

## N-channel 650 V, 0.32 $\Omega$ typ., 11 A MDmesh M2 Power MOSFETs in TO-220 and IPAK packages

Datasheet – production data

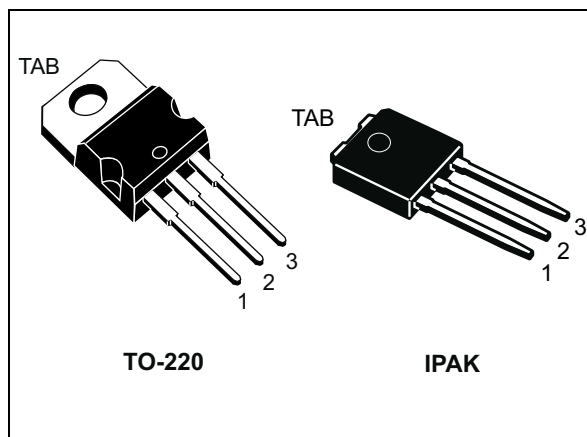
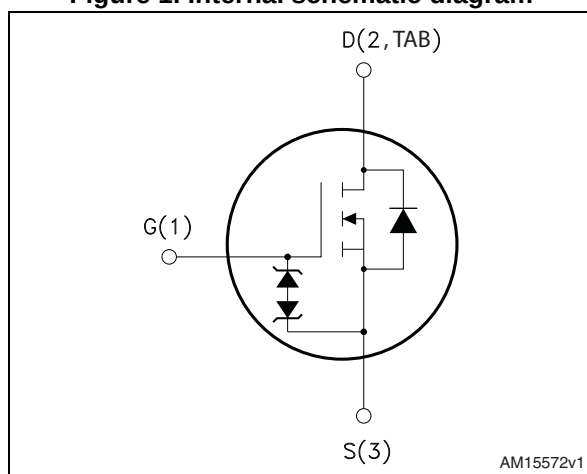


Figure 1. Internal schematic diagram



### Features

| Order code | $V_{DS} @ T_{Jmax}$ | $R_{DS(on)} max$ | $I_D$ |
|------------|---------------------|------------------|-------|
| STP16N65M2 | 710 V               | 0.36 $\Omega$    | 11 A  |
| STU16N65M2 | 710 V               | 0.36 $\Omega$    | 11 A  |

- Extremely low gate charge
- Excellent output capacitance ( $C_{oss}$ ) profile
- 100% avalanche tested
- Zener-protected

### Applications

- Switching applications

### Description

These devices are N-channel Power MOSFETs developed using MDmesh™ M2 technology. Thanks to their strip layout and improved vertical structure, the devices exhibit low on-resistance and optimized switching characteristics, rendering them suitable for the most demanding high efficiency converters.

Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|---------|---------|-----------|
| STP16N65M2  | 16N65M2 | TO-220  | Tube      |
| STU16N65M2  | 16N65M2 | IPAK    | Tube      |

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                                                         | Value       | Unit               |
|----------------|-------------------------------------------------------------------|-------------|--------------------|
| $V_{GS}$       | Gate-source voltage                                               | $\pm 25$    | V                  |
| $I_D$          | Drain current (continuous) at $T_C = 25\text{ }^{\circ}\text{C}$  | 11          | A                  |
| $I_D$          | Drain current (continuous) at $T_C = 100\text{ }^{\circ}\text{C}$ | 6.9         | A                  |
| $I_{DM}^{(1)}$ | Drain current (pulsed)                                            | 44          | A                  |
| $P_{TOT}$      | Total dissipation at $T_C = 25\text{ }^{\circ}\text{C}$           | 110         | W                  |
| $dv/dt^{(2)}$  | Peak diode recovery voltage slope                                 | 15          | V/ns               |
| $dv/dt^{(3)}$  | MOSFET $dv/dt$ ruggedness                                         | 50          | V/ns               |
| $T_{stg}$      | Storage temperature                                               | - 55 to 150 | $^{\circ}\text{C}$ |
| $T_j$          | Max. operating junction temperature                               |             |                    |

1. Pulse width limited by safe operating area.
2.  $I_{SD} \leq 11\text{ A}$ ,  $di/dt \leq 400\text{ A}/\mu\text{s}$ ;  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD}=400\text{ V}$ .
3.  $V_{DS} \leq 520\text{ V}$

**Table 3. Thermal data**

| Symbol         | Parameter                                          | Value  |      | Unit                        |
|----------------|----------------------------------------------------|--------|------|-----------------------------|
|                |                                                    | TO-220 | IPAK |                             |
| $R_{thj-case}$ | Thermal resistance junction-case max               | 1.14   |      | $^{\circ}\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-amb max <sup>(1)</sup> | 62.50  | 100  | $^{\circ}\text{C}/\text{W}$ |

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

**Table 4. Avalanche characteristics**

| Symbol   | Parameter                                                                                       | Value | Unit |
|----------|-------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not repetitive (pulse width limited by $T_{jmax}$ )            | 1.9   | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j=25^{\circ}\text{C}$ , $I_D=I_{AR}$ ; $V_{DD}=50$ ) | 360   | mJ   |

## 2 Electrical characteristics

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

**Table 5. On /off states**

| Symbol        | Parameter                         | Test conditions                                                        | Min. | Typ. | Max.     | Unit          |
|---------------|-----------------------------------|------------------------------------------------------------------------|------|------|----------|---------------|
| $V_{(BR)DSS}$ | Drain-source breakdown voltage    | $V_{GS} = 0, I_D = 1\text{ mA}$                                        | 650  |      |          | V             |
| $I_{DSS}$     | Zero gate voltage drain current   | $V_{GS} = 0, V_{DS} = 650\text{ V}$                                    |      |      | 1        | $\mu\text{A}$ |
|               |                                   | $V_{GS} = 0, V_{DS} = 650\text{ V}, T_C = 125\text{ }^{\circ}\text{C}$ |      |      | 100      | $\mu\text{A}$ |
| $I_{GSS}$     | Gate-body leakage current         | $V_{DS} = 0, V_{GS} = \pm 25\text{ V}$                                 |      |      | $\pm 10$ | $\mu\text{A}$ |
| $V_{GS(th)}$  | 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 | $V_{GS} = 10\text{ V}, I_D = 5.5\text{ A}$                             |      | 0.32 | 0.36     | $\Omega$      |

**Table 6. Dynamic**

| Symbol                     | Parameter                     | Test conditions                                                                                   | Min. | Typ. | Max. | Unit     |
|----------------------------|-------------------------------|---------------------------------------------------------------------------------------------------|------|------|------|----------|
| $C_{iss}$                  | Input capacitance             | $V_{GS} = 0, V_{DS} = 100\text{ V}, f = 1\text{ MHz}$                                             | -    | 718  | -    | pF       |
| $C_{oss}$                  | Output capacitance            |                                                                                                   | -    | 32   | -    | pF       |
| $C_{rss}$                  | Reverse transfer capacitance  |                                                                                                   | -    | 1.1  | -    | pF       |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{GS} = 0, V_{DS} = 0\text{ to }520\text{ V}$                                                   | -    | 189  | -    | pF       |
| $R_G$                      | Intrinsic gate resistance     | $f = 1\text{ MHz open drain}$                                                                     | -    | 5.2  | -    | $\Omega$ |
| $Q_g$                      | Total gate charge             | $V_{DD} = 520\text{ V}, I_D = 11\text{ A}, V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> ) | -    | 19.5 | -    | nC       |
| $Q_{gs}$                   | Gate-source charge            |                                                                                                   | -    | 4    | -    | nC       |
| $Q_{gd}$                   | Gate-drain charge             |                                                                                                   | -    | 8.3  | -    | 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%  $V_{DSS}$

Table 7. Switching times

| Symbol       | Parameter           | Test conditions                                                                                                                                             | Min. | Typ. | Max. | Unit |
|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $t_{d(on)}$  | Turn-on delay time  | $V_{DD} = 325\text{ V}$ , $I_D = 5.5\text{ A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$<br>(see <a href="#">Figure 16</a> and <a href="#">21</a> ) | -    | 11.3 | -    | ns   |
| $t_r$        | Rise time           |                                                                                                                                                             | -    | 8.2  | -    | ns   |
| $t_{d(off)}$ | Turn-off delay time |                                                                                                                                                             | -    | 36   | -    | ns   |
| $t_f$        | Fall time           |                                                                                                                                                             | -    | 11.3 | -    | ns   |

Table 8. Source drain diode

| Symbol          | Parameter                     | Test conditions                                                                                                                                               | Min. | Typ. | Max. | Unit          |
|-----------------|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{SD}$        | Source-drain current          |                                                                                                                                                               | -    |      | 11   | A             |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                                                                                                                                               | -    |      | 44   | A             |
| $V_{SD}^{(2)}$  | Forward on voltage            | $V_{GS} = 0$ , $I_{SD} = 11\text{ A}$                                                                                                                         | -    |      | 1.6  | V             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ (see <a href="#">Figure 18</a> )                                        | -    | 342  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                               | -    | 3.5  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                               | -    | 20.4 |      | A             |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 11\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$<br>$V_{DD} = 60\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$<br>(see <a href="#">Figure 18</a> ) | -    | 458  |      | ns            |
| $Q_{rr}$        | Reverse recovery charge       |                                                                                                                                                               | -    | 4.6  |      | $\mu\text{C}$ |
| $I_{RRM}$       | Reverse recovery current      |                                                                                                                                                               | -    | 20.5 |      | 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-220

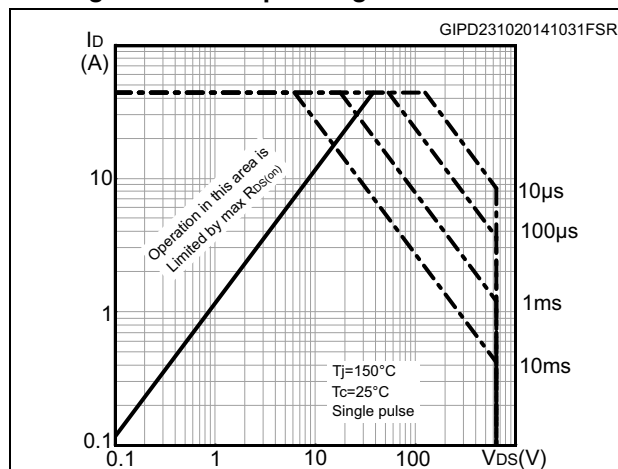


Figure 3. Thermal impedance for TO-220

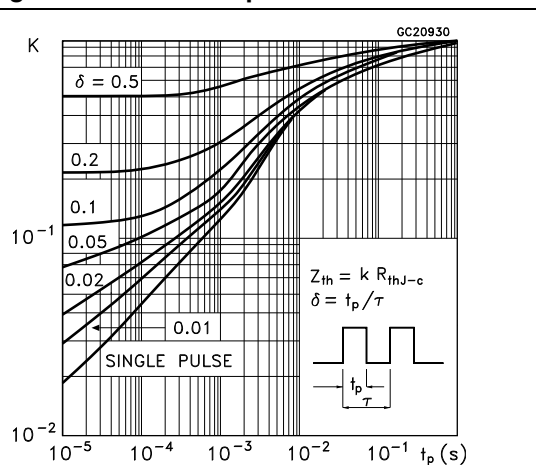


Figure 4. Safe operating area for IPAK

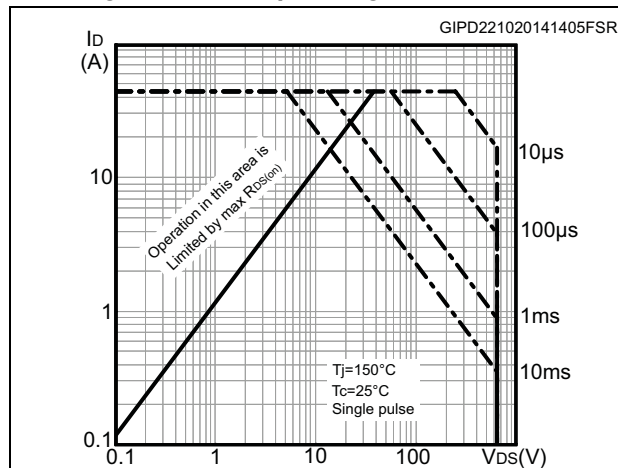


Figure 5. Thermal impedance for IPAK

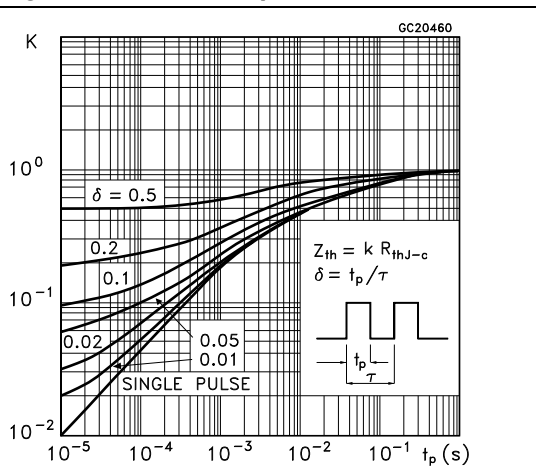


Figure 6. Output characteristics

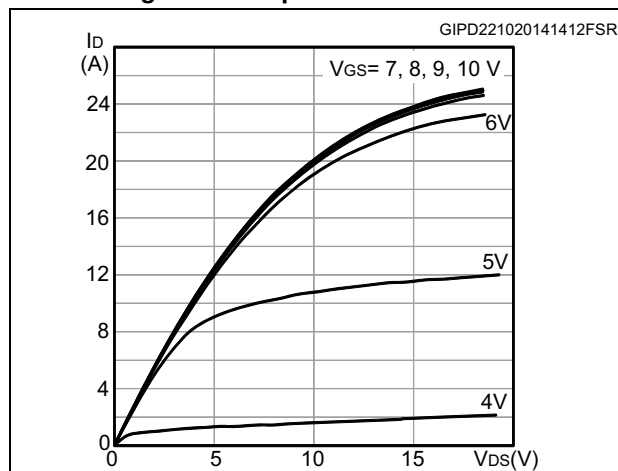


Figure 7. Transfer characteristics

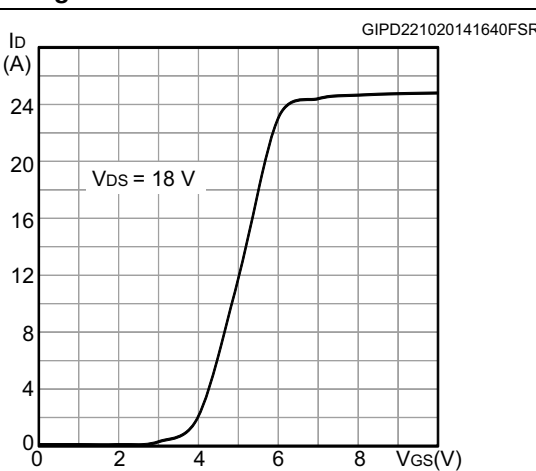


Figure 8. Normalized gate threshold voltage vs. temperature

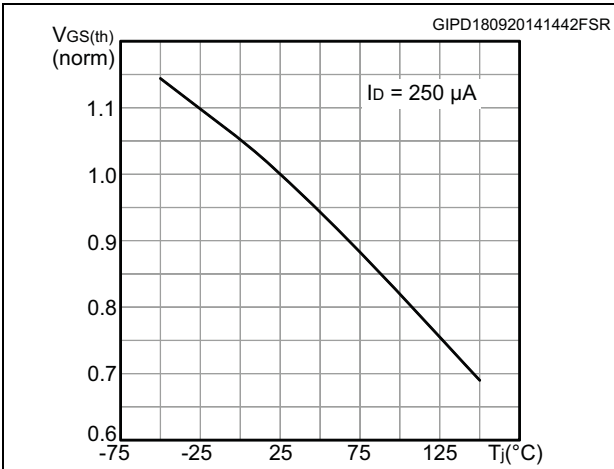


Figure 9. Normalized  $V_{(BR)DSS}$  vs. temperature

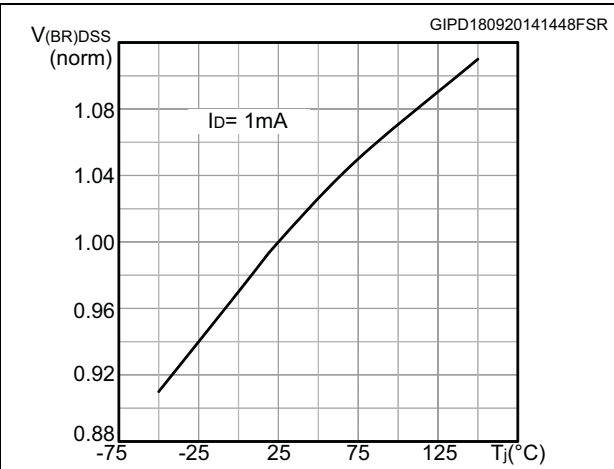


Figure 10. Static drain-source on-resistance

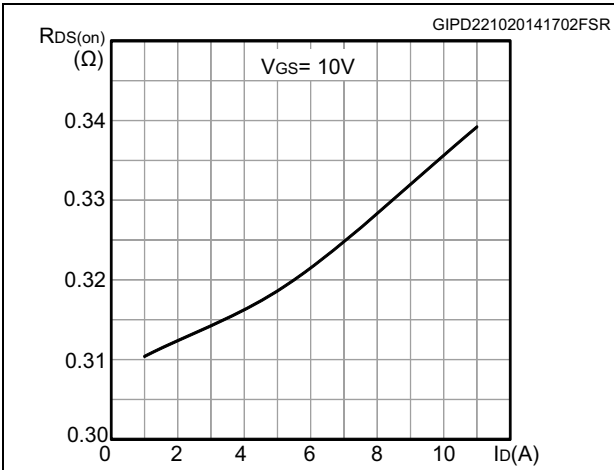


Figure 11. Normalized on-resistance vs. temperature

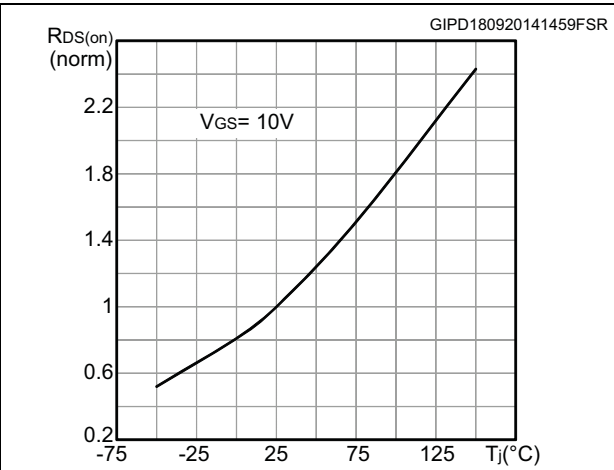


Figure 12. Gate charge vs. gate-source voltage

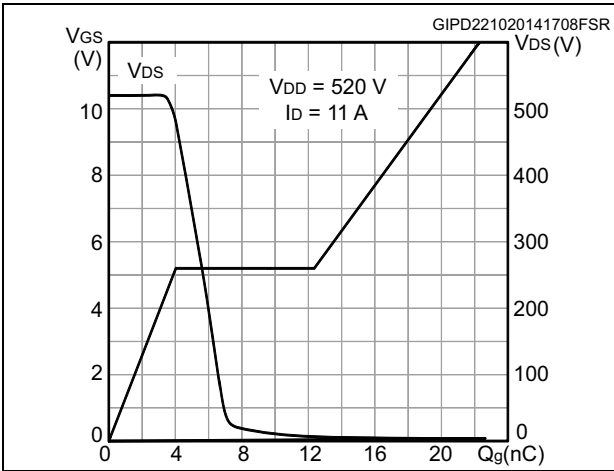


Figure 13. Capacitance variations

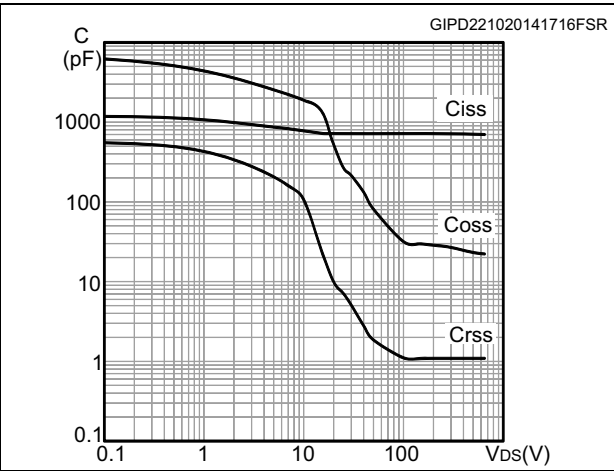


Figure 14. Output capacitance stored energy

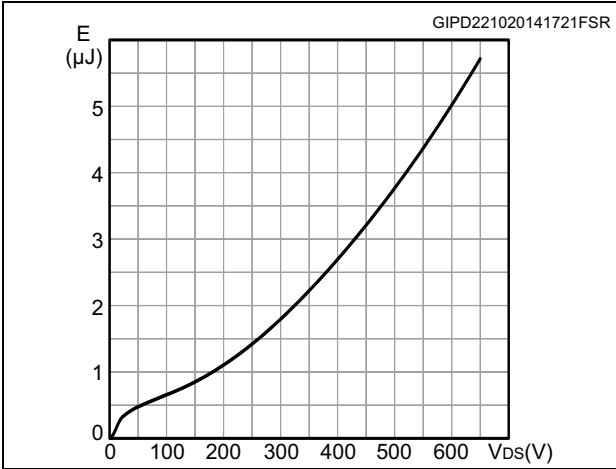
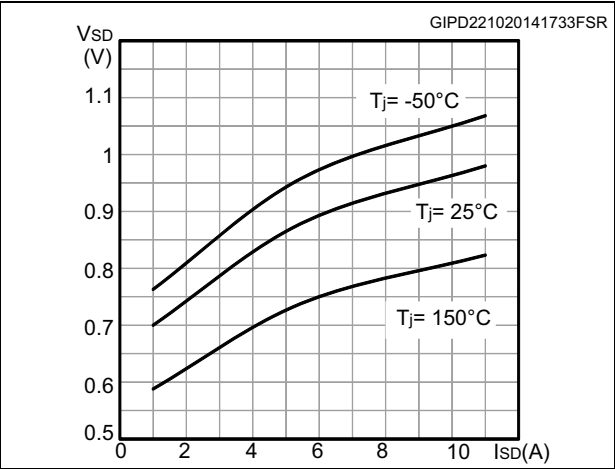


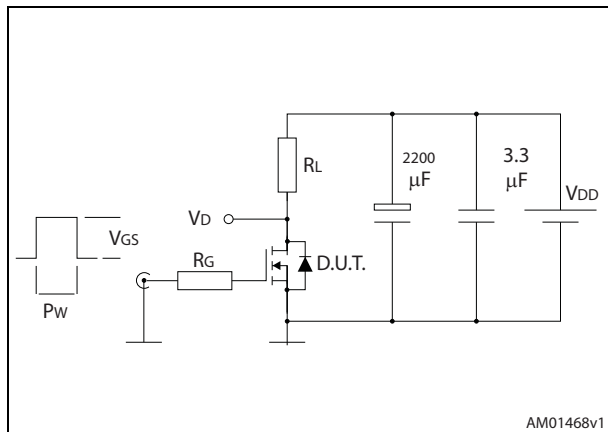
Figure 15. Source-drain diode forward characteristics



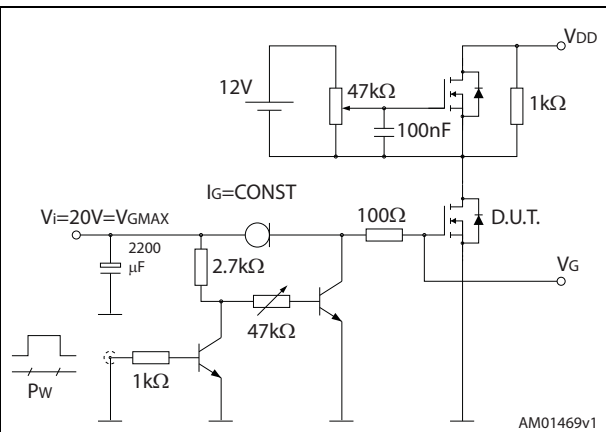


### 3 Test circuits

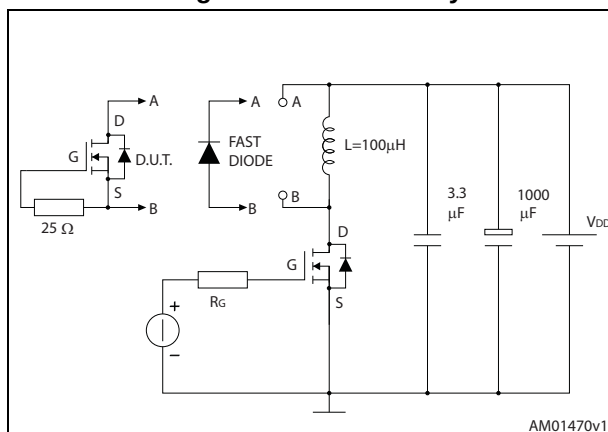
**Figure 16. Switching times test circuit for resistive load**



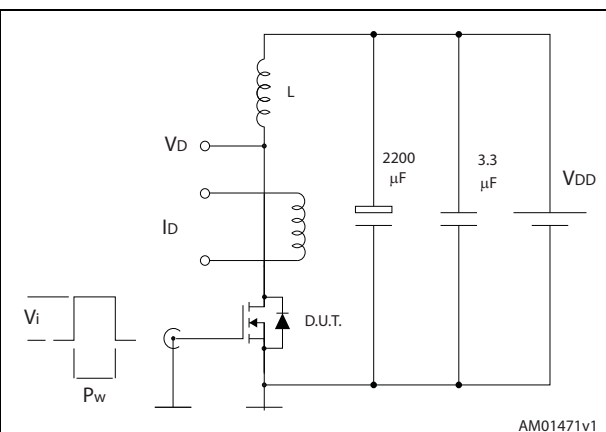
**Figure 17. Gate charge test circuit**



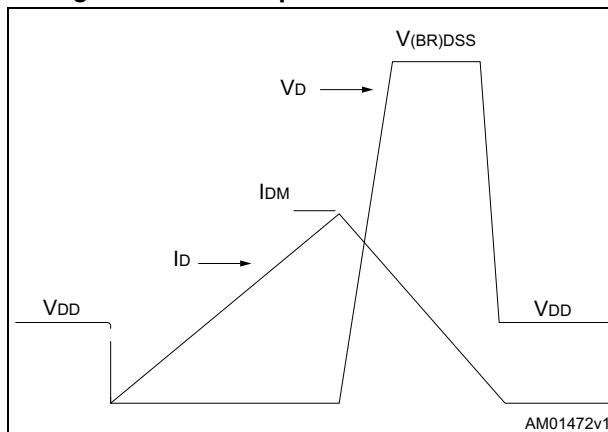
**Figure 18. Test circuit for inductive load switching and diode recovery times**



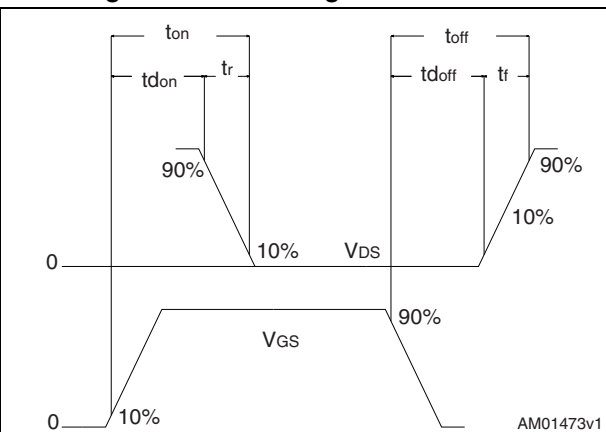
**Figure 19. Unclamped inductive load test circuit**



**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 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.

## 4.1 TO-220, STP16N65M2

Figure 22. TO-220 type A drawing

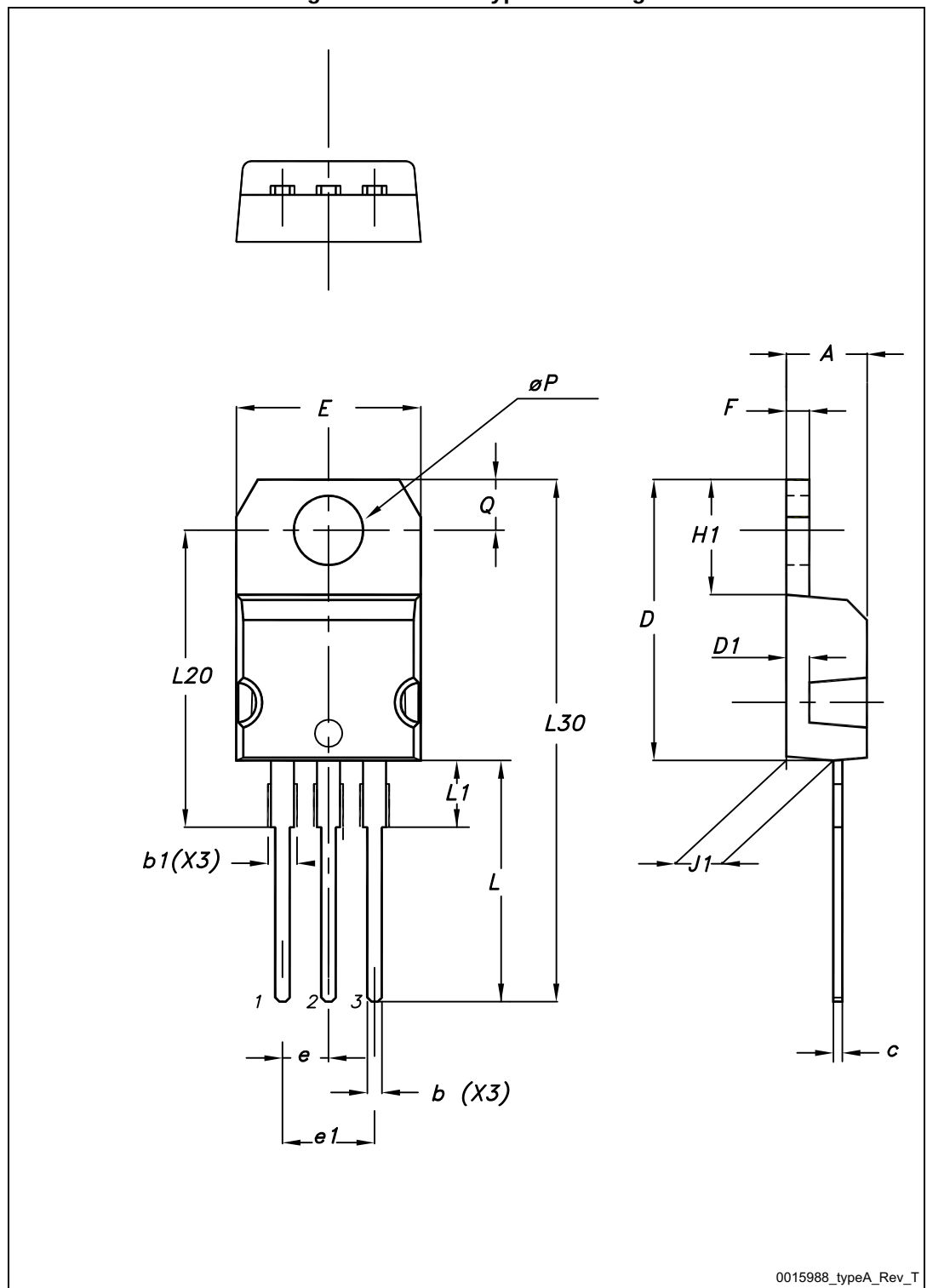


Table 9. TO-220 type A mechanical data

| 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  |

## 4.2 IPAK, STU16N65M2

Figure 23. IPAK (TO-251) type A drawing

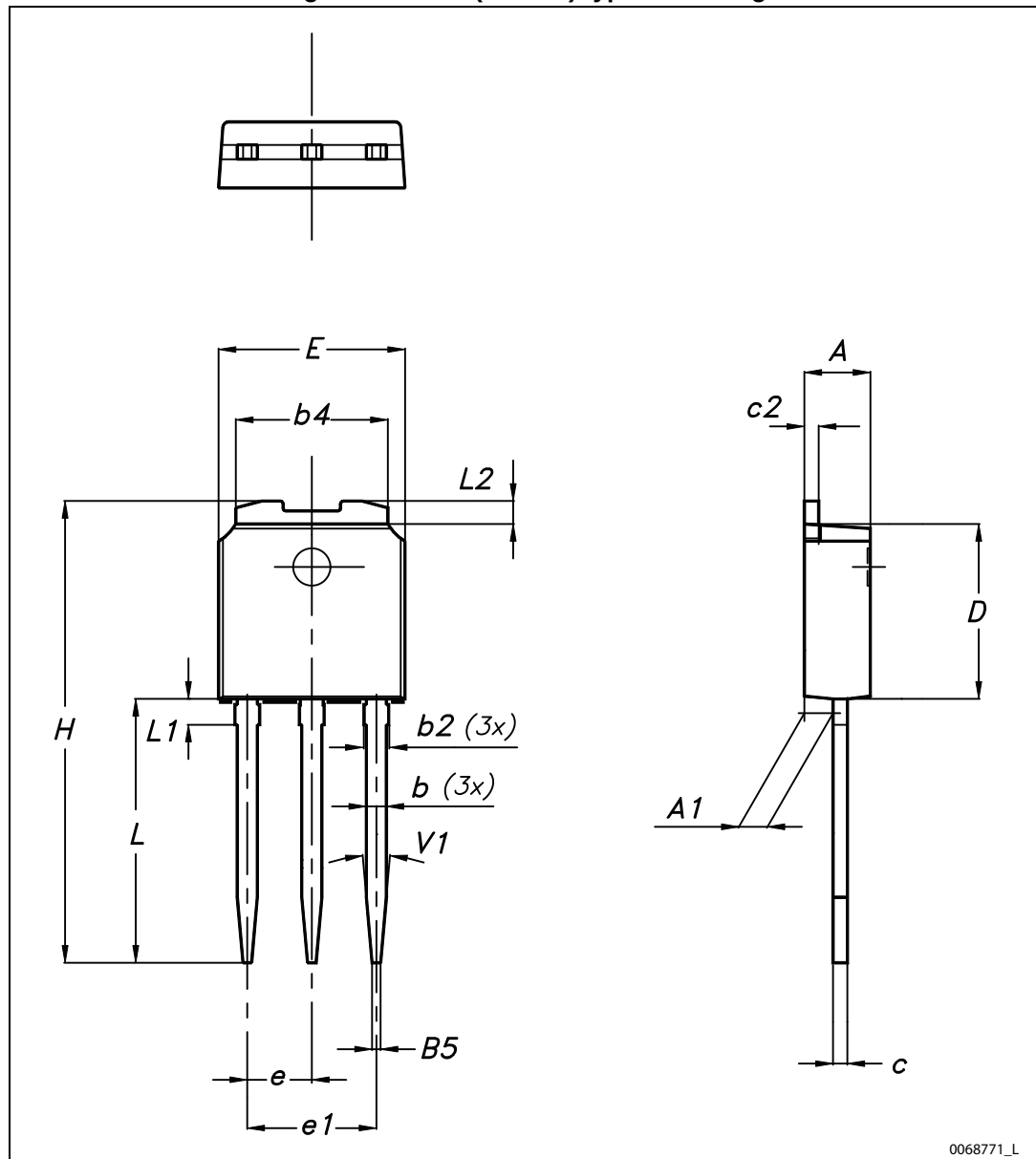


Table 10. IPAK (TO-251) type A mechanical data

| 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 |
| B5  |      | 0.30  |      |
| 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  | 1.00 |
| V1  |      | 10°   |      |

## 5 Revision history

**Table 11. Document revision history**

| Date        | Revision | Changes        |
|-------------|----------|----------------|
| 24-Oct-2014 | 1        | First release. |

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