

- **Low $r_{DS(on)}$:**
 0.25 Ω Typ (Full H-Bridge)
 0.15 Ω Typ (Triple Half H-Bridge)
- **Pulsed Current:**
 6 A Per Channel (Full H-Bridge)
 8 A Per Channel (Triple Half H-Bridge)
- **Matched Sense Transistor for Class A-B Linear Operation**
- **Fast Commutation Speed**

description

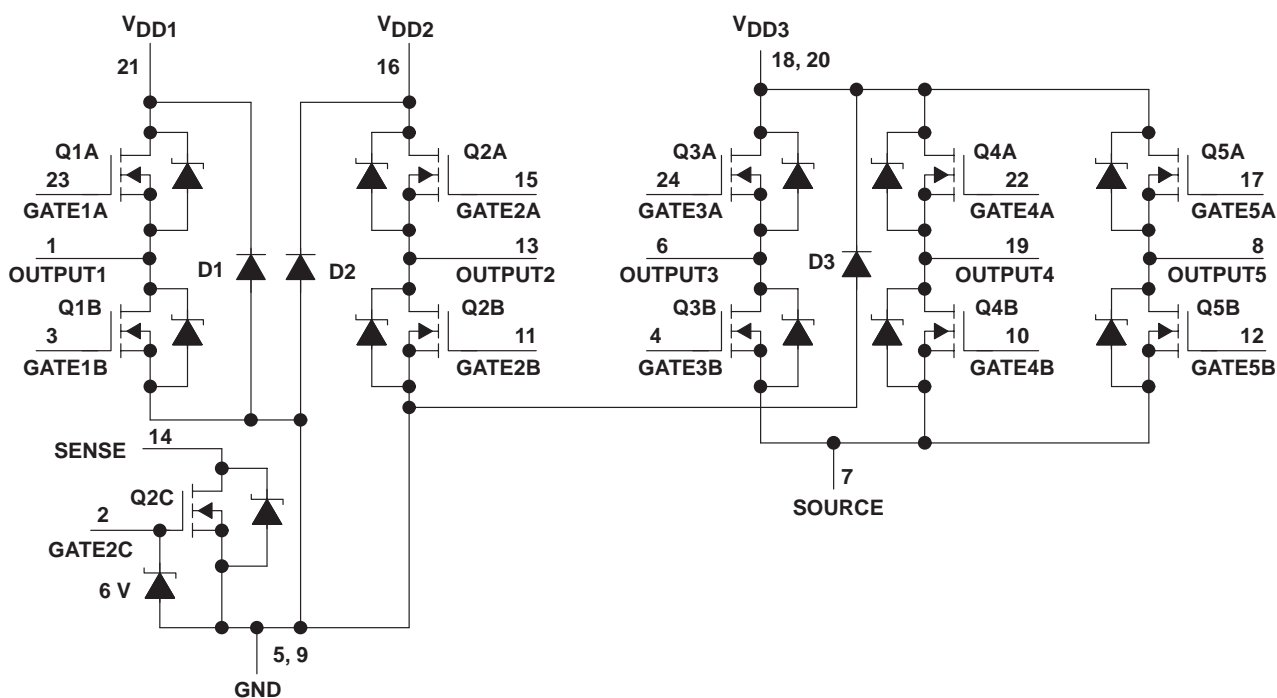
The TPIC1504 is a monolithic power DMOS array that consists of ten electrically isolated N-channel enhancement-mode power DMOS transistors, four of which are configured as a full H-bridge and six as a triple half H-bridge. The lower stage of the full H-bridge is provided with an integrated sense-FET to allow biasing of the bridge in class A-B operation.

The TPIC1504 is offered in a 24-pin wide-body surface-mount (DW) package and is characterized for operation over the case temperature range of -40°C to 125°C .

**DW PACKAGE
(TOP VIEW)**

OUTPUT1	1	24	GATE3A
GATE2C	2	23	GATE1A
GATE1B	3	22	GATE4A
GATE3B	4	21	V _{DD1}
GND	5	20	V _{DD3}
OUTPUT3	6	19	OUTPUT4
SOURCE	7	18	V _{DD3}
OUTPUT5	8	17	GATE5A
GND	9	16	V _{DD2}
GATE4B	10	15	GATE2A
GATE2B	11	14	SENSE
GATE5B	12	13	OUTPUT2

schematic



- NOTES:
- Terminals 5 and 9 must be externally connected.
 - Terminals 18 and 20 must be externally connected.
 - No output may be taken greater than 0.5 V below GND.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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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TPIC1504

QUAD AND HEX POWER DMOS ARRAY

SLIS057 – OCTOBER 1996

absolute maximum ratings, $T_C = 25^\circ\text{C}$ (unless otherwise noted)[†]

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)	± 20 V
Gate-to-source voltage, V_{GS} (Q2C)	-0.7 V to 6 V
Continuous gate-to-source zener-diode current (Q2C)	± 10 mA
Pulsed gate-to-source zener-diode current (Q2C)	± 50 mA
Continuous drain current, each output (Q1A, Q1B, Q2A, Q2B)	1.5 A
Continuous drain current, each output (Q3A, Q3B, Q4A, Q4B, Q5A, Q5B)	2 A
Continuous drain current (Q2C)	5 mA
Continuous source-to-drain diode current (Q1A, Q1B, Q2A, Q2B)	1.5 A
Continuous source-to-drain diode current (Q3A, Q3B, Q4A, Q4B, Q5A, Q5B)	2 A
Continuous source-to-drain diode current (Q2C)	5 mA
Pulsed drain current, each output, I_{max} (Q1A, Q1B, Q2A, Q2B) (see Note 1 and Figure 24)	6 A
Pulsed drain current, each output, I_{max} (Q3A, Q3B, Q4A, Q4B, Q5A, Q5B) (see Note 1 and Figure 25)	8 A
Pulsed drain current, each output, I_{max} (Q2C) (see Note 1)	20 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°C to 150°C
Operating case temperature range, T_C	-40°C to 125°C
Storage temperature range, T_{stg}	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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.

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

electrical characteristics, Q1A, Q1B, Q2A, Q2B, $T_C = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(BR)DSX}$	Drain-to-source breakdown voltage	$I_D = 250\ \mu\text{A}$, $V_{GS} = 0$	20			V
$V_{GS(th)}$	Gate-to-source threshold voltage	$I_D = 1\ \text{mA}$, See Figure 5 $V_{DS} = V_{GS}$	1.5	1.9	2.2	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 = $250\ \mu\text{A}$ (D1, D2)	20			V
$V_{(BR)GS}$	Gate-to-source threshold breakdown voltage, Q2C	$I_{GS} = 100\ \mu\text{A}$	6			V
$V_{(BR)SG}$	Source-to-gate breakdown voltage, Q2C	$I_{SG} = 100\ \mu\text{A}$	0.5			V
$V_{(DS)on}$	Drain-to-source on-state voltage	$I_D = 1.5\ \text{A}$, $V_{GS} = 10\ \text{V}$, See Notes 3 and 4		0.375	0.45	V
V_F	Forward on-state voltage, GND-to- V_{DD1} , GND-to- V_{DD2}	$I_D = 1.5\ \text{A}$ (D1, D2) 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 19		0.85	1.2	V
I_{DSS}	Zero-gate-voltage drain current	$V_{DS} = 16\ \text{V}$, $V_{GS} = 0$, $T_C = 25^\circ\text{C}$		0.05	1	μA
		$T_C = 125^\circ\text{C}$		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	$V_{SG} = 0.5\ \text{V}$, $V_{DS} = 0$		10	100	nA
I_{lkg}	Leakage current, V_{DD1} -to-GND, V_{DD2} -to-GND, gate shorted to source	$V_{DGND} = 16\ \text{V}$, $T_C = 25^\circ\text{C}$		0.05	1	μA
		$T_C = 125^\circ\text{C}$		0.5	10	
$r_{DS(on)}$	Static drain-to-source on-state resistance	$V_{GS} = 10\ \text{V}$, $I_D = 1.5\ \text{A}$, See Notes 3 and 4 and Figure 9, $T_C = 25^\circ\text{C}$		0.25	0.3	Ω
		$T_C = 125^\circ\text{C}$		0.4	0.475	
g_{fs}	Forward transconductance	$V_{DS} = 14\ \text{V}$, $I_D = 750\ \text{mA}$, See Notes 3 and 4 and Figure 13	0.8	1.2		S
C_{iss}	Short-circuit input capacitance, common source	$V_{DS} = 14\ \text{V}$, $V_{GS} = 0$, $f = 1\ \text{MHz}$, See Figure 17		99		pF
C_{oss}	Short-circuit output capacitance, common source			81		
C_{rss}	Short-circuit reverse transfer capacitance, common source			59		
α_S	Sense-FET drain current ratio	$V_{DS} = 6\ \text{V}$, $I_{D(Q2C)} = 40\ \mu\text{A}$	100	150	200	

NOTES: 3. Technique should limit $T_J - T_C$ to 10°C maximum.

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

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	$I_S = 750\ \text{mA}$, $V_{GS} = 0$, $V_{DS} = 14\ \text{V}$, $di/dt = 100\ \text{A}/\mu\text{s}$, See Figures 1 and 23		18		ns
Q_{RR}	Total diode charge			13		nC

TPIC1504

QUAD AND HEX POWER DMOS ARRAY

SLIS057 – OCTOBER 1996

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	$V_{DD} = 14\text{ V}$, $R_L = 18.7\ \Omega$, $t_{en} = 10\text{ ns}$, $t_{dis} = 10\text{ ns}$, See Figure 3		11		ns
$t_{d(off)}$ Turn-off delay time			16		
t_r Rise time			3		
t_f Fall time			4		
Q_g Total gate charge	$V_{DS} = 14\text{ V}$, $I_D = 750\text{ mA}$, $V_{GS} = 10\text{ V}$, See Figure 4 and Figure 21		1.8	2.5	nC
$Q_{gs(th)}$ Threshold gate-to-source charge			0.3	0.4	
Q_{gd} Gate-to-drain charge			0.5	0.6	
L_D Internal drain inductance			7		nH
L_S Internal source inductance			7		
R_g Internal gate resistance			10		Ω

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	$I_D = 250\ \mu\text{A}$, $V_{GS} = 0$	20			V
$V_{GS(th)}$ Gate-to-source threshold voltage	$I_D = 1\text{ mA}$, $V_{DS} = V_{GS}$, See Figure 6	1.5	1.9	2.2	V
$V_{(BR)}$ 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	$I_D = 2\text{ A}$, $V_{GS} = 10\text{ V}$, See Notes 3 and 4		0.3	0.35	V
V_F Forward on-state voltage, GND-to- V_{DD3}	$I_D = 2\text{ A}$ (D3), See Notes 3 and 4		1.5		V
$V_F(SD)$ Forward on-state voltage, source-to-drain	$I_S = 2\text{ A}$, $V_{GS} = 0$, See Notes 3 and 4 and Figure 20		0.85	1.2	V
I_{DSS} Zero-gate-voltage drain current	$V_{DS} = 16\text{ V}$, $V_{GS} = 0$	$T_C = 25^\circ\text{C}$	0.05	1	μA
		$T_C = 125^\circ\text{C}$	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	μA
		$T_C = 125^\circ\text{C}$	0.5	10	
$r_{DS(on)}$ Static drain-to-source on-state resistance	$V_{GS} = 10\text{ V}$, $I_D = 2\text{ A}$, See Notes 3 and 4 and Figure 10	$T_C = 25^\circ\text{C}$	0.15	0.175	Ω
		$T_C = 125^\circ\text{C}$	0.24	0.275	
g_{fs} Forward transconductance	$V_{DS} = 14\text{ V}$, $I_D = 1\text{ A}$, See Notes 3 and 4 and Figure 14	1	1.7		S
C_{iss} Short-circuit input capacitance, common source	$V_{DS} = 14\text{ V}$, $V_{GS} = 0$, $f = 1\text{ MHz}$, See Figure 18		160		pF
C_{oss} Short-circuit output capacitance, common source			220		
C_{rss} Short-circuit reverse transfer capacitance, common source			110		

NOTES: 3: Technique should limit $T_J - T_C$ to 10°C maximum.

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



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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	$I_S = 1\text{ A}$, $V_{GS} = 0$, $V_{DS} = 14\text{ V}$, $di/dt = 100\text{ A}/\mu\text{s}$,		34		ns
Q_{RR} Total diode charge	See Figures 2 and 23		30		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	$V_{DD} = 14\text{ V}$, $R_L = 14\ \Omega$, $t_{en} = 10\text{ ns}$, $t_{dis} = 10\text{ ns}$, See Figure 3		30		ns
$t_{d(off)}$ Turn-off delay time			34		
t_r Rise time			15		
t_f Fall time			21		
Q_g Total gate charge	$V_{DS} = 14\text{ V}$, $I_D = 1\text{ A}$, $V_{GS} = 10\text{ V}$, See Figure 4 and Figure 22		3.2	4.5	nC
$Q_{gs(th)}$ Threshold gate-to-source charge			0.5	0.6	
Q_{gd} Gate-to-drain charge			0.9	1.1	
L_D Internal drain inductance			7		nH
L_S Internal source inductance			7		
R_g Internal gate resistance			10		Ω

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		52		
$R_{\theta JP}$ Junction-to-pin thermal resistance	See Notes 7 and 8		28		

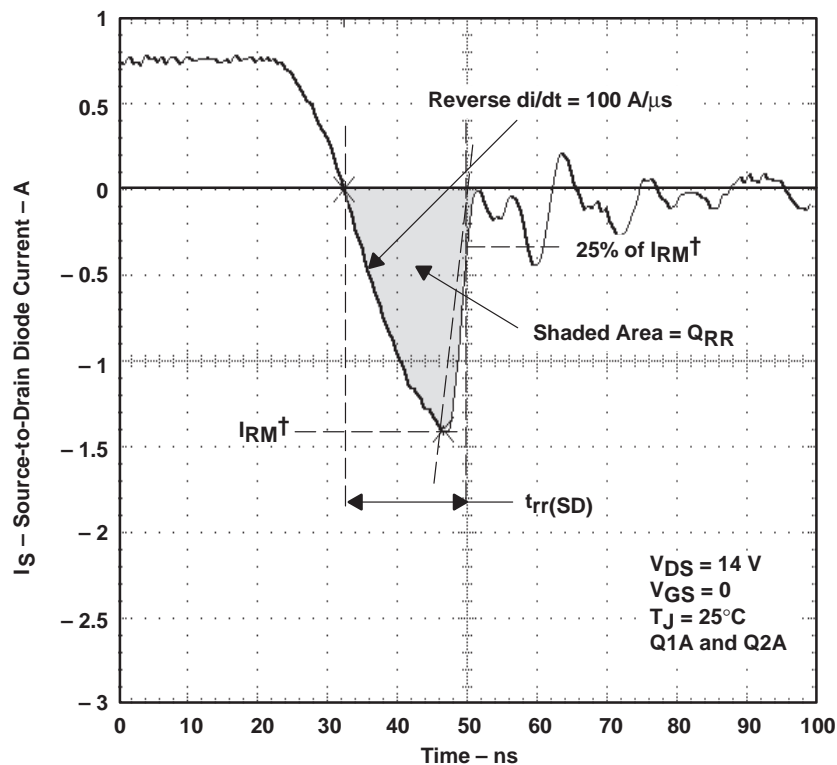
- NOTES:
5. Package mounted on a FR4 printed-circuit board with no heatsink.
 6. Package mounted on a 24 in², 4-layer FR4 printed-circuit board.
 7. Package mounted in intimate contact with infinite heatsink.
 8. All outputs with equal power

TPIC1504

QUAD AND HEX POWER DMOS ARRAY

SLIS057 – OCTOBER 1996

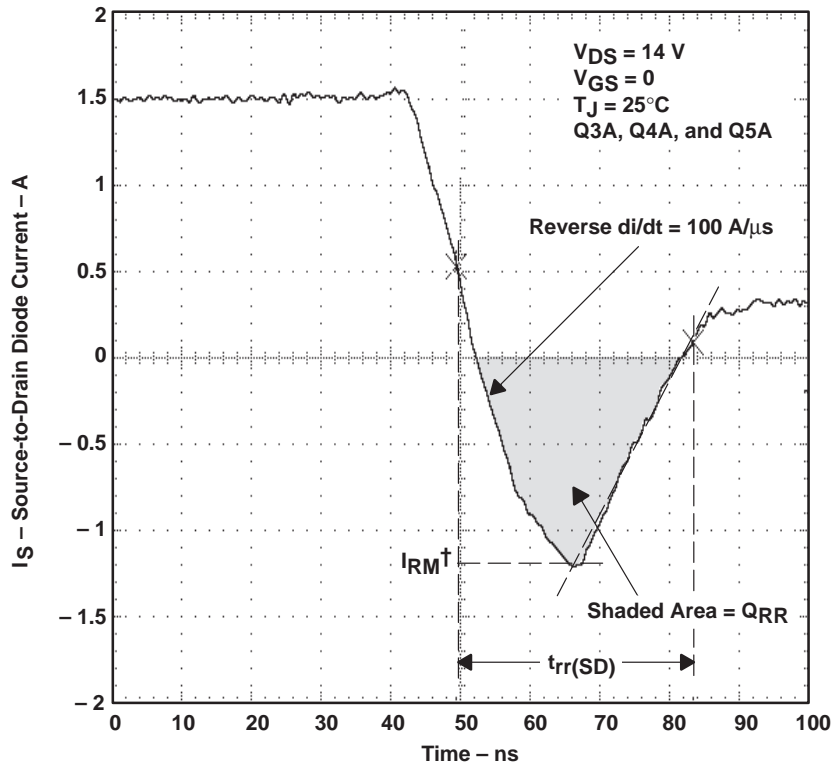
PARAMETER MEASUREMENT INFORMATION



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

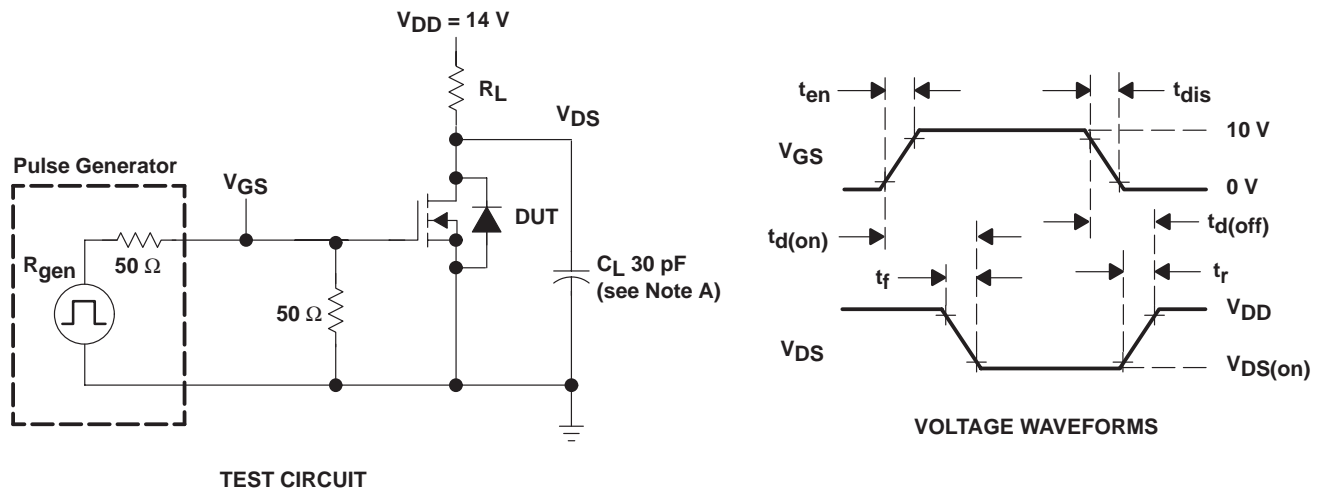
Figure 1. Reverse-Recovery-Current Waveform of Source-to-Drain Diodes

PARAMETER MEASUREMENT INFORMATION



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

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



NOTE A: C_L includes probe and jig capacitance.

Figure 3. Resistive-Switching Test Circuit and Voltage Waveforms

TPIC1504
QUAD AND HEX POWER DMOS ARRAY

SLIS057 – OCTOBER 1996

PARAMETER MEASUREMENT INFORMATION

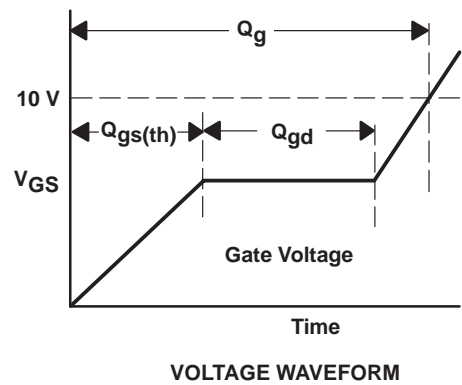
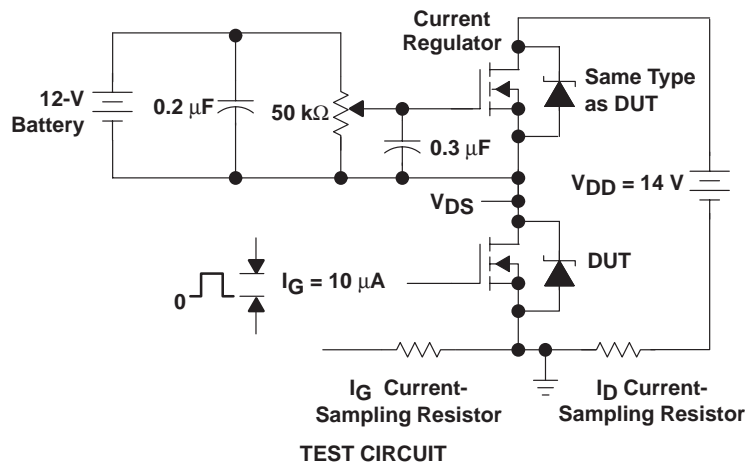


Figure 4. Gate-Charge Test Circuit and Voltage Waveform

TYPICAL CHARACTERISTICS

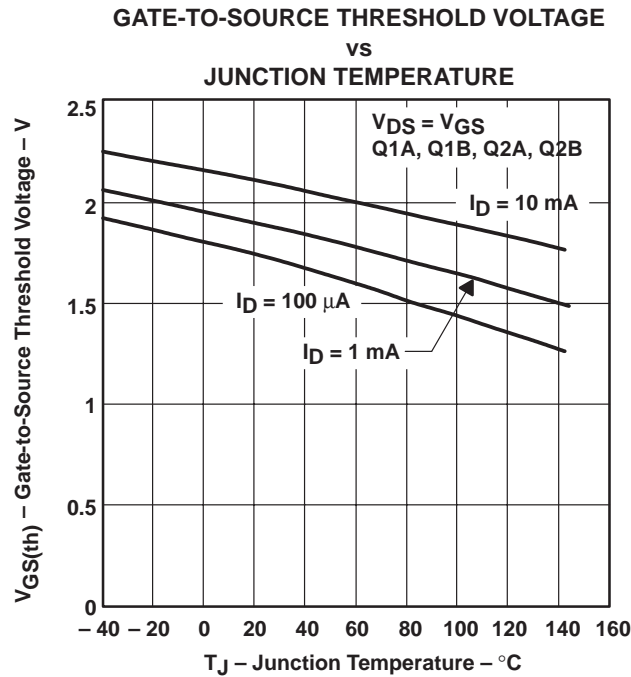


Figure 5

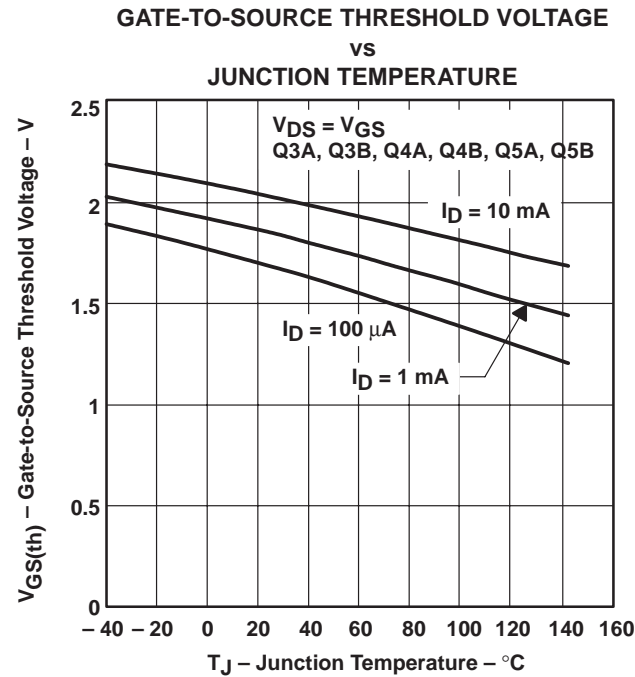


Figure 6

TYPICAL CHARACTERISTICS

STATIC DRAIN-TO-SOURCE ON-STATE RESISTANCE vs JUNCTION TEMPERATURE

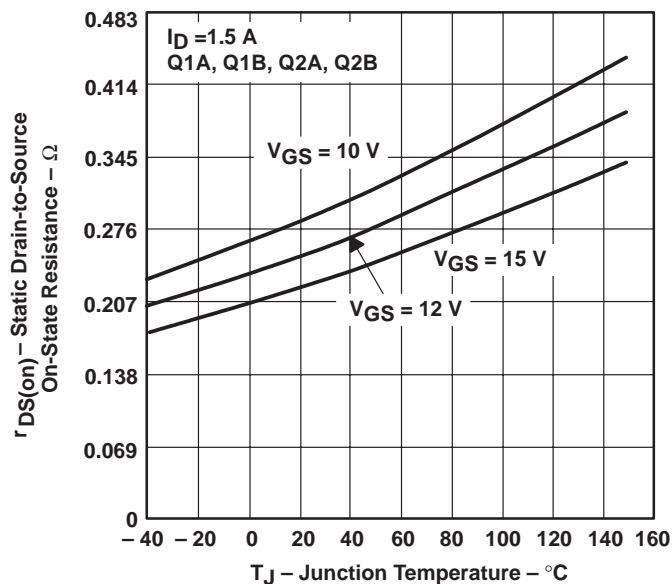


Figure 7

STATIC DRAIN-TO-SOURCE ON-STATE RESISTANCE vs JUNCTION TEMPERATURE

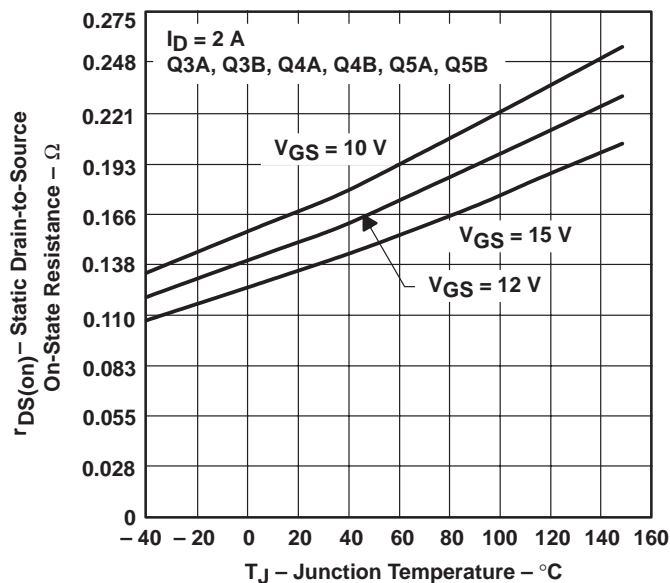


Figure 8

TYPICAL CHARACTERISTICS

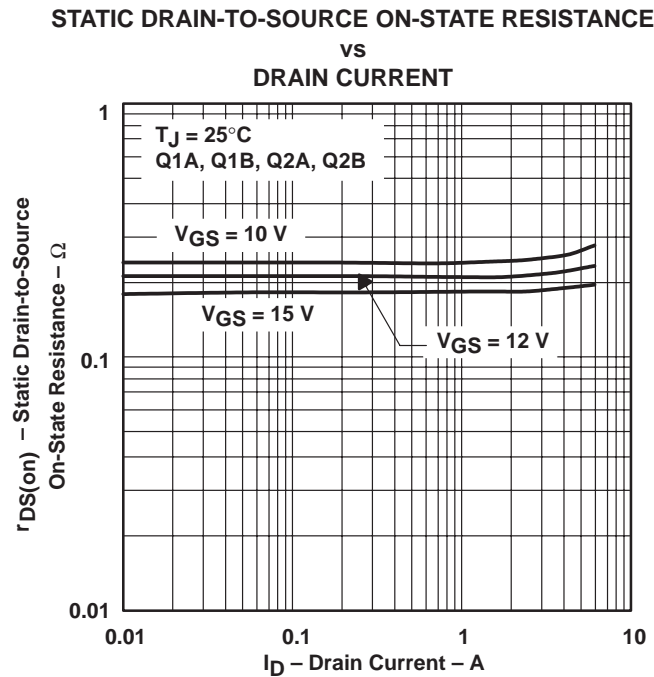


Figure 9

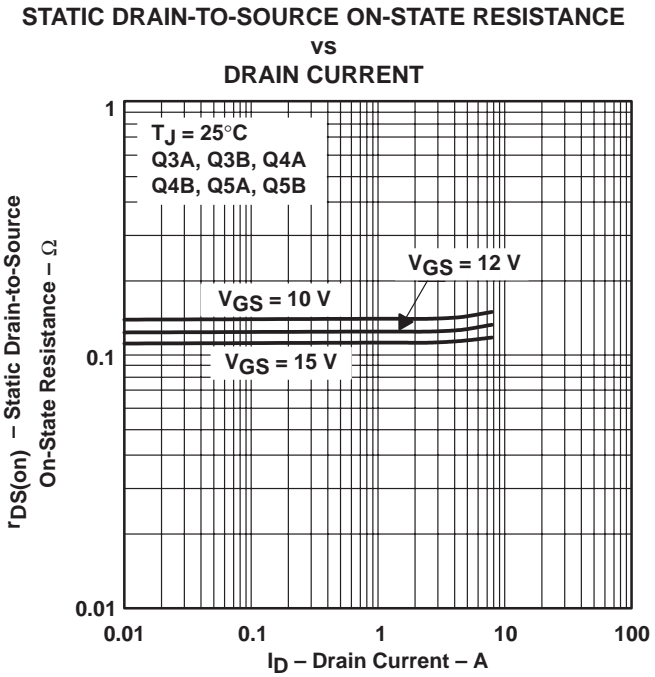


Figure 10

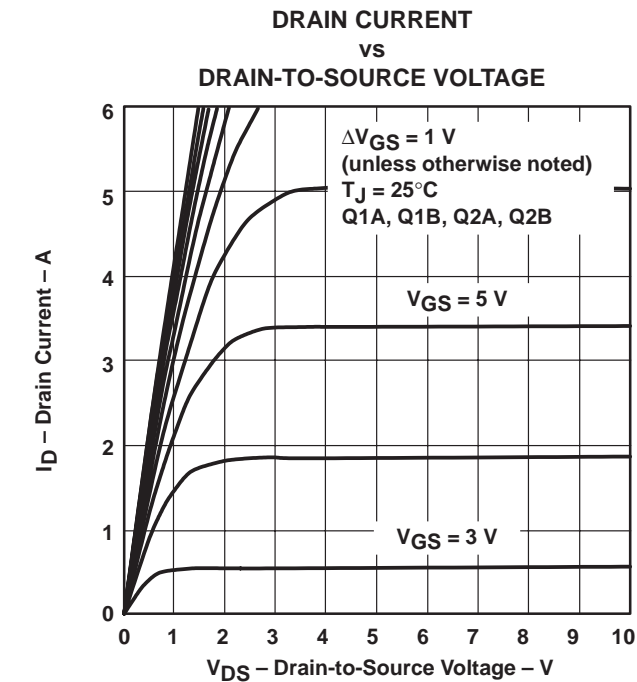


Figure 11

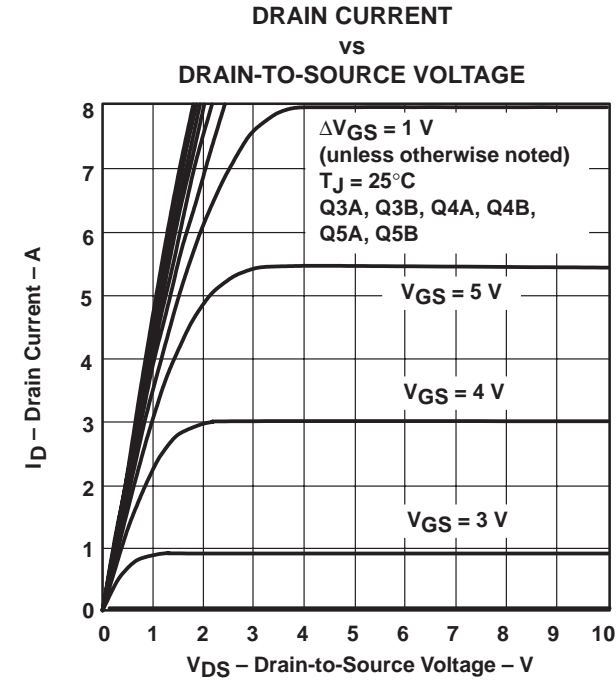


Figure 12

TYPICAL CHARACTERISTICS

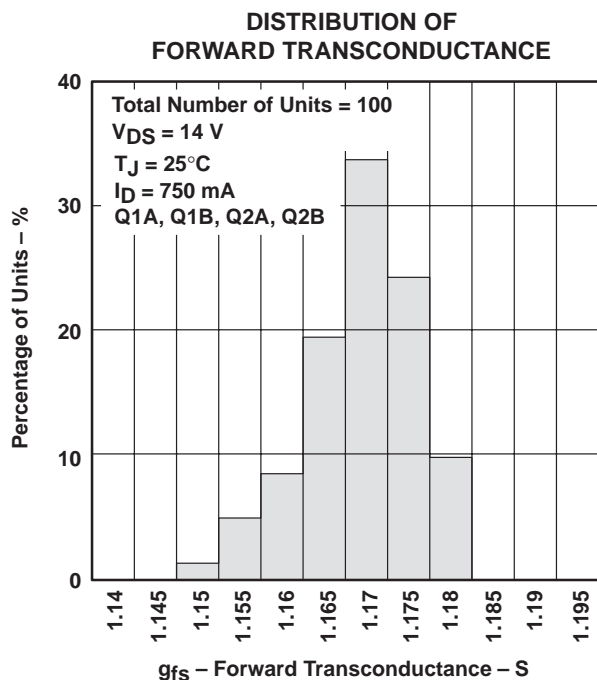


Figure 13

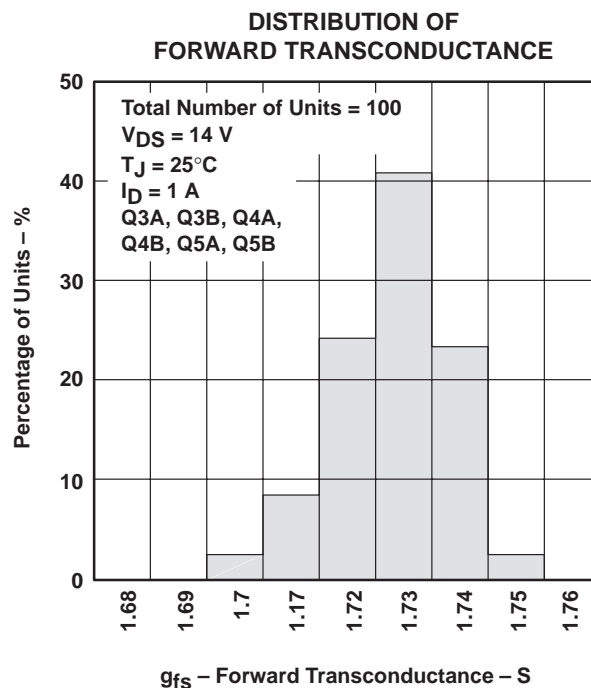


Figure 14

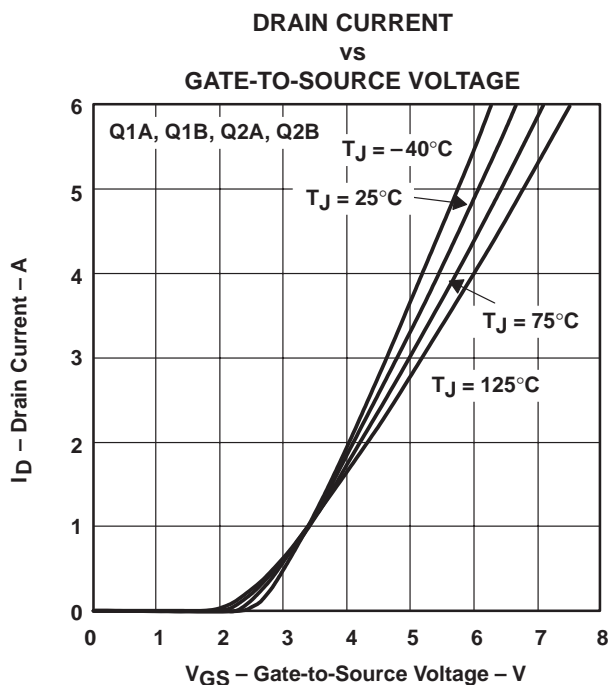


Figure 15

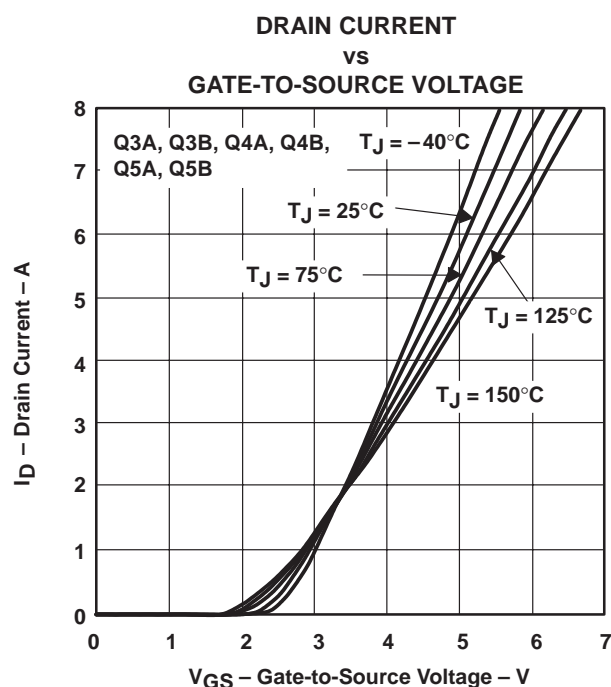


Figure 16

TYPICAL CHARACTERISTICS

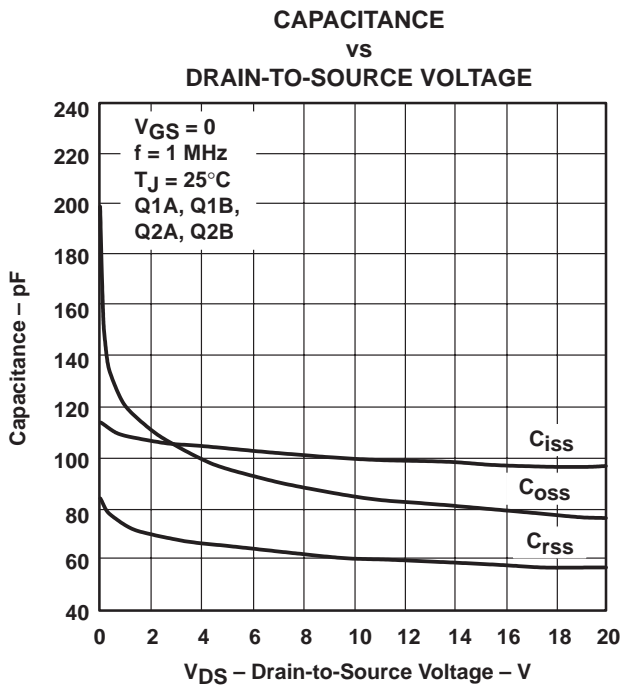


Figure 17

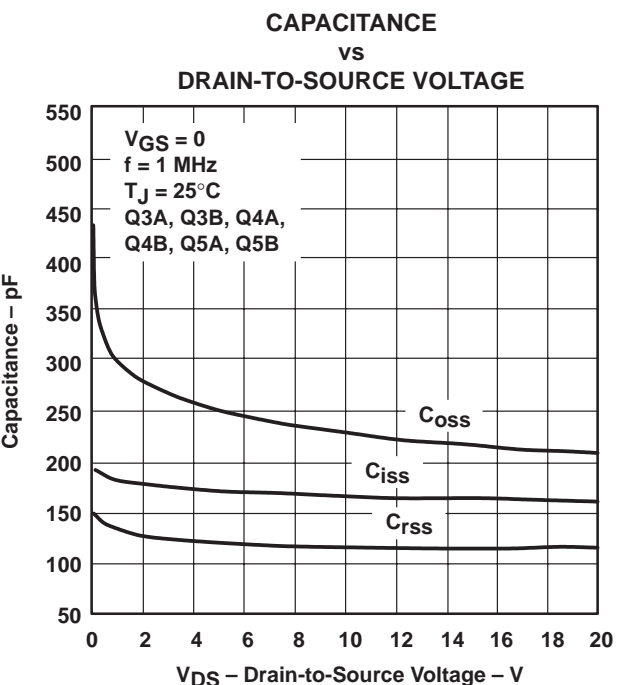


Figure 18

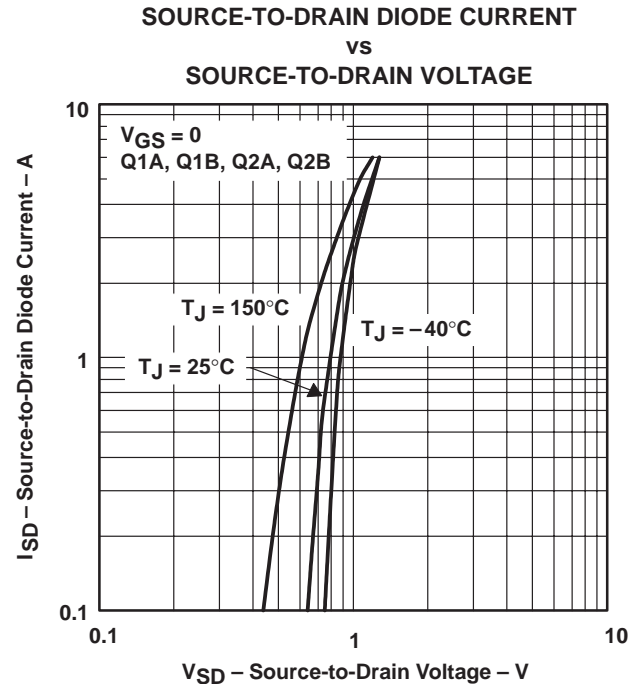


Figure 19

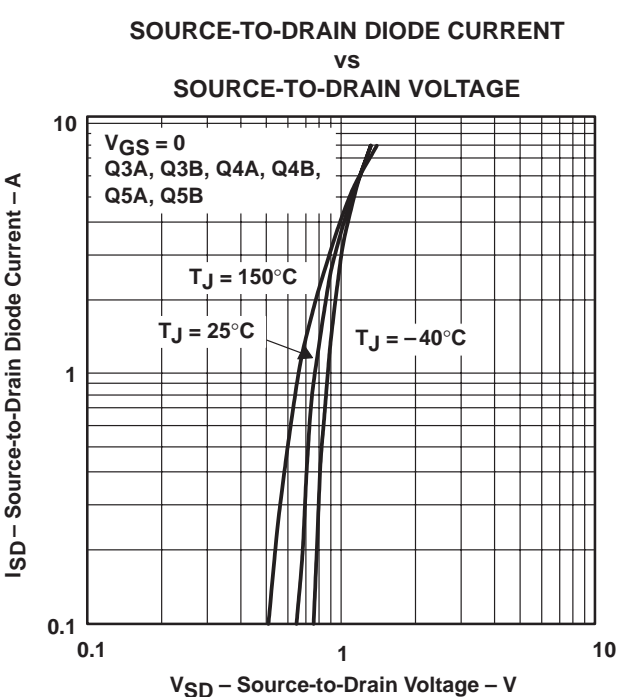
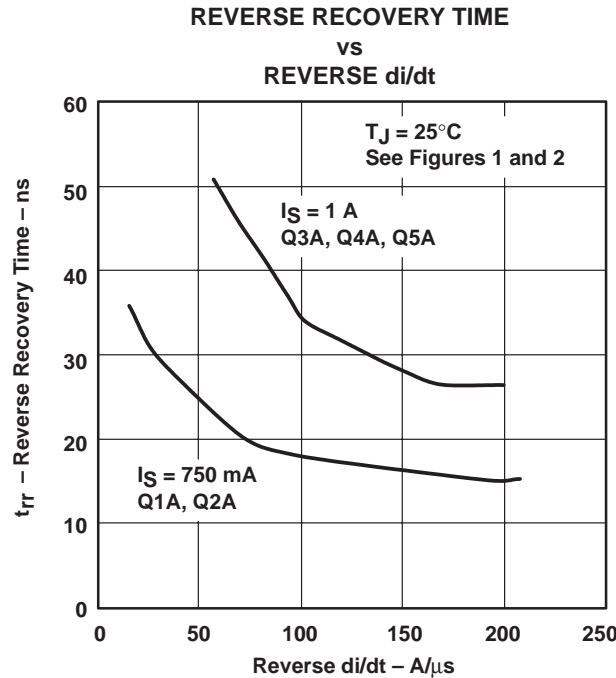
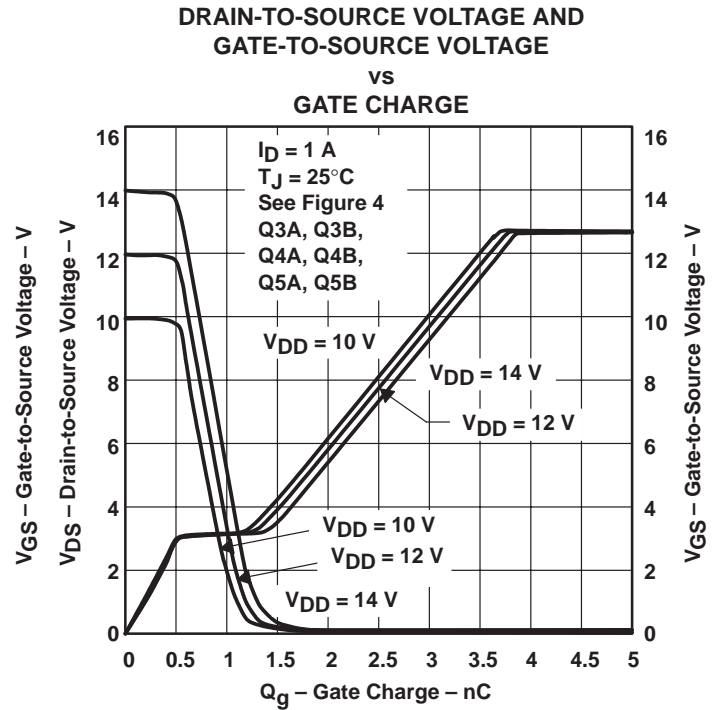
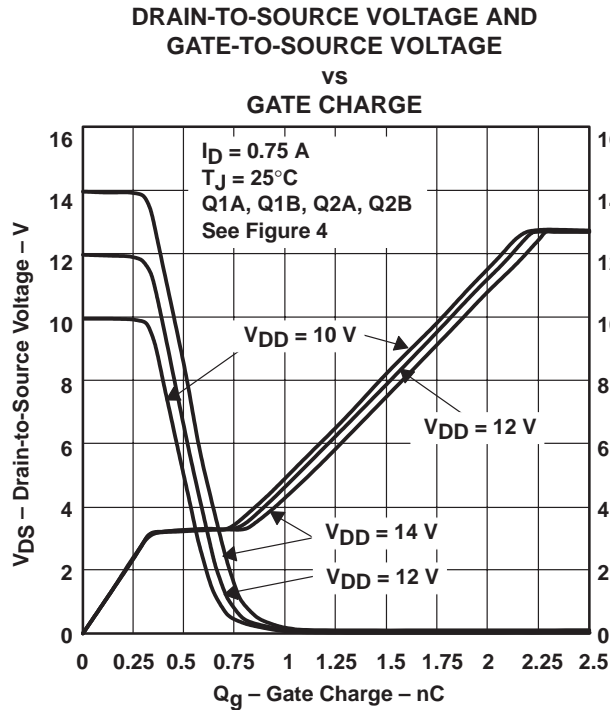


Figure 20

TYPICAL CHARACTERISTICS



TPIC1504

QUAD AND HEX POWER DMOS ARRAY

SLIS057 – OCTOBER 1996

THERMAL INFORMATION

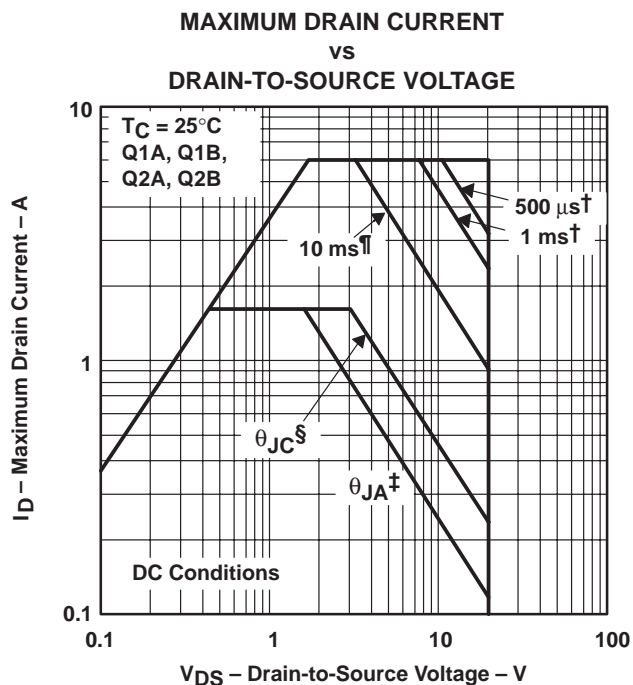


Figure 24

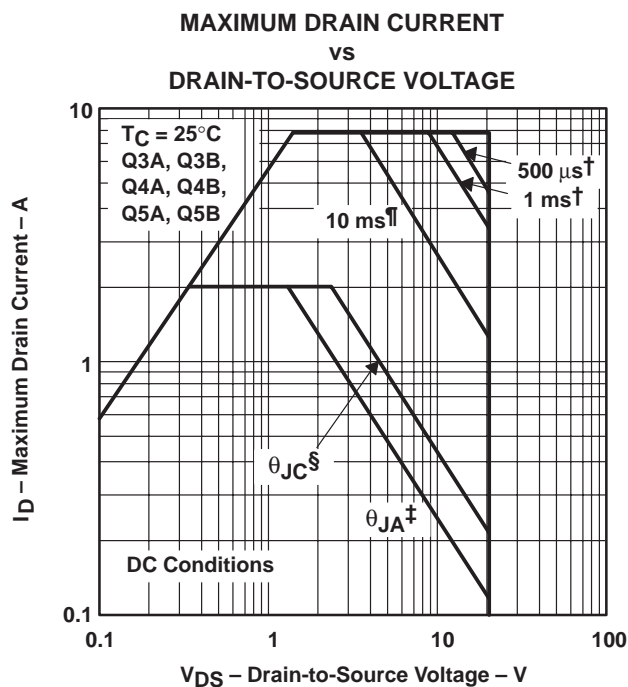


Figure 25

† Less than 10% duty cycle

‡ Device mounted on a 24-in², 4-layer FR4 printed-circuit board.

§ Device mounted in intimate contact with infinite heat sink.

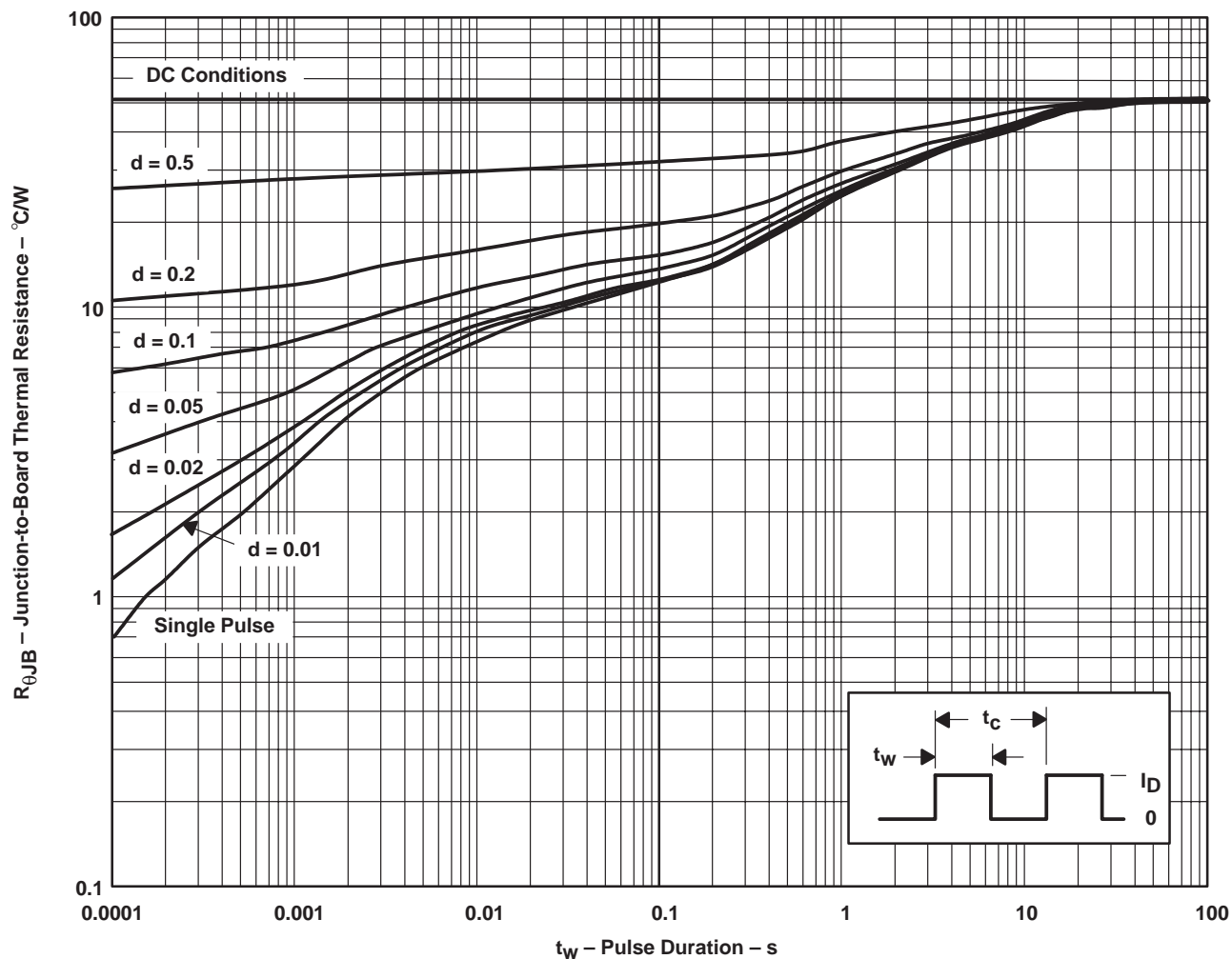
¶ Less than 2% duty cycle



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THERMAL INFORMATION

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



† Device is mounted on 24-in², 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

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