# Load Switch with Level-Shift

| PRODUCT SUMMARY | | |
|---|---|---|
| $V_{DS2}$ (V) | $R_{DS(on)}$ (Ω) | $I_D$ (A) |
| 1.8 to 20 | 0.165 at $V_{IN}$ = 4.5 V | ± 1.2 |
| | 0.222 at $V_{IN}$ = 2.5 V | ± 1.0 |
| | 0.303 at $V_{IN}$ = 1.8 V | ± 0.7 |

## DESCRIPTION

The Si1869DH includes a p- and n-channel MOSFET in a single SC70-6 package. The low on-resistance p-channel TrenchFET is tailored for use as a load switch. The n-channel, with an external resistor, can be used as a level-shift to drive the p-channel load-switch. The n-channel MOSFET has internal ESD protection and can be driven by logic signals as low as 1.5 V. The Si1869DH operates on supply lines from 1.8 V to 20 V, and can drive loads up to 1.2 A.

## FEATURES

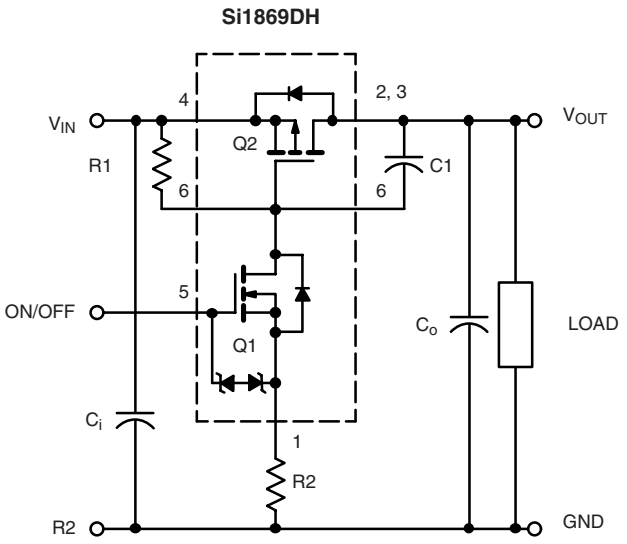
- **Halogen-free According to IEC 61249-2-21 Definition**
- TrenchFET® Power MOSFETs: 1.8 V Rated
- ESD Protected: 2000 V On Input Switch, $V_{ON/OFF}$
- 165 mΩ Low $R_{DS(on)}$
- 1.8 to 20 V Input
- 1.5 to 8 V Logic Level Control
- Low Profile, Small Footprint SC70-6 Package
- Adjustable Slew-Rate
- Compliant to RoHS Directive 2002/95/EC

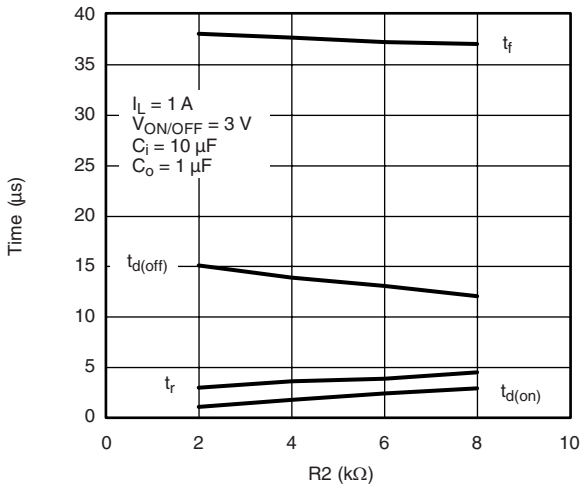
Pb-free
RoHS COMPLIANT
HALOGEN FREE Available

## APPLICATIONS

- Level Shift for Portable Devices

## APPLICATION CIRCUITS




Note: For R2 switching variations with other $V_{IN}$/R1 combinations see Typical Characteristics

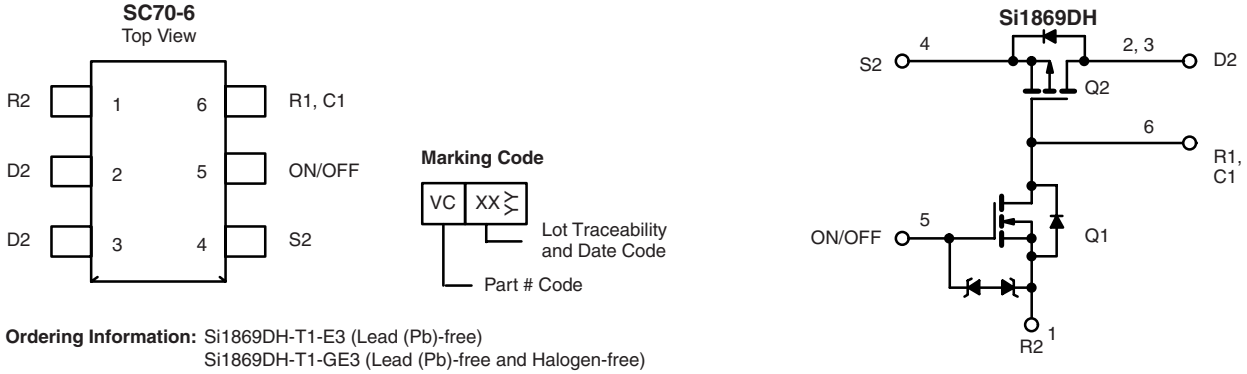
**Switching Variation**
**R2 at $V_{IN}$ = 2.5 V, R1 = 20 kΩ**

| COMPONENTS | | |
|---|---|---|
| R1 | Pull-Up Resistor | Typical 10 kΩ to 1 MΩ* |
| R2 | Optional Slew-Rate Control | Typical 0 to 100 kΩ* |
| C1 | Optional Slew-Rate Control | Typical 1000 pF |

* Minimum R1 value should be at least 10 x R2 to ensure Q1 turn-on.

The Si1869DH is ideally suited for high-side load switching in portable applications. The integrated n-channel level-shift device saves space by reducing external components. The slew rate is set externally so that rise-times can be tailored to different load types.

## FUNCTIONAL BLOCK DIAGRAM




**Ordering Information:** Si1869DH-T1-E3 (Lead (Pb)-free)
Si1869DH-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 (D2-S2) | | $V_{DS}$ | - 20 | V |
| Input Voltage | | $V_{IN}$ | 20 | |
| ON/OFF Voltage | | $V_{ON/OFF}$ | 8 | |
| Load Current | Continuous[a, b] | $I_L$ | ± 1.2 | A |
| | Pulsed[b, c] | | ± 3 | |
| Continuous Intrinsic Diode Conduction[a] | | $I_S$ | - 0.4 | |
| Maximum Power Dissipation[a] | | $P_D$ | 1.0 | W |
| Operating Junction and Storage Temperature Range | | $T_J$, $T_{stg}$ | - 55 to 150 | °C |
| ESD Rating, MIL-STD-883D Human Body Model (100 pF, 1500 Ω) | | ESD | 2 | kV |

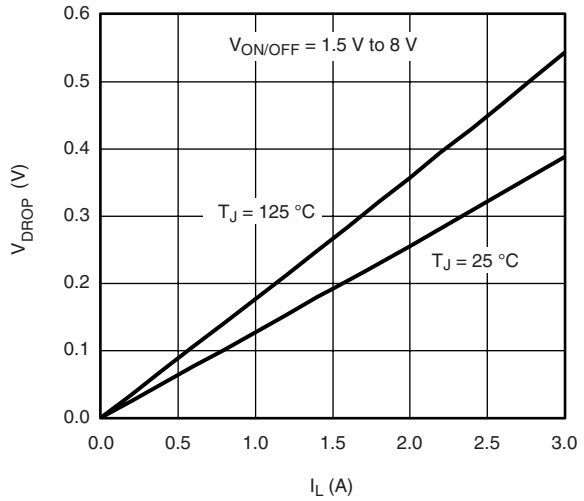
| **THERMAL RESISTANCE RATINGS** | | | | |
|---|---|---|---|---|
| **Parameter** | **Symbol** | **Typical** | **Maximum** | **Unit** |
| Maximum Junction-to-Ambient (Continuous Current)[a] | $R_{thJA}$ | 100 | 125 | °C/W |
| Maximum Junction-to-Foot (Q2) | $R_{thJF}$ | 44 | 55 | |

| **SPECIFICATIONS** $T_J$ = 25 °C unless otherwise noted | | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Symbol** | **Test Conditions** | **Min.** | **Typ.** | **Max.** | **Unit** |
| **OFF Characteristics** | | | | | | |
| Reverse Leakage Current | $I_{FL}$ | $V_{IN}$ = 8 V, $V_{ON/OFF}$ = 0 V | | | 1 | µA |
| Diode Forward Voltage | $V_{SD}$ | $I_S$ = - 0.4 A | 0.4 | 0.6 | 1.1 | V |
| **ON Characteristics** | | | | | | |
| Input Voltage Range | $V_{IN}$ | | 1.8 | | 20 | V |
| Drain to Source Breakdown Voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = - 250 µA | - 20 | | | |
| On-Resistance (P-Channel) at 1 A | $R_{DS(on)}$ | $V_{ON/OFF}$ = 1.5 V, $V_{IN}$ = 4.5 V, $I_D$ = 1.2 A | | 0.132 | 0.165 | Ω |
| | | $V_{ON/OFF}$ = 1.5 V, $V_{IN}$ = 2.5 V, $I_D$ = 1.0 A | | 0.177 | 0.222 | |
| | | $V_{ON/OFF}$ = 1.5 V, $V_{IN}$ = 1.8 V, $I_D$ = 0.7 A | | 0.242 | 0.303 | |
| On-State (P-Channel) Drain-Current | $I_{D(on)}$ | $V_{IN-OUT} \leq$ 0.2 V, $V_{IN}$ = 5 V, $V_{ON/OFF}$ = 1.5 V | 1 | | | A |
| | | $V_{IN-OUT} \leq$ 0.3 V, $V_{IN}$ = 3 V, $V_{ON/OFF}$ = 1.5 V | 1 | | | |

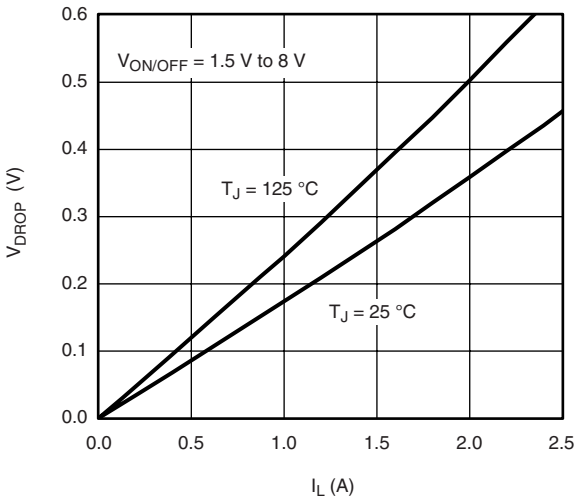
Notes:
a. Surface mounted on FR4 board.
b. $V_{IN}$ = 20 V, $V_{ON/OFF}$ = 8 V, $T_A$ = 25 °C.
c. Pulse test: pulse width ≤ 300 µs, duty cycle ≤ 2 %.

*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.*

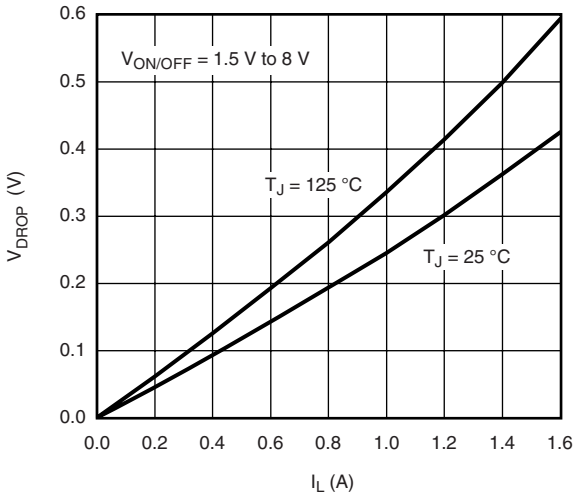
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



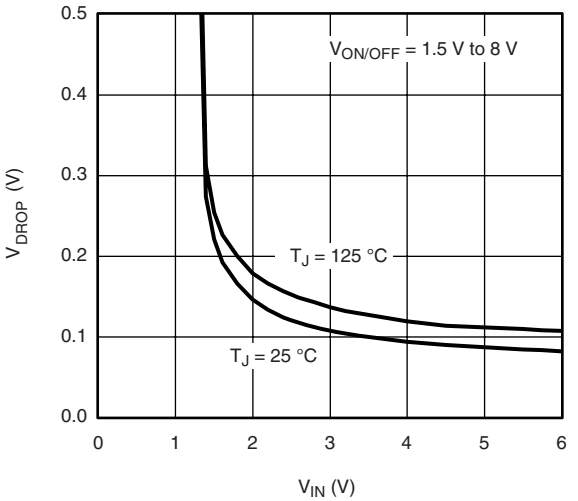

**$V_{DROP}$ vs. $I_L$ at $V_{IN}$ = 4.5 V**



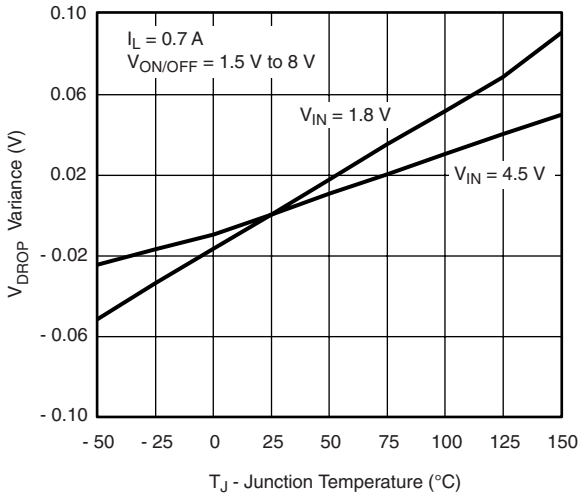

**$V_{DROP}$ vs. $I_L$ at $V_{IN}$ = 2.5 V**



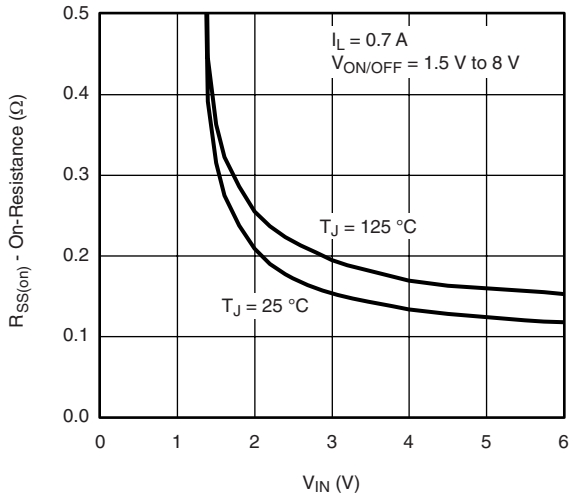

**$V_{DROP}$ vs. $I_L$ at $V_{IN}$ = 1.8 V**




**$V_{DROP}$ vs. $V_{IN}$ at $I_L$ = 0.7 A**

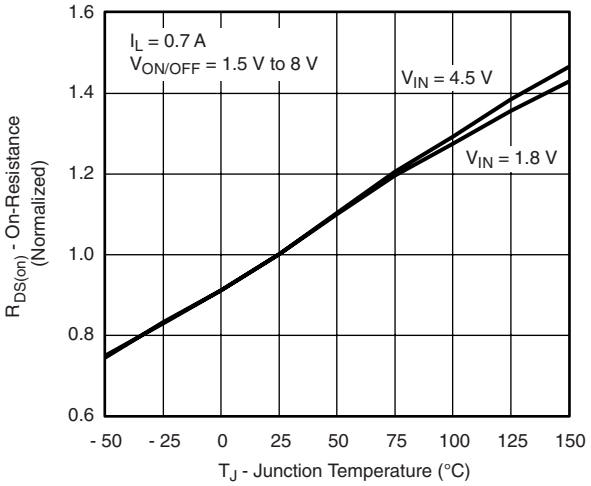



**$V_{DROP}$ Variance vs. Junction Temperature**

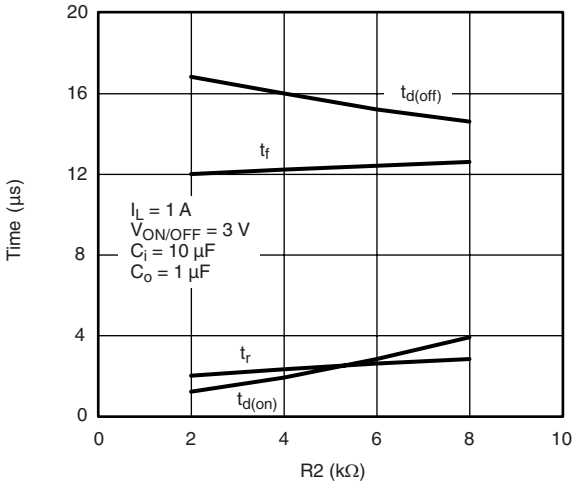



**On-Resistance vs. Input Voltage**

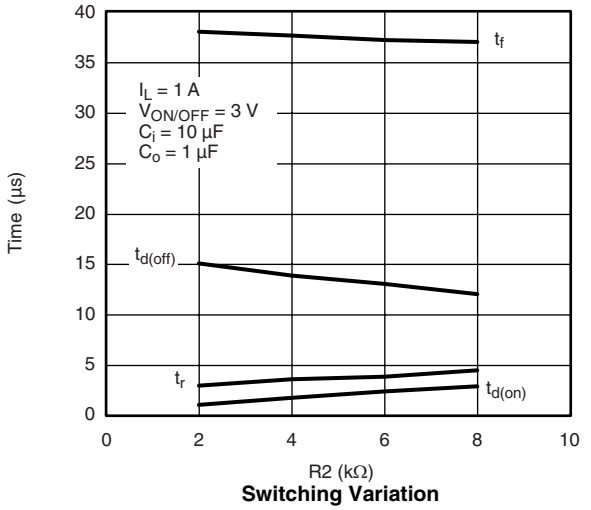
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted



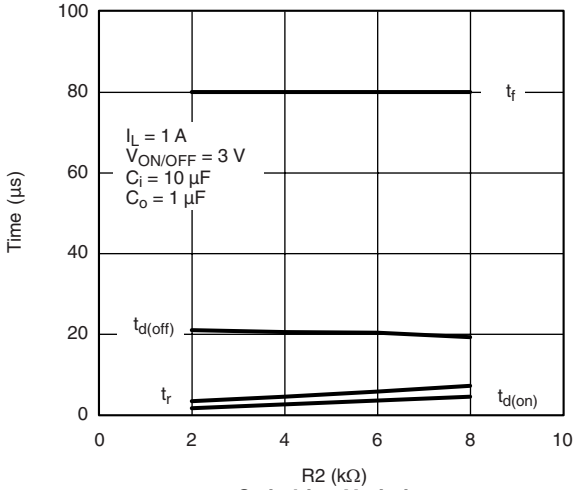

**Normalized On-Resistance vs. Junction Temperature**



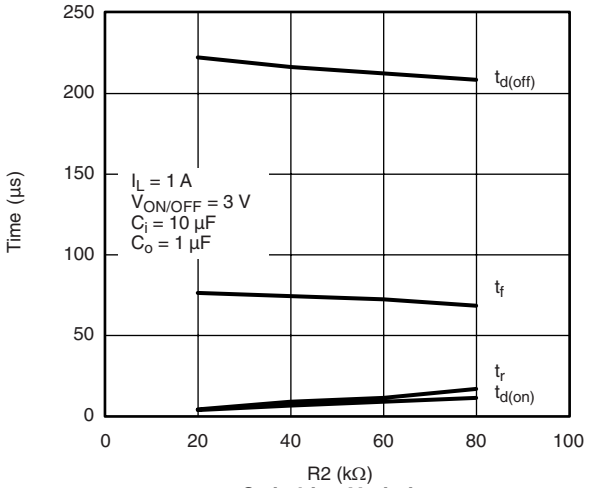

**Switching Variation**
**R2 at $V_{IN}$ = 4.5 V, R1 = 20 kΩ**



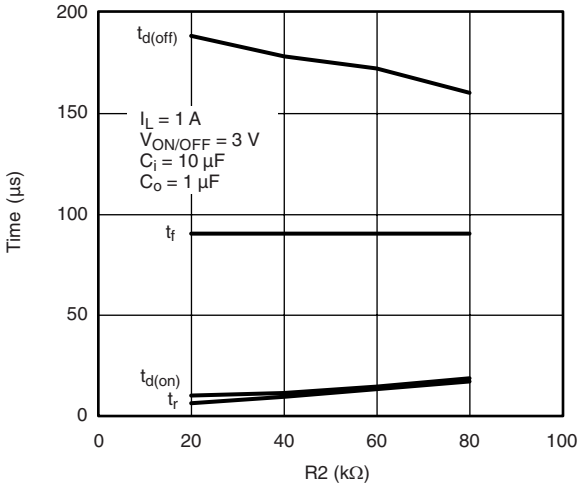

**Switching Variation**
**R2 at $V_{IN}$ = 2.5 V, R1 = 20 kΩ**




**Switching Variation**
**R2 at $V_{IN}$ = 1.8 V, R1 = 20 kΩ**

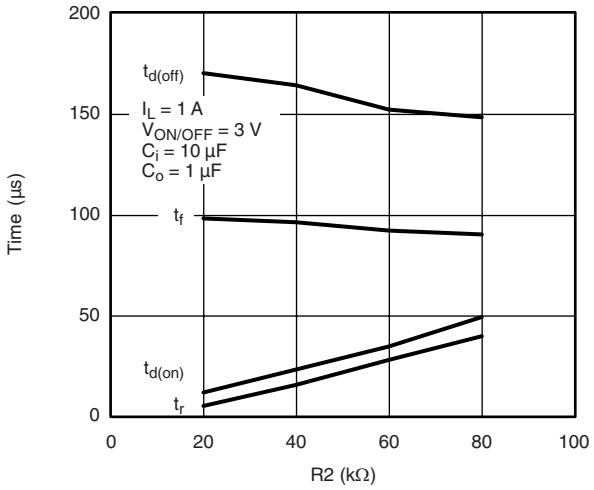



**Switching Variation**
**R2 at $V_{IN}$ = 4.5 V, R1 = 300 kΩ**

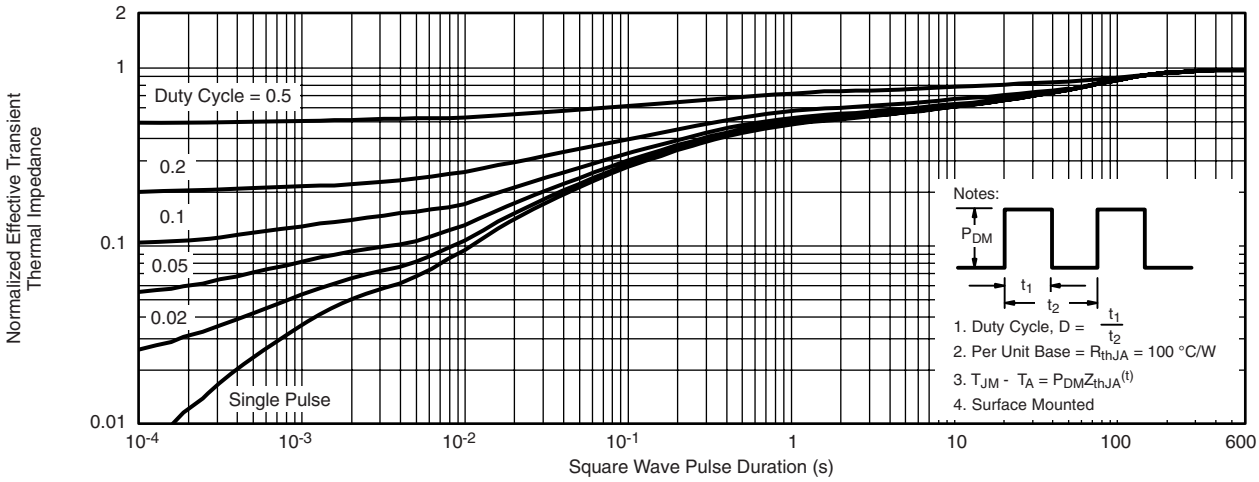



**Switching Variation**
**R2 at $V_{IN}$ = 2.5 V, R1 = 300 kΩ**

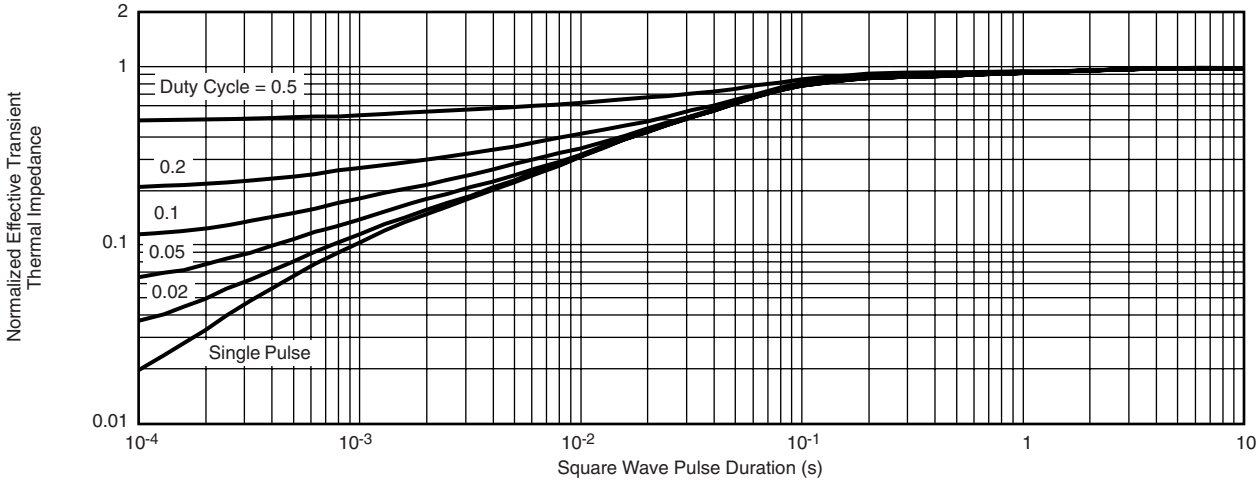
## TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted




**Switching Variation**
**R2 at $V_{IN}$ = 1.8 V, R1 = 300 kΩ**



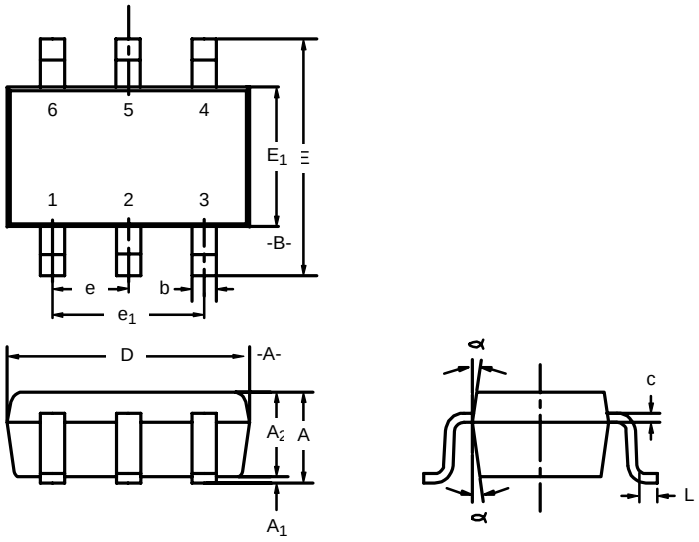

**Normalized Thermal Transient Impedance, Junction-to-Ambient**




**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?73449.*

## 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.

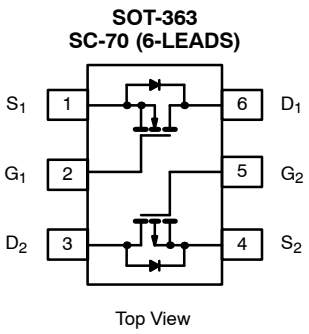



**FIGURE 1.**

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.

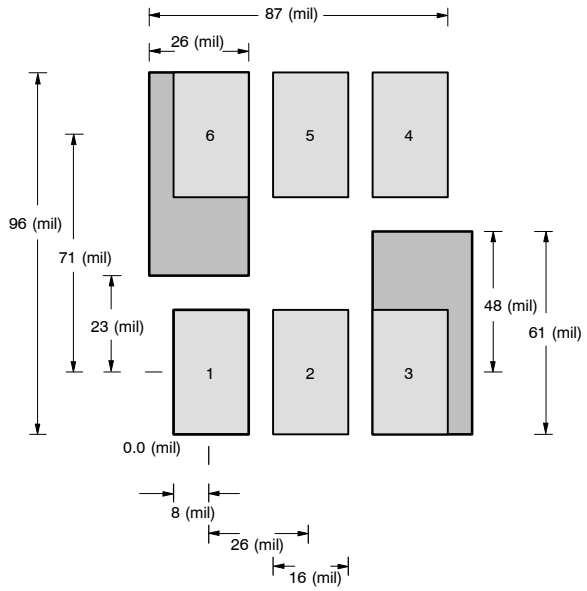



**FIGURE 2.** SC-70 (6 leads) Dual

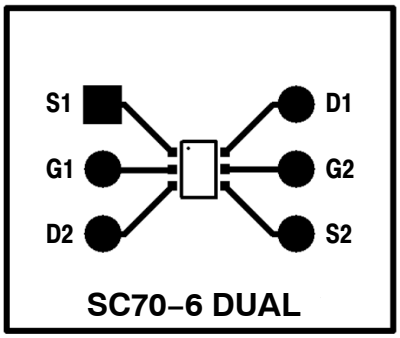
## EVALUATION BOARD FOR THE DUAL-CHANNEL SC70-6

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

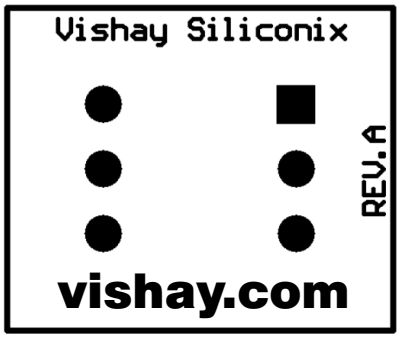



**FIGURE 3.**

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

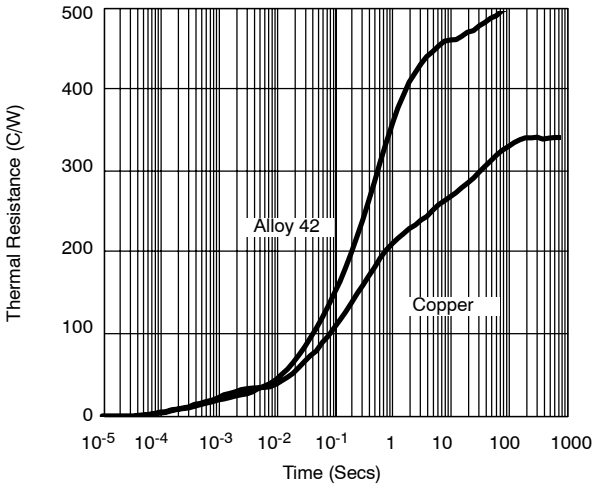



**FIGURE 4.** Dual SC70-6 Thermal Performance on EVB

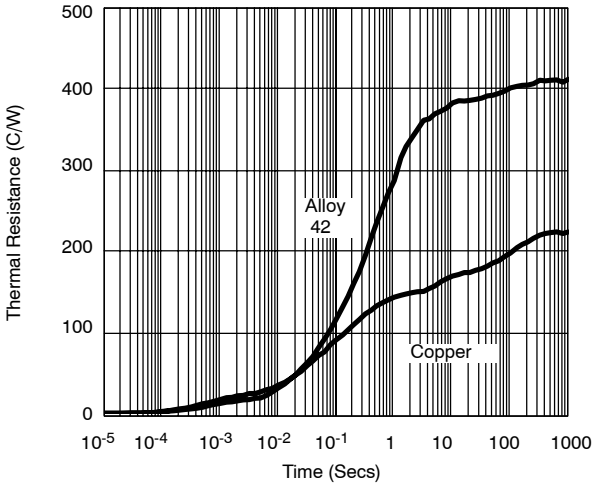
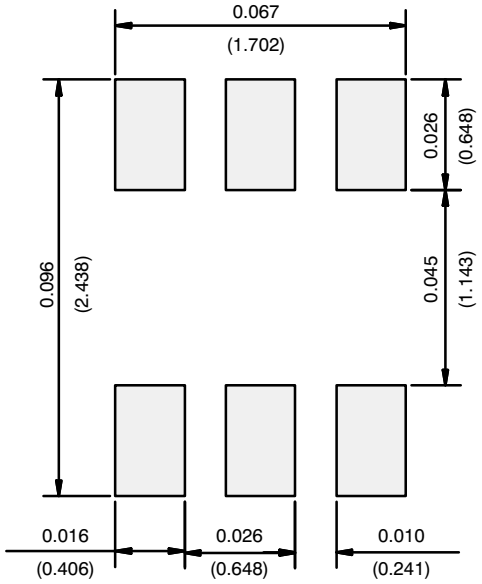



**FIGURE 5.** Dual SC70-6 Comparison on 1-inch$^2$ PCB

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




Recommended Minimum Pads
Dimensions in Inches/(mm)

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