Feature Description

TM1680 is a kind of driver chip switched by memory, displayed and controlled by LED, which can select multiple ROW/COM mode (32ROW/8COM and 24ROW/16COM) to drive dot matrix LED. The chip provides pulse width modulation control output of 16 levels set by software, which can adjust the brightness of LED cycle display. By the method of serial interface (I2C communication interface) serial input, it can easily enter command mode (COMMAND, MDOE) and data mode (DATA, MODE). Only with a simple command, the communication between main control chip and TM1680 can be established. Through TM1680, continuous output display can be realized. TM1680 is widely applicable in the display of LED light, such as industrial instrument control, digital clock/thermometer/counter/voltmeter display, reading of meter data, LED display, smart bracelet and other applications. The product has excellent performance and reliable quality.

Functional Characteristics

- Working voltage 2.4 ~ 5.5V
- 32ROW*8COM and 24ROW16COM, two display options
- Integrated display memory - 64*4 display RAM (32ROW*8COM), 96*4 display RAM (24ROW* 16COM)
- 16 levels of pulse width modulation to control brightness
- Built-in 256KHz RC oscillator
- I2C interface (SDA, SCL) communication
- Data mode and command mode instructions
- Optional NMOS output channel and PMOS output channel
- Package type: LQFP48, LQFP52

Internal Structure Block Diagram

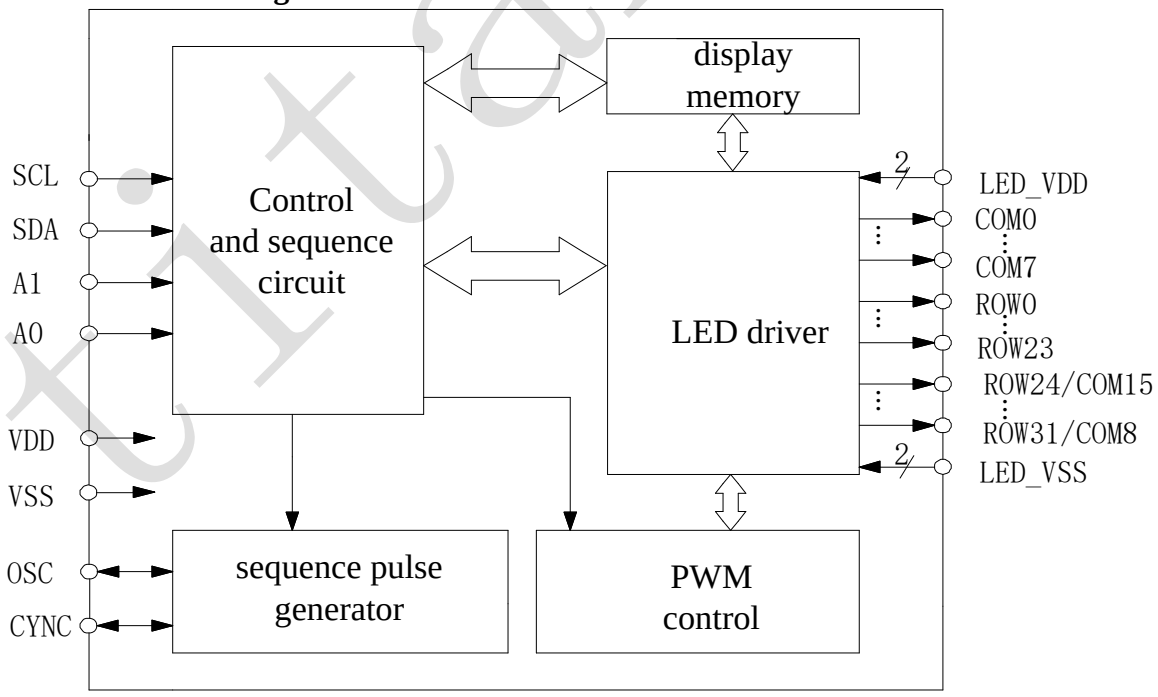


Figure 1

Pin Configuration

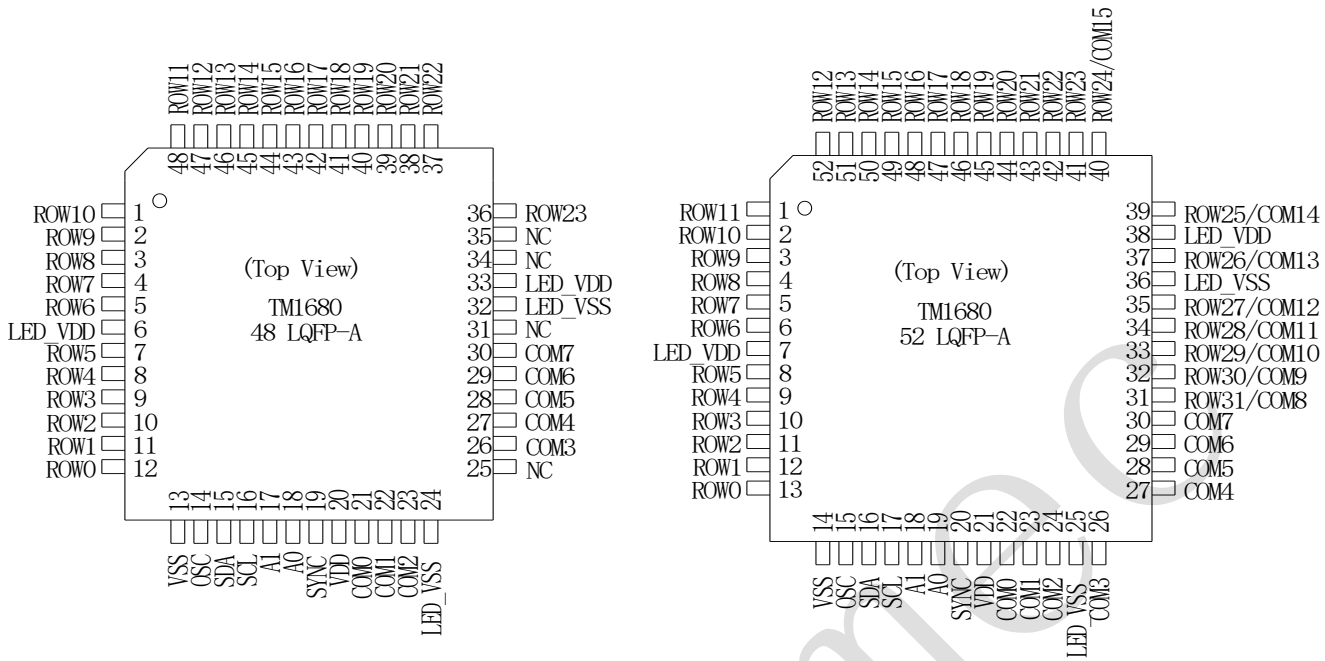


Figure 2

Pin Function

Pin Name	Pin Number	I/O	Function Description
VDD	21	-	the positive of chip logic power
VSS	14	-	the negative of chip logic power
LED_VDD	7/38	-	the positive of LED drive power, It must be connected to the same voltage as the 21 pin VDD
LED_VSS	25/36	-	the negative of LED drive power,connected to VSS
ROW0～ROW23	1～6/8～13/41～52	O	LED line drive output
ROW24/COM15～ROW31/COM8	31～35/37/39/40	O	LED line drive output or common output end, each COM pin with double keys
COM0～COM7	22～24/26～30	I	LED common output end, each COM pin with double keys
SYNC	20	I/O	If the main trigger mode or external expansion trigger mode is selected, the synchronizing signal will be outputted from SYNC pin; if the passive mode is selected, the synchronizing signal will be inputted from SYNC pin.
OSC	15	I/O	If RC oscillator main trigger mode is selected, the system clock will be generated by on-chip RC oscillation, and outputted from OSC pin. If the passive mode or external expansion trigger mode is selected, the system clock will be inputted by OSC pin from outside.
A0	19	I	Slave address extension bit, pull-up resistor already built-in.
A1	18	I	Slave address extension bit, pull-up resistor already built-in.
SCL	17	I	I2C communication clock input, at the rising edge of the SCL signal, SDA online data is also written into TM1680, pull-up resistor already built-in.
SDA	16	I/O	I2C communication data input/output port, at application, it requires to connect an external pull-up resistor.

***** Note: The pin numbers in the table above, take LQFP52 package as an example. Different packages have different pin positions, please refer to the pin configuration diagram. 48PIN package has the display mode of 24*8, which does not support 1/16 order brightness.

Input and Output Equivalent Circuit

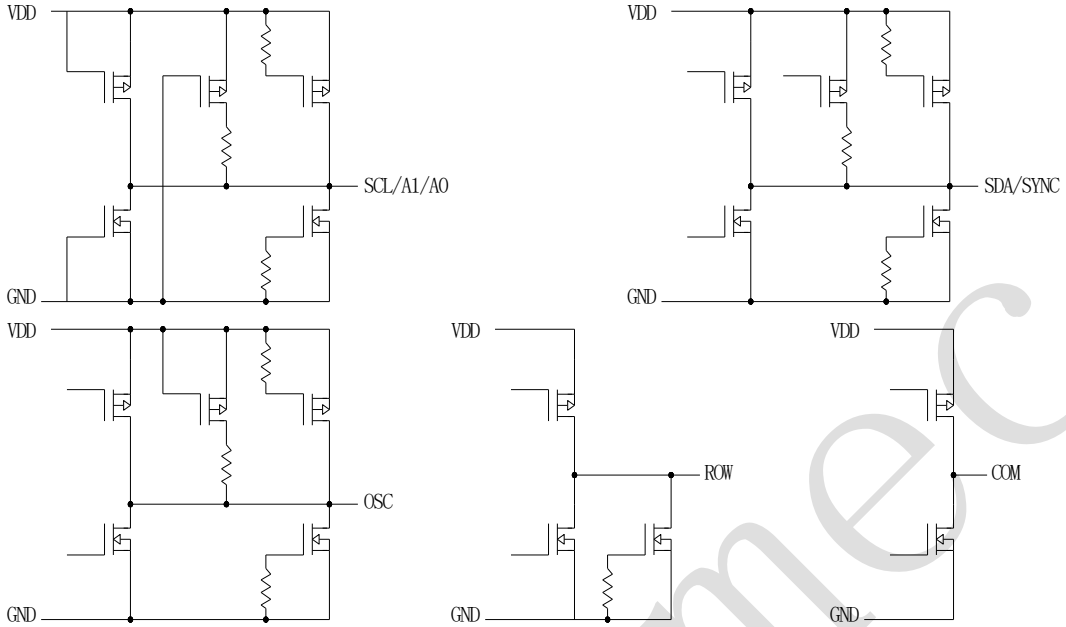


Figure 3

Integrated circuits is a static-sensitive device which is prone to generate a large number of static electricity in dry season or dry environment. Electrostatic discharge may damage the integrated circuit. Titan Micro Electronics recommends that all appropriate integrated circuit prevention measures should be implemented. Improper welding may cause ESD damage or performance degradation, so the chip can not work properly.

Limit Parameter（1）（2）

Parameter Name		Parameter Symbol	Limit Value	Unit
Logic power voltage		VDD	VSS-0.3V ～ VSS+6V	V
Input end voltage range	SDA,SCL,OSC,SYNC	Vin	VSS-0.3～VDD+0.3	V
working temperature range		Topt	-40～+85	℃
storage temperature range		Tstg	-55～+125	℃

(1) If the chip works for a long time under the condition of above limit parameters,it may cause reliability reduction or permanent damage of the device. Titan Micro Electronics recommends that all parameter can't reach or exceed these limit values at use.

(2) All voltage values are measured relatively to the system GND.

Recommended Working Condition

Parameter Name	Parameter Symbol	Minimum Value	Typical Value	Maximum Value	Unit
working voltage	VDD	2.4	5.0	5.5	V
input low level low voltage	Vil	0	-	0.3VDD	V
input high level high voltage	Vih	0.7VDD	-	5	V

DC Electrical Characteristics

Test under the condition of VDD=2.4~ 5.5V and Ta=+25℃, unless otherwise specified				TM1680			Unit
Parameter Name	**Parameter Symbol**	**VDD**	**Test Condition**	**Minimum Value**	**Typical Value**	**Maximum Value**	
working current	IDD	5.0V	on-chip RC, no load, open display		0.3	0.6	mA
standby current	ISTB	5.0V	power saving mode, no load		0.1	10	μA
OSC,SYNC,SDA sink current	IOL1	5.0V	Vol=0.5V	18	25	-	mA
OSC,SYNC,SDA source current	IOH1	5.0V	Voh=4.5V	-10	-13	-	mA
ROW sink current	IOL2	5.0V	Vol=0.5V	12	16	-	mA
ROW source current	IOH2	5.0V	Voh=4.5V	-50	-70	-	mA
COM sink current	IOL3	5.0V	Vol=0.5V	250	350	-	mA
COM source current	IOH3	5.0V	Voh=4.5V	-45	-60	-	mA
pull-up resistor	Rph	5.0V	SDA,SCL,OSC,SYNC	18	27	40	kΩ

Switch Characteristics

Test under the working temperature of 25℃, unless otherwise specified			VDD=2.4V~5.5V		VDD=3.0V~5.5V		Unit
Parameter Name	**Parameter Symbol**	**Test Condition**	**Minimum Value**	**Maximum Value**	**Minimum Value**	**Maximum Value**	
clock frequency	fSCL	internal clock of the chip	-	100	-	400	kHZ
bus idle time	tBUF	The bus idle time until the next clock arrival	4.7	-	1.3	-	μs
Start signal hold time	tHD:STA	-	4	-	0.6	-	μs
SCL low level time	tLOW	-	4.7	-	1.3	-	μs
SCL high level time	tHIGH	-	4	-	0.6	-	μs
Start signal setup time	tSU:STA	-	4.7	-	0.6	-	μs
Data hold time	tHD:DAT	-	0	-	0	-	μs
Data setup time	tSU:DAT	-	250	-	100	-	ns
SDA/SCL rise time	tr	-	-	1	-	0.3	μs
SDA/SCL fall time	tf	-	-	0.3	-	0.3	μs
Stop signal setup time	tSU:STO	-	4	-	0.6	-	μs
noise elimination time at SDA/SCL input	tSP	noise elimination time	-	20	-	20	ns

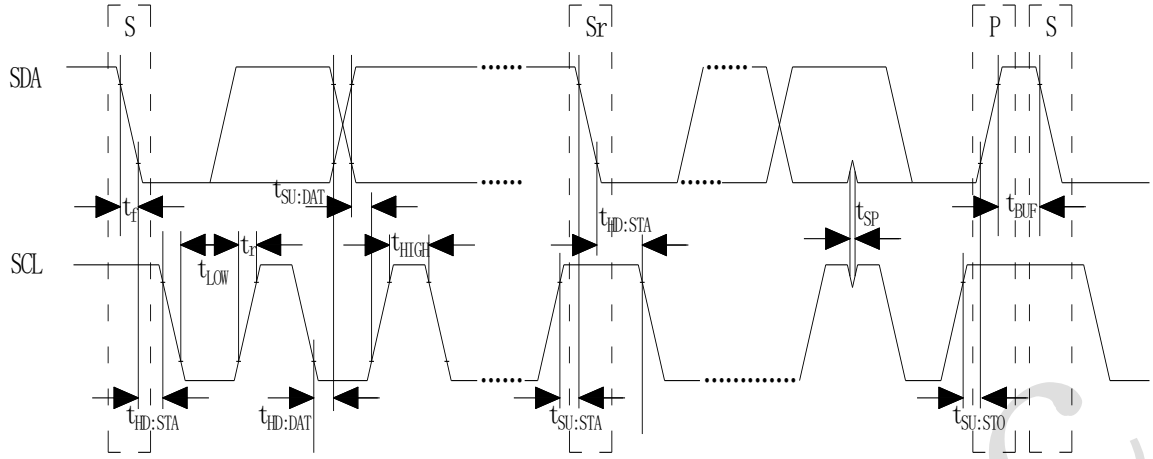


Figure 4

Function Description

1 Display Memory (RAM)

The static display memory contains two formats of 64*4 bit and 96*4 bit to store the data to be displayed. If the mode of 32ROW/8COM is selected, the RAM storage space is 64*4 bit; if the mode of 24ROW/16COM is selected, the RAM storage space is 96*4 bit. The data in RAM is mapped directly to the LED display driver. And if the RAM data set as "1", the corresponding LED will be lighten. The following Figure 5 and Figure 6 show the map from RAM to LED:

	COM7	COM6	COM5	COM4		COM3	COM2	COM1	COM0	
ROW0					01H					00H
ROW1					03H					02H
⋮					⋮					⋮
					3FH					3EH
	D3	D2	D1	D0	Addr / Data	D3	D2	D1	D0	Addr / Data

32 ROW & 8 COM for 64×4 Display RAM

Figure 5

	COM15	COM14	COM13	COM12		COM3	COM2	COM1	COM0	
ROW0					03H					00H
ROW1					07H					04H
⋮					⋮					⋮
ROW24					5FH					5CH
	D3	D2	D1	D0	Addr / Data	D3	D2	D1	D0	Addr / Data

24 ROW & 16 COM for 96×4 Display RAM

Figure 6

2 System Clock

The system clock of TM1680 is used to generate clock frequency of system operation. LED driving clock, system clock can be taken from the on-chip RC oscillator (256KHz) or use the S/W set to be inputted by external clock. The system oscillator configuration is as shown in Figure 7. When SYS DIS command is executed, the system clock stops and the LED working cycle will be turned off (this instruction can only be applied to the on-chip RC oscillator). Once the system clock stops, the LED display is blank and the time base loses its function. The LED_OFF command is used to turn off the LED working cycle. After the LED working cycle is turned off, SYS DIS command can be used to save power and act as a power saving command. If the off-chip clock source is selected, the

use of SYS DIS command can't turn off oscillator to execute the power saving mode. The crystal oscillator can provide clock frequency through OSC pin, in which case, the system will not be able to enter the power saving mode. When the system is powered up, TM1680 is in SYS DIS status by default.

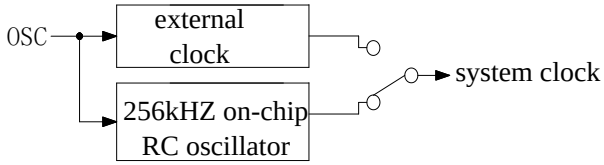


Figure 7

3 LED Driver

TM1680 contains two modes of LED driver, respectively 256 (32*8) and 384 (24*16) . It can be set as display mode of 32*8 or 24*16. Through the COM port output, N-MOS or P-MOS output channel can be selected. These features make TM1680 adapt to different LED applications. The LED driving clock is sourced from system clock. Generally, the driving clock selects the on-chip RC oscillator 256KHz or the extended external oscillator. For detailed setting commands, please see Command Summary Table.

4 Cascade Operation

At cascade operation, the first chip of the cascade is set as host mode, with its pins SYNC and OSC used as outputs; the second chip of the cascade is set as slave mode, with its pins SYNC and OSC used as inputs, and connected with SYNC and OSC pins of the host chip. The device address of TM1680 contains two external address select bits, A1 and A0, so a maximum of four TM1680s can be connected to the same bus. For detailed configuration, please refer to Cascade Application Circuit Diagram.

5 LED driving mode Output Waveform

32×8 N-MOS open-drain output driving mode output waveform is as shown below (Tclk = 1/Fsys)

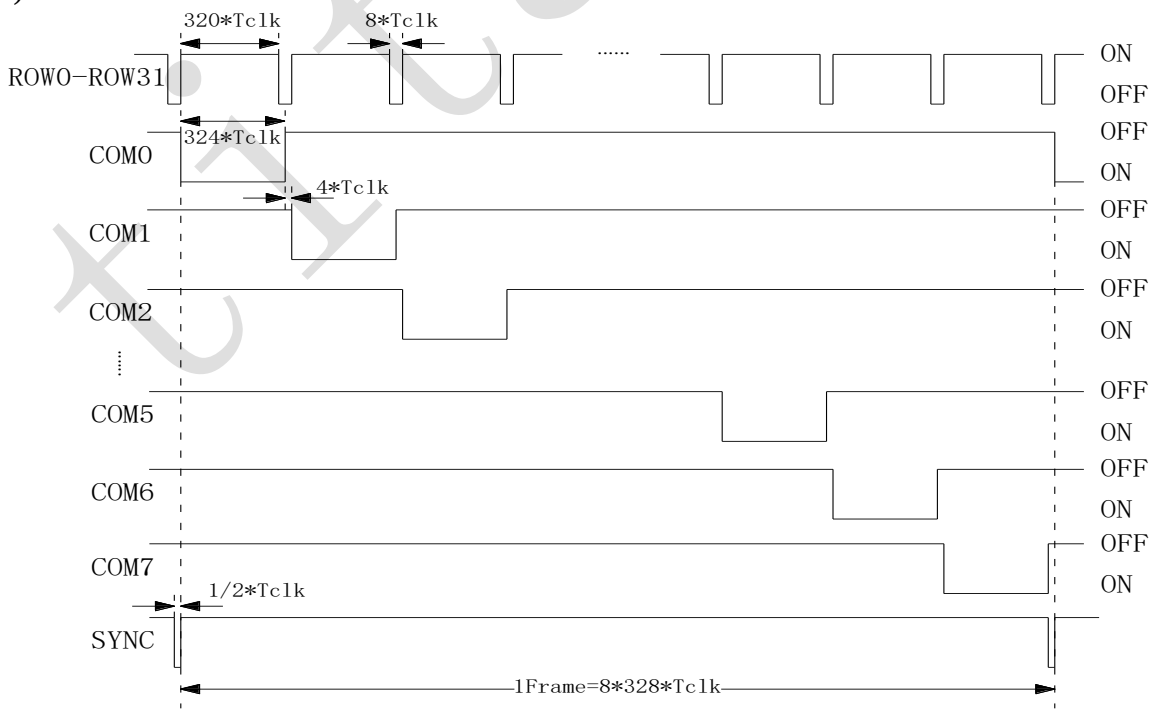


Figure 9

24×16 P-MOS open-drain output driving mode (Tclk = 1/Fsys, COM pin plus transistor):

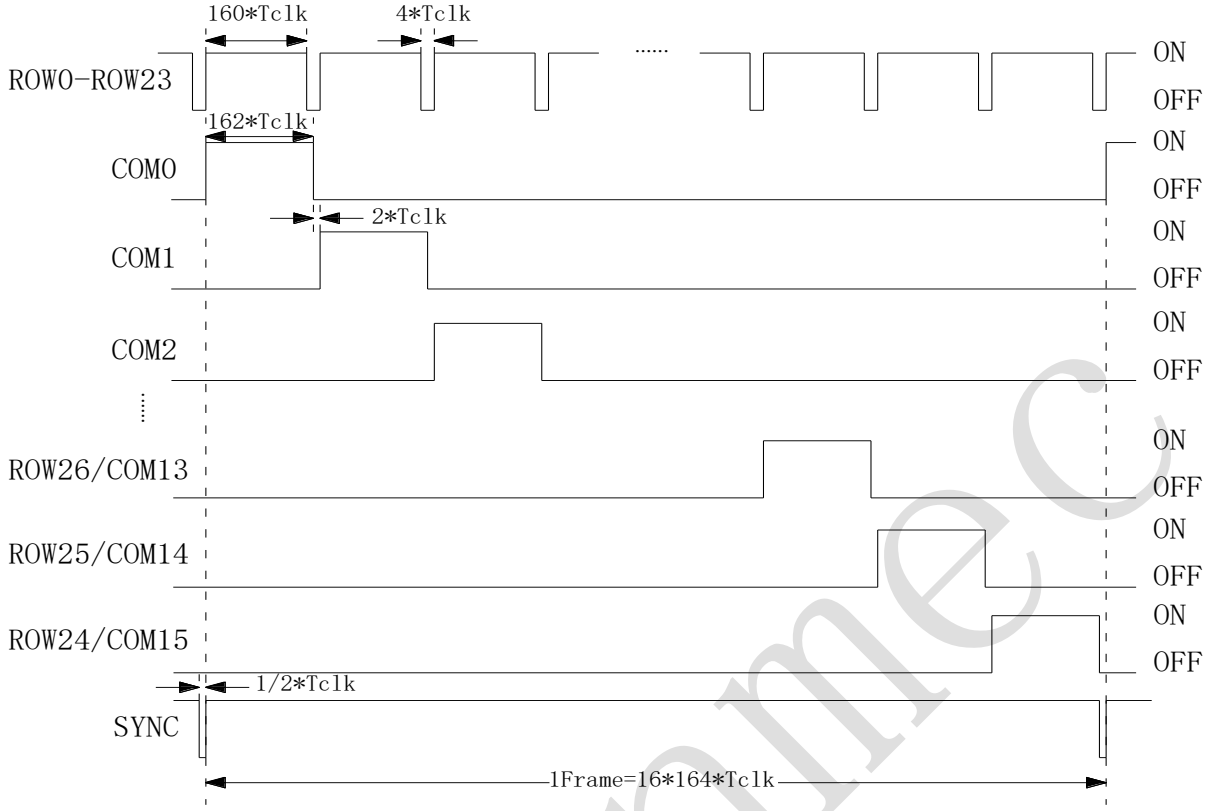


Figure 10

6 Flashlight

TM1680 has a flashing function, to make all LEDs flash at a certain frequency. The flashing rate can be set by Blink command, which can be divided into 2Hz /1Hz/0.5Hz. The following is the output waveform at a flashing frequency of 2Hz:

Figure 8

7 Brightness Adjustment and Setting

TM1680 can implement a variety of brightness controls by setting PWM drive pulse width at ROW end. The following Figure 11 shows the output waveforms of COM and ROW at different duty cycles: (1) T = 20×Tclk (32×8 driving mode); (2) T = 10×Tclk (24×16 driving mode); (3) Tclk = 1/Fsys

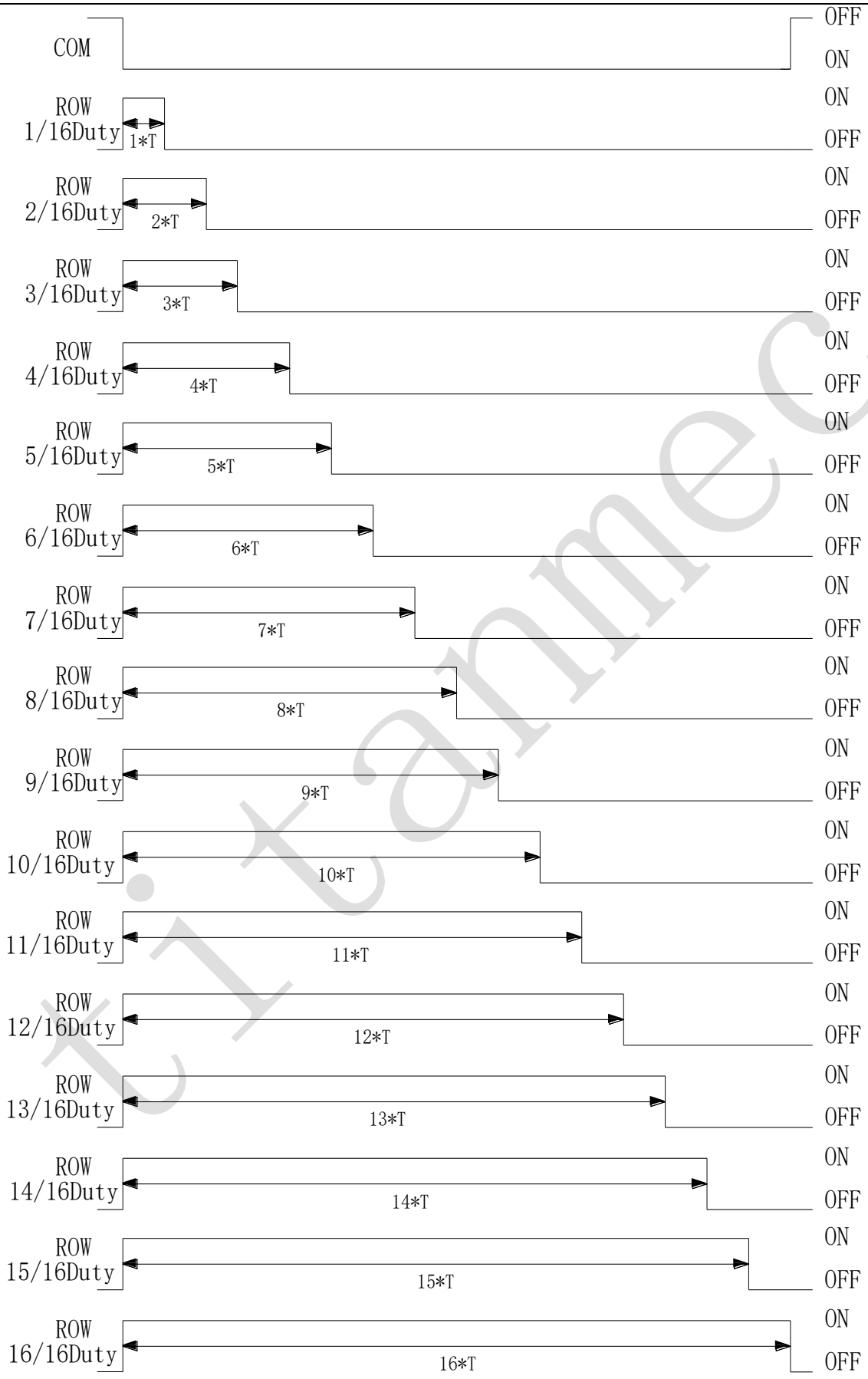


Figure 11

8 Command Format

The chip to input command or display data, must follow the steps below:

(1) Form the start condition

(2) Send the slave address (Slave Address)

(3) Command, display the transmission of data

(4) Form the stop condition

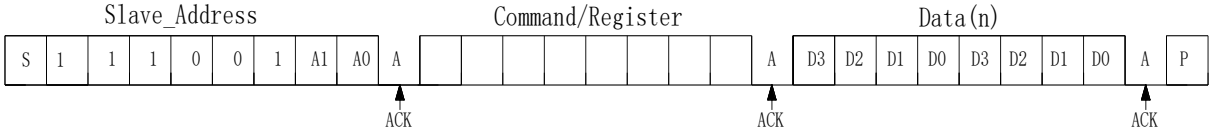


Figure 12

9 I2C Serial Interface

The chip makes data transmission by I2C protocol 2-wire serial interface, including a serial data line SDA and clock line SCL, 2-wire built-in pull-up resistor. The bus has a high level at idle.

At each data transfer, a start signal is generated by the controller, data transmission by synchronous serial. After receive every byte of data, TM1680 sends an ACK response signal. Each byte sent to the SDA line must be 8 bits. And the number of bytes that can be transmitted per transfer is unlimited. Each byte must be followed by an ACK response signal. When the ACK signal is not required, a low level "L" is required to be inputted from the 8th signal falling edge to the 9th signal falling edge of SCL signal. When the data is transmitted from the highest bit, the controller terminates the bus transmission by generating a stop signal, and during the data transmission by resenting start signal, which will not pass the stop signal.

When SCL has a high level, the data on SDA remains stable; When SCL has a low level,SDA change is allowed. If SCL has a high level, the falling edge generated on SDA is considered as a start signal. If SCL has a high level, the rising edge generated on SDA is considered as a stop signal, as shown in the following figure:

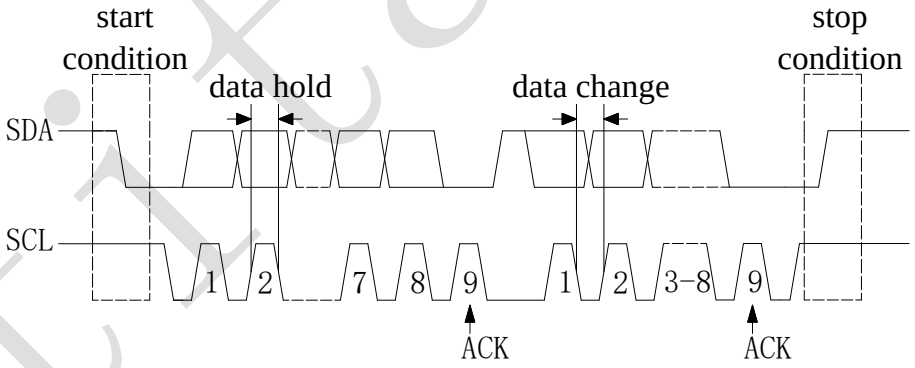


Figure 13

Sequence Diagram

1 Write Command

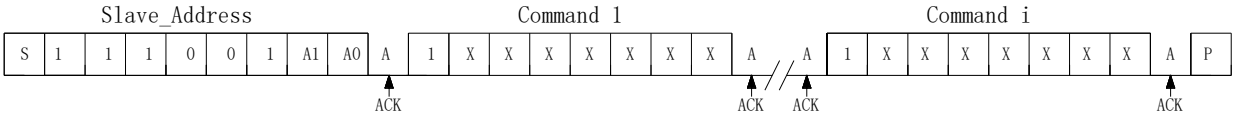


Figure 14

As shown in Figure 15, the upper 6 bits of the slave address of the slave device 8 bits is fixed to 111001, the next two bits A1 and A0 as the address bits external to the device.

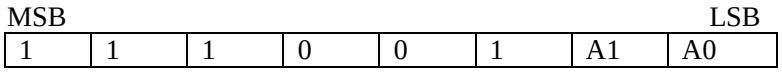


Figure 15

2 Byte Write Operation

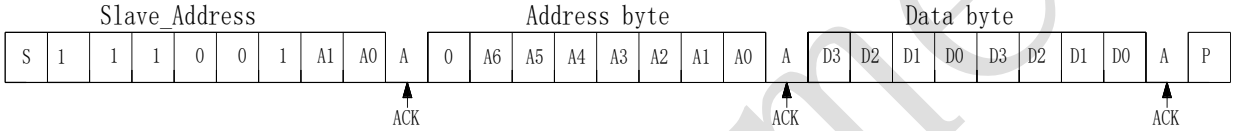


Figure 16

3 Page Write Operation

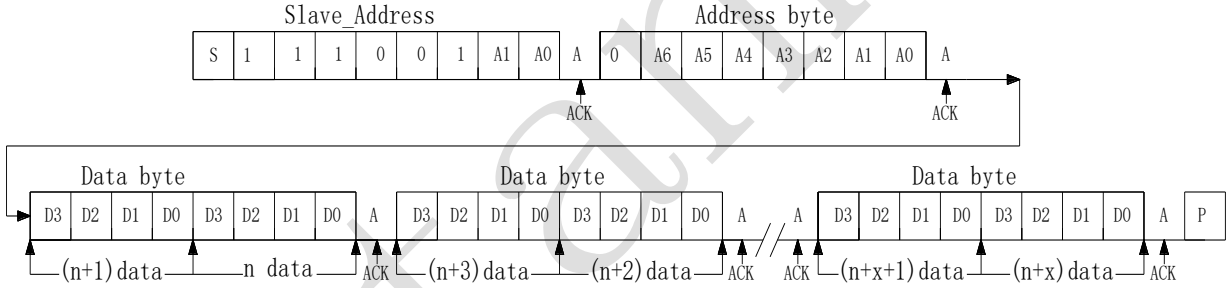


Figure 17

4 Write Command + Write Data

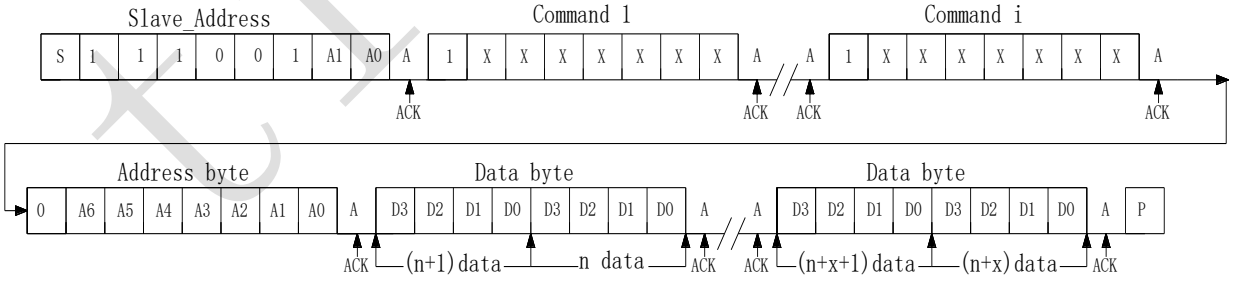


Figure 18

Application Circuit

Low-power LED application (direct driving mode): 32ROW*8COM mode example is as shown in Figure 19

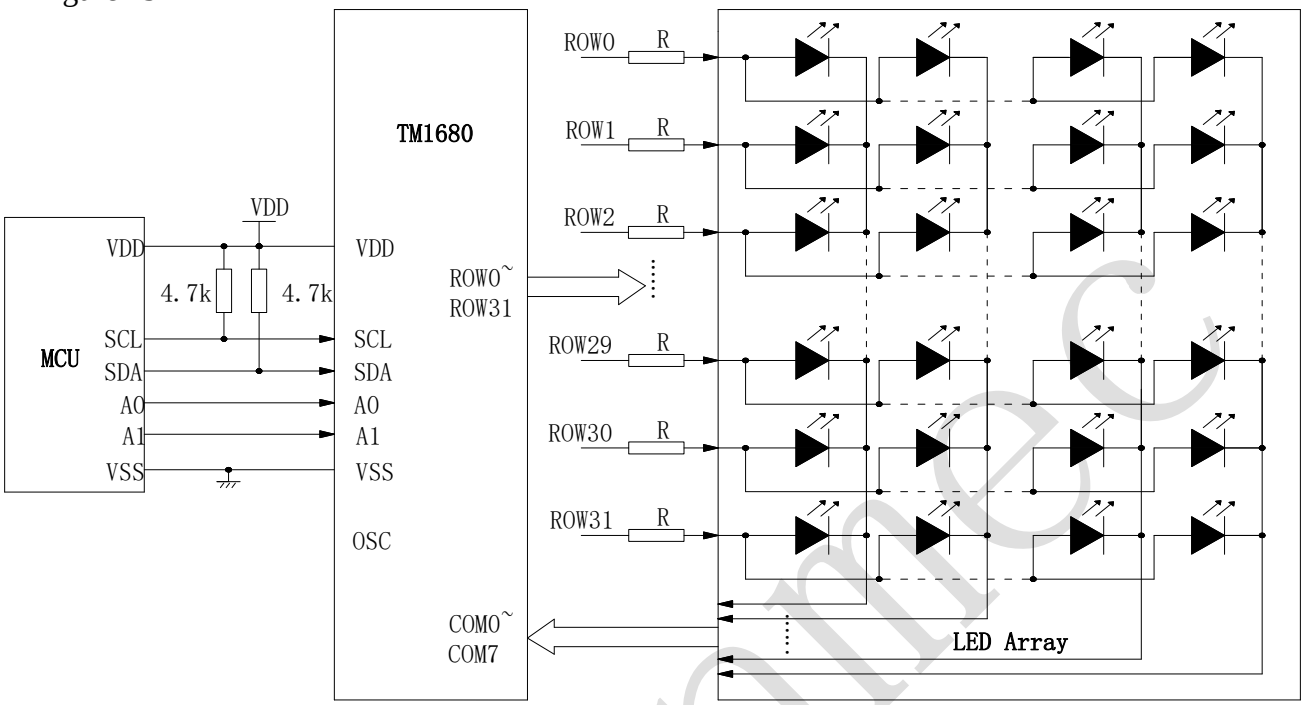


Figure 19

Low-power LED application (direct driving mode): 24ROW*16COM mode example is as shown in Figure 20

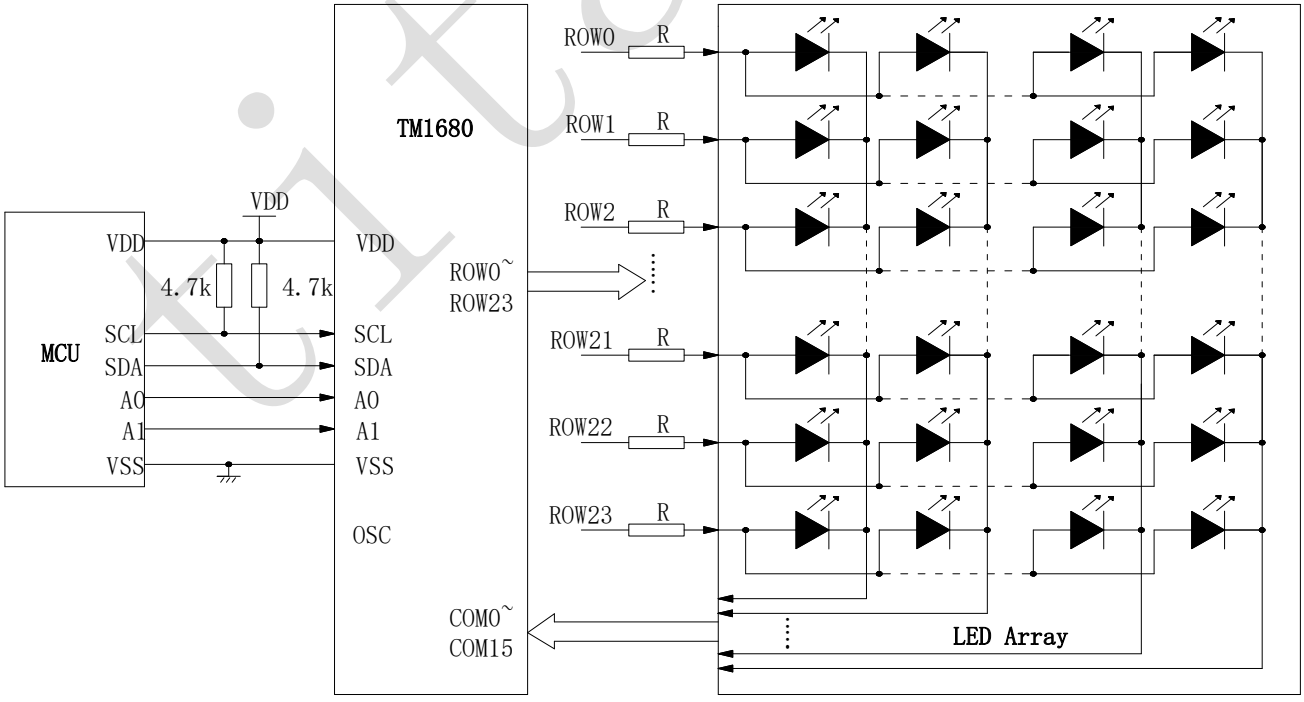


Figure 20

Medium-power LED application (COM plus transistor driving mode): 32ROW*8COM mode example is as shown in Figure 21

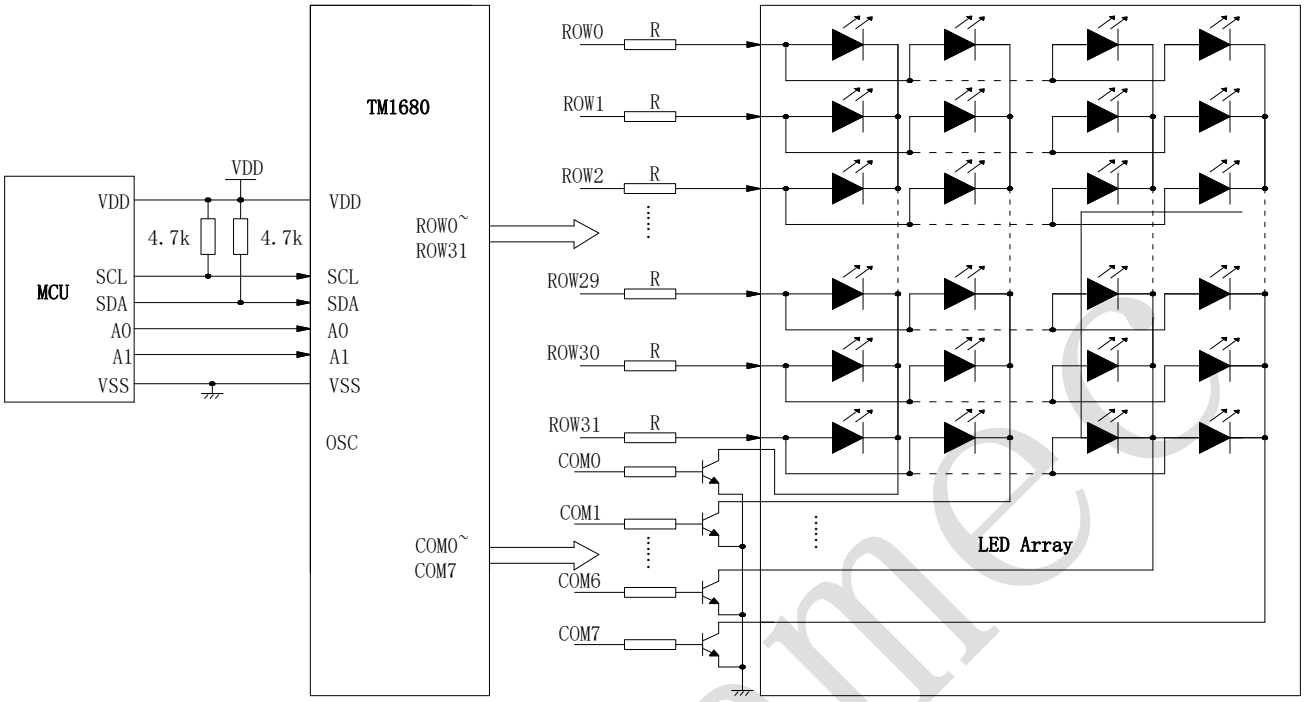


Figure 21

Medium-power LED application (COM plus transistor driving mode): 24ROW*16COM mode example is as shown in Figure 22

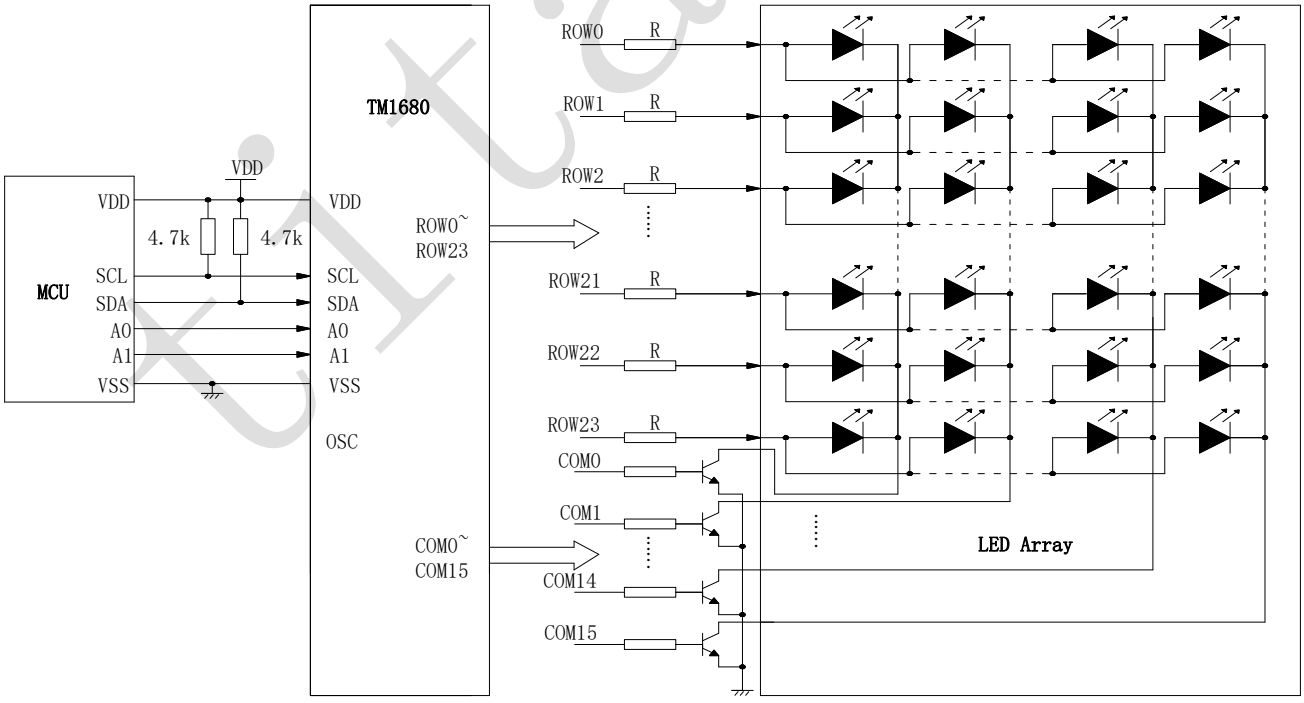


Figure 22

Large-power LED application (ROW and COM plus transistor driving mode): 32ROW*8COM mode example is as shown in Figure 23

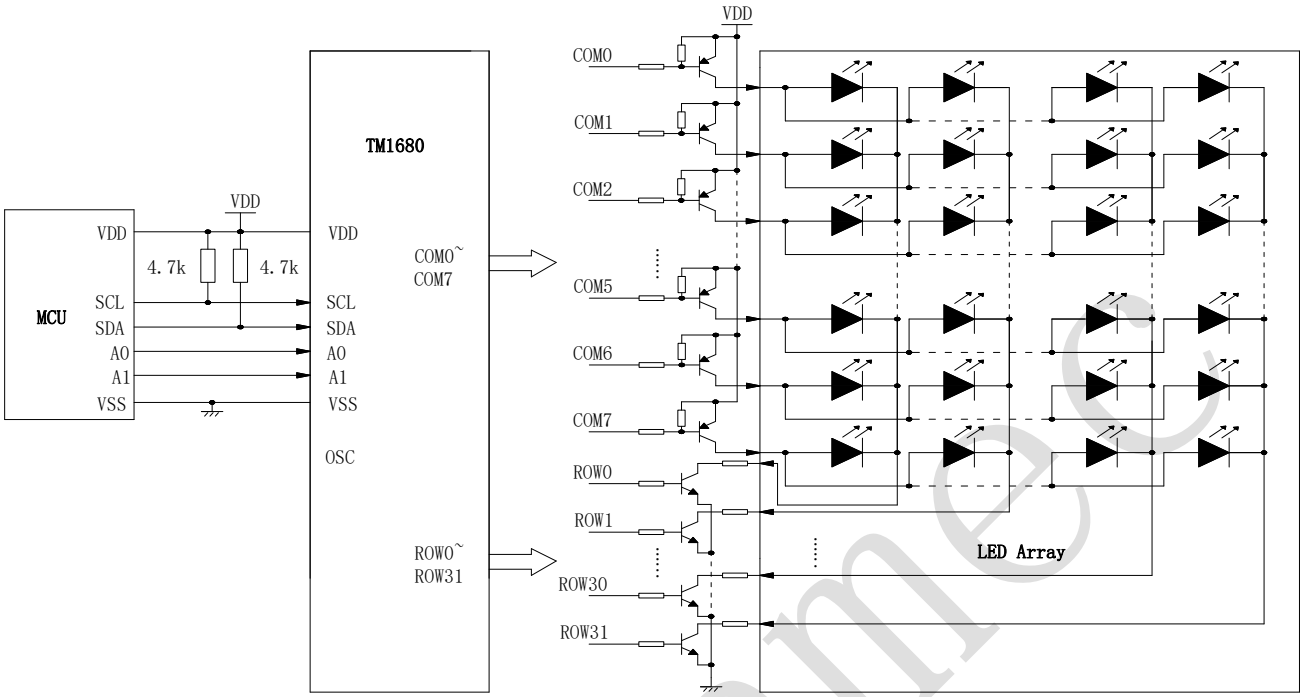


Figure 23

Large-power LED application (ROW and COM plus transistor driving mode): 24ROW*16COM mode example is as shown in Figure 24

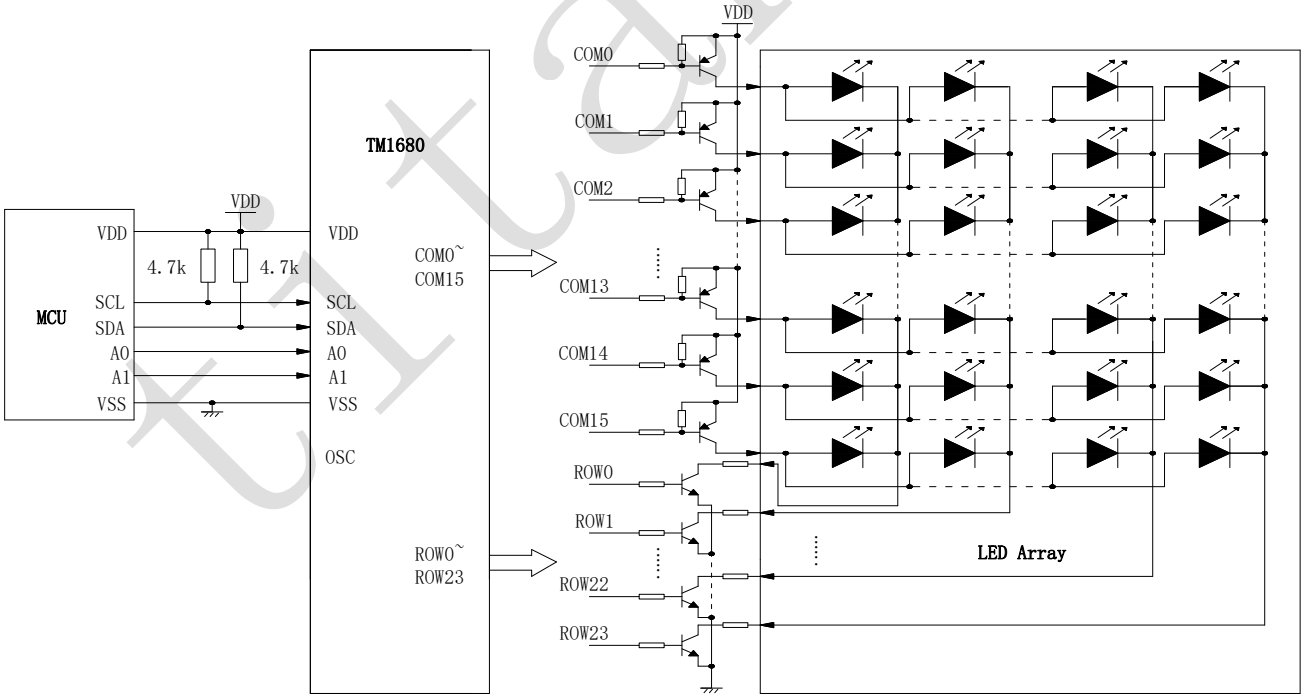


Figure 24

Cascade application (direct driving mode): 32ROW*8COM mode example is as shown in Figure 25

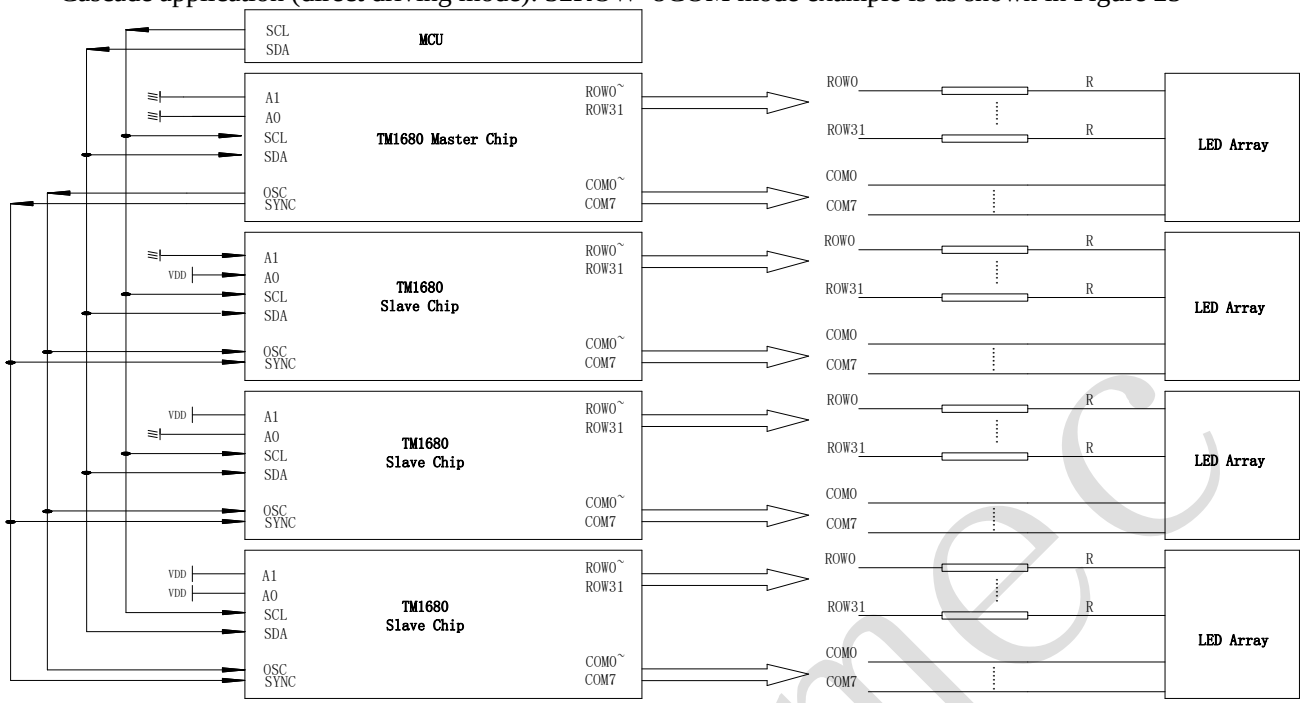


Figure 25

Cascade application (COM plus transistor driving mode): 32ROW*8COM mode example is as shown in Figure 26

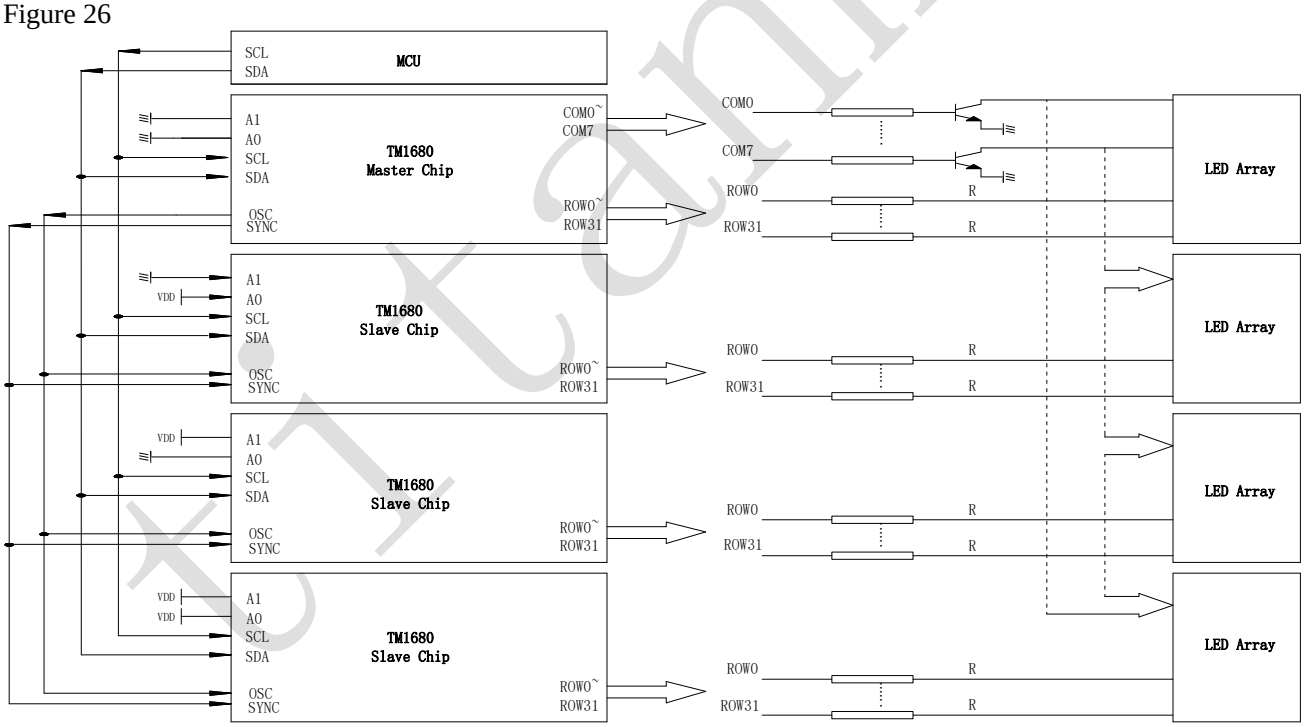


Figure 26

Cascade application (direct driving mode): 24ROW*16COM mode example is as shown in Figure 27

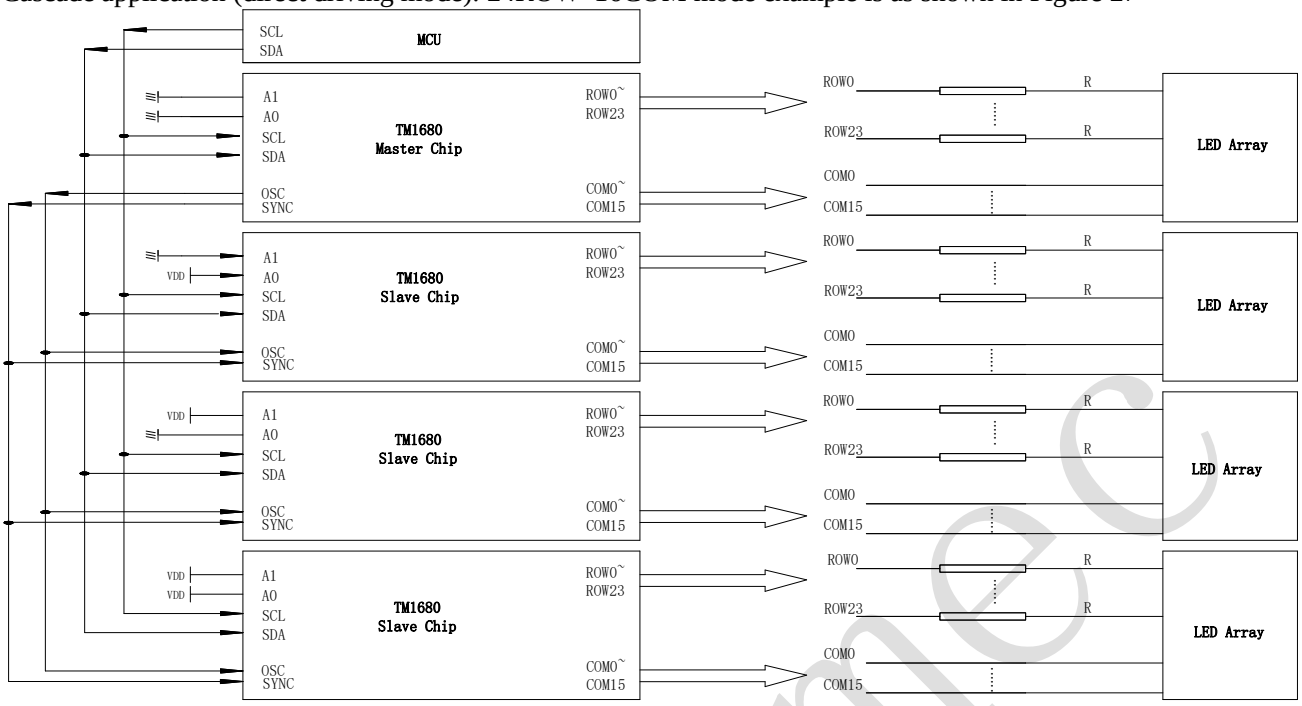


Figure 27

Cascade application (COM plus transistor driving mode): 24ROW*16COM mode example is as shown in Figure 28

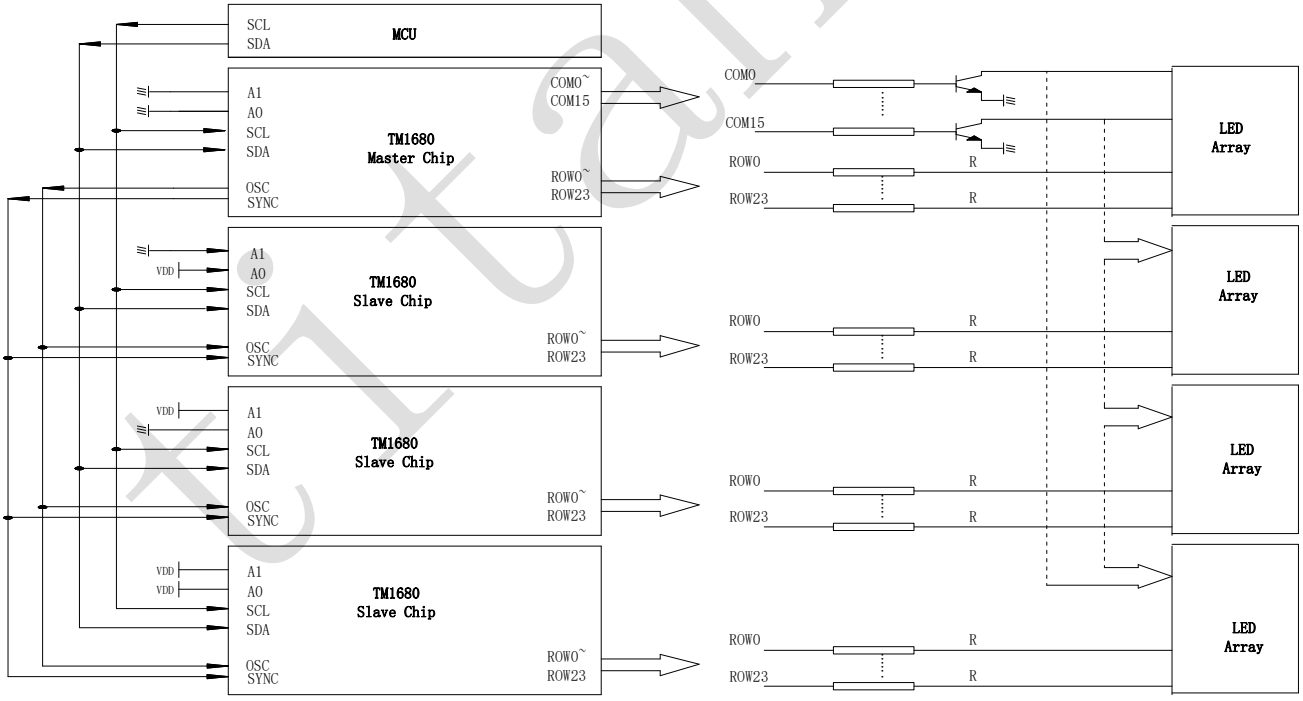
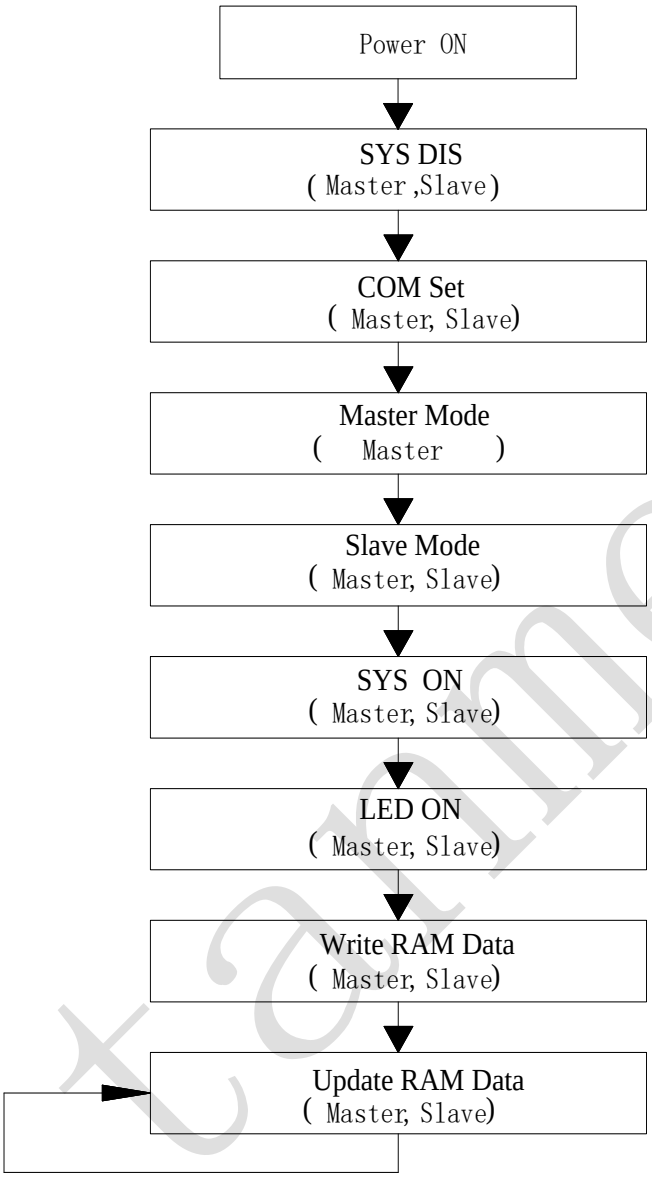


Figure 28

General Design Flowchart

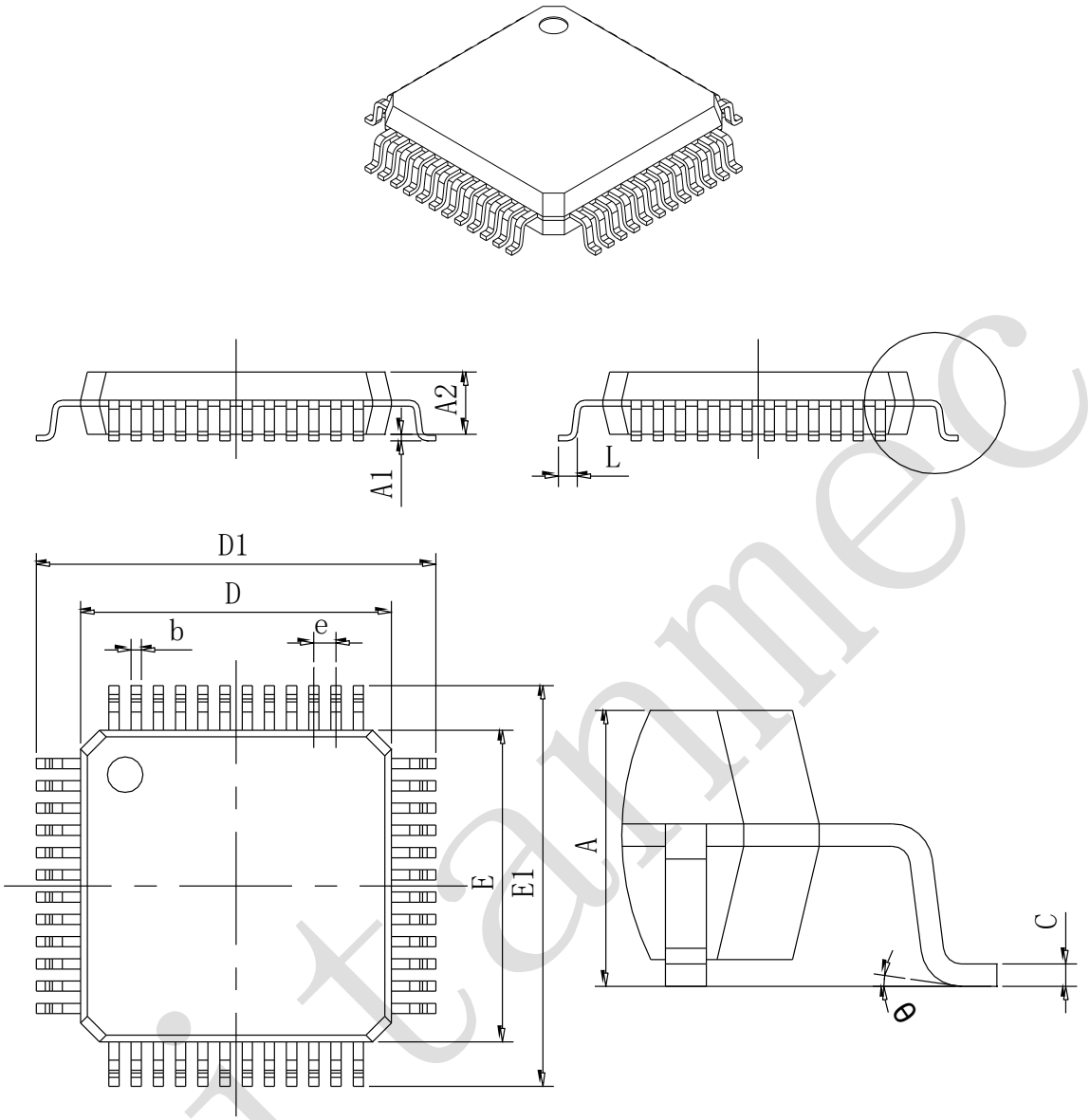


Command Summary Table

Command Name	Command Code	D/C	Function Description	Default
WRITE	1110-01A1A0	D	Write slave address	
Data Address（I2C）	0 A6 A5 A4 A3 A2 A1 A0	D	Write RAM address	
Data Format（I2C）	$D_{A3}D_{A2}D_{A1}D_{A0}D_{B3}D_{B2}D_{B1}D_{B0}$	D	A3-A0 3 bits high，B3-B0 4 bits low	
SYS DIS	1000-0000	C	Turn off system clock and LED cycle	√
SYS EN	1000-0001	C	Turn on system oscillator	
LED OFF	1000-0010	C	Turn off LED cycle	√
LED ON	1000-0011	C	Turn on LED cycle	
BLINK OFF	1000-1000	C	Turn off the flashing function	√
BLINK 2Hz	1000-1001	C	LED flashes at a frequency of 2Hz	
BLINK_1Hz	1000-1010	C	LED flashes at a frequency of 1Hz	
BLINK_0.5Hz	1000-1011	C	LED flashes at a frequency of 0.5Hz	
SLAVE MODE	1001-0XXX	C	External oscillation,clock inputted by the OSC pin, synchronizing signal inputted by the SYN pin	
RC Master Mode0	1001-100X	C	Built-in oscillation; OSC remains low level; synchronizing signal remains high level on SYN pin, only for single chip	√
RC Master Mode1	1001-101X	C	Built-in oscillation internal frequency outputted at OSC,synchronizing signal outputted at SYN pin	
EXT CLK Master Mode0	1001-110X	C	External oscillation, clock inputted by the OSC pin, synchronizing signal remains high level by the SYN pin, only for single chip	√
EXT CLK Master Mode1	1001-111X	C	External oscillation,clock inputted by the OSC pin, synchronizing signal outputted by the SYN pin	
COM Option	1010-abXX	C	When ab=00，8COM Nmos; When ab=01，16COM Nmos; When ab=10，8COM Pmos; When ab=11，16COM PMOS;	00
PWM Duty	1011-abcd	C	abcd changing from 0-F respectively corresponds to 16-order brightness adjustment of LED from 1/16--16/16	F

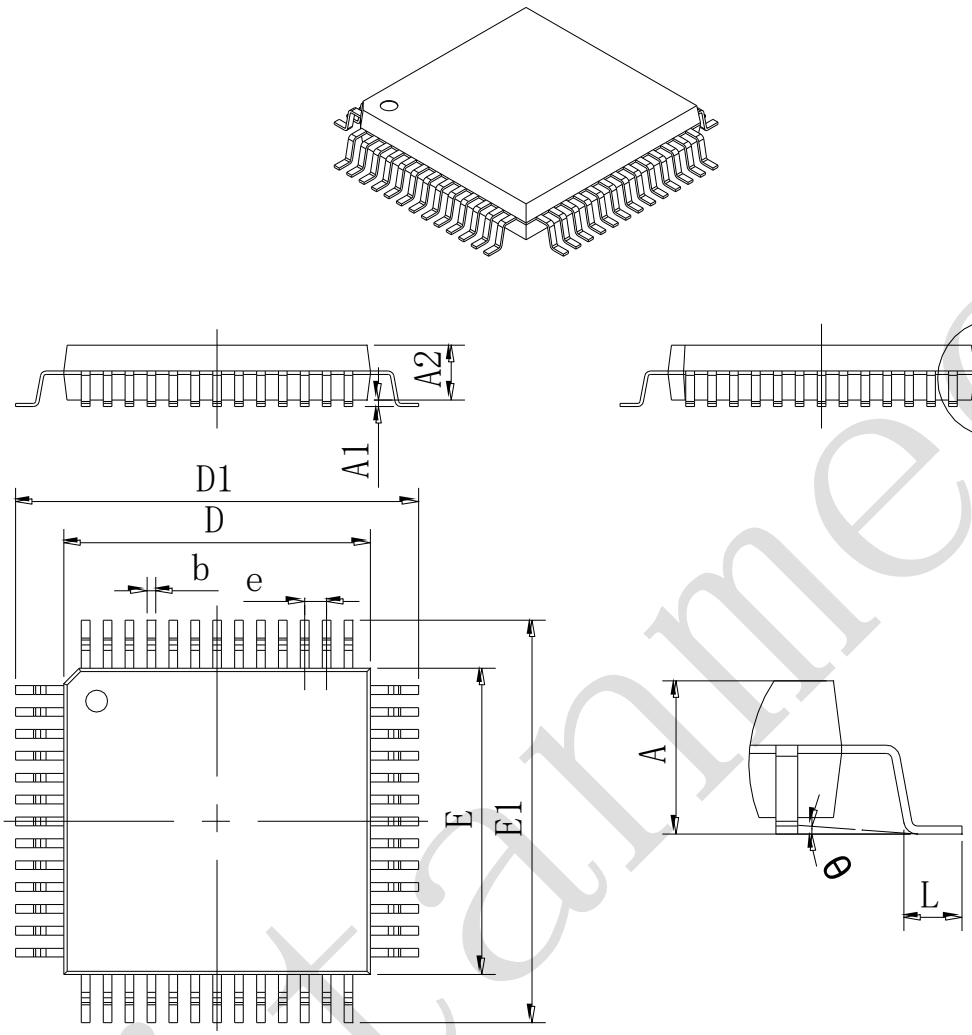
Note：
1. X not important, it is recommended to write as "0".
2. A6 ~ A0 memory address.
3. D0 ~ D3 memory data.
4. D/C data/command mode.
5. The default: the chip state after power on and reset.

Package Diagram（LQFP48　7mm*7mm）



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A		1.600		0.063
A1	0.050	0.150	0.002	0.006
A2	1.350	1.450	0.053	0.057
b	0.190	0.260	0.007	0.010
c	0.090	0.200	0.004	0.008
D	6.900	7.100	0.272	0.280
D1	8.850	9.150	0.348	0.360
E	6.900	7.100	0.272	0.280
E1	8.850	9.150	0.348	0.360
e	0.500(BSC)		0.020(BSC)	
L	0.450	0.750	0.018	0.030
θ	1°	7°	1°	7°

Package Diagram（QFP52　14mm*14mm）



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	---	3.400	---	0.134
A1	0.100		0.004	
A2	2.500	3.100	0.098	0.122
b	0.400 (BSC)		0.016 (BSC)	
D	13.900	14.100	0.547	0.555
D1	17.300	17.500	0.681	0.689
E	13.900	14.100	0.547	0.555
E1	17.300	17.500	0.681	0.689
e	1.000 (BSC)		0.039(BSC)	
L	0.730	1.030	0.029	0.041
θ	1°	7°	1°	7°

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