□Maple Bus 1.0□

Function Type Specifications

FT2□B/W LCD Function

Revision 0.81

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Revision□

10/14/97	0.70	Preview Version
2/10/98	0.80	Title change Added definition of B/W LCD function Added B/W LCD function control Amended specifications of the function definition block Added LCD number (PT) specifications Changed access number (WA) specifications Changed specifications for data arrangement (H/V) and added diagrams 2.5 ~ 2.10 Changed B/W (Fig.2.11) Amended specifications for the Get_Media_Info command Added LCD number (PT) specifications Added diagrams 3.4, 3.5 Changed specifications for Block_Write command Changed specifications for LCD Data capacity Added specifications for function error codes Added Device_Reply command Added LCD_Error command Added warnings for data creation (Chapter 4) Added specifications for protocol flow Added flow diagram for LCD display processing (Fig.5.2)
3/31/98	0.81	Added operations during function initialization Changed Block No. which can be specified for the Block_Write command Added Set_Condition command Added method for adjusting the contrast using the same command Edited the LCD_Error command Changed error operations and responses to errors Added information regarding gradual conversion of image data Deleted data transmission during contrast adjustment Added information regarding data transmission between LCDs with different gradations Changed the layout

Contents:

1 Overview of B/W LCD

1.1Definition of B/W LCD Function

The "B/W LCD" contains a reflective, monochrome liquid crystal display with functions for output of simple images. The B/W LCD function must fulfill the following requirements.

1 The monochrome dot matrix liquid crystal display must be on the surface of the unit and the user must be able to confirm the screen's status. There are no other restrictions on the outer appearance
2 The B/W LCD function must adhere to the "Maple Bus 1.0" Standard Specifications.

It will be possible to display game subscreens and messages using the B/W LCD Function.
For example, by displaying specific information to each user, it will be possible to create game software of a more strategic nature.

1.2Restrictions on B/W LCD Functions

The following are restrictions on the B/W LCD Function

1 LCD dot number X axis direction Y axis direction
2 Gradation Only gradations of 2,4, 8, 16 can be set
3 The LCD display speed will change depending on the block size during data transmission and the number of transmissions. The data to be displayed on the LCD will be displayed when all of the data is complete.
4 Backlighting controls Not supported.

1.3Operation during Initialization

The B/W LCD Function will operate as follows during initialization.

Ÿ LCD Display LCD Display is turned off. In addition, the memory area for image data is cleared.
Ÿ Contrast The contrast brightness setting is returned to its initial value.

Moreover, the above settings are applicable when the power is turned on and in the case of a reset.

2 Device ID

The ID conforms to the Device ID prescribed in the "Maple Bus 1.0" Standard Specifications.
The notation indicates the host's memory image.

2.1Composition of Device IDs

According to "Maple Bus 1.0", Device IDs are structured as shown below.

bit	7	6	5	4	3	2	1	0
1st Data	FT_{31}	FT_{30}	FT_{29}	FT_{28}	FT_{27}	FT_{26}	FT_{25}	FT_{24}
2nd Data	FT_{23}	FT_{22}	FT_{21}	FT_{20}	FT_{19}	FT_{18}	FT_{17}	FT_{16}
3rd Data	FT_{15}	FT_{14}	FT_{13}	FT_{12}	FT_{11}	FT_{10}	FT_9	FT_8
4th Data	FT_7	FT_6	FT_5	FT_4	FT_3	FT_2	FT_1	FT_0
5th Data	$FD1_{31}$	$FD1_{30}$	$FD1_{29}$	$FD1_{28}$	$FD1_{27}$	$FD1_{26}$	$FD1_{25}$	$FD1_{24}$
6th Data	$FD1_{23}$	$FD1_{22}$	$FD1_{21}$	$FD1_{20}$	$FD1_{19}$	$FD1_{18}$	$FD1_{17}$	$FD1_{16}$
7th Data	$FD1_{15}$	$FD1_{14}$	$FD1_{13}$	$FD1_{12}$	$FD1_{11}$	$FD1_{10}$	$FD1_9$	$FD1_8$
8th Data	$FD1_7$	$FD1_6$	$FD1_5$	$FD1_4$	$FD1_3$	$FD1_2$	$FD1_1$	$FD1_0$
9th Data	$FD2_{31}$	$FD2_{30}$	$FD2_{29}$	$FD2_{28}$	$FD2_{27}$	$FD2_{26}$	$FD2_{25}$	$FD2_{24}$
10th Data	$FD2_{23}$	$FD2_{22}$	$FD2_{21}$	$FD2_{20}$	$FD2_{19}$	$FD2_{18}$	$FD2_{17}$	$FD2_{16}$
11th Data	$FD2_{15}$	$FD2_{14}$	$FD2_{13}$	$FD2_{12}$	$FD2_{11}$	$FD2_{10}$	$FD2_9$	$FD2_8$
12th Data	$FD2_7$	$FD2_6$	$FD2_5$	$FD2_4$	$FD2_3$	$FD2_2$	$FD2_1$	$FD2_0$
13th Data	$FD3_{31}$	$FD3_{30}$	$FD3_{29}$	$FD3_{28}$	$FD3_{27}$	$FD3_{26}$	$FD3_{25}$	$FD3_{24}$
14th Data	$FD3_{23}$	$FD3_{22}$	$FD3_{21}$	$FD3_{20}$	$FD3_{19}$	$FD3_{18}$	$FD3_{17}$	$FD3_{16}$
15th Data	$FD3_{15}$	$FD3_{14}$	$FD3_{13}$	$FD3_{12}$	$FD3_{11}$	$FD3_{10}$	$FD3_9$	$FD3_8$
16th Data	$FD3_7$	$FD3_6$	$FD3_5$	$FD3_4$	$FD3_3$	$FD3_2$	$FD3_1$	$FD3_0$

Fig. 2.1 Device ID

FT: Indicates the peripheral device's function type.
FD1: First function definition block.
FD2: Second function definition block.
FD3: Third function definition block.

1 FT_{31} ~ FT_0: Function type
Indicates the function implemented by the peripheral device.
A total of 32 types of functions are defined.

2 FD_{31} ~ FD_0 Function definition block
This is the block which defines the individual elements which make up the function.
(One peripheral device can have up to three different functions.)

2.2Function Types

Indicates the function type (FT) within the Device ID.
The B/W LCD Function's function type is defined as FT_2='1'.

bit	7	6	5	4	3	2	1	0
1st Data	FT_{31}	FT_{30}	FT_{29}	FT_{28}	FT_{27}	FT_{26}	FT_{25}	FT_{24}
2nd Data	FT_{23}	FT_{22}	FT_{21}	FT_{20}	FT_{19}	FT_{18}	FT_{17}	FT_{16}
3rd Data	FT_{15}	FT_{14}	FT_{13}	FT_{12}	FT_{11}	FT_{10}	FT_9	FT_8
4th Data	FT_7	FT_6	FT_5	FT_4	FT_3	1	FT_1	FT_0

Fig. 2.2 B/W LCD Function Type

For example, in the case of a peripheral device which only implements the B/W LCD Function, the function type is defined as FT='00h-00h-00h-04h'.
Also, in the case of peripheral devices which implement other functions, the function type corresponding to each function has its bit set to '1'.

2.3Function Definition Block

Indicates the function definition block within the Device ID.
The function definition block is a 32 bit data table specific to each function. The elements which make up each function and the methods of data transmission and receipt are determined by this data.

The structure of the B/W LCD Function's function definition block is as shown below.

bit	7	6	5	4	3	2	1	0
1st Data	PT_7	PT_6	PT_5	PT_4	PT_3	PT_2	PT_1	PT_0
2nd Data	BB_7	BB_6	BB_5	BB_4	BB_3	BB_2	BB_1	BB_0
3rd Data	WA_3	WA_2	WA_1	WA_0	0	0	0	0
4th Data	H/V_1	H/V_0	B/W	FD_4	FD_3	FD_2	FD_1	FD_0

Fig. 2.3 Structure of the B/W LCD function definition block

PT: Number of LCDs
Can be set from 1 to 256.

Number of LCDs = (PT+1)
(Except for unusual cases, '00h' (LCD number = 1) is the value which is normally used)

BB: Number of bytes during Block transmission
It is the number of bytes which are transmitted in one block transmission.
It can be set between 32 and 8192 bytes

The number of bytes in 1 block = (BB+1) ´ 32 [byte]

WA: Number of accesses to Block Write

Sets the number of accesses needed to Write 1 Block of data.

The number of accesses can be set from 1 to 15 times.

The data amount of 1 access is calculated by dividing the capacity of 1 Block by the number of accesses.

Number of accesses = WA [times]

Capacity of 1 access = 1 Block capacity □ WA [byte]

(WA = 0 cannot be set)

H/V: Specifies whether the LCD data rows are horizontal or vertical.

Except for unusual cases, H/V = '00' is the value which is normally used.

Data Rows	H/V_1	H/V_0
Horizontal 1	0	0
Horizontal 2	0	1
Vertical 1	1	0
Vertical 2	1	1

Fig. 2.4 Values of H/V

Examples of H/V settings and LCD data arrangement are shown below.

(For more information about the LCD matrix size (dX, dY) used in the example, please refer to Chapter 3.1.)

Example 1: H/V = '00' (LCD data 16 bytes, LCD matrix size dX=31, dY=3)

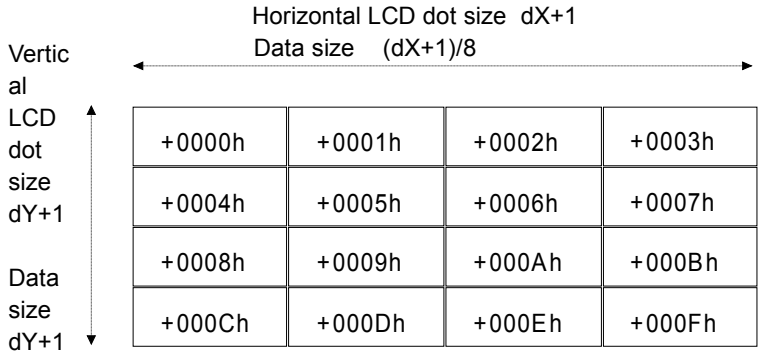


Fig. 2.5 H/V = '00' Data arrangement

Example 2: H/V = '01' (LCD data 16 bytes, LCD matrix size dX=31, dY=3)

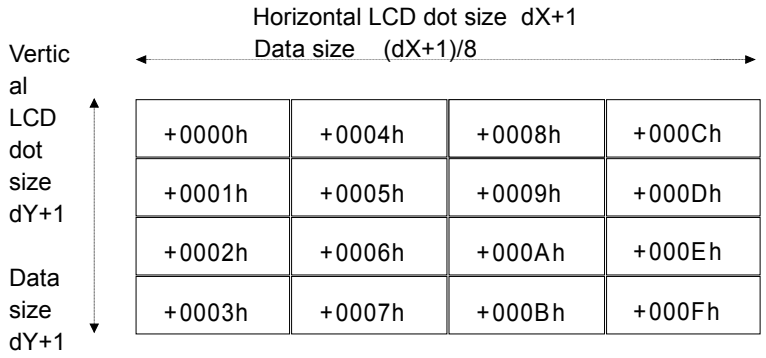


Fig. 2.6 H/V = '01' Data arrangement

Example 3: H/V = '10' (LCD data 16 bytes, LCD matrix size dX=7, dY=15)

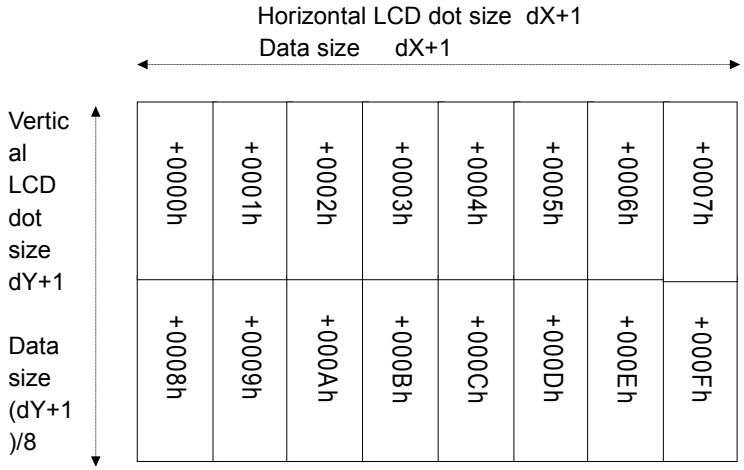


Fig. 2.7 H/V = '10' Data arrangement

Example 4: H/V = '11' (LCD data 16 bytes, LCD matrix size dX=7, dY=15)

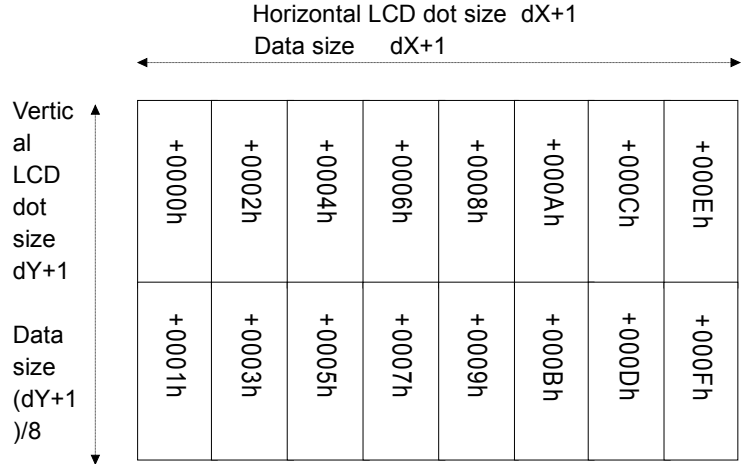


Fig. 2.8 H/V = '11' Data arrangement

The relationship between the data direction and the LCD dot position is shown below.

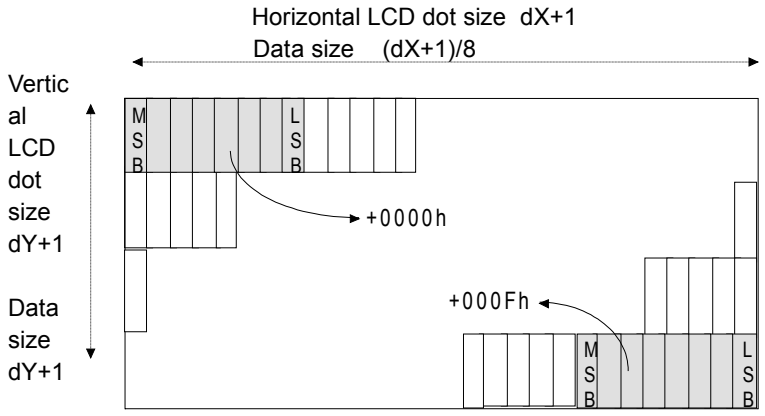


Fig. 2.9 Horizontal Data Rows (in comparison to LCD Panel)

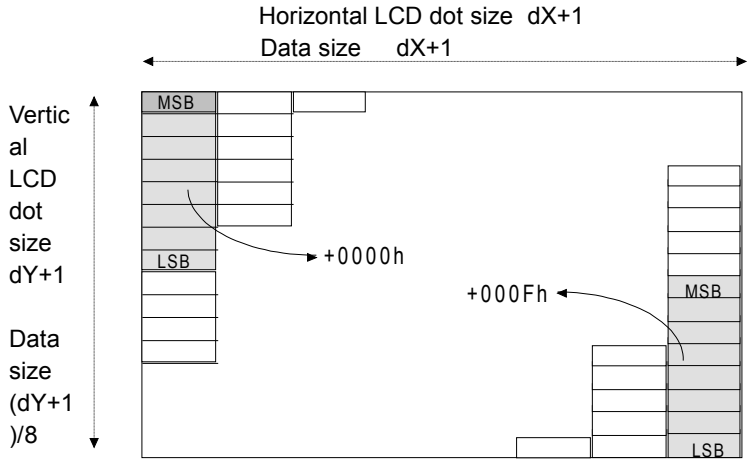


Fig. 2.10 Vertical Data Rows (in comparison to LCD Panel)

B/W: Specifies Normally Black or Normally White.

Normally	B/W
White	0
Block	1

Fig. 2.11 Values of B/W

Normally White: LCD Data = '0' is White and LCD Data = '1' is Black
Normally Black: LCD Data = '1' is White and LCD Data = '0' is Black
Except for unusual cases, B/W='0' is used.

FD: Reserved
The fixed value of '0' is used.

3 Warnings for LCD Data Creation

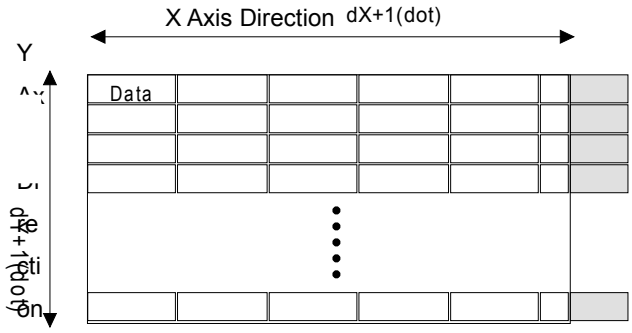
This section gives examples of things to be careful of when creating LCD data.

3.1 If the LCD Matrix Size is not a Multiple of 8

Basically, 1 LCD dot is 1 bit of data and the LCD dots are managed in 1 byte units.
Therefore, if the LCD matrix size is not a multiple of 8, the excess data will be ignored.

Ex.1 Horizontal Data Row (H/V='00','01')

If the X axis dot size is not a multiple of 8, the data outside of the LCD matrix will be ignored.
Data outside of the Y axis matrix will not be generated.

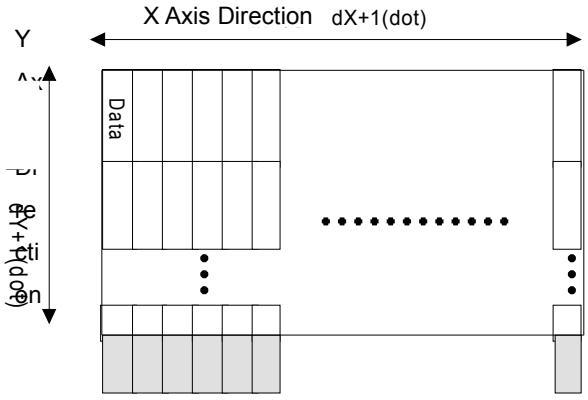


Data outside of the LCD matrix will be ignored

Fig. 3.1 H/V = '00', '01'

Ex.2 Vertical Data Row (H/V='10','11')

If the Y axis dot size is not a multiple of 8, the data outside of the LCD matrix will be ignored.
Data outside of the X axis matrix will not be generated.



Data outside of the LCD matrix will be ignored

Fig. 3.2 H/V = '10', '11'

3.2If the LCD Gradation Exceeds 2 Gradations

This section gives examples to explain the data structure of the LCD image when the LCD Gradation Exceeds 2 Gradations.

Moreover, a "Plane" is defined as the "LCD image data when the LCD gradation is 1 bit/dot".

3.2.1 Definition of Gradation

Ex. LCD which can be set to 16 levels of gradation

When setting 16 gradations of data, 1 dot requires 4 bits of data. (The media information's TE is '111h')

Therefore, the LCD data becomes 4 Planes of data as shown below.

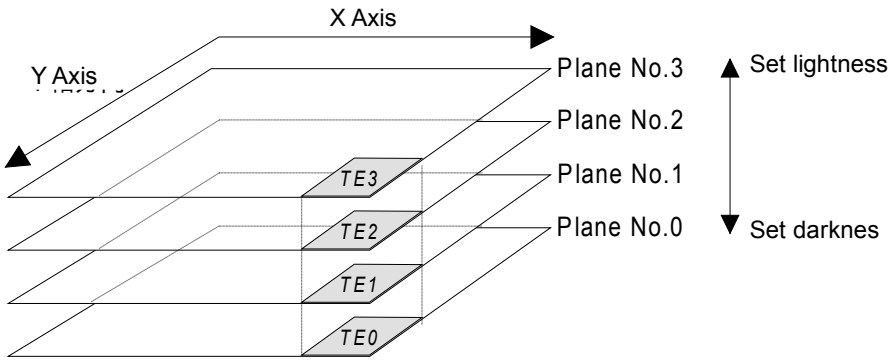


Fig. 3.3 LCD Data Structure

The figure above shows the data structure of an LCD image with 16 possible gradation settings.

The gray area in the figure (TE3~TE0) represents a specific coordinate (x, y) on the LCD.

When viewing the LCD, the layers of the Planes are placed on top of each other.

The gradation of the point shown at the coordinate (x,y) on the LCD is calculated with the following formula.

TE(x , y) = TE0 □ 8 + TE1 □ 4 + TE2 □ 2 + TE3

If (TE0, TE1, TE2, TE3) = (1,0,1,0) then,

TE(x , y) = 1 □ 8 + 0 □ 4 + 1 □ 2 + 0 = 10□'Ah'□

In addition, the data actually written on the Plane has a '1' at the Plane 0,2 coordinate (x,y) and a '0' at the Plane 1,3 coordinate (x,y).

On LCD's with gradation other than 16, there are Planes for expressing only that gradation.

2 Gradations: Plane 0

4 Gradations: Plane 0, 1

8 Gradations: Plane 0, 1, 2

3.2.2 Plain and Block Arrangement

This section explains the arrangement of data sent to and from the B/W LCD Function.

The data size of one Plane is different in comparison with the LCD matrix size, but the data size needed for one Plane and the size of one Block are matched by the peripheral device (B/W LCD Function).

The figure below shows the relationship between image data and the Block in the B/W LCD Function which supports 16 gradations.
The data size of one Plane and one Block are the same.

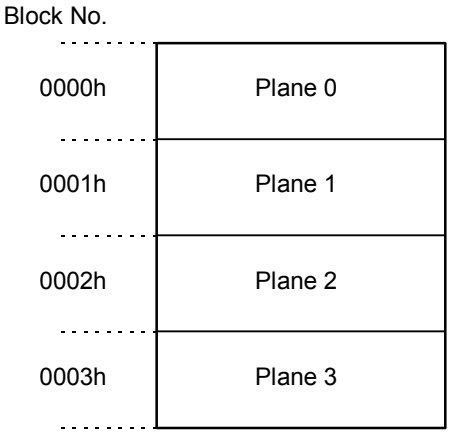


Fig. 3.4 Arrangement of image data

Because the Plane's data size is the same as one screen of LCD data with 2 gradations, it is determined solely by the LCD's matrix size.

The data size of one plane is as follows,

Plane data size = (dX+1) □ (dY+1) □ 8 [byte]

The maximum data size of one Plane according to the above formula is

Plane data size (Max) = (255+1) □ (255+1) □ 8

= 8192 [byte]

Thus, the maximum data size is 8192 bytes.

The maximum data size of one Block is prescribed at 8192 bytes.
(Refer to "2.3 Function Definition Blocks")

Therefore, one Plane can be stored in one Block regardless of the data size.

3.2.3 Gradation Conversion

This section discusses the situation where image data with a specific gradation is sent to a B/W LCD Function with a different gradation.
The following two things can occur when image data is sent to a B/W LCD Function with a different gradation.

1 If the data is sent to a function with an LCD gradation lower than that of the image data

The method for sending data to an LCD function with a lower gradation is shown below.

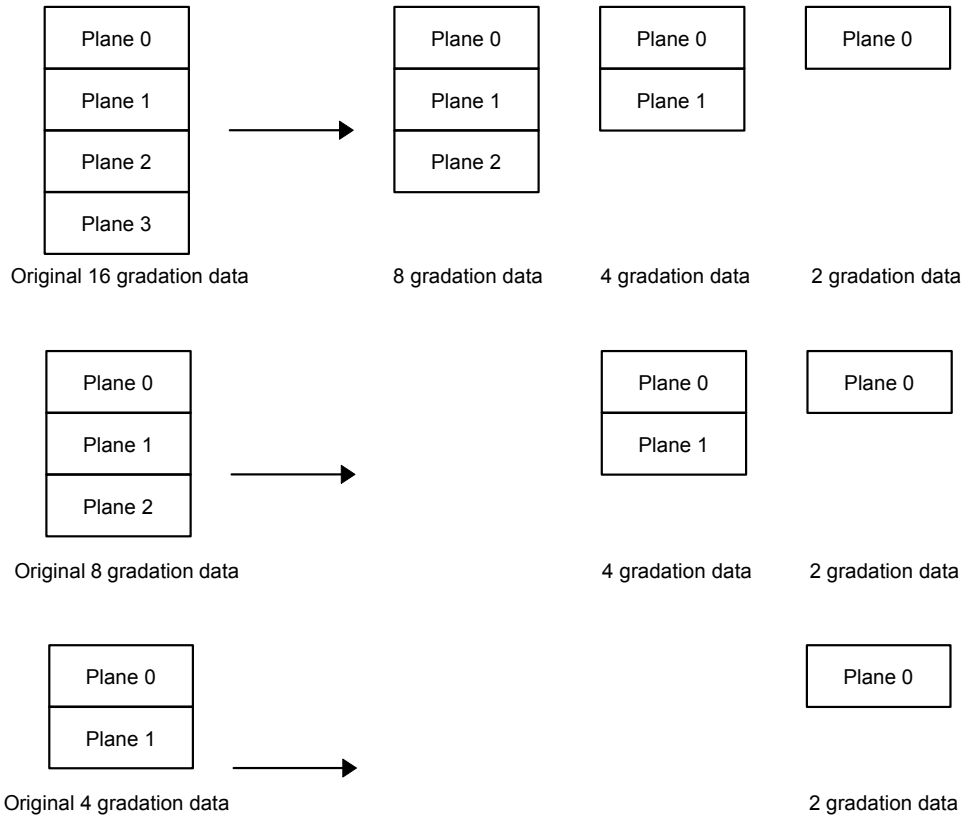


Fig. 3.5 Sending image data to an LCD Function with a lower gradation

When image data is sent to an LCD function with low gradation, the data transmission is canceled in order from the highest data (data indicating the lightness of the darkness) Plane No. according to the difference in gradation.

For example, when data with 16 gradations is sent to an LCD function with 2 gradations, the transmission of 3 Planes (Plane No. 3,2,1) worth of data is canceled in order from the highest Plane No.
If the Plane No. 3,2,1 data (Block No. 3,2,1) is sent, it will result in an [LCD Error].

The LCD function will only display the Plan No. data which was sent.

2 If the data is sent to a function with an LCD gradation higher than that of the image data

The method for sending data to an LCD function with a higher gradation is shown below.

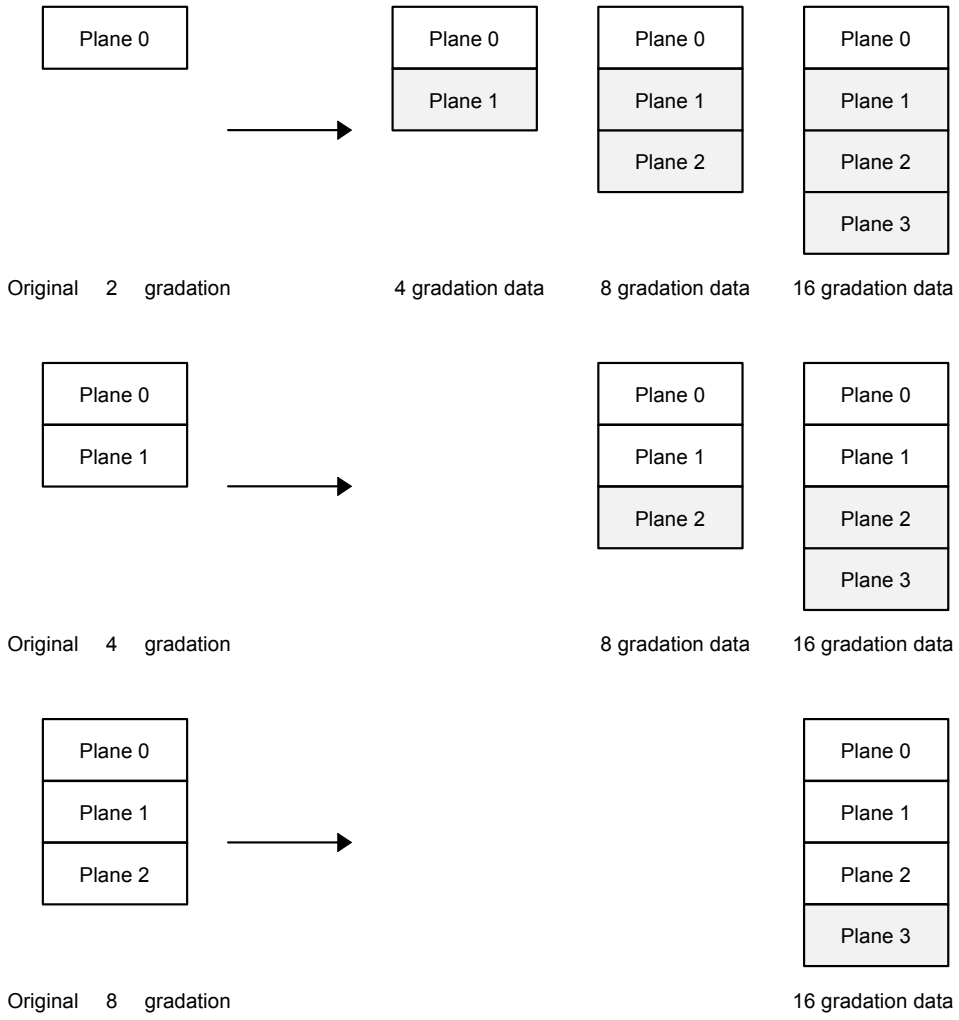


Fig. 3.6 Sending image data to an LCD Function with a higher gradation

When image data is sent to an LCD Function with a higher gradation, it sends "Dummy Plane data" for the difference in gradation. The Dummy Plane data is all '00h'. (grayed out area in figure)
For example, if 2 gradation data is send to an LCD function of 16 gradation, then Dummy Plane data is added to the Planes 1,2,3 of the original data and sent.
The LCD function displays the received data (including Dummy data) on the LCD.

The Plane No.'s used for each gradation is shown below (Planes being used = 'O')

Gradation after data conversion	PlaneNo.3	Plane No.2	Plane No.1	Plane No.0
2 Gradations				O
4 Gradations			O	O
8 Gradations		O	O	O
16 Gradations	O	O	O	O

Fig. 3.7 Number of Planes used for image data after gradation conversion

4 Commands

This section lists the commands in the "Maple Bus 1.0" Standard Specifications which are supported by the B/W LCD function.
All settings examples assume connection to Port A and LM-Bus No. 1.

4.1Control Commands

4.1.1 Get_Media_Info

Issuing authority: Host
Command code: 0Ah
Data size: 02h (8byte)
Data: Function type: 4byte
PT: 1byte
Fixed value: 3byte
Expected return value: [Data Transfer]
Description: This command is for receiving media information necessary for issuing other commands to the B/W LCD.
Example commands are shown below.

Data address	Data	Setting	Description
+0000h	Command code	0Ah	Specifies [Get_Media_Info]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No. 1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	02h	Data size is 8 bytes
+0004h	Function type	00h	Function type specifies [B/W LCD]
+0005h		00h	
+0006h		00h	
+0007h		04h	
+0008h	PT	00h	Specifies the LCD No.
+0009h	Fixed value	00h	Uses fixed value of '00h'
+000Ah		00h	
+000Bh		00h	

Fig. 4.1 Example of Get_Media_Info Commands

PT: LCD Number
Specifies which LCD to access since 1 to 256 LCDs can be accessed at once on the same peripheral device.
Number of LCDs = (PT+1)
(Except for unusual cases, '00h' (LCD number = 1) is the value which is normally used)

Because each LCD has its own specific media information, it is necessary to issue this command to each LCD.

When the B/W LCD function receives this command, it sends the media information shown in fig. 4.2 to the host via [Data Transfer].

For more information about [Data Transfer], please refer to "4.1.5 Data Transfer".

Data address	Data	Setting	Description
+0000h	Command code	08h	Specifies [Data Transfer]
+0001h	Transfer destination AP	00h	Port A
+0002h	Transfer source AP	01h	Expansion Device (LM-Bus No.1)
+0003h	Data size	02h	Data size is 8 bytes
+0004h	Function type	00h	Function type specifies [B/W LCD]
+0005h		00h	
+0006h		00h	
+0007h		04h	
+0008h □ +000Bh	Media information		Refer to Fig. 4.3

Fig. 4.2 Replies to the Get_Media_Info command

The following figure shows the details of the media information

bit	7	6	5	4	3	2	1	0
1st Data	dX_7	dX_6	dX_5	dX_4	dX_3	dX_2	dX_1	dX_0
2nd Data	dY_7	dY_6	dY_5	dY_4	dY_3	dY_2	dY_1	dY_0
3rd Data	TE_3	TE_2	TE_1	TE_0	CT_3	CT_2	CT_1	CT_0
4th Data	RE_7	RE_6	RE_5	RE_4	RE_3	RE_2	RE_1	RE_0

Fig. 4.3 Composition of Media Information

dX:	1byte	Number of X Axis dots	Number of dots = (dX+1) 1~256dot
dY:	1byte	Number of Y Axis dots	Number of dots = (dY+1) 1~256dot
TE:	4bit	Gradation (bit/dot)	Refer to Fig. 4.5
CT:	4bit	Contrast	0~15 Gradat X Axis s no contrast adjustment)
RE:	8bit	Reserved area, uses '0'	

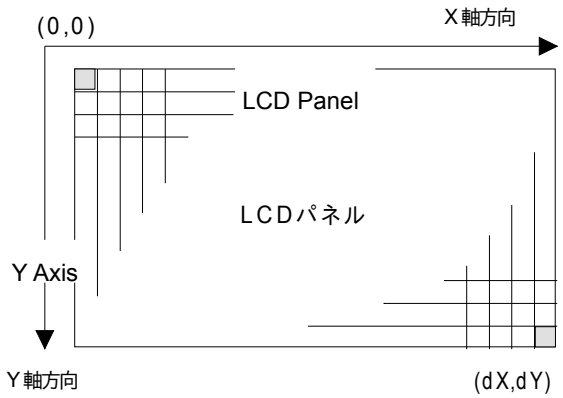


Fig. 4.4 Direction of the LCD Dot Matrix Coordinates

The figure below shows the gradation (TE) setting values.

Moreover, TE specifies how many planes are used to show the gradation.

For more information on Planes, please refer to Chapter 3.2.

TE_3	TE_2	TE_1	TE_0	Gradation	No. of Planes Used
0	0	0	1	2 gradations	1
0	0	1	1	4 gradations	2
0	1	1	1	8 gradations	3
1	1	1	1	16 gradations	4

Fig. 4.5 Gradation (TE) setting values

4.1.2 Block_Write

Issuing authority: Host

Command code: 0Ch

Data size: 02h + n (8byte + n □ 4 byte)

Data:

Function type:	4byte
PT:	1byte
Phase:	1byte
Block No.:	2byte
LCD Data:	n □4byte

Description: This command tells the B/W LCD function to write in (Block transfer) the data into the specified Block No. (Plane).

The figure below contains examples of commands.

Data address	Data	Setting	Description
+0000h	Command code	0Ch	Specifies [Block_Write]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No.1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	02h + n	
+0004h	Function type	00h	Expansion Device (LM-Bus No.1)
+0005h		00h	
+0006h		00h	
+0007h		04h	
+0008h	PT	00h	Specifies LCD No.
+0009h	Phase		Specifies Phase
+000Ah	Block No.		Specifies the Block No. (Plane) to Write to
+000Bh			
+000Ch □	Write Data		LCD Data n × 4 byte

Fig. 4.6 Examples of Block_Write commands

If one screen of data cannot be written in one access (WA□2), then the screen data is divided by the number of WA and sent. Phase is used to indicate the sequential number of the divided data.

Ex.) 1 screen of 512 bytes of data is written 3 times. (WA=3)
This, the data amount of one access is 171 bytes.
In this case, a total of 513 bytes of data is sent in 3 accesses, but the one extra Block (above 512 bytes) is filled with '00h'.
(On the third access, the 171st byte of data is '00h'.)

Phase must be issue consecutively starting from '00h' and continuing '01h', '02h', '03h', ...
If another command is issued during the Block_Write Phase or if the Phase value is not issued continuously, an [LCD Error] is returned. Data is not written into that Block (Plane).

In order to indicate the Plane, the Block No. value has a range from '0000h' to '0003h'.

LCD Data capacity = (dx+1) □ (dy+1) □(No. of Planes) □ 8 [byte]

Capacity of 1 access = LCD Data capacity □ WA [byte]

4.1.3 Set_Condition

Issuing authority: Host
Command code: 0Eh
Data size: 02h (8byte)
Data: Function type: 4byte
PT: 1byte
Contrast increase/decrease value: 1byte
Reserved: 2byte
Description: Command which specifies the physical status of the B/W LCD Function.
This command is used by the B/W LCD Function to adjust the LCD contrast value and to acquire the current contrast value.

Data address	Data	Setting	Description
+0000h	Command code	0Eh	Specifies [Set_Condition]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No.1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	02h	Data size is 8 bytes
+0004h	Function type	00h	Function type specifies [B/W LCD]
+0005h		00h	
+0006h		00h	
+0007h		04h	
+0008h	PT	00h	Specifies LCD No.
+0009h	Contrast increase/decrease value		See below
+000Ah	Reserved	00h	Fixed value
+000Bh		00h	

Fig. 4.7 Examples of Commands for Adjusting Contrast

Contrast automatically changes the LCD brightness at the B/W LCD Function, so there is no need for the host to change the LCD data being displayed.
Contrast is performed on the entire LCD screen.

Contrast increase/decrease values are specified as follows.

Increase contrast (darken): Contrast increase/decrease value = '01h'
Decrease contrast (lighten): Contrast increase/decrease value = '80h'
To reset the contrast: Contrast increase/decrease value = '00h'
To acquire the contrast value: Contrast increase/decrease value = 'FFh'

If the contrast value exceeds the LCD's set range (CT), or if a value other than those above is specified, it will result in an [LCD Error].

When the B/W LCD receives this command, the following data is returned to the host via [Data Transfer].

Data address	Data	Setting	Description
+0000h	Command code	08h	Specifies [Data Transfer]
+0001h	Transfer destination AP	00h	Port A
+0002h	Transfer source AP	01h	Expansion Device (LM-Bus No.1)
+0003h	Data size	02h	Data size is 8 bytes
+0004h	Function type	00h	Function type specifies [B/W LCD]
+0005h		00h	
+0006h		00h	
+0007h		04h	
+0008h	PT	00h	Specifies LCD No.
+0009h	CT	0xh	Contrast value
+000Ah	Reserved	00h	Fixed value
+000Bh		00h	

Fig. 4.8 Replies to Set_Condition command

Contrast value: Returns the Contrast value after the execution of the Set_Condition command.
The upper 4 bits are fixed at '0'.

4.1.4 Device Reply

Issuing authority: Host
Command code: 07h
Data size: 00h
Data: none
Description: This command is returned to the host after the host command has successfully completed within the function.
Used for the Block_Write reply.
Examples of this command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	07h	Specifies [Device Reply]
+0001h	Transfer destination AP	00h	Port A
+0002h	Transfer source AP	01h	Expansion Device (LM-Bus No.1)
+0003h	Data size	00h	Data size is 0 bytes

Fig. 4.9 Example of Device Reply Commands

4.1.5 Data Transfer

Issuing authority:	B/W LCD Function	
Command code:	08h	
Data size:	For [Get_Media_Info]:	02h
	For [Set_Condition]:	02h
Data:	For [Get_Media_Info]	
	Function type:	4byte
	Media information:	4byte
	For [Set_Condition]	
	Function type:	4byte
	PT:	1byte
	CT:	1byte
	Reserved ('00h'):	2byte
Description:	Returns data in response to a request from the host.	
	In the case of [Get_Media_Info], the Media information is returned. For more details, please refer to "4.1.1 Get_Media_Info".	
	In the case of [Set_Condition], the contrast data is returned.	
	Examples of the command are shown below.	

Data address	Data	Setting	Description
+0000h	Command code	08h	Specifies [Data Transfer]
+0001h	Transfer destination AP	00h	Port A
+0002h	Transfer source AP	01h	Expansion Device (LM-Bus No.1)
+0003h	Data size	02h	
+0004h	Function type	00h	Function type specifies [B/W LCD]
+0005h		00h	
+0006h		00h	
+0007h		04h	
+0008h □ +000Bh	Data		Data

Fig. 4.10 Examples of Data_Transfer Commands

4.1.6 Device Request

Issuing authority: Host
Command code: 01h
Data size: 00h
Data: none
Expected return value: [Device Status]
Description: This command requests a [Device Status] from the transfer destination AP's peripheral device.
After the initialization of the function, the B/W LCD will not respond to any other commands until this command is received.
Examples of the command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	01h	Specifies [Device Request]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No.1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	00h	Data size is 0 bytes

Fig. 4.11 Examples of Device Request commands

4.1.7 All Status Request

Issuing authority: Host
Command code: 02h
Data size: 00h
Data Area: none
Expected return value: [Device All Status]
Description: Requests the transfer destination AP's peripheral device to provide the device status (both Fixed and Free Device Status) of all devices.
Examples of the command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	02h	Specifies [All Status Request]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No.1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	00h	Data size is 0 bytes

Fig. 4.12 Examples of the All Status Request command

4.1.8 Device Reset

Issuing authority: Host
Command code: 03h
Data size: 00h
Data Area: none
Expected return value: [Device Reply]
Order of operation: (1) Return [Device Reply]
(2) Initializes
Description: Can initialize the peripheral device specified by the transfer destination AP.
When initializing, the LCD screen is cleared.
Examples of the command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	03h	Specifies [Device Reset]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No.1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	00h	Data size is 0 bytes

Fig. 4.13 Examples of the Device Reset command

4.1.9 Device Kill

Issuing authority: Host
Command code: 04h
Data size: 00h
Data Area: none
Expected return value: [Device Reply]
Order of operation: (1) Return [Device Reply]
(2) Halts operation
Description: Does not permit operation of peripheral device specified by the transfer destination AP.
After the function clears the LCD, it waits on standby using consumption current and will not receive any command.
To resume operation, it is necessary to perform a hard reset or shut off the power and restart.
Examples of the command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	04h	Specifies [Device Reset]
+0001h	Transfer destination AP	01h	Expansion Device (LM-Bus No.1)
+0002h	Transfer source AP	00h	Port A
+0003h	Data size	00h	Data size is 0 bytes

Fig. 4.14 Examples of the Device Kill command

4.1.10 Device Status

Issuing authority: Peripheral device

Command code: 05h

Data size: 1Ch (28)

Data Area:

Device ID:	16Byte
Regional code:	1Byte
Product name:	31Byte
License:	60Byte
Standby consumption current:	2Byte
Maximum consumption current:	2Byte

Description: Returns the Fixed Device Status in response to the [Device Request] from the host.
Examples of the command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	05h	Specifies [Device Status]
+0001h	Transfer destination AP	00h	Port A
+0002h	Transfer source AP	01h	Expansion Device (LM-Bus No.1)
+0003h	Data size	1Ch	Data size is 112 bytes
+0004h □ +0013h	Device ID		Specifies the Device ID
+0014h	Regional code		Specifies the Regional code
+0015h □ +0033h	Product name		Specifies the Product name
+0034h □ +006Fh	License		Specifies the License
+0070h	Standby consumption current		Specifies the Standby consumption current
+0071h			
+0072h	Maximum consumption current		Specifies the Maximum consumption current
+0073h			

Fig. 4.15 Examples of the Device Status command

4.1.11 Device All Status

Issuing authority:	Peripheral device	
Command code:	06h	
Data size:	1Ch + n	
Data Area:	Fixed Device Status: 112Byte	
	Device ID:	16Byte
	Regional code:	1Byte
	Product name:	31Byte
	License:	60Byte
	Standby consumption current:	2Byte
	Maximum consumption current:	2Byte
	Free Device Status: n □ 4Byte	
Description:	Returns both the Fixed Device Status and Free Device Status in response to the [All Status Request] from the host.	

4.2Error Commands

4.2.1 Function Type Unknown

Issuing authority:	Peripheral device
Command code:	FEh
Data size:	00h
Data Area:	none
Description:	Returned when the function type sent is not in the peripheral device.
Possible causes:	(1) Function type specification is incorrect. (2) Data statement is incorrect. (3) Device ID data is corrupt. (4) Data corruption occurred during transmission.
Solutions:	(1) Correct the Function type specification. (2) Correct the Data statement. (3) Resend the [Device Request] and receive the Device ID. (4) Receive the function type again. (Up to a maximum of three times, more than that will cause a Time Out)

4.2.2 Command Unknown

Issuing authority:	B/W LCD Function
Command code:	FDh
Data size:	00h
Data Area:	none
Description:	Returned when the command which was sent is not supported by the B/W LCD Function.
Possible causes:	(1) Command specification is incorrect. (2) Data statement is incorrect. (3) Device ID data is corrupt. (4) Data corruption occurred during transmission.
Solutions:	(1) Correct the Command specification. (2) Correct the Data statement. (3) Resend the [Device Request] and receive the Device ID. (4) Receive the command again. (Up to a maximum of three times, more than that will cause a Time Out)

4.2.3 Transmit Again

Issuing authority: Host, B/W LCD Function
Command code: FCh
Data size: 00h
Data Area: none
Description: If an error occurs in data which is sent, this command requests that the data be sent once again.
Possible causes: (1) Parity error occurred.
(2) The data overflowed.
(3) Data corruption occurred during transmission.
(4) Other
Solutions: Resend the data. (Up to a maximum of three times, more than that will cause a Time Out)

4.2.4 LCD Error

Issuing authority: B/W LCD Function
Command code: FAh
Data size: 01h
Data: Function error code: 4byte
Description: This command is returned to the host when an error occurs in processing (when a series of commands is processed over several instances, it is considered as one process) a command received from the host.
Examples of the command are shown below.

Data address	Data	Setting	Description
+0000h	Command code	FAh	Specifies [LCD Error]
+0001h	Transfer destination AP	00h	Port A
+0002h	Transfer source AP	01h	Expansion Device (LM-Bus No.1)
+0003h	Data size	01h	Data size is 4 bytes
+0004h	Function error code		Refer to fig. 4.17
+0005h			
+0006h			
+0007h			

Fig. 4.16 Examples of the LCD Error command

The details of the Function Error Codes are shown below.

bit	7	6	5	4	3	2	1	0
1st Data	FE_{31}	FE_{30}	FE_{29}	FE_{28}	FE_{27}	FE_{26}	FE_{25}	FE_{24}
2nd Data	FE_{23}	FE_{22}	FE_{21}	FE_{20}	FE_{19}	FE_{18}	FE_{17}	FE_{16}
3rd Data	FE_{15}	FE_{14}	FE_{13}	FE_{12}	FE_{11}	FE_{10}	FE_{9}	FE_{8}
4th Data	FE_{7}	FE_{6}	FE_{5}	FE_{4}	FE_{3}	FE_{2}	FE_{1}	FE_{0}

Fig. 4.17 Function Error Codes

Items with an error have a '1' and those without an error have a '0'.

The descriptions of the errors are as follows.
If the error is not fixed by the host's response, then it will be disconnected or a user message will be displayed.

FE_0 : PT Error

Error description:	The LCD indicated by the specified PT does not exist.
Function operation:	All of the data at the time of the error is rejected.
Host response:	The data is resent (up to a maximum of three times)

FE_1 : Phase Error

Error description:	The Phase+1 value exceeds the WA value. (Block_Write execution)
	Counted a Phase value other than +1. (ex: Phase : 0 □ 2 □ 1)
Function operation:	All of the data at the time of the error is rejected.
Host response:	The data is resent (up to a maximum of three times)
	The data is resent by Block transfer from Phase = 0.

FE_2 : Block Error

Error description:	The specified Block (Plane) does not exist.
Function operation:	All of the data at the time of the error is rejected.
Host response:	The data is resent (up to a maximum of three times)

FE_3 : Write Error

Error description:	The data is not properly written into the function's image memory.
Function operation:	The incorrect data is written into memory, but it does not delete the data.
	Therefore, the incorrect screen is displayed on the LCD.
Host response:	The data is resent (up to a maximum of three times)
	Or, the next screen is sent.

FE_4 : Length Error

Error description:	The LCD data capacity and the size of the data sent do not match.
Function operation:	The data is displayed using the actual LCD data capacity.
	Therefore, the incorrect screen is displayed on the LCD.
Host response:	The data is resent (up to a maximum of three times)

FE_5 : Contrast Error

Error description:	The contrast value has exceeded the range of the LCD settings or the setting method is incorrect.
Function operation:	The contrast value is changed so that it does not exceed the range.
Host response:	None.

FE_{31} : Undefined Error

Error description:	An undefined error occurred.
Function operation:	All of the data (Block) at the time of the error is rejected.
Host response:	The data is resent (up to a maximum of three times)

Errors other than those above are reserved.

5 Protocol Flow

5.1 Overview of Transmission Protocols

The figure below shows the fundamental protocols between the host and the B/W LCD.

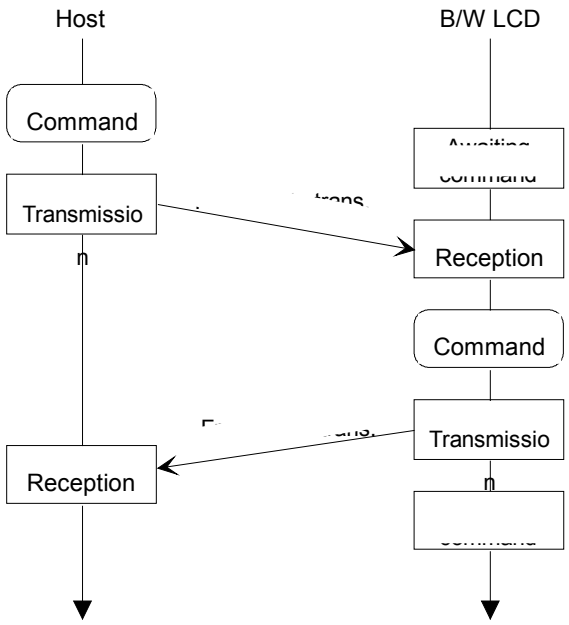


Fig. 5.1 Overview of Transmission Protocols

5.2Processing Flow of LCD Display

The following diagram shows the overall flow of LCD display.

For more information about the processing flow of acquisition of LCD parameters and transmission of image data, please refer to "Get_Media_Info Processing Flow" and "Block_Write Processing Flow".

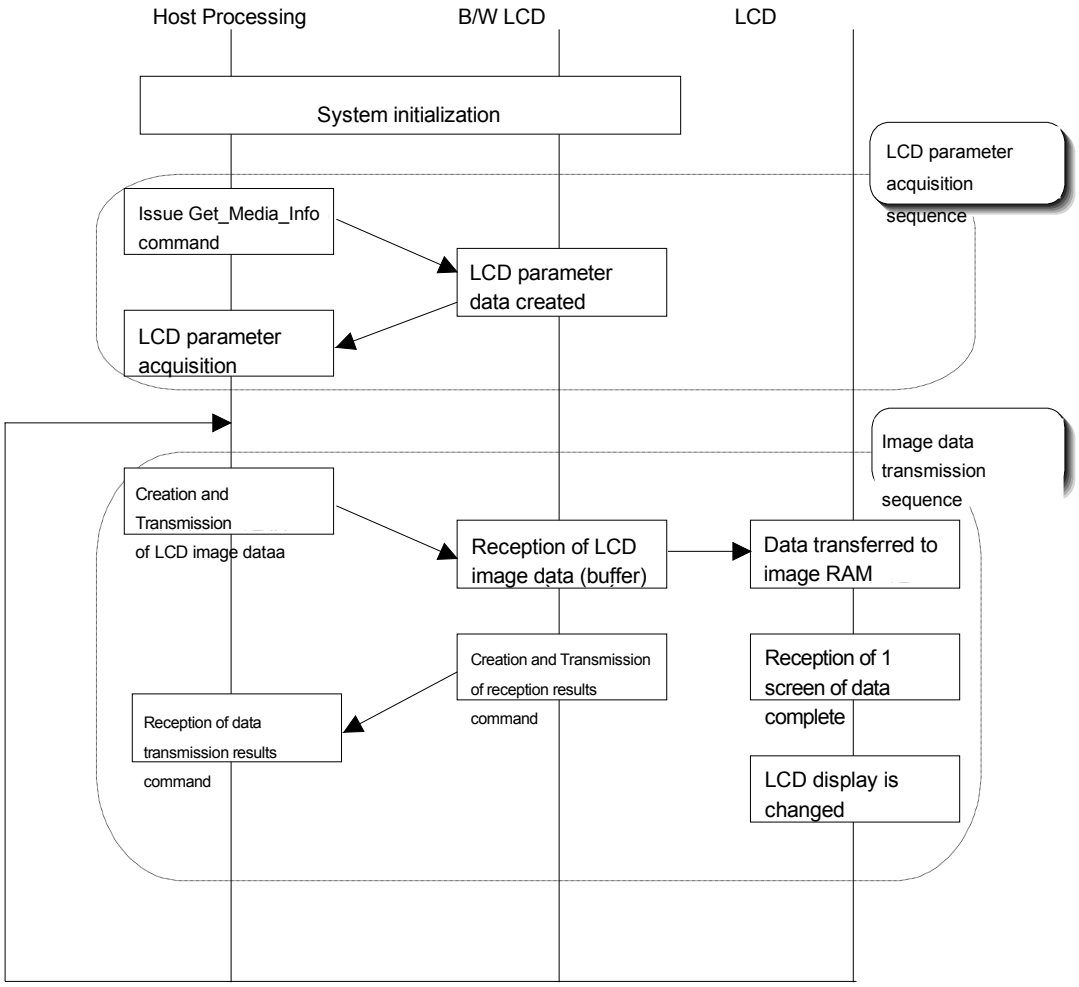


Fig. 5.2 Processing Flow of LCD Display

5.3Processing Flow of Get_Media_Info

The following diagram shows the overall flow of the Get_Media_Info processing.

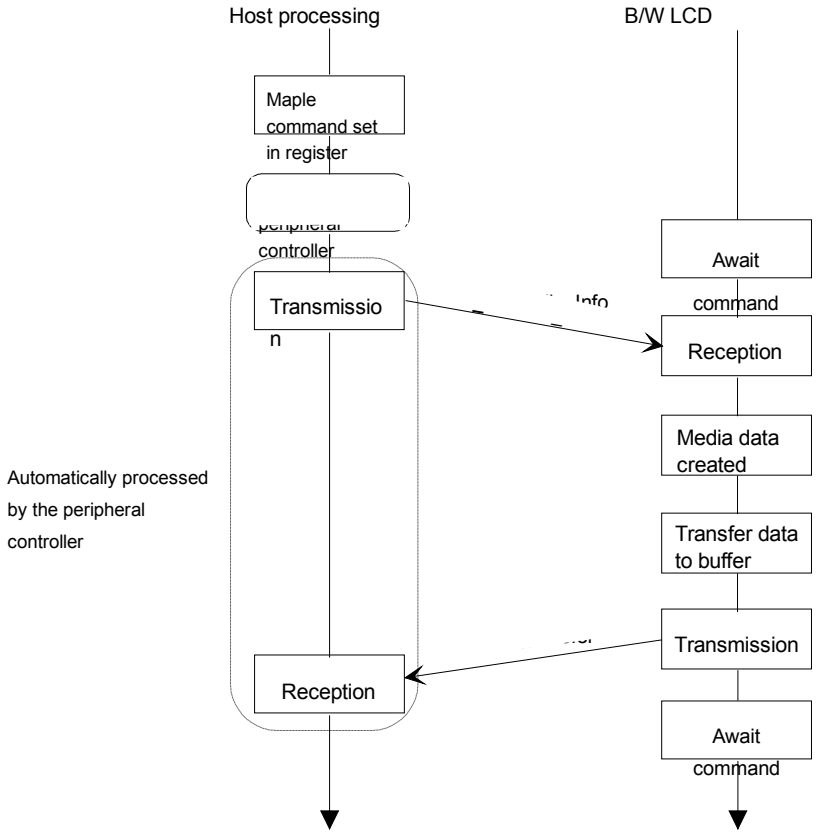


Fig. 5.3 Processing Flow of Get_Media_Info

5.4Processing Flow of Block_Write

The following diagram shows the overall flow of the Block_Write processing.

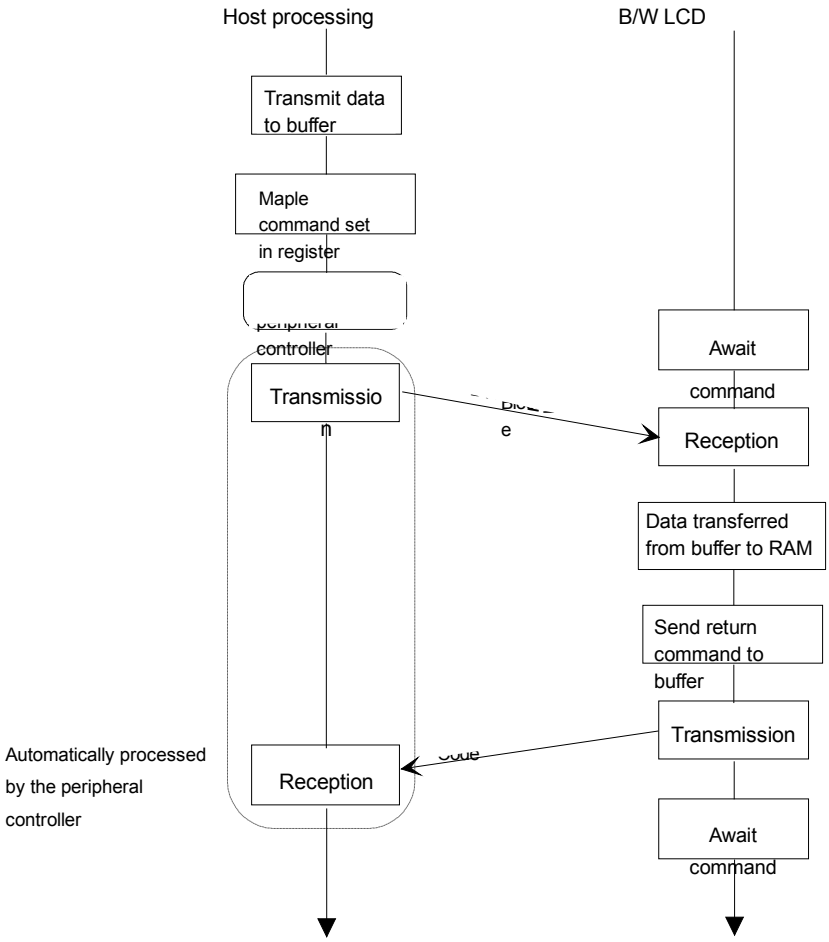


Fig. 5.4 Processing Flow of Block_Write

6 Afterword

The contents of these specifications are subject to change in part or in whole until the formal version is issued (Rev. 1.0).