

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

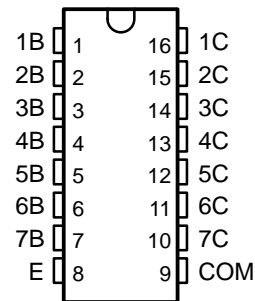
SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

The ULN2001A is obsolete  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
- Designed to Be Interchangeable With Sprague ULN2001A Series
- Package Options Include Plastic Small Outline (D, NS) Packages and Plastic DIP (N)

ULN2001A . . . D OR N PACKAGE  
ULN2002A . . . N PACKAGE  
ULN2003A, ULN2004A . . . D, N, OR NS PACKAGE  
ULQ2003A, ULQ2004A . . . D OR N PACKAGE

(TOP VIEW)



## description

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.

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.

### AVAILABLE OPTIONS

T <sub>A</sub>	PACKAGES	
	SMALL OUTLINE (D, NS)	PLASTIC DIP (N)
–20°C to 70°C	–	ULN2002AN
	ULN2003AD ULN2003ANS	ULN2003AN
	ULN2004AD ULN2004ANS	ULN2004AN
–40°C to 85°C	ULQ2003AD	ULQ2003AN
	ULQ2004AD	ULQ2004AN

The D package is available taped and reeled. Add the suffix R to device type (e.g., ULN2003ADR). The NS package is only available taped and reeled.



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**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

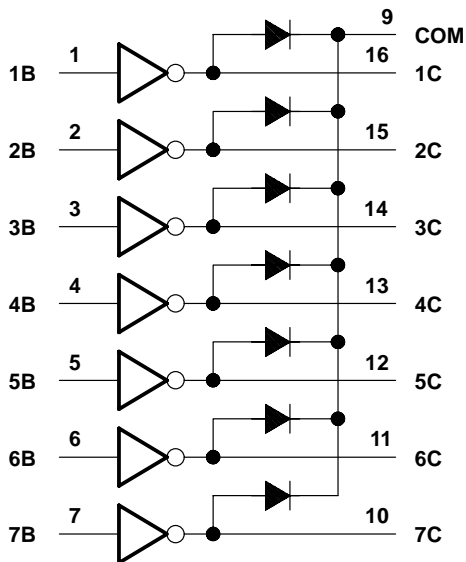
Copyright © 2002, Texas Instruments Incorporated

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

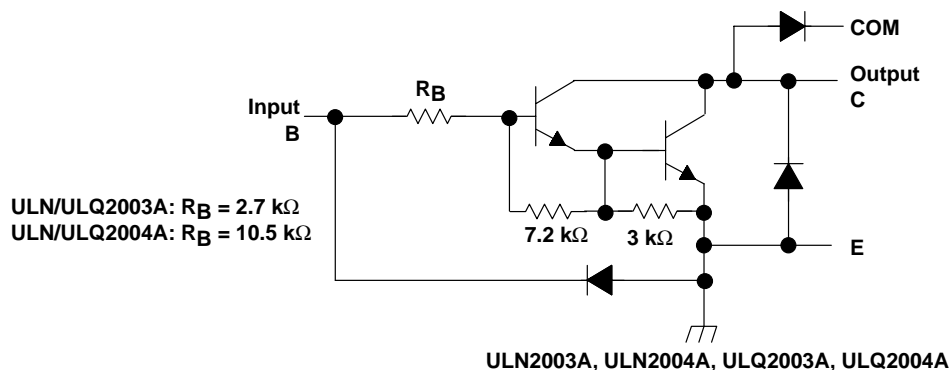
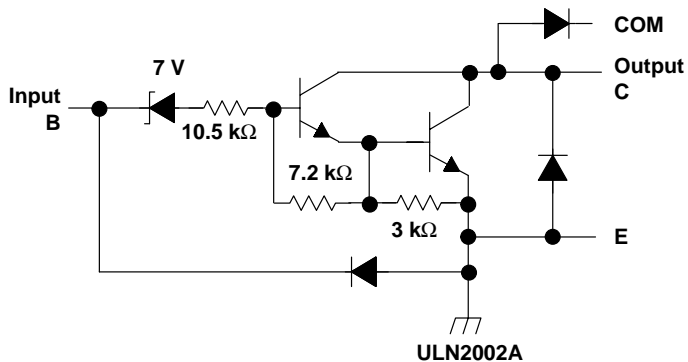
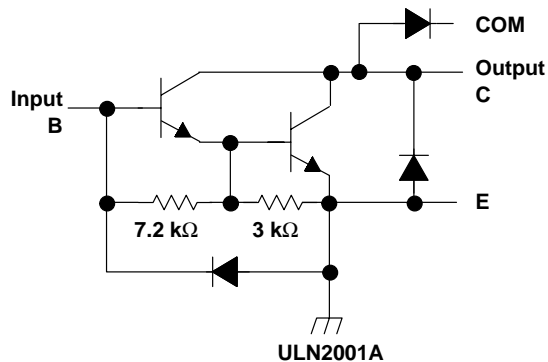
SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

The ULN2001A is obsolete  
and is no longer supplied.

## logic diagram



## schematics (each Darlington pair)



All resistor values shown are nominal.

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

The ULN2001A is obsolete  
and is no longer supplied.

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

## 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
Continuous total power dissipation	See Dissipation Rating Table
Package thermal impedance, $\theta_{JA}$ (see Note 2): D package	73°C/W
N package	67°C/W
NS package	64°C/W
Operating free-air temperature range, $T_A$ , ULN200xA	-20°C to 70°C
ULQ200xA	-40°C to 85°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: 1. All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.  
2. The package thermal impedance is calculated in accordance with JESD 51-7.

**DISSIPATION RATING TABLE**

PACKAGE	$T_A = 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 85^\circ\text{C}$ POWER RATING
D	950 mW	7.6 mW/°C	494 mW
N	1150 mW	9.2 mW/°C	598 mW

## 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



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

The ULN2001A is obsolete  
and is no longer supplied.

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

**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	$\mu\text{A}$	
	2	$V_{CE} = 50\text{ V}, T_A = 70^\circ\text{C}$	$I_I = 0$					100		
			$V_I = 1\text{ V}$					500		
$V_F$ 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	$\mu\text{A}$	
		$V_R = 50\text{ V}, T_A = 70^\circ\text{C}$						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**

The ULN2001A is obsolete  
and is no longer supplied.

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

**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		
			$I_C = 250\text{ mA}$								
			$I_C = 275\text{ mA}$								7
			$I_C = 300\text{ mA}$								3
			$I_C = 350\text{ mA}$								
$V_{CE(sat)}$ 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	$V_{CE} = 50\text{ V}$	$I_I = 0$					100			
			$V_I = 1\text{ V}$					500			
$V_F$ Clamp forward voltage	8	$I_F = 350\text{ mA}$		1.7	2.2		1.7	2	V		
$I_{I(off)}$ Off-state input current	3	$V_{CE} = 50\text{ V}$ , $I_C = 500\text{ }\mu\text{A}$		30	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	$\mu\text{A}$		
		$V_R = 50\text{ V}$			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



PARAMETER MEASUREMENT INFORMATION

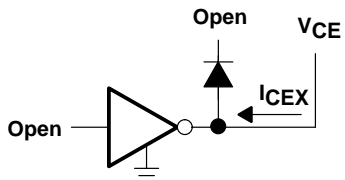


Figure 1.  $I_{CEX}$  Test Circuit

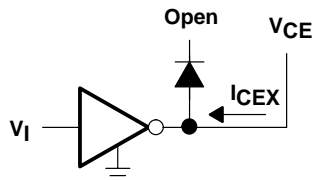


Figure 2.  $I_{CEX}$  Test Circuit

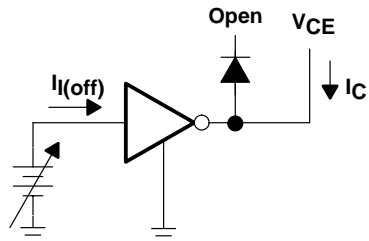


Figure 3.  $I_{I(off)}$  Test Circuit

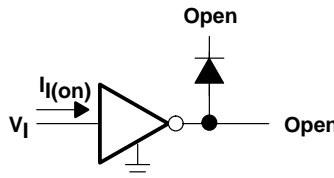
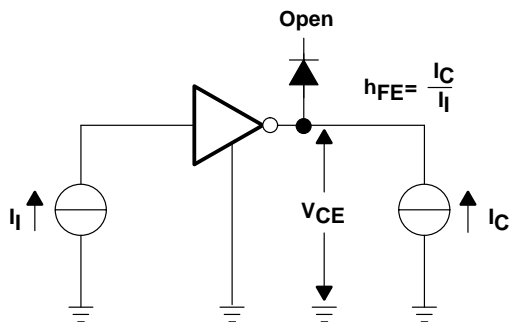


Figure 4.  $I_I$  Test Circuit



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

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

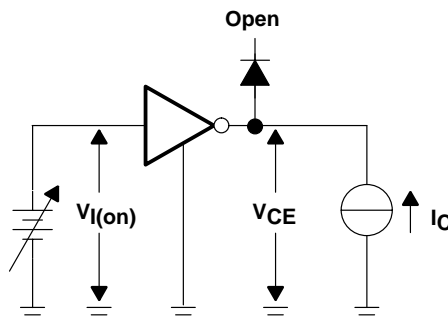


Figure 6.  $V_{I(on)}$  Test Circuit

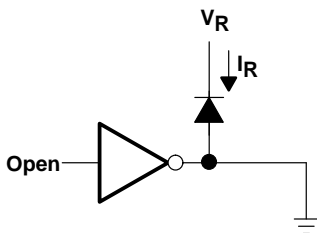


Figure 7.  $I_R$  Test Circuit

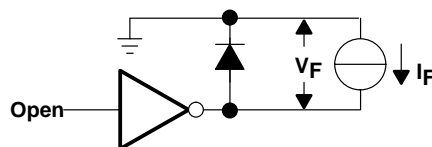


Figure 8.  $V_F$  Test Circuit

The ULN2001A is obsolete  
and is no longer supplied.

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

PARAMETER MEASUREMENT INFORMATION

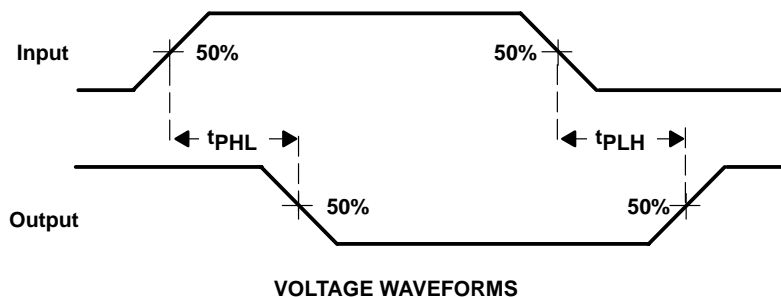
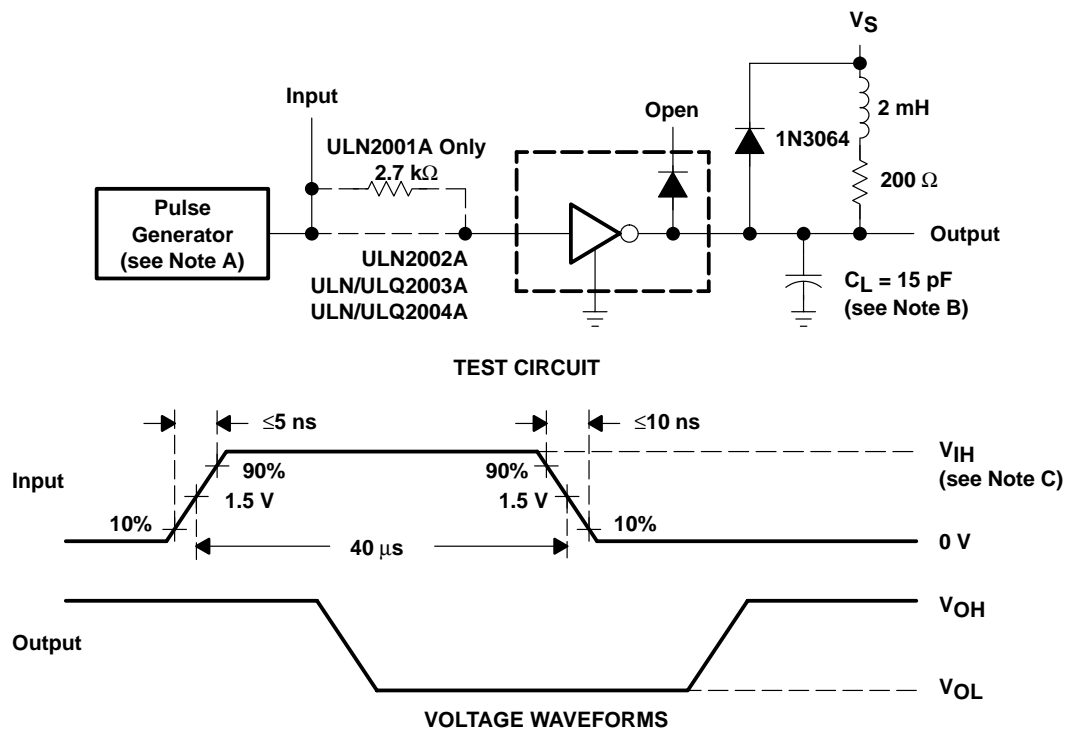


Figure 9. Propagation Delay-Time Waveforms



- 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

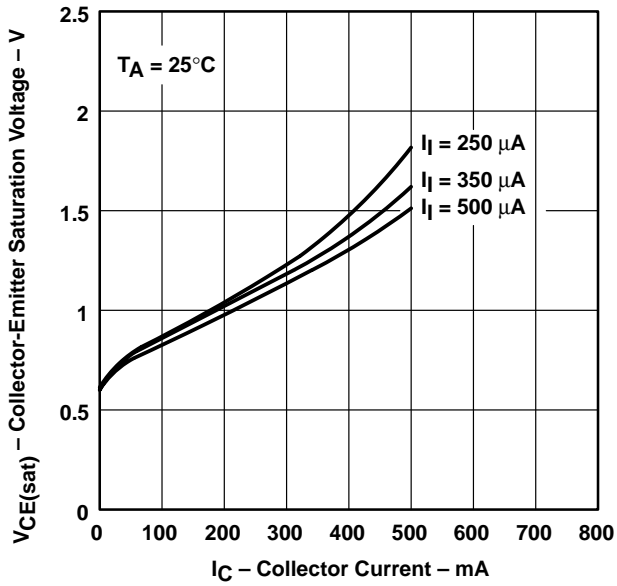
**ULN2001A, ULN2002A, ULN2003A, ULN2004A, ULQ2003A, ULQ2004A,  
HIGH-VOLTAGE HIGH-CURRENT DARLINGTON  
TRANSISTOR ARRAY**

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

The ULN2001A is obsolete  
and is no longer supplied.

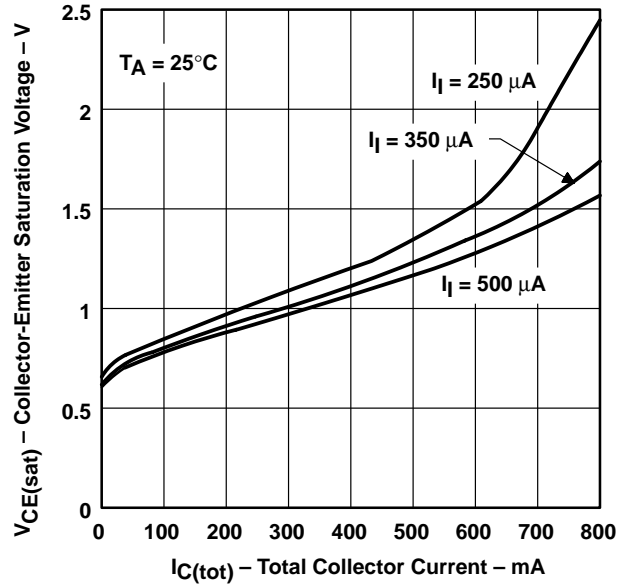
**TYPICAL CHARACTERISTICS**

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



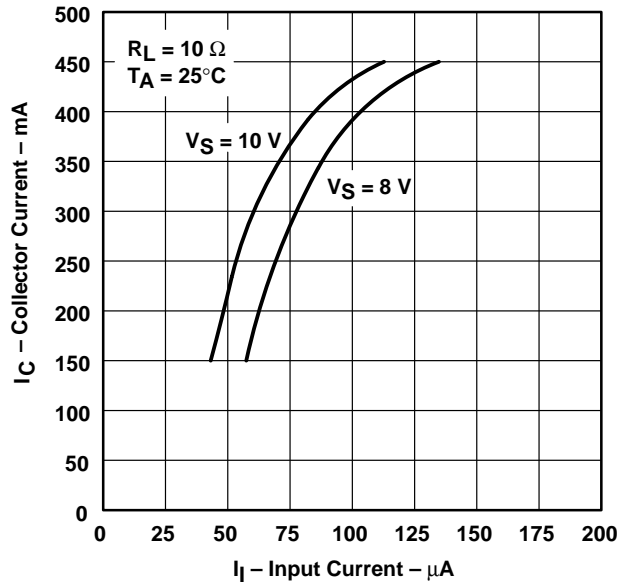
**Figure 11**

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



**Figure 12**

**COLLECTOR CURRENT  
vs  
INPUT CURRENT**



**Figure 13**



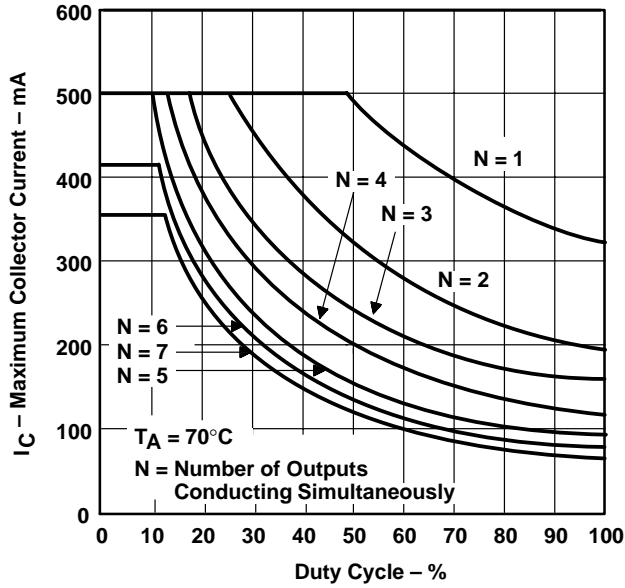


The ULN2001A is obsolete  
 and is no longer supplied.

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

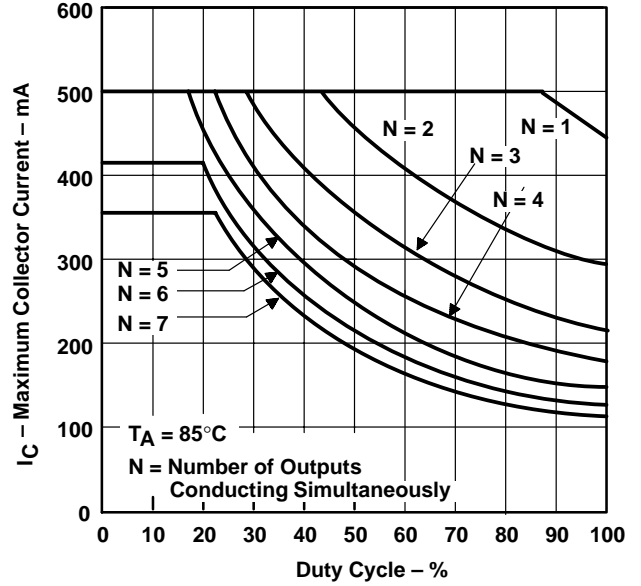
**THERMAL INFORMATION**

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



**Figure 14**

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



**Figure 15**

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

SLRS027E – DECEMBER 1976 – REVISED SEPTEMBER 2002

The ULN2001A is obsolete  
and is no longer supplied.

## APPLICATION INFORMATION

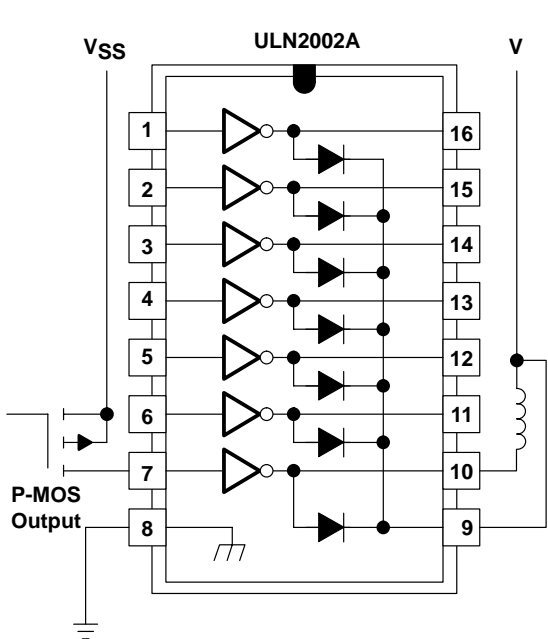


Figure 16. P-MOS to Load

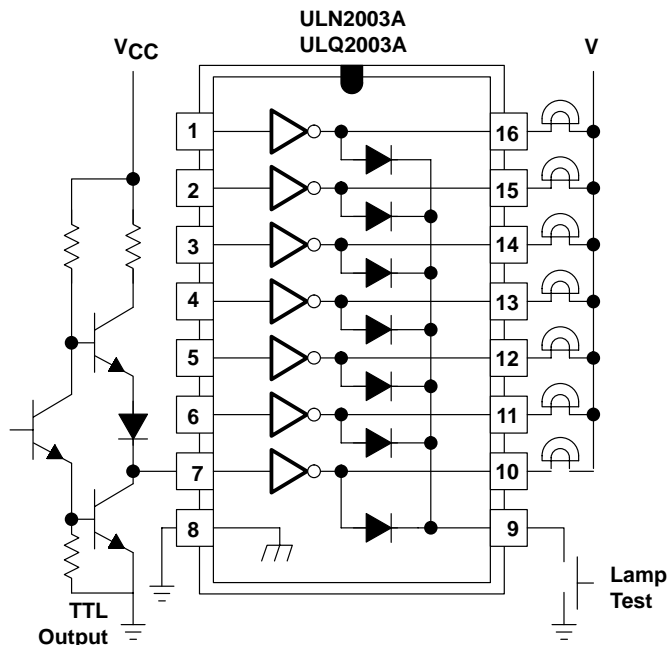


Figure 17. TTL to Load

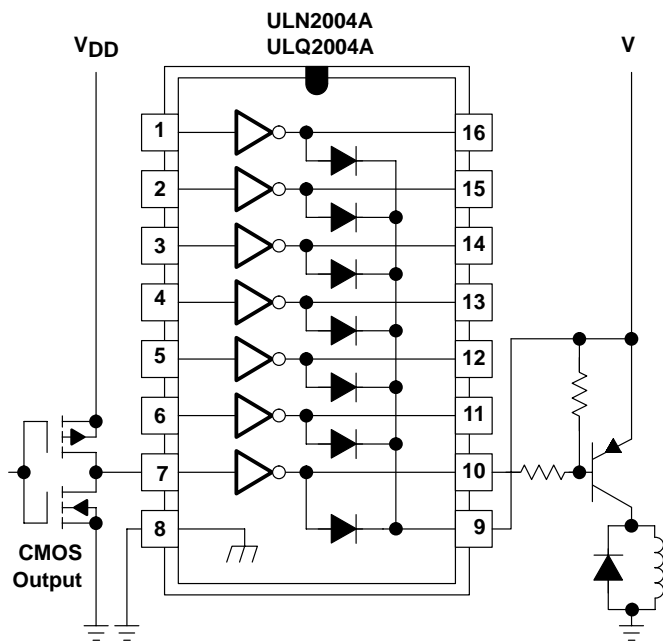


Figure 18. Buffer for Higher Current Loads

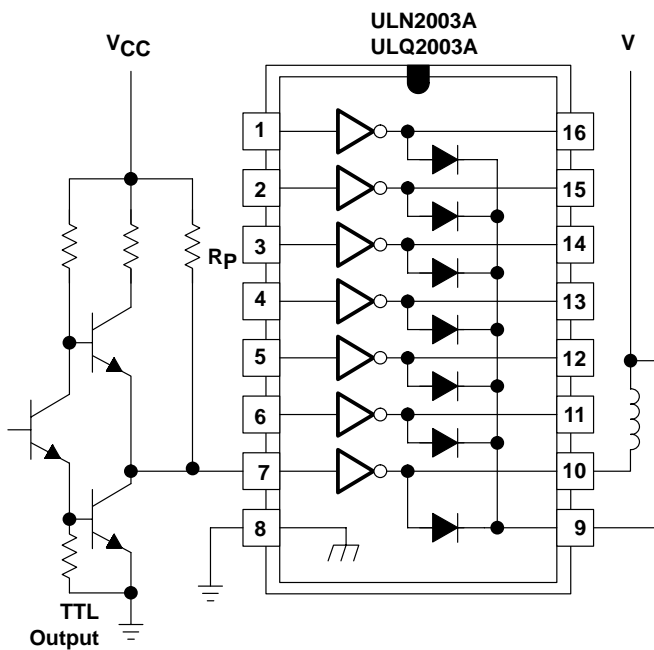


Figure 19. Use of Pullup Resistors  
to Increase Drive Current

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

### Mailing Address:

Texas Instruments  
Post Office Box 655303  
Dallas, Texas 75265