



# STD4NK50ZD - STD4NK50ZD-1 STF4NK50ZD - STP4NK50ZD

N-channel 500V - 2.4Ω - 3A - TO-220 - TO-220FP- DPAK - IPAK  
Fast diode SuperMESH™ Power MOSFET

## General features

| Type         | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>W</sub> |
|--------------|------------------|---------------------|----------------|----------------|
| STD4NK50ZD-1 | 500V             | <2.7Ω               | 3A             | 45W            |
| STD4NK50ZD   | 500V             | <2.7Ω               | 3A             | 45W            |
| STF4NK50ZD   | 500V             | <2.7Ω               | 3A             | 20W            |
| STP4NK50ZD   | 500V             | <2.7Ω               | 3A             | 45W            |

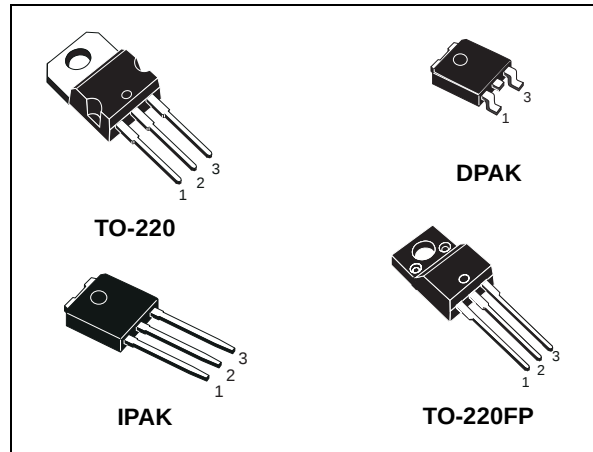
- 100% avalanche tested
- Extremely high dv/dt capability
- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeability

## Description

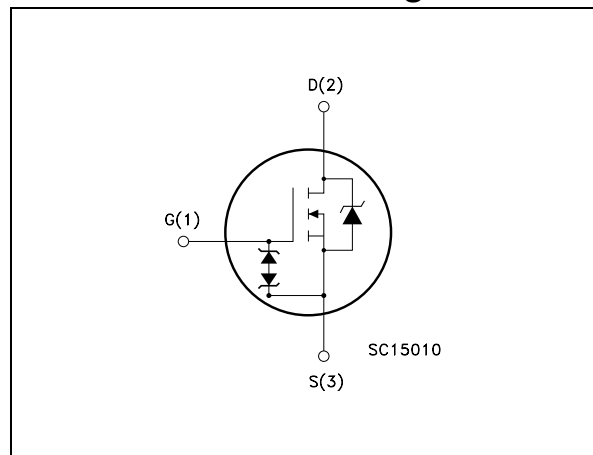
The fast SuperMESH™ series associates all advantages of reduced on-resistance, zener gate protection and outstanding dc/dt capability with a Fast body-drain recovery diode. Such series complements the FDmesh™ advanced technology.

## Applications

- Switching application



## Internal schematic diagram



## Order codes

| Part number  | Marking    | Package  | Packaging   |
|--------------|------------|----------|-------------|
| STD4NK50ZD-1 | D4NK50ZD-1 | IPAK     | Tube        |
| STD4NK50ZD   | D4NK50ZD   | DPAK     | Tape & reel |
| STF4NK50ZD   | F4NK50ZD   | TO-220FP | Tube        |
| STP4NK50ZD   | P4NK50ZD   | TO-220   | Tube        |

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol             | Parameter                                             | Value      |                    |                    | Unit |
|--------------------|-------------------------------------------------------|------------|--------------------|--------------------|------|
|                    |                                                       | TO-220     | IPAK/DPAK          | TO-220FP           |      |
| $V_{DS}$           | Drain-source voltage ( $V_{GS} = 0$ )                 | 500        |                    |                    | V    |
| $V_{DGR}$          | Drain-gate voltage ( $R_{GS} = 20K\Omega$ )           | 500        |                    |                    | V    |
| $V_{GS}$           | Gate-source voltage                                   | $\pm 30$   |                    |                    | V    |
| $I_D$              | Drain current (continuous) at $T_C = 25^\circ C$      | 3          | 3 <sup>(1)</sup>   | 3 <sup>(1)</sup>   | A    |
| $I_D$              | Drain current (continuous) at $T_C = 100^\circ C$     | 1.9        | 1.9 <sup>(1)</sup> | 1.9 <sup>(1)</sup> | A    |
| $I_{DM}^{(2)}$     | Drain current (pulsed)                                | 12         | 12 <sup>(1)</sup>  | 12 <sup>(1)</sup>  | A    |
| $P_{TOT}$          | Total dissipation at $T_C = 25^\circ C$               | 45         |                    |                    | W    |
|                    | Derating factor                                       | 0.36       |                    |                    | W/°C |
| $V_{ESD(G-D)}$     | Gate source ESD(HBM-C=100pF, R=1.5KΩ)                 | 2800       |                    |                    | V    |
| $dv/dt^{(3)}$      | Peak diode recovery voltage slope                     | 15         |                    |                    | V/ns |
| $V_{ISO}$          | Insulation withstand voltage (DC)                     | --         | --                 | 2500               | V    |
| $T_J$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature | -55 to 150 |                    |                    | °C   |

1. Limited only by maximum temperature allowed

2. Pulse width limited by safe operating area

3.  $I_{SD} \leq 3A$ ,  $di/dt \leq 200A/\mu s$ ,  $V_{DD} = 80\%V_{(BR)DSS}$

**Table 2. Thermal resistance**

| Symbol         | Parameter                                      | Value  |           |          | Unit |
|----------------|------------------------------------------------|--------|-----------|----------|------|
|                |                                                | TO-220 | IPAK/DPAK | TO-220FP |      |
| $R_{thj-case}$ | Thermal resistance junction-case Max           | 2.78   |           |          | °C/W |
| $R_{thj-a}$    | Thermal resistance junction-ambient Max        | 62.5   | 100       | 62.5     | °C/W |
| $T_I$          | Maximum lead temperature for soldering purpose | 300    |           |          | °C   |

**Table 3. Avalanche data**

| Symbol   | Parameter                                                                                      | Value | Unit |
|----------|------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_J$ Max)             | 3     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J = 25^\circ C$ , $I_d = I_{AR}$ , $V_{dd} = 50V$ ) | 120   | mJ   |

## 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                                     | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|-------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{mA}$ , $V_{GS} = 0$                                                   | 500  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$ ,<br>$V_{DS} = \text{Max rating @}125^{\circ}\text{C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{V}$                                                           |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 50\mu\text{A}$                                           | 2.5  | 3.5  | 4.5      | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{V}$ , $I_D = 1.5\text{A}$                                         |      | 2.3  | 2.7      | $\Omega$                       |

**Table 5. Dynamic**

| Symbol                              | Parameter                                                               | Test conditions                                                                        | Min. | Typ.            | Max. | Unit           |
|-------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------|------|-----------------|------|----------------|
| $g_{fs}^{(1)}$                      | Forward transconductance                                                | $V_{DS} = 15\text{V}$ , $I_D = 1.5\text{A}$                                            |      | 1.5             |      | S              |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$ | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{V}$ , $f = 1\text{MHz}$ ,<br>$V_{GS} = 0$                            |      | 310<br>49<br>10 |      | pF<br>pF<br>pF |
| $C_{oss\ eq}^{(2)}$                 | Equivalent output capacitance                                           | $V_{GS} = 0$ , $V_{DS} = 0\text{V to } 400\text{V}$                                    |      | 33              |      | pF             |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$       | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 400\text{V}$ , $I_D = 3\text{A}$<br>$V_{GS} = 10\text{V}$<br>(see Figure 11) |      | 12<br>3<br>7    |      | nC<br>nC<br>nC |

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

2.  $C_{oss\ eq}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

**Table 6. Switching times**

| Symbol                                        | Parameter                                                           | Test conditions                                                                                                | Min. | Typ.                    | Max. | Unit                 |
|-----------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|------|-------------------------|------|----------------------|
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Turn-off delay time<br>Fall time | $V_{DD} = 250\text{V}$ , $I_D = 1.5\text{A}$ ,<br>$R_G = 4.7\Omega$ , $V_{GS} = 10\text{V}$<br>(see Figure 18) |      | 9.5<br>15.5<br>23<br>22 |      | ns<br>ns<br>ns<br>ns |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                              | Min | Typ. | Max | Unit |
|-----------------|-------------------------------|------------------------------------------------------------------------------|-----|------|-----|------|
| $I_{SD}$        | Source-drain current          |                                                                              |     |      | 3   | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                              |     |      | 12  | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 3A, V_{GS}=0$                                                      |     |      | 1.6 | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 3A,$<br>$di/dt = 100A/\mu s,$<br>$V_{DD} = 34V, T_j = 25^\circ C$  |     | 73   |     | ns   |
| $Q_{rr}$        | Reverse recovery charge       |                                                                              |     | 140  |     | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                              |     | 3.82 |     | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 3A,$<br>$di/dt = 100A/\mu s,$<br>$V_{DD} = 34V, T_j = 150^\circ C$ |     | 118  |     | ns   |
| $Q_{rr}$        | Reverse Recovery Charge       |                                                                              |     | 260  |     | nC   |
| $I_{RRM}$       | Reverse recovery current      |                                                                              |     | 4.4  |     | A    |

1. Pulse width limited by safe operating area
2. Pulsed: pulse duration=300 $\mu s$ , duty cycle 1.5%

**Table 8. Gate-source zener diode**

| Symbol           | Parameter                     | Test conditions                 | Min. | Typ. | Max | Unit |
|------------------|-------------------------------|---------------------------------|------|------|-----|------|
| $BV_{GSO}^{(1)}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1mA$ (open drain) | 30   |      |     | V    |

1. The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

## 2.1 Electrical characteristics (curves)

Figure 1. Safe operating area for TO-220

Figure 2. Thermal impedance for TO-220

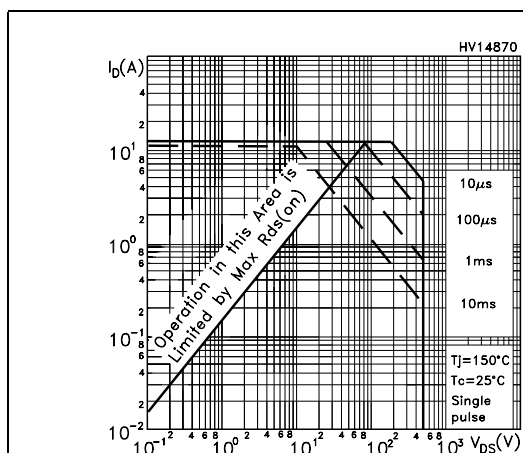


Figure 3. Safe operating area for TO-220FP

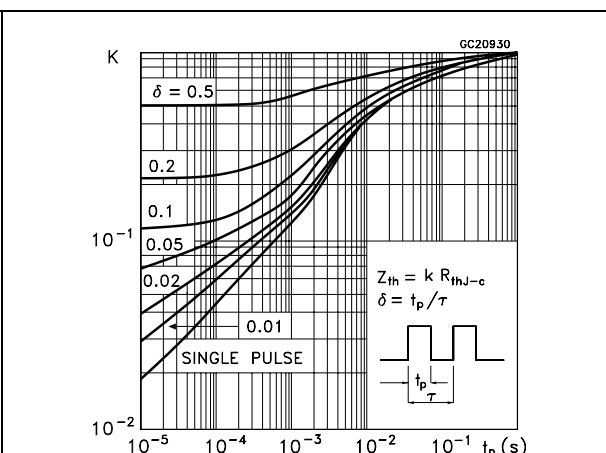


Figure 4. Thermal impedance for TO-220FP

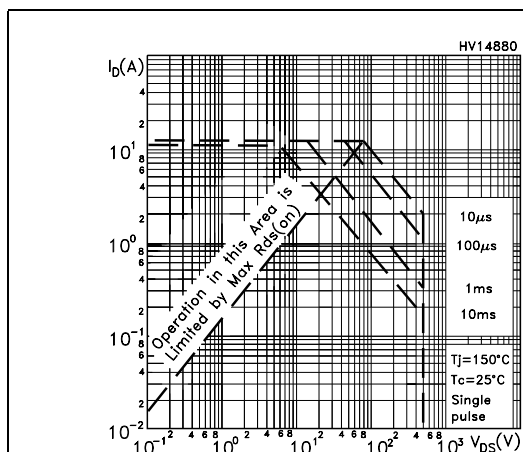


Figure 5. Safe operating area for DPAK/IPAK

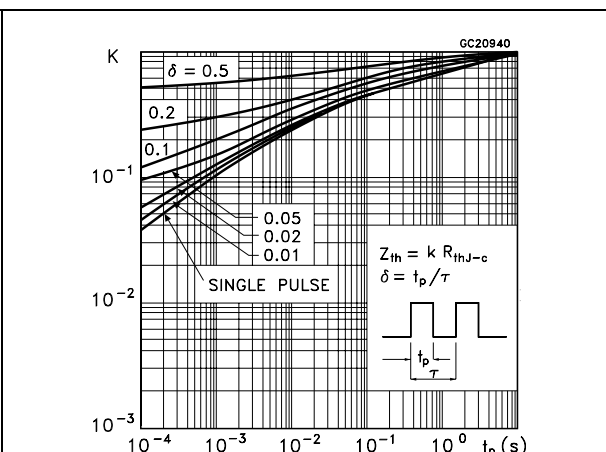


Figure 6. Thermal impedance for DPAK/IPAK

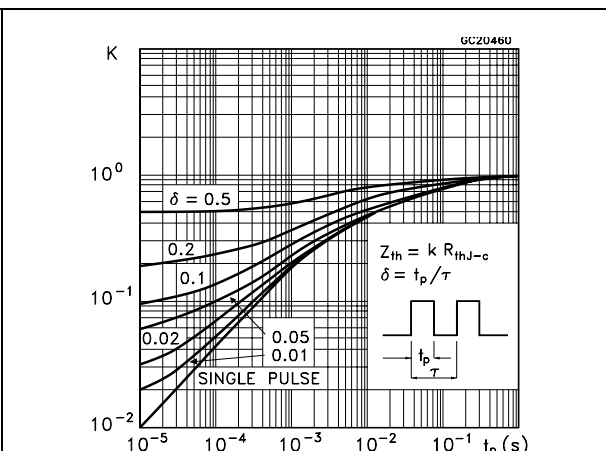
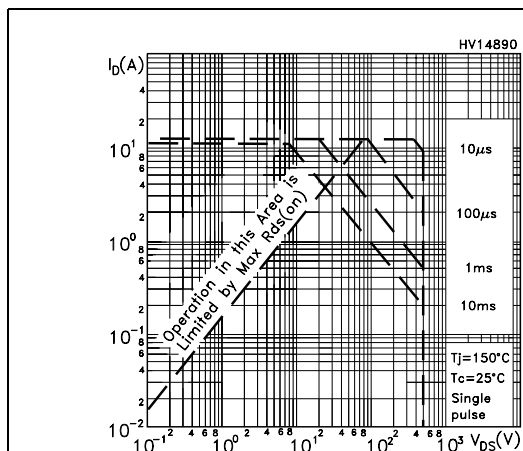


Figure 7. Output characteristics

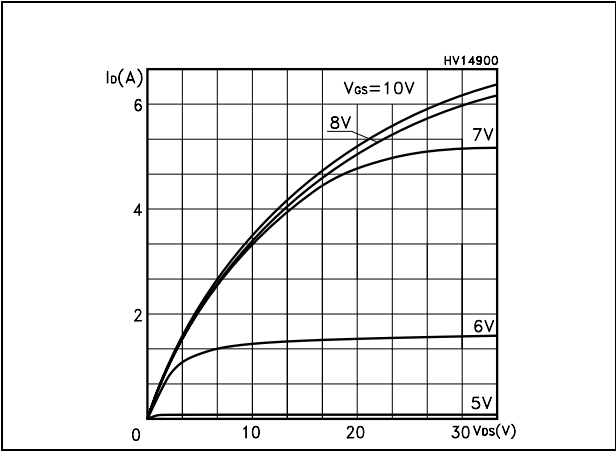


Figure 8. Transfer characteristics

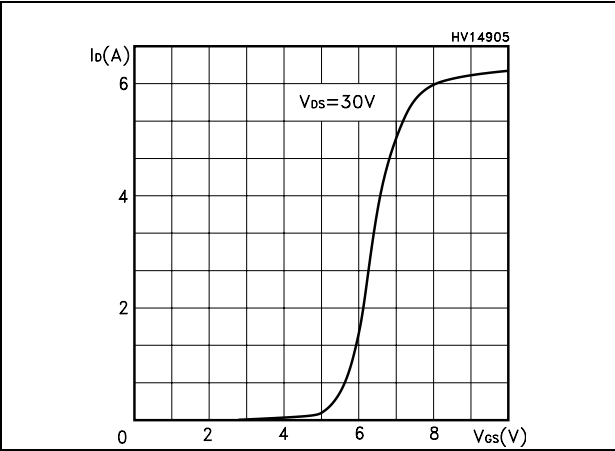


Figure 9. Transconductance

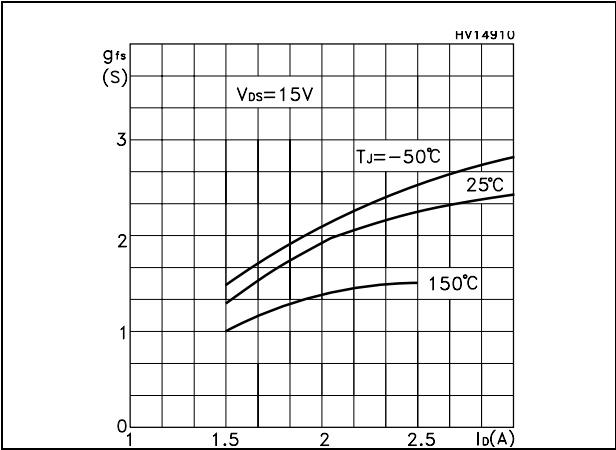


Figure 10. Static drain-source on resistance

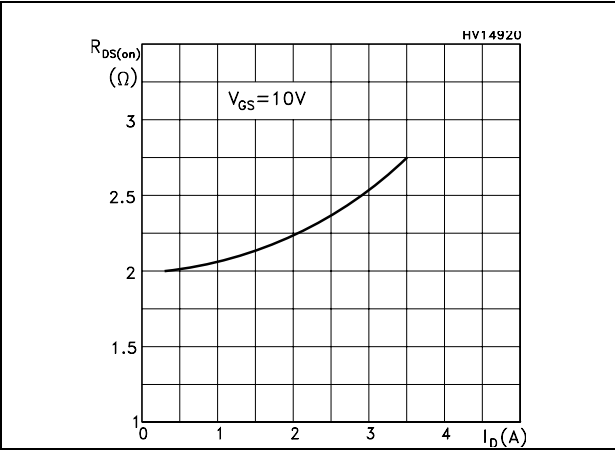


Figure 11. Gate charge vs gate-source voltage

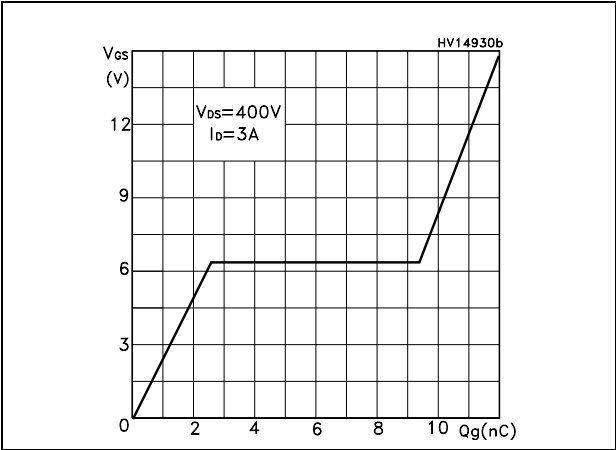


Figure 12. Capacitance variations

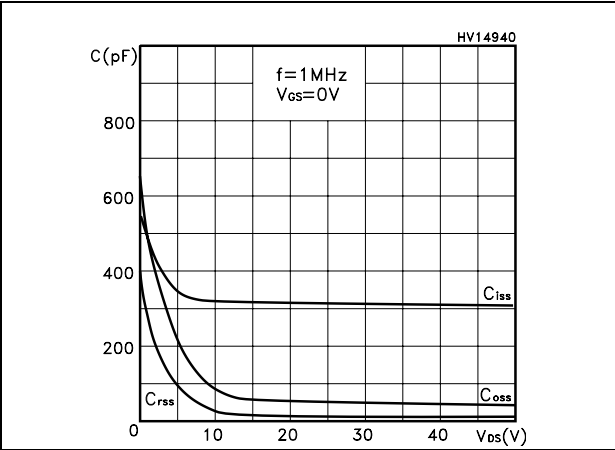


Figure 13. Normalized gate threshold voltage vs temperature

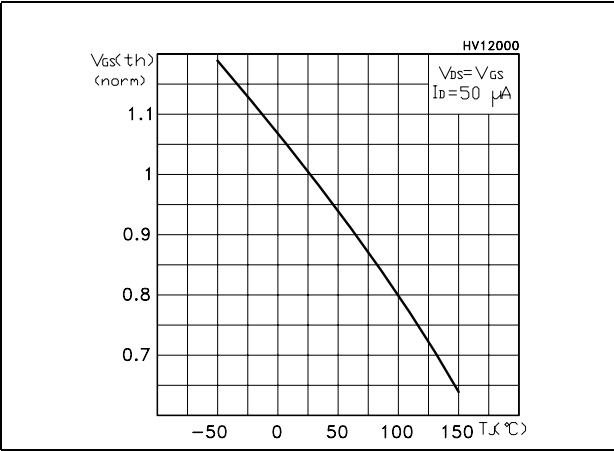


Figure 14. Normalized on resistance vs temperature

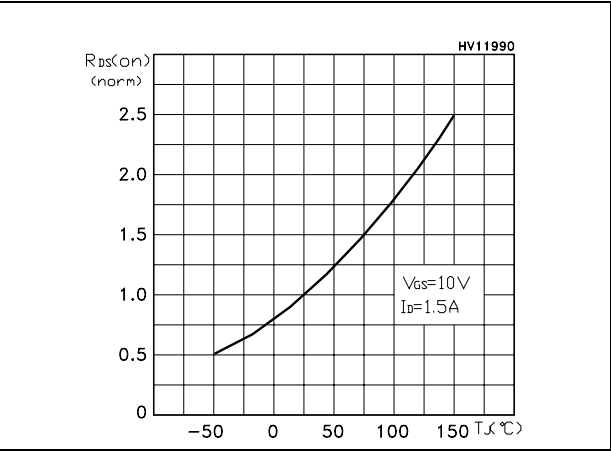


Figure 15. Source-drain diode forward characteristics

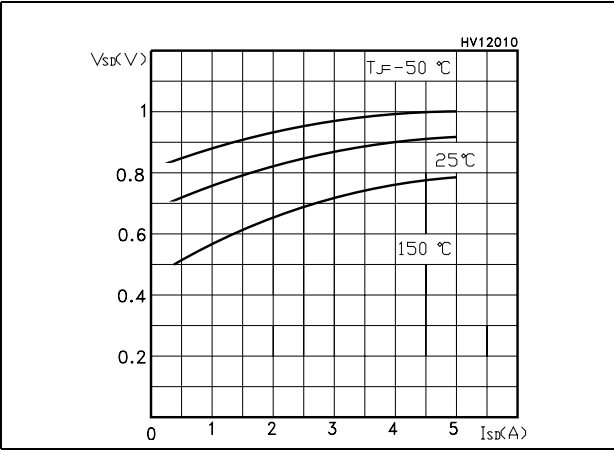


Figure 16. Normalized  $B_{VDS}$  vs temperature

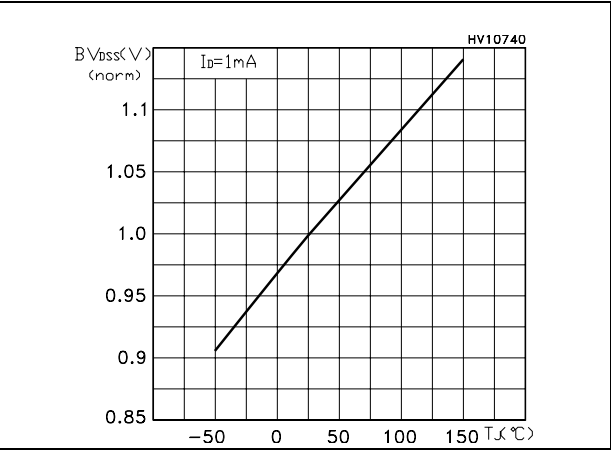
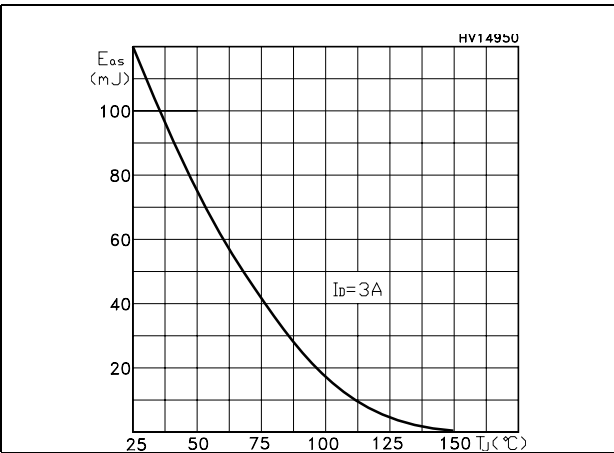


Figure 17. Maximum avalanche energy vs temperature



### 3 Test circuit

Figure 18. Switching times test circuit for resistive load

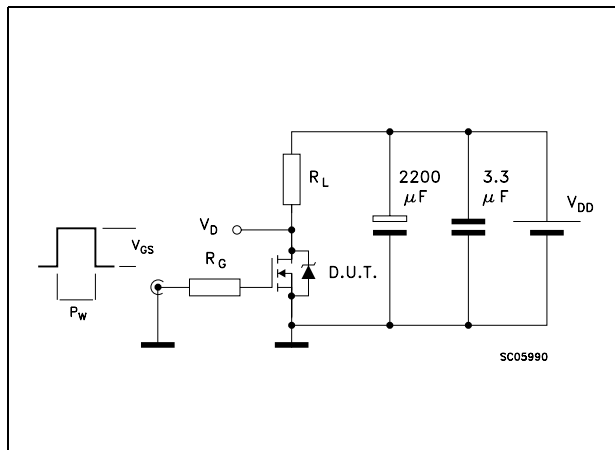


Figure 19. Gate charge test circuit

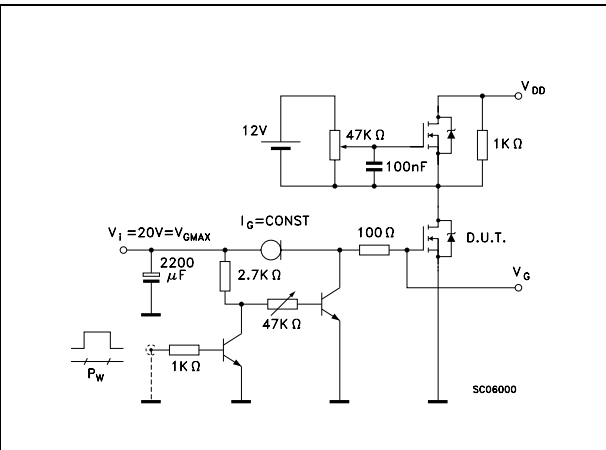


Figure 20. Test circuit for inductive load switching and diode recovery times

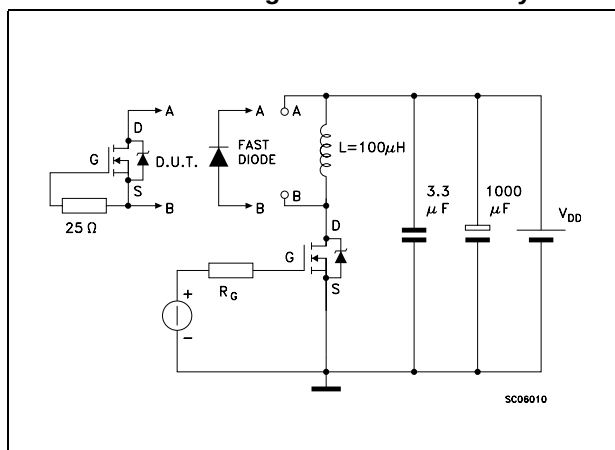


Figure 21. Unclamped inductive load test circuit

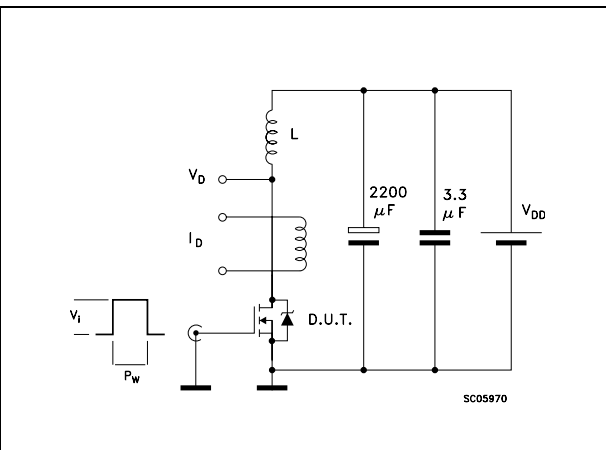


Figure 22. Unclamped inductive waveform

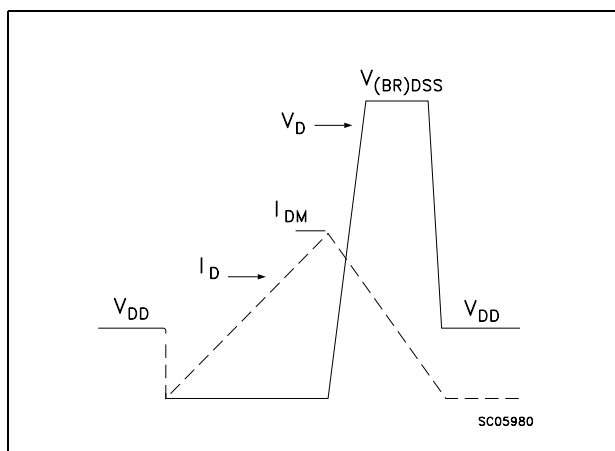
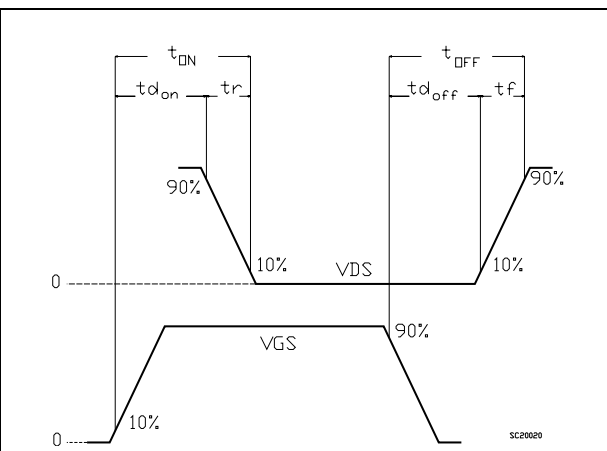


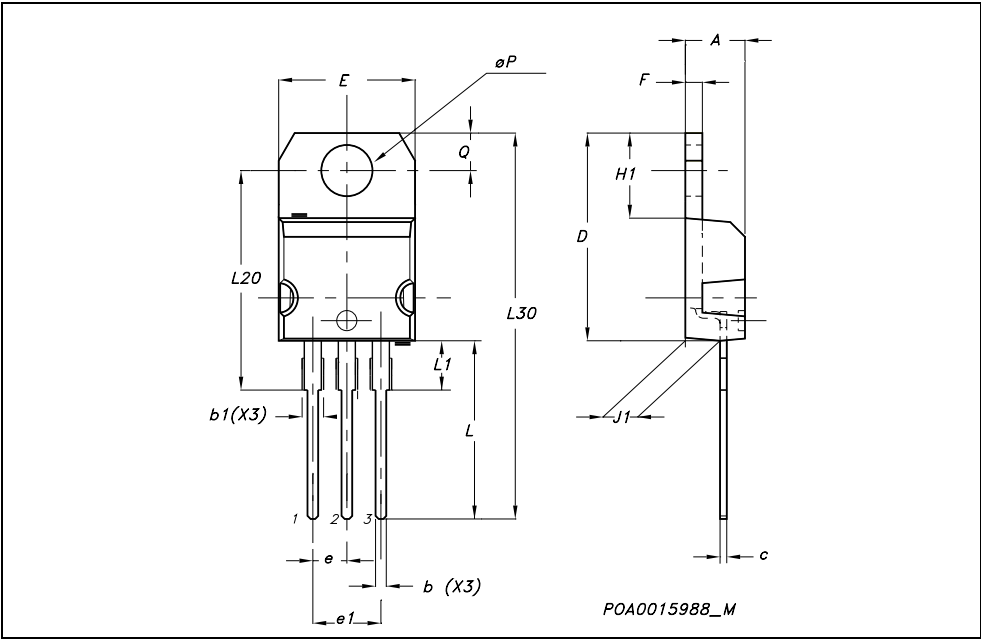
Figure 23. Switching time waveform



## 4 Package mechanical data

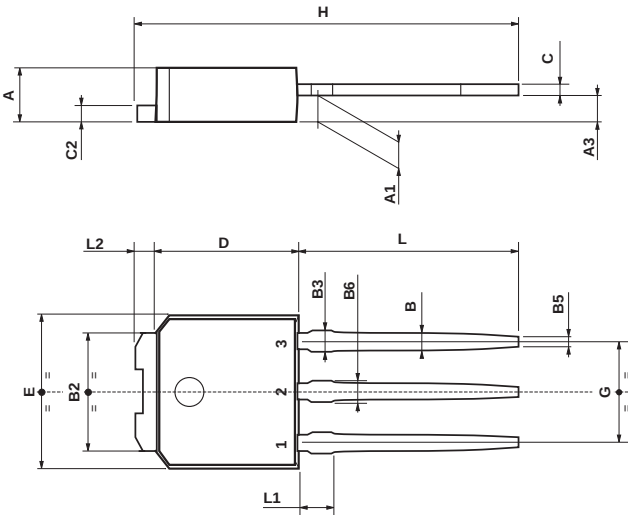
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

| 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                     | 1.15  |       | 1.70  | 0.045 |       | 0.066 |
| c                      | 0.49  |       | 0.70  | 0.019 |       | 0.027 |
| D                      | 15.25 |       | 15.75 | 0.60  |       | 0.620 |
| 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 |       | 0.052 |
| 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 |       |
| øP                     | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q                      | 2.65  |       | 2.95  | 0.104 |       | 0.116 |



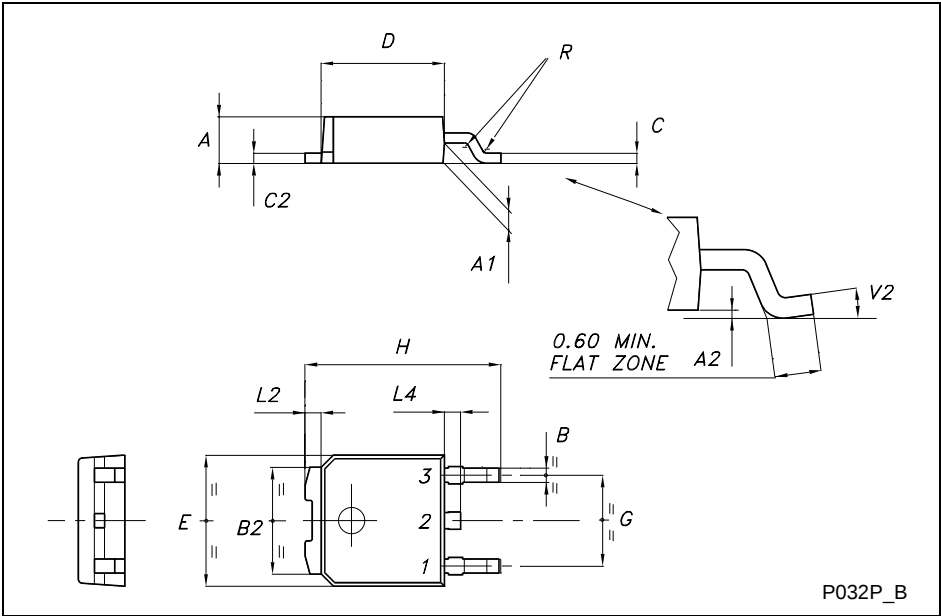
TO-251 (IPAK) MECHANICAL DATA

| DIM. | mm   |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 2.2  |      | 2.4  | 0.086 |       | 0.094 |
| A1   | 0.9  |      | 1.1  | 0.035 |       | 0.043 |
| A3   | 0.7  |      | 1.3  | 0.027 |       | 0.051 |
| B    | 0.64 |      | 0.9  | 0.025 |       | 0.031 |
| B2   | 5.2  |      | 5.4  | 0.204 |       | 0.212 |
| B3   |      |      | 0.85 |       |       | 0.033 |
| B5   |      | 0.3  |      |       | 0.012 |       |
| B6   |      |      | 0.95 |       |       | 0.037 |
| C    | 0.45 |      | 0.6  | 0.017 |       | 0.023 |
| C2   | 0.48 |      | 0.6  | 0.019 |       | 0.023 |
| D    | 6    |      | 6.2  | 0.236 |       | 0.244 |
| E    | 6.4  |      | 6.6  | 0.252 |       | 0.260 |
| G    | 4.4  |      | 4.6  | 0.173 |       | 0.181 |
| H    | 15.9 |      | 16.3 | 0.626 |       | 0.641 |
| L    | 9    |      | 9.4  | 0.354 |       | 0.370 |
| L1   | 0.8  |      | 1.2  | 0.031 |       | 0.047 |
| L2   |      | 0.8  | 1    |       | 0.031 | 0.039 |



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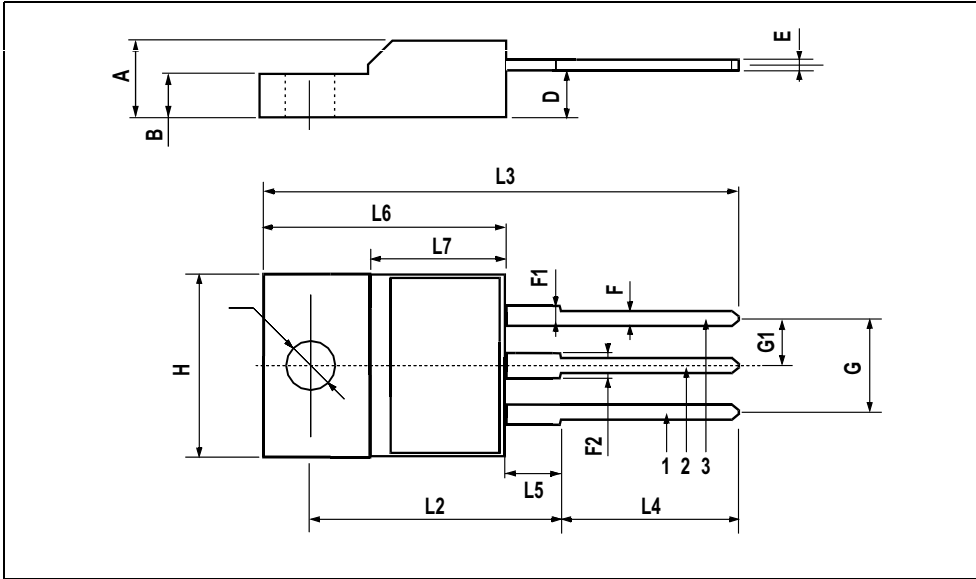
| TO-252 (DPAK) MECHANICAL DATA |      |      |       |       |       |       |
|-------------------------------|------|------|-------|-------|-------|-------|
| DIM.                          | mm   |      |       | inch  |       |       |
|                               | MIN. | TYP. | MAX.  | MIN.  | TYP.  | MAX.  |
| A                             | 2.20 |      | 2.40  | 0.087 |       | 0.094 |
| A1                            | 0.90 |      | 1.10  | 0.035 |       | 0.043 |
| A2                            | 0.03 |      | 0.23  | 0.001 |       | 0.009 |
| B                             | 0.64 |      | 0.90  | 0.025 |       | 0.035 |
| B2                            | 5.20 |      | 5.40  | 0.204 |       | 0.213 |
| C                             | 0.45 |      | 0.60  | 0.018 |       | 0.024 |
| C2                            | 0.48 |      | 0.60  | 0.019 |       | 0.024 |
| D                             | 6.00 |      | 6.20  | 0.236 |       | 0.244 |
| E                             | 6.40 |      | 6.60  | 0.252 |       | 0.260 |
| G                             | 4.40 |      | 4.60  | 0.173 |       | 0.181 |
| H                             | 9.35 |      | 10.10 | 0.368 |       | 0.398 |
| L2                            |      | 0.8  |       |       | 0.031 |       |
| L4                            | 0.60 |      | 1.00  | 0.024 |       | 0.039 |
| V2                            | 0°   |      | 8°    | 0°    |       | 0°    |



P032P\_B

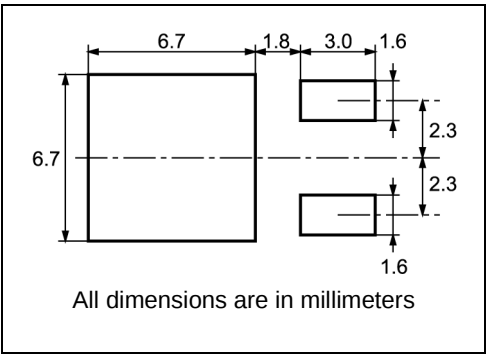
TO-220FP MECHANICAL DATA

| DIM. | mm.  |     |      | inch  |       |       |
|------|------|-----|------|-------|-------|-------|
|      | MIN. | TYP | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6  | 0.173 |       | 0.181 |
| B    | 2.5  |     | 2.7  | 0.098 |       | 0.106 |
| D    | 2.5  |     | 2.75 | 0.098 |       | 0.108 |
| E    | 0.45 |     | 0.7  | 0.017 |       | 0.027 |
| F    | 0.75 |     | 1    | 0.030 |       | 0.039 |
| F1   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| F2   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| G    | 4.95 |     | 5.2  | 0.195 |       | 0.204 |
| G1   | 2.4  |     | 2.7  | 0.094 |       | 0.106 |
| H    | 10   |     | 10.4 | 0.393 |       | 0.409 |
| L2   |      | 16  |      |       | 0.630 |       |
| L3   | 28.6 |     | 30.6 | 1.126 |       | 1.204 |
| L4   | 9.8  |     | 10.6 | .0385 |       | 0.417 |
| L5   | 2.9  |     | 3.6  | 0.114 |       | 0.141 |
| L6   | 15.9 |     | 16.4 | 0.626 |       | 0.645 |
| L7   | 9    |     | 9.3  | 0.354 |       | 0.366 |
| Ø    | 3    |     | 3.2  | 0.118 |       | 0.126 |

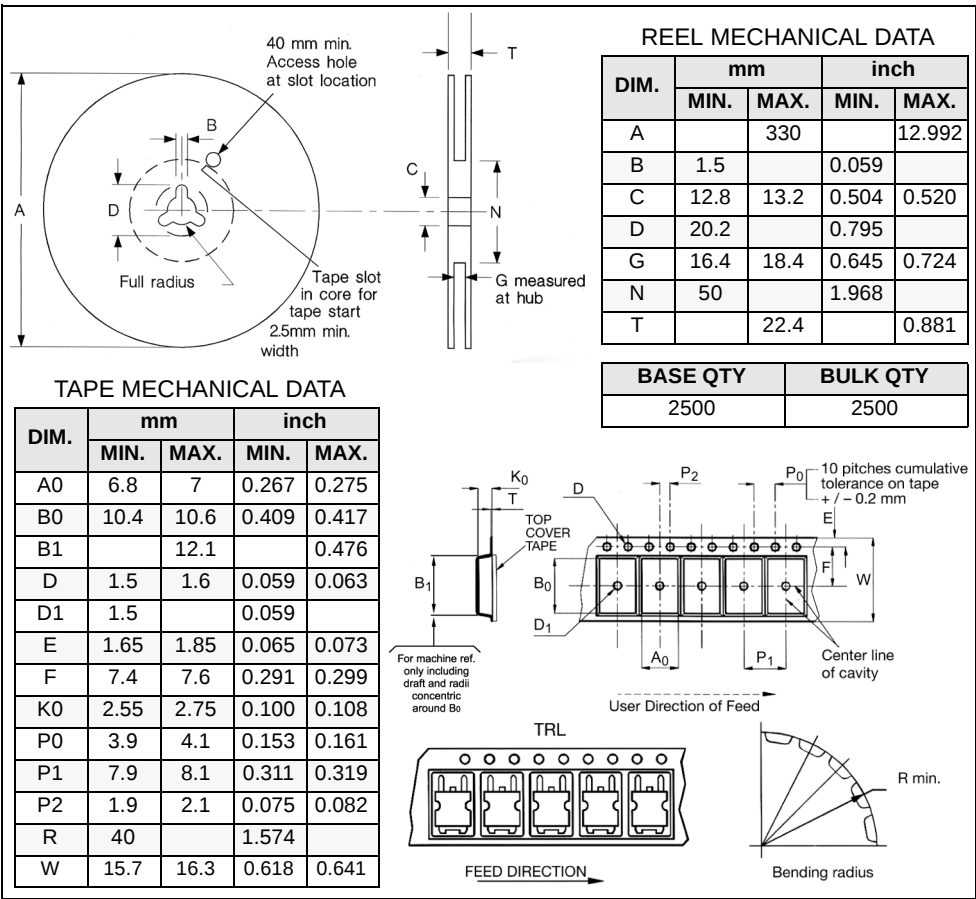


# 5 Packaging mechanical data

## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT



## 6 Revision history

**Table 9.** Revision history

| Date        | Revision | Changes                                   |
|-------------|----------|-------------------------------------------|
| 09-Feb-2006 | 1        | First Release                             |
| 20-Feb-2006 | 2        | Corrected Part Number                     |
| 27-Apr-2006 | 3        | Modified curves <a href="#">on page 6</a> |

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