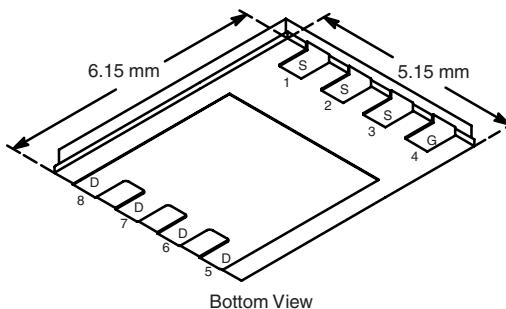


N-Channel 20-V (D-S) MOSFET

PRODUCT SUMMARY			
V_{DS} (V)	$R_{DS(on)}$ (Ω)	I_D (A) ^a	Q_g (Typ.)
20	0.00225 at $V_{GS} = 10$ V	40	46 nC
	0.00275 at $V_{GS} = 4.5$ V	40	

PowerPAK SO-8



Ordering Information: Si7868ADP-T1-E3 (Lead (Pb)-free)
Si7868ADP-T1-GE3 (Lead (Pb)-free and Halogen-free)

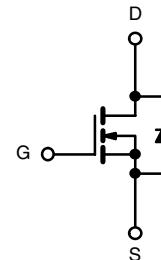


FEATURES

- Halogen-free available
- TrenchFET® Power MOSFET
- Low $R_{DS(on)}$
- PWM (Q_{gd} and R_g) Optimized
- 100 % R_g Tested

APPLICATIONS

- Low Output Voltage Synchronous Rectifier



N-Channel MOSFET

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

Parameter	Symbol	Limit	Unit
Drain-Source Voltage	V_{DS}	20	V
Gate-Source Voltage	V_{GS}	± 16	
Continuous Drain Current ($T_J = 150$ °C)	I_D	40	A
		32	
		35 ^{b, c}	
		28 ^{b, c}	
Pulsed Drain Current	I_{DM}	70	
Continuous Source-Drain Diode Current	I_S	40	
		4.9 ^{b, c}	
Single-Pulse Avalanche Current	I_{AS}	30	
Single-Pulse Avalanche Energy	E_{AS}	45	mJ
Maximum Power Dissipation	P_D	83	W
		53	
		5.4 ^{b, c}	
		3.4 ^{b, c}	
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-55 to 150	°C
Soldering Recommendations (Peak Temperature) ^{d, e}		260	

THERMAL RESISTANCE RATINGS

Parameter	Symbol	Typical	Maximum	Unit
Maximum Junction-to-Ambient ^{b, f}	R_{thJA}	18	23	°C/W
Maximum Junction-to-Case (Drain)	R_{thJC}	1.0	1.5	

Notes:

- Based on $T_C = 25$ °C.
- Surface Mounted on 1" x 1" FR4 board.
- $t = 10$ s.
- See Solder Profile (<http://www.vishay.com/ppg?73257>). The PowerPAK SO-8 is a leadless package. The end of the lead terminal is exposed copper (not plated) as a result of the singulation process in manufacturing. A solder fillet at the exposed copper tip cannot be guaranteed and is not required to ensure adequate bottom side solder interconnection.
- Rework Conditions: manual soldering with a soldering iron is not recommended for leadless components.
- Maximum under Steady State conditions is 65 °C/W.

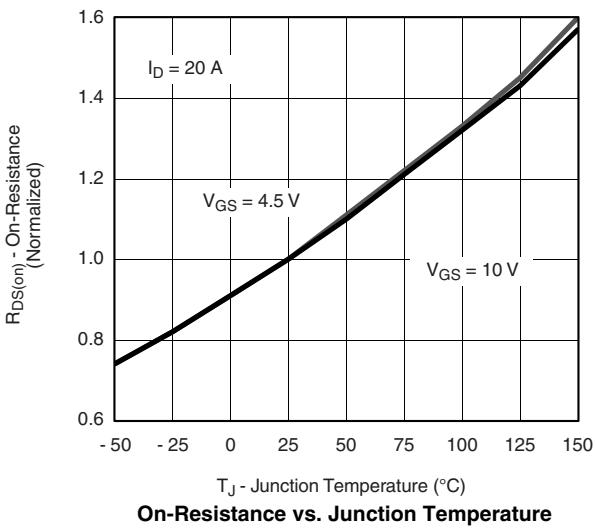
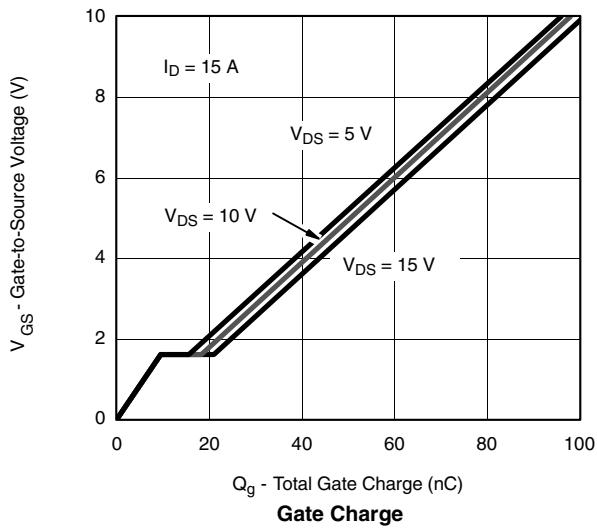
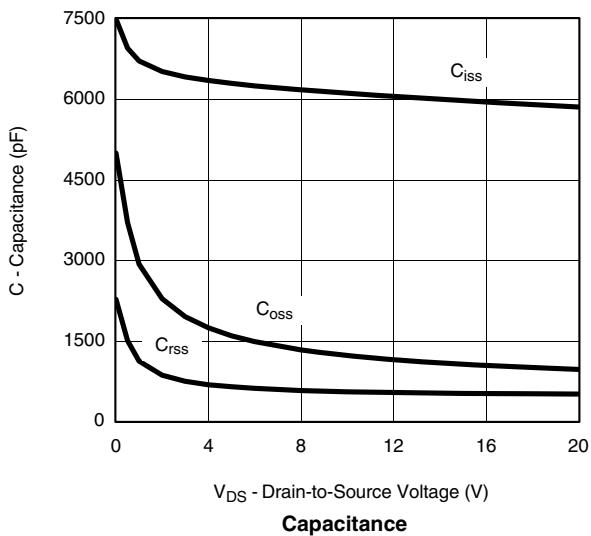
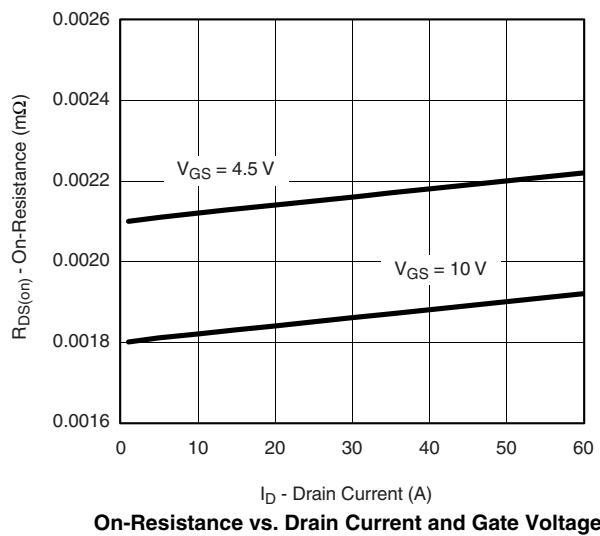
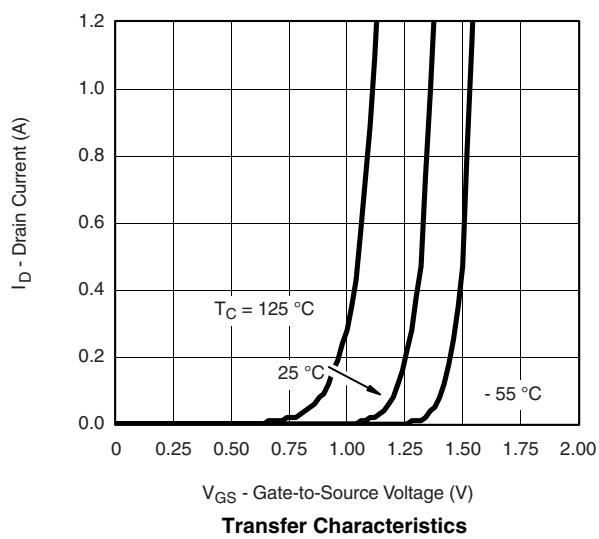
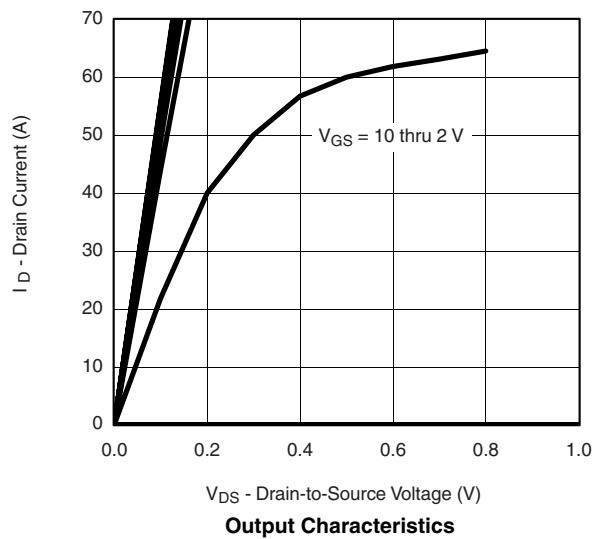
SPECIFICATIONS $T_J = 25^\circ\text{C}$, unless otherwise noted

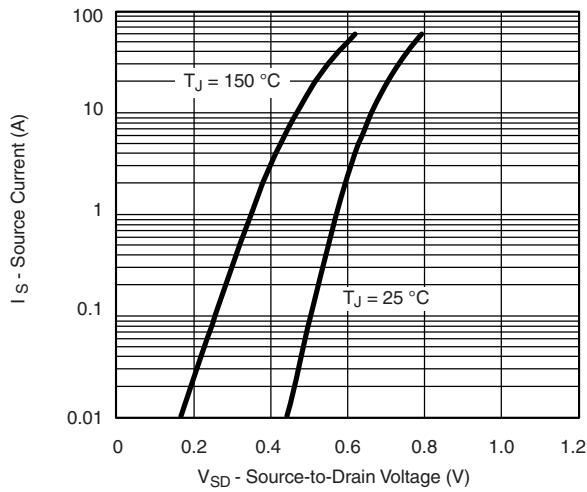
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit	
Static							
Drain-Source Breakdown Voltage	V_{DS}	$V_{GS} = 0 \text{ V}$, $I_D = 250 \mu\text{A}$	20			V	
V_{DS} Temperature Coefficient	$\Delta V_{DS}/T_J$	$I_D = 5 \text{ mA}$		23		mV/°C	
$V_{GS(\text{th})}$ Temperature Coefficient	$\Delta V_{GS(\text{th})}/T_J$			4			
Gate-Source Threshold Voltage	$V_{GS(\text{th})}$	$V_{DS} = V_{GS}$, $I_D = 250 \mu\text{A}$	0.6		1.6	V	
Gate-Source Leakage	I_{GSS}	$V_{DS} = 0 \text{ V}$, $V_{GS} = \pm 16 \text{ V}$			± 100	nA	
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 20 \text{ V}$, $V_{GS} = 0 \text{ V}$			1	μA	
		$V_{DS} = 20 \text{ V}$, $V_{GS} = 0 \text{ V}$, $T_J = 55^\circ\text{C}$			10		
On-State Drain Current ^a	$I_{D(\text{on})}$	$V_{DS} \geq 5 \text{ V}$, $V_{GS} = 10 \text{ V}$	30			A	
Drain-Source On-State Resistance ^a	$R_{DS(\text{on})}$	$V_{GS} = 10 \text{ V}$, $I_D = 20 \text{ A}$		0.0018	0.00225	Ω	
		$V_{GS} = 4.5 \text{ V}$, $I_D = 20 \text{ A}$		0.0021	0.00275		
Forward Transconductance ^a	g_{fs}	$V_{DS} = 15 \text{ V}$, $I_D = 20 \text{ A}$		150		S	
Dynamic^b							
Input Capacitance	C_{iss}	$V_{DS} = 10 \text{ V}$, $V_{GS} = 0 \text{ V}$, $f = 1 \text{ MHz}$		6110		pF	
Output Capacitance	C_{oss}			1225			
Reverse Transfer Capacitance	C_{rss}			550			
Total Gate Charge	Q_g	$V_{DS} = 10 \text{ V}$, $V_{GS} = 10 \text{ V}$, $I_D = 15 \text{ A}$		98	150	nC	
Gate-Source Charge	Q_{gs}	$V_{DS} = 10 \text{ V}$, $V_{GS} = 4.5 \text{ V}$, $I_D = 15 \text{ A}$		46	70		
Gate-Drain Charge	Q_{gd}			9.5			
Gate Resistance	R_g		$f = 1 \text{ MHz}$	0.5	1.1	1.7	Ω
Turn-On Delay Time	$t_{d(\text{on})}$			28	45	ns	
Rise Time	t_r	$V_{DD} = 10 \text{ V}$, $R_L = 1 \Omega$ $I_D \geq 10 \text{ A}$, $V_{GEN} = 4.5 \text{ V}$, $R_g = 1 \Omega$		120	180		
Turn-Off Delay Time	$t_{d(\text{off})}$			52	80		
Fall Time	t_f			12	20		
Turn-On Delay Time	$t_{d(\text{on})}$			16	25		
Rise Time	t_r	$V_{DD} = 10 \text{ V}$, $R_L = 1 \Omega$ $I_D \geq 10 \text{ A}$, $V_{GEN} = 10 \text{ V}$, $R_g = 1 \Omega$		97	150		
Turn-Off Delay Time	$t_{d(\text{off})}$			58	90		
Fall Time	t_f			8	15		
Drain-Source Body Diode Characteristics							
Continuous Source-Drain Diode Current	I_S	$T_C = 25^\circ\text{C}$			40	A	
Pulse Diode Forward Current ^a	I_{SM}				70		
Body Diode Voltage	V_{SD}	$I_S = 5 \text{ A}$		0.65	1.1	V	
Body Diode Reverse Recovery Time	t_{rr}	$I_F = 20 \text{ A}$, $di/dt = 100 \text{ A}/\mu\text{s}$, $T_J = 25^\circ\text{C}$		50	75	ns	
Body Diode Reverse Recovery Charge	Q_{rr}			43	60	nC	
Reverse Recovery Fall Time	t_a			24		ns	
Reverse Recovery Rise Time	t_b			26			

Notes:

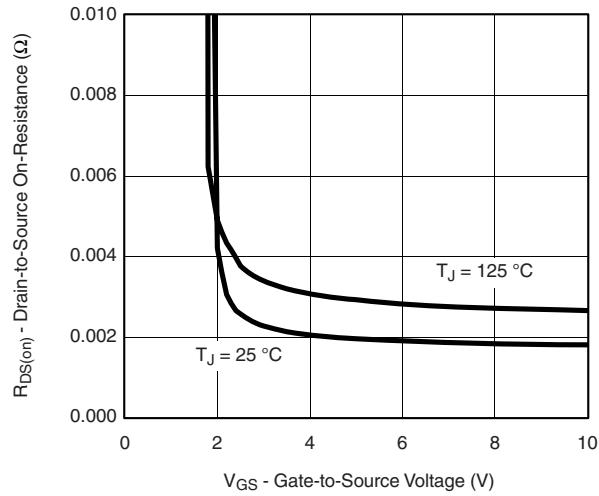
a. Pulse test; pulse width $\leq 300 \mu\text{s}$, duty cycle $\leq 2 \%$.
b. Guaranteed by design, not subject to production testing.

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.

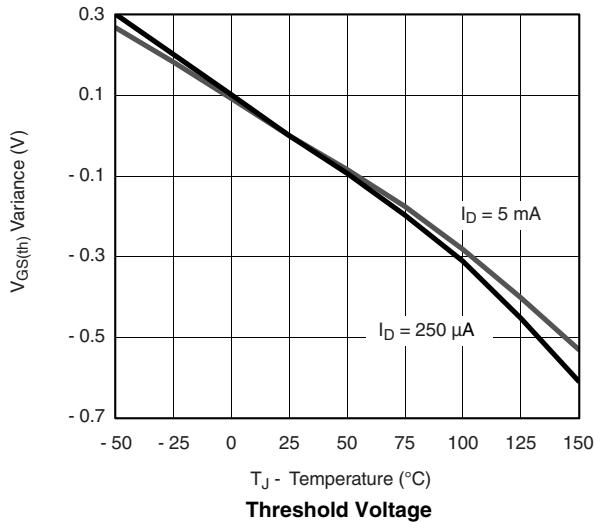
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted


TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted


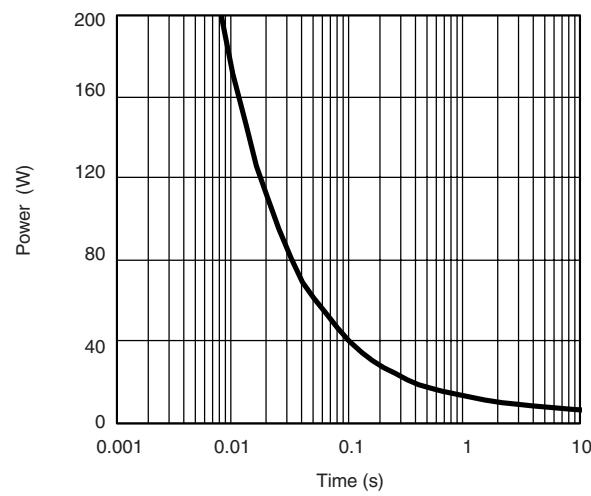
Source-Drain Diode Forward Voltage



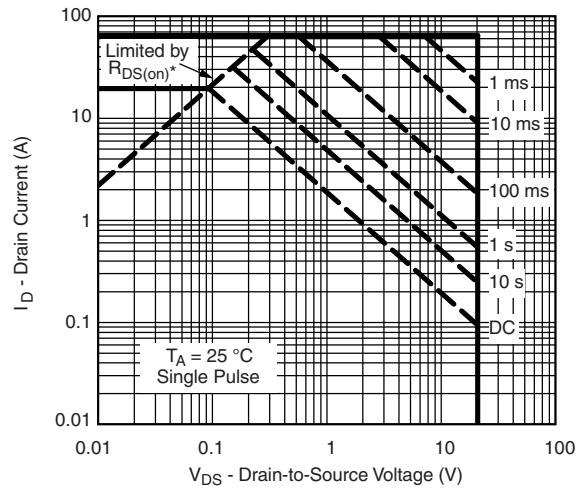
On-Resistance vs. Gate-to-Source Voltage



Threshold Voltage

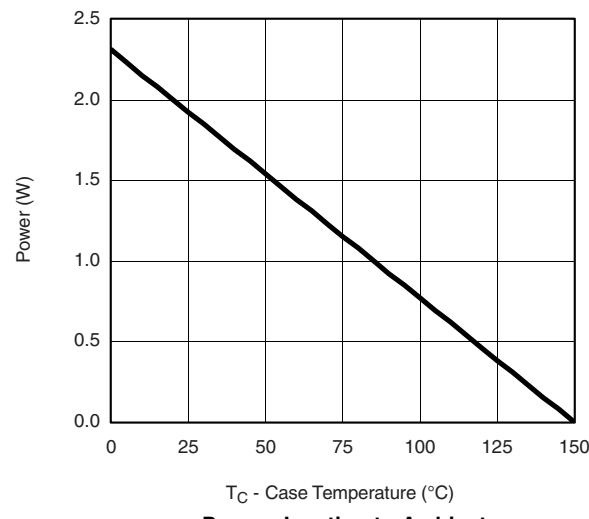
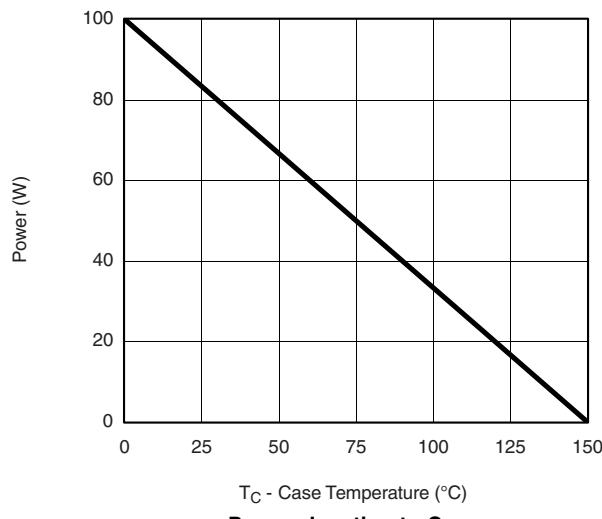
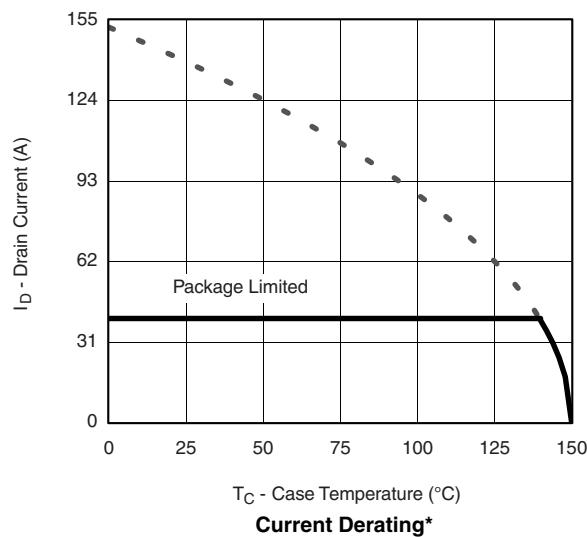


Single Pulse Power, Junction-to-Ambient

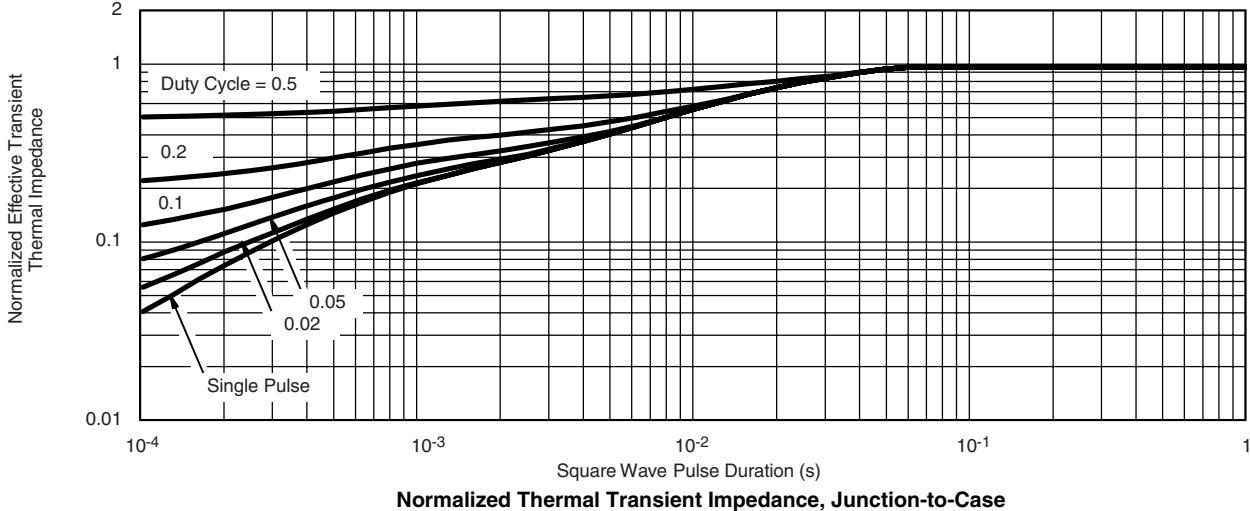
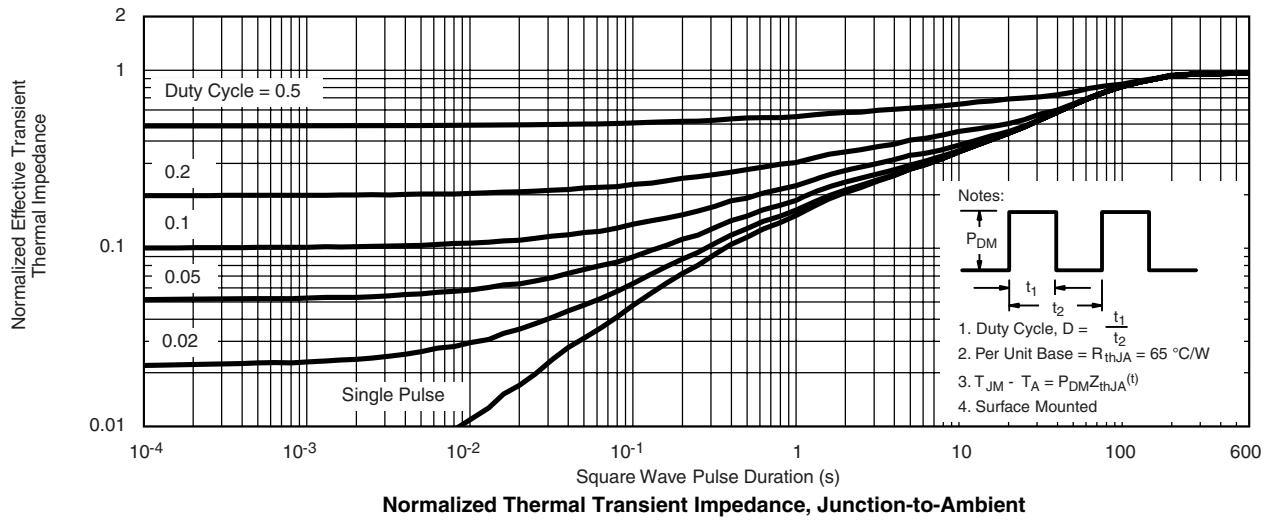


* $V_{GS} >$ minimum V_{GS} at which $R_{DS(on)}$ is specified

Safe Operating Area, Junction-to-Ambient

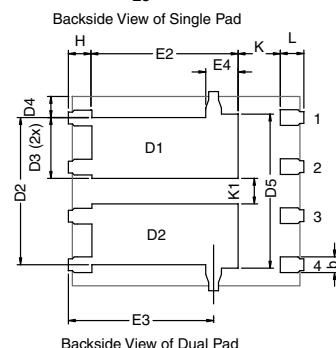
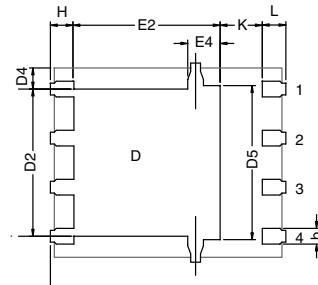
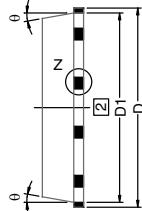
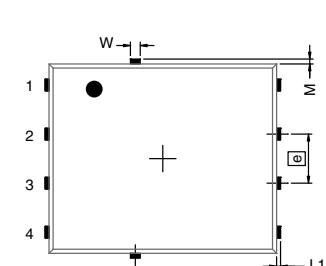
TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted


* The power dissipation P_D is based on $T_{J(max)} = 175$ °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.

TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted

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 <http://www.vishay.com/ppg?73384>.

PowerPAK® SO-8, (Single/Dual)


Notes

1. Inch will govern.
2. Dimensions exclusive of mold gate burrs.
3. Dimensions exclusive of mold flash and cutting burrs.

DIM.	MILLIMETERS			INCHES			
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	
A	0.97	1.04	1.12	0.038	0.041	0.044	
A1		-	0.05	0	-	0.002	
b	0.33	0.41	0.51	0.013	0.016	0.020	
c	0.23	0.28	0.33	0.009	0.011	0.013	
D	5.05	5.15	5.26	0.199	0.203	0.207	
D1	4.80	4.90	5.00	0.189	0.193	0.197	
D2	3.56	3.76	3.91	0.140	0.148	0.154	
D3	1.32	1.50	1.68	0.052	0.059	0.066	
D4	0.57 typ.			0.0225 typ.			
D5	3.98 typ.			0.157 typ.			
E	6.05	6.15	6.25	0.238	0.242	0.246	
E1	5.79	5.89	5.99	0.228	0.232	0.236	
E2 (for AL product)	3.30	3.48	3.66	0.130	0.137	0.144	
E2 (for other product)	3.48	3.66	3.84	0.137	0.144	0.151	
E3	3.68	3.78	3.91	0.145	0.149	0.154	
E4 (for AL product)	0.58 typ.			0.023 typ.			
E4 (for other product)	0.75 typ.			0.030 typ.			
e	1.27 BSC			0.050 BSC			
K (for AL product)	1.45 typ.			0.057 typ.			
K (for other product)	1.27 typ.			0.050 typ.			
K1	0.56	-	-	0.022	-	-	
H	0.51	0.61	0.71	0.020	0.024	0.028	
L	0.51	0.61	0.71	0.020	0.024	0.028	
L1	0.06	0.13	0.20	0.002	0.005	0.008	
θ	0°	-	12°	0°	-	12°	
W	0.15	0.25	0.36	0.006	0.010	0.014	
M	0.125 typ.			0.005 typ.			

ECN: C13-0702-Rev. K, 20-May-13
DWG: 5881

PowerPAK® SO-8 Mounting and Thermal Considerations

by Wharton McDaniel

MOSFETs for switching applications are now available with die on resistances around $1\text{ m}\Omega$ and with the capability to handle 85 A. While these die capabilities represent a major advance over what was available just a few years ago, it is important for power MOSFET packaging technology to keep pace. It should be obvious that degradation of a high performance die by the package is undesirable. PowerPAK is a new package technology that addresses these issues. In this application note, PowerPAK's construction is described. Following this mounting information is presented including land patterns and soldering profiles for maximum reliability. Finally, thermal and electrical performance is discussed.

THE PowerPAK PACKAGE

The PowerPAK package was developed around the SO-8 package (figure 1). The PowerPAK SO-8 utilizes the same footprint and the same pin-outs as the standard SO-8. This allows PowerPAK to be substituted directly for a standard SO-8 package. Being a leadless package, PowerPAK SO-8 utilizes the entire SO-8 footprint, freeing space normally occupied by the leads, and thus allowing it to hold a larger die than a standard SO-8. In fact, this larger die is slightly larger than a full sized DPAK die. The bottom of the die attach pad is exposed for the purpose of providing a direct, low resistance thermal path to the substrate the device is mounted on. Finally, the package height is lower than the standard SO-8, making it an excellent choice for applications with space constraints.

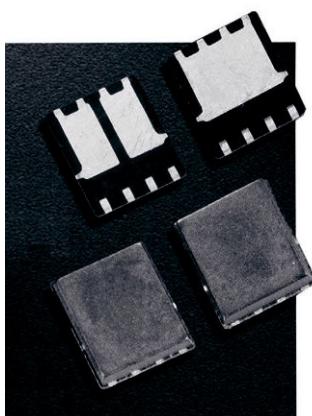
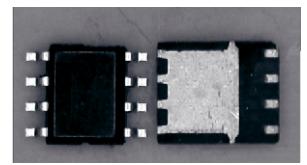


Fig. 1 PowerPAK 1212 Devices

PowerPAK SO-8 SINGLE MOUNTING

The PowerPAK single is simple to use. The pin arrangement (drain, source, gate pins) and the pin dimensions are the same as standard SO-8 devices (see figure 2). Therefore, the PowerPAK connection pads match directly to those of the SO-8. The only difference is the extended drain connection area. To take immediate advantage of the PowerPAK SO-8 single devices, they can be mounted to existing SO-8 land patterns.



Standard SO-8 PowerPAK SO-8

Fig. 2

The minimum land pattern recommended to take full advantage of the PowerPAK thermal performance see Application Note 826, [Recommended Minimum Pad Patterns With Outline Drawing Access for Vishay Siliconix MOSFETs](#). Click on the PowerPAK SO-8 single in the index of this document.

In this figure, the drain land pattern is given to make full contact to the drain pad on the PowerPAK package.

This land pattern can be extended to the left, right, and top of the drawn pattern. This extension will serve to increase the heat dissipation by decreasing the thermal resistance from the foot of the PowerPAK to the PC board and therefore to the ambient. Note that increasing the drain land area beyond a certain point will yield little decrease in foot-to-board and foot-to-ambient thermal resistance. Under specific conditions of board configuration, copper weight and layer stack, experiments have found that more than about 0.25 in^2 to 0.5 in^2 of additional copper (in addition to the drain land) will yield little improvement in thermal performance.

PowerPAK® SO-8 Mounting and Thermal Considerations

PowerPAK SO-8 DUAL

The pin arrangement (drain, source, gate pins) and the pin dimensions of the PowerPAK SO-8 dual are the same as standard SO-8 dual devices. Therefore, the PowerPAK device connection pads match directly to those of the SO-8. As in the single-channel package, the only exception is the extended drain connection area. Manufacturers can likewise take immediate advantage of the PowerPAK SO-8 dual devices by mounting them to existing SO-8 dual land patterns.

To take the advantage of the dual PowerPAK SO-8's thermal performance, the minimum recommended land pattern can be found in Application Note 826, [Recommended Minimum Pad Patterns With Outline Drawing Access for Vishay Siliconix MOSFETs](#). Click on the PowerPAK 1212-8 dual in the index of this document.

The gap between the two drain pads is 24 mils. This matches the spacing of the two drain pads on the PowerPAK SO-8 dual package.

REFLOW SOLDERING

Vishay Siliconix surface-mount packages meet solder reflow reliability requirements. Devices are subjected to solder reflow as a test preconditioning and are then reliability-tested using temperature cycle, bias humidity, HAST, or pressure pot. The solder reflow temperature profile used, and the temperatures and time duration, are shown in figures 3 and 4.

For the lead (Pb)-free solder profile, see www.vishay.com/doc?73257.

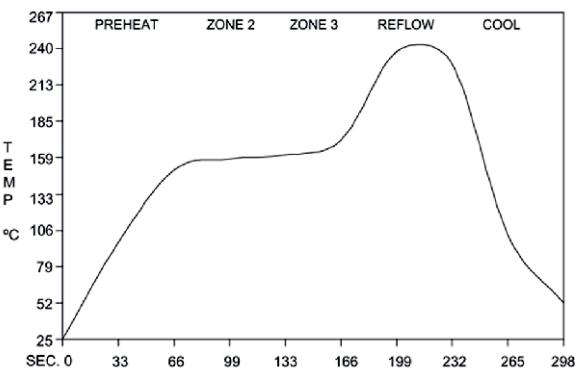


Fig. 3 Solder Reflow Temperature Profile

Ramp-Up Rate	+ 3 °C /s max.
Temperature at 150 - 200 °C	120 s max.
Temperature Above 217 °C	60 - 150 s
Maximum Temperature	255 + 5/- 0 °C
Time at Maximum Temperature	30 s
Ramp-Down Rate	+ 6 °C/s max.

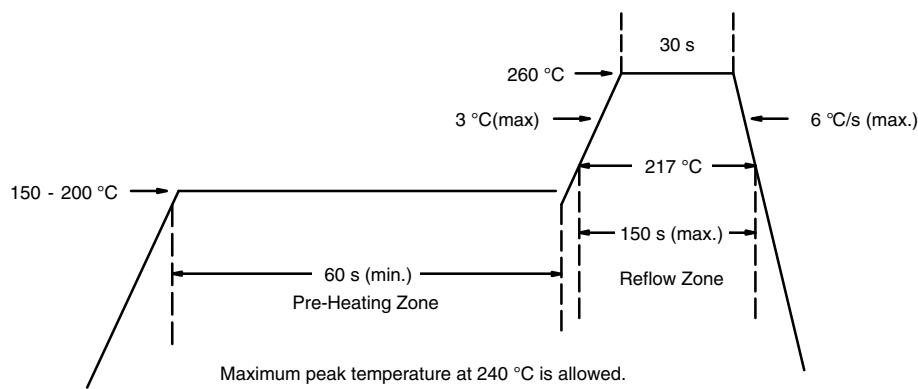


Fig. 4 Solder Reflow Temperatures and Time Durations

PowerPAK® SO-8 Mounting and Thermal Considerations

THERMAL PERFORMANCE

Introduction

A basic measure of a device's thermal performance is the junction-to-case thermal resistance, R_{thJC} , or the junction-to-foot thermal resistance, R_{thJF} . This parameter is measured for the device mounted to an infinite heat sink and is therefore a characterization of the device only, in other words, independent of the properties of the object to which the device is mounted. Table 1 shows a comparison of the DPAK, PowerPAK SO-8, and standard SO-8. The PowerPAK has thermal performance equivalent to the DPAK, while having an order of magnitude better thermal performance over the SO-8.

TABLE 1 - DPAK AND POWERPAK SO-8 EQUIVALENT STEADY STATE PERFORMANCE			
	DPAK	PowerPAK SO-8	Standard SO-8
Thermal Resistance R_{thJC}	1.2 °C/W	1 °C/W	16 °C/W

Thermal Performance on Standard SO-8 Pad Pattern

Because of the common footprint, a PowerPAK SO-8 can be mounted on an existing standard SO-8 pad pattern. The question then arises as to the thermal performance of the PowerPAK device under these conditions. A characterization was made comparing a standard SO-8 and a PowerPAK device on a board with a trough cut out underneath the PowerPAK drain pad. This configuration restricted the heat flow to the SO-8 land pads. The results are shown in figure 5.

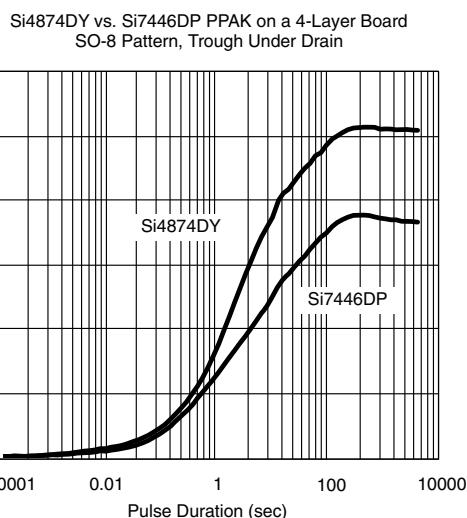


Fig. 5 PowerPAK SO-8 and Standard SO-8 Land Pad Thermal Path

PowerPAK® SO-8 Mounting and Thermal Considerations

SYSTEM AND ELECTRICAL IMPACT OF PowerPAK SO-8

In any design, one must take into account the change in MOSFET $R_{DS(on)}$ with temperature (figure 7).

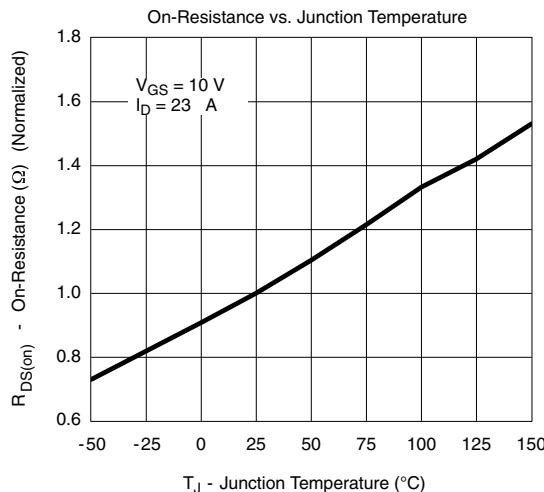


Fig. 7 MOSFET $R_{DS(on)}$ vs. Temperature

A MOSFET generates internal heat due to the current passing through the channel. This self-heating raises the junction temperature of the device above that of the PC board to which it is mounted, causing increased power dissipation in the device. A major source of this problem lies in the large values of the junction-to-foot thermal resistance of the SO-8 package.

PowerPAK SO-8 minimizes the junction-to-board thermal resistance to where the MOSFET die temperature is very close to the temperature of the PC board. Consider two devices mounted on a PC board heated to 105 °C by other components on the board (figure 8).

Suppose each device is dissipating 2.7 W. Using the junction-to-foot thermal resistance characteristics of the PowerPAK SO-8 and the standard SO-8, the die temperature is determined to be 107 °C for the PowerPAK (and for DPAK) and 148 °C for the standard SO-8. This is a 2 °C rise above the board temperature for the PowerPAK and a 43 °C rise for the standard SO-8. Referring to figure 7, a 2 °C difference has minimal effect on $R_{DS(on)}$ whereas a 43 °C difference has a significant effect on $R_{DS(on)}$.

Minimizing the thermal rise above the board temperature by using PowerPAK has not only eased the thermal design but it has allowed the device to run cooler, keep $r_{DS(on)}$ low, and permits the device to handle more current than the same MOSFET die in the standard SO-8 package.

CONCLUSIONS

PowerPAK SO-8 has been shown to have the same thermal performance as the DPAK package while having the same footprint as the standard SO-8 package. The PowerPAK SO-8 can hold larger die approximately equal in size to the maximum that the DPAK can accommodate implying no sacrifice in performance because of package limitations.

Recommended PowerPAK SO-8 land patterns are provided to aid in PC board layout for designs using this new package.

Thermal considerations have indicated that significant advantages can be gained by using PowerPAK SO-8 devices in designs where the PC board was laid out for the standard SO-8. Applications experimental data gave thermal performance data showing minimum and typical thermal performance in a SO-8 environment, plus information on the optimum thermal performance obtainable including spreading copper. This further emphasized the DPAK equivalency.

PowerPAK SO-8 therefore has the desired small size characteristics of the SO-8 combined with the attractive thermal characteristics of the DPAK package.

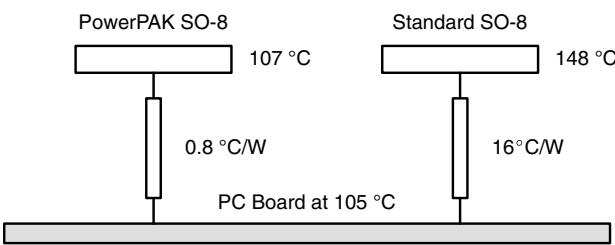
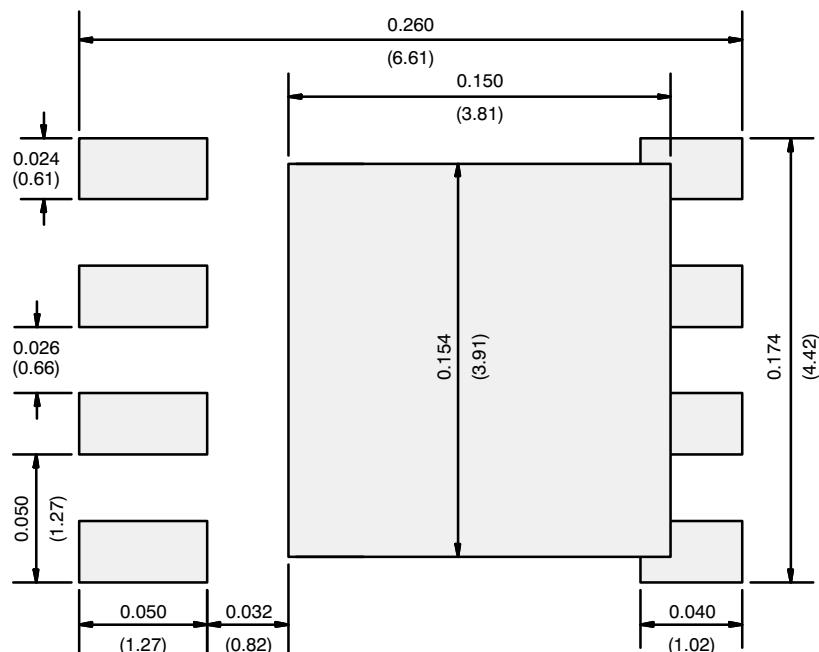


Fig. 8 Temperature of Devices on a PC Board

RECOMMENDED MINIMUM PADS FOR PowerPAK® SO-8 Single

Recommended Minimum Pads
Dimensions in Inches/(mm)

[Return to Index](#)

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