

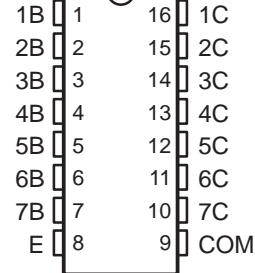
# ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

SLRS027G – DECEMBER 1976 – REVISED JUNE 2004

The ULN2001A is obsolete  
and is no longer supplied.

- 500-mA-Rated Collector Current (Single Output)
- High-Voltage Outputs . . . 50 V
- Output Clamp Diodes
- Inputs Compatible With Various Types of Logic
- Relay-Driver Applications

ULN2001A . . . D OR N PACKAGE  
ULN2002A . . . N PACKAGE  
ULN2003A . . . D, N, NS, OR PW PACKAGE  
ULN2004A . . . D, N, OR NS PACKAGE  
ULQ2003A, ULQ2004A . . . D OR N PACKAGE  
(TOP VIEW)



## description/ordering information

The ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, and ULQ2004A are high-voltage, high-current Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. For 100-V (otherwise interchangeable) versions of the ULN2003A and ULN2004A, see the SN75468 and SN75469, respectively.

## ORDERING INFORMATION

T <sub>A</sub>	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-20°C to 70°C	PDIP (N)	Tube of 25	ULN2002AN	ULN2002AN
			ULN2003AN	ULN2003AN
			ULN2004AN	ULN2004AN
	SOIC (D)	Tube of 40	ULN2003AD	ULN2003A
			Reel of 2500	
		Tube of 40	ULN2004AD	ULN2004A
			Reel of 2500	
	SOP (NS)	Reel of 2000	ULN2003ANSR	ULN2003A
			ULN2004ANSR	ULN2004A
	TSSOP (PW)	Tube of 90	ULN2003APW	UN2003A
Reel of 2000		ULN2003APWR		
-40°C to 85°C	PDIP (N)	Tube of 25	ULQ2003AN	ULQ2003A
			ULQ2004AN	ULQ2004AN
	SOIC (D)	Tube of 40	ULQ2003AD	ULQ2003A
		Reel of 2500	ULQ2003ADR	ULQ2003A
		Tube of 40	ULQ2004AD	ULQ2004A
		Reel of 2500	ULQ2004ADR	ULQ2004A

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).



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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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

# ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

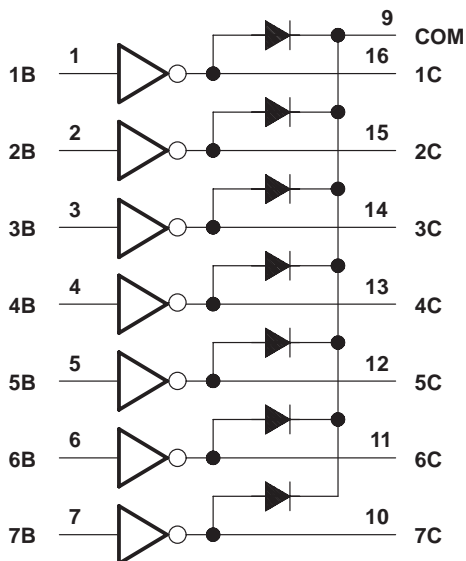
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The ULN2001A is obsolete  
and is no longer supplied.

## description/ordering information (continued)

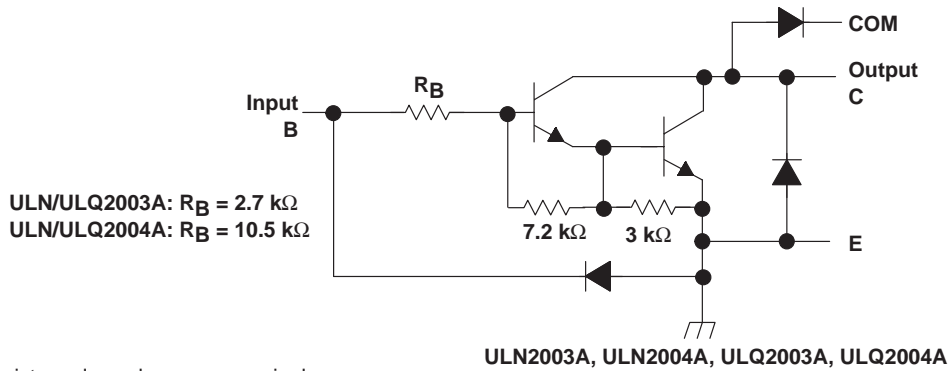
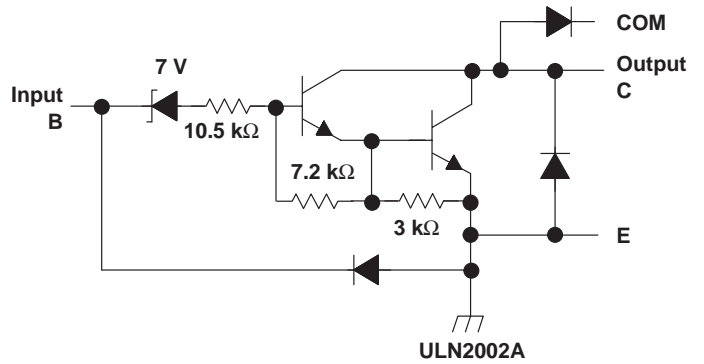
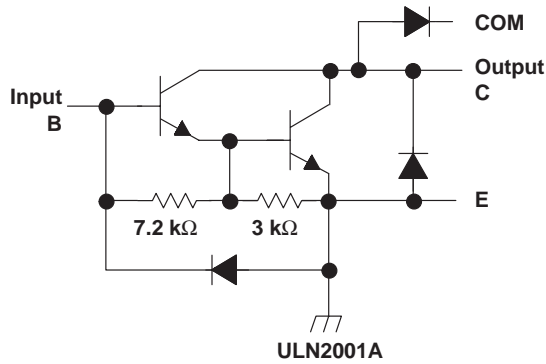
The ULN2001A is a general-purpose array and can be used with TTL and CMOS technologies. The ULN2002A is designed specifically for use with 14-V to 25-V PMOS devices. Each input of this device has a Zener diode and resistor in series to control the input current to a safe limit. The ULN2003A and ULQ2003A have a 2.7-k $\Omega$  series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices. The ULN2004A and ULQ2004A have a 10.5-k $\Omega$  series base resistor to allow operation directly from CMOS devices that use supply voltages of 6 V to 15 V. The required input current of the ULN/ULQ2004A is below that of the ULN/ULQ2003A, and the required voltage is less than that required by the ULN2002A.

## logic diagram



The ULN2001A is obsolete  
and is no longer supplied.

schematics (each Darlington pair)



All resistor values shown are nominal.

# ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAY

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The ULN2001A is obsolete  
and is no longer supplied.

## absolute maximum ratings at 25°C free-air temperature (unless otherwise noted)†

Collector-emitter voltage	50 V
Clamp diode reverse voltage (see Note 1)	50 V
Input voltage, $V_I$ (see Note 1)	30 V
Peak collector current (see Figures 14 and 15)	500 mA
Output clamp current, $I_{OK}$	500 mA
Total emitter-terminal current	-2.5 A
Operating free-air temperature range, $T_A$ , ULN200xA	-20°C to 70°C
ULQ200xA	-40°C to 85°C
ULQ200xAT	-40°C to 105°C
Package thermal impedance, $\theta_{JA}$ (see Notes 2 and 3): D package	73°C/W
N package	67°C/W
NS package	64°C/W
PW package	108°C/W
Package thermal impedance, $\theta_{JC}$ (see Notes 4 and 5): D package	36°C/W
N package	54°C/W
Operating virtual junction temperature, $T_J$	150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C
Storage temperature range, $T_{stg}$	-65°C to 150°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:
- All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
  - Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  - The package thermal impedance is calculated in accordance with JEDEC 51-7.
  - Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JC}$ , and  $T_C$ . The maximum allowable power dissipation at any allowable case temperature is  $P_D = (T_J(\max) - T_C)/\theta_{JC}$ . Operating at the absolute maximum  $T_J$  of 150°C can affect reliability.
  - The package thermal impedance is calculated in accordance with MIL-STD-883.

## electrical characteristics, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST FIGURE	TEST CONDITIONS	ULN2001A			ULN2002A			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$ On-state input voltage	6	$V_{CE} = 2\text{ V}$ , $I_C = 300\text{ mA}$						13	V
$V_{CE(sat)}$ Collector-emitter saturation voltage	5	$I_I = 250\ \mu\text{A}$ , $I_C = 100\text{ mA}$	0.9	1.1	0.9	1.1			V
		$I_I = 350\ \mu\text{A}$ , $I_C = 200\text{ mA}$	1	1.3	1	1.3			
		$I_I = 500\ \mu\text{A}$ , $I_C = 350\text{ mA}$	1.2	1.6	1.2	1.6			
$V_F$ Clamp forward voltage	8	$I_F = 350\text{ mA}$	1.7	2	1.7	2		V	
$I_{CEX}$ Collector cutoff current	1	$V_{CE} = 50\text{ V}$ , $I_I = 0$			50	50			$\mu\text{A}$
	2	$V_{CE} = 50\text{ V}$ , $T_A = 70^\circ\text{C}$ , $I_I = 0$ , $V_I = 6\text{ V}$			100	100	500		
$I_{I(off)}$ Off-state input current	3	$V_{CE} = 50\text{ V}$ , $T_A = 70^\circ\text{C}$ , $I_C = 500\ \mu\text{A}$	50	65	50	65		$\mu\text{A}$	
$I_I$ Input current	4	$V_I = 17\text{ V}$				0.82	1.25	mA	
$I_R$ Clamp reverse current	7	$V_R = 50\text{ V}$ , $T_A = 70^\circ\text{C}$			100	100		$\mu\text{A}$	
		$V_R = 50\text{ V}$			50	50			
$h_{FE}$ Static forward-current transfer ratio	5	$V_{CE} = 2\text{ V}$ , $I_C = 350\text{ mA}$	1000						
$C_i$ Input capacitance		$V_I = 0$ , $f = 1\text{ MHz}$	15	25	15	25		pF	



The ULN2001A is obsolete  
and is no longer supplied.

electrical characteristics,  $T_A = 25^\circ\text{C}$  (unless otherwise noted) (continued)

PARAMETER	TEST FIGURE	TEST CONDITIONS		ULN2003A			ULN2004A			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$ On-state input voltage	6	$V_{CE} = 2\text{ V}$	$I_C = 125\text{ mA}$						5	V
			$I_C = 200\text{ mA}$			2.4			6	
			$I_C = 250\text{ mA}$			2.7				
			$I_C = 275\text{ mA}$						7	
			$I_C = 300\text{ mA}$			3				
			$I_C = 350\text{ mA}$						8	
$V_{CE(sat)}$ Collector-emitter saturation voltage	5	$I_I = 250\ \mu\text{A}$ , $I_C = 100\text{ mA}$		0.9	1.1		0.9	1.1	V	
		$I_I = 350\ \mu\text{A}$ , $I_C = 200\text{ mA}$		1	1.3		1	1.3		
		$I_I = 500\ \mu\text{A}$ , $I_C = 350\text{ mA}$		1.2	1.6		1.2	1.6		
$I_{CEX}$ Collector cutoff current	1	$V_{CE} = 50\text{ V}$ , $I_I = 0$			50			50	$\mu\text{A}$	
	2	$V_{CE} = 50\text{ V}$ , $T_A = 70^\circ\text{C}$ , $V_I = 1\text{ V}$			100			100		
$V_F$ Clamp forward voltage	8	$I_F = 350\text{ mA}$		1.7	2		1.7	2	V	
$I_{I(off)}$ Off-state input current	3	$V_{CE} = 50\text{ V}$ , $T_A = 70^\circ\text{C}$ , $I_C = 500\ \mu\text{A}$	50	65		50	65		$\mu\text{A}$	
$I_I$ Input current	4	$V_I = 3.85\text{ V}$		0.93	1.35				mA	
		$V_I = 5\text{ V}$				0.35	0.5			
		$V_I = 12\text{ V}$				1	1.45			
$I_R$ Clamp reverse current	7	$V_R = 50\text{ V}$			50			50	$\mu\text{A}$	
		$V_R = 50\text{ V}$ , $T_A = 70^\circ\text{C}$			100			100		
$C_i$ Input capacitance		$V_I = 0$ , $f = 1\text{ MHz}$		15	25		15	25	pF	

**ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A**  
**HIGH-VOLTAGE HIGH-CURRENT**  
**DARLINGTON TRANSISTOR ARRAY**

SLRS027G – DECEMBER 1976 – REVISED JUNE 2004

The ULN2001A is obsolete  
and is no longer supplied.

**electrical characteristics over recommended operating conditions (unless otherwise noted)**

PARAMETER	TEST FIGURE	TEST CONDITIONS		ULQ2003A			ULQ2004A			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$ On-state input voltage	6	$V_{CE} = 2\text{ V}$	$I_C = 125\text{ mA}$						5	V
			$I_C = 200\text{ mA}$						6	
			$I_C = 250\text{ mA}$						2.7	
			$I_C = 275\text{ mA}$						2.9	
			$I_C = 300\text{ mA}$						3	
			$I_C = 350\text{ mA}$						7	
$V_{CE(sat)}$ Collector-emitter saturation voltage	5		$I_I = 250\text{ }\mu\text{A}$ , $I_C = 100\text{ mA}$	0.9	1.2		0.9	1.1	V	
			$I_I = 350\text{ }\mu\text{A}$ , $I_C = 200\text{ mA}$	1	1.4		1	1.3		
			$I_I = 500\text{ }\mu\text{A}$ , $I_C = 350\text{ mA}$	1.2	1.7		1.2	1.6		
$I_{CEX}$ Collector cutoff current	1	$V_{CE} = 50\text{ V}$ , $I_I = 0$						100	$\mu\text{A}$	
	2	$V_{CE} = 50\text{ V}$	$I_I = 0$					500		
$V_F$ Clamp forward voltage	8	$I_F = 350\text{ mA}$		1.7	2.3		1.7	2	V	
$I_{I(off)}$ Off-state input current	3	$V_{CE} = 50\text{ V}$ , $I_C = 500\text{ }\mu\text{A}$		65		50	65		$\mu\text{A}$	
$I_I$ Input current	4		$V_I = 3.85\text{ V}$	0.93	1.35				mA	
			$V_I = 5\text{ V}$				0.35	0.5		
			$V_I = 12\text{ V}$				1	1.45		
$I_R$ Clamp reverse current	7	$V_R = 50\text{ V}$ , $T_A = 25^\circ\text{C}$			100			50	$\mu\text{A}$	
					100			100		
$C_i$ Input capacitance		$V_I = 0$ , $f = 1\text{ MHz}$		15	25		15	25	pF	

**switching characteristics,  $T_A = 25^\circ\text{C}$**

PARAMETER	TEST CONDITIONS	ULN2001A, ULN2002A, ULN2003A, ULN2004A			UNIT
		MIN	TYP	MAX	
$t_{PLH}$ Propagation delay time, low- to high-level output	See Figure 9		0.25	1	$\mu\text{s}$
$t_{PHL}$ Propagation delay time, high- to low-level output	See Figure 9		0.25	1	$\mu\text{s}$
$V_{OH}$ High-level output voltage after switching	$V_S = 50\text{ V}$ , $I_O \approx 300\text{ mA}$ , See Figure 10		$V_S - 20$		mV

**switching characteristics over recommended operating conditions (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	ULQ2003A, ULQ2004A			UNIT
		MIN	TYP	MAX	
$t_{PLH}$ Propagation delay time, low- to high-level output	See Figure 9		1	10	$\mu\text{s}$
$t_{PHL}$ Propagation delay time, high- to low-level output	See Figure 9		1	10	$\mu\text{s}$
$V_{OH}$ High-level output voltage after switching	$V_S = 50\text{ V}$ , $I_O \approx 300\text{ mA}$ , See Figure 10		$V_S - 500$		mV



The ULN2001A is obsolete and is no longer supplied.

PARAMETER MEASUREMENT INFORMATION

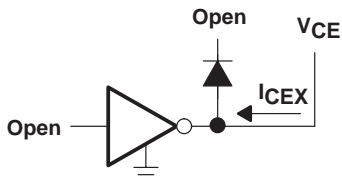


Figure 1.  $I_{CEX}$  Test Circuit

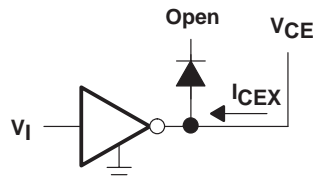


Figure 2.  $I_{CEX}$  Test Circuit

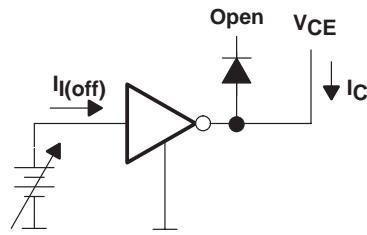


Figure 3.  $I_{I(off)}$  Test Circuit

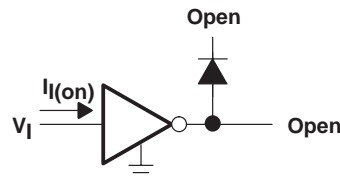
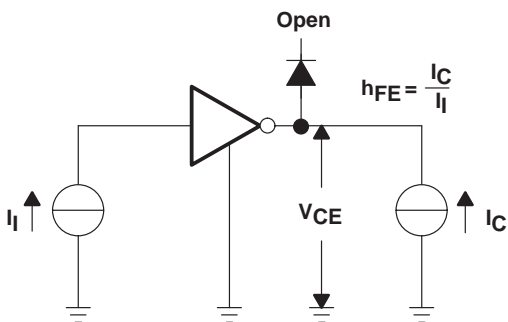


Figure 4.  $I_I$  Test Circuit



NOTE:  $I_I$  is fixed for measuring  $V_{CE(sat)}$ , variable for measuring  $h_{FE}$ .

Figure 5.  $h_{FE}$ ,  $V_{CE(sat)}$  Test Circuit

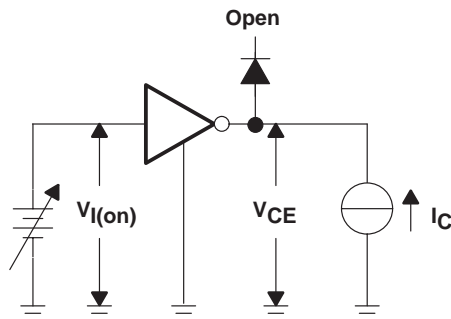


Figure 6.  $V_{I(on)}$  Test Circuit

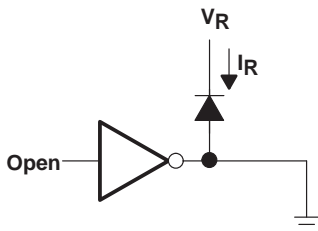


Figure 7.  $I_R$  Test Circuit

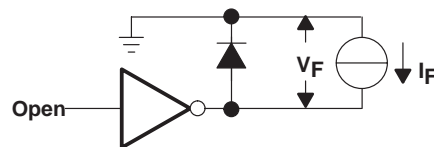


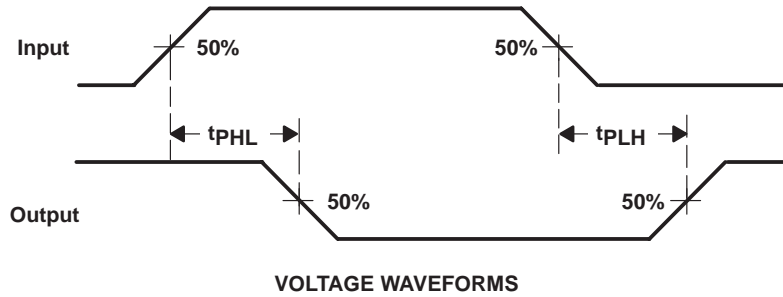
Figure 8.  $V_F$  Test Circuit

**ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A**  
**HIGH-VOLTAGE HIGH-CURRENT**  
**DARLINGTON TRANSISTOR ARRAY**

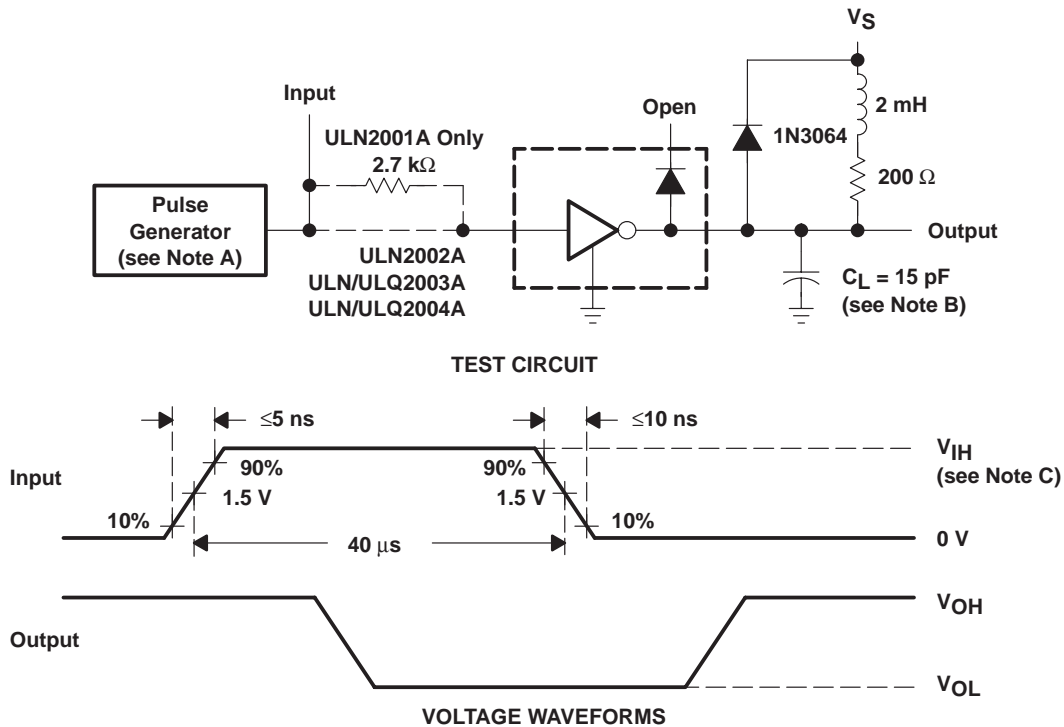
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The ULN2001A is obsolete  
 and is no longer supplied.

**PARAMETER MEASUREMENT INFORMATION**



**Figure 9. Propagation Delay-Time Waveforms**



- NOTES: A. The pulse generator has the following characteristics: PRR = 12.5 kHz,  $Z_O = 50 \Omega$ .  
 B.  $C_L$  includes probe and jig capacitance.  
 C. For testing the ULN2001A, the ULN2003A, and the ULQ2003A,  $V_{IH} = 3 \text{ V}$ ; for the ULN2002A,  $V_{IH} = 13 \text{ V}$ ; for the ULN2004A and the ULQ2004A,  $V_{IH} = 8 \text{ V}$ .

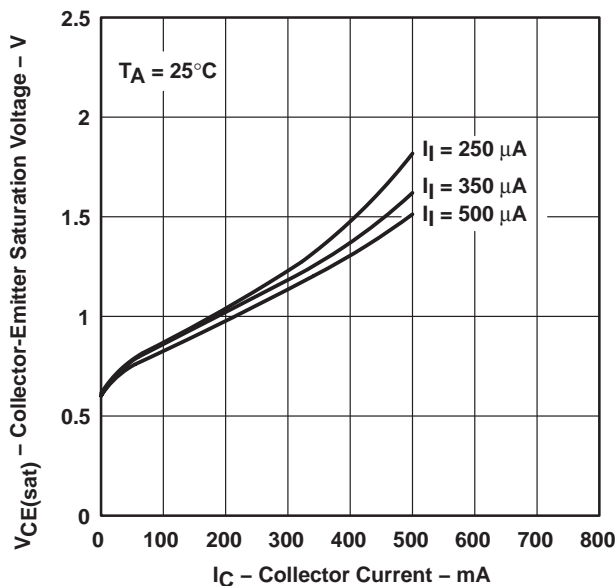
**Figure 10. Latch-Up Test Circuit and Voltage Waveforms**



The ULN2001A is obsolete and is no longer supplied.

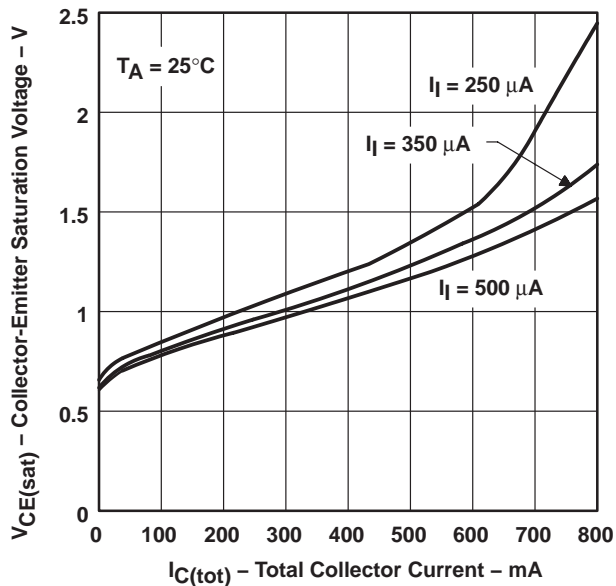
**TYPICAL CHARACTERISTICS**

**COLLECTOR-EMITTER SATURATION VOLTAGE  
vs  
COLLECTOR CURRENT  
(ONE DARLINGTON)**



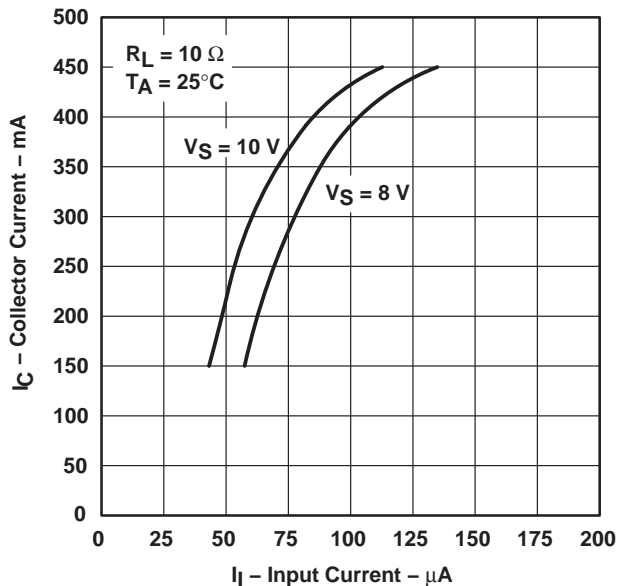
**Figure 11**

**COLLECTOR-EMITTER SATURATION VOLTAGE  
vs  
TOTAL COLLECTOR CURRENT  
(TWO DARLINGTONS IN PARALLEL)**



**Figure 12**

**COLLECTOR CURRENT  
vs  
INPUT CURRENT**



**Figure 13**

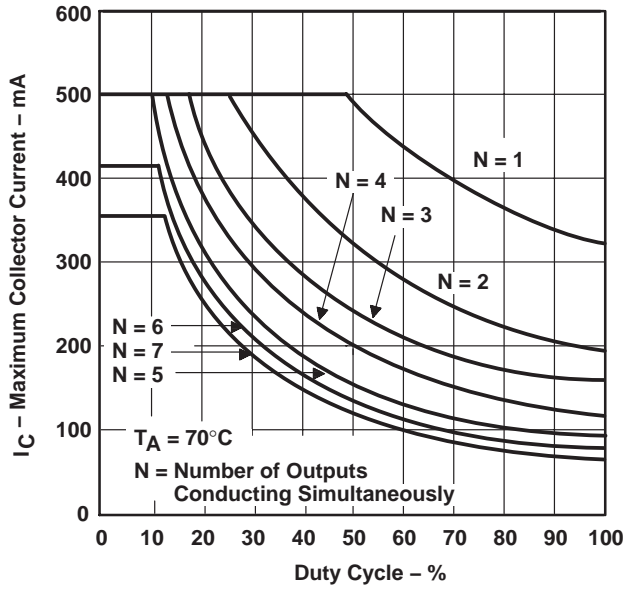
**ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A**  
**HIGH-VOLTAGE HIGH-CURRENT**  
**DARLINGTON TRANSISTOR ARRAY**

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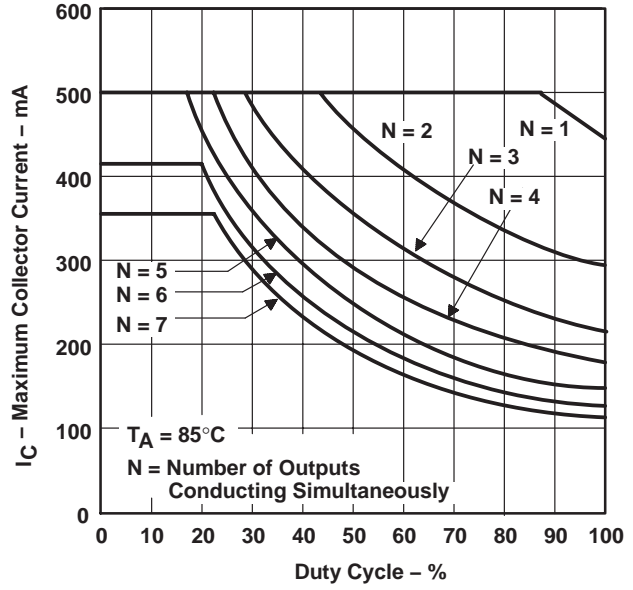
**THERMAL INFORMATION**

**D PACKAGE**  
**MAXIMUM COLLECTOR CURRENT**  
**vs**  
**DUTY CYCLE**



**Figure 14**

**N PACKAGE**  
**MAXIMUM COLLECTOR CURRENT**  
**vs**  
**DUTY CYCLE**



**Figure 15**

The ULN2001A is obsolete and is no longer supplied.

**APPLICATION INFORMATION**

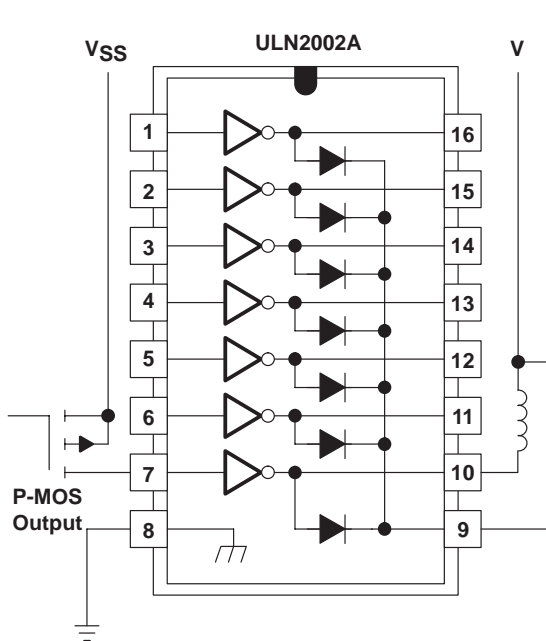


Figure 16. P-MOS to Load

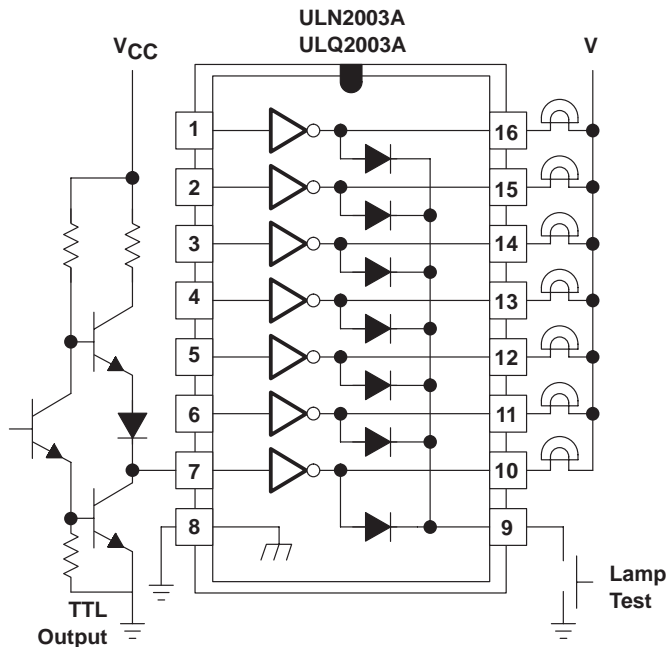


Figure 17. TTL to Load

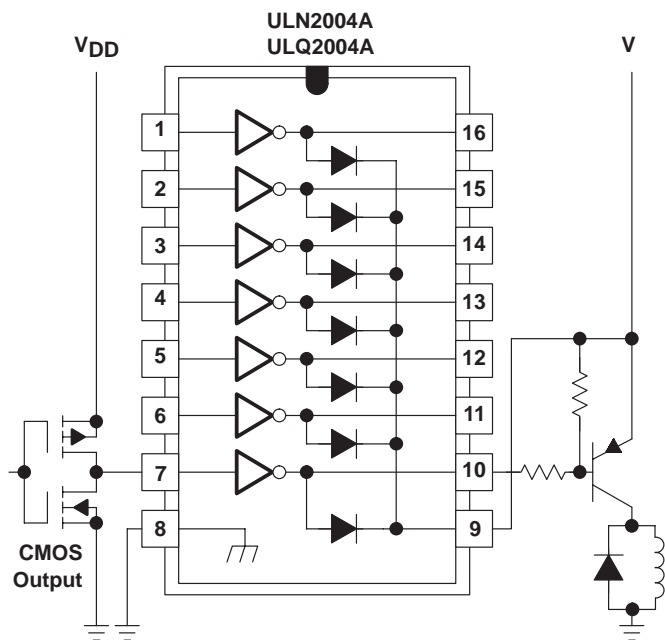


Figure 18. Buffer for Higher Current Loads

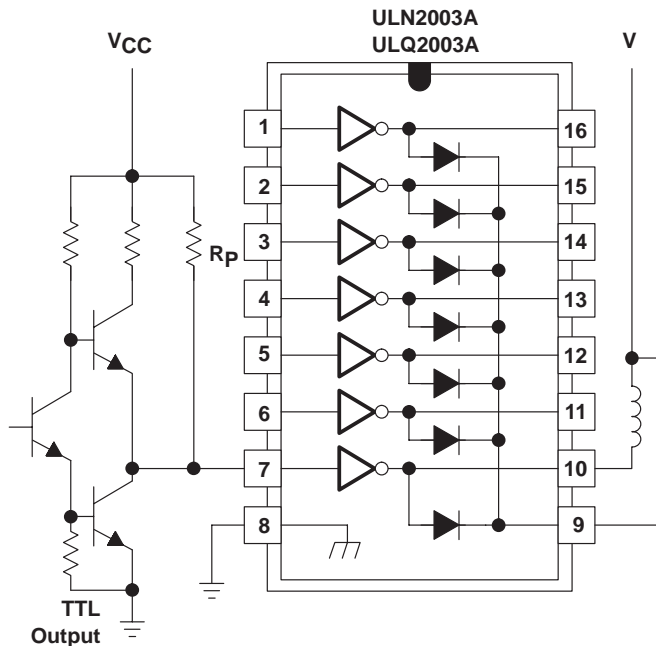


Figure 19. Use of Pullup Resistors to Increase Drive Current

J (R-GDIP-T\*\*)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - This package is hermetically sealed with a ceramic lid using glass frit.
  - Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

N (R-PDIP-T\*\*)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



D (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-4/F 07/2004

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - 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-012 variation AC.

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153



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