LED Driver with Key Scan Function

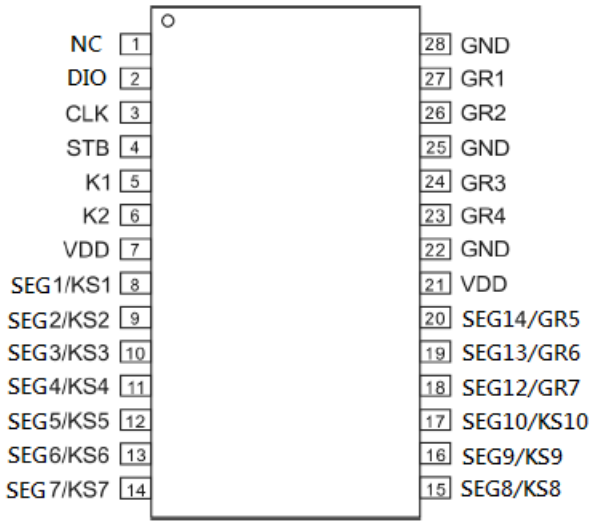
. General Description

TT1628(SOP 28) / TT1668(SOP 24) is an LED Controller driver with key scan function . Ten segment output lines, four grid output lines, Three segment/grid output lines , display memory, pulse width control circuit , key scan circuit , 3 wire interface circuit are all incorporated into a single chip to build a highly reliable peripheral device for a single chip microcomputer.

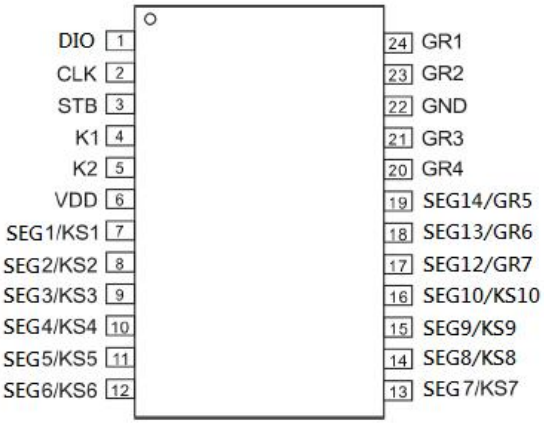
Features

- ✧ Multiple Display Modes (10 segment X 7 Grid to 13 segment X 4 Grid)
- ✧ Key Scanning (10 x 2)
- ✧ 8 step Dimming adjustment
- ✧ Build-in RC oscillator
- ✧ Serial interface for clock, data Input/ output, strobe pins
- ✧ SOP28 package (TT1628) / SOP24 package(TT1668)
- ✧ CMOS technology
- ✧ Low power consumption

.Pin Assignment



TT1628



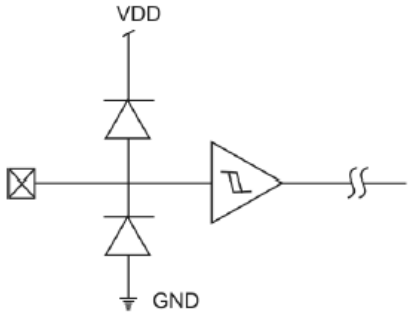
TT1668

Pin Description

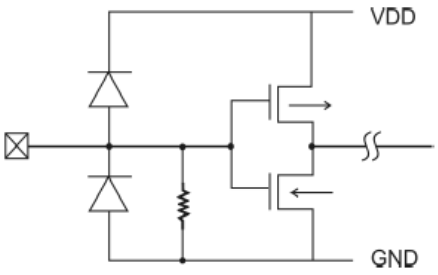
Pin Name	I/O	Pin Description
DIO	I/O	Data Input Pin : This pin inputs serial data at the rising edge of the shift clock (starting from the lower bit) Data Output Pin (N-Channel, Open-Drain)
CLK	I	Clock Input Pin This pin reads serial data at the rising edge and outputs data at the falling edge.
STB	I	Serial Interface Strobe Pin The data input after the STB has fallen is processed as a command. When this pin is HIGH", CLK is ignored.
K1 ~ K2		Key Data Input Pins The data sent to these pins are latched at the end of the display cycle. (Internal Pull-Low Resistor)
VDD	P	Power Supply
SEG1/KS1 ~ SEG10/KS10	O	Segment Output Pins (p-channel, open drain) Also acts as the Key Source
SEG12/GR7 ~ SEG14/GR5		Segment / Grid Output Pins
GND	P	Ground Pin
GR4 ~ GR1	O	Grid Output Pins

Equivalent Circuits for Inputs and Outputs

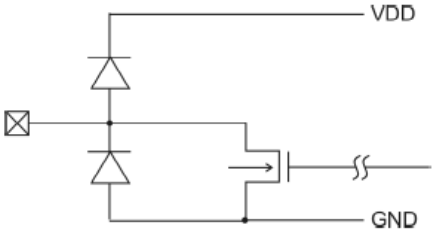
INPUT PINS: CLK, STB



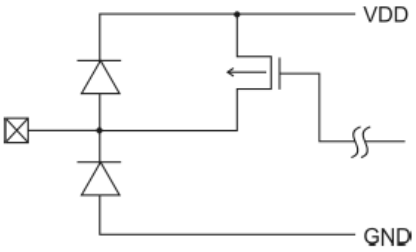
INPUT PINS: K1 TO K2



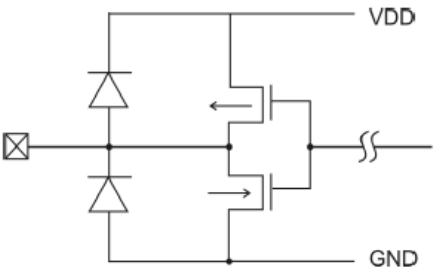
OUTPUT PINS: GR1 TO GR4



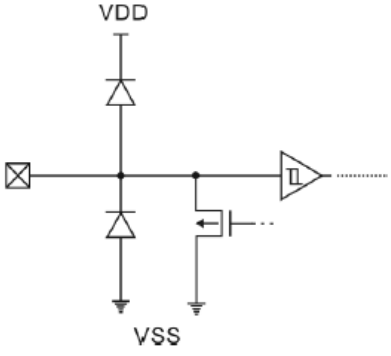
OUTPUT PINS: SEG1/KS1 TO SEG10/KS10



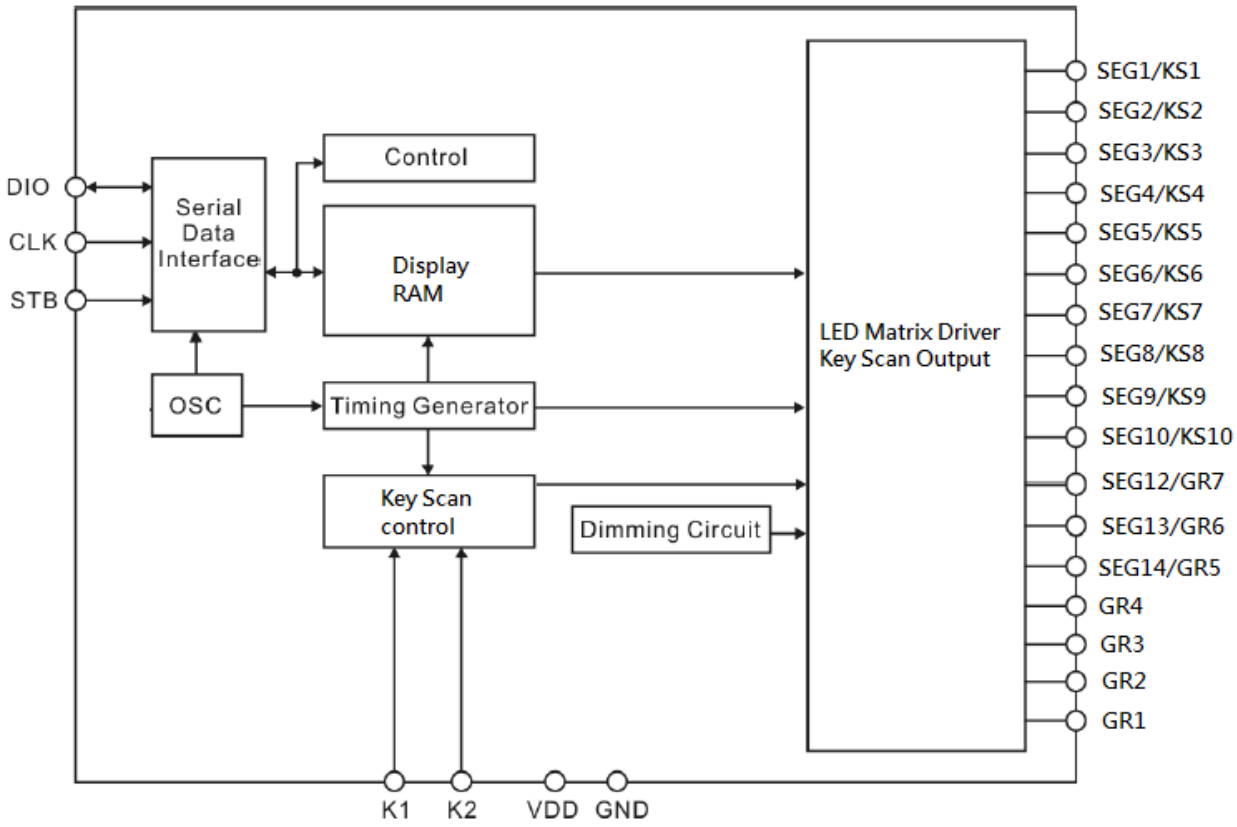
OUTPUT PINS: SEG14/GR5, SEG13/GR6, SEG12/GR7



INPUT PIN & OUTPUT PIN: DIO



. Block Diagram



FUNCTION DESCRIPTION

COMMANDS

A command is the first byte (b0 to b7) inputted to TT1628/TT1668 via the DIO Pin after STB Pin has changed from HIGH to LOW State. If for some reason the STB Pin is set to HIGH while data or commands are being transmitted, the serial communication is initialized, and the data/commands being transmitted are considered invalid.

B7	B6	COMMANDS
0	0	DISPLAY MODE SETTING COMMANDS
0	1	DATA SETTING COMMANDS
1	0	DISPLAY CONTROL COMMANDS
1	1	ADDRESS SETTING COMMANDS

1: DISPLAY MODE SETTING COMMANDS

TT1628/TT1668 provides four display mode settings as shown in the diagram below: As stated earlier a command is the first one byte (b0 to b7) transmitted to TT1628/TT1668 via the DIO Pin when STB is LOW. However, for these commands, the bit 3 to bit 6 (b2 to b5) are ignored, bit 7 & bit 8 (b6 to b7) are given a value of 0. The Display Mode Setting Commands determine the number of segments and grids to be used (10 to 13 segments, 7 to 4 grids).
A display commands ON must be executed in order to resume display. If the same mode setting is selected, no command execution is take place, therefore, nothing happens.

When Power is turned ON, the 7-grid, 10-segment modes is selected.

MSB LSB

B7	B6	B5	B4	B3	B2	B1	B0	DISPLAY MODE
0	0	--	--	--	--	0	0	4 digits, 13 segments
0	0	--	--	--	--	0	1	5 digits, 12 segments
0	0	--	--	--	--	1	0	6 digits, 11 segments
0	0	--	--	--	--	1	1	7 digits, 10 segments

2: DATA SETTING COMMANDS

The Data Setting Commands executes the Data Write or Data Read Modes for TT1628/TT1668. The data Setting Command, the bits 5 and 6 (b4, b5) are ignored, bit 7 (b6) is given the value of 1 while bit 8 (b7) is given the value of 0.
Please refer to the diagram below.
When power is turned ON, bit 4 to bit 1 (b3 to b0) are given the value of 0.

MSB LSB

0	1	-	-	B3	B2	B1	B0

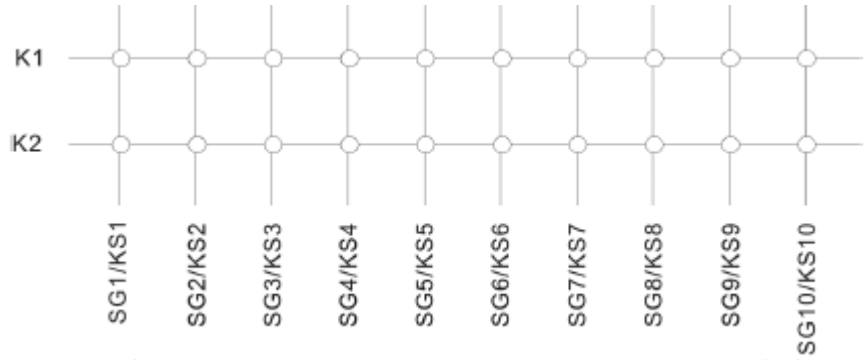
B1:B0 : Data write & read mode settings:
0 0 : Write data to display mode
1 0 : Read key data

B2 : Data write & read mode settings:
0 : Increment address after data has been written
1 : Fixed address

B3 : Mode settings:
0 : Normal operation mode
1 : Test mode

TT1628/TT1668 KEY MATRIX & KEY INPUT DATA STORAGE RAM

TT1628/TT1668 Key Matrix consists of 10 x 2 array as shown below:



Each data entered by each key is stored as follows and read by a READ Command, starting from the last significant bit. When the most significant bit of the data (b7) has been read, the least significant bit of the next data (b0) is read.

K1~~~~~~~~~~~~~~~~K2	K1~~~~~~~~~~~~~~~~K2	
SEG1/KS1	SEG2/KS2	X
SEG3/KS3	SEG4/KS4	X
SEG5/KS5	SEG6/KS6	X
SEG7/KS7	SEG8/KS8	X
SEG9/KS9	SEG10/KS10	X
B0~~~~~~~~~~~~~~~~B1	B3~~~~~~~~~~~~~~~~~~B4	B6~~~~~~~~~~~~~~~~B7

3: ADDRESS SETTING COMMANDS

Address Setting Commands are used to set the address of the display memory. The address is considered valid if it has a value of 00_H to $0D_H$. If the address is set to $0E_H$ or higher, the data is ignored until a valid address is set. When power is turned ON, the address is set at 00_H.

Please refer to the diagram below.

MSB LSB

1	1	-	-	B3	B2	B1	B0

B3:B0 : Address: 00_H to $0D_H$

SEG1	SEG2	SEG3	SEG4	SEG5	SEG6	SEG7	SEG8	SEG9	SEG10	X	SEG12	SEG13	SEG14	X	X		
B0	B1	B2	B3	B4	B5	B6	B7									00_H	DIG1
								B0	B1	B2	B3	B4	B5	B6	B7	01_H	
B0	B1	B2	B3	B4	B5	B6	B7									02_H	DIG2
								B0	B1	B2	B3	B4	B5	B6	B7	03_H	
B0	B1	B2	B3	B4	B5	B6	B7									04_H	DIG3
								B0	B1	B2	B3	B4	B5	B6	B7	05_H	
B0	B1	B2	B3	B4	B5	B6	B7									06_H	DIG4
								B0	B1	B2	B3	B4	B5	B6	B7	07_H	
B0	B1	B2	B3	B4	B5	B6	B7									08_H	DIG5
								B0	B1	B2	B3	B4	B5	B6	B7	09_H	
B0	B1	B2	B3	B4	B5	B6	B7									$0A_H$	DIG6
								B0	B1	B2	B3	B4	B5	B6	B7	$0B_H$	
B0	B1	B2	B3	B4	B5	B6	B7									$0C_H$	DIG7
								B0	B1	B2	B3	B4	B5	B6	B7	$0D_H$	

4: DISPLAY CONTROL COMMANDS

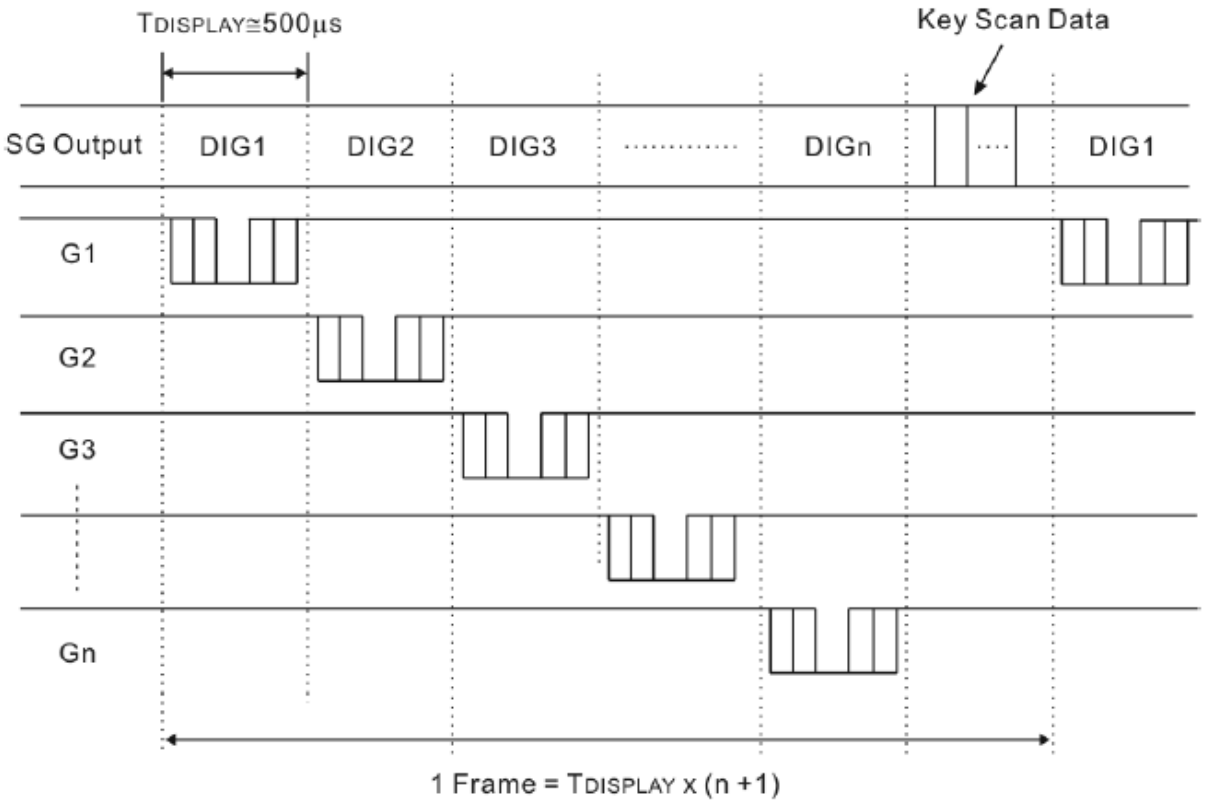
The Display Control Commands are used to turn ON or OFF a display. It also used to set the pulse width. Please refer to the diagram below. When the power is turned ON, a 1/16 pulse width is selected and the displayed is turned OFF (the key scanning is started).

MSB							LSB
1	0	-	-	B3	B2	B1	B0

B2~B0 : Dimming quantity settings:
- 000: Pulse width=1/16
- 001: Pulse width=2/16
- 010: Pulse width=4/16
- 011: Pulse width=10/16
- 100: Pulse width=11/16
- 101: Pulse width=12/16
- 110: Pulse width=13/16
- 111: Pulse width=14/16

B3: Display settings:
- 0: Display off (Key scan continues)
- 1: Display on

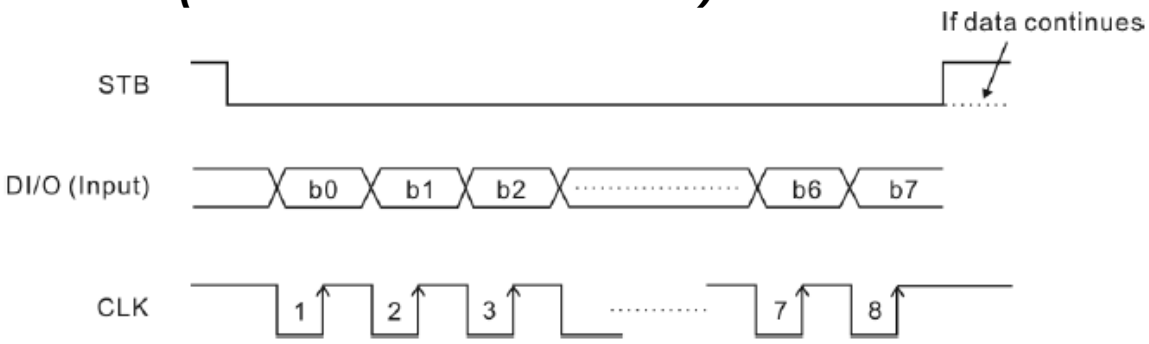
SCANNING AND DISPLAY TIMING



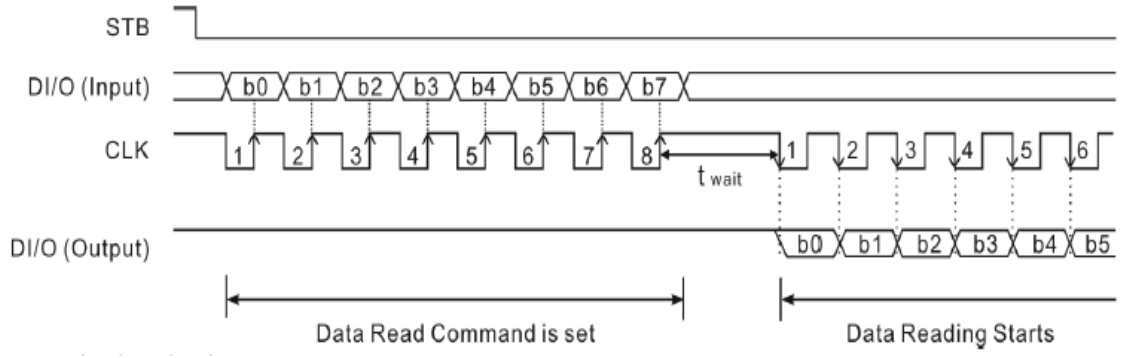
SERIAL COMMUNICATION FORMAT

The following diagram shows the TT1628/TT1668 serial communication format. The DIO Pin is an N-channel, open-drain output pin; therefore, it is highly recommended that an external pull-up resistor (1KΩ to 10KΩ) must be connected to DIO.

RECEPTION (DATA/COMMAND WRITE)



TRANSMISSION (DATA READ)

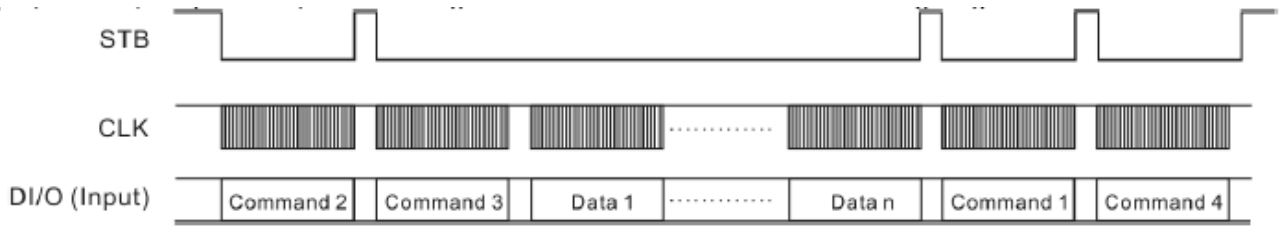


Where: t_{wait} (waiting time) ≥ 1μs

It must be noted that when the data is read, the waiting time (t_{wait}) between the rise of the eighth clock that has set the command and the falling of the first clock that has read the data is greater or equal to 1μs.

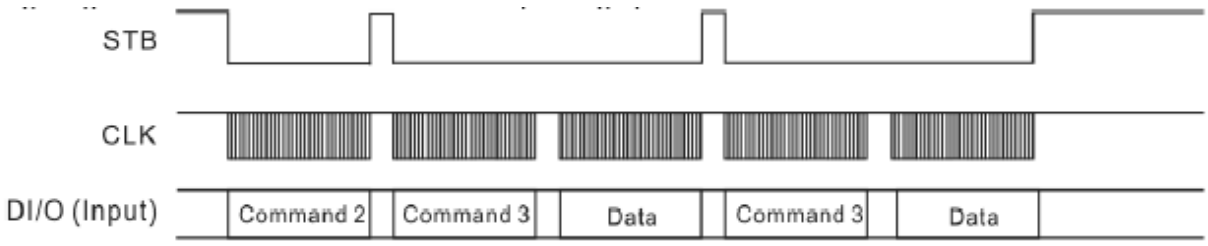
APPLICATIONS

Display memory is updated by incrementing addresses. Please refer to the following diagram.



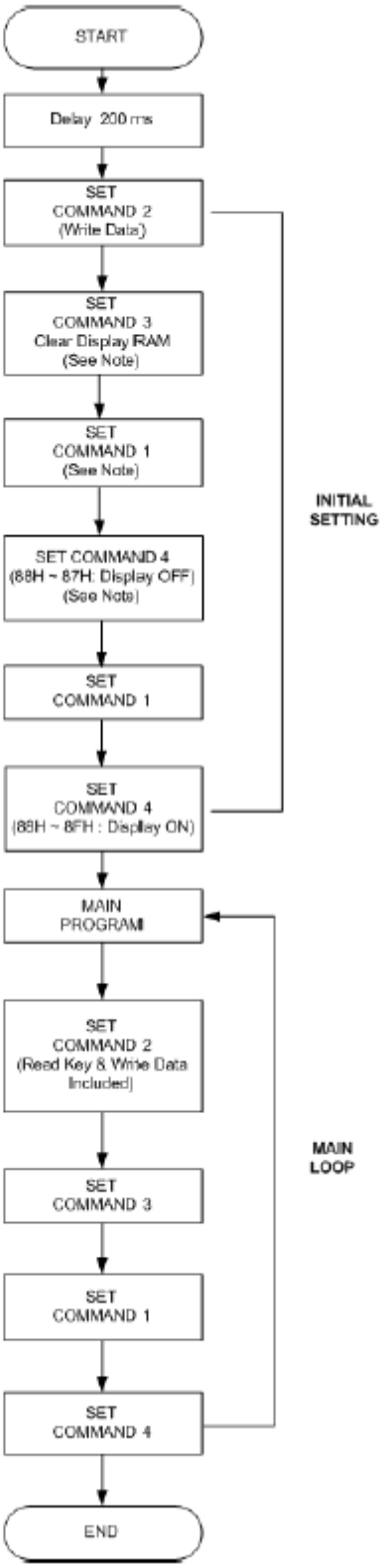
Where:
Command 1: Display mode setting command
Command 2: Data setting command
Command 3: Address setting command
Data 1 to n: Transfer display data (14 bytes max.)
Command 4: Display control command

The following diagram shows the waveforms when updating specific addresses.



Where:
Command 2: Data setting command
Command 3: Address setting command
Data: Data display data

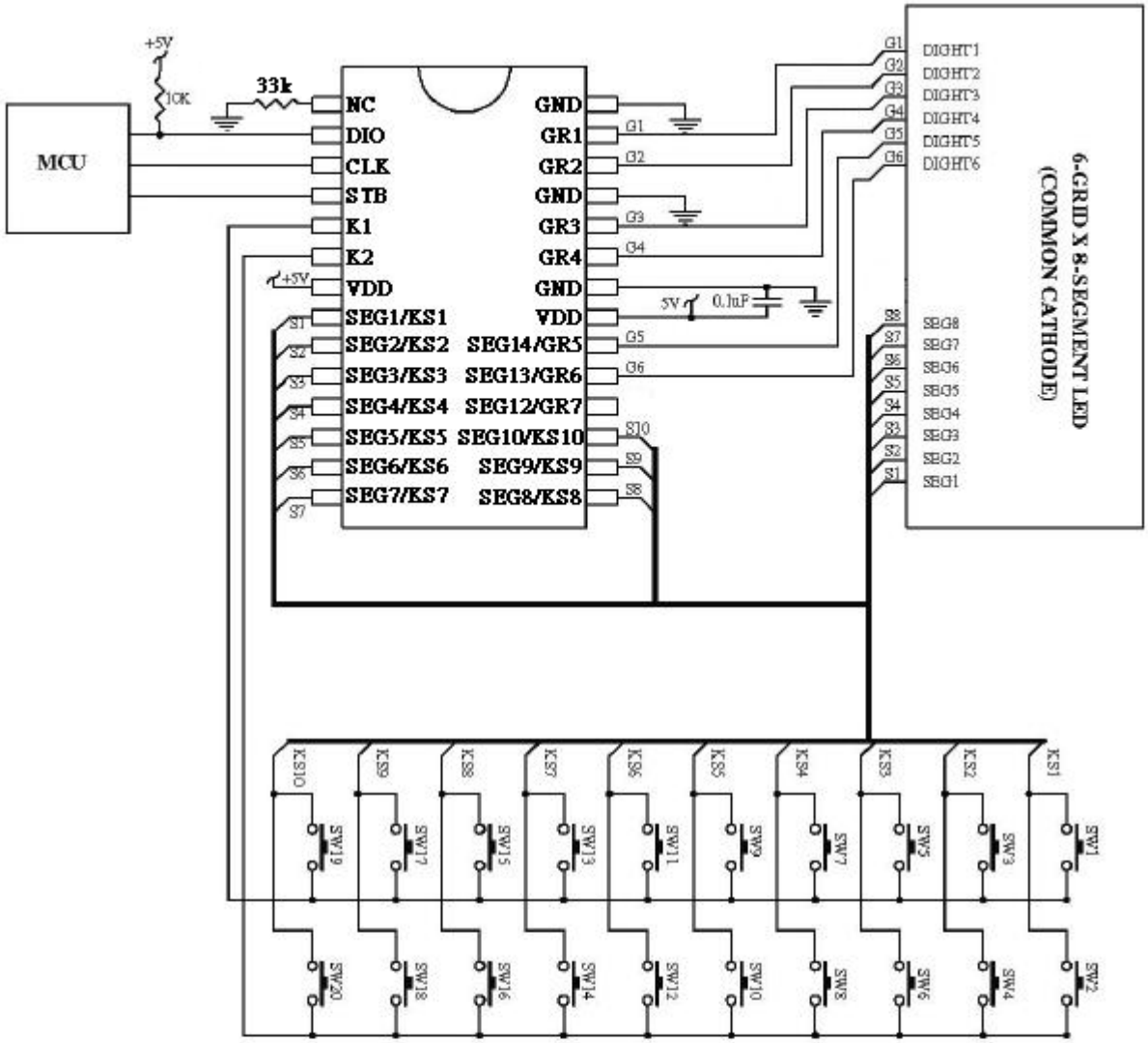
RECOMMENDED SOFTWARE FLOWCHART



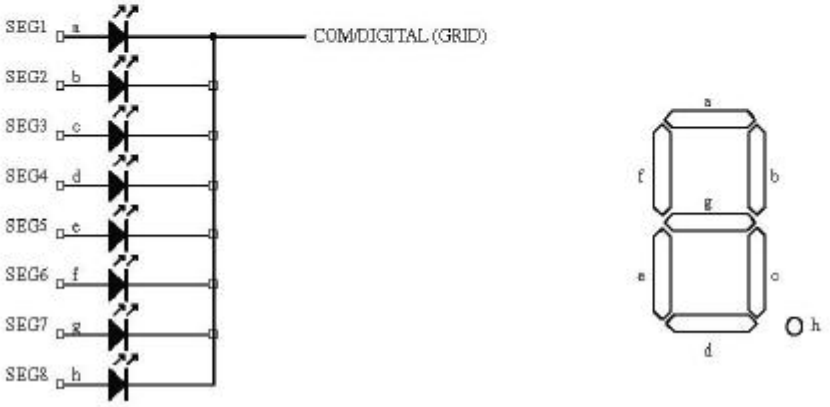
1. Command 1: Display Mode Commands
2. Command 2: Data Setting Commands
3. Command 3: Address Setting Commands
4. Command 4: Display Control Commands
5. When IC power is applied for the first time, the content of the Display RAM is not defined;
   Thus, it is strongly suggested that the contents of the Display RAM be cleared during the initial setting.

Application circuit：

(Common Cathode Type)



Common Cathode Type LED Panel：



. Absolutely Maximum Rating (Unless otherwise stated, Ta=25℃, GND=0V)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{DD}	-0.5~7.0	V
Input voltage	V_{IN}	-0.5~V_{DD}+ 0.5	V
LED Seg. Output current	I_{O1}	-50	mA
LED Grid. Output current	I_{O2}	200	mA
Maximum driver output current/total	I_{total}	400	mA
Operating Temperature	T_{opr}	-40~+85	℃
Storage Temperature	T_{stg}	-65~+150	℃

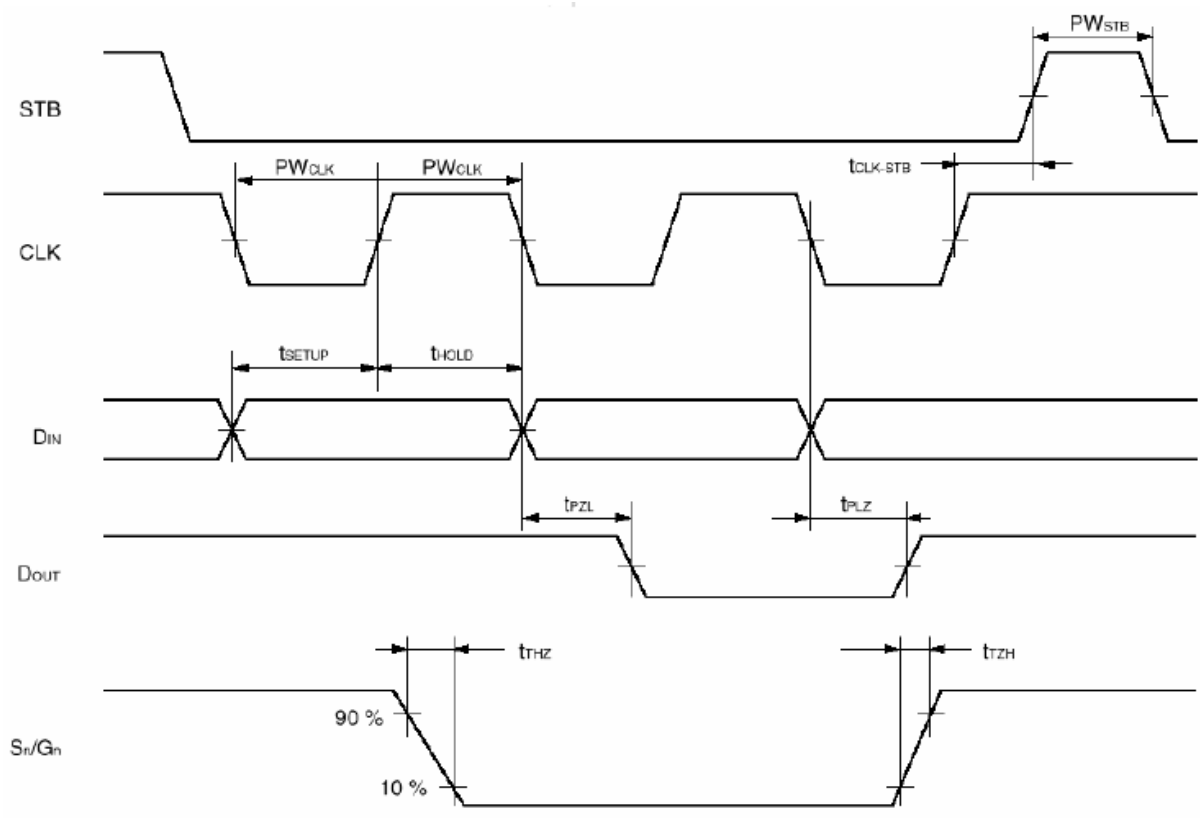
.DC Electrical Characteristics (Unless otherwise stated, VDD=5V, GND=0V, Ta=25℃)

Characteristics	Symbol	Conditions	Min	Typ	Max	Unit
Supply Voltage	V_{DD}		4.5	5	5.5	V
Operating Current	I_{DD}	LED off , No load		100	200	uA
Input high Voltage	V_{IH}		0.7VDD		VDD	V
Input low Voltage	V_{IL}		0		0.3VDD	V
Output high Current	I_{OHSEG1}	VO=VDD-2V SEG1/KS1 to SEG10/KS10, SEG12/GR7 to SEG14/GR5	-20	-25	-40	mA
	I_{OHSEG2}	VO=VDD-3V SEG1/KS1 to SEG10/KS10, SEG12/GR7 to SEG14/GR5	-25	-30	-50	
Output low Current	I_{OLGR}	VO=0.3V GR1 to GR4 SEG14/GR5 to SEG12/GR7	100	140		mA
Output low Current	I_{OLIO}	VO=0.4V , DIO	4			mA
Segment out high Current tolerance	I_{TOLSG}	VO=V_{DD}-3V(V_{DD}=5V) VO=V_{DD}-2V(V_{DD}=3V) SEG1/KS1 to SEG10/KS10, SEG12/GR7 to SEG14/GR5			5	%
K1 to K2 Pull down Resistor	R_L		40		100	KΩ
Input high Voltage	V_{IH}	CLK,DIO,STB	0.7VDD		VDD	V
Input low Voltage	V_{IL}	CLK,DIO,STB	GND		0.3 VDD	V

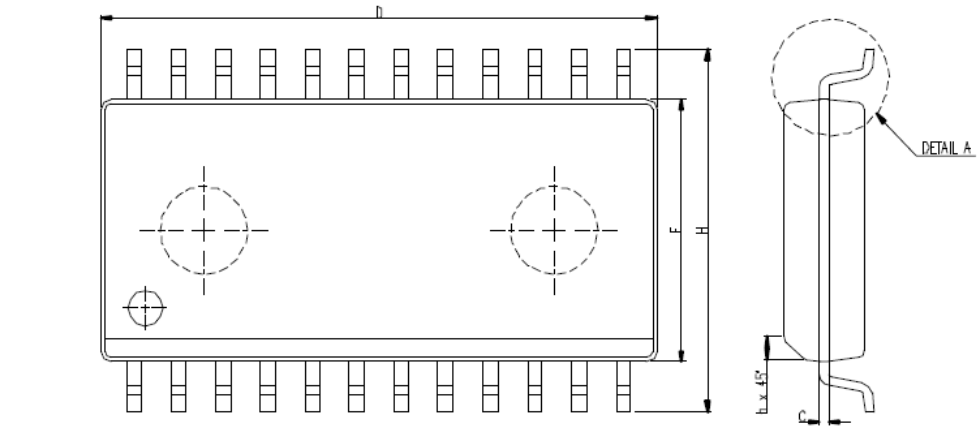
.AC Electrical Characteristics

Characteristics	Symbol	Conditions	Min	Typ	Max	Unit
Oscillation frequency	f_{osc}		350	500	650	KHz
Propagation delay time	t_{PLZ}	CLK → DIO CL=15pF , RL=10KΩ			300	ns
	t_{PZL}				100	
Output rising time	t_{TZH1}	SEG1～SEG10 CL=300pF			2	us
	t_{TZH2}	Grid1～Grid4 SEG12/Grid7～ SEG14/Grid5 CL=300pF			0.5	
Output falling time	T_{THZ}	CL = 300pF， Segn， Gridn			120	us
Clock Frequency	F_{max}	Duty=50%			1	MHz
Input Capacitor	C_I				15	pF
Clock Pulse Width	PW_{CLK}		400			ns
Strobe Pulse Width	PW_{STB}		1			us
Data setup time	t_{SETUP}					ns
Data hold time	t_{HOLD}					ns
CLK →STB	$t_{CLK-STB}$	CLK↑→STB↑	1			us
Wait time	t_{WAIT}	CLK↑→CLK↓	1			us

Timing Diagram



. Package Information



SYMBOL	DIMENSION IN MM		DIMENSION IN INCH	
	MIN.	MAX.	MIN.	MAX.
A	2.35	2.65	0.0926	0.1043
A1	0.10	0.30	0.0040	0.0118
B	0.33	0.51	0.013	0.020
C	0.23	0.32	0.0091	0.0125
e	1.27 BSC		0.050 BSC	
E	7.40	7.60	0.2914	0.2992
H	10.00	10.65	0.394	0.419
L	0.40	1.27	0.016	0.050
h	0.25	0.75	0.010	0.029
θ	0°	8°	0°	8°

	D DIMENSION (IN MM)		D DIMENSION (IN INCH)		
N	MIN.	MAX.	MIN.	MAX.	JEDEC
20	12.60	13.00	0.4961	0.5118	MS-013 (AC)
24	15.20	15.60	0.5985	0.6141	MS-013 (AD)
28	17.70	18.10	0.6969	0.7125	MS-013 (AE)

⚠NOTES : DIMENSION " D " DOES NOT INCLUDE MOLD FLASH , PROTRUSIONS OR GATE BURRS.
MOLD FLASH , PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED 0.15 MM (0.006 INCH) PER SIDE.