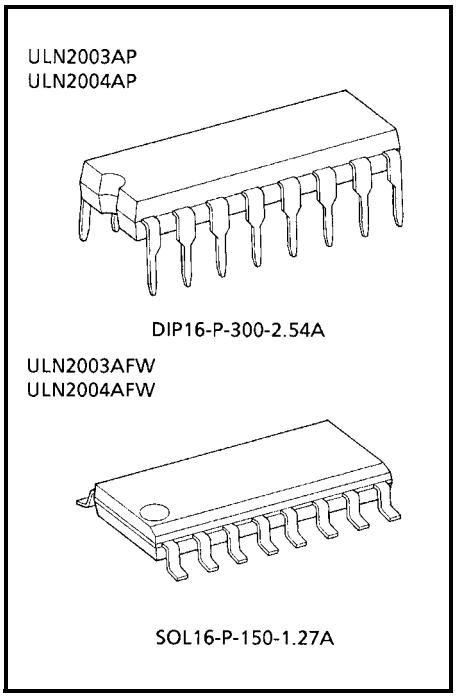
TOSHIBA Bipolar Digital Integrated Circuit Silicon Monolithic

ULN2003AP,ULN2003AFW,ULN2004AP,ULN2004AFW (Manufactured by Toshiba Malaysia)

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.



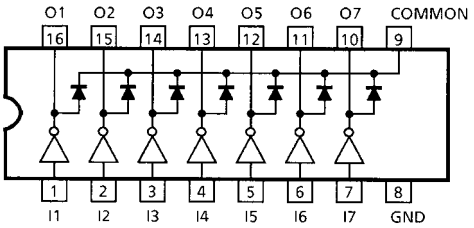
Weight
DIP16−P-300-2.54A : 1.11 g (typ.)
SOL16−P-150-1.27A: 0.15 g (typ.)

Features

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

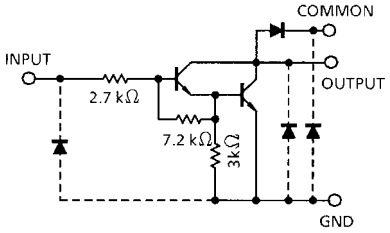
Type	Input Base Resistor	Designation
ULN2003AP/AFW	2.7 kΩ	TTL, 5 V CMOS
ULN2004AP/AFW	10.5 kΩ	6~15 V PMOS, CMOS

Pin Connection (top view)

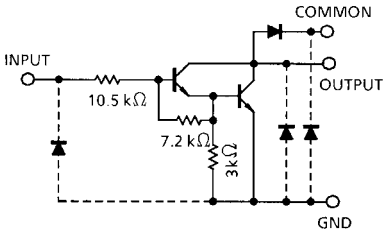


Schematics (each driver)

ULN2003AP/AFW



ULN2004AP/AFW



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		1.25 (Note)	
Operating Temperature		T_{opr}	−40~85	°C
Storage Temperature		T_{stg}	−55~150	°C

Note: On PCB (Test Board: JEDEC 2s2p)

Recommended Operating Conditions (Ta = –40 to 85°C)

Characteristic		Symbol	Test Condition		Min	Typ.	Max	Unit
Output sustaining voltage		$V_{CE\ (SUS)}$			0	—	50	V
Output current	AP	I_{OUT}	T_{pw} = 25 ms 7 Circuits Ta = 85°C T_j = 120°C	Duty = 10%	0	—	350	mA/ch
				Duty = 50%	0	—	100	
	AFW			Duty = 10%	0	—	300	
				Duty = 50%	0	—	90	
Input voltage		V_{IN}			0	—	24	V
Input voltage (output on)	ULN2003A	$V_{IN\ (ON)}$	I_{OUT} = 400 mA h_{FE} = 800		2.8	—	24	V
	ULN2004A				6.2	—	24	
Input voltage (output off)	ULN2003A	$V_{IN\ (OFF)}$			0	—	0.7	V
	ULN2004A				0	—	1.0	
Clamp diode reverse voltage		V_R			—	—	50	V
Clamp diode forward current		I_F			—	—	350	mA
Power dissipation	AP	P_D	Ta = 85°C		—	—	0.76	W
	AFW		Ta = 85°C	(Note)	—	—	0.65	

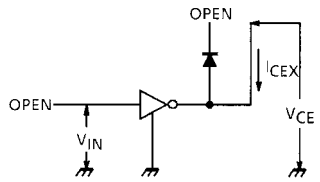
Note: On PCB (Test Board: JEDEC 2s2p)

Electrical Characteristics (Ta = 25°C unless otherwise noted)

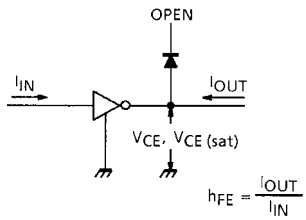
Characteristic		Symbol	Test Circuit	Test Condition		Min	Typ.	Max	Unit
Output leakage current		I_{CEX}	1	V_{CE} = 50 V, Ta = 25°C		—	—	50	μA
				V_{CE} = 50 V, Ta = 85°C		—	—	100	
Collector−emitter saturation voltage		$V_{CE\ (sat)}$	2	I_{OUT} = 350 mA, I_{IN} = 500 μA		—	1.3	1.6	V
				I_{OUT} = 200 mA, I_{IN} = 350 μA		—	1.1	1.3	
				I_{OUT} = 100 mA, I_{IN} = 250 μA		—	0.9	1.1	
DC Current transfer ratio		h_{FE}	2	V_{CE} = 2 V, I_{OUT} = 350 mA		1000	—	—	
Input current (output on)	ULN2003A	$I_{IN\ (ON)}$	3	V_{IN} = 2.4 V, I_{OUT} = 350 mA		—	0.4	0.7	mA
	ULN2004A			V_{IN} = 9.5 V, I_{OUT} = 350 mA		—	0.8	1.2	
Input current (output off)		$I_{IN\ (OFF)}$	4	I_{OUT} = 500 μA, Ta = 85°C		50	65	—	μA
Input voltage (output on)	ULN2003A	$V_{IN\ (ON)}$	5	V_{CE} = 2 V h_{FE} = 800	I_{OUT} = 350 mA	—	—	2.6	V
					I_{OUT} = 200 mA	—	—	2.0	
	ULN2004A				I_{OUT} = 350 mA	—	—	4.7	
					I_{OUT} = 200 mA	—	—	4.4	
Clamp diode reverse current		I_R	6	V_R = 50 V, Ta = 25°C		—	—	50	μA
				V_R = 50 V, Ta = 85°C		—	—	100	
Clamp diode forward voltage		V_F	7	I_F = 350 mA		—	—	2.0	V
Input capacitance		C_{IN}	—			—	15	—	pF
Turn−on delay		t_{ON}	8	V_{OUT} = 50 V, R_L = 125 Ω C_L = 15 pF		—	0.1	—	μs
Turn−off delay		t_{OFF}	8	V_{OUT} = 50 V, R_L = 125 Ω C_L = 15 pF		—	0.2	—	

Test Circuit

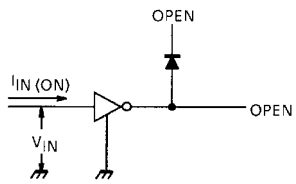
1. I_{CEX}



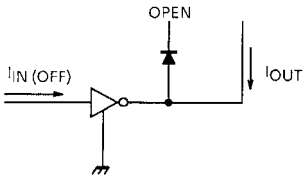
2. $V_{CE\ (sat)}$, h_{FE}



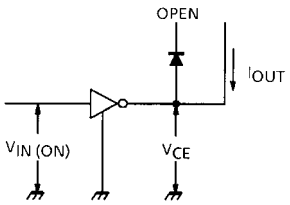
3. $I_{IN\ (ON)}$



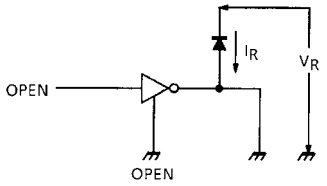
4. $I_{IN\ (OFF)}$



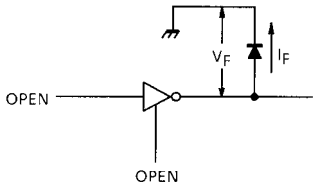
5. $V_{IN\ (ON)}$



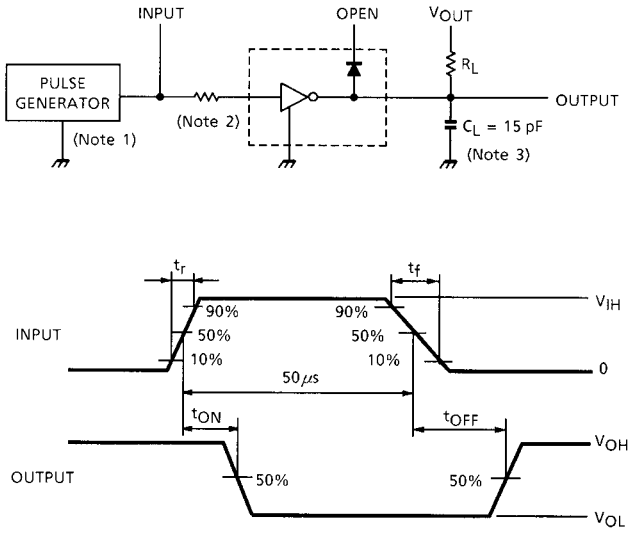
6. I_R



7. V_F



8. t_{ON}, t_{OFF}



Note 1: Pulse width 50 μs, duty cycle 10%
Output impedance 50 Ω, $t_r \leq 5$ ns, $t_f \leq 10$ ns

Note 2: See below

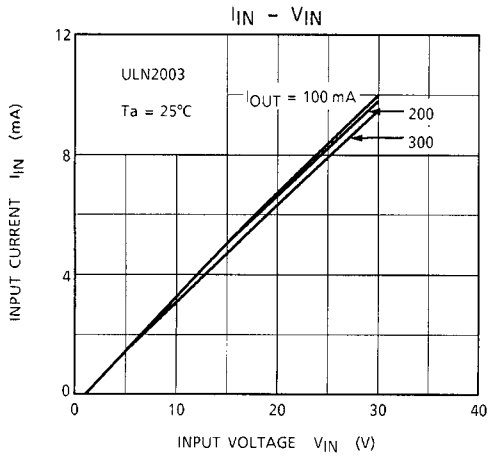
Input Condition

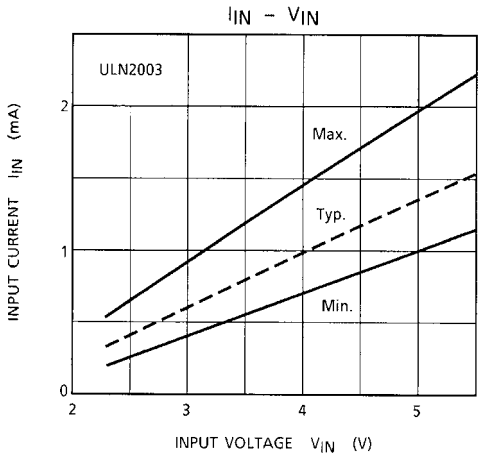
Type Number	R1	V_{IH}
ULN2003AP/AFW	0	3 V
ULN2004AP/AFW	0	8 V

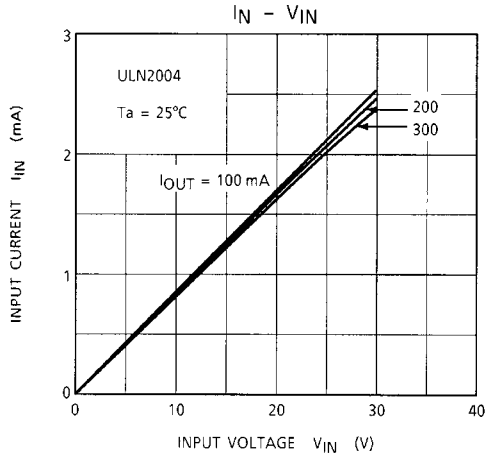
Note 3: C_L includes probe and jig capacitance.

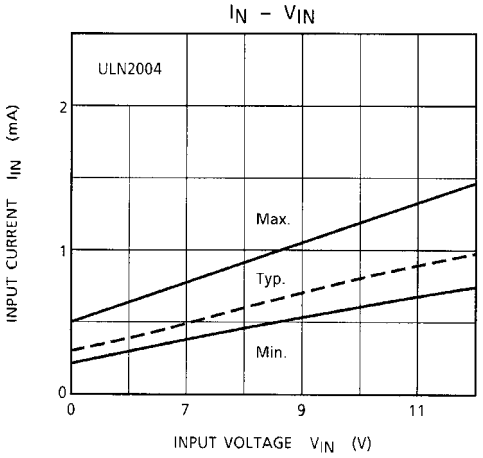
Precautions for Using

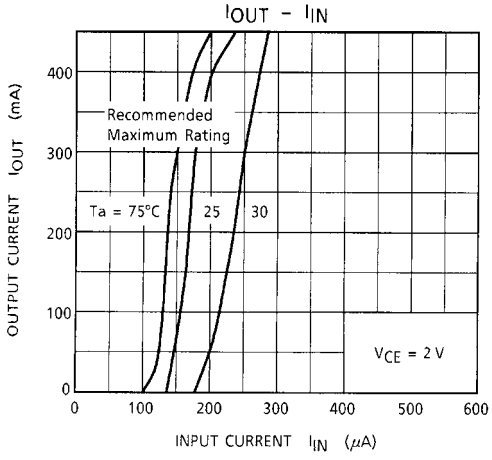
This IC does not include built-in protection circuits for excess current or overvoltage.
If this IC is subjected to excess current or overvoltage, it may be destroyed.
Hence, the utmost care must be taken when systems which incorporate this IC are designed.
Utmost care is necessary in the design of the 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.

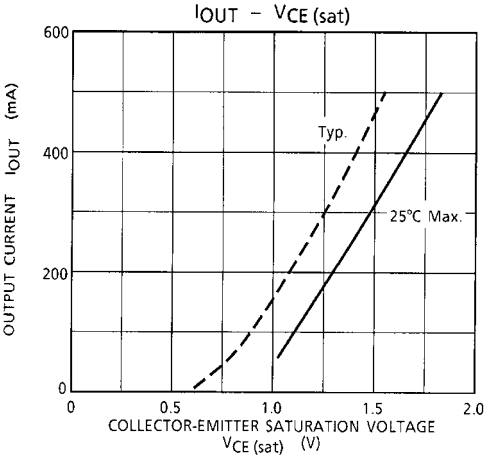

I_{IN} – V_{IN}
ULN2003
Ta = 25°C
I_{OUT} = 100 mA
200
300
INPUT CURRENT I_{IN} (mA)
INPUT VOLTAGE V_{IN} (V)
0
4
8
12
0
10
20
30
40

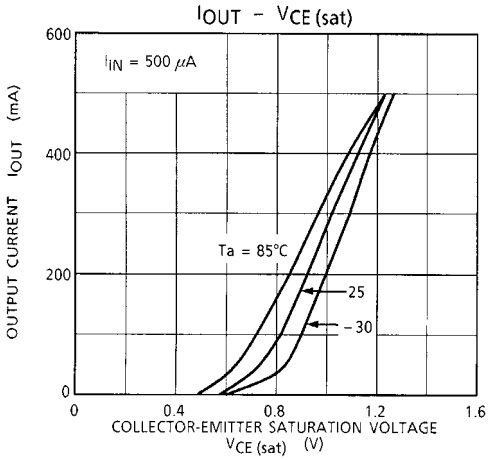

I_{IN} – V_{IN}
ULN2003
Max.
Typ.
Min.
INPUT CURRENT I_{IN} (mA)
INPUT VOLTAGE V_{IN} (V)
0
1
2
2
3
4
5

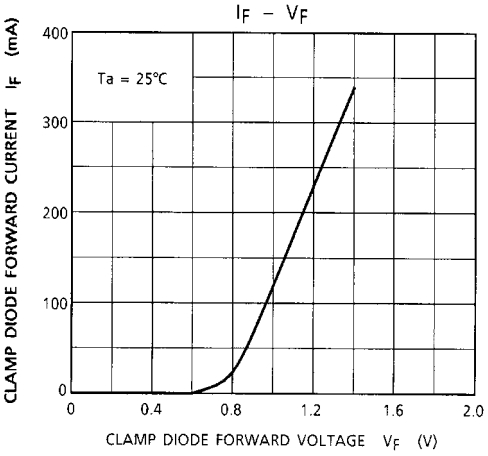

I_N – V_{IN}
ULN2004
Ta = 25°C
200
300
I_{OUT} = 100 mA
INPUT CURRENT I_{IN} (mA)
INPUT VOLTAGE V_{IN} (V)
0
1
2
3
0
10
20
30
40

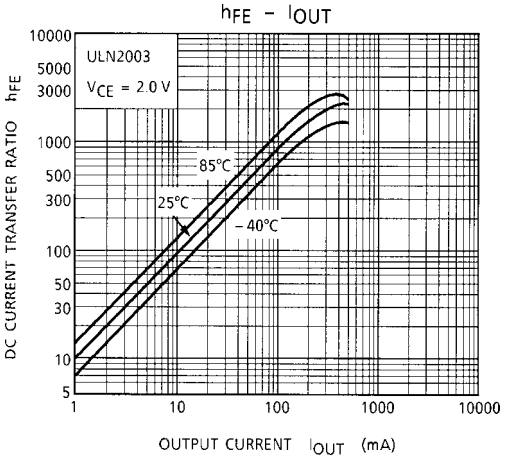

I_N – V_{IN}
ULN2004
Max.
Typ.
Min.
INPUT CURRENT I_{IN} (mA)
INPUT VOLTAGE V_{IN} (V)
0
1
2
0
7
9
11

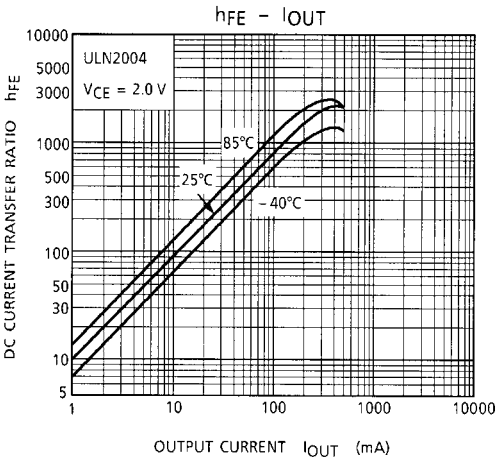

I_{OUT} – I_{IN}
Recommended
Maximum Rating
Ta = 75°C
25
30
V_{CE} = 2 V
OUTPUT CURRENT I_{OUT} (mA)
INPUT CURRENT I_{IN} (μA)
0
100
200
300
400
0
100
200
300
400
500
600

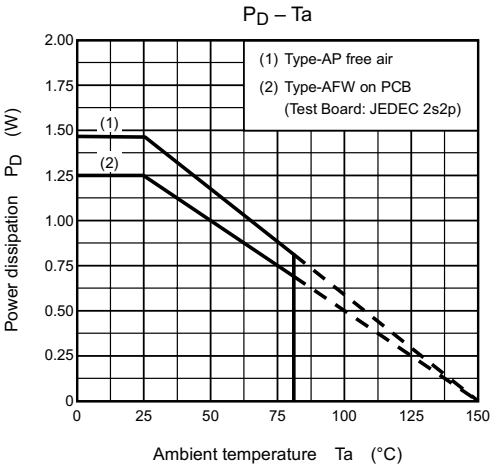

I_{OUT} – $V_{CE (sat)}$
Typ.
25°C Max.
OUTPUT CURRENT I_{OUT} (mA)
COLLECTOR-EMITTER SATURATION VOLTAGE
$V_{CE (sat)}$ (V)
0
200
400
600
0
0.5
1.0
1.5
2.0


I_{OUT} – $V_{CE (sat)}$
I_{IN} = 500 μA
Ta = 85°C
25
– 30
OUTPUT CURRENT I_{OUT} (mA)
COLLECTOR-EMITTER SATURATION VOLTAGE
$V_{CE (sat)}$ (V)


I_F – V_F
Ta = 25°C
CLAMP DIODE FORWARD CURRENT I_F (mA)
CLAMP DIODE FORWARD VOLTAGE V_F (V)

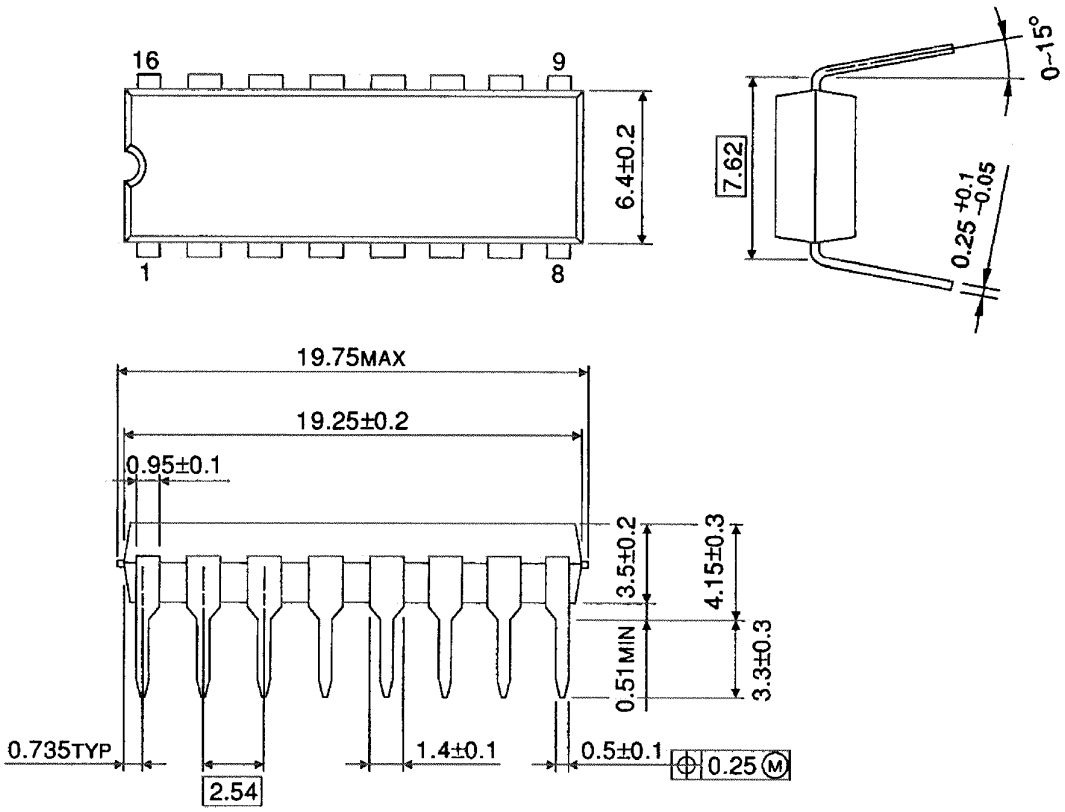

h_{FE} – I_{OUT}
ULN2003
V_{CE} = 2.0 V
85°C
25°C
– 40°C
DC CURRENT TRANSFER RATIO h_{FE}
OUTPUT CURRENT I_{OUT} (mA)


h_{FE} – I_{OUT}
ULN2004
V_{CE} = 2.0 V
85°C
25°C
– 40°C
DC CURRENT TRANSFER RATIO h_{FE}
OUTPUT CURRENT I_{OUT} (mA)


P_D – Ta
(1) Type-AP free air
(2) Type-AFW on PCB
(Test Board: JEDEC 2s2p)
(1)
(2)
Power dissipation P_D (W)
Ambient temperature Ta (°C)

Package Dimensions

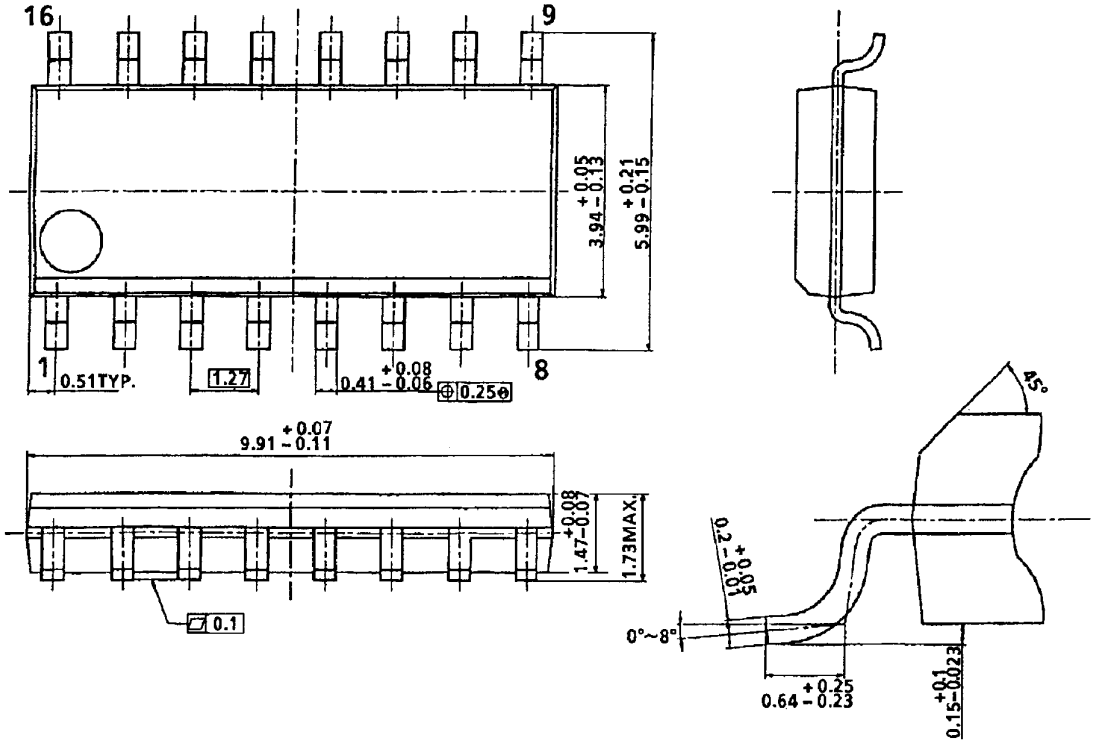
DIP16-P-300-2.54A Unit : mm



Weight: 1.11 g (typ.)

Package Dimensions

SOL16-P-150-1.27A Unit : mm



Weight: 0.15 g (typ.)

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030519EBA

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