NEC

MOS INTEGRATED CIRCUIT

μPD16312

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

The μPD16312 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 μPD16312 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 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, D_{IN}, D_{OUT})

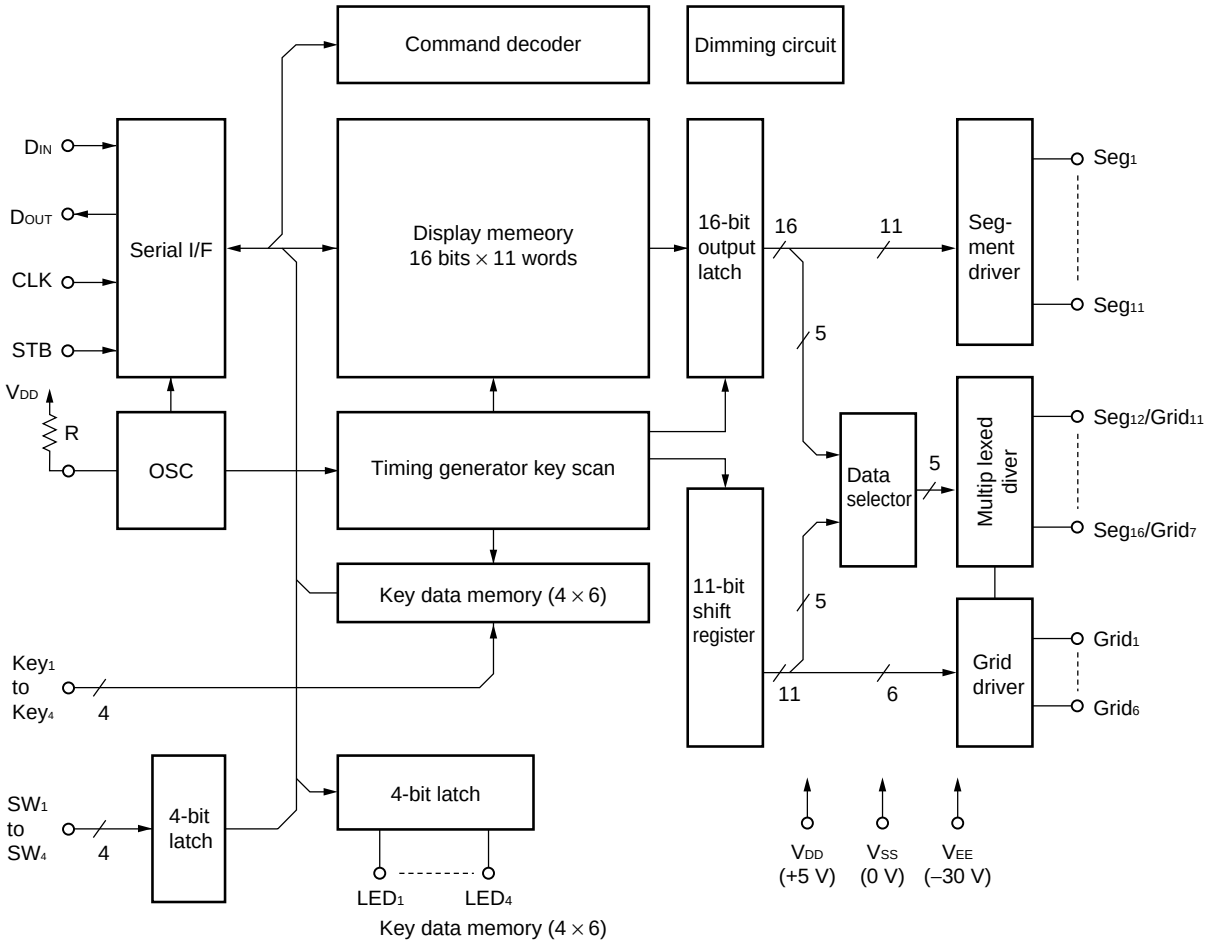
ORDERING INFORMATION

Part Number	Package
μPD16312GB-3B4	44-pin plastic QFP (□10)

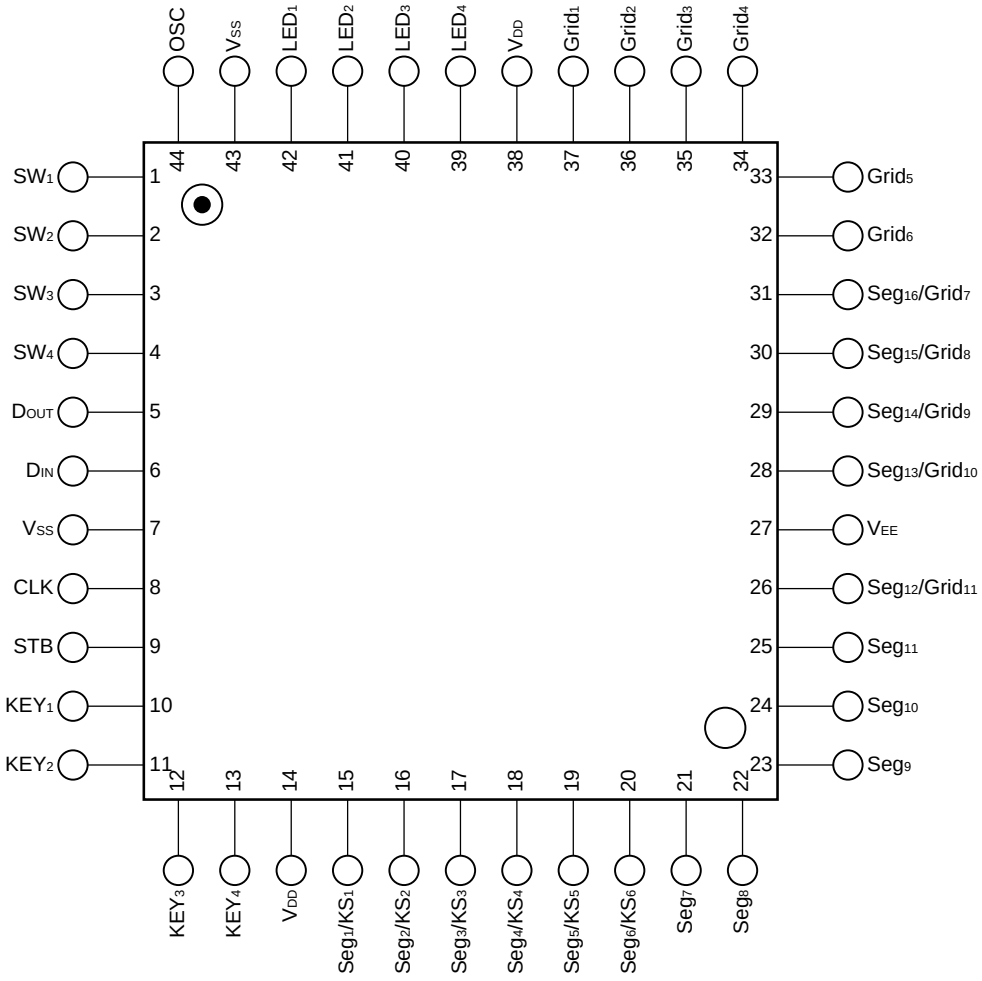
Document No. IC-3307 (1st edition)
Date Published March 1997 P
Printed in Japan

© NEC Corporation 1993

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

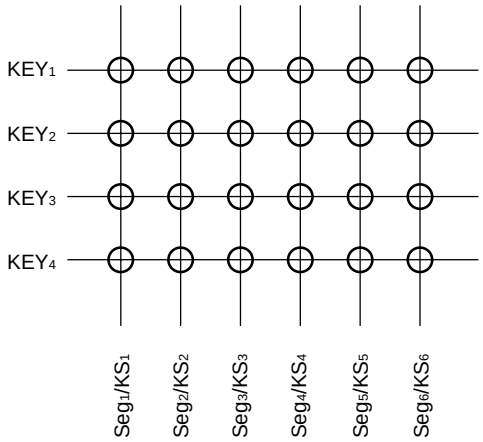
The display RAM stores the data transmitted from an external device to the μPD16312 through the serial interface, and is assigned addresses as follows, in 8 bits unit:

Seg_1		Seg_4	Seg_8		Seg_{12}	Seg_{16}	
$00H_L$		$00H_U$	$01H_L$		$01H_U$		DIG_1
$02H_L$		$02H_U$	$03H_L$		$03H_U$		DIG_2
$04H_L$		$04H_U$	$05H_L$		$05H_U$		DIG_3
$06H_L$		$06H_U$	$07H_L$		$07H_U$		DIG_4
$08H_L$		$08H_U$	$09H_L$		$09H_U$		DIG_5
$0AH_L$		$0AH_U$	$0BH_L$		$0BH_U$		DIG_6
$0CH_L$		$0CH_U$	$0DH_L$		$0DH_U$		DIG_7
$0EH_L$		$0EH_U$	$0FH_L$		$0FH_U$		DIG_8
$10H_L$		$10H_U$	$11H_L$		$11H_U$		DIG_9
$12H_L$		$12H_U$	$13H_L$		$13H_U$		DIG_{10}
$14H_L$		$14H_U$	$15H_L$		$15H_U$		DIG_{11}

b_0	b_3	b_4	b_7
xxH_L		xxH_U	
Lower 4 bits		Higher 4 bits	

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.

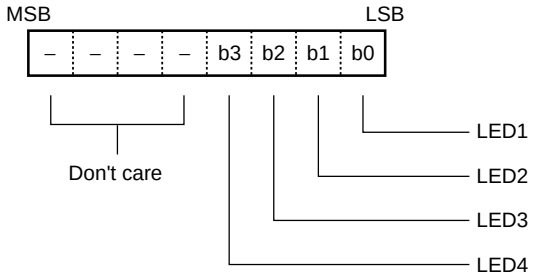
KEY1…KEY4	KEY1…KEY4
Seg1/KS1	Seg2/KS2
Seg3/KS3	Seg4/KS4
Seg5/KS5	Seg6/KS6

Reading sequence

b0---------- b3 b4 ----------b7

LED Port

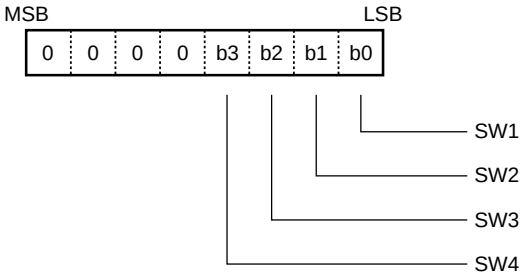
Data is written to the LED port with the write command, starting from the least port's least significant bit. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED truns off. The data of bits 5 through 8 are ignored.



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.

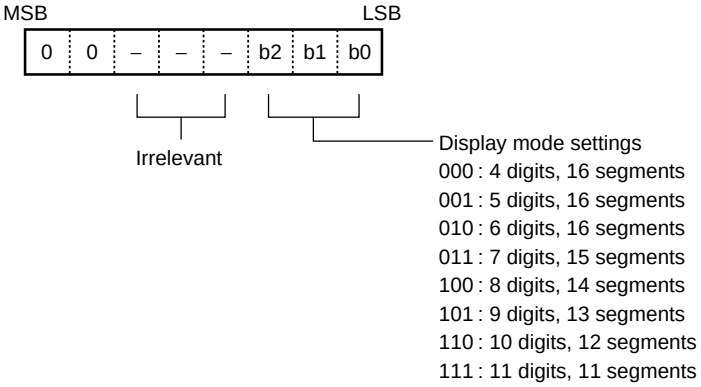
The first 1 byte input to the μPD16312 through the D_{IN} pin after the STB pin has fallen is regarded as a command.

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).

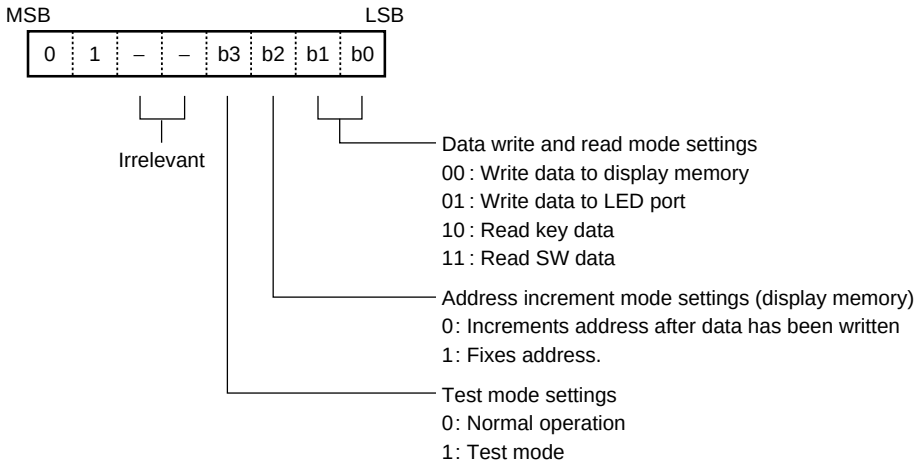
When these commands are executed, the display is forcibly turned off, and key scanning is also stopped. To resume display, the display command "ON" must be executed. If the same mode is selected, however, nothing happens.



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

(2) Data setting commands

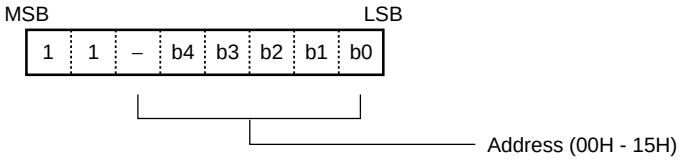
These commands set data write and data read modes.



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

(3) Address setting commands

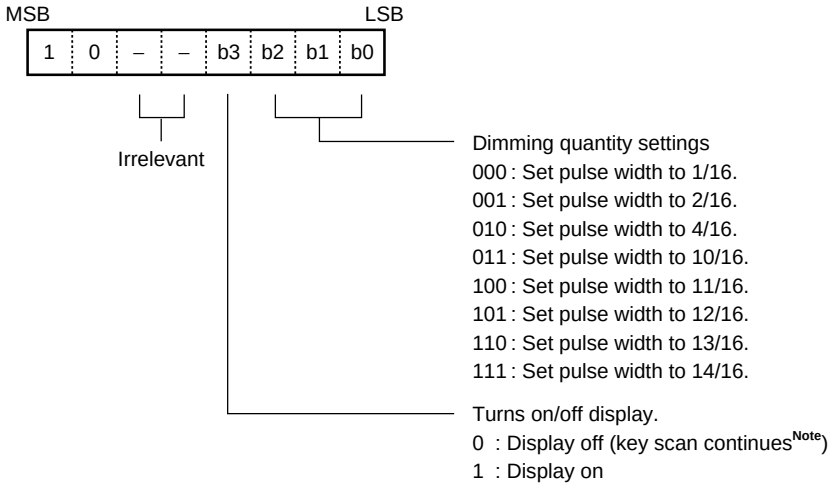
These commands set an address of the display memory.



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.

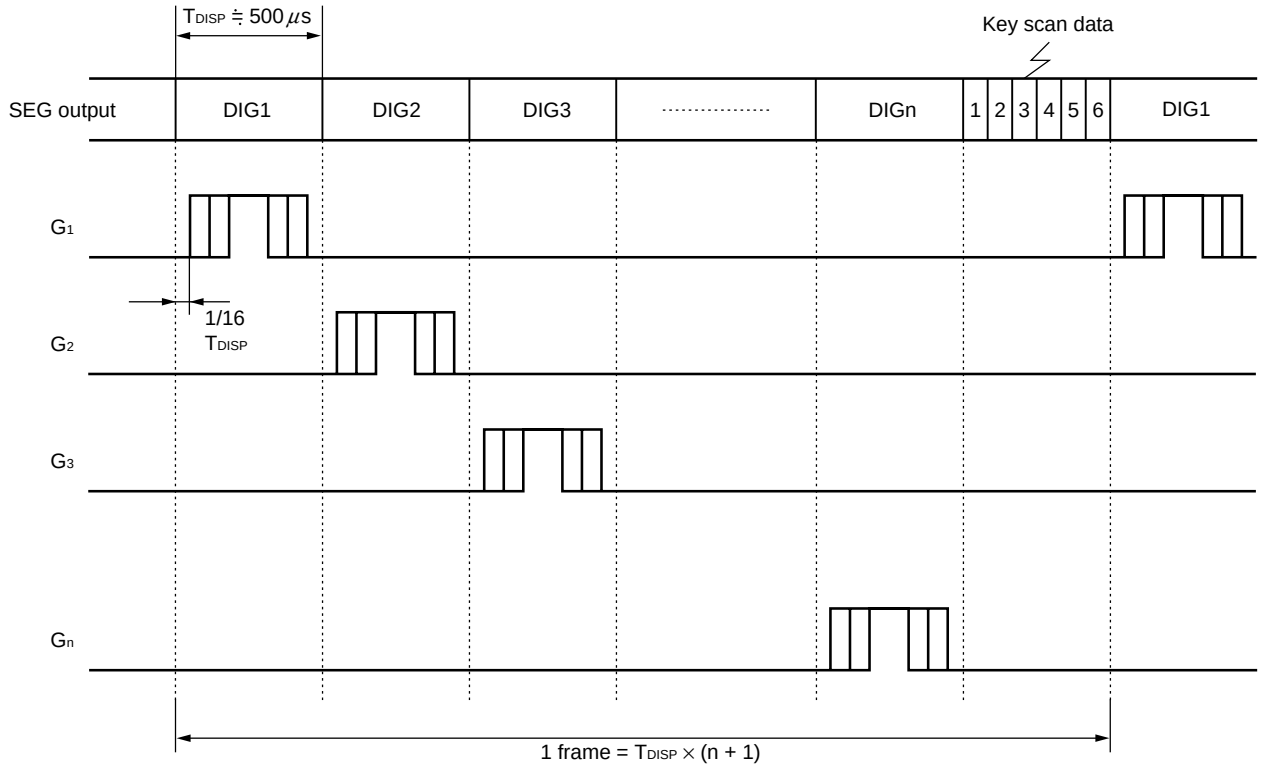
(4) Display control commands



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

Note On power application, key scanning is stopped.

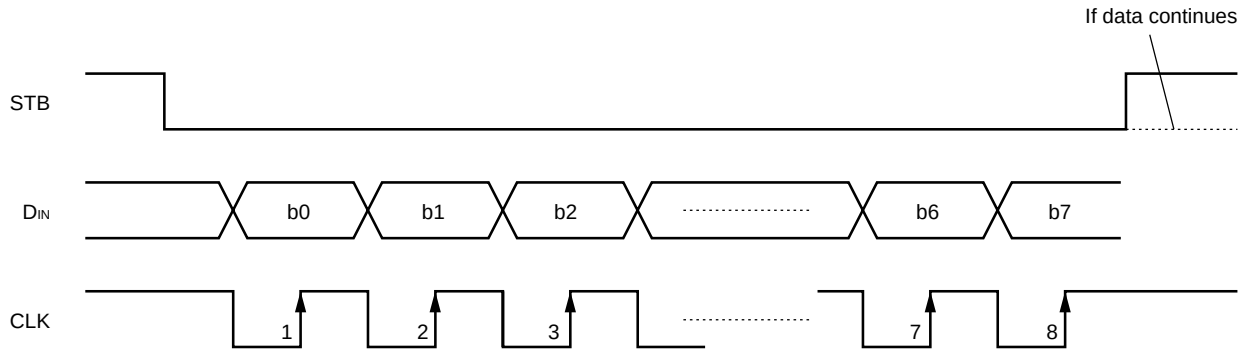
Key Scanning and Display Timing



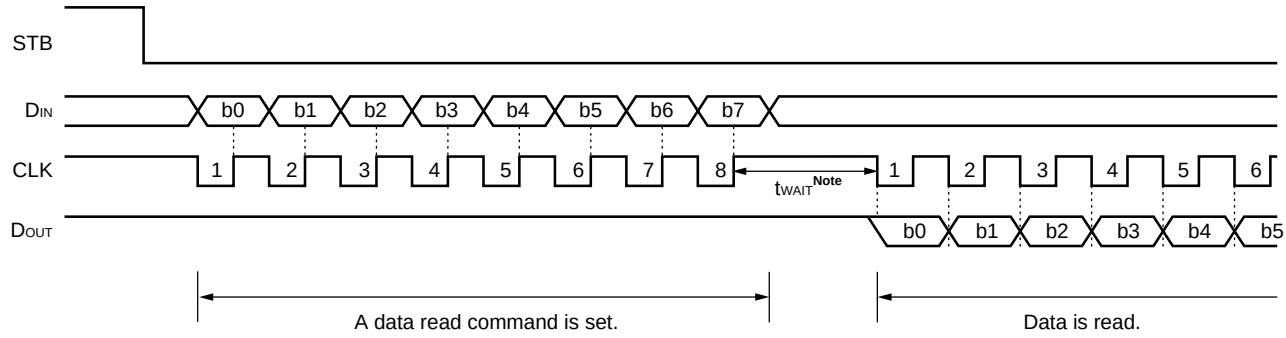
One cycle of key scanning consists of one frame, and data in a 6 × 4 matrix is stored in RAM.

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 Votlage	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 = $(V_{DD} – V_{EE})^2/50 \times$ (number of segments + 1) (mW)
LED driver dissipation = number of LEDs × 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,
FIP 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

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)

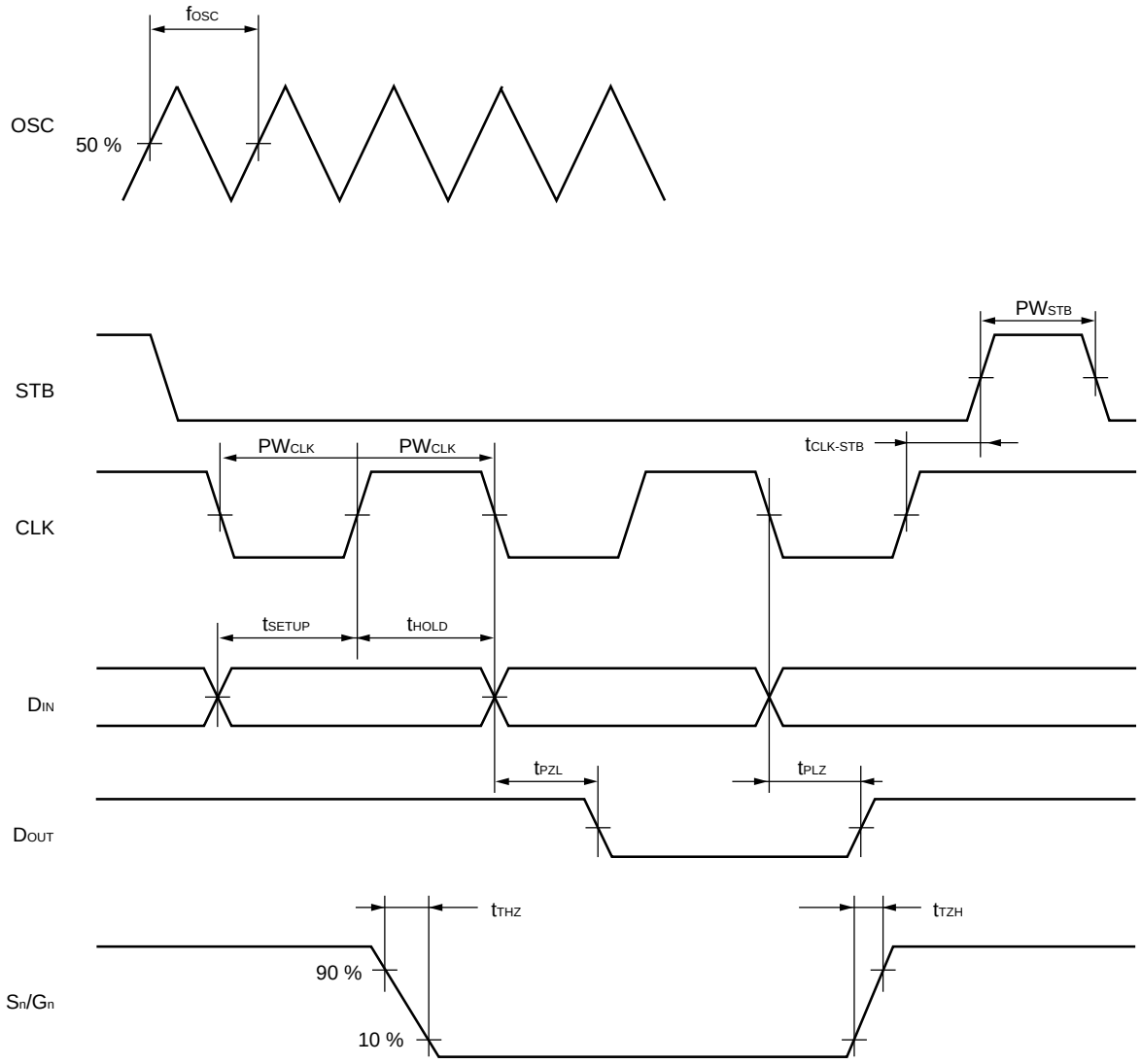
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS	
Oscillation Frequency	t_{OSC}	350	500	650	kHz	R = 51 kΩ	
Propagation Delay Time	t_{PLZ}			300	ns	CLK → D_{OUT}	
	t_{PZL}			100	ns	C_L = 15 pF, R_L = 10 kΩ	
Rise Time	t_{TZH1}			2	μs	C_L = 300 pF	Seg_1 to Seg_{11}
	t_{TZH2}			0.5	μs		$Grid_1$ to $Grid_6$, Seg_{12}/$Grid_{11}$ to Seg_{16}/$Grid_7$
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 Pule 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]

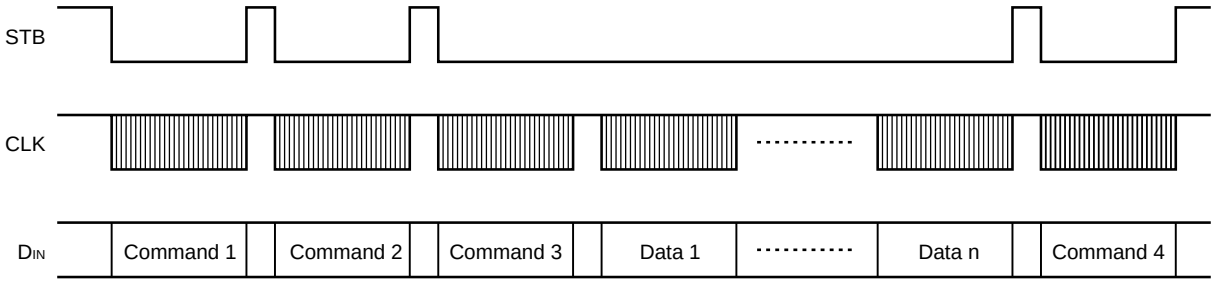
Note Refer to page 11.

Switching Characteristic Waveforms



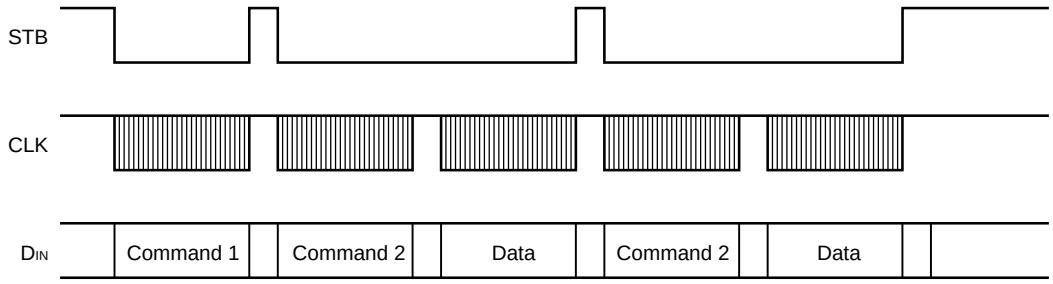
Applications

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 diplay

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 cae other soldering process is used, or in case soldering is done under different conditions.

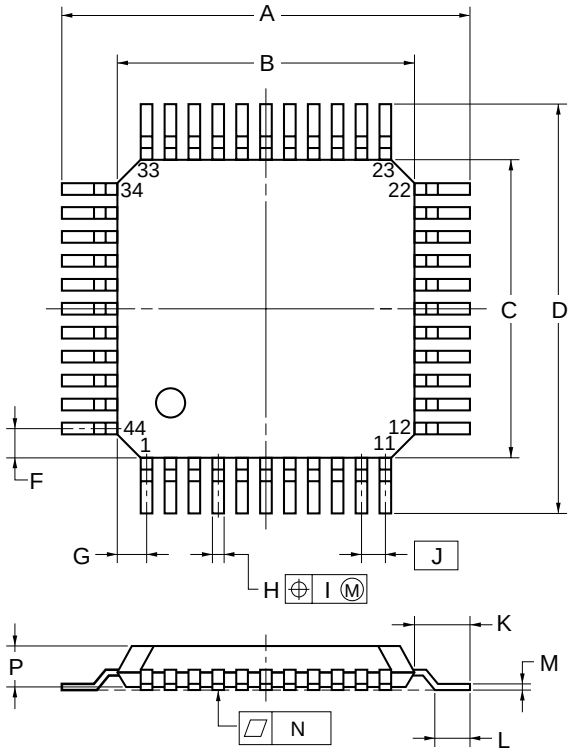
μPC16312GB-3B4

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	

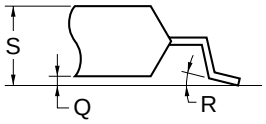
***** Exposure limit before soldering after dry-pack package is opened.
Storage conditions: 25 °C and relative humidity at 65 % or less.

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.

M4 96.5