

360 $\mu\Omega$, 5 V/60 A N-Channel MOSFET

Product Description

The PI5101 $\mu R_{DS(on)}$ FET™ solution combines a high-performance 5 V, 360 $\mu\Omega$ 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 $R_{DS(on)} \times Q_G$, 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.

Product Summary

Symbol	Condition	Value	
I_D	$T_A = 25^\circ\text{C}$	60 A _{DC}	Max
$V_{(BR)DSS}$	$I_D = 5 \text{ mA}$	5 V	Min
$R_{DS(ON)}$	$V_{GS} = 4.5 \text{ V}$	360 $\mu\Omega$	Typ
	$V_{GS} = 3.5 \text{ V}$	380 $\mu\Omega$	Typ
Q_G	$V_{GS} = 4.5 \text{ V}$	65 nC	Typ
R_G		0.1 Ω	Typ
L_{DS}		0.1 nH	Typ

Features

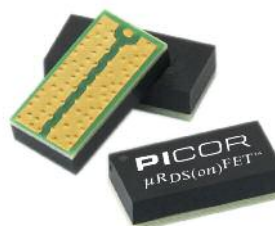
- Ultra Low “micro-Ohm” $R_{DS(on)}$
- Extremely Low Gate Charge
- Very Low Gate Resistance
- High Density, Low Profile
- Very Low Package Inductance
- Low Thermal Resistance

Applications

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

Package Information

- 4.1mm x 8mm x 2mm
Thermally Enhanced LGA



Order Information

Part Number	Package	Transport Media
PI5101-01-LGIZ	4.1mm x 8mm x 2mm 3-Lead LGA	T&R

Maximum Rating and Thermal Characteristics

$T_A = 25^\circ\text{C}$ 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	$T_{AV} < 100 \mu\text{s}$	I_{AS}	100	A
Maximum Power Dissipation	$T_A = 25^\circ\text{C}$	P_D	3.1	W
	$T_A = 70^\circ\text{C}$		2	W
Operating Junction and Storage Temperature Range		T_J, T_{STG}	-55 to 150	$^\circ\text{C}$
Thermal Resistance ^[1]	Junction-to-Ambient	$R_{\theta JA}$	40	$^\circ\text{C/W}$
	Junction-to-PCB	$R_{\theta J-PCB}$	6	$^\circ\text{C/W}$
Lead Temperature (Soldering, 20 sec)			260	$^\circ\text{C}$

^[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 drain current

Electrical Characteristics

$T_A = 25^\circ\text{C}$ unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Specifications						
Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	$V_{GS} = 0\text{ V}, I_D = 5\text{ mA}$	5.0			V
Breakdown Voltage Temperature Coefficient	$\frac{\Delta V_{(BR)DSS}}{\Delta T_J}$	Reference to 25°C , $V_{GS} = 0\text{ V}, I_D = 5\text{ mA}$		3.1		mV/ $^\circ\text{C}$
Drain-to-Source Leakage Current	I_{DSS}	$V_{DS} = 4.8\text{ V}, V_{GS} = 0\text{ V}$		0.2	2	μA
Gate-to-Source Leakage	I_{GSS}	$V_{GS} = 5\text{ V}, V_{DS} = 0\text{ V}$		10	200	nA
Gate Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 1\text{ mA}$	0.4		0.8	V
Drain-to-Source On-State Resistance	$R_{DS(on)}$	$V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}$		360	450	$\mu\Omega$
		$V_{GS} = 3.5\text{ V}, I_D = 60\text{ A}$		380	475	$\mu\Omega$
Turn-On Delay Time	$t_{d(on)}$	$V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}, R_G = 0.1\Omega$		14		ns
Rise Time	t_r	$V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}, R_G = 0.1\Omega$		4.5		ns
Turn-Off Delay Time	$t_{d(off)}$	$V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}, R_G = 0.1\Omega$		23		ns
Fall Time	t_f	$V_{GS} = 4.5\text{ V}, I_D = 60\text{ A}, R_G = 0.1\Omega$		3.5		ns
Forward Transconductance	g_{fs}	$I_D = 60\text{ A}, V_{DS} = 4\text{ V}$		620		S
Gate Capacitance						
Input Capacitance	C_{iss}	$V_{DS} = 5\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$; See Figure 6		7600		pF
Output Capacitance	C_{oss}	$V_{DS} = 5\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$; See Figure 6		5200		pF
Reverse Transfer Capacitance	C_{rss}	$V_{DS} = 5\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$		1100		pF
Gate Charge						
Total Gate Charge	Q_g	$V_{GS} = 4.5\text{ V}, V_{DD} = 4.4\text{ V}, I_D = 60\text{ A}$; See Figure 3		65		nC
Gate-to-Source Charge	Q_{gs}	$V_{GS} = 4.5\text{ V}, V_{DD} = 4.4\text{ V}, I_D = 60\text{ A}$		7.7		nC
Gate-to-Drain Charge	Q_{gd}	$V_{GS} = 4.5\text{ V}, V_{DD} = 4.4\text{ V}, I_D = 60\text{ A}$		9.0		nC
Gate Resistance	R_G			0.1		Ω
Reverse Diode						
Source-to-Drain Reverse Recovery Time	t_{rr}	$I_S = 16\text{ A}, di/dt = 33\text{ A}/\mu\text{s}$		300		ns
Diode Forward Voltage	V_{SD}	$I_S = 16\text{ A}, V_{GS} = 0\text{ V}$ (Pulse Test)		0.63	1.0	V
Package Inductance	L_{DS}			0.1		nH

Typical Characteristics

$T_A = 25^\circ\text{C}$ unless otherwise specified.

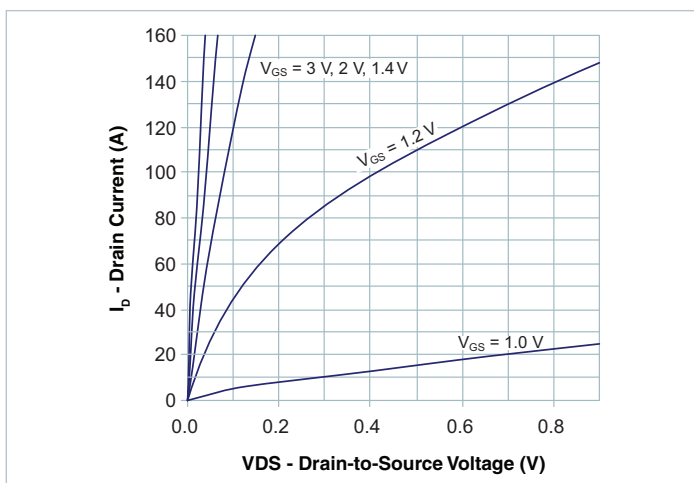


Figure 1 — Output Characteristics (Pulsed V_{GS})

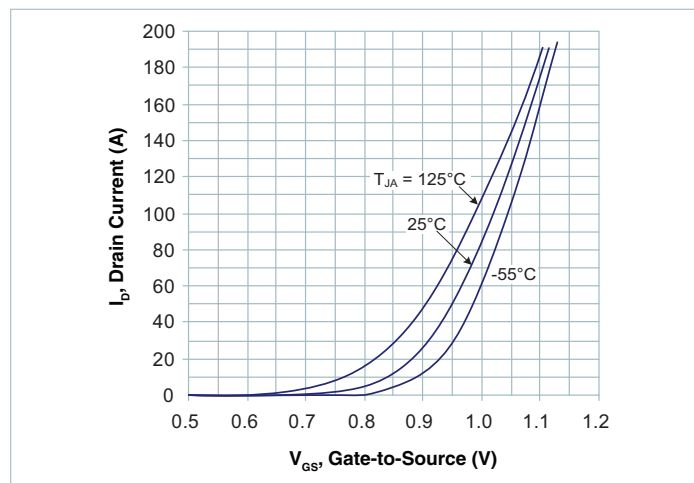


Figure 4 — Transfer Characteristics (Pulsed V_{GS})

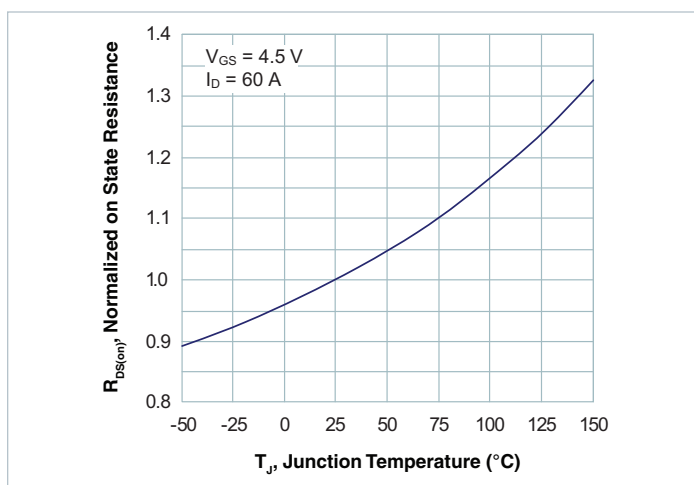


Figure 2 — On-Resistance vs. Junction Temperature

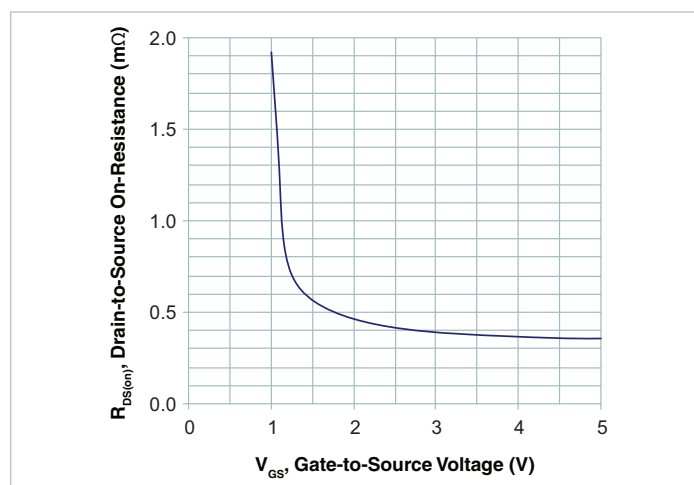


Figure 5 — On-Resistance vs. Gate Voltage

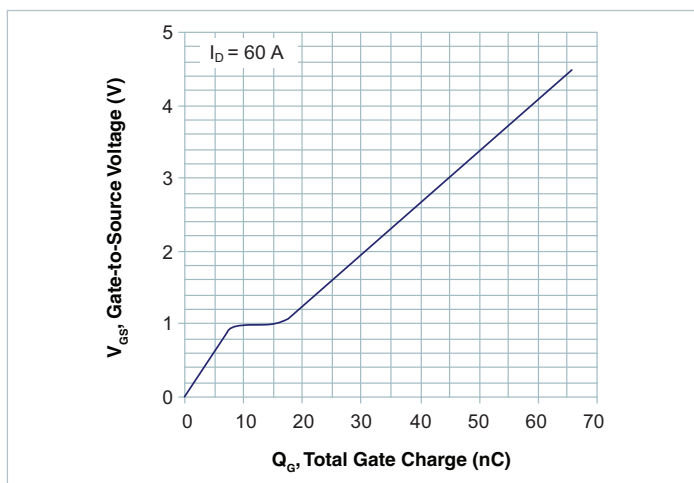


Figure 3 — Gate Charge

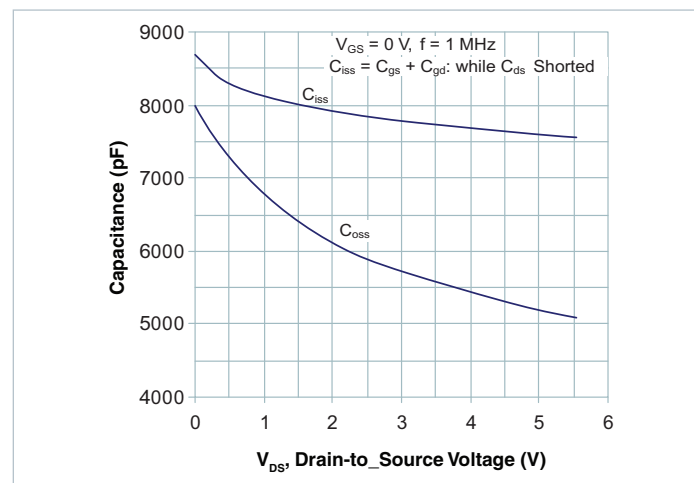


Figure 6 — Gate Capacitance vs. Drain-to Source Voltage

Typical Characteristics

$T_A = 25^\circ\text{C}$ unless otherwise specified.

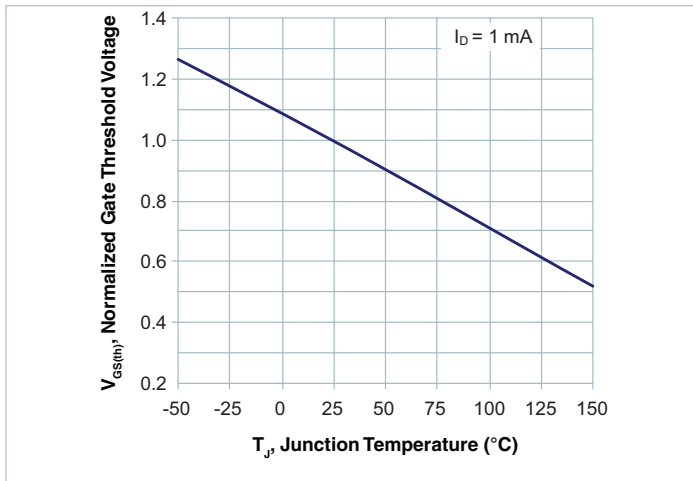


Figure 7 — Gate Threshold Voltage vs. Temperature

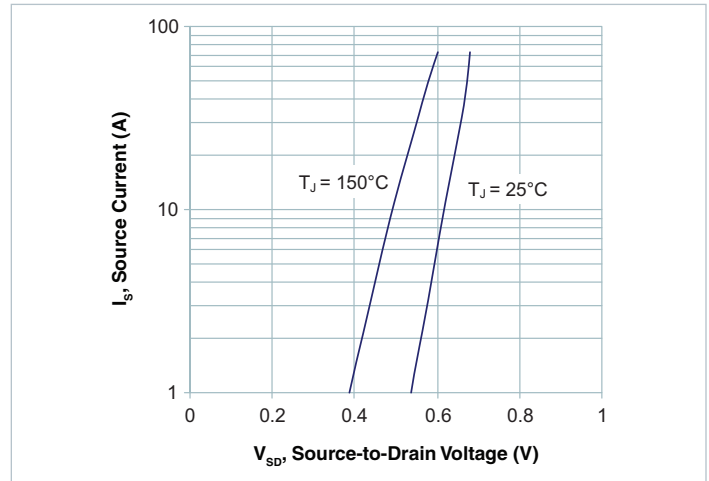


Figure 10 — Reverse Diode Forward Voltage (Pulsed Test)

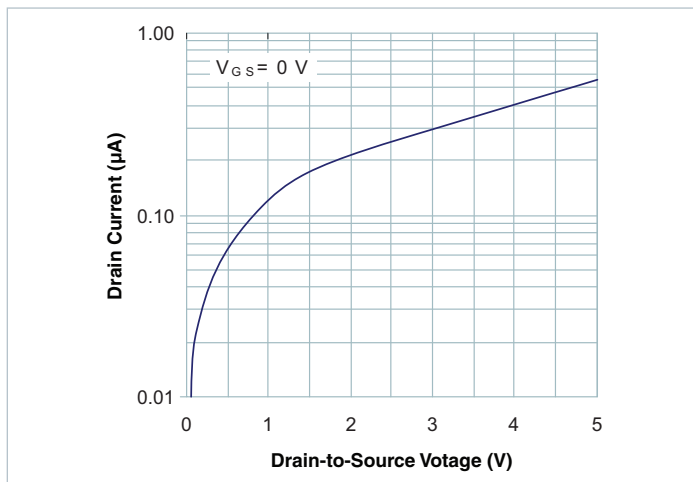


Figure 8 — Drain-to-Source Leakage Current

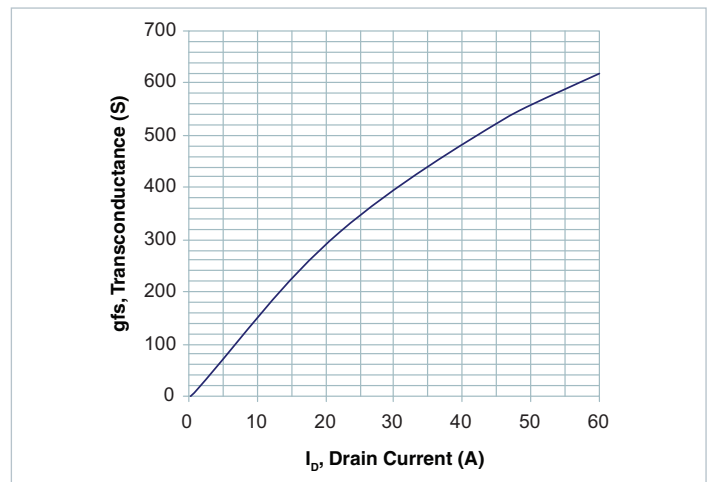


Figure 11 — Forward Transconductance

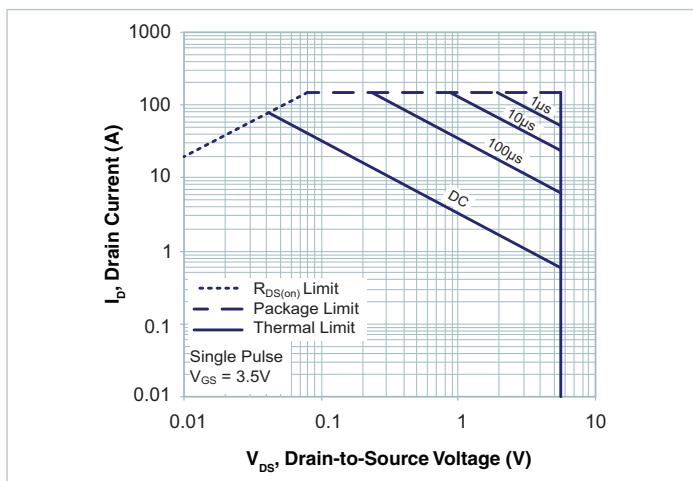


Figure 9 — Maximum Safe Operation Area

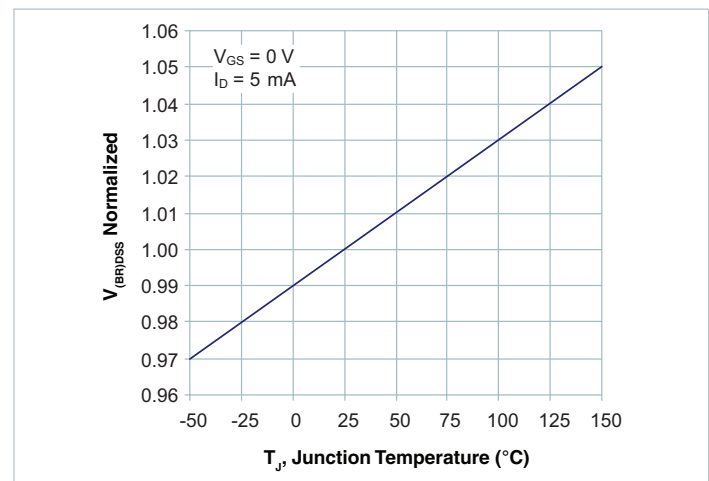


Figure 12 — Drain-to-Source Breakdown Voltage vs. temperature

Typical Characteristics

$T_A = 25^\circ\text{C}$ unless otherwise specified.

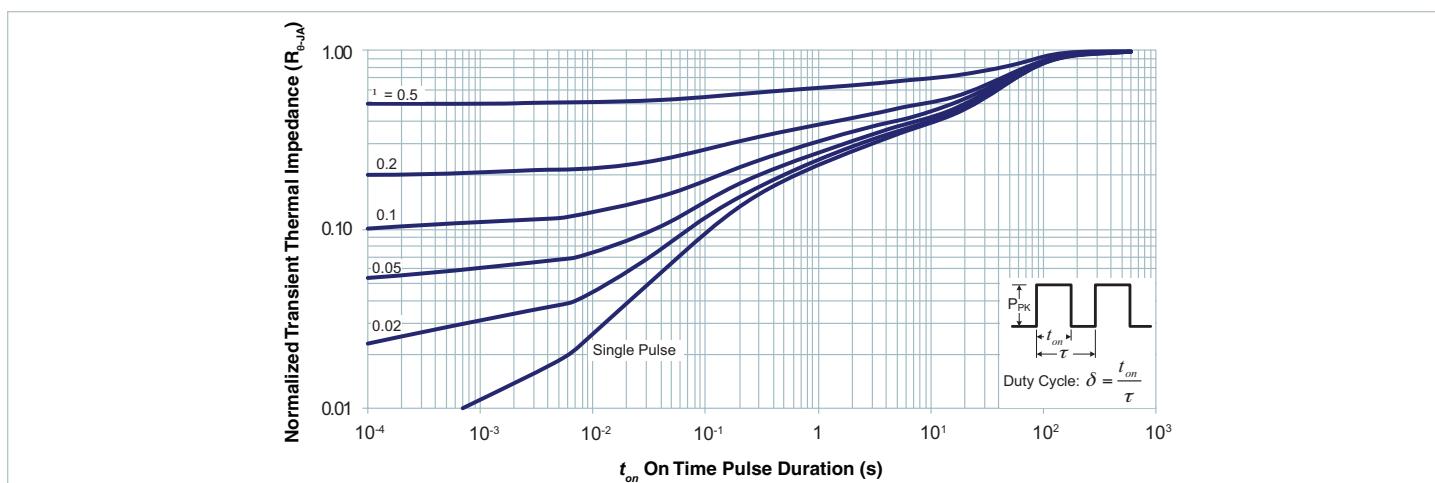


Figure 13 — Normalized Transient Thermal Impedance, Junction-to-Ambient

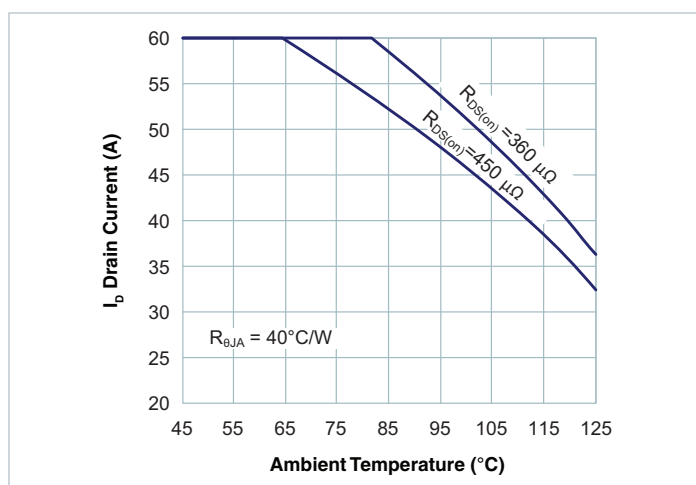


Figure 14 — PI5101 Drain current de-rating based on the maximum $T_J = 150^\circ\text{C}$ vs. ambient temperature

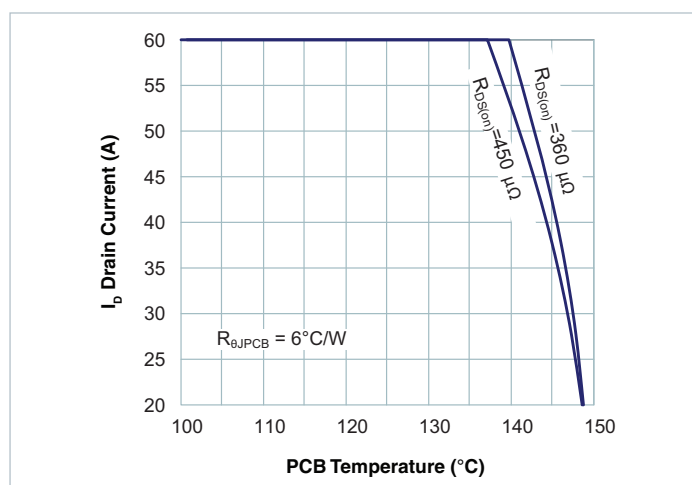


Figure 15 — PI5101 Drain current de-rating vs. PCB temperature, for maximum T_J at 150°C

MOSFET Power Dissipation vs. Junction Temperature

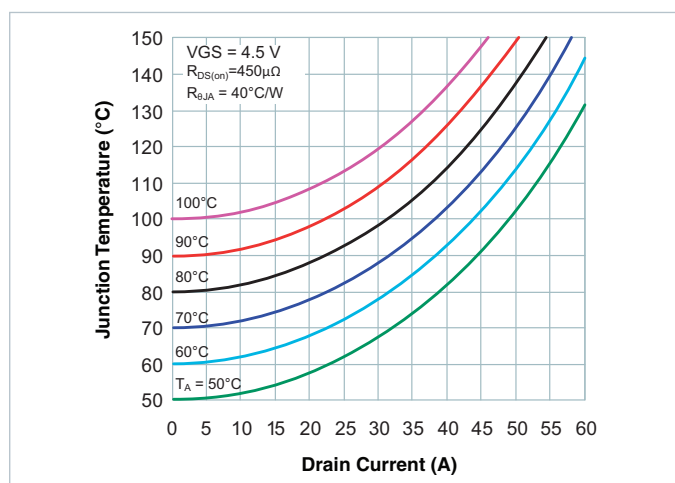


Figure 16 — Junction Temperature vs. Drain Current for a given ambient temperature (OLFM)

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:

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

Where:

P_D: MOSFET power dissipation
I_D: Drain Current
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 450 μΩ and will increase by 24% at 125°C junction temperature.

The junction temperature rise is a function of power dissipation and thermal resistance.

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

Where:

R_{θJA}: Junction-to-Ambient thermal resistance (40°C/W)

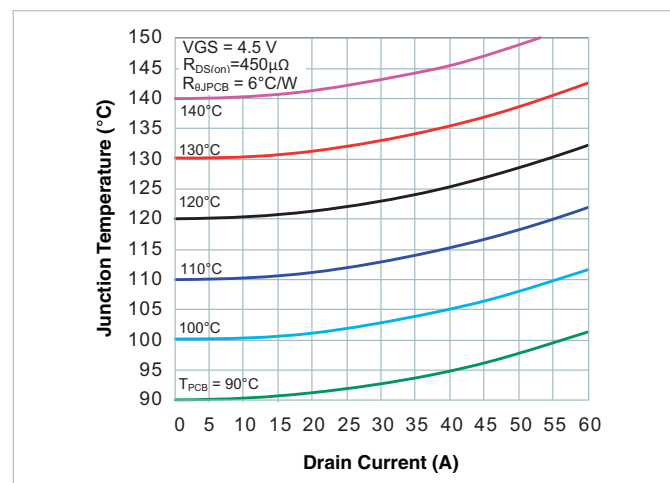


Figure 17 — Junction Temperature vs. Drain Current for a given PCB temperature

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 0 LFM 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 50 A and maximum operating ambient temperature is 70°C.

First use Figure 16 to find the final junction temperature for 50 A drain current at 70°C ambient temperature. In Figure 16 (illustrated in Figure 18) draw a vertical line from 50 A 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 50 A 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:

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

Maximum power dissipation is:

$$P_{Dmax} = I_D^2 \cdot R_{DS(on)} = 50 A \cdot 558 \mu\Omega = 1.39 W$$

Maximum junction temperature is:

$$T_{Jmax} = 70^\circ C + \frac{40^\circ C}{W} 50 A^2 \cdot 558 \mu\Omega = 125.8^\circ C$$

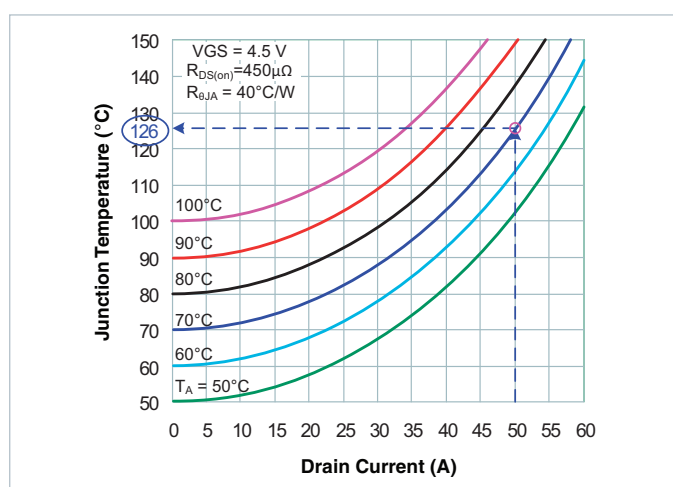
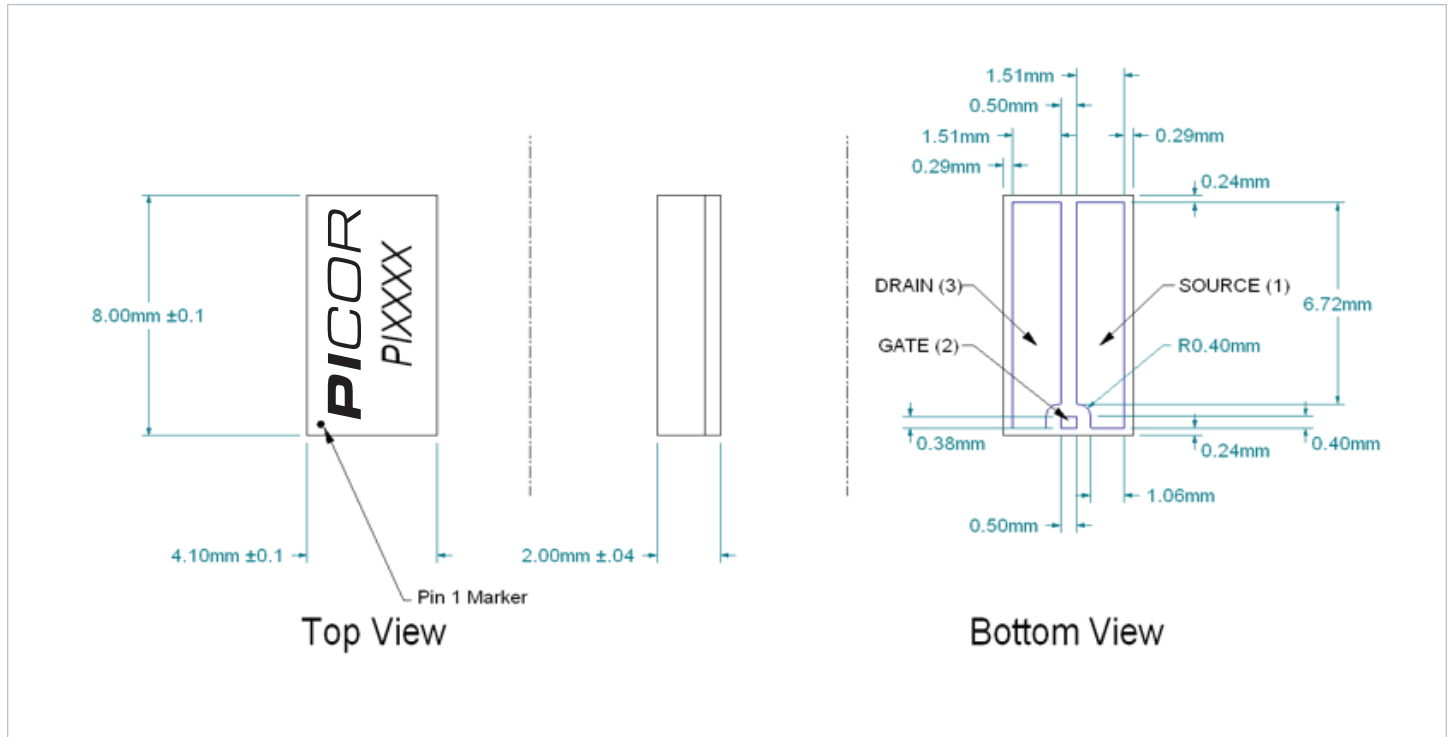
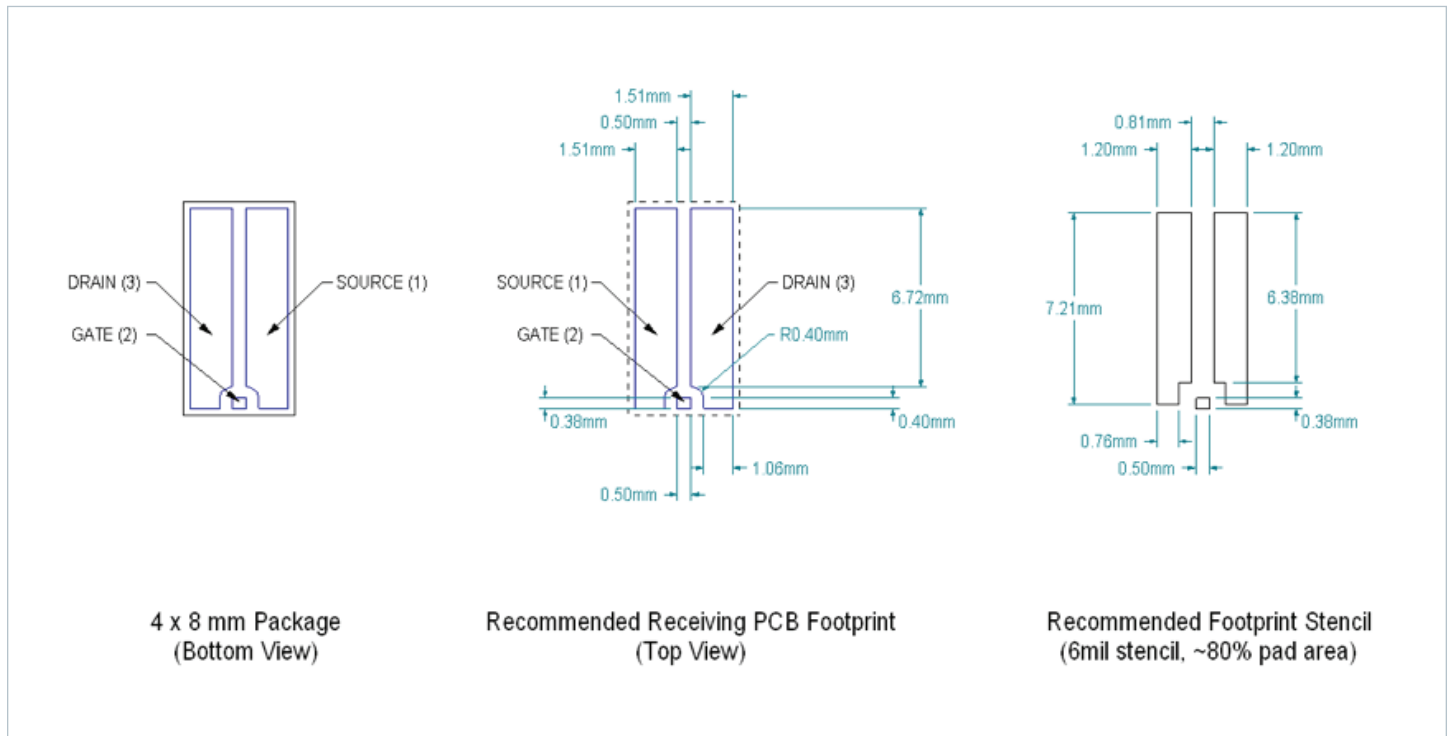


Figure 18 — Example graphing of MOSFET junction temperature at $I_D = 50 A$ and $T_A = 70^\circ C$

Package Drawing



Layout Recommendation



Vicor's comprehensive line of power solutions includes high density AC-DC and DC-DC modules and accessory components, fully configurable AC-DC and DC-DC power supplies, and complete custom power systems.

Information furnished by Vicor is believed to be accurate and reliable. However, no responsibility is assumed by Vicor for its use. Vicor makes no representations or warranties with respect to the accuracy or completeness of the contents of this publication. Vicor reserves the right to make changes to any products, specifications, and product descriptions at any time without notice. Information published by Vicor has been checked and is believed to be accurate at the time it was printed; however, Vicor assumes no responsibility for inaccuracies. Testing and other quality controls are used to the extent Vicor deems necessary to support Vicor's product warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

Specifications are subject to change without notice.

Vicor's Standard Terms and Conditions

All sales are subject to Vicor's Standard Terms and Conditions of Sale, which are available on Vicor's webpage or upon request.

Product Warranty

In Vicor's standard terms and conditions of sale, Vicor warrants that its products are free from non-conformity to its Standard Specifications (the "Express Limited Warranty"). This warranty is extended only to the original Buyer for the period expiring two (2) years after the date of shipment and is not transferable.

UNLESS OTHERWISE EXPRESSLY STATED IN A WRITTEN SALES AGREEMENT SIGNED BY A DULY AUTHORIZED VICOR SIGNATORY, VICOR DISCLAIMS ALL REPRESENTATIONS, LIABILITIES, AND WARRANTIES OF ANY KIND (WHETHER ARISING BY IMPLICATION OR BY OPERATION OF LAW) WITH RESPECT TO THE PRODUCTS, INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OR REPRESENTATIONS AS TO MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, INFRINGEMENT OF ANY PATENT, COPYRIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT, OR ANY OTHER MATTER.

This warranty does not extend to products subjected to misuse, accident, or improper application, maintenance, or storage. Vicor shall not be liable for collateral or consequential damage. Vicor disclaims any and all liability arising out of the application or use of any product or circuit and assumes no liability for applications assistance or buyer product design. Buyers are responsible for their products and applications using Vicor products and components. Prior to using or distributing any products that include Vicor components, buyers should provide adequate design, testing and operating safeguards.

Vicor will repair or replace defective products in accordance with its own best judgment. For service under this warranty, the buyer must contact Vicor to obtain a Return Material Authorization (RMA) number and shipping instructions. Products returned without prior authorization will be returned to the buyer. The buyer will pay all charges incurred in returning the product to the factory. Vicor will pay all reshipment charges if the product was defective within the terms of this warranty.

Life Support Policy

VICOR'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF VICOR CORPORATION. As used herein, life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness. Per Vicor Terms and Conditions of Sale, the user of Vicor products and components in life support applications assumes all risks of such use and indemnifies Vicor against all liability and damages.

Intellectual Property Notice

Vicor and its subsidiaries own Intellectual Property (including issued U.S. and Foreign Patents and pending patent applications) relating to the products described in this data sheet. No license, whether express, implied, or arising by estoppel or otherwise, to any intellectual property rights is granted by this document. Interested parties should contact Vicor's Intellectual Property Department.

Vicor Corporation
25 Frontage Road
Andover, MA 01810 USA

Picor Corporation
51 Industrial Drive
North Smithfield, RI 02896 USA

email

Customer Service: custserv@vicorpower.com

Technical Support: apps@vicorpower.com