

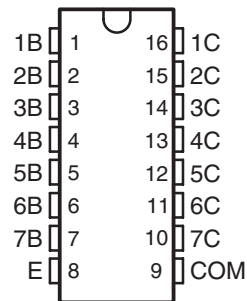
## HIGH-VOLTAGE, HIGH-CURRENT DARLINGTON TRANSISTOR ARRAYS

Check for Samples: [ULN2002A](#), [ULN2003A](#), [ULN2003AI](#), [ULN2004A](#), [ULQ2003A](#), [ULQ2004A](#)

### FEATURES

- **500-mA-Rated Collector Current (Single Output)**
- **High-Voltage Outputs: 50 V**
- **Output Clamp Diodes**
- **Inputs Compatible With Various Types of Logic**
- **Relay-Driver Applications**

ULN2002A . . . N PACKAGE  
ULN2003A . . . D, N, NS, OR PW PACKAGE  
ULN2004A . . . D, N, OR NS PACKAGE  
ULQ2003A, ULQ2004A . . . D OR N PACKAGE  
(TOP VIEW)



### DESCRIPTION

The ULN2002A, ULN2003A, ULN2003AI, ULN2004A, ULQ2003A, and ULQ2004A are high-voltage high-current Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. For 100-V (otherwise interchangeable) versions of the ULN2003A and ULN2004A, see the [SN75468](#) and [SN75469](#), respectively.

The ULN2001A is a general-purpose array and can be used with TTL and CMOS technologies. The ULN2002A is designed specifically for use with 14-V to 25-V PMOS devices. Each input of this device has a Zener diode and resistor in series to control the input current to a safe limit. The ULN2003A and ULQ2003A have a 2.7-k $\Omega$  series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices. The ULN2004A and ULQ2004A have a 10.5-k $\Omega$  series base resistor to allow operation directly from CMOS devices that use supply voltages of 6 V to 15 V. The required input current of the ULN/ULQ2004A is below that of the ULN/ULQ2003A, and the required voltage is less than that required by the ULN2002A.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

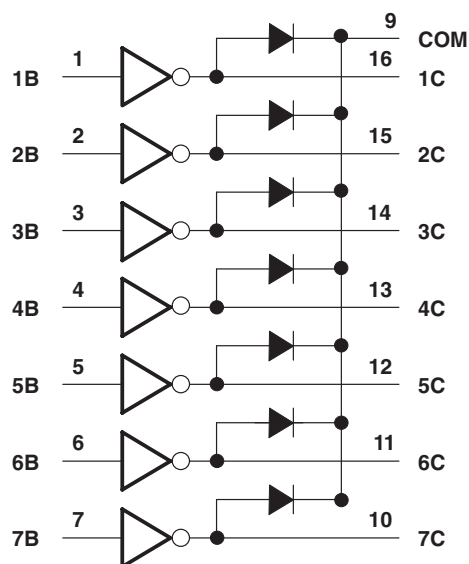
## ORDERING INFORMATION<sup>(1)</sup>

| T <sub>A</sub> | PACKAGE <sup>(2)</sup> |              | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|------------------------|--------------|-----------------------|------------------|
| –20°C to 70°C  | PDIP – N               | Tube of 25   | ULN2002AN             | ULN2002AN        |
|                |                        |              | ULN2003AN             | ULN2003AN        |
|                |                        |              | ULN2004AN             | ULN2004AN        |
|                | SOIC – D               | Tube of 40   | ULN2003AD             | ULN2003A         |
|                |                        | Reel of 2500 | ULN2003ADR            |                  |
|                |                        | Reel of 2500 | ULN2003ADRG3          |                  |
|                |                        | Tube of 40   | ULN2004AD             | ULN2004A         |
|                |                        | Reel of 2500 | ULN2004ADRG3          |                  |
|                | SOP – NS               | Reel of 2000 | ULN2003ANSR           | ULN2003A         |
|                |                        |              | ULN2004ANSR           | ULN2004A         |
|                | TSSOP – PW             | Tube of 90   | ULN2003APW            | UN2003A          |
|                |                        | Reel of 2000 | ULN2003APWR           |                  |
| –40°C to 85°C  | PDIP – N               | Tube of 25   | ULQ2003AN             | ULQ2003A         |
|                |                        |              | ULQ2004AN             | ULQ2004AN        |
|                | SOIC – D               | Tube of 40   | ULQ2003AD             | ULQ2003A         |
|                |                        | Reel of 2500 | ULQ2003ADR            |                  |
|                |                        | Tube of 40   | ULQ2004AD             | ULQ2004A         |
|                |                        | Reel of 2500 | ULQ2004ADR            |                  |
|                | SOP – NS               | Reel of 2000 | ULN2003AINSR          | ULN2003AI        |
| –40°C to 105°C | PDIP – N               | Tube of 425  | ULN2003AIN            | ULN2003AIN       |
|                | SOIC – D               | Tube of 40   | ULN2003AID            | ULN2003AI        |
|                |                        | Reel of 2500 | ULN2003AIDR           |                  |
|                | TSSOP – PW             | Reel of 2500 | ULN2003AIPWR          | UN2003AI         |

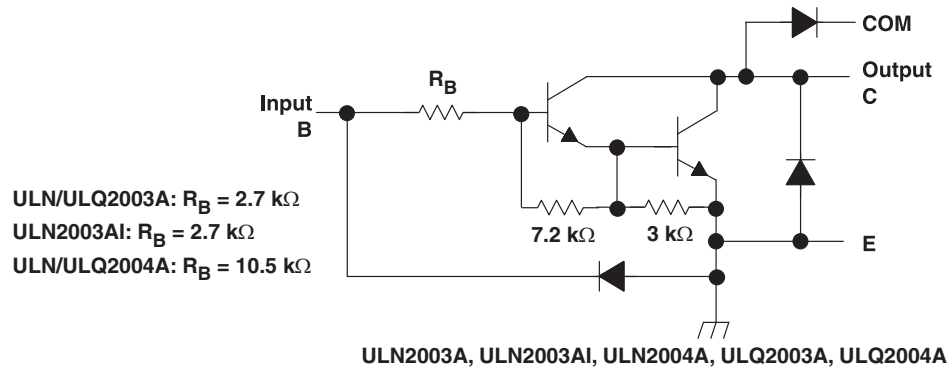
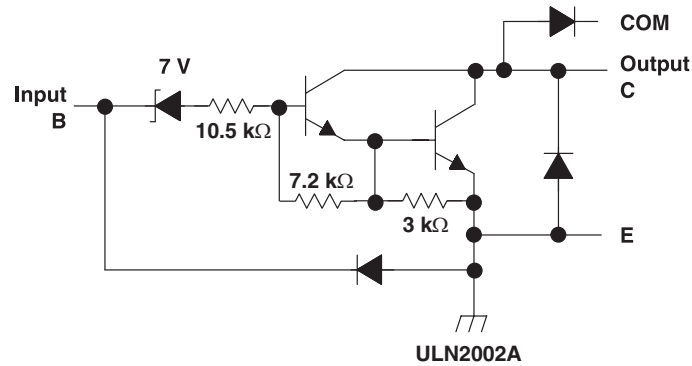
(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

## LOGIC DIAGRAM



### SCHEMATICS (EACH DARLINGTON PAIR)



All resistor values shown are nominal.

The collector-emitter diode is a parasitic structure and should not be used to conduct current. If the collector(s) go below ground an external Schottky diode should be added to clamp negative undershoots.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

at 25°C free-air temperature (unless otherwise noted)

|                  |  |                             | MIN | MAX  | UNIT |
|------------------|--|-----------------------------|-----|------|------|
| V <sub>CC</sub>  | Collector-emitter voltage  |                             |     | 50   | V    |
|                  | Clamp diode reverse voltage <sup>(2)</sup>                       |                             |     | 50   | V    |
| V <sub>I</sub>   | Input voltage <sup>(2)</sup>                                     |                             |     | 30   | V    |
|                  | Peak collector current   | See Figure 14 and Figure 15 |     | 500  | mA   |
| I <sub>OK</sub>  | Output clamp current   |                             |     | 500  | mA   |
|                  | Total emitter-terminal current                                   |                             |     | –2.5 | A    |
| T <sub>A</sub>   | Operating free-air temperature range                             | ULN200xA                    | –20 | 70   | °C   |
|                  |  | ULN200xAI                   | –40 | 105  |      |
|                  |  | ULQ200xA                    | –40 | 85   |      |
|                  |  | ULQ200xAT                   | –40 | 105  |      |
| θ <sub>JA</sub>  | Package thermal impedance <sup>(3) (4)</sup>                     | D package                   |     | 73   | °C/W |
|                  |  | N package                   |     | 67   |      |
|                  |  | NS package                  |     | 64   |      |
|                  |  | PW package                  |     | 108  |      |
| θ <sub>JC</sub>  | Package thermal impedance <sup>(5) (6)</sup>                     | D package                   |     | 36   | °C/W |
|                  |  | N package                   |     | 54   |      |
| T <sub>J</sub>   | Operating virtual junction temperature                           |                             |     | 150  | °C   |
|                  | Lead temperature for 1.6 mm (1/16 inch) from case for 10 seconds |                             |     | 260  | °C   |
| T <sub>stg</sub> | Storage temperature range  |                             | –65 | 150  | °C   |

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values are with respect to the emitter/substrate terminal E, unless otherwise noted.
- (3) Maximum power dissipation is a function of T<sub>J</sub>(max), θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J</sub>(max) – T<sub>A</sub>)/θ<sub>JA</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.
- (5) Maximum power dissipation is a function of T<sub>J</sub>(max), θ<sub>JC</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is P<sub>D</sub> = (T<sub>J</sub>(max) – T<sub>A</sub>)/θ<sub>JC</sub>. Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
- (6) The package thermal impedance is calculated in accordance with MIL-STD-883.

## ELECTRICAL CHARACTERISTICS

T<sub>A</sub> = 25°C

| PARAMETER            | TEST FIGURE                          | TEST CONDITIONS | ULN2002A   |     |         | UNIT         |
|----------------------|--------------------------------------|-----------------|--|-----|---------|--------------|
|                      |                                      |                 | MIN  | TYP | MAX     |              |
| V <sub>I(on)</sub>   | On-state input voltage               | Figure 6        | V <sub>CE</sub> = 2 V, I <sub>C</sub> = 300 mA   |     |         | 13 V         |
| V <sub>CE(sat)</sub> | Collector-emitter saturation voltage | Figure 4        | I <sub>I</sub> = 250 μA, I <sub>C</sub> = 100 mA |     | 0.9 1.1 | V            |
|                      |                                      |                 | I <sub>I</sub> = 350 μA, I <sub>C</sub> = 200 mA |     | 1 1.3   |              |
|                      |                                      |                 | I <sub>I</sub> = 500 μA, I <sub>C</sub> = 350 mA |     | 1.2 1.6 |              |
| V <sub>F</sub>       | Clamp forward voltage                | Figure 7        | I <sub>F</sub> = 350 mA                          |     |         | 1.7 2 V      |
| I <sub>CEX</sub>     | Collector cutoff current             | Figure 1        | V <sub>CE</sub> = 50 V, I <sub>I</sub> = 0       |     |         | 50           |
|                      |                                      | Figure 2        | V <sub>CE</sub> = 50 V, T <sub>A</sub> = 70°C    |     | 100 500 | μA           |
| I <sub>I(off)</sub>  | Off-state input current              | Figure 2        | V <sub>CE</sub> = 50 V, I <sub>C</sub> = 500 μA  |     |         | 50 65 μA     |
| I <sub>I</sub>       | Input current                        | Figure 3        | V <sub>I</sub> = 17 V                            |     |         | 0.82 1.25 mA |
| I <sub>R</sub>       | Clamp reverse current                | Figure 6        | V <sub>R</sub> = 50 V                            |     | 100     | μA           |
|                      |                                      |                 | T <sub>A</sub> = 70°C                            |     | 50      |              |
| C <sub>i</sub>       | Input capacitance                    |                 | V <sub>I</sub> = 0, f = 1 MHz                    |     |         | 25 pF        |

## ELECTRICAL CHARACTERISTICS

 $T_A = 25^\circ\text{C}$ 

| PARAMETER  | TEST FIGURE | TEST CONDITIONS  |                          | ULN2003A |      |      | ULN2004A |      |      | UNIT          |
|--|-------------|--|--------------------------|----------|------|------|----------|------|------|---------------|
|  |             |  |                          | MIN      | TYP  | MAX  | MIN      | TYP  | MAX  |               |
| $V_{I(on)}$ On-state input voltage                 | Figure 6    | $V_{CE} = 2\text{ V}$  | $I_C = 125\text{ mA}$    |          |      |      |          |      |      | 5             |
|  |             |  | $I_C = 200\text{ mA}$    |          |      | 2.4  |          |      |      | 6             |
|  |             |  | $I_C = 250\text{ mA}$    |          |      | 2.7  |          |      |      |               |
|  |             |  | $I_C = 275\text{ mA}$    |          |      |      |          |      |      | 7             |
|  |             |  | $I_C = 300\text{ mA}$    |          |      | 3    |          |      |      |               |
|  |             |  | $I_C = 350\text{ mA}$    |          |      |      |          |      |      | 8             |
| $V_{CE(sat)}$ Collector-emitter saturation voltage | Figure 5    | $I_I = 250\text{ }\mu\text{A}$ , $I_C = 100\text{ mA}$                             |                          |          | 0.9  | 1.1  |          | 0.9  | 1.1  | V             |
|  |             | $I_I = 350\text{ }\mu\text{A}$ , $I_C = 200\text{ mA}$                             |                          |          | 1    | 1.3  |          | 1    | 1.3  |               |
|  |             | $I_I = 500\text{ }\mu\text{A}$ , $I_C = 350\text{ mA}$                             |                          |          | 1.2  | 1.6  |          | 1.2  | 1.6  |               |
| $I_{CEX}$ Collector cutoff current                 | Figure 1    | $V_{CE} = 50\text{ V}$ , $I_I = 0$   |                          |          |      | 50   |          |      | 50   | $\mu\text{A}$ |
|  | Figure 2    | $V_{CE} = 50\text{ V}$ , $T_A = 70^\circ\text{C}$                                  | $I_I = 0$                |          |      | 100  |          |      | 100  |               |
|  |             |  | $V_I = 6\text{ V}$       |          |      |      |          |      | 500  |               |
| $V_F$ Clamp forward voltage                        | Figure 8    | $I_F = 350\text{ mA}$  |                          |          | 1.7  | 2    |          | 1.7  | 2    | V             |
| $I_{I(off)}$ Off-state input current               | Figure 3    | $V_{CE} = 50\text{ V}$ , $T_A = 70^\circ\text{C}$ , $I_C = 500\text{ }\mu\text{A}$ |                          | 50       | 65   |      | 50       | 65   |      | $\mu\text{A}$ |
| $I_I$ Input current                                | Figure 4    | $V_I = 3.85\text{ V}$  |                          |          | 0.93 | 1.35 |          |      |      | mA            |
|  |             | $V_I = 5\text{ V}$   |                          |          |      |      |          | 0.35 | 0.5  |               |
|  |             | $V_I = 12\text{ V}$  |                          |          |      |      |          | 1    | 1.45 |               |
| $I_R$ Clamp reverse current                        | Figure 7    | $V_R = 50\text{ V}$  |                          |          |      | 50   |          |      | 50   | $\mu\text{A}$ |
|  |             |  | $T_A = 70^\circ\text{C}$ |          |      | 100  |          |      | 100  |               |
| $C_i$ Input capacitance                            |             | $V_I = 0$ , $f = 1\text{ MHz}$   |                          |          | 15   | 25   |          | 15   | 25   | pF            |

## ELECTRICAL CHARACTERISTICS

 $T_A = 25^\circ\text{C}$ 

| PARAMETER  | TEST FIGURE | TEST CONDITIONS   |                       | ULN2003AI |      |      | UNIT          |
|--|-------------|---|-----------------------|-----------|------|------|---------------|
|  |             |   |                       | MIN       | TYP  | MAX  |               |
| $V_{I(on)}$ On-state input voltage                 | Figure 6    | $V_{CE} = 2\text{ V}$                                   | $I_C = 200\text{ mA}$ |           |      | 2.4  | V             |
|  |             |   | $I_C = 250\text{ mA}$ |           |      | 2.7  |               |
|  |             |   | $I_C = 300\text{ mA}$ |           |      | 3    |               |
| $V_{CE(sat)}$ Collector-emitter saturation voltage | Figure 5    | $I_I = 250\text{ }\mu\text{A}$ , $I_C = 100\text{ mA}$  |                       |           | 0.9  | 1.1  | V             |
|  |             | $I_I = 350\text{ }\mu\text{A}$ , $I_C = 200\text{ mA}$  |                       |           | 1    | 1.3  |               |
|  |             | $I_I = 500\text{ }\mu\text{A}$ , $I_C = 350\text{ mA}$  |                       |           | 1.2  | 1.6  |               |
| $I_{CEX}$ Collector cutoff current                 | Figure 1    | $V_{CE} = 50\text{ V}$ , $I_I = 0$                      |                       |           |      | 50   | $\mu\text{A}$ |
| $V_F$ Clamp forward voltage                        | Figure 8    | $I_F = 350\text{ mA}$                                   |                       |           | 1.7  | 2    | V             |
| $I_{I(off)}$ Off-state input current               | Figure 3    | $V_{CE} = 50\text{ V}$ , $I_C = 500\text{ }\mu\text{A}$ |                       | 50        | 65   |      | $\mu\text{A}$ |
| $I_I$ Input current                                | Figure 4    | $V_I = 3.85\text{ V}$                                   |                       |           | 0.93 | 1.35 | mA            |
| $I_R$ Clamp reverse current                        | Figure 7    | $V_R = 50\text{ V}$                                     |                       |           |      | 50   | $\mu\text{A}$ |
| $C_i$ Input capacitance                            |             | $V_I = 0$ , $f = 1\text{ MHz}$                          |                       |           | 15   | 25   | pF            |

## ELECTRICAL CHARACTERISTICS

$T_A = -40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$

| PARAMETER  | TEST FIGURE | TEST CONDITIONS  | ULN2003AI |                 |                   | UNIT          |
|--|-------------|--|-----------|-----------------|-------------------|---------------|
|  |             |  | MIN       | TYP             | MAX               |               |
| $V_{I(on)}$ On-state input voltage                 | Figure 6    | $V_{CE} = 2\text{ V}$<br>$I_C = 200\text{ mA}$<br>$I_C = 250\text{ mA}$<br>$I_C = 300\text{ mA}$   |           |                 | 2.7<br>2.9<br>3   | V             |
| $V_{CE(sat)}$ Collector-emitter saturation voltage | Figure 5    | $I_I = 250\text{ }\mu\text{A}$ , $I_C = 100\text{ mA}$<br>$I_I = 350\text{ }\mu\text{A}$ , $I_C = 200\text{ mA}$<br>$I_I = 500\text{ }\mu\text{A}$ , $I_C = 350\text{ mA}$ |           | 0.9<br>1<br>1.2 | 1.2<br>1.4<br>1.7 | V             |
| $I_{CEX}$ Collector cutoff current                 | Figure 1    | $V_{CE} = 50\text{ V}$ , $I_I = 0$   |           |                 | 100               | $\mu\text{A}$ |
| $V_F$ Clamp forward voltage                        | Figure 8    | $I_F = 350\text{ mA}$  |           | 1.7             | 2.2               | V             |
| $I_{I(off)}$ Off-state input current               | Figure 3    | $V_{CE} = 50\text{ V}$ , $I_C = 500\text{ }\mu\text{A}$  | 30        | 65              |                   | $\mu\text{A}$ |
| $I_I$ Input current                                | Figure 4    | $V_I = 3.85\text{ V}$  |           | 0.93            | 1.35              | mA            |
| $I_R$ Clamp reverse current                        | Figure 7    | $V_R = 50\text{ V}$  |           |                 | 100               | $\mu\text{A}$ |
| $C_i$ Input capacitance                            |             | $V_I = 0$ , $f = 1\text{ MHz}$   |           | 15              | 25                | pF            |

## ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER  | TEST FIGURE          | TEST CONDITIONS   | ULQ2003A |                 |                   | ULQ2004A        |                   |                       | UNIT          |
|--|----------------------|---|----------|-----------------|-------------------|-----------------|-------------------|-----------------------|---------------|
|  |                      |   | MIN      | TYP             | MAX               | MIN             | TYP               | MAX                   |               |
| $V_{I(on)}$ On-state input voltage                 | Figure 6             | $V_{CE} = 2\text{ V}$<br>$I_C = 125\text{ mA}$<br>$I_C = 200\text{ mA}$<br>$I_C = 250\text{ mA}$<br>$I_C = 275\text{ mA}$<br>$I_C = 300\text{ mA}$<br>$I_C = 350\text{ mA}$ |          |                 |                   |                 |                   | 5<br>6<br>7<br>7<br>8 | V             |
| $V_{CE(sat)}$ Collector-emitter saturation voltage | Figure 5             | $I_I = 250\text{ }\mu\text{A}$ , $I_C = 100\text{ mA}$<br>$I_I = 350\text{ }\mu\text{A}$ , $I_C = 200\text{ mA}$<br>$I_I = 500\text{ }\mu\text{A}$ , $I_C = 350\text{ mA}$  |          | 0.9<br>1<br>1.2 | 1.2<br>1.4<br>1.7 | 0.9<br>1<br>1.2 | 1.1<br>1.3<br>1.6 |                       | V             |
| $I_{CEX}$ Collector cutoff current                 | Figure 1<br>Figure 2 | $V_{CE} = 50\text{ V}$ , $I_I = 0$<br>$V_{CE} = 50\text{ V}$ , $T_A = 70^{\circ}\text{C}$ , $I_I = 0$<br>$V_I = 6\text{ V}$   |          |                 | 100               |                 |                   | 50<br>100<br>500      | $\mu\text{A}$ |
| $V_F$ Clamp forward voltage                        | Figure 8             | $I_F = 350\text{ mA}$   |          | 1.7             | 2.3               | 1.7             | 2                 |                       | V             |
| $I_{I(off)}$ Off-state input current               | Figure 3             | $V_{CE} = 50\text{ V}$ , $T_A = 70^{\circ}\text{C}$ , $I_C = 500\text{ }\mu\text{A}$  |          | 65              |                   | 50              | 65                |                       | $\mu\text{A}$ |
| $I_I$ Input current                                | Figure 4             | $V_I = 3.85\text{ V}$<br>$V_I = 5\text{ V}$<br>$V_I = 12\text{ V}$  |          | 0.93            | 1.35              |                 | 0.35<br>1         | 0.5<br>1.45           | mA            |
| $I_R$ Clamp reverse current                        | Figure 7             | $V_R = 50\text{ V}$ , $T_A = 25^{\circ}\text{C}$  |          |                 | 100               |                 |                   | 50<br>100             | $\mu\text{A}$ |
| $C_i$ Input capacitance                            |                      | $V_I = 0$ , $f = 1\text{ MHz}$  |          | 15              | 25                | 15              | 25                |                       | pF            |

## SWITCHING CHARACTERISTICS

 $T_A = 25^\circ\text{C}$ 

| PARAMETER   | TEST CONDITIONS   | ULN2002A, ULN2003A, ULN2004A |      |     | UNIT          |
|---|---|------------------------------|------|-----|---------------|
|   |   | MIN                          | TYP  | MAX |               |
| $t_{PLH}$ Propagation delay time, low- to high-level output | See <a href="#">Figure 9</a>  |                              | 0.25 | 1   | $\mu\text{s}$ |
| $t_{PHL}$ Propagation delay time, high- to low-level output | See <a href="#">Figure 9</a>  |                              | 0.25 | 1   | $\mu\text{s}$ |
| $V_{OH}$ High-level output voltage after switching          | $V_S = 50\text{ V}$ , $I_O = 300\text{ mA}$ , See <a href="#">Figure 10</a> | $V_S - 20$                   |      |     | mV            |

## SWITCHING CHARACTERISTICS

 $T_A = 25^\circ\text{C}$ 

| PARAMETER   | TEST CONDITIONS   | ULN2003AI  |      |     | UNIT          |
|---|---|------------|------|-----|---------------|
|   |   | MIN        | TYP  | MAX |               |
| $t_{PLH}$ Propagation delay time, low- to high-level output | See <a href="#">Figure 9</a>  |            | 0.25 | 1   | $\mu\text{s}$ |
| $t_{PHL}$ Propagation delay time, high- to low-level output | See <a href="#">Figure 9</a>  |            | 0.25 | 1   | $\mu\text{s}$ |
| $V_{OH}$ High-level output voltage after switching          | $V_S = 50\text{ V}$ , $I_O \approx 300\text{ mA}$ , See <a href="#">Figure 10</a> | $V_S - 20$ |      |     | mV            |

## SWITCHING CHARACTERISTICS

 $T_A = -40^\circ\text{C}$  to  $105^\circ\text{C}$ 

| PARAMETER   | TEST CONDITIONS   | ULN2003AI  |     |     | UNIT          |
|---|---|------------|-----|-----|---------------|
|   |   | MIN        | TYP | MAX |               |
| $t_{PLH}$ Propagation delay time, low- to high-level output | See <a href="#">Figure 9</a>  |            | 1   | 10  | $\mu\text{s}$ |
| $t_{PHL}$ Propagation delay time, high- to low-level output | See <a href="#">Figure 9</a>  |            | 1   | 10  | $\mu\text{s}$ |
| $V_{OH}$ High-level output voltage after switching          | $V_S = 50\text{ V}$ , $I_O \approx 300\text{ mA}$ , See <a href="#">Figure 10</a> | $V_S - 50$ |     |     | mV            |

## SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

| PARAMETER   | TEST CONDITIONS   | ULQ2003A, ULQ2004A |     |     | UNIT          |
|---|---|--------------------|-----|-----|---------------|
|   |   | MIN                | TYP | MAX |               |
| $t_{PLH}$ Propagation delay time, low- to high-level output | See <a href="#">Figure 9</a>  |                    | 1   | 10  | $\mu\text{s}$ |
| $t_{PHL}$ Propagation delay time, high- to low-level output | See <a href="#">Figure 9</a>  |                    | 1   | 10  | $\mu\text{s}$ |
| $V_{OH}$ High-level output voltage after switching          | $V_S = 50\text{ V}$ , $I_O = 300\text{ mA}$ , See <a href="#">Figure 10</a> | $V_S - 20$         |     |     | mV            |

## PARAMETER MEASUREMENT INFORMATION

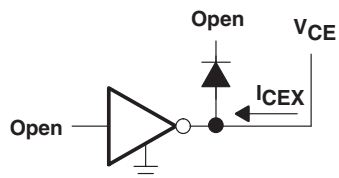


Figure 1.  $I_{CEX}$  Test Circuit

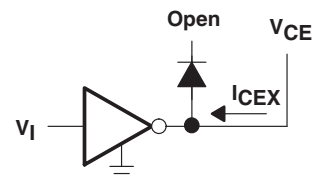


Figure 2.  $I_{CEX}$  Test Circuit

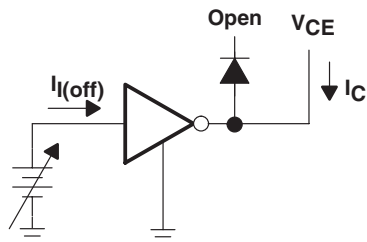


Figure 3.  $I_{I(off)}$  Test Circuit

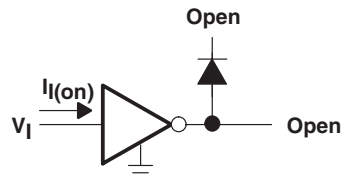


Figure 4.  $I_I$  Test Circuit

A.  $I_I$  is fixed for measuring  $V_{CE(sat)}$ , variable for measuring  $h_{FE}$ .

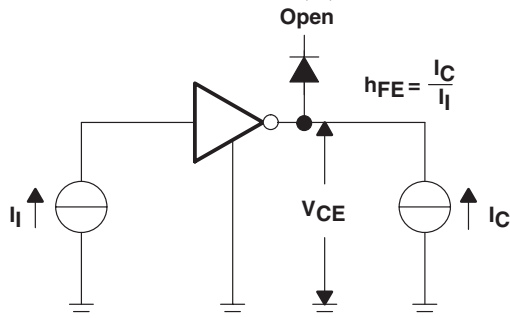


Figure 5.  $h_{FE}$ ,  $V_{CE(sat)}$  Test Circuit

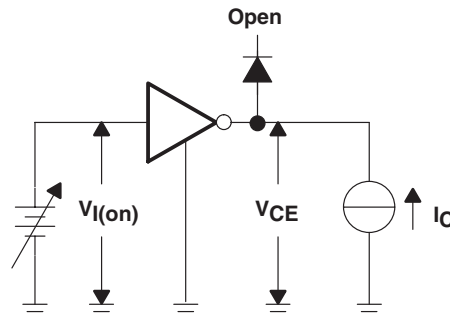


Figure 6.  $V_{I(on)}$  Test Circuit

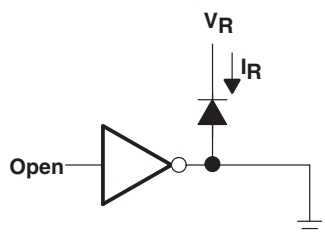


Figure 7.  $I_R$  Test Circuit

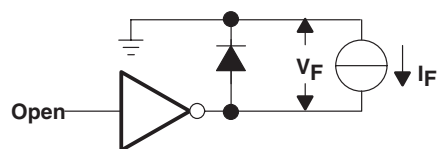
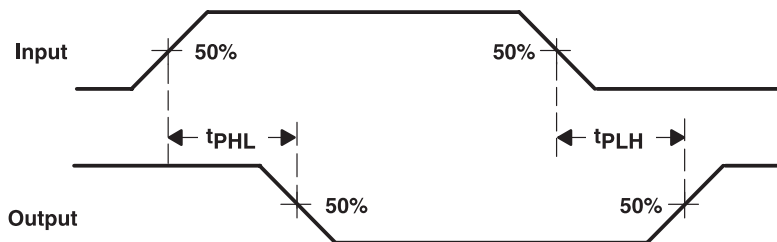


Figure 8.  $V_F$  Test Circuit

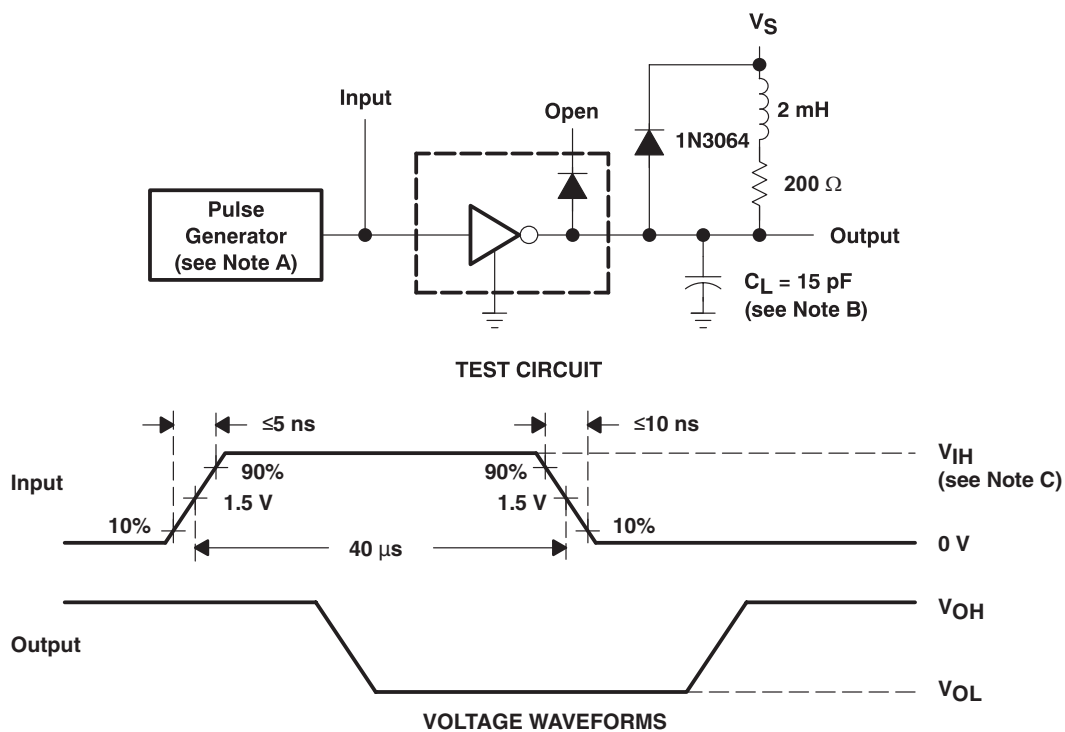


VOLTAGE WAVEFORMS

Figure 9. Propagation Delay-Time Waveforms



## PARAMETER MEASUREMENT INFORMATION (continued)



- A. The pulse generator has the following characteristics: PRR = 12.5 kHz,  $Z_O = 50 \Omega$ .
- B.  $C_L$  includes probe and jig capacitance.
- C. For testing the ULN2003A, ULN2003AI, and ULQ2003A,  $V_{IH} = 3 \text{ V}$ ; for the ULN2002A,  $V_{IH} = 13 \text{ V}$ ; for the ULN2004A and the ULQ2004A,  $V_{IH} = 8 \text{ V}$ .

**Figure 10. Latch-Up Test Circuit and Voltage Waveforms**

## TYPICAL CHARACTERISTICS

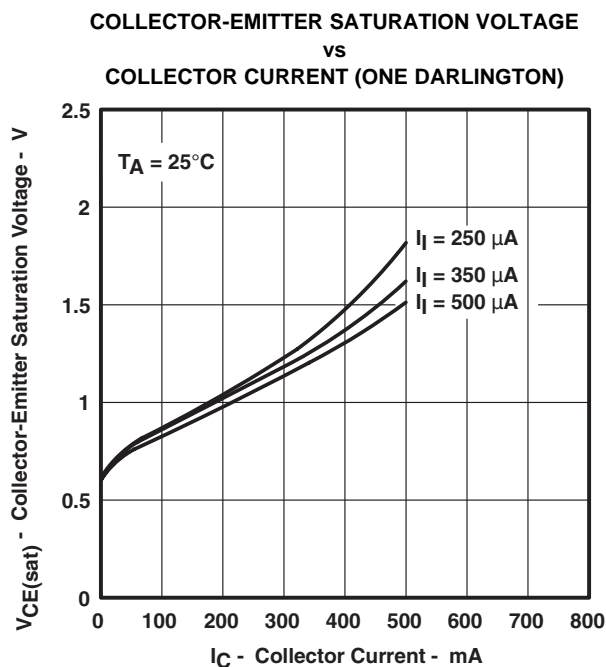


Figure 11.

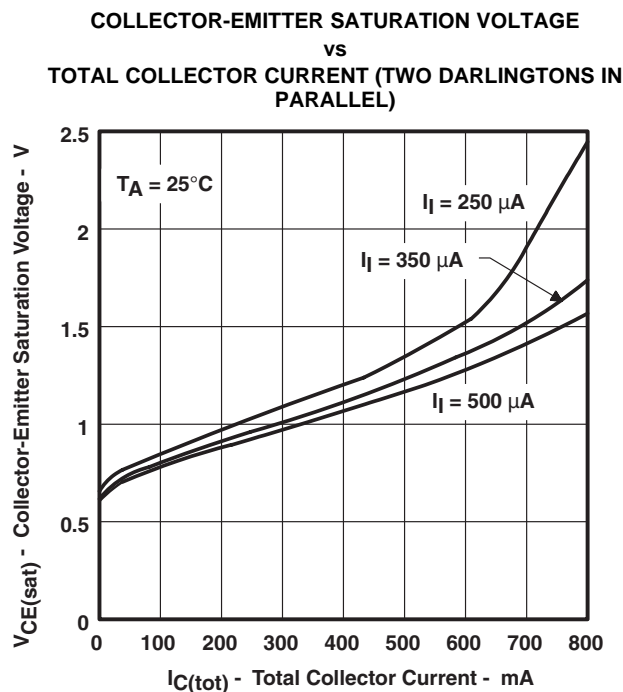


Figure 12.

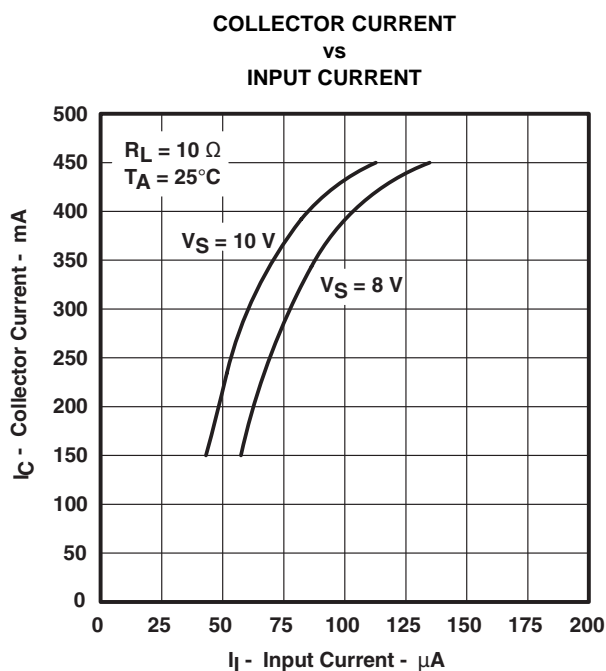


Figure 13.

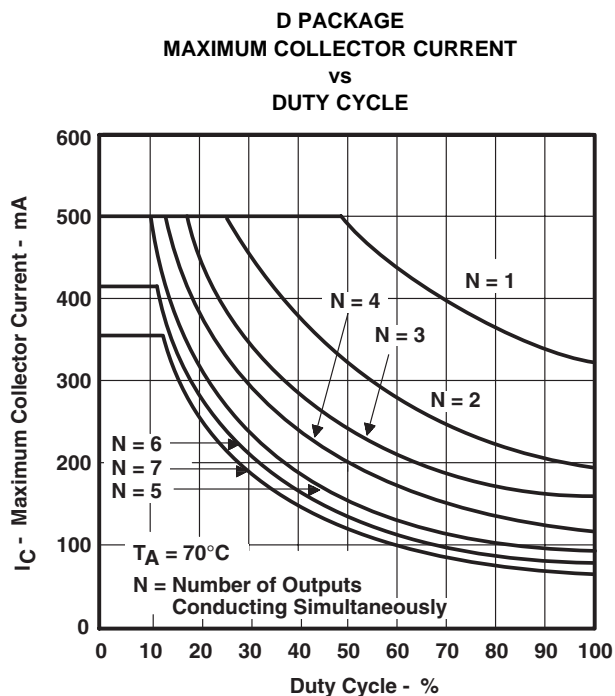


Figure 14.

## TYPICAL CHARACTERISTICS (continued)

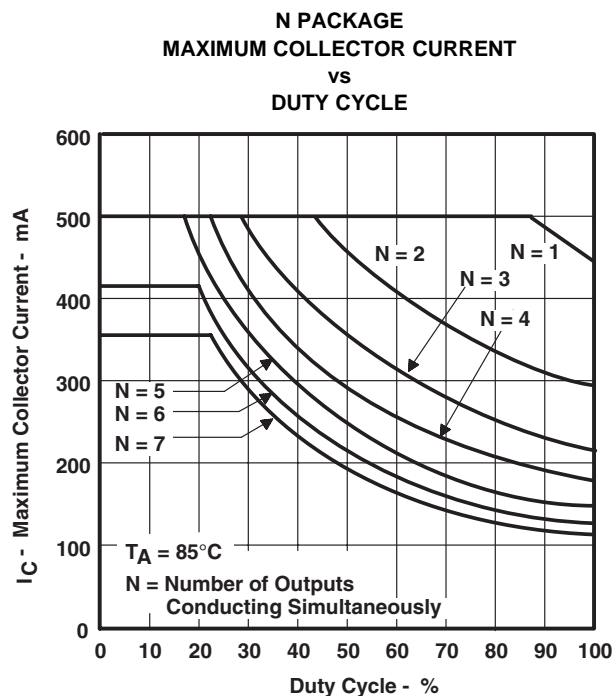


Figure 15.

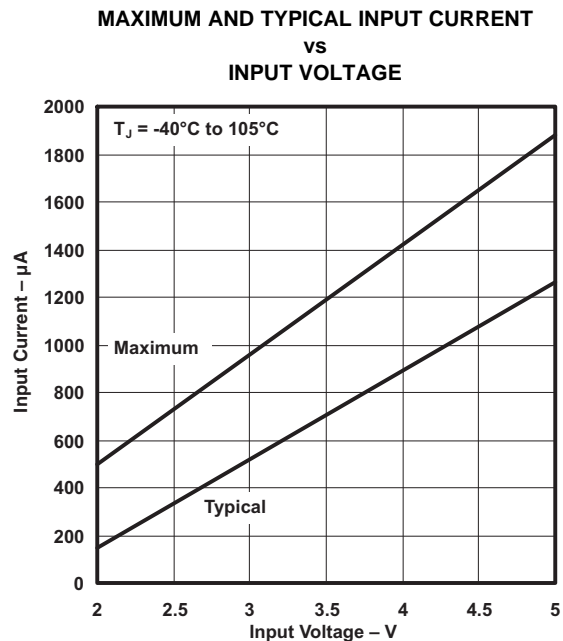


Figure 16.

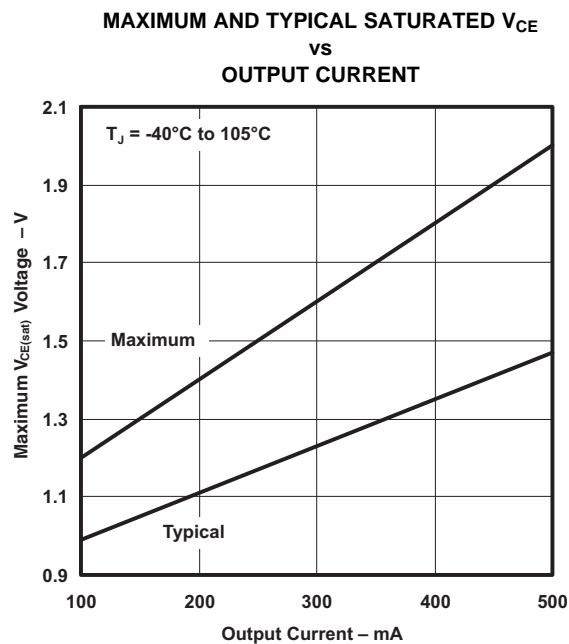


Figure 17.

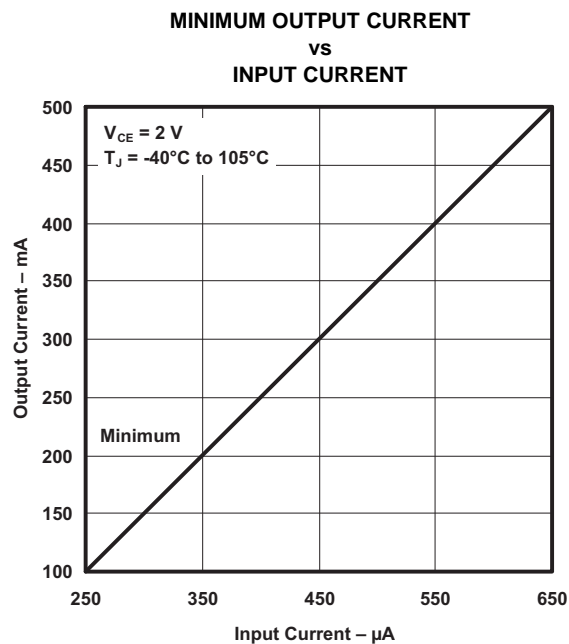


Figure 18.

## APPLICATION INFORMATION

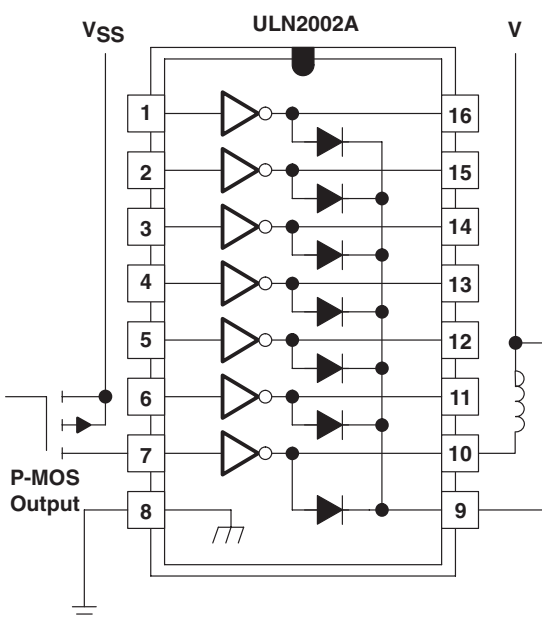


Figure 19. P-MOS to Load

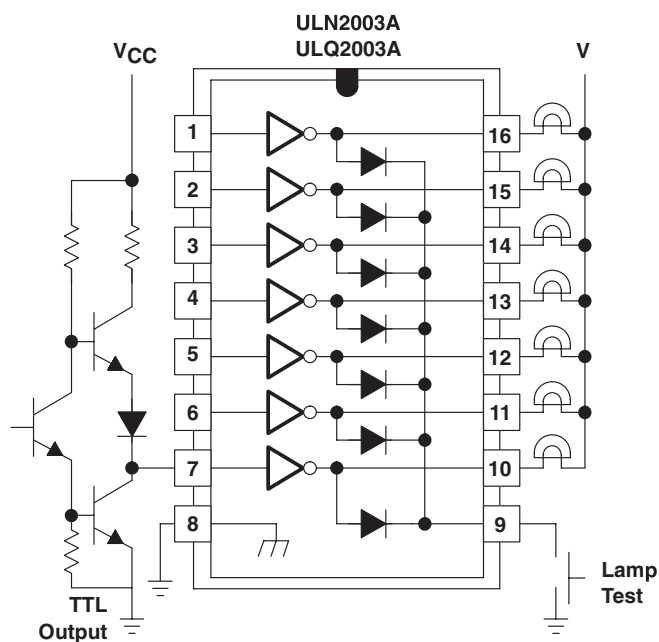


Figure 20. TTL to Load

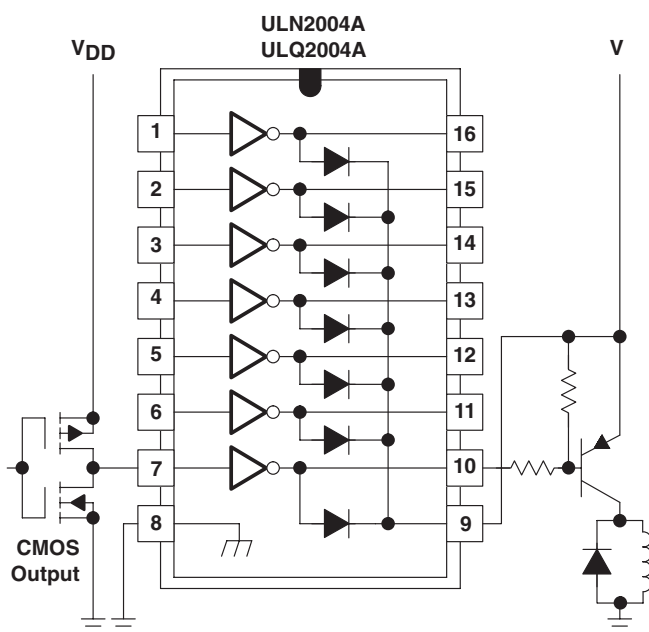


Figure 21. Buffer for Higher Current Loads

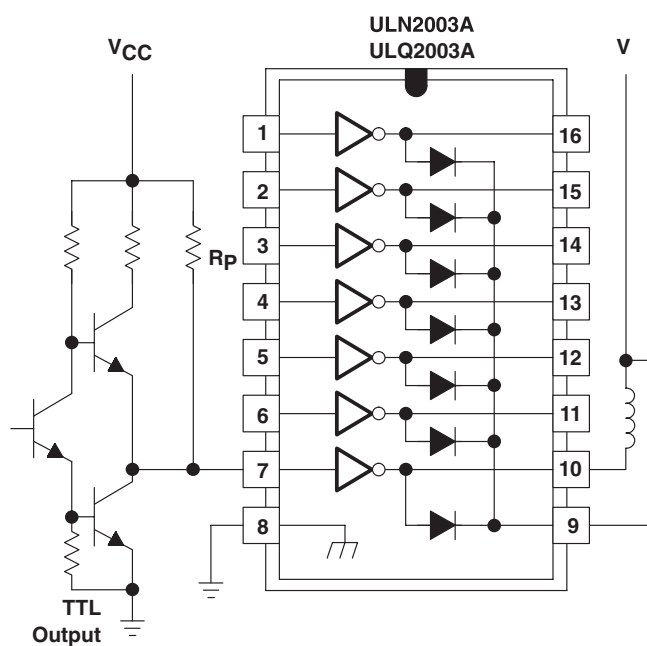


Figure 22. Use of Pullup Resistors to Increase Drive Current

## REVISION HISTORY

| Changes from Revision J (September 2010) to Revision K  | Page |
|---|------|
| • Added SOP – NS Package to the $-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$ $T_A$ range in the Ordering Information table. .... | 2    |
| • Added Input Current ( $I_I$ ) parameters .....  | 5    |
| • Added Input Current ( $I_I$ ) parameters .....  | 6    |

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup>    | Lead/<br>Ball Finish | MSL Peak Temp <sup>(3)</sup> | Samples<br>(Requires Login) |
|------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| ULN2001AD        | OBSOLETE              | SOIC         | D               | 16   |             | TBD                        | Call TI              | Call TI                      |                             |
| ULN2001ADR       | OBSOLETE              | SOIC         | D               | 16   |             | TBD                        | Call TI              | Call TI                      |                             |
| ULN2001AN        | OBSOLETE              | PDIP         | N               | 16   |             | TBD                        | Call TI              | Call TI                      |                             |
| ULN2002AD        | OBSOLETE              | SOIC         | D               | 16   |             | TBD                        | Call TI              | Call TI                      |                             |
| ULN2002AN        | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2002ANE4      | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2003AD        | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ADE4      | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ADG4      | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ADR       | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ADRE4     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ADRG3     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU SN                | Level-1-260C-UNLIM           |                             |
| ULN2003ADRG4     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AID       | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIDE4     | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIDG4     | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIDR      | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIDRE4    | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIDRG4    | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIN       | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup>    | Lead/<br>Ball Finish | MSL Peak Temp <sup>(3)</sup> | Samples<br>(Requires Login) |
|------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| ULN2003AINE4     | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2003AINSR     | ACTIVE                | SO           | NS              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIPW      | ACTIVE                | TSSOP        | PW              | 16   | 90          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIPWE4    | ACTIVE                | TSSOP        | PW              | 16   | 90          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIPWG4    | ACTIVE                | TSSOP        | PW              | 16   | 90          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIPWR     | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIPWRE4   | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AIPWRG4   | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003AJ        | OBSOLETE              | CDIP         | J               | 16   |             | TBD                        | Call TI              | Call TI                      |                             |
| ULN2003AN        | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2003ANE3      | PREVIEW               | PDIP         | N               | 16   | 25          | TBD                        | Call TI              | Call TI                      |                             |
| ULN2003ANE4      | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2003ANSR      | ACTIVE                | SO           | NS              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ANSRE4    | ACTIVE                | SO           | NS              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003ANSRG4    | ACTIVE                | SO           | NS              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003APW       | ACTIVE                | TSSOP        | PW              | 16   | 90          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003APWE4     | ACTIVE                | TSSOP        | PW              | 16   | 90          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003APWG4     | ACTIVE                | TSSOP        | PW              | 16   | 90          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003APWR      | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2003APWRE4    | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup>    | Lead/<br>Ball Finish | MSL Peak Temp <sup>(3)</sup> | Samples<br>(Requires Login) |
|------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| ULN2003APWRG4    | ACTIVE                | TSSOP        | PW              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004AD        | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004ADE4      | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004ADG4      | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004ADR       | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004ADRE4     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004ADRG4     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004AN        | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2004ANE4      | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULN2004ANSR      | ACTIVE                | SO           | NS              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULN2004ANSRG4    | ACTIVE                | SO           | NS              | 16   | 2000        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2003AD        | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2003ADG4      | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2003ADR       | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2003ADRG4     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2003AN        | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |
| ULQ2004AD        | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2004ADG4      | ACTIVE                | SOIC         | D               | 16   | 40          | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2004ADR       | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |



| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup>    | Lead/<br>Ball Finish | MSL Peak Temp <sup>(3)</sup> | Samples<br>(Requires Login) |
|------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| ULQ2004ADRG4     | ACTIVE                | SOIC         | D               | 16   | 2500        | Green (RoHS<br>& no Sb/Br) | CU NIPDAU            | Level-1-260C-UNLIM           |                             |
| ULQ2004AN        | ACTIVE                | PDIP         | N               | 16   | 25          | Pb-Free (RoHS)             | CU NIPDAU            | N / A for Pkg Type           |                             |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

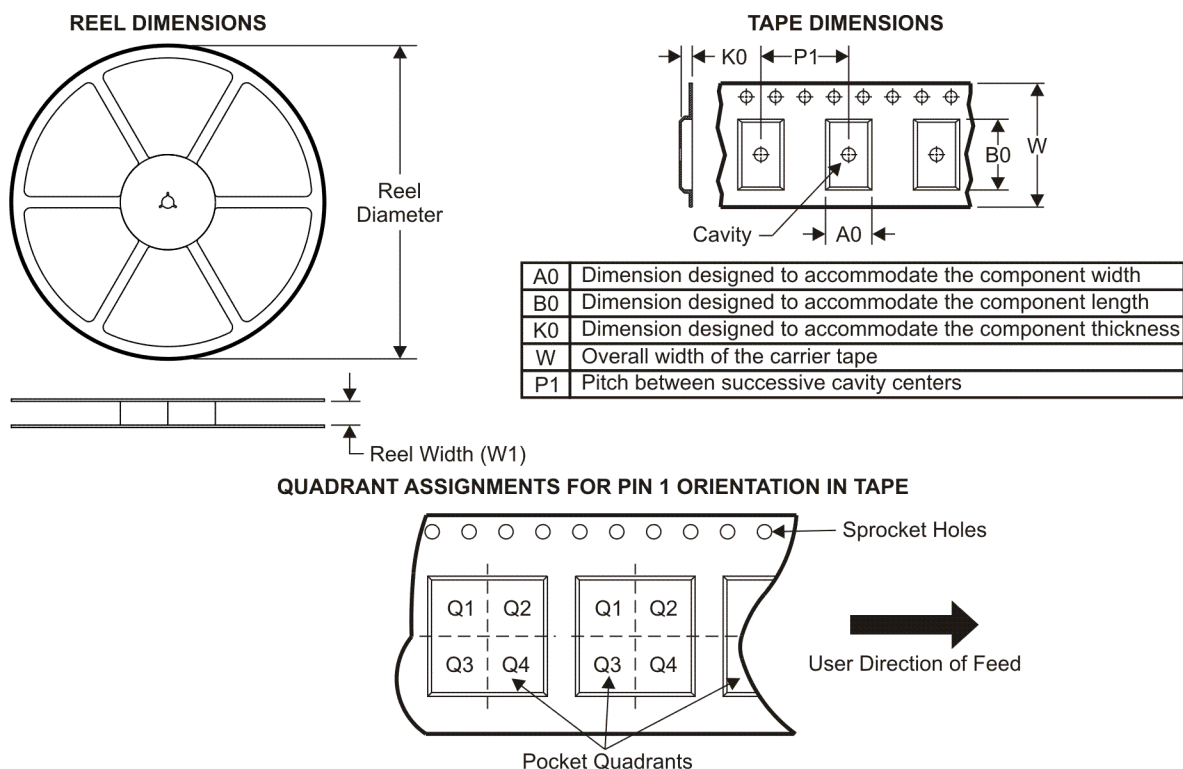
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

#### OTHER QUALIFIED VERSIONS OF ULQ2003A, ULQ2004A :

- Automotive: [ULQ2003A-Q1](#), [ULQ2004A-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| ULN2003ADR   | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| ULN2003AINSR | SO           | NS              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 10.5    | 2.5     | 12.0    | 16.0   | Q1            |
| ULN2003AIPWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| ULN2003AIPWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 7.0     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| ULN2003ANSR  | SO           | NS              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 10.5    | 2.5     | 12.0    | 16.0   | Q1            |
| ULN2003APWR  | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| ULN2003APWR  | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 7.0     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| ULN2004ANSR  | SO           | NS              | 16   | 2000 | 330.0              | 16.4               | 8.2     | 10.5    | 2.5     | 12.0    | 16.0   | Q1            |
| ULQ2003ADR   | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| ULN2003ADR   | SOIC         | D               | 16   | 2500 | 346.0       | 346.0      | 33.0        |
| ULN2003AINSR | SO           | NS              | 16   | 2000 | 346.0       | 346.0      | 33.0        |
| ULN2003AIPWR | TSSOP        | PW              | 16   | 2000 | 346.0       | 346.0      | 29.0        |
| ULN2003AIPWR | TSSOP        | PW              | 16   | 2000 | 364.0       | 364.0      | 27.0        |
| ULN2003ANSR  | SO           | NS              | 16   | 2000 | 346.0       | 346.0      | 33.0        |
| ULN2003APWR  | TSSOP        | PW              | 16   | 2000 | 346.0       | 346.0      | 29.0        |
| ULN2003APWR  | TSSOP        | PW              | 16   | 2000 | 364.0       | 364.0      | 27.0        |
| ULN2004ANSR  | SO           | NS              | 16   | 2000 | 346.0       | 346.0      | 33.0        |
| ULQ2003ADR   | SOIC         | D               | 16   | 2500 | 333.2       | 345.9      | 28.6        |

J (R-GDIP-T\*\*)

14 LEADS SHOWN

# CERAMIC DUAL IN-LINE PACKAGE



| PINS **<br>DIM | 14                     | 16                     | 18                     | 20                     |
|----------------|------------------------|------------------------|------------------------|------------------------|
| A              | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC | 0.300<br>(7,62)<br>BSC |
| B MAX          | 0.785<br>(19,94)       | .840<br>(21,34)        | 0.960<br>(24,38)       | 1.060<br>(26,92)       |
| B MIN          | —                      | —                      | —                      | —                      |
| C MAX          | 0.300<br>(7,62)        | 0.300<br>(7,62)        | 0.310<br>(7,87)        | 0.300<br>(7,62)        |
| C MIN          | 0.245<br>(6,22)        | 0.245<br>(6,22)        | 0.220<br>(5,59)        | 0.245<br>(6,22)        |



4040083/F 03/03

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package is hermetically sealed with a ceramic lid using glass frit.
  - D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
  - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

## N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



| PINS **             | 14               | 16               | 18               | 20               |
|---------------------|------------------|------------------|------------------|------------------|
| DIM                 |                  |                  |                  |                  |
| A MAX               | 0.775<br>(19,69) | 0.775<br>(19,69) | 0.920<br>(23,37) | 1.060<br>(26,92) |
| A MIN               | 0.745<br>(18,92) | 0.745<br>(18,92) | 0.850<br>(21,59) | 0.940<br>(23,88) |
| MS-001<br>VARIATION | AA               | BB               | AC               | AD               |



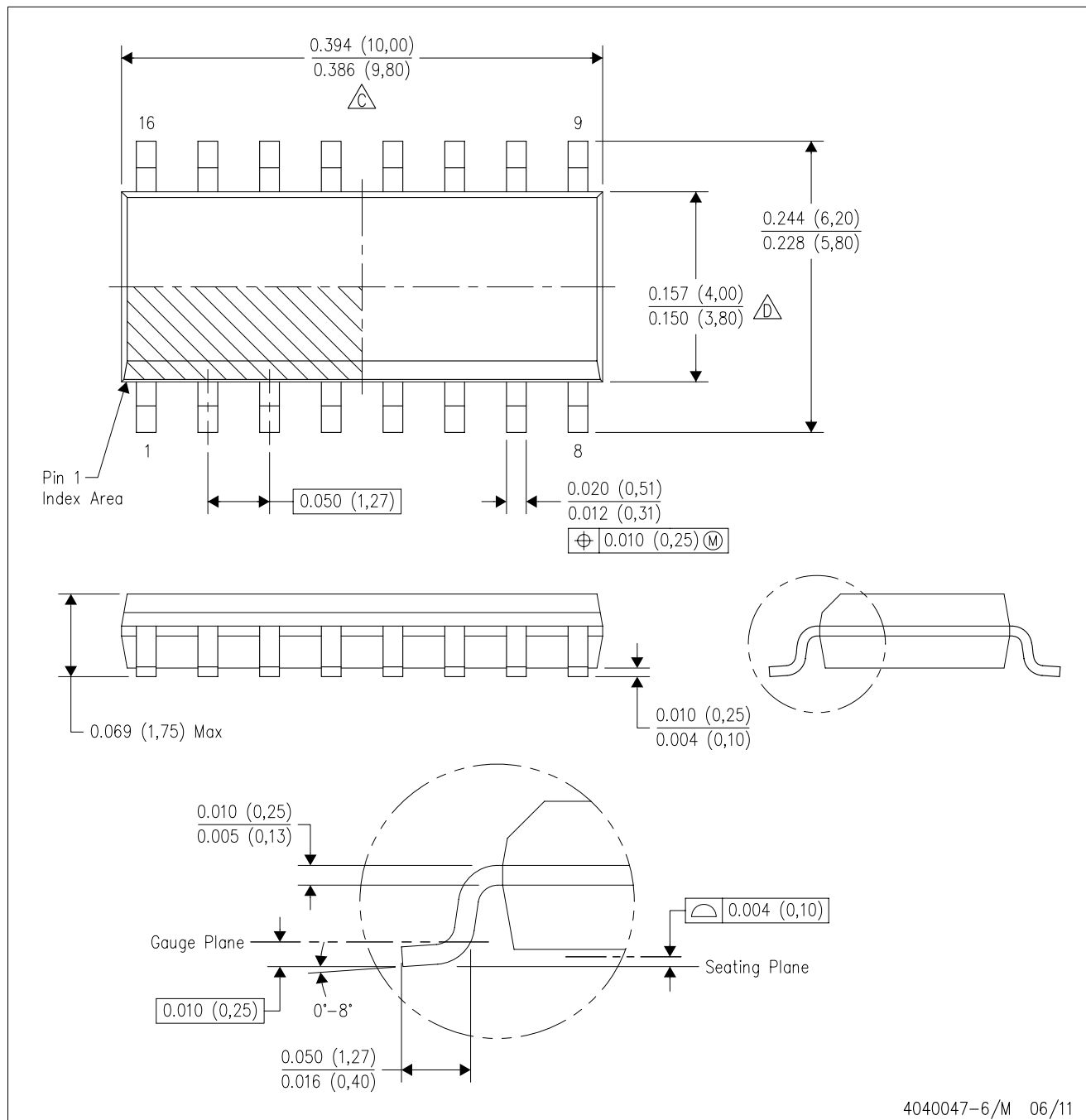
14/18 Pin Only  
20 Pin vendor option

4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE

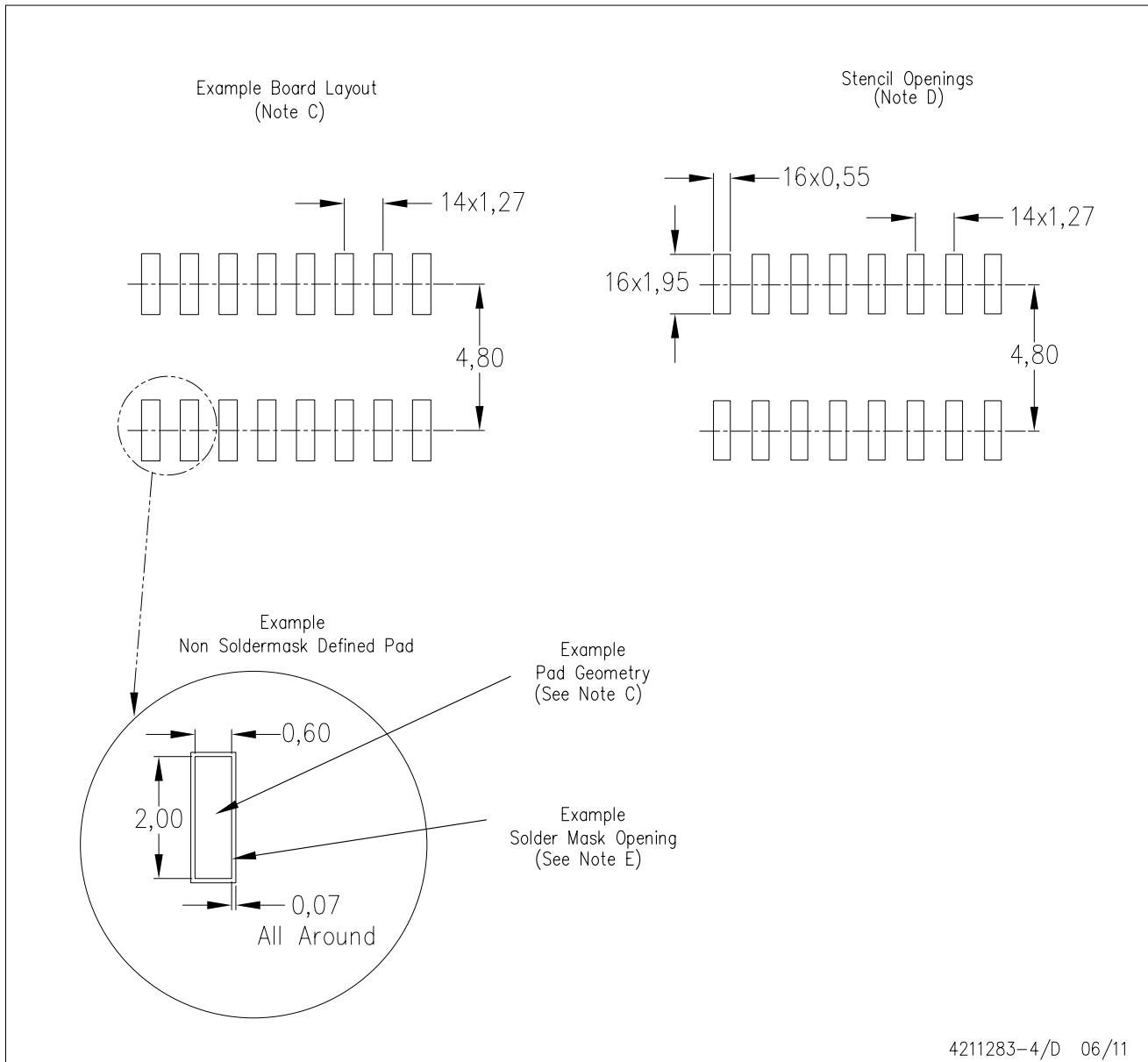


4040047-6/M 06/11

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AC.

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE

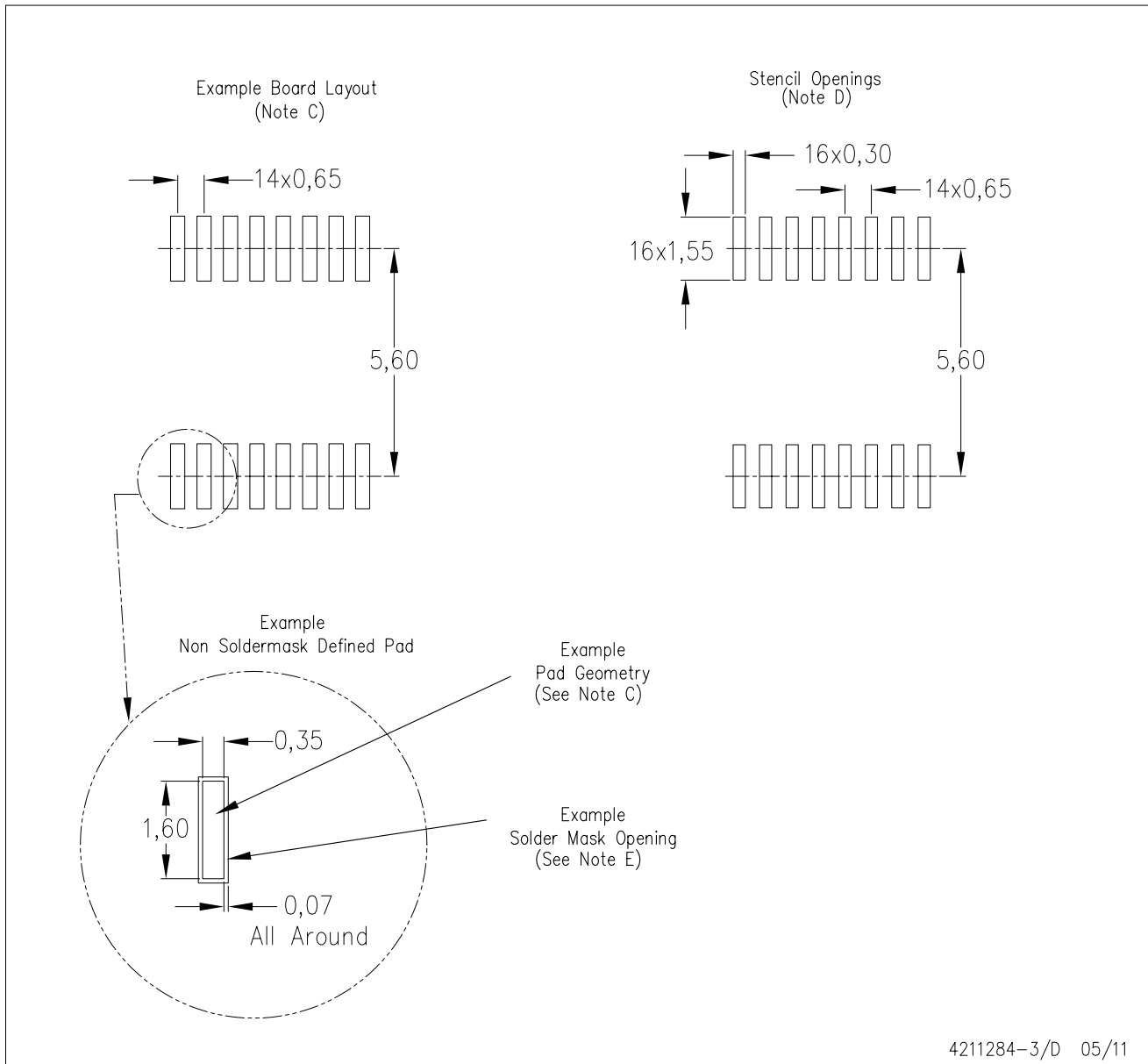


- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153



PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

# MECHANICAL DATA

NS (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

|                        |  |
|------------------------|--|
| Audio                  | <a href="http://www.ti.com/audio">www.ti.com/audio</a>                               |
| Amplifiers             | <a href="http://amplifier.ti.com">amplifier.ti.com</a>                               |
| Data Converters        | <a href="http://dataconverter.ti.com">dataconverter.ti.com</a>                       |
| DLP® Products          | <a href="http://www.dlp.com">www.dlp.com</a>   |
| DSP                    | <a href="http://dsp.ti.com">dsp.ti.com</a>   |
| Clocks and Timers      | <a href="http://www.ti.com/clocks">www.ti.com/clocks</a>                             |
| Interface              | <a href="http://interface.ti.com">interface.ti.com</a>                               |
| Logic                  | <a href="http://logic.ti.com">logic.ti.com</a>                                       |
| Power Mgmt             | <a href="http://power.ti.com">power.ti.com</a>                                       |
| Microcontrollers       | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a>                   |
| RFID                   | <a href="http://www.ti-rfid.com">www.ti-rfid.com</a>                                 |
| OMAP Mobile Processors | <a href="http://www.ti.com/omap">www.ti.com/omap</a>                                 |
| Wireless Connectivity  | <a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a> |

### Applications

|                               |  |
|-------------------------------|--|
| Communications and Telecom    | <a href="http://www.ti.com/communications">www.ti.com/communications</a>                 |
| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
| Transportation and Automotive | <a href="http://www.ti.com/automotive">www.ti.com/automotive</a>                         |
| Video and Imaging             | <a href="http://www.ti.com/video">www.ti.com/video</a>                                   |

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated