



# AD6312

## 1/4- to 1/11 Duty VFD Controller/Driver

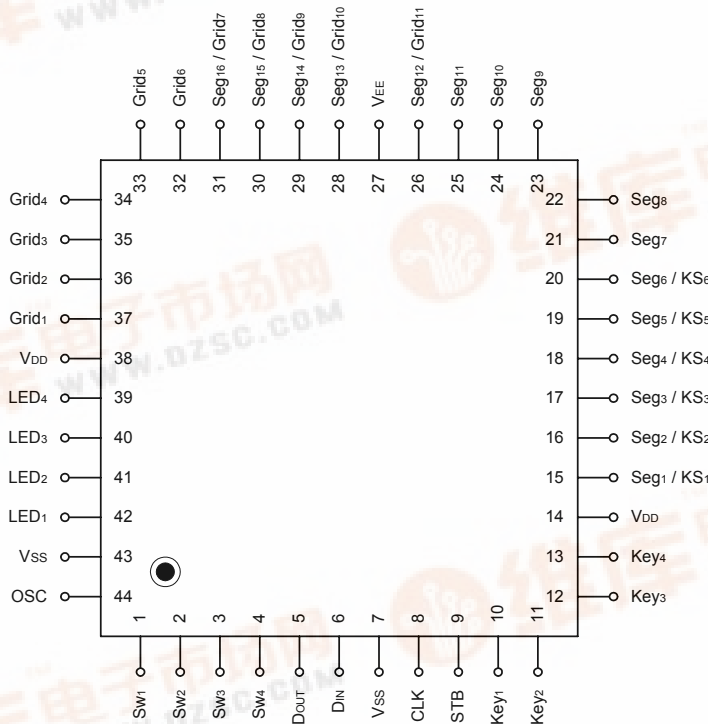
### ■ Features

- 4-pin serial interface
- Key scanning (6x 4 matrices)
- Programming display modes (11-segments & 11-digits to 16-segments & 6-digits)
- Programming dimming step
- High-voltage output ( $V_{DD}$ -35V max).
- 4 channels LED ports.
- 4-pin General-purpose input port
- Built-in oscillator
- No external resistor necessary for driver outputs

### ■ General Description

The AD6312 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/4- to 1/11 duty factor (include key scan). It consists of 5 segment output lines, 6 segment/key scan 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 AD6312 through a four-line serial interface.

### ■ Pin Assignments



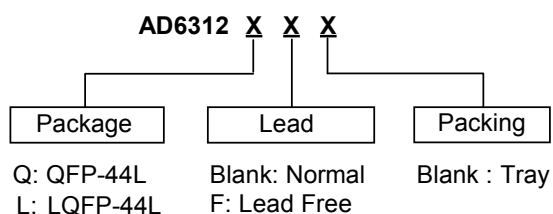
Use all power pins.



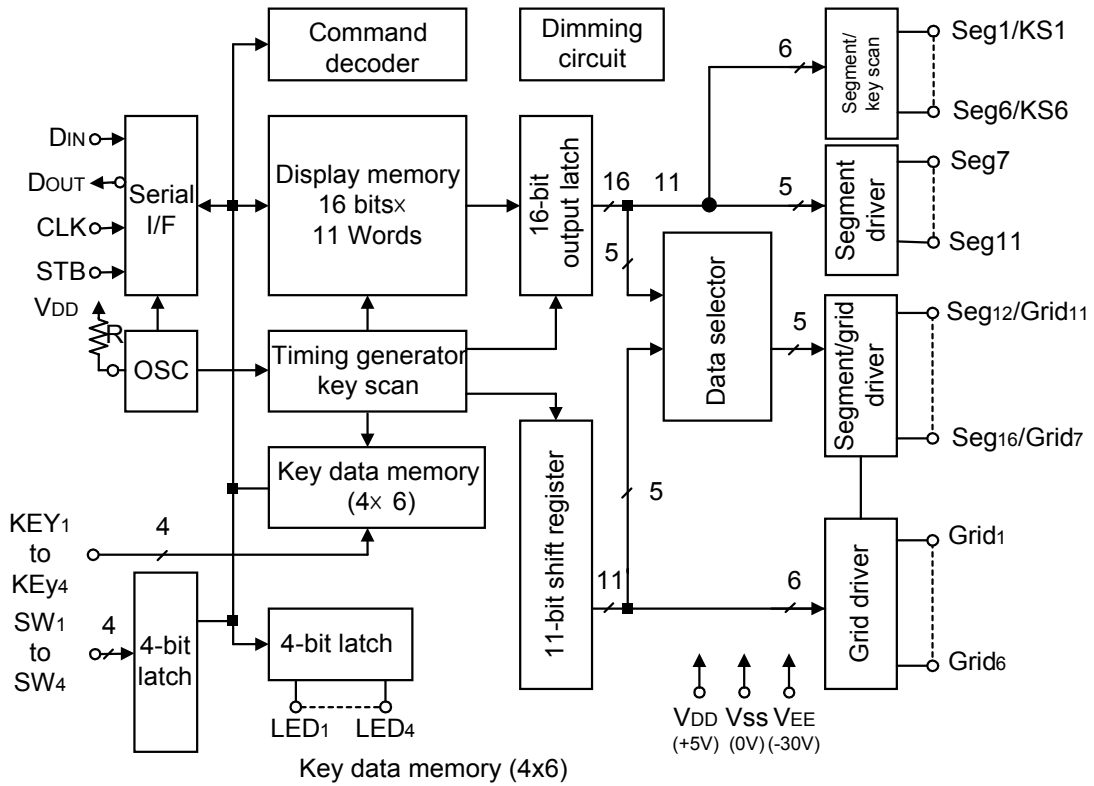
### ■ Pin Descriptions

Symbol	Name	No.	Description
D <sub>IN</sub>	Data input	6	Input serial data at rising edge of shift clock, starting from the low order bit.
D <sub>OUT</sub>	Data output	5	Output serial data at the falling edge of the shift clock, starting from low order bit. This is N-ch open-drain output pin.
STB	Strobe	9	Initializes serial interface at the rising or falling edge of the AD6312. It then waits for reception of a command. Data input after STB falling 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.
CLK	Clock input	8	Reads serial data at the rising edge, and outputs data at the falling edge.
OSC	Oscillator pin	44	Connect resistor in between this pin and V <sub>SS</sub> to set up the oscillation frequency.
Seg <sub>7</sub> to Seg <sub>11</sub>	High-voltage output (Segment)	21 to 25	Segment output pins
Seg <sub>7</sub> /KS <sub>1</sub> to Seg <sub>6</sub> /KS <sub>6</sub>	High-voltage output	15 to 20	Multi-function pins, Segment output pins (Dual function as key scan source)
Grid <sub>1</sub> to Grid <sub>6</sub>	High-voltage output (Grid)	32 to 37	Grid output pins
Seg <sub>12</sub> /Grid <sub>11</sub> to Seg <sub>16</sub> /Grid <sub>7</sub>	High-voltage output (Segment/grid)	26, 28 to 31	These pins are selectable for segment or grid driving.
LED <sub>1</sub> to LED <sub>4</sub>	LED output	39 to 42	CMOS output
KEY <sub>1</sub> to KEY <sub>4</sub>	Key data input	10 to 13	Data input to these pins is latched at the end of the display cycle.
V <sub>DD</sub>	Logic power	14, 38	Logic power supply
V <sub>SS</sub>	Logic ground	7, 43	Connect this pin to system GND.
V <sub>EE</sub>	Pull-down level	27	Driver power supply
SW <sub>1</sub> to SW <sub>4</sub>	Switch input	1 to 4	These pins constitute a 4-bit general-purpose input port.

### ■ Ordering Information



### ■ Block Diagram





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### ■ Absolute Maximum Ratings ( $T_A=25^{\circ}\text{C}, V_{SS}=0\text{V}$ )

Parameter	Symbol	Rating	Unit
Logic Supply Voltage	$V_{DD}$	-0.5 to +7.0	V
Driver Supply Voltage	$V_{EE}$	$V_{DD}+0.5$ to $V_{DD}-40$	V
Logic Input Voltage	$V_{I1}$	-0.5 to $V_{DD}+0.5$	V
VFD Driver Output Voltage	$V_{O2}$	$V_{EE}-0.5$ to $V_{DD}+0.5$	V
LED Driver Output Current	$I_{O1}$	+15	mA
VFD Driver Output Current	$I_{O2}$	-40 (grid) -15 (segment)	mA
Operating Ambient Temperature	$T_{OPT}$	-25 to +85	$^{\circ}\text{C}$
Storage Temperature	$T_{STG}$	-50 to +125	$^{\circ}\text{C}$

### ■ Operating Conditions ( $T_A=0$ to $+70^{\circ}\text{C}, V_{SS}=0\text{V}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Logic Supply Voltage	$V_{DD}$		4.5	5	5.5	V
High-Level Input Voltage	$V_{IH}$		$0.7 \cdot V_{DD}$		$V_{DD}$	V
Low-Level Input Voltage	$V_{IL}$		0		$0.3 \cdot V_{DD}$	V
Driver Supply Voltage	$V_{EE}$		0		$V_{DD}-35$	V

### ■ DC Characteristics ( $T_A=0$ to $70^{\circ}\text{C}, V_{DD}=4.5$ to $5.5\text{V}, V_{SS}=0\text{V}, V_{EE}=V_{DD}-35\text{V}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
High-Level Output Voltage	$V_{OH1}$	LED <sub>1</sub> -LED <sub>4</sub> , $I_{OH1}=-1\text{mA}$	$0.9V_{DD}$			V
Low-Level Output Voltage	$V_{OL1}$	LED <sub>1</sub> -LED <sub>4</sub> , $I_{OL1}=12\text{mA}$			1	V
Low-Level Output Voltage	$V_{OL2}$	$D_{OUT}, I_{OL2}=2\text{mA}$			0.4	V
High-Level Output Current	$I_{OH21}$	$V_O=V_{DD}-2\text{V}$ , Seg <sub>1</sub> to Seg <sub>11</sub>	-3			mA
High-Level Output Current	$I_{OH22}$	$V_O=V_{DD}-2\text{V}$ , 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	$I_{OLEAK}$	$V_O=V_{DD}-35\text{V}$ , driver off			-10	$\mu\text{A}$
Output Pull-Down Resistor	$R_L$	Driver output	50	100	150	$\text{k}\Omega$
High-Level Input Voltage	$V_{IH}$		$0.7V_{DD}$			V
Low-Level Input Voltage	$V_{IL}$				$0.3V_{DD}$	V

### ■ AC Characteristics ( $T_a=0$ to $+70^{\circ}\text{C}, V_{DD}=4.5$ to $5.5\text{V}, V_{EE}=-30\text{V}$ )

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Oscillation Frequency	$f_{OSC}$	$R=51\text{ k}\Omega$	350	500	650	$\text{kHz}$
Maximum Clock Frequency	$f_{max.}$	Duty=50%			1	$\text{MHz}$
Clock Pulse Width	$PW_{CLK}$		500			ns
Strobe Pulse Width	$PW_{STB}$		1			$\mu\text{s}$
Data Setup Time	$t_{SETUP}$		100			ns
Data Hold Time	$t_{HOLD}$		100			ns
Clock-Strobe Time	$t_{CLK-STB}$	CLK $\uparrow$ $\rightarrow$ STB $\uparrow$	1			$\mu\text{s}$
Wait Time	$t_{WAIT}$	CLK $\uparrow$ $\rightarrow$ CLK $\downarrow$ (Note)	1			$\mu\text{s}$

Note : Refer to page 8.

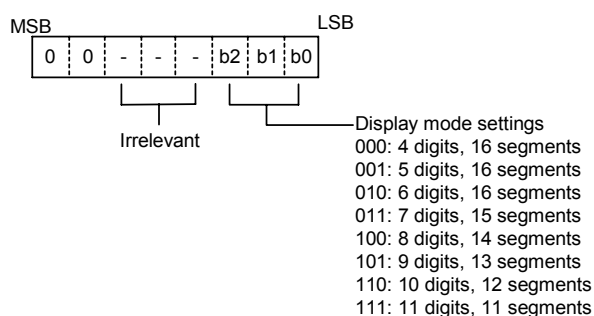
### ■ Function Descriptions

#### 1.0 Commands

Commands set the display mode and status of the VFD driver. The first 1 byte input to the AD6312 through the  $D_{IN}$  pin after the STB pin has fallen is regarded as a command. If STB is set high while a commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are invalid (however, the commands/data previously transmitted remain valid).

#### 1.1 Display mode setting commands

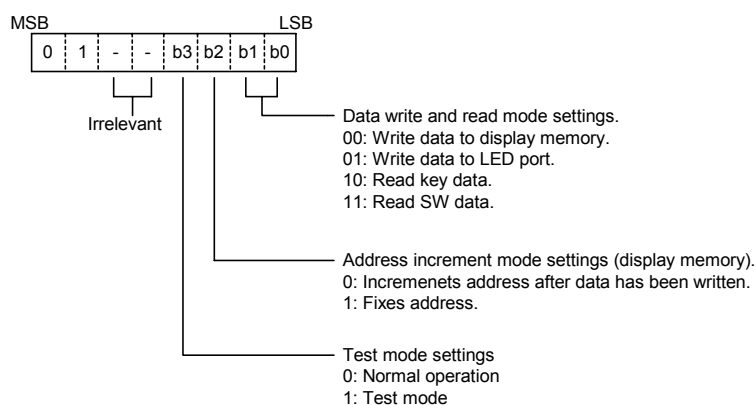
These commands initialize the AD6312 and select the number of segments and the number of grids (4 grids & 16 segments to 11 grids & 11 segments to). When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command "ON" must be executed. If the same mode is selected, however, nothing happens.



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

#### 1.2 Data setting commands

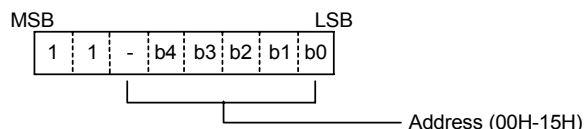
These commands set data write and data read modes. On power application, the normal operation and address increment modes are set.



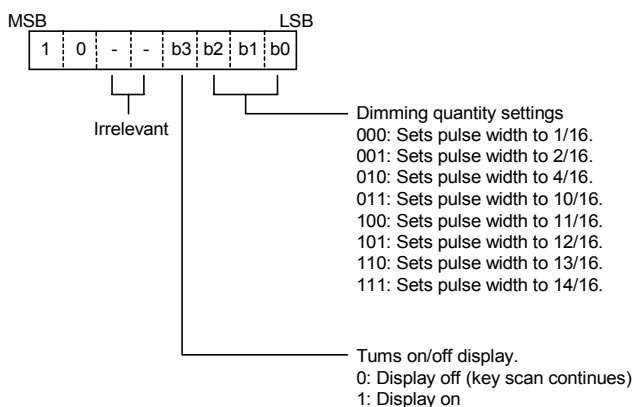
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### 1.3 Address setting commands

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 power application, the address is set to 00H.



### 1.4 Display control commands

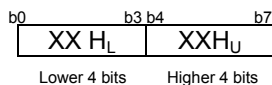


On power application, the 1/16-pulse width is set, the display is turned off and key scanning is stopped.

### 2.0 Display RAM Address and Display Mode

The display RAM stores the data transmitted from an external device to the AD6312 through the serial interface, and is assigned addresses as follows, in 8 bits unit:

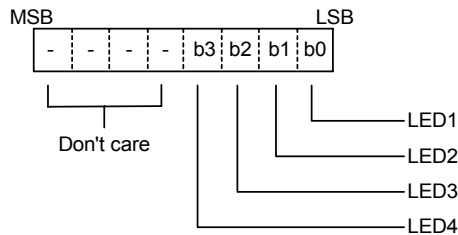
Seg <sub>1</sub>	Seg <sub>4</sub>	Seg <sub>8</sub>	Seg <sub>12</sub>	Seg <sub>16</sub>	
00 H <sub>L</sub>	00 H <sub>U</sub>	01 H <sub>L</sub>	01 H <sub>U</sub>	DIG <sub>1</sub>	
02 H <sub>L</sub>	02 H <sub>U</sub>	03 H <sub>L</sub>	03 H <sub>U</sub>	DIG <sub>2</sub>	
04 H <sub>L</sub>	04 H <sub>U</sub>	05 H <sub>L</sub>	05 H <sub>U</sub>	DIG <sub>3</sub>	
06 H <sub>L</sub>	06 H <sub>U</sub>	07 H <sub>L</sub>	07 H <sub>U</sub>	DIG <sub>4</sub>	
08 H <sub>L</sub>	08 H <sub>U</sub>	09 H <sub>L</sub>	09 H <sub>U</sub>	DIG <sub>5</sub>	
0 A H <sub>L</sub>	0 A H <sub>U</sub>	0 B H <sub>L</sub>	0 B H <sub>U</sub>	DIG <sub>6</sub>	
0 C H <sub>L</sub>	0 C H <sub>U</sub>	0 D H <sub>L</sub>	0 D H <sub>U</sub>	DIG <sub>7</sub>	
0 E H <sub>L</sub>	0 E H <sub>U</sub>	0 F H <sub>L</sub>	0 F H <sub>U</sub>	DIG <sub>8</sub>	
10 H <sub>L</sub>	10 H <sub>U</sub>	11 H <sub>L</sub>	11 H <sub>U</sub>	DIG <sub>9</sub>	
12 H <sub>L</sub>	12 H <sub>U</sub>	13 H <sub>L</sub>	13 H <sub>U</sub>	DIG <sub>10</sub>	
14 H <sub>L</sub>	14 H <sub>U</sub>	15 H <sub>L</sub>	15 H <sub>U</sub>	DIG <sub>11</sub>	



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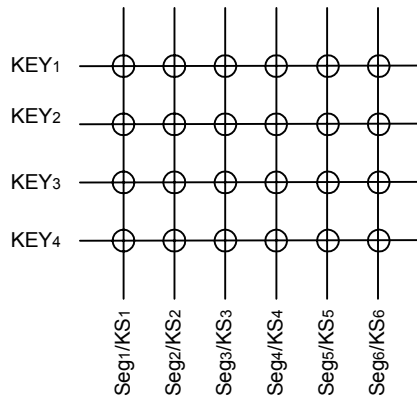
### 3.0 LED Port

Data is written to the LED port with the write 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.

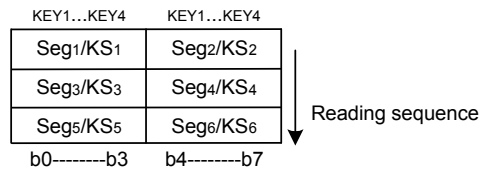


### 4.0 Key Matrix and Key-Input data Storage RAM

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



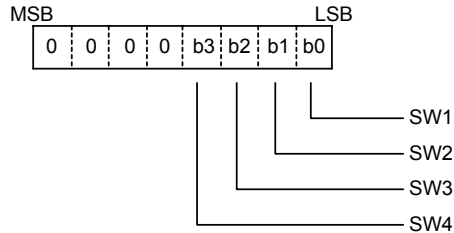
The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.



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### 5.0 SW Data

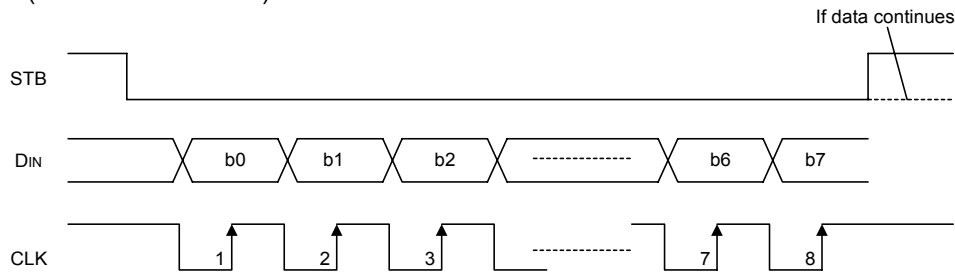
SW data is read with the read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.



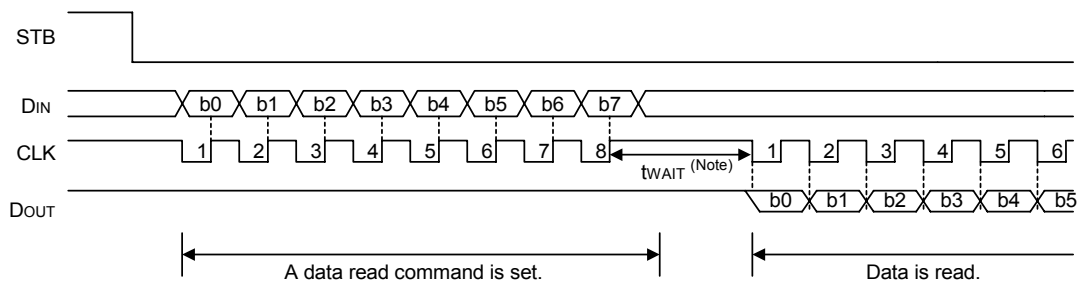
### ■ Timing Diagram

#### (1) Serial Communication Format

Reception (command/write data)



Transmission (read data)



Because the  $D_{OUT}$  pin is an N-ch, open-drain output pin, be sure to connect an external pull-up resistor to this pin ( $1k\Omega$  to  $10k\Omega$ ).

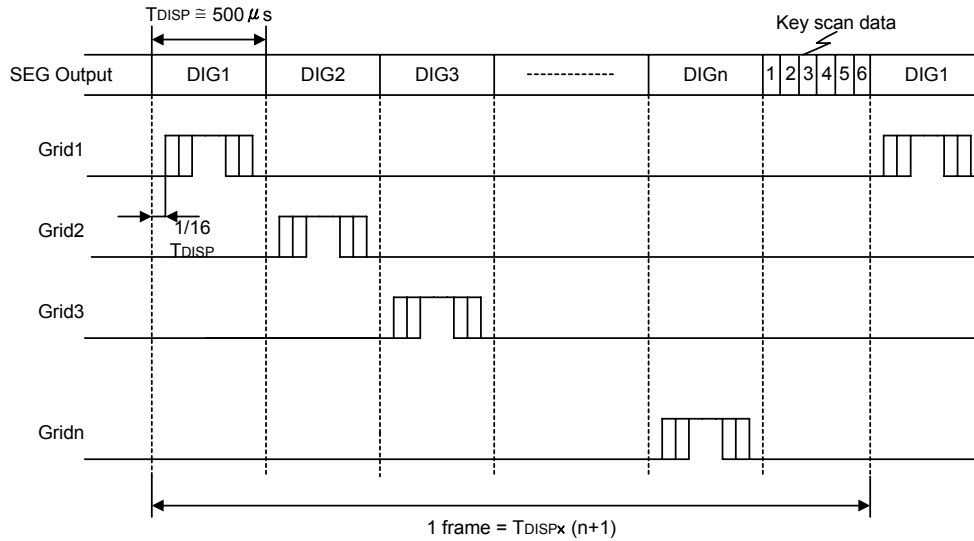
Note : When data is read, a wait time  $t_{WAIT}$  of  $1 \mu s$  is necessary since the rising of the eighth clock that has set the command, until the falling of the first clock that has read the data.



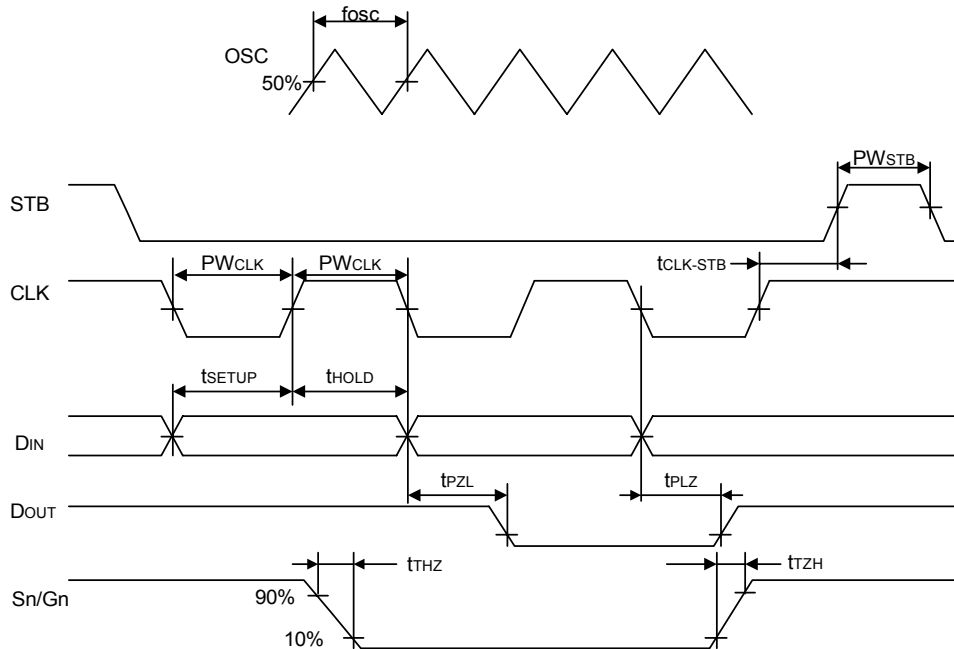
## 1/4- to 1/11 Duty VFD Controller/Driver

### (2) Key Scanning and Display Timing

One cycle of key scanning consists of one frame, and data in a 6x 4 matrix is stored in RAM.



### Switching characteristic waveforms



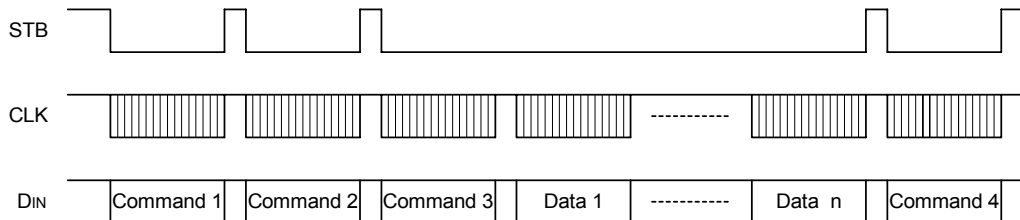


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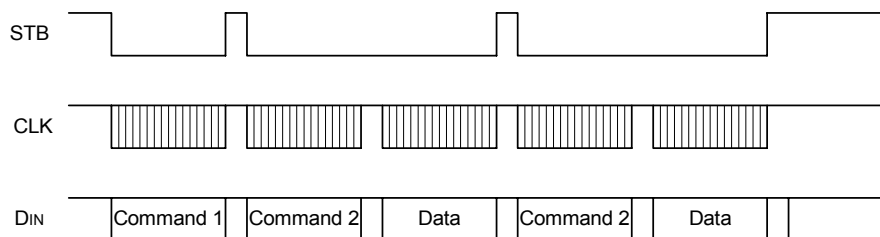
### Applications

Updating display memory by incrementing address



- Command 1: sets display mode
- Command 2: sets data(write data to display memory)
- Command 3: sets address
- Data 1 to n: transfers display data (22bytes max.)
- Command 4: controls display

Updating specific display memory

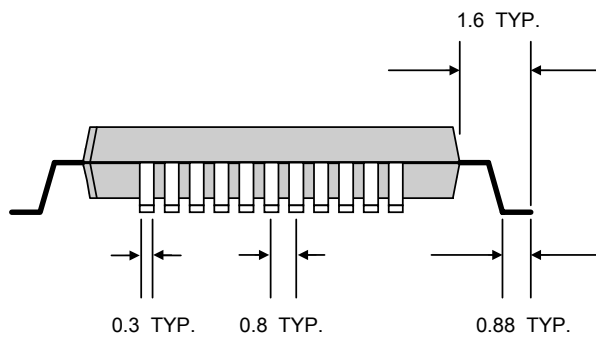
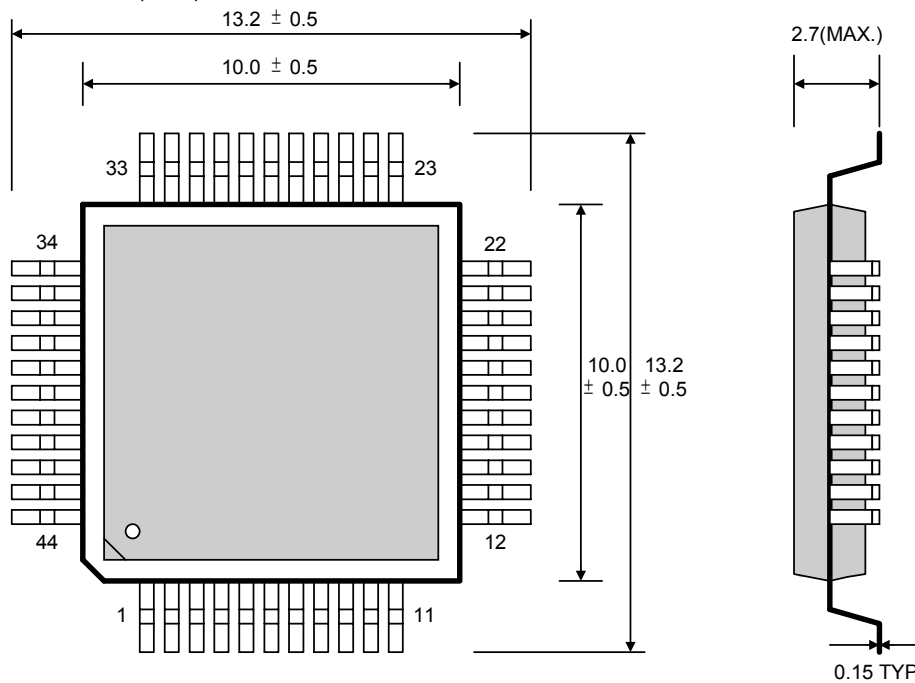


- Command 1: sets data
- Command 2: sets address
- Data: display data

### ■ Package Information

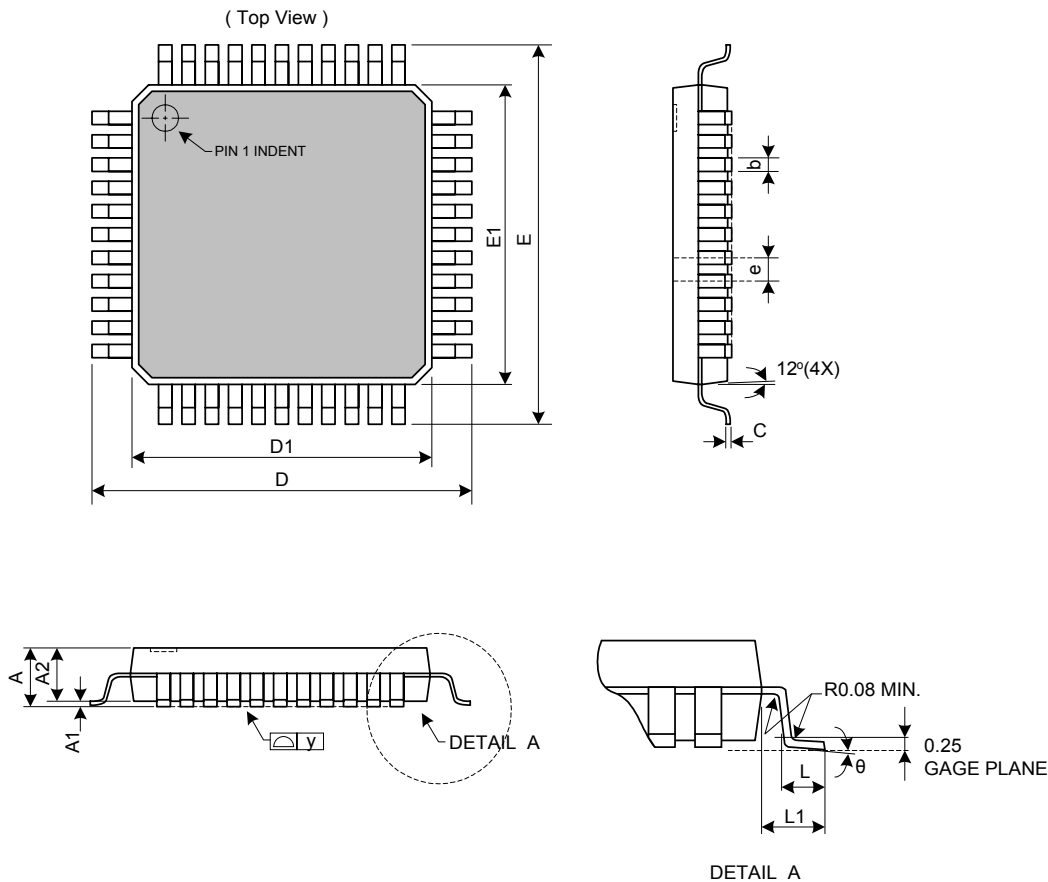
#### (1) Package Type: QFP-44L

Dimension in millimeter (mm.)



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### (2) Package Type: LQFP-44L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.60	-	-	0.063
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
b	0.30	0.37	0.45	0.012	0.015	0.018
C	0.09	-	0.20	0.004	-	0.008
E	11.50	12.00	12.50	0.453	0.472	0.492
E1	9.50	10.00	10.50	0.374	0.394	0.413
D	11.80	12.00	12.20	0.465	0.472	0.480
D1	9.90	10.00	10.10	0.390	0.394	0.398
e	-	0.80	-	-	0.031	-
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	-	1.00	-	-	0.039	-
θ	0°	3.5°	7°	0°	3.5°	7°
y	0.00	-	0.08	0.000	-	0.003



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## ■ Marking Information

