DATA SHEET

NEC

MOS INTEGRATED CIRCUIT

μPD16311

1/8- to 1/16-DUTY FIP™ (VFD) CONTROLLER/DRIVER

The μPD16311 is a FIP (Fluorescent Indicator Panel or Vacuum Fluorescent Display) controller/driver that is driven on a 1/8- to 1/16 duty factor. It consists of 12 segment output lines, 8 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 μPD16311 through a three-line serial interface. This FIP controller/driver is ideal as a peripheral device of a single-chip microcomputer.

FEATURES

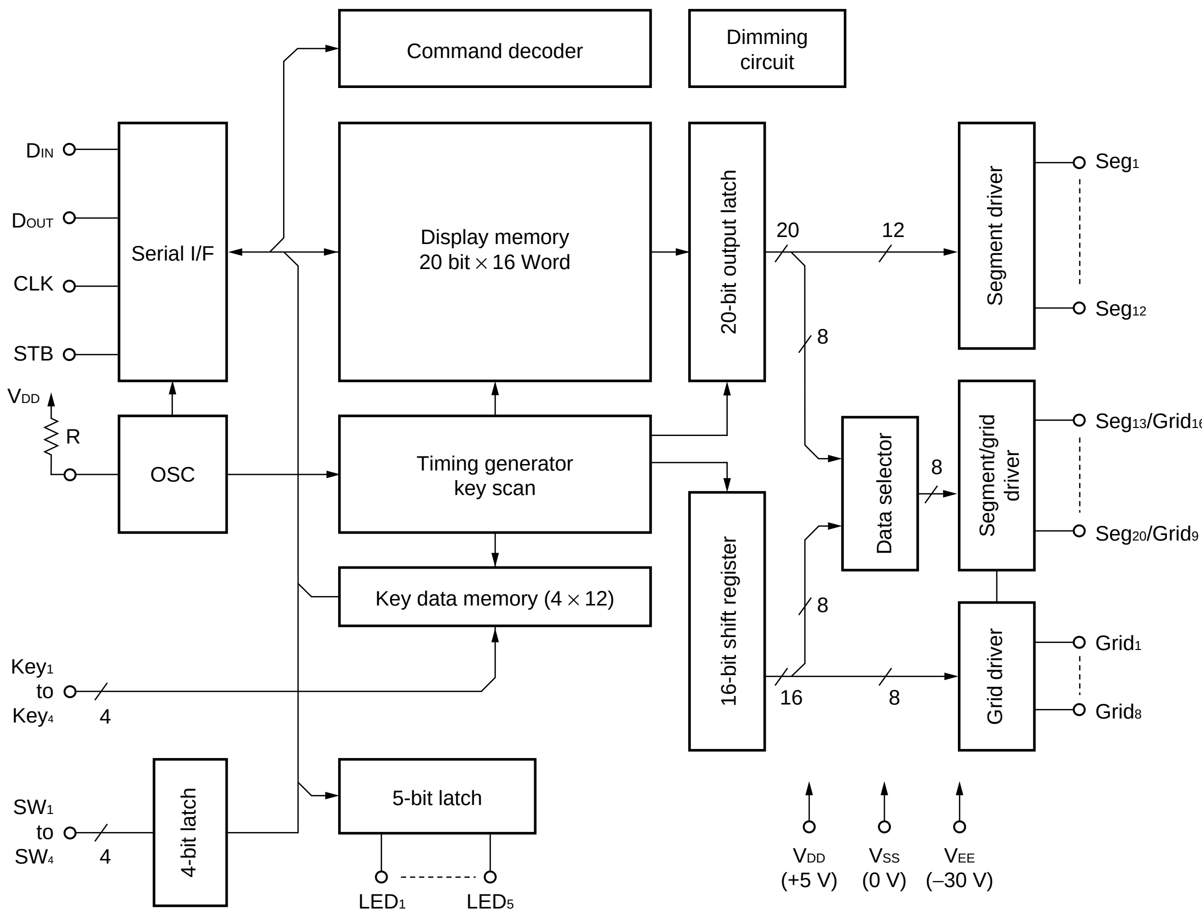
- Many display modes (12-segment & 16-digit to 20-segment & 8-digit)
- Key scanning (12 × 4 matrices)
- Dimming circuit (eight steps)
- High-voltage output (V_{DD} − 35 V max).
- LED ports (5 chs., 20 mA max).
- General-purpose input port (4 bits)
- No external resistor necessary for driver outputs (P-ch open-drain + pull-down resistor output)
- Serial interface (CLK, STB, D_{IN}, D_{OUT})

ORDERING INFORMATION

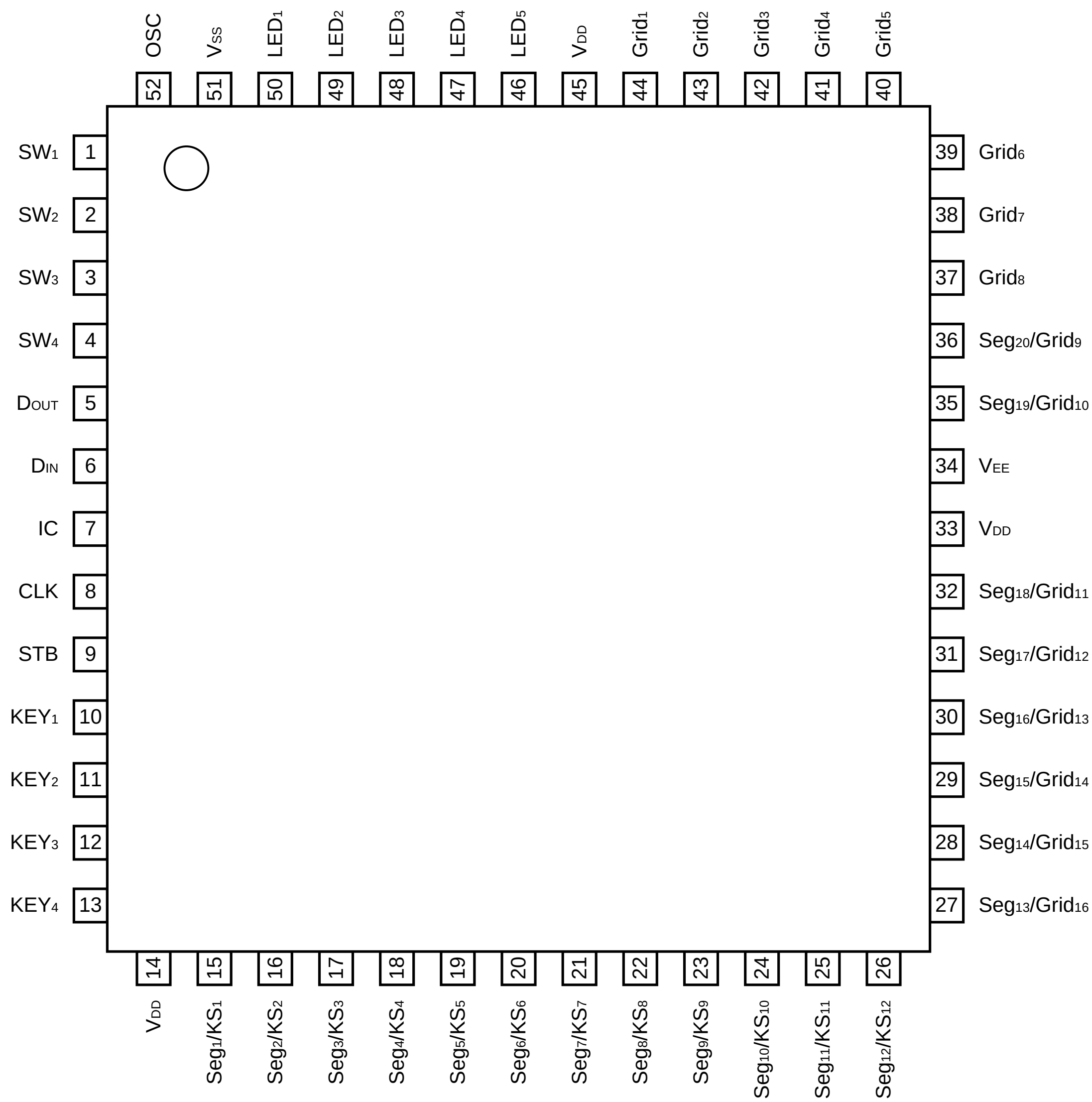
Part Number	Package
μPD16311GC-AB6	52-pin plastic QFP (□14)

Document No. IC-3306 (1st edition)
Date Published March 1997 P
Printed in Japan

BLOCK DIAGRAM



PIN CONFIGURATION (Top View)



Use all the power pins. Leave the IC pin open.

Pin Function

Pin No.	Symbol	Pin Name	Description
6	D_{IN}	Data input	Inputs serial data at rising edge of shift clock, starting from lower bit.
5	D_{OUT}	Data output	Outputs serial data at falling edge of shift clock, starting from lower bit. This is N-ch open-drain output pin.
9	STB	Strobe	Initializes serial interface at rising or falling edge to make μPD16311 waiting for reception of command. Data input after STB has fallen is processed as command. While command data is processed, current processing is stopped, and serial interface is initialized. While STB is high, CLK is ignored.
8	CLK	Clock input	Reads serial data at rising edge, and outputs data at falling edge.
52	OSC	Oscillator pin	Connect resistor for determining oscillation frequency to this pin.
15 to 26	Seg_1/KS_1 to Seg_{12}/KS_{12}	High-voltage output (segment)	Segment output pins (Dual function as key source)
44 to 37	$Grid_1$ to $Grid_6$	High-voltage output (grid)	Grid output pins
27 to 32 35 to 36	$Seg_{13}/Grid_{16}$ to $Seg_{20}/Grid_9$	High-voltage output (segment/grid)	These pins are selectable for segment or grid output.
50 to 46	LED_1 to LED_5	LED output	CMOS output. +20 mA max.
10 to 13	Key_1 to Key_4	Key data input	Data input to these pins is latched at end of display cycle.
1 to 4	SW_1 to SW_4	Switch input	These pins constitute 4-bit general-purpose input port.
14, 33, 45	V_{DD}	Logic power	5 V ± 10 %
51	V_{SS}	Logic ground	Connect this pin to GND of system.
34	V_{EE}	Pull-down level	V_{DD} − 35 V max.
7	IC	Internally connected	Be sure to leave this pin open (this pin is at V_{DD} level).

Display RAM Address and Display Mode

The display RAM stores the data transmitted from an external device to the μPD16311 through the serial interface, and is assigned addresses as follows, in units of 8 bits:

Seg$_1$ … Seg$_4$	Seg$_8$	Seg$_{12}$	Seg$_{16}$	Seg$_{20}$	
00 H$_L$	00 H$_U$ 01 H$_L$	01 H$_U$ 02 H$_L$			
03 H$_L$ 03 H$_U$	04 H$_L$ 04 H$_U$	05 H$_L$			

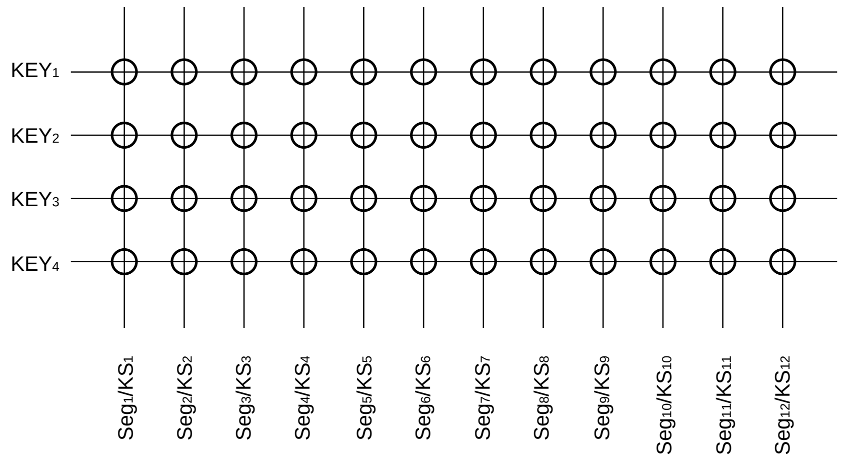
00 H$_L$	00 H$_U$	01 H$_L$	01 H$_U$	02 H$_L$	DIG$_1$
03 H$_L$	03 H$_U$	04 H$_L$	04 H$_U$	05 H$_L$	DIG$_2$
06 H$_L$	06 H$_U$	07 H$_L$	07 H$_U$	08 H$_L$	DIG$_3$
09 H$_L$	09 H$_U$	0 AH$_L$	0 AH$_U$	0 BH$_L$	DIG$_4$
0 CH$_L$	0 CH$_U$	0 DH$_L$	0 DH$_U$	0 EH$_L$	DIG$_5$
0 FH$_L$	0 FH$_U$	10 H$_L$	10 H$_U$	11 H$_L$	DIG$_6$
12 H$_L$	12 H$_U$	13 H$_L$	13 H$_U$	14 H$_L$	DIG$_7$
15 H$_L$	15 H$_U$	16 H$_L$	16 H$_U$	17 H$_L$	DIG$_8$
18 H$_L$	18 H$_U$	19 H$_L$	19 H$_U$	1 AH$_L$	DIG$_9$
1 BH$_L$	1 BH$_U$	1 CH$_L$	1 CH$_U$	1 DH$_L$	DIG$_{10}$
1 EH$_L$	1 EH$_U$	1 FH$_L$	1 FH$_U$	20 H$_L$	DIG$_{11}$
21 H$_L$	21 H$_U$	22 H$_L$	22 H$_U$	23 H$_L$	DIG1$_2$
24 H$_L$	24 H$_U$	25 H$_L$	25 H$_U$	26 H$_L$	DIG$_{13}$
27 H$_L$	27 H$_U$	28 H$_L$	28 H$_U$	29 H$_L$	DIG$_{14}$
2 AH$_L$	2 AH$_U$	2 BH$_L$	2 BH$_U$	2 CH$_L$	DIG$_{15}$
2 DH$_L$	2 DH$_U$	2 EH$_L$	2 EH$_U$	2 FH$_L$	DIG$_{16}$

b$_0$ … b$_3$	b$_4$ … b$_7$
XX H$_L$	XX H$_U$
Lower 4 bits	Higher 4 bits

Only the lower 4 bits of the addresses assigned to Seg$_{17}$ through Seg$_{20}$ are valid, and the higher 4 bits are ignored.

Key Matrix and Key-Input Data Storage RAM

The key matrix is of 12 × 4 configuration, as shown below.



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

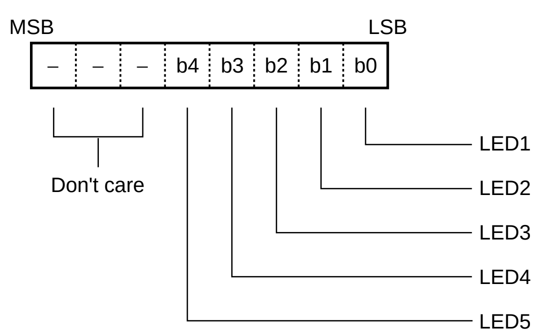
$KEY_1 \ldots KEY_4$	$KEY_1 \ldots KEY_4$
Seg_1/KS_1	Seg_2/KS_2
Seg_3/KS_3	Seg_4/KS_4
Seg_5/KS_5	Seg_6/KS_6
Seg_7/KS_7	Seg_8/KS_8
Seg_9/KS_9	Seg_{10}/KS_{10}
Seg_{11}/KS_{11}	Seg_{12}/KS_{12}
b0------------ b3	b4 ------------b7

Reading sequence ↓

When the most significant bit of data (Seg_{12} b_7) has been read, the least significant bit of the next data (Seg_1 b_0) is read.

LED Port

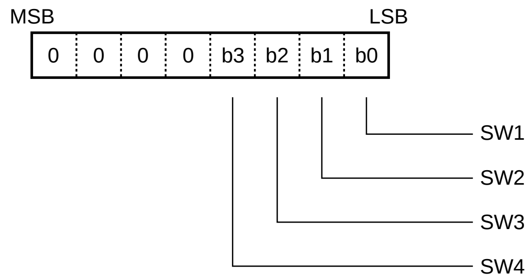
Data is written to the LED port by a write command, starting from the least significant bit of the port. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED goes off. The data of bits 6 through 8 is ignored.



On power application, all the LEDs remain dark.

SW Data

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



Command

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

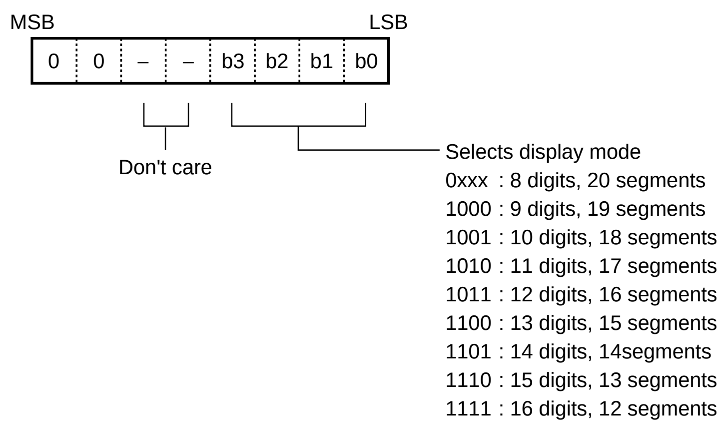
The first 1 byte input to the μPD16311 through the D_{IN} pin after the STB pin has fallen is regarded as a command.

If STB is made high while a command/data is transmitted, serial communication is initialized, and the command/data being transmitted is invalid (however, the command/data already transmitted remains valid).

(1) Display mode setting command

This command initializes the μPD16311 and selects the number of segments and number of grids (1/8 to 1/16 duty, 12 segments to 20 segments).

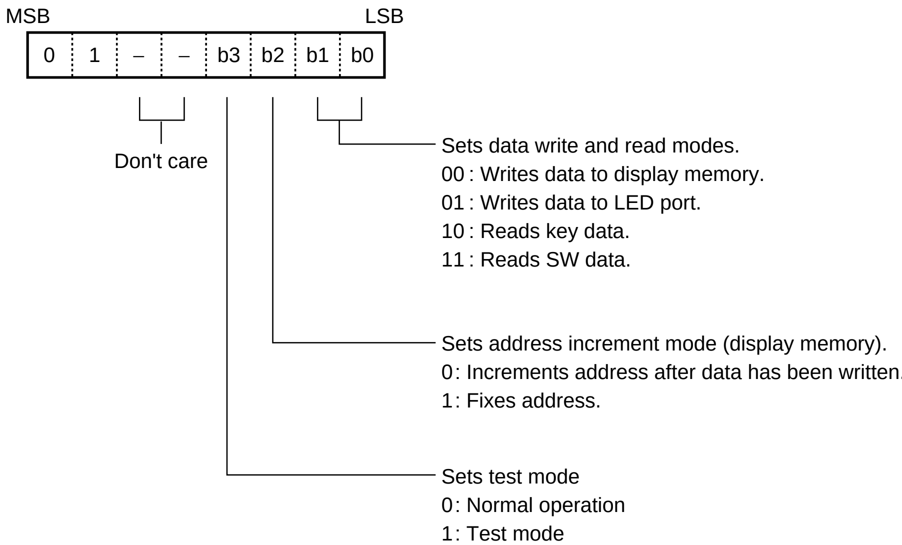
When this command is executed, display is forcibly turned off, and key scanning is also stopped. To resume display, a display ON command must be executed. If the same mode is selected, however, nothing is performed.



On power application, the 16-digit, 12-segment mode is selected.

(2) Data setting command

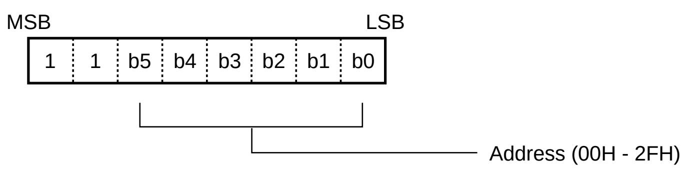
This command sets data write and data read modes.



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

(3) Address setting command

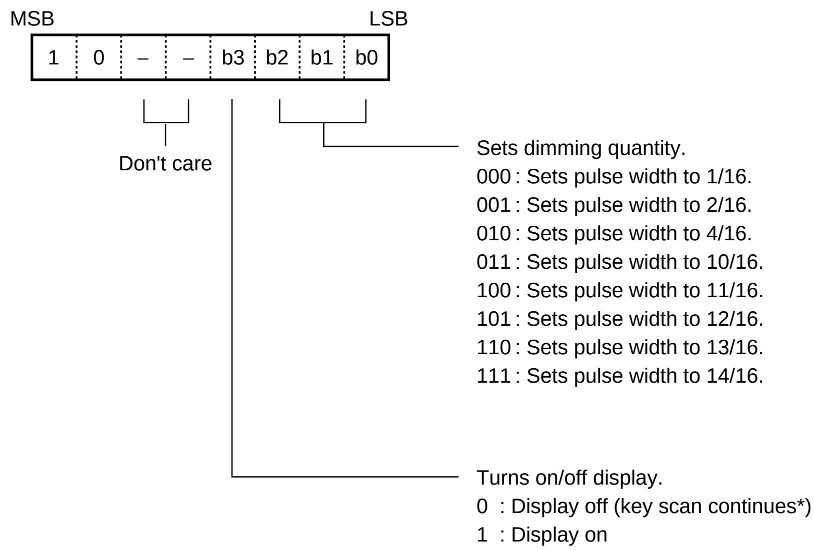
This command sets an address of the display memory.



If address 30H or higher is set, the data is ignored, until a correct address is set.

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

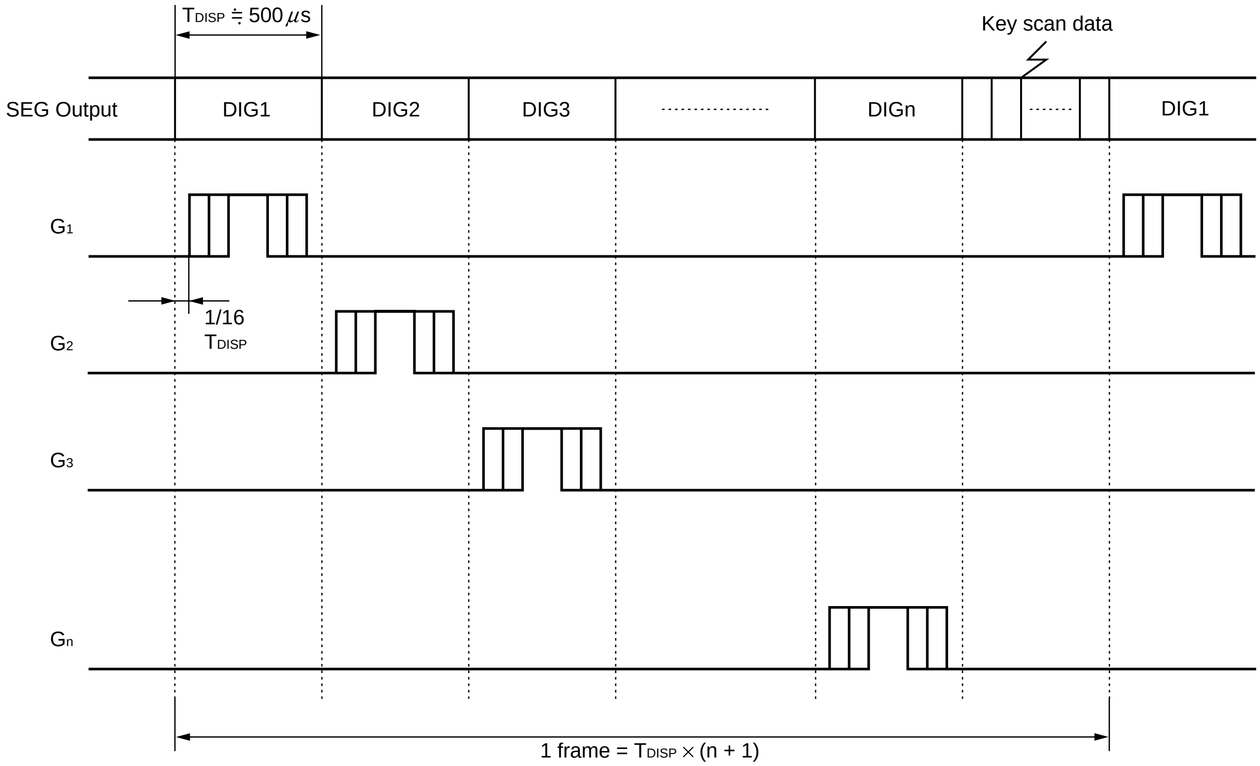
(4) Display control command



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

*: On power application, key scanning is stopped.

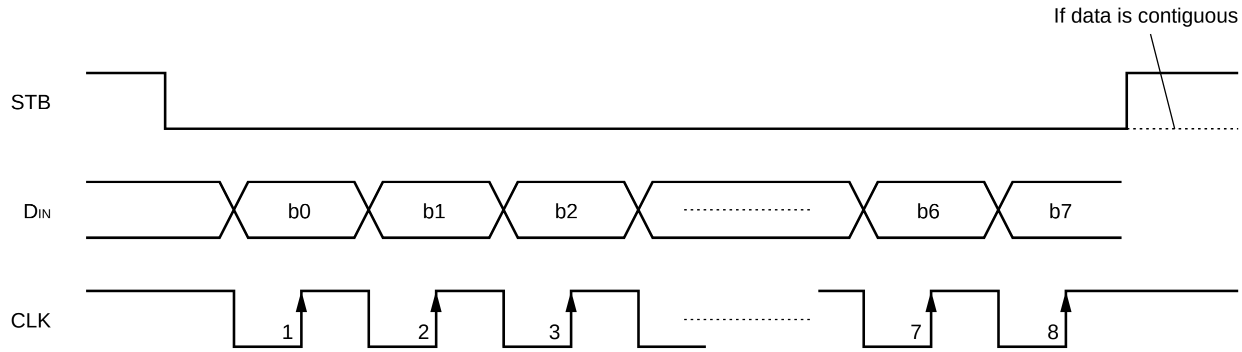
Key Scanning and Display Timing



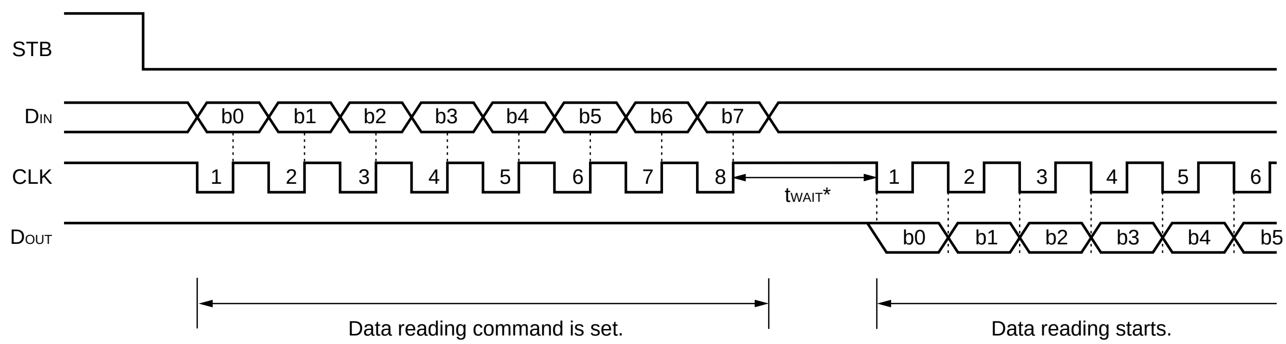
One cycle of key scanning consists of two frames, and data of 12 × 4 matrices is stored in RAM.

Serial Communication Format

Reception (command/data write)



Transmission (data read)



Because the DOUT 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).

*: 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	1200*	mW
Operating Ambient Temperature	T_{opt}	−40 to +85	°C
Storage Temperature	T_{stg}	−65 to +150	°C

***:** Derate at −9.6 mW/°C at T_a = 25 °C or higher.

RECOMMENDED OPERATING CONDITIONS (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 = $(V_{DD} - V_{EE})^2/50$ × (segment + 1) (mW)
LED driver dissipation = number of LEDs × 20 (mW)
Dynamic power consumption = V_{DD} × 5 (mW)

Example
Where V_{EE} = −30 V, V_{DD} = 5 V, and in 16-segment and 12-digit modes,
FIP driver dissipation = 16 × 6 +12/13 × 35 = 128
R_L dissipation = $35^2/50$ × 17 = 417
LED driver dissipation = 5 × 20 = 100
Dynamic power consumption = 5 × 5 = 25

Total 670 mW

ELECTRICAL SPECIFICATIONS (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_5, I_{OH1} = –1 mA
Low-Level Output Voltage	V_{OL1}			1	V	LED_1 – LED_5, 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_{12}
High-Level Output Current	I_{OH22}	–15			mA	V_O = V_{DD} –2 V, $Grid_1$ to $Grid_8$, Seg_{13}/ $Grid_{16}$ to Seg_{12}/ $Grid_9$
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)

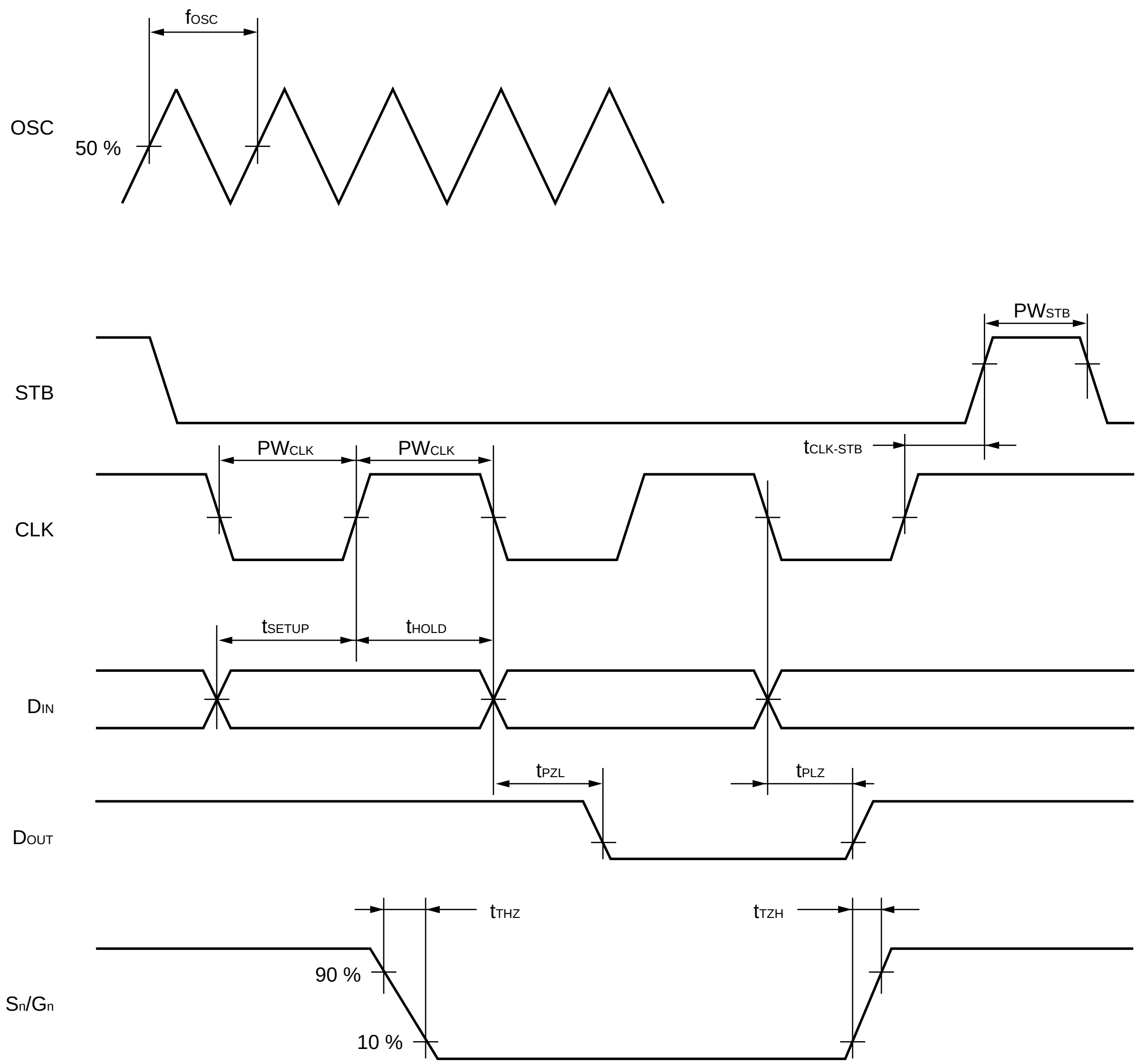
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS	
Oscillation Frequency	t_{OSC}	350	500	650	kHz	R = 56 kΩ	
Propagation Delay Time	t_{PLZ}			300	ns	CLK → D_{OUT}	
	t_{PZL}			100	ns	C_L = 15 pF, R_L = 10 kΩ	
Rise Time	t_{TZH1}			2	μs	C_L = 300 pF	Seg_1 to Seg_{12}
	t_{TZH2}			0.5	μs		$Grid_1$ to $Grid_8$, Seg_{13}/$Grid_{16}$ to Seg_{20}/$Grid_9$
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 ↓*

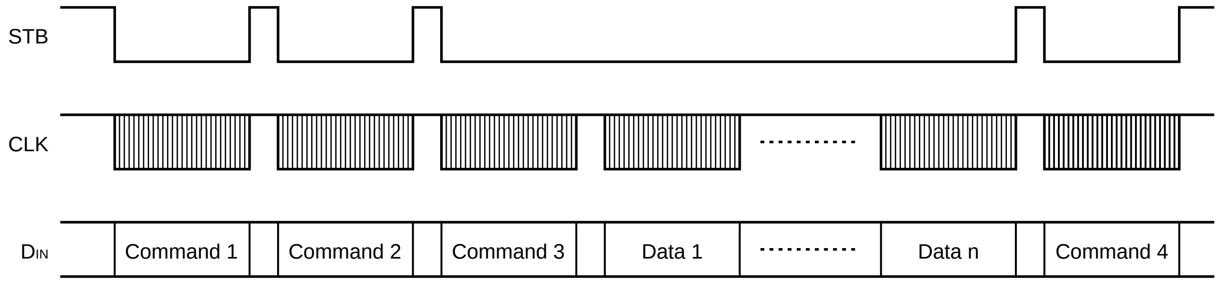
*: Refer to page 11.

Switching Characteristic Waveform



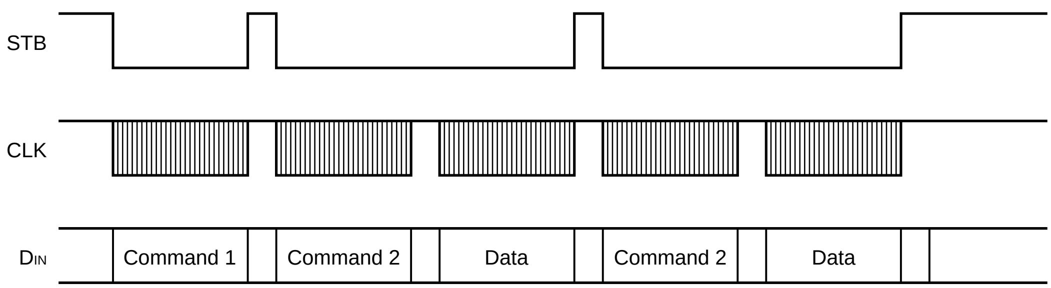
Applications

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 (48 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 officers in case other soldering process is used or in case soldering is done under different conditions.

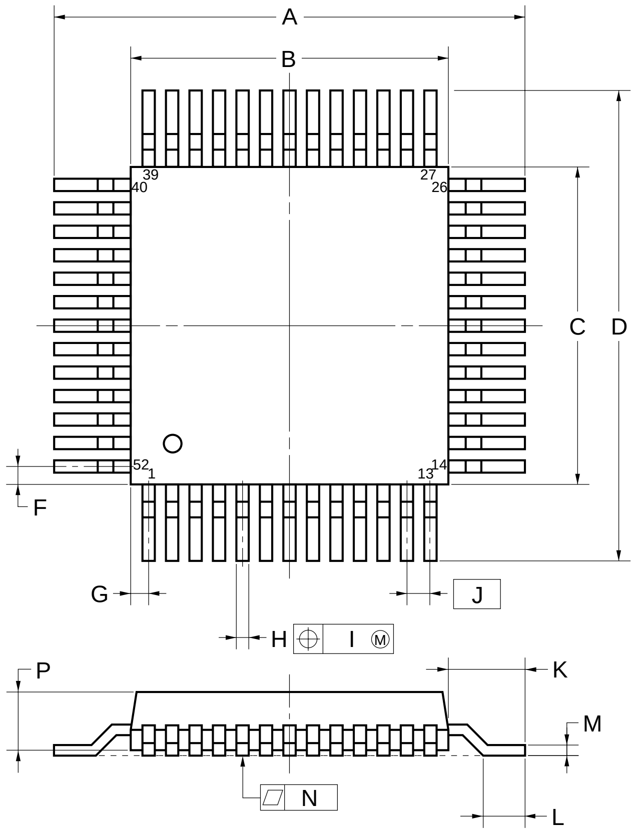
μPD16311GC-AB6

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	

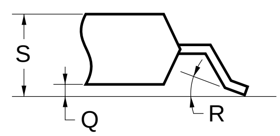
***** Exposure limit before soldering after dry-pack package is opened.
Storage conditions: 25 °C and relative humidity at 65 % or less.

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

52 PIN PLASTIC QFP (14 × 14)



detail of lead end



NOTE

Each lead centerline is located within 0.20 mm (0.008 inch) of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS	INCHES
A	17.6±0.4	0.693±0.016
B	14.0±0.2	$0.551^{+0.009}_{-0.008}$
C	14.0±0.2	$0.551^{+0.009}_{-0.008}$
D	17.6±0.4	0.693±0.016
F	1.0	0.039
G	1.0	0.039
H	0.40±0.10	$0.016^{+0.004}_{-0.005}$
I	0.20	0.008
J	1.0 (T.P.)	0.039 (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	2.6	0.102
Q	0.1±0.1	0.004±0.004
R	5°±5°	5°±5°
S	3.0 MAX.	0.119 MAX.

P52GC-100-AB6-4

[MEMO]

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