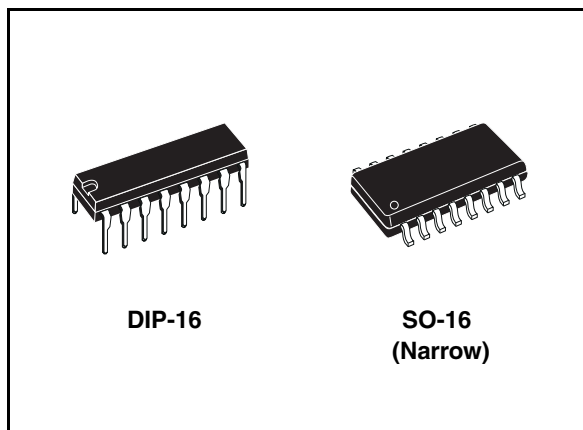


## Seven darlington array

### Features

- Seven darlingtontons 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 (14-25V PMOS)
- ULN2003 (5V TTL, CMOS)
- ULN2004 (6-15V 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**

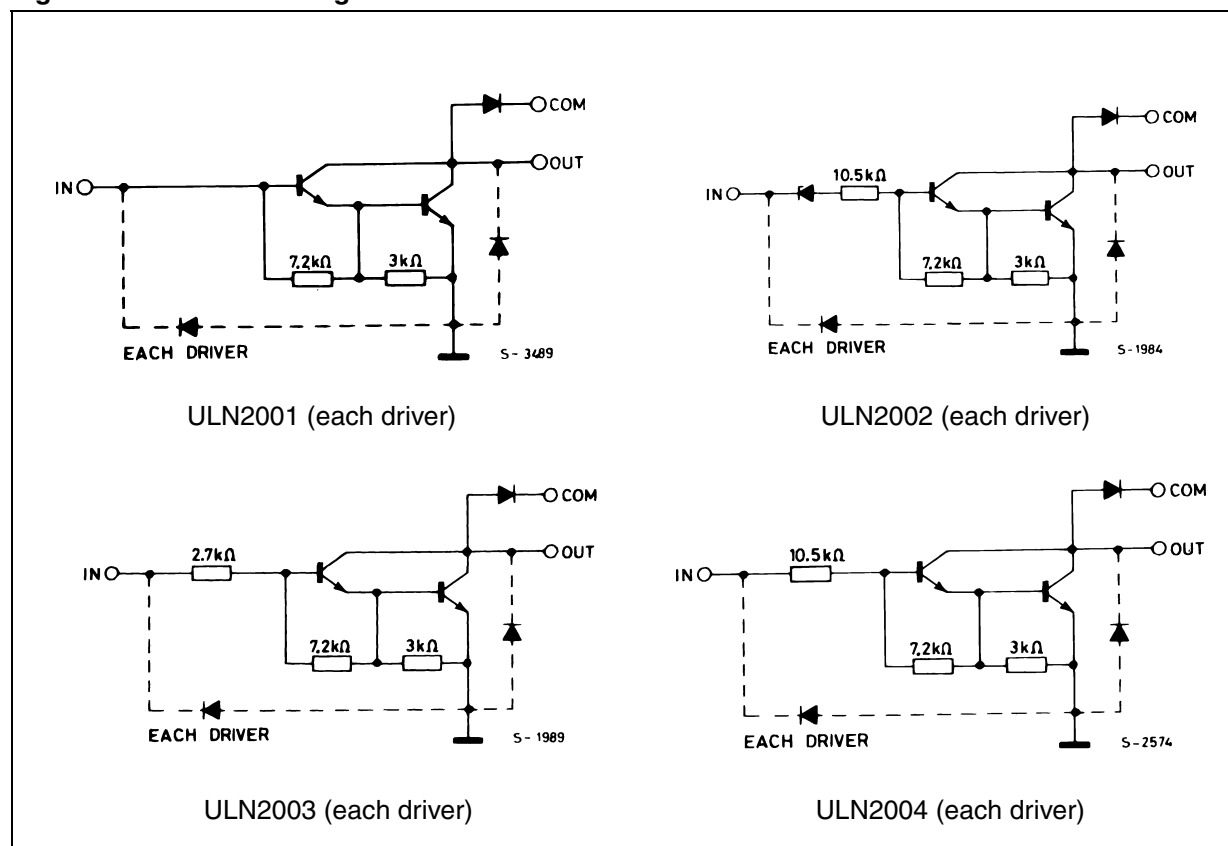
| Order code |                |
|------------|----------------|
| ULN2001A   | ULN2001D1013TR |
| ULN2002A   | ULN2002D1013TR |
| ULN2003A   | ULN2003D1013TR |
| ULN2004A   | ULN2004D1013TR |

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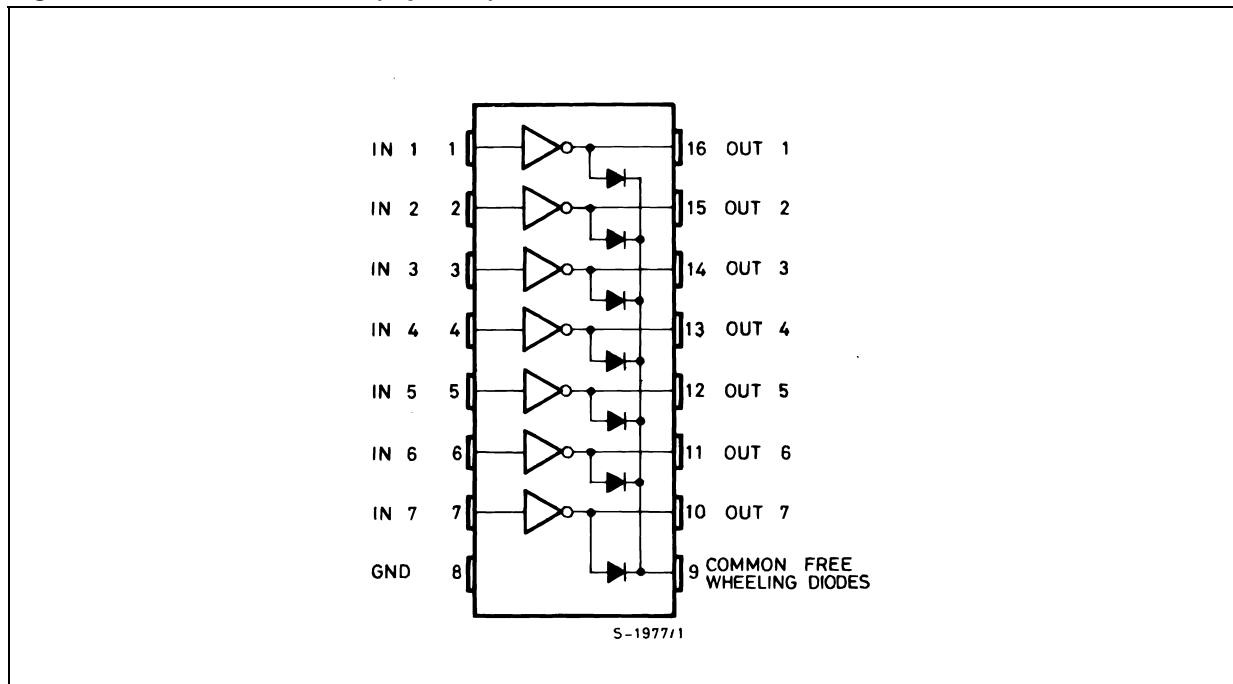
# 1 Diagram

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                | - 20 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

**Table 4. Electrical characteristics**  
( $T_A = 25^\circ\text{C}$  unless otherwise specified).

| Symbol        | Parameter                                        | Test condition                                                                                                                                                                                                                                                            | Min. | Typ. | Max.                                      | Unit          |
|---------------|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------------------------------------------|---------------|
| $I_{CEX}$     | Output leakage current                           | $V_{CE} = 50\text{ V}$ , (Figure 3.)                                                                                                                                                                                                                                      |      |      | 50                                        | $\mu\text{A}$ |
|               |                                                  | $T_A = 70^\circ\text{C}$ , $V_{CE} = 50\text{ V}$ (Figure 3.)                                                                                                                                                                                                             |      |      | 100                                       |               |
|               |                                                  | $T_A = 70^\circ\text{C}$ for ULN2002, $V_{CE} = 50\text{ V}$ , $V_I = 6\text{ V}$ (Figure 4.)                                                                                                                                                                             |      |      | 500                                       |               |
|               |                                                  | $T_A = 70^\circ\text{C}$ for ULN2002, $V_{CE} = 50\text{ V}$ , $V_I = 1\text{ V}$ (Figure 4.)                                                                                                                                                                             |      |      | 500                                       |               |
| $V_{CE(SAT)}$ | Collector-emitter saturation voltage (Figure 5.) | $I_C = 100\text{ mA}$ , $I_B = 250\text{ }\mu\text{A}$                                                                                                                                                                                                                    |      | 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 (Figure 6.)                        | 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 (Figure 7.)                        | $T_A = 70^\circ\text{C}$ , $I_C = 500\text{ }\mu\text{A}$                                                                                                                                                                                                                 | 50   | 65   |                                           | $\mu\text{A}$ |
| $V_{I(ON)}$   | Input voltage (Figure 8.)                        | $V_{CE} = 2\text{ V}$ , 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 (Figure 5.)              | 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                               | $0.5\text{ V}_I$ 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 (Figure 9.)          | $V_R = 50\text{ V}$                                                                                                                                                                                                                                                       |      |      | 50                                        | $\mu\text{A}$ |
|               |                                                  | $T_A = 70^\circ\text{C}$ , $V_R = 50\text{ V}$                                                                                                                                                                                                                            |      |      | 100                                       |               |
| $V_F$         | Clamp diode forward voltage (Figure 10.)         | $I_F = 350\text{ mA}$                                                                                                                                                                                                                                                     |      | 1.7  | 2                                         | V             |

## 5 Test circuits

Figure 3. Output leakage current

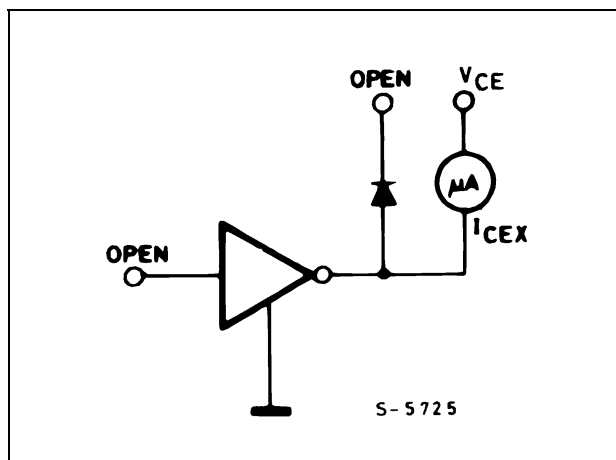


Figure 4. Output leakage current (for ULN2002 only)

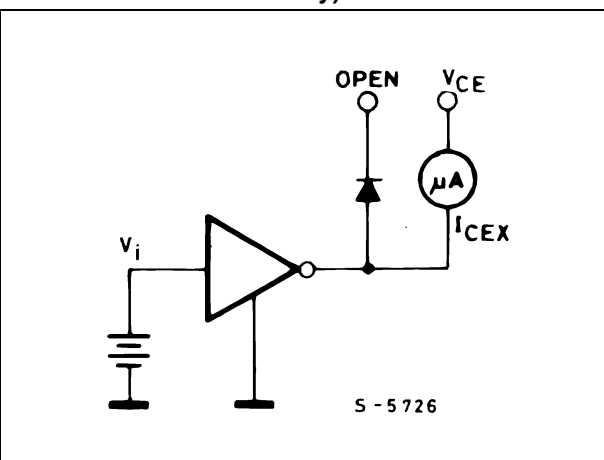


Figure 5. Collector-emitter saturation voltage

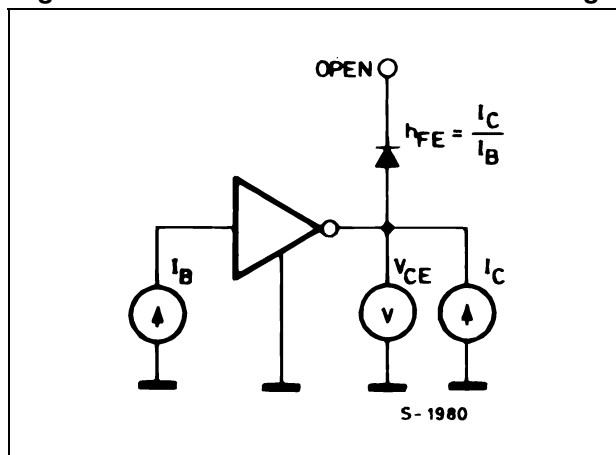


Figure 6. Input current (ON)

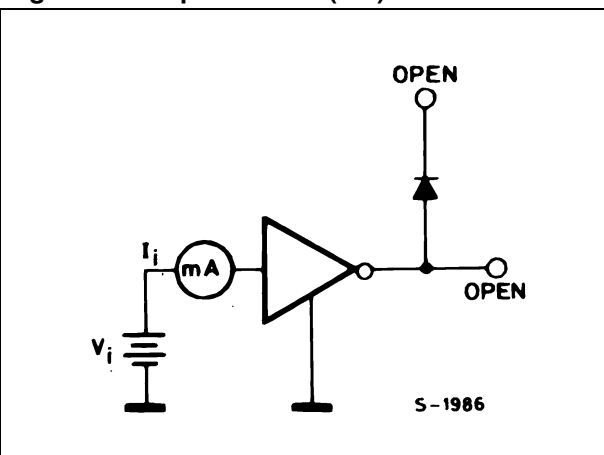


Figure 7. Input current (OFF)

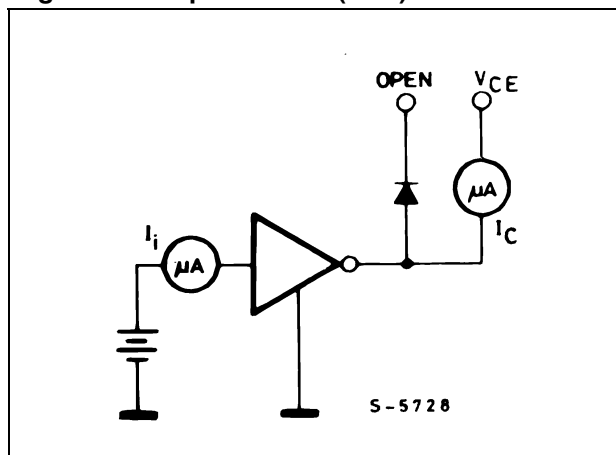


Figure 8. Input voltage

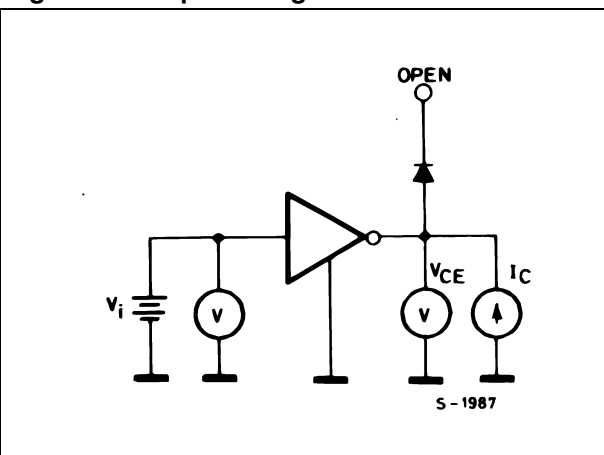


Figure 9. Clamp diode leakage current

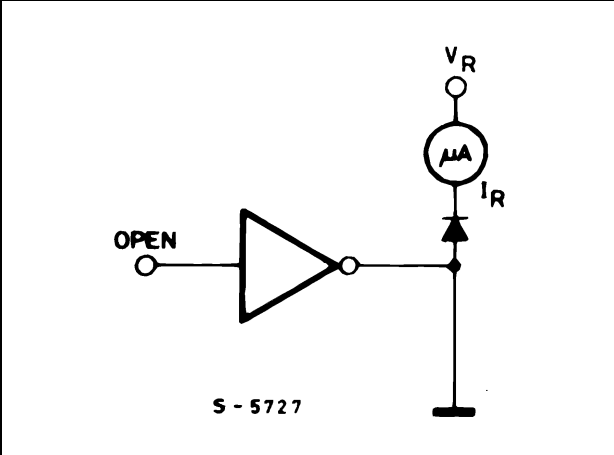


Figure 10. Clamp diode forward voltage

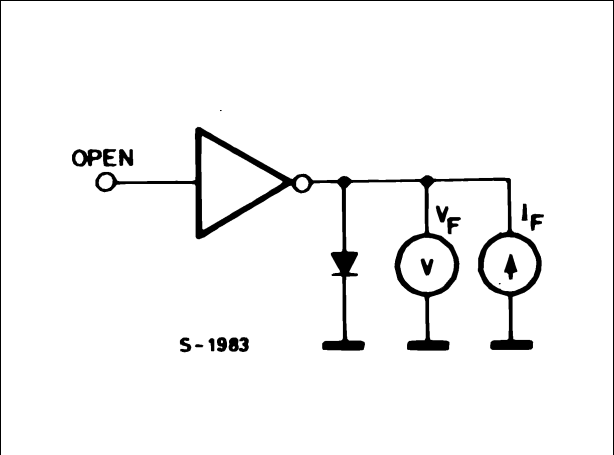


Figure 11. Collector current vs input current

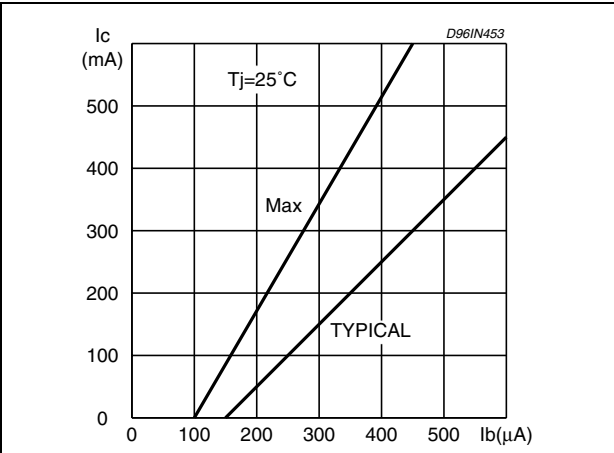


Figure 12. Collector current vs saturation voltage

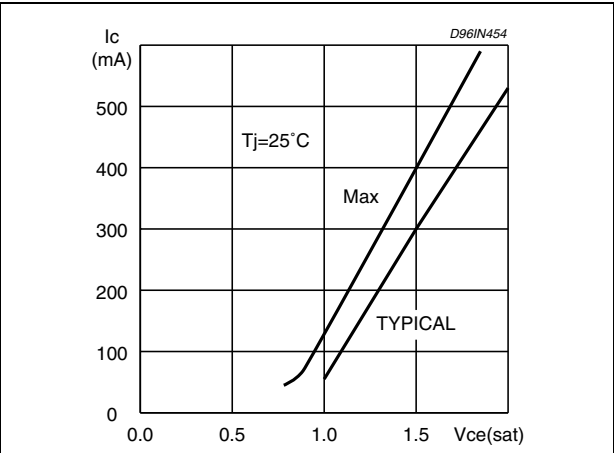


Figure 13. Peak collector current vs duty cycle

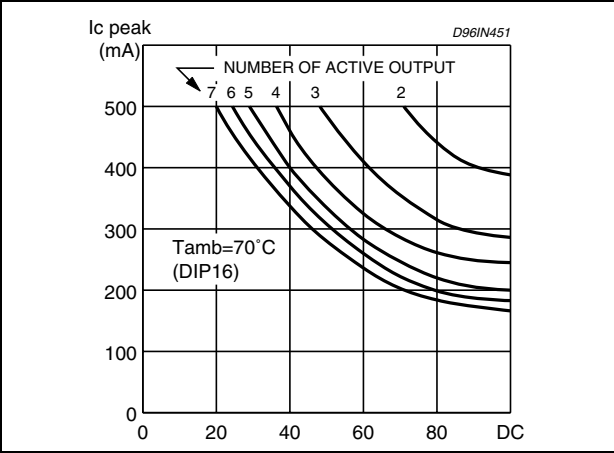
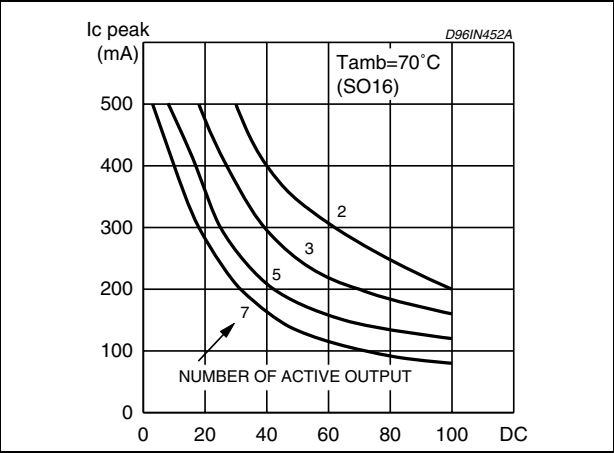


Figure 14. Peak collector current vs duty cycle

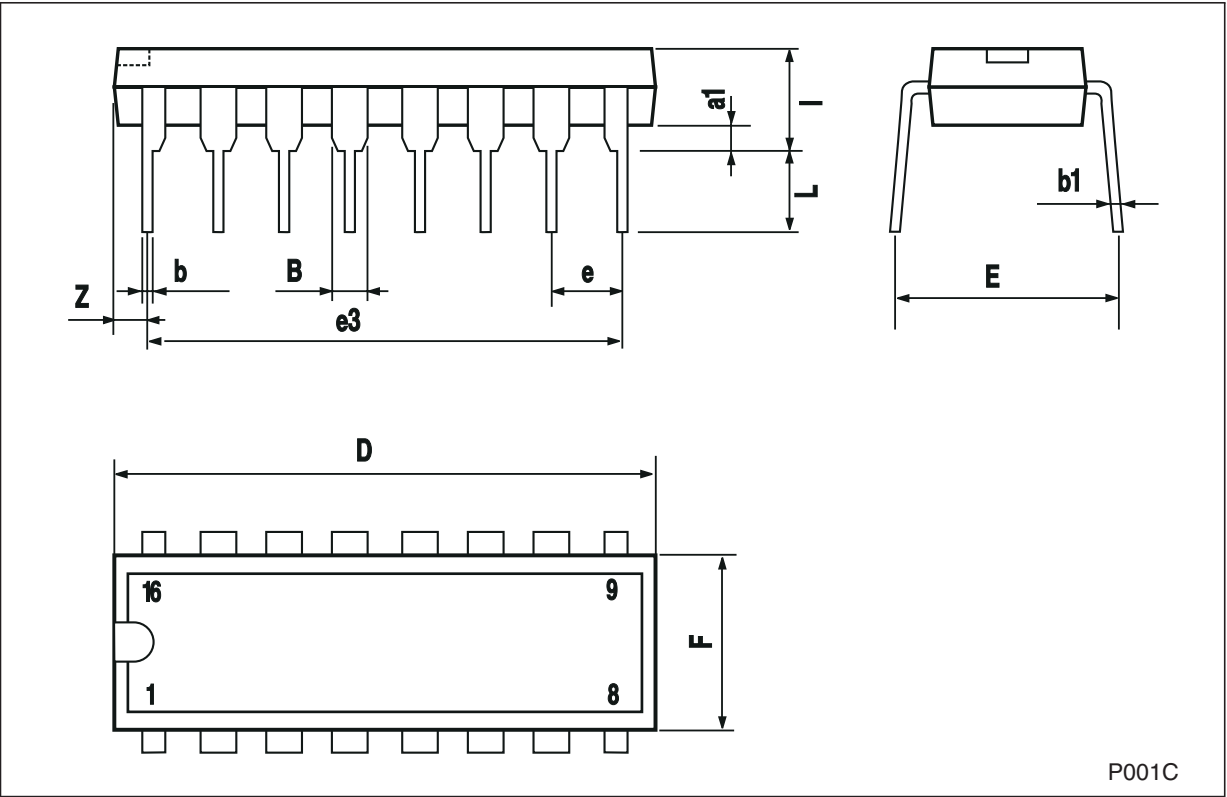


## 6 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK<sup>®</sup> packages. These packages have a Lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

Plastic DIP-16 (0.25) mechanical data

| Dim. | mm.  |       |      | inch. |       |       |
|------|------|-------|------|-------|-------|-------|
|      | Min. | Typ.  | Max. | Min.  | Typ.  | Max.  |
| a1   | 0.51 |       |      | 0.020 |       |       |
| B    | 0.77 |       | 1.65 | 0.030 |       | 0.065 |
| b    |      | 0.5   |      |       | 0.020 |       |
| b1   |      | 0.25  |      |       | 0.010 |       |
| D    |      |       | 20   |       |       | 0.787 |
| E    |      | 8.5   |      |       | 0.335 |       |
| e    |      | 2.54  |      |       | 0.100 |       |
| e3   |      | 17.78 |      |       | 0.700 |       |
| F    |      |       | 7.1  |       |       | 0.280 |
| I    |      |       | 5.1  |       |       | 0.201 |
| L    |      | 3.3   |      |       | 0.130 |       |
| Z    |      |       | 1.27 |       |       | 0.050 |

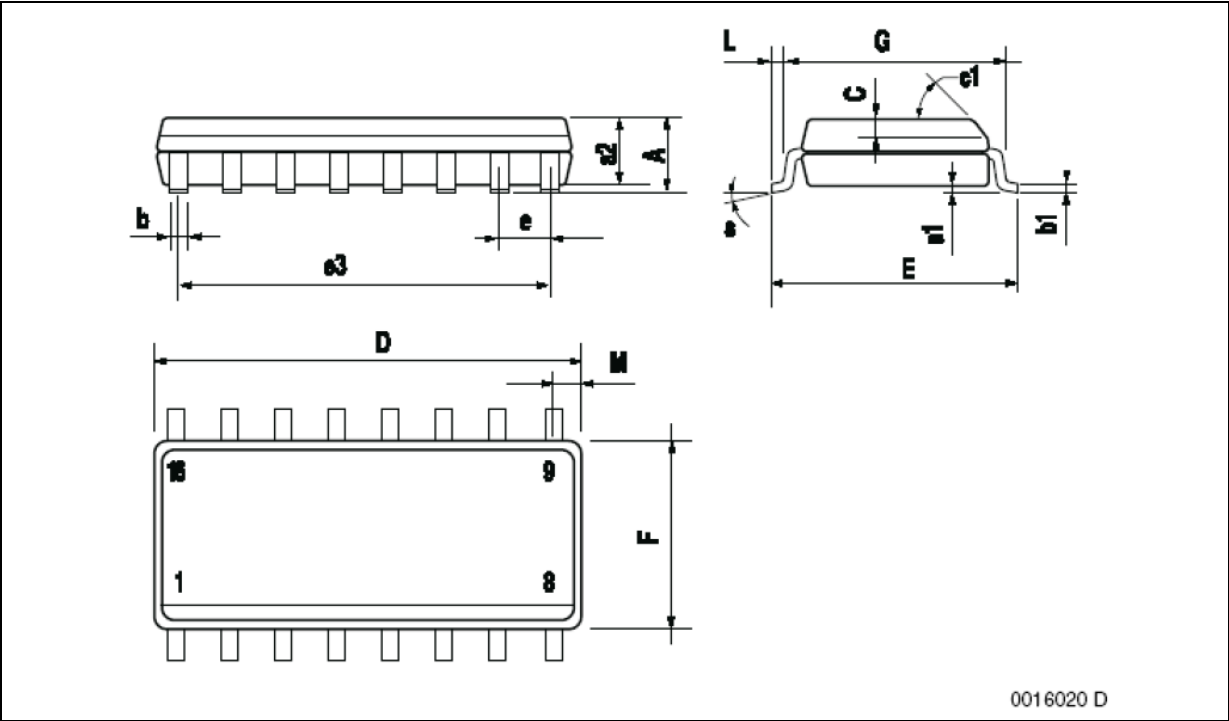


P001C

Table 5. 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 15. Package dimensions



## 7 Order code

**Table 6. Order code**

| Part numbers   | Package              |
|----------------|----------------------|
| ULN2001A       | DIP-16               |
| ULN2002A       | DIP-16               |
| ULN2003A       | DIP-16               |
| ULN2004A       | DIP-16               |
| ULN2001D1013TR | SO-16 in Tape & Reel |
| ULN2002D1013TR | SO-16 in Tape & Reel |
| ULN2003D1013TR | SO-16 in Tape & Reel |
| ULN2004D1013TR | SO-16 in Tape & Reel |

## 8 Revision history

Table 7. 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. |

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