**NE PACKAGE** 

(TOP VIEW)

SLIS094A - MARCH 2000 - REVISED MAY 2005

- Low r<sub>DS(on)</sub> . . . 1 Ω Typ
- Output Short-Circuit Protection
- Avalanche Energy . . . 75 mJ
- Eight 350-mA DMOS Outputs
- 50-V Switching Capability
- Enhanced Cascading for Multiple Stages
- All Registers Cleared With Single Input
- Low Power Consumption

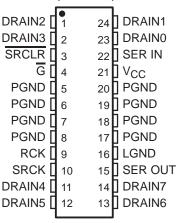
### description

The TPIC6A596 is a monolithic, high-voltage, high-current power logic 8-bit shift register designed for use in systems that require relatively high load power. The device contains a built-in voltage clamp on the outputs for inductive transient protection. Power driver applications include relays, solenoids, and other medium-current or high-voltage loads. Each open-drain DMOS transistor features an independent chopping current-limiting circuit to prevent damage in the case of a short circuit.

This device contains an 8-bit serial-in, parallel-out shift register that feeds an 8-bit, D-type storage register. Data transfers through both the shift and storage registers on the rising edge of the shift-register clock (SRCK) and the register clock (RCK), respectively. The storage register transfers data to the output buffer when shift-

20 DRAIN1 DRAIN2 DRAIN3 🛚 2 19 DRAN0 SRCLR 3 18 SER IN G [] 4 17 V<sub>CC</sub> PGND **∏** 5 16 PGND PGND 6 15 PGND RCK **∏** 7 14 ∏ LGND SRCK [] 8 13 SER OUT DRAIN4 [] 9 12 DRAIN7 DRAIN5 10 11 DRAIN6

#### DW PACKAGE (TOP VIEW)



register clear  $(\overline{SRCLR})$  is high. When  $\overline{SRCLR}$  is low, all registers in the device are cleared. When output enable  $\overline{G}$  is held high, all data in the output buffers is held low and all drain outputs are off. When  $\overline{G}$  is held low, data from the storage register is transparent to the output buffers. The serial output (SER OUT) is clocked out of the device on the falling edge of SRCK to provide additional hold time for cascaded applications. This will provide improved performance for applications where clock signals may be skewed, devices are not located near one another, or the system must tolerate electromagnetic interference.

Outputs are low-side, open-drain DMOS transistors with output ratings of 50 V and a 350-mA continuous sink current capability. When data in the output buffers is low, the DMOS-transistor outputs are off. When data is high, the DMOS-transistor outputs have sink current capability.

Separate power ground (PGND) and logic ground (LGND) terminals are provided to facilitate maximum system flexibility. All PGND terminals are internally connected, and each PGND terminal must be externally connected to the power system ground in order to minimize parasitic impedance. A single-point connection between LGND and PGND must be made externally in a manner that reduces crosstalk between the logic and load circuits.

The TPIC6A596 is offered in a thermally-enhanced dual-in-line (NE) package and a wide-body surface-mount (DW) package. The TPIC6A596 is characterized for operation over the operating case temperature range of  $-40^{\circ}$ C to  $125^{\circ}$ C.

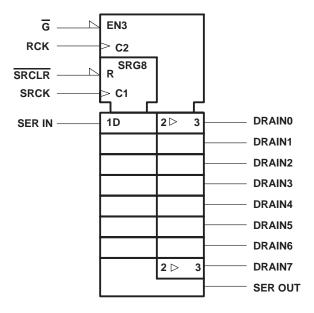


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



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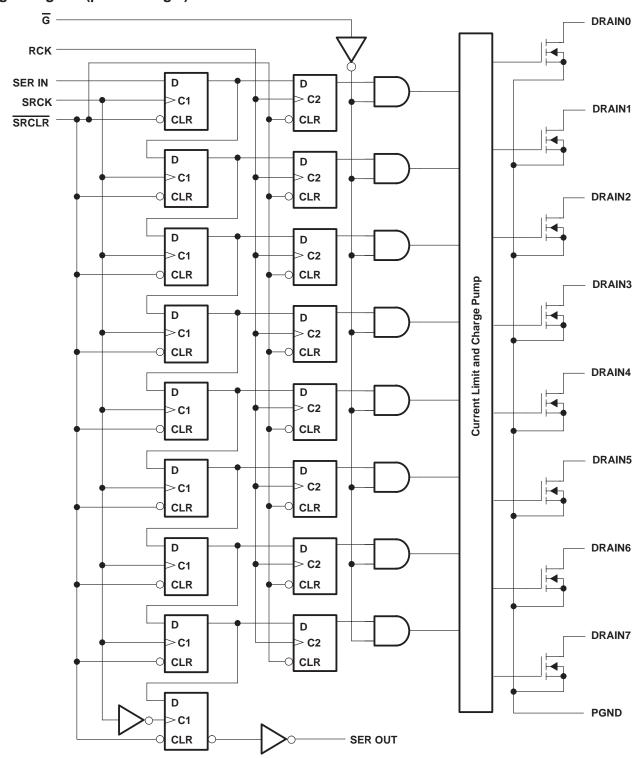
# logic symbol†



<sup>&</sup>lt;sup>†</sup> This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

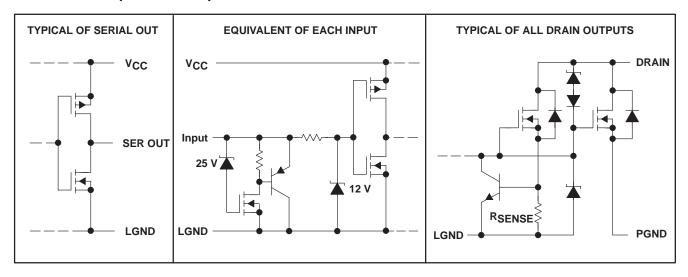


# logic diagram (positive logic)





### schematic of inputs and outputs



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

Logic supply voltage, V <sub>CC</sub> (see Note 1)	7 V
Logic input voltage range, V <sub>I</sub>	0.3 V to 7 V
Power DMOS drain-to-source voltage, V <sub>DS</sub> (see Note 2)	50 V
Continuous source-drain diode anode current	
Pulsed source-drain diode anode current (see Note 3)	2 A
Pulsed drain current, each output, all outputs on, I <sub>Dn.</sub> T <sub>A</sub> = 25°C (see Note 3)	1.1 A
Continuous drain current, each output, all outputs on, $I_{Dn}$ , $T_A = 25$ °C	
Peak drain current, single output, T <sub>A</sub> = 25°C (see Note 3)	1.1 A
Single-pulse avalanche energy, E <sub>AS</sub> (see Figure 6)	75 mJ
Avalanche current, I <sub>AS</sub> (see Note 4)	600 mA
Continuous total dissipation	See Dissipation Rating Table
Operating case temperature range, T <sub>C</sub>	–40°C to 125°C
Operating virtual junction temperature range, T <sub>J</sub>	–40°C to 150°C
Storage temperature range, T <sub>stq</sub>	–65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	

<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. All voltage values are with respect to LGND and PGND.
  - 2. Each power DMOS source is internally connected to PGND.
  - 3. Pulse duration  $\leq$  100  $\mu$ s and duty cycle  $\leq$  2 %.
  - 4. DRAIN supply voltage = 15 V, starting junction temperature (TJS) = 25°C, L = 210 mH, IAS = 600 mA (see Figure 6).

#### **DISSIPATION RATING TABLE**

PACKAGE	$T_C \le 25^{\circ}C$ POWER RATING	DERATING FACTOR ABOVE T <sub>C</sub> = 25°C	T <sub>C</sub> = 125°C POWER RATING
DW	1750 mW	14 mW/°C	350 mW
NE	2500 mW	20 mW/°C	500 mW



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## recommended operating conditions

	MIN	MAX	UNIT
Logic supply voltage, V <sub>CC</sub>	4.5	5.5	V
High-level input voltage, V <sub>IH</sub>	0.85 V <sub>CC</sub>	Vcc	V
Low-level input voltage, V <sub>IL</sub>	0	0.15 V <sub>CC</sub>	V
Pulsed drain output current, T <sub>C</sub> = 25°C, V <sub>CC</sub> = 5 V (see Notes 3 and 5)	-1.8	0.6	Α
Setup time, SER IN high before SRCK↑, t <sub>SU</sub> (see Figure 2)	10		ns
Hold time, SER IN high after SRCK↑, th (see Figure 2)	10		ns
Pulse duration, t <sub>W</sub> (see Figure 2)	20		ns
Operating case temperature, T <sub>C</sub>	-40	125	°C

NOTES: 3. Pulse duration  $\leq$  100  $\mu s$  and duty cycle  $\leq$  2%.

5. Technique should limit  $T_J - T_C$  to 10°C maximum.

# electrical characteristics, $V_{CC}$ = 5 V, $T_{C}$ = 25°C (unless otherwise noted)

	PARAMETER	TE	ST COND	ITIONS	MIN	TYP	MAX	UNIT
V(BR)DSX	Drain-to-source breakdown voltage	I <sub>D</sub> = 1 mA			50			V
V <sub>SD</sub>	Source-to-drain diode forward voltage	I <sub>F</sub> = 350 mA,		0.8	1.1	V		
V	High-level output voltage,	$I_{OH} = -20  \mu A$			V <sub>CC</sub> -0.1	Vcc		
VOH	SER OUT	$I_{OH} = -4 \text{ mA}$			V <sub>CC</sub> -0.5	V <sub>CC</sub> -0.2		V
V	Low-level output voltage,	I <sub>OL</sub> = 20 μA				0	0.1	
VOL	SER OUT	I <sub>OL</sub> = 4 mA				0.2	0.5	V
lн	High-level input current	$V_I = V_{CC}$			1	μΑ		
I <sub>I</sub> L	Low-level input current	V <sub>I</sub> = 0			-1	μΑ		
IO(chop)	Output current at which chopping starts	T <sub>C</sub> = 25°C,	See No	te 5 and Figures 3 and 4	0.6	0.8	1.1	А
Icc	Logic supply current	$I_{O} = 0$ ,	$V_I = V_C$	C or 0		0.5	5	mA
I <sub>CC(FRQ)</sub>	Logic supply current at frequency	f <sub>SRCK</sub> = 5 MHz, V <sub>I</sub> = V <sub>CC</sub> or 0,		C <sub>L</sub> = 30 pF, 5 V, See Figure 7		1.3		mA
I <sub>(nom)</sub>	Nominal current	V <sub>DS(on)</sub> = 0.5 V, V <sub>CC</sub> = 5 V,	I <sub>(nom)</sub> = See No	= I <sub>D</sub> , T <sub>C</sub> = 85°C, tes 5, 6, and 7		350		mA
	5	$V_{DS} = 40 \text{ V},$	T <sub>C</sub> = 25	i°C		0.1	1	
lD	Drain current, off-state	V <sub>DS</sub> = 40 V,	T <sub>C</sub> = 12	25°C		0.2	5	μΑ
Static drain-source		$I_D = 350 \text{ mA}, T_C$	= 25°C	See Notes 5 and 6 and		1	1.5	-
rDS(on)	on-state resistance	$I_D = 350 \text{ mA}, T_C$	= 125°C	Figures 10 and 11		1.7	2.5	Ω

NOTES: 5. Technique should limit  $T_J-T_C$  to  $10^{\circ}C$  maximum.

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

7. Nominal current is defined for a consistent comparison between devices from different sources. It is the current that produces a voltage drop of 0.5 V at T<sub>C</sub> = 85°C.



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## switching characteristics, V<sub>CC</sub> = 5 V, T<sub>C</sub> = 25°C

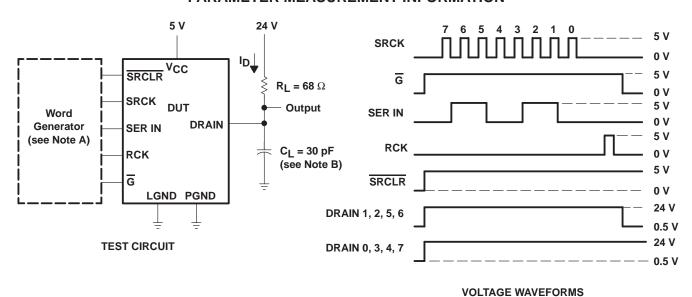
	PARAMETER	TEST CONDITIONS	MIN TYP MAX	UNIT
tPHL	Propagation delay time, high-to-low-level output from $\overline{G}$		30	ns
tPLH	Propagation delay time, low-to-high-level output from $\overline{G}$	$C_L = 30 \text{ pF}, \qquad I_D = 350 \text{ mA},$	125	ns
t <sub>r</sub>	Rise time, drain output	See Figures 1, 2, and 12	60	ns
tf	Fall time, drain output		30	ns
t <sub>pd</sub>	Propagation delay time, SRCK↓ to SEROUT	$C_L = 30 \text{ pF},$ $I_D = 350 \text{ mA},$ See Figure 2	20	ns
f(SRCK)	Serial clock frequency	$C_L = 30 \text{ pF}, \qquad I_D = 350 \text{ mA},$ See Note 8	10	MHz
ta	Reverse-recovery-current rise time	$I_F = 350 \text{ mA},  \text{di/dt} = 20 \text{ A/}\mu\text{s},$	100	ns
t <sub>rr</sub>	Reverse-recovery time	See Notes 5 and 6 and Figure 5	300	ns

- NOTES: 5. Technique should limit  $T_J T_C$  to 10°C maximum.
  - 6. These parameters are measured with voltage-sensing contacts separate from the current-carrying contacts.
  - 8. This is the maximum serial clock frequency assuming cascaded operation where serial data is passed from one stage to a second stage. The clock period allows for SRCK → SEROUT propagation delay and setup time plus some timing margin.

#### thermal resistance

	PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT		
_	<b>-</b>	DW			10	0000	
$R_{\theta JC}$	Thermal resistance, junction-to-case		All eight outputs with equal power		10	°C/W	
_	The second and interest in a street in a section of	DW	All about a standard with a small a surro		50	0000	
$R_{\theta JA}$	Thermal resistance, junction-to-ambient	NE	All eight outputs with equal power		50	°C/W	

#### PARAMETER MEASUREMENT INFORMATION



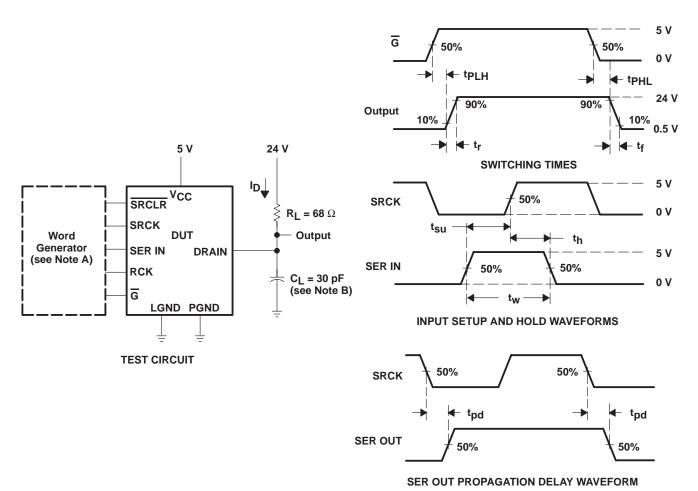
NOTES: A. The word generator has the following characteristics:  $t_{\Gamma} \le 10$  ns,  $t_{W} = 300$  ns, pulsed repetition rate (PRR) = 5 kHz,  $Z_{O} = 50~\Omega$ .

B. CL includes probe and jig capacitance.

Figure 1. Resistive Load Operation



#### PARAMETER MEASUREMENT INFORMATION



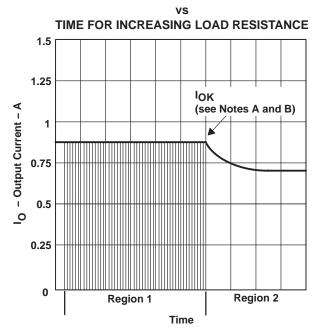
NOTES: A. The word generator has the following characteristics:  $t_{\Gamma} \le 10$  ns,  $t_{W} = 300$  ns, pulsed repetition rate (PRR) = 5 kHz,  $Z_{O} = 50~\Omega$ .

B. C<sub>L</sub> includes probe and jig capacitance.

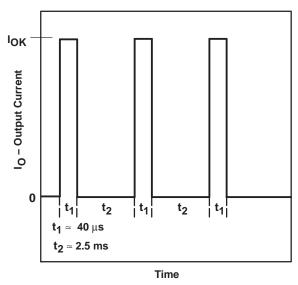
Figure 2. Test Circuit, Switching Times, and Voltage Waveforms

#### PARAMETER MEASUREMENT INFORMATION

#### **OUTPUT CURRENT**



#### **REGION 1 CURRENT WAVEFORM**



First output current pulses after turn-on in chopping mode with resistive load.

- NOTES: A. Figure 3 illustrates the output current characteristics of the device energizing a load having initially low, increasing resistance, e.g., an incandescent lamp. In region 1, chopping occurs and the peak current is limited to I<sub>OK</sub>. In region 2, output current is continuous. The same characteristics occur in reverse order when the device energizes a load having an initially high, decreasing resistance.
  - B. Region 1 duty cycle is approximately 2%.

Figure 3. Chopping-Mode Characteristics

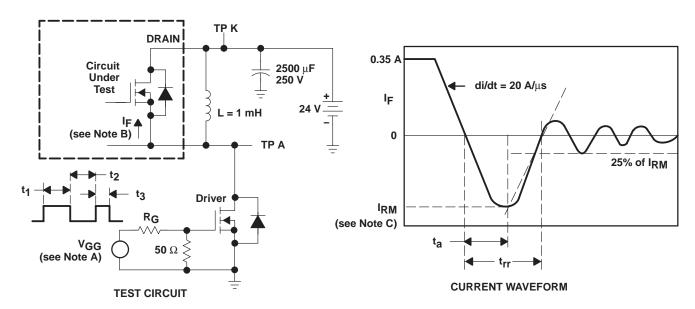
#### **OUTPUT CURRENT LIMIT**

# **CASE TEMPERATURE** 1.5 $V_{CC} = 5.5 V$ 1.2 Output Current Limit – A 0.9 V<sub>C</sub>C = 4.5 \ 0.6 0.3 - 25 25 50 75 100 125 150 - 50 T<sub>C</sub> - Case Temperature - °C

Figure 4

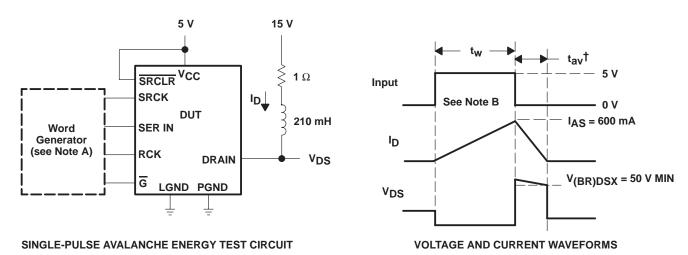


#### PARAMETER MEASUREMENT INFORMATION



- NOTES: A. The VGG amplitude and RG are adjusted for di/dt = 20 A/ $\mu$ s. A VGG double-pulse train is used to set IF = 0.35 A, where t<sub>1</sub> = 10  $\mu$ s, t<sub>2</sub> = 7  $\mu$ s, and t<sub>3</sub> = 3  $\mu$ s.
  - B. The DRAIN terminal under test is connected to the TP K test point. All other terminals are connected together and connected to the TP A test point.
  - C. I<sub>RM</sub> = maximum recovery current

Figure 5. Reverse-Recovery-Current Test Circuit and Waveforms of Source-Drain Diode



† Non JEDEC symbol for avalanche time.

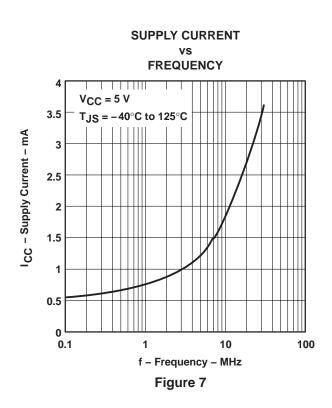
NOTES: A. The word generator has the following characteristics:  $t_f \le 10$  ns,  $t_f \le 10$  ns,  $Z_O = 50 \Omega$ .

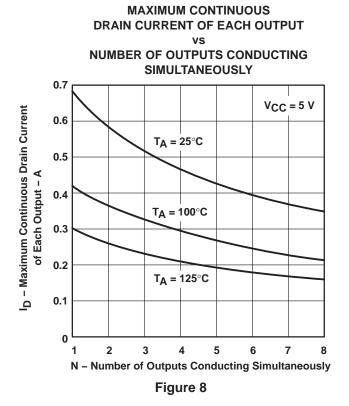
B. Input pulse duration,  $t_{W}$ , is increased until peak current  $I_{AS} = 600$  mA. Energy test level is defined as  $E_{AS} = (I_{AS} \times V_{(BR)DSX} \times t_{aV})/2 = 75$  mJ.

Figure 6. Single-Pulse Avalanche Energy Test Circuit and Waveforms



#### TYPICAL CHARACTERISTICS





# MAXIMUM PEAK DRAIN CURRENT OF EACH OUTPUT

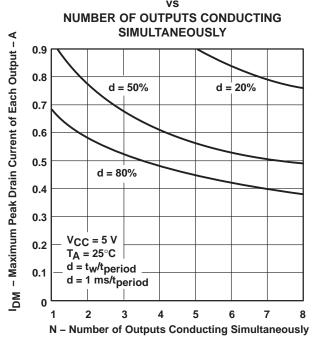
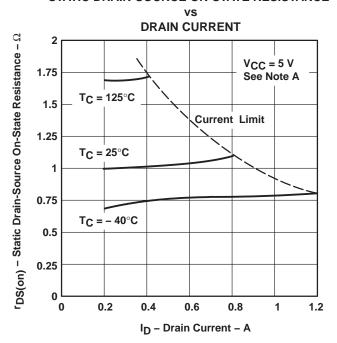


Figure 9

#### STATIC DRAIN-SOURCE ON-STATE RESISTANCE

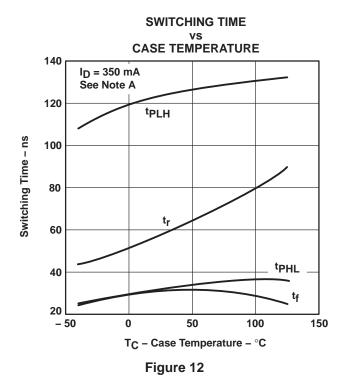


NOTE A: Technique should limit  $T_J - T_C$  to 10°C maximum. Figure 10



#### **TYPICAL CHARACTERISTICS**

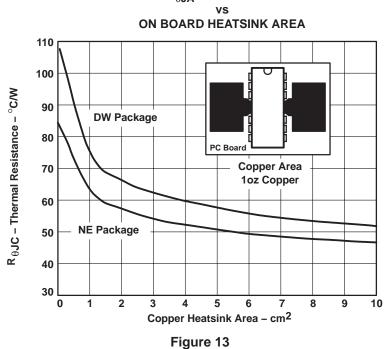
# STATIC DRAIN-SOURCE ON-STATE RESISTANCE **LOGIC SUPPLY VOLTAGE** r DS(on) – Static Drain-Source On-State Resistance – $\Omega$ 2 1.75 T<sub>C</sub> = 125°C 1.5 1.25 $T_C = 25^{\circ}C$ 0.75 $T_C = -40^{\circ}C$ 0.5 I<sub>D</sub> = 350 mA 0.25 See Note A V<sub>CC</sub> - Logic Supply Voltage - V



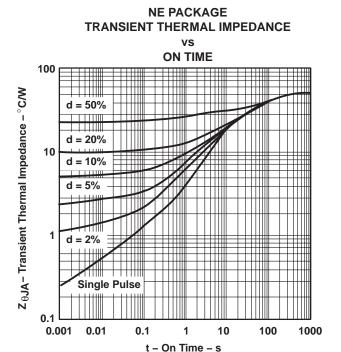
NOTE A: Technique should limit  $T_J - T_C$  to 10°C maximum.

Figure 11

## TYPICAL $R_{\theta JA}$ THERMAL RESISTANCE



#### THERMAL INFORMATION



The single-pulse curve represents measured data. The curves for various pulse durations are based on the following equation:

$$Z_{\theta JA} \; = \; \left| \; \frac{t_w}{t_c} \; \right| \; R_{\theta JA} \; + \; \left| \; 1 - \frac{t_w}{t_c} \; \right| \; Z_{\theta}(t_w + t_c)$$

Where:

 $Z_{\theta}(t_{w})$  = the single-pulse thermal impedance for t =  $t_{w}$  seconds

 $+ \ \mathsf{Z}_{\boldsymbol{\theta}}(\mathsf{t}_{\boldsymbol{w}})\!\!-\!\!\mathsf{Z}_{\boldsymbol{\theta}}\!\big(\mathsf{t}_{\boldsymbol{c}}\big)$ 

 $Z_{\theta}(t_c)$  = the single-pulse thermal impedance for t =  $t_c$  seconds

 $\mathbf{Z}_{\theta} \! \left( \mathbf{t_W} + \mathbf{t_C} \right) = \text{ the single-pulse thermal impedance } \\ \text{ for } \mathbf{t} = \mathbf{t_W} + \mathbf{t_C} \text{ seconds}$ 

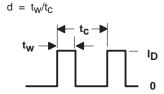


Figure 14

Revision History

DATE	REV	PAGE	SECTION	DESCRIPTION
5/18/05	Α	6	Figure 1	Changed SRCLR timing diagram and changed title on Drain timing diagrams
3/2000	*			Original reversion

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.





30-Apr-2012

#### **PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
TPIC6A596DW	ACTIVE	SOIC	DW	24	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPIC6A596DWG4	ACTIVE	SOIC	DW	24	25	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPIC6A596DWR	ACTIVE	SOIC	DW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPIC6A596DWRG4	ACTIVE	SOIC	DW	24	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
TPIC6A596NE	ACTIVE	PDIP	NE	20	20	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	

(1) 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.

(2) 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)

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

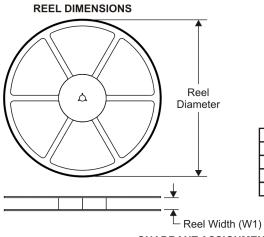
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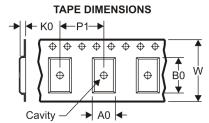
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# **PACKAGE MATERIALS INFORMATION**

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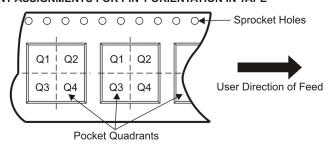
## TAPE AND REEL INFORMATION





	Dimension designed to accommodate the component width
	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

## QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



#### \*All dimensions are nominal

Device	Package Type	Package Drawing			Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPIC6A596DWR	SOIC	DW	24	2000	330.0	24.4	10.75	15.7	2.7	12.0	24.0	Q1

www.ti.com 9-Dec-2010



#### \*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPIC6A596DWR	SOIC	DW	24	2000	346.0	346.0	41.0

DW (R-PDSO-G24)

# PLASTIC SMALL OUTLINE



NOTES: A. All linear dimensions are in inches (millimeters). Dimensioning and tolerancing per ASME Y14.5M-1994.

- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS-013 variation AD.



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