

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

The  $\mu$ PD16311 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  $\mu$ PD16311 through a three-line serial interface. This FIP controller/driver is ideal as a peripheral device of a single-chip microcomputer.

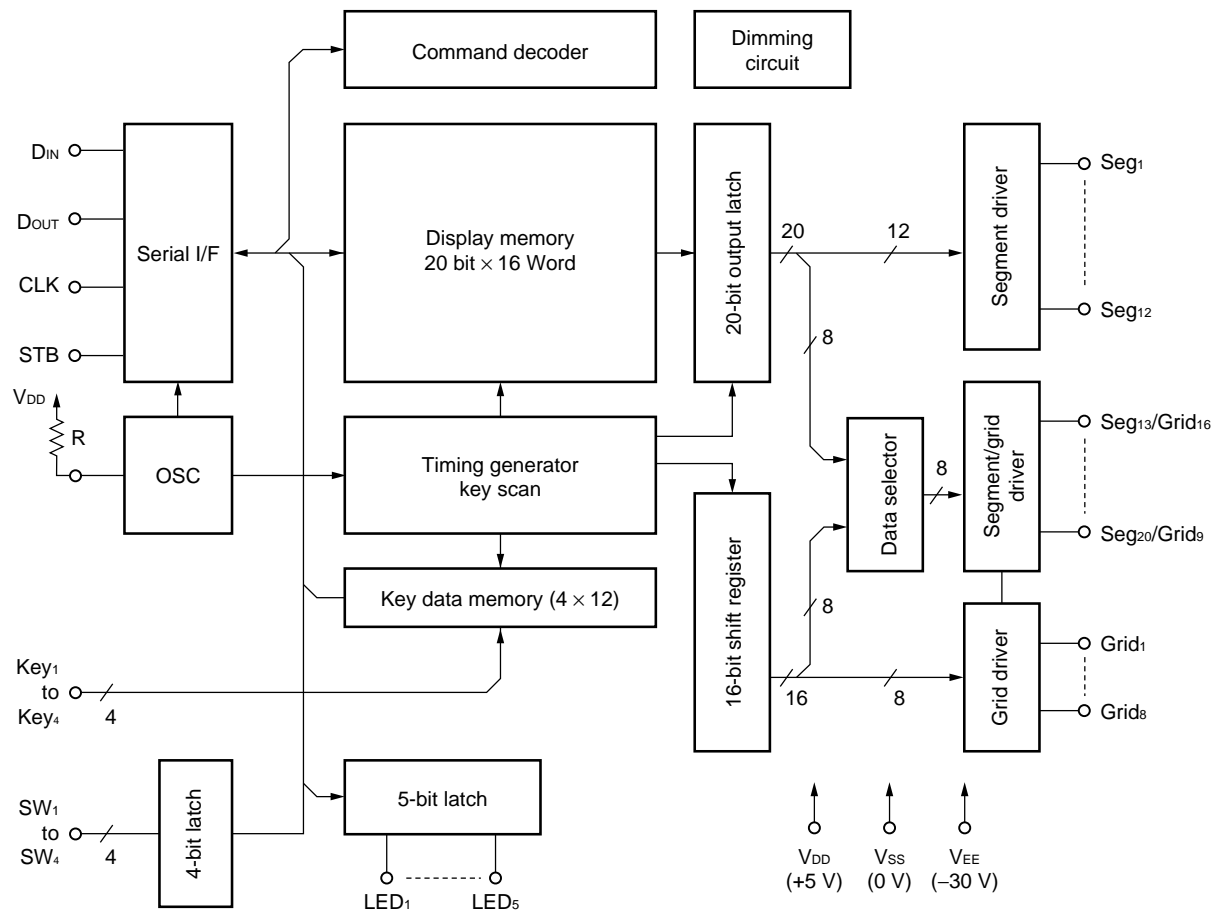
**FEATURES**

- Many display modes (12-segment & 16-digit to 20-segment & 8-digit)
- Key scanning (12 × 4 matrices)
- Dimming circuit (eight steps)
- High-voltage output ( $V_{DD} - 35\text{ V max}$ ).
- 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, DIN, DOUT)

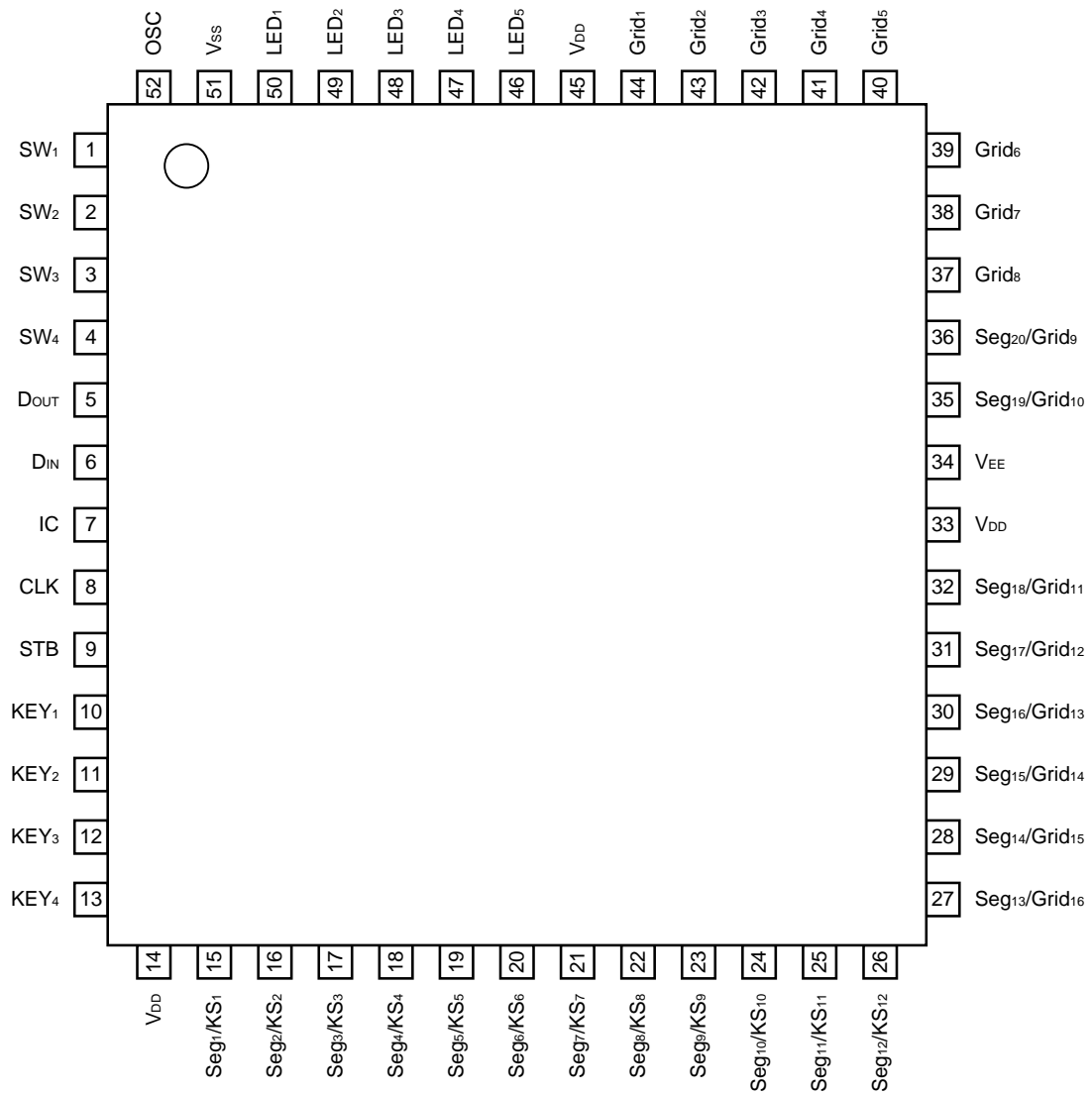
**ORDERING INFORMATION**

Part Number	Package
$\mu$ PD16311GC-AB6	52-pin plastic QFP ( $\square$ 14)

BLOCK DIAGRAM



**PIN CONFIGURATION (Top View)**



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

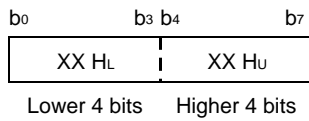
Pin Function

Pin No.	Symbol	Pin Name	Description
6	D <sub>IN</sub>	Data input	Inputs serial data at rising edge of shift clock, starting from lower bit.
5	D <sub>OUT</sub>	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 <sub>1</sub> /KS <sub>1</sub> to Seg <sub>12</sub> /KS <sub>12</sub>	High-voltage output (segment)	Segment output pins (Dual function as key source)
44 to 37	Grid <sub>1</sub> to Grid <sub>6</sub>	High-voltage output (grid)	Grid output pins
27 to 32 35 to 36	Seg <sub>13</sub> /Grid <sub>16</sub> to Seg <sub>20</sub> /Grid <sub>9</sub>	High-voltage output (segment/grid)	These pins are selectable for segment or grid output.
50 to 46	LED <sub>1</sub> to LED <sub>5</sub>	LED output	CMOS output. +20 mA max.
10 to 13	Key <sub>1</sub> to Key <sub>4</sub>	Key data input	Data input to these pins is latched at end of display cycle.
1 to 4	SW <sub>1</sub> to SW <sub>4</sub>	Switch input	These pins constitute 4-bit general-purpose input port.
14, 33, 45	V <sub>DD</sub>	Logic power	5 V ± 10 %
51	V <sub>SS</sub>	Logic ground	Connect this pin to GND of system.
34	V <sub>EE</sub>	Pull-down level	V <sub>DD</sub> – 35 V max.
7	IC	Internally connected	Be sure to leave this pin open (this pin is at V <sub>DD</sub> 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:

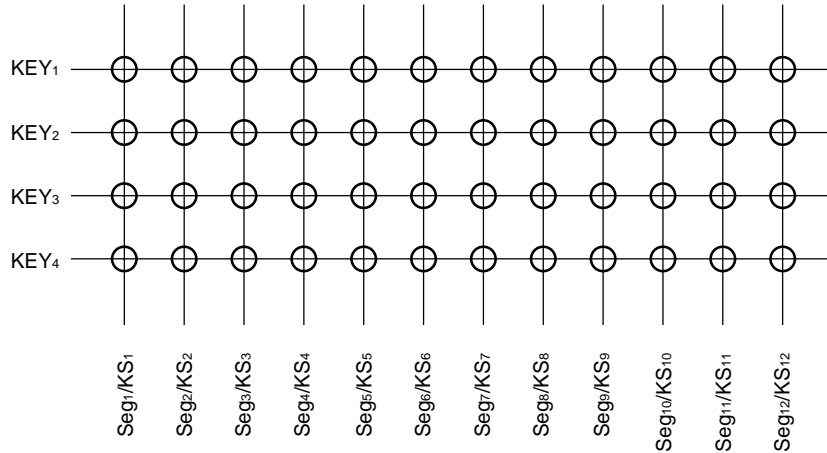
Seg <sub>1</sub>	Seg <sub>4</sub>	Seg <sub>8</sub>	Seg <sub>12</sub>	Seg <sub>16</sub>	Seg <sub>20</sub>	
00 HL	00 HU	01 HL	01 HU	02 HL		DIG <sub>1</sub>
03 HL	03 HU	04 HL	04 HU	05 HL		DIG <sub>2</sub>
06 HL	06 HU	07 HL	07 HU	08 HL		DIG <sub>3</sub>
09 HL	09 HU	0 AHL	0 AHU	0 BHL		DIG <sub>4</sub>
0 CHL	0 CHU	0 DHL	0 DHU	0 EHL		DIG <sub>5</sub>
0 FHL	0 FHU	10 HL	10 HU	11 HL		DIG <sub>6</sub>
12 HL	12 HU	13 HL	13 HU	14 HL		DIG <sub>7</sub>
15 HL	15 HU	16 HL	16 HU	17 HL		DIG <sub>8</sub>
18 HL	18 HU	19 HL	19 HU	1 AHL		DIG <sub>9</sub>
1 BHL	1 BHU	1 CHL	1 CHU	1 DHL		DIG <sub>10</sub>
1 EHL	1 EHU	1 FHL	1 FHU	20 HL		DIG <sub>11</sub>
21 HL	21 HU	22 HL	22 HU	23 HL		DIG <sub>12</sub>
24 HL	24 HU	25 HL	25 HU	26 HL		DIG <sub>13</sub>
27 HL	27 HU	28 HL	28 HU	29 HL		DIG <sub>14</sub>
2 AHL	2 AHU	2 BHL	2 BHU	2 CHL		DIG <sub>15</sub>
2 DHL	2 DHU	2 EHL	2 EHU	2 FHL		DIG <sub>16</sub>



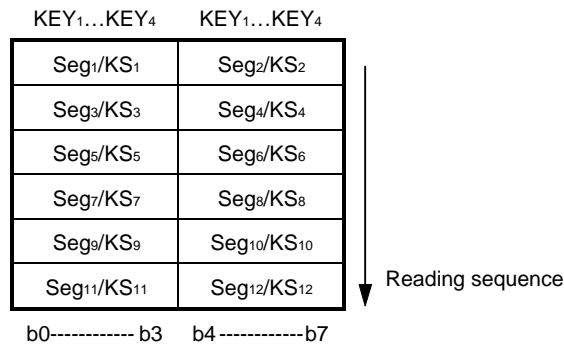
Only the lower 4 bits of the addresses assigned to Seg<sub>17</sub> through Seg<sub>20</sub> are valid, and the higher 4 bits are ignored.

**Key Matrix and Key-Input Data Storage RAM**

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



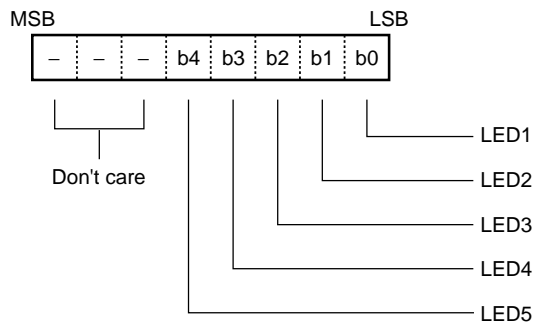
The data of each key is stored as illustrated below, and is read by a read command, starting from the least significant bit.



When the most significant bit of data (Seg12 b7) has been read, the least significant bit of the next data (Seg1 b0) is read.

**LED Port**

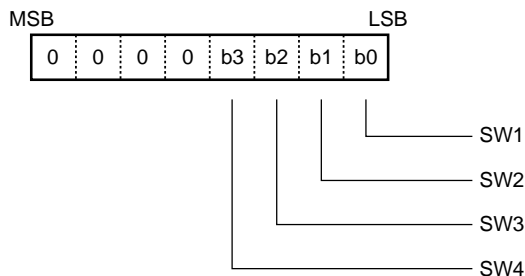
Data is written to the LED port by a write command, starting from the least significant bit of the port. When a bit of this port is 0, the corresponding LED lights; when the bit is 1, the LED goes off. The data of bits 6 through 8 is ignored.



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.

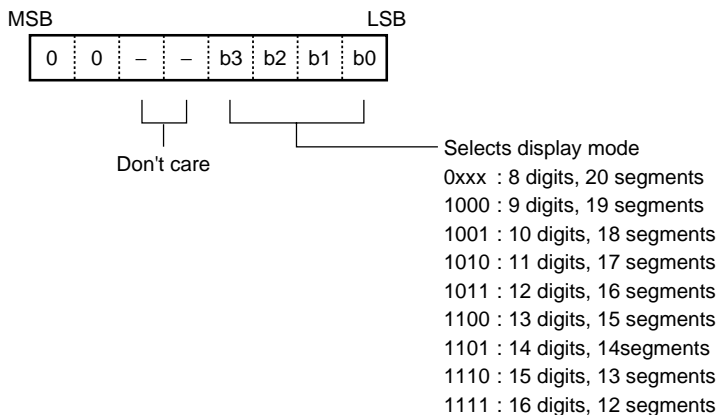
The first 1 byte input to the μPD16311 through the D<sub>IN</sub> pin after the STB pin has fallen is regarded as a command.

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).

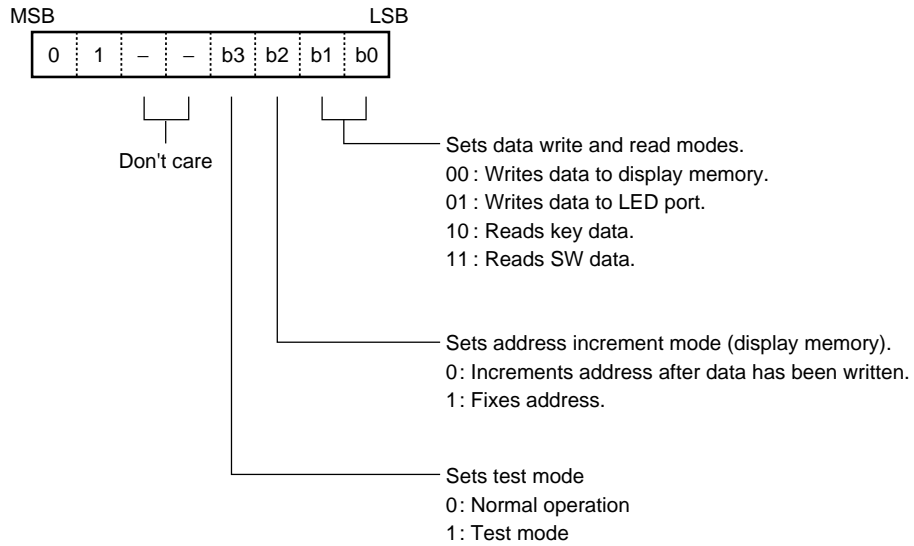
When this command is executed, display is forcibly turned off, and key scanning is also stopped. To resume display, a display ON command must be executed. If the same mode is selected, however, nothing is performed.



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

**(2) Data setting command**

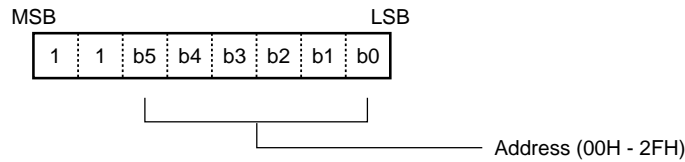
This command sets data write and data read modes.



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.

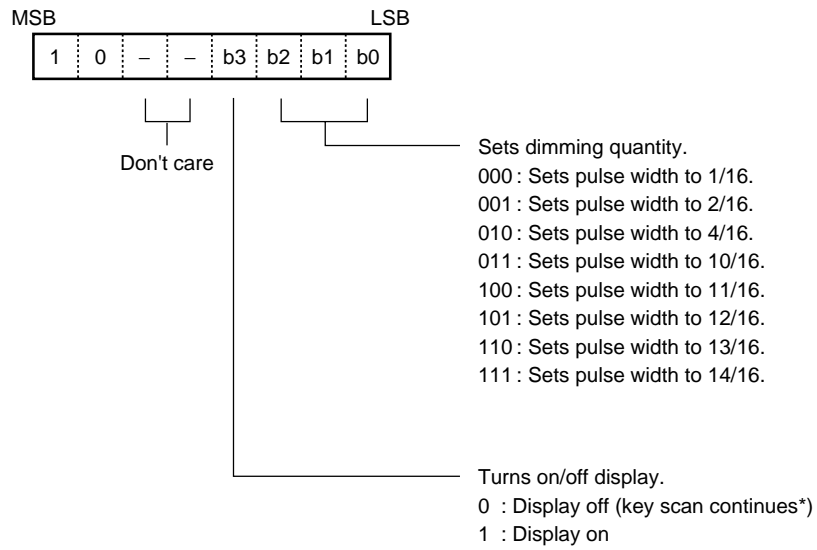


If address 30H or higher is set, the data is ignored, until a correct address is set.

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



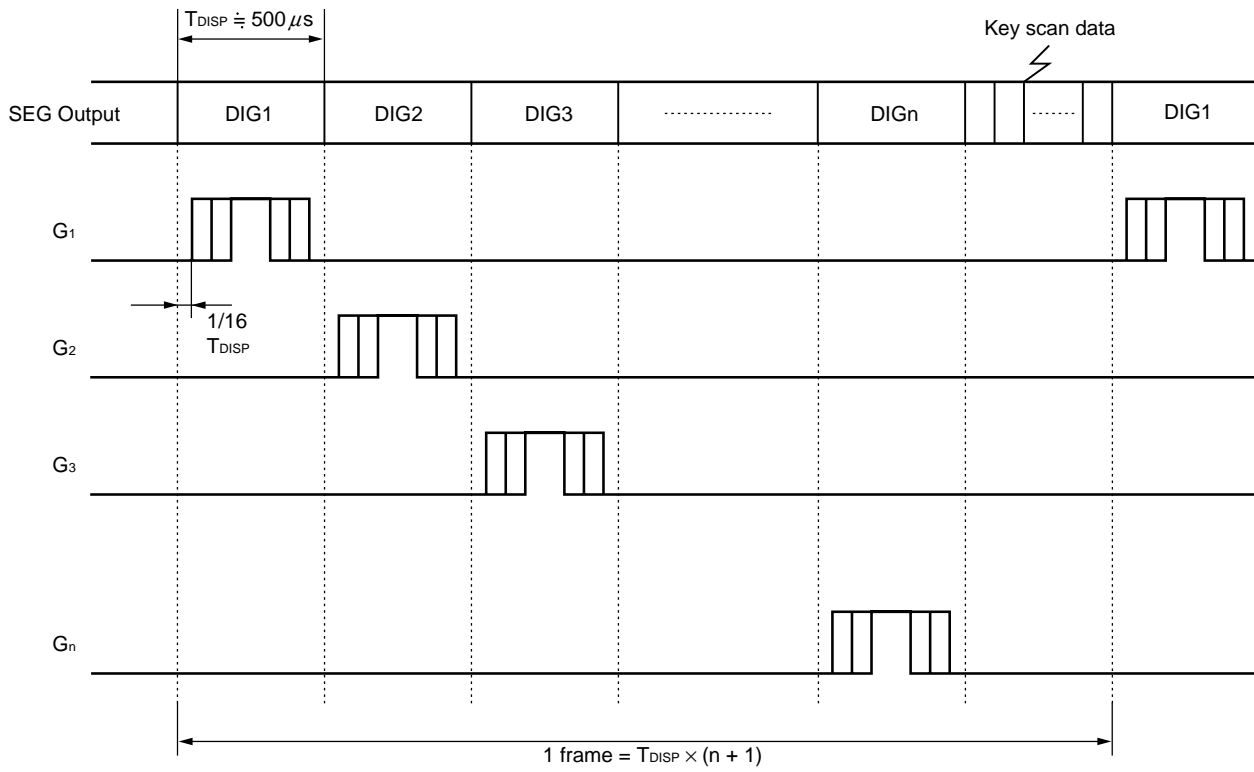
(4) Display control command



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

\*: On power application, key scanning is stopped.

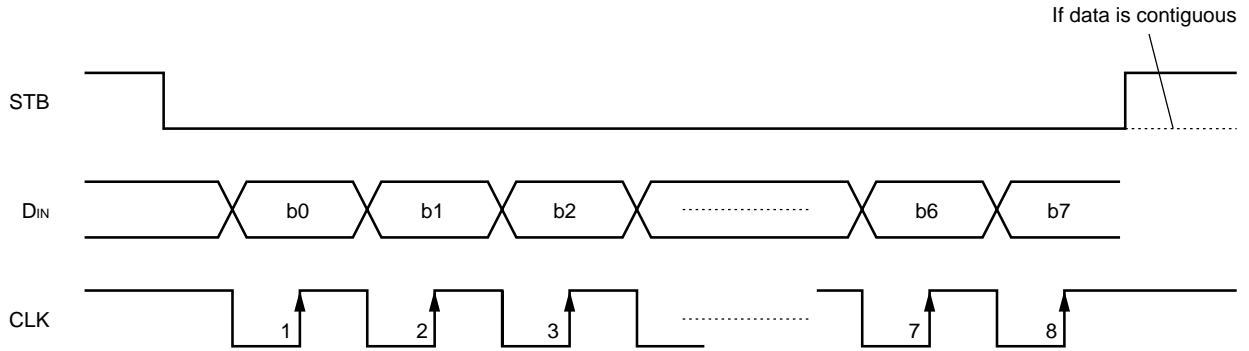
**Key Scanning and Display Timing**



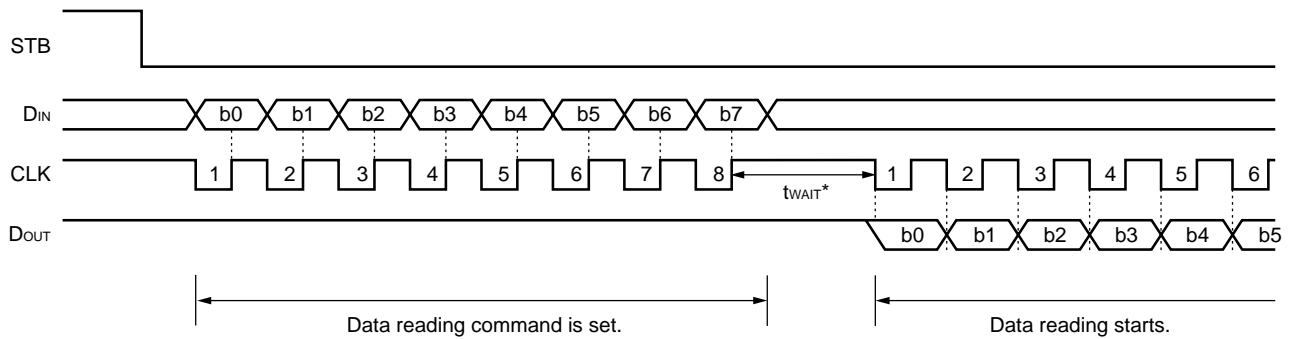
One cycle of key scanning consists of two frames, and data of  $12 \times 4$  matrices is stored in RAM.

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<sub>a</sub> = 25 °C, V<sub>SS</sub> = 0 V)**

PARAMETER	SYMBOL	RATINGS	UNIT
Logic Supply Voltage	V <sub>DD</sub>	-0.5 to +7.0	V
Driver Supply Voltage	V <sub>EE</sub>	V <sub>DD</sub> +0.5 to V <sub>DD</sub> -40	V
Logic Input Voltage	V <sub>I1</sub>	-0.5 to V <sub>DD</sub> +0.5	V
FIP Driver Output Voltage	V <sub>O2</sub>	V <sub>EE</sub> -0.5 to V <sub>DD</sub> +0.5	V
LED Driver Output Current	I <sub>O1</sub>	+25	mA
FIP Driver Output Current	I <sub>O2</sub>	-40 (grid) -15 (segment)	mA
Power Dissipation	P <sub>D</sub>	1200*	mW
Operating Ambient Temperature	T <sub>opt</sub>	-40 to +85	°C
Storage Temperature	T <sub>stg</sub>	-65 to +150	°C

\*: Derate at -9.6 mW/°C at T<sub>a</sub> = 25 °C or higher.

**RECOMMENDED OPERATING CONDITIONS (T<sub>a</sub> = -20 to +70 °C, V<sub>SS</sub> = 0 V)**

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Logic Supply Voltage	V <sub>DD</sub>	4.5	5	5.5	V	
High-Level Input Voltage	V <sub>IH</sub>	0.7 • V <sub>DD</sub>		V <sub>DD</sub>	V	
Low-Level Input Voltage	V <sub>IL</sub>	0		0.3 • V <sub>DD</sub>	V	
Driver Supply Voltage	V <sub>EE</sub>	0		V <sub>DD</sub> - 35	V	

Maximum power consumption P<sub>MAX.</sub> = FIP driver dissipation + R<sub>L</sub> 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<sub>L</sub> dissipation = (V<sub>DD</sub> - V<sub>EE</sub>)<sup>2</sup>/50 × (segment + 1) (mW)

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

Dynamic power consumption = V<sub>DD</sub> × 5 (mW)

Example

Where V<sub>EE</sub> = -30 V, V<sub>DD</sub> = 5 V, and in 16-segment and 12-digit modes,

FIP driver dissipation = 16 × 6 + 12/13 × 35 = 128

R<sub>L</sub> dissipation = 35<sup>2</sup>/50 × 17 = 417

LED driver dissipation = 5 × 20 = 100

Dynamic power consumption = 5 × 5 = 25

Total 670 mW

**ELECTRICAL SPECIFICATIONS (T<sub>a</sub> = -20 to +70 °C, V<sub>DD</sub> = 4.5 to 5.5 V, V<sub>SS</sub> = 0 V, V<sub>EE</sub> = V<sub>DD</sub> - 35 V)**

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
High-Level Output Voltage	V <sub>OH1</sub>	0.9 V <sub>DD</sub>			V	LED <sub>1</sub> - LED <sub>5</sub> , I <sub>OH1</sub> = -1 mA
Low-Level Output Voltage	V <sub>OL1</sub>			1	V	LED <sub>1</sub> - LED <sub>5</sub> , I <sub>OL1</sub> = 20 mA
Low-Level Output Voltage	V <sub>OL2</sub>			0.4	V	D <sub>OUT</sub> , I <sub>OL2</sub> = 4 mA
High-Level Output Current	I <sub>OH21</sub>	-3			mA	V <sub>O</sub> = V <sub>DD</sub> - 2 V, Seg <sub>1</sub> to Seg <sub>12</sub>
High-Level Output Current	I <sub>OH22</sub>	-15			mA	V <sub>O</sub> = V <sub>DD</sub> - 2 V, Grid <sub>1</sub> to Grid <sub>8</sub> , Seg <sub>13</sub> / Grid <sub>16</sub> to Seg <sub>12</sub> / Grid <sub>9</sub>
Driver Leakage Current	I <sub>OLEAK</sub>			-10	μA	V <sub>O</sub> = V <sub>DD</sub> - 35 V, driver off
Output Pull-Down Resistor	R <sub>L</sub>	50	100	150	KΩ	Driver output
Input Current	I <sub>I</sub>			±1	μA	V <sub>I</sub> = V <sub>DD</sub> or V <sub>SS</sub>
High-Level Input Voltage	V <sub>IH</sub>	0.7 V <sub>DD</sub>			V	
Low-Level Input Voltage	V <sub>IL</sub>			0.3 V <sub>DD</sub>	V	
Hysteresis Voltage	V <sub>H</sub>		0.35		V	CLK, D <sub>IN</sub> , STB
Dynamic Current Consumption	I <sub>DDdyn</sub>			5	mA	Under no load, display off

**SWITCHING CHARACTERISTICS (T<sub>a</sub> = -20 to +70 °C, V<sub>DD</sub> = 4.5 to 5.5 V, V<sub>EE</sub> = -30 V)**

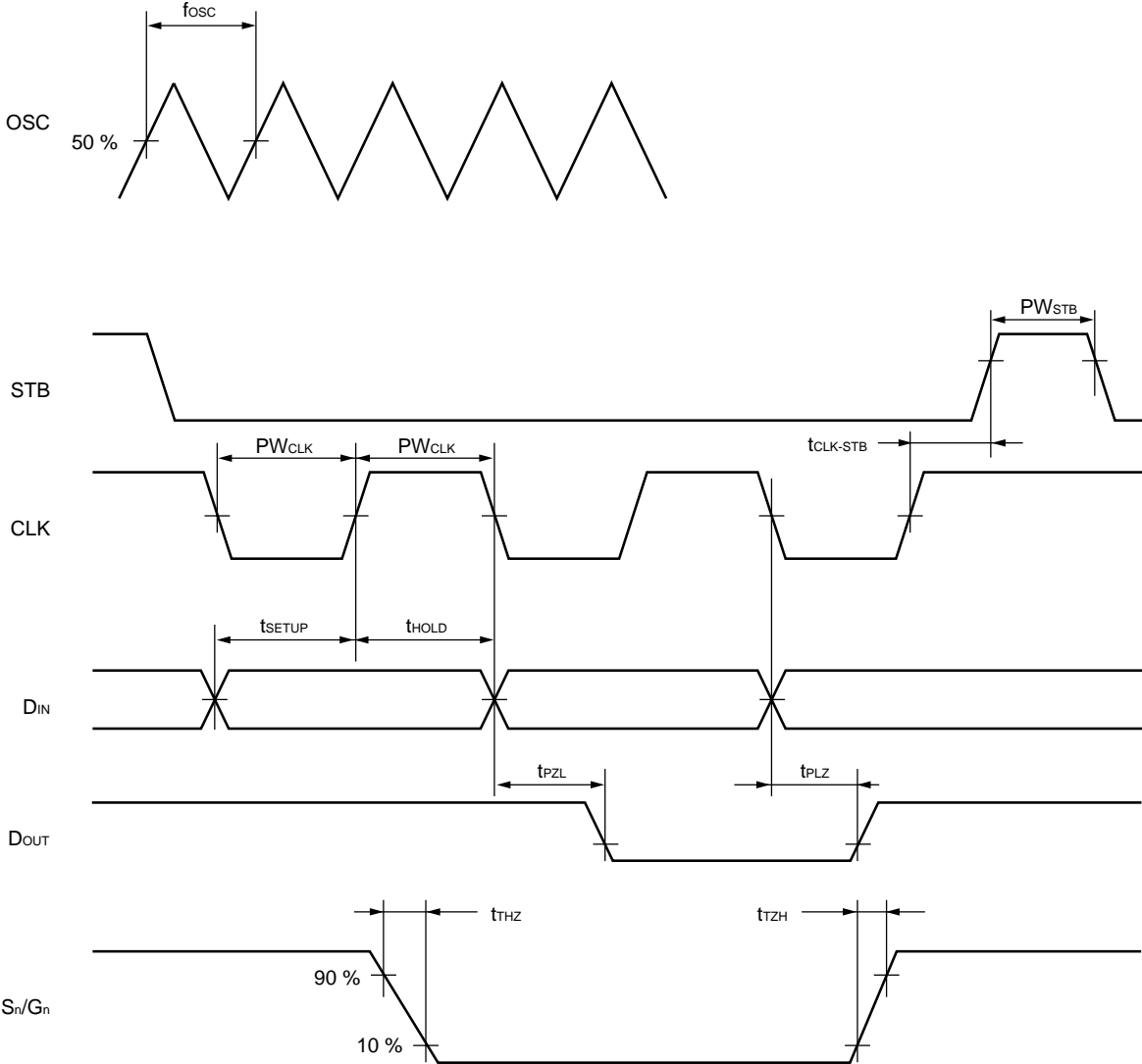
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Oscillation Frequency	t <sub>osc</sub>	350	500	650	kHz	R = 56 kΩ
Propagation Delay Time	t <sub>PLZ</sub>			300	ns	CLK → D <sub>OUT</sub>
	t <sub>PZL</sub>			100	ns	C <sub>L</sub> = 15 pF, R <sub>L</sub> = 10 kΩ
Rise Time	t <sub>TZH1</sub>			2	μs	C <sub>L</sub> = 300 pF Seg <sub>1</sub> to Seg <sub>12</sub> Grid <sub>1</sub> to Grid <sub>8</sub> , Seg <sub>13</sub> /Grid <sub>16</sub> to Seg <sub>20</sub> /Grid <sub>9</sub>
	t <sub>TZH2</sub>			0.5	μs	
Fall time	t <sub>THZ</sub>			120	μs	C <sub>L</sub> = 300 pF, Seg <sub>n</sub> , Grid <sub>n</sub>
Maximum Clock Frequency	f <sub>max.</sub>	1			MHz	Duty = 50 %
Input Capacitance	C <sub>I</sub>			15	pF	

**TIMING CONDITIONS (T<sub>a</sub> = -20 to +70 °C, V<sub>DD</sub> = 4.5 to 5.5 V)**

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITIONS
Clock Pulse Width	PW <sub>CLK</sub>	400			ns	
Strobe Pulse Width	PW <sub>STB</sub>	1			μs	
Data Setup Time	t <sub>SETUP</sub>	100			ns	
Data Hold Time	t <sub>HOLD</sub>	100			ns	
Clock-Strobe Time	t <sub>CLK-STB</sub>	1			μs	CLK ↑ → STB ↑
Wait Time	t <sub>WAIT</sub>	1			μs	CLK ↑ → CLK ↓*

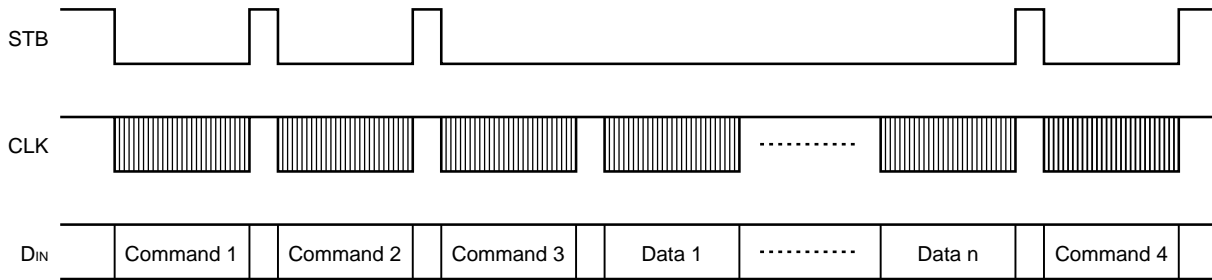
\*: Refer to page 11.

Switching Characteristic Waveform



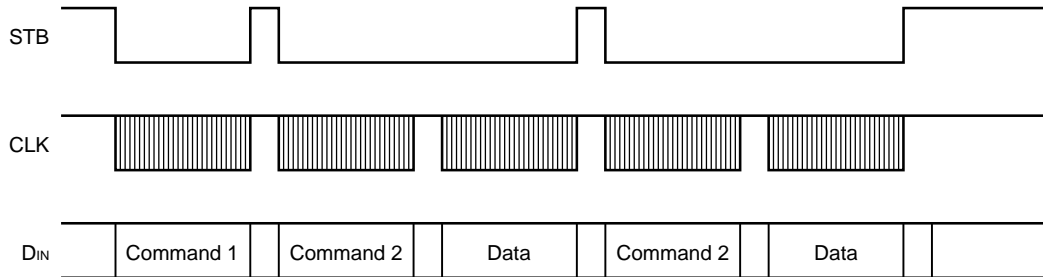
**Applications**

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

**μPD16311GC-AB6**

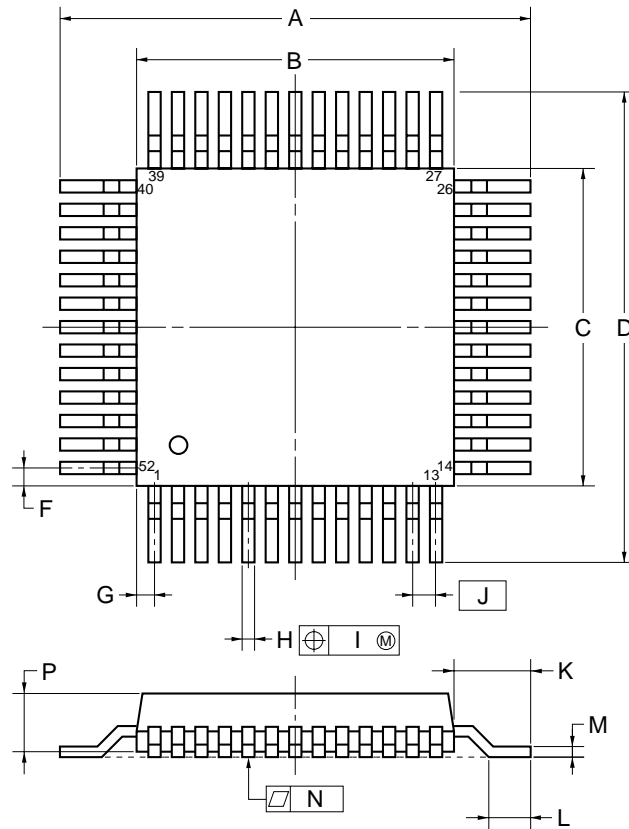
Soldering process	Soldering conditions	Symbol
Infrared ray reflow	Peak package's surface temperature: 235 °C or below, Reflow time: 30 seconds or below (210 °C or higher), Number of reflow process: 2, Exposure limit*: None	IR35-00-2
VPS	Peak package's surface temperature: 215 °C or below, Reflow time: 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.

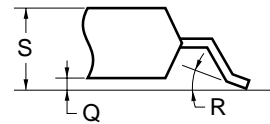
**Note** Do not apply more than a single process at once, except for "Partial heating method".



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 <sup>+0.009</sup> <sub>-0.008</sub>
C	14.0±0.2	0.551 <sup>+0.009</sup> <sub>-0.008</sub>
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 <sup>+0.004</sup> <sub>-0.005</sub>
I	0.20	0.008
J	1.0 (T.P.)	0.039 (T.P.)
K	1.8±0.2	0.071 <sup>+0.008</sup> <sub>-0.009</sub>
L	0.8±0.2	0.031 <sup>+0.009</sup> <sub>-0.008</sub>
M	0.15 <sup>+0.10</sup> <sub>-0.05</sub>	0.006 <sup>+0.004</sup> <sub>-0.003</sub>
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]

[MEMO]

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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)

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Anti-radioactive design is not implemented in this product.