

# AD16312

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

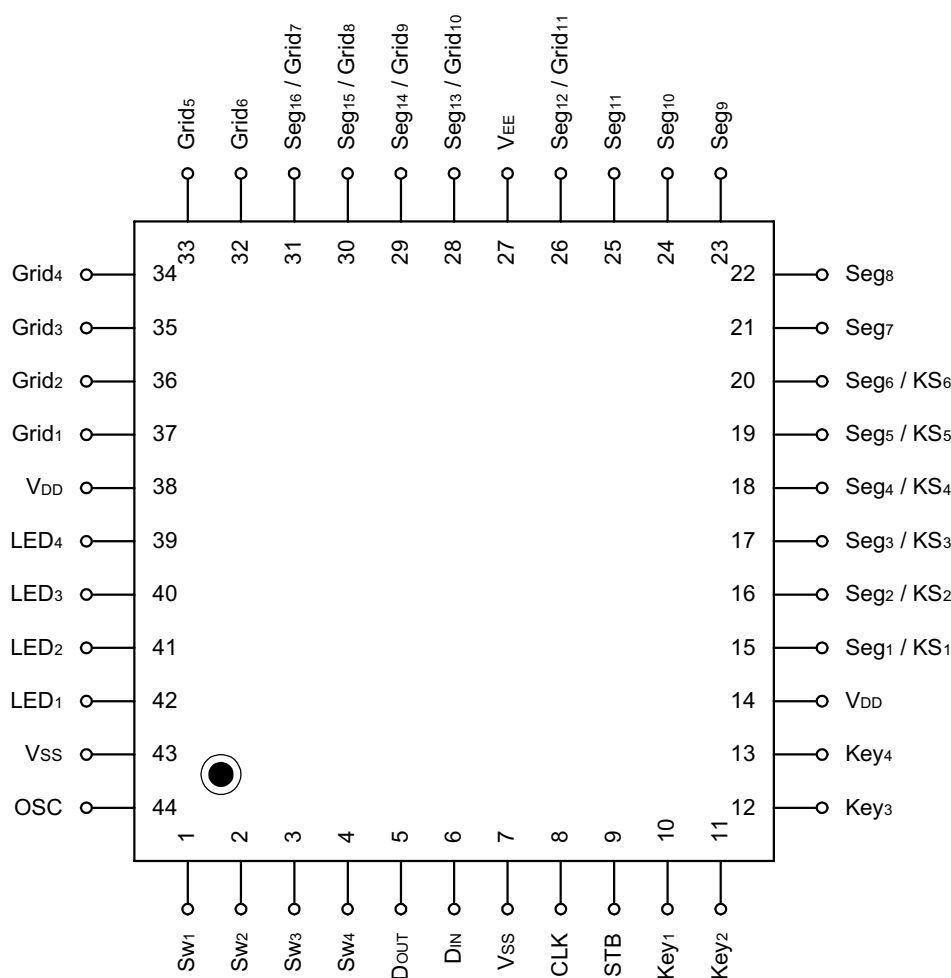
### ■ Features

- 4-pin serial interface
- Key scanning (6x 4 matrices)
- Programming display modes (11-digit & 11-segment to 16-digit & 4-segment)
- Programming Dimming step
- High-voltage output ( $V_{DD}$ -35V max).
- LED ports (4 channels., 20 mA max).
- 4-pin General-purpose input port
- Built in oscillator
- No external resistor necessary for driver outputs

### ■ General Description

The AD16312 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/5- to 1/12 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 AD16312 through a four-line serial interface.

### ■ Pin Assignment (Top View)



Use all power pins.

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# AD16312



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

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### ■ Pin Descriptions

**Data input (D<sub>IN</sub>) (Pin #6)**

Input serial data at rising edge of shift clock, starting from the LSB.

**Data output (D<sub>OUT</sub>) Pin #5**

Output serial data at falling edge of shift clock, starting from the LSB. This is an N-ch open-drain output pin.

**Strobe (STB) (Pin #9)**

Initializes serial interface at the rising or falling edge of the AD16312. 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.

**Clock input (CLK) (Pin #8)**

Reads serial data at the rising edge, and outputs data at the falling edge.

**Oscillator pin (OSC) (Pin #44)**

Connect resistor to this pin to determine the oscillation frequency to this pin.

**High-voltage output (Seg<sub>1</sub>/KS<sub>1</sub> to Seg<sub>6</sub>/KS<sub>6</sub>) (Pin #15 to 20)**

Multi-function pins. Segment output pins (Dual function as key scan source)

**High-voltage output(Segment) (Seg<sub>7</sub> to Seg<sub>11</sub>) (Pin #21 to 25)**

Segment output pins

**High-voltage output(grid) (Grid<sub>1</sub> to Grid<sub>6</sub>) (Pin #37 to 32)**

Grid output pins

**High-voltage output(segment/grid) (Seg<sub>12</sub>/Grid<sub>11</sub> to Seg<sub>16</sub>/Grid<sub>7</sub>) (Pin #26,28 to 31)**

These pins are selectable for segment or grid driving.

**LED output (LED<sub>1</sub> to LED<sub>4</sub>) (Pin #42 to 39)**

CMOS output.

**Key data input (Key<sub>1</sub> to Key<sub>4</sub>) (Pin #10 to 13)**

Data input to these pins is latched at the end of the display cycle.

**Switch input (SW<sub>1</sub> to SW<sub>4</sub>) (Pin #1 to 4)**

These pins constitute a 4-bit general-purpose input port.

**Logic power (V<sub>DD</sub>) (Pin #14,38)**

5V±10%

**Logic ground (V<sub>SS</sub>) (Pin #7,43)**

Connect this pin to system GND.

**Pull-down level (V<sub>EE</sub>) (Pin#27)**

# AD16312



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

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

| PARAMETER                     | SYMBOL    | RATINGS                      | 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     | $I_{O1}$  | +25                          | mA                 |
| VFD Driver Output Current     | $I_{O2}$  | -40(grid)<br>-15(segment)    | mA                 |
| Operating Ambient Temperature | $T_{opt}$ | 0 to +85                     | $^{\circ}\text{C}$ |
| Storage Temperature           | $T_{stg}$ | -20 to +125                  | $^{\circ}\text{C}$ |

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

| PARAMETER                | SYMBOL   | MIN.               | TYP. | MAX.               | UNIT | TEST CONDITIONS |
|--------------------------|----------|--------------------|------|--------------------|------|-----------------|
| 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      | MIN.        | TYP. | MAX.        | UNIT             | TEST CONDITIONS   |
|---------------------------|-------------|-------------|------|-------------|------------------|---|
| High-Level Output Voltage | $V_{OH1}$   | $0.9V_{DD}$ |      |             | V                | LED <sub>1</sub> -LED <sub>4</sub> , $I_{OH1}=-1\text{mA}$  |
| Low-Level Output Voltage  | $V_{OL1}$   |             |      | 1           | V                | LED <sub>1</sub> -LED <sub>4</sub> , $I_{OL1}=20\text{mA}$  |
| Low-Level Output Voltage  | $V_{OL2}$   |             |      | 0.4         | V                | $D_{OUT}, I_{OL2}=4\text{mA}$   |
| High-Level Output Current | $I_{OH21}$  | -3          |      |             | mA               | $V_O=V_{DD}-2\text{V}, \text{Seg}_1$ to $\text{Seg}_{11}$   |
| High-Level Output Current | $I_{OH22}$  | -15         |      |             | mA               | $V_O=V_{DD}-2\text{V}, \text{Grid}_1$ to $\text{Grid}_6$<br>$\text{Seg}_{12}/\text{Grid}_{11}$ to $\text{Seg}_{16}/\text{Grid}_7$ |
| Driver Leakage Current    | $I_{OLEAK}$ |             |      | -10         | $\mu\text{A}$    | $V_O=V_{DD}-35\text{V}$ , driver off  |
| Output Pull-Down Resistor | $R_L$       | 50          | 100  | 150         | $\text{k}\Omega$ | Driver output   |
| 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        | MIN. | TYP. | MAX. | UNIT          | TEST CONDITIONS                                    |
|-------------------------|---------------|------|------|------|---------------|--|
| Oscillation Frequency   | $f_{OSC}$     | 350  | 500  | 650  | $\text{KHz}$  | $R=51\text{ k}\Omega$                              |
| Maximum Clock Frequency | $f_{max.}$    |      |      | 1    | $\text{MHz}$  | Duty=50%   |
| 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       | $t_{CLK-STB}$ | 1    |      |      | $\mu\text{s}$ | CLK $\uparrow$ $\rightarrow$ STB $\uparrow$        |
| Wait Time               | $t_{WAIT}$    | 1    |      |      | $\mu\text{s}$ | CLK $\uparrow$ $\rightarrow$ CLK $\downarrow$ *(2) |

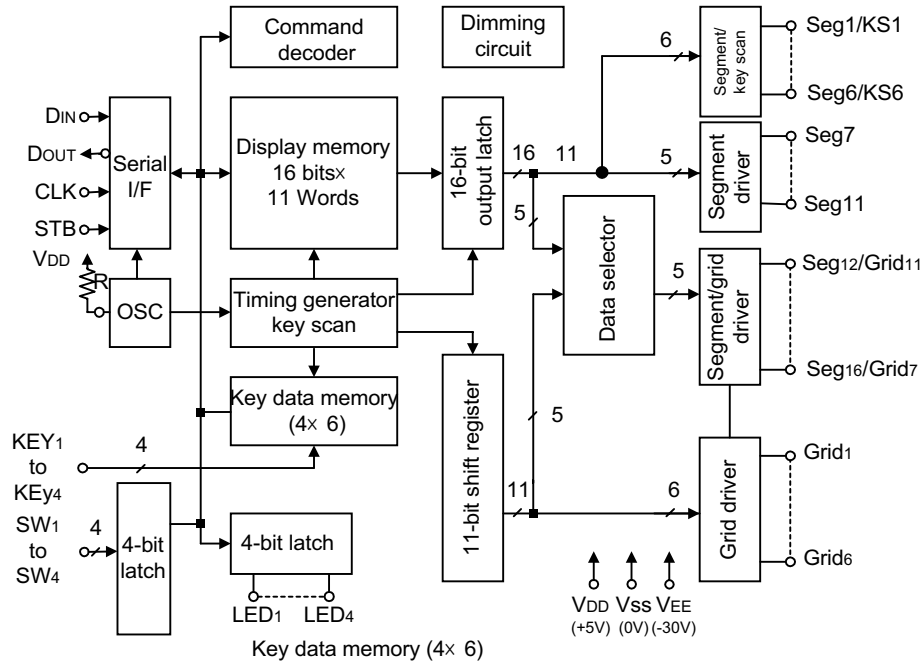
\*(2):Refer to page 8.

# AD16312

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



### ■ Block Diagram



### ■ Function Description

#### 1.0 Commands

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

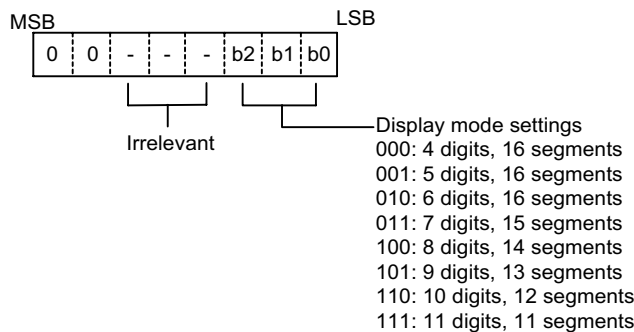
The first 1 byte input to the AD16312 through the  $D_{IN}$  pin after the STB pin has fallen is regarded as a command.

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 AD16312 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.



# AD16312

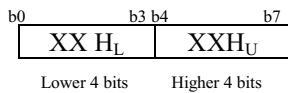


## 1/4- To 1/11-Duty VFD Controller/Driver

### 2.0 Display RAM Address and Display Mode

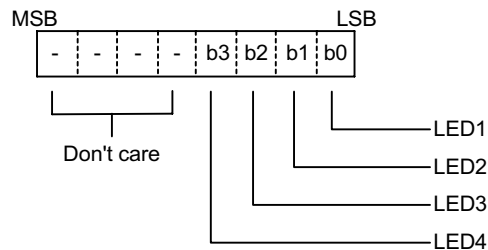
The display RAM stores the data transmitted from an external device to the AD16312 through the serial interface, and is assigned addresses as follows, in 8 bits unit:

| 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 AH <sub>L</sub> | 0 AH <sub>U</sub> | 0 BH <sub>L</sub> | 0 BH <sub>U</sub> |                   | DIG <sub>6</sub>  |
| 0 CH <sub>L</sub> | 0 CH <sub>U</sub> | 0 DH <sub>L</sub> | 0 DH <sub>U</sub> |                   | DIG <sub>7</sub>  |
| 0 EH <sub>L</sub> | 0 EH <sub>U</sub> | 0 FH <sub>L</sub> | 0 FH <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> |



### 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.

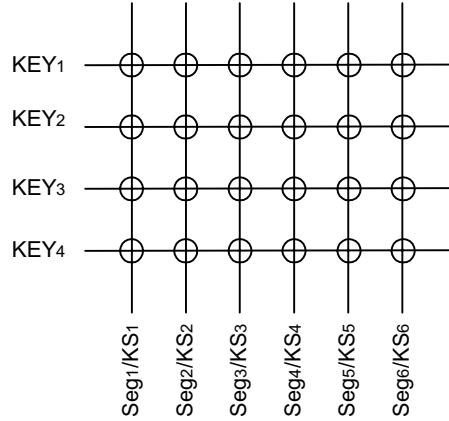


On power application, all LEDs are unlit.

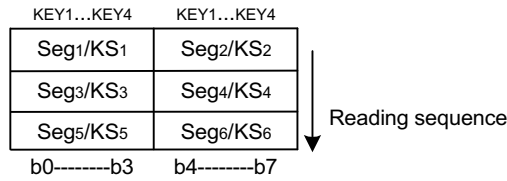
## 1/4- To 1/11-Duty VFD Controller/Driver

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

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

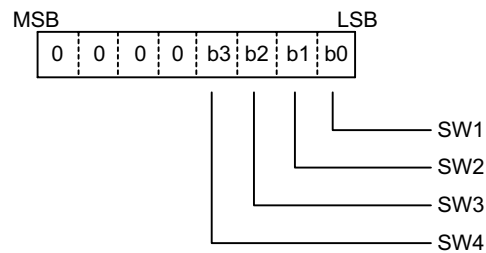


The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.



### 5.0 SW Data

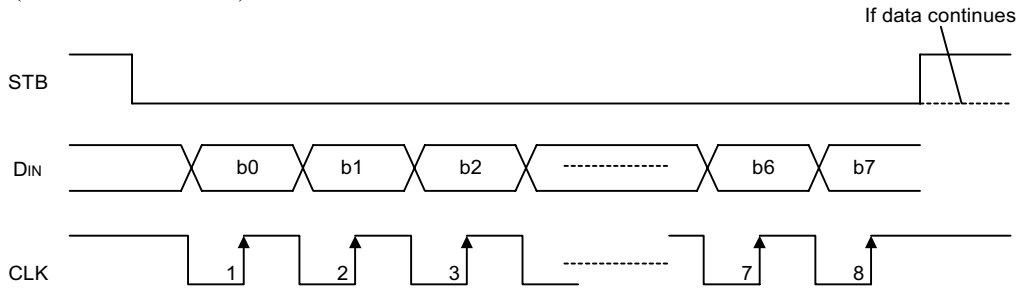
SW data is read with the read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.



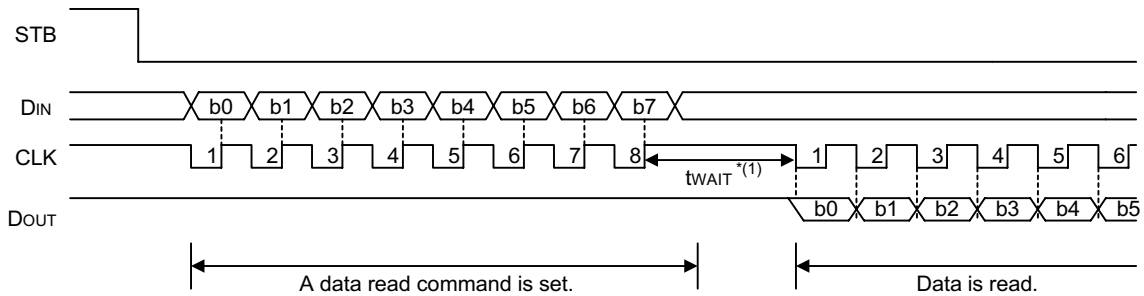
### ■ Timing Diagram

#### (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  $10k\Omega$ ).

\*(1): 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.

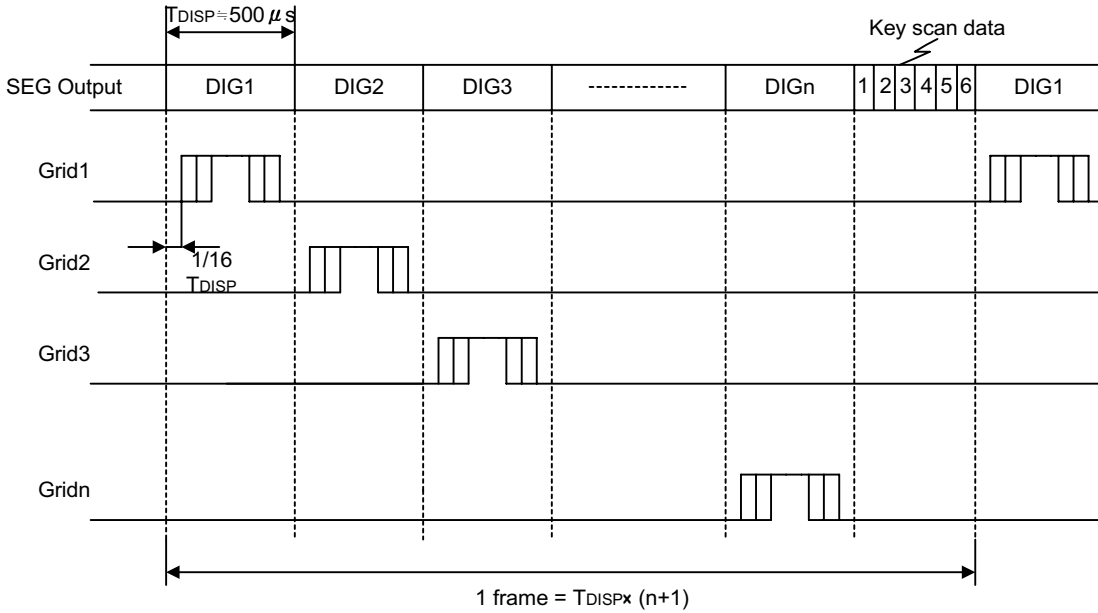


# AD16312



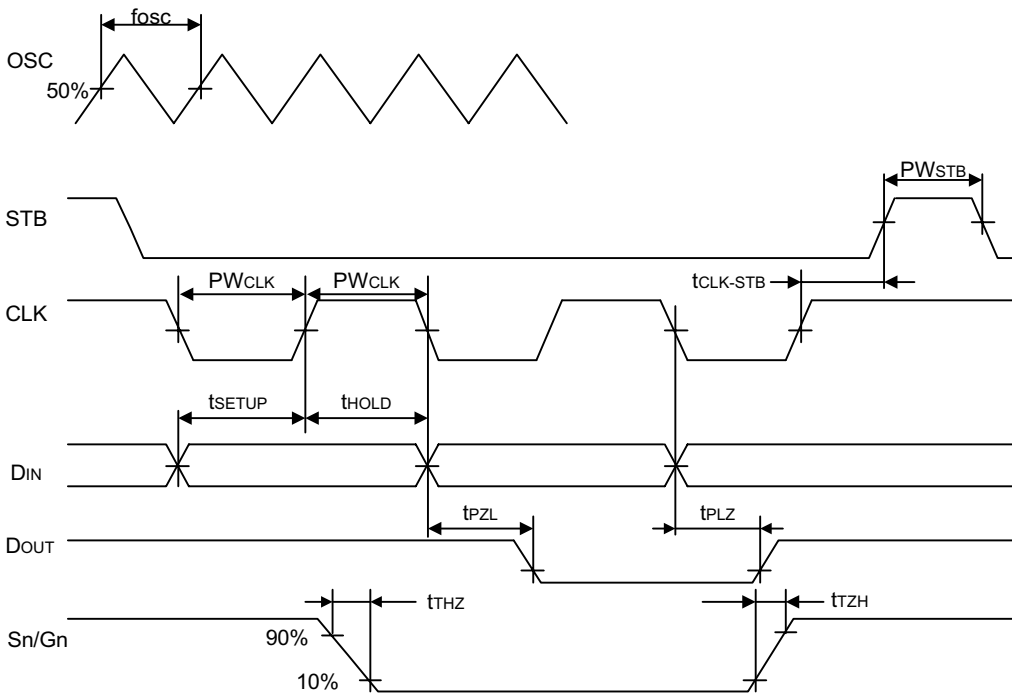
## 1/4- To 1/11-Duty VFD Controller/Driver

### (2) Key Scanning and Display Timing



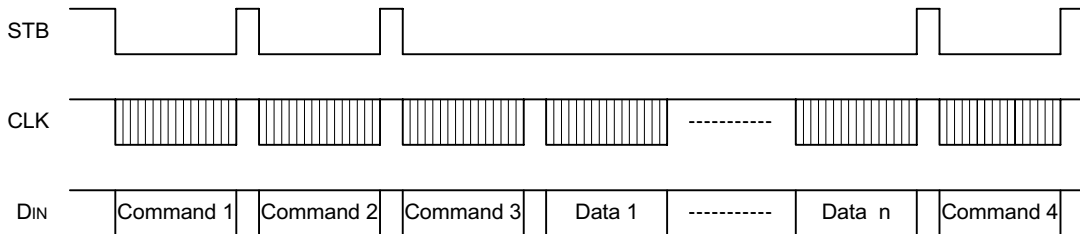
One cycle of key scanning consists of one frame, and data in a 6x 4 matrix is stored in RAM.

### Switching Characteristic Waveforms



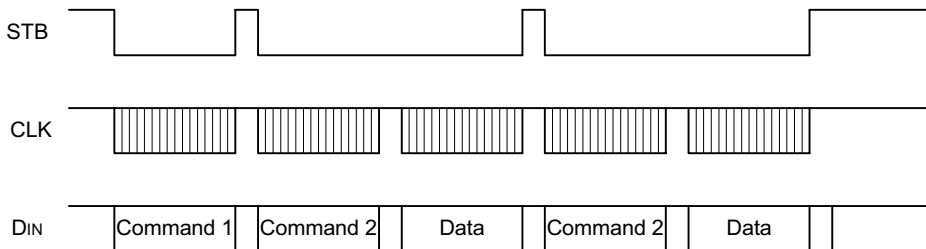
### ■ Applications

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

# AD16312



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

### ■ Package Dimension

(1) Package Type : QFP-44L

