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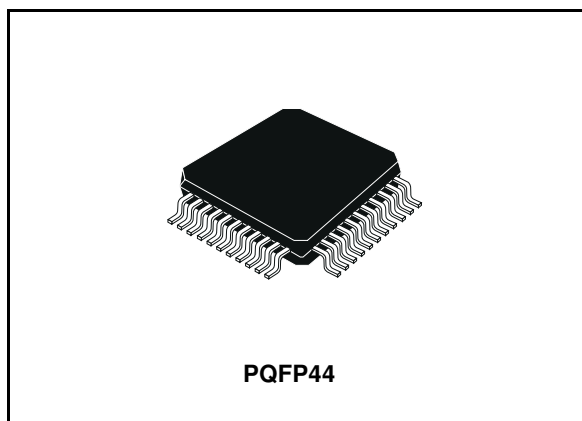
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**1/4 to 1/11-duty VFD controller/driver****General features**

- Many display modes (11 segments & 11 digits to 16 segments & 4 digits)
- Key scanning (6 x 4 matrix)
- Dimming circuit (eight steps)
- High-voltage output ( $V_{DD} - 35V$  max)
- LED ports (4 chs, 20mA max)
- General purpose input port (4 bits)
- No external resistor necessary for driver output (P-channel open drain + pull down resistor output)
- Serial interface (CLK, STB,  $D_{IN}$ ,  $D_{OUT}$ )

**Description**

The STM86312 is a VFD (Vacuum Fluorescent Display) controller/driver that is driven on a 1/4 to 1/11-duty factor. It consists of 11-segments output lines, 6 grid output lines, 5 segments/grid output drive lines, a display memory, a control circuit, and a key scan circuit. Serial data are input to the STM86312 through a three-line serial interface. This VFD controller/driver is ideal as a peripheral device for a single-chip microcomputer.

**Order codes**

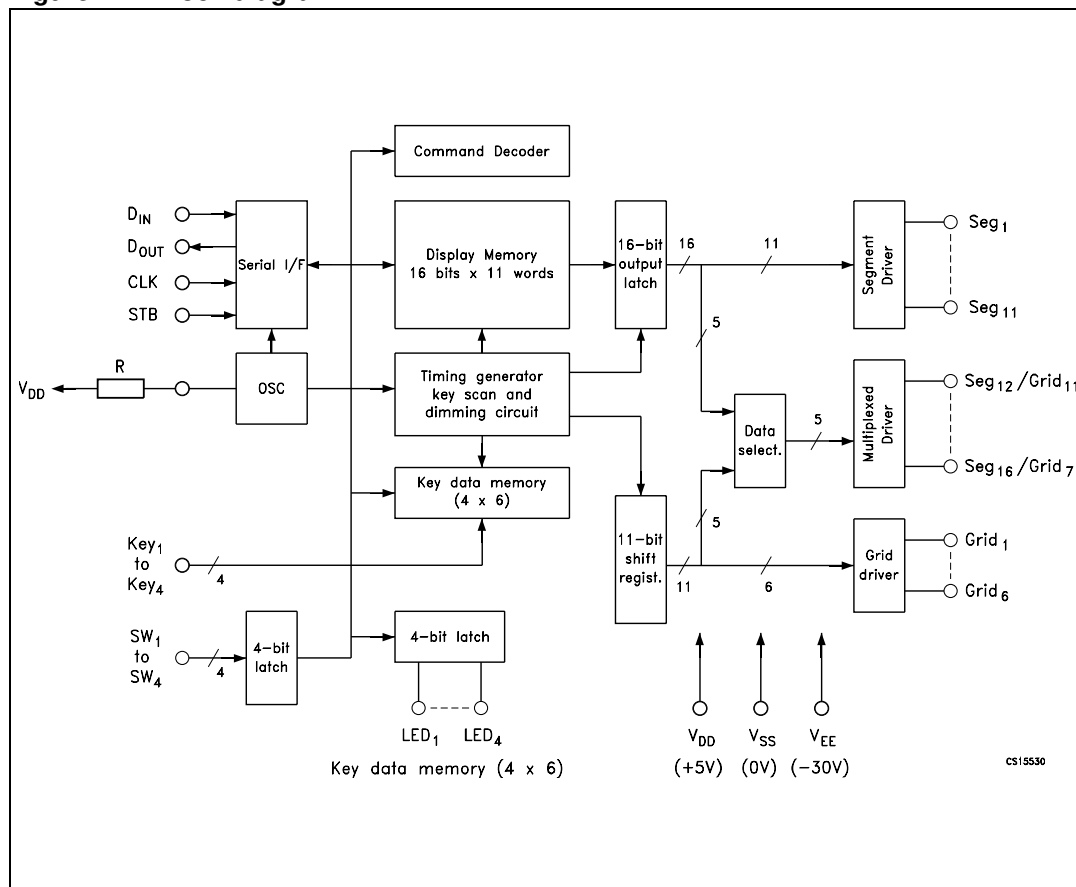
| Part number | Temperature range | Package | Tube |
|-------------|-------------------|---------|------|
| STM86312    | -40 to 85 °C      | PQFP44  | Tray |

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# 1 Block diagram

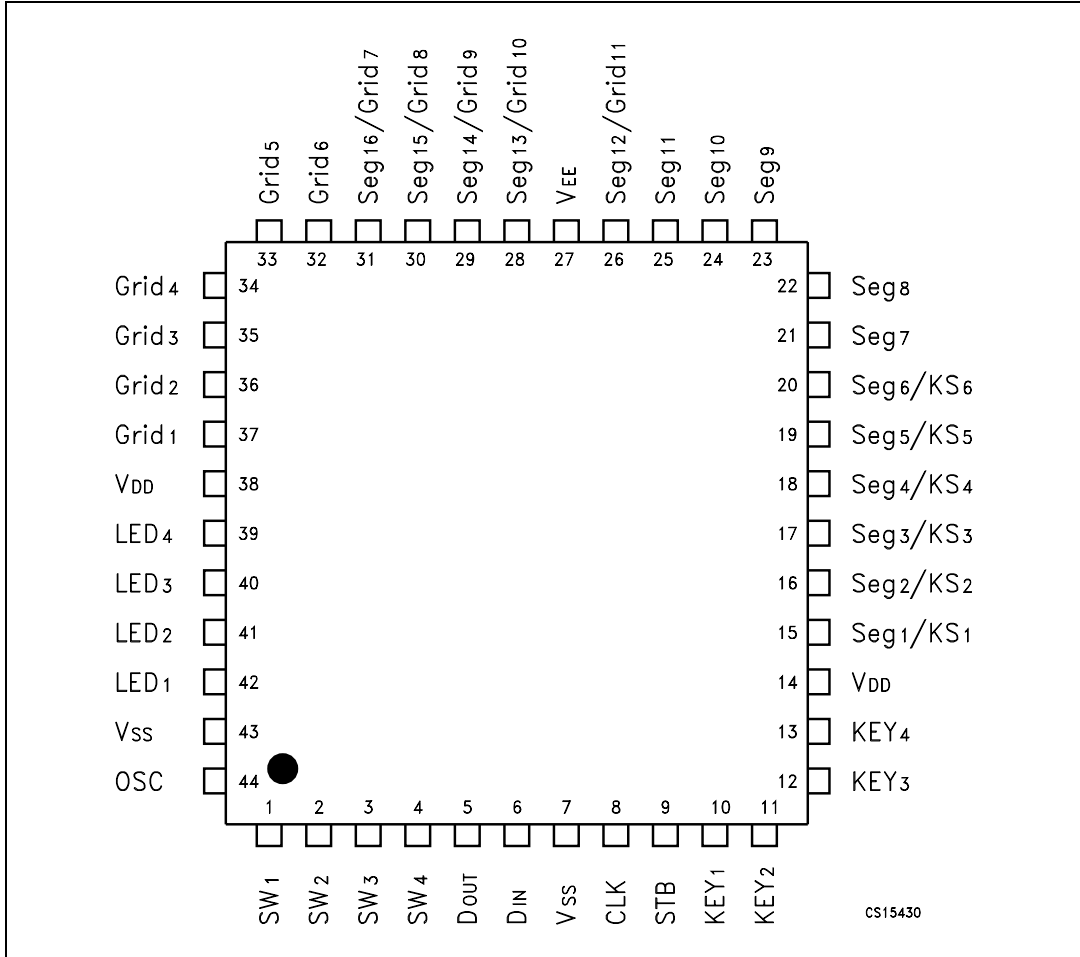
Figure 1. Block diagram



## 2 Pin settings

### 2.1 Pin connection

Figure 2. Pin connection



## 2.2 Pin description

**Table 1. Pin description**

| Pin N°                    | Symbol                         | Name and function  |
|---------------------------|--------------------------------|--|
| 1, 2, 3, 4                | SW1, SW2,<br>SW3, SW4          | General-purpose switch inputs.   |
| 5                         | D <sub>OUT</sub>               | Output serial data at falling edge of the shift clock, starting from lower bit. This is N-ch open-drain output pin.  |
| 6                         | D <sub>IN</sub>                | Input serial data at rising edge of the shift clock, starting from lower bit.  |
| 8                         | CLK                            | Reads serial data at rising edge, and outputs data at falling edge.  |
| 9                         | STB                            | Initializes serial interface at rising or falling edge to make STM86312 waiting for reception of command. Data input after STB has fallen are processed as a command. While command data are processed, current processing is stopped, and the serial interface is initialized. While STB is high, CLK is ignored. |
| 10, 11, 12, 13            | KEY1, KEY2,<br>KEY3, KEY4      | Input data to these pins are latched at end of the display cycle.  |
| 14, 38                    | V <sub>DD</sub>                | 5V ± 10%.  |
| 15, 16, 17,<br>18, 19, 20 | SEG1/KS1 to<br>SEG6/KS6        | Segment output pins (Dual function as key source).   |
| 21, 22, 23,<br>24, 25     | SEG7 to SEG11                  | Segment output pins.   |
| 26, 28, 29,<br>30, 31     | SEG12/GRID11 to<br>SEG16/GRID7 | These pins are selectable for segment or grid driving.   |
| 32, 33, 34,<br>35, 36, 37 | GRID1 to GRID6                 | Grid output pins.  |
| 39, 40, 41, 42            | LED1 to LED4                   | CMOS outputs. +20 mA max.  |
| 7, 43                     | V <sub>SS</sub>                | Connect this pin to system GND.  |
| 27                        | V <sub>EE</sub>                | Pull-down level. V <sub>DD</sub> - 35V max.  |
| 44                        | OSC                            | Connect to an external resistor.   |

### 3 Maximum rating

Stressing the device above the rating listed in the “Absolute Maximum Ratings” table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE Program and other relevant quality documents.

**Table 2. Absolute maximum ratings**

| Symbol          | Parameter                     | Value  | Unit |
|-----------------|-------------------------------|--|------|
| V <sub>DD</sub> | Logic Supply Voltage          | -0.5 to 7                                    | V    |
| V <sub>EE</sub> | Driver Supply Voltage         | V <sub>DD</sub> +0.5 to V <sub>DD</sub> -40  | V    |
| V <sub>I</sub>  | Logic Input Voltage           | -0.5 to V <sub>DD</sub> +0.5                 | V    |
| V <sub>O2</sub> | VFD Driver Output Voltage     | V <sub>EE</sub> -0.5 to V <sub>DD</sub> +0.5 | V    |
| I <sub>O1</sub> | LED Driver Output Current     | 25   | mA   |
| I <sub>O2</sub> | VFD Driver Output Current     | -40 (Grid)                                   | mA   |
|                 |                               | -15 (Segment)                                |      |
| T <sub>A</sub>  | Operating Ambient Temperature | -40 to 85                                    | °C   |

#### 3.1 Thermal data

**Table 3. Thermal data**

| Symbol            | Parameter                        | Value | Unit |
|-------------------|----------------------------------|-------|------|
| R <sub>thJC</sub> | Thermal Resistance Junction-case | 56    | °C/W |

#### 3.2 Recommended operating conditions

**Table 4. Recommended operating conditions**

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

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

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

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

$R_L$  dissipation =  $(V_{DD} - V_{EE})^2 / 50 \times (\text{segment} + 1)$  (mW)

LED driver dissipation = number of LEDs  $\times 20$  (mW)

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

#### Example

Where  $V_{EE} = -25$  V,  $V_{DD} = 5$  V, and in 16-segment and 6-digit modes,

VFD driver dissipation =  $16 \times 6 + 6/7 \times 30 = 122$

$R_L$  dissipation =  $30^2 / 50 \times 17 = 306$

LED driver dissipation =  $4 \times 20 = 80$

Dynamic power consumption =  $5 \times 5 = 25$

Total 553 mW.



## 4 Electrical characteristics

**Table 5. Electrical characteristics** ( $V_{DD} = 4.5$  to  $5.5V$ ,  $V_{SS} = 0V$ ,  $V_{EE} = V_{DD} - 35V$ ,  $T_A = -20$  to  $70^\circ C$ , unless otherwise noted. Typical values are at  $T_A = 25^\circ C$ )

| Symbol      | Parameter                   | Test Conditions   | Value       |      |             | Unit      |
|-------------|-----------------------------|---|-------------|------|-------------|-----------|
|             |                             |   | Min.        | Typ. | Max.        |           |
| $V_{OH1}$   | High Level Output Voltage   | LED1-LED4, $I_{OH1} = -1mA$                                       | $0.9V_{DD}$ |      |             | V         |
| $V_{OL1}$   | Low Level Output Voltage    | LED1-LED4, $I_{OL1} = 20mA$                                       |             |      | 1           | V         |
| $V_{OL2}$   | Low Level Output Voltage    | $D_{OUT}$ , $I_{OL2} = 4mA$                                       |             |      | 0.4         | V         |
| $I_{OH21}$  | High Level Output Current   | $V_O = V_{DD} - 2V$ , Seg1 to Seg11                               | -3          |      |             | mA        |
| $I_{OH22}$  | High Level Output Current   | $V_O = V_{DD} - 2V$ , Grid1 to Grid6, Seg12/Grid11 to Seg16/Grid7 | -15         |      |             | mA        |
| $I_{OLEAK}$ | Driver Leakage Current      | $V_O = V_{DD} - 35V$ , driver off                                 |             |      | -10         | $\mu A$   |
| $R_L$       | Output Pull-Down Resistor   | Driver Output   | 50          | 100  | 150         | $k\Omega$ |
| $I_I$       | Input Current               | $V_I = V_{DD}$ or $V_{SS}$  |             |      | $\pm 1$     | $\mu A$   |
| $V_{IH}$    | High Level Input Voltage    |   | $0.7V_{DD}$ |      |             | V         |
| $V_{IL}$    | Low Level Input Voltage     |   |             |      | $0.3V_{DD}$ | V         |
| $V_{HYS}$   | Hysteresis Voltage          | CLK, $D_{IN}$ , STB   |             | 0.35 |             | V         |
| $I_{DDdyn}$ | Dynamic Current Consumption | Under no load, display off  |             |      | 5           | mA        |

**Table 6. Switching characteristics** ( $V_{DD} = 4.5$  to  $5.5V$ ,  $V_{SS} = 0V$ ,  $V_{EE} = V_{DD} - 35V$ ,  $T_A = -20$  to  $70^\circ C$ , unless otherwise noted. Typical values are at  $T_A = 25^\circ C$ )

| Symbol     | Parameter               | Test Conditions   | Value   |      |      | Unit    |
|------------|-------------------------|---|---|------|------|---------|
|            |                         |   | Min.  | Typ. | Max. |         |
| $t_{PLZ}$  | Propagation Delay       | CLK $\rightarrow$ $D_{OUT}$<br>$R_L = 10 k\Omega$ , $C_L = 15 pF$ |   |      | 300  | ns      |
| $t_{PZL}$  |                         |   |   |      | 100  |         |
| $t_{TZH1}$ | Rise Time               | $C_L = 300 pF$<br>Seg1 to Seg11                                   |   |      | 2    | $\mu s$ |
| $t_{TZH2}$ |                         |   | Grid1 to Grid6,<br>Seg12/Grid11 to<br>Seg16/Grid7 |      |      |         |
| $t_{THZ}$  | Fall Time               | $C_L = 300 pF$ , Segn, Gridn                                      |   |      | 120  | $\mu s$ |
| $f_{MAX}$  | Maximum Clock Frequency | Duty = 50%  | 1   |      |      | MHz     |
| $C_I$      | Input Capacitance       |   |   |      | 15   | pF      |

**Table 7. Timing Characteristics** ( $V_{DD} = 4.5$  to  $5.5V$ ,  $T_A = -20$  to  $70^\circ C$ , unless otherwise noted. Typical values are at  $T_A = 25^\circ C$ )

| Symbol        | Parameter          | Test Conditions                               | Value |      |      | Unit    |
|---------------|--------------------|---|-------|------|------|---------|
|               |                    |   | Min.  | Typ. | Max. |         |
| $PW_{CLK}$    | Clock Pulse Width  |   | 400   |      |      | ns      |
| $PW_{STB}$    | Strobe Pulse Width |   | 1     |      |      | $\mu s$ |
| $t_{SETUP}$   | Data Setup Time    |   | 100   |      |      | ns      |
| $t_{HOLD}$    | Data Hold Time     |   | 100   |      |      | ns      |
| $t_{CLK-STB}$ | Clock-Strobe Time  | CLK $\uparrow$ $\rightarrow$ STB $\uparrow$   | 1     |      |      | $\mu s$ |
| $t_{WAIT}$    | Wait Time (Note 1) | CLK $\uparrow$ $\rightarrow$ CLK $\downarrow$ | 1     |      |      | $\mu s$ |

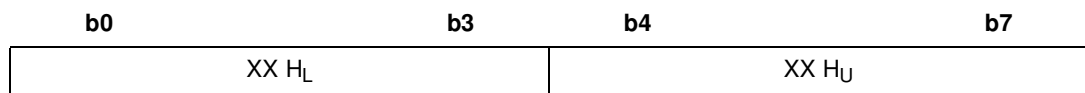
Note: Refer to page Serial Communication Format.

## 5 Display RAM address and display mode

The display RAM stores the data transmitted from an external device to the STM86312 through the serial interface; addresses are as follows, in 8-bits unit:

RAM stores addresses

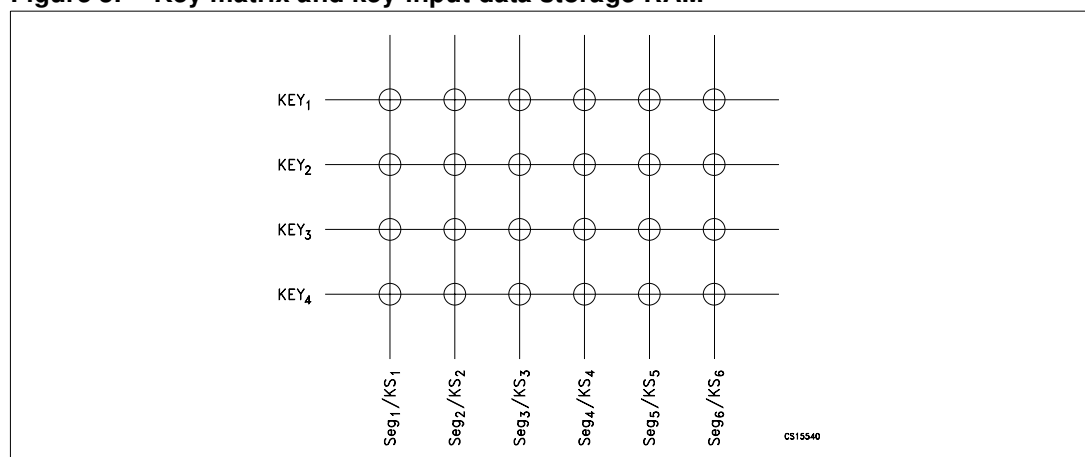
| Seg1              | Seg4 | Seg8              | Seg12             | Seg16             |       |
|-------------------|------|-------------------|-------------------|-------------------|-------|
| 00 H <sub>L</sub> |      | 00 H <sub>U</sub> | 01 H <sub>L</sub> | 01 H <sub>U</sub> | DIG1  |
| 02 H <sub>L</sub> |      | 02 H <sub>U</sub> | 03 H <sub>L</sub> | 03 H <sub>U</sub> | DIG2  |
| 04 H <sub>L</sub> |      | 04 H <sub>U</sub> | 05 H <sub>L</sub> | 05 H <sub>U</sub> | DIG3  |
| 06 H <sub>L</sub> |      | 06 H <sub>U</sub> | 07 H <sub>L</sub> | 07 H <sub>U</sub> | DIG4  |
| 08 H <sub>L</sub> |      | 08 H <sub>U</sub> | 09 H <sub>L</sub> | 09 H <sub>U</sub> | DIG5  |
| 0A H <sub>L</sub> |      | 0A H <sub>U</sub> | 0B H <sub>L</sub> | 0B H <sub>U</sub> | DIG6  |
| 0C H <sub>L</sub> |      | 0C H <sub>U</sub> | 0D H <sub>L</sub> | 0D H <sub>U</sub> | DIG7  |
| 0E H <sub>L</sub> |      | 0E H <sub>U</sub> | 0F H <sub>L</sub> | 0F H <sub>U</sub> | DIG8  |
| 10 H <sub>L</sub> |      | 10 H <sub>U</sub> | 11 H <sub>L</sub> | 11 H <sub>U</sub> | DIG9  |
| 12 H <sub>L</sub> |      | 12 H <sub>U</sub> | 13 H <sub>L</sub> | 13 H <sub>U</sub> | DIG10 |
| 14 H <sub>L</sub> |      | 14 H <sub>U</sub> | 15 H <sub>L</sub> | 15 H <sub>U</sub> | DIG11 |



Note: "0" in memory means V<sub>EE</sub> on output; "1" in memory means V<sub>DD</sub> on output.

The key matrix is of 6 x 4 configuration, as shown below

Figure 3. Key matrix and key-input data storage RAM



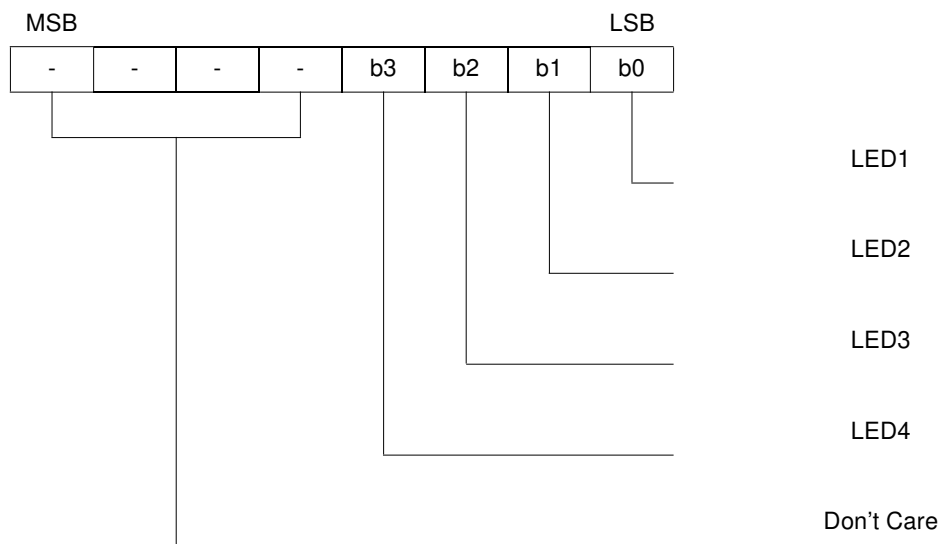
The data of each key are stored as illustrated below, and are read by the appropriate read command, starting from the least significant bit

| KEY1     | KEY4 | KEY1 | KEY4     |   |
|----------|------|------|----------|---|
| Seg1/KS1 |      |      | Seg2/KS2 | ∅ |
| Seg3/KS3 |      |      | Seg4/KS4 |   |
| Seg5/KS5 |      |      | Seg6/KS6 |   |
| b0       | b3   | b4   | b7       |   |

## 6 LED port

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

**Figure 4. LED port**

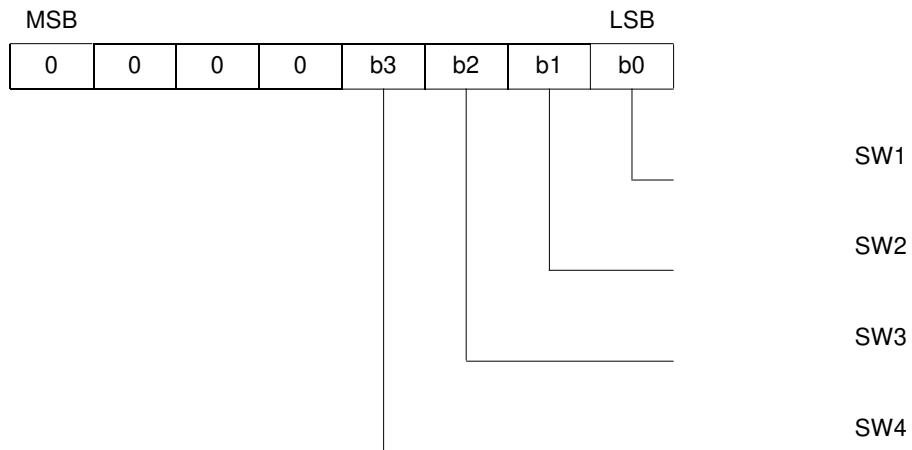


On power application, all the LEDs remain dark.

## 7 SW data

The SW data are read by the appropriate read command, starting from the least significant bit. Bits 5 through 8 of the SW data are 0.

**Figure 5. SW data**



## 8 Commands

A command sets the display mode and status of the VFD driver.

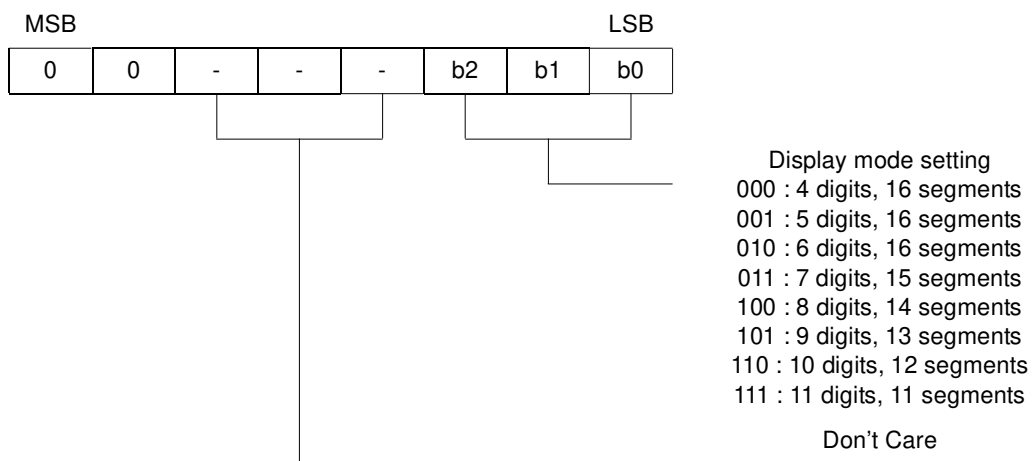
The first 1 byte input to the STM86312 through the D<sub>IN</sub> pin after the STB pin has fallen is regarded as a command. If STB is set high while commands/data are transmitted, serial communication is initialized, and the commands/data being transmitted are invalid (however, the commands/data already transmitted remain valid).

### 8.1 Display mode setting command

This command initializes the STM86312 and selects the number of segments and number of grids (1/4 to 1/11 duty, 11 segments to 16 segments).

When this command is executed, display is forcibly turned off, and key scanning is also stopped. To resume display, the display ON command must be executed. If the same mode is selected, however, nothing is performed.

**Figure 6. Display mode settings**

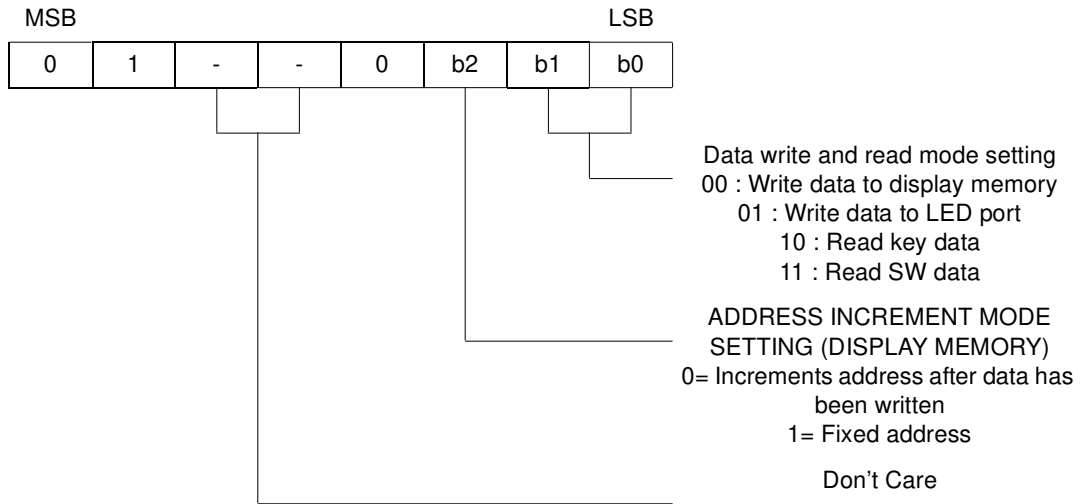


On power application, the 11-digit 11-segment mode is selected.

## 8.2 Data setting command

This command sets data write and data read modes.

**Figure 7. Data setting command**

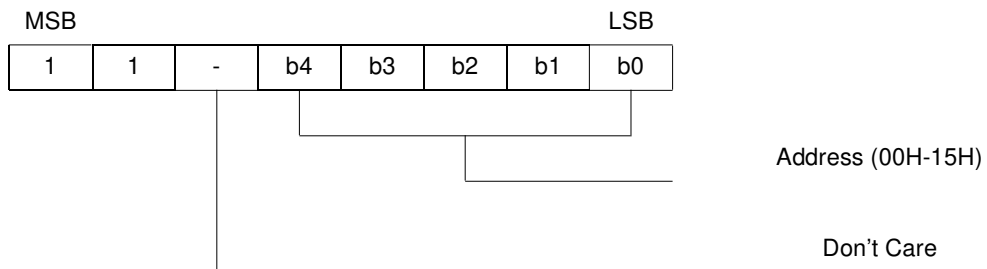


On power application, the normal operation mode and address increment mode are set.  
 Do not use STM86312 in test mode.

## 8.3 Address setting command

This command sets an address of the display memory

**Figure 8. Address setting command**

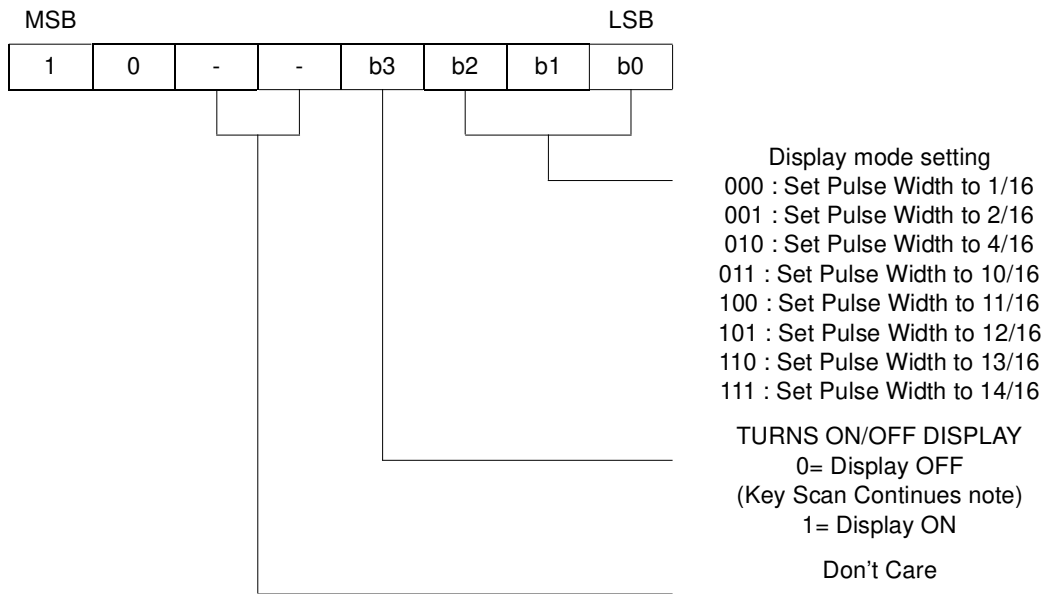


If address 16H or higher is set, the data are ignored, until a correct address is set.  
 On power application, the address is set to 00H.



### 8.4 Display control command

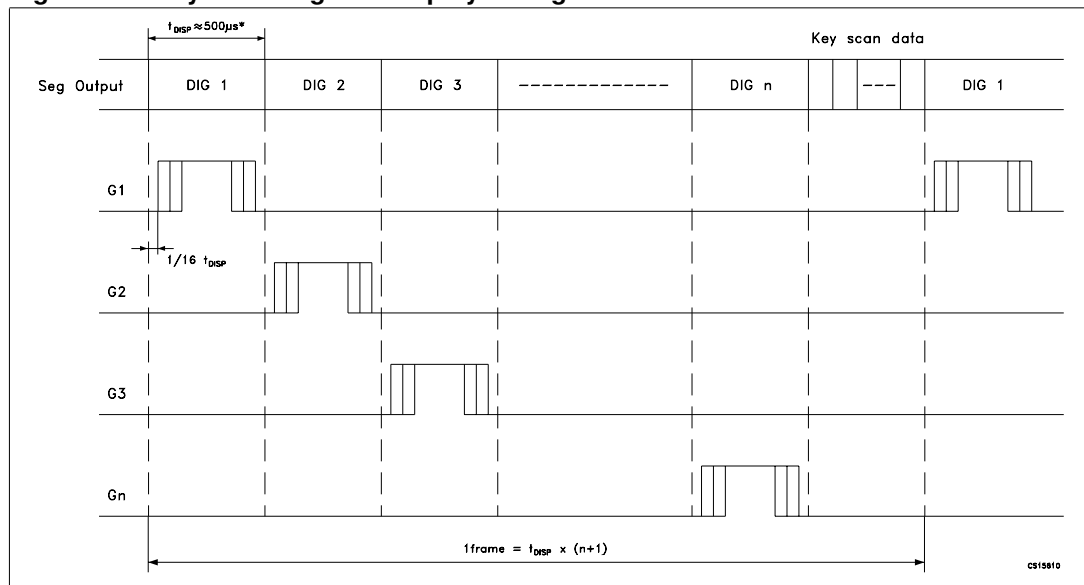
Figure 9. Display control command



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

Note: On power application, key scanning is stopped.

Figure 10. Key scanning and display timing



Note: \* The value can be modified by trimming  $R_{\text{OSC}}$ .

One cycle of key scanning consists of one frame, and data of 6 x 4 matrices are stored in RAM.

# 9 Serial communication format

Figure 11. Reception (command/data write)

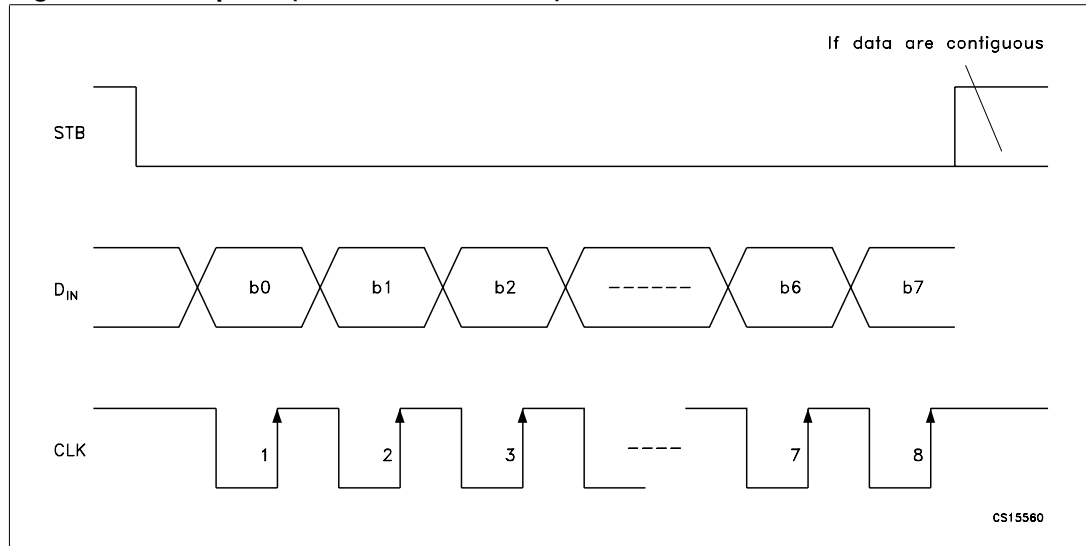
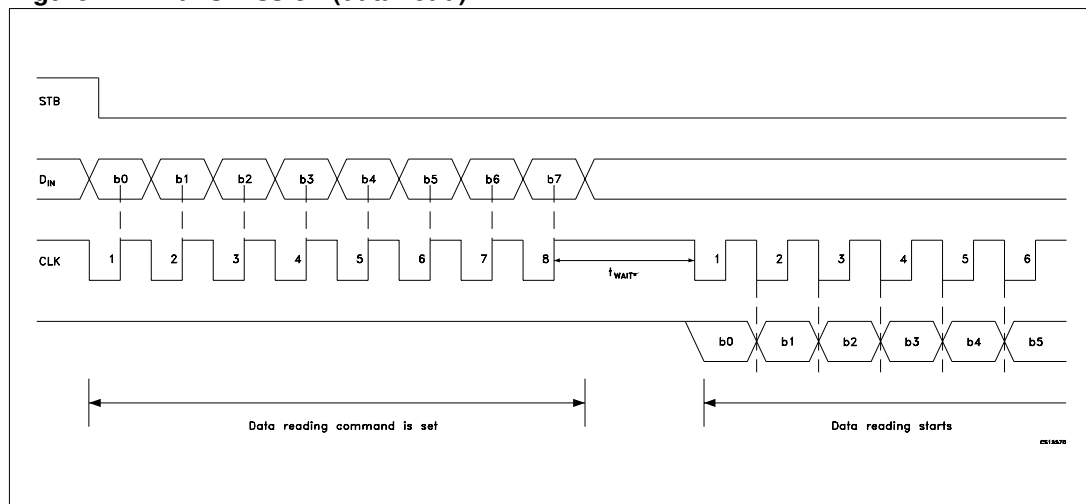


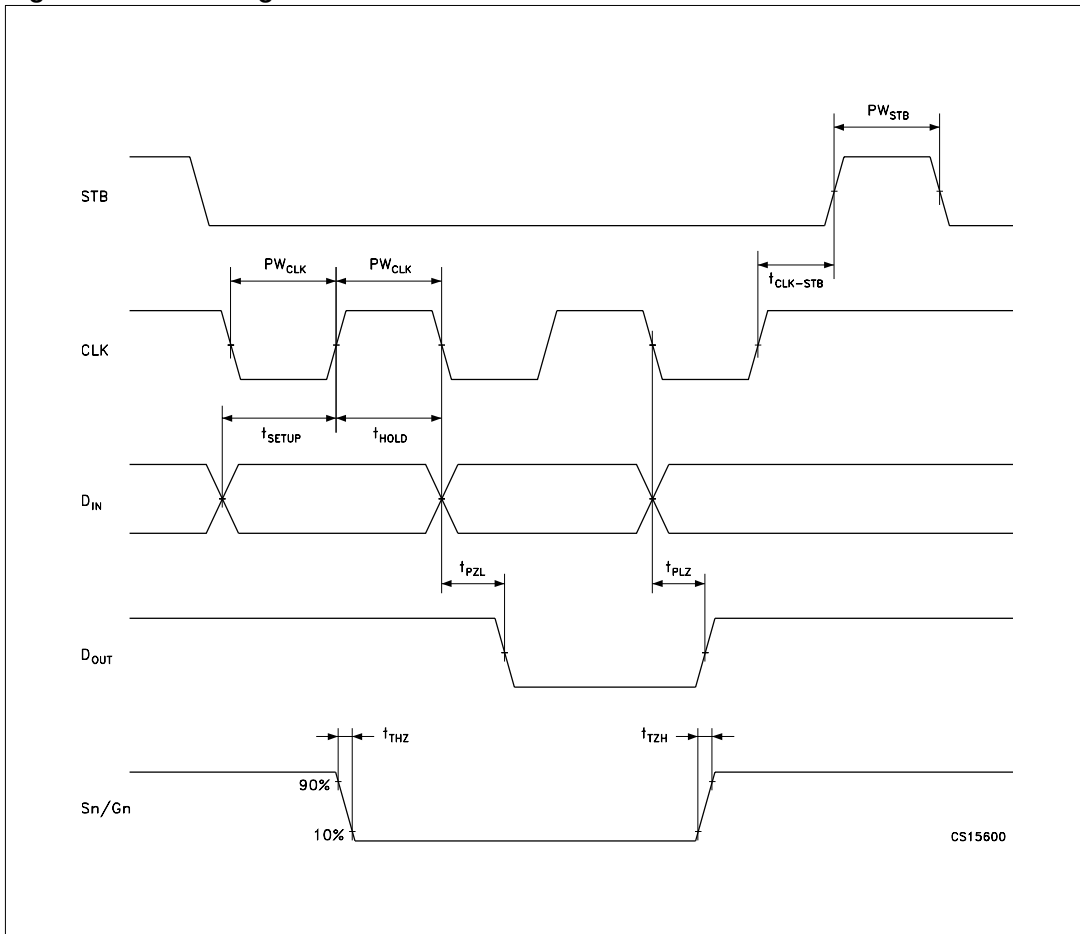
Figure 12. Transmission (data read)



Because the D<sub>OUT</sub> pin is an N-ch open-drain output pin, be sure to connect an external pull-up resistor to this pin (1 kΩ to 10 kΩ).

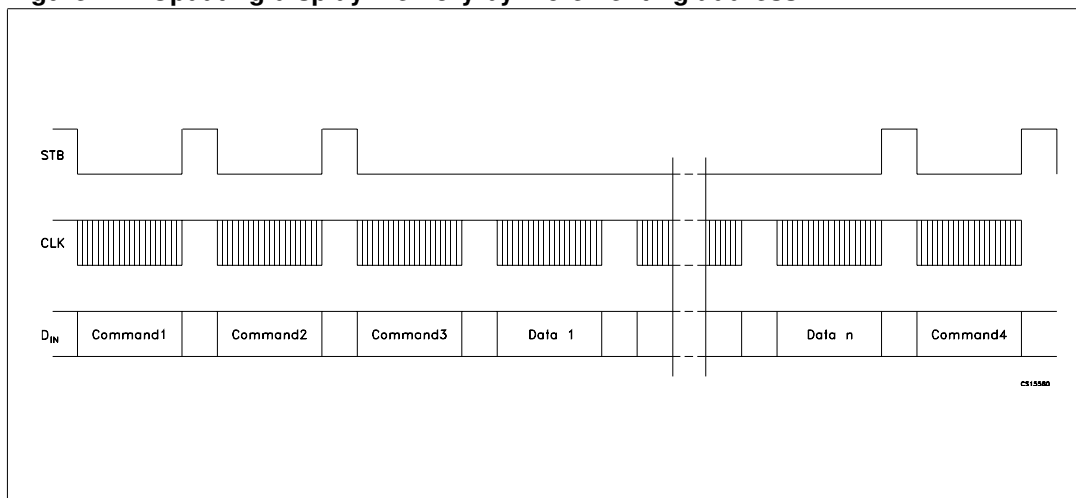
*Note:* \*: When data are read, a wait time  $t_{WAIT}$  of 1μs is necessary within the rising edge of the eighth clock that has set the command and the falling one of the first clock that has read the data.

Figure 13. Switching characteristics waveform



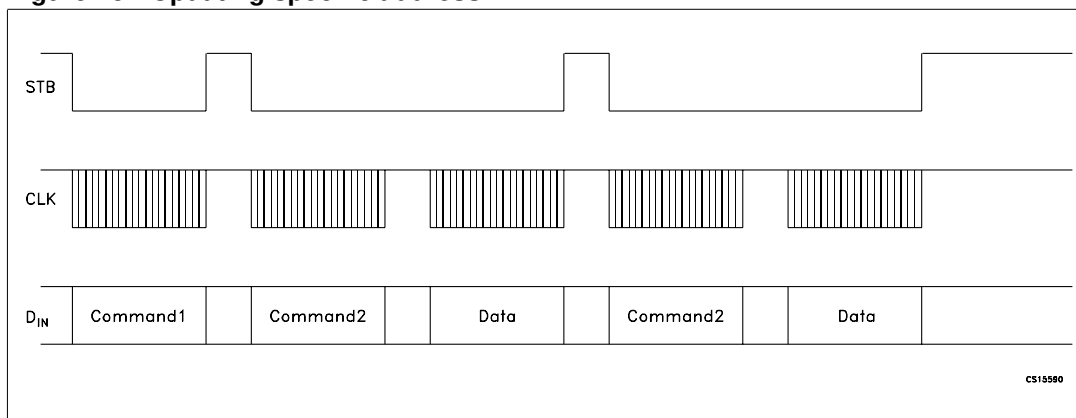
# 10 Application

**Figure 14. Updating display memory by incrementing address**



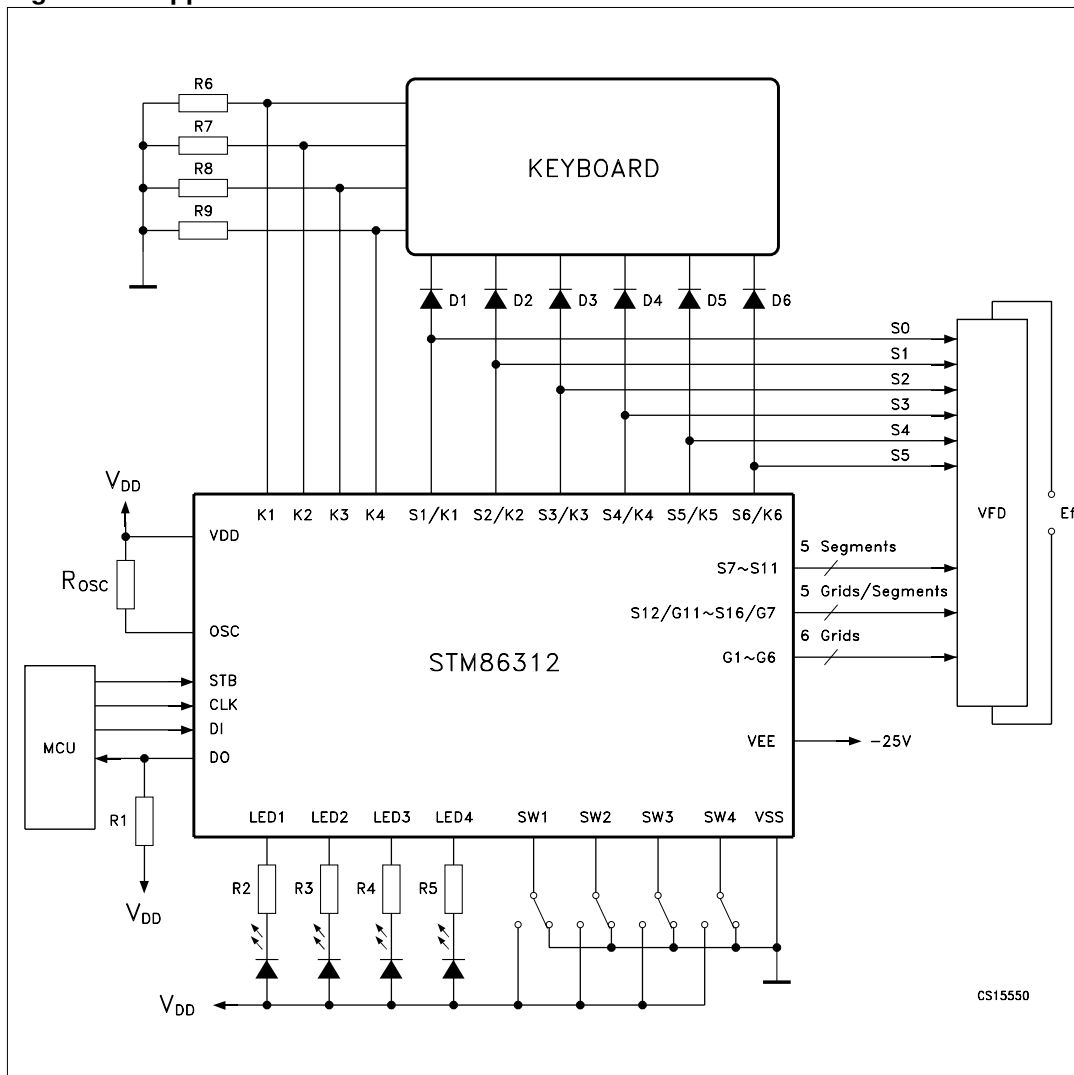
- Command 1: sets display mode
- Command 2: sets data
- Command 3: sets address
- Data 1 to n: transfers display data (22 bytes max.)
- Command 4: controls display

**Figure 15. Updating specific address**



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

Figure 16. Application circuit



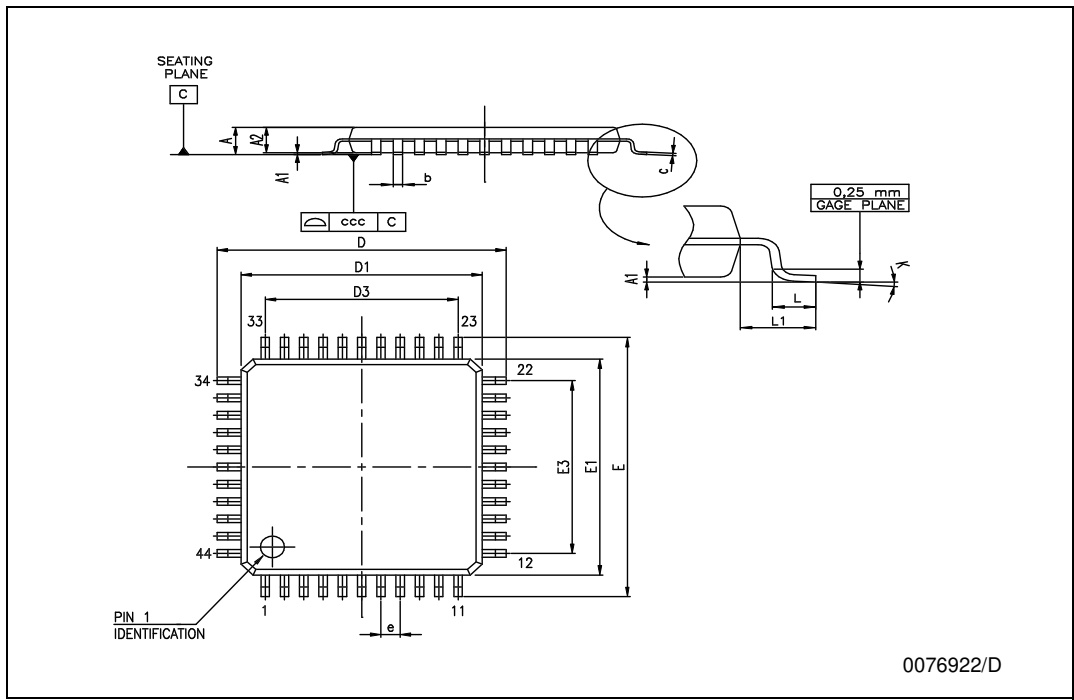
- Note:
- 1  $R_{OSC} = 47k\Omega$  for oscillator resistor
  - 2  $R1 = 1 \sim 10 k\Omega$  for external pull-high resistor
  - 3  $R2 \sim R5 = 750\Omega \sim 1.2 k\Omega$
  - 4  $R6 \sim R9 = 10k\Omega$  for external pull-low resistor
  - 5  $D1 \sim D6 = 1N4001$
  - 6  $Ef =$  Filament voltage for VFD.

## 11 Mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

**PQFP44 MECHANICAL DATA**

| DIM. | mm.  |       |      | inch  |       |       |
|------|------|-------|------|-------|-------|-------|
|      | MIN. | TYP   | MAX. | MIN.  | TYP.  | MAX.  |
| A    |      |       | 2.45 |       |       | 0.096 |
| A1   |      |       | 0.25 |       |       | 0.010 |
| A2   | 1.80 | 2.00  | 2.20 | 0.071 | 0.079 | 0.087 |
| b    | 0.29 |       | 0.45 | 0.011 |       | 0.018 |
| c    | 0.11 |       | 0.23 | 0.004 |       | 0.009 |
| D    |      | 13.2  |      |       | 0.520 |       |
| D1   |      | 10.00 |      |       | 0.394 |       |
| D3   |      | 8.00  |      |       | 0.315 |       |
| E    |      | 13.2  |      |       | 0.520 |       |
| E1   |      | 10.00 |      |       | 0.394 |       |
| E3   |      | 8.00  |      |       | 0.315 |       |
| e    |      | 0.80  |      |       | 0.031 |       |
| L    | 0.73 | 0.88  | 1.03 | 0.029 | 0.035 | 0.041 |
| L1   |      | 1.6   |      |       | 0.063 |       |
| K    | 0°   | 3.5°  | 7°   | 0°    | 3.5°  | 7°    |



## 12 Revision history

**Table 8. Revision history**

| <b>Date</b> | <b>Revision</b> | <b>Changes</b>        |
|-------------|-----------------|-----------------------|
| 27-May-2004 | 1               | First Release         |
| 27-Mar-2006 | 2               | New Temp, few changes |



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