LCD DRIVER

Data Sheet

AX6963

Dot Matrix LCD CONTROL LSI

AsLic Microelectronics Corporation
LCD Controller

2003 Apr 09
Version: 3.0

DOT MATRIX LCD CONTROL LSI

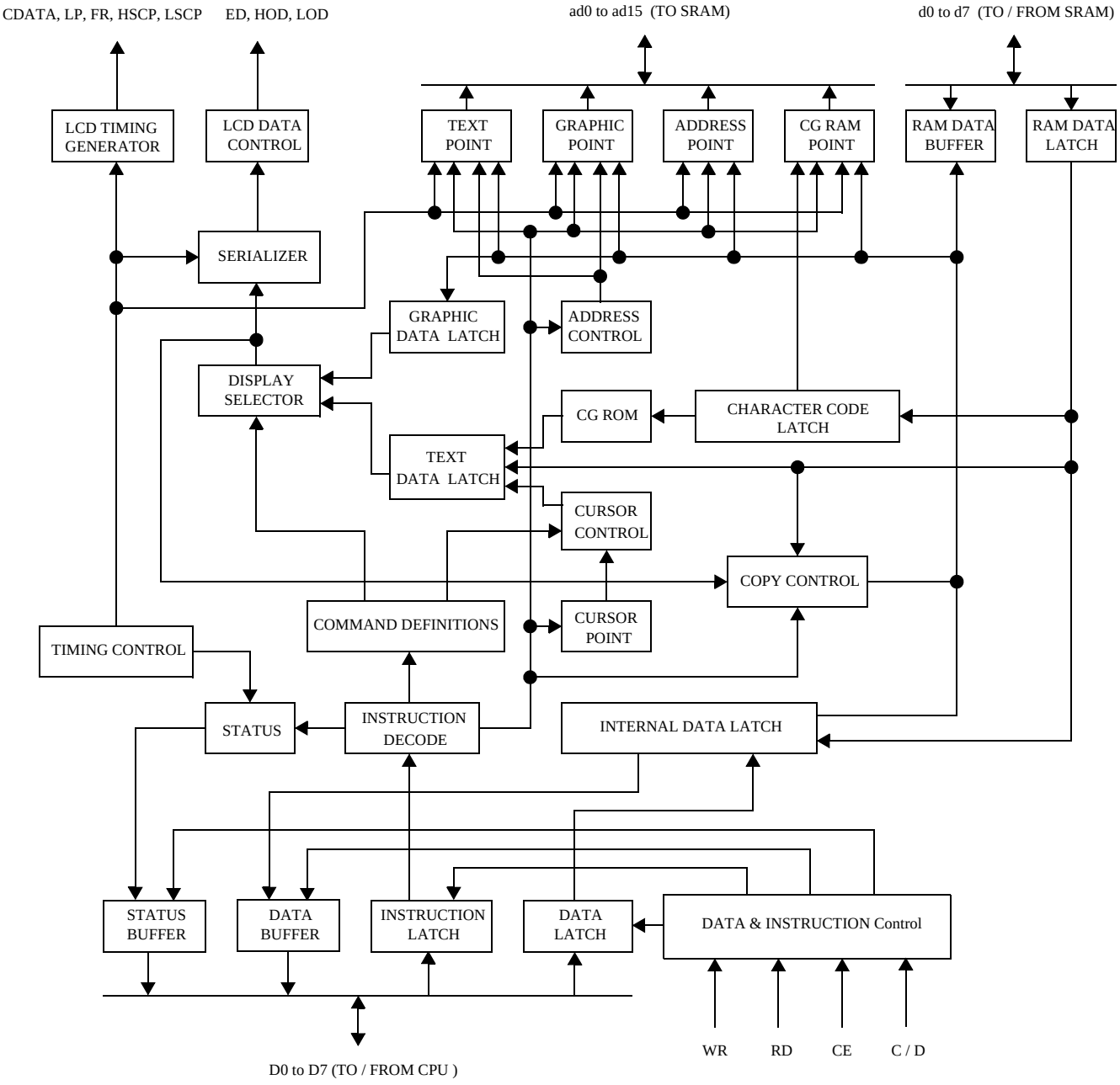
The AX6963 is an LCD controller designed to be used with LCD control driver LSIs and data display memories. The device has an 8-bit parallel data bus and control lines for reading or writing through an MPU interface.It can be directly connected to a TMPZ-80.
It has a 128-word character generator ROM which can control an external display RAM of up to 64 Kbytes.Allocation of text, graphics and external character generator RAM can be made easily and the display window can be moved freely within the allocated memory range.
The device supports a very broad range of LCD formats by allowing selection of different combinations via a set of programmable inputs.It can be used in text, graphic and combination text-and-graphic modes, and includes various attribute functions.

■ FEATURES

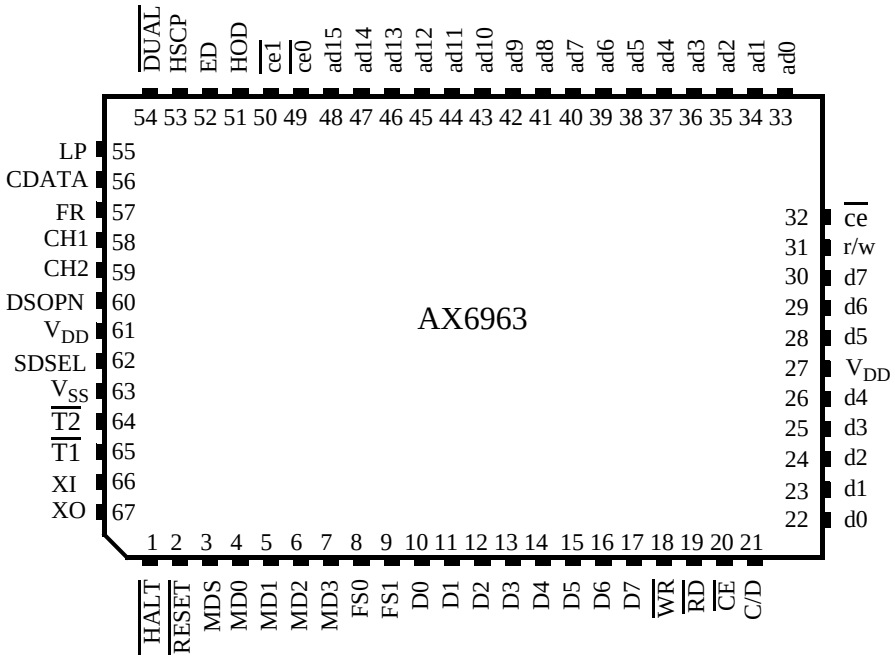
- Display format (pin-selectable)
  Columns : 32, 40, 64, 80
  Lines : 2, 4, 6, 8, 10, 12, 14, 16, 20, 24, 28, 32
  The combination of number of columns and number of lines must not cause the frequency to exceed 6 MHz. (See Fig.2)
- Character font (pin-selectable)
  Horizontal dots : 5, 6, 7, 8
  Vertical dots : 8 (fixed)
  It is necessary to set a character font in Graphic mode just as in Text mode.The oscillation frequency does not change with the font selection.
- Display duty : 1/16 to 1/128
- A 128-word character generator ROM (code 0101) AX6963-0101 is built in as standard.
- External display memory : 64 KB Max
  The addresses in display memory of the text area, graphic area and external character generator area are determined by software.
- Read or Write operations from the CPU do not disturb the display.

- A crystal oscillator circuit is built in. The oscillation frequency is adjusted according to the display size.If using an external clock, use the XI pin as the clock input. (XO open.)
  External capacitors Crystal oscillation : 20 to 30 pF
  Ceramic oscillation : 30 to 100 pF
  Built-in feedback resistor : 900 kΩ (typ.)
- External display RAM must be static RAM. The AX6963 cannot refresh D-RAM.
- The attribute functions can only be used in Text mode.They cannot be used in Graphic or Combination character mode.

BLOCK DIAGRAM



■ PIN ASSIGNMENT



■ PIN FUNCTIONS

<table>
<tr><th>PIN NAME</th><th>I/O</th><th>FUNCTIONS</th></tr>
<tr><td>MDS
MD0
MD1</td><td>Input</td><td>Pins for selection of LCD size
<table>
<tr><td>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><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><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><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><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><td>18</td><td>20</td><td>22</td><td>24</td><td>26</td><td>28</td><td>30</td><td>32</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><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>
<tr><td></td><td colspan="8">1 SCREEN</td><td colspan="8">2 SCREENS</td></tr>
</table></td></tr>
<tr><td>MD2
MD3</td><td>Input</td><td>Pins for selection of number of columns
<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>FS0
FS1</td><td>Input</td><td>Pins for selection of font
<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*8</td><td>6*8</td><td>7*8</td><td>8*8</td></tr>
</table></td></tr>
<tr><td>D0 to D7</td><td>I/O</td><td>Data I/O pins between CPU and AX6963 (D7 is MSB)</td></tr>
<tr><td>$\overline{WR}$</td><td>Input</td><td>Data Write.Write data into AX6963 when $\overline{WR}$=L.</td></tr>
<tr><td>$\overline{RD}$</td><td>Input</td><td>Data Read.Read data from AX6963 when $\overline{RD}$=L.</td></tr>
<tr><td>$\overline{CE}$</td><td>Input</td><td>Chip Enable for AX6963.$\overline{CE}$ must be L when CPU communicates with AX6963.</td></tr>
</table>

<table>
<tr><th>PIN NAME</th><th>I/O</th><th>FUNCTIONS</th></tr>
<tr><td>C/D</td><td>Input</td><td>$\overline{WR}$=L ..... C/D = H : Command Write C/D=L : Data Write
$\overline{RD}$ =L ..... C/D = H : Status Read C/D=L : Data Read</td></tr>
<tr><td>$\overline{HALT}$</td><td>Input</td><td>H ..... Normal, L ..... Stops the oscillation of the clock</td></tr>
<tr><td>$\overline{RESET}$</td><td>Input</td><td>H ..... Normal (AX6963 has internal pull-up resistor)
L ..... Initialize AX6963.Text and graphic have addresses and text and graphic</td></tr>
<tr><td>DSPON</td><td>Output</td><td>Control pin for external DC/DC.DSPON is L when $\overline{HALT}$ is L or $\overline{RESET}$ is L.
(When DSPON goes H,the column drivers are cleared.)</td></tr>
<tr><td>$\overline{DUAL}$</td><td>Input</td><td>H ..... Single-Scan
L ..... Dual-Scan
<table>
<tr><td>$\overline{DUAL}$</td><td>H</td><td>H</td><td>L</td><td>L</td></tr>
<tr><td>$\overline{SDSEL}$</td><td>H</td><td>L</td><td>H</td><td>L</td></tr>
</table></td></tr>
<tr><td>$\overline{SDSEL}$</td><td>Input</td><td>H ..... Sending data by odd/even separation
L ..... Sending data by simple serial method
<table>
<tr><td>Upper screen</td><td>HOD, ED</td><td>ED</td><td>HOD, ED</td><td>ED</td></tr>
<tr><td>Lower screen</td><td>_</td><td>_</td><td>LOD, ED</td><td>ED</td></tr>
</table></td></tr>
<tr><td>$\overline{ce0}$
(LOD)</td><td>Output</td><td>$\overline{ce0}$ at $\overline{DUAL}$=H Chip enable pin for display memory in the address range 0000h to 07FFH
LOD at $\overline{DUAL}$=L Serial data output for odd columns in lower area of LCD</td></tr>
<tr><td>$\overline{ce1}$
(LSCP)</td><td>Output</td><td>$\overline{ce1}$ at $\overline{DUAL}$=H Chip enable pin for display memory in the address range 0800h to 0FFFH
LSCP at $\overline{DUAL}$=L Shift clock pulse output for column drivers in lower area of LCD</td></tr>
<tr><td>$\overline{ce}$</td><td>Output</td><td>Chip enable pin for display memory of any address</td></tr>
<tr><td>d0 to d7</td><td>I/O</td><td>Data I/O pins for display memory</td></tr>
<tr><td>ad0 to ad15</td><td>Output</td><td>Address outputs for display memory
(ad15=L : for upper area of LCD, ad15=H : for lower area of LCD)</td></tr>
<tr><td>R/W</td><td>Output</td><td>Read/Write signal for display memory</td></tr>
<tr><td>ED</td><td>Output</td><td>$\overline{SDSEL}$=H : Data output for even columns in both upper and lower areas of LCD
$\overline{SDSEL}$=L : Date output for columns in both upper and lower areas of LCD</td></tr>
<tr><td>HOD</td><td>Output</td><td>Date output for odd columns in upper area of LCD</td></tr>
<tr><td>CDATA</td><td>Output</td><td>Synchronous signal for row driver</td></tr>
<tr><td>HSCP</td><td>Output</td><td>Shift clock pulse for column driver of upper area of LCD</td></tr>
<tr><td>LP</td><td>Output</td><td>Latch pulse for column driver.Shift clock pulse for row driver</td></tr>
<tr><td>FR</td><td>Output</td><td>Frame signal</td></tr>
<tr><td>XI</td><td>Input</td><td>Crystal oscillator input</td></tr>
<tr><td>XO</td><td>Output</td><td>Crystal oscillator output</td></tr>
<tr><td>CH1, CH2</td><td>Output</td><td>Check signal</td></tr>
</table>

$\overline{T1}$, $\overline{T2}$	Input	Test input.Usually open
V_{DD}	–	Power supply (5.0V)
V_{SS}	–	Power supply (0V)

■FUNCTIONAL DEFINITION

- After power on, it is necessary to reset. $\overline{RESET}$ is kept L between 5 clocks up (oscillation clock).
- When $\overline{HALT}$ =L, the oscillation stops.The power supply for the LCD must now be turned off, to protect the LCD from DC bias.
- The $\overline{HALT}$ function includes the RESET function.
- The column/line counter and display register are cleared by RESET.(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 AX6963 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 execute the command.
- The character codes used by the AX6963 are different from ASCII codes.

• **State after RESET/HALT (Fig.1)**

TERMINAL	HALT	RESET
D0 toD7	F	F
do to d7	F	F
r/w	H	H
$\overline{ce}$	H (Note1)	H (Note1)
ad0 to ad15	H (Note2)	H (Note2)
$\overline{ce0}$, $\overline{ce1}$	H (Note1)	H (Note1)
ED, HOD	Final data	Final data
HSCP	L	L
LP	L	L
CDATA	H	H
FR	H	H
CH1	L	K0
CH2	L	VEND
DSPON	L	L
XO	H	OSC clock

H : Level H
L : Level L
F : Floating (high impedance)
K0 : Test signal
VEND : Test signal
(Note 1) : In Attribute mode, H or L according to state of graphic pointer
(Note 2) : In Attribute mode, data of graphic pointer

- **The relationship between number of row / column and oscillation clock (Fig.2)**

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

f_{OSC} : Frequency of oscillation

f_{SCP} : Frequency of shift clock ($f_{SCP} = f_{OSC}/2$)

fR : Frequency of Frame

M : Number of characters on one line (number of dots on one line = 8M)
For all font sizes (e.g. 7*8, 6*8, 5*8) the oscillation frequency remains constant.

N : Number of rows (duty = 1/8N)

$$\frac{8M}{fscp} \times 8N = \frac{1}{fR}$$

$f_{OSC} = f_R*64*2*M*N$

(f_R = 60Hz)

Unit : [MHz]

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

(Note 1) : Upper ... Single-Scan, lower ... Dual-Scan at f_R = 60Hz

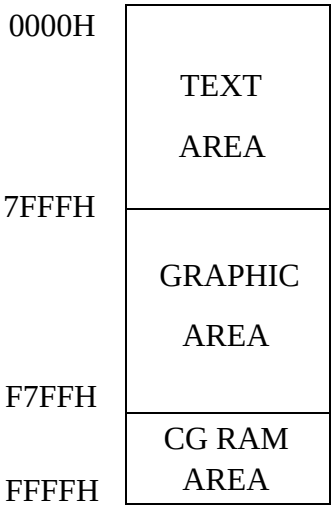
Upper
Lower

• **RAM Interface**

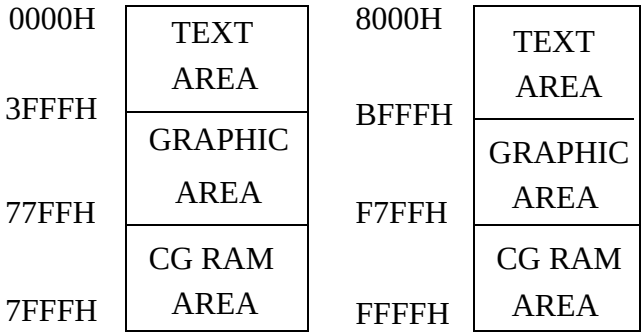
The external RAM is used to store display data (text, graphic and external CG data).
With single-scan,text data, graphic data and external CG data can be freely allocated to the memory area (64 KB max).
With dual-scan, LCD I is allocated to 0000H to 7FFFH (32 KB max) , LCD II is allocated to 8000H to FFFFH (32 KB max).Text data,graphic data and external CG date can be freely allocated in LCD I.In LCD II, the same addresses must be allocated as in LCD I, except ad15.ad15 determines selection of LCD I or LCD II.
It can be use the address decoded signals $\overline{ce0}$ (0000 to 07FFH), $\overline{ce1}$ (0800 to0FFFH) within 4 KB.
$\overline{ce0}$ and $\overline{ce1}$ allow decoding of addresses in the ranges (0000 to 07FFH) and (0800 to 0FFFH) respectively within a 4-KB memory space.

(Example)

(1) Single-Scan



(2) Dual-Scan



CG : Character Generator

• **Flowchart of communications with MPU**

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

Status check

The Status of AX6963 can be read from the data lines.

$\overline{RD}$	L
$\overline{WR}$	H
$\overline{CE}$	L
C/D	H
D0 to D7	Status word

(1) Status Read

The AX6963 status word format is as follows:

MSB LSB

STA7 D7	STA6 D6	STA5 D5	STA4 D4	STA3 D3	STA2 D2	STA1 D1	STA0 D0

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 Peek and 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.

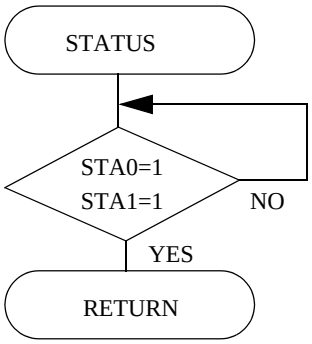
· There is a possibility of erroneous operation due to a hardware interrupt.

(Note 2) : For most modes STA0/STA1 are used as a status check

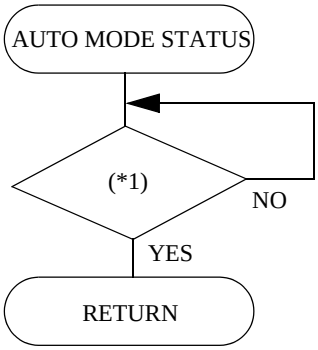
(Note 3) : STA2 and STA3 are valid in Auto mode; STA0 and STA1 are invalid.

Status checking flow

a)



b)



(*1)
STA2=1 (Read)
or
STA3=1 (Write)

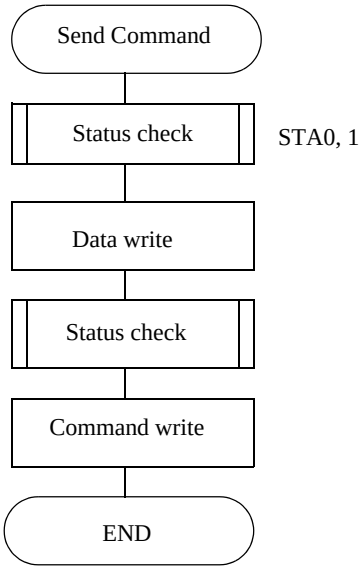
(Note 4) : When using the MSB=0 command, a Status Read must be performed.
If a status check is not carried out, the AX6963 cannot operate normally, even after a delay time.
The hardware interrupt occurs during the address calculation period (at the end of each line).
If a MSB=0 command is sent to the AX6963 during this period, the AX6963 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 the command or data will not be received.

(2) Setting data

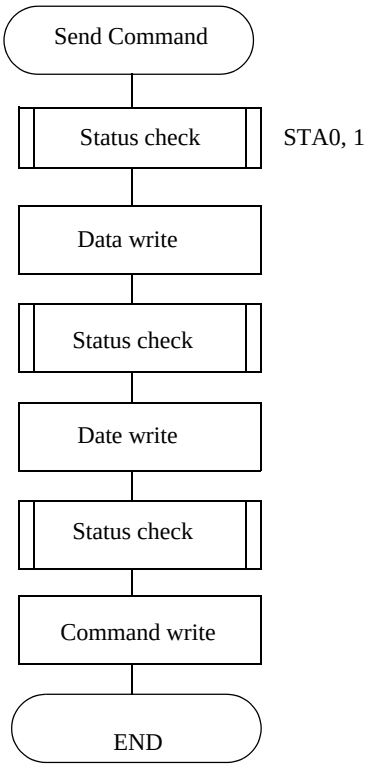
When using the AX6963, first set the data,then set the command.

Procedure for sending a command

a)The case of 1 data



b)The case of 2 data



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

■ FUNCTIONAL DEFINITION

COMMAND	CODE	D1	D2	FUNCTION
REGISTERS SETTING	00100001 00100010 00100100	X address Data Low address	Y address 00H High address	Set Cursor Pointer Set Offset Register Set Address Pointer
SET CONTROL WORD	01000000 01000001 01000010 01000011	Low address Columns Low address Columns	High address 00H High address 00H	Set Text Home Address Set Text Area Set Graphic Home Address Set Graphic Area
MODE SET	1000*000 1000*001 1000*011 1000*100 10000*** 10001***	- - - - - -	- - - - - -	OR mode EXOR mode AND mode Text Attribute mode Internal CG ROM mode External CG RAM mode
DISPLAY MODE	10010000 1001**10 1001**11 100101** 100110** 100111**	- - - - - -	- - - - - -	Display off Cusor on, blink off Cursor on, blink on Text on, graphic off Text off, graphic on Text on, graphic on
CURSOR PATTERN SELECT	10100000 10100001 10100010 10100011 10100100 10100101 10100110 10100111	- - - - - - - -	- - - - - - - -	1-line cursor 2-line cursor 3-line cursor 4-line cursor 5-line cursor 6-line cursor 7-line cursor 8-line cursor
DATA AUTO READ/ WRITE	10110000 10110001 10110010	- - -	- - -	Set Data Auto Write Set Data Auto Read Auto Reset
DATA READ/WRITE	11000000 11000001 11000010 11000011 11000100 11000101	Data - Data - Data -	- - - - - -	Data Write and Increment ADP Data Read and Increment ADP Data Write and Decrement ADP Data Read and Decrement ADP Data Write and Nonvariable ADP Data Read and Nonvariable ADP
SCREEN PEEK	11100000	-	-	Screen Peek
SCREEN COPY	11101000			Screen Copy
BIT SET/RESET	11110*** 11111*** 1111*000 1111*001 1111*010 1111*011 1111*100 1111*101 1111*110 1111*111	- - - - - - - - - -	- - - - - - - - - -	Bit Reset Bit Set Bit 0 (LSB) Bit 1 Bit 2 Bit 3 Bit 4 Bit 5 Bit 6 Bit 7 (MSB)

* : invalid

• **Setting registers**

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

(1) Set Cursor Pointer

The position of the cursor is specified by X ADRS and Y ADRS. 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 00 to 4 FH

Y ADRS 00H to 0FH

b)Dual-Scan

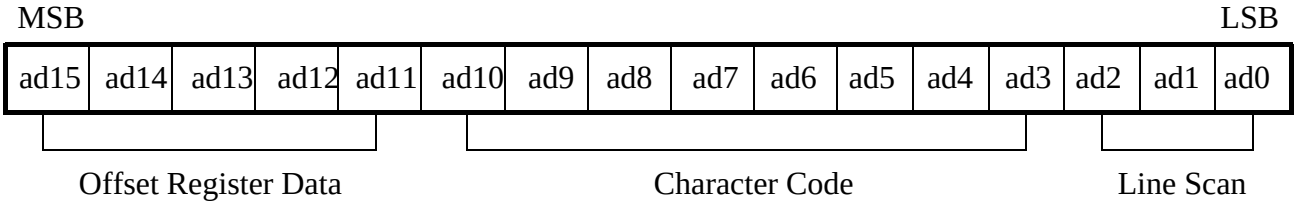
X ADRS 00H to 4 FH

Y ADRS 00H to 0FH
Upper screen

Y ADRS 10H to 1FH
Lower screen

(2) Set Offset Register

The offset register is used to determine the external character generator RAM area.
The AX6963 has a 16-bit address bus as follows:



AX6963 assign External character generator, when character code set 80H to FFH in using inernal charac ter generator. Character code 00H to 80H assign External character generator, when External generator mode.

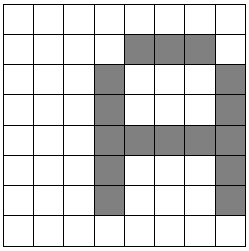
The senior five bits define the start address in external memory of the CG RAM area. The next eight bits represent the character code of the character. In internal CG ROM mode, character codes 00H to 7 FH rep resent the predefined "internal" CG ROM characters, and codes 80H to FFH represent the user's own "external" characters. In external CG RAM mode,all 256 codes from 00H to FFH can be used to repre sent 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

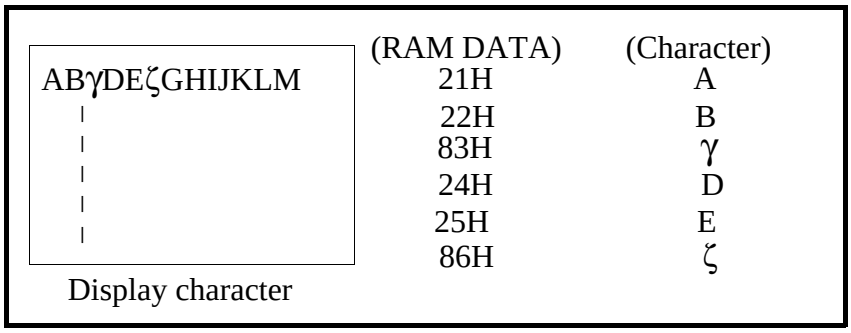
(Example 1)

Offset register	02H				
Character code	80H				
Character generator RAM start address	0001	0100	0000	0000	
	1	4	0	0	H



(address)	(data)
1400H	00H
1401H	0EH
1402H	11H
1403H	11H
1404H	1FH
1405H	11H
1406H	11H
1407H	00H

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

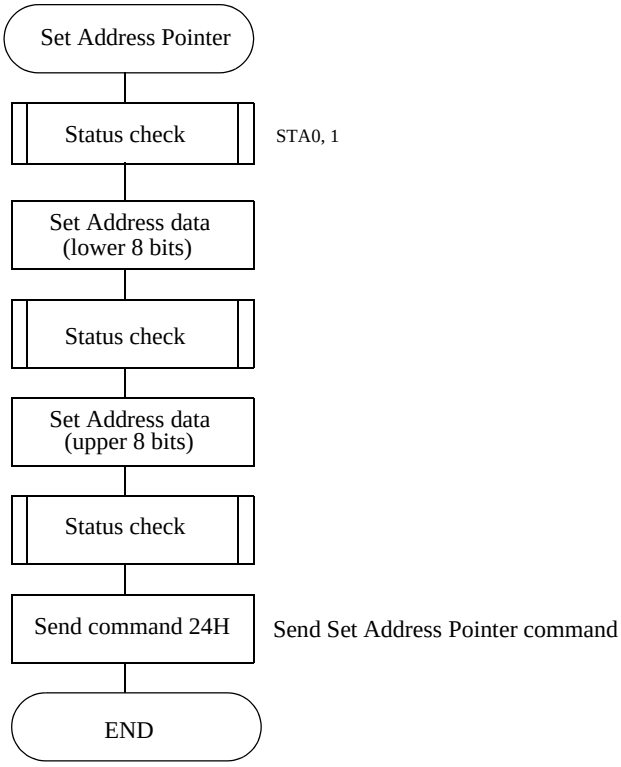


γ and ζ are displayed by character generator RAM.

(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



- **Set Control Word**

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.

(1) Set Text Home Address

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

The relationship between external display RAM address and display position

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 : 32columns
DUAL = H, MDS = L, MD0 = L, MD1 = H : 4 lines

0000H	0001H		001EH	001FH
0020H	0021H		003EH	002FH
0040H	0041H		005EH	005FH
0060H	0061H		007EH	007FH

(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.

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 : 32columns
$\overline{\text{DUAL}}$ = H, MDS = L, MD0 = H, MD1 = H : 2 lines

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

(3) Set Text Area

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

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

(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

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.

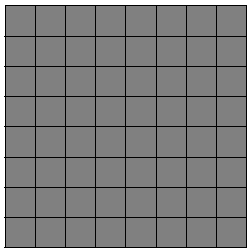
- **Mode set**

CODE	FUNCTION	OPERAND
1000*000	OR Mode	_
1000*001	EXOR Mode	_
1000*011	AND Mode	_
1000*100	TEXT ATTRIBUTE Mode	_
10000***	Internal Character Generator Mode	_
10001***	External Character Generator Mode	_

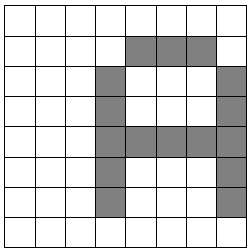
* : invalid

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.

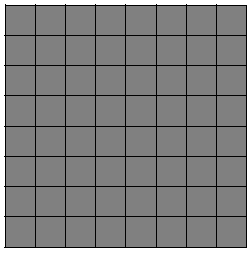
(Example)



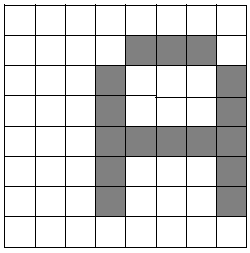
GRAPHIC



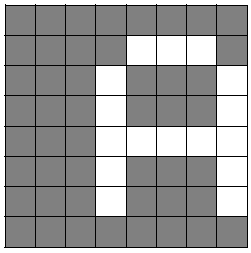
TEXT



"OR"



"AND"



"EXOR"

(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 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 in order for the Attribute function to be 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

*	*	*	*	d3	d2	d1	d0

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

* : invalid

- **Display mode**

CODE	FUNCTION	OPERAND
10010000	Display off	-
1001**10	Cursor on, blink off	-
1001**11	Cursor on, blink off	-
100101**	Text on, graphic off	-
100110**	Text off, graphic on	-
100111**	Text on, graphic on	-

* : invalid

1	0	0	1	D3	D2	D1	D0

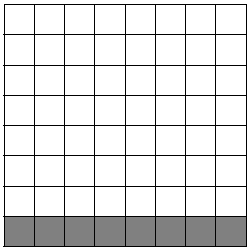
D0 — Cursor blink on : 1, off : 0
D1 — Cursor display on : 1, off : 0
D2 — Text display on : 1, off : 0
D3 — Graphic display on : 1, off : 0

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

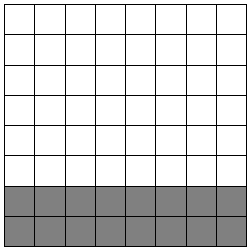
• **Cursor pattern select**

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	_

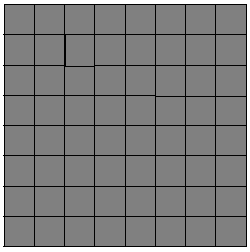
When cursor display is ON, this command selects the cursor pattern in the range 1 line to 8 lines. The cursor address is defined by the Cursor Pointer Set command.



1-line cursor



2-line cursor



8-line cursor

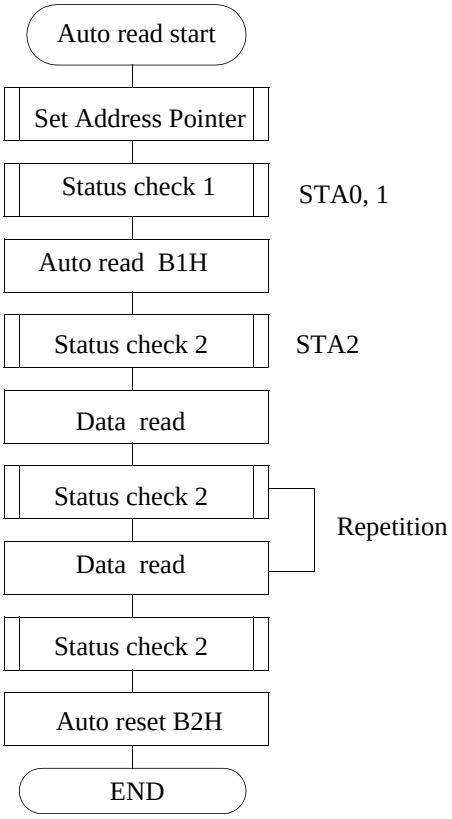
• **Data Auto Read/Write**

CODE	HEX.	FUNCTION	OPERAND
10110000	B0H	Set Data Auto Write	_
10110001	B1H	Set Data Auto Read	_
10110010	B2H	Auto Reset	_

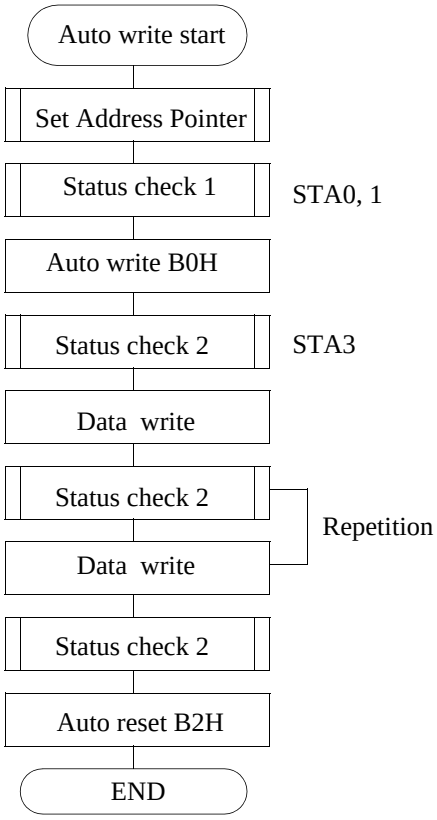
This command is convenient for sending a full screen of data from the external display RAM.After setting Auto mode, a Data Write (or Read) command is need not be sent between each datum.A Data Auto Write (or Read) command must be sent after a Set Address Pointer command.After this command, the address pointer is automatically incremented by 1 after each datum. In auto mode, the AX6963 cannot accept any other commands.
The Auto Reset command must be sent to the AX6963 after all data has been sent, to clear Auto mode.

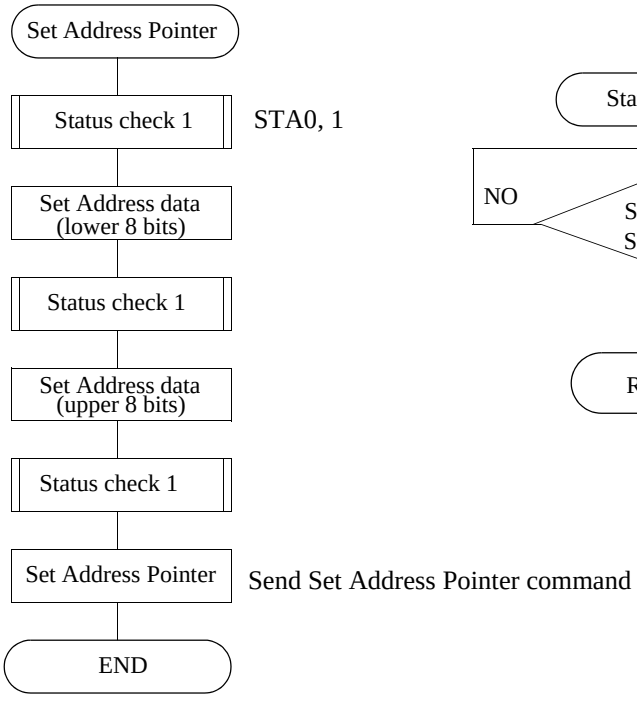
(Note) : A Status check for Auto mode
(STA2, STA3 should be checked between sending of each datum. Auto Reset should be performed after checking STA3=1 (STA2=1).Refer to the following flowchart.

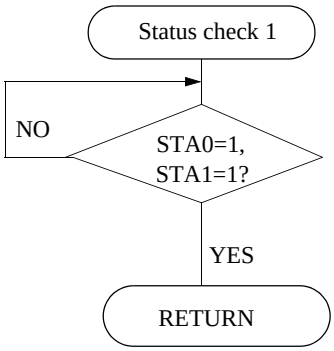
a) Auto Read mode

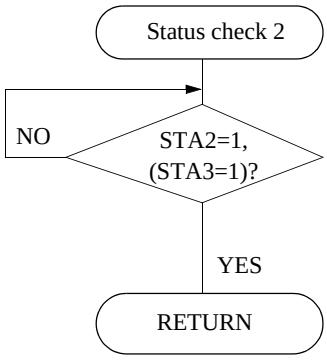


b) Auto Write mode







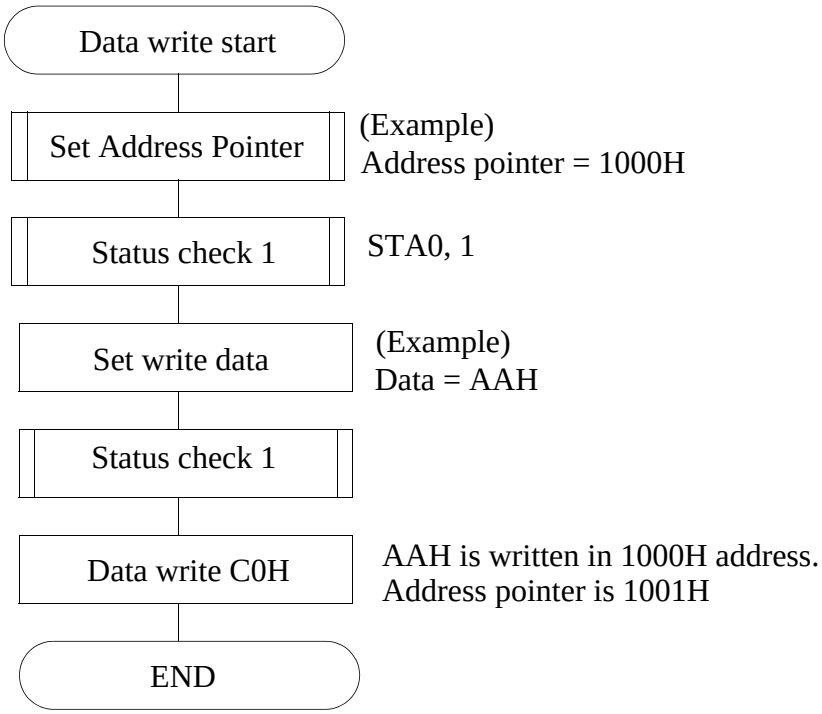


• **Data Read/Write**

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 Read and Decrement ADP	_
11000100	C4H	Data Write and Nonvariable ADP	Data
11000101	C5H	Data Read and Nonvariable ADP	_

This command is used for writing data from the MPU to external display RAM, and reading data from external display RAM to the MPU.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.

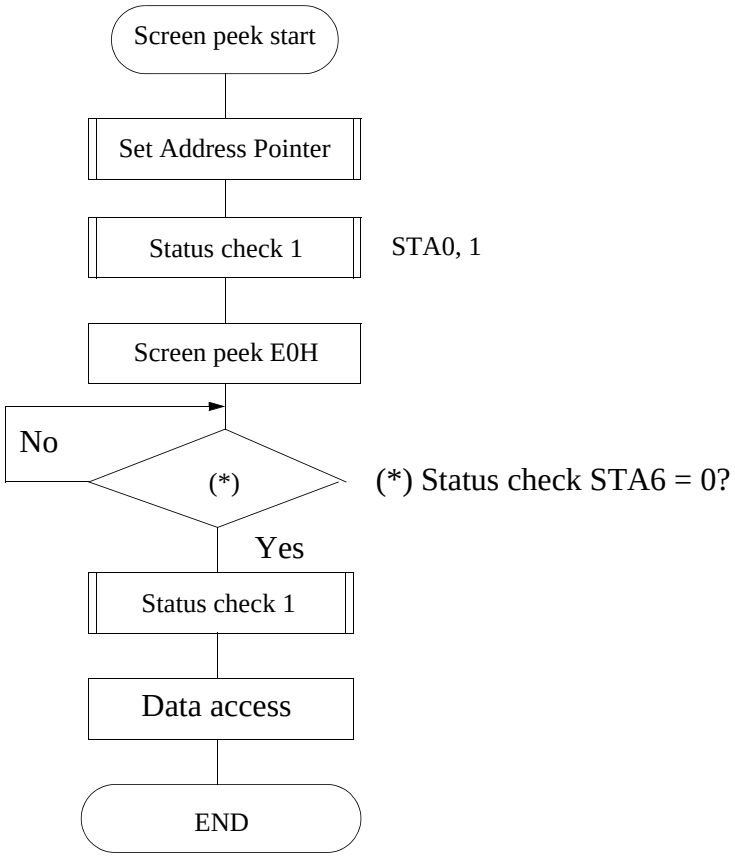
(Note) : This command is necessary for each 1-byte datum.
Refer to the following flowchart.



• **Screen Peek**

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 then 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.

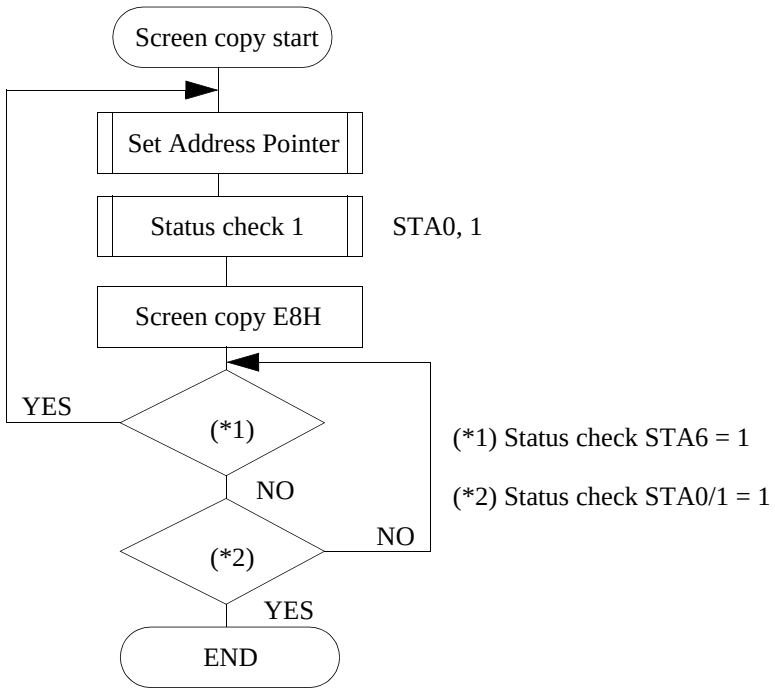


(Note) : This command is available when hardware column number and software column mumber are the same.
Hardware column number is related to MD2 and MD3 setting.
Software column number is related to Set Text Area and Set Graphic Area command.
The data read command must be performed after screen peek command.

• **Screen Copy**

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 AX6963 cannot separate the upper screen data and lower screen data).
Refer to the following flowchart.



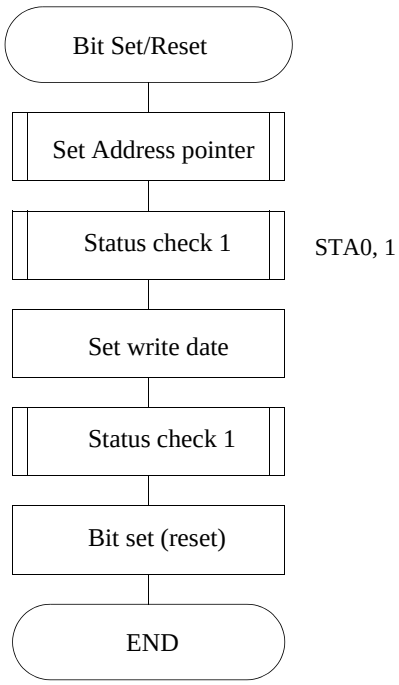
(Note) : This command is available when hardware column number and software column number are the same.
Hardware column number is related to MD2 and MD3 setting.
Software column number is related to Set Text Area and Set Graphic Area command.

- **Bit Set / Reset**

CODE	FUNCTION	OPERAND
11110***	Bit Reset	-
11111***	Bit Set	-
1111*000	Bit 0 (LSB)	-
1111*001	Bit 1	-
1111*010	Bit 2	-
1111*011	Bit 3	-
1111*100	Bit 4	-
1111*101	Bit 5	-
1111*110	Bit 6	-
1111*111	Bit 7 (MSB)	-

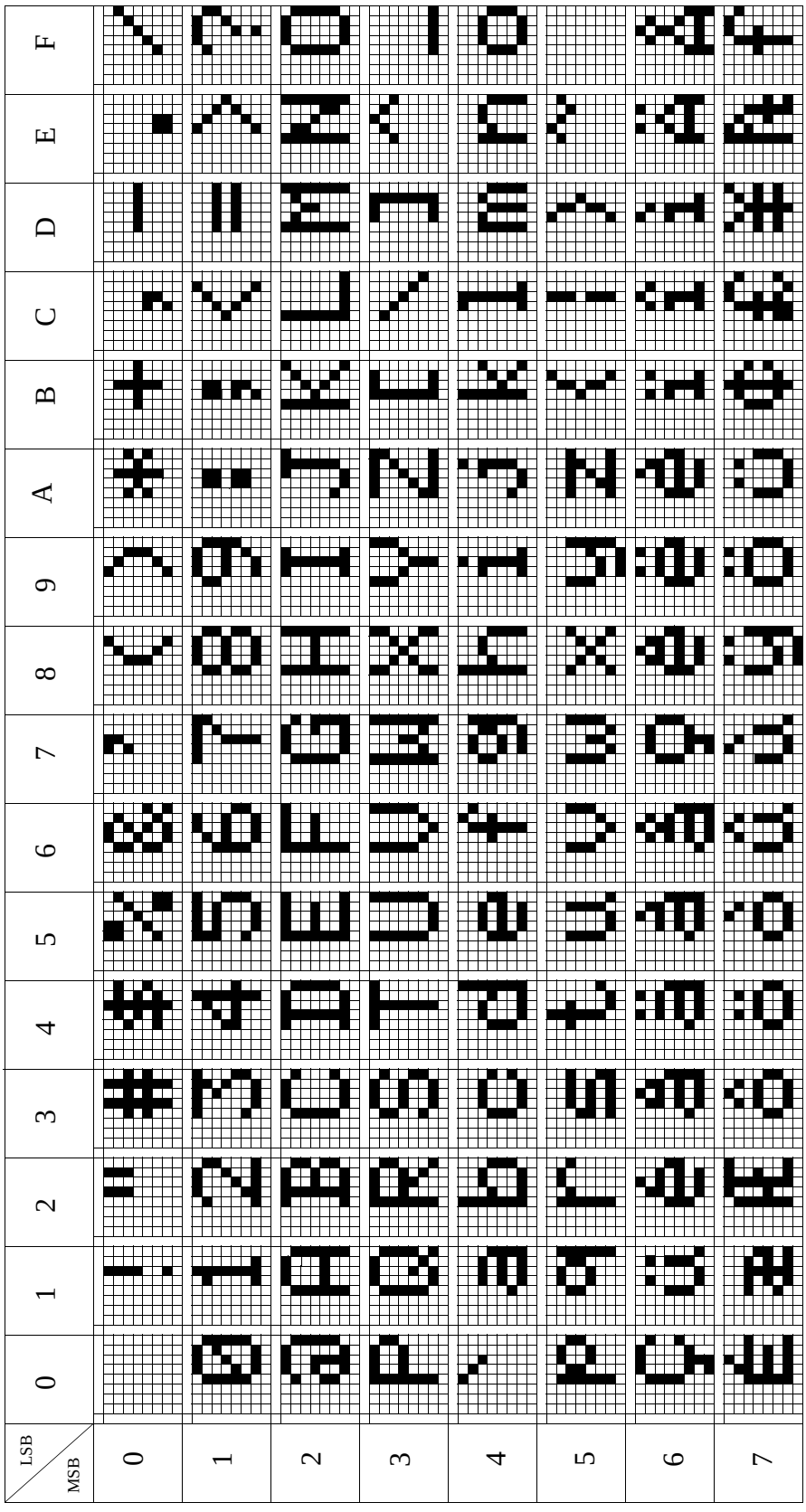
* : invalid

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



Character Code Map

The relation between character codes and character pattern (CG ROM TYPE 0101)



Character Code Map

The relation between character codes and character pattern (CG ROM TYPE 0201)

LSB / MSB	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0																
1																
2																
3																
4																
5																
6																
7																

Absolute Maximum Ratings (Ta=25℃)

ITEM	SYMBOL	RATING	UNIT
Supply Voltage	V_{DD} (Note)	-0.3 to 7.0	V
Input Voltage	V_{IN} (Note)	-0.3 to V_{DD}+0.3	V
Operating Temperature	T_{opr}	-20 to 70	℃
Storage Temperature	T_{stg}	-55 to 125	℃

(Note) : Refernced to V_{SS} = 0V.

ELECTRICAL CHARACTERISTICS

DC CHARACTERISTICS

TEST CONDITIONS (Unless otherwise noted, VSS = 0V, VDD = 5.0± 10%, Ta = -20 to 75℃)

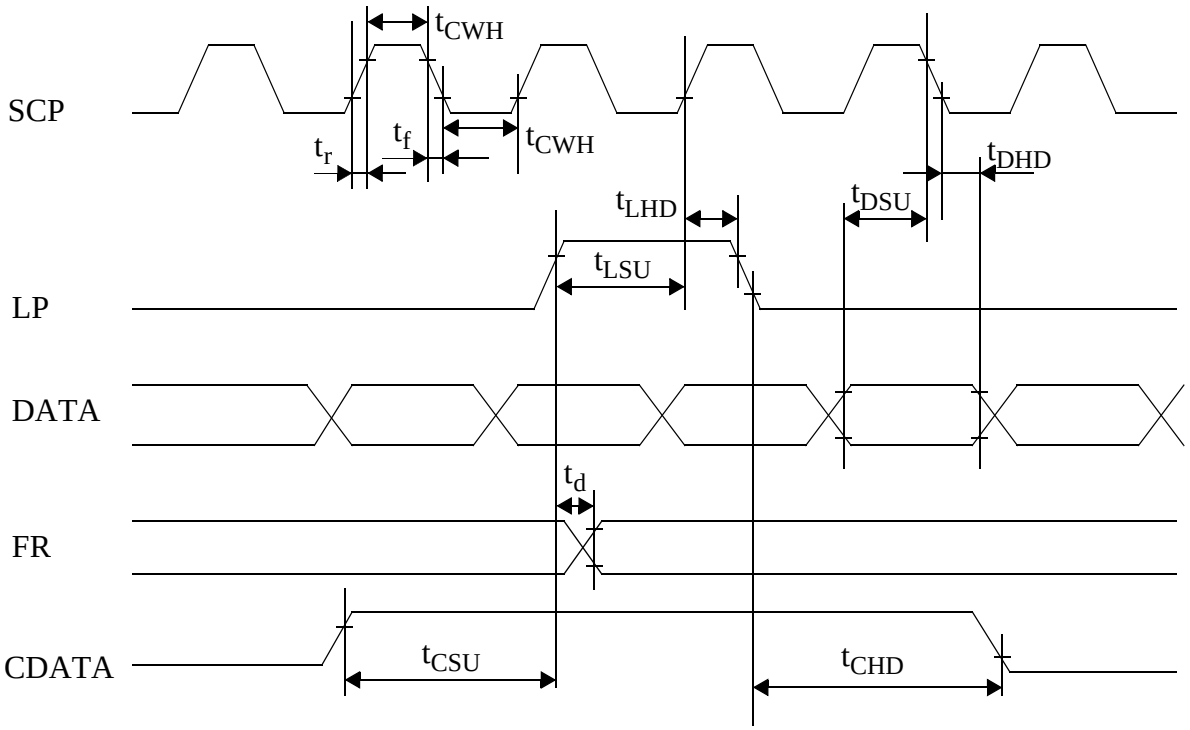
Item		Symbol	Test Cir-cuit	Test Condition	Min	Typ.	Max	Unit	Pin Name
Operating Voltage		V_{DD}	–	–	3.0	5.0	5.5	V	V_{DD}
Input	H Level	V_{IH}	–	–	0.8V_{DD}	–	V_{DD}	V	Input pins
	L Level	V_{IL}		–	0	–	0.8	V	Input pins
Output Voltage	H Level	V_{OH}	–	–	V_{DD} - 0.4	–	V_{DD}	V	Output pins
	L Leval	V_{OL}		–	0	–	0.3	V	Output pins
Output Resistance	H Level	R_{OH}		V_{OUT} = V_{DD} - 0.5V	–	–	300	Ω	Output pins
	L Level	R_{OL}		V_{OUT} = 0.5V	–	–	300	Ω	Output pins
Input Pull-up Resistance		RPU	–	–	50	100	200	kΩ	(Note 1)
Operating Frequency		f_{OSC}	–	–	0.4	–	12	MHz	
Current Consumption (Operating)		I_{DD}(1)	–	V_{DD} = 5.0V (Note 2) f_{OSC} = 3.0MHz	–	3.3	6	mA	V_{DD}
Current Consumption (Halt)		I_{DD}(2)	–	V_{DD} = 5.0V	–	–	3	μA	V_{DD}

(Note 1) : Applied $\overline{T1}$, $\overline{T2}$, $\overline{RESET}$

(Note 2) : MDS=L, MD0=L, MD1=L, MD2=H, MD3=H, FS0=L, FS1=L, $\overline{SDSEL}$=L, $\overline{DUAL}$=H, D7 to D0 = LHLHLHLH

Ac Characteristics

• Switching Characteristics (1)



Test Conditions(Unless Otherwise Noted, V_{DD} =5.0± 10%, V_{ss} =0V, Ta=-20 to 75℃)

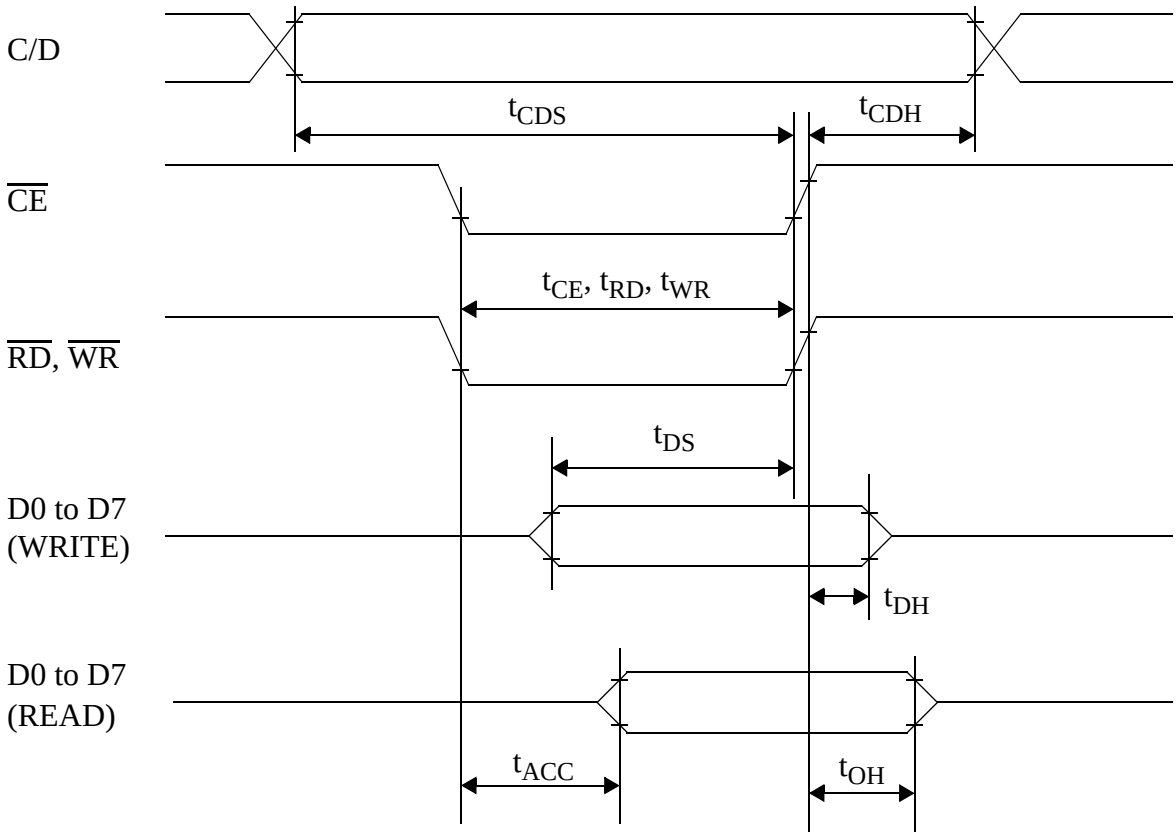
Item	Symbol	Test Conditions	Min	Max	Unit
Operating Frequency	f_{SCP}	Ta = -10~70℃	_	3	MHz
SCP Pulse Width	t_{CWH}, t_{CWL}	_	150	_	ns
SCP Rise/Fall Time	t_r, t_f	_	_	25	ns
LP Set-up Time	t_{LSU}	_	160	290	ns
LP Hold Time	t_{LHD}	_	5	40	ns
Data Set-up Time	t_{DSU}	_	220	_	ns
Data Hold Time	t_{DHD}	_	80	_	ns
FR Delay Time	t_d	_	0	50	ns
CDATA Hikd Time	t_{CSU}	_	500	850	ns
CDATA Hold Time	t_{CHD}	_	450	950	ns

Test Conditions(Unless Otherwise Noted, V_{DD} =3.0, V_{ss} =0V, Ta=-20 to 75℃)

Item	Symbol	Test Conditions	Min	Max	Unit
Operating Frequency	f_{SCP}	Ta = -10~70℃	_	3	MHz
SCP Pulse Width	t_{CWH}, t_{CWL}	_	150	_	ns
SCP Rise/Fall Time	t_r, t_f	_	_	25	ns
LP Set-up Time	t_{LSU}	_	180	330	ns
LP Hold Time	t_{LHD}	_	6	60	ns
Data Set-up Time	t_{DSU}	_	230	_	ns
Data Hold Time	t_{DHD}	_	90	_	ns
FR Delay Time	t_d	_	0	70	ns
CDATA Set-up Time	t_{CSU}	_	520	850	ns
CDATA Hold Time	t_{CHD}	_	470	950	ns

• **Switching Characteristics (2)**

Bus Timing



Test Conditions(Unless Otherwise Noted, V_{DD} =5.0± 10%, V_{ss} =0V, Ta=-20 to 75℃)

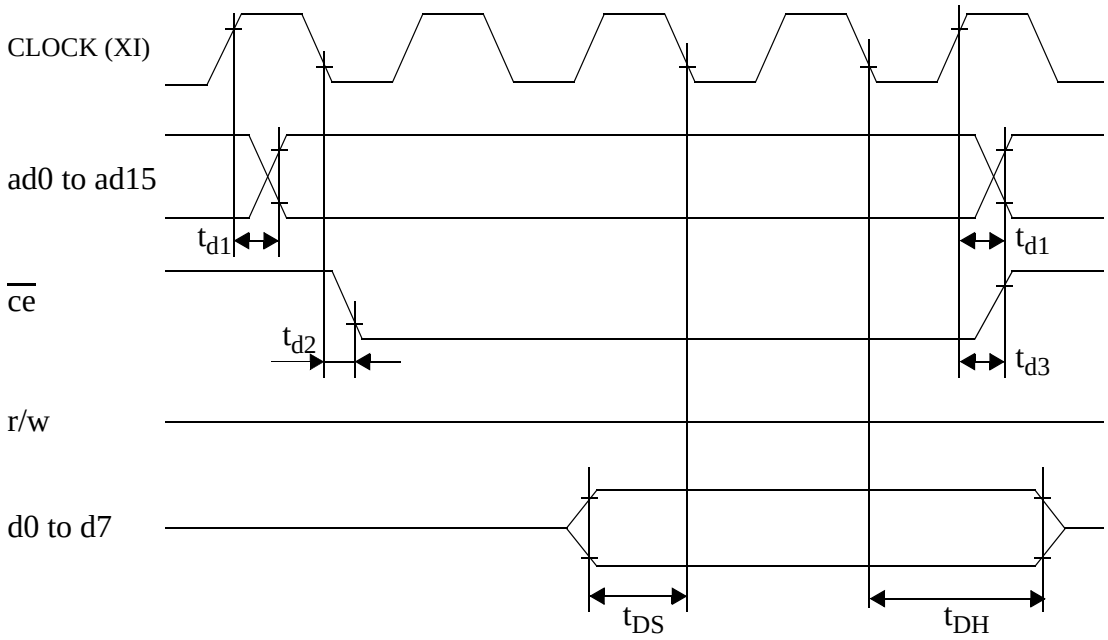
Item	Symbol	Test Conditions	Min	Max	Unit
C/D Set-up Time	t_{CDS}	–	100	–	ns
C/DHold Time	t_{CDH}	–	10	–	ns
CE, RD, WR Pulse Width	t_{CE}, t_{RD}, t_{WR}	–	80	–	ns
Data Set-up Time	t_{DS}	–	80	–	ns
Data Hold Time	t_{DH}	–	40	–	ns
Access Time	t_{ACC}	–	–	150	ns
Output Hold Time	t_{OH}	–	10	50	ns

Test Conditions(Unless Otherwise Noted, V_{DD} =3.0, V_{ss} =0V, Ta=-20 to 75℃)

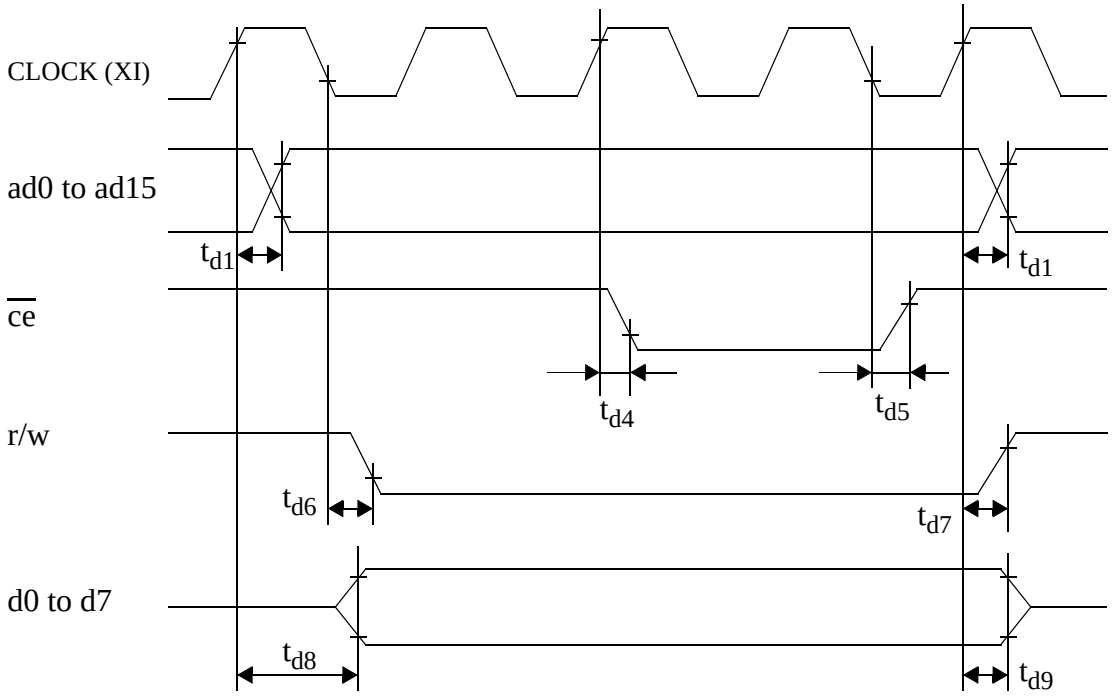
Item	Symbol	Test Conditions	Min	Max	Unit
C/D Set-up Time	t_{CDS}	–	150	–	ns
C/DHold Time	t_{CDH}	–	20	–	ns
CE, RD, WR Pulse Width	t_{CE}, t_{RD}, t_{WR}	–	100	–	ns
Data Set-up Time	t_{DS}	–	100	–	ns
Data Hold Time	t_{DH}	–	50	–	ns
Access Time	t_{ACC}	–	–	250	ns
Output Hold Time	t_{OH}	–	20	80	ns

- **Switching Characteristics (3)**

(1) External RAM Read mode



(2) External RAM Write mode



Item	Symbol	Test Conditions	Min	Max	Unit
Address Delay time	t_{d1}	_	_	250	ns
$\overline{ce}$ Fall Delay Time (Read)	t_{d2}	_	_	180	ns
$\overline{ce}$ Rise Delay Time (Read)	t_{d3}	_	_	180	ns
Data Set-up Time	t_{DS}	_	0	_	ns
Data Hold Time	t_{DH}	_	30	_	ns
$\overline{ce}$ Fall Delay Time (Write)	t_{d4}	_	_	200	ns
$\overline{ce}$ Rise Delay Time (Write)	t_{d5}	_	_	200	ns
r/w Fall Delay Time	t_{d6}	_	_	180	ns
r/w Rise Delay Time	t_{d7}	_	_	180	ns
Data Stable Time	t_{d8}	_	_	450	ns
Data Hold Time	t_{d9}	_	_	200	ns

Test Conditions (Unless Otherwise Noted, VDD = 3.0, VSS = 0V, Ta = -20 to 70°C)

Item	Symbol	Test Conditions	Min	Max	Unit
Address Delay time	t_{d1}	_	_	300	ns
$\overline{ce}$ Fall Delay Time (Read)	t_{d2}	_	_	200	ns
$\overline{ce}$ Rise Delay Time (Read)	t_{d3}	_	_	200	ns
Data Set-up Time	t_{DS}	_	0	_	ns
Data Hold Time	t_{DH}	_	30	_	ns
$\overline{ce}$ Fall Delay Time (Write)	t_{d4}	_	_	220	ns
$\overline{ce}$ Rise Delay Time (Write)	t_{d5}	_	_	220	ns
r/w Fall Delay Time	t_{d6}	_	_	200	ns
r/w Rise Delay Time	t_{d7}	_	_	200	ns
Data Seable Time	t_{d8}	_	_	550	ns
Data Hold Time	t_{d9}	_	_	280	ns

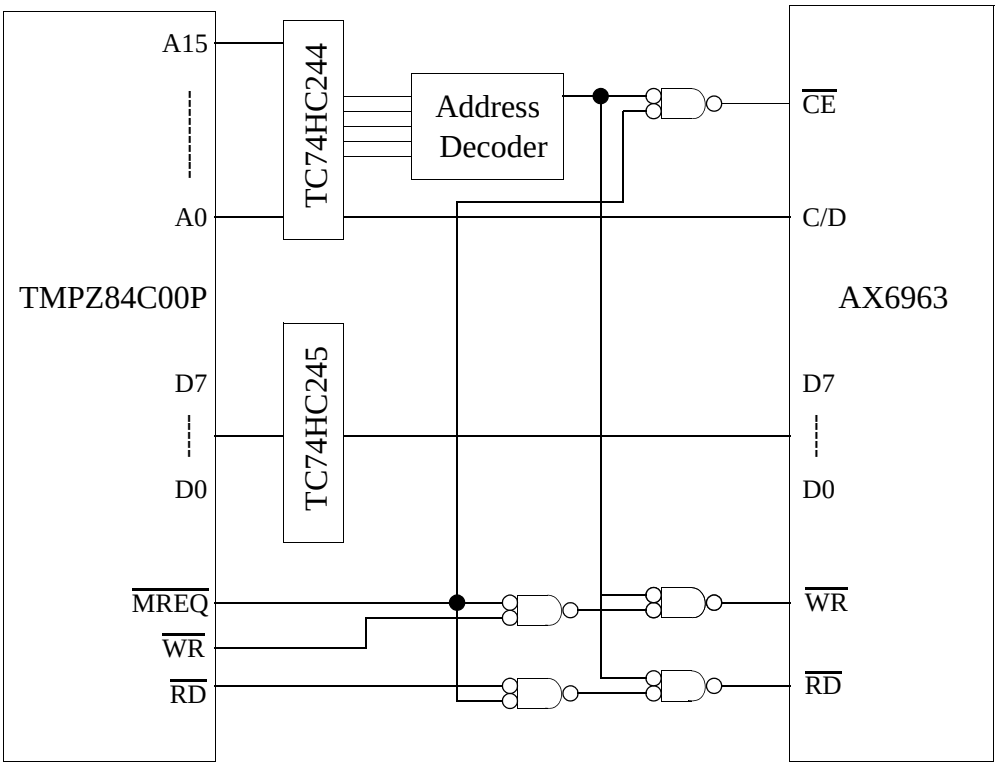
AX6963 Example of Application Circuit

The AX6963 can be directly connected to a TMPZ84C00A (Z80 (Note 1) CMOS).The AX6963 can be used with a TMPZ84C00A as shown in the following application circuit.

- **MPU memory address mapping**

Data is transferred to the AX6963 using a memory request signal.

	Address
DATA (I/O)	****H
Command / Status	****+1H

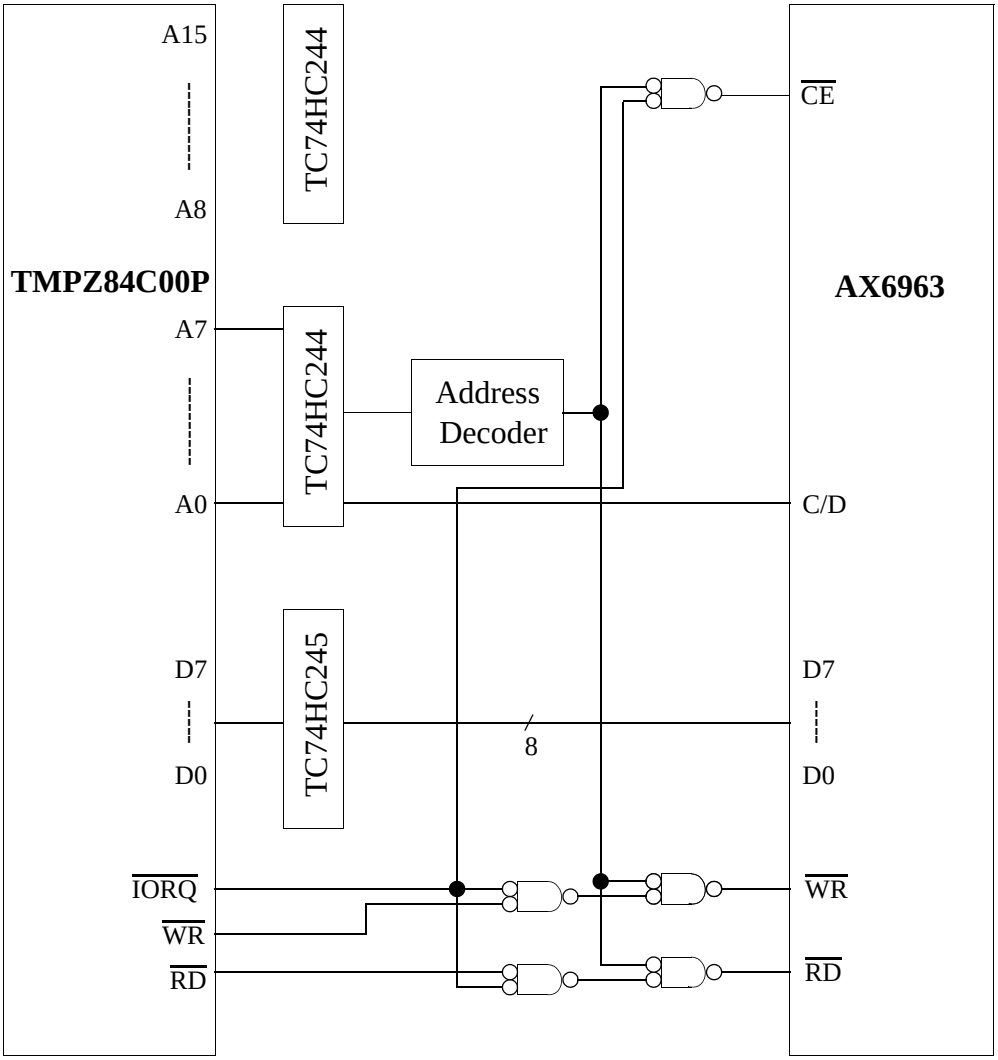


(Note 1) : Z80 is a trademark of Zliog Inc.

- **MPU I/O addressing**

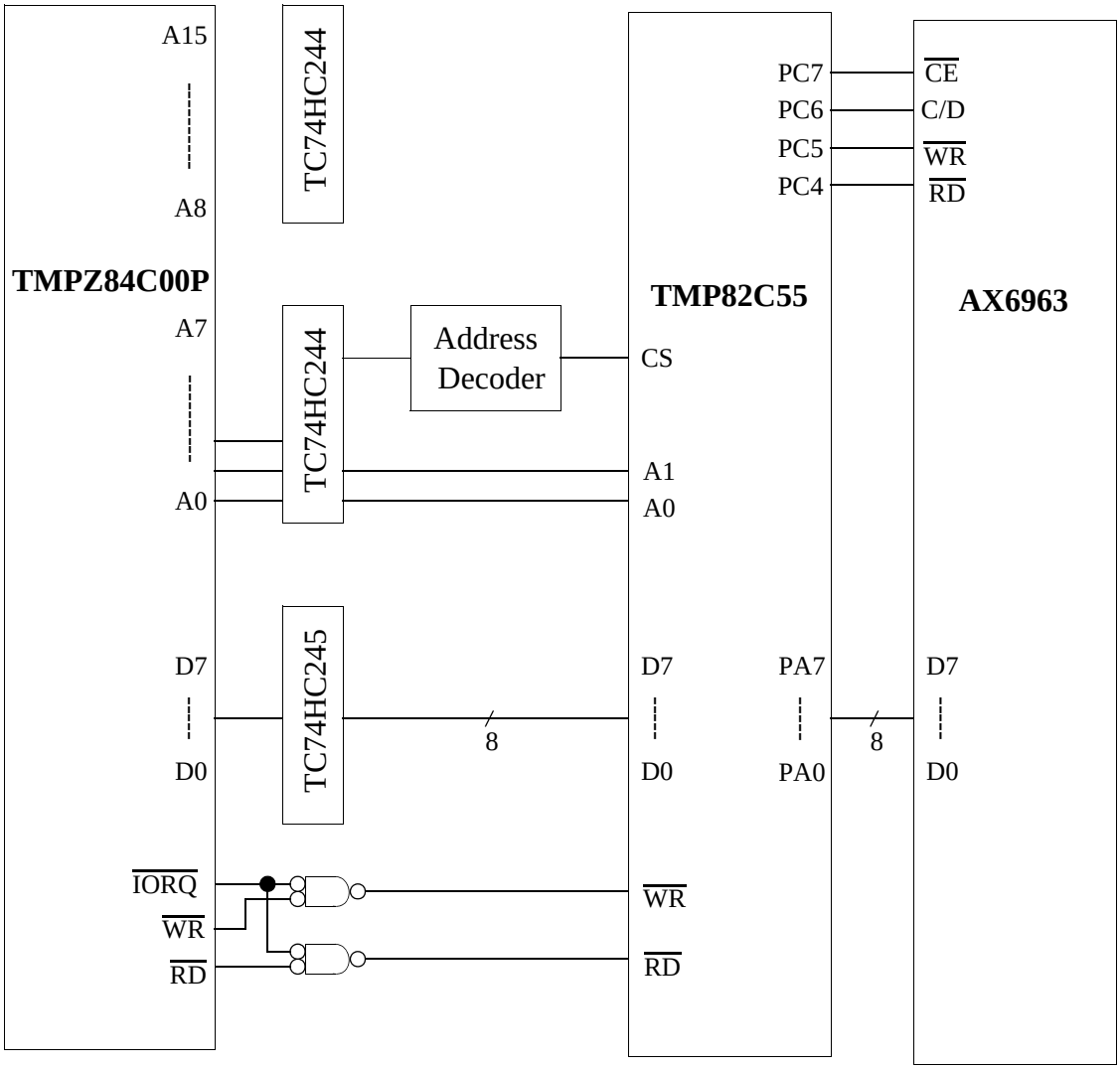
Data is transferred to the AX6963 using an I/O request signal.

	I/O Address
DATA	**H
Command / Status	**+1H

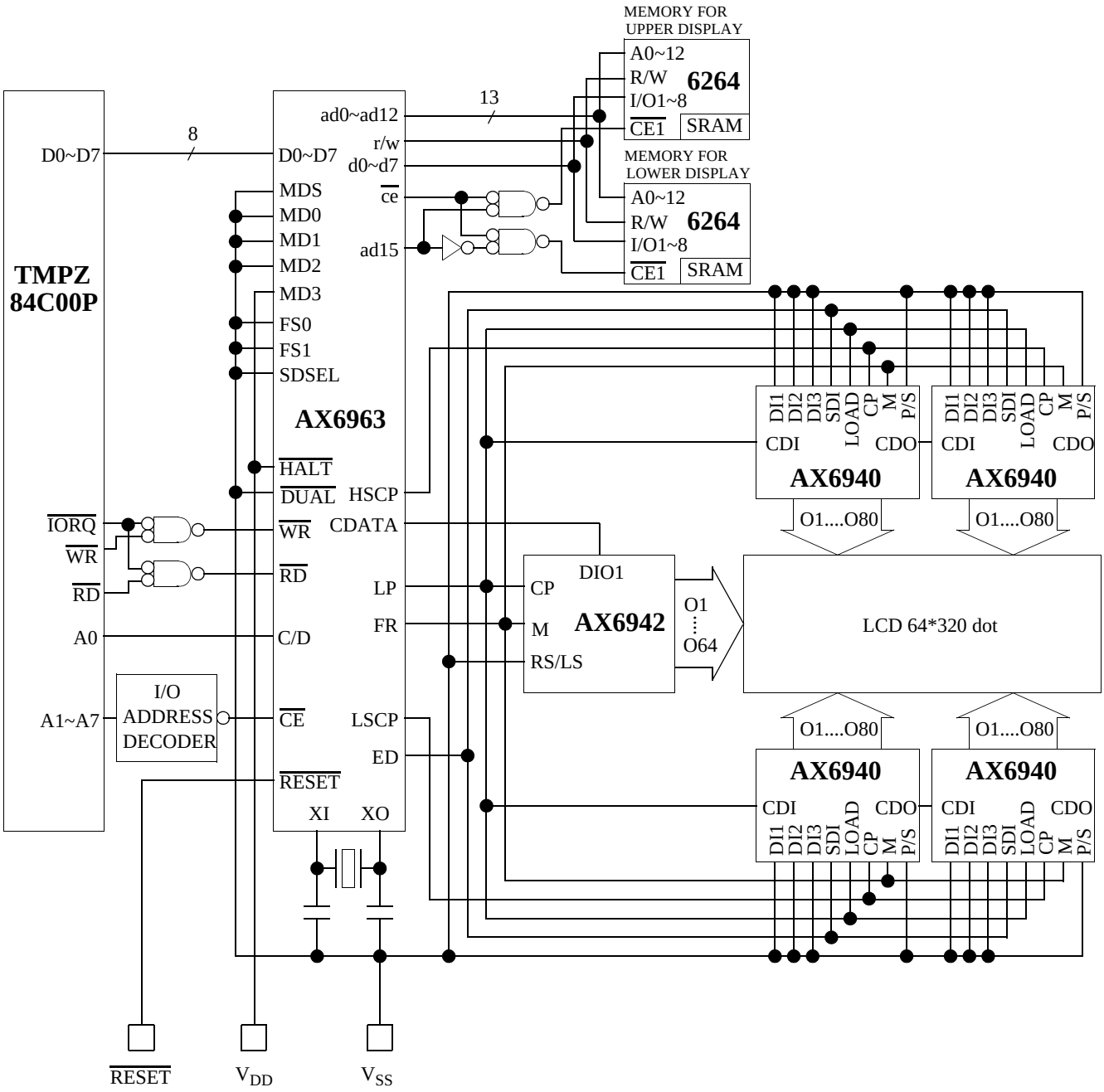


- **When using PPI LSI (TMP82C55)**

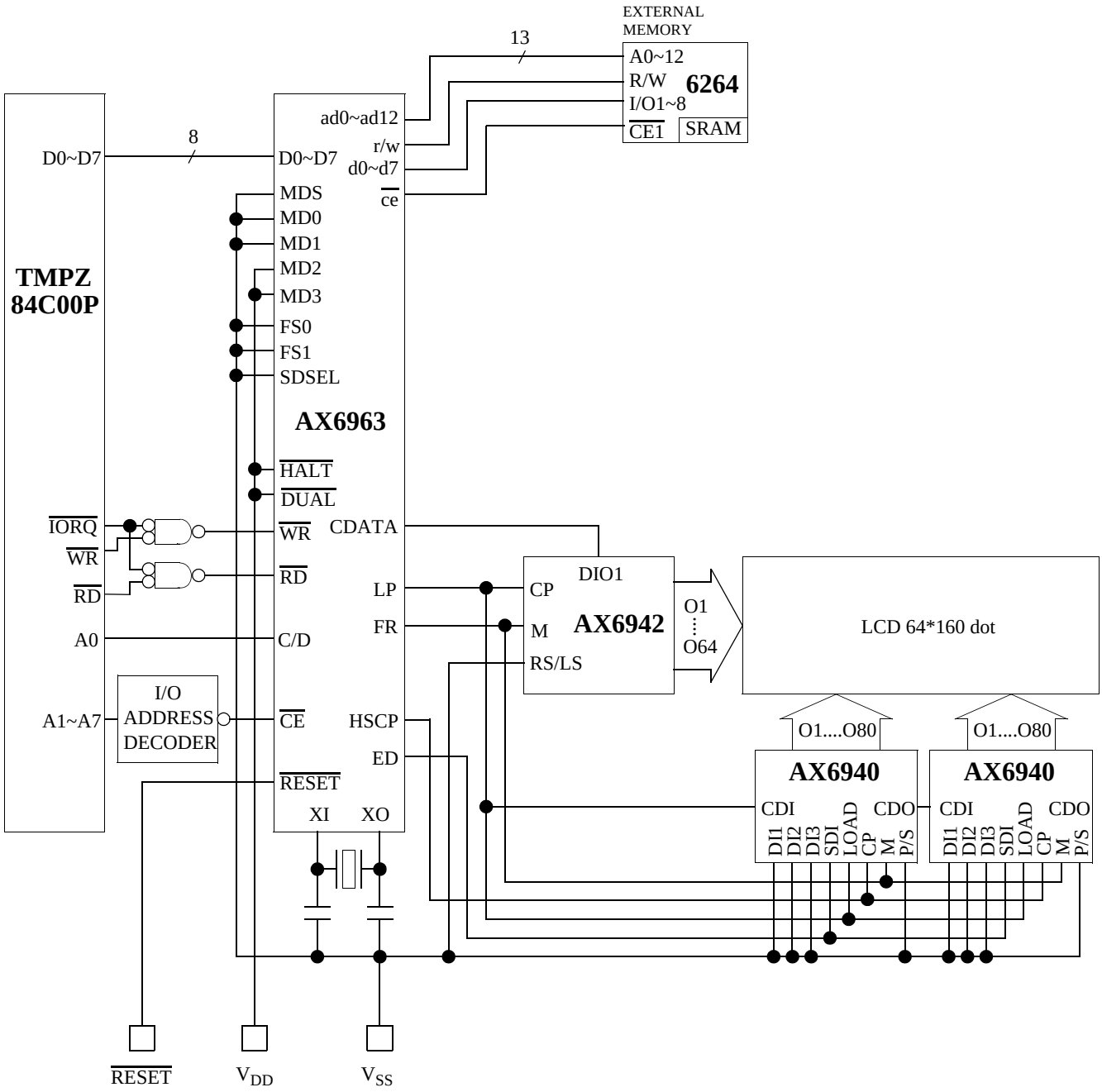
  The AX6963 can be connected to a PPI LSI.
  The port A connects to the data bus.
  The port C connects to the control bus. (C/D, $\overline{CE}$, $\overline{WR}$, $\overline{RD}$)



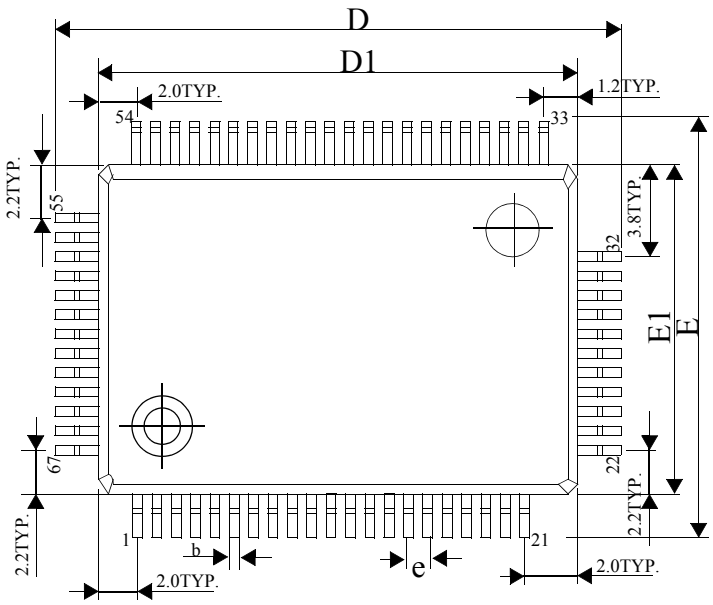
Application Circuit (1)



Application Circuit (2)

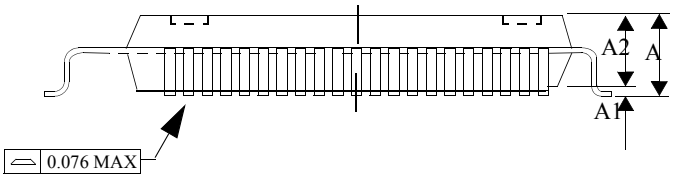


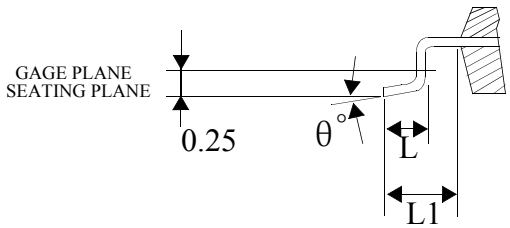
Package Dimensions



Symbol	MIN	NOM	MAX
A	--	--	1.80
A1	0.05	--	0.25
A2	1.35	1.40	1.45
b	0.20	0.30	0.40
D	24.10 BASIC		
D1	20.00 BASIC		
e	0.8 BASIC		
E	18.10 BASIC		
E1	14.00 BASIC		
L	1.15	1.35	1.55
L1	2.5 REF.		
θ°	0	3.5	7

UNT: mm





NOTES:

1.JEDEC:N/A.

2.DATUM PLANE H IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.

3.DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION.ALLOWABLE PROTRUSION IS 0.25 mm PER SIDE.DIMENSIONS D1 AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.

4.DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION.