

## Seven Darlington array

### Features

- Seven Darlington per package
- Extended temperature range: -40 to 105 °C
- Output current 500 mA per driver (600 mA peak)
- Output voltage 50 V
- Automotive Grade product in SO16 package
- 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 ULQ2001, ULQ2003 and ULQ2004 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. 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 ULQ2001A/2003A and 2004A are supplied in 16 pin plastic DIP packages with a copper lead-frame to reduce thermal resistance. They are available also in small outline package (SO16) as ULQ2003D1/2004D1. The ULQ2003 is available as Automotive Grade in SO16 package. The commercial part numbers is shown in the order codes. This device is qualified according to the specification AEC-Q100 of the Automotive market, in the temperature range -40 °C to 125 °C and the statistical tests PAT, SYL, SBL are performed.

**Table 1. Device summary**

| Part numbers | Order codes                    | Description                           | Packages              |
|--------------|--------------------------------|---------------------------------------|-----------------------|
| ULQ2001      | ULQ2001A                       | General purpose, DTL, TTL, PMOS, CMOS | DIP-16                |
| ULQ2003      | ULQ2003A                       | 5 V TTL, CMOS                         | DIP-16                |
| ULQ2004      | ULQ2004A                       | 6–15 V CMOS, PMOS                     | DIP-16                |
| ULQ2003      | ULQ2003D1013TR                 |                                       | SO16 in tape and reel |
| ULQ2003      | ULQ2003D1013TRY <sup>(1)</sup> |                                       | SO16 in tape and reel |
| ULQ2004      | ULQ2004D1013TR                 |                                       | SO16 in tape and reel |

1. Automotive Grade products.

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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    |
| $V_{IN}$  | Input voltage (for ULQ2003A/D1 - 2004A/D1) | 30         | V    |
| $I_C$     | Continuous collector current               | 500        | mA   |
| $I_B$     | Continuous base current                    | 25         | mA   |
| $T_A$     | Operating ambient temperature range        | -40 to 105 | °C   |
| $T_{STG}$ | Storage temperature range                  | -55 to 150 | °C   |
| $T_J$     | Junction temperature                       | 150        | °C   |

**Table 3. Thermal data**

| Symbol     | Parameter                                 | DIP-16 | SO16 | Unit |
|------------|---|--------|------|------|
| $R_{thJA}$ | Thermal resistance junction-ambient, max. | 70     | 120  | °C/W |

## 4 Electrical characteristics

$T_J = -40$  to  $105$  °C for DIP16 unless otherwise specified,  
 $T_J = -25$  to  $105$  °C for SO16 unless otherwise specified.

**Table 4. Electrical characteristics**

| Symbol                        | Parameter                                       | Test conditions  | Min. | Typ. | Max.              | Unit    |
|-------------------------------|---|--|------|------|-------------------|---------|
| $I_{CEX}$                     | Output leakage current                          | $V_{CE} = 50V$ , (Figure 3)  |      |      | 50                | $\mu A$ |
|                               |   | $T_J = 105^\circ C$ , $V_{CE} = 50V$ (Figure 3)                            |      |      | 100               |         |
|                               |   | $T_J = 105^\circ C$ for ULQ2004, $V_{CE} = 50V$ ,<br>$V_I = 1V$ (Figure 4) |      |      | 500               |         |
| $V_{CE(SAT)}$                 | Collector-emitter saturation voltage (Figure 5) | $I_C = 100mA$ , $I_B = 250\mu A$   |      | 0.9  | 1.1               | V       |
|                               |   | $I_C = 200mA$ , $I_B = 350\mu A$   |      | 1.1  | 1.3               |         |
|                               |   | $I_C = 350mA$ , $I_B = 500\mu A$   |      | 1.3  | 1.6               |         |
| $I_{I(ON)}$                   | Input current (Figure 6)                        | for ULQ2003, $V_I = 3.85V$   |      | 0.93 | 1.35              | mA      |
|                               |   | for ULQ2004, $V_I = 5V$  |      | 0.35 | 0.5               |         |
|                               |   | for ULQ2004, $V_I = 12V$   |      | 1    | 1.45              |         |
| $I_{I(OFF)}$                  | Input current (Figure 7)                        | $T_J = 105^\circ C$ , $I_C = 500\mu A$                                     | 50   | 65   |                   | $\mu A$ |
| $V_{I(ON)}$                   | Input voltage (Figure 8)                        | for ULQ2003  |      |      | 2.4               | V       |
|                               |   | $V_{CE} = 2V$ , $I_C = 200mA$  |      |      | 2.7               |         |
|                               |   | $V_{CE} = 2V$ , $I_C = 250mA$  |      |      | 3                 |         |
|                               |   | $V_{CE} = 2V$ , $I_C = 300mA$  |      |      | 3                 |         |
|                               |   | for ULQ2004  |      |      | 5                 |         |
|                               |   | $V_{CE} = 2V$ , $I_C = 125mA$  |      |      | 6                 |         |
|                               |   | $V_{CE} = 2V$ , $I_C = 200mA$  |      |      | 7                 |         |
| $V_{CE} = 2V$ , $I_C = 275mA$ |   |  | 8    |      |                   |         |
| $V_{CE} = 2V$ , $I_C = 350mA$ |   |  | 8    |      |                   |         |
| $h_{FE}$                      | DC forward current gain (Figure 5)              | for ULQ2001, $V_{CE} = 2V$ ,<br>$I_C = 350mA$                              | 1000 |      |                   |         |
| $C_I$                         | Input capacitance                               |  |      | 15   | 25 <sup>(1)</sup> | pF      |
| $t_{PLH}$                     | Turn-on delay time                              | $0.5 V_I$ to $0.5 V_O$   |      | 0.25 | 1 <sup>(1)</sup>  | $\mu s$ |
| $t_{PHL}$                     | Turn-off delay time                             | $0.5 V_I$ to $0.5 V_O$   |      | 0.25 | 1 <sup>(1)</sup>  | $\mu s$ |
| $I_R$                         | Clamp diode leakage current (Figure 9)          | $V_R = 50V$  |      |      | 50                | $\mu A$ |
|                               |   | $T_J = 105^\circ C$ , $V_R = 50V$  |      |      | 100               |         |
| $V_F$                         | Clamp diode forward voltage (Figure 10)         | $I_F = 350mA$  |      | 1.7  | 2                 | V       |

1. Guaranteed by design.

T<sub>J</sub> = -40 to 125 °C for SO16 unless otherwise specified.

**Table 5. Electrical characteristics for ULQ2003D1013TRY (Automotive Grade)**

| Symbol               | Parameter  | Test conditions  | Min. | Typ. | Max.            | Unit |
|----------------------|--|--|------|------|-----------------|------|
| I <sub>CEX</sub>     | Output leakage current<br>( <a href="#">Figure 3</a> )               | V <sub>CE</sub> = 50V  |      |      | 50              | μA   |
| V <sub>CE(SAT)</sub> | Collector-emitter saturation voltage<br>( <a href="#">Figure 5</a> ) | I <sub>C</sub> = 100mA, I <sub>B</sub> = 250μA   |      | 0.9  | 1.1             | V    |
|                      |  | I <sub>C</sub> = 200mA, I <sub>B</sub> = 350μA   |      | 1.1  | 1.3             |      |
|                      |  | I <sub>C</sub> = 350mA, I <sub>B</sub> = 500μA   |      | 1.3  | 1.6             |      |
| I <sub>I(ON)</sub>   | Input current ( <a href="#">Figure 6</a> )                           | V <sub>I</sub> = 3.85V   |      | 0.93 | 1.35            | mA   |
| I <sub>I(OFF)</sub>  | Input current ( <a href="#">Figure 7</a> )                           | I <sub>C</sub> = 500μA   | 50   | 65   |                 | μA   |
| V <sub>I(ON)</sub>   | Input voltage ( <a href="#">Figure 8</a> )                           | V <sub>CE</sub> = 2V, I <sub>C</sub> = 200mA<br>V <sub>CE</sub> = 2V, I <sub>C</sub> = 250mA<br>V <sub>CE</sub> = 2V, I <sub>C</sub> = 300mA |      |      | 2.4<br>2.7<br>3 | V    |
| C <sub>I</sub>       | Input capacitance  |  |      | 15   | 25              | pF   |
| t <sub>PLH</sub>     | Turn-on delay time   | 0.5 V <sub>I</sub> to 0.5V <sub>O</sub>  |      | 0.25 | 1               | μs   |
| t <sub>PHL</sub>     | Turn-off delay time  | 0.5 V <sub>I</sub> to 0.5V <sub>O</sub>  |      | 0.25 | 1               | μs   |
| I <sub>R</sub>       | Clamp diode leakage current<br>( <a href="#">Figure 9</a> )          | V <sub>R</sub> = 50V   |      |      | 50              | μA   |
| V <sub>F</sub>       | Clamp diode forward voltage<br>( <a href="#">Figure 10</a> )         | I <sub>F</sub> = 350mA   |      | 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)

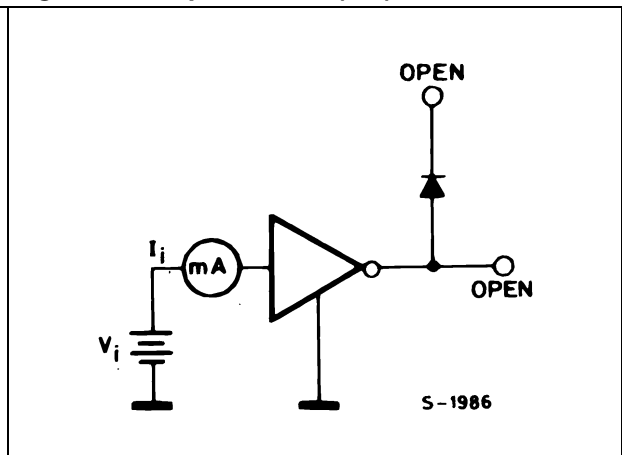
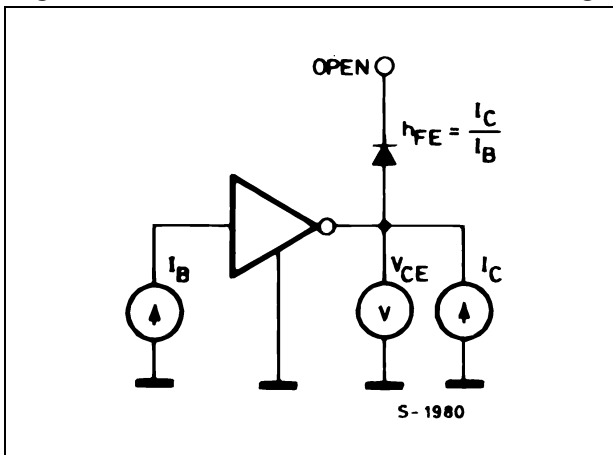


Figure 7. Input current (OFF)



Figure 8. Input voltage





Figure 9. Clamp diode leakage current

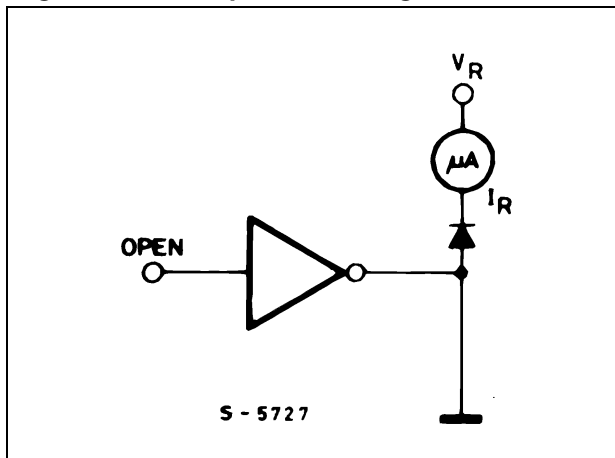
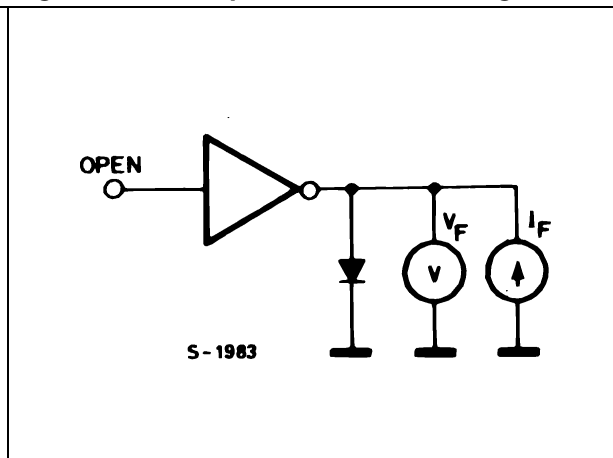


Figure 10. Clamp diode forward voltage



## 6 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.

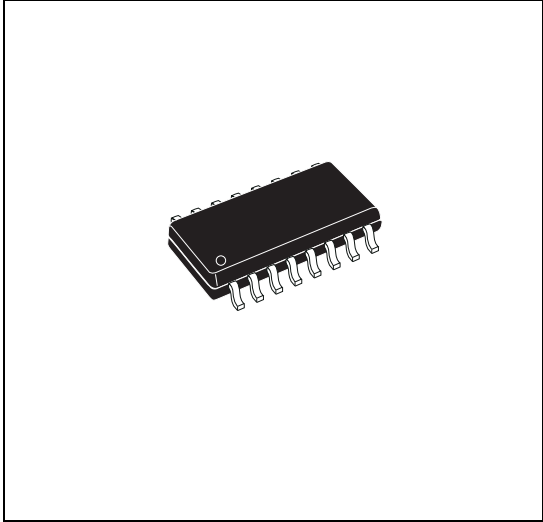
**Plastic DIP-16 (0.25) mechanical data**

| 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 |

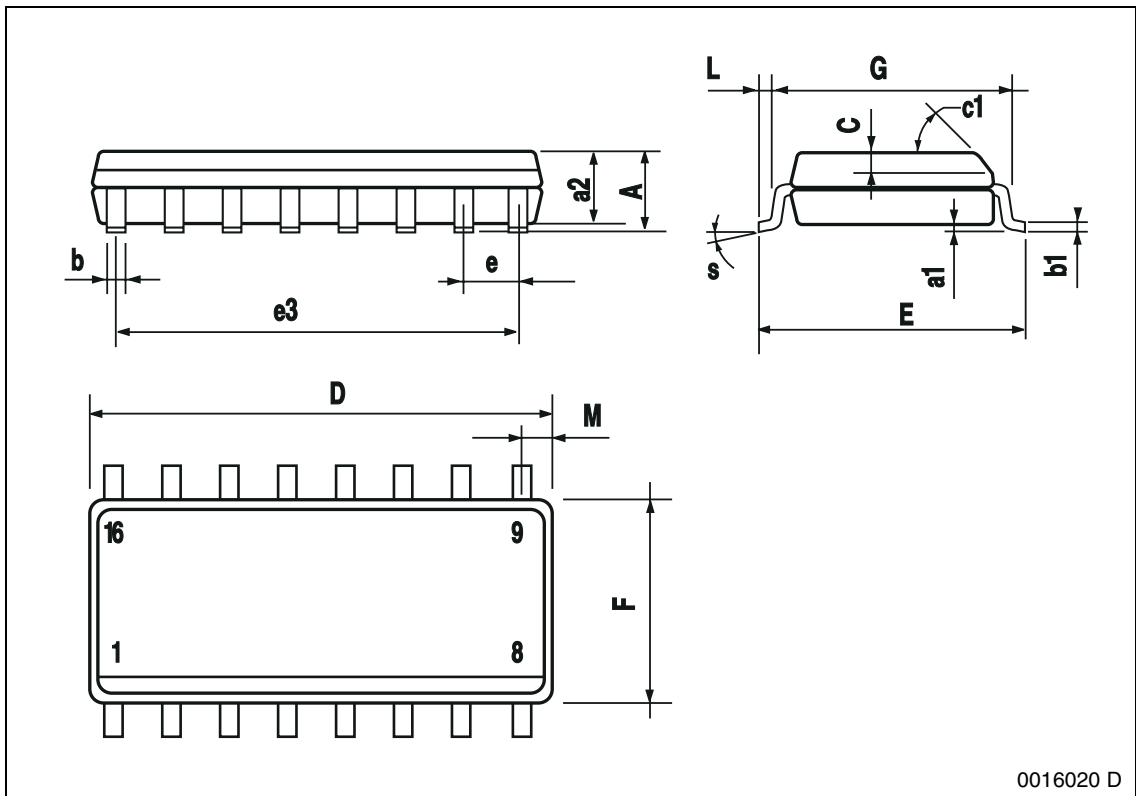


| DIM.  | mm         |      |      | inch   |       |       |
|---|------------|------|------|--------|-------|-------|
|   | MIN.       | TYP. | MAX. | MIN.   | TYP.  | MAX.  |
| A   |            |      | 1.75 |        |       | 0.069 |
| a1  | 0.1        |      | 0.25 | 0.004  |       | 0.009 |
| a2  |            |      | 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 <sup>(1)</sup>  | 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 <sup>(1)</sup>  | 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.) |      |      |        |       |       |
| (1) "D" and "F" do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.006inc.) |            |      |      |        |       |       |

**OUTLINE AND MECHANICAL DATA**



**SO16 (Narrow)**



## 7 Revision history

**Table 6. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 05-Dec-2006 | 2        | Order codes updated.  |
| 23-May-2007 | 3        | Order codes updated.  |
| 17-Apr-2008 | 4        | Added new order codes for Automotive grade products see <a href="#">Table 1 on page 1</a> . |
| 25-Aug-2008 | 5        | Modified: <a href="#">Table 4 on page 6</a> and <a href="#">Table 5 on page 7</a> .         |
| 11-Feb-2011 | 6        | Modified: $T_J = -25$ to $105$ °C <a href="#">Table 4 on page 6</a> .                       |

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