

## N-channel 600 V, 1.7 $\Omega$ typ., 4 A Zener-protected SuperMESH™ Power MOSFETs in TO-220 and TO-220FP packages

Datasheet - production data

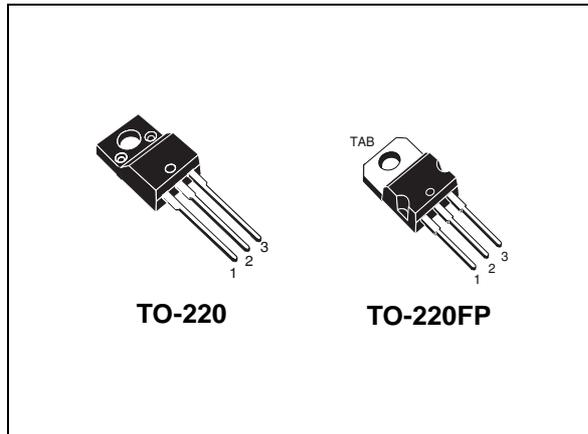
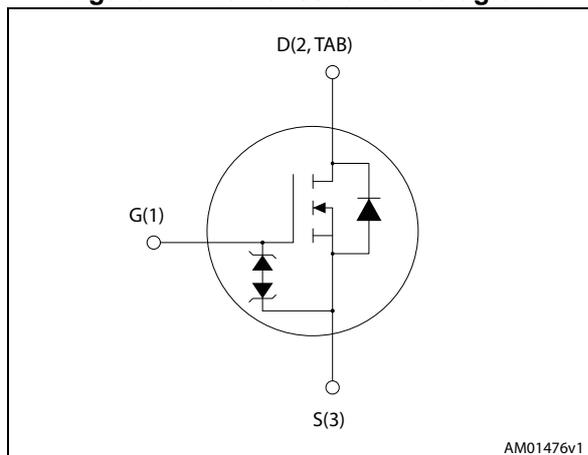


Figure 1. Internal schematic diagram



### Features

| Order codes | $V_{DS}$ | $R_{DS(on)}$ max. | $P_{TOT}$ | $I_D$ |
|-------------|----------|-------------------|-----------|-------|
| STP4NK60Z   | 600 V    | 2 $\Omega$        | 70 W      | 4 A   |
| STP4NK60ZFP |          |                   |           |       |

- 100% avalanche tested
- Very low intrinsic capacitances
- Zener-protected

### Applications

- Switching applications

### Description

These devices are N-channel Zener-protected Power MOSFETs developed using STMicroelectronics' SuperMESH™ technology, achieved through optimization of ST's well established strip-based PowerMESH™ layout. In addition to a significant reduction in on-resistance, this device is designed to ensure a high level of  $dv/dt$  capability for the most demanding applications.

Table 1. Device summary

| Order codes | Marking   | Packages | Packaging |
|-------------|-----------|----------|-----------|
| STP4NK60Z   | P4NK60Z   | TO-220   | Tube      |
| STP4NK60ZFP | P4NK60ZFP | TO-220FP |           |

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol               | Parameter  | Value      |                    | Unit |
|----------------------|--|------------|--------------------|------|
|                      |  | TO-220     | TO-220FP           |      |
| $V_{DS}$             | Drain-source voltage   | 600        |                    | V    |
| $V_{GS}$             | Gate- source voltage   | ± 30       |                    | V    |
| $I_D$                | Drain current (continuous) at $T_C = 25\text{ °C}$   | 4          | 4 <sup>(1)</sup>   | A    |
| $I_D$                | Drain current (continuous) at $T_C = 100\text{ °C}$  | 2.5        | 2.5 <sup>(1)</sup> | A    |
| $I_{DM}^{(2)}$       | Drain current (pulsed)   | 16         | 16 <sup>(1)</sup>  | A    |
| $P_{TOT}$            | Total dissipation at $T_C = 25\text{ °C}$  | 70         | 25                 | W    |
|                      | Derating factor  | 0.56       | 0.2                | W/°C |
| ESD                  | Gate-source human body model (C=100 pF, R=1.5 kΩ)  | 3          |                    | kV   |
| dv/dt <sup>(3)</sup> | Peak diode recovery voltage slope  | 4.5        |                    | V/ns |
| $V_{ISO}$            | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; $T_C=25\text{ °C}$ ) |            | 2500               | V    |
| $T_{stg}$            | Storage temperature  | -55 to 150 |                    | °C   |
| $T_j$                | Max operating junction temperature   | 150        |                    | °C   |

1. Limited by maximum junction temperature.
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 4\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq T_{JMAX}$ .

**Table 3. Thermal data**

| Symbol         | Parameter                               | Value  |          | Unit |
|----------------|---|--------|----------|------|
|                |   | TO-220 | TO-220FP |      |
| $R_{thj-case}$ | Thermal resistance junction-case max    | 1.79   | 5        | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max | 62.5   |          | °C/W |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter  | Value | Unit |
|----------|--|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_{jmax}$ )                 | 4     | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_J = 25\text{ °C}$ , $I_D=I_{AR}$ , $V_{DD}=50\text{ V}$ ) | 120   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off states**

| Symbol        | Parameter  | Test conditions   | Min. | Typ. | Max.     | Unit                           |
|---------------|--|---|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 1\text{ mA}$   | 600  |      |          | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 600\text{ V}$<br>$V_{DS} = 600\text{ V}, T_C = 125\text{ °C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{ V}$  |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}, I_D = 50\text{ }\mu\text{A}$                          | 3    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}, I_D = 2\text{ A}$                                |      | 1.7  | 2        | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                     | Parameter                     | Test conditions   | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|---|------|------|------|------|
| $g_{fs}^{(1)}$             | Forward transconductance      | $V_{DS} = 15\text{ V}, I_D = 2\text{ A}$  | -    | 3    |      | S    |
| $C_{iss}$                  | Input capacitance             | $V_{DS} = 25\text{ V}, f = 1\text{ MHz},$<br>$V_{GS} = 0$   | -    | 510  |      | pF   |
| $C_{oss}$                  | Output capacitance            |   | -    | 67   |      | pF   |
| $C_{rss}$                  | Reverse transfer capacitance  |   | -    | 13   |      | pF   |
| $C_{oss\text{ eq.}}^{(2)}$ | Equivalent output capacitance | $V_{DS} = 0, V_{DS} = 0\text{ to }480\text{ V}$   | -    | 38.5 |      | pF   |
| $t_{d(on)}$                | Turn-on delay time            | $V_{DD} = 300\text{ V}, I_D = 2\text{ A},$<br>$R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 17</a> ) | -    | 12   |      | ns   |
| $t_r$                      | Rise time                     |   | -    | 9.5  |      | ns   |
| $t_{d(off)}$               | Turn-off delay time           |   | -    | 29   |      | ns   |
| $t_f$                      | Fall time                     |   | -    | 16.5 |      | ns   |
| $t_{r(voff)}$              | Off-voltage rise time         | $V_{DD} = 480\text{ V}, I_D = 4\text{ A},$<br>$R_G = 4.7\text{ }\Omega, V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 19</a> ) | -    | 12   |      | ns   |
| $t_f$                      | Fall time                     |   | -    | 12   |      | ns   |
| $t_c$                      | Cross-over time               |   | -    | 19.5 |      | ns   |
| $Q_g$                      | Total gate charge             | $V_{DD} = 480\text{ V}, I_D = 4\text{ A},$<br>$V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 18</a> )                          | -    | 18.8 | 26   | nC   |
| $Q_{gs}$                   | Gate-source charge            |   | -    | 3.8  |      | nC   |
| $Q_{gd}$                   | Gate-drain charge             |   | -    | 9.8  |      | nC   |

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          |   | -    |      | 4    | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |   | -    |      | 16   | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 4\text{ A}, V_{GS} = 0$                       | -    |      | 1.6  | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 4\text{ A}, di/dt = 100\text{ A}/\mu\text{s}$ | -    | 400  |      | ns   |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 24\text{ V}, T_j = 150\text{ }^\circ\text{C}$ | -    | 1700 |      | nC   |
| $I_{RRM}$       | Reverse recovery current      | (see <a href="#">Figure 19</a> )                        | -    | 8.5  |      | A    |

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

Table 8. Gate-source Zener diode

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

The built-in back-to-back Zener diodes have been specifically designed to enhance not only the device's ESD capability, but also to make them capable of safely absorbing any voltage transients that may occasionally be applied from gate to source. In this respect, the Zener voltage is appropriate to achieve efficient and cost-effective protection of device integrity. The integrated Zener diodes thus eliminate the need for external components.

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

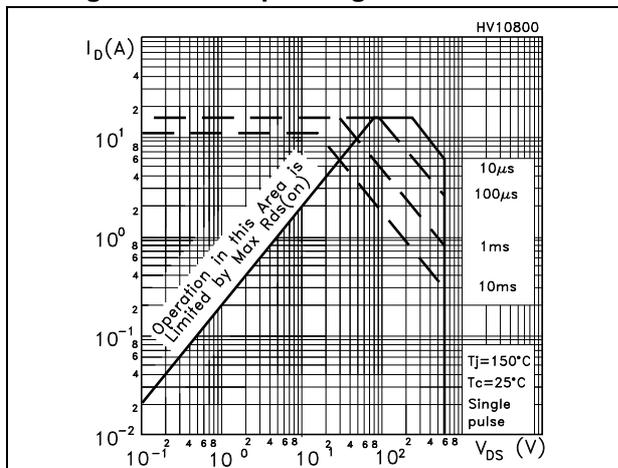


Figure 3. Thermal impedance for TO-220

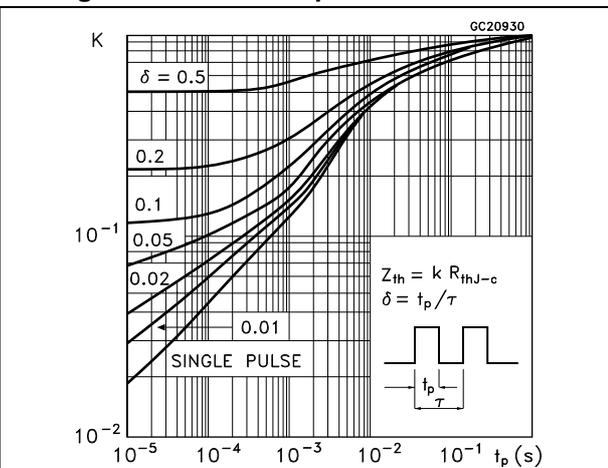


Figure 4. Safe operating area for TO-220FP

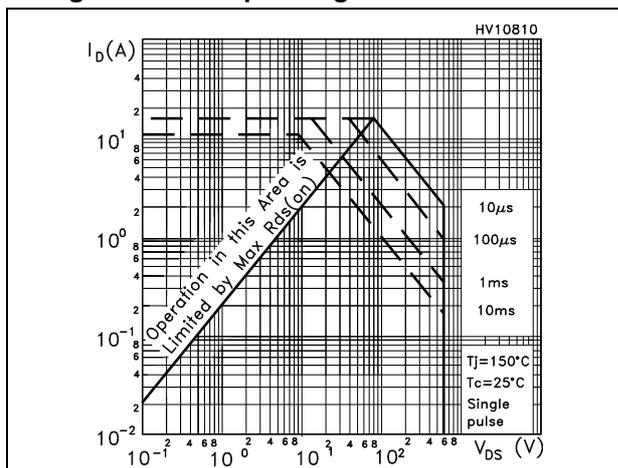


Figure 5. Thermal impedance for TO-220FP

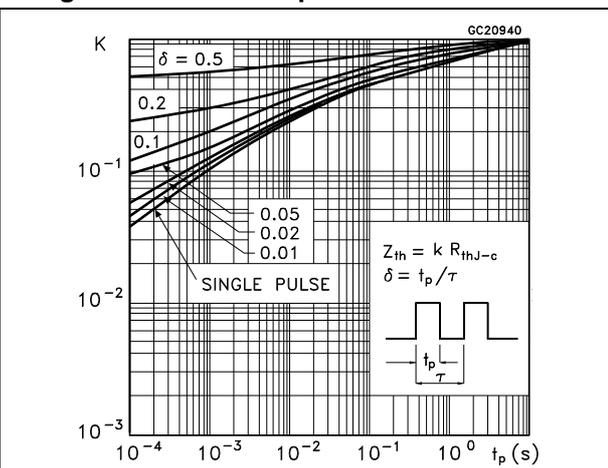


Figure 6. Output characteristics

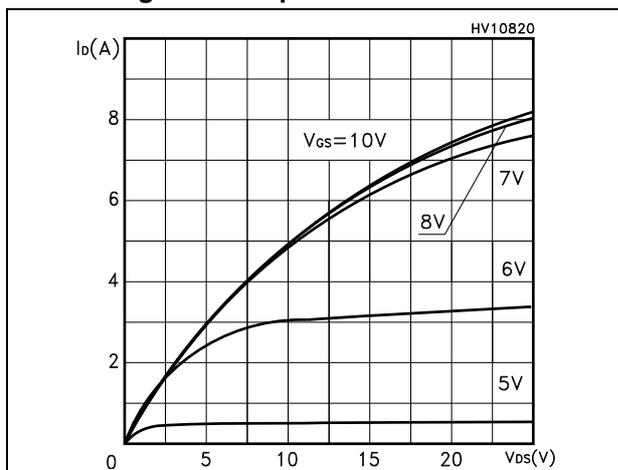


Figure 7. Transfer characteristics

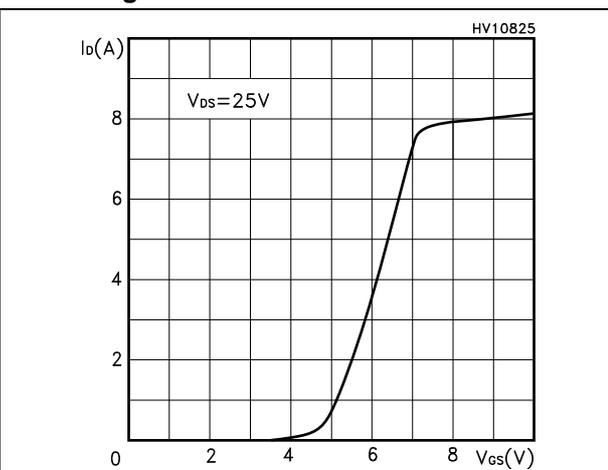


Figure 8. Transconductance

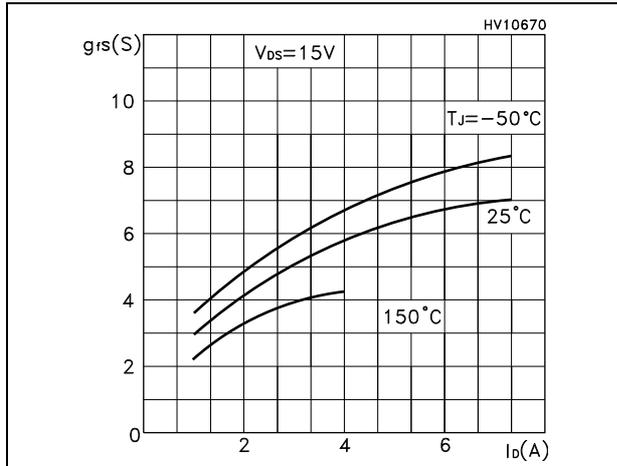


Figure 9. Static drain-source on-resistance

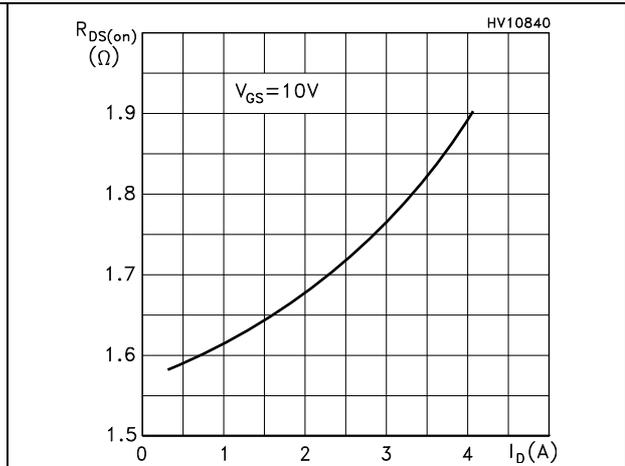


Figure 10. Gate charge vs gate-source voltage

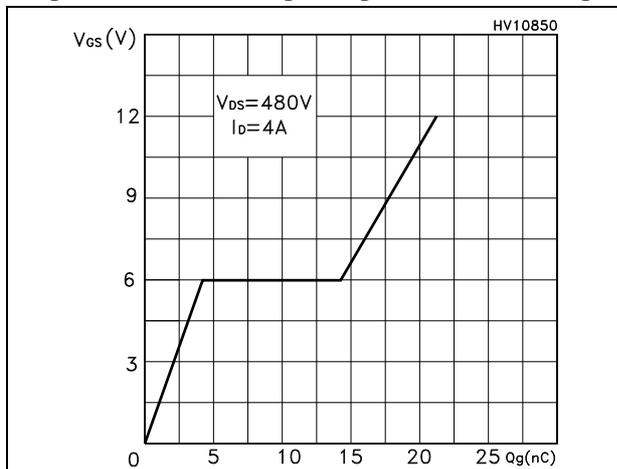


Figure 11. Capacitance variations

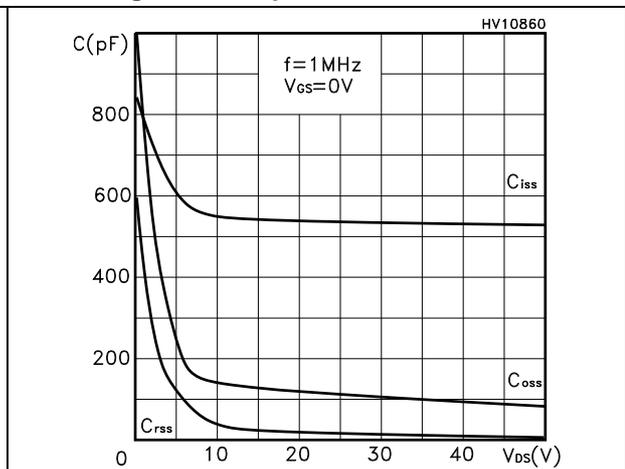


Figure 12. Normalized gate threshold voltage vs temperature

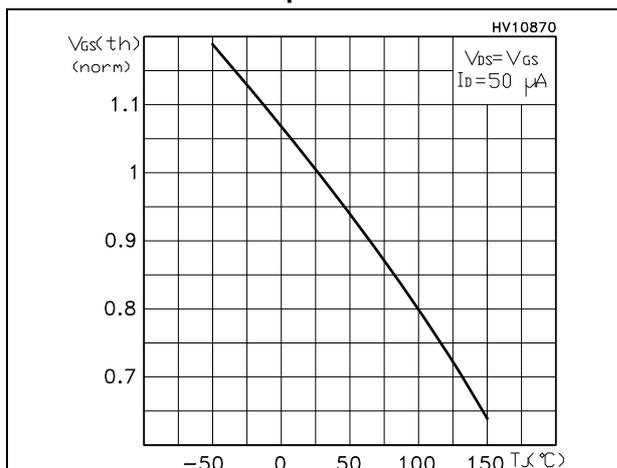


Figure 13. Normalized  $R_{DS(on)}$  vs temperature

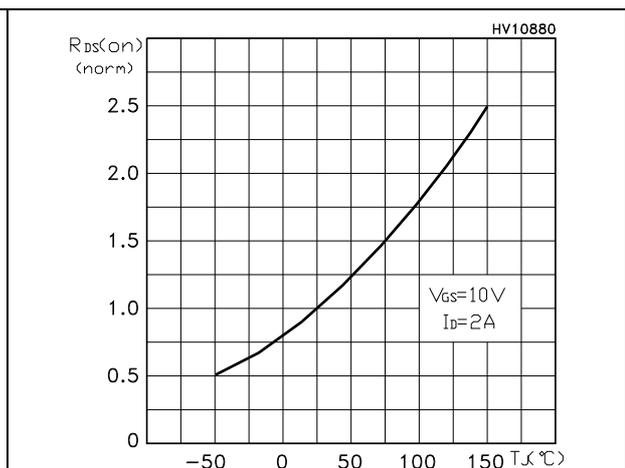


Figure 14. Source-drain diode forward characteristic

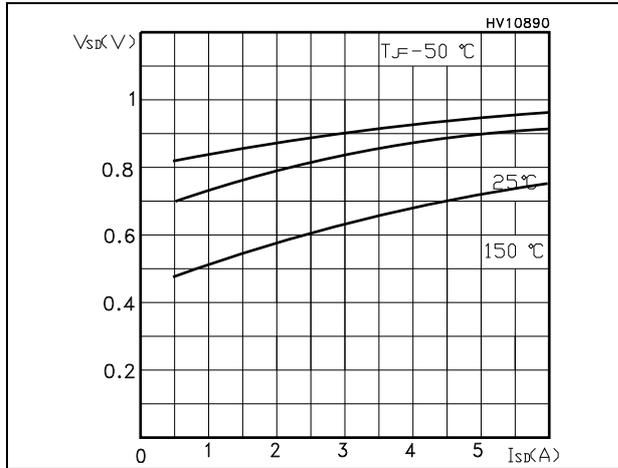


Figure 15. Normalized  $V_{ds}$  vs temperature

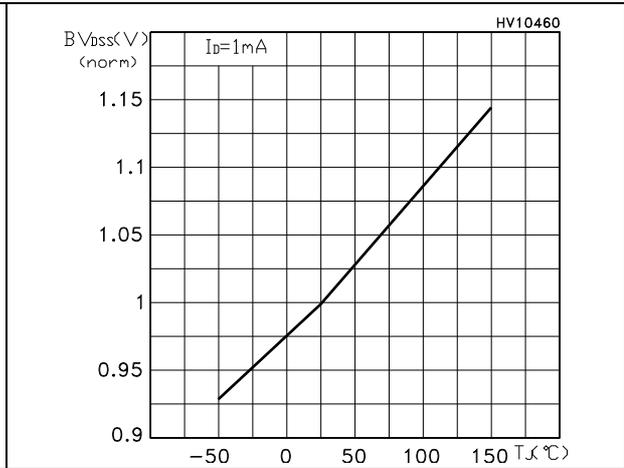
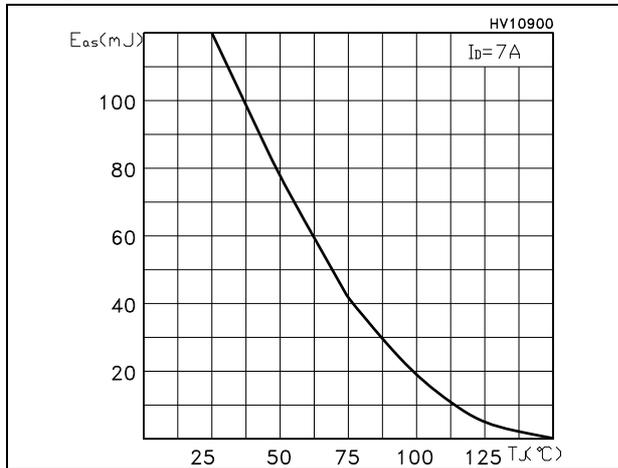
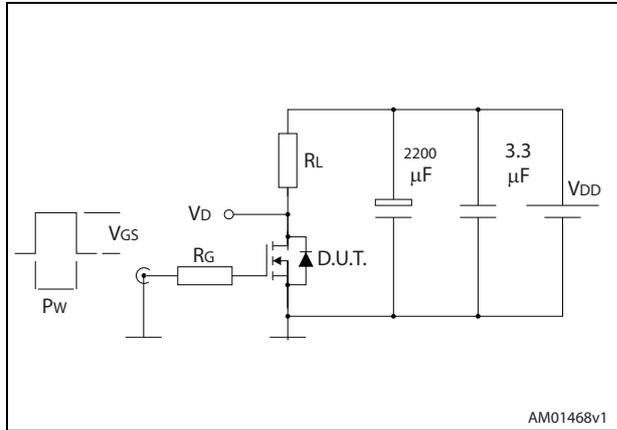


Figure 16. Avalanche energy vs temperature



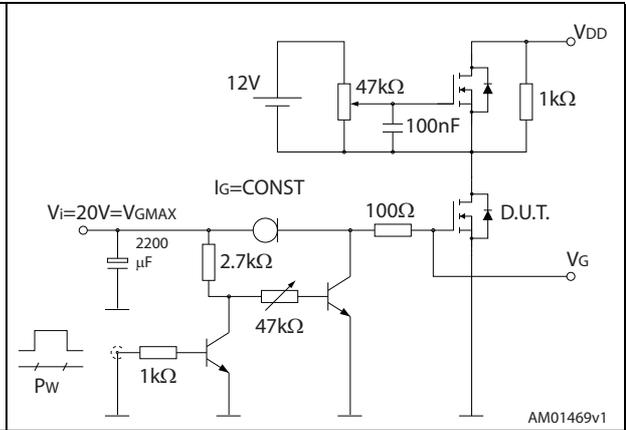
### 3 Test circuits

Figure 17. Switching times test circuit for resistive load



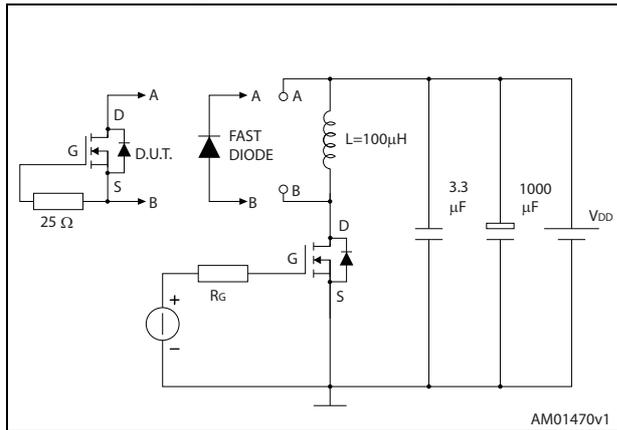
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Figure 18. Gate charge test circuit



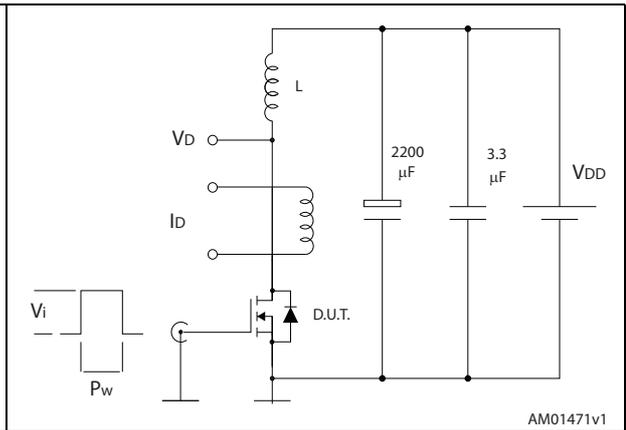
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Figure 19. Test circuit for inductive load switching and diode recovery times



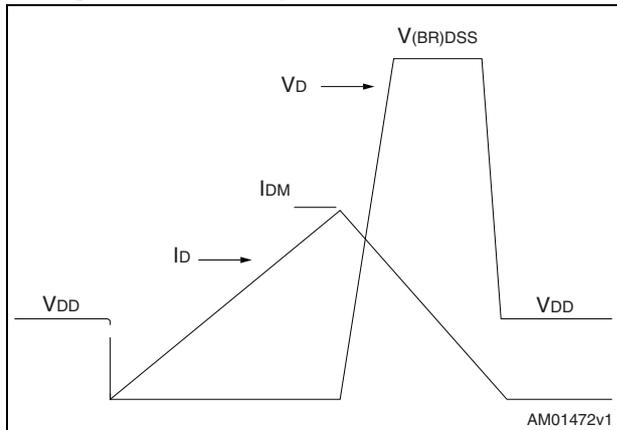
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Figure 20. Unclamped inductive load test circuit



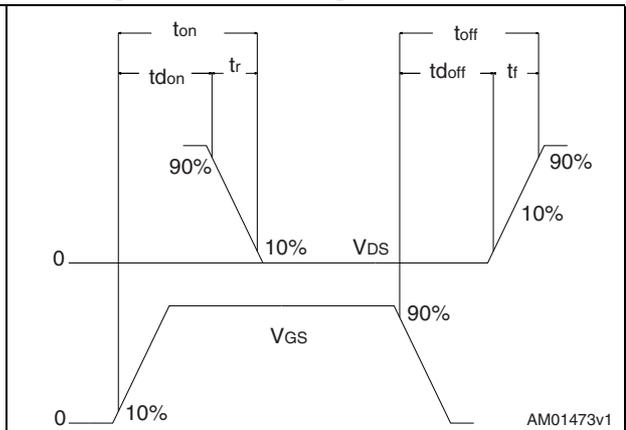
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Figure 21. Unclamped inductive waveform



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<sup>®</sup> is an ST trademark.

Table 9. 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 23. TO-220 type A drawing

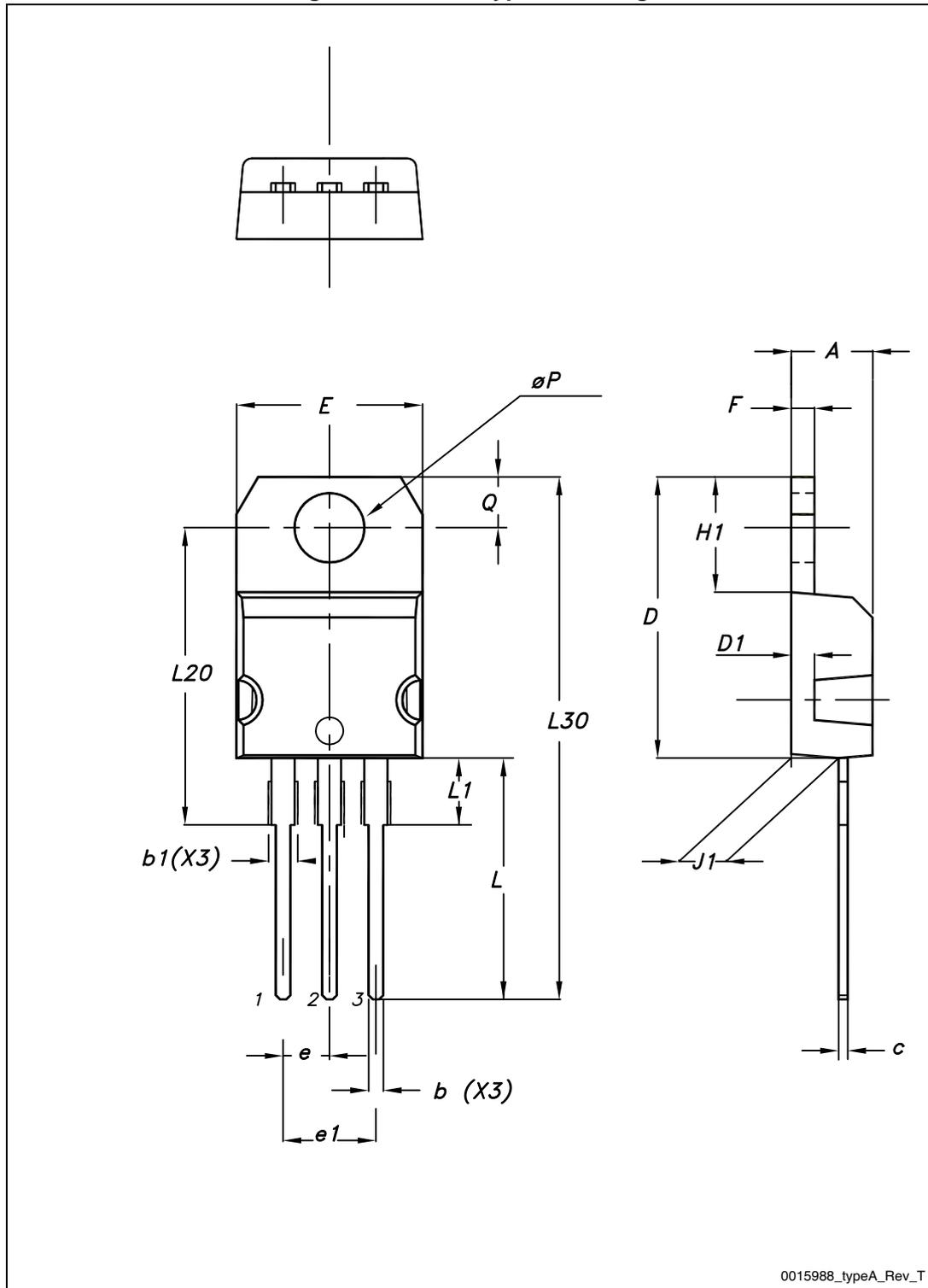
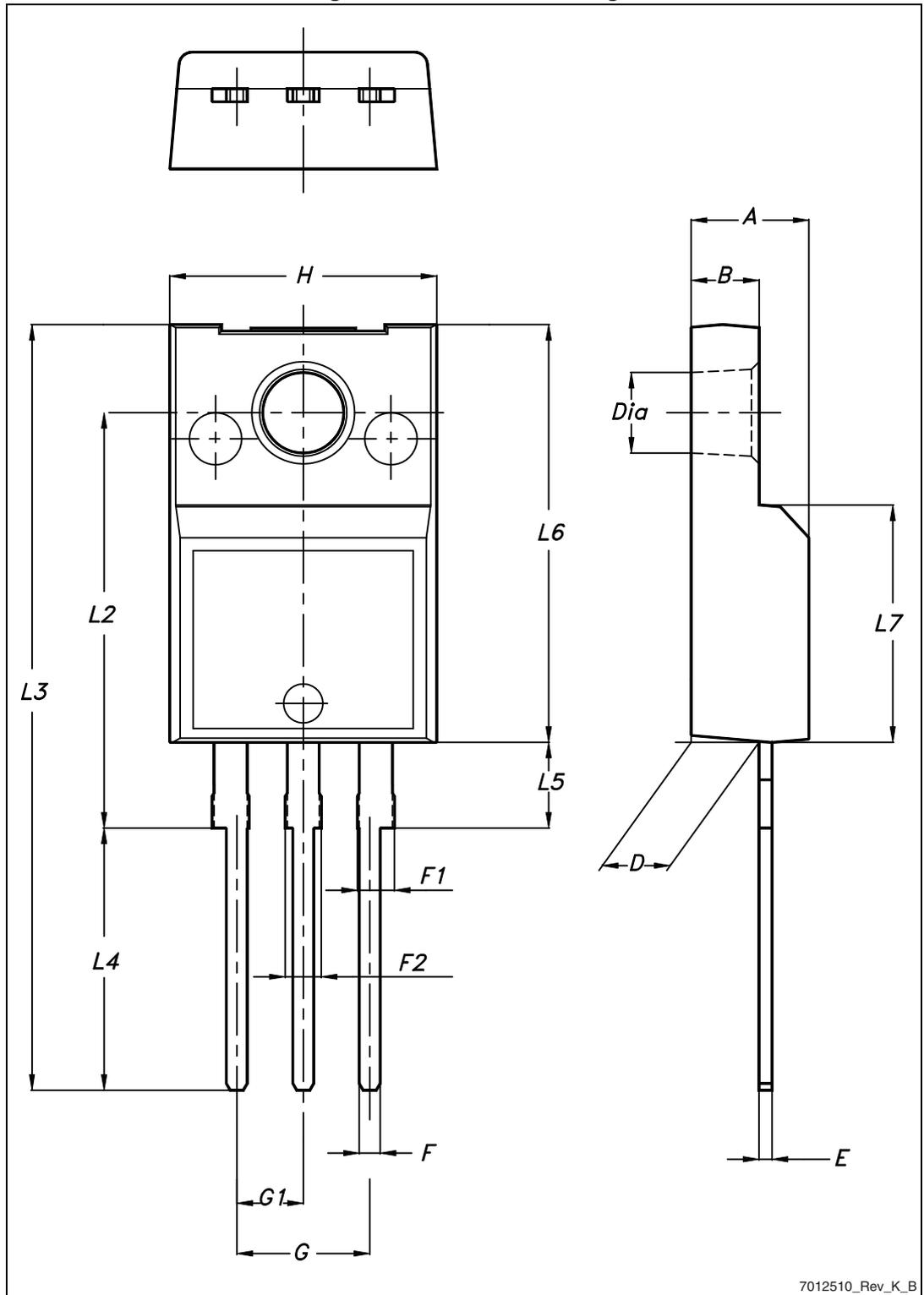


Table 10. TO-220FP mechanical data

| 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 24. TO-220FP drawing



7012510\_Rev\_K\_B

## 5 Revision history

Table 11. Document revision history

| Date          | Revision | Changes  |
|---------------|----------|--|
| 19-Jul-201318 | 1        | First release. Part numbers previously included in datasheet DocID8882 |

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