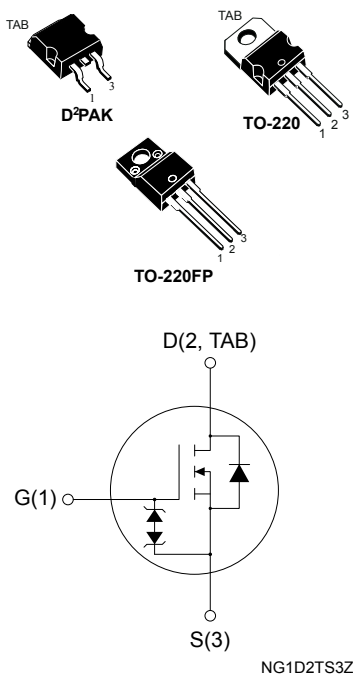


## N-channel 400 V, 0.47 $\Omega$ typ., 9 A SuperMESH Power MOSFETs in a D<sup>2</sup>PAK, TO-220 and TO-220FP packages



### Features

| Order code   | $V_{DS}$ | $R_{DS(on)}$ max. | $I_D$ | Package            |
|--------------|----------|-------------------|-------|--------------------|
| STB11NK40ZT4 | 400 V    | 0.55 $\Omega$     | 9 A   | D <sup>2</sup> PAK |
| STP11NK40Z   |          |                   |       | TO-220             |
| STP11NK40ZFP |          |                   |       | TO-220FP           |

- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitance
- Zener-protected

### Applications

- Switching applications

### Description

These high-voltage devices are Zener-protected N-channel Power MOSFETs developed using the SuperMESH™ technology by STMicroelectronics, an optimization of the well-established PowerMESH™. In addition to a significant reduction in on-resistance, these devices are designed to ensure a high level of dv/dt capability for the most demanding applications.

#### Product status link

[STB11NK40ZT4](#)
[STP11NK40Z](#)
[STP11NK40ZFP](#)

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol                         | Parameter                                                                                                          | Value                         |                     | Unit |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------|------|
|                                |                                                                                                                    | D <sup>2</sup> PAK,<br>TO-220 | TO-220FP            |      |
| V <sub>DS</sub>                | Drain-source voltage                                                                                               | 400                           |                     | V    |
| V <sub>GS</sub>                | Gate-source voltage                                                                                                | ±30                           |                     | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25 °C                                                               | 9                             | 9 <sup>(1)</sup>    | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 100 °C                                                              | 5.67                          | 5.67 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current (pulsed)                                                                                             | 36                            | 36 <sup>(1)</sup>   | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C                                                                        | 110                           | 30                  | W    |
| ESD                            | Gate-source human body model<br>(C = 100 pF, R = 1.5 kΩ)                                                           | 3.5                           |                     | kV   |
| dv/dt <sup>(3)</sup>           | Peak diode recovery voltage slope                                                                                  | 4.5                           |                     | V/ns |
| V <sub>ISO</sub>               | Insulation withstand voltage (RMS) from all three leads to<br>external heat sink (t = 1 s; T <sub>C</sub> = 25 °C) |                               | 2.5                 | kV   |
| T <sub>J</sub>                 | Operating junction temperature range                                                                               | -55 to 150                    |                     | °C   |
| T <sub>stg</sub>               | Storage temperature range                                                                                          |                               |                     |      |

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area.
3.  $I_{SD} \leq 9\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 80\% V_{(BR)DSS}$ ,  $T_J \leq T_{JMAX}$ .

**Table 2. Thermal data**

| Symbol                              | Parameter                           | Value              |        |          | Unit |
|-------------------------------------|-------------------------------------|--------------------|--------|----------|------|
|                                     |                                     | D <sup>2</sup> PAK | TO-220 | TO-220FP |      |
| R <sub>thj-case</sub>               | Thermal resistance junction-case    | 1.14               |        | 4.17     | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-ambient |                    | 62.5   |          | °C/W |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-pcb     | 50                 |        |          | °C/W |

1. When mounted on 1inch<sup>2</sup> FR-4 board, 2 oz Cu.

**Table 3. Avalanche characteristics**

| Symbol          | Parameter                                                                                                                  | Value | Unit |
|-----------------|----------------------------------------------------------------------------------------------------------------------------|-------|------|
| I <sub>AR</sub> | Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> Max)                                | 9     | A    |
| E <sub>AS</sub> | Single pulse avalanche energy (starting T <sub>J</sub> = 25 °C, I <sub>D</sub> = I <sub>AR</sub> , V <sub>DD</sub> = 50 V) | 190   | mJ   |

## 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol               | Parameter                         | Test condition                                                                         | Min. | Typ. | Max. | Unit |
|----------------------|-----------------------------------|----------------------------------------------------------------------------------------|------|------|------|------|
| V <sub>(BR)DSS</sub> | Drain-source Breakdown voltage    | I <sub>D</sub> = 1 mA, V <sub>GS</sub> = 0 V                                           | 400  |      |      | V    |
| I <sub>DSS</sub>     | Zero gate voltage drain current   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 400 V                                         |      |      | 1    | μA   |
|                      |                                   | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 400 V, T <sub>C</sub> = 125 °C <sup>(1)</sup> |      |      | 50   | μA   |
| I <sub>GSS</sub>     | Gate body leakage current         | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ±20 V                                         |      |      | ±10  | μA   |
| V <sub>GS(th)</sub>  | Gate threshold voltage            | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 100 μA                            | 3    | 3.75 | 4.5  | V    |
| R <sub>DS(on)</sub>  | Static drain-source on resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4.5 A                                         |      | 0.47 | 0.55 | Ω    |

1. Defined by design, not subject to production test.

**Table 5. Dynamic**

| Symbol                              | Parameter                     | Test condition                                                                                                                    | Min. | Typ. | Max. | Unit |
|-------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| C <sub>iss</sub>                    | Input capacitance             | V <sub>DS</sub> = 25 V, f = 1 MHz, V <sub>GS</sub> = 0 V                                                                          | -    | 930  | -    | pF   |
| C <sub>oss</sub>                    | Output capacitance            |                                                                                                                                   |      | 140  |      |      |
| C <sub>rss</sub>                    | Reverse transfer capacitance  |                                                                                                                                   |      | 30   |      |      |
| C <sub>oss eq.</sub> <sup>(1)</sup> | Equivalent output capacitance | V <sub>DS</sub> = 0 to 320 V, V <sub>GS</sub> = 0 V                                                                               | -    | 78   | -    | pF   |
| Q <sub>g</sub>                      | Total gate charge             | V <sub>DD</sub> = 320 V, I <sub>D</sub> = 9 A, V <sub>GS</sub> = 0 to 10 V (see Figure 16. Test circuit for gate charge behavior) | -    | 32   | -    | nC   |
| Q <sub>gs</sub>                     | Gate-source charge            |                                                                                                                                   |      | 6    |      |      |
| Q <sub>gd</sub>                     | Gate-drain charge             |                                                                                                                                   |      | 18.5 |      |      |

1. 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>DS</sub> increases from 0 to 80% V<sub>DSS</sub>.

**Table 6. Switching times**

| Symbol               | Parameter             | Test condition                                                                                                                                            | Min. | Typ. | Max. | Unit |
|----------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| t <sub>d(on)</sub>   | Turn-on delay time    | V <sub>DD</sub> = 200 V, I <sub>D</sub> = 4.5 A,                                                                                                          | -    | 20   | -    | ns   |
| t <sub>r</sub>       | Rise time             | R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V<br>(see Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform) |      | 20   |      |      |
| t <sub>d(off)</sub>  | Turn-off delay time   |                                                                                                                                                           |      | 40   |      |      |
| t <sub>f</sub>       | Fall time             |                                                                                                                                                           |      | 18   |      |      |
| t <sub>r(Voff)</sub> | Off-voltage rise time | V <sub>DD</sub> = 320 V, I <sub>D</sub> = 9 A,                                                                                                            |      | 15   |      |      |
| t <sub>f</sub>       | Fall time             | R <sub>G</sub> = 4.7 Ω, V <sub>GS</sub> = 10 V (see Figure 17. Test circuit for inductive load switching and diode recovery times)                        |      | 17   |      |      |
| t <sub>c</sub>       | Cross-over time       |                                                                                                                                                           |      | 30   |      |      |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test condition                                                                                                                                                                                                    | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                                                                                   | -    |      | 9    | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                                                                                   |      |      | 36   |               |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 9\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                                                                                                                     | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 9\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 45\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see Figure 17. Test circuit for inductive load switching and diode recovery times) | -    | 225  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                                                                                   |      | 1.6  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                                                                                   |      | 14   |      | A             |

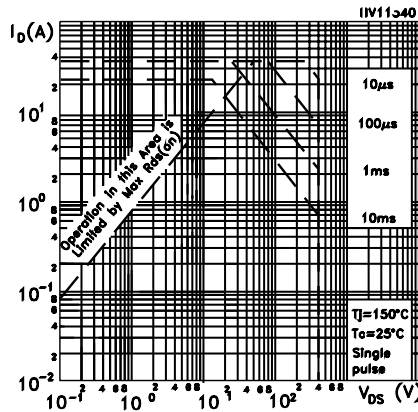
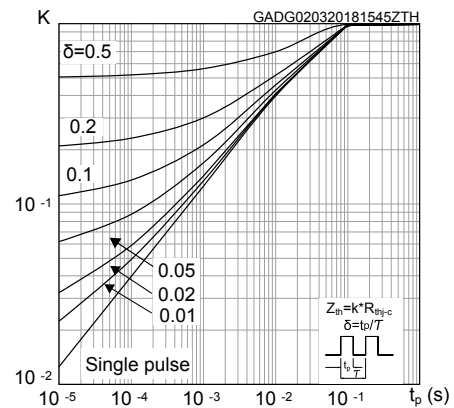
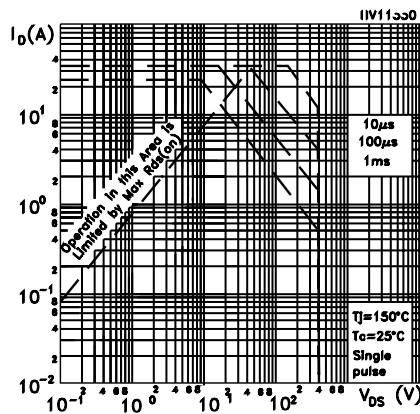
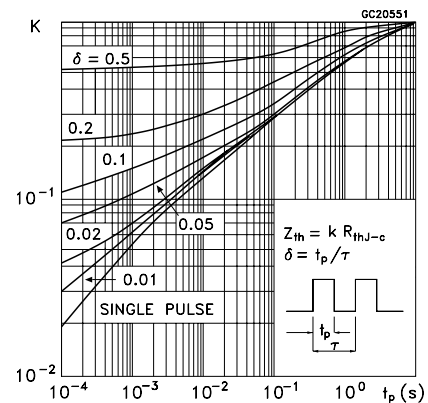
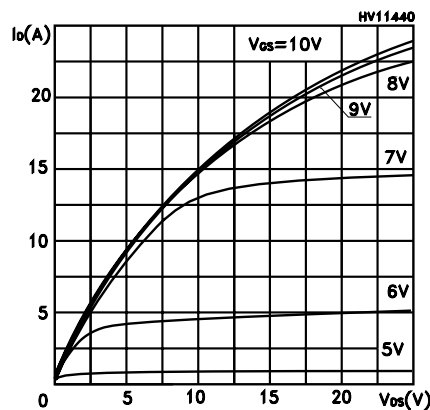
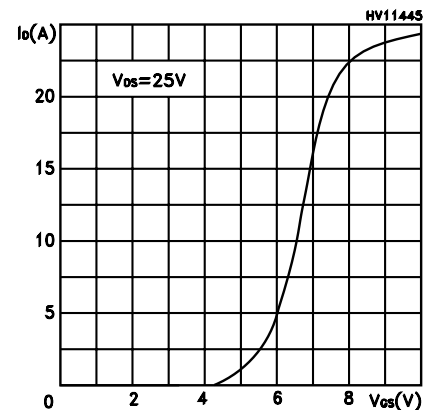
1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

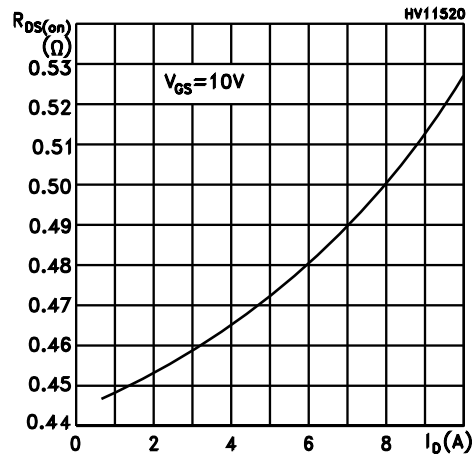
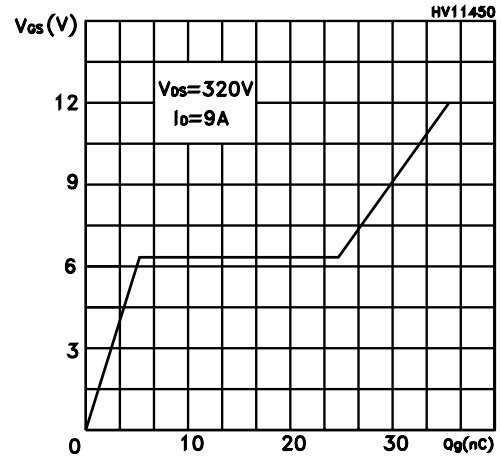
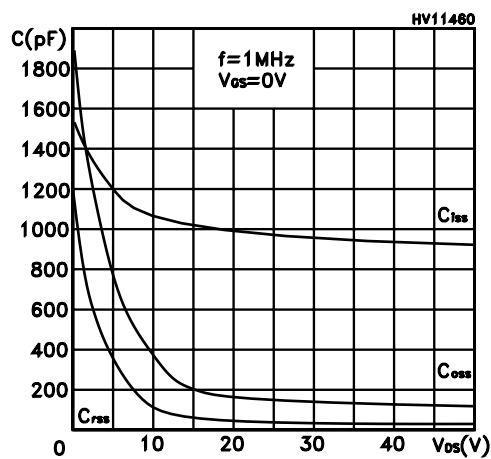
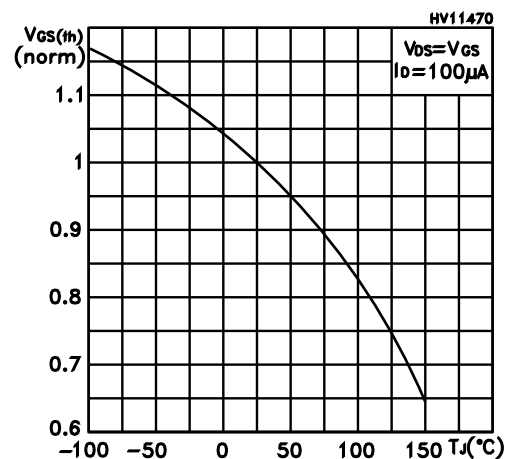
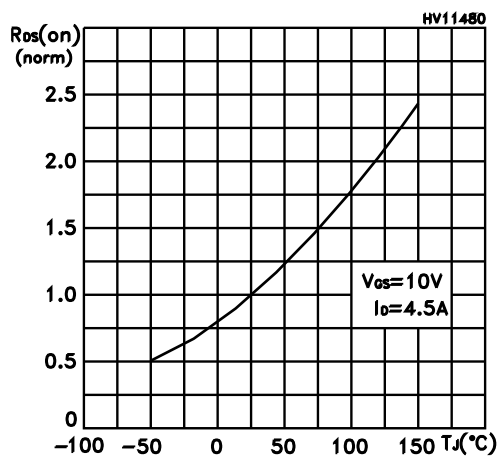
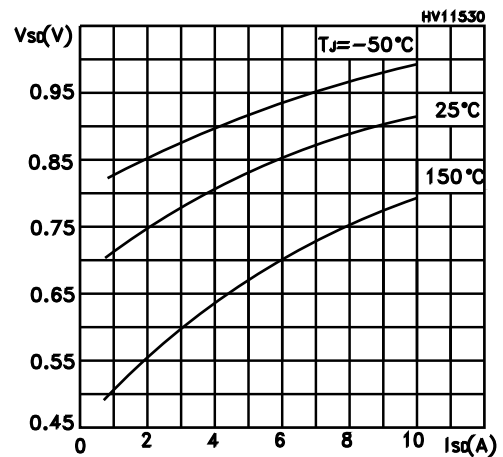
**Table 8. Gate-source Zener diode**

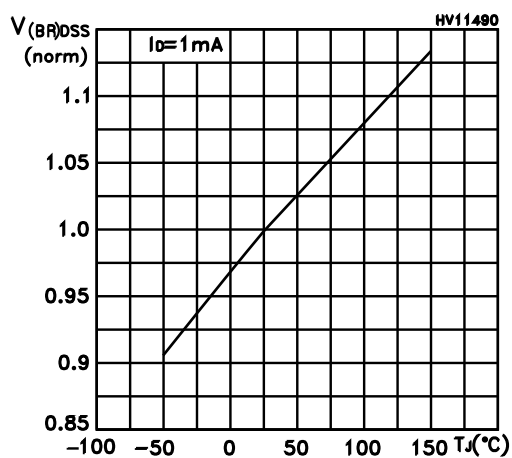
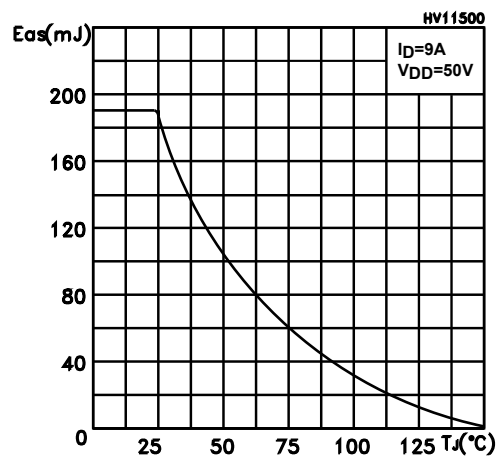
| Symbol        | Parameter                     | Test conditions                                 | Min.     | Typ. | Max. | Unit |
|---------------|-------------------------------|-------------------------------------------------|----------|------|------|------|
| $V_{(BR)GSO}$ | Gate-source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$ , $I_D = 0\text{ A}$ | $\pm 30$ | -    | -    | V    |

The built-in back-to-back Zener diodes are specifically designed to enhance the ESD performance of the device. The Zener voltage facilitates efficient and cost-effective device integrity protection, thus eliminating the need for additional external componentry.

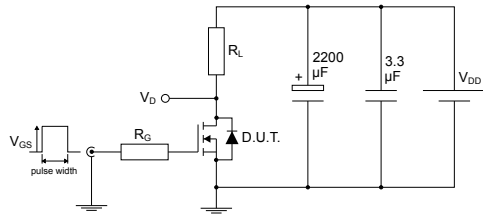
## 2.1 Electrical characteristics curves

**Figure 1. Safe operating area for TO-220, D<sup>2</sup>PAK**

**Figure 2. Thermal impedance for TO-220, D<sup>2</sup>PAK**

**Figure 3. Safe operating area for TO-220FP**

**Figure 4. Thermal impedance for TO-220FP**

**Figure 5. Output characteristics**

**Figure 6. Transfer characteristics**


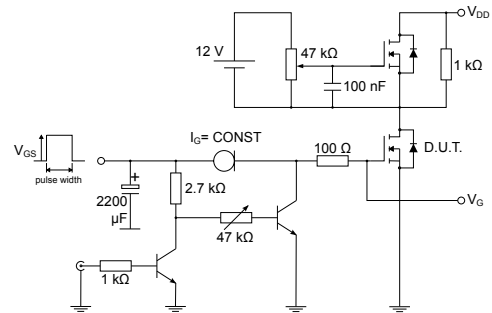
**Figure 7. Static drain-source on resistance**

**Figure 8. Gate charge vs gate-source voltage**

**Figure 9. Capacitance variations**

**Figure 10. Normalized gate threshold voltage vs temperature**

**Figure 11. Normalized on resistance vs temperature**

**Figure 12. Source-drain diode forward characteristics**


**Figure 13. Normalized  $V_{(BR)DSS}$  vs temperature**

**Figure 14. Maximum avalanche energy vs temperature**


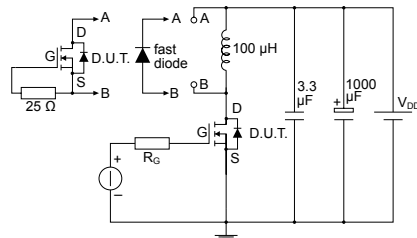
### 3 Test circuits

**Figure 15. Test circuit for resistive load switching times**


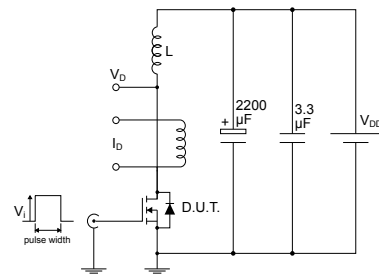
AM01468v1

**Figure 16. Test circuit for gate charge behavior**


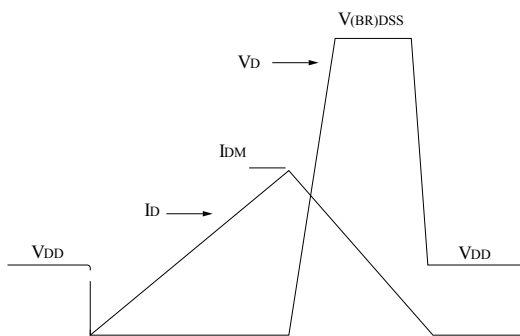
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**Figure 17. Test circuit for inductive load switching and diode recovery times**


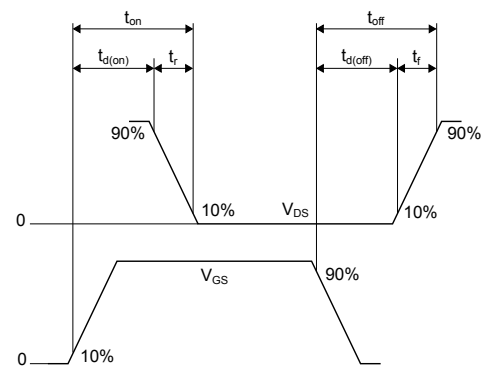
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**Figure 18. Unclamped inductive load test circuit**


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**Figure 19. Unclamped inductive waveform**


AM01472v1

**Figure 20. Switching time waveform**


AM01473v1



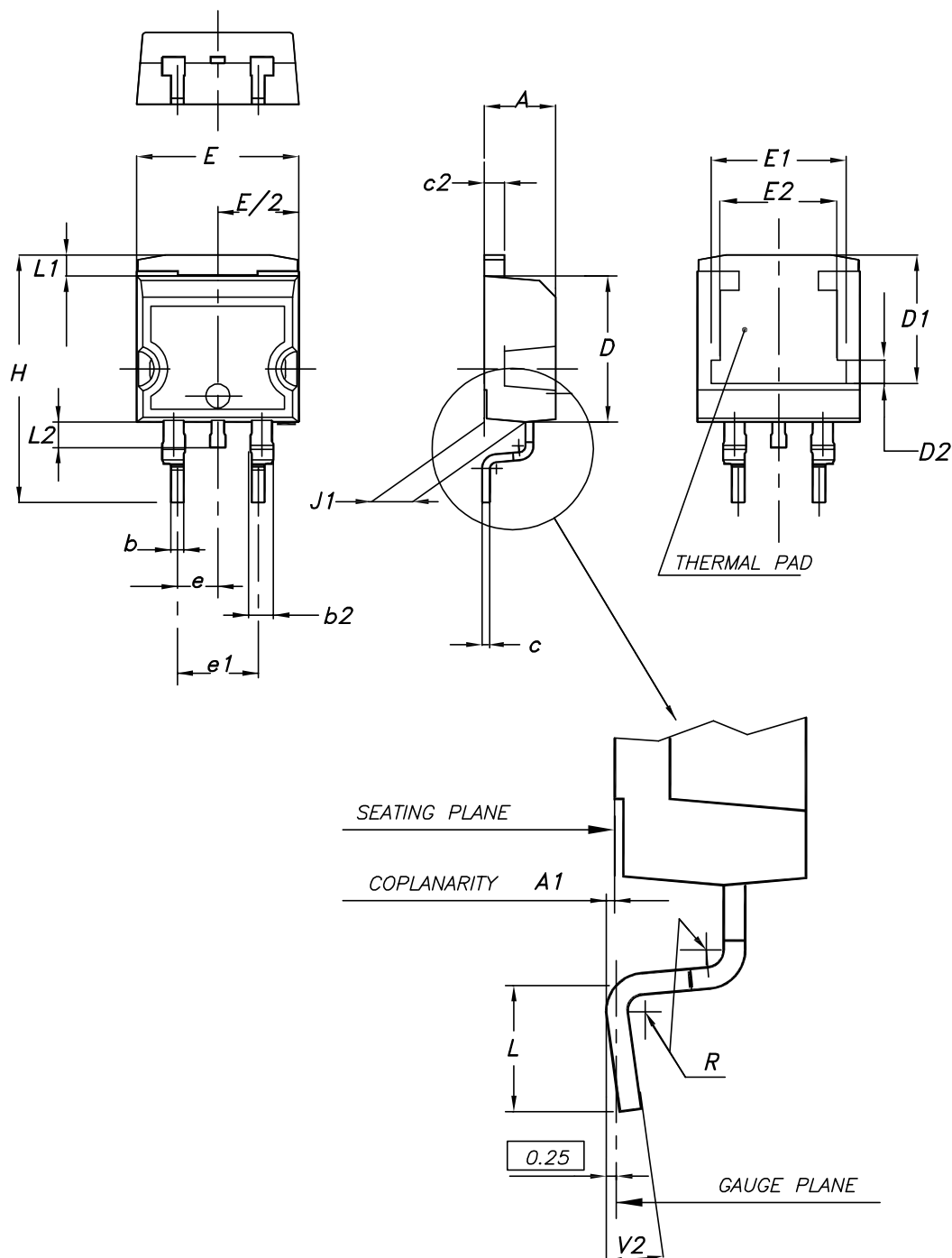
## 4 Package information

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

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

Figure 21. D<sup>2</sup>PAK (TO-263) type A package outline



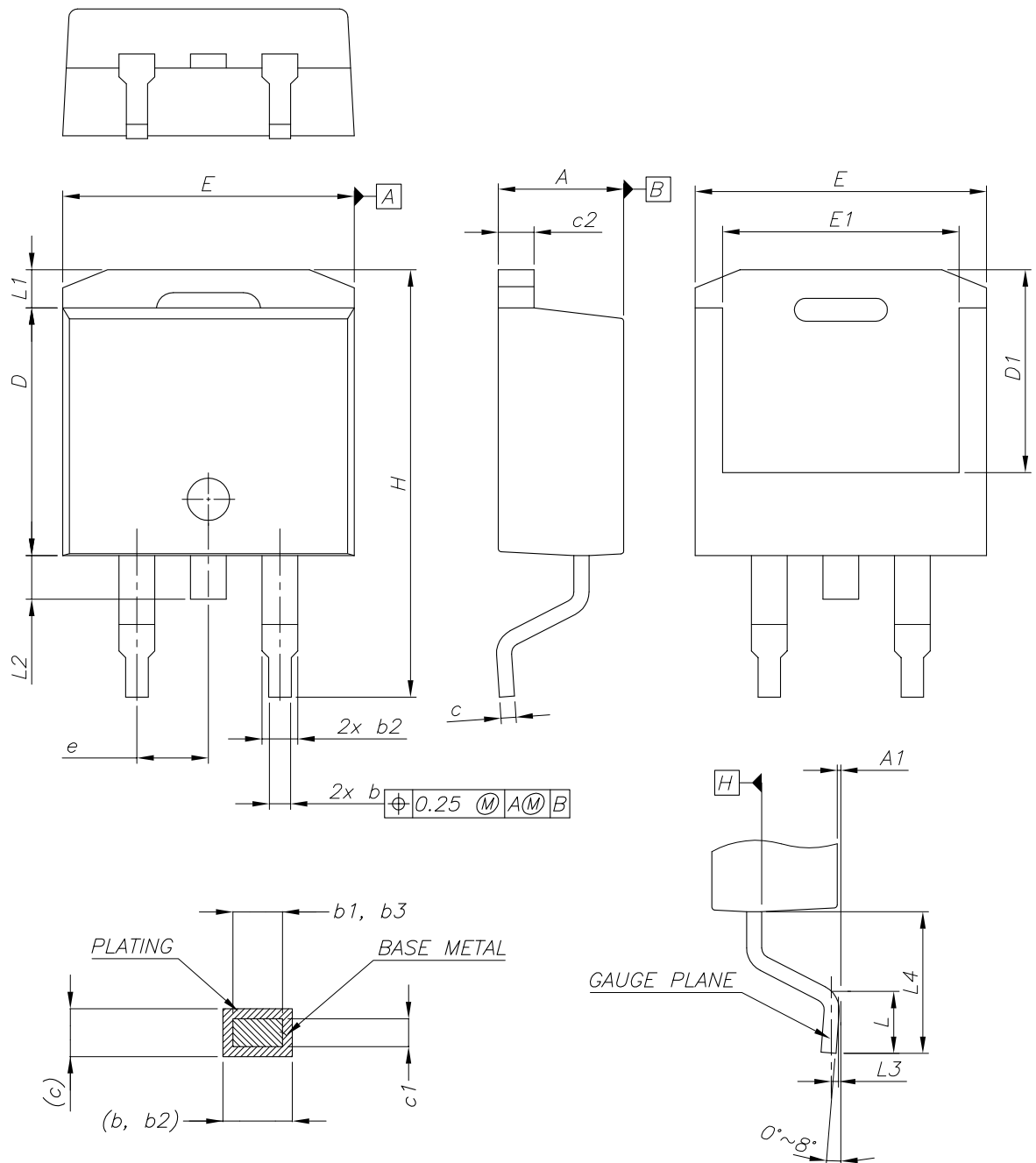
0079457\_25

**Table 9. D<sup>2</sup>PAK (TO-263) type A package mechanical data**

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 4.40  |      | 4.60  |
| A1   | 0.03  |      | 0.23  |
| b    | 0.70  |      | 0.93  |
| b2   | 1.14  |      | 1.70  |
| c    | 0.45  |      | 0.60  |
| c2   | 1.23  |      | 1.36  |
| D    | 8.95  |      | 9.35  |
| D1   | 7.50  | 7.75 | 8.00  |
| D2   | 1.10  | 1.30 | 1.50  |
| E    | 10.00 |      | 10.40 |
| E1   | 8.30  | 8.50 | 8.70  |
| E2   | 6.85  | 7.05 | 7.25  |
| e    |       | 2.54 |       |
| e1   | 4.88  |      | 5.28  |
| H    | 15.00 |      | 15.85 |
| J1   | 2.49  |      | 2.69  |
| L    | 2.29  |      | 2.79  |
| L1   | 1.27  |      | 1.40  |
| L2   | 1.30  |      | 1.75  |
| R    |       | 0.40 |       |
| V2   | 0°    |      | 8°    |

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

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

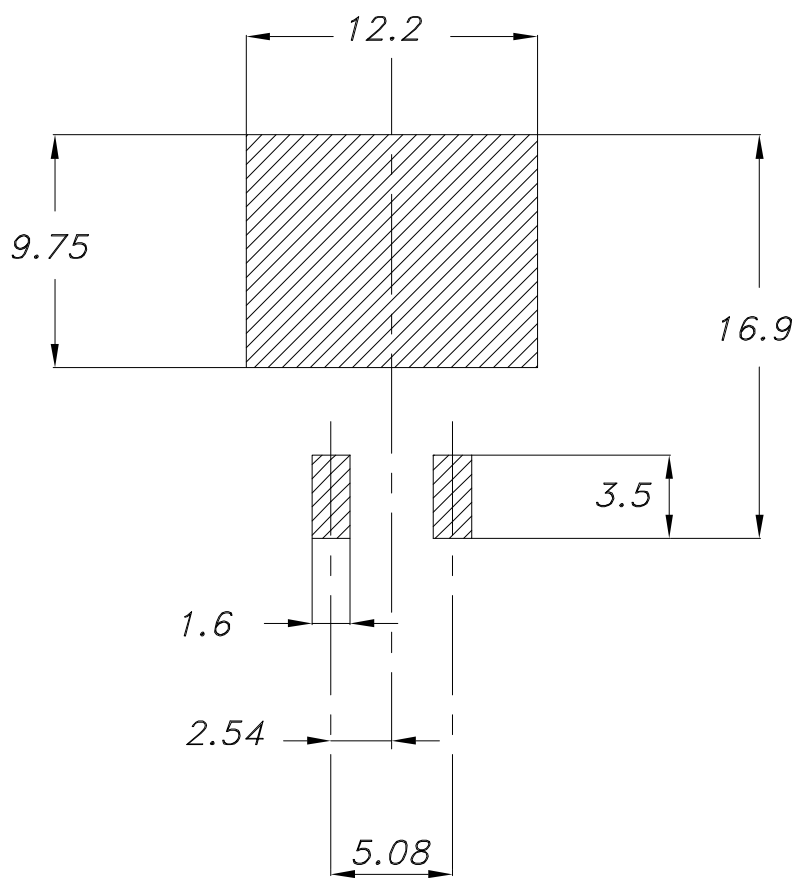


0079457\_25\_B

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

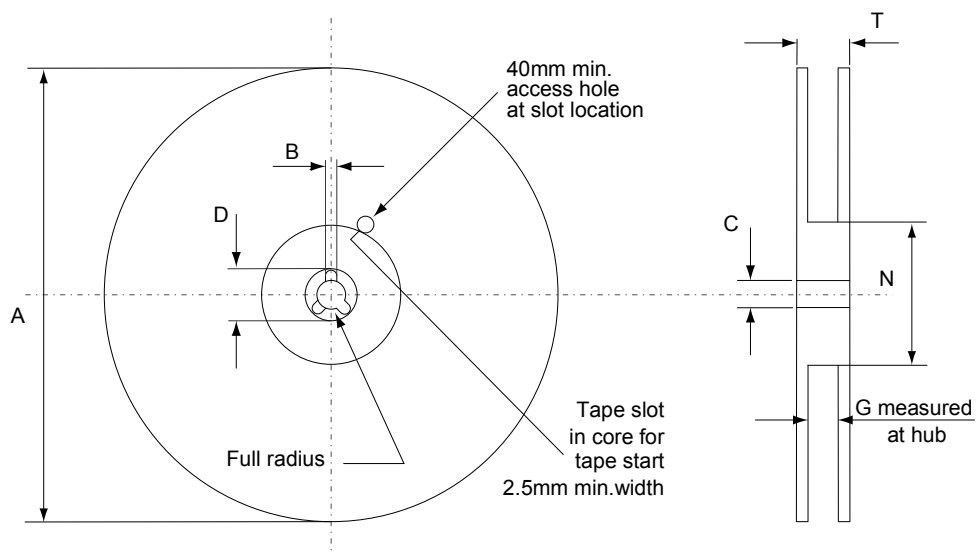
| Dim. | mm       |      |       |
|------|----------|------|-------|
|      | Min.     | Typ. | Max.  |
| A    | 4.36     |      | 4.56  |
| A1   | 0        |      | 0.25  |
| b    | 0.70     |      | 0.90  |
| b1   | 0.51     |      | 0.89  |
| b2   | 1.17     |      | 1.37  |
| b3   | 1.36     | 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

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



Footprint



**Figure 25. D<sup>2</sup>PAK reel outline**


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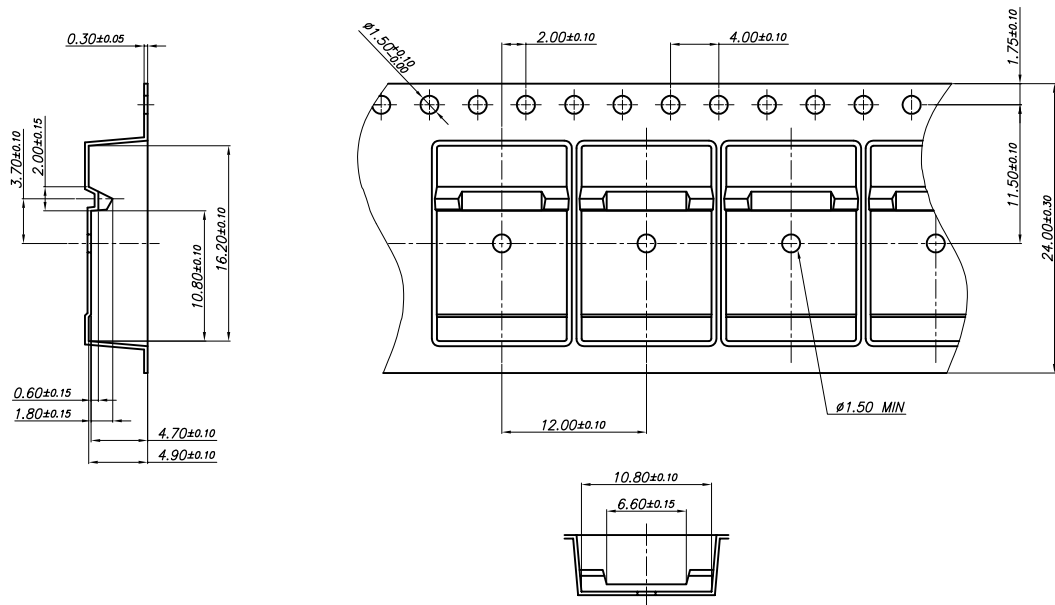
**Table 11. D<sup>2</sup>PAK tape and reel mechanical data**

| Tape |      |      | Reel          |      |      |
|------|------|------|---------------|------|------|
| Dim. | mm   |      | Dim.          | mm   |      |
|      | Min. | Max. |               | Min. | Max. |
| A0   | 10.5 | 10.7 | A             |      | 330  |
| B0   | 15.7 | 15.9 | B             | 1.5  |      |
| D    | 1.5  | 1.6  | C             | 12.8 | 13.2 |
| D1   | 1.59 | 1.61 | D             | 20.2 |      |
| E    | 1.65 | 1.85 | G             | 24.4 | 26.4 |
| F    | 11.4 | 11.6 | N             | 100  |      |
| K0   | 4.8  | 5.0  | T             |      | 30.4 |
| P0   | 3.9  | 4.1  |               |      |      |
| P1   | 11.9 | 12.1 | Base quantity |      | 1000 |
| P2   | 1.9  | 2.1  | Bulk quantity |      | 1000 |
| R    | 50   |      |               |      |      |
| T    | 0.25 | 0.35 |               |      |      |
| W    | 23.7 | 24.3 |               |      |      |

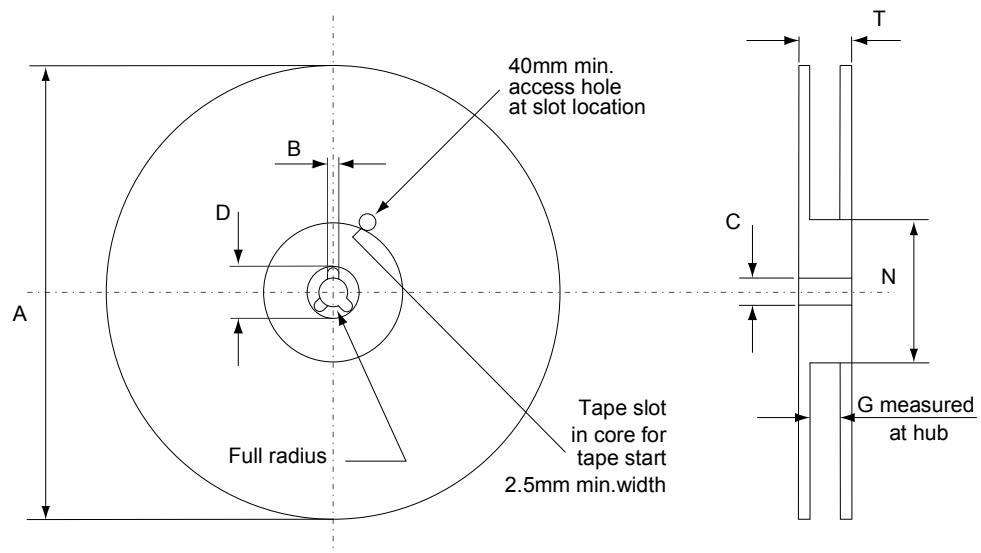


#### 4.4 D<sup>2</sup>PAK type B packing information

**Figure 26. D<sup>2</sup>PAK type B tape outline**



**Figure 27. D<sup>2</sup>PAK type B reel outline**



AM06038v1

**Table 12. D<sup>2</sup>PAK type B reel mechanical data**

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

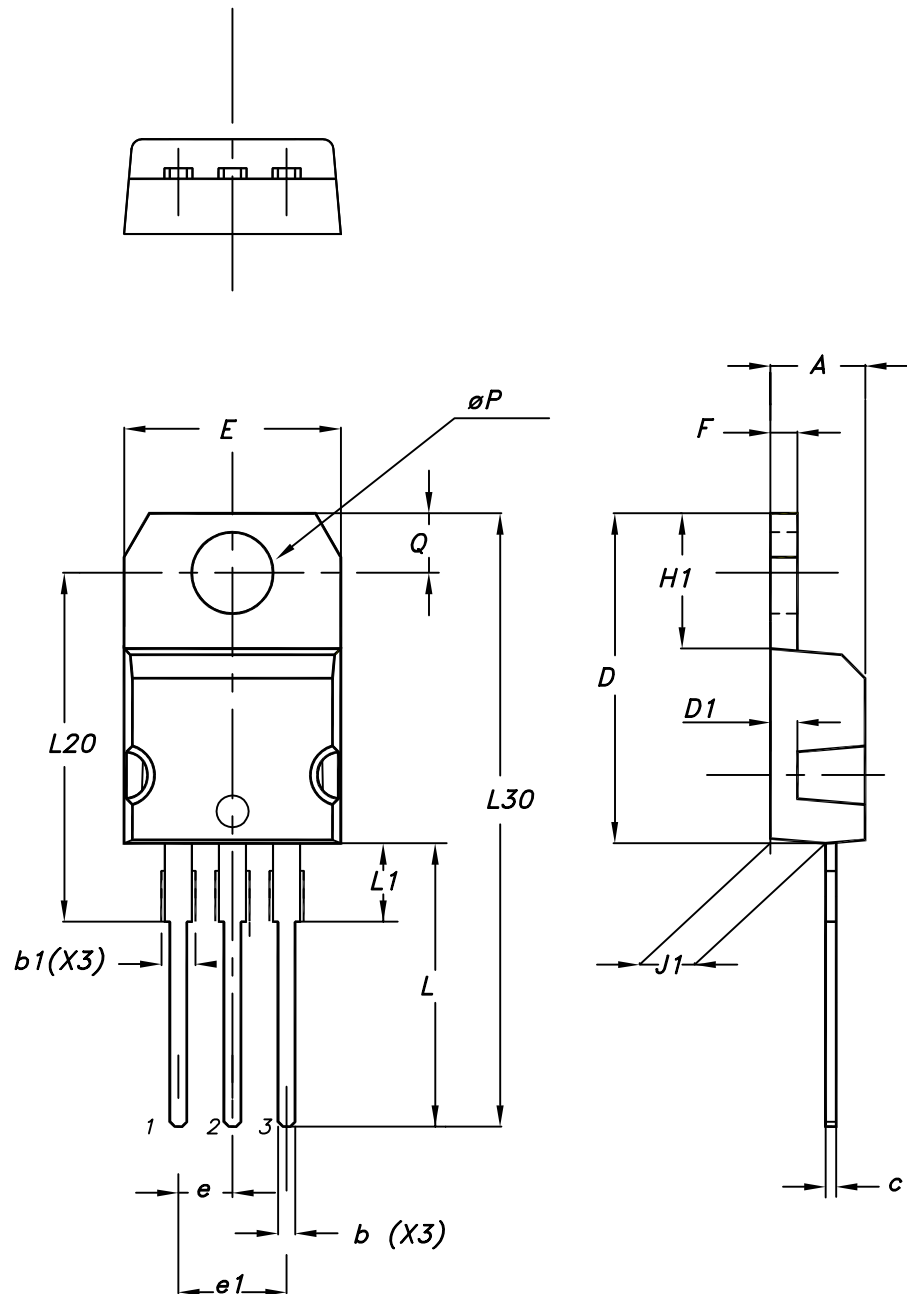


**Table 13. TO-220FP package mechanical data**

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| G    | 4.95 |      | 5.2  |
| G1   | 2.4  |      | 2.7  |
| H    | 10   |      | 10.4 |
| L2   |      | 16   |      |
| L3   | 28.6 |      | 30.6 |
| L4   | 9.8  |      | 10.6 |
| L5   | 2.9  |      | 3.6  |
| L6   | 15.9 |      | 16.4 |
| L7   | 9    |      | 9.3  |
| Dia  | 3    |      | 3.2  |

## 4.6 TO-220 type A package information

Figure 29. TO-220 type A package outline



0015988\_typeA\_Rev\_21

**Table 14. TO-220 type A package mechanical data**

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

## 5 Ordering information

**Table 15. Order codes**

| Order code   | Marking    | Package            | Packing       |
|--------------|------------|--------------------|---------------|
| STB11NK40ZT4 | B11NK40Z   | D <sup>2</sup> PAK | Tape and reel |
| STP11NK40Z   | P11NK40Z   | TO-220             | Tube          |
| STP11NK40ZFP | P11NK40ZFP | TO-220FP           |               |

## Revision history

**Table 16. Document revision history**

| Date        | Version | Changes                                                                        |
|-------------|---------|--------------------------------------------------------------------------------|
| 23-Aug-2005 | 2       | Preliminary version                                                            |
| 28-Oct-2005 | 3       | Complete version                                                               |
| 26-Jul-2006 | 4       | New template, no content change                                                |
| 22-Nov-2006 | 5       | Corrected unit on <i>Table 5.: On/off states</i>                               |
| 18-Jan-2007 | 6       | Typo mistakes on page 1                                                        |
| 20-Apr-2009 | 7       | Updated mechanical data                                                        |
| 02-Oct-2018 | 8       | Updated <a href="#">Section 4 Package information</a> .<br>Minor text changes. |



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