1/4- to 1/11-DUTY FIP^{TM} (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.
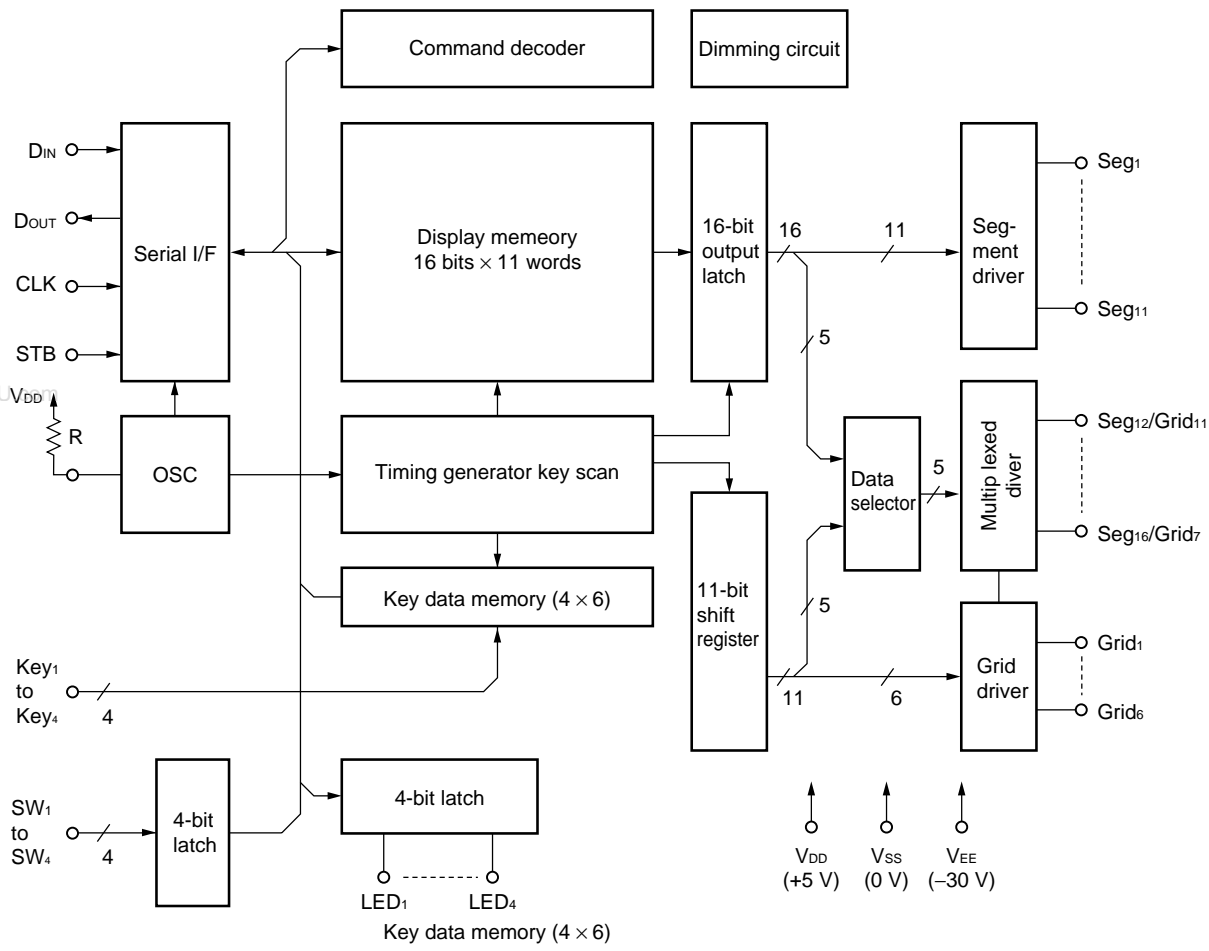
FEATURES

- 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)
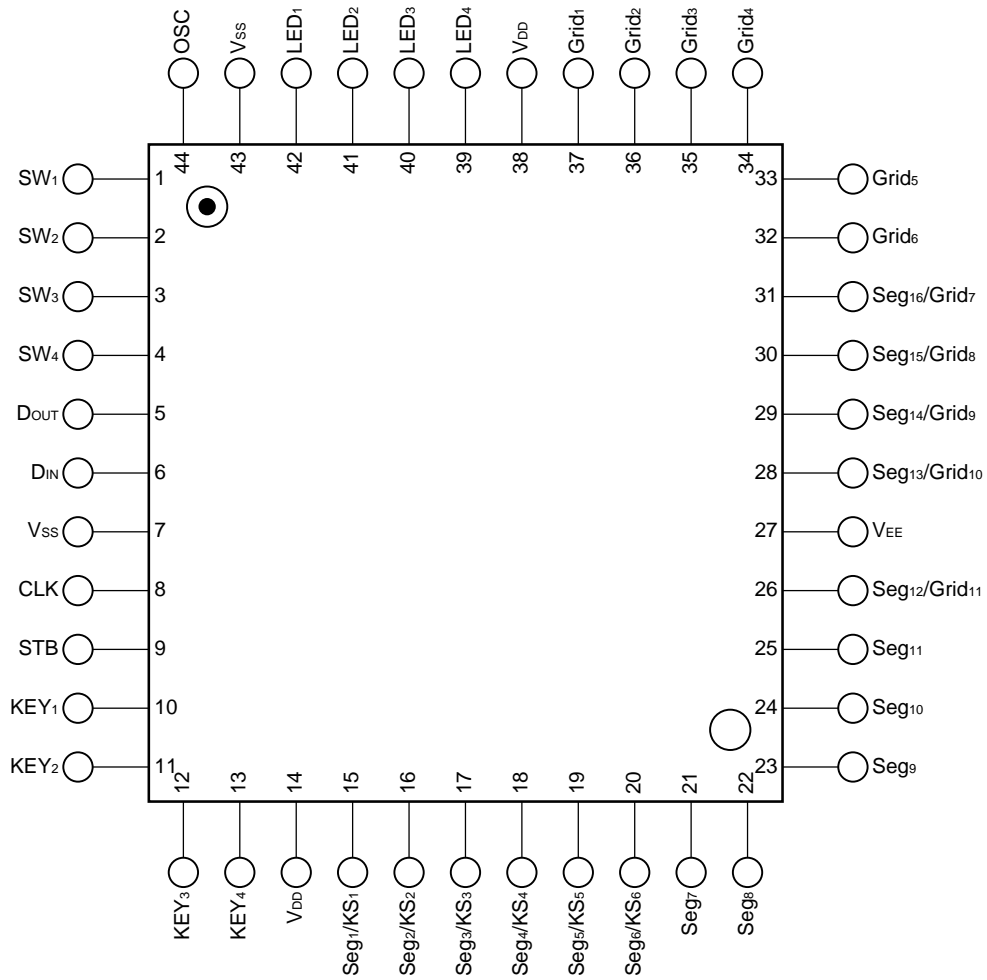- Serial interface (CLK, STB, D$_{IN}$, D$_{OUT}$)

ORDERING INFORMATION

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

BLOCK DIAGRAM

Command decoder

Dimming circuit

D_{IN}

D_{OUT}

CLK

STB

Serial I/F

V_{DD}

R

OSC

Display memeory
16 bits × 11 words

16-bit output latch

16

11

Seg-ment driver

Seg₁

Seg₁₁

5

Timing generator key scan

Data selector

5

Multip lexed diver

Seg₁₂/Grid₁₁

Seg₁₆/Grid₇

Key data memory (4 × 6)

11-bit shift register

5

Key₁
to
Key₄   4

5

11   6

Grid driver

Grid₁

Grid₆

SW₁
to
SW₄   4

4-bit latch

4-bit latch

V_{DD}
(+5 V)

V_{SS}
(0 V)

V_{EE}
(−30 V)

LED₁   LED₄
Key data memory (4 × 6)

PIN CONFIGURATION (Top View)

Top pins (44 to 34): OSC, Vss, LED1, LED2, LED3, LED4, VDD, Grid1, Grid2, Grid3, Grid4

Left pins (1 to 11):
- 1 SW1
- 2 SW2
- 3 SW3
- 4 SW4
- 5 DOUT
- 6 DIN
- 7 Vss
- 8 CLK
- 9 STB
- 10 KEY1
- 11 KEY2

Right pins (33 to 23):
- 33 Grid5
- 32 Grid6
- 31 Seg16/Grid7
- 30 Seg15/Grid8
- 29 Seg14/Grid9
- 28 Seg13/Grid10
- 27 VEE
- 26 Seg12/Grid11
- 25 Seg11
- 24 Seg10
- 23 Seg9

Bottom pins (12 to 22): KEY3, KEY4, VDD, Seg1/KS1, Seg2/KS2, Seg3/KS3, Seg4/KS4, Seg5/KS5, Seg6/KS6, Seg7, Seg8

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 $\pm$ 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
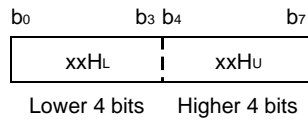
Key Matrix and Key-Input Data Storage RAM

The key matrix is made up of a 6×4 matrix, as shown below.
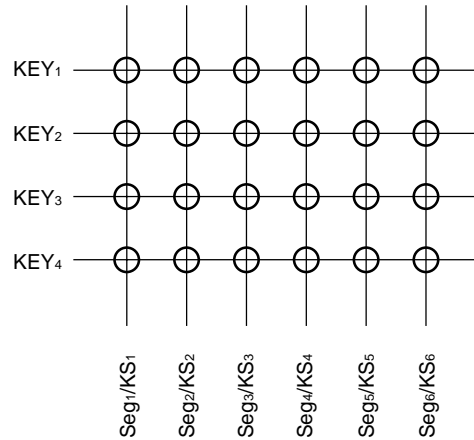
The data of each key is stored as illustrated below, and is read with the read command, starting from the least significant bit.
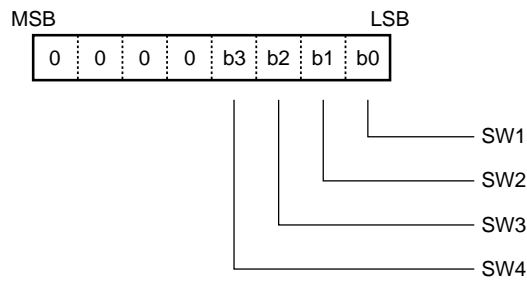
KEY$_1$…KEY$_4$	KEY$_1$…KEY$_4$
Seg$_1$/KS$_1$	Seg$_2$/KS$_2$
Seg$_3$/KS$_3$	Seg$_4$/KS$_4$
Seg$_5$/KS$_5$	Seg$_6$/KS$_6$

Reading sequence

b0------------ b3   b4 ------------b7
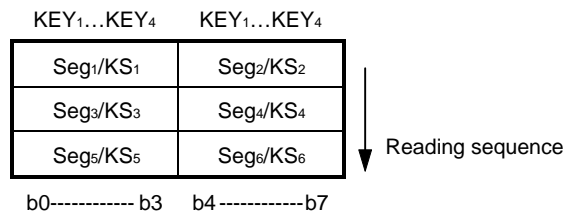
LED Port

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.
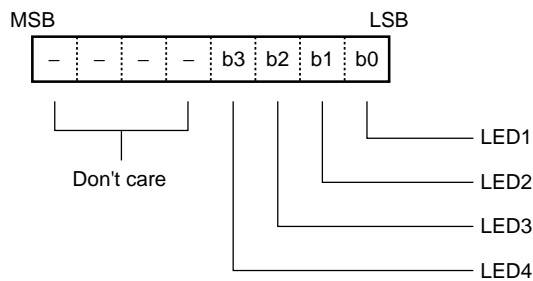
On power application, all LEDs are unlit.

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.

```
MSB                          LSB
 0   0   0   0   b3  b2  b1  b0
                     |   |   |___ SW1
                     |   |_____ SW2
                     |_____ SW3
                     _____ SW4
```

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.

```
MSB                          LSB
 0   0   –   –   –   b2  b1  b0
```

Irrelevant

Display mode settings
000 : 4 digits, 16 segments
001 : 5 digits, 16 segments
010 : 6 digits, 16 segments
011 : 7 digits, 15 segments
100 : 8 digits, 14 segments
101 : 9 digits, 13 segments
110 : 10 digits, 12 segments
111 : 11 digits, 11 segments
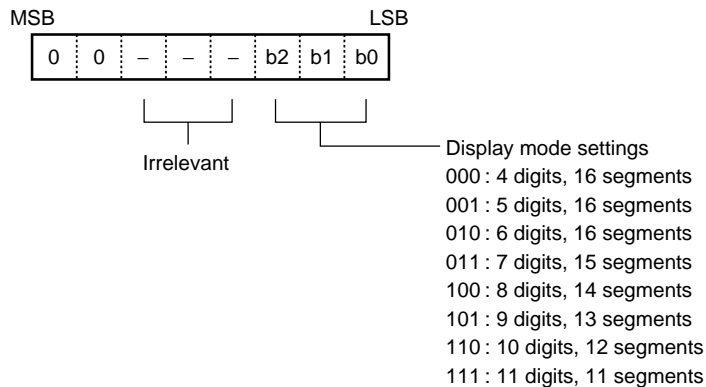
On power application, the 11-digit, 11-segment mode is selected.

(2) Data setting commands

These commands set data write and data read modes.

```
MSB                        LSB
┌───┬───┬───┬───┬───┬───┬───┬───┐
│ 0 │ 1 │ – │ – │b3 │b2 │b1 │b0 │
└───┴───┴───┴───┴───┴───┴───┴───┘
```

Irrelevant

Data write and read mode settings
00 : Write data to display memory
01 : Write data to LED port
10 : Read key data
11 : Read SW data

Address increment mode settings (display memory)
0: Increments address after data has been written
1: Fixes address.

Test mode settings
0: Normal operation
1: Test mode
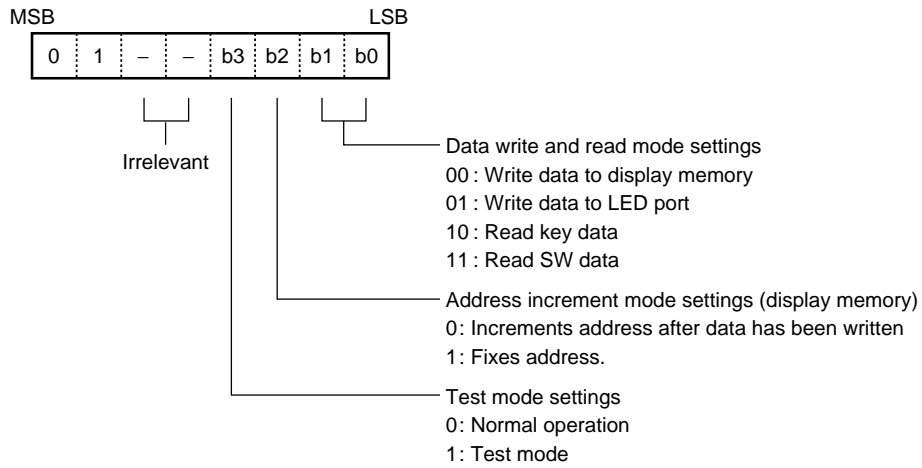
On power application, the normal operation and address increment modes are set.

(3) Address setting commands

These commands set an address of the display memory.

```
MSB                          LSB
┌───┬───┬───┬───┬───┬───┬───┬───┐
│ 1 │ 1 │ – │b4 │b3 │b2 │b1 │b0 │
└───┴───┴───┴───┴───┴───┴───┴───┘
```

Address (00H - 15H)
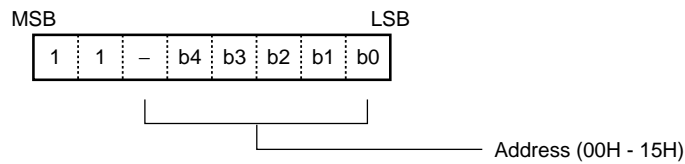
If address 16H or higher is set, data is ignored, until a valid address is set.

On power application, the address is set to 00H.

8

(4) Display control commands
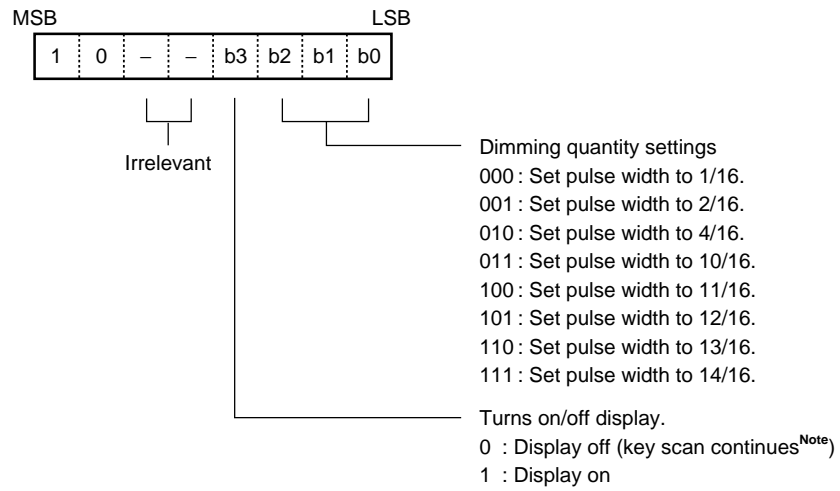
On power application, the 1/16 pulse width is set and the display is turned off.

Note On power application, key scanning is stopped.

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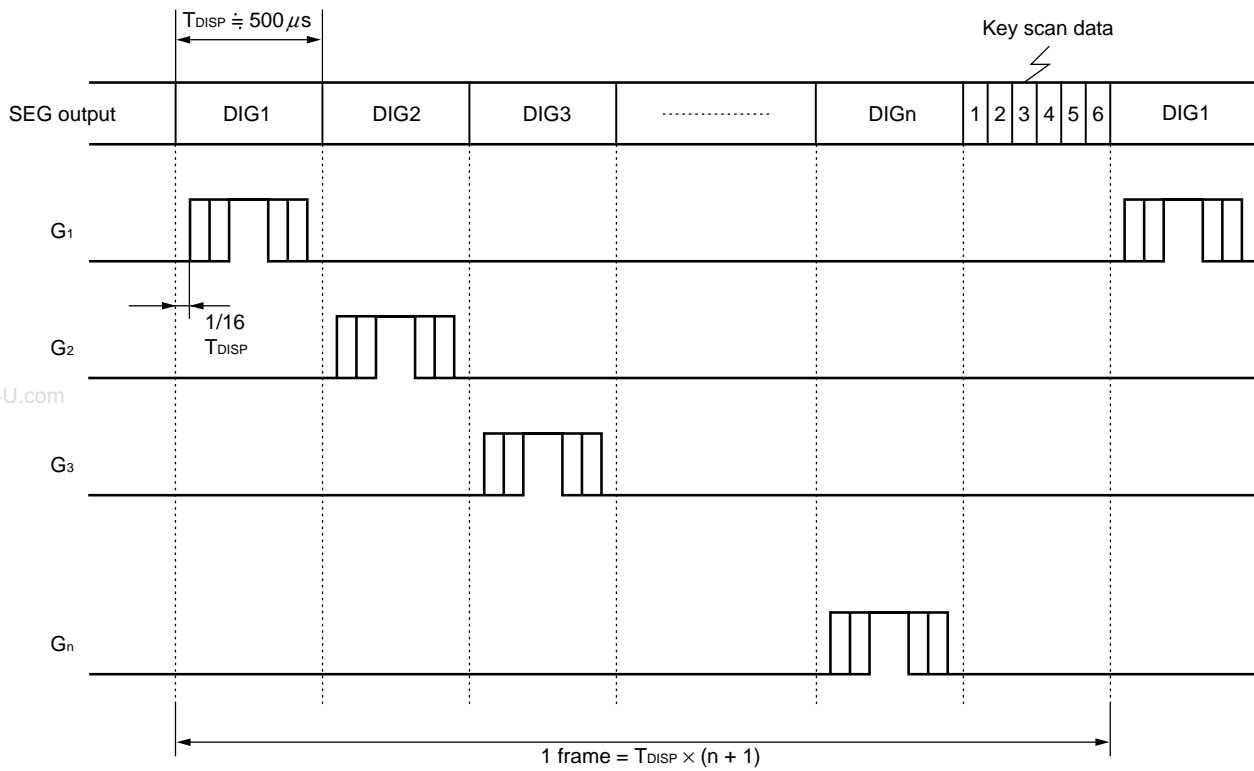
One cycle of key scanning consists of one frame, and data in a 6 × 4 matrix is stored in RAM.

Serial Communication Format

Reception (command/data write)
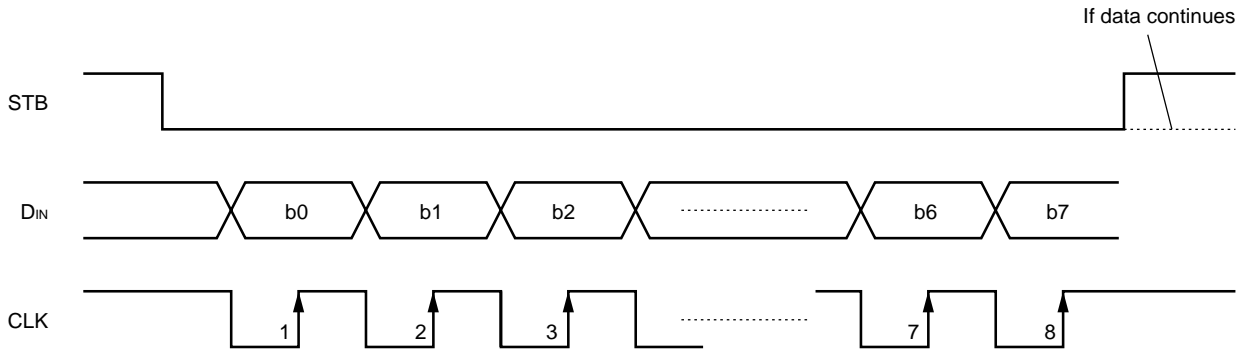
Transmission (data read)
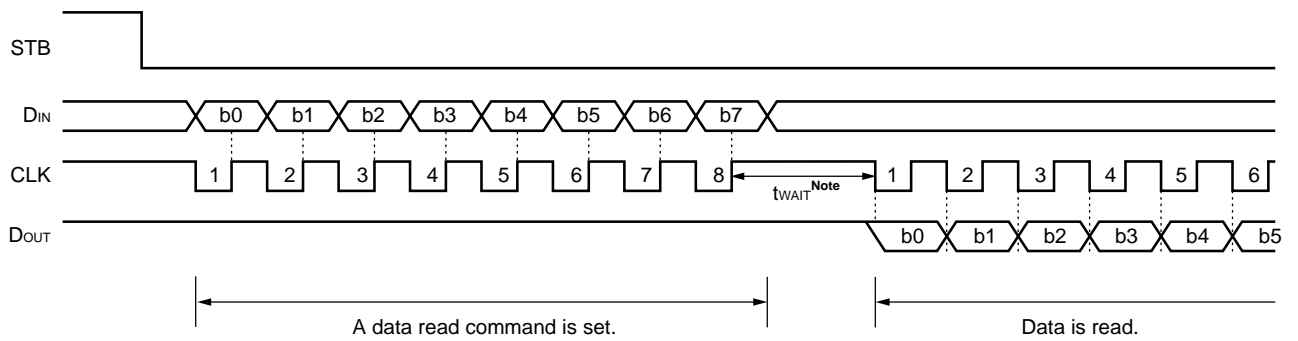
Because the D$_{OUT}$ pin is an N-ch, open-drain output pin, be sure to connect an external pull-up resistor to this pin (1 kΩ to 10 kΩ).

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 $\times$ 6 + number of grids/(number of grids + 1) $\times$ 30 (mW)

R$_L$ dissipation = (V$_{DD}$ − V$_{EE}$)^2/50 $\times$ (number of segments + 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,

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 $^\circ$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$_I$			$\pm$1	μA	V$_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 $^\circ$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 $\rightarrow$ 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 $^\circ$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 $\uparrow$ $\rightarrow$ STB $\uparrow$
Wait Time	t$_{WAIT}$	1			μs	CLK $\uparrow$ $\rightarrow$ CLK $\downarrow$[Note]

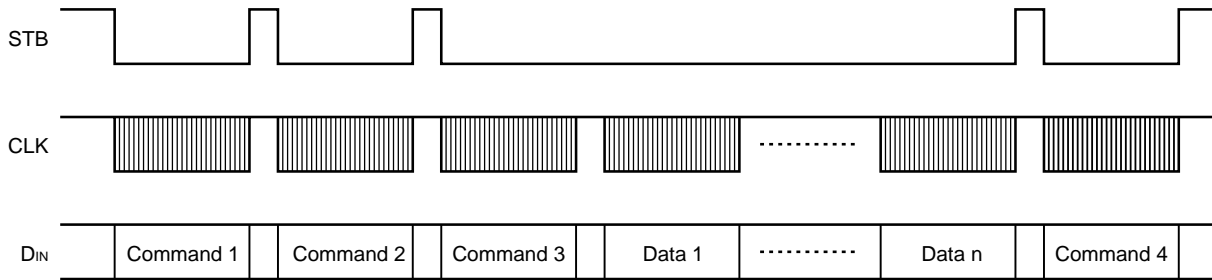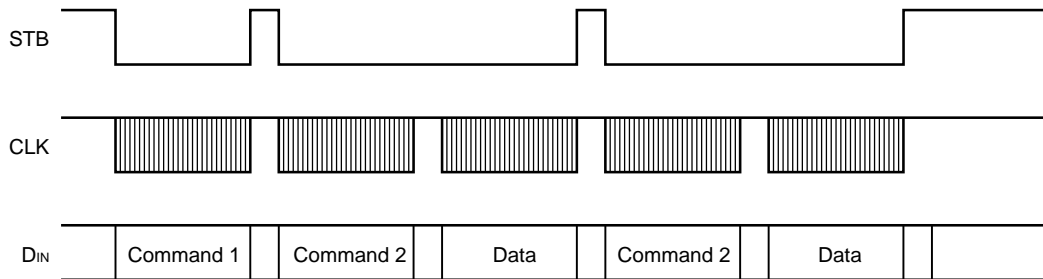**Note** Refer to page 11.

Switching Characteristic Waveforms
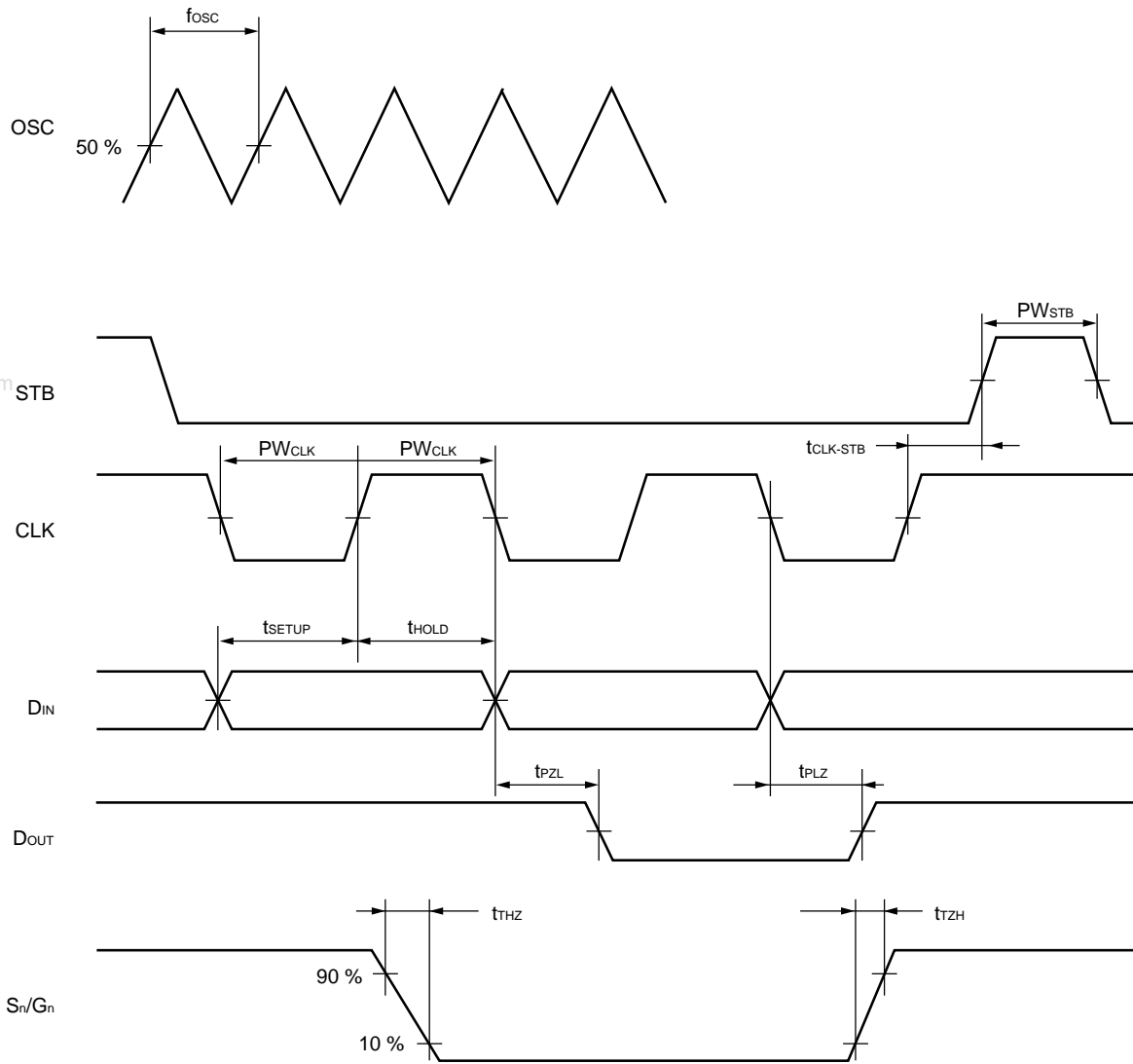
Applications

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.

μ**PC16312GB-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)
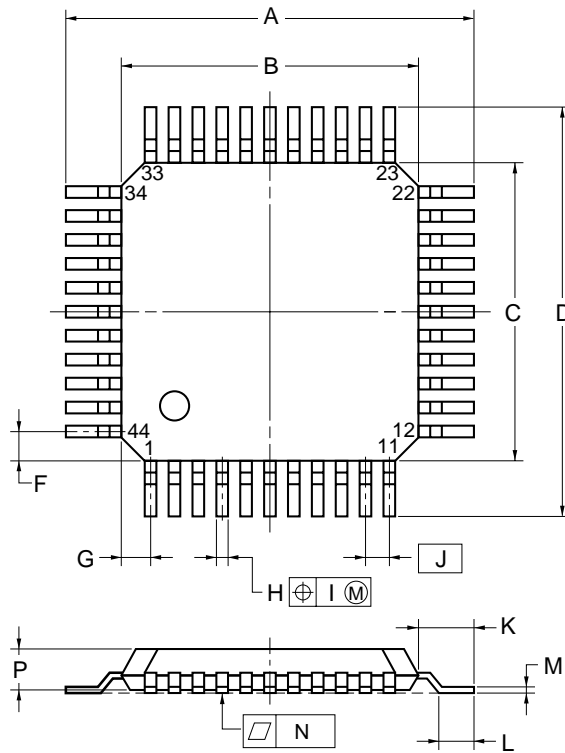
detail of lead end
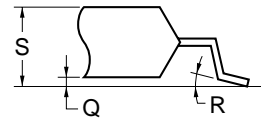
NOTE

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]

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