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RoHS Compliant

VACUUM FLUORESCENT DISPLAY

MODULE

SPECIFICATION

MODEL : CU16024-UX3J

SPECIFICATION NO.	: DS-1688-0000-03	
DATE OF ISSUE	: October 17, 2011	(00)
REVISION	: October 27, 2011	(01)
	: February 19, 2015	(02)
	: July 17,2015	(03)
	:	

PUBLISHED BY

NORITAKE ITRON CORP. / JAPAN

http://www.noritake-itron.jp

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This product complies with RoHS Directive

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1 General Description

1.1 Application : Readout of computer, micro-computer, communication terminal and automatic instruments.

1.2 Construction : Single board display module consists of 32 characters (2×16) VFD, a controller which includes character generator ROM, RAM and DC/DC converter.

1.3 Scope : Interface is synchronous serial.
+5V single power supply is required.

1.4 Weight : About 23 g

2 Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Power Supply Voltage	V_{CC}	0	–	5.5	V_{DC}	–
Logic Input Voltage	V_I	0	–	V_{CC}+0.3	V_{DC}	–

3 Electrical Ratings

Measuring Conditions: TA (Ambient temperature) = 25 degree

Parameter		Symbol	Min.	Typ.	Max.	Unit	Condition
Logic Input Voltage SCK, STB	"H"	V_{IH1}	2.0	–	V_{CC}	V_{DC}	$V_{CC} - V_{SS}$ = 5.0V
	"L"	V_{IL1}	V_{SS}	–	0.8		
Logic Input Voltage SI/SO	"H"	V_{IH2}	0.7V_{CC}	–	V_{CC}	V_{DC}	$V_{CC} - V_{SS}$ = 5.0V
	"L"	V_{IL2}	V_{SS}	–	0.3V_{CC}		
Power supply Voltage		V_{CC}-V_{SS}	4.75	5.00	5.25	V_{DC}	–

4 Electrical Characteristics

Measuring Conditions: TA (Ambient temperature) = 25degree, V_{CC} = 5.0V_{DC}

Parameter		Symbol	Min.	Typ.	Max.	Unit	Condition
Logic Output Voltage	"H"	V_{OH}	V_{CC}-0.8	–	–	V_{DC}	I_{OH} = -4 mA
	"L"	V_{OL}	–	–	0.6		I_{OL} = 4 mA
	"H"	V_{OH}	V_{CC}-0.5	–	–	V_{DC}	I_{OH} = -2 mA
	"L"	V_{OL}	–	–	0.5		I_{OL} = 2 mA
Power Supply Current 1		I_{CC1}	–	160	200	mA	Display ON Brightness 200%
Power Supply Current 2		I_{CC2}	–	135	170	mA	Display ON Brightness 100%
Power Supply Current 3		I_{CC3}	–	7	20	mA	Display OFF
Power Consumption			–	0.80	1.00	W	Display ON Brightness 200%
Power Consumption			–	0.68	0.85	W	Display ON Brightness 100%

Note: I_{CC1} shows the current, when all dots are turned on.
I_{CC} might be anticipated twice as usual at power on rush.

5 Optical Characteristics

Number of characters	:	32 (2 lines×16 chars)
Matrix format	:	5×7 dot
Display area	:	46.54×7.65 mm (X×Y)
Character size	:	2.065×3.569 mm (X×Y)
Character pitch	:	2.965 mm
Line pitch	:	4.081 mm
Dot size	:	0.333×0.407 mm (X×Y)
Dot pitch	:	0.433×0.527 mm (X×Y)
Luminance	:	In case of brightness 100%: 1000 cd/m^2 Typ., 350 cd/m^2 Min. In case of brightness 200%: 2000 cd/m^2 Typ.
Color of illumination	:	Green (Blue-green)

6 Environmental Conditions

Operating temperature	:	-40 to +85 degree
Storage temperature	:	-50 to +85 degree
Operating humidity	:	20 to 80 % RH (Non condensation)
Vibration (Non operation)	:	10 to 55 to 10 Hz (Frequency), 1.0 mm (Total Amplitude) 30 Min. (Duration) X, Y, Z each direction
Shock (Non operation)	:	980 m/s^2, 6ms

7 Functional Descriptions

7.1 Instruction table

Instruction	CODE										Time	Description
	RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Display Clear	0	0	0	0	0	0	0	0	0	1	100μs MAX.	Clears all display and sets DD RAM address 0 in the address counter.
Cursor Home	0	0	0	0	0	0	0	0	1	*	666ns	Sets DD RAM address 0 in the address counter. Also returns the display being shifted to the original position. DD RAM contents remain unchanged.
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	666ns	Sets the cursor direction and specifies display shift. These operations are performed during writing/reading data.
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	666ns	Sets all display ON/OFF(D),cursor ON/OFF(C),cursor blink of character position (B).
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	666ns	Shifts display or cursor, keeping DD RAM contents.
Function Set	0	0	0	0	1	IF=1	*	*	*	*	666ns	-
Brightness Control	1	0	*	*	*	*	*	*	BR1	BR0	666ns	Accepts 1 byte data of just after "Function set" as brightness control data.

Instruction	CODE										Time	Description
	RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
CG RAM Address setting	0	0	0	1	ACG						666ns	Sets the CG RAM address.
DD RAM Address setting	0	0	1	ADD							666ns	Sets the DD RAM address.
Busy flag & Address Reading	0	1	BF	ACC							666ns	Reads busy flag (BF) and address counter.
Data Writing to CG or DD RAM	1	0	Data writing								666ns	Writes data into CG RAM or DD RAM.
Data Reading from CG or DD RAM	1	1	Data reading								666ns	Reads data from CG RAM or DD RAM.
	I/D = 1 : Increment I/D = 0 : Decrement S = 1 : Display shift enabled S = 0 : Cursor shift enabled S/C = 1 : Display shift S/C = 0 : Cursor move R/L = 1 : Shift to the right R/L = 0 : Shift to the left BR1,BR0 = 00 : 200% 01 : 150% 10 : 100% 11 : 50%							IF = 1 : 8-bits IF = 0 : 4-bits BF = 1 : Busy BF = 0 : Not busy				DD RAM: Display Data RAM CG RAM: Character Generator RAM ACG: CG RAM Address ADD: DD RAM Address ACC: Address Counter

Note:

*: Don't care.

7.2 Display Clear

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	0	0	0	1	01H

RS=0

This instruction

1. Fills all locations in the display data (DD) RAM with 20H (Blank character).
2. Clears the contents of the address counter to 0H.
3. Sets the display for zero character shift.
4. Sets the address counter to point to the DD RAM.
5. If the cursor is displayed, the cursor moves to the left most character in the top line (Line 1).
6. Sets the address counter to increment on each access of DD RAM or CG RAM.

7.3 Cursor Home

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	0	0	1	*	02H to 03H

RS=0

*: Don't care.

This instruction

1. Clears the contents of the address counter to 0H.
2. Sets the address counter to point to the DD RAM.
3. Sets the display for zero character shift.
4. If the cursor is displayed, moves the left most character in the top line (Line 1).

7.4 Entry Mode Set

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	0	1	I/D	S	04H to 07H

RS=0

The I/D bit selects the way in which the contents of the address counter are modified after every access to DD RAM or CG RAM.

I/D=1: The address counter is increment.

I/D=0: The address counter is decrement.

The S bit enables display shifts instead of cursor shift, after each write or read to the DD RAM.

S=1: Display shift enabled.

S=0: Cursor shift enabled.

The direction in which the display is shifted is opposite in sense to that of the cursor. For example if S=0 and I/D=1, the cursor would shift one character to the right after a CPU writes to DD RAM. However if S=1 and I/D=1, the display would shift one character to the left and the cursor would maintain its position on the panel.

The cursor will already be shifted in the direction selected by I/D during reads of the DD RAM, irrespective of the value of S. Similarly reading and writing the CG RAM always shifts the cursor. Also both lines are shifted simultaneously.

Cursor move and Display shift by the "Entry Mode Set"

I/D	S	After writing DD RAM data	After reading DD RAM data
0	0	The cursor moves one character to the left.	The cursor moves one character to the left.
1	0	The cursor moves one character to the right.	The cursor moves one character to the right.
0	1	The display shifts one character to the right without cursor's move.	The cursor moves one character to the left.
1	1	The display shifts one character to the left without cursor's move.	The cursor moves one character to the right.

7.5 Display ON/OFF

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	0	1	D	C	B	08H to 0FH

RS=0

This instruction controls various features of the display.
The D bit turns the entire display on or off.
D=1: Display on
D=0: Display off
Note: When display is turned off, power converter is also inhibited and reduces a power consumption.

The C bit turns the cursor on or off.
C=1: Cursor on
C=0: Cursor off

The B bit enables blinking of the character the cursor coincides with.
B=1: Blinking on
B=0: Blinking off

Blinking is achieved by alternating between a normal and all on display of a character.
The cursor blinks with a frequency of about 1Hz and DUTY 50%.

7.6 Cursor/Display Shift

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	0	1	S/C	R/L	*	*	10H to 1FH

RS=0

*: Don't care.

This instruction shifts the display and/or moves the cursor, on character to either left or right, without neither reading nor writing DD RAM.
The S/C bit selects movement of the cursor or movement of both the cursor and the display.
S/C=1: Shift both cursor and display.
S/C=0: Shift cursor only.

The R/L bit selects left ward or right ward movement of the display and/or cursor.
R/L=1: Shift one character right.
R/L=0: Shift one character left.

Cursor move and Display shift by the "Cursor/Display Shift"

S/C	R/L	Cursor shift	Display shift
0	0	Move one character to the left	No shift
0	1	Move one character to the right	No shift
1	0	Shift one character to left with display	Shift one character to the left
1	1	Shift one character to right with display	Shift one character to the right

7.7 Function Set

7.7.1 Function Set Command

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	0	1	IF	*	*	*	*	20H to 3FH

RS=0

*: Don't care.

IF = 1 [Don't change.]

This instruction sets screen brightness by next one byte data.

7.7.2 Brightness Control

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
*	*	*	*	*	*	BR1	BR0	00H to 03H

RS=1

*: Don't care.

One byte data (RS=1) which follows the "Function Set Command" is considered as brightness data. When a command (RS=0) is written after the "Function Set Command", the brightness control function is not initiated. Screen brightness is as follows.

BR1	BR0	Brightness
0	0	200 % (Brightness boost mode)
0	1	150 %
1	0	100 % (It is recommended to use under this condition usually.)
1	1	50 %

7.8 Set CG RAM Address

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
0	1	ACG						40H to 7FH

RS=0

This instruction
1. Loads a new 6-bit address into the address counter.
2. Sets the address counter to address CG RAM.

Once "Set CG RAM Address" has been executed, the contents of the address counter will be automatically modified after every access of CG RAM, as determined by the "7.4 Entry Mode Set" instruction. The active width of the address counter, when it is addressing CG RAM, is 6-bits so the counter will wrap around to 00H from 3FH if more than 64 bytes of data are written to CG RAM.

7.9 Set DD RAM Address

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	ADD						

RS=0

80H to A7H (1 line), C0H to E7H (2 line)

This instruction
1. Loads a new 7-bit address into the address counter.
2. Sets the address counter to point to the DD RAM.

Once the "Set DD RAM Address" instruction has been executed, the contents of the address counter will be automatically modified after each access of DD RAM, as selected by the "7.4 Entry Mode Set" instruction.

Valid DD RAM Address (ADD) Range

	Number of Characters	Address
1st line	40	00H to 27H
2nd line	40	40H to 67H

7.10 Write Data

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
DATA WRITE								00H to FFH

RS=1

This instruction writes the data in DB7 to DB0 into either the CG RAM or the DD RAM. The RAM space (CG or DD), and the address in that space, that is accessed depends on whether a "Set CG RAM Address" or a "Set DD RAM Address" instruction was last executed, and on the parameters of that instruction. The contents of the address counter will be automatically modified after each "Write Data", as determined by the "7.4 Entry Mode Set". When data is written to the CG RAM, the DB7, DB6 and DB5 bits are not displayed as characters.

7.11 Read Data

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
DATA READ							

RS=1

This instruction reads data from either CG RAM or DD RAM, depending on the type of "Set RAM Address" instructions last sent. The address in that space depends on the "Set RAM Address" instruction parameters. Immediately before executing "Read Data", "Set CG RAM Address" or "Set DD RAM Address" must be executed. The contents of the address counter are modified after each "Read Data". As determined by the "7.4 Entry Mode Set". Display shift is not executed, as described at of the "7.4 Entry Mode Set".

7.12 Read Busy Flag/Address Counter

DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
BF	ACC						

RS=0

Reading the instruction register yields the current value of the address counter and the busy flag. This instruction must be executed prior to any other instructions. ACC, the address counter value, will point to a location in either CG RAM or DD RAM, depending on the type of "Set RAM Address" instruction last sent.
In "Busy Flag Check" immediately after executing "Write Data" instruction, a valid address counter value can be ready as soon as BF goes low. The BF bit shows the status of the busy flag.

BF=1: busy.

BF=0: ready for next instruction, command receivable.

8 Other features

8.1 CG RAM

The display module has CG RAM of 320 bit = (5×8 bit /char) × 8 chars which is for user definable character fonts. The character fonts consist of 5×7 dots. The number 1-35 corresponds to character fonts.

Character code	CG RAM address						CG RAM data (character pattern)							
	DB5	DB4	DB3	DB2	DB1	DB0	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
00H or (08H)	0	0	0	0	0	0	*	*	*	1	2	3	4	5
	0	0	0	0	0	1	*	*	*	6	7	8	9	10
	0	0	0	0	1	0	*	*	*	11	12	13	14	15
	0	0	0	0	1	1	*	*	*	16	17	18	19	20
	0	0	0	1	0	0	*	*	*	21	22	23	24	25
	0	0	0	1	0	1	*	*	*	26	27	28	29	30
	0	0	0	1	1	0	*	*	*	31	32	33	34	35
	0	0	0	1	1	1	*	*	*	0	0	0	0	0
01H or (09H)	0	0	1	0	0	0	*	*	*	1	2	3	4	5
	0	0	1	0	0	1	*	*	*	6	7	8	9	10
	0	0	1	0	1	0	*	*	*	11	12	13	14	15
	0	0	1	0	1	1	*	*	*	16	17	18	19	20
	0	0	1	1	0	0	*	*	*	21	22	23	24	25
	0	0	1	1	0	1	*	*	*	26	27	28	29	30
	0	0	1	1	1	0	*	*	*	31	32	33	34	35
	0	0	1	1	1	1	*	*	*	0	0	0	0	0

REMARKS; "*": Don't care. "0": Turned off. "1": Turned on.

Dot assignment

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35

8.2 Power-on reset

Internal status of the module is initialized, when the controller detects the rising of power supply up. The statuses are as follows:

1. Display clear
   Fills the DD RAM with 20Hex (Space code).
   During executing of "Display Clear" (Max. 100μs), the busy flag (BF) is "1".

2. Sets the address counter to 0H.
   Sets the address counter to point the DD RAM.

3. Display ON/OFF
   D=0: Display OFF
   C=0: Cursor OFF
   B=0: Blink OFF

4. Entry Mode Set
   I/D=1: Increment (+1)
   S=0: No display shift

5. Function Set
   IF=1

6. Brightness Control
   BR0=BR1=0: 200% (Brightness boost)

Remarks
There is a possibility that reset doesn't work by slow start power supply.
Therefore the initializing by commands needs.
And, after power-on reset the command to adjust brightness level to 100% (BR1=1, BR0=0) should be inputted. Brightness boost mode should be used only when it is necessary. Otherwise, the life of the module will be shortened.

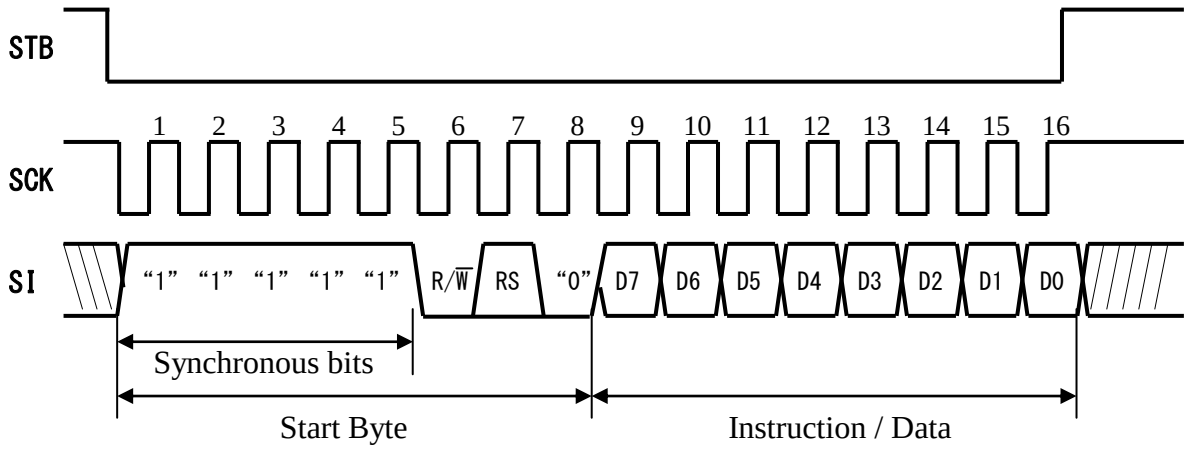
8.2.1 Serial data transfer

Serial data can be inputted when the Strobe goes to “0”.
Serial data consists of 2 bytes. The first byte (Start Byte) consists of a total of 8 bits: the Synchronous bits (bit1-bit5), R/$\overline{W}$ (bit6), RS (bit7) and bit8. The register is selected (Instruction Register or Data Register) by the RS (bit7). RS is “0” in Instruction Register, and it is “1” in Data Register. The data write or read is selected by R/W (bit6). R/W is “0” when the data is written, and it is “1” when the data is read.

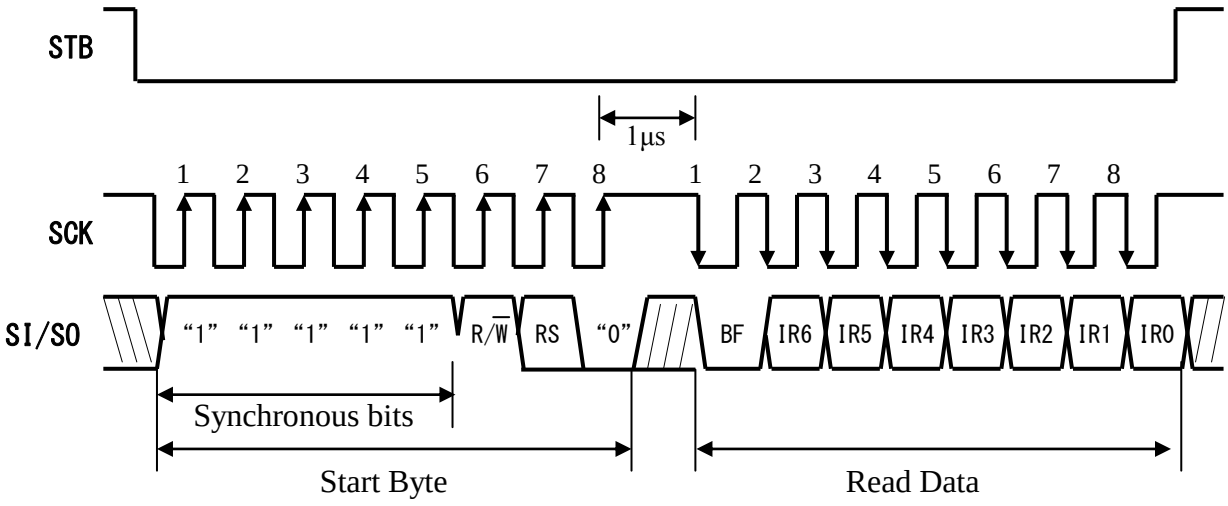
	0	1
R/$\overline{W}$	Data Write	Data Read
RS	Instruction Register	Data Register

In "Data Write", the second byte (8-bit Instruction / Data Byte) is written after the Start Byte. On the other hand, the second byte is the read data in "Data Read", such as the Busy Flag + Address Counter or the data written in the DD RAM or CG RAM. The read data is outputted at the falling edge of the shift clock.

<Data Write>



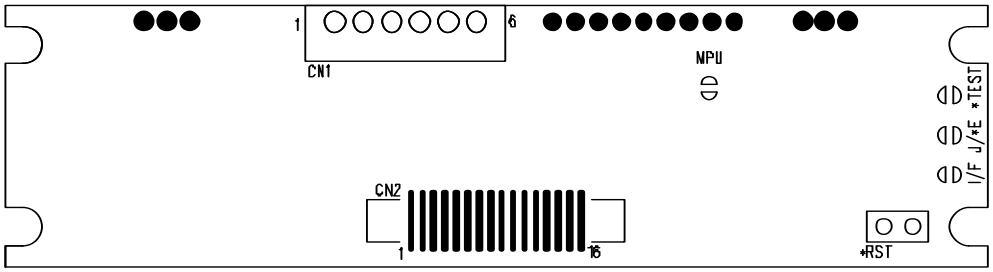
<Data Read>



8.3 Jumper

Some jumpers are prepared on the PCB board, to set operating mode of the display module.
A soldering iron is required to short jumper.
The following figure shows the location of each jumper.

Location



The following table shows the function of 'J/*E'.
Default setting is Katakana font.

Table of 'J/*E' setting

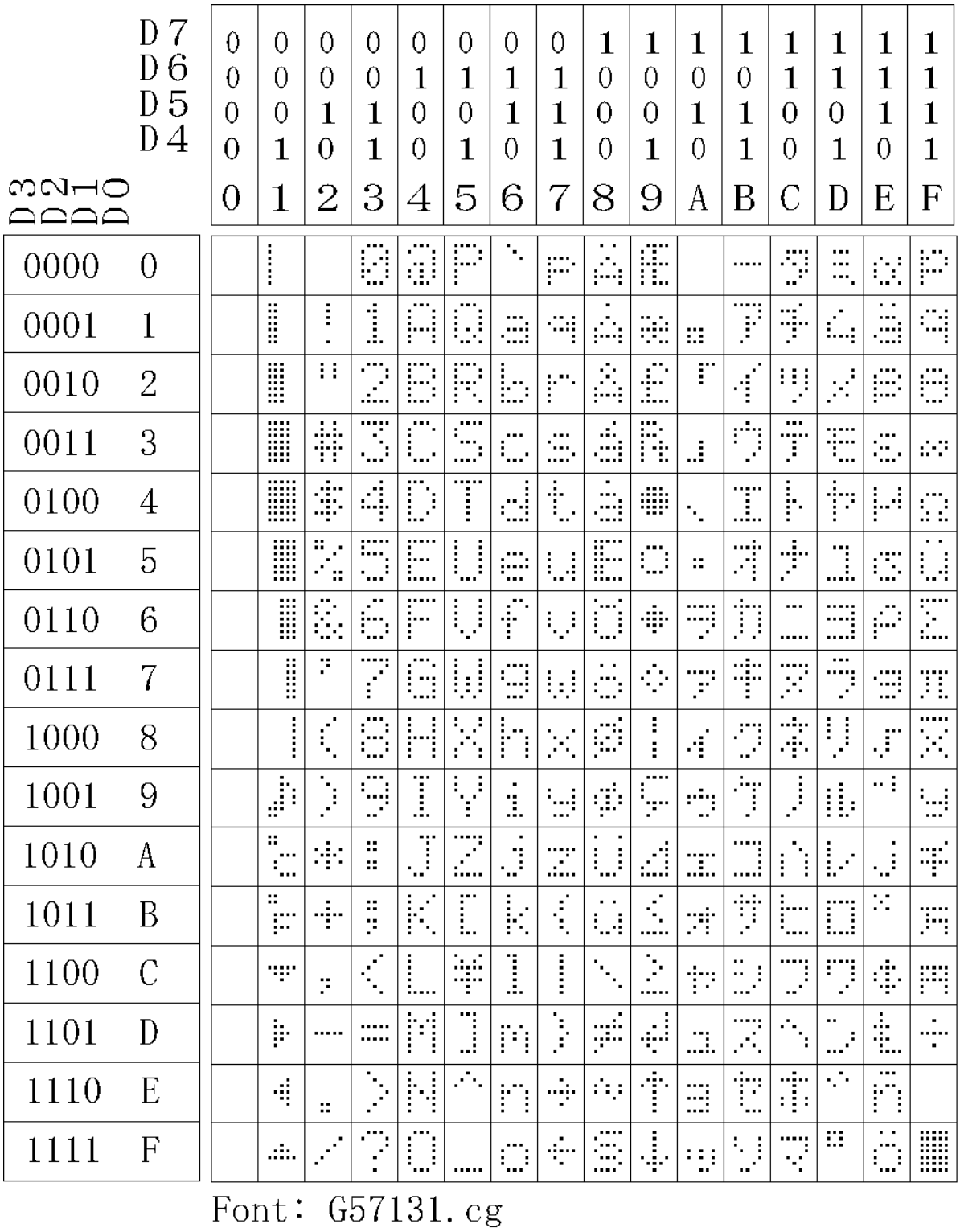
J/*E	Character font
open	Katakana font
short	International font

'*TEST', 'MPU' and 'I/F' is factory use only.

9 Character Font

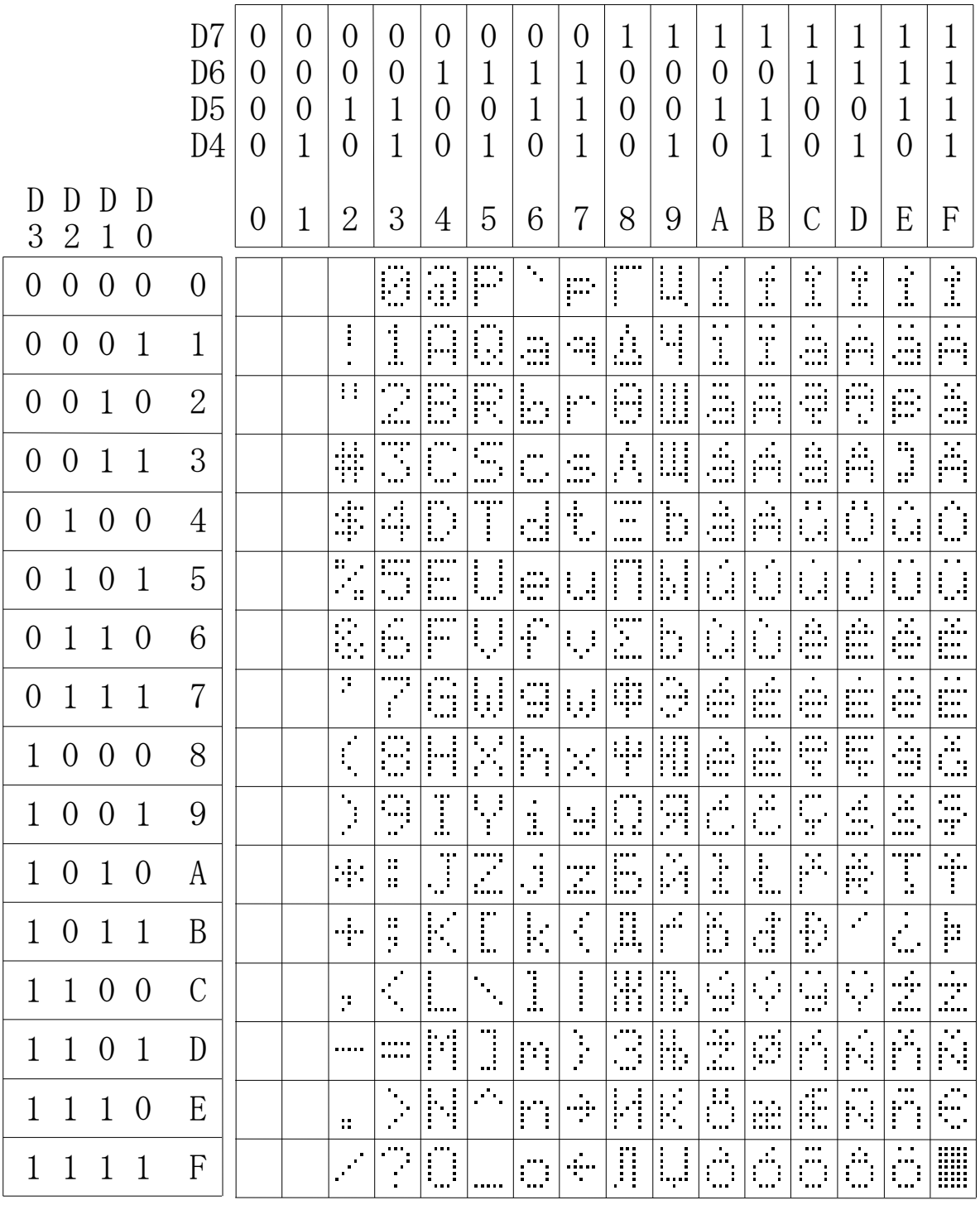
Note: Font number 00-07Hex (08-0FHex) is User Definable Character Fonts.

9.1 Katakana character font



Font: G57131.cg

9.2 International character font

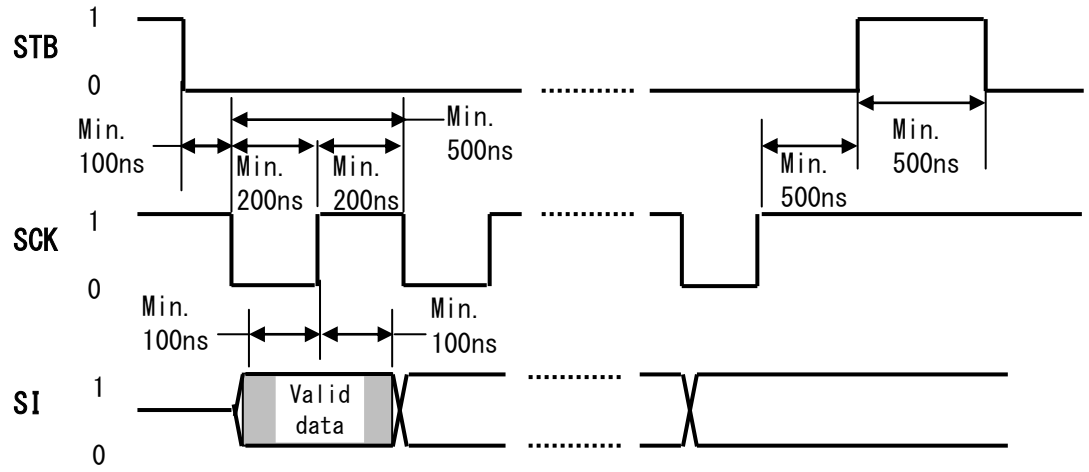


Font: G57206.cg

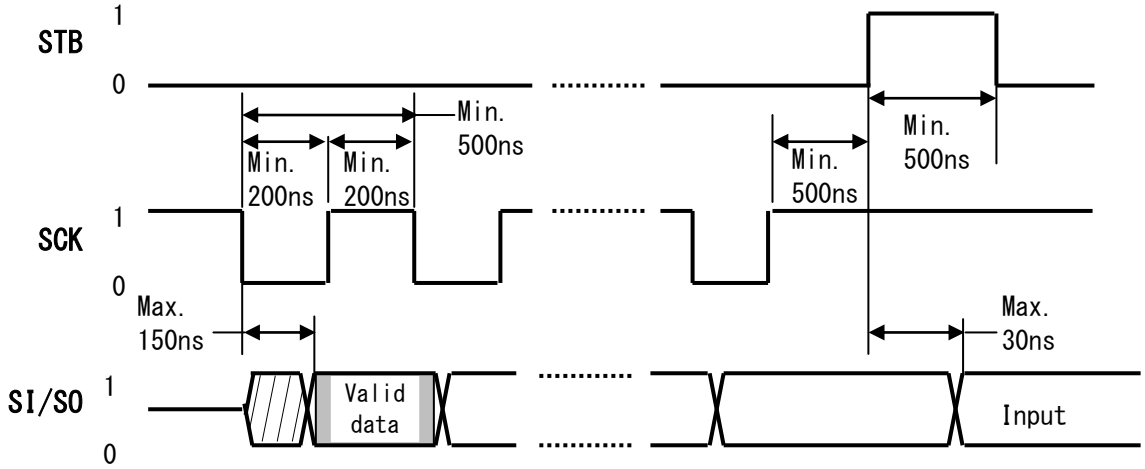
10 Timing

Input signal rise time and fall time < 15 ns.

10.1 Write timing (Serial interface)



10.2 Read timing (Serial interface)



11 Connector Pin assignment

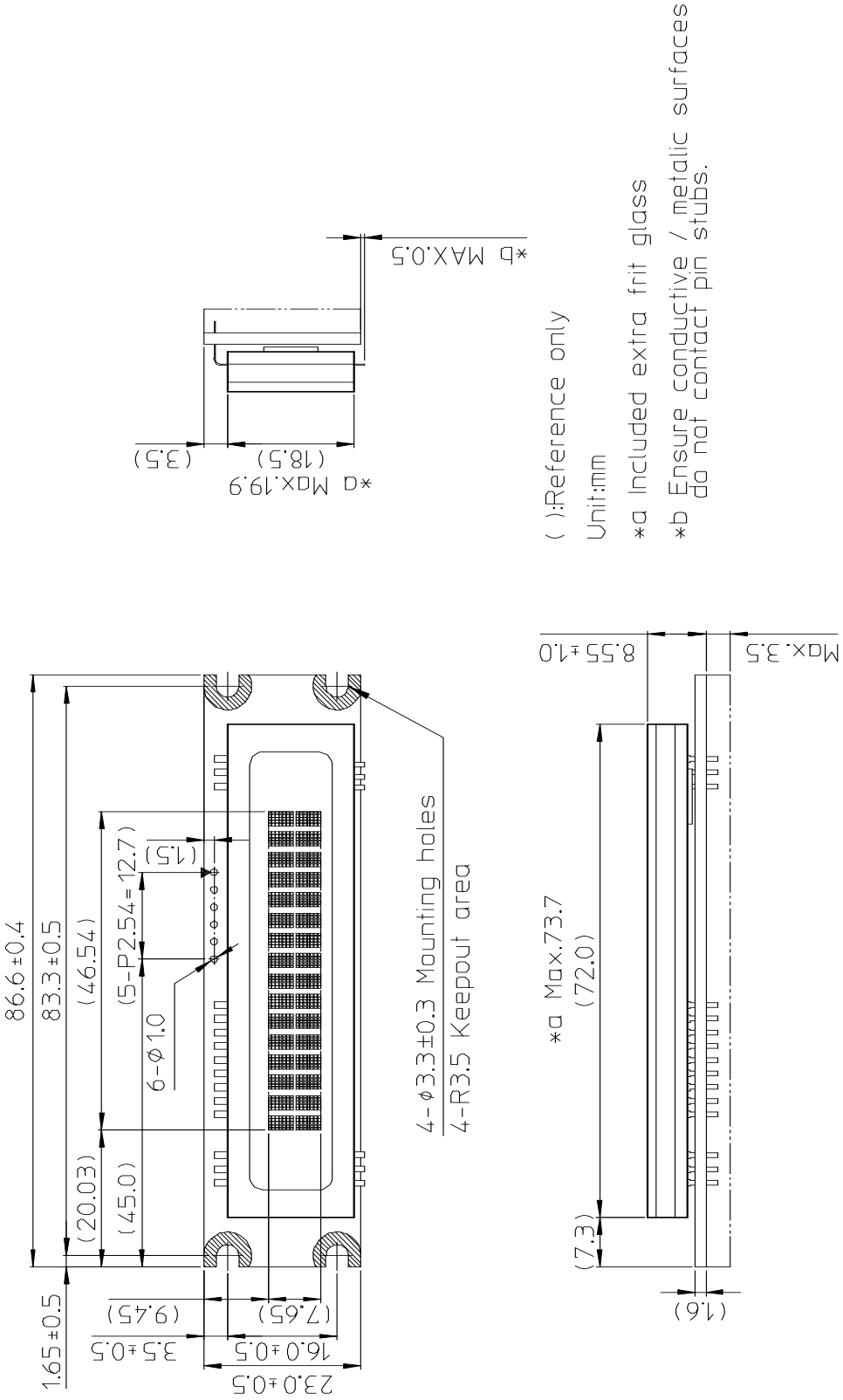
Two connectors are provided for power supply and data communications.
A connector, or pins, etc may be soldered to the terminals.

11.1 Connector (CN1) for serial interface (six through-holes)

Diameter of holes is 1.0mm.

Pin No.	Signal name	Function	Direction
1	VCC	Power supply	Input
2	SI/SO	Data input/output	Input/Output
3	GND	Ground	Input
4	STB	Strobe	Input
5	SCK	Display clock	Input
6	NC	Non connection	-

12 Outline dimension



DS-1688-0100-01

Notice for the Cautious Handling of VFD Modules

Handling and Usage Precautions:
Please carefully follow the appropriate product application notes and operation standards for proper usage, safe handling, and maximum performance.

[VFD tubes are made of glass]
- The edges of the VFD glass envelope are not smooth, so it is necessary to handle carefully to avoid injuries to hands.
- Use caution to avoid breaking the VFD glass envelope, to prevent injury from sharp glass particles.
- The tip of the exhaust pipe is fragile so avoid shock from impact.
- It is recommended to allow sufficient open space surrounding the exhaust pipe to avoid possible damage.
- Please design the PCB for the VFD module within 0.3 mm warping tolerance to avoid any forces that may damage the display due to PCB distortion causing a breakdown of the electrical circuit leading to VFD failure.

[High voltage]
- Avoid touching conductive electrical parts, because the VFD module uses high voltage exceeding 30 – 100 volts.
- Even when electric power is turned off, it may take more than one minute for the electrical current to discharge.

[Cable connection]
- Do not unplug the power and/or data cables of VFD modules during operation, because unrecoverable damage may result.
- Sending input signals to the VFD module when not powered can cause I/O port damage.
- It is recommended to use a 30cm or shorter signal cable to prevent functional failures.

[Electrostatic charge]
- VFD modules need electrostatic-free packaging and protection from electrostatic charges during handling and usage.

[Structure]
- During operation, VFD and VFD modules generate heat. Please consider sufficient heat radiation dissipation using heat sink solutions.
- Preferably, use UL-grade materials or components in conjunction with VFD modules.
- Warp and twist movement causes stress and may break VFDs and VFD modules. Please adhere to allowances within 0.3mm at the point of attachment.

[Power]
- Apply regulated power to the VFD module within specified voltages to protect from failures.
- VFD modules may draw in-rush current exceeding twice the typical current at power-on, so a power supply with sufficient capacity and quick starting of the power regulator is recommended.
- VFD module needs a specified voltage at the point of connection. Please use an adequate power cable to avoid a decrease in voltage. As a safety measure, a fuse or other over-current protection is recommended.

[Operating consideration]
- Illuminating phosphor will decrease in brightness during extended operation. If a fixed pattern illuminates for an extended period (several hours), the phosphor efficiency will decrease compared to the non-operating phosphor, causing non-uniform brightness. Please consider programming the display patterns to use all phosphor segments evenly. Scrolling may be a consideration for a period of time to refresh the phosphor condition and improve even illumination of the pixels.
- A signal cable 30cm or less is recommended to avoid possible disturbances to the signal.

[Storage and operating environment]
- Please use VFD modules under the recommended specified environmental conditions. Salty, sulfuric and dusty environments may damage the VFD module even during storage.

[Disposal]
- VFD uses lead-containing materials (RoHS directive exempts these lead compounds in the glass for electronic devices). When discarding VFDs or VFD modules, please adhere to applicable laws and regulations.

[Other cautions]
- Although the VFD module is designed to be protected from electrical noise, please plan your circuitry to exclude as much noise as possible.
- Do not reconstruct or repair the VFD module without our authorization. We cannot assure the quality or reliability of unauthorized reconstructed VFD modules.

Notice:
- We do not authorize the use of any patents that may be inherent in these specifications.
- Neither whole nor partial copying of these specifications is permitted without our approval. If necessary, please ask for assistance from our sales consultant.
- This product is not designed for military, aerospace, medical or other life-critical applications. If you choose to use this product for these applications, please ask us for prior consultation or we cannot accept responsibility for problems that may occur.

MBBZ-009-S18A

Revision Note

Specification No.	Date	Revision
DS-1688-0000-00	Oct.17.2011	Initial issue.
DS-1688-0000-01	Oct.27.2011	The information of the parallel interface has been deleted.
DS-1688-0000-02	Feb.19.2015	This product has applicable to the RoHS Directive "RoHS2011 / 65 / EU". **"RoHS2002/95/EC" → "RoHS2011/65/EU"**
DS-1688-0000-03	Jul.17.2015	RoHS notation (of first page) changed. “RoHS 2011/65/EU” → ” RoHS Compliant” “This product complies with RoHS Directive 2011/65/EU” → “This product complies with RoHS Directive. Please contact our sales consultant for details and to confirm the current status”