

# TPIC5403 4-CHANNEL INDEPENDENT GATE-PROTECTED POWER DMOS ARRAY

SLIS038A – SEPTEMBER 1994 – REVISED SEPTEMBER 1995

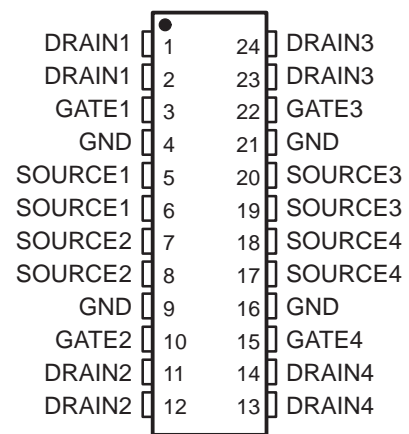
- Low  $r_{DS(on)}$  . . . 0.23  $\Omega$  Typ
- High Voltage Output . . . 60 V
- Extended ESD Capability . . . 4000 V
- Pulsed Current . . . 11.25 A Per Channel
- Fast Commutation Speed

## description

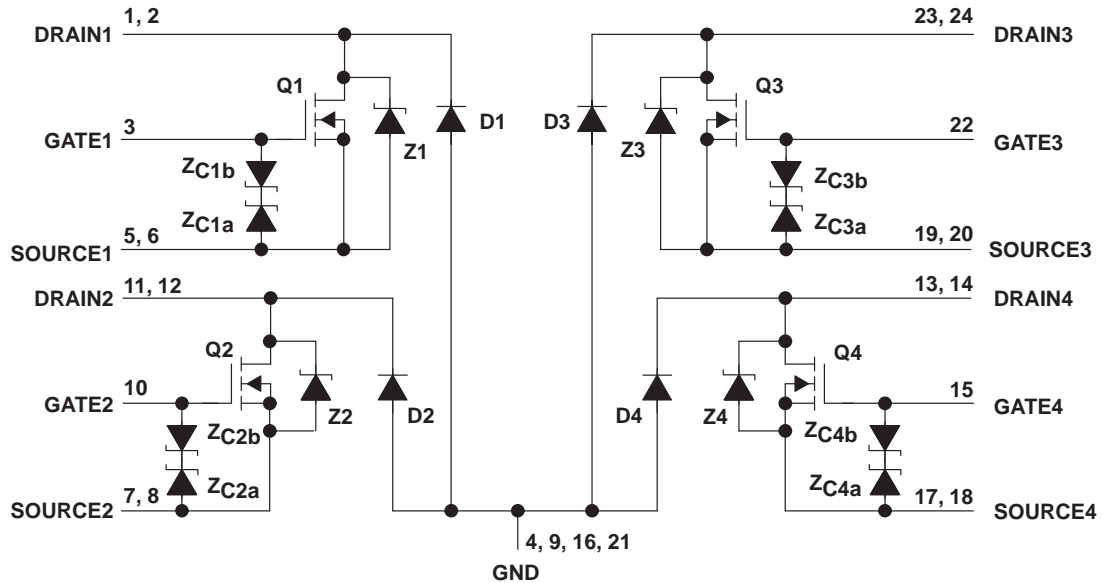
The TPIC5403 is a monolithic gate-protected power DMOS array that consists of four independent electrically isolated N-channel enhancement-mode DMOS transistors. Each transistor features integrated high-current zener diodes ( $Z_{CXa}$  and  $Z_{CXb}$ ) to prevent gate damage in the event that an overstress condition occurs. These zener diodes also provide up to 4000 V of ESD protection when tested using the human-body model of a 100-pF capacitor in series with a 1.5-k $\Omega$  resistor.

The TPIC5403 is offered in a 24-pin wide-body surface-mount (DW) package and is characterized for operation over the case temperature range of  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

DW PACKAGE  
(TOP VIEW)



## schematic



NOTE A: For correct operation, no terminal may be taken below GND.

# TPIC5403

## 4-CHANNEL INDEPENDENT GATE-PROTECTED POWER DMOS ARRAY

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### absolute maximum ratings over operating case temperature range (unless otherwise noted)†

Drain-to-source voltage, $V_{DS}$	60 V
Source-to-GND voltage	100 V
Drain-to-GND voltage	100 V
Gate-to-source voltage range, $V_{GS}$	-9 V to 18 V
Continuous drain current, each output, $T_C = 25^\circ\text{C}$	2.25 A
Continuous source-to-drain diode current, $T_C = 25^\circ\text{C}$	2.25 A
Pulsed drain current, each output, $I_{max}$ , $T_C = 25^\circ\text{C}$ (see Note 1 and Figure 15)	11.25 A
Continuous gate-to-source zener diode current, $T_C = 25^\circ\text{C}$	$\pm 50$ mA
Pulsed gate-to-source zener diode current, $T_C = 25^\circ\text{C}$	$\pm 500$ mA
Single-pulse avalanche energy, $E_{AS}$ , $T_C = 25^\circ\text{C}$ (see Figures 4, 15, and 16)	17.2 mJ
Continuous total power dissipation, $T_C = 25^\circ\text{C}$ (see Figure 15)	1.39 W
Operating virtual junction temperature range, $T_J$	$-40^\circ\text{C}$ to $150^\circ\text{C}$
Operating case temperature range, $T_C$	$-40^\circ\text{C}$ to $125^\circ\text{C}$
Storage temperature range, $T_{stg}$	$-65^\circ\text{C}$ to $150^\circ\text{C}$
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	$260^\circ\text{C}$

† 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 under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: Pulse duration = 10 ms, duty cycle = 2%



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**electrical characteristics,  $T_C = 25^\circ\text{C}$  (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{(BR)DSX}$	Drain-to-source breakdown voltage	$I_D = 250\ \mu\text{A}$ ,	$V_{GS} = 0$	60			V
$V_{GS(th)}$	Gate-to-source threshold voltage	$I_D = 1\ \text{mA}$ , See Figure 5	$V_{DS} = V_{GS}$	1.5	1.75	2.2	V
$V_{(BR)GS}$	Gate-to-source breakdown voltage	$I_{GS} = 250\ \mu\text{A}$		18			V
$V_{(BR)SG}$	Source-to-gate breakdown voltage	$I_{SG} = 250\ \mu\text{A}$		9			V
$V_{(BR)}$	Reverse drain-to-GND breakdown voltage (across D1, D2, D3, and D4)	Drain-to-GND current = $250\ \mu\text{A}$		100			V
$V_{DS(on)}$	Drain-to-source on-state voltage	$I_D = 2.25\ \text{A}$ , See Notes 2 and 3	$V_{GS} = 10\ \text{V}$ ,		0.5	0.62	V
$V_{F(SD)}$	Forward on-state voltage, source-to-drain	$I_S = 2.25\ \text{A}$ , $V_{GS} = 0$ (Z1, Z2, Z3, Z4), See Notes 2 and 3 and Figure 12			0.9	1.1	V
$V_F$	Forward on-state voltage, GND-to-drain	$I_D = 2.25\ \text{A}$ (D1, D2, D3, D4), See Notes 2 and 3			2.5		V
$I_{DSS}$	Zero-gate-voltage drain current	$V_{DS} = 48\ \text{V}$ , $V_{GS} = 0$	$T_C = 25^\circ\text{C}$	0.05	1		$\mu\text{A}$
			$T_C = 125^\circ\text{C}$	0.5	10		
$I_{GSSF}$	Forward gate current, drain short circuited to source	$V_{GS} = 15\ \text{V}$ ,	$V_{DS} = 0$		20	200	nA
$I_{GSSR}$	Reverse gate current, drain short circuited to source	$V_{SG} = 5\ \text{V}$ ,	$V_{DS} = 0$		10	100	nA
$I_{lkg}$	Leakage current, drain-to-GND	$V_{DGND} = 48\ \text{V}$	$T_C = 25^\circ\text{C}$	0.05	1		$\mu\text{A}$
			$T_C = 125^\circ\text{C}$	0.5	10		
$r_{DS(on)}$	Static drain-to-source on-state resistance	$V_{GS} = 10\ \text{V}$ , $I_D = 2.25\ \text{A}$ , See Notes 2 and 3 and Figures 6 and 7	$T_C = 25^\circ\text{C}$	0.23	0.27		$\Omega$
			$T_C = 125^\circ\text{C}$	0.35	0.4		
$g_{fs}$	Forward transconductance	$V_{DS} = 15\ \text{V}$ , See Notes 2 and 3 and Figure 9	$I_D = 1.125\ \text{A}$ ,	1.6	2.1		S
$C_{iss}$	Short-circuit input capacitance, common source				200	250	pF
$C_{oss}$	Short-circuit output capacitance, common source	$V_{DS} = 25\ \text{V}$ , $f = 1\ \text{MHz}$ ,	$V_{GS} = 0$ , See Figure 11		100	175	
$C_{rss}$	Short-circuit reverse-transfer capacitance, common source				60	75	

- NOTES: 2. Technique should limit  $T_J - T_C$  to  $10^\circ\text{C}$  maximum.  
3. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.

**source-to-drain and GND-to-drain diode characteristics,  $T_C = 25^\circ\text{C}$**

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$t_{rr}$	Reverse-recovery time	$I_S = 1.125\ \text{A}$ , $V_{GS} = 0$ , See Figures 1 and 14	$V_{DS} = 48\ \text{V}$ , $di/dt = 100\ \text{A}/\mu\text{s}$ ,	Z1, Z2, Z3, and Z4	80		ns
				D1, D2, D3, and D4	160		
$Q_{RR}$	Total diode charge			Z1, Z2, Z3, and Z4	0.12		$\mu\text{C}$
				D1, D2, D3, and D4	0.5		



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**resistive-load switching characteristics,  $T_C = 25^\circ\text{C}$**

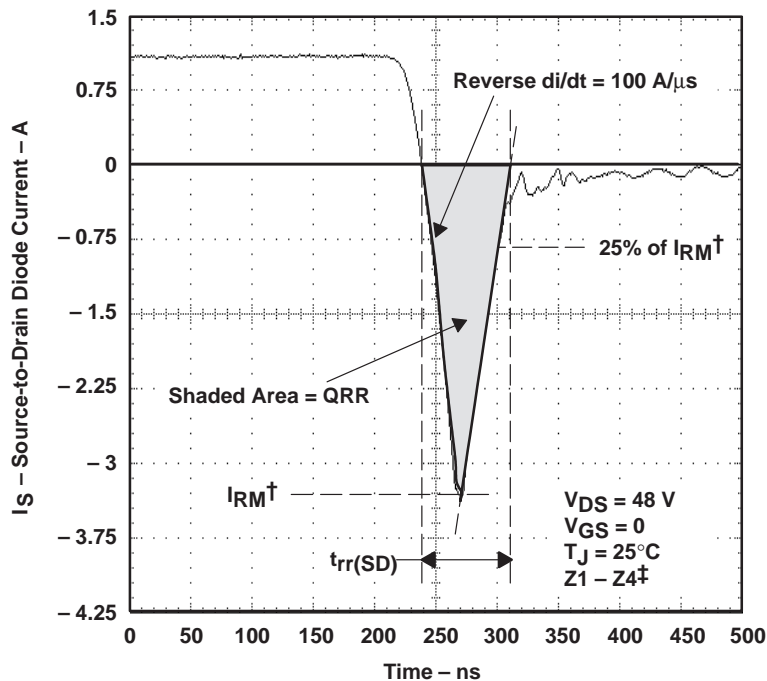
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{d(on)}$ Turn-on delay time	$V_{DD} = 25\text{ V}$ , $R_L = 20\ \Omega$ , $t_{r1} = 10\text{ ns}$ , See Figure 2		32	55	ns
$t_{d(off)}$ Turn-off delay time			27	50	
$t_{r2}$ Rise time			14	30	
$t_{f2}$ Fall time			7	15	
$Q_g$ Total gate charge	$V_{DS} = 48\text{ V}$ , $I_D = 1.125\text{ A}$ , $V_{GS} = 10\text{ V}$ , See Figure 3		6.6	8	nC
$Q_{gs(th)}$ Threshold gate-to-source charge			0.6	0.7	
$Q_{gd}$ Gate-to-drain charge			2.8	3.2	
$L_D$ Internal drain inductance			5		nH
$L_S$ Internal source inductance			5		
$R_g$ Internal gate resistance			0.25		$\Omega$

**thermal resistance**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{\theta JA}$ Junction-to-ambient thermal resistance	See Notes 4 and 7		90		$^\circ\text{C/W}$
$R_{\theta JB}$ Junction-to-board thermal resistance	See Notes 5 and 7		49		$^\circ\text{C/W}$
$R_{\theta JP}$ Junction-to-pin thermal resistance	See Notes 6 and 7		28		$^\circ\text{C/W}$

- NOTES: 4. Package mounted on an FR4 printed-circuit board with no heatsink  
5. Package mounted on a 24 inch<sup>2</sup>, 4-layer FR4 printed-circuit board  
6. Package mounted in intimate contact with infinite heatsink  
7. All outputs with equal power

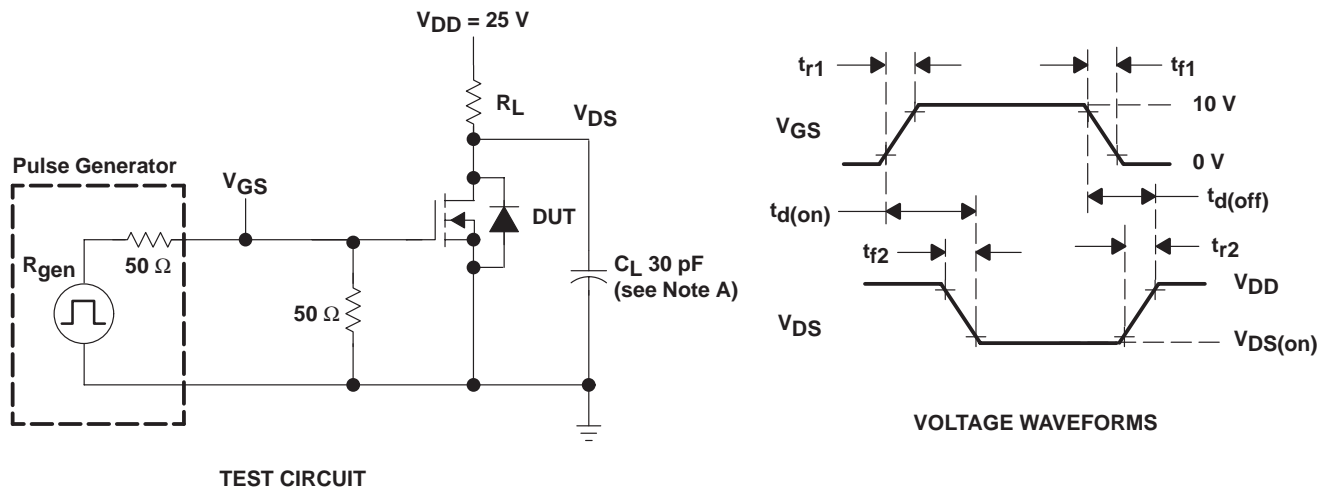
**PARAMETER MEASUREMENT INFORMATION**



$^\dagger I_{RM}$  = maximum recovery current

$\ddagger$  The above waveform is representative of D1, D2, D3, and D4 in shape only.

**Figure 1. Reverse-Recovery-Current Waveform of Source-to-Drain Diode**



**TEST CIRCUIT**

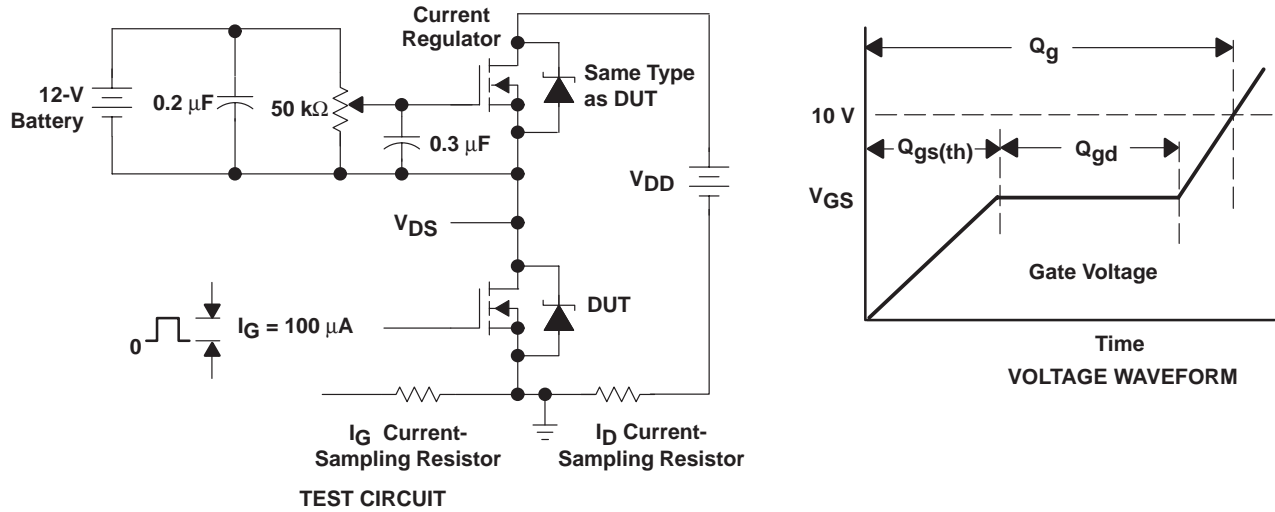
NOTE A:  $C_L$  includes probe and jig capacitance.

**Figure 2. Resistive-Switching Test Circuit and Voltage Waveforms**

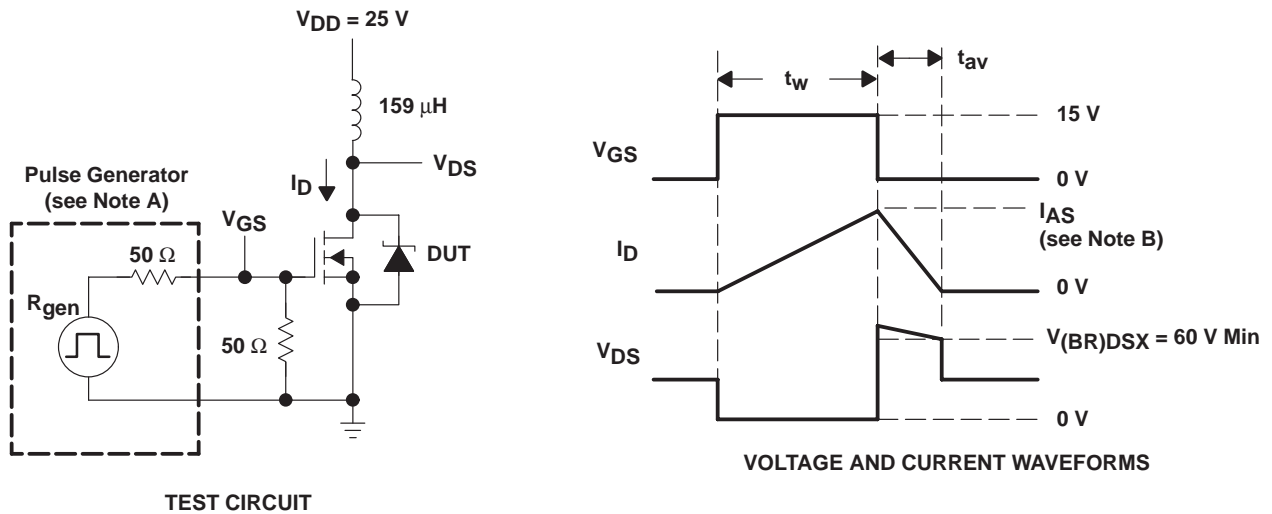
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**PARAMETER MEASUREMENT INFORMATION**



**Figure 3. Gate-Charge Test Circuit and Voltage Waveform**



NOTES: A. The pulse generator has the following characteristics:  $t_r \leq 10$  ns,  $t_f \leq 10$  ns,  $Z_0 = 50 \Omega$ .

B. Input pulse duration ( $t_w$ ) is increased until peak current  $I_{AS} = 11.25$  A.

$$\text{Energy test level is defined as } E_{AS} = \frac{I_{AS} \times V_{(BR)DSX} \times t_{av}}{2} = 17.2 \text{ mJ.}$$

**Figure 4. Single-Pulse Avalanche-Energy Test Circuit and Waveforms**

TYPICAL CHARACTERISTICS

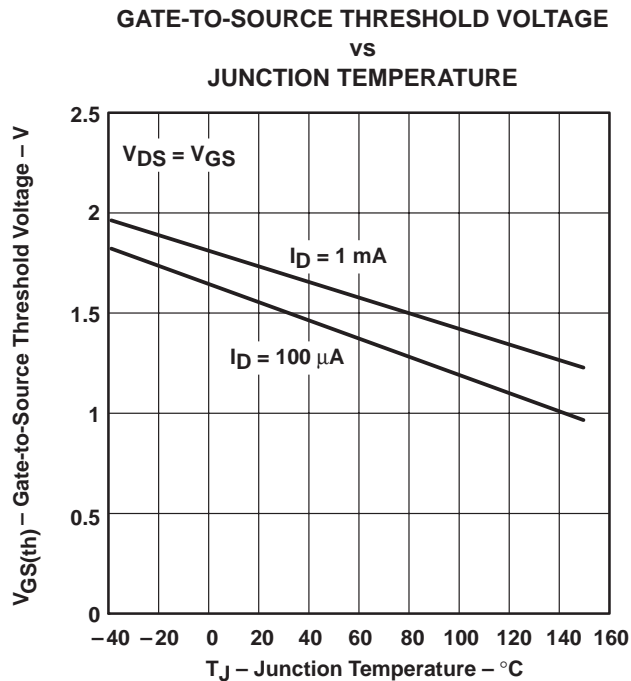


Figure 5

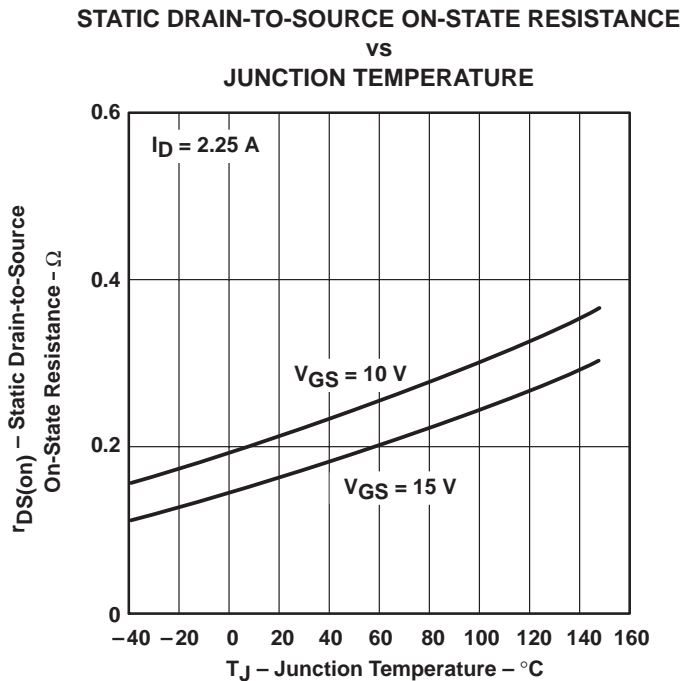


Figure 6

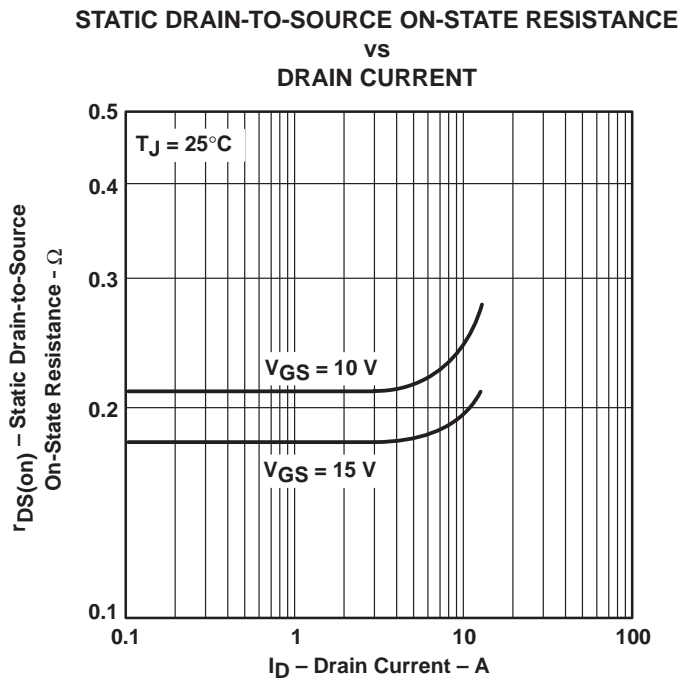


Figure 7

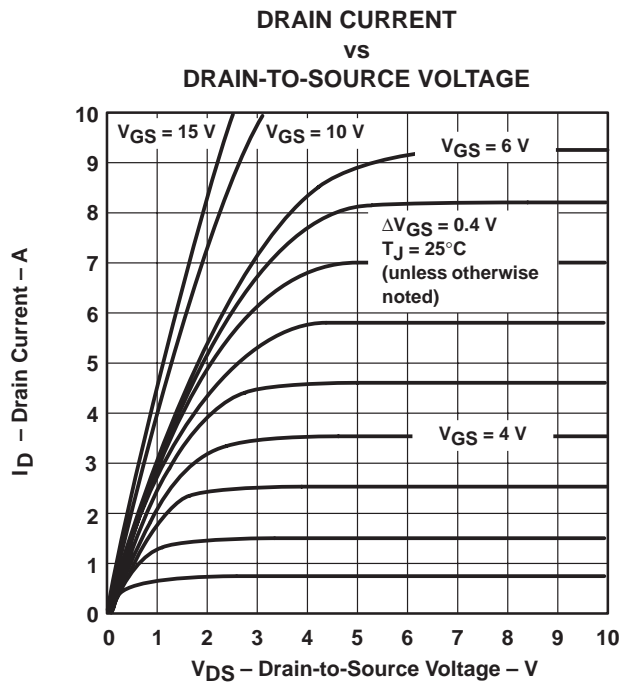


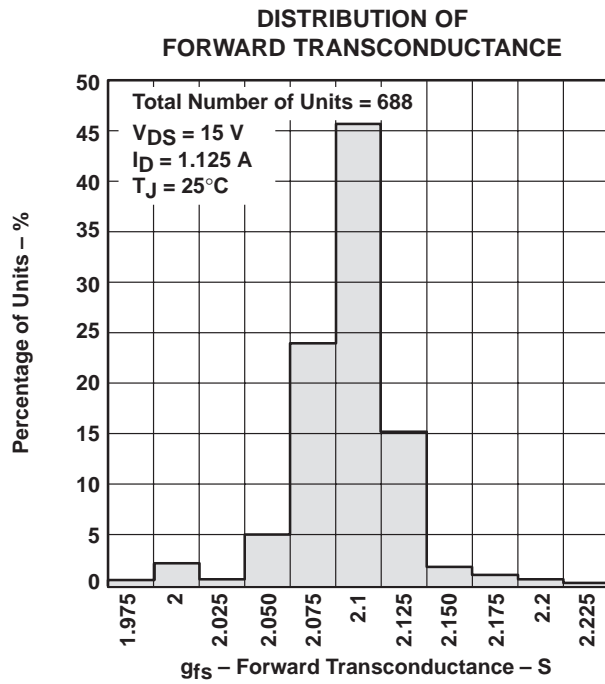
Figure 8

PRODUCT PREVIEW

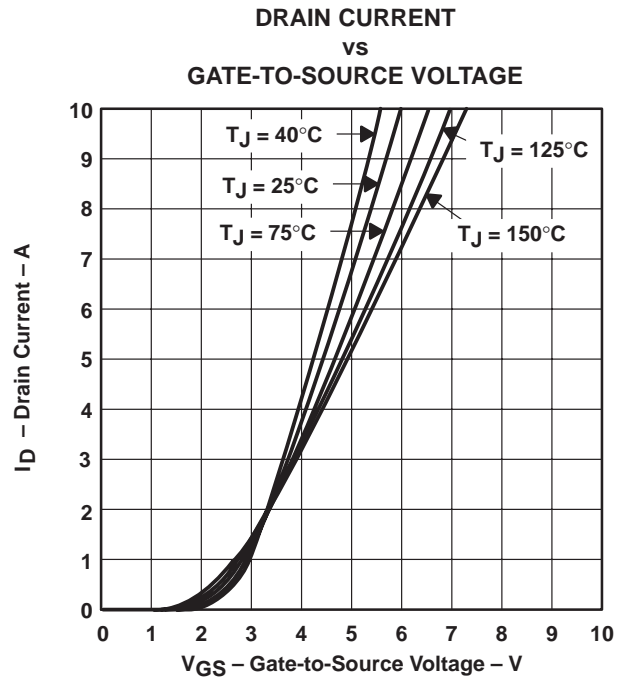
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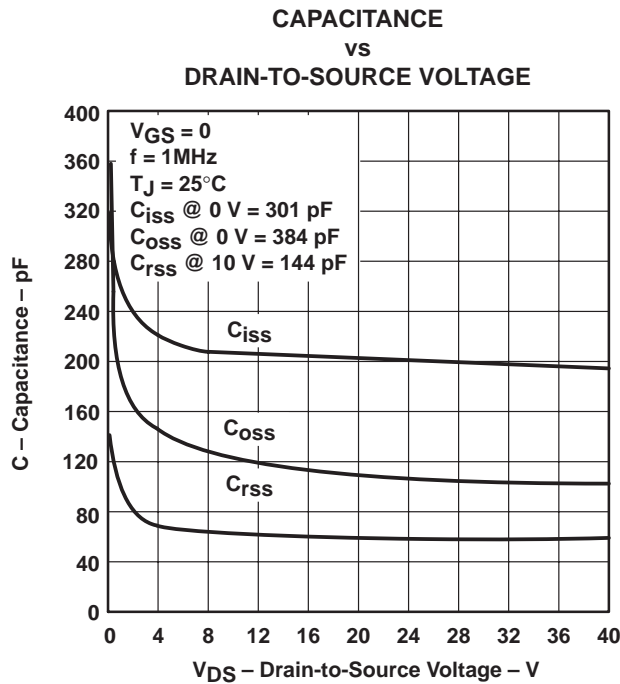
**TYPICAL CHARACTERISTICS**



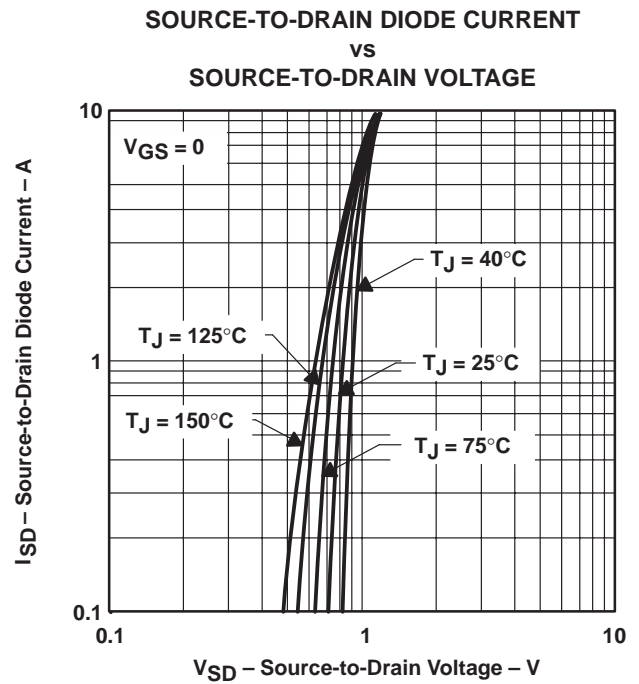
**Figure 9**



**Figure 10**



**Figure 11**



**Figure 12**

**TYPICAL CHARACTERISTICS**

**DRAIN-TO-SOURCE VOLTAGE AND  
GATE-TO-SOURCE VOLTAGE  
vs  
GATE CHARGE**

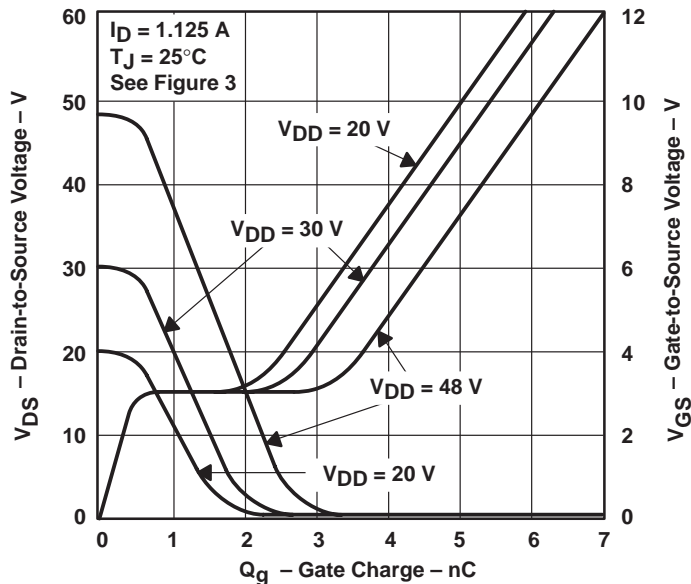


Figure 13

**REVERSE-RECOVERY TIME  
vs  
REVERSE  $di/dt$**

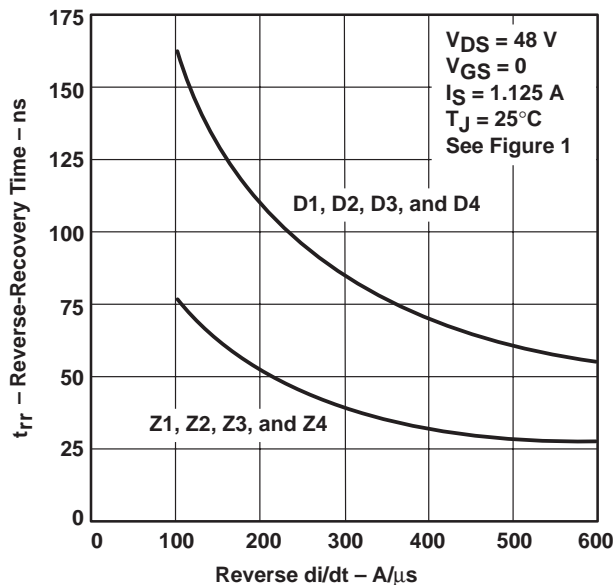


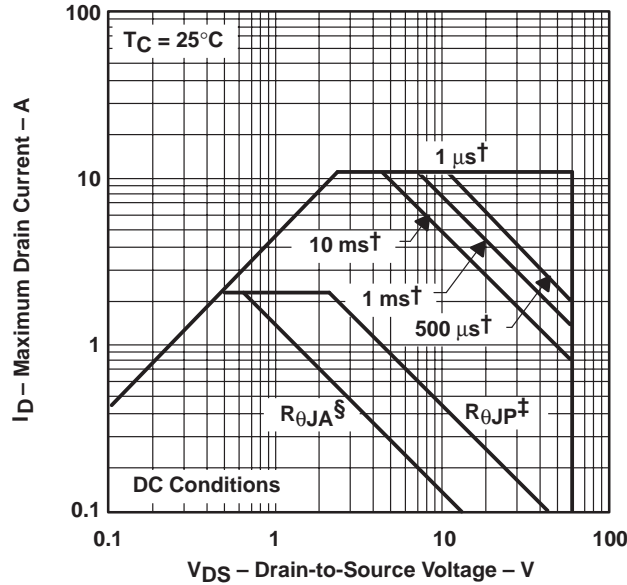
Figure 14

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**THERMAL INFORMATION**

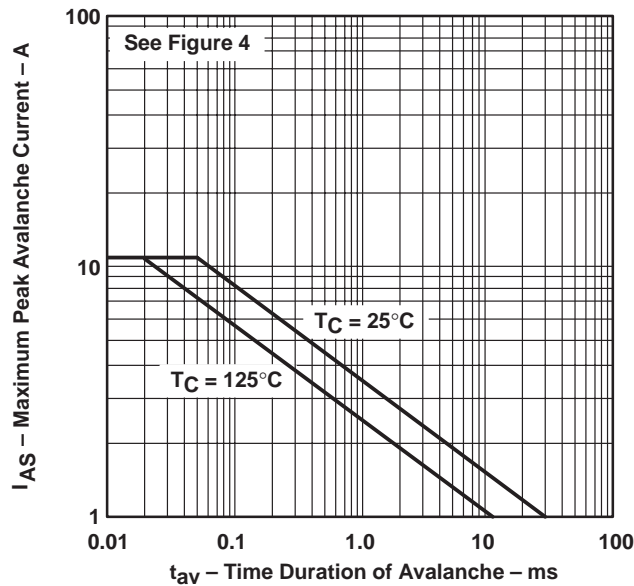
**MAXIMUM DRAIN CURRENT**  
**vs**  
**DRAIN-TO-SOURCE VOLTAGE**



† Less than 2% duty cycle  
 ‡ Device mounted in intimate contact with infinite heatsink.  
 § Device mounted on FR4 printed circuit board with no heatsink.

**Figure 15**

**MAXIMUM PEAK AVALANCHE CURRENT**  
**vs**  
**TIME DURATION OF AVALANCHE**

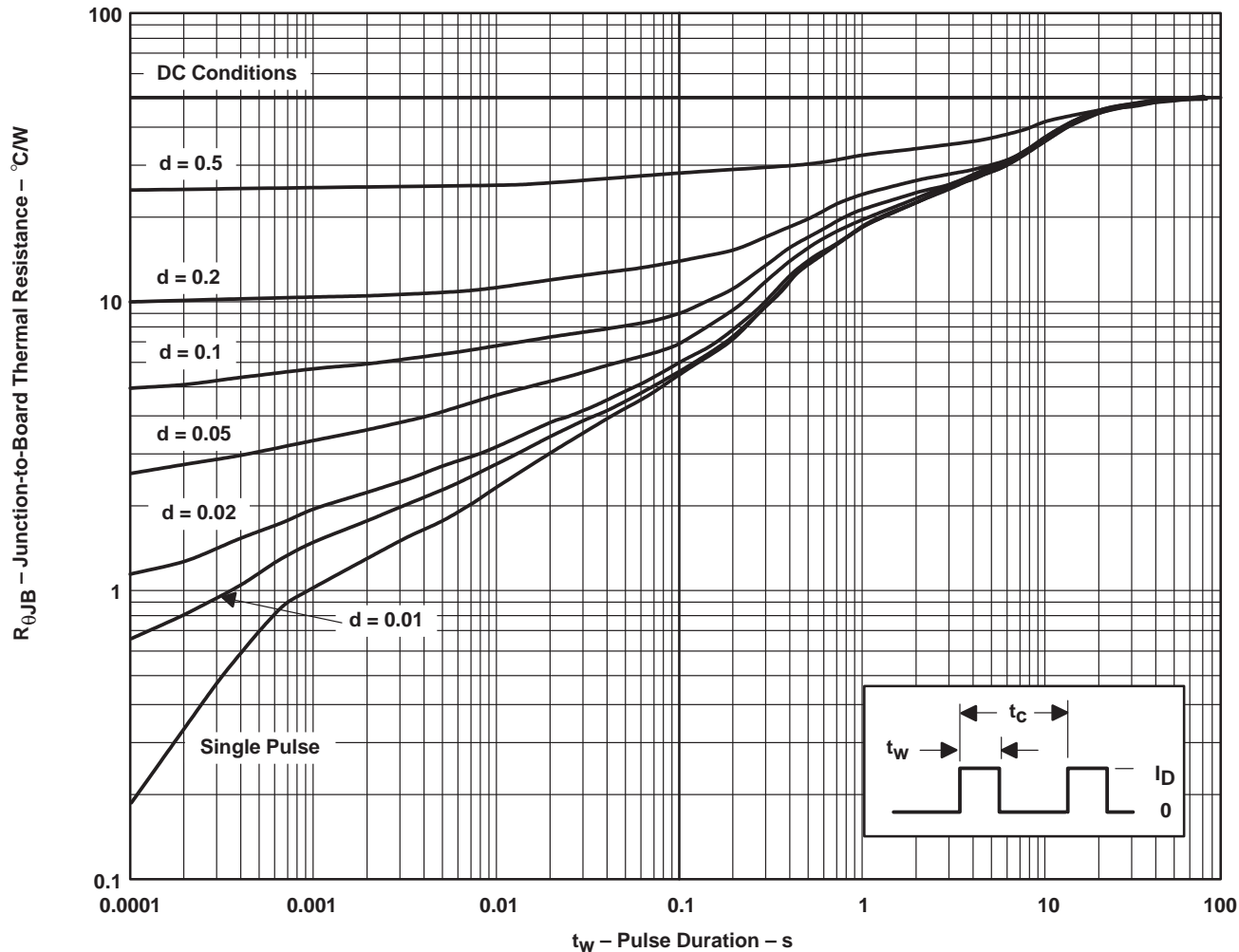


**Figure 16**



THERMAL INFORMATION

DW PACKAGE†  
 JUNCTION-TO-BOARD THERMAL RESISTANCE  
 VS  
 PULSE DURATION



† Device mounted on 24in<sup>2</sup>, 4-layer FR4 printed-circuit board with no heatsink.

NOTE A:  $Z_{\theta JB}(t) = r(t) R_{\theta JB}$   
 $t_w$  = pulse duration  
 $t_c$  = cycle time  
 $d$  = duty cycle =  $t_w/t_c$

Figure 17

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
TPIC5403DW	OBSOLETE	SOIC	DW	24		TBD	Call TI	Call TI

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
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Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
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