PICOR
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RoHS

PI5101
μ$R_{DS(on)}$FET™ Series

360μΩ, 5V/60A N-Channel MOSFET

Features

- Ultra Low "micro-Ohm" $R_{DS(on)}$
- Extremely Low Gate Charge
- Very Low Gate Resistance
- High Density, Low Profile
- Very Low Package Inductance
- Low Thermal Resistance

Applications

- Power Path Management Solutions
- Active ORing & Load Switches
- High Current DC-DC Converters

Product Summary

Symbol	Condition	Value	
I_D	T_A = 25°C	60A_{DC}	Max
$V_{(BR)DSS}$	I_D = 5mA	5V	Min
$R_{DS(on)}$	V_{GS} = 4.5V	360μΩ	Typ
	V_{GS} = 3.5V	380μΩ	Typ
Q_G	V_{GS} = 4.5V	65nC	Typ
R_G		0.1Ω	Typ
L_{DS}		0.1nH	Typ

Patent Pending

4.1mm x 8mm x 2mm
Thermally Enhanced LGA

Description

The PI5101 μ$R_{DS(on)}$FET™ solution combines a high-performance 5V, 360μΩ lateral N-Channel MOSFET with a thermally enhanced high density 4.1mm x 8mm x 2mm land-grid-array (LGA) package to enable world class performance in the footprint area of an industry standard SO-8 package. The PI5101 offers unprecedented figure-of-merits for DC & switching applications. The PI5101 will replace up to 6 conventional "SO-8 form factor" devices for the same on-state resistance, reducing board space by ~80%. The PI5101 offers unprecedented figure-of-merit for $R_{DS(on)}$ x Q_G, gate resistance (R_G) and package inductance (L_{DS}) outperforming conventional Trench MOSFETs and enabling very low loss operation.

The PI5101 LGA package is fully compatible with industry standard SMT assembly processes.

Maximum Rating and Thermal Characteristics (*T_A = 25°C unless otherwise Specified)*

Parameter		Symbol	Limit	Unit
Drain-to-Source Voltage		V_{DS}	5	V
Gate-to-Source Voltage		V_{GS}	±5	V
Drain Current	Continuous	I_D	60	A
	Pulsed	I_{DM}	150	A
Single Pulse Avalanche Current	T_{AV} <100μs	I_{AS}	100	A
Maximum Power Dissipation	T_A = 25°C	P_D	3.1	W
	T_A = 70°C		2	W
Operating Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 150	°C
Thermal Resistance (1)	Junction-to-Ambient	$R_{θJ-A}$	40	°C/W
	Junction-to-PCB	$R_{θJ-PCB}$	6	°C/W
Lead Temperature (Soldering, 20 sec)			260	°C

Note 1: *The thermal resistance is measured when the device is mounted on 1 inch square 4-layer 2-oz copper FR-4 PCB at 0LFM and 40A load current*

Electrical Characteristics: *T_A = 25°C unless otherwise Specified*

Parameter	Symbol	Min	Typ	Max	Units	Test Condition
Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	5.0			V	V_{GS} = 0V, I_D = 5mA
Breakdown Voltage Temperature Coefficient	$\frac{\Delta V_{(BR)DSS}}{\Delta T_J}$		3.1		mV/°C	Reference to 25°C, V_{GS} = 0V, I_D = 5mA
Drain-to-Source Leakage Current	I_{DSS}		0.2	2	µA	V_{DS} = 4.8V, V_{GS} = 0V
Gate-to-Source Leakage	I_{GSS}		10	200	nA	V_{GS} = 5V, V_{DS} = 0V
Gate Threshold Voltage	$V_{GS(th)}$	0.4		0.8	V	V_{DS} = V_{GS}, I_D = 1mA
Drain-to-Source On-State Resistance	$R_{DS(on)}$		360	450	µΩ	V_{GS} = 4.5V, I_D = 60A
			380	475	µΩ	V_{GS} = 3.5V, I_D = 60A
Turn-On Delay Time	$t_{d(on)}$		14		ns	V_{GS} = 4.5V, I_D = 60A R_G = 0.1Ω
Rise Time	t_r		4.5		ns	
Turn-Off Delay Time	$t_{d(off)}$		23		ns	
Fall Time	t_f		3.5		ns	
Forward Transconductance	gfs		620		S	I_D = 60A, V_{DS} = 4V
Gate Capacitance						
Input Capacitance	C_{iss}		7600		pF	V_{DS} = 5V, V_{GS} = 0V, f = 1MHz
Output Capacitance	C_{oss}		5200		pF	
Reverse Transfer Capacitance	C_{rss}		1100		pF	
Gate Charge						
Total Gate Charge	Q_g		65		nC	V_{GS} = 4.5V, V_{DS} = 4.4V, I_D = 60A
Gate-to-Source Charge	Q_{gs}		7.7		nC	
Gate-to-Drain Charge	Q_{gd}		9.0		nC	
Gate Resistance	R_G		0.1		Ω	
Reverse Diode						
Source-to-Drain Reverse Recovery Time	t_{rr}		300		ns	I_S = 16A, $di/dt = 33A/\mu A$
Diode Forward Voltage	V_{SD}		0.63	1.0	V	I_S = 16A, V_{GS} = 0V
Package Inductance	L_{DS}		0.1		nH	

Typical Characteristics: *T_A = 25°C unless otherwise Specified*

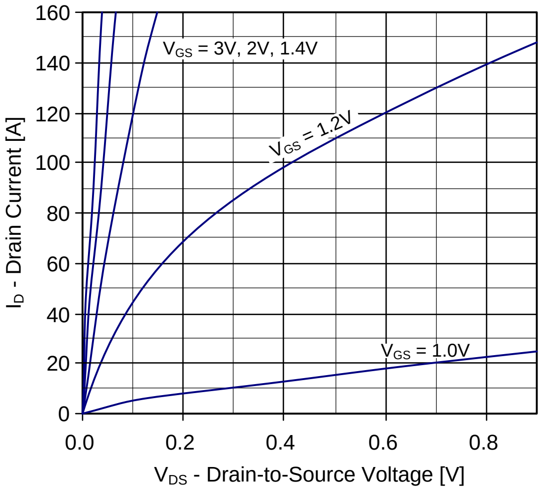


Figure 1: Output Characteristics. (Pulsed V_{GS})

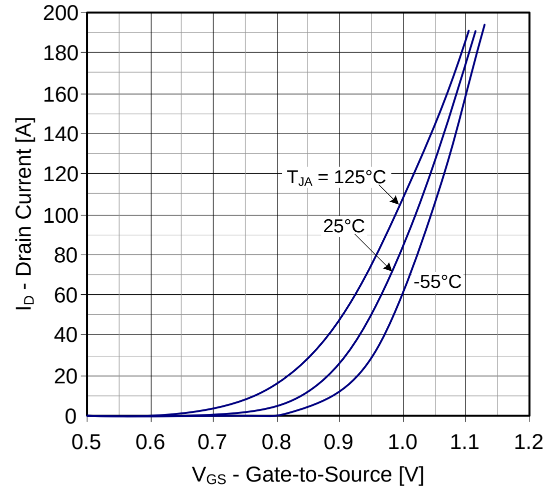


Figure 4: Transfer Characteristics. (Pulsed V_{GS})

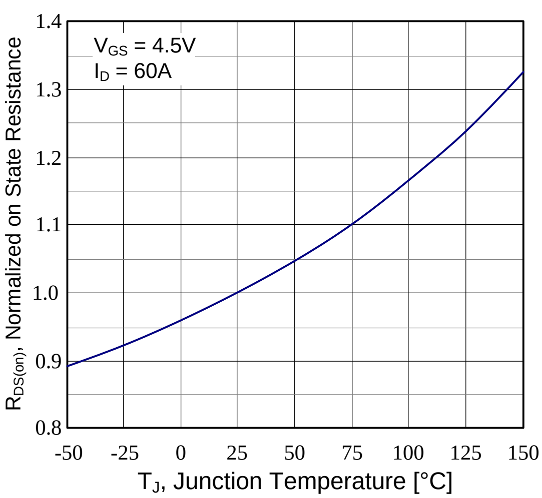


Figure 2: On-Resistance vs. Junction Temperature

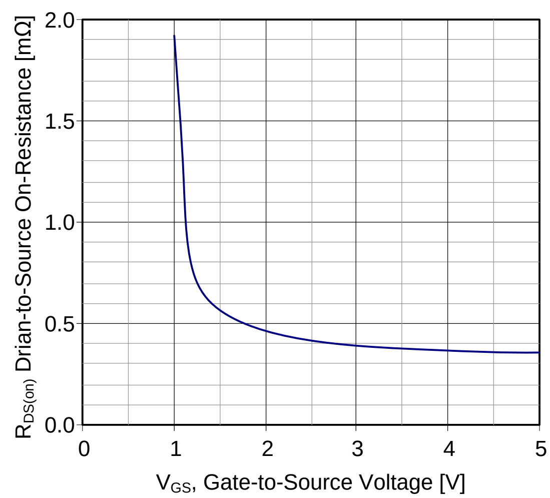


Figure 5: On-Resistance vs. Gate Voltage

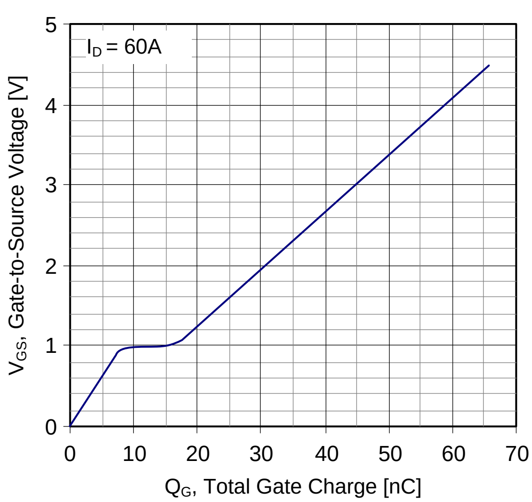


Figure 3: Gate Charge.

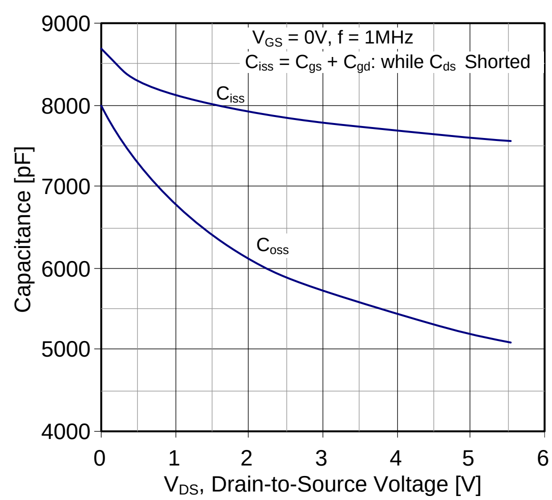


Figure 6: Gate Capacitance vs. Drain-to Source Voltage.

Typical Characteristics: *T_A = 25°C unless otherwise Specified*

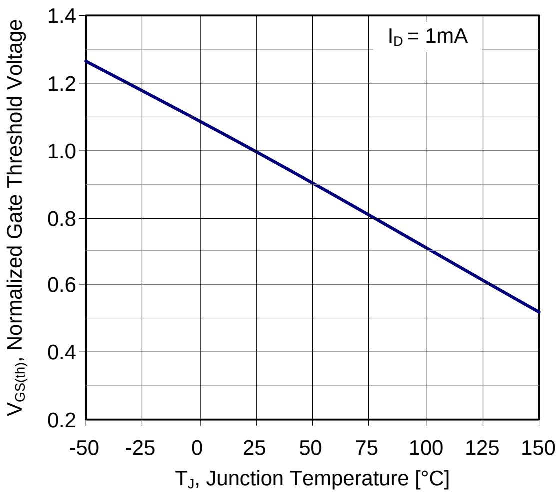


Figure 7: Gate Threshold Voltage vs. Temperature

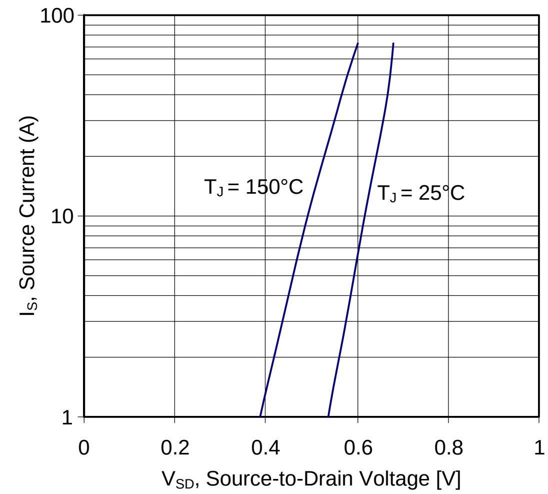


Figure 10: Reverse Diode Forward Voltage

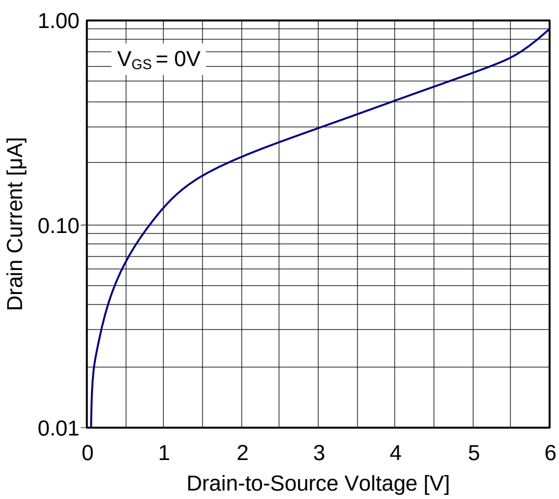


Figure 8: Drain-to-Source Leakage Current.

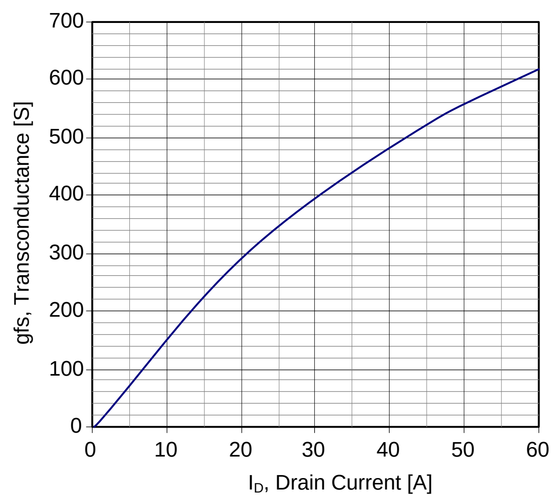


Figure 11: Forward Transconductance

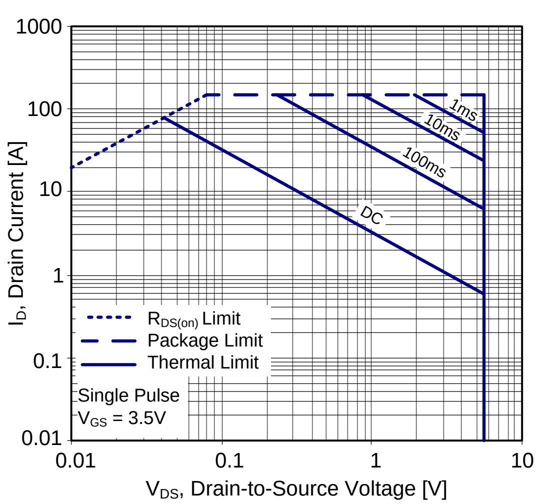


Figure 9: Maximum Safe Operation Area

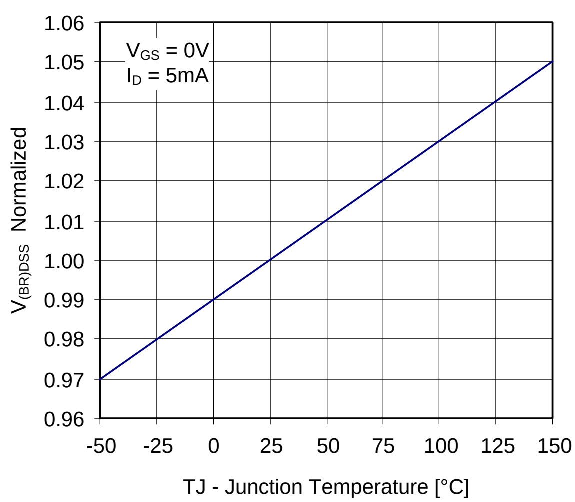


Figure 12: Drain-to-Source Breakdown Voltage vs. temperature.

Typical Characteristics: *T_A = 25°C unless otherwise Specified*

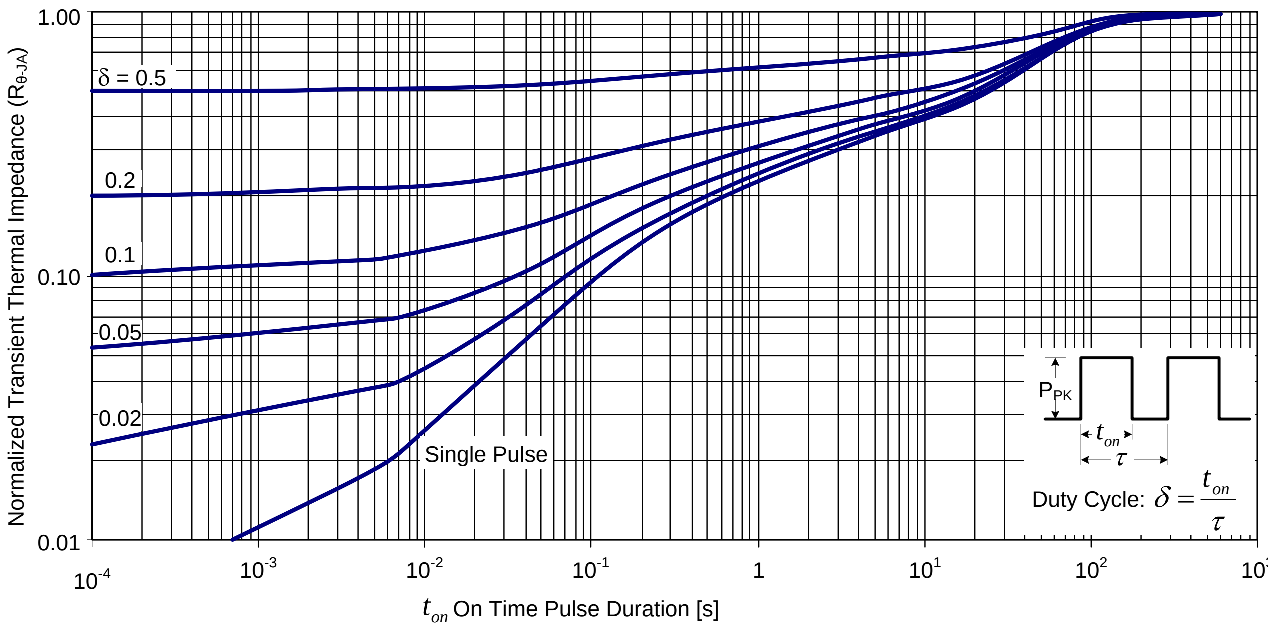


Figure 13: Normalized Transient Thermal Impedance, Junction-to-Ambient

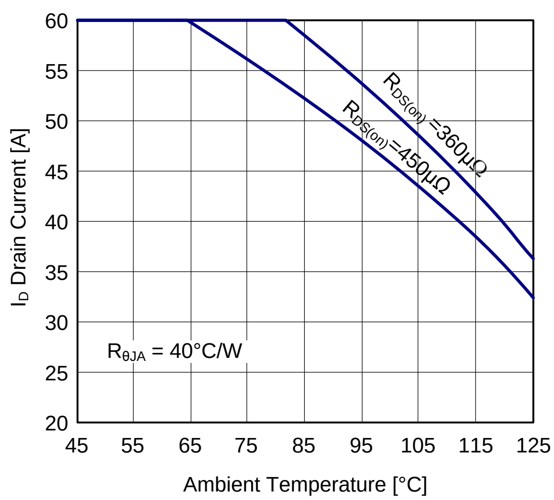


Figure 14: PI5101 Drain current de-rating based on the maximum T_J=150°C vs. ambient temperature

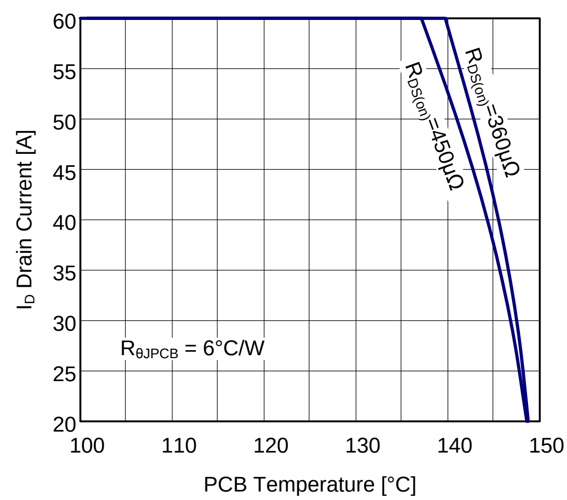


Figure 15: PI5101 Drain current de-rating vs. PCB temperature, for maximum T_J at 150°C

MOSFET Power Dissipation vs. Junction Temperature

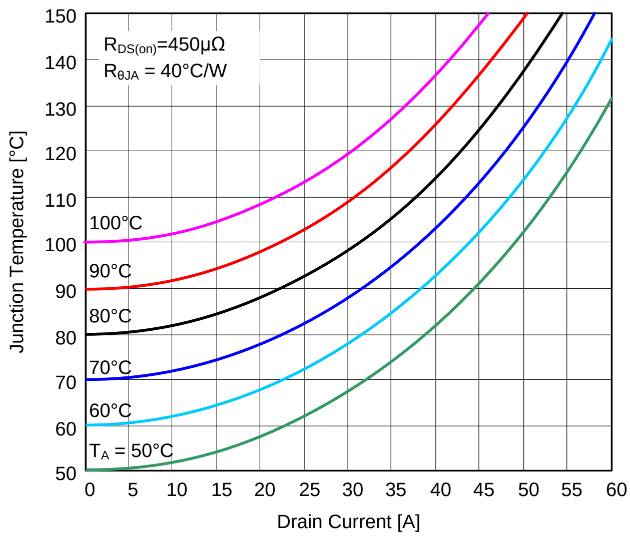


Figure 16: Junction Temperature vs. Drain Current for a given ambient temperature (0LFM)

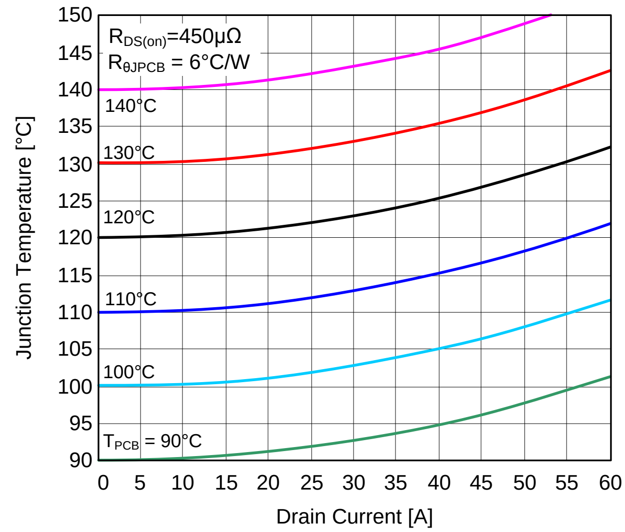


Figure 17: Junction Temperature vs. Drain Current for a given PCB temperature

In applications such as low loss ORing Diodes or circuit breakers where the MOSFET is normally on during steady state operation, the MOSFET power dissipation is derived from the total Drain current and the on-state resistance of the MOSFET.

The PI5101 power dissipation can be calculated with the following equation:

$$\mathbf{P_D = I_D{}^2 * R_{DS(on)}}$$

Where:

$\mathbf{P_D}$: MOSFET power dissipation

$\mathbf{I_D}$: Drain Current

$\mathbf{R_{DS(on)}}$: MOSFET on-state resistance

Note: For the worst case condition, calculate with maximum rated $R_{DS(on)}$ at the MOSFET maximum operating junction temperature because $R_{DS(on)}$ is temperature dependent. Refer to Figure 2 for normalized $R_{DS(on)}$ values over temperature. The PI5101 maximum $R_{DS(on)}$ at 25°C is 450µΩ and will increase by 24% at 125°C junction temperature.

The Junction Temperature rise is a function of power dissipation and thermal resistance.

$$\mathbf{T_{rise} = R_{\theta JA} * P_D = R_{\theta JA} * I_D{}^2 * R_{DS(on)}}$$

Where:

$\mathbf{R_{\theta JA}}$: Junction-to-Ambient thermal resistance (40°C/W)

This may require iteration to get to the final junction temperature. Figure 16 and Figure 17 are added to aid the user to find the final Junction temperature without the iterative calculations.

Figure 16 shows the MOSFETs final junction temperature curves versus conducted current at maximum $R_{DS(on)}$, and at given ambient temperatures at 0LFM air flow. Figure 17 shows the MOSFETs final junction temperature curves versus conducted current at maximum $R_{DS(on)}$ at given PCB temperatures.

To find the final junction temperature for a given drain continuous DC or RMS current and a given ambient or PCB temperature; draw a vertical line from the drain current at the X-axis to intersect the ambient or PCB temperature line. At the intersection draw a horizontal line towards the Y-axis (Junction Temperature).

Example:

Assume that the MOSFET maximum drain current is 50A and maximum operating ambient temperature is 70°C.

First use Figure 16 to find the final junction temperature for 50A load current at 70°C ambient temperature. In Figure 16 (illustrated in Figure 18) draw a vertical line from 50A to intersect the 70°C ambient temperature line (dark blue). At the intersection draw a horizontal line towards the Y-axis (Junction Temperature). The typical junction temperature with maximum $R_{DS(on)}$, at load current of 50A and 70°C ambient is 126°C.

As a check, recalculate the junction temperature to confirm the plot results. Start from the final junction temperature, 126°C, and use the following steps:

$R_{DS(on)}$ is 450µΩ maximum at 25°C and will increase as the Junction temperature increases. From Figure 2, at 126°C $R_{DS(on)}$ will increase by 24%, then $R_{DS(on)}$ maximum at 126°C is:

$$R_{DS(on)} = 450\mu\Omega * 1.24 = 558\mu\Omega$$

Maximum power dissipation is:

$$\mathbf{P_D}_{max} = I_D{}^2 * R_{DS(on)} = 50A^2 * 558\mu\Omega = 1.39W$$

Maximum junction temperature is:

$$\mathbf{T_J}_{max} = 70°C + \frac{40°C}{W} * 50A^2 * 558\mu\Omega = 125.8°C$$

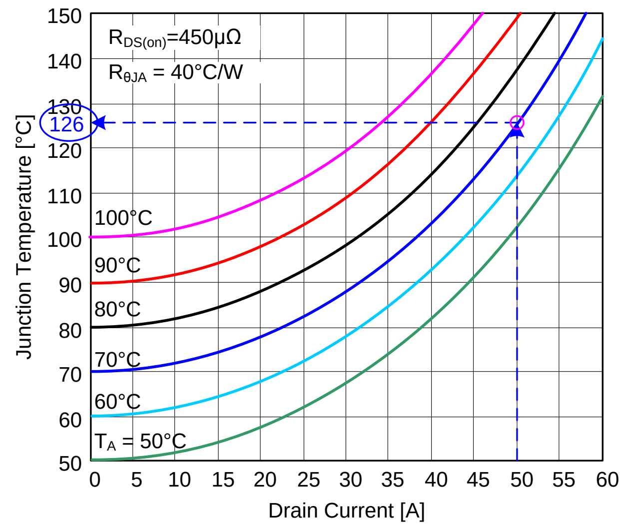
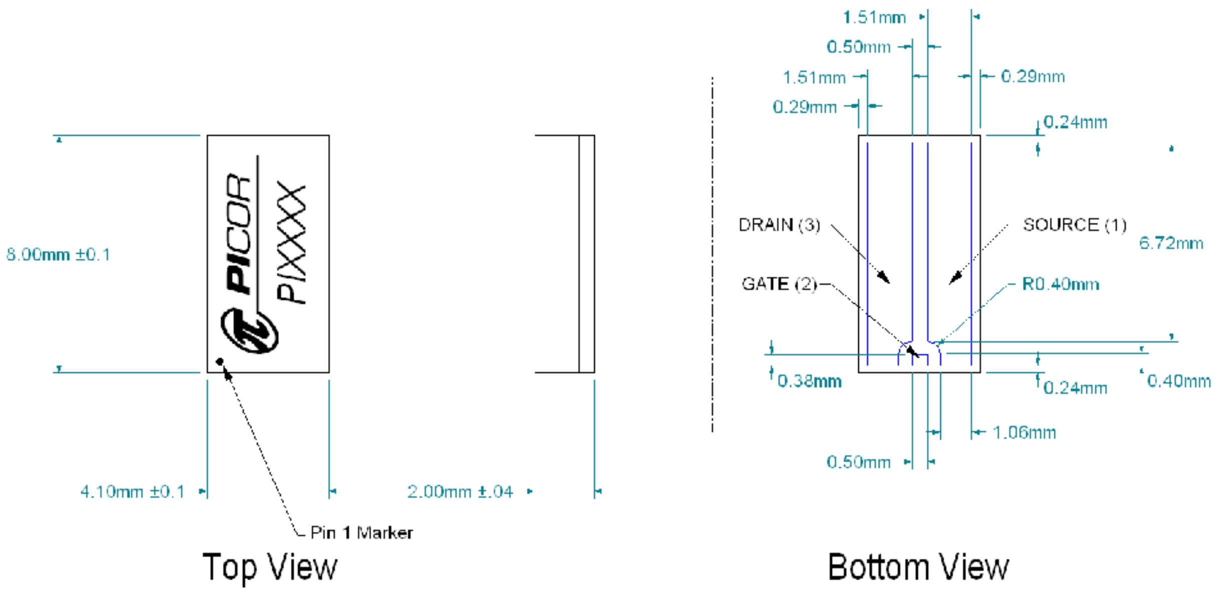
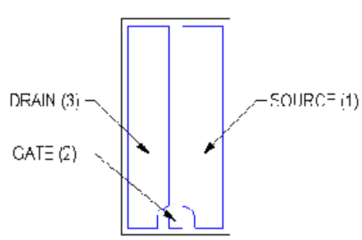


Figure 18: Example graphing of MOSFET junction temperature at I_D=50A and T_A =70°C

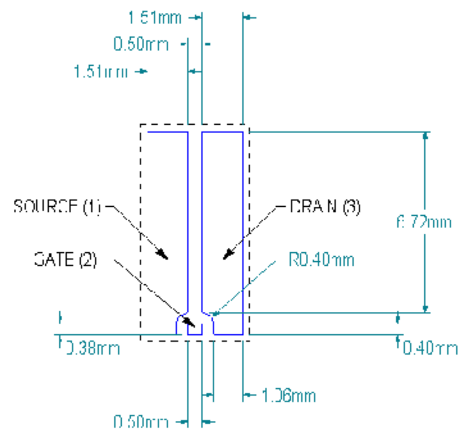
Package Drawing:



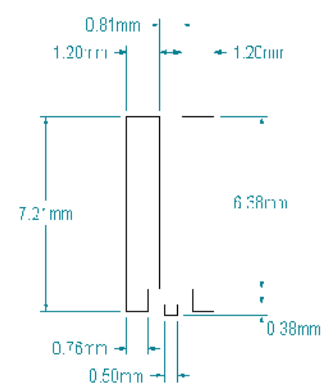
Layout Recommendation:



4.1 x 8mm Package
(Bottom View)



Recommended Receiving PCB Footprint
(Top View)



Recommended Footprint Stencil
(6mil stencil, ~80% pad area)

Ordering Information:

Part Number	Package	Transport Media
PI5101-00-LGIZ	4.1mm x 8mm x 2mm 3-Lead LGA	T&R

Warranty

Vicor products are guaranteed for two years from date of shipment against defects in material or workmanship when in normal use and service. This warranty does not extend to products subjected to misuse, accident, or improper application or maintenance. Vicor shall not be liable for collateral or consequential damage. This warranty is extended to the original purchaser only.

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