I. General

TM1651 is a LED (Light Emitting Diode) driver control IC with keyboard scan interface. Its internal integration includes MCU digital interface, data latch, LED high-voltage drive, keyboard scan, etc. With good performance and reliable quality, the product is mainly applied to display driver of electromagnetic oven, microwave oven and small household appliances. It adopts SOP16/DIP16 packaging.

II. Features

- **Power CMOS technology.**
- **Display (7 segments× 4 bits), CA LED display supported**
- **Key scanning (7×1bit): enhanced anti-jamming key identification circuit**
- **Brightness adjustment circuit (8 levels of duty ratio, adjustable)**
- **Serial interface (CLK, DIO)**
- **Oscillation: built-in RC oscillator (450KHz±5%)**
- **Built-in power-on reset circuit**
- **Built-in automatic blanking circuit**
- **Packaging: DIP16/SOP16**

III. Pin Definitions

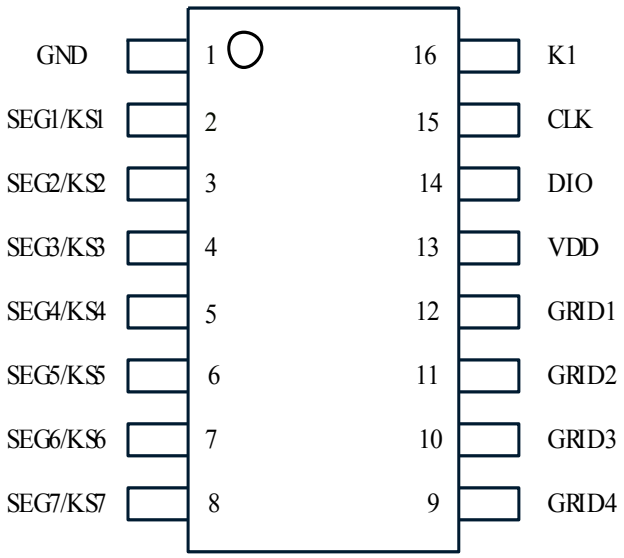


Fig. 1 Pin Definitions

IV. Pin Functions

Symbol	Pin name	Pin No.	Description
DIO	Data input/output	14	Serial data input/output, input data changing at low level of CLK, transmitted at high level of CLK; for each transmission of one byte, one ACK will be generated at the 9th clock inside the chip.
CLK	Clock input	15	Rising-edge input/output data
K1	Key scan data input	16	Data inputted to this pin will be latched after the end of display cycle.
SEG1~SEG7	Output (segment)	2-8	Segment output (also for key scan), N tube open-drain output
GRIG4~GRIG1	Output (bit)	9-12	Bit output, P tube open-drain output
VDD	Logic power	13	To system power
VSS	Logic ground	1	To system ground

V. Display Register Address

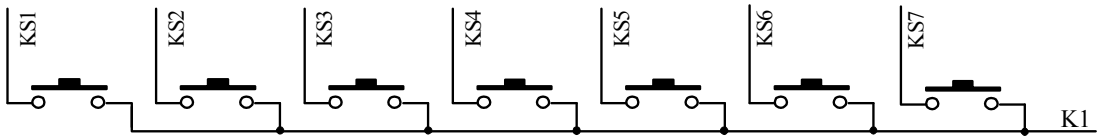
The register stores the data transmitted from peripheral device to TM1651 via serial interface. The address 00H-03H has 4 byte units, respectively corresponding to the LED lights connected with chip SEG and GRID pins, as shown in the figure below:

The operation of writing LED display data shall follow the principle of "from low bit to high bit" of display address and "from low bit to high bit" of data byte.

SEG1	**SEG2**	**SEG3**	**SEG4**	**SEG5**	**SEG6**	**SEG7**	**X**	
xxHL（low four bits）				xxHU(high four bits)				
B0	B1	B2	B3	B4	B5	B6	B7	
00HL				00HU				**GRID1**
01HL				01HU				**GRID2**
02HL				02HU				**GRID3**
03HL				03HU				**GRID4**

VI. Key Scan & Key Scan Data Register

Key scan matrix is 7×1bit, as shown below:



When there is a key pressed, reading key data are as follows:

	SEG1/KS1	SEG2/KS2	SEG3/KS3	SEG4/KS4	SEG5/KS5	SEG6/KS6	SEG7/KS7
K1	1110_1111	0110_1111	1010_1111	0010_1111	1100_1111	0100_1111	1000_1111

Note: when there is no key pressed, reading key data is 1111_1111, with low bits ahead of high bits.

VII. Instruction Description

Instruction is to set display mode and state of LED driver.

After CLK falling edge, the first byte inputted by DIO is an instruction. After decoding, the highest two bits, B7 and B6, are used as instructions for differentiating from each other.

B7	B6	Command
0	0	display mode setting
0	1	data command setting
1	0	display control command setting
1	1	address command setting

7.1 Data command setting:

This instruction is to set data writing and reading, and B1 and B0 bits shall not be set 01 or 11.

MSB **LSB**

B7	B6	B5	B4	B3	B2	B1	B0	Function	Description
0	1	For irrelevant items, fill "0" in.				0	0	To set data read/write mode	Write data to display register
0	1					1	0		Read key scan data
0	1				0			To set address adding mode	Automatic address adding
0	1				1				Fixed address
0	1			0				To set testing mode (for internal use)	Common mode
0	1			1					Testing mode

7.2 Address command setting:

MSB **LSB**

B7	B6	B5	B4	B3	B2	B1	B0	Display address
1	1	For irrelevant		0	0	0	0	00H
1	1			0	0	0	1	01H

1	1	items, fill "0" in.	0	0	1	0	02H
1	1		0	0	1	1	03H

This instruction is to set the address of display register. If the address is set 0C4H or higher, the data will be omitted until a valid address is set. When power on, the default address is 00H.

7.3 Display control

MSB **LSB**

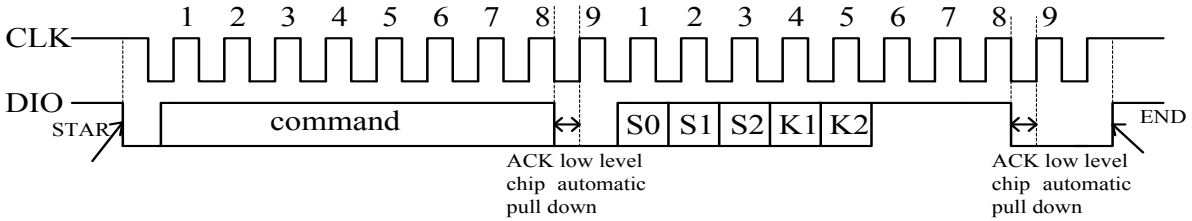
B7	B6	B5	B4	B3	B2	B1	B0	Function	Description
1	0	For irrelevant items, fill "0" in.			0	0	0	To set gray scale	Set pulse width 1/16
1	0				0	0	1		Set pulse width 2/16
1	0				0	1	0		Set pulse width 4/16
1	0				0	1	1		Set pulse width 10/16
1	0				1	0	0		Set pulse width 11/16
1	0				1	0	1		Set pulse width 12/16
1	0				1	1	0		Set pulse width 13/16
1	0				1	1	1		Set pulse width 14/16
1	0			0				To set display on/off	Display off
1	0			1					Display on

VIII. Serial Data Transmission Format

The data of microprocessor communicate with TM1651 via two-line bus interface. During data input, DIO signal must keep unchanged when CLK is at high level. Only when CLK clock signal is at low level can DIO signal be changed. The condition of starting data input is that DIO changes from high to low when CLK is at high level, and its condition of ending is that DIO changes from low to high when CLK is at high level.

TM1651 data transmission has the acknowledge signal ACK. When data is correct, at the falling edge of the 8th clock, one ACK will be generated inside the chip and DIO pin will be pulled low; and the rising edge of the 9th clock releases port line.

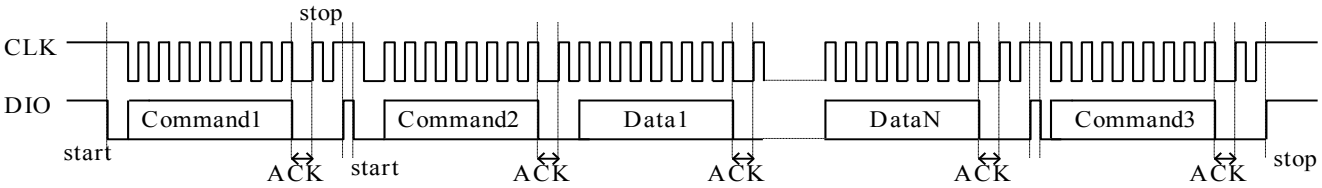
Process of command data transmission is shown as below (time sequence of reading key data):



Command: read key command

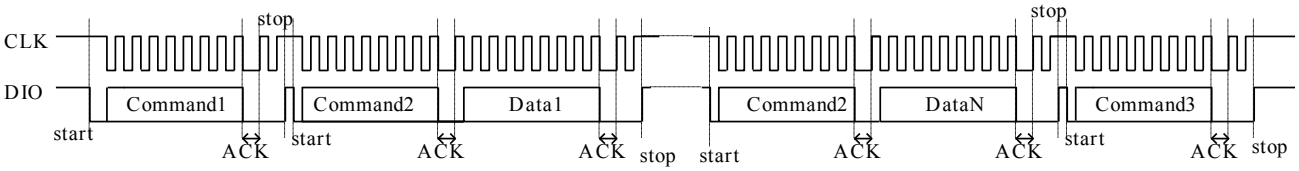
S0, S1, S2 and K1 compose key information code. S0, S1 and S2 are codes of SG; and K1 and K2 are codes of K1. Reading keys, CLK frequency shall be less than 250K, first low bits and then high bits.

Writing SRAM data, address automatic plus 1 mode



Command1: set data
Command2: set address
Data1~N: transmit display data.
Command3: control display

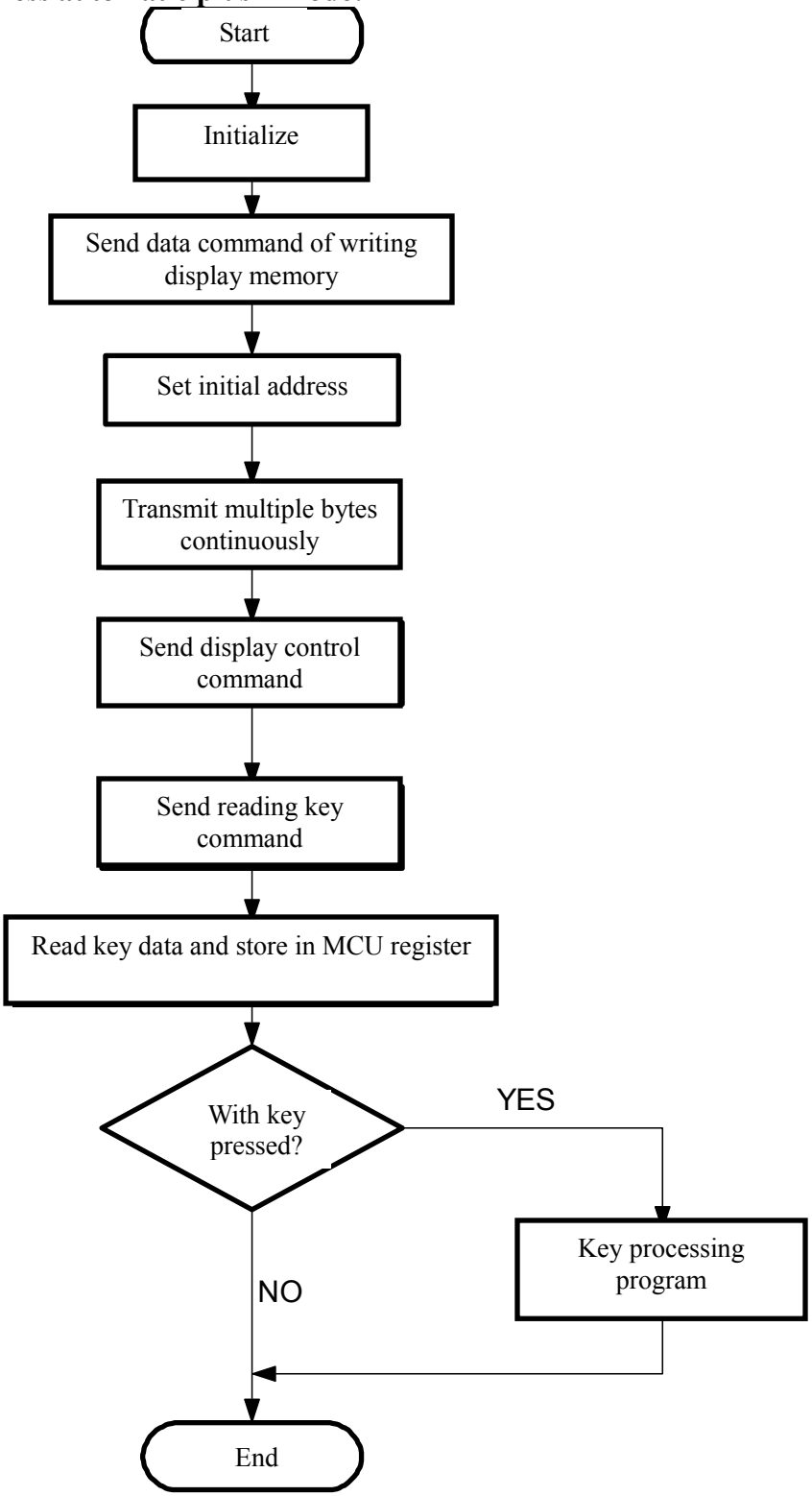
Writing SRAM data, fixed address mode



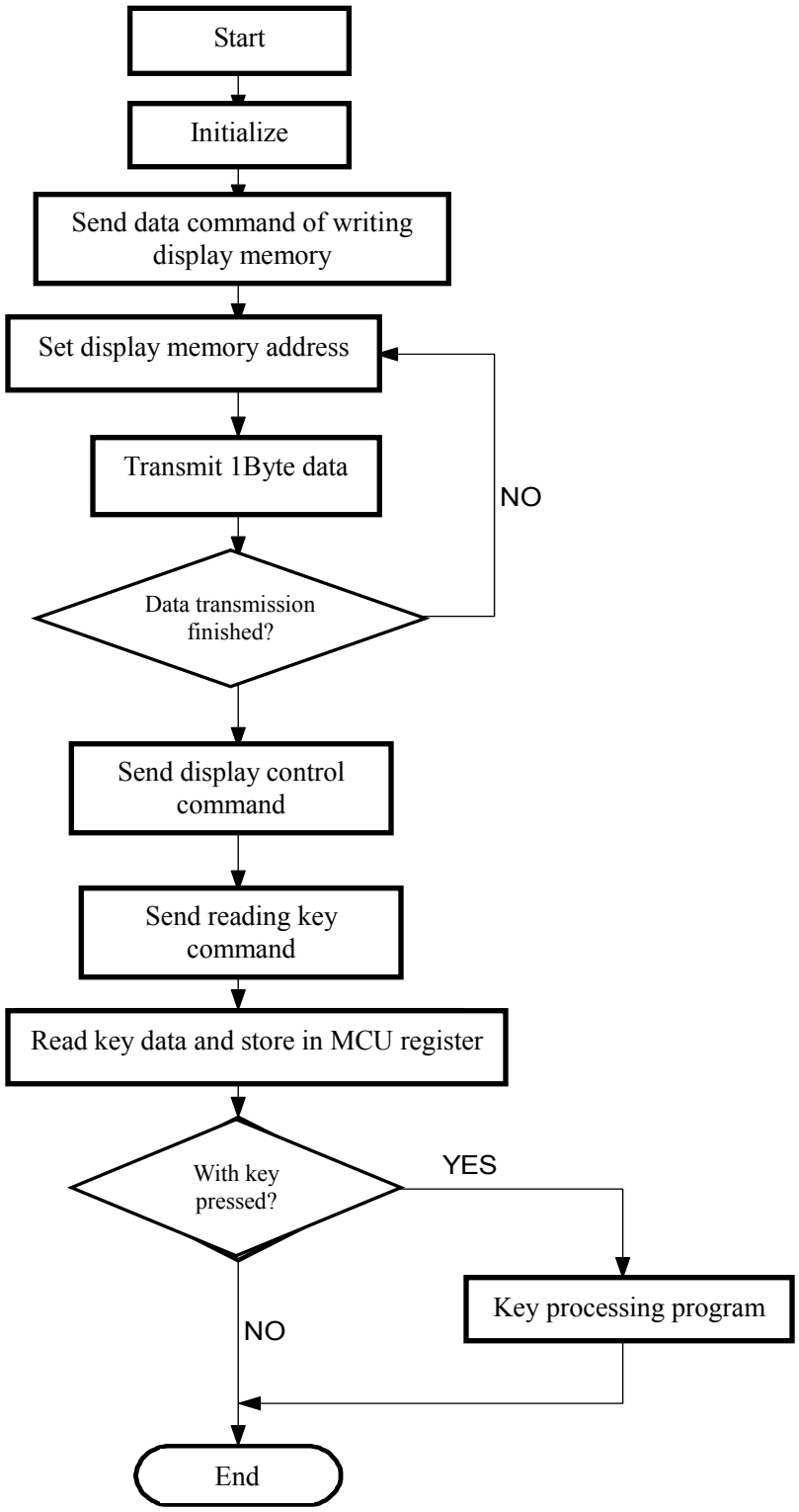
Command1: set data
Command2: set address
Data1~N: transmit display data.
Command3: control display

IX. Flow Chart of Program

Flow chart of address automatic plus 1 mode:

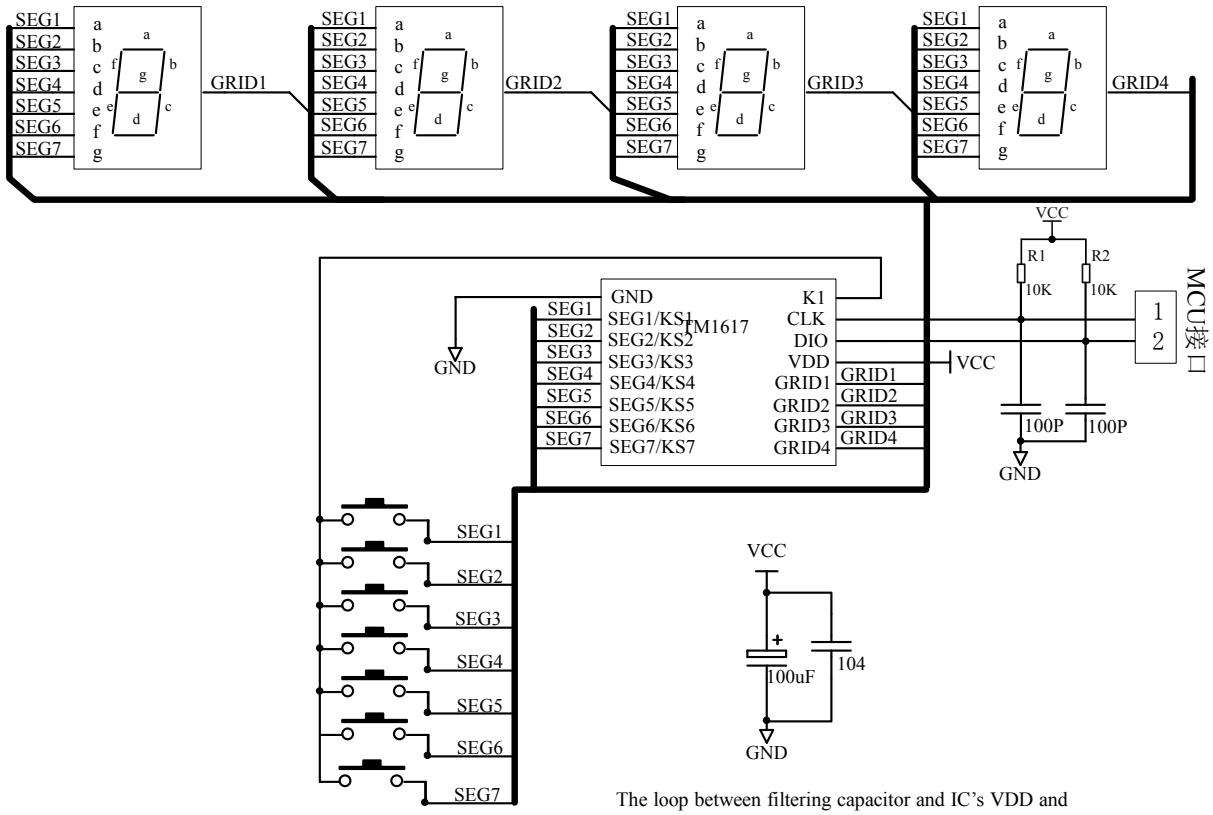


Flow chart of fixed address mode:



X. Application Circuits

The LED display in the circuit is CA type.



The loop between filtering capacitor and IC's VDD and GND shall be as short as possible.

XI. Electrical Parameters:

Limit parameters (Ta = 25℃, Vss = 0 V)

Parameter	Symbol	Range	Unit
Logic supply voltage	VDD	-0.5 ～+7.0	V
Logic input voltage	VI1	-0.5 ～ VDD + 0.5	V
LED SEG drive sink current	IO1	50	mA
LED GRID drive source current	IO2	200	mA
Power loss	PD	400	mW
Operating temperature	Topt	-40 ～ +85	℃
Storage temperature	Tstg	-65 ～+150	℃

Normal operating range (Ta = -40～+85℃, Vss = 0 V)

Parameter	Symbol	Min.	Typical	Max.	Unit	Test conditions
Logic supply 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 features (Ta = -40~+85℃, VDD = 4.5~5.5 V, Vss = 0 V)

Parameter	Symbol	Min.	Typical	Max.	Unit	Test conditions
GRID drive source current	Ioh1	80	120	180	mA	GRID1~GRID4, Vo = Vdd-2V
	Ioh2	80	140	200	mA	GRID1~GRID4, Vo = vdd-3V
SEG drive sink current	IOL1	20	30	50	mA	SEG1~SEG7 Vo=0.3V
DOUT pin output low-level current	Idout	4	-	-	mA	Vo = 0.4V, dout
Output pull down resistance	RL		10		KΩ	K1
Input current	II	-	-	±1	μA	VI = VDD / VSS
High-level input voltage	VIH	0.7 VDD	-		V	CLK, DIO
Low-level input voltage	VIL	-	-	0.3 VDD	V	CLK, DIO
Lagging voltage	VH	-	0.35	-	V	CLK, DIO
Dynamic current loss	IDDdyn	-	-	5	mA	Load-free, display off

Switch features (Ta = -40~+85℃, VDD = 4.5~5.5 V)

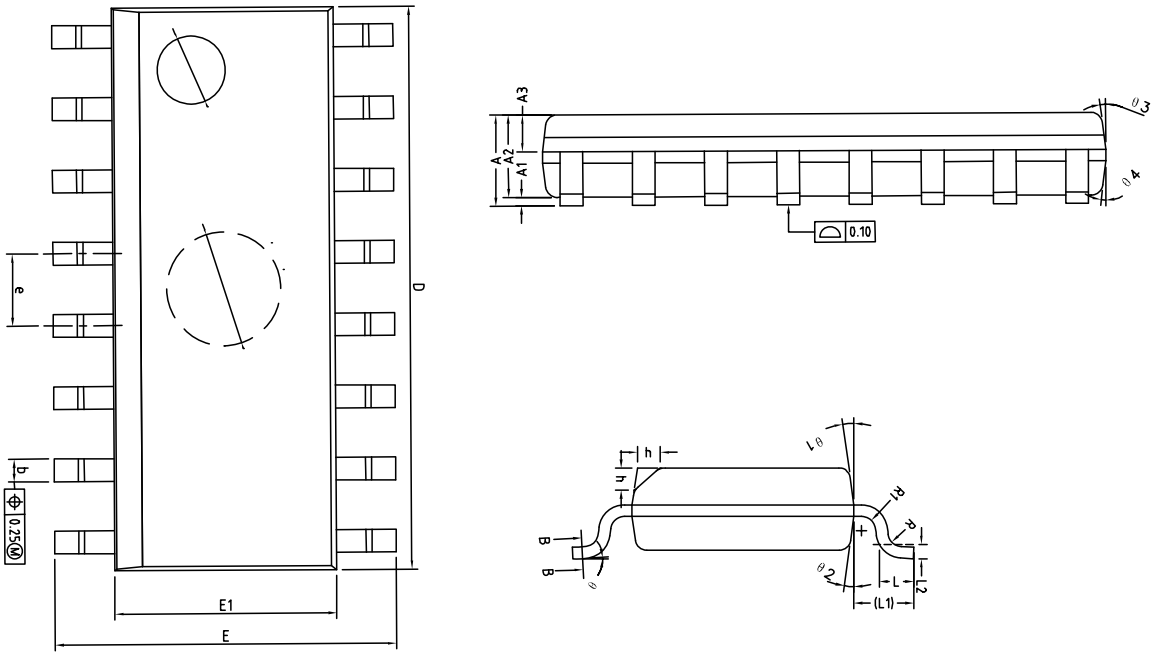
Parameter	Symbol	Min.	Typical	Max.	Unit	Test conditions	
Oscillation frequency	fosc	-	450	-	KHz		
Propagation delay time	tPLZ	-	-	300	ns	CLK → DIO CL = 15pF, RL = 10K Ω	
	tPZL	-	-	100	ns		
Rise time	TTZH1	-	-	2	μs	CL = 300p F	SEG1/KS1 ～ SEG7/KS7
Fall time	TTHZ	-	-	120	μs	CL = 300pF，SEGn，GRIDn	
Max. clock frequency	Fmax	-	-	500	KHz	Duty ratio 50%	
Input capacitance	CI	-	-	15	pF	-	

- **Time sequence features (Ta = -40~+85℃, VDD = 4.5~5.5 V)**

Parameter	Symbol	Min.	Typical	Max.	Unit	Test conditions
Clock pulse width	PWCLK	400	-	-	ns	-
Data setup time	tSETUP	100	-	-	ns	-
Data holding time	tHOLD	100	-	-	ns	-
Waiting time	tWAIT	1	-	-	μs	CLK↑→CLK↓

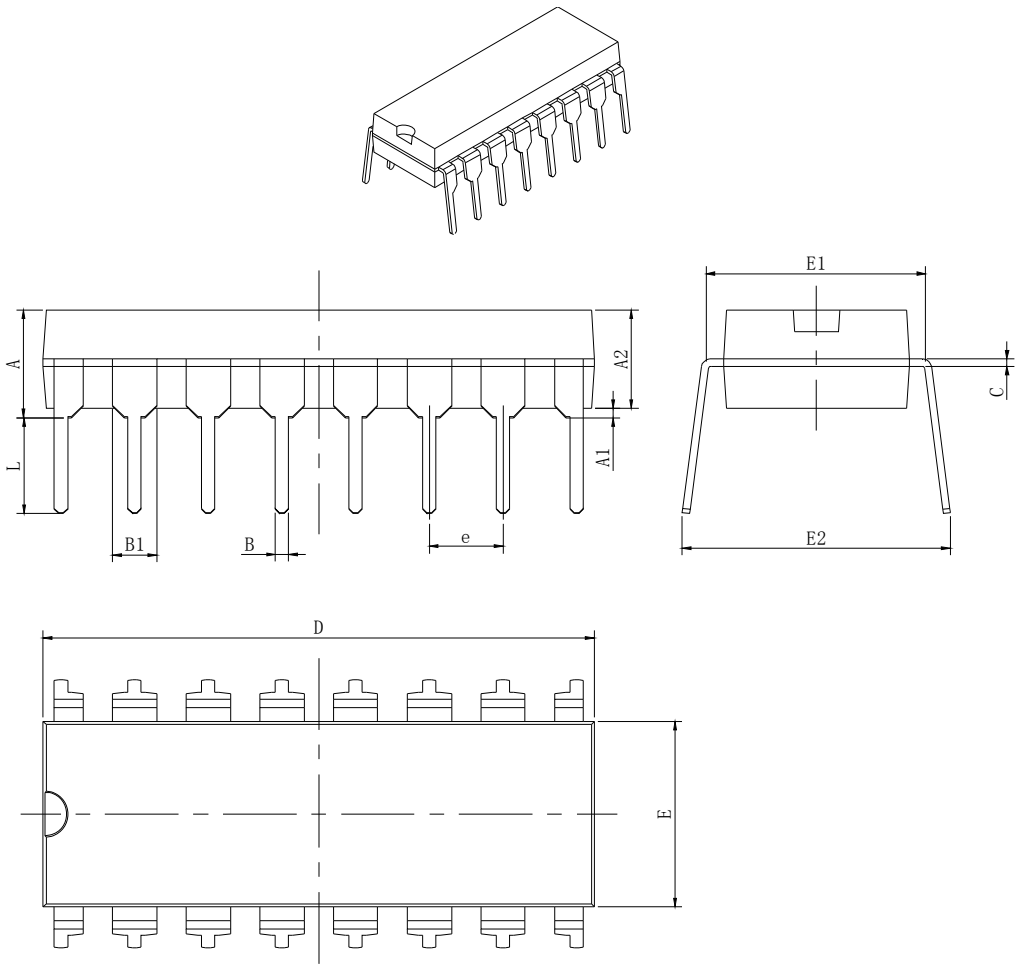
XII. Diagrammatic Sketches of IC Encapsulation:

SOP16:



SYMBOL	MIN/mm	NOM/mm	MAX/mm
A	–	–	1.75
A1	0.10	0.15	0.25
A2	1.35	1.45	1.55
A3	0.55	0.65	0.75
b	0.36	–	0.51
b1	0.35	0.40	0.45
c	0.18	–	0.25
c1	0.17	0.20	0.23
D	9.80	9.90	10.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.22	1.27	1.32
L	0.45	0.60	0.80
L1	1.04REF		
L2	0.25BSC		
R	0.07	–	–
R1	0.07	–	–
h	0.30	0.40	0.50
θ	0°	–	8°
θ 1	6°	8°	10°
θ 2	6°	8°	10°
θ 3	5°	7°	9°
θ 4	5°	7°	9°

DIP16:



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	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524 (BSC)		0.060 (BSC)	
C	0.204	0.360	0.008	0.014
D	18.800	19.200	0.740	0.756
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540 (BSC)		0.100 (BSC)	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354

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