RAiO

RA6963

Dot Matrix

LCD Controller

Specification

Version 1.3

February 26, 2008

RAiO Technology Inc.
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Update History		
Version	**Date**	**Description**
1.0	May 29, 2007	Formal Release
1.1	September 27, 2007	Update Figure 9-4
1.2	November 15, 2007	Update < Table 8-2 > Max. f_{OSC} to 18MHz. Update < Table 8-4 > Max. f_{SCP} to 9MHz. Update the Chapter 5-4 “Misc Interface” – the description of pin “MDS” and MD[1:0].
1.3	February 26, 2008	Update the description of pin “X1” in Section 5-4. Update Figure 6-13, 6-14, 9-5 and 9-6.

Chapter	Contents	Pages

1. Overview 5
2. Features 5
3. Block Diagram 5
4. Package 6
5. Pin Descriptions 6
5-1 MPU Interface 6
5-2 LCD Driver Interface 7
5-3 Memory Interface 7
5-4 Misc. Interface 8
6. Functions Description 10
6-1 Functional Definition 10
6-2 State After RESET/HALT 10
6-3 Row / Column and Oscillation Clock 11
6-4 RAM Interface 12
6-5 Communications with MPU 13
6-5-1 Status Read 13
6-5-2 Setting Data 15
6-5-3 Command Definitions 16
6-6 Setting Registers 17
6-6-1 Set Cursor Pointer 17
6-6-2 Set Offset Register 18
6-6-3 Set Address Pointer 19
6-7 Set Control Word 20
6-7-1 Set Text Home Address 20
6-7-2 Set Graphic Home Address 21
6-7-3 Set Text Area 22
6-7-4 Set Graphic Area 23
6-8 Mode Set 24
6-9 Display Mode 25
6-10 Cursor Pattern Select 26
6-11 Data Auto Read/Write 26
6-12 Data Read/Write 28
6-13 Screen Peek 29
6-14 Screen Copy 30
6-15 Bit Set/Reset 31
6-16 Screen Reverse 32
6-17 Blink Time 32
6-18 Cursor Auto Moving 33

6-19 CGROM Font Select 33
6-20 Character Font Map 34
6-21 RA6963 vs. T6963C 35
7. Package Dimensions 36
7-1 Die Form 36
7-2 Part Number: 36
7-3 XY Coordinate 37
7-4 Outline Drawing 38
8. Specifications 39
8-1 Absolute Maximum Ratings 39
8-2 MPU Interface Timing 40
8-3 Driver Interface Timing 40
8-4 External Memory Interface 41
9. Application 43
9-1 MPU Memory Address Mapping 43
9-2 MPU I/O Addressing 44
9-3 Use PPI LSI 44
9-4 Application Block Diagram 45
9-5 Application Circuit(1) 46
9-6 Application Circuit(2) 46

1. Overview

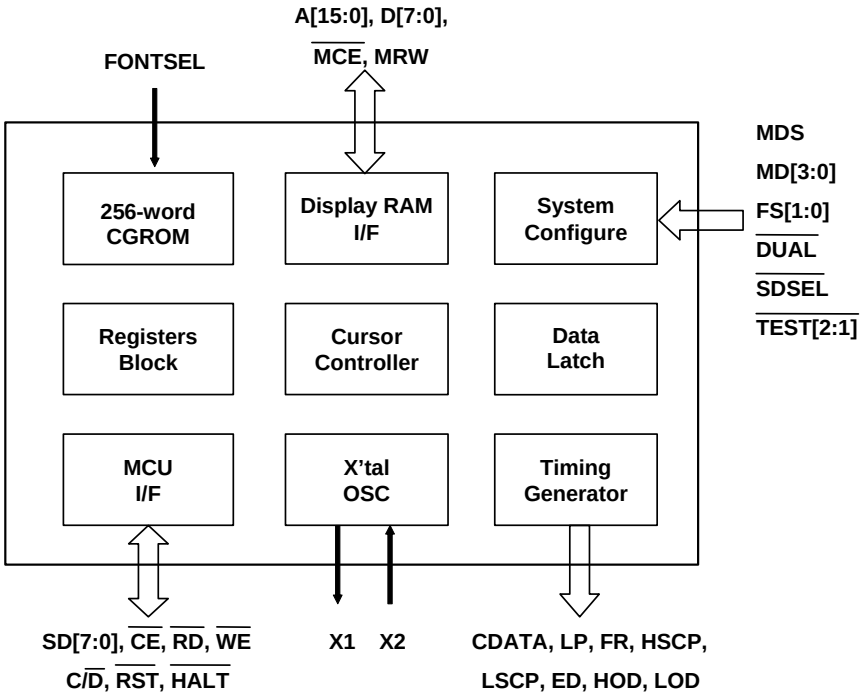
The RA6963 is a dot matrix LCD Controller which fully compatible with T6963C. It supports various LCD Driver for standard or custom-made LCD module. The RA6963 built-in a 256-word CG(Character Generator) ROM that for ASCII, Japanese or numeric display in text mode. It also supports Graphics mode and mixed display with Text. The supported maximum external display RAM is 64Kbyte and the display Window can be moved freely within the allocated memory range. The RA6963 has an 8-bit parallel data bus that can be directly connected to an 8080 series MPU.

The RA6963 supports a very broad range of LCD formats by allowing selection of different combinations via a set and combination text-and-graphic modes, and includes various attribute functions.

2. Features

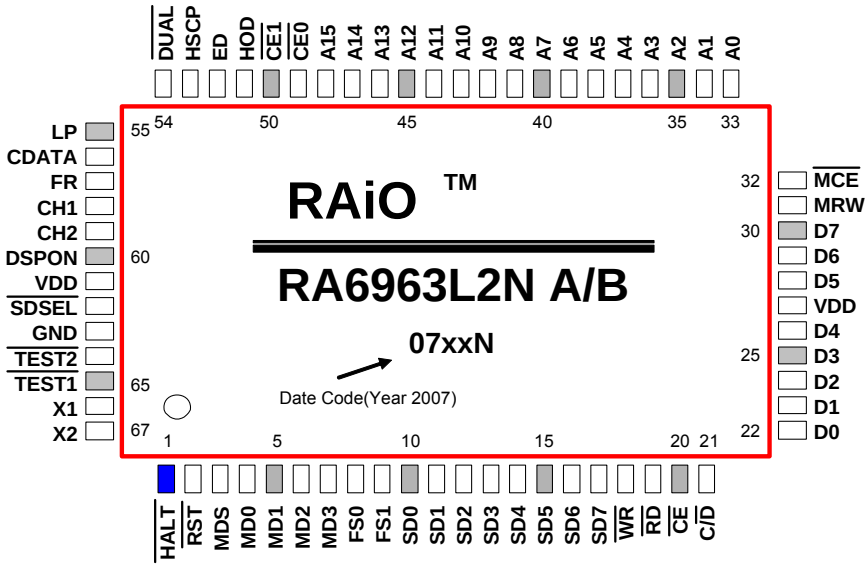
- Support Display Range:
  Columns → 32, 40, 64, 80
  Rows → 2, 4, 6, 8, 10, 12, 14, 16, 20, 24, 28, 32
- Support 8080 8-bit MPU Interface
- Built-in 256-word Font ROM: Basic ASCII、Japanese、Numeric
- Support Max. 64Kbyte External Display SRAM
- Display Mode : Character、Graphics and Mixed Mode
- Font Size :
  Horizontal → 5, 6, 7, 8 Pixels
  Vertical → 8 Pixels
- Support Bold Font and Reverse Display
- Support Various LCD Driver
- Support 1/16 ~1/128 Duty
- Built-in X'tal Oscillator or Using External Clock
- Power Supply Range: 3.0~5.5V
- Package: LQFP-67Pin (RoHS Compliance)

3. Block Diagram



< Figure 3-1 >

4. Package



< Figure 4-1 >

RA6963L2NA : LQFP-67 Pin, RoHS Compliance Package, Font-01 (Refer to Chapter 6-20)
RA6963L2NB : LQFP-67 Pin, RoHS Compliance Package, Font-02 (Refer to Chapter 6-20)

5. Pin Descriptions

5-1 MPU Interface

< Table 5-1 >

<table>
<tr><th>Pin Name</th><th>I/O</th><th>Description</th></tr>
<tr><td>SD[7..0]</td><td>I/O</td><td>Data Bus
This is bus for data transfer between MPU and RA6963.</td></tr>
<tr><td>$\overline{RD}$</td><td>I</td><td>Read Control
$\overline{RD}$ is a data read signal. When Low, MPU read data from RA6963.</td></tr>
<tr><td>$\overline{WR}$</td><td>I</td><td>Write Control
$\overline{WR}$ is a data write signal. When Low, MPU write data into RA6963.</td></tr>
<tr><td>C/ $\overline{D}$</td><td>I</td><td>Command/Data Select or Register Select
This is a Data or Command select signal.
<table>
<tr><th>C/ $\overline{D}$</th><th>$\overline{WR}$ = Low</th><th>$\overline{RD}$ = Low</th></tr>
<tr><td>High</td><td>Command Write</td><td>Status Read</td></tr>
<tr><td>Low</td><td>Data Write</td><td>Data Read</td></tr>
</table></td></tr>
<tr><td>$\overline{CE}$</td><td>I</td><td>Chip Enable
This s chip enable of RA6963. When MPU communicate with RA6963, this pin must be Low.</td></tr>
</table>

5-2 LCD Driver Interface

< Table 5-2 >

Pin Name	I/O	Description
FR	O	**Frame**
LP	O	**Latch** Latch pulse for column driver. Shift clock pulse for Row Driver
CDATA	O	**Synchronous Data** **Synchronous Data** for Row Driver.
HSCP	O	**Shift Clock Pulse** Shift clock pulse for Column Driver in upper area of LCD.
HOD	O	**Data Output** Data output for Odd Columns in upper area of LCD.
ED	O	**Data Output** $\overline{SDSEL}$ = High → Data output for even columns in both upper and lower area of LCD. $\overline{SDSEL}$ = Low → Data output for columns in both upper and lower area of LCD.
DSPON	O	**Display On** Display On/Off control signal. When $\overline{HALT}$ or $\overline{RST}$ is Low, DSPON output Low (LCD Display Off).

5-3 Memory Interface

< Table 5-3 >

Pin Name	I/O	Description
A[15:0]	O	**Address Output for External Memory**
D[7:0]	I/O	**Data Bus for External Memory**
$\overline{MCE}$	O	**Memory Chip Enable** $\overline{MCE}$ = Low → Memory Enable. $\overline{MCE}$ = High → Memory Disable.
MRW	O	**Memory Read/Write Control** MRW = Low → Memory Write Enable. MRW = High → Memory Read Enable.
$\overline{CE0}$ LOD	O	**Memory Chip Enable 0** If $\overline{DUAL}$ = High → Chip enable pin for display memory in the address range 0000~07FFh. If $\overline{DUAL}$ = Low → Serial data output for odd columns in lower area of LCD.
$\overline{CE1}$ LSCP	O	**Memory Chip Enable 1** If $\overline{DUAL}$ = High → Chip enable pin for display memory in the address range 0800~0FFFh. If $\overline{DUAL}$ = Low → Shift clock output for Column Driver in lower area of LCD.
VDD	P	**Power**
GND	P	**Ground**

5-4 Misc. Interface

< Table 5-4 >

<table>
<tr><th>Pin Name</th><th>I/O</th><th>Description</th></tr>
<tr><td>$\overline{\text{DUAL}}$</td><td>I</td><td>Scan Select
$\overline{\text{DUAL}}$ = Low → Dual-Scan Mode.
$\overline{\text{DUAL}}$ = High → Signal-Scan Mode.</td></tr>
<tr><td>MDS
MD[1:0]</td><td>I</td><td>LCD Size Selection
One Screen:
<table>
<tr><td>$\overline{\text{DUAL}}$</td><td>H</td><td>H</td><td>H</td><td>H</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>MDS</td><td>L</td><td>L</td><td>L</td><td>L</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>MD1</td><td>H</td><td>H</td><td>L</td><td>L</td><td>H</td><td>H</td><td>L</td><td>L</td></tr>
<tr><td>MD0</td><td>H</td><td>L</td><td>H</td><td>L</td><td>H</td><td>L</td><td>H</td><td>L</td></tr>
<tr><td>Lines</td><td>2</td><td>4</td><td>6</td><td>8</td><td>10</td><td>12</td><td>14</td><td>16</td></tr>
<tr><td>V-Dots</td><td>16</td><td>32</td><td>48</td><td>64</td><td>80</td><td>96</td><td>112</td><td>128</td></tr>
</table>
Two Screens:
<table>
<tr><td>$\overline{\text{DUAL}}$</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td></tr>
<tr><td>MDS</td><td>L</td><td>L</td><td>L</td><td>L</td><td>H</td><td>H</td><td>H</td><td>H</td></tr>
<tr><td>MD1</td><td>H</td><td>H</td><td>L</td><td>L</td><td>H</td><td>H</td><td>L</td><td>L</td></tr>
<tr><td>MD0</td><td>H</td><td>L</td><td>H</td><td>L</td><td>H</td><td>L</td><td>H</td><td>L</td></tr>
<tr><td>Lines</td><td>4</td><td>8</td><td>12</td><td>16</td><td>20</td><td>24</td><td>28</td><td>32</td></tr>
<tr><td>V-Dots</td><td>32</td><td>64</td><td>96</td><td>128</td><td>160</td><td>192</td><td>224</td><td>256</td></tr>
</table></td></tr>
<tr><td>X1</td><td>I</td><td>Crystal Oscillator Input
A crystal oscillator circuit is built in. The oscillation frequency is adjusted according to the display size. If using an external clock, use the X1 pin as the clock input. (X2 open.) External capacitors 15 to 20pF.</td></tr>
<tr><td>X2</td><td>O</td><td>Crystal Oscillator Output</td></tr>
<tr><td>FS[1:0]</td><td>I</td><td>Font Selection
<table>
<tr><td>FS0</td><td>H</td><td>L</td><td>H</td><td>L</td></tr>
<tr><td>FS1</td><td>H</td><td>H</td><td>L</td><td>L</td></tr>
<tr><td>Font</td><td>5 X 8</td><td>6 X 8</td><td>7 X 8</td><td>8 X 8</td></tr>
</table></td></tr>
<tr><td>MD[3:2]</td><td>I</td><td>Columns Selection
<table>
<tr><td>MD2</td><td>H</td><td>L</td><td>H</td><td>L</td></tr>
<tr><td>MD3</td><td>H</td><td>H</td><td>L</td><td>L</td></tr>
<tr><td>Columns</td><td>32</td><td>40</td><td>64</td><td>80</td></tr>
</table></td></tr>
<tr><td>$\overline{\text{SDSEL}}$</td><td>I</td><td>Data Transfer Mode
$\overline{\text{SDSEL}}$ = Low → Sending data by simple serial mode.
$\overline{\text{SDSEL}}$ = High → Sending data by odd/even separtion mode.</td></tr>
</table>

$\overline{HALT}$	I	**Halt Signal** $\overline{HALT}$ = Low → Stop the Clock. $\overline{HALT}$ = High → Normal Mode.
$\overline{RST}$	I	**Reset Signal** $\overline{RST}$ = Low → RA6963 will be reset. $\overline{RST}$ = High → Normal mode. RA6963 built-in a Pull-Hi resistor.
$\overline{TEST[2:1]}$	I	**Test Pins** These are test pins. No need for connection(NC).
CH1, CH2	O	**Check Signals**
FONTSEL	I	**CGROM Font Select** This pin is used to select the character of CGROM. Refer to Chapter 6-20. Please note, this pin is only reserved for die base chip only. Refer to Chapter 7-2. FONTSEL = Low → Select default CGROM Font-01. FONTSEL = High → Select default CGROM Font-02.

6. Functions Description

6-1 Functional Definition

- ◆ After power on, it is necessary to reset. The $\overline{RST}$ is kept Low between 5 clocks up (oscillation clock).
- ◆ When $\overline{HALT}$ = Low, the oscillation stops. The power supply for the LCD must be turned off, to protect the LCD from DC bias.
- ◆ The HALT function($\overline{HALT}$ = Low) includes the RESET function($\overline{RST}$ =Low).
- ◆ The column/line counter and display register are cleared by $\overline{RST}$. (Other registers are not cleared.) Disable the display using the clear-display register
- ◆ The status must be checked before data or commands are sent. The MSB=0 status check must be done in particular. There is a possibility of erroneous operation due to a hard interrupt.
- ◆ STA0 and STA1 must be checked at the same time. When a command is executed, data transmission errors may occur.
- ◆ The RA6963 can only handle one byte per machine cycle (16 clocks). It is impossible to send more than two data in a machine cycle.
- ◆ When using a command with operand data, it important to send the data first, and then executes the command.
- ◆ The character fonts used by the RA6963 are different from ASCII codes.

6-2 State After RESET/HALT

< Table 6-1 >

Pins	HALT	RESET
SD[7:0]	Floating	Floating
D[7:0]	Floating	Floating
MRW	Hi	Hi
$\overline{MCE}$	Hi (Note 1)	Hi (Note 1)
A[15:0]	Hi (Note 2)	Hi (Note 2)
$\overline{CE0}$, $\overline{CE1}$	Hi (Note 1)	Hi (Note 1)
ED, HOD	Final data	Final data
HSCP	Low	Low
LP	Low	Low
CDATA	Hi	Hi
FR	Hi	Hi
CH1	Low	Test Signal
CH2	Low	Test Signal
DSPON	Low	Low
X2	Hi	OSC Clock

Note 1 :In Attribute mode, Hi or Low according to state of graphic pointer
Note 2 :In Attribute mode, data to graphic pointer

6-3 Row / Column and Oscillation Clock

The frequency of the crystal oscillator is adjusted by the following formula.

f_{OSC} : Frequency of oscillation
f_{SCP} : Frequency of shift clock ($f_{SCP} = f_{OSC} / 2$)
f_R : Frequency of Frame
M : Number of characters on one line (number of dots on one line =8M)
For all font sizes (e.g. 7 x 8, 7 x 8, 5 x 8) the oscillation frequency remains constant.
N : Number of rows (Duty=1/8N)

$$\frac{8M}{f_{SCP}} \times 8N = \frac{1}{f_R}$$

$f_{OSC} = f_R \times 64 \times 2 \times M \times N$
($f_R = 60Hz$)

< Table 6-2 >

Unit: MHz

N \ M		32	40	64	80	Duty
2	Upper	0.492	0.614	0.983	1.229	1/16
	Lower	0.983	1.229	1.966	2.458	
4	Upper	0.983	1.229	1.966	2.458	1/32
	Lower	1.966	2.458	3.932	4.915	
6	Upper	1.475	1.843	2.949	3.688	1/48
	Lower	2.949	3.685	5.898	7.372	
8	Upper	1.966	2.458	3.932	4.915	1/64
	Lower	3.932	4.915	7.864	9.830	
10	Upper	2.458	3.072	4.915	6.144	1/80
	Lower	4.915	6.144	9.830	12.288	
12	Upper	2.949	3.686	5.898	7.373	1/96
	Lower	5.898	7.373	11.776	14.746	
14	Upper	3.440	4.300	6.881	8.602	1/112
	Lower	6.881	8.601	13.763	17.203	
16	Upper	3.932	4.915	7.864	9.830	1/128
	Lower	7.864	9.830	15.729	19.660	

Note 1: Upper → Single-Scan. Lower → Dual-Scan at $f_R = 60Hz$

6-4 RAM Interface

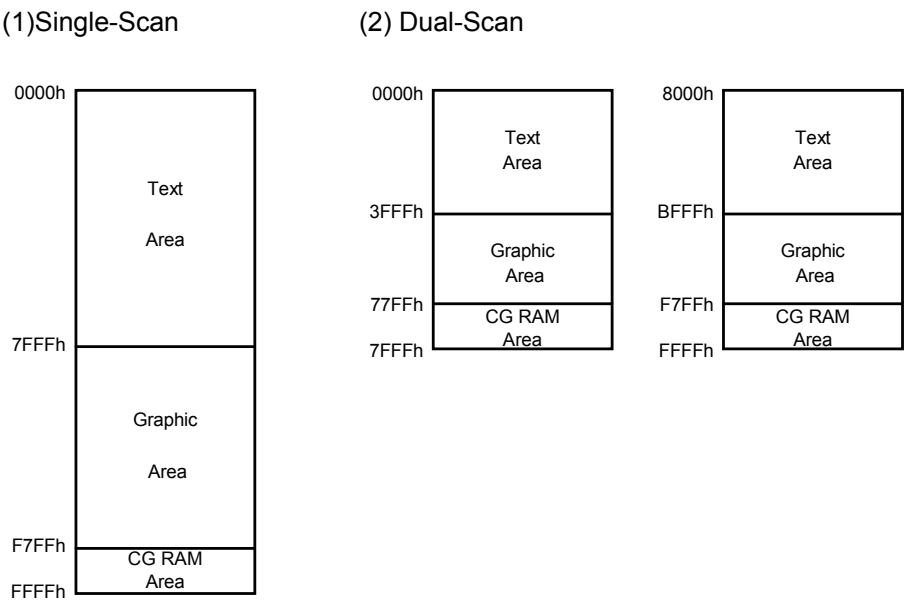
The external RAM is used to store display data (text, graphic and external CG data).

With single-scan, text data, graphic data and external CG data can be freely allocated to the memory area (64 KB max).

With dual-scan, LCD-I is allocated to 0000h to 7FFFh (32 KB max), LCD-II is allocated to 8000h to FFFFh (32-KB Max). Text data, graphic data and external CG data can be freely allocated in LCD-I. In LCD-II, the same addresses must be allocated as in LCD-I, except A15. A15 determines selection of LCD-I or LCD-II.

It can be used the address-decoded signals $\overline{CE0}$ (0000h to 07FFh), $\overline{CE1}$ (0800h to 0FFFh) within 4 KB. $\overline{CE0}$ and $\overline{CE1}$ allow decoding of addresses in the ranges (0000h to 07FFh) and (0800h to 0FFFh) respectively within a 4-KB memory space.

(Example)



< Figure 6-1 >

6-5 Communications with MPU

6-5-1 Status Read

A status check must be performed before data is read or written.

Status Check

The Status of RA6963 can be read from the data lines.

< Table 6-3 >

$\overline{RD}$	$\overline{WR}$	$\overline{CS}$	C/$\overline{D}$	SD[7:0]
L	H	L	H	Status Word

The RA6963 status word format is as follows:

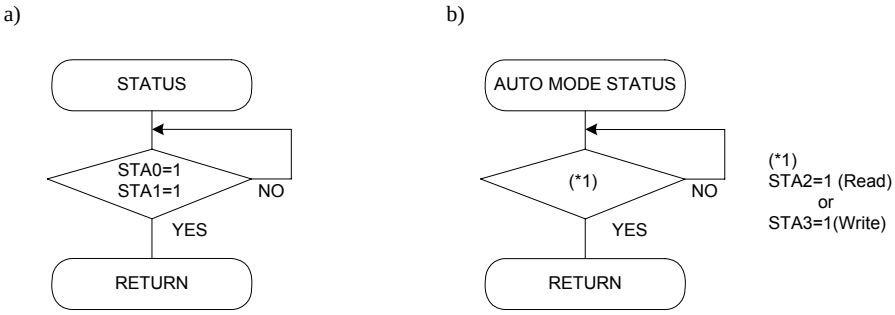
MSB							LSB
SD7	**SD6**	**SD5**	**SD4**	**SD3**	**SD2**	**SD1**	**SD0**
STA7	STA6	STA5	STA4	STA3	STA2	STA1	STA0

< Table 6-4 >

STA0	Check command execution capability	0: Disable 1: Enable
STA1	Check data read/write capability	0: Disable 1: Enable
STA2	Check Auto mode data read capability	0: Disable 1: Enable
STA3	Check Auto mode data write capability	0: Disable 1: Enable
STA4	Not used	
STA5	Check controller operation capability	0: Disable 1: Enable
STA6	Error flag. Used for Screen copy commands.	0: No error 1: Error
STA7	Check the blink condition	0: Display off 1: Normal display

Note 1: It is necessary to check STA0 and STA1 at the same time.
There is a possibility of erroneous operation due to a hardware interrupt.
Note 2: For most modes STA0 /STA1 are used as a status check.
Note 3: STA2 and STA3 are valid in Auto mode; STA0 and STA1 are invalid.

Status Checking Flow



< Figure 6-2 >

Note 4: When using the MSB=0 command, a Status Read must be performed.
If a status check is not carried out, the RA6963 cannot operate normally, even after a delay time.

The hardware interrupt occurs during the address calculation period (at the end of each line).

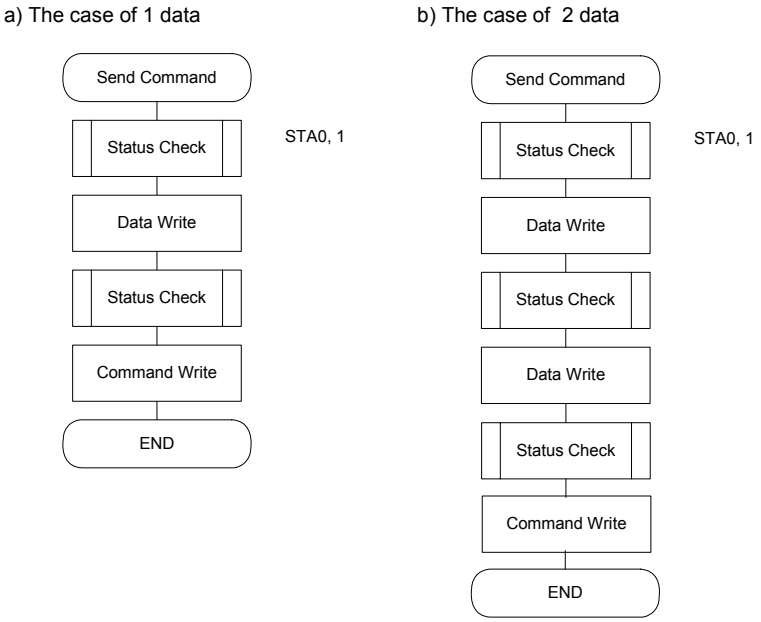
If a MSB=0 command is sent to the RA6963 during this period, the RA6963 enters Wait status.

If a status check is not carried out in this state before the next command is sent, there is the possibility that command or data will not be received.

6-5-2 Setting Data

When using the RA6963, first set the data, then set the command.

Procedure for Sending a Command



< Figure 6-3 >

Note: When sending more than two data, the last datum (or last two data) is valid.

6-5-3 Command Definitions

< Table 6-5 >

Command	Code	D1	D2	Function
Registers Setting	00100001	X address	Y address	Set cursor pointer
	00100010	Data	00h	Set Offset Register
	00100100	Low address	High address	Set Address pointer
Set Control Word	01000000	Low address	High address	Set Text Home Address
	01000001	Columns	00h	Set Text Area
	01000010	Low address	High address	Set Graphic Home Address
	01000011	Columns	00h	Set Graphic Area
Mode Set	1000X000	--	--	OR mode
	1000X001	--	--	EXOR mode
	1000X011	--	--	AND mode
	1000X100	--	--	Text Attribute mode
	10000XXX	--	--	Internal CG ROM mode
	10001XXX	--	--	External CG RAM mode
Display Mode	10010000	--	--	Display off
	1001XX10	--	--	Cursor on, blink off
	1001XX11	--	--	Cursor on, blink on
	100101XX	--	--	Text on, graphic off
	100110XX	--	--	Text off, graphic on
	100111XX	--	--	Text on, graphic on
Cursor Pattern Select	10100000	--	--	1-line cursor
	10100001	--	--	2-line cursor
	10100010	--	--	3-line cursor
	10100011	--	--	4-line cursor
	10100100	--	--	5-line cursor
	10100101	--	--	6-line cursor
	10100110	--	--	7-line cursor
	10100111	--	--	8-line cursor
Data Read/Write	11000000	Data	--	Data Write and Increment ADP
	11000001	--	--	Data Read and Increment ADP
	11000010	Data	--	Data Write and Decrement ADP
	11000011	--	--	Data Read and Decrement ADP
	11000100	Data	--	Data Write and Non-variable ADP
	11000101	--	--	Data Read and Non-variable ADP
Data auto Read/Write	10110000	--	--	Set Data Auto Write
	10110001	--	--	Set Data Auto Read
	10110010	--	--	Auto Reset
Screen Peek	11100000	--	--	Screen Peek
Screen Copy	11101000			Screen Copy
Bit Set/Reset	11110XXX	--	--	Bit Reset
	11111XXX	--	--	Bit Set
	1111X000	--	--	Bit 0 (LSB)
	1111X001	--	--	Bit 1
	1111X010	--	--	Bit 2
	1111X011	--	--	Bit 3
	1111X100	--	--	Bit 4
	1111X101	--	--	Bit 5
	1111X110	--	--	Bit 6
	1111X111	--	--	Bit 7 (MSB)
Screen Reverse	11010000	Data	--	Whole screen reverse

				Data Bit 0 0 : Normal 1 : Reverse
Blink Time	01010000	Data	Don't care (Note)	If Frame = 60Hz Data Bit 2:0 000 : 0.066s 001 : 0.25s 010 : 0.5s (Default) 011 : 0.75s 100 : 1s 101 : 1.25s 110 : 1.5s 111 : 2s
Cursor Auto Moving	01100000	Data	Don't care (Note)	Data Bit 0 0 : Disable.(Default) 1 : Enable.
CGROM Font Select	01110000	Data	Don't care (Note)	Data Bit 1:0 00 : Do not care.(Default) 01 : Do not care. 10 : CGROM Font-01. 11 : CGROM Font-02.

Note： In these functions, it must be sent two data before sending the command, but the contents of the second datum (D2) can be any values.

6-6 Setting Registers

< Table 6-6 >

Code	Hex.	Function	D1	D2
00100001	21h	Set Cursor Pointer	X-Adrs	Y-Adrs
00100010	22h	Set Offset Register	Data	00h
00100100	24h	Set Address Pointer	Low Adrs	High Adrs

6-6-1 Set Cursor Pointer

The X-Adrs and Y-Adrs specify the position of the cursor. The cursor position can only be moved by this command. Data read /write from the MPU never changes the cursor pointer. X-Adrs and Y-Adrs are specified as follows.

X-Adrs 00h to 4Fh (lower 7 bits are valid)
Y-Adrs 00h to 1Fh (lower 5 bits are valid)

a) Single-Scan
X-Adrs 00h to 4Fh

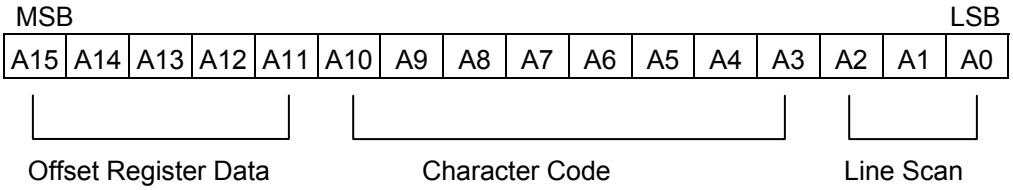
Y-Adrs 00h to 0Fh

b) Dual-Scan
X-Adrs 00h to 4Fh

Y-Adrs 00h to 0Fh Upper Screen
Y-Adrs 10h to 1Fh Lower Screen

6-6-2 Set Offset Register

The offset register is used to determine the external character generator RAM area. The RA6963 has a 16-bit address bus as follows:



RA6963 assign External character generator, when character code set 80h to FFh in using Internal character generator. Character code 00h to 80h assign External character generator, when External generator mode.

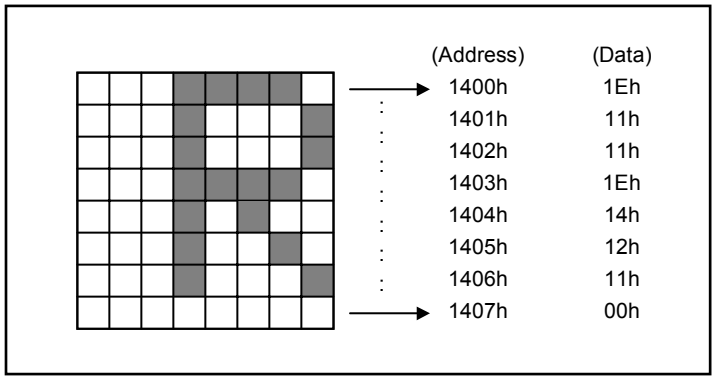
The senior five bits define the start address in external memory of the CG RAM area. The next eight bits represent the character code of the character. In internal CG ROM mode, character Codes 00h to 7Fh represent the predefined “internal” CG ROM characters, and codes 80h to FFh Represent the user’s own “external” characters. In external CG RAM mode, all 256 codes from 00h to FFh can be used to represent the user’s own characters. The three least significant bits indicate one of the eight rows of eight dots that define the character’s shape.

The Relationship between Display RAM Address and Offset Register

Offset Register Data	CG RAM hex. Address (Start to End)
00000	0000 to 07FFh
00001	0800 to 0FFFh
00010	1000 to 17FFh
11100	E000 to E7FFh
11101	E800 to EFFFh
11110	F000 to F7FFh
11111	F800 to FFFFh

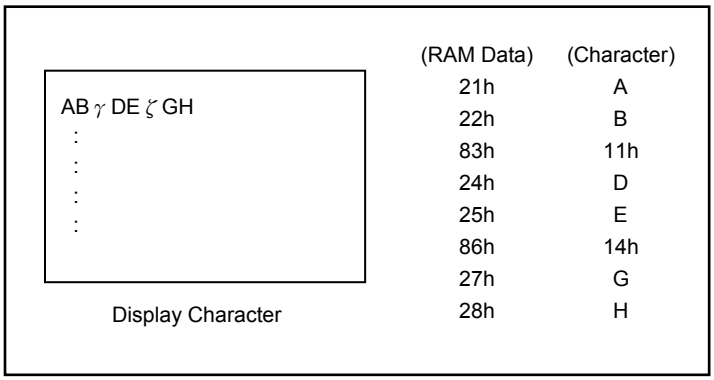
(Example 1)

Offset Register	02h				
Character Code	80h				
Character Generator RAM Start Address	0001	0100	0000	0000	
	1	4	0	0	h



< Figure 6-4 >

(Example 2) The relationship between Display RAM data and display characters



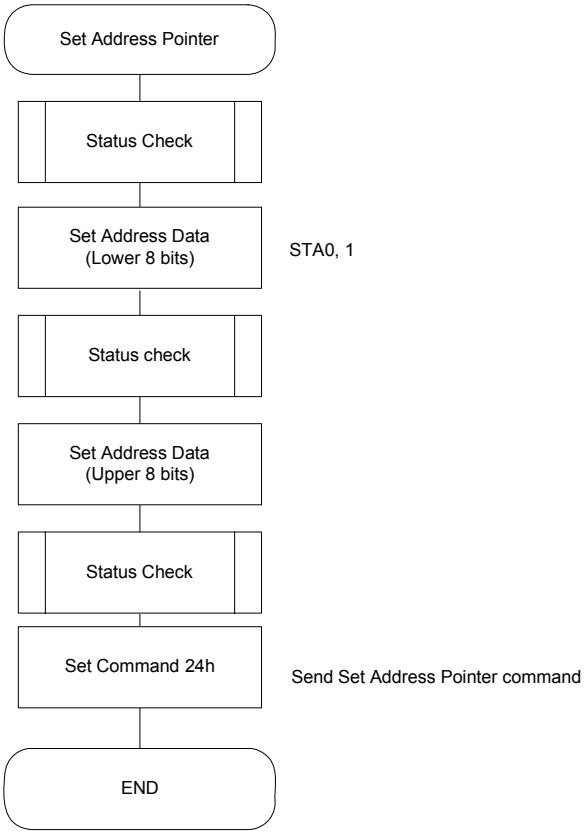
< Figure 6-5 >

The “γ” and “ζ” are displayed by character generator RAM.

6-6-3 Set Address Pointer

The Set Address Pointer command is used to indicate the start address for writing to (or reading from) External RAM.

The Flowchart for Set Address Pointer Command



< Figure 6-6 >

6-7 Set Control Word

< Table 6-7 >

Code	Hex.	Function	D1	D2
01000000	40h	Set Text Home Address	Low Address	High Address
01000001	41h	Set Text Area	Columns	00h
01000010	42h	Set Graphic Home Address	Low Address	High Address
01000011	43h	Set Graphic Area	Columns	00h

The home address and column size are defined by this command.

6-7-1 Set Text Home Address

The starting address in the external display RAM for text display is defined by this command. The text home address indicates the leftmost and uppermost position.

The Relationship between Display RAM Address and Display Position

< Table 6-8 >

TH	……	TH + CL
TH + TA	……	TH + TA + CL
(TH + TA) + TA	……	TH + 2TA + CL
(TH + 2TA) + TA	……	TH + 3TA + CL
:	:	:
TH + (n-1) TA	……	TH + (n-1) TA + CL

TH: Text home address
TA: Text area number (columns)
CL: Columns are fixed by hardware (pin-programmable).

(Example)

Text Home Address : 0000h
Text Area : 0020h
MD2=H, MD3=H : 32 Columns
$\overline{DUAL}$ =H, MDS=L, MD0=L, MD1=H : 4 Lines

< Table 6-9 >

0000h	0001h	……	001Eh	001Fh
0020h	0021h	……	003Eh	002Fh
0040h	0041h	……	005Eh	005Fh
0060h	0061h	……	007Eh	007Fh

6-7-2 Set Graphic Home Address

The starting address of the external display RAM used for graphic display is defined by this Command. The graphic home address indicates the leftmost and uppermost position.

The Relationship between External Display RAM Address and Display Position

< Table 6-10 >

GH	……	GH + CL
GH + GA	……	GH + GA + CL
(GH + GA) + GA	……	GH + 2GA + CL
(GH + 2GA) + GA	……	GH + 3GA + CL
: : : :	: : : :	: : : :
GH + (n-1) GA	……	GH + (n-1) GA + CL

GH: Graphic Home Address
GA: Graphic Area Number (columns)
CL: Columns are fixed by hardware (pin-programmable).

(Example)

Graphic Home Address	: 0000h
Graphic Area	: 0020h
MD2=H, MD3=H	: 32 columns
$\overline{\text{DUAL}}$ =H, MDS=L, MD0=H, MD1=H	: 2 lines

< Table 6-11 >

0000h	0001h	……	001Eh	001Fh
0020h	0021h	……	003Eh	003Fh
0040h	0041h	……	005Eh	005Fh
0060h	0061h	……	007Eh	007Fh
0080h	0081h	……	009Eh	009Fh
00A0h	00A1h	……	00BEh	00BFh
00C0h	00C1h	……	00DEh	00DFh
00E0h	00E1h	……	00FEh	00FFh
0100h	0101h	……	011Eh	011Fh
0120h	0121h	……	013Eh	013Fh
0140h	0141h	……	015Eh	015Fh
0160h	0161h	……	017Eh	017Fh
0180h	0181h	……	019Eh	019Fh
01A0h	01A1h	……	01BEh	01BFh
01C0h	01C1h	……	01DEh	01DFh
01E0h	01E1h	……	01FEh	01FFh

6-7-3 Set Text Area

The display columns are defined by the hardware setting. This command can be used adjust the columns of the display.

(Example)

LCD Size	: 20 columns, 4 lines
Text Home Address	: 0000h
Text Area	: 0014h
MD2=H, MD3=H	: 32 columns
$\overline{\text{DUAL}}$ =H , MDS =L, MD0= L, MD1=H	: 4 lines

< Table 6-12 >

0000	0001	……	0013	0014	……	001F
0014	0015	……	0027	0028	……	0033
0028	0029	……	003B	003C	……	0047
003C	003D	……	004F	0050	……	005B

6-7-4 Set Graphic Area

The display columns are defined by the hardware setting. This command can be used to adjust the columns of the graphic display.

(Example)

LCD Size	: 20 columns, 2 lines
Graphic Home Address	: 0000h
Graphic Area	: 0014h
MD2=H, MD3=H	: 32 columns
$\overline{\text{DUAL}}$ =H, MDS=L MD0=H, MD1=H	: 2 lines

< Table 6-13 >

0000	0001	.....	0013	0014	.....	001F
0014	0015	.....	0027	0028	.....	0033
0028	0029	.....	003B	003C	.....	0047
003C	003D	.....	004F	0050	.....	005B
0050	0051	.....	0063	0064	.....	006F
0064	0065	.....	0077	0078	.....	0083
0078	0079	.....	008B	008C	.....	0097
008C	008D	.....	009F	00A0	.....	00AB
00A0	00A1	.....	00B3	00B4	.....	00BF
00B4	00B5	.....	00C7	00C8	.....	00D3
00C8	00C9	.....	00DB	00DC	.....	00E7
00DC	00DD	.....	00EF	00F0	.....	00FD
00F0	00F1	.....	0103	0104	.....	011F
0104	0105	.....	0127	0128	.....	0123
0128	0129	.....	013B	013C	.....	0147
013C	013D	.....	014F	0150	.....	015B

If the graphic area setting is set to match the desired number of columns on the LCD, the addressing scheme will be automatically modified so that the start address of each line equals the end address of the previous line +1.

6-8 Mode Set

< Table 6-14 >

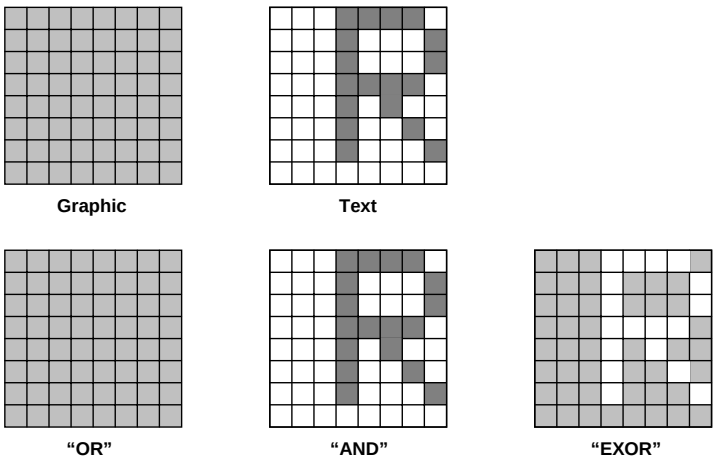
Code	Function	Operand
1000X000	OR Mode	—
1000X001	EXOR Mode	—
1000X011	AND Mode	—
1000X100	Text Attribute Mode	—
10000XXX	Internal Character Generator Mode	—
10001XXX	External Character Generator Mode	—

X: Invalid

The display mode is defined by this command. The display mode does not change until the next command is sent. The logical OR, EXOR, AND of text or graphic display can be displayed.

In internal Character Generator mode, character codes 00h to 7Fh are assigned to the built-in Character generator ROM. The character codes 80h to FFh are automatically assigned to the external character generator RAM.

(Example)



< Figure 6-7 >

Note: Attribute functions can only be applied to text display, since the attribute data is placed in the graphic RAM area.

Attribute Function

The attribute operations are Reverse display, Character blink, bold and Inhibit. The attribute data is written into the graphic area, which was defined by the Set Control word command. Only text display is possible in Attribute Function mode; graphic display is automatically disabled. However, the Display Mode command must be used to turn both Text and Graphic on that in order to for the Attribute function available.

The attribute data for each character in the text area is written to the same address in the graphic area.

The Attribute function is defined as follows.

Attribute RAM 1byte

X	X	X	X	d3	d2	d1	d0

X: Invalid

< Table 6-15 >

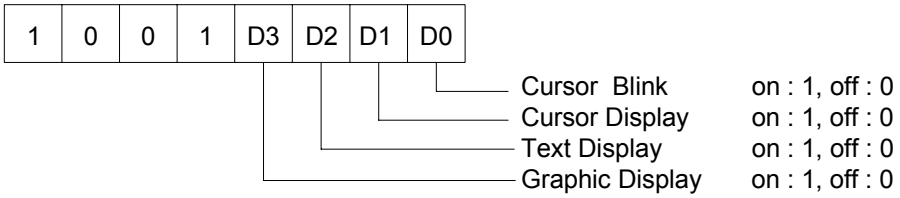
d3	d2	d1	d0	Function
0	0	0	0	Normal Display
0	1	0	1	Reverse Display
0	0	1	1	Inhibit Display
1	0	0	0	Blink of Normal Display
1	1	0	1	Blink of Reverse Display
1	0	1	1	Blink of Inhibit Display
0	1	1	1	Bold Display
1	1	1	1	Blink of Bold Display

6-9 Display Mode

< Table 6-16 >

Code	Function	Operand
10010000	Display off	—
1001XX10	Cursor on, Blink off	—
1001XX11	Cursor on, Blink on	—
100101XX	Text on, Graphic off	—
100110XX	Text off, Graphic on	—
100111XX	Text on, Graphic on	—

X: Invalid



Note: It is necessary to turn on “Text Display“ and “Graphic Display” in the following cases.
a) Combination of text /graphic display
b) Attribute function

6-10 Cursor Pattern Select

< Table 6-17 >

Code	Function	Operand
10100000	1-line cursor	—
10100001	2-line cursor	—
10100010	3-line cursor	—
10100011	4-line cursor	—
10100100	5-line cursor	—
10100101	6-line cursor	—
10100110	7-line cursor	—
10100111	8-line cursor	—

When cursor display is ON, this command selects the cursor pattern in the range 1 line to 8 lines. The cursor address is defined by the Cursor pointer Set command.

6-11 Data Auto Read/Write

< Table 6-18 >

Code	Hex.	Function	Operand
10110000	B0h	Set Data Auto Write	—
10110001	B1h	Set Data Auto Read	—
10110010	B2h	Auto Reset	—

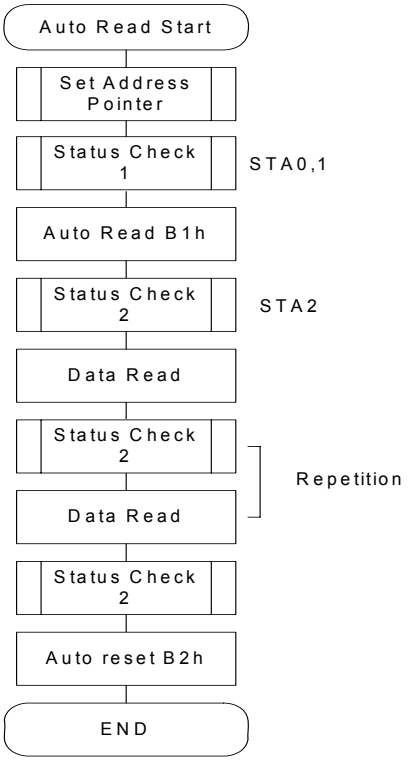
This command is convenient for sending a full screen of data from the external display RAM. After Setting Auto mode, a Data Write (or Read) command does not need sent between each datum. A Data Auto Write (or Read) command must be sent after a Set Address Pointer command. After this Command, the address pointer is automatically incremented by 1 after each datum. In Auto mode, the RA6963 cannot accept any other commands.

The Auto Reset command must be sent to the RA6963 after all data has been sent, to clear Auto Mode.

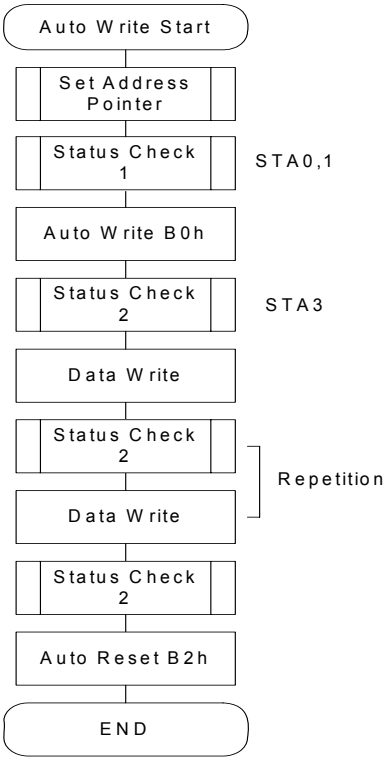
Note: A Status Check for Auto Mode

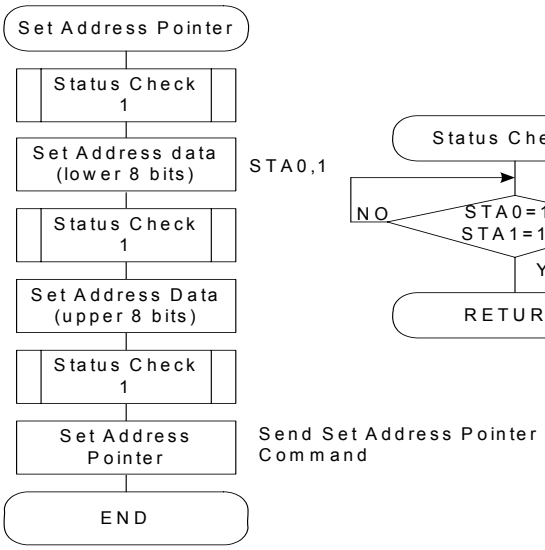
STA2, STA3 should be checked between sending of each datum. Auto Reset should be performed after checking STA3=1 (STA2=1). Refer to the following flowchart.

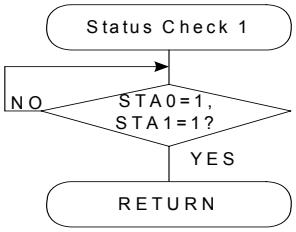
a) Auto Read mode

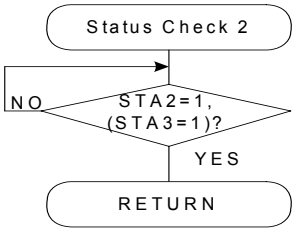


b) Auto Write mode









< Figure 6-8 >

6-12 Data Read/Write

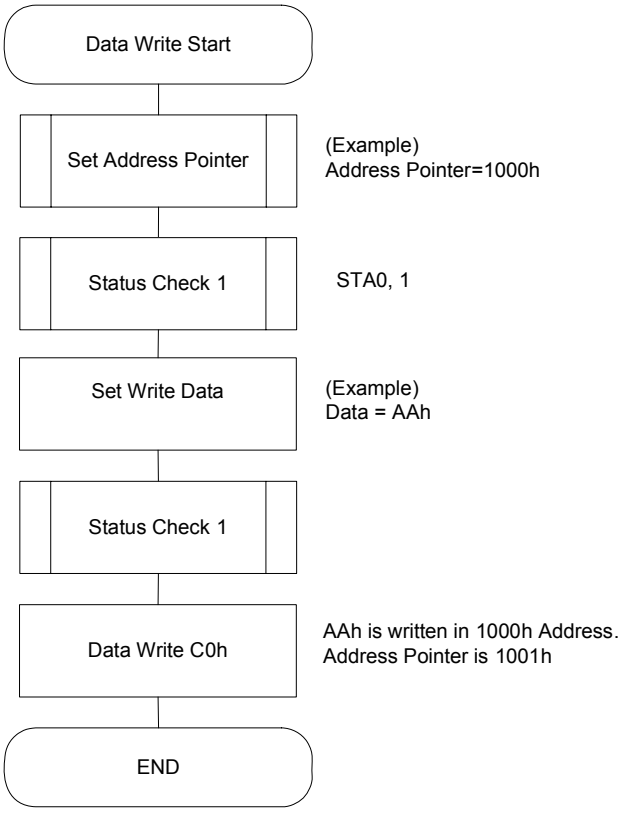
< Table 6-19 >

Code	Hex.	Function	Operand
11000000	C0h	Data Write and Increment ADP	Data
11000001	C1h	Data Read and Increment ADP	—
11000010	C2h	Data Write and Decrement ADP	Data
11000011	C3h	Data Write and Decrement ADP	—
11000100	C4h	Data Write and Non-variable ADP	Data
11000101	C5h	Data Read and Non-variable ADP	—

This command is used for writing data from the MPU to external display RAM, and reading data from external display RAM. Data Write / Data Read should be executed after setting address using Set Address Pointer command, The address pointer can be automatically incremented or decremented using this command.

Note: This command is necessary for each 1-byte datum.

Refer to the following flowchart.



< Figure 6-9 >

6-13 Screen Peek

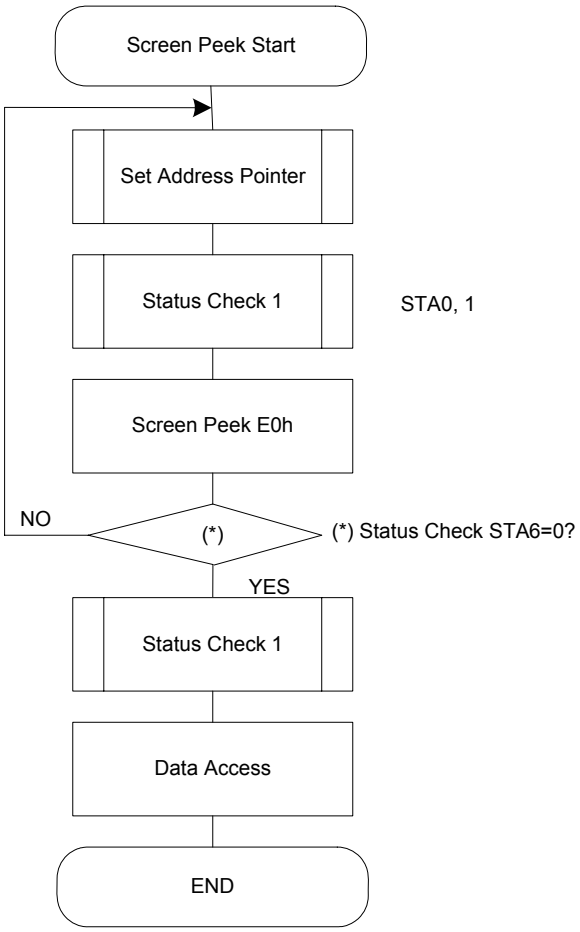
< Table 6-20 >

Code	Hex.	Function	Operand
11100000	E0h	Screen Peek	—

This command is used to transfer 1 byte of displayed data to the data stack; this byte can be read from the MPU by data access. The logical combination of text and graphic display data on the LCD screen can be read by this command.

The status (STA6) should be checked just after the Screen Peek command. If the address Determined by the Set Address Pointer command is not in the graphic area, this command is ignored and a status flag (STA6) is set.

Refer to the following flowchart.



< Figure 6-10 >

Note: This command is available when hardware column number and software column number are the same. Hardware column number is related to MD2 and MD3 setting. Software column number is related to Set Text Area and Set Graphic Area command.

6-14 Screen Copy

< Table 6-21 >

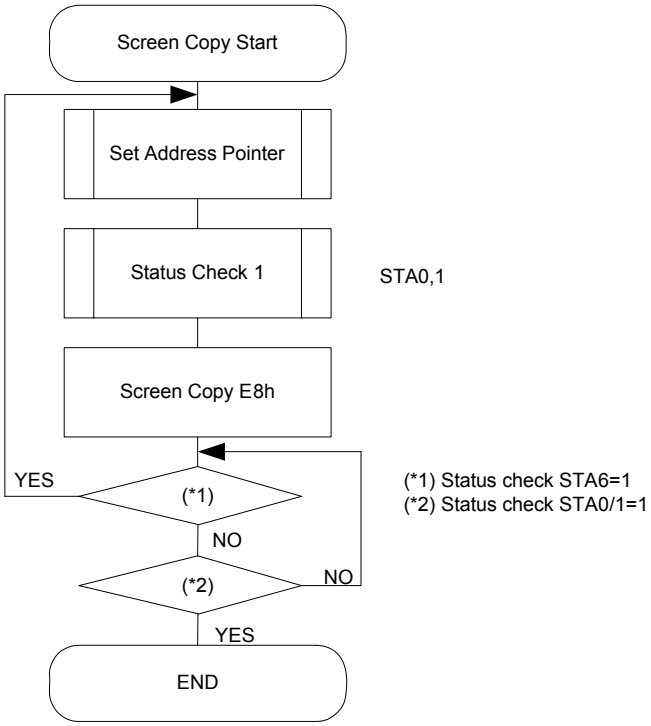
Code	Hex.	Function	Operand
11101000	E8h	Screen Copy	—

This command copies a single raster line of data to the graphic area.
The start point must be set using the Set Address Pointer command.

Note 1: If the attribute function is being used, this command is not available. (With Attribute data is graphic area data.)

Note 2: With Dual-Scan, this command cannot be used (because the RA6963 cannot separate the upper screen data and lower screen data).

Refer to the following flowchart.



< Figure 6-11 >

Note: This command is available when hardware column number is the same. Hardware column number is related to MD2 and MD3 setting. Software column number is related to Set Text Area and Set Graphic Area command.

6-15 Bit Set/Reset

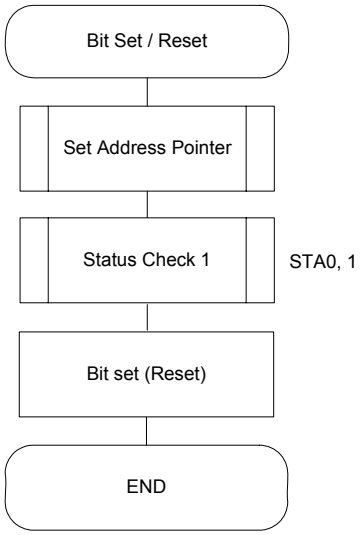
< Table 6-22 >

Code	Function	Operand
11110XXX	Bit Reset	—
11111XXX	Bit Set	—
1111X000	Bit 0 (LSB)	—
1111X001	Bit 1	—
1111X010	Bit 2	—
1111X011	Bit 3	—
1111X100	Bit 4	—
1111X101	Bit 5	—
1111X110	Bit 6	—
1111X111	Bit 7 (MSB)	—

X: Invalid

This command used to set or reset a bit of the byte specified by the address pointer. Only one bit can be set / reset at time.

Refer to following flowchart.



< Figure 6-12 >

6-16 Screen Reverse

<Table 6-23>

Code	Hex.	Function	D1	D2
11010000	D0h	Enable/Disable the whole screen reversing	Data	-

<Table 6-24>
Screen Reverse Selection (D1)

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
x	x	x	x	x	x	x	0/1

Bit0 = 0： Normally display.
Bit0 = 1： Reverse the whole screen.

This command (D0h) is used to reverse the displayed data of the whole screen. When this function is enabled, the displayed data on the LCD are reversed to show reversing pattern.

6-17 Blink Time

<Table 6-25>

Code	Hex.	Function	D1	D2
01010000	50h	Adjust the blink time for the blink functions of the RA6963	Data (Bit2~Bit0)	Do not care (Note)

Note： In this function, it must be sent two data before sending the command, but the contents of the second datum (D2) can be any values.

<Table 6-26>
Blink Time Selection (D1)

Bit 2	Bit 1	Bit 0	Blink Time(If f_R=60Hz)
0	0	0	0.066 sec.
0	0	1	0.25 sec.
0	1	0	0.5 sec.
0	1	1	0.75 sec.
1	0	0	1 sec.
1	0	1	1.25 sec.
1	1	0	1.5 sec.
1	1	1	2 sec.

The blink time of the blink functions are adjusted by this command (50h). For example, if the frequency of the frame equals 60Hz, the blink time can be adjusted from 0.066 second to 2 second by using software selections. The selections are listed in the Table 6-26.

6-18 Cursor Auto Moving

<Table 6-27>

Code	Hex.	Function	D1	D2
01100000	60h	Enable/Disable the automatic cursor movement	Data (Bit0)	Do not care (Note)

Note： In this function, it must be sent two data before sending the command, but the contents of the second datum (D2) can be any values.

<Table 6-28>
Cursor Auto Moving Selection (D1)

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
x	x	x	x	x	x	x	0/1

Bit0 = 0： Disable.
Bit0 = 1： Enable.

The RA6963 provides a unique function for the automatic cursor movement. After writing (reading) each displayed datum, the cursor pointer is automatically increased/decreased by one in the Cursor Auto-Moving mode.

6-19 CGROM Font Select

<Table 6-29>

Code	Hex.	Function	D1	D2
01110000	70h	Change the Character Font Map	Data (Bit1~Bit0)	Do not care (Note)

Note： In this function, it must be sent two data before sending the command, but the contents of the second datum (D2) can be any values.

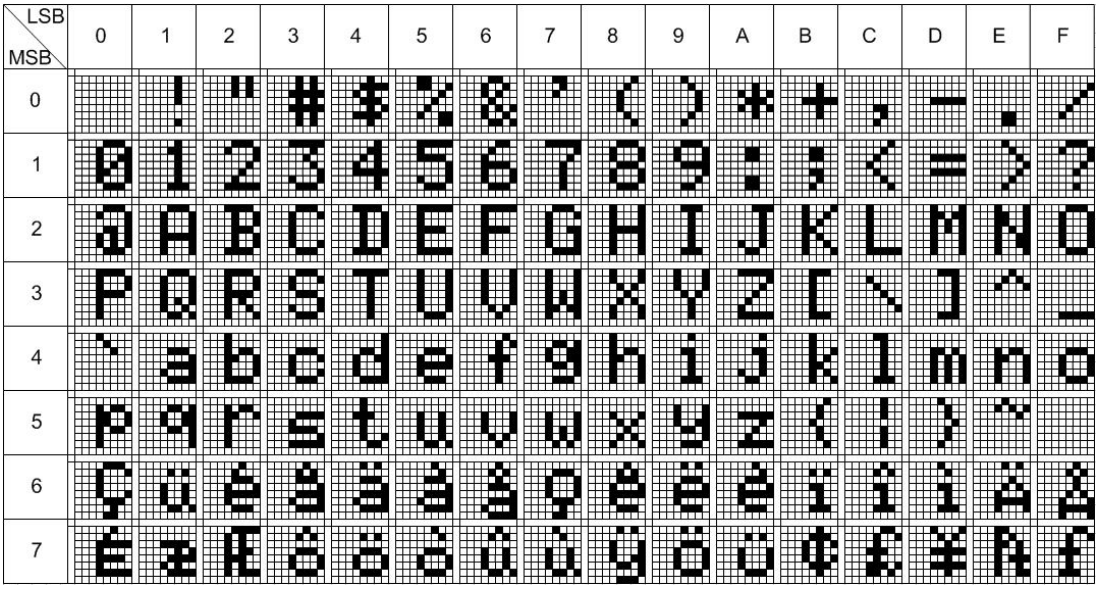
<Table 6-30>
CGROM Font Selection (D1)

Bit 1	Bit 0	CGROM Font
0	0	Do not care(Default)
0	1	Do not care
1	0	CGROM Font-01.
1	1	CGROM Font-02.

This command (70h) is a convenient function for selecting the Character Font Map. The user can get more built-in characters from CGROM Font-01 or CGROM Font-02, which is determined by software selections. The selections are listed in the Table 6-30.

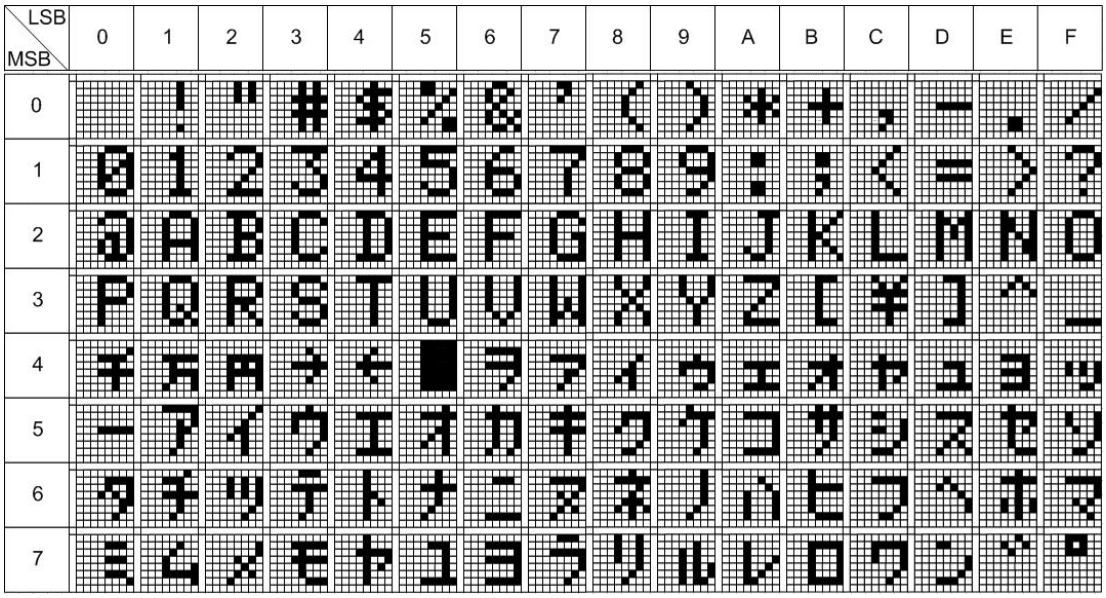
6-20 Character Font Map

CGROM Font - 01



< Figure 6-13 >

CGROM Font – 02



< Figure 6-14 >

The RA6963 has two part number - RA6963L2NA and RA6963L2NB. The RA6963L2NA is compatible to T6963C(code 0101) and the default font is Figure 6-13 as above. The RA6963L2NB is compatible to T6963C(code 0201) and the default font is Figure 6-14 as above.

Although RA6963 provide a extra internal command for MCU to select both font of above, but you do not need to change the software to select the font that if you chose the right part number.

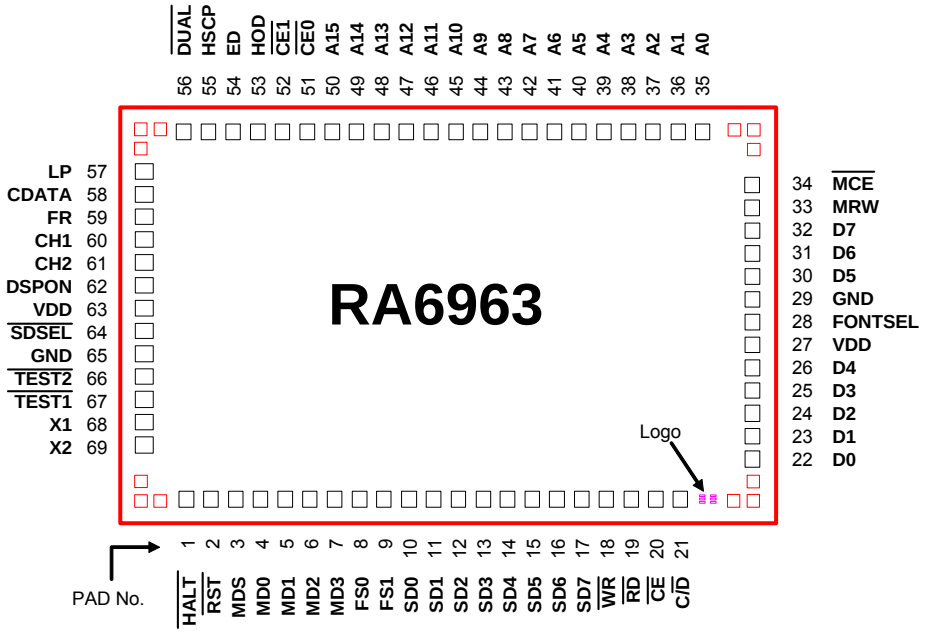
6-21 RA6963 vs. T6963C

< Table 6-23 >

Item	Description	RAiO RA6963	Toshiba T6963C	Note
1	CGROM Font Select	Yes	--	RA6963 provides two CGROMs – Font-01 and Font-02
2	Blink Time Selection	Yes	--	RA6963 provides eight selections for blinking.
3	Cursor Auto Move	Yes	--	
4	Whole Screen Reverse	Yes	--	
5	Bold Text and Blink	Yes	--	RA6963 provides Bold Text feature.

7. Package Dimensions

7-1 Die Form



< Figure 7-1 >

7-2 Part Number:

RA6963L2NA : LQFP-67 Pin, RoHS Compliance Package, the default font is Font-01
RA6963L2NB : LQFP-67 Pin, RoHS Compliance Package, the default font is Font-02
(Refer to Chapter 6-20)

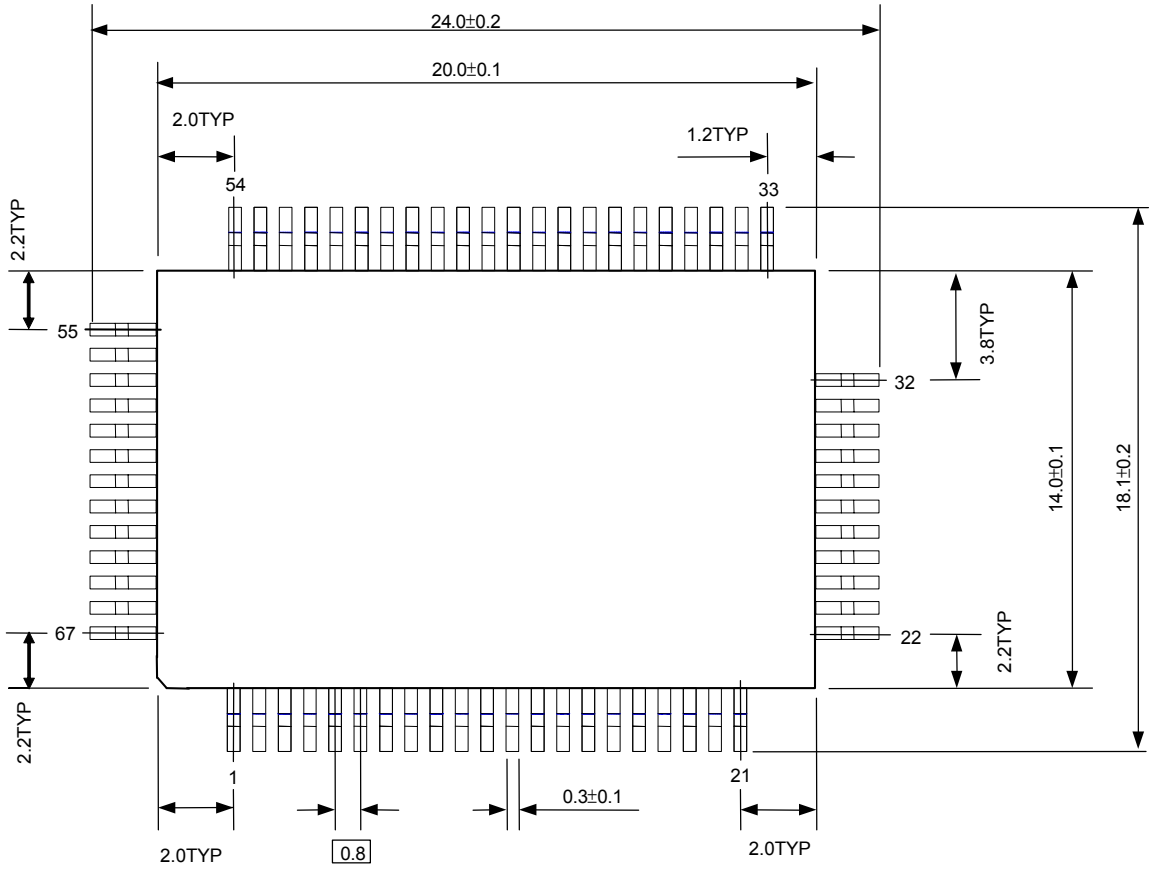
7-3 XY Coordinate

Pad No.	Pad 名稱	X 座標	Y 座標
1	$\overline{HALT}$	-1060.5	-964.65
2	$\overline{RST}$	-959.5	-964.65
3	MDS	-858.5	-964.65
4	MD0	-757.5	-964.65
5	MD1	-656.5	-964.65
6	MD2	-555.5	-964.65
7	MD3	-454.5	-964.65
8	FS0	-353.5	-964.65
9	FS1	-252.5	-964.65
10	SD0	-151.5	-964.65
11	SD1	-50.5	-964.65
12	SD2	50.5	-964.65
13	SD3	151.5	-964.65
14	SD4	252.5	-964.65
15	SD5	353.5	-964.65
16	SD6	454.5	-964.65
17	SD7	555.5	-964.65
18	$\overline{WR}$	656.5	-964.65
19	$\overline{RD}$	757.5	-964.65
20	$\overline{CE}$	858.5	-964.65
21	C/ $\overline{D}$	959.5	-964.65
22	D0	1320.4	-704.75
23	D1	1320.4	-603.75
24	D2	1320.4	-502.75
25	D3	1320.4	-401.75
26	D4	1320.4	-300.75
27	VDD	1320.4	-199.75
28	FONTSEL	1320.4	-98.75
29	GND	1320.4	10.25
30	D5	1320.4	115.25
31	D6	1320.4	216.25
32	D7	1320.4	317.25
33	MRW	1320.4	418.25
34	$\overline{MCE}$	1320.4	519.25

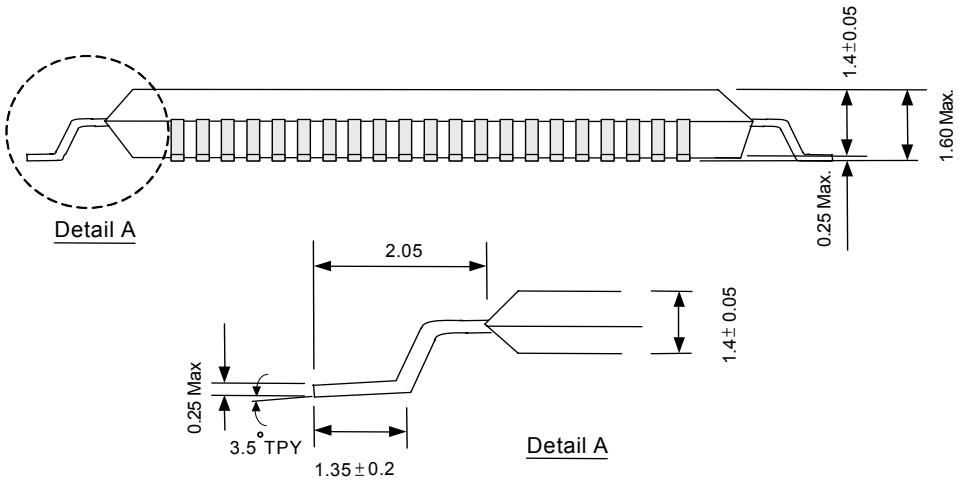
Pad No.	Pad 名稱	X 座標	Y 座標
35	A0	1060.5	964.65
36	A1	959.5	964.65
37	A2	858.5	964.65
38	A3	757.5	964.65
39	A4	656.5	964.65
40	A5	555.5	964.65
41	A6	454.5	964.65
42	A7	353.5	964.65
43	A8	252.5	964.65
44	A9	151.5	964.65
45	A10	50.5	964.65
46	A11	-50.5	964.65
47	A12	-151.5	964.65
48	A13	-252.5	964.65
49	A14	-353.5	964.65
50	A15	-454.5	964.65
51	$\overline{CE0}$	-555.5	964.65
52	$\overline{CE1}$	-656.5	964.65
53	HOD	-757.5	964.65
54	ED	-858.5	964.65
55	HSCP	-959.5	964.65
56	$\overline{DUAL}$	-1060.5	964.65
57	LP	-1320.4	591.45
58	CDATA	-1320.4	490.45
59	FR	-1320.4	389.45
60	CH1	-1320.4	288.45
61	CH2	-1320.4	187.45
62	DSPON	-1320.4	86.45
63	VDD	-1320.4	-14.55
64	$\overline{SDSEL}$	-1320.4	-115.55
65	GND	-1320.4	-224.55
66	$\overline{TEST2}$	-1320.4	-329.55
67	$\overline{TEST1}$	-1320.4	-430.55
68	X1	-1320.4	-556.8
69	X2	-1320.4	-692.8

7-4 Outline Drawing

LQFP-67Pin



< Figure 7-2 >



< Figure 7-3 >

8. Specifications

8-1 Absolute Maximum Ratings

< Table 8-1 >

Ta=25℃

Parameter	Symbol	Rating	Unit
Supply Voltage Range	V_{DD}(Note 1)	-0.3 to +7.0	V
Input Voltage Range	V_{in}(Note 1)	-0.3 to VDD +0.3	V
Operating Temperature Range	T_{op}	-30 to +85	℃
Storage Temperature Range	T_{stg}	-55 to +125	℃
Solder Temperature Range	T_{sdt}(Note 2)	400	℃

Note 1: Gnd = 0V.
Note 2: Solder Time = 8 Minutes.

< Table 8-2 >

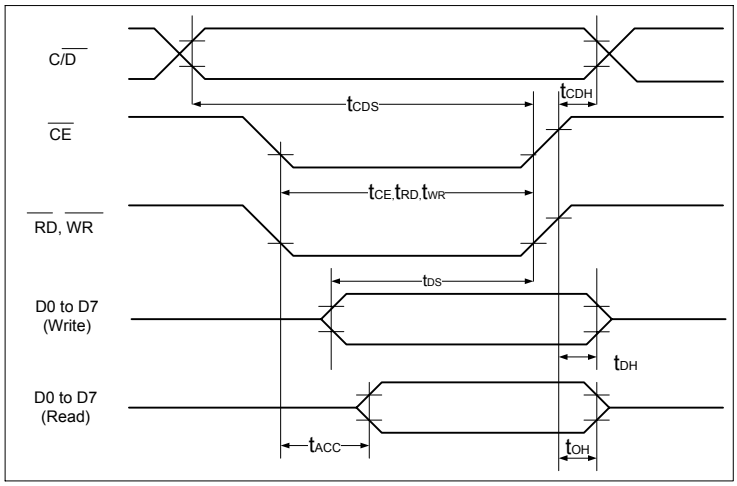
（V_{DD}=+5V±5%,GND=0V,Ta= -20 to +70℃）

Item		Symbol	Test Conditions	Min.	Typ.	Max.	Unit	Pin Name
Operating Voltage	V_{DD}	V_{DD}	--	3.0	3.3/5.0	5.5	V	VDD
Input	"H"	V_{IH}	--	V_{DD}-2.2	--	V_{DD}	V	I/P
	"L"	V_{IL}	--	0	--	0.8	V	I/P
Output	"H"	V_{OH}	--	V_{DD}-0.3	--	V_{DD}	V	O/P
	"L"	V_{OL}	--	0	--	0.3.	V	O/P
Output Resistance	"H"(1)	R_{OH}	V_{OUT}=V_{DD}-0.5	--	--	400	Ω	O/P
	"L"	R_{OL}	V_{OUT}=0.5	--	--	400	Ω	O/P
Current Consumption	Operating	I_{DD}(1)	V_{DD}=5.0V (Note 2) f_{OSC}=3.0MHz	--	3.0	5	mA	VDD
	Halt	I_{DD}(2)	V_{DD}=5.0V	--	0.9	2	μA	VDD
Input Pull Up Resistance		RPU	--	50	100	200	KΩ	(Note 1)
Operating Frequency		f_{OSC}	--	0.4	--	18	MHz	
Solder Temperature		T_{SDT}	(Note 3)	--	260	--	℃	

Note 1: Applied $\overline{TEST[2:1]}$, $\overline{RST}$.

Note 2: MDS=L, MD[1:0]=LL, MD[3:2]=HH, FS[1:0]=LL, $\overline{SDSEL}$ =L, $\overline{DUAL}$ =H, D[7:0]=LHLHLHLH.
Note 3: Solder Time = 20~40 Seconds.

8-2 MPU Interface Timing



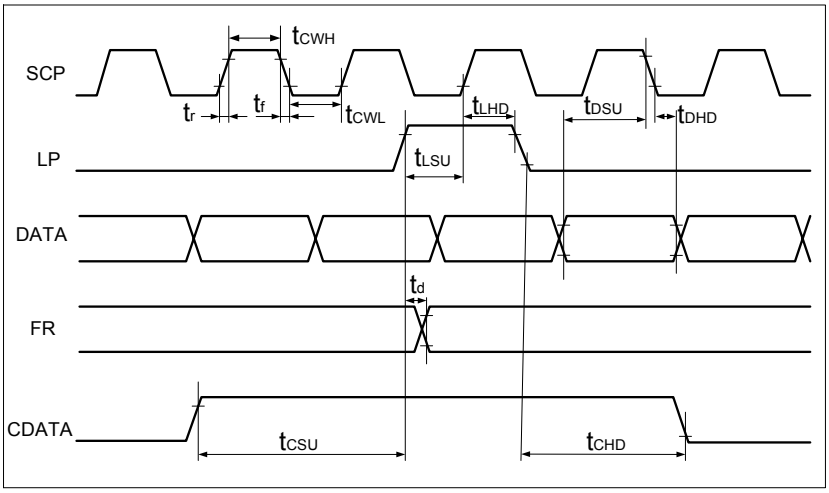
< Figure 8-1 >

< Table 8-3 >

（V_{DD}=+5V±5%,GND=0V,Ta= -20 to +70℃）

Item	Symbol	Test Conditions	Min.	Max.	Unit
C/$\overline{D}$ Set Up Time	t_{CDS}	--	100	--	ns
C/$\overline{D}$ Hold Time	t_{CDH}	--	10	--	ns
$\overline{CE}$, $\overline{RD}$, $\overline{WR}$ Pulse Width	t_{CE}, t_{RD}, t_{WR}	--	80	--	ns
Data Set Up Time	t_{DS}	--	80	--	ns
Data Hold Time	t_{DH}	--	40	--	ns
Access Time	t_{ACC}	--	--	150	ns
Output Hold Time	t_{OH}	--	10	50	ns

8-3 Driver Interface Timing



< Figure 8-2 >

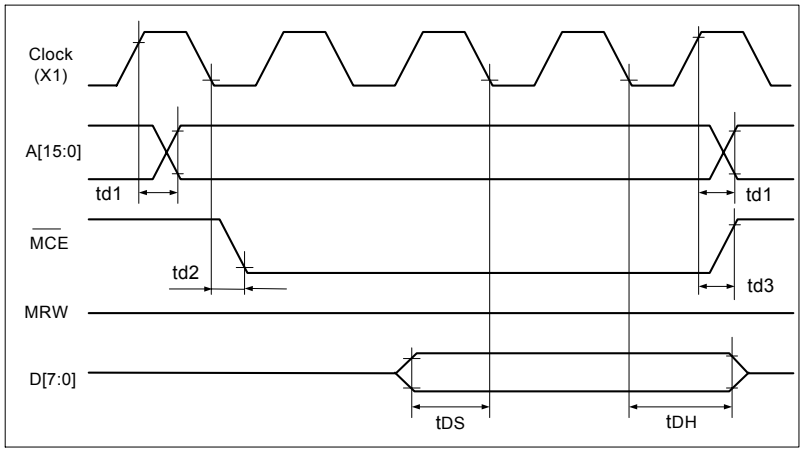
< Table 8-4 >

（V_{DD}=+5V±5%,GND=0V,Ta= -20 to +70℃）

Item	Symbol	Test Conditions	Min.	Max.	Unit
Operating Frequency	f_{SCP}	Ta = -20~70℃	--	9	MHz
SCP Pulse Width	t_{CWH}, t_{CWL}	--	150	--	ns
SCP Rise/Fall Time	t_r,t_f	--	--	30	ns
LP Setup Time	t_{LSU}	--	150	290	ns
LP Hold Time	t_{LHD}	--	5	40	ns
Data Setup Time	t_{DSU}	--	170	--	ns
Data Hold Time	t_{DHD}	--	80	--	ns
FR Delay Time	t_d	--	0	90	ns
CDATA Setup Time	t_{CSU}	--	450	850	ns
CDATA Hold Time	t_{CHD}	--	450	950	ns

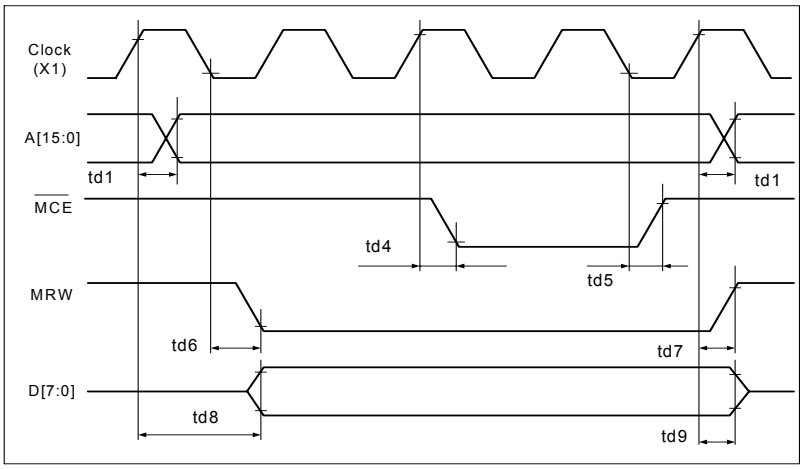
8-4 External Memory Interface

External RAM Read



< Figure 8-3 >

External RAM Write



< Figure 8-4 >

< Table 8-5 >

（V_{DD}=+5V±5%,GND=0V,Ta= -20 to +70℃）

Item	Symbol	Test Conditions	Min.	Max.	Unit
Address Delay Time	t_{d1}	--	--	250	ns
$\overline{MCE}$ Fall Delay Time(Read)	t_{d2}	--	--	180	ns
$\overline{MCE}$ Rise Delay Time(Read)	t_{d3}	--	--	180	ns
Data Setup Time	t_{DS}	--	--	--	ns
Data Hold Time	t_{DH}	--	--	--	ns
$\overline{MCE}$ Fall Delay Time(Write)	t_{d4}	--	--	200	ns
$\overline{MCE}$ Rise Delay Time(Write)	t_{d5}	--	--	200	ns
MRW Fall Delay Time	t_{d6}	--	--	180	ns
MRW Rise Delay Time	t_{d7}	--	--	180	ns
Data Stable Time	t_{d8}	--	--	450	ns
Data Hold Time	t_{d9}	--	--	200	ns

9. Application

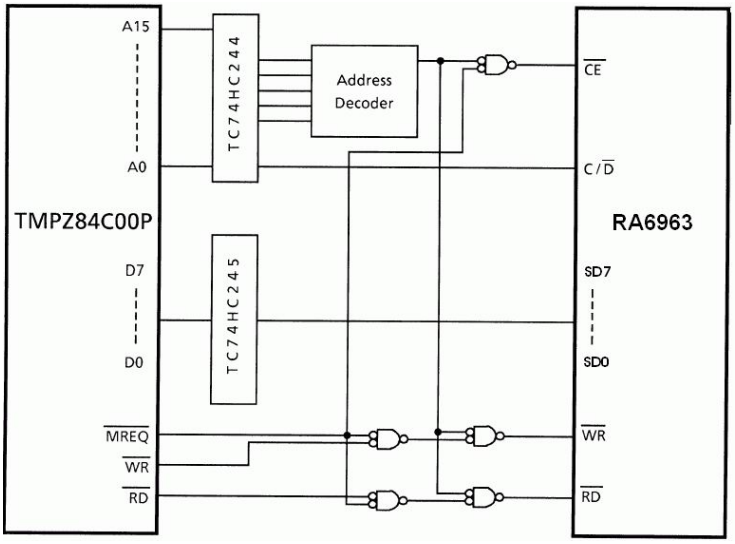
The RA6963 can be directly connected to Z80(Note 1) series MPU. The following applications are use a TMPZ84C00A to connect RA6963.

9-1 MPU Memory Address Mapping

Data is transferred to the RA6963 using a memory request signal.

< Table 9-1 >

	Address
DATA (I/O)	XXXXh
Command/Status	XXXX + 1h



< Figure 9-1 >

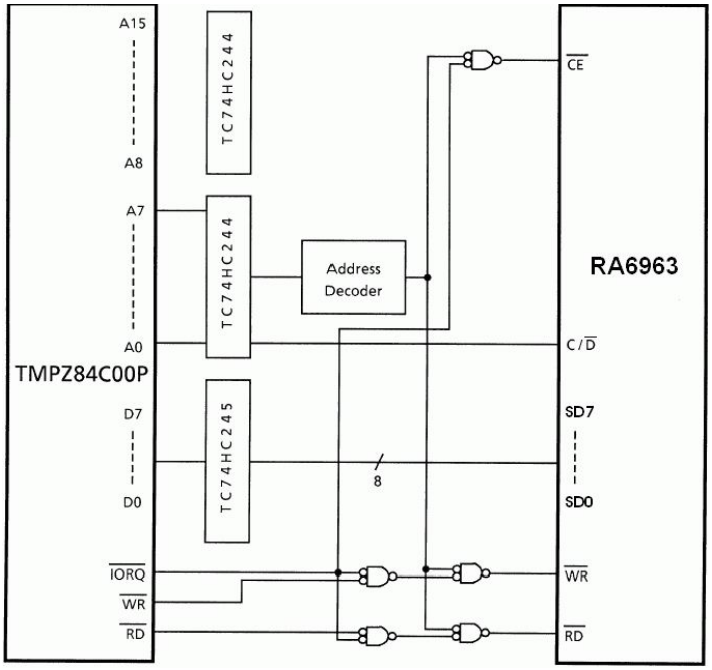
Note 1: Z80 is a trademark of Zilog Inc.

9-2 MPU I/O Addressing

Data is transferred to the RA6963 using an I/O request signal.

< Table 9-2 >

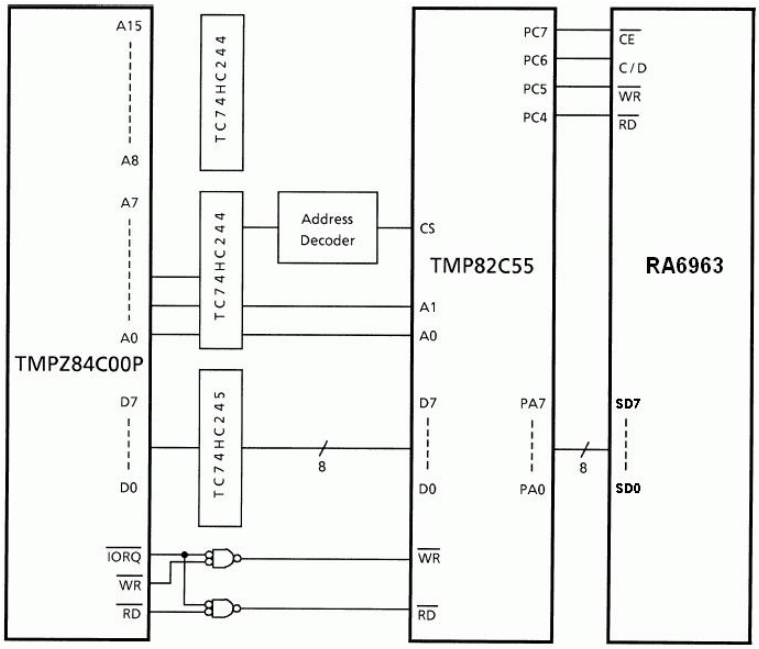
	I/O Address
DATA	XXh
Command / Status	XX + 1h



< Figure 9-2 >

9-3 Use PPI LSI

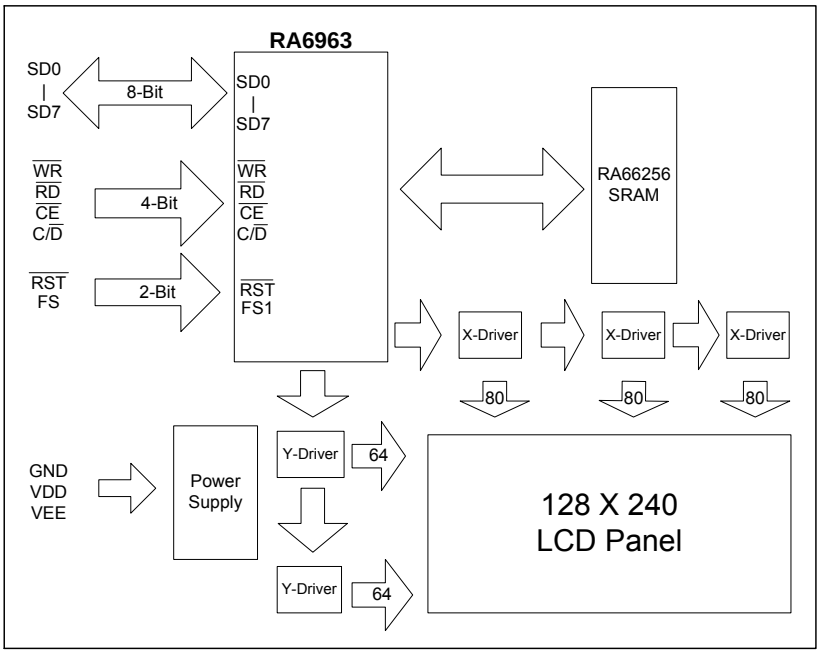
The RA6963 can be connected to a PPI LSI.
The port A connects to the data bus.
The port C connects to the control bus. (C/$\overline{D}$, $\overline{CE}$, $\overline{WR}$, $\overline{RD}$)



< Figure 9-3 >

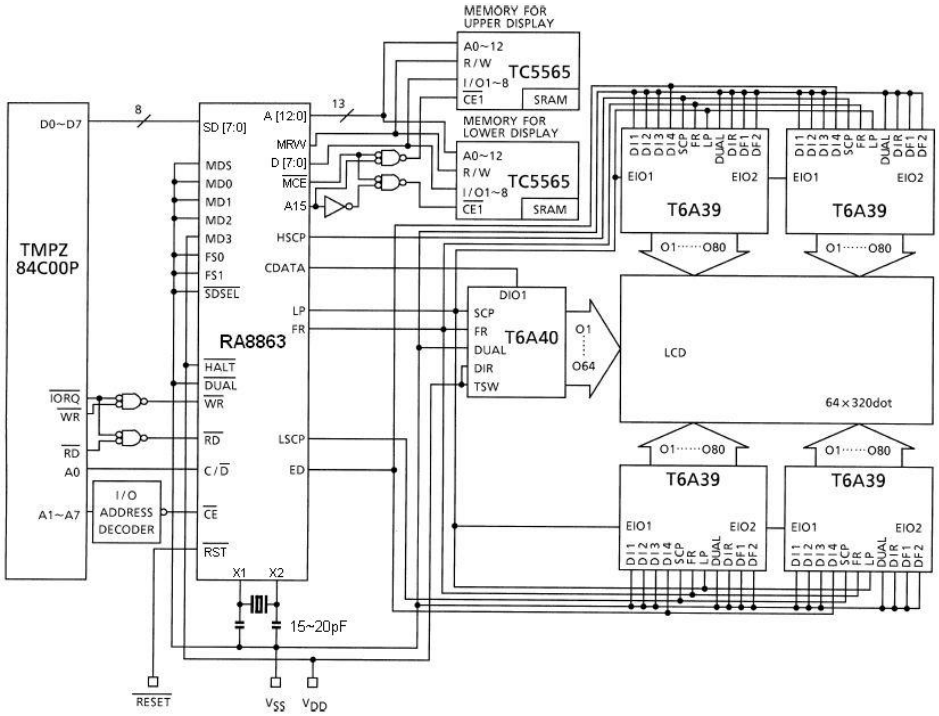
9-4 Application Block Diagram

All LCD require two power sources, VDD for logic circuits and VEE for Liquid Crystal (LC) drive. Some graphics LCD modules will run directly of a single VDD supply by generating the VEE voltage on-board; others will require an external DC-DC converter to generate the negative VEE voltage. Refer to individual specifications for details.



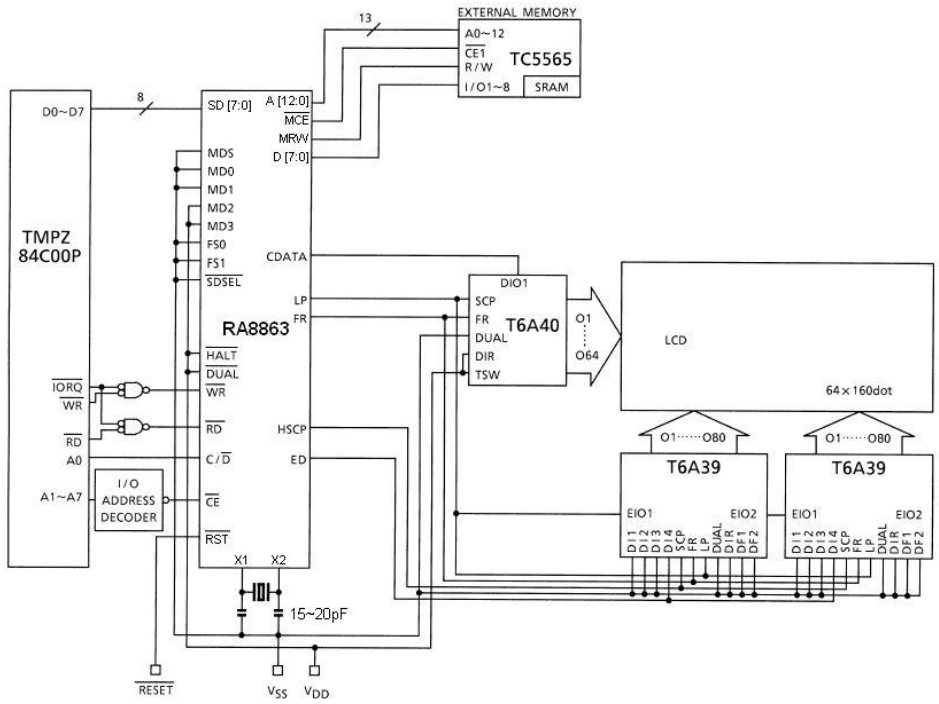
< Figure 9-4 >

9-5 Application Circuit(1)



< Figure 9-5 >

9-6 Application Circuit(2)



< Figure 9-6 >