



# 2N7000 2N7002

N-channel 60 V, 1.8  $\Omega$ , 0.35 A, SOT23-3L, TO-92  
STripFET™ Power MOSFET

## Features

| Type   | V <sub>DSS</sub> | R <sub>DS(on)</sub> max | I <sub>D</sub> |
|--------|------------------|-------------------------|----------------|
| 2N7000 | 60 V             | < 5 $\Omega$ (@10V)     | 0.35 A         |
| 2N7002 | 60 V             | < 5 $\Omega$ (@10V)     | 0.20 A         |

- Low Q<sub>g</sub>
- Low threshold drive

## Application

- Switching applications

## Description

This Power MOSFET is the second generation of STMicroelectronics unique “single feature size” strip-based process. The resulting transistor shows extremely high packing density for low on-resistance, rugged avalanche characteristics and less critical alignment steps therefore a remarkable manufacturing reproducibility.

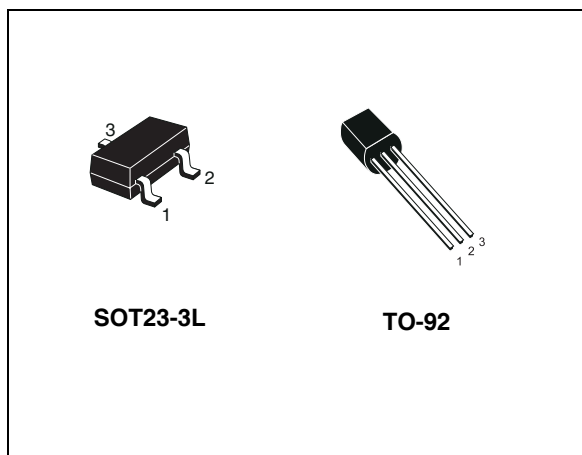


Figure 1. Internal schematic diagram

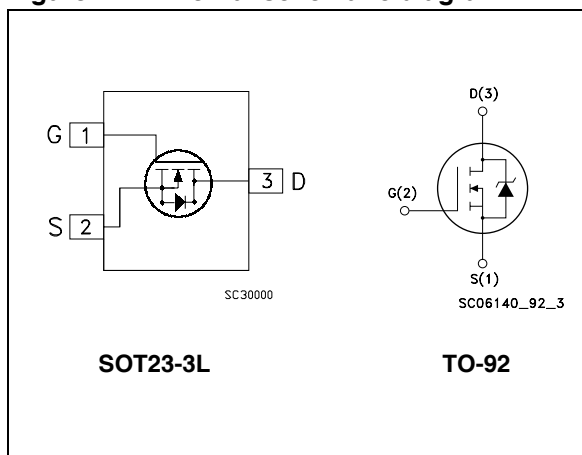


Table 1. Device summary

| Order codes | Marking | Package  | Packaging     |
|-------------|---------|----------|---------------|
| 2N7000      | 2N7000G | TO-92    | Bulk          |
| 2N7002      | ST2N    | SOT23-3L | Tape and reel |

# Contents

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter   | Value    |          | Unit |
|----------------|---|----------|----------|------|
|                |   | TO-92    | SOT23-3L |      |
| $V_{DS}$       | Drain-source voltage ( $V_{GS} = 0$ )                           | 60       |          | V    |
| $V_{DGR}$      | Drain-gate voltage ( $R_{GS} = 20 \text{ k}\Omega$ )            | 60       |          | V    |
| $V_{GS}$       | Gate- source voltage  | $\pm 18$ |          | V    |
| $I_D$          | Drain current (continuous) at $T_C = 25 \text{ }^\circ\text{C}$ | 0.35     | 0.20     | A    |
| $I_{DM}^{(1)}$ | Drain current (pulsed)  | 1.4      | 1        | A    |
| $P_{TOT}$      | Total dissipation at $T_C = 25 \text{ }^\circ\text{C}$          | 1        | 0.35     | W    |

1. Pulse width limited by safe operating area

**Table 3. Thermal data**

| Symbol        | Parameter                               | Value       |                      | Unit                      |
|---------------|---|-------------|----------------------|---------------------------|
|               |   | TO-92       | SOT23-3L             |                           |
| $R_{thj-amb}$ | Thermal resistance junction-ambient max | 125         | 357.1 <sup>(1)</sup> | $^\circ\text{C}/\text{W}$ |
| $T_J$         | Operating junction temperature          | - 55 to 150 |                      | $^\circ\text{C}$          |
| $T_{stg}$     | Storage temperature                     |             |                      |                           |

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

## 2 Electrical characteristics

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

**Table 4. On/off states**

| Symbol        | Parameter  | Test conditions   | Min. | Typ.     | Max.      | Unit                           |
|---------------|--|---|------|----------|-----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage                   | $I_D = 250\ \mu\text{A}$ , $V_{GS} = 0$   | 60   |          |           | V                              |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = \text{max rating}$<br>$V_{DS} = \text{max rating}$ ,<br>$T_C = 125\text{ °C}$         |      |          | 1<br>10   | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 18\text{ V}$  |      |          | $\pm 100$ | nA                             |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}$ , $I_D = 250\ \mu\text{A}$  | 1    | 2.1      | 3         | V                              |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10\text{ V}$ , $I_D = 0.5\text{ A}$<br>$V_{GS} = 4.5\text{ V}$ , $I_D = 0.5\text{ A}$ |      | 1.8<br>2 | 5<br>5.3  | $\Omega$<br>$\Omega$           |

**Table 5. Dynamic**

| Symbol         | Parameter                    | Test conditions  | Min. | Typ. | Max. | Unit |
|----------------|------------------------------|--|------|------|------|------|
| $g_{fs}^{(1)}$ | Forward transconductance     | $V_{DS} = 10\text{ V}$ , $I_D = 0.5\text{ A}$  |      | 0.6  |      | S    |
| $C_{iss}$      | Input capacitance            | $V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ ,<br>$V_{GS} = 0$  |      | 43   |      | pF   |
| $C_{oss}$      | Output capacitance           |  |      | 20   |      | pF   |
| $C_{rss}$      | Reverse transfer capacitance |  |      | 6    |      | pF   |
| $t_{d(on)}$    | Turn-on delay time           | $V_{DD} = 30\text{ V}$ , $I_D = 0.5\text{ A}$<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 4.5\text{ V}$<br>(see <a href="#">Figure 16</a> ) |      | 5    |      | ns   |
| $t_r$          | Rise time                    |  |      | 15   |      | ns   |
| $t_{d(off)}$   | Turn-off delay time          |  |      | 7    |      | ns   |
| $t_f$          | Fall time                    |  |      | 8    |      | ns   |
| $Q_g$          | Total gate charge            | $V_{DD} = 30\text{ V}$ , $I_D = 1\text{ A}$ ,<br>$V_{GS} = 5\text{ V}$<br>(see <a href="#">Figure 17</a> )                         |      | 1.4  | 2    | nC   |
| $Q_{gs}$       | Gate-source charge           |  |      | 0.8  |      | nC   |
| $Q_{gd}$       | Gate-drain charge            |  |      | 0.5  |      | nC   |

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

**Table 6. Source drain diode**

| Symbol                            | Parameter  | Test conditions  | Min. | Typ.            | Max.         | Unit          |
|-----------------------------------|--|--|------|-----------------|--------------|---------------|
| $I_{SD}$<br>$I_{SDM}^{(1)}$       | Source-drain current<br>Source-drain current<br>(pulsed)                     |  |      |                 | 0.35<br>1.40 | A<br>A        |
| $V_{SD}^{(2)}$                    | Forward on voltage   | $I_{SD} = 1\text{ A}$ , $V_{GS} = 0$   |      |                 | 1.2          | V             |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD} = 1\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,<br>$V_{DD} = 20\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 18</a> ) |      | 32<br>25<br>1.6 |              | ns<br>nC<br>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 TO-92

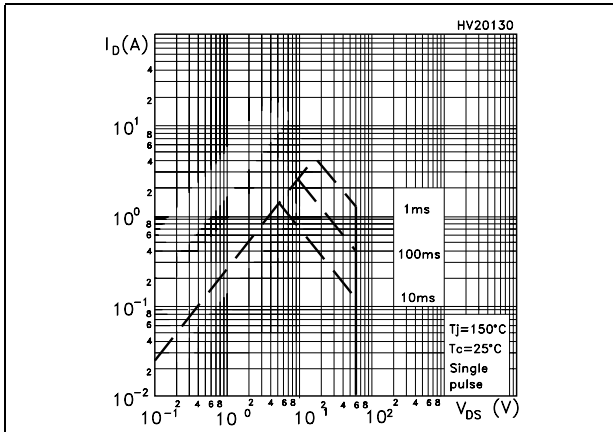


Figure 3. Thermal impedance for TO-92

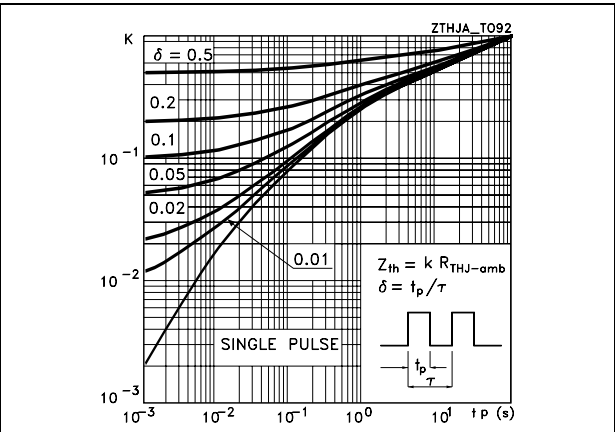


Figure 4. Safe operating area for SOT23-3L

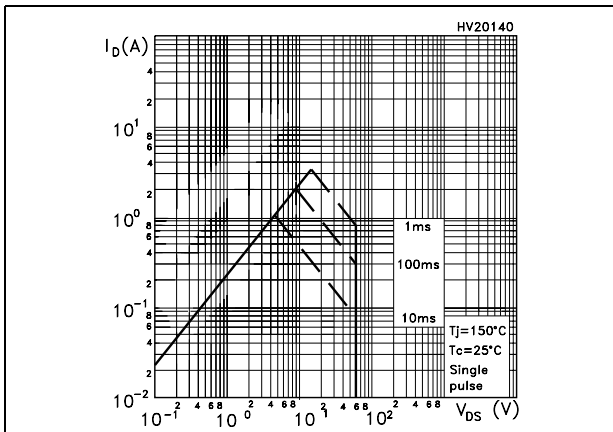


Figure 5. Thermal impedance for SOT23-3L

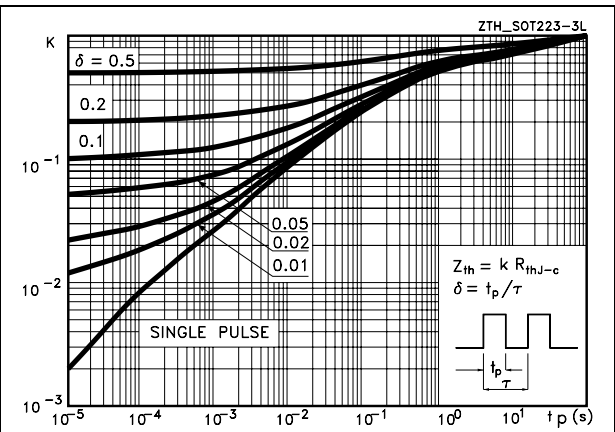


Figure 6. Output characteristics

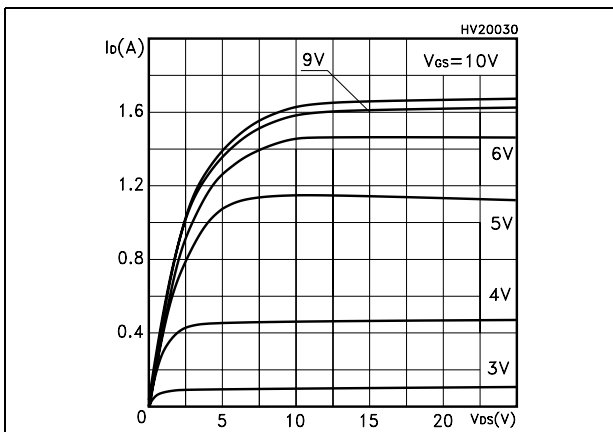


Figure 7. Transfer characteristics

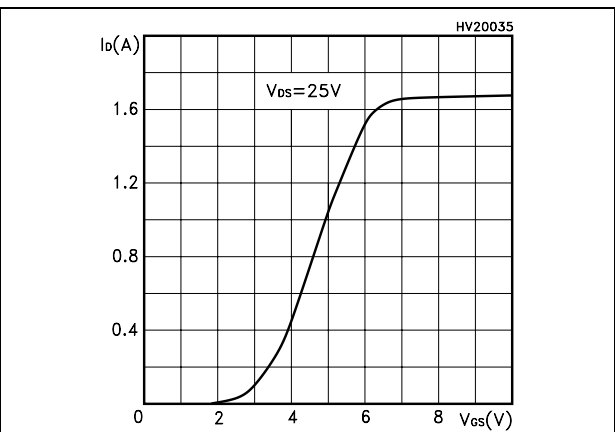


Figure 8. Transconductance

Figure 9. Static drain-source on resistance

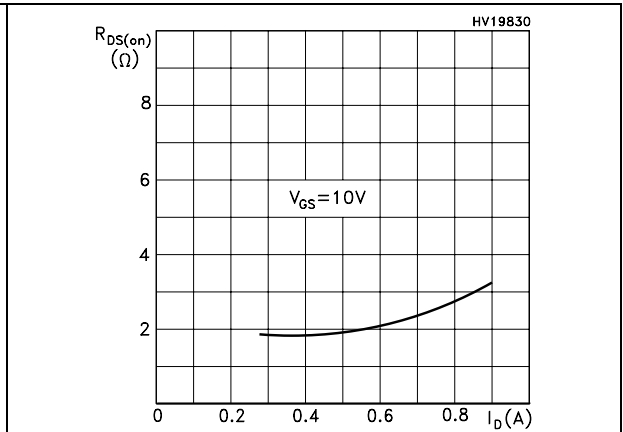
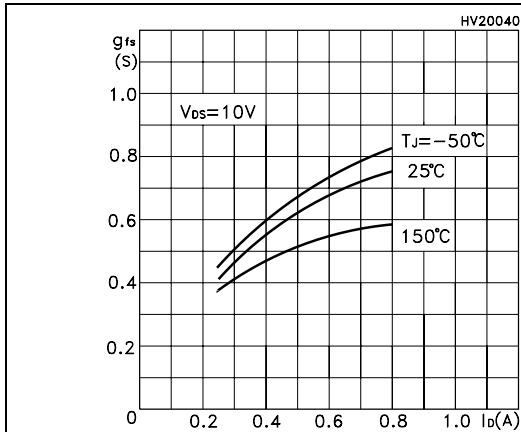


Figure 10. Gate charge vs gate-source voltage Figure 11. Capacitance variations

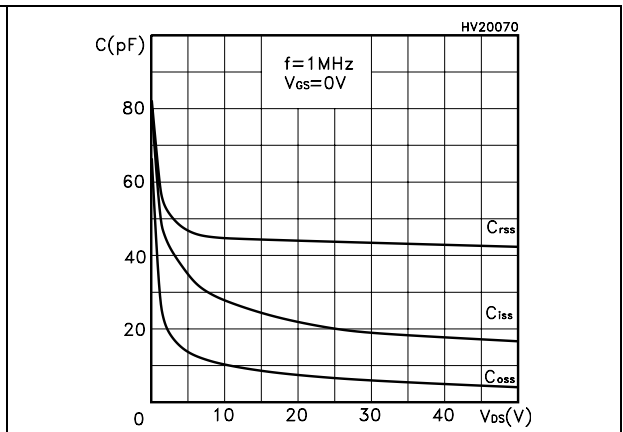
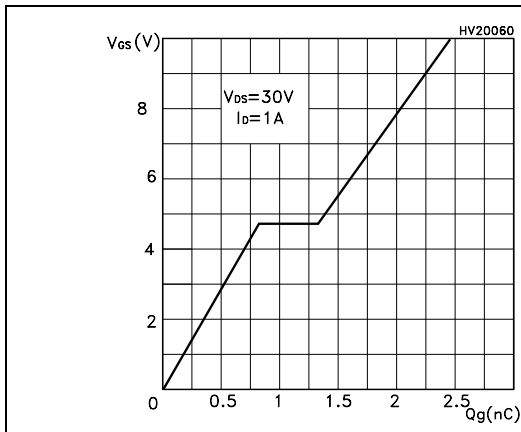


Figure 12. Normalized gate threshold voltage vs temperature

Figure 13. Normalized on resistance vs temperature

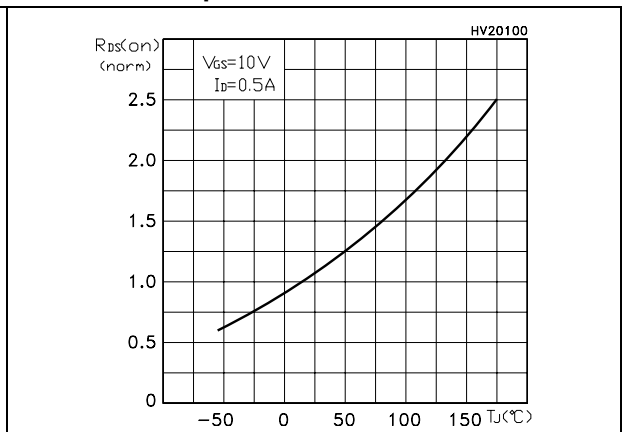
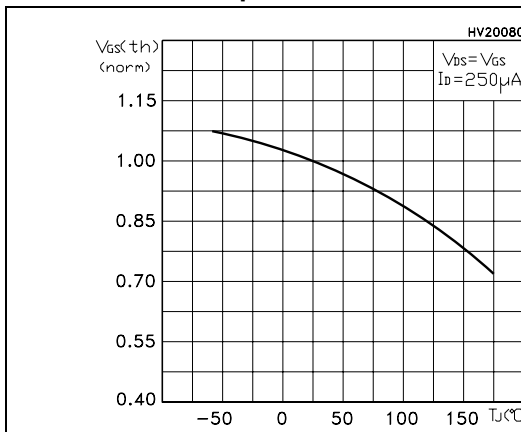


Figure 14. Source-drain diode forward characteristics

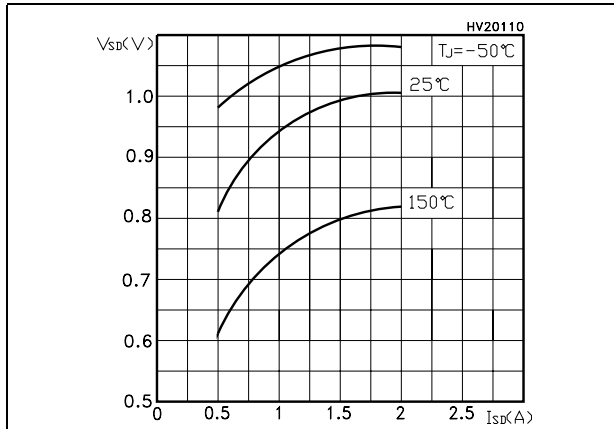
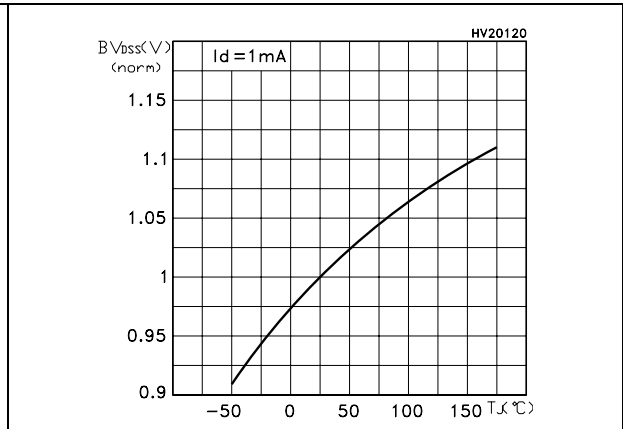


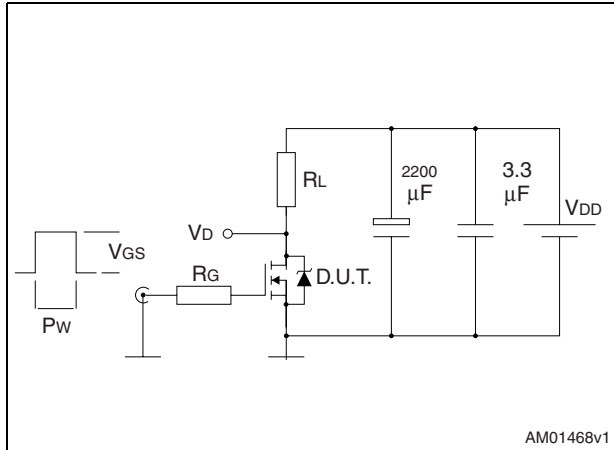
Figure 15. Normalized  $B_{VDSS}$  vs temperature



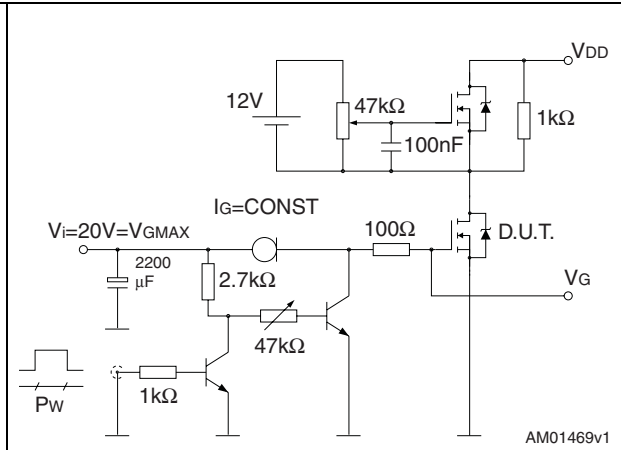


### 3 Test circuits

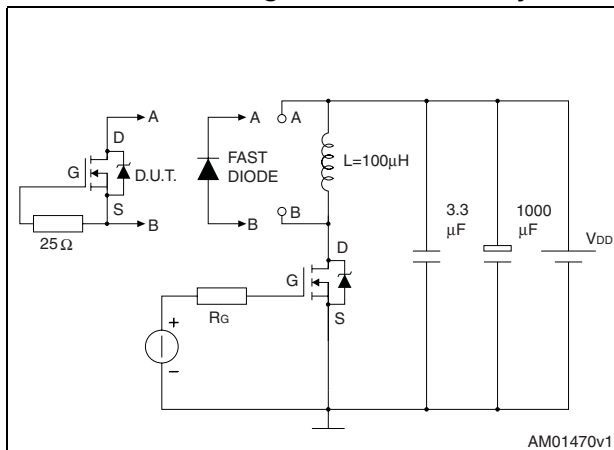
**Figure 16. Switching times test circuit for resistive load**



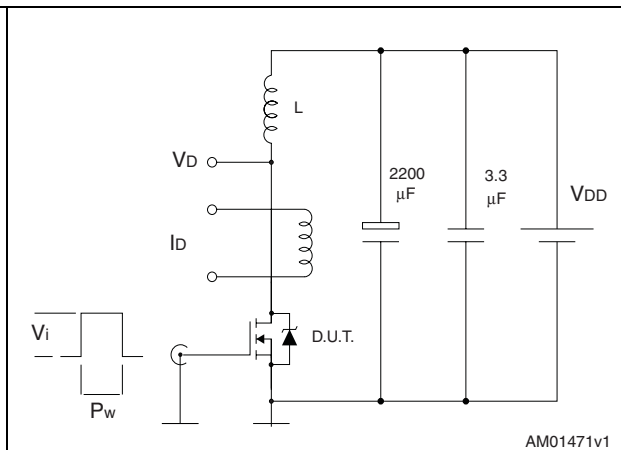
**Figure 17. Gate charge test circuit**



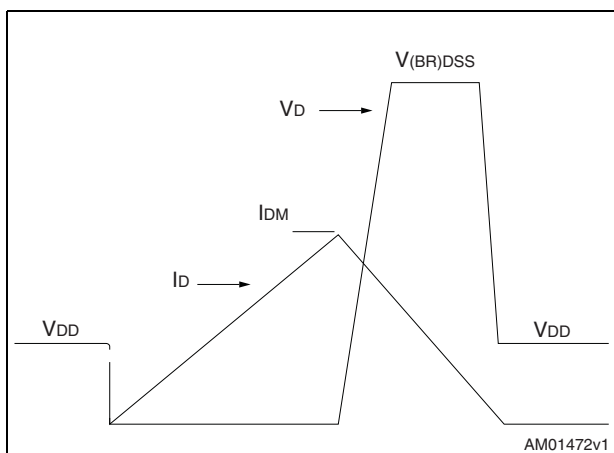
**Figure 18. Test circuit for inductive load switching and diode recovery times**



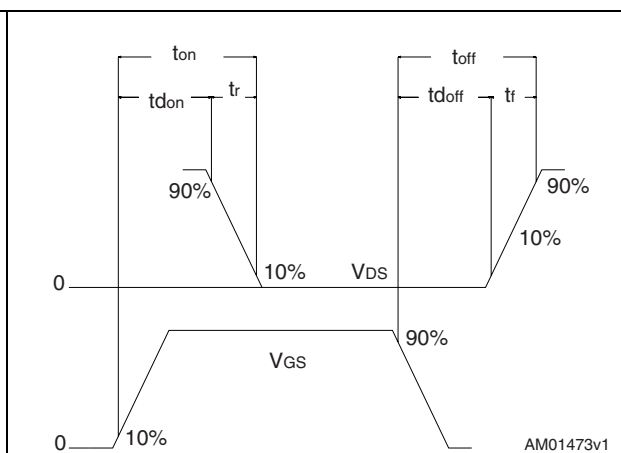
**Figure 19. Unclamped Inductive load test circuit**



**Figure 20. Unclamped inductive waveform**



**Figure 21. Switching time waveform**



## 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

Table 7. TO-92 mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    | 4.32  |      | 4.95  |
| b    | 0.36  |      | 0.51  |
| D    | 4.45  |      | 4.95  |
| E    | 3.30  |      | 3.94  |
| e    | 2.41  |      | 2.67  |
| e1   | 1.14  |      | 1.40  |
| L    | 12.70 |      | 15.49 |
| R    | 2.16  |      | 2.41  |
| S1   | 0.92  |      | 1.52  |
| W    | 0.41  |      | 0.56  |
| V    |       | 5°   |       |

Figure 22. TO-92 drawing

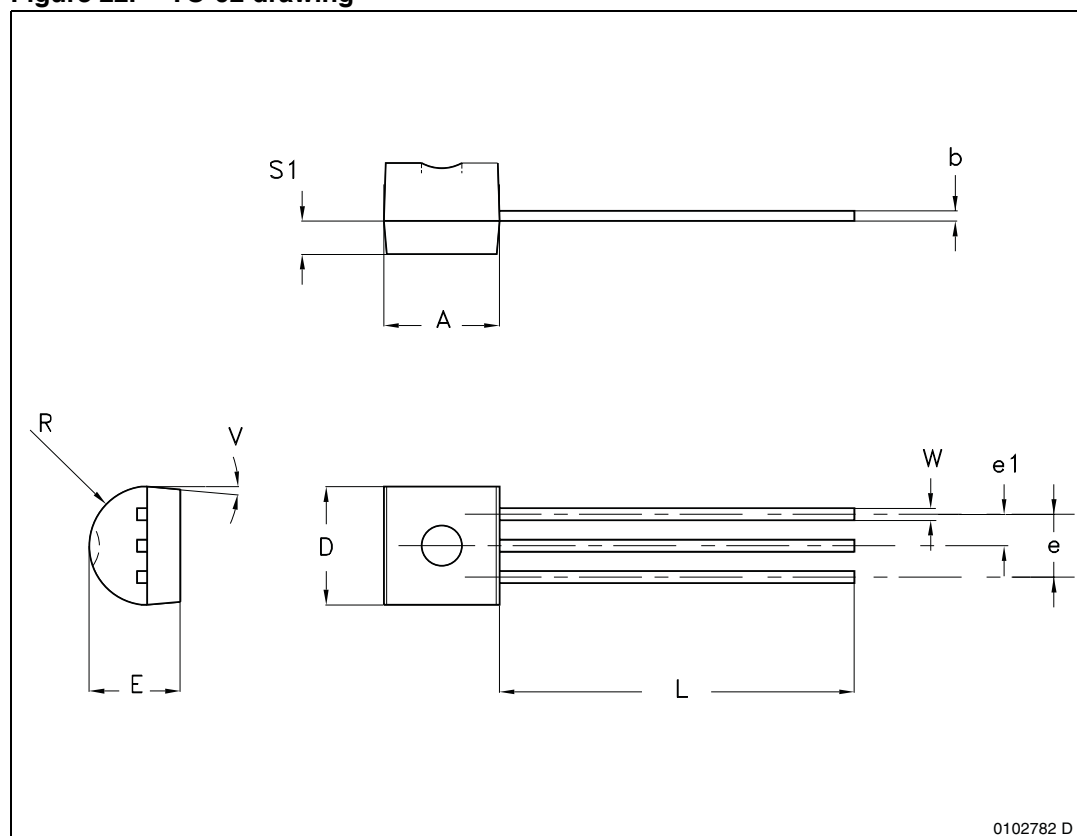
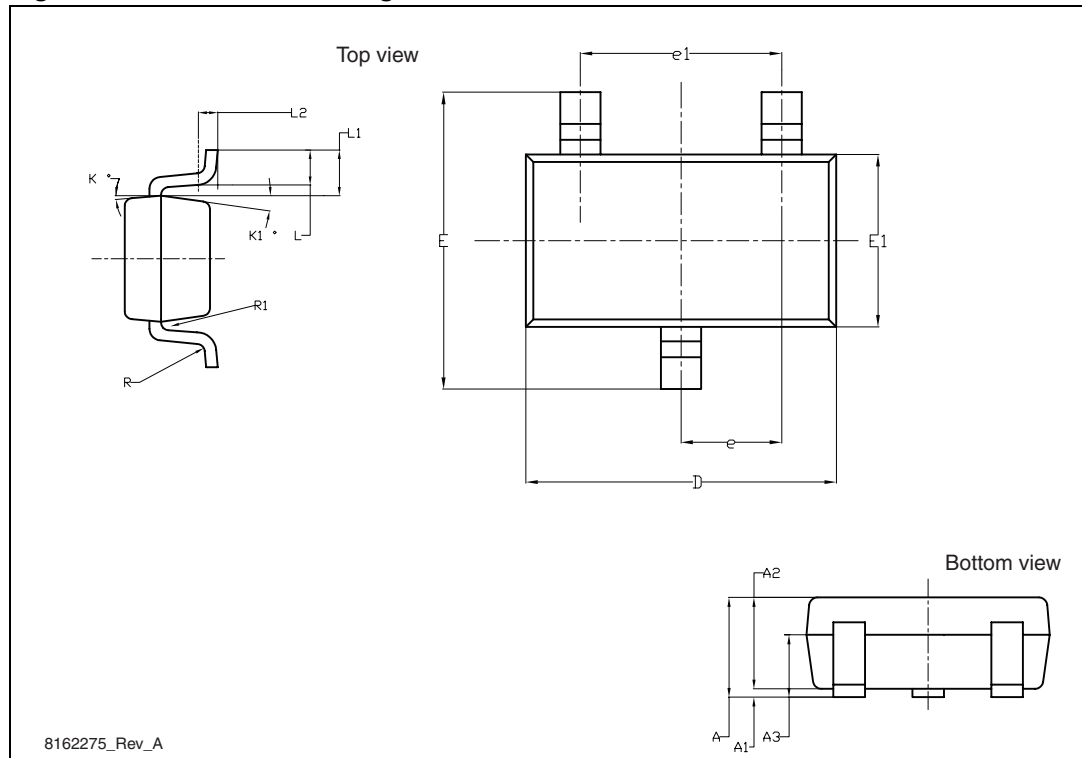


Table 8. SOT23-3L mechanical data

| Dim. | mm    |      |       |
|------|-------|------|-------|
|      | Min.  | Typ. | Max.  |
| A    |       |      | 1.25  |
| A1   | 0     |      | 0.15  |
| A2   | 1.00  |      | 1.20  |
| A3   | 0.60  |      | 0.70  |
| D    | 2.826 |      | 3.026 |
| E    | 2.60  |      | 3.00  |
| E1   | 1.526 |      | 1.726 |
| e    |       | 0.95 |       |
| e1   |       | 1.90 |       |
| L    | 0.35  |      | 0.60  |
| L1   |       | 0.59 |       |
| L2   |       | 0.25 |       |
| R    | 0.05  |      |       |
| R1   | 0.05  |      | 0.20  |
| K    | 3°    |      | 7°    |
| K1   | 6°    |      | 10°   |

Figure 23. SOT23-3L drawing



## 5 Revision history

**Table 9. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 09-Oct-2004 | 1        | First document   |
| 22-Jun-2004 | 2        | Complete document  |
| 06-Apr-2005 | 3        | New typ and max value inserted for Vgs(th)   |
| 19-Apr-2005 | 4        | The document has been reformatted  |
| 26-Apr-2005 | 5        | New Pin configuration for TO-92  |
| 28-Apr-2005 | 6        | Pin configuration change again   |
| 19-Jun-2006 | 7        | New template, no content change  |
| 03-Sep-2007 | 8        | Corrected marking on first page  |
| 04-Nov-2008 | 9        | <ul style="list-style-type: none"> <li>– Updated <i>Table 7: TO-92 mechanical data</i> and <i>Figure 22: TO-92 drawing</i>.</li> <li>– Updated <i>Table 8: SOT23-3L mechanical data</i> and <i>Figure 23: SOT23-3L drawing</i>.</li> </ul> |

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