

TPIC5401

H-BRIDGE GATE-PROTECTED POWER DMOS ARRAY

SLIS024A – DECEMBER 1993 – REVISED MARCH 1994

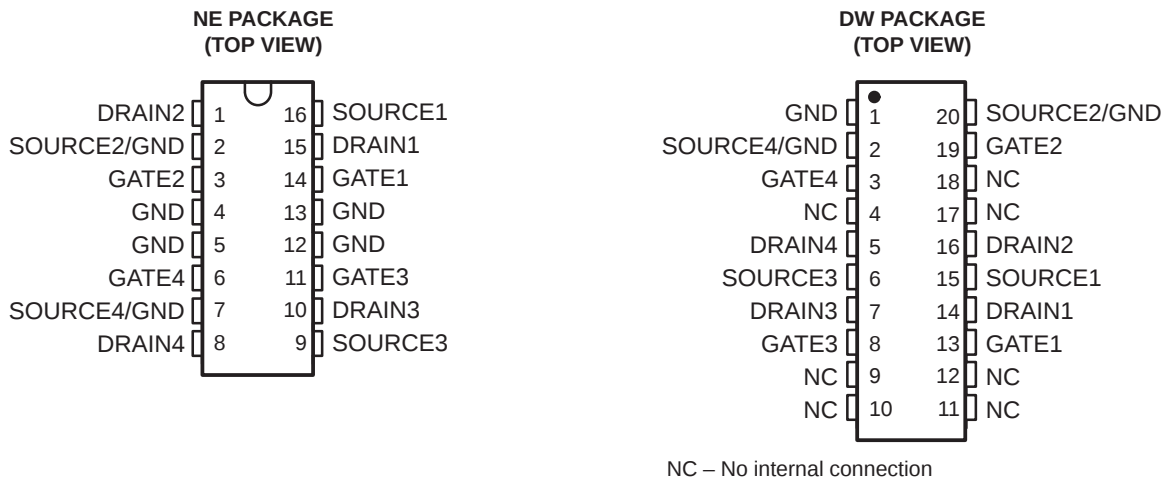
- Low $r_{DS(on)}$. . . 0.3 Ω Typ
- High Voltage Output . . . 60 V
- Extended ESD Capability . . . 4000 V

- Pulsed Current . . . 10 A Per Channel
- Fast Commutation Speed

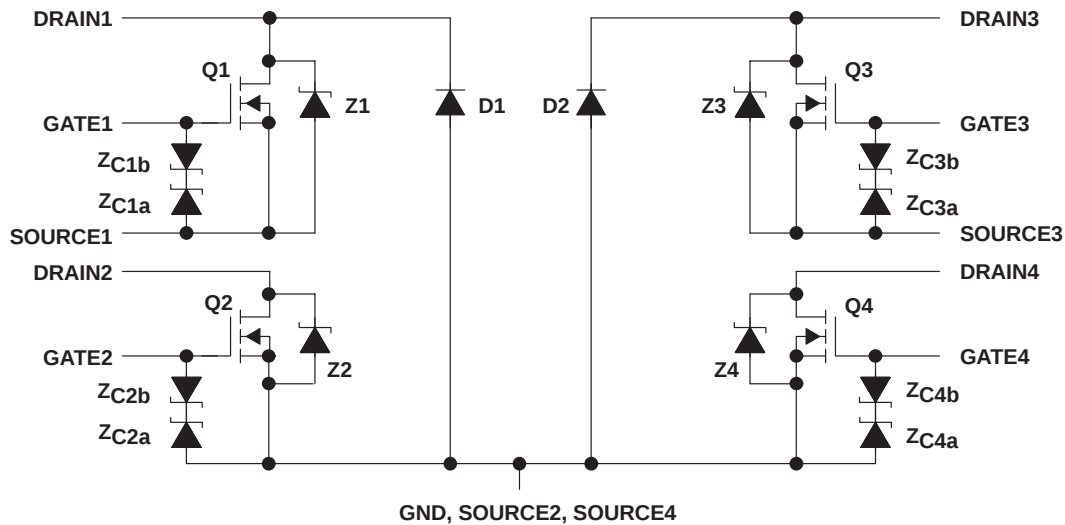
description

The TPIC5401 is a monolithic gate-protected power DMOS array that consists of four N-channel enhancement-mode DMOS transistors, two of which are configured with a common source. 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 Ω resistor.

The TPIC5401 is offered in a 16-pin thermally enhanced dual-in-line (NE) package and a 20-pin wide-body surface-mount (DW) package and is characterized for operation over the case temperature range of -40°C to 125°C .



schematic



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

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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 (Q1, Q3)	100 V
Drain-to-GND voltage (Q1, Q3)	100 V
Drain-to-GND voltage (Q2, Q4)	60 V
Gate-to-source voltage range, V_{GS}	–9 V to 18 V
Continuous drain current, each output, $T_C = 25^\circ\text{C}$: DW package	1.7 A
NE package	2 A
Continuous source-to-drain diode current, $T_C = 25^\circ\text{C}$	2 A
Pulsed drain current, each output, I_{max} , $T_C = 25^\circ\text{C}$ (see Note 1 and Figure 15)	10 A
Continuous gate-to-source zener-diode current, $T_C = 25^\circ\text{C}$	± 50 mA
Pulsed gate-to-source zener-diode current, $T_C = 25^\circ\text{C}$	± 500 mA
Single-pulse avalanche energy, E_{AS} , $T_C = 25^\circ\text{C}$ (see Figures 4, 15, and 16)	21 mJ
Continuous total dissipation	See Dissipation Rating Table
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,	–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.

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

DISSIPATION RATING TABLE

PACKAGE	$T_C \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_C = 25^\circ\text{C}$	$T_C = 125^\circ\text{C}$ POWER RATING
DW	1389 mW	11.1 mW/°C	279 mW
NE	2075 mW	16.6 mW/°C	415 mW

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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	1.85	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)	Drain-to-GND current = $250\ \mu\text{A}$		100			V
$V_{DS(on)}$	Drain-to-source on-state voltage	$I_D = 2\ \text{A}$, See Notes 2 and 3	$V_{GS} = 10\ \text{V}$,		0.6	0.7	V
$V_{F(SD)}$	Forward on-state voltage, source-to-drain	$I_S = 2\ \text{A}$, $V_{GS} = 0$ (Z1, Z2, Z3, Z4), See Notes 2 and 3 and Figure 12			1	1.2	V
V_F	Forward on-state voltage, GND-to-drain	$I_D = 2\ \text{A}$ (D1, D2), See Notes 2 and 3			7.5		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		μA
			$T_C = 125^\circ\text{C}$	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		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 2 and 3 and Figures 6 and 7	$T_C = 25^\circ\text{C}$	0.3	0.35		Ω
			$T_C = 125^\circ\text{C}$	0.47	0.5		
g_{fs}	Forward transconductance	$V_{DS} = 15\ \text{V}$, See Notes 2 and 3 and Figure 9	$I_D = 1\ \text{A}$,	1.6	1.9		S
C_{iss}	Short-circuit input capacitance, common source	$V_{DS} = 25\ \text{V}$, $f = 1\ \text{MHz}$,	$V_{GS} = 0$, See Figure 11	220	275		pF
C_{oss}	Short-circuit output capacitance, common source			120	150		
C_{rss}	Short-circuit reverse-transfer capacitance, common source			100	125		

NOTES: 2. Technique should limit $T_J - T_C$ to 10°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 A, V _{GS} = 0, See Figures 1 and 14	V _{DS} = 48 V, di/dt = 100 A/μs,	Z1 and Z3	120		ns
				Z2 and Z4	280		
				D1 and D2	260		
Q _{RR}	Total diode charge			Z1 and Z3	0.12		μC
				Z2 and Z4	0.9		
				D1 and D2	2.2		

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

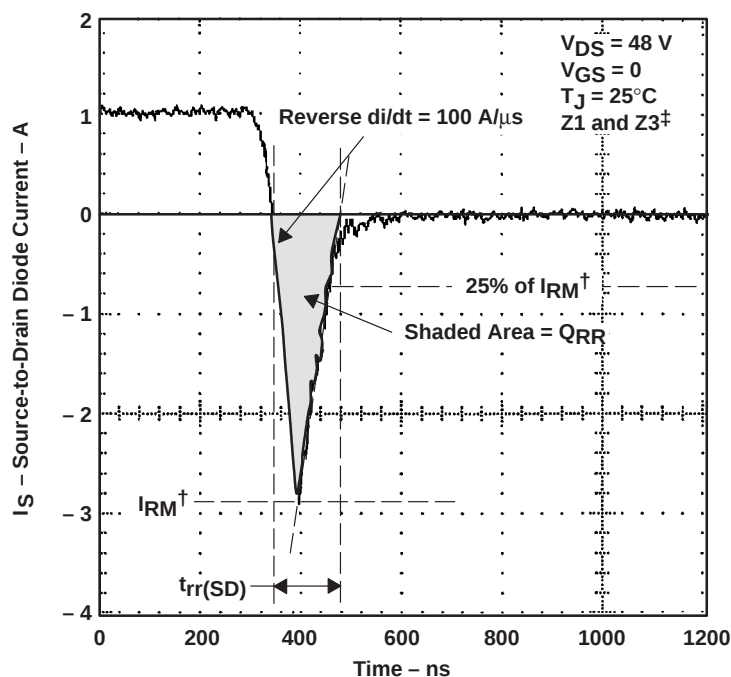
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{d(on)}$ Turn-on delay time	$V_{DD} = 25\text{ V}$, $R_L = 25\ \Omega$, $t_{en} = 10\text{ ns}$, $t_{dis} = 10\text{ ns}$, See Figure 2		32	65	ns
$t_{d(off)}$ Turn-off delay time			40	80	
t_r Rise time			15	30	
t_f Fall time			25	50	
Q_g Total gate charge	$V_{DS} = 48\text{ V}$, $I_D = 1\text{ A}$, $V_{GS} = 10\text{ V}$, See Figure 3		6.6	8	nC
$Q_{gs(th)}$ Threshold gate-to-source charge			0.8	1	
Q_{gd} Gate-to-drain charge			2.6	3.2	
L_d Internal drain inductance			5		nH
L_s Internal source inductance			5		
R_g Internal gate resistance			0.25		Ω

thermal resistances

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{\theta JA}$ Junction-to-ambient thermal resistance (see Note 4)	DW		90		$^\circ\text{C/W}$
	NE		60		
$R_{\theta JB}$ Junction-to-board thermal resistance	DW		53		
$R_{\theta JP}$ Junction-to-pin thermal resistance	DW		30		
	NE		25		
All outputs with equal power					

NOTE 4: Package mounted on an FR4 printed-circuit board with no heatsink.

PARAMETER MEASUREMENT INFORMATION

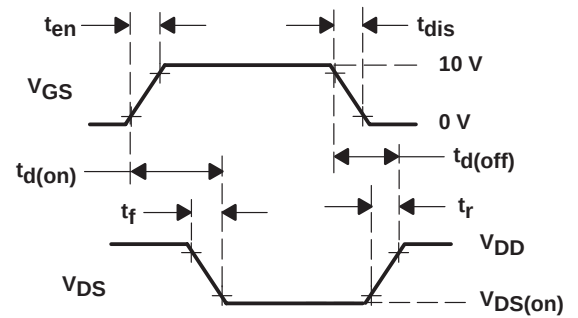
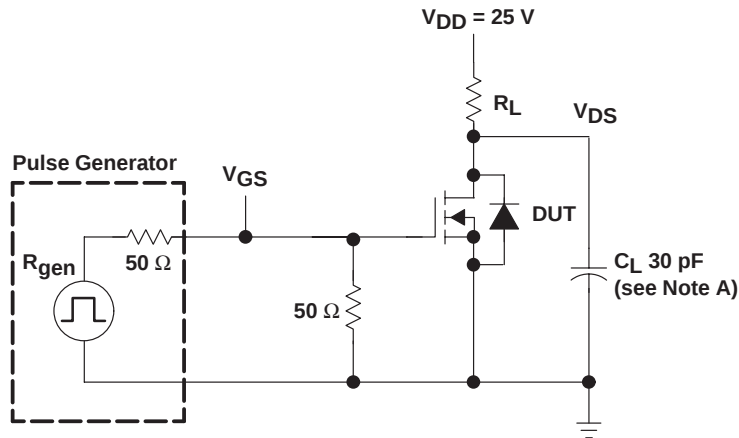


$^\dagger I_{RM}$ = maximum recovery current

‡ The above waveform is representative of Z2, Z4, D1, and D2 in shape only.

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

PARAMETER MEASUREMENT INFORMATION

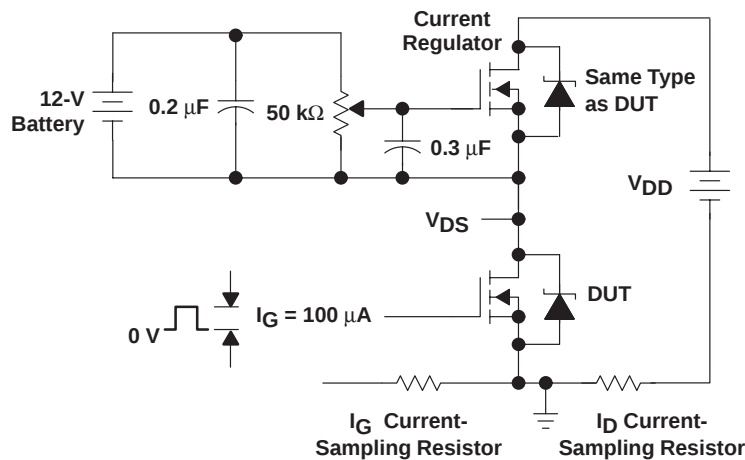


VOLTAGE WAVEFORMS

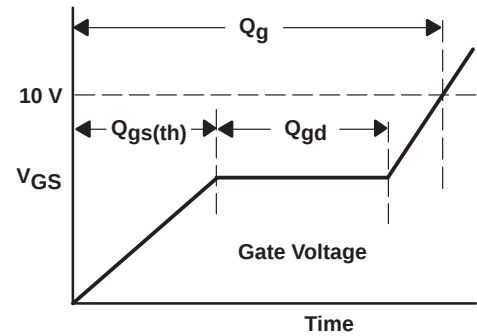
TEST CIRCUIT

NOTE A: C_L includes probe and jig capacitance.

Figure 2. Resistive-Switching Test Circuit and Voltage Waveforms



TEST CIRCUIT



WAVEFORM

Figure 3. Gate-Charge Test Circuit and Waveform

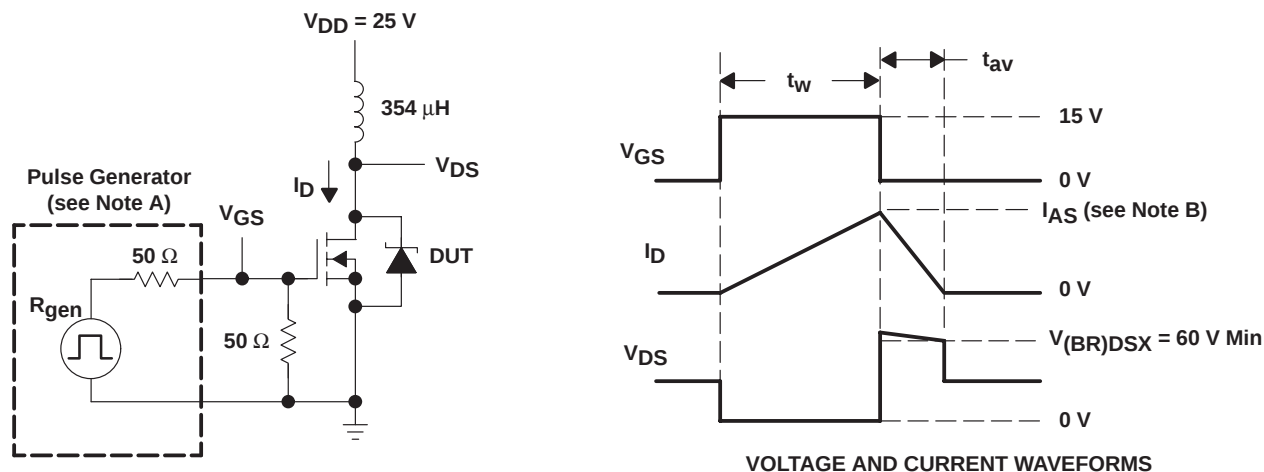
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PARAMETER MEASUREMENT INFORMATION



NOTES: A. The pulse generator has the following characteristics: $t_r \leq 10$ ns, $t_f \leq 10$ ns, $Z_O = 50 \Omega$.
B. Input pulse duration (t_w) is increased until peak current $I_{AS} = 10$ A.

$$\text{Energy test level is defined as } E_{AS} = \frac{I_{AS} \times V_{(BR)DSX} \times t_{av}}{2} = 21 \text{ mJ.}$$

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

TYPICAL CHARACTERISTICS

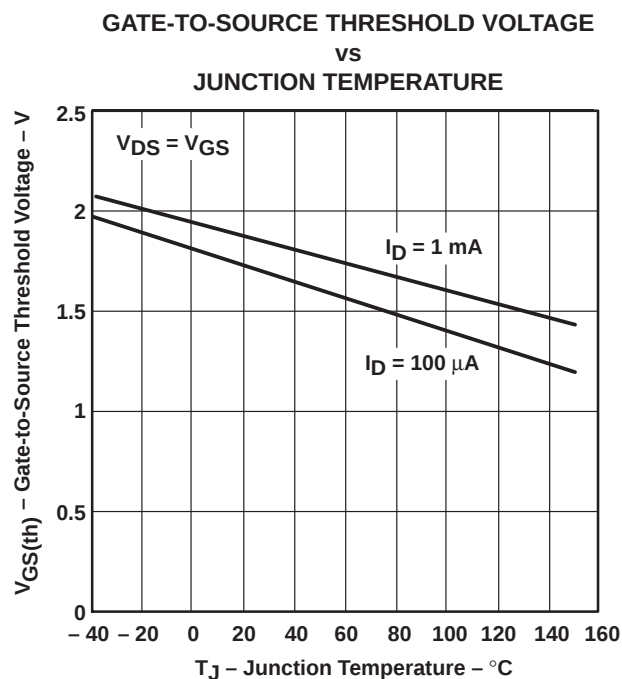


Figure 5

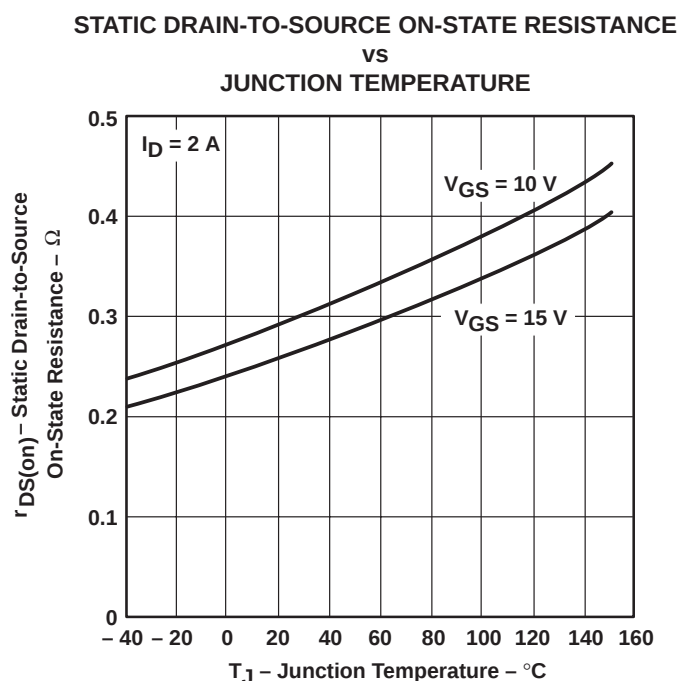


Figure 6

TYPICAL CHARACTERISTICS

STATIC DRAIN-TO-SOURCE ON-STATE RESISTANCE
vs
DRAIN CURRENT

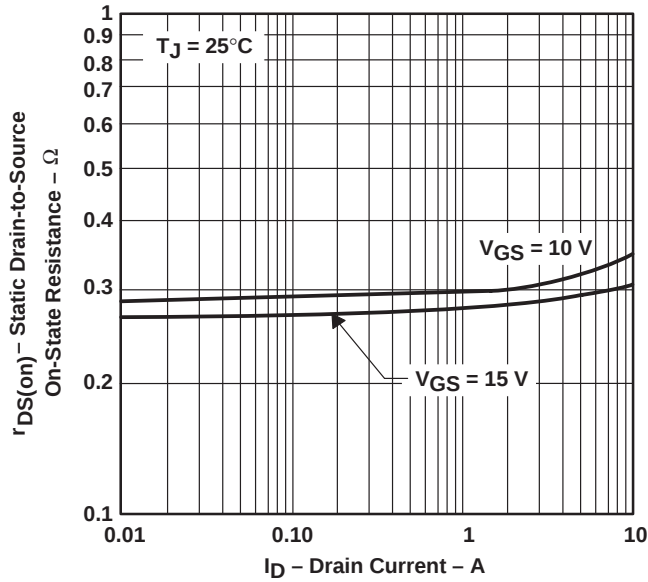


Figure 7

DRAIN CURRENT
vs
DRAIN-TO-SOURCE VOLTAGE

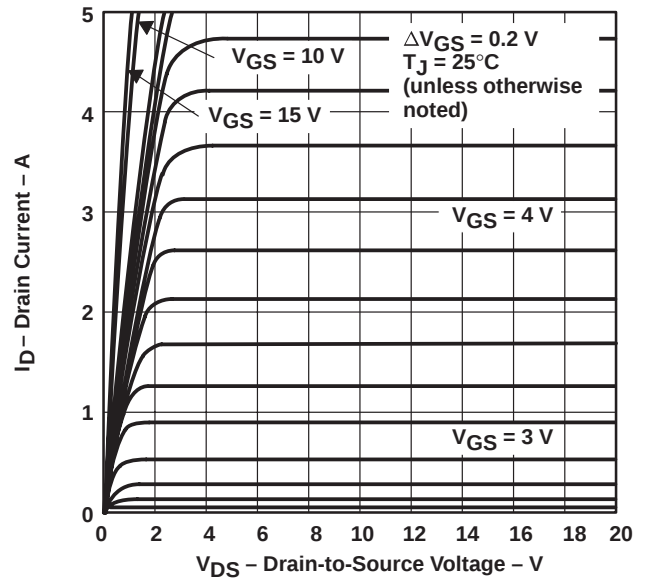


Figure 8

DISTRIBUTION OF
FORWARD TRANSCONDUCTANCE

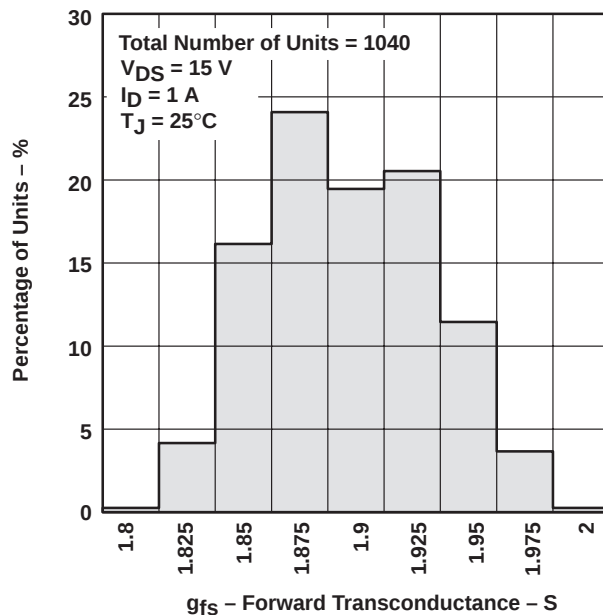


Figure 9

DRAIN CURRENT
vs
GATE-TO-SOURCE VOLTAGE

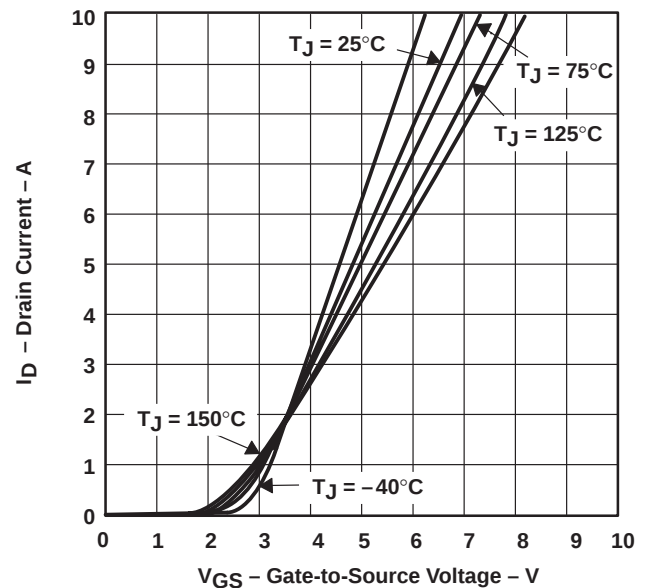


Figure 10

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TYPICAL CHARACTERISTICS

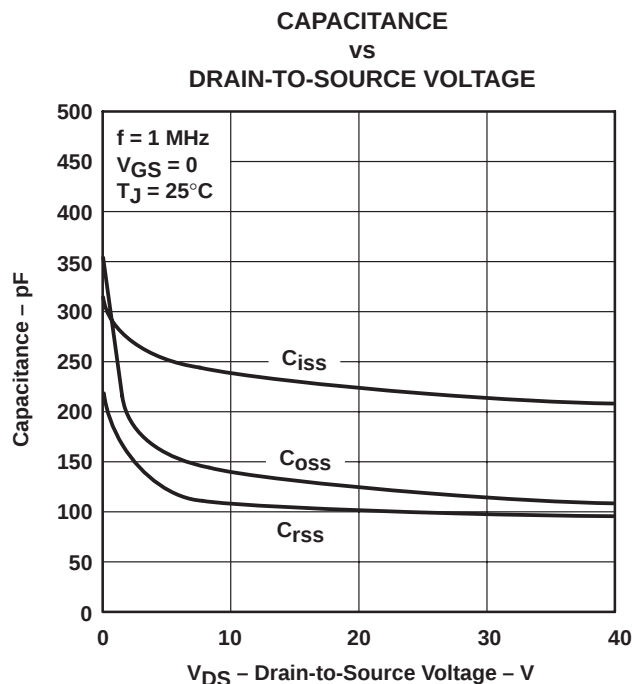


Figure 11

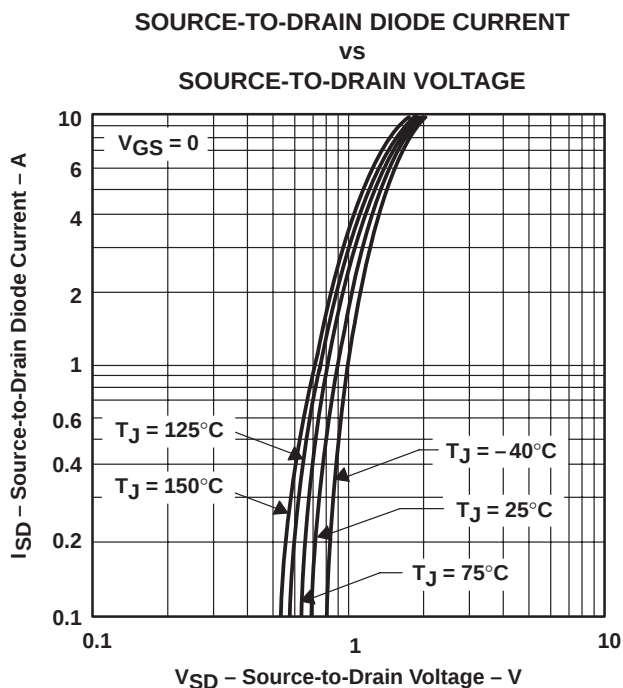


Figure 12

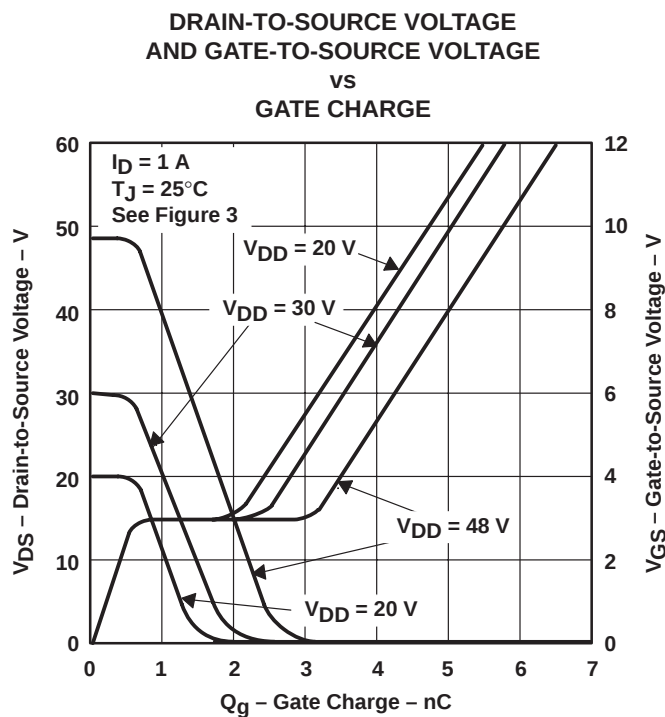


Figure 13

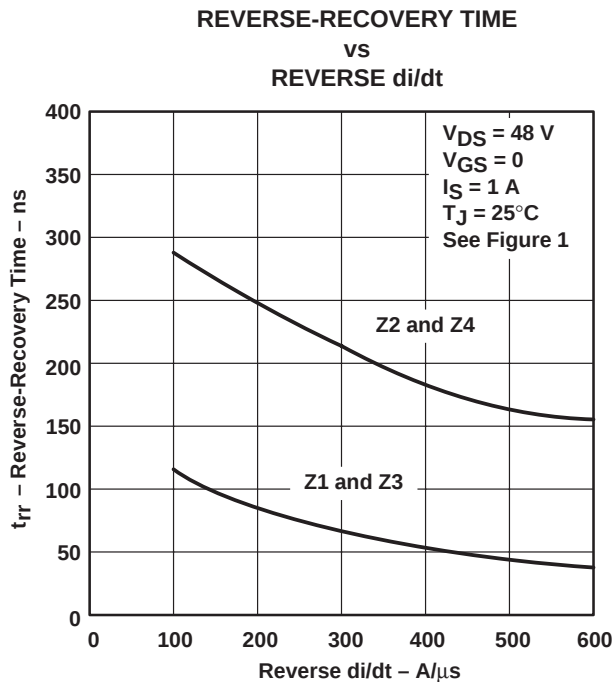
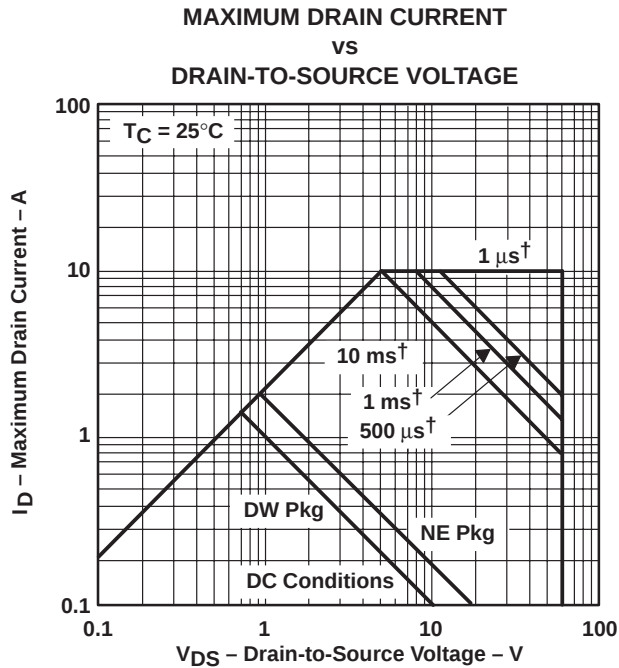


Figure 14

THERMAL INFORMATION



† Less than 2% duty cycle

Figure 15

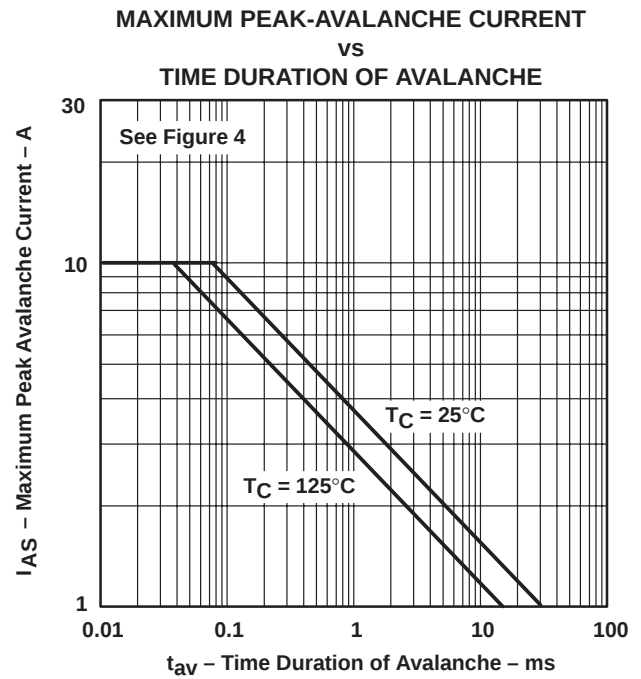


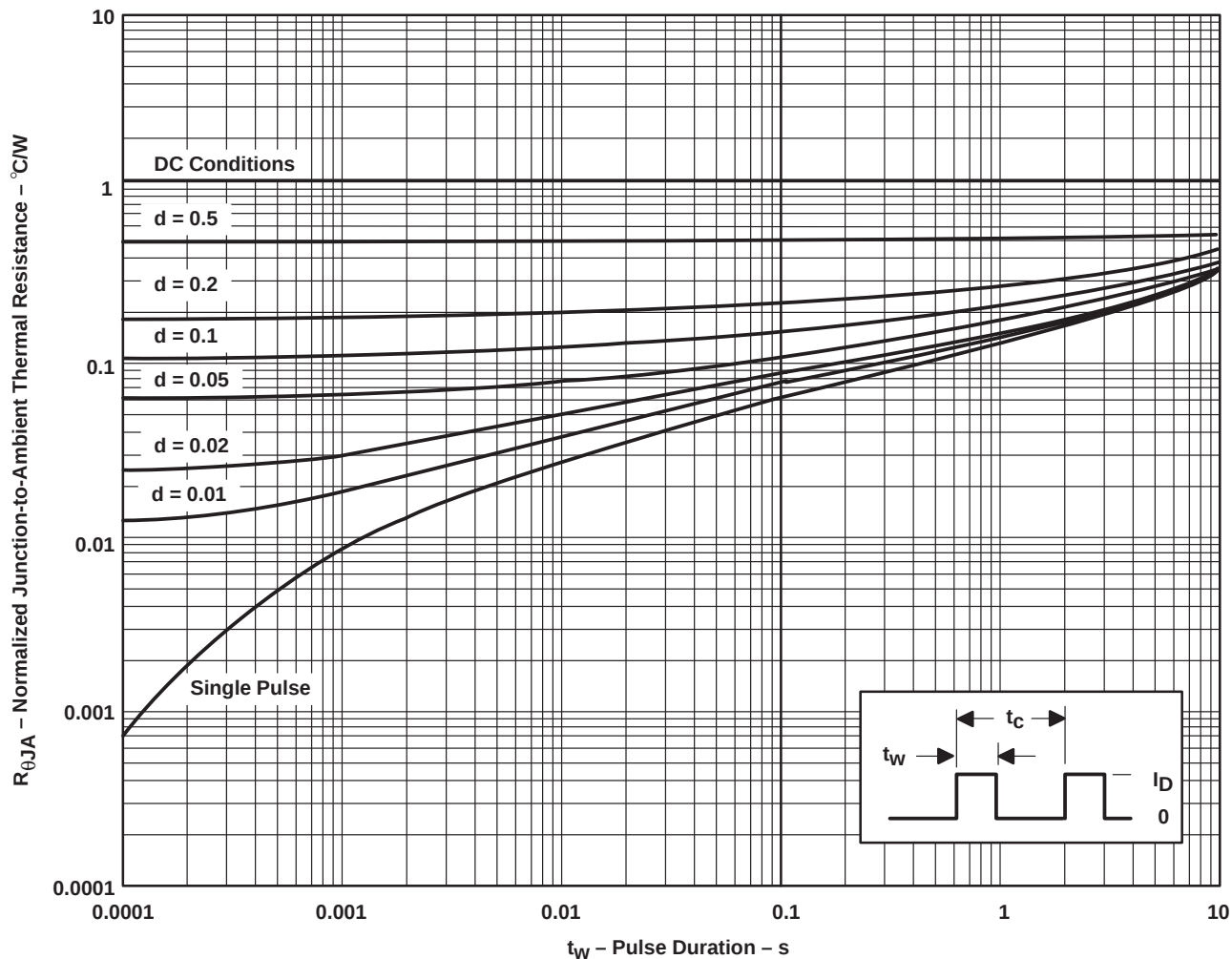
Figure 16

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THERMAL INFORMATION

NE PACKAGE[†]
 NORMALIZED JUNCTION-TO-AMBIENT THERMAL RESISTANCE
 VS
 PULSE DURATION



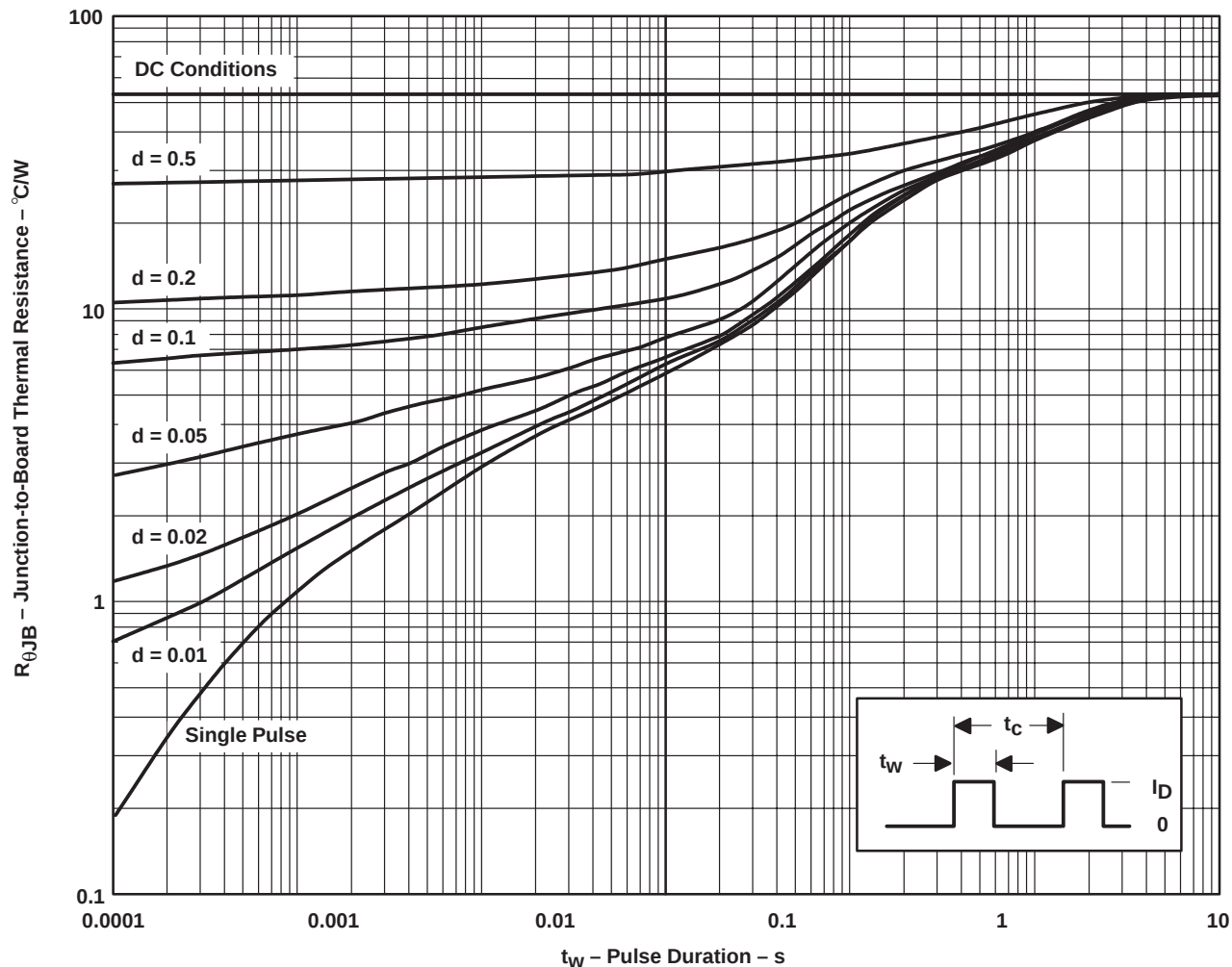
[†] Device mounted on FR4 printed-circuit board with no heatsink.

NOTE A: $Z_{\theta JA}(t) = r(t) R_{\theta JA}$
 t_W = pulse duration
 t_C = cycle time
 d = duty cycle = t_W/t_C

Figure 17

THERMAL INFORMATION

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



[†] Device mounted on 24 in², 4-layer FR4 printed-circuit board with no heatsink.

NOTE B: $Z_{\theta JB}(t) = r(t) R_{\theta JB}$

t_W = pulse duration

t_C = cycle time

d = duty cycle = t_W/t_C

Figure 18

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