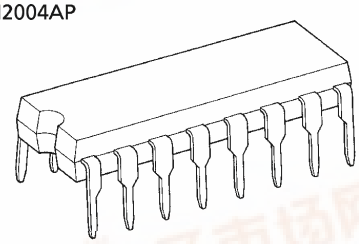
TOSHIBA BIPOLAR DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

ULN2003AP, ULN2003AFW, ULN2004AP, ULN2004AFW

7CH DARLINGTON SINK DRIVER

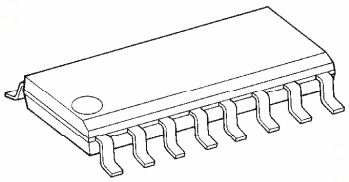
The ULN2003AP / AFW Series are high-voltage, high-current darlington drivers comprised of seven NPN darlington pairs.
All units feature integral clamp diodes for switching inductive loads.
Applications include relay, hammer, lamp and display (LED) drivers.

ULN2003AP
ULN2004AP



DIP16-P-300-2.54A

ULN2003AFW
ULN2004AFW



SOL16-P-150-1.27A

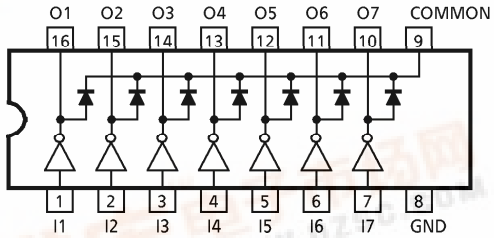
Weight
DIP16-P-300-2.54A : 1.11g (Typ.)
SOL16-P-150-1.27A : 0.15g (Typ.)

FEATURES

- Output current (single output) 500mA MAX.
- High sustaining voltage output
  50V MIN. (ULN2003AP / AFW Series)
- 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	2.7kΩ	TTL, 5V CMOS
ULN2004AP / AFW	10.5kΩ	6~15V PMOS, CMOS

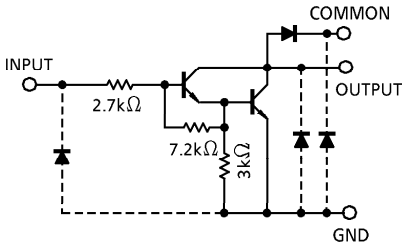
PIN CONNECTION (TOP VIEW)



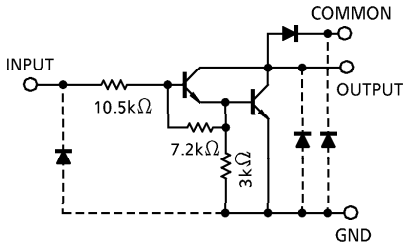
961001EBA1

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		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 × 1.6mm Cu 50%)

RECOMMENDED OPERATING CONDITIONS (Ta = −40~85°C)

CHARACTERISTIC		SYMBOL	CONDITION		MIN.	TYP.	MAX.	UNIT
Output Sustaining Voltage		$V_{CE\ (SUS)}$			0	—	50	V
Output Current	AP	I_{OUT}	T_{pw} = 25ms 7 Circuits Ta = 85°C T_j = 120°C	Duty = 10%	0	—	370	mA / ch
				Duty = 50%	0	—	130	
	AFW			Duty = 10%	0	—	233	
				Duty = 50%	0	—	70	
Input Voltage		V_{IN}			0	—	24	V
Input Voltage (Output On)	ULN2003A	$V_{IN\ (ON)}$	I_{OUT} = 400mA 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		(Note) Ta = 85°C		—	—	0.325	

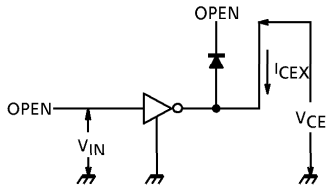
(Note) On glass epoxy PCB (30 × 30 × 1.6mm Cu 50%)

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

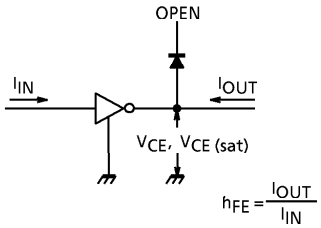
CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Output Leakage Current		I_{CEX}	1	V_{CE} = 50V, Ta = 25°C		—	—	50	μA
				V_{CE} = 50V, Ta = 85°C		—	—	100	
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$	2	I_{OUT} = 350mA, I_{IN} = 500μA		—	1.3	1.6	V
				I_{OUT} = 200mA, I_{IN} = 350μA		—	1.1	1.3	
				I_{OUT} = 100mA, I_{IN} = 250μA		—	0.9	1.1	
DC Current Transfer Ratio		h_{FE}	2	V_{CE} = 2V, I_{OUT} = 350mA		1000	—	—	
Input Current (Output On)	ULN2003A	$I_{IN\ (ON)}$	3	V_{IN} = 2.4V, I_{OUT} = 350mA		—	0.4	0.7	mA
	ULN2004A			V_{IN} = 9.5V, I_{OUT} = 350mA		—	0.8	1.2	
Input Current (Output Off)		$I_{IN\ (OFF)}$	4	I_{OUT} = 500μA, Ta = 85°C		50	65	—	μA
Input Voltage (Output On)	ULN2003A	$V_{IN\ (ON)}$	5	V_{CE} = 2V, h_{FE} = 800	I_{OUT} = 350mA	—	—	2.6	V
					I_{OUT} = 200mA	—	—	2.0	
	ULN2004A				I_{OUT} = 350mA	—	—	4.7	
					I_{OUT} = 200mA	—	—	4.4	
Clamp Diode Reverse Current		I_R	6	V_R = 50V, Ta = 25°C		—	—	50	μA
				V_R = 50V, Ta = 85°C		—	—	100	
Clamp Diode Forward Voltage		V_F	7	I_F = 350mA		—	—	2.0	V
Input Capacitance		C_{IN}	—			—	15	—	pF
Turn-On Delay		t_{ON}	8	V_{OUT} = 50V, R_L = 125Ω, C_L = 15pF		—	0.1	—	μs
Turn-Off Delay		t_{OFF}	8	V_{OUT} = 50V, R_L = 125Ω, C_L = 15pF		—	0.2	—	

TEST CIRCUIT

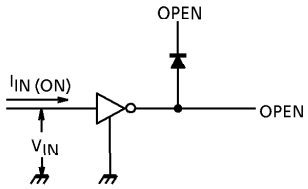
1. I_{CEX}



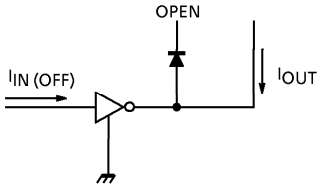
2. $V_{CE\ (sat)}$, h_{FE}



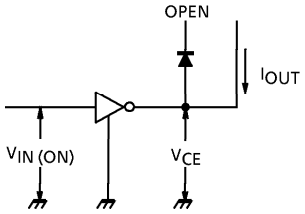
3. $I_{IN\ (ON)}$



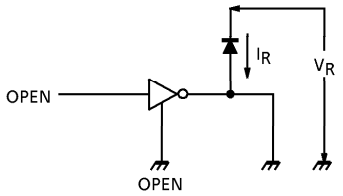
4. $I_{IN\ (OFF)}$



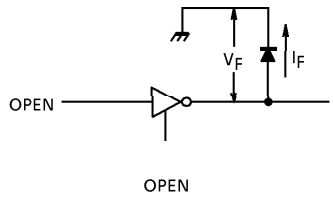
5. $V_{IN\ (ON)}$



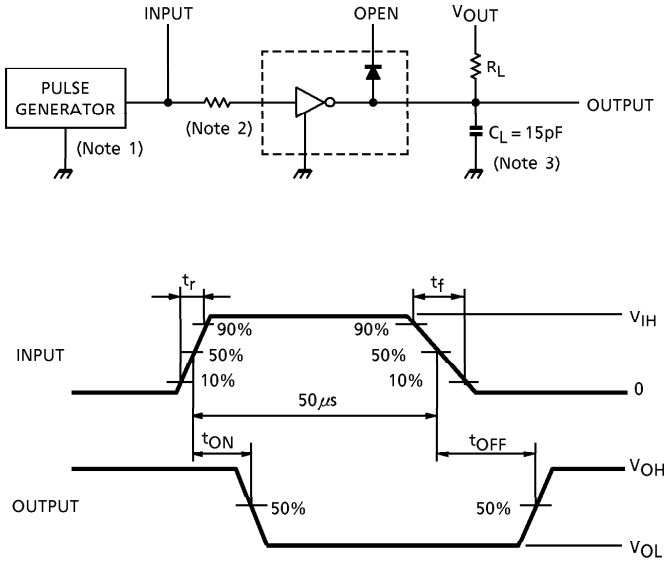
6. I_R



7. V_F



8. t_{ON}, t_{OFF}



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

(Note 2) See below

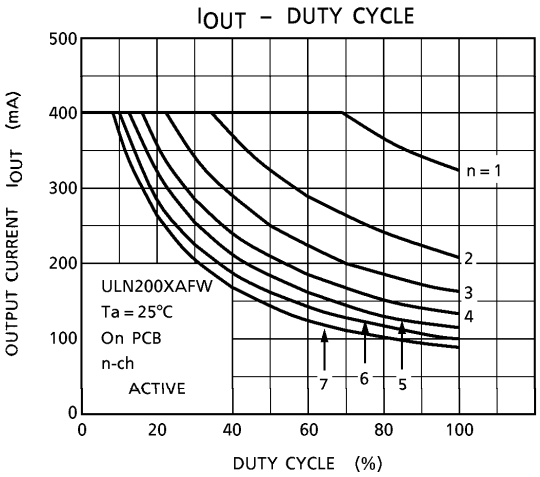
INPUT CONDITION

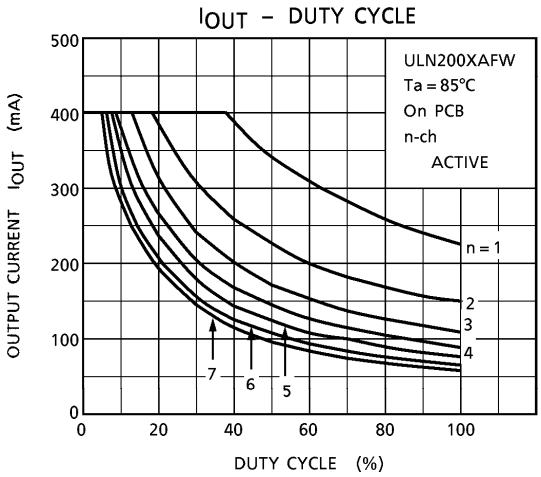
TYPE NUMBER	R1	V_{IH}
ULN2003AP / AFW	0	3V
ULN2004AP / AFW	0	8V

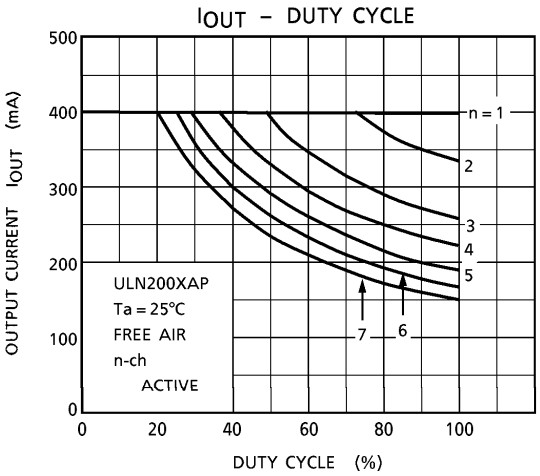
(Note 3) C_L includes probe and jig capacitance.

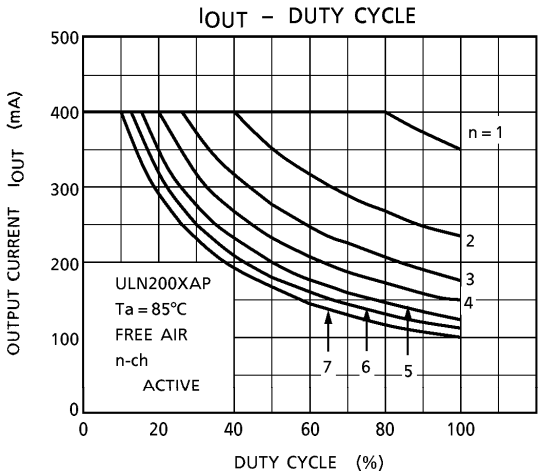
PRECAUTIONS for USING

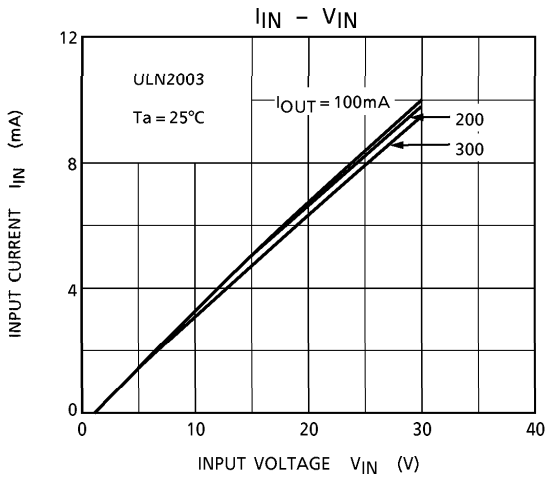
Utmost care is necessary in the design of the output line, COMMON and GND line since IC may be destroyed due to short-circuit between outputs, air contamination fault, or fault by improper grounding.

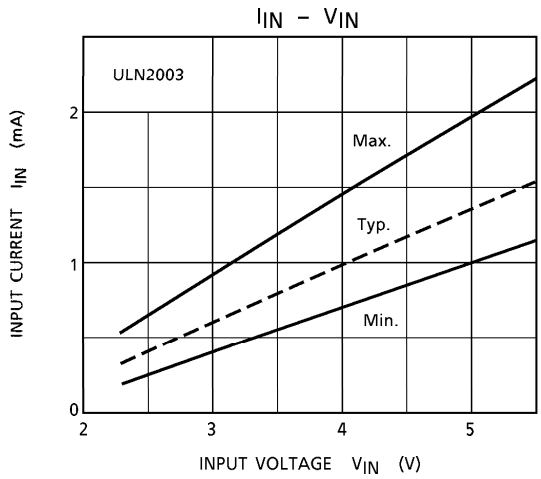

I_{OUT} – DUTY CYCLE
OUTPUT CURRENT I_{OUT} (mA)
DUTY CYCLE (%)
ULN200XAFW
Ta = 25°C
On PCB
n-ch
ACTIVE
n = 1
2
3
4
7
6
5


I_{OUT} – DUTY CYCLE
OUTPUT CURRENT I_{OUT} (mA)
DUTY CYCLE (%)
ULN200XAFW
Ta = 85°C
On PCB
n-ch
ACTIVE
n = 1
2
3
4
7
6
5

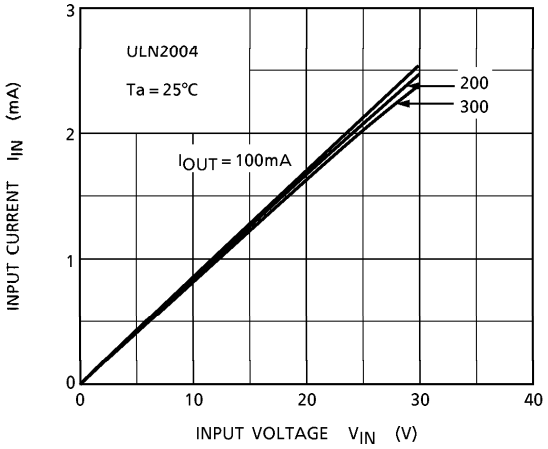

I_{OUT} – DUTY CYCLE
OUTPUT CURRENT I_{OUT} (mA)
DUTY CYCLE (%)
ULN200XAP
Ta = 25°C
FREE AIR
n-ch
ACTIVE
n = 1
2
3
4
5
7
6


I_{OUT} – DUTY CYCLE
OUTPUT CURRENT I_{OUT} (mA)
DUTY CYCLE (%)
ULN200XAP
Ta = 85°C
FREE AIR
n-ch
ACTIVE
n = 1
2
3
4
7
6
5

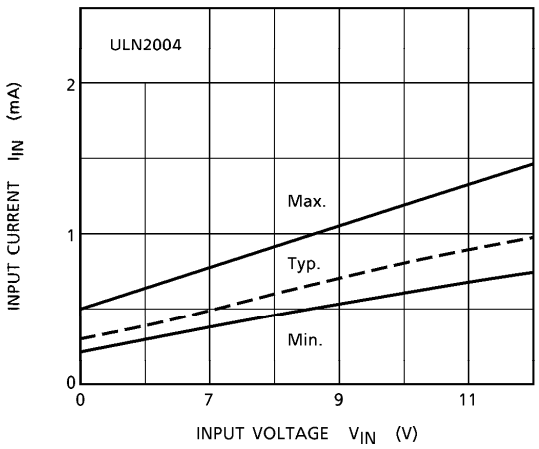

I_{IN} – V_{IN}
INPUT CURRENT I_{IN} (mA)
INPUT VOLTAGE V_{IN} (V)
ULN2003
Ta = 25°C
I_{OUT} = 100mA
200
300


I_{IN} – V_{IN}
INPUT CURRENT I_{IN} (mA)
INPUT VOLTAGE V_{IN} (V)
ULN2003
Max.
Typ.
Min.

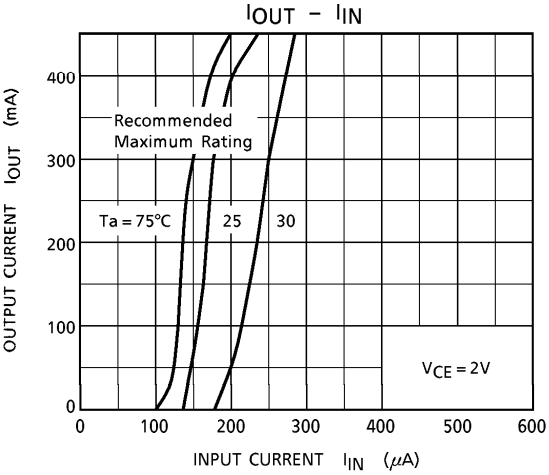
$I_N - V_{IN}$



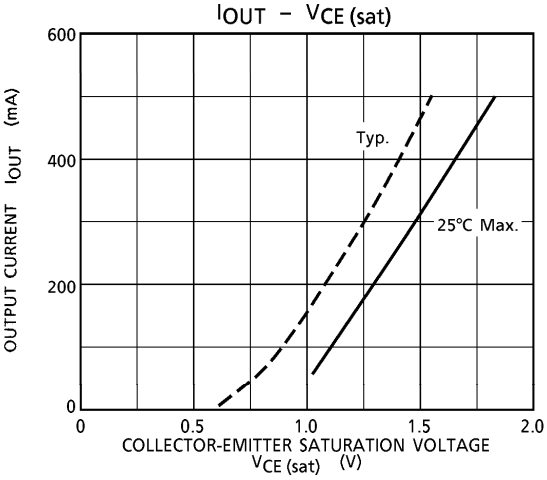
$I_N - V_{IN}$



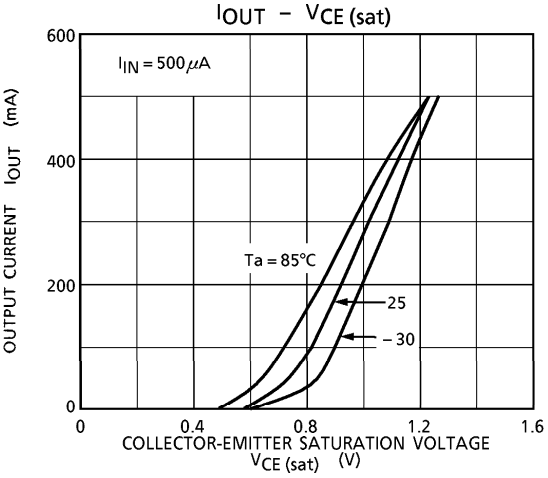
$I_{OUT} - I_{IN}$



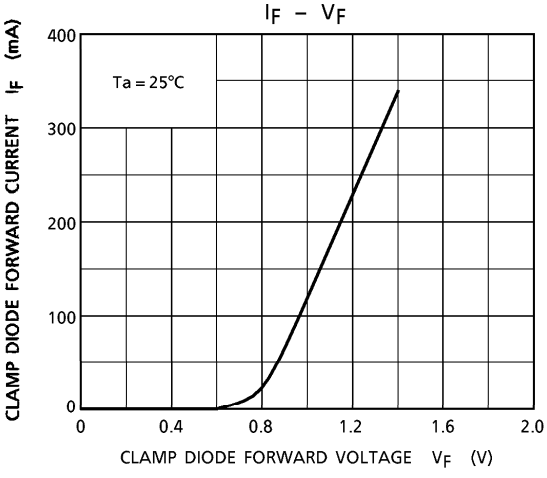
$I_{OUT} - V_{CE\,(sat)}$

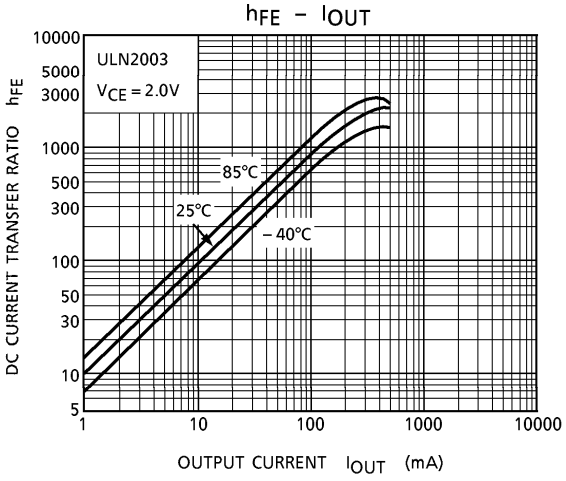


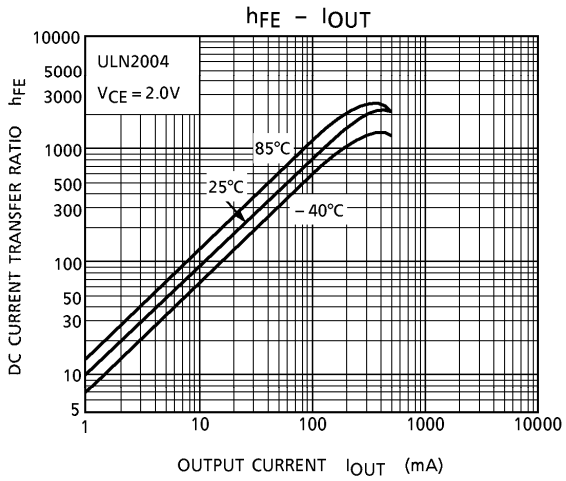
$I_{OUT} - V_{CE\,(sat)}$

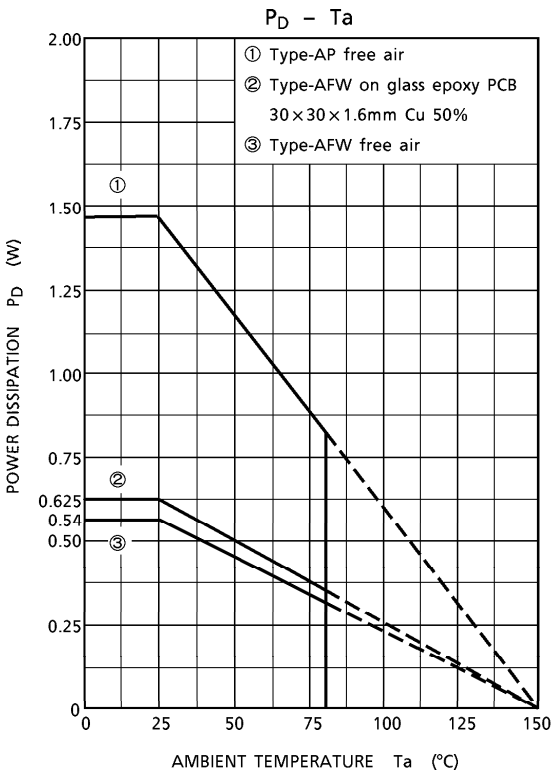


$I_F - V_F$

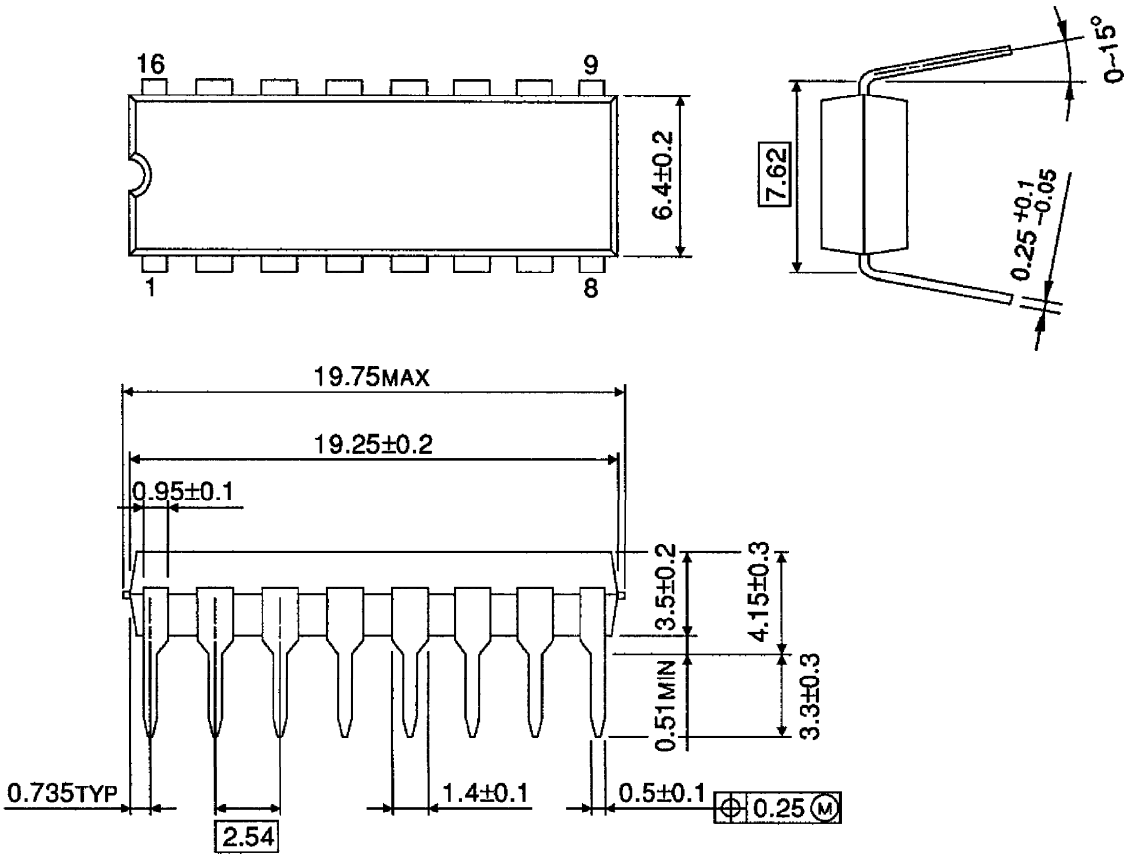



h_{FE} – I_{OUT}
ULN2003
V_{CE} = 2.0V
85°C
25°C
– 40°C
DC CURRENT TRANSFER RATIO h_{FE}
OUTPUT CURRENT I_{OUT} (mA)
10000
5000
3000
1000
500
300
100
50
30
10
5
1
10
100
1000
10000


h_{FE} – I_{OUT}
ULN2004
V_{CE} = 2.0V
85°C
25°C
– 40°C
DC CURRENT TRANSFER RATIO h_{FE}
OUTPUT CURRENT I_{OUT} (mA)
10000
5000
3000
1000
500
300
100
50
30
10
5
1
10
100
1000
10000

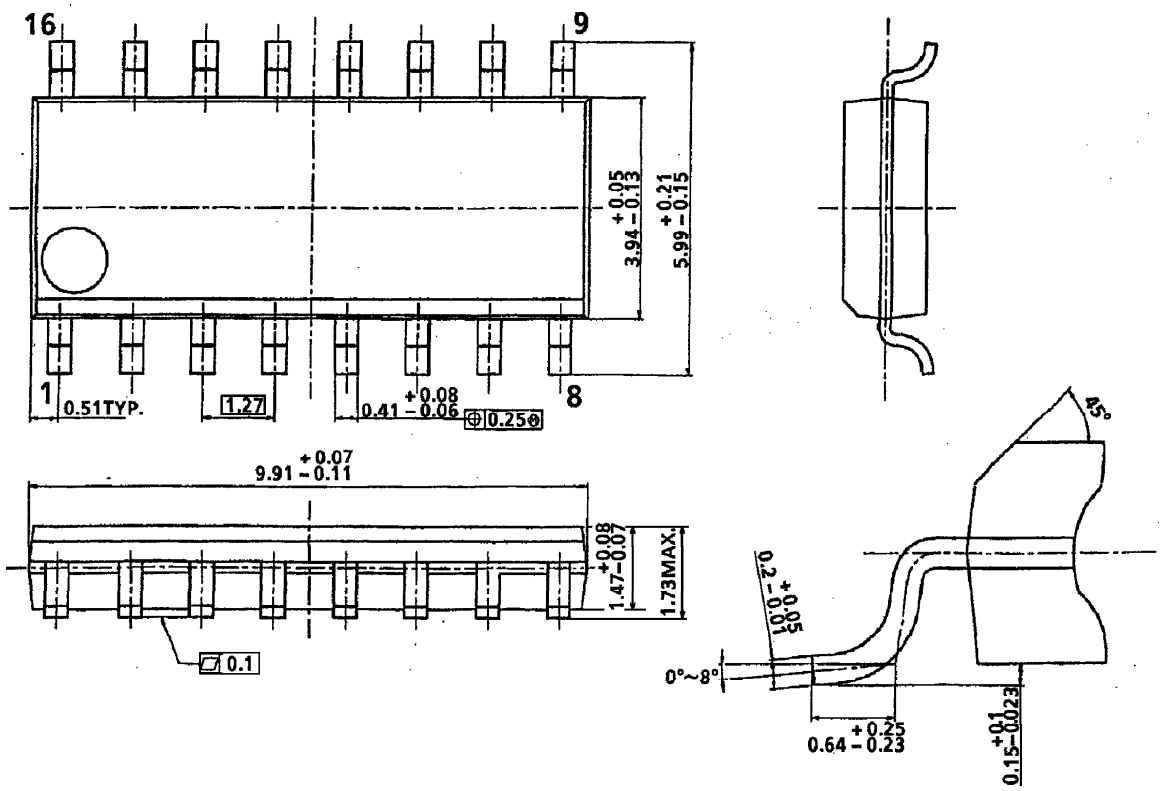

P_D – Ta
① Type-AP free air
② Type-AFW on glass epoxy PCB
30×30×1.6mm Cu 50%
③ Type-AFW free air
POWER DISSIPATION P_D (W)
AMBIENT TEMPERATURE Ta (°C)
2.00
1.75
1.50
1.25
1.00
0.75
0.625
0.54
0.50
0.25
0
0
25
50
75
100
125
150

OUTLINE DRAWING
DIP16-P-300-2.54A



Weight : 1.11g (Typ.)

OUTLINE DRAWING
SOL16-P-150-1.27A



Weight : 0.15g (Typ.)