

STF24NM60N, STI24NM60N, STP24NM60N, STW24NM60N

N-channel 600 V, 0.168 Ω typ., 17 A MDmesh™ II Power MOSFETs
in TO-220FP, I²PAK, TO-220 and TO-247 packages

Datasheet – production data

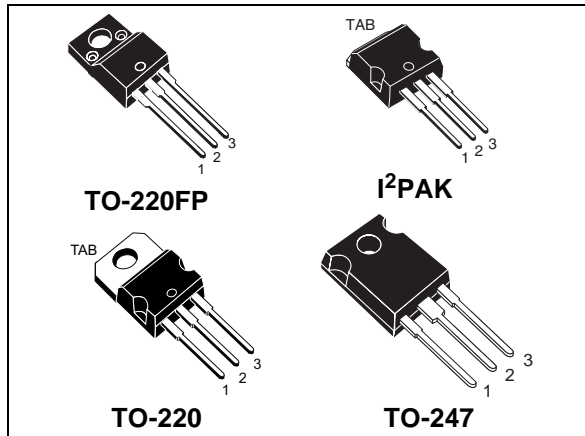
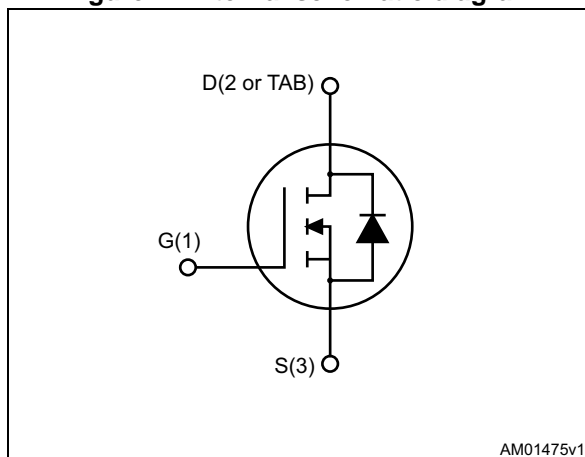


Figure 1. Internal schematic diagram



Features

| Order codes | V _{DS} @T _{jmax} | R _{DS(on)} max. | I _D |
|-------------|------------------------------------|--------------------------|----------------|
| STF24NM60N | 650 V | 0.19 Ω | 17 A |
| STI24NM60N | | | |
| STP24NM60N | | | |
| STW24NM60N | | | |

- 100% avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance

Applications

- Switching applications

Description

These devices are N-channel Power MOSFETs developed using the second generation of MDmesh™ technology. This revolutionary Power MOSFET associates a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. It is therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

| Order code | Marking | Packages | Packaging |
|------------|---------|--------------------|-----------|
| STF24NM60N | 24NM60N | TO-220FP | Tube |
| STI24NM60N | | I ² PAK | |
| STP24NM60N | | TO-220 | |
| STW24NM60N | | TO-247 | |

Contents

| | | |
|----------|---|-----------|
| 1 | Electrical ratings | 3 |
| 2 | Electrical characteristics | 4 |
| 2.1 | Electrical characteristics (curves) | 6 |
| 3 | Test circuits | 9 |
| 4 | Package mechanical data | 10 |
| 4.1 | TO-220FP, STF24NM60N | 11 |
| 4.2 | I ² PAK, STI24NM60N | 13 |
| 4.3 | TO-220, STP24NM60N | 15 |
| 4.4 | TO-247, STW24NM60N | 17 |
| 5 | Revision history | 19 |

1 Electrical ratings

Table 2. Absolute maximum ratings

| Symbol | Parameter | Value | | Unit |
|------------------------------------|--|--|-------------------|------|
| | | I ² PAK TO-220 TO-247 | TO-220FP | |
| V _{GS} | Gate- source voltage | ± 30 | | V |
| I _D | Drain current (continuous) at T _C = 25 °C | 17 | 17 ⁽¹⁾ | A |
| I _D | Drain current (continuous) at T _C = 100 °C | 11 | 11 ⁽¹⁾ | A |
| I _{DM} ⁽²⁾ | Drain current (pulsed) | 68 | 68 ⁽¹⁾ | A |
| P _{TOT} | Total dissipation at T _C = 25 °C | 125 | 30 | W |
| dv/dt ⁽³⁾ | Peak diode recovery voltage slope | 15 | | V/ns |
| V _{ISO} | Insulation withstand voltage (RMS) from all three leads to external heat sink (t=1 s; T _C =25 °C) | | 2500 | V |
| T _J T _{stg} | Operating junction temperature Storage temperature | -55 to 150 | | °C |

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- I_{SD} ≤ 17 A, di/dt ≤ 400 A/μs, peak V_{DS} ≤ V_{(BR)DSS}, V_{DD} = 80% V_{(BR)DSS}

Table 3. Thermal data

| Symbol | Parameter | Value | | | | Unit |
|-----------------------|--|----------|--------------------|--------|--------|------|
| | | TO-220FP | I ² PAK | TO-220 | TO-247 | |
| R _{thj-case} | Thermal resistance junction-case max. | 4.17 | 1 | | | °C/W |
| R _{thj-amb} | Thermal resistance junction-ambient max. | 62.5 | | | 50 | °C/W |

Table 4. Avalanche characteristics

| Symbol | Parameter | Value | Unit |
|-----------------|--|-------|------|
| I _{AR} | Avalanche current, repetitive or not-repetitive (pulse width limited by T _J max) | 6 | A |
| E _{AS} | Single pulse avalanche energy (starting T _J = 25 °C, I _D = I _{AR} , V _{DD} = 50 V) | 300 | mJ |

2 Electrical characteristics

(T_{case} = 25 °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 mA | 600 | | | V |
| I _{DSS} | Zero gate voltage drain current | V _{GS} = 0, V _{DS} = 600 V | | | 1 | μA |
| | | V _{GS} = 0, V _{DS} = 600 V, T _C = 125 °C | | | 100 | μA |
| I _{GSS} | Gate-body leakage current | V _{DS} = 0, V _{GS} = ± 25 V | | | ±100 | nA |
| V _{GS(th)} | Gate threshold voltage | V _{DS} = V _{GS} , I _D = 250 μA | 2 | 3 | 4 | V |
| R _{DS(on)} | Static drain-source on- resistance | V _{GS} = 10 V, I _D = 8 A | | 0.168 | 0.19 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|--------------------------|-------------------------------|---|------|------|------|------|
| C _{iss} | Input capacitance | V _{DS} = 50 V, f = 1 MHz, V _{GS} = 0 | - | 1330 | - | pF |
| C _{oss} | Output capacitance | | - | 80 | - | pF |
| C _{rss} | Reverse transfer capacitance | | - | 3.2 | - | pF |
| C _{oss eq.} (1) | Equivalent output capacitance | V _{DS} = 0 to 480 V, V _{GS} = 0 | - | 182 | - | pF |
| R _g | Gate input resistance | f = 1 MHz open drain | - | 5 | - | Ω |
| Q _g | Total gate charge | V _{DD} = 480 V, I _D = 17 A, V _{GS} = 10 V (see Figure 19) | - | 44 | - | nC |
| Q _{gs} | Gate-source charge | | - | 7 | - | nC |
| Q _{gd} | Gate-drain charge | | - | 24 | - | nC |

1. C_{o(eff)} 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. Switching times

| Symbol | Parameter | Test conditions | Min. | Typ. | Max | Unit |
|--------------|---------------------|---|------|------|-----|------|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 300\text{ V}$, $I_D = 8.5\text{ A}$, $R_G = 4.7\ \Omega$, $V_{GS} = 10\text{ V}$ (see Figure 18) | - | 11.5 | - | ns |
| $t_{r(v)}$ | Voltage rise time | | - | 16.5 | - | ns |
| $t_{d(off)}$ | Turn-off-delay time | | - | 73 | - | ns |
| $t_{f(i)}$ | Fall time | | - | 37 | - | ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max | Unit |
|-----------------|-------------------------------|--|------|------|-----|---------------|
| I_{SD} | Source-drain current | | - | | 17 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 68 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 17\text{ A}$, $V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 17\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$ (see Figure 20) | - | 340 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 4.6 | | μC |
| I_{RRM} | Reverse recovery current | | - | 27 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 17\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 60\text{ V}$, $T_J = 150\text{ }^\circ\text{C}$ (see Figure 20) | - | 404 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 5.7 | | μC |
| I_{RRM} | Reverse recovery current | | - | 28 | | 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

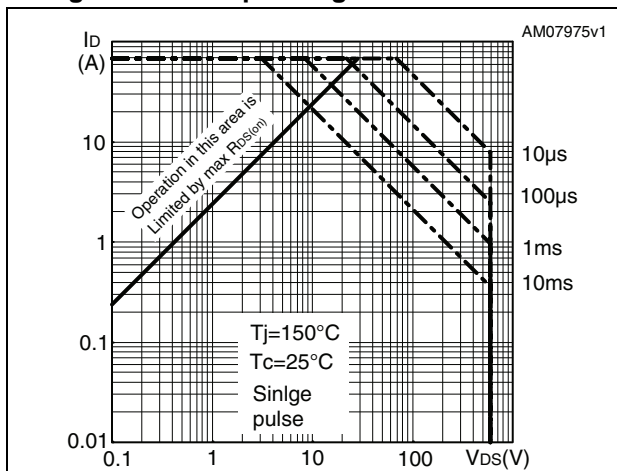


Figure 3. Thermal impedance for TO-220FP

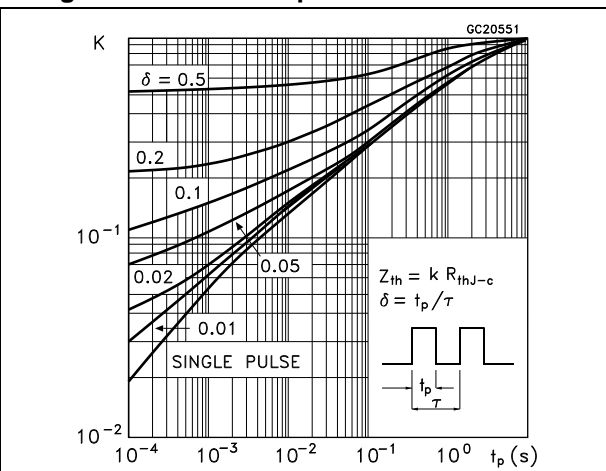


Figure 4. Safe operating area for I²PAK and TO-220

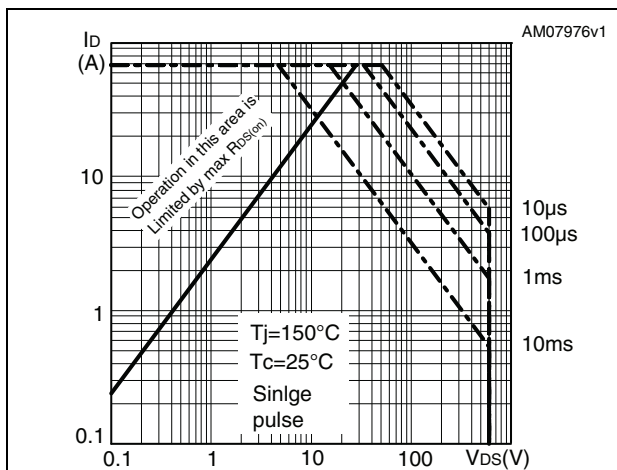


Figure 5. Thermal impedance for I²PAK and TO-220

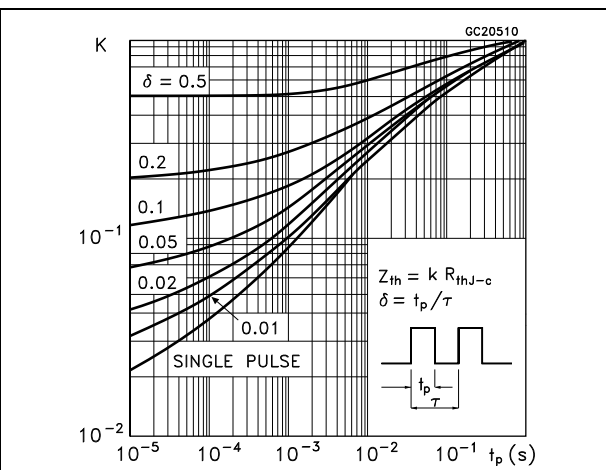


Figure 6. Safe operating area for TO-247

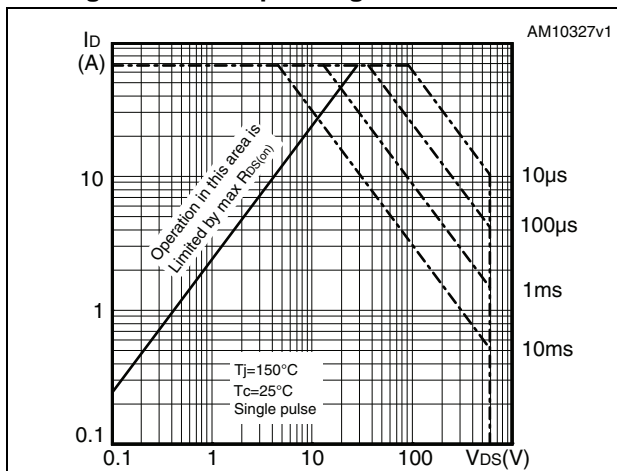


Figure 7. Thermal impedance for TO-247

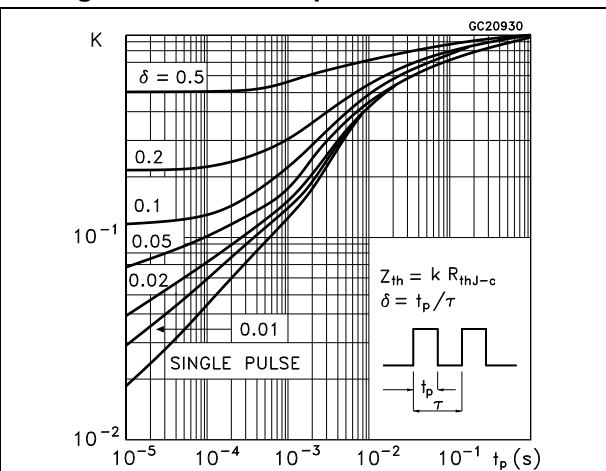


Figure 8. Output characteristics

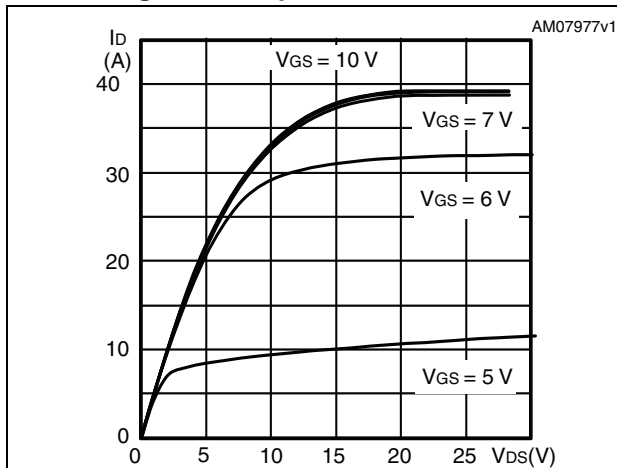


Figure 9. Transfer characteristics

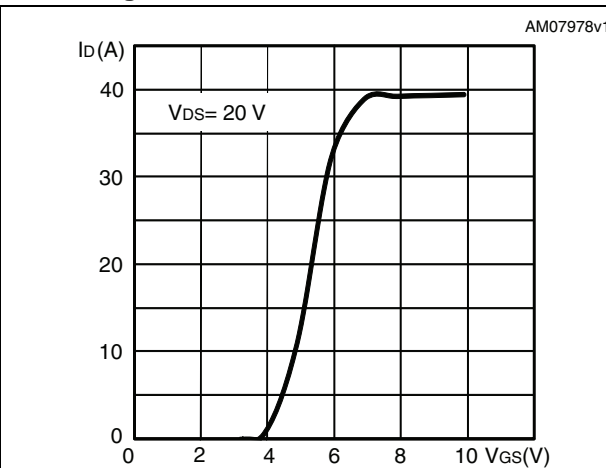


Figure 10. Gate charge vs gate-source voltage

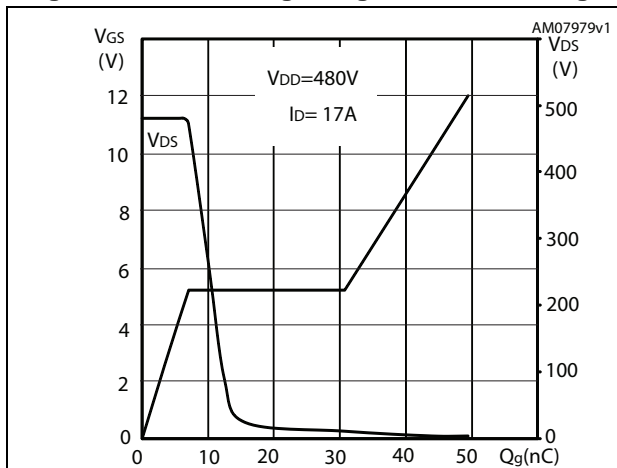


Figure 11. Static drain-source on-resistance

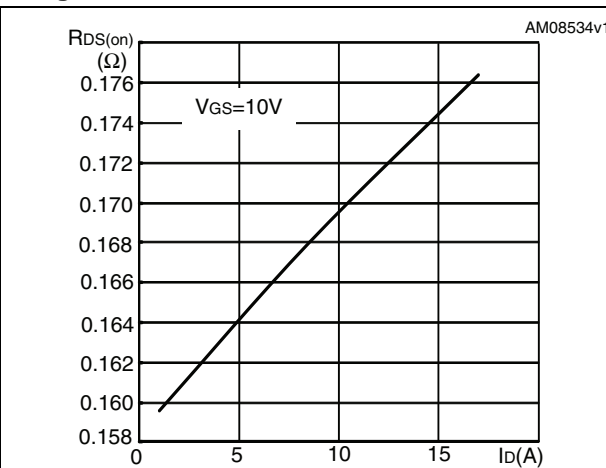


Figure 12. Capacitance variations

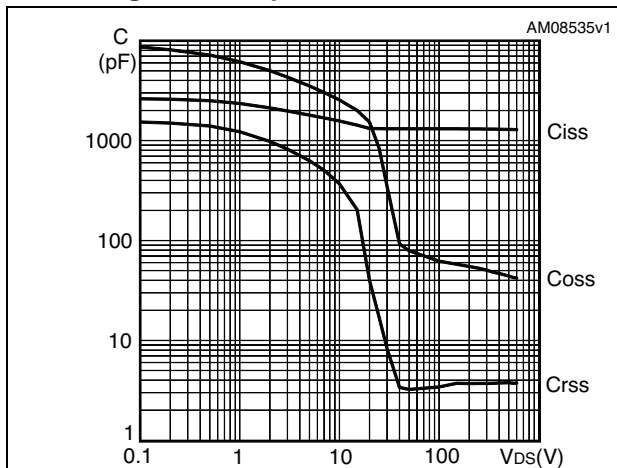


Figure 13. Output capacitance stored energy

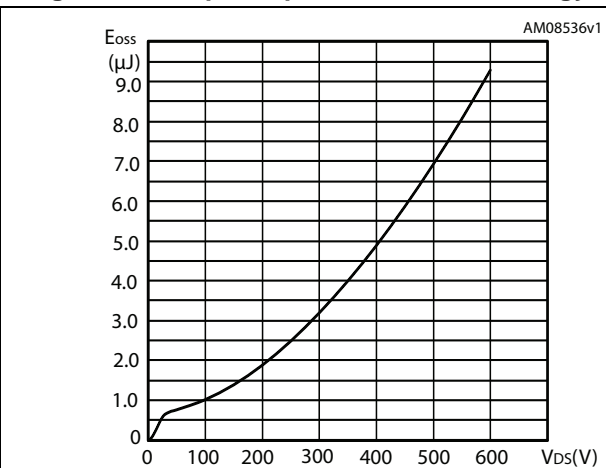


Figure 14. Normalized gate threshold voltage vs temperature

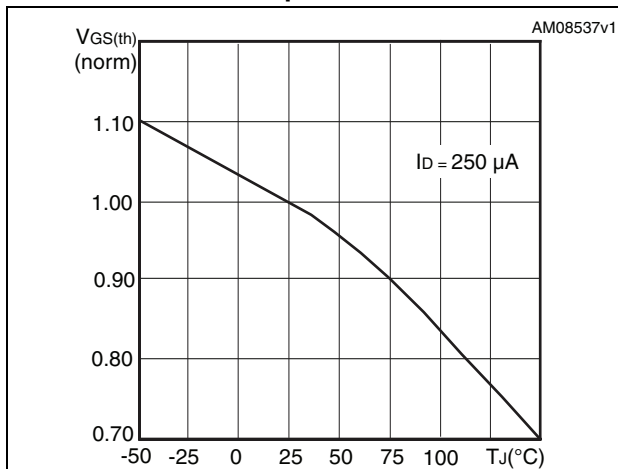


Figure 15. Normalized on-resistance vs temperature

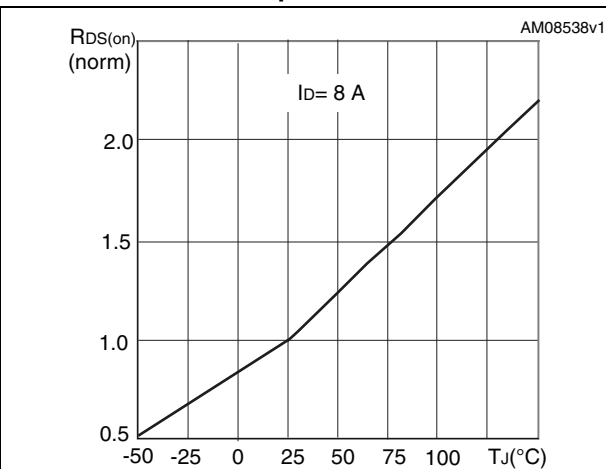


Figure 16. Normalized V_{(BR)DSS} vs temperature

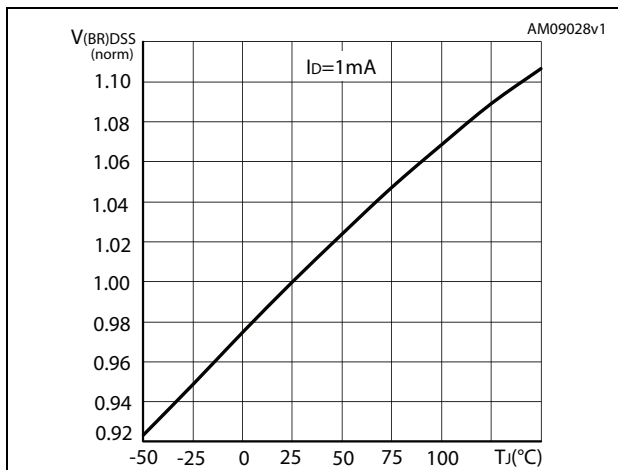
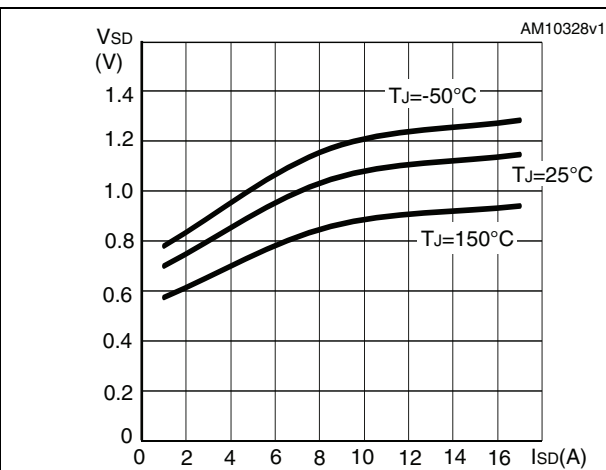


Figure 17. Source-drain diode forward characteristics



3 Test circuits

Figure 18. Switching times test circuit for resistive load



Figure 19. Gate charge test circuit

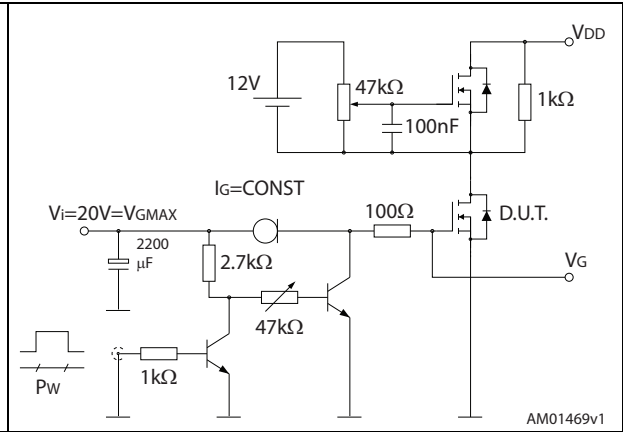


Figure 20. Test circuit for inductive load switching and diode recovery times

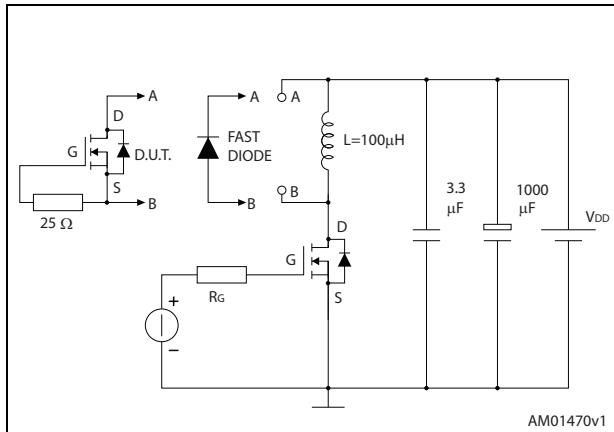


Figure 21. Unclamped inductive load test circuit

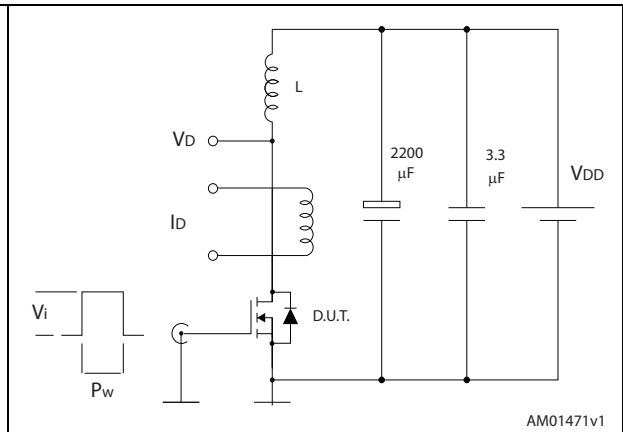


Figure 22. Unclamped inductive waveform

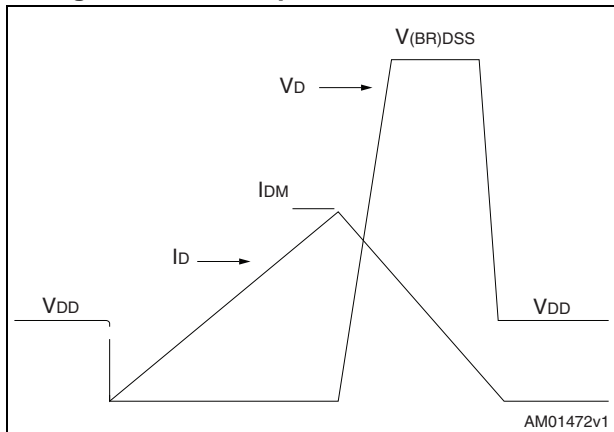
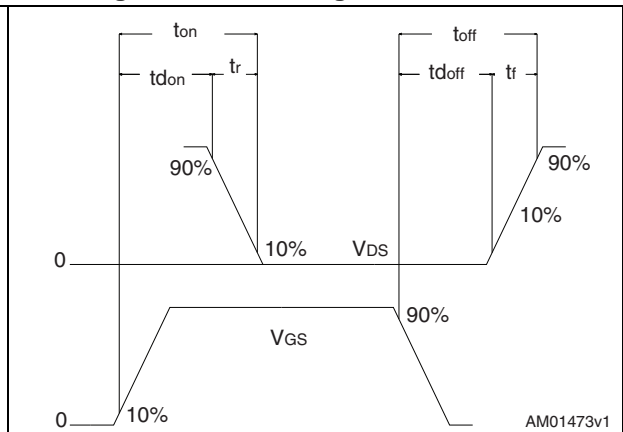


Figure 23. Switching time waveform

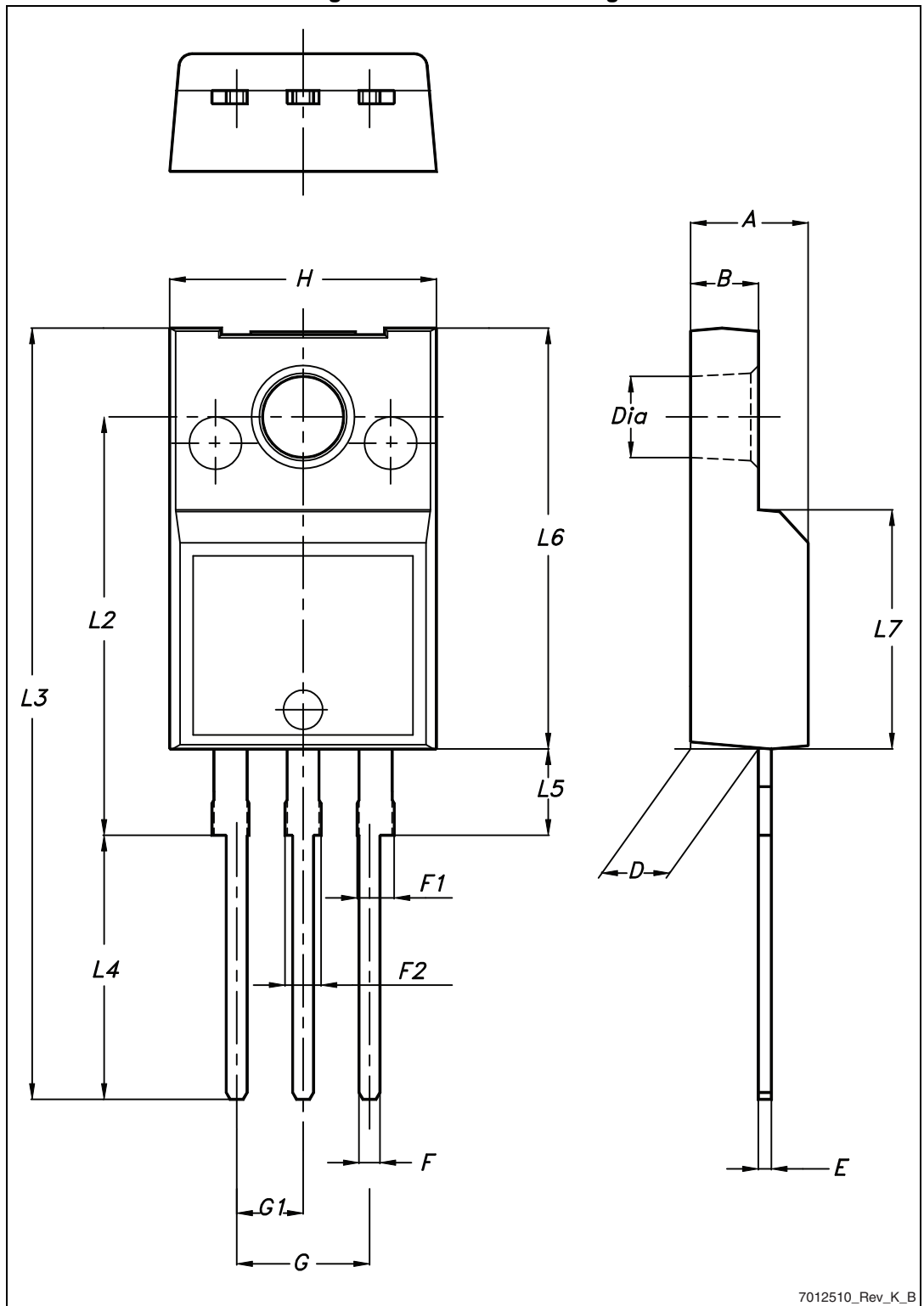


4 Package mechanical data

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. ECOPACK[®] is an ST trademark.

4.1 TO-220FP, STF24NM60N

Figure 24. TO-220FP drawing



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 |
| Ø | 3 | | 3.2 |

4.2 I²PAK, STI24NM60N

Figure 25. I²PAK (TO-262) drawing

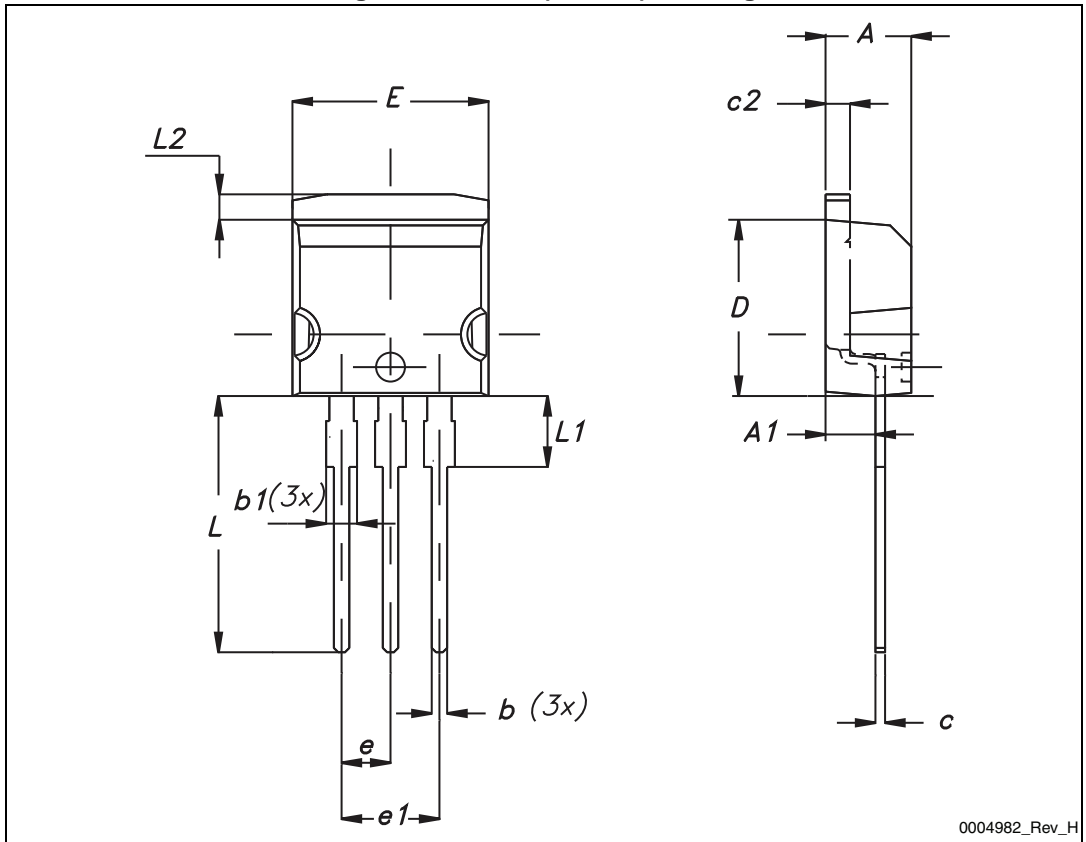


Table 10. I²PAK (TO-262) mechanical data

| DIM. | mm. | | |
|------|------|-----|-------|
| | min. | typ | max. |
| A | 4.40 | | 4.60 |
| A1 | 2.40 | | 2.72 |
| b | 0.61 | | 0.88 |
| b1 | 1.14 | | 1.70 |
| c | 0.49 | | 0.70 |
| c2 | 1.23 | | 1.32 |
| D | 8.95 | | 9.35 |
| e | 2.40 | | 2.70 |
| e1 | 4.95 | | 5.15 |
| E | 10 | | 10.40 |
| L | 13 | | 14 |
| L1 | 3.50 | | 3.93 |
| L2 | 1.27 | | 1.40 |

4.3 TO-220, STP24NM60N

Figure 26. TO-220 type A drawing

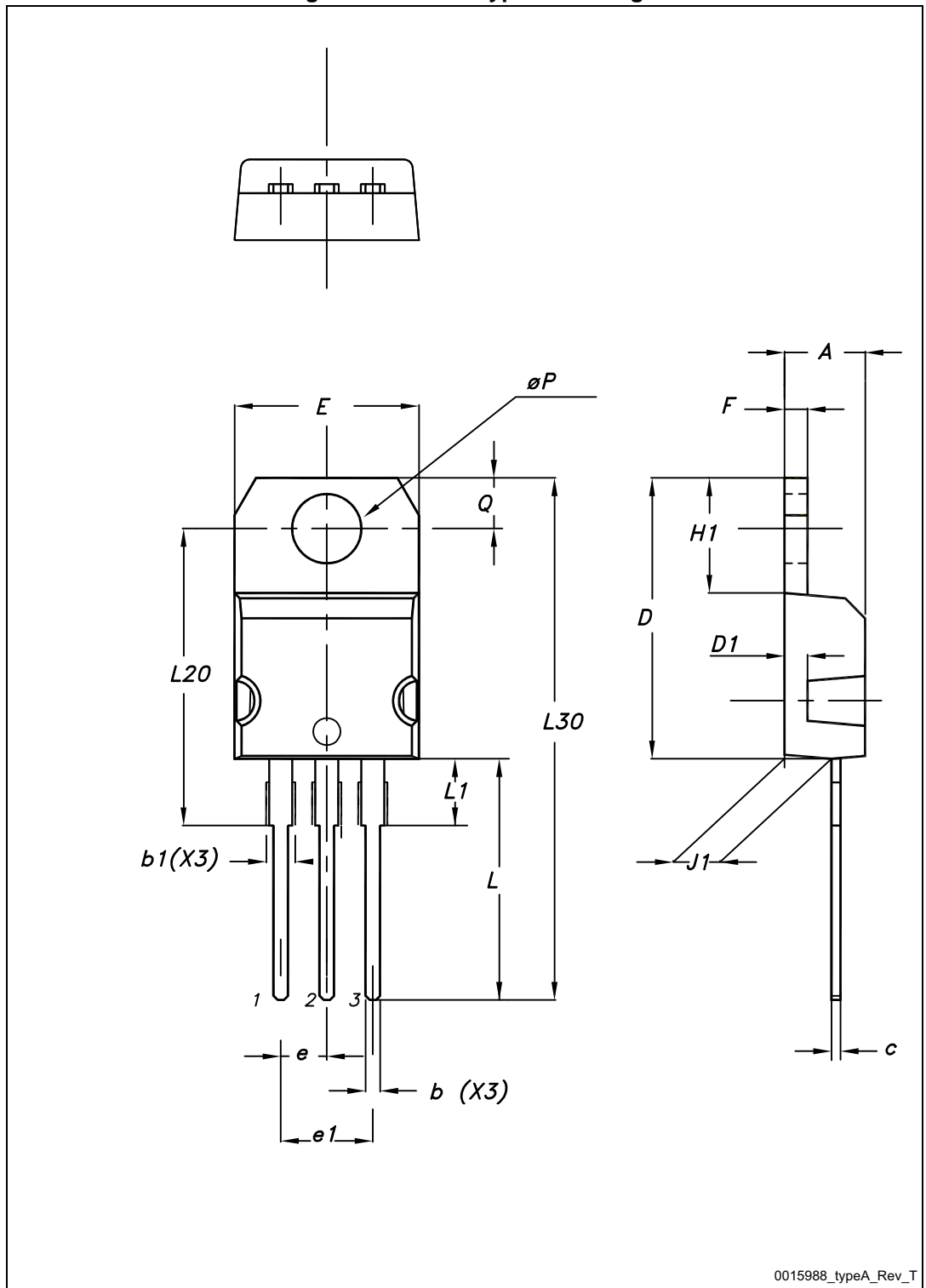


Table 11. TO-220 type A mechanical data

| 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 |

4.4 TO-247, STW24NM60N

Figure 27. TO-247 drawing

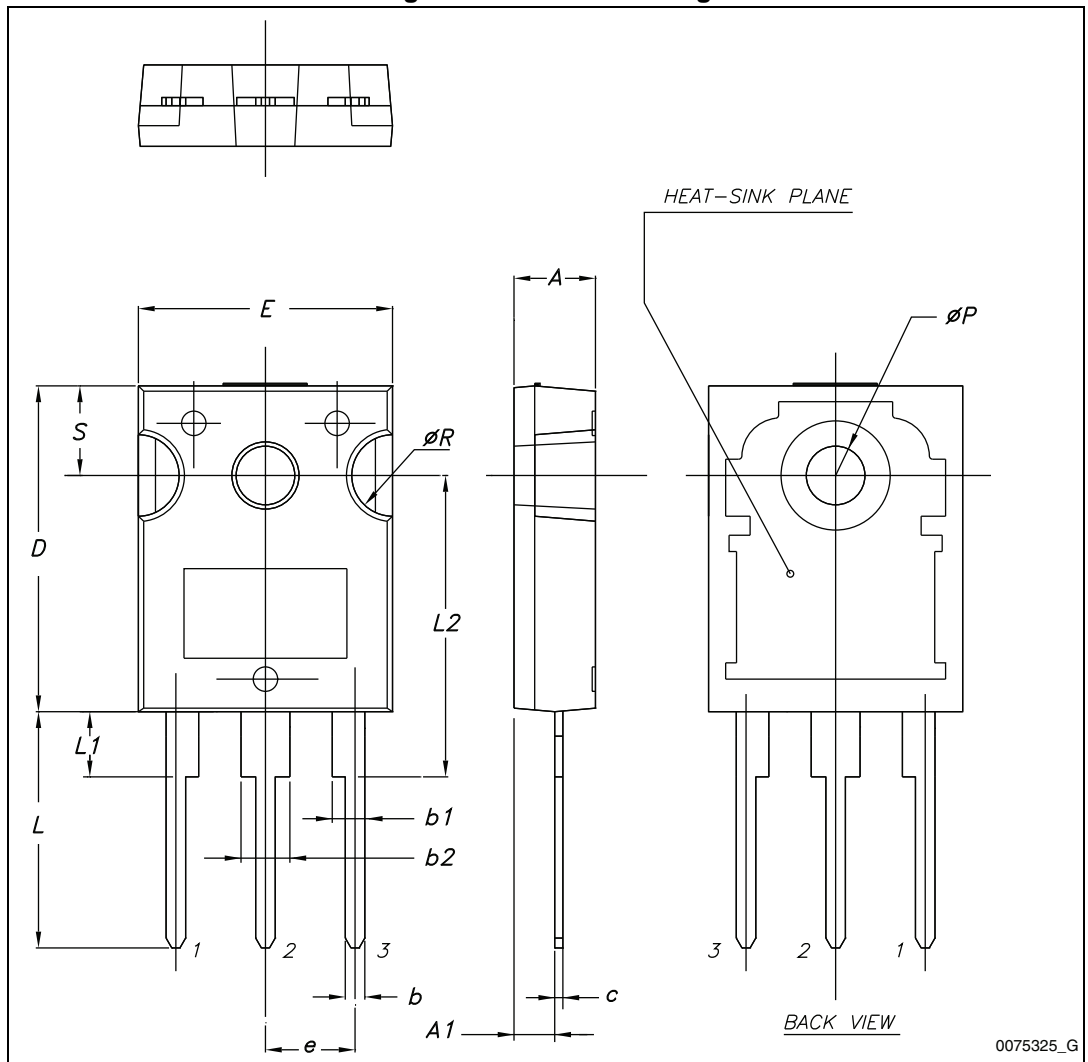


Table 12. TO-247 mechanical data

| 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 | 5.30 | 5.45 | 5.60 |
| L | 14.20 | | 14.80 |
| L1 | 3.70 | | 4.30 |
| L2 | | 18.50 | |
| ØP | 3.55 | | 3.65 |
| ØR | 4.50 | | 5.50 |
| S | 5.30 | 5.50 | 5.70 |

5 Revision history

Table 13. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 05-Jan-2011 | 1 | First release. |
| 01-Jul-2011 | 2 | Corrected $R_{thj-amb}$ value (see Table 3: Thermal data) Added new package and mechanical data: TO-247. |
| 22-Aug-2011 | 3 | Inserted device in I ² PAK: updated Table 1: Device summary , Table 2: Absolute maximum ratings , Table 3: Thermal data inserted new mechanical data in Section 4: Package mechanical data |
| 24-Jul-2014 | 4 | <ul style="list-style-type: none"> – Modified: the entire typical values in Table 6 – Modified: Figure 12 – Updated: Section 4: Package mechanical data – Minor text changes |

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2014 STMicroelectronics – All rights reserved

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[STMicroelectronics:](#)

[STP24NM60N](#) [STI24NM60N](#) [STF24NM60N](#) [STW24NM60N](#)