WINSOURCE ELECTRONICS

THE DATASHEET OF

ULN2004AS16-13

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 (14V to 25V PMOS)
- ULN2003A (5V TTL, CMOS)
- ULN2004A (6V to15V 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.

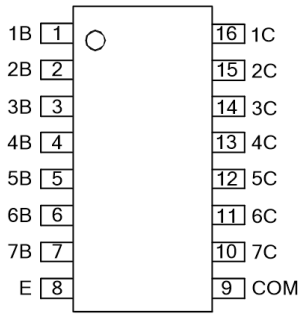
The ULN2002A, ULN2003A, and ULN2004A are available in both a small outline 16-pin package (SO-16) and a PDIP-16 package. The ULN2003A has an additional TSSOP-16 (Type CJ) package available for small footprint requirements.

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)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

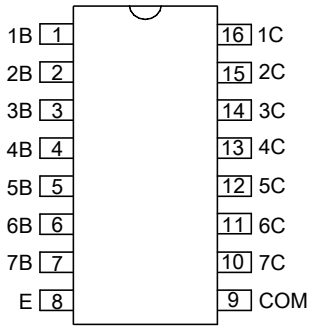
Pin Assignments

(Top View)



SO-16
TSSOP-16 (Type CJ) (ULN2003A Only)

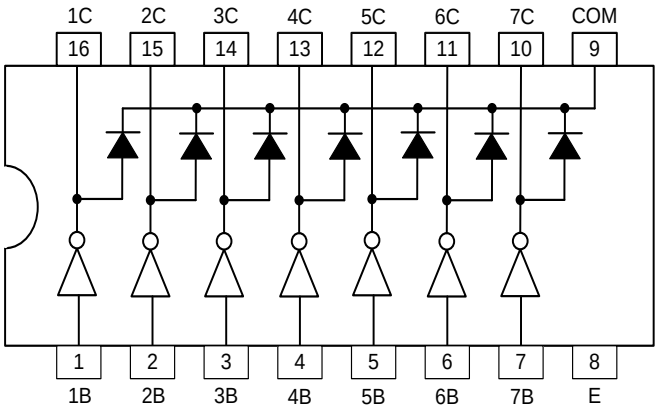
(Top View)



PDIP-16

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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.

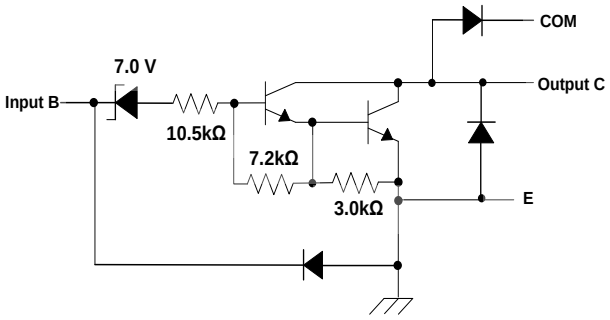
Connection Diagram



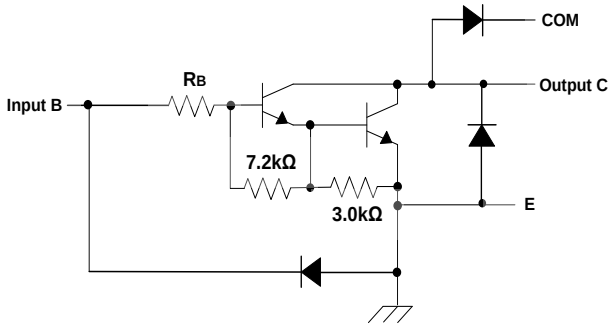
Pin Descriptions

Pin Number SO-16/PDIP-16/TSSOP-16 (Type CJ)	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
		TSSOP-16 (Type CJ) (ULN2003A)	98	
		PDIP-16	50.0	
θ_{JC}	Thermal Resistance Junction-to-Case (Note 7)	SO-16	12.0	°C/W
		TSSOP-16 (Type CJ) (ULN2003A)	31	
		PDIP-16	15.0	
ESD	HBM		2	kV
	CDM		2	kV
T_J	Junction Temperature		+150	°C
T_{STG}	Storage Temperature		-65 to +150	°C

Notes:
4. Stresses greater than those listed under *Absolute Maximum Ratings* can 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 Ratings* for extended periods can 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 $P_D = (T_J(max) – T_C)/\theta_{JC}$. 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	0	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_{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 (continued) (@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
			V_{CE} = 2V, I_C = 250mA	—	—	2.9	
			V_{CE} = 2V, 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	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 = 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	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 = 300mA)	V_S-50	—	—	mV

Parameter Measurement Circuits

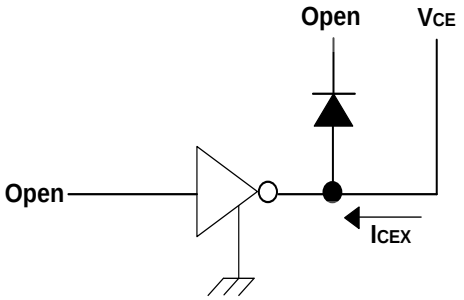


Fig.1 I_{CEX} Test Circuit

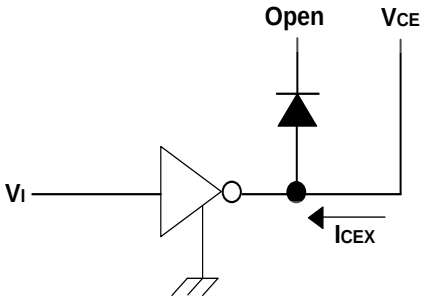


Fig.2 I_{CEX} Test Circuit

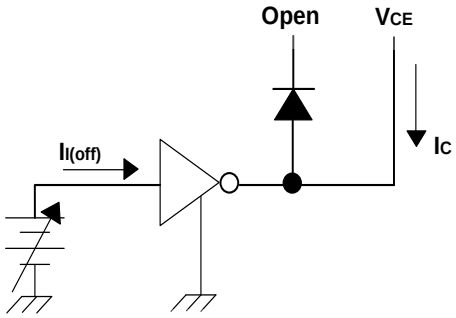


Fig.3 $I_{I(off)}$ Test Circuit

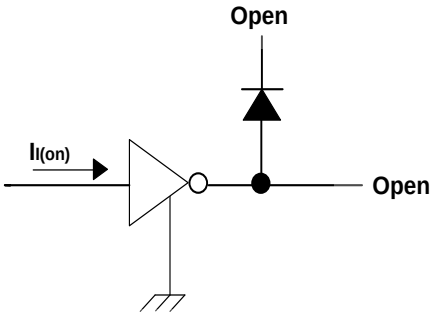


Fig.4 I_I Test Circuit

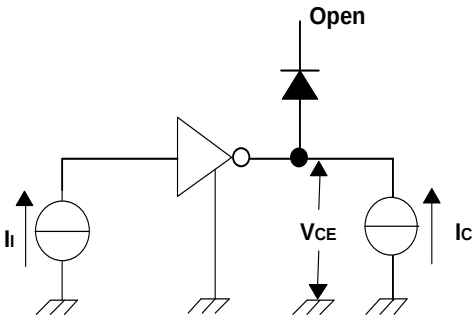


Fig. 5 h_{FE} , $V_{CE(sat)}$ Test Circuit

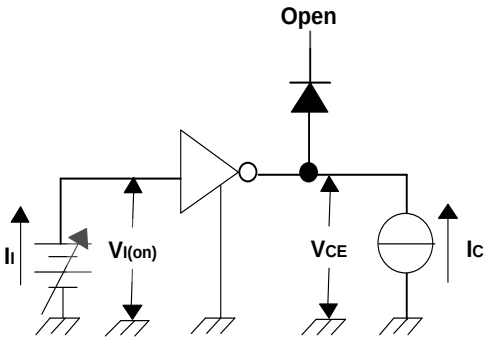


Fig. 6 $V_{I(on)}$ Test Circuit

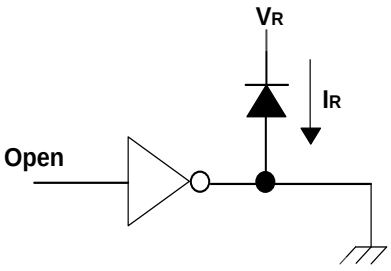


Fig. 7 I_R Test Circuit

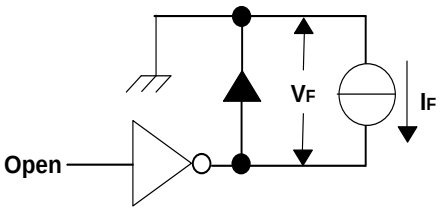


Fig. 8 V_F Test Circuit

Parameter Measurement Circuits (continued)

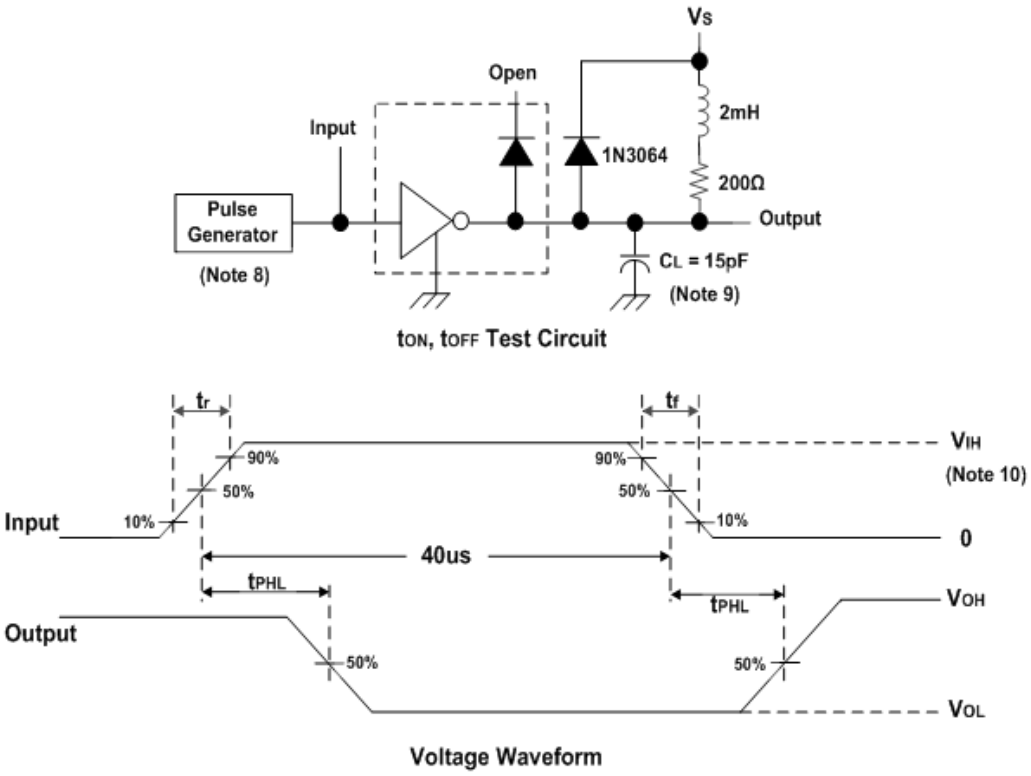
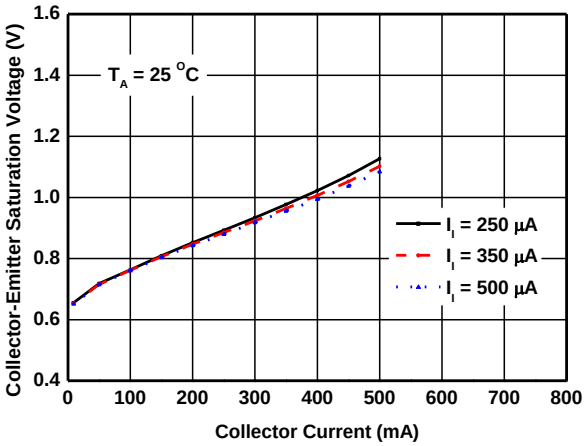


Fig. 9 Latchup Test Circuit and Voltage Waveform

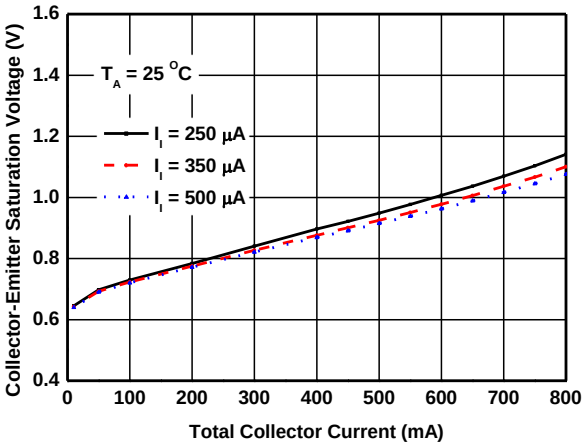
Notes: 8. The pulse generator has the following characteristics: Pulse width = 12.5Hz, output impedance 50Ω, tr ≤ 5ns, tr ≤ 10ns.
9. C_L includes prove and jig capacitance.
10. For testing the ULN2002A, V_{IH} = 13V; for the ULN2003A, V_{IH} = 3V; for the ULN2004A, V_{IH} = 8V.

Typical Performance Characteristics

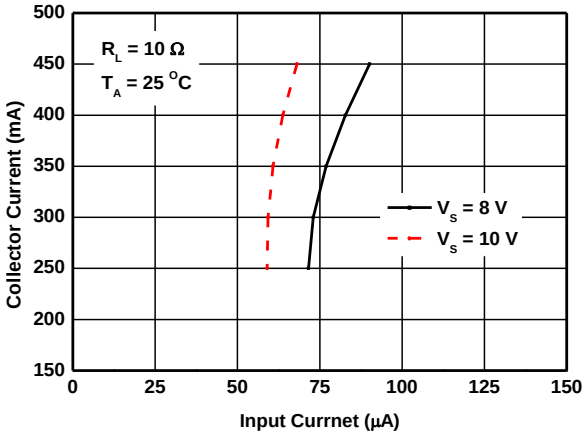
Collector-Emitter Saturation Voltage vs. Collector Current (One Darlington)



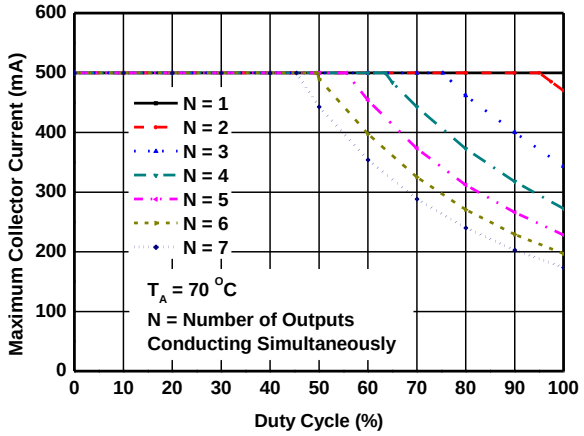
Collector-Emitter Saturation Voltage vs. Collector Current (Two Darlington in Parallel)



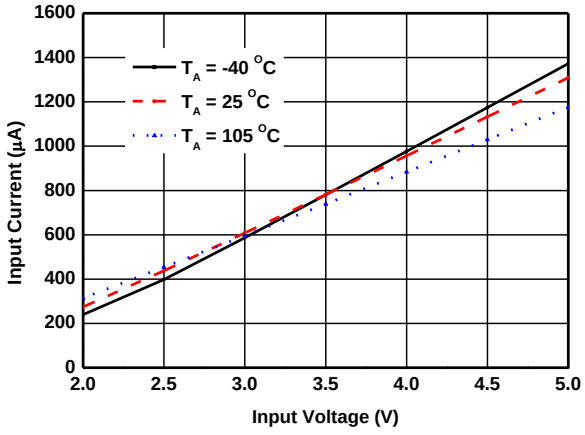
Collector Current vs. Input Current



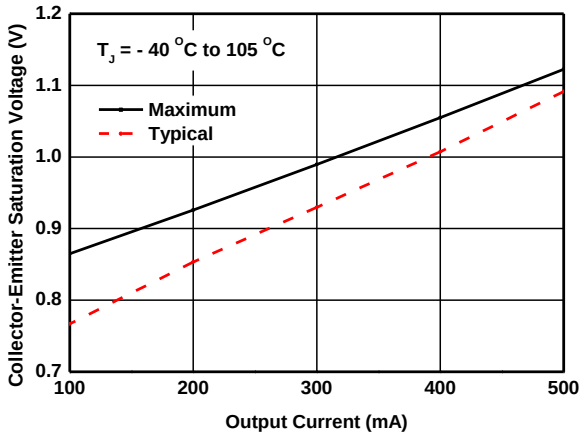
Maximum Collector Current vs. Duty Cycle



Input Current vs. Input Voltage

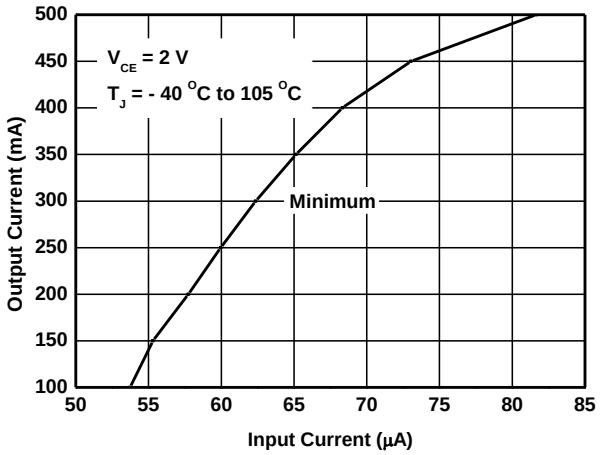


Collector-Emitter Saturation Voltage vs. Output Current

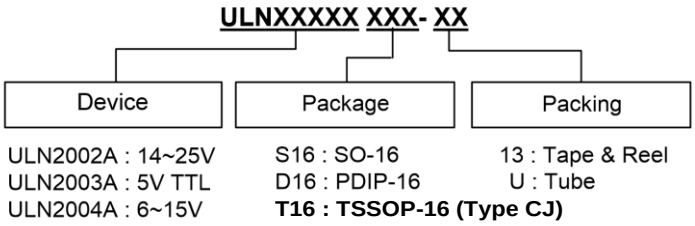


Typical Performance Characteristics (continued)

Output Current vs. Input Current



Ordering Information



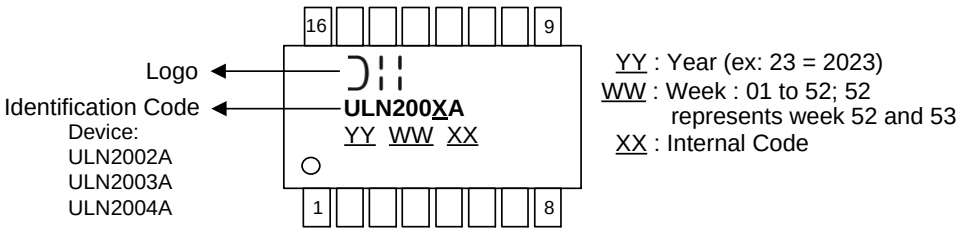
Part Number	Part Number Suffix	Package Code	Package	Status	Packing	
					Qty.	Carrier
ULN2002AS16-13	-13	S16	SO-16	Production	2,500	13” Tape and Reel
ULN2003AS16-13	-13	S16	SO-16	Production	2,500	13” Tape and Reel
ULN2004AS16-13	-13	S16	SO-16	Production	2,500	13” Tape and Reel
ULN2002AD16-U	-U	D16	PDIP-16	EOL*	25	Tube
ULN2003AD16-U	-U	D16	PDIP-16	EOL*	25	Tube
ULN2004AD16-U	-U	D16	PDIP-16	EOL*	25	Tube
ULN2003AT16-13	-13	T16	TSSOP-16 (Type CJ)	Production	2,500	13” Tape and Reel

* EOL = End of life. Please contact us.

Marking Information

(1) SO-16, TSSOP-16 (Type CJ)

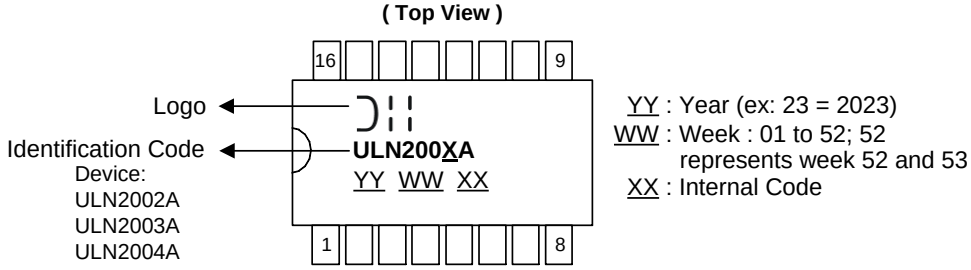
(Top View)



Part Number	Package	Identification Code
ULN200xAS16-13	SO-16	ULN200xA
ULN2003AT16-13	TSSOP-16 (Type CJ)	ULN2003A

(2) PDIP-16

(Top View)

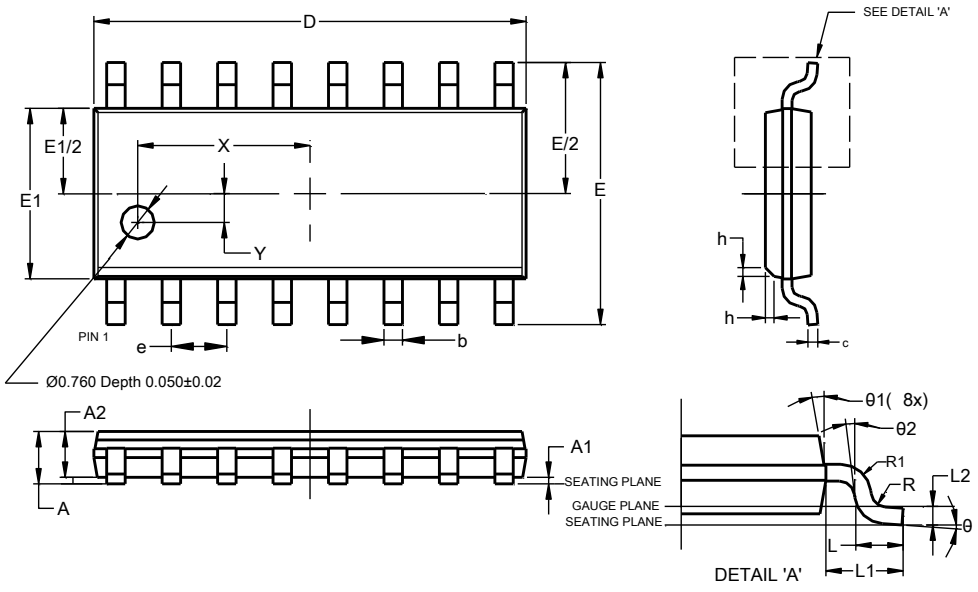


Part Number	Package	Identification Code
ULN200xAD16-U	PDIP-16	ULN200xA

Package Outline Dimensions

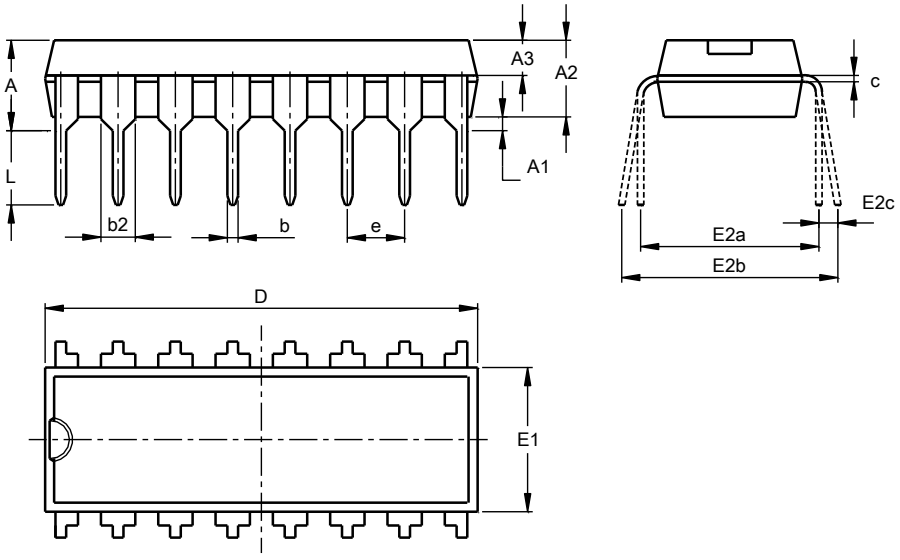
Please see http://www.diodes.com/package-outlines.html for the latest version.

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		
θ	0°	8°	--
θ1	5°	15°	--
θ2	0°	--	--
All Dimensions in mm			

PDIP-16

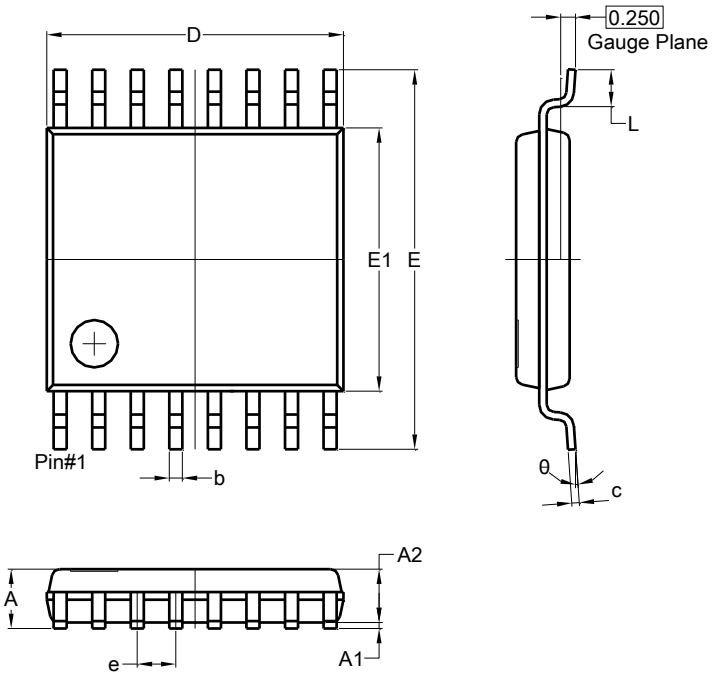


PDIP-16			
Dim	**Min**	**Max**	**Nom**
A	3.60	4.00	3.80
A1	0.51	-	-
A2	3.20	3.40	3.30
A3	1.47	1.57	1.52
b	0.44	0.53	-
b2	1.52BSC		
c	0.25	0.31	-
D	18.90	19.30	19.10
E1	6.15	6.55	6.35
E2a	7.62 BSC		
E2b	7.62	9.30	-
E2c	0.00	0.84	-
e	2.54BSC		
L	3.00	-	-
All Dimensions in mm			

Package Outline Dimensions (continued)

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

TSSOP-16 (Type CJ)

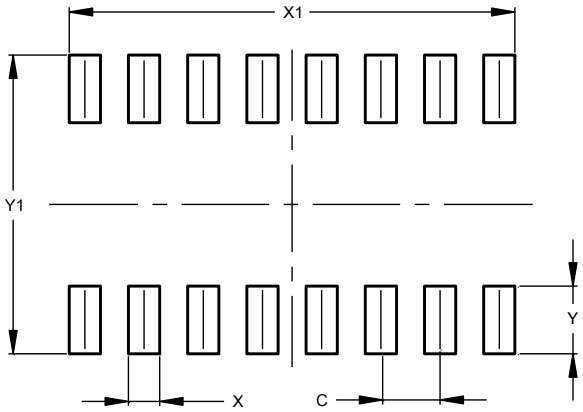


TSSOP-16 (Type CJ)			
Dim	**Min**	**Max**	**Typ**
A	--	1.200	--
A1	0.020	0.100	--
A2	0.800	1.000	--
b	0.190	0.300	--
c	0.090	0.200	
D	4.900	5.100	--
E	6.250	6.550	--
E1	4.300	4.500	--
e	0.650 BSC		
L	0.500	0.700	--
θ	1°	7°	--
All Dimensions in mm			

Suggested Pad Layout

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

SO-16

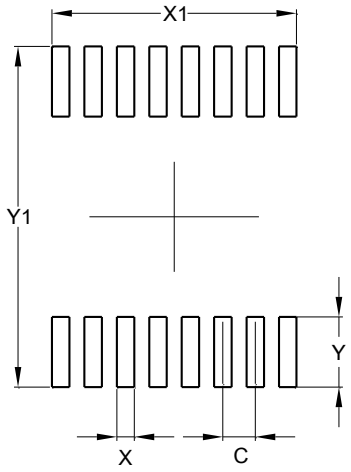


Dimensions	Value (in mm)
C	1.270
X	0.670
X1	9.560
Y	1.450
Y1	6.400

Suggested Pad Layout (continued)

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

TSSOP-16 (Type CJ)



Dimensions	Value (in mm)
C	0.650
X	0.350
X1	4.900
Y	1.400
Y1	6.800

Mechanical Data

- Moisture Sensitivity:
  - SO-16: Level 1 per J-STD-020
  - TSSOP-16 (Type CJ): Level 1 per J-STD-020
- Terminals: Finish—Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight:
  - SO-16: 0.13 grams (Approximate)
  - TSSOP-16 (Type CJ): 0.055 grams (Approximate)
  - PDIP-16: 1.095 grams (Approximate)

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