

### Features

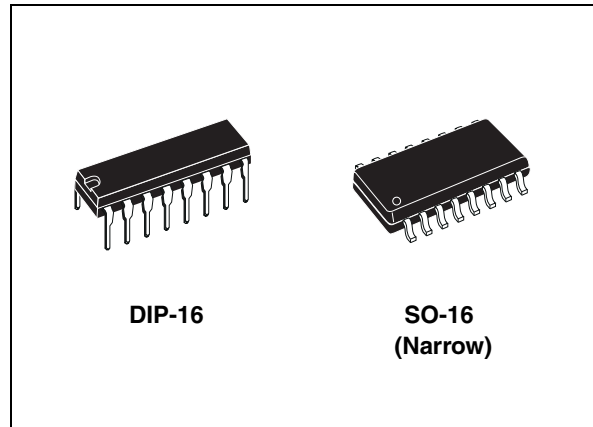
- Seven Darlington pairs per package
- Output current 500 mA per driver (600 mA peak)
- Output voltage 50 V
- Integrated suppression diodes for inductive loads
- Outputs can be paralleled for higher current
- TTL/CMOS/PMOS/DTL compatible inputs
- Inputs pinned opposite outputs to simplify layout

### Description

The ULN2001, ULN2002, ULN2003 and ULN2004 are high voltage, high current Darlington arrays each containing seven open collector Darlington pairs with common emitters. Each channel rated at 500 mA and can withstand peak currents of 600 mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

The versions interface to all common logic families:

- ULN2001 (general purpose, DTL, TTL, PMOS, CMOS)
- ULN2002 (14 - 25 V PMOS)
- ULN2003 (5 V TTL, CMOS)
- ULN2004 (6 - 15 V CMOS, PMOS)



These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors, LED displays filament lamps, thermal printheads and high power buffers.

The ULN2001A/2002A/2003A and 2004A are supplied in 16 pin plastic DIP packages with a copper leadframe to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D1/2002D1/2003D1/2004D1

**Table 1. Device summary**

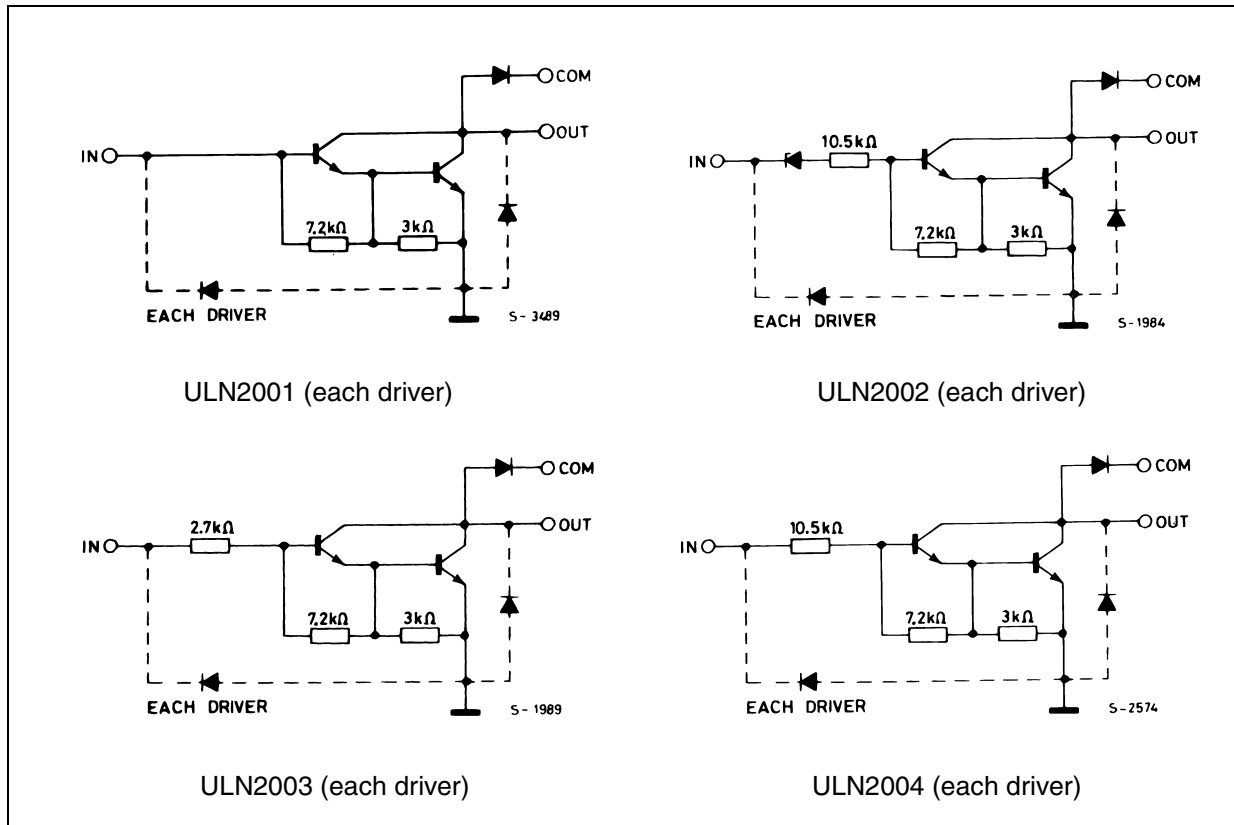
Order codes	
ULN2001A	ULN2001D1013TR
ULN2002A	ULN2002D1013TR
ULN2003A	ULN2003D1013TR
ULN2004A	ULN2004D1013TR

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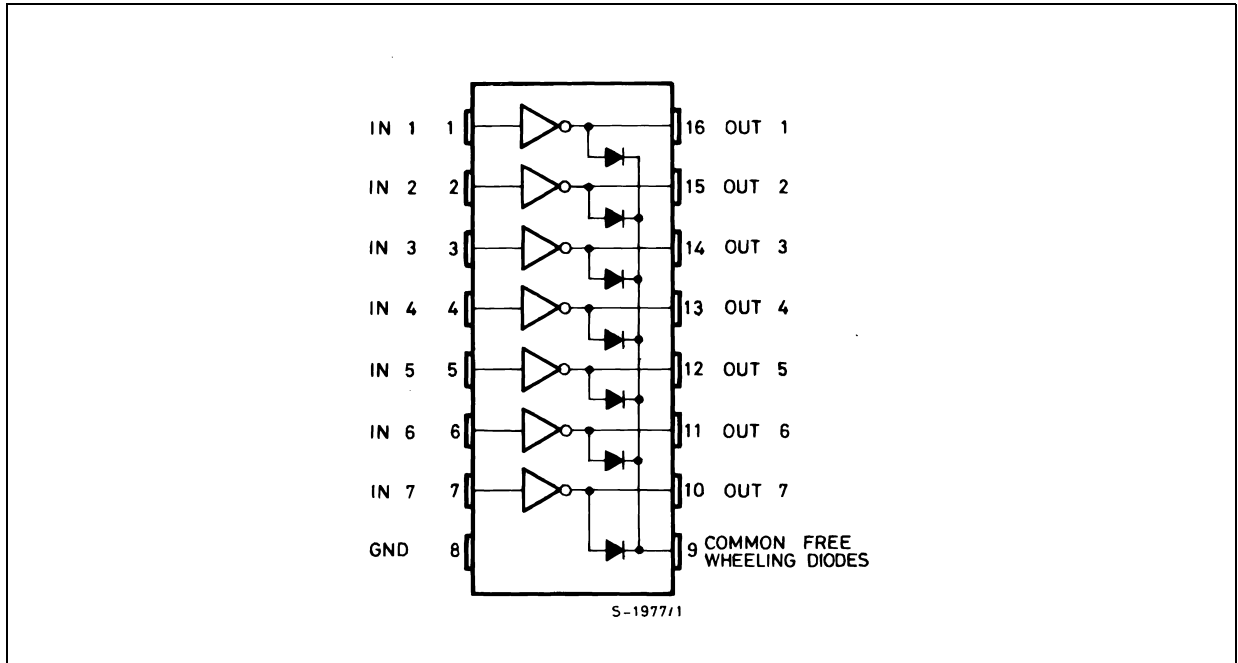
# 1 Diagram

Figure 1. Schematic diagram



## 2 Pin configuration

Figure 2. Pin connections (top view)



### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_O$	Output voltage	50	V
$V_I$	Input voltage (for ULN2002A/D - 2003A/D - 2004A/D)	30	V
$I_C$	Continuous collector current	500	mA
$I_B$	Continuous base current	25	mA
$T_A$	Operating ambient temperature range	- 40 to 85	°C
$T_{STG}$	Storage temperature range	- 55 to 150	°C
$T_J$	Junction temperature	150	°C

**Table 3. Thermal data**

Symbol	Parameter	DIP-16	SO-16	Unit
$R_{thJA}$	Thermal resistance junction-ambient, Max.	70	120	°C/W

## 4 Electrical characteristics

$T_A = 25\text{ }^\circ\text{C}$  unless otherwise specified.

**Table 4. Electrical characteristics**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$I_{CEX}$	Output leakage current	$V_{CE} = 50\text{ V}$ , ( <i>Figure 3.</i> )			50	$\mu\text{A}$
		$T_A = 85^\circ\text{C}$ , $V_{CE} = 50\text{ V}$ ( <i>Figure 3.</i> )			100	
		$T_A = 85^\circ\text{C}$ for ULN2002, $V_{CE} = 50\text{ V}$ , $V_I = 6\text{ V}$ ( <i>Figure 4.</i> )			500	
		$T_A = 85^\circ\text{C}$ for ULN2002, $V_{CE} = 50\text{ V}$ , $V_I = 1\text{ V}$ ( <i>Figure 4.</i> )			500	
$V_{CE(SAT)}$	Collector-emitter saturation voltage ( <i>Figure 5.</i> )	$I_C = 100\text{ mA}$ , $I_B = 250\text{ }\mu\text{A}$		0.9	1.1	V
		$I_C = 200\text{ mA}$ , $I_B = 350\text{ }\mu\text{A}$		1.1	1.3	
		$I_C = 350\text{ mA}$ , $I_B = 500\text{ }\mu\text{A}$		1.3	1.6	
$I_{I(ON)}$	Input current ( <i>Figure 6.</i> )	for ULN2002, $V_I = 17\text{ V}$		0.82	1.25	mA
		for ULN2003, $V_I = 3.85\text{ V}$		0.93	1.35	
		for ULN2004, $V_I = 5\text{ V}$		0.35	0.5	
		$V_I = 12\text{ V}$		1	1.45	
$I_{I(OFF)}$	Input current ( <i>Figure 7.</i> )	$T_A = 85^\circ\text{C}$ , $I_C = 500\text{ }\mu\text{A}$	50	65		$\mu\text{A}$
$V_{I(ON)}$	Input voltage ( <i>Figure 8.</i> )	$V_{CE} = 2\text{ V}$ , for ULN2002			13	V
		$I_C = 300\text{ mA}$			2.4	
		for ULN2003			2.7	
		$I_C = 200\text{ mA}$			3	
		$I_C = 250\text{ mA}$			5	
		for ULN2004			6	
		$I_C = 125\text{ mA}$			7	
		$I_C = 200\text{ mA}$			8	
$h_{FE}$	DC Forward current gain ( <i>Figure 5.</i> )	for ULN2001, $V_{CE} = 2\text{ V}$ , $I_C = 350\text{ mA}$	1000			
$C_I$	Input capacitance			15	25	pF
$t_{PLH}$	Turn-on delay time	$0.5 V_I$ to $0.5 V_O$		0.25	1	$\mu\text{s}$
$t_{PHL}$	Turn-off delay time	$0.5 V_I$ to $0.5 V_O$		0.25	1	$\mu\text{s}$
$I_R$	Clamp diode leakage current ( <i>Figure 9.</i> )	$V_R = 50\text{ V}$			50	$\mu\text{A}$
		$T_A = 85^\circ\text{C}$ , $V_R = 50\text{ V}$			100	
$V_F$	Clamp diode forward voltage ( <i>Figure 10.</i> )	$I_F = 350\text{ mA}$		1.7	2	V

# 5 Test circuits

Figure 3. Output leakage current

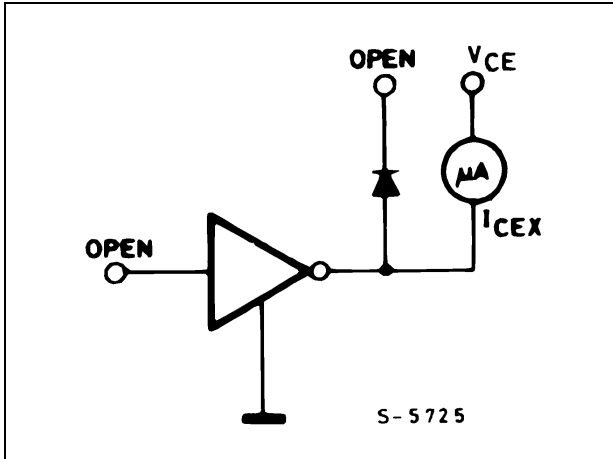


Figure 4. Output leakage current (for ULN2002 only)

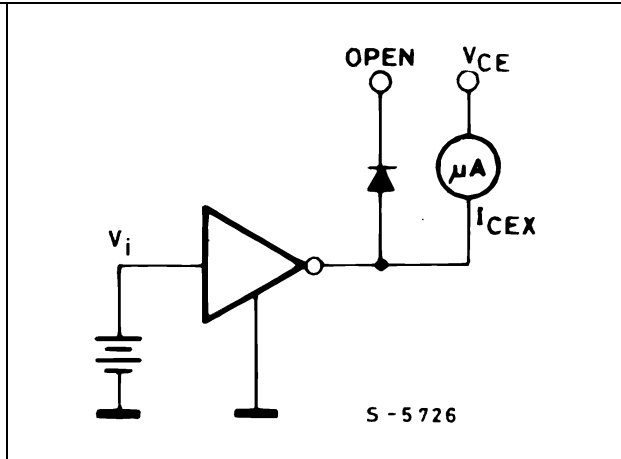


Figure 5. Collector-emitter saturation voltage Figure 6. Input current (ON)

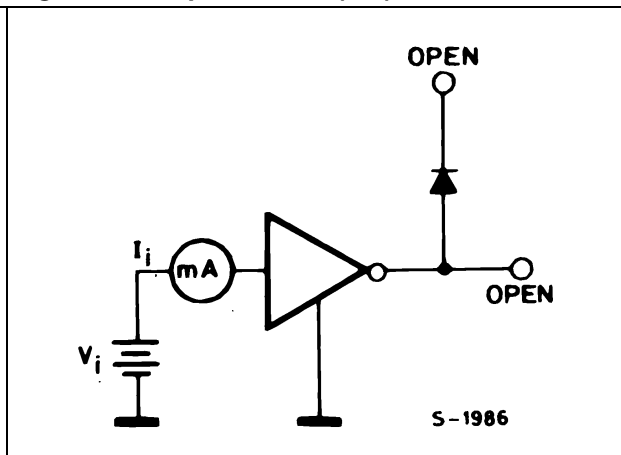
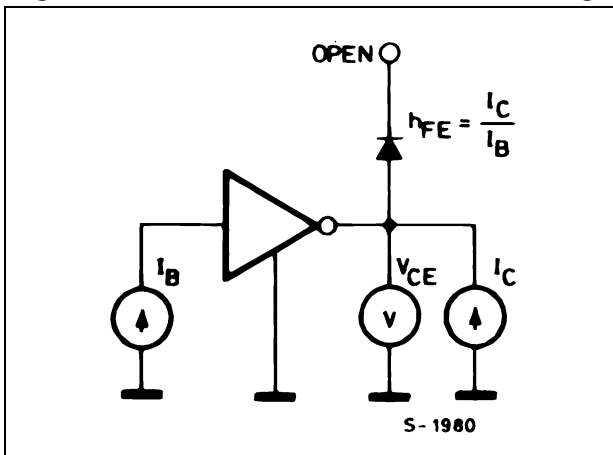


Figure 7. Input current (OFF)

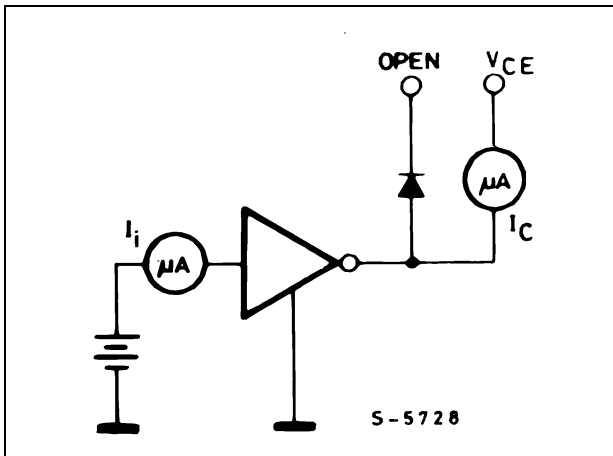


Figure 8. Input voltage

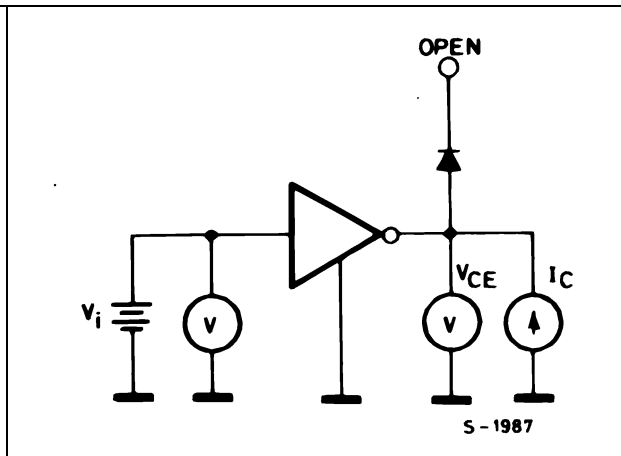


Figure 9. Clamp diode leakage current

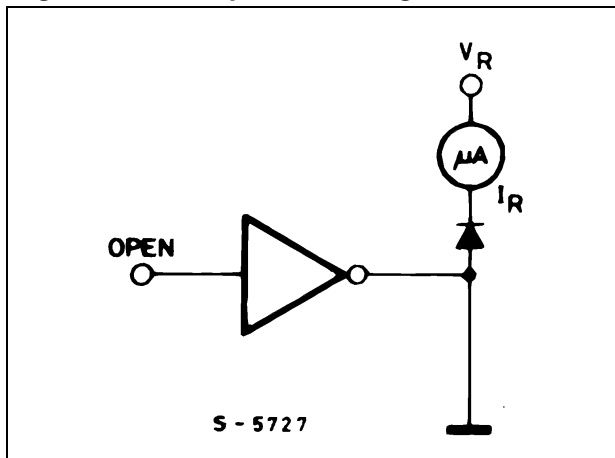
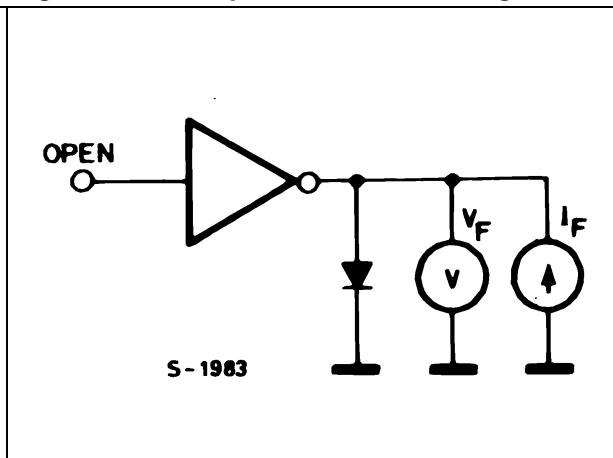


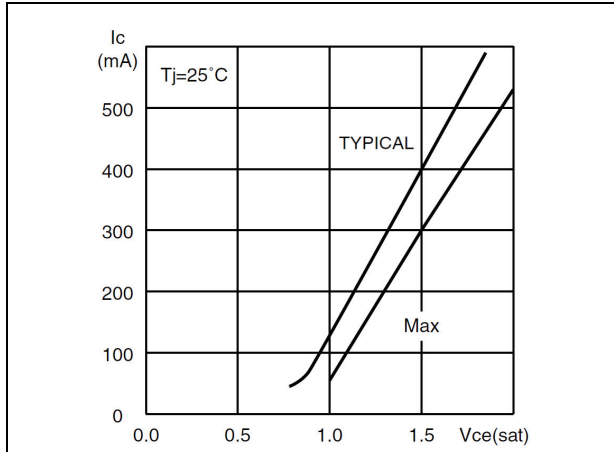
Figure 10. Clamp diode forward voltage



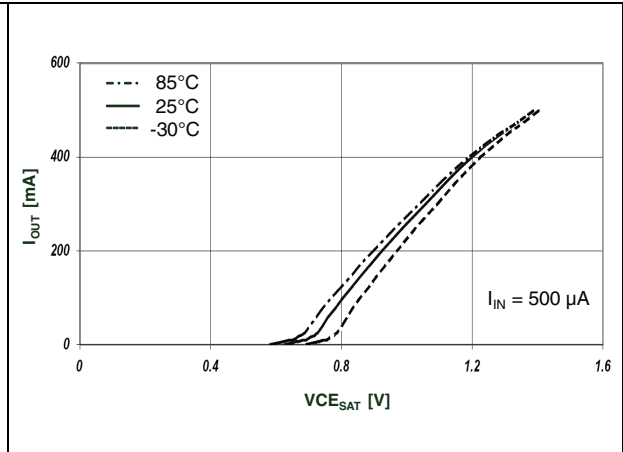


## 6 Typical performance characteristics

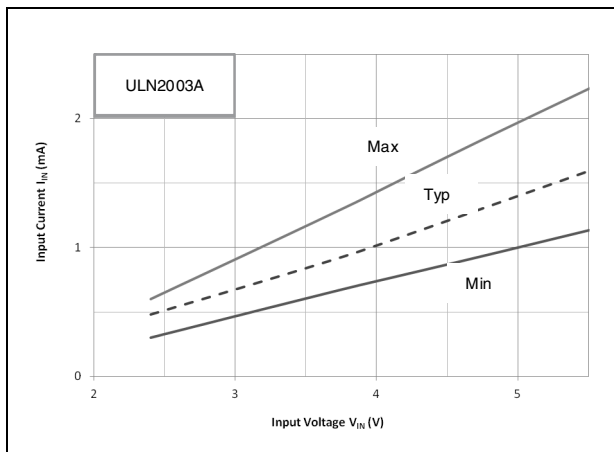
**Figure 11. Collector current vs. saturation voltage ( $T_J = 25^\circ\text{C}$ )**



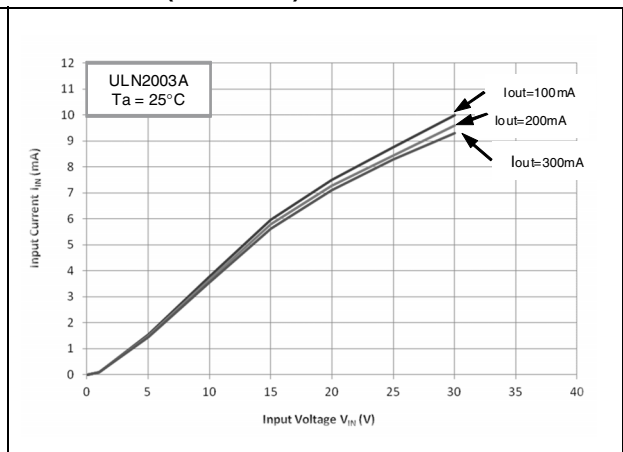
**Figure 12. Collector current vs. saturation voltage**



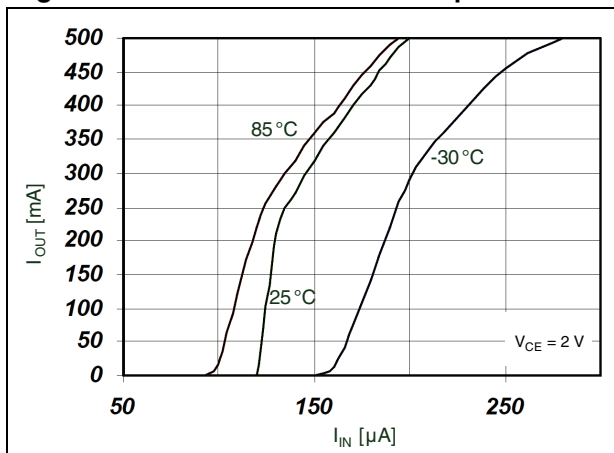
**Figure 13. Input current vs. input voltage**



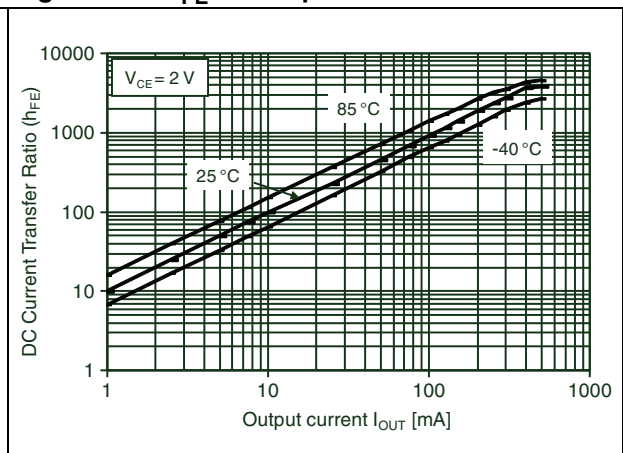
**Figure 14. Input current vs. input voltage ( $T_a = 25^\circ\text{C}$ )**



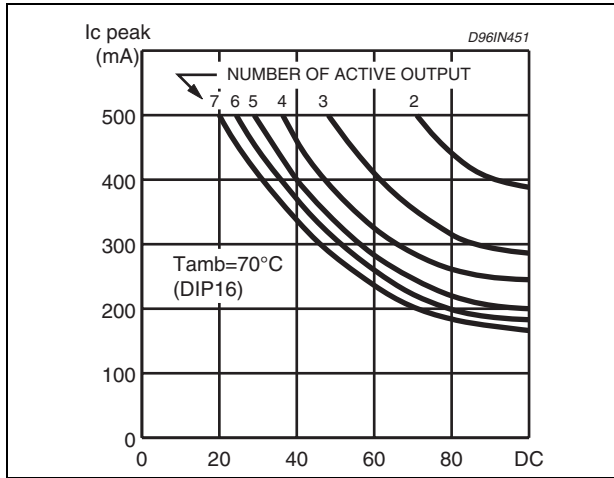
**Figure 15. Collector current vs. input current**



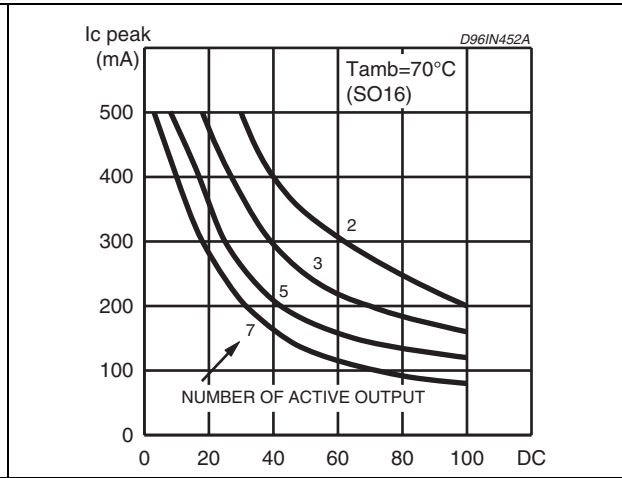
**Figure 16.  $h_{FE}$  vs. output current**



**Figure 17. Peak collector current vs. duty cycle (DIP-16)**



**Figure 18. Peak collector current vs. duty cycle (SO-16)**



## 7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

**Table 5. DIP-16L mechanical data**

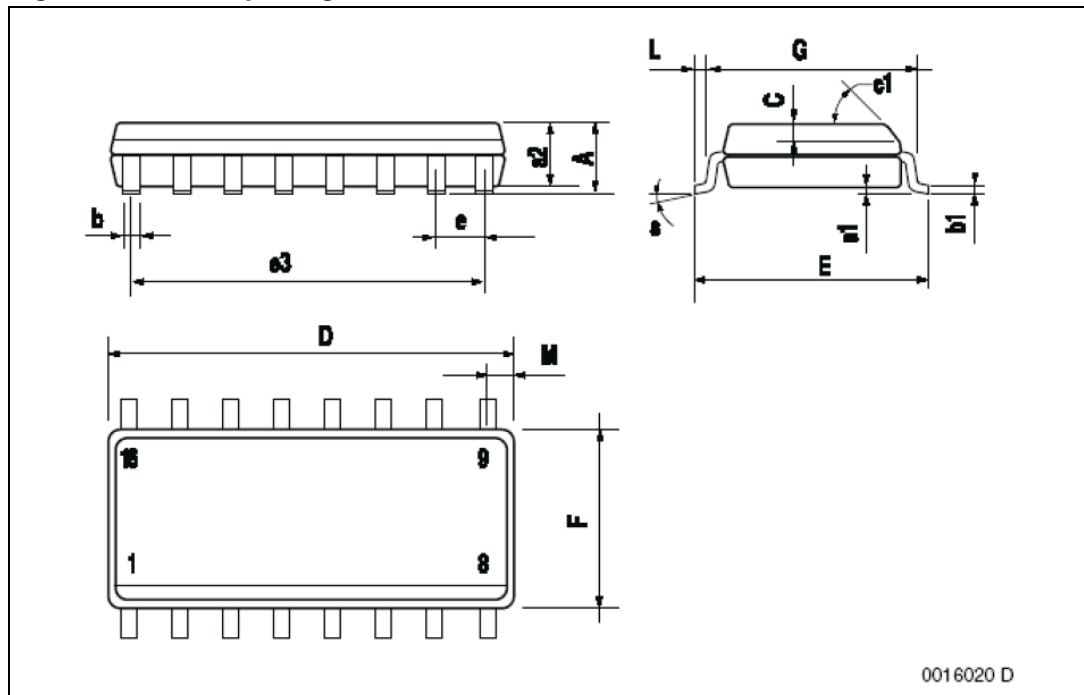
Dim.	mm.		
	Min.	Typ.	Max.
A			5.33
A1	0.38		
A2	2.92	3.30	4.95
b	0.36	0.46	0.56
b2	1.14	1.52	1.78
c	0.20	0.25	0.36
D	18067	19.18	19.69
E	7.62	7.87	8.26
E1	6.10	6.35	7.11
e		2.54	
e1		17.78	
eA		7.62	
eB			10.92
L	2.92	3.30	3.81



Table 6. SO-16 narrow mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.009
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1			45°	(typ.)		
D(1)	9.8		10	0.386		0.394
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		8.89			0.350	
F(1)	3.8		4.0	0.150		0.157
G	4.60		5.30	0.181		0.208
L	0.4		1.27	0.150		0.050
M			0.62			0.024
S	8° (max.)					

Figure 20. SO-16 package dimensions



## 8 Order codes

**Table 7. Order codes**

Part numbers	Packages
ULN2001A	DIP-16
ULN2002A	DIP-16
ULN2003A	DIP-16
ULN2004A	DIP-16
ULN2001D1013TR	SO-16 in tape and reel
ULN2002D1013TR	SO-16 in tape and reel
ULN2003D1013TR	SO-16 in tape and reel
ULN2004D1013TR	SO-16 in tape and reel

## 9 Revision history

**Table 8. Revision history**

Date	Revision	Changes
05-Dec-2006	5	Order code updated and document reformatted.
28-Aug-2007	6	Added <a href="#">Table 1</a> in cover page.
07-May-2012	7	Modified: <a href="#">Figure 12 on page 9</a> . Added: <a href="#">Figure 13, 14, 15</a> and <a href="#">Figure 16 on page 9</a> .
01-Jun-2012	8	Updated: DIP-16L package mechanical data <a href="#">Table 5 on page 11</a> and <a href="#">Figure 19 on page 12</a> .

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