

N-channel 600 V, 1.06 Ω typ., 4.5 A MDmesh™ M2 Power MOSFETs in TO-220FP, TO-220 and IPAK packages

Datasheet - production data

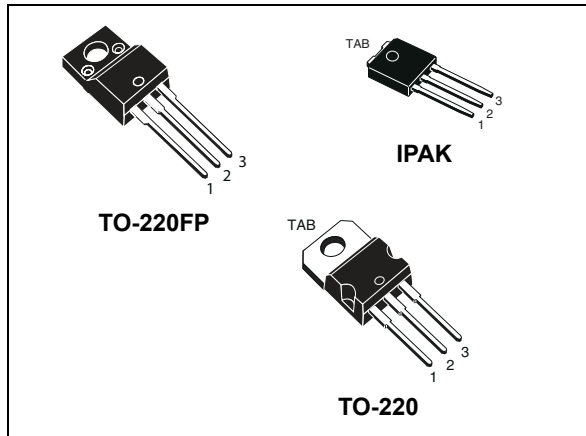
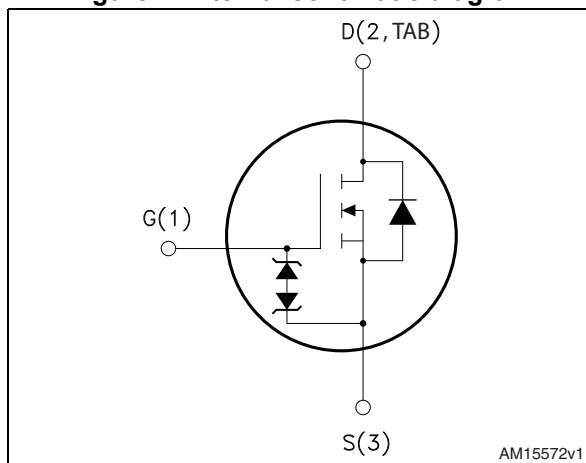


Figure 1. Internal schematic diagram



Features

| Order code | $V_{DS} @ T_{Jmax}$ | $R_{DS(on) max}$ | I_D |
|------------|---------------------|------------------|-------|
| STF6N60M2 | 650 V | 1.2 Ω | 4.5 A |
| STP6N60M2 | | | |
| STU6N60M2 | | | |

- 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 code | Marking | Package | Packing |
|------------|---------|----------|---------|
| STF6N60M2 | 6N60M2 | TO-220FP | Tube |
| STP6N60M2 | | TO-220 | |
| STU6N60M2 | | IPAK | |

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1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|----------------|---|--------------------|--------------|------|
| | | TO-220FP | TO-220, IPAK | |
| V_{GS} | Gate-source voltage | ± 25 | | V |
| I_D | Drain current (continuous) at $T_C = 25\text{ °C}$ | 4.5 ⁽¹⁾ | 4.5 | A |
| I_D | Drain current (continuous) at $T_C = 100\text{ °C}$ | 2.9 ⁽¹⁾ | 2.9 | A |
| $I_{DM}^{(2)}$ | Drain current (pulsed) | 18 ⁽¹⁾ | 18 | A |
| P_{TOT} | Total dissipation at $T_C = 25\text{ °C}$ | 20 | 60 | W |
| V_{ISO} | Insulation withstand voltage (RMS) from all three leads to external heat sink ($t=1\text{ s}$; $T_C=25\text{ °C}$) | 2500 | | V |
| $dv/dt^{(3)}$ | Peak diode recovery voltage slope | 15 | | V/ns |
| $dv/dt^{(4)}$ | MOSFET dv/dt ruggedness | 50 | | |
| T_{stg} | Storage temperature | - 55 to 150 | | °C |
| T_j | Operating junction temperature | | | |

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- $I_{SD} \leq 4.5\text{ A}$, $di/dt \leq 400\text{ A}/\mu\text{s}$; $V_{DS\ peak} < V_{(BR)DSS}$, $V_{DD}=400\text{ V}$
- $V_{DS} \leq 480\text{ V}$

Table 3. Thermal data

| Symbol | Parameter | Value | | | Unit |
|----------------|---|----------|--------|------|------|
| | | TO-220FP | TO-220 | IPAK | |
| $R_{thj-case}$ | Thermal resistance junction-case max | 6.25 | 2.08 | | °C/W |
| $R_{thj-amb}$ | Thermal resistance junction-ambient max | 62.5 | | 100 | °C/W |

Table 4. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|----------|---|-------|------|
| I_{AR} | Avalanche current, repetitive or not repetitive (pulse width limited by T_{jmax}) | 1 | A |
| E_{AS} | Single pulse avalanche energy (starting $T_j=25\text{ °C}$, $I_D=I_{AR}$; $V_{DD}=50$) | 86 | 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 ($V_{GS} = 0$) | $V_{DS} = 600\text{ V}$ | | | 1 | μA |
| | | $V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}$ | | | 100 | μA |
| I_{GSS} | Gate-body leakage current ($V_{DS} = 0$) | $V_{GS} = \pm 25\text{ V}$ | | | ± 10 | μA |
| $V_{GS(th)}$ | 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 | $V_{GS} = 10\text{ V}$, $I_D = 2.25\text{ A}$ | | 1.06 | 1.2 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|--|------|------|------|----------|
| C_{iss} | Input capacitance | $V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$ | - | 232 | - | pF |
| C_{oss} | Output capacitance | | - | 14 | - | pF |
| C_{rss} | Reverse transfer capacitance | | - | 0.7 | - | pF |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$, $V_{GS} = 0$ | - | 71 | - | pF |
| R_G | Intrinsic gate resistance | $f = 1\text{ MHz}$ open drain | - | 6.5 | - | Ω |
| Q_g | Total gate charge | $V_{DD} = 480\text{ V}$, $I_D = 4.5\text{ A}$, $V_{GS} = 10\text{ V}$ (see Figure 18) | - | 8 | - | nC |
| Q_{gs} | Gate-source charge | | - | 1.7 | - | nC |
| Q_{gd} | Gate-drain charge | | - | 4 | - | 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 | $V_{DD} = 300\text{ V}$, $I_D = 1.65\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ (see Figure 17 and Figure 22) | - | 9.5 | - | ns |
| t_r | Rise time | | - | 7.4 | - | ns |
| $t_{d(off)}$ | Turn-off delay time | | - | 24 | - | ns |
| t_f | Fall time | | - | 22.5 | - | ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|--|------|------|------|---------------|
| I_{SD} | Source-drain current | | - | | 4.5 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 18 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 4.5 \text{ A}$, $V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 4.5 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ (see Figure 19) | - | 274 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 1.47 | | μC |
| I_{RRM} | Reverse recovery current | | - | 10.7 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 4.5 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$, $T_j = 150 \text{ }^\circ\text{C}$ (see Figure 19) | - | 376 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 1.96 | | μC |
| I_{RRM} | Reverse recovery current | | - | 10.5 | | A |

1. Pulse width limited by safe operating area.
2. Pulsed: pulse duration = 300 μs , duty cycle 1.5%

2.1 Electrical characteristics (curves)

Figure 2. Safe operating area for TO-220FP

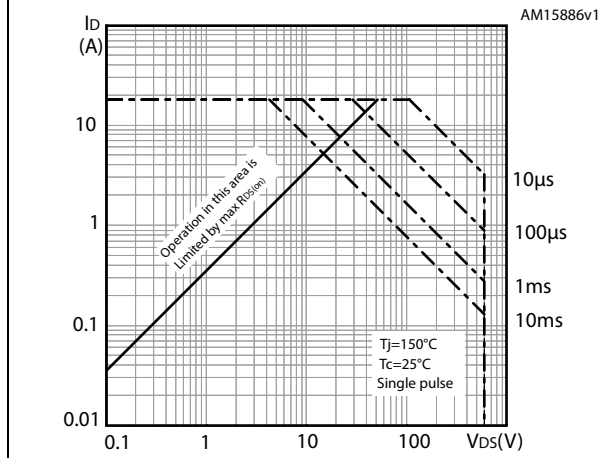


Figure 3. Thermal impedance for TO-220FP

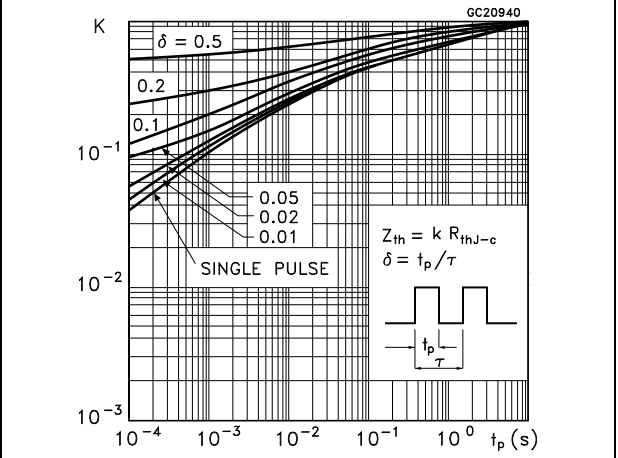


Figure 4. Safe operating area for TO-220

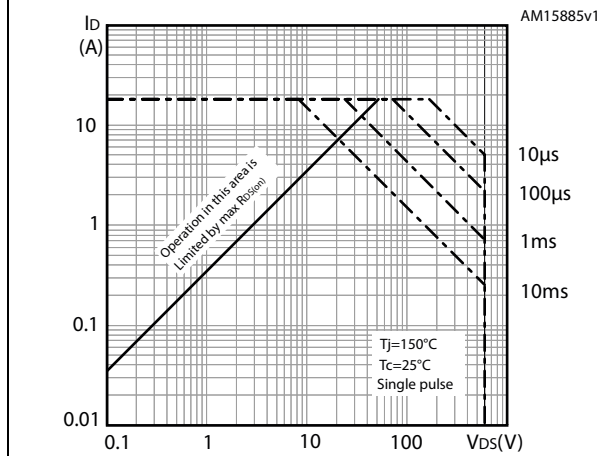


Figure 5. Thermal impedance for TO-220

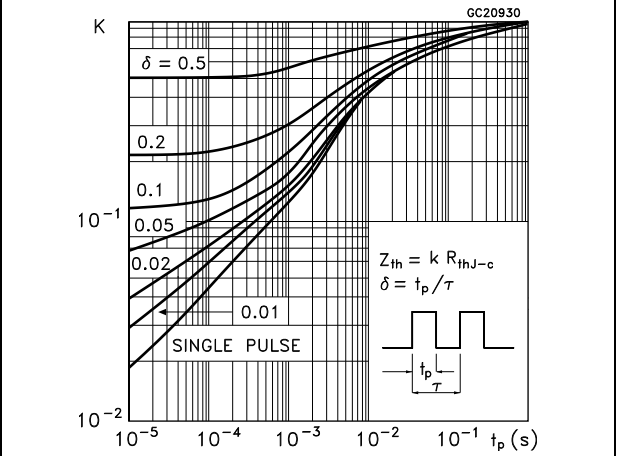


Figure 6. Safe operating area for IPAK

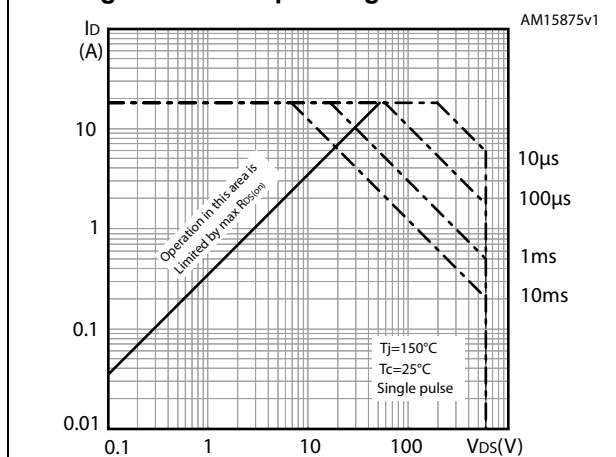
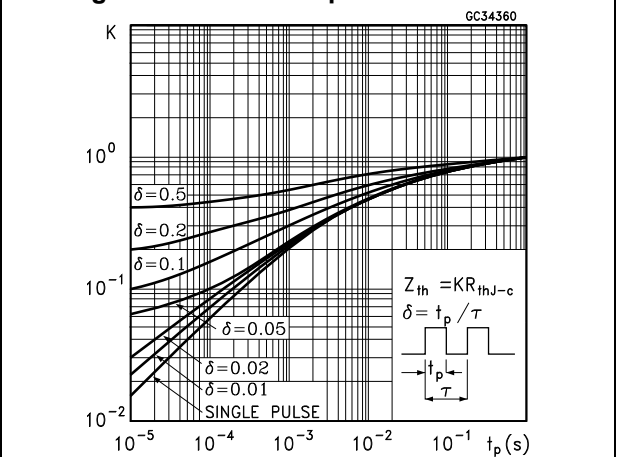


Figure 7. Thermal impedance for IPAK



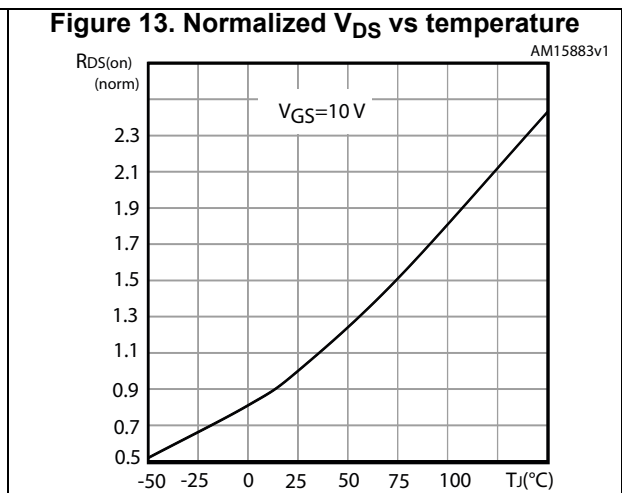
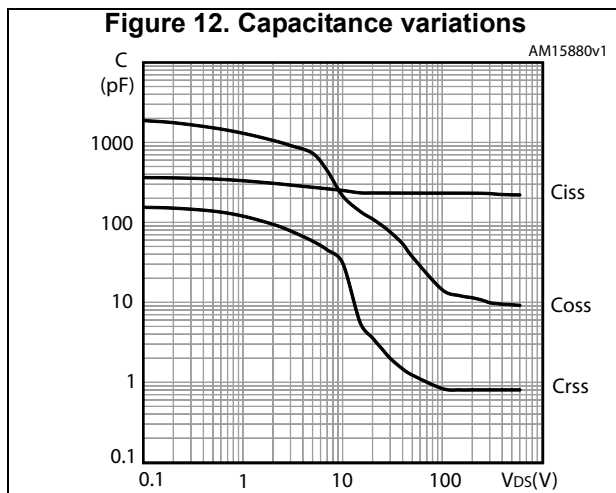
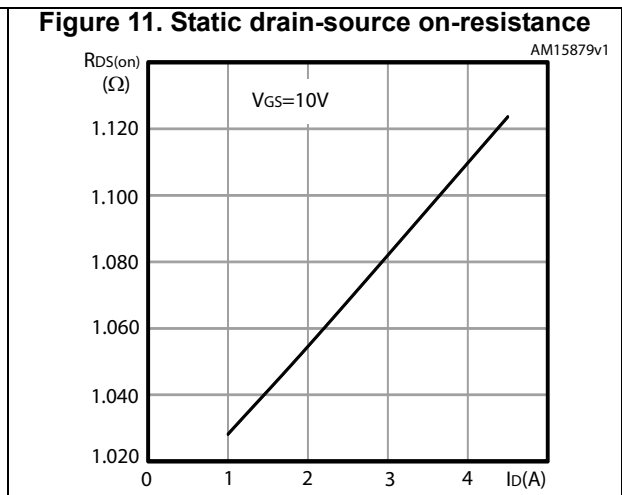
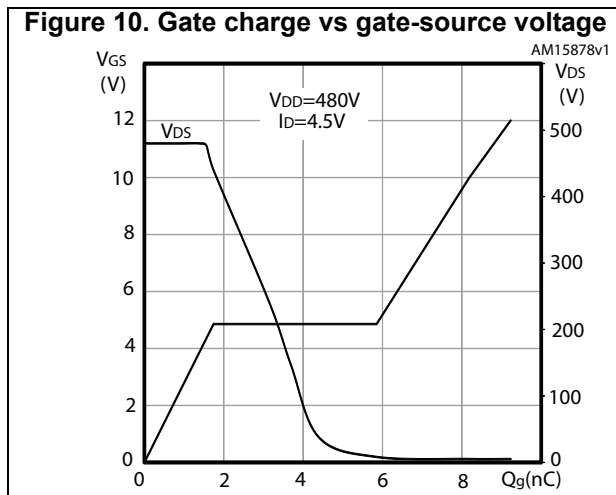
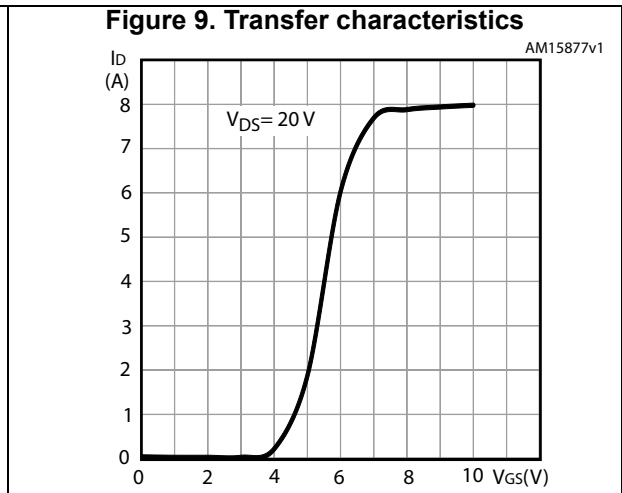
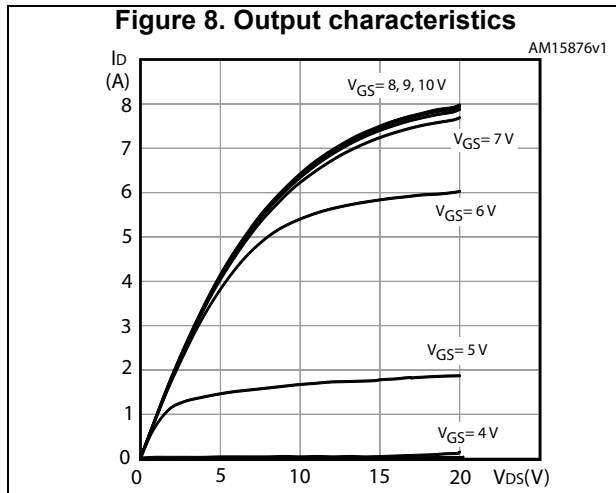


Figure 14. Normalized gate threshold voltage vs temperature

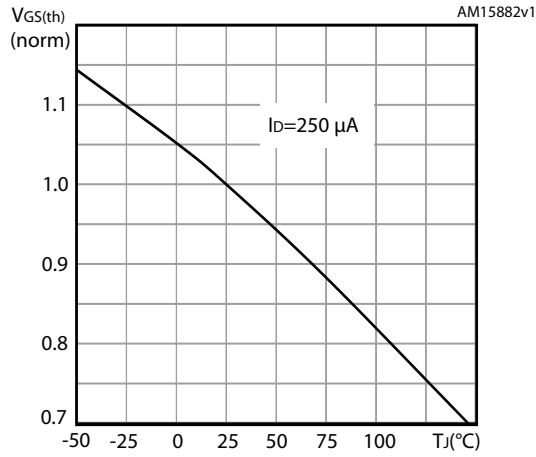


Figure 15. Normalized on-resistance vs temperature

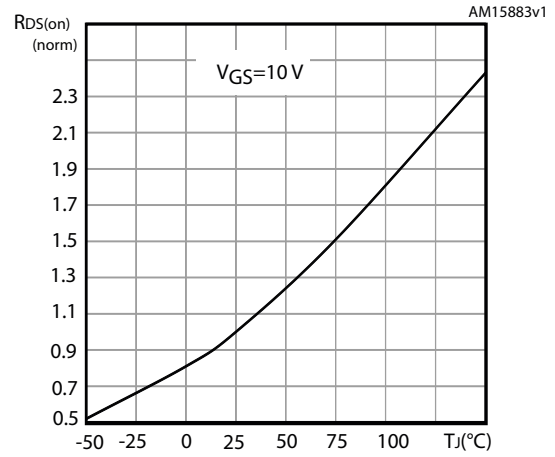
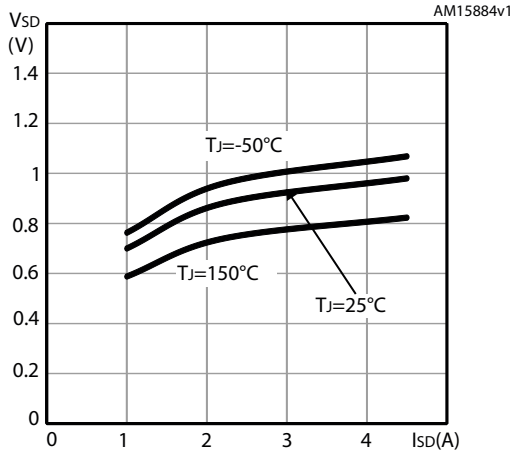
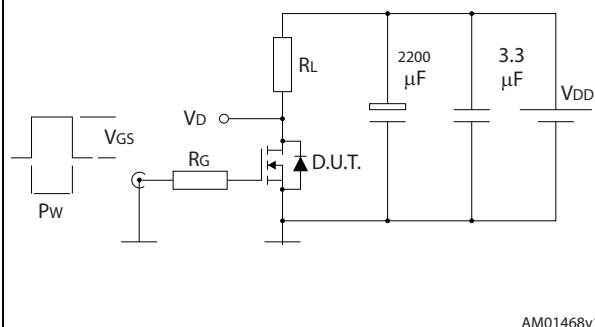


Figure 16. Source-drain diode forward characteristics



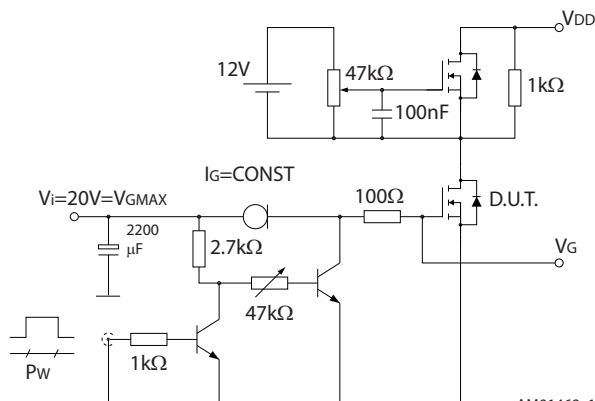
3 Test circuits

Figure 17. Switching times test circuit for resistive load



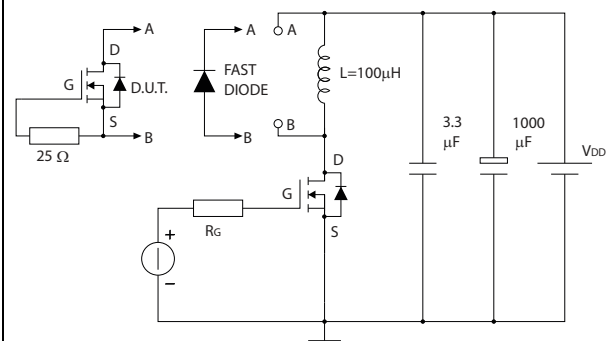
AM01468v1

Figure 18. Gate charge test circuit



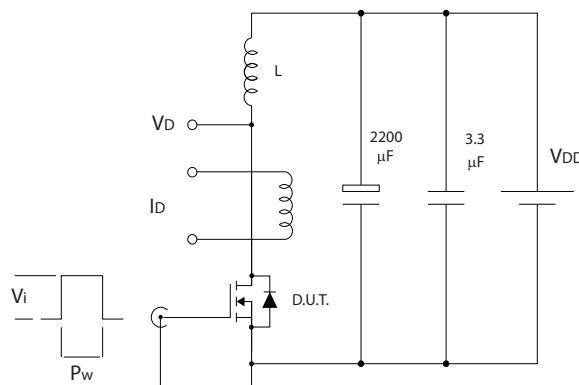
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Figure 19. Test circuit for inductive load switching and diode recovery times



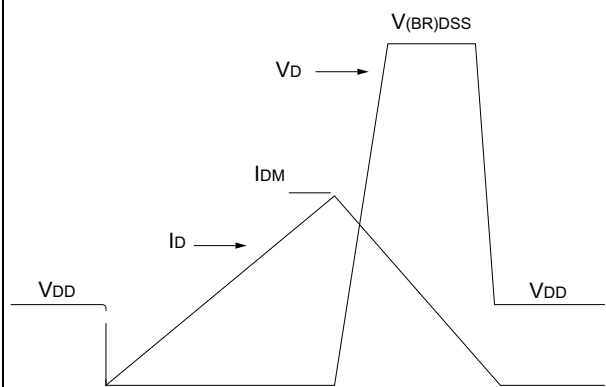
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Figure 20. Unclamped inductive load test circuit



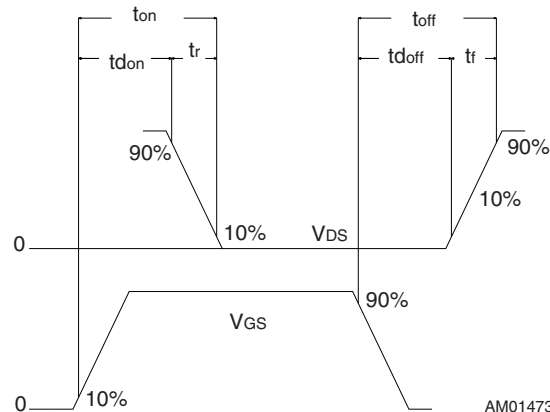
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Figure 21. Unclamped inductive waveform



AM01472v1

Figure 22. Switching time waveform



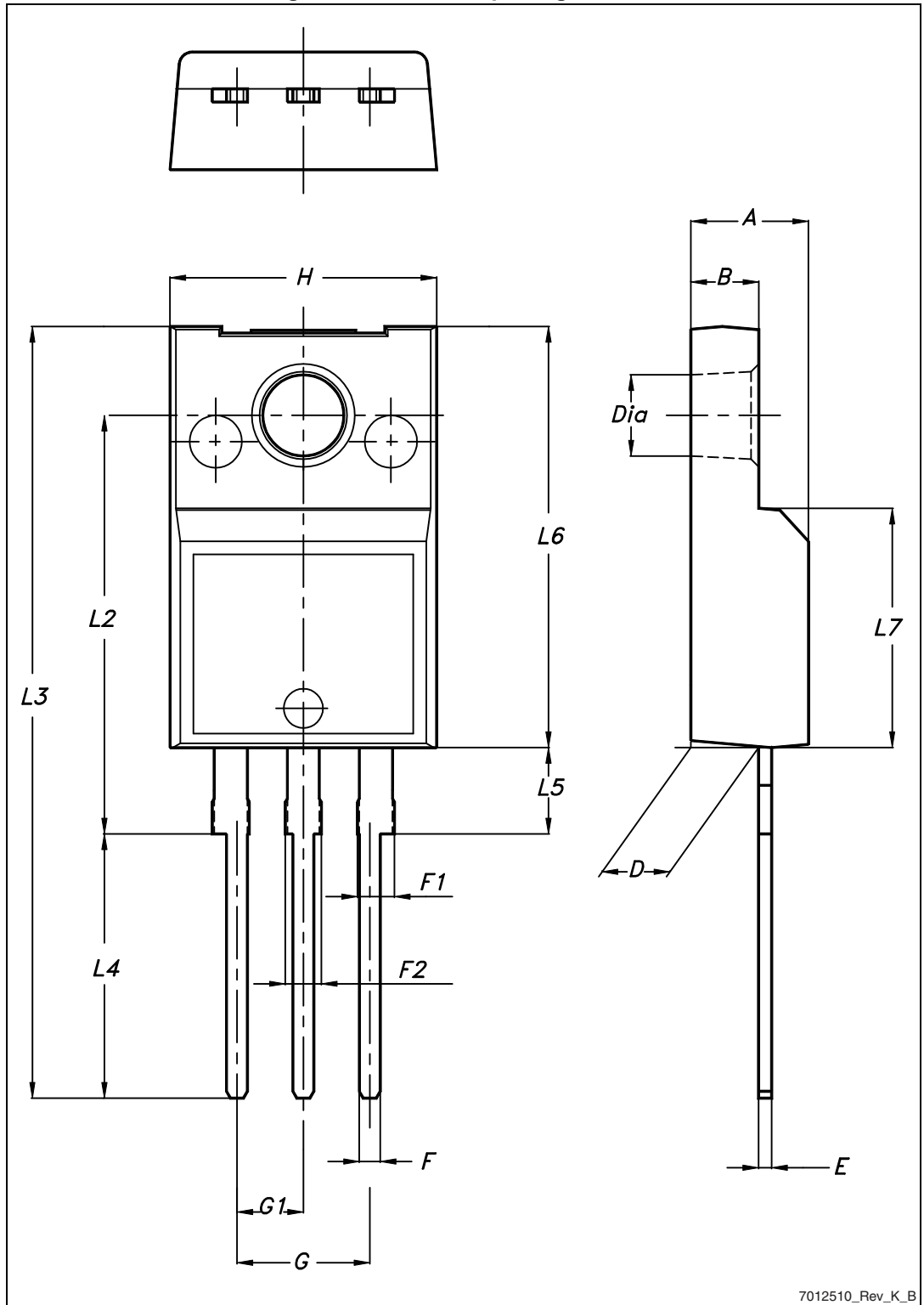
AM01473v1

4 Package information

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. ECOPACK[®] is an ST trademark.

4.1 TO-220FP package information

Figure 23. TO-220FP package outline



7012510_Rev_K_B

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 |

4.2 TO-220 package information

Figure 24. TO-220 type A package outline

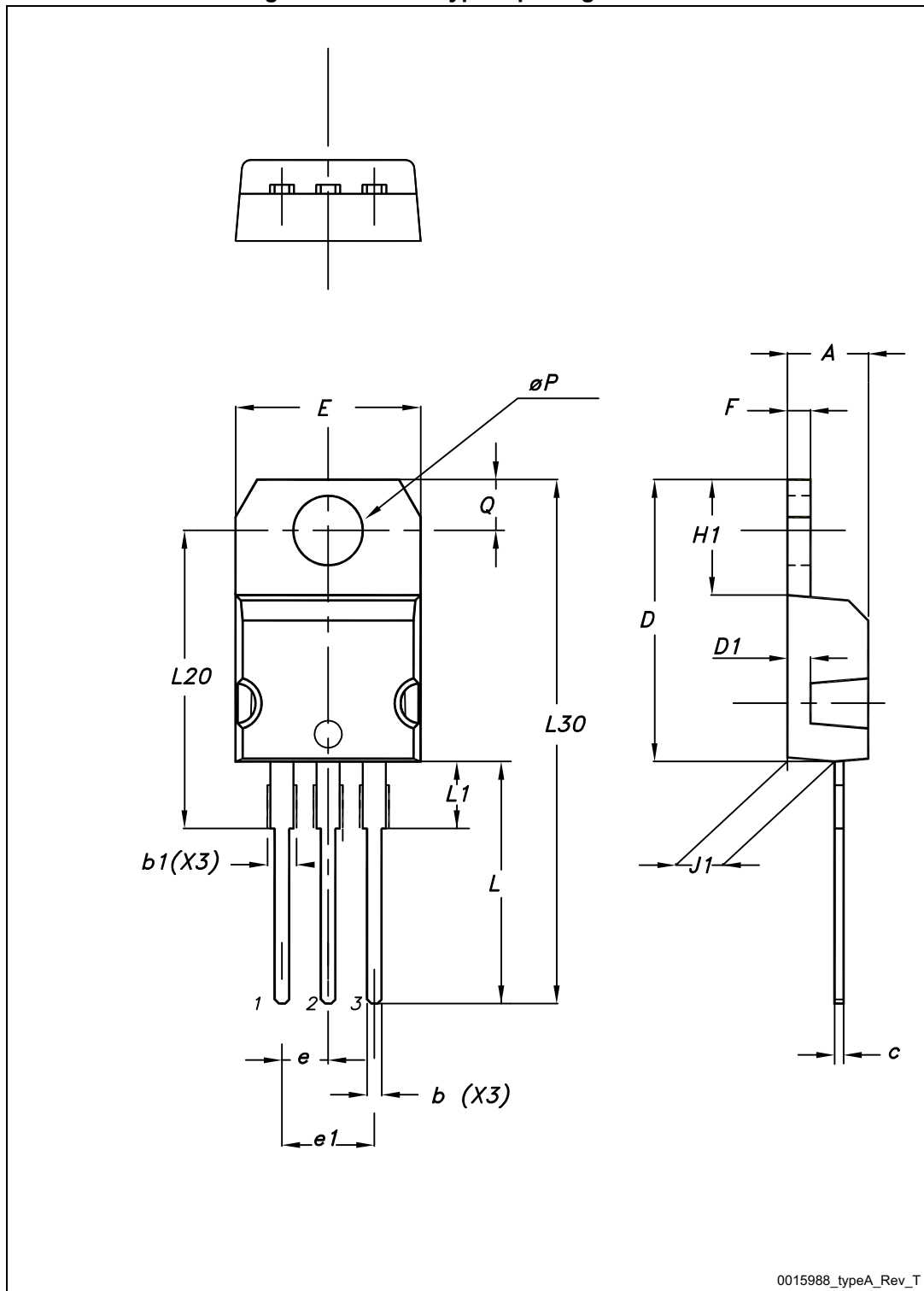


Table 10. TO-220 type A mechanical data

| 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 |

4.3 IPAK(TO-251) package information

Figure 25. IPAK (TO-251) type A package outline

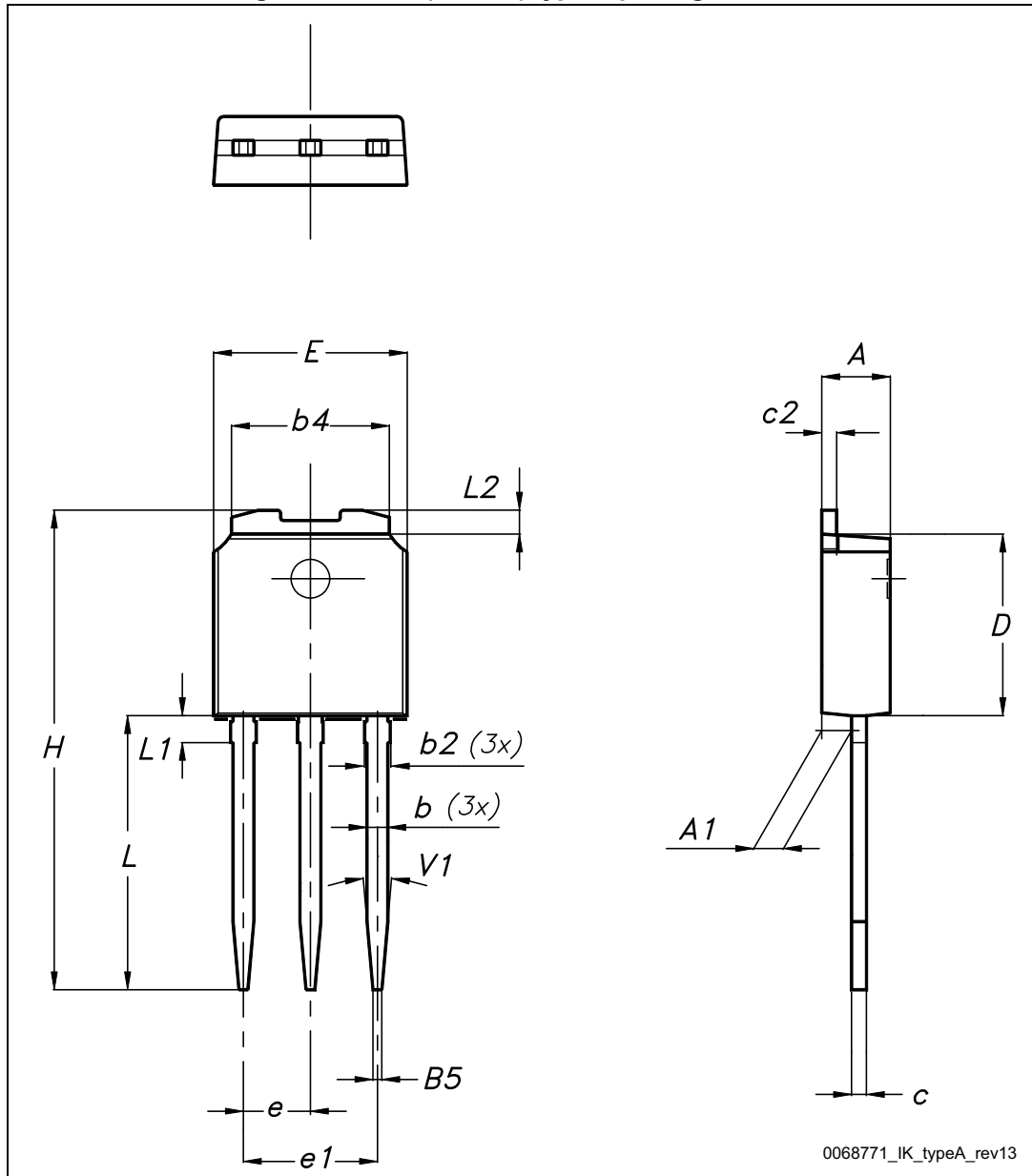


Table 11. IPAK (TO-251) type A mechanical data

| 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 12. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 11-Jun-2013 | 1 | First release. |
| 01-Oct-2015 | 2 | Updated title, features and description. Updated Table 2.: Absolute maximum ratings and Table 8.: Source drain diode . Updated 4.3: IPAK(TO-251) package information . Minor text changes. |

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