Futaba

APPLICATION NOTE

VACUUM FLUORESCENT DISPLAY MODULE

GRAPHIC DISPLAY MODULE

GP9002A01A

GENERAL DESCRIPTION

FUTABA GP9002A01A is a graphic display module using a FUTABA 128×64 VFD.
Consisting of a VFD, display drivers and a control circuit, the module can be driven by connecting to the host system through a simple interface.

⚠ <u>Important Safety Notice</u>

Please read this note carefully before using the product.

Warning

- The module should be disconnected from the power supply before handling.

- The power supply should be switched off before connecting or disconnecting the power or interface cables.

- The module contains electronic components that generate high voltages (approx.64V) which may cause an electrical shock when touched.

- Do not touch the electronic components of the module with any metal objects.

- The VFD used on the module is made of glass and should be handled with care. When handling the VFD, it is recommended that cotton gloves be used.

- The module is equipped with a circuit protection fuse.

- Under no circumstances should the module be modified or repaired. Any unauthorized modifications or repairs will invalidate the product warranty.

- The module should be abolished as the factory waste.

CONTENTS

1. FEATURES

1-1. High quality and long life can be achieved with FUTABA VFD.

1-2. It consists of a control ASIC and a power circuit.

1-3. Compact and light weight unit by using packed display drivers and one chip VFD controller.

1-4. The Interface can be selected from 8bit Parallel or synchronous serial.

2. GENERAL DESCRIPTION

2-1. DIMENSIONS, WEIGHT (Refer to FIGURE-4)

Table-1

Item	Specification	Unit
Outer dimensions	(W) 103±1 (H) 53.5±1 (T) 22.2 MAX.	mm
Weight	Approx. 85	g

2-2. SPECIFICATIONS OF THE DISPLAY PANEL

Table-2

Item	Specification	Unit
Display Area	57.48(W)×28.68(H)	mm
Number of Dots	128×64	Dot
Dot Size (H×W)	0.33×0.33	mm
Dot Pitch (H×W)	0.45×0.45	mm
Color Illumination (VFD)	Green (λ p=505nm)	–
Luminance	500 (Typ)	cd/m^2

Note) By using a filter, uniform color range from blue to orange (including white) can be obtained.

2-3. ENVIRONMENT CONDITIONS

Table-3

Item	Symbol	Min.	Max.	Unit
Operation Temperature	Topr	-40	+85	°C
Storage Temperature	Tstg	-40	+85	°C
Operating Humidity	Hopr	20	85	%
Storage Humidity	Hstg	20	90	%
Vibration (10 ~ 55Hz)	–	–	4	G
Shock	–	–	40	G

Note) Avoid operations and or storage in moist environmental conditions.

2-4. ABSOLUTE MAXIMUM RATINGS

Table-4

Item	Symbol	Min.	Max.	Unit
Supply Voltage	V_{CC}	-0.3	6.0	V
Input Signal Voltage	V_I	-0.5	$V_{CC}+0.5$	V

2-5. RECOMMEND OPERATING CONDITIONS

Table-5

Item	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
H-Level Input Voltage	V_{IH}	$V_{CC}\times0.7$	–	V_{CC}	V
L-Level Input Voltage	V_{IL}	0	–	$V_{CC2}\times0.3$	V

2-6. ELECTRICAL CHARACTERISTICS

Table-6

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Current	I_{CC}	$V_{CC}=5.0Vdc$ All on	–	500	650	mA
Power Consumption	—		–	2.5	3.5	W
Luminance (VFD)	L		250	500	–	cd/m^2
H-Level Output Voltage	V_{OH}	$I_{OH}=-2mA$	$V_{CC}-0.6$	–	V_{CC}	V
L-Level Output Voltage	V_{OL}	$I_{OL}=2mA$	0	–	0.4	V

Note) The surge current can be approx. 5 times the specified supply current at power on.

3. BASIC FUNCTION

3-1. Function Table

Table-7

$\overline{CS}$	$\overline{WR}$	$\overline{RD}$	$C/\overline{D}$	MODE
L	↑	H	H	Command Write-in
L	↑	H	L	Data Write-in
L	H	L	H	─
L	H	L	L	Data Read-out

note)If the interface is selected Serial, please refer to 5-2 Timing Chart.

3-2. Function of Signal Lines

Table-8

Signal	I/O	Function
D0～D7	I/O	8bit Data Bus
$\overline{WR}$	I	Write Signal
$\overline{RD}$	I	Read Signal
$\overline{CS}$	I	Chip Select Signal
$C/\overline{D}$	I	Command / Data Select Signal $C/\overline{D}$="H" : Command $C/\overline{D}$="L" : Data Write and Data Read
INT	O	Frame Signal (One output pulse per one display frame)
SEL	I	Port to switch the interface. Open: Parallel Connect to GND: synchronous serial
SCLK	I	Synchronous Clock Signal
SI	I	Synchronous Input Signal
SO	O	Synchronous Output Signal
Vcc	─	+5V
GND	─	GND

3-3. Command Table

The followings are all commands of this module.

After writing the command, necessary setting data should be written.

Table-9

Command (C/$\overline{D}$="H")	Setting Data (C/$\overline{D}$="L")	Function	Default Select
00H	―	1st & 2nd Screens are Displayed off	○
01H	―	1st Screen is Displayed on	
02H	―	2nd Screen is Displayed on	
04H	―	Read/Write address is automatically incremented	○
05H	―	Read/Write address is held	
06H	―	Clear Screen	
07H	D0~D7	Control Power supply	00H
08H	D0~D7	Display data write-in	
09H	D0~D7	Display data read-out	
0AH	D0~D7	Setting lower address for 1st Screen started	00H
0BH	D0~D3	Setting upper address for 1st Screen started	00H
0CH	D0~D7	Setting lower address for 2nd Screen started	00H
0DH	D0~D3	Setting upper address for 2nd Screen started	00H
0EH	D0~D7	Setting lower address of Read/Write	00H
0FH	D0~D3	Setting upper address of Read/Write	00H
10H	―	Display OR of 1st & 2nd Screens	
11H	―	Display EX-OR of 1st & 2nd Screens	
12H	―	Display AND of 1st & 2nd Screens	
13H	D0~D7	Luminance Adjustment	00H
14H	D0~D7	Display Mode	00H
15H	D0~D7	INT Signal Mode	00H
20H	D0~D7	Display Character	
21H	D0~D7	Setting the Character Starting Location of RAM	(X, Y) =(00H, 00H)
22H	D0~D7	Setting Size of Character	(X,Y) =(00H, 00H)
24H	D0~D7	Setting Brightness of Character	00H

Note) "―" in the above table is shown that the setting data is not needed.

3-4. Relationship of The Display Area to Address and Data

The following map is shown in case of 000H or display start address.

The actual display area is the part of enclosing with the solid line of FIG.1 and FIG.2.

FIG.1 & FIG.3 indicate the map at start address to set to 000H.

	1	2	3	…	126	127	128	129	…	254	255	256
8-1 (D0-D7)	0	8	10		3E8	3F0	3F8	400		7E8	7F0	7F8
16-9 (D0-D7)	1	9	11		3E9	3F1	3F9	401		7E9	7F1	7F9
24-17 (D0-D7)	2	A	12		3EA	3F2	3FA	402		7EA	7F2	7FA
32-25 (D0-D7)	3	B	13		3EB	3F3	3FB	403		7EB	7F3	7FB
40-33 (D0-D7)	4	C	14		3EC	3F4	3FC	404		7EC	7F4	7FC
48-41 (D0-D7)	5	D	15		3ED	3F5	3FD	405		7ED	7F5	7FD
56-49 (D0-D7)	6	E	16		3EE	3F6	3FE	406		7EE	7F6	7FE
64-57 (D0-D7)	7	F	17		3EF	3F7	3FF	407		7EF	7F7	7FF

FIG.1 Position of display dot to address and data

	1	2	3	4	…	126	127	128	129	…	254	255	256
8-1 (D0-D7)	7F0	7F8	0	8		3D8	3E0	3E8	3F0		7C8	7E1	7E8
16-9 (D0-D7)	7F1	7F9	1	9		3D9	3E1	3E9	3F1		7C9	7E2	7E9
24-17 (D0-D7)	7F2	7FA	2	A		3DA	3E2	3EA	3F2		7CA	7E2	7EA
32-25 (D0-D7)	7F3	7FB	3	B		3DB	3E3	3EB	3F3		7CB	7E3	7EB
40-33 (D0-D7)	7F4	7FC	4	C		3DC	3E4	3EC	3F4		7CC	7E4	7EC
48-41 (D0-D7)	7F5	7FD	5	D		3DD	3E5	3ED	3F5		7CD	7E5	7ED
56-49 (D0-D7)	7F6	7FE	6	E		3DE	3E6	3EE	3F6		7CE	7E6	7EE
64-57 (D0-D7)	7F7	7FF	7	F		3DF	3E7	3EF	3F7		7CF	7E7	7EF

FIG. 2 Indicate the map at start address to set to 7F0H

ADDRESS	000H	008H	010H	018H	020H	028H	030H	038H
D7								
D6			■					
D5		■		■				
D4	■				■			
D3	■				■			
D2	■	■	■	■	■			
D1	■				■			
D0	■				■			
DATA	1FH	24H	44H	24H	1FH			

FIG. 3

Note) If the Screen mode is selected Gray scale mode, The total RAM area is 128 x 64.

3-5. Function of Commands

3-5-1. Screen Display on / off Control (00H, 01H, 02H, 03H)

The latest command becomes effective.

At power on, 1st and 2nd screens are set to Display off mode.

Therefore, the Display on mode command should be written in, after display pattern data input. In case of executing Display on mode before display data input at initial, random pattern may be displayed.

3-5-2. Setting of Write Address Mode (04H, 05H)

These commands select either the write or read address is incremented by single step automatically or is held after data write and data read.

When a memory address is set to 7FFH, next memory address is set to 000H.

3-5-3. Clear Screen (06H)

Data of all area of screen RAM are filled with 00H.

After this command, all command is canceled in approximately 260μs.

3-5-4. Control Power supply(07H)
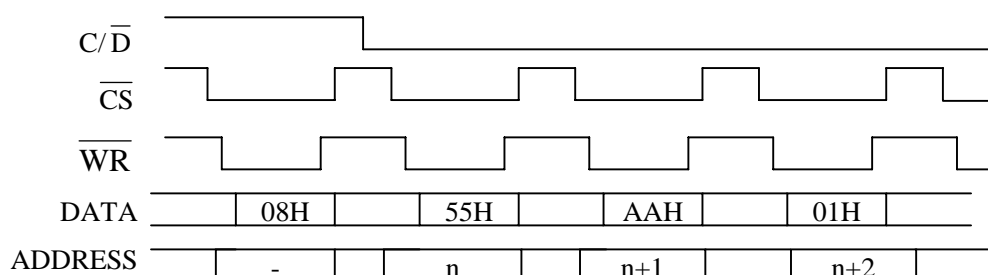
The Power supply in the module is turned off by this command.

Table-10

Mode	D7	D6	D5	D4	D3	D2	D1	D0
Power ON	0	0	0	0	0	0	0	0
Power OFF	0	0	0	0	0	0	0	1

3-5-5. Data Write (08H)

After executing the Write address setting command, this command shall be executed.

The following indicate the display data 55H, AAH and 01H write-in.

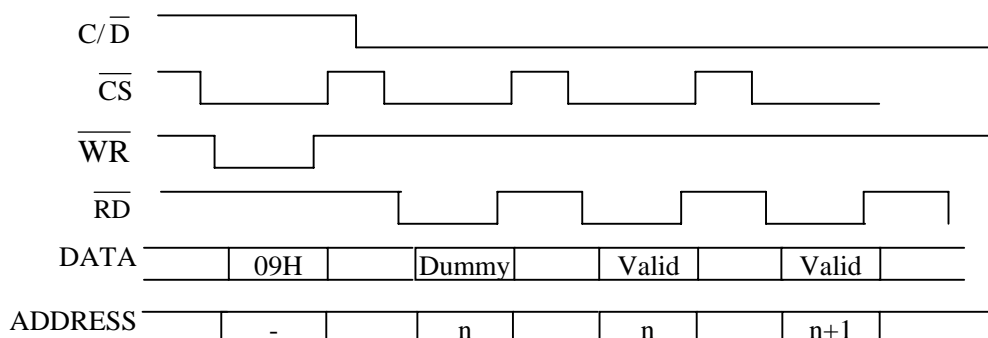|	
DATA	08H 55H AAH 01H
ADDRESS	- n n+1 n+2

3-5-6. Data Read (09H)

After executing the Read address setting command, this command shall be executed.

Dummy read is necessary. The correct data can be read from the second byte.

The following indicate the display data read out.

DATA	09H Dummy Valid Valid
ADDRESS	- n n n+1

### 3-5-7. Setting of Display Start Address (0AH, 0BH, 0CH, 0DH)

The display start address is just pointed to the left and top line of the display area.

1st and 2nd screens can be independently set the display start address each other.

This address is divided to the two portions with upper (four bits) and lower (eight bits) address, and lower address shall be set first, then set the upper address.

The smooth scroll of displaying can be achieved by synchronizing with the change of display address by the INT signal at every frame.

The following indicate the display start address of 1st screen to set to 23EH.
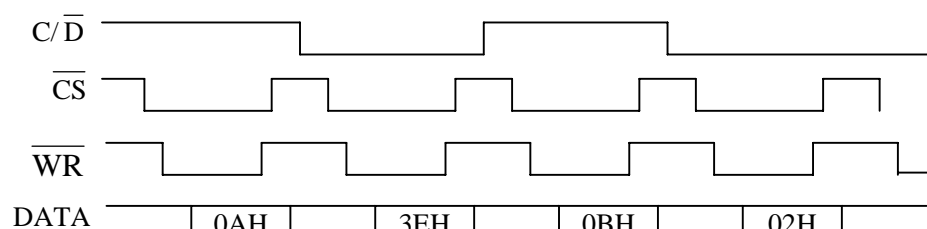
3-5-8. Setting of Write/Read Address (0EH, 0FH)

This command is set the write/read address of displaying data.

This address is divided the two portions with upper (four bits) and lower (eight bits) address, and lower address shall be set first, then set the upper address.

Only the upper address is available to be changed independently.

When the lower address is changed, it is required to change the both address.

3-5-9. Screen OR / EX-OR / AND Display Select (10H、11H、12H)

The latest command becomes effective. These commands set both 1st and 2nd screens on.

3-5-10. Luminance Adjustment (13H)

Write-in data allows luminance to be adjusted.

When the module is turned on, it is set to level 100%.

Table-11

Luminance	Input Data	
	No gray scale mode	Gray scale mode
100% (Max.)	00H	00H
90%	06H	07H
80%	0CH	0EH
70%	12H	15H
60%	18H	1CH
50%	1EH	24H
40%	24H	2BH
30%	2AH	32H
0% (Display blank)	FFH	FFH

Note1) Write-in data (FFH) allows luminance to be 0%.
Note2) Write-in data is available from 00H to 2AH with no gray scale mode.
Note3) Write-in data is available from 00H to 32H with gray scale mode.
Note4) Write-in data (from 2BH to FEH) prohibits with no gray scale mode.
Note5) Write-in data (from 33H to FEH) prohibits with gray scale mode.

3-5-11. Display Mode (14H)
   When the module is turned on, it has to be selected the following display mode
   before other command is sent.
   The display mode can be selected no gray scale mode or gray scale mode
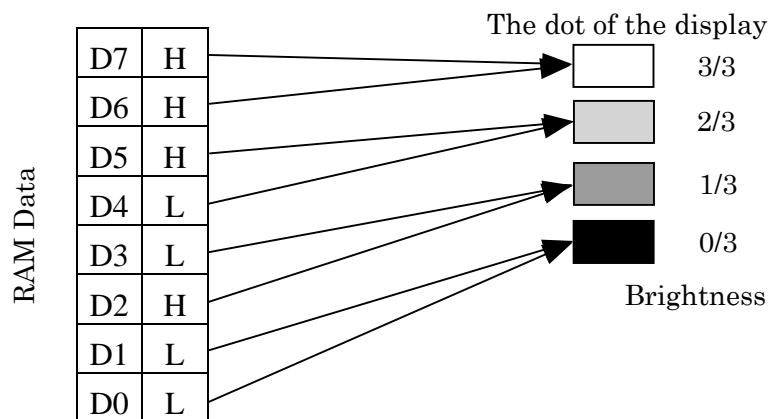   with 4 levels of brightness.

Table-12

Mode	D7	D6	D5	D4	D3	D2	D1	D0
No gray scale mode	0	0	0	1	0	0	0	0
Gray scale mode	0	0	0	1	0	1	0	0

If the mode is gray scale, each dot has one of 4 brightness levels.
The relationship between the data and the display brightness is as follows.
4 levels gradation is able to be displayed 1 dot by 2 bits data of D7-D6, D5-D4,
D3-D2, and D1-D0.

3-5-12. INT Signal mode (15H)
   This command sets the mode of INT signal.

Table-13

Signal Mode		D7	D6	D5	D4	D3	D2	D1	D0
No signal		0	0	0	0	0	0	0	0
Positive		0	0	0	0	0	0	0	1
Negative		0	0	0	0	0	0	1	1

3-5-13. Display Character (20H)

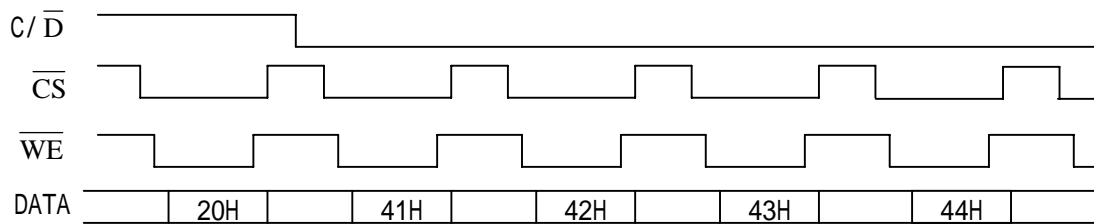By this command character can be displayed.
Character location of the RAM and Font is applied by the following commands.
- Setting the Character Starting Location of RAM (Command 21H)
- Setting Size of Character (Command 22H)
- Setting Brightness of Character (Command 24H)

After this command, the data should be written as string.
If the character is displayed, the location of character will be moved.
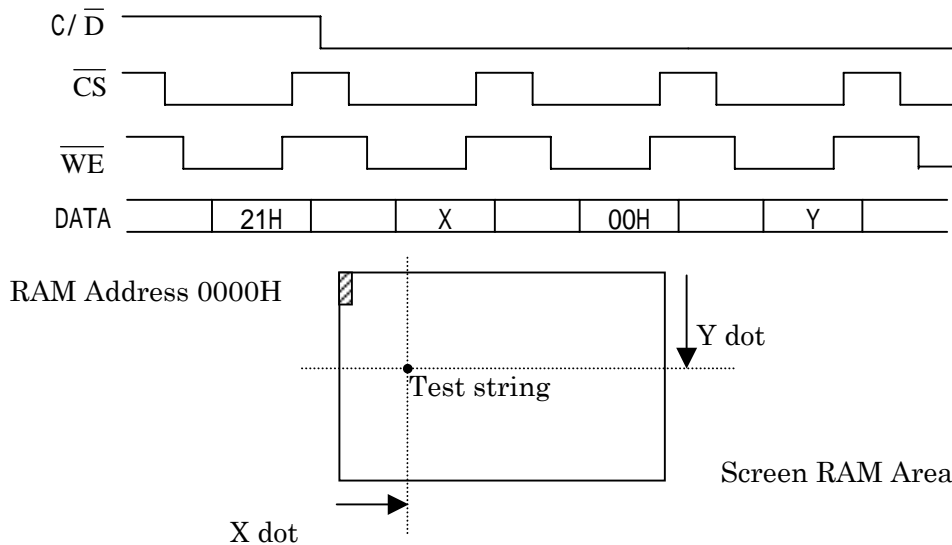The following indicate when the string "ABCD" is displayed.

```
C/D̄  _____|‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾

C̄S̄   ‾|_|‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾

W̄Ē   ‾|_|‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾

DATA ___| 20H | | 41H | | 42H | | 43H | | 44H |___
```

3-5-14. Setting the Character Starting Location of RAM (21H)

By this command the location of character is set.
X and Y should be set.

```
C/D̄  _____|‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾‾

C̄S̄   ‾|_|‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾

W̄Ē   ‾|_|‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾‾‾|_|‾‾‾

DATA ___| 21H | | X | | 00H | | Y |___
```

RAM Address 0000H

Test string

Y dot

X dot

Screen RAM Area

3-5-15. Setting Size of Character (22H)

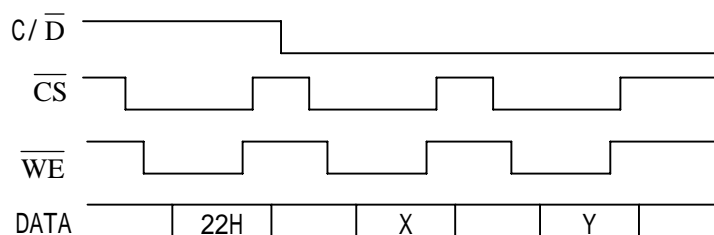By this command the size of character is set.

X and Y should be set.

Table-14

Size		00H	Normal
	X	01H	Double width
		02H	Triple width
		03H	Quad width
	Y	00H	Normal
		01H	Double height
		02H	Triple height
		03H	Quad height

Note) The only Y = 00H can be set with grey scale mode.

3-5-16. Setting Brightness of Character (24H)

By this command the brightness of character is set.

Table-15

Gray Scale number	00H	Brightness 3/3
	01H	Brightness 2/3
	02H	Brightness 1/3

Note) This command is invalid with no gray scale mode.

4. INTERFACE CONNECTION

The using connector: 2213-20G (NELTRON Industrial)

(a) Selected the Parallel (SEL is open)

Table - 16

Pin No.	Description	Pin No.	Description
1	D0	2	D1
3	D2	4	D3
5	D4	6	D5
7	D6	8	D7
9	GND	10	INT
11	$\overline{WR}$	12	$\overline{RD}$
13	$\overline{CS}$	14	C/$\overline{D}$
15	Vcc	16	Vcc
17	Vcc	18	GND
19	GND	20	SEL (open)

Note1) All GND pins are connected in the module.

Note2) Please don't connect any to the No.20(SEL).

(b) Selected the synchronous serial (SEL is connected to GND.)

Table - 17

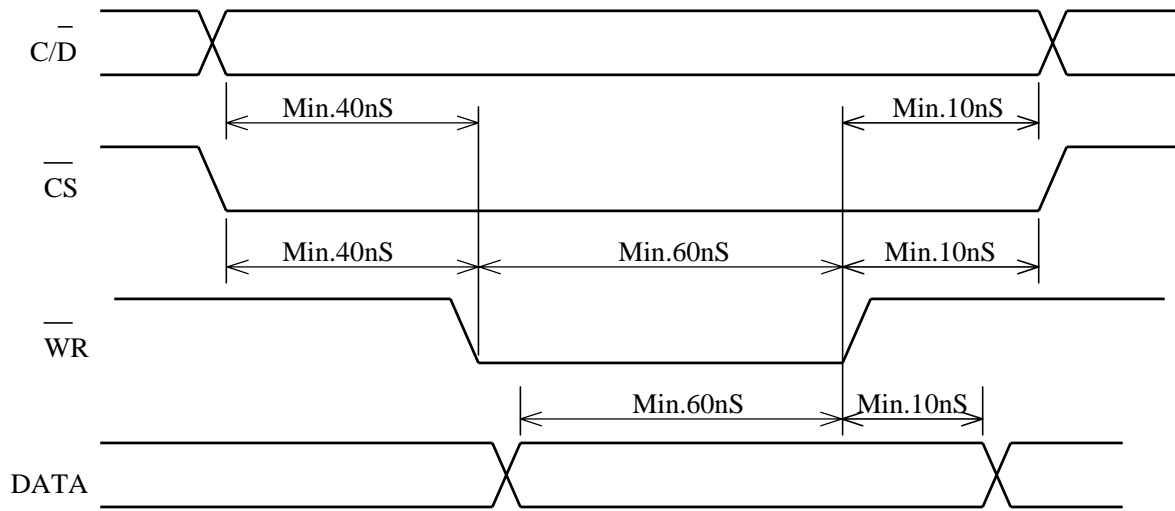| Pin No.	Description	Pin No.	Description
1	N.C. (open)	2	N.C. (open)
3	N.C. (open)	4	N.C. (open)
5	N.C. (open)	6	N.C. (open)
7	N.C. (open)	8	SO
9	GND	10	INT
11	CLK	12	SI
13	$\overline{CS}$	14	C/$\overline{D}$
15	Vcc	16	Vcc
17	Vcc	18	GND
19	GND	20	SEL (GND)

Note1) All GND pins are connected in the module.

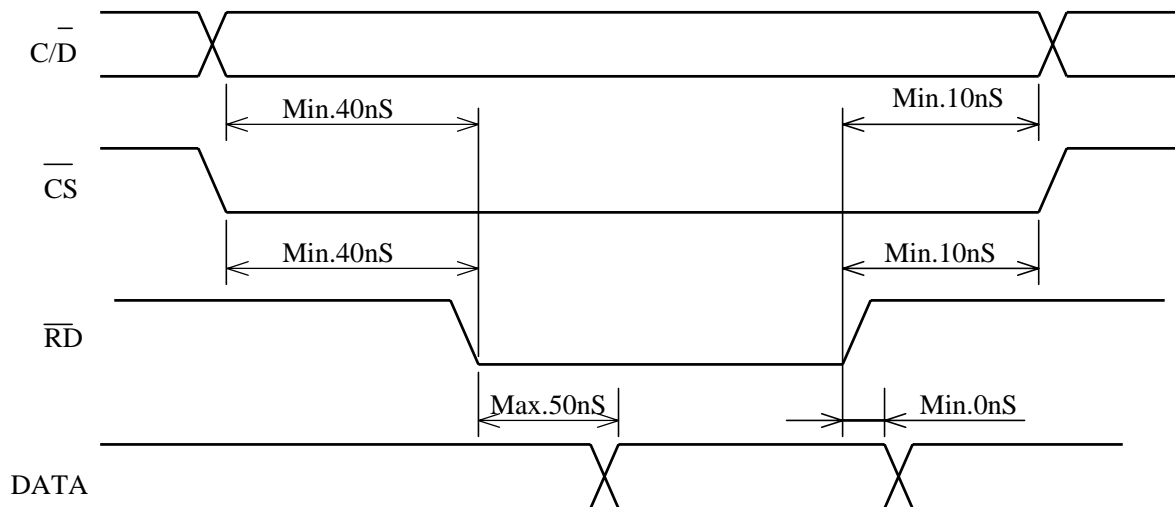Note2) Please connect GND to the No.20(SEL).

5. TIMING CHART
5-1. The Parallel interface
5-1-1. Write-in timing

C/D

| Min.40nS | | Min.10nS |

CS

| Min.40nS | Min.60nS | Min.10nS |

WR

| Min.60nS | Min.10nS |

DATA

1) The time of each one byte access is neccessary with 600ns min.

5-1-2. Read-out timing

C/D

| Min.40nS | | Min.10nS |

CS

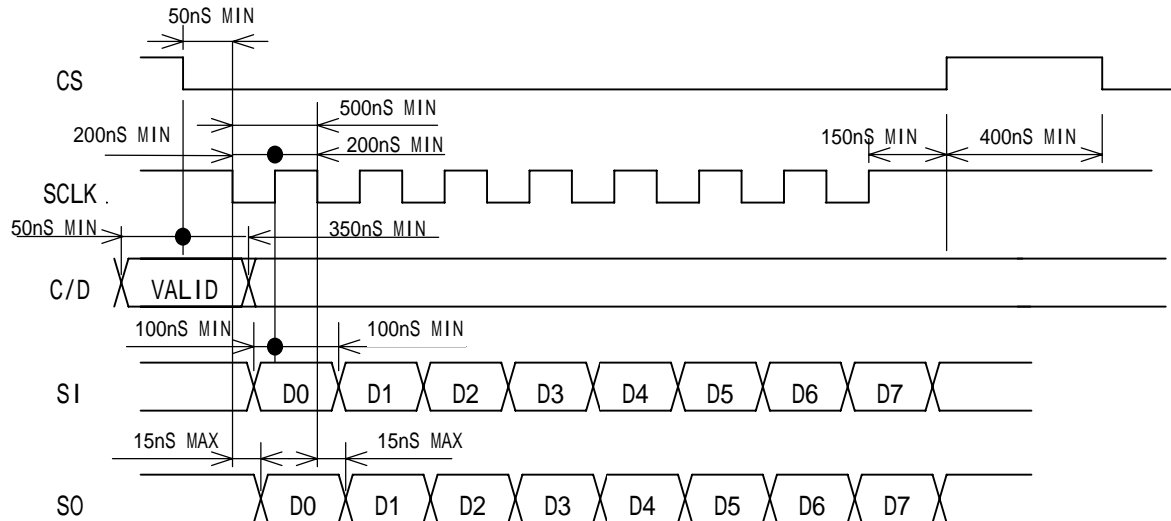| Min.40nS | | Min.10nS |

RD

| Max.50nS | | Min.0nS |

DATA

1) The time of each one byte access is neccessary with 1us min.

5-2 Synchronous serial interface

The SI signal should be input from the LSB.
The SI signal is gotten when the SCLK rises.
The distinction of SI signal between DATA and COMMAND depends C/D signal when CS is down.

Ex.1) Display data write-in（the way to write 2 bytes of display data.）

Table-18

Step	Content from host	Epexegesis
1	Output 'H' to C/D	
2	CS ↓	The usage of SI signal after this step is determined. By the step1, The SI signal is command because of C/D='H'.
3	Send 08H to SI	Command 08H Display data write-in
4	CS ↑	
5	Output 'L' to C/D	
6	CS ↓	The usage of SI signal after this step is determined. By the step5, The SI signal is data because of C/D='L'. In addition, the 400ns interval needs between step4 and step 6.
7	Send 55H to SI	Display data 55H write-in
8	Send 21H to SI	Display data 21H write-in In addition, the 600ns interval needs between step7 and step 8.
9	CS ↑	

Ex.2) Display data read-out（the way to read 2 bytes of display data.）   Table-19

Step	Content from host	Epexegesis
1	Output 'H' to C/D	
2	CS ↓	The usage of SI signal after this step is determined. By the step1, The SI signal is command because of C/D='H'.
3	Send 09H to SI	Command 09H　Display data read-out
4	CS ↑	
5	Output 'L' to C/D	
6	CS ↓	The usage of SI signal after this step is determined. By the step5, The SI signal is ignore because of C/D='L'. In addition, the 400ns interval needs between step4 and step 6.
7	Receive 1byte from SO	Dummy read-out
8	Receive 1byte from SO	Display data read-out（First byte） In addition, the 1us interval needs between step7 and step 8.
9	Receive 1byte from SO	Display data read-out（Second byte） In addition, the 1us interval needs between step8 and step 9.
10	CS ↑	

5-3. INT timing

INT signal synchronizes frame frequency. The module generates 65μsec of INT signal at every 8.4msec.

For smooth scroll, Setting Start Address should be executed during period of INT＝"H".
(INT＝"L", if logic mode is negative.)
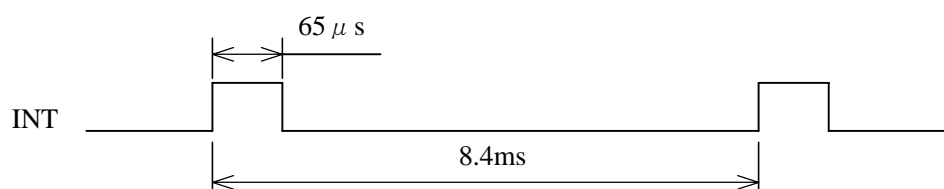
6. THE INITIALIZE AFTER POWER-ON

Host should do the initialize after power-on.

The following command is used in initialize.

・command 14H Display Mode

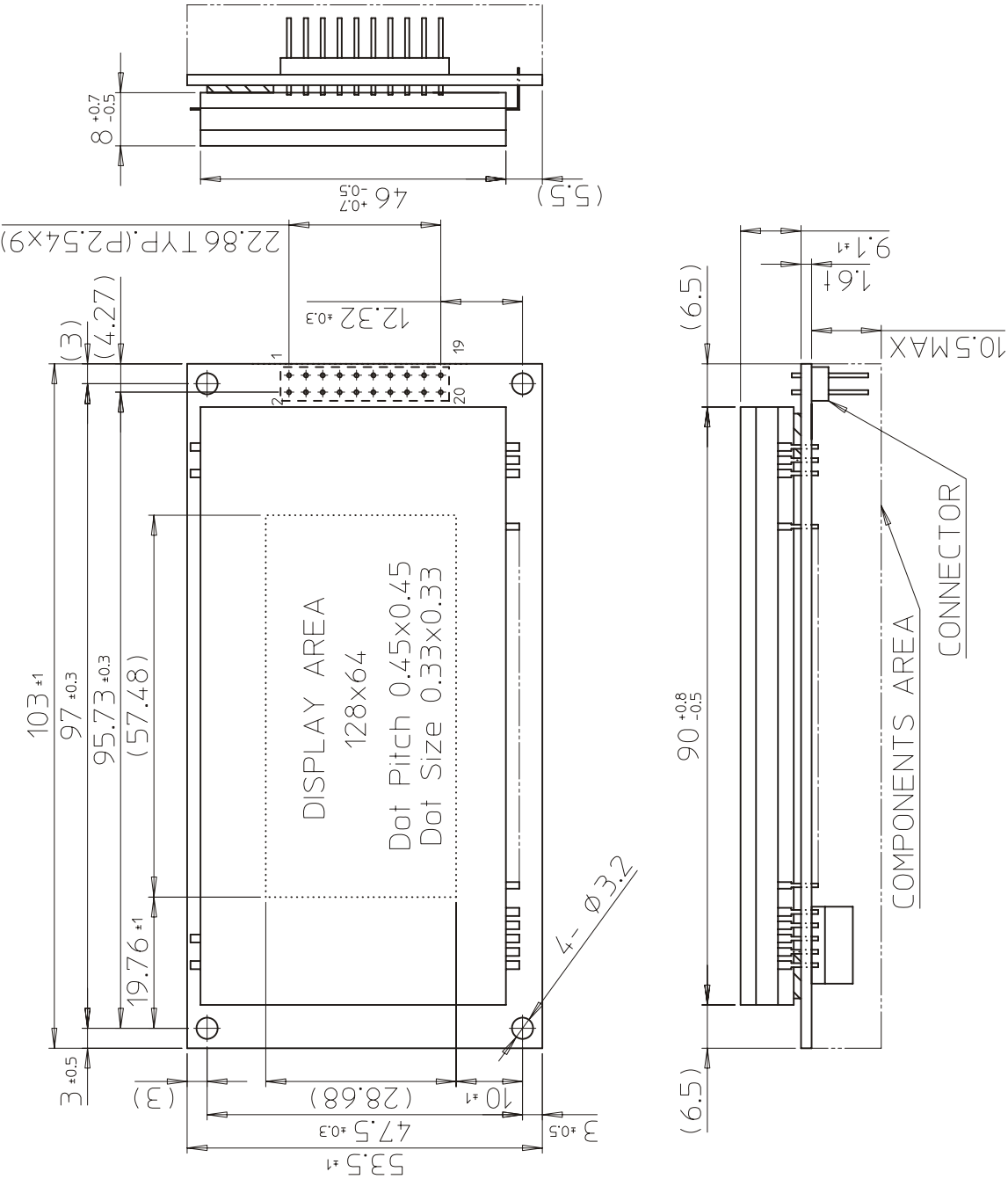Ex.) To turn on a pixel which located in 10th from screen left end and 4th from screen top end.

（Parallel Interface）   Table-20

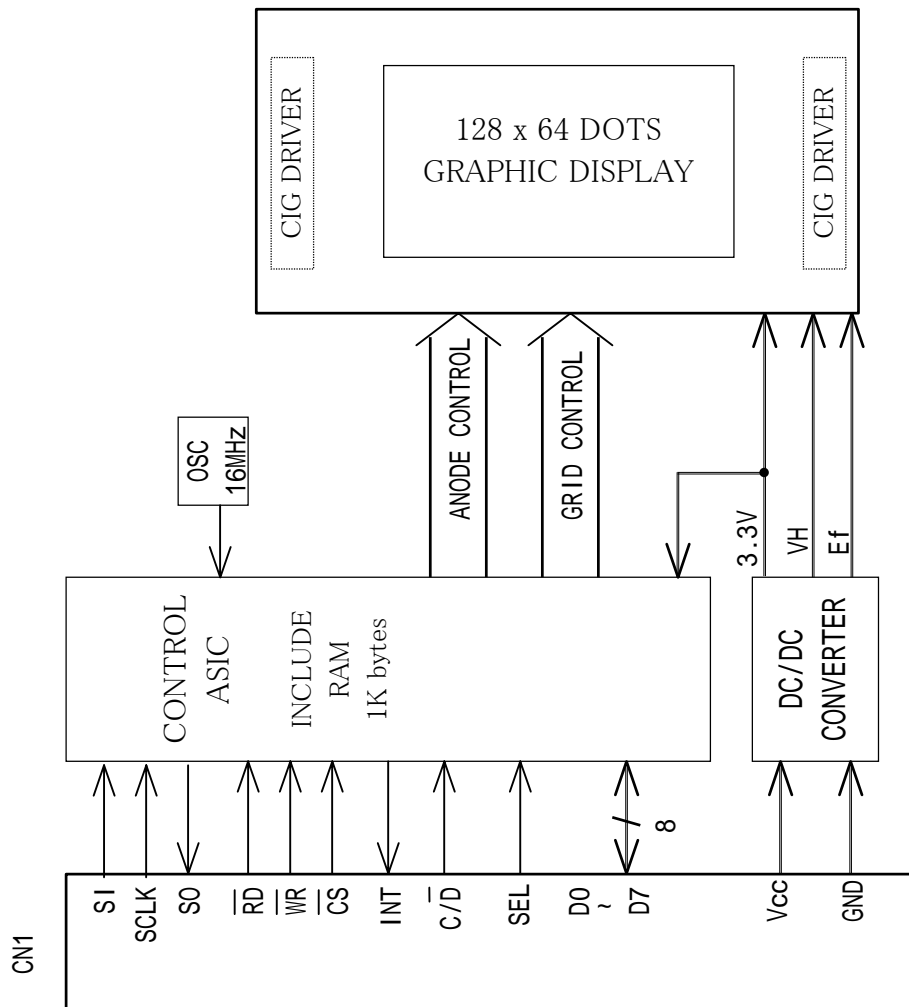| Step	Content from host	Epexegesis
1	C/D='H' 14H　WR ↓	Display Mode command
2	C/D='L' 10H　WR ↓	The display mode (no gray scale mode)
3	C/D='L' 06H　WR ↓	Clear Screen (06H)
4	C/D='H' 01H　WR ↓	1st Screen is Displayed on（01H）
5	C/D='H' 0AH　WR ↓	Setting lower address for 1st Screen started
6	C/D='L' 10H　WR ↓	Setting lower address 10H
7	C/D='H' 0BH　WR ↓	Setting upper address for 1st Screen started
8	C/D='L' 00H　WR ↓	Setting upper 3bits 000B
9	C/D='H' 08H　WR ↓	Display data write-in(08H)
10	C/D='L' 10H　WR ↓	The display data 10H

DISPLAY AREA

128x64

Dot Pitch 0.45x0.45
Dot Size 0.33x0.33

CONNECTOR

COMPONENTS AREA

4- Ø3.2

CIRCUIT BLOCK DIAGRAM

FIGURE-5

128 x 64 DOTS
GRAPHIC DISPLAY

CIG DRIVER

CIG DRIVER

OSC
16MHz

ANODE CONTROL

GRID CONTROL

3.3V

VH

Ef

CONTROL
ASIC

INCLUDE
RAM
1K bytes

DC/DC
CONVERTER

CN1

SI
SCLK
SO
$\overline{RD}$
$\overline{WR}$
$\overline{CS}$
INT
C/$\overline{D}$
SEL
D0
D7
/8

Vcc
GND

FONT TABLE

FIGURE-6

7. WARRANTY

    This display module is guaranteed for 1 year after the shipment from FUTABA.

8. CAUTIONS FOR DETERMINING AND EXPORTING REGULATED GOODS OR SERVICES

    This product does not correspond to the goods or services regulated by Japan's Foreign Exchange and Foreign Trade Law. If this product is combined with other products in order to make equipment, whether this product is regulated or not is judged by such newly made equipment. We ask you to determine by yourself whether the equipment corresponds to the regulated goods when this product is incorporated in the equipment.
    We also ask you to confirm that this product will not be incorporated in any weapon or used for manufacturing any weapon.
    If you export or re-export this product, we recommend you to adopt measures for appropriate export procedures, if any.

9. CAUTIONS FOR OPERATION

    9-1. Applying lower voltage than the specified may cause non activation for selected pixels. Conversely, higher voltage may cause non-selected pixel to be activated.
           If such a phenomenon is observed, check the voltage level of the power supply.

    9-2. The DC/DC converter generates approximately 64Vdc, avoid touching it with bare hands, or to other circuits.

    9-3. Avoid using the module where excessive noise interface is expected. Noise affects the interface signal and causes improper operation.
           Keep the length of the interface cable less than 30cm.
           (When the longer cable is required, please confirm there is no noise affection.)

    9-4. When power is turned off, the capacitor will not discharge immediately. Avoid touching IC and others.
           The shorting of the mounted components within 30 sec., after power off, may cause damage.

    9-5. When fixed pattern is displayed for a long time, you may see uneven luminance. It is recommended to change the display patterns sometimes in order to keep best display quality.

    9-6. DC/DC converter is equipped on the module, the surge current may be approximately 5 times the specified supply current at the power on.

REMARKS :

    The specification is subject to change without prior notice.

    Your consultation with FUTABA sales office is recommended for the use of this module.

Mouser Electronics

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