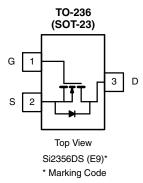




# N-Channel 40 V (D-S) MOSFET

PRODUCT SUMMARY						
V <sub>DS</sub> (V)	$R_{DS(on)}\left(\Omega\right)$ Max.	I <sub>D</sub> (A) <sup>a</sup>	Q <sub>g</sub> (Typ.)			
	0.051 at V <sub>GS</sub> = 10 V	4.3				
40	0.054 at V <sub>GS</sub> = 4.5 V	4.1	3.8 nC			
	0.070 at V <sub>GS</sub> = 2.5 V	3.6				



#### **Ordering Information:**

Si2356DS-T1-GE3 (Lead (Pb)-free and Halogen-free)

#### **FEATURES**

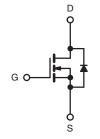
- TrenchFET® Power MOSFET
- 100 % R<sub>q</sub> Tested
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912



HALOGEN **FREE** 

#### **APPLICATIONS**

- DC/DC Converter
- Load Switch
- LED Backlighting
- **Power Management**



N-Channel MOSFET

<b>ABSOLUTE MAXIMUM RATINGS</b> (T <sub>A</sub> = 25 °C, unless otherwise noted)						
Parameter		Symbol	Limit	Unit		
Drain-Source Voltage		V <sub>DS</sub>	40	V		
Gate-Source Voltage		V <sub>GS</sub>	± 12	v		
	T <sub>C</sub> = 25 °C		4.3			
Continuous Drain Current (T = 150 °C)	T <sub>C</sub> = 70 °C		3.4			
Continuous Drain Current (T <sub>J</sub> = 150 °C)	T <sub>A</sub> = 25 °C	I <sub>D</sub>	3.2 <sup>a,b</sup>			
	T <sub>A</sub> = 70 °C		2.6 <sup>a,b</sup>	Α		
Pulsed Drain Current (t = 100 μs)		I <sub>DM</sub>	20			
0 " 0 0 0 0	T <sub>C</sub> = 25 °C		1.4			
Continuous Source-Drain Diode Current	T <sub>A</sub> = 25 °C	l <sub>S</sub>	0.8 <sup>a,b</sup>			
	T <sub>C</sub> = 25 °C		1.7			
Mariana Barra Birahadia	T <sub>C</sub> = 70 °C		1.1			
Maximum Power Dissipation	T <sub>A</sub> = 25 °C	P <sub>D</sub>	0.96 <sup>a,b</sup>	W		
	T <sub>A</sub> = 70 °C		0.62 <sup>a,b</sup>			
Operating Junction and Storage Temperature	e Range	T <sub>J</sub> , T <sub>stg</sub>	- 55 to 150	°C		

THERMAL RESISTANCE RATINGS								
Parameter	Symbol	Typical	Maximum	Unit				
Maximum Junction-to-Ambient a,c	t ≤ 5 s	R <sub>thJA</sub>	100	130	°C/W			
Maximum Junction-to-Foot (Drain)	Steady State	R <sub>thJF</sub>	60	75				

#### Notes:

- a. Surface mounted on 1" x 1" FR4 board.
- b. t = 5 s.
- c. Maximum under steady state conditions is 175  $^{\circ}\text{C/W}.$

Document Number: 62893 S13-1814-Rev. A, 12-Aug-13 For technical questions, contact: pmostechsupport@vishav.com

## Vishay Siliconix



<b>SPECIFICATIONS</b> (T <sub>J</sub> = 25 °C, unless otherwise noted)							
Parameter	Symbol	Test Conditions	Min.	Тур.	Max.	Unit	
Static							
Drain-Source Breakdown Voltage	V <sub>DS</sub>	$V_{GS} = 0 \text{ V}, I_D = 250 \mu\text{A}$	40			V	
V <sub>DS</sub> Temperature Coefficient	$\Delta V_{DS}/T_{J}$	L = 250 uA		43			
V <sub>GS(th)</sub> Temperature Coefficient	$\Delta V_{GS(th)}/T_J$	$I_D = 250  \mu A$		- 3.8		mV/°C	
Gate-Source Threshold Voltage	V <sub>GS(th)</sub>	$V_{DS} = V_{GS}$ , $I_D = 250 \mu A$	0.6		1.5	V	
Gate-Source Leakage	I <sub>GSS</sub>	$V_{DS} = 0 \text{ V}, V_{GS} = \pm 12 \text{ V}$			± 100	nA	
		$V_{DS} = 40 \text{ V}, V_{GS} = 0 \text{ V}$			1		
Zero Gate Voltage Drain Current	I <sub>DSS</sub>	V <sub>DS</sub> = 40 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 55 °C			10	μΑ	
On-State Drain Current <sup>a</sup>	I <sub>D(on)</sub>	$V_{DS} \ge 5 \text{ V}, V_{GS} = 10 \text{ V}$	10			Α	
		$V_{GS} = 10 \text{ V}, I_D = 3.2 \text{ A}$		0.042	0.051	Ω	
Drain-Source On-State Resistance <sup>a</sup>	R <sub>DS(on)</sub>	$V_{GS} = 4.5 \text{ V}, I_D = 3.1 \text{ A}$		0.045	0.054		
		$V_{GS} = 2.5 \text{ V}, I_D = 2 \text{ A}$		0.056	0.070		
Forward Transconductance <sup>a</sup>	9 <sub>fs</sub>	V <sub>DS</sub> = 15 V, I <sub>D</sub> = 3.2 A		13		S	
Dynamic <sup>b</sup>	l		L	<u> </u>	l		
Input Capacitance	C <sub>iss</sub>			370		pF	
Output Capacitance	C <sub>oss</sub>	V <sub>DS</sub> = 20 V, V <sub>GS</sub> = 0 V, f = 1 MHz		50			
Reverse Transfer Capacitance	C <sub>rss</sub>			17			
·		V <sub>DS</sub> = 20 V, V <sub>GS</sub> = 10 V, I <sub>D</sub> = 3.2 A		8.1	13	nC	
Total Gate Charge	$Q_g$	$V_{DS} = 20 \text{ V}, V_{GS} = 4.5 \text{ V}, I_D = 3.2 \text{ A}$		3.8	5.7		
Gate-Source Charge	Q <sub>gs</sub>			0.72			
Gate-Drain Charge	Q <sub>gd</sub>			0.81			
Gate Resistance	R <sub>g</sub>	f = 1 MHz	0.2	0.7	1.4	Ω	
Turn-On Delay Time	t <sub>d(on)</sub>			6	12		
Rise Time	t <sub>r</sub>	$V_{DD} = 20 \text{ V}, R_1 = 7.7 \Omega$		12	20		
Turn-Off Delay Time	t <sub>d(off)</sub>	$I_D \cong 2.6 \text{ A}, V_{GEN} = 10 \text{ V}, R_g = 1 \Omega$		13	20		
Fall Time	t <sub>f</sub>			6	12		
Turn-On Delay Time	t <sub>d(on)</sub>			10	20	ns	
Rise Time	t <sub>r</sub>	$V_{DD} = 20 \text{ V}, R_1 = 7.7 \Omega$		52	78	-	
Turn-Off Delay Time	t <sub>d(off)</sub>	$I_D \cong 2.6 \text{ A}, V_{GEN} = 4.5 \text{ V}, R_g = 1 \Omega$		18	27		
Fall Time	t <sub>f</sub>	_		53	80	1	
Drain-Source Body Diode Characteristic	S			L			
Continuous Source-Drain Diode Current	I <sub>S</sub>	T <sub>C</sub> = 25 °C			1.4		
Pulse Diode Forward Current (t = 100 μs)	I <sub>SM</sub>				20	A	
Body Diode Voltage	V <sub>SD</sub>	I <sub>S</sub> = 2.6 A, V <sub>GS</sub> = 0 V		0.8	1.2	V	
Body Diode Reverse Recovery Time	t <sub>rr</sub>			12	20	ns	
Body Diode Reverse Recovery Charge	Q <sub>rr</sub>			5	10	nC	
Reverse Recovery Fall Time	t <sub>a</sub>	$I_F = 2.6 \text{ A}, \text{ dI/dt} = 100 \text{ A/}\mu\text{s}, T_J = 25 ^{\circ}\text{C}$		8.5			
Reverse Recovery Rise Time	t <sub>b</sub>			3.5		ns	

#### Notes:

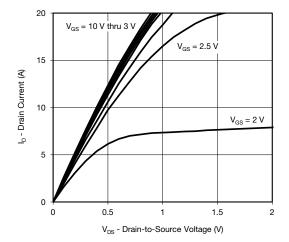
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

a. Pulse test; pulse width  $\leq 300~\mu s,$  duty cycle  $\leq 2~\%.$ 

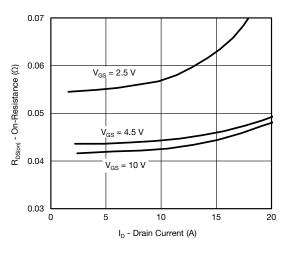
b. Guaranteed by design, not subject to production testing.



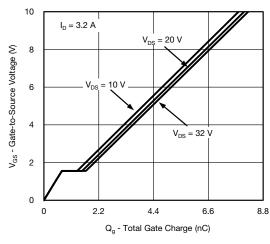
### TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



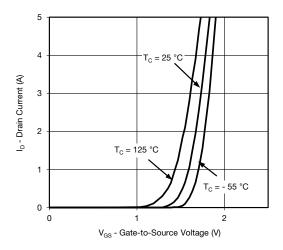
#### **Output Characteristics**



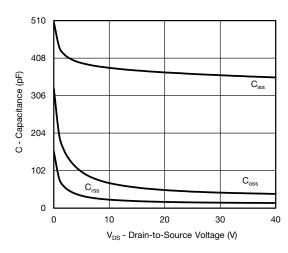
On-Resistance vs. Drain Current and Gate Voltage



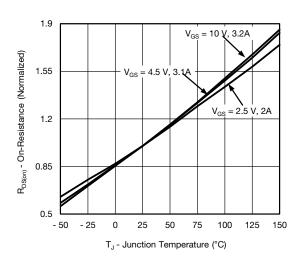
Gate Charge



**Transfer Characteristics** 



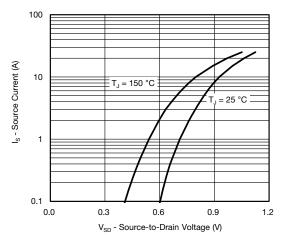
Capacitance



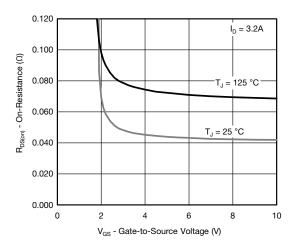
On-Resistance vs. Junction Temperature

## Vishay Siliconix

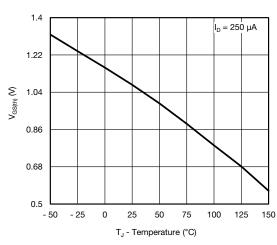
### TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



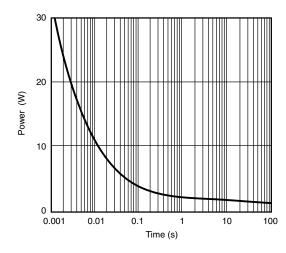
Source-Drain Diode Forward Voltage



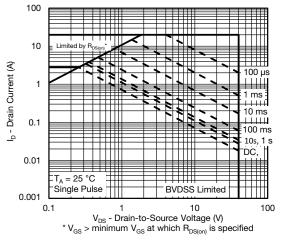
On-Resistance vs. Gate-to-Source Voltage



**Threshold Voltage** 



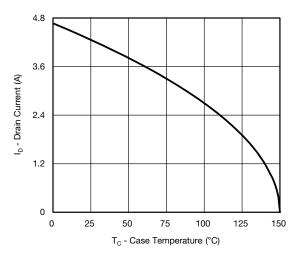
Single Pulse Power (Junction-to-Ambient)



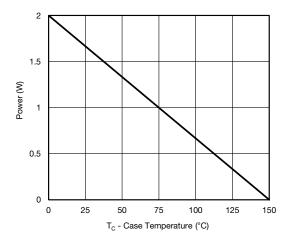
Safe Operating Area, Junction-to-Ambient



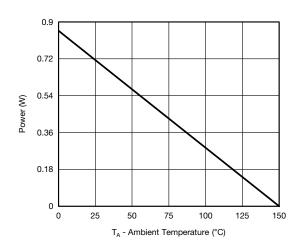
### TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)



#### **Current Derating\***





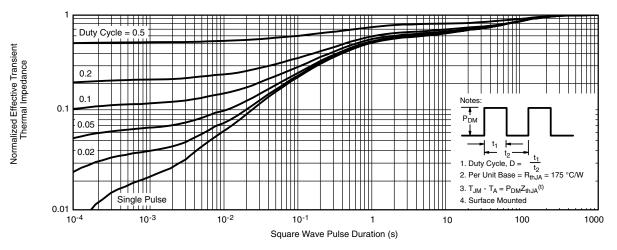


Power Junction-to-Ambient

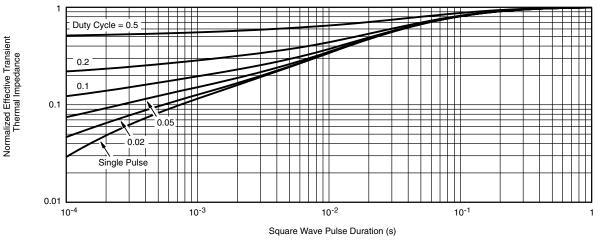
<sup>\*</sup> The power dissipation  $P_D$  is based on  $T_{J(max.)} = 150$  °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below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

## Vishay Siliconix

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



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

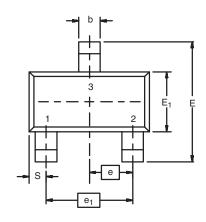


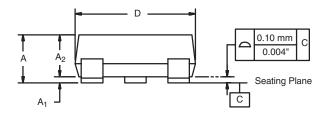
Normalized Thermal Transient Impedance, Junction-to-Foot

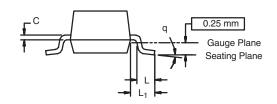
Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see www.vishay.com/ppg?62893.



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







Dim	MILLI	METERS	INCHES		
	Min	Max	Min	Max	
Α	0.89	1.12	0.035	0.044	
A <sub>1</sub>	0.01	0.10	0.0004	0.004	
A <sub>2</sub>	0.88	1.02	0.0346	0.040	
b	0.35	0.50	0.014	0.020	
С	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 <sub>1</sub>	1.20	1.40	0.047	0.055	
е	0.9	5 BSC	0.037	4 Ref	
e <sub>1</sub>	1.9	0 BSC	0.074	8 Ref	
L	0.40	0.60	0.016	0.024	
L <sub>1</sub>	0.64 Ref		0.025 Ref		
S	0.50 Ref		0.020 Ref		
q	3°	8°	3°	8°	
FCN: S-03946-Rev K 09-	lul-01	•			

ECN: S-03946-Rev. K, 09-Jul-01

DWG: 5479

Document Number: 71196 www.vishay.com 09-Jul-01





# **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.

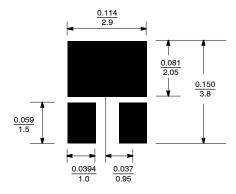


FIGURE 1. Footprint With Copper Spreading

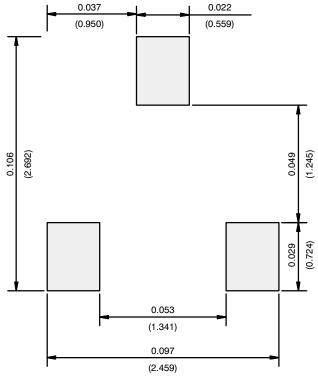
Since surface-mounted packages are small, and reflow soldering is the most common way in which these are affixed to the PC board, "thermal" connections from the planar copper to the pads have not been used. Even if additional planar copper area is used, there should be no problems in the soldering process. 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.

Document Number: 70739 26-Nov-03



#### **RECOMMENDED MINIMUM PADS FOR SOT-23**



Recommended Minimum Pads Dimensions in Inches/(mm)

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APPLICATION NOTE



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Vishay

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