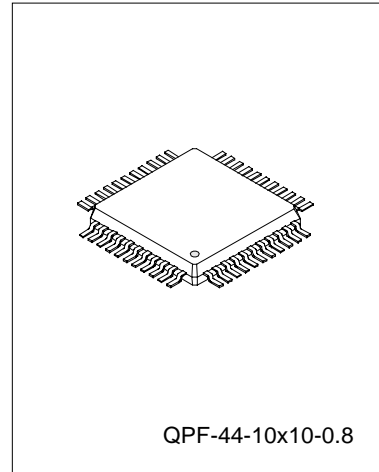


**1/4 to 1/11 DUTY FIP(VFD) CONTROLLER/DRIVER**

**DESCRIPTION**

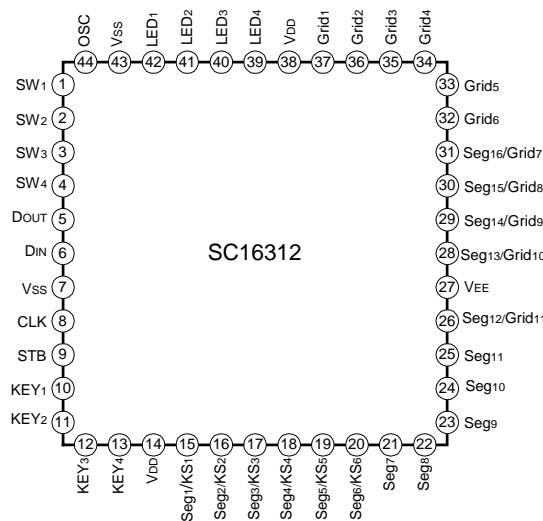
The SC16312 is a FIP (Fluorescent Indicator Panel, or Vacuum Fluorescent Display) controller/driver that is driven on a 1/4 or 1/11 duty factor. It consists of 11 segment output lines, 6 grid output lines, 5 segment/grid output drive lines, a display memory, a control circuit, and a key scan circuit. Serial data is input to the SC16312 through a three-line serial interface. This FIP controller/driver is ideal as a peripheral device for a single-chip microcomputer.



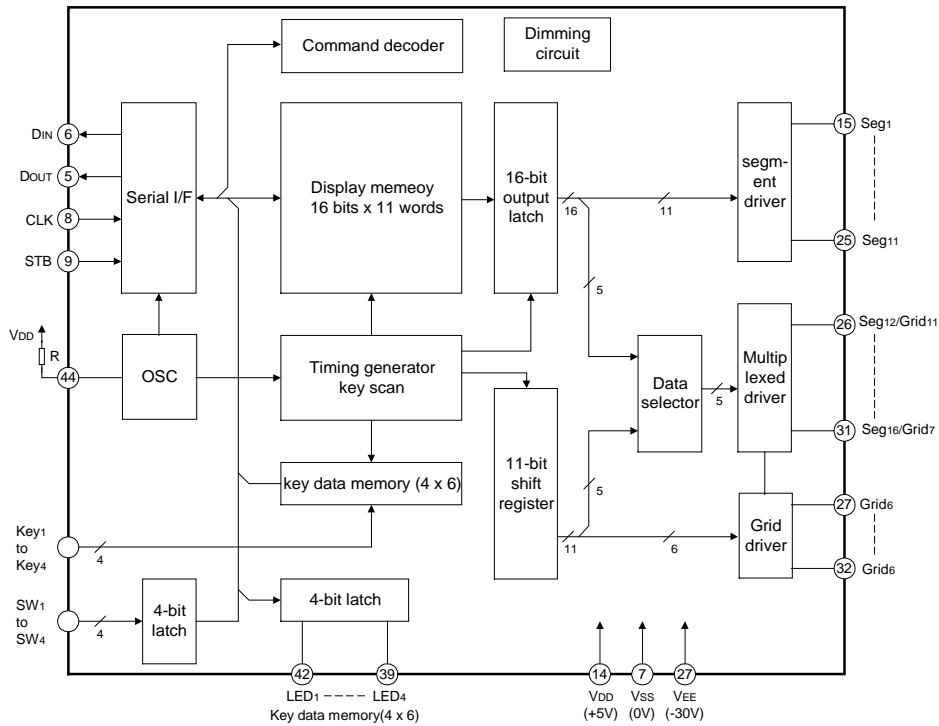
**FEATURES**

- \* Multiple display modes (11-segment & 11-dight to 16-segment & 4-digit).
- \* Key scanning (6x4 matrix).
- \* Dimming circuit (eight steps).
- \* High-voltage output ( $V_{DD} - 35V$  max).
- \* LED ports (4 chs., 20 mA max).
- \* General-purpose input port (4 bits)
- \* No external resistors necessary for driver outputs (P-ch open-drain + pull-down resistor output)
- \* Serial interface (CLK, STB, DIN, DOUT)

**PAD CONFIGURATION**



**BLOCK DIAGRAM**



**ABSOLUTE MAXIMUM RATING** (Ta=25°C, Vss=0V)

Characteristic	Symbol	Value	Unit
Logic Supply Voltage	VDD	-0.5 ~ 7.0	V
Driver Supply Voltage	VEE	VDD + 0.5 ~ VDD - 40	V
Logic Input Voltage	V <sub>I1</sub>	-0.5 ~ VDD + 0.5	V
FIP Driver Output Voltage	VO <sub>2</sub>	VEE - 0.5 ~ VDD + 0.5	V
LED Driver Output Current	IO <sub>1</sub>	+25	mA
FIP Driver Output Current	IO <sub>2</sub>	-40 (grid) ; -15 (segment)	mA
Power Dissipation	PD	800 *	mW
Storage temperature	T <sub>STG</sub>	-65 ~ +150	°C
Operating Ambient Temperature	T <sub>OPT</sub>	-40 ~ + 85	°C

\* Note: Derate at -6.4 mW/°C at Ta=25°C or higher

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**RECOMMENDED OPERATING RANGE** (Ta=-20 ~ 70 °C, Vss=0V)

Parameter	Symbol	Min	Typ	Max	Unit
Logic Supply Voltage	V <sub>DD</sub>	4.5	5	5.5	V
High-Level Input Voltage	V <sub>IH</sub>	0.7x V <sub>DD</sub>	--	V <sub>DD</sub>	V
Low-Level Input Voltage	V <sub>IL</sub>	0	--	0.3xV <sub>DD</sub>	V
Driver Supply Voltage	V <sub>EE</sub>	0	--	V <sub>DD</sub> -35	V

Maximum power consumption P<sub>MAX</sub> = FIP driver dissipation + R<sub>L</sub> dissipation + LED driver dissipation + dynamic power consumption

Where segment current = 3mA, grid current = 15mA, and LED current = 20mA,

FIP driver dissipation = number of segments x 6 + number of grids/(number of grids + 1) x 30(mW)

R<sub>L</sub> dissipation = (V<sub>DD</sub>-V<sub>EE</sub>)<sup>2</sup> /50 x (number of segments + 1)(mW)

LED driver dissipation = number of LEDs x 20(mW)

Dynamic power consumption = V<sub>DD</sub> x 5(mW)

**Example**

Where V<sub>EE</sub> = -25V, V<sub>DD</sub> = 5V, and in 16-segment and 6-digit modes,

FIP driver dissipation = 16 x 6 + 6/7 x 30 = 122

R<sub>L</sub> dissipation = 30<sup>2</sup> /50 x 17 = 306

LED driver dissipation = 4 x 20 = 80

Dynamic power consumption = 5 x 5 = 25

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Total 553 Mw

**ELECTRICAL CHARACTERISTICS** (Ta=-20 ~ 70 °C, V<sub>DD</sub> =4.5 ~ 5.5V, V<sub>EE</sub>=-30V)

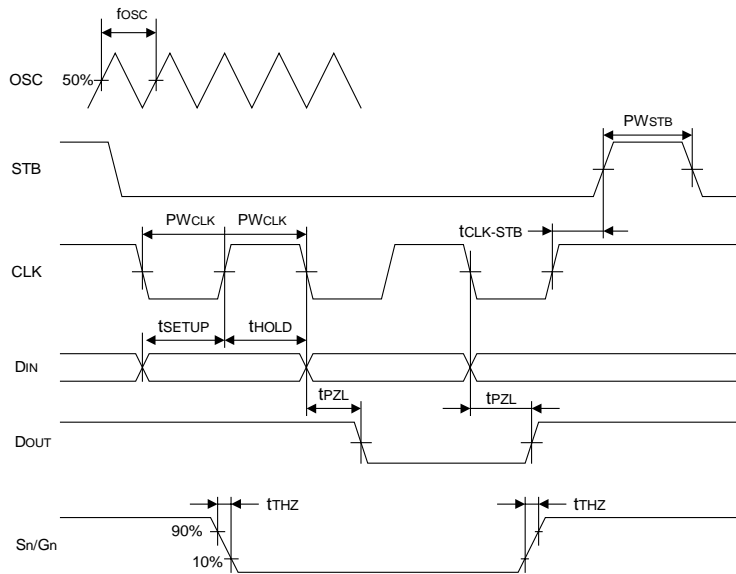
Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
High-Level Output Voltage	V <sub>OH1</sub>	LED1- LED4, I <sub>OH1</sub> =-1mA	0.9V <sub>DD</sub>	--	--	V
Low -Level Output Voltage	V <sub>OL1</sub>	LED1- LED4, I <sub>OL1</sub> =20mA	--	--	1	V
Low -Level Output Voltage	V <sub>OL2</sub>	D <sub>OUT</sub> , I <sub>OL2</sub> =4mA	--	--	0.4	V
High-Level Output Current	I <sub>OH21</sub>	V <sub>O</sub> =V <sub>DD</sub> -2V, Seg <sub>1</sub> to Seg <sub>11</sub>	-3	--	--	mA
High-Level Output Current	I <sub>OH22</sub>	V <sub>O</sub> =V <sub>DD</sub> -2V, Grid <sub>1</sub> to Grid <sub>6</sub> Seg <sub>12</sub> /Grid <sub>11</sub> to Seg <sub>16</sub> /Grid <sub>7</sub>	-15	--	--	mA
Driver Leakage Current	I <sub>OLEAK</sub>	V <sub>O</sub> = V <sub>DD</sub> -35V,driver off	--	--	-10	μA
Output Pull-Down Resistor	R <sub>L</sub>	Driver output	50	100	150	kΩ
Input Current	I <sub>I</sub>	V <sub>I</sub> =V <sub>DD</sub> or V <sub>SS</sub>	--	--	±1	μA
High-Level Input Voltage	V <sub>IH</sub>	--	0.7V <sub>DD</sub>	--	--	V
Low-Level Input Voltage	V <sub>IL</sub>	--	--	--	0.3V <sub>DD</sub>	V
Hysteresis voltage	V <sub>H</sub>	CLK, D <sub>IN</sub> , STB	--	0.35	--	V
Dynamic Current Consumption	I <sub>DDdyn</sub>	Under no load, display off	--	--	5	mA

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**SWITCHING CHARACTERISTICS** ( $T_a = -20 \sim 70 \text{ }^\circ\text{C}$ ,  $V_{DD} = 4.5 \sim 5.5\text{V}$ ,  $V_{EE} = -30\text{V}$ )

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
Oscillation Frequency	$t_{OSC}$	$R=51\Omega$	350	500	650	kHz
Propagation Delay Time	$t_{PLZ}$	$CLK \rightarrow D_{OUT}$	--	--	300	ns
	$t_{PZL}$	$C_L=15\text{pF}$ , $R_L=10\text{k}\Omega$	--	--	100	ns
Rise Time	$t_{TZH1}$	$C_L=300\text{pF}$ Seg <sub>1</sub> to Seg <sub>11</sub> Grid <sub>1</sub> to Grid <sub>6</sub> , Seg <sub>12</sub> /Grid <sub>11</sub> to Seg <sub>16</sub> /Grid <sub>7</sub>	--	--	2	$\mu\text{s}$
	$t_{TZH2}$		--	--	0.5	$\mu\text{s}$
Fall Time	$t_{THZ}$	$C_L=300\text{pF}$ , Seg <sub>n</sub> , Grid <sub>n</sub>	--	--	120	$\mu\text{s}$
Maximum Clock Frequency	$f_{max}$	Duty=50%	1	--	--	MHz
Input Capacitance	$C_i$	--	--	--	15	pF

**SWITCHING CHARACTERISTIC WAVEFORMS**


**TIMING CONDITIONS**( $T_a = -20 \sim 70 \text{ }^\circ\text{C}$ ,  $V_{DD} = 4.5 \sim 5.5\text{V}$ )

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
Clock Pulse Width	PW <sub>CLK</sub>	--	400	--	--	ns
Strobe Pulse Width	PW <sub>STB</sub>	--	1	--	--	$\mu\text{s}$
Data Setup Time	t <sub>SETUP</sub>	--	100	--	--	ns
Data Hold Time	t <sub>HOLD</sub>	--	100	--	--	ns
Clock-Strobe Time	t <sub>CLK-STB</sub>	CLK $\uparrow$ $\rightarrow$ STB $\uparrow$	1	--	--	$\mu\text{s}$
Wait Time	t <sub>WAIT</sub>	CLK $\uparrow$ $\rightarrow$ CLK $\downarrow$ <sup>Note</sup>	1	--	--	$\mu\text{s}$

Note: When data is read, a wait time t<sub>WAIT</sub> of 1  $\mu\text{s}$  is necessary since the rising of the eighth clock that has set the command, until the falling of the first clock that has read the data.

**PAD DESCRIPTION**

Pin No.	Symbol	Pin Name	Description
6	D <sub>IN</sub>	Data input	Input serial data at rising edge of shift clock, starting from the low order bit.
5	D <sub>OUT</sub>	Data output	Output serial data at the falling edge of the shift clock, starting from low order bit. This is N-ch open-drain output pin.
9	STB	Strobe	Initializes serial interface at the rising or falling edge of the SC16312. It then waits for reception of a command. Data input after STB has fallen is processed as a command. While command data is processed, current processing is stopped, and the serial interface is initialized. While STB is high, CLK is ignored.
8	CLK	Clock input	Reads serial data at the rising edge, and outputs data at the falling edge.
44	OSC	Oscillator pin	Connect resistor to this pin to determine the oscillation frequency to this pin.
15 ~ 20	Seg <sub>1</sub> /KS <sub>1</sub> to Seg <sub>6</sub> /KS <sub>6</sub>	High-voltage output	Segment output pins (Dual function as key source).
21 ~ 25	Seg <sub>7</sub> to Seg <sub>11</sub>	High-voltage output (segment)	Segment output pins.
37 ~ 32	Grid <sub>1</sub> to Grid <sub>6</sub>	High-voltage output (grid)	Grid output pins.

(to be continued)

(continued)

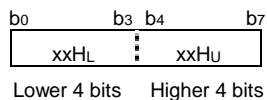
Pin No.	Symbol	Pin Name	Description
26,28 ~ 31	Seg <sub>12</sub> /Grid <sub>11</sub> to Seg <sub>16</sub> /Grid <sub>7</sub>	High-voltage output (segment/grid)	These pins are selectable for segment or grid driving.
42 ~ 39	LED <sub>1</sub> to LED <sub>4</sub>	LED output	CMOS output. +20mA max.
10 ~ 13	KEY <sub>1</sub> to KEY <sub>4</sub>	Key data input	Data input to these pins is latched at the end of the display cycle.
1 ~ 4	SW <sub>1</sub> to SW <sub>4</sub>	Switch input	These pins constitute a 4-bit general-purpose input port.
14,38	V <sub>DD</sub>	Logic power	5V±10%
7,43	V <sub>SS</sub>	Logic ground	Connect this pin to system GND.
27	V <sub>EE</sub>	Pull-down level	V <sub>DD</sub> -35V max.

## FUNCTIONAL DESCRIPTION

### 1. DISPLAY RAM ADDRESS AND DISPLAY MODE

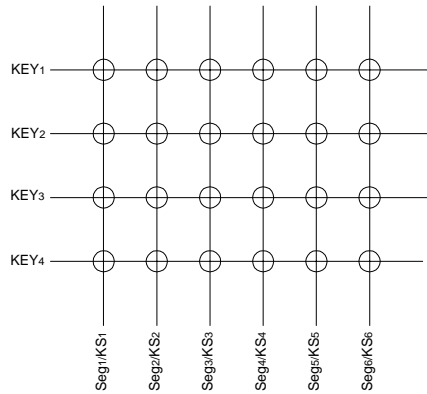
The display RAM stores the data transmitted from an external device to the SC16312 through the serial interface, and is assigned addresses as follows, in 8 bits unit:

Seg <sub>1</sub>	Seg <sub>4</sub>	Seg <sub>8</sub>	Seg <sub>12</sub>	Seg <sub>16</sub>	
00HL	00Hu	01HL	01Hu		DIG <sub>1</sub>
02HL	02Hu	03HL	03Hu		DIG <sub>2</sub>
04HL	04Hu	05HL	05Hu		DIG <sub>3</sub>
06HL	06Hu	07HL	07Hu		DIG <sub>4</sub>
08HL	08Hu	09HL	09Hu		DIG <sub>5</sub>
0AHL	0AHu	0BHL	0BH <u>u</u>		DIG <sub>6</sub>
0CHL	0CHu	0DHL	0DHu		DIG <sub>7</sub>
0EHL	0EHu	0FHL	0FHu		DIG <sub>8</sub>
10HL	10Hu	11HL	11Hu		DIG <sub>9</sub>
12HL	12Hu	13HL	13Hu		DIG <sub>10</sub>
14HL	14Hu	15HL	15Hu		DIG <sub>11</sub>

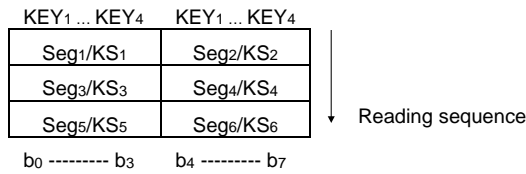


**2. KEY MATRIX AND KEY-INPUT DATA STORAGE RAM**

The key matrix is made up of a 6 x 4 matrix, as shown below.

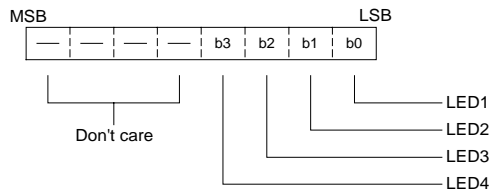


The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.



**3. LED PORT**

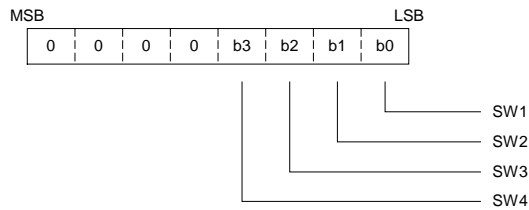
Data is written to the LED port with command, starting from the least port's least significant bit. When a bit of this port is 0, the corresponding LED lights; When the bit is 1, the LED turns off. The data of bits 5 through 8 are ignored.



On power application, all LEDs are unlit.

**4. SW DATA**

SW data is read with the read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.



**5. COMMANDS**

Commands set the display mode and status of the FIP driver.

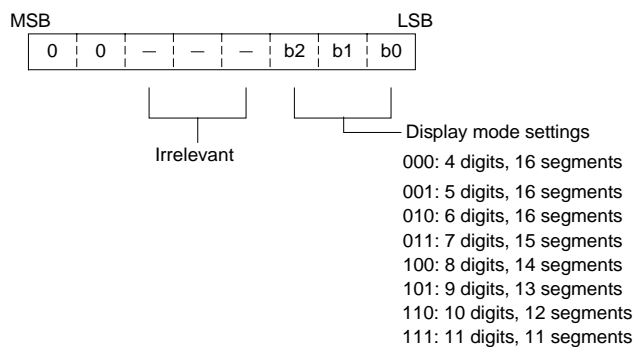
The first 1 byte input to the SC16312 through the DIN pin after the STB pin has fallen is regarded as a command.

If STB is set high while commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are invalid(however, the commands/data previously transmitted remain valid).

(1) Display mode setting commands

These commands initialize the SC16312 and select the number of segments and the number of grid(1/4 to 1/11 duty, 11 segments to 16 segments).

When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command "ON" must be executed. If the same mode is selected, however, nothing happens.

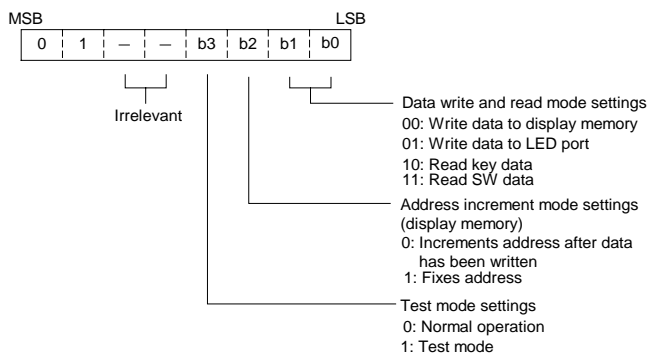


On power application, the 11-digit, 11-segment mode is selected.



(2) Data setting commands

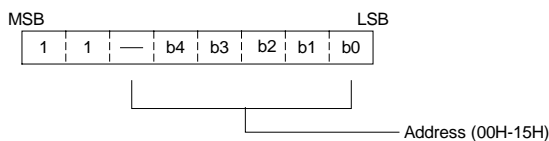
These commands set data write and data read modes.



On power application, the normal operation and address increment modes are set.

(3) Address setting commands

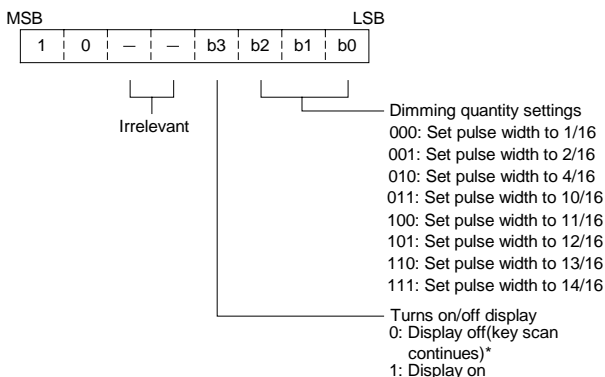
These commands set an address of the display memory.



If address 16H or higher is set, data is ignored, until a valid address is set.

On the power application, the address is set to 00H.

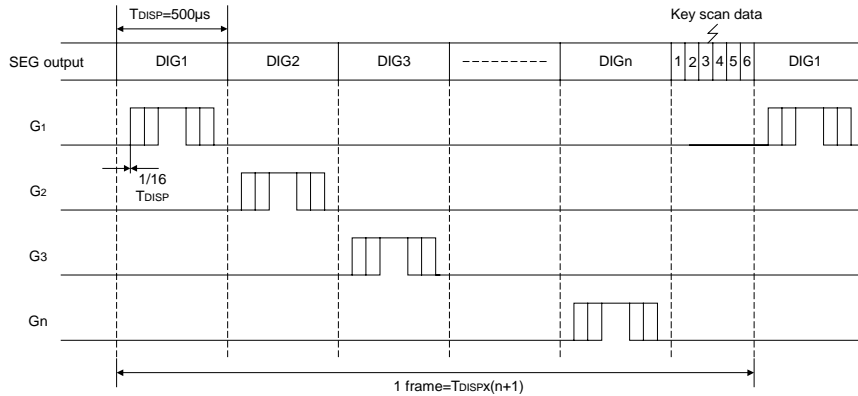
(4) Display control commands



On power application, the 1/6 pulse width is set and the display is turned off.

\*Note: On power application, key scanning is stopped.

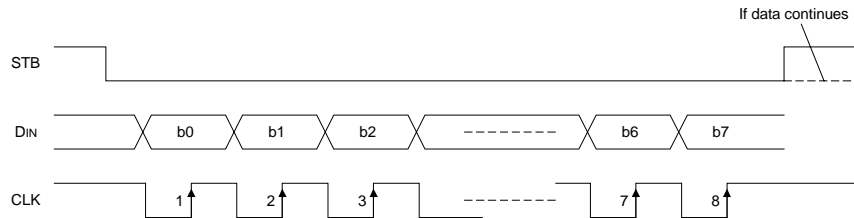
**KEY SCANNING AND DISPLAY TIMING**



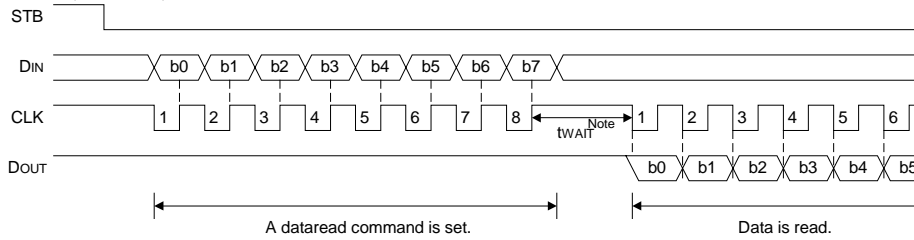
One cycle of key scanning consists of one frame, and data in a 6x4 matrix is stored in RAM.

**SERIAL COMMUNICATION FORMAT**

Reception(command/data write)



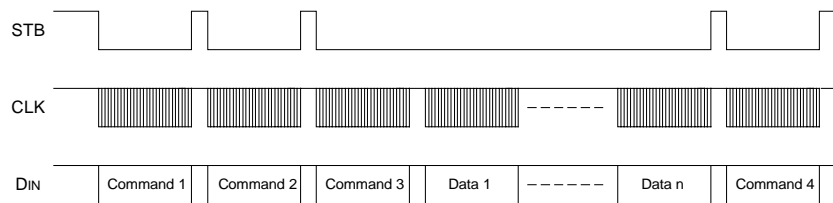
Transmission(data read)



Because the DOUT pin is an N-ch, open-drain output pin, be sure to connect an external pull-up resistor to this pin(1kΩ to 10kΩ)..

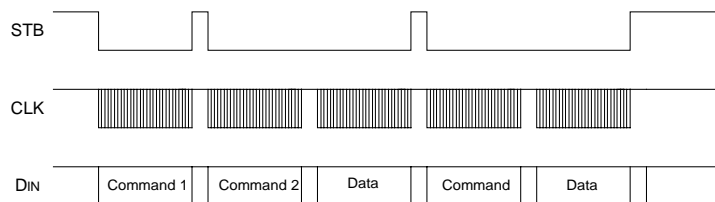
**APPLICATION**

Updating display memory by incrementing address



- Command1: sets display mode
- Command2: sets data
- Command3: sets address
- Data 1 to n: transfers display data(22 bytes max.)
- Command4: controls display

Updating specific address



- Command1: set data
- Command2: sets address
- Data: display data

**PACKAGE OUTLINE**

