

## ULN2003AP, ULN2003AFW, ULN2004AP, ULN2004AFW

### 7CH DARLINGTON SINK DRIVER

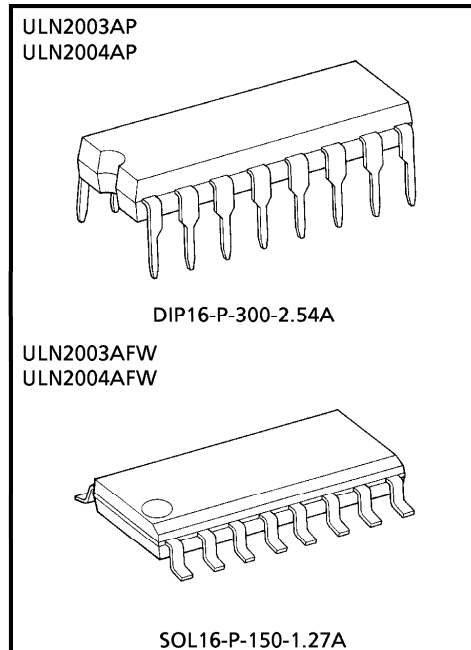
The ULN2003AP / AFW Series are high-voltage, high-current darlington drivers comprised of seven NPN darlington pairs.

All units feature integral clamp diodes for switching inductive loads.

Applications include relay, hammer, lamp and display (LED) drivers.

#### FEATURES

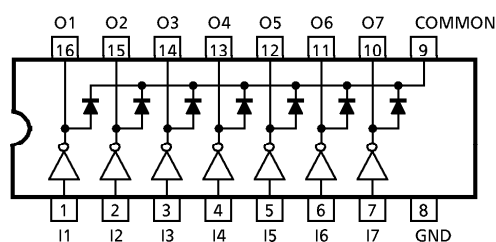
- Output current (single output) 500 mA MAX.
- High sustaining voltage output  
50 V MIN. (ULN2003AP / AFW Series)
- Output clamp diodes
- Inputs compatible with various types of logic
- Package Type-AP : DIP-16pin
- Package Type-AFW : SOL-16pin



Weight  
DIP16-P-300-2.54A : 1.11 g (Typ.)  
SOL16-P-150-1.27A : 0.15 g (Typ.)

| TYPE            | INPUT BASE RESISTOR | DESIGNATION       |
|-----------------|---------------------|-------------------|
| ULN2003AP / AFW | 2.7 k $\Omega$      | TTL, 5 V CMOS     |
| ULN2004AP / AFW | 10.5 k $\Omega$     | 6~15 V PMOS, CMOS |

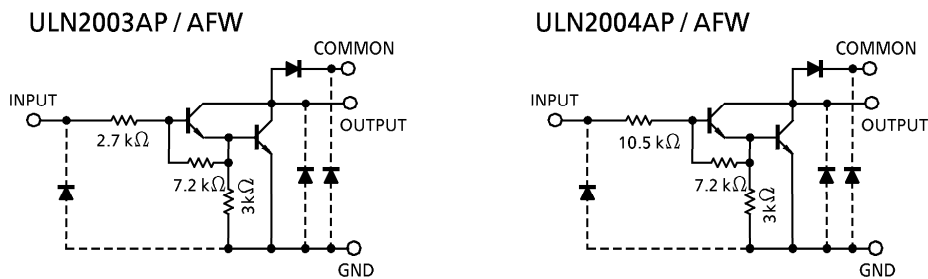
#### PIN CONNECTION (TOP VIEW)



980910EBA1

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SCHEMATICS (EACH DRIVER)



(Note) : The input and output parasitic diodes cannot be used as clamp diodes.

MAXIMUM RATINGS (Ta = 25°C)

| CHARACTERISTIC              |     | SYMBOL        | RATING              | UNIT    |
|-----------------------------|-----|---------------|---------------------|---------|
| Output Sustaining Voltage   |     | $V_{CE(SUS)}$ | - 0.5~50            | V       |
| Output Current              |     | $I_{OUT}$     | 500                 | mA / ch |
| Input Voltage               |     | $V_{IN}$      | - 0.5~30            | V       |
| Clamp Diode Reverse Voltage |     | $V_R$         | 50                  | V       |
| Clamp Diode Forward Current |     | $I_F$         | 500                 | mA      |
| Power Dissipation           | AP  | $P_D$         | 1.47                | W       |
|                             | AFW |               | 0.54 / 0.625 (Note) |         |
| Operating Temperature       |     | $T_{opr}$     | - 40~85             | °C      |
| Storage Temperature         |     | $T_{stg}$     | - 55~150            | °C      |

(Note) : On glass epoxy PCB (30 × 30 × 1.6 mm Cu 50%)

**RECOMMENDED OPERATING CONDITIONS** ( $T_a = -40 \sim 85^\circ\text{C}$ )

| CHARACTERISTIC                |          | SYMBOL                | CONDITION                                                        |            | MIN. | TYP. | MAX.  | UNIT    |
|-------------------------------|----------|-----------------------|------------------------------------------------------------------|------------|------|------|-------|---------|
| Output Sustaining Voltage     |          | V <sub>CE (SUS)</sub> |                                                                  |            | 0    | —    | 50    | V       |
| Output Current                | AP       | I <sub>OUT</sub>      | T <sub>pw</sub> = 25 ms<br>7 Circuits<br>Ta = 85°C<br>Tj = 120°C | Duty = 10% | 0    | —    | 370   | mA / ch |
|                               |          |                       |                                                                  | Duty = 50% | 0    | —    | 130   |         |
|                               | AFW      |                       |                                                                  | Duty = 10% | 0    | —    | 233   |         |
|                               |          |                       |                                                                  | Duty = 50% | 0    | —    | 70    |         |
| Input Voltage                 |          | V <sub>IN</sub>       |                                                                  |            | 0    | —    | 24    | V       |
| Input Voltage<br>(Output On)  | ULN2003A | V <sub>IN (ON)</sub>  | I <sub>OUT</sub> = 400 mA<br>h <sub>FE</sub> = 800               |            | 2.8  | —    | 24    | V       |
|                               | ULN2004A |                       |                                                                  |            | 6.2  | —    | 24    |         |
| Input Voltage<br>(Output Off) | ULN2003A | V <sub>IN (OFF)</sub> |                                                                  |            | 0    | —    | 0.7   | V       |
|                               | ULN2004A |                       |                                                                  |            | 0    | —    | 1.0   |         |
| Clamp Diode Reverse Voltage   |          | V <sub>R</sub>        |                                                                  |            | —    | —    | 50    | V       |
| Clamp Diode Forward Current   |          | I <sub>F</sub>        |                                                                  |            | —    | —    | 350   | mA      |
| Power Dissipation             | AP       | P <sub>D</sub>        | Ta = 85°C                                                        |            | —    | —    | 0.76  | W       |
|                               | AFW      |                       | (Note) Ta = 85°C                                                 |            | —    | —    | 0.325 |         |

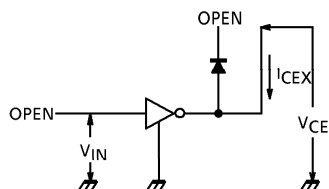
(Note) : On glass epoxy PCB (30 × 30 × 1.6 mm Cu 50%)

## ELECTRICAL CHARACTERISTICS (Ta = 25°C unless otherwise noted)

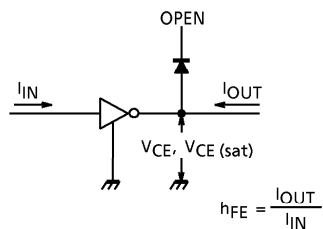
| CHARACTERISTIC                       |          | SYMBOL                | TEST CIR-<br>CUIT | TEST CONDITION                                                            |                           | MIN. | TYP. | MAX. | UNIT |
|--------------------------------------|----------|-----------------------|-------------------|---------------------------------------------------------------------------|---------------------------|------|------|------|------|
| Output Leakage Current               |          | I <sub>CEX</sub>      | 1                 | V <sub>CE</sub> = 50 V, Ta = 25°C                                         |                           | —    | —    | 50   | μA   |
|                                      |          |                       |                   | V <sub>CE</sub> = 50 V, Ta = 85°C                                         |                           | —    | —    | 100  |      |
| Collector-Emitter Saturation Voltage |          | V <sub>CE (sat)</sub> | 2                 | I <sub>OUT</sub> = 350 mA, I <sub>IN</sub> = 500 μA                       |                           | —    | 1.3  | 1.6  | V    |
|                                      |          |                       |                   | I <sub>OUT</sub> = 200 mA, I <sub>IN</sub> = 350 μA                       |                           | —    | 1.1  | 1.3  |      |
|                                      |          |                       |                   | I <sub>OUT</sub> = 100 mA, I <sub>IN</sub> = 250 μA                       |                           | —    | 0.9  | 1.1  |      |
| DC Current Transfer Ratio            |          | h <sub>FE</sub>       | 2                 | V <sub>CE</sub> = 2 V, I <sub>OUT</sub> = 350 mA                          |                           | 1000 | —    | —    |      |
| Input Current (Output On)            | ULN2003A | I <sub>IN (ON)</sub>  | 3                 | V <sub>IN</sub> = 2.4 V, I <sub>OUT</sub> = 350 mA                        |                           | —    | 0.4  | 0.7  | mA   |
|                                      | ULN2004A |                       |                   | V <sub>IN</sub> = 9.5 V, I <sub>OUT</sub> = 350 mA                        |                           | —    | 0.8  | 1.2  |      |
| Input Current (Output Off)           |          | I <sub>IN (OFF)</sub> | 4                 | I <sub>OUT</sub> = 500 μA, Ta = 85°C                                      |                           | 50   | 65   | —    | μA   |
| Input Voltage (Output On)            | ULN2003A | V <sub>IN (ON)</sub>  | 5                 | V <sub>CE</sub> = 2 V<br>h <sub>FE</sub> = 800                            | I <sub>OUT</sub> = 350 mA | —    | —    | 2.6  | V    |
|                                      |          |                       |                   |                                                                           | I <sub>OUT</sub> = 200 mA | —    | —    | 2.0  |      |
|                                      | ULN2004A |                       |                   |                                                                           | I <sub>OUT</sub> = 350 mA | —    | —    | 4.7  |      |
|                                      |          |                       |                   |                                                                           | I <sub>OUT</sub> = 200 mA | —    | —    | 4.4  |      |
| Clamp Diode Reverse Current          |          | I <sub>R</sub>        | 6                 | V <sub>R</sub> = 50 V, Ta = 25°C                                          |                           | —    | —    | 50   | μA   |
|                                      |          |                       |                   | V <sub>R</sub> = 50 V, Ta = 85°C                                          |                           | —    | —    | 100  |      |
| Clamp Diode Forward Voltage          |          | V <sub>F</sub>        | 7                 | I <sub>F</sub> = 350 mA                                                   |                           | —    | —    | 2.0  | V    |
| Input Capacitance                    |          | C <sub>IN</sub>       | —                 |                                                                           |                           | —    | 15   | —    | pF   |
| Turn-On Delay                        |          | t <sub>ON</sub>       | 8                 | V <sub>OUT</sub> = 50 V, R <sub>L</sub> = 125 Ω<br>C <sub>L</sub> = 15 pF |                           | —    | 0.1  | —    | μs   |
| Turn-Off Delay                       |          | t <sub>OFF</sub>      | 8                 | V <sub>OUT</sub> = 50 V, R <sub>L</sub> = 125 Ω<br>C <sub>L</sub> = 15 pF |                           | —    | 0.2  | —    |      |

**TEST CIRCUIT**

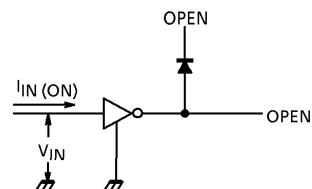
1.  $I_{CEX}$



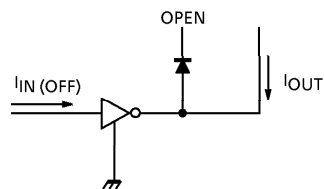
2.  $V_{CE} \text{ (sat)}, h_{FE}$



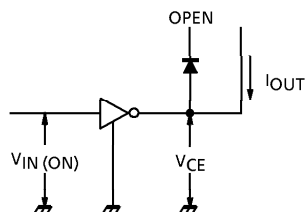
3.  $I_{IN} \text{ (ON)}$



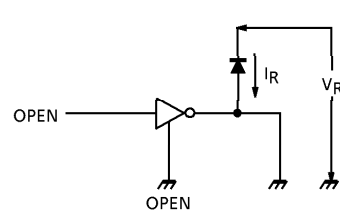
4.  $I_{IN} \text{ (OFF)}$



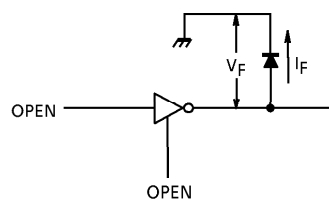
5.  $V_{IN} \text{ (ON)}$



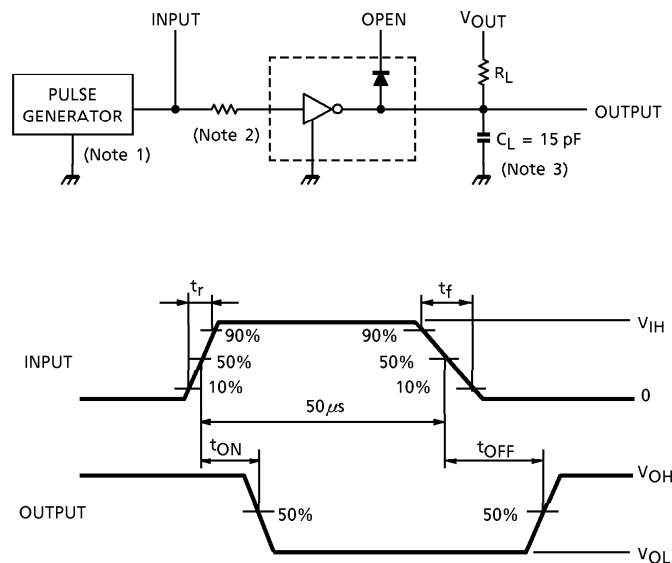
6.  $I_R$



7.  $V_F$



8.  $t_{ON}$ ,  $t_{OFF}$



- (Note 1) : Pulse width  $50 \mu s$ , duty cycle 10%  
Output impedance  $50 \Omega$ ,  $t_r \leq 5 ns$ ,  $t_f \leq 10 ns$
- (Note 2) : See below

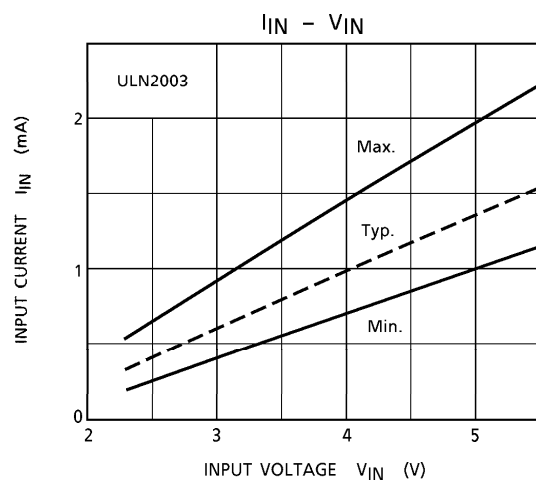
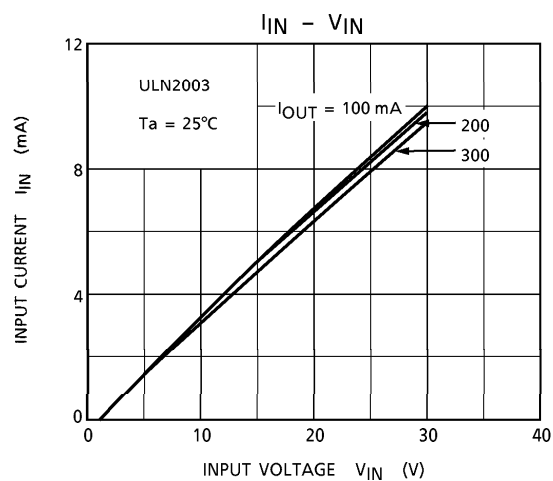
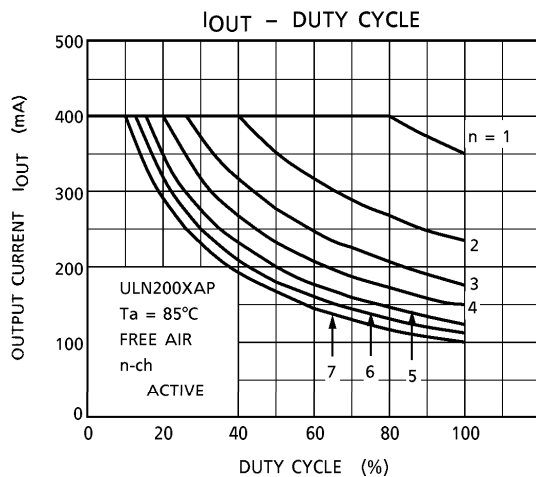
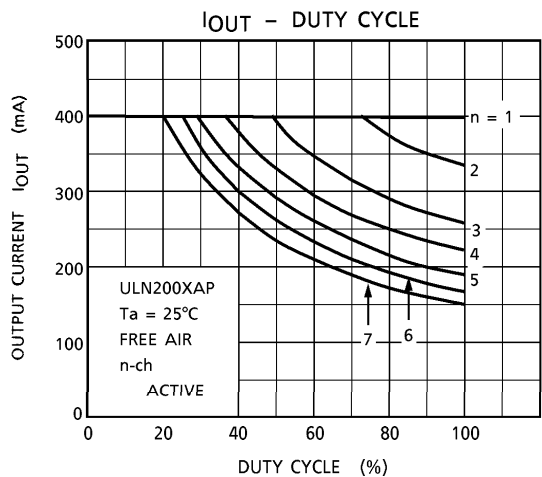
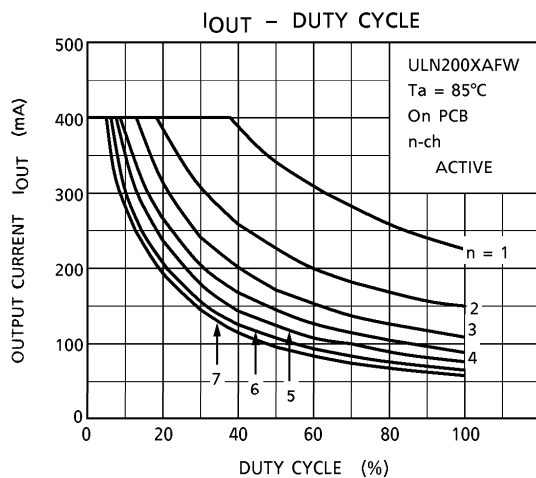
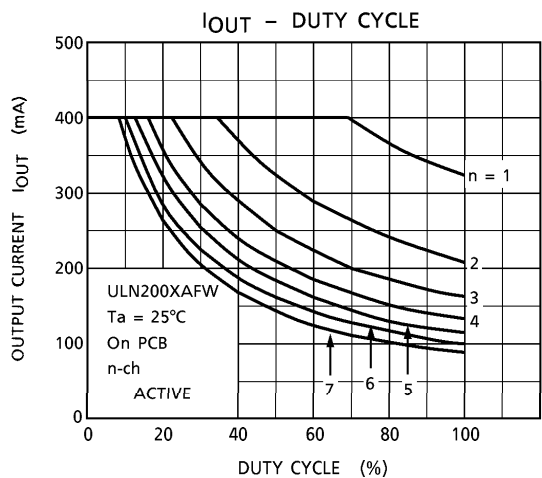
INPUT CONDITION

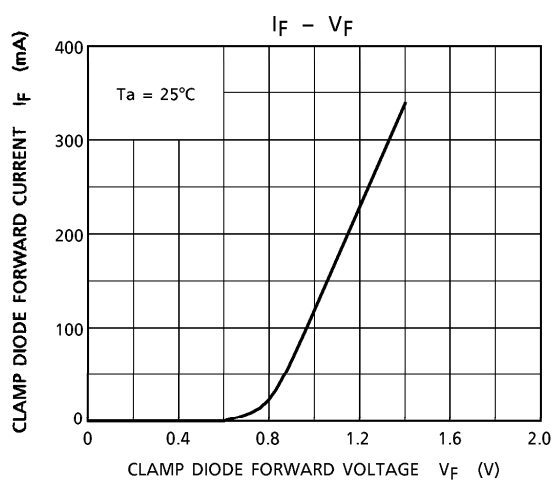
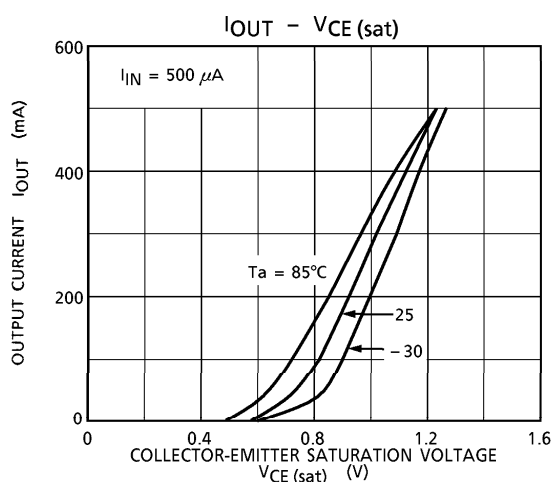
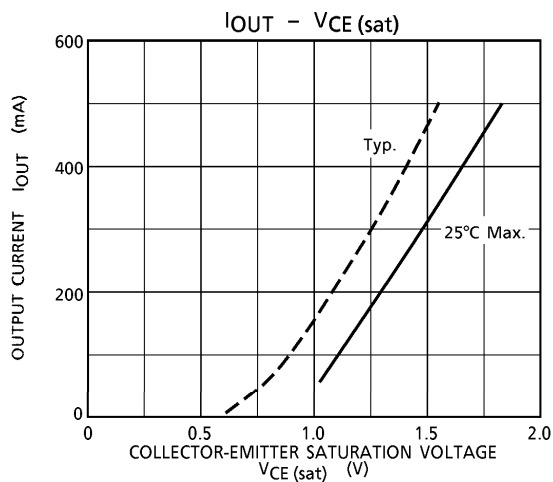
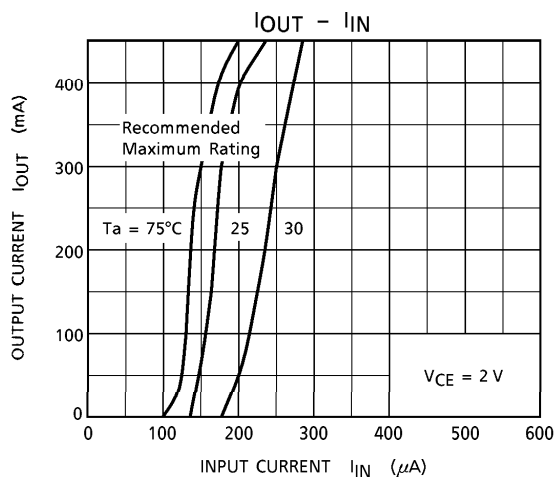
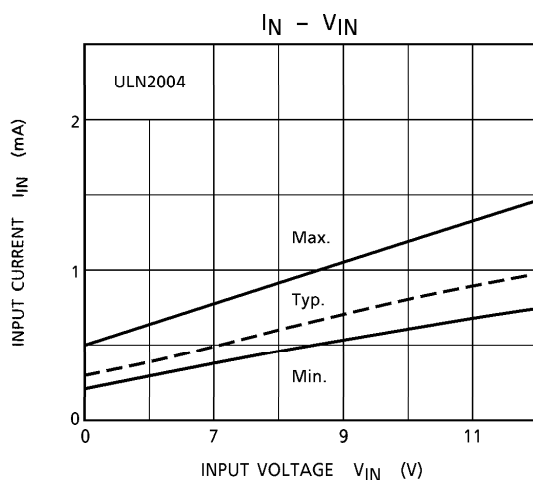
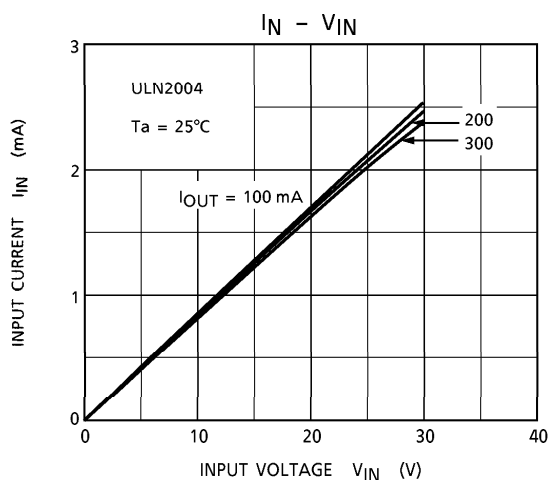
| TYPE NUMBER     | R1 | $V_{IH}$ |
|-----------------|----|----------|
| ULN2003AP / AFW | 0  | 3 V      |
| ULN2004AP / AFW | 0  | 8 V      |

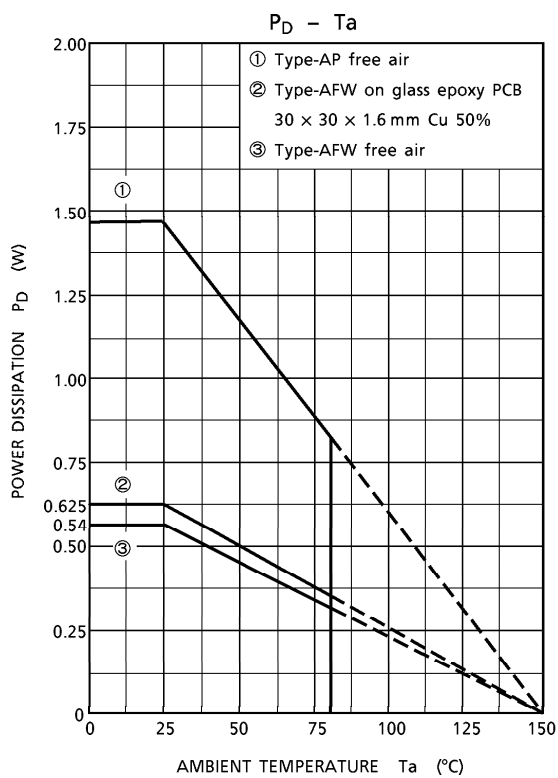
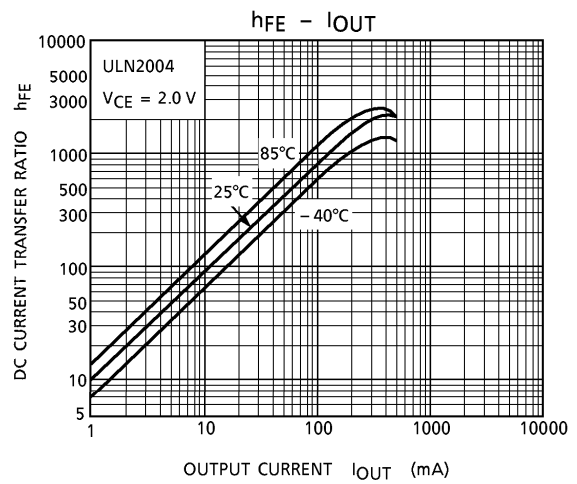
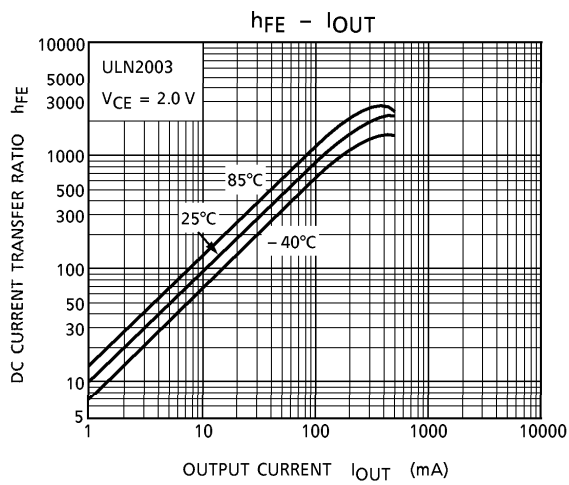
- (Note 3) :  $C_L$  includes probe and jig capacitance.

PRECAUTIONS for USING

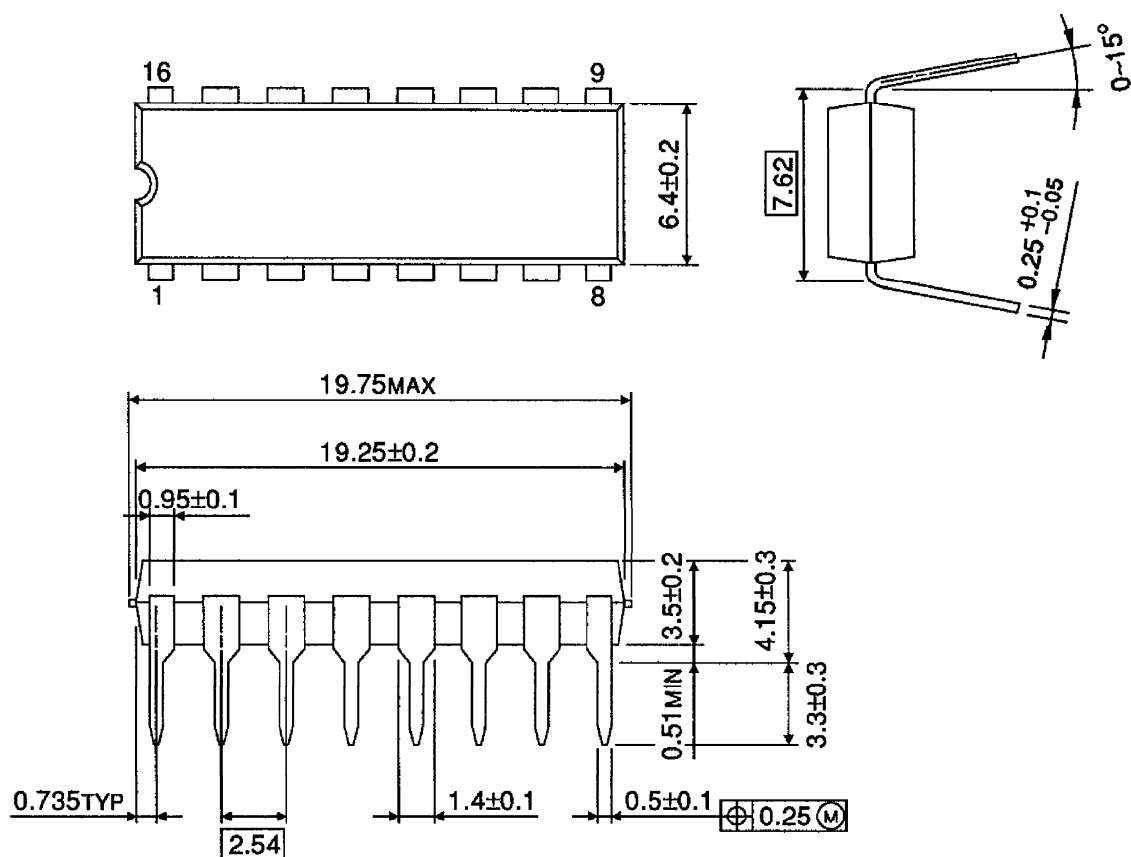
Utmost care is necessary in the design of the output line, COMMON and GND line since IC may be destroyed due to short-circuit between outputs, air contamination fault, or fault by improper grounding.





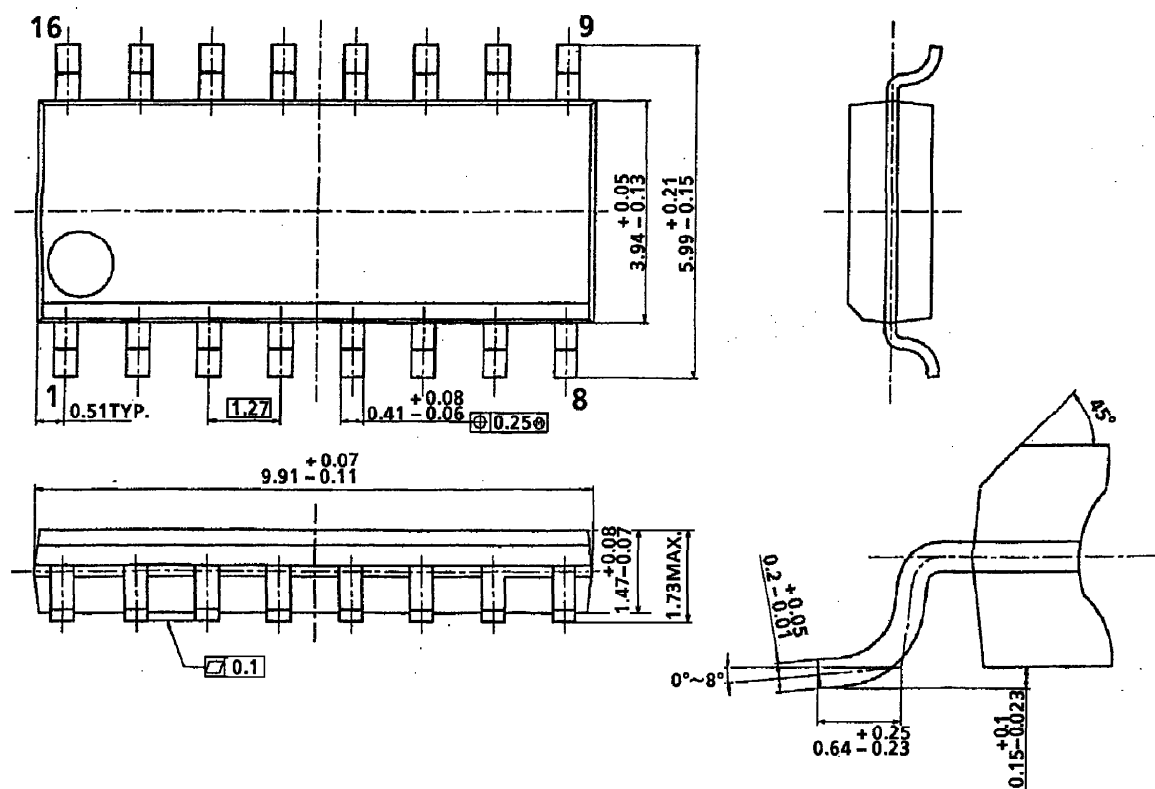


**OUTLINE DRAWING**  
DIP16-P-300-2.54A



Weight : 1.11 g (Typ.)

**OUTLINE DRAWING**  
SOL16-P-150-1.27A



Weight : 0.15 g (Typ.)