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:

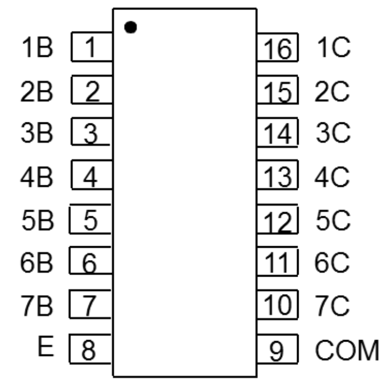
ULN2002A (14-25V PMOS)
ULN2003A (5V TTL, CMOS)
ULN2004A (6-15V CMOS, PMOS)

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

Pin Assignments

(Top View)



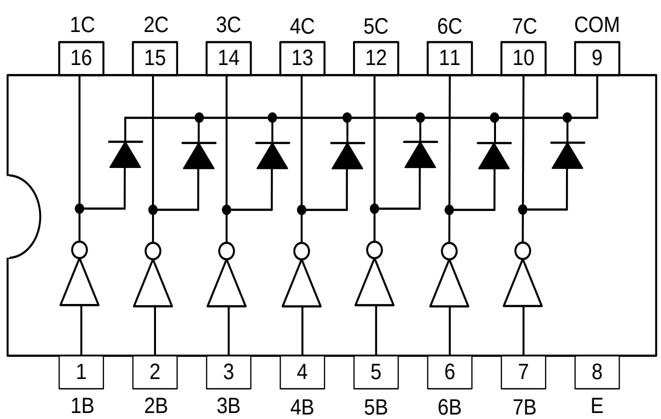
SO-16/DIP-16

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 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.

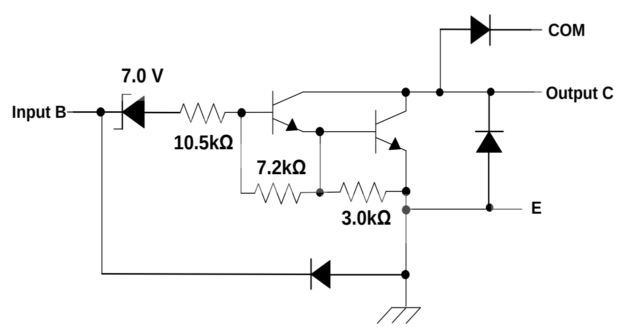
Connection Diagram



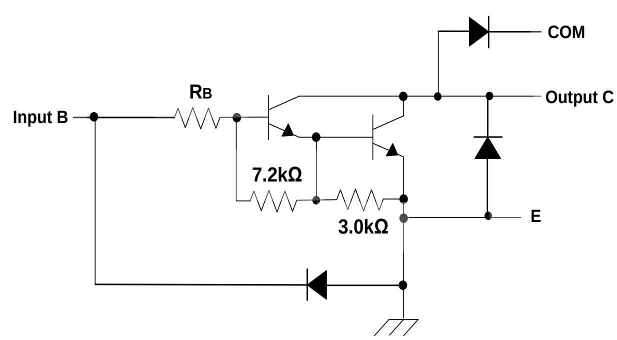
Pin Descriptions

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_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	See typical characteristics	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
		DIP-16	50.0	
θ_{JC}	Thermal Resistance Junction-to-Case (Note 6)	SO-16	12.0	°C/W
		DIP-16	15.0	
T_J	Junction Temperature		150	°C
T_{STG}	Storage Temperature		-65 to +150	°C

Notes:
4. 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.
5. All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
6. 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 $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
7. 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 $P_D = (T_J(max) – T_C)/\theta_{JA}$. 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

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_{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	
				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 (@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	-	-	100	
				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 = 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 (@T_A = -40°C to +105°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	-	-	2.7	V
				I_C = 250mA	-	-	2.9	
				I_C = 300mA	-	-	3	
$V_{CE(sat)}$	Collector Emitter Saturation Voltage	5	I_I = 250µA, I_C = 100mA		-	0.9	1.2	V
			I_I = 350µA, I_C = 200mA		-	1	1.4	
			I_I = 500µA, I_C = 350mA		-	1.2	1.7	
V_F	Clamp Forward Voltage	8	I_F = 350mA		-	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 = 500µA		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 = 1MHz		-	15	25	pF

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

ULN2002A, ULN2003A, ULN2004A						
Parameter		Test figure	Min	Typ	Max	Unit
t_{PLH}	Propagation delay time, low to high level output	10	-	0.25	1	µs
t_{PLL}	Propagation delay time, high to low level output	10	-	0.25	1	µs
V_{OH}	High level output voltage after switching	10 (V_S = 50V, I_O = 300mA)	V_S-20	-	-	mV

Switching Characteristics (@T_A = -40 to +105°C, unless otherwise specified.)

ULN2003A						
Parameter		Test figure	Min	Typ	Max	Unit
t_{PLH}	Propagation delay time, low to high level output	10	-	1	10	µs
t_{PLL}	Propagation delay time, high to low level output	10	-	1	10	µs
V_{OH}	High level output voltage after switching	10 (V_S = 50V, I_O = 300mA)	V_S-50	-	-	mV

Parameter Measurement Circuits

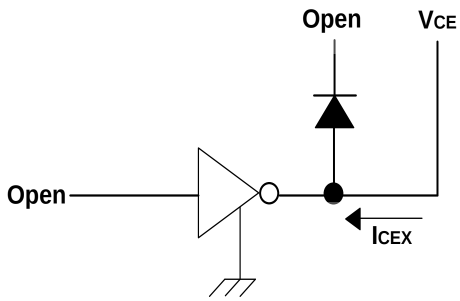


Fig.1 I_{CEX} Test Circuit

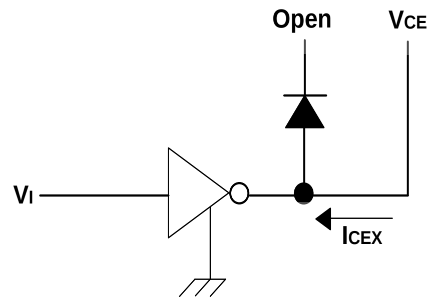


Fig.2 I_{CEX} Test Circuit

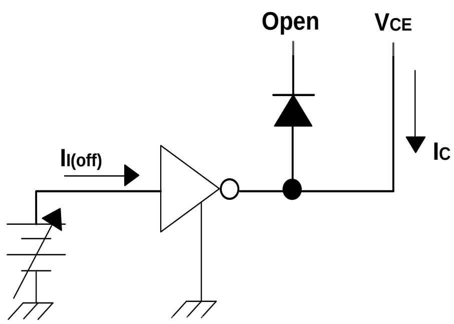


Fig.3 $I_{I(off)}$ Test Circuit

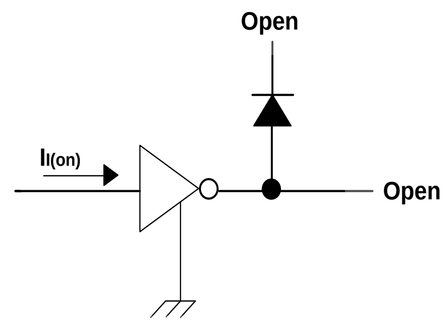


Fig.4 I_I Test Circuit

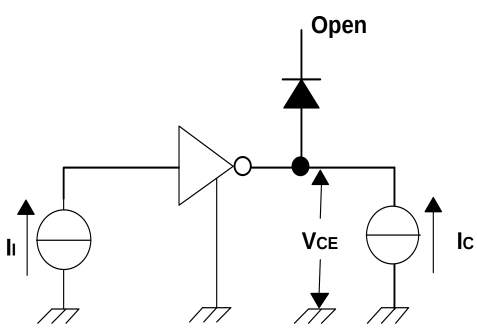


Fig. 5 h_{FE} , $V_{CE(sat)}$ Test Circuit

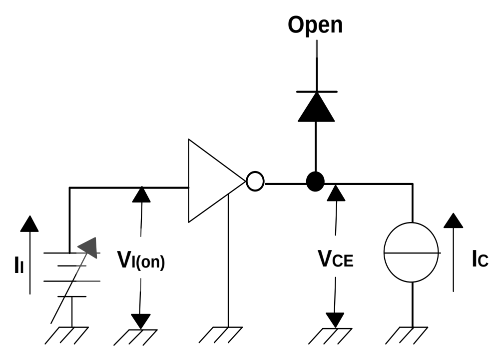


Fig. 6 $V_{I(on)}$ Test Circuit

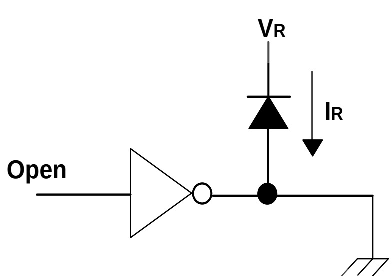


Fig. 7 I_R Test Circuit

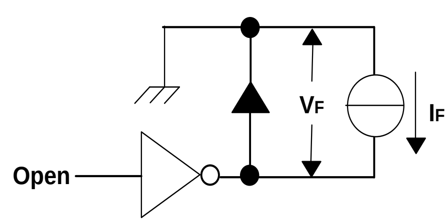


Fig. 8 V_F Test Circuit

Parameter Measurement Circuits (continued)

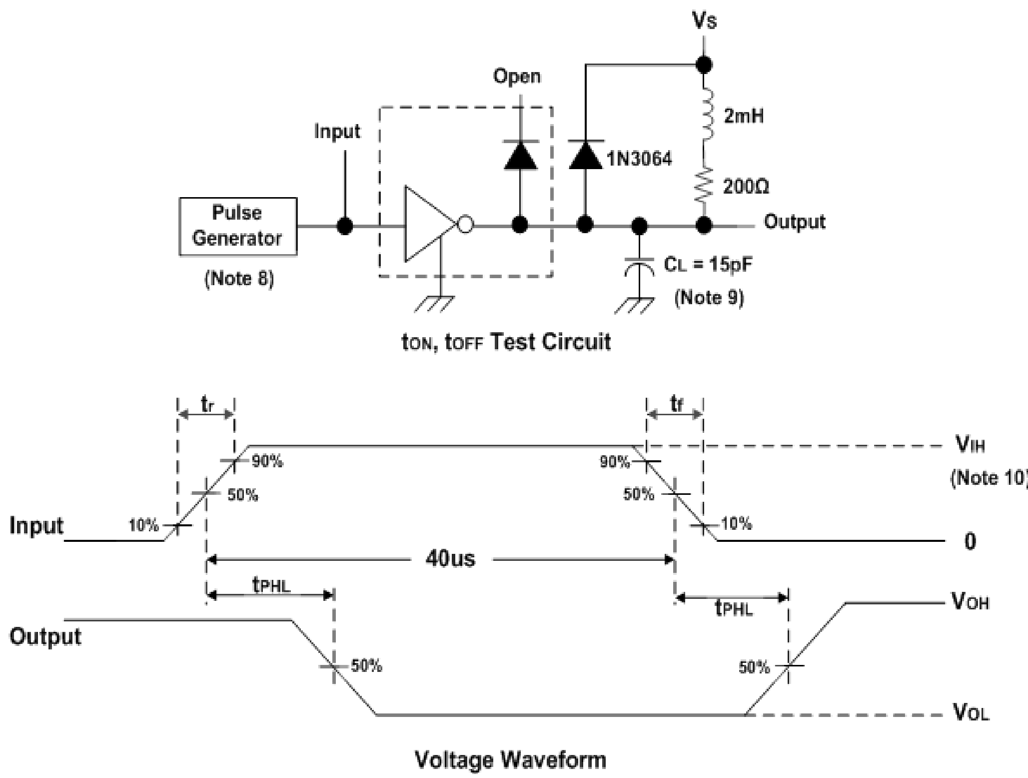


Fig. 10 Latch-Up Test Circuit and Voltage Waveform

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

Typical Performance Characteristics

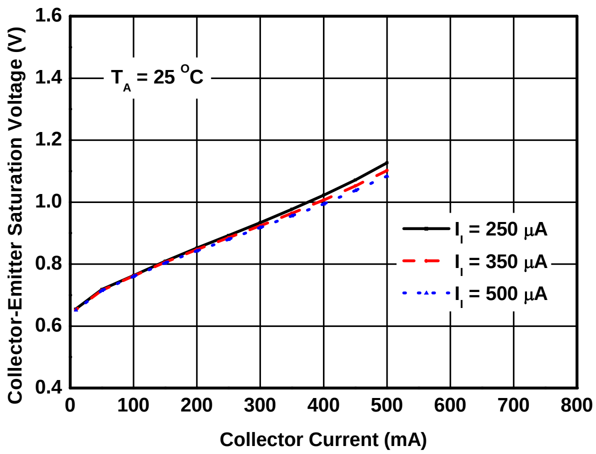


Figure 11 Collector-Emitter Saturation Voltage vs. Collector Current (One Darlington

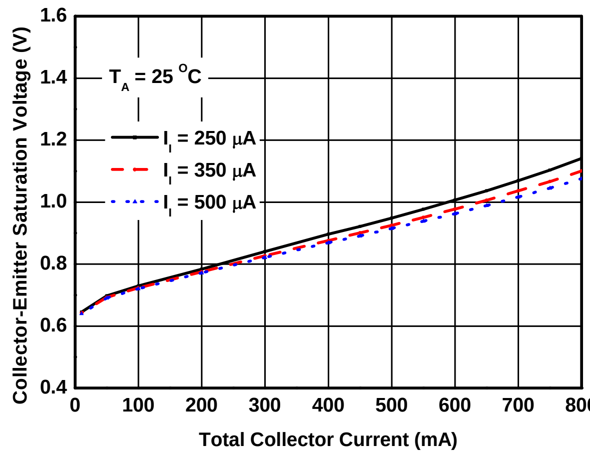


Figure 12 Collector-Emitter Saturation Voltage vs. Collector Current (Two Darlington in Parallel)

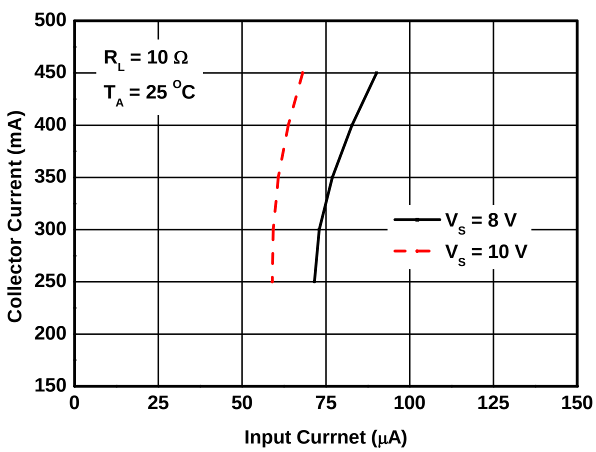


Figure 13 Collector Current vs. Input Current

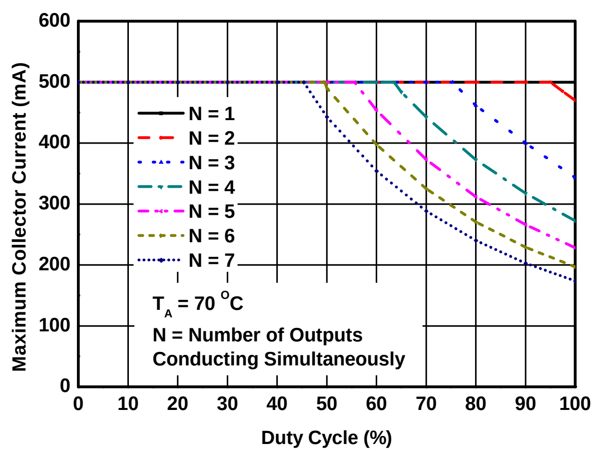


Figure 14 Maximum Collector Current vs. Duty Cycle

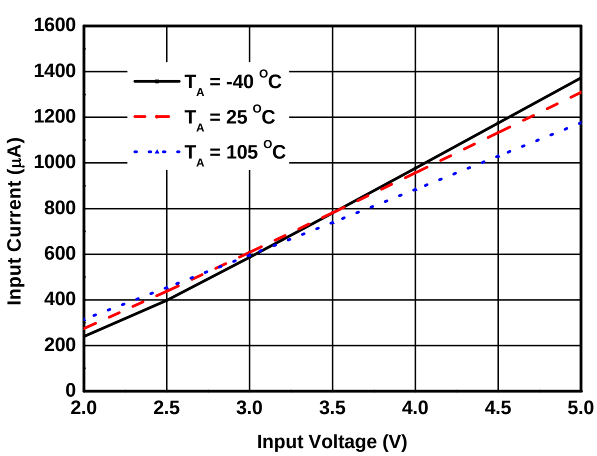


Figure 15. Input Current vs. Input Voltage

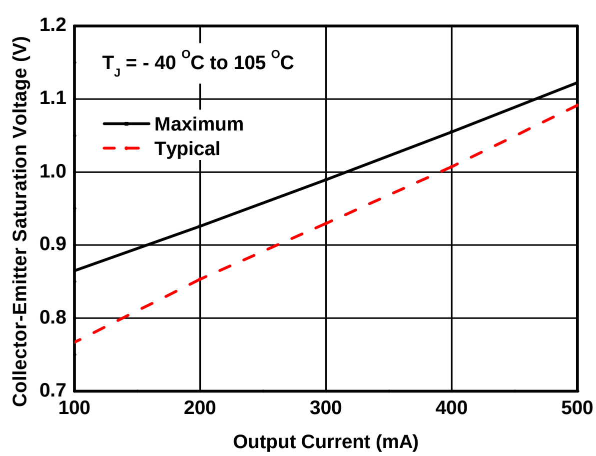


Figure 16. Collector-Emitter Saturation Voltage vs. Output Current

Typical Performance Characteristics (continued)

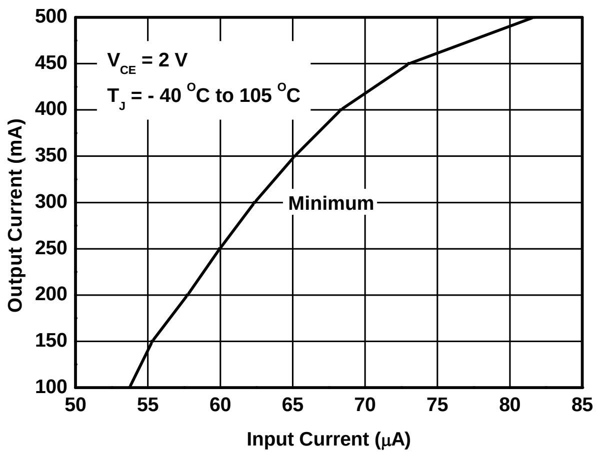


Figure 17. Output Current vs. Input Current

Ordering Information

ULNXXXXX XXX- XX

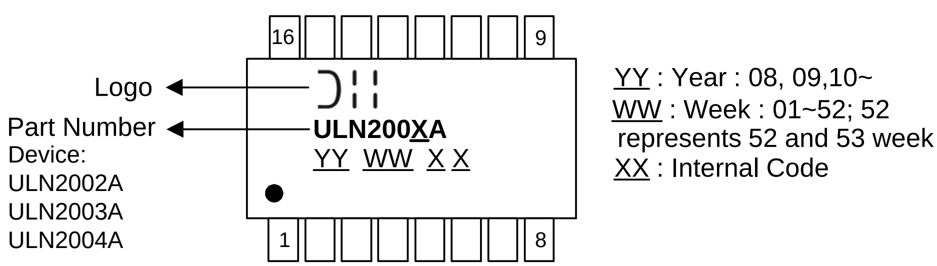
Device	Package	Packing
2002A : 14~25V 2003A : 5V TTL 2004A : 6~15V	S16 : SO-16 D16 : DIP-16	13 : Tape & Reel U : Tube

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

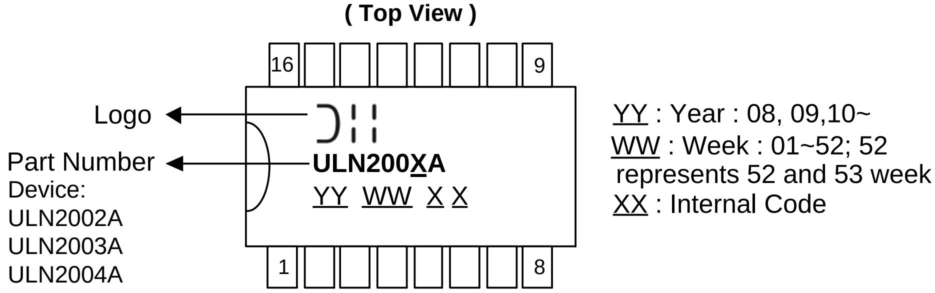
Note: 11. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Marking Information

(1) SO-16



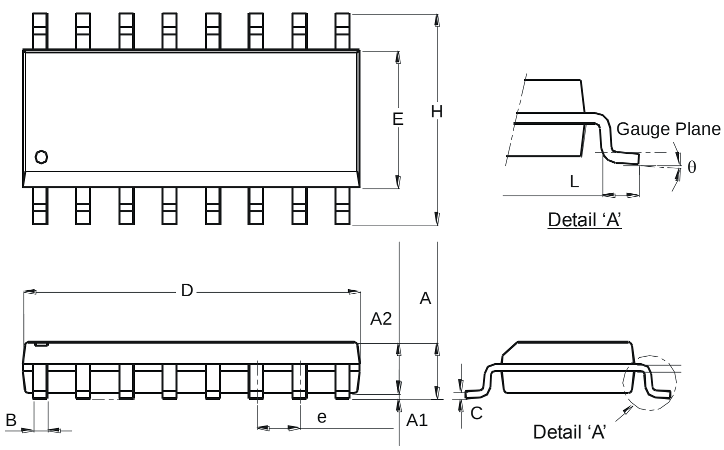
(2) PDIP-16



Package Outline Drawings

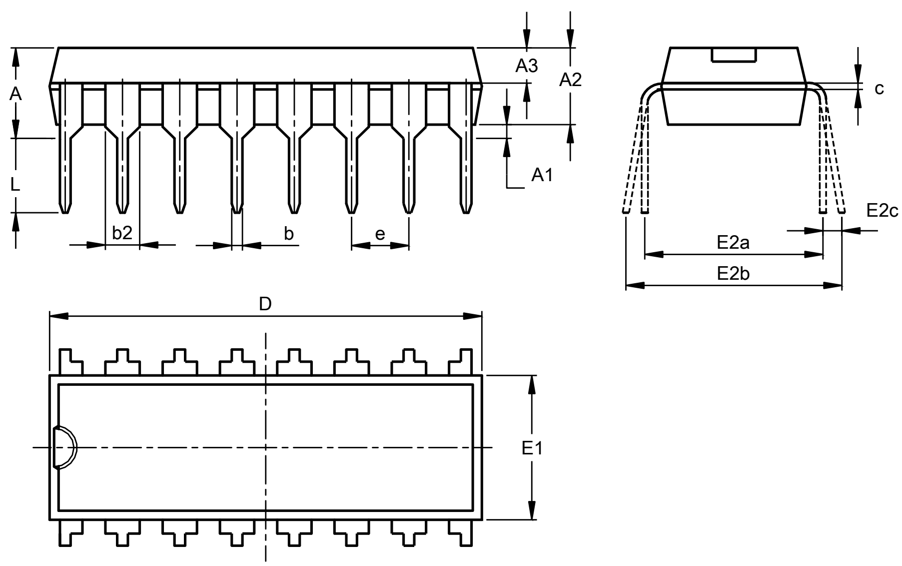
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

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
θ	0°	8°
All Dimensions in mm		

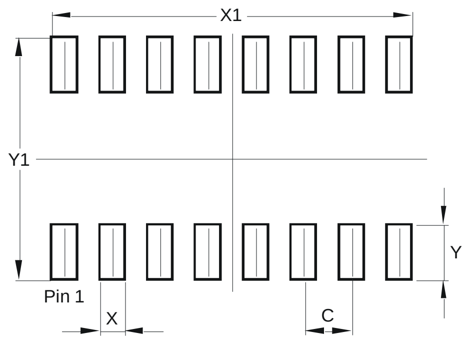
PDIP-16



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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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.

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