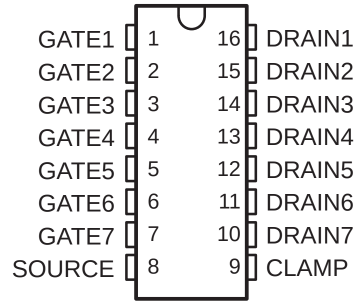
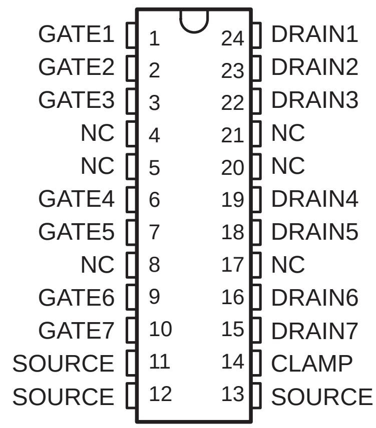
- **Seven 0.5-A Independent Output Channels**
- **Integrated Clamp Diode With Each Output**
- **Low $r_{DS(on)}$ . . . 0.5 Ω Typical**
- **Output Voltage . . . 60 V**
- **Pulsed Current . . . 3 A Per Channel**
- **Avalanche Energy . . . 22 mJ**

TPIC2701
N PACKAGE
(TOP VIEW)



TPIC2701M
J PACKAGE†
(TOP VIEW)



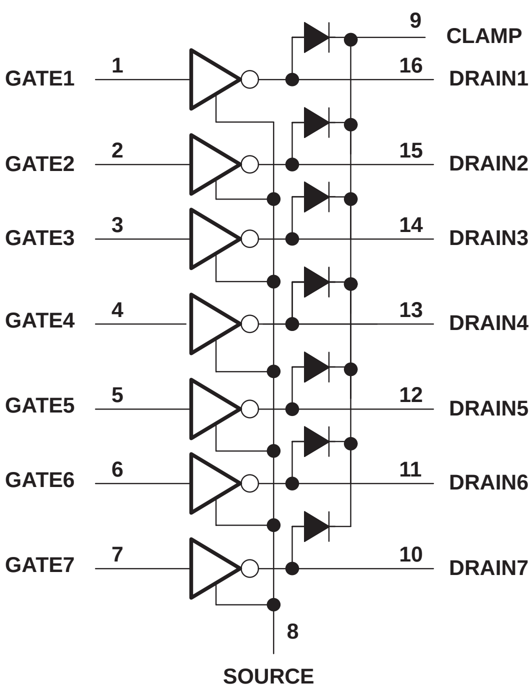
NC – No internal connection
† Refer to the mechanical data for the JW package.

description

The TPIC2701 is a monolithic power DMOS transistor array that consists of seven independent N-channel enhancement-mode DMOS transistors connected in a common-source configuration with open drains. The TPIC2701 is pin-for-pin functionally compatible with the Texas Instruments ULN2001A through ULN2004A.

The TPIC2701 is characterized for operation over a temperature range of 0°C to 125°C.The TPIC2701M is characterized for operation over the full military temperature range of –55°C to 125°C.

logic diagram



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.

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

Drain-source voltage, V_{DS} . . . . . 60 V
Gate-source voltage, V_{GS} . . . . . ±20 V
Clamp-drain voltage, V_{CD} . . . . . 60 V
Continuous source-drain diode current . . . . . 0.5 A
Pulsed drain current, each output, I_D (see Note 1 and Figure 17) . . . . . 3 A
Pulsed clamp current, I_{CL} (see Note 1 and Figure 18) . . . . . 3 A
Continuous drain current, each output, all outputs on . . . . . 0.5 A
Single-pulse avalanche energy, E_{AS} (see Figure 4) . . . . . 22 mJ
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating virtual junction temperature range, T_J: TPIC2701 . . . . . –40°C to 150°C
TPIC2701M . . . . . –55°C to 150°C
Operating case temperature range, T_C: TPIC2701 . . . . . –40°C to 125°C
TPIC2701M . . . . . –55°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: N Package . . . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: J Package . . . . . 300°C

NOTE 1: Pulse duration = 10 ms, duty cycle = 6%.

DISSIPATION RATING TABLE

PACKAGE	$T_A \le 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ POWER RATING
J	2660 mW	21.3 mW/°C	1701 mW	1382 mW	530 mW
N	1400 mW	11.0 mW/°C	905 mW	740 mW	300 mW

electrical characteristics, $T_C = 25°C$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS		TPIC2701 MIN	TPIC2701 TYP	TPIC2701 MAX	UNIT
$V_{(BR)DS}$	Drain-source breakdown voltage	$I_D = 1\ \mu A$, $V_{GS} = 0$		60			V
V_{TGS}	Gate-source threshold voltage	$I_D = 1$ mA, $V_{DS} = V_{GS}$		1.2	1.75	2.4	V
$V_{DS(on)}$	Drain-source on-state voltage	$I_D = 0.5$ A, $V_{GS} = 15$ V, See Notes 2 and 3			0.25	0.4	V
I_{DSS}	Zero-gate-voltage drain current	$V_{DS} = 48$ V, $V_{GS} = 0$	$T_C = 25°C$		0.05	1	µA
			$T_C = 125°C$		0.5	10	
I_{GSSF}	Forward gate current, drain short circuited to source	$V_{GS} = 20$ V, $V_{DS} = 0$			10	100	nA
I_{GSSR}	Reverse gate current, drain short circuited to source	$V_{GS} = -20$ V, $V_{DS} = 0$			10	100	nA
$r_{DS(on)}$	Forward drain-source on-state resistance	$V_{GS} = 15$ V, $I_D = 0.5$ A, See Notes 2 and 3 and Figures 5 and 6	$T_C = 25°C$		0.5	0.8	Ω
			$T_C = 125°C$		0.8	1.3	
g_{fs}	Forward transconductance	$V_{DS} = 15$ V, $I_D = 0.5$ A, See Notes 2 and 3		0.5	0.8		S
C_{iss}	Short-circuit input capacitance, common source	$V_{DS} = 25$ V, $V_{GS} = 0$, f = 300 kHz			105		pF
C_{oss}	Short-circuit output capacitance, common source				65		
C_{rss}	Short-circuit reverse transfer capacitance, common source				15		

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 with a single output transistor conducting.

electrical characteristics over case temperature operating range (unless otherwise noted) (see Note 4)

PARAMETER		TEST CONDITIONS	T_C†	TPIC2701M			UNIT
				MIN	TYP	MAX	
$V_{(BR)DS}$	Drain-to-source breakdown voltage	I_D = 1 µA, V_{GS} = 0	25°C	60			V
		I_D = 1 mA, V_{GS} = 0	Full range				
V_{TGS}	Gate-to-source input threshold voltage	I_D = 1 mA, $V_{DS} = V_{GS}$	Full range	1.2	1.75	2.4	V
$V_{DS(on)}$	Drain-to-source on-state voltage	I_D = 0.5 A, V_{GS} = 15 V	25°C		0.25	0.45	V
			Full range			0.65	
I_{DSS}	Zero-gate-voltage drain current	V_{DS} = 48 V, V_{GS} = 0	25°C		0.05	1	µA
			Full range			10	
I_{GSSF}	Forward gate current, drain short-circuited to source	V_{GS} = 20 V, V_{DS} = 0	25°C		10	100	nA
			Full range			10	µA
I_{GSSR}	Reverse gate current, drain short-circuited to source	V_{GS} = –20 V, V_{DS} = 0	25°C		10	100	nA
			Full range			10	µA
$r_{DS(on)}$	Forward drain-source on-state resistance	V_{GS} = 15 V, I_D = 0.5 A	25°C		0.5	0.9	Ω
			Full range			1.3	
g_{fs}	Forward transconductance	V_{DS} = 15 V, I_D = 0.5 A	25°C		0.8		S
C_{iss}	Short-circuit input capacitance, common source	V_{DS} = 25 V, V_{GS} = 0, f = 300 kHz	Full range		105		pF
C_{oss}	Short-circuit output capacitance, common source				65		
C_{rss}	Short-circuit reverse transfer capacitance, common source				15		

† Full range is –55°C to 125°C.

NOTE 4: Pulse testing techniques are used to maintain the virtual junction temperature as close to the case temperature as possible. Thermal effects must be taken into account separately.

source-drain diode characteristics, T_C = 25°C

PARAMETER		TEST CONDITIONS	TPIC2701			UNIT
			MIN	TYP	MAX	
V_{SD}	Forward On voltage	I_S = 0.5 A, V_{GS} = 0		0.9	1.4	V
$t_{rr(SD)}$	Reverse-recovery time	I_S = 0.5 A, V_{GS} = 0, V_{DS} = 48 V, di/dt = 25 A/µs, See Figure 1		165		ns
Q_{RR}	Total source-drain diode charge			250		nC

source-to-drain diode characteristics over operating case temperature range (unless otherwise noted) (see Note 4)

PARAMETER		TEST CONDITIONS	TPIC2701M			UNIT
			MIN	TYP	MAX	
V_{SD}	Forward On voltage	I_S = 0.5 A, V_{GS} = 0		0.9	1.4	V
t_{rr}	Reverse recovery time	I_S = 0.5 A, V_{GS} = 0, V_{DS} = 48 V, di/dt = 25 A/µs, T_C = 25°C, See Figure 1		165		ns
Q_{RR}	Total source-to-drain diode charge			250		nC

NOTE 4: Pulse testing techniques are used to maintain the virtual junction temperature as close to the case temperature as possible. Thermal effects must be taken into account separately.

clamp diode characteristics, T_C = 25°C

PARAMETER		TEST CONDITIONS	TPIC2701			UNIT
			MIN	TYP	MAX	
V_F	Forward on-voltage	I_F = 0.5 A		1	1.5	V
V_{BR}	Breakdown voltage	I_R = 1 µA	60			V
I_R	Reverse leakage current	V_R = 48 V		0.05	1	µA
$t_{rr(CD)}$	Reverse-recovery time	I_F = 0.1 A, di/dt = 25 A/µs, V_{CD} = 48 V, See Figure 1		90		ns
Q_{RR}	Total source-drain diode charge			100		nC

clamp diode characteristics over operating case temperature range (unless otherwise noted) (see Note 4)

PARAMETER		TEST CONDITIONS		TPIC2701M			UNIT
				MIN	TYP	MAX	
V_F	Forward voltage	I_F = 0.5 A			1	1.5	V
$V_{(BR)}$	Breakdown voltage	I_R = 1 µA,	T_C = 25°C	60			V
		I_R = 1 mA					
I_R	Reverse leakage current	V_R = 48 V	T_C = 25°C		0.05	1	µA
						10	
$t_{rr(SD)}$	Reverse recovery time, source-to-drain	I_F = 0.1 A, di/dt = 25 A/µs, T_C = 25°C, V_{CD} = 48 V, See Figure 1			90		ns
Q_{RR}	Total source-to-drain diode charge				100		nC

NOTE 4: Pulse testing techniques are used to maintain the virtual junction temperature as close to the case temperature as possible. Thermal effects must be taken into account separately.

resistive-load switching characteristics, T_C = 25°C

PARAMETER		TEST CONDITIONS	TPIC2701			UNIT
			MIN	TYP	MAX	
$t_{d(on)}$	Turn-on delay time	V_{DD} = 25 V, R_L = 100 Ω, t_{en} = 10 ns, t_{dis} = 10 ns, See Figure 2		10		ns
$t_{d(off)}$	Turn-off delay time			30		
t_r	Rise time			15		
t_f	Fall time			5		
Q_g	Total gate charge	V_{DS} = 48 V, I_D = 0.25 A, V_{GS} = 10 V, See Figure 3		2.8	3.6	nC
Q_{gs}	Gate-source charge			1.6	2	
Q_{gd}	Gate-drain charge			1.2	1.6	

resistive-load switching characteristics over operating case temperature range (unless otherwise noted) (see Note 4)

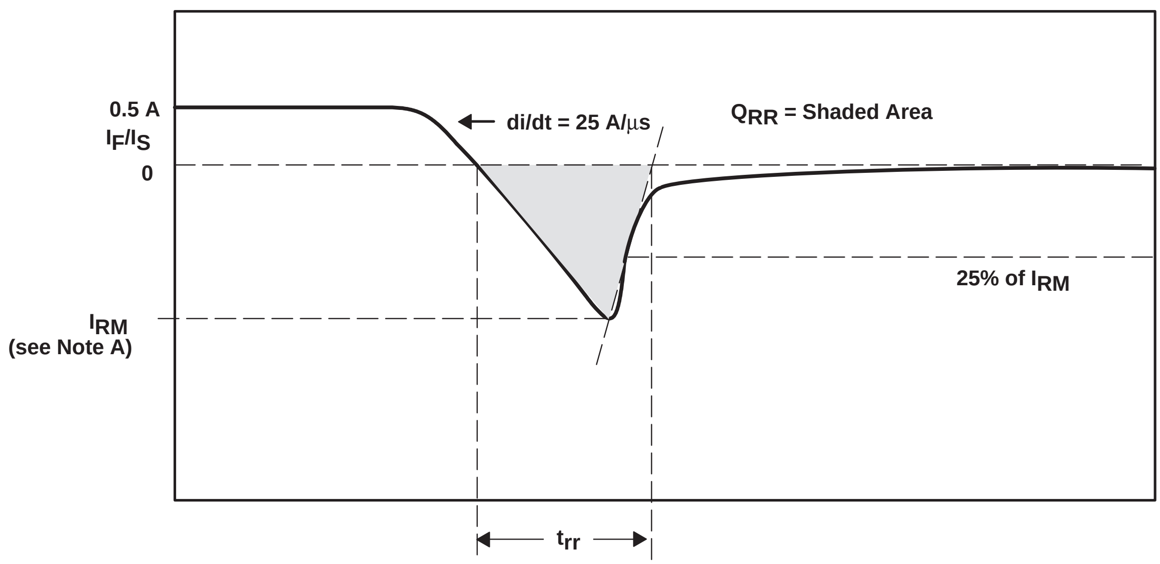
PARAMETER		TEST CONDITIONS	TPIC2701M MIN	TPIC2701M TYP	TPIC2701M MAX	UNIT
$t_{d(on)}$	Turn-on delay time	V_{DD} = 25 V, R_L = 100 Ω, t_{en} = 10 ns, t_{dis} = 10 ns, See Figure 2		10		ns
$t_{d(off)}$	Turn-off delay time			30		
t_r	Rise time			15		
t_f	Fall time			5		
Q_g	Total gate charge	V_{DS} = 48 V, I_D = 0.25 A, V_{GS} = 10 V, See Figure 3		2.8		nC
Q_{gs}	Gate-to-source charge			1.6		
Q_{gd}	Gate-to-drain charge			1.2		

NOTE 4: Pulse testing techniques are used to maintain the virtual junction temperature as close to the case temperature as possible. Thermal effects must be taken into account separately.

thermal resistance

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	N package with all outputs at equal power			90	°C/W
		J package with all outputs at equal power			66	

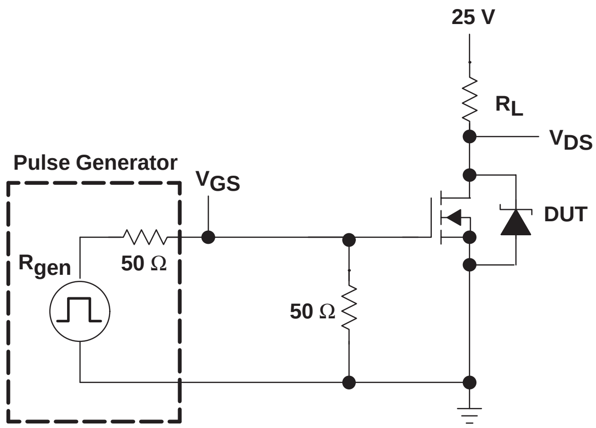
PARAMETER MEASUREMENT INFORMATION



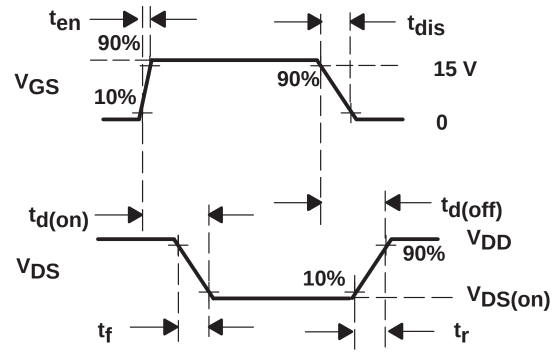
NOTE A: I_{RM} = maximum recovery current

Figure 1. Reverse-Recovery-Current Waveforms of Source-Drain and Clamp Diodes

PARAMETER MEASUREMENT INFORMATION

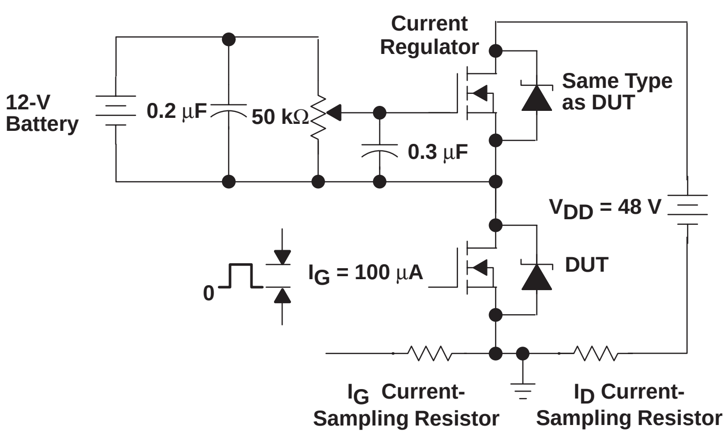


TEST CIRCUIT

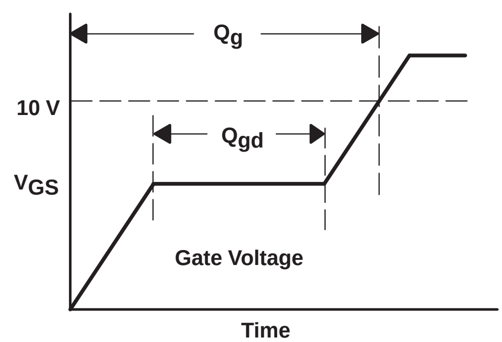


VOLTAGE WAVEFORM

Figure 2. Resistive Switching



TEST CIRCUIT

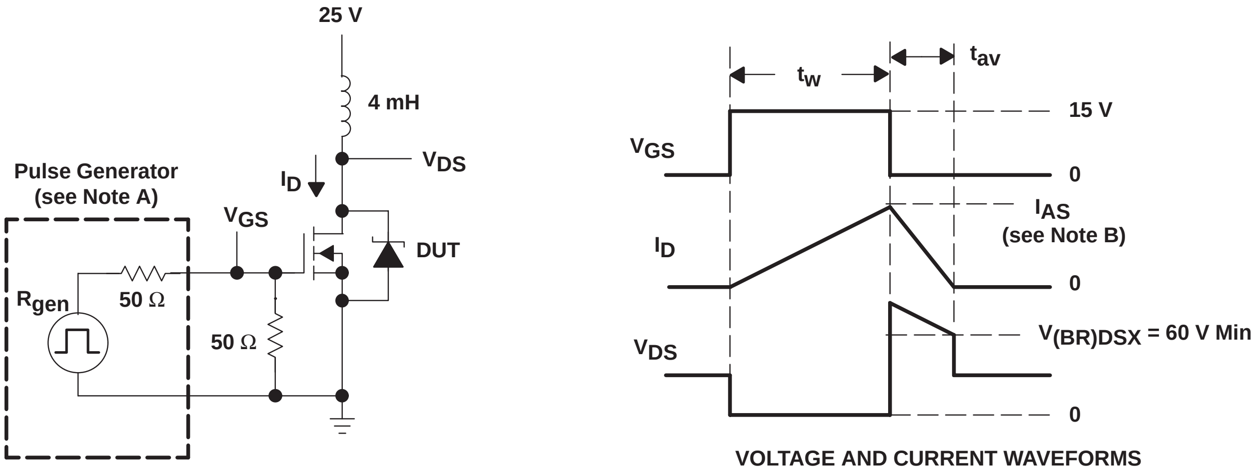


$Q_{gs} = Q_g - Q_{gd}$

WAVEFORM

Figure 3. Gate Charge Test Circuit and Waveform

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

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 $I_{AS} = 2.5$ A.

Energy test level is defined as $E_{AS} = \dfrac{I_{AS} \times V_{(BR)DSX} \times t_{av}}{2} = 22$ mJ min.

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

TYPICAL CHARACTERISTICS

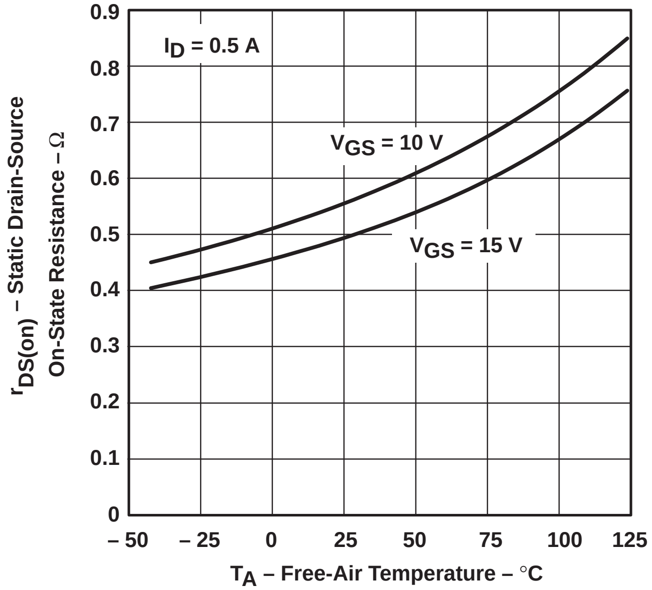


Figure 5

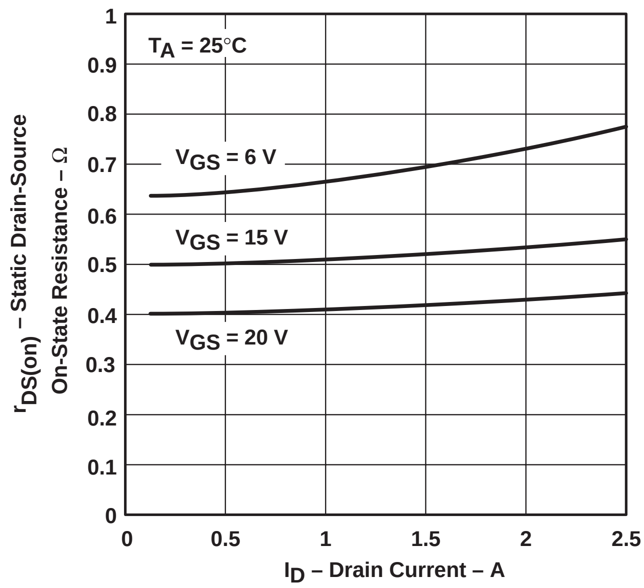


Figure 6

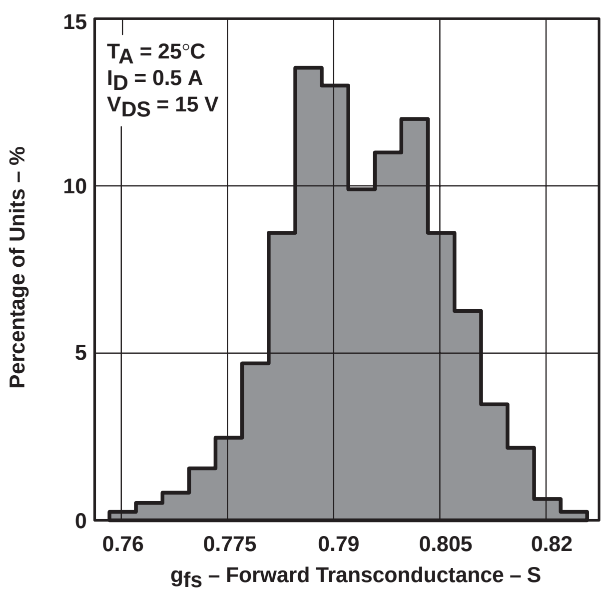


Figure 7

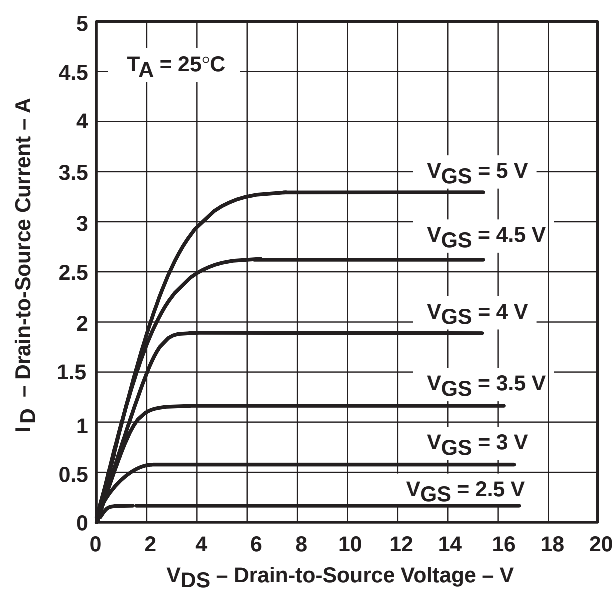


Figure 8

TYPICAL CHARACTERISTICS

GATE-SOURCE THRESHOLD VOLTAGE
vs
FREE-AIR TEMPERATURE

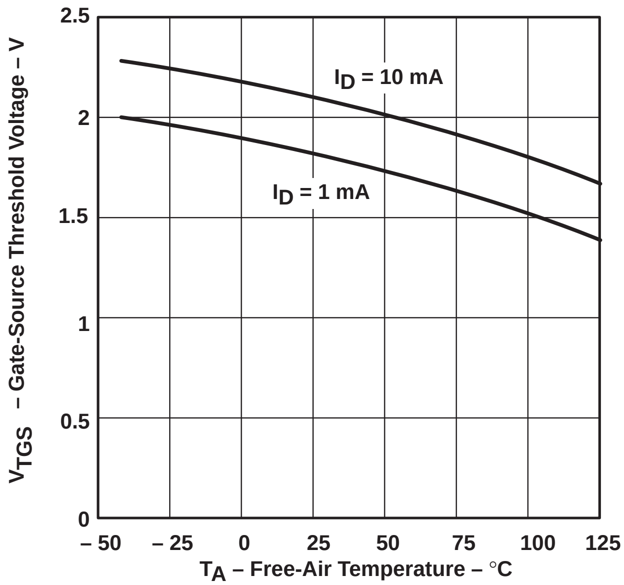


Figure 9

GATE-SOURCE VOLTAGE
vs
GATE CHARGE

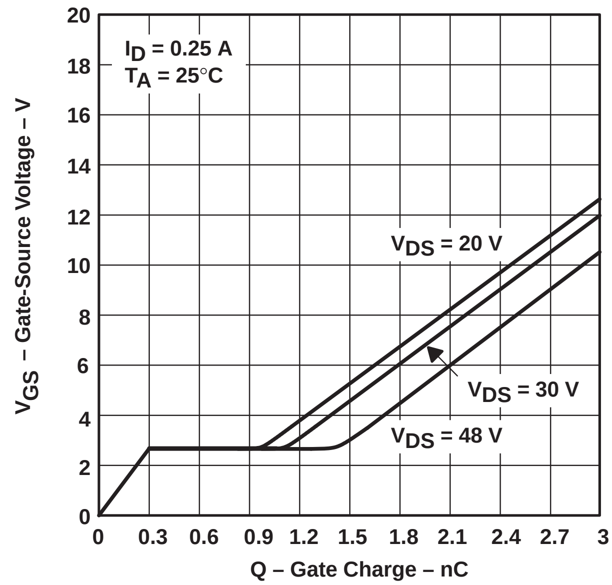


Figure 10

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

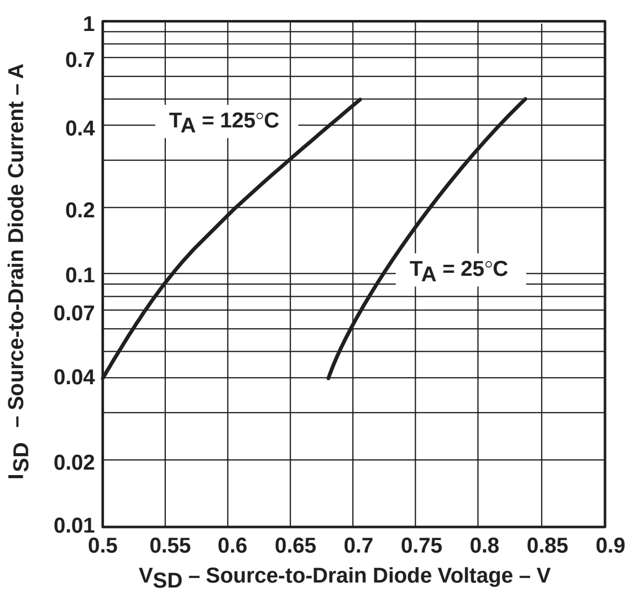


Figure 11

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

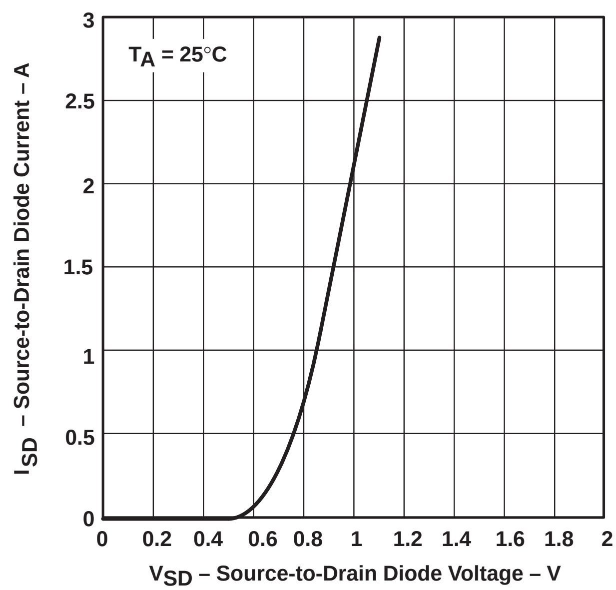


Figure 12

TYPICAL CHARACTERISTICS

CLAMP-DIODE CURRENT vs CLAMP-DIODE VOLTAGE

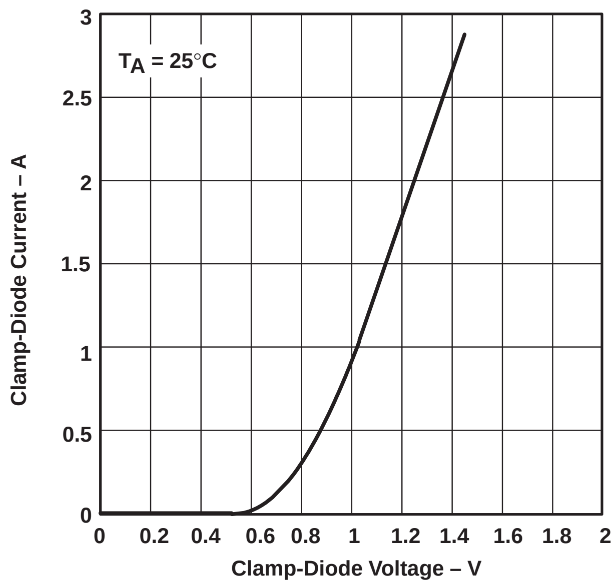


Figure 13

CLAMP-DIODE REVERSE RECOVERY TIME vs REVERSE di/dt

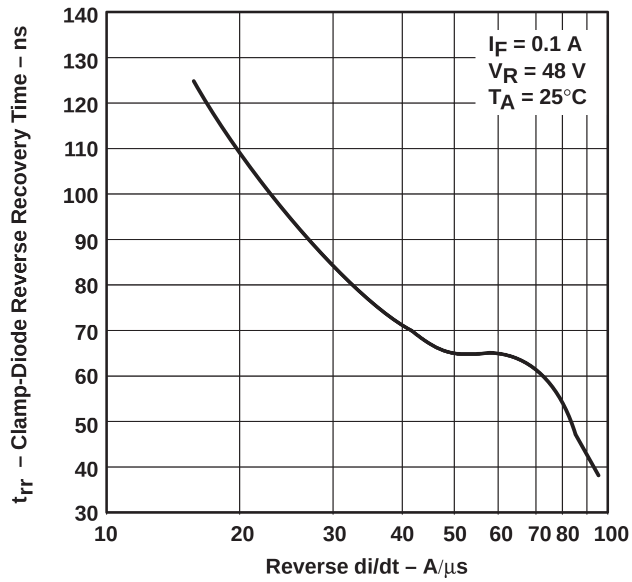
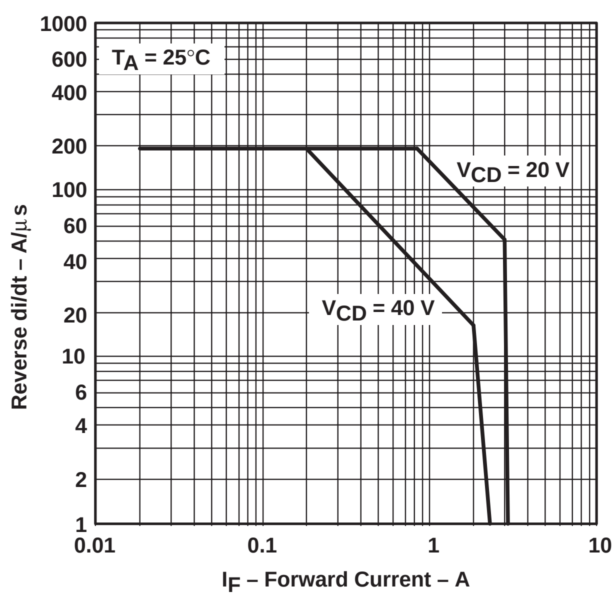


Figure 14

REVERSE di/dt vs FORWARD CURRENT



NOTE A: $V_{CD} = V_{clamp} – V_{drain}$

Figure 15

TYPICAL CHARACTERISTICS

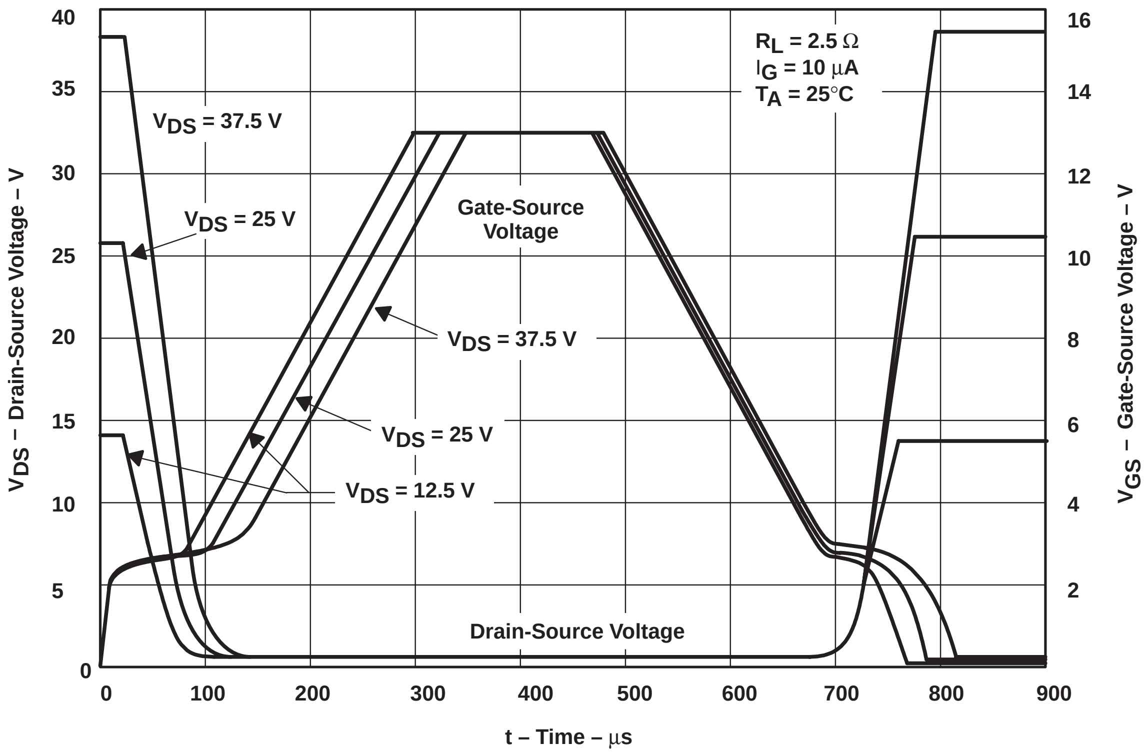


Figure 16. Resistive Switching Waveforms

THERMAL INFORMATION

MAXIMUM DRAIN CURRENT
vs
DUTY CYCLE

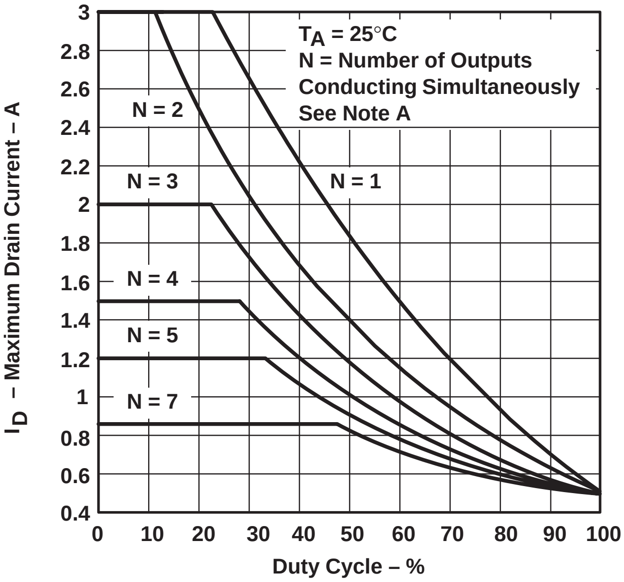


Figure 17

MAXIMUM CLAMP-DIODE CURRENT
vs
DUTY CYCLE

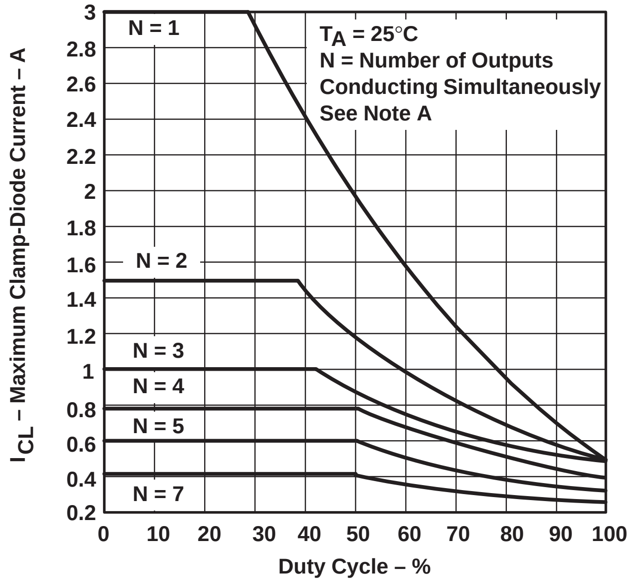
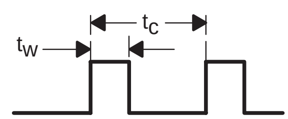


Figure 18

NOTE A: For Figures 17 and 18, d = t_W/t_C = 10 ms / t_C, where t_W and t_C are defined by the following:



PEAK AVALANCHE CURRENT
vs
TIME DURATION OF AVALANCHE

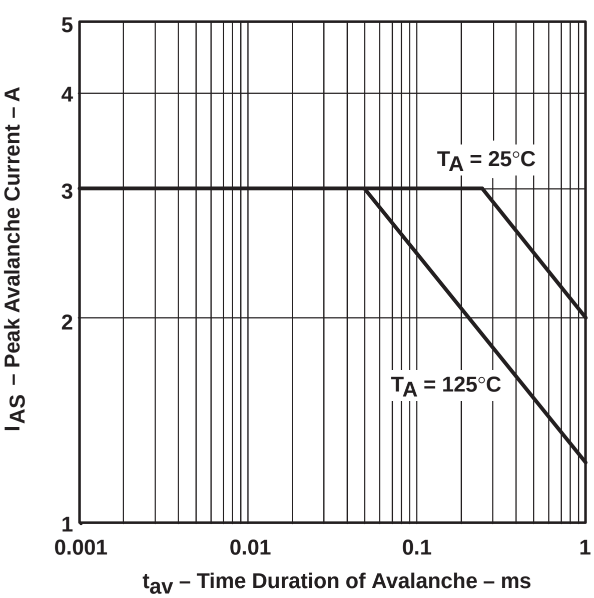


Figure 19

MAXIMUM DRAIN CURRENT
vs
DRAIN-SOURCE VOLTAGE

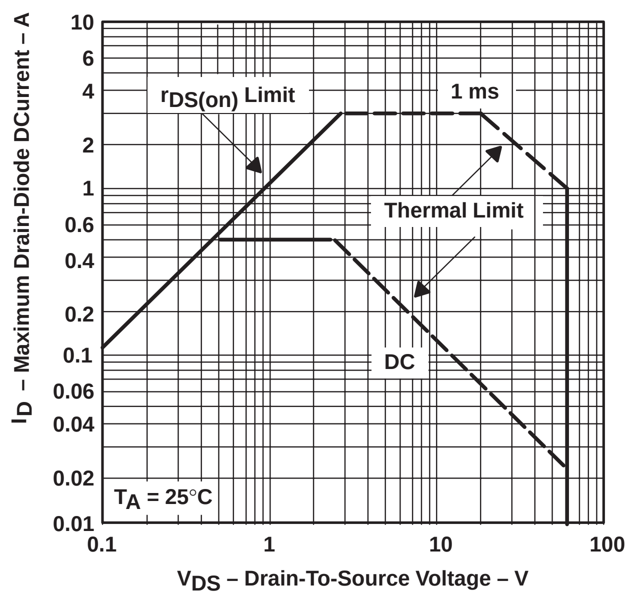
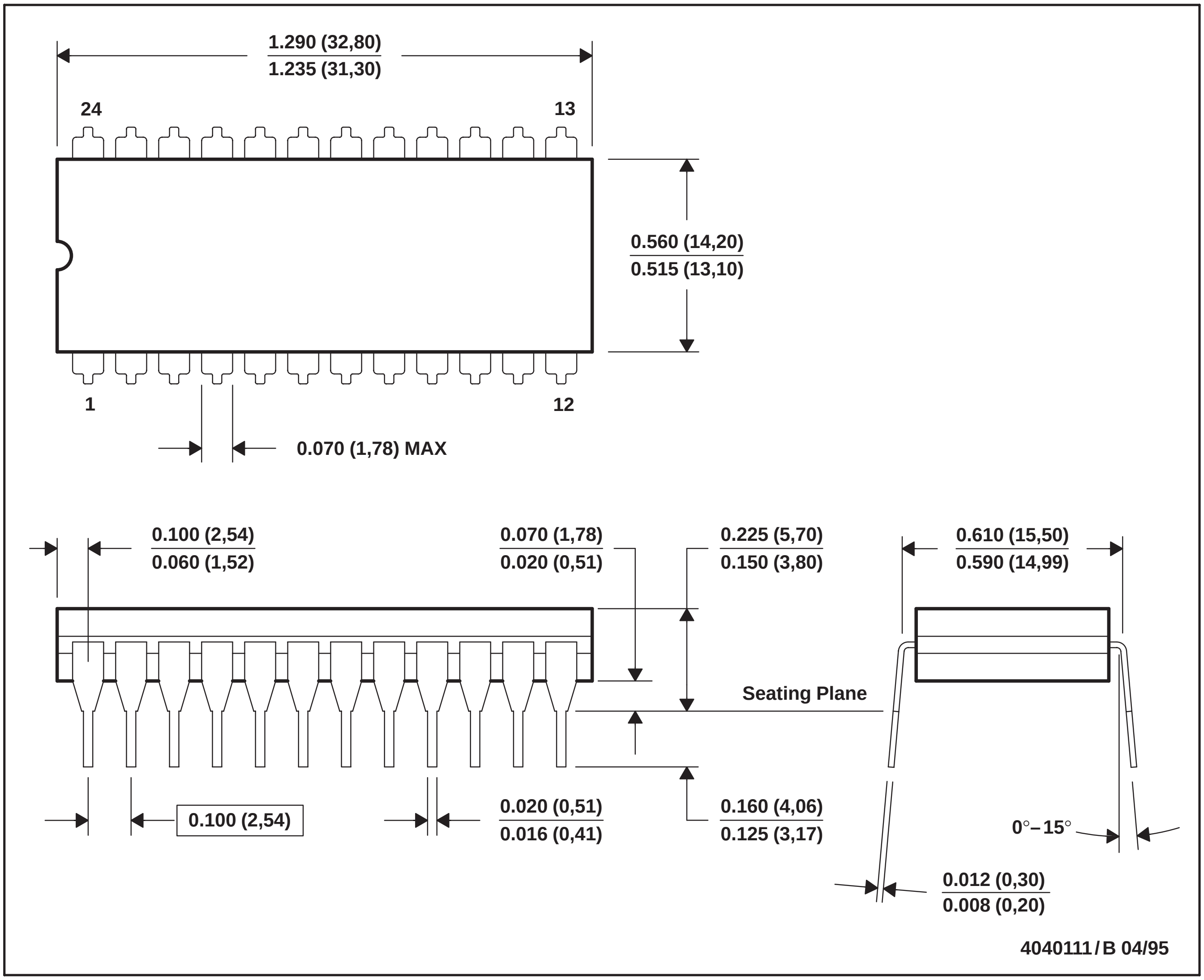


Figure 20

MECHANICAL INFORMATION

JW (R-GDIP-T24) **CERAMIC DUAL-IN-LINE PACKAGE**



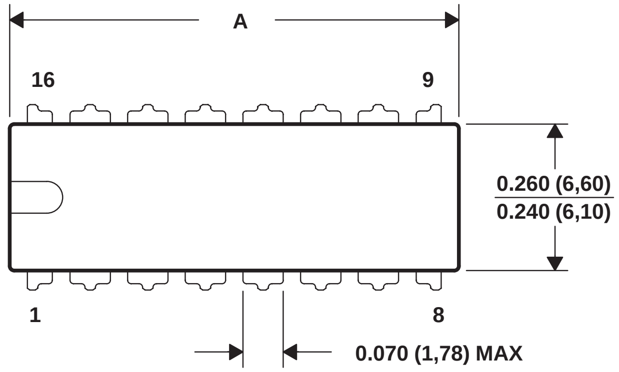
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only
E. Falls within MIL-STD-1835 GDIP5-T24

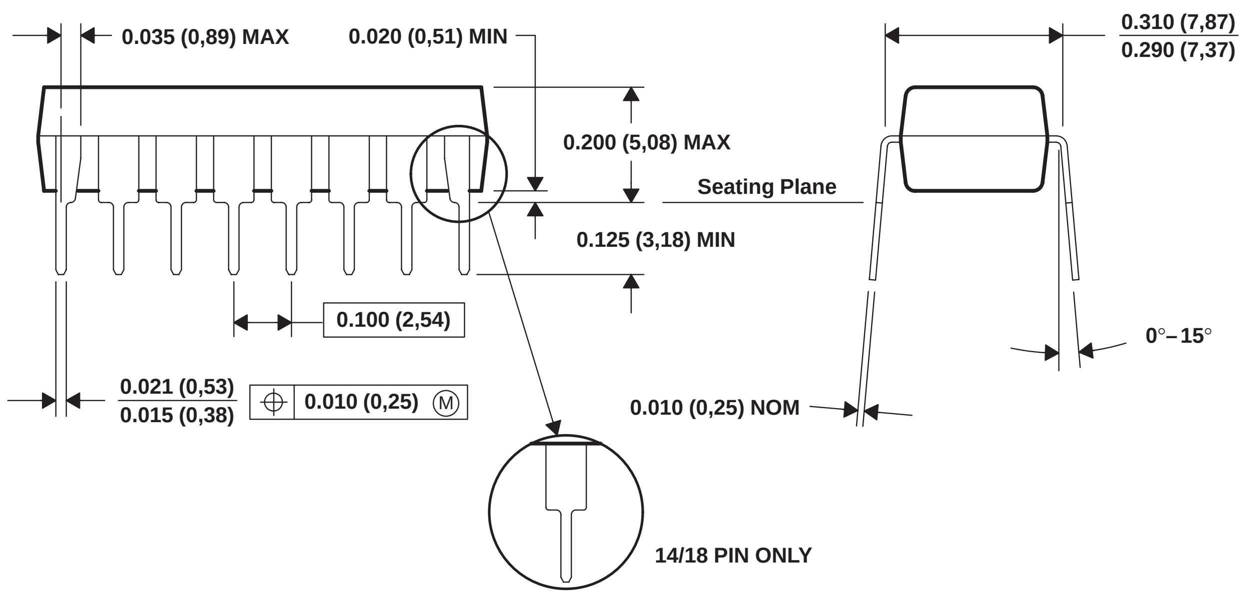
MECHANICAL INFORMATION

N (R-PDIP-T)** **PLASTIC DUAL-IN-LINE PACKAGE**

16 PIN SHOWN

DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23.37)	0.975 (24,77)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21.59)	0.940 (23,88)





4040049/C 08/95

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 (20 pin package is shorter then MS-001.)

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