

1/4- to 1/12-DUTY FIP™(VFD) CONTROLLER/DRIVER

DESCRIPTION

The μ PD16315 is a FIP (Fluorescent Indicator Panel, or Vacuum Fluorescent Display) controller/driver that is driven on a 1/4- to 1/12- duty factor. It consists of 16 segment output lines, 4 grid output lines, 8 segment/grid output drive lines, a display memory, a control circuit, and a key scan circuit. Serial data is input to the μ PD16315 through a three-line serial interface. This FIP controller/driver is ideal as a peripheral device for a single-chip microcomputer.

FEATURES

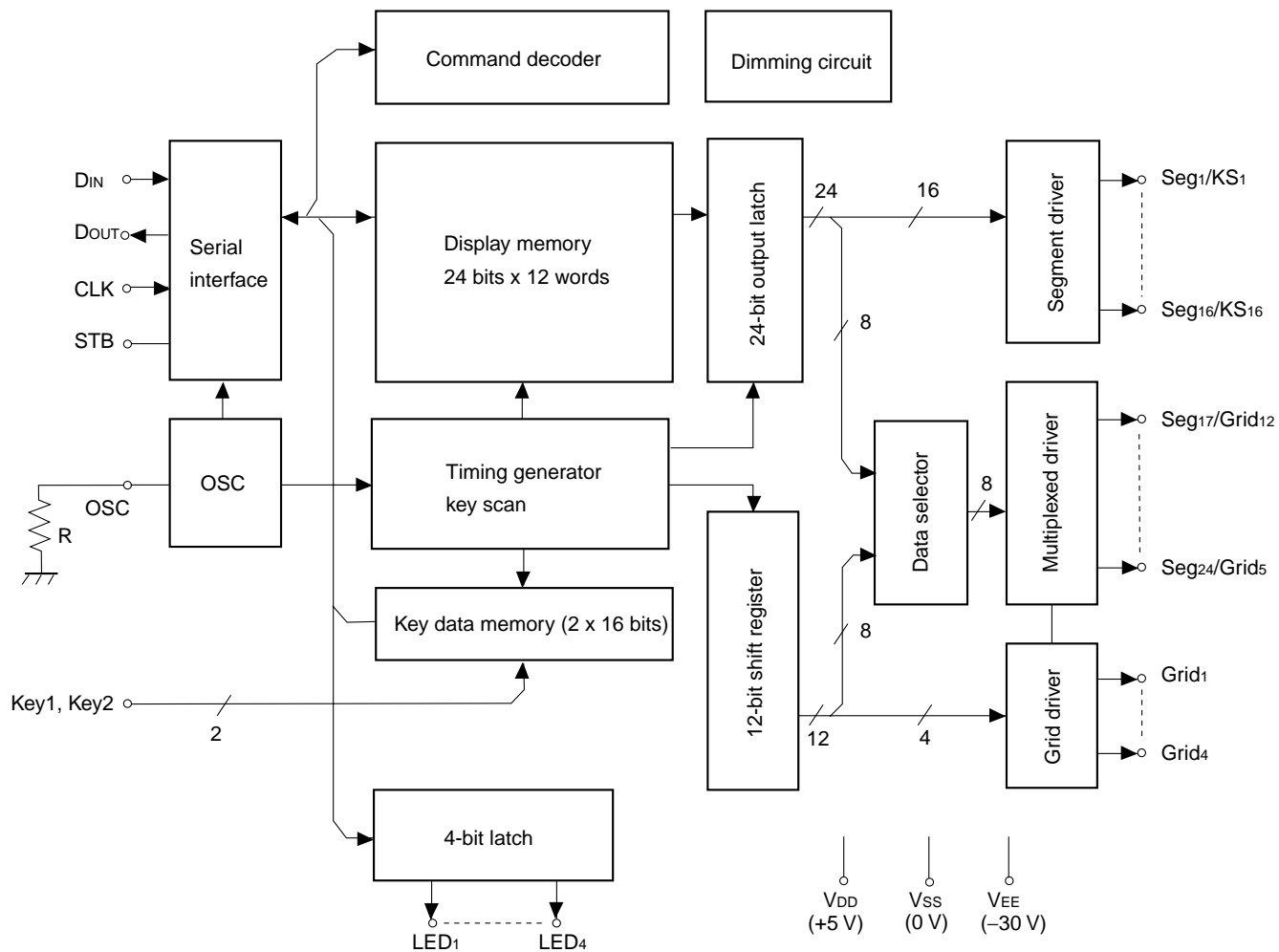
- Multiple display modes: 16-segment & 12-digit to 24-segment & 4-digit
- Key scanning: 16 x 2 matrix
- Dimming circuit: 8 steps
- High-withstanding-voltage output: $V_{DD} - 35$ V MAX.
- LED ports: 4 chs., 20 mA MAX.
- No external resistors necessary for driver outputs: P-ch open-drain + pull-down resistor output
- Serial interface: CLK, STB, DIN, DOUT

ORDERING INFORMATION

| Part Number | Package |
|---------------------|------------------------------|
| μ PD16315GB-3BS | 44-pin Plastic QFP (10 x 10) |

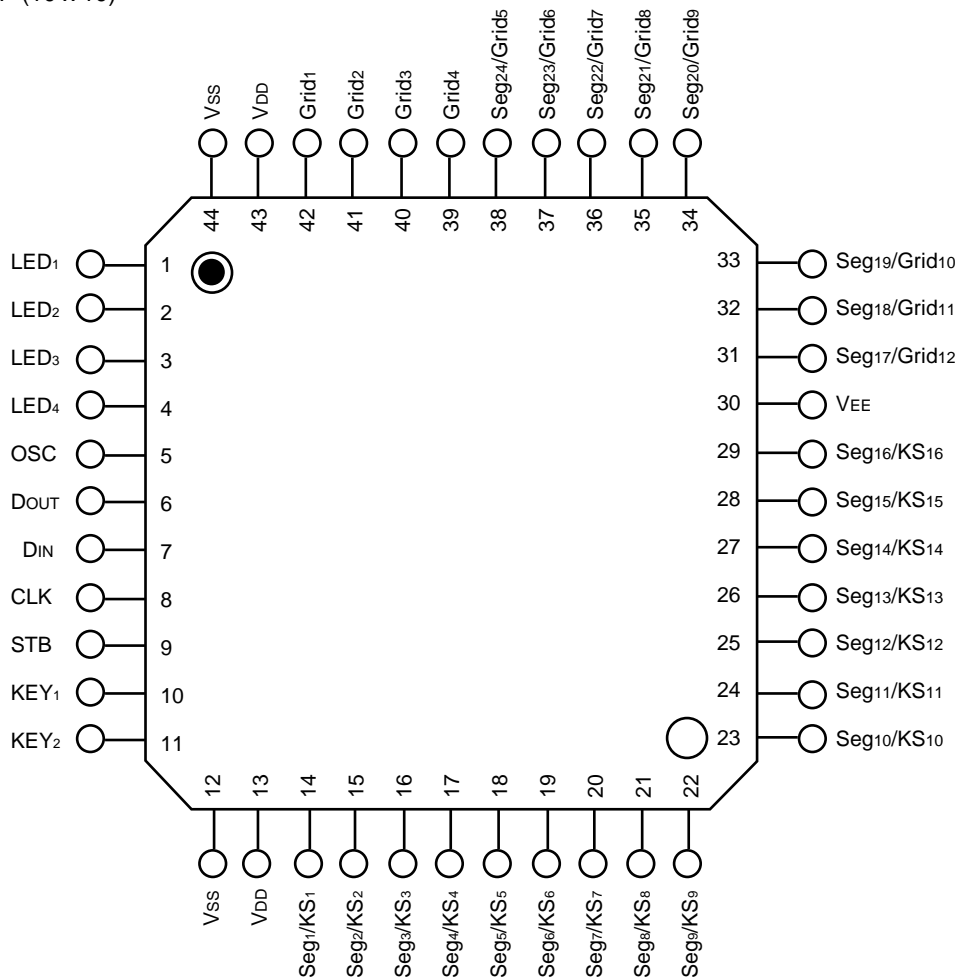
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1. BLOCK DIAGRAM



2. PIN CONFIGURATION (Top View)

44-pin Plastic QFP (10 x 10)



Caution Use all of the power supply pins.

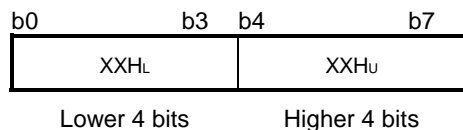
3. PIN FUNCTION

| Symbol | Pin Name | Pin No. | I/O | Description |
|--|--|----------|--------|---|
| D _{IN} | Data input | 7 | Input | Input serial data at rising edge of shift clock, starting from the low order bit. |
| D _{OUT} | Data output | 6 | 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. |
| STB | Strobe | 9 | – | Initializes serial interface at the rising or falling edge of the μ PD16315. 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 | Input | 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 _{SS}). |
| Seg ₁ /KS ₁ to Seg ₁₆ /KS ₁₆ | High-withstanding-voltage output (Segment) | 14 to 29 | Output | Segment output pins (Dual function as key source) |
| Grid ₁ to Grid ₄ | High-withstanding-voltage output (grid) | 39 to 42 | Output | Grid output pins |
| Seg ₁₇ /Grid ₁₂ to Seg ₂₄ /Grid ₅ | High-withstanding-voltage output (segment/grid) | 31 to 38 | Output | These pins are selectable for segment or grid driving. |
| LED ₁ to LED ₄ | LED output | 1 to 4 | Output | CMOS output, +20 mA MAX. |
| KEY ₁ , KEY ₂ | Key data input | 10, 11 | Input | Data input to these pins is latched at the end of the display cycle. |
| V _{DD} | Logic power | 13, 43 | – | 5 V \pm 10% |
| V _{SS} | Logic ground | 12, 44 | – | Connect this pin to system GND. |
| V _{EE} | Pull-down level | 30 | – | V _{DD} – 35 V MAX. |

4. DISPLAY RAM ADDRESS AND DISPLAY MODE

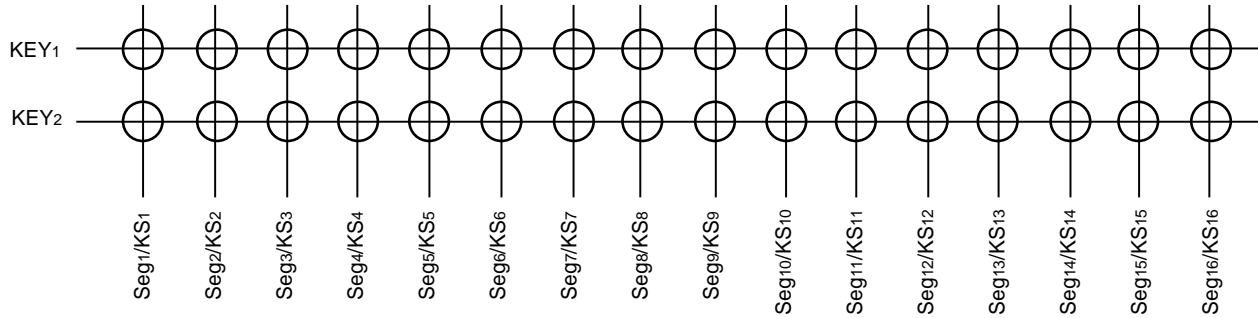
The display RAM stores the data transmitted to the μPD16315 through the serial communication. The addresses are allocated in 8-bit units.

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

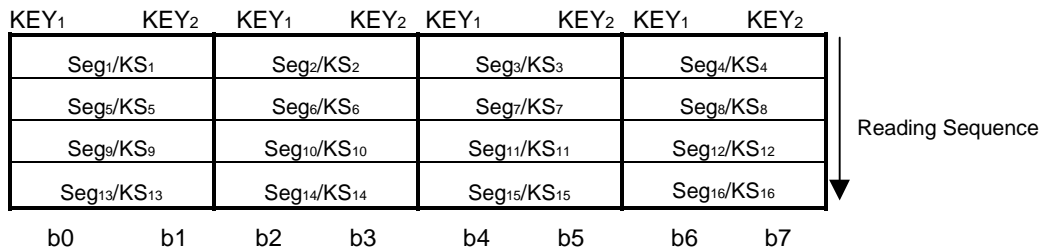


5. KEY MATRIX AND KEY-INPUT DATA STORAGE RAM

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

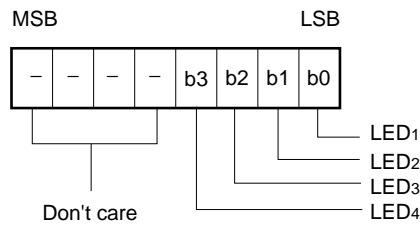


The data of each key is stored as follows, and is read with the read command starting from the least significant bit.



5.1 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 5th bit are ignored.



Remark Power ON application, all the LED ports are “L” output.

6. COMMANDS

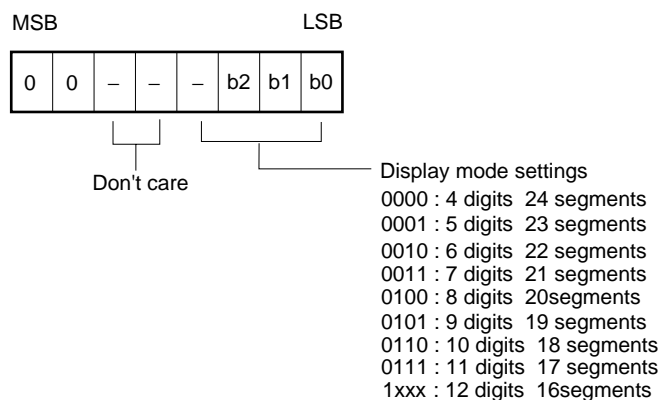
Commands set the display mode and status of the FIP™ (VFD) driver.

The first 1 byte input to the μPD16315 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 μPD16315 and select the number of segments and the number of grids (1/4- to 1/12-duty, 16 segments to 24 segments).

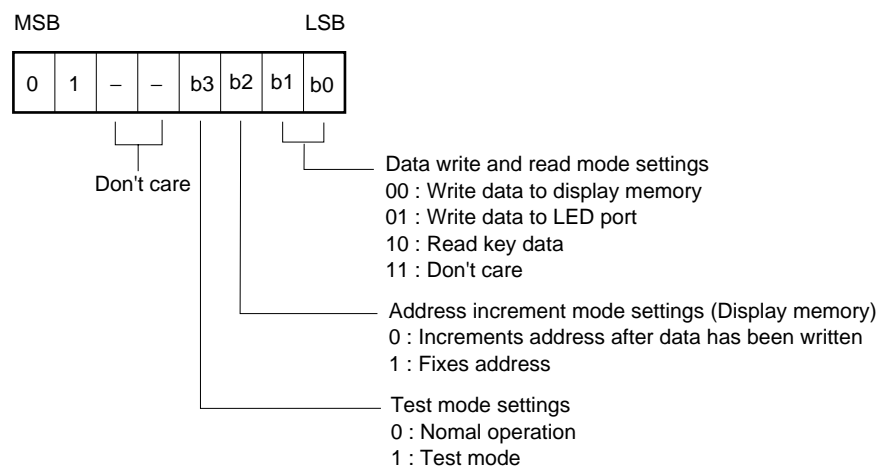
When these commands are executed, the display is forcibly turned OFF, and key scanning is also stopped. To resume display, the display command “ON” must be executed. If the same mode is selected, however, nothing happens.



Remark Power ON application, the 12-digit, 16-segment mode is selected.

(2) Data setting commands

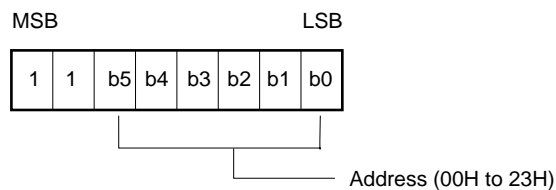
These commands set data write and data read modes.



Remark Power ON application, the normal operation and address increment modes are set.

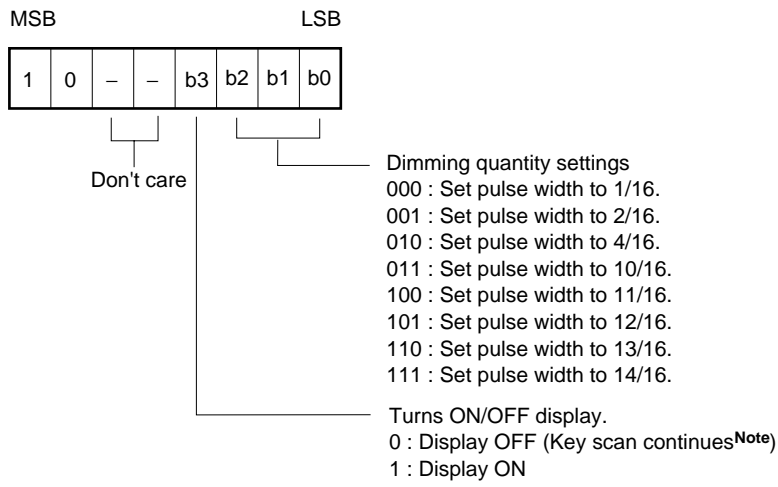
(3) Address setting commands

These commands set an address of the display memory.



- Remarks**
1. If address 24H or higher is set, data is ignored, until a valid address is set.
 2. Power ON application, the address is set to 00H.

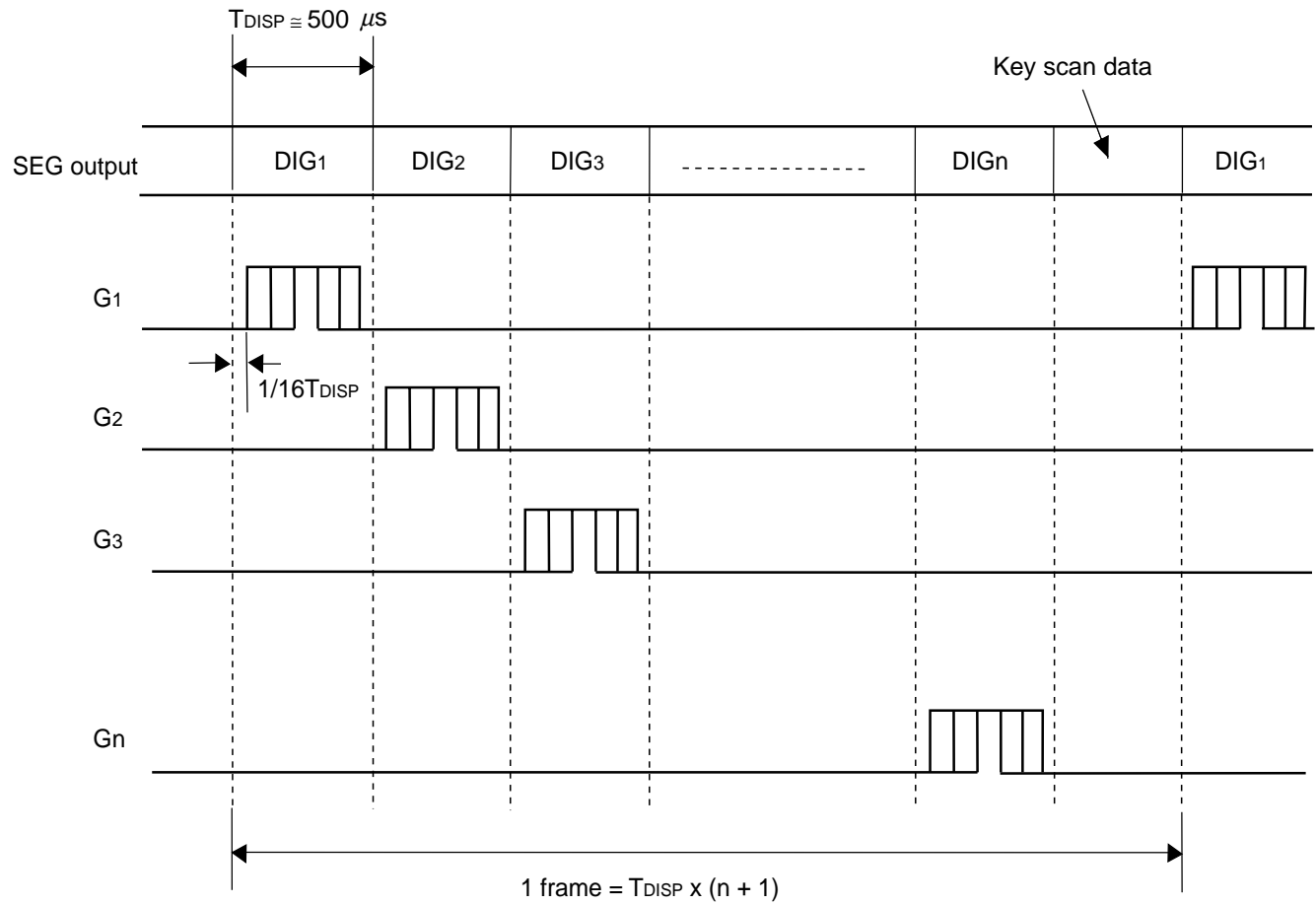
(4) Display control commands



Note Power ON application, key scanning is stopped.

Remark Power ON application, the 1/16 pulse width is set and the display is turned OFF.

7. KEY SCANNING AND DISPLAY TIMING



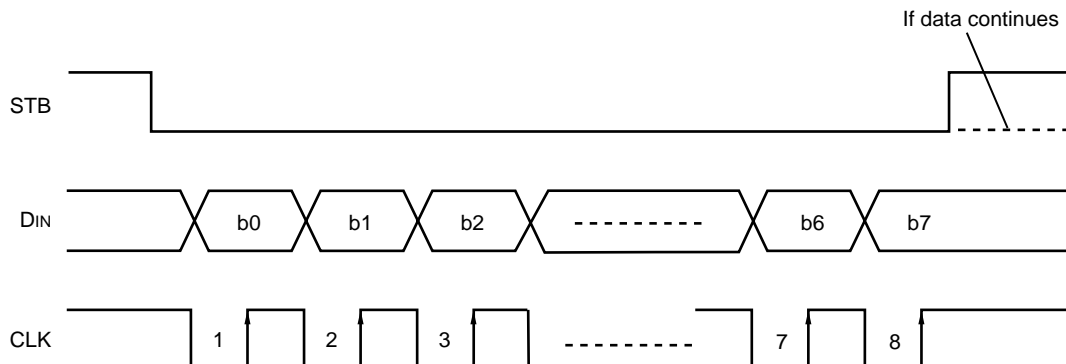
Remark One cycle of key scanning consists of two frame, and data in a 16 x 2 matrix is stored in RAM.

Key Scan Expansion

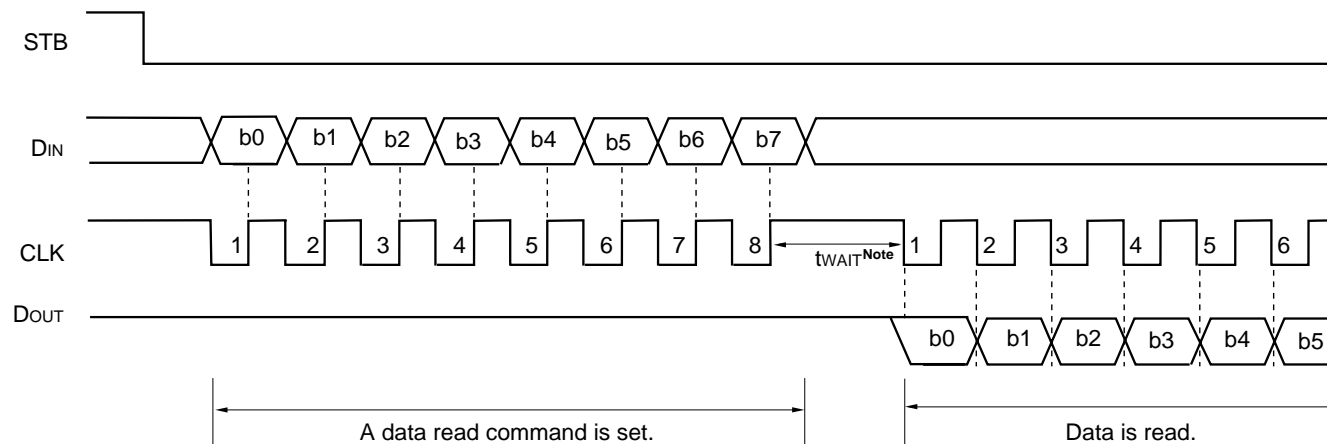
| | | | | | | | | | | |
|-----------|------|---|----|----|----|----|----|----|----|------|
| 1st frame | DIGn | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DIG1 |
| 2nd frame | | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | |

8. SERIAL COMMUNICATION FORMAT

Reception (command/data write)



Transmission (data read)



Note When data is read, a wait time t_{WAIT} of 1 μs 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 to 10 kΩ) to this pin.

9. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_A = 25°C, V_{SS} = 0 V)

| Parameter | Symbol | Ratings | 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 |
| FIP Driver Output Voltage | V _{O2} | V _{EE} - 0.5 to V _{DD} + 0.5 | V |
| LED Driver Output Current | I _{O1} | ±20 | mA |
| FIP Driver Output Current | I _{O2} | -40 (grid) -15 (segment) | mA |
| Power Dissipation | P _D | 800 ^{Note} | mW |
| Operating Ambient Temperature | T _A | -40 to +85 | °C |
| Storage Temperature | T _{stg} | -65 to +150 | °C |

Note Derate at -6.4 mW/°C at T_A = 25°C or higher.

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Operating Range (T_A = -20 to 70°C, V_{SS} = 0 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.} = FIP driver dissipation + R_L dissipation + LED driver dissipation + dynamic power consumption

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

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

R_L dissipation ≅ (V_{DD} - V_{EE})²/50 x (number of segments + 1) (mW)

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

Dynamic power consumption = V_{DD} x 5 (mW)

Electrical Characteristics (T_A = -20 to +70°C, V_{DD} = 4.5 to 5.5 V, V_{SS} = 0 V, V_{EE} = V_{DD} - 35 V)

| Parameter | Symbol | Test Conditions | MIN. | TYP. | MAX. | Unit |
|-----------------------------|--------------------|---|---------------------|------|---------------------|------|
| High-Level Output Voltage | V _{OH1} | LED ₁ - LED ₄ , I _{OH1} = -15 mA | V _{DD} - 1 | | | V |
| Low-Level Output Voltage | V _{OL1} | LED ₁ - LED ₄ , I _{OL1} = +15 mA | | | 1 | V |
| Low-Level Output Voltage | V _{OL2} | D _{OUT} , I _{OL2} = 4 mA | | | 0.4 | V |
| High-Level Output Current | I _{OH21} | V _O = V _{DD} - 2 V, Seg ₁ /KS ₁ to Seg ₁₆ /KS ₁₆ | -3 | | | mA |
| High-Level Output Current | I _{OH22} | V _O = V _{DD} - 2 V, Grid ₁ to Grid ₄ Seg ₁₇ /Grid ₁₂ to Seg ₂₄ /Grid ₅ | -15 | | | mA |
| Driver Leakage Current | I _{OLEAK} | V _O = V _{DD} - 35 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} | | 0.7 V _{DD} | | | V |
| Low-Level Input Voltage | V _{IL} | | | | 0.3 V _{DD} | V |
| Hysteresis Voltage | V _H | CLK, D _{IN} , STB | | 0.35 | | V |
| Dynamic Current Consumption | I _{DDdyn} | Under no load, display OFF | | | 5 | mA |

Switching Characteristics (T_A = -20 to +70°C, V_{DD} = 4.5 to 5.5 V, V_{EE} = -30 V)

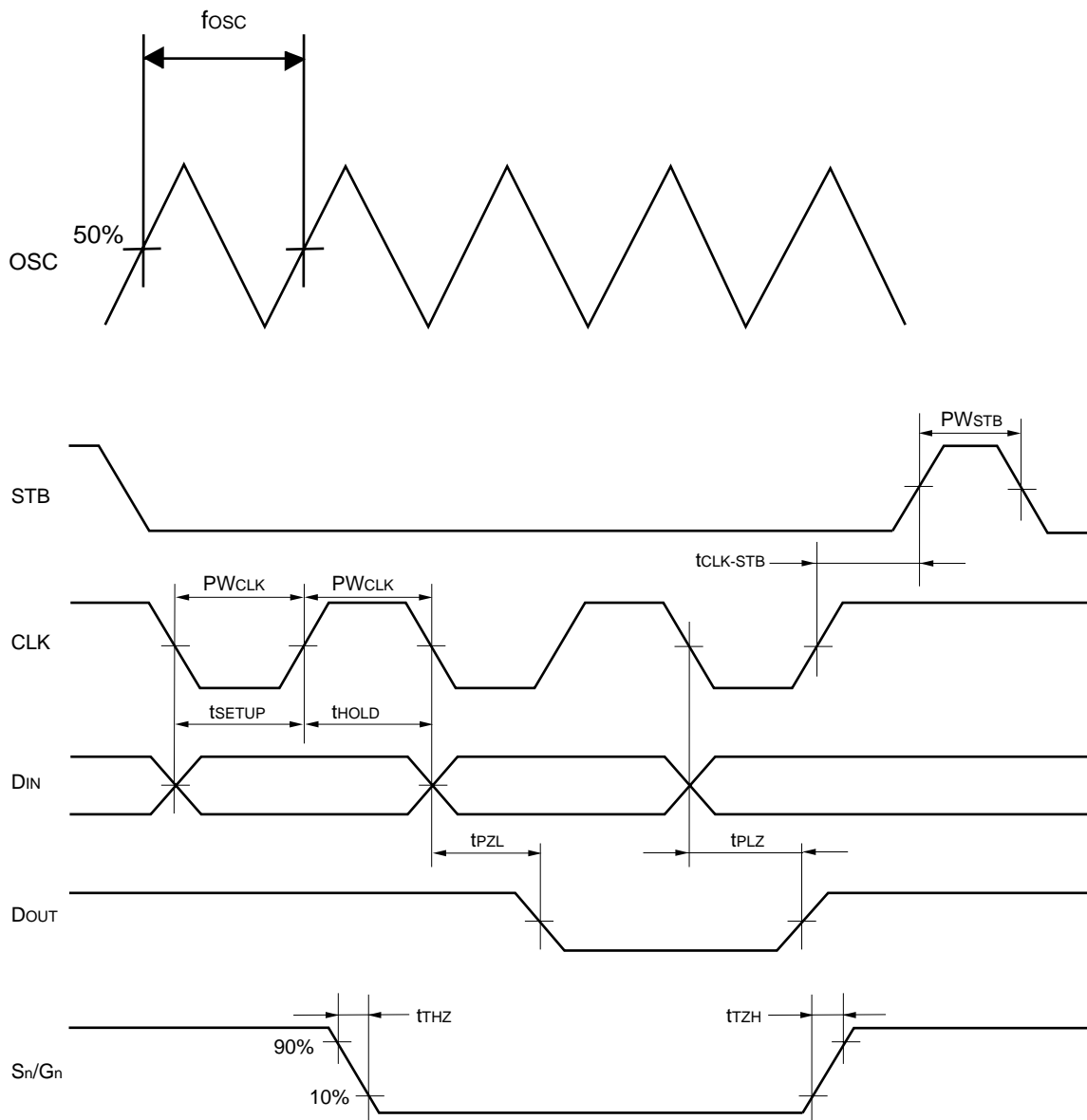
| Parameter | Symbol | Test Conditions | MIN. | TYP. | MAX. | Unit |
|-------------------------|-------------------|---|--|------|------|------|
| Oscillation Frequency | f _{OSC} | R = 82 kΩ | 350 | 500 | 650 | kHz |
| Propagation Delay Time | t _{PLZ} | CLK → D _{OUT} | | | 300 | ns |
| | t _{PZL} | C _L = 15 pF, R _L = 10 kΩ | | | 100 | ns |
| Rise Time | t _{TZH1} | C _L = 300 pF Seg ₁ /KS ₁ to Seg ₁₆ /KS ₁₆ | | | 2 | μs |
| | t _{TZH2} | | Grid ₁ to Grid ₄ , Seg ₁₇ /Grid ₁₂ to Seg ₂₄ /Grid ₅ | | | 0.5 |
| Fall Time | t _{THZ} | C _L = 300 pF, Seg _n , Grid _n | | | 160 | μs |
| Maximum Clock Frequency | f _{MAX} | Duty = 50% | 1 | | | MHz |
| Input Capacitance | C _I | | | | 15 | pF |

Timing Conditions (T_A = -20 to 70°C, V_{DD} = 4.5 to 5.5 V)

| Parameter | Symbol | Test Conditions | MIN. | TYP. | MAX. | Unit |
|--------------------|----------------------|-------------------------------|------|------|------|------|
| Clock Pulse Width | PW _{CLK} | | 400 | | | ns |
| Strobe Pulse Width | PW _{STB} | | 1 | | | μs |
| Data Setup Time | t _{SETUP} | | 100 | | | ns |
| Data Hold Time | t _{HOLD} | | 100 | | | ns |
| Clock-Strobe Time | t _{CLK-STB} | CLK ↑ → STB ↑ | 1 | | | μs |
| Wait Time | t _{WAIT} | CLK ↑ → CLK ↓ ^{Note} | 1 | | | μs |

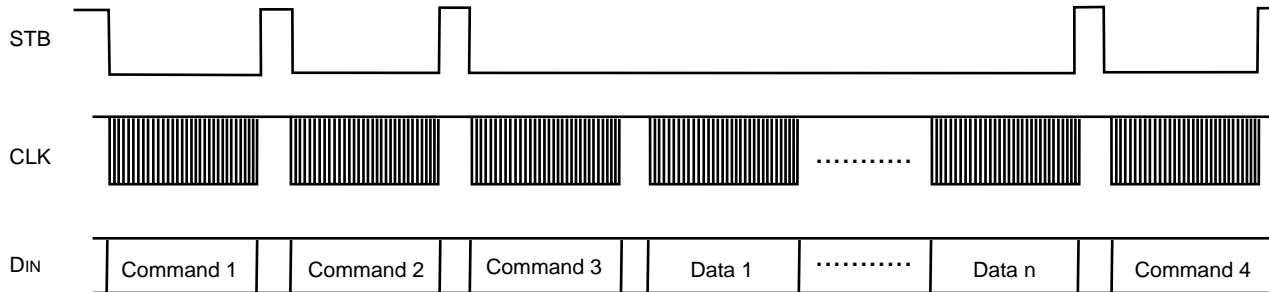
Note Refer to the **SERIAL COMMUNICATION FORMAT**.

Switching Characteristic Waveforms



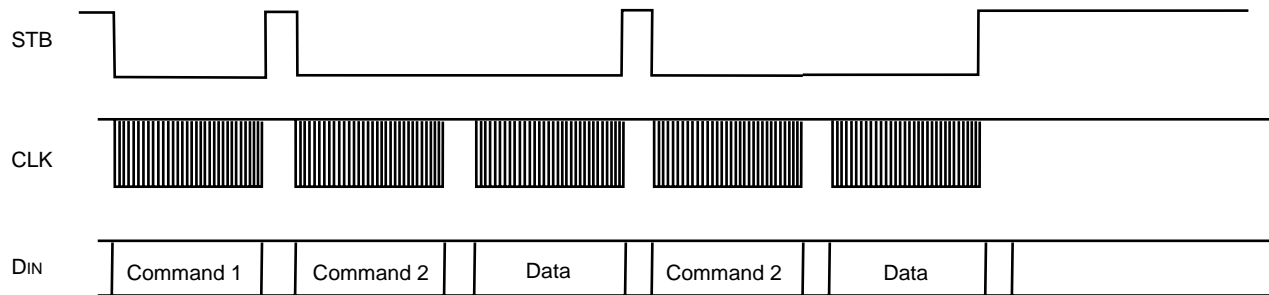
10. APPLICATIONS

Updating display memory by incrementing address



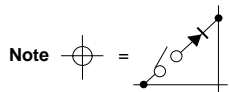
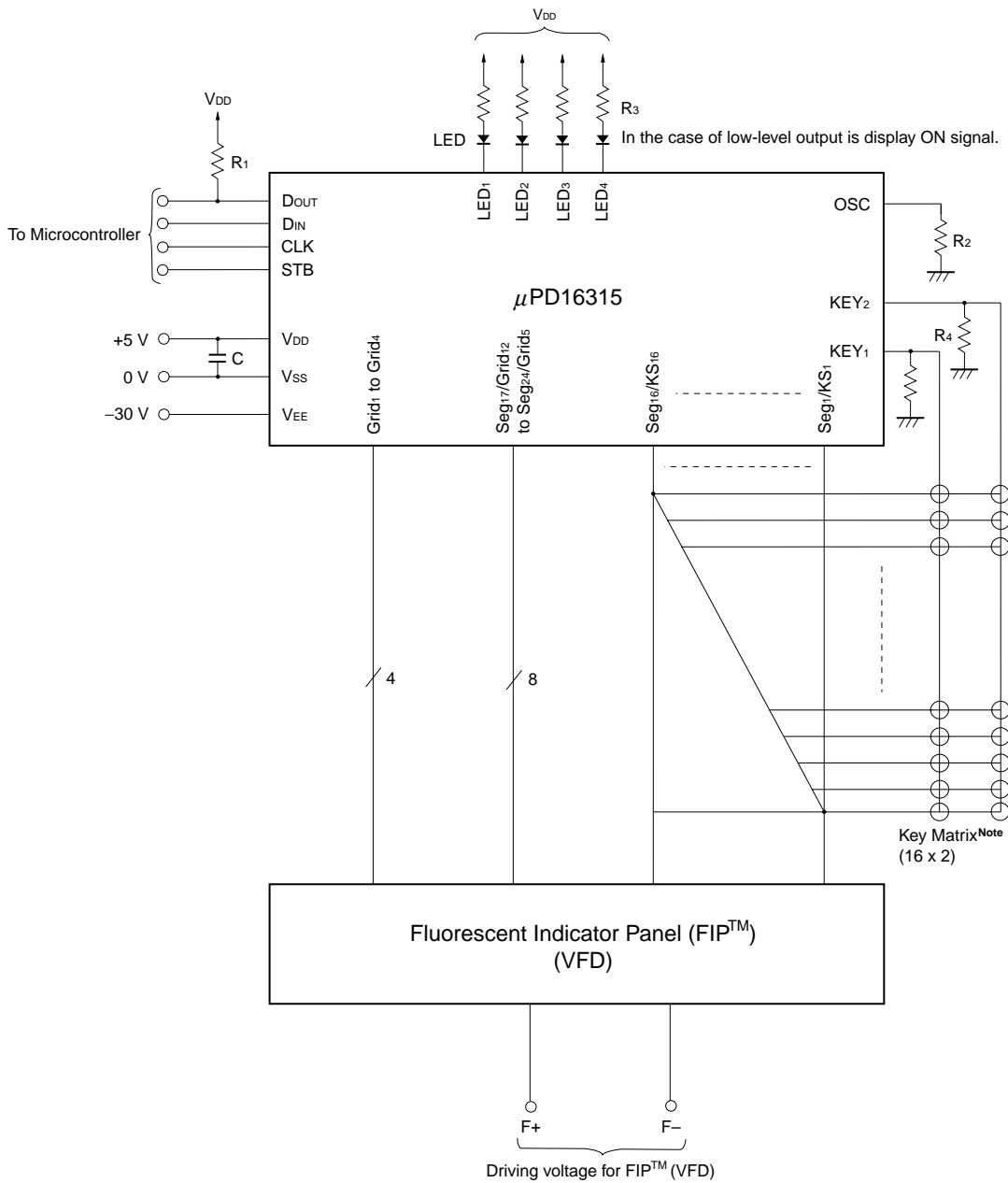
- Command 1 : sets display mode
- Command 2 : sets data
- Command 3 : sets address
- Data 1 to n : transfers display data (36 bytes MAX.)
- Command 4 : controls display

Updating specific address



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

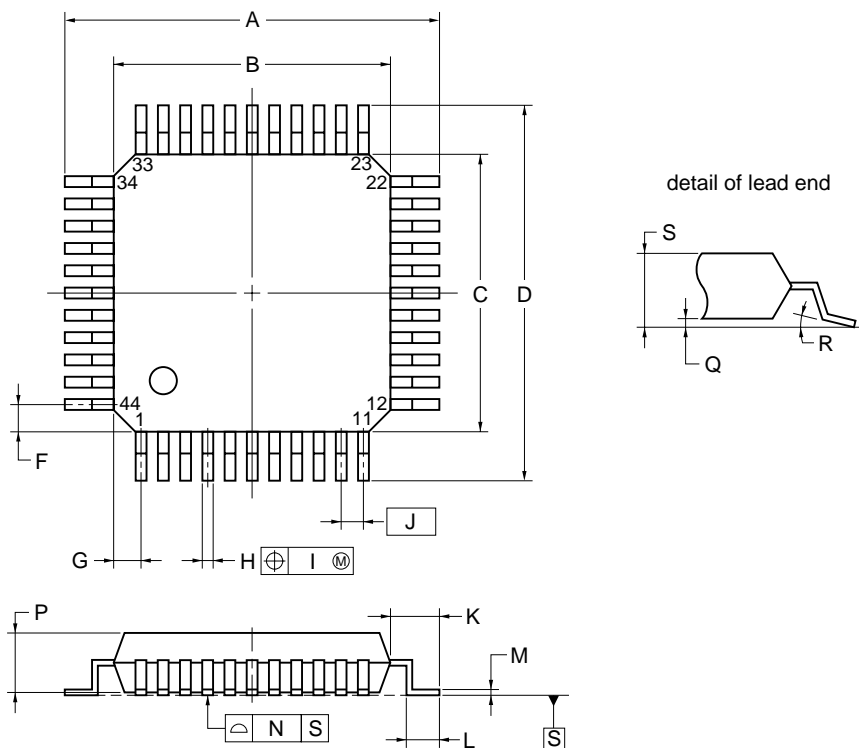
11. CIRCUIT EXAMPLE FOR APPLICATION



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

12. PACKAGE DRAWING

44-PIN PLASTIC QFP (10x10)



NOTE

Each lead centerline is located within 0.16 mm of its true position (T.P.) at maximum material condition.

| ITEM | MILLIMETERS |
|-----------------------|--|
| A | 13.2±0.2 |
| B | 10.0±0.2 |
| C | 10.0±0.2 |
| D | 13.2±0.2 |
| F | 1.0 |
| G | 1.0 |
| H | 0.37 ^{+0.08} _{-0.07} |
| I | 0.16 |
| J | 0.8 (T.P.) |
| K | 1.6±0.2 |
| L | 0.8±0.2 |
| M | 0.17 ^{+0.06} _{-0.05} |
| N | 0.10 |
| P | 2.7±0.1 |
| Q | 0.125±0.075 |
| R | 3 [°] _{-3[°]} |
| S | 3.0 MAX. |
| S44GB-80-3BS-2 | |

13. RECOMMENDED SOLDERING CONDITIONS

The following conditions must be met for soldering conditions of the μ PD16315.

For more details, refer to the **Semiconductor Device Mounting Technology Manual (C10535E)**.

Please consult with our sales offices in case other soldering process is used, or in case the soldering is done under different conditions.

Type of Surface Mount Device

μ PD16315GB-3BS : 44-pin plastic QFP (10 x 10)

| Soldering process | Soldering conditions | Symbol |
|------------------------|---|-----------|
| Infrared ray reflow | Peak package's surface temperature: 235°C or below, Reflow time: 30 seconds or below (210°C or higher), Number of reflow process: MAX.3 | IR35-00-3 |
| VPS | Peak package's temperature: 215°C or below, Reflow time: 25 to 40 seconds (200°C or higher), Number of reflow process: MAX.3 | VP15-00-3 |
| Wave Soldering | Solder temperature: 260°C or below, Flow time: 10 seconds or below Temperature of pre-heat: 120°C or below (Plastic surface temperature) Number of flow process: 1 | WS60-00-1 |
| Partial heating method | Terminal temperature: 300°C or below, Time 3 seconds or below (per side of pin position) | - |

Caution Do not apply more than a single process at once, except for partial heating method.

NOTES FOR CMOS DEVICES**① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.