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ROHS

PRODUCT SPECIFICATION

MONO LCD MODULE
MODEL：ELC1602Q8FSW1B-A4 Ver:1.0

< ◇ > Preliminary Specification

< ◆ > Finally Specification

CUSTOMER'S APPROVAL	
CUSTOMER :	
SIGNATURE:	**DATE:**

APPROVED BY	PM REVIEWED	PD REVIEWED	PREPARED By

Revision Status

Version	Revise Date	Page	Content	Modified By
Ver. 1.0	2013.9.27		First Issued	

Table of Contents

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1. Features

The features of LCD are as follows

* Display mode   : FSTN / Transflective / positive

* Controller IC   : ST7066U-0A

* Display format   : 16X2 Characters

* Interface Input Data : 8 Bit 6800

* Driving Method   : 1/16Duty, 1/4Bias

* Viewing Direction   : 6 O'clock

* Backlight   : LED /White

* Sample NO.   : C1602Q8FSW1B-C0 _01/20130927

2. MECHANICAL SPECIFICATIONS

Item	Specification	Unit
Module Size	122.0(W) x44.0(H) x13.3Max(T)	mm
Viewing Area	99.0(W) x 25(H)	mm
Activity Area	94.84(W)x20(H)	mm
Character Font	5x7 Dots +Cursor	-
Character Size	4.84(W)x9.66(H)	mm
Character Pitch	6(W)x10.34(H)	mm
Dot Size	0.92(W)x1.1(H)	mm

3. ELECTRICAL SPECIFICATIONS

3-1 ABSOLUTE MAXIMUM RATINGS (Ta = 25 °C)

Item	Symbol	Standard Value			Unit
		Min.	Typ.	Max.	
Supply Voltage For Logic	$V_{DD} - V_{SS}$	-0.3	-	7	V
Supply Voltage For LCD Drive	$V_{OP} = V_{DD} - V_0$	V_{cc} -10.0	-	V_{cc} +0.3	V
Input Voltage	Vin	-0.3	-	V_{cc}+0.3	V
Operating Temp.	Top	0	-	+50	°C
Storage Temp.	Tst	-10	-	+60	°C

*. NOTE: The response time will be extremely slow when the operating temperature is around -10℃, and the back ground will become darker at high temperature operating.

3-2 ELECTICAL CHARACTERISTICS
3-2-1.DC CHARACTERISTICS (VDD=4.5V~5.5V,Ta=25°C)

Item		Symbol	Test Condition	Min.	Typ.	Max.	Unit
Logic supply Voltage		$V_{DD} - V_{ss}$	Ta = 25 °C	3.0	3.3	3.6	V
LCD Drive		$V_{OP}=V_{DD}-V_0$		2.9	3.2	3.3	V
Input Voltage	"H" Level	V_{IH}		$0.7V_{cc}$	-	V_{cc}	V
	"L" Level	V_{IL}		0.3	-	0.6	V
Frame Frequency		f_{FLM}	$V_{DD}=3.3V\pm5\%$	-	-	75	Hz
Current Consumption		I_{DD}		-	1.85	-	mA

3-3. BACKLIGHT
3-3-1. Absolute Maximum Ratings

Item	Symbol	Condition	min	Typ	Max	Unit
Forward Current	IF	Ta = 25 °C	-	30	50	mA
Power Dissipation	PD		-	-	150	mW
Reverse Current	IR	VR=5V	-	-	2*10	uA

3-3-2. Electrical-optical Characteristics

| Item	Symbol	Condition	min		Typ		Max		Unit
Forward Voltage	IF		-		30		36		mA
Average Luminous Intensity	lv		100		250		-		cd/m²
Colour coordinate		Ta = 25 °C Vf=3.0V	X	Y	X	Y	X	Y	-
			0.25	0.25	0.28	0.28	0.31	0.31	
Module luminance			25		37		-		cd/m²
Uniformity			75%		-		-		

The backlight brightness is measured without LCD panel

For operation above 25℃, The Ifm Ifp &Pd must be derated,the current derating is -0.36mA/℃ for DC drive and -0.86 mA/℃ for Pulse drive, the Power dissipation is -0.75mW/℃.The produt working current must not more than the 60％ of the Ifm or Ifp according to the working temperature.

The module brightness is measured with LCD showing nothing

3-3-3. Luminance Measuring
Surface Luminance: L_V = average ($L_{P1}:L_{P3}$)
Uniformity = Minimal ($L_{P1}:L_{P3}$) / Maximal ($L_{P1}:L_{P3}$) * 100%
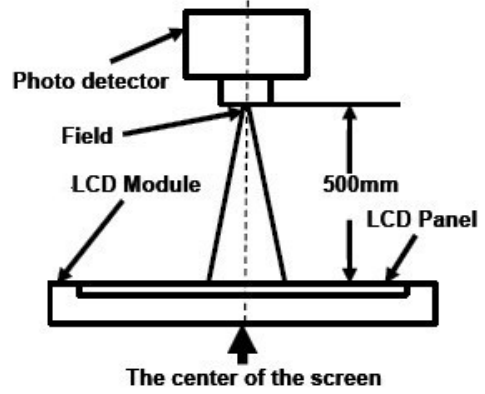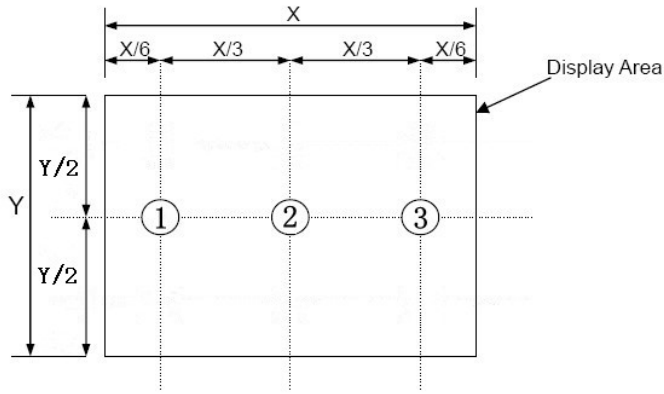
4 . TERMINAL FUNCTIONS AND BLOCK DIAGRAM

4-1. INTERFACE PIN FUNCTION DESCRIPTION

| PIN NO.	SYMBOL	FUNCIONS
1	LED_K	Backlight (-) /0V
2	LED_A	Backlight (+)/3.0V
3	VSS	Ground
4	VDD	Supply voltage for logical circuit/3.3V
5	V0	Supply voltage for LCD driving
6	RS	A signal for selecting registers: 1: Data Register (for read and write) 0: Instruction Register (for write)
7	R/W	A signal for selecting read or write actions.1: Read, 0: Write.
8	E	Enable signal for reading or writing data.
9-16	DB0-DB7	8 Bit Data Bus

4-2. BLOCK DIAGRAM
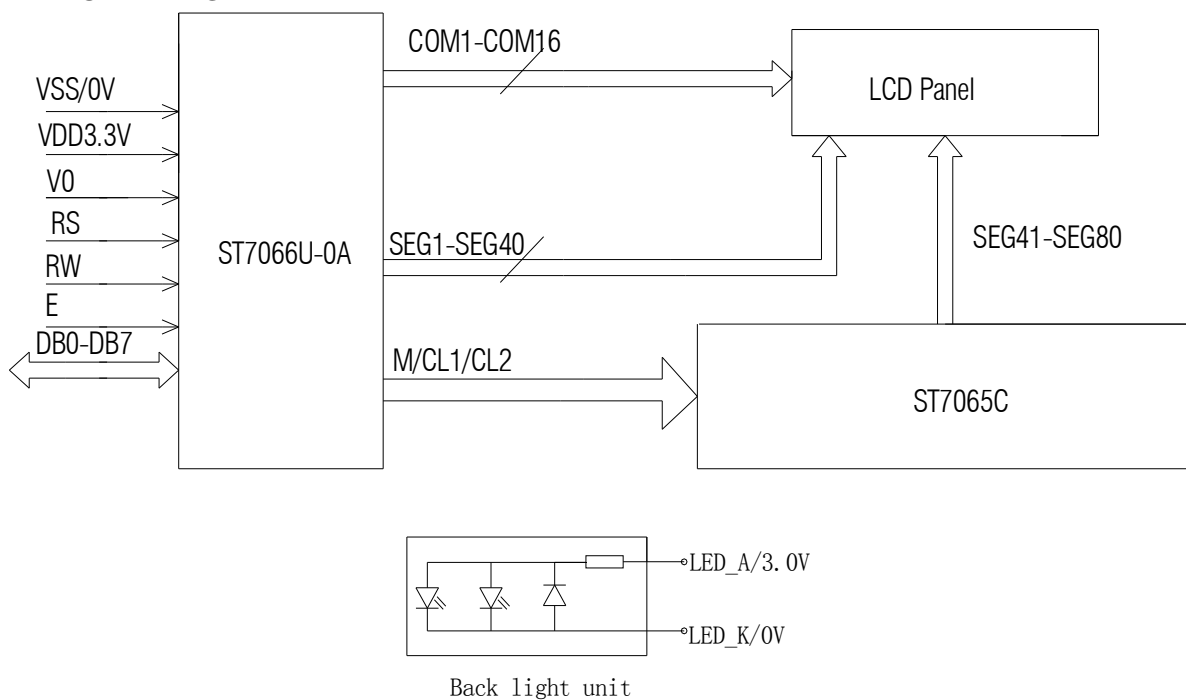
5. TIMING CHARACTERISTICS

5-1. Write mode

● Writing data from MPU to ST7066U
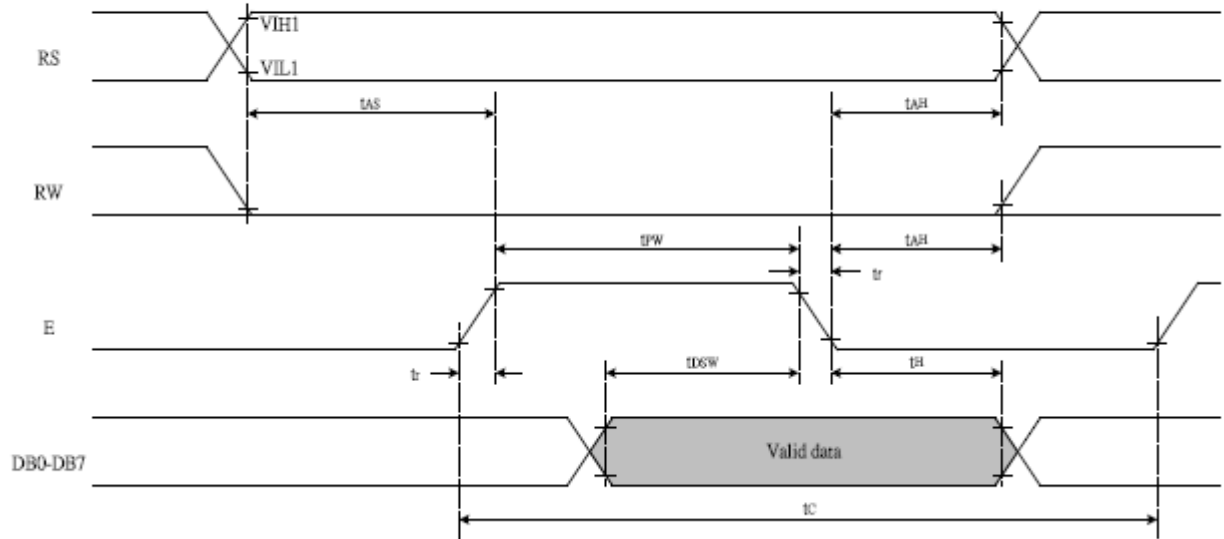
5-2. Read mode

● Reading data from ST7066U to MPU
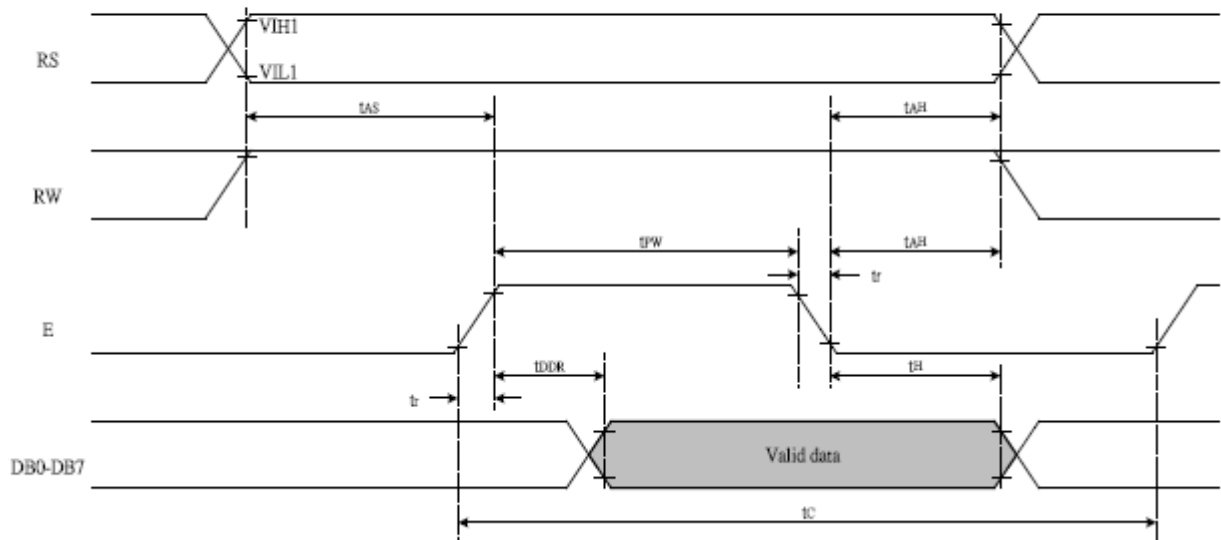
5-3 Power Supply Conditions
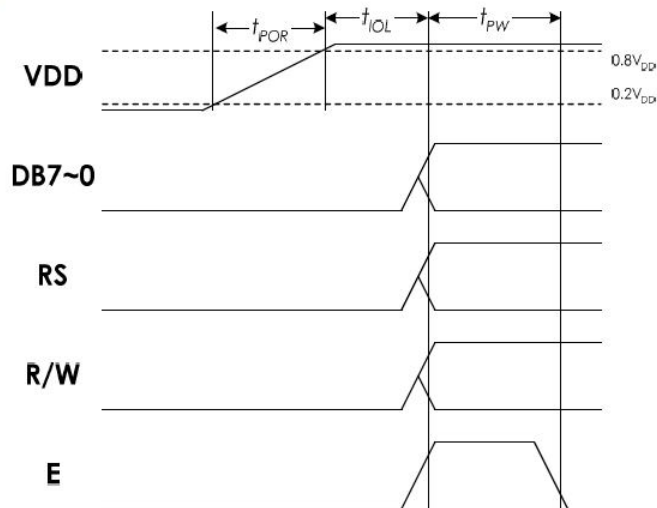
Symbol	Characteristics	Description	Min.	Typ.	Max.	Unit
tPOR	Power rise time	Power rise time that will trigger internal power on reset circuit	0.1		100	ms
tIOL	I/O Low time	The period that I/O is kept low.	40			ms
tPW	Enable pulse width	Please refer to the following tables.				

1. During tPOR, VDD noise should be reduced (especially close to 2.0V). Otherwise the Power-ON-Reset function might be triggered several times and maybe cause unexpected result.

2. During tIOL, the I/O ports of the interface (control and data signals) should be kept at "Low".

5-4 8-bit Interface (fosc=270KHz)

POWER ON

↓

Wait time >40mS
After Vcc >4.5V

↓

Function set

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

BF cannot be checked before this instruction.

↓

Wait time >37uS

↓

Function set

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

BF cannot be checked before this instruction.

↓

Wait time >37uS

↓

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

↓

Wait time >37uS

↓

Display clear

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

↓

Wait time >1.52mS

↓

Entry mode set

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

↓

Initialization end

5-5 4 bit Interface (fosc=270KHz)

```
POWER ON
```
↓
```
Wait time >40mS
After Vcc >4.5V
```
↓

Function set

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

◄------ BF cannot be checked before this instruction.

↓
```
Wait time >37uS
```
↓

Function set

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

◄------ BF cannot be checked before this instruction.

↓
```
Wait time >37uS
```
↓

Function set

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

◄------ BF cannot be checked before this instruction.

↓
```
Wait time >37uS
```
↓

Display ON/OFF control

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

↓
```
Wait time >37uS
```
↓

Display clear

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

↓
```
Wait time >1.52mS
```
↓

Entry mode set

RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	X	X	X	X
0	0	0	1	I/D	S	X	X	X	X

↓
```
Initialization end
```

6. COMMAND LIST

Instruction Table:

Instruction	Instruction Code										Description	Description Time (270KHz)
	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 DDRAM. and set DDRAM address to "00H" from AC	1.52 ms
Return Home	0	0	0	0	0	0	0	0	1	x	Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.	1.52 ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 us
Display ON/OFF	0	0	0	0	0	0	1	D	C	B	D=1:entire display on C=1:cursor on B=1:cursor position on	37 us
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	x	x	Set cursor moving and display shift control bit, and the direction, without changing DDRAM data.	37 us
Function Set	0	0	0	0	1	DL	N	F	x	x	DL:interface data is 8/4 bits N:number of line is 2/1 F:font size is 5x11/5x8	37 us
Set CGRAM address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address counter	37 us
Set DDRAM address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address counter	37 us
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.	0 us
Write data to RAM	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM)	37 us
Read data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM)	37 us

Note:
Be sure the ST7066U is not in the busy state (BF = 0) before sending an instruction from the MPU to the ST7066U. If an instruction is sent without checking the busy flag, the time between the first instruction and next instruction will take much longer than the instruction time itself. Refer to Instruction Table for the list of each instruction execution time.
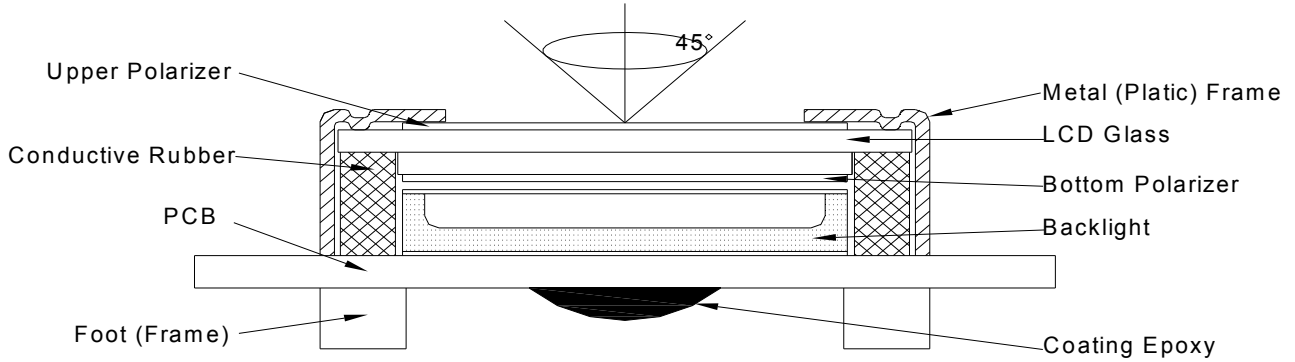
7. CHARACTER GENERATOR ROM

NO.7066-0A

b7-b4 / b3-b0	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	CG RAM (1)		0	@	P	`	p				—	タ	ミ	0	p
0001	(2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
0010	(3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
0011	(4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
0100	(5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
0101	(6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
0110	(7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
0111	(8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
1000	(1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
1001	(2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	-1	y
1010	(3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
1011	(4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	x	万
1100	(5)		,	<	L	¥	l					ャ	シ	フ	ワ	¢	円
1101	(6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
1110	(7)		.	>	N	^	n	→			ョ	セ	ホ	゙	ñ	
1111	(8)		/	?	O	_	o	←			ッ	ソ	マ	゚	ö	■

8. QUALITY SPECIFICATIONS
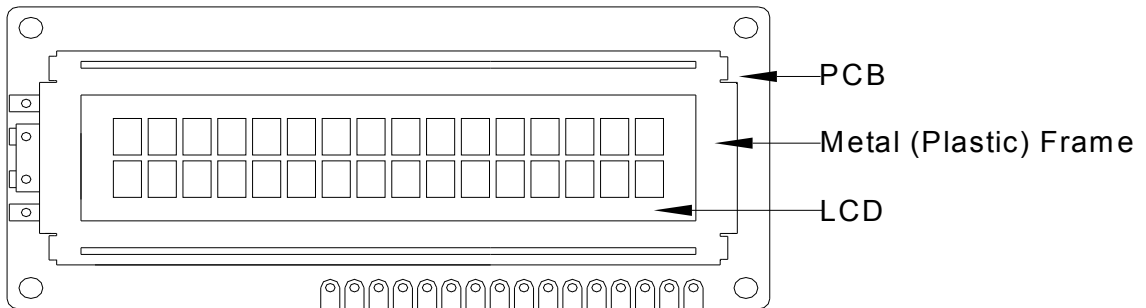
8 - 1. LCM Appearance and Electric inspection Condition

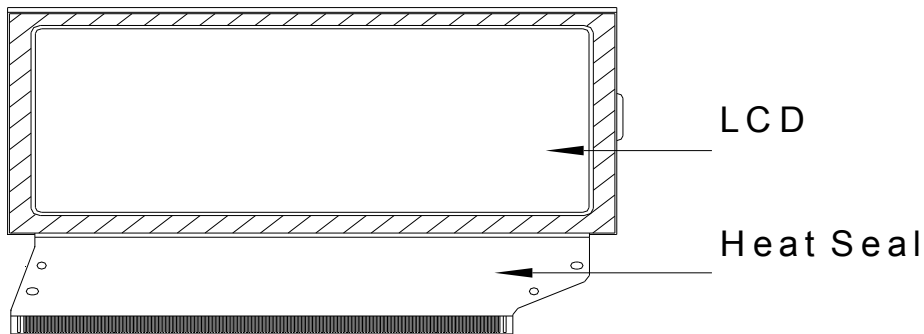**1. Inspection will be done by placing LCM 30cm away from inspector's eyeballs under normal illumination.**

45°

Upper Polarizer

Conductive Rubber

PCB

Foot (Frame)

Metal (Platic) Frame

LCD Glass

Bottom Polarizer

Backlight

Coating Epoxy

2. View Angle: with in 45° around perpendicular line.

8- 2. Definition

1. COB

PCB

Metal (Plastic) Frame

LCD

2. Heat Seal

L C D

H e a t S e a l

3. TAB and COG

LCD Glass

ITO Terminal Pad

IC

TAB

LCD Glass

IC

Pin

COG

Issued Date:2013-9-27
Doc. No.:
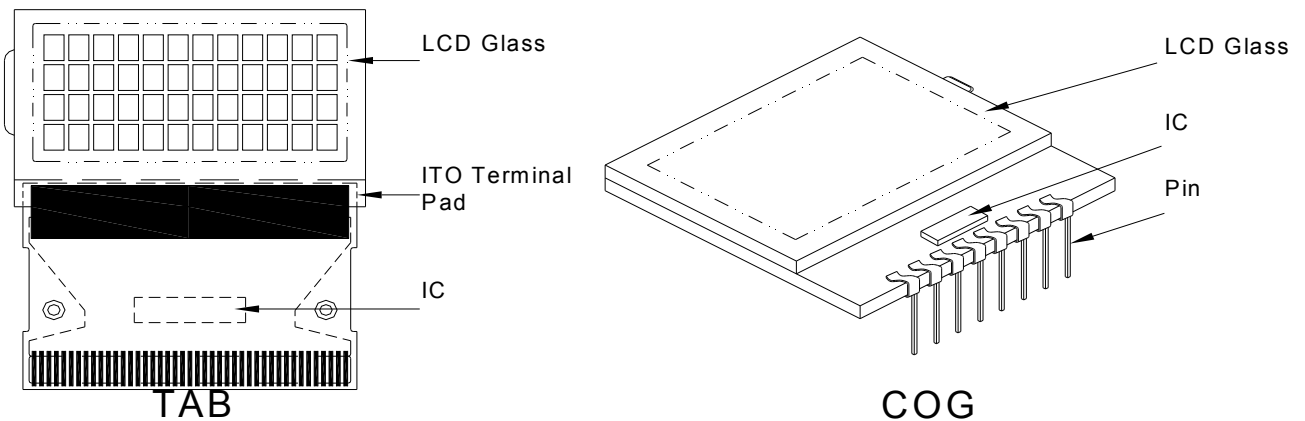
8-3. Sampling Plan and Acceptance

1. Sampling Plan
   MIL - STD - 105E (‖) ordinary single inspection is used.
2. Acceptance
   Major defect: AQL = 0.65%
   Minor defect: AQL = 1.5%
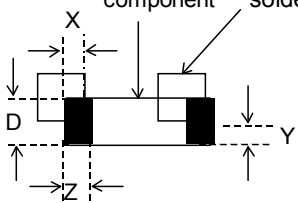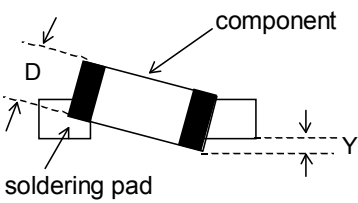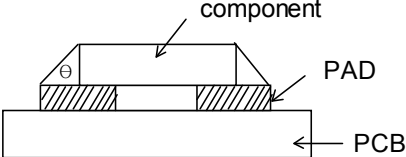
8-4. Criteria

1. COB

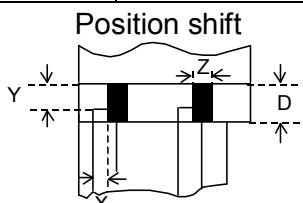| Defect	Inspection Item	Inspection Standards	
Major	PCB copper flakes peeling off	Any copper flake in viewing Area should be greater than $1.0mm^2$	Reject
Major	Height of coating epoxy	Exceed the dimension of drawing	Reject
Major	Void or hole of coating epoxy	Expose bonding wire or IC	Reject
Major	PCB cutting defect	Exceed the dimension of drawing	Reject

2. SMT

Defect	Inspection Item	Inspection Standards	
Minor	Component marking not readable		Reject
Minor	Component height	Exceed the dimension Of drawing	Reject
Major	Component solder defect (missing , extra, wrong component or wrong orientation		Reject
Minor	Component position shift	X < 3/4Z Y > 1/3D	Reject Reject
Minor	Component tilt	Y > 1/3D	Reject
Minor	Insufficient solder	$\theta \leq 20°$	Reject

3. Metal (Plastic) Frame

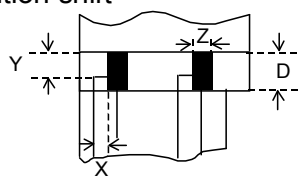| Defect	Inspection Item	Inspection Standards		
Major	Crack / breakage	Anywhere		Reject
Minor	Frame Scratch	W	L	Acceptable of Scratch
		w<0.1mm	Any	Ignore
		0.1≤w<0.2mm	L≤5.0mm	2
		0.2≤w<0.3mm	L≤3.0mm	1
		w≥0.3mm	Any	0
		Note : 1. Above criteria applicable to scratch lines with distance greater than 5mm.　2. Scratch on the back side of frame (not visible) can be ignored .		
Minor	Frame Dent , Prick $\Phi = \dfrac{L + W}{2}$			Acceptable of Dents / Pricks
		$\Phi \le 1.0mm$		2
		$1.0 < \Phi \le 1.5mm$		1
		$1.5mm < \Phi$		0
		Note : 1. Above criteria applicable to any two dents / pricks with distance greater than 5mm　2. Dent / prick on the back side of frame (not visible) can be ignored		
Minor	Frame Deformation	Exceed the dimension of drawing		
Minor	Metal Frame Oxidation	Any rust		

4. Flexible Film Connector (FFC)

Defect	Inspection Item		Inspection Standards	
Minor	Tilted soldering		Within the angle +5°	Acceptable
Minor	Uneven solder joint /bump			Reject
Minor	Hole	$\Phi = \dfrac{L + W}{2}$	Expose the conductive line	Reject
			$\Phi > 1.0mm$	Reject
Minor	Position shift		Y > 1/3D	Reject
			X > 1/2Z	Reject

5. Screw

Defect	Inspection Item	Inspection Standards	
Major	Screw missing/loosen		Reject
Minor	Screw oxidation	Any rust	Reject
Minor	Screw deformation	Difficult to accept screw driver	Reject

6. Heat-seal 、TCP 、FPC

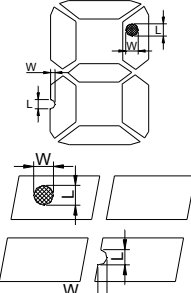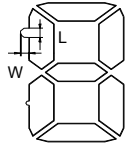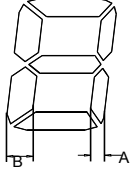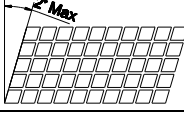| Defect	Inspection Item		Inspection Standards	
Major	Scratch expose conductive layer			Reject
Minor	HS Hole	$\Phi = \dfrac{L + W}{2}$	$\Phi > 0.5mm$	Reject
Major	Adhesion strength		Less than the specification	Reject
Minor	Position shift		$Y > 1/3D$	Reject
			$X > 1/2Z$	Reject
Major	Conductive line break			Reject

7. LED Backing Protective Film and Others

Defect	Inspection Item	Inspection Standards	
Minor	LED dirty, prick	Acceptable number of units	
		$\Phi \leq 0.10mm$	Ignore
		$0.10 < \Phi \leq 0.15mm$	2
		$0.15 < \Phi \leq 0.2mm$	1
		$\Phi > 0.2mm$	0
		The distance between any two spots should be $\geq 5mm$ Any spot/dot/void outside of viewing area is acceptable	
Minor	Protective film tilt	Not fully cover LCD	Reject
Major	COG coating	Not fully cover ITO circuit	Reject

8. Electric Inspection

Defect	Inspection Item	Inspection Standards	
Major	Short		Reject
Major	Open		Reject

9. Inspection Specification of LCD

Defect	Inspect Item	Inspection Standards			

Linear Defect (Minor)

Inspect Item: ∗ Glass Scratch ∗ Polarizer Scratch ∗ Fiber and Linear material

W	W≤0.03		0.03<W≤0.05	W>0.05
L	L<5		L<3	Any
ACC. NO.	1		1	Reject
Note	L is the length and W is the width of the defect			

Black Spot and Polarizer Pricked (Minor)

Inspect Item: ∗ Foreign material between glass and polarizer or glass and glass ∗ Polarizer hole or protuberance by external force

Φ	Φ≤0.1	0.1<Φ≤0.15	0.15<Φ≤0.2	Φ>0.2
ACC. NO.	3EA / 100mm^2	2	1	0
Note	Φ is the average diameter of the defect. Distance between two defects > 10mm.			

White Spot and Bubble in polarizer (Minor)

Inspect Item: ∗ Unobvious transparant foreign material between glass and glass or glass and polarizer ∗ Air protuberance between polarizer and glass

Φ	Φ≤0.3		0.3<Φ≤0.5	0.5<Φ
ACC. NO.	3EA / 100mm^2		1	0
Note	Φ is the average diameter of the defect. Distance between two defects > 10mm.			

Segment Defect (Minor)

Φ	Φ≤0.10	0.10<Φ≤0.20	0.20<Φ≤0.25	Φ>0.25
ACC. NO.	3EA / 100mm^2	2	1	0

Note	W is more than 1/2 segment width	Reject
	$\Phi = \dfrac{L + W}{2}$ Distance between two defect is 10mm	

Protuberant Segment (Minor)

$\Phi = (L + W) / 2$

Φ	Φ≤0.10	0.10<Φ≤0.20	0.20<Φ≤0.25	Φ>0.25
W	Glue	W≤1/2 Seg W≤0.2	W≤1/2 Seg W≤0.2	Ignore
ACC. NO.	3EA / 100mm^2	2	1	0

Assembly Mis-alignment (Minor)

1. Segment

B	B≤0.4mm	0.4<B≤1.0mm	B>1.0mm
B-A	B-A<1/2B	B-A<0.2	B-A<0.25
Judge	Acceptable	Acceptable	Acceptable

2. Dot Matrix

Deformation>2°	Reject

Stain on LCD Panel Surface (Minor)

Accept when stains can be wiped lightly with a soft cloth or a similar one. Otherwise, judged according to the above items: "Black spot" and "White Spot"

9. RELIABILITY

NO.	Item	Condition	Criterion
1	High Temperature Operating	50℃, 96Hrs	No defect in cosmetic and operational function allowable. Total current Consumption should be below double of initial value.
2	Low Temperature Operating	0℃, 96Hrs	
3	High Humidity	40℃, 90%RH, 96Hrs	
4	High Temperature Storage	60℃, 96Hrs	
5	Low Temperature Storage	-10℃, 96Hrs	
6	Vibration	Random wave 10 ~ 100Hz Acceleration: 2g 2 Hrs per direction(X,Y,Z)	
7	Thermal Shock	0℃ to 25℃ to 50℃ (60Min) (5Min) (60Min) 16Cycles	
8	ESD Testing	Contract Discharge Voltage: +1 ~ 4kV and –1 ~ –4kV	There will be discharged ten times at every discharging voltage cycle. The voltage gap is 1kV.
		Air Discharge Voltage: +1 ~ 6kV and –1 ~ -6kV	

Note: 1) Above conditions are suitable for our company standard products.
2) For restrict products, the test conditions listed as above must be revised.
3) Thereliability test quantity no less than 8 pcs

10. HANDLING PRECAUTION

(1) Mounting Method

　　The panel of the LCD Module consists of two thin glass plates with polarizers
　　which easily get damaged since the Module is fixed by utilizing fitting holes
　　in the printed circuit board. Extreme care should be taken when handling
　　the LCD Modules.

(2) Caution of LCD handling & cleaning

　　When cleaning the display surface, use soft cloth with solvent (recommended
　　below) and wipe lightly.
　　- Isopropyl alcohol
　　- Ethyl alcohol
　　- Trichloro trifloro thane

　Do not wipe the display surface with dry or hard materials that will damage the polarizer surface.

　　Do not use the following solvent:
　　- Water
　　- Ketone
　　- Aromatics

(3) Caution against static charge

　　The LCD Module use C-MOS LSI drivers, so we recommend that you connect
　　any unused input terminal to VDD or VSS, do not input any signals before power
　　is turned on. And ground your body, Work/assembly table. And assembly
　　equipment to protect against static electricity.

(4) Packaging

　　- Modules use LCD elements, and must be treated as such. Avoid intense shock and falls
　　　from a height.
　　- To prevent modules from degradation. Do not operate or store them exposed directly to
　　　sunshine or high temperature/humidity.

(5) Caution for operation

　　- It is indispensable to drive LCD's within the specified voltage limit since the higher voltage
　　　than the limit shorten LCD life. An electrochemical reaction due to direct current causes LCD
　　　deterioration, Avoid the use of direct current drive.
　　- Response time will be extremely delayed at lower temperature than the operating
　　　temperature range and on the other hand at higher temperature LCD's show dark color in
　　　them.However those phenomena do not mean malfunction or out of order with LCD's. Which
　　　will come back in the specified operating temperature range.
　　- If the display area is pushed hard during operation, some font will be abnormally displayed
　　　but it resumes normal condition after turning off once.
　　- A slight dew depositing on terminals is a cause for electro-chemical reaction resulting in
　　　terminal open circuit.
　　Usage under the relative condition of 40°C, 50%RH or less is reequired.

(6) Storage

　　In the case of storing for a long period of time (for instance.) For years) for the purpose or
　　　replacement use, The following ways are recommended.
　　- Storage in a polyethylene bag with sealed so as not to enter fresh air outside in it, And with
　　　no desiccant.
　　- Placing in a dark place where neither exposure to direct sunlight nor light is. Keeping
　　　temperature in the specified storage temperature range.
　　- Storing with no touch on polarizer surface by the anything else. (It is recommended to store
　　　them as they have been contained in the inner container at the time of delivery)

(7) Safety

　　- It is recommendable to crash damaged or unnecessary LCD into pieces and wash off liquid
　　　crystal by using solvents such as acetone and ethanol.
　　Which should be burned up later.

　　-　When any liquid crystal leaked out of a damaged glass cell comes in contact with your
　　　hands, please wash it off well with soap and water.

11. OUTLINE DIMENSION

Pin assignment NO.	Symbol
1	LED_K
2	LED_A
3	VSS
4	VDD
5	V0
6	RS
7	R/W
8	E
9	DB0
10	DB1
11	DB2
12	DB3
13	DB4
14	DB5
15	DB6
16	DB7

BACK

FRONT

1.6
13.3 Max
8.7±0.3

Detail dots:2/1

6
4.84
0.98
0.92
1.1
1.1
8.69
6.99
43.01
61.1

122.0±0.3
115.0±0.3
104.4±0.3
(V.A.) 99.0±0.2
(A.A. 94.84)

16-Φ1.0
1
16
1.8
P2.54*(16-1)=38.1
11.0
5.2

Inject

3.0±0.44
3.0±0.73
6.3
4.3×3

Elpa Displays

Outline

VERSION A
DATE 2013.10.07
NO. 1/1
UNIT mm
SCALE
TITLE: Outline
DRAWN
CHECKED
APPROVED
FILE NAME:

General Tolerance ±

REVISION RECORD
First Issue
REV
APPROVED