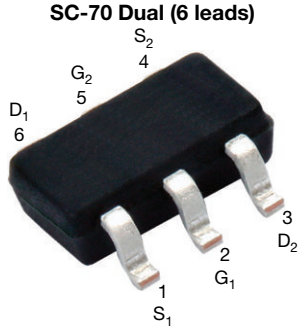
# N-and P-Channel 30 V (D-S) 175 °C MOSFET

| PRODUCT SUMMARY | | |
|---|---|---|
| | N-CHANNEL | P-CHANNEL |
| $V_{DS}$ (V) | 30 | -30 |
| $R_{DS(on)}$ (Ω) at $V_{GS}$ = ± 10 V | 0.280 | 0.940 |
| $R_{DS(on)}$ (Ω) at $V_{GS}$ = ± 4.5 V | 0.380 | 1.800 |
| $I_D$ (A) | 0.85 | -0.85 |
| Configuration | N & P Pair | |
| Package | SC-70 | |

**SOT-363**
**SC-70 Dual (6 leads)**




Top View

## FEATURES

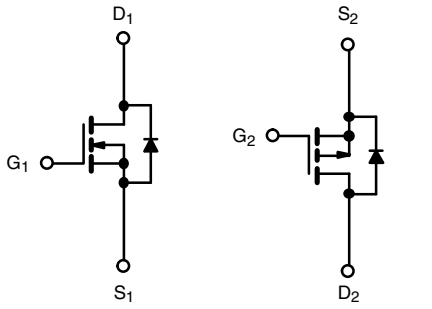
- TrenchFET® power MOSFET
- AEC-Q101 qualified
- 100 % $R_g$ and UIS tested
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

HALOGEN FREE




N-Channel MOSFET P-Channel MOSFET

**Marking Code**: 9R

| ABSOLUTE MAXIMUM RATINGS ($T_C$ = 25 °C, unless otherwise noted) | | | | | |
|---|---|---|---|---|---|
| PARAMETER | | SYMBOL | N-CHANNEL | P-CHANNEL | UNIT |
| Drain-Source Voltage | | $V_{DS}$ | 30 | -30 | V |
| Gate-Source Voltage | | $V_{GS}$ | ± 20 | | |
| Continuous Drain Current [c] | $T_C$ = 25 °C | $I_D$ | 0.85 | -0.85 | A |
| | $T_C$ = 125 °C | | 0.85 | -0.56 | |
| Continuous Source Current (Diode Conduction) | | $I_S$ | 0.85 | -0.85 | |
| Pulsed Drain Current [a] | | $I_{DM}$ | 3.3 | -3.3 | |
| Single Pulse Avalanche Current | L = 0.1 mH | $I_{AS}$ | 3.5 | -1.9 | |
| Single Pulse Avalanche Energy | | $E_{AS}$ | 0.6 | 0.2 | mJ |
| Maximum Power Dissipation [a] | $T_C$ = 25 °C | $P_D$ | 1.5 | 1.5 | W |
| | $T_C$ = 125 °C | | 0.5 | 0.5 | |
| Operating Junction and Storage Temperature Range | | $T_J$, $T_{stg}$ | -55 to +175 | | °C |

| THERMAL RESISTANCE RATINGS | | | | | |
|---|---|---|---|---|---|
| PARAMETER | | SYMBOL | N-CHANNEL | P-CHANNEL | UNIT |
| Junction-to-Ambient | PCB Mount [b] | $R_{thJA}$ | 220 | 220 | °C/W |
| Junction-to-Foot (Drain) | | $R_{thJF}$ | 100 | 100 | |

**Notes**

a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %.
b. When mounted on 1" square PCB (FR4 material).
c. Package limited.



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| **SPECIFICATIONS** ($T_C$ = 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 | | N-Ch | 30 | - | - | V |
| | | $V_{GS}$ = 0 V, $I_D$ = -250 µA | | P-Ch | -30 | - | - | |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | | N-Ch | 1 | 1.8 | 2.6 | |
| | | $V_{DS}$ = $V_{GS}$, $I_D$ = -250 µA | | P-Ch | -1 | -1.8 | -2.6 | |
| Gate-Source Leakage | $I_{GSS}$ | $V_{DS}$ = 0 V, $V_{GS}$ = ± 20 V | | N-Ch | - | - | ± 100 | nA |
| | | | | P-Ch | - | - | ± 100 | |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 30 V | N-Ch | - | - | 1 | µA |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = -30 V | P-Ch | - | - | -1 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = 30 V, $T_J$ = 125 °C | N-Ch | - | - | 50 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = -30 V, $T_J$ = 125 °C | P-Ch | - | - | -50 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = 30 V, $T_J$ = 175 °C | N-Ch | - | - | 150 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = -30 V, $T_J$ = 175 °C | P-Ch | - | - | -150 | |
| On-State Drain Current [a] | $I_{D(on)}$ | $V_{GS}$ = 10 V | $V_{DS}$ = 5 V | N-Ch | 2 | - | - | A |
| | | $V_{GS}$ = -10 V | $V_{DS}$ = -5 V | P-Ch | -0.5 | - | - | |
| Drain-Source On-State Resistance [a] | $R_{DS(on)}$ | $V_{GS}$ = 10 V | $I_D$ = 1 A | N-Ch | - | 0.210 | 0.280 | Ω |
| | | $V_{GS}$ = -10 V | $I_D$ = -0.5 A | P-Ch | - | 0.788 | 0.940 | |
| | | $V_{GS}$ = 4.5 V | $I_D$ = 0.1 A | N-Ch | - | 0.290 | 0.380 | |
| | | $V_{GS}$ = -4.5 V | $I_D$ = -0.1 A | P-Ch | - | 1.400 | 1.800 | |
| Forward Transconductance [b] | $g_{fs}$ | $V_{DS}$ = 15 V, $I_D$ = 0.7 A | | N-Ch | - | 1.2 | - | S |
| | | $V_{DS}$ = -15 V, $I_D$ = -0.5 A | | P-Ch | - | 0.6 | - | |
| **Dynamic [b]** | | | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 15 V, f = 1 MHz | N-Ch | - | 38 | 48 | pF |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = -15 V, f = 1 MHz | P-Ch | - | 40 | 50 | |
| Output Capacitance | $C_{oss}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 15 V, f = 1 MHz | N-Ch | - | 14 | 21 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = -15 V, f = 1 MHz | P-Ch | - | 14 | 21 | |
| Reverse Transfer Capacitance | $C_{rss}$ | $V_{GS}$ = 0 V | $V_{DS}$ = 15 V, f = 1 MHz | N-Ch | - | 6 | 10 | |
| | | $V_{GS}$ = 0 V | $V_{DS}$ = -15 V, f = 1 MHz | P-Ch | - | 5 | 9 | |
| Total Gate Charge | $Q_g$ | $V_{GS}$ = 4.5 V | $V_{DS}$ = 15 V, $I_D$ = 0.7 A | N-Ch | - | 1 | 1.4 | nC |
| | | $V_{GS}$ = -4.5 V | $V_{DS}$ = -15 V, $I_D$ = -0.5 A | P-Ch | - | 1.2 | 1.6 | |
| Gate-Source Charge | $Q_{gs}$ | $V_{GS}$ = 4.5 V | $V_{DS}$ = 15 V, $I_D$ = 0.7 A | N-Ch | - | 0.2 | - | |
| | | $V_{GS}$ = -4.5 V | $V_{DS}$ = -15 V, $I_D$ = -0.5 A | P-Ch | - | 0.3 | - | |
| Gate-Drain Charge [c] | $Q_{gd}$ | $V_{GS}$ = 4.5 V | $V_{DS}$ = 15 V, $I_D$ = 0.7 A | N-Ch | - | 0.4 | - | |
| | | $V_{GS}$ = -4.5 V | $V_{DS}$ = -15 V, $I_D$ = -0.5 A | P-Ch | - | 0.6 | - | |
| Gate Resistance | $R_g$ | f = 1 MHz | | N-Ch | 5.8 | - | 17.3 | Ω |
| | | | | P-Ch | 3.7 | - | 11.1 | |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD}$ = 15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ 0.7 A, $V_{GEN}$ = 4.5 V, $R_g$ = 1 Ω | | N-Ch | - | 3 | 6 | ns |
| | | $V_{DD}$ = -15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ -0.5 A, $V_{GEN}$ = -4.5 V, $R_g$ = 1 Ω | | P-Ch | - | 4 | 8 | |
| Rise Time | $t_r$ | $V_{DD}$ = 15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ 0.7 A, $V_{GEN}$ = 4.5 V, $R_g$ = 1 Ω | | N-Ch | - | 18 | 28 | |
| | | $V_{DD}$ = -15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ -0.5 A, $V_{GEN}$ = -4.5 V, $R_g$ = 1 Ω | | P-Ch | - | 39 | 50 | |
| Turn-Off Delay Time | $t_{d(off)}$ | $V_{DD}$ = 15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ 0.7 A, $V_{GEN}$ = 4.5 V, $R_g$ = 1 Ω | | N-Ch | - | 8 | 14 | |
| | | $V_{DD}$ = -15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ -0.5 A, $V_{GEN}$ = -4.5 V, $R_g$ = 1 Ω | | P-Ch | - | 10 | 16 | |
| Fall Time | $t_f$ | $V_{DD}$ = 15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ 0.7 A, $V_{GEN}$ = 4.5 V, $R_g$ = 1 Ω | | N-Ch | - | 32 | 46 | |
| | | $V_{DD}$ = -15 V, $R_L$ = 20 Ω<br>$I_D$ ≅ -0.5 A, $V_{GEN}$ = -4.5 V, $R_g$ = 1 Ω | | P-Ch | - | 17 | 25 | |


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| **SPECIFICATIONS** ($T_C$ = 25 °C, unless otherwise noted) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Source-Drain Diode Ratings and Characteristics** [b] | | | | | | | |
| Pulsed Current [a] | $I_{SM}$ | $T_C$ = 25 °C | N-Ch | - | - | 3.3 | A |
| | | | P-Ch | - | - | -3.3 | |
| Forward Voltage | $V_{SD}$ | $I_S$ = 0.5 A | N-Ch | - | 0.8 | 1.2 | V |
| | | $I_S$ = -0.4 A | P-Ch | - | -0.8 | -1.2 | |

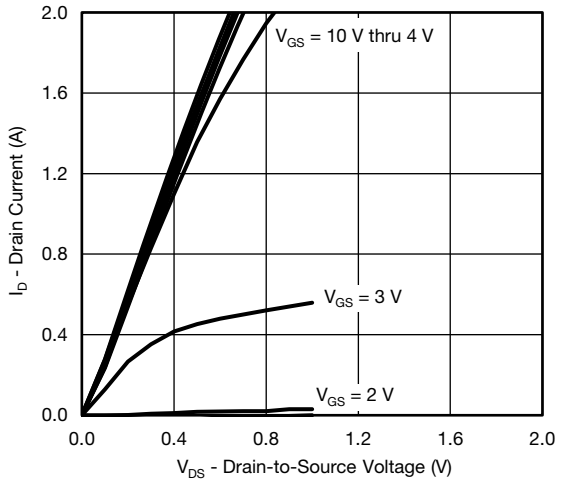
**Notes**

a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %.
b. Guaranteed by design, not subject to production testing.
c. Independent of operating temperature.

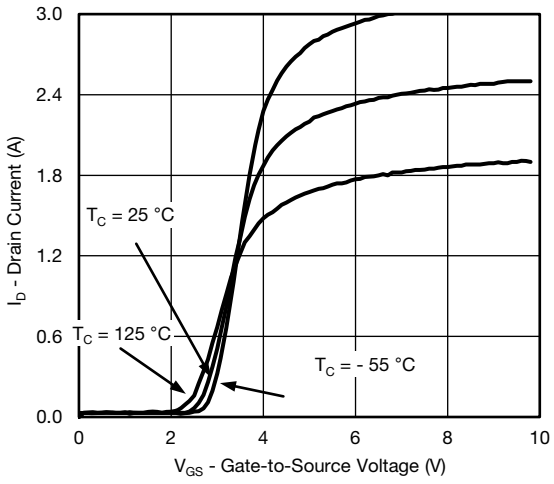
*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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


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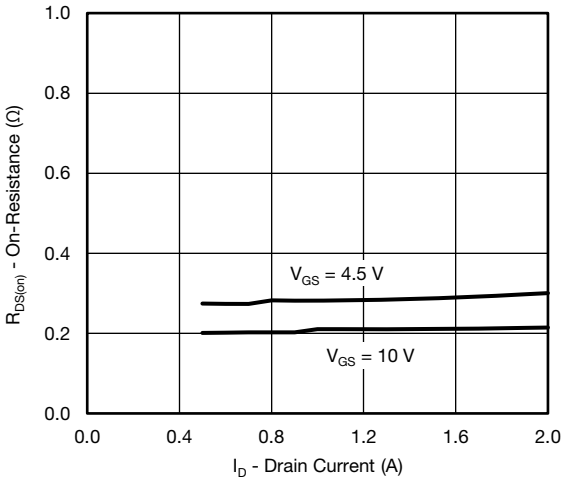
## N-CHANNEL TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



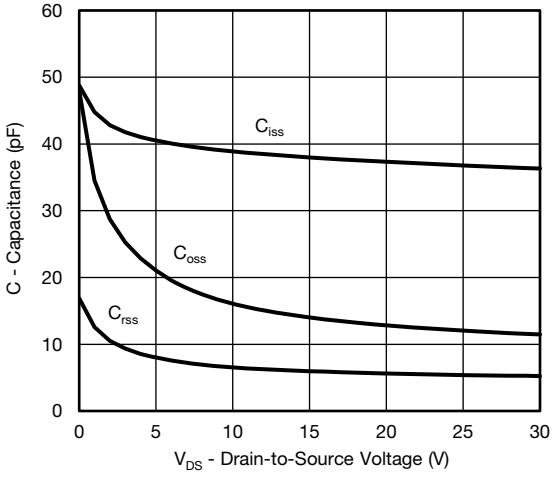

**Output Characteristics**



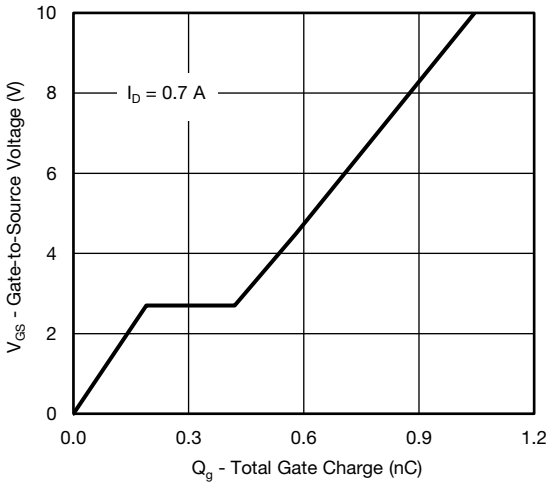

**Transfer Characteristics**



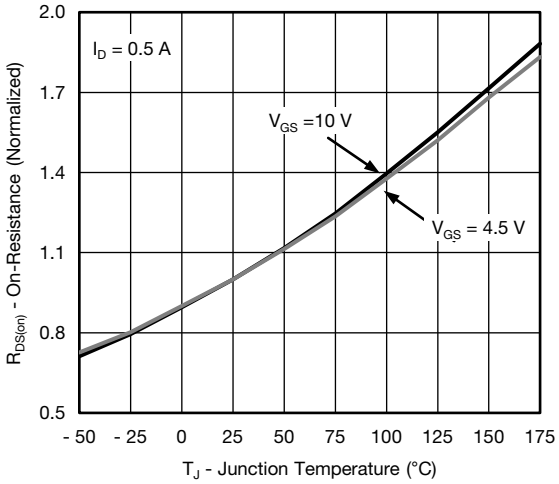

**On-Resistance vs. Drain Current**




**Capacitance**



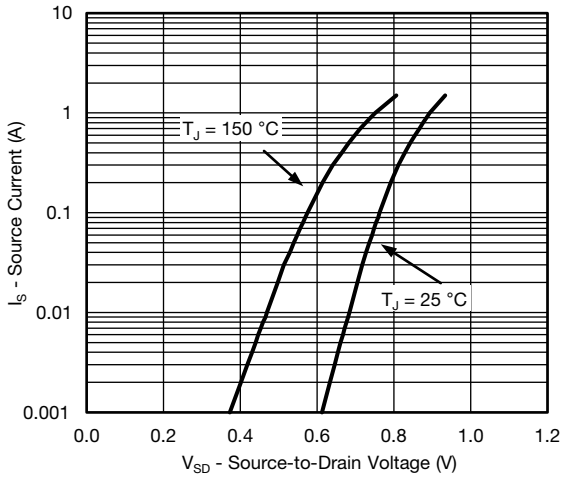

**Gate Charge**



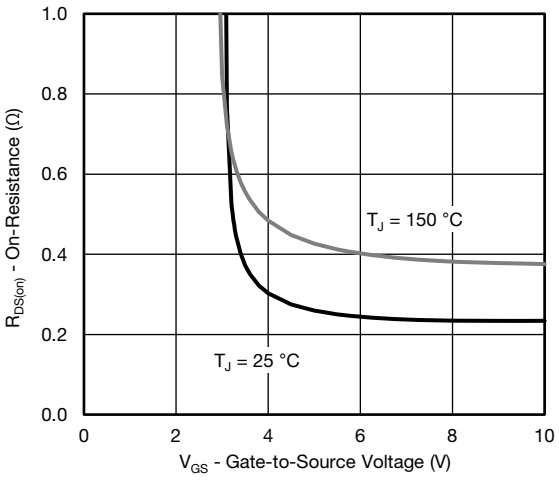

**On-Resistance vs. Junction Temperature**


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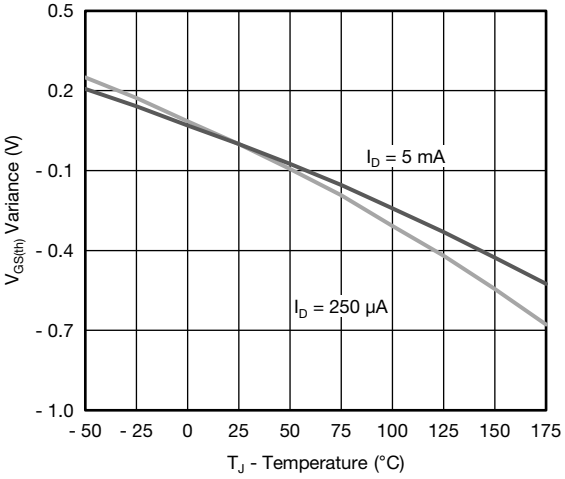
## N-CHANNEL TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



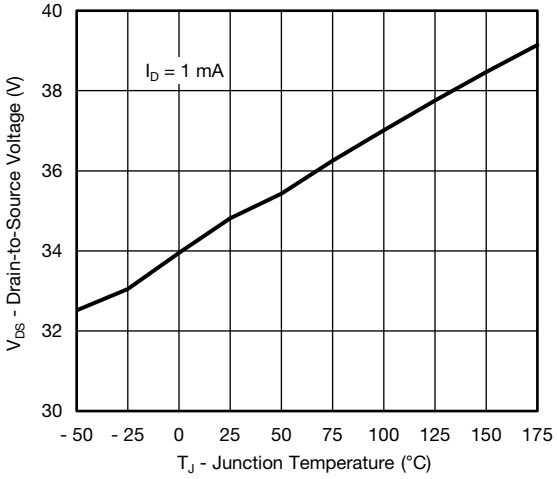

**Source Drain Diode Forward Voltage**



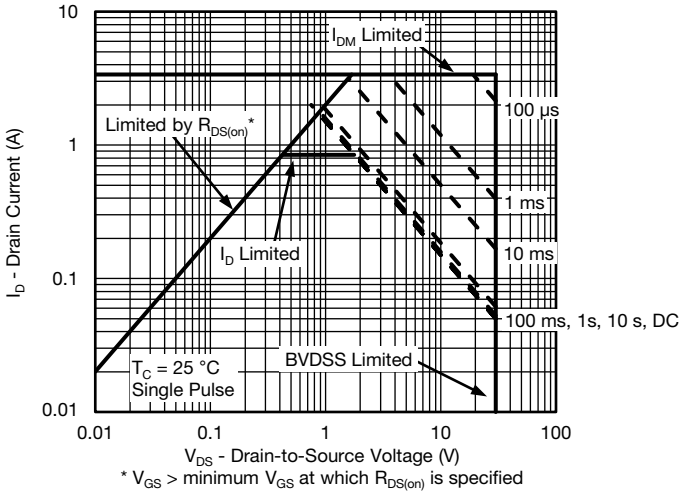

**On-Resistance vs. Gate-to-Source Voltage**




**Threshold Voltage**



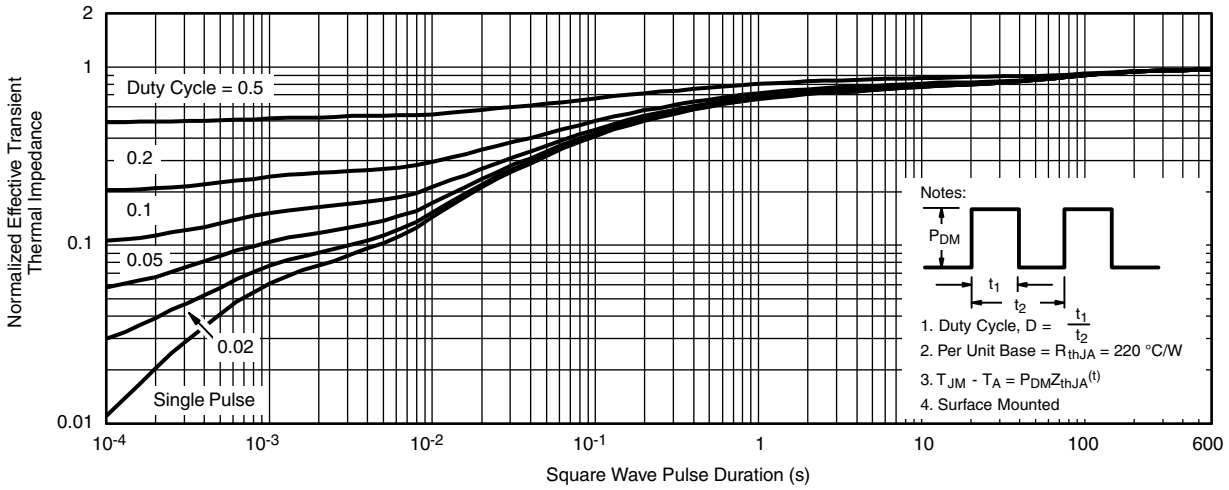

**Drain Source Breakdown vs. Junction Temperature**



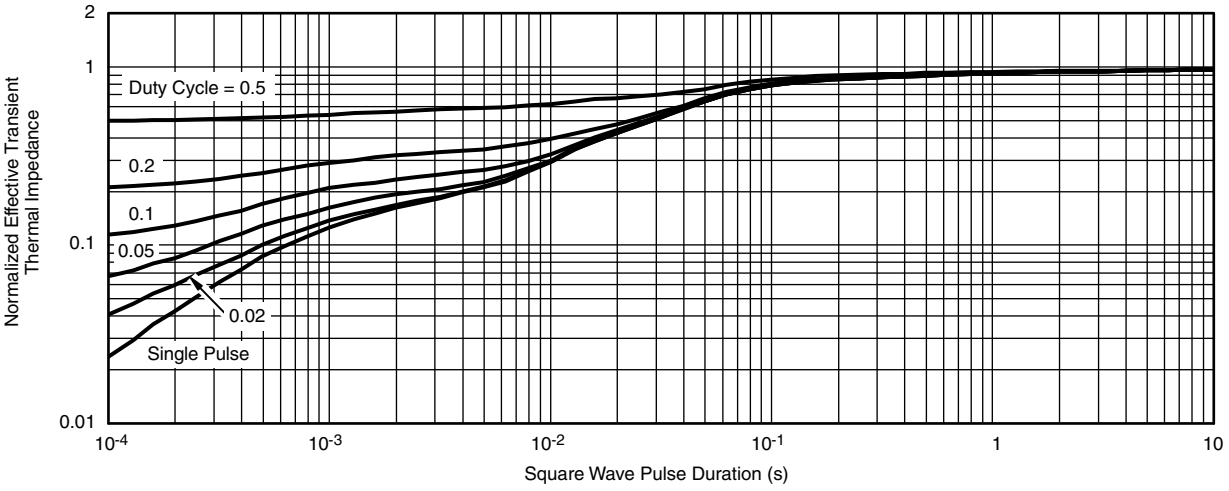

**Safe Operating Area**


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## N-CHANNEL THERMAL RATINGS ($T_A$ = 25 °C, unless otherwise noted)




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




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

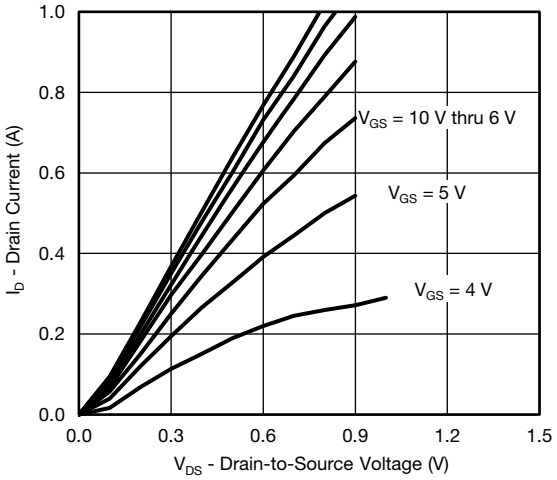
**Note**

- The characteristics shown in the two graphs
  - Normalized Transient Thermal Impedance Junction-to-Ambient (25 °C)
  - Normalized Transient Thermal Impedance Junction-to-Case (25 °C)

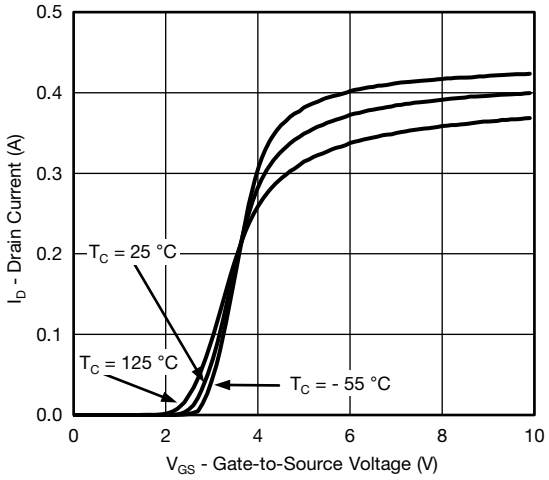
  are given for general guidelines only to enable the user to get a “ball park” indication of part capabilities. The data are extracted from single pulse transient thermal impedance characteristics which are developed from empirical measurements. The latter is valid for the part mounted on printed circuit board - FR4, size 1" x 1" x 0.062", double sided with 2 oz. copper, 100 % on both sides. The part capabilities can widely vary depending on actual application parameters and operating conditions.


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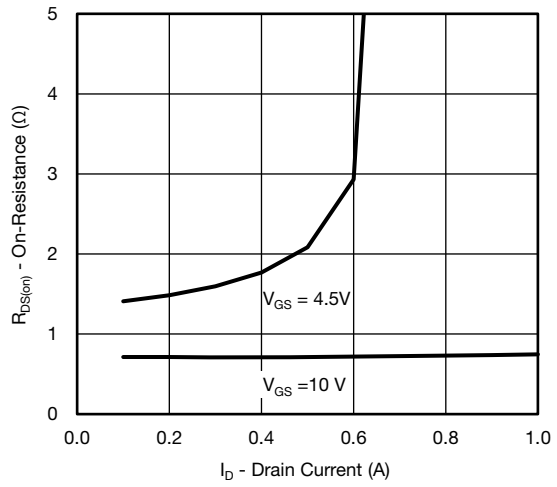
## P-CHANNEL TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



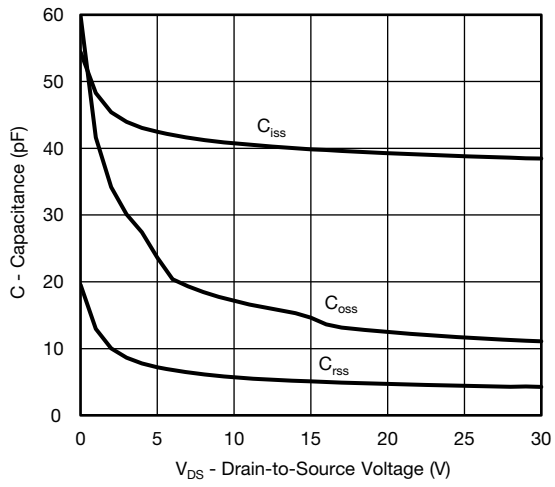

**Output Characteristics**



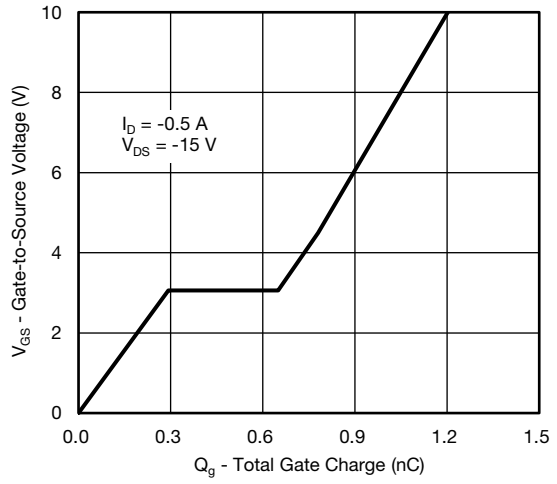

**Transfer Characteristics**



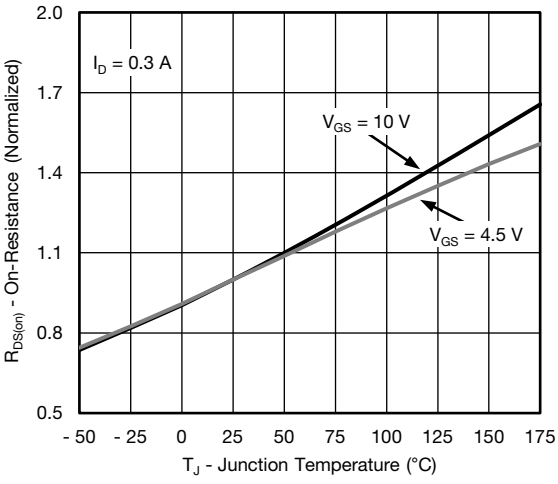

**On-Resistance vs. Drain Current**




**Capacitance**



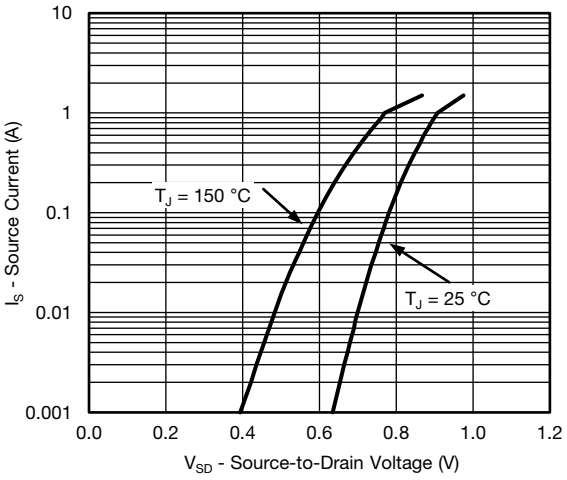

**Gate Charge**



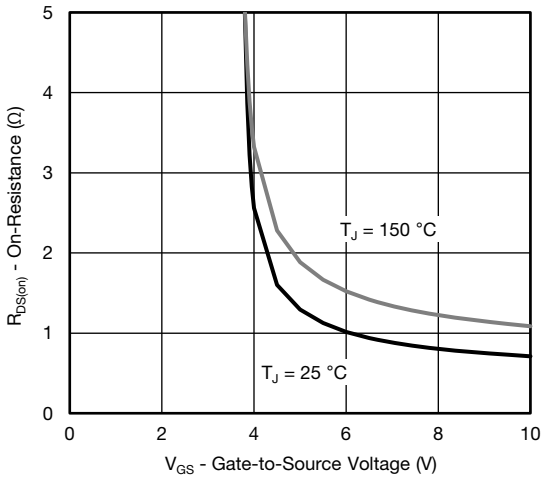

**On-Resistance vs. Junction Temperature**


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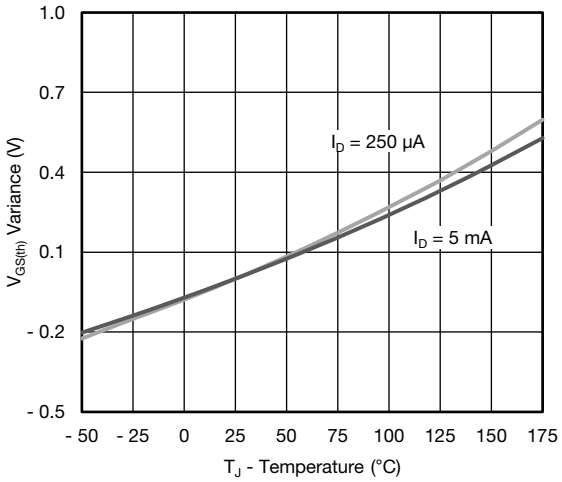
## P-CHANNEL TYPICAL CHARACTERISTICS ($T_A$ = 25 °C, unless otherwise noted)



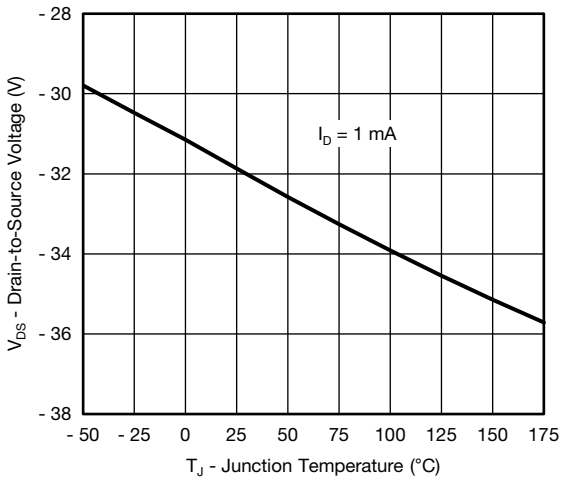

**Source Drain Diode Forward Voltage**



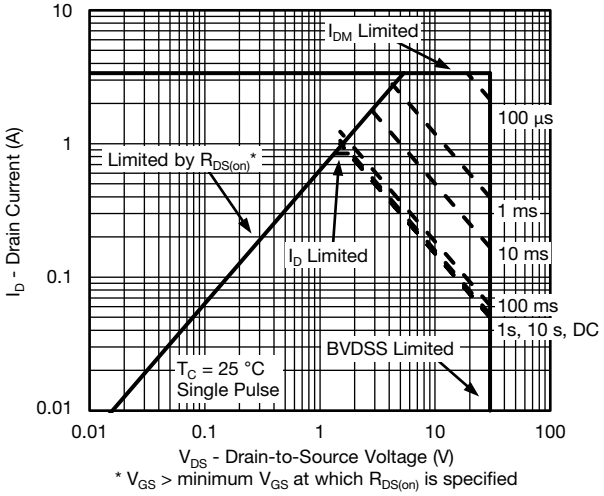

**On-Resistance vs. Gate-to-Source Voltage**




**Threshold Voltage**




**Drain Source Breakdown vs. Junction Temperature**

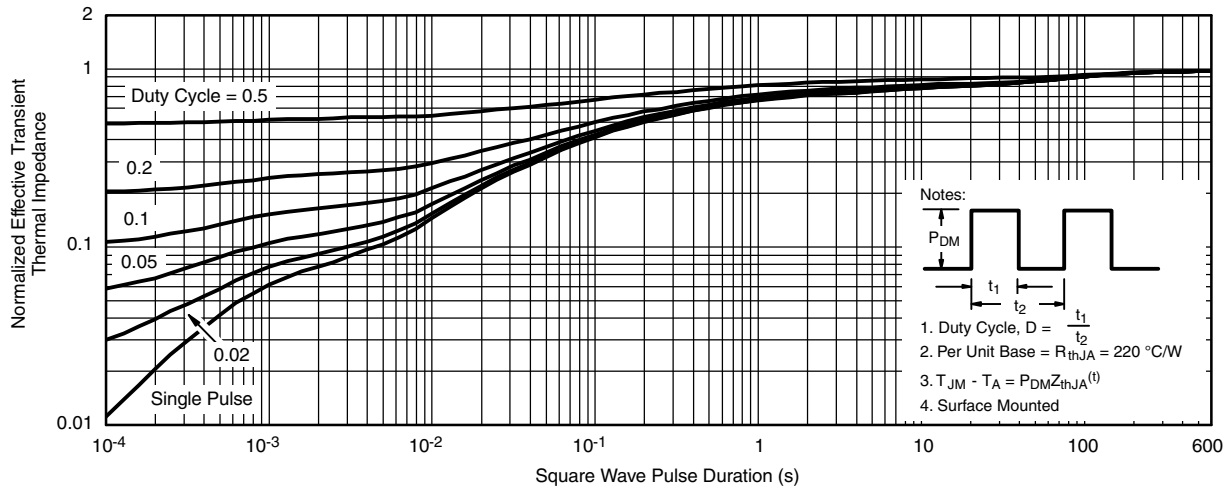



* $V_{GS}$ > minimum $V_{GS}$ at which $R_{DS(on)}$ is specified

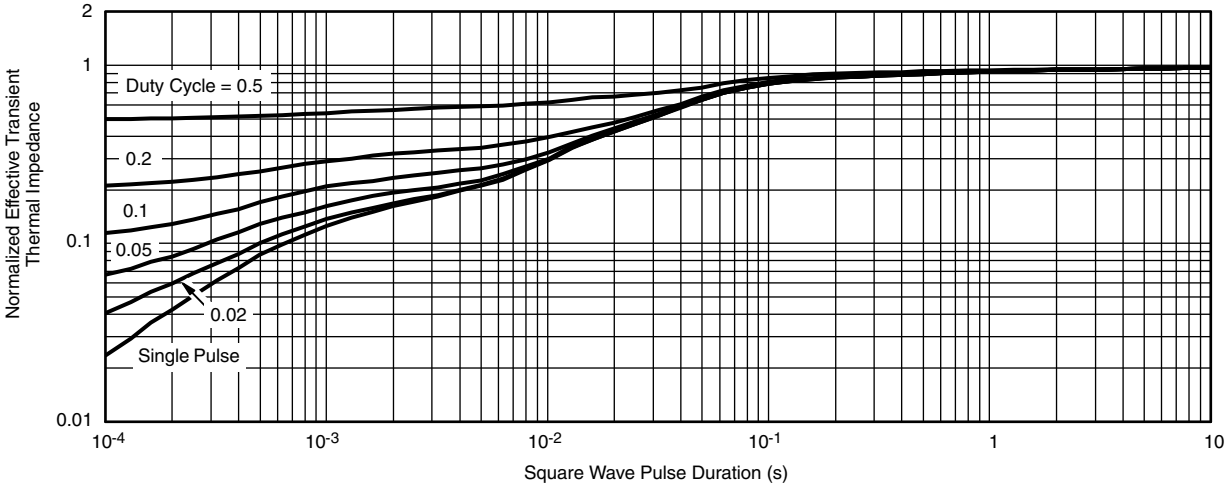
**Safe Operating Area**


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## P-CHANNEL THERMAL RATINGS ($T_A$ = 25 °C, unless otherwise noted)




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




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

**Note**

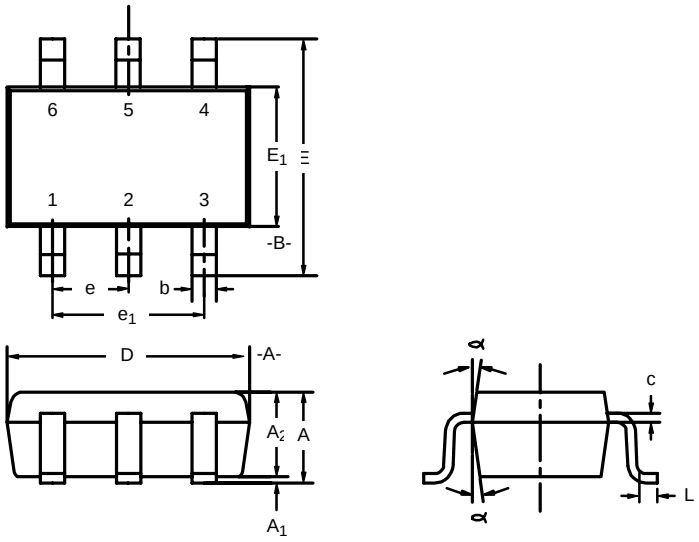
- The characteristics shown in the two graphs
  - Normalized Transient Thermal Impedance Junction-to-Ambient (25 °C)
  - Normalized Transient Thermal Impedance Junction-to-Case (25 °C)

  are given for general guidelines only to enable the user to get a “ball park” indication of part capabilities. The data are extracted from single pulse transient thermal impedance characteristics which are developed from empirical measurements. The latter is valid for the part mounted on printed circuit board - FR4, size 1" x 1" x 0.062", double sided with 2 oz. copper, 100 % on both sides. The part capabilities can widely vary depending on actual application parameters and operating conditions.

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## 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 | | |

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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.

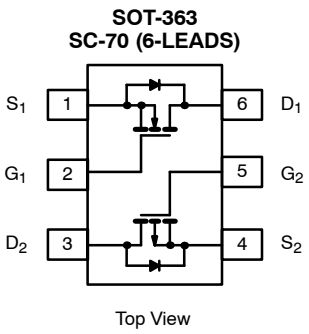



**FIGURE 1.**

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.

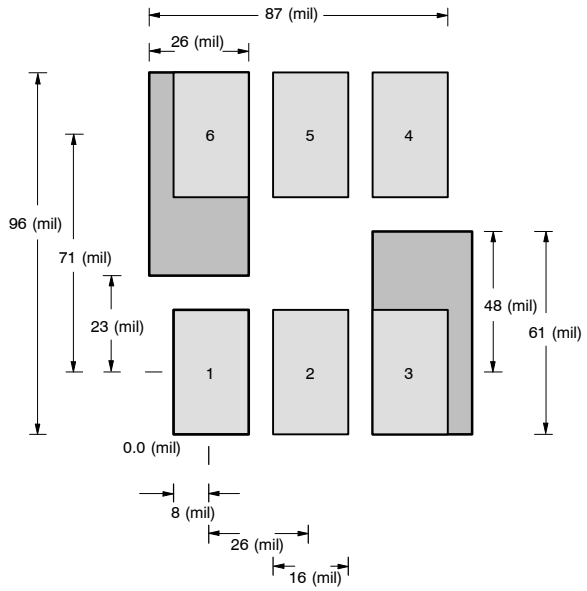



**FIGURE 2.** SC-70 (6 leads) Dual

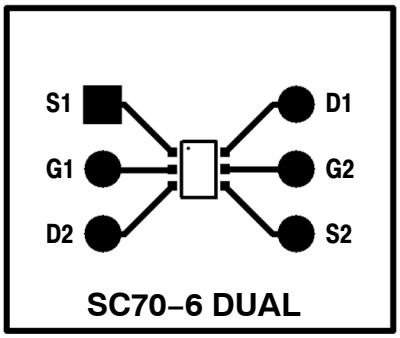
## EVALUATION BOARD FOR THE DUAL-CHANNEL SC70-6

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

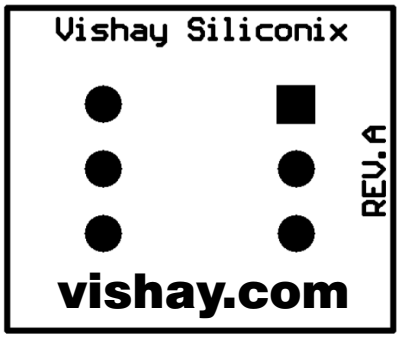



**FIGURE 3.**

## 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** |
| $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ | $P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ |
| $P_D = \frac{150^oC - 25^oC}{413^oC/W}$ | $P_D = \frac{150^oC - 60^oC}{413^oC/W}$ |
| $P_D$ = 303 mW | $P_D$ = 218 mW |

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

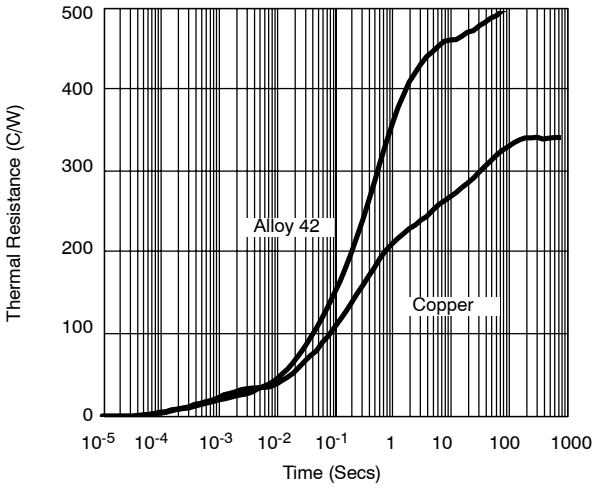



**FIGURE 4.** Dual SC70-6 Thermal Performance on EVB

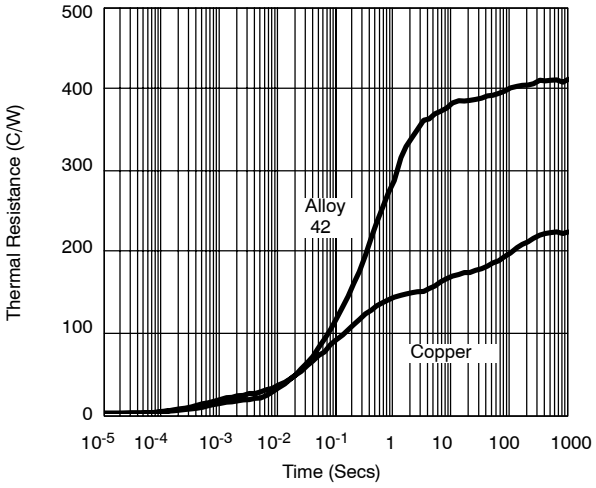
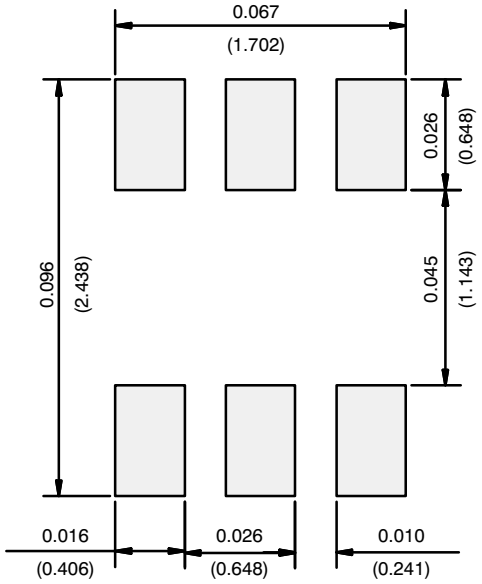



**FIGURE 5.** Dual SC70-6 Comparison on 1-inch$^2$ PCB

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




Recommended Minimum Pads
Dimensions in Inches/(mm)

Return to Index

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