A new seven-channel high-voltage, high-current Darlington transistor array

1. Description

The ULN2003A is a monolithic integrated high-voltage, high-current Darlington transistor array. The circuit internally contains seven independent Darlington driver channels. It features built-in freewheeling diodes for driving inductive loads such as relays and stepper motors. Each Darlington transistor can deliver up to 500mA of collector current. Higher output current capability can be achieved by paralleling multiple Darlington transistors. This device is widely used in relay drivers, lighting drivers, display (LED) drivers, stepper motor drivers, and logic buffers.

Each Darlington channel of the ULN2003A includes a series 2.7 kΩ base resistor, allowing direct interfacing with TTL/CMOS logic at 5 V operating voltage. It can directly handle data that would otherwise require standard logic buffers.

2. Features

- 500mA collector output current (per channel)
- High-voltage resistant (50V)
- Input compatible TTL/CMOS logic signals
- Widely used in relay drive applications
- Electrostatic capacity: 2000V(HBM)

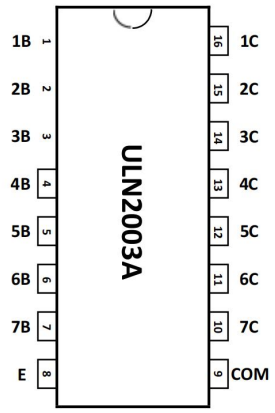
3. Applications

- Relay drive
- Indicator light drive
- Display drive

4.Order Information

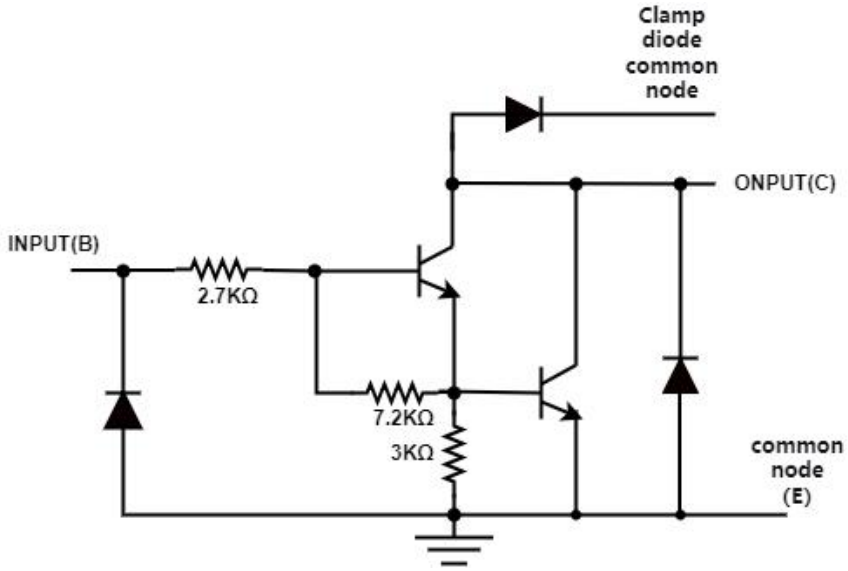
Part Number	Temperature Range	Package Description	Ordering Code	Packing Quantity
ULN2003A	-40℃ ~ +85℃	SOP16	ULN2003AYSOP16G/TR	Tape and Reel,4000
	-40℃ ~ +85℃	DIP-16	ULN2003AYDIP16G/TB	Tube,25

5. Pin Configuration and Functions



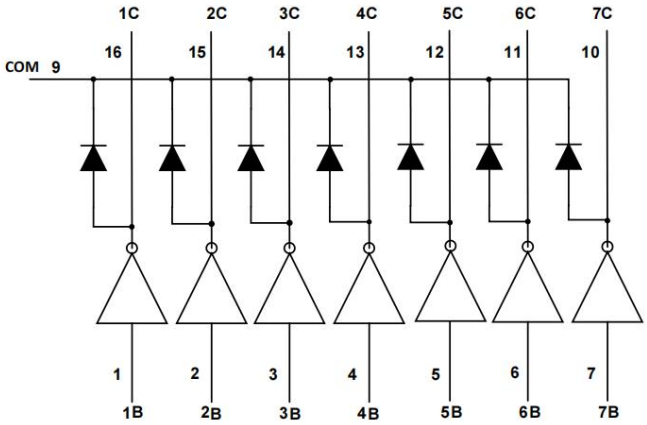
Pin Number	Pin Name	Input/Output	Pin Function Description
1	1B	I	I Channel Input Pin
2	2B	I	2 Channel Input Pin
3	3B	I	3 Channel Input Pin
4	4B	I	4 Channel Input Pin
5	5B	I	5 Channel Input Pin
6	6B	I	6 Channel Input Pin
7	7B	I	7 Channel Input Pin
8	E	-	GND
9	COM	-	Common terminal of the clamping diode
10	7C	O	7 Channel Output Pin
11	6C	O	6 Channel Output Pin
12	5C	O	5 Channel Output Pin
13	4C	O	4 Channel Output Pin
14	3C	O	3 Channel Output Pin
15	2C	O	2 Channel Output Pin
16	1C	O	I Channel Output Pin

6. Functional Block Diagram (Single-channel Darlington)



Schematic diagram of the ULN2003A single-channel drive circuit

7. Logic Diagram



8. Absolute Maximum Ratings

(T_A= 25°C, Unless Otherwise Specified)

Parameter		Symbol	Range	Unit
Collector-Emitter voltage (Pins 10–16)		V_{CE}	-0.5~50	V
COM Terminal Voltage (Pin 9)		V_{COM}	50	V
Input Voltage (Pin 1–7)		V_I	-0.5~30	V
Collector peak current		I_{CP}	500	mA/ch
Positive peak current of the output clamping diode in forward direction		I_{OK}	500	mA
Maximum peak current of the total emitter		I_{ET}	-2.5	A
Maximum operating temperature (2)		T_J	150	℃
Welding temperature		-	260	℃,10s
Storage Temperature Range		T_{stg}	-60 to +150	℃
Power consumption (1) (2)	DIP-16	P_D	1.47	W
	SOP16		0.54/0.625(3)	

Note:

1. Maximum power consumption can be calculated using the following relationship

$$P_D = (T_j - T_A)/9_{JA}$$

2 . T_j(max) is 150°C, and T_A represents the ambient temperature at which the circuit operates.

3 . On a glass-reinforced epoxy resin PCB board (30×30×1.6 mm, with 50% copper content).

9.Recommended Operating Conditions

(T_A= 25°C, Unless Otherwise Specified)

Parameter		Symbol	Condition		Min	Max	Unit
Collector-Emitter voltage		V_{CE}			0	50	V
Output	DIP-16	I_{OUT}	T_{PW}=25ms T_A=85℃ T_J=120℃	Duty=10%	0	370	mA/ch
				Duty=50%	0	130	
	SOP16			Duty=10%	0	233	
				Duty=50%	0	70	
Control signal input voltage		V_{IN}			0	24	V
Input Voltage(Output On)		$V_{IN(ON)}$	I_{out}=400mA h_{FE}=800		2.8	24	V
Input Voltage (Output Off)		$V_{IN(OFF)}$			0	0.7	V
Clamping diode reverse voltage		V_R				50	V
Peak forward current of the clamping diode		I_F				350	mA
Operating temperature range	DIP-16	T_A			-40	+85	℃
	SOP16				-40	+85	
Power dissipation	DIP-16	P_D	T_A = 85℃			0.76	W
	SOP16					0.325	

Note: Applied on a glass epoxy resin PCB board (30×30×1.6 mm, copper layer with 50% coverage).

10. Electrical Characteristics

(T_A= 25°C, Unless Otherwise Specified)

Parameter		Test Pattern	Test condition		Min	Typ	Max	Unit
$V_{I(ON)}$	Conduction state input voltage	Graph 4	V_{CE}=2V	IC=200mA	-	1.78	2.4	V
				IC=250mA	-	1.82	2.7	
				IC=300mA	-	1.87	3	
$V_{CE(SAT)}$	Collector-emitter saturation voltage drop	Graph 5	V_I=2.4V I_C=30mA		-	0.72	-	V
			V_I=2.4V I_C=60mA		-	0.77	-	
			V_I=2.4V I_C=120mA		-	0.84	-	
			V_I=2.4V I_C=240mA		-	1.06	-	
			V_I=2.4V I_C=350mA		-	1.35	-	
V_F	Forward voltage drop of the clamping diode	Graph 8	I_F=350mA		-	1.4	1.6	V
I_{CEX}	Collector turn-off leakage current	Graph 1	V_{CE}=50V I_I=0		-	-	50	μA
		Graph 2	V_{CE}=50V T_A=85℃ V_I=0V		-	-	100	
I_I	Input current	Graph 4	V_{IN}=12V	I_C=60mA	-	4	-	mA
			V_{IN}=6V		-	1.7	-	
			V_{IN}=4.5V		-	1.1	-	
			V_{IN}=2.4V		-	0.35	-	
I_R	Reverse current of the clamping diode	Graph 7	V_R=50V		-	-	100	μA
C_{IN}	Input capacitance	-	-		-	15	-	pF
t_{PLH}	Transfer Delay: Low to High	Graph 9	VL=12V RL=45Ω		-	0.25	1	μs
t_{PHL}	Transfer Delay High-Low	Graph 9	VL=12V RL=45Ω		-	0.25	1	μs

11.Test Circuit Diagrams

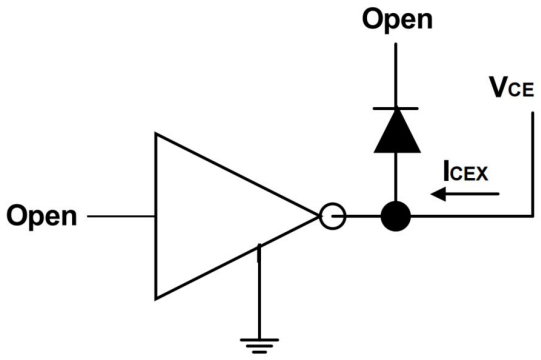


Figure 1.I_{CEX} Test Circuit

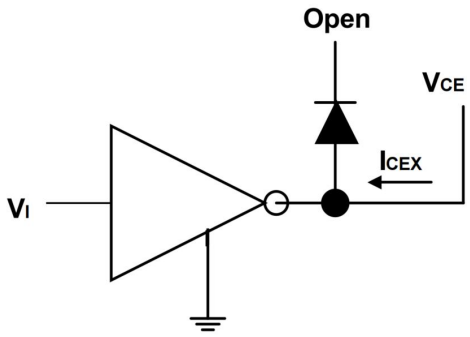


Figure 2.I_{CEX} Test Circuit

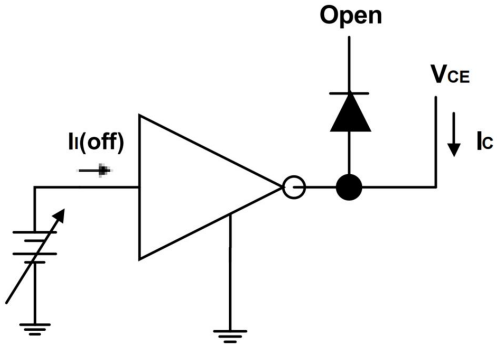


Figure 3.$I_{I(off)}$ Test Circuit

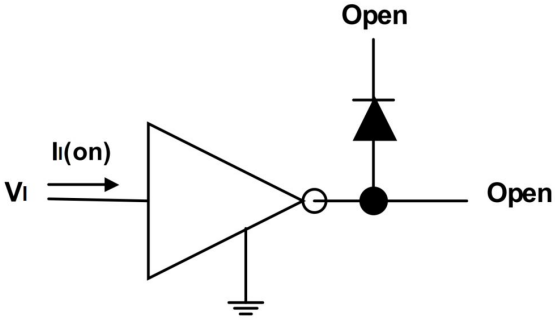


Figure 4.I_I Test Circuit

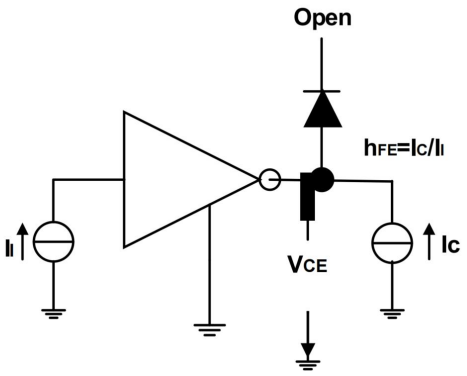


Figure 5.H_{FE},$V_{CE(sat)}$ Test Circuit

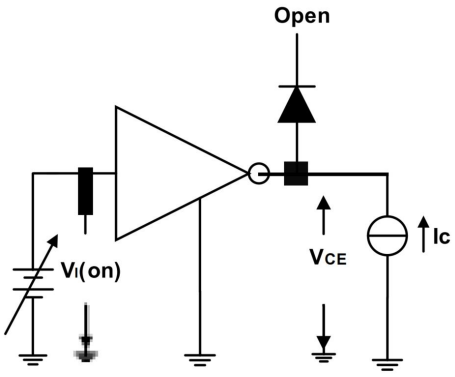


Figure 6.$V_{I(on)}$ Test Circuit

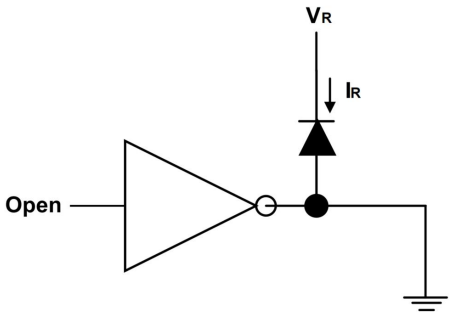


Figure 7.I_R Test Circuit

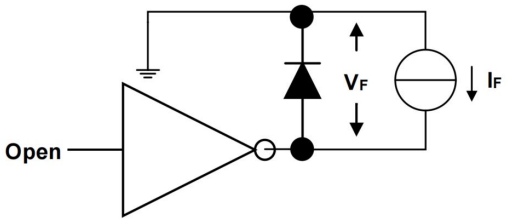
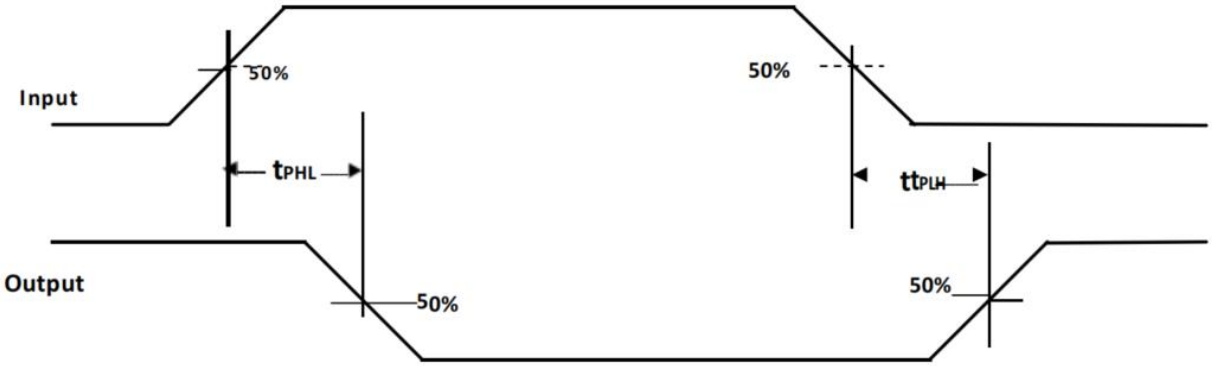


Figure 8.V_R Test Circuit



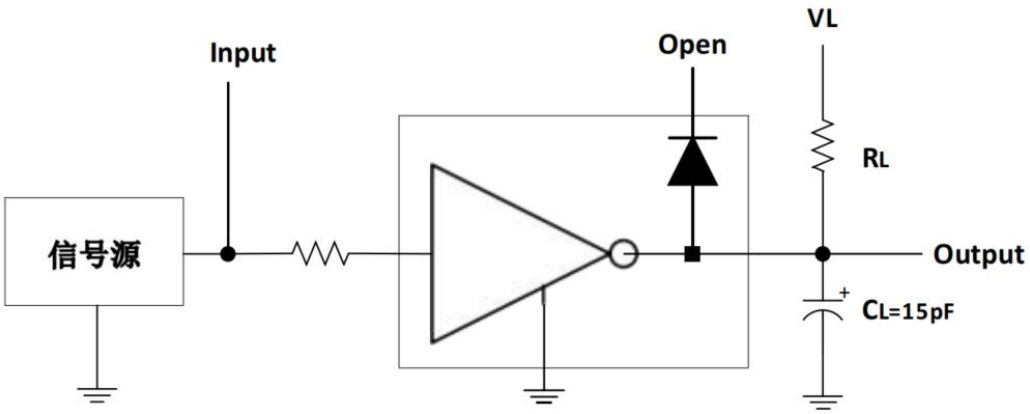


Figure 9.Transmission

Note: The Capacitive Load in Figure 9 Represents the Parasitic Capacitance of the Oscilloscope Probe.

12.Typical Application

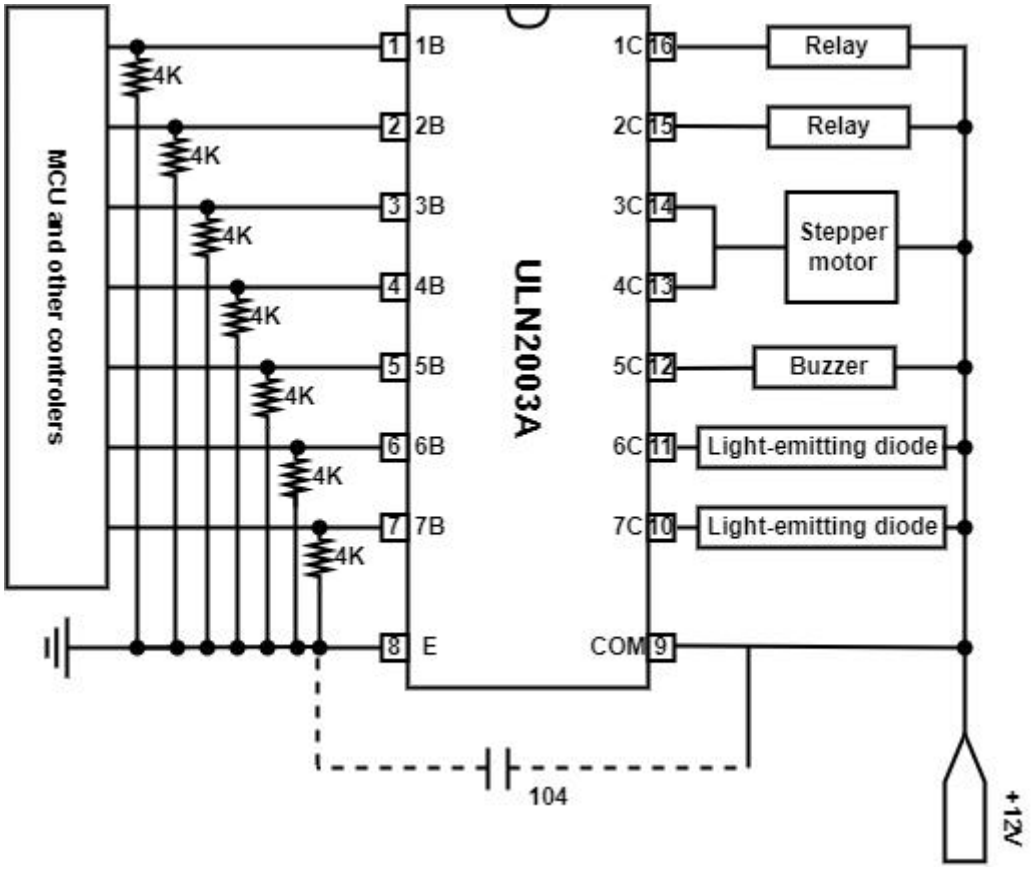
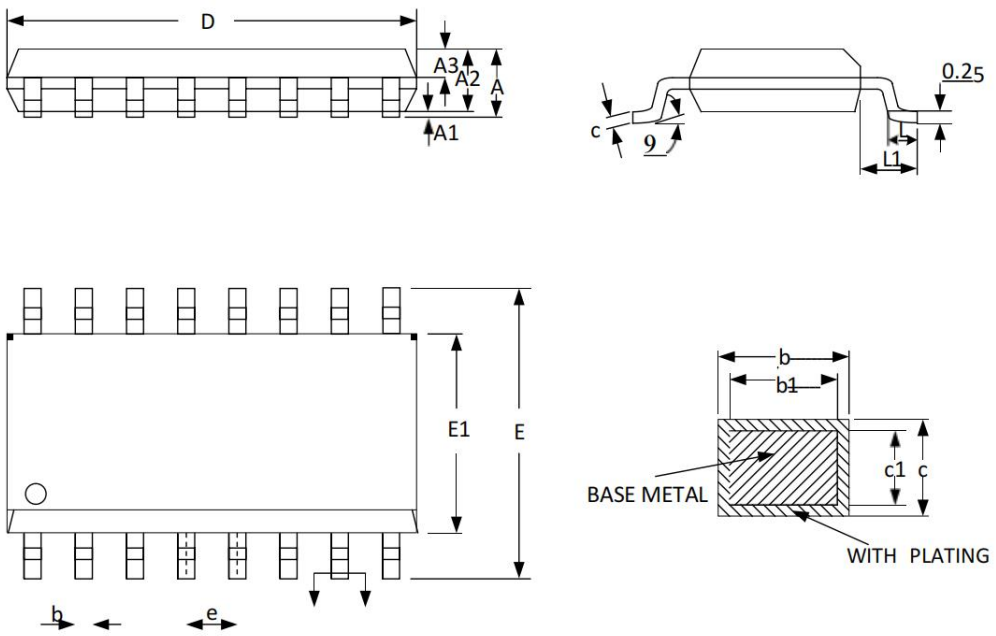


Figure 10.Schematic Diagram of the ULN2003A Application

Considering that some applications use microcontrollers with built-in pull-up resistors, the output state of the microcontroller may be undefined during power-up. At this time, the input stage of the ULN2003A can be affected by the microcontroller's pull-up resistor, which may inadvertently turn on the load. To avoid such false load activation, it is recommended that customers experiencing this issue connect a 4 kΩ pull-down resistor to ground at the input stage, as shown in the figure above.

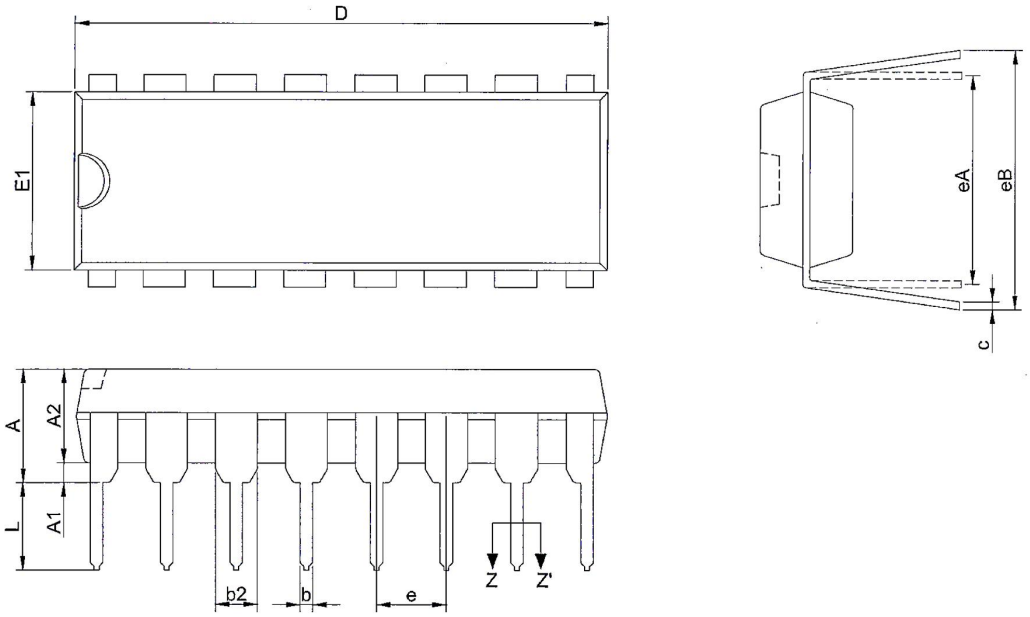
13.Package Information

(1) SOP16 Package Dimensions:



Symbol	Millimeter		
	Min	Nom	Max
A	—	—	1.77
A1	0.08	0.18	0.28
A2	1.20	1.40	1.60
A3	0.55	0.65	0.75
b	0.39	-	0.48
b1	0.38	0.41	0.43
c	0.21	-	0.26
c1	0.19	0.20	0.21
D	9.70	9.90	10.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.5	0.65	0.80
L1	1.05BSC		
9	0°	—	8°

(2) DIP-16 Package Dimensions:



Symbol	Millimeter		
	Min	Nom	Max
A	3.60	—	4.45
A1	0.51	—	—
A2	3.00	3.10	3.20
b	0.41	—	0.52
b1	0.41	0.46	0.49
b2	1.52 Ref.		
C	0.21	—	0.35
C1	0.20	0.25	0.26
D	18.85	19.00	19.15
E1	6.00	6.150	6.30
e	2.54 Bsc.		
Ea	7.62 Bsc.		
Eb	8.20	—	8.80
L	3.00	—	3.60

12.Important Notice And Disclaimer

- We reserve the right to change the instruction manual without prior notice.
- Any semiconductor product has a certain possibility of failure or malfunction under specific conditions. The buyer is responsible for complying with safety standards and taking safety measures when using our products for system design and overall manufacturing to avoid potential failure risks that may cause personal injury or property damage.
- The improvement of product quality is endless, our company will be dedicated to provide customers with better products.

13.Version Modification Record

Version Number	Revision
first edition	
V0.1	1. Update the Functional Block Diagram on page 3.