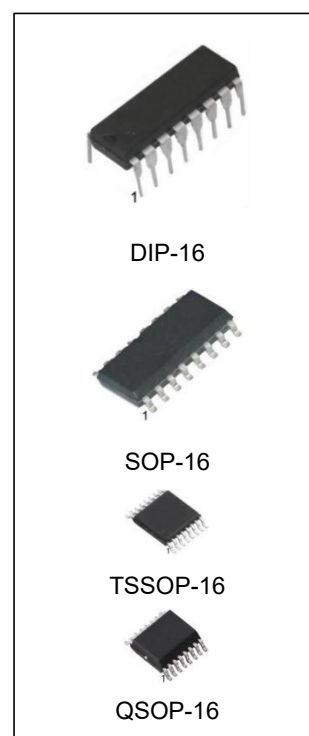


HIGH-VOLTAGE HIGH-CURRENT DARLINGTON TRANSISTOR ARRAYS

Features

- 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



Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
ULN2003N	DIP-16	ULN2003	TUBE	1000pcs/Box
ULN2004N	DIP-16	ULN2004	TUBE	1000pcs/Box
ULN2003M/TR	SOP-16	ULN2003	REEL	2500pcs/Reel
ULN2004M/TR	SOP-16	ULN2004	REEL	2500pcs/Reel
ULN2003MT/TR	TSSOP-16	ULN2003	REEL	2500pcs/Reel
ULN2004MT/TR	TSSOP-16	ULN2004	REEL	2500pcs/Reel
ULN2003MS/TR	QSOP-16	ULN2003	REEL	2500pcs/Reel
ULN2004MS/TR	QSOP-16	ULN2004	REEL	2500pcs/Reel

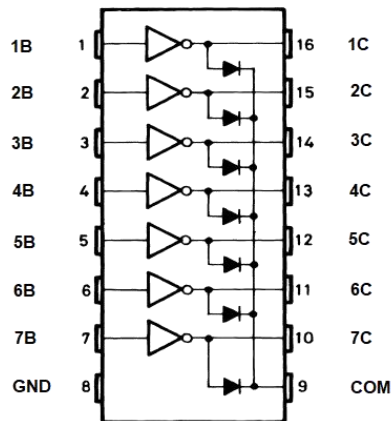
Description

The ULN2003 and ULN2004 are monolithic 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 may 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.

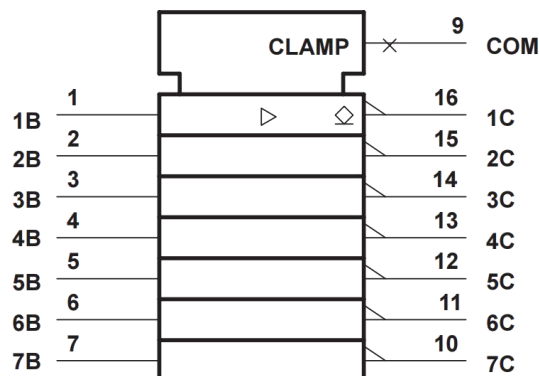
Each input of this device has a zener diode and resistor in series to control the input current to a safe limit. The ULN2003 has a 2.7-k Ω series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices. The ULN2004 has a 10.5-k Ω series base resistor to allow its operation directly from CMOS devices that use supply voltages of 6 to 15 V. The required input current of the ULN2004 is below that of the ULN2003.

Pin configuration

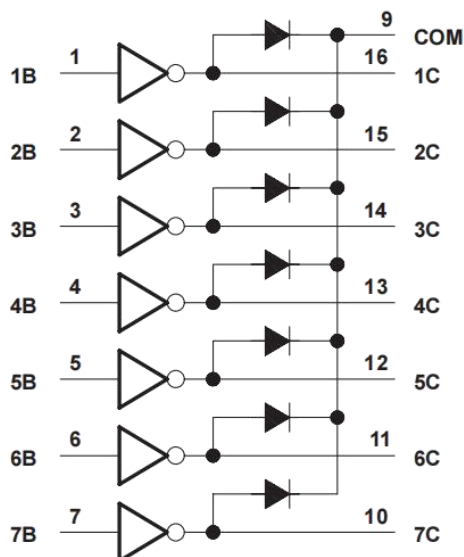
DIP-16/SOP-16/TSSOP-16/QSOP-16



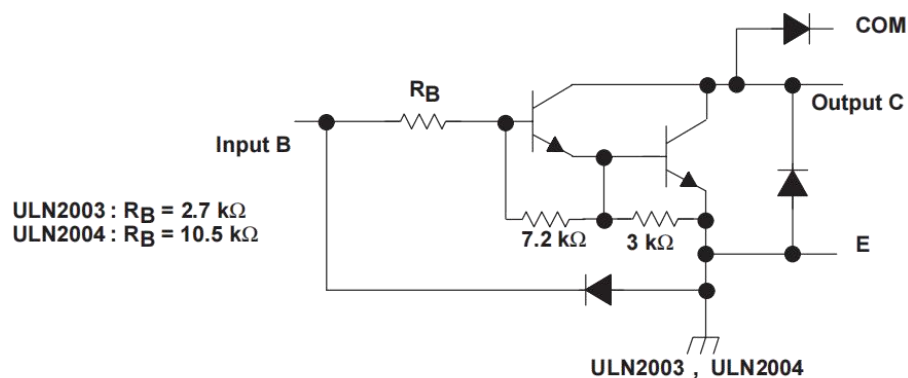
logic symbol



logic diagram



schematics



All resistor values shown are nominal.

Absolute maximum ratings

at 25°C free-air temperature (unless otherwise noted)

Parameter	Value	Unit
Collector-emitter voltage	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	
Operating free-air temperature range, T_A	- 20 to 85	°C
Storage temperature range, T_{stg}	- 65 to 150	°C
Lead Temperature (Soldering, 10 seconds)	260	°C

Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured.

NOTE 1: All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.

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
SOP	950 mW	7.6 mW/°C	494 mW
DIP	1150 mW	9.2 mW/°C	598 mW

Electrical Characteristics, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST FIGURE	TEST CONDITIONS		ULN2003			ULN2004			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
$V_{I(on)}$ On-state input voltage	6	$V_{CE}=2V$	$I_C = 125\text{mA}$						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	
$V_{CE(at)}$ 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	$V_{CE}=50V, I_I=0$				50			50	μA
	2	$V_{CE}=50V,$ $T_A=70^\circ\text{C}$	$I_I = 0$			100			100	
			$V_I = 1V$						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	$V_{CE}=50V, I_C=500\mu\text{A}, T_A=70^\circ\text{C}$		50	65		50	65		μA
I_I Input current	4	$V_I = 3.85V$			0.93	1.35				mA
		$V_I = 5V$						0.35	0.5	
		$V_I = 12V$						1	1.45	
I_R Clamp reverse current	7	$V_R = 50V$				50			50	μA
		$V_R = 50V, T_A = 70^\circ\text{C}$				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	MIN	TYP	MAX	UNIT
t_{PLH} Propagation delay time, low-to-high-level output	See Figure 9		0.25	1	μs
t_{PHL} Propagation delay time, high-to-low-level output			0.25	1	μs
V_{OH} High-level output voltage after switching	$V_S = 50V, I_O \approx 300\text{mA}$, See Figure 10	$V_S - 20$			V

Parameter Measurement Information

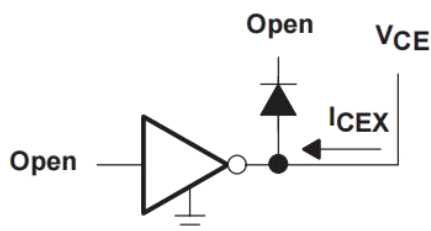


Figure 1. I_{CEX} Test Circuit

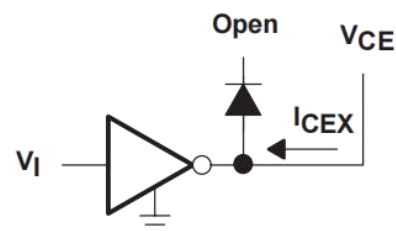


Figure 2. I_{CEX} Test Circuit

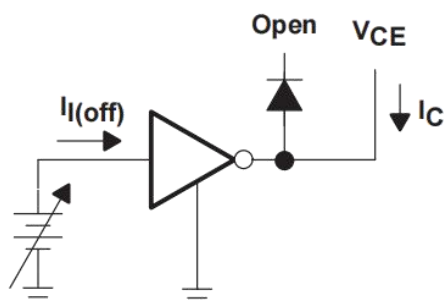


Figure 3. $I_{I(off)}$ Test Circuit

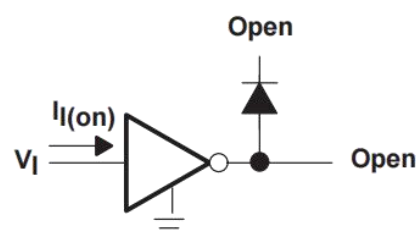
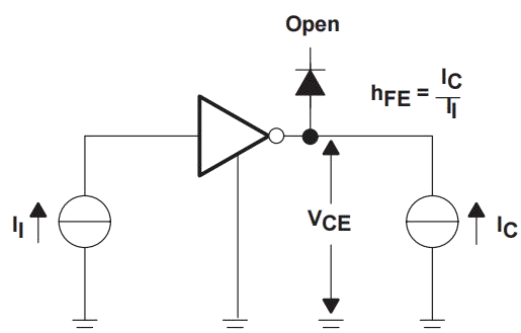


Figure 4. I_I Test Circuit



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

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

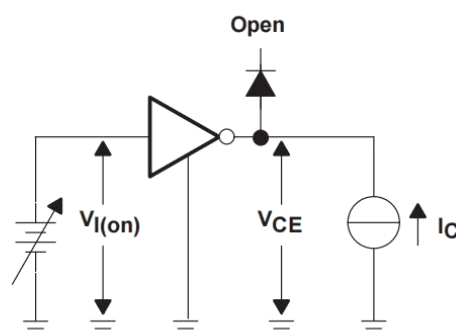


Figure 6. $V_{I(on)}$ Test Circuit

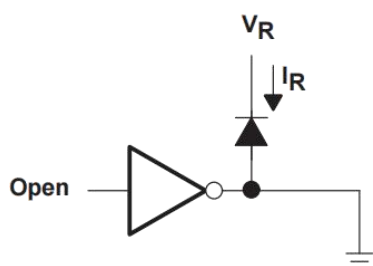


Figure 7. I_R Test Circuit

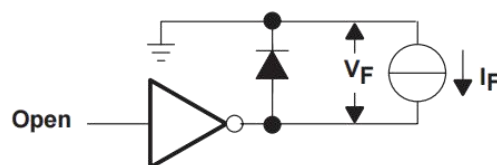


Figure 8. V_F Test Circuit

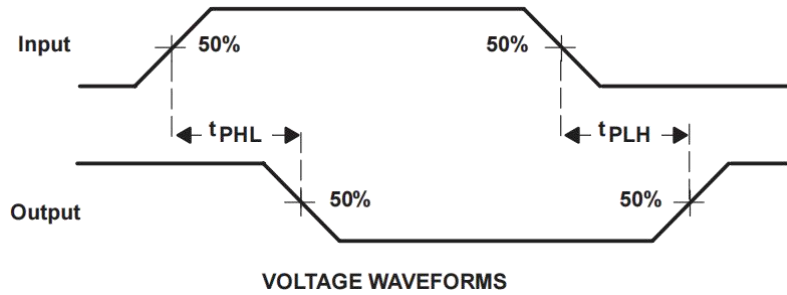
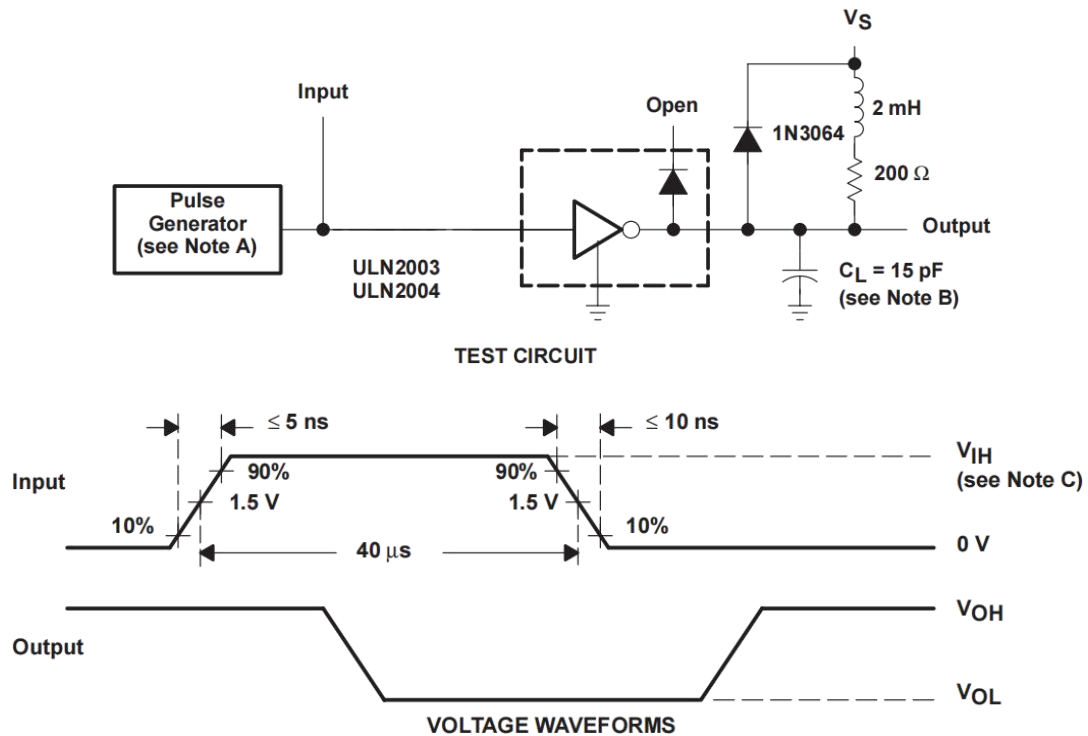


Figure 9. Propagation Delay Time Waveforms



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 ULN2003A, $V_{IH} = 3 \text{ V}$

for the ULN2004A, $V_{IH} = 8 \text{ V}$.

Figure 10. Latch-Up Test Circuit and Voltage Waveforms

Typical Characteristics

COLLECTOR-EMITTER
SATURATION VOLTAGE
 V_s
COLLECTOR CURRENT
(ONE DARLINGTON)

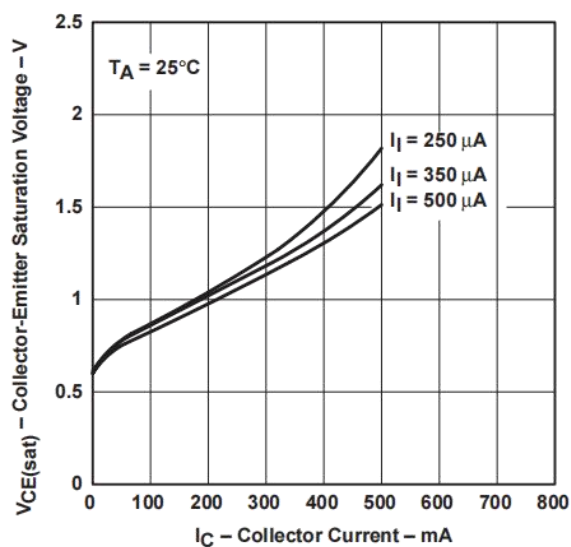


Figure 11

COLLECTOR-EMITTER
SATURATION VOLTAGE
 V_s
TOTAL COLLECTOR CURRENT
(TWO DARLINGTONS PARALLELED)

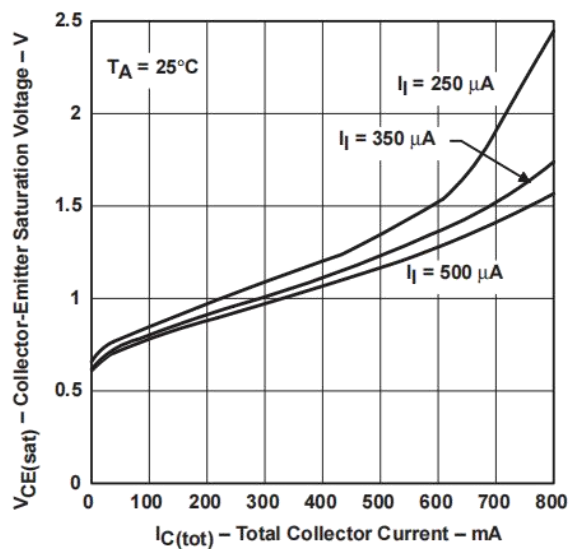


Figure 12

COLLECTOR CURRENT
vs
INPUT CURRENT

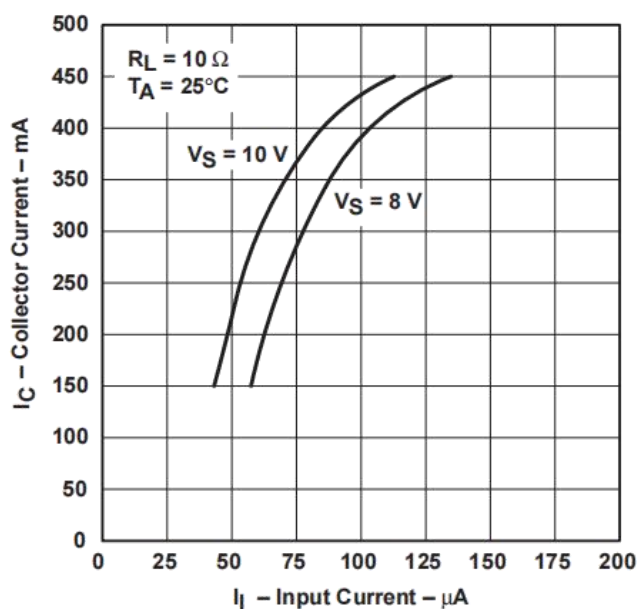


Figure 13

Thermal Information

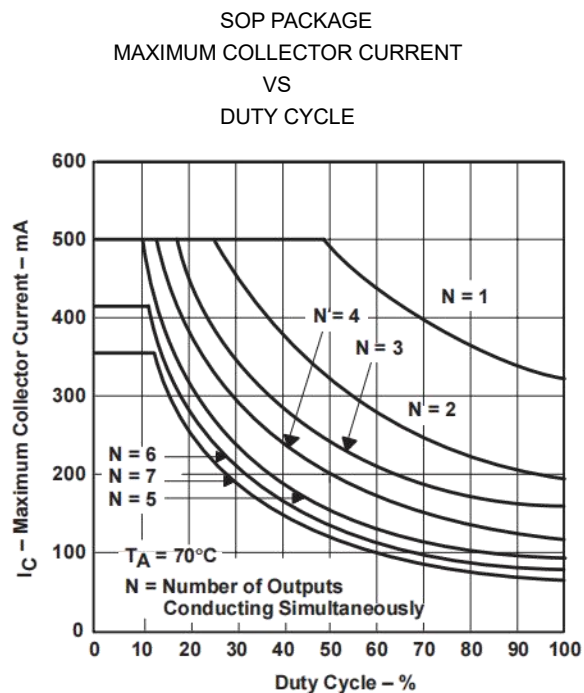


Figure 14

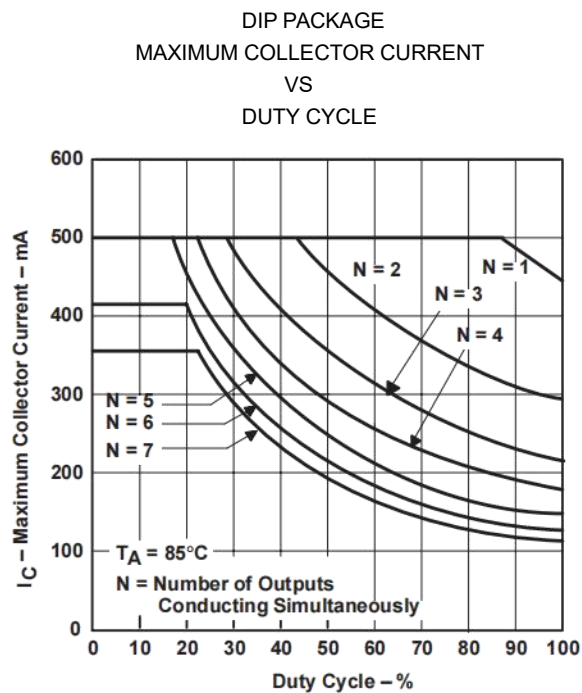


Figure 15

Application Information

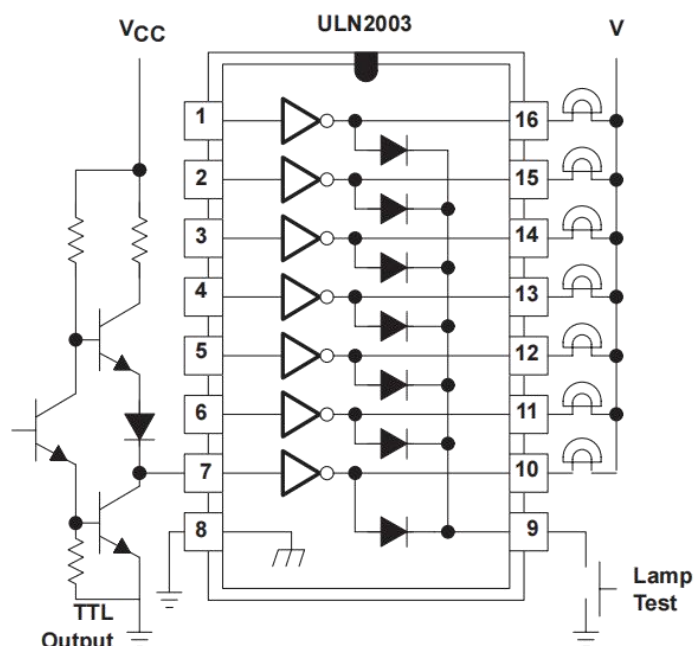


Figure 17. TTL to Load

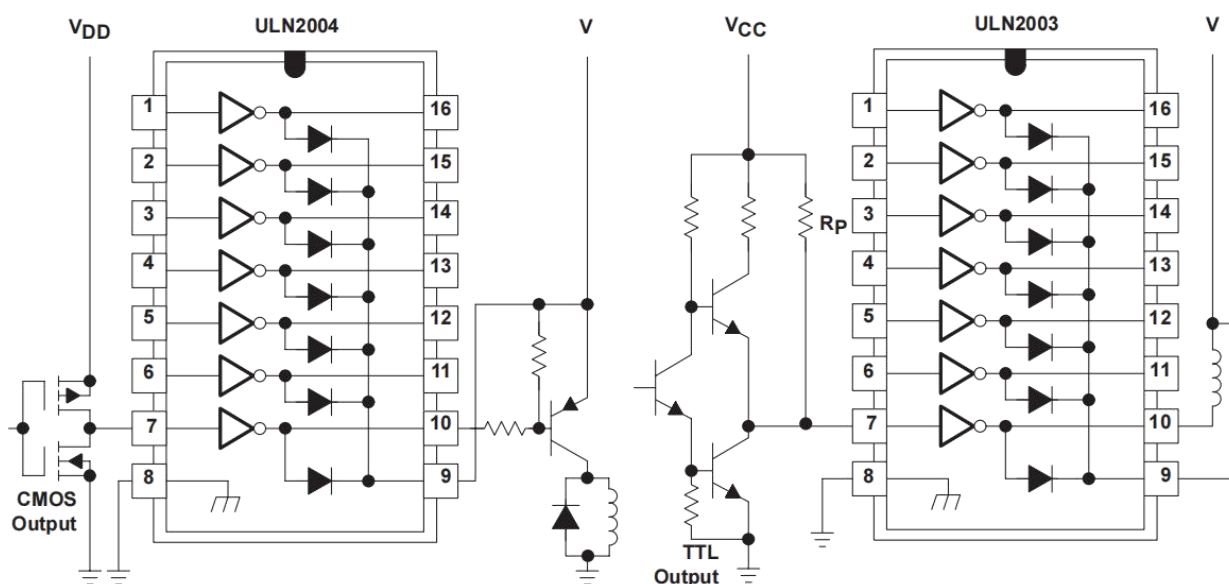
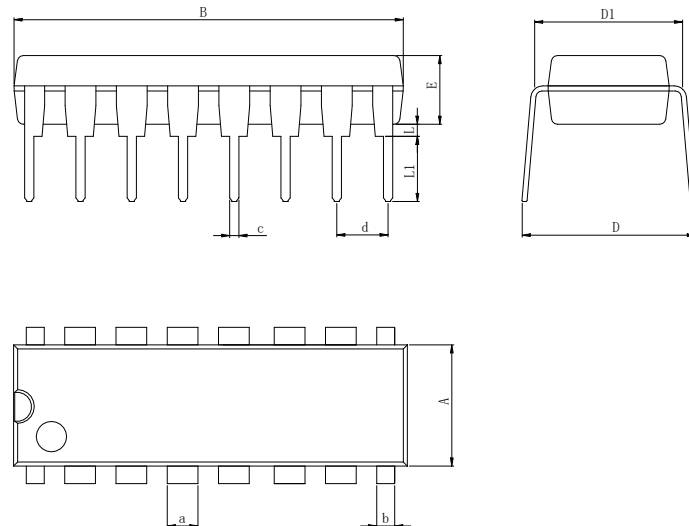


Figure 18. Buffer for Higher Current Loads

Figure 19. Use of Pullup Resistors to Increase Drive Current

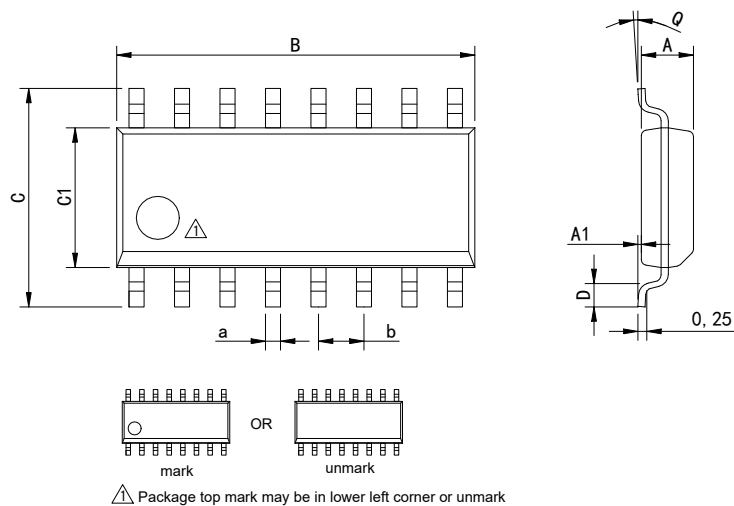
Physical Dimensions

DIP-16



Dimensions In Millimeters(DIP-16)											
Symbol:	A	B	D	D1	E	L	L1	a	b	c	d
Min:	6.10	18.94	8.10	7.42	3.10	0.50	3.00	1.50	0.85	0.40	2.54 BSC
Max:	6.68	19.56	10.9	7.82	3.55	0.70	3.60	1.55	0.90	0.50	

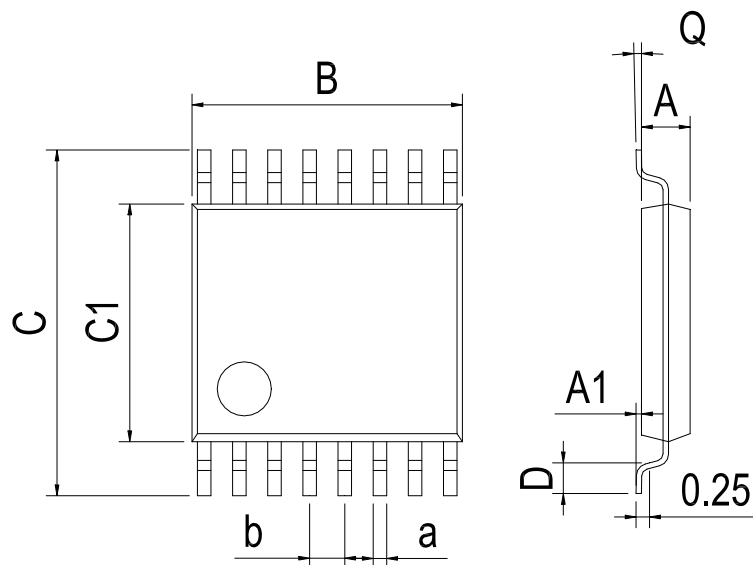
SOP-16



Dimensions In Millimeters(SOP-16)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	9.80	5.80	3.80	0.40	0°	0.35	1.27 BSC
Max:	1.55	0.20	10.0	6.20	4.00	0.80	8°	0.45	

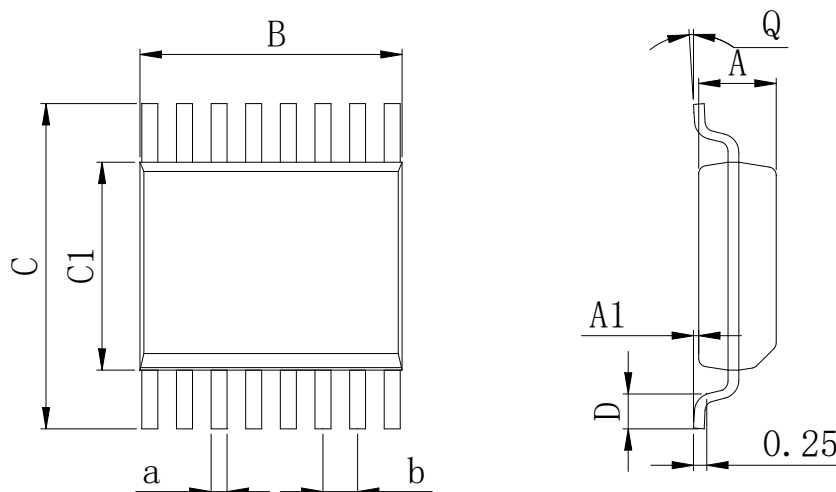
Physical Dimensions

TSSOP-16



Dimensions In Millimeters(TSSOP-16)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.85	0.05	4.90	6.20	4.30	0.40	0°	0.20	0.65 BSC
Max:	0.95	0.20	5.10	6.60	4.50	0.80	8°	0.25	

QSOP-16



Dimensions In Millimeters(QSOP-16)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	1.35	0.05	4.80	5.80	3.80	0.40	0°	0.20	0.635 BSC
Max:	1.55	0.20	5.10	6.20	4.00	0.80	8°	0.25	

Revision History

REVISION NUMBER	DATE	REVISION	PAGE
V1.0	2019-11	New	1-14
V1.2	2023-9	Document Reformatting	1-14
V1.2	2024-11	Update Lead Temperature	4
V1.3	2025-6	Add QSOP-16 package model	1
V1.4	2025-12	Update important statements、 Update SOP-16 Dimension drawing	11、 14

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