

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

PRODUCT SUMMARY				
	V <sub>DS</sub> (V)	R <sub>DS(on)</sub> (Ω)	I <sub>D</sub> (A) <sup>a</sup>	Q <sub>g</sub> (Typ.)
N-Channel	30	0.388 at V <sub>GS</sub> = 10 V	0.7	0.55
		0.525 at V <sub>GS</sub> = 4.5 V	0.6	
P-Channel	- 30	0.890 at V <sub>GS</sub> = - 10 V	- 0.5	0.8
		1.7 at V <sub>GS</sub> = - 4.5 V	- 0.3	

### FEATURES

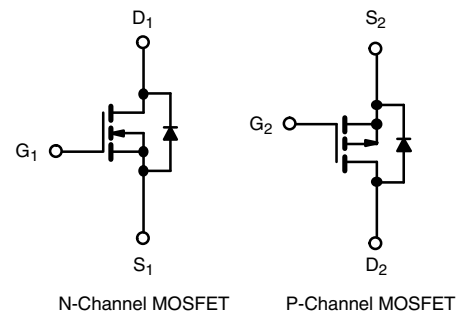
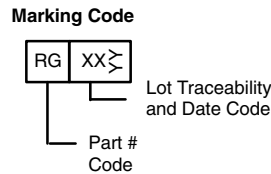
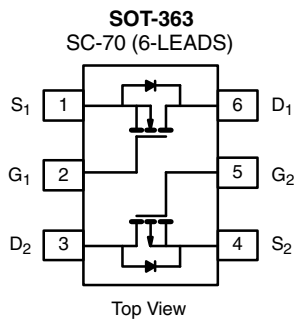
- Halogen-free According to IEC 61249-2-21 Definition
- TrenchFET<sup>®</sup> Power MOSFET
- 100 % R<sub>g</sub> Tested



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**

### APPLICATIONS

- DC/DC Converter
- Load Switch



Ordering Information: Si1539CDL-T1-GE3 (Lead (Pb)-free and Halogen-free)

ABSOLUTE MAXIMUM RATINGS (T <sub>A</sub> = 25 °C, unless otherwise noted)					
Parameter	Symbol	N-Channel	P-Channel	Unit	
Drain-Source Voltage	V <sub>DS</sub>	30	- 30	V	
Gate-Source Voltage	V <sub>GS</sub>	± 20			
Continuous Drain Current (T <sub>J</sub> = 150 °C)	I <sub>D</sub>	T <sub>C</sub> = 25 °C	0.7	- 0.5	A
		T <sub>C</sub> = 70 °C	0.6	- 0.4	
		T <sub>A</sub> = 25 °C	0.7 <sup>b, c</sup>	- 0.4 <sup>b, c</sup>	
		T <sub>A</sub> = 70 °C	0.5 <sup>b, c</sup>	- 0.4 <sup>b, c</sup>	
Source-Drain Current Diode Current	I <sub>S</sub>	T <sub>C</sub> = 25 °C	0.3	- 0.3	A
		T <sub>A</sub> = 25 °C	0.2 <sup>b, c</sup>	- 0.2 <sup>b, c</sup>	
Pulsed Drain Current	I <sub>DM</sub>	2	- 1	A	
Maximum Power Dissipation	P <sub>D</sub>	T <sub>C</sub> = 25 °C	0.34	0.34	W
		T <sub>C</sub> = 70 °C	0.22	0.22	
		T <sub>A</sub> = 25 °C	0.29 <sup>b, c</sup>	0.29 <sup>b, c</sup>	
		T <sub>A</sub> = 70 °C	0.18 <sup>b, c</sup>	0.18 <sup>b, c</sup>	
Operating Junction and Storage Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 55 to 150		°C	

THERMAL RESISTANCE RATINGS							
Parameter	Symbol	N-Channel		P-Channel		Unit	
		Typ.	Max.	Typ.	Max.		
Maximum Junction-to-Ambient <sup>b, d</sup>	t ≤ 10 s	R <sub>thJA</sub>	365	438	365	438	°C/W
Maximum Junction-to-Foot (Drain)	Steady State	R <sub>thJF</sub>	308	370	308	370	

Notes:

- Based on T<sub>C</sub> = 25 °C.
- Surface mounted on 1" x 1" FR4 board.
- t = 10 s.
- Maximum under steady state conditions is 486 °C/W (N-Channel) and 486 °C/W (P-Channel).

**SPECIFICATIONS** ( $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted)

Parameter	Symbol	Test Conditions	Min.	Typ. <sup>a</sup>	Max.	Unit	
<b>Static</b>							
Drain-Source Breakdown Voltage	$V_{DS}$	$V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$	N-Ch	30		V	
		$V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$	P-Ch	-30			
$V_{DS}$ Temperature Coefficient	$\Delta V_{DS}/T_J$	$I_D = 250\text{ }\mu\text{A}$	N-Ch		30	mV/ $^\circ\text{C}$	
		$I_D = -250\text{ }\mu\text{A}$	P-Ch		-18		
$V_{GS(th)}$ Temperature Coefficient	$\Delta V_{GS(th)}/T_J$	$I_D = 250\text{ }\mu\text{A}$	N-Ch		-3.6		
		$I_D = -250\text{ }\mu\text{A}$	P-Ch		3.3		
Gate-Source Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	N-Ch	1.2		V	
		$V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$	P-Ch	-1.2			-2.5
Gate-Body Leakage	$I_{GSS}$	$V_{DS} = 0\text{ V}, V_{GS} = \pm 20\text{ V}$	N-Ch		$\pm 100$	nA	
			P-Ch		$\pm 100$		
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 30\text{ V}, V_{GS} = 0\text{ V}$	N-Ch		1	$\mu\text{A}$	
		$V_{DS} = -30\text{ V}, V_{GS} = 0\text{ V}$	P-Ch		-1		
		$V_{DS} = 30\text{ V}, V_{GS} = 0\text{ V}, T_J = 55\text{ }^\circ\text{C}$	N-Ch		10		
		$V_{DS} = -30\text{ V}, V_{GS} = 0\text{ V}, T_J = 55\text{ }^\circ\text{C}$	P-Ch		-10		
On-State Drain Current <sup>b</sup>	$I_{D(on)}$	$V_{DS} = 5\text{ V}, V_{GS} = 10\text{ V}$	N-Ch	2		A	
		$V_{DS} = -5\text{ V}, V_{GS} = -10\text{ V}$	P-Ch	-1			
Drain-Source On-State Resistance <sup>b</sup>	$R_{DS(on)}$	$V_{GS} = 10\text{ V}, I_D = 0.6\text{ A}$	N-Ch		0.323	0.388	$\Omega$
		$V_{GS} = -10\text{ V}, I_D = -0.4\text{ A}$	P-Ch		0.740	0.890	
		$V_{GS} = 4.5\text{ V}, I_D = 0.1\text{ A}$	N-Ch		0.437	0.525	
		$V_{GS} = -4.5\text{ V}, I_D = -0.1\text{ A}$	P-Ch		1.4	1.7	
Forward Transconductance <sup>b</sup>	$g_{fs}$	$V_{DS} = 15\text{ V}, I_D = 0.6\text{ A}$	N-Ch		1.2	S	
		$V_{DS} = -15\text{ V}, I_D = -0.4\text{ A}$	P-Ch		0.6		
<b>Dynamic<sup>a</sup></b>							
Input Capacitance	$C_{iss}$	N-Channel $V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	N-Ch		28	pF	
			P-Ch		34		
Output Capacitance	$C_{oss}$		P-Channel $V_{DS} = -15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	N-Ch			10
				P-Ch			12
Reverse Transfer Capacitance	$C_{rss}$	N-Ch			5		
		P-Ch			7		
Total Gate Charge	$Q_g$	$V_{DS} = 15\text{ V}, V_{GS} = 10\text{ V}, I_D = 0.6\text{ A}$	N-Ch		1	1.5	nC
		$V_{DS} = -15\text{ V}, V_{GS} = -10\text{ V}, I_D = -0.4\text{ A}$	P-Ch		1.5	3	
		N-Channel $V_{DS} = 15\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 0.6\text{ A}$	N-Ch		0.55	1.1	
			P-Ch		0.8	1.2	
Gate-Source Charge	$Q_{gs}$	P-Channel $V_{DS} = -15\text{ V}, V_{GS} = -4.5\text{ V}, I_D = -0.4\text{ A}$	N-Ch		0.2		
			P-Ch		0.4		
Gate-Drain Charge	$Q_{gd}$		N-Ch		0.2		
			P-Ch		0.35		
Gate Resistance	$R_g$	$f = 1\text{ MHz}$	N-Ch	0.7	3.7	7.4	$\Omega$
			P-Ch	1.7	8.3	16.6	



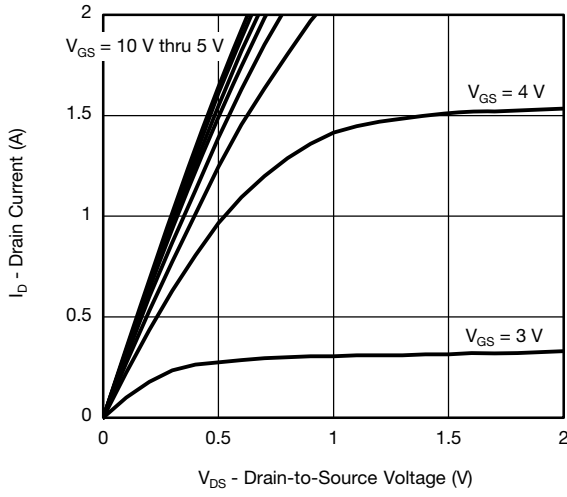
<b>SPECIFICATIONS</b> ( $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted)							
Parameter	Symbol	Test Conditions	Min.	Typ. <sup>a</sup>	Max.	Unit	
<b>Dynamic<sup>a</sup></b>							
Turn-On Delay Time	$t_{d(on)}$	N-Channel $V_{DD} = 15\text{ V}, R_L = 30\ \Omega$ $I_D \cong 0.5\text{ A}, V_{GEN} = 10\text{ V}, R_g = 1\ \Omega$  P-Channel $V_{DD} = -15\text{ V}, R_L = 38\ \Omega$ $I_D \cong -0.4\text{ A}, V_{GEN} = -10\text{ V}, R_g = 1\ \Omega$	N-Ch		2	4	ns
			P-Ch		1	2	
Rise Time	$t_r$		N-Ch		14	21	
			P-Ch		9	18	
Turn-Off Delay Time	$t_{d(off)}$		N-Ch		11	20	
			P-Ch		8	16	
Fall Time	$t_f$		N-Ch		9	18	
			P-Ch		8	16	
Turn-On Delay Time	$t_{d(on)}$	N-Channel $V_{DD} = 15\text{ V}, R_L = 30\ \Omega$ $I_D \cong 0.5\text{ A}, V_{GEN} = 4.5\text{ V}, R_g = 1\ \Omega$  P-Channel $V_{DD} = -15\text{ V}, R_L = 38\ \Omega$ $I_D \cong -0.4\text{ A}, V_{GEN} = -4.5\text{ V}, R_g = 1\ \Omega$	N-Ch		26	39	
			P-Ch		32	48	
Rise Time	$t_r$		N-Ch		25	38	
			P-Ch		19	29	
Turn-Off Delay Time	$t_{d(off)}$		N-Ch		14	21	
			P-Ch		4	8	
Fall Time	$t_f$		N-Ch		15	23	
			P-Ch		10	20	
<b>Drain-Source Body Diode Characteristics</b>							
Continuous Source-Drain Diode Current	$I_S$	$T_C = 25\text{ }^\circ\text{C}$	N-Ch			0.3	A
			P-Ch			-0.3	
Pulse Diode Forward Current <sup>a</sup>	$I_{SM}$		N-Ch			2	
			P-Ch			-1	
Body Diode Voltage	$V_{SD}$	$I_S = 0.5\text{ A}$ $I_S = -0.4\text{ A}$	N-Ch		0.8	1.2	V
			P-Ch		-0.8	-1.2	
Body Diode Reverse Recovery Time	$t_{rr}$	N-Channel $I_F = 0.5\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}, T_J = 25\text{ }^\circ\text{C}$  P-Channel $I_F = -0.5\text{ A}, dI/dt = -100\text{ A}/\mu\text{s}, T_J = 25\text{ }^\circ\text{C}$	N-Ch		10	20	ns
P-Ch			16	24			
Body Diode Reverse Recovery Charge	$Q_{rr}$		N-Ch		3	6	nC
			P-Ch		8	16	
Reverse Recovery Fall Time	$t_a$		N-Ch		6		ns
			P-Ch		9		
Reverse Recovery Rise Time	$t_b$		N-Ch		4		
			P-Ch		7		

Notes:

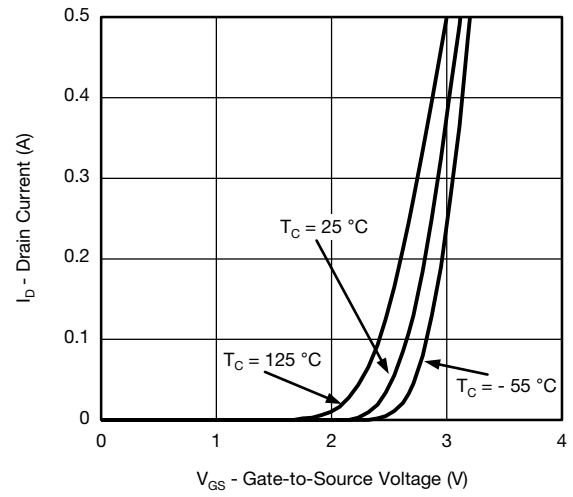
- a. Guaranteed by design, not subject to production testing.
- b. Pulse test; pulse width  $\leq 300\ \mu\text{s}$ , duty cycle  $\leq 2\%$ .

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.

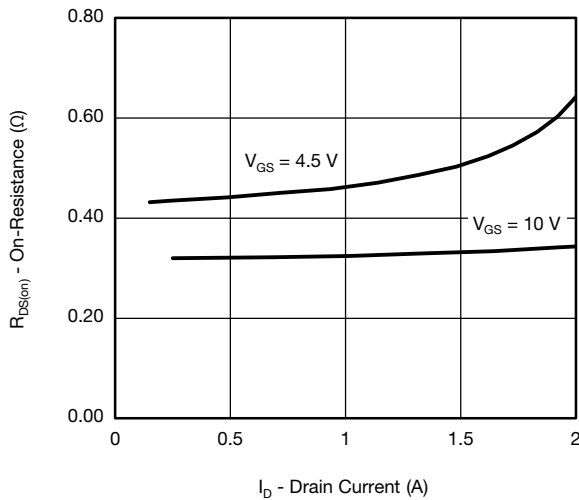
**N-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



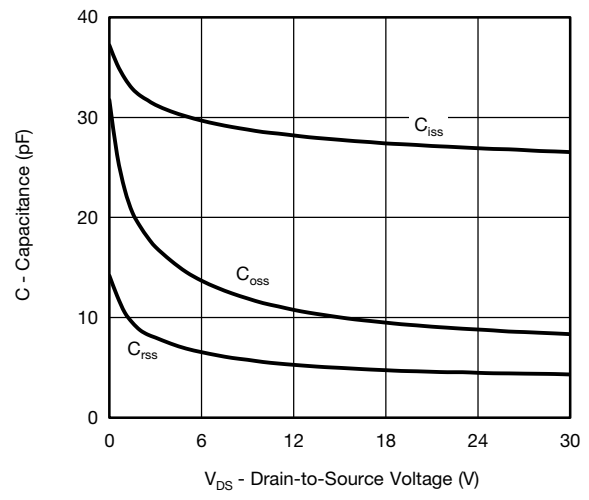
**Output Characteristics**



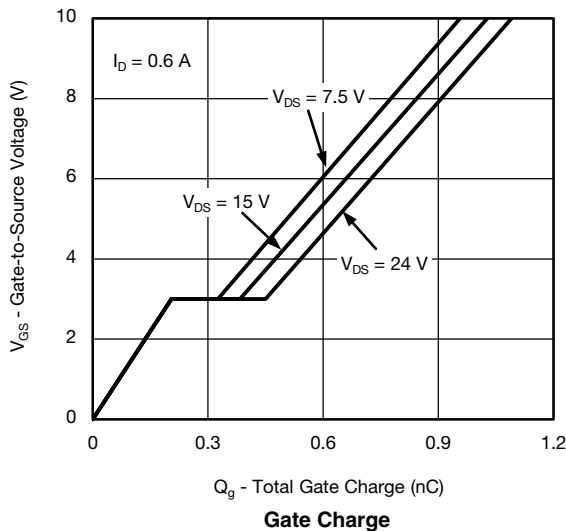
**Transfer Characteristics**



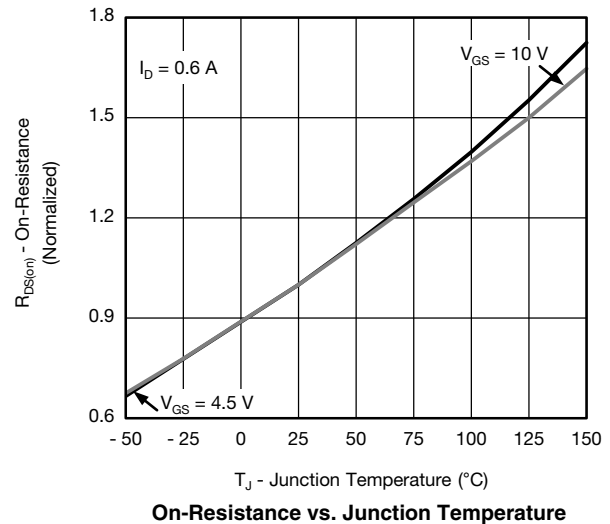
**On-Resistance vs. Drain Current and Gate Voltage**



**Capacitance**

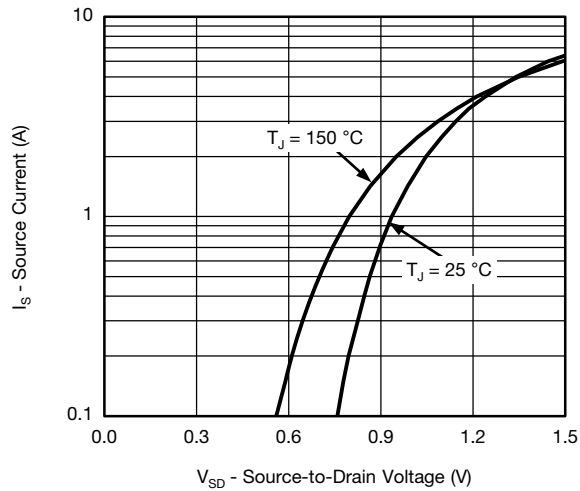


**Gate Charge**

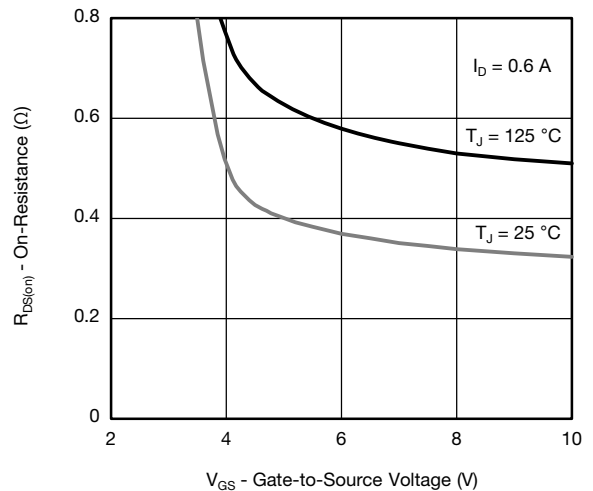


**On-Resistance vs. Junction Temperature**

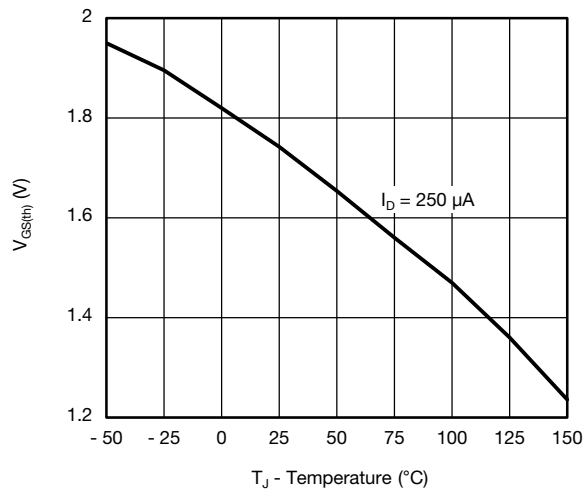
**N-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



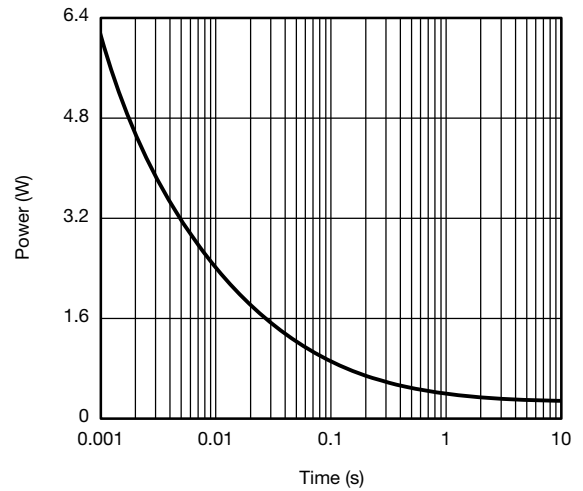
**Source-Drain Diode Forward Voltage**



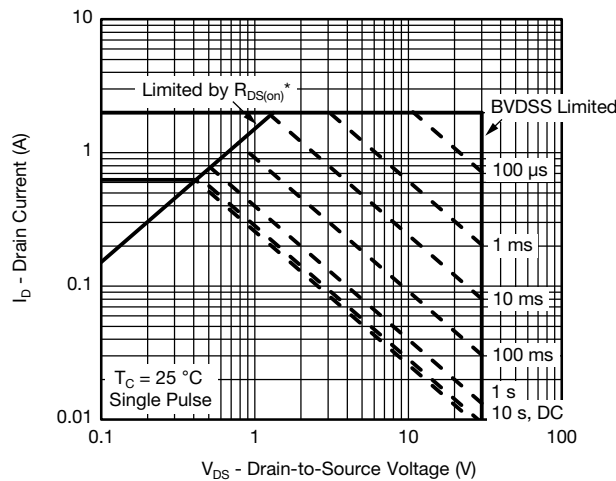
**On-Resistance vs. Gate-to-Source Voltage**



**Threshold Voltage**



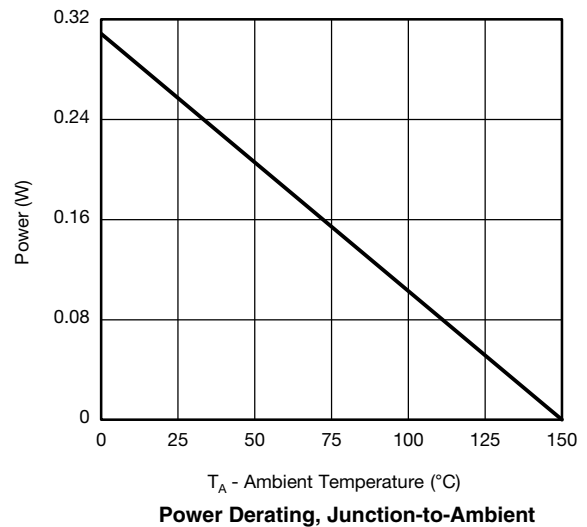
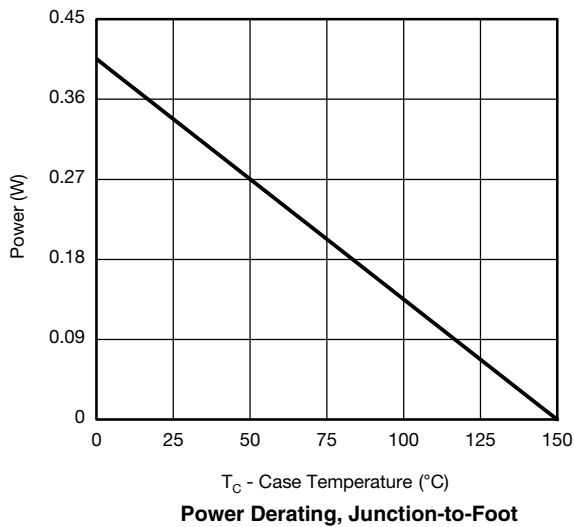
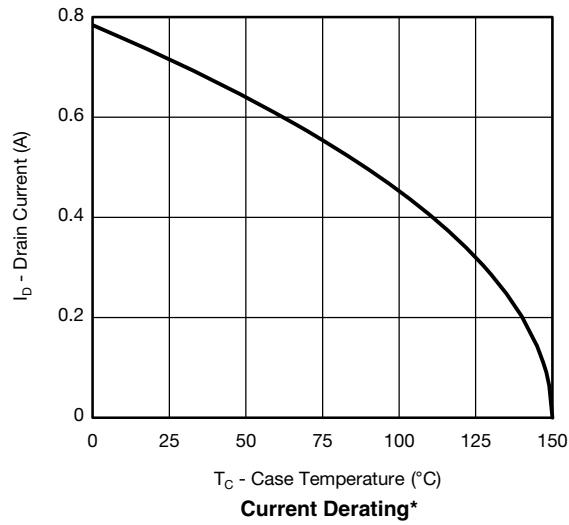
**Single Pulse Power, Junction-to-Ambient**



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

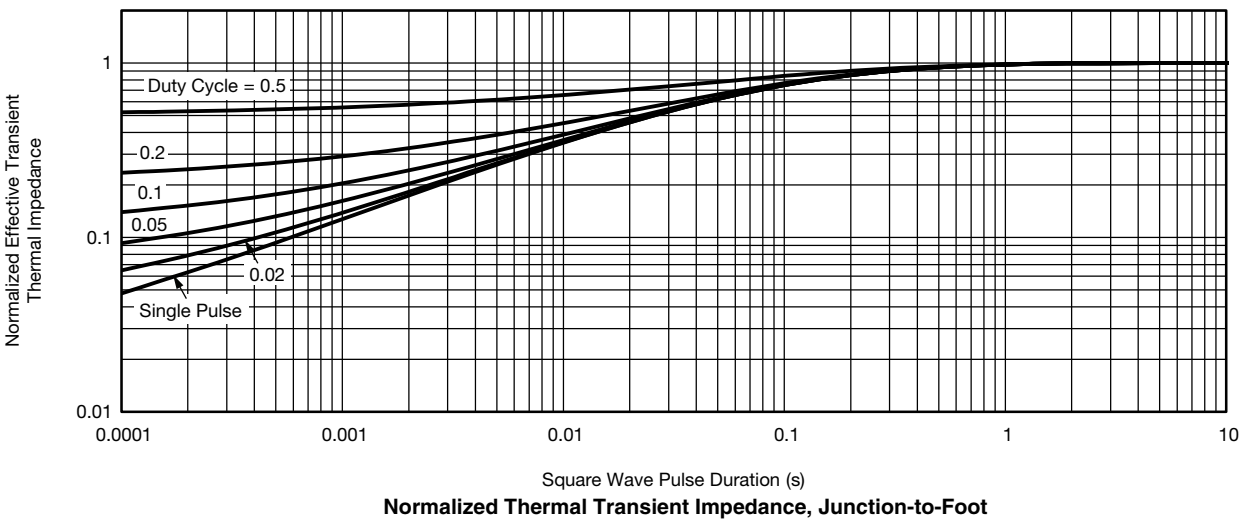
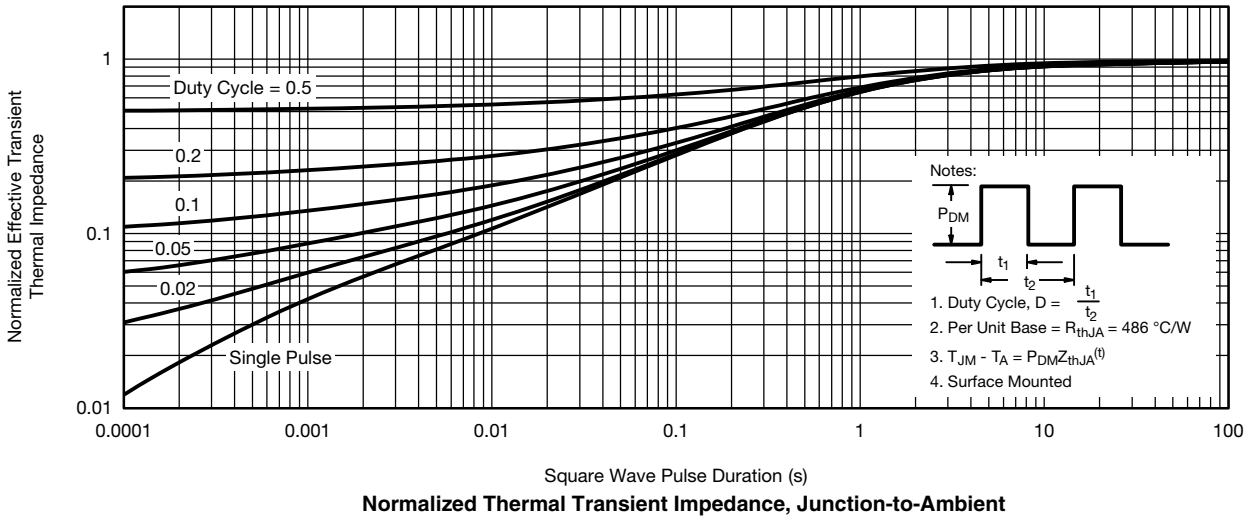
**Safe Operating Area, Junction-to-Ambient**

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

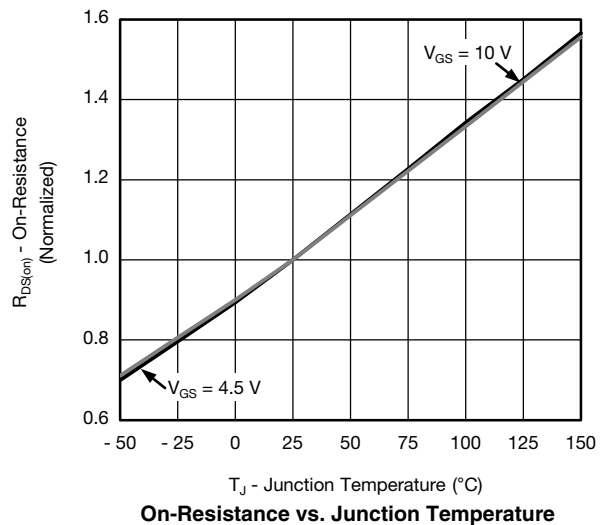
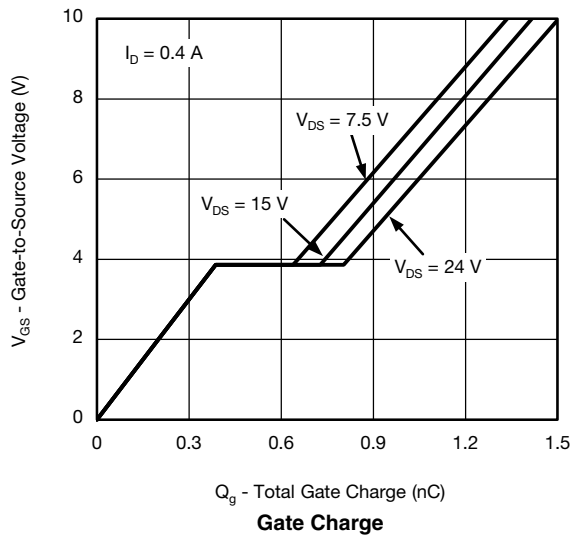
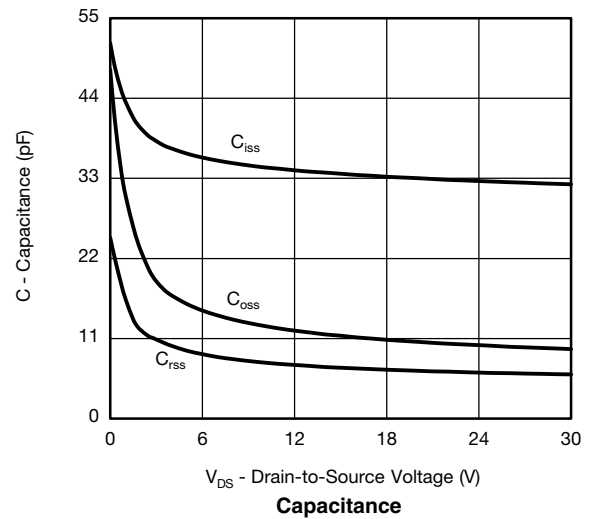
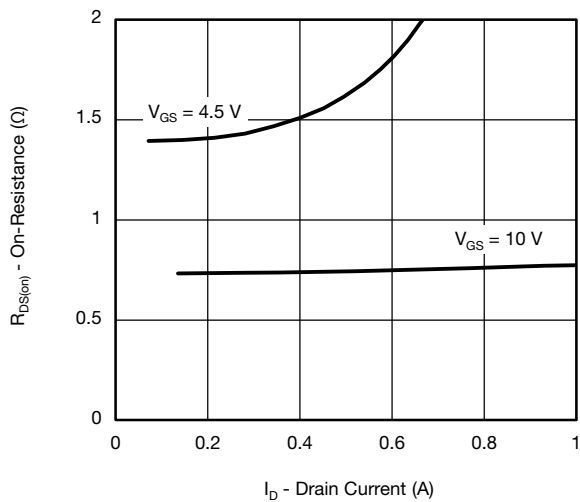
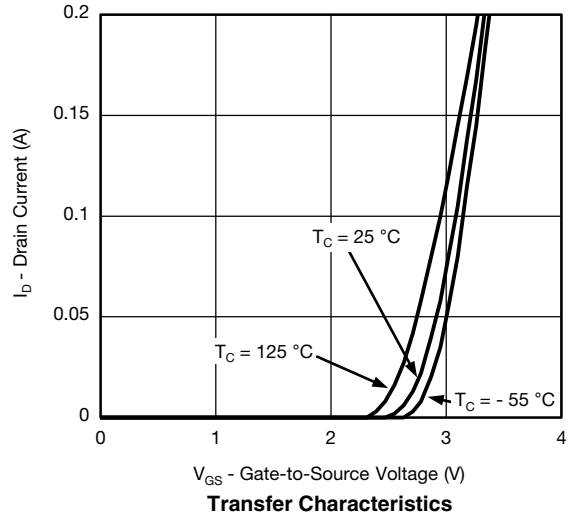
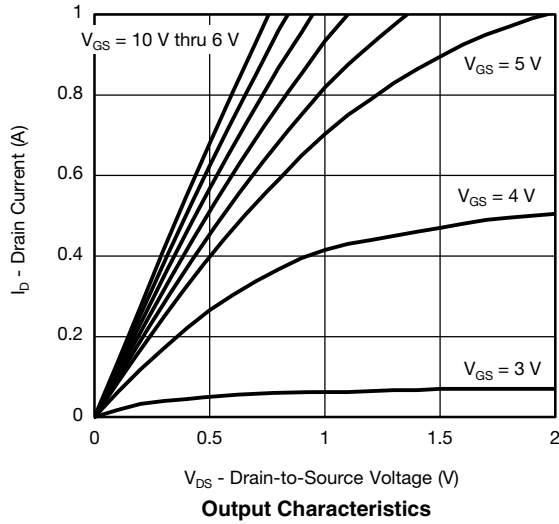


\* The power dissipation  $P_D$  is based on  $T_{J(max)} = 150$  °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit.

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

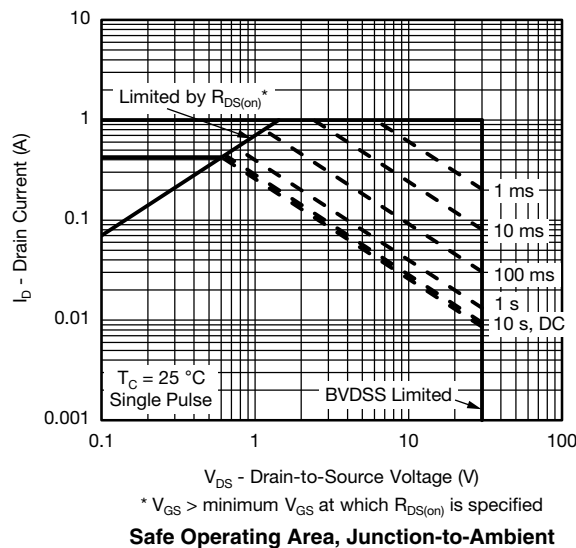
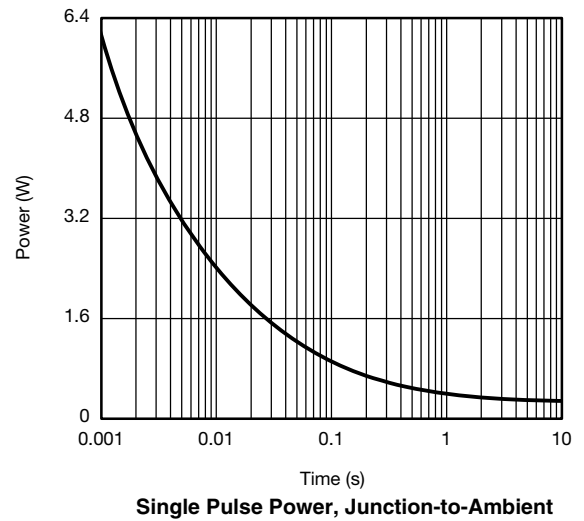
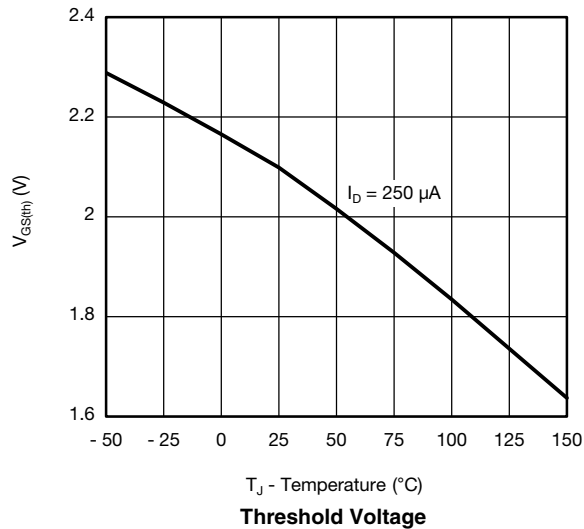
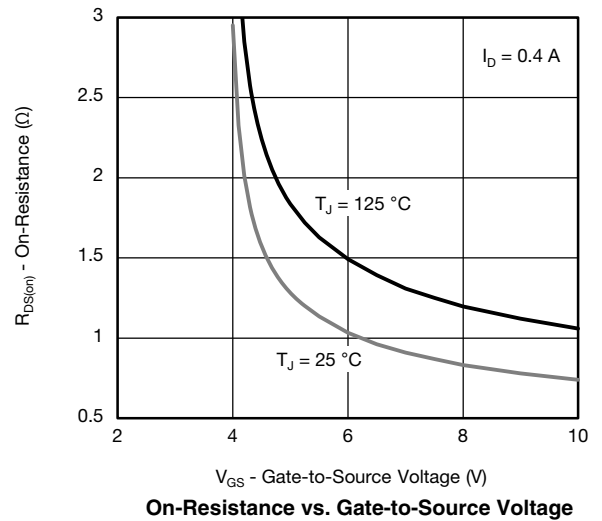
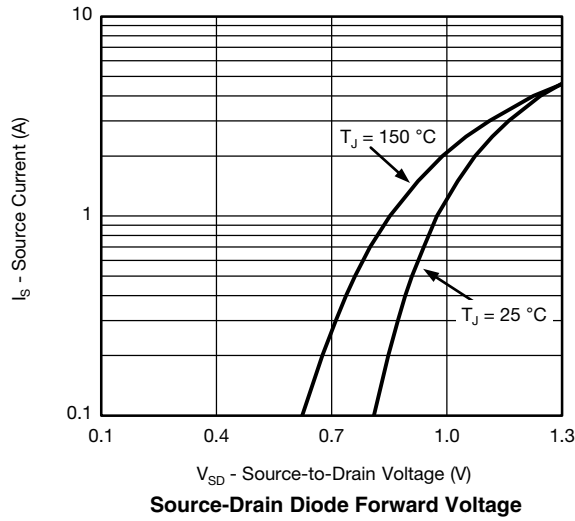


**P-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

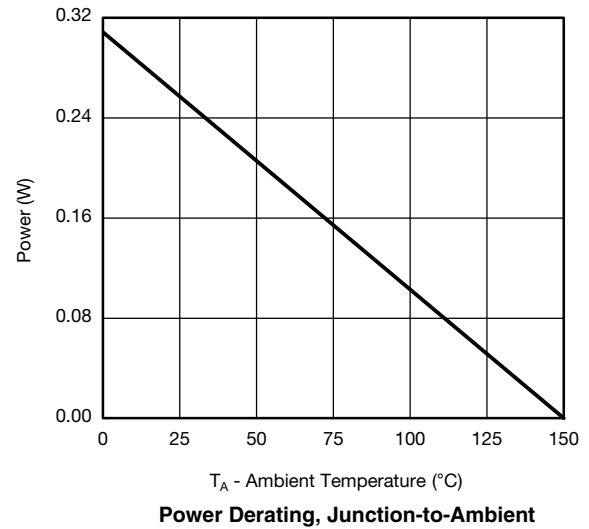
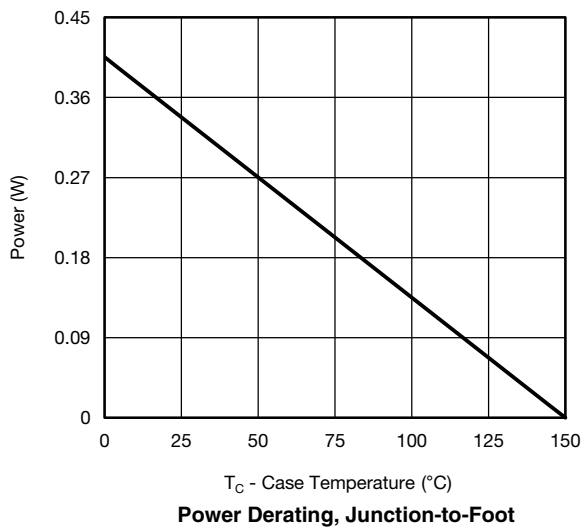
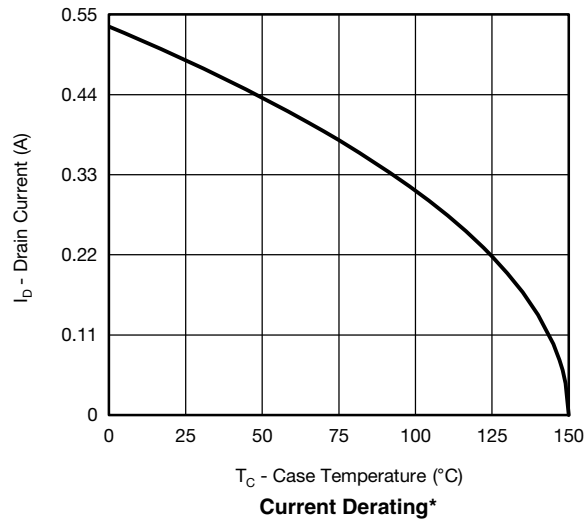




**P-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

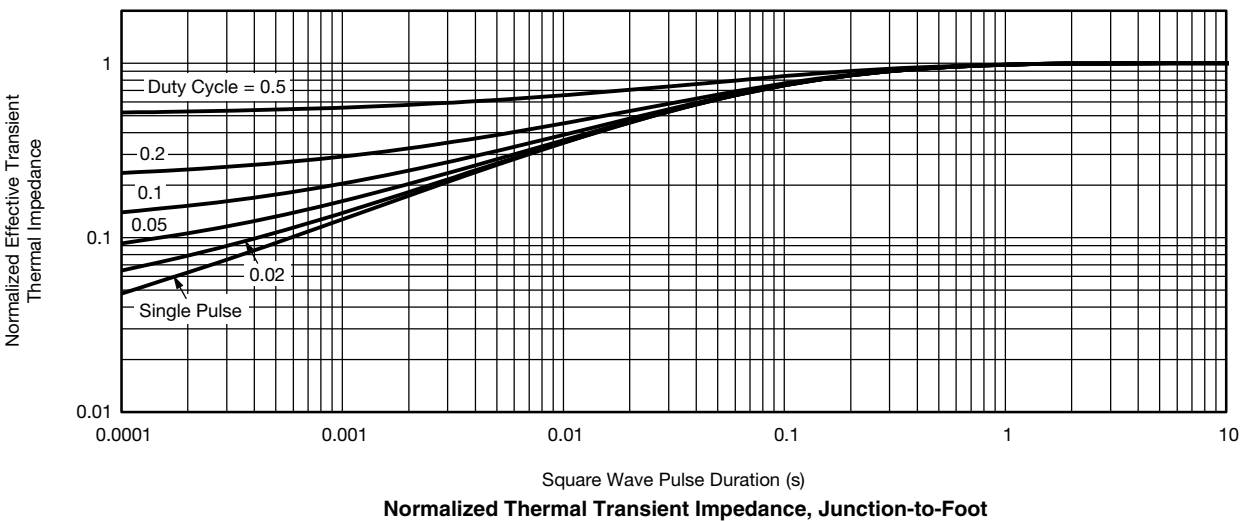
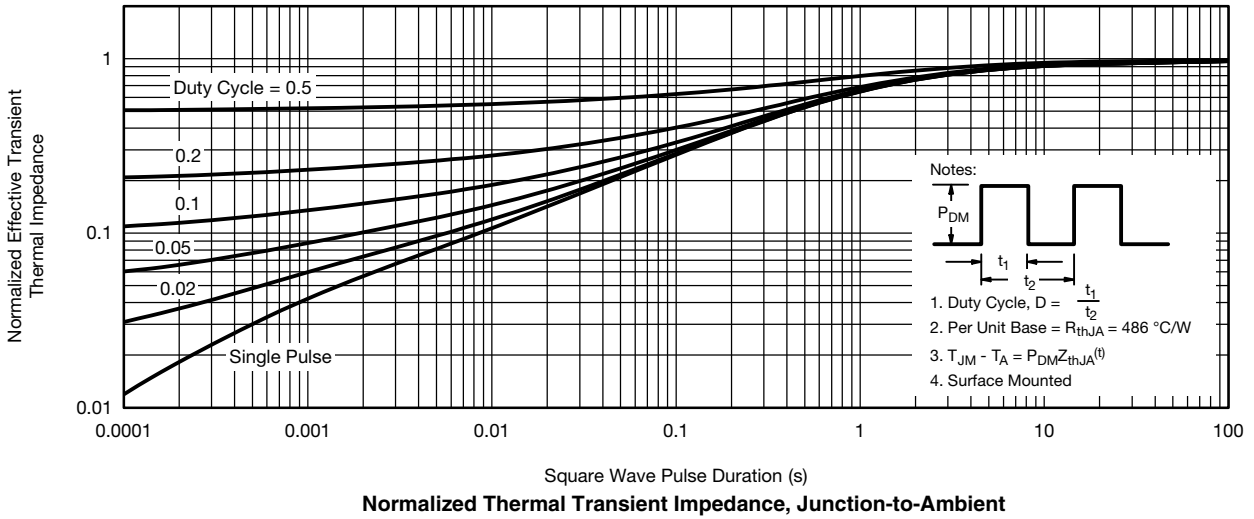


## P-CHANNEL TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



\* 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.

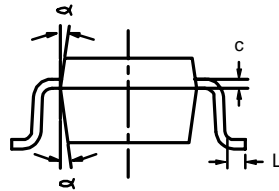
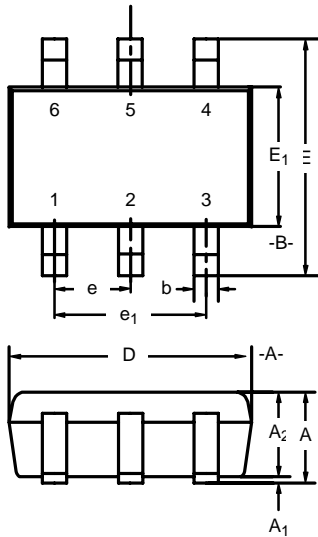
**P-CHANNEL TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



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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 <sub>1</sub>	-	-	0.10	-	-	0.004
A <sub>2</sub>	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 <sub>1</sub>	1.15	1.25	1.35	0.045	0.049	0.053
e	0.65BSC			0.026BSC		
e <sub>1</sub>	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® SC-70 6-Pin MOSFET Recommended Pad Pattern and Thermal Performance

## INTRODUCTION

This technical note discusses the pin-outs, package outlines, pad patterns, evaluation board layout, and thermal performance for dual-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 250 mA) need to be switched, either directly or by using a level shift configuration. Vishay provides these devices with a range of on-resistance specifications in 6-pin versions. The new 6-pin SC-70 package enables improved on-resistance values and enhanced thermal performance.

## 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.



**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 6-pin SC-70. This basic pad pattern is sufficient for the low-power

applications for which this package is intended. For the 6-pin device, increasing the pad patterns yields a reduction in thermal resistance on the order of 20% when using a 1-inch square with full copper on both sides of the printed circuit board (PCB).

## EVALUATION BOARDS FOR THE DUAL SC70-6

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

The thermal performance of the dual SC-70 has been measured on the EVB with the results shown below. The minimum recommended footprint on the evaluation board was compared with the industry standard 1-inch square FR4 PCB with copper on both sides of the board.

## THERMAL PERFORMANCE

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

Thermal performance for the dual SC-70 6-pin package measured as junction-to-foot thermal resistance is 300°C/W typical, 350°C/W maximum. The “foot” is the drain lead of the device as it connects with the body. 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 dual 6-pin SC-70 is 400°C/W steady state. Maximum ratings are 460°C/W for the dual. All figures based on the 1-inch square FR4 test board. The following example shows how the thermal resistance impacts power dissipation for the dual 6-pin SC-70 package at two different ambient temperatures.

<b>SC-70 (6-PIN)</b>	
<b>Room Ambient 25 °C</b>	<b>Elevated Ambient 60 °C</b>
$P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$	$P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$
$P_D = \frac{150^{\circ}C - 25^{\circ}C}{400^{\circ}C/W}$	$P_D = \frac{150^{\circ}C - 60^{\circ}C}{400^{\circ}C/W}$
$P_D = 312 \text{ mW}$	$P_D = 225 \text{ mW}$

NOTE: Although they are intended for low-power applications, devices in the 6-pin SC-70 will handle power dissipation in excess of 0.2 W.

**Testing**

To aid comparison further, Figure 2 illustrates the dual-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. The measured steady state values of  $R\theta_{JA}$  for the dual 6-pin SC-70 are as follows:

<b>LITTLE FOOT SC-70 (6-PIN)</b>	
1) Minimum recommended pad pattern (see Figure 2) on the EVB of 0.5 inches x 0.6 inches.	518 °C/W
2) Industry standard 1" square PCB with maximum copper both sides.	413 °C/W



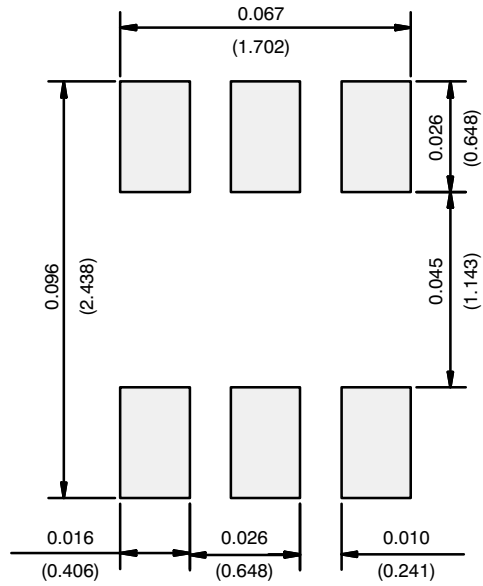
**FIGURE 2.** Comparison of Dual SC70-6 on EVB and 1" Square FR4 PCB.

The results show that if the board area can be increased and maximum copper traces are added, the thermal resistance reduction is limited to 20%. This fact confirms that the power dissipation is restricted with the package size and the Alloy 42 leadframe.

**ASSOCIATED DOCUMENT**

Single-Channel LITTLE FOOT SC-70 6-Pin MOSFET Copper Leadframe Version, REcommended Pad Pattern and Thermal Performance, AN815, (<http://www.vishay.com/doc?71334>).

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



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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