



# STP12NK60Z STF12NK60Z, STW12NK60Z

N-channel 650 V @Tjmax, 0.53  $\Omega$ , 10 A TO-220, TO-220FP, TO-247  
 Zener-protected SuperMESH™ Power MOSFET

## Features

| Type       | V <sub>DSS</sub><br>(@Tjmax) | R <sub>DS(on)</sub><br>max | I <sub>D</sub> | P <sub>W</sub> |
|------------|------------------------------|----------------------------|----------------|----------------|
| STP12NK60Z | 650 V                        | <0.640 $\Omega$            | 10 A           | 150 W          |
| STF12NK60Z | 650 V                        | <0.640 $\Omega$            | 10 A           | 35 W           |
| STW12NK60Z | 650 V                        | <0.640 $\Omega$            | 10 A           | 150 W          |

- Extremely high dv/dt capability
- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitances
- Very good manufacturing repeatability

## Application

- Switching applications

## Description

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, specialties is taken to ensure a very good dv/dt capability for the most demanding application. Such series complements ST full range of high voltage Power MOSFETs.

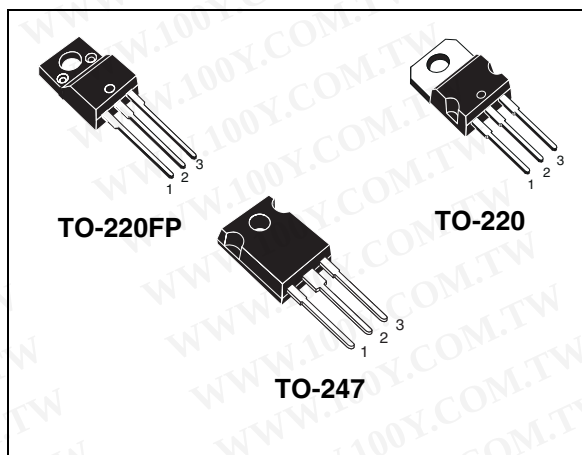


Figure 1. Internal schematic diagram

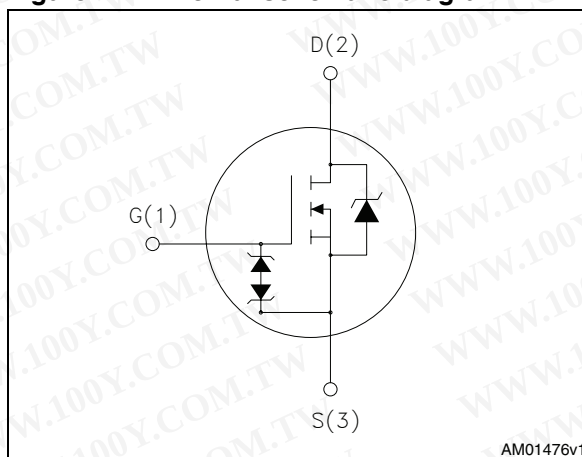


Table 1. Device summary

| Order codes | Marking  | Package  | Packaging |
|-------------|----------|----------|-----------|
| STP12NK60Z  | P12NK60Z | TO-220   | Tube      |
| STF12NK60Z  | F12NK60Z | TO-220FP | Tube      |
| STW12NK60Z  | W12NK60Z | TO-247   | Tube      |

## Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol                  | Parameter                                                                                                                               | Value          |                    | Unit                  |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------------|-----------------------|
|                         |                                                                                                                                         | TO-220, TO-247 | TO-220FP           |                       |
| $V_{DS}$                | Drain-source voltage ( $V_{GS} = 0$ )                                                                                                   | 600            |                    | V                     |
| $V_{GS}$                | Gate-source voltage                                                                                                                     | $\pm 30$       |                    | V                     |
| $I_D$                   | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$                                                                        | 10             | 10 <sup>(1)</sup>  | A                     |
| $I_D$                   | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$                                                                       | 6.3            | 6.3 <sup>(1)</sup> | A                     |
| $I_{DM}$ <sup>(2)</sup> | Drain current (pulsed)                                                                                                                  | 40             | 40 <sup>(1)</sup>  | A                     |
| $P_{TOT}$               | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$                                                                                 | 150            | 35                 | W                     |
|                         | Derating factor                                                                                                                         | 1.2            | 0.27               | W/ $^{\circ}\text{C}$ |
| $V_{ESD(G-S)}$          | Gate source ESD (HBM-C=100 pF, R=1.5 k $\Omega$ )                                                                                       |                | 2500               | V                     |
| $dv/dt$ <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 ( $t = 1\text{ s}$ ; $T_C = 25\text{ }^{\circ}\text{C}$ ) |                | 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.  $I_{SD} \leq 10\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 480\text{ V}$

**Table 3. Thermal data**

| Symbol         | Parameter                                      | Value  |        |          | Unit                        |
|----------------|------------------------------------------------|--------|--------|----------|-----------------------------|
|                |                                                | TO-220 | TO-247 | TO-220FP |                             |
| $R_{thj-case}$ | Thermal resistance junction-case max           | 0.83   |        | 3.6      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max        | 62.5   | 50     | 62.5     | $^{\circ}\text{C}/\text{W}$ |
| $T_l$          | Maximum lead temperature for soldering purpose | 300    |        |          | $^{\circ}\text{C}$          |

**Table 4. Avalanche characteristics**

| Symbol   | Parameter                                                                                                              | Value | Unit |
|----------|------------------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AS}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ Max)                                     | 10    | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25\text{ }^{\circ}\text{C}$ , $I_D = I_{AS}$ , $V_{DD} = 50\text{ V}$ ) | 260   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On/off**

| 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>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                           | $V_{DS} = V_{GS}$ , $I_D = 100\text{ }\mu\text{A}$                                   | 3    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 5\text{ A}$                                          |      | 0.53 | 0.64     | $\Omega$                       |

**Table 6. Dynamic**

| Symbol                                        | Parameter                                                               | Test conditions                                                                                                          | Min. | Typ.                       | Max. | Unit                 |
|-----------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------|----------------------------|------|----------------------|
| $g_{fs}^{(1)}$                                | Forward transconductance                                                | $V_{DS} = 10\text{ V}$ , $I_D = 5\text{ A}$                                                                              | -    | 9                          | -    | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$                                                            | -    | 1740<br>195<br>49          | -    | pF<br>pF<br>pF       |
| $C_{oss\text{ eq.}}^{(2)}$                    | Equivalent output capacitance                                           | $V_{GS} = 0$ , $V_{DS} = 0\text{ to }480\text{ V}$                                                                       | -    | 101                        | -    | 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     | $V_{DD} = 300\text{ V}$ , $I_D = 5\text{ A}$ ,<br>$R_G = 4.7\text{ }\Omega$<br>$V_{GS} = 10\text{ V}$<br>(see Figure 19) | -    | 22.5<br>18.5<br>55<br>31.5 | -    | 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            | $V_{DD} = 480\text{ V}$ , $I_D = 10\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$<br>(see Figure 20)                             | -    | 59<br>10<br>32             | -    | nC<br>nC<br>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%  $V_{DS}$

Table 7. Source drain diode

| Symbol          | Parameter                     | Test conditions                                             | Min | Typ. | Max | Unit          |
|-----------------|-------------------------------|-------------------------------------------------------------|-----|------|-----|---------------|
| $I_{SD}$        | Source-drain current          |                                                             | -   |      | 10  | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                             | -   |      | 40  | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 10\text{ A}$ , $V_{GS} = 0$                       | -   |      | 1.6 | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 10\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ | -   | 358  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 50\text{ V}$                                      | -   | 3    |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      | (see Figure 24)                                             | -   | 17   |     | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 10\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ | -   | 460  |     | ns            |
| $Q_{rr}$        | Reverse recovery charge       | $V_{DD} = 50\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$  | -   | 4.2  |     | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      | (see Figure 24)                                             | -   | 18.2 |     | 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 |
|------------------|-------------------------------|-----------------------------------------|-----|-----|-----|------|
| $BV_{GSO}^{(1)}$ | Gate-Source breakdown voltage | $I_{GS} = \pm 1\text{ mA}$ (open drain) | 30  | -   | -   | V    |

1. The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.



## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220

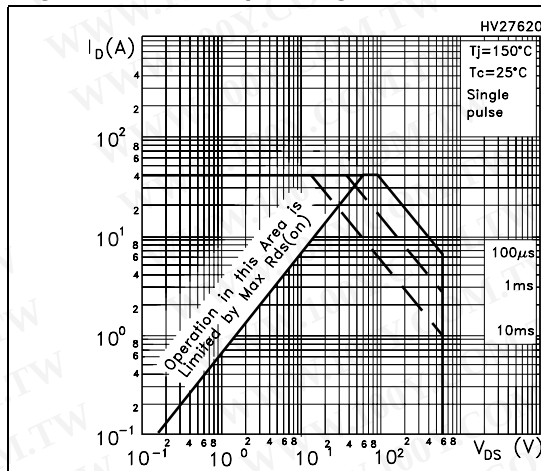


Figure 3. Thermal impedance for TO-220

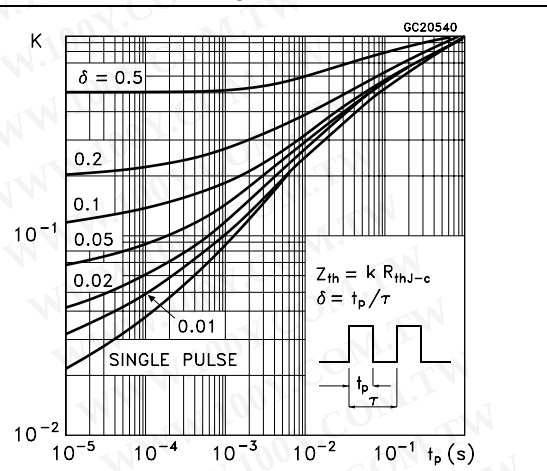


Figure 4. Safe operating area for TO-247

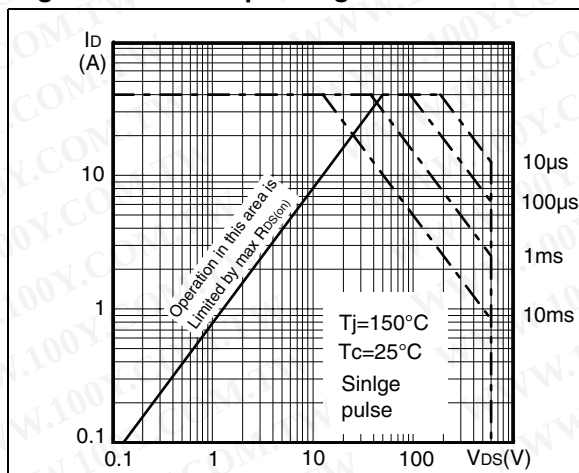


Figure 5. Thermal impedance for TO-247

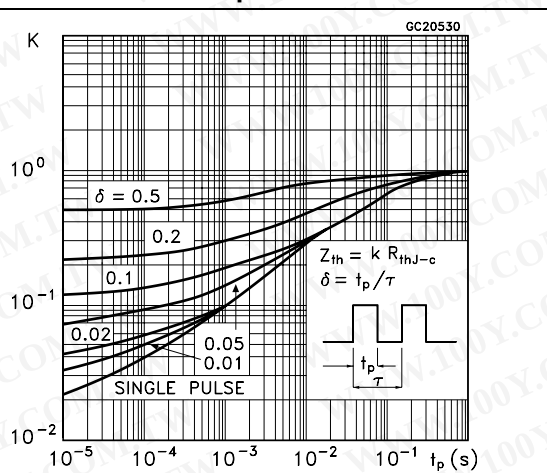


Figure 6. Safe operating area for TO-220FP

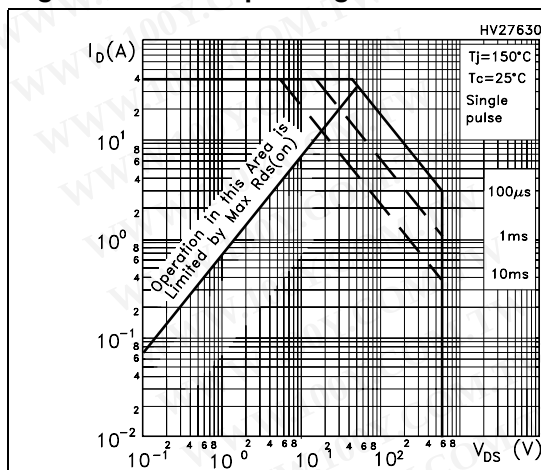


Figure 7. Thermal impedance for TO-220FP

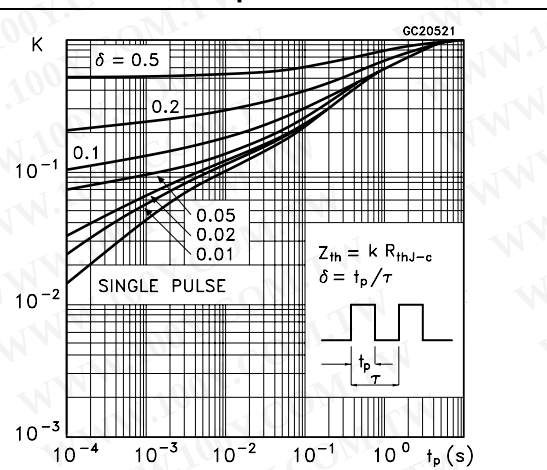


Figure 8. Output characteristics

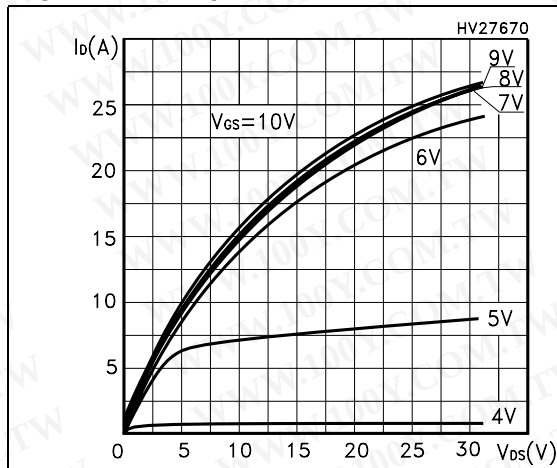


Figure 9. Transfer characteristics

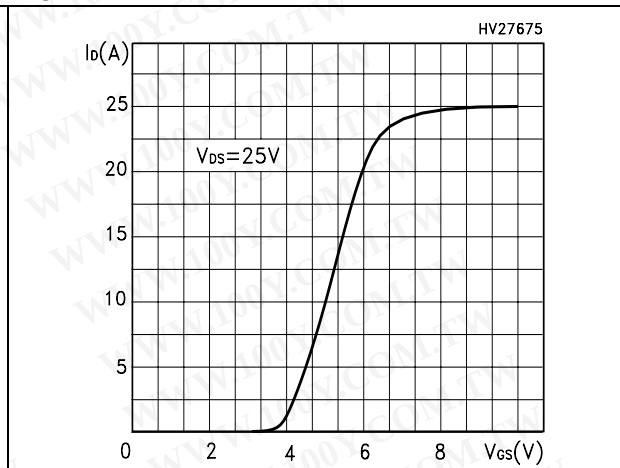


Figure 10. Transconductance

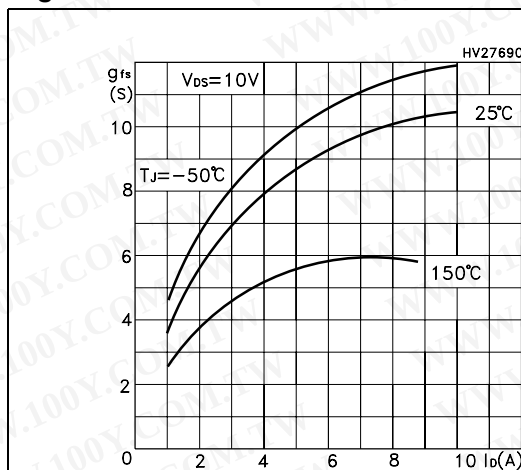


Figure 11. Static drain-source on resistance

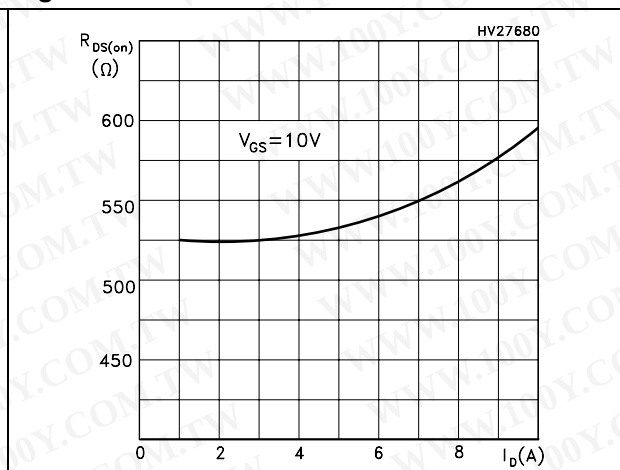


Figure 12. Gate charge vs gate-source voltage

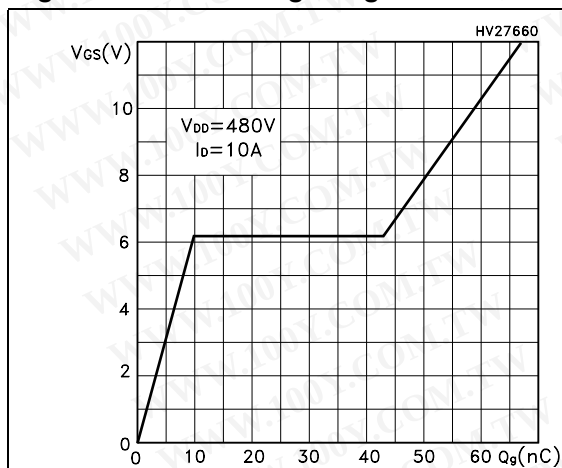


Figure 13. Capacitance variations

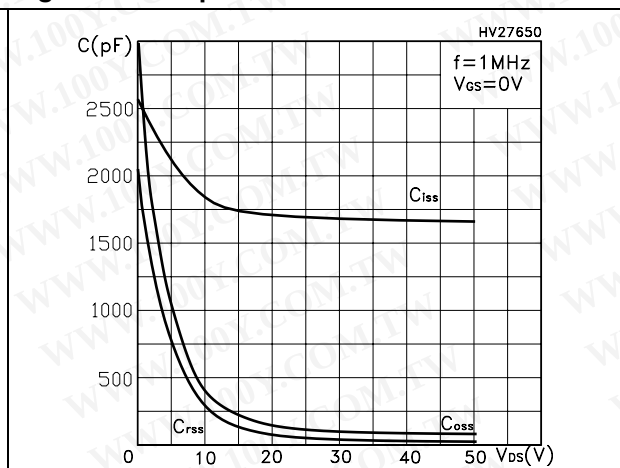


Figure 14. Normalized gate threshold voltage vs temperature

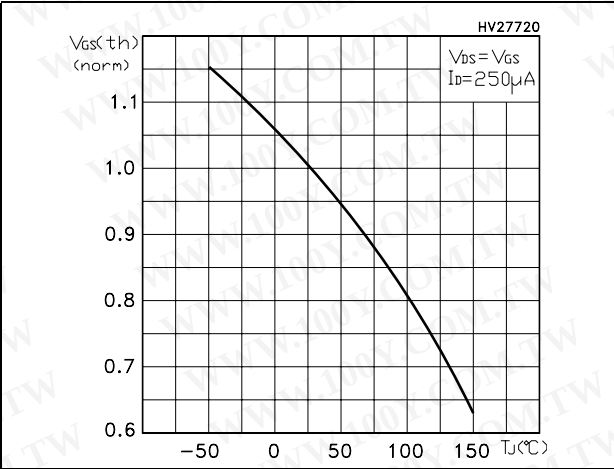


Figure 15. Normalized on resistance vs temperature

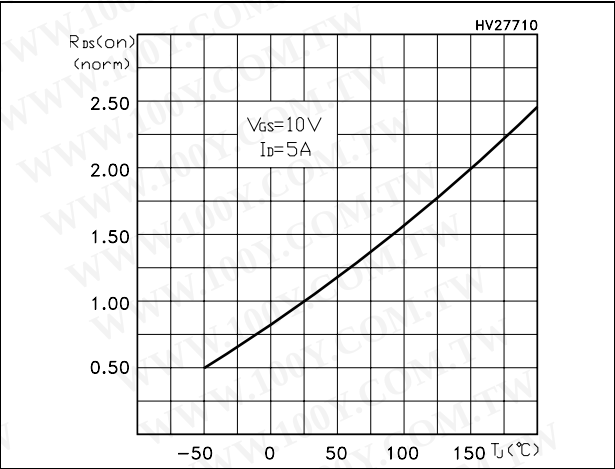


Figure 16. Source-drain diode forward characteristics

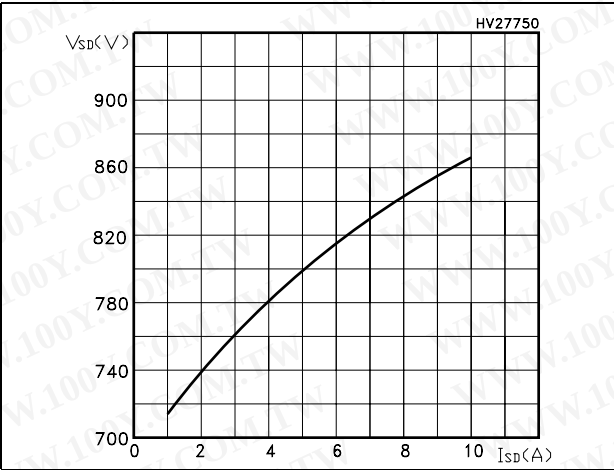


Figure 17. Normalized breakdown voltage vs temperature

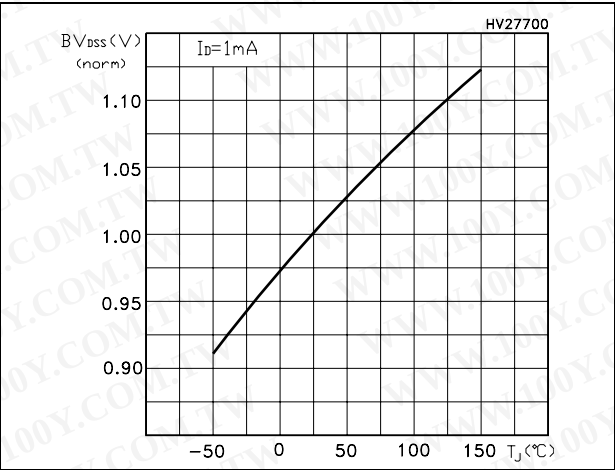
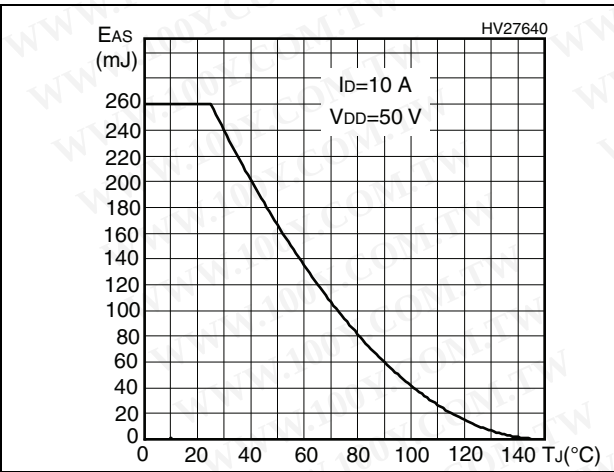


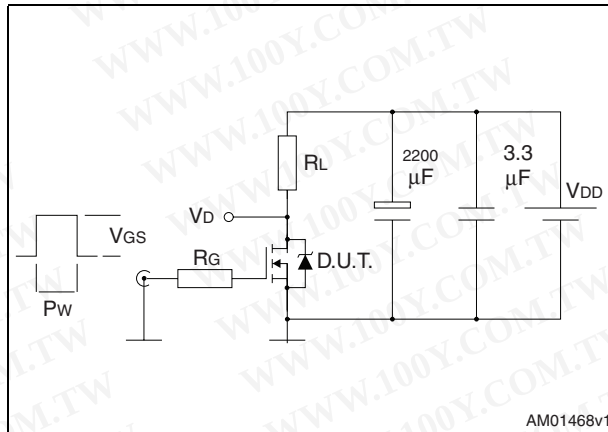
Figure 18. Maximum avalanche energy vs temperature



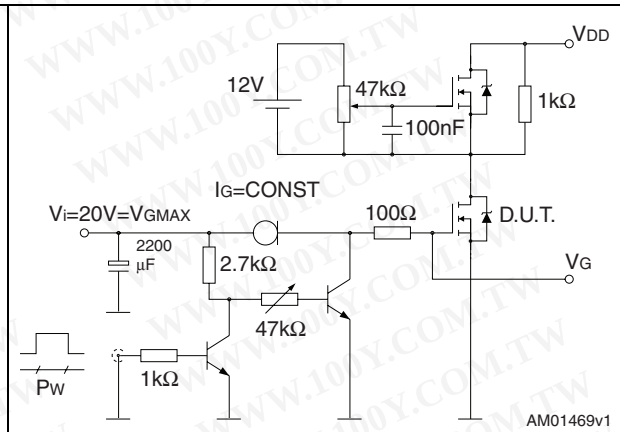


### 3 Test circuits

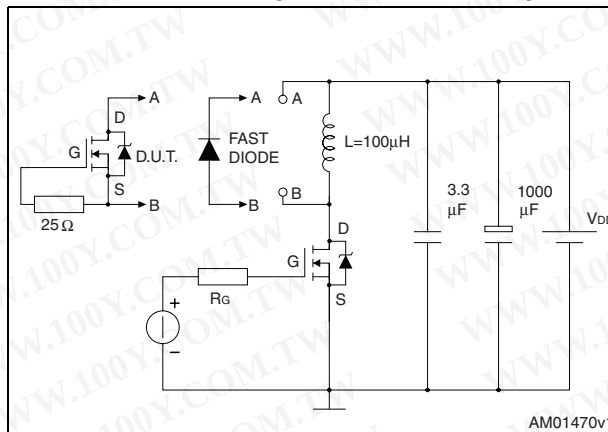
**Figure 19. Switching times test circuit for resistive load**



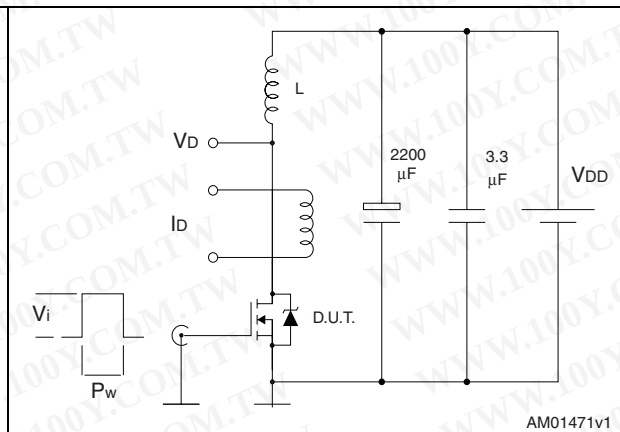
**Figure 20. Gate charge test circuit**



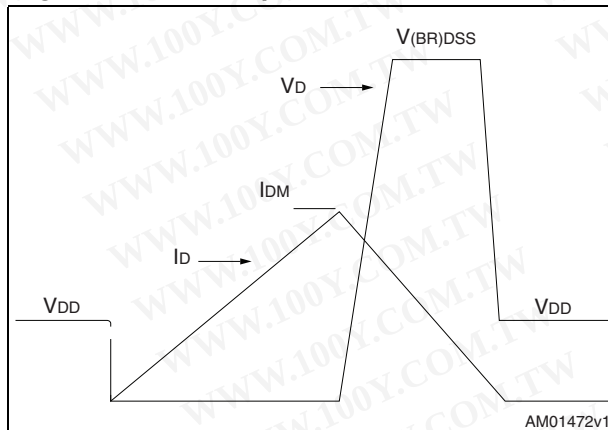
**Figure 21. Test circuit for inductive load switching and diode recovery times**



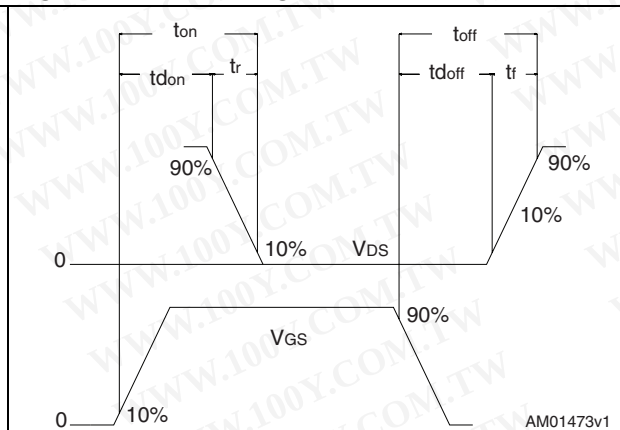
**Figure 22. Unclamped inductive load test circuit**



**Figure 23. Unclamped inductive waveform**



**Figure 24. Switching time waveform**

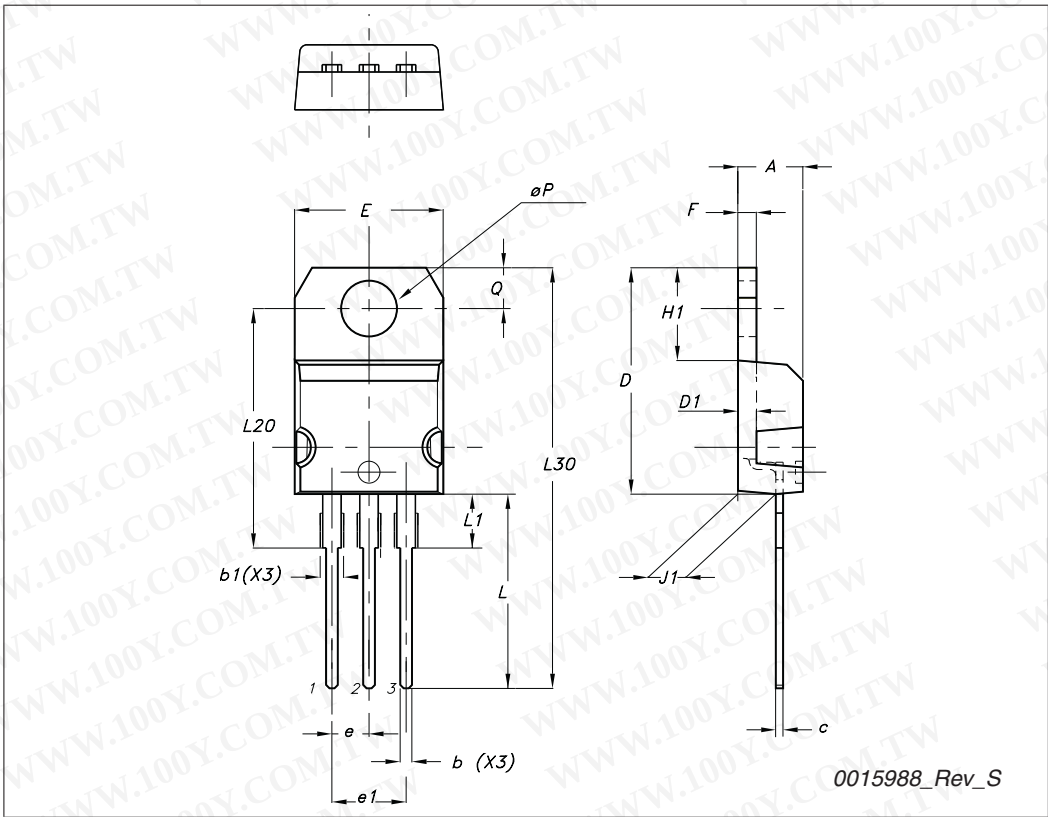


## 4 Package mechanical data

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.

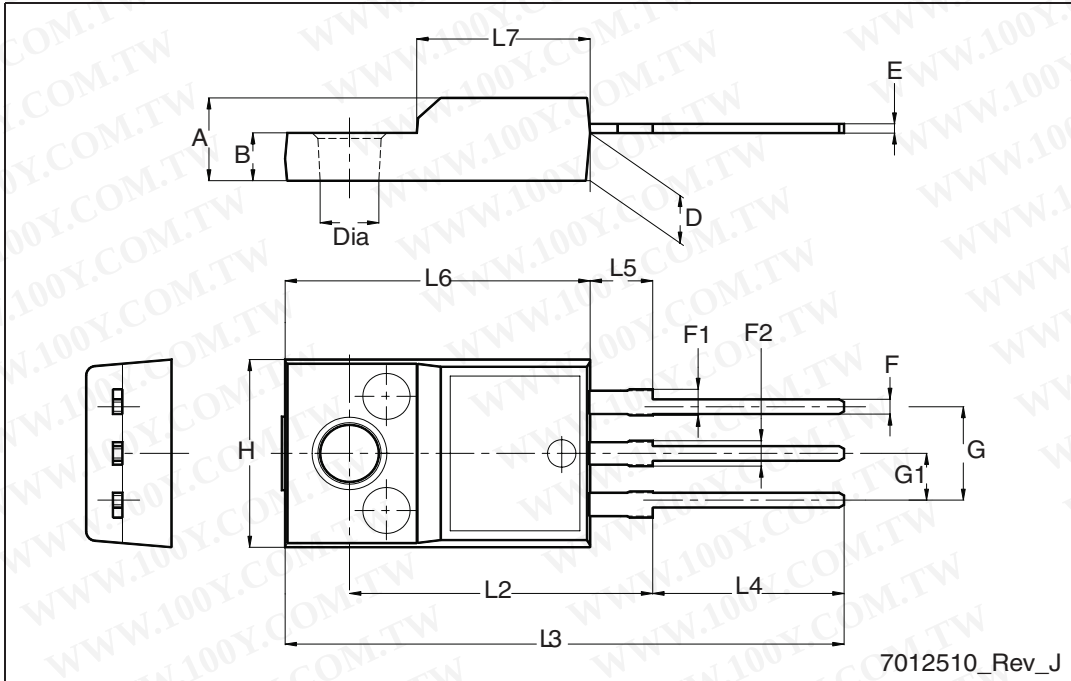
TO-220 type A mechanical data

| 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  |



TO-220FP mechanical data

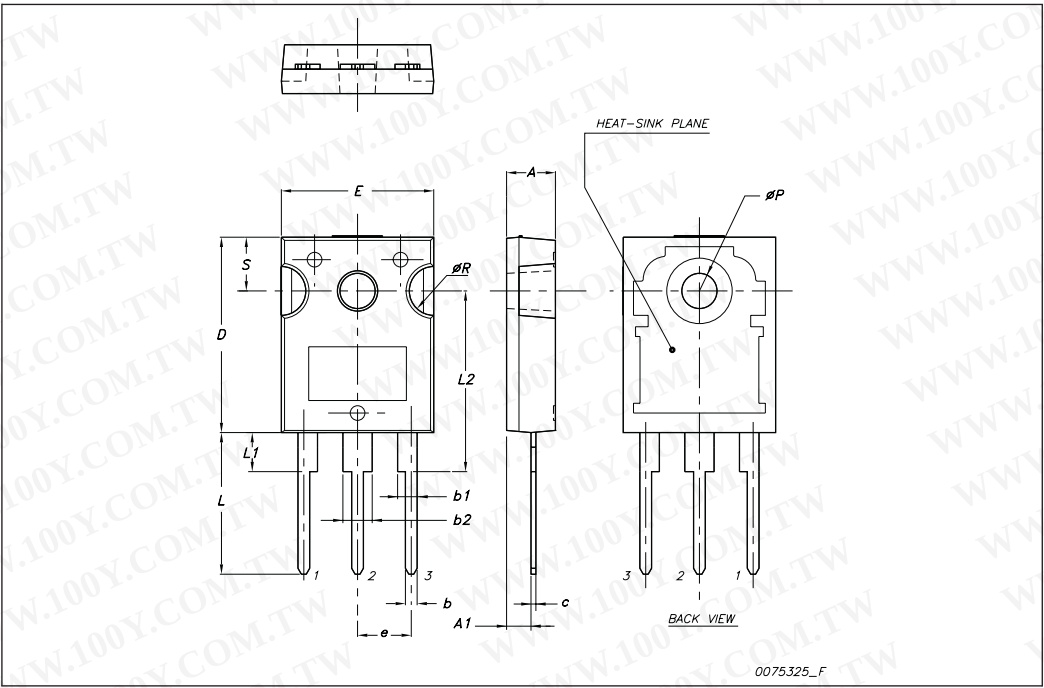
| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 4.4  |      | 4.6  |
| B    | 2.5  |      | 2.7  |
| D    | 2.5  |      | 2.75 |
| E    | 0.45 |      | 0.7  |
| F    | 0.75 |      | 1    |
| F1   | 1.15 |      | 1.70 |
| F2   | 1.15 |      | 1.5  |
| 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  |



7012510\_Rev\_J

TO-247 mechanical data

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





## 5 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes                                                                    |
|-------------|----------|----------------------------------------------------------------------------|
| 12-Apr-2004 | 1        | First release                                                              |
| 06-Sep-2005 | 2        | Inserted ecopack indication                                                |
| 13-Sep-2005 | 3        | Final version                                                              |
| 05-Sep-2006 | 4        | The document has been reformatted                                          |
| 26-Apr-2007 | 5        | The document has been updated on <a href="#">1: Electrical ratings</a>     |
| 25-Jan-2008 | 6        | Modified: dv/dt value on <a href="#">Table 2: Absolute maximum ratings</a> |
| 13-Oct-2009 | 7        | Added new package, mechanical data: TO-247                                 |

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