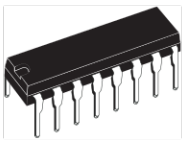
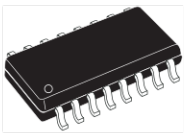
# ULN2001, ULN2002 ULN2003, ULN2004

Seven Darlington arrays

**Datasheet - production data**



**DIP-16L**



**SO-16 (Narrow)**

## 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
- Input pins placed opposite to output pins to simplify layout

## Description

The ULN2001, ULN2002, ULN2003 and ULN 2004 are high-voltage, high-current Darlington arrays each containing seven open collector Darlington pairs with common emitters. Each channel is 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, relay DC motors, LED display filament lamps, thermal printheads and high-power buffers.

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



This is information on a product in full production. www.st.com

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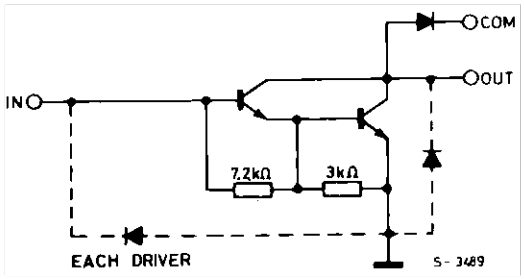
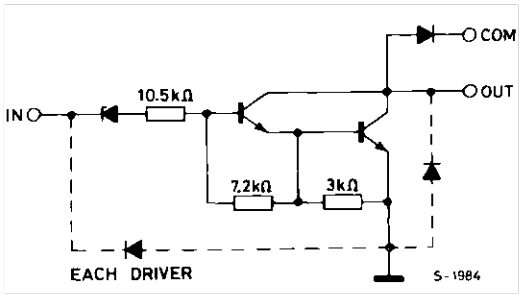
# 1 Diagram

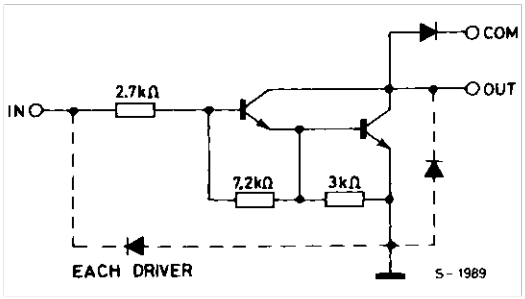
**Figure 1. Schematic diagram**



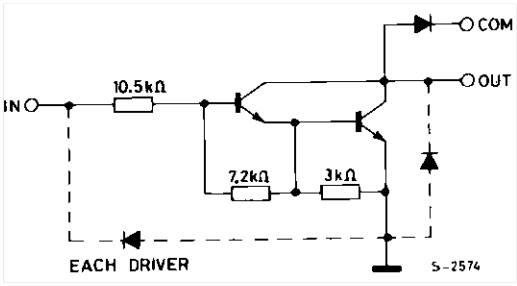

ULN2001 (each driver)




ULN2002 (each driver)



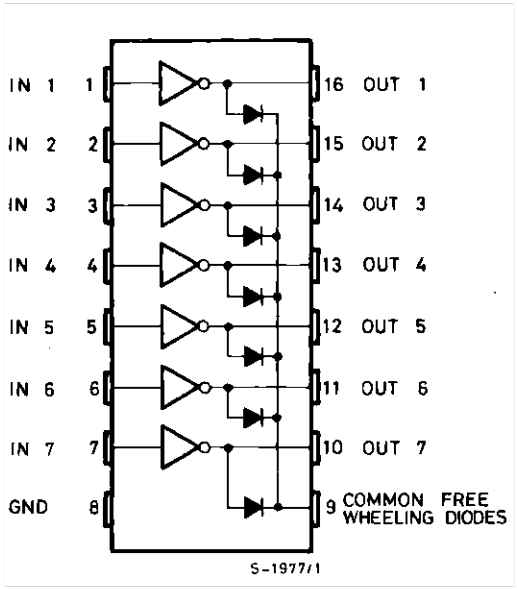

ULN2003 (each driver)




ULN2004 (each driver)

# 2 Pin configuration

**Figure 2. Pin connections (top view)**



# 3 Maximum ratings

**Table 1. 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 |
| $I_F$ | Clamping diode continuous current | 350 | mA |
| $V_R$ | Clamping diode reverse voltage | 50 | V |
| $T_A$ | Operating ambient temperature range | - 40 to 85 | °C |
| $T_{STG}$ | Storage temperature range | - 55 to 150 | °C |
| $T_J$ | Junction temperature | 150 | °C |
| ESD | Electrostatic discharge rating - HBM | 2 | kV |

**Table 2. Thermal data**

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

*Note: Maximum power dissipation is a function of $T_{J(max)}$, $R_{thJA}$ and $T_A$. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} – T_A) / R_{thJA}$. Operating at the absolute maximum $T_J$ of +150°C can affect reliability.*

# 4 Electrical characteristics

$T_A$ = 25 °C unless otherwise specified.

**Table 3. Electrical characteristics**

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{CEX}$ | Output leakage current | $V_{CE}$ = 50 V, (*Figure 3*) | | | 50 | µA |
| | | $T_A$ = 85 °C, $V_{CE}$ = 50 V (*Figure 3*) | | | 100 | |
| | | $T_A$ = 85 °C for ULN2002, $V_{CE}$ = 50 V, $V_I$ = 6 V (*Figure 4*) | | | 500 | |
| | | $T_A$ = 85 °C for ULN2002, $V_{CE}$ = 50 V, $V_I$ = 1V (*Figure 4*) | | | 500 | |
| $V_{CE(SAT)}$ | Collector-emitter saturation voltage (*Figure 5*) | $I_C$ = 100 mA, $I_B$ = 250 µA | | 0.9 | 1.1 | V |
| | | $I_C$ = 200 mA, $I_B$= 350 µA | | 1.1 | 1.3 | |
| | | $I_C$ = 350 mA, $I_B$= 500 µA | | 1.3 | 1.6 | |
| $I_{I(ON)}$ | Input current (*Figure 6*) | for ULN2002, $V_I$ = 17 V | | 0.82 | 1.25 | mA |
| | | for ULN2003, $V_I$ = 3.85 V | | 0.93 | 1.35 | |
| | | for ULN2004, $V_I$ = 5 V | | 0.35 | 0.5 | |
| | | $V_I$ = 12 V | | 1 | 1.45 | |
| $I_{I(OFF)}$ | Input current (*Figure 7*) | $T_A$ = 85 °C, $I_C$ = 500 µA | 50 | 65 | | µA |
| $V_{I(ON)}$ | Input voltage (*Figure 8*) | $V_{CE}$= 2 V, for ULN2002<br>$I_C$ = 300 mA<br>for ULN2003<br>$I_C$ = 200 mA<br>$I_C$ = 250 mA<br>$I_C$ = 300 mA<br>for ULN2004<br>$I_C$ = 125 mA<br>$I_C$ = 200 mA<br>$I_C$ = 275 mA<br>$I_C$ = 350 mA | | | 13<br><br>2.4<br>2.7<br>3<br><br>5<br>6<br>7<br>8 | V |
| $h_{FE}$ | DC Forward current gain (*Figure 5*) | for ULN2001, $V_{CE}$ = 2 V, $I_C$ = 350 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 | µs |
| $t_{PHL}$ | Turn-off delay time | 0.5 $V_I$ to 0.5 $V_O$ | | 0.25 | 1 | µs |
| $I_R$ | Clamp diode leakage current (*Figure 9*) | $V_R$ = 50 V | | | 50 | µA |
| | | $T_A$ = 85 °C, $V_R$ = 50 V | | | 100 | |
| $V_F$ | Clamp diode forward voltage (*Figure 10*) | $I_F$ = 350 mA | | 1.7 | 2 | V |

# 5 Test circuits

Figure 3. Output leakage current

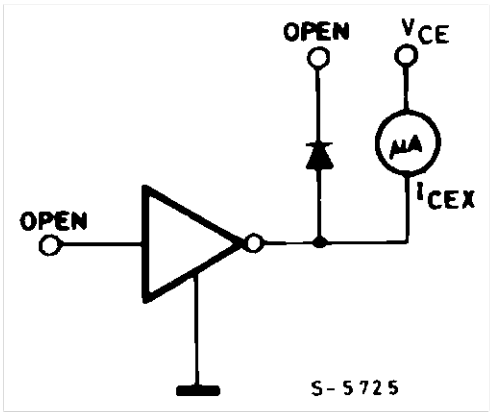



Figure 4. Output leakage current (for ULN2002 only)

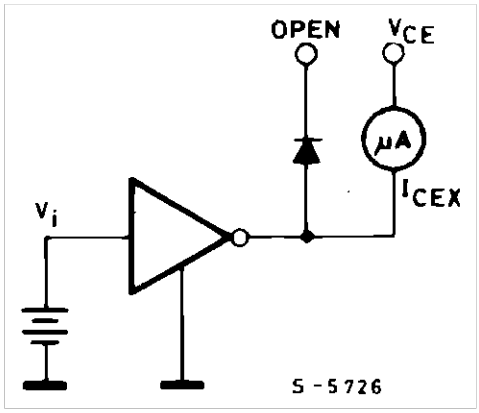



Figure 5. Collector-emitter saturation voltage

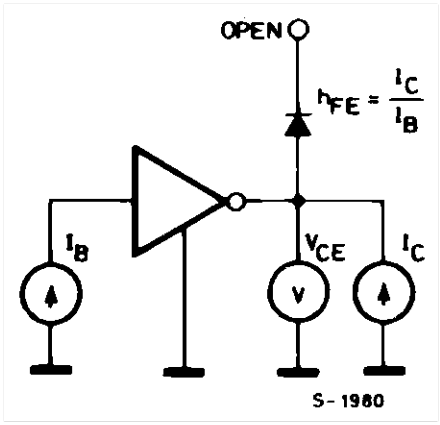



Figure 6. Input current (ON)

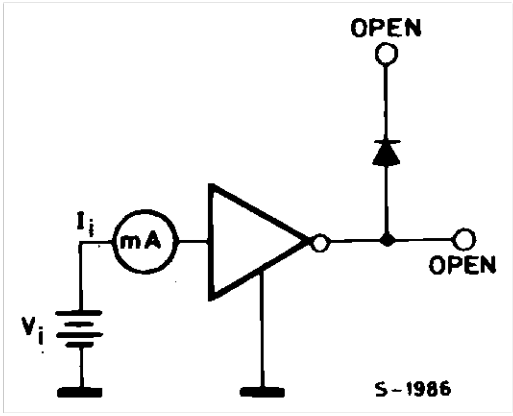



Figure 7. Input current (OFF)

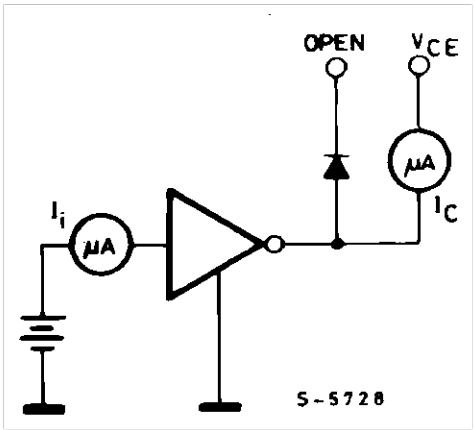



Figure 8. Input voltage

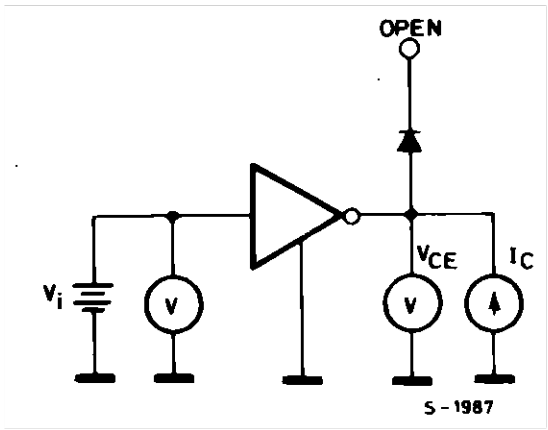


Figure 9. Clamp diode leakage current

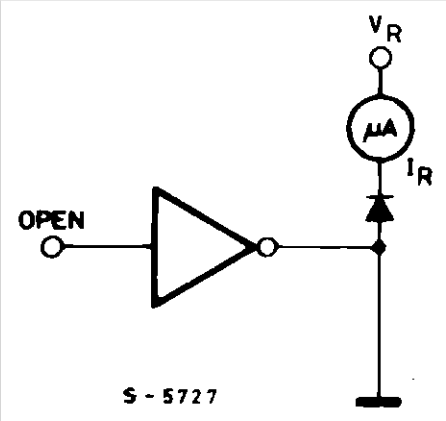
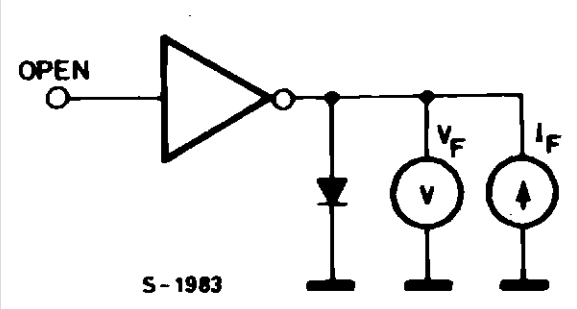



Figure 10. Clamp diode forward voltage



# 6 Typical performance characteristics

**Figure 11. Collector current vs. saturation voltage ($T_J$ = 25 °C)**

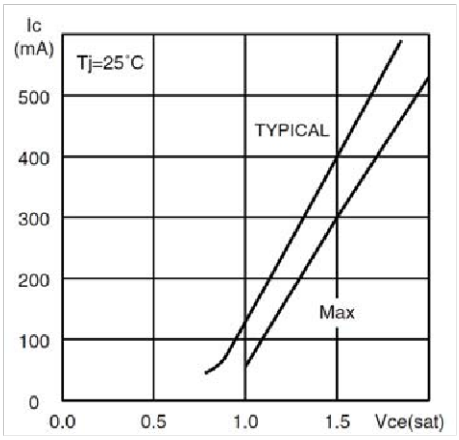



**Figure 12. Collector current vs. saturation voltage**

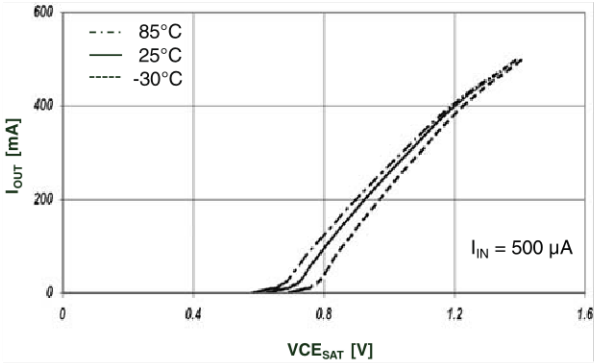



**Figure 13. Input current vs. input voltage**

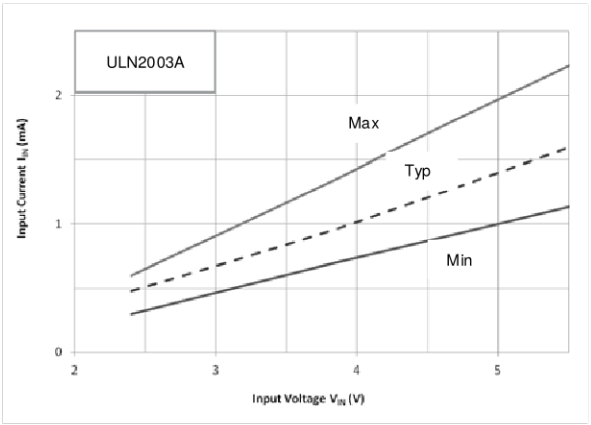



**Figure 14. Input current vs. input voltage (Ta = 25 °C)**

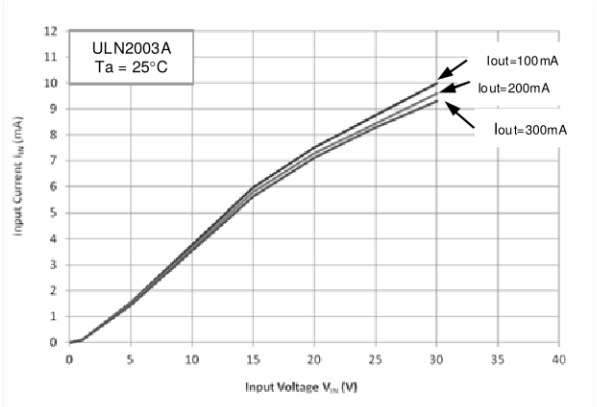



**Figure 15. Collector current vs. input current**

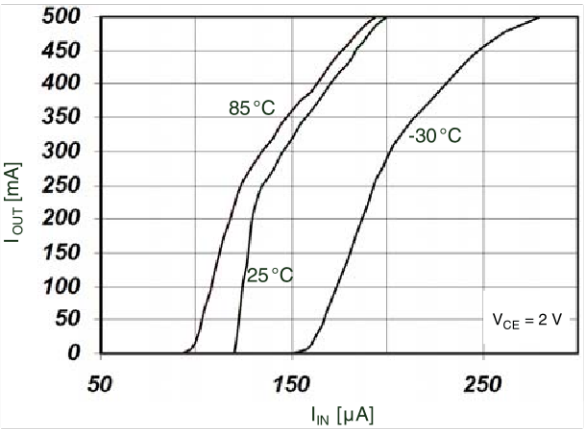



**Figure 16. $h_{FE}$ vs. output current**

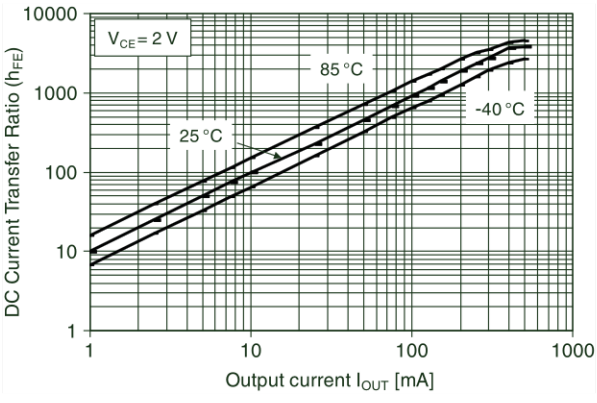


**Figure 17. Peak collector current vs. duty cycle (DIP-16)**

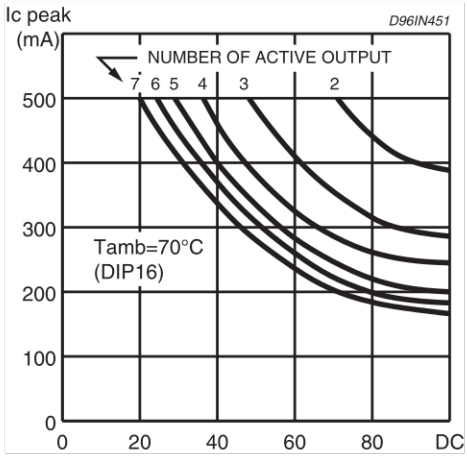
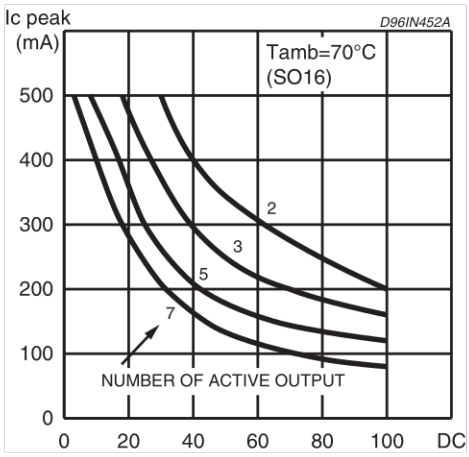



**Figure 18. Peak collector current vs. duty cycle (SO-16)**



# 7 Package information

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*. ECOPACK is an ST trademark.

## 7.1 DIP-16L package information

**Figure 19. DIP-16L package outline**

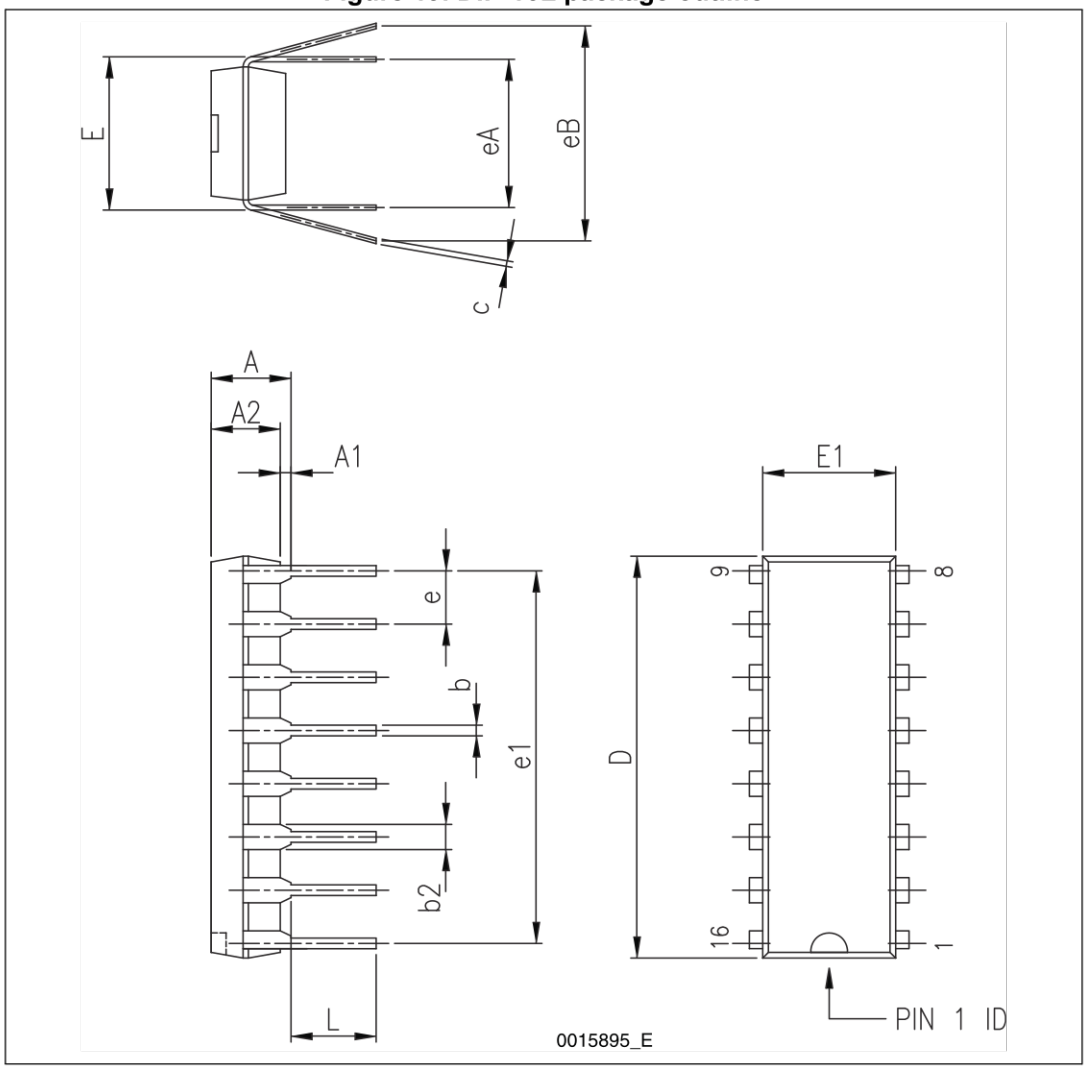


**Table 4. DIP-16L mechanical data**

| 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 |

## 7.2 SO-16 Narrow package information

Figure 20. SO-16 package outline

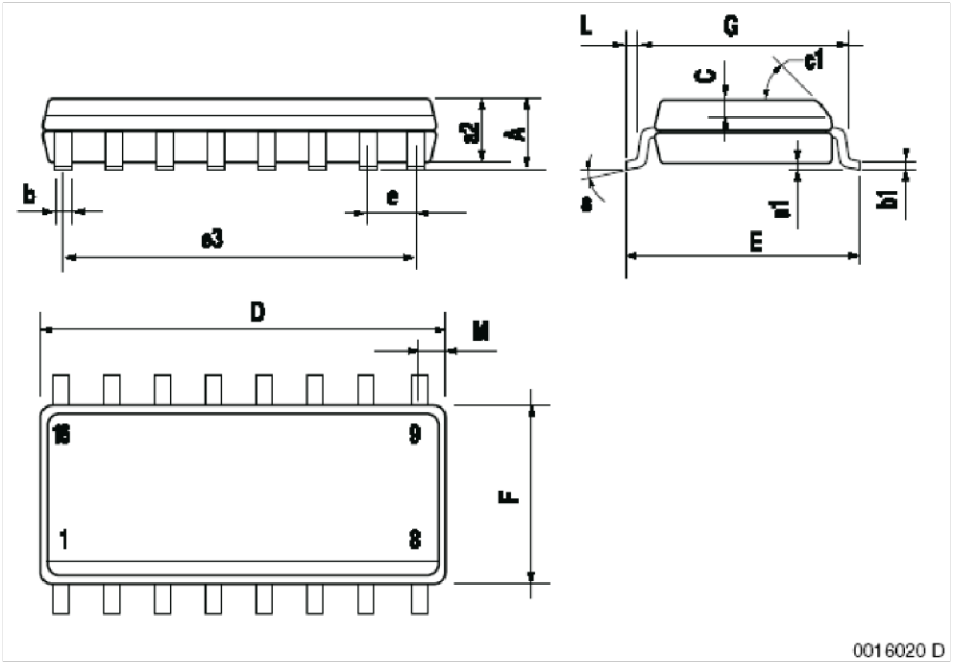


**Table 5. SO-16 Narrow mechanical data**

| 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.) | | | | | |

# 8 Order codes

**Table 6. Order codes**

| Part number | Package |
|---|---|
| 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 7. Revision history**

| Date | Revision | Changes |
|---|---|---|
| 05-Dec-2006 | 5 | Order code updated and document reformatted. |
| 28-Aug-2007 | 6 | Added Table 1 in cover page. |
| 07-May-2012 | 7 | Modified: Figure 12 on page 9.<br>Added: Figure 13, 14, 15 and Figure 16 on page 9. |
| 01-Jun-2012 | 8 | Updated: DIP-16L package mechanical data Table 4 on page 12 and Figure 19 on page 11. |
| 22-Jul-2015 | 9 | Added Plastic DIP16-L package.<br>Removed Device summary table.<br>Updated Table 7: Order code.<br>Added Section 7.2: Plastic DIP-16L package information.<br>Minor text changes. |
| 07-Nov-2017 | 10 | Removed plastic DIP-16L package and associated order code ULN2003A |
| 27-Jun-2018 | 11 | Updated: $I_{I(ON)}$ test condition in Table 3: Electrical characteristics. |
| 09-Jul-2019 | 12 | Added $I_F$, $V_R$, ESD parameters in *Table 1: Absolute maximum ratings* and note in *Table 2: Thermal data*. |

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