



SPECIFICATION FOR LCD MODULE

CUSTOMER:	TM Standard LCM
CUSTOMER NO.:	-----
PRODUCT NO.:	TM24064BBCWVBYD
PRODUCT TYPE:	Graphic Matrix STN
VERSION:	1.1

- Preliminary specification
- Final specification

CUSTOMER APPROVED	
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PREPARED BY	CHECKED BY	VERIFIED BY QA DEPT.	APPROVED BY

REVISION RECORD

Version	Page	Revision Items	Name	Date
1.0		First release	Lihong Zhou	2007.12.26
1.1		Change the outline drawing(Page 5) Change the recommend power supply circuit(Page 7) Change the description of PIN21(Page 8) Change forward voltage of LED(Page 13)	KXH	2009-5-14

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1 Description

The TM24064BBCWVBYD, a Graphic LCM unit consists of 240(segment)×64(common) dots dot-matrix LCD panel, LCD driver and controller, bias circuits on a single PCB. Incorporating mask ROM-based character generator and display data RAM in the controller LSI, the unit can efficiently display the desired dot-matrix under microprocessor controller.

- ◆ Wide viewing angle
- ◆ Wide operation temp.
- ◆ Built-in temp. compensation circuit
- ◆ Built-in character generator
- ◆ Requirements on environmental protection: RoHS.

2 Features

Item	Contents
LCD type	STN
	Positive
LCD Duty	1/64
LCD Bias	1/9
Polarizer	Transflective
LCD background color	Yellow-Green
Segment color	Blue-black
Backlighting	LED
Backlighting type	Bottom
Backlighting color	Yellow-Green
View direction	6:00
Operating temperature	-20℃~70℃
Storage temperature	-30℃~80℃
LCD Controller	SAP1024
Frame	SPCC(Black)
Technology	COB
Data Transfer	8 Bit Parallel

3 Absolute maximum ratings

(VSS=0V, Ta=25°C)

Parameter	Symbol	Min	Max	Unit	Remark
Logic circuit supply voltage	V _{DD}	-0.3	+6.0	V	---
Input voltage of logic control or data pins	V _I	-0.3	V _{DD} +0.3	V	---
Voltage of V ₀	V ₀	-20	0.3	V	---
Voltage of V _{EE}	V _{EE}	-20	0.3	V	---
LCD driving voltage	V _{LCD}	-0.3	20	V	Note [3-2]
Operating temperature range	T _{OP}	-20	+70	°C	Note [3-3]
Storage temperature range	T _{ST}	-30	+80	°C	

Note [3-1]: No parameter is allowed to exceed these maximum ratings.

Note [3-2]: LCD operating voltage is calculated as V_{LCD}=V_{DD}-V_S.

Note [3-3]: 95% RH MAX (40 °C ≥ Ta);

Maximum wet-bulb temperature is 39°C or less. (Ta >40 °C) No dew condensation.

Note [3-4]: Only operation is guaranteed at operating temperature. Contrast, response time and another display quality are evaluated at +25°C.

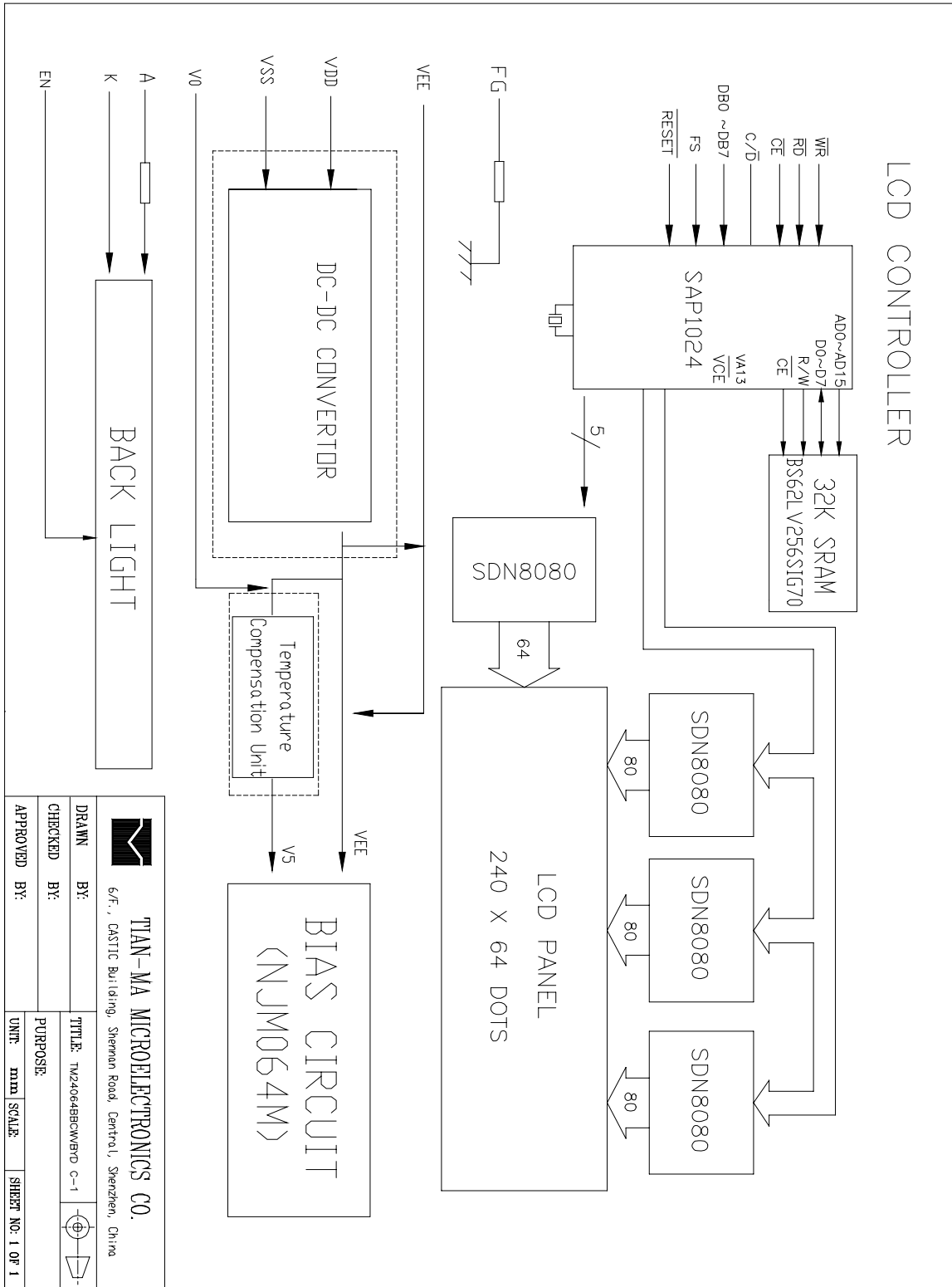
4 Mechanical Characteristics

4.1 Mechanical features

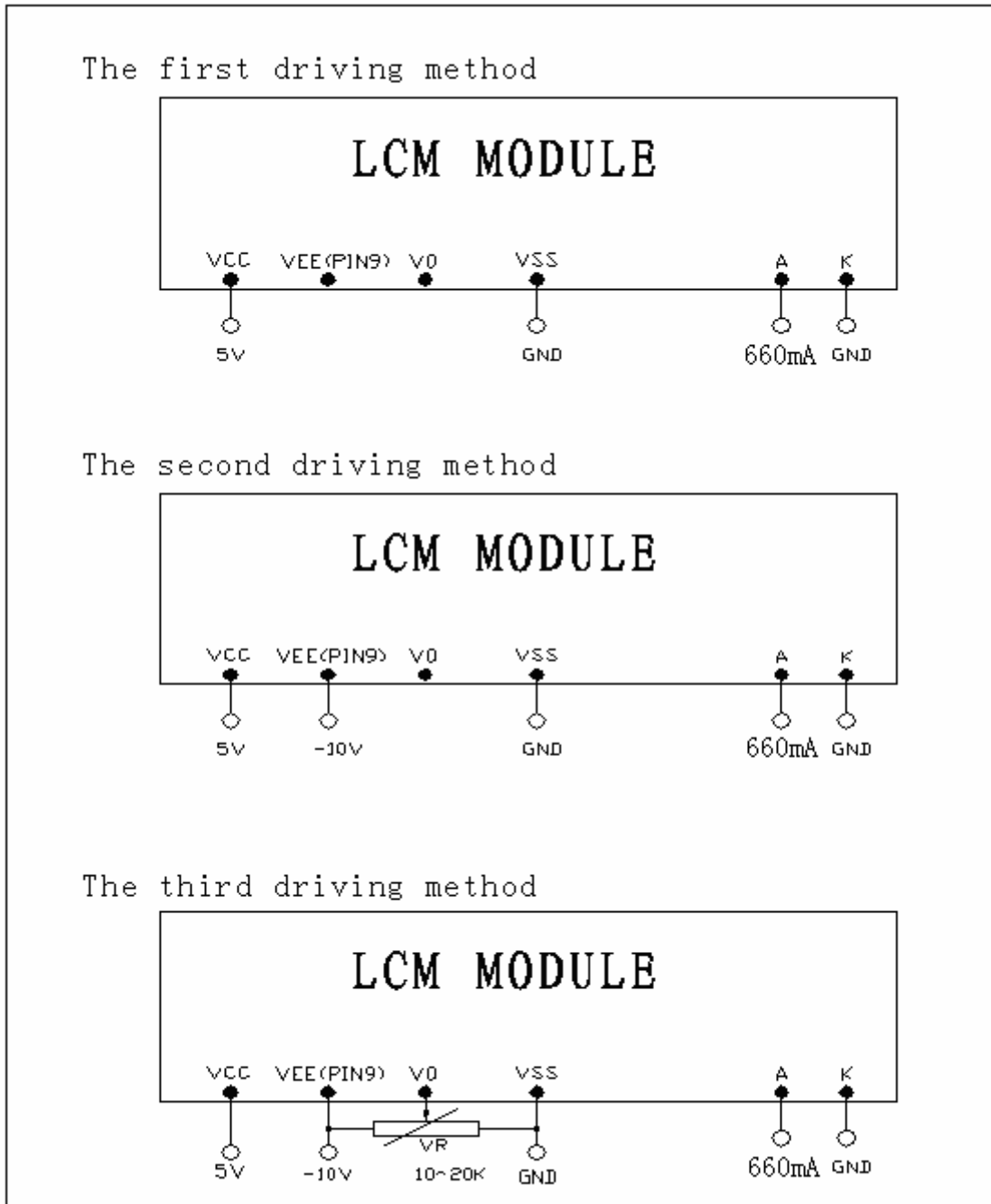
Parameter	Standard Value	Unit
Display type	Graphics Matrix LCM	--
Character size(W×H)	8×8 or 6×8	mm
Number of dots	240× 64	--
View area (W×H)	132.00 × 39.00	mm
Active Area (W×H)	127.16 × 33.88	mm
Dot Size (W×H)	0.49 × 0.49	mm
Dot Pitch (W×H)	0.53 × 0.53	mm
Module size(W×H×D)	180.00 × 65.00 × 14.50(MAX)	mm
Module total weight (approx)	200	g

5 Circuit

5.1 Block Diagram



5.2 Recommend power supply circuit



Note [5-1]: The first driving method is the default method, if you needn't DC-DC circuit and you want to input negative power supply by VEE directly (the second driving method), please remove the R10 on the PCB first.

Note [5-2]: If you want to control the contrast outside, please add the VR and its circuit. Both first driving methods and second driving method can be changed to the third driving method.

6 Interface description

Pin No.	Symbol	I/O	Description
1	FG	I	Frame Ground
2	V _{SS}	I	Ground
3	V _{CC}	I	Power supply voltage for logic circuits and LCD(+5V)
4	V ₀	I/O	V _{OP} adjust control pin, refer to 5.2
5	/WR	I	Write execution control signal. Low active
6	/RD	I	Read execution control signal. Low active
7	/CE	I	Chip enable signal for SAP1024. Low active
8	C/D	I	Command/data select control pin. When C/D=1, it writes command to the internal register or reads the register status. When C/D=0, it writes data to the display data memory or reads from it.
9	NC (VEE)	I/O	The output voltage of DC/DC converter for LCD(-), or the Input for V _{EE}
10	/RESET	I	Reset execution control pin
11	DB0	I/O	Data bus bit0(LSB)
12	DB1	I/O	Data bus bit1
13	DB2	I/O	Data bus bit2
14	DB3	I/O	Data bus bit3
15	DB4	I/O	Data bus bit4
16	DB5	I/O	Data bus bit5
17	DB6	I/O	Data bus bit6
18	DB7	---	Data bus bit7(MSB)
19	FS	I	The internal character font size select pin. When FS=1, the character font is 6×8. When FS=0, the character font is 8×8
20	NC (EN)	I	No connection
21	A		Power supply voltage for LED(+), 660mA
22	K		Power supply voltage for LED(-)

7 Instruction Code & Timing characteristics

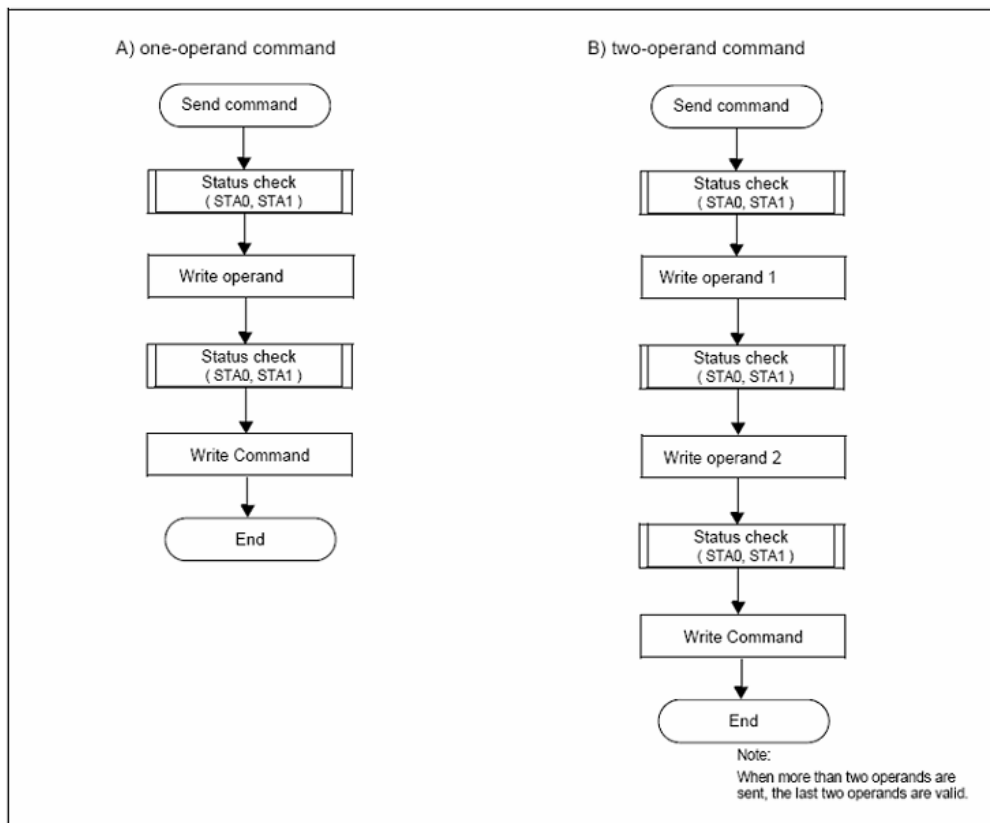
7.1 Command and initial code

The module TM24064BBCWVBYD includes SAP1024 as its driver. After reset, we have to use some commands to set up the display. And we may use this when we want to change the display type. We explain some commands below. For more details, please refer to the datasheet of SAP1024.

COMMAND	CODE	OPERAND 1	OPERAND 2	FUNCTION
Register Setting	0010 0001	X address	Y address	Set cursor pointer
	0010 0010	Data	00H	Set offset register
	0010 0100	Low address	High address	Set address pointer
Set Control Word	0100 0000	Low address	High address	Set text home address
	0100 0001	Columns	00H	Set text area
	0100 0010	Low address	High address	Set graphic home address
	0100 0011	Columns	00H	Set graphic area
Mode Set	1000 x000			OR mode
	1000 x001			EXOR mode
	1000 x011			AND mode
	1000 x100			Text Attribute mode
	1000 0xxx			Internal CG ROM mode
	1000 1xxx			External CG RAM mode
Display mode	1001 0000			Display OFF.
	1001 xx10			Cursor ON, blink OFF.
	1001 xx11			Cursor ON, blink ON.
	1001 01xx			Text ON, graphic OFF.
	1001 10xx			Text OFF, graphic ON.
	1001 11xx			Text ON, graphic ON.
Cursor Pattern Select	1010 0000			Select one-line cursor.
	1010 0001			Select two-line cursor.
	1010 0010			Select three-line cursor.
	1010 0011			Select four-line cursor.
	1010 0100			Select five-line cursor.
	1010 0101			Select six-line cursor.
	1010 0110			Select seven-line cursor.
	1010 0111			Select eight-line cursor.
Data Auto Read/Write	1011 0000			Select Data Auto Write
	1011 0001			Select Data Auto Read
	1011 0010			Reset Auto Read/Write

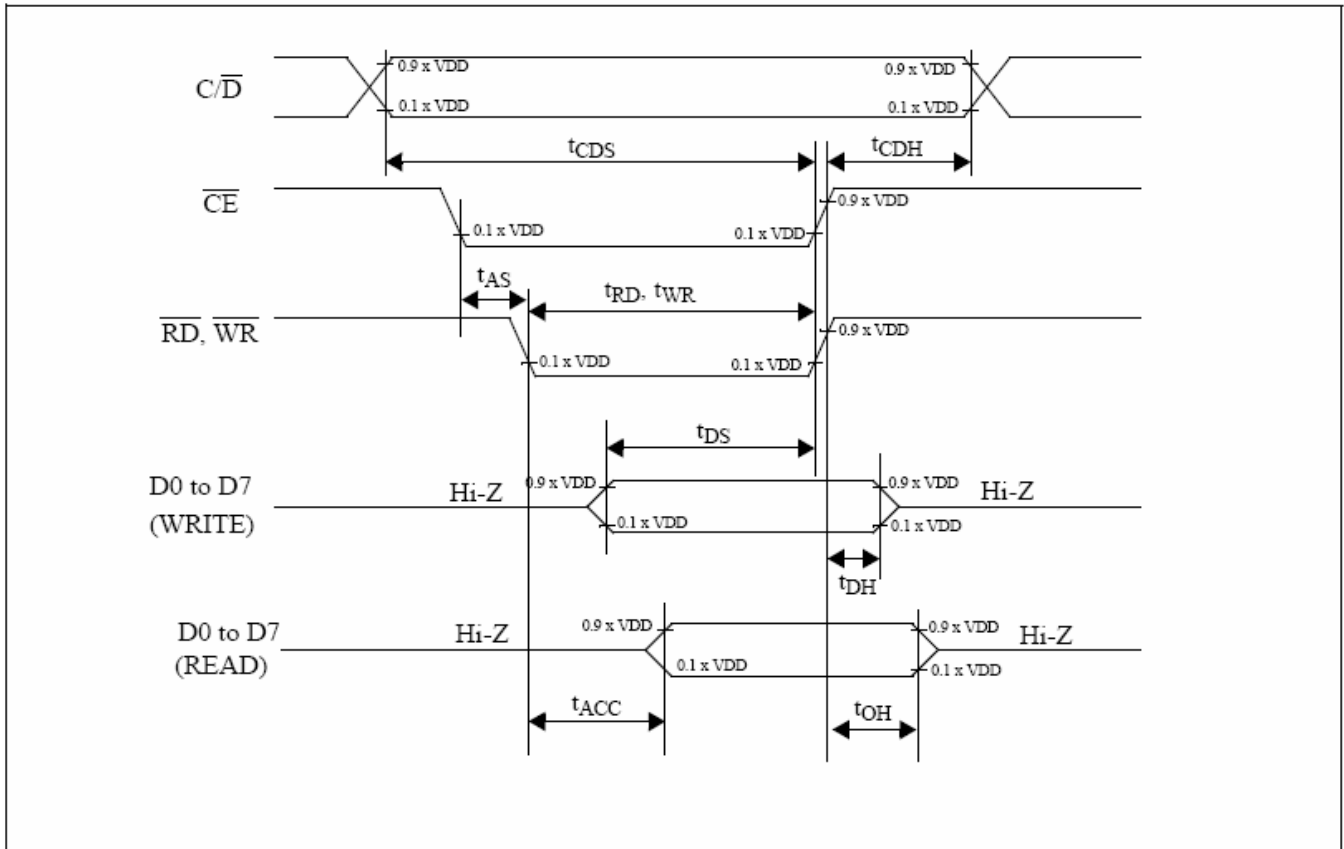
COMMAND	CODE	OPERAND 1	OPERAND 2	FUNCTION
Data READ / WRITE	1100 0000	Data		Data Write and increment Address Pointer
	1100 0001			Data Read and increment Address Pointer
	1100 0010	Data		Data Write and decrement Address Pointer.
	1100 0011			Data Read and decrement Address Pointer
	1100 0100	Data		Data Write and Keep Address Pointer
	1100 0101			Data Read and Keep Address Pointer
Screen Peek	1110 0000			Screen peek
Screen Copy	1110 1000			Screen copy
Bit Set/Reset	1111 0xxxx			Bit Reset
	1111 1xxxx			Bit Set
	1111 x000			Bit 0
	1111 x001			Bit 1
	1111 x010			Bit 2
	1111 x011			Bit 3
	1111 x100			Bit 4
	1111 x101			Bit 5
	1111 x110			Bit 6
	1111 x111			Bit 7

The SAP1024 has three types of commands: one-byte command, two-byte command and three-byte command. A one-byte command only has only command code. A two-byte command has a command code and an operand (data). A three-byte command has a command code and two operands (data). When a command is sent, its operands should be sent out first. The flow chart for sending a command is given below.



7.2 Interface Timing characteristics

Please refer to SAP1024's datasheet for more details.

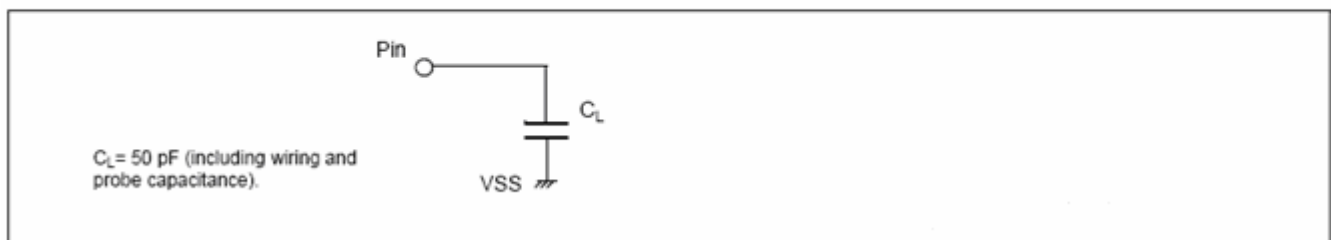


$V_{DD} = 5\text{ V} \pm 10\%$; $V_{SS} = 0\text{ V}$; $T_{amb} = -20\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$.

symbol	parameter	MIN.	MAX.	test conditons	Unit
t_{CDS}	C/\bar{D} set-up time	100			ns
t_{CDH}	C/\bar{D} hold time	10			ns
t_{RD}, t_{WR}	\bar{RD} , \bar{WR} pulse width	80			ns
t_{AS}	Address set-up time	0			ns
t_{AH}	Address hold time	0			ns
t_{DS}	Data set-up time	80			ns
t_{DH}	Data hold time	40		Note	ns
t_{ACC}	Access time		150	Note	ns
t_{OH}	Output hold time	10	50	Note	ns

Note:

The measurement is with the load circuit connected.



7.3 Character generator code map

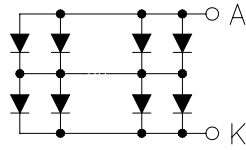
MSB \ LSB	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0		!	"	#	\$	%	&	'	()	*	+	,	-	.	/
1	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
2	a	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3	P	Q	R	S	T	U	W	X	Y	Z	[\]	^	_	
4	\	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
5	p	q	r	s	t	u	v	w	x	y	z	{		}	~	
6	ç	ü	ë	ä	å	ä	ä	ö	è	é	è	é	ì	í	î	ä
7	é	æ	ê	ö	ö	ö	ö	ü	ö	ö	ö	ø	ø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

8 Electrical characteristics

Parameter	Symbol	Condition	MIN	TYP	MAX	UNIT	
Logic circuit supply voltage	V_{DD}	--	4.8	5.0	5.2	V	
Power supply LCD(-)	V_{OUT}			-10			
Input voltage for logic circuit	"H" level	$V_{DD}=5.0V$	$0.8 V_{DD}$	V_{DD}	$V_{DD} + 0.3$		
	"L" level		$V_{SS} - 0.3$	V_{SS}	$0.2V_{DD}$		
Output voltage for logic circuit	"H" level		--	V_{DD}	--		
	"L" level		--	V_{SS}	--		
Logic power supply current (Without backlighting)	I_{DD}			--	10		--
Used driver IC	SAP1024(Controller)+SDN8080(COM/SEG Driver)						

9 LED backlight characteristics

CIRCUIT DIAGRAM (LED: 2×66=132 dies)



Item	Symbol	Condition	MIN.	TYP.	MAX.	Unit	Remark
Forward voltage	V_f	$I_f=660\text{mA}$	4.0	4.1	4.4	V	---
Forward current	I_f	$V_f=4.2\text{V}$	--	660	---	mA	---
Wavelength	λ_p	$I_f=660\text{mA}$	569	572	575	nm	Note [9-1,2]
Lifetime	t	--	--	TBD	--	hour	Note [9-3]

Note [9-1]: The wavelength is measured with the bare LED backlight unit.

Note [9-2]: If the backlight is used above its' driving voltage or current for a long time, its lifetime will reduce or it will cause poor reliability.

Note [9-3]: The backlight lifetime lasts until the luminance reduces to 50% of its initial value.

10 Optical Characteristics

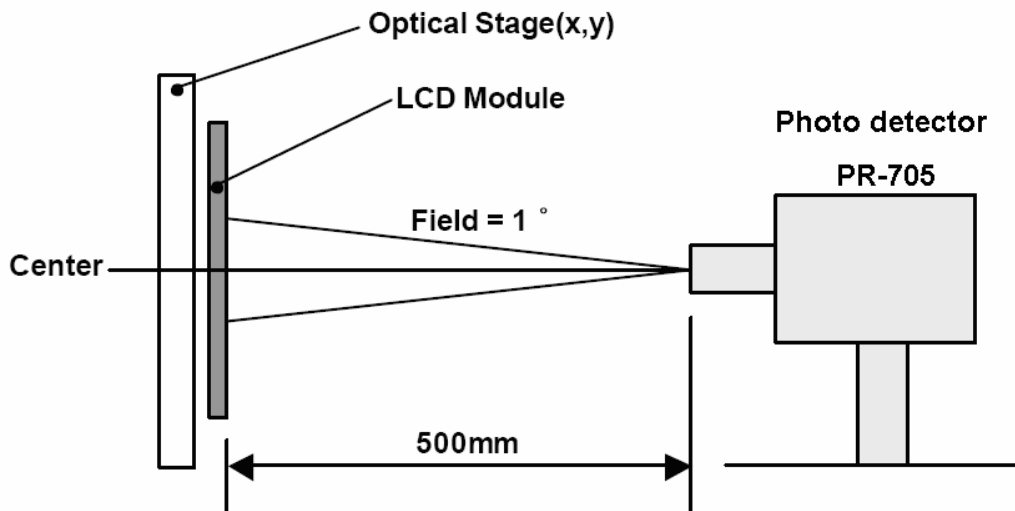
1/64Duty, 1/9Bias, $V_0=11.0V$ (Note [10-2]), $f=70Hz$

Parameter	Symbol	Ratings			Unit	Measuring Temp.	Remark	
		Min	Type	Max.				
Contrast ratio	C_r ($\theta=0^\circ, \Phi=0^\circ$)	---	3.0	---	---	25°C	Note[10-1,3]	
Response time	Turn on	t_{on}	---	120	---	ms	25°C	Note[10-1,4]
			---	TBD	---		0°C	
	Turn off	t_{off}	---	200	---	ms	25°C	
			---	TBD	---		0°C	
Viewing angle ($C_r \geq 2$)	Up-down	θ_1 ($\Phi=0^\circ$)	---	45	---	deg	25°C	Note[10-1,5]
			---	35	---			
	Left-right	θ_2 ($\theta=0^\circ$)	---	30	---	deg	25°C	
			---	35	---			
Luminance	Y_L ($\theta=0^\circ, \Phi=0^\circ$)	---	25	---	Cd/m^2	25°C	Note[10-1] ($I_f=660mA$)	
Luminance Uniformity	L_U ($\theta=0^\circ, \Phi=0^\circ$)	70	---	---	%	25°C	Note[10-1,6]	

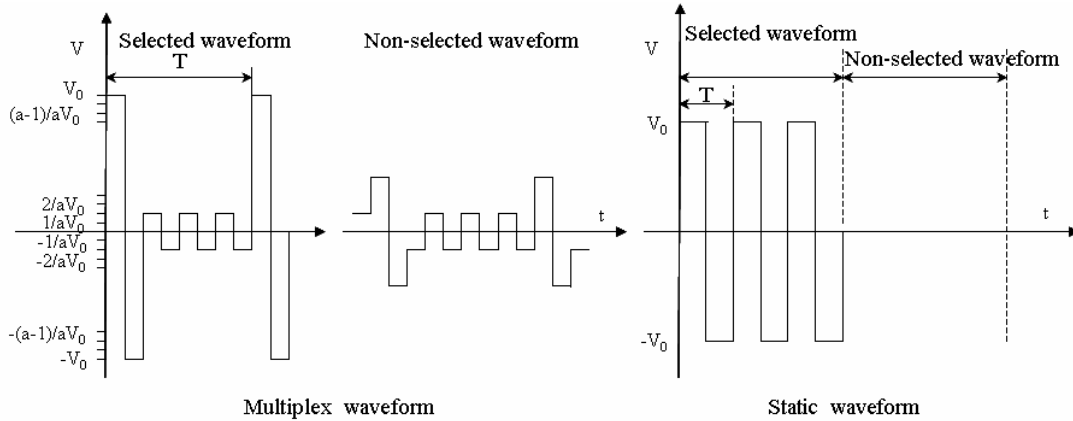
Note [10-1]: Measuring equipments: DMS-501, PR-705.

Measuring condition:

- After stabilizing and leaving the panel alone at a given temperature for 30 min, the measurement should be executed,
- Measuring surroundings: a stable, windless and dark room,
- Measuring temperature: $T_a=25^\circ C$,
- 30 min after lighting the back-light.



Note [10-2]: The maximum and minimum ratings don't mean the LCD works well in the whole range of V_o . V_o must be adjusted to optimize the viewing angle and contrast. Refer to the following definition of drive voltage:



Operating voltage: V_o	Frame frequency: $f=1/T$
Duty: $1/N$	Bias: $1/a$

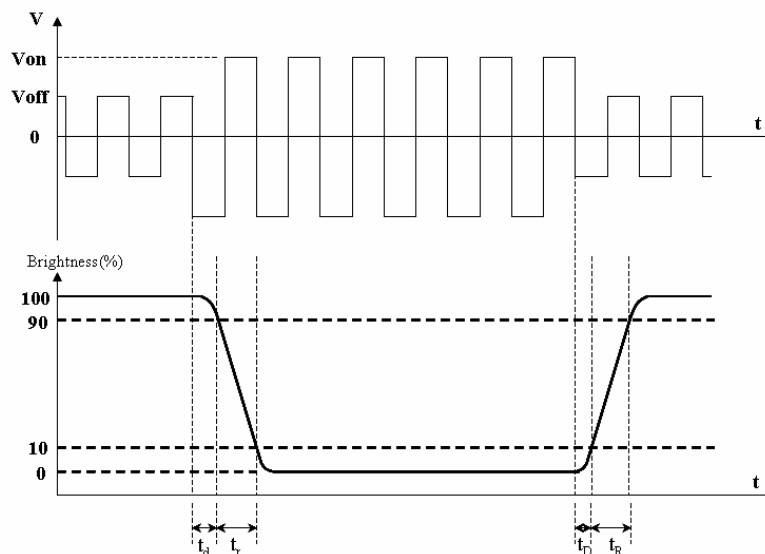
Note [10-3]: Contrast ratio(CR) is defined as follows:

$$CR = \frac{L_{ON} \text{ (Luminance of the ON segments)}}{L_{OFF} \text{ (Luminance of the OFF segments)}}$$

Note [10-4]: Definition of response time:

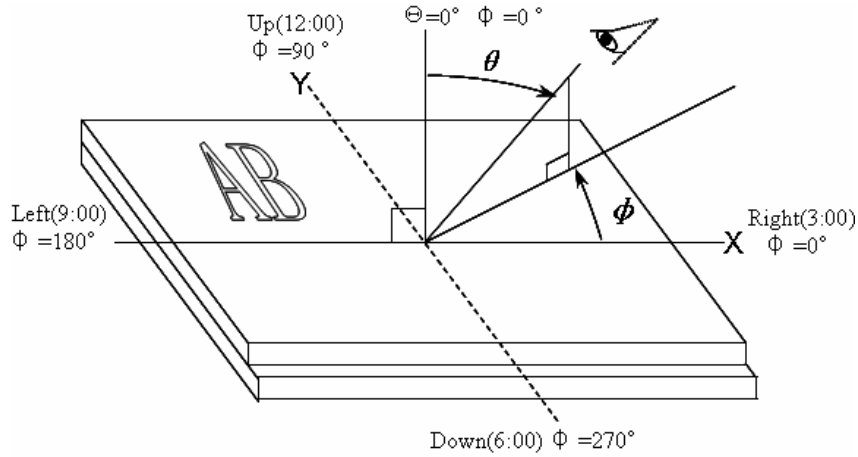
Turn on time (rise time): $t_{on} = t_d + t_r$ (The time that the luminance level reaches 90% of the saturation level from 0% when ON signal is applied)

Turn off time (fall time): $t_{off} = t_d + t_r$ (The time that the luminance level reaches 10% of the saturation level from 100% when OFF signal is applied)

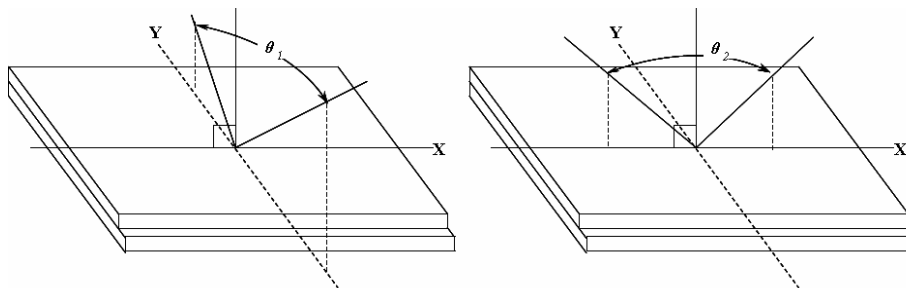


Note [10-5]: Definition of viewing direction

Refer to the picture below marked by θ and Φ



Definition of viewing angle



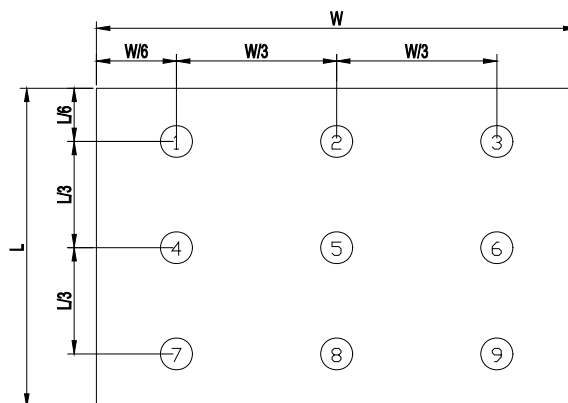
θ_1 ——range of viewing angle from up to down; θ_2 ——range of viewing angle from left to right.

Note [10-6]: The definition of luminance uniformity:

The luminance uniformity is calculated by using following formula.

$$\text{Luminance uniformity (Lu)} = \frac{\text{Minimum luminance from ① to ⑨}}{\text{Maximum luminance from ① to ⑨}}$$

The luminance is measured at near the 9 points shown below.



11 Reliability

11.1 Content of Reliability Test

No.	Test Item	Test condition	Remark	Criterion
1	High Temperature Storage	Ta=80°C, 120H		Remark1 Remark2 Remake3 Remake4
2	Low Temperature Storage	Ta=-30°C, 120H	Note[11-1]	
3	High Temperature Operation	Ta=70°C, 120H		
4	Low Temperature Operation	Ta=-20°C, 120H	Note[11-1]	
5	High Temperature & High Humidity Operation	Ta=60°C,90%RH,120H	Note[11-1]	
6	Temperature Cycle Test (Non-Operating)	-30 °C↔+25 °C↔+80 °C,100 Cycles 30min 5min 30min	Note[11-1]	
7	Vibration Test	Frequency: 10 ~150 Hz, Stroke: 1.5mm Sweep time: 11 min Test Period: 6 Cycles for each direction of X,Y,Z,120 min every direction	Note[11-2]	Remark1 Remark5 Remark6
8	Shock Test	Waveform : Half Sinusoidal Wave Shock Level:50 G, Pulse Width:11 ms, Direction: ±X, ±Y, ±Z, Cycle:3 times	Note[11-2]	

Note [11-1]: No dew condensation to be observed.

Note [11-2]: Vibration test will be conducted to the product itself without putting it in a container.

Note [11-3]: The test sample is inspected after 2 hours or more storing at room temperature and room humidity after each test item is finished.

Note [11-4]: The criteria refer to 11.2.

11.2 Inspection of criteria

Remark NO.	Content
1	Function test is OK. Missing Segment, shorts, unclear segment, non-display, display abnormally, liquid crystal leak are unallowable.
2	After testing, cosmetic defects should not happen, no low temperature bubbles, seal loose and fall, frame rainbow, ACF bubble growing are unallowable in the appearance test.
3	Total current consumption should not be over 10% of initial value.
4	After tests, the contrast ratio must be larger than 70% of its value before.
5	No glass crack, chipped glass, end seal loose frame crack and so on.
6	No structure looseness.

12 Package

TBD

13 Quality level

Examination or Test	At T _a =25°C (Unless otherwise stated)	Inspection				
		Min	Max	Unit	IL	AQL
External Visual Inspection	Under normal illumination and eyesight condition, the distance between eyes and LCD is 25cm.	Refer to appendix A			II	Major 1.0 Minor 2.5
Display Defects	Under normal illumination and eyesight condition, display on inspection.	Refer to appendix B			II	Major 1.0 Minor 2.5
Note: Major defects: Open segment or common, Short, Serious damages, Leakage Miner defects: Others Sampling standard conforms to GB2828						

14 Precautions for Use of LCD Modules

14.1 Handling Precautions

- 14.1.1 The display panel is made of glass. Do not subject it to a mechanical shock by dropping it from a high place, etc.
- 14.1.2 Liquid in LCD is hazardous substance, if the display panel is damaged and the liquid crystal substance inside it leaks out, be sure not to get any in your mouth, if the substance comes into contact with your skin or clothes, thoroughly and promptly wash it off using soap and water.
- 14.1.3 Do not apply excessive force to the display surface or the adjoining areas since this may cause the color tone to vary.
- 14.1.4 Don't touch, push or rub the exposed polarizer covering the display surface of the LCD module with anything harder than an HB pencil lead, the polarizer is soft and easily scratched, handle it carefully.
- 14.1.5 Don't put or attach anything on the display area to avoid leaving any marks on.
- 14.1.6 If the display surface is contaminated or becomes dusty, breathe on the surface and gently wipe it with a soft dry cloth. do not scrub hard to avoid damage the surface. If still not completely clear, moisten cloth with one of the following solvents:
- Isopropyl alcohol
 - Ethyl alcohol
- Solvents other than those mentioned above may damage the polarizer. Especially, do not use the following:
- Water
 - Ketone
 - Aromatic solvents
- 14.1.7 Do not attempt to disassemble the LCD Module.
- 14.1.8 If the logic circuit power is off, do not apply the input signals.
- 14.1.9 Avoid using the same display pattern long time (continuous ON segment).Software must be prepared so that the pattern will be changed

- 14.1.10 To prevent destruction of the elements by static electricity, be careful to maintain an optimum work environment.
- Be sure to ground the body and electric appliances when handling the LCD Modules. It is preferable to use conductive mat on table and wear cotton clothes or conductive processed fibre. Synthetic fibre is not recommended.
 - Tools required for assembly, such as soldering irons, must be properly ground.
 - To reduce the amount of static electricity generated, do not conduct assembly and other work under dry conditions.
 - The LCD Module is coated with a film to protect the display surface. Be careful and slow when peeling off this protective film since static electricity may be generated. It is recommended to use ionic fan or machine when operating. It is recommended to remove the protection foil slowly (> 3 sec.).
 - It is preferable to wear gloves etc, to avoid damaging the LCD. Please do not touch electrodes with bare hands or avoid any other contamination.

14.2 Storage precautions

- 14.2.1 When storing the LCD modules, avoid exposure to direct sunlight or to the light of fluorescent lamps.
- 14.2.2 The LCD modules should be stored under the storage temperature range. If the LCD modules will be stored for a long time, the recommend condition is:
- Temperature : 5°C ~ 40°C
- Relatively humidity: ≤80%
- 14.2.3 The LCD modules should be stored in a clean environment or room, free from acid, alkali and harmful gas.
- 14.2.4 Store the module in anti-static electricity container and without any physical load.

14.3 Transportation precautions

The LCD modules should be no falling and violent shocking during transportation, and also should avoid excessive press, water, damp and sunshine.

14.4 Soldering

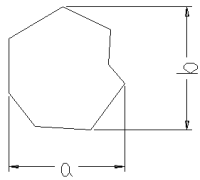
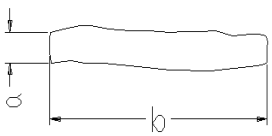
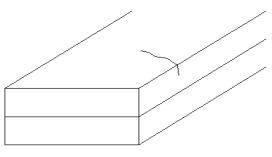
- 14.4.1 Use the high quality solders, only solder the I/O terminals.
- 14.4.2 No higher than 280°C and time less than 3-4 second during soldering.
- 14.4.3 Rewiring: no more than 3 times.
- 14.4.4 when you remove connector or cable soldered to I/O terminals, please confirm that solder is fully melted. If you remove by force, electrodes at I/O terminals may be damaged (or stripped off). It is recommended to use solder suction machine.

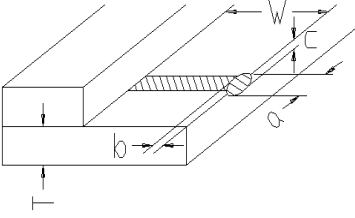
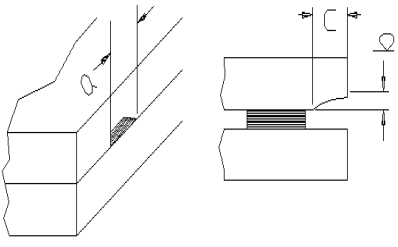
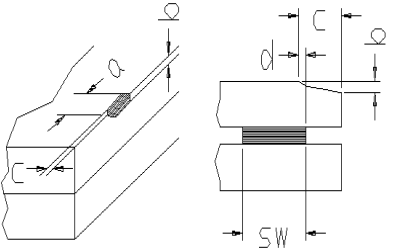
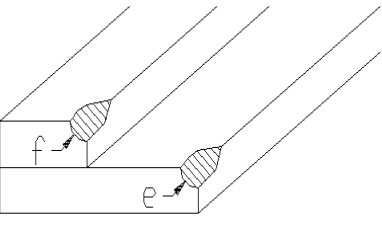
15. LCD Module Part Numbering System

TM	24064	B	B	C	W	V	B	Y	D
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩

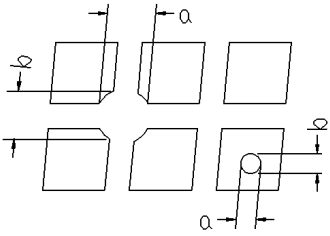
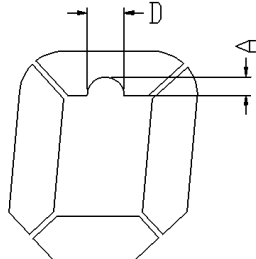
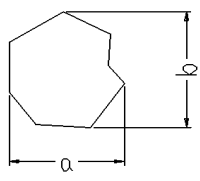
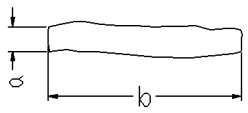
NO.	Explanation
①	TIANMA module indicating
②	Module type: 240 columns × 64 rows
③	TIANMA module series
④	LCD type
	B Positive, Yellow-Green mode, STN
⑤	Backlight type
	C Transflective, LED
⑥	Temperature range
	W Wide temperature
⑦	Viewing Angle
	V Wide viewing direction
⑧	Technology
	B COB (including SMT)
⑨	The color of backlight
	Y Yellow-green
⑩	Module type
	D Include DC-DC and Temp. Compensate circuit

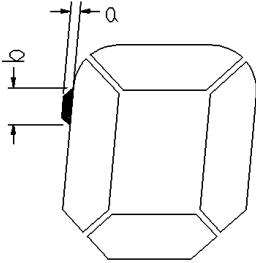
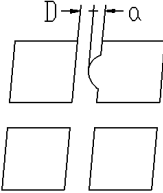
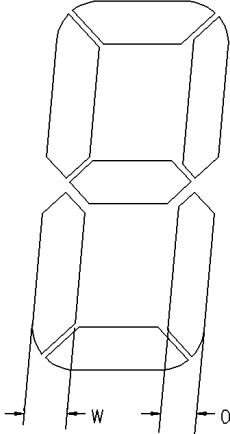
Appendix A
Inspection items and criteria for appearance defects

Items	Contents	Criteria	
Protective Glue		No clear defects	
Cover Tape		Covering all of the chip and no clear crimple	
Leakage		Not permitted	
Rainbow		According to the limit specimen	
Polarizer	Wrong polarizer attachment	Not permitted	
	Bubble between polarizer and glass	Not counted	Max. 3 defects allowed
		$\phi < 0.3\text{mm}$	$0.3\text{mm} \leq \phi \leq 0.5\text{mm}$
Scratches of polarizer	According to the limit specimen		
Black spot (in viewing area)		Not counted	Max. 3 spots allowed
		$X < 0.20\text{mm}$	$0.20\text{mm} \leq X \leq 0.5\text{mm}$
		$X = (a+b)/2$	
Black line (in viewing area)		Not counted	Max. 3 lines allowed
		$a < 0.02\text{mm}$	$0.02\text{mm} \leq a \leq 0.05\text{mm}$ $b \leq 2.0\text{mm}$
Progressive cracks		Not permitted	

Item	Contents	Criteria							
Glass Cracks	Cracks on pads 	a	b	c	Max. 2 Cracks allowed	Max. 5 cracks allowed			
		$\leq 3\text{mm}$	$\leq W/5$	$\leq T/2$					
		$\leq 2\text{mm}$	$\leq W/5$	$T/2 < C < T$					
	Cracks on contact side 	a	b		Max. 2 cracks allowed				
		$\leq 3\text{mm}$	$\leq T/2$						
		$\leq 2\text{mm}$	$T/2 < b < T$						
		C shall be not reach the seal area							
	Cracks on non-contact side 	a	b		Max. 2 cracks allowed				
		$\leq 3\text{mm}$	$\leq T/2$						
		$\leq 2\text{mm}$	$T/2 < b < T$						
	$C \leq 0.5\text{mm}$								
	$d \leq SW/3$								
Corner cracks 	$e < 2.0\text{mm}^2$ $f < 2.0\text{mm}^2$			Max. 3 cracks allowed					

Appendix B
Inspection items and criteria for display defects

Items	Contents	Criteria			
Open segment or open common		Not permitted			
Short		Not permitted			
Wrong viewing angle		Not permitted			
Contrast ratio uneven		According to the limit specimen			
Crosstalk		According to the limit specimen			
Pin holes and cracks in segment (DOT)		Not counted	Max.3 dots allowed	Max.3 dots allowed	
		$X < 0.1\text{mm}$	$0.1\text{mm} \leq X \leq 0.2\text{mm}$		
		$X = (a+b)/2$			
		Not counted	Max.2 dots allowed		
$A < 0.1\text{mm}$	$0.1\text{mm} \leq A \leq 0.2\text{mm}$ $D < 0.25\text{mm}$				
Black spot (in viewing area)			Not counted	Max.3 spots allowed	Max.3 spots (lines) allowed
		$X < 0.1\text{mm}$	$0.1\text{mm} \leq X \leq 0.2\text{mm}$		
		$X = (a+b)/2$			
Black line (in viewing area)		Not counted	Max.3 lines allowed		
		$a < 0.02\text{mm}$	$0.02\text{mm} \leq a \leq 0.05\text{mm}$ $b \leq 0.5\text{mm}$		

Items	Content	Criteria			
Transformation of segment		Not counted	Max. 2 defects allowed	Max.3 defects allowed	
		$x < 0.1\text{mm}$	$0.1\text{mm} \leq x \leq 0.2\text{mm}$		
		$x = (a+b)/2$			
		Not counted	Max. 1 defects allowed		
		$a < 0.1\text{mm}$	$0.1\text{mm} \leq a \leq 0.2\text{mm}$ $D > 0$		
		Max.2 defects allowed $0.8W \leq a \leq 1.2W$ $a = \text{measured value of width}$ $W = \text{nominal value of width}$			