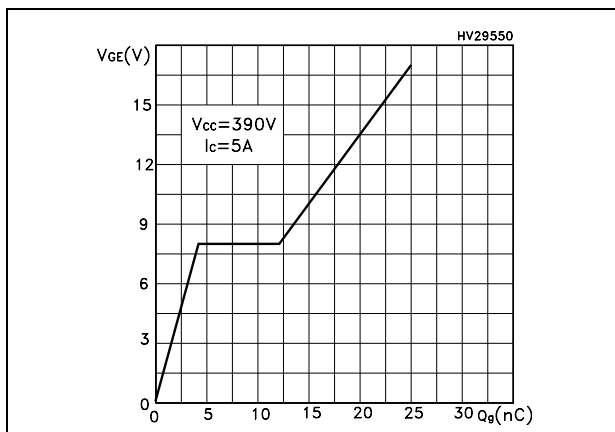




Figure 8. Normalized gate threshold voltage vs temperature

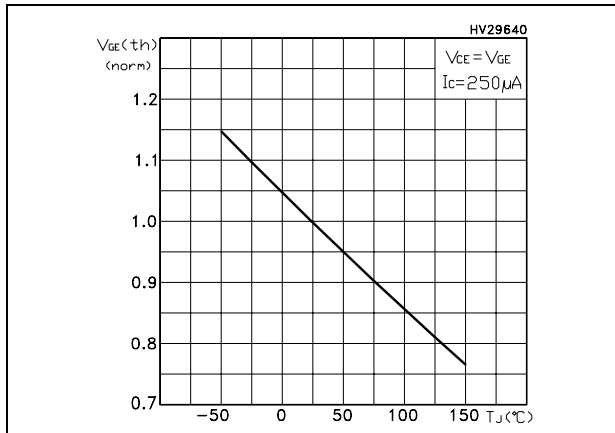


Figure 9. Collector-emitter on voltage vs collector current

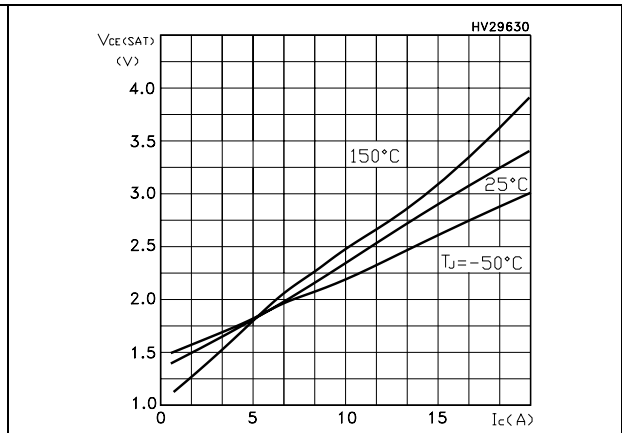


Figure 10. Normalized breakdown voltage vs temperature

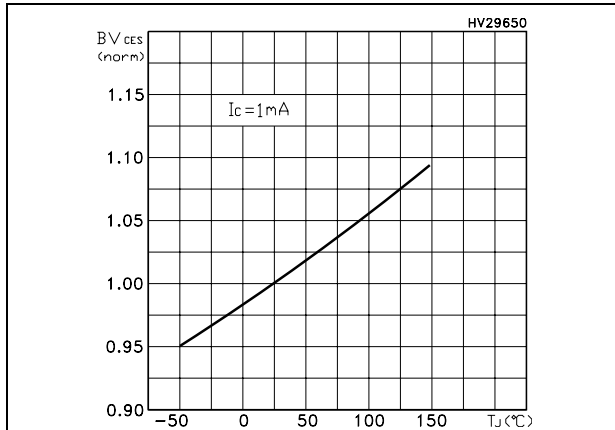


Figure 11. Switching losses vs temperature

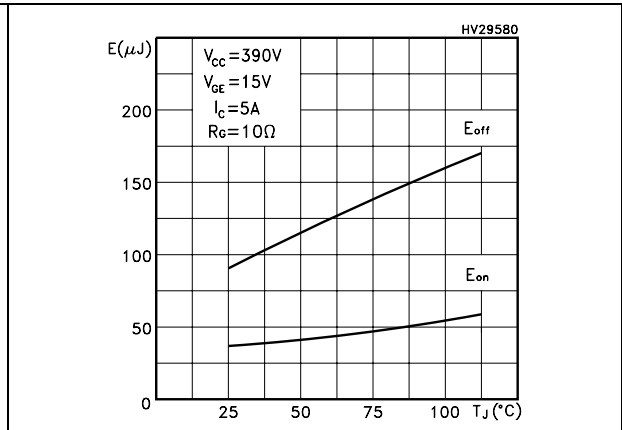


Figure 12. Switching losses vs gate resistance

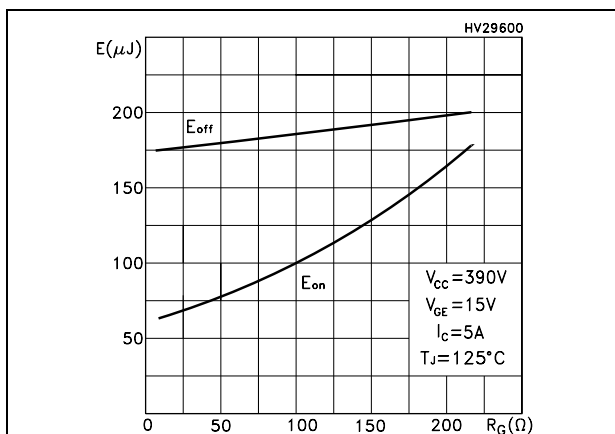


Figure 13. Switching losses vs collector current

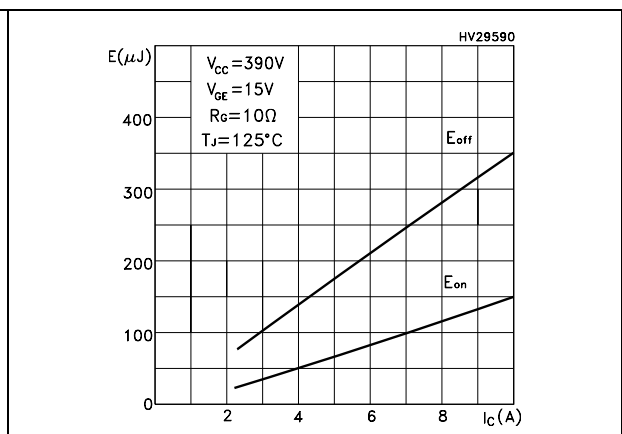


Figure 14. Thermal impedance for TO-220 / D<sup>2</sup>PAK / DPAK

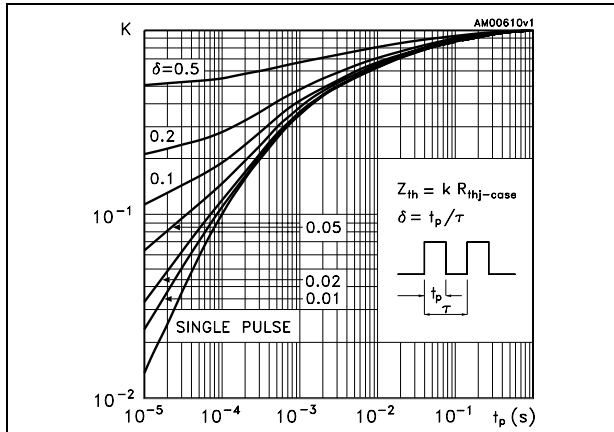


Figure 15. Turn-off SOA

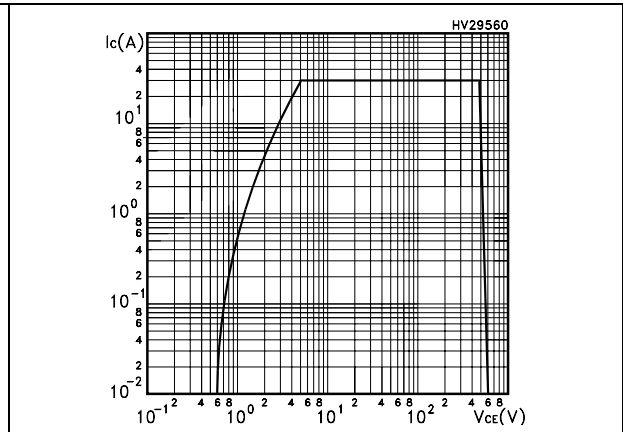
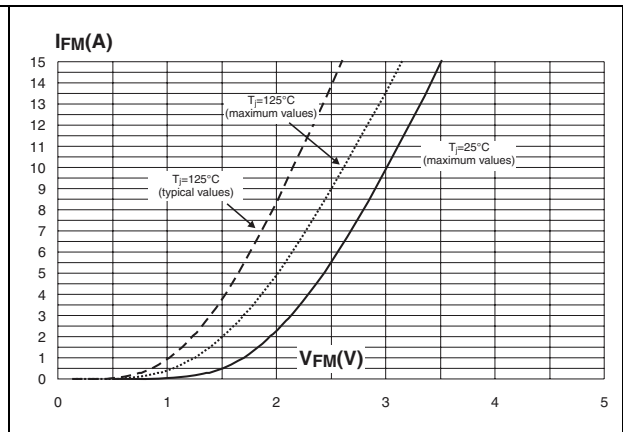
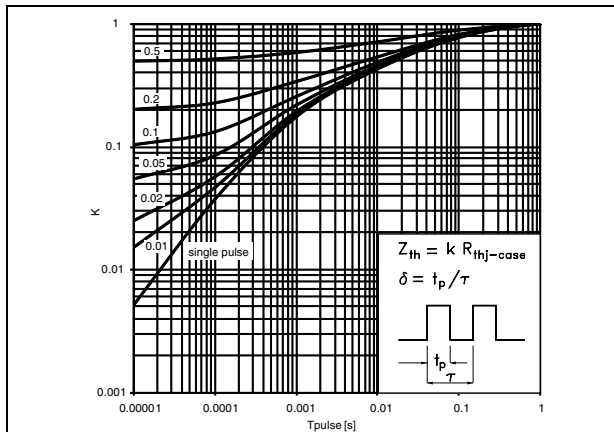


Figure 16. Thermal impedance for TO-220FP Figure 17. Emitter-collector diode characteristics



### 3 Test circuit

Figure 18. Test circuit for inductive load switching

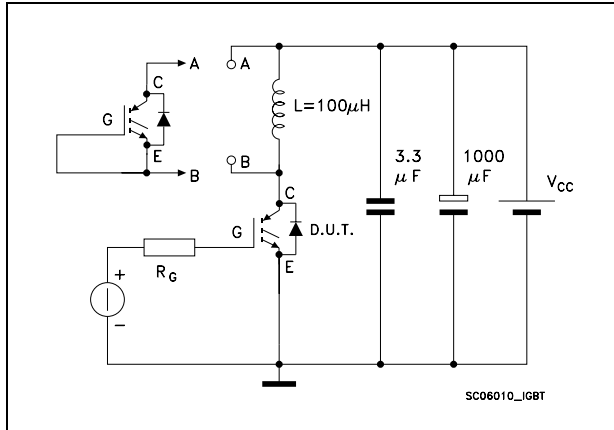


Figure 20. Switching waveform

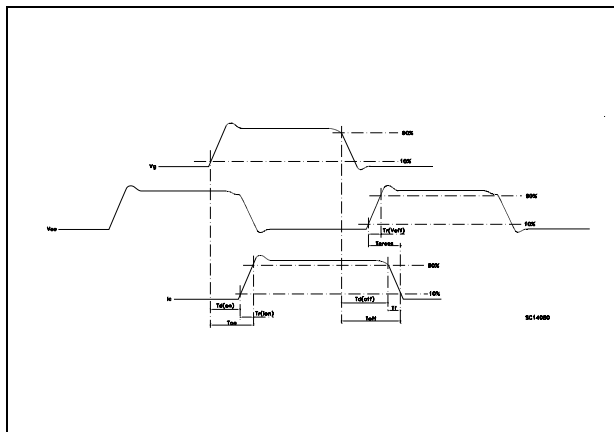


Figure 19. Gate charge test circuit

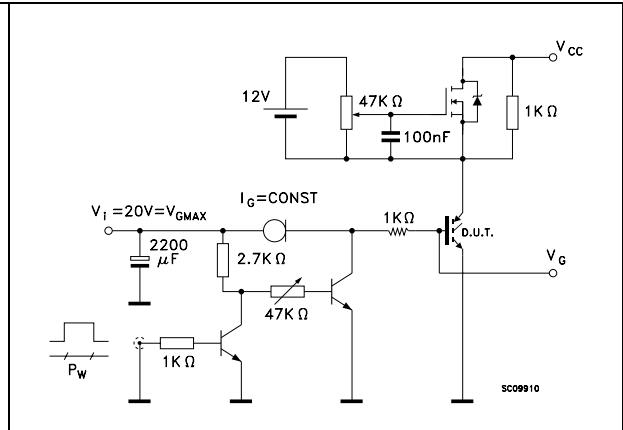
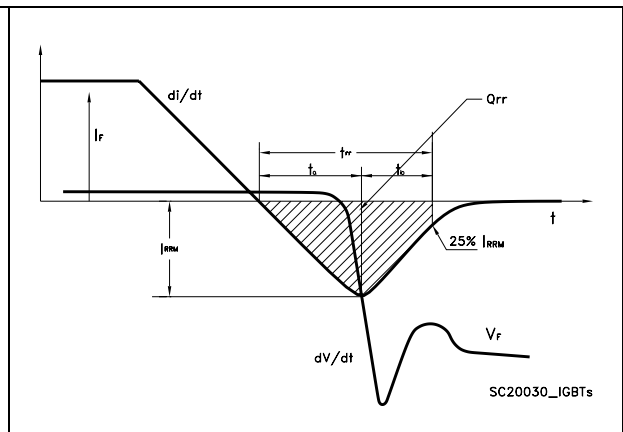


Figure 21. Diode recovery time waveform

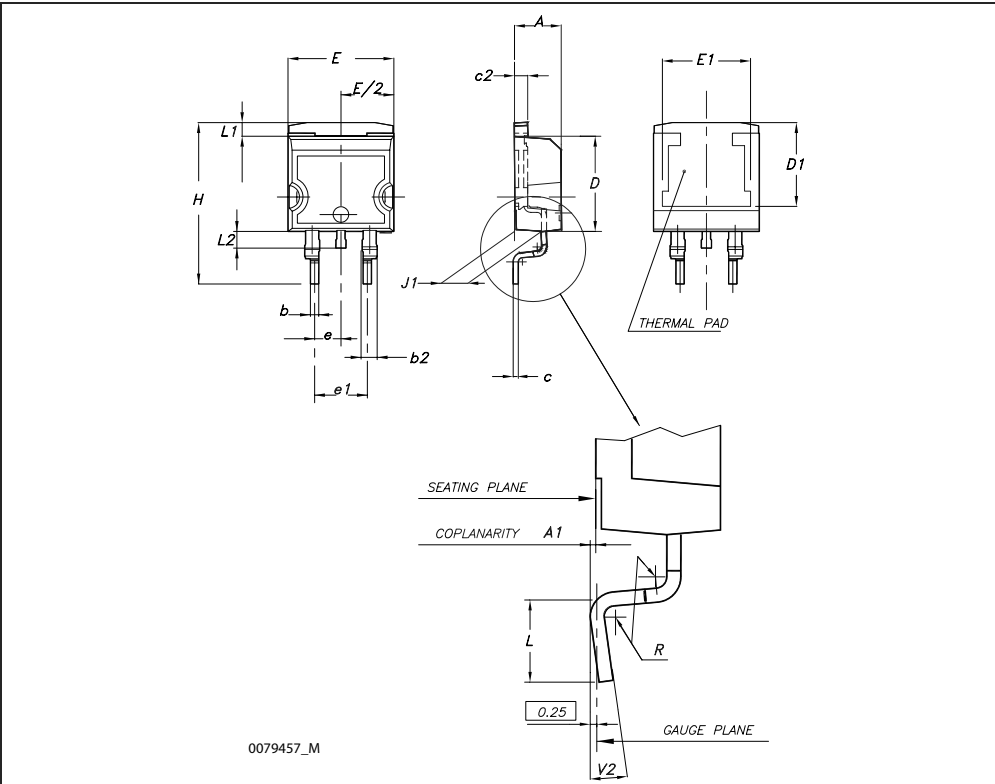


## 4 Package mechanical data

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

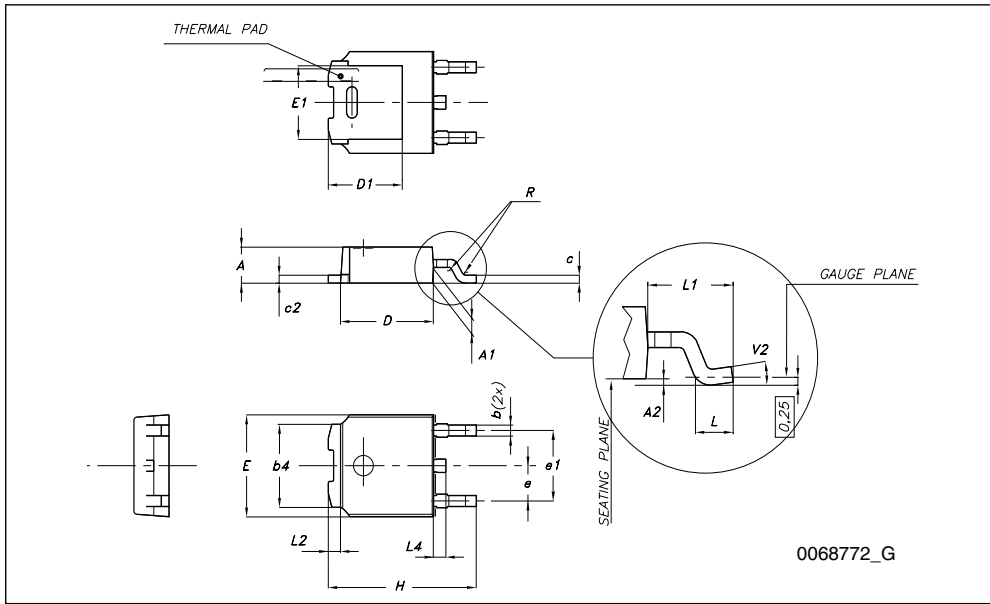
D<sup>2</sup>PAK (TO-263) mechanical data

| Dim | mm   |      |       | inch  |       |       |
|-----|------|------|-------|-------|-------|-------|
|     | Min  | Typ  | Max   | Min   | Typ   | Max   |
| A   | 4.40 |      | 4.60  | 0.173 |       | 0.181 |
| A1  | 0.03 |      | 0.23  | 0.001 |       | 0.009 |
| b   | 0.70 |      | 0.93  | 0.027 |       | 0.037 |
| b2  | 1.14 |      | 1.70  | 0.045 |       | 0.067 |
| c   | 0.45 |      | 0.60  | 0.017 |       | 0.024 |
| c2  | 1.23 |      | 1.36  | 0.048 |       | 0.053 |
| D   | 8.95 |      | 9.35  | 0.352 |       | 0.368 |
| D1  | 7.50 |      |       | 0.295 |       |       |
| E   | 10   |      | 10.40 | 0.394 |       | 0.409 |
| E1  | 8.50 |      |       | 0.334 |       |       |
| e   |      | 2.54 |       |       | 0.1   |       |
| e1  | 4.88 |      | 5.28  | 0.192 |       | 0.208 |
| H   | 15   |      | 15.85 | 0.590 |       | 0.624 |
| J1  | 2.49 |      | 2.69  | 0.099 |       | 0.106 |
| L   | 2.29 |      | 2.79  | 0.090 |       | 0.110 |
| L1  | 1.27 |      | 1.40  | 0.05  |       | 0.055 |
| L2  | 1.30 |      | 1.75  | 0.051 |       | 0.069 |
| R   |      | 0.4  |       |       | 0.016 |       |
| V2  | 0°   |      | 8°    | 0°    |       | 8°    |



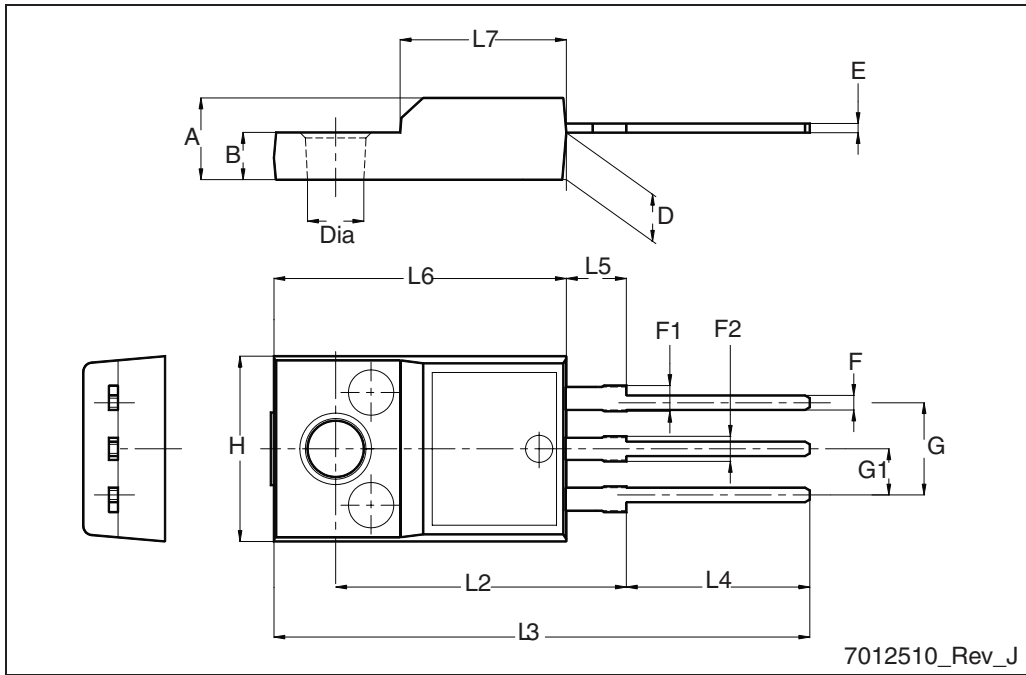
TO-252 (DPAK) mechanical data

| 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   |      | 5.10 |       |
| E    | 6.40 |      | 6.60  |
| E1   |      | 4.70 |       |
| e    |      | 2.28 |       |
| e1   | 4.40 |      | 4.60  |
| H    | 9.35 |      | 10.10 |
| L    | 1    |      |       |
| L1   |      | 2.80 |       |
| L2   |      | 0.80 |       |
| L4   | 0.60 |      | 1     |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |



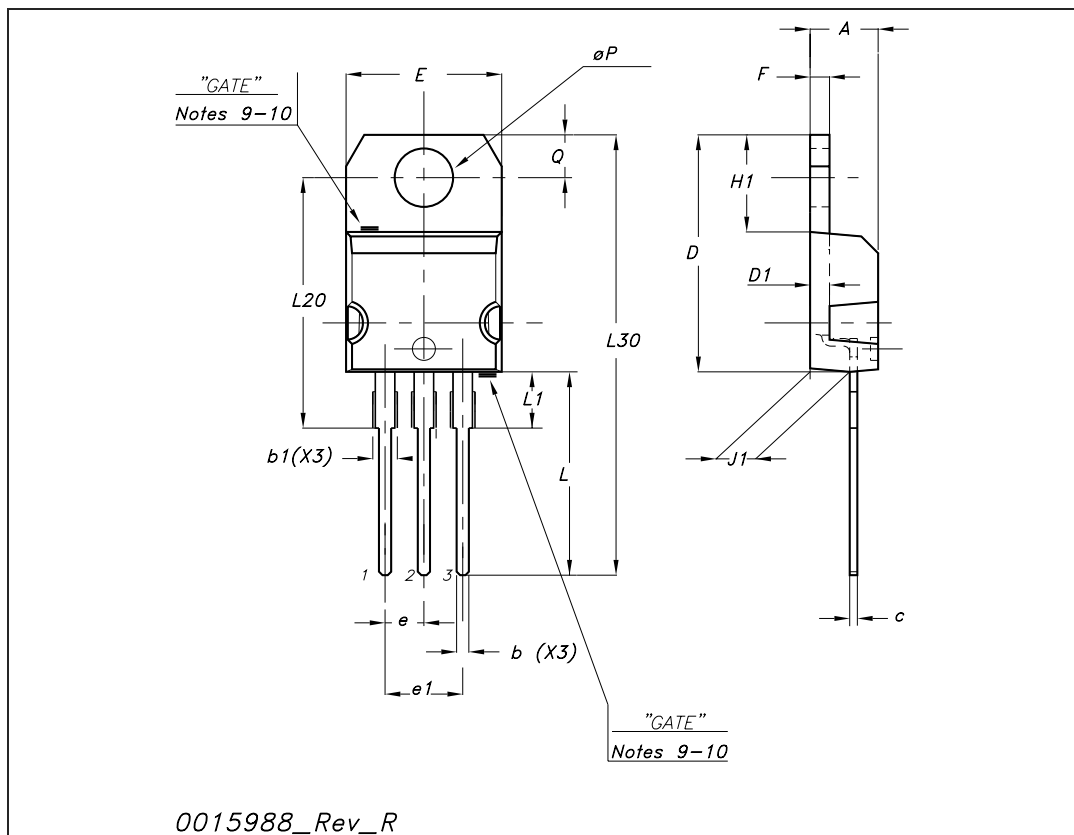
TO-220FP mechanical data

| 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 |      | 1.5  |
| 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  |



TO-220 mechanical data

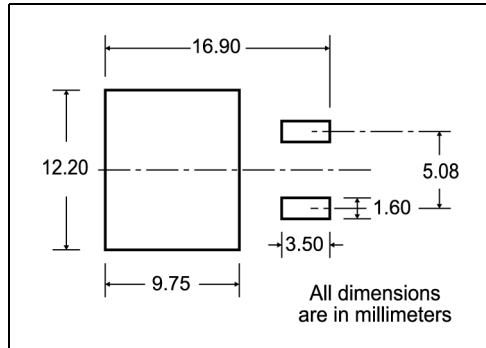
| Dim | mm    |       |       | inch  |       |       |
|-----|-------|-------|-------|-------|-------|-------|
|     | Min   | Typ   | Max   | Min   | Typ   | Max   |
| A   | 4.40  |       | 4.60  | 0.173 |       | 0.181 |
| b   | 0.61  |       | 0.88  | 0.024 |       | 0.034 |
| b1  | 1.14  |       | 1.70  | 0.044 |       | 0.066 |
| c   | 0.48  |       | 0.70  | 0.019 |       | 0.027 |
| D   | 15.25 |       | 15.75 | 0.6   |       | 0.62  |
| D1  |       | 1.27  |       |       | 0.050 |       |
| E   | 10    |       | 10.40 | 0.393 |       | 0.409 |
| e   | 2.40  |       | 2.70  | 0.094 |       | 0.106 |
| e1  | 4.95  |       | 5.15  | 0.194 |       | 0.202 |
| F   | 1.23  |       | 1.32  | 0.048 |       | 0.051 |
| H1  | 6.20  |       | 6.60  | 0.244 |       | 0.256 |
| J1  | 2.40  |       | 2.72  | 0.094 |       | 0.107 |
| L   | 13    |       | 14    | 0.511 |       | 0.551 |
| L1  | 3.50  |       | 3.93  | 0.137 |       | 0.154 |
| L20 |       | 16.40 |       |       | 0.645 |       |
| L30 |       | 28.90 |       |       | 1.137 |       |
| ∅P  | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q   | 2.65  |       | 2.95  | 0.104 |       | 0.116 |





### 4.1 Packaging mechanical data

#### D<sup>2</sup>PAK FOOTPRINT



#### TAPE AND REEL SHIPMENT

**TAPE MECHANICAL DATA**

| DIM. | mm   |      | inch   |        |
|------|------|------|--------|--------|
|      | MIN. | MAX. | MIN.   | MAX.   |
| A0   | 10.5 | 10.7 | 0.413  | 0.421  |
| B0   | 15.7 | 15.9 | 0.618  | 0.626  |
| D    | 1.5  | 1.6  | 0.059  | 0.063  |
| D1   | 1.59 | 1.61 | 0.062  | 0.063  |
| E    | 1.65 | 1.85 | 0.065  | 0.073  |
| F    | 11.4 | 11.6 | 0.449  | 0.456  |
| K0   | 4.8  | 5.0  | 0.189  | 0.197  |
| P0   | 3.9  | 4.1  | 0.153  | 0.161  |
| P1   | 11.9 | 12.1 | 0.468  | 0.476  |
| P2   | 1.9  | 2.1  | 0.075  | 0.082  |
| R    | 50   |      | 1.574  |        |
| T    | 0.25 | 0.35 | 0.0098 | 0.0137 |
| W    | 23.7 | 24.3 | 0.933  | 0.956  |

**REEL MECHANICAL DATA**

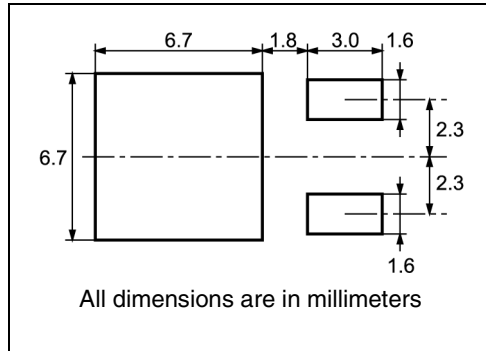
| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 24.4 | 26.4 | 0.960 | 1.039  |
| N    | 100  |      | 3.937 |        |
| T    |      | 30.4 |       | 1.197  |

| BASE QTY | BULK QTY |
|----------|----------|
| 1000     | 1000     |

\* on sales type

**DPAK FOOTPRINT**



**TAPE AND REEL SHIPMENT**

**REEL MECHANICAL DATA**

| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 16.4 | 18.4 | 0.645 | 0.724  |
| N    | 50   |      | 1.968 |        |
| T    |      | 22.4 |       | 0.881  |

**TAPE MECHANICAL DATA**

| DIM. | mm   |      | inch  |       |
|------|------|------|-------|-------|
|      | MIN. | MAX. | MIN.  | MAX.  |
| A0   | 6.8  | 7    | 0.267 | 0.275 |
| B0   | 10.4 | 10.6 | 0.409 | 0.417 |
| B1   |      | 12.1 |       | 0.476 |
| D    | 1.5  | 1.6  | 0.059 | 0.063 |
| D1   | 1.5  |      | 0.059 |       |
| E    | 1.65 | 1.85 | 0.065 | 0.073 |
| F    | 7.4  | 7.6  | 0.291 | 0.299 |
| K0   | 2.55 | 2.75 | 0.100 | 0.108 |
| P0   | 3.9  | 4.1  | 0.153 | 0.161 |
| P1   | 7.9  | 8.1  | 0.311 | 0.319 |
| P2   | 1.9  | 2.1  | 0.075 | 0.082 |
| R    | 40   |      | 1.574 |       |
| W    | 15.7 | 16.3 | 0.618 | 0.641 |

## 5 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 30-Jan-2006 | 1        | Initial release  |
| 06-Nov-2006 | 2        | Complete version   |
| 08-Feb-2007 | 3        | The document has been reformatted                        |
| 05-Oct-2007 | 4        | Added TO-220FP, <a href="#">Table 2</a> has been updated |
| 16-Dec-2008 | 5        | Added DPAK package                                       |

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