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ULN2002A/ ULN2003A/ ULN2004A

**HIGH VOLTAGE, HIGH CURRENT
DARLINGTON TRANSISTOR ARRAYS**

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, ULN2003A and ULN2004A are available in both a small outline 16-pin package (SO-16) and PDIP-16 package.

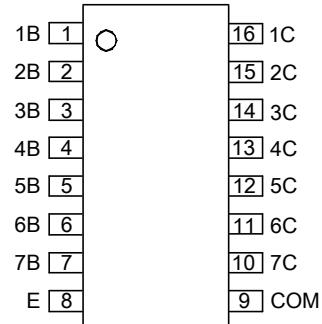
Features

- 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 (Notes 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 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.

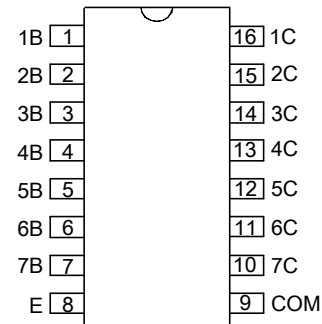
Pin Assignments

(Top View)



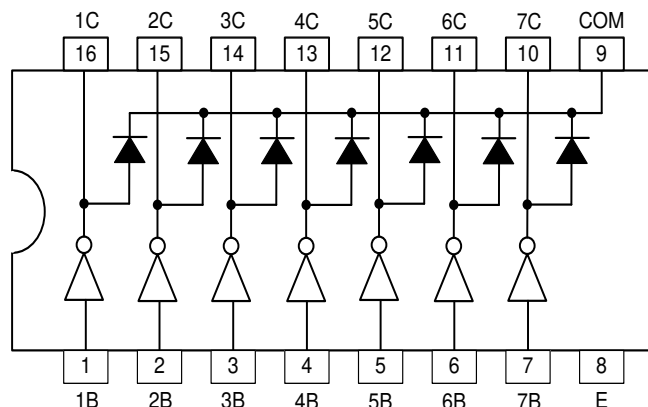
SO-16

(Top View)



PDIP-16

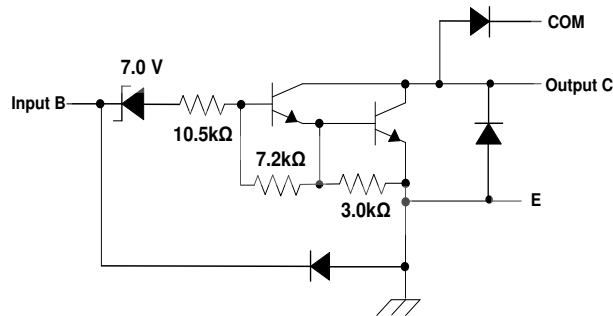
Connection Diagram



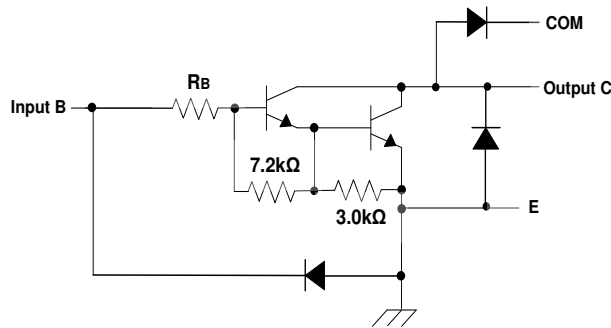
Pin Descriptions

Pin Number SO-16/PDIP-16	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: $R_B = 2.7k$
 ULN2004A: $R_B = 10.5k$

ULN2003A, ULN2004A

Absolute Maximum Ratings (Note 4) (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter		Rating	Unit
V _{CC}	Collector to Emitter Voltage		50	V
V _R	Clamp Diode Reverse Voltage (Note 5)		50	V
V _I	Input Voltage (Note 5)		30	V
I _{CP}	Peak Collector Current		500	mA
I _{OK}	Output Clamp Current		500	mA
I _{TE}	Total Emitter Current		-2.5	A
θ _{JA}	Thermal Resistance Junction-to-Ambient (Note 6)	SO-16	63.0	°C/W
		PDIP-16	50.0	
θ _{JC}	Thermal Resistance Junction-to-Case (Note 7)	SO-16	12.0	°C/W
		PDIP-16	15.0	
T _J	Junction Temperature		+150	°C
T _{STG}	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_{J(max)}, θ_{JA} and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} - T_A)/θ_{JA}. Operating at the absolute maximum T_J of +150°C can affect reliability.
 - Maximum power dissipation is a function of T_{J(max)}, θ_{JC} and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} - T_C)/θ_{JC}. Operating at the absolute maximum T_J of +150°C can affect reliability.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V _{CC}	Collector to Emitter Voltage	—	50	V
T _A	Operating Ambient Temperature	-40	+105	°C

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

ULN2002A								
Symbol	Parameter	Test Figure	Test Conditions	Min	Typ	Max	Unit	
V _{I(ON)}	On State Input Voltage	6	V _{CE} = 2V, I _C = 300mA	—	—	13	V	
V _{CE(SAT)}	Collector Emitter Saturation Voltage	5	I _I = 250μA, I _C = 100mA	—	0.9	1.1	V	
			I _I = 350μA, I _C = 200mA	—	1	1.3		
			I _I = 500μA, I _C = 350mA	—	1.2	1.6		
V _F	Clamp Forward Voltage	8	I _F = 350mA	—	1.7	2	V	
I _{C(EX)}	Collector Cut-off Current	1	V _{CE} = 50V, I _I = 0	—	—	50	μA	
		2	V _{CE} = 50V, T _A = +105°C, I _I = 0, V _I = 6V	—	—	500		
I _{I(OFF)}	Off State Input Current	3	V _{CE} = 50V, I _C = 500μA	50	65	—	μA	
I _I	Input Current	4	V _I = 17V	—	0.82	1.25	mA	
I _R	Clamp Reverse Current	7	V _R = 50V	T _A = +105°C	—	—	100	μA
				—	—	—	50	
C _I	Input Capacitance	—	V _I = 0, f = 1MHz	—	—	25	pF	

Electrical Characteristics (Cont.) (@T_A = +25°C, unless otherwise specified.)

ULN2003A								
Parameter		Test Figure	Test Conditions	Min	Typ	Max	Unit	
V _{I(ON)}	On State Input Voltage	6	V _{CE} = 2V	I _C = 200mA	—	—	2.4	V
				I _C = 250mA	—	—	2.7	
				I _C = 300mA	—	—	3	
V _{CE(SAT)}	Collector Emitter Saturation Voltage	5		I _I = 250μA, I _C = 100mA	—	0.9	1.1	V
				I _I = 350μA, I _C = 200mA	—	1	1.3	
				I _I = 500μA, I _C = 350mA	—	1.2	1.6	
V _F	Clamp Forward Voltage	8	I _F = 350mA	—	1.7	2	V	
I _{CEX}	Collector Cut-off Current	1	V _{CE} = 50V, I _I = 0	—	—	50	μA	
		2	V _{CE} = 50V, T _A = +105°C, I _I = 0	—	—	100		
I _{I(OFF)}	Off State Input Current	3	V _{CE} = 50V, I _C = 500μA	50	65	—	μA	
I _I	Input Current	4	V _I = 3.85V	—	0.93	1.35	mA	
I _R	Clamp Reverse Current	7	V _R = 50V	T _A = +105°C	—	—	100	μA
				—	—	—	50	
C _I	Input Capacitance	—	V _I = 0, f = 1MHz	—	15	25	pF	
ULN2004A								
Parameter		Test Figure	Test Conditions	Min	Typ	Max	Unit	
V _{I(ON)}	On State Input Voltage	6	V _{CE} = 2V	I _C = 125mA	—	—	5	V
				I _C = 200mA	—	—	6	
				I _C = 275mA	—	—	7	
				I _C = 350mA	—	—	8	
V _{CE(SAT)}	Collector Emitter Saturation Voltage	5		I _I = 250μA, I _C = 100mA	—	0.9	1.1	V
				I _I = 350μA, I _C = 200mA	—	1	1.3	
				I _I = 500μA, I _C = 350mA	—	1.2	1.6	
V _F	Clamp Forward Voltage	8	I _F = 350mA	—	1.7	2	V	
I _{CEX}	Collector Cut-off Current	1	V _{CE} = 50V, I _I = 0	—	—	50	μA	
		2	V _{CE} = 50V, T _A = +105°C, I _I = 0, V _I = 6V	—	—	100		
I _{I(OFF)}	Off State Input Current	3	V _{CE} = 50V, I _C = 500μA	50	65	—	μA	
I _I	Input Current	4	V _I = 5V	—	0.35	0.5	mA	
I _R	Clamp Reverse Current	7	V _R = 50V	T _A = +105°C	—	—	100	μA
				—	—	—	50	
C _I	Input Capacitance	—	V _I = 0, f = 1MHz	—	15	25	pF	

Electrical Characteristics (Cont.) (@ $T_A = -40^\circ\text{C}$ to $+105^\circ\text{C}$, unless otherwise specified.)

ULN2003A							
Parameter	Test Figure	Test Conditions	Min	Typ	Max	Unit	
$V_{I(ON)}$	On State Input Voltage	$V_{CE} = 2V$	$I_C = 200\text{mA}$	—	—	2.7	V
			$I_C = 250\text{mA}$	—	—	2.9	
			$I_C = 300\text{mA}$	—	—	3	
$V_{CE(SAT)}$	Collector Emitter Saturation Voltage	5	$I_I = 250\mu\text{A}, I_C = 100\text{mA}$	—	0.9	1.2	V
			$I_I = 350\mu\text{A}, I_C = 200\text{mA}$	—	1	1.4	
			$I_I = 500\mu\text{A}, I_C = 350\text{mA}$	—	1.2	1.7	
V_F	Clamp Forward Voltage	8	$I_F = 350\text{mA}$	—	1.7	2.2	V
I_{CEX}	Collector Cut-off Current	1	$V_{CE} = 50V, I_I = 0$	—	—	100	μA
$I_{I(OFF)}$	Off State Input Current	3	$V_{CE} = 50V, I_C = 500\mu\text{A}$	30	65	—	μA
I_I	Input Current	4	$V_I = 3.85V$	—	0.93	1.35	mA
I_R	Clamp Reverse Current	7	$V_R = 50V$	—	—	100	μA
C_I	Input Capacitance	—	$V_I = 0, f = 1\text{MHz}$	—	15	25	pF

Switching Characteristics (@ $T_A = +25^\circ\text{C}$, unless otherwise specified.)

ULN2002A, ULN2003A, ULN2004A						
Parameter	Test figure	Min	Typ	Max	Unit	
t_{PLH}	Propagation Delay Time, Low to High Level Output	9	—	0.25	1	μs
t_{PHL}	Propagation Delay Time, High to Low Level Output	9	—	0.25	1	μs
V_{OH}	High Level Output Voltage after Switching	9 ($V_S = 50V, I_O = 300\text{mA}$)	$V_S - 20$	—	—	mV

Switching Characteristics (@ $T_A = -40$ to $+105^\circ\text{C}$, unless otherwise specified.)

ULN2003A						
Parameter	Test figure	Min	Typ	Max	Unit	
t_{PLH}	Propagation Delay Time, Low to High Level Output	9	—	1	10	μs
t_{PHL}	Propagation Delay Time, High to Low Level Output	9	—	1	10	μs
V_{OH}	High Level Output Voltage after Switching	9 ($V_S = 50V, I_O = 300\text{mA}$)	$V_S - 50$	—	—	mV

Parameter Measurement Circuits

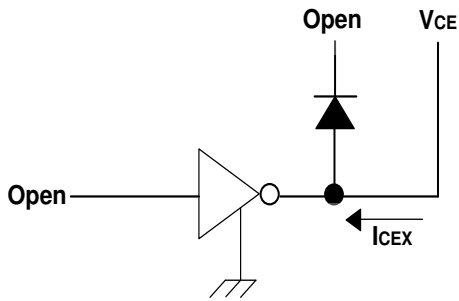


Fig.1 ICEX Test Circuit

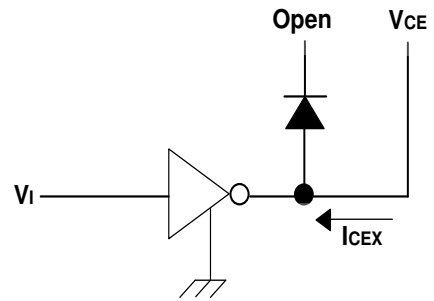


Fig.2 ICEX Test Circuit

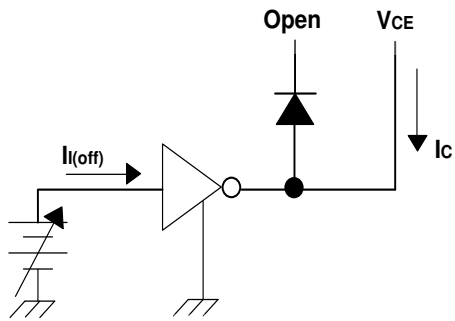


Fig.3 I_{i(off)} Test Circuit

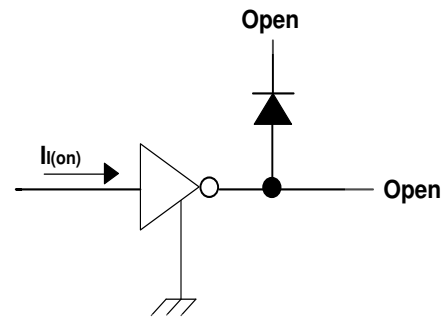


Fig.4 I_i Test Circuit

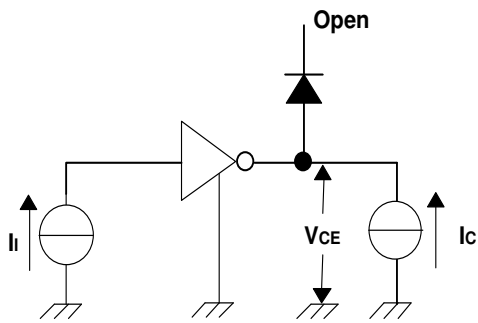


Fig. 5 h_{FE} , V_{CE(sat)} Test Circuit

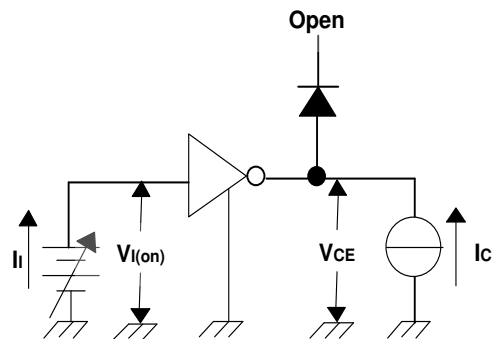


Fig. 6 V_{I(on)} Test Circuit

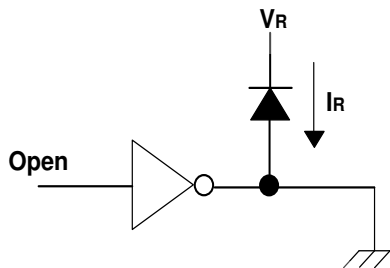


Fig. 7 I_R Test Circuit

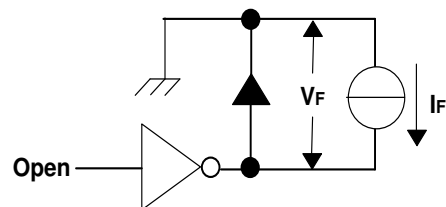


Fig. 8 V_F Test Circuit

Parameter Measurement Circuits (Cont.)

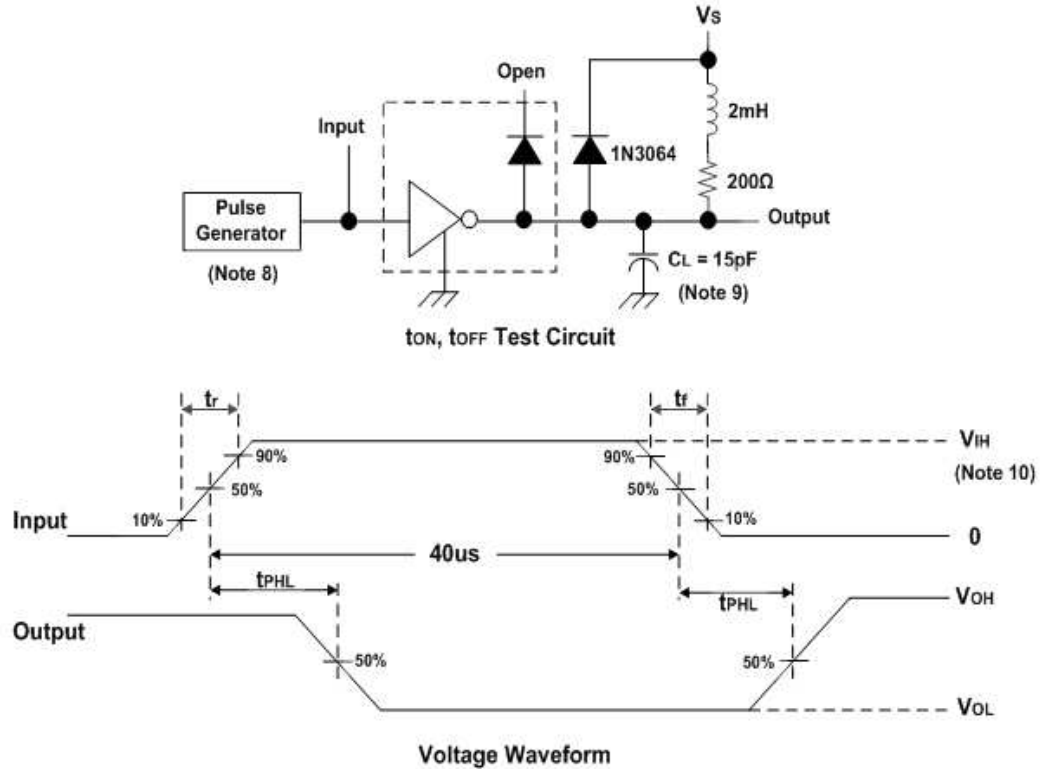
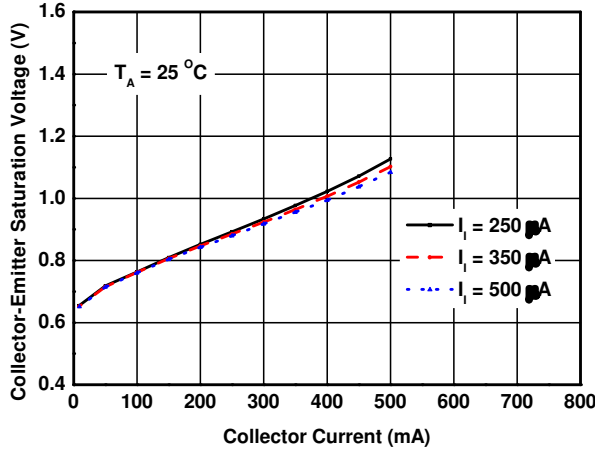


Fig. 9 Latch-Up Test Circuit and Voltage Waveform

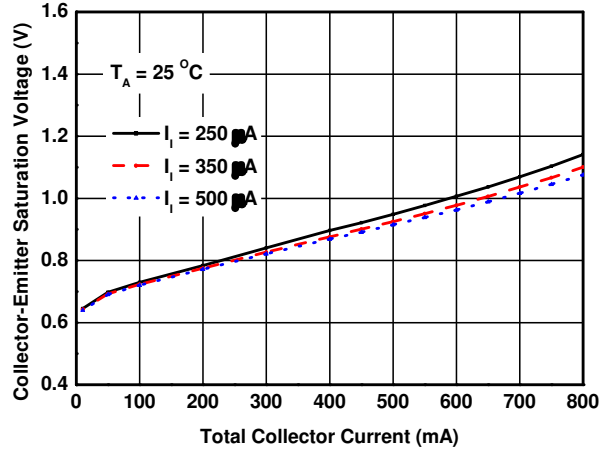
- Notes:
- 8. The pulse generator has the following characteristics: Pulse Width = 12.5Hz, output impedance 50Ω, $t_r \leq 5\text{ns}$, $t_f \leq 10\text{ns}$.
 - 9. C_L includes probe and jig capacitance.
 - 10. For testing the ULN2002A, $V_{IH} = 13\text{V}$; for the ULN2003A, $V_{IH} = 3\text{V}$;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

Typical Performance Characteristics

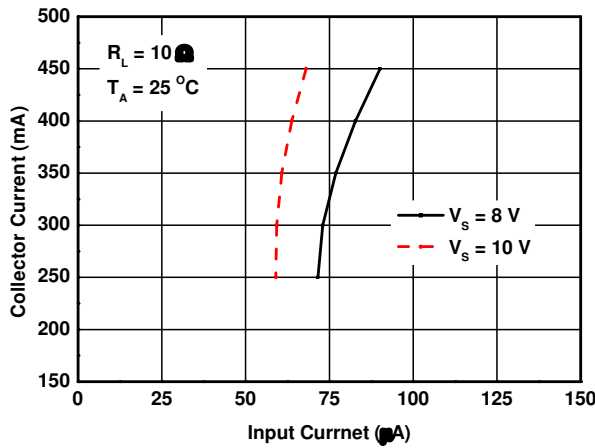
Collector-Emitter Saturation Voltage vs. Collector Current (One Darlington)



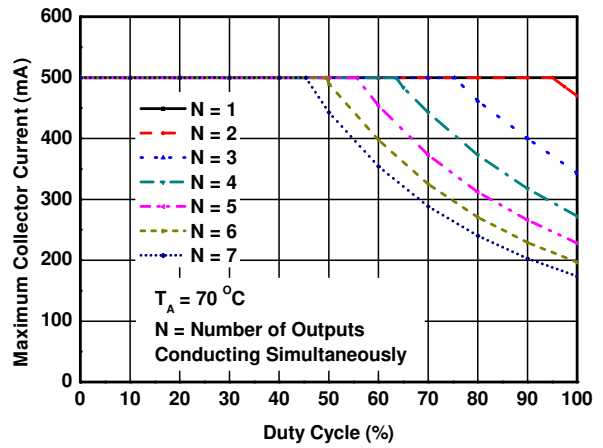
Collector-Emitter Saturation Voltage vs. Collector Current (Two Darlington in Parallel)



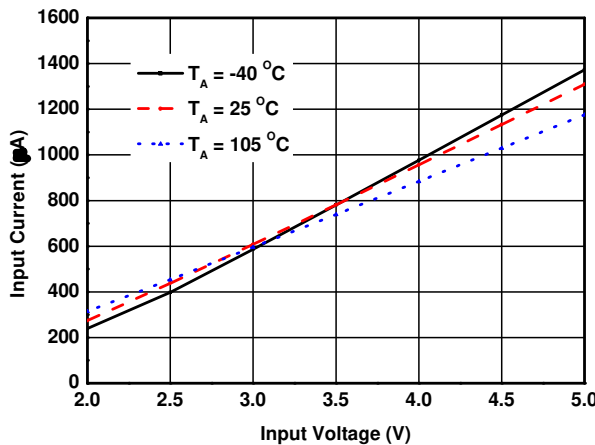
Collector Current vs. Input Current



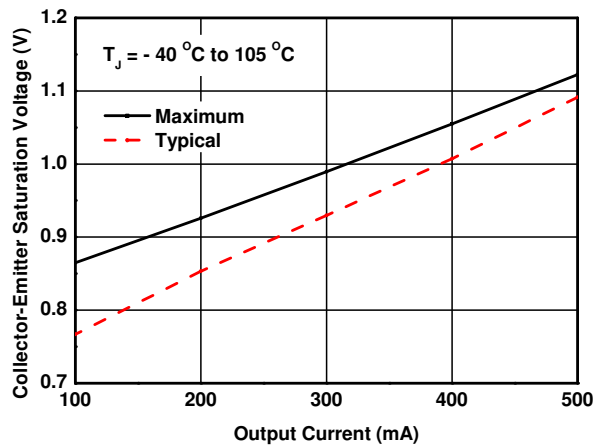
Maximum Collector Current vs. Duty Cycle



Input Current vs. Input Voltage

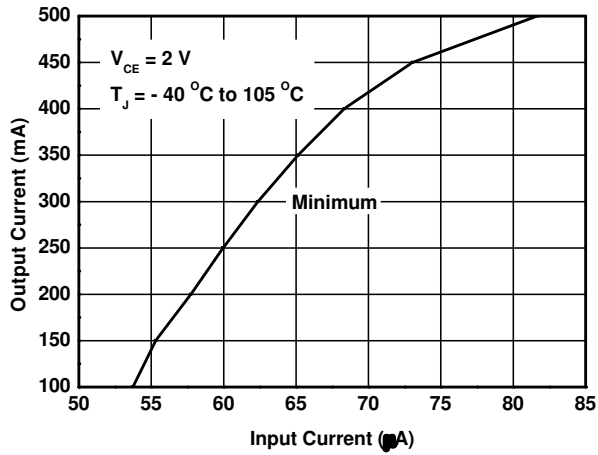


Collector-Emitter Saturation Voltage vs. Output Current

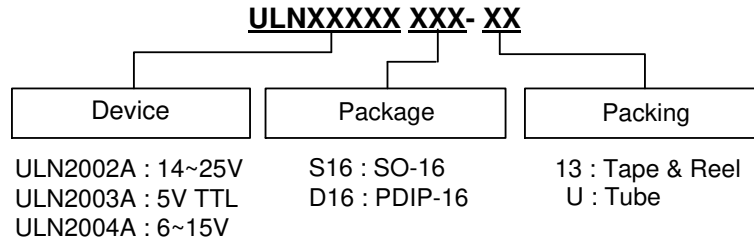


Typical Performance Characteristics (Cont.)

Output Current vs. Input Current



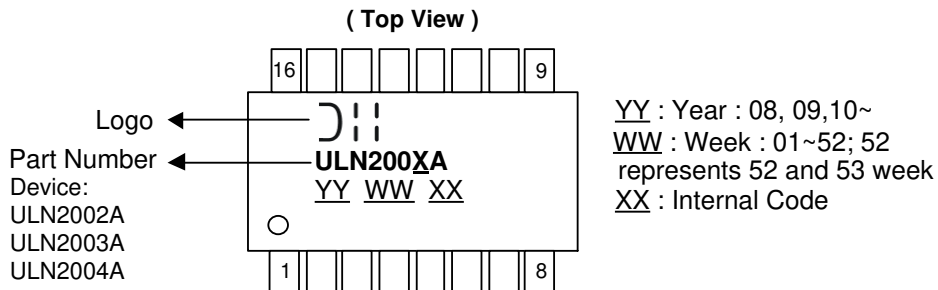
Ordering Information



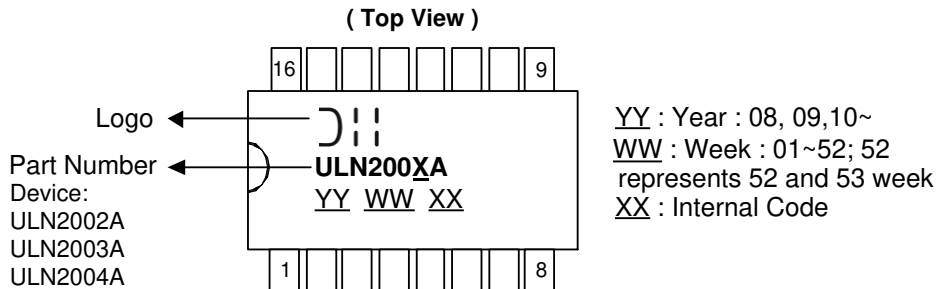
Part Number	Package Code	Package	13" Tape and Reel		Tube	
			Quantity	Part Number Suffix	Quantity	Part Number Suffix
ULN2002AS16-13	S16	SO-16	2,500/Tape & Reel	-13	NA	NA
ULN2003AS16-13	S16	SO-16	2,500/Tape & Reel	-13	NA	NA
ULN2004AS16-13	S16	SO-16	2,500/Tape & Reel	-13	NA	NA
ULN2002AD16-U	D16	PDIP-16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

Marking Information

(1) SO-16



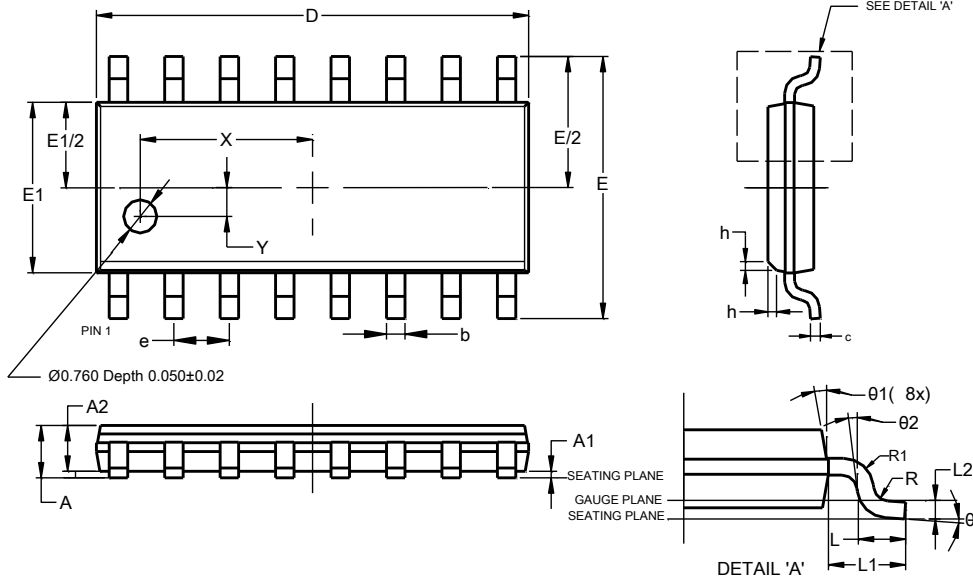
(2) PDIP-16



Package Outline Dimensions

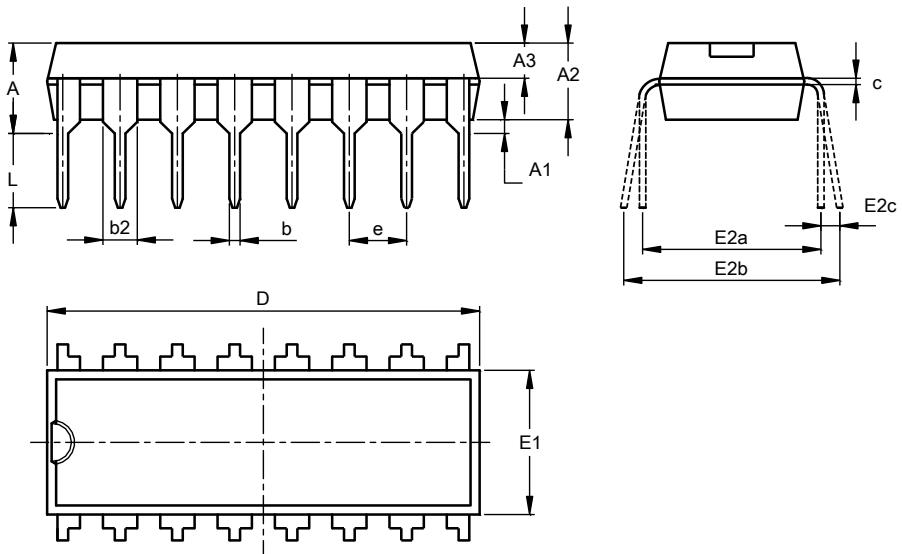
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) Package Type: SO-16



SO-16			
Dim	Min	Max	Typ
A	--	1.260	--
A1	0.10	0.23	--
A2	1.02	--	--
b	0.31	0.51	--
c	0.10	0.25	--
D	9.80	10.00	--
E	5.90	6.10	--
E1	3.80	4.00	--
e	1.27 BSC		
h	0.15	0.25	0.20
L	0.40	1.27	--
L1	1.04 REF		
L2	0.25 BSC		
R	0.07	--	--
R1	0.07	--	--
X	3.945 REF		
Y	0.661 REF		
theta	0°	8°	--
theta1	5°	15°	--
theta2	0°	--	--
All Dimensions in mm			

(2) Package Type: PDIP-16

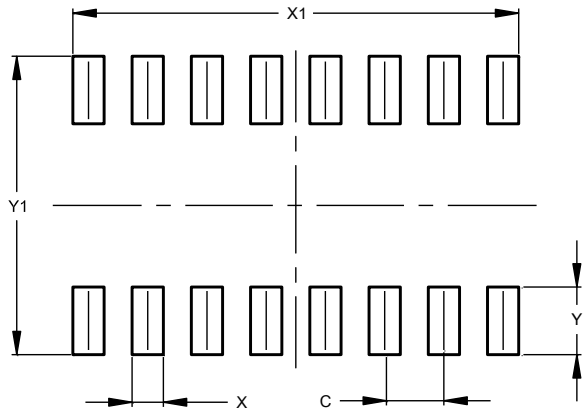


PDIP-16			
Dim	Min	Max	Nom
A	3.60	4.00	3.80
A1	0.51	-	-
A2	3.20	3.40	3.30
A3	1.47	1.57	1.52
b	0.44	0.53	-
b2	1.52BSC		
c	0.25	0.31	-
D	18.90	19.30	19.10
E1	6.15	6.55	6.35
E2a	7.62 BSC		
E2b	7.62	9.30	-
E2c	0.00	0.84	-
e	2.54BSC		
L	3.00	-	-
All Dimensions in mm			

Suggested Pad Layout

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) Package Type: SO-16



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

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A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

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