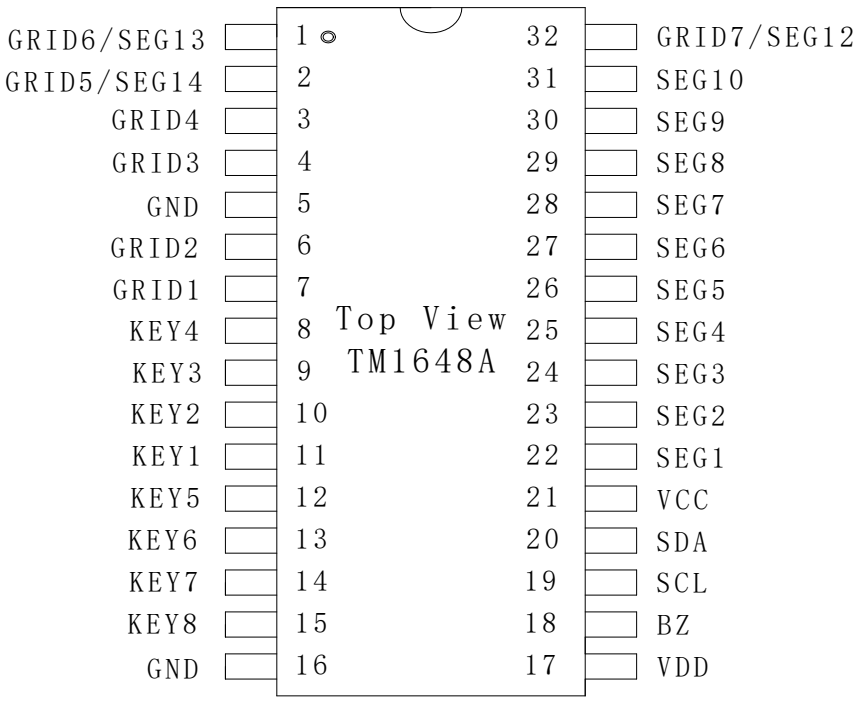
1. **Characteristic Description**

The TM1648A is an LED digital tube driver control IC with 8 touch buttons scanning function, which is highly integrated and requires very few external components to achieve the touch button detection. The chip has integrated MCU digital interface, data latch, key scan, LED driver and active buzzer driver, etc. It has high supply voltage rejection ratio to reduce the occurrence of key detection errors, automatic calibration function, and resistance to voltage fluctuations. It is mainly applicable to induction cooker, touch display and other solutions. This product has excellent performance and reliable quality.

2. Functional features

- Automatic calibration function
- Built in drive active buzzer control program
- Maximum key output time detection
- With anti voltage fluctuation function
- Support standard I2C communication mode
- External capacitance adjustment sensitivity
- Adopt CMOS technology
- Multiple display modes (10 segments × 7-13 segments × 4 digits)
- Brightness adjustment circuit (8-stage duty cycle adjustable)
- Oscillation mode: built in RC oscillation
- Built in power on reset circuit
- Built in data latch circuit
- Built in optimization circuit for dark light caused by LED reverse bias leakage
- Strong anti-interference ability
- Packaging form: SOP32

3. Pin arrangement



4. Pin function

Pin name	Pin serial number	I/O	Function description
GRID6/SEG13 ～ GRID5/SEG14	1～2	O	Segment / bit multiplex output, only segment or bit output can be selected
GRID4～GRID3	3～4	O	Bit output, n-tube open drain output, built-in 2.7K pull-up resistor
GRID2～GRID1	6～7	O	Bit output, n-tube open drain output, built-in 2.7K pull-up resistor
GND	5,16	--	Negative pole of logic power supply
Key4～Key1	8～11	I	Touch key input port (grounding is required for unused)
Key5～Key8	13～15	I	Touch key input port (grounding is required for unused)
VDD	17	--	Positive pole of logic power supply
PA7/BZ	18	O	Active buzzer drive
PA2/SCL	19	I	I2C communication clock input
PA0/SDA	20	I/O	I2C communication data input / output
VCC	21	--	Positive pole of logic power supply
SEG1～SEG10	22～31	O	Segment output, p-tube open drain output, built-in 4K pull-down resistance
GRID7/SEG12	32	O	Segment / bit multiplex output, only segment or bit output can be selected

Integrated circuits are electrostatic sensitive devices, which are prone to generate a large amount of static electricity when used in dry seasons or dry environments. Electrostatic discharge may damage integrated circuits. Titan Micro Electronics recommends taking all appropriate integrated circuit preventive measures and improper operations

Welding may cause ESD damage or performance degradation, and the chip cannot work normally.

4.1. Extreme working conditions

Parameter name	Parameter symbols	Limit value	Unit
supply voltage	V_{DD}	-0.3～+6.5	V
Input voltage range	V_{IN}	-0.3～VDD+0.3	V
Operating temperature range	T_{opr}	-40～+85	℃
Storage temperature range	t_{stg}	-50～+125	℃
Total power consumption		500	mW

(1) If the chip works under the above limit parameters for a long time, the reliability of the device may be reduced or permanently damaged. Titan Micro Electronics does not recommend that any parameter reach or exceed these limits in actual use.

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

4.2. Recommended working conditions

Test at ta=+25 ℃, unless otherwise specified			TM1648A			Unit
Parameter name	Parameter symbols	Test conditions	minimum value	Typical value	Maximum value	
supply voltage	V_{DD}	--	-	5	-	V
working temperature	T_a	—	-40	—	+85	℃
Working junction temperature	T_j	—	-50	—	+125	℃

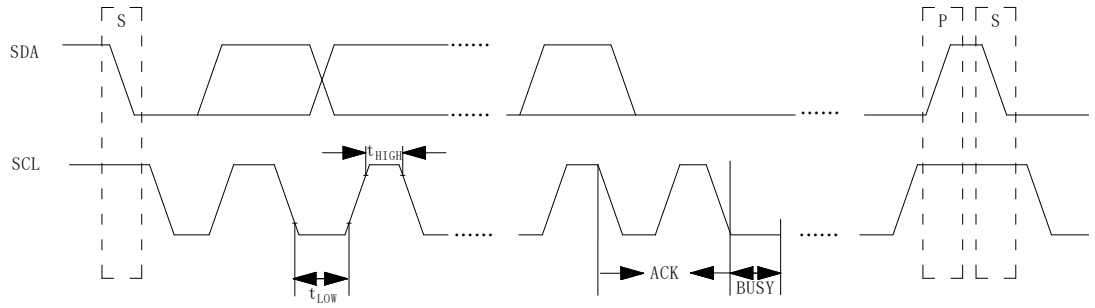
5. Chip parameters

5.1 Electrical characteristics

Test at ta=+25 ℃, vdd=5v, unless otherwise specified			TM1648A			Unit
Parameter name	Parameter symbols	Test conditions	minimum value	Typical value	Maximum value	
Scl/sda pin high level input voltage	V_{IH}	VDD=5V	3.5	-	5	V
		--	0.7VDD	-	VDD	
Scl/sda pin low level input voltage	V_{IL}	VDD=5V	0	-	1.5	V
		--	0		0.2VDD	
BZ buzzer drive current	I_{BZ}	VDD=3V	-	-	20	mA
		VDD=5V	-	-	50	mA
High level output current	Ioh1	SEG1～SEG10, Vo = VDD -3V	20	35	60	mA
Low level input current	I_{OL}	GRID1～GRID7 Vo=0.3V	80	120	-	mA

5.2 Switching characteristics

Test at ta=+25 ℃, vdd=2.5v ~ 5.5V, unless otherwise specified			TM1648A			Unit
Parameter name	Parameter symbols	Test conditions	minimum value	Typical value	Maximum value	
Longest key holding room	t_{KH}	--	60	64	68	s
Start bit low level time	TSTART	--	-	-	t_{NS}	s
SCL low level time	TLOW	--	5	-	-	us
SCL high level time	THIGH	--	5	-	-	us
ACK minimum time	ACK	--	10	-	-	us
Busy minimum time	BUSY	--	10	-	-	us



6 IIC communication mode description

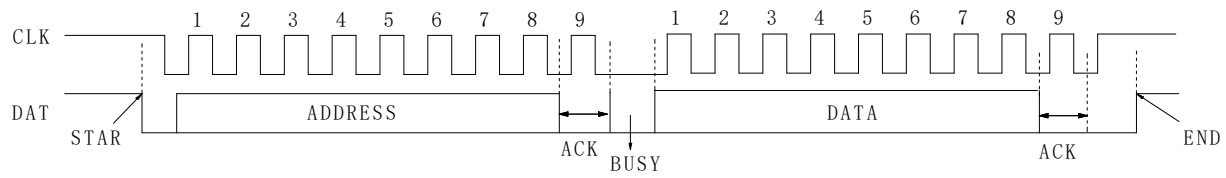
The TM1648A provides a slave I2C communication interface (Slave), which supports the standard I2C bus protocol, and the TM1648A communication address is 0xA0. The master can read the touch key status information, and also write the data to drive the digital tube display and the buzzer data, and the I2C rate supports the standard mode 100KHZ.

After reading the key information, the interval is at least 10ms before reading the key information again.

The interval between writing display data is at least 1ms, and the interval between writing other data is at least 200us before writing data to TM1648A again.

Timing diagram of I2C.

I2C sequence diagram:



Slave busy:

After one byte of data (8bit +ack) is completed, the slave starts to process the data (the slave is busy) and cannot receive the next byte of data. At this time, the slave pulls the SCL down, and the host needs to wait for the SCL to be high before continuing data transmission.

I2C data format:

TM1648A chip supports single data reading. Write slave address is 0xa0, read slave address is 0xa1, address is the address of the read register, and data1 is the read data. Read a data format as:

The host writes data to the TM1648A chip, which supports single data writing or multiple data continuous writing. The format of writing multiple data is:

In order to reduce the I2C locking problem caused by receiving the wrong clock source, TM1648A provides a timeout function. If the I2C bus does not receive the clock source within about 63ms, the I2C circuit and register will be reset.

When the timeout counter receives the "start" signal and the "address matching" condition on the I2C bus, the timeout counter starts counting and clears at the falling edge of SCL. Before the next falling edge of SCL comes, if the waiting time is greater than the timeout set by the i2ctoc register, a timeout will occur. When the I2C "stop" condition occurs, the timeout counter will stop counting.

IIC timeout may cause abnormal data forwarding, so it is necessary to avoid IIC timeout when using.

7 Function description

7.1 register description

The external MCU accesses the register through I2C, which can read the status information of touch keys, write display commands and data, drive the buzzer to make sound, and enter and wake up the sleep mode.

TM1648A register function description:

Serial number	TM1648A register address	R/W	Initial value	Function description
1	0xBD	W	0x00	Display mode setting
2	0xBE	W	0x40	Data read / write and address increase mode settings
3~16	0xC0 ~ 0xCD	W	0x00	Display content settings
4	0xBF	W	0x00	Display switch and brightness setting
19	0xCE	W	0x00	Buzzer sound time setting
20	0xCF	W	0x00	Sleep mode setting
21	0xF0	R	0x00	Touch key register

(Note: W means that the register is writable, R means that the register is readable)

(1) Register 0xbd in TM1648A is used to set the number of segments and bits (4-7 bits, 10-13 segments). When the command is executed, the display is forced off. When the display mode remains unchanged, the data in the video memory will not be changed, and the display control command controls the display switch. When powered on, the default display mode is 7 bits and 10 segments. If there is no need to change the bit segment mode, this register does not need to be written.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	display mode
0	0	Irrelevant items, fill in 0				0	0	4-digit 13 segment
0	0					0	one	5-digit 12 segment
0	0					one	0	6-digit 11 segment
0	0					one	one	7-digit 10 segment

(2) The register 0xbe in TM1648A is used to set the read / write and address increase mode of data. Bits B1 and B0 are not allowed to set 01 or 11. Because the display data is stored in the address self adding mode, it must be set to 0x40. TM1648A has been set to 0x40 during initialization, so there is no need to write again.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	function	explain
0	1	Irrelevant items, fill in 0				0	0	Data read / write mode setting	Write data to display register
0	1					1	0		Read key scan data
0	1				0			Address increase mode setting	Automatic address increase
0	1				1				Fixed address
0	1			0				Test mode setting (internal use)	Normal mode
0	1			1					Test mode

(3) Registers 0xc0~0xcd in TM1648A are used to set the starting display address and display content data. The valid address can be up to 14 bits (c0h-cdh). For example, if 0xc0 and 14 byte display content are sent, the display address c0-cd display content is 14 byte data in turn.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	display address
1	1	Irrelevant items, fill in 0		0	0	0	0	C0H
1	1			0	0	0	1	C1H
1	1			0	0	1	0	C2H
1	1			0	0	1	1	C3H
1	1			0	1	0	0	C4H
1	1			0	1	0	1	C5H
1	1			0	1	1	0	C6H
1	1			0	1	1	1	C7H
1	1			1	0	0	0	C8H
1	1			1	0	0	1	C9H
1	1			1	0	1	0	CAH
1	1			1	0	1	1	CBH
1	1			1	1	0	0	CCH
1	1			1	1	0	1	CDH

(4) Register 0xbf in TM1648A is used to set the display switch and display brightness adjustment. There are 8 levels of brightness for adjustment.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	function	explain
one	0	Irrelevant items, fill in 0			0	0	0	Extinction quantity setting	Set the pulse width to 1/16
one	0				0	0	1		Set the pulse width to 2/16
one	0				0	1	0		Set pulse width to 4/16
one	0				0	1	1		Set the pulse width to 10/16
one	0				1	0	0		Set the pulse width to 11/16
one	0				1	0	1		Set the pulse width to 12/16
one	0				1	1	0		Set pulse width to 13/16
one	0				1	1	1		Set the pulse width to 14/16
one	0			0				Display switch settings	Display off
one	0			1					Show on

(5) The register 0xCE in TM1648A is used to set the driving time of the active buzzer. TM1648A has built-in active buzzer drive control program. External MCU can turn on the buzzer by writing data to register 0xCE. The driving time of the buzzer has 255 levels of adjustment, and the level adjustment is achieved by changing the data value (write value range: 0x00-0xff). The buzzer time of each level is 40ms.

IIC communication format is as follows:

(6) The register 0xcf in TM1648A is used to set the sleep mode of the chip. The chip has two working modes, sleep mode and normal working mode.

There are two ways to enter sleep: one is to enter sleep without pressing the key for 8s after power on; Second, IIC communication, write 0x01 to register 0xcf, and about 1s TM1648A enters sleep.

There are two ways to wake up sleep: one is to wake up sleep when a key is touched; The second is IIC communication. The correct IIC communication format will immediately wake up to sleep. If the write operation that wakes up sleep is the forwarded content of the TM1648A to the external display chip, it will be forwarded; The correct IIC reading operation will get the current key touch information.

(7) Register 0xf0 in TM1648A is used as a register for IIC to read key touch data. Bit7 ~ bit0 are used to indicate whether the corresponding touch keys Key8 ~ key1 are touched. (Note: if the read register is not 0xf0, the return value is 0xff.)

The read format is as follows:

(write slave address is 0xa0, read slave address is 0xa1)

Bit0:key1 status (1 = touch, 0= untouched)
Bit1:key2 status (1 = touch, 0= untouched)
Bit2:key3 status (1 = touch, 0= untouched)
Bit3:key4 status (1 = touch, 0= untouched)
Bit4:key5 status (1 = touch, 0= untouched)
Bit5:key6 status (1 = touch, 0= untouched)
Bit6:key7 status (1 = touch, 0= untouched)
Bit7:key8 status (1 = touch, 0= untouched)

7.2 description of the longest key duration

In order to minimize unintentional key detection such as accidentally touching the induction electrode, the chip is equipped with the function of maximum key duration. When a touch key is pressed, the internal timer starts timing. Once the key is pressed for a long time, more than 64S, the touch chip will ignore the state of the touched key, recalibrate to obtain a new reference value, and reset the output state to the initial state.

7.3 description of automatic calibration function

After power on, the chip will initialize and obtain the first reference value. No key is pressed. After a fixed time period, the touch chip will automatically calibrate the reference value, so that the reference value can change dynamically according to the external environment.

7.4 sensitivity description

Sensitivity adjustment: in most applications, adjusting the sensitivity of touch keys according to the needs of users is a very important consideration. The sensitivity can be adjusted by changing the size and floor area of the PCB electrode (directly below the electrode), or by changing the thickness of the insulating material. At the same time, TM1648A provides a way to add capacitance on the touch input pin to adjust different sensitivity requirements.

7.5. TM1648A drives nixie tube display

(1) Drive common cathode nixie tube:

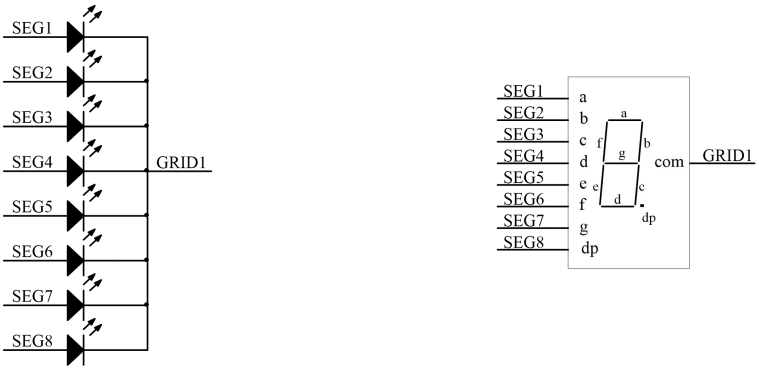


Figure (7)

Figure 7 shows the connection diagram of the common cathode nixie tube. If the nixie tube displays "0", you only need to write 0x3f data to C0H (GRID1) address from the low order. At this time, 00h corresponds to the data of each seg1-seg8 in the following table.

SEG8	SEG7	SEG6	SEG5	SEG4	SEG3	SEG2	SEG1	
0	0	1	1	1	1	1	1	GRID1(C0H)
B7	B6	B5	B4	B3	B2	B1	B0	

(2) Drive common anode nixie tube:

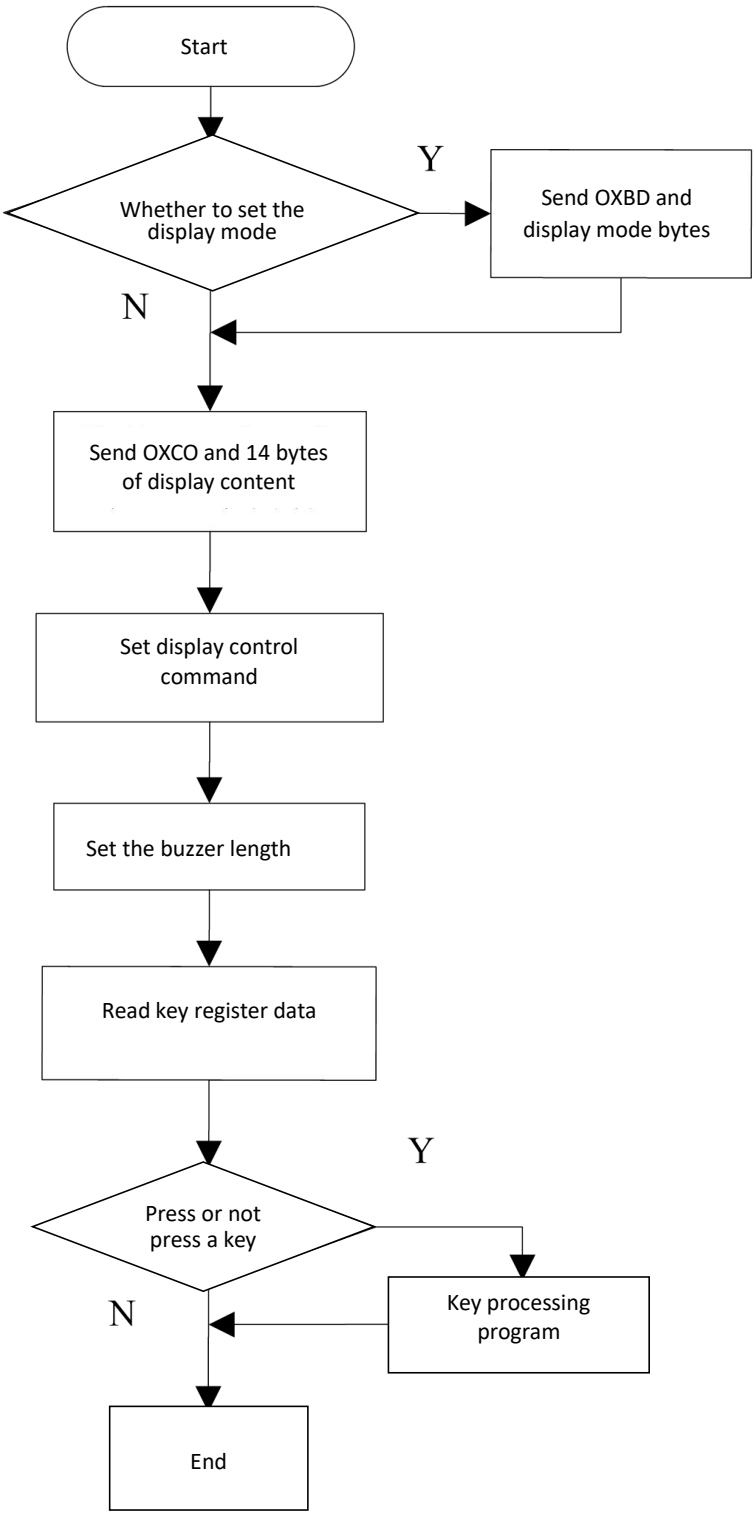
Figure (8)

Figure 8 shows the connection diagram of common anode nixie tube. If the nixie tube displays "0", write data 01h to address units C0H (GRID1), C2H (grid2), C4H (grid3), C6H (grid4), C8H (grid5), CAH (grid6) respectively, and write data 00h to other address CCH (grid7) units. The data corresponding to each seg1-seg8 is shown in the following table.

SEG8	SEG7	SEG6	SEG5	SEG4	SEG3	SEG2	SEG1	
0	0	0	0	0	0	0	1	GRID1(C0H)
0	0	0	0	0	0	0	1	GRID2(C2H)
0	0	0	0	0	0	0	1	GRID3(C4H)
0	0	0	0	0	0	0	1	GRID4(C6H)
0	0	0	0	0	0	0	1	GRID5(C8H)
0	0	0	0	0	0	0	1	GRID6(CAH)
0	0	0	0	0	0	0	0	GRID7(CCH)
B7	B6	B5	B4	B3	B2	B1	B0	

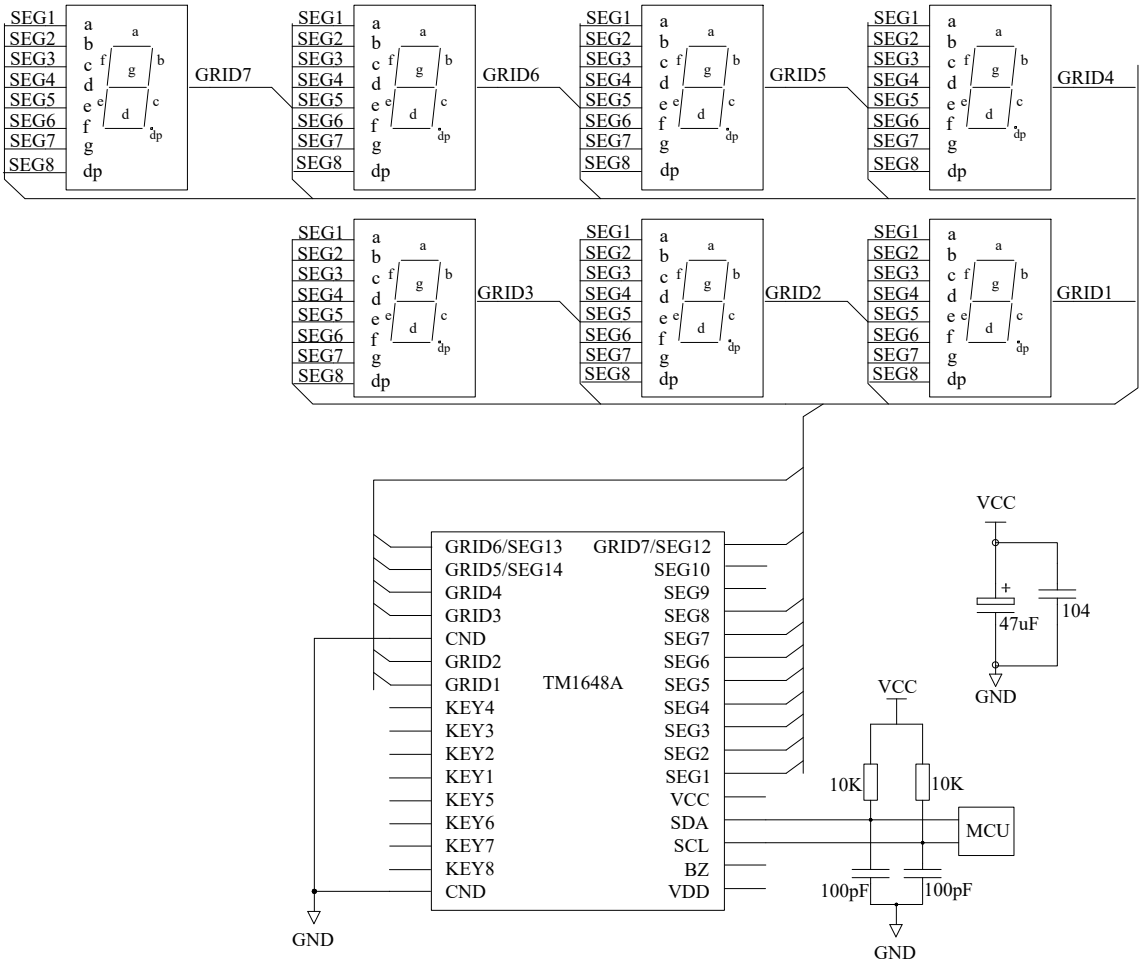
▲ note: whether driving the common cathode nixie tube or driving the common anode nixie tube, the SEG pin can only be connected to the anode of the LED, and the grid can only be connected to the cathode of the LED, which cannot be reversed.

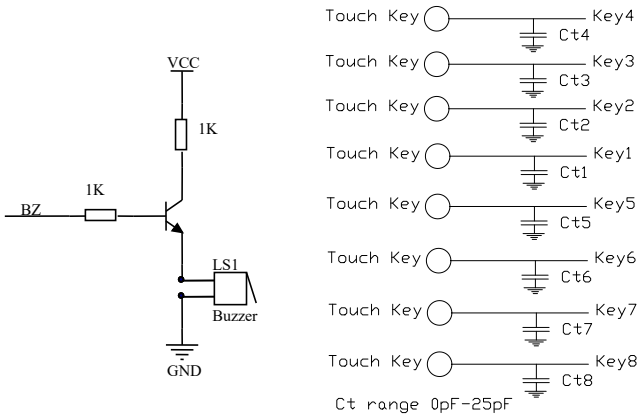
8 Program design flow chart:



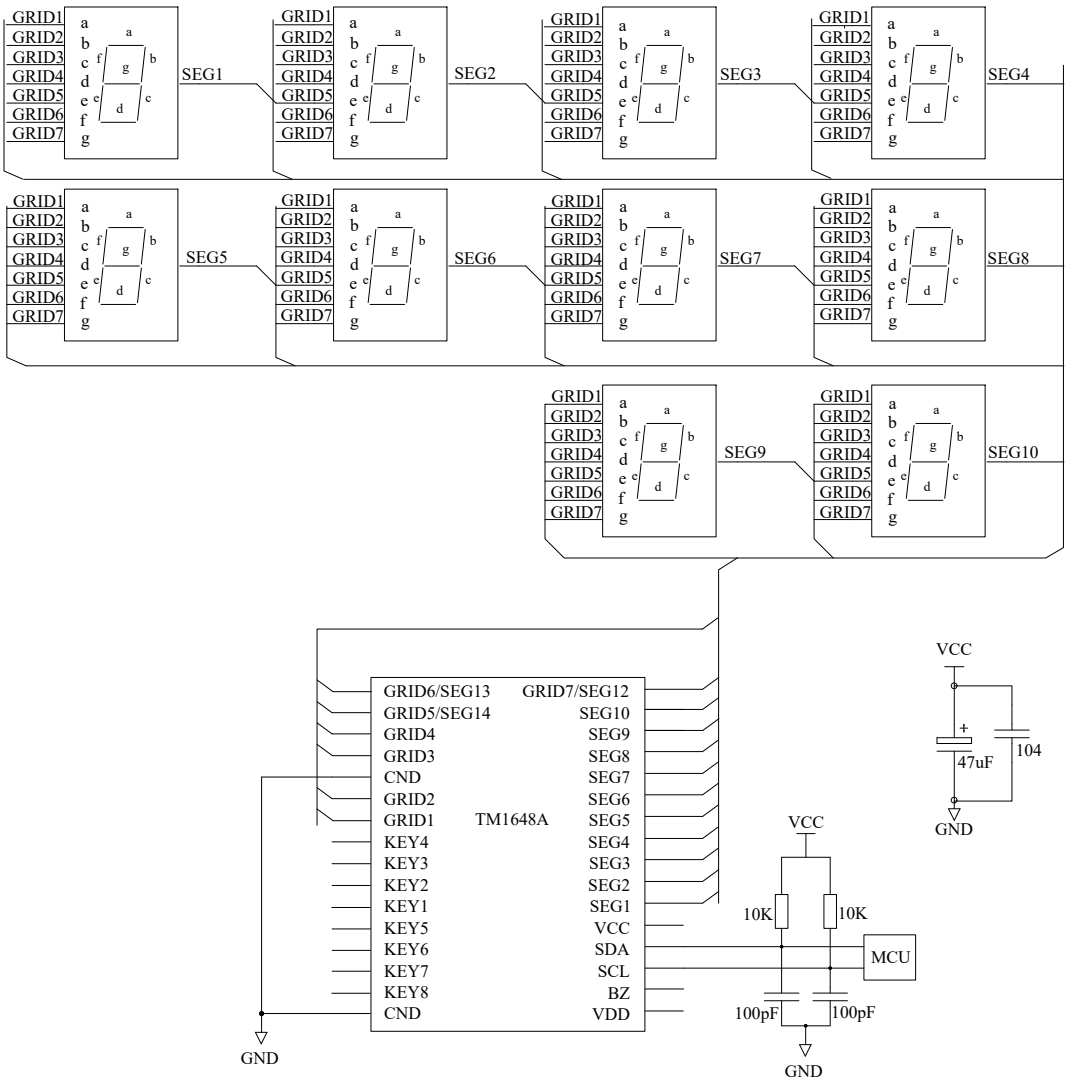
9 Application circuit diagram

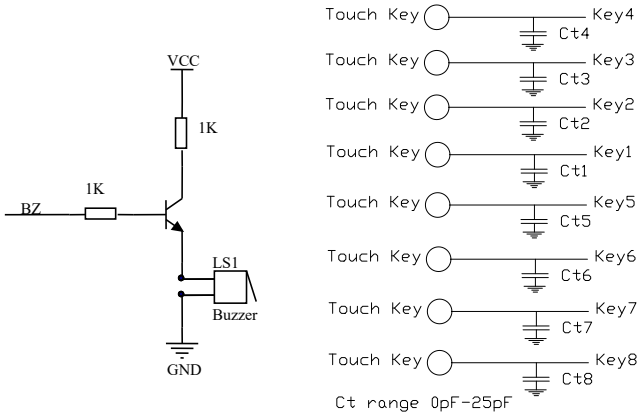
Hardware circuit diagram of TM1648A driving common cathode digital screen



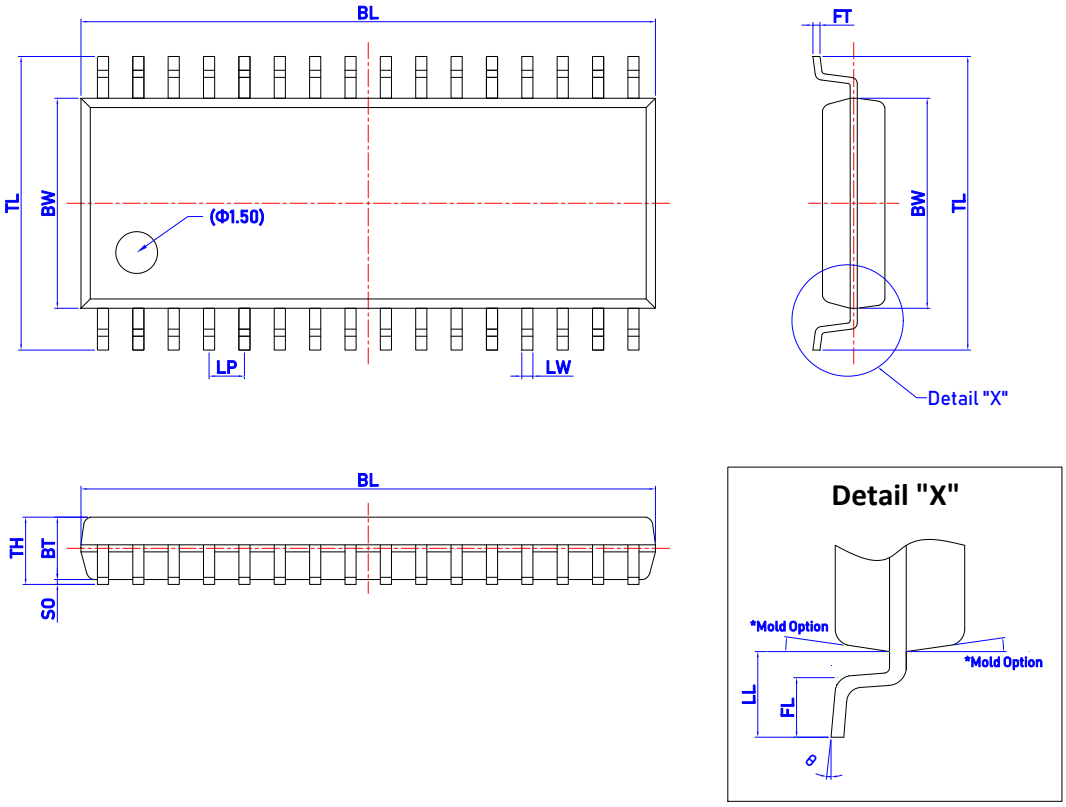


Hardware circuit diagram of TM1648A drive Gongyang digital screen





10 SOP32 packaging diagram



Dimensions

Item	BL	BW	TL	LW	LP	FT	BT	SO	TH	LL	FL	θ
表示	总长	胶体宽度	跨度	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	20.73 (20.63) 20.53	7.64 (7.54) 7.44	10.60 (10.40) 10.20	0.400 TYP	1.270 TYP	0.250 (0.200) 0.170	2.34 (2.24) 2.14	0.250 (0.175) 0.100	2.490 Max.	1.60 (1.50) 1.40	0.95 (0.75) 0.55	8 (4) 0

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