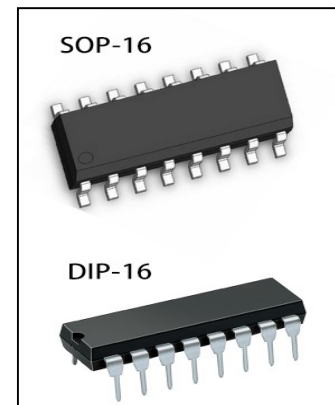


## High-voltage High-current Darlington Transistor Arrays

### ULN2003

#### General Description

ULN2003 is a single-chip integrated high voltage, high current Darlington tube array, The circuit contains seven independent Darlington tube drive single channel. The circuit is designed with continuous diode, which can be used to drive relay, stepping motor and other inductive loads. A single darlington collector can output 500mA current. Higher output current capacity can be achieved by connecting darlington tubes in parallel.



#### Features

- 500mA-Rated Collector Current(single output)
- Input Compatible TTL/CMOS logic signals
- High-Voltage Outputs:50V
- Relay-Driver Applications
- Package: SOP-16, DIP-16

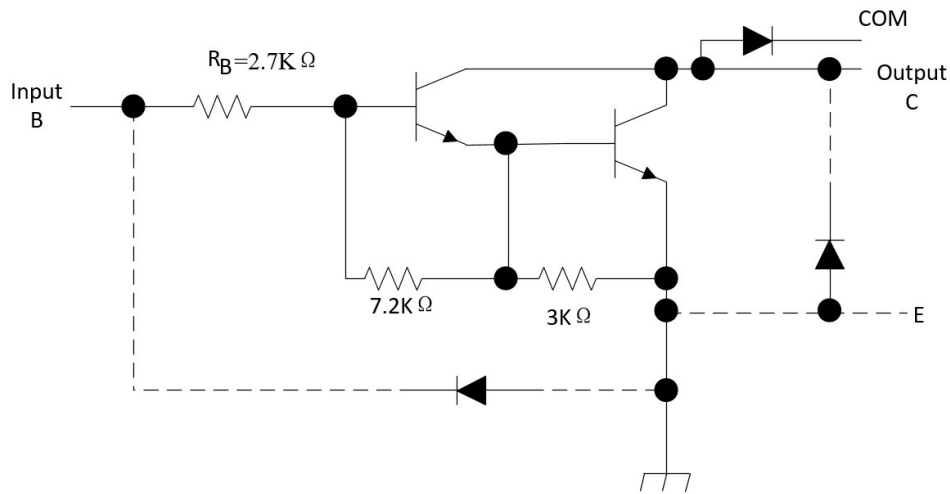
#### Applications

- Solenoids
- Relays
- DC motors
- LED displays
- Filament lamps
- Thermal-print heads
- High-power buffers

#### Order information

Product model	Package	Manner of packing	Minimum packing quantity
ULN2003-SOP16	SOP-16	reel	3500
ULN2003-DIP16	DIP-16	Tube	50

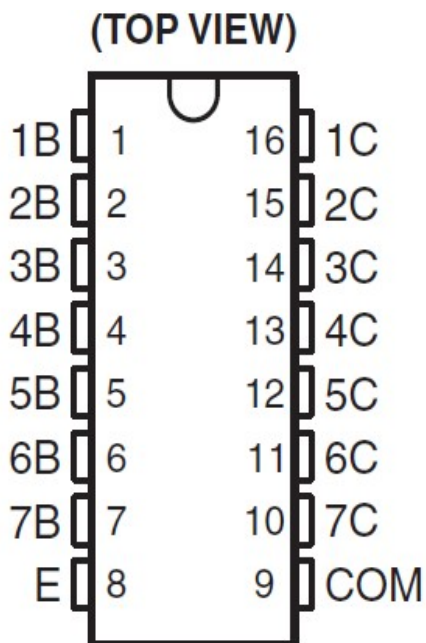
### Functional Block Diagram



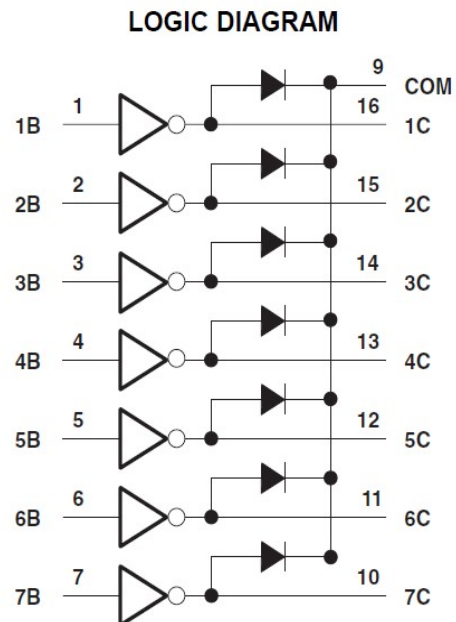
Note: All resistor values shown are nominal.

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.

### Pin Assignments



### Connection Diagram



## Pin Descriptions

Pin Number	Pin Name	Function
1	1B	Input pair1
2	2B	Input pair2
3	3B	Input pair3
4	4B	Input pair4
5	5B	Input pair5
6	6B	Input pair6
7	7B	Input pair7
8	E	Common Emitter (ground)
9	COM	Common Clamp Diodes
10	7C	Output pair7
11	6C	Output pair6
12	5C	Output pair5
13	4C	Output pair4
14	3C	Output pair3
15	2C	Output pair2
16	1C	Output pair1

## Absolute Maximum Ratings<sup>(1)</sup>

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

Symbol	Parameter	Min	Max	Unit
V <sub>CC</sub>	Collector to emitter voltage		50	V
V <sub>R</sub>	Clamp diode reverse voltage(2)		50	V
V <sub>I</sub>	Input voltage(2)		30	V
I <sub>CP</sub>	Peak collector current		500	mA
I <sub>OK</sub>	Output clamp current		500	mA
I <sub>TE</sub>	Total emitter-terminal current		-2.5	A
T <sub>A</sub>	Operating free-air temperature range	-20	70	°C
θ <sub>JA</sub>	Thermal Resistance Junction-to-Ambient(3)		63	°C/W
θ <sub>JC</sub>	Thermal Resistance Junction-to-Case(4)		12	
T <sub>J</sub>	Operating virtual junction temperature		150	°C
T <sub>STG</sub>	Storage temperature range	-40	85	°C

- (1) Exceeding the absolute maximum rating may cause permanent damage to the chip. These are only maximum ratings and prolonged use at absolute maximum ratings may affect the reliability of the chip.
- (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(max)</sub>, θ<sub>JA</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is  $PD = (T_J(max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.
- (4) Maximum power dissipation is a function of T<sub>J(max)</sub>, θ<sub>JC</sub>, and T<sub>A</sub>. The maximum allowable power dissipation at any allowable ambient temperature is  $PD = (T_J(max) - T_A)/\theta_{JC}$ . Operating at the absolute maximum T<sub>J</sub> of 150°C can affect reliability.

## Electrical Characteristics

(TA=+25°C, unless otherwise specified)

Symbol	Parameter	Test Figure	Test Conditions		ULN2003			Unit
					MIN	TYP	MAX	
$V_{I(on)}$	On-state input voltage	Figure 6	$V_{CE}=2V$	$I_C=200mA$	--	--	2.4	V
				$I_C=250mA$	--	--	2.7	
				$I_C=300mA$	--	--	3	
$V_{CE(sat)}$	Collector-emitter saturation voltage	Figure 5	$I_I=250\mu A$ ,	$I_C=100mA$	--	0.9	1.1	V
			$I_I=350\mu A$ ,	$I_C=200mA$	--	1	1.3	
			$I_I=500\mu A$ ,	$I_C=350mA$	--	1.2	1.6	
$I_{CEX}$	Collector cutoff current	Figure 1	$V_{CE}=50V$ ,	$I_I=0$	--	--	50	$\mu A$
		Figure 2	$V_{CE}=50V$ , $T_A=+105^\circ C$	$I_I=0$	--	--	100	
$V_F$	Clamp forward voltage	Figure 8	$I_F=350mA$		--	1.7	2	V
$I_{I(off)}$	Off-state input current	Figure 3	$V_{CE}=50V$ , $I_C=500\mu A$		50	65	--	$\mu A$
$I_I$	Input current	Figure 4	$V_I=3.85V$		--	0.93	1.35	mA
			$V_I=5V$		--	--	--	
			$V_I=12V$		--	--	--	
$I_R$	Clamp reverse current	Figure 7	$V_R=50V$		--	--	50	$\mu A$
				$T_A=70^\circ C$	--	--	100	
$C_i$	Input capacitance		$V_I=0$ , $f=1MHz$		--	15	25	pF

## Switching Characteristics

(TA = +25° C, unless otherwise specified)

Symbol	Parameter	Test pattern	Test Conditions		ULN2003			UNIT
					MIN	TYP	MAX	
$t_{PLH}$	Propagation delay time, low-to high-level output	See Figure 9			--	0.25	1	$\mu s$
$t_{PHL}$	Propagation delay time, high-to low-level output	See Figure 9			--	0.25	1	$\mu s$
$V_{OH}$	High-level output voltage After switching	See Figure 9	$V_S = 50V$ , $I_O = 300mA$ ,		$V_S-20$	--	--	mV

Parameter Measurement Information

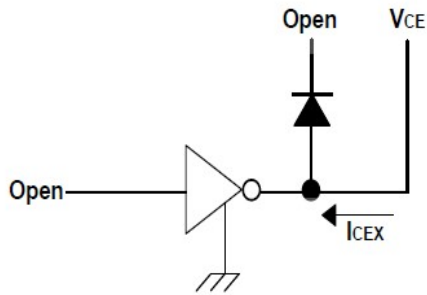


Fig.1 ICEX Test Circuit

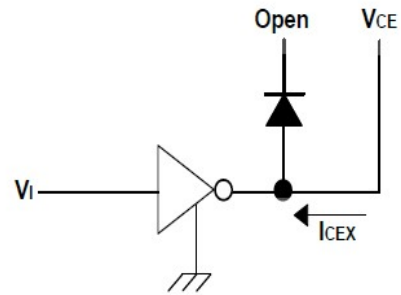


Fig.2 ICEX Test Circuit

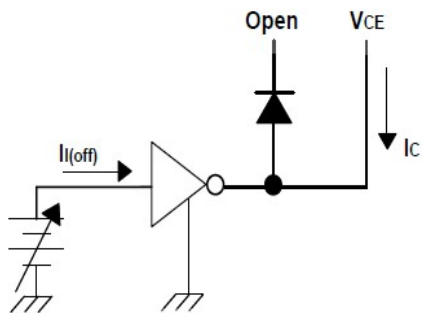


Fig.3  $I_{(off)}$  Test Circuit

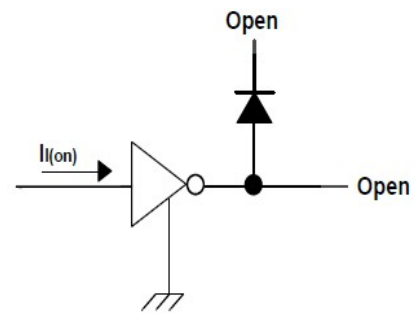


Fig.4  $I_{(on)}$  Test Circuit

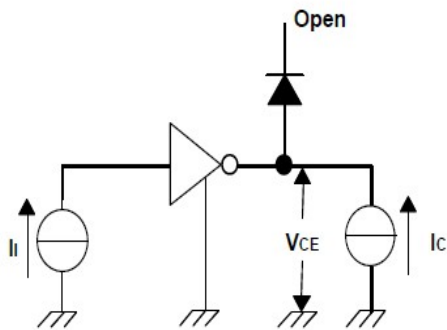


Fig.5  $h_{FE}$ ,  $V_{CE(sat)}$  Test Circuit

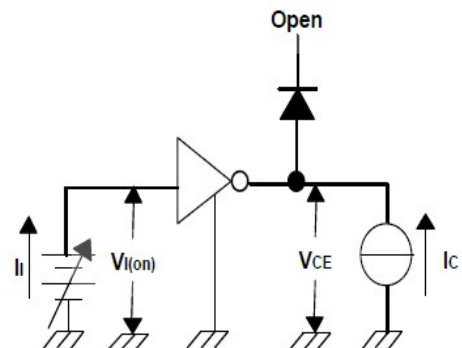


Fig.6  $V_{I(on)}$  Test Circuit

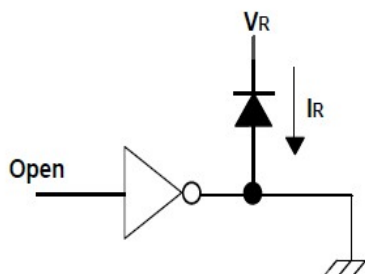


Fig.7  $I_R$  Test Circuit

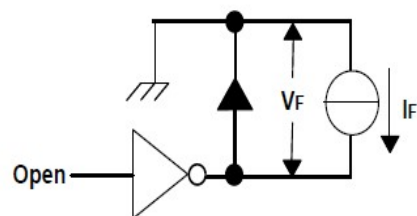


Fig.8  $V_F$  Test Circuit

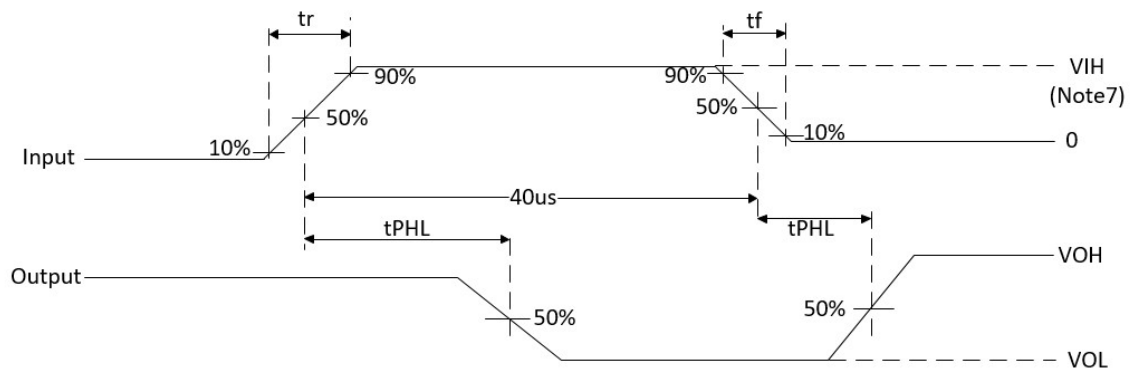
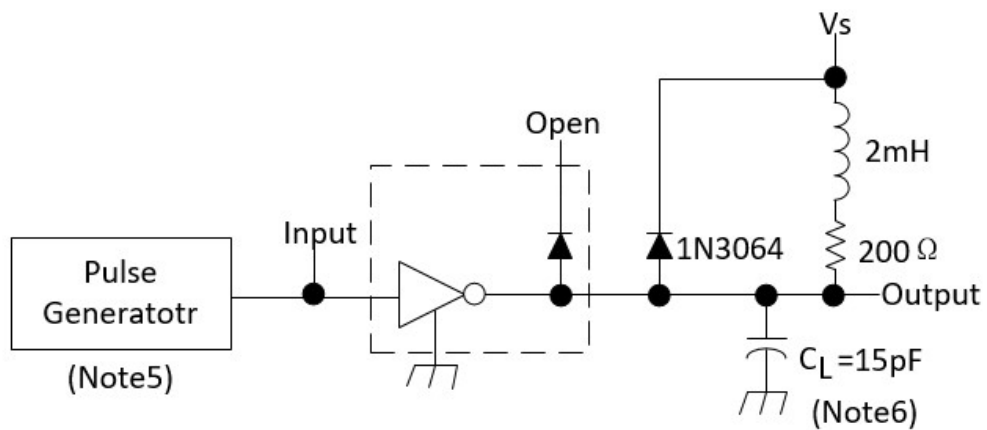
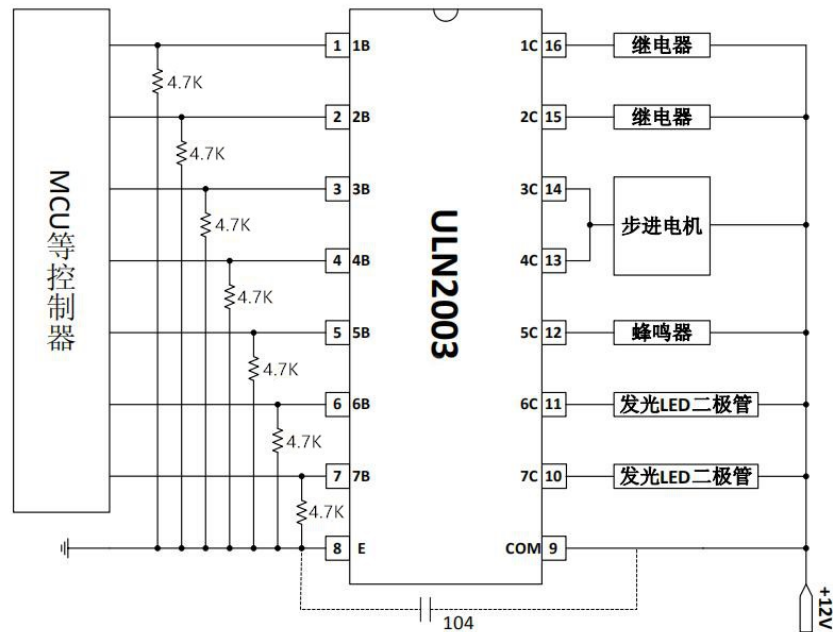


Fig.9 Transmission delay waveform diagram

- Notes:
- (5) The pulse generator has the following characteristics:  
Pulse Width=12.5Hz, output impedance  $50\Omega$ ,  $t_r \leq 5\text{ns}$ ,  $t_r \leq 10\text{ns}$ .
  - (6)  $C_L$  includes probe and jig capacitance.
  - (7)  $V_{IH} = 3\text{V}$

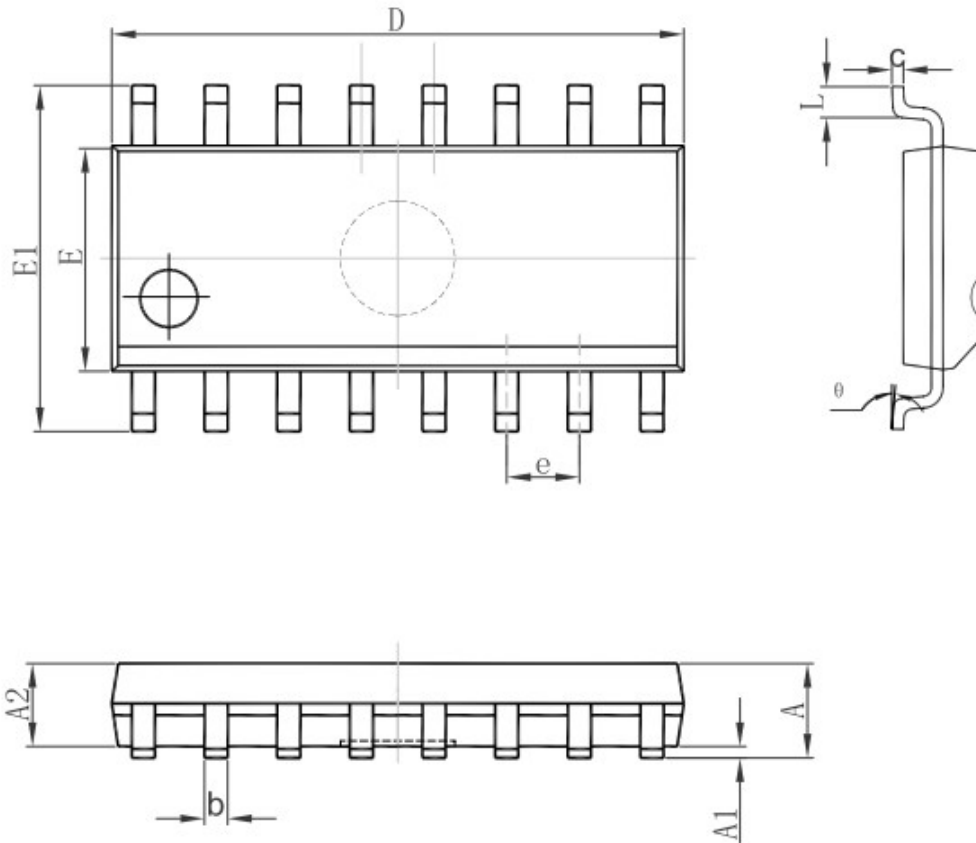
Typical application



Considering that some applications use a single-chip machine with pull resistance, The output state of the single chip is unstable during power-up. At this time, the ULN2003 input stage will be affected by the single-chip pull-up resistance and turn on the load. In order to avoid load misoperation, it is recommended that customers with such application problems connect a 4.7K pull-down resistance at the input stage, as shown in the figure above.

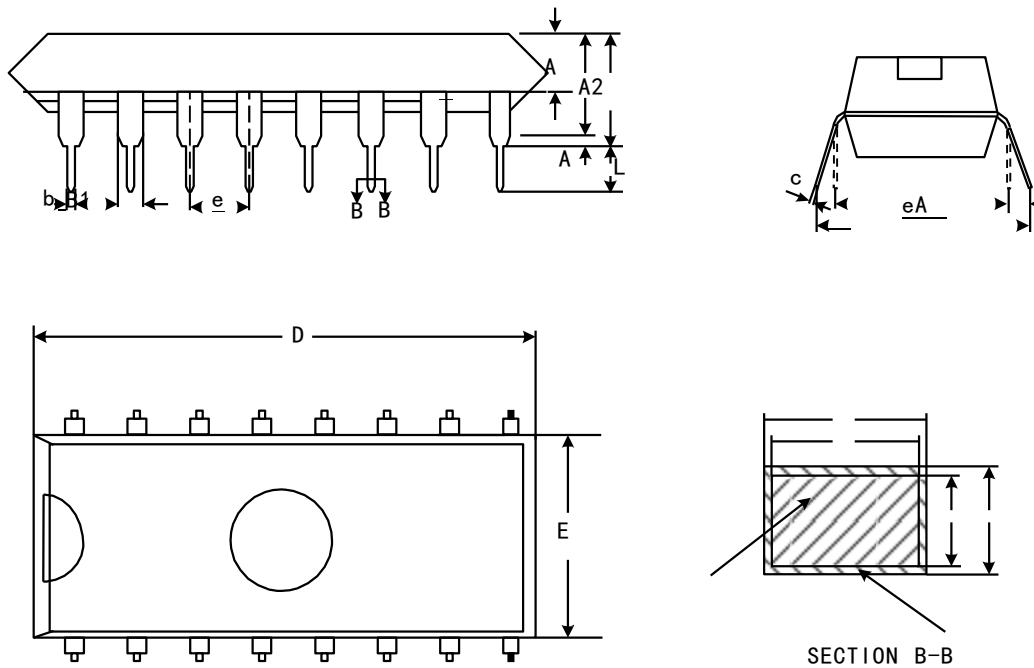


Packaging Information (SOP-16)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Packaging Information (DIP-16)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	3.60	3.80	4.00
A1	0.51	—	—
A2	3.10	3.30	3.50
A3	1.42	1.52	1.62
b	0.44	—	0.53
b1	0.43	0.46	0.48
B1	1.52BSC		
c	0.25	—	0.31
c1	0.24	0.25	0.26
D	18.90	19.10	19.30
E1	6.15	6.35	6.55
e	2.54BSC		
eA	7.62BSC		
eB	7.62	—	9.50
eC	0	—	0.94
L	3.00	—	—

## Special Version

The company reserves the right of final interpretation of this specification.

## Version Change Description

---

Versions: V1.3

Writer: Si Yuan Wu

Time: 2021.9.7

## Amendant record:

- 1.Re-typesetting the manual and checking some data