



# ULN2001A-ULN2002A ULN2003A-ULN2004A

## SEVEN DARLINGTON ARRAYS

- SEVEN DARLINGTONS PER PACKAGE
- OUTPUT CURRENT 500mA PER DRIVER (600mA PEAK)
- OUTPUT VOLTAGE 50V
- 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

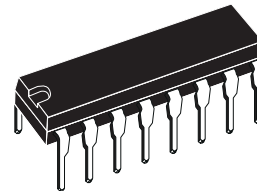
The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current darlington arrays each containing seven open collector darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

The four versions interface to all common logic families :

|          |                                       |
|----------|---------------------------------------|
| ULN2001A | General Purpose, DTL, TTL, PMOS, CMOS |
| ULN2002A | 14-25V PMOS                           |
| ULN2003A | 5V TTL, CMOS                          |
| ULN2004A | 6-15V CMOS, PMOS                      |

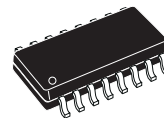
These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors, LED displays filament lamps, thermal print-heads and high power buffers.

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 ULN2001D/2002D/2003D/2004D.



DIP16

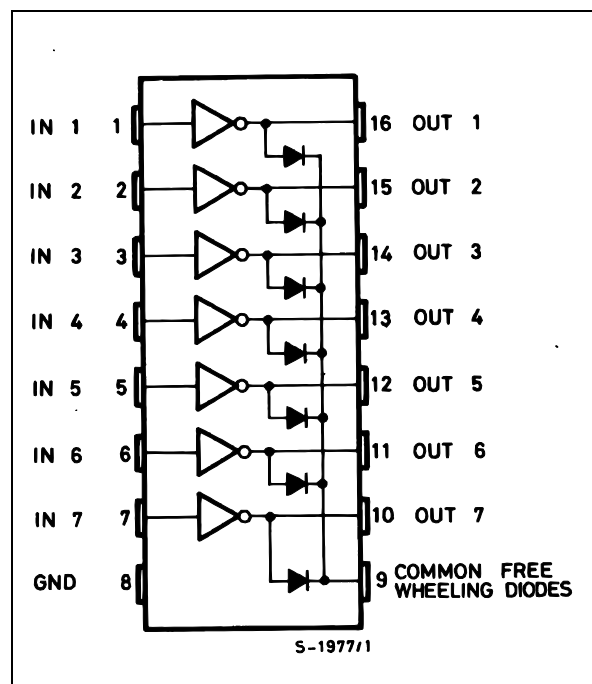
ORDERING NUMBERS: ULN2001A/2A/3A/4A



SO16

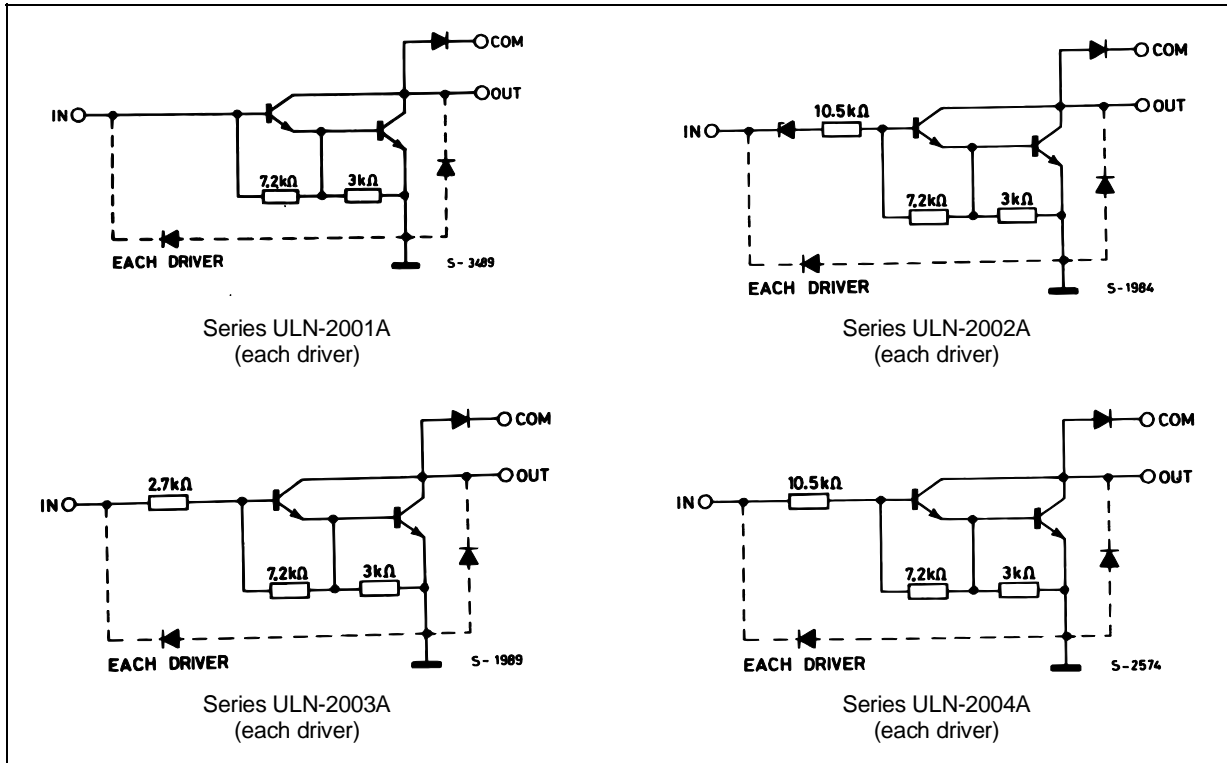
ORDERING NUMBERS: ULN2001D/2D/3D/4D

### PIN CONNECTION



# ULN2001A - ULN2002A - ULN2003A - ULN2004A

## SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

| Symbol    | Parameter  | Value       | Unit |
|-----------|--|-------------|------|
| $V_o$     | Output Voltage                                     | 50          | V    |
| $V_{in}$  | 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   |
| $T_{amb}$ | Operating Ambient Temperature Range                | - 20 to 85  | °C   |
| $T_{stg}$ | Storage Temperature Range                          | - 55 to 150 | °C   |
| $T_j$     | Junction Temperature                               | 150         | °C   |

## THERMAL DATA

| Symbol         | Parameter                           | DIP16   | SO16 | Unit |
|----------------|-------------------------------------|---------|------|------|
| $R_{th j-amb}$ | Thermal Resistance Junction-ambient | Max. 70 | 120  | °C/W |

**ULN2001A - ULN2002A - ULN2003A - ULN2004A**

**ELECTRICAL CHARACTERISTICS** ( $T_{amb} = 25^{\circ}\text{C}$  unless otherwise specified)

| Symbol        | Parameter                            | Test Conditions  | Min. | Typ. | Max.      | Unit                           | Fig.     |
|---------------|--------------------------------------|--|------|------|-----------|--------------------------------|----------|
| $I_{CEX}$     | Output Leakage Current               | $V_{CE} = 50\text{V}$<br>$T_{amb} = 70^{\circ}\text{C}, V_{CE} = 50\text{V}$             |      |      | 50<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ | 1a<br>1a |
|               |                                      | $T_{amb} = 70^{\circ}\text{C}$<br>for ULN2002A<br>$V_{CE} = 50\text{V}, V_i = 6\text{V}$ |      |      | 500       | $\mu\text{A}$                  | 1b       |
|               |                                      | for ULN2004A<br>$V_{CE} = 50\text{V}, V_i = 1\text{V}$                                   |      |      | 500       | $\mu\text{A}$                  | 1b       |
|               |                                      |  |      |      |           |                                |          |
| $V_{CE(sat)}$ | Collector-emitter Saturation Voltage | $I_C = 100\text{mA}, I_B = 250\mu\text{A}$   |      | 0.9  | 1.1       | V                              | 2        |
|               |                                      | $I_C = 200\text{mA}, I_B = 350\mu\text{A}$   |      | 1.1  | 1.3       | V                              | 2        |
|               |                                      | $I_C = 350\text{mA}, I_B = 500\mu\text{A}$   |      | 1.3  | 1.6       | V                              | 2        |
| $I_{i(on)}$   | Input Current                        | for ULN2002A, $V_i = 17\text{V}$   |      | 0.82 | 1.25      | mA                             | 3        |
|               |                                      | for ULN2003A, $V_i = 3.85\text{V}$   |      | 0.93 | 1.35      | mA                             | 3        |
|               |                                      | for ULN2004A, $V_i = 5\text{V}$  |      | 0.35 | 0.5       | mA                             | 3        |
|               |                                      | $V_i = 12\text{V}$   |      | 1    | 1.45      | mA                             | 3        |
| $I_{i(off)}$  | Input Current                        | $T_{amb} = 70^{\circ}\text{C}, I_C = 500\mu\text{A}$                                     | 50   | 65   |           | $\mu\text{A}$                  | 4        |
| $V_{i(on)}$   | Input Voltage                        | $V_{CE} = 2\text{V}$<br>for ULN2002A<br>$I_C = 300\text{mA}$                             |      |      | 13        | V                              | 5        |
|               |                                      | for ULN2003A<br>$I_C = 200\text{mA}$   |      |      | 2.4       |                                |          |
|               |                                      | $I_C = 250\text{mA}$   |      |      | 2.7       |                                |          |
|               |                                      | $I_C = 300\text{mA}$   |      |      | 3         |                                |          |
|               |                                      | for ULN2004A<br>$I_C = 125\text{mA}$   |      |      | 5         |                                |          |
|               |                                      | $I_C = 200\text{mA}$   |      |      | 6         |                                |          |
|               |                                      | $I_C = 275\text{mA}$   |      |      | 7         |                                |          |
|               |                                      | $I_C = 350\text{mA}$   |      |      | 8         |                                |          |
| $h_{FE}$      | DC Forward Current Gain              | for ULN2001A<br>$V_{CE} = 2\text{V}, I_C = 350\text{mA}$                                 | 1000 |      |           |                                | 2        |
| $C_i$         | 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          | $V_R = 50\text{V}$   |      |      | 50        | $\mu\text{A}$                  | 6        |
|               |                                      | $T_{amb} = 70^{\circ}\text{C}, V_R = 50\text{V}$   |      |      | 100       | $\mu\text{A}$                  | 6        |
| $V_F$         | Clamp Diode Forward Voltage          | $I_F = 350\text{mA}$   |      | 1.7  | 2         | V                              | 7        |

TEST CIRCUITS

Figure 1a.

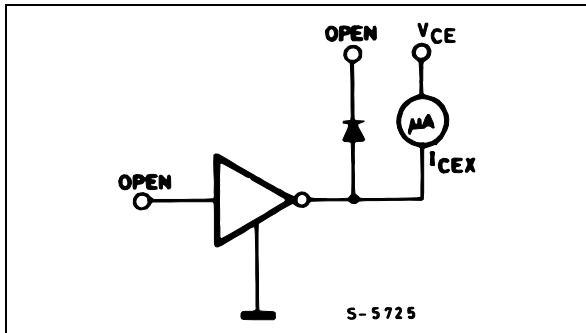


Figure 1b.

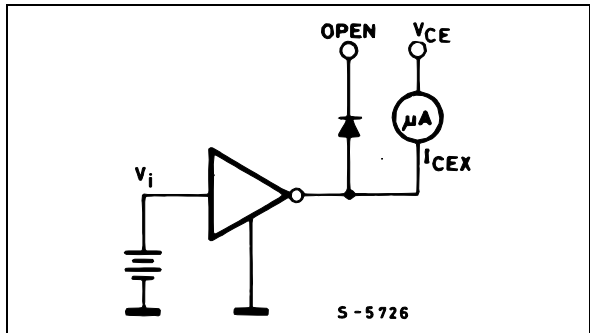


Figure 2.

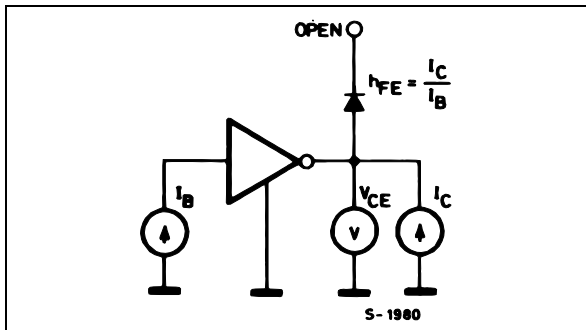


Figure 3.

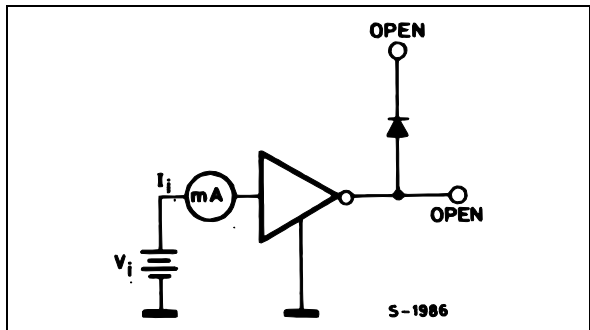


Figure 4.

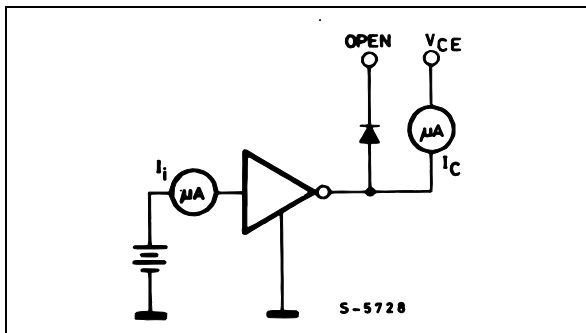


Figure 5.

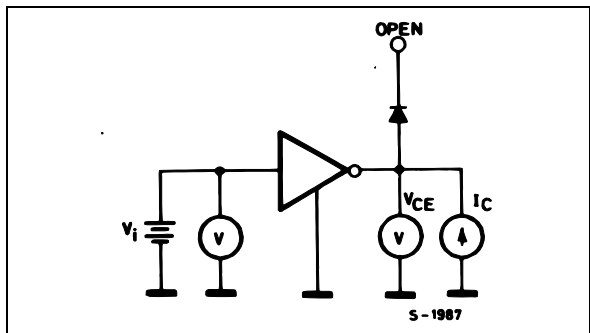


Figure 6.

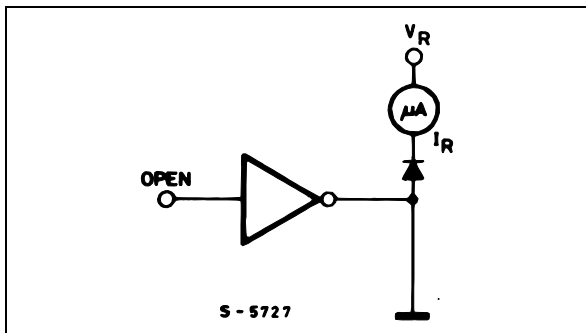
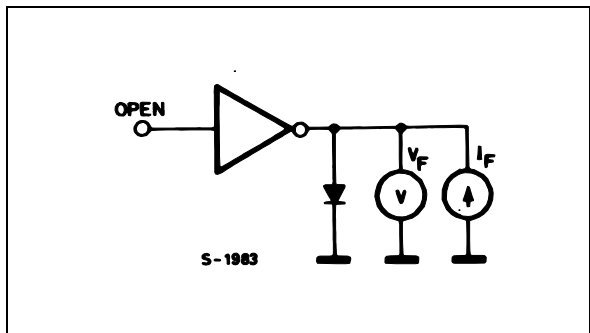
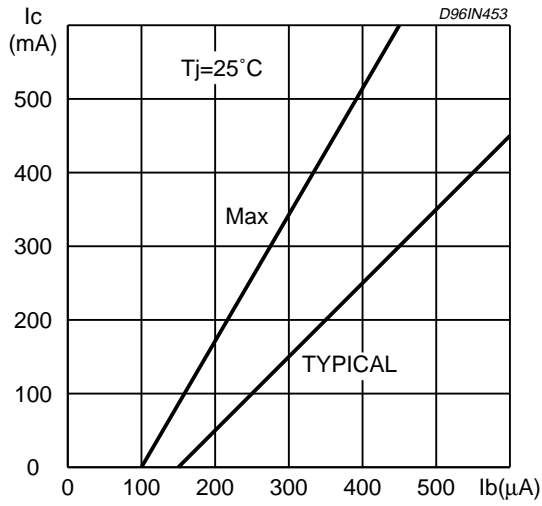


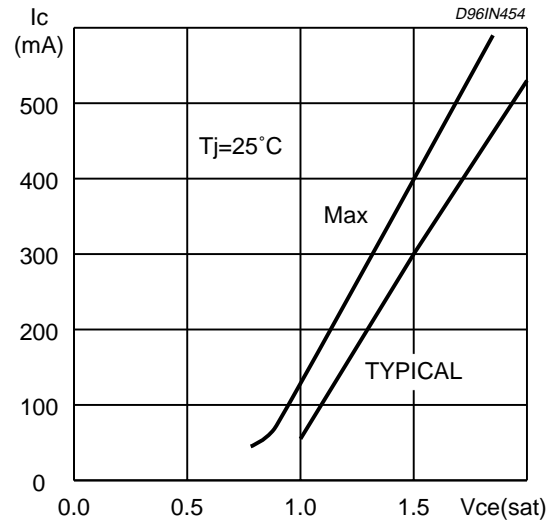
Figure 7.



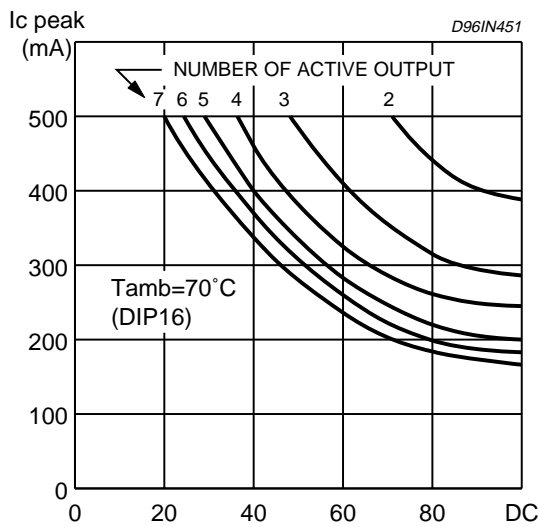
**Figure 8:** Collector Current versus Input Current



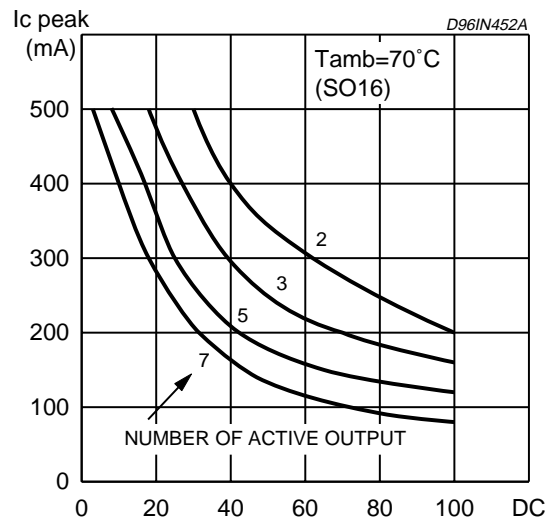
**Figure 9:** Collector Current versus Saturation Voltage



**Figure 10:** Peak Collector Current versus Duty Cycle



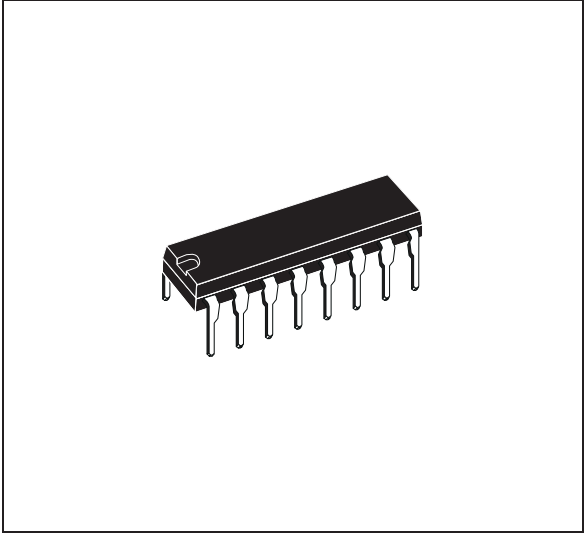
**Figure 11:** Peak Collector Current versus Duty Cycle



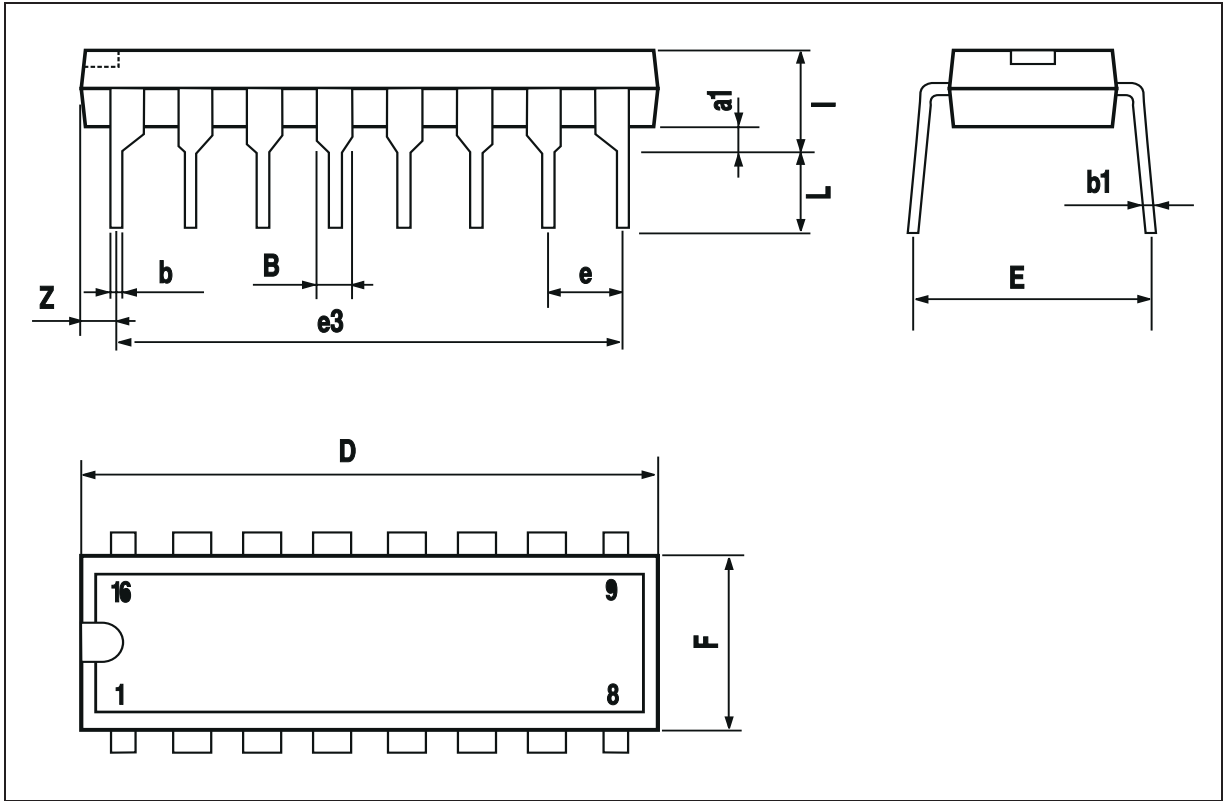
ULN2001A - ULN2002A - ULN2003A - ULN2004A

| 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 |

OUTLINE AND MECHANICAL DATA

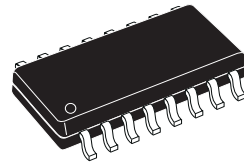


DIP16



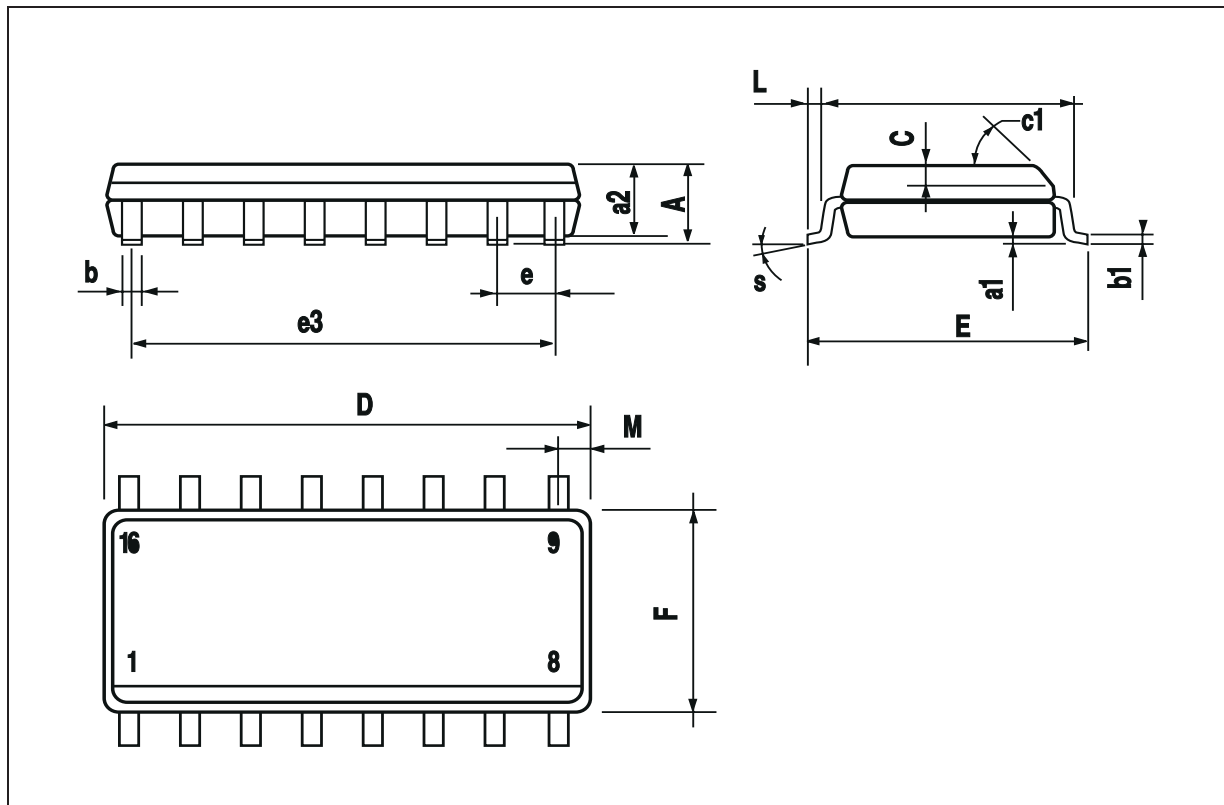
| DIM.  | mm         |      |      | inch  |       |       |
|-------|------------|------|------|-------|-------|-------|
|       | MIN.       | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A     |            |      | 1.75 |       |       | 0.069 |
| a1    | 0.1        |      | 0.25 | 0.004 |       | 0.009 |
| 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    | 0.150 |       | 0.157 |
| G     | 4.6        |      | 5.3  | 0.181 |       | 0.209 |
| L     | 0.4        |      | 1.27 | 0.016 |       | 0.050 |
| M     |            |      | 0.62 |       |       | 0.024 |
| S     | 8°(max.)   |      |      |       |       |       |

**OUTLINE AND MECHANICAL DATA**



**SO16 Narrow**

(1) D and F do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm (.006inch).



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