



# STW24NM65N-STI24NM65N-STF24NM65N STB24NM65N - STP24NM65N

N-channel 650 V - 0.16  $\Omega$  - 19 A - TO-220 - TO-220FP - D<sup>2</sup>PAK  
I<sup>2</sup>PAK - TO-247 second generation MDmesh™ Power MOSFET

## Features

| Type       | V <sub>DSS</sub><br>(@T <sub>J</sub> max) | R <sub>DS(on)</sub> max | I <sub>D</sub>      |
|------------|-------------------------------------------|-------------------------|---------------------|
| STB24NM65N | 710 V                                     | < 0.19 $\Omega$         | 19 A                |
| STI24NM65N | 710 V                                     | < 0.19 $\Omega$         | 19 A                |
| STF24NM65N | 710 V                                     | < 0.19 $\Omega$         | 19 A <sup>(1)</sup> |
| STP24NM65N | 710 V                                     | < 0.19 $\Omega$         | 19 A                |
| STW24NM65N | 710 V                                     | < 0.19 $\Omega$         | 19 A                |

1. Limited only by maximum temperature allowed

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

## Application

- Switching applications

## Description

This series of devices is designed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a new vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

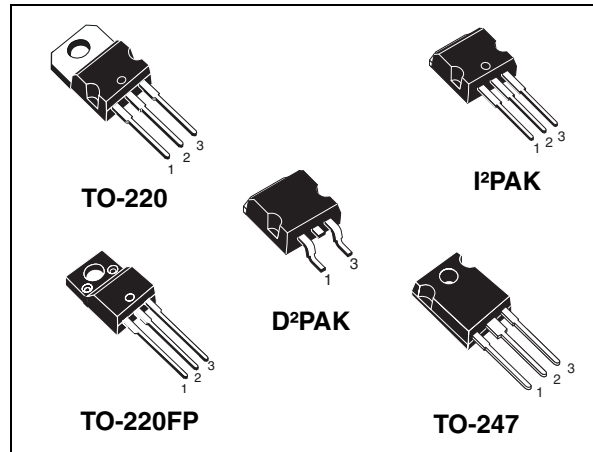


Figure 1. Internal schematic diagram

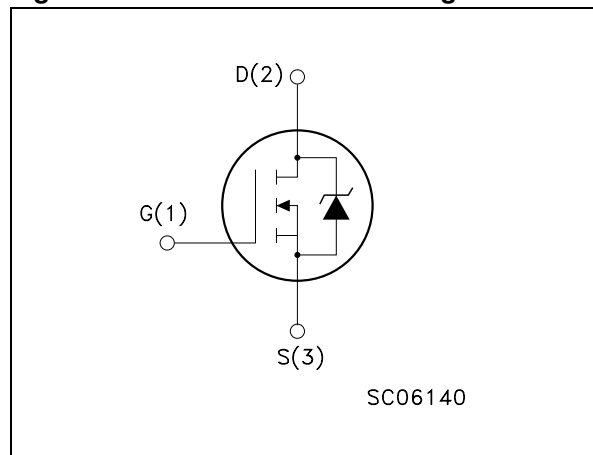


Table 1. Device summary

| Order codes | Marking | Package            | Packaging     |
|-------------|---------|--------------------|---------------|
| STB24NM65N  | 24NM65N | D <sup>2</sup> PAK | Tape and reel |
| STI24NM65N  | 24NM65N | I <sup>2</sup> PAK | Tube          |
| STF24NM65N  | 24NM65N | TO-220FP           | Tube          |
| STP24NM65N  | 24NM65N | TO-220             | Tube          |
| STW24NM65N  | 24NM65N | TO-247             | Tube          |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                                                                                                                        | Value                                                  |                   | Unit               |
|----------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------------------|--------------------|
|                |                                                                                                                                  | TO-220/I <sup>2</sup> PAK<br>TO-247/D <sup>2</sup> PAK | TO-220FP          |                    |
| $V_{DS}$       | Drain-source voltage ( $V_{GS}=0$ )                                                                                              | 650                                                    |                   | V                  |
| $V_{GS}$       | Gate-source voltage                                                                                                              | $\pm 25$                                               |                   | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                 | 19                                                     | 19 <sup>(1)</sup> | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                | 12                                                     | 12 <sup>(1)</sup> | A                  |
| $I_{DM}^{(2)}$ | Drain current (pulsed)                                                                                                           | 76                                                     | 76 <sup>(1)</sup> | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                          | 160                                                    | 40                | W                  |
| $dv/dt^{(3)}$  | Peak diode recovery voltage slope                                                                                                | 15                                                     |                   | V/ns               |
| $V_{ISO}$      | Insulation withstand voltage (RMS) from all three leads to external heat sink ( $t=1\text{ s}; T_C=25\text{ }^{\circ}\text{C}$ ) | --                                                     | 2500              | V                  |
| $T_{stg}$      | Storage temperature                                                                                                              | -55 to 150                                             |                   | $^{\circ}\text{C}$ |
| $T_J$          | Max. operating junction temperature                                                                                              | 150                                                    |                   | $^{\circ}\text{C}$ |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 19\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol         | Parameter                                       | TO-220 | I <sup>2</sup> PAK | TO-247 | D <sup>2</sup> PAK | TO-220FP | Unit                        |
|----------------|-------------------------------------------------|--------|--------------------|--------|--------------------|----------|-----------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case max            | 0.78   |                    |        |                    | 3.1      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-amb max             | 62.5   |                    | 50     | --                 | 62.5     | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max             | --     | --                 | --     | 30                 | --       | $^{\circ}\text{C}/\text{W}$ |
| $T_l$          | Maximum lead temperature for soldering purposes | 300    |                    |        |                    |          | $^{\circ}\text{C}$          |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter                                                                                                           | Max value | Unit |
|----------|---------------------------------------------------------------------------------------------------------------------|-----------|------|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive<br>(pulse width limited by $T_J$ max)                               | 6         | A    |
| $E_{AS}$ | Single pulse avalanche energy<br>(starting $T_J=25\text{ }^{\circ}\text{C}$ , $I_D=I_{AS}$ , $V_{DD}=50\text{ V}$ ) | 500       | mJ   |

## 2 Electrical characteristics

(T<sub>CASE</sub>=25 °C unless otherwise specified)

**Table 5. On/off states**

| Symbol               | Parameter                                             | Test conditions                                                         | Min. | Typ. | Max.     | Unit     |
|----------------------|-------------------------------------------------------|-------------------------------------------------------------------------|------|------|----------|----------|
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage                        | I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0                              | 650  |      |          | V        |
| dv/dt <sup>(1)</sup> | Drain source voltage slope                            | V <sub>DD</sub> = 520 V, I <sub>D</sub> =19 A,<br>V <sub>GS</sub> =10 V | 35   |      |          | V/ns     |
| I <sub>DSS</sub>     | Zero gate voltage drain current (V <sub>GS</sub> = 0) | V <sub>DS</sub> = max rating<br>V <sub>DS</sub> = max rating, @ 125 °C  |      |      | 1<br>100 | μA<br>μA |
| I <sub>GSS</sub>     | Gate-body leakage current (V <sub>DS</sub> = 0)       | V <sub>GS</sub> = ± 20 V                                                |      |      | ±100     | nA       |
| V <sub>GS(th)</sub>  | Gate threshold voltage                                | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA             | 2    | 3    | 4        | V        |
| R <sub>DS(on)</sub>  | Static drain-source on resistance                     | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 9.5 A                          |      | 0.16 | 0.19     | Ω        |

1. Characteristic value at turn off on inductive load

**Table 6. Dynamic**

| Symbol                                                   | Parameter                                                               | Test conditions                                                                               | Min. | Typ.              | Max. | Unit           |
|----------------------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------|-------------------|------|----------------|
| g <sub>fs</sub> <sup>(1)</sup>                           | Forward transconductance                                                | V <sub>DS</sub> = 15 V, I <sub>D</sub> = 9.5 A                                                |      | 14                |      | S              |
| C <sub>iss</sub><br>C <sub>oss</sub><br>C <sub>rss</sub> | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | V <sub>DS</sub> = 50 V, f = 1 MHz,<br>V <sub>GS</sub> = 0                                     |      | 2500<br>120<br>10 |      | pF<br>pF<br>pF |
| C <sub>oss eq</sub> <sup>(2)</sup>                       | Equivalent output capacitance                                           | V <sub>GS</sub> = 0, V <sub>DS</sub> = 0 to 520 V                                             |      | 310               |      | pF             |
| Q <sub>g</sub><br>Q <sub>gs</sub><br>Q <sub>gd</sub>     | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | V <sub>DD</sub> = 520 V, I <sub>D</sub> = 19 A,<br>V <sub>GS</sub> = 10 V,<br>(see Figure 19) |      | 70<br>10<br>40    |      | nC<br>nC<br>nC |
| R <sub>G</sub>                                           | Gate input resistance                                                   | f=1 MHz gate DC bias = 0<br>Test signal level = 20 mV<br>open drain                           |      | 2.5               |      | Ω              |

1. Pulsed: pulse duration = 300μs, duty cycle 1.5%

2. C<sub>oss eq.</sub> is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DSS</sub> increases from 0 to 80% V<sub>DSS</sub>

**Table 7. Switching times**

| Symbol       | Parameter           | Test conditions                                                                                                   | Min | Typ | Max | Unit |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 325\text{ V}$ , $I_D = 9.5\text{ A}$<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see Figure 18) |     | 25  |     | ns   |
| $t_r$        | Rise time           |                                                                                                                   |     | 10  |     | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                   |     | 80  |     | ns   |
| $t_f$        | Fall time           |                                                                                                                   |     | 20  |     | ns   |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                               | Min | Typ | Max | Unit          |
|-----------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                               |     |     | 19  | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                               |     |     | 76  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 19\text{ A}$ , $V_{GS} = 0$                                                                                                         |     |     | 1.3 | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 19\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 100\text{ V}$<br>(see Figure 20)                                     |     | 460 |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                               |     | 7   |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                               |     | 30  |     | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 19\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 100\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see Figure 20) |     | 620 |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                               |     | 9   |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                               |     | 29  |     | A             |

1. Pulse width limited by safe operating area

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

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220 - D<sup>2</sup>PAK - I<sup>2</sup>PAK

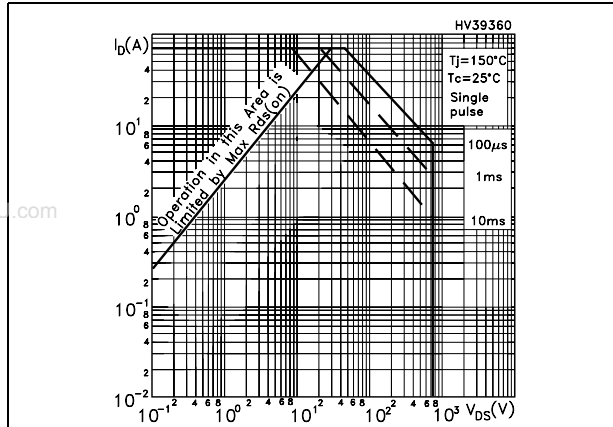


Figure 3. Thermal impedance for TO-220 - D<sup>2</sup>PAK - I<sup>2</sup>PAK

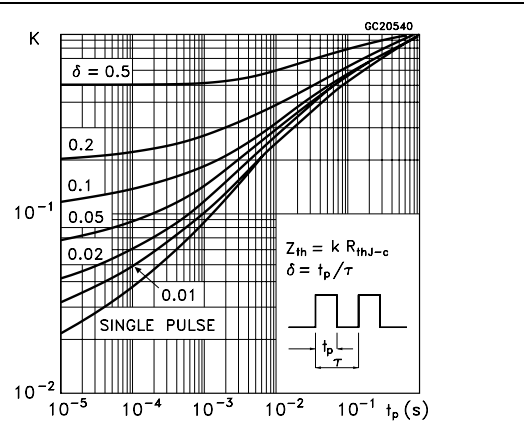


Figure 4. Safe operating area for TO-220FP

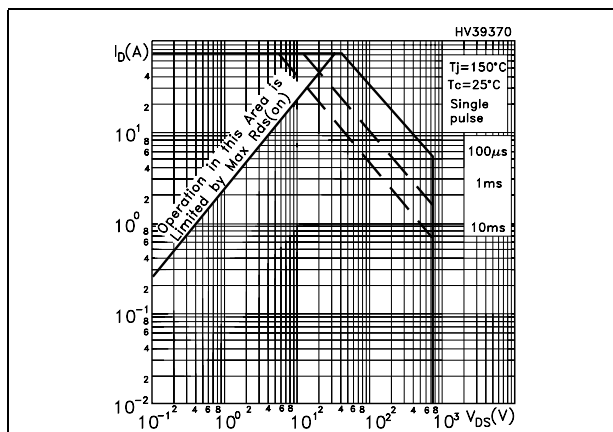


Figure 5. Thermal impedance for TO-220FP

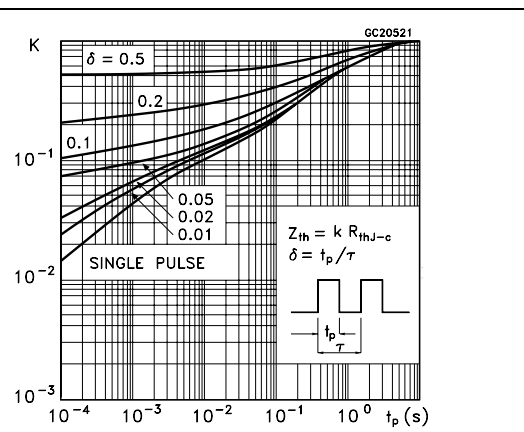


Figure 6. Safe operating area for TO-247

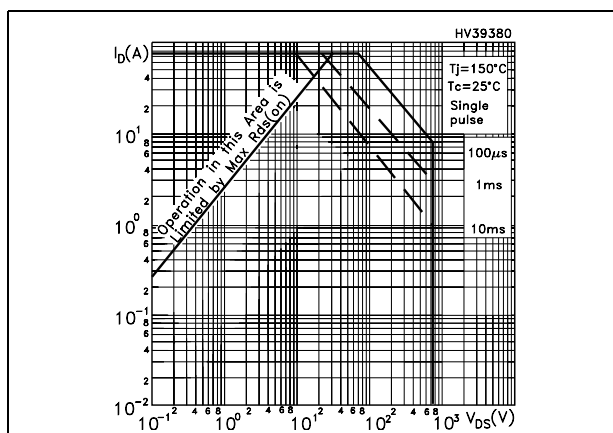


Figure 7. Thermal impedance for TO-247

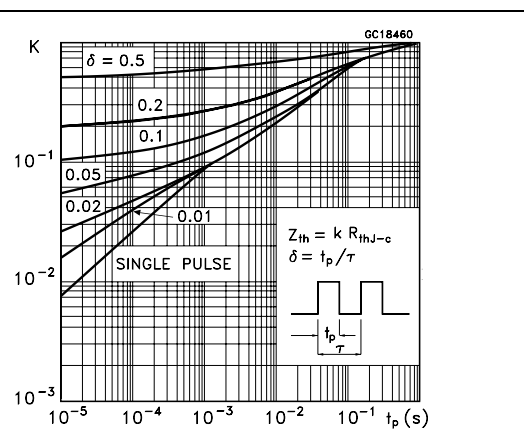


Figure 8. Output characteristics

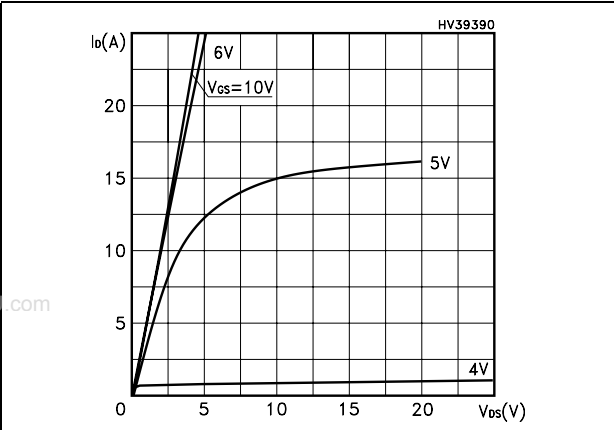


Figure 9. Transfer characteristics

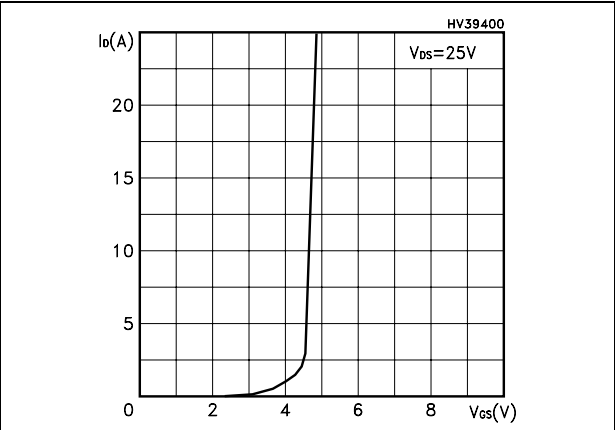


Figure 10. Transconductance

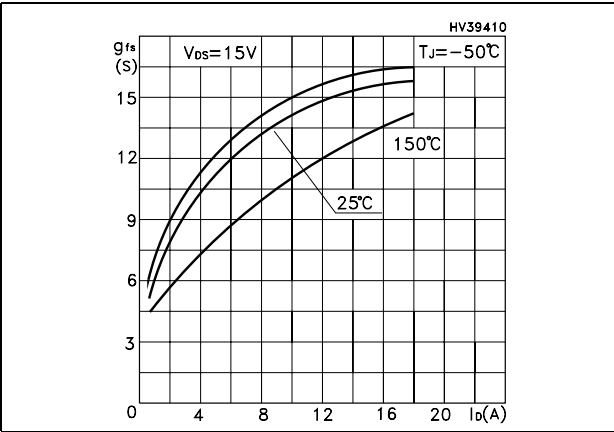


Figure 11. Static drain-source on resistance

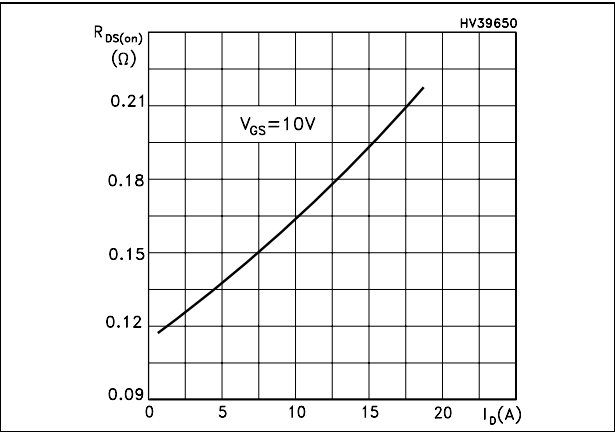


Figure 12. Gate charge vs gate-source voltage

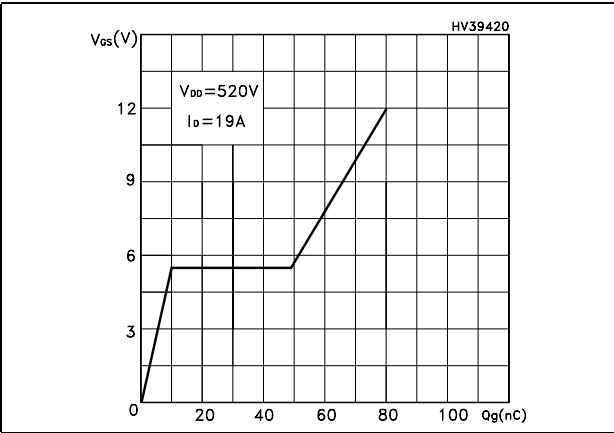


Figure 13. Capacitance variations

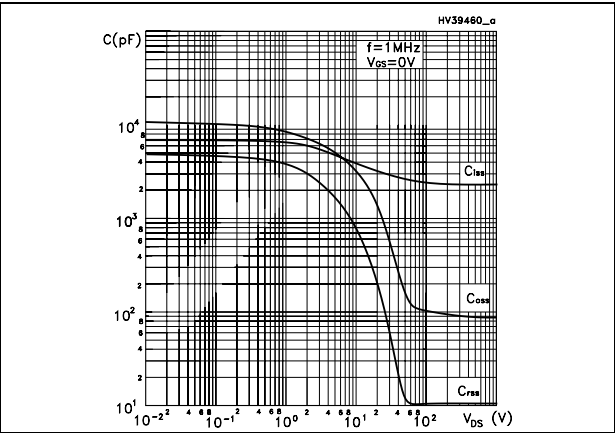


Figure 14. Normalized gate threshold voltage vs temperature

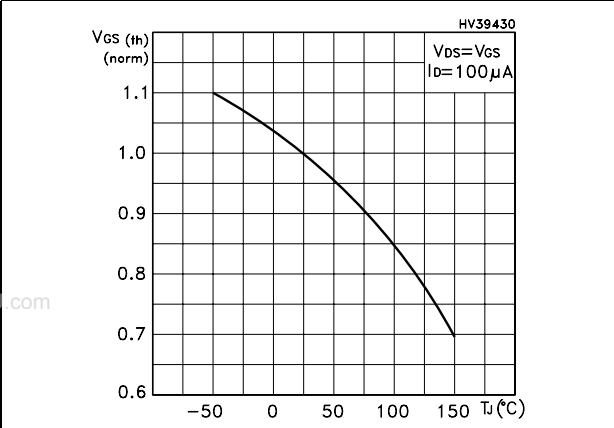


Figure 15. Normalized on resistance vs temperature

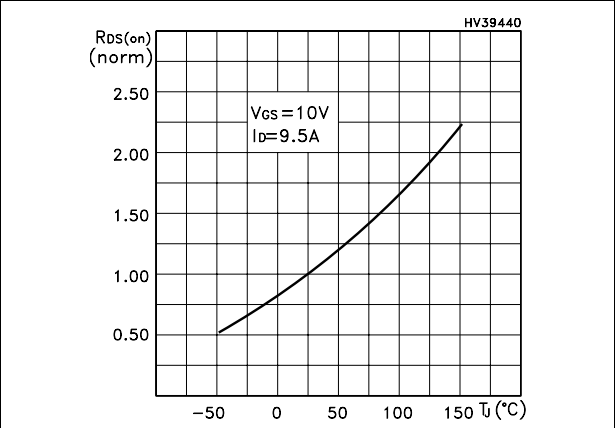


Figure 16. Source-drain diode forward characteristics

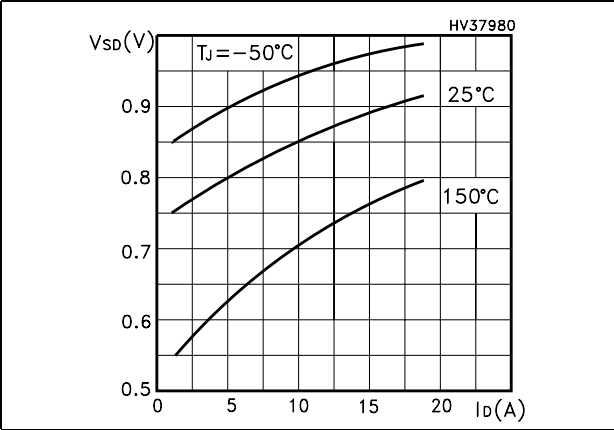
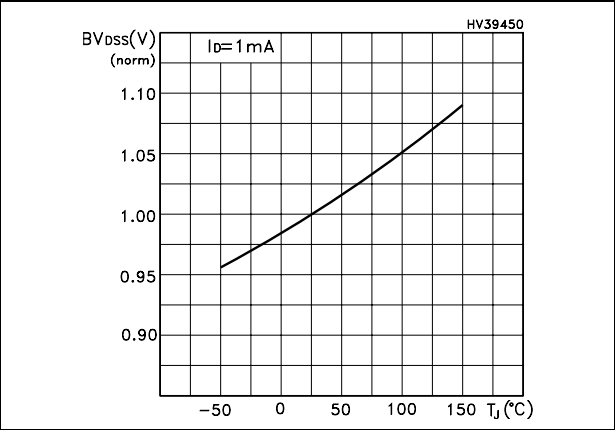
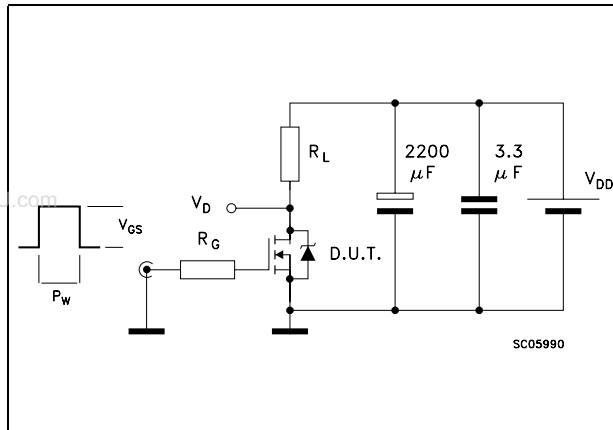


Figure 17. Normalized  $B_{V_{DS}}$  vs temperature

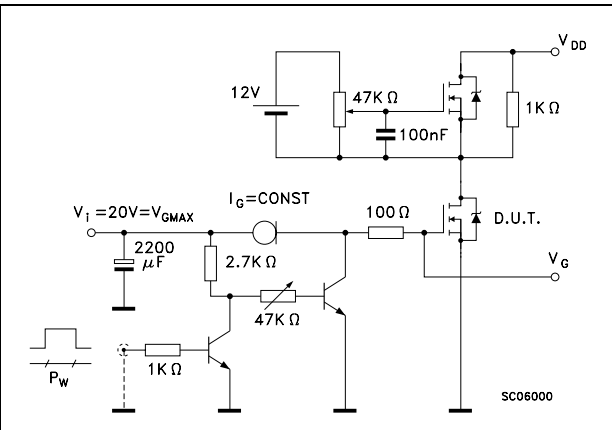


### 3 Test circuit

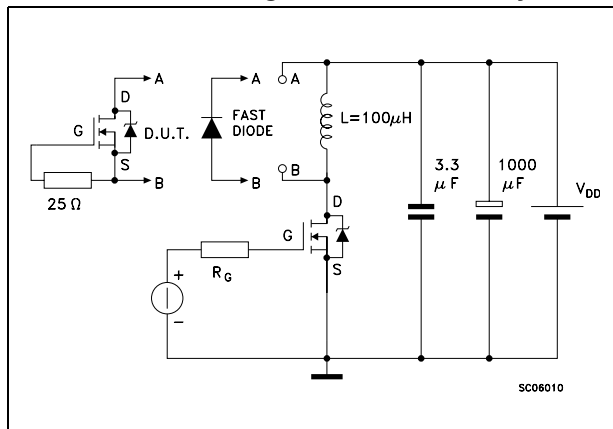
**Figure 18. Switching times test circuit for resistive load**



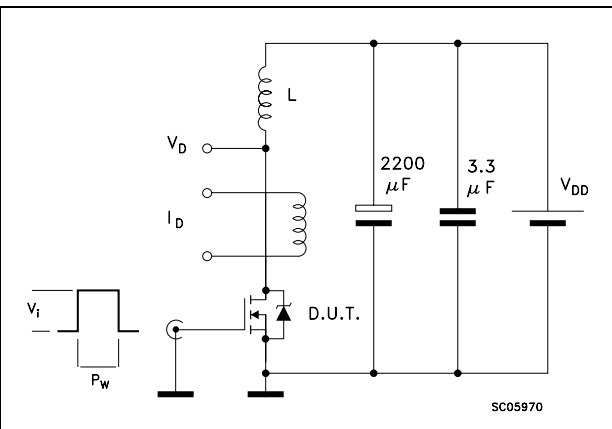
**Figure 19. Gate charge test circuit**



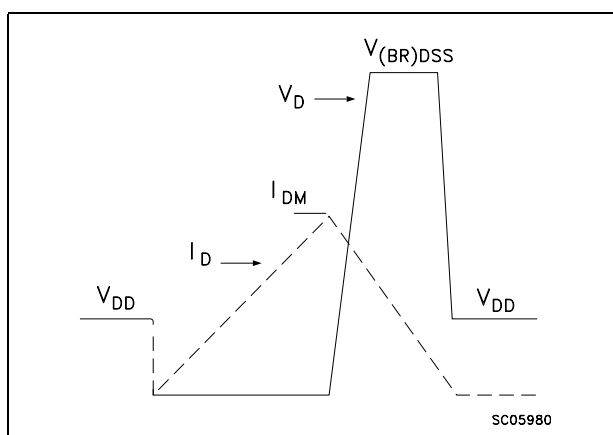
**Figure 20. Test circuit for inductive load switching and diode recovery times**



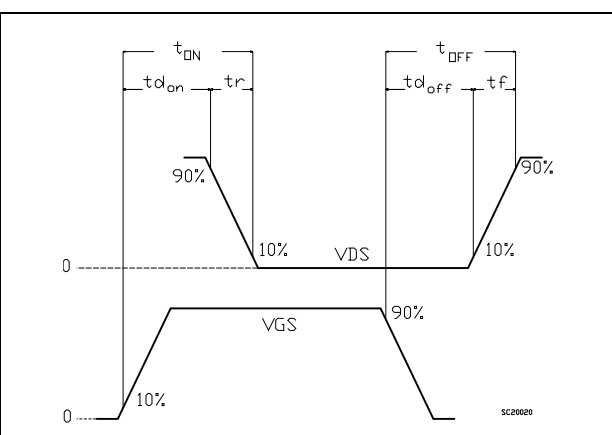
**Figure 21. Unclamped Inductive load test circuit**



**Figure 22. Unclamped inductive waveform**



**Figure 23. Switching time waveform**

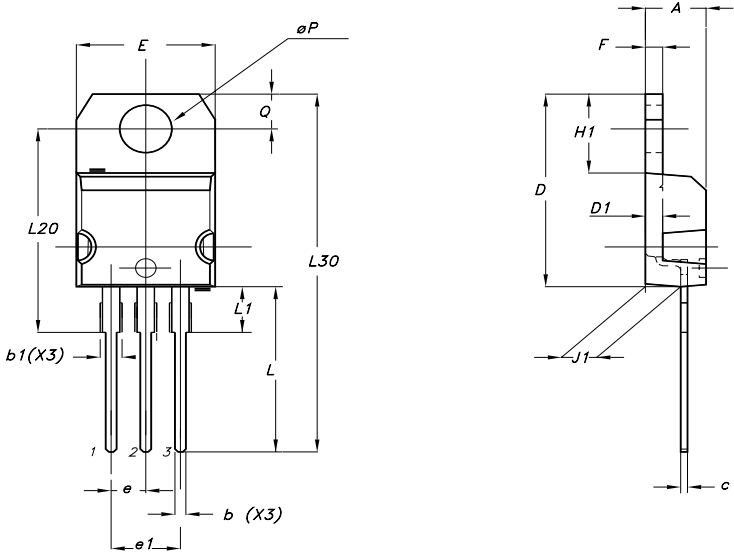


## 4 Package mechanical data

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

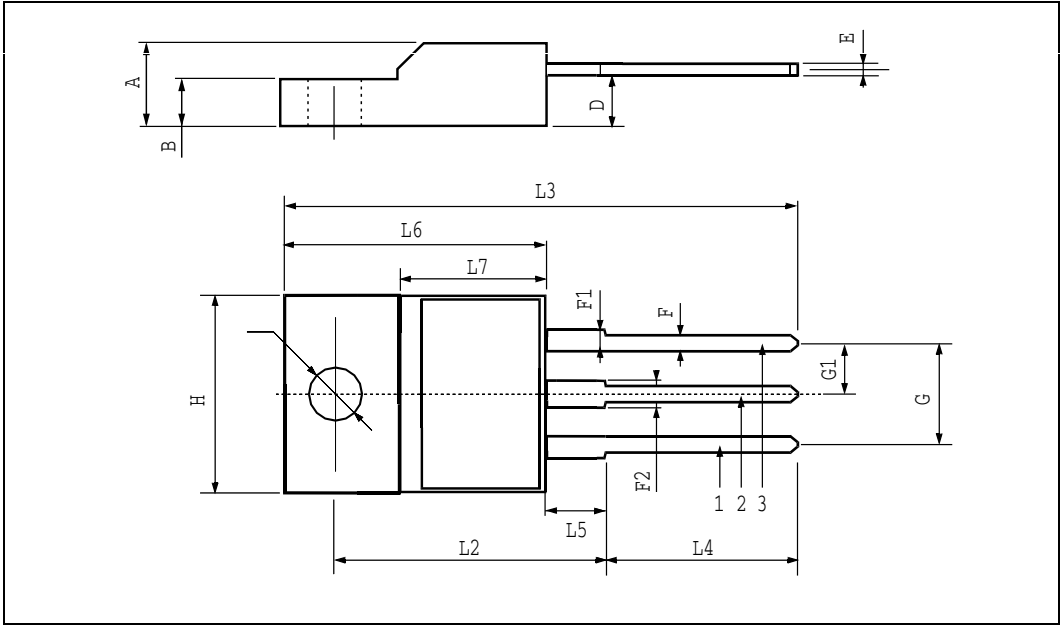
| Dim | mm    |       |       | inch  |       |       |
|-----|-------|-------|-------|-------|-------|-------|
|     | Min   | Typ   | Max   | Min   | Typ   | Max   |
| A   | 4.40  |       | 4.60  | 0.173 |       | 0.181 |
| b   | 0.61  |       | 0.88  | 0.024 |       | 0.034 |
| b1  | 1.14  |       | 1.70  | 0.044 |       | 0.066 |
| c   | 0.49  |       | 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 |       |
| ØP  | 3.75  |       | 3.85  | 0.147 |       | 0.151 |
| Q   | 2.65  |       | 2.95  | 0.104 |       | 0.116 |



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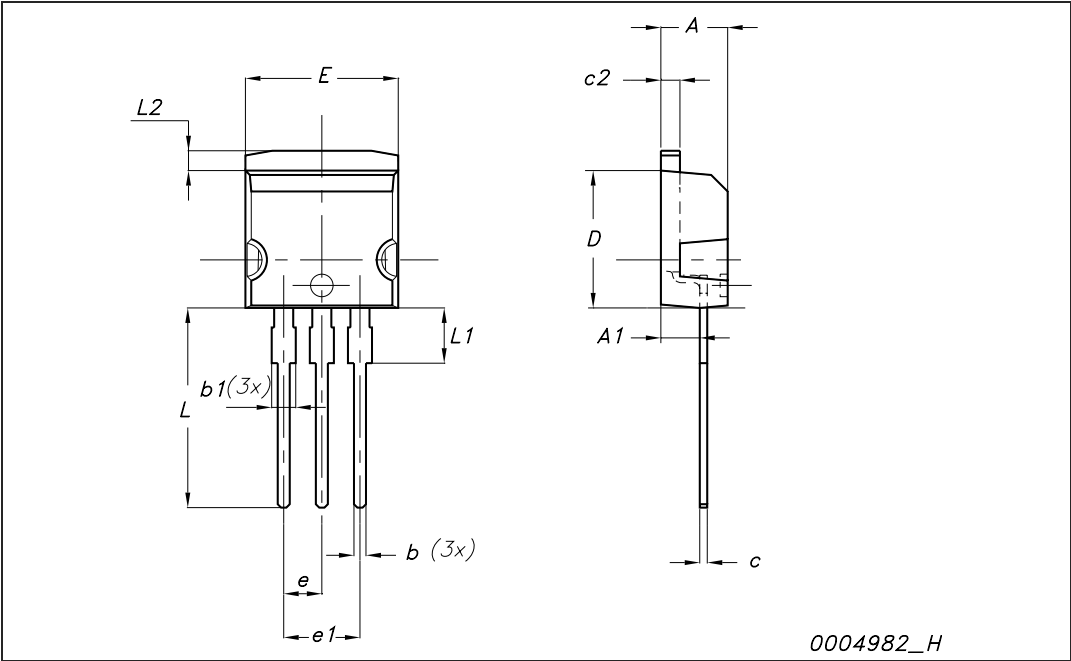
TO-220FP mechanical data

| 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 |



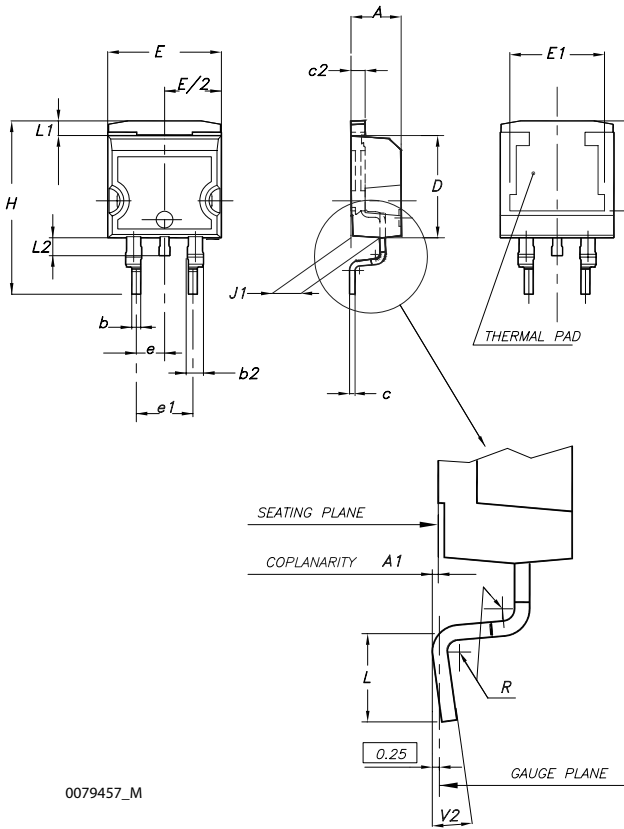
TO-262 mechanical data

| Dim | mm   |     |       | inch  |     |       |
|-----|------|-----|-------|-------|-----|-------|
|     | Min  | Typ | Max   | Min   | Typ | Max   |
| A   | 4.40 |     | 4.60  | 0.173 |     | 0.181 |
| A1  | 2.40 |     | 2.72  | 0.094 |     | 0.107 |
| b   | 0.61 |     | 0.88  | 0.024 |     | 0.034 |
| b1  | 1.14 |     | 1.70  | 0.044 |     | 0.066 |
| c   | 0.49 |     | 0.70  | 0.019 |     | 0.027 |
| c2  | 1.23 |     | 1.32  | 0.048 |     | 0.052 |
| D   | 8.95 |     | 9.35  | 0.352 |     | 0.368 |
| e   | 2.40 |     | 2.70  | 0.094 |     | 0.106 |
| e1  | 4.95 |     | 5.15  | 0.194 |     | 0.202 |
| E   | 10   |     | 10.40 | 0.393 |     | 0.410 |
| L   | 13   |     | 14    | 0.511 |     | 0.551 |
| L1  | 3.50 |     | 3.93  | 0.137 |     | 0.154 |
| L2  | 1.27 |     | 1.40  | 0.050 |     | 0.055 |



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

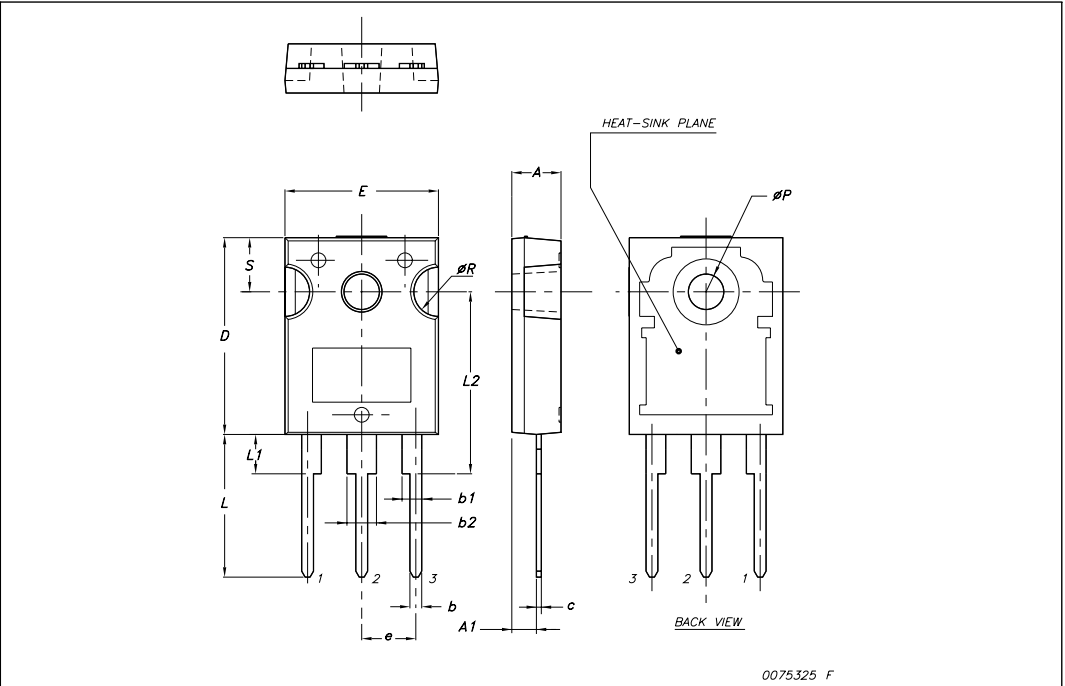
| Dim | mm   |      |       | inch  |       |       |
|-----|------|------|-------|-------|-------|-------|
|     | Min  | Typ  | Max   | Min   | Typ   | Max   |
| A   | 4.40 |      | 4.60  | 0.173 |       | 0.181 |
| A1  | 0.03 |      | 0.23  | 0.001 |       | 0.009 |
| b   | 0.70 |      | 0.93  | 0.027 |       | 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°    |



0079457\_M

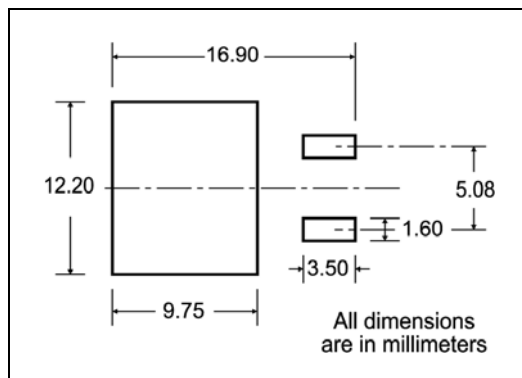
TO-247 Mechanical data

| Dim. | mm.   |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ   | Max.  |
| A    | 4.85  |       | 5.15  |
| A1   | 2.20  |       | 2.60  |
| b    | 1.0   |       | 1.40  |
| b1   | 2.0   |       | 2.40  |
| b2   | 3.0   |       | 3.40  |
| c    | 0.40  |       | 0.80  |
| D    | 19.85 |       | 20.15 |
| E    | 15.45 |       | 15.75 |
| e    |       | 5.45  |       |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| øP   | 3.55  |       | 3.65  |
| øR   | 4.50  |       | 5.50  |
| S    |       | 5.50  |       |

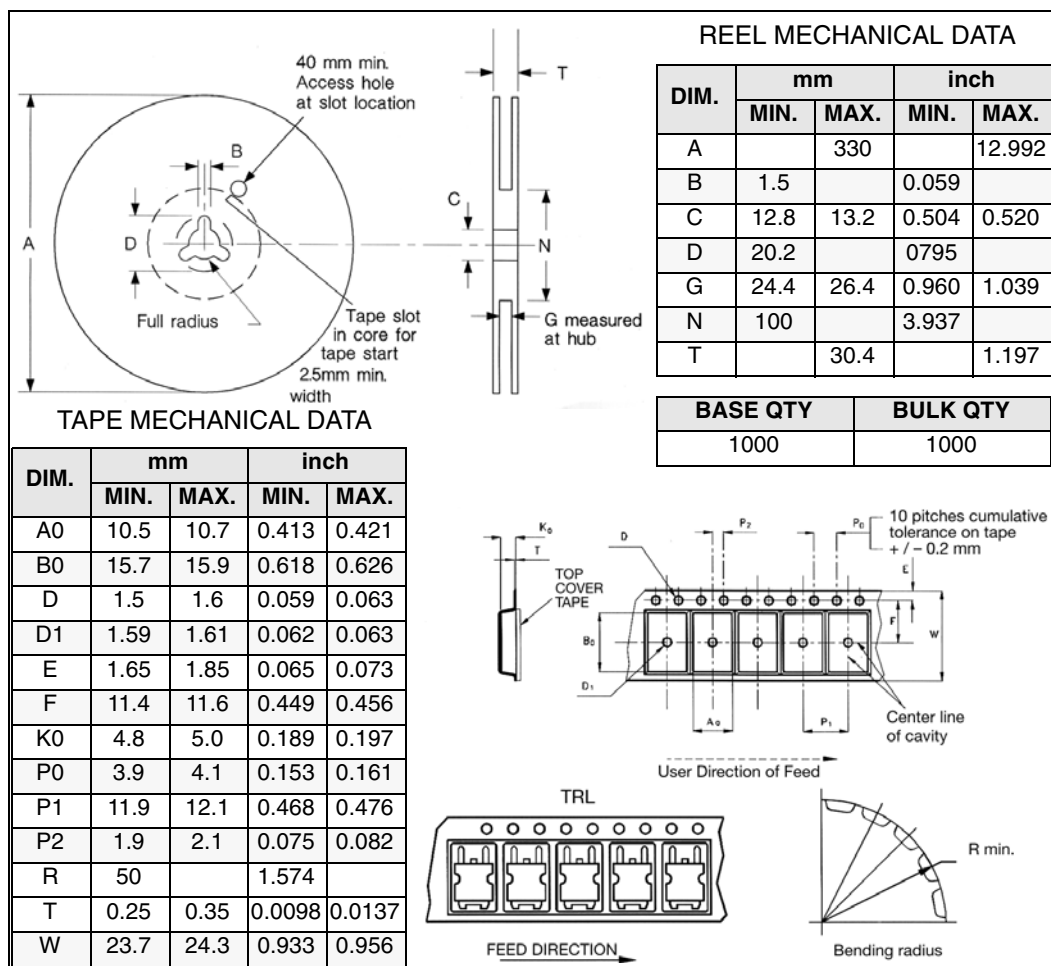


## 5 Packaging mechanical data

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



### TAPE AND REEL SHIPMENT



\* on sales type

## 6 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes       |
|-------------|----------|---------------|
| 14-Feb-2008 | 1        | First release |

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