

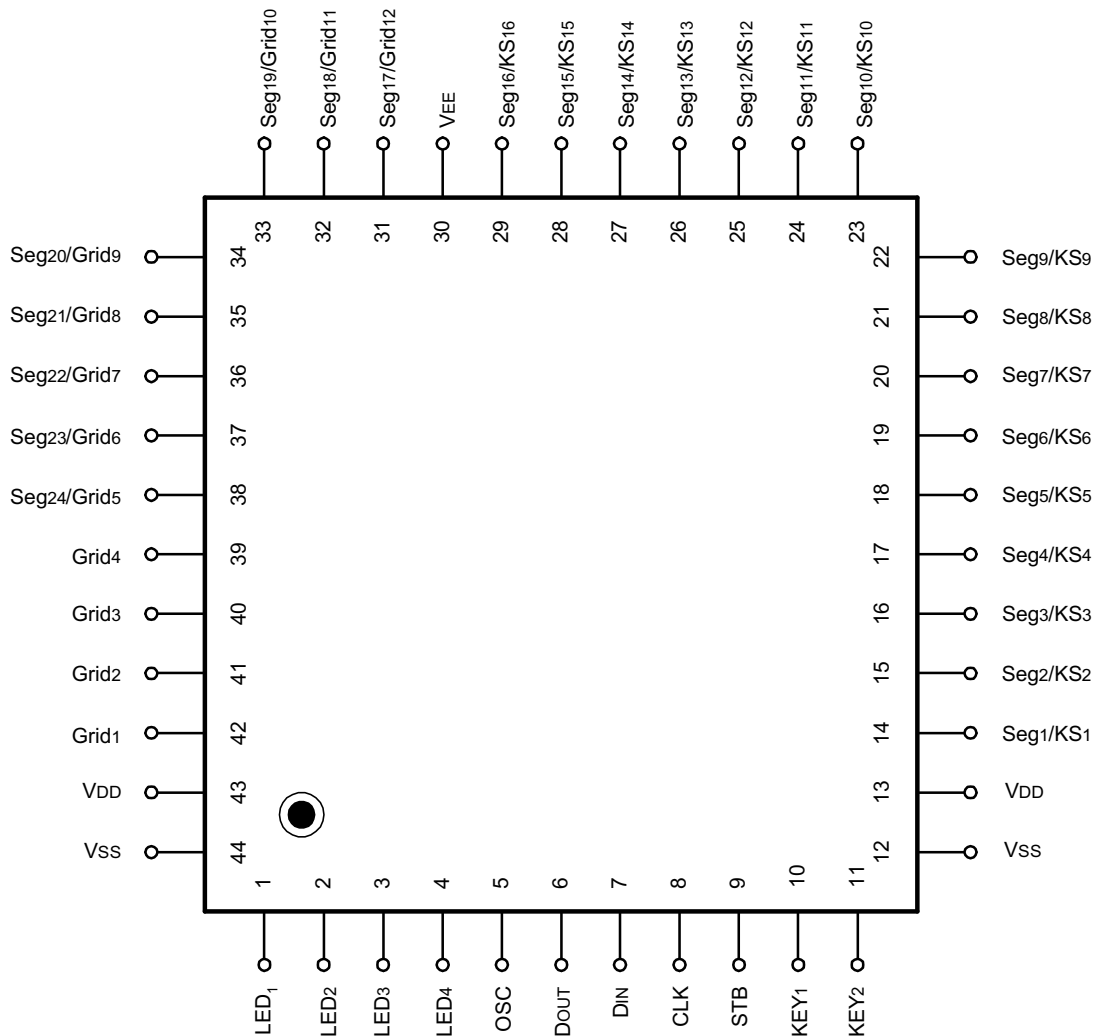
## ■ Features

- Multiple display modes (16-segment & 12-digit to 24-segment & 4-digit)
- Key scanning (16 x 2 matrix)
- Dimming circuit (eight steps)
- High-voltage output (  $V_{EE(max)} = V_{DD} - 35V$  )
- LED ports (4 channel, 20 mA max.)
- No external resistors necessary for driver outputs (P-ch open-drain + pull-down resistor output)
- Serial interface (CLK, STB, D<sub>IN</sub>, D<sub>OUT</sub>)
- Package: 44-pin plastic QFP and LQFP

## ■ General Description

The AD16315 is a VFD (Vacuum Fluorescent Display or fluorescent Indicator Panel) driver that is driven on a 1/4- to 1/12- duty factor. It consists of 16 segments and 4 grids output lines, 8 segments / grid output driving lines, a display memory, a control circuit, and a key scan circuit. Serial data is input to the AD16315 through a 3-wire serial interface. This VFD driver is ideal as a peripheral device for a single-chip microcomputer.

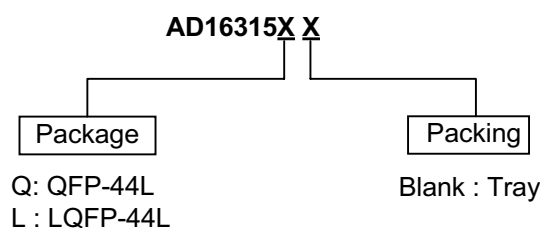
## ■ Pin Assignments



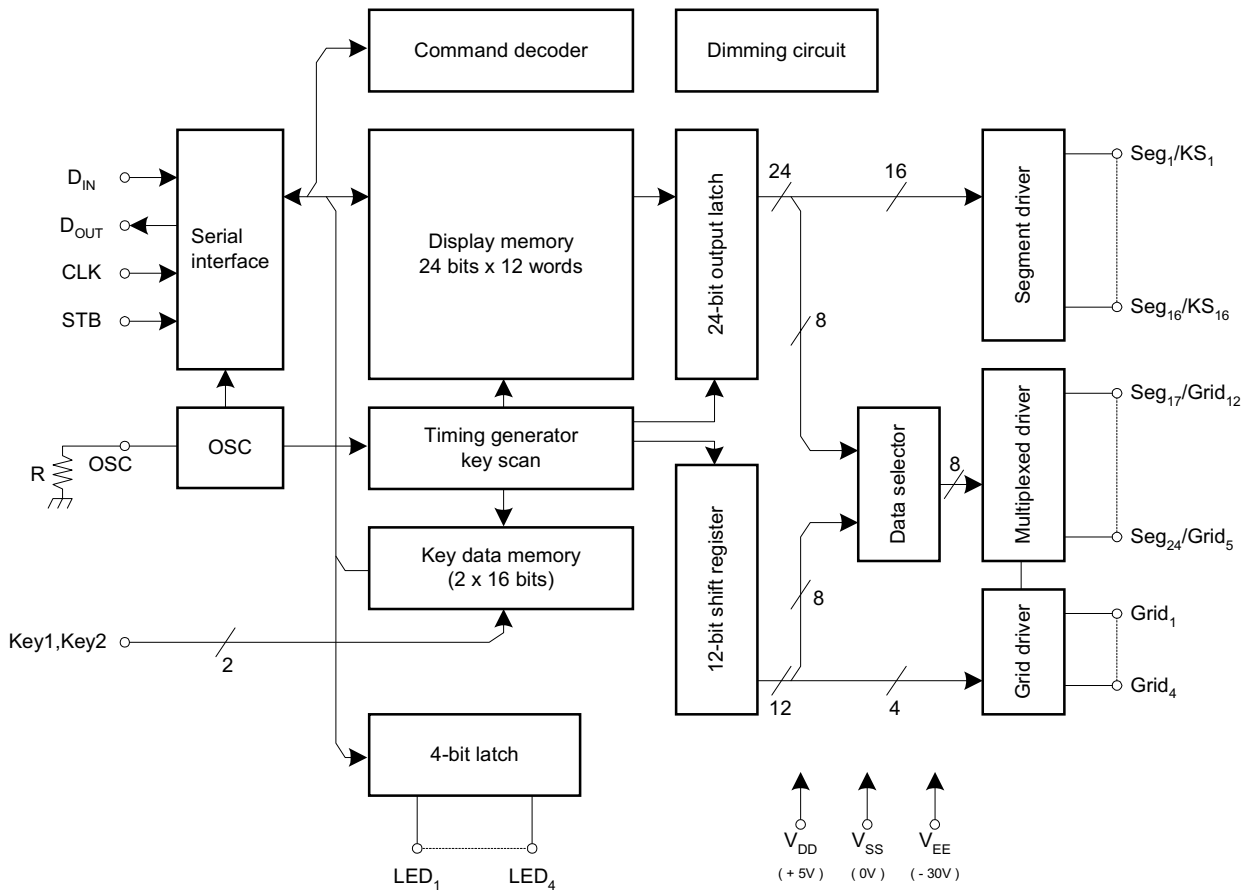
## ■ Pin Descriptions

| Symbol  | Name                               | No.      | Description   |
|---|------------------------------------|----------|---|
| D <sub>IN</sub>   | Data input                         | 7        | Input serial data at rising edge of shift clock, starting from the low order bit.   |
| D <sub>OUT</sub>  | Data output                        | 6        | 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 AD16315. 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. |
| CLK   | Clock input                        | 8        | Reads serial data at the rising edge, and outputs data at the falling edge.   |
| OSC   | Oscillator pin                     | 5        | Connect resistor to this pin to determine the oscillation frequency to this pin. Connect resistor between this pin and GND (V <sub>SS</sub> ).  |
| Seg <sub>1</sub> /KS <sub>1</sub> to Seg <sub>16</sub> /KS <sub>16</sub>      | High-voltage output (Segment)      | 14 to 29 | Segment output pins (Dual function as key source)   |
| Grid <sub>1</sub> to Grid <sub>4</sub>  | High-voltage output (Grid)         | 39 to 42 | Grid output pins  |
| Seg <sub>17</sub> /Grid <sub>12</sub> to Seg <sub>24</sub> /Grid <sub>5</sub> | High-voltage output (Segment/grid) | 31 to 38 | These pins are selectable for segment or grid driving.  |
| LED <sub>1</sub> to LED <sub>4</sub>  | LED output                         | 1 to 4   | CMOS output, +20mA MAX.   |
| KEY <sub>1</sub> , KEY <sub>2</sub>   | Key data input                     | 10, 11   | Data input to these pins is latched at the end of the display cycle.  |
| V <sub>DD</sub>   | Logic power                        | 13, 43   | 5V ± 10%  |
| V <sub>SS</sub>   | Logic ground                       | 12, 44   | Connect this pin to system GND.   |
| V <sub>EE</sub>   | Pull-down level                    | 30       | (V <sub>DD</sub> - 35V) MAX.  |

## ■ Ordering Information



■ **Block Diagram**



**■ 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 +6.0                     | 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     | $I_{O1}$  | $\pm 20$                         | mA               |
| VFD driver output current     | $I_{O2}$  | -40 (grid)<br>-15 (segment)      | mA               |
| Power dissipation             | $P_D$     | 800 (Note)                       | mW               |
| Operating ambient temperature | $T_A$     | -25 to +85                       | $^\circ\text{C}$ |
| Storage temperature           | $T_{stg}$ | -50 to +150                      | $^\circ\text{C}$ |

Note : Derate at  $-6.4\text{W}/^\circ\text{C}$  at  $T_A = 25^\circ\text{C}$  or higher.

Caution : If the absolute maximum rating of even one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. Absolute maximum ratings, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the range of the absolute maximum ratings.

**■ Recommended Operating Range** ( $T_A = -20$  to  $70^\circ\text{C}, V_{SS} = 0\text{V}$ )

| Parameter                | Symbol   | Min.         | Typ. | Max.         | Unit |
|--------------------------|----------|--------------|------|--------------|------|
| Logic supply voltage     | $V_{DD}$ | 4.5          | 5    | 5.5          | V    |
| High-level input voltage | $V_{IH}$ | $0.7 V_{DD}$ |      | $V_{DD}$     | V    |
| Low-level input voltage  | $V_{IL}$ | 0            |      | $0.3 V_{DD}$ | V    |
| Driver supply voltage    | $V_{EE}$ | 0            |      | $V_{DD}-35$  | V    |

Remark :

Maximum power consumption

$$P_{max} = \text{VFD driver dissipation} + R_L \text{ dissipation} + \text{LED driver dissipation} + \text{dynamic power consumption}$$

Where

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

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

$R_L$  dissipation  $\cong (V_{DD} - V_{EE})^2 / 50 \times (\text{number of segments} + 1)$  (mW)

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

Dynamic power consumption =  $V_{DD} \times 5$  (mW)

**■ Electrical Characteristics** ( $T_A = -20$  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> , $I_{OH1} = -15$ mA   | $V_{DD} - 1$ |      |              | V    |
| Low-level output voltage    | $V_{OL1}$   | LED <sub>1</sub> – LED <sub>4</sub> , $I_{OL1} = +15$ mA   |              |      | 1            | V    |
| Low-level output voltage    | $V_{OL2}$   | D <sub>OUT</sub> , $I_{OL2} = 4$ mA  |              |      | 0.4          | V    |
| High-level output current   | $I_{OH21}$  | $V_O = V_{DD} - 2\text{V}$ ,<br>Seg <sub>1</sub> /KS <sub>1</sub> to Seg <sub>16</sub> /KS <sub>16</sub>   | -0.3         |      |              | mA   |
| High-level output current   | $I_{OH22}$  | $V_O = V_{DD} - 2\text{V}$ , Grid <sub>1</sub> to Grid <sub>4</sub> ,<br>Seg <sub>17</sub> /Grid <sub>12</sub> to Seg <sub>24</sub> /Grid <sub>5</sub> | -15          |      |              | mA   |
| Driver leakage current      | $I_{OLEAK}$ | $V_O = V_{DD} - 35\text{V}$ , driver off   |              |      | -10          | μA   |
| Output pull-down resistor   | $R_L$       | Driver output  | 40           | 65   | 120          | kΩ   |
| Input current               | $I_I$       | $V_I = V_{DD}$ or $V_{SS}$   |              |      | ±1           | μA   |
| High-level input voltage    | $V_{IH}$    |  | $0.7V_{DD}$  |      |              | V    |
| Low-level input voltage     | $V_{IL}$    |  |              |      | $0.3 V_{DD}$ | V    |
| Hysteresis voltage          | $V_H$       | CLK, D <sub>IN</sub> , STB   |              | 0.35 |              | V    |
| Dynamic current consumption | $I_{DDdyn}$ | Under no load, display off   |              |      | 5            | mA   |

**■ Switching Characteristics** ( $T_A = -20$  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   | $f_{OSC}$  | $R = 82$ kΩ  | 350   | 500  | 650  | kHz  |
| Propagation delay time  | $t_{PHZ}$  | CLK → D <sub>OUT</sub><br>$C_L = 15\text{pF}, R_L = 10$ kΩ                                       |   |      | 300  | ns   |
|                         | $t_{PZL}$  |  |   |      | 100  | ns   |
| Rise time               | $t_{TZH1}$ | $C_L = 300\text{pF}$<br>Seg <sub>1</sub> /KS <sub>1</sub> to Seg <sub>16</sub> /KS <sub>16</sub> |   |      | 2    | μS   |
|                         | $t_{TZH2}$ |  | Grid <sub>1</sub> to Grid <sub>4</sub> ,<br>Seg <sub>17</sub> /Grid <sub>12</sub> to Seg <sub>24</sub> /Grid <sub>5</sub> |      |      | 0.5  |
| Fall time               | $t_{THZ}$  | $C_L = 300\text{pF}$ , Seg <sub>n</sub> , Grid <sub>n</sub>                                      |   |      | 160  | μS   |
| Maximum clock frequency | $F_{MAX.}$ | Duty=50%   |   |      | 1    | MHz  |
| Input capacitance       | $C_I$      |  |   |      | 15   | pF   |



■ **Timing Characteristics** ( $T_A = -20$  to  $+70^\circ\text{C}$ ,  $V_{DD} = 4.5$  to  $5.5\text{V}$ )

| Parameter          | Symbol        | Conditions   | Min. | Typ. | Max. | Unit          |
|--------------------|---------------|--|------|------|------|---------------|
| Clock pulse width  | $PW_{CLK}$    |  | 400  |      |      | ns            |
| Strobe pulse width | $PW_{STB}$    |  | 1    |      |      | $\mu\text{S}$ |
| Data setup time    | $t_{SETU}$    |  | 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 $\uparrow$ $\rightarrow$ STB $\downarrow$ (Note) | 1    |      |      | $\mu\text{S}$ |

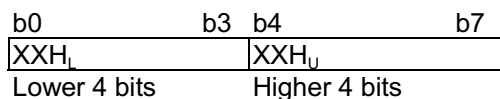
Note : Refer to the **Serial communication format**.

■ **Function Descriptions**

(1) **Display RAM Address and Display Mode**

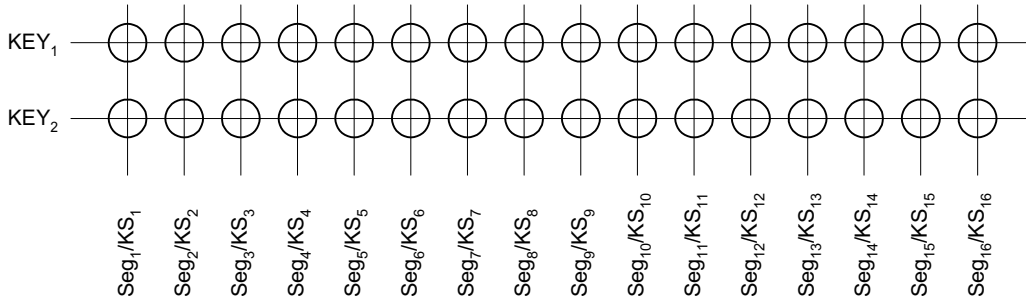
The display RAM stores the data transmitted to the AD16315 through the serial communication. The addresses are allocated in 8-bit units.

| Seg <sub>1</sub> | Seg <sub>4</sub> | Seg <sub>8</sub> | Seg <sub>12</sub> | Seg <sub>16</sub> | Seg <sub>20</sub> | Seg <sub>24</sub> |                   |
|------------------|------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 00H <sub>L</sub> | 00H <sub>U</sub> | 01H <sub>L</sub> | 01H <sub>U</sub>  | 02H <sub>L</sub>  | 02H <sub>U</sub>  |                   | DIG <sub>1</sub>  |
| 03H <sub>U</sub> | 03H <sub>U</sub> | 04H <sub>L</sub> | 04H <sub>U</sub>  | 05H <sub>L</sub>  | 05H <sub>U</sub>  |                   | DIG <sub>2</sub>  |
| 06H <sub>L</sub> | 06H <sub>U</sub> | 07H <sub>L</sub> | 07H <sub>U</sub>  | 08H <sub>L</sub>  | 08H <sub>U</sub>  |                   | DIG <sub>3</sub>  |
| 09H <sub>L</sub> | 09H <sub>U</sub> | 0AH <sub>L</sub> | 0AH <sub>U</sub>  | 0BH <sub>L</sub>  | 0BH <sub>U</sub>  |                   | DIG <sub>4</sub>  |
| 0CH <sub>L</sub> | 0CH <sub>U</sub> | 0DH <sub>L</sub> | 0DH <sub>U</sub>  | 0EH <sub>L</sub>  | 0EH <sub>U</sub>  |                   | DIG <sub>5</sub>  |
| 0FH <sub>L</sub> | 0FH <sub>U</sub> | 10H <sub>L</sub> | 10H <sub>U</sub>  | 11H <sub>L</sub>  | 11H <sub>U</sub>  |                   | DIG <sub>6</sub>  |
| 12H <sub>L</sub> | 12H <sub>U</sub> | 13H <sub>L</sub> | 13H <sub>U</sub>  | 14H <sub>L</sub>  | 14H <sub>U</sub>  |                   | DIG <sub>7</sub>  |
| 15H <sub>L</sub> | 15H <sub>U</sub> | 16H <sub>L</sub> | 16H <sub>U</sub>  | 17H <sub>L</sub>  | 17H <sub>U</sub>  |                   | DIG <sub>8</sub>  |
| 18H <sub>L</sub> | 18H <sub>U</sub> | 19H <sub>L</sub> | 19H <sub>U</sub>  | 1AH <sub>L</sub>  | 1AH <sub>U</sub>  |                   | DIG <sub>9</sub>  |
| 1BH <sub>L</sub> | 1BH <sub>U</sub> | 1CH <sub>L</sub> | 1CH <sub>U</sub>  | 1DH <sub>L</sub>  | 1DH <sub>U</sub>  |                   | DIG <sub>10</sub> |
| 1EH <sub>L</sub> | 1EH <sub>U</sub> | 1FH <sub>L</sub> | 1FH <sub>U</sub>  | 20H <sub>L</sub>  | 20H <sub>U</sub>  |                   | DIG <sub>11</sub> |
| 21H <sub>L</sub> | 21H <sub>U</sub> | 22H <sub>L</sub> | 22H <sub>U</sub>  | 23H <sub>L</sub>  | 23H <sub>U</sub>  |                   | DIG <sub>12</sub> |



**(2) Key Matrix and Key-input Data Storage RAM**

The key matrix is made up of a 16 X 2 matrix, as shown below.

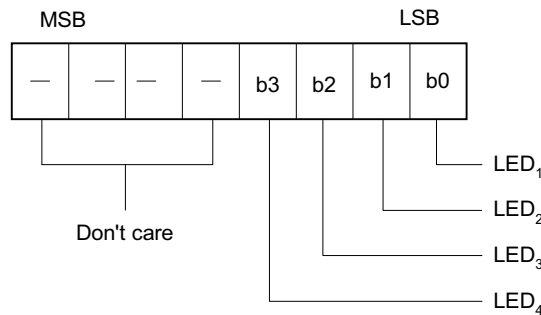


The data of each key is stored as follows, and is read with the read command starting from the least significant bit.



**(3) LED Port**

Data is written to the LED port with the write command, starting from the least significant bit. "L" output when the bit of this port is 0, and "H" output when the bit is 1. The data of bits after the 5<sup>th</sup> bit are ignored.



Note: On power application, all the LED ports are "L" output.

**(4) Commands**

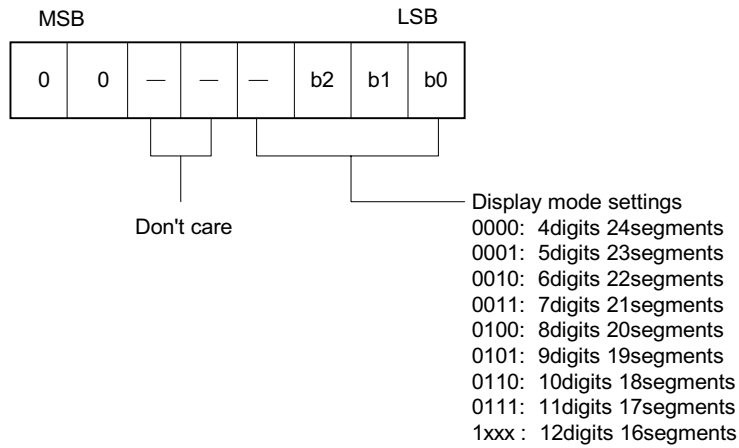
Commands set the display mode and status of the VFD driver.

The first 1 byte input to the AD16315 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).

**( I ) Display mode setting commands**

These commands initialize the AD16315 and select the number of segments and the number of grids (1/4- to 1/12- duty, 16 segments to 24 segments).

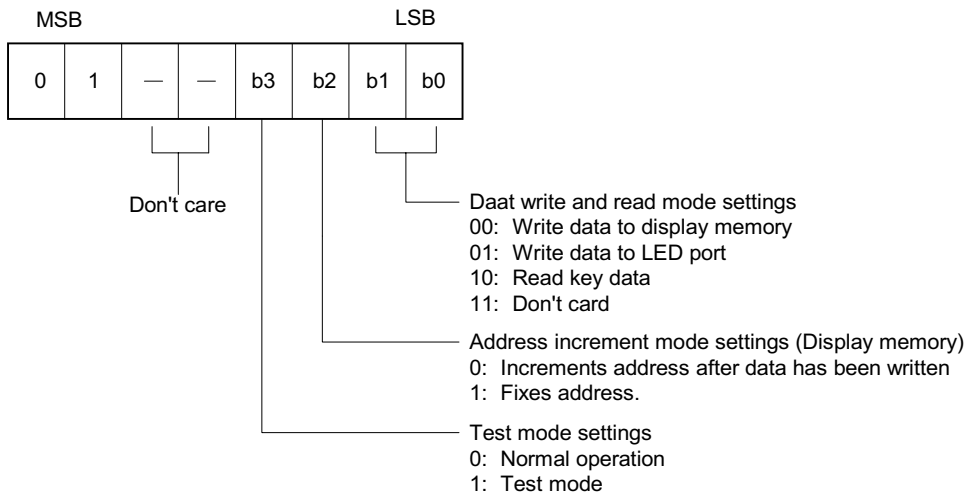
When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command "ON" must be executed. If the same mode is selected, however, nothing happens.



Note: On power application, the 12-digit, 16-segment mode is selected.

**( II ) Data setting commands**

These commands set data write and data read modes.

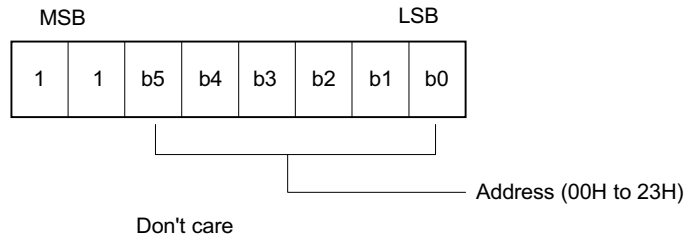


Note: For power application, the normal operation and address increment modes are set.



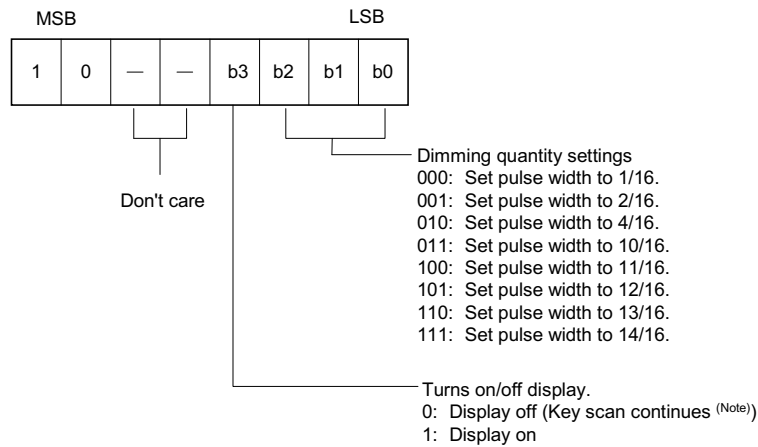
**(III) Address setting command**

These commands set an address of the display memory.



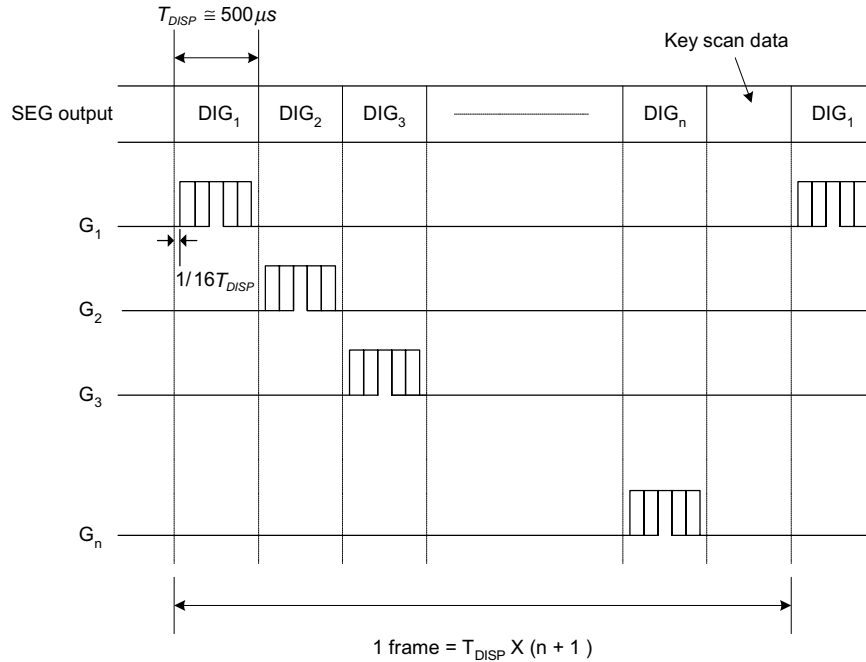
Note : (a) If address 24H or higher is set, data is ignored, until a valid address is set.  
(b) On power application, the address is set to 00H.

**(IV) Display control commands**



Note : (a) On power application, key scanning is stopped.  
(b) 1/16 pulse width is set and the display is turned off.

**(5) Key Scanning And Display Timing**



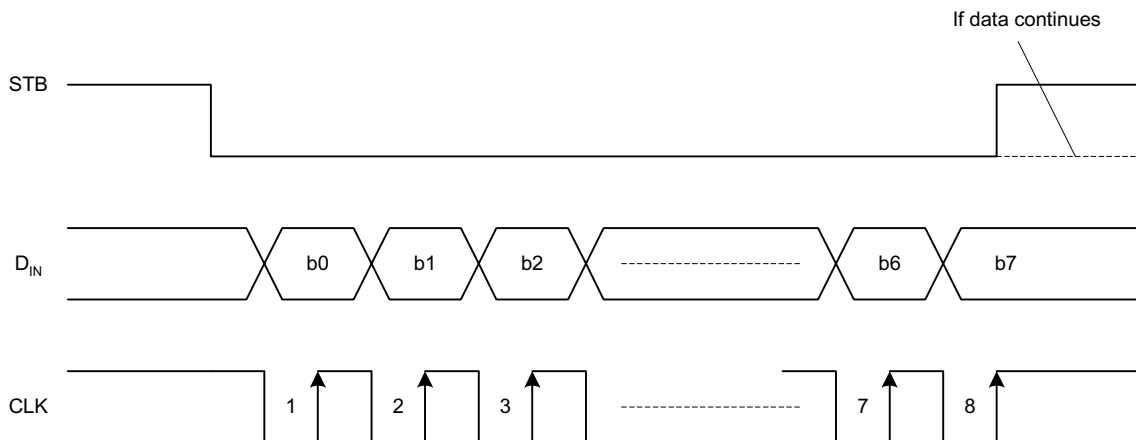
Note : One cycle of key scanning consists of two frame, and data in 1 16 X 2 matrix is stored in RAM.

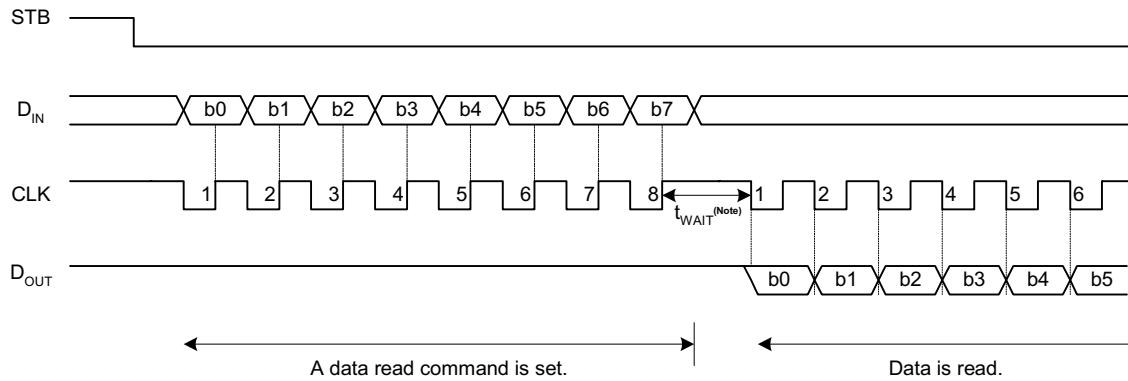
**(6) Key Scan Expansion**

|           |                  |   |    |    |    |    |    |    |    |                  |
|-----------|------------------|---|----|----|----|----|----|----|----|------------------|
| 1st frame |                  | 1 | 2  | 3  | 4  | 5  | 6  | 7  | 8  |                  |
| 2nd frame | DIG <sub>n</sub> | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | DIG <sub>1</sub> |

**(7) Serial Communication Format**

Reception (command/data write)





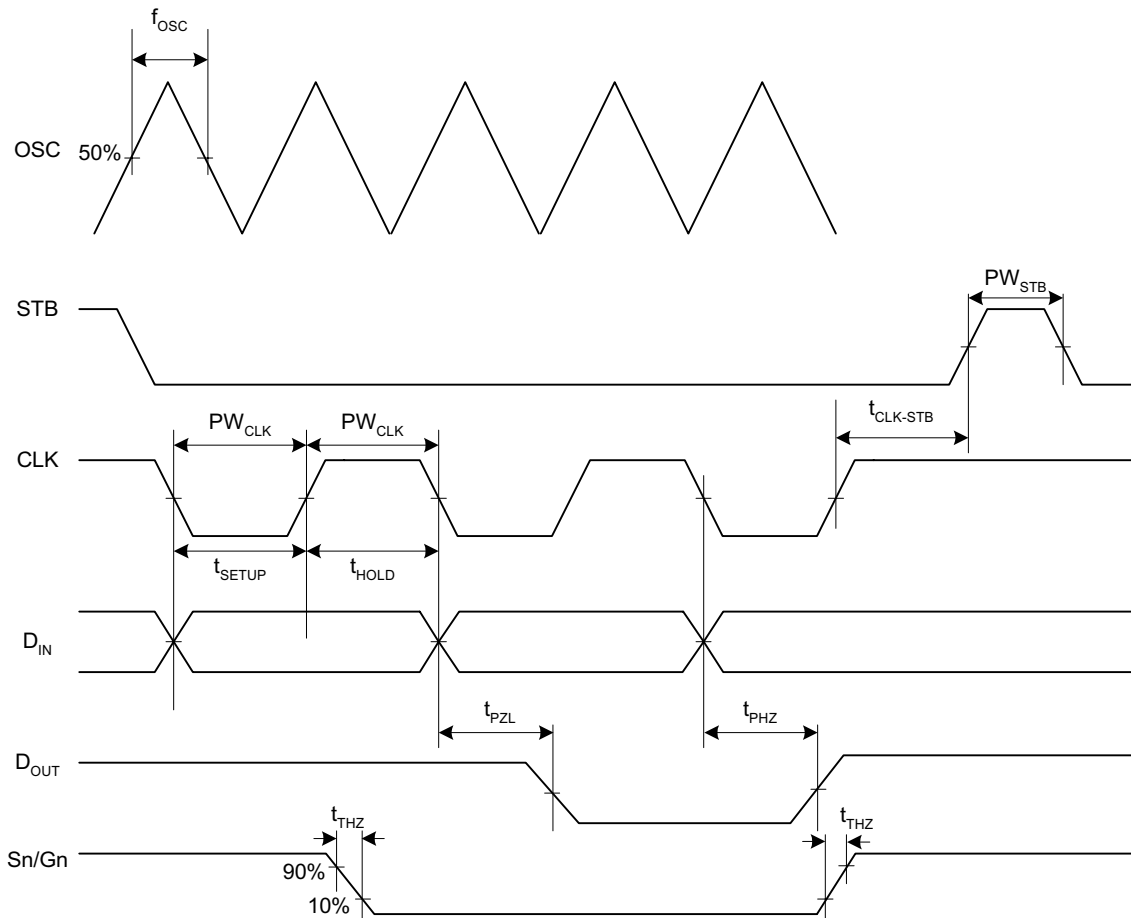
**Transmission (data read)**

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.

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

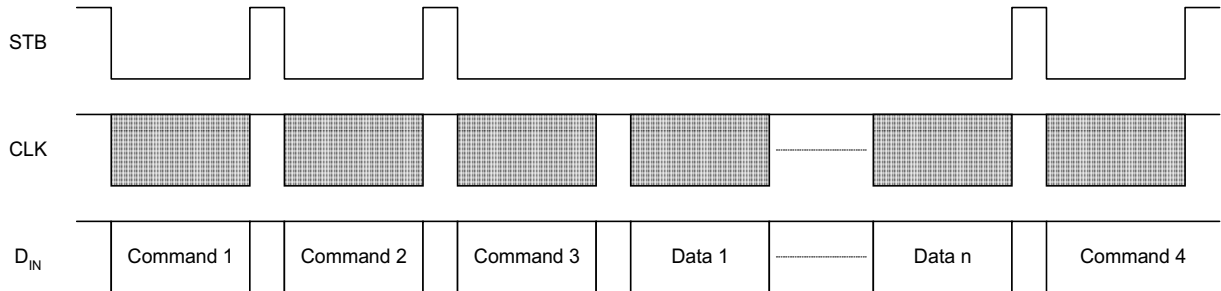
**(8) Switching Characteristic Waveforms**

Typical Characteristics (Unless otherwise specified,  $T_A = 25^\circ C$ ,  $V_{DD} = 5V$ ,  $V_{EE} = V_{DD} - 35V$ )



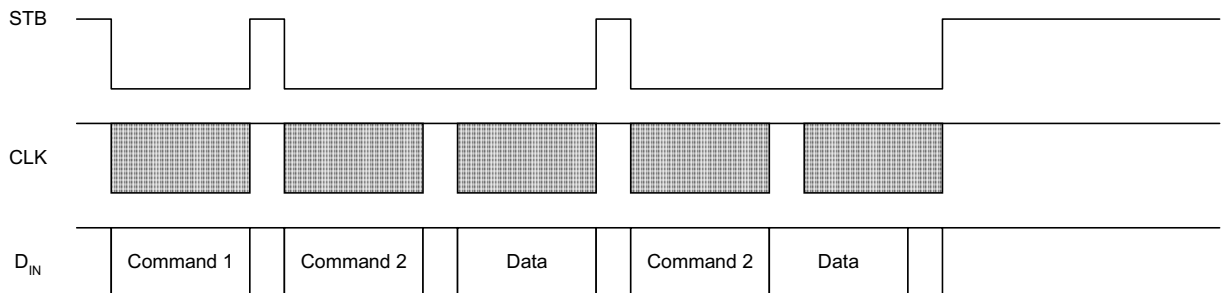
**(9) Applications**

Updating display memory by incrementing address



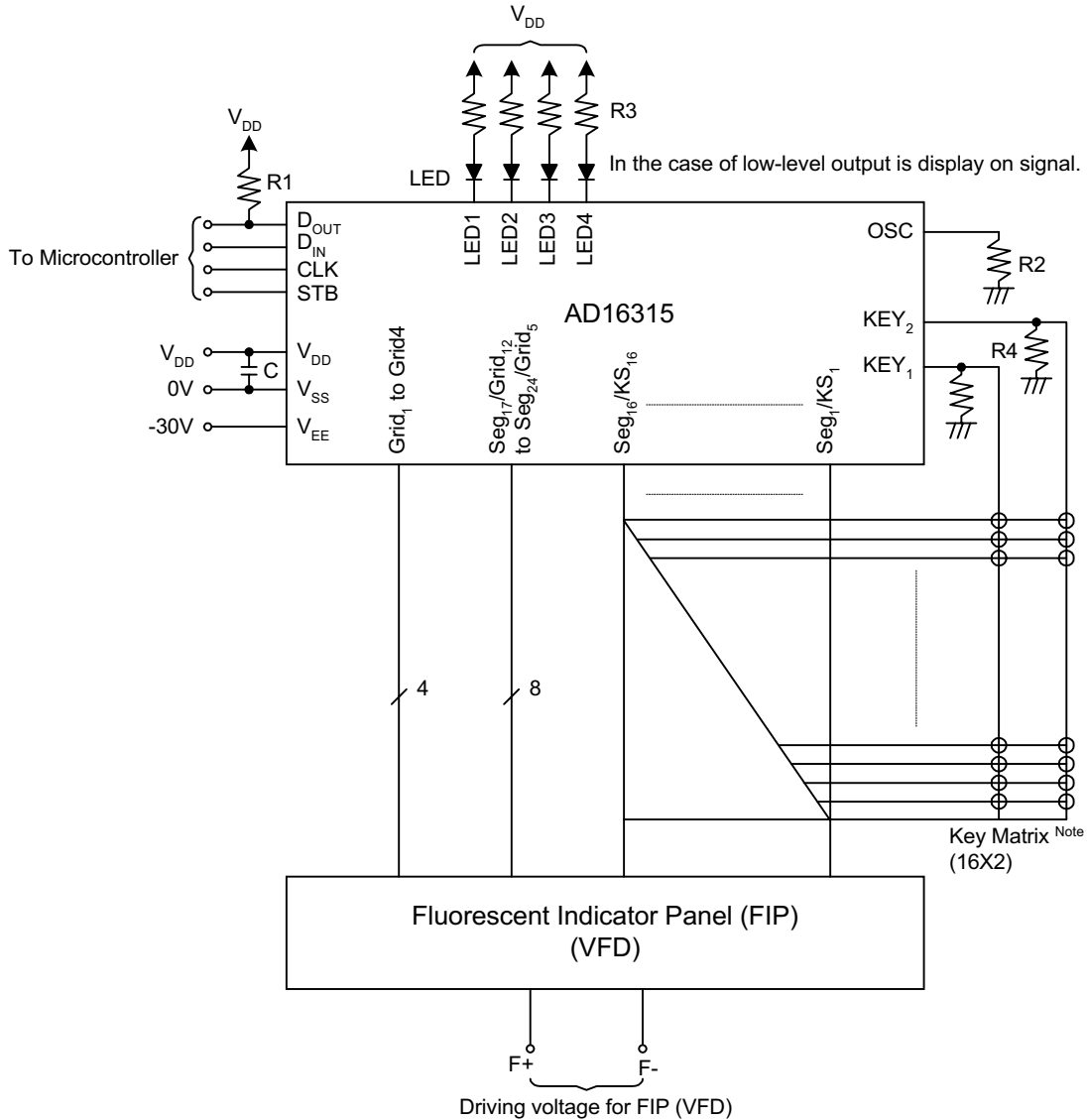
- Command 1 : sets display mode
- Command 2 : sets data
- Command 3 : sets address
- Data 1 to n : transfers display data (36 bytes MAX.)
- Command 4 : controls display

Updating specific address

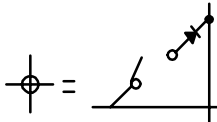


- Command 1 : sets data
- Command 2 : sets address
- Data : display data

■ **Application Circuit**



Note :

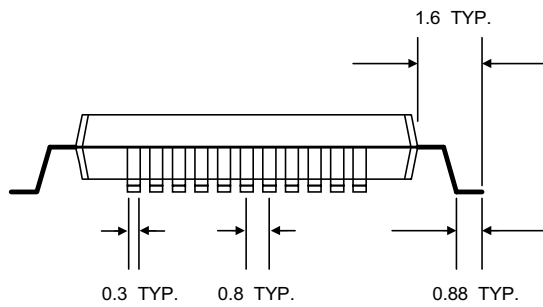
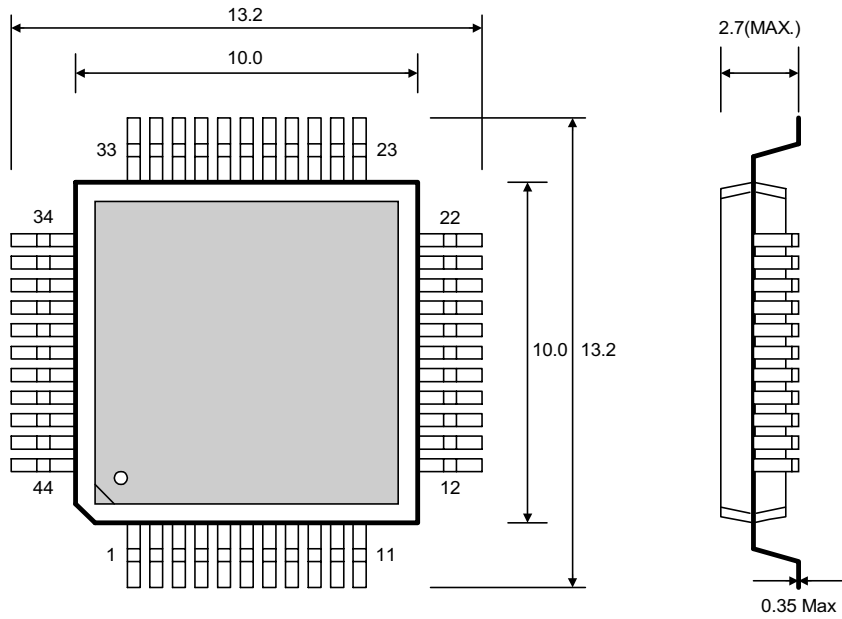


Remark : R1, R4 = 1k to 10k  
 R2 = 82k  
 R3 = 330 TO 1K  
 C = 0.1μ to 1.0μF

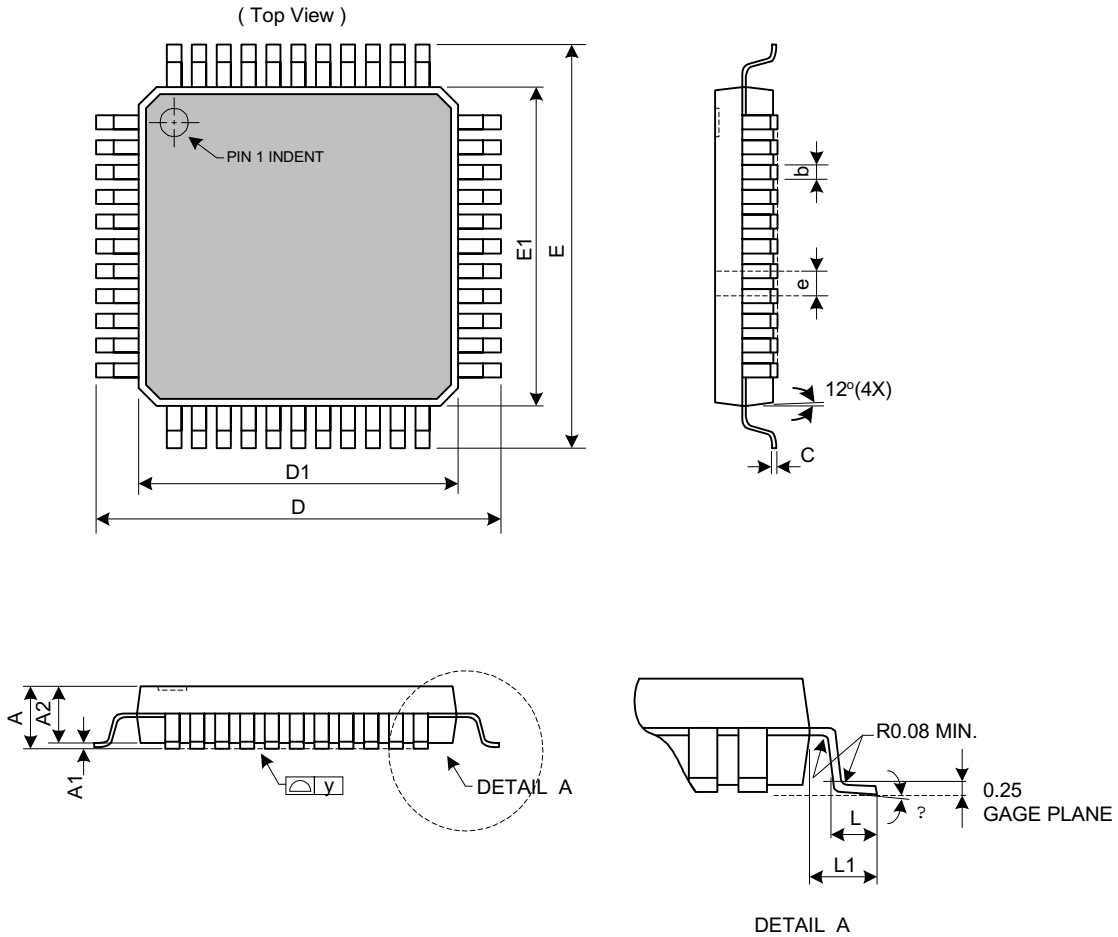
■ **Package Information**

(1) **Package Type: Plastic QFP-44L**

Dimension in millimeter (mm.).



(2) Package Type: LQFP-44L



| Symbol | Dimensions In Millimeters |       |       |
|--------|---------------------------|-------|-------|
|        | Min.                      | Nom.  | Max.  |
| A      | --                        | --    | 1.60  |
| A1     | 0.05                      | --    | 0.15  |
| A2     | 1.35                      | 1.40  | 1.45  |
| b      | 0.30                      | 0.37  | 0.45  |
| C      | 0.09                      | --    | 0.20  |
| E      | 11.80                     | 12.00 | 12.20 |
| E1     | 9.90                      | 10.00 | 10.10 |
| D      | 11.80                     | 12.00 | 12.20 |
| D1     | 9.90                      | 10.00 | 10.10 |
| e      | --                        | 0.80  | --    |
| L      | 0.45                      | 0.60  | 0.75  |
| L1     | --                        | 1.00  | --    |
| θ      | 0°                        | 3.5°  | 7°    |
| y      | 0.0                       | --    | 0.08  |