



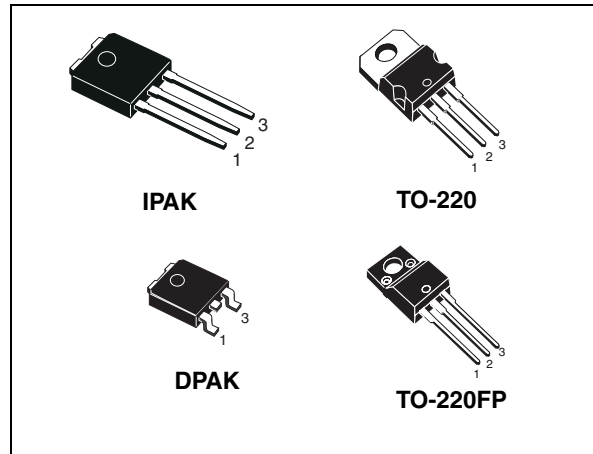
# STD7NM60N, STF7NM60N STP7NM60N, STU7NM60N

N-channel 600 V, 5 A, 0.84  $\Omega$  DPAK, TO-220FP, TO-220, IPAK  
second generation MDmesh™ Power MOSFET

## Features

| Order codes                                      | V <sub>DSS</sub> @<br>T <sub>Jmax</sub> | R <sub>DS(on)</sub><br>max. | I <sub>D</sub> |
|--|---|-----------------------------|----------------|
| STD7NM60N<br>STF7NM60N<br>STP7NM60N<br>STU7NM60N | 650 V                                   | < 0.9 $\Omega$              | 5 A            |

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



## Application

Switching applications

## Description

These devices are N-channel Power MOSFETs realized using the second generation of MDmesh™ technology. It applies the benefits of the multiple drain process to STMicroelectronics' well-known PowerMESH™ horizontal layout structure. The resulting product offers improved on-resistance, low gate charge, high dv/dt capability and excellent avalanche characteristics.

Figure 1. Internal schematic diagram



Table 1. Device summary

| Order codes | Marking | Package  | Packaging     |
|-------------|---------|----------|---------------|
| STD7NM60N   | 7NM60N  | DPAK     | Tape and reel |
| STF7NM60N   |         | TO-220FP | Tube          |
| STP7NM60N   |         | TO-220   | Tube          |
| STU7NM60N   |         | IPAK     | Tube          |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter   | Value              |                   | Unit             |
|----------------|---|--------------------|-------------------|------------------|
|                |   | TO-220, IPAK, DPAK | TO-220FP          |                  |
| $V_{DS}$       | Drain-source voltage ( $V_{GS} = 0$ )   | 600                |                   | V                |
| $V_{GS}$       | Gate-source voltage   | $\pm 25$           |                   | V                |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$  | 5                  | 5 <sup>(1)</sup>  | A                |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$   | 3                  | 3 <sup>(1)</sup>  | A                |
| $I_{DM}^{(2)}$ | Drain current (pulsed)  | 20                 | 20 <sup>(1)</sup> | A                |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^\circ\text{C}$   | 45                 | 20                | 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.  $I_{SD} \leq 5\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ,  $V_{Peak} < V_{(BR)DSS}$

**Table 3. Thermal data**

| Symbol         | Parameter                                      | Value |      |        |          | Unit                      |
|----------------|--|-------|------|--------|----------|---------------------------|
|                |  | DPAK  | IPAK | TO-220 | TO-220FP |                           |
| $R_{thj-case}$ | Thermal resistance junction-case max           | 2.78  |      | 6.25   |          | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max        |       | 100  | 62.5   |          | $^\circ\text{C}/\text{W}$ |
| $R_{thj-pcb}$  | Thermal resistance junction-pcb max            | 50    |      |        |          | $^\circ\text{C}/\text{W}$ |
| $T_l$          | Maximum lead temperature for soldering purpose | 300   |      |        |          | $^\circ\text{C}$          |

**Table 4. Thermal data**

| Symbol   | Parameter  | Value | Unit |
|----------|--|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                                   | 2     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 119   | mJ   |

## 2 Electrical characteristics

( $T_C = 25\text{ °C}$  unless otherwise specified)

**Table 5. On /off states**

| Symbol        | Parameter  | Test conditions  | Min. | Typ. | Max.     | Unit                           |
|---------------|--|--|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$ , $V_{GS} = 0$   | 600  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max rating}$<br>$V_{DS} = \text{Max rating}$ , $T_C = 125\text{ °C}$ |      |      | 1<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$   |      |      | 100      | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                   | 2    | 3    | 4        | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 2.5\text{ A}$  |      | 0.84 | 0.9      | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                     | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit     |
|----------------------------|-------------------------------|--|------|------|------|----------|
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 50\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$  | -    | 363  | -    | pF       |
| $C_{oss}$                  | Output capacitance            |  |      | 24.6 |      | pF       |
| $C_{rss}$                  | Reverse transfer capacitance  |  |      | 1.1  |      | pF       |
| $C_{oss\text{ eq.}}^{(1)}$ | Output equivalent capacitance | $V_{DS} = 0\text{ to }480\text{ V}$ , $V_{GS} = 0$   | -    | 130  | -    | pF       |
| $R_G$                      | Intrinsic gate resistance     | $f = 1\text{ MHz}$ open drain  | -    | 5.4  | -    | $\Omega$ |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}$ , $I_D = 5\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 18</a> ) | -    | 14   | -    | nC       |
| $Q_{gs}$                   | Gate-source charge            |  |      | 2.7  |      | nC       |
| $Q_{gd}$                   | Gate-drain charge             |  |      | 7.7  |      | nC       |

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

**Table 7. Switching times**

| Symbol       | Parameter           | Test conditions  | Min. | Typ. | Max | Unit |    |
|--------------|---------------------|--|------|------|-----|------|----|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 300\text{ V}$ , $I_D = 2.5\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 19</a> ) |      | 7    |     | ns   |    |
| $t_r$        | Rise time           |  |      | 10   |     | ns   |    |
| $t_{d(off)}$ | Turn-off-delay time |  |      |      | 26  |      | ns |
| $t_f$        | Fall time           |  |      |      | 12  |      | ns |

**Table 8. Source drain diode**

| Symbol          | Parameter                     | Test conditions  | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|--|------|------|------|------|
| $I_{SD}$        | Source-drain current          |  |      |      | 5    | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |  |      |      | 20   | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 5\text{ A}$ , $V_{GS} = 0$   |      |      | 1.3  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 22</a> )  |      | 213  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |  |      | 1.5  |      | nC   |
| $I_{RRM}$       | Reverse recovery current      |  |      | 14   |      | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 5\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 22</a> ) |      | 265  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       |  |      | 1.8  |      | nC   |
| $I_{RRM}$       | 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%

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for DPAK, IPAK Figure 3. Thermal impedance for DPAK, IPAK

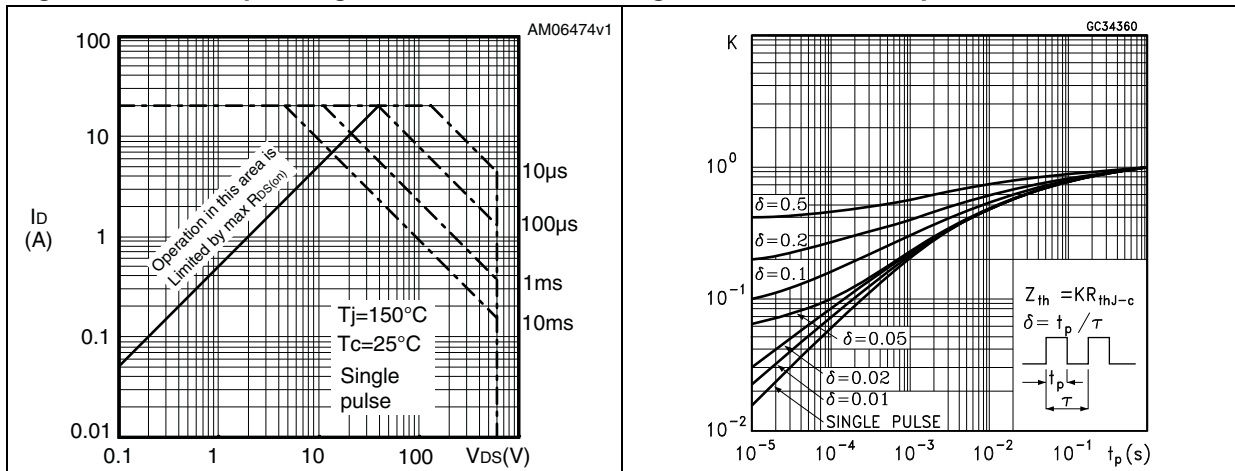


Figure 4. Safe operating area for TO-220FP Figure 5. Thermal impedance for TO-220FP

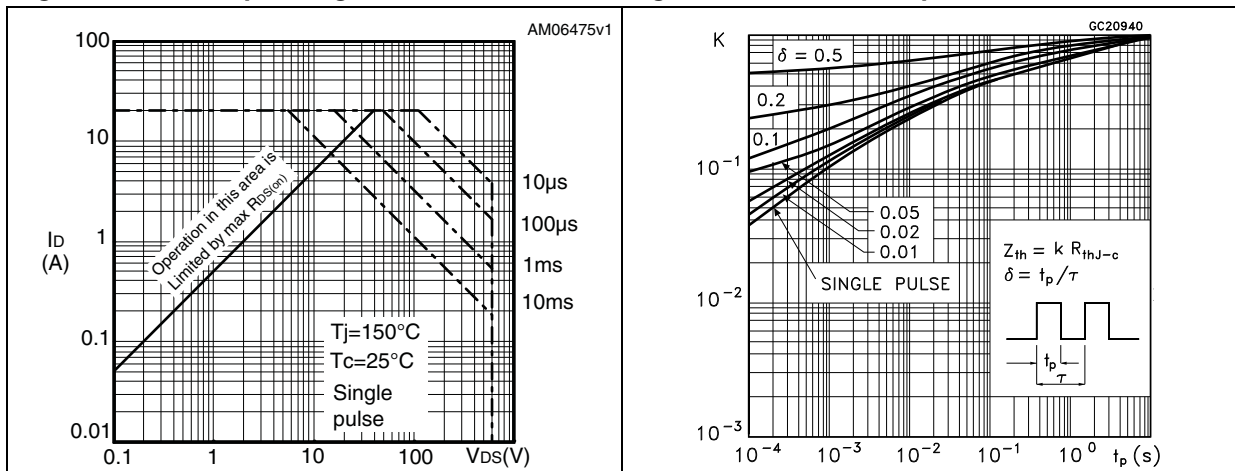


Figure 6. Safe operating area for TO-220 Figure 7. Thermal impedance for TO-220

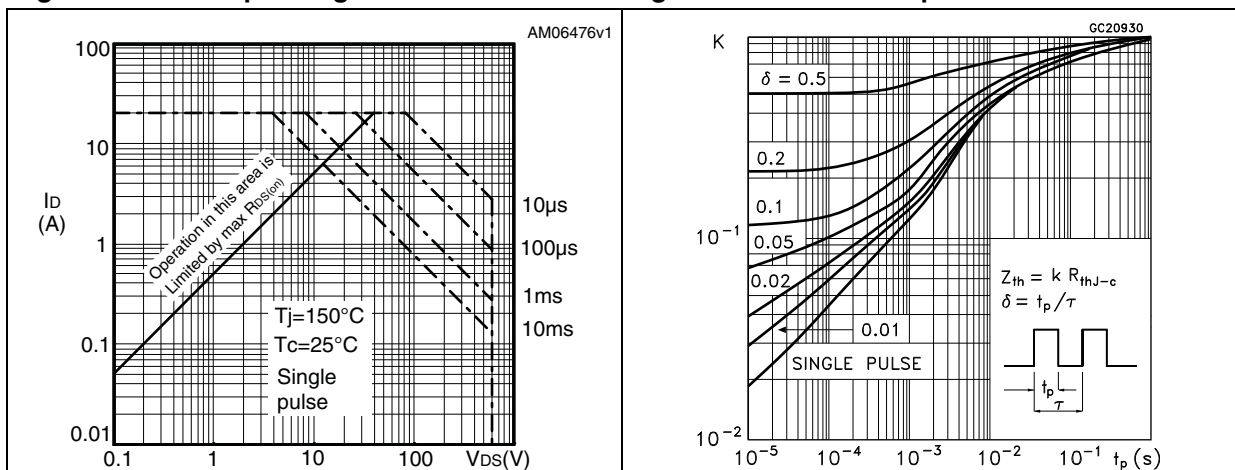


Figure 8. Output characteristics

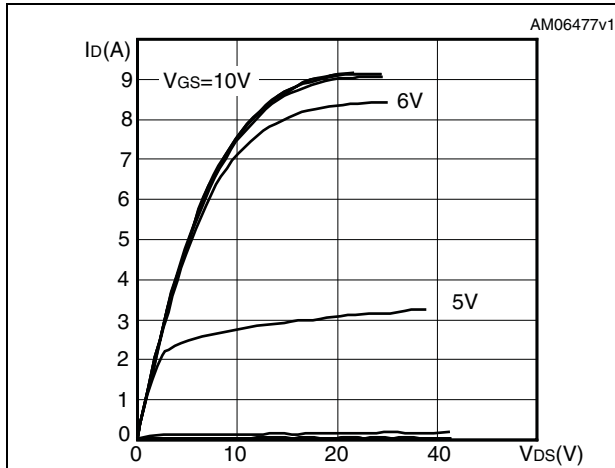


Figure 9. Transfer characteristics

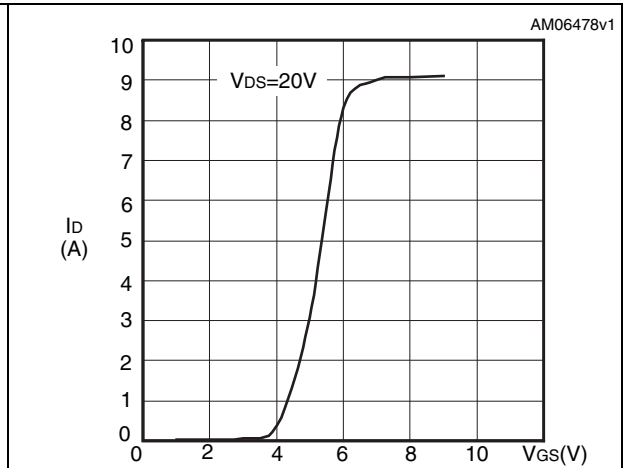


Figure 10. Gate charge vs gate-source voltage Figure 11. Static drain-source on resistance

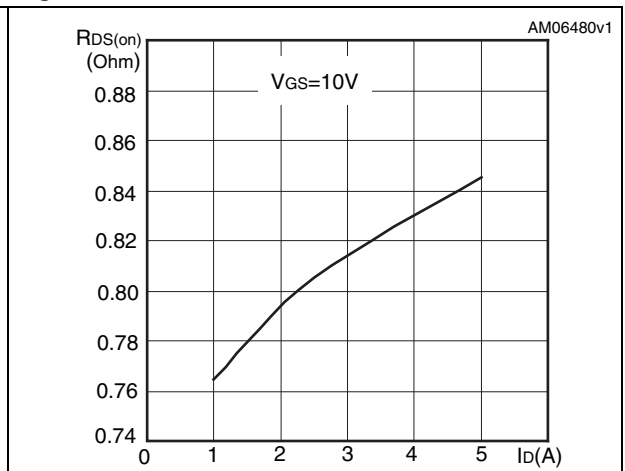
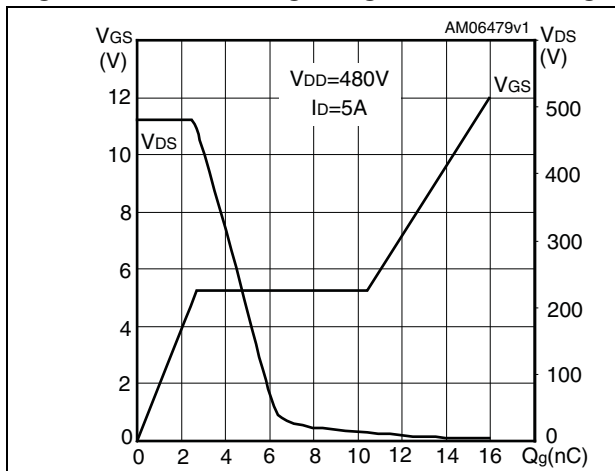


Figure 12. Capacitance variations

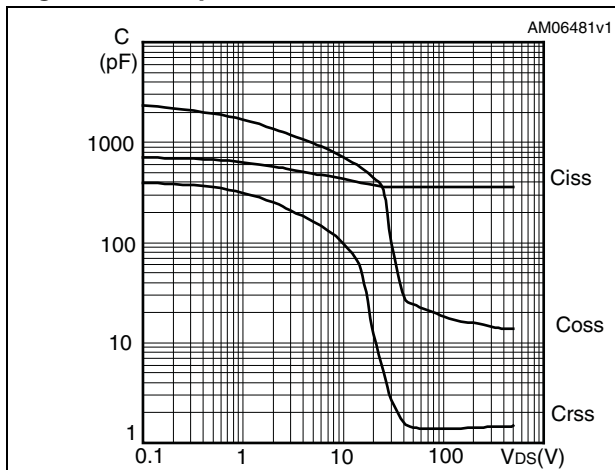
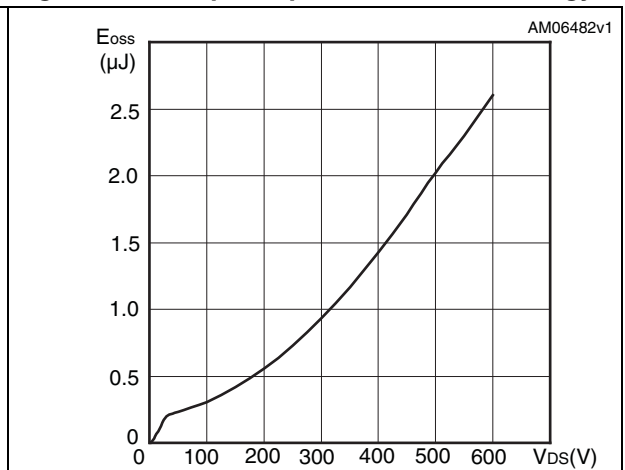
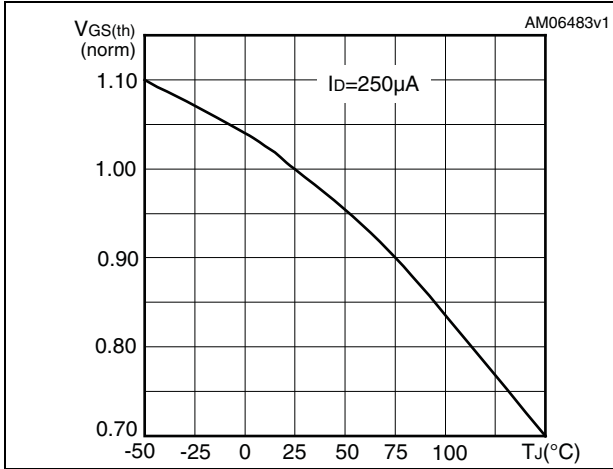


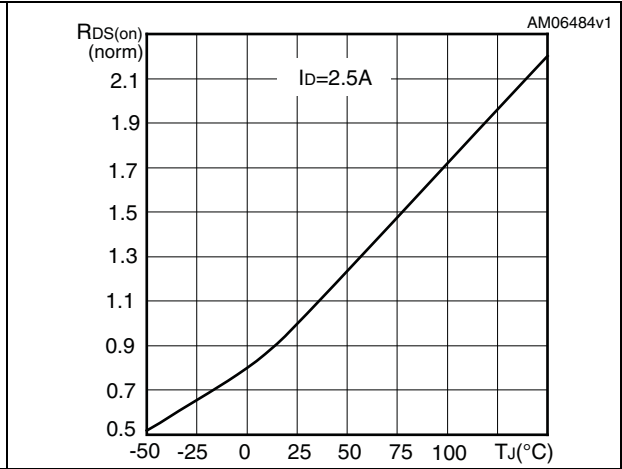
Figure 13. Output capacitance stored energy



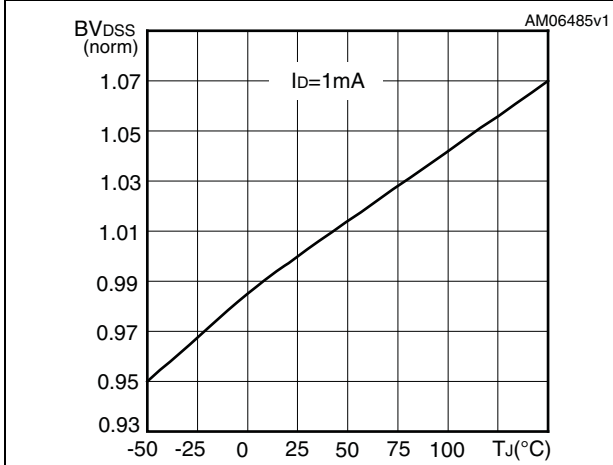
**Figure 14. Normalized gate threshold voltage vs temperature**



**Figure 15. Normalized on resistance vs temperature**



**Figure 16. Normalized B<sub>V</sub>DSS vs temperature**





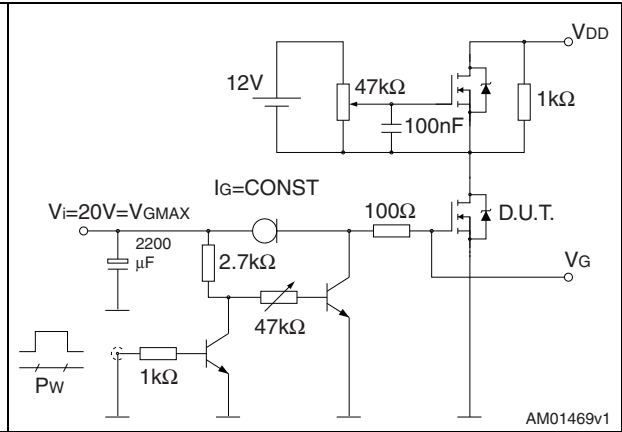
### 3 Test circuits

**Figure 17. Switching times test circuit for resistive load**



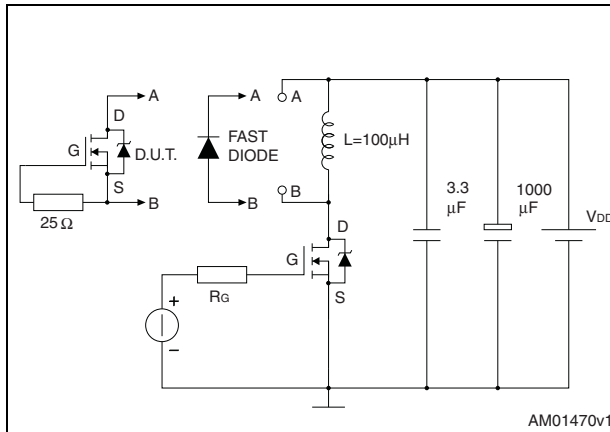
AM01468v1

**Figure 18. Gate charge test circuit**



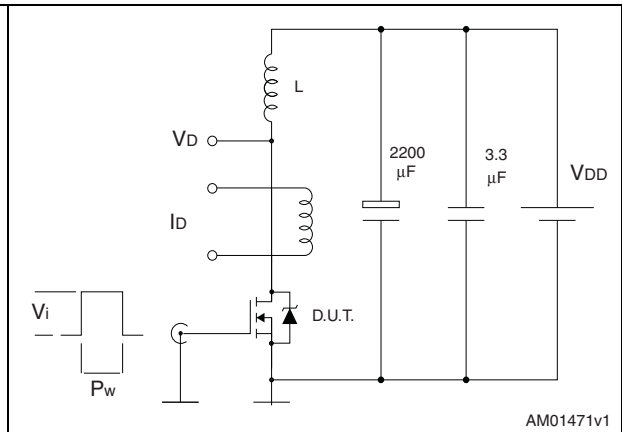
AM01469v1

**Figure 19. Test circuit for inductive load switching and diode recovery times**



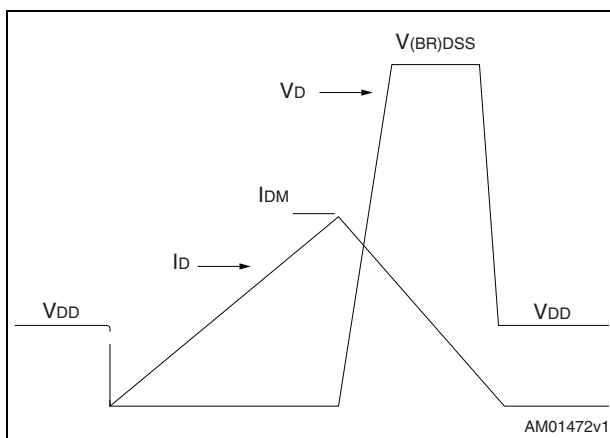
AM01470v1

**Figure 20. Unclamped inductive load test circuit**



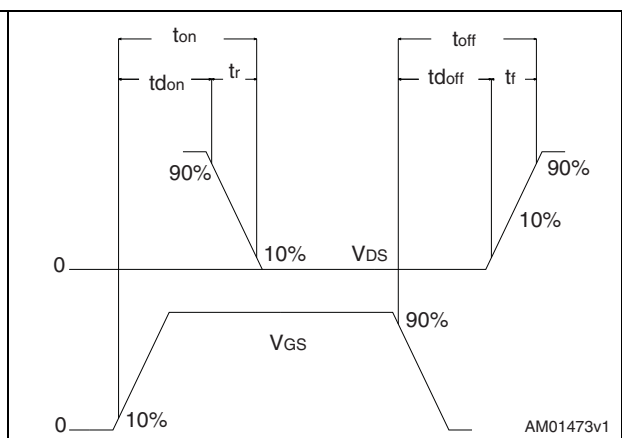
AM01471v1

**Figure 21. Unclamped inductive waveform**



AM01472v1

**Figure 22. Switching time waveform**



AM01473v1

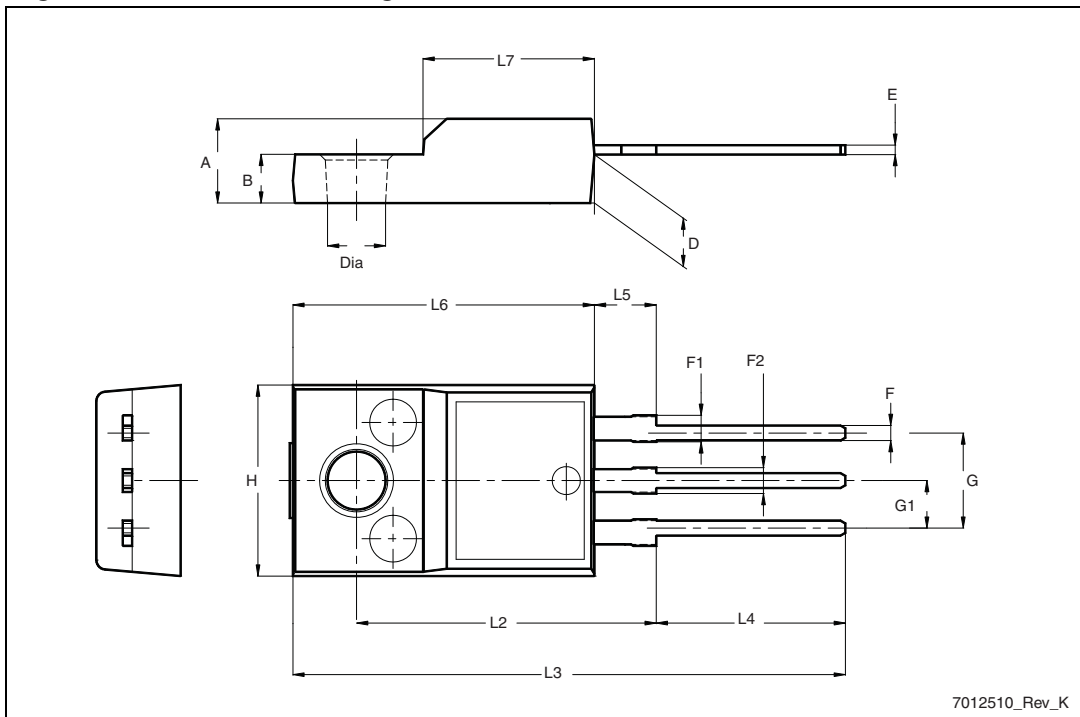
## 4 Package mechanical data

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

Table 9. TO-220FP mechanical data

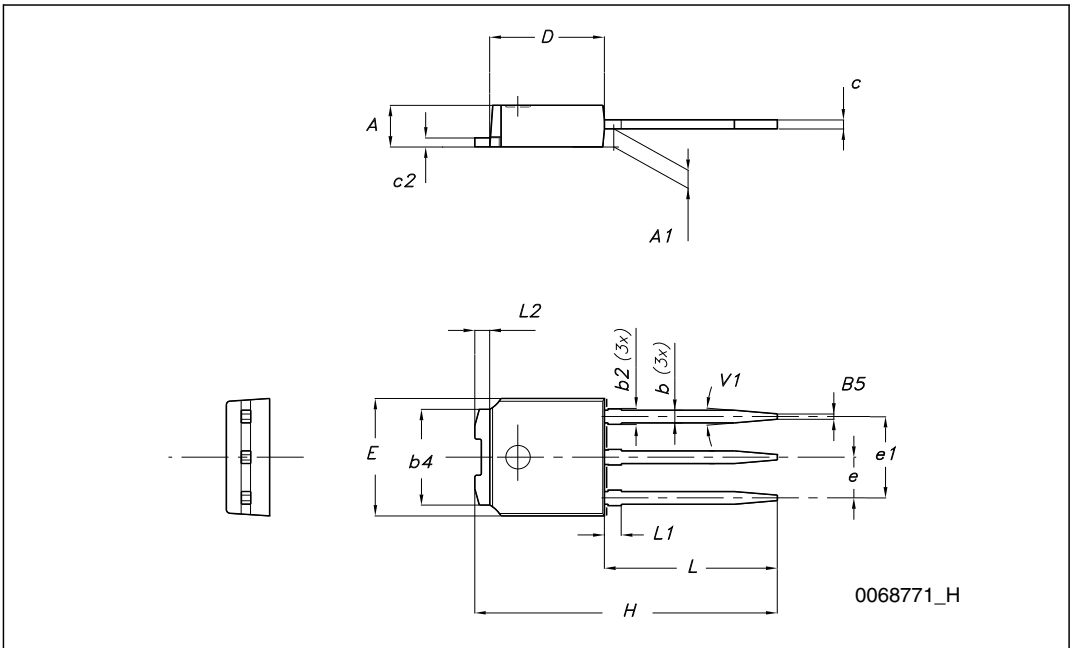
| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.70 |
|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

Figure 23. TO-220FP drawing mechanical data



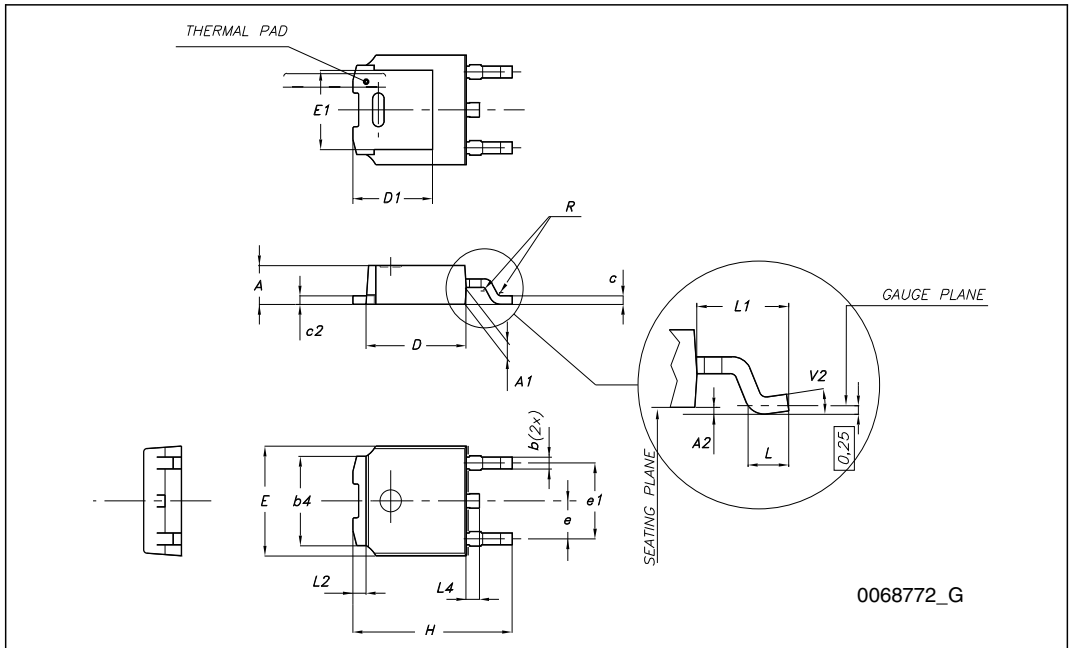
**TO-251 (IPAK) mechanical data**

| DIM. | mm.  |       |      |
|------|------|-------|------|
|      | min. | typ   | max. |
| A    | 2.20 |       | 2.40 |
| A1   | 0.90 |       | 1.10 |
| b    | 0.64 |       | 0.90 |
| b2   |      |       | 0.95 |
| b4   | 5.20 |       | 5.40 |
| c    | 0.45 |       | 0.60 |
| c2   | 0.48 |       | 0.60 |
| D    | 6.00 |       | 6.20 |
| E    | 6.40 |       | 6.60 |
| e    |      | 2.28  |      |
| e1   | 4.40 |       | 4.60 |
| H    |      | 16.10 |      |
| L    | 9.00 |       | 9.40 |
| (L1) | 0.80 |       | 1.20 |
| L2   |      | 0.80  |      |
| V1   |      | 10°   |      |



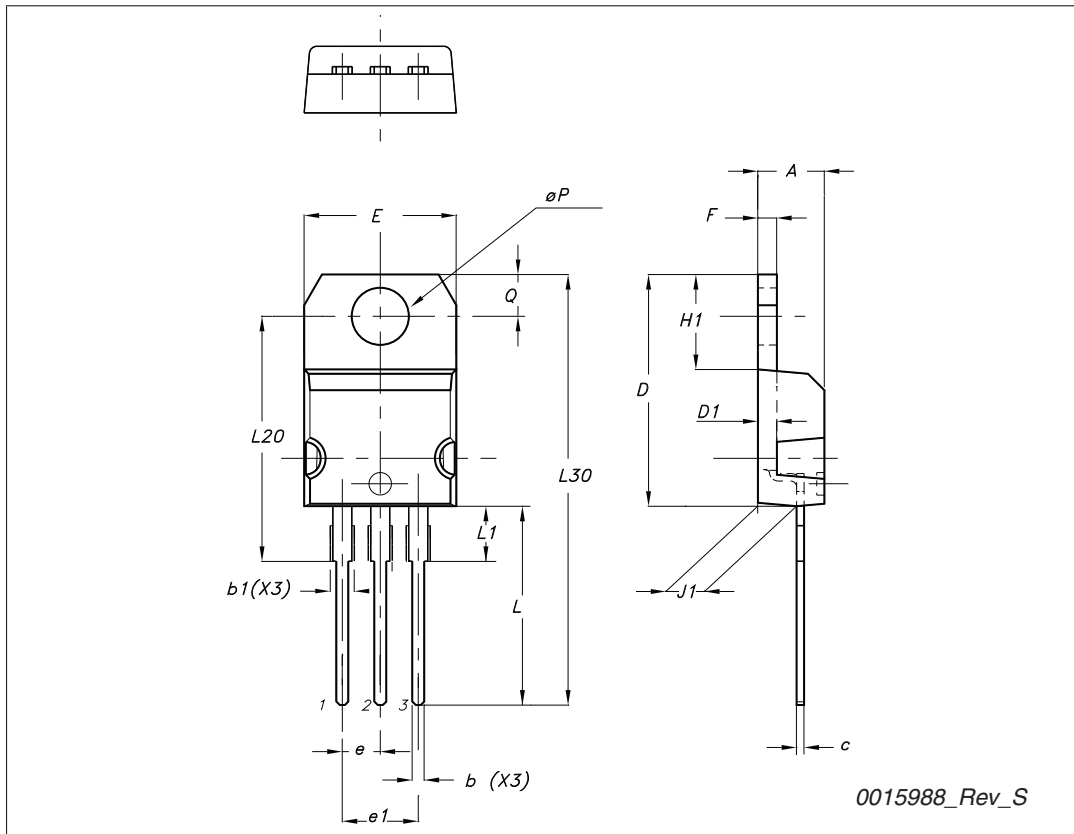
**TO-252 (DPAK) mechanical data**

| DIM. | mm.  |      |       |
|------|------|------|-------|
|      | min. | typ  | max.  |
| A    | 2.20 |      | 2.40  |
| A1   | 0.90 |      | 1.10  |
| A2   | 0.03 |      | 0.23  |
| b    | 0.64 |      | 0.90  |
| b4   | 5.20 |      | 5.40  |
| c    | 0.45 |      | 0.60  |
| c2   | 0.48 |      | 0.60  |
| D    | 6.00 |      | 6.20  |
| D1   |      | 5.10 |       |
| E    | 6.40 |      | 6.60  |
| E1   |      | 4.70 |       |
| e    |      | 2.28 |       |
| e1   | 4.40 |      | 4.60  |
| H    | 9.35 |      | 10.10 |
| L    | 1    |      |       |
| L1   |      | 2.80 |       |
| L2   |      | 0.80 |       |
| L4   | 0.60 |      | 1     |
| R    |      | 0.20 |       |
| V2   | 0°   |      | 8°    |



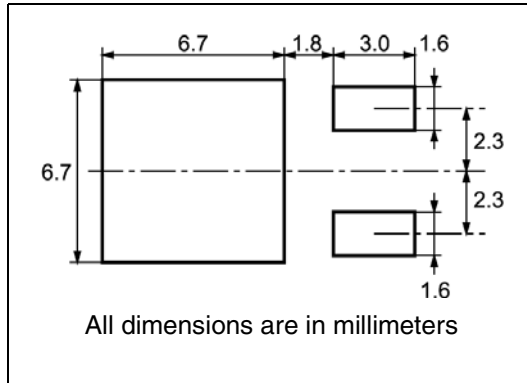
TO-220 type A mechanical data

| 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 |       |
| ∅P  | 3.75  |       | 3.85  |
| Q   | 2.65  |       | 2.95  |



# 5 Packaging mechanical data

## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start 2.5mm min. width

G measured at hub

### REEL MECHANICAL DATA

| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 16.4 | 18.4 | 0.645 | 0.724  |
| N    | 50   |      | 1.968 |        |
| T    |      | 22.4 |       | 0.881  |

### TAPE MECHANICAL DATA

| DIM. | mm   |      | inch  |       |
|------|------|------|-------|-------|
|      | MIN. | MAX. | MIN.  | MAX.  |
| A0   | 6.8  | 7    | 0.267 | 0.275 |
| B0   | 10.4 | 10.6 | 0.409 | 0.417 |
| B1   |      | 12.1 |       | 0.476 |
| D    | 1.5  | 1.6  | 0.059 | 0.063 |
| D1   | 1.5  |      | 0.059 |       |
| E    | 1.65 | 1.85 | 0.065 | 0.073 |
| F    | 7.4  | 7.6  | 0.291 | 0.299 |
| K0   | 2.55 | 2.75 | 0.100 | 0.108 |
| P0   | 3.9  | 4.1  | 0.153 | 0.161 |
| P1   | 7.9  | 8.1  | 0.311 | 0.319 |
| P2   | 1.9  | 2.1  | 0.075 | 0.082 |
| R    | 40   |      | 1.574 |       |
| W    | 15.7 | 16.3 | 0.618 | 0.641 |

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

For machine ref. only including draft and radii concentric around B0

TRL

FEED DIRECTION

Bending radius R min.

## 6 Revision history

Table 10. Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 29-Oct-2009 | 1        | First release.  |
| 19-Jul-2010 | 2        | Corrected values in <a href="#">Table 3: Thermal data</a> . |
| 11-Oct-2010 | 3        | Inserted new value in <a href="#">Table 6: Dynamic</a>      |
| 04-Nov-2010 | 4        | Changed $R_{DS(on)}$ typical value.                         |



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