# P-Channel 20-V (D-S) MOSFET

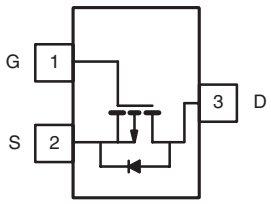
| MOSFET PRODUCT SUMMARY | | | |
|---|---|---|---|
| $V_{DS}$ (V) | $R_{DS(on)}$ (Ω) | $I_D$ (A)[a] | $Q_g$ (Typ.) |
| - 20 | 0.115 at $V_{GS}$ = - 4.5 V | - 3.0 | 3.2 nC |
| | 0.205 at $V_{GS}$ = - 2.5 V | - 2.2 | |

## FEATURES

- **Halogen-free Option Available**
- TrenchFET® Power MOSFET
- PWM Optimized
- 100 % $R_g$ Tested

Pb-free
RoHS COMPLIANT

**TO-236**
**(SOT-23)**




Top View
Si2351DS (G1)*
* Marking Code

**Ordering Information:** Si2351DS-T1-E3 (Lead (Pb)-free)
Si2351DS-T1-GE3 (Lead (Pb)-free and Halogen-free)

| ABSOLUTE MAXIMUM RATINGS $T_A$ = 25 °C, unless otherwise noted | | | | |
|---|---|---|---|---|
| **Parameter** | | **Symbol** | **Limit** | **Unit** |
| Drain-Source Voltage | | $V_{DS}$ | - 20 | V |
| Gate-Source Voltage | | $V_{GS}$ | ± 12 | |
| Continuous Drain Current ($T_J$ = 150 °C) | $T_C$ = 25 °C | $I_D$ | - 2.8 | A |
| | $T_C$ = 70 °C | | - 2.4 | |
| | $T_A$ = 25 °C | | - 2.2[b, c] | |
| | $T_A$ = 70 °C | | - 1.8[b, c] | |
| Pulsed Drain Current | | $I_{DM}$ | - 10 | |
| Continuous Source-Drain Diode Current | $T_C$ = 25 °C | $I_S$ | - 2.0 | |
| | $T_A$ = 25 °C | | - 0.91[b, c] | |
| Maximum Power Dissipation | $T_C$ = 25 °C | $P_D$ | 2.1 | W |
| | $T_C$ = 70 °C | | 1.5 | |
| | $T_A$ = 25 °C | | 1.0[b, c] | |
| | $T_A$ = 70 °C | | 0.7[b, c] | |
| Operating Junction and Storage Temperature Range | | $T_J$, $T_{stg}$ | - 55 to 150 | °C |

| THERMAL RESISTANCE RATINGS | | | | | |
|---|---|---|---|---|---|
| **Parameter** | | **Symbol** | **Typical** | **Maximum** | **Unit** |
| Maximum Junction-to-Ambient[b, d] | ≤ 5 s | $R_{thJA}$ | 90 | 115 | °C/W |
| Maximum Junction-to-Foot (Drain) | Steady State | $R_{thJF}$ | 60 | 75 | |

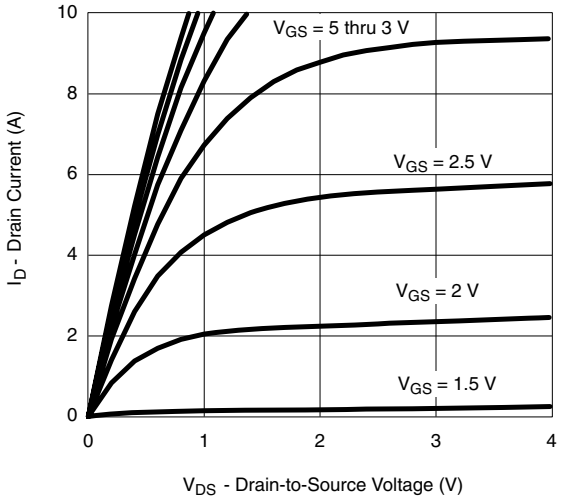
Notes:
a. Based on $T_C$ = 25 °C.
b. Surface Mounted on 1" x 1" FR4 board.
c. t = 5 s.
d. Maximum under Steady State conditions is 130 °C/W.

| **MOSFET SPECIFICATIONS** $T_J$ = 25 °C, unless otherwise noted | | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Symbol** | **Test Conditions** | **Min.** | **Typ.** | **Max.** | **Unit** |
| **Static** | | | | | | |
| Drain-Source Breakdown Voltage | $V_{DS}$ | $V_{DS}$ = 0 V, $I_D$ = - 250 µA | - 20 | | | V |
| $V_{DS}$ Temperature Coefficient | $\Delta V_{DS}/T_J$ | $I_D$ = - 250 µA | | - 16.7 | | mV/°C |
| $V_{GS(th)}$ Temperature Coefficient | $\Delta V_{GS(th)}/T_J$ | | | 2.1 | | |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = - 250 µA | - 0.6 | | - 1.5 | V |
| Gate-Source Leakage | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ± 12 V | | | ± 100 | nA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{DS}$ = - 20 V, $V_{GS}$ = 0 V | | | - 1 | µA |
| | | $V_{DS}$ = - 20 V, $V_{GS}$ = 0 V, $T_J$ = 55 °C | | | - 10 | |
| On-State Drain Current[a] | $I_{D(on)}$ | $V_{DS} \geq$ - 5 V, $V_{GS}$ = - 4.5 V | - 10 | | | A |
| Drain-Source On-State Resistance[a] | $R_{DS(on)}$ | $V_{GS}$ = - 4.5 V, $I_D$ = - 2.4 A | | 0.092 | 0.115 | Ω |
| | | $V_{GS}$ = - 2.5 V, $I_D$ = - 1.8 A | | 0.164 | 0.205 | |
| Forward Transconductance[a] | $g_{fs}$ | $V_{DS}$ = - 10 V, $I_D$ = - 2.4 A | | 5.5 | | S |
| **Dynamic[b]** | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{DS}$ = - 10 V, $V_{GS}$ = 0 V, f = 1 MHz | | 250 | | pF |
| Output Capacitance | $C_{oss}$ | | | 80 | | |
| Reverse Transfer Capacitance | $C_{rss}$ | | | 55 | | |
| Total Gate Charge | $Q_g$ | $V_{DS}$ = - 10 V, $V_{GS}$ = - 5.0 V, $I_D$ = - 2.4 A | | 3.4 | 5.1 | nC |
| | | $V_{DS}$ = - 10 V, $V_{GS}$ = - 4.5 V, $I_D$ = - 2.4 A | | 3.2 | 5 | |
| Gate-Source Charge | $Q_{gs}$ | | | 0.5 | | |
| Gate-Drain Charge | $Q_{gd}$ | | | 1.4 | | |
| Gate Resistance | $R_g$ | f = 1 MHz | | 8.5 | 13 | Ω |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD}$ = - 10 V, $R_L$ = 5.26 Ω<br>$I_D \cong$ - 1.9 A, $V_{GEN}$ = - 4.5 V, $R_G$ = 1 Ω | | 9 | 14 | ns |
| Rise Time | $t_r$ | | | 30 | 45 | |
| Turn-Off Delay Time | $t_{d(off)}$ | | | 32 | 48 | |
| Fall Time | $t_f$ | | | 16 | 24 | |
| **Drain-Source Body Diode Characteristics** | | | | | | |
| Continuous Source-Drain Diode Current | $I_S$ | $T_C$ = 25 °C | | | - 2.0 | A |
| Pulse Diode Forward Current[a] | $I_{SM}$ | | | | - 10 | |
| Body Diode Voltage | $V_{SD}$ | $I_S$ = - 2.0 A | | - 0.8 | - 1.2 | V |
| Body Diode Reverse Recovery Time | $t_{rr}$ | $I_F$ = - 2.0 A, di/dt = 100 A/µs, $T_J$ = 25 °C | | 17 | 26 | ns |
| Body Diode Reverse Recovery Charge | $Q_{rr}$ | | | 5 | 8 | nC |
| Reverse Recovery Fall Time | $t_a$ | | | 14 | | ns |
| Reverse Recovery Rise Time | $t_b$ | | | 3 | | |

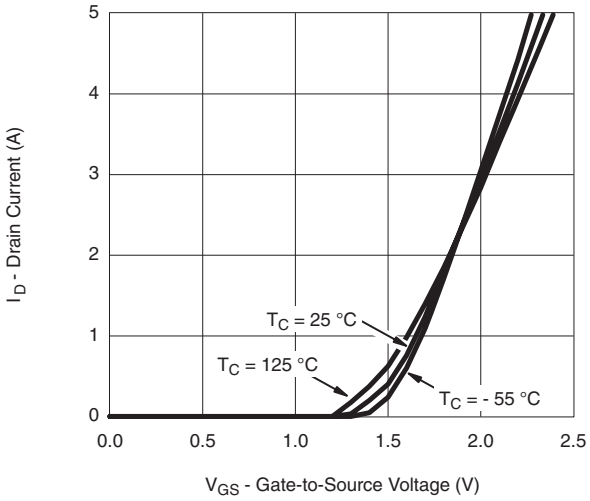
Notes:
a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %.
b. Guaranteed by design, not subject to production testing.

*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.*

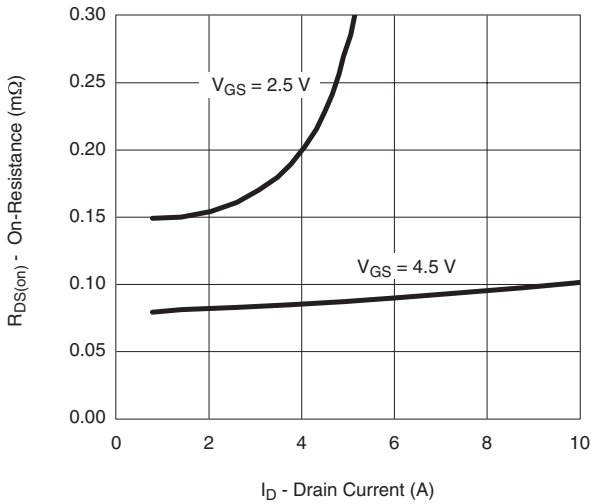
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



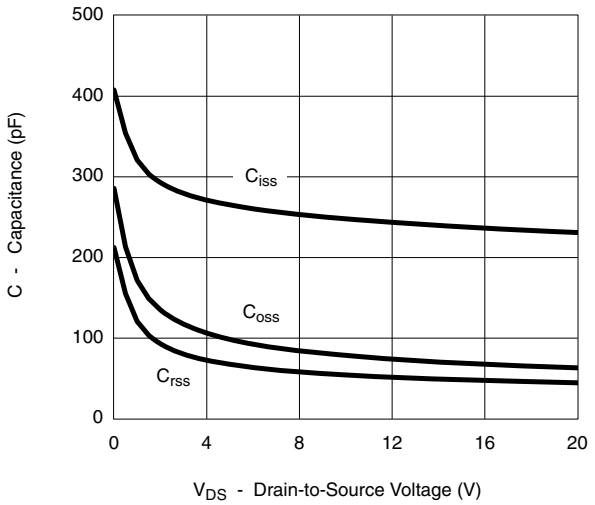

**Output Characteristics**



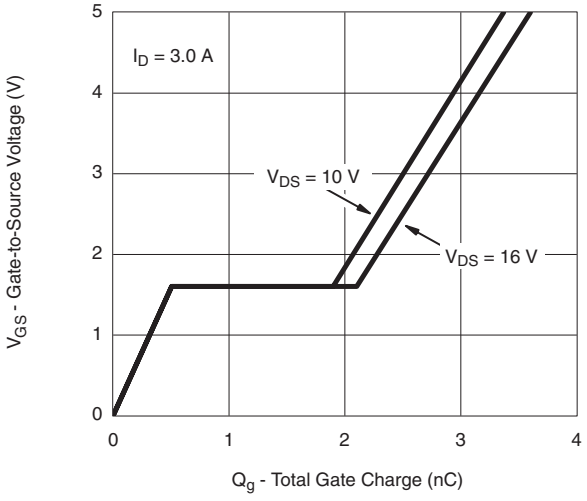

**Transfer Characteristics**



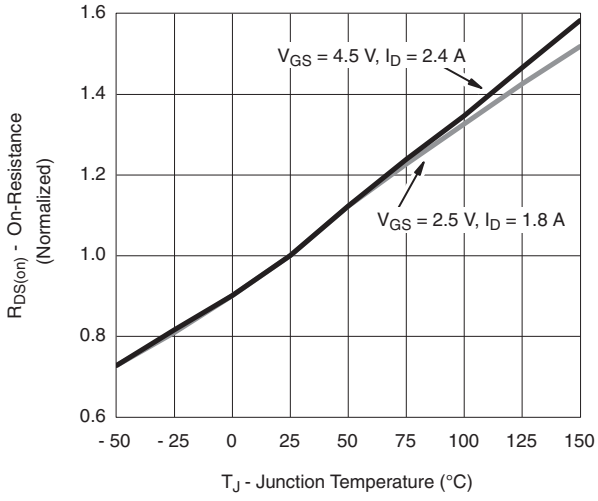

**On-Resistance vs. Drain Current and Gate Voltage**




**Capacitance**

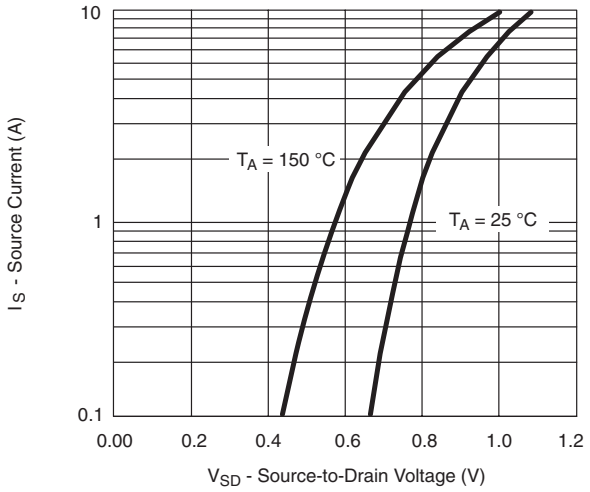



**Gate Charge**

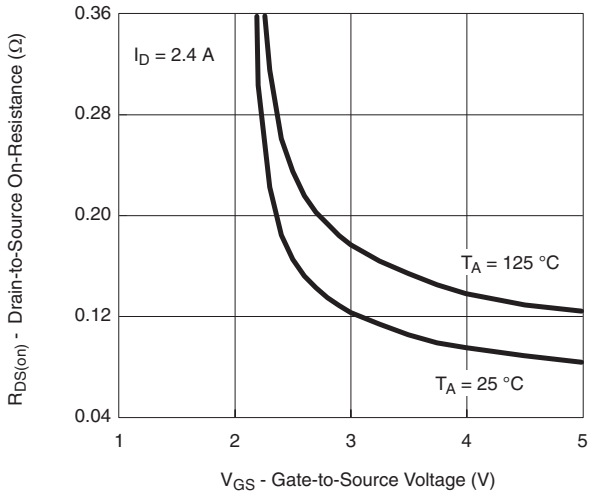



**On-Resistance vs. Junction Temperature**

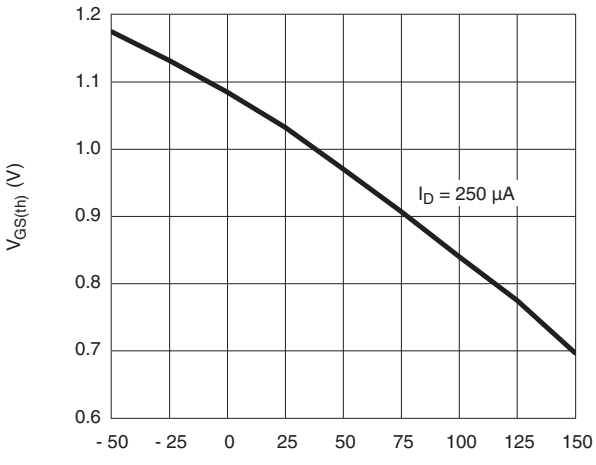
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



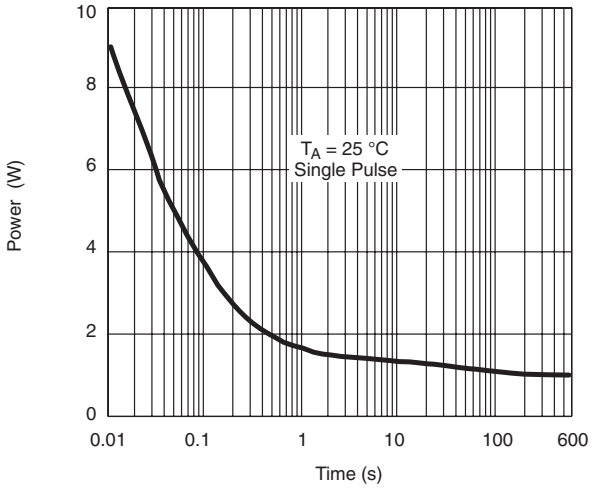

**Source-Drain Diode Forward Voltage**



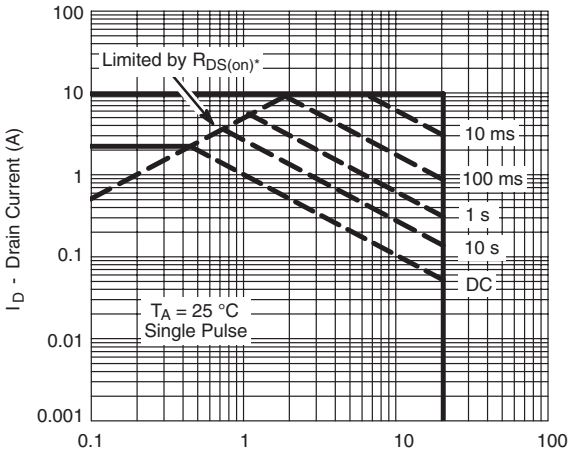

**On-Resistance vs. Gate-to-Source Voltage**




**Threshold Voltage**



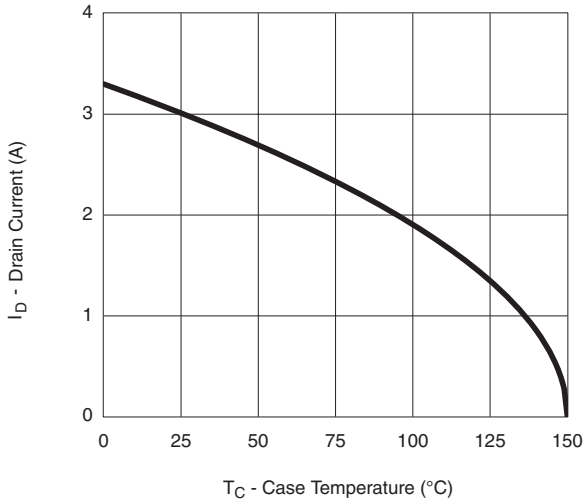

**Single Pulse Power**



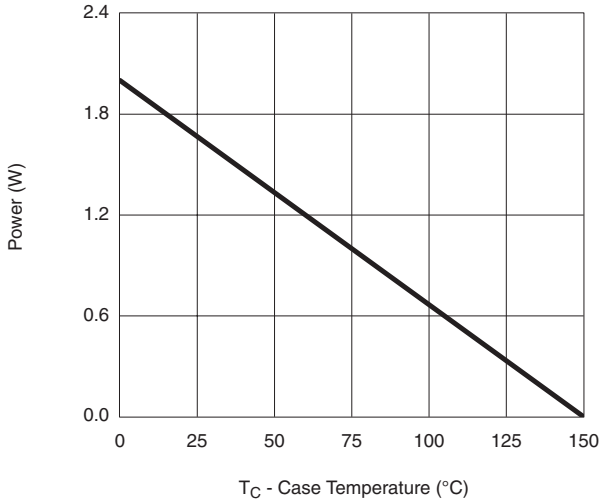

* $V_{GS}$ > minimum $V_{GS}$ at which $R_{DS(on)}$ is specified

**Safe Operating Area**

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



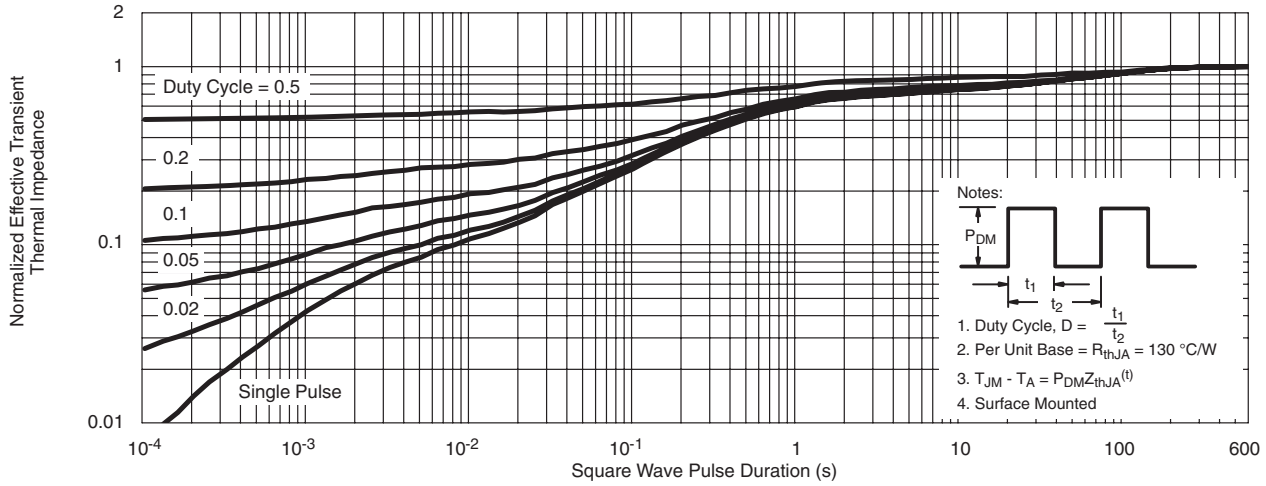

**Current Derating***



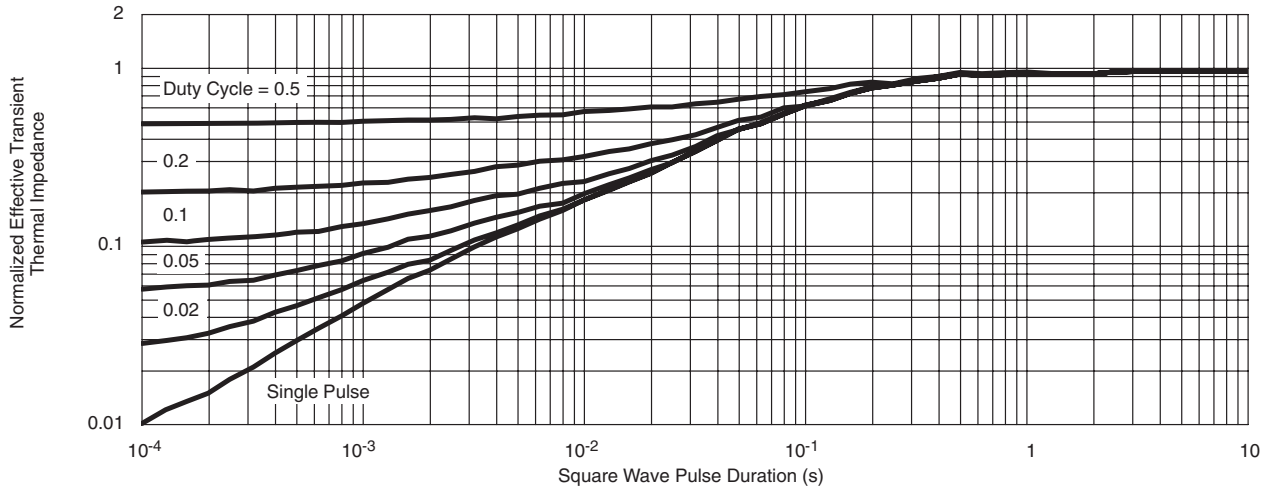

**Power Derating, Junction-to-Foot**

* 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



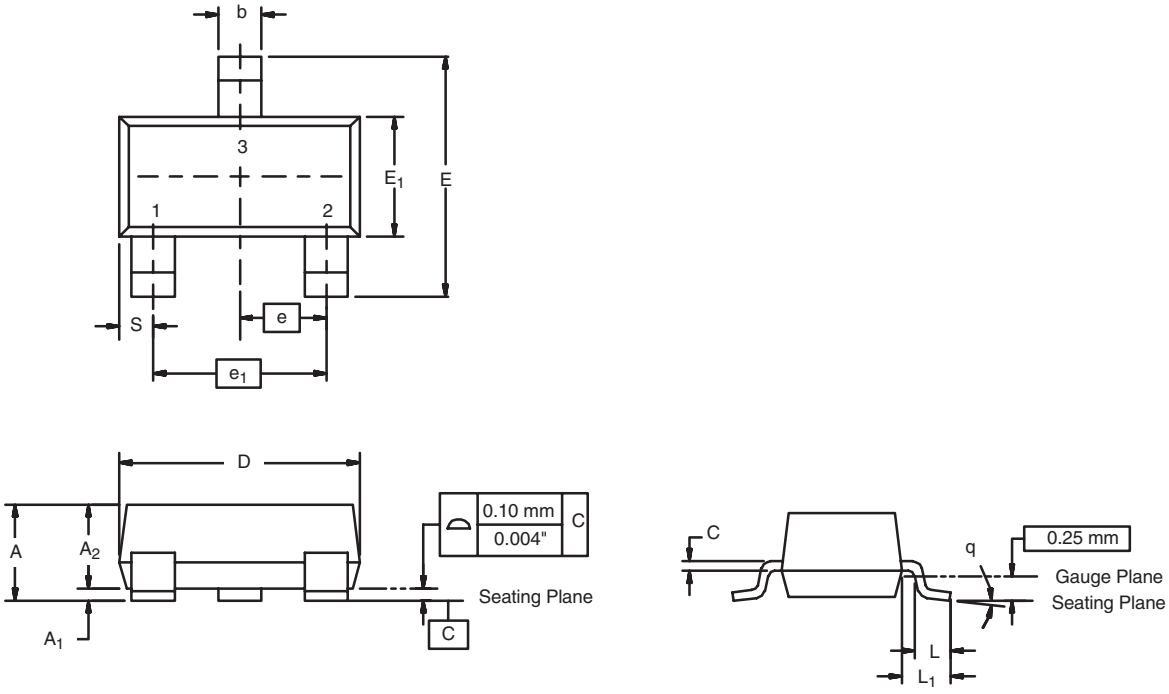

**Normalized Thermal Transient Impedance, Junction-to-Ambient**




**Normalized Thermal Transient Impedance, Junction-to-Foot**

*Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see http://www.vishay.com/ppg?73702*

## SOT-23 (TO-236): 3-LEAD




| Dim | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.89 | 1.12 | 0.035 | 0.044 |
| $A_1$ | 0.01 | 0.10 | 0.0004 | 0.004 |
| $A_2$ | 0.88 | 1.02 | 0.0346 | 0.040 |
| b | 0.35 | 0.50 | 0.014 | 0.020 |
| c | 0.085 | 0.18 | 0.003 | 0.007 |
| D | 2.80 | 3.04 | 0.110 | 0.120 |
| E | 2.10 | 2.64 | 0.083 | 0.104 |
| $E_1$ | 1.20 | 1.40 | 0.047 | 0.055 |
| e | 0.95 BSC | | 0.0374 Ref | |
| $e_1$ | 1.90 BSC | | 0.0748 Ref | |
| L | 0.40 | 0.60 | 0.016 | 0.024 |
| $L_1$ | 0.64 Ref | | 0.025 Ref | |
| S | 0.50 Ref | | 0.020 Ref | |
| q | 3° | 8° | 3° | 8° |
| ECN: S-03946-Rev. K, 09-Jul-01<br>DWG: 5479 | | | | |

# Mounting LITTLE FOOT® SOT-23 Power MOSFETs

*Wharton McDaniel*

Surface-mounted LITTLE FOOT power MOSFETs use integrated circuit and small-signal packages which have been been modified to provide the heat transfer capabilities required by power devices. Leadframe materials and design, molding compounds, and die attach materials have been changed, while the footprint of the packages remains the same.

See Application Note 826, *Recommended Minimum Pad Patterns With Outline Drawing Access for Vishay Siliconix MOSFETs*, (http://www.vishay.com/doc?72286), for the basis of the pad design for a LITTLE FOOT SOT-23 power MOSFET footprint . In converting this footprint to the pad set for a power device, designers must make two connections: an electrical connection and a thermal connection, to draw heat away from the package.

The electrical connections for the SOT-23 are very simple. Pin 1 is the gate, pin 2 is the source, and pin 3 is the drain. As in the other LITTLE FOOT packages, the drain pin serves the additional function of providing the thermal connection from the package to the PC board. The total cross section of a copper trace connected to the drain may be adequate to carry the current required for the application, but it may be inadequate thermally. Also, heat spreads in a circular fashion from the heat source. In this case the drain pin is the heat source when looking at heat spread on the PC board.

Figure 1 shows the footprint with copper spreading for the SOT-23 package. This pattern shows the starting point for utilizing the board area available for the heat spreading copper. To create this pattern, a plane of copper overlies the drain pin and provides planar copper to draw heat from the drain lead and start the process of spreading the heat so it can be dissipated into the ambient air. This pattern uses all the available area underneath the body for this purpose.

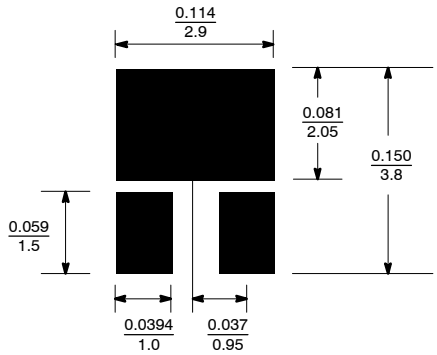
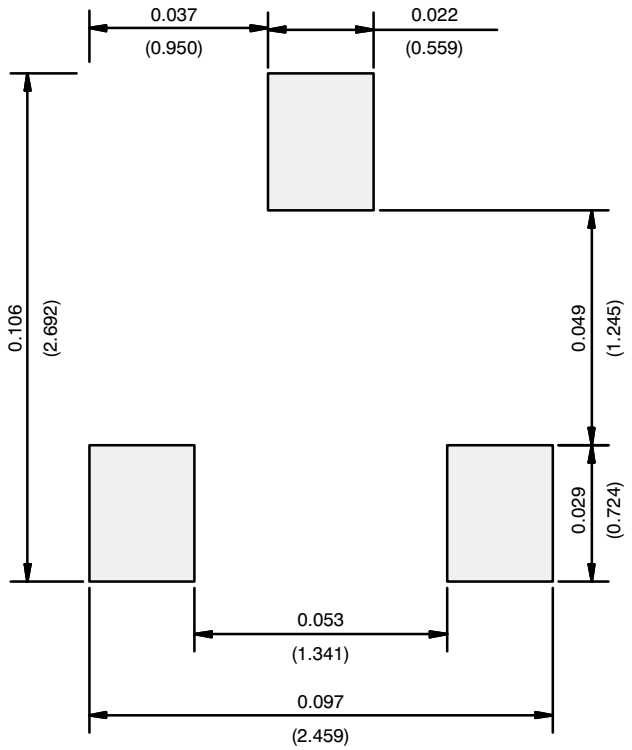



**FIGURE 1.** Footprint With Copper Spreading

Since surface-mounted packages are small, and reflow soldering is the most common way in which these are affixed to the PC board, “thermal” connections from the planar copper to the pads have not been used. Even if additional planar copper area is used, there should be no problems in the soldering process. The actual solder connections are defined by the solder mask openings. By combining the basic footprint with the copper plane on the drain pins, the solder mask generation occurs automatically.

A final item to keep in mind is the width of the power traces. The absolute minimum power trace width must be determined by the amount of current it has to carry. For thermal reasons, this minimum width should be at least 0.020 inches. The use of wide traces connected to the drain plane provides a low-impedance path for heat to move away from the device.

## RECOMMENDED MINIMUM PADS FOR SOT-23




Recommended Minimum Pads
Dimensions in Inches/(mm)

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