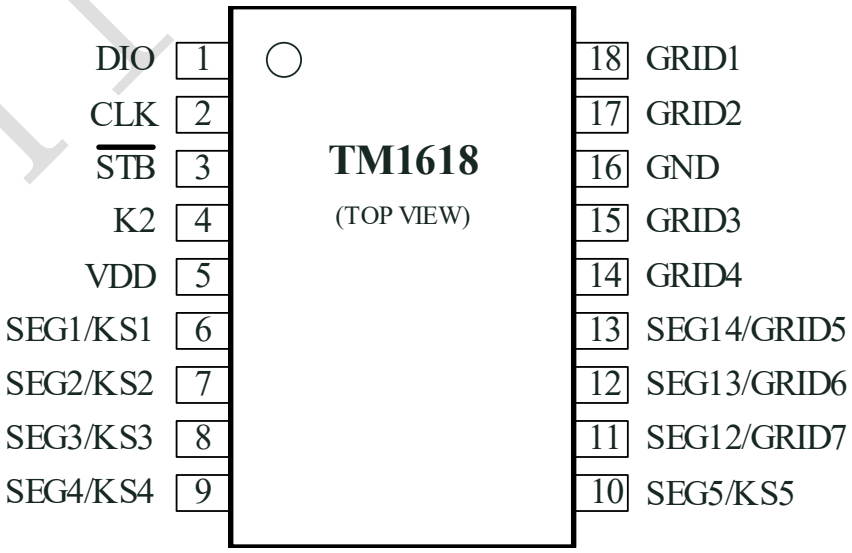
I. Overview

TM1618 is a LED (Light Emitting Diode Display) drive control circuit with the keyboard scan interface integrating MCU digital interface, digital latch, LED high voltage drive circuit, keyboard scan etc. The product has excellent performance and reliable quality, and is mainly applied in display drive of VCR, VCD, DVD, home theatre and etc. Its encapsulation mode is SOP18.

II. Features

- Adopt low power-consumption CMOS technology
- Display mode (5segments x 6 bits ~ 8 segments x 4 bits)
- Press key (5x 1 bit)
- Brightness adjusting circuit (duty cycle adjustable among 8 levels)
- Serial interface (CLK, STB, DIO)
- Mode of oscillation: built-in RC oscillation (450 KHz ± 5%)
- Built-in power-on reset circuit
- Encapsulation mode: SOP18/DIP18

III. Definitions of the pins:



IV. Functions of the pins：

Sign	Name	Description
DIO	Data Input/Output	Input serial data at rising edge of clock with beginning from low bit. uilt-in 13.3 KΩ pull-up resistor
STB	Chip Selection	Initialize serial interface at falling edge and wait for receiving instruction. STB takes the first byte after the instruction is low; other processes shall be stopped when processing the instruction. CLK shall be ignored when STB is high. uilt-in 13.3KΩ pull-up resistor
CLK	Clock Input	Read serial data at rising edge and export data from falling edge. uilt-in 13.3KΩ pull-up resistor
K2	Keyboard scan data input	Input data from the foot is latched after a display circle ended.
SEG1/KS1～ SEG5/KS5	Output (segment)	Segment output, PMOS open-drain output. output with a 4KΩ pull-down resistor
GRID1～ GRID4	Input (bit)	Bit output, NMOS open-drain output. output with a 2.7KΩ pull-up resistor
SEG12/GRID7 ～ SEG14/GRID5	Output (segment / bit)	Segment and bit multiplexing output.
VDD	Logic power supply	5V±10%
GND	Logic grounding	Connect to system grounding

▲ Attention：

DIO interface output data is N tube drain output, it needs external connections of 1k~10k pull-up resistors while reading the key. The 10k pull-up resistor is recommended.

Reading is unstable while DIO control action of N tube on the clock falling edge, you can refer to figure (6), reading become stabilized on the clock rising edge.

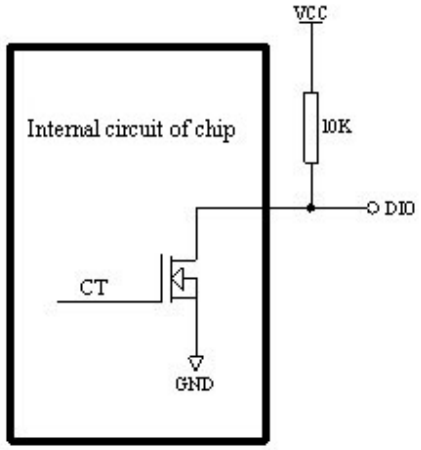


Figure (1)

V. Display register and display mode:

The register stores data that is transmitted to TM1618 from external device through serial interface, there are total 14-byte locations from address 00H-0DH, which correspond with the LED lamps connected with the pins of chip SGE and GRID respectively. Distribution is shown as following chart.

When writing LED display data, operation according to display address from low to high and data byte from low bit to high bit.

SEG1	**SEG2**	**SEG3**	**SEG4**	**SEG5**	**X**	**X**	**X**	**X**	**X**	**X**	**SEG12**	**SEG13**	**SEG14**	**X**	**X**	
xxHL（low 4 bits）				xxHU (high 4 bits)				xxHL (low 4 bits)				xxHU（high 4 bits）				
B0	B1	B2	B3	B4	B5	B6	B7	B0	B1	B2	B3	B4	B5	B6	B7	
00HL				00HU				01HL				01HU				**GRID1**
02HL				02HU				03HL				03HU				**GRID2**
04HL				04HU				05HL				05HU				**GRID3**
06HL				06HU				07HL				07HU				**GRID4**
08HL				08HU				09HL				09HU				**GRID5**

0AHL	0AHU	0BHL	0BHU	**GRID6**
0CHL	0CHU	0DHL	0DHU	**GRID7**

Figure (2)

VI. Keyboard scan and data register:

Keyboard scan matrix is ×1bit，as follows：

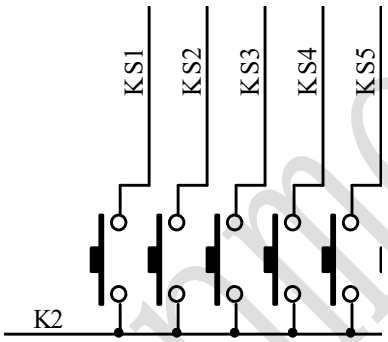


Figure (3)

The storage address of keyboard scan is shown as following chart, after reading key command, start reading Byte 1~ Byte 3 of key data which output from low bit, B0, B2, B3, B5, B6 and B7 are invalid bits, the chip output is 0 at this time. When press the keys correspond with the pins of chip K and KS, corresponding bit within the byte is 1.

B0	B1	B2	B3	B4	B5	B6	B7	
-	K2	-	-	K2	-	-	-	
KS1			KS2			0	0	BYTE1
KS3			KS4			0	0	BYTE2
KS5			-			0	0	BYTE3

Figure (4)

▲ Attention：

1. TM1618 read 3 bytes maximum, more reading is not allowed.

2. Data byte can be read only from Byte 1~ Byte 3 in sequence, it can not be read across the byte. E.g., when press the key correspond with the K2 and KS6, if need read data of this key, must read till the 4 bit of Byte 3.

VII. Descriptions of instruction:

Instruction is used to set display mode and the status of LED driver.

The first byte input through DIO after STB falling edge is taken as one instruction. Take the two highest bits B7, B6 to distinguish different instructions through decoding.

B7	B6	Instruction
0	0	The Setting of Display Mode
0	1	The Setting of Data Command
1	0	The Setting of Display Control Command
1	1	The Setting of Address Command

If STB is set at high level when instruction or data is transmitted, serial communication is initialized, meanwhile, the being transmitted instruction or data is invalid (previous transmitted instruction or data is kept valid).

(1) The setting of display mode:

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	Display mode
0	0	Fill in 0 for the irrelevant.				0	0	4 bits 8 segments
0	0					0	1	5 bits 7 segments
0	0					1	0	6 bits 5 segments

The instruction is used to set the number of the segments and bits (4~7 bits, 6~9 segments).

When execute instructions, the display is forced off. If transmit display control command to turn on the display, the original displayed data will not be changed. However, above situation does not happen while setting same mode.

(2) The setting of data command:

The instruction is used to set the writing and reading of data. B1 and B0 bit is set to 01 or 11 is not allowed.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	Function	Description
0	1	Fill in 0 for the irrelevant.				0	0	Setting of data read-write mode	Write data to display register
0	1					1	0		Read key scan data
0	1				0			Setting of address increment mode	Auto address plus
0	1				1				Fixed address
0	1			0				Setting of test mode (Internal use)	Common mode
0	1			1					Test mode

(3) The setting of address command:

The instruction is used to set the address of display register. When address is set as 0EH or higher, data is ignored until valid address is set. The address is set as 00H when it is power on.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	Display Address
1	1	Fill in 0 for the irrelevant.		0	0	0	0	00H
1	1			0	0	0	1	01H
1	1			0	0	1	0	02H
1	1			0	0	1	1	03H
1	1			0	1	0	0	04H
1	1			0	1	0	1	05H
1	1			0	1	1	0	06H
1	1			0	1	1	1	07H

1	1		1	0	0	0	08H
1	1		1	0	0	1	09H
1	1		1	0	1	0	0AH
1	1		1	0	1	1	0BH
1	1		1	1	0	0	0CH
1	1		1	1	0	1	0DH

(4) The setting of display control command:

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	Function	Description
1	0	Fill in 0 for the irrelevant.			0	0	0	Extinction Number setting	Set pulse width to 1/16
1	0				0	0	1		Set pulse width to 2/16
1	0				0	1	0		Set pulse width to 4/16
1	0				0	1	1		Set pulse width to 10/16
1	0				1	0	0		Set pulse width to 11/16
1	0				1	0	1		Set pulse width to 12/16
1	0				1	1	0		Set pulse width to 13/16
1	0				1	1	1		Set pulse width to 14/16
1	0			0				Display switch setting	Display off
1	0			1					Display on

VIII. Serial Data Transmission Format

The operation of reading and receiving 1 Bit is on the clock rising edge.

Data acceptance（write data）

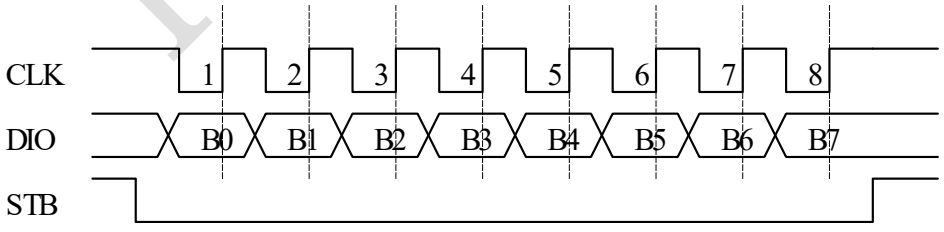


Figure (5)

Data acceptance（read data）

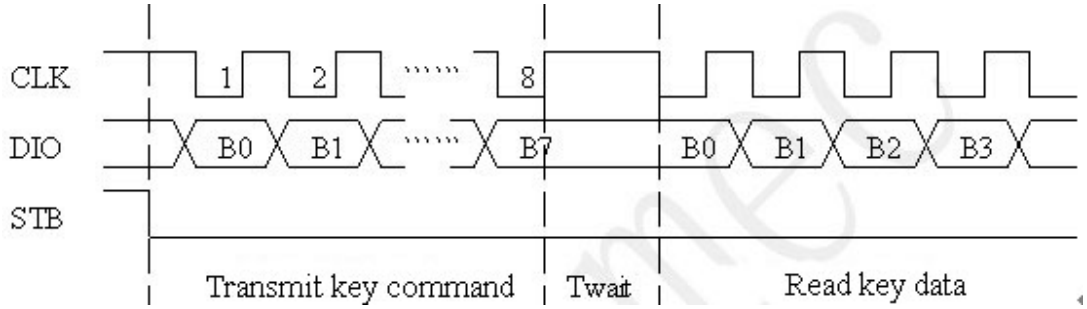


Figure (6)

▲ Attention：

While reading data, it need some time to wait if instructions are set from the serial CLK on the 8th rising edge to the falling edge. (Twait min. 1μS).

IX. Display and keyboard scan

(1) Display:

1. Drive common cathode digital tubes:

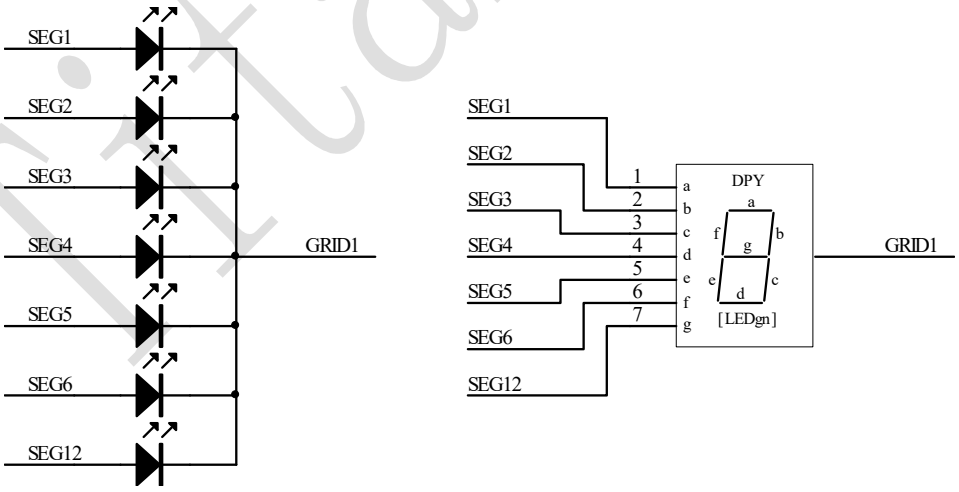


Figure (7)

Figure (7) shows the connection diagram of common cathode digital tubes, if need it display "0", you should make SEG1，SEG2，SEG3，SEG4，SEG5，SEG6 at high level and SEG12

at low level when GRID 1 is in low level.

Pls. refer to Figure (2) display address chart, you can make the digital tubes display “0” when write data 3FH in the 00H address and write data 00H in the 01H address.

SEG8	SEG7	SEG6	SEG5	SEG4	SEG3	SEG2	SEG1	
0	0	1	1	1	1	1	1	00H
B7	B6	B5	B4	B3	B2	B1	B0	

2. Drive common anode digital tubes:：

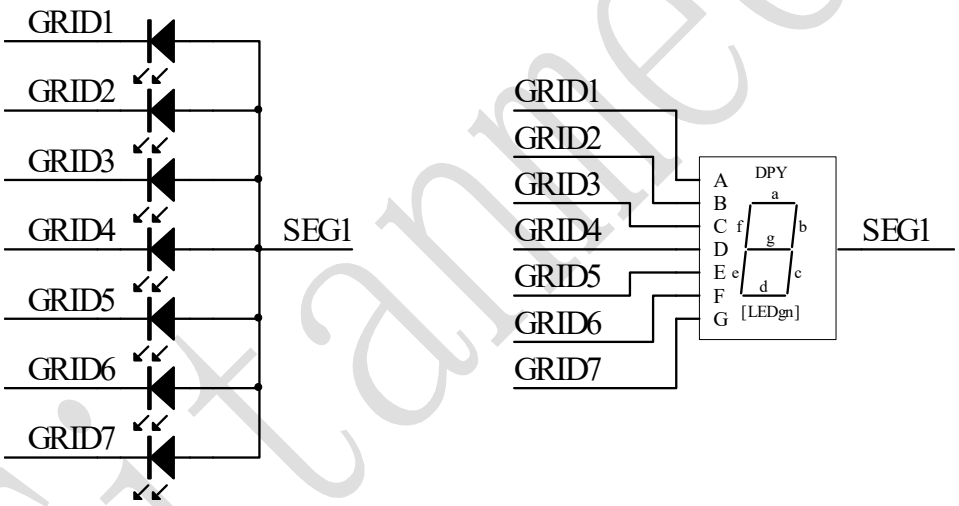


Figure (8)

Figure (8) shows the connection diagram of common anode digital tubes, if need it display “0”, you should make SEG1 at high level when GRID1，GRID2，GRID3，GRID4，GRID5，GRID6 are in low level, make SEG1 at low level when GRID7 is in low level. Or write data 01H in 00H，02H，04H，06H，08H，0AH address separately, and data 00H in other addresses.

SEG8	SEG7	SEG6	SEG5	SEG4	SEG3	SEG2	SEG1	
0	0	0	0	0	0	0	1	00H
0	0	0	0	0	0	0	1	02H
0	0	0	0	0	0	0	1	04H
0	0	0	0	0	0	0	1	06H

0	0	0	0	0	0	0	1	08H
0	0	0	0	0	0	0	1	0AH
0	0	0	0	0	0	0	0	0CH
B7	B6	B5	B4	B3	B2	B1	B0	

▲ **Attention：** SEG1-11 is P tube open drain output, GRID-7 is N tube open drain output. When use them, SEG1-11 can be connect with LED anode only, and GRID for cathode only. Reversed connection is not allowed.

Waveform of SEGN / KSN when IC is under keyboard scanning

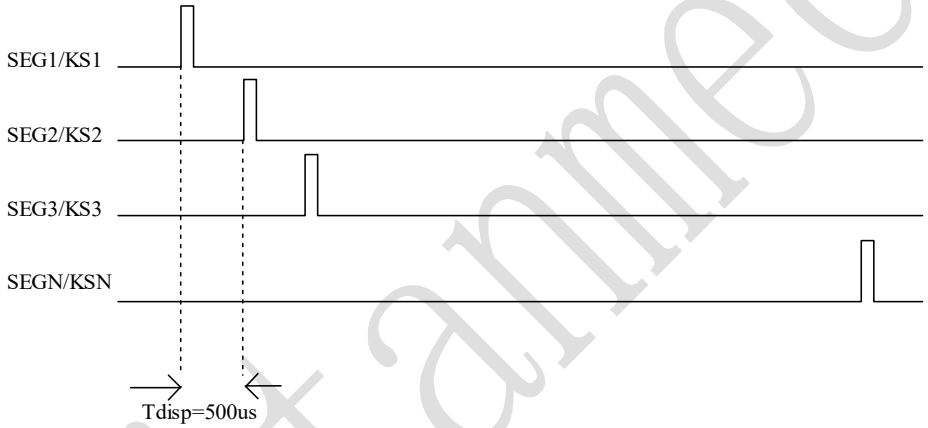


Figure (10)

Tdisp is related on the oscillation frequency of IC. After many improvement of TM1618, its oscillation frequency is not exactly match. 500US is just for your reference, pls. respect the actual measurement.

By general us Figure (11), It can meet the requirement for the key design

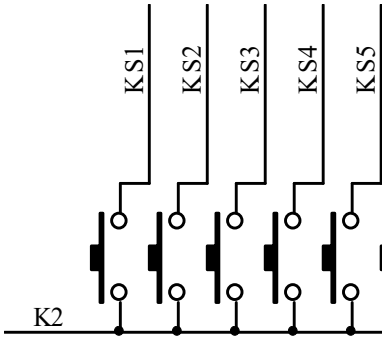


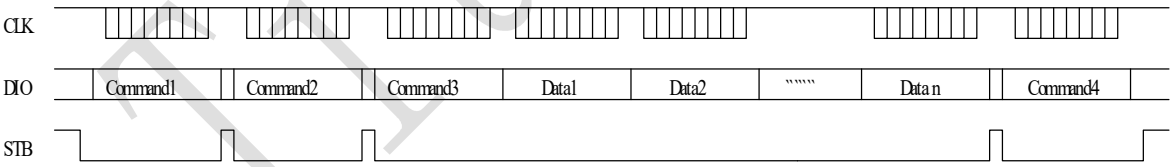
Figure (11)

When press S1, "1" will be read at B1 on the 1st byte. When press more keys, more "1" will be read. When press S1, S2, "1"will be read at B1, B4 on the 1st byte.

X. The Typical Transmission Mode of Serial Data When Applying

(1) Address-adding mode

Use the mode of automatic address adding 1, the setting of address is setting of initial address where data is stored. When complete the transmission of initial address command, "STB"does not need to be set high and then transmit data immediately, 14 bytes in maximum, "STB"will be set high after the transmission of data end.



Command1: Set display mode

Command2: Set data command

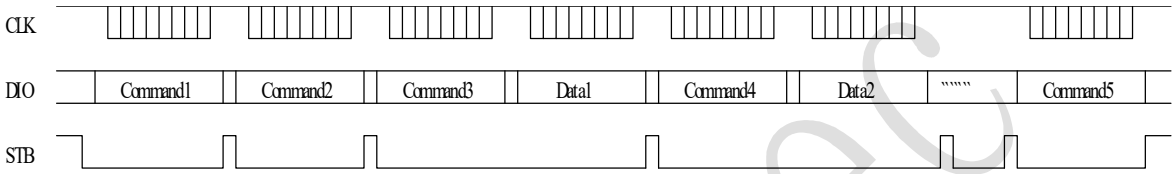
Command3: Set display address

Data1~n: Transmit display data to the address set by Command3 and subsequent address (14 bytes in maximum)

Command4: Display control command

(2) Fixed-address mode

Use fixed address mode. In fact setting of address is the setting of the address that stores 1BYTE data that needs to be transmitted. The transmission of address is complete. STB does not need to be set high. Then transmit 1 BYTE data immediately. Set “STB” high after the transmission of data is complete. Then set the address that needs store the second data again. Set “STB” as high after the transmission of 14Bytes data is complete.



Command1: Set display mode

Command2: Set data command

Command3: Set display address1

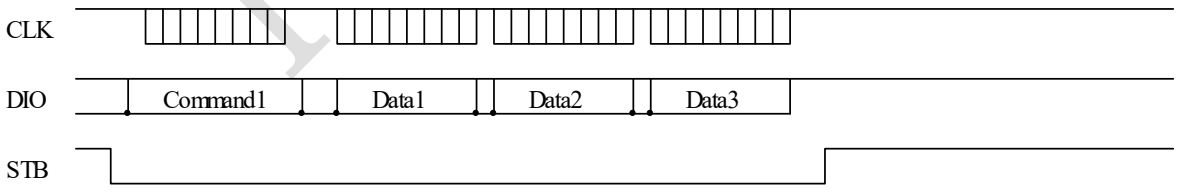
Data1: Transmit display data1 to the address set by Command3

Command4: Set display address2

Data2: Transmit display data2 to the address set by Command4

Command5: Display control command

(3) Read time sequence of the key

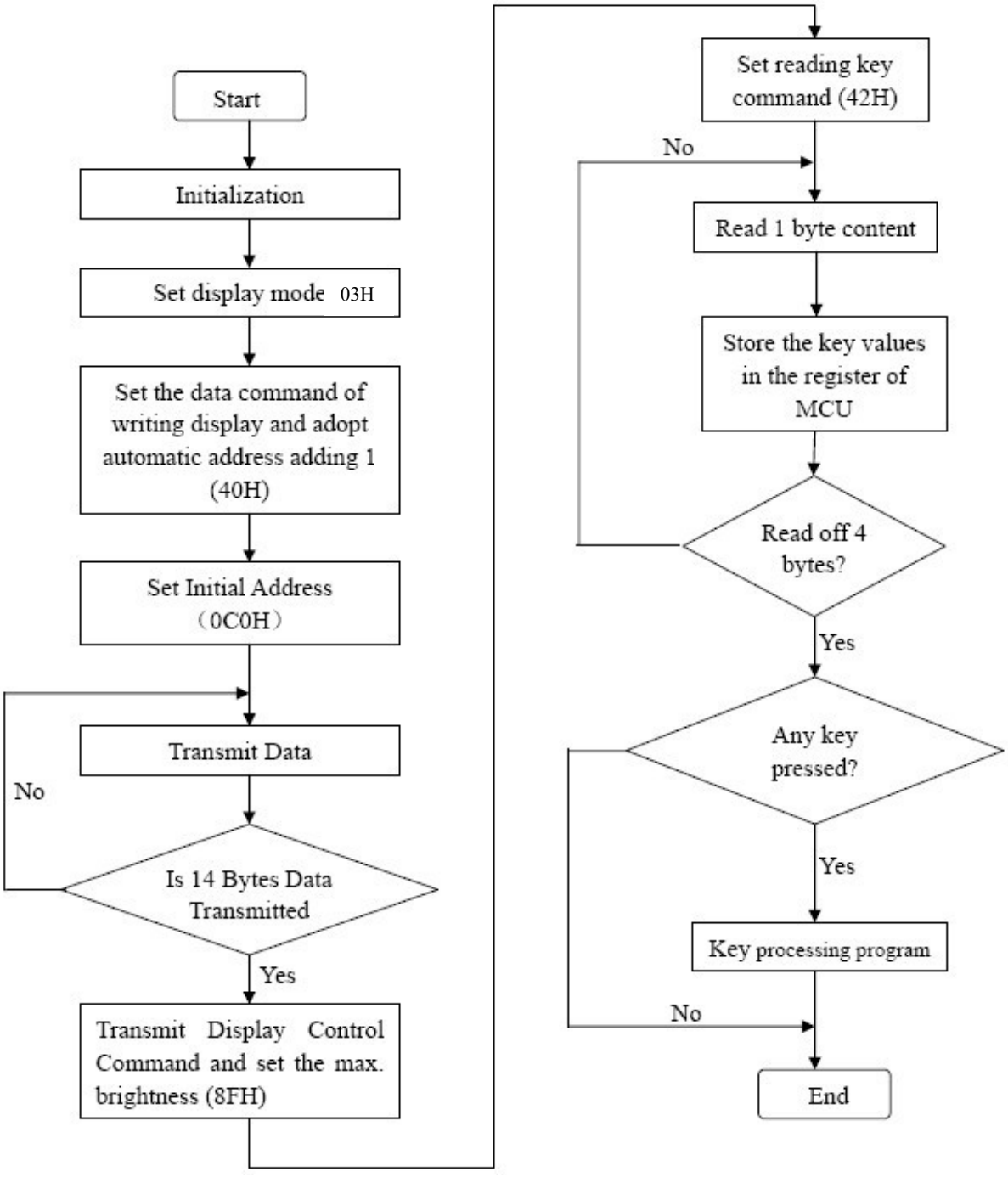


Command1: Set display mode

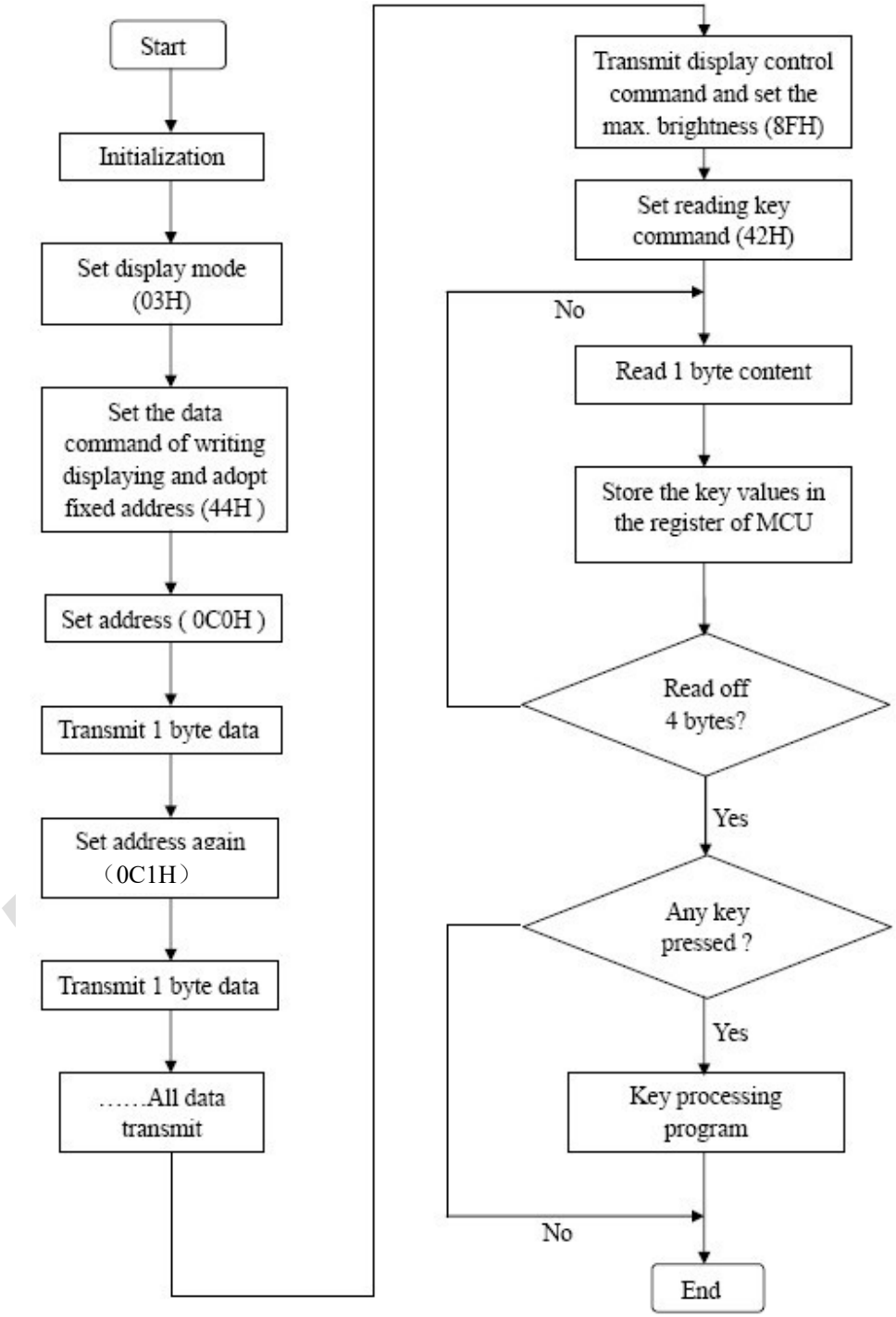
Data1～3: Read key data

(4) Program Flow Chart:

The program flow chart adopts the mode of automatic address adding 1:



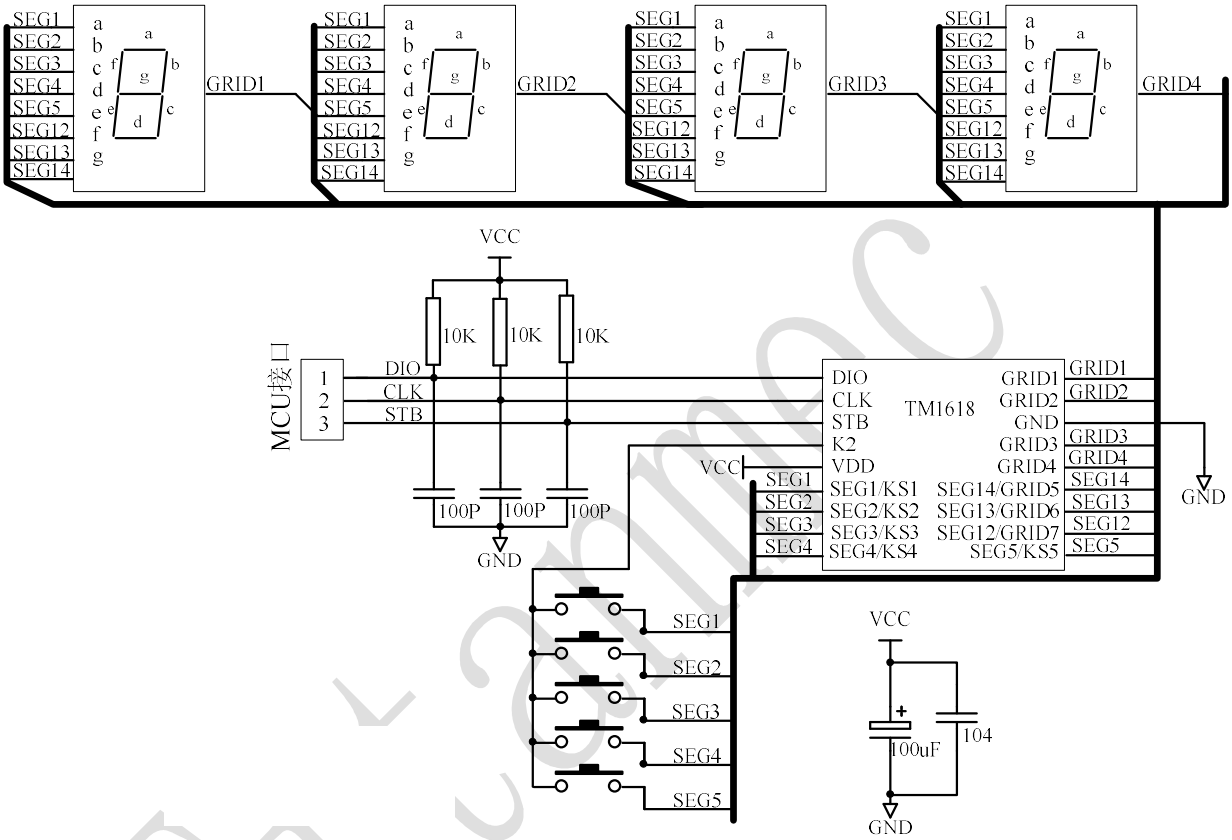
The program chart adopt fixed address mode：



XI. Application Schematic Diagram:

The typical application circuit of TM1618 used for drive common cathode digital tubes:

Figure (16)



Note: The loop between filtering capacitance and chips VDD.GND tries to be as short as possible.

Figure (16)

▲ Attention:

1. The filter capacitor between VDD and GND should be close to TM1618 chip to be wired on PCB to strengthen the effect of filtering.
2. Three 100 pF capacitances connected in the DIO, CLK, STB communication ports can reduce the interference from communication ports.
3. The blue ray digital tubes drop voltage to 3V, therefore should choose 5V power supply for TM1618

XII. Electrical Parameter：

Limit parameter (Ta = 25℃, Vss = 0V)

Parameter	Symbol	Range	Unit
Logic power voltage	VDD	-0.5 ～+7.0	V
Logic input voltage	VI1	-0.5 ～ VDD + 0.5	V
LED Seg drive output current	IO1	-50	mA
LED Grid drive output current	IO2	+200	mA
Power consumption	PD	400	mW
Operating temperature	Topt	-40 ～ +85	℃
Storage temperature	Tstg	-65 ～+150	℃

Normal Operating Range (Vss = 0V)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Test Condition
Logic power voltage	VDD	-	5	-	V	-
High level input voltage	VIH	0.7 VDD	-	VDD	V	-
Low level input voltage	VIL	0	-	0.3 VDD	V	-

Electrical Characteristics (VDD = 4.5~5.5V, Vss = 0V)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Test Condition
High level output voltage	Ioh1	20	25	40	mA	Seg1~Seg12，Vo = vdd-2V
	Ioh2	20	30	50	mA	Seg1~Seg12，Vo = vdd-3V
Low level input voltage	IOL1	80	140	-	mA	Grid1~Grid6 Vo=0.3V
Low level output voltage	Idout	4	-	-	mA	VO = 0.4V，dout
High level output current	Itolsg	-	-	5	%	VO = VDD – 3V，Seg1～Seg12
output pull-down resistor	RL		10		KΩ	K1~K3
Input current	II	-	-	±1	μA	VI = VDD / VSS
High level input voltage	VIH	0.7 VDD	-		V	CLK，DIN，STB
Low level input current	VIL	-	-	0.3 VDD	V	CLK，DIN，STB
Lagging voltage	VH	-	0.35	-	V	CLK，DIN，STB
Dynamic current loss	IDDdyn	-	-	5	mA	No load. Display: Turn off

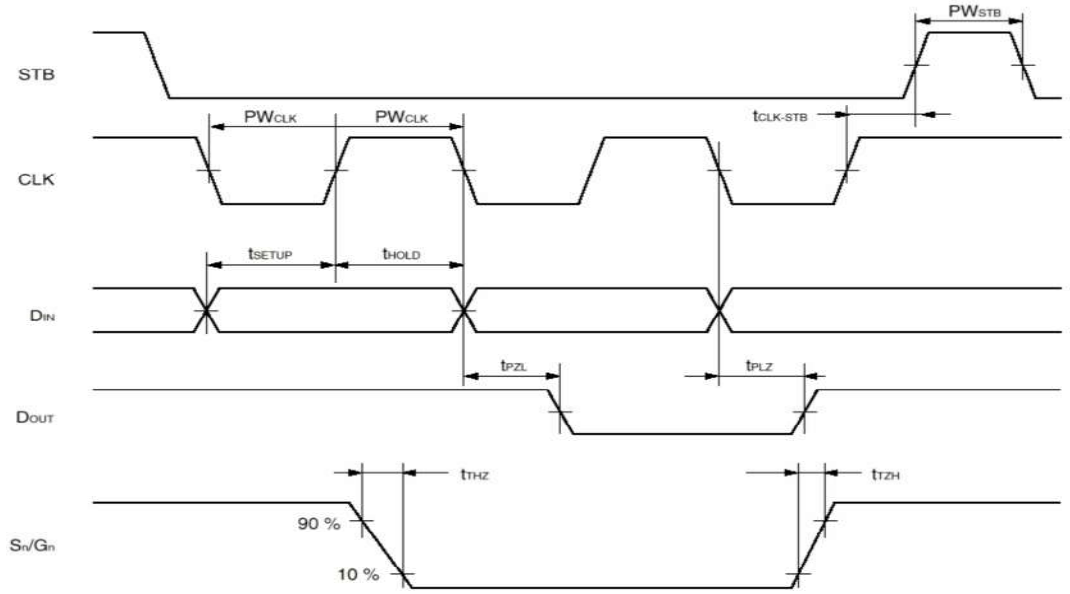
Switching Characteristics (VDD = 4.5~5.5V)

Parameter	Symbol	Min.	Typical	Max.	Unit	Test Condition	
Oscillation frequency	fosc	–	500	–	KHz	R = 16.5 KΩ	
Transmission Delay Time	tPLZ	–	–	300	ns	CLK → DOUT	
	tPZL	–	–	100	ns	CL = 15pF, RL = 10K Ω	
Rising time	TTZH 1	–	–	2	μs	CL = 300p F	Seg1～Seg6
	TTZH 2	–	–	0.5	μs		Grid1～Grid4 Seg12/Grid7～ Seg14/Grid5
Falling time	TTHZ	–	–	120	μs	CL = 300pF, Segn, Gridn	
Maximum clock frequency	Fmax	1	–	–	MHz	Duty cycle 50%	
Input capacitance	CI	–	–	15	pF	–	

Time Sequential Characteristics (Ta = -20 ~ +70℃, VDD = 4.5~5.5V)

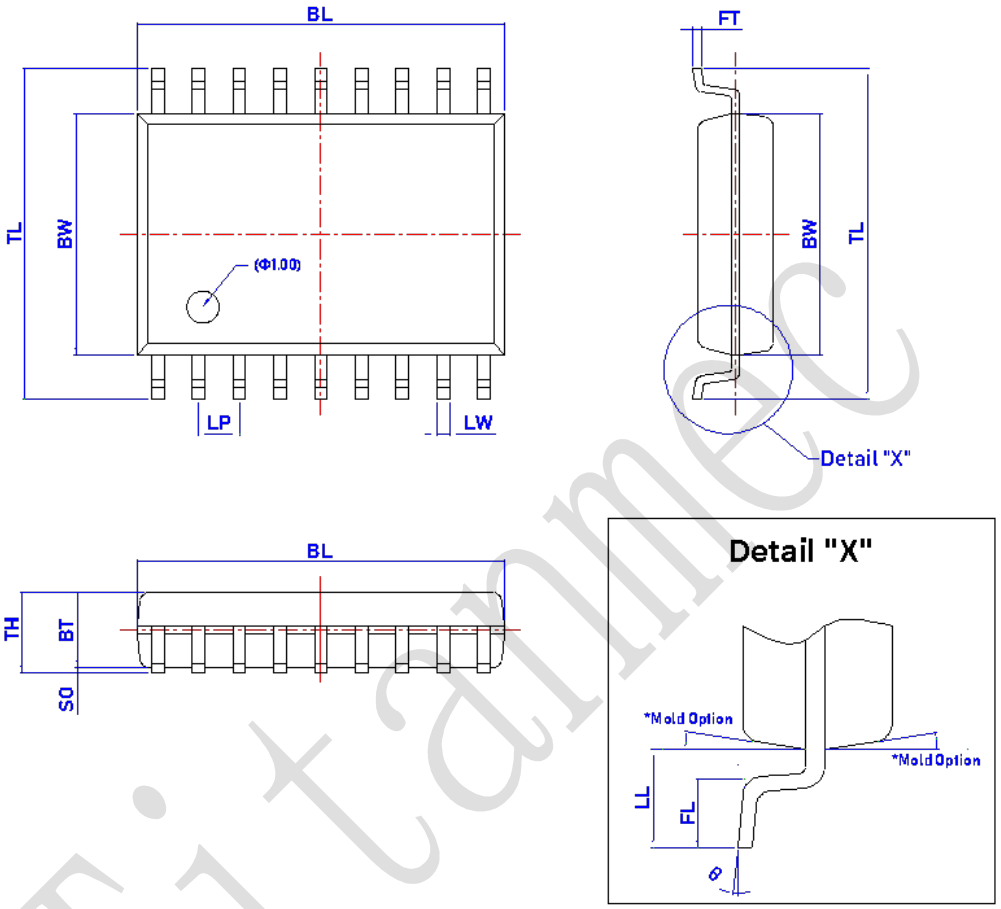
Parameter	Symbol	Min.	Typical	Max.	Unit	Test Condition
Clock-pulse width	PWCLK	400	–	–	ns	–
Gate width	PWSTB	1	–	–	μs	–
Data setup time	tSETUP	100	–	–	ns	–
Data hold time	tHOLD	100	–	–	ns	–
CLK →STB time	tCLK STB	1	–	–	μs	CLK↑→STB↑
Waiting time	tWAIT	1	–	–	μs	CLK↑→CLK↓

Time Sequential Oscillogram：



XIII. IC Encapsulation Drawing:

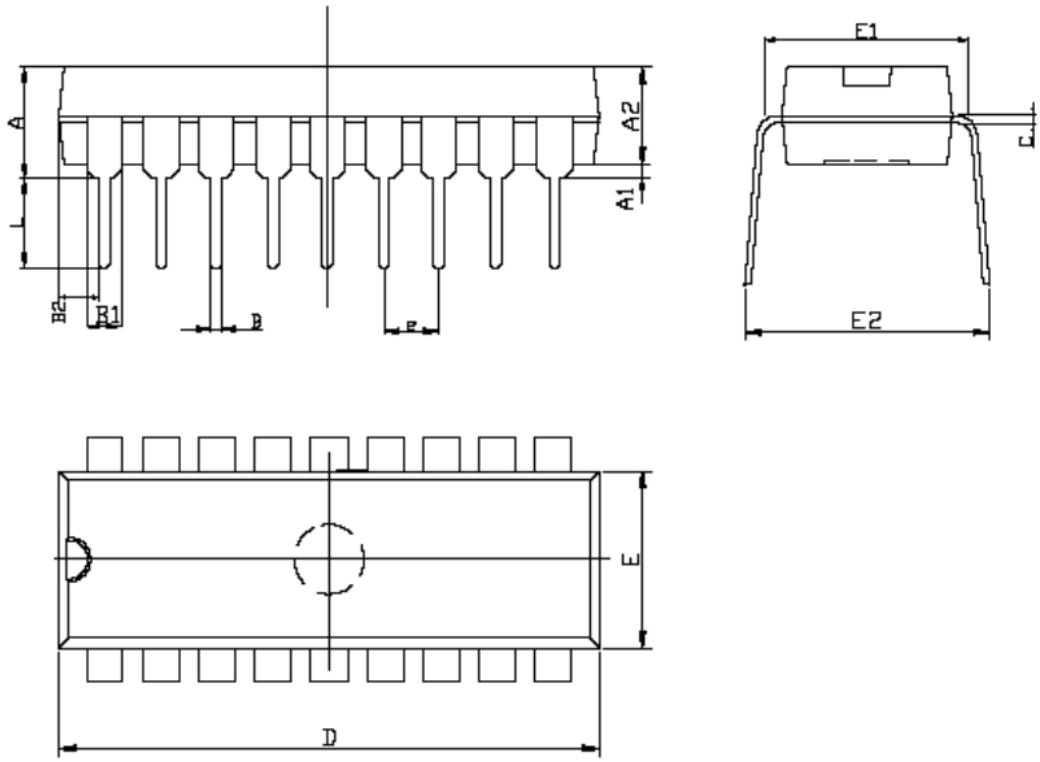
SOP18-300



Dimensions

Item	BL	BW	TL	LW	LP	FT	BT	SO	TH	LL	FL	θ
表示	总长	胶体宽度	宽度	脚宽	脚间距	脚厚	胶体厚度	站高	胶体高度	单边长	脚长	脚角度
Unit	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	°
Spec	11.65 (11.45) 11.25	7.70 (7.50) 7.30	10.50 (10.30) 10.10	0.400 TYP	1.270 TYP	0.300 (0.250) 0.200	2.44 (2.34) 2.24	0.250 (0.150) 0.100	2.590 Max.	1.50 (1.40) 1.30	1.00 (0.80) 0.70	8 (4) 0

DIP18



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	0.010
A2	3.200	3.600	0.126	0.142
B	0.356	0.510	0.014	0.020
B1	1.524(BSC)		0.060(BSC)	
C	0.204	0.360	0.008	0.014
D	22.700	23.100	0.894	0.909
E	6.200	6.600	0.244	0.260
E1	7.62	8.255	0.300	0.325
e	2.540(TYP)		0.100(TYP)	
L	3.000	3.600	0.118	0.142
E2	8.200	9.000	0.323	0.354
B2	0.871	1.171	0.034	0.046

- All specs and applications shown above subject to change without prior notice.