



# ULN2001, ULN2002 ULN2003, ULN2004

## Seven Darlington array

Datasheet — production data

### Features

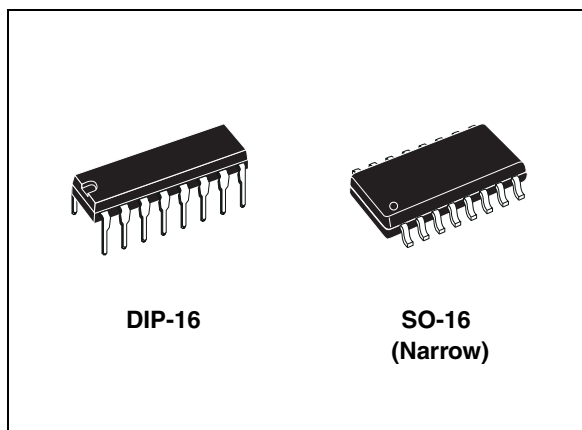
- Seven Darlingtons per package
- Output current 500 mA per driver (600 mA peak)
- Output voltage 50 V
- Integrated suppression diodes for inductive loads
- Outputs can be paralleled for higher current
- TTL/CMOS/PMOS/DTL compatible inputs
- Inputs pinned opposite outputs to simplify layout

### 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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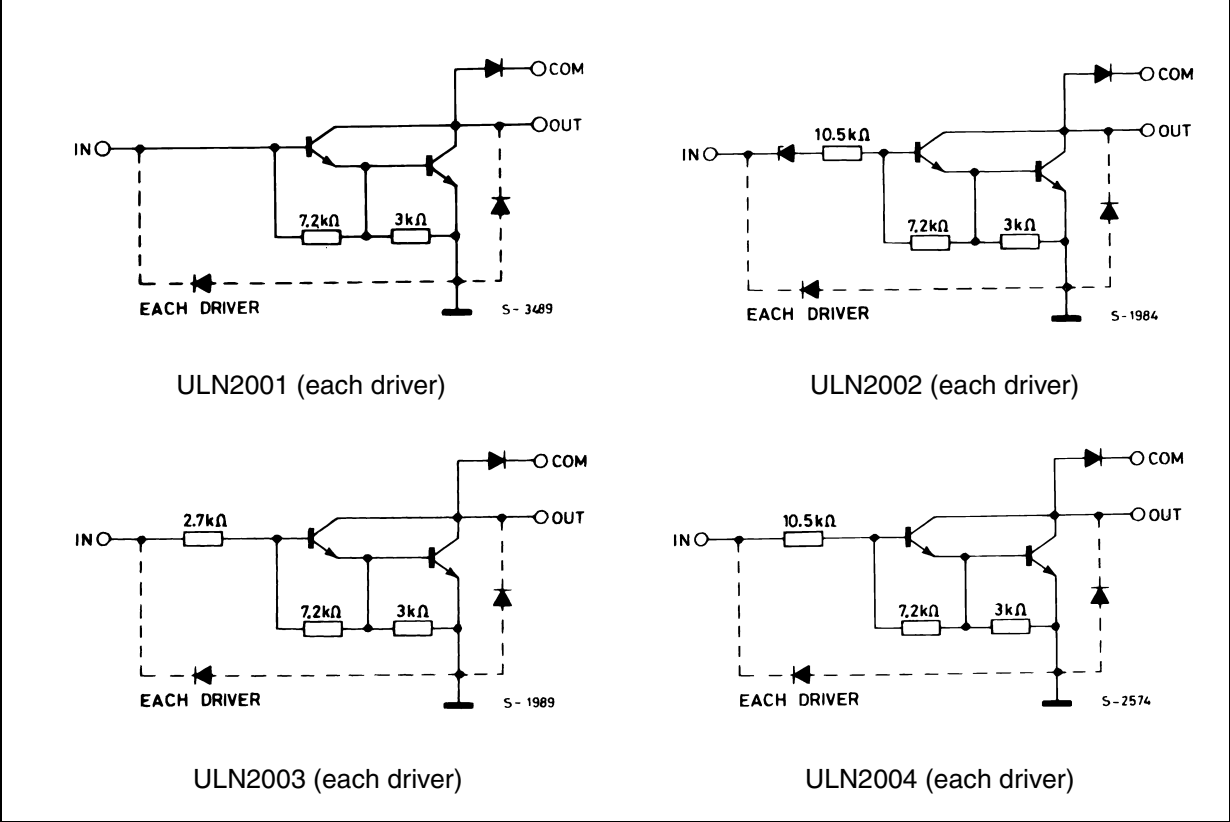
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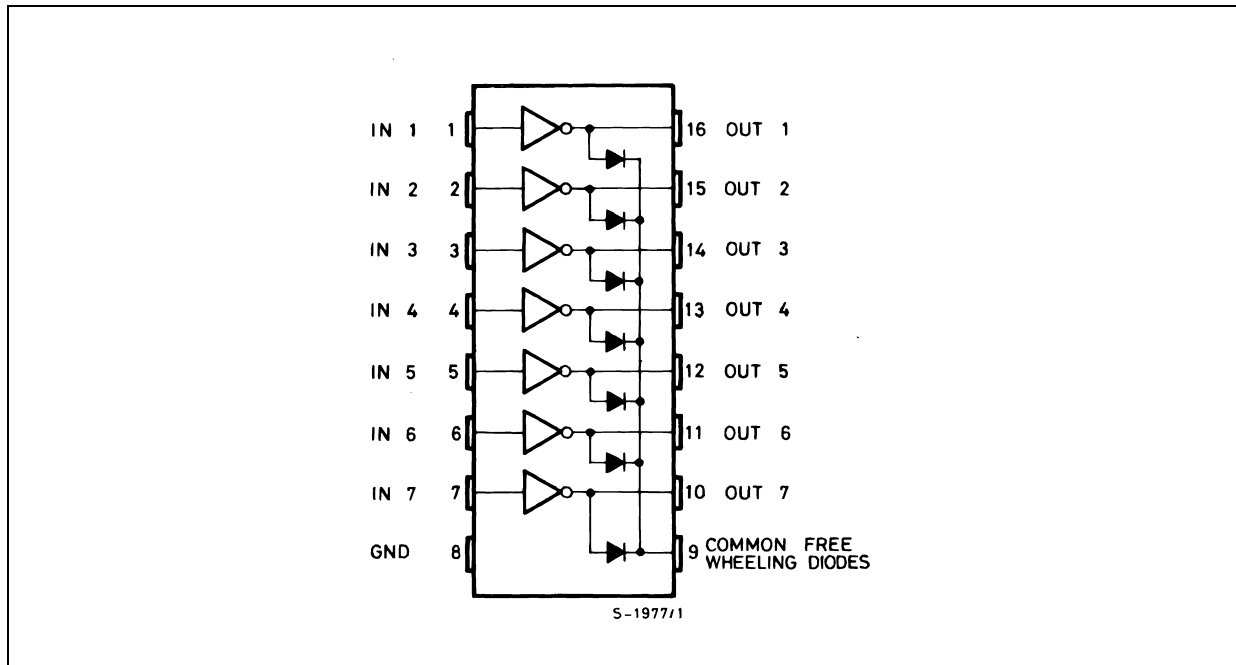
# 1 Diagram

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                                             | $V_{CE} = 50\text{ V}$ , ( <a href="#">Figure 3.</a> )                                                                                                                                                                                                                    |      |      | 50                                        | $\mu\text{A}$ |
|               |                                                                    | $T_A = 85^{\circ}\text{C}$ , $V_{CE} = 50\text{ V}$ ( <a href="#">Figure 3.</a> )                                                                                                                                                                                         |      |      | 100                                       |               |
|               |                                                                    | $T_A = 85^{\circ}\text{C}$ for ULN2002, $V_{CE} = 50\text{ V}$ , $V_I = 6\text{ V}$ ( <a href="#">Figure 4.</a> )                                                                                                                                                         |      |      | 500                                       |               |
|               |                                                                    | $T_A = 85^{\circ}\text{C}$ for ULN2002, $V_{CE} = 50\text{ V}$ , $V_I = 1\text{ V}$ ( <a href="#">Figure 4.</a> )                                                                                                                                                         |      |      | 500                                       |               |
| $V_{CE(SAT)}$ | Collector-emitter saturation voltage ( <a href="#">Figure 5.</a> ) | $I_C = 100\text{ mA}$ , $I_B = 250\text{ }\mu\text{A}$                                                                                                                                                                                                                    |      | 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 ( <a href="#">Figure 6.</a> )                        | 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 ( <a href="#">Figure 7.</a> )                        | $T_A = 85^{\circ}\text{C}$ , $I_C = 500\text{ }\mu\text{A}$                                                                                                                                                                                                               | 50   | 65   |                                           | $\mu\text{A}$ |
| $V_{I(ON)}$   | Input voltage ( <a href="#">Figure 8.</a> )                        | $V_{CE} = 2\text{ V}$ , for ULN2002<br>$I_C = 300\text{ mA}$<br>for ULN2003<br>$I_C = 200\text{ mA}$<br>$I_C = 250\text{ mA}$<br>$I_C = 300\text{ mA}$<br>for ULN2004<br>$I_C = 125\text{ mA}$<br>$I_C = 200\text{ mA}$<br>$I_C = 275\text{ mA}$<br>$I_C = 350\text{ mA}$ |      |      | 13<br>2.4<br>2.7<br>3<br>5<br>6<br>7<br>8 | V             |
| $h_{FE}$      | DC Forward current gain ( <a href="#">Figure 5.</a> )              | for ULN2001, $V_{CE} = 2\text{ V}$ ,<br>$I_C = 350\text{ mA}$                                                                                                                                                                                                             | 1000 |      |                                           |               |
| $C_I$         | Input capacitance                                                  |                                                                                                                                                                                                                                                                           |      | 15   | 25                                        | pF            |
| $t_{PLH}$     | Turn-on delay time                                                 | $0.5\text{ }V_I$ to $0.5\text{ }V_O$                                                                                                                                                                                                                                      |      | 0.25 | 1                                         | $\mu\text{s}$ |
| $t_{PHL}$     | Turn-off delay time                                                | $0.5\text{ }V_I$ to $0.5\text{ }V_O$                                                                                                                                                                                                                                      |      | 0.25 | 1                                         | $\mu\text{s}$ |
| $I_R$         | Clamp diode leakage current ( <a href="#">Figure 9.</a> )          | $V_R = 50\text{ V}$                                                                                                                                                                                                                                                       |      |      | 50                                        | $\mu\text{A}$ |
|               |                                                                    | $T_A = 85^{\circ}\text{C}$ , $V_R = 50\text{ V}$                                                                                                                                                                                                                          |      |      | 100                                       |               |
| $V_F$         | Clamp diode forward voltage ( <a href="#">Figure 10.</a> )         | $I_F = 350\text{ mA}$                                                                                                                                                                                                                                                     |      | 1.7  | 2                                         | V             |

5 Test circuits

Figure 3. Output leakage current

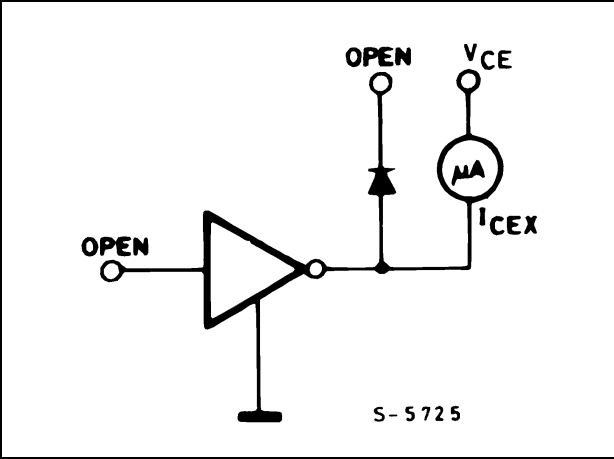


Figure 4. Output leakage current (for ULN2002 only)

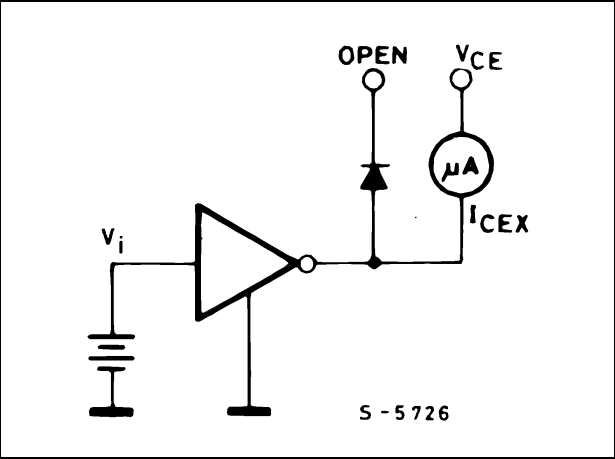


Figure 5. Collector-emitter saturation voltage

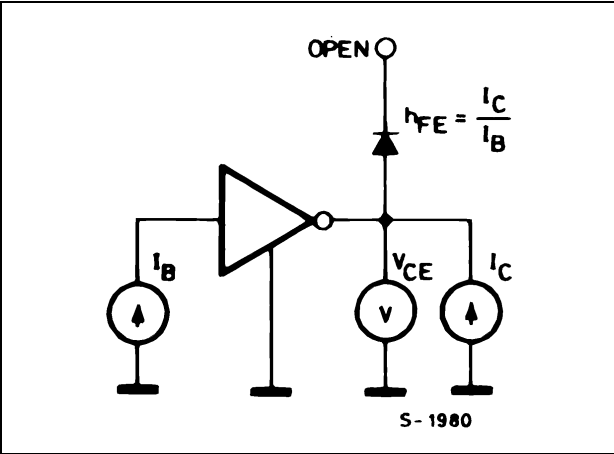


Figure 6. Input current (ON)

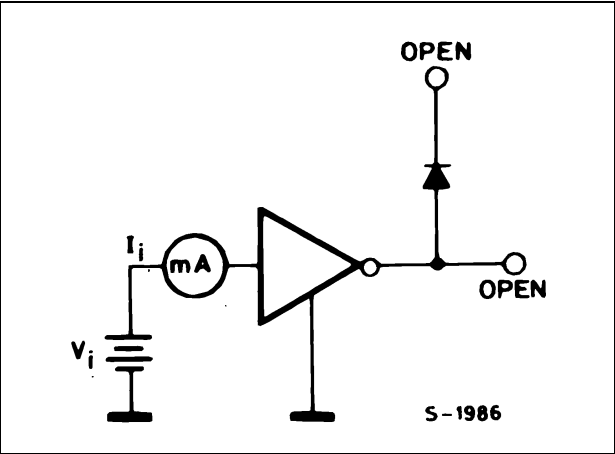


Figure 7. Input current (OFF)

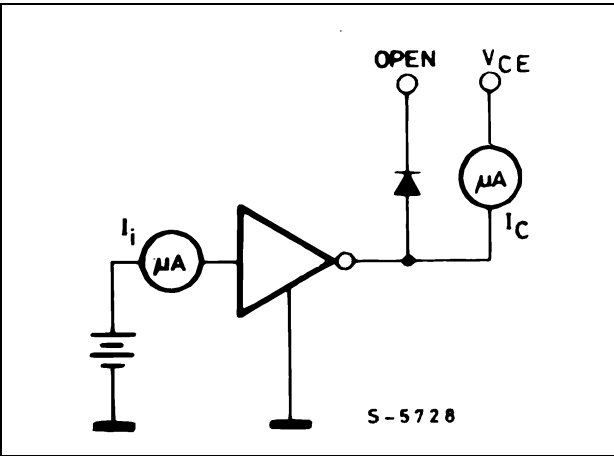


Figure 8. Input voltage

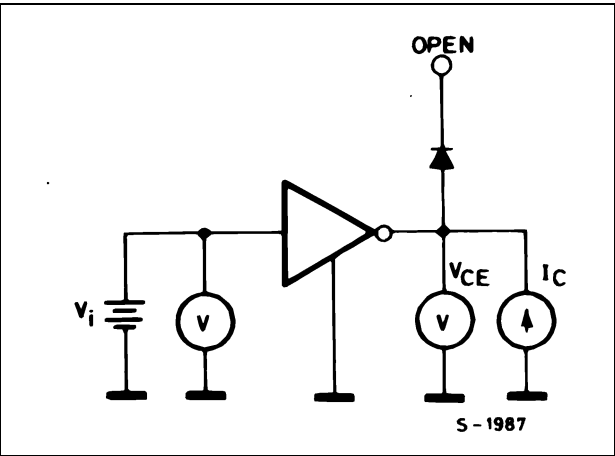


Figure 9. Clamp diode leakage current

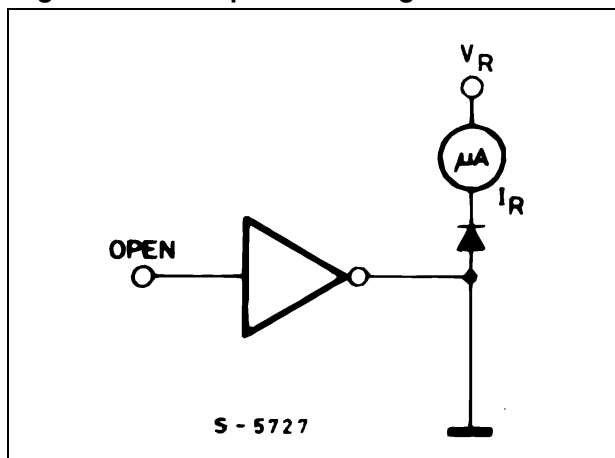
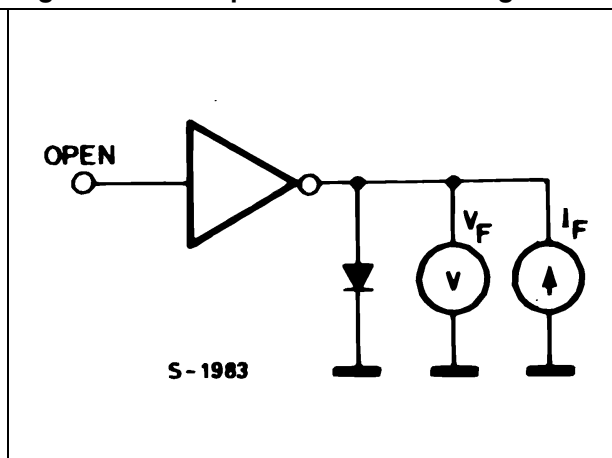
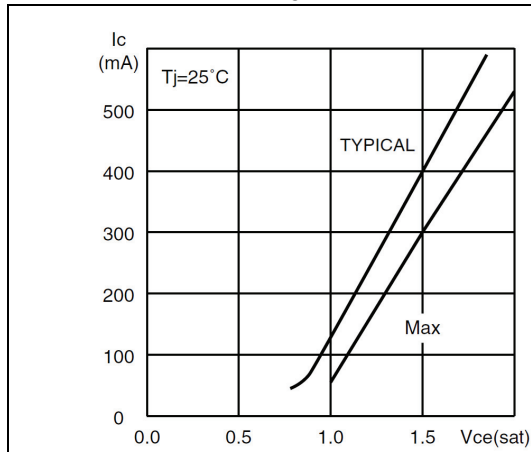


Figure 10. Clamp diode forward voltage

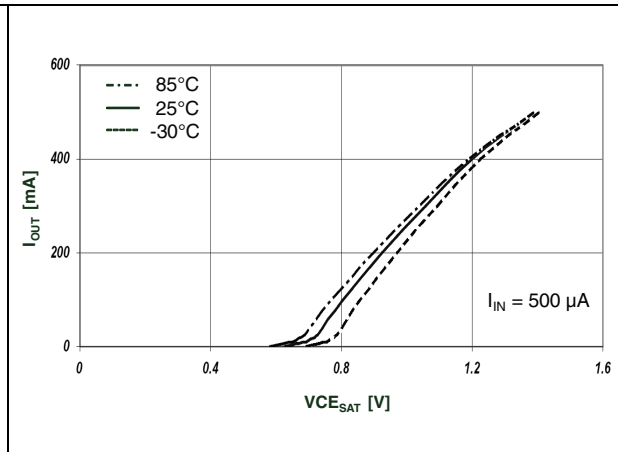


## 6 Typical performance characteristics

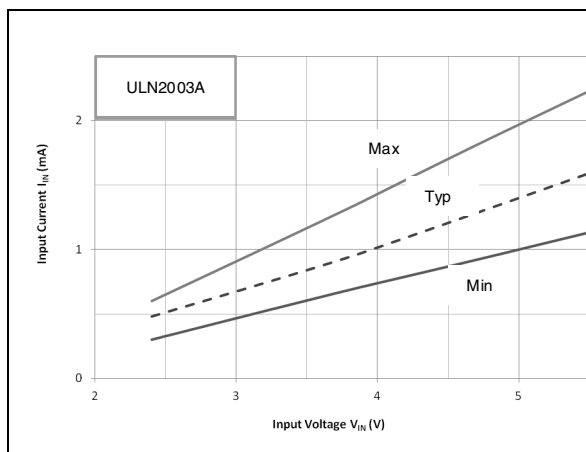
**Figure 11. Collector current vs. saturation voltage ( $T_J = 25^\circ\text{C}$ )**



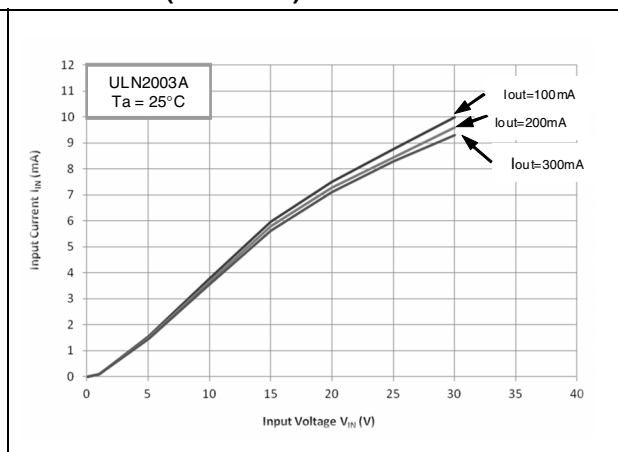
**Figure 12. Collector current vs. saturation voltage**



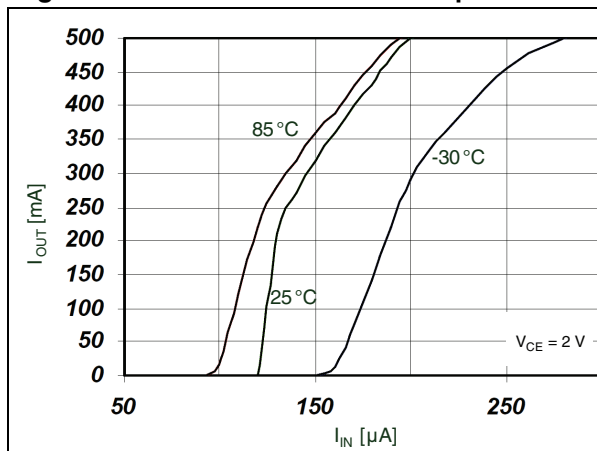
**Figure 13. Input current vs. input voltage**



**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**

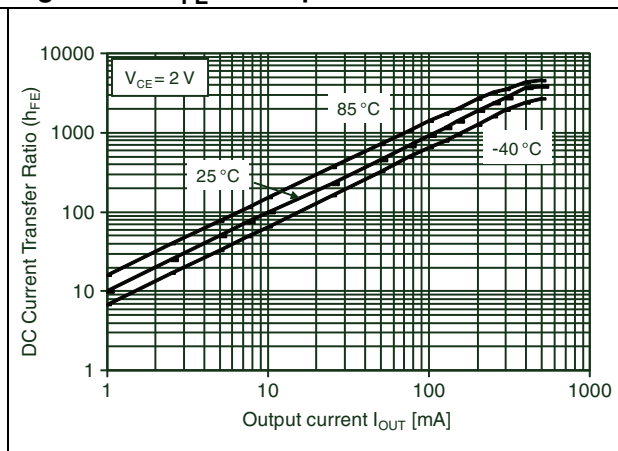


Figure 17. Peak collector current vs. duty cycle (DIP-16)

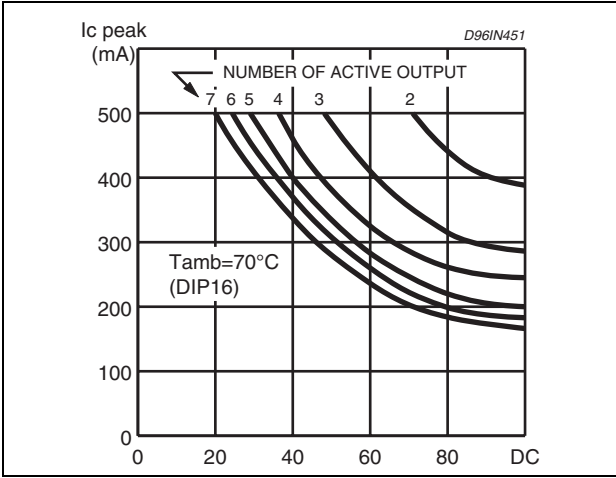
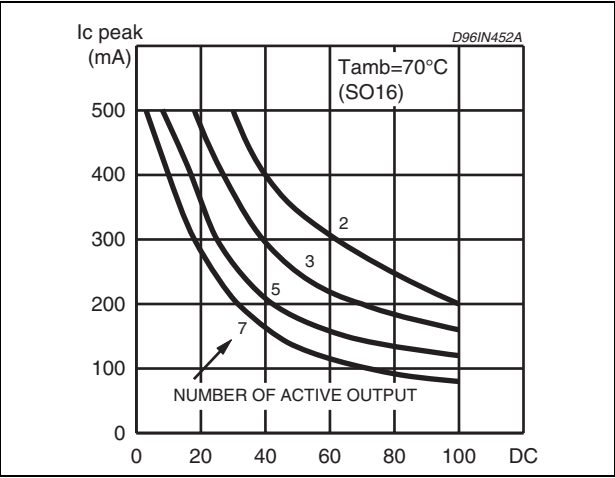


Figure 18. Peak collector current vs. duty cycle (SO-16)



## 7 Package mechanical data

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

Figure 19. DIP-16L package dimensions

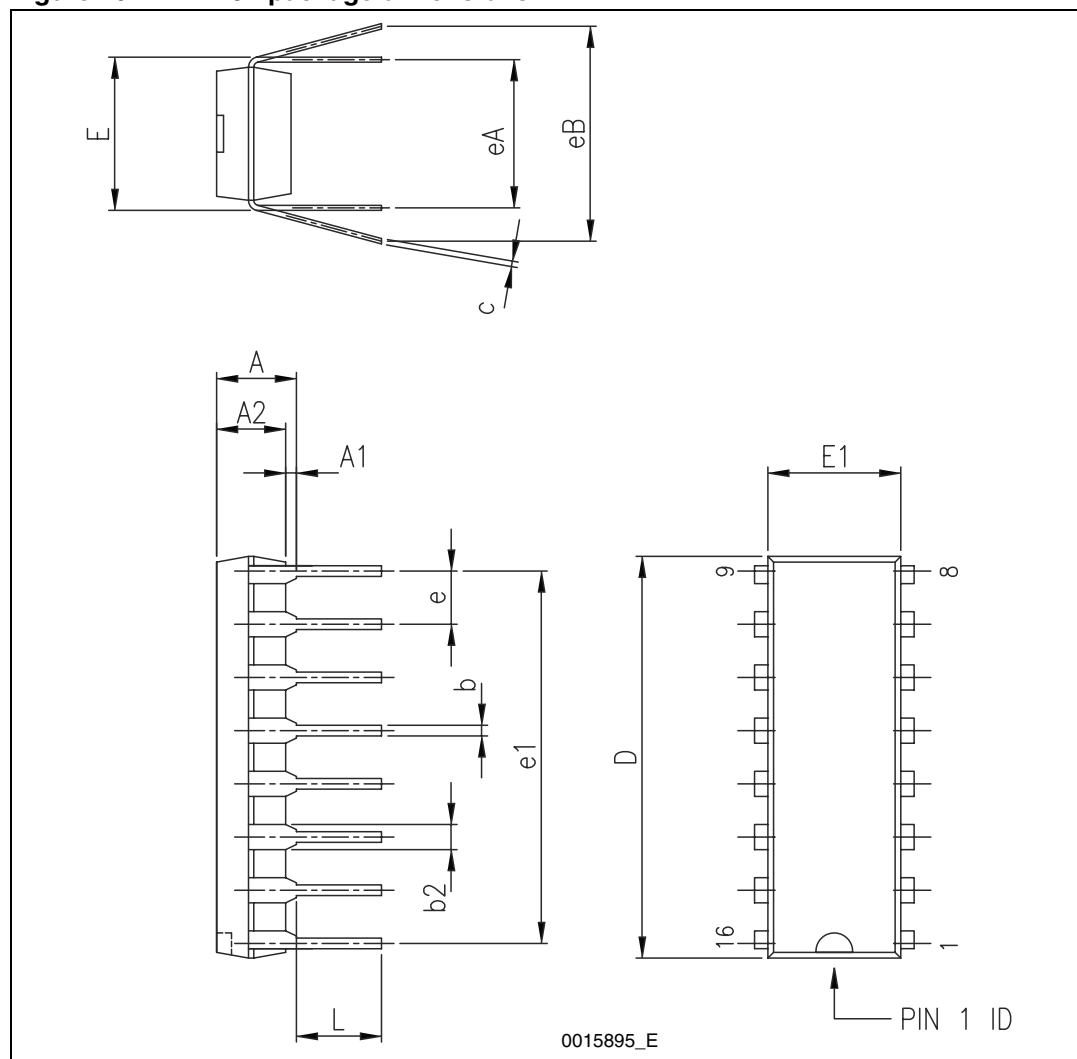
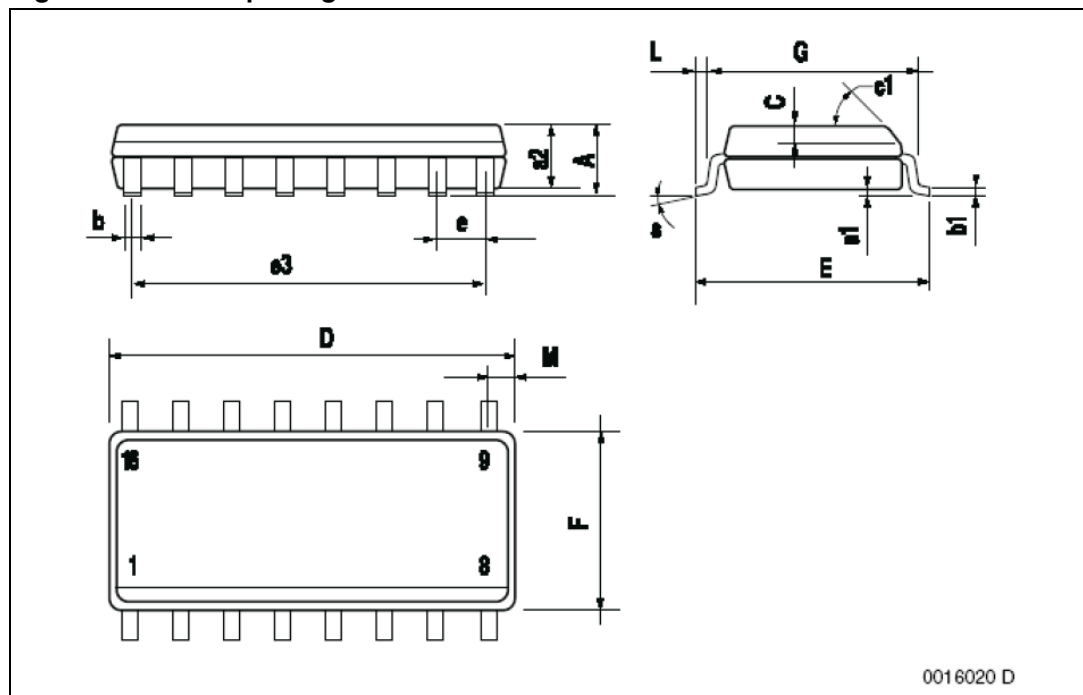


Table 6. SO-16 narrow mechanical data

| 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> .<br>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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