Feature Description

The TM1652 is a dedicated chip for driving and controlling LEDs (light-emitting diodes, digital tubes, dot matrix displays). It integrates digital communication circuitry, decoding circuitry, data latches, an oscillator, and LED driver circuitry. Communication is via asynchronous serial communication (UART) protocol. Since the chip only receives data from the microcontroller, only one TX port of the microcontroller needs to send data to the chip, achieving single-wire communication. For display driving, the chip uses a dynamic scanning method, offering two display modes, adjustable 8-segment drive current, and adjustable 16-segment duty cycle. The TM1652 also includes built-in blanking optimization circuitry.

This product is widely used in various consumer electronics products, such as air conditioner panels, washing machine panels, DVD display panels, and set-top box displays. It boasts excellent performance and reliable quality.

Features

Power CMOS process

Typical operating voltage: 5V

Supports common cathode digital tube display

Two display modes (7-segment x 6-bit, 8-segment x 5-bit)

Brightness adjustment circuit (16-level adjustable duty cycle, 8-level adjustable segment drive current);

Serial interface (SDA), compatible with UART protocol, supporting baud rate 19200bps; Built-in.OSC

2.5MHz frequency

Built-in power-on reset circuit

Built-in optimized circuitry for dim/brightness issues

Package type: SOP16

Internal structure diagram

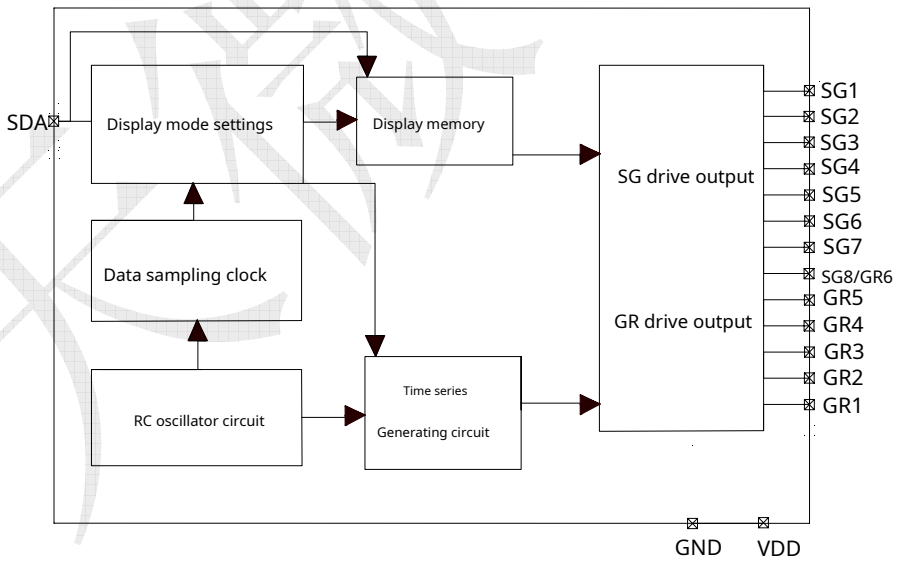


Figure 1

Pin arrangement

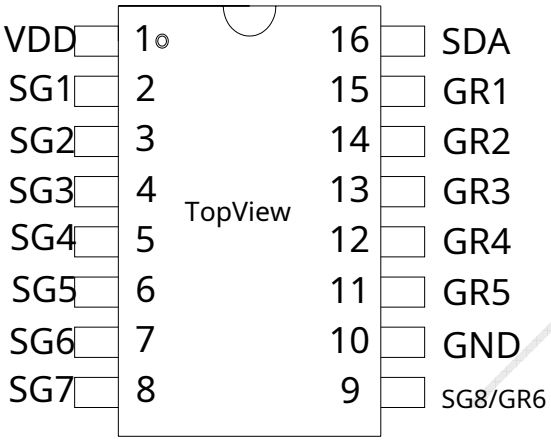


Figure 2

Pin Functions

Pin Name	Pin number	I/O	Function Description
VDD	1	- -	Power positive
SG1～SG7	2～8	O	Segmented output, built-in PMOS 8-stage adjustable drive current, used for driving LED current output
SG8/GR6	9	O	Segment/bit multiplexed output, combining the functions of SEG and GRID, by software. Configuration
GR1～GR5	11-15	O	Bit output, built-in NMOS 16-stage adjustable duty cycle, used as a driver LED sinking current output
GND	10	- -	power ground
SDA	16	I	Data input pin

Notice: The multiplexed output pins of SG8/GR6 cannot be connected to both the segment drive pin and the digit drive pin of the digital tube at the same time. If connected in this way, it will cause the digital display to light up incorrectly, resulting in abnormal display.

Input-output equivalent circuit

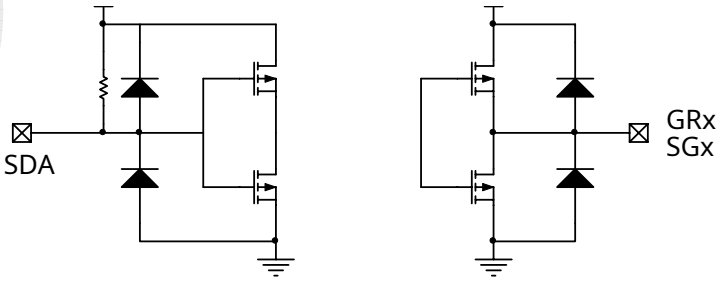


Figure 3

Integrated circuits are electrostatic sensitive devices. They are prone to generating large amounts of static electricity during dry seasons or in dry environments. Electrostatic discharge can damage integrated circuits. Tianwei Electronics recommends taking all appropriate preventative measures for integrated circuits and avoiding improper operation.

Soldering may cause ESD damage or performance degradation, preventing the chip from working properly.

Limiting parameters

Parameter name	Parameter symbol	Limit value	unit
Logic power supply voltage	VDD	+7.0	V
Logic input voltage	VI1	VDD + 0.5	V
GR drive output current	IO2	170mA@0.3V	mA
Power loss	PD	400	mW
Operating temperature	Topt	-40 ~ +80	℃
Storage temperature	Tstg	-65 ~ +150	℃
ESD	Human Body Model (HBM)	3000	V
	Machine Mode (MM)	200	V

(1) If the chip operates under the above-mentioned extreme parameter conditions for a long time, it may cause a decrease in device reliability or permanent damage. Tianwei Electronics does not recommend that the chip be used under these extreme parameter conditions.

Any parameter that reaches or exceeds these limit values.

(2) All voltage values are tested relative to the system.

Recommended working conditions

Test at -45℃ to +85℃, unless otherwise specified.			TM1652			unit
Parameter name	Parameter symbol	Test conditions	Minimum value	Typical value	Maximum value	
Logic power supply voltage	VDD	—	3	5	6	V
High-level input voltage	VIH	—	0.7VDD	—	VDD	V
Low-level input voltage	VIL	—	0	—	0.3VDD	V

Electrical characteristics

Test at -20℃ to +85℃, unless otherwise specified; VDD = 5 V, GND = 0 V			TM1652			unit
Parameter name	Parameter symbol	Test conditions	Minimum value	Typical value	Maximum value	
SG high-level output current	Ioh1	SG drive strength 8/8, SG1~SG8 ports Apply 3V when it is high level test	20	25	30	mA
	Ioh2	SG drive strength 8/8, SG1~SG8 ports Apply 2V when it is high level test	20	30	40	mA
GRLow-level input current	IOL1	GR1~GR6 ports are low When the voltage is at level, apply 0.3V. test	80	140	—	mA
SDAInput current	Isda	VDD=5V, other feet suspended null	—	—	±1	μA

High-level input voltage	VIH	VDD=5V	0.7 VDD	—	—	V
Low-level input voltage	VIL	VDD=5V	—	—	0.3 VDD	V
Lag voltage	VH	VDD=5V	—	0.35	—	V
Dynamic current loss	IDDdyn	No load, display off	—	—	5	mA

Switching characteristics

Test at -20℃ to +85℃, unless otherwise specified. VDD=5V, GND=0V			**TM1652**			**unit**
Parameter name	**Parameter symbol**	**Test conditions**	**Minimum value**	**Typical value**	**Maximum value**	
Internal oscillation frequency	fosc	—	—	2.5	—	MHz
GR scan cycle	Fgr	SG8*GR5 mode	450	500	550	Hz
		SG7*GR6 mode	370	420	470	
Baud rate bit width range	Bsda	VDD=5V	47	52	57	μs
SDA data frequency	Fmax	50% duty cycle	1	—	—	MHz
SDA input capacitor	CI	—	—	—	15	pF

Function Description

1. Communication Protocol

This chip uses the asynchronous serial communication (UART) protocol, and its working principle is to transmit each character of the data one bit at a time serially. The following diagram shows its working mode:

Figure 4

The time for each bit of the TM1652 is 52μs.

The meaning of each bit is as follows:

▲ Start bit: The low level time, which is one bit, indicates the start of character transmission.

▲ Data bits: D0-D7 immediately following the start bit, with the least significant bit sent first.

▲ Parity bit: This is the time of one bit. If the number of 1s in the 8 data bits is odd, this bit is set to 0 (low level), otherwise it is set to 1 (high level).

▲ Stop bit: Set high. The time is one bit, which is the end marker for sending one character of data.

▲ Idle bit: Set high. If the idle bit is held high for more than 3ms, the TM1652 considers the current data frame to be finished, and the data is loaded from the temporary register into the corresponding register to start controlling the chip's output. If a data transmission frame is not finished, it is recommended to set the idle bit time within the range of 0-0.5ms.

A frame of data from the TM1652 includes the following two forms:

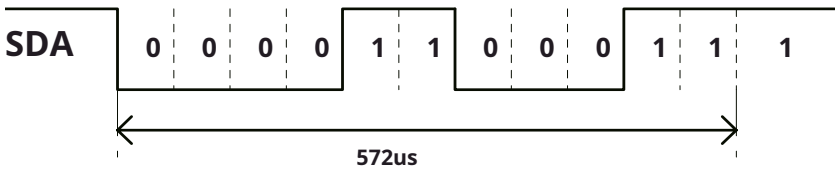
(1) Display address command + display data;

(2) Display control commands + display control adjustment commands.

Baud rate: A measure of data transfer rate. It is expressed as the number of binary digits (bits) transmitted per second. For example, data transfer rate. The transmission rate is 120 characters/second, and each character is 11 bits, so the baud rate is 11 × 120 = 1320 bits/second = 1320 baud. The TM1652 supports a baud rate range of 17500bps to 21200bps, and we recommend using 19200bps, i.e., 11 bits/second.

The time is: 1 second / 19200 ≈ 52 microseconds. Therefore, the time range for each bit supported by the TM1652 is 47 microseconds to 57 microseconds. When using IO to simulate UART communication, the bit width of the SDA data should meet the provided bit width range.

Below, we take a baud rate of 19200bps as an example and send the display control command "0X18" to the SDA pin. The timing waveform diagram is as follows:



picture5

As shown in the image above5,send"0X18"Total11The positions, from left to right, are:1Start bit,8Bit data bits,1Bit check bit,1The stop bit has a time of approximately 1 stop bit.52us,11The total time is approximately572usThe binary representation of the image above is "".00011000"That is, converting to hexadecimal is "0X18".

Notice: The TM1652 can receive control signals from MCUs powered by 5V or 3.3V, but it is not recommended to use systems with different power supplies.

2. Display command description

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	illustrate
Address			0	1	0	0	0	Display address command
0	0	0	1					Display control commands

B3 to B0 are fixed data of 1000, used for internal clock calibration.

3. Display Data Description

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0
SG8	SG7	SG6	SG5	SG4	SG3	SG2	SG1

For the corresponding bit, setting it to "0" indicates invalidity and outputs a low level, while setting it to "1" indicates validity and outputs a high level. For example, "0x01" indicates that SG1 outputs high.

4. Description of the Display Address command

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	Display address
0	0	0	0	1	0	0	0	GR1 address
1	0	0						GR2 address
0	1	0						GR3 address
1	1	0						GR4 address
0	0	1						GR5 address
1	0	1						GR6 address

B3 to B0 are fixed values of 1000, used for internal clock calibration. Setting B4 to "0" indicates that the current data is a display address command.

5. Description of display control and adjustment commands

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	Function	illustrate
0	0	0	0					Display switch settings	Turn off screen
1	0	0	0					Bit drive duty cycle setting Place	Set the duty cycle to 1/16
0	1	0	0						Set the duty cycle to 2/16.
1	1	0	0						Set the duty cycle to 3/16.
0	0	1	0						Set the duty cycle to 4/16.
1	0	1	0						Set the duty cycle to 5/16.
0	1	1	0						Set the duty cycle to 6/16.
1	1	1	0						Set the duty cycle to 7/16.
0	0	0	1						Set the duty cycle to 8/16.
1	0	0	1						Set the duty cycle to 9/16.
0	1	0	1						Set the duty cycle to 10/16.
1	1	0	1						Set the duty cycle to 11/16.
0	0	1	1						Set the duty cycle to 12/16.
1	0	1	1						Set the duty cycle to 13/16.
0	1	1	1						Set the duty cycle to 14/16.
1	1	1	1						Set the duty cycle to 15/16.
				0	0	0		Segment drive current setting	Set the segment drive current to 1/8
				1	0	0			Set the segment drive current to 2/8
				0	1	0			Set the segment drive current to 3/8
				1	1	0			Set the segment drive current to 4/8
				0	0	1			Set the segment drive current to 5/8
				1	0	1			Set the segment drive current to 6/8
				0	1	1			Set the segment drive current to 7/8
				1	1	1			Set the segment drive current to 8/8
							0	Display mode settings	Set 8-segment 5-bit output
							1		Set 7-segment 6-bit output

This command is used to set the bit duty cycle, segment drive current, and display mode selection.

Notice: Since the current provided by the chip is insufficient to light up a regular digital tube when the segment drive current is 1/8, it is recommended to set the segment drive current to at least 2/8.

Application Information

1. TM1652 Command Data Definition

The first byte contains control command settings, with the least significant bit sent first. The lower four bits (B3-B0) are fixed values of 1000. B4 is the register type selection: "1" selects the display control command, and "0" selects the display address command. B7-B5 set the display address.

The data begins from the second byte and is loaded into the corresponding temporary register according to the address in the first byte. If it is a display control command, the second byte must contain the display control adjustment command. If it is a display address command, it can be multiple bytes of data, with subsequent bytes incremented by 1 and loaded into the corresponding temporary register. If the address exceeds the corresponding valid address (display address 101 or higher), the excess data is invalid. If the address contained in the first byte exceeds the corresponding valid address or is invalid, the data in this instance is invalid. It is recommended to first...

Send the display data first, then send the control data (turn on the display). If the control data (turn on the display) is sent first and the display register is not cleared, random data in the display register will be output, causing the digital tube to display garbled characters until the display register receives the correct display data.

2. Driving the common cathode digital tube:

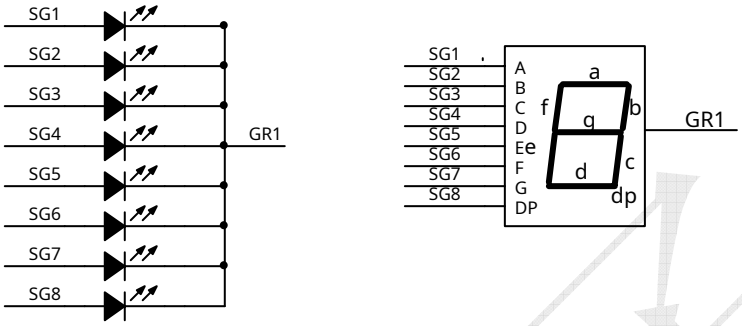


Figure 5

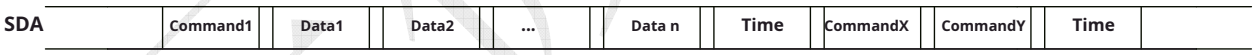
The diagram above shows the connection of a common cathode seven-segment display. To make the display show "0", SG1, SG2, SG3, SG4, SG5, and SG6 need to be set to high level while GR1 is low, and SG7 and SG8 need to be set to low level. Referring to the display address table below, you only need to write the data 3FH to the 00H display address unit to make the display show "0". The detailed data packet is as follows: First, send the address command "0X08", followed by the display data "0X3F", which stores "0X3F" in address 00H and outputs it through the SG pin. For other addresses, you can send all "0X00" to prevent the display from showing. Then, after setting the SDA pin high for at least 3ms, send the display control command and display control adjustment command. After sending, set the SDA pin high for at least 3ms, at which point the display will show "0".

SG8	SG7	SG6	SG5	SG4	SG3	SG2	SG1	
0	0	1	1	1	1	1	1	00H
B7	B6	B5	B4	B3	B2	B1	B0	

3. Data packet transmission method

3.1 Address auto-increment mode

Using the auto-incrementing address mode, setting the address actually sets the starting address for storing the transmitted data stream. After the starting address command word is sent, data is sent immediately, up to 6 bytes. After the data is sent, the data line is set high.



picture6

Command1: Select display address command (0x08)
Data1~Data n: Send display data (maximum 6 bytes) Time:
Data line high duration (minimum 3ms)
CommandX: Select display control command (0x18) CommandY: Send display control adjustment commands (including bit duty cycle, segment drive current, and display mode settings)

3.2 Fixed Address Mode

Using the fixed address mode, setting the address actually sets the address where the 1-byte display data to be sent will be stored. After the address is sent, the 1-byte display data is sent immediately. After the data is sent, the data line is held high for at least 3ms, then the address is sent again, followed by another 1-byte display data, and then the data line is held high for at least 3ms again, and so on, until the address and data are sent.

Figure 7

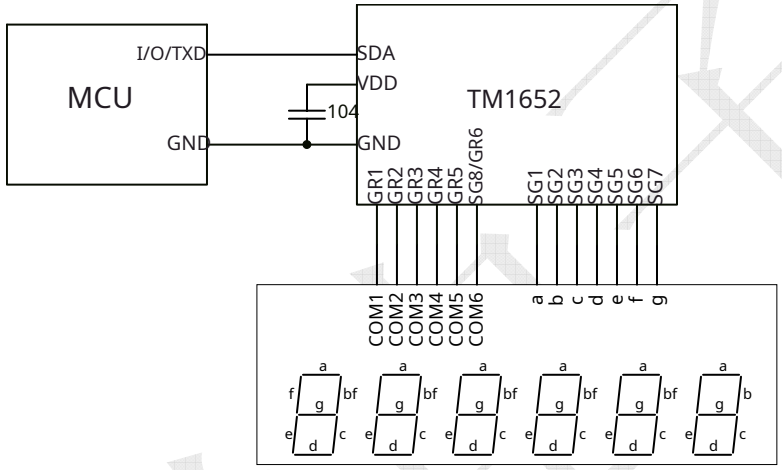
Command1~Command n: Send the command to display the address, address 1~n (up to 6 addresses can be set). Data1~Data n: Send the data to display (up to 6 bytes).

Time: Data cable high-time (minimum time is 3ms)

CommandX: Send display control command (0x18) CommandY: Send display control adjustment command (including bit duty cycle, segment drive current, and display mode settings)

The chip does not require commands to set whether it operates in auto-incrementing address mode or fixed address mode. Strictly speaking, it only has one auto-incrementing address mode. This distinction is made here to better illustrate that the chip can also write display data to a specific display register address. If display data is written to a specific display address, only one display data can be written immediately after writing the display address, and the signal line must be set high for at least 3ms. If several display data are written immediately afterward, the display address will automatically increment by 1 at the specified address after receiving the first data, and then the chip will receive the second display data, until it receives the display data for the last display address.

Sections 4 and 7×6-bit application circuit connection method:



picture8

Sections 5 and 8×5-bit application circuit connection method:

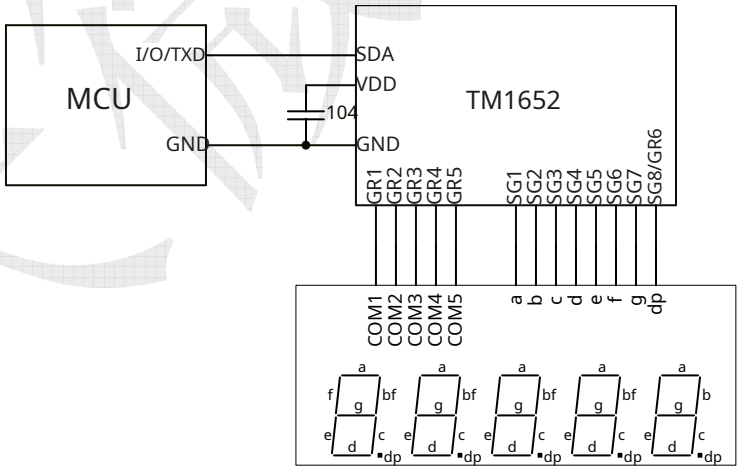
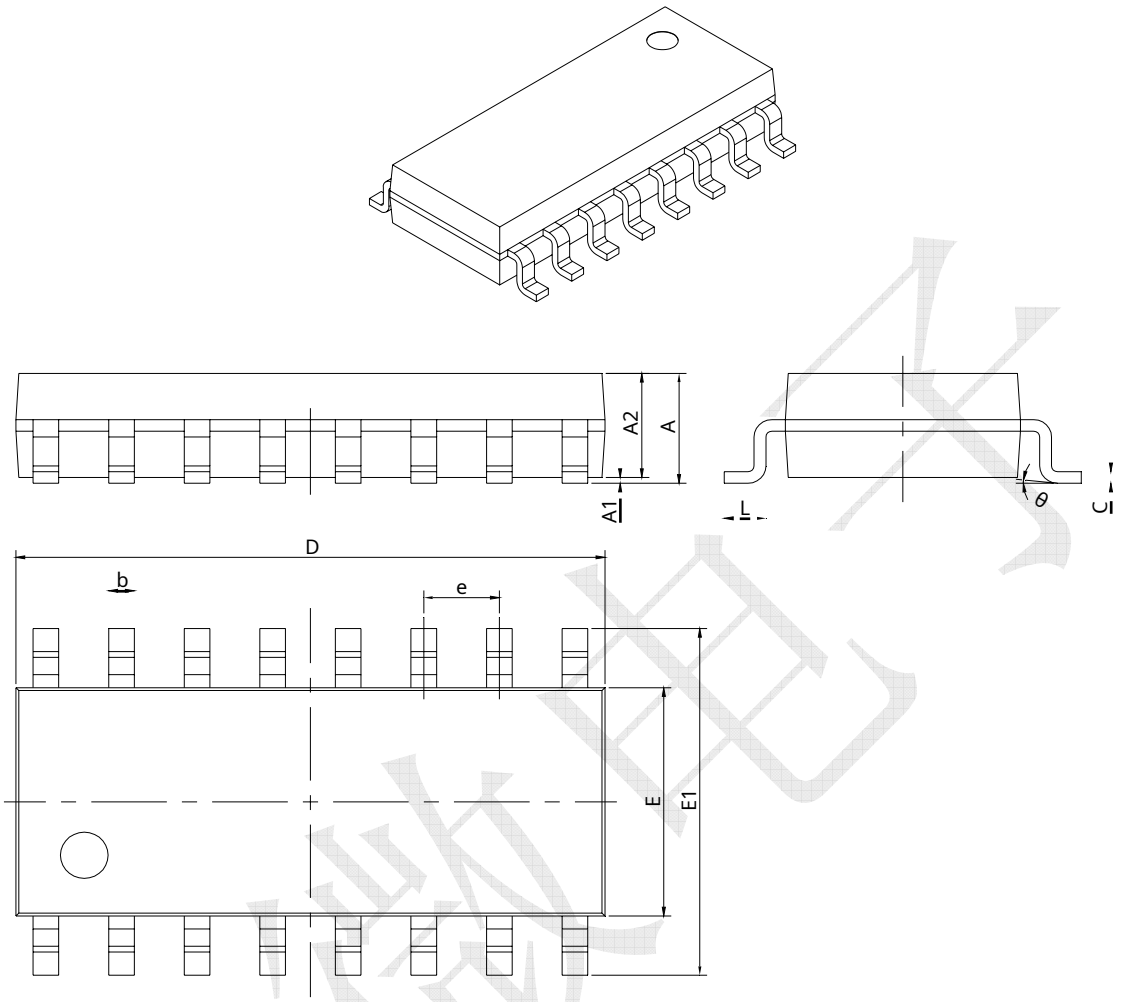


Figure 9

Notice: When applying this technology, please add a 104 decoupling capacitor between the chip's VDD and GND. The shorter the connection between the decoupling capacitor and the chip's VDD and GND, the better the decoupling effect and the more stable the chip operation.

The chip is designed for driving common cathode digital tubes and is not suitable for driving common anode digital tubes.

Package diagram (SOP16)



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°

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

(The circuits and specifications above are for reference only. Please note that the company may make corrections without prior notice.)