A M O T E C

ADM2004A

SPECIFICATIONS OF LCD MODULE

Features

1. 5x8 dots
2. Built-in controller (ST7066 or equivalent)
3. +5V power supply (also available for =3.0V)
4. 1/16 duty cycle
5. Easy interface with 4-bit or 8-bit MPU
6. Backlight optional
7. 20x4 characters

Outline dimension

Unit: mm

Absolute maximum ratings

Item	Symbol	Standard			Unit
Power voltage	V_{DD}-V_{SS}	-0.3	-	7.0	V
Input voltage	VIN	-0.3	-	VDD+0.3	
Operating temperature range	Top	0	-	+50	℃
Storage temperature range	Tst	-10	-	+60	

*Wide temperature range is available
(operating/storage temperature as −20~+70/-30~+80℃)

Block diagram

Interface pin description

Pin no.	Symbol	External connection	Function
1	VSS	Power supply	Signal ground for LCM (GND)
2	VDD		Power supply for logic for LCM
3	V0		Contrast adjust
4	RS	MPU	Register select signal
5	R/W	MPU	Read/write select signal
6	E	MPU	Operation (data read/write) enable signal
7~10	DB0~DB3	MPU	Four low order bi-directional three-state data bus lines. Used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation.
11~14	DB4~DB7	MPU	Four high order bi-directional three-state data bus lines. Used for data transfer between the MPU
15	LED+	LED BKL power Supply	Power supply for BKL (Anode)
16	LED-		Power supply for BKL (GND)

Contrast adjust
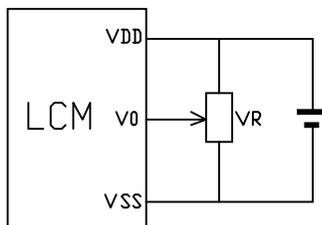
V_{DD}~V_0: LCD Driving voltage
VR: 10k~20k

Optical characteristics

STN type display module (Ta=25 ℃, VDD=5.0V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Viewing angle	θ	$C_r \geqslant 2$	-60	-	35	deg
	Φ		-40	-	40	
Contrast ratio	C_r		-	8	-	-
Response time (rise)	T_r	-	-	200	250	ms
Response time (fall)	T_r	-	-	300	350	

FSTN type display module (Ta=25 ℃, VDD=5.0V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Viewing angle	θ	$C_r \geqslant 2$	-60	-	45	deg
	Φ		-40	-	40	
Contrast ratio	C_r		-	10	-	-
Response time (rise)	T_r	-	-	300		ms
Response time (fall)	T_r	-	-	280		

Electrical characteristics

DC characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage for LCD	$V_{DD}-V_0$	Ta =25 ℃	-	4.5	-	V
Input voltage	V_{DD}		4.7	-	5.5	
Backlight supply voltage	V_F		-	-	-	
Supply current	I_{DD}	Ta=25 ℃, V_{DD}=5.0V	-	1.5	3	mA
Input leakage current	I_{LKG}		-	-	1.0	uA
"H" level input voltage	V_{IH}		2.2	-	V_{DD}	V
"L" level input voltage	V_{IL}	Twice initial value or less	0	-	0.6	
"H" level output voltage	V_{OH}	LOH=-0.25mA	2.4	-	-	
"L" level output voltage	V_{OL}	LOH=1.6mA	-	-	0.4	

Read cycle (Ta=25 ℃, VDD=5.0V)

Parameter	Symbol	Test pin	Min.	Typ.	Max.	Unit
Enable cycle time	t_c	E	500	-	-	ns
Enable pulse width	t_w		230	-	-	
Enable rise/fall time	t_r, t_f		-	-	20	
RS; R/W setup time	t_{su}	RS; R/W	40	-	-	
RS; R/W address hold time	t_h		10	-	-	
Data output delay	t_d	DB0~DB7	-	-	120	
Data hold time	t_{dh}		5	-	-	

Write cycle

Parameter	Symbol	Test pin	Min.	Typ.	Max.	Unit
Enable cycle time	t_c	E	500	-	-	ns
Enable pulse width	t_w		230	-	-	
Enable rise/fall time	t_r, t_f		-	-	20	
RS; R/W setup time	t_{su1}	RS; R/W	40	-	-	
RS; R/W address hold time	t_{h1}		10	-	-	
Data output delay	t_{su2}	DB0~DB7	80	-	-	
Data hold time	t_{h2}		10	-	-	

Write mode timing diagram
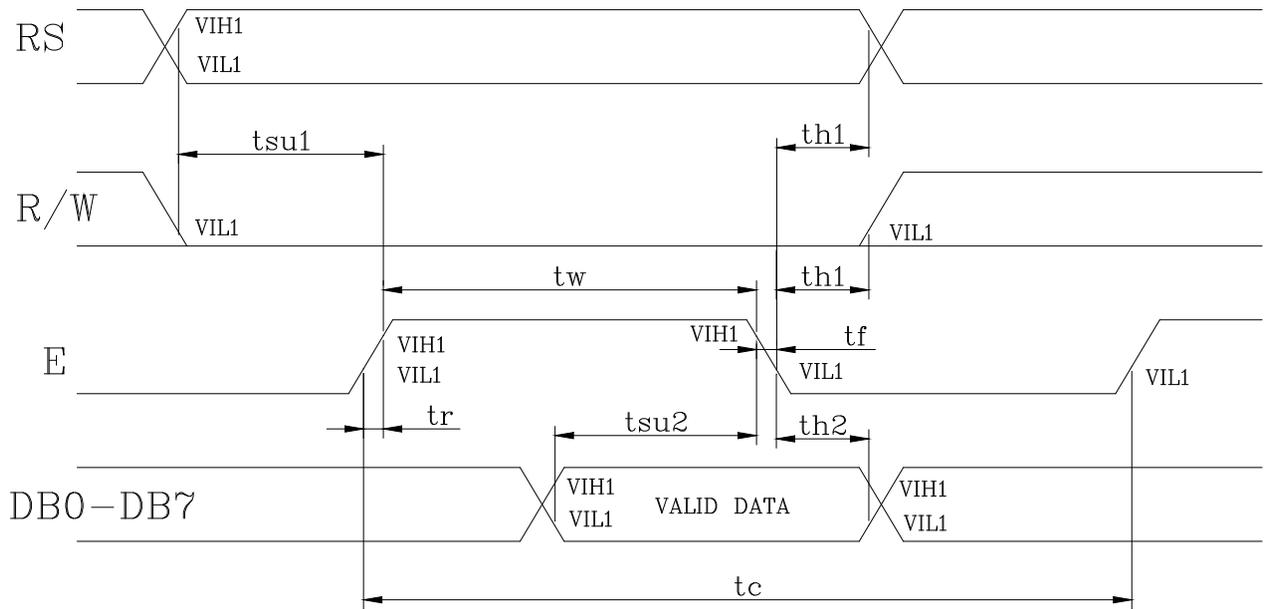
Read mode timing diagram
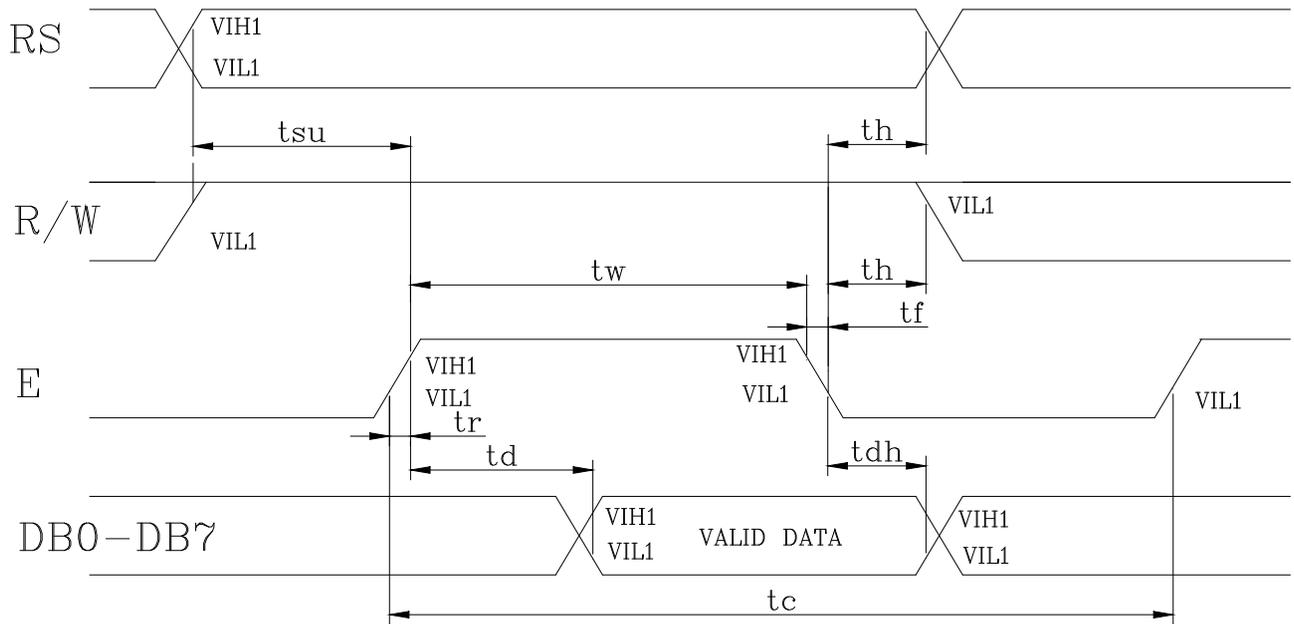
Instruction description

Outline

To overcome the speed difference between the internal clock of KS0066U and the MPU clock, KS0066U performs internal operations by storing control in formations to IR or DR. The internal operation is determined according to the signal from MPU, composed of read/write and da ta bus (Refer to Table7).

Instructions can be divided largely into four groups:

1) KS0066U function set instructions (set display methods, set data length, etc.)
2) Address set instructions to internal RAM
3) Data transfer instructions with internal RAM
4) Others

The address of the internal RAM is automatically increased or decreased by 1.

Note: during internal operation, busy flag (DB7) is read "High".

Busy flag check must be preceded by the next instruction.

When an MPU program with checking the busy flag (DB7) is ma de, it must be necessary 1/2 fuss for executing the next instruction by the falling edge of the "E" signal after the busy flag (DB7) goes to "LOW".

Contents

1) Clear display

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	0	1

Clear all the display data by writing "20H" (space code) to all DDRAM address, and set DDRAM address to "00H" into AC (address counter).

Return cursor to the original status, namely, brings the cursor to the left edge on the fist line of the display.

Make the entry mode increment (I/D="High").

2) Return home

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	1	-

Return home is cursor return home instruction.

Set DDRAM address to "00H" into the address counter.

Return cursor to its original site and return display to i ts original status, if shifted.

Contents of DDRAM does not change.

3) Entry mode set

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	I/D	SH

Set the moving direction of cursor and display.

I/D: increment / decrement of DDRAM address (cursor or bli nk)

When I/D="high", cursor/blink moves to right and DDRAM address is increased by 1.

When I/D="Low", cursor/blink moves to left and DDRAM address is increased by 1.

*CGRAM operates the same way as DDRAM, when reading from or writing to CGRAM.

(I/D="high". shift left, I/D="Low". Shift right).

4) Display ON/OFF control

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	1	D	C	B

Control display/cursor/blink ON/OFF 1 bit register.

D: Display ON/OFF control bit

When D="High", entire display is turned on.

When D="Low", display is turned off, but display data remains in DDRAM.

C: cursor ON/OFF control bit

When D="High", cursor is turned on.

When D="Low", cursor is disappeared in current display, but I/D register preserves its data.

B: Cursor blink ON/OFF control bit

When B="High", cursor blink is on, which performs alternately between all the "High" data and display characters at the cursor position.

When B="Low", blink is off.

5) Cursor or display shift

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	1	S/C	R/L	-	-

Shifting of right/left cursor position or display without writing or reading of display data.

This instruction is used to correct or search display data. (Refer to Table 6)

During 2-line mode display, cursor moves to the 2nd line after the 40th digit of the 1st line.

When display data is shifted repeatedly, each line is shifted individually.

When display shift is performed, the contents of the address counter are not changed.

Shift patterns according to S/C and R/L bits

S/C	R/L	Operation
0	0	Shift cursor to the left, AC is decreased by 1
0	1	Shift cursor to the right, AC is increased by 1
1	0	Shift all the display to the left, cursor moves according to the display
1	1	Shift all the display to the right, cursor moves according to the display

6) Function set

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	F	-	-

DL: Interface data length control bit

When DL="High", it mans 8-bit bus mode with MPU.

When DL="Low", it mans 4-bit bus mode with MPU. Hence, DL is a signal to select 8-bit or 4-bit bus mode.

When 4-but bus mode, it needs to transfer 4-bit data twice.

N: Display line number control bit

When N="Low", 1-line display mode is set.

When N="High", 2-line display mode is set.

F: Display line number control bit

When F="Low", 5x8 dots format display mode is set.

When F="High", 5x11 dots format display mode.

7) Set CGRAM address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0

Set CGRAM address to AC.

The instruction makes CGRAM data available from MPU.

8) Set DDRAM address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0

Set DDRAM address to AC.

This instruction makes DDRAM data available form MPU.

When 1-line display mode (N=LOW), DDRAM address is form "00H" to "4FH".

In 2-line display mode (N=High), DDRAM address in the 1st line form "00H" to "27H", and DDRAM address

In the 2nd line is from "40H" to "67H".

9) Read busy flag & address

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0

This instruction shows whether KS0066U is in internal operation or not.

If the resultant BF is "High", internal operation is in progress and should wait BF is to be LOW, which by then if the nest instruction can be performed. In this instruction you can also read the value of the addr ess counter.

10) Write data to RAM

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	0	D7	D6	D5	D4	D3	D2	D1	D0

Write binary 8-bit data to DDRAM/CGRAM.

The selection of RAM from DDRAM, and CGRAM, is set by the previous address set instruction (DDRAM address set, CGRAM address set).

RAM set instruction can also determine the AC direction to RAM.

After write operation. The address is automatically increased/decreased by 1, according to the entry mode.

11) Read data from RAM

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
1	1	D7	D6	D5	D4	D3	D2	D1	D0

Read binary 8-bit data from DDRAM/CGRAM.

The selection of RAM is set by the previous address set instruction. If the address set instruction of RAM is not performed before this instruction, the data that has been read first is inv alid, as the direction of AC is not yet determined. If RAM data is read several times without RAM address instructions set before, read operation, the correct RAM data can be obtained from the second. But the first data would be incorrect, as there is no t ime margin to transfer RAM data. In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction,

It also transfers RAM data to output data register.

After read operation, address counter is automatically incr eased/decreased by 1 according to the entry mode.

After CGRAM read operation, display shift may not be executed correctly.

NOTE: In case of RAM write operation, AC is increased/decreased by 1 as in read operation.

At this time, AC indicates next add ress position, but only the previous data can be read by the read instruction.

Instruction table

Instruction	Instruction code										Description	Execution Time (fosc= 270 KHZ)
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRA and set DDRAM address to "00H" from AC	1.53ms
Return Home	0	0	0	0	0	0	0	0	1	-	Set DDRAM address to "00H" From AC and return cursor to Its original position if shifted. The contents of DDRAM are not changed.	1.53ms
Entry mode Set	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction And blinking of entire display	39us
Display ON/ OFF control	0	0	0	0	0	0	1	D	C	B	Set display (D), cursor (C), and Blinking of cursor (B) on/off Control bit.	
Cursor or Display shift	0	0	0	0	0	1	S/C	R/L	-	-	Set cursor moving and display Shift control bit, and the Direction, without changing of DDRAM data.	39us
Function set	0	0	0	0	1	DL	N	F	-	-	Set interface data length (DL: 8-Bit/4-bit), numbers of display Line (N: =2-line/1-line) and, Display font type (F: 5x11/5x8)	39us
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address Counter.	39us
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address Counter.	39us
Read busy Flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal Operation or not can be known By reading BF. The contents of Address counter can also be read.	0us
Write data to Address	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43us
Read data From RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43us

NOTE: When an MPU program with checking the busy flag (DB7) is made, it must be necessary 1/2fosc is necessary for executing the next instruction by the falling edge of the "E" signal after the busy flag (DB7) goes to "Low".

DDRAM address:

Display position

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53
14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27
54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67

DDRAM address

Standard character pattern

Upper 4bit / Lower 4bit	LLLL	LLLH	LLHL	LLHH	LHLL	LHLH	LHHL	LHHH	HLLL	HLLH	HLHL	HLHH	HHLL	HHLH	HHHL	HHHH
LLLL	CG RAM (1)		0	@	P	`	p					–	ヲ	タ	ミ	p
LLLH	(2)	!	1	A	Q	a	q				。	ア	チ	ム	q
LLHL	(3)	"	2	B	R	b	r				「	イ	ツ	メ	モ	θ
LLHH	(4)	#	3	C	S	c	s				」	ウ	テ	モ	∞
LHLL	(5)	$	4	D	T	d	t				、	エ	ト	ヤ	Ω
LHLH	(6)	%	5	E	U	e	u				・	オ	ナ	ユ	▪	Ü
LHHL	(7)	&	6	F	V	f	v				ヲ	カ	ニ	ヨ	ρ	Σ
LHHH	(8)	'	7	G	W	g	w				ァ	キ	ヌ	ラ	g	π
HLLL	(1)	(	8	H	X	h	x				ィ	ク	ネ	リ	√	x̄
HLLH	(2)	)	9	I	Y	i	y				ゥ	ケ	ノ	ル	¹	y
HLHL	(3)	*	:	J	Z	j	z				ェ	コ	ハ	レ	j	千
HLHH	(4)	+	;	K	[	k	{				ォ	サ	ヒ	ロ	ˣ	万
HHLL	(5)	,	<	L	¥	l						ャ	シ	フ	ワ	¢	円
HHLH	(6)	-	=	M	]	m	}				ュ	ス	ヘ	ン	±	÷
HHHL	(7)	.	>	N	^	n	→				ョ	セ	ホ	゛	円	
HHHH	(8)	/	?	O	_	o	←				ッ	ソ	マ	゜	ö	█

LCM Operation Precautions

(1) It is an indispensable condition to drive LCD within the specified voltage limit since the higher voltage than the limit causes the shorter LCD life. An electrochemical reaction due to direct current causes LCD's undesirable deterioration, so that the use of direct current driver should be avoided.

(2) Response time will be extremely delayed at lower temperature than the specified operating temperature range and on the other hand LCD's show dark blue color in the higher temperature. However, those phenomena do not mean any malfunction or display out of order with LCD's, which will come back in the specified operation temperature range.

(3) If the display area is pushed hard during operation, some font s will be abnormally displayed. But it resumes normal condition after turning off once.

(4) A slight dew depositing on terminals could be a cause for electrochemical reaction resulting in terminal open circuit.

(5) Display contrast varies with the change of liquid crystal driving voltage (V_o). Adjust V_o to show the best contrast.

(6) Condensation on terminals can cause an electrochemical reaction disrupting the terminal circuit. Therefore, it is suggested to use the LCD under the relative condition of 40°C, 85% RH.

(7) When turning the power on, input each signal after the positive/negative voltage becomes stable.
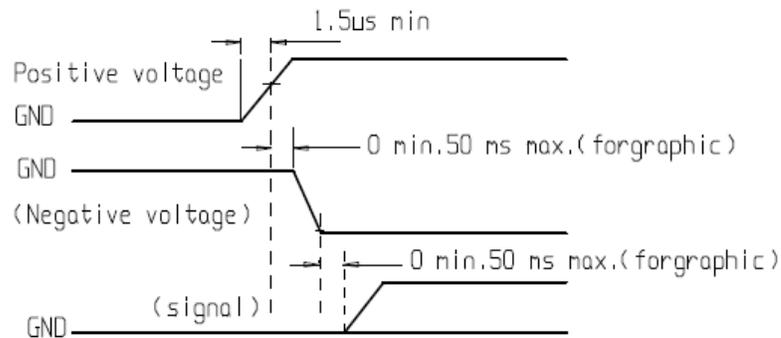
(8) The backlight must be operated within the condition of specification. The overload current or too high voltage will reduce the life time or destroy the backlight.

Handing Precautions

(1) The display panel is made of glass. Do not subject it to a mechanical shock by dropping it or impact.

(2) If the display panel is damaged and the liquid crystal substance leaks out, be sure not to get any in your mouth. If the substance contacts your skin or clothes, wash it off using soap and water.

(3) Do not apply excessive force to the display surface or the adjoining areas since this may cause the color tone to vary.

(4) The polarizer covering the display surface of the LCD module is soft and eas ily scratched. Please handle the polarizer carefully.

(5) If the display surface becomes contaminated, breathe on the surface and gently wipe it with a soft dry cloth. If it is heavily contaminated, moisten cloth with one of the following solvents :

- Isopropyl alcohol

- Ethyl alcohol

(6) Solvents other than those above -mentioned may damage the polarizer. Especially, do not use the following.

- Water

- Ketone

- Aromatic solvents

(7) Exercise care to minimize corrosion of the electrode. Corrosion of the elec trodes is accelerated by water droplets, moisture condensation or a current flow in a high -humidity environment.

(8) Install the LCD Module by using the mounting holes. When mounting the LCD module make sure it is free of twisting, warping and distortion. In particular, do not forcibly pull or bend the IO cable or the backlight cable.

(9) Do not attempt to disassemble or process the LCD module.

(10) NC terminal should be open. Do not connect anything.

(11) If the logic circuit power is off, do not apply the input signals.

(12) To prevent destruction of the elements by static electricity, be careful to maintain an optimum work environment.

- Be sure to ground the body when handling the LCD modules.

- Tools required for assembling, such as soldering irons, mus t be properly grounded.

- To reduce the amount of static electricity generated, do not conduct assembling and other work under dry conditions.

- The LCD module is coated with a film to protect the display surface. Exercise care when peeling off this protec tive film since static electricity may be generated.

Installing Precautions

The hole in the printed circuit board is used to fix LCM as shown in the picture below. Attend to the following items when installing the LCM.

(1) Cover the surface with a transparent protective plate to protect the polarizer and LC cell.
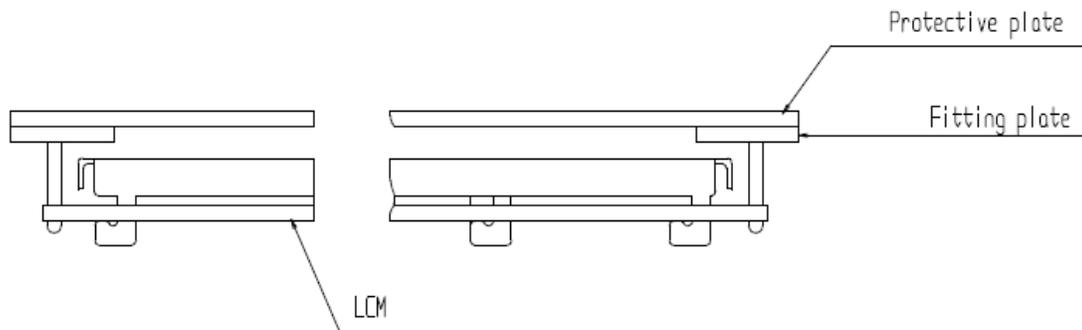
(2) When assembling the LCM into other equipment, the spacer to the bit between the LCM and the fitting plate should have enough height to avoid causing stress to the module surface, refer to the i ndividual specifications for measurements. The measurement tolerance should be 0.1mm.

Storage Precautions

In case of storing for a long period of time for the purpose of replacement use, the following ways are recommended.

(1) Storage in a polyethylene ba g with the opening sealed so as not to enter fresh air outside in it, and with no desiccant.

(2) Placing in a dark place where neither exposure to direct sunlight nor light is, keeping temperature in the range

from -30°C to 80°C

(3) Storing with no touch on polarizer surface by anything else. (It is recommended to store them as they have been contained in the inner container at the time of delivery from us.)

Safety

(1) It is recommended to crush damaged or unnecessary LCDs into pieces and wash them off wit h solvents such as acetone and ethanol, which should later be burned.
(2) If any liquid leaks out of a damaged glass cell and comes in contact with the hands, wash off thoroughly with soap and water.

Others

Liquid crystals solidify under low temperature (below the storage temperature range) leading to defective orientation or
the generation of air bubbles (black or white). Air bubbles may also be generated if the module is subject to a low temperature. If the LCD modules have been operating for a long time showing the same display patterns, the display patterns may remain on the screen as ghost images and a slight contrast irregularity may also appear. A normal operating status can be regained by suspending use for some time. It should be noted that this ph enomenon does not adversely affect performance reliability. To minimize the performance degradation of the LCD modules resulting from destruction caused by static electricity
etc., exercise care to avoid holding the following sections when handling the mod ules.
- Exposed area of the printed circuit board.
- Terminal electrode sections.