

1/4- to 1/11-DUTY FIP™ (VFD) CONTROLLER/DRIVER

The μ PD16312 is a FIP (fluorescent Indicator Panel, or Vacuum Fluorescent Display) controller/driver that is driven on a 1/4- to 1/11 duty factor. It consists of 11 segment 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 μ PD16312 through a three-line serial interface. This FIP controller/driver is ideal as a peripheral device for a single-chip microcomputer.

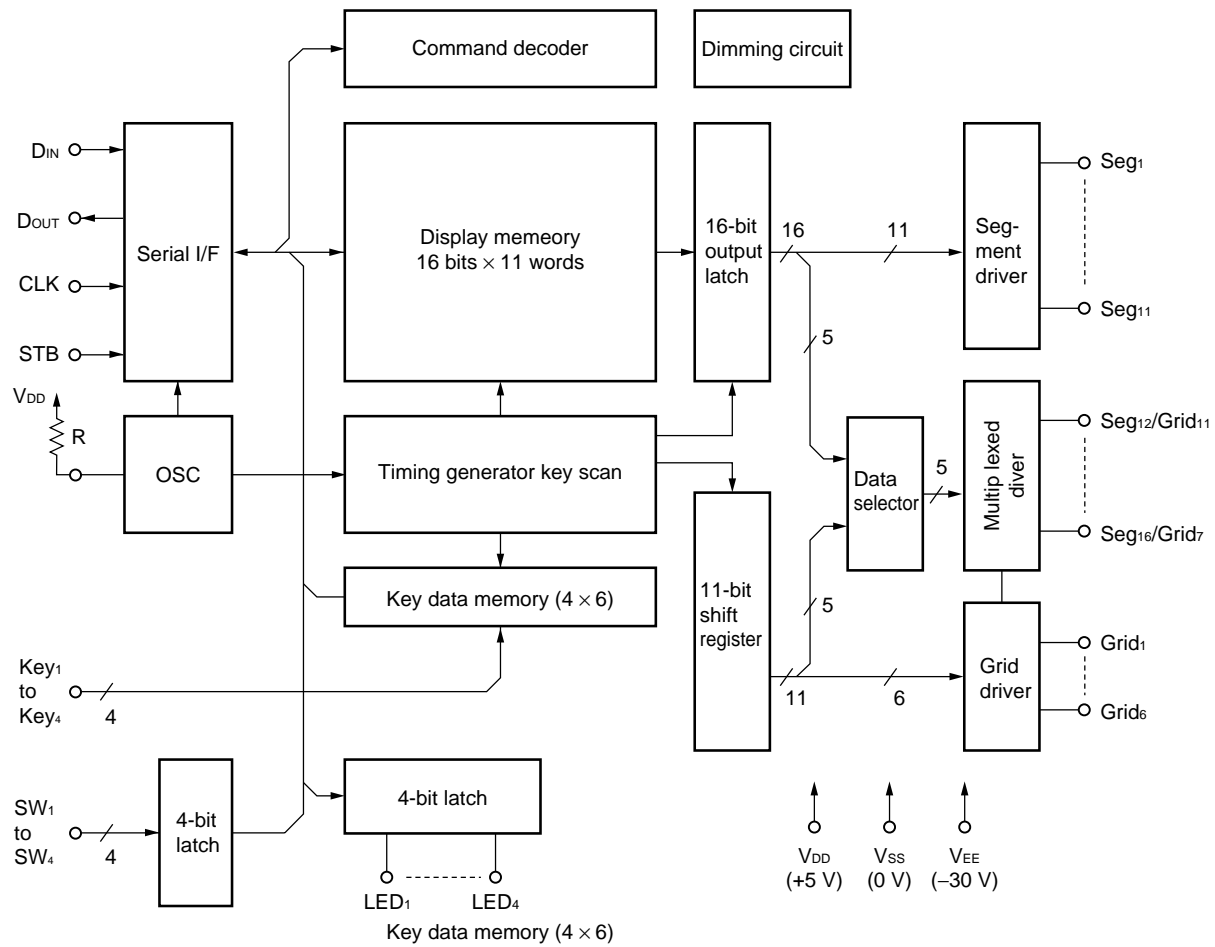
FEATURES

- Multiple display modes (11-segment & 11-digit to 16-segment & 4-digit)
- Key scanning (6 × 4 matrix)
- Dimming circuit (eight steps)
- High-voltage output ($V_{DD} - 35\text{ V max}$).
- LED ports (4 chs., 20 mA max).
- General-purpose input port (4 bits)
- No external resistors necessary for driver outputs (P-ch open-drain + pull-down resistor output)
- Serial interface (CLK, STB, DIN, DOUT)

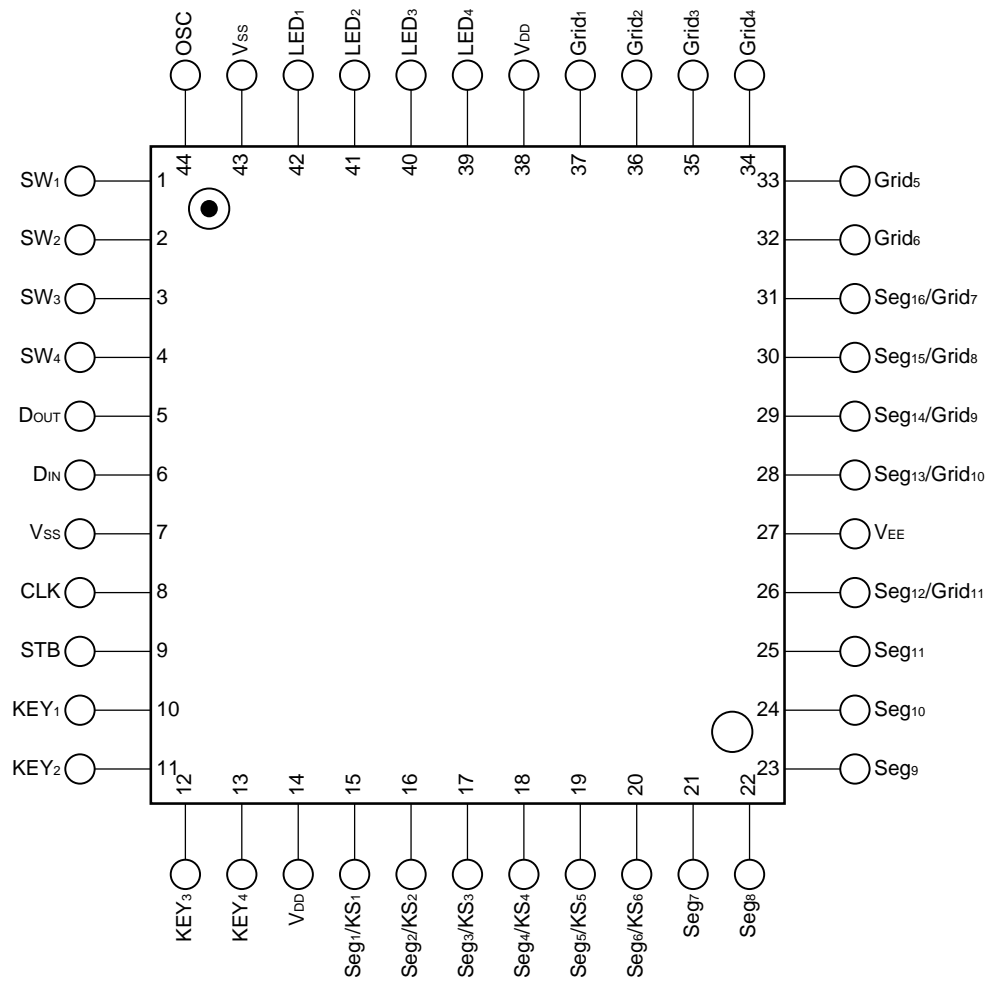
ORDERING INFORMATION

Part Number	Package
μ PD16312GB-3B4	44-pin plastic QFP ($\square 10$)

BLOCK DIAGRAM



PIN CONFIGURATION (Top View)



Use all power pins.

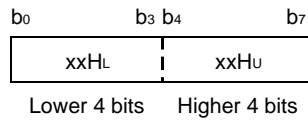
Pin Function

Symbol	Pin Name	Pin No	Description
D _{IN}	Data input	6	Input serial data at rising edge of shift clock, starting from the low order bit.
D _{OUT}	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 μPD16312. 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	44	Connect resistor to this pin to determine the oscillation frequency to this pin.
Seg ₁ /KS ₁ to Seg ₆ /KS ₆	High-voltage output	15 to 20	Segment output pins (Dual function as key source)
Seg ₇ to Seg ₁₁	High-voltage output (segment)	21 to 25	Segment output pins
Grid ₁ to Grid ₆	High-voltage output (grid)	37 to 32	Grid output pins
Seg ₁₂ /Grid ₁₁ to Seg ₁₆ /Grid ₇	High-voltage output (segment/grid)	26, 28 to 31	These pins are selectable for segment or grid driving.
LED ₁ to LED ₄	LED output	42 to 39	CMOS output. +20 mA max.
KEY ₁ to KEY ₄	Key data input	10 to 13	Data input to these pins is latched at the end of the display cycle.
SW ₁ to SW ₄	Switch input	1 to 4	These pins constitute a 4-bit general-purpose input port.
V _{DD}	Logic power	14, 38	5 V ± 10 %
V _{SS}	Logic ground	7, 43	Connect this pin to system GND.
V _{EE}	Pull-down level	27	V _{DD} – 35 V max.

Display RAM Address and Display Mode

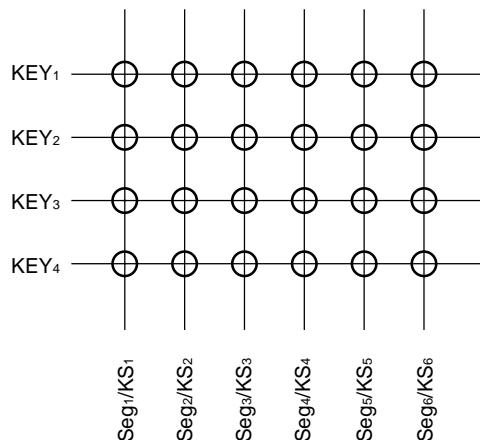
The display RAM stores the data transmitted from an external device to the μPD16312 through the serial interface, and is assigned addresses as follows, in 8 bits unit:

Seg ₁	Seg ₄	Seg ₈	Seg ₁₂	Seg ₁₆	
00HL	00Hu	01HL	01Hu		DIG ₁
02HL	02Hu	03HL	03Hu		DIG ₂
04HL	04Hu	05HL	05Hu		DIG ₃
06HL	06Hu	07HL	07Hu		DIG ₄
08HL	08Hu	09HL	09Hu		DIG ₅
0AHL	0AHu	0BHL	0BH _u		DIG ₆
0CHL	0CH _u	0DHL	0DH _u		DIG ₇
0EHL	0EH _u	0FHL	0FH _u		DIG ₈
10HL	10Hu	11HL	11Hu		DIG ₉
12HL	12Hu	13HL	13Hu		DIG ₁₀
14HL	14Hu	15HL	15Hu		DIG ₁₁

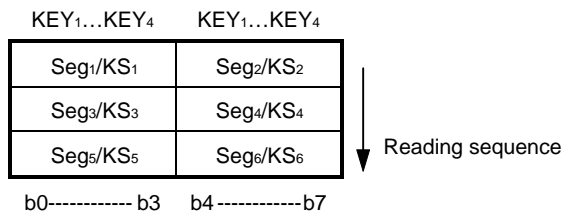


Key Matrix and Key-Input Data Storage RAM

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

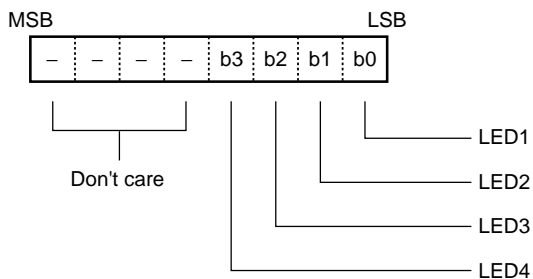


The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.



LED Port

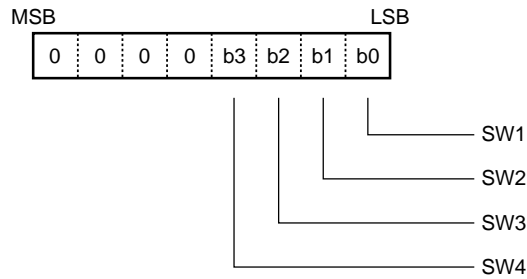
Data is written to the LED port with the write command, starting from the least port's least significant bit. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED turns off. The data of bits 5 through 8 are ignored.



On power application, all LEDs are unlit.

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.



Commands

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

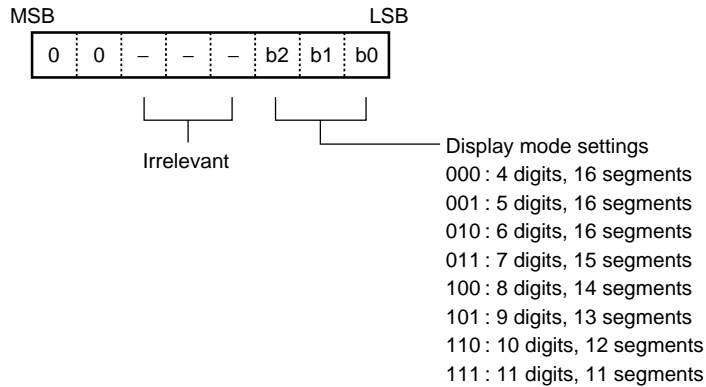
The first 1 byte input to the μPD16312 through the D_{IN} pin after the STB pin has fallen is regarded as a command.

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 μPD16312 and select the number of segments and the number of grids (1/4 to 1/11 duty, 11 segments to 16 segments).

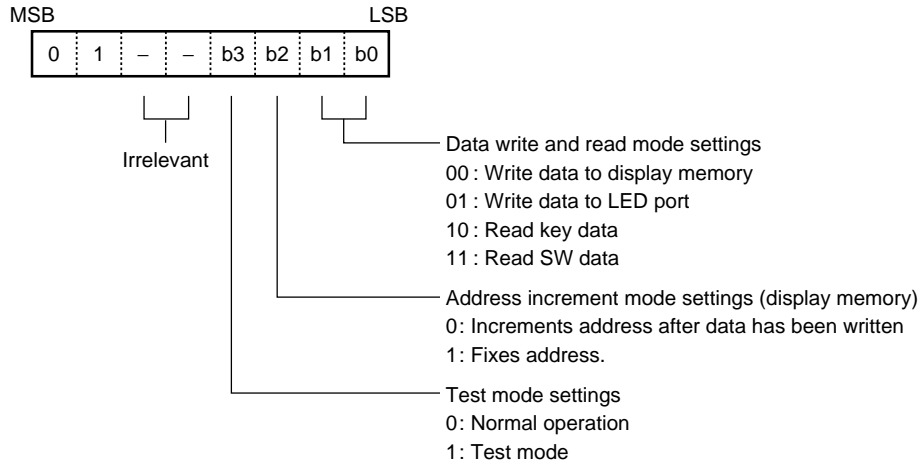
When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command “ON” must be executed. If the same mode is selected, however, nothing happens.



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

(2) Data setting commands

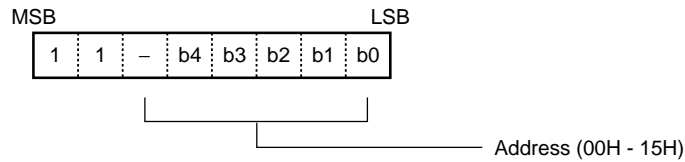
These commands set data write and data read modes.



On power application, the normal operation and address increment modes are set.

(3) Address setting commands

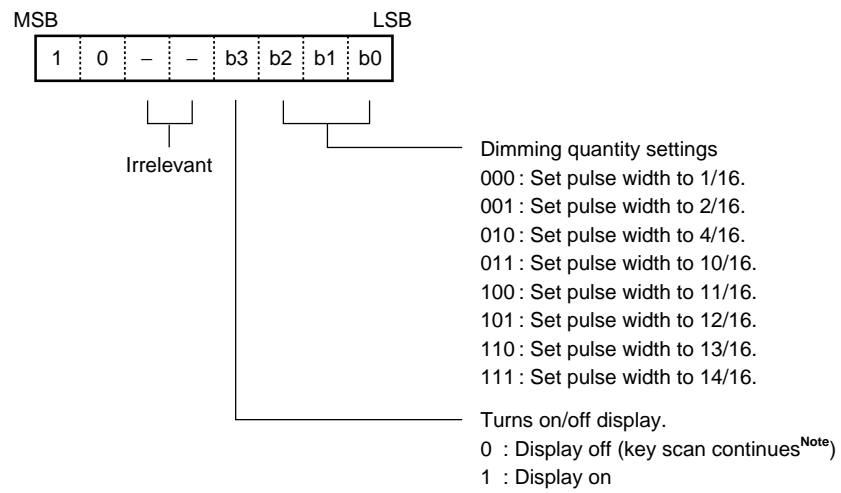
These commands set an address of the display memory.



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.

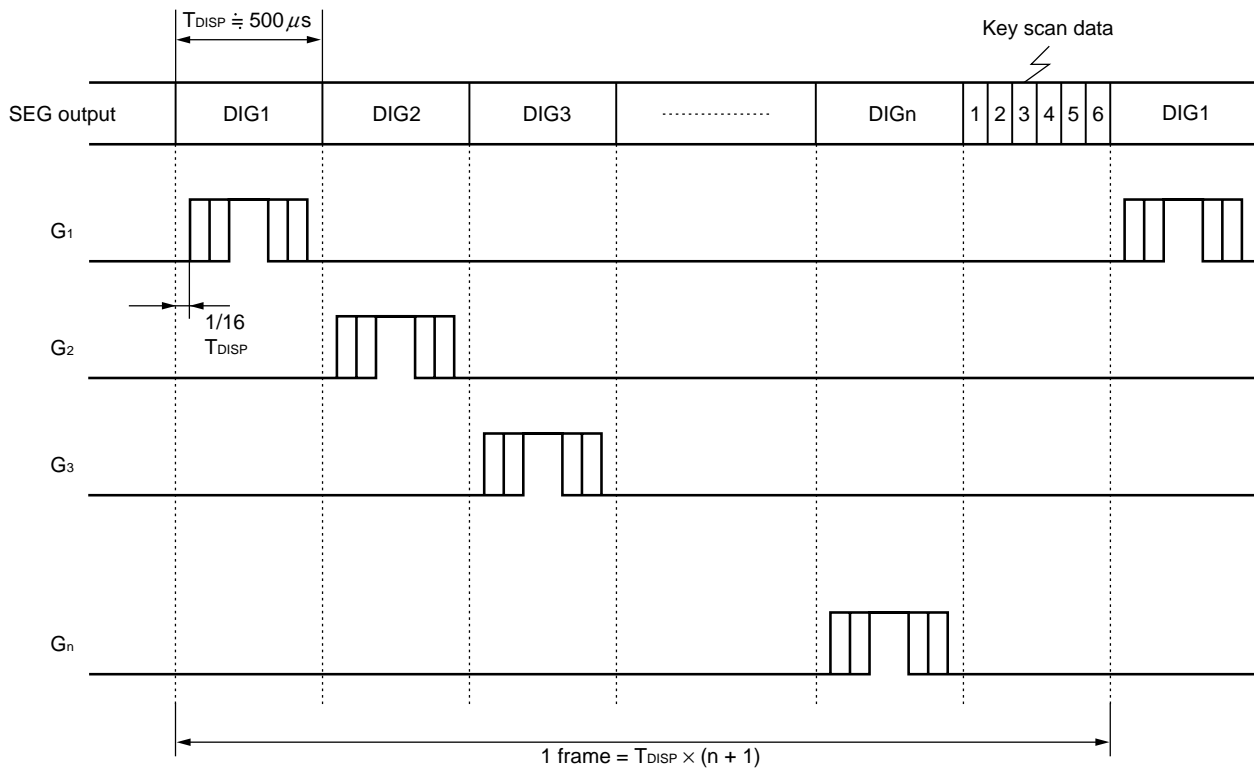
(4) Display control commands



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

Note On power application, key scanning is stopped.

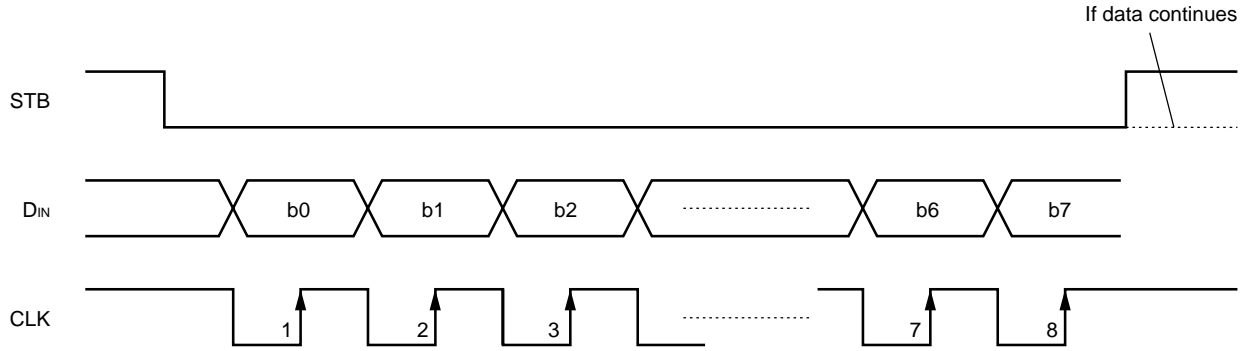
Key Scanning and Display Timing



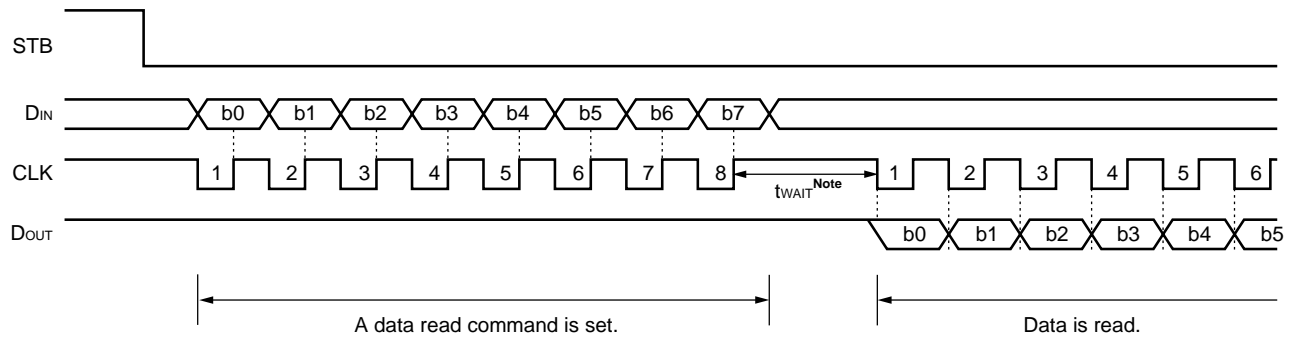
One cycle of key scanning consists of one frame, and data in a 6×4 matrix is stored in RAM.

Serial Communication Format

Reception (command/data write)



Transmission (data read)



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 (1 kΩ to 10 kΩ).

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.

ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C, V_{SS} = 0 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
FIP Driver Output Voltage	V _{O2}	V _{EE} -0.5 to V _{DD} +0.5	V
LED Driver Output Current	I _{O1}	+25	mA
FIP Driver Output Current	I _{O2}	-40 (grid) -15 (segment)	mA
Power Dissipation	P _D	800 ^{Note}	mW
Operating Ambient temperature	T _{opt}	-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.

RECOMMENDED OPERATING RANGE (T_a = -20 to 70 °C, V_{SS} = 0 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 • 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	

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 × 6 + number of grids/(number of grids + 1) × 30 (mW)

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

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

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

Example

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

FIP driver dissipation = 16 × 6 + 6/7 × 30 = 122

R_L dissipation = 30²/50 × 17 = 306

LED driver dissipation = 4 × 20 = 80

Dynamic power consumption = 5 × 5 = 25

Total 553 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	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
High-Level Output Voltage	V _{OH1}	0.9 V _{DD}			V	LED ₁ - LED ₄ , I _{OH1} = -1 mA
Low-Level Output Voltage	V _{OL1}			1	V	LED ₁ - LED ₄ , I _{OL1} = 20 mA
Low-Level Output Voltage	V _{OL2}			0.4	V	D _{OUT} , I _{OL2} = 4 mA
High-Level Output Current	I _{OH21}	-3			mA	V _O = V _{DD} -2 V, Seg ₁ to Seg ₁₁
High-Level Output Current	I _{OH22}	-15			mA	V _O = V _{DD} -2 V, Grid ₁ to Grid ₆ Seg ₁₂ / Grid ₁₁ to Seg ₁₆ / Grid ₇
Driver Leakage Current	I _{OLEAK}			-10	μA	V _O = V _{DD} -35 V, driver off
Output Pull-Down Resistor	R _L	50	100	150	KΩ	Driver output
Input Current	I _I			±1	μA	V _I = V _{DD} or V _{SS}
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		0.35		V	CLK, D _{IN} , STB
Dynamic Current Consumption	I _{DDdyn}			5	mA	Under no load, display off

SWITCHING CHARACTERISTICS (T_a = -20 to +70 °C, V_{DD} = 4.5 to 5.5 V, V_{EE} = -30 V)

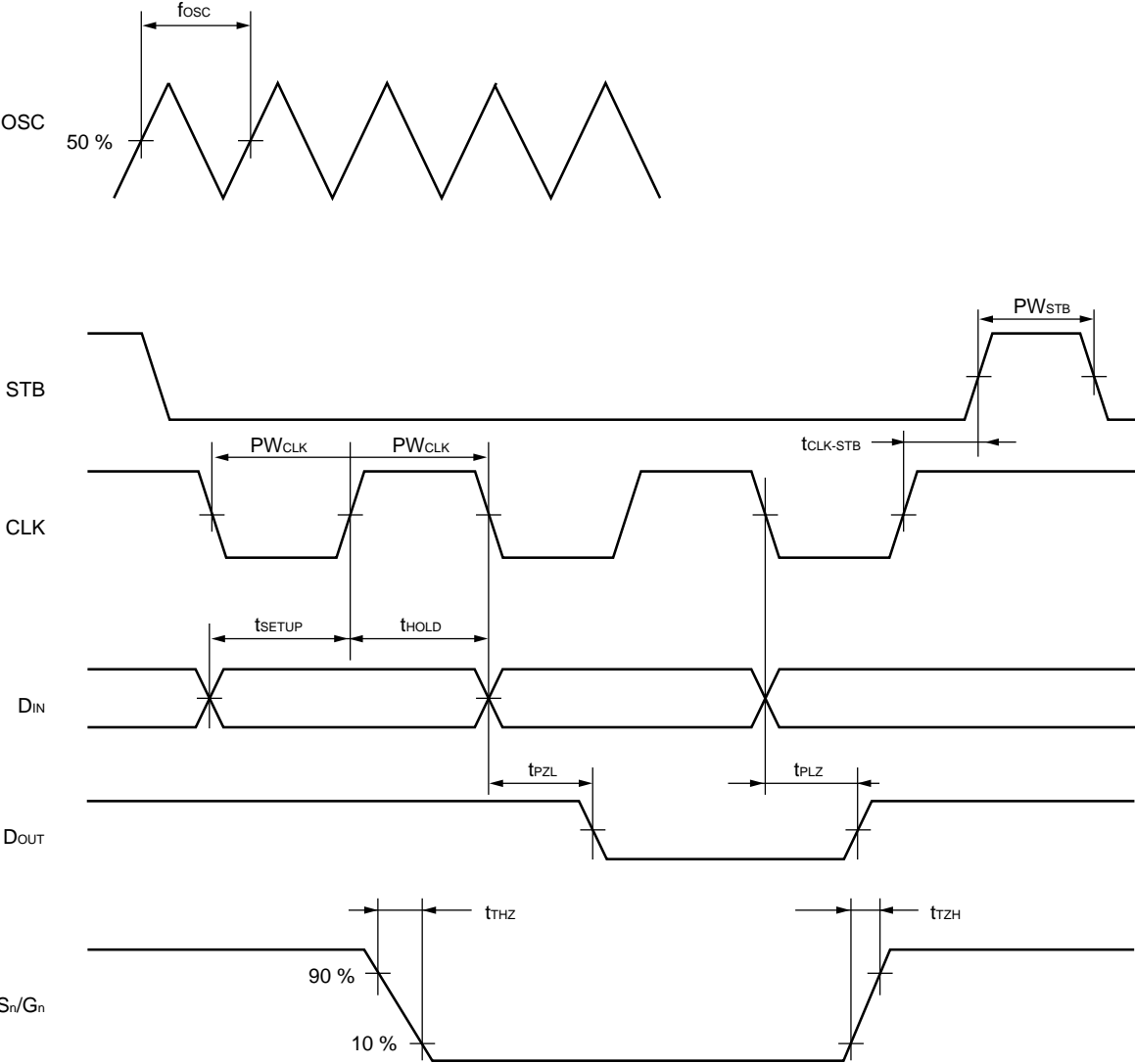
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Oscillation Frequency	t _{osc}	350	500	650	kHz	R = 51 kΩ
Propagation Delay Time	t _{PLZ}			300	ns	CLK → D _{OUT}
	t _{PZL}			100	ns	C _L = 15 pF, R _L = 10 kΩ
Rise Time	t _{TZH1}			2	μs	C _L = 300 pF Seg ₁ to Seg ₁₁ Grid ₁ to Grid ₆ , Seg ₁₂ /Grid ₁₁ to Seg ₁₆ /Grid ₇
	t _{TZH2}			0.5	μs	
Fall Time	t _{THZ}			120	μs	C _L = 300 pF, Seg _n , Grid _n
Maximum Clock Frequency	f _{max.}	1			MHz	Duty = 50 %
Input Capacitance	C _I			15	pF	

TIMING CONDITIONS (T_a = -20 to 70 °C, V_{DD} = 4.5 to 5.5 V)

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
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}	1			μs	CLK ↑ → STB ↑
Wait Time	t _{WAIT}	1			μs	CLK ↑ → CLK ↓ ^{Note}

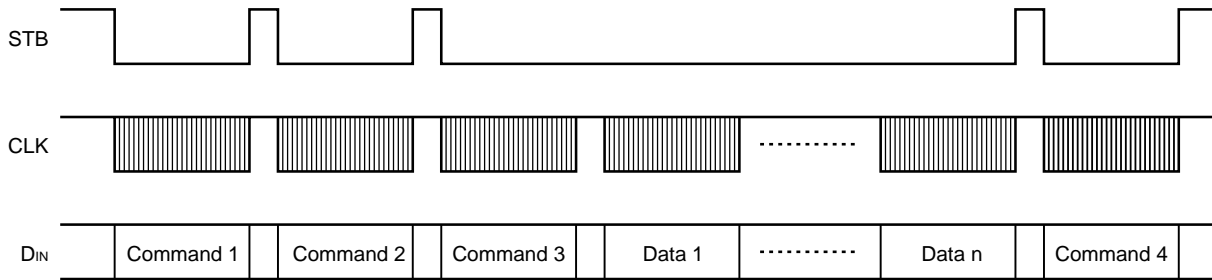
Note Refer to page 11.

Switching Characteristic Waveforms



Applications

Updating display memory by incrementing address



Command 1: sets display mode

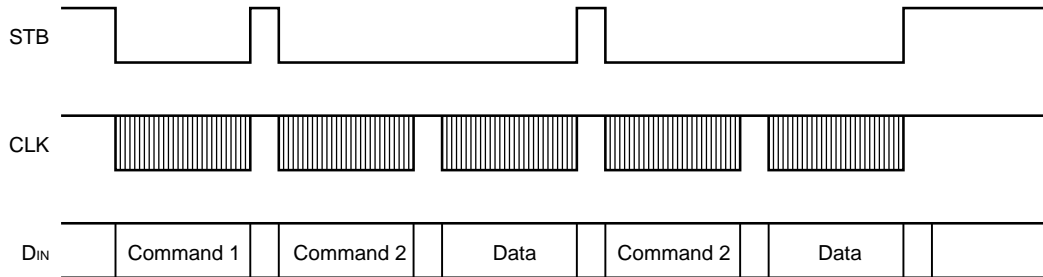
Command 2: sets data

Command 3: sets address

Data 1 to n: transfers display data (22 bytes max.)

Command 4: controls display

Updating specific address



Command 1: sets data

Command 2: sets address

Data: display data

RECOMMENDED SOLDERING CONDITIONS

The following conditions (see table below) must be met when soldering this product. Please consult with our sales offices in case other soldering process is used, or in case soldering is done under different conditions.

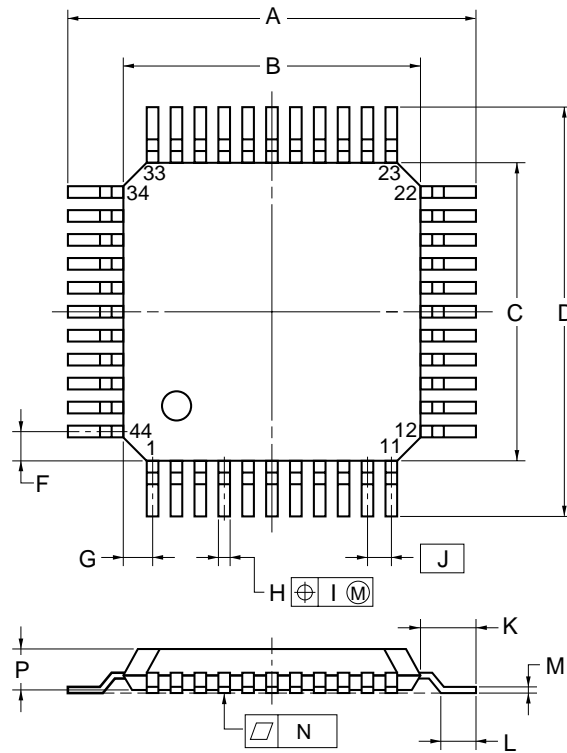
μPC16312GB-3B4

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: 2, Exposure limit*: None	IR35-00-2
VPS	Peak package's surface temperature: 215 °C or below, Reflow time: 40 seconds or below (200 °C or higher), Number of reflow process: 2, Exposure limit*: None	VP15-00-2
Wave soldering	Solder temperature: 260 °C or below, Flow time: 10 seconds or below Number of flow process: 1, Exposure limit*: None	WS60-00-1
Partial heating method	Terminal temperature: 300 °C or below, Flow time 10 seconds or below, Exposure limit*: None	

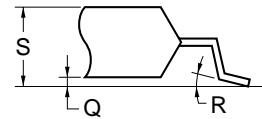
* Exposure limit before soldering after dry-pack package is opened.
Storage conditions: 25 °C and relative humidity at 65 % or less.

Note Do not apply more than a single process at once, except for "Partial heating method".

44 PIN PLASTIC QFP (□10)



detail of lead end



NOTE

Each lead centerline is located within 0.15 mm (0.006 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	13.6±0.4	0.535 ^{+0.017} _{-0.016}
B	10.0±0.2	0.394 ^{+0.008} _{-0.009}
C	10.0±0.2	0.394 ^{+0.008} _{-0.009}
D	13.6±0.4	0.535 ^{+0.017} _{-0.016}
F	1.0	0.039
G	1.0	0.039
H	0.35±0.10	0.014 ^{+0.004} _{-0.005}
I	0.15	0.006
J	0.8 (T.P.)	0.031 (T.P)
K	1.8±0.2	0.071 ^{+0.008} _{-0.009}
L	0.8±0.2	0.031 ^{+0.009} _{-0.008}
M	0.15 ^{+0.10} _{-0.05}	0.006 ^{+0.004} _{-0.003}
N	0.10	0.004
P	2.7	0.106
Q	0.1±0.1	0.004±0.004
R	5°±5°	5°±5°
S	3.0 MAX.	0.119 MAX.

P44GB-80-3B4-3

[MEMO]

[MEMO]

FIP™ is a trademark of NEC Corporation.

No part of this document may be copied or reproduced in any form or by any means without the prior written consent of NEC Corporation. NEC Corporation assumes no responsibility for any errors which may appear in this document.

NEC Corporation does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from use of a device described herein or any other liability arising from use of such device. No license, either express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Corporation or others.

While NEC Corporation has been making continuous effort to enhance the reliability of its semiconductor devices, the possibility of defects cannot be eliminated entirely. To minimize risks of damage or injury to persons or property arising from a defect in an NEC semiconductor device, customers must incorporate sufficient safety measures in its design, such as redundancy, fire-containment, and anti-failure features.

NEC devices are classified into the following three quality grades:

"Standard", "Special", and "Specific". The Specific quality grade applies only to devices developed based on a customer designated "quality assurance program" for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade of each device before using it in a particular application.

Standard: Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots

Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)

Specific: Aircrafts, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.

The quality grade of NEC devices is "Standard" unless otherwise specified in NEC's Data Sheets or Data Books. If customers intend to use NEC devices for applications other than those specified for Standard quality grade, they should contact an NEC sales representative in advance.

Anti-radioactive design is not implemented in this product.