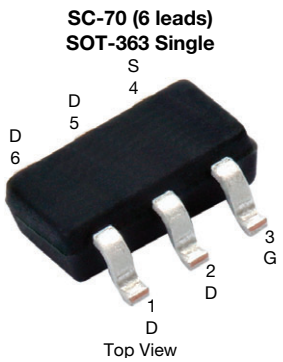
N-Channel 30 V (D-S) MOSFET



Marking code: AR

FEATURES

- TrenchFET® power MOSFET
- Typical ESD protection 1500 V in HBM
- 100 % R_g tested
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

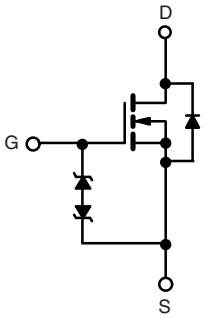
Pb-free

RoHS COMPLIANT

HALOGEN FREE

APPLICATIONS

- Portable devices such as smart phones and tablet PCs
  - DC/DC converters
  - High frequency switching
  - OVP switch
  - Load switch



N-Channel MOSFET

PRODUCT SUMMARY	
V_{DS} (V)	30
$R_{DS(on)}$ max. (Ω) at V_{GS} = 10 V	0.058
$R_{DS(on)}$ max. (Ω) at V_{GS} = 4.5 V	0.064
$R_{DS(on)}$ max. (Ω) at V_{GS} = 2.5 V	0.077
Q_g typ. (nC)	3.5
I_D (A) [a]	3.9
Configuration	Single

ORDERING INFORMATION	
Package	SC-70
Lead (Pb)-free and halogen-free	Si1416EDH-T1-GE3

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

PARAMETER		SYMBOL	LIMIT	UNIT
Drain-source voltage		V_{DS}	30	V
Gate-source voltage		V_{GS}	± 12	
Continuous drain current (T_J = 150 °C)	T_C = 25 °C	I_D	3.9 [a]	A
	T_C = 70 °C		3.9 [a]	
	T_A = 25 °C		3.9 [a, b, c]	
	T_A = 70 °C		3.9 [a, b, c]	
Pulsed drain current (t = 300 µs)		I_{DM}	15	
Continuous source-drain diode current	T_C = 25 °C	I_S	2.3 [a]	
	T_A = 25 °C		1.3 [b, c]	
Maximum power dissipation	T_C = 25 °C	P_D	2.8	W
	T_C = 70 °C		1.8	
	T_A = 25 °C		1.56 [b, c]	
	T_A = 70 °C		1 [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}	60	80	°C/W
Maximum junction-to-foot (drain)	Steady state	R_{thJF}	34	45	

Notes

a. Package limited, T_C = 25 °C
b. Surface mounted on 1" x 1" FR4 board
c. t = 5 s
d. Maximum under steady state conditions is 125 °C/W

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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	30	-	-	V
V_{DS} temperature coefficient	$\Delta V_{DS}/T_J$	I_D = 250 µA	-	34	-	mV/°C
$V_{GS(th)}$ temperature coefficient	$\Delta V_{GS(th)}/T_J$		-	-3.3	-	
Gate-source threshold voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 250 µA	0.6	-	1.4	V
Gate-source leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ± 4.5 V	-	-	± 0.5	µA
		V_{DS} = 0 V, V_{GS} = ± 12 V	-	-	± 20	
Zero gate voltage drain current	I_{DSS}	V_{DS} = 30 V, V_{GS} = 0 V	-	-	1	
		V_{DS} = 30 V, V_{GS} = 0 V, T_J = 55 °C	-	-	10	
On-state drain current [a]	$I_{D(on)}$	$V_{DS} \geq$ 5 V, V_{GS} = 10 V	10	-	-	A
Drain-source on-state resistance [a]	$R_{DS(on)}$	V_{GS} = 10 V, I_D = 3.1 A	-	0.047	0.058	Ω
		V_{GS} = 4.5 V, I_D = 2 A	-	0.052	0.064	
		V_{GS} = 2.5 V, I_D = 1 A	-	0.062	0.077	
Forward transconductance [a]	g_{fs}	V_{DS} = 15 V, I_D = 3.1 A	-	13	-	S
Dynamic [b]						
Total gate charge	Q_g	V_{DS} = 15 V, V_{GS} = 10 V, I_D = 4 A	-	7.5	12	nC
		V_{DS} = 15 V, V_{GS} = 4.5 V, I_D = 4 A	-	3.5	5.5	
Gate-source charge	Q_{gs}		-	1.8	-	
Gate-drain charge	Q_{gd}		-	0.7	-	
Gate resistance	R_g	f = 1 MHz	0.6	3.3	6.6	Ω
Turn-on delay time	$t_{d(on)}$	V_{DD} = 15 V, R_L = 4.7 Ω $I_D \cong$ 3.2 A, V_{GEN} = 4.5 V, R_g = 1 Ω	-	20	40	ns
Rise time	t_r		-	60	120	
Turn-off delay time	$t_{d(off)}$		-	25	50	
Fall time	t_f		-	45	90	
Turn-on delay time	$t_{d(on)}$	V_{DD} = 15 V, R_L = 4.7 Ω $I_D \cong$ 3.2 A, V_{GEN} = 10 V, R_g = 1 Ω	-	1.5	5	
Rise time	t_r		-	30	60	
Turn-off delay time	$t_{d(off)}$		-	15	30	
Fall time	t_f		-	50	100	
Drain-Source Body Diode Characteristics						
Continuous source-drain diode current	I_S	T_C = 25 °C	-	-	3.9	A
Pulse diode forward current	I_{SM}		-	-	15	
Body diode voltage	V_{SD}	I_S = 3.2 A, V_{GS} = 0 V	-	0.87	1.2	V
Body diode reverse recovery time	t_{rr}	I_F = 3.2 A, di/dt = 100 A/µs, T_J = 25 °C	-	10	20	ns
Body diode reverse recovery charge	Q_{rr}		-	4	10	nC
Reverse recovery fall time	t_a		-	5.3	-	ns
Reverse recovery rise time	t_b		-	4.6	-	

Notes

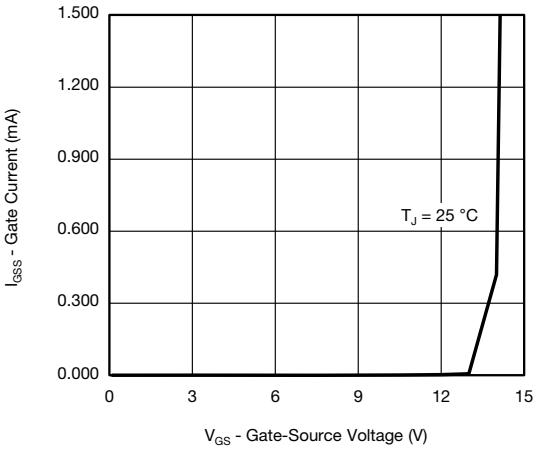
a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2%

b. Guaranteed by design, not subject to production testing

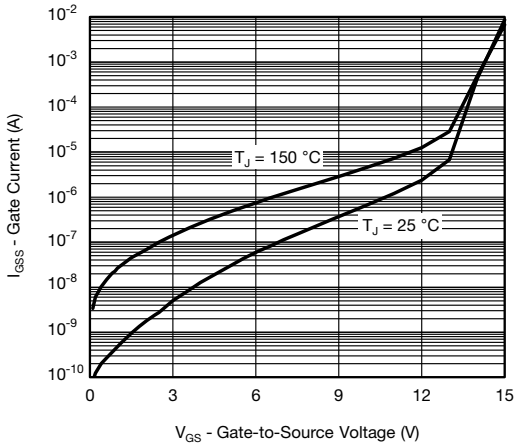
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

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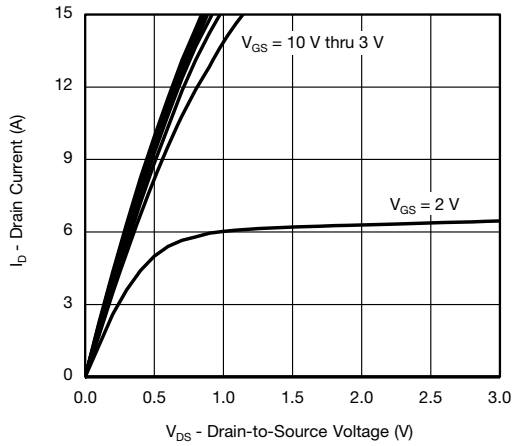
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



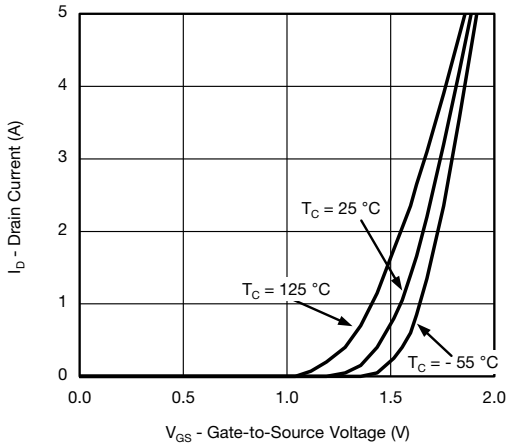
Gate Current vs. Gate-to-Source Voltage



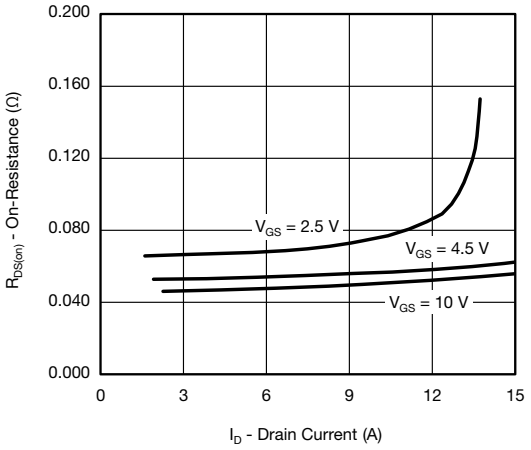
Gate Current vs. Gate-to-Source Voltage



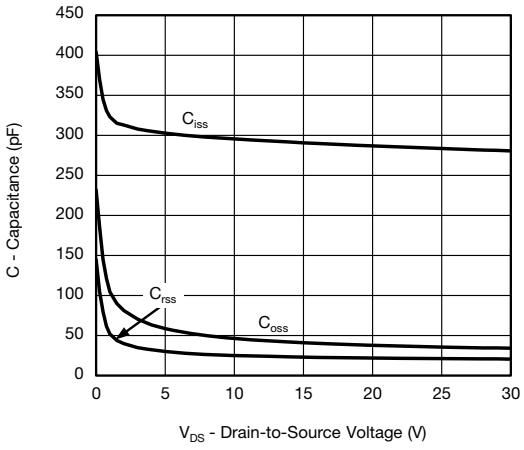
Output Characteristics



Transfer Characteristics



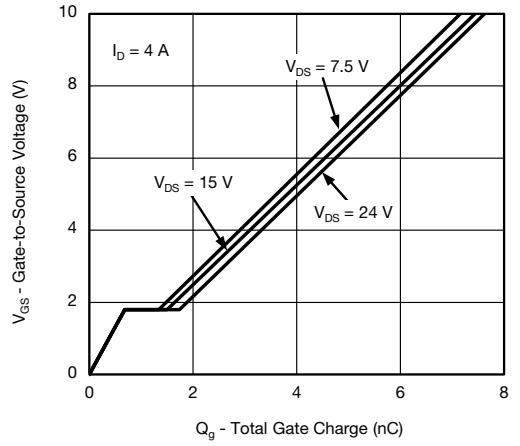
Transconductance



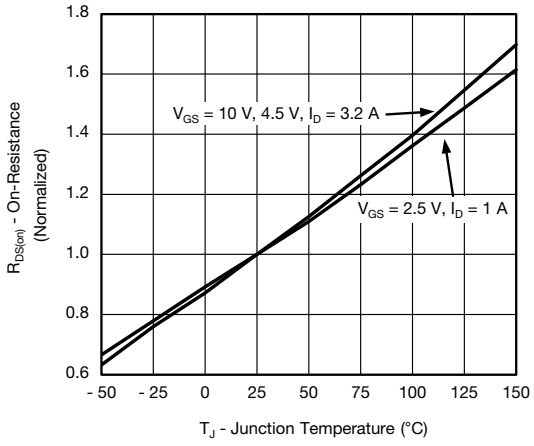
On-Resistance vs. Drain Current

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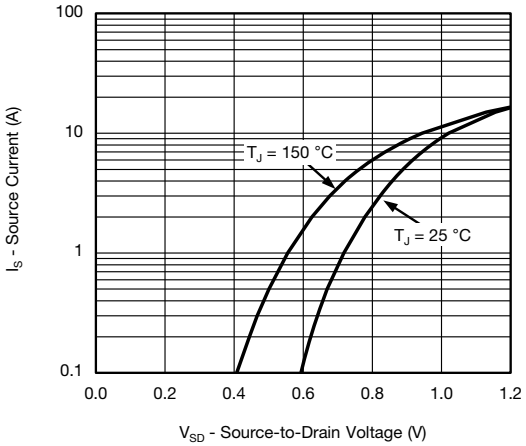
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



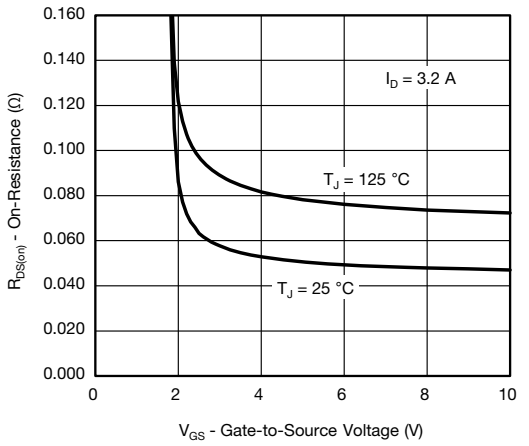
Gate Charge



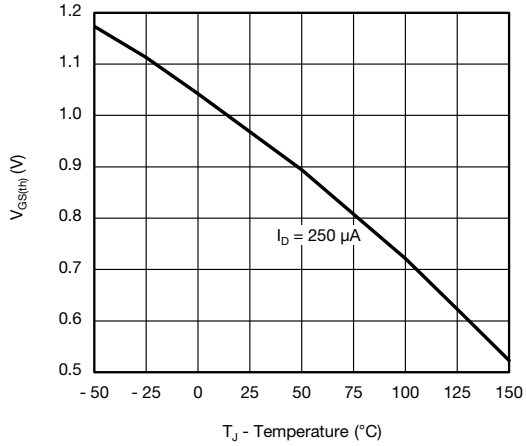
Normalized On-Resistance vs. Junction Temperature



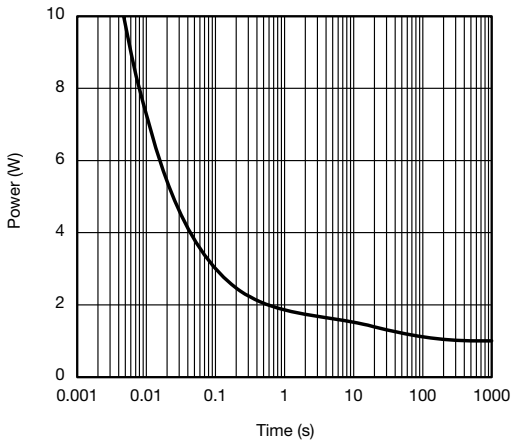
Source-Drain Diode Forward Voltage



On-Resistance vs. Gate-to-Source Voltage



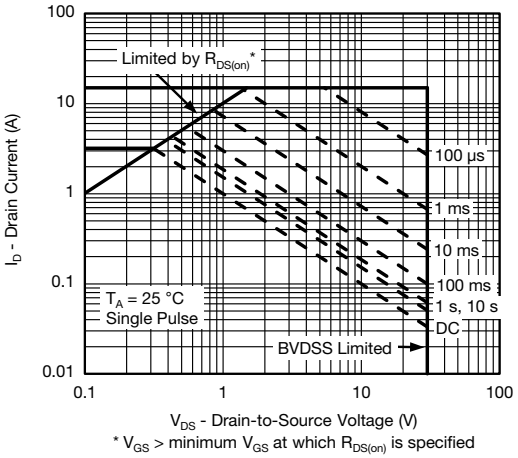
Threshold Voltage



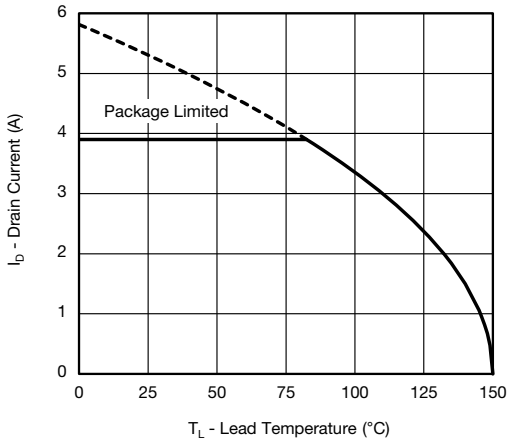
Single Pulse Power, Junction-to-Ambient

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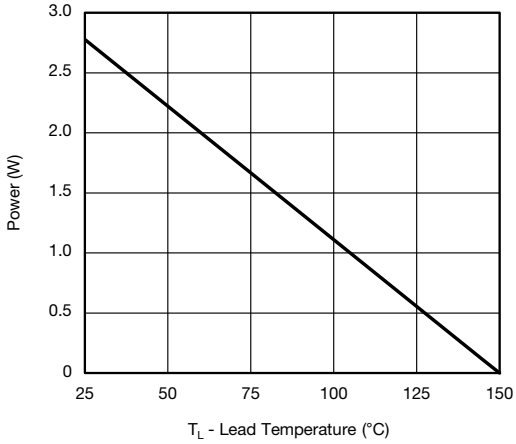
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



Safe Operating Area, Junction-to-Ambient



Current Derating [a]



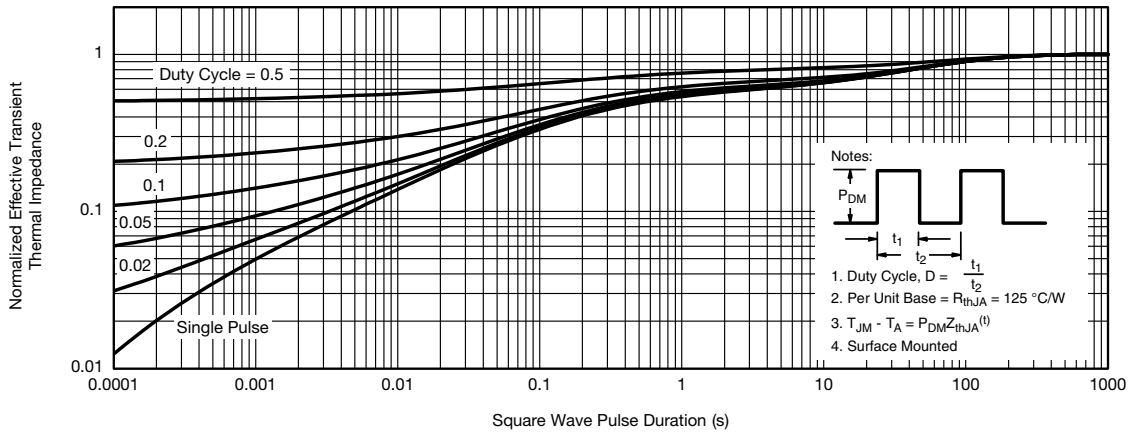
Power Derating

Note

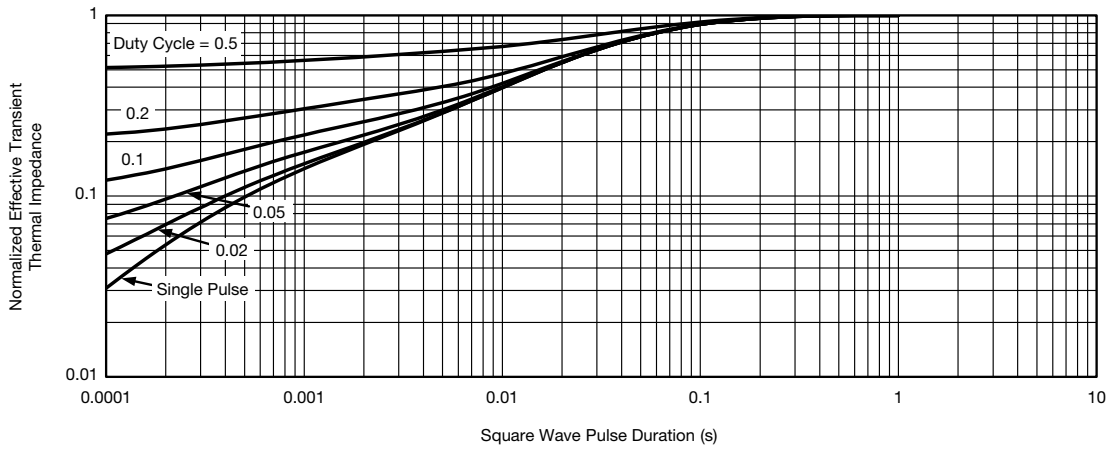
a. The power dissipation P_D is based on T_J max. = 150 °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit

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TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



Normalized Thermal Transient Impedance, Junction-to-Ambient

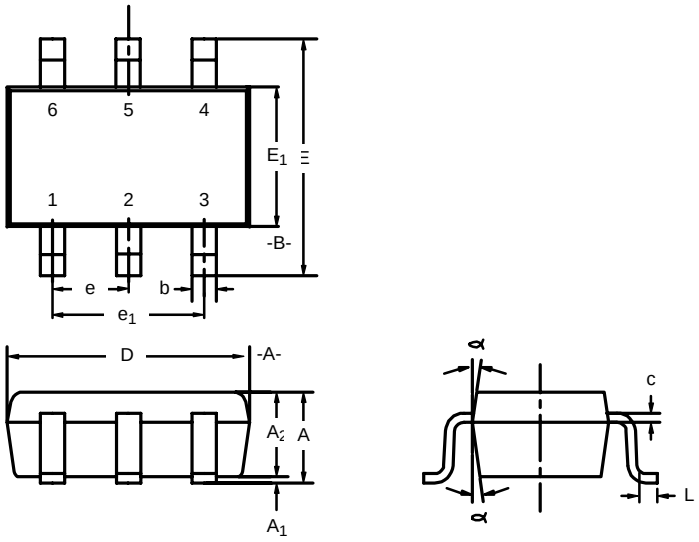


Normalized Thermal Transient Impedance, Junction-to-Foot

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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		

ECN: S-03946—Rev. B, 09-Jul-01
DWG: 5550

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

INTRODUCTION

The new single 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 single-channel version.

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. These pad patterns are sufficient for the low to medium power applications for which this package is intended. Increasing the drain pad pattern yields a reduction in thermal resistance and is a preferred footprint. 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.

PIN-OUT

Figure 1 shows the pin-out description and Pin 1 identification.The pin-out of this device allows the use of four pins as drain leads, which helps to reduce on-resistance and junction-to-ambient thermal resistance.

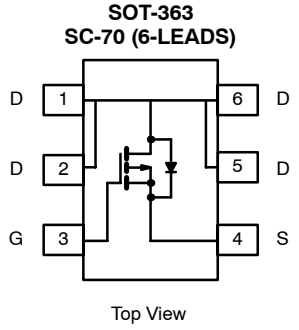


FIGURE 1.

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

EVALUATION BOARDS — SINGLE SC70-6

The evaluation board (EVB) measures 0.6 inches by 0.5 inches. The copper pad traces are the same as in Figure 2. The board allows examination from the outer pins to 6-pin DIP connections, permitting test sockets to be used in evaluation testing. See Figure 3.

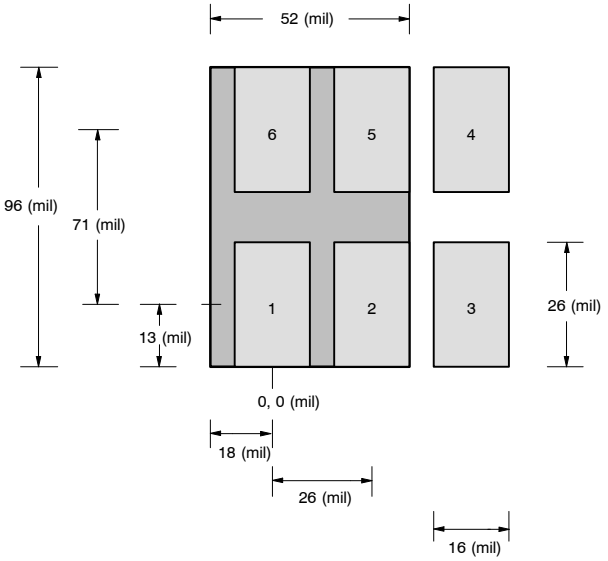


FIGURE 2. SC-70 (6 leads) Single

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

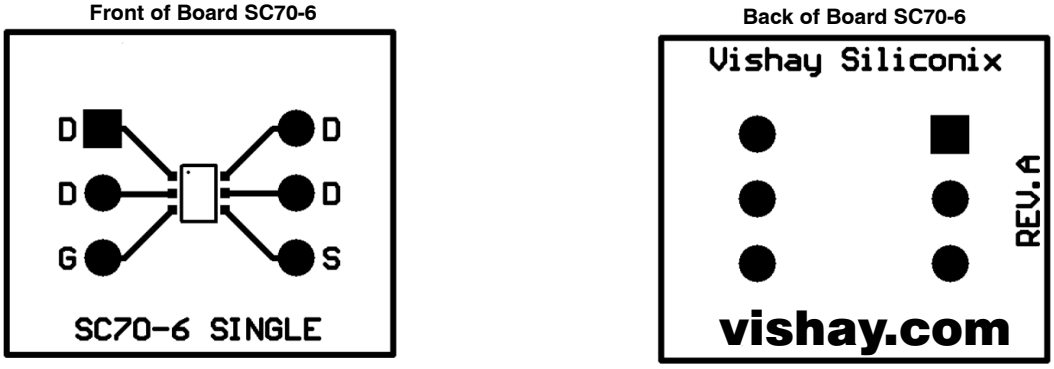


FIGURE 3.

THERMAL PERFORMANCE

Junction-to-Foot Thermal Resistance (Package Performance)

The junction to foot thermal resistance is a useful method of comparing different packages thermal performance.

A helpful way of presenting the thermal performance of the 6-Pin SC-70 copper leadframe device is to compare it to the traditional Alloy 42 version.

Thermal performance for the 6-pin SC-70 measured as junction-to-foot thermal resistance, where the “foot” is the drain lead of the device at the bottom where it meets the PCB. The junction-to-foot thermal resistance is typically 40°C/W in the copper leadframe and 163°C/W in the Alloy 42 leadframe — a four-fold improvement. This improved performance is obtained by the enhanced thermal conductivity of copper over Alloy 42.

Power Dissipation

The typical $R\theta_{JA}$ for the single 6-pin SC-70 with copper leadframe is 103°C/W steady-state, compared with 212°C/W for the Alloy 42 version. The figures are based on the 1-inch^2 FR4 test board. The following example shows how the thermal resistance impacts power dissipation for the two different leadframes at varying ambient temperatures.

ALLOY 42 LEADFRAME	
Room Ambient 25 °C	**Elevated Ambient 60 °C**
$P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ $P_D = \frac{150°C - 25°C}{212°C/W}$ $P_D = 590$ mW	$P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ $P_D = \frac{150°C - 25°C}{212°C/W}$ $P_D = 425$ mW

COOPER LEADFRAME	
Room Ambient 25 °C	**Elevated Ambient 60 °C**
$P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ $P_D = \frac{150°C - 25°C}{124°C/W}$ $P_D = 1.01$ W	$P_D = \frac{T_{J(max)} - T_A}{R\theta_{JA}}$ $P_D = \frac{150°C - 60°C}{124°C/W}$ $P_D = 726$ mW

As can be seen from the calculations above, the compact 6-pin SC-70 copper leadframe LITTLE FOOT power MOSFET can handle up to 1 W under the stated conditions.

Testing

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

LITTLE FOOT 6-PIN SC-70		
	Alloy 42	**Copper**
1) Minimum recommended pad pattern on the EVB board V (see Figure 3.	329.7°C/W	208.5°C/W
2) Industry standard 1-inch^2 PCB with maximum copper both sides.	211.8°C/W	103.5°C/W

The results indicate that designers can reduce thermal resistance ($R\theta_{JA}$) by 36% simply by using the copper leadframe device rather than the Alloy 42 version. In this example, a 121°C/W reduction was achieved without an increase in board area. If increasing in board size is feasible, a further 105°C/W reduction could be obtained by utilizing a 1-inch^2 square PCB area.

The copper leadframe versions have the following suffix:

Single:	Si14xxEDH
Dual:	Si19xxEDH
Complementary:	Si15xxEDH

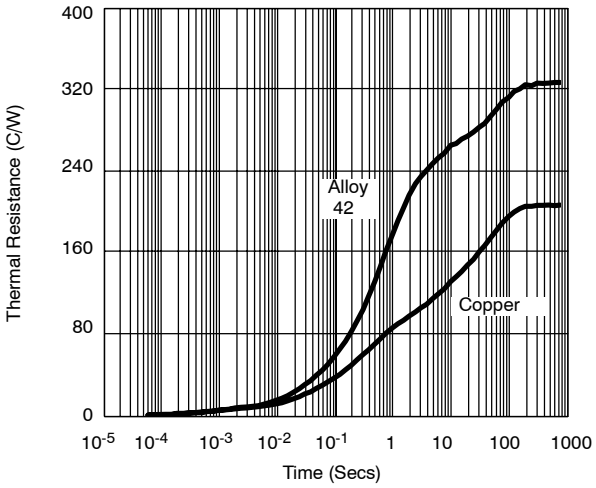


FIGURE 4. Leadframe Comparison on EVB

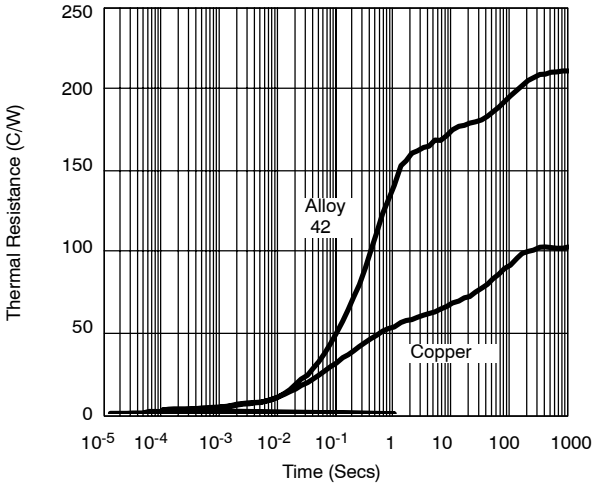
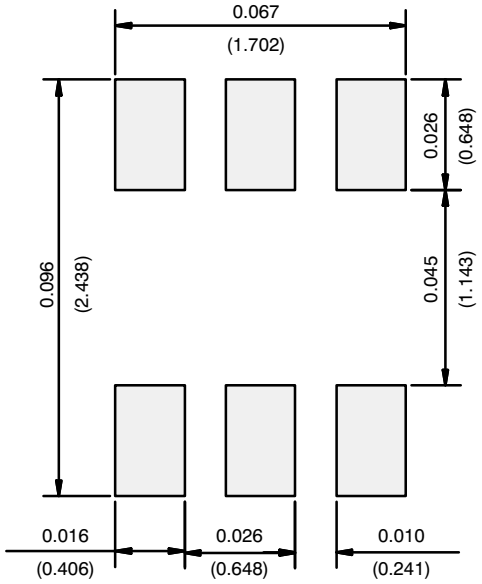


FIGURE 5. Leadframe Comparison on Alloy 42 1-inch^2 PCB

RECOMMENDED MINIMUM PADS FOR SC-70: 6-Lead



Recommended Minimum Pads
Dimensions in Inches/(mm)

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