

# TPIC1501A QUAD AND HEX POWER DMOS ARRAY

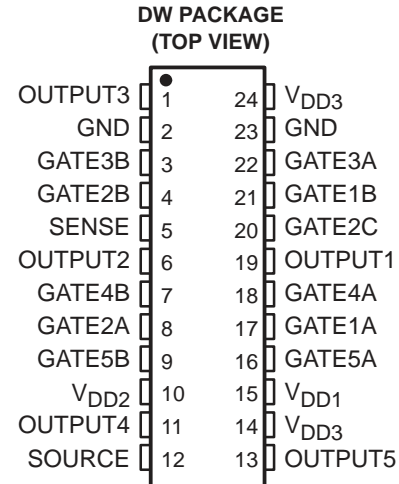
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- **Low  $r_{DS(on)}$ :**  
0.1  $\Omega$  Typ (Full H-Bridge)  
0.4  $\Omega$  Typ (Triple Half H-Bridge)
- **Pulsed Current:**  
12 A Per Channel (Full H-Bridge)  
6 A Per Channel (Triple Half H-Bridge)
- **Matched Sense Transistor for Class A-B Linear Operation**
- **Fast Commutation Speed**

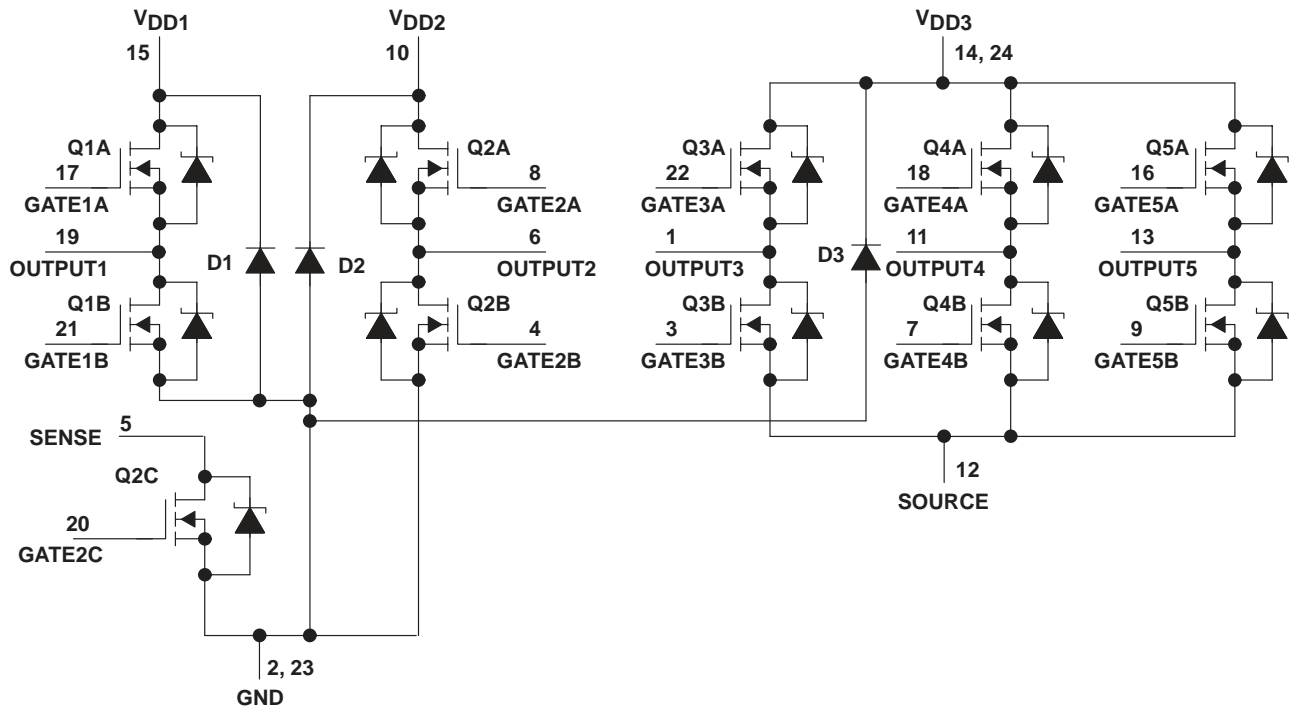
## description

The TPIC1501A is a monolithic power array that consists of ten electrically isolated N-channel enhancement-mode power DMOS transistors, four of which are configured as a full H-bridge and six as a triple half H-bridge. The lower stage of the full H-bridge features an integrated sense FET to allow biasing of the bridge in class A-B operation.

The TPIC1501A 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  $125^{\circ}\text{C}$ .



## schematic



- NOTES: A. Pins 2 and 23 must be externally connected.  
B. Pins 14 and 24 must be externally connected.  
C. No output may be taken greater than 0.5 V below GND.



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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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# TPIC1501A

## QUAD AND HEX POWER DMOS ARRAY

SLIS046A – MAY 1995 – REVISED JUNE 1996

### absolute maximum ratings, $T_C = 25^\circ\text{C}$ (unless otherwise noted)<sup>†</sup>

Supply-to-GND voltage	20 V
Source-to-GND voltage (Q3A, Q4A, Q5A)	20 V
Output-to-GND voltage	20 V
Sense-to-GND voltage	20 V
Gate-to-source voltage range, $V_{GS}$ (Q1A, Q1B, Q2A, Q2B, Q3A, Q3B, Q4A, Q4B, Q5A, Q5B)	$\pm 20$ V
Gate-to-source voltage range, $V_{GS}$ (Q2C)	-0.7 V to 6 V
Continuous drain current, each output (Q1A, Q1B, Q2A, Q2B)	3 A
Continuous drain current, each output (Q3A, Q3B, Q4A, Q4B, Q5A, Q5B)	1.5 A
Continuous drain current (Q2C)	15 mA
Continuous source-to-drain diode current (Q1A, Q1B, Q2A, Q2B)	3 A
Continuous source-to-drain diode current (Q3A, Q3B, Q4A, Q4B, Q5A, Q5B)	1.5 A
Continuous source-to-drain diode current (Q2C)	15 mA
Pulsed drain current, each output, $I_{max}$ (Q1A, Q1B, Q2A, Q2B) (see Note 1 and Figure 24)	12 A
Pulsed drain current, each output, $I_{max}$ (Q3A, Q3B, Q4A, Q4B, Q5A, Q5B) (see Note 1 and Figure 25)	6 A
Pulsed drain current, $I_{max}$ (Q2C) (see Note 1)	60 mA
Continuous total power dissipation, $T_C = 70^\circ\text{C}$ (see Note 2 and Figures 24 and 25)	2.86 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	$260^\circ\text{C}$

<sup>†</sup> 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.

- NOTES: 1. Pulse duration = 10 ms, duty cycle = 2%  
 2. Package is mounted in intimate contact with infinite heat sink.



**TPIC1501A**  
**QUAD AND HEX POWER DMOS ARRAY**

SLIS046A – MAY 1995 – REVISED JUNE 1996

**electrical characteristics, Q1A, Q1B, Q2A, Q2B, T<sub>C</sub> = 25°C (unless otherwise noted)**

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V <sub>(BR)DSX</sub>	Drain-to-source breakdown voltage	I <sub>D</sub> = 250 μA,	V <sub>GS</sub> = 0	20			V
V <sub>GS(th)</sub>	Gate-to-source threshold voltage	I <sub>D</sub> = 1 mA, See Figure 5	V <sub>DS</sub> = V <sub>GS</sub> ,	1.4	1.7	2.1	V
V <sub>GS(th)match</sub>	Gate-to-source threshold voltage matching	I <sub>D</sub> = 1 mA,	V <sub>DS</sub> = V <sub>GS</sub>			40	mV
V <sub>(BR)</sub>	Reverse drain-to-GND breakdown voltage	Drain-to-GND current = 250 μA (D1, D2)		20			V
V <sub>DS(on)</sub>	Drain-to-source on-state voltage	I <sub>D</sub> = 2 A, See Notes 3 and 4	V <sub>GS</sub> = 10 V,		0.2	0.24	V
V <sub>F</sub>	Forward on-state voltage, GND-to-V <sub>DD1</sub> , GND-to-V <sub>DD2</sub>	I <sub>D</sub> = 3 A (D1, D2) See Notes 3 and 4			1.8		V
V <sub>F(SD)</sub>	Forward on-state voltage, source-to-drain	I <sub>S</sub> = 2 A, V <sub>GS</sub> = 0, See Notes 3 and 4 and Figure 19			0.85	1.05	V
		I <sub>S</sub> = 3 A, V <sub>GS</sub> = 0, See Notes 3 and 4 and Figure 19			0.9	1.1	
I <sub>DSS</sub>	Zero-gate-voltage drain current	V <sub>DS</sub> = 16 V, V <sub>GS</sub> = 0	T <sub>C</sub> = 25°C		0.05	1	μA
			T <sub>C</sub> = 125°C		0.5	10	
I <sub>GSSF</sub>	Forward-gate current, drain short circuited to source	V <sub>GS</sub> = 16 V,	V <sub>DS</sub> = 0		10	100	nA
I <sub>GSSR</sub>	Reverse-gate current, drain short circuited to source	V <sub>SG</sub> = 16 V,	V <sub>DS</sub> = 0		10	100	nA
I <sub>lkg</sub>	Leakage current, V <sub>DD1</sub> -to-GND, V <sub>DD2</sub> -to-GND, gate shorted to source	V <sub>DGND</sub> = 16 V	T <sub>C</sub> = 25°C		0.05	1	μA
			T <sub>C</sub> = 125°C		0.5	10	
r <sub>DS(on)</sub>	Static drain-to-source on-state resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2 A, See Notes 3 and 4 and Figure 9	T <sub>C</sub> = 25°C		0.1	0.12	Ω
			T <sub>C</sub> = 125°C		0.14	0.18	
			T <sub>C</sub> = 25°C		0.1	0.12	
			T <sub>C</sub> = 125°C		0.14	0.18	
g <sub>fs</sub>	Forward transconductance	V <sub>DS</sub> = 14 V, See Notes 3 and 4	I <sub>D</sub> = 1 A,		1.5	2.5	S
			I <sub>D</sub> = 1.5 A, See Notes 3 and 4 and Figure 13		2	3.1	
C <sub>iss</sub>	Short-circuit input capacitance, common source				240		pF
C <sub>oss</sub>	Short-circuit output capacitance, common source	V <sub>DS</sub> = 14 V, f = 1 MHz,	V <sub>GS</sub> = 0, See Figure 17		170		
C <sub>rss</sub>	Short-circuit reverse transfer capacitance, common source				130		
α <sub>s</sub>	Sense-FET drain current ratio	V <sub>DS</sub> = 6 V,	I <sub>D(Q2C)</sub> = 40 μA	75	130	200	

NOTES: 3. Technique should limit T<sub>J</sub> – T<sub>C</sub> to 10°C maximum.

4. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.



# TPIC1501A

## QUAD AND HEX POWER DMOS ARRAY

SLIS046A – MAY 1995 – REVISED JUNE 1996

### source-to-drain diode characteristics, Q1A, Q2A, $T_C = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$t_{rr}$	Reverse-recovery time	$I_S = 1.5\text{ A}$ , $V_{DS} = 14\text{ V}$ , See Figures 1 and 23	$V_{GS} = 0$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,		70		ns
$Q_{RR}$	Total diode charge				90		nC
$t_{rr}$	Reverse-recovery time	$I_S = 2\text{ A}$ , $V_{DS} = 14\text{ V}$ ,	$V_{GS} = 0$ , $di/dt = 100\text{ A}/\mu\text{s}$		75		ns
$Q_{RR}$	Total diode charge				110		nC

### resistive-load switching characteristics, Q1A, Q1B, Q2A, Q2B, $T_C = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 14\text{ V}$ , $t_{dis} = 10\text{ ns}$ ,	$R_L = 9.3\ \Omega$ , See Figure 3	$t_{en} = 10\text{ ns}$ ,		20		ns
$t_{d(off)}$	Turn-off delay time					30		
$t_r$	Rise time					15		
$t_f$	Fall time					25		
$Q_g$	Total gate charge	$V_{DS} = 14\text{ V}$ , See Figure 4	$I_D = 1.5\text{ A}$ ,	$V_{GS} = 10\text{ V}$ ,		5.6	7	nC
$Q_{gs(th)}$	Threshold gate-to-source charge					0.8	1	
$Q_{gd}$	Gate-to-drain charge					1.4	1.75	
$L_{(drain)}$	Internal drain inductance					5		nH
$L_{(source)}$	Internal source inductance					5		
$r_{(gate)}$	Internal gate resistance					0.25		$\Omega$



# TPIC1501A QUAD AND HEX POWER DMOS ARRAY

SLIS046A – MAY 1995 – REVISED JUNE 1996

## electrical characteristics, Q3A, Q3B, Q4A, Q4B, Q5A, Q5B, $T_C = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$V_{(BR)DSX}$	Drain-to-source breakdown voltage	$I_D = 250\ \mu\text{A}$ ,	$V_{GS} = 0\ \text{V}$	20			V
$V_{GS(th)}$	Gate-to-source threshold voltage	$I_D = 1\ \text{mA}$ , See Figure 6	$V_{DS} = V_{GS}$ ,	1.4	1.7	2.1	V
$V_{GS(th)match}$	Gate-to-source threshold voltage matching	$I_D = 1\ \text{mA}$ ,	$V_{DS} = V_{GS}$			40	mV
$V_{(BR)}$	Reverse drain-to-GND breakdown voltage	Drain-to-GND current = $250\ \mu\text{A}$ (D3)		20			V
$V_{DS(on)}$	Drain-to-source on-state voltage	$I_D = 1.5\ \text{A}$ , See Notes 3 and 4	$V_{GS} = 10\ \text{V}$ ,	0.6		0.68	V
$V_F$	Forward on-state voltage, GND-to- $V_{DD3}$	$I_D = 1.5\ \text{A}$ (D3) See Notes 3 and 4		1.7			V
$V_{F(SD)}$	Forward on-state voltage, source-to-drain	$I_S = 1.5\ \text{A}$ , $V_{GS} = 0$ , See Notes 3 and 4 and Figure 20		1		1.2	V
		$I_S = 2\ \text{A}$ , $V_{GS} = 0$ , See Notes 3 and 4 and Figure 20		1.1		1.3	
$I_{DSS}$	Zero-gate-voltage drain current	$V_{DS} = 16\ \text{V}$ , $V_{GS} = 0$	$T_C = 25^\circ\text{C}$	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	$V_{GS} = 16\ \text{V}$ ,	$V_{DS} = 0$	10		100	nA
$I_{GSSR}$	Reverse-gate current, drain short circuited to source	$V_{SG} = 16\ \text{V}$ ,	$V_{DS} = 0$	10		100	nA
$I_{lkg}$	Leakage current, $V_{DD3}$ -to-GND, gate shorted to source	$V_{DGND} = 16\ \text{V}$	$T_C = 25^\circ\text{C}$	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	$V_{GS} = 10\ \text{V}$ , $I_D = 0.3\ \text{A}$ , See Notes 3 and 4 and Figure 10	$T_C = 25^\circ\text{C}$	0.35		0.39	$\Omega$
			$T_C = 125^\circ\text{C}$	0.5		0.56	
			$T_C = 25^\circ\text{C}$	0.4		0.45	
			$T_C = 125^\circ\text{C}$	0.56		0.65	
$g_{fs}$	Forward transconductance	$V_{DS} = 14\ \text{V}$ , See Notes 3 and 4	$I_D = 500\ \text{mA}$ ,	0.3		0.8	S
			$I_D = 750\ \text{mA}$ , See Notes 3 and 4 and Figure 14	0.4		0.93	
$C_{iss}$	Short-circuit input capacitance, common source			96		pF	
$C_{oss}$	Short-circuit output capacitance, common source	$V_{DS} = 14\ \text{V}$ , $f = 1\ \text{MHz}$ ,	$V_{GS} = 0$ , See Figure 18	98			
$C_{rss}$	Short-circuit reverse transfer capacitance, common source			65			

NOTES: 3. Technique should limit  $T_J - T_C$  to  $10^\circ\text{C}$  maximum.

4. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.



# TPIC1501A

## QUAD AND HEX POWER DMOS ARRAY

SLIS046A – MAY 1995 – REVISED JUNE 1996

### source-to-drain diode characteristics, Q3A, Q4A, Q5A, $T_C = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$t_{rr}$	Reverse-recovery time	$I_S = 750\text{ mA}$ , $V_{DS} = 14\text{ V}$ , See Figures 2 and 23	$V_{GS} = 0$ , $di/dt = 100\text{ A}/\mu\text{s}$ ,		60		ns
$Q_{RR}$	Total diode charge				55		nC
$t_{rr}$	Reverse-recovery time	$I_S = 1.5\text{ A}$ , $V_{DS} = 14\text{ V}$ ,	$V_{GS} = 0$ , $di/dt = 100\text{ A}/\mu\text{s}$		120		ns
$Q_{RR}$	Total diode charge				150		nC

### resistive-load switching characteristics, Q3A, Q3B, Q4A, Q4B, Q5A, Q5B, $T_C = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 14\text{ V}$ , $t_{dis} = 10\text{ ns}$ ,	$R_L = 18.7\ \Omega$ , See Figure 3	$t_{en} = 10\text{ ns}$ ,		18		ns
$t_{d(off)}$	Turn-off delay time					25		
$t_r$	Rise time					13		
$t_f$	Fall time					20		
$Q_g$	Total gate charge	$V_{DS} = 14\text{ V}$ , See Figure 4	$I_D = 750\text{ mA}$ ,	$V_{GS} = 10\text{ V}$ ,		1.6	2	nC
$Q_{gs(th)}$	Threshold gate-to-source charge					0.26	0.32	
$Q_{gd}$	Gate-to-drain charge					0.42	0.52	
$L_{(drain)}$	Internal drain inductance					5		nH
$L_{(source)}$	Internal source inductance					5		
$r_{(gate)}$	Internal gate resistance					0.25		$\Omega$

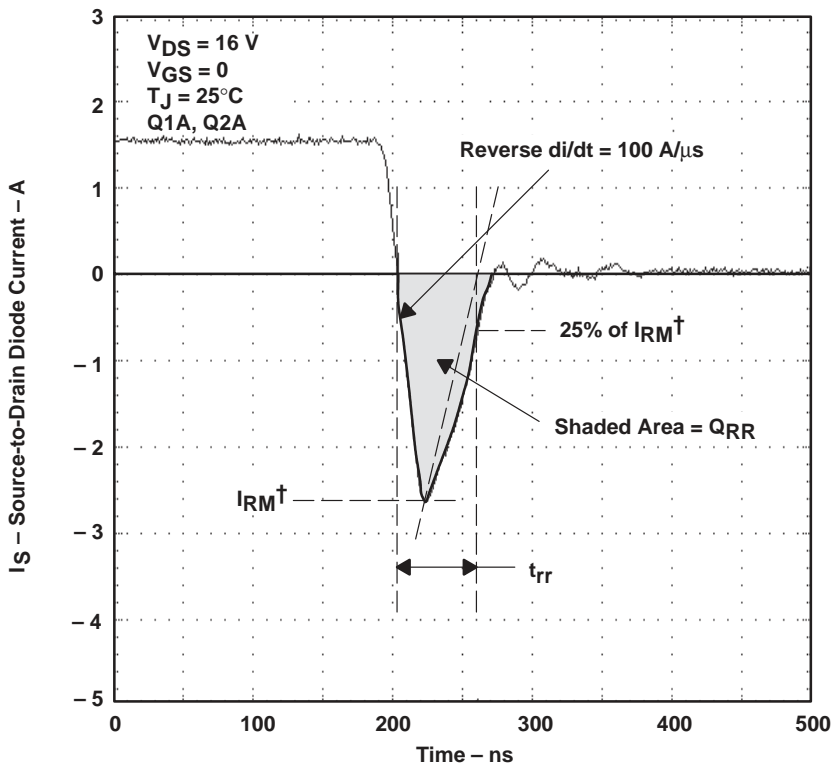
### thermal resistance

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	See Notes 5 and 8			90		$^\circ\text{C}/\text{W}$
$R_{\theta JB}$	Junction-to-board thermal resistance	See Notes 6 and 8			38		
$R_{\theta JP}$	Junction-to-pin thermal resistance	See Notes 7 and 8			28		

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



PARAMETER MEASUREMENT INFORMATION



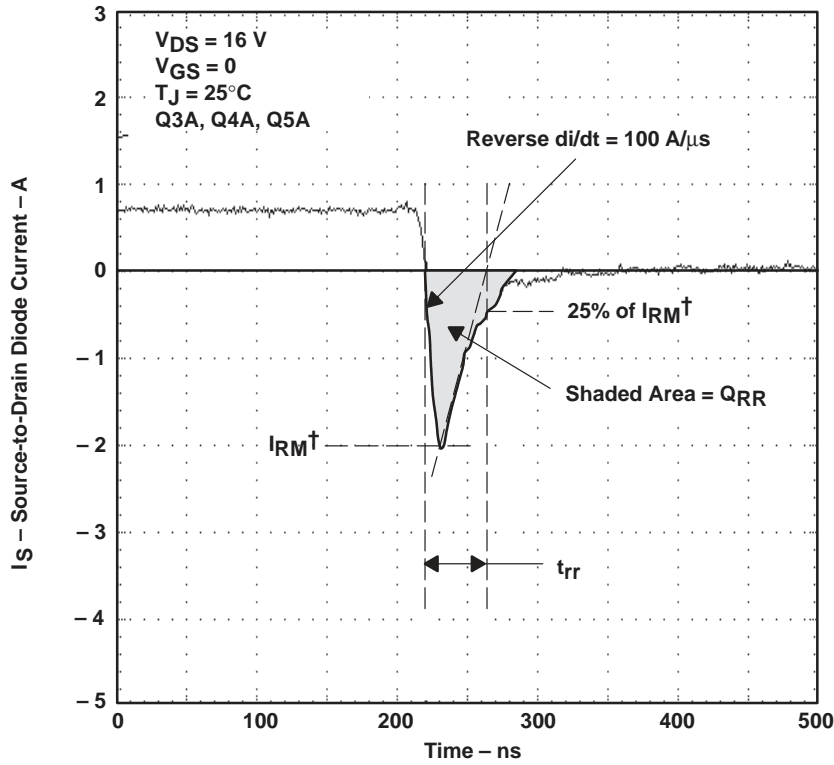
$^\dagger I_{RM}$  = maximum recovery current

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

# TPIC1501A QUAD AND HEX POWER DMOS ARRAY

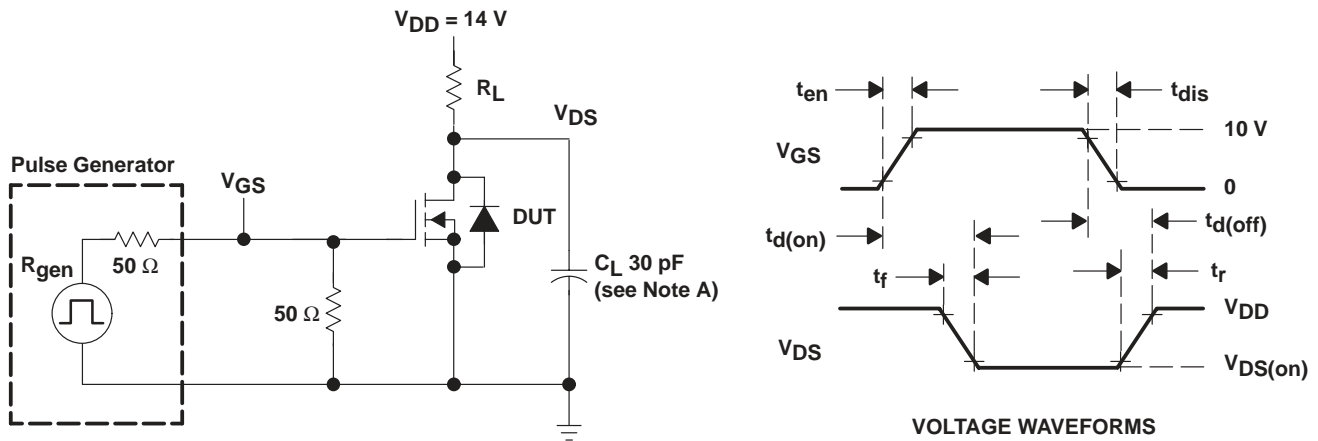
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## PARAMETER MEASUREMENT INFORMATION



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

Figure 2. Reverse-Recovery-Current Waveform of Source-to-Drain Diodes



TEST CIRCUIT

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

Figure 3. Resistive-Switching Test Circuit and Voltage Waveforms



PARAMETER MEASUREMENT INFORMATION

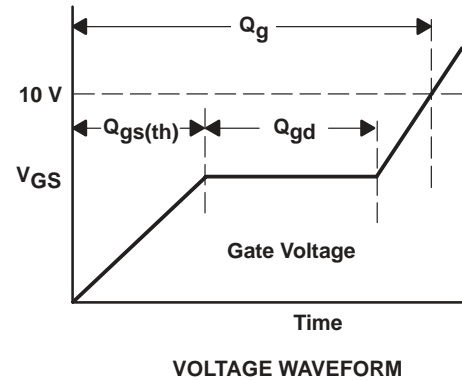
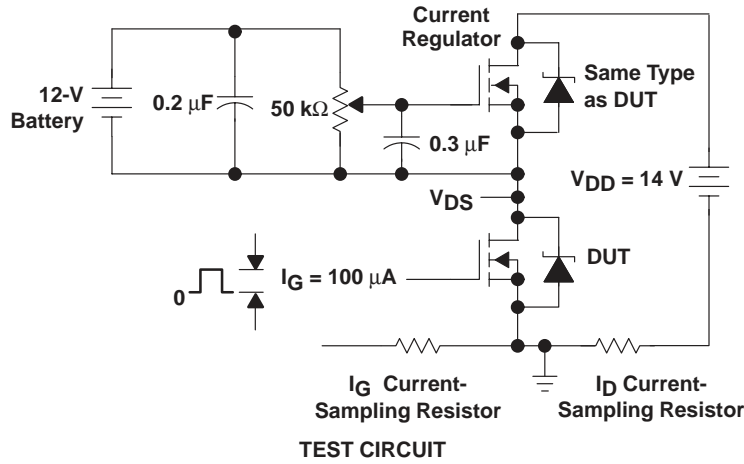


Figure 4. Gate-Charge Test Circuit and Voltage Waveform

TYPICAL CHARACTERISTICS

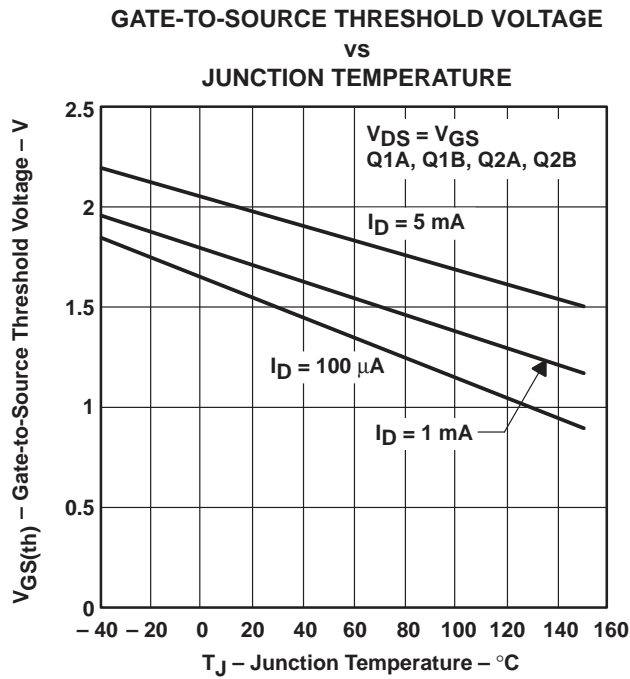


Figure 5

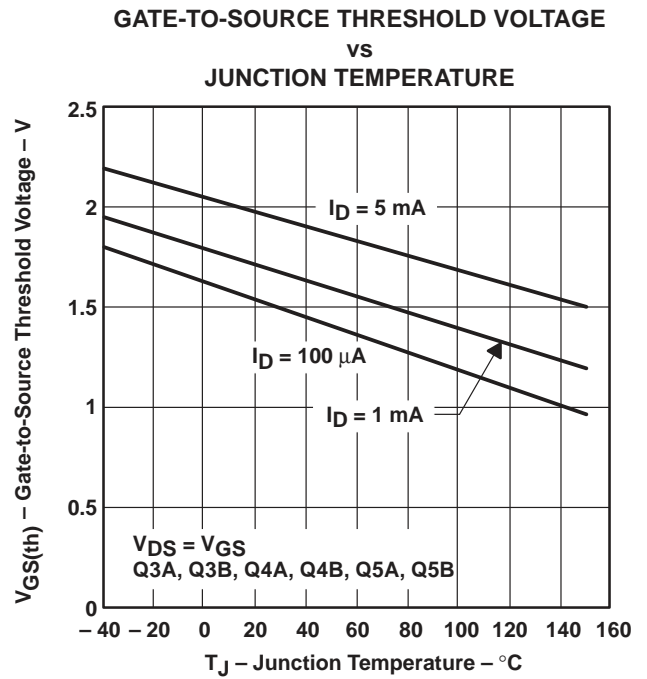


Figure 6

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SLIS046A – MAY 1995 – REVISED JUNE 1996

## TYPICAL CHARACTERISTICS

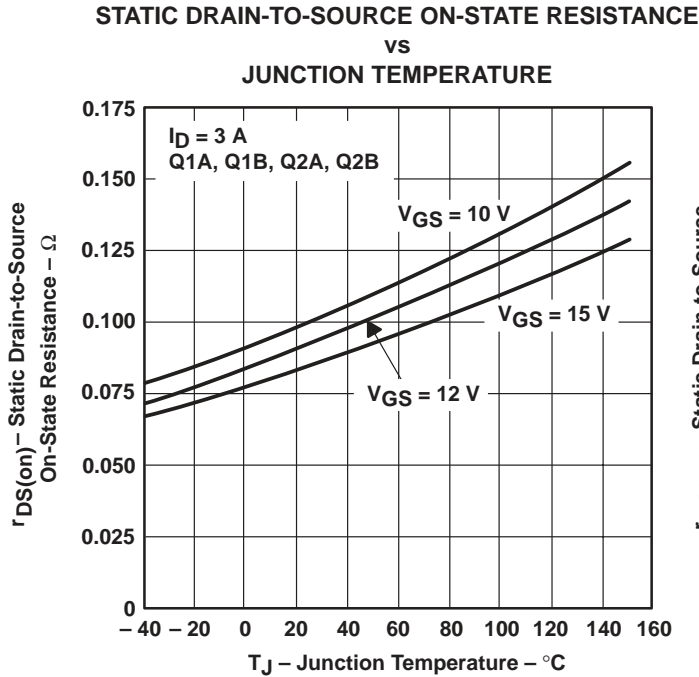


Figure 7

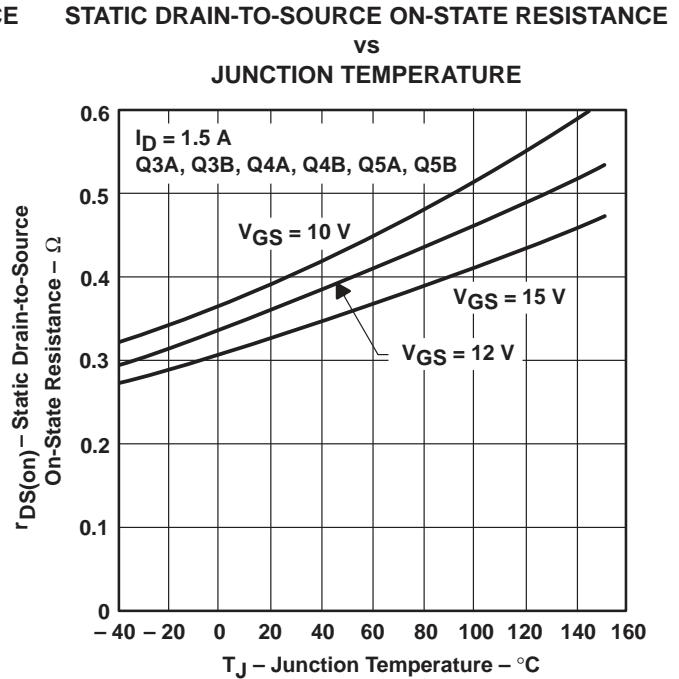


Figure 8

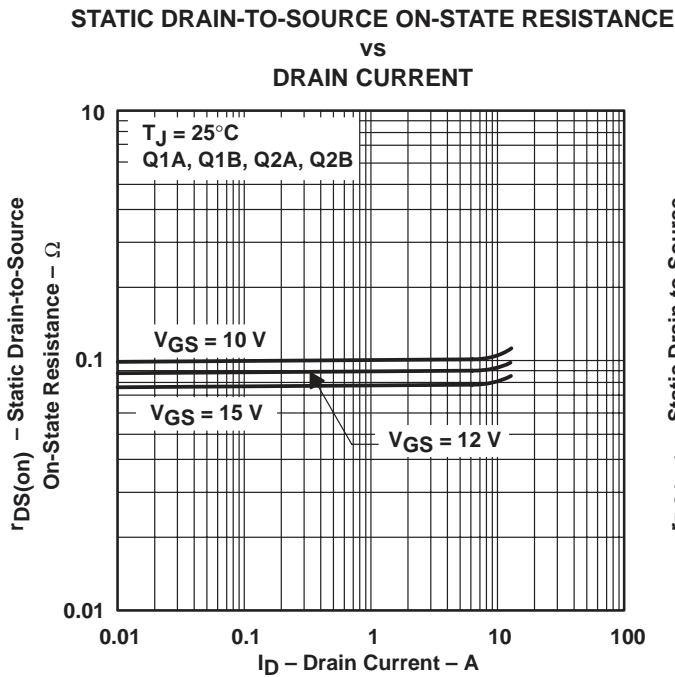


Figure 9

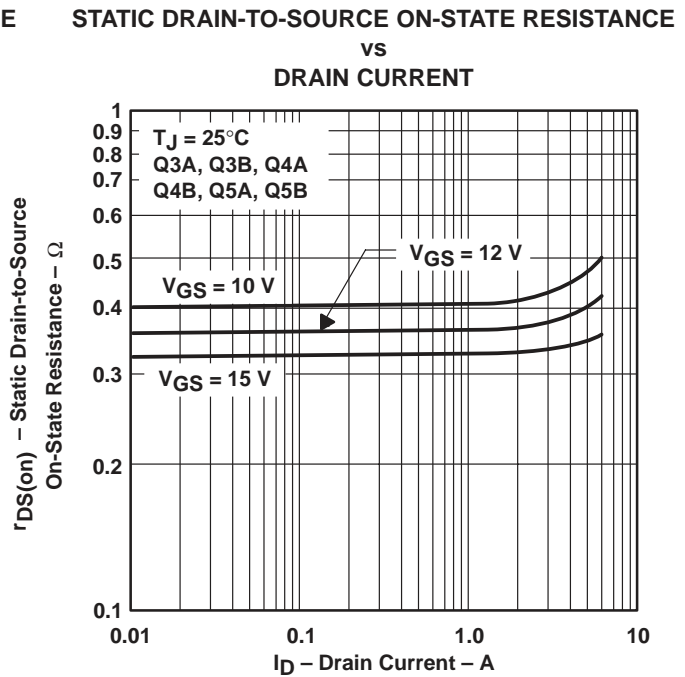


Figure 10

TYPICAL CHARACTERISTICS

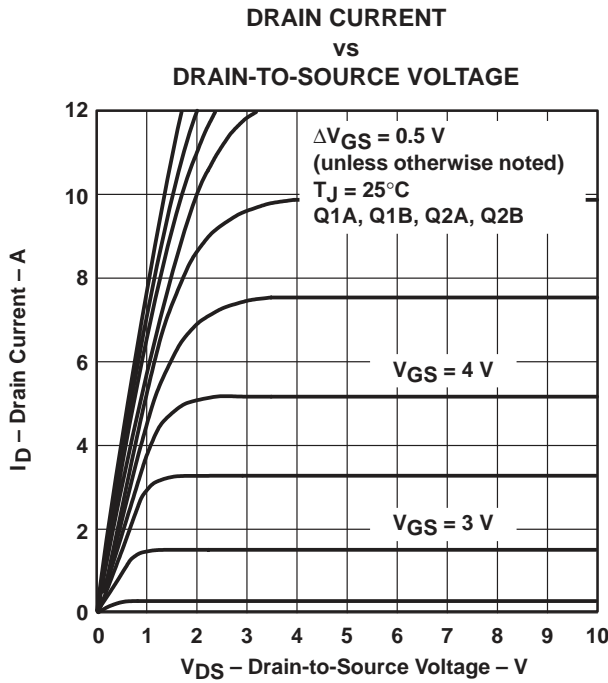


Figure 11

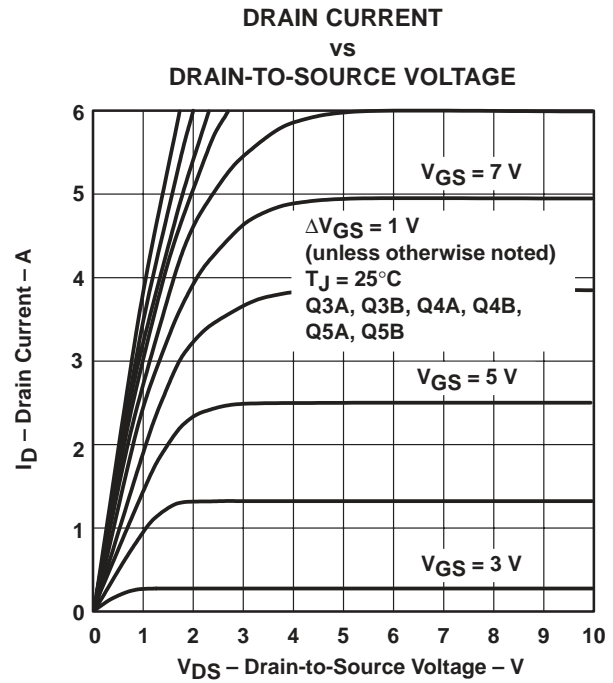


Figure 12

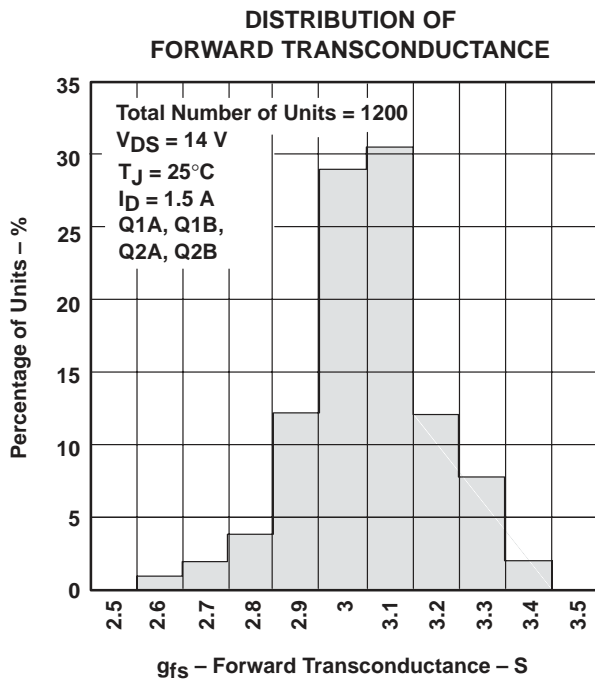


Figure 13

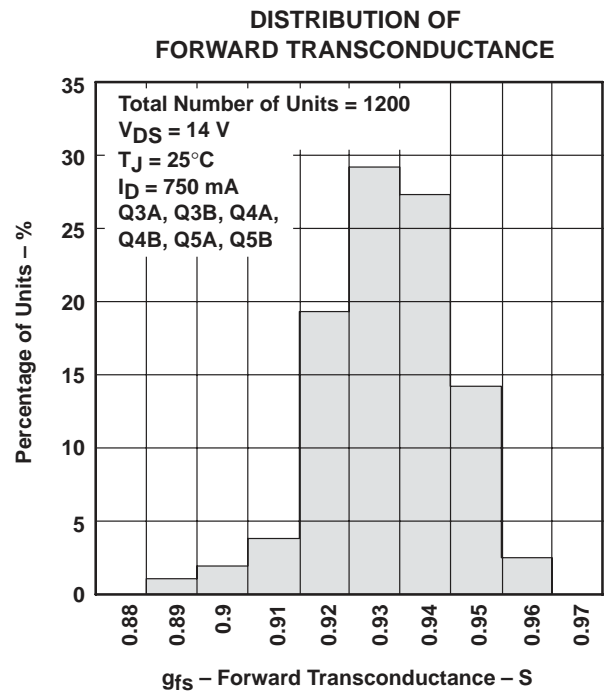


Figure 14

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SLIS046A – MAY 1995 – REVISED JUNE 1996

## TYPICAL CHARACTERISTICS

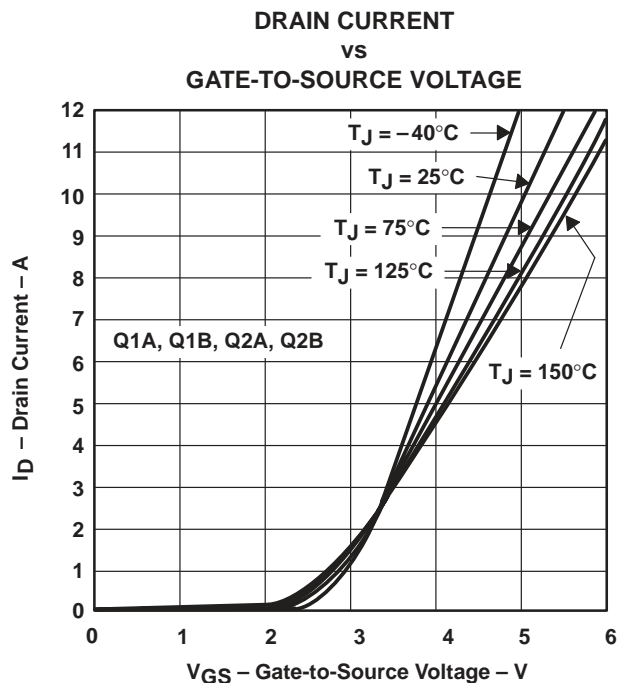


Figure 15

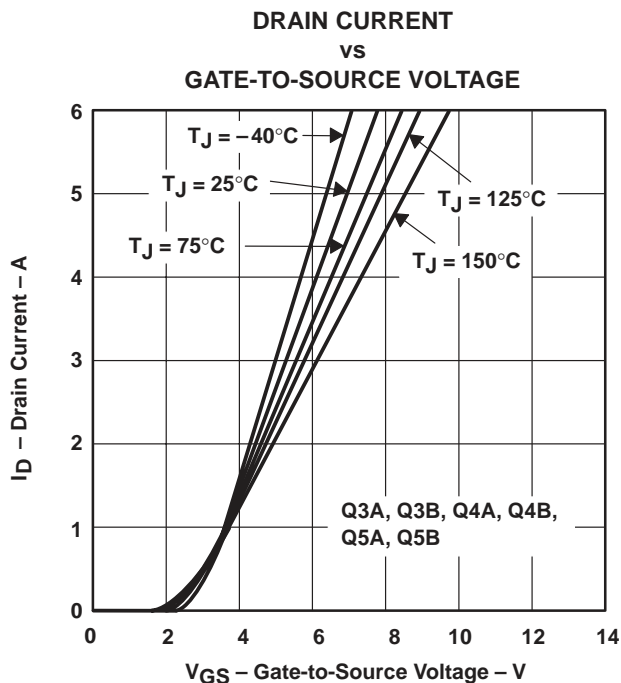


Figure 16

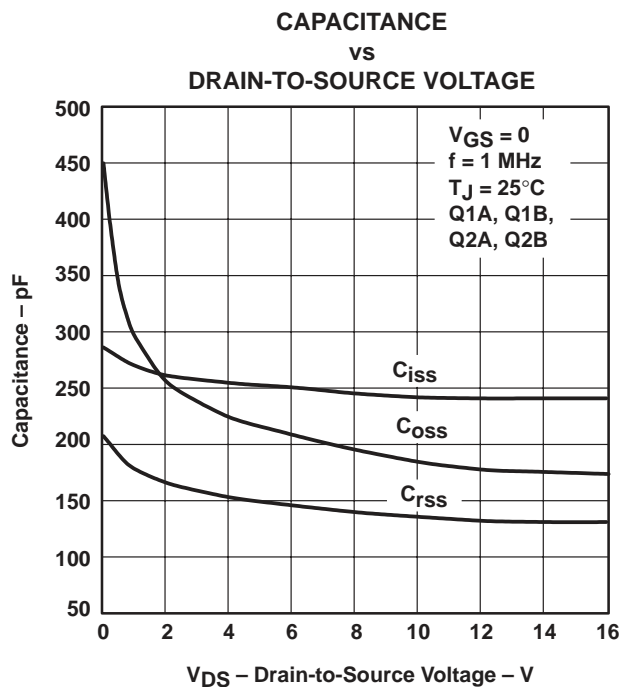


Figure 17

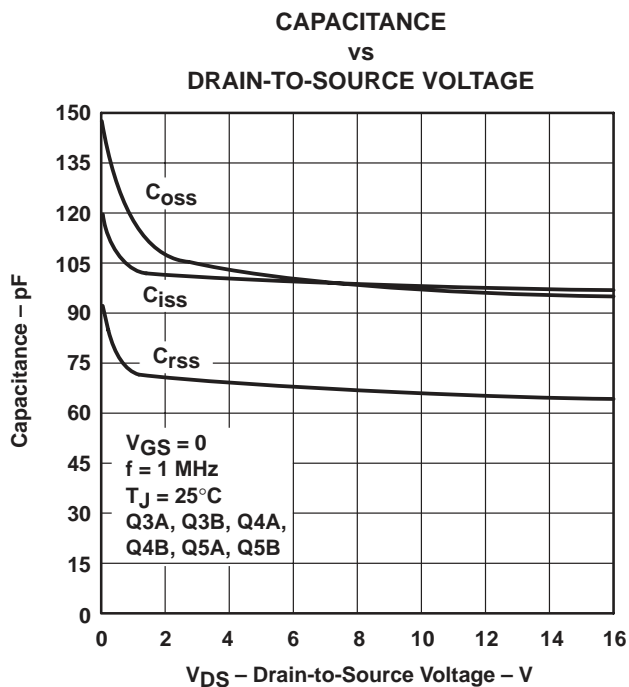


Figure 18



TYPICAL CHARACTERISTICS

SOURCE-TO-DRAIN DIODE CURRENT  
 vs  
 SOURCE-TO-DRAIN VOLTAGE

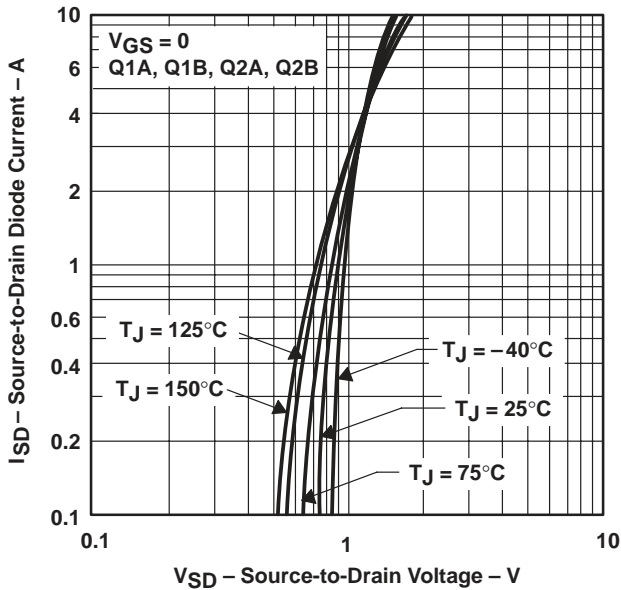


Figure 19

SOURCE-TO-DRAIN DIODE CURRENT  
 vs  
 SOURCE-TO-DRAIN VOLTAGE

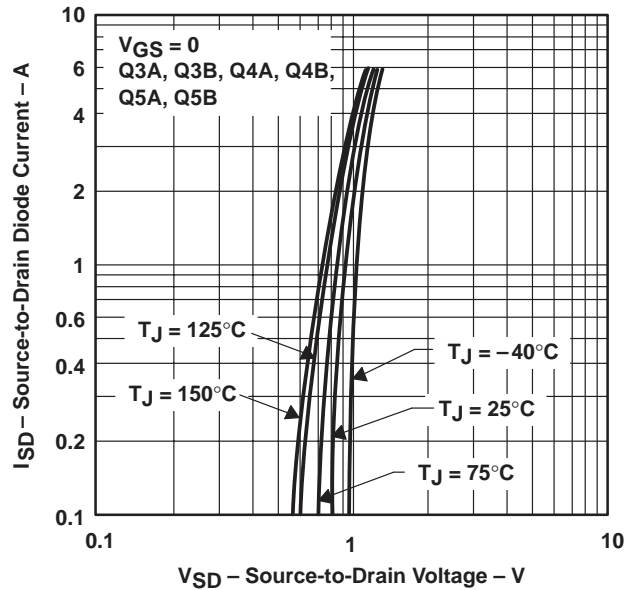


Figure 20

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

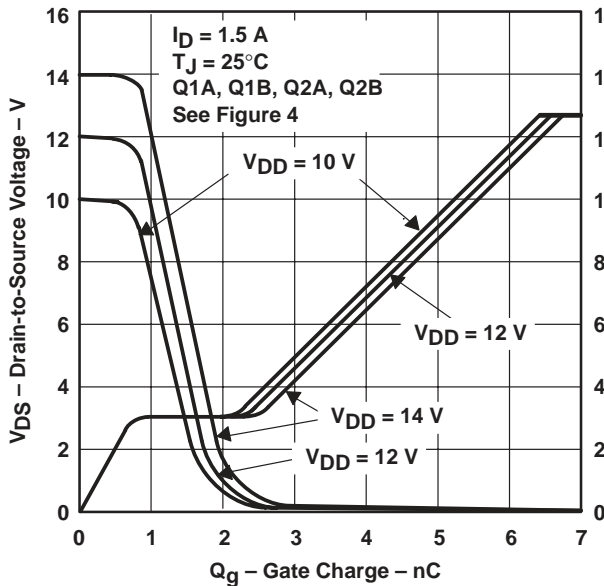


Figure 21

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

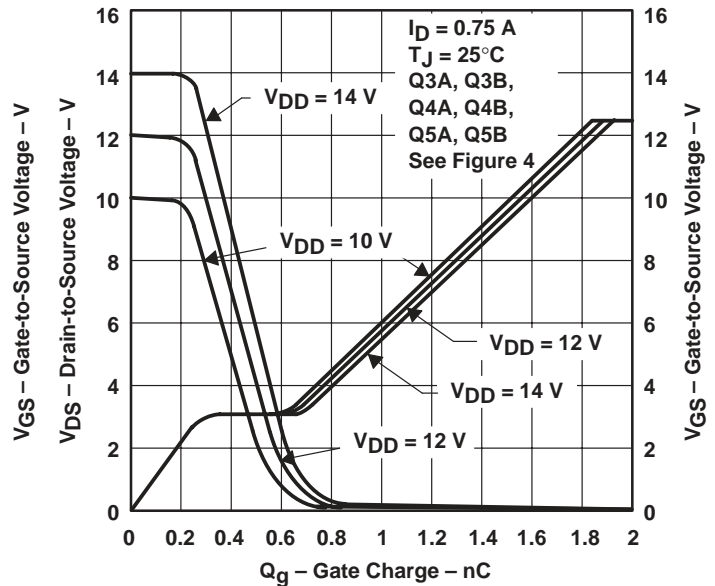


Figure 22

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## TYPICAL CHARACTERISTICS

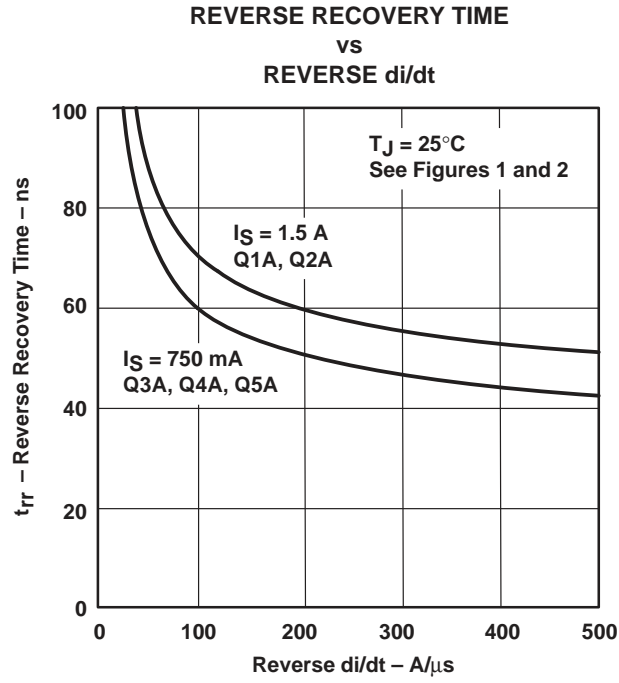


Figure 23

THERMAL INFORMATION

MAXIMUM DRAIN CURRENT  
 vs  
 DRAIN-TO-SOURCE VOLTAGE

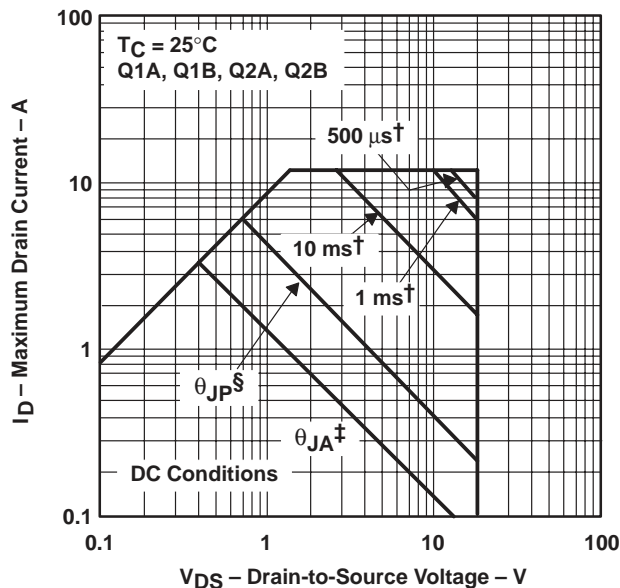


Figure 24

MAXIMUM DRAIN CURRENT  
 vs  
 DRAIN-TO-SOURCE VOLTAGE

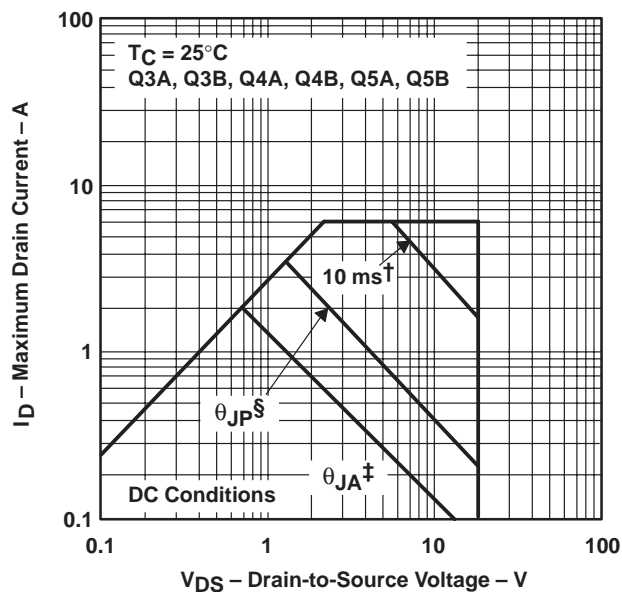


Figure 25

† Less than 10% duty cycle

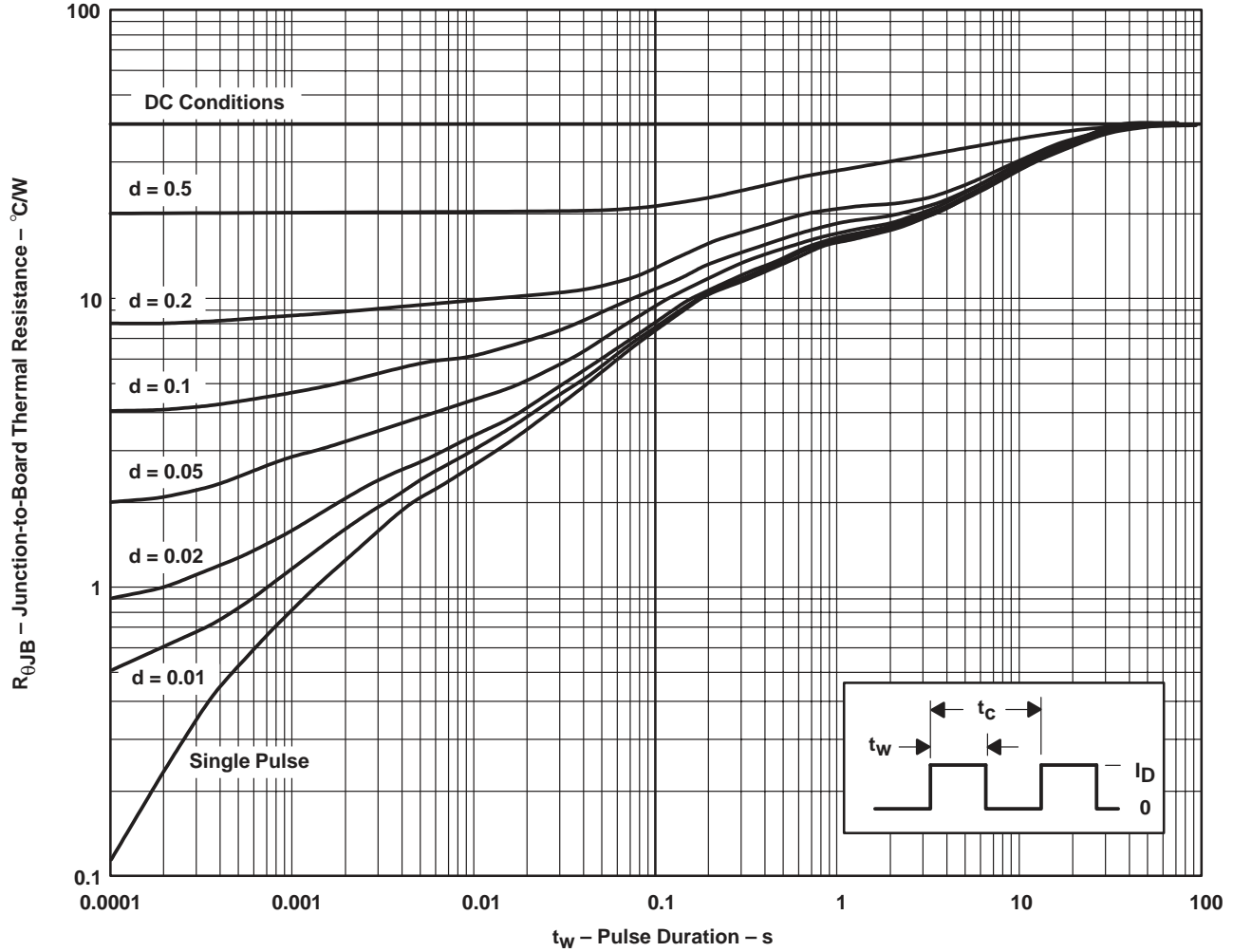
‡ Device is mounted on a 24 in<sup>2</sup>, 4 layer FR4 printed-circuit board.

§ Device is mounted in intimate contact with infinite heat sink.

# TPIC1501A QUAD AND HEX POWER DMOS ARRAY

SLIS046A – MAY 1995 – REVISED JUNE 1996

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



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

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

Figure 26



**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>	Samples (Requires Login)
TPIC1501ADW	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), Pb-Free (RoHS Exempt), 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.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**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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