

# N-Channel 60 V (D-S), MOSFET

## PRODUCT SUMMARY

| V <sub>DS</sub> (V) | R <sub>DS(on)</sub> (Ω)          | I <sub>D</sub> (A) <sup>a</sup> | Q <sub>g</sub> (Typ.) |
|---------------------|----------------------------------|---------------------------------|-----------------------|
| 60                  | 0.031 at V <sub>GS</sub> = 10 V  | 9.1                             | 6.5 nC                |
|                     | 0.045 at V <sub>GS</sub> = 4.5 V | 7.6                             |                       |

## FEATURES

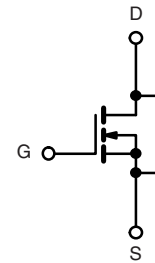
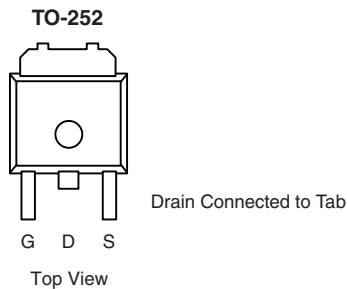
- Halogen-free According to IEC 61249-2-21 Definition
- TrenchFET® Power MOSFET
- 100 % R<sub>g</sub> and UIS Tested
- Compliant to RoHS Directive 2002/95/EC



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**

## APPLICATIONS

- DC/DC Converters



Ordering Information: SUD23N06-31-GE3 (Lead (Pb)-free and Halogen-free)

N-Channel MOSFET

## ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub> = 25 °C, unless otherwise noted)

| Parameter                                          |                        | Symbol                            | Limit            | Unit |
|----------------------------------------------------|------------------------|-----------------------------------|------------------|------|
| Drain-Source Voltage                               |                        | V <sub>DS</sub>                   | 60               | V    |
| Gate-Source Voltage                                |                        | V <sub>GS</sub>                   | ± 20             |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C) | T <sub>C</sub> = 25 °C | I <sub>D</sub>                    | 21.4             | A    |
|                                                    | T <sub>C</sub> = 70 °C |                                   | 17.1             |      |
|                                                    | T <sub>A</sub> = 25 °C |                                   | 9.1 <sup>a</sup> |      |
|                                                    | T <sub>A</sub> = 70 °C |                                   | 7.6 <sup>a</sup> |      |
| Pulsed Drain Current                               |                        | I <sub>DM</sub>                   | 50               |      |
| Continuous Source-Drain Diode Current              | T <sub>C</sub> = 25 °C | I <sub>S</sub>                    | 20.8             |      |
|                                                    | T <sub>A</sub> = 25 °C |                                   | 3.8 <sup>a</sup> |      |
| Single Pulse Avalanche Current                     | L = 0.1 mH             | I <sub>AS</sub>                   | 20               |      |
| Avalanche Energy                                   |                        | E <sub>AS</sub>                   | 20               | mJ   |
| Maximum Power Dissipation                          | T <sub>C</sub> = 25 °C | P <sub>D</sub>                    | 31.25            | W    |
|                                                    | T <sub>C</sub> = 70 °C |                                   | 20               |      |
|                                                    | T <sub>A</sub> = 25 °C |                                   | 5.7 <sup>a</sup> |      |
|                                                    | T <sub>A</sub> = 70 °C |                                   | 3.6 <sup>a</sup> |      |
| Operating Junction and Storage Temperature Range   |                        | T <sub>J</sub> , T <sub>stg</sub> | - 55 to 150      | °C   |

## THERMAL RESISTANCE RATINGS

| Parameter                                | Symbol       | Typical           | Maximum | Unit |
|------------------------------------------|--------------|-------------------|---------|------|
| Maximum Junction-to-Ambient <sup>a</sup> | t ≤ 10 s     | R <sub>thJA</sub> | 18      | °C/W |
| Maximum Junction-to-Case                 | Steady State | R <sub>thJC</sub> | 3.2     |      |

Notes:

a. Surface mounted on 1" x 1" FR4 board, t ≤ 10 s.

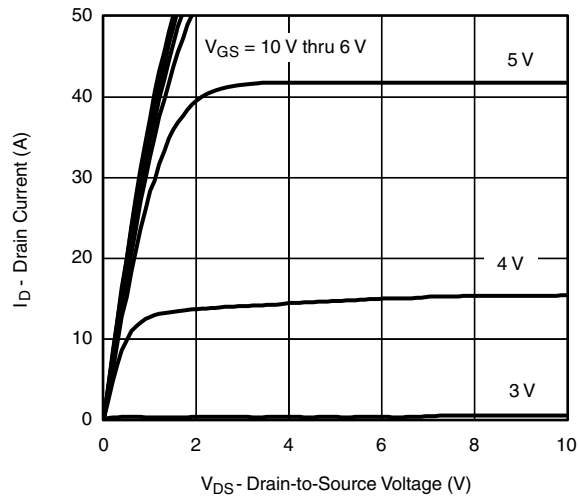
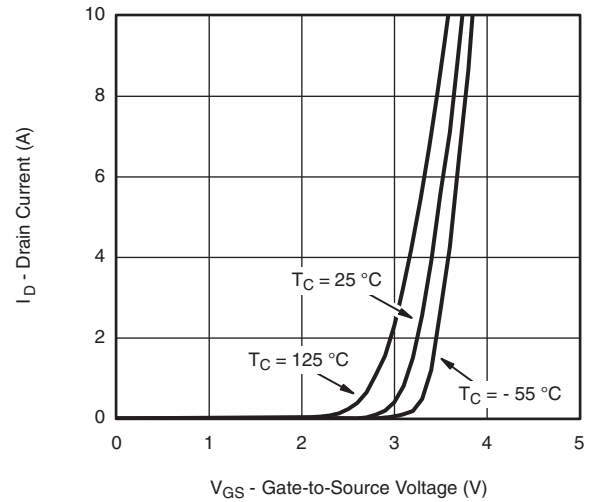
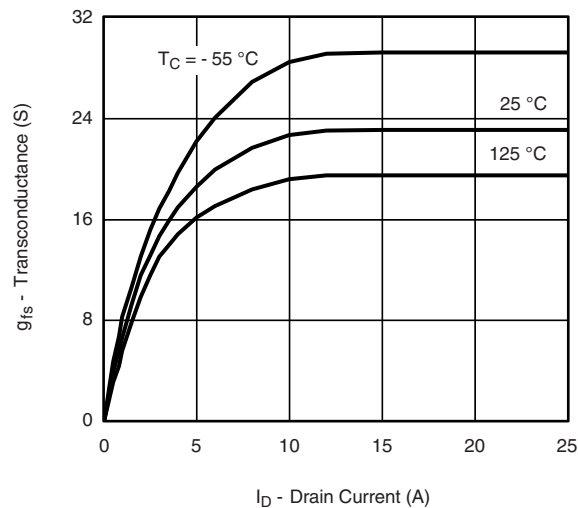
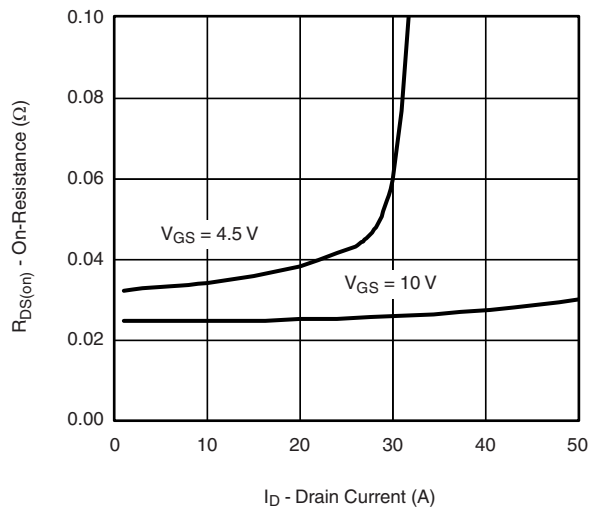
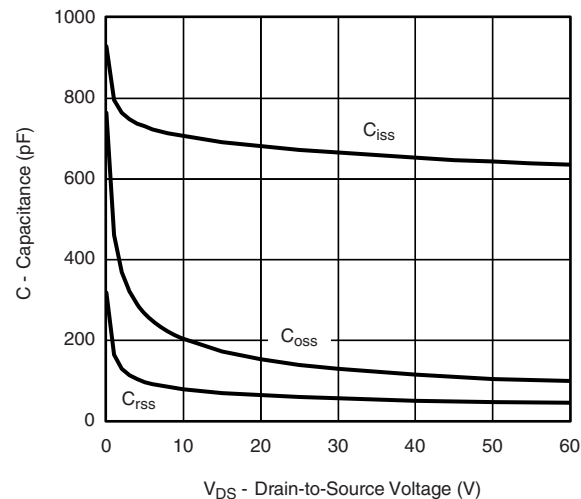
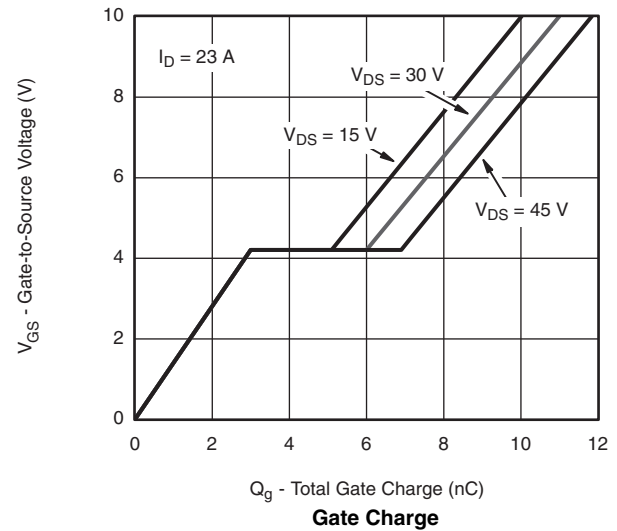
| SPECIFICATIONS (T <sub>J</sub> = 25 °C, unless otherwise noted) |                                      |                                                                                                                         |      |       |       |       |
|-----------------------------------------------------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------|------|-------|-------|-------|
| 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                                                                          | 60   |       |       | V     |
| V <sub>DS</sub> Temperature Coefficient                         | ΔV <sub>DS</sub> /T <sub>J</sub>     | I <sub>D</sub> = 250 μA                                                                                                 |      | 65    |       | mV/°C |
| V <sub>GS(th)</sub> Temperature Coefficient                     | ΔV <sub>GS(th)</sub> /T <sub>J</sub> |                                                                                                                         |      | - 6.3 |       |       |
| Gate-Source Threshold Voltage                                   | V <sub>GS(th)</sub>                  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                             | 1.0  |       | 3.0   | V     |
| Gate-Source Leakage                                             | I <sub>GSS</sub>                     | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = ± 20 V                                                                         |      |       | ± 100 | nA    |
| Zero Gate Voltage Drain Current                                 | I <sub>DSS</sub>                     | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V                                                                           |      |       | 1     | μA    |
|                                                                 |                                      | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 70 °C                                                   |      |       | 20    |       |
| On-State Drain Current <sup>a</sup>                             | I <sub>D(on)</sub>                   | V <sub>DS</sub> ≥ 5 V, V <sub>GS</sub> = 10 V                                                                           | 50   |       |       | A     |
| Drain-Source On-State Resistance <sup>a</sup>                   | R <sub>DS(on)</sub>                  | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 15 A                                                                           |      | 0.025 | 0.031 | Ω     |
|                                                                 |                                      | V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 10 A                                                                          |      | 0.037 | 0.045 |       |
| Forward Transconductance <sup>a</sup>                           | g <sub>fs</sub>                      | V <sub>DS</sub> = 15 V, I <sub>D</sub> = 15 A                                                                           |      | 20    |       | S     |
| Dynamic <sup>b</sup>                                            |                                      |                                                                                                                         |      |       |       |       |
| Input Capacitance                                               | C <sub>iss</sub>                     | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V, f = 1 MHz                                                                |      | 670   |       | pF    |
| Output Capacitance                                              | C <sub>oss</sub>                     |                                                                                                                         |      | 140   |       |       |
| Reverse Transfer Capacitance                                    | C <sub>rss</sub>                     |                                                                                                                         |      | 60    |       |       |
| Total Gate Charge                                               | Q <sub>g</sub>                       | V <sub>DS</sub> = 30 V, V <sub>GS</sub> = 10 V, I <sub>D</sub> = 23 A                                                   |      | 11    | 17    | nC    |
|                                                                 |                                      | V <sub>DS</sub> = 30 V, V <sub>GS</sub> = 4.5 V, I <sub>D</sub> = 23 A                                                  |      | 6.5   | 13    |       |
| Gate-Source Charge                                              | Q <sub>gs</sub>                      |                                                                                                                         |      | 3.0   |       |       |
| Gate-Drain Charge                                               | Q <sub>gd</sub>                      |                                                                                                                         |      | 3.0   |       |       |
| Gate Resistance                                                 | R <sub>g</sub>                       | f = 1 MHz                                                                                                               |      | 1.6   | 3.2   | Ω     |
| Turn-On Delay Time                                              | t <sub>d(on)</sub>                   | V <sub>DD</sub> = 30 V, R <sub>L</sub> = 1.3 Ω<br>I <sub>D</sub> ≅ 23 A, V <sub>GEN</sub> = 4.5 V, R <sub>g</sub> = 1 Ω |      | 18    | 30    | ns    |
| Rise Time                                                       | t <sub>r</sub>                       |                                                                                                                         |      | 250   | 400   |       |
| Turn-Off Delay Time                                             | t <sub>d(off)</sub>                  |                                                                                                                         |      | 35    | 55    |       |
| Fall Time                                                       | t <sub>f</sub>                       |                                                                                                                         |      | 68    | 110   |       |
| Turn-On Delay Time                                              | t <sub>d(on)</sub>                   | V <sub>DD</sub> = 30 V, R <sub>L</sub> = 1.3 Ω<br>I <sub>D</sub> ≅ 23 A, V <sub>GEN</sub> = 10 V, R <sub>g</sub> = 1 Ω  |      | 8     | 15    |       |
| Rise Time                                                       | t <sub>r</sub>                       |                                                                                                                         |      | 15    | 25    |       |
| Turn-Off Delay Time                                             | t <sub>d(off)</sub>                  |                                                                                                                         |      | 30    | 45    |       |
| Fall Time                                                       | t <sub>f</sub>                       |                                                                                                                         |      | 25    | 40    |       |
| Drain-Source Body Diode Characteristics                         |                                      |                                                                                                                         |      |       |       |       |
| Continuous Source-Drain Diode Current                           | I <sub>S</sub>                       | T <sub>C</sub> = 25 °C                                                                                                  |      |       | 20.8  | A     |
| Pulse Diode Forward Current <sup>a</sup>                        | I <sub>SM</sub>                      |                                                                                                                         |      |       | 50    |       |
| Body Diode Voltage                                              | V <sub>SD</sub>                      | I <sub>S</sub> = 15 A                                                                                                   |      | 1.0   | 1.5   | V     |
| Body Diode Reverse Recovery Time                                | t <sub>rr</sub>                      | I <sub>F</sub> = 15 A, dI/dt = 100 A/μs, T <sub>J</sub> = 25 °C                                                         |      | 30    | 60    | ns    |
| Body Diode Reverse Recovery Charge                              | Q <sub>rr</sub>                      |                                                                                                                         |      | 35    | 70    | nC    |
| Reverse Recovery Fall Time                                      | t <sub>a</sub>                       |                                                                                                                         |      | 20    |       | ns    |
| Reverse Recovery Rise Time                                      | t <sub>b</sub>                       |                                                                                                                         |      | 10    |       |       |

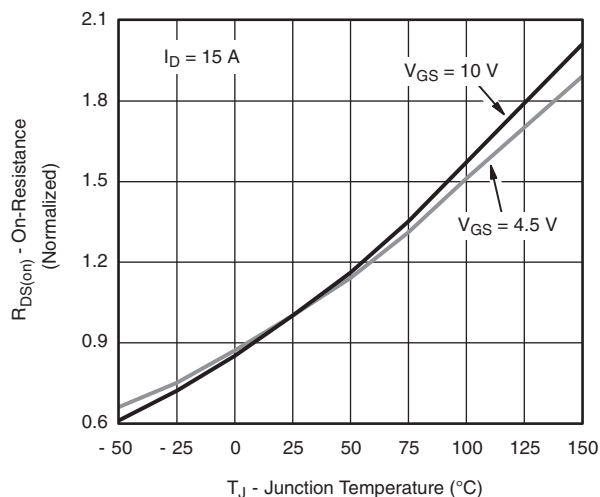
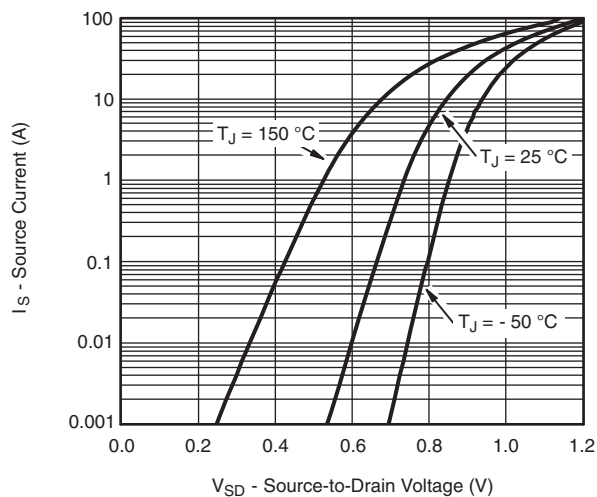
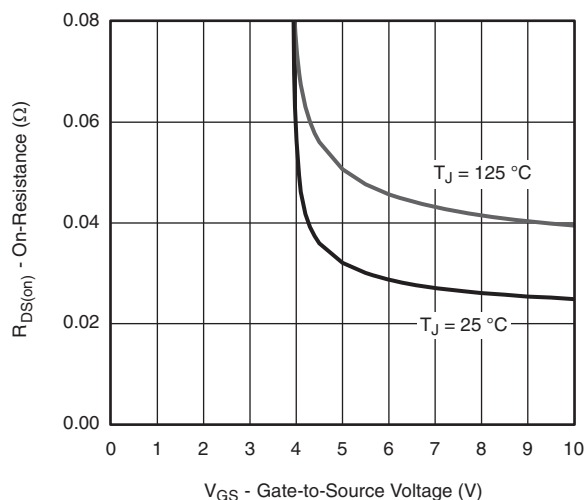
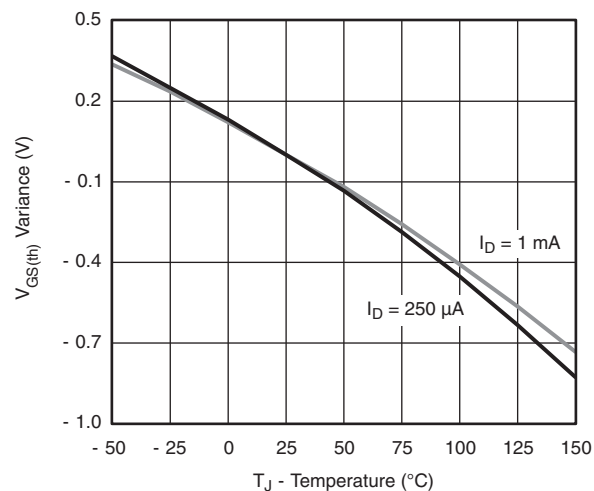
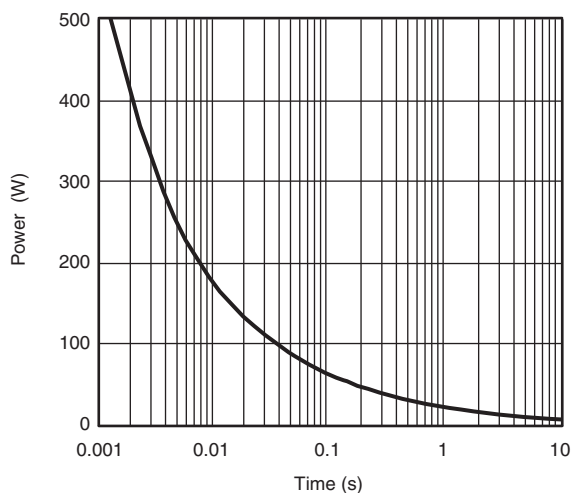
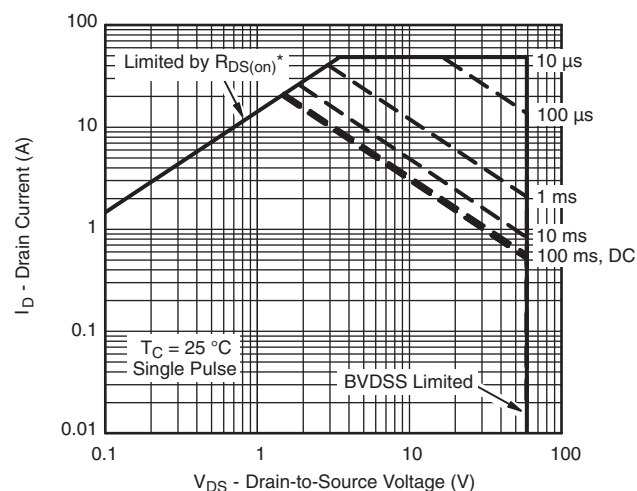
Notes:

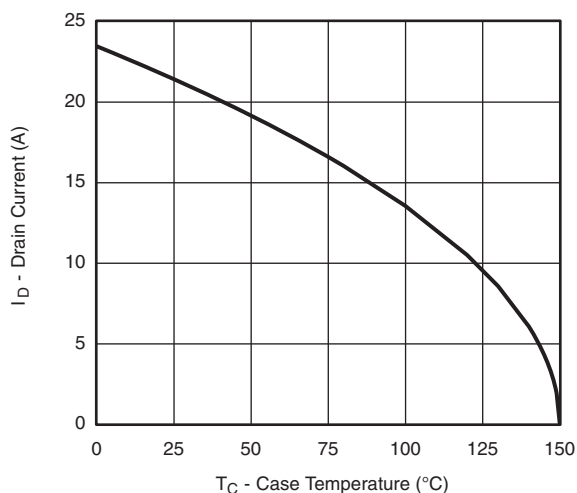
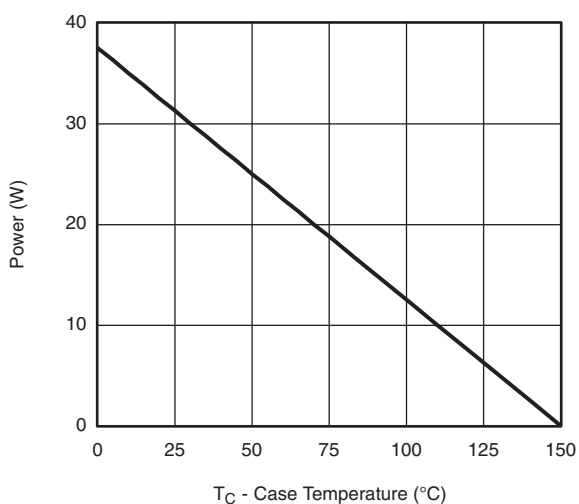
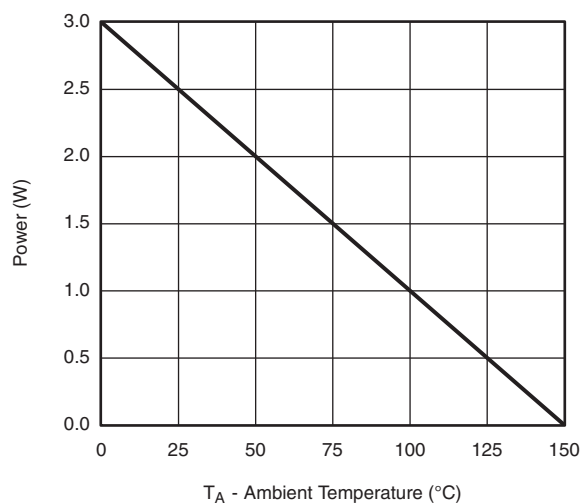
a. Pulse test; pulse width  $\leq 300\text{ }\mu\text{s}$ , duty cycle  $\leq 2\%$ .

b. Guaranteed by design, not subject to production testing.

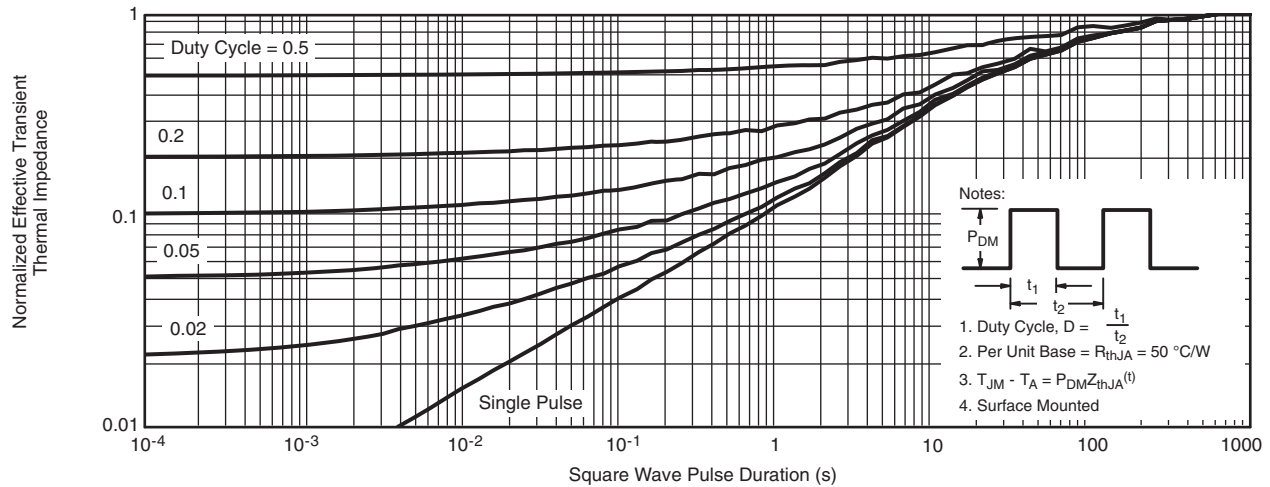
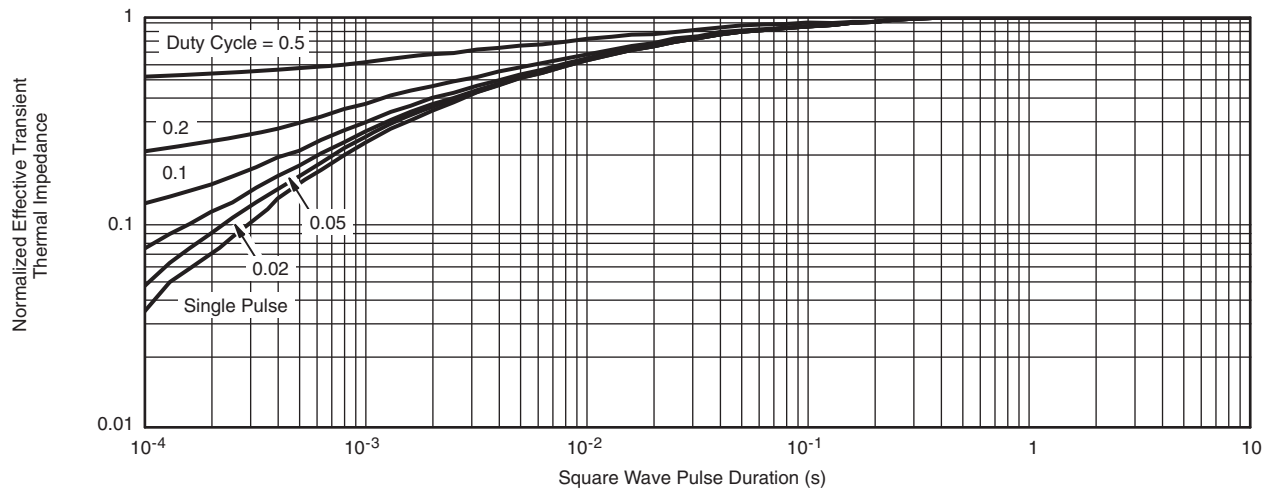
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

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

**Output Characteristics**

**Transfer Characteristics**

**Transconductance**

**On-Resistance vs. Drain Current**

**Capacitance**

**Gate Charge**

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)**On-Resistance vs. Junction Temperature****Source-Drain Diode Forward Voltage****On-Resistance vs. Gate-to-Source Voltage****Threshold Voltage****Single Pulse Power, Junction-to-Ambient**\*  $V_{GS} >$  minimum  $V_{GS}$  at which  $R_{DS(on)}$  is specified**Single Pulse Power, Junction-to-Case**

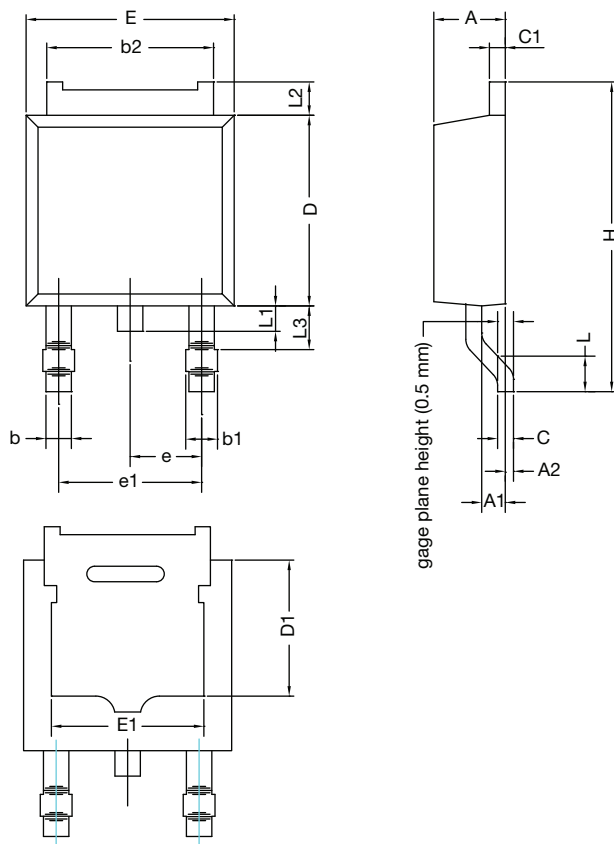
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**Current Derating\*, Junction-to-Case**

**Power, Junction-to-Case**

**Power, Junction-to-Ambient**

\* The power dissipation  $P_D$  is based on  $T_{J(max)} = 150$  °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit.

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)**Normalized Thermal Transient Impedance, Junction-to-Ambient****Normalized Thermal Transient Impedance, Junction-to-Case**

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## TO-252AA CASE OUTLINE

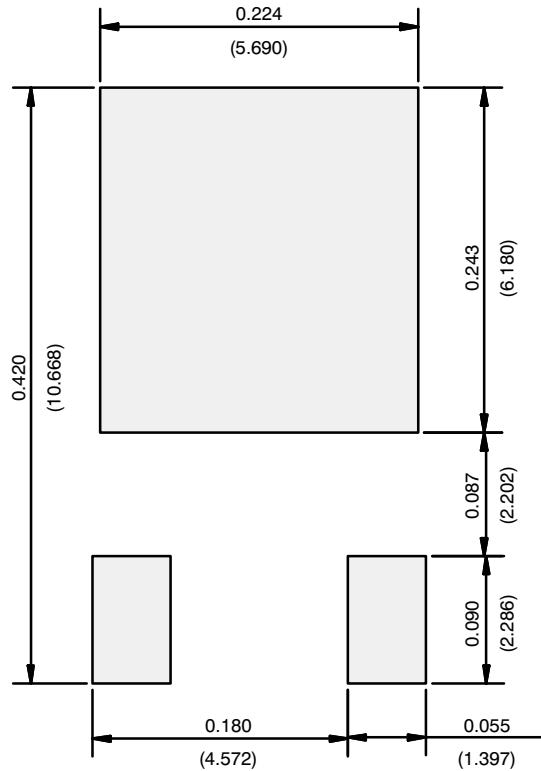


| DIM.                                         | MILLIMETERS |       | INCHES    |       |
|----------------------------------------------|-------------|-------|-----------|-------|
|                                              | MIN.        | MAX.  | MIN.      | MAX.  |
| A                                            | 2.21        | 2.38  | 0.087     | 0.094 |
| A1                                           | 0.89        | 1.14  | 0.035     | 0.045 |
| A2                                           | 0.030       | 0.127 | 0.001     | 0.005 |
| b                                            | 0.71        | 0.88  | 0.028     | 0.035 |
| b1                                           | 0.76        | 1.14  | 0.030     | 0.045 |
| b2                                           | 5.23        | 5.44  | 0.206     | 0.214 |
| C                                            | 0.46        | 0.58  | 0.018     | 0.023 |
| C1                                           | 0.46        | 0.58  | 0.018     | 0.023 |
| D                                            | 5.97        | 6.22  | 0.235     | 0.245 |
| D1                                           | 4.10        | 4.45  | 0.161     | 0.175 |
| E                                            | 6.48        | 6.73  | 0.255     | 0.265 |
| E1                                           | 4.49        | 5.50  | 0.177     | 0.217 |
| e                                            | 2.28 BSC    |       | 0.090 BSC |       |
| e1                                           | 4.57 BSC    |       | 0.180 BSC |       |
| H                                            | 9.65        | 10.41 | 0.380     | 0.410 |
| L                                            | 1.40        | 1.78  | 0.055     | 0.070 |
| L1                                           | 0.64        | 1.02  | 0.025     | 0.040 |
| L2                                           | 0.89        | 1.27  | 0.035     | 0.050 |
| L3                                           | 1.15        | 1.52  | 0.040     | 0.060 |
| ECN: T11-0110-Rev. L, 18-Apr-11<br>DWG: 5347 |             |       |           |       |

### Note

- Dimension L3 is for reference only.

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



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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