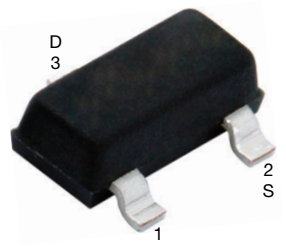
# P-Channel 20 V (D-S) MOSFET

SC-70 (3 leads)
SOT-323




Top View

**Marking code:** LK

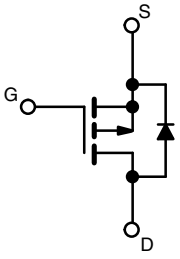
## FEATURES

- TrenchFET® power MOSFET
- 100 % $R_g$ tested
- Material categorization:
  for definitions of compliance please see
  www.vishay.com/doc?99912

Pb-free
RoHS COMPLIANT
HALOGEN FREE

## APPLICATIONS

- Load switch
- DC/DC converters




P-Channel MOSFET

| PRODUCT SUMMARY | |
|---|---|
| $V_{DS}$ (V) | -20 |
| $R_{DS(on)}$ max. (Ω) at $V_{GS}$ = -4.5 V | 0.150 |
| $R_{DS(on)}$ max. (Ω) at $V_{GS}$ = -2.5 V | 0.192 |
| $R_{DS(on)}$ max. (Ω) at $V_{GS}$ = -1.8 V | 0.270 |
| $Q_g$ typ. (nC) | 4.3 |
| $I_D$ (A) [c] | -1.4 |
| Configuration | Single |

| ORDERING INFORMATION | |
|---|---|
| Package | SC-70 |
| Lead (Pb)-free and halogen-free | Si1317DL-T1-GE3 |

**ABSOLUTE MAXIMUM RATINGS** ($T_A$ = 25 °C, unless otherwise noted)

| PARAMETER | | SYMBOL | LIMIT | UNIT |
|---|---|---|---|---|
| Drain-source voltage | | $V_{DS}$ | -20 | V |
| Gate-source voltage | | $V_{GS}$ | ± 8 | |
| Continuous drain current ($T_J$ = 150 °C) | $T_C$ = 25 °C | $I_D$ | -1.4 | A |
| | $T_C$ = 70 °C | | -1.1 | |
| | $T_A$ = 25 °C | | -1.4 [a, b] | |
| | $T_A$ = 70 °C | | -1.1 [a, b] | |
| Pulsed drain current | | $I_{DM}$ | -6 | |
| Continuous source-drain diode current | $T_C$ = 25 °C | $I_S$ | -0.4 | |
| | $T_A$ = 25 °C | | -0.3 | |
| Maximum power dissipation | $T_C$ = 25 °C | $P_D$ | 0.5 | W |
| | $T_C$ = 70 °C | | 0.3 | |
| | $T_A$ = 25 °C | | 0.4 [a, b] | |
| | $T_A$ = 70 °C | | 0.3 [a, b] | |
| Operating junction and storage temperature range | | $T_J$, $T_{stg}$ | -50 to +150 | °C |
| Soldering recommendations (peak temperature) | | | 260 | |

**THERMAL RESISTANCE RATINGS**

| PARAMETER | | SYMBOL | TYPICAL | MAXIMUM | UNIT |
|---|---|---|---|---|---|
| Maximum junction-to-ambient [a, d] | t ≤ 10 s | $R_{thJA}$ | 250 | 300 | °C/W |
| Maximum junction-to-foot (drain) | Steady state | $R_{thJF}$ | 225 | 270 | |

**Notes**

a. Surface mounted on 1" x 1" FR4 board
b. t = 10 s
c. Based on $T_C$ = 25 °C
d. Maximum under steady state conditions is 360 °C/W

| **SPECIFICATIONS** ($T_J$ = 25 °C, unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Static** | | | | | | |
| Drain-source breakdown voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = -250 µA | -20 | - | - | V |
| $V_{DS}$ temperature coefficient | $\Delta V_{DS}/T_J$ | $I_D$ = -250 µA | - | -14 | - | mV/°C |
| $V_{GS(th)}$ temperature coefficient | $\Delta V_{GS(th)}/T_J$ | | - | 2.4 | - | |
| Gate-source threshold voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = -250 µA | -0.45 | - | -0.8 | V |
| Gate-source leakage | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ± 8 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] | $I_{D(on)}$ | $V_{DS} \leq$ -5 V, $V_{GS}$ = -4.5 V | -2 | - | - | A |
| Drain-source on-state resistance [a] | $R_{DS(on)}$ | $V_{GS}$ = -4.5 V, $I_D$ = -1.4 A | - | 0.125 | 0.150 | Ω |
| | | $V_{GS}$ = -2.5 V, $I_D$ = -1.2 A | - | 0.160 | 0.192 | |
| | | $V_{GS}$ = -1.8 V, $I_D$ = -0.3 A | - | 0.180 | 0.270 | |
| Forward transconductance [a] | $g_{fs}$ | $V_{DS}$ = -5 V, $I_D$ = -1.4 A | - | 5 | - | S |
| **Dynamic [b]** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{DS}$ = -10 V, $V_{GS}$ = 0 V, f = 1 MHz | - | 272 | - | pF |
| Output capacitance | $C_{oss}$ | | - | 55 | - | |
| Reverse transfer capacitance | $C_{rss}$ | | - | 44 | - | |
| Total gate charge | $Q_g$ | $V_{DS}$ = -10 V, $V_{GS}$ = -4.5 V, $I_D$ = -1.4 A | - | 4.3 | 6.5 | nC |
| | | $V_{DS}$ = -10 V, $V_{GS}$ = -2.5 V, $I_D$ = -1.4 A | - | 2.7 | 4.1 | |
| Gate-source charge | $Q_{gs}$ | | - | 0.7 | - | |
| Gate-drain charge | $Q_{gd}$ | | - | 1 | - | |
| Gate resistance | $R_g$ | f = 1 MHz | 1.4 | 7 | 14 | Ω |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = -10 V, $R_L$ = 9.1 Ω<br>$I_D \cong$ -1.1 A, $V_{GEN}$ = -4.5 V, $R_g$ = 1 Ω | - | 12 | 20 | ns |
| Rise time | $t_r$ | | - | 20 | 30 | |
| Turn-off delay time | $t_{d(off)}$ | | - | 23 | 35 | |
| Fall time | $t_f$ | | - | 9 | 18 | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = -10 V, $R_L$ = 9.1 Ω<br>$I_D \cong$ -1.1 A, $V_{GEN}$ = -8 V, $R_g$ = 1 Ω | - | 5 | 10 | |
| Rise time | $t_r$ | | - | 10 | 20 | |
| Turn-off delay time | $t_{d(off)}$ | | - | 18 | 27 | |
| Fall time | $t_f$ | | - | 7 | 14 | |
| **Drain-Source Body Diode Characteristics** | | | | | | |
| Continuous source-drain diode current | $I_S$ | $T_C$ = 25 °C | - | - | -0.4 | A |
| Pulse diode forward current [a] | $I_{SM}$ | | - | - | -6 | |
| Body diode voltage | $V_{SD}$ | $I_F$ = -0.7 A | - | -0.8 | -1.2 | V |
| Body diode reverse recovery time | $t_{rr}$ | $I_F$ = -0.7 A, di/dt = 100 A/µs,<br>$T_J$ = 25 °C | - | 18 | 27 | ns |
| Body diode reverse recovery charge | $Q_{rr}$ | | - | 7 | 14 | nC |
| Reverse recovery fall time | $t_a$ | | - | 7 | - | ns |
| Reverse recovery rise time | $t_b$ | | - | 11 | - | |

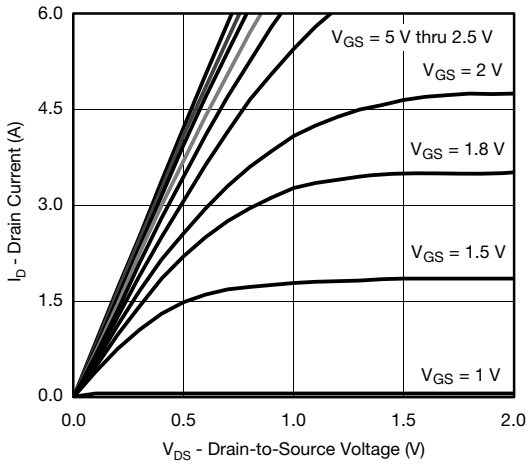
**Notes**

a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2%

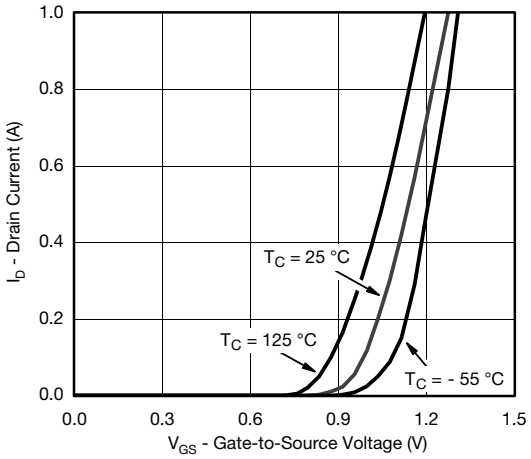
b. Guaranteed by design, not subject to production testing

*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*

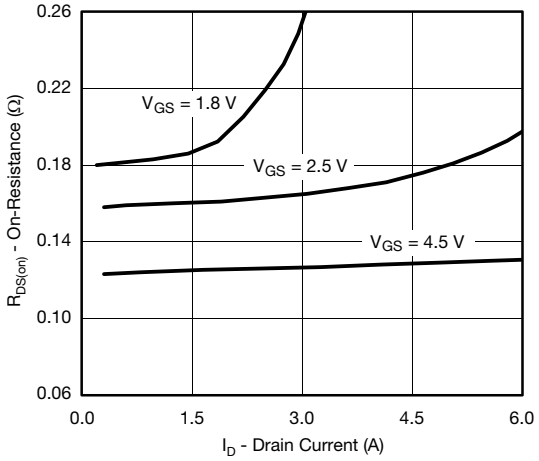
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



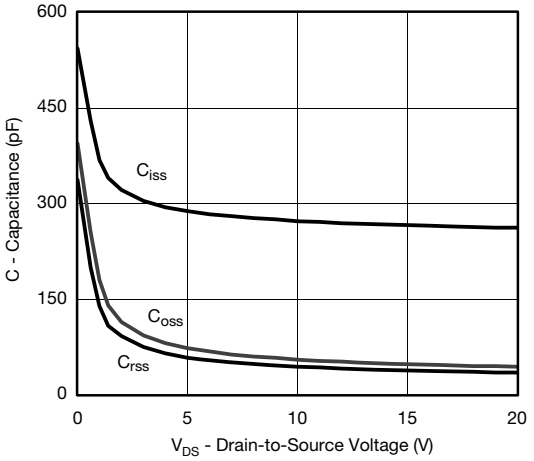

**Output Characteristics**



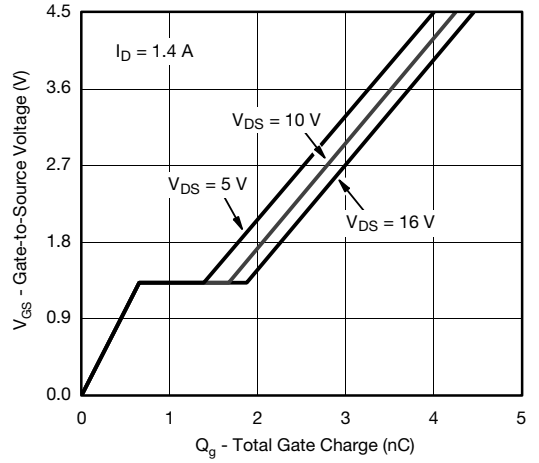

**Transfer Characteristics**



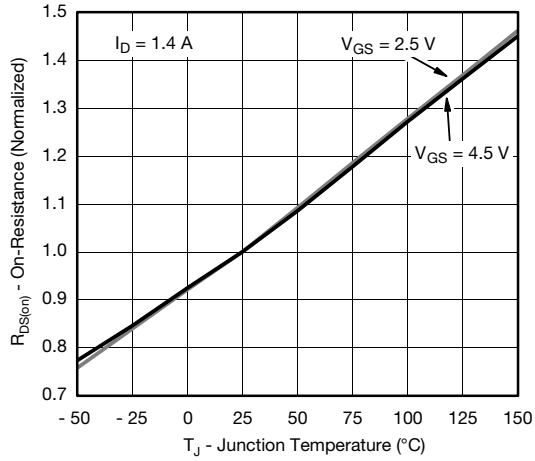

**On-Resistance vs. Drain Current**




**Capacitance**

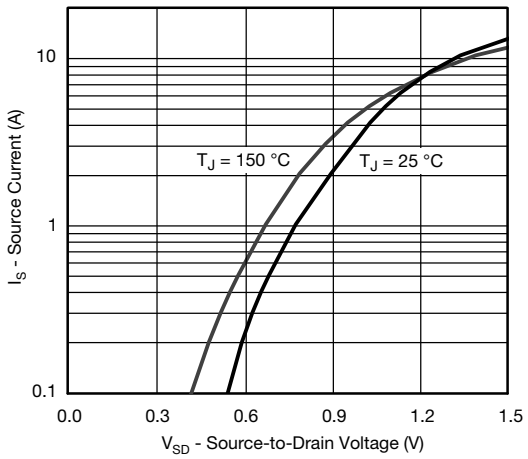



**Gate Charge**

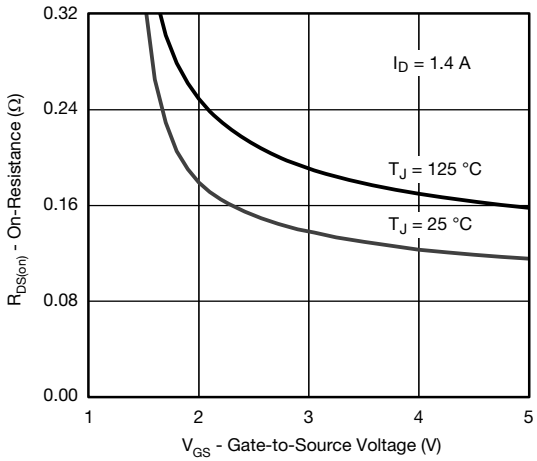



**On-Resistance vs. Junction Temperature**

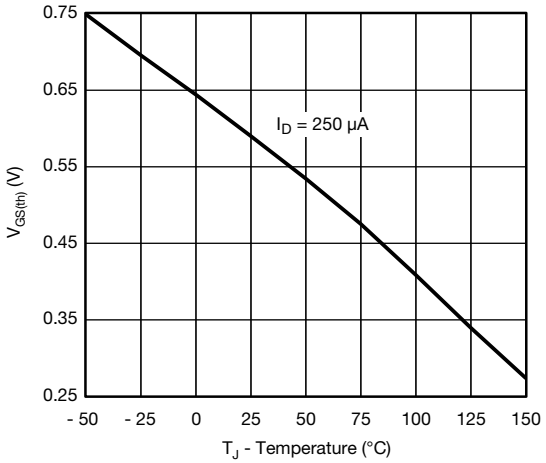
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



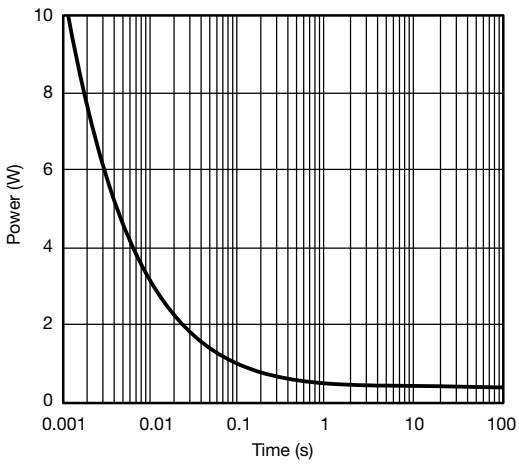

**Source-Drain Diode Forward Voltage**



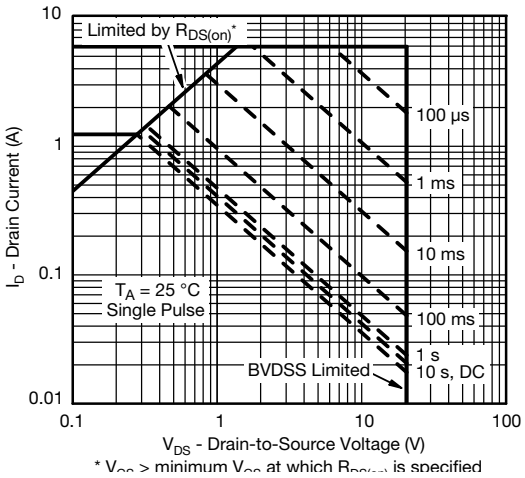

**On-Resistance vs. Gate-to-Source Voltage**




**Threshold Voltage**

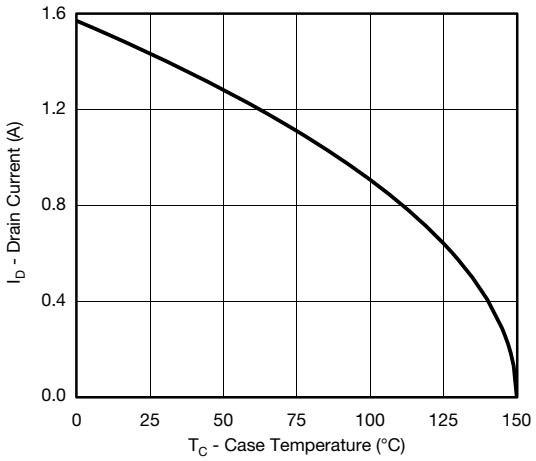



**Single Pulse Power, Junction-to-Ambient**

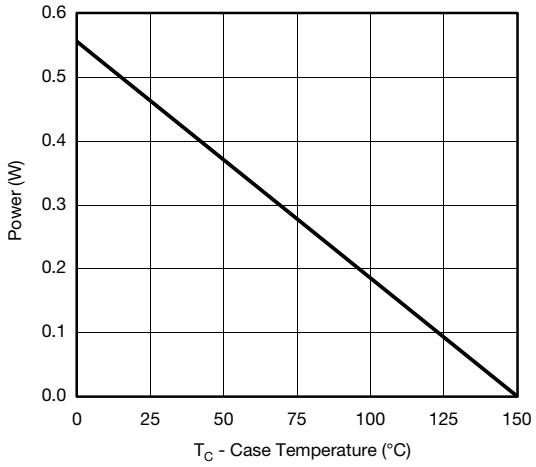



**Safe Operating Area, Junction-to-Ambient**

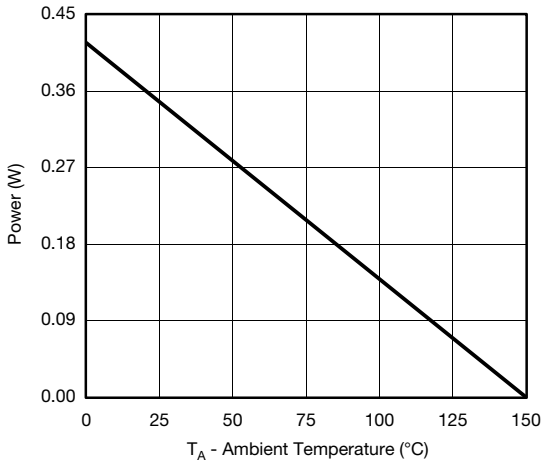
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)




**Current Derating** [a]




**Power, Junction-to-Case**

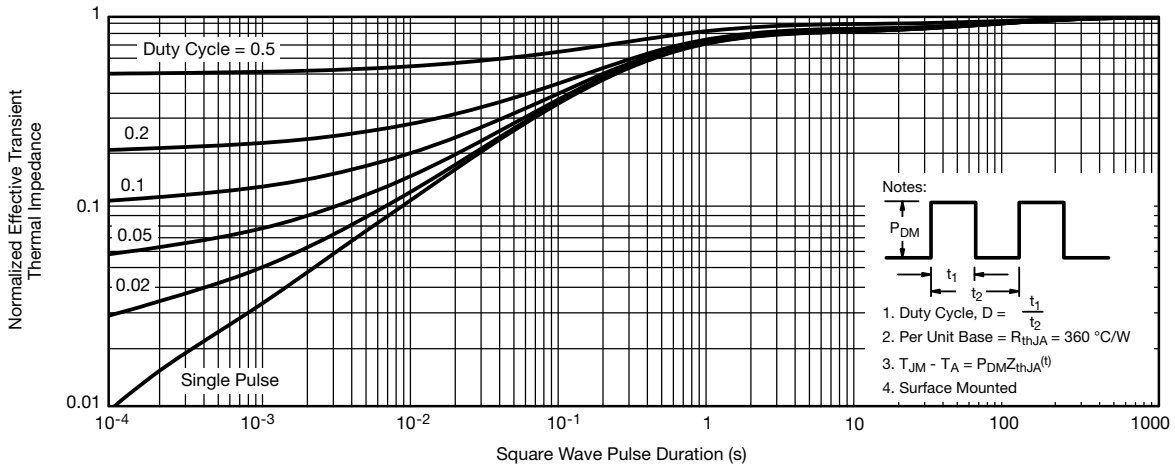



**Power, Junction-to-Ambient**

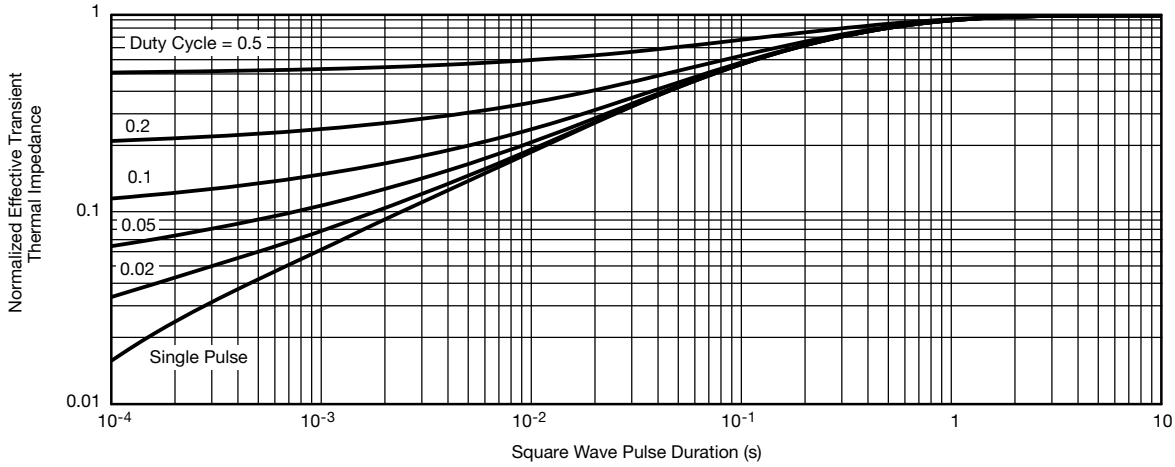
**Note**

a. 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)



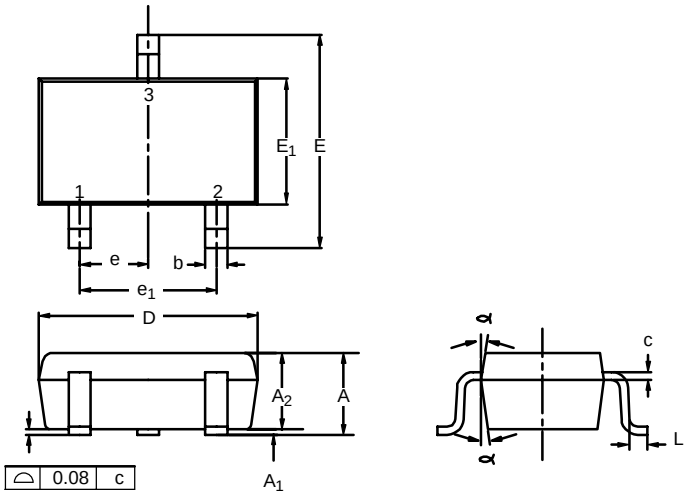

**Normalized Thermal Transient Impedance, Junction-to-Ambient**




**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 www.vishay.com/ppg?67194.*

## SC-70: 3-LEADS




| Dim | MILLIMETERS | | | INCHES | | |
|---|---|---|---|---|---|---|
| | Min | Nom | Max | Min | Nom | Max |
| A | 0.90 | – | 1.10 | 0.035 | – | 0.043 |
| $A_1$ | – | – | 0.10 | – | – | 0.004 |
| $A_2$ | 0.80 | – | 1.00 | 0.031 | – | 0.039 |
| b | 0.25 | – | 0.40 | 0.010 | – | 0.016 |
| c | 0.10 | – | 0.25 | 0.004 | – | 0.010 |
| D | 1.80 | 2.00 | 2.20 | 0.071 | 0.079 | 0.087 |
| E | 1.80 | 2.10 | 2.40 | 0.071 | 0.083 | 0.094 |
| $E_1$ | 1.15 | 1.25 | 1.35 | 0.045 | 0.049 | 0.053 |
| e | 0.65BSC | | | 0.026BSC | | |
| $e_1$ | 1.20 | 1.30 | 1.40 | 0.047 | 0.051 | 0.055 |
| L | 0.10 | 0.20 | 0.30 | 0.004 | 0.008 | 0.012 |
| α | 7°Nom | | | 7°Nom | | |

ECN: S-03946—Rev. C, 09-Jul-01
DWG: 5549

# Single-Channel LITTLE FOOT® SC-70 3-Pin and 6-Pin MOSFET Recommended Pad Pattern and Thermal Peformance

## INTRODUCTION

This technical note discusses pin-outs, package outlines, pad patterns, evaluation board layout, and thermal performance for single-channel LITTLE FOOT power MOSFETs in the SC-70 package. These new Vishay Siliconix devices are intended for small-signal applications where a miniaturized package is needed and low levels of current (around 350 mA) need to be switched, either directly or by using a level shift configuration. Vishay provides these single devices with a range of on-resistance specifications and in both traditional 3-pin and new 6-pin versions. The new 6-pin SC-70 package enables improved on-resistance values and enhanced thermal performance compared to the 3-pin package.

## PIN-OUT

Figure 1 shows the pin-out description and Pin 1 identification for the single-channel SC-70 device in both 3-pin and 6-pin configurations. The pin-out of the 6-pin device allows the use of four pins as drain leads, which helps to reduce on-resistance and junction-to-ambient thermal resistance.

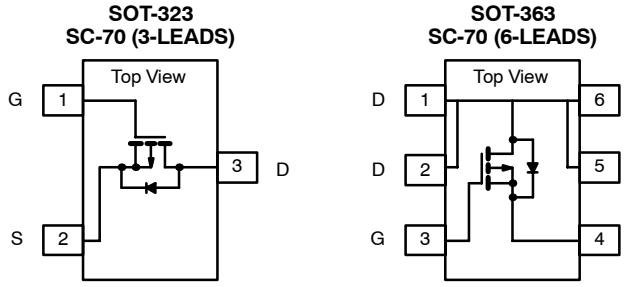



**FIGURE 1.**

For package dimensions see outline drawings:
SC-70 (3-Leads) (http://www.vishay.com/doc?71153)
SC-70 (6-Leads) (http://www.vishay.com/doc?71154)

## BASIC PAD PATTERNS

See Application Note 826, *Recommended Minimum Pad Patterns With Outline Drawing Access for Vishay Siliconix MOSFETs*, (http://www.vishay.com/doc?72286) for the basic pad layout and dimensions for the 3-pin SC-70 and the 6-pin SC-70. These pad patterns are sufficient for the low-power applications for which this package is intended. Increasing the pad pattern has little effect on thermal resistance for the 3-pin device, reducing it by only 10% to 15%. But for the 6-pin device, increasing the pad patterns yields a reduction in thermal resistance on the order of 35% when using a 1-inch square with full copper on both sides of the printed circuit board (PCB). The availability of four drain leads rather than the traditional single drain lead allows a better thermal path from the package to the PCB and external environment.

## EVALUATION BOARDS FOR THE SINGLE SC70-3 AND SC70-6

Figure 2 shows the 3-pin and 6-pin SC-70 evaluation boards (EVB). Both measure 0.6 inches by 0.5 inches. Their copper pad traces are the same as described in the previous section, *Basic Pad Patterns*. Both boards allow interrogation from the outer pins to 6-pin DIP connections, permitting test sockets to be used in evaluation testing.

The thermal performance of the single SC-70 has been measured on the EVB for both the 3-pin and 6-pin devices, the results shown in Figures 3 and 4. The minimum recommended footprint on the evaluation board was compared with the industry standard of 1-inch square FR4 PCB with copper on both sides of the board.

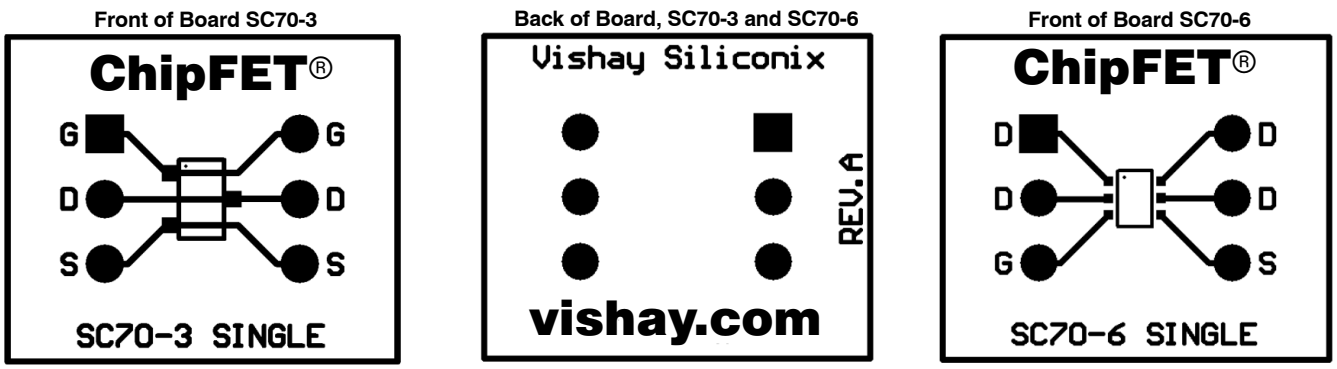



**FIGURE 2.**

## THERMAL PERFORMANCE

### Junction-to-Foot Thermal Resistance (the Package Performance)

Thermal performance for the 3-pin SC-70 measured as junction-to-foot thermal resistance is 285°C/W typical, 340°C/W maximum. Junction-to-foot thermal resistance for the 6-pin SC70-6 is 105°C/W typical, 130°C/W maximum — a nearly two-thirds reduction compared with the 3-pin device. The "foot" is the drain lead of the device as it connects with the body. This improved performance is obtained by the increase in drain leads from one to four on the 6-pin SC-70. Note that these numbers are somewhat higher than other LITTLE FOOT devices due to the limited thermal performance of the Alloy 42 lead-frame compared with a standard copper lead-frame.

### Junction-to-Ambient Thermal Resistance (dependent on PCB size)

The typical $R\theta_{JA}$ for the single 3-pin SC-70 is 360°C/W steady state, compared with 180°C/W for the 6-pin SC-70. Maximum ratings are 430°C/W for the 3-pin device versus 220°C/W for the 6-pin device. All figures are based on the 1-inch square FR4 test board.The following table shows how the thermal resistance impacts power dissipation for the two different pin-outs at two different ambient temperatures.

| SC-70 (3-PIN) | |
|---|---|
| **Room Ambient 25 °C** | **Elevated Ambient 60 °C** |
| $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$<br>$P_D = \frac{150°C - 25°C}{360°C/W}$<br>$P_D = 347\ mW$ | $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$<br>$P_D = \frac{150°C - 60°C}{360°C/W}$<br>$P_D = 250\ mW$ |

| SC-70 (6-PIN) | |
|---|---|
| **Room Ambient 25 °C** | **Elevated Ambient 60 °C** |
| $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$<br>$P_D = \frac{150°C - 25°C}{180°C/W}$<br>$P_D = 694\ mW$ | $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$<br>$P_D = \frac{150°C - 60°C}{180°C/W}$<br>$P_D = 500\ mW$ |

NOTE: Although they are intended for low-power applications, devices in the 6-pin SC-70 will handle power dissipation in excess of 0.5 W.

### Testing

To aid comparison further, Figures 3 and 4 illustrate single-channel SC-70 thermal performance on two different board sizes and two different pad patterns. The results display the thermal performance out to steady state and produce a graphic account of the thermal performance variation between the two packages. The measured steady state values of $R\theta_{JA}$ for the single 3-pin and 6-pin SC-70 are as follows:

| LITTLE FOOT SC-70 | | |
|---|---|---|
| | **3-Pin** | **6-Pin** |
| 1) Minimum recommended pad pattern (see Figure 4) on the EVB. | 410.31°C/W | 329.7°C/W |
| 2) Industry standard 1" square PCB with maximum copper both sides. | 360°C/W | 211.8°C/W |

The results show that designers can reduce thermal resistance $R\theta_{JA}$ on the order of 20% simply by using the 6-pin device rather than the 3-pin device. In this example, a 80°C/W reduction was achieved without an increase in board area. If increasing board size is an option, a further 118°C/W reduction could be obtained by utilizing a 1-inch square PCB area.

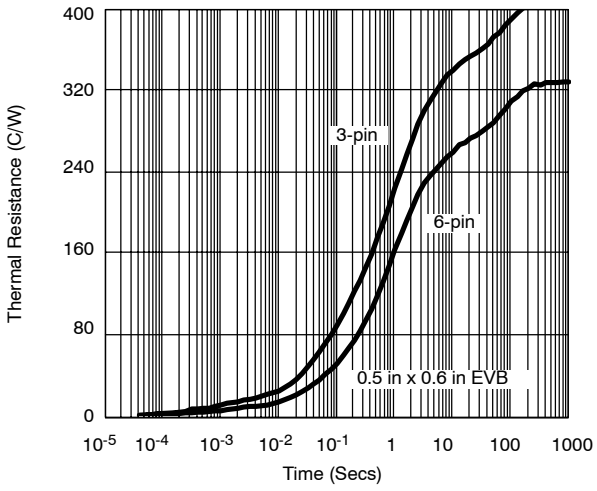



**FIGURE 3.** Comparison of SC70-3 and SC70-6 on EVB

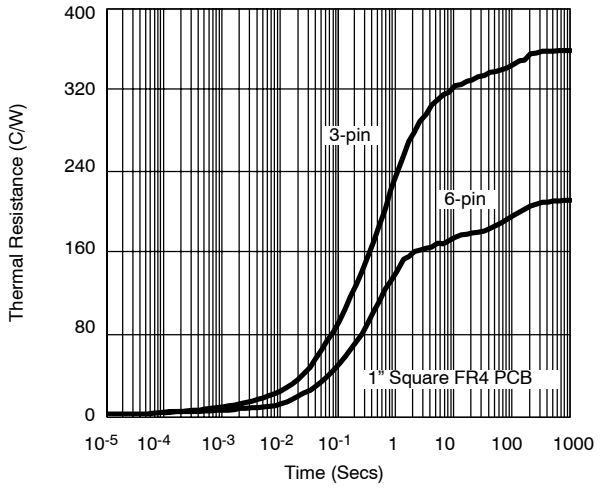
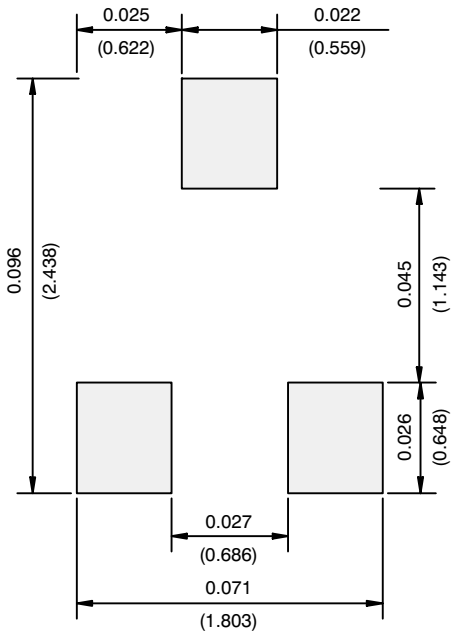



**FIGURE 4.** Comparison of SC70-3 and SC70-6 on 1" Square FR4 PCB

**RECOMMENDED MINIMUM PADS FOR SC-70: 3-Lead**




Recommended Minimum Pads
Dimensions in Inches/(mm)

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