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STF33N60M2, STI33N60M2, STP33N60M2, STW33N60M2

N-channel 600 V, 0.108 Ω typ., 26 A MDmesh II Plus™ low Q_g Power MOSFETs in TO-220FP, I²PAK, TO-220 and TO-247 packages

Datasheet - production data

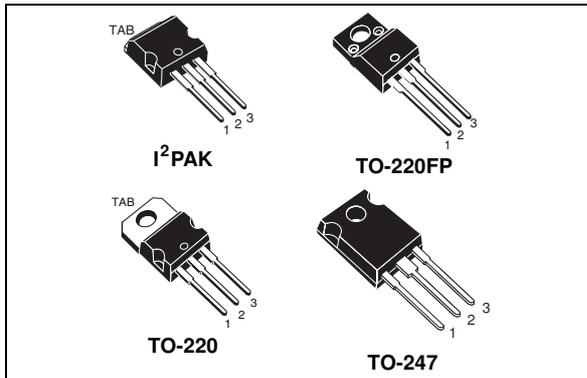
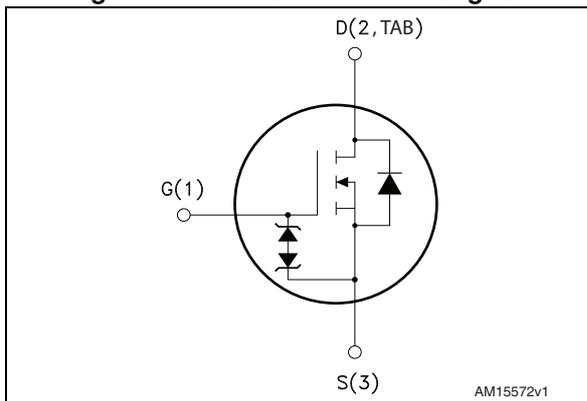


Figure 1. Internal schematic diagram



Features

| Order codes | $V_{DS} @ T_{Jmax}$ | $R_{DS(on) max}$ | I_D |
|-------------|---------------------|------------------|---------------------|
| STF33N60M2 | 650 V | 0.125 Ω | 26 A ⁽¹⁾ |
| STI33N60M2 | | | 26 A |
| STP33N60M2 | | | |
| STW33N60M2 | | | |

1. Limited by maximum junction temperature.

- Extremely low gate charge
- Lower $R_{DS(on)}$ x area vs previous generation
- MDmesh™ II technology
- Low gate input resistance
- 100% avalanche tested
- Zener-protected

Applications

- Switching applications
- LCC converters, resonant converters

Description

These devices are N-channel Power MOSFETs developed using a new generation of MDmesh™ technology: MDmesh II Plus™ low Q_g . These revolutionary Power MOSFETs associate a vertical structure to the company's strip layout to yield one of the world's lowest on-resistance and gate charge. They are therefore suitable for the most demanding high efficiency converters.

Table 1. Device summary

| Order codes | Marking | Package | Packaging |
|-------------|---------|--------------------|-----------|
| STF33N60M2 | 33N60M2 | TO-220FP | Tube |
| STI33N60M2 | | I ² PAK | |
| STP33N60M2 | | TO-220 | |
| STW33N60M2 | | TO-247 | |

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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 | ± 25 | | V |
| I _D | Drain current (continuous) at T _C = 25 °C | 26 | 26 ⁽¹⁾ | A |
| I _D | Drain current (continuous) at T _C = 100 °C | 16 | 16 ⁽¹⁾ | A |
| I _{DM} ⁽²⁾ | Drain current (pulsed) | 104 | 104 ⁽¹⁾ | A |
| P _{TOT} | Total dissipation at T _C = 25 °C | 190 | 35 | W |
| dv/dt ⁽³⁾ | Peak diode recovery voltage slope | 15 | | V/ns |
| dv/dt ⁽⁴⁾ | MOSFET dv/dt ruggedness | 50 | | 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 _{stg} | Storage temperature | - 55 to 150 | | °C |
| T _j | Max. operating junction temperature | | | |

- Limited by maximum junction temperature.
- Pulse width limited by safe operating area.
- I_{SD} ≤ 26 A, di/dt ≤ 400 A/μs; V_{DS peak} < V_{(BR)DSS}; V_{DD} = 400 V.
- V_{DS} ≤ 480 V

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 | 3.6 | 0.66 | | °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 _{jmax}) | 5 | A |
| E _{AS} | Single pulse avalanche energy (starting T _j =25°C, I _D = I _{AR} ; V _{DD} =50) | 2300 | 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 ($V_{GS} = 0$) | $V_{DS} = 600\text{ V}$ $V_{DS} = 600\text{ V}$, $T_C = 125\text{ °C}$ | | | 1 100 | μA 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 | $V_{GS} = 10\text{ V}$, $I_D = 13\text{ A}$ | | 0.108 | 0.125 | Ω |

Table 6. Dynamic

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|----------------------------|-------------------------------|---|------|------|------|----------|
| C_{iss} | Input capacitance | $V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$, $V_{GS} = 0$ | - | 1781 | - | pF |
| C_{oss} | Output capacitance | | - | 85 | - | pF |
| C_{rss} | Reverse transfer capacitance | | - | 2.5 | - | pF |
| $C_{oss\text{ eq.}}^{(1)}$ | Equivalent output capacitance | $V_{DS} = 0\text{ to }480\text{ V}$, $V_{GS} = 0$ | - | 135 | - | pF |
| R_G | Intrinsic gate resistance | $f = 1\text{ MHz}$ open drain | - | 5.2 | - | Ω |
| Q_g | Total gate charge | $V_{DD} = 480\text{ V}$, $I_D = 26\text{ A}$, $V_{GS} = 10\text{ V}$ (see Figure 19) | - | 45.5 | - | nC |
| Q_{gs} | Gate-source charge | | - | 9.9 | - | nC |
| Q_{gd} | Gate-drain charge | | - | 18.5 | - | 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 | $V_{DD} = 300\text{ V}$, $I_D = 13\text{ A}$, $R_G = 4.7\text{ }\Omega$, $V_{GS} = 10\text{ V}$ (see Figure 18 and Figure 23) | - | 16 | - | ns |
| $t_r(v)$ | Voltage rise time | | - | 9.6 | - | ns |
| $t_d(off)$ | Turn-off-delay time | | - | 109 | - | ns |
| $t_f(i)$ | Fall time | | - | 9 | - | ns |

Table 8. Source drain diode

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|---|------|------|------|---------------|
| I_{SD} | Source-drain current | | - | | 26 | A |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) | | - | | 104 | A |
| $V_{SD}^{(2)}$ | Forward on voltage | $I_{SD} = 26 \text{ A}$, $V_{GS} = 0$ | - | | 1.6 | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 26 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$ (see Figure 23) | - | 375 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 5.6 | | μC |
| I_{RRM} | Reverse recovery current | | - | 30 | | A |
| t_{rr} | Reverse recovery time | $I_{SD} = 26 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$ $V_{DD} = 60 \text{ V}$, $T_j = 150 \text{ }^\circ\text{C}$ (see Figure 23) | - | 478 | | ns |
| Q_{rr} | Reverse recovery charge | | - | 7.7 | | μC |
| I_{RRM} | Reverse recovery current | | - | 32.5 | | 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

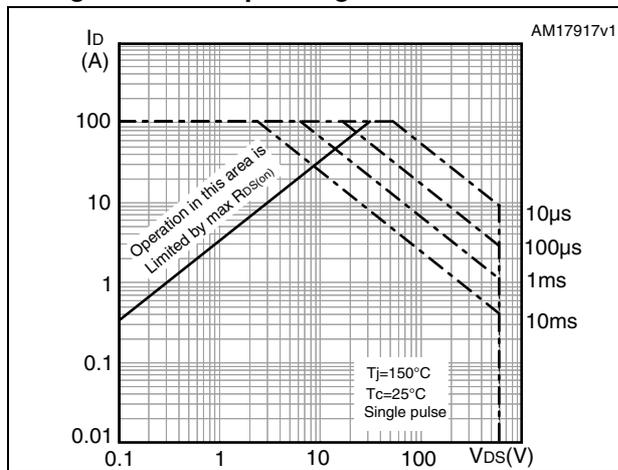


Figure 3. Thermal impedance for TO-220FP

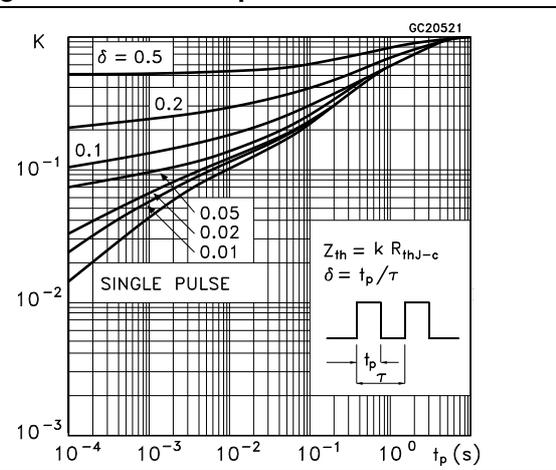


Figure 4. Safe operating area for I²PAK and TO-220

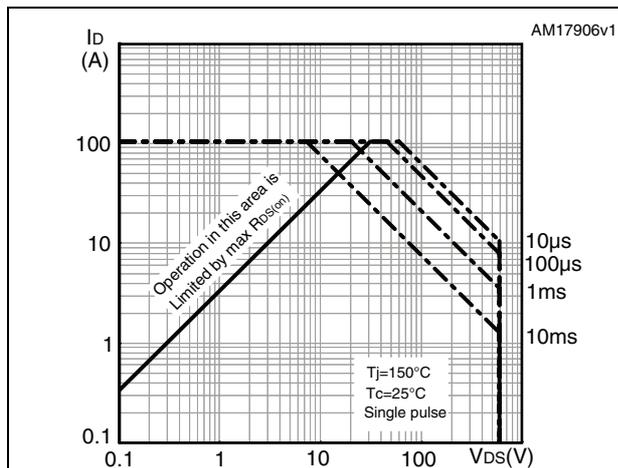


Figure 5. Thermal impedance for I²PAK and TO-220

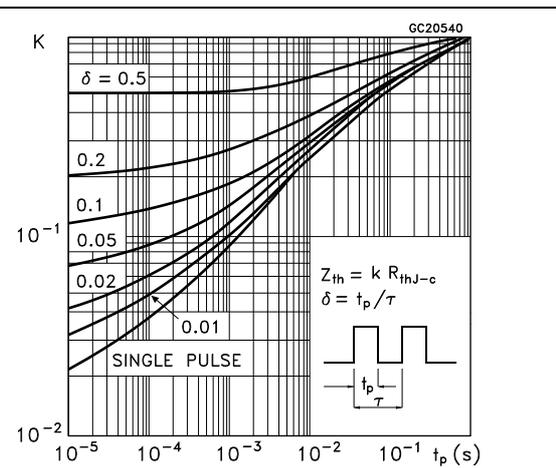


Figure 6. Safe operating area for TO-247

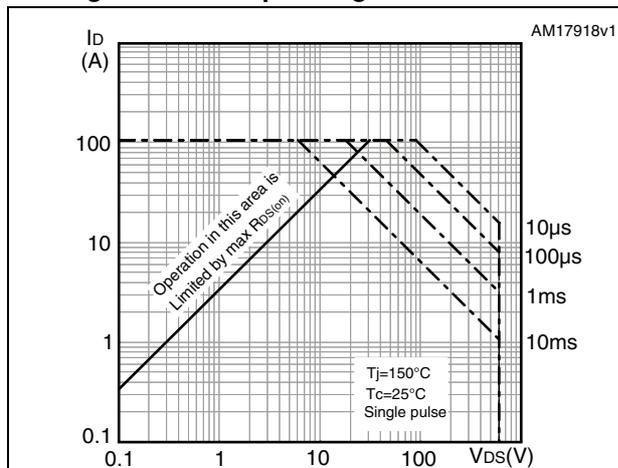


Figure 7. Thermal impedance for TO-247

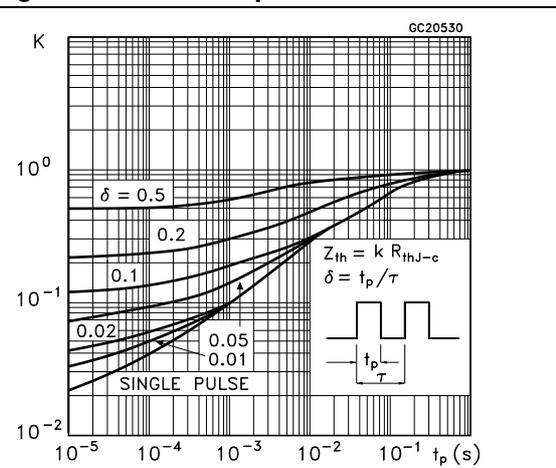


Figure 8. Output characteristics

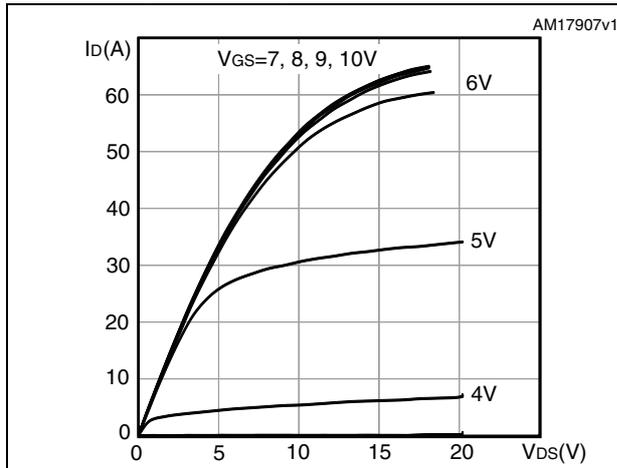


Figure 9. Transfer characteristics

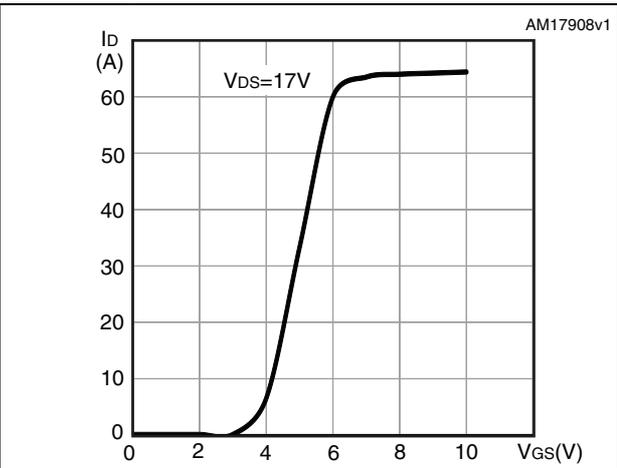


Figure 10. Gate charge vs gate-source voltage

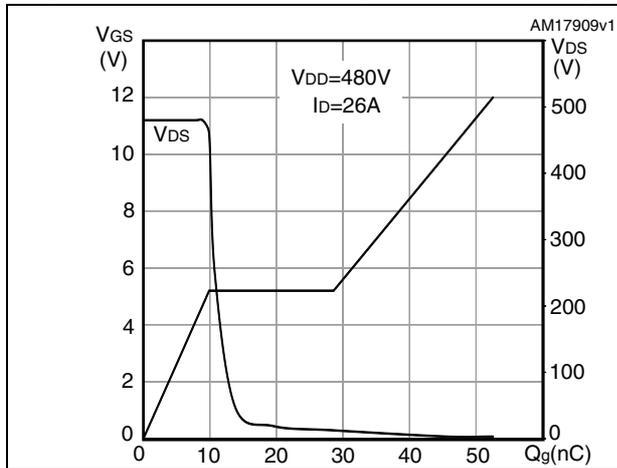


Figure 11. Static drain-source on-resistance

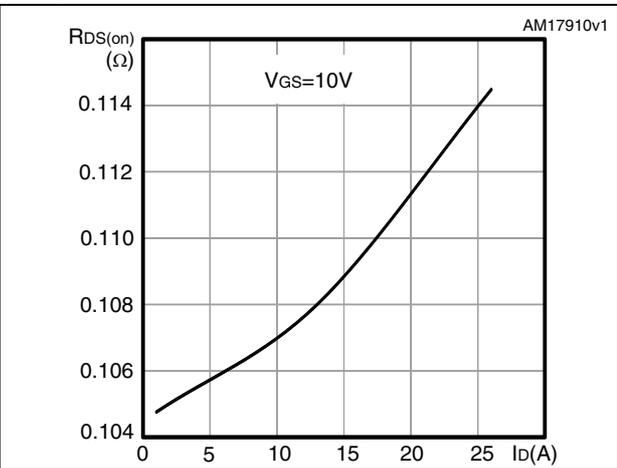


Figure 12. Capacitance variations

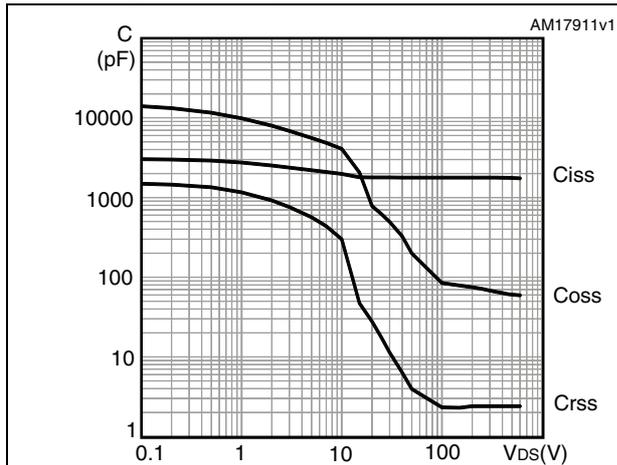


Figure 13. Output capacitance stored energy

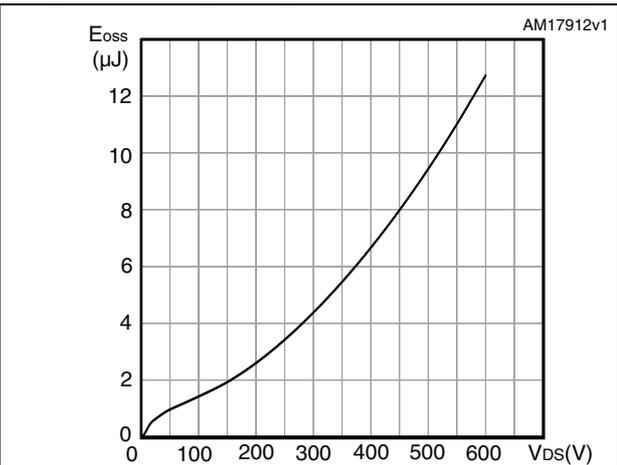


Figure 14. Normalized gate threshold voltage vs temperature

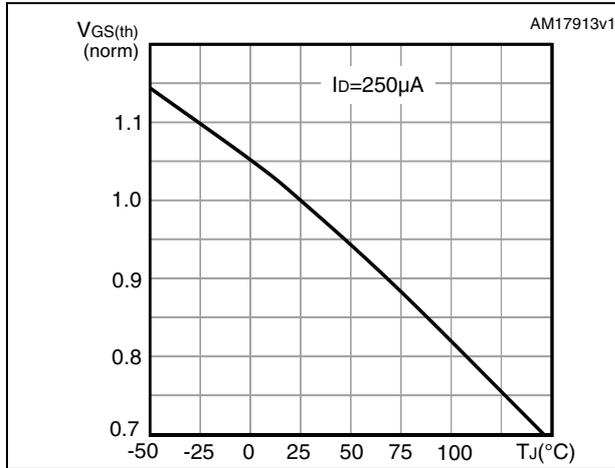


Figure 15. Normalized on-resistance vs temperature

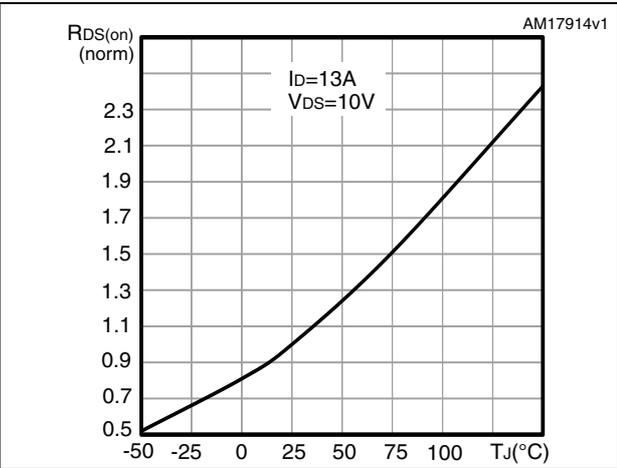


Figure 16. Normalized V_{DS} vs temperature

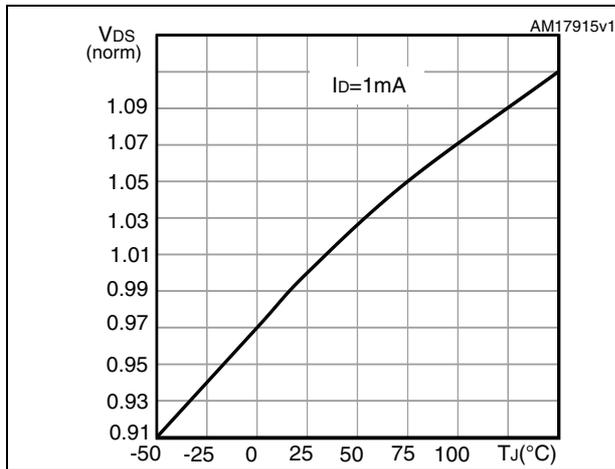
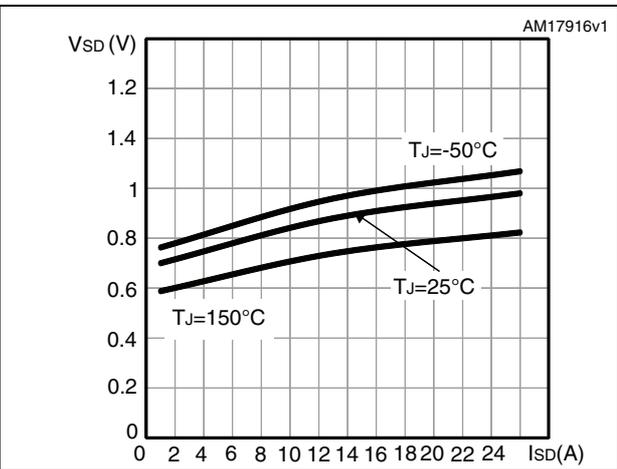
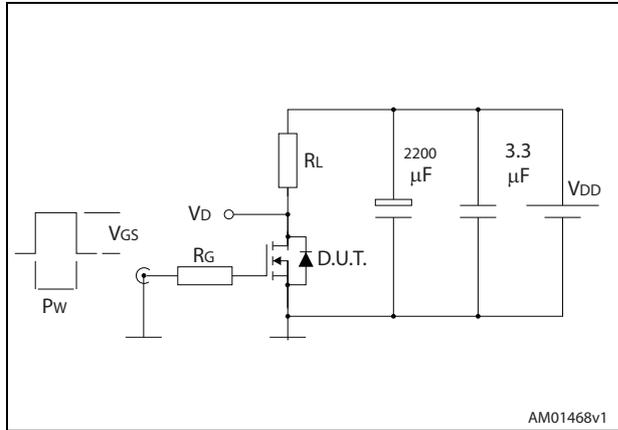


Figure 17. Source-drain diode forward characteristics



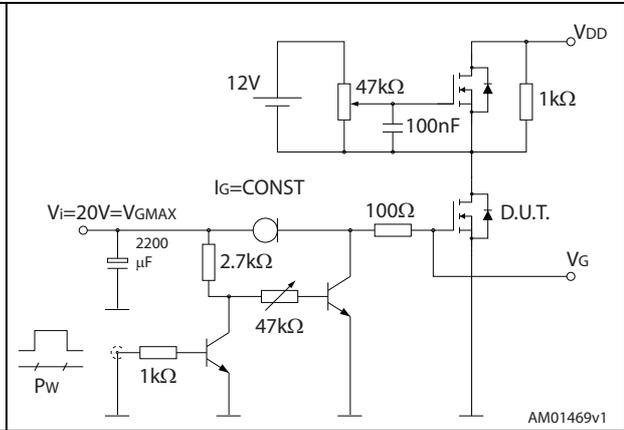
3 Test circuits

Figure 18. Switching times test circuit for resistive load



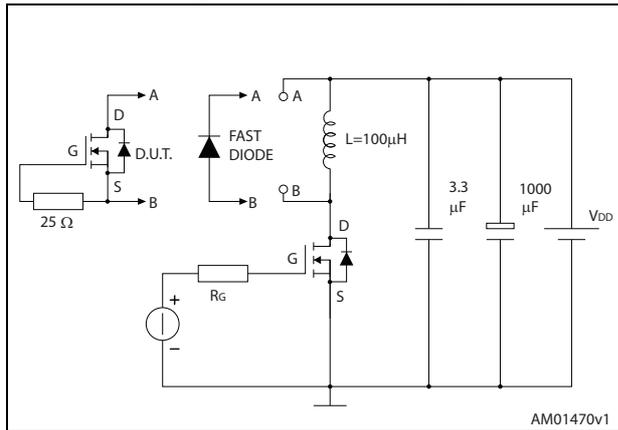
AM01468v1

Figure 19. Gate charge test circuit



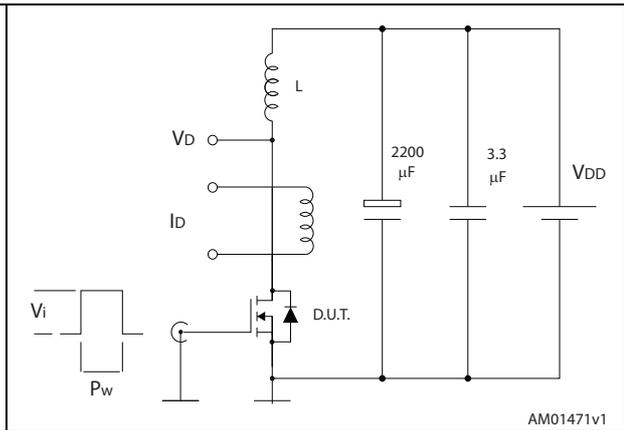
AM01469v1

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



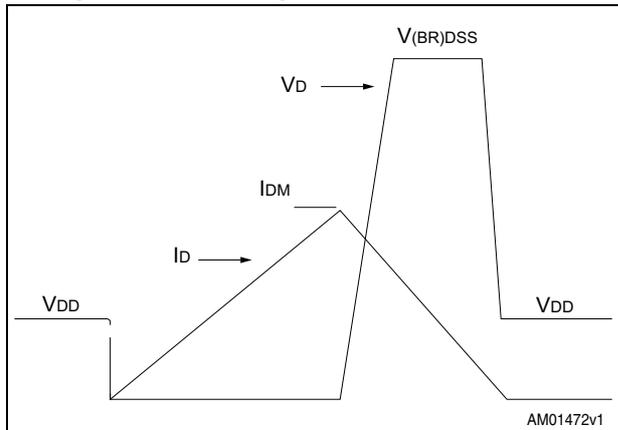
AM01470v1

Figure 21. Unclamped inductive load test circuit



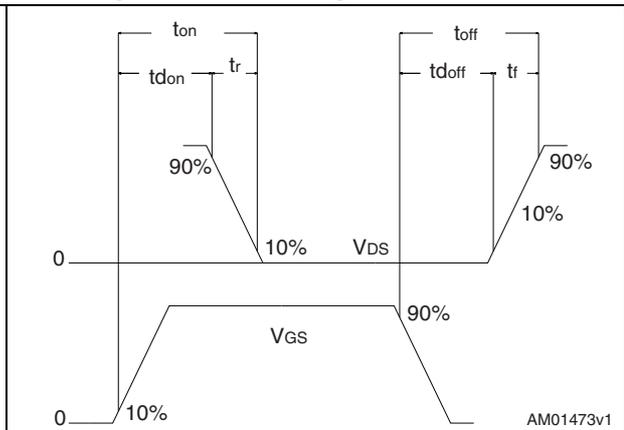
AM01471v1

Figure 22. Unclamped inductive waveform



AM01472v1

Figure 23. Switching time waveform



AM01473v1

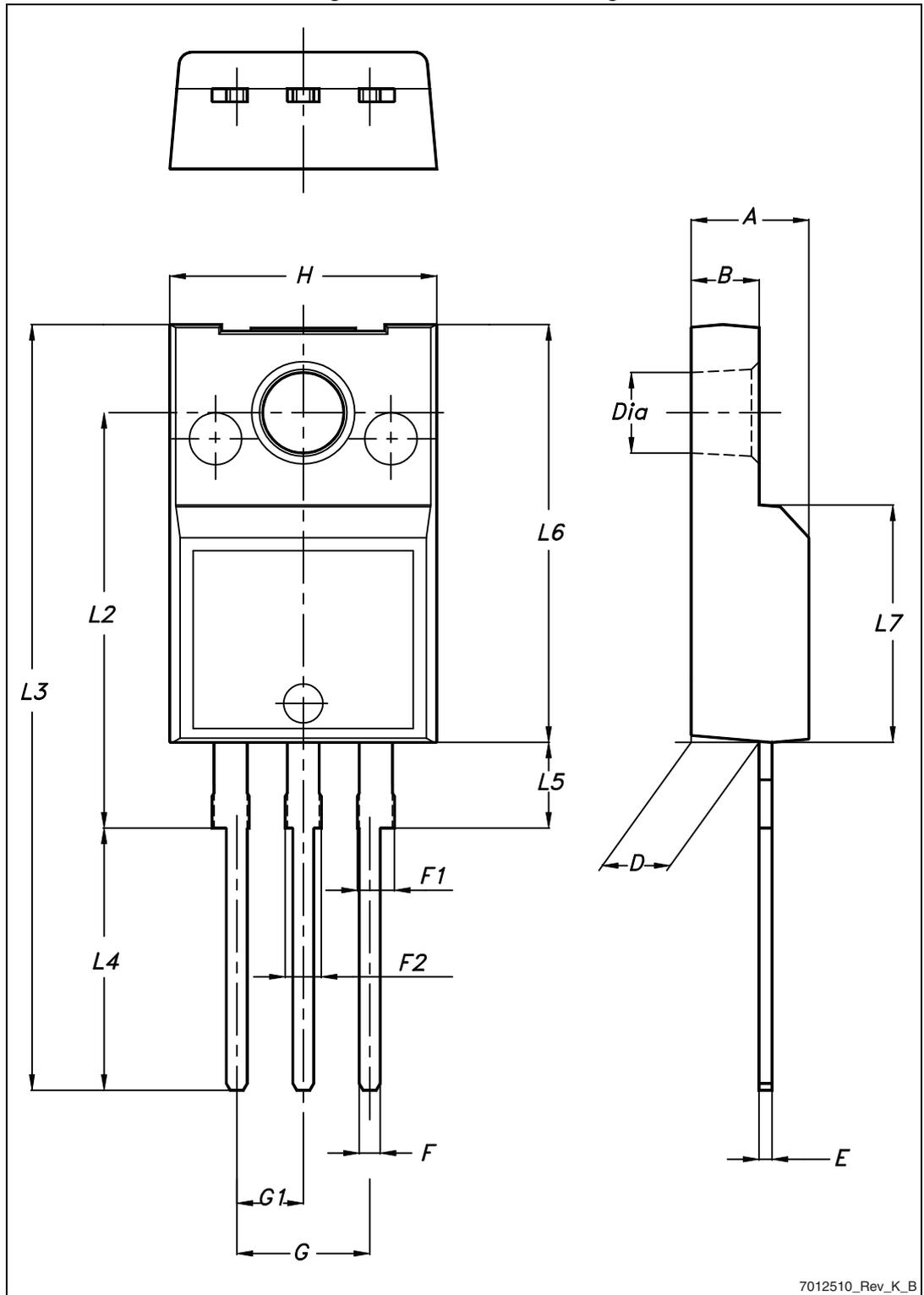
4 Package mechanical data

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.

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 |

Figure 24. TO-220FP drawing

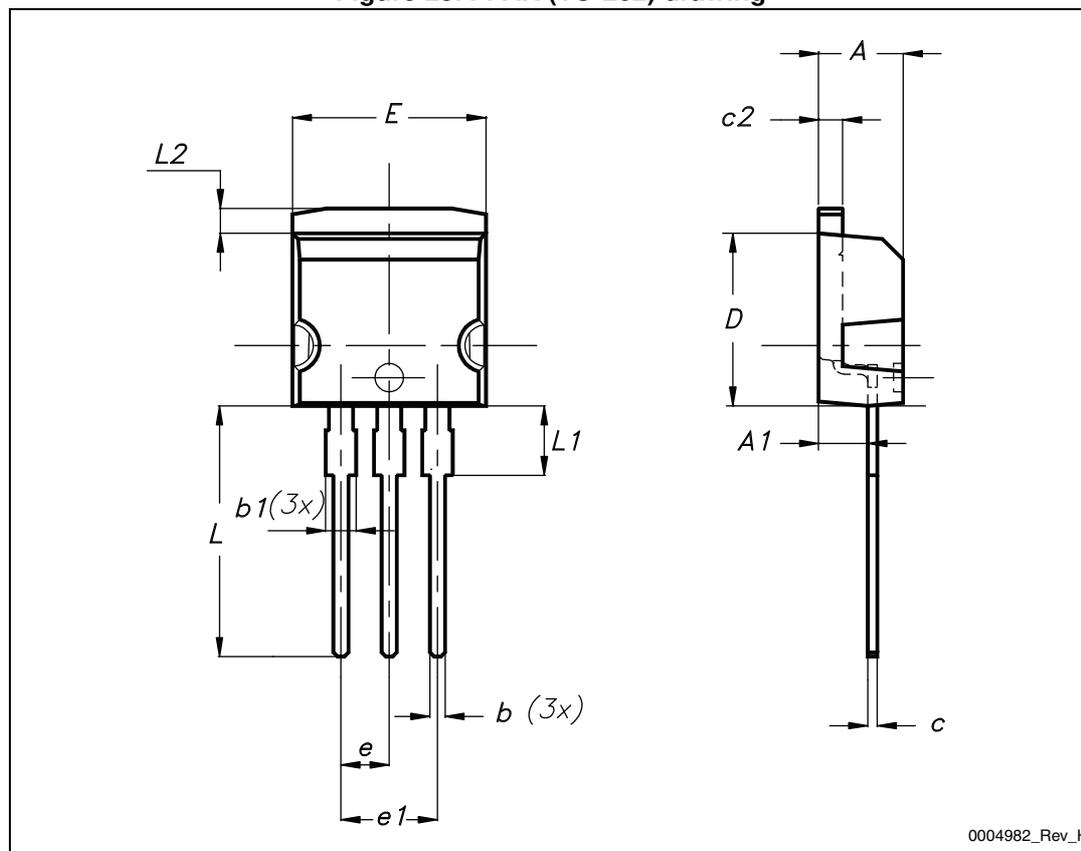


7012510_Rev_K_B

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 |

Figure 25. I²PAK (TO-262) drawing



0004982_Rev_H

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 |

Figure 26. TO-220 type A drawing

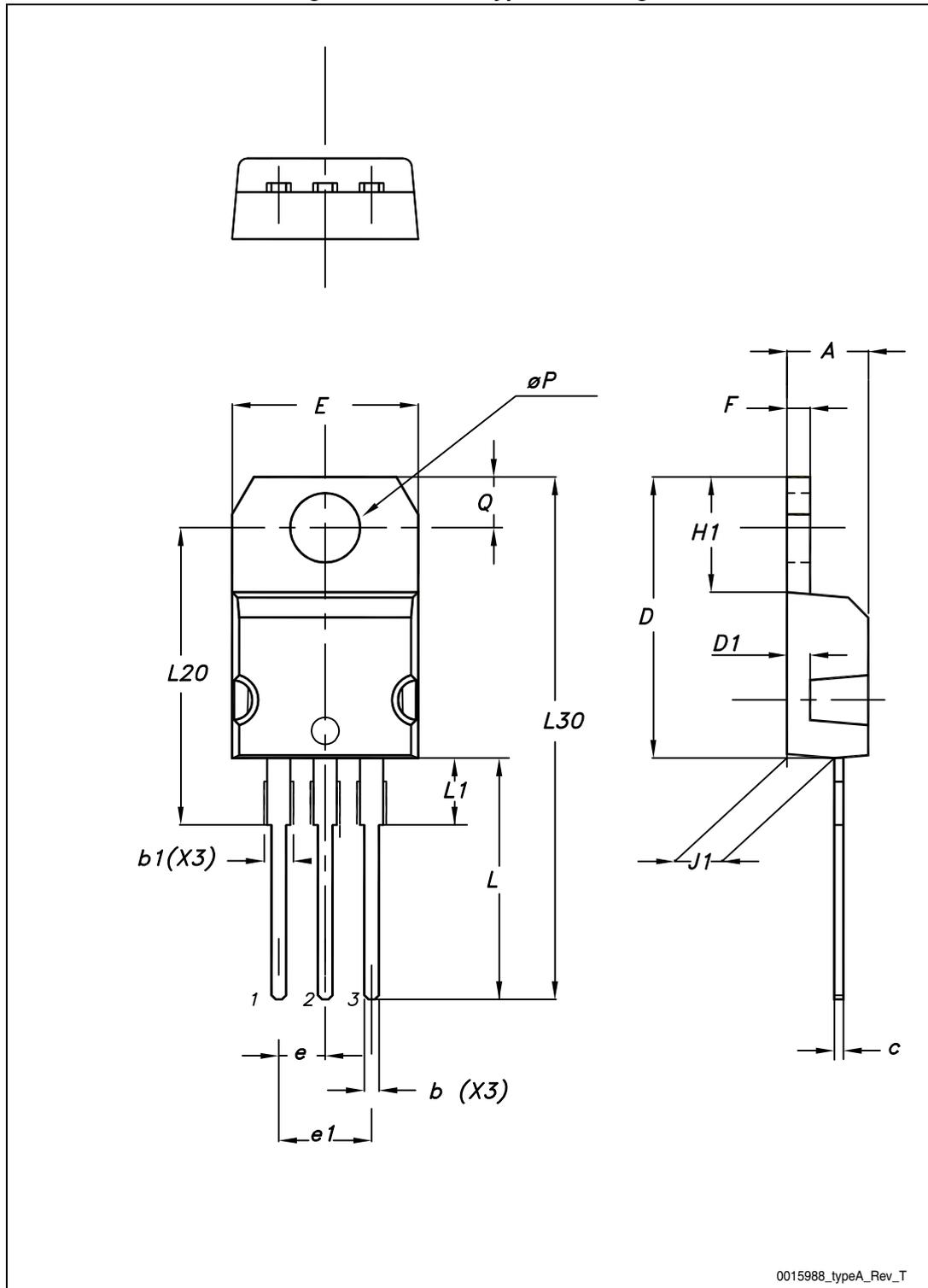
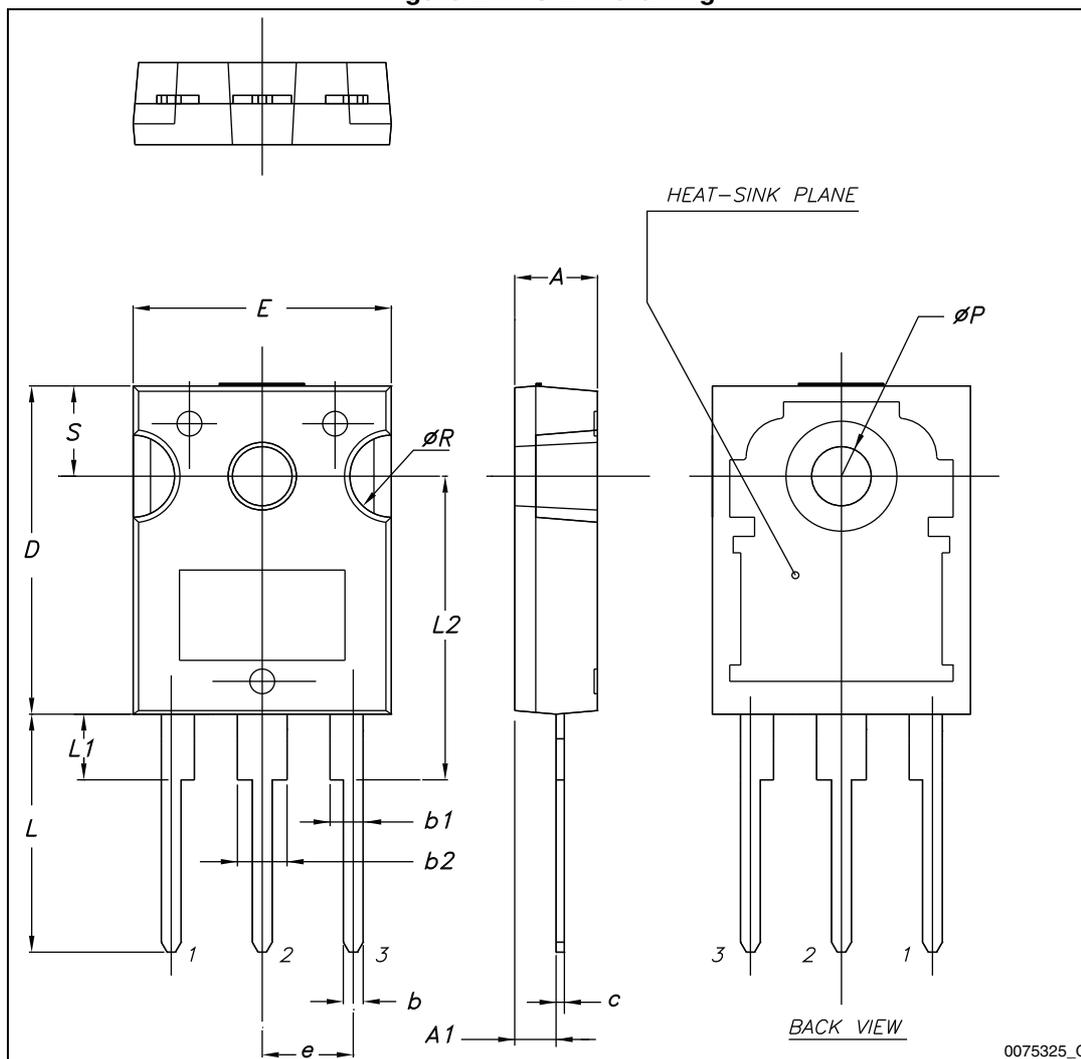


Table 12. TO-247 mechanical data

| 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 |

Figure 27. TO-247 drawing



5 Revision history

Table 13. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 13-Sep-2013 | 1 | First release. |
| 19-Nov-2013 | 2 | <ul style="list-style-type: none">– Modified: $R_{DS(on)}$ and I_D values in cover page– Modified: values in Table 4– Modified: $R_{DS(on)}$ typical and maximum values in Table 5, the entire typical values in Table 6, 7 and 8– Added: Section 2.1: Electrical characteristics (curves)– Minor text changes |

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