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

| PRODUCT SUMMARY | | | |
|---|---|---|---|
| $V_{DS}$ (V) | $R_{DS(on)}$ (Ω) | $I_D$ (A) | $Q_g$ (Typ.) |
| - 20 | 0.490 at $V_{GS}$ = - 4.5 V | - 1.3[a] | 1.6 nC |
| | 0.640 at $V_{GS}$ = - 2.5 V | - 1.2 | |
| | 0.790 at $V_{GS}$ = - 1.8 V | - 1.0 | |

## FEATURES

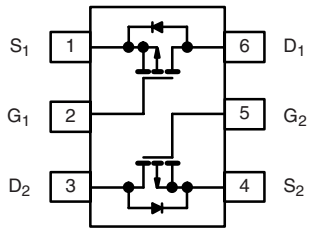
- **Halogen-free According to IEC 61249-2-21 Definition**
- TrenchFET® Power MOSFET
- PWM Optimized
- Compliant to RoHS Directive 2002/95/EC

Pb-free
RoHS COMPLIANT
HALOGEN FREE Available

## APPLICATIONS

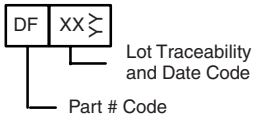
- Load Switch for Portable Devices

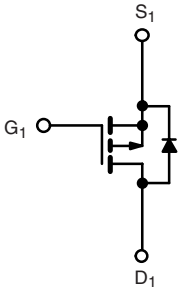
**SOT-363**
SC-70 (6-LEADS)



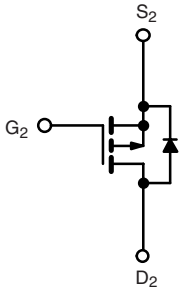

Top View

**Marking Code**




P-Channel MOSFET




P-Channel MOSFET

**Ordering Information:** Si1967DH-T1-E3 (Lead (Pb)-free)
Si1967DH-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 | | $V_{GS}$ | ± 8 | |
| Continuous Drain Current ($T_J$ = 150 °C) | $T_C$ = 25 °C | $I_D$ | - 1.3[a] | A |
| | $T_C$ = 70 °C | | - 1.1 | |
| | $T_A$ = 25 °C | | - 1.0[b, c] | |
| | $T_A$ = 70 °C | | - 0.83[b, c] | |
| Pulsed Drain Current | | $I_{DM}$ | - 3 | |
| Continuous Source-Drain Diode Current | $T_C$ = 25 °C | $I_S$ | - 1 | |
| | $T_A$ = 25 °C | | - 0.6[b, c] | |
| Maximum Power Dissipation | $T_C$ = 25 °C | $P_D$ | 1.25 | W |
| | $T_C$ = 70 °C | | 0.8 | |
| | $T_A$ = 25 °C | | 0.74[b, c] | |
| | $T_A$ = 70 °C | | 0.47[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] | t ≤ 5 s | $R_{thJA}$ | 130 | 170 | °C/W |
| Maximum Junction-to-Foot (Drain) | Steady State | $R_{thJF}$ | 80 | 100 | |

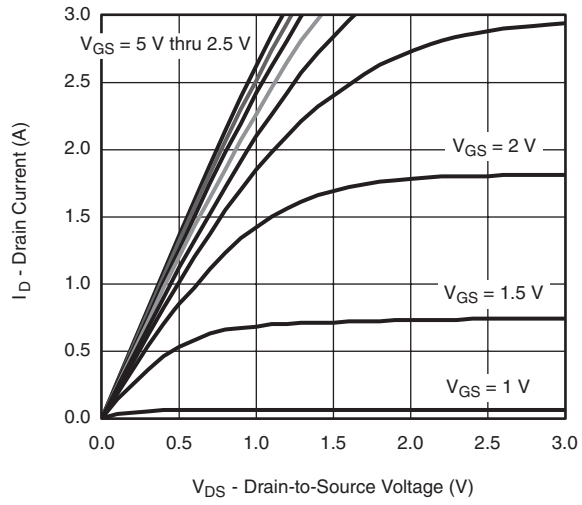
Notes:
a. Package limited.
b. Surface mounted on 1" x 1" FR4 board.
c. t = 5 s.
d. Maximum under steady state conditions is 220 °C/W.

| **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 | | - 20 | | mV/°C |
| $V_{GS(th)}$ Temperature Coefficient | $\Delta V_{GS(th)}/T_J$ | | | 2 | | |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$ , $I_D$ = - 250 µA | - 0.4 | | - 1.0 | 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, $T_J$ = 85 °C | | | - 10 | |
| On-State Drain Current[a] | $I_{D(on)}$ | $V_{DS} \leq$ - 5 V, $V_{GS}$ = - 4.5 V | - 3 | | | A |
| Drain-Source On-State Resistance[a] | $R_{DS(on)}$ | $V_{GS}$ = - 4.5 V, $I_D$ = - 0.91 A | | 0.390 | 0.490 | Ω |
| | | $V_{GS}$ = - 2.5 V, $I_D$ = - 0.8 A | | 0.500 | 0.640 | |
| | | $V_{GS}$ = - 1.8 V, $I_D$ = - 0.25 A | | 0.640 | 0.790 | |
| Forward Transconductance[a] | $g_{fs}$ | $V_{DS}$ = - 10 V, $I_D$ = - 0.91 A | | 2 | | S |
| **Dynamic[b]** | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{DS}$ = - 10 V, $V_{GS}$ = 0 V, f = 1 MHz | | 110 | | pF |
| Output Capacitance | $C_{oss}$ | | | 26 | | |
| Reverse Transfer Capacitance | $C_{rss}$ | | | 16 | | |
| Total Gate Charge | $Q_g$ | $V_{DS}$ = - 10 V, $V_{GS}$ = - 8 V, $I_D$ = - 1.1 A | | 2.6 | 4.0 | nC |
| | | $V_{DS}$ = - 10 V, $V_{GS}$ = - 4.5 V, $I_D$ = - 1.1 A | | 1.6 | 2.4 | |
| Gate-Source Charge | $Q_{gs}$ | | | 0.36 | | |
| Gate-Drain Charge | $Q_{gd}$ | | | 0.33 | | |
| Gate Resistance | $R_g$ | f = 1 MHz | | 7.5 | | Ω |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD}$ = - 10 V, $R_L$ = 12 Ω<br>$I_D \cong$ - 0.83 A, $V_{GEN}$ = - 4.5 V, $R_g$ = 1 Ω | | 12 | 20 | ns |
| Rise Time | $t_r$ | | | 27 | 40 | |
| Turn-Off Delay Time | $t_{d(off)}$ | | | 15 | 25 | |
| Fall Time | $t_f$ | | | 10 | 15 | |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD}$ = - 10 V, $R_L$ = 12 Ω<br>$I_D \cong$ - 0.83 A, $V_{GEN}$ = - 8 V, $R_g$ = 1 Ω | | 2 | 5 | |
| Rise Time | $t_r$ | | | 12 | 20 | |
| Turn-Off Delay Time | $t_{d(off)}$ | | | 12 | 20 | |
| Fall Time | $t_f$ | | | 10 | 15 | |
| **Drain-Source Body Diode Characteristics** | | | | | | |
| Continuous Source-Drain Diode Current | $I_S$ | $T_C$ = 25 °C | | | - 1.0 | A |
| Pulse Diode Forward Current[a] | $I_{SM}$ | | | | - 3.0 | |
| Body Diode Voltage | $V_{SD}$ | $I_S$ = - 0.9 A | | - 0.8 | - 1.2 | V |
| Body Diode Reverse Recovery Time | $t_{rr}$ | $I_F$ = - 0.83 A, dI/dt = 100 A/µs, $T_J$ = 25 °C | | 25 | 50 | ns |
| Body Diode Reverse Recovery Charge | $Q_{rr}$ | | | 15 | 30 | nC |
| Reverse Recovery Fall Time | $t_a$ | | | 12 | | ns |
| Reverse Recovery Rise Time | $t_b$ | | | 13 | | |

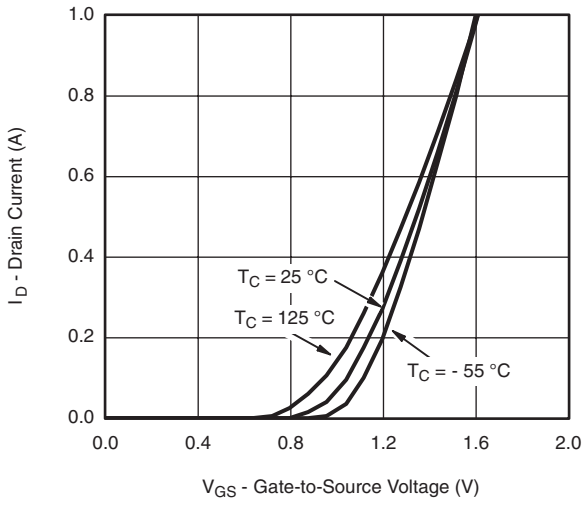
Notes:
a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %
b. Guaranteed by design, not subject to production testing.

*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.*

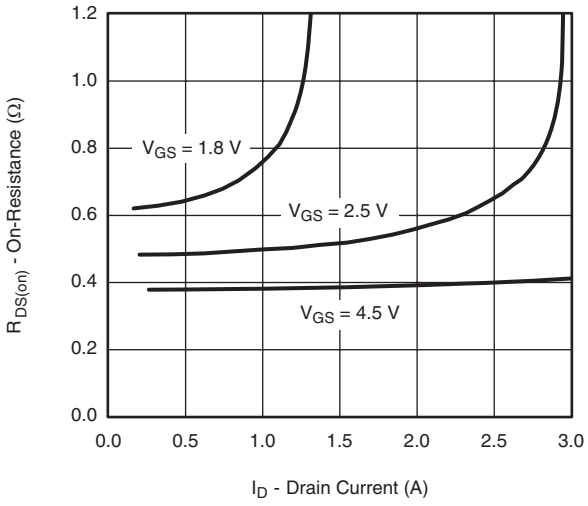
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



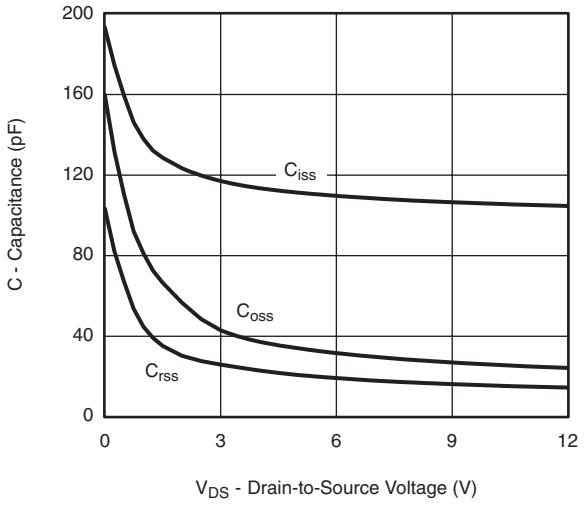

**Output Characteristics**



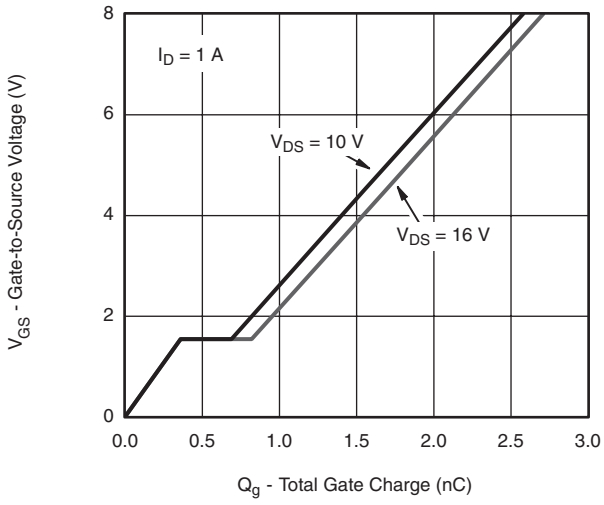

**Transfer Characteristics**



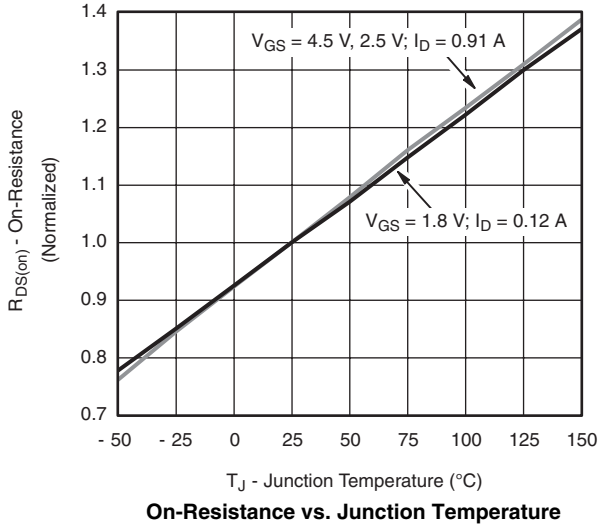

**On-Resistance vs. Drain Current and Gate Voltage**




**Capacitance**

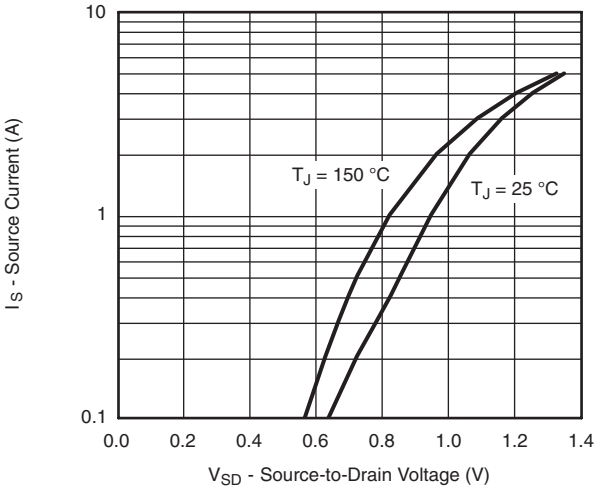



**Gate Charge**

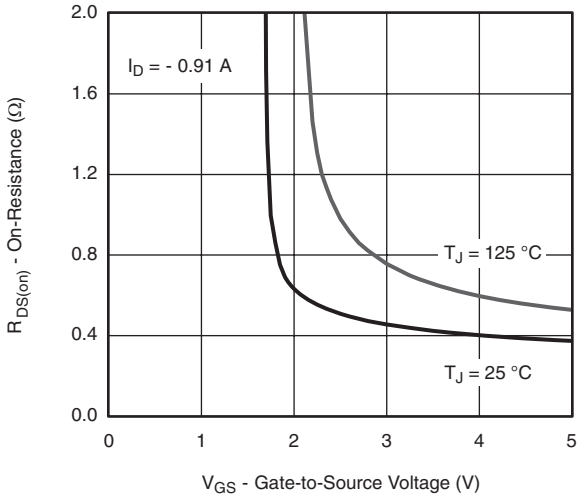



**On-Resistance vs. Junction Temperature**

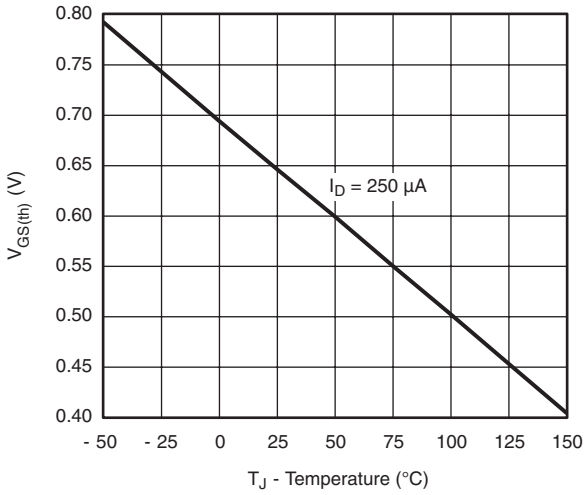
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



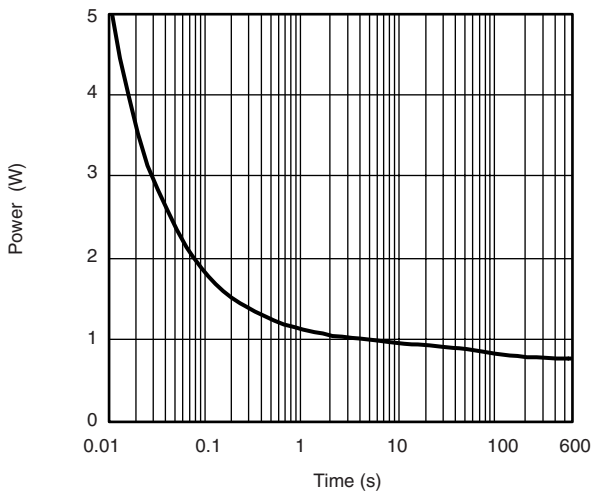

**Source-Drain Diode Forward Voltage**



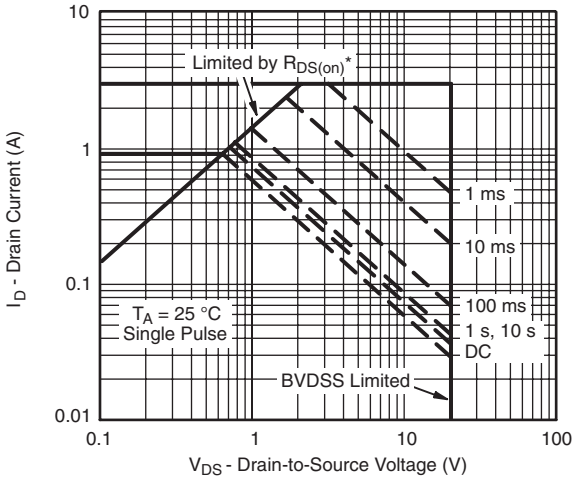

**On-Resistance vs. Gate-to-Source Voltage**




**Threshold Voltage**



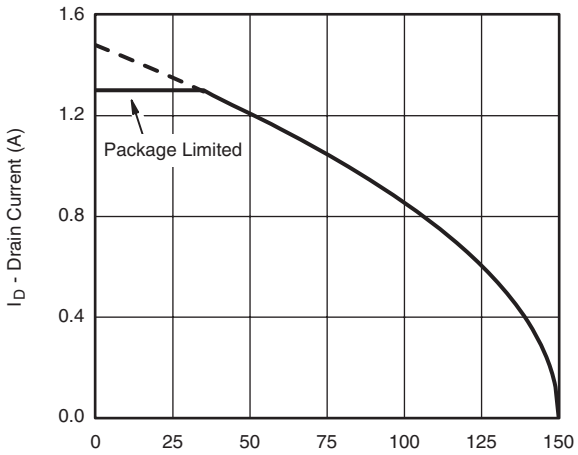

**Single Pulse Power**



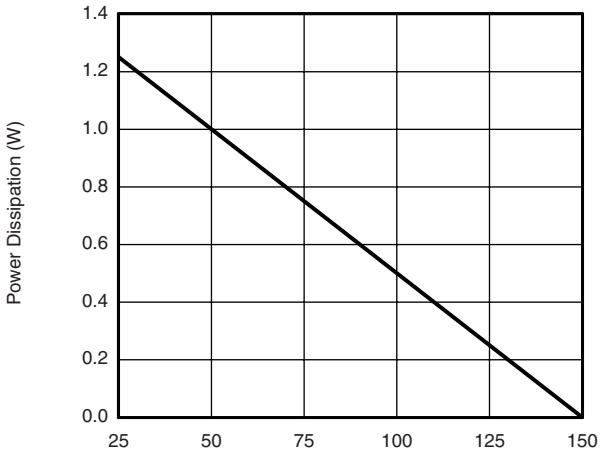

* $V_{GS}$ > minimum $V_{GS}$ at which $R_{DS(on)}$ is specified

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

## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



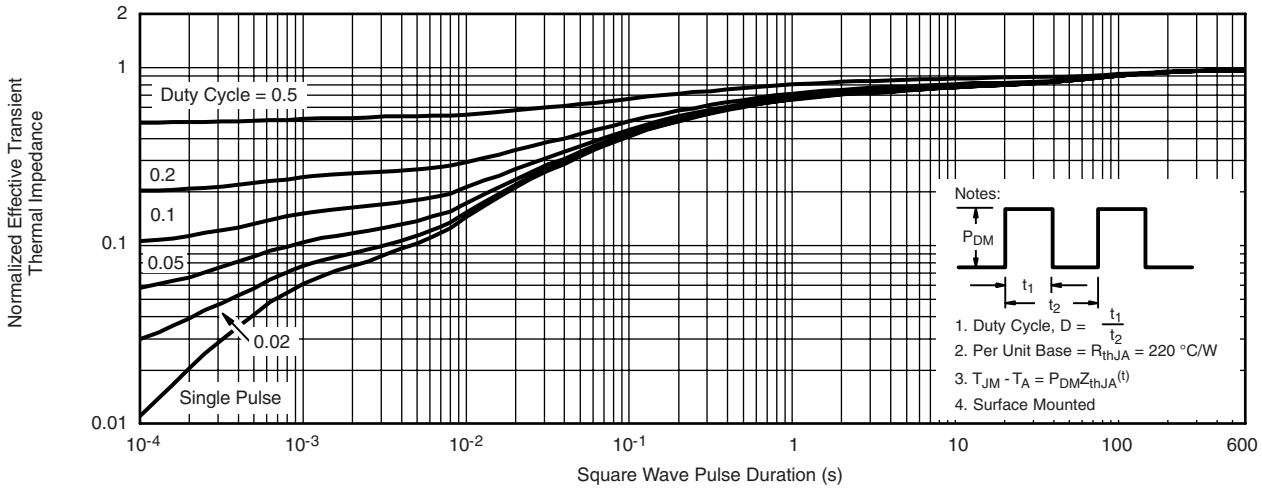

**Current Derating***



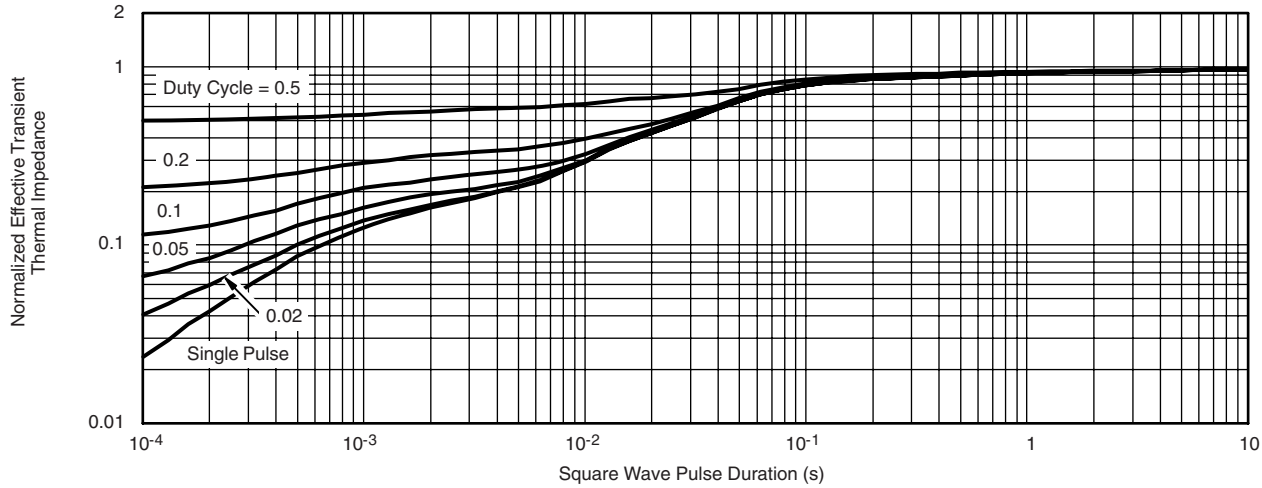

**Power, Junction-to-Foot**

* 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



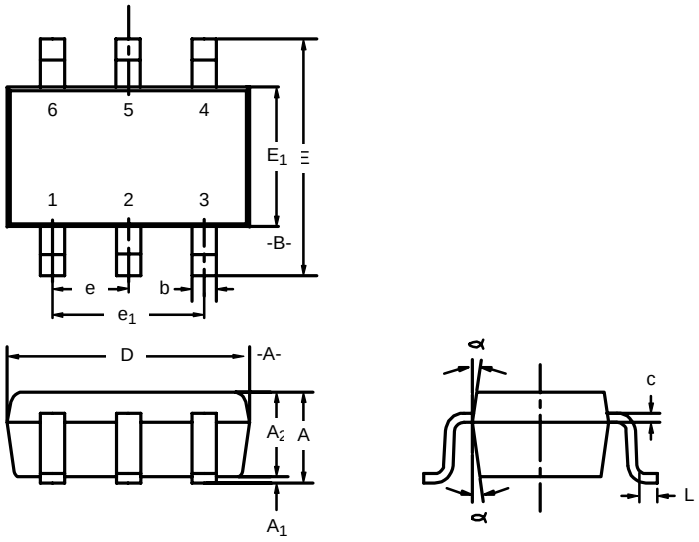

**Normalized Thermal Transient Impedance, Junction-to-Ambient**




**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 www.vishay.com/ppg?68784.*

## SC-70: 6-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 | 0.15 | – | 0.30 | 0.006 | – | 0.012 |
| 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. B, 09-Jul-01
DWG: 5550

# Dual-Channel LITTLE FOOT® 6-Pin SC-70 MOSFET Copper Leadframe Version Recommended Pad Pattern and Thermal Performance

## INTRODUCTION

The new dual 6-pin SC-70 package with a copper leadframe enables improved on-resistance values and enhanced thermal performance as compared to the existing 3-pin and 6-pin packages with Alloy 42 leadframes. These devices are intended for small to medium load applications where a miniaturized package is required. Devices in this package come in a range of on-resistance values, in n-channel and p-channel versions. This technical note discusses pin-outs, package outlines, pad patterns, evaluation board layout, and thermal performance for the dual-channel version.

## PIN-OUT

Figure 1 shows the pin-out description and Pin 1 identification for the dual-channel SC-70 device in the 6-pin configuration. Both n-and p-channel devices are available in this package – the drawing example below illustrates the p-channel device.

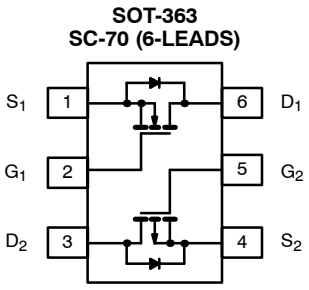



**FIGURE 1.**

For package dimensions see outline drawing 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 SC-70 6-pin basic pad layout and dimensions. This pad pattern is sufficient for the low-power applications for which this package is intended. Increasing the drain pad pattern (Figure 2) yields a reduction in thermal resistance and is a preferred footprint.

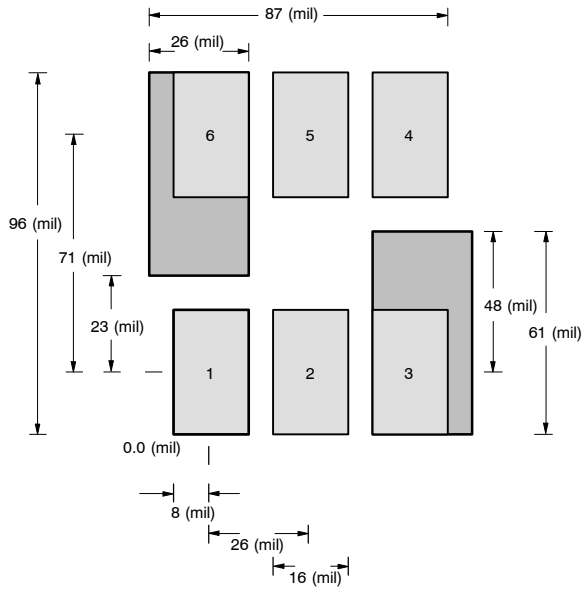



**FIGURE 2.** SC-70 (6 leads) Dual

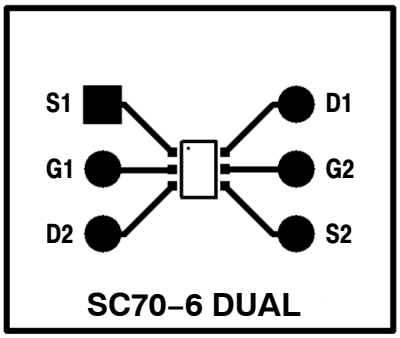
## EVALUATION BOARD FOR THE DUAL-CHANNEL SC70-6

The 6-pin SC-70 evaluation board (EVB) shown in Figure 3 measures 0.6 in. by 0.5 in. The copper pad traces are the same as described in the previous section, *Basic Pad Patterns*. The board allows for examination from the outer pins to the 6-pin DIP connections, permitting test sockets to be used in evaluation testing.

The thermal performance of the dual 6-pin SC-70 has been measured on the EVB, comparing both the copper and Alloy 42 leadframes. This test was then repeated using the 1-inch$^2$ PCB with dual-side copper coating.

A helpful way of displaying the thermal performance of the 6-pin SC-70 dual copper leadframe is to compare it to the traditional Alloy 42 version.

Front of Board SC70-6




Back of Board SC70-6

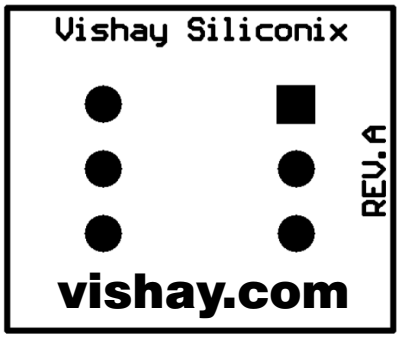



FIGURE 3.

## THERMAL PERFORMANCE

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

Thermal performance for the dual SC-70 6-pin package is measured as junction-to-foot thermal resistance, in which the "foot" is the drain lead of the device as it connects with the body. The junction-to-foot thermal resistance for this device is typically 80°C/W, with a maximum thermal resistance of approximately 100°C/W. This data compares favorably with another compact, dual-channel package – the dual TSOP-6 – which features a typical thermal resistance of 75°C/W and a maximum of 90°C/W.

### Power Dissipation

The typical $R\theta_{JA}$ for the dual-channel 6-pin SC-70 with a copper leadframe is 224°C/W steady-state, compared to 413°C/W for the Alloy 42 version. All figures are based on the 1-inch$^2$ FR4 test board. The following example shows how the thermal resistance impacts power dissipation for the dual 6-pin SC-70 package at varying ambient temperatures.

*Alloy 42 Leadframe*

| ALLOY 42 LEADFRAME | |
|---|---|
| **Room Ambient 25 °C** | **Elevated Ambient 60 °C** |
| $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ | $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ |
| $P_D = \frac{150°C - 25°C}{413°C/W}$ | $P_D = \frac{150°C - 60°C}{413°C/W}$ |
| $P_D$ = 303 mW | $P_D$ = 218 mW |

| COOPER LEADFRAME | |
|---|---|
| **Room Ambient 25 °C** | **Elevated Ambient 60 °C** |
| $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ | $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ |
| $P_D = \frac{150°C - 25°C}{224°C/W}$ | $P_D = \frac{150°C - 60°C}{224°C/W}$ |
| $P_D$ = 558 mW | $P_D$ = 402 mW |

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

## TESTING

To further aid the comparison of copper and Alloy 42 leadframes, Figures 4 and 5 illustrate the dual-channel 6-pin SC-70 thermal performance on two different board sizes and pad patterns. The measured steady-state values of $R\theta_{JA}$ for the dual 6-pin SC-70 with varying leadframes are as follows:

| LITTLE FOOT 6-PIN SC-70 | | |
|---|---|---|
| | **Alloy 42** | **Copper** |
| 1) Minimum recommended pad pattern on the EVB board (see Figure 3). | 518°C/W | 344°C/W |
| 2) Industry standard 1-inch$^2$ PCB with maximum copper both sides. | 413°C/W | 224°C/W |

The results indicate that designers can reduce thermal resistance (θJA) by 34% simply by using the copper leadframe device as opposed to the Alloy 42 version. In this example, a 174°C/W reduction was achieved without an increase in board area. If an increase in board size is feasible, a further 120°C/W reduction can be obtained by utilizing a 1-inch$^2$. PCB area.

The Dual copper leadframe versions have the following suffix:

| | |
|---|---|
| Dual: | Si19xxEDH |
| Compl.: | Si15xxEDH |

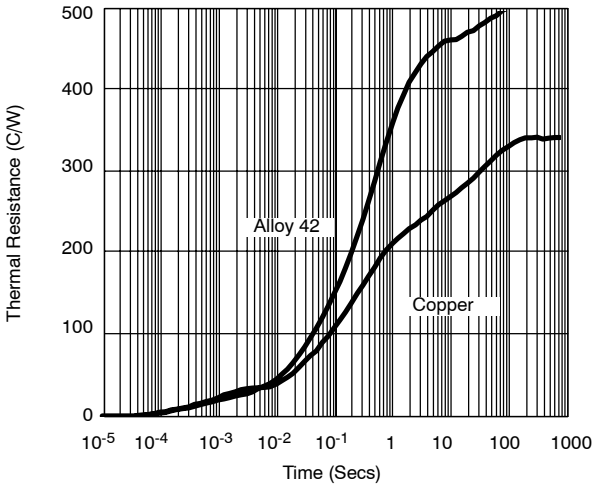



**FIGURE 4.** Dual SC70-6 Thermal Performance on EVB

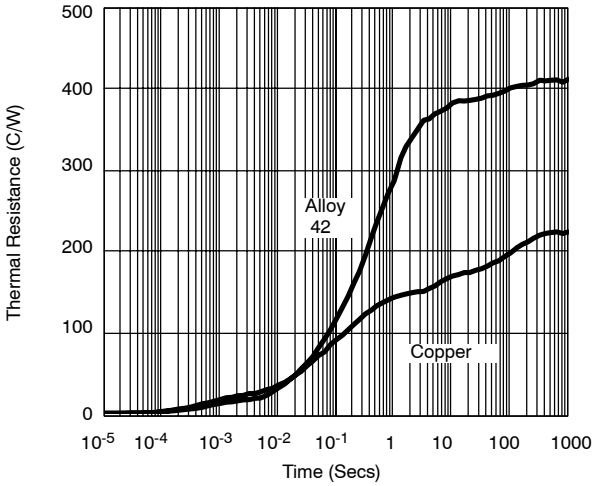
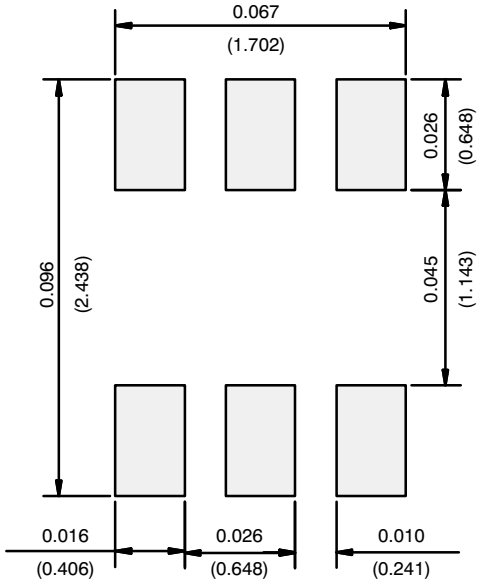



**FIGURE 5.** Dual SC70-6 Comparison on 1-inch$^2$ PCB

## RECOMMENDED MINIMUM PADS FOR SC-70: 6-Lead




Recommended Minimum Pads
Dimensions in Inches/(mm)

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