

## Description

The ULN2002A, ULN2003A and ULN2004A are high voltage, high current Darlington arrays each containing seven open collector common emitter pairs. Each pair is rated at 500mA. Suppression diodes are included for inductive load driving, the inputs and outputs are pinned in opposition to simplify board layout.

Device options are designed to be compatible with common logic families:

- ULN2002A (14-25V PMOS)
- ULN2003A (5V TTL, CMOS)
- ULN2004A (6-15V CMOS, PMOS)

These devices are capable of driving a wide range of loads including solenoids, relays, DC motors, LED displays, filament lamps, thermal print-heads and high-power buffers.

The ULN2002A, 2003A and 2004A are available in both a small outline 16-pin package (SO-16) and DIP-16 package.

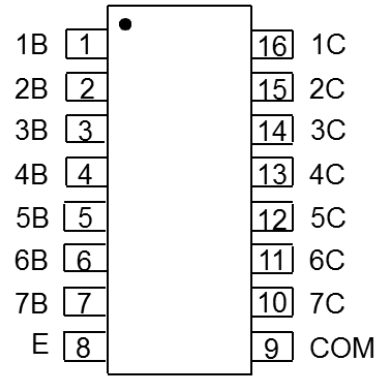
## Features

- 500mA Rated Collector Current (single output)
- High Voltage Outputs: 50V
- Output Clamp Diodes
- Inputs Compatible with Popular Logic Types
- Relay Driver Applications
- "Green" Molding Compound (No Br, Sb)
- **Totally Lead-Free & Fully RoHS Compliant (Note 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
  2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

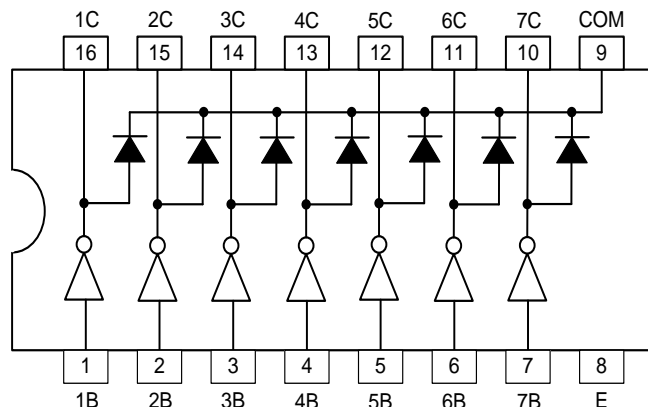
## Pin Assignments

( Top View )



**SO-16/DIP-16**

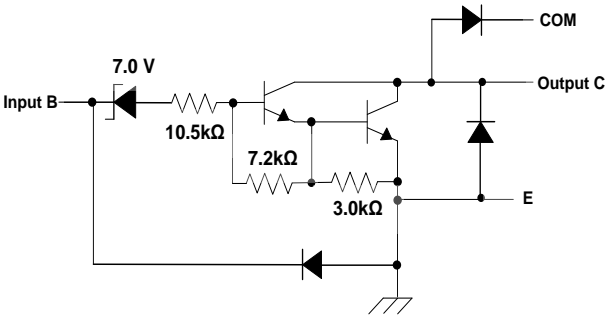
## Connection Diagram



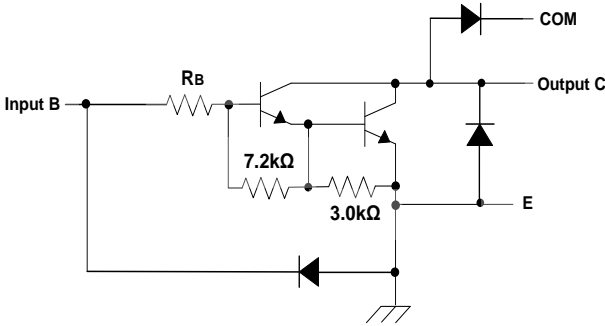
Pin Descriptions

Pin Number	Pin Name	Function
1	1B	Input Pair 1
2	2B	Input Pair 2
3	3B	Input Pair 3
4	4B	Input Pair 4
5	5B	Input Pair 5
6	6B	Input Pair 6
7	7B	Input Pair 7
8	E	Common Emitter (ground)
9	COM	Common Clamp Diodes
10	7C	Output Pair 7
11	6C	Output Pair 6
12	5C	Output Pair 5
13	4C	Output Pair 4
14	3C	Output Pair 3
15	2C	Output Pair 2
16	1C	Output Pair 1

Functional Block Diagram



ULN2002A



ULN2003A:  $R_B = 2k7$   
 ULN2004A:  $R_B = 10k5$   
**ULN2003A, ULN2004A**

**Absolute Maximum Ratings** (Note 4) (@T<sub>A</sub> = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit	
V <sub>CC</sub>	Collector to Emitter Voltage	50	V	
V <sub>R</sub>	Clamp Diode Reverse Voltage (Note 5)	50	V	
V <sub>I</sub>	Input Voltage (Note 5)	30	V	
I <sub>CP</sub>	Peak Collector Current	See typical characteristics	500 mA	
I <sub>OK</sub>	Output Clamp Current	500	mA	
I <sub>TE</sub>	Total Emitter Current	-2.5	A	
θ <sub>JA</sub>	Thermal Resistance Junction-to-Ambient (Note 6)	SO-16	63.0	°C/W
		DIP-16	50.0	
θ <sub>JC</sub>	Thermal Resistance Junction-to-Case (Note 6)	SO-16	12.0	°C/W
		DIP-16	15.0	
T <sub>J</sub>	Junction Temperature	150	°C	
T <sub>STG</sub>	Storage Temperature	-65 to +150	°C	

- Notes:
- Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only. 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.
  - All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
  - Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> - T<sub>A</sub>)/θ<sub>JA</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
  - Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JC</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J(max)</sub> - T<sub>C</sub>)/θ<sub>JC</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.

**Recommended Operating Conditions**

Symbol	Parameter	Min	Max	Unit
V <sub>CC</sub>	Collector to Emitter voltage	-	50	V
T <sub>A</sub>	Operating Ambient Temperature	-40	+105	°C

**Electrical Characteristics** (@T<sub>A</sub> = +25°C, unless otherwise specified.)

ULN2002A								
Parameter	Test Figure	Test Conditions	Min	Typ	Max	Unit		
V <sub>I(on)</sub>	On State Input Voltage	6	V <sub>CE</sub> = 2V, I <sub>C</sub> = 300mA	-	-	13	V	
V <sub>CE(sat)</sub>	Collector Emitter Saturation Voltage	5	I <sub>I</sub> = 250μA, I <sub>C</sub> = 100mA	-	0.9	1.1	V	
			I <sub>I</sub> = 350μA, I <sub>C</sub> = 200mA	-	1	1.3		
			I <sub>I</sub> = 500μA, I <sub>C</sub> = 350mA	-	1.2	1.6		
V <sub>F</sub>	Clamp Forward Voltage	8	I <sub>F</sub> = 350mA	-	1.7	2	V	
I <sub>CEX</sub>	Collector Cut-off Current	1	V <sub>CE</sub> = 50V, I <sub>I</sub> = 0	-	-	50	μA	
			2	V <sub>CE</sub> = 50V, T <sub>A</sub> = +105°C, I <sub>I</sub> = 0, V <sub>I</sub> = 6V	-	-		100
I <sub>I(off)</sub>	Off State Input Current	3	V <sub>CE</sub> = 50V, I <sub>C</sub> = 500μA	50	65	-	μA	
I <sub>I</sub>	Input Current	4	V <sub>I</sub> = 17V	-	0.82	1.25	mA	
I <sub>R</sub>	Clamp Reverse Current	7	V <sub>R</sub> = 50V	T <sub>A</sub> = +105°C	-	-	100	μA
				-	-	-	50	
C <sub>I</sub>	Input Capacitance	-	V <sub>I</sub> = 0, f = 1MHz	-	-	25	pF	

**Electrical Characteristics** (@T<sub>A</sub> = +25°C, unless otherwise specified.)

<b>ULN2003A</b>								
<b>Parameter</b>		<b>Test Figure</b>	<b>Test Conditions</b>		<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
V <sub>I(on)</sub>	On State Input Voltage	6	V <sub>CE</sub> = 2V	I <sub>C</sub> = 200mA	-	-	2.4	V
				I <sub>C</sub> = 250mA	-	-	2.7	
				I <sub>C</sub> = 300mA	-	-	3	
V <sub>CE(sat)</sub>	Collector Emitter Saturation Voltage	5		I <sub>I</sub> = 250μA, I <sub>C</sub> = 100mA	-	0.9	1.1	V
				I <sub>I</sub> = 350μA, I <sub>C</sub> = 200mA	-	1	1.3	
				I <sub>I</sub> = 500μA, I <sub>C</sub> = 350mA	-	1.2	1.6	
V <sub>F</sub>	Clamp Forward Voltage	8	I <sub>F</sub> = 350mA	-	1.7	2	V	
I <sub>CEX</sub>	Collector Cut-off Current	1	V <sub>CE</sub> = 50V, I <sub>I</sub> = 0	-	-	50	μA	
		2	V <sub>CE</sub> = 50V, T <sub>A</sub> = +105°C, I <sub>I</sub> = 0	-	-	100		
I <sub>I(off)</sub>	Off State Input Current	3	V <sub>CE</sub> = 50V, I <sub>C</sub> = 500μA	50	65	-	μA	
I <sub>I</sub>	Input Current	4	V <sub>I</sub> = 3.85V	-	0.93	1.35	mA	
I <sub>R</sub>	Clamp Reverse Current	7	V <sub>R</sub> = 50V	T <sub>A</sub> = +105°C	-	-	100	μA
				-	-	-	50	
C <sub>I</sub>	Input Capacitance	-	V <sub>I</sub> = 0, f = 1MHz	-	15	25	pF	
<b>ULN2004A</b>								
<b>Parameter</b>		<b>Test Figure</b>	<b>Test Conditions</b>		<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
V <sub>I(on)</sub>	On State Input Voltage	6	V <sub>CE</sub> = 2V	I <sub>C</sub> = 125mA	-	-	5	V
				I <sub>C</sub> = 200mA	-	-	6	
				I <sub>C</sub> = 275mA	-	-	7	
				I <sub>C</sub> = 350mA	-	-	8	
V <sub>CE(sat)</sub>	Collector Emitter Saturation Voltage	5		I <sub>I</sub> = 250μA, I <sub>C</sub> = 100mA	-	0.9	1.1	V
				I <sub>I</sub> = 350μA, I <sub>C</sub> = 200mA	-	1	1.3	
				I <sub>I</sub> = 500μA, I <sub>C</sub> = 350mA	-	1.2	1.6	
V <sub>F</sub>	Clamp Forward Voltage	8	I <sub>F</sub> = 350mA	-	1.7	2	V	
I <sub>CEX</sub>	Collector Cut-off Current	1	V <sub>CE</sub> = 50V, I <sub>I</sub> = 0	-	-	50	μA	
		2	V <sub>CE</sub> = 50V, T <sub>A</sub> = +105°C, I <sub>I</sub> = 0, V <sub>I</sub> = 6V	-	-	500		
I <sub>I(off)</sub>	Off State Input Current	3	V <sub>CE</sub> = 50V, I <sub>C</sub> = 500μA	50	65	-	μA	
I <sub>I</sub>	Input Current	4	V <sub>I</sub> = 5V	-	0.35	0.5	mA	
I <sub>R</sub>	Clamp Reverse Current	7	V <sub>R</sub> = 50V	T <sub>A</sub> = +105°C	-	-	100	μA
				-	-	-	50	
C <sub>I</sub>	Input Capacitance	-	V <sub>I</sub> = 0, f = 1MHz	-	15	25	pF	

**Electrical Characteristics** (@T<sub>A</sub> = -40°C to +105°C, unless otherwise specified.)

ULN2003A								
Parameter		Test Figure	Test Conditions	Min	Typ	Max	Unit	
V <sub>I(on)</sub>	On State Input Voltage	6	V <sub>CE</sub> = 2V	I <sub>C</sub> = 200mA	-	-	2.7	V
				I <sub>C</sub> = 250mA	-	-	2.9	
				I <sub>C</sub> = 300mA	-	-	3	
V <sub>CE(sat)</sub>	Collector Emitter Saturation Voltage	5		I <sub>I</sub> = 250μA, I <sub>C</sub> = 100mA	-	0.9	1.2	V
				I <sub>I</sub> = 350μA, I <sub>C</sub> = 200mA	-	1	1.4	
				I <sub>I</sub> = 500μA, I <sub>C</sub> = 350mA	-	1.2	1.7	
V <sub>F</sub>	Clamp Forward Voltage	8	I <sub>F</sub> = 350mA	-	1.7	2.2	V	
I <sub>CEX</sub>	Collector Cut-off Current	1	V <sub>CE</sub> = 50V, I <sub>I</sub> = 0	-	-	100	μA	
I <sub>I(off)</sub>	Off State Input Current	3	V <sub>CE</sub> = 50V, I <sub>C</sub> = 500μA	30	65	-	μA	
I <sub>I</sub>	Input Current	4	V <sub>I</sub> = 3.85V	-	0.93	1.35	mA	
I <sub>R</sub>	Clamp Reverse Current	7	V <sub>R</sub> = 50V	-	-	100	μA	
C <sub>I</sub>	Input Capacitance	-	V <sub>I</sub> = 0, f = 1MHz	-	15	25	pF	

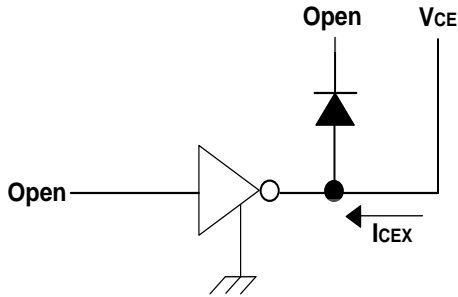
**Switching Characteristics** (@T<sub>A</sub> = +25°C, unless otherwise specified.)

ULN2002A, ULN2003A, ULN2004A						
Parameter		Test figure	Min	Typ	Max	Unit
t <sub>PLH</sub>	Propagation delay time, low to high level output	10	-	0.25	1	μs
t <sub>PLL</sub>	Propagation delay time, high to low level output	10	-	0.25	1	μs
V <sub>OH</sub>	High level output voltage after switching	10 (V <sub>S</sub> = 50V, I <sub>O</sub> = 300mA)	V <sub>S</sub> -20	-	-	mV

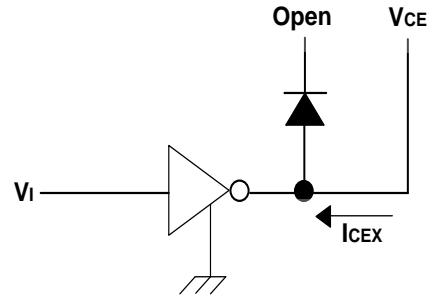
**Switching Characteristics** (@T<sub>A</sub> = -40 to +105°C, unless otherwise specified.)

ULN2003A						
Parameter		Test figure	Min	Typ	Max	Unit
t <sub>PLH</sub>	Propagation delay time, low to high level output	10	-	1	10	μs
t <sub>PLL</sub>	Propagation delay time, high to low level output	10	-	1	10	μs
V <sub>OH</sub>	High level output voltage after switching	10 (V <sub>S</sub> = 50V, I <sub>O</sub> = 300mA)	V <sub>S</sub> -50	-	-	mV

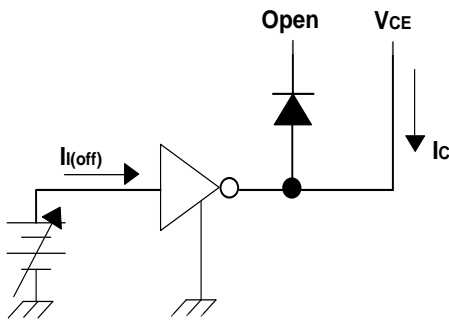
**Parameter Measurement Circuits**



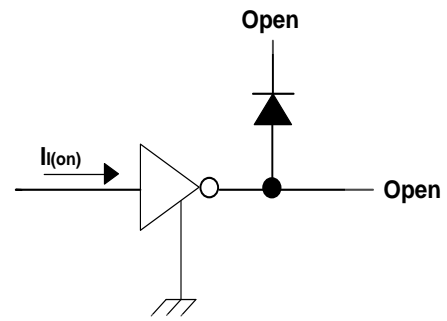
**Fig.1 ICEX Test Circuit**



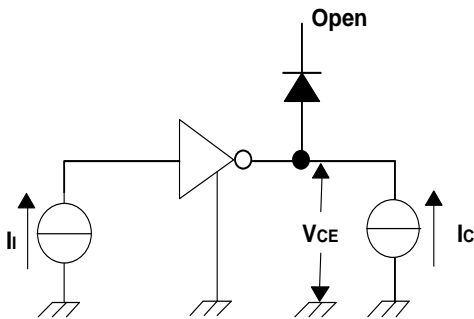
**Fig.2 ICEX Test Circuit**



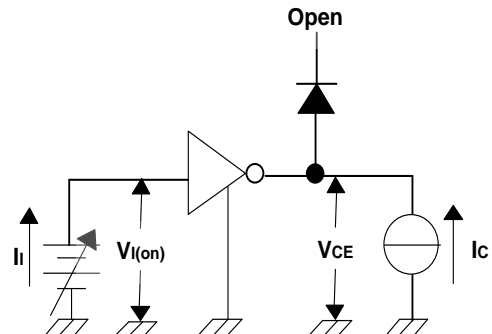
**Fig.3 I(off) Test Circuit**



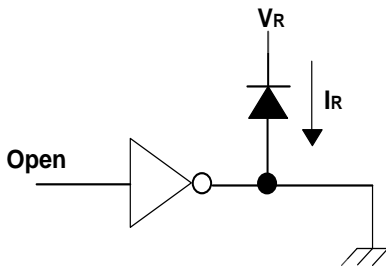
**Fig.4 I(on) Test Circuit**



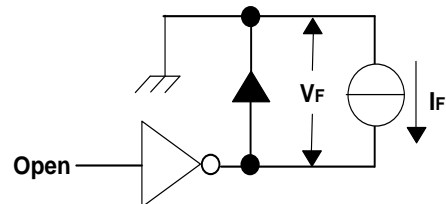
**Fig. 5 hFE , VCE(sat) Test Circuit**



**Fig. 6 VI(on) Test Circuit**

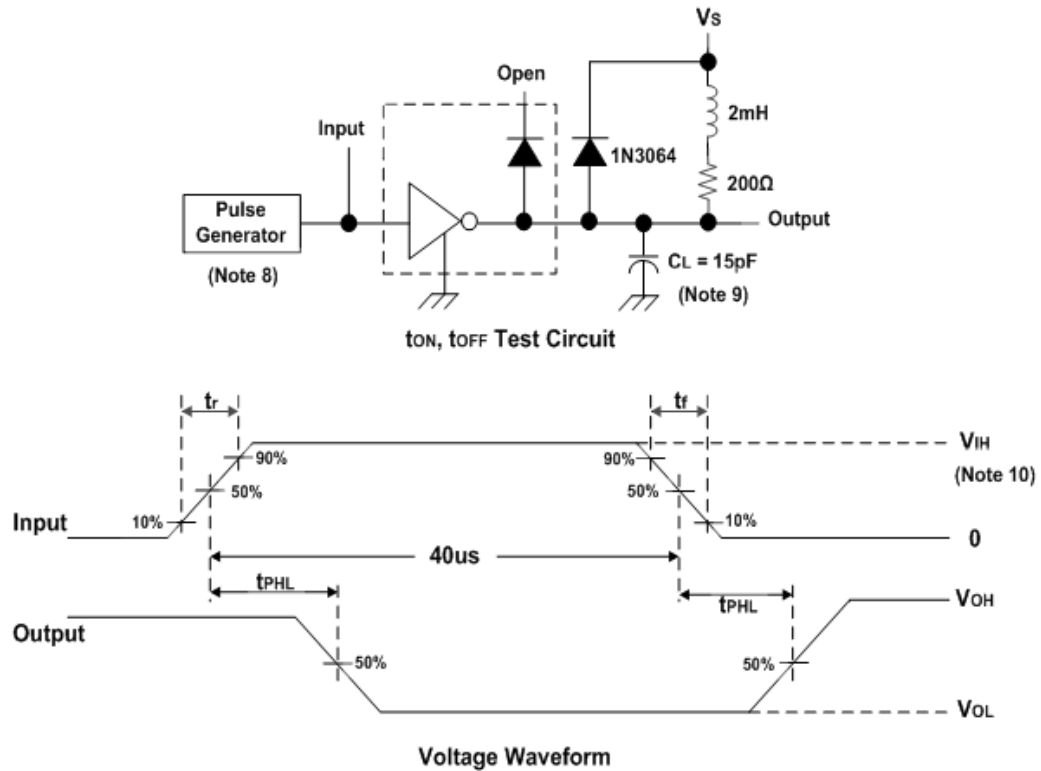


**Fig. 7 IR Test Circuit**



**Fig. 8 VF Test Circuit**

**Parameter Measurement Circuits** (continued)



**Fig. 10 Latch-Up Test Circuit and Voltage Waveform**

- Notes:
- 8. The pulse generator has the following characteristics: Pulse Width = 12.5Hz, output impedance 50Ω,  $t_r \leq 5\text{ns}$ ,  $t_f \leq 10\text{ns}$ .
  - 9.  $C_L$  includes probe and jig capacitance.
  - 10. For testing the ULN2002A,  $V_{IH} = 13\text{V}$ ; for the ULN2003A,  $V_{IH} = 3\text{V}$ ; for the ULN2004A,  $V_{IH} = 8\text{V}$ .

**Typical Performance Characteristics**

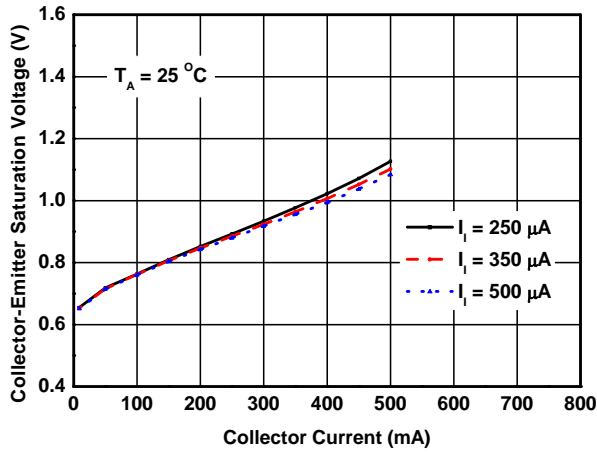


Figure 11 Collector-Emitter Saturation Voltage vs. Collector Current (One Darlington)

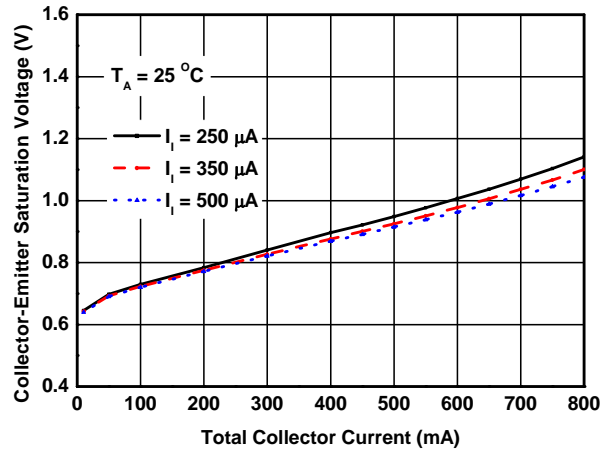


Figure 12 Collector-Emitter Saturation Voltage vs. Collector Current (Two Darlington in Parallel)

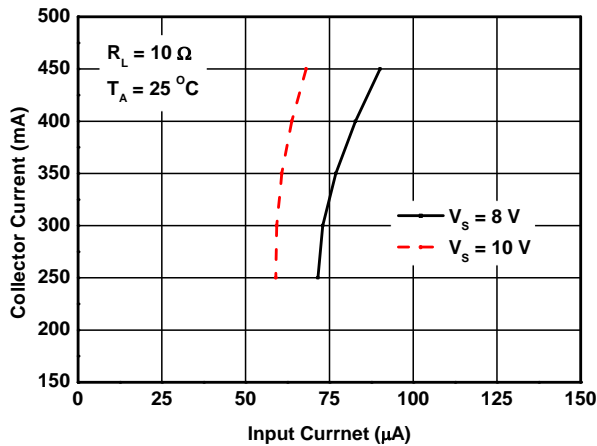


Figure 13 Collector Current vs. Input Current

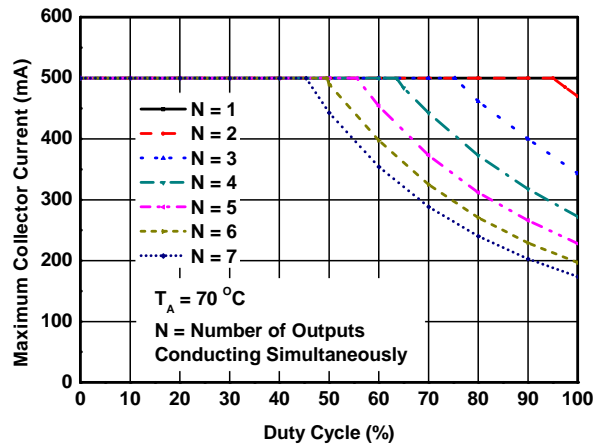


Figure 14 Maximum Collector Current vs. Duty Cycle

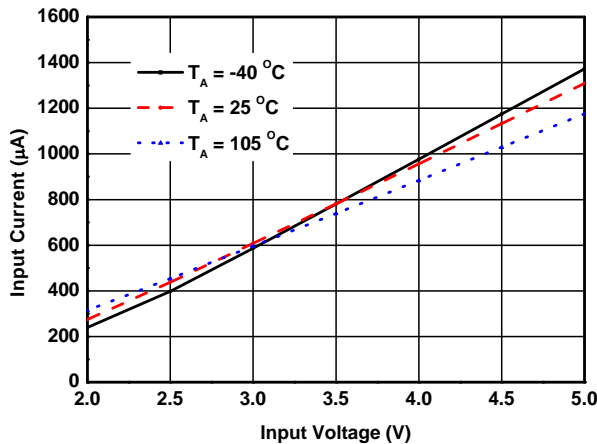


Figure 15. Input Current vs. Input Voltage

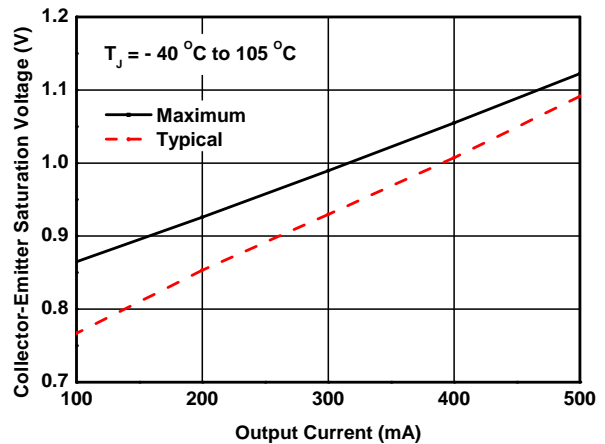


Figure 16. Collector-Emitter Saturation Voltage vs. Output Current



**Typical Performance Characteristics** (continued)

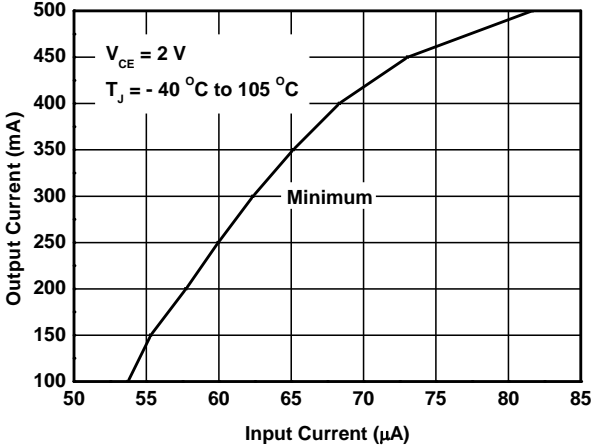
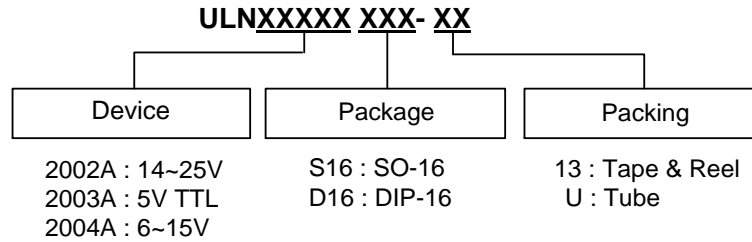


Figure 17. Output Current vs. Input Current

## Ordering Information

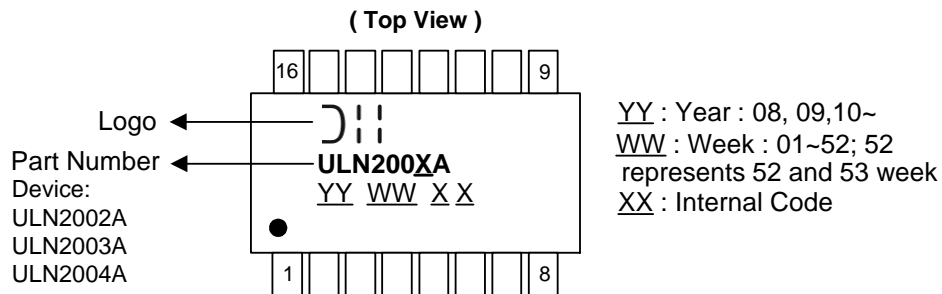


Part Number	Package Code	Packaging	13" Tape and Reel		Tube	
			Quantity	Part Number Suffix	Quantity	Part Number Suffix
ULN2002AS16-13	S16	SO-16	2,500/Tape & Reel	-13	NA	NA
ULN2003AS16-13	S16	SO-16	2,500/Tape & Reel	-13	NA	NA
ULN2004AS16-13	S16	SO-16	2,500/Tape & Reel	-13	NA	NA
ULN2002AD16-U	D16	PDIP-16	NA	NA	25/Tube	-U
ULN2003AD16-U	D16	PDIP-16	NA	NA	25/Tube	-U
ULN2004AD16-U	D16	PDIP-16	NA	NA	25/Tube	-U

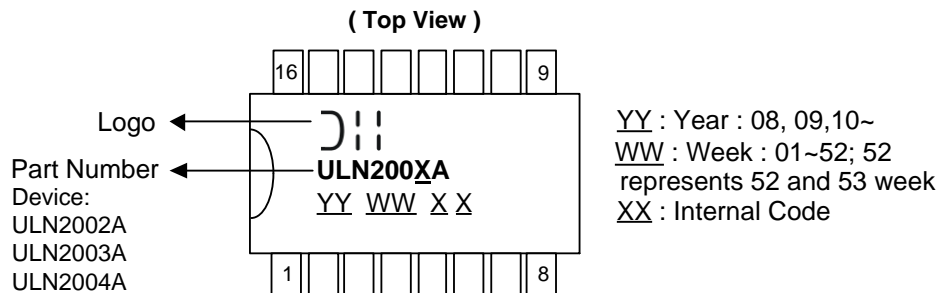
Note: 11. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

## Marking Information

### (1) SO-16



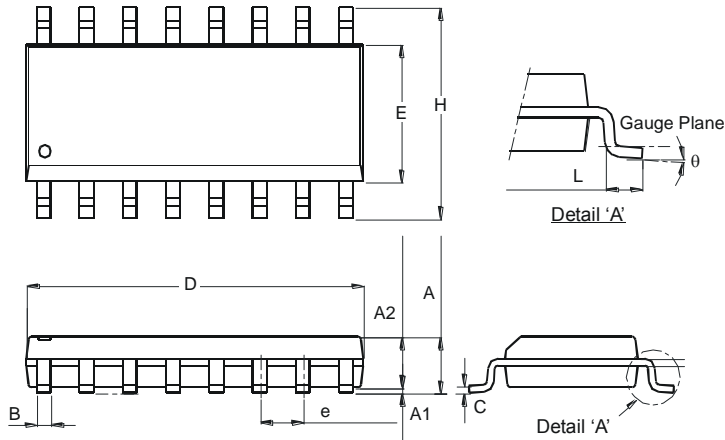
### (2) PDIP-16



**Package Outline Drawings**

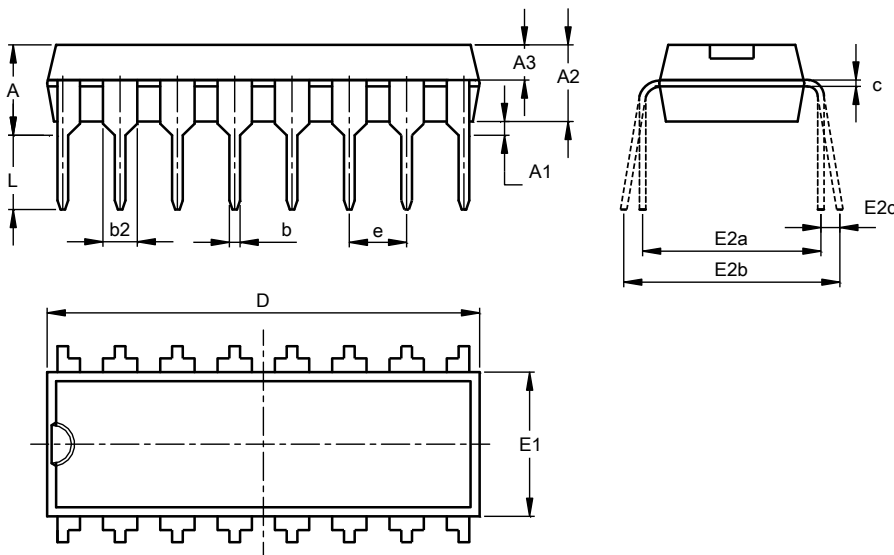
Please see AP02002 at <http://www.diodes.com/datasheets/ap02002.pdf> for the latest version.

**SO-16**



SO-16		
Dim	Min	Max
A	1.40	1.75
A1	0.10	0.25
A2	1.30	1.50
B	0.33	0.51
C	0.19	0.25
D	9.80	10.00
E	3.80	4.00
e	1.27 Typ	
H	5.80	6.20
L	0.38	1.27
$\theta$	0°	8°
All Dimensions in mm		

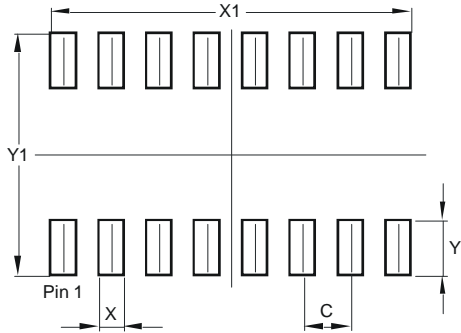
**PDIP-16**



PDIP-16			
Dim	Min	Max	Nom
A	3.60	4.00	3.80
A1	0.51	-	-
A2	3.20	3.40	3.30
A3	1.47	1.57	1.52
b	0.44	0.53	-
b2	1.52BSC		
c	0.25	0.31	-
D	18.90	19.30	19.10
E1	6.15	6.55	6.35
E2a	7.62 BSC		
E2b	7.62	9.30	-
E2c	0.00	0.84	-
e	2.54BSC		
L	3.00	-	-
All Dimensions in mm			

**Suggested Pad Layout**

Please see AP02001 at <http://www.diodes.com/datasheets/ap02001.pdf> for the latest version.



Dimensions	Value (in mm)
C	1.270
X	0.670
X1	9.560
Y	1.450
Y1	6.400

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