

# Power MOSFET

## PRODUCT SUMMARY

|                           |                        |   |
|---------------------------|------------------------|---|
| $V_{DS}$ (V)              | 600                    |   |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ | 7 |
| $Q_g$ (Max.) (nC)         | 14                     |   |
| $Q_{gs}$ (nC)             | 2.7                    |   |
| $Q_{gd}$ (nC)             | 8.1                    |   |
| Configuration             | Single                 |   |

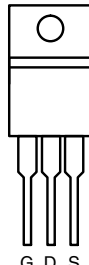
## FEATURES

- Halogen-free According to IEC 61249-2-21 Definition
- Dynamic dV/dt Rating
- Repetitive Avalanche Rated
- Available in Tape and Reel
- Fast Switching
- Ease of Paralleling
- Compliant to RoHS Directive 2002/95/EC



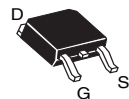
**RoHS\***  
COMPLIANT  
HALOGEN  
**FREE**  
Available

TO-220AB

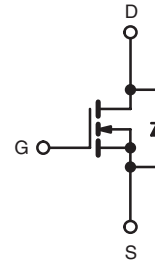
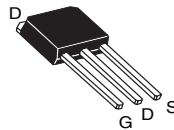


Top View

DPAK  
(TO-252)



IPAK  
(TO-251)



N-Channel MOSFET

## ABSOLUTE MAXIMUM RATINGS $T_C = 25\text{ }^\circ\text{C}$ , unless otherwise noted

| PARAMETER                                          |                         |                         | SYMBOL                            | LIMIT            | UNIT |
|----------------------------------------------------|-------------------------|-------------------------|-----------------------------------|------------------|------|
| Drain-Source Voltage                               |                         |                         | V <sub>DS</sub>                   | 600              | V    |
| Gate-Source Voltage                                |                         |                         | V <sub>GS</sub>                   | ± 20             |      |
| Continuous Drain Current                           | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 1.4              | A    |
|                                                    |                         | T <sub>C</sub> = 100 °C |                                   | 0.89             |      |
| Pulsed Drain Current <sup>a</sup>                  |                         |                         | I <sub>DM</sub> 5.6               |                  |      |
| Linear Derating Factor                             |                         |                         |                                   | 0.28             | W/°C |
| Linear Derating Factor (PCB Mount) <sup>e</sup>    |                         |                         |                                   | 0.020            |      |
| Single Pulse Avalanche Energy <sup>b</sup>         |                         |                         | E <sub>AS</sub>                   | 93               | mJ   |
| Repetitive Avalanche Current <sup>a</sup>          |                         |                         | I <sub>AR</sub>                   | 1.4              | A    |
| Repetitive Avalanche Energy <sup>a</sup>           |                         |                         | E <sub>AR</sub>                   | 3.6              | mJ   |
| Maximum Power Dissipation                          | T <sub>C</sub> = 25 °C  |                         | P <sub>D</sub>                    | 36               | W    |
| Maximum Power Dissipation (PCB Mount) <sup>e</sup> | T <sub>A</sub> = 25 °C  |                         |                                   | 2.5              |      |
| Peak Diode Recovery dV/dt <sup>c</sup>             |                         |                         | dV/dt                             | 3.8              | V/ns |
| Operating Junction and Storage Temperature Range   |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | - 55 to + 150    | °C   |
| Soldering Recommendations (Peak Temperature)       | for 10 s                |                         |                                   | 260 <sup>d</sup> |      |

### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{DD} = 50\text{ V}$ , starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 37\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 1.4\text{ A}$  (see fig. 12).
- $I_{SD} \leq 1.4\text{ A}$ ,  $dI/dt \leq 40\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$ .
- 1.6 mm from case.
- When mounted on 1" square PCB (FR-4 or G-10 material).

\* Pb containing terminations are not RoHS compliant, exemptions may apply

| THERMAL RESISTANCE RATINGS                           |            |      |      |      |      |
|------------------------------------------------------|------------|------|------|------|------|
| PARAMETER                                            | SYMBOL     | MIN. | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient                          | $R_{thJA}$ | -    | -    | 110  | °C/W |
| Maximum Junction-to-Ambient (PCB Mount) <sup>a</sup> | $R_{thJA}$ | -    | -    | 50   |      |
| Maximum Junction-to-Case (Drain)                     | $R_{thJC}$ | -    | -    | 3.5  |      |

**Note**

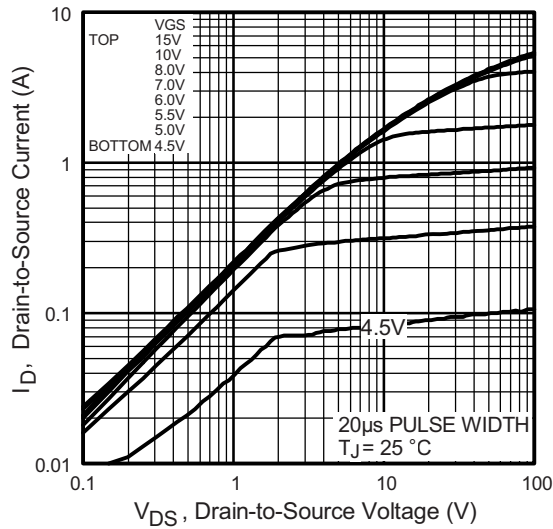
a. When mounted on 1" square PCB (FR-4 or G-10 material).

| SPECIFICATIONS T <sub>J</sub> = 25 °C, unless otherwise noted |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
|---------------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------|------|-------|------|
| PARAMETER                                                     | SYMBOL                           | TEST CONDITIONS                                                                                                             |                                                                                    | MIN. | TYP. | MAX.  | UNIT |
| Static                                                        |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
| Drain-Source Breakdown Voltage                                | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                                                              |                                                                                    | 600  | -    | -     | V    |
| V <sub>DS</sub> Temperature Coefficient                       | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = 1 mA                                                                                   |                                                                                    | -    | 0.88 | -     | V/°C |
| Gate-Source Threshold Voltage                                 | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                 |                                                                                    | 2.0  | -    | 4.0   | V    |
| Gate-Source Leakage                                           | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 20 V                                                                                                    |                                                                                    | -    | -    | ± 100 | nA   |
| Zero Gate Voltage Drain Current                               | I <sub>DSS</sub>                 | V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V                                                                              |                                                                                    | -    | -    | 100   | μA   |
|                                                               |                                  | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C                                                     |                                                                                    | -    | -    | 500   |      |
| Drain-Source On-State Resistance                              | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                      | I <sub>D</sub> = 1.2 A <sup>b</sup>                                                | -    | -    | 7.0   | Ω    |
| Forward Transconductance                                      | g <sub>fs</sub>                  | V <sub>DS</sub> = 50 V, I <sub>D</sub> = 1.2 A                                                                              |                                                                                    | 1.4  | -    | -     | S    |
| Dynamic                                                       |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
| Input Capacitance                                             | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = - 25 V,<br>f = 1.0 MHz, see fig. 5                                              |                                                                                    | -    | 229  | -     | pF   |
| Output Capacitance                                            | C <sub>oss</sub>                 |                                                                                                                             |                                                                                    | -    | 42   | -     |      |
| Reverse Transfer Capacitance                                  | C <sub>rss</sub>                 |                                                                                                                             |                                                                                    | -    | 2.6  | -     |      |
| Total Gate Charge                                             | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                      | I <sub>D</sub> = 1.4 A, V <sub>DS</sub> = 360 V,<br>see fig. 6 and 13 <sup>b</sup> | -    | -    | 14    | nC   |
| Gate-Source Charge                                            | Q <sub>gs</sub>                  |                                                                                                                             |                                                                                    | -    | -    | 2.7   |      |
| Gate-Drain Charge                                             | Q <sub>gd</sub>                  |                                                                                                                             |                                                                                    | -    | -    | 8.1   |      |
| Turn-On Delay Time                                            | t <sub>d(on)</sub>               | V <sub>DD</sub> = 300 V, I <sub>D</sub> = 1.4 A,<br>R <sub>g</sub> = 18 Ω, R <sub>D</sub> = 135 Ω, see fig. 10 <sup>b</sup> |                                                                                    | -    | 10   | -     | ns   |
| Rise Time                                                     | t <sub>r</sub>                   |                                                                                                                             |                                                                                    | -    | 13   | -     |      |
| Turn-Off Delay Time                                           | t <sub>d(off)</sub>              |                                                                                                                             |                                                                                    | -    | 30   | -     |      |
| Fall Time                                                     | t <sub>f</sub>                   |                                                                                                                             |                                                                                    | -    | 25   | -     |      |
| Internal Drain Inductance                                     | L <sub>D</sub>                   | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact                                                  |                                                                                    | -    | 4.5  | -     | nH   |
| Internal Source Inductance                                    | L <sub>S</sub>                   |                                                                                                                             |                                                                                    | -    | 7.5  | -     |      |
| Drain-Source Body Diode Characteristics                       |                                  |                                                                                                                             |                                                                                    |      |      |       |      |
| Continuous Source-Drain Diode Current                         | I <sub>S</sub>                   | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode                                                    |                                                                                    | -    | -    | 2.0   | A    |
| Pulsed Diode Forward Current <sup>a</sup>                     | I <sub>SM</sub>                  |                                                                                                                             |                                                                                    | -    | -    | 8.0   |      |
| Body Diode Voltage                                            | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 1.4 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                          |                                                                                    | -    | -    | 1.6   | V    |
| Body Diode Reverse Recovery Time                              | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 1.4 A, dI/dt = 100 A/μs <sup>b</sup>                                               |                                                                                    | -    | 290  | 580   | ns   |
| Body Diode Reverse Recovery Charge                            | Q <sub>rr</sub>                  |                                                                                                                             |                                                                                    | -    | 0.67 | 1.3   | μC   |
| Forward Turn-On Time                                          | t <sub>on</sub>                  | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )                           |                                                                                    |      |      |       |      |

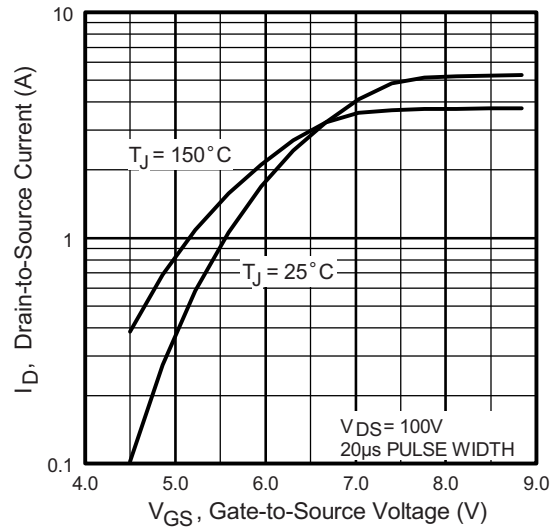
**Notes**

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).  
 b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\text{ }\%$ .

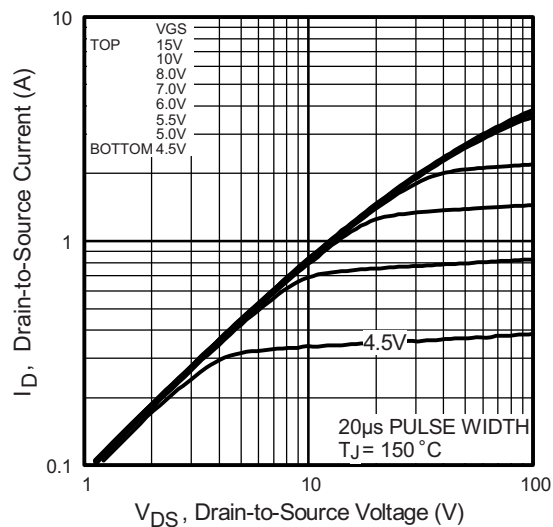
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



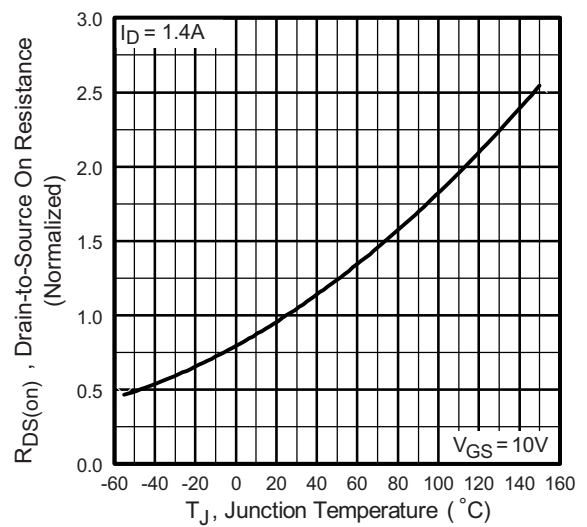
**Fig. 1 - Typical Output Characteristics**



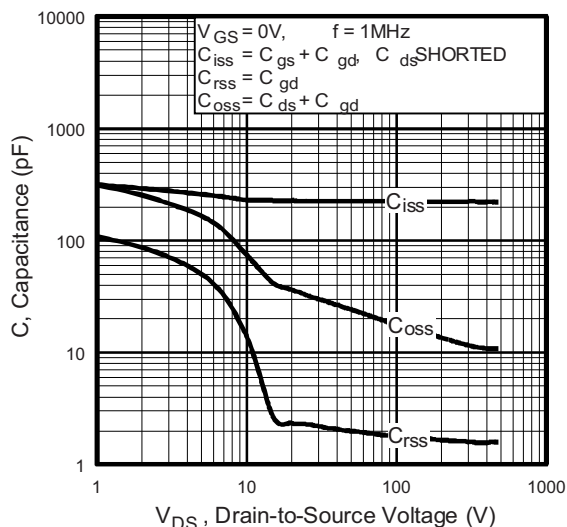
**Fig. 3 - Typical Transfer Characteristics**



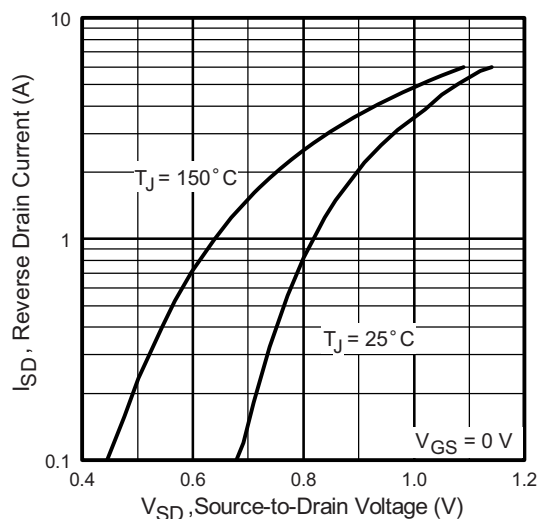
**Fig. 2 - Typical Output Characteristics**



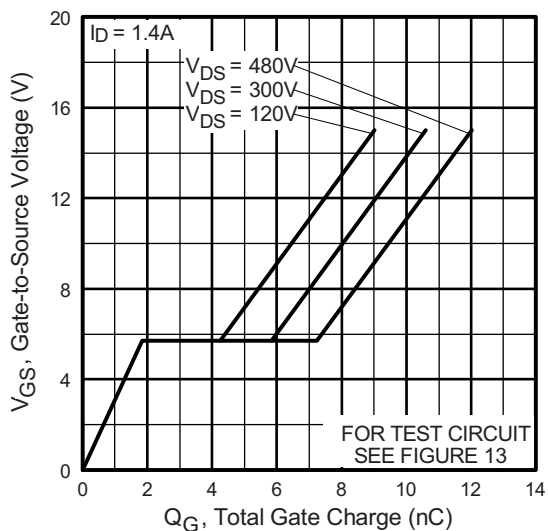
**Fig. 4 - Normalized On-Resistance vs. Temperature**



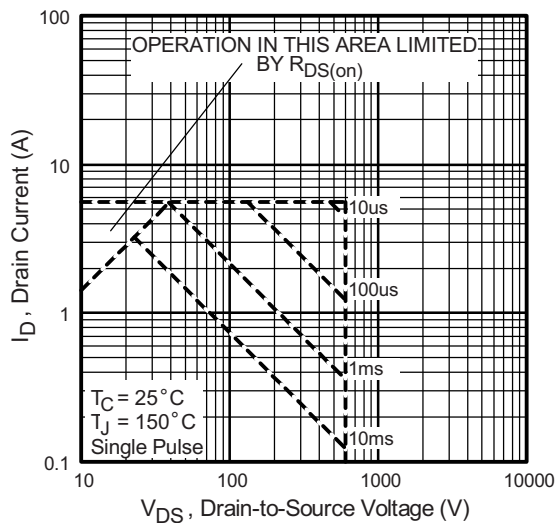
**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**



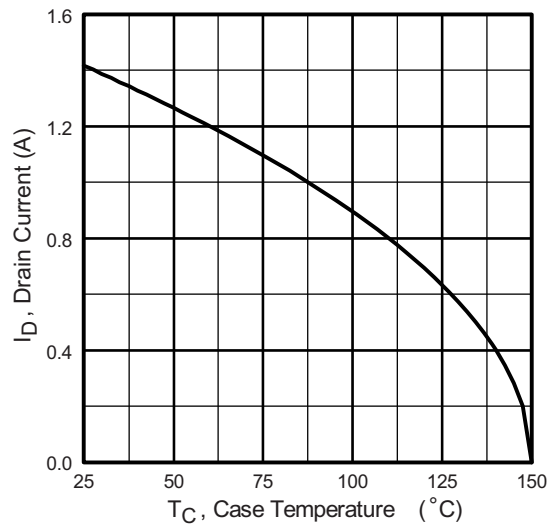
**Fig. 7 - Typical Source-Drain Diode Forward Voltage**



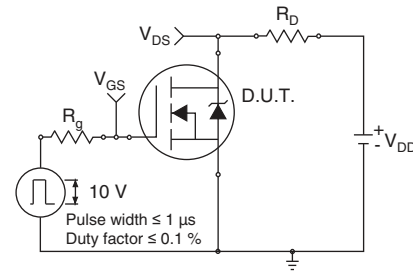
**Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage**



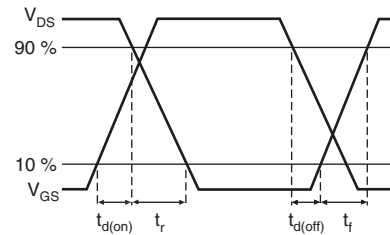
**Fig. 8 - Maximum Safe Operating Area**



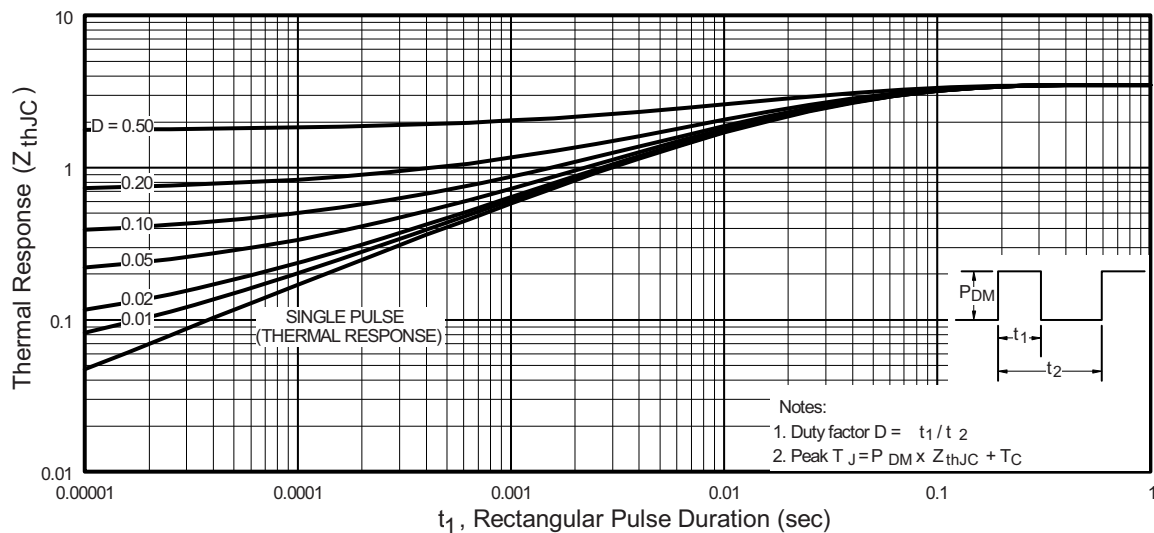
**Fig. 9 - Maximum Drain Current vs. Case Temperature**



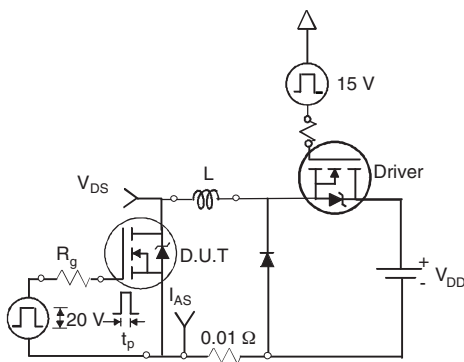
**Fig. 10a - Switching Time Test Circuit**



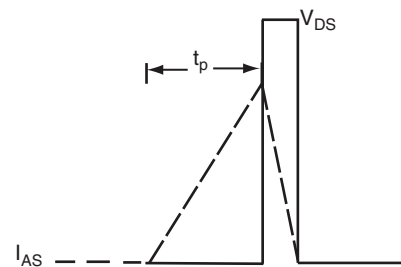
**Fig. 10b - Switching Time Waveforms**



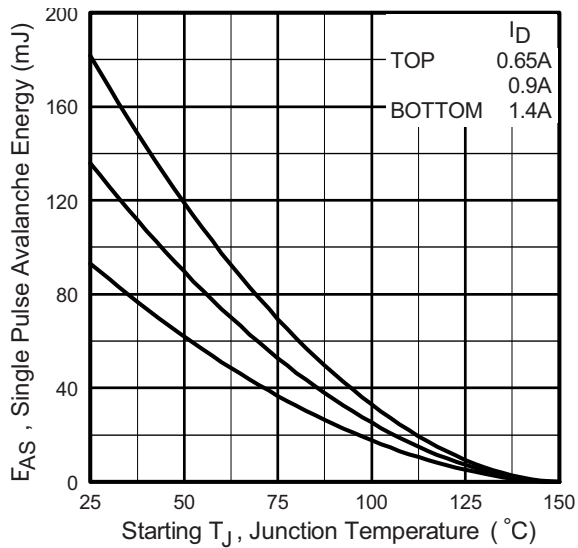
**Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**



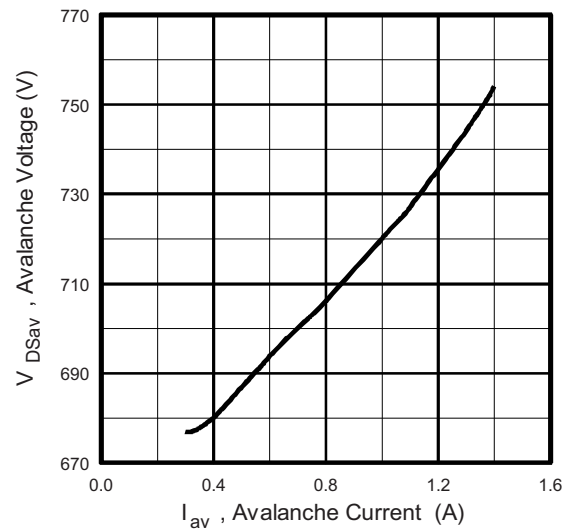
**Fig. 12a - Unclamped Inductive Test Circuit**



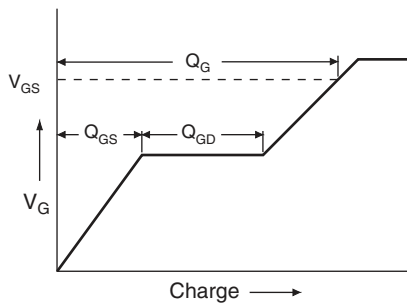
**Fig. 12b - Unclamped Inductive Waveforms**



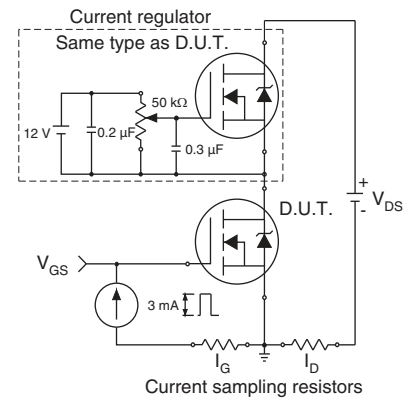
**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**



**Fig. 12d - Basic Gate Charge Waveform**

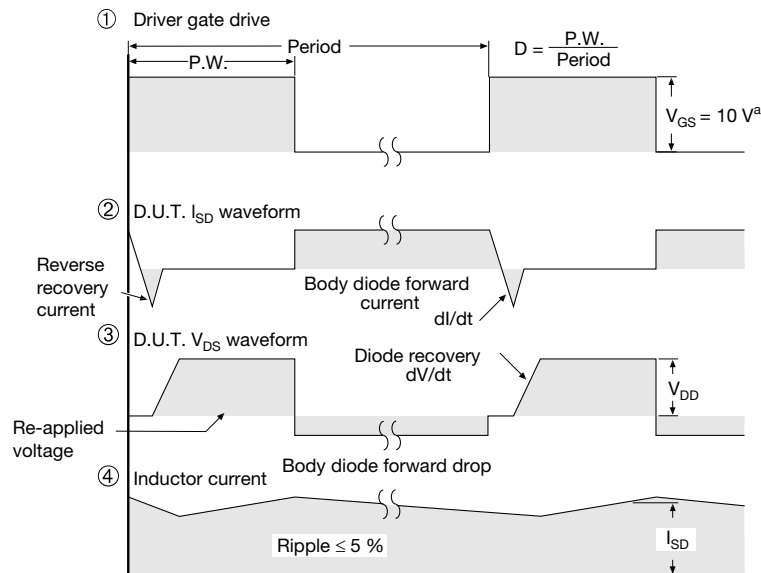
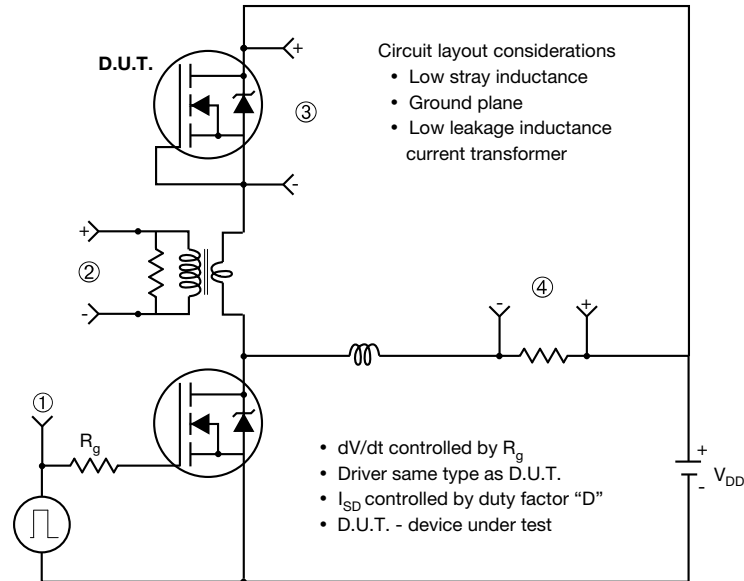


**Fig. 13a - Maximum Avalanche Energy vs. Drain Current**



**Fig. 13b - Gate Charge Test Circuit**

**Peak Diode Recovery dV/dt Test Circuit**

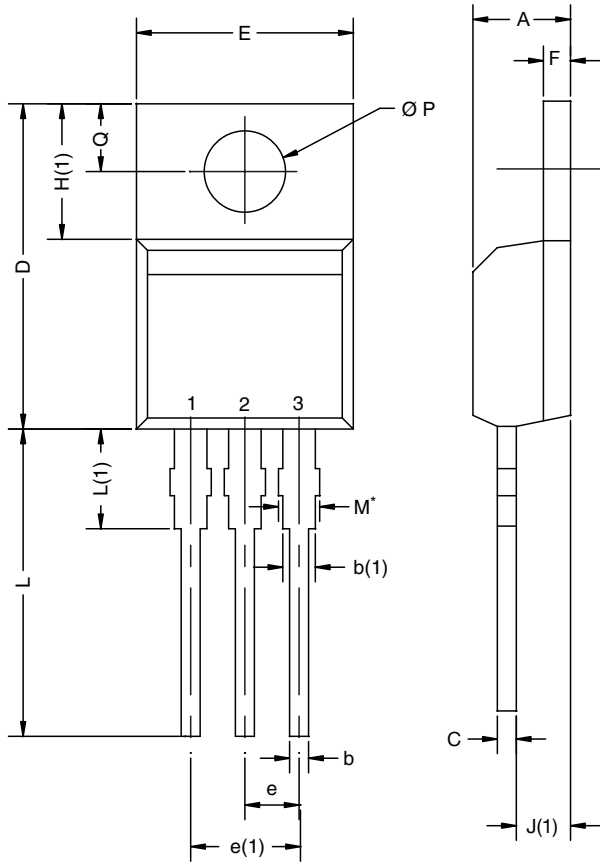


**Note**

a.  $V_{GS} = 5 V$  for logic level devices

**Fig. 14 - For N-Channel**

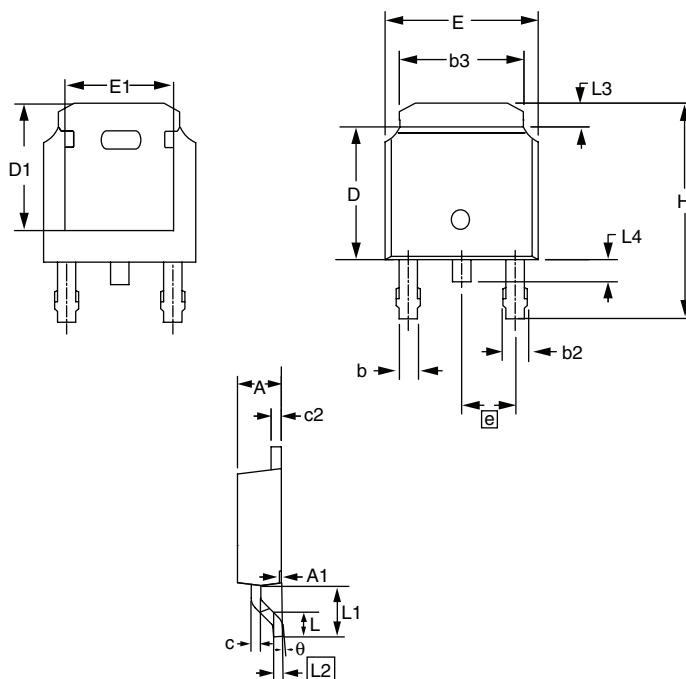
## TO-220AB



| DIM.                                         | MILLIMETERS |       | INCHES |       |
|----------------------------------------------|-------------|-------|--------|-------|
|                                              | MIN.        | MAX.  | MIN.   | MAX.  |
| A                                            | 4.25        | 4.65  | 0.167  | 0.183 |
| b                                            | 0.69        | 1.01  | 0.027  | 0.040 |
| b(1)                                         | 1.20        | 1.73  | 0.047  | 0.068 |
| c                                            | 0.36        | 0.61  | 0.014  | 0.024 |
| D                                            | 14.85       | 15.49 | 0.585  | 0.610 |
| E                                            | 10.04       | 10.51 | 0.395  | 0.414 |
| e                                            | 2.41        | 2.67  | 0.095  | 0.105 |
| e(1)                                         | 4.88        | 5.28  | 0.192  | 0.208 |
| F                                            | 1.14        | 1.40  | 0.045  | 0.055 |
| H(1)                                         | 6.09        | 6.48  | 0.240  | 0.255 |
| J(1)                                         | 2.41        | 2.92  | 0.095  | 0.115 |
| L                                            | 13.35       | 14.02 | 0.526  | 0.552 |
| L(1)                                         | 3.32        | 3.82  | 0.131  | 0.150 |
| $\varnothing P$                              | 3.54        | 3.94  | 0.139  | 0.155 |
| Q                                            | 2.60        | 3.00  | 0.102  | 0.118 |
| ECN: X12-0208-Rev. N, 08-Oct-12<br>DWG: 5471 |             |       |        |       |

### Notes

\* M = 1.32 mm to 1.62 mm (dimension including protrusion)  
Heatsink hole for HVM

**TO-252AA (HIGH VOLTAGE)**


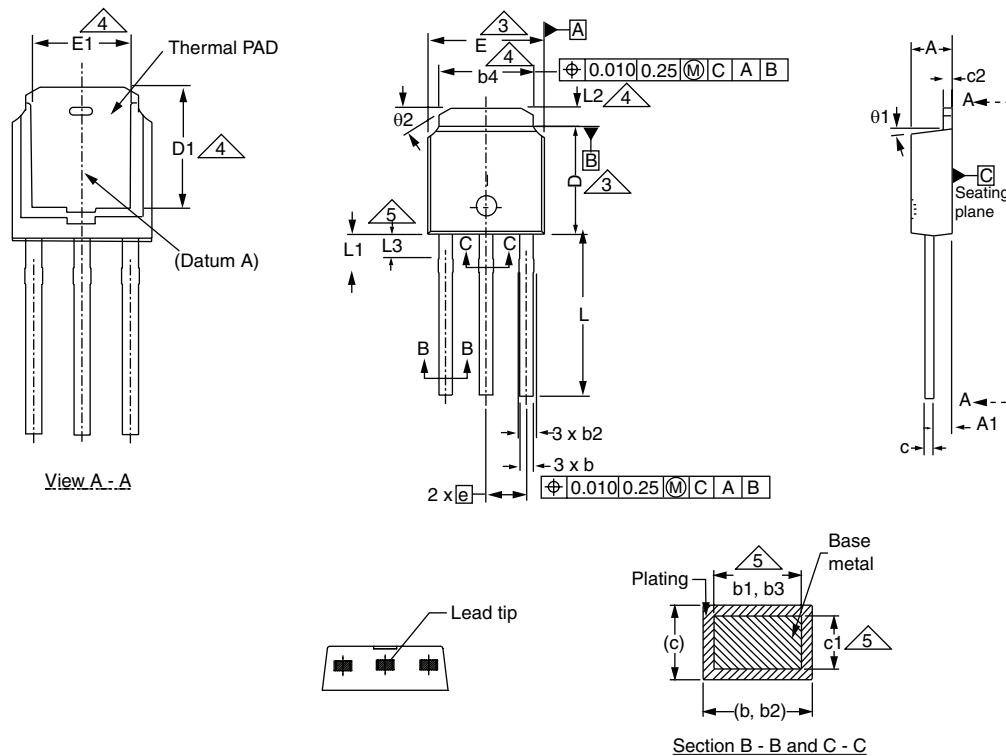
| DIM. | MILLIMETERS |       | INCHES    |       |
|------|-------------|-------|-----------|-------|
|      | MIN.        | MAX.  | MIN.      | MAX.  |
| E    | 6.40        | 6.73  | 0.252     | 0.265 |
| L    | 1.40        | 1.77  | 0.055     | 0.070 |
| L1   | 2.743 REF   |       | 0.108 REF |       |
| L2   | 0.508 BSC   |       | 0.020 BSC |       |
| L3   | 0.89        | 1.27  | 0.035     | 0.050 |
| L4   | 0.64        | 1.01  | 0.025     | 0.040 |
| D    | 6.00        | 6.22  | 0.236     | 0.245 |
| H    | 9.40        | 10.40 | 0.370     | 0.409 |
| b    | 0.64        | 0.88  | 0.025     | 0.035 |
| b2   | 0.77        | 1.14  | 0.030     | 0.045 |
| b3   | 5.21        | 5.46  | 0.205     | 0.215 |
| e    | 2.286 BSC   |       | 0.090 BSC |       |
| A    | 2.20        | 2.38  | 0.087     | 0.094 |
| A1   | 0.00        | 0.13  | 0.000     | 0.005 |
| c    | 0.45        | 0.60  | 0.018     | 0.024 |
| c2   | 0.45        | 0.58  | 0.018     | 0.023 |
| D1   | 5.30        | -     | 0.209     | -     |
| E1   | 4.40        | -     | 0.173     | -     |
| θ    | 0°          | 10°   | 0°        | 10°   |

ECN: S-81965-Rev. A, 15-Sep-08  
 DWG: 5973

**Notes**

1. Package body sizes exclude mold flash, protrusion or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 0.10 mm per side.
2. Package body sizes determined at the outermost extremes of the plastic body exclusive of mold flash, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.
3. The package top may be smaller than the package bottom.
4. Dimension "b" does not include dambar protrusion. Allowable dambar protrusion shall be 0.10 mm total in excess of "b" dimension at maximum material condition. The dambar cannot be located on the lower radius of the foot.

**TO-251AA (HIGH VOLTAGE)**



| DIM. | MILLIMETERS |      | INCHES |       |
|------|-------------|------|--------|-------|
|      | MIN.        | MAX. | MIN.   | MAX.  |
| A    | 2.18        | 2.39 | 0.086  | 0.094 |
| A1   | 0.89        | 1.14 | 0.035  | 0.045 |
| b    | 0.64        | 0.89 | 0.025  | 0.035 |
| b1   | 0.65        | 0.79 | 0.026  | 0.031 |
| b2   | 0.76        | 1.14 | 0.030  | 0.045 |
| b3   | 0.76        | 1.04 | 0.030  | 0.041 |
| b4   | 4.95        | 5.46 | 0.195  | 0.215 |
| c    | 0.46        | 0.61 | 0.018  | 0.024 |
| c1   | 0.41        | 0.56 | 0.016  | 0.022 |
| c2   | 0.46        | 0.86 | 0.018  | 0.034 |
| D    | 5.97        | 6.22 | 0.235  | 0.245 |

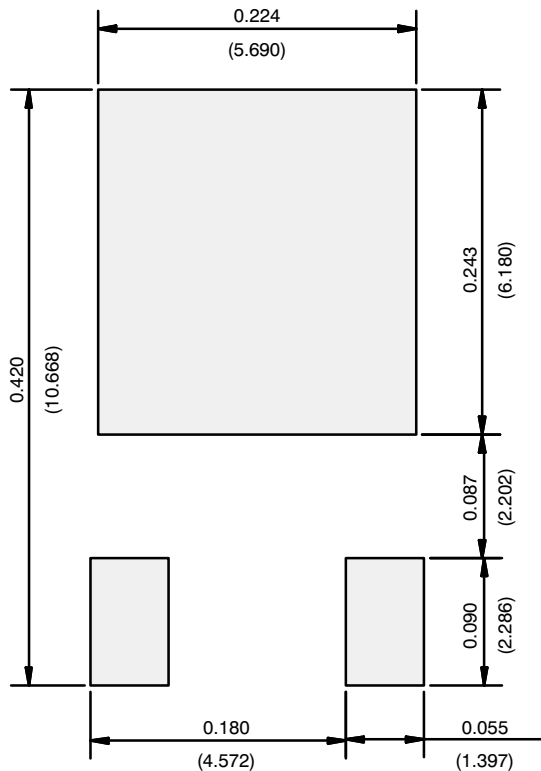
| DIM. | MILLIMETERS |      | INCHES   |       |
|------|-------------|------|----------|-------|
|      | MIN.        | MAX. | MIN.     | MAX.  |
| D1   | 5.21        | -    | 0.205    | -     |
| E    | 6.35        | 6.73 | 0.250    | 0.265 |
| E1   | 4.32        | -    | 0.170    | -     |
| e    | 2.29 BSC    |      | 2.29 BSC |       |
| L    | 8.89        | 9.65 | 0.350    | 0.380 |
| L1   | 1.91        | 2.29 | 0.075    | 0.090 |
| L2   | 0.89        | 1.27 | 0.035    | 0.050 |
| L3   | 1.14        | 1.52 | 0.045    | 0.060 |
| θ1   | 0°          | 15°  | 0°       | 15°   |
| θ2   | 25°         | 35°  | 25°      | 35°   |

ECN: S-82111-Rev. A, 15-Sep-08  
DWG: 5968

**Notes**

1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Dimension are shown in inches and millimeters.
3. Dimension D and E do not include mold flash. Mold flash shall not exceed 0.13 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body.
4. Thermal pad contour optional with dimensions b4, L2, E1 and D1.
5. Lead dimension uncontrolled in L3.
6. Dimension b1, b3 and c1 apply to base metal only.
7. Outline conforms to JEDEC outline TO-251AA.

**RECOMMENDED MINIMUM PADS FOR DPAK (TO-252)**



Recommended Minimum Pads  
Dimensions in Inches/(mm)

[Return to Index](#)

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