



# STD1NK60 - STD1NK60-1 STQ1HNK60R - STN1HNK60

N-CHANNEL 600V - 8Ω - 1A DPAK/TO-92/IPAK/SOT-223

SuperMESH™ MOSFET

**Table 1: General Features**

| TYPE       | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>w</sub> |
|------------|------------------|---------------------|----------------|----------------|
| STD1NK60   | 600 V            | < 8.5 Ω             | 1 A            | 30 W           |
| STD1NK60-1 | 600 V            | < 8.5 Ω             | 1 A            | 30 W           |
| STQ1HNK60R | 600 V            | < 8.5 Ω             | 0.4 A          | 3 W            |
| STN1HNK60  | 600 V            | < 8.5 Ω             | 0.4 A          | 3.3 W          |

- TYPICAL R<sub>DS(on)</sub> = 8 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- ESD IMPROVED CAPABILITY
- 100% AVALANCHE TESTED
- NEW HIGH VOLTAGE BENCHMARK
- GATE CHARGE MINIMIZED

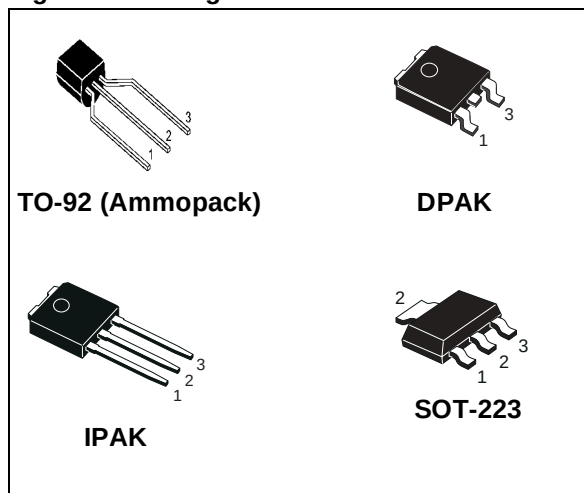
## DESCRIPTION

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications. Such series complements ST full range of high voltage MOSFETs including revolutionary MDmesh™ products.

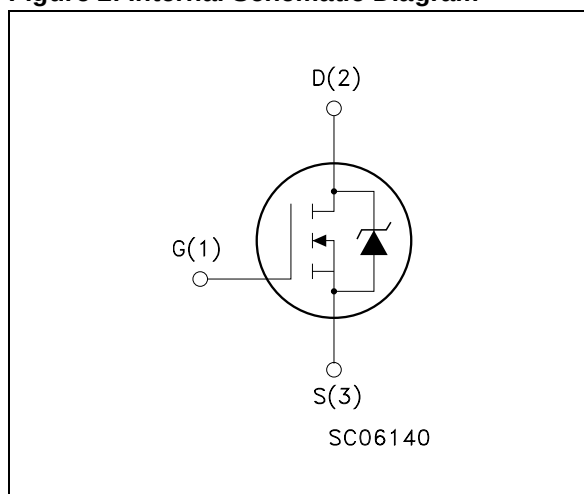
## APPLICATIONS

- LOW POWER BATTERY CHARGERS
- SWITCH MODE LOW POWER SUPPLIES(SMPS)
- LOW POWER, BALLAST, CFL (COMPACT FLUORESCENT LAMPS)

**Figure 1: Package**



**Figure 2: Internal Schematic Diagram**



**Table 2: Order Codes**

| Part Number   | Marking | Package | Packaging   |
|---------------|---------|---------|-------------|
| STD1NK60T4    | D1NK60  | DPAK    | TAPE & REEL |
| STD1NK60-1    | D1NK60  | IPAK    | TUBE        |
| STQ1HNK60R    | 1HNK60R | TO-92   | BULK        |
| STQ1HNK60R-AP | 1HNK60R | TO-92   | AMMOPAK     |
| STN1HNK60     | N1HNK60 | SOT-223 | TAPE & REEL |

Rev. 3

## STD1NK60 - STD1NK60-1 - STQ1HNK60R - STN1HNK60

**Table 3: Absolute Maximum ratings**

| Symbol             | Parameter                                               | Value       |       |         | Unit                |
|--------------------|---------------------------------------------------------|-------------|-------|---------|---------------------|
|                    |                                                         | DPAK / IPAK | TO-92 | SOT-223 |                     |
| $V_{DS}$           | Drain-source Voltage ( $V_{GS} = 0$ )                   | 600         |       |         | V                   |
| $V_{DGR}$          | Drain-gate Voltage ( $R_{GS} = 20\text{ k}\Omega$ )     | 600         |       |         | V                   |
| $V_{GS}$           | Gate- source Voltage                                    | $\pm 30$    |       |         | V                   |
| $I_D$              | Drain Current (continuous) at $T_C = 25^\circ\text{C}$  | 1.0         | 0.4   | 0.4     | A                   |
| $I_D$              | Drain Current (continuous) at $T_C = 100^\circ\text{C}$ | 0.63        | 0.25  | 0.25    | A                   |
| $I_{DM}(\bullet)$  | Drain Current (pulsed)                                  | 4           | 1.6   | 1.6     | A                   |
| $P_{TOT}$          | Total Dissipation at $T_C = 25^\circ\text{C}$           | 30          | 3     | 3.3     | W                   |
|                    | Derating Factor                                         | 0.24        | 0.025 | 0.025   | W/ $^\circ\text{C}$ |
| $dv/dt(1)$         | Peak Diode Recovery voltage slope                       | 3           |       |         | V/ns                |
| $T_j$<br>$T_{stg}$ | Operating Junction Temperature<br>Storage Temperature   | -55 to 150  |       |         | $^\circ\text{C}$    |

( $\bullet$ ) Pulse width limited by safe operating area

(1)  $I_{SD} \leq 1.0\text{A}$ ,  $di/dt \leq 100\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_j \leq T_{jMAX}$ .

**Table 4: Thermal Data**

|           |                                                | DPAK/IPAK | TO-92 | SOT-223   | Unit                      |
|-----------|------------------------------------------------|-----------|-------|-----------|---------------------------|
| Rthj-case | Thermal Resistance Junction-case Max           | 4.16      | --    | --        | $^\circ\text{C}/\text{W}$ |
| Rthj-amb  | Thermal Resistance Junction-ambient Max        | 100       | 120   | 37.87 (#) | $^\circ\text{C}/\text{W}$ |
| Rthj-lead | Thermal Resistance Junction-lead Max           | --        | 40    | --        | $^\circ\text{C}/\text{W}$ |
| $T_l$     | Maximum Lead Temperature For Soldering Purpose | 275       | 260   |           | $^\circ\text{C}$          |

(#) When mounted on FR-4 board of 1 in<sup>2</sup>, 2oz Cu, t < 10 sec

**Table 5: Avalanche Characteristics**

| Symbol   | Parameter                                                                                                    | Max Value | Unit |
|----------|--------------------------------------------------------------------------------------------------------------|-----------|------|
| $I_{AR}$ | Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by $T_j$ max)                           | 1         | A    |
| $E_{AS}$ | Single Pulse Avalanche Energy (starting $T_j = 25^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 25        | mJ   |

## ELECTRICAL CHARACTERISTICS ( $T_{CASE} = 25^\circ\text{C}$ UNLESS OTHERWISE SPECIFIED)

**Table 6: On/Off**

| Symbol        | Parameter                                        | Test Conditions                                                                          | Min. | Typ. | Max.      | Unit                           |
|---------------|--------------------------------------------------|------------------------------------------------------------------------------------------|------|------|-----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source Breakdown Voltage                   | $I_D = 1\text{mA}$ , $V_{GS} = 0$                                                        | 600  |      |           | V                              |
| $I_{DSS}$     | Zero Gate Voltage Drain Current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ , $T_C = 125^\circ\text{C}$ |      |      | 1<br>50   | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body Leakage Current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 30\text{V}$                                                                |      |      | $\pm 100$ | nA                             |
| $V_{GS(th)}$  | Gate Threshold Voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                       | 2.25 | 3    | 3.7       | V                              |
| $R_{DS(on)}$  | Static Drain-source On Resistance                | $V_{GS} = 10\text{V}$ , $I_D = 0.5\text{ A}$                                             |      | 8    | 8.5       | $\Omega$                       |

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Table 7: Dynamic**

| Symbol       | Parameter                    | Test Conditions                                                                                                                     | Min. | Typ. | Max. | Unit |
|--------------|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $g_{fs}$ (1) | Forward Transconductance     | $V_{DS} = 15\text{ V}$ , $I_D = 0.5\text{ A}$                                                                                       |      | 1    |      | S    |
| $C_{iss}$    | Input Capacitance            | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0$                                                                          |      | 156  |      | pF   |
| $C_{oss}$    | Output Capacitance           |                                                                                                                                     |      | 23.5 |      | pF   |
| $C_{rss}$    | Reverse Transfer Capacitance |                                                                                                                                     |      | 3.8  |      | pF   |
| $t_{d(on)}$  | Turn-on Delay Time           | $V_{DD} = 300\text{ V}$ , $I_D = 0.5\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(Resistive Load see, Figure 21) |      | 6.5  |      | ns   |
| $t_r$        | Rise Time                    |                                                                                                                                     |      | 5    |      | ns   |
| $t_{d(off)}$ | Turn-off Delay Time          |                                                                                                                                     |      | 19   |      | ns   |
| $t_f$        | Fall Time                    |                                                                                                                                     |      | 25   |      | ns   |
| $Q_g$        | Total Gate Charge            | $V_{DD} = 480\text{ V}$ , $I_D = 1\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ , $R_G = 4.7\ \Omega$<br>(see, Figure 23)                  |      | 7    | 10   | nC   |
| $Q_{gs}$     | Gate-Source Charge           |                                                                                                                                     |      | 1.1  |      | nC   |
| $Q_{gd}$     | Gate-Drain Charge            |                                                                                                                                     |      | 3.7  |      | nC   |

**Table 8: Source Drain Diode**

| Symbol        | Parameter                     | Test Conditions                                                                                                                                     | Min. | Typ. | Max. | Unit          |
|---------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$      | Source-drain Current          |                                                                                                                                                     |      |      | 1    | A             |
| $I_{SDM}$ (2) | Source-drain Current (pulsed) |                                                                                                                                                     |      |      | 4    | A             |
| $V_{SD}$ (1)  | Forward On Voltage            | $I_{SD} = 1.0\text{ A}$ , $V_{GS} = 0$                                                                                                              |      |      | 1.6  | V             |
| $t_{rr}$      | Reverse Recovery Time         | $I_{SD} = 1.0\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 25\text{ V}$ , $T_j = 25^\circ\text{C}$<br>(see test circuit, Figure 22)  |      | 140  |      | ns            |
| $Q_{rr}$      | Reverse Recovery Charge       |                                                                                                                                                     |      | 240  |      | $\mu\text{C}$ |
| $I_{RRM}$     | Reverse Recovery Current      |                                                                                                                                                     |      | 3.3  |      | A             |
| $t_{rr}$      | Reverse Recovery Time         | $I_{SD} = 1.0\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 25\text{ V}$ , $T_j = 150^\circ\text{C}$<br>(see test circuit, Figure 22) |      | 229  |      | ns            |
| $Q_{rr}$      | Reverse Recovery Charge       |                                                                                                                                                     |      | 377  |      | $\mu\text{C}$ |
| $I_{RRM}$     | Reverse Recovery Current      |                                                                                                                                                     |      | 3.3  |      | A             |

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

(2) Pulse width limited by safe operating area.

Figure 3: Safe Operating Area For SOT-223

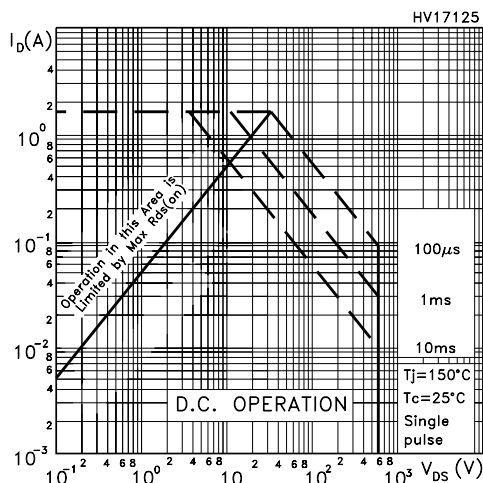


Figure 4: Safe Operating Area For DPAK/IPAK

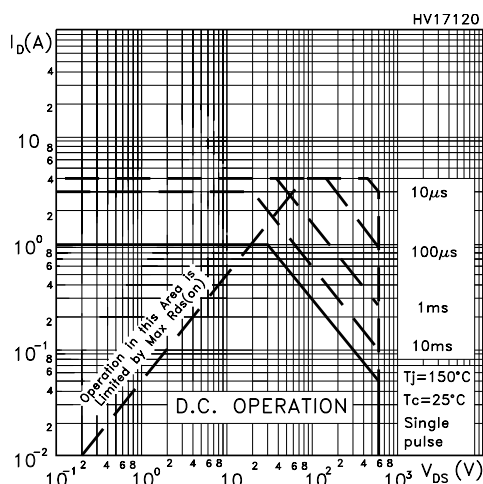


Figure 5: Safe Operating Area For TO-92

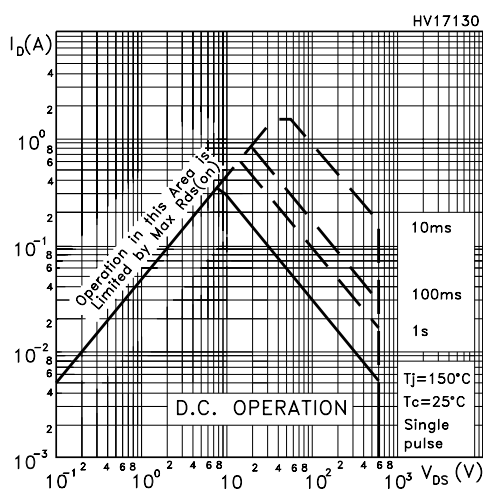


Figure 6: Thermal Impedance For SOT-223

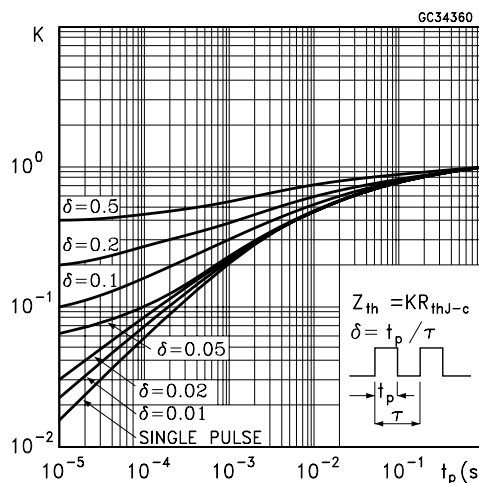


Figure 7: Thermal Impedance For DPAK/IPAK

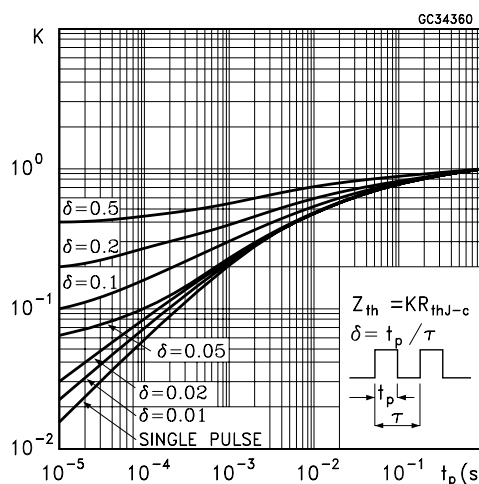


Figure 8: Thermal Impedance For TO-92

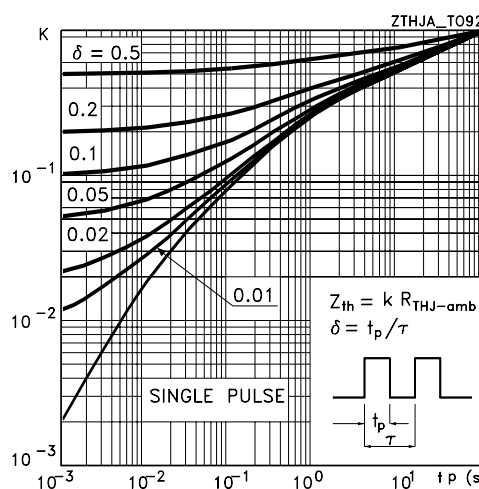


Figure 9: Output Characteristics

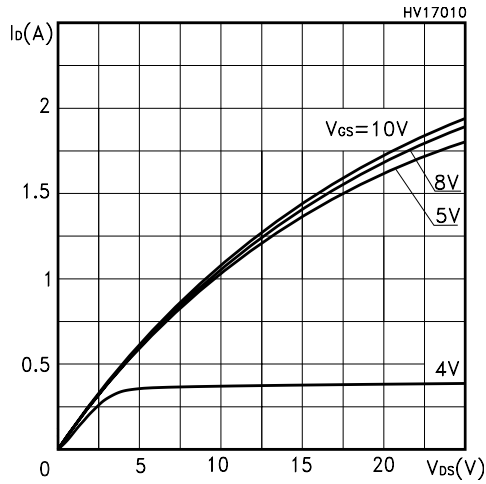


Figure 10: Transconductance

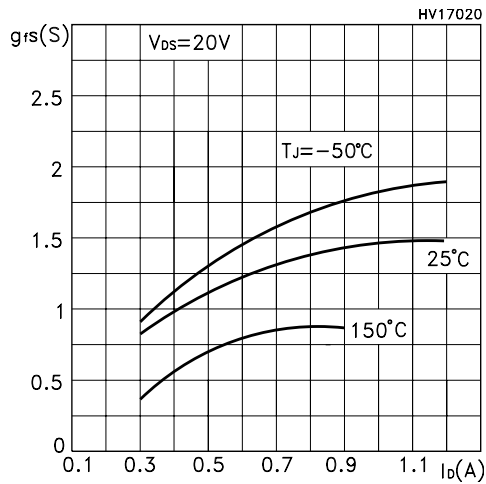


Figure 11: Capacitance Variations

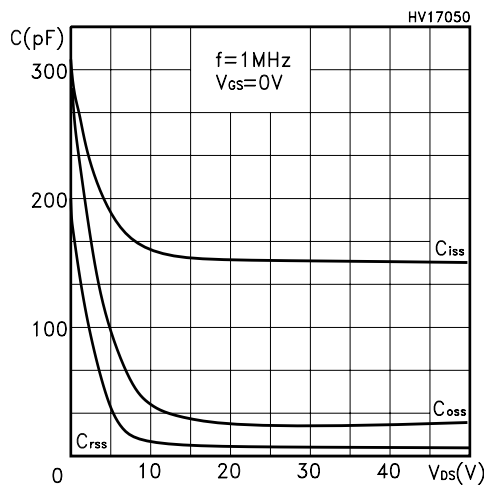


Figure 12: Transfer Characteristics

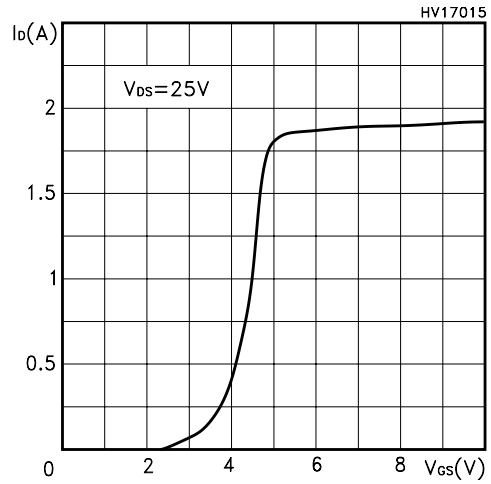


Figure 13: Gate Charge vs Gate-source Voltage

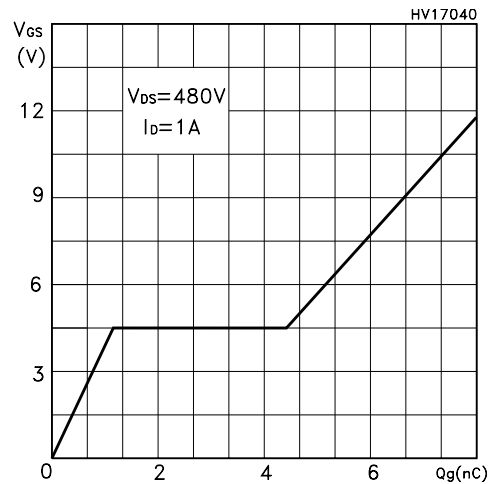


Figure 14: Static Drain-source On Resistance

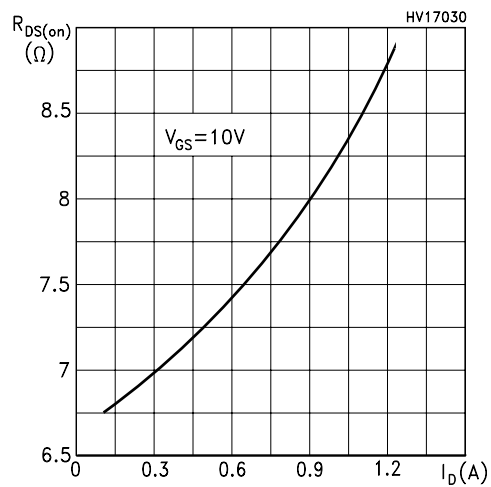


Figure 15: Normalized Gate Threshold Voltage vs Temperature

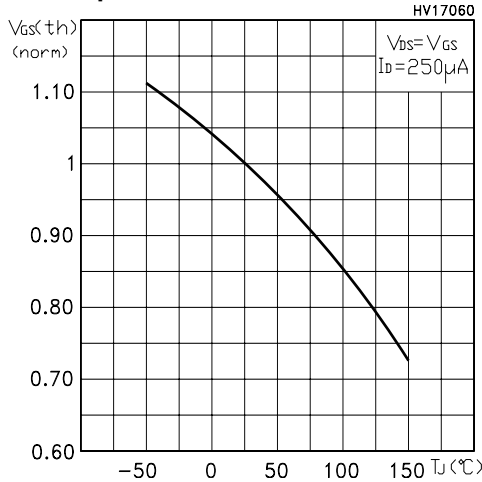


Figure 16: Source-Drain Forward Characteristics

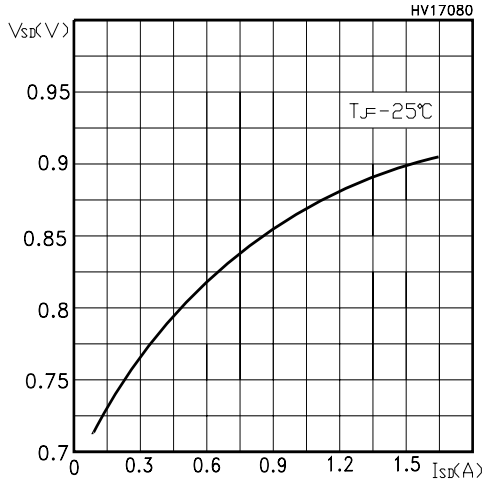


Figure 17: Maximum Avalanche Energy vs Temperature

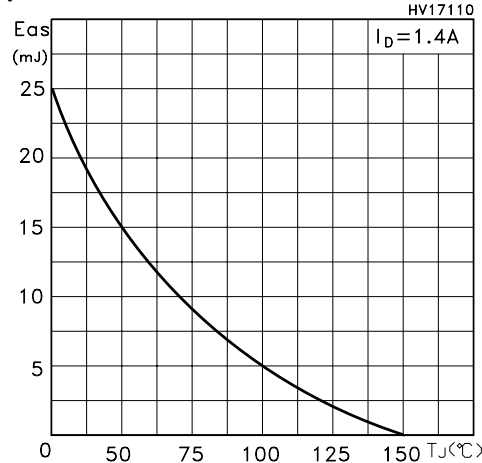


Figure 18: Normalized On Resistance vs Temperature

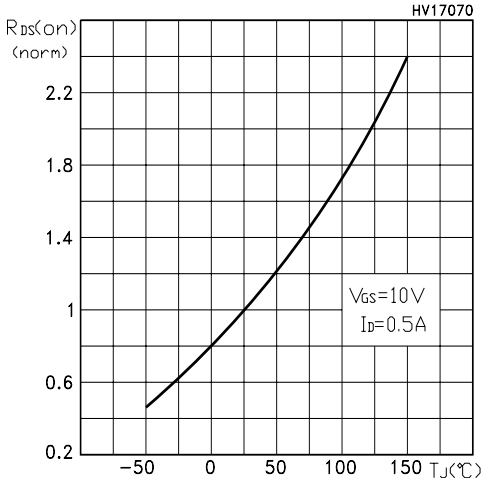


Figure 19: Normalized BV<sub>DSS</sub> vs Temperature

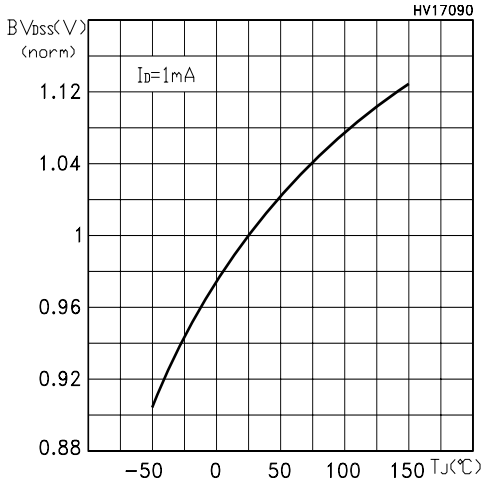
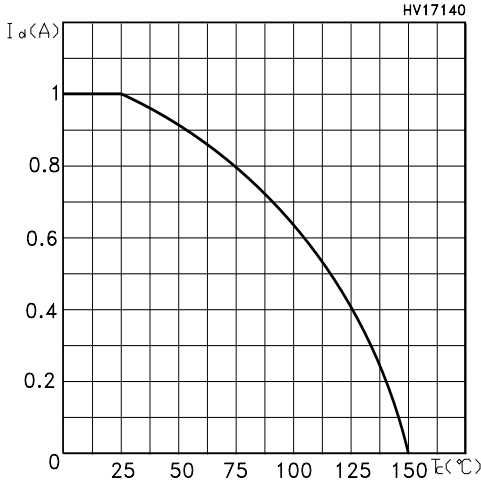
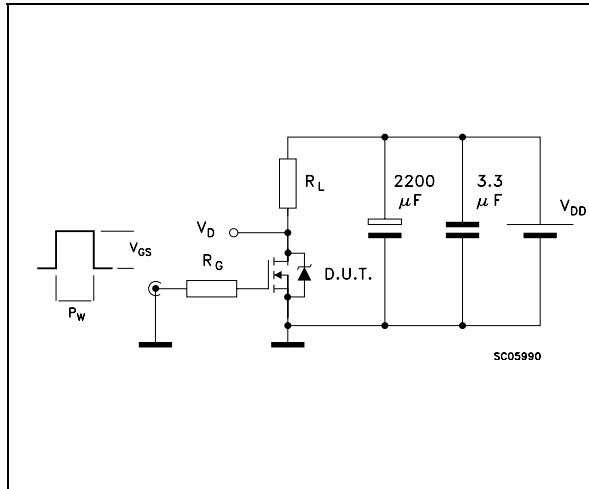


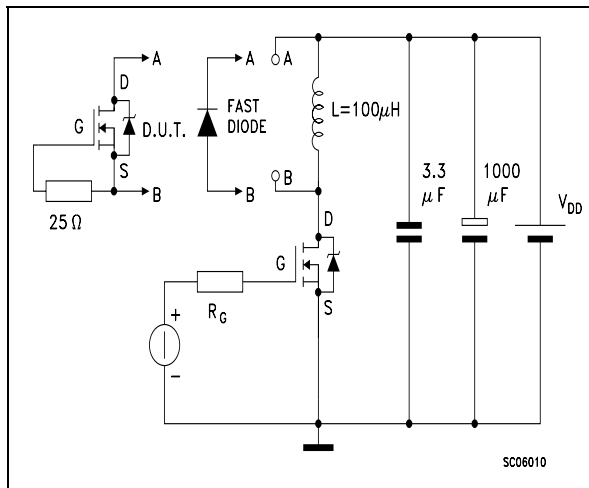
Figure 20: Max Id Current vs Tc



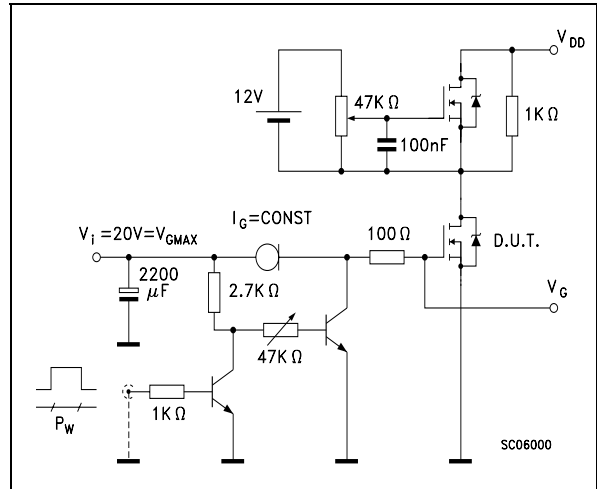
**Figure 21: Switching Times Test Circuit For Resistive Load**



**Figure 22: Test Circuit For Inductive Load Switching and Diode Recovery Times**

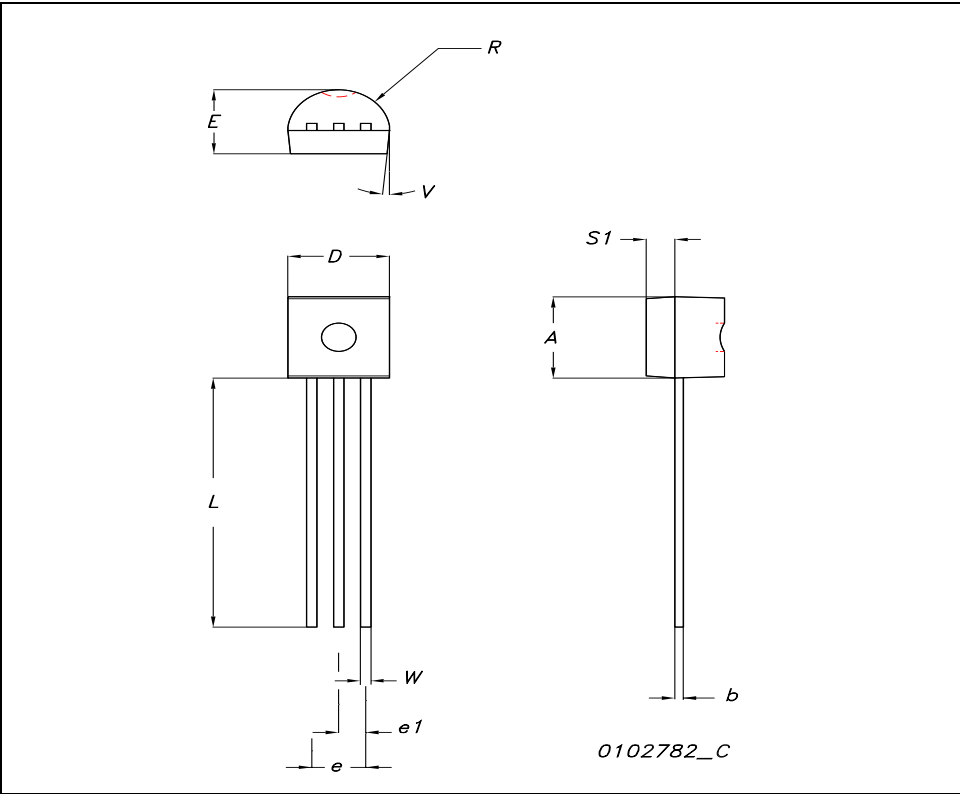


**Figure 23: Gate Charge Test Circuit**



TO-92 MECHANICAL DATA

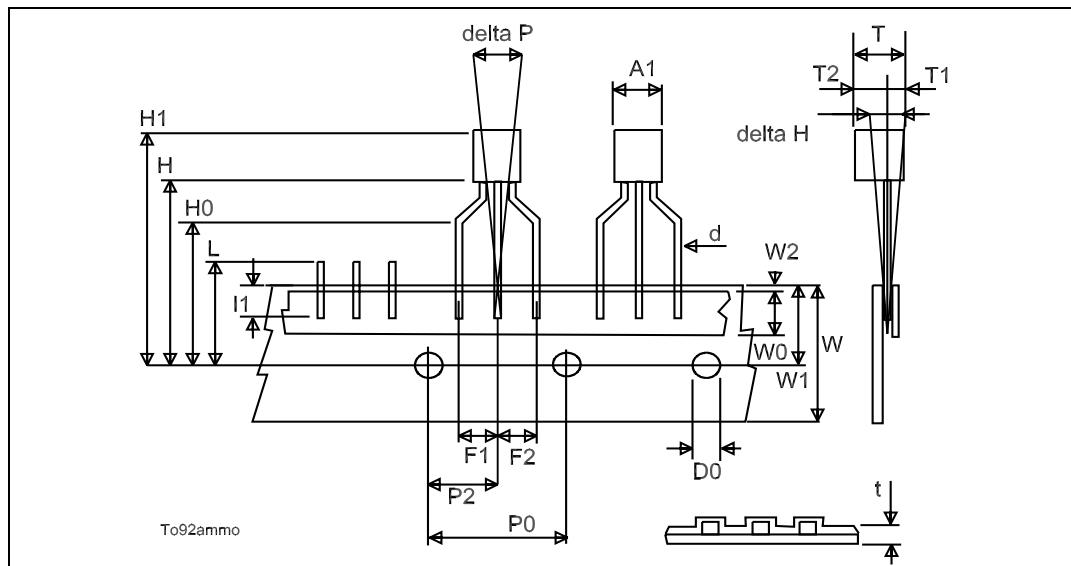
| DIM. | mm.   |      |       | inch  |      |       |
|------|-------|------|-------|-------|------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP. | MAX.  |
| A    | 4.32  |      | 4.95  | 0.170 |      | 0.194 |
| b    | 0.36  |      | 0.51  | 0.014 |      | 0.020 |
| D    | 4.45  |      | 4.95  | 0.175 |      | 0.194 |
| E    | 3.30  |      | 3.94  | 0.130 |      | 0.155 |
| e    | 2.41  |      | 2.67  | 0.094 |      | 0.105 |
| e1   | 1.14  |      | 1.40  | 0.044 |      | 0.055 |
| L    | 12.70 |      | 15.49 | 0.50  |      | 0.610 |
| R    | 2.16  |      | 2.41  | 0.085 |      | 0.094 |
| S1   | 0.92  |      | 1.52  | 0.036 |      | 0.060 |
| W    | 0.41  |      | 0.56  | 0.016 |      | 0.022 |
| V    |       | 5°   |       |       | 5°   |       |





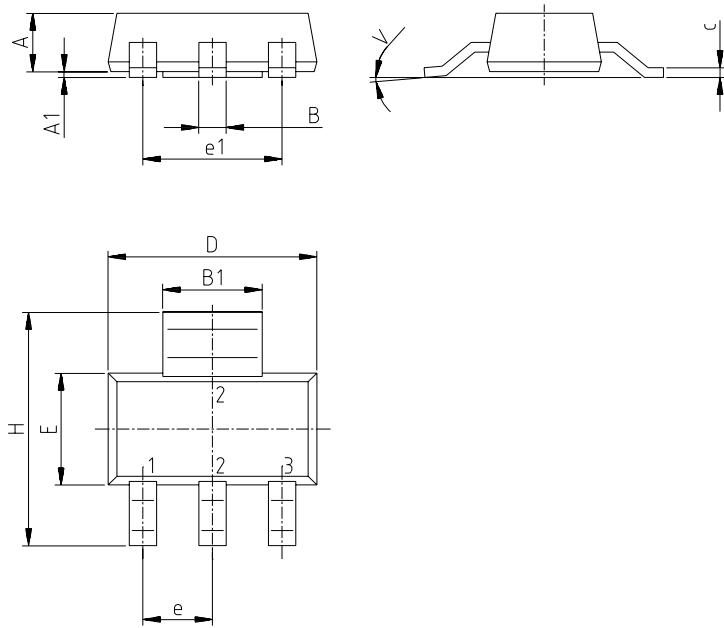
TO-92 AMMOPACK

| DIM.    | mm.  |      |      | inch  |       |       |
|---------|------|------|------|-------|-------|-------|
|         | MIN. | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A1      | 4.45 |      | 4.95 | 0.170 |       | 0.194 |
| T       | 3.30 |      | 3.94 | 0.130 |       | 0.155 |
| T1      |      |      | 1.6  |       |       | 0.06  |
| T2      |      |      | 2.3  |       |       | 0.09  |
| d       | 0.41 |      | 0.56 | 0.016 |       | 0.022 |
| P0      | 12.5 | 12.7 | 12.9 | 0.49  | 0.5   | 0.51  |
| P2      | 5.65 | 6.35 | 7.05 | 0.22  | 0.25  | 0.27  |
| F1, F2  | 2.44 | 2.54 | 2.94 | 0.09  | 0.1   | 0.11  |
| delta H | -2   |      | 2    | -0.08 |       | 0.08  |
| W       | 17.5 | 18   | 19   | 0.69  | 0.71  | 0.74  |
| W0      | 5.7  | 6    | 6.3  | 0.22  | 0.23  | 0.24  |
| W1      | 8.5  | 9    | 9.25 | 0.33  | 0.35  | 0.36  |
| W2      |      |      | 0.5  |       |       | 0.02  |
| H       | 18.5 |      | 20.5 | 0.72  |       | 0.80  |
| H0      | 15.5 | 16   | 16.5 | 0.61  | 0.63  | 0.65  |
| H1      |      |      | 25   |       |       | 0.98  |
| D0      | 3.8  | 4    | 4.2  | 0.15  | 0.157 | 0.16  |
| t       |      |      | 0.9  |       |       | 0.035 |
| L       |      |      | 11   |       |       | 0.43  |
| l1      | 3    |      |      | 0.11  |       |       |
| delta P | -1   |      | 1    | -0.04 |       | 0.04  |



SOT-223 MECHANICAL DATA

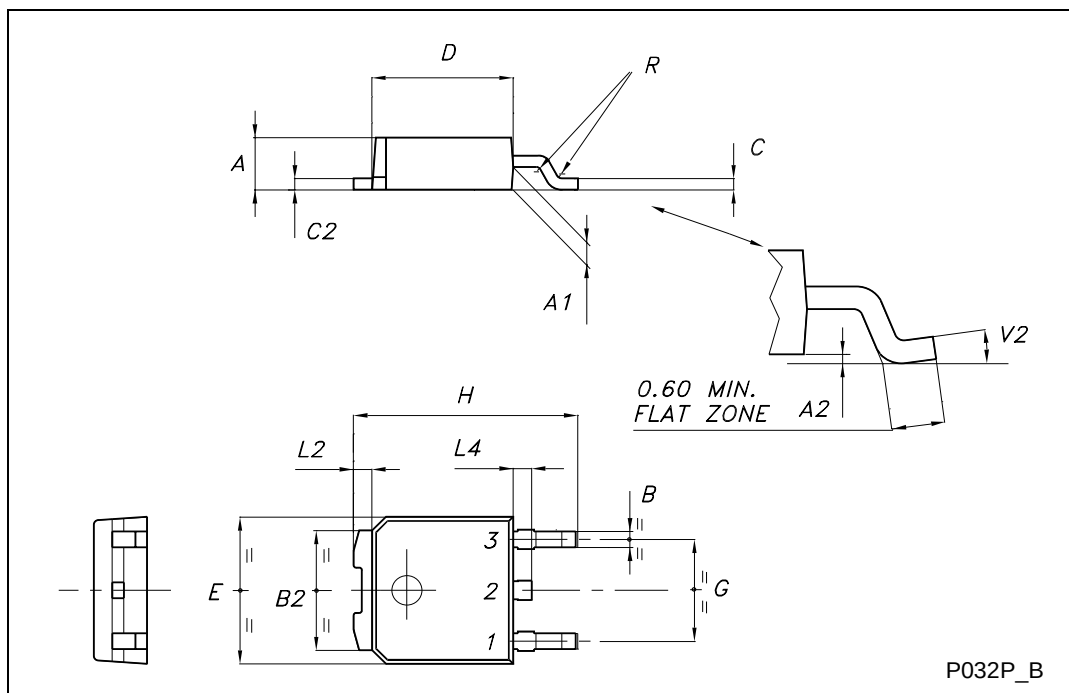
| DIM. | mm   |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A    |      |      | 1.80 |       |       | 0.071 |
| B    | 0.60 | 0.70 | 0.80 | 0.024 | 0.027 | 0.031 |
| B1   | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| c    | 0.24 | 0.26 | 0.32 | 0.009 | 0.010 | 0.013 |
| D    | 6.30 | 6.50 | 6.70 | 0.248 | 0.256 | 0.264 |
| e    |      | 2.30 |      |       | 0.090 |       |
| e1   |      | 4.60 |      |       | 0.181 |       |
| E    | 3.30 | 3.50 | 3.70 | 0.130 | 0.138 | 0.146 |
| H    | 6.70 | 7.00 | 7.30 | 0.264 | 0.276 | 0.287 |
| V    |      |      | 10°  |       |       | 10°   |
| A1   |      | 0.02 |      |       |       |       |



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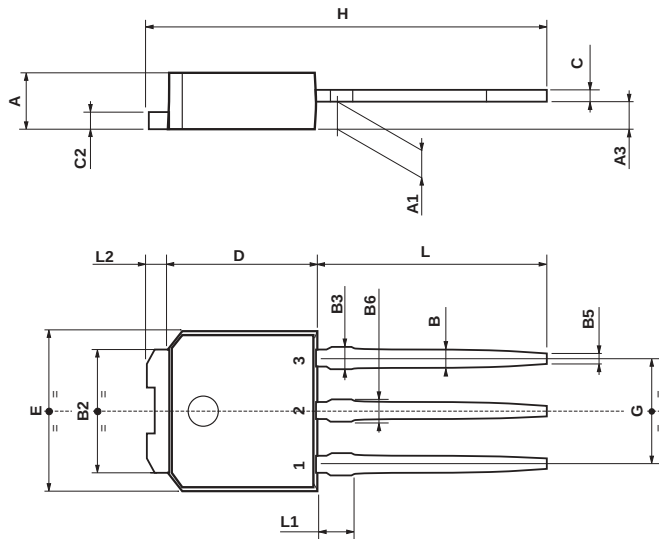
TO-252 (DPAK) MECHANICAL DATA

| 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°    |



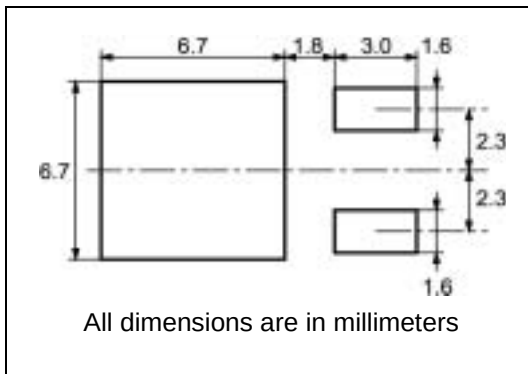
TO-251 (IPAK) MECHANICAL DATA

| 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 |

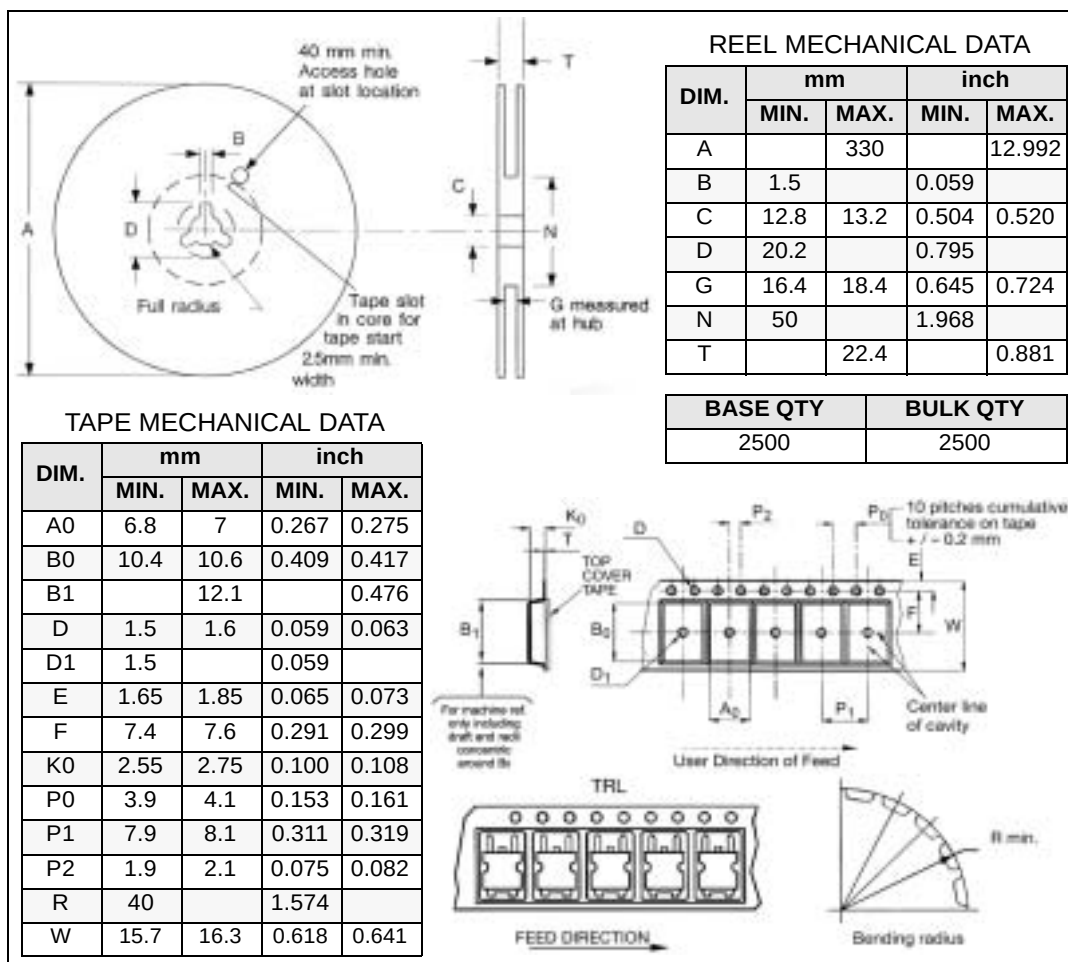


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## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT



**Table 9: Revision History**

| <b>Date</b> | <b>Revision</b> | <b>Description of Changes</b>            |
|-------------|-----------------|------------------------------------------|
| 22-Nov-2004 | 2               | Added SOT-223 Package and new stylesheet |
| 14-Feb-2006 | 3               | Modified marking on Table 2              |

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