



# STx25NM60ND

N-channel 600 V, 0.13  $\Omega$ , 21 A FDmesh™ II Power MOSFET  
(with fast diode) in D<sup>2</sup>PAK, TO-220FP, TO-220, TO-247

## Features

| Type        | V <sub>DSS</sub> @<br>T <sub>JMAX</sub> | R <sub>DS(on)</sub> max | I <sub>D</sub>      |
|-------------|-----------------------------------------|-------------------------|---------------------|
| STB25NM60ND | 650 V                                   | 0.16 $\Omega$           | 21 A                |
| STF25NM60ND |                                         |                         | 21 A <sup>(1)</sup> |
| STP25NM60ND |                                         |                         | 21 A                |
| STW25NM60ND |                                         |                         | 21 A                |

1. Limited only by maximum temperature allowed

- The worldwide best R<sub>DS(on)</sub>\*area amongst the fast recovery diode devices
- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Extremely high dv/dt and avalanche capabilities

## Application

- Switching applications

## Description

These FDmesh™ II Power MOSFETs with intrinsic fast-recovery body diode are produced using the second generation of MDmesh™ technology. Utilizing a new strip-layout vertical structure, these revolutionary devices feature extremely low on-resistance and superior switching performance. They are ideal for bridge topologies and ZVS phase-shift converters.

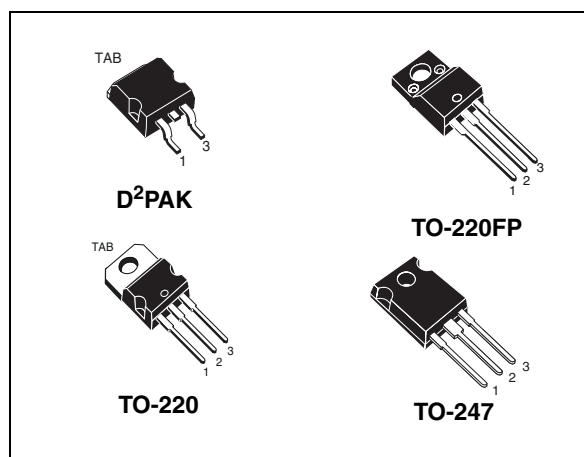
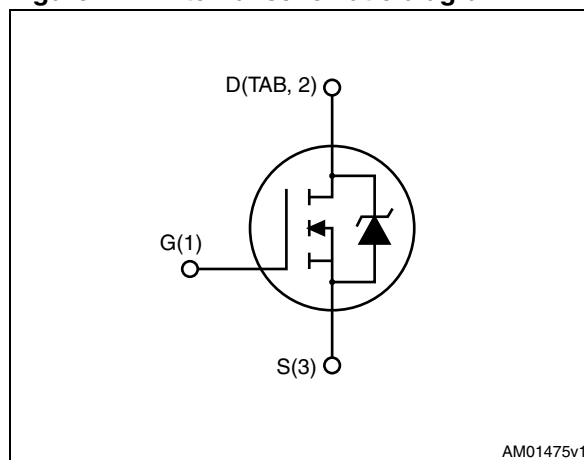


Figure 1. Internal schematic diagram



AM01475v1

Table 1. Device summary

| Order codes | Marking  | Package            | Packaging     |
|-------------|----------|--------------------|---------------|
| STB25NM60ND | 25NM60ND | D <sup>2</sup> PAK | Tape and reel |
| STF25NM60ND | 25NM60ND | TO-220FP           | Tube          |
| STP25NM60ND | 25NM60ND | TO-220             | Tube          |
| STW25NM60ND | 25NM60ND | TO-247             | Tube          |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                         | Parameter                                                                                                    | Value                              |                   | Unit |
|--------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------|------|
|                                |                                                                                                              | D <sup>2</sup> PAK, TO-220, TO-247 | TO-220FP          |      |
| V <sub>DS</sub>                | Drain-source voltage                                                                                         | 600                                |                   | V    |
| V <sub>GS</sub>                | Gate-source voltage                                                                                          | ±25                                |                   | V    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 25 °C                                                         | 21                                 | 21 <sup>(1)</sup> | A    |
| I <sub>D</sub>                 | Drain current (continuous) at T <sub>C</sub> = 100 °C                                                        | 13                                 | 13 <sup>(1)</sup> | A    |
| I <sub>DM</sub> <sup>(2)</sup> | Drain current (pulsed)                                                                                       | 84                                 | 84(1)             | A    |
| P <sub>TOT</sub>               | Total dissipation at T <sub>C</sub> = 25 °C                                                                  | 160                                | 40                | W    |
| dv/dt <sup>(3)</sup>           | Peak diode recovery voltage slope                                                                            | 40                                 |                   | V/ns |
| V <sub>iso</sub>               | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T <sub>C</sub> =25 °C) |                                    | 2500              | V    |
| T <sub>stg</sub>               | Storage temperature                                                                                          | -55 to 150                         |                   | °C   |
| T <sub>J</sub>                 | Max. operating junction temperature                                                                          | 150                                |                   | °C   |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3. I<sub>SD</sub> ≤ 21 A, di/dt ≤ 600 A/μs, V<sub>DD</sub> = 80% V<sub>(BR)DSS</sub>

**Table 3. Thermal data**

| Symbol                              | Parameter                               | D <sup>2</sup> PAK | TO-220FP | TO-220 | TO-247 | Unit |
|-------------------------------------|-----------------------------------------|--------------------|----------|--------|--------|------|
| R <sub>thj-case</sub>               | Thermal resistance junction-case max    | 0.78               | 3.1      | 0.78   |        | °C/W |
| R <sub>thj-amb</sub>                | Thermal resistance junction-ambient max |                    | 62.5     |        | 50     | °C/W |
| R <sub>thj-pcb</sub> <sup>(1)</sup> | Thermal resistance junction-ambient max | 30                 |          |        |        | °C/W |

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

**Table 4. Avalanche characteristics**

| Symbol          | Parameter                                                                                                                  | Max value | Unit |
|-----------------|----------------------------------------------------------------------------------------------------------------------------|-----------|------|
| I <sub>AS</sub> | Avalanche current, repetitive or not-repetitive (pulse width limited by T <sub>J</sub> max)                                | 10        | A    |
| E <sub>AS</sub> | Single pulse avalanche energy (starting T <sub>J</sub> = 25 °C, I <sub>D</sub> = I <sub>AS</sub> , V <sub>DD</sub> = 50 V) | 850       | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off states**

| Symbol        | Parameter                                        | Test conditions                                                                          | Value |      |           | Unit                           |
|---------------|--------------------------------------------------|------------------------------------------------------------------------------------------|-------|------|-----------|--------------------------------|
|               |                                                  |                                                                                          | Min.  | Typ. | Max.      |                                |
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$                                                       | 600   |      |           | V                              |
| $dv/dt^{(1)}$ | Drain source voltage slope                       | $V_{DD} = 480\text{ V}$ , $I_D = 21\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$                | 48    |      |           | V/ns                           |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 600\text{ V}$<br>$V_{DS} = 600\text{ V}$ @ $T_C = 125\text{ }^{\circ}\text{C}$ |       |      | 1<br>100  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$                                                               |       |      | $\pm 100$ | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                       | 3     | 4    | 5         | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 10.5\text{ A}$                                           |       | 0.13 | 0.16      | $\Omega$                       |

1. Characteristic value at turn off on inductive load.

**Table 6. Dynamic**

| Symbol                                        | Parameter                                                               | Test conditions                                                                                                                              | Min. | Typ.                 | Max. | Unit                 |
|-----------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------|------|----------------------|
| $g_{fs}^{(1)}$                                | Forward transconductance                                                | $V_{DS} = 15\text{ V}$ , $I_D = 10.5\text{ A}$                                                                                               | -    | 17                   | -    | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                                                                                | -    | 2400<br>150<br>15    | -    | pF<br>pF<br>pF       |
| $C_{oss\text{ eq.}}^{(2)}$                    | Equivalent output capacitance                                           | $V_{GS} = 0$ , $V_{DS} = 0\text{ to }480\text{ V}$                                                                                           | -    | 320                  | -    | pF                   |
| $t_{d(on)}$<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     | $V_{DD} = 300\text{ V}$ , $I_D = 10.5\text{ A}$<br>$R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$<br>(see Figure 23),<br>(see Figure 18) | -    | 60<br>30<br>50<br>40 | -    | ns<br>ns<br>ns<br>ns |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$                 | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $V_{DD} = 480\text{ V}$ , $I_D = 21\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ ,<br>(see Figure 19)                                               | -    | 80<br>15<br>40       | -    | nC<br>nC<br>nC       |
| $R_g$                                         | Gate input resistance                                                   | $f = 1\text{ MHz}$ gate DC bias=0<br>Test signal level = 20 mV<br>open drain                                                                 | -    | 1.6                  | -    | $\Omega$             |

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

2.  $C_{oss\text{ eq.}}$  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 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                                                                                                                                 | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                 | -    |      | 21   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                 | -    |      | 84   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 21\text{ A}$ , $V_{GS} = 0$                                                                                                           | -    |      | 1.3  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 21\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$<br>(see Figure 20)                                        | -    | 160  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                 |      | 1    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                 |      | 15   |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 21\text{ A}$ , $V_{DD} = 60\text{ V}$<br>$di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$T_J = 150\text{ }^\circ\text{C}$<br>(see Figure 20) | -    | 230  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                 |      | 2    |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                 |      | 19   |      | 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 D<sup>2</sup>PAK and TO-220

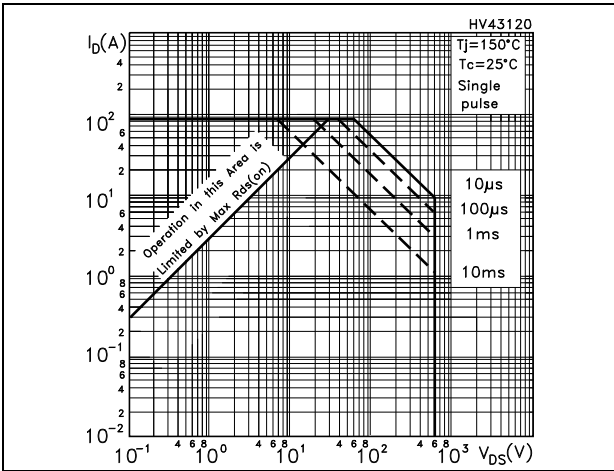


Figure 3. Thermal impedance for D<sup>2</sup>PAK and TO-220

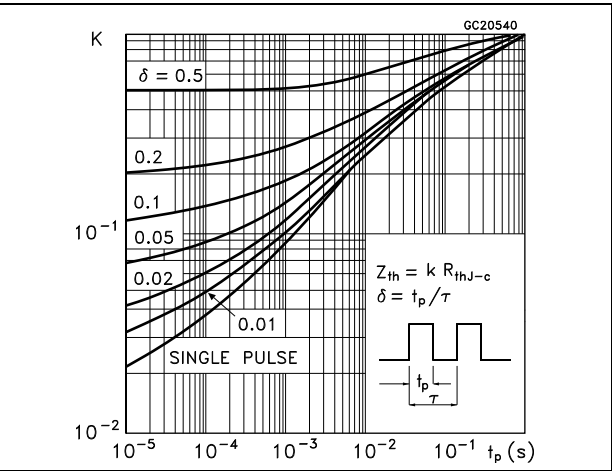


Figure 4. Safe operating area for TO-220FP

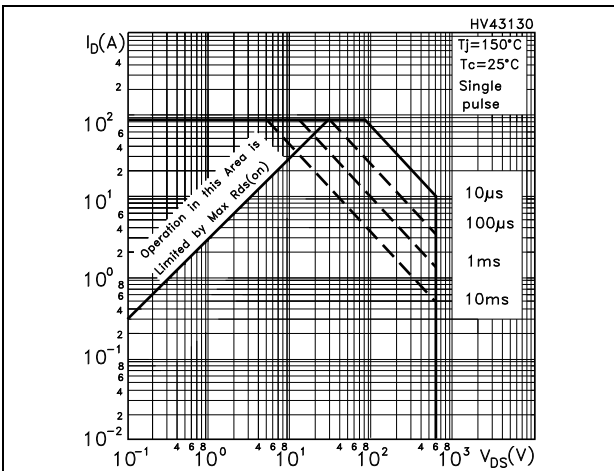


Figure 5. Thermal impedance for TO-220FP

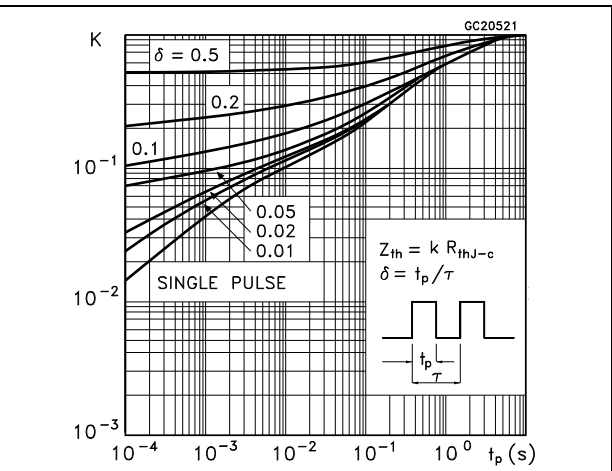


Figure 6. Safe operating area for TO-247

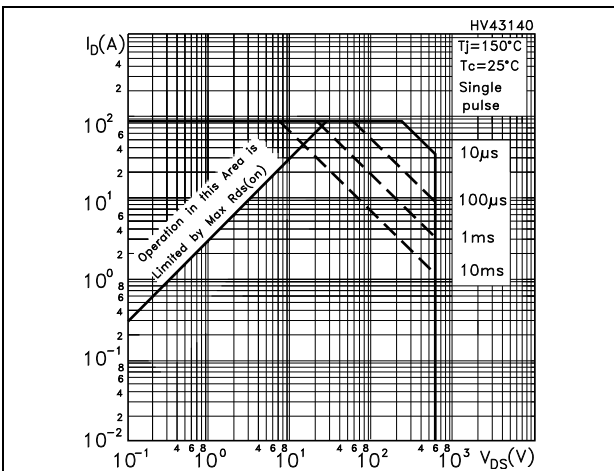


Figure 7. Thermal impedance for TO-247

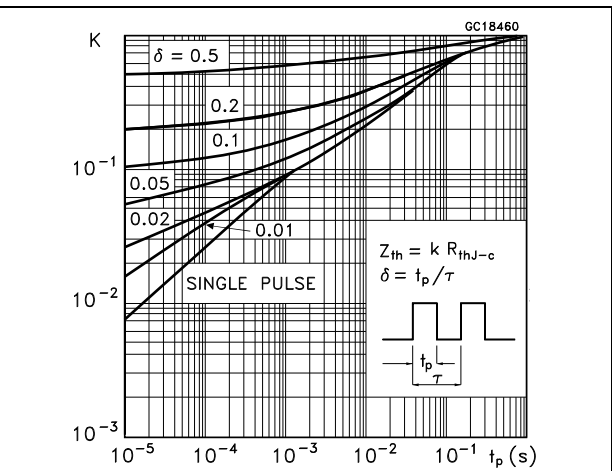


Figure 8. Output characteristics

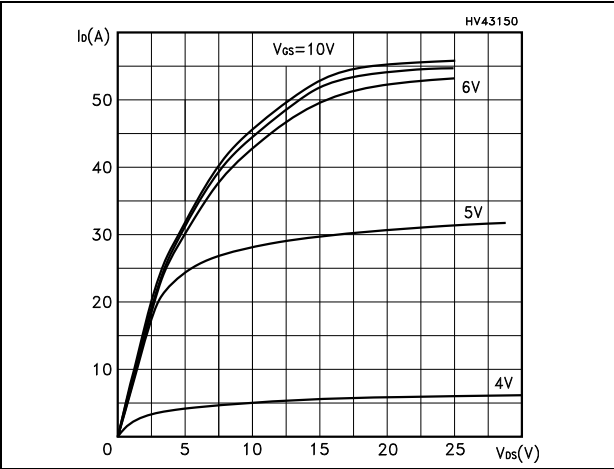


Figure 9. Transfer characteristics

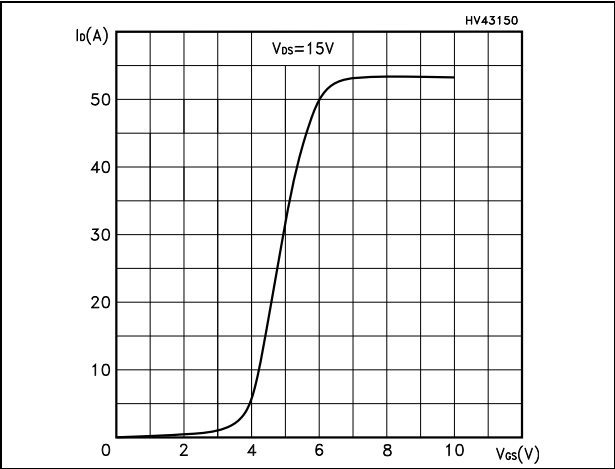


Figure 10. Transconductance

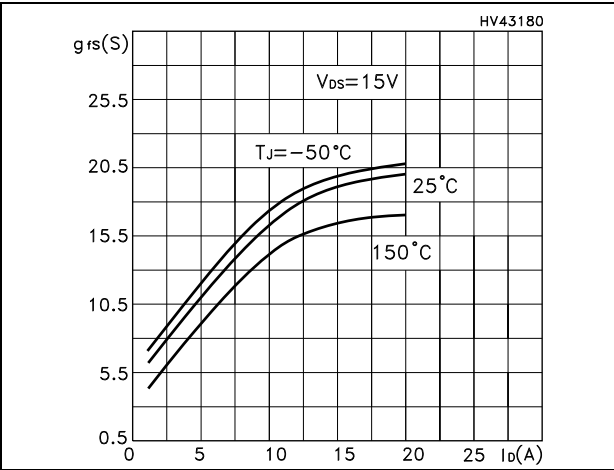


Figure 11. Static drain-source on resistance

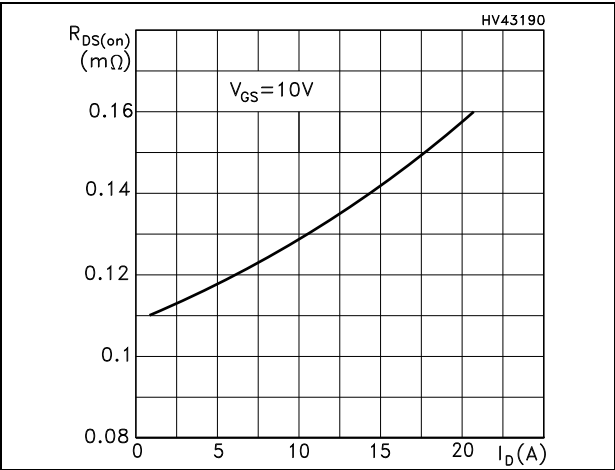


Figure 12. Gate charge vs gate-source voltage

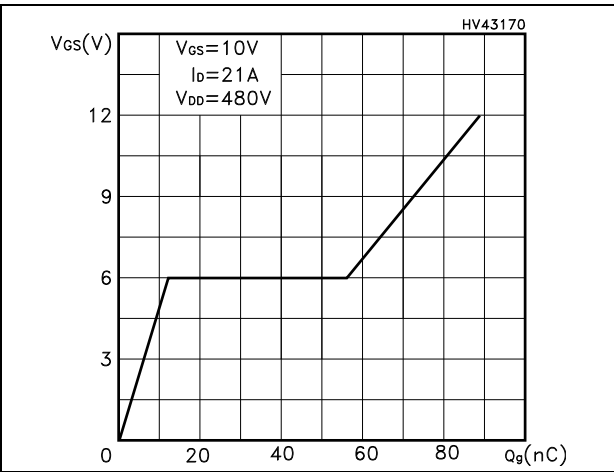


Figure 13. Capacitance variations

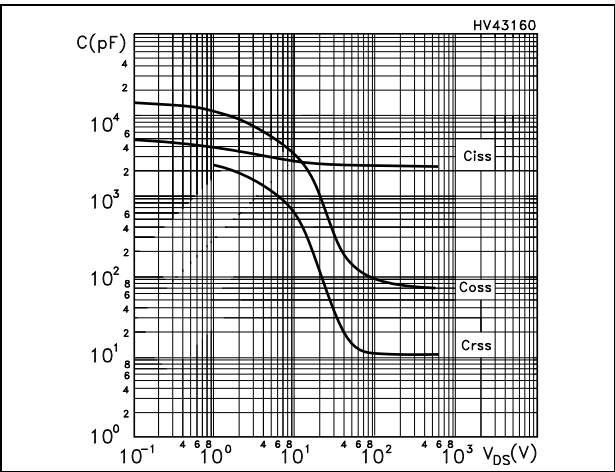


Figure 14. Normalized gate threshold voltage vs temperature

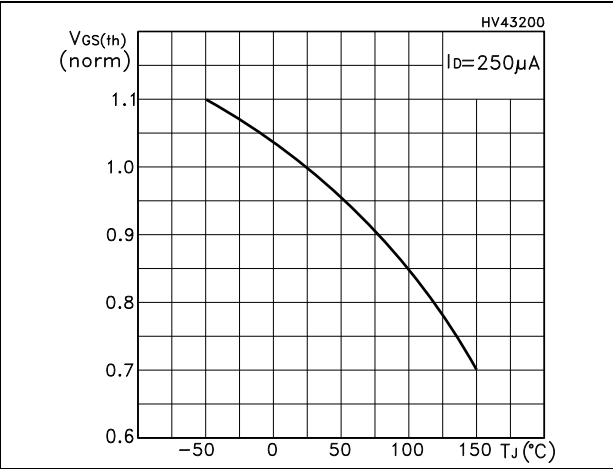


Figure 15. Normalized on resistance vs temperature

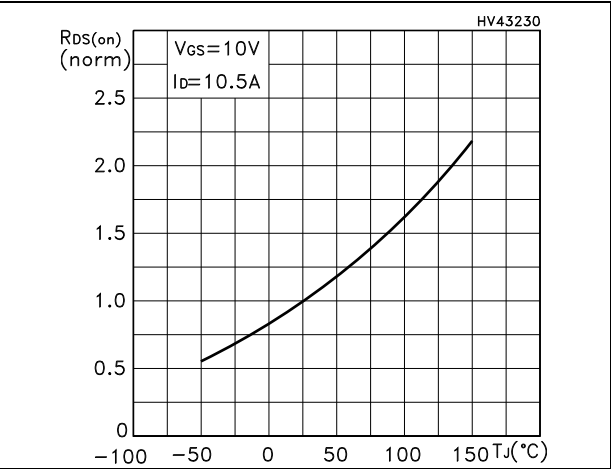


Figure 16. Source-drain diode forward characteristics

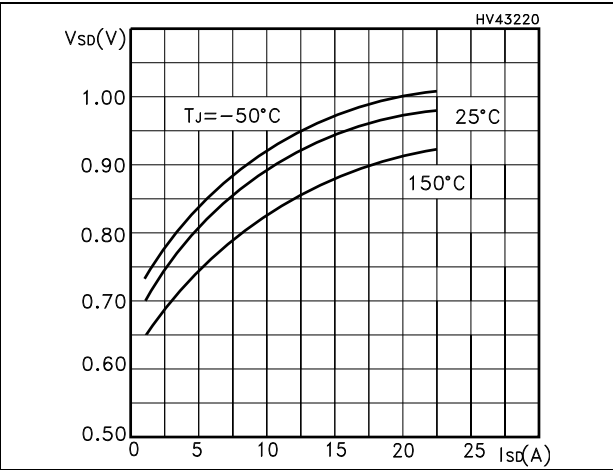
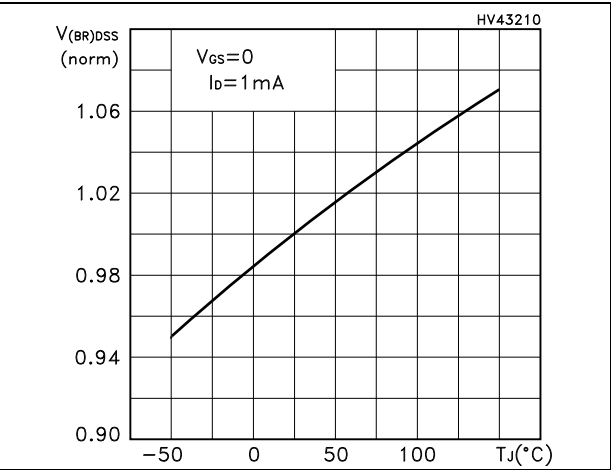
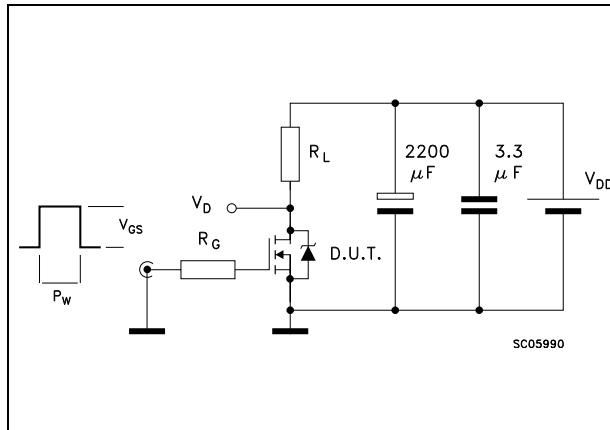


Figure 17. Normalized B<sub>VDSS</sub> vs temperature

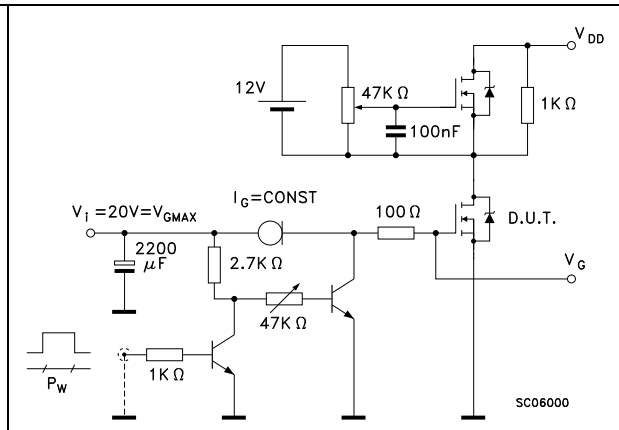


### 3 Test circuits

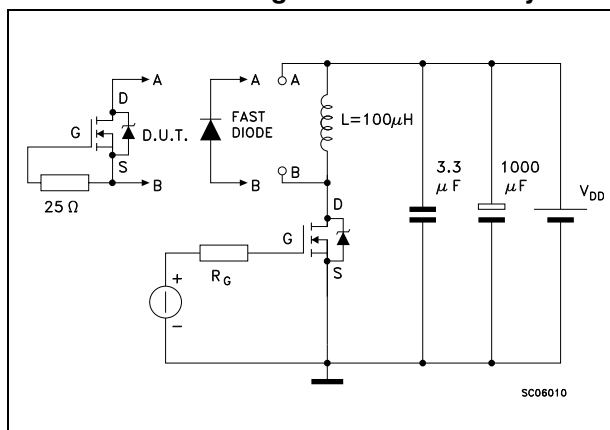
**Figure 18. Switching times test circuit for resistive load**



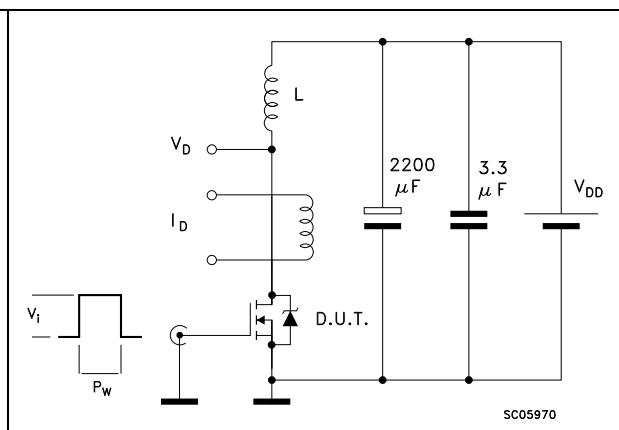
**Figure 19. Gate charge test circuit**



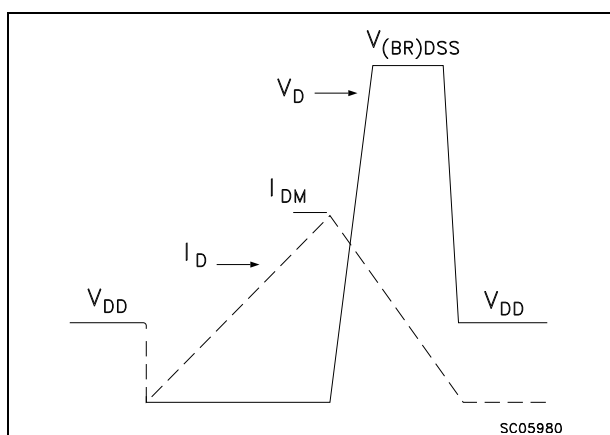
**Figure 20. Test circuit for inductive load switching and diode recovery times**



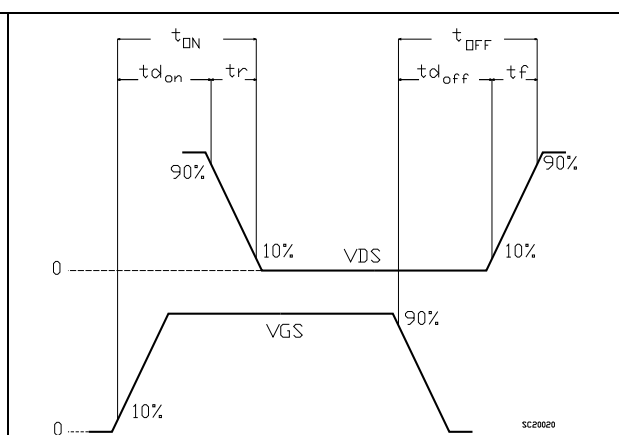
**Figure 21. Unclamped inductive load test circuit**



**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 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.

Table 8. D<sup>2</sup>PAK (TO-263) 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 |      |       |
| E    | 10   |      | 10.40 |
| E1   | 8.50 |      |       |
| e    |      | 2.54 |       |
| e1   | 4.88 |      | 5.28  |
| H    | 15   |      | 15.85 |
| J1   | 2.49 |      | 2.69  |
| L    | 2.29 |      | 2.79  |
| L1   | 1.27 |      | 1.40  |
| L2   | 1.30 |      | 1.75  |
| R    |      | 0.4  |       |
| V2   | 0°   |      | 8°    |

Figure 24. D<sup>2</sup>PAK (TO-263) drawing

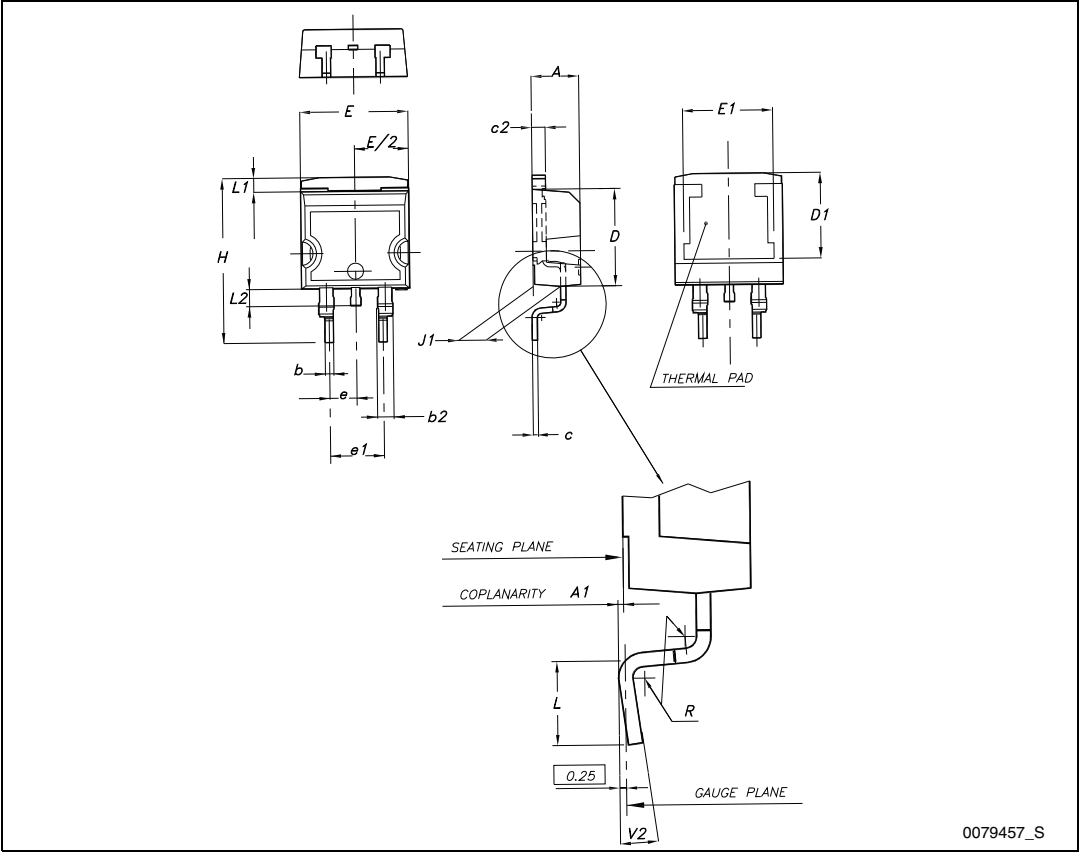
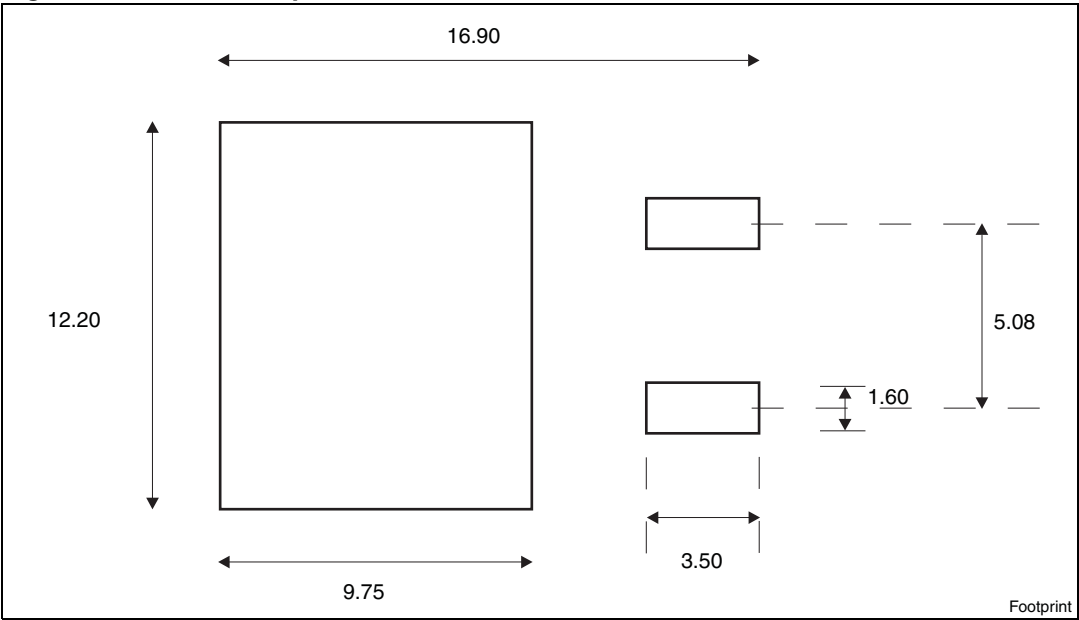


Figure 25. D<sup>2</sup>PAK footprint<sup>(a)</sup>



a. All dimension are in millimeters

Table 9. TO-220FP mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
| 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  |

TO-220FP drawing

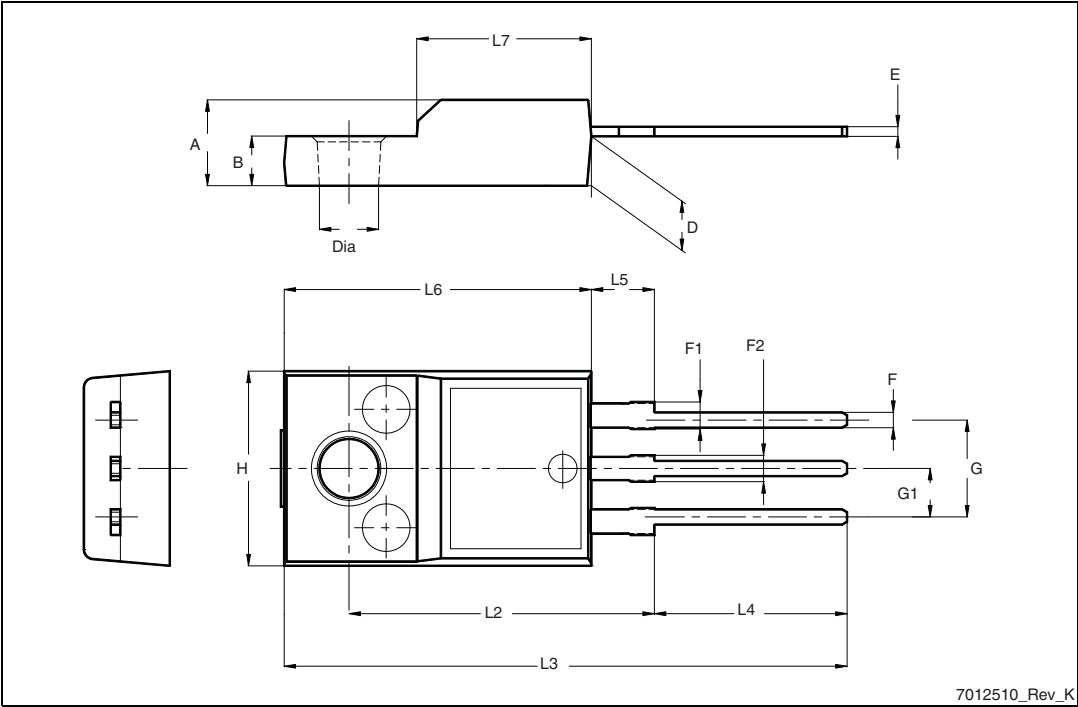


Table 10. TO-220 type A mechanical data

| Dim. | mm    |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 4.40  |       | 4.60  |
| b    | 0.61  |       | 0.88  |
| b1   | 1.14  |       | 1.70  |
| c    | 0.48  |       | 0.70  |
| D    | 15.25 |       | 15.75 |
| D1   |       | 1.27  |       |
| E    | 10    |       | 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    |       | 14    |
| L1   | 3.50  |       | 3.93  |
| L20  |       | 16.40 |       |
| L30  |       | 28.90 |       |
| ØP   | 3.75  |       | 3.85  |
| Q    | 2.65  |       | 2.95  |

Figure 26. TO-220 type A drawing

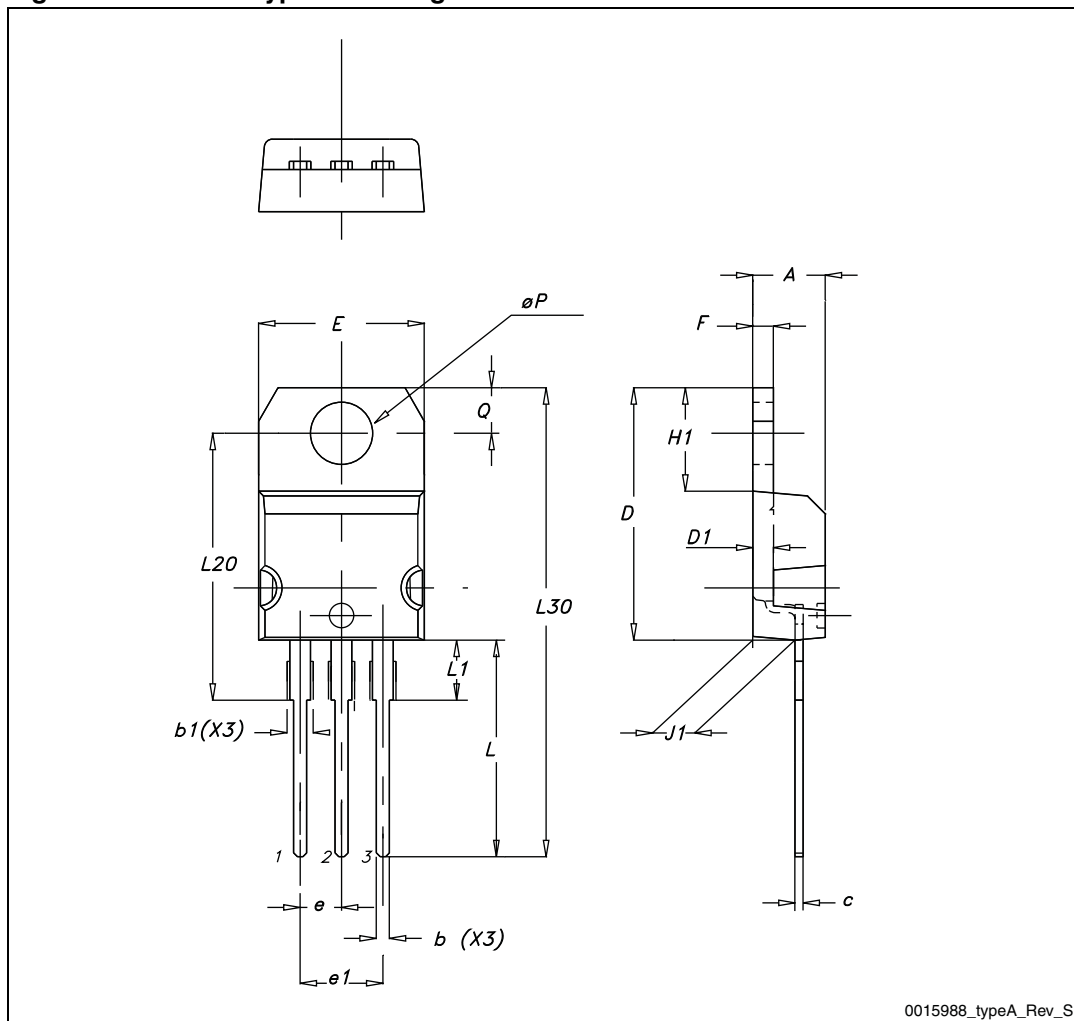
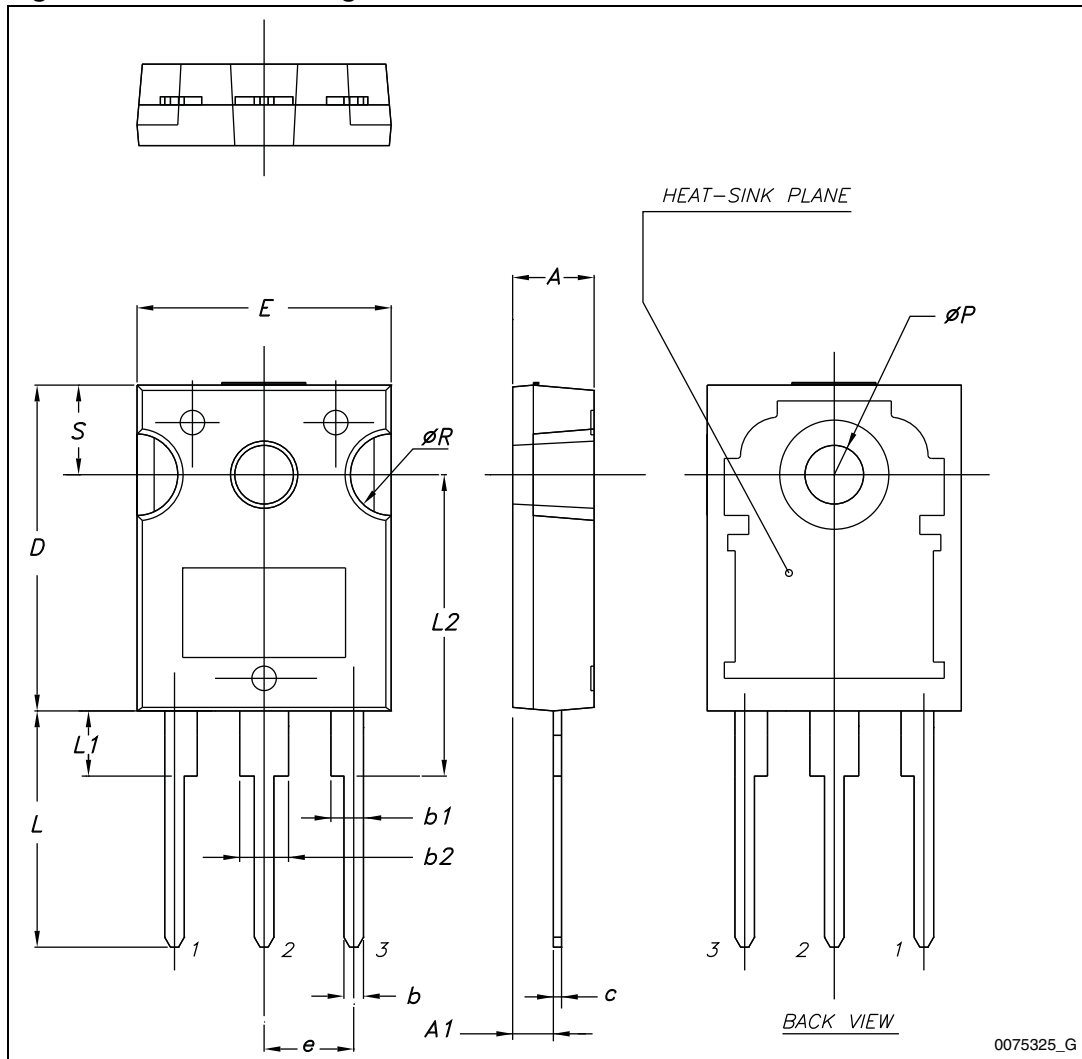


Table 11. TO-247 mechanical data

| 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    | 5.30  | 5.45  | 5.60  |
| L    | 14.20 |       | 14.80 |
| L1   | 3.70  |       | 4.30  |
| L2   |       | 18.50 |       |
| ØP   | 3.55  |       | 3.65  |
| ØR   | 4.50  |       | 5.50  |
| S    | 5.30  | 5.50  | 5.70  |

Figure 27. TO-247 drawing



## 5 Packing mechanical data

**Table 12. D<sup>2</sup>PAK (TO-263) 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 qty |      | 1000 |
| P2   | 1.9  | 2.1  | Bulk qty |      | 1000 |
| R    | 50   |      |          |      |      |
| T    | 0.25 | 0.35 |          |      |      |
| W    | 23.7 | 24.3 |          |      |      |

Figure 28. Tape

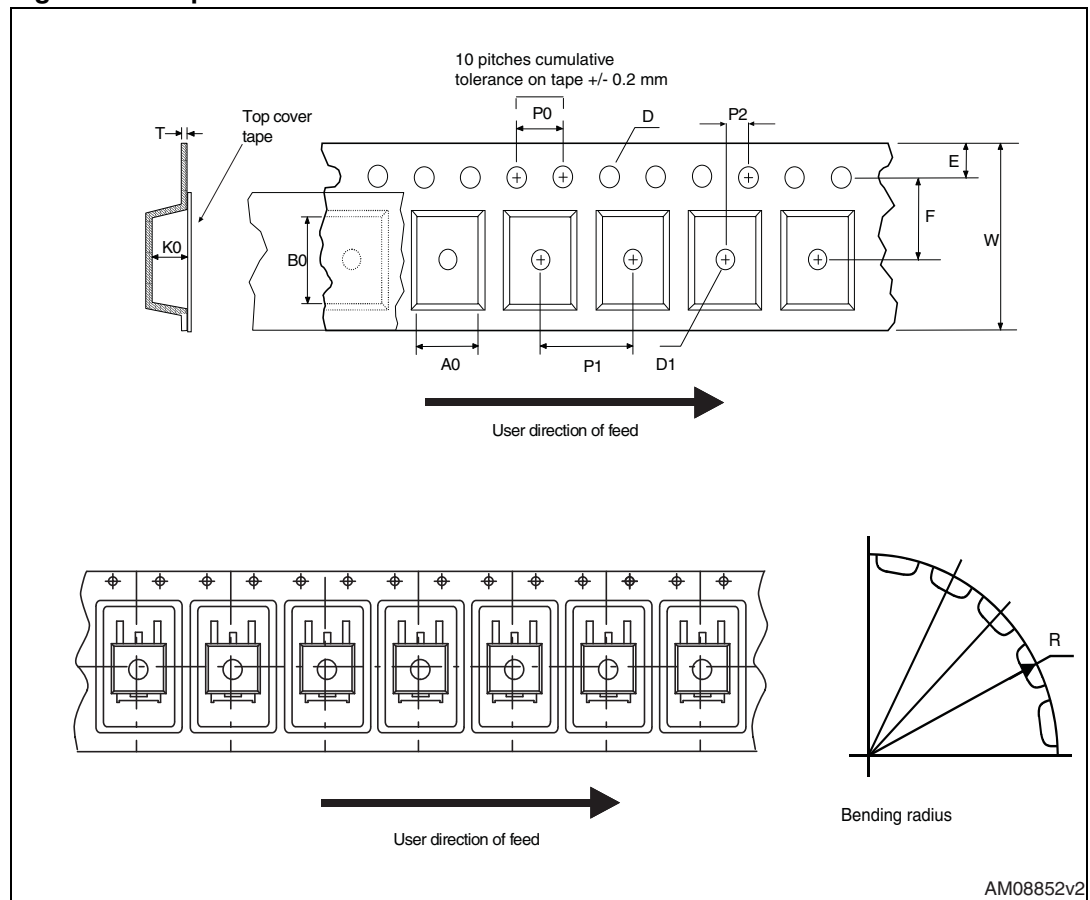
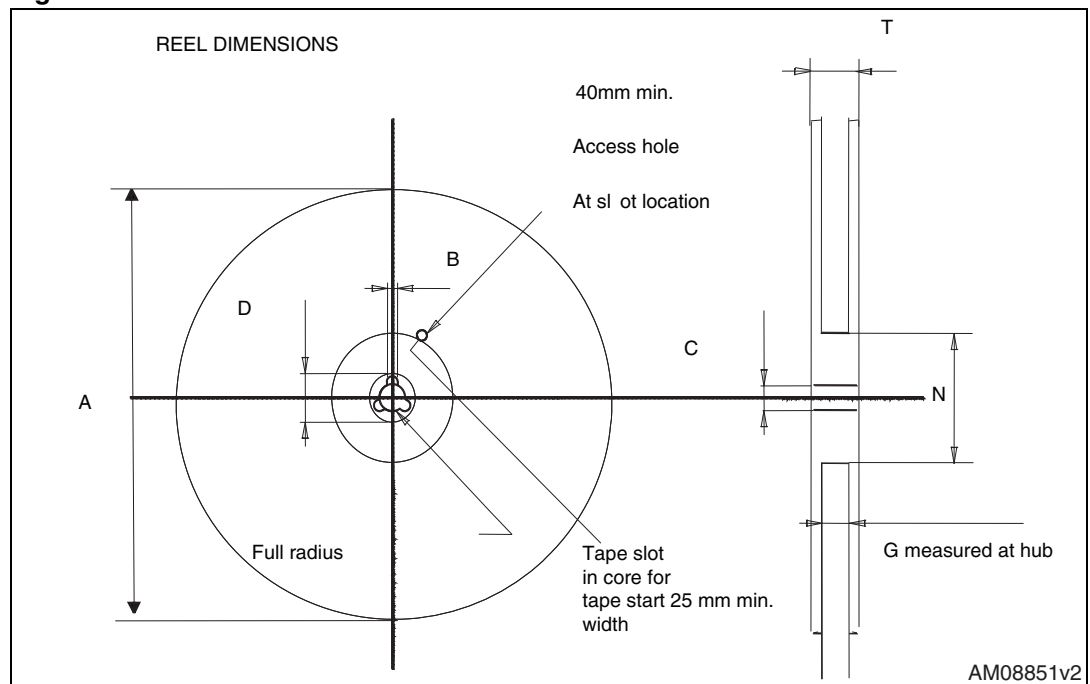


Figure 29. Reel



## 6 Revision history

**Table 13. Document revision history**

| Date        | Revision | Changes                                                                                                                                    |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 15-Nov-2007 | 1        | First release.                                                                                                                             |
| 22-Jan-2008 | 2        | Document status promoted from target specification to preliminary data.                                                                    |
| 08-Apr-2008 | 3        | – Updated <a href="#">Table 3: Thermal data on page 3</a> ;<br>– Document status promoted from preliminary data to datasheet.              |
| 03-Mar-2009 | 4        | Q <sub>g</sub> value has been updated.                                                                                                     |
| 28-Nov-2011 | 5        | Updated <a href="#">Section 4: Package mechanical data</a> and <a href="#">Section 5: Packing mechanical data</a> .<br>Minor text changes. |

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