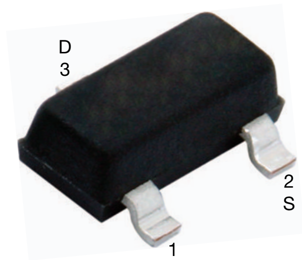
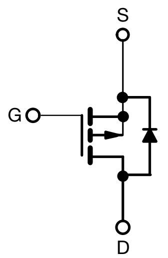
Automotive P-Channel 60 V (D-S) 175 °C MOSFET

PRODUCT SUMMARY	
V_{DS} (V)	-60
$R_{DS(on)}$ (Ω) at V_{GS} = -10 V	0.177
$R_{DS(on)}$ (Ω) at V_{GS} = -4.5 V	0.246
I_D (A)	-2.8
Configuration	Single

SOT-23 (TO-236)



Top View



P-Channel MOSFET

Marking Code: 9Dxxx

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

ORDERING INFROMATION	
Package	SOT-23
Lead (Pb)-free and Halogen-free	SQ2361ES-T1-GE3

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

PARAMETER		SYMBOL	LIMIT	UNIT
Drain-Source Voltage		V_{DS}	-60	V
Gate-Source Voltage		V_{GS}	± 20	
Continuous Drain Current	T_C = 25 °C	I_D	-2.8	A
	T_C = 125 °C		-1.6	
Continuous Source Current (Diode Conduction)		I_S	-2.5	
Pulsed Drain Current [a]		I_{DM}	-11	
Single Pulse Avalanche Current	L = 0.1 mH	I_{AS}	-12.5	
Single Pulse Avalanche Energy		E_{AS}	7.8	mJ
Maximum Power Dissipation [a]	T_C = 25 °C	P_D	2	W
	T_C = 125 °C		0.67	
Operating Junction and Storage Temperature Range		T_J, T_{stg}	-55 to +175	°C

THERMAL RESISTANCE RATINGS

PARAMETER		SYMBOL	LIMIT	UNIT
Junction-to-Ambient	PCB Mount [b]	R_{thJA}	175	°C/W
Junction-to-Foot (Drain)		R_{thJF}	75	

Notes

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

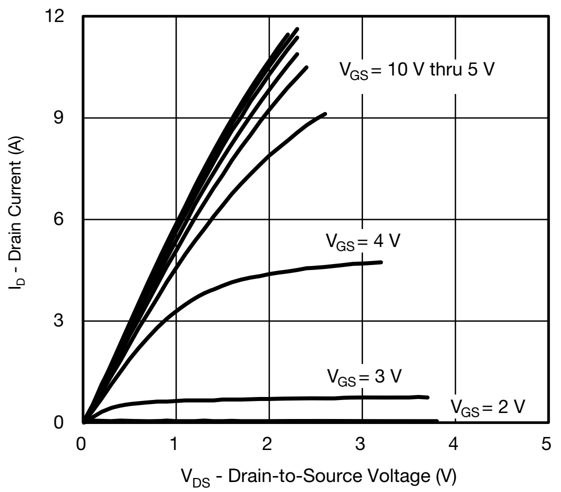
SPECIFICATIONS (T_C = 25 °C, unless otherwise noted)							
PARAMETER	**SYMBOL**	**TEST CONDITIONS**		**MIN.**	**TYP.**	**MAX.**	**UNIT**
Static							
Drain-Source Breakdown Voltage	V_{DS}	V_{GS} = 0 V, I_D = -250 µA		-60	-	-	V
Gate-Source Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = -250 µA		-1.5	-	-2.5	
Gate-Source Leakage	I_{GSS}	V_{DS} = 0 V, V_{GS} = ± 20 V		-	-	± 100	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{GS} = 0 V	V_{DS} = -60 V	-	-	-1	µA
		V_{GS} = 0 V	V_{DS} = -60 V, T_J = 125 °C	-	-	-50	
		V_{GS} = 0 V	V_{DS} = -60 V, T_J = 175 °C	-	-	-150	
On-State Drain Current [a]	$I_{D(on)}$	V_{GS} = -10 V	$V_{DS} \leq$ -5 V	-10	-	-	A
Drain-Source On-State Resistance [a]	$R_{DS(on)}$	V_{GS} = -10 V	I_D = -2.4 A	-	0.130	0.177	Ω
		V_{GS} = -10 V	I_D = -2.4 A, T_J = 125 °C	-	-	0.310	
		V_{GS} = -10 V	I_D = -2.4 A, T_J = 175 °C	-	-	0.320	
		V_{GS} = -4.5 V	I_D = -1.8 A	-	0.205	0.246	
Forward Transconductance [b]	g_{fs}	V_{DS} = -10 V, I_D = -2 A		-	5	-	S
Dynamic [b]							
Input Capacitance	C_{iss}	V_{GS} = 0 V	V_{DS} = -30 V, f = 1 MHz	-	380	550	pF
Output Capacitance	C_{oss}			-	50	75	
Reverse Transfer Capacitance	C_{rss}			-	30	42	
Total Gate Charge [c]	Q_g	V_{GS} = -10 V	V_{DS} = -30 V, I_D = -6 A	-	9	12	nC
Gate-Source Charge [c]	Q_{gs}			-	1.6	-	
Gate-Drain Charge [c]	Q_{gd}			-	3.3	-	
Gate Resistance	R_g	f = 1 MHz		3.1	4.1	5.2	Ω
Turn-On Delay Time [c]	$t_{d(on)}$	V_{DD} = -30 V, R_L = 20 Ω $I_D \cong$ -1.5 A, V_{GEN} = -10 V, R_g = 1 Ω		-	8	11	ns
Rise Time [c]	t_r			-	9	12	
Turn-Off Delay Time [c]	$t_{d(off)}$			-	22	26	
Fall Time [c]	t_f			-	4	6	
Source-Drain Diode Ratings and Characteristics [b]							
Pulsed Current [a]	I_{SM}			-	-	-11	A
Forward Voltage	V_{SD}	I_F = -1.5 A, V_{GS} = 0 V		-	-0.9	-1.2	V

Notes

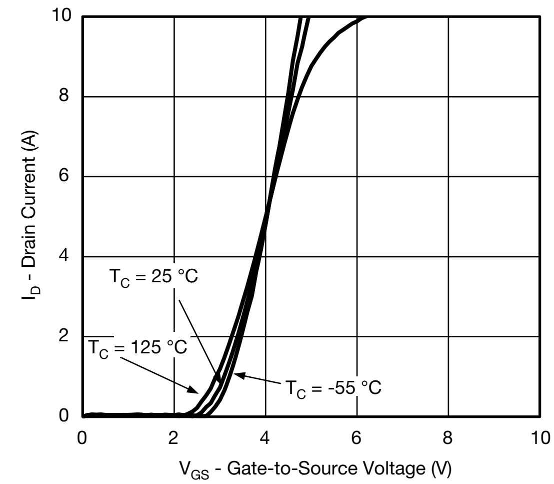
a. Pulse test; pulse width ≤ 300 µs, duty cycle ≤ 2 %.
b. Guaranteed by design, not subject to production testing.
c. Independent of operating temperature.

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.

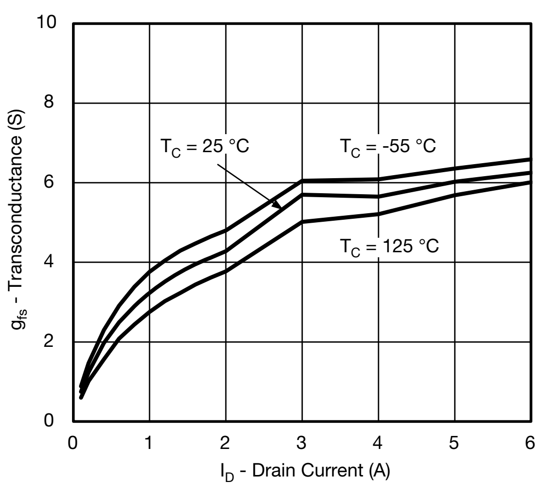
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



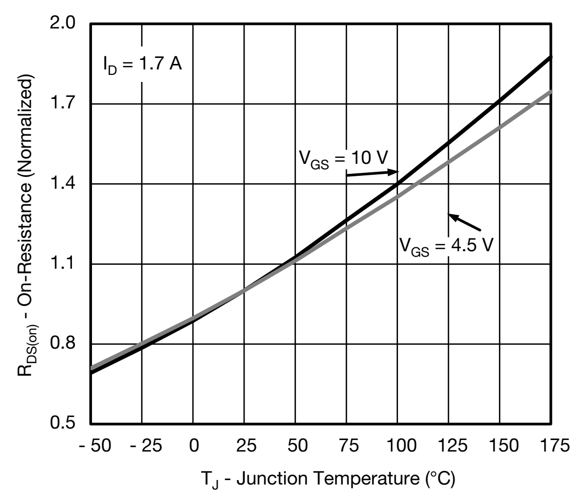
Output Characteristics



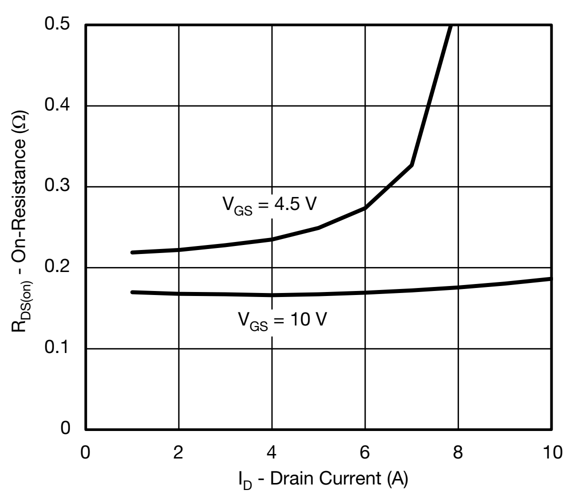
Transfer Characteristics



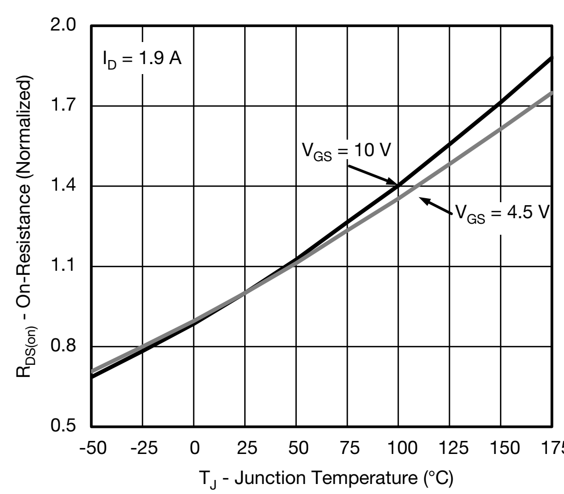
Transconductance



On-Resistance vs. Junction Temperature

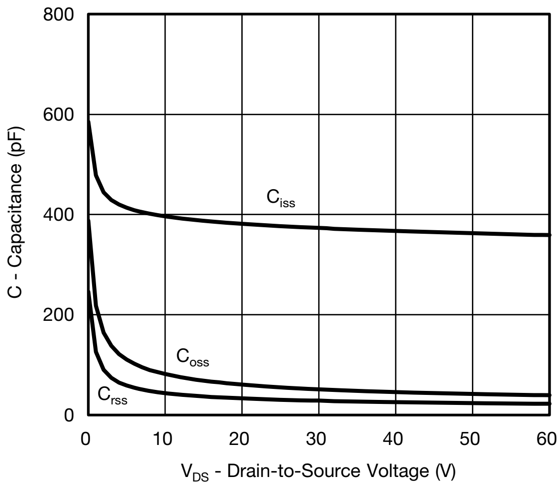


On-Resistance vs. Drain Current

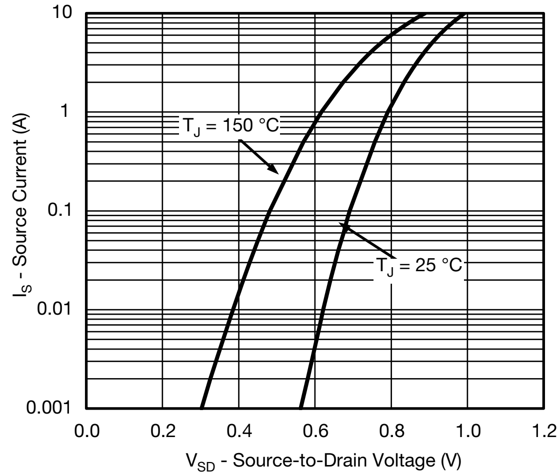


On-Resistance vs. Junction Temperature

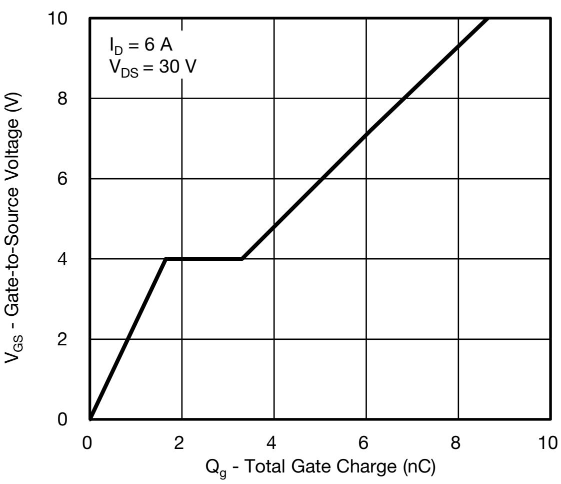
TYPICAL CHARACTERISTICS (T_A = 25 °C, unless otherwise noted)



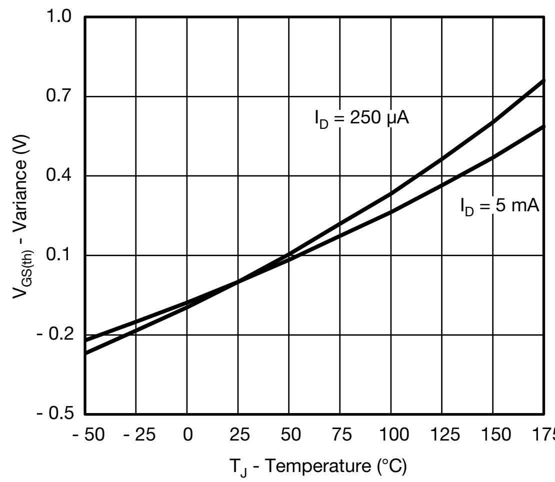
Capacitance



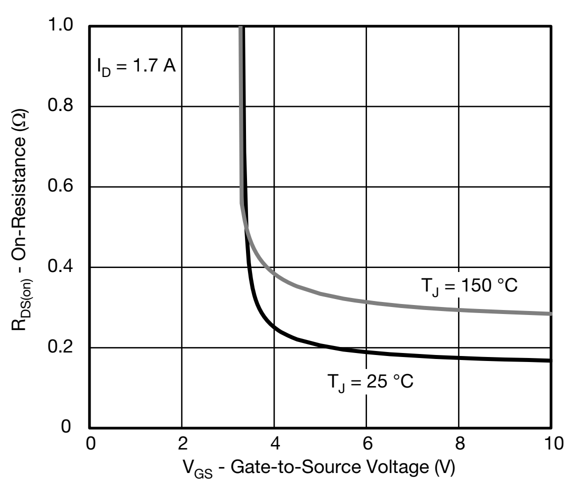
Source-Drain Diode Forward Voltage



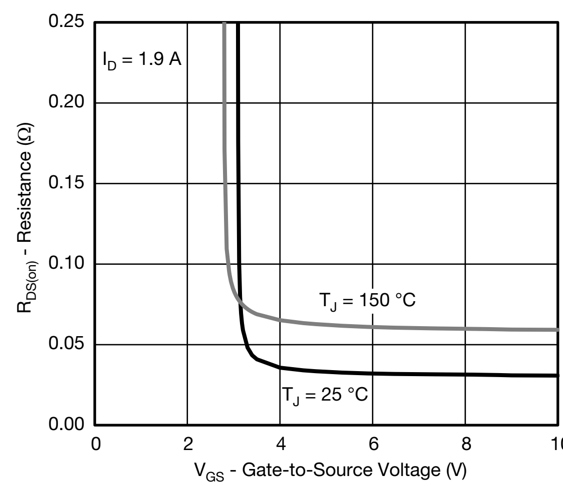
Gate Charge



Threshold Voltage

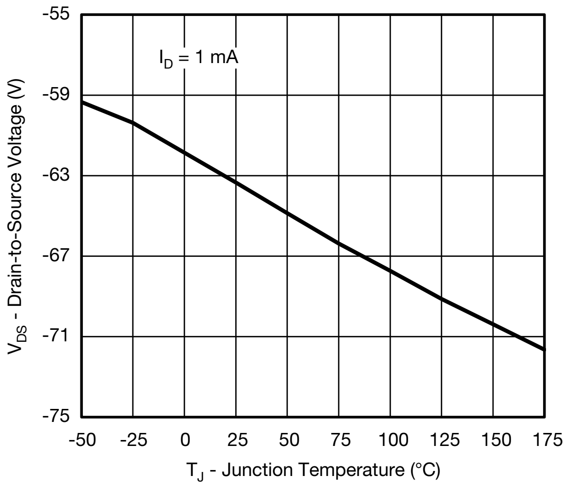


On-Resistance vs. Gate-Source Voltage

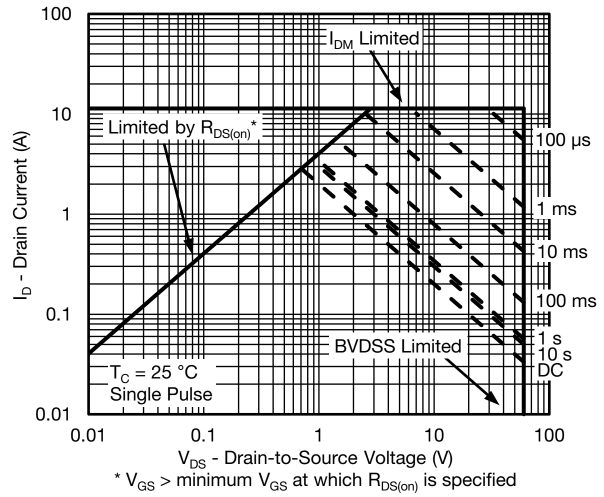


On-Resistance vs. Gate-Source Voltage

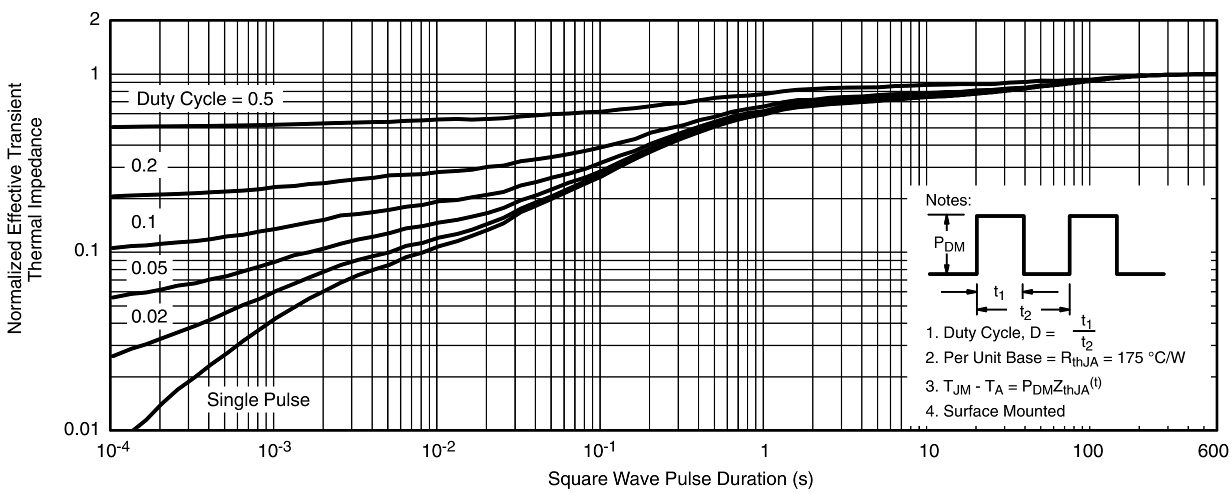
THERMAL RATINGS (T_A = 25 °C, unless otherwise noted)



Drain-Source Breakdown vs. Junction Temperature

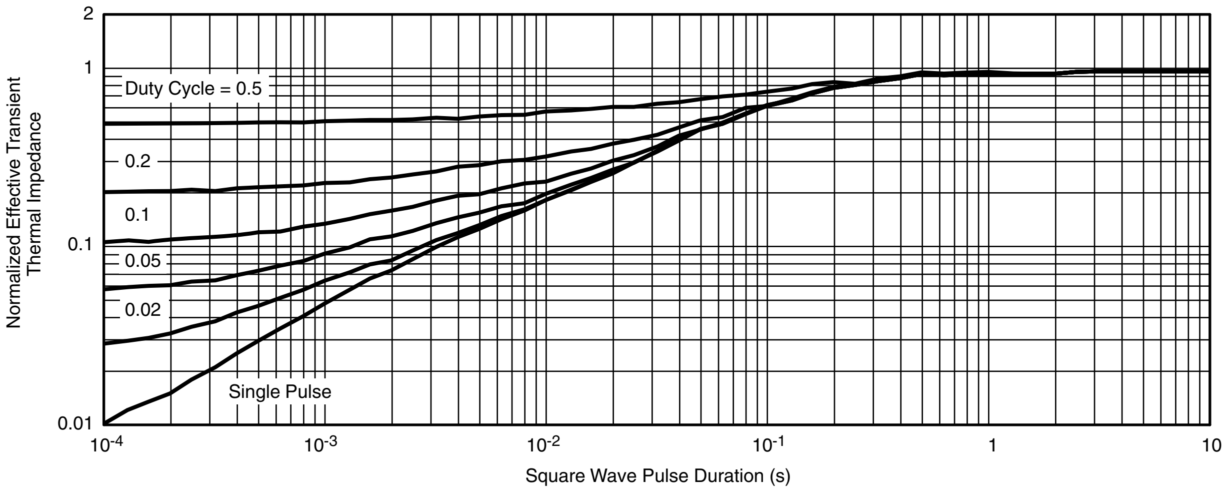


Safe Operating Area



Normalized Thermal Transient Impedance, Junction-to-Ambient

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



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-Foot (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.

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?66894.

SOT-23

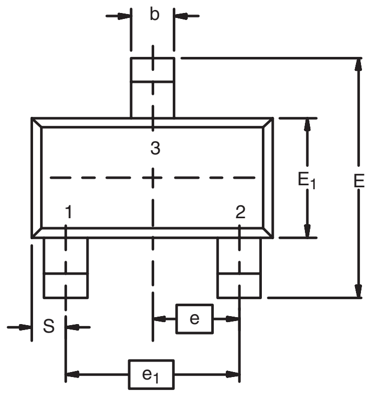
Ordering codes for the SQ rugged series power MOSFETs in the SOT-23 package:

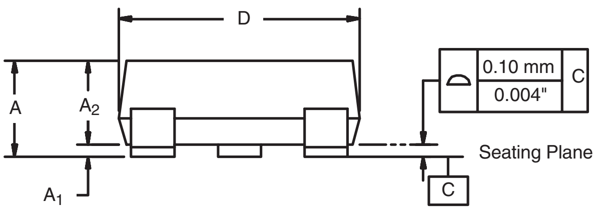
DATASHEET PART NUMBER	OLD ORDERING CODE [a]	NEW ORDERING CODE
SQ2301ES	SQ2301ES-T1-GE3	**SQ2301ES-T1_GE3**
SQ2303ES	SQ2303ES-T1-GE3	**SQ2303ES-T1_GE3**
SQ2308CES	SQ2308CES-T1-GE3	**SQ2308CES-T1_GE3**
SQ2309ES	SQ2309ES-T1-GE3	**SQ2309ES-T1_GE3**
SQ2310ES	SQ2310ES-T1-GE3	**SQ2310ES-T1_GE3**
SQ2315ES	SQ2315ES-T1-GE3	**SQ2315ES-T1_GE3**
SQ2318AES	SQ2318AES-T1-GE3	**SQ2318AES-T1_GE3**
SQ2319ADS	-	**SQ2319ADS-T1_GE3**
SQ2325ES	SQ2325ES-T1-GE3	**SQ2325ES-T1_GE3**
SQ2337ES	SQ2337ES-T1-GE3	**SQ2337ES-T1_GE3**
SQ2348ES	SQ2348ES-T1-GE3	**SQ2348ES-T1_GE3**
SQ2351ES	SQ2351ES-T1-GE3	**SQ2351ES-T1_GE3**
SQ2361AEES	SQ2361AEES-T1-GE3	**SQ2361AEES-T1_GE3**
SQ2361ES	-	**SQ2361ES-T1_GE3**
SQ2362ES	-	**SQ2362ES-T1_GE3**
SQ2389ES	-	**SQ2389ES-T1_GE3**
SQ2398ES	-	**SQ2398ES-T1_GE3**

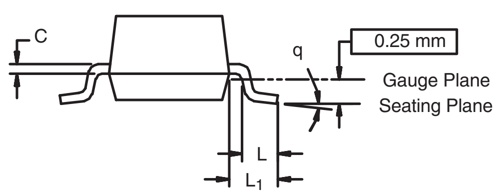
Note

a. Old ordering code is obsolete and no longer valid for new orders

SOT-23 (TO-236): 3-LEAD







Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	0.89	1.12	0.035	0.044
A_1	0.01	0.10	0.0004	0.004
A_2	0.88	1.02	0.0346	0.040
b	0.35	0.50	0.014	0.020
c	0.085	0.18	0.003	0.007
D	2.80	3.04	0.110	0.120
E	2.10	2.64	0.083	0.104
E_1	1.20	1.40	0.047	0.055
e	0.95 BSC		0.0374 Ref	
e_1	1.90 BSC		0.0748 Ref	
L	0.40	0.60	0.016	0.024
L_1	0.64 Ref		0.025 Ref	
S	0.50 Ref		0.020 Ref	
q	3°	8°	3°	8°
ECN: S-03946-Rev. K, 09-Jul-01 DWG: 5479				

Mounting LITTLE FOOT® SOT-23 Power MOSFETs

Wharton McDaniel

Surface-mounted LITTLE FOOT power MOSFETs use integrated circuit and small-signal packages which have been been modified to provide the heat transfer capabilities required by power devices. Leadframe materials and design, molding compounds, and die attach materials have been changed, while the footprint of the packages remains the same.

See Application Note 826, *Recommended Minimum Pad Patterns With Outline Drawing Access for Vishay Siliconix MOSFETs*, (http://www.vishay.com/doc?72286), for the basis of the pad design for a LITTLE FOOT SOT-23 power MOSFET footprint . In converting this footprint to the pad set for a power device, designers must make two connections: an electrical connection and a thermal connection, to draw heat away from the package.

The electrical connections for the SOT-23 are very simple. Pin 1 is the gate, pin 2 is the source, and pin 3 is the drain. As in the other LITTLE FOOT packages, the drain pin serves the additional function of providing the thermal connection from the package to the PC board. The total cross section of a copper trace connected to the drain may be adequate to carry the current required for the application, but it may be inadequate thermally. Also, heat spreads in a circular fashion from the heat source. In this case the drain pin is the heat source when looking at heat spread on the PC board.

Figure 1 shows the footprint with copper spreading for the SOT-23 package. This pattern shows the starting point for utilizing the board area available for the heat spreading copper. To create this pattern, a plane of copper overlies the drain pin and provides planar copper to draw heat from the drain lead and start the process of spreading the heat so it can be dissipated into the ambient air. This pattern uses all the available area underneath the body for this purpose.

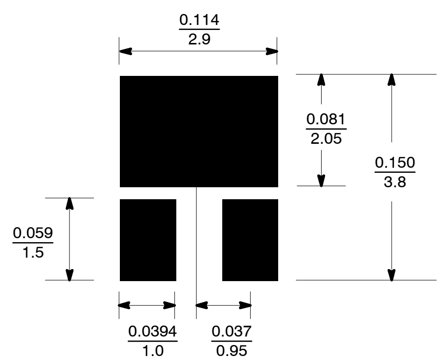
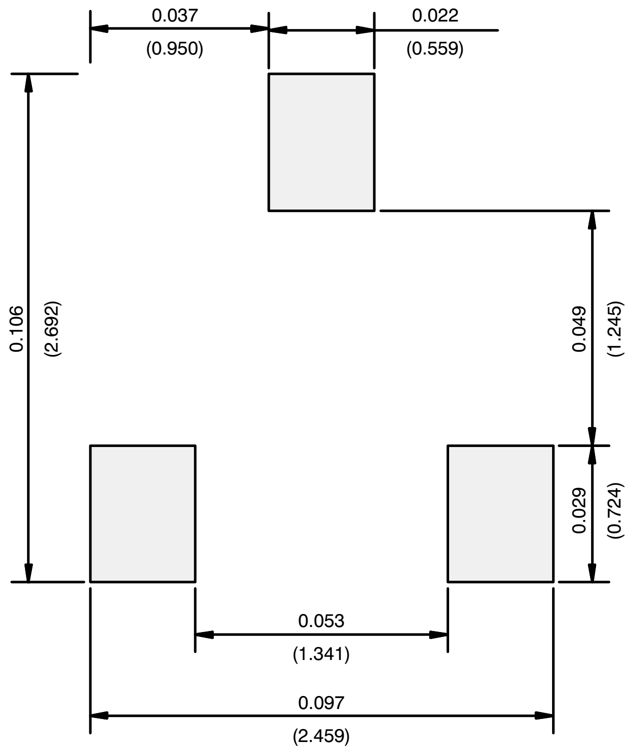


FIGURE 1. Footprint With Copper Spreading

Since surface-mounted packages are small, and reflow soldering is the most common way in which these are affixed to the PC board, “thermal” connections from the planar copper to the pads have not been used. Even if additional planar copper area is used, there should be no problems in the soldering process. The actual solder connections are defined by the solder mask openings. By combining the basic footprint with the copper plane on the drain pins, the solder mask generation occurs automatically.

A final item to keep in mind is the width of the power traces. The absolute minimum power trace width must be determined by the amount of current it has to carry. For thermal reasons, this minimum width should be at least 0.020 inches. The use of wide traces connected to the drain plane provides a low-impedance path for heat to move away from the device.

RECOMMENDED MINIMUM PADS FOR SOT-23



Recommended Minimum Pads
Dimensions in Inches/(mm)

Return to Index

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