



# ***PALM TECHNOLOGY CO., LTD.***

***The LCD(M) Specialist***

*CONTACT ADDRESS : 14F~15F, No.383, Yangming Rd.,Samin District,  
Kaohsiung City 807,Taiwan(R.O.C)  
Tel: 886-7-3983966  
Fax: 886-7-3982966  
E-mail: sales@palmtech.com.tw*

**PART NO. : PRG1212A-SERIES**

**FOR MESSRS. : \_\_\_\_\_**

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ACCEPTED BY: \_\_\_\_\_

PROPOSED BY: \_\_\_\_\_



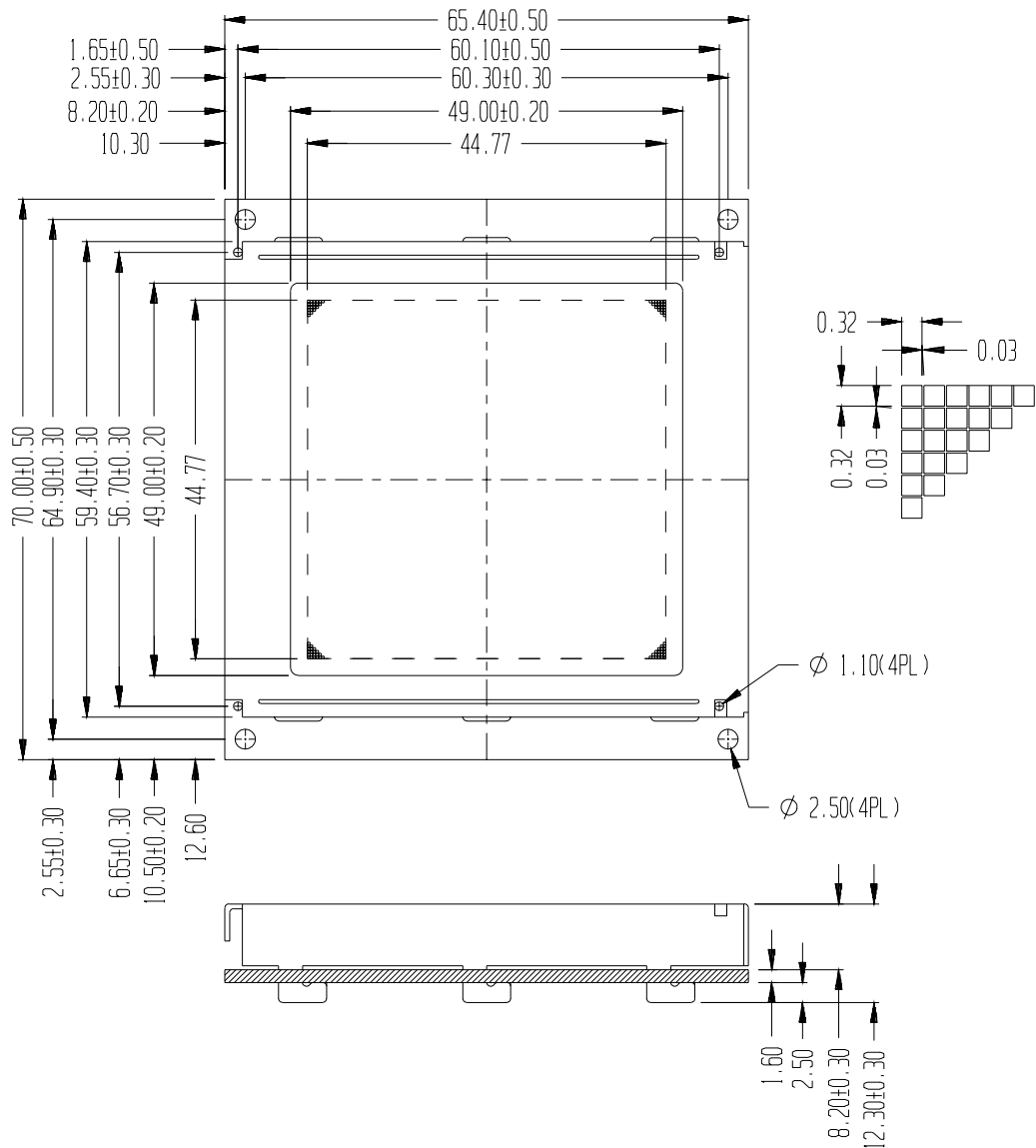
## RECORD OF REVISION

DATE	PAGE	SUMMARY

## ■ PHYSICAL DATA

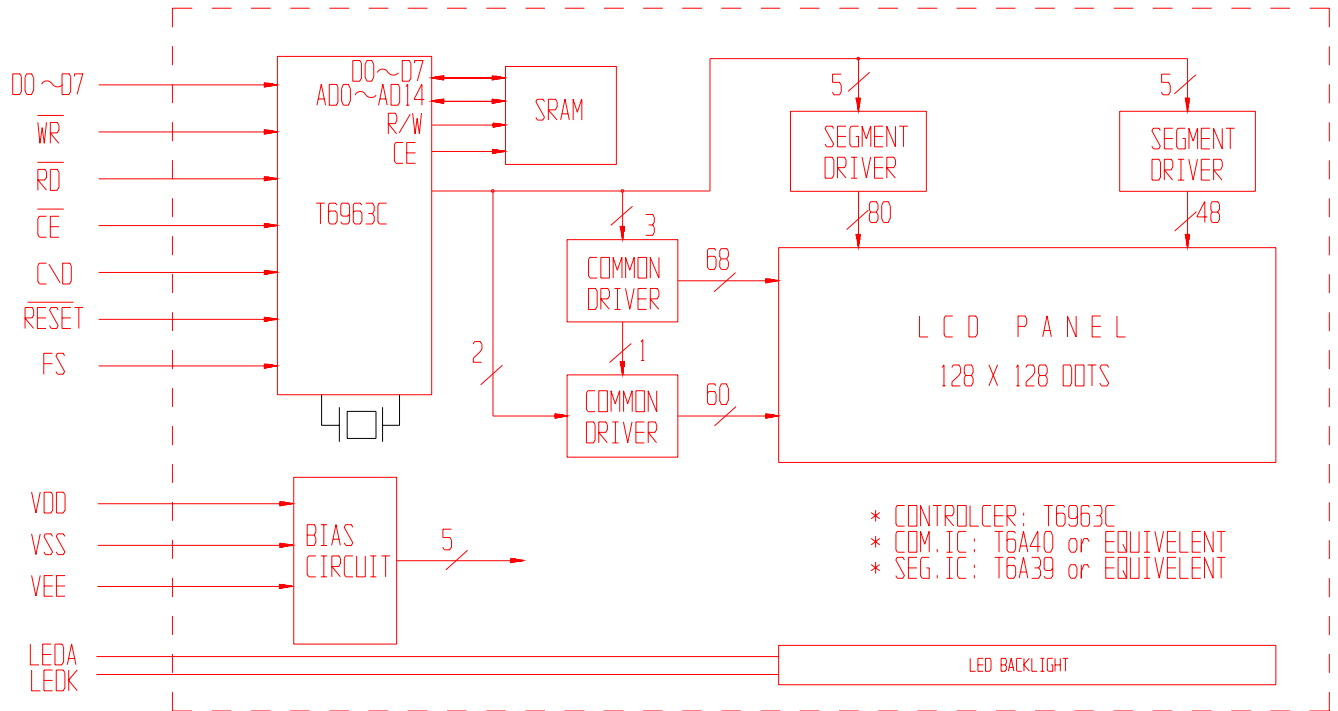
Item	Contents	Unit
LCD type	STN	---
LCD duty	1/128	---
LCD bias	1/12	---
Viewing direction	6	o'clock
Module size (W×H×T)	65 × 70 × 12.3MAX (2.60" × 2.76" × 0.48"MAX)	mm
Viewing area (W×H)	49 × 49 (1.93" × 1.93")	mm
Number of dots	128 × 128	dots
Dot size (W×H)	0.32 × 0.32 (0.013" × 0.013")	mm
Dot pitch (W×H)	0.35 × 0.35 (0.014" × 0.014")	mm

## ■ EXTERNAL DIMENSIONS



## ■ BLOCK DIAGRAM

20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
LEDA	LEDK	NC	FS	O7	O6	O5	O4	O3	O2	O1	O0	RESET	C/D	CE	RD	WR	VEE	VDD	VSS



## ■ ABSOLUTE MAXIMUM RATINGS (Ta = 25°C)

Parameter	Symbol	Min	Max	Unit
Supply voltage for logic	VDD	0	6.7	V
Supply voltage for LCD	VDD - VO	0	28	V
Input voltage	VI	0	VDD	V
Operating temperature	TOP	0	50	°C
Storage temperature	TST	-10	60	°C

## ■ ELECTRICAL CHARACTERISTICS (VDD = +5V±10% , VSS = 0V, Ta = 25°C)

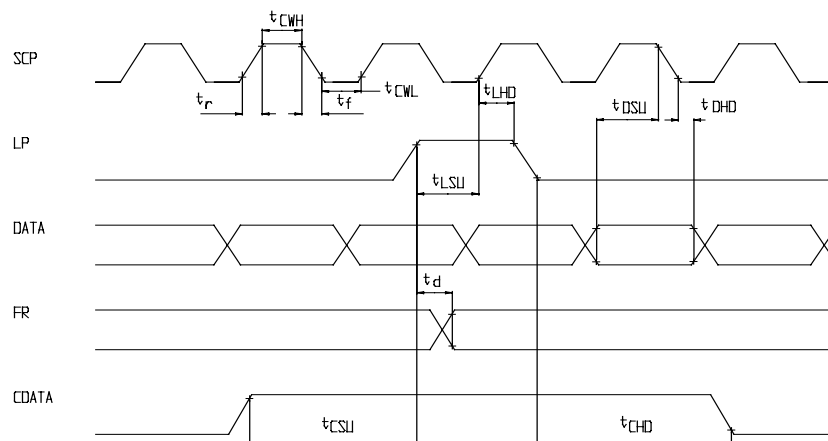
### ▼ DC Characteristics

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Supply voltage for logic	VDD	---	4.5	5.0	5.5	V
Supply current for logic	IDD	---	---	5.8	12	mA
Operating voltage for LCD	VDD - VO	0°C	17.1	18.0	18.9	V
		25°C	16.6	17.5	18.4	V
		50°C	16.0	16.9	17.8	V
Supply voltage for back light	VF	---	---	4.2	4.6	V
Supply current for back light	IF	VF=4.2V	---	380	640	mA
Input voltage 'H' level	VIH	---	VDD - 2.2	---	VDD	V
Input voltage 'L' level	VIL	---	0	---	0.8	V

## ▼ AC Characteristics

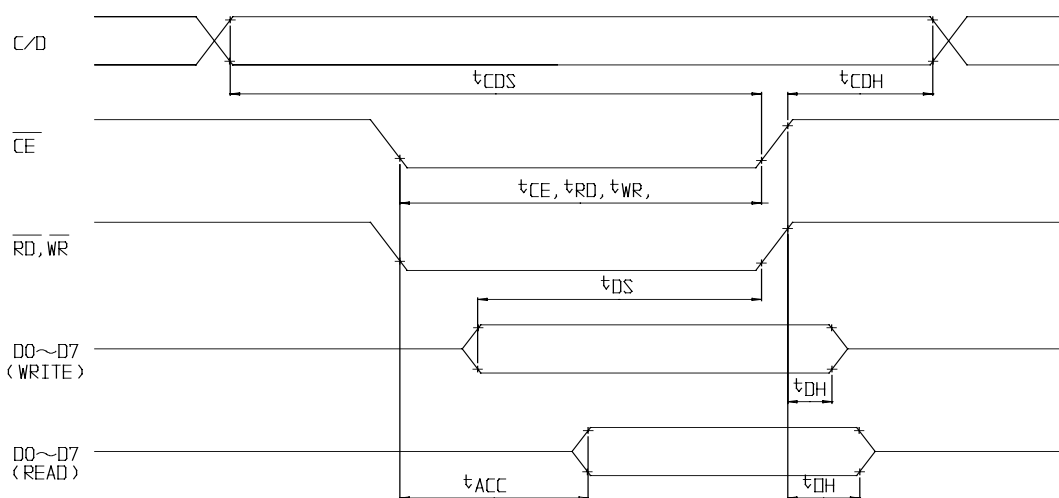
### ● AC Characteristics (1)

Parameter	Symbol	Min	Max	Unit
Operating frequency	$f_{SCP}$	---	2.75	MHz
SCP pulse width	$t_{CWH}, t_{CWL}$	150	---	ns
SCP rise/fall time	$t_r, t_f$	---	30	ns
LP set up time	$t_{LSU}$	150	290	ns
LP hold time	$t_{LHD}$	5	40	ns
Data set up time	$t_{DSU}$	170	---	ns
Data hold time	$t_{DHD}$	80	---	ns
FR delay time	$t_d$	0	90	ns
CDATA set up time	$t_{CSU}$	450	850	ns
CDATA hold time	$t_{CHD}$	450	950	ns



### ● AC Characteristics (2)

Parameter	Symbol	Min	Max	Unit
C/D set up time	$t_{CDS}$	100	---	ns
C/D hold 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



# ■ OPERATING PRINCIPLES & METHODS

## ▼ Flowchart of Communications with MPU

### ● Status Read

Before sending data (Read/Write) command, it is necessary to check the status.

#### Status check

Status of T6963C can be read from data lines.

RD	L
WR	H
CE	L
C/D	H
D0-D7	Status word

T6963C status word format is following.

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

STA0	Check capability of command execution	0 : Disable 1 : Enable
STA1	Check capability of data read/write	0 : Disable 1 : Enable
STA2	Check capability of auto mode data read	0 : Disable 1 : Enable
STA3	Check capability of auto mode data write	0 : Disable 1 : Enable
STA4	Not use	
STA5	Check capability of controller operation	0 : Disable 1 : Enable
STA6	Error flag. Using screen peek/copy command	0 : No error 1 : Error
STA7	Check the condition blink	0 : Display off 1 : Normal display

Note 1 : It is necessary to check STA0 and STA1 at the same time. The error is happened by sending data at executing command.

Note 2 : The status check will be enough to check STA0/STA1.

Note 3 : STA2/STA3 are valid in auto mode STA0/STA1 are invalid.

#### Status checking flow

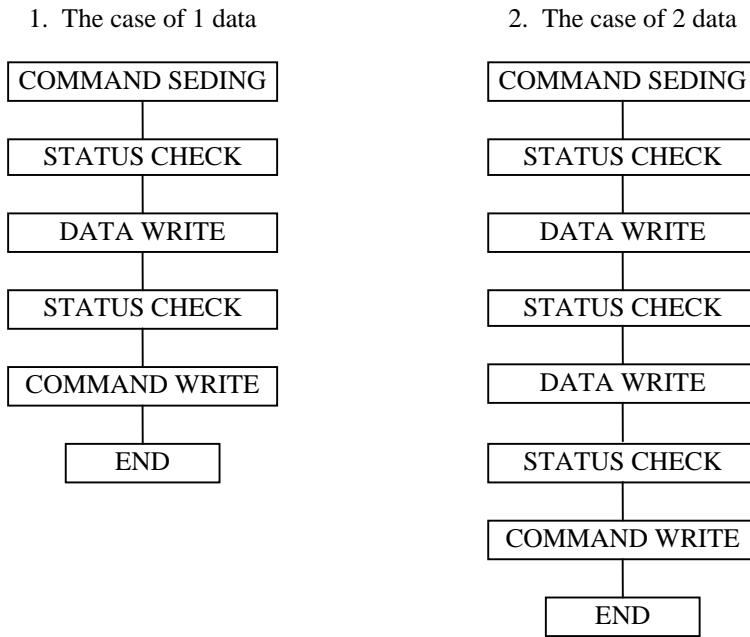


Note 4 : It is impossible to save status check in the case of command of MSB0. To have the delay time cannot be save status check. The interrupt of hardware is happened at the end of lines. If command of MSB0 is sent in this period, the command executing is waited. The state of waiting doesn't be known without to check status. The sending next command or data is disregarded or rewrites data of waiting command.

● Data Set

In T6963C, the data have been set and command executes.

The order of procedure of command sending



Note : In case of over 2 data sending, the last data (or last 2 data) is valid.

▼ **Description of Command**

● Register Set

Code	Hex	Function	D1	D2
00100001	21H	Cursor Pointer Set	X ADRS	Y ADRS
00100010	22H	Offset Register Set	Data	00H
00100100	24H	Address Pointer Set	Low ADRS	High ADRS

(1) Cursor Pointer Set

The position of cursor is specified by X ADRS, Y ADRS. The cursor position is moved only by this command. The cursor pointer doesn't have the function of increment and decrement. The shift of cursor are set by this command. X ADRS, Y ADRS are specified following.

X ADRS            00H~4FH (Lower 7bits are valid)  
 Y ADRS            00H~1FH (Lower 5bits are valid)

1 screen drive	2 screens drive
X ADRS 00~4FH	X ADRS 00~4FH
Y ADRS 00H~0FH	Y ADRS 00H~0FH Upper screen
	Y ADRS 10H~1FH Lower screen

(2) Offset Register Set

The offset register is used to determine external character generator RAM area.

T6963C has 16 bit address lines as follow.

MSB														LSB	
ad15	ad14	ad13	ad12	ad11	ad10	ad9	ad8	ad7	ad6	ad5	ad4	ad3	ad2	ad1	ad0

The upper 5 bit (ad15~ad11) are determined by offset register. The middle 8 bit (ad10~ad3) are determined by character code. The lower 3 bit (ad2~ad0) are determined by vertical counter. The lower 5 bit of D1 (data) are valid. The data format of external character generator RAM.

The relationship of display RAM address and offset register

Data of offset register	CG RAM HEX address(start-end)
00000	0000-07FFH
00001	0800-0FFFH
00010	1000-17FFH
11100	E000-E7FFH
11101	E800-EFFFH
11110	F000-F7FFH
11111	F800-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	1FH
	1402H	04H
	1403H	04H
	1404H	04H
	1405H	04H
	1406H	04H
1407H	00H	

(Example 2)

The relationship of display RAM data and display character

	( RAM Data )	( Character )
	21H	A
	22H	B
	83H	γ
	24H	D
	25H	E
	86H	ζ

Display character

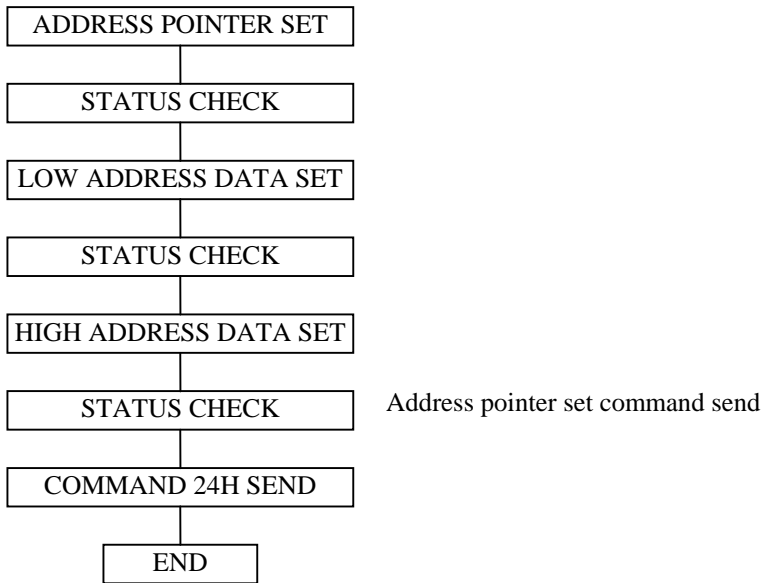
Note : γ and ζ are displayed by character generator RAM.



### (3) Address Pointer Set

The address pointer set command is used to indicate the start address for writing (or reading) to external RAM.

The flow chart address pointer set command



#### ● Control Word Set

Code	Hex	Function	D1	D2
01000000	40H	Text home address set	Low address	High address
01000001	41H	Text area set	Columns	00H
01000010	42H	Graphic home address set	Low address	High address
01000011	43H	Graphic area set	Columns	00H

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

#### (1) Text Home Address Set

The starting address of external display RAM for Text display is defined by this command. The text home address shows the left end and most upper position.

The relationship of 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=L : 32 columns  
 DUAL=H, MDX=L, MD0=L, MD1=H : 4 lines

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

(2) Graphic Home Address Set

The starting address of external display RAM for Graphic display is defined by this command. The graphic home address shows the left end most upper line.

The relationship of 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=L : 32 columns  
 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) Text Area Set

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

(Example)

LCD size : 20 columns, 4 lines  
 Text home address : 0000H  
 Text area : 0014H  
 MD2=H, MD3=L : 32 columns  
 DUAL=H, MDS=L, MD0=L, MD1=H : 4 lines

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



#### (4) Graphic Area Set

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

(Example)

LCD size : 20 columns, 2 lines  
Text home address : 0000H  
Text area : 0014H  
MD2=H, MD3=L : 32 columns  
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

|-----> LCD <-----|

The address in graphic area can be continuous and RAM area can be used without ineffective area, if graphic area is defined the same number as the actual column number of LCD display.

#### ● Mode Set

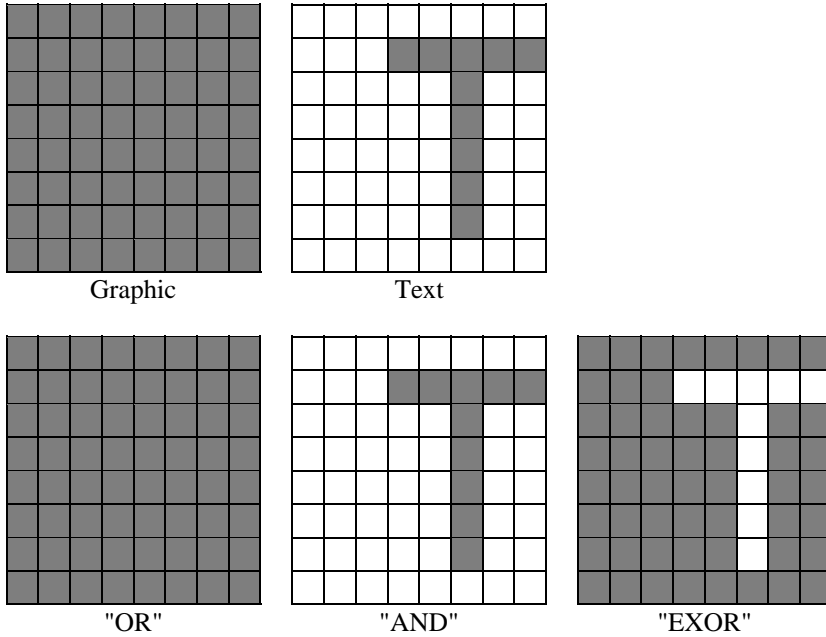
Code	Function	Operand
1000x000	"OR" Mode	---
1000x001	"EXOR" Mode	---
1000x011	"AND" Mode	---
1000x100	"TEXT ATTRIBUTE" Mode	---
1000xxx	Internal Character Generator Mode	---
10001xxx	External Character Generator Mode	---

x : Don't care

The display mode is defined by this command. The display mode don't have changed until to send next this command. Logically "OR", "EXOR", "AND" of text and graphic display can be displayed.

When internal character generator mode is selected, character code 00H~7FH are selected from built-in character generator ROM. The character code 80H~FFH are automatically selected external character generator RAM.

(Example)



Note : Only text display is attributed, because attribute data is located in graphic RAM area.

Attribute function

"Reverse display", "Character blink" and "Inhibit" are called "Attribute". The attribute data is written in the graphic area defined by control word set command. The mode set command selects text display only and graphic display cannot be displayed.

The attribute data of the 1st character in text area is written at the 1st byte in graphic area, and attribute data of n-th character is written at the n-th byte in graphic area. Attribute function is defined as follow.

Attribute RAM byte 

x	x	x	x	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

● Display Mode

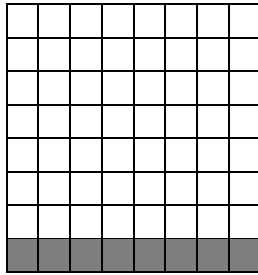
Code	Function	Operand
10010000	Display off	---
1001xx10	Cursor on, blink off	---
1001xx11	Cursor on, blink on	---
100101xx	Text on, graphic off	---
100110xx	Text off, graphic on	---
100111xx	Text on, graphic on	---

1	0	0	1	d3	d2	d1	d0
---	---	---	---	----	----	----	----

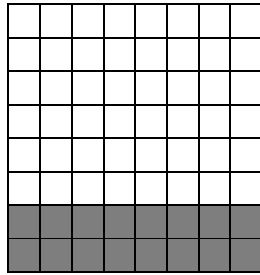
● Cursor Pattern Select

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

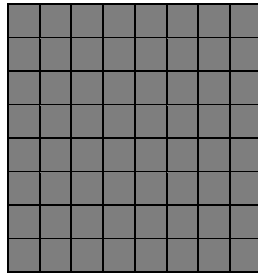
When cursor display is ON, this command selects the cursor pattern from 1 line to 8 lines. The cursor address is defined by cursor pointer set command.



1 line cursor



2 lines cursor



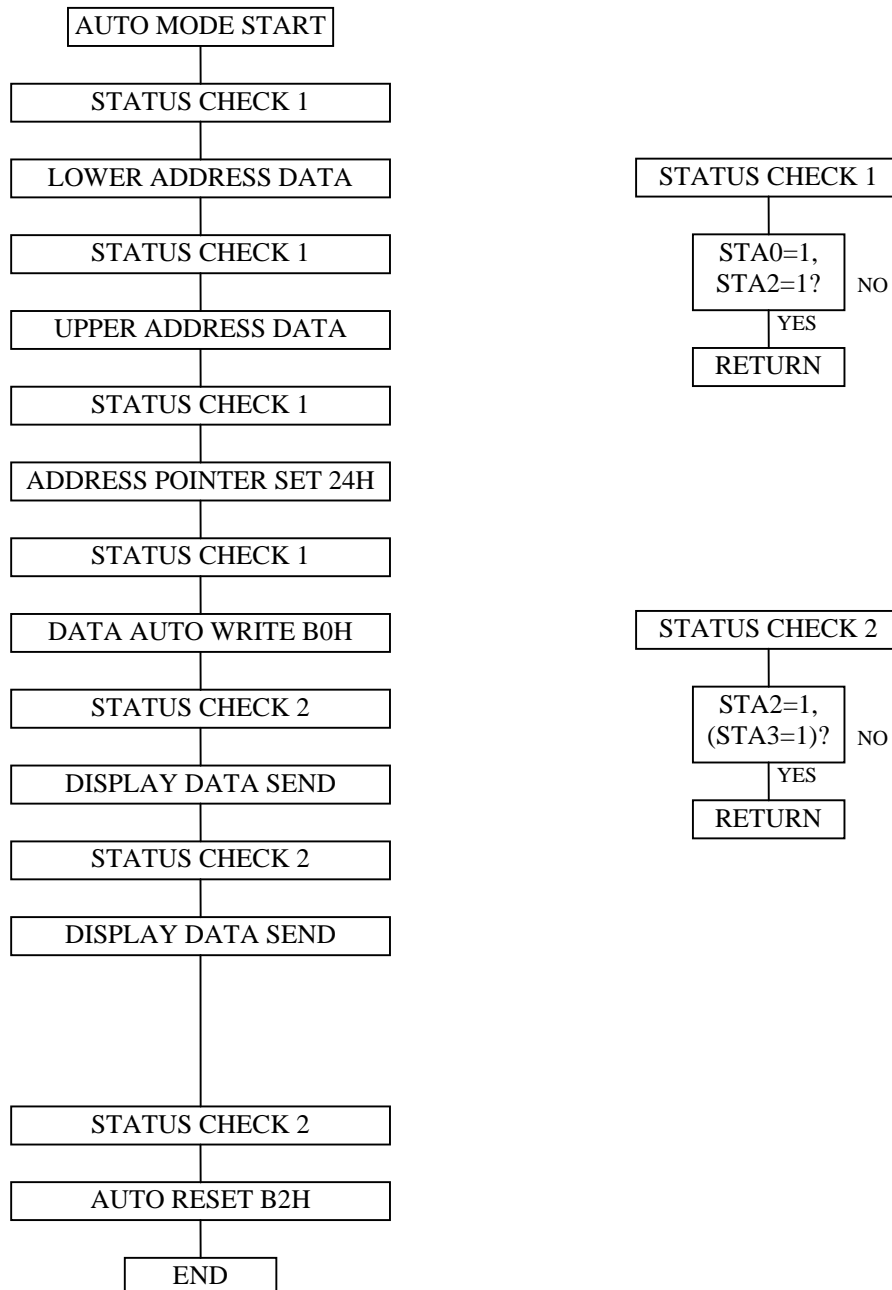
8 lines cursor

● Data Auto Read/Write

Code	Hex	Function	Operand
10110000	B0H	Data auto write set	---
10110001	B1H	Data auto read set	---
10110010	B2H	Auto reset	---

This command is convenient to send full screen data from external display RAM. After setting auto mode, "Data write (or read)" command is not necessary between each data. "Data auto write (or read)" command should follow the "Address pointer set" and address pointer is automatically increment by + 1 after each data. After sending (or receiving) all data "Auto reset" is necessary to return normal operation because all data is regarded "Display data" and no command can be accepted in the auto mode.

Note : Status check for auto mode (STA2,STA3) should be checked between each data. Auto reset should be performed after checking STA3=1 (STA2=1). Please refer following flow chart.

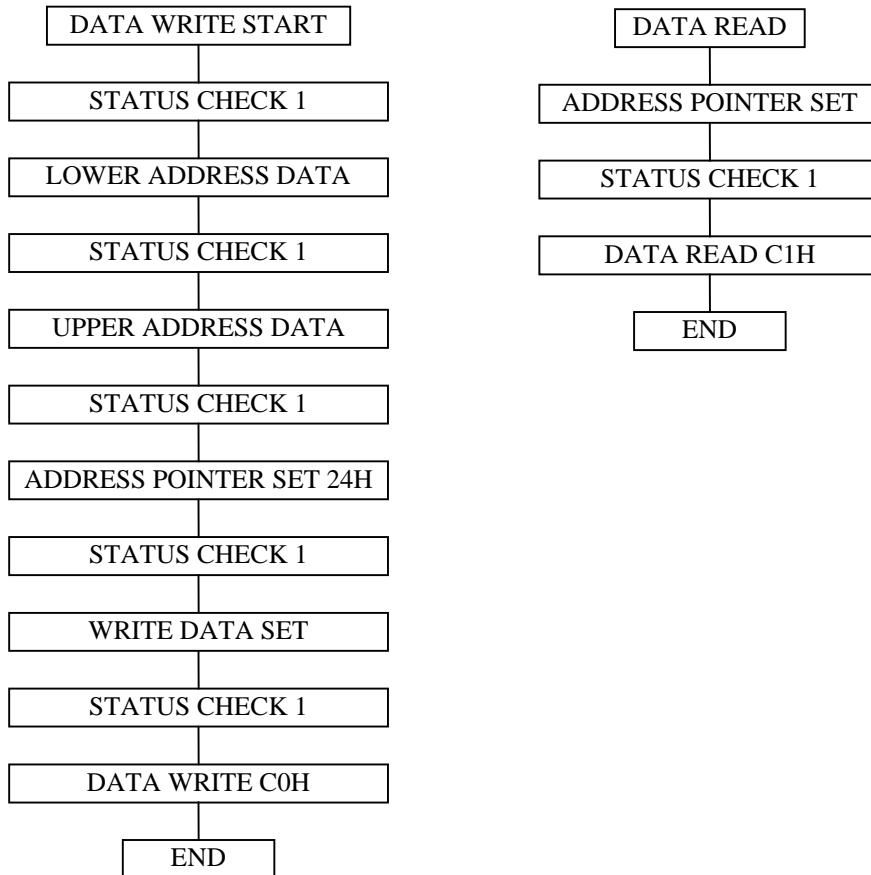


● Data Read Write

Code	Hex	Function	Operand
11000000	C0H	Data write and ADP increment	Data
11000001	C1H	Data read and ADP increment	---
11000010	C2H	Data write and ADP decrement	Data
11000011	C3H	Data read and ADP decrement	---
11000100	C4H	Data write and ADP nonvariable	Data
11000101	C5H	Data read and ADP nonvariable	---

This command is used for data write from MPU to external display RAM, and data read from external display RAM to MPU. Data write/data read should be executed after setting address by address pointer set command. Address pointer can be automatically increment or decrement by setting this command.

Note : This command is necessary for each 1 byte data. Please refer following flow chart.



● Screen Peek

Code	Hex	Function	Operand
11100000	E0H	Screen Peek	---

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

The status (STA6) should be checked just after "Screen peek" command. If the address determined by "Address pointer Set" command is not in graphic area, this command ignored and status flag (STA6) is set. Please refer following flow chart.

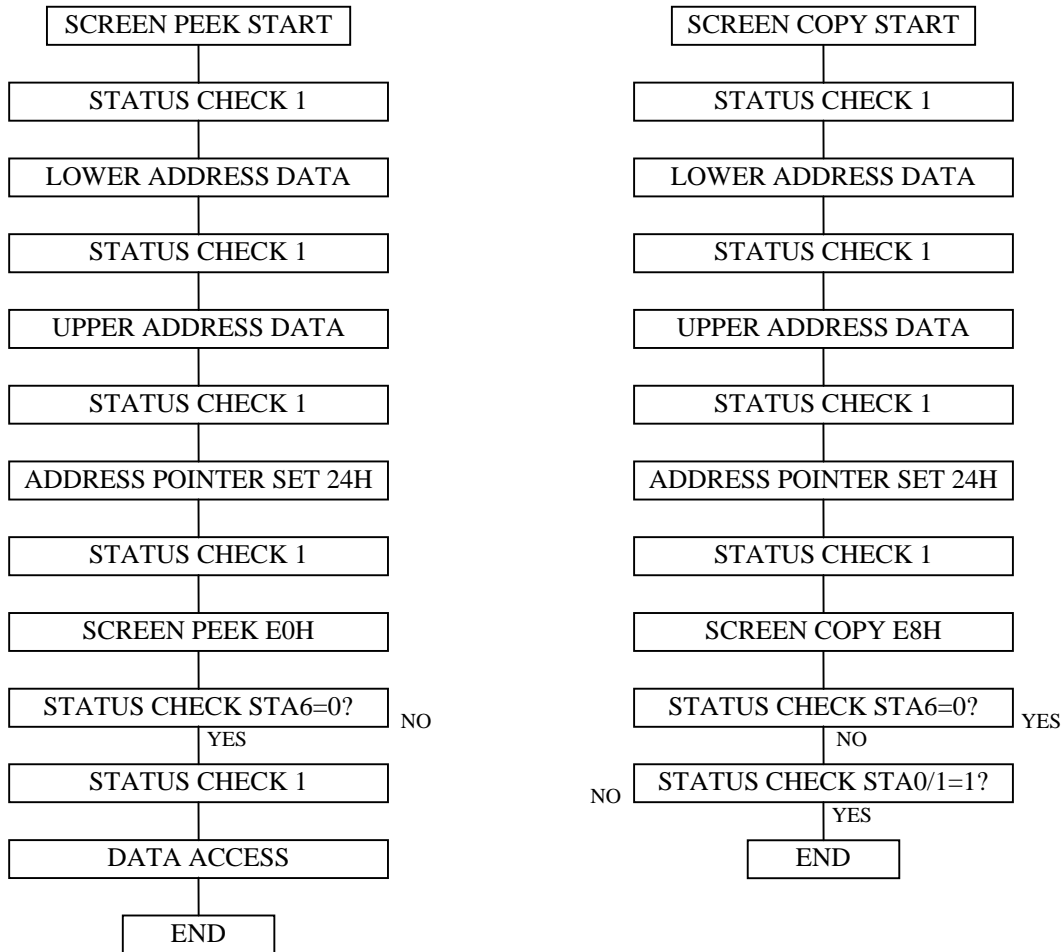
● Screen Copy

Code	Hex	Function	Operand
11101000	E8H	Screen copy	---

This command is used to copy displayed 1 line data to graphic area. The start point of 1 line data in the screen is determined by the address pointer. Please refer following flow chart.

Note 1 : In attribute function, this command is invalid. (Because attribute data is in the graphic area.)

Note 2 : In case of 2 screen drive, this command is invalid. (Because T6963C cannot separate upper screen data and lower screen data.)

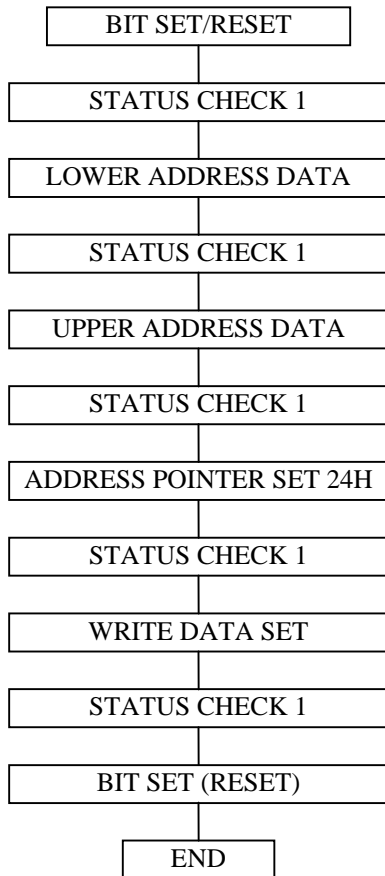




● Bit Set/Reset

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)	---

This command is used to set or reset a bit of 1 byte is specified by address pointer. Plural bits in the 1 byte data cannot be set/reset at a time. Please refer following flow chart.



▼ **Command List**

<b>Command</b>	<b>Code</b>	<b>D1</b>	<b>D2</b>	<b>Function</b>
Register Set	00100001	X address	Y address	Cursor pointer set
	00100010	Data	00H	Offset register set
	00100100	Low address	High address	Address pointer set
Control Word Set	01000000	Low address	High address	Text home address set
	01000001	Columns	00H	Text area set
	01000010	Low address	High address	Graphic home address set
	01000011	Columns	00H	Graphic area set
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 lines cursor
	10100010	---	---	3 lines cursor
	10100011	---	---	4 lines cursor
	10100100	---	---	5 lines cursor
	10100101	---	---	6 lines cursor
	10100110	---	---	7 lines cursor
	10100111	---	---	8 lines cursor
Data Auto Read/Write	10110000	---	---	Data auto write set
	10110001	---	---	Data auto read set
	10110010	---	---	Auto reset
Data Read Write	11000000	Data	---	Data write and ADP increment
	11000001	---	---	Data read and ADP increment
	11000010	Data	---	Data write and ADP decrement
	11000011	---	---	Data read and ADP decrement
	11000100	Data	---	Data write and ADP nonvariable
	11000101	---	---	Data read and ADP nonvariable
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)

▼ Character Code Map

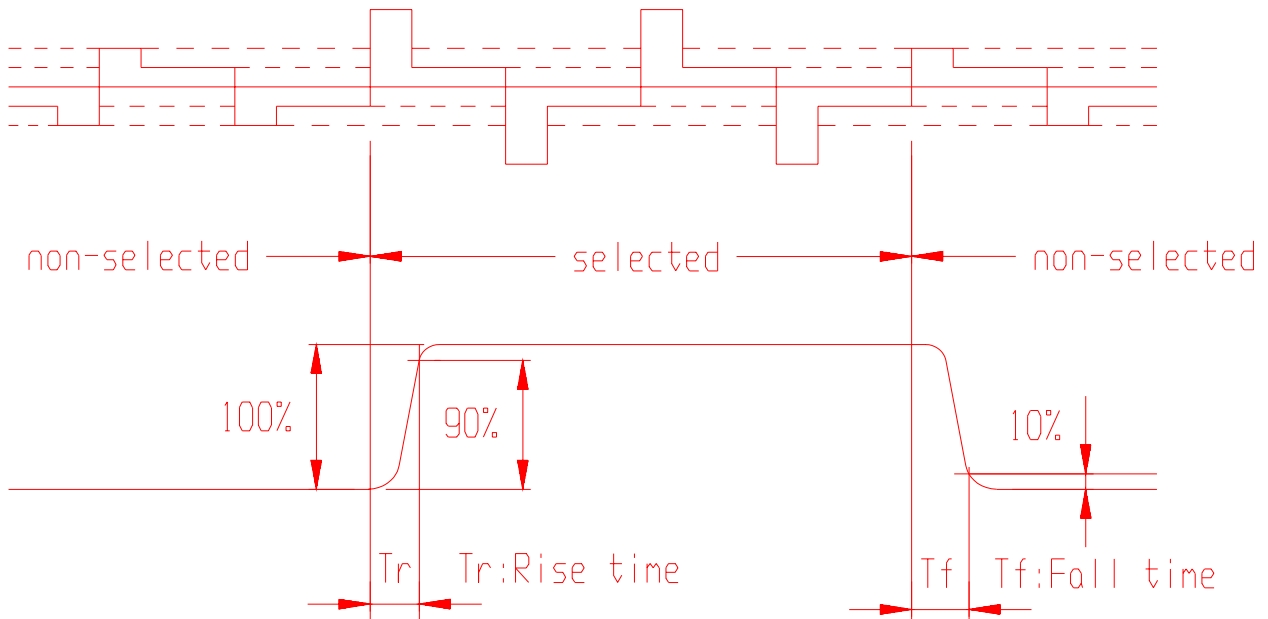
ROM CODE 0101

LSB MSB	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0		!	"	#	\$	%	&	'	(	)	*	+	,	-	.	/
1	@	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
2	a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3	P	Q	R	S	T	U	U	W	X	Y	Z	[	\	]	^	_
4	'	ab	c	d	e	f	g	h	i	j	k	l	m	n	o	
5	p	q	r	s	t	u	v	w	x	y	z	{		}	~	
6	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
7	a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

# ■ ELECTRO-OPTICAL CHARACTERISTICS ( $V_{OP} = 17.5V, T_a = 25^{\circ}C$ )

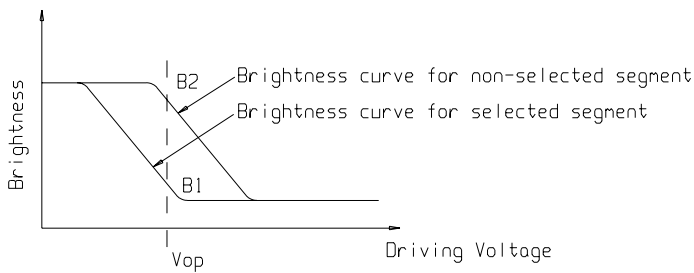
Item	Symbol	Condition	Min	Typ	Max	Unit	Remarks	Note
Response time	Tr	---	---	347	---	ms	---	1
	Tf	---	---	117	---	ms	---	1
Contrast ratio	Cr	---	---	20.0	---	---	---	2
Viewing angle range	$\theta$	$Cr \geq 2$	32	---	---	deg	$\varnothing = 90^{\circ}$	3
			28	---	---	deg	$\varnothing = 270^{\circ}$	3
			38	---	---	deg	$\varnothing = 0^{\circ}$	3
			59	---	---	deg	$\varnothing = 180^{\circ}$	3

Note1: Definition of response time.

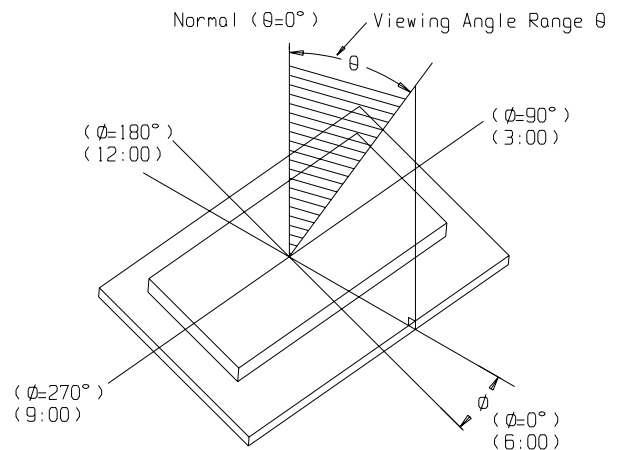


Note2: Definition of contrast ratio 'Cr' .

$$Cr = \frac{\text{Brightness of non-selected segment}(B2)}{\text{Brightness of selected segment}(B1)}$$



Note3: Definition of viewing angle range 'θ'.



## ■ INTERFACE PIN CONNECTIONS

Pin No.	Symbol	Level	Description
1	VSS	0V	Ground
2	VDD	5.0V	Supply voltage for Logic
3	VEE	---	Input voltage for LCD
4	WR	L	Write signal
5	RD	L	Read signal
6	CE	L	Chip enable signal
7	C/D	H/L	H : Instruction Code, L : Data
8	RESET	L	Reset signal
9	D0	H/L	Data bit 0
10	D1	H/L	Data bit 1
11	D2	H/L	Data bit 2
12	D3	H/L	Data bit 3
13	D4	H/L	Data bit 4
14	D5	H/L	Data bit 5
15	D6	H/L	Data bit 6
16	D7	H/L	Data bit 7
17	FS	H/L	Font select signal ( H : 6 x 8 dots, L : 8 x 8 dots )
18	NC	---	No connection
19	LEDA	4.2V	Back light anode
20	LEDK	0V	Back light cathode