

Display Elektronik GmbH

DATA SHEET

TFT MODULE

**DEM 480272A1 TMH-PW-N
(A-TOUCH)**

4,3“ TFT + TP

Product Specification

Ver.: 1

03.03.2015

Revise Records

Rev.	Date	Contents	Written	Approved
0	13.11.2013	Preliminary Specification	AR	MH
1	03.03.2015	Modify Interface Pin Assignment	AR	MH

Special Notes

Note1.	
Note2.	
Note3.	
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Note5.	

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1. General Description and Features

DEM 480272A1 TMH-PW-N(A-TOUCH) is a TM (Transmissive) type color active matrix TFT (Thin Film Transistor) liquid crystal display (LCD) that uses amorphous silicon TFT as a switching devices. This model is composed of a TFT-LCD module, a driver circuit, a back-light unit and Touch panel. The resolution of a 4.3" contains 480xRGBx272 dots and can display up to 16.7M colors. The following table described the features of DEM 480272A1 TMH-PW-N(A-TOUCH).

1.1 Features

- Transmissive and back-light with 7th LEDs are available.
- TN (Twisted Nematic) mode.
- 8-Bits-8080-MCU-System-Interface
- With integrated 4-Wire-Resistive Touch-Panel
- RoHS Compliance

1.2 LCD Module

Item	Specification	Unit
Screen Size	4.3 Inches	Diagonal
Display Resolution	480 x RGB x 272	Pixel
Active Area	95.04 x 53.856	mm
Display Mode	Normally White Mode / Transmissive	--
Pixel Arrangement	R,G,B Vertical Tripe	--
Surface Type(TSP)	Anti-Glare	--
Pixel Size	0.198 x 0.198	mm
Display Color	16.7 Million Colors	--
Viewing Direction	6 o'clock (Gray Inversion)	--
Input Interface	8-Bits-8080-MCU-System-Interface	--
LCD Controller	SSD1963	--

2. Mechanical Information

Item	Min.	Typ.	Max.	Unit	Note
Module Size	Horizontal (H)	--	105.5	--	mm (1,2)
	Vertical (V)	--	67.2	--	mm (1,2)
	Thickness (T)	--	5.75	--	mm (1)
Weight	--	60	--	g	--

Note (1) Not include Component. Refer to the Outline Dimension Drawing as attached.

(2) Back-light unit is included.

3. Electrical Specifications

3.1 Absolute Max. Ratings

3.1.1 Absolute Ratings of Environment

If the operating condition exceeds the following absolute maximum ratings, the TFT LCD module may be damaged permanently.

(Ta=25±2°C, Vss=GND=0)

Item	Symbol	Min.	Max.	Unit	Note
Storage Temperature	T _{STG}	-30	80	°C	(1)
Operating Temperature	T _{OPR}	-20	70	°C	(1,2,3)

Note (1) 95 % RH Max. (40°C ≥ Ta). Maximum wet-bulb temperature at 39 °C or less. (Ta > 40°C) No condensation.

Note (2) In case of below 0°, the response time of liquid crystal (LC) becomes slower and the color of panel becomes darker than normal one. Level of retardation depends on temperature, because of LC's character

Note (3) Only operation is guarantied at operating temperature. Contrast, response time, another display quality are evaluated at +25°C.

3.1.2 Electrical Absolute Maximum Ratings

(Vss=GND=0)

Parameter	Symbol	Min.	Max.	Unit	Remark
Power supply voltage	VCC	-0.5	4.5	V	

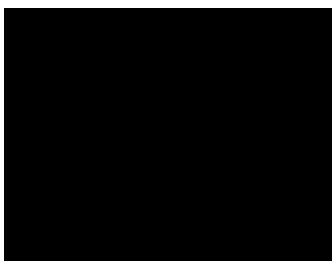
3.2 Electrical Characteristics

3.2.1 DC Electrical Characteristics of the TFT LCD

(Ta=25±2°C, Vss=GND=0)

Item	Symbol	Min.	Typ.	Max.	Unit	Remark
Power Supply	VCC	3.0	3.3	3.6	V	
Power Supply Current	ICC		(20)	(30)	mA	Note 1

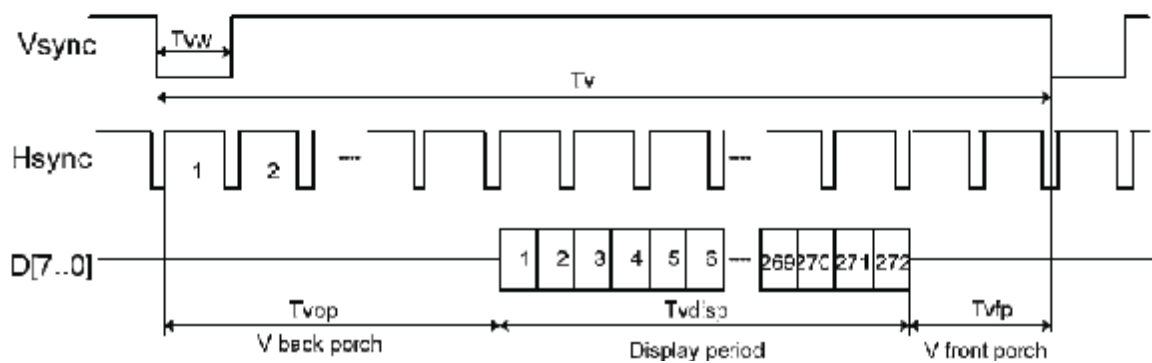
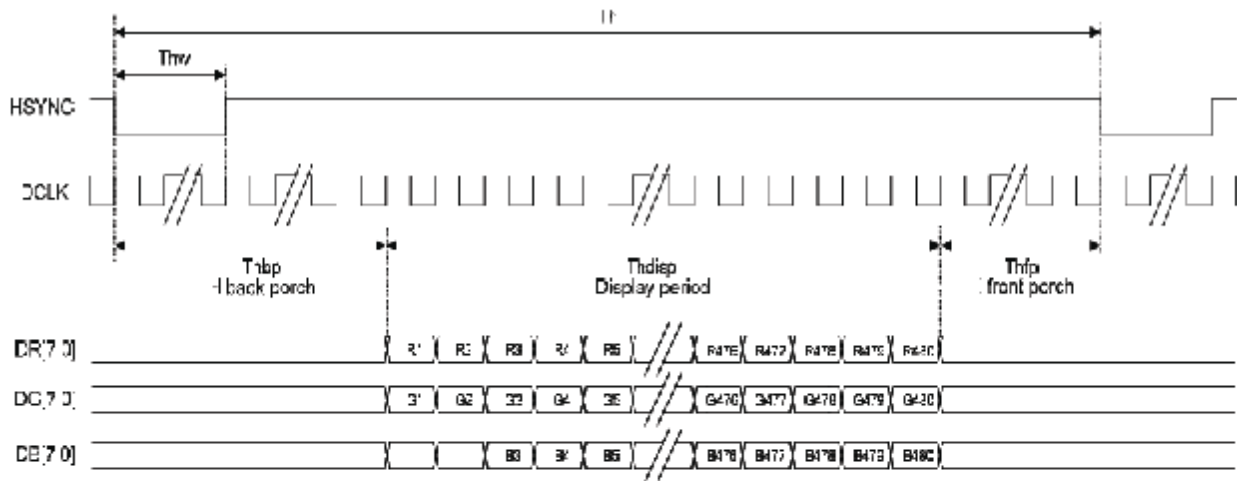
Note1: fv =60Hz, Ta=25°C , Display pattern : Black pattern



3.3 AC Timing Characteristic of The LCD

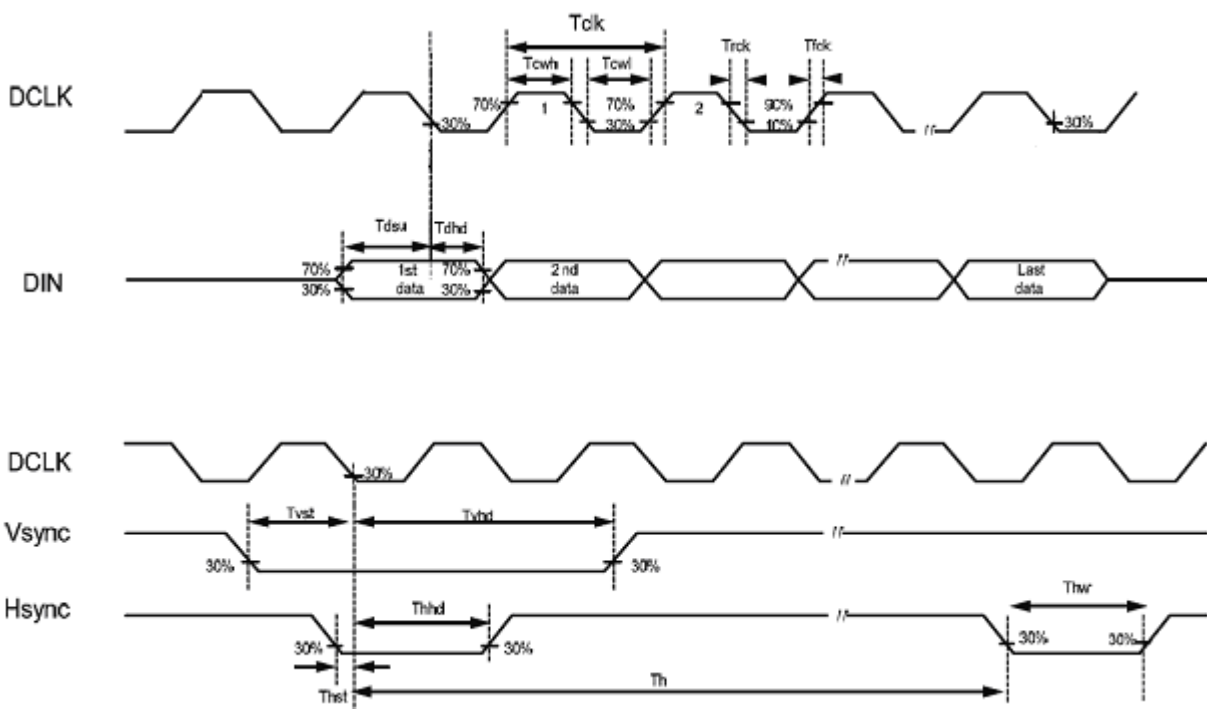
3.3.1 Timing Condition

Signal	Parameter	Symbol	Min.	Typ.	Max.	Unit.	Remark
DCLK	DCLK frequency	Fclk	5	9	12	MHz	
	DCLK period	Tclk	83	110	200	ns	
Hsync	Period Time	Th	490	531	605	DCLK	
	Display Period	Thdisp	-	480	-	DCLK	
	Back Porch	Thbp	8	43	-	DCLK	
	Front Porch	Thfp	2	8	-	DCLK	
	Pulse Width	Thw	1	-	-	DCLK	
Vsync	Period Time	Tv	275	288	335	H	
	Display Period	Tvdisp	-	272	-	H	
	Back Porch	Tvbp	2	12	-	H	
	Front Porch	Tvfp	1	4	-	H	
	Pulse Width	Tvw	1	10	-	H	



3.3.2 AC Timing Waveform

Parameter	Symbol	Min	Typ	Max	Unit
CLK pulse duty	Tcw	40	50	60	%
Hsync width	Thw	1.0	-	-	DCLK
Hsync period	Th	55	60	65	us
Vsync setup time	Tvst	12	-	-	ns
Vsync hold time	Tvhd	12	-	-	ns
Hsync setup time	Thst	12	-	-	ns </td
Hsync hold time	Thhd	12	-	-	ns
Data set-up time	Tdsu	12	-	-	ns
Data hold time	Tdhd	12	-	-	ns



3.3.3 8080-series Interface Timing Condition

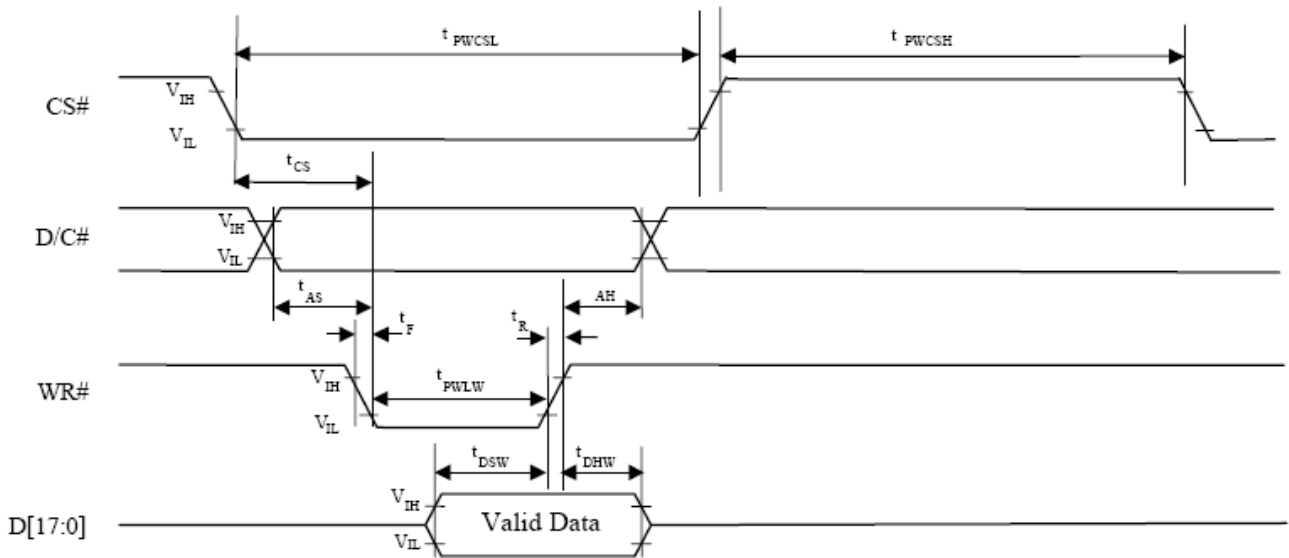
Parameter	Symbol	Min.	Typ.	Max.	Unit.	Remark
System Clock Frequency	f_{MCLK}	1	-	110	MHz	Note
System Clock Period	t_{MCLK}	1/ f_{MCLK}	-	-	ns	Note
Control Pulse High Width Write	t_{PWCSL}	13	1.5* t_{MCLK}	-	ns	
Control Pulse High Width Read	t_{PWCSL}	30	3.5* t_{MCLK}	-	ns	
Control Pulse Low Width Write(next write cycle)	t_{PWCSH}	13	1.5* t_{MCLK}	-	ns	
Control Pulse Low Width Write(next read cycle)	t_{PWCSH}	80	9* t_{MCLK}	-	ns	
Control Pulse Low Width Read	t_{PWCSH}	80	9* t_{MCLK}	-	ns	
Address Setup Time	t_{AS}	1	-	-	ns	
Address Hold Time	t_{AH}	2			ns	
Write Data Setup Time	t_{DSW}	4	-	-	ns	
Write Data Hold Time	t_{DHW}	1	-	-	ns	
Write Low Time	t_{PWLW}	12	-	-	ns	
Read Data Hold Time	t_{DHR}	1	-	-	ns	
Access Time	t_{ACC}	32	-	-	ns	
Read Low Time	t_{PWLR}	36	-	-	ns	
Rise Time	t_R	-	-	0.5	ns	
Fall Time	t_F	-	-	0.5	ns	
Chip select setup time	t_{CS}	2	-	-	ns	
Chip select hold time to read signal	t_{CSH}	3	-	-	ns	

Note : System Clock Denotes external input clock(PLL-bypass) or internal generated clock(PLL-enabled)

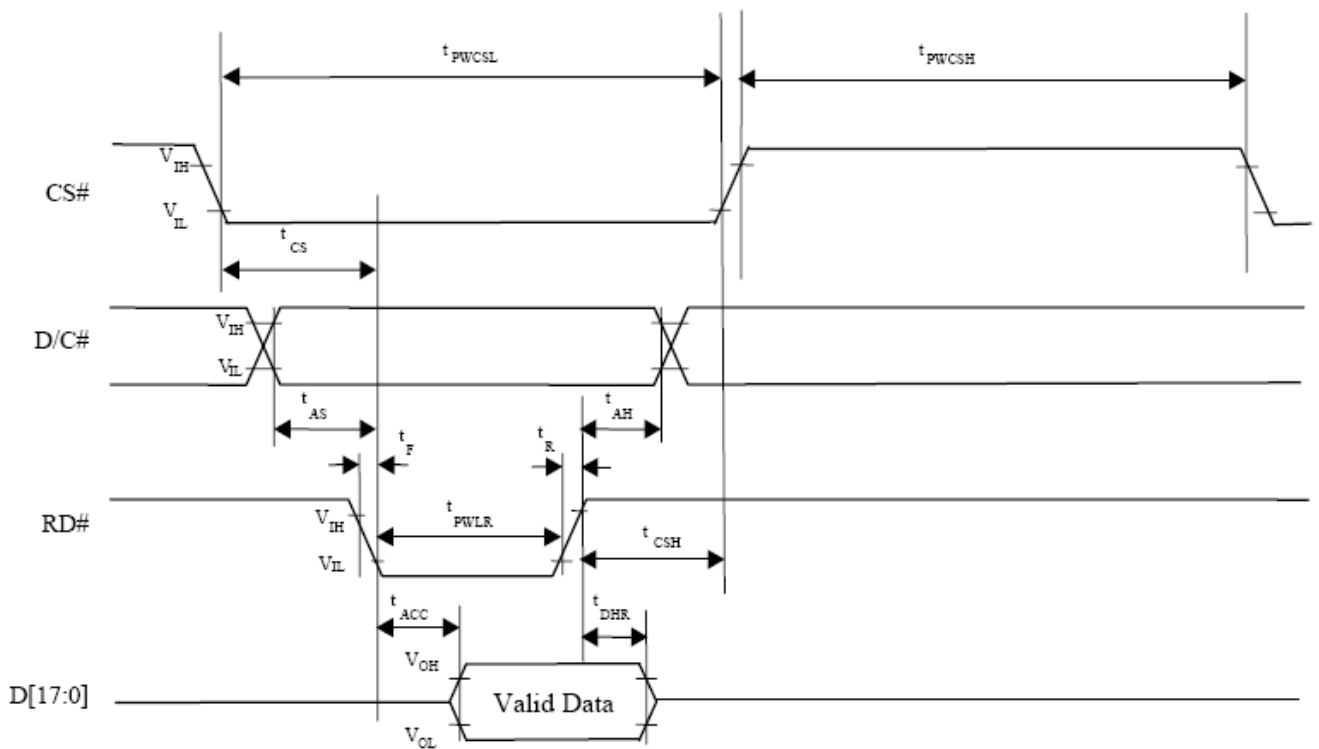
Reference input clock=10MHz.

About Command setting , Please refer to SSD1963.

3.3.4 Parallel 8080-series Interface Timing Diagram(Write Cycle)



3.3.5 Parallel 8080-series Interface Timing Diagram(Read Cycle)



3.3.6 Mapping for writing an Pixel Data

Interface	Cycle	D[23]	D[22]	D[21]	D[20]	D[19]	D[18]	D[17]	D[16]	D[15]	D[14]	D[13]	D[12]	D[11]	D[10]	D[9]	D[8]	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]	
8 bits	1 st																		R7	R6	R5	R4	R3	R2	R1	R0
	2 nd																		G7	G6	G5	G4	G3	G2	G1	G0
	3 rd																		B7	B6	B5	B4	B3	B2	B1	B0

3.4 Backlight Unit

The Back-light system is an edge-lighting type with 7 white LED (Light Emitting Diodes).
The characteristics of 7 white LEDs are shown in the following tables.

(Ta=25±2°C)

Item	Symbol	Value			Unit	Condition
		Min.	Typ.	Max.		
LED Voltage	V _L	(20.3)	(22.4)	(23.8)	V	
LED Current	I _f	-	20	25	mA	
Power Consumption	P _{LED}	-	(448)	(595)	mW	(2)
LED Lifetime (25°C)	-	(20000)	-	-	hr	(3)

Note (1) LEDS in 7 series type.

(2) Where I_f = 20mA, V_L = 22.4, P_{LED} = V_L × I_f

(3) The environmental conducted under ambient air flow, at Ta=25±2°C,60%RH±5%

4. Optical Characteristics

4.1 Optical characteristic of the LCD

The following items are measured under stable conditions. The optical characteristics should be measured in a dark room or equivalent state.

Measuring equipment: BM-7A

(Ta=25±2°C, VCC =3.3V, If=20mA)

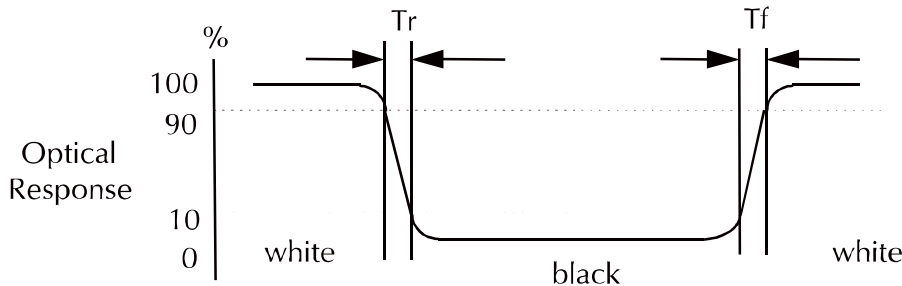
Item	Symbol	Condition	Min	Type	Max	Unit	Note
Brightness	--	--	(320)	(400)	--	cd/m ²	--
Response Time	T _R	θ=0°	--	10	15	ms	--
	T _F		--	20	30	ms	
Contrast Ratio	CR	At optimized viewing angle	(250)	(350)	--	--	--
Color Chromaticity	Red	R _X	(0.57)	(0.62)	(0.67)	--	--
		R _Y	(0.29)	(0.34)	(0.39)		
	Green	G _X	(0.29)	(0.34)	(0.39)	--	
		G _Y	(0.52)	(0.57)	(0.62)		
	Blue	B _X	(0.09)	(0.14)	(0.19)	--	
		B _Y	(0.05)	(0.10)	(0.15)		
	White	W _X	(0.27)	(0.32)	(0.37)	--	
		W _Y	(0.29)	(0.34)	(0.39)		
Viewing Angle (6H)	Hor.	θ _R	50	(65)	Degree	--	
		θ _L	50	(65)			
	Ver.	θ _U	40	(50)			
		θ _D	50	(60)			

a. Test equipment setup

After stabilizing and leaving the panel alone shall be warmed up for the stable operation of LCM, the measurement should be executed. Measurement should be executed in a stable, windless, and dark room. Optical specifications are measured by Topcon BM-7(fast) with a viewing angle of 2° at a distance of 50cm and normal direction.

b. Definition of response time: Tr and Tf

The response time is defined as the following figure and shall be measured by switching the input signal for "black" and "white".

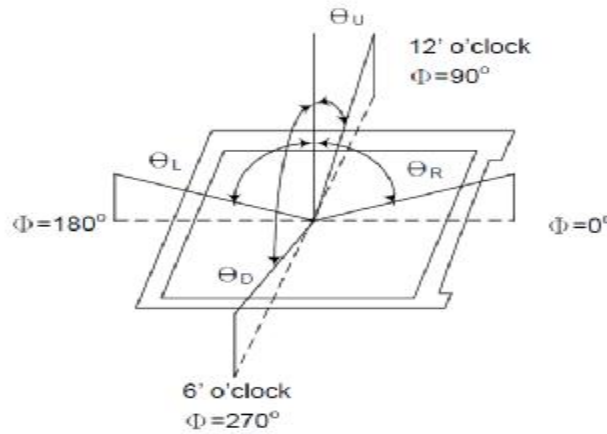


c. Definition of contrast ratio:

$$\text{Contrast Ratio (CR)} = \frac{\text{Brightness measured when LCD is at "white state"}}{\text{Brightness measured when LCD is at "black state"}}$$

d. Measured at the center area of the panel when all the input terminals of LCD panel are electrically opened.

e. View Angle



f. Definition of Luminance of White: Luminance of white at the center points

Light Source of Back-Light Unit	LED Type
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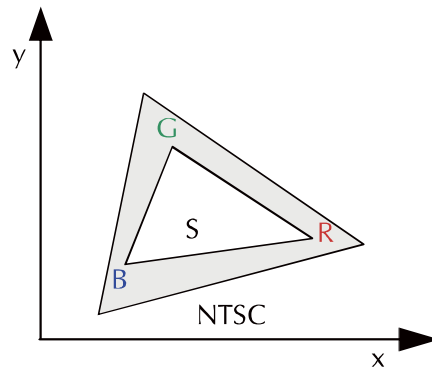
g. Definition of White Uniformity

$$\text{White Uniformity} = \frac{\text{Min. luminance of white among 9-points}}{\text{Max. luminance of white among 9-points}}$$

h. The definition of Color Gamut -Color Chromaticity CIE 1931

Color coordinate of white & red, green, blue at center point.

Color Gamut : NTSC(%) = (RGB Triangle Area / NTSC Triangle Area) x 100



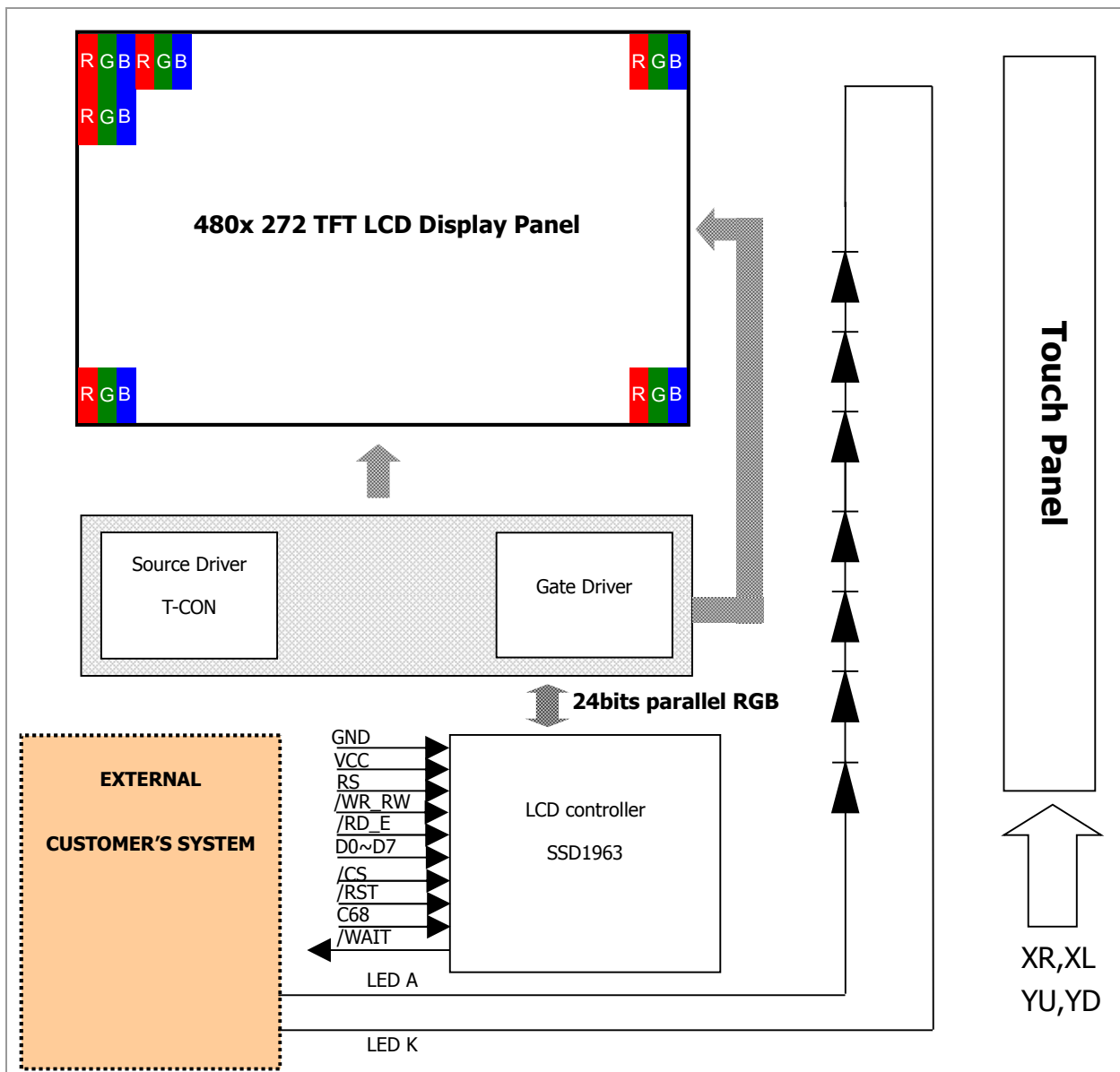
5. I/O Terminal

5.1 Pin Assignment

Pin No.	Symbol	I/O	Function	Remark
1	VCC	P	Power supply	
2	VCC	P	Power supply	
3	GND	P	GND	
4	GND	P	GND	
5	/RST	I	Reset signal	
6	NC	-	No connect	
7	/WAIT	O	Tearing effect	
8	C68	I	MCU interface configuration 1: 8080 Interface	
9	/CS	I	Chip select	
10	RS	I	Data/Command select	
11	/RD_E	I	8080 mode: RD# (read strobe signal)	
12	/WR_RW	I	8080 mode: WR# (write strobe signal)	
13	GND	P	GND	
14	DB0	IO	Data bus 0	(1)
15	DB1	IO	Data bus 1	(1)
16	DB2	IO	Data bus 2	(1)
17	DB3	IO	Data bus 3	(1)
18	DB4	IO	Data bus 4	(1)
19	DB5	IO	Data bus 5	(1)
20	DB6	IO	Data bus 6	(1)
21	DB7	IO	Data bus 7	(1)
22	NC	-	No connect	(1)
23	NC	-	No connect	(1)
24	NC	-	No connect	(1)
25	NC	-	No connect	(1)
26	NC	-	No connect	(1)
27	NC	-	No connect	(1)
28	NC	-	No connect	(1)
29	NC	-	No connect	(1)
30	GND	P	GND	
31	NC	-	No connect	
32	NC	-	No connect	
33	GND	P	GND	
34	GND	P	GND	
35	XR	O	Touch panel Right	
36	YD	O	Touch panel Down	
37	XL	O	Touch panel Left	
38	YU	O	Touch panel Up	
39	LED A	P	Backlight Anode	
40	LED K	P	Backlight Cathode	

NOTE 1: DATA Pins not used should be floating

5.2 Block Diagram



5.3 Basic Display Color and Gray Scale

	Color & Gray Scale	Data Signal																							
		R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
Basic Color	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Red(0)	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Green(0)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	
	Blue(0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	
	Cyan	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	Magenta	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	
	Yellow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	
	White	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Red	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Red(1)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Red(2)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:		
	Red(31)	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	
	Red(62)	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Red(63)	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Green	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Green(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		
	Green(2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0		
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:		
	Green(31)	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0		
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:		
	Green(62)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0		
	Green(63)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0		
Blue	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	Blue(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
	Blue(2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:		
	Blue(31)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1		
	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:		
	Blue(62)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1		
	Blue(63)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1		

Each basic color can be displayed in 256 gray scales from 8 bit data signals. With the combination of total 24 bit data signals, the 16.7M-color display can be achieved on the screen.

6. Touch Screen Panel Specifications**6.1 Electrical Characteristics**

Item	Min.	Typ.	Max.	Unit	Note
Linearity	-1.5	-	1.5	%	Analog X and Y directions
Terminal resistance	(500)	-	(1300)	Ω	X (Glass side)
	(100)	-	(540)	Ω	Y (Film side)
Insulation resistance	20	-	-	M Ω	DC 25V
Voltage	-	5.0	7.0	V	DC
Chattering	-	-	10	ms	100k Ω pull-up

6.2 Mechanical & Reliability Characteristics

Item	Min.	Typ.	Max.	Unit	Note
Activation force	60		100	g	
Durability-surface scratching	Write 100,000	-	-	characters	
Durability-surface pitting	1,000,000	-	-	touches	
Surface hardness	3	-	-	H	JIS K5400,ASTM D3363

7. Reliability Condition

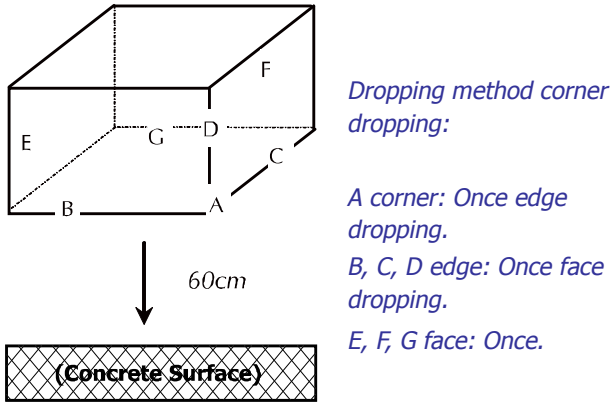
No change on display and in operation under the following test condition.

Condition: Unless otherwise specified, tests will be conducted under the following condition.

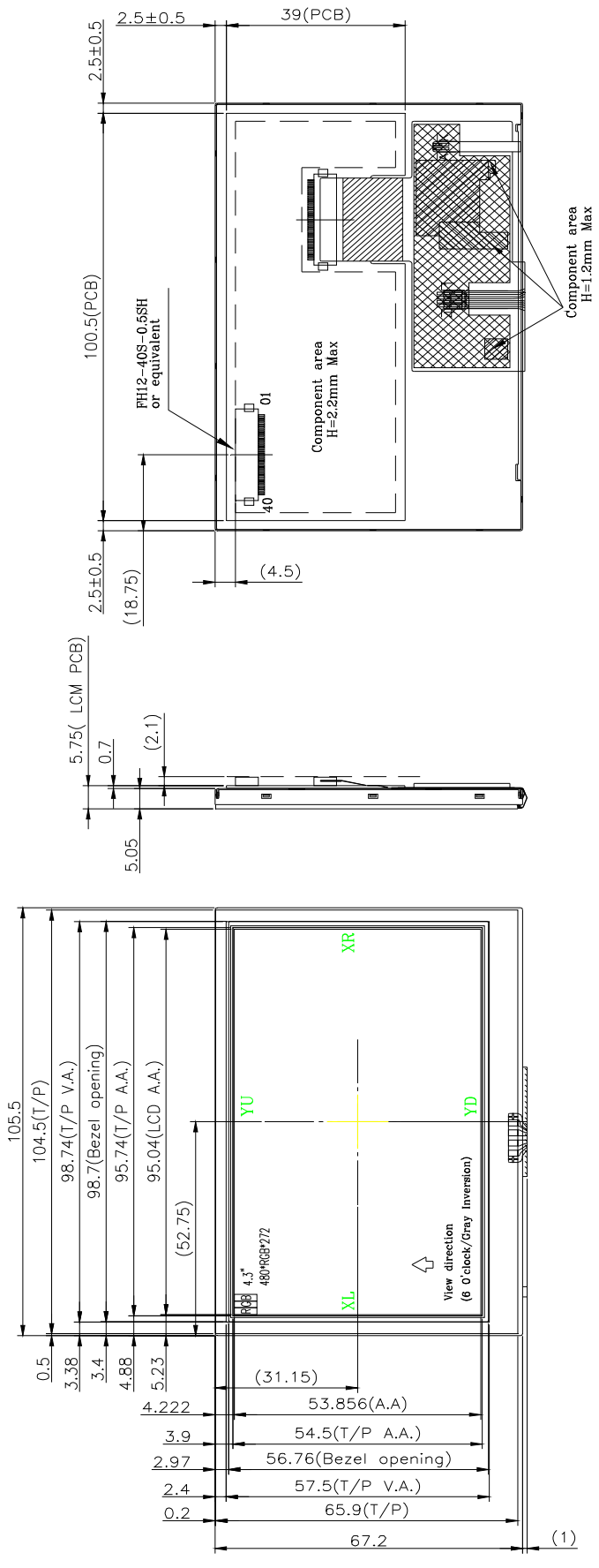
Temperature: 20±5°C.

Humidity: 65±5%RH.

Tests will be not conducted under functioning state.

No.	Parameter	Condition	Notes
1	High Temperature Operating	70°C±2°C, 240hrs (Operation state).	-
2	Low Temperature Operating	-20°C±2°C, 240hrs (Operation state).	-
3	High Temperature Storage	80°C±2°C, 240hrs.	-
4	Low Temperature Storage	-30°C±2°C, 240hrs.	-
5	High Temperature and High Humidity Operation Test	50°C±2°C, 90%, 240hrs.	-
6	Vibration Test	Total fixed amplitude: 1.5mm. Vibration Frequency: 10~55Hz. One cycle 60 seconds to 3 direction of X, Y, Z each 15 minutes.	-
7.	Drop Test	To be measured after dropping from 60cm high on the concrete surface in packing state.  <p><i>Dropping method corner dropping:</i> <i>A corner: Once edge dropping.</i> <i>B, C, D edge: Once face dropping.</i> <i>E, F, G face: Once.</i></p>	-

8. Dimensional Outlines



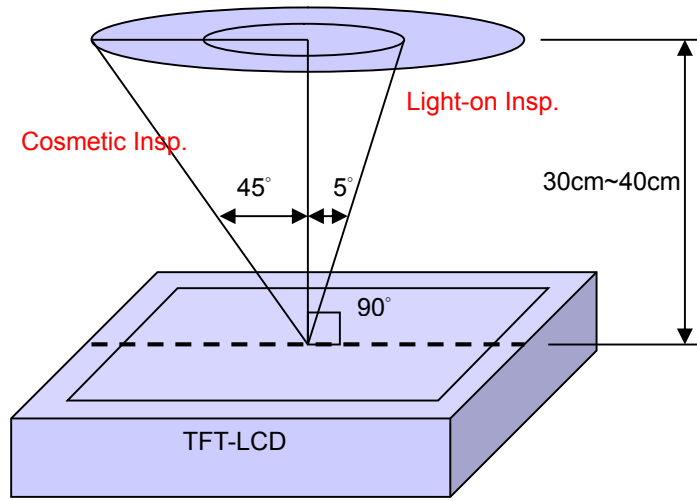
PIN FUNCTION		PIN SYMBOL	PIN SYMBOL
1	VCC	21	DB7
2	VCC	22	NC
3	GND	23	NC
4	GND	24	NC
5	RST	25	NC
6	NC	26	NC
7	WAIT	27	NC
8	C68	28	NC
9	CS	29	NC
10	RS	30	GND
11	RD/BI	31	NC / VLDD:3.3V
12	WR/RW	32	NC / PWM
13	GND	33	GND
14	DB0	34	GND
15	DB1	35	XR
16	DB2	36	YD
17	DB3	37	XL
18	DB4	38	YU
19	DB5	39	LED A / NC
20	DB6	40	LED K / NC

9. Incoming Inspection Standards

9.1 Inspection and Environment Conditions

9.1.1 Inspection Conditions:

- (1) Inspection Distance: 35 cm±5cm
- (2) View Angle : Light-on Inspection Angle : ±5°
Cosmetic Inspection Angle : ±45°



(perpendicular to LCD panel surface)

9.1.2 Environment Conditions:

Ambient Temperature		23°C ±5°C
Ambient Humidity		55±10%RH
Ambient Illumination	Cosmetic Inspection	more than 600 Lux
	Functional Inspection	300~500 Lux

9.1.3 Sampling Conditions:

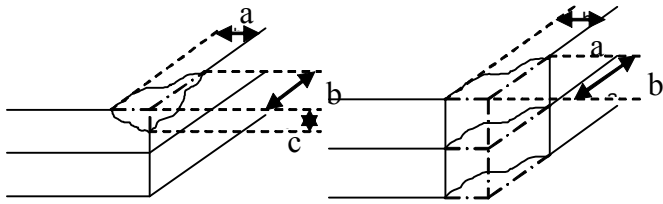
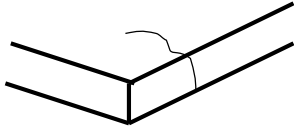
- (1) Lot Size: Quantity of shipment lot per model
- (2) Sampling Method:

Sampling Plan		MIL-STD-105E
		Normal Inspection, Single Sampling
		Level II
AQL	Major Defect	1.0%
	Minor Defect	1.5%

(3) The classification of Major(MA) and Minor(MI) defects is shown as 3. Inspection Criteria.

9.1.4 Inspection Criteria

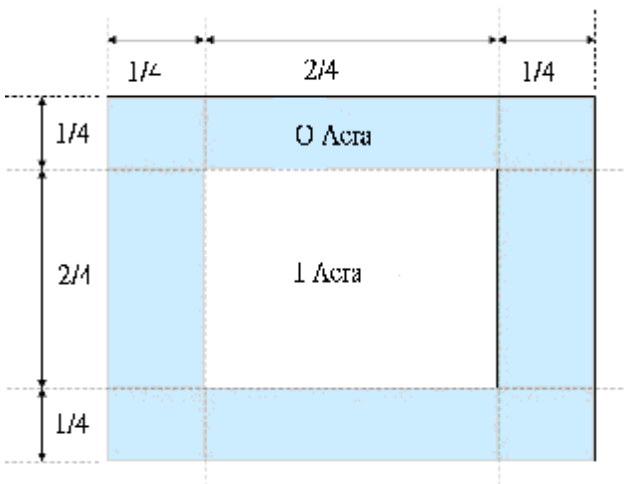
9.1.4.1 Cosmetic Inspection(Panel):

Item	Judgment Criteria	Classification
Chipping on Panel	 <p>$a \leq 3.0\text{mm}$ · $b \leq 3.0\text{mm}$ · $c \leq t$ (Bottom glass thickness)</p>	MA
Scratch on Panel *Note-2	$W \leq 0.05\text{mm}$ or $L < 5\text{mm}$: Ignored $0.05\text{mm} < W \leq 0.1\text{mm}$ and $L \leq 5\text{mm}$: $N \leq 5$ $W > 0.1\text{mm}$ or $L > 5\text{mm}$: Not allowed	MI
Bubble or Dent on Panel *Note-3	$D \leq 0.2\text{mm}$: Ignored $0.2\text{mm} < D \leq 0.3\text{mm}$: $N \leq 5$ $D > 0.3\text{mm}$: Not allowed	MI
Panel Crack	 <p>Not Allowed crack</p>	MA
Bezel Deformation	Obvious deformation is not allowed.	MI
Bezel Oxidation	Not allowed if it rusts continuously over 1 cm (It is out of warranty with rusted tin plate)	MI
Bezel Scratch	$L \leq 20\text{mm}$, $W \leq 0.2$, $N \leq 3$	MI
Metal Squash Dent /Flange(Front Side)	$D(W) \leq 1, L \leq 3, N \leq 3;$	MI
B/L High Voltage Wire Denudation	Not allowed	MA
Polarizer flaw or leak out resin	Defect is defined as the active area.	MI
Outline Dimension	Must in Spec, refer to related product spec.	MI

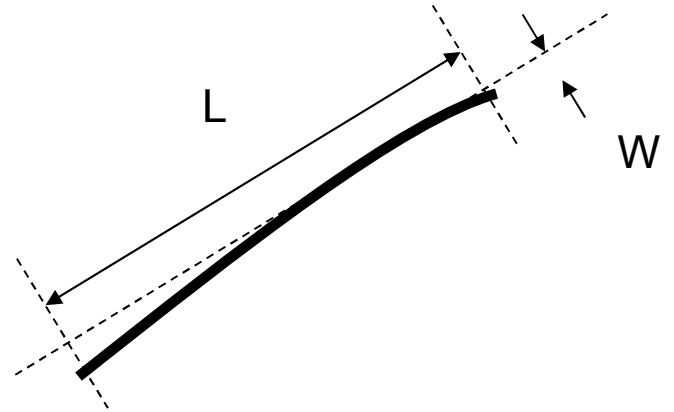
9.1.4.2 Functional Inspection:

Item	Judgment Criteria			Classification
	Area(Note1)	I	O	
Point Defect	Bright dot	Random	2	
		2 dots adjacent	0	0
		3 dots adjacent or more	0	0
	Dark dot	Random	3	
		2 dots adjacent	0	
		3 dots adjacent or more	0	0
	Total Dot Defect		5	
	Distance	Distance between Bright and Bright dot	$L \geq 5\text{mm}$	
		Distance between Bright and Dark dot	$L \geq 5\text{mm}$	
		Distance between Dark dot	$L \geq 5\text{mm}$	
(1) It is defined as Point Defect if defect area > 0.5dot (2) It is ignored if defect area $\leq 0.5\text{dot}$ (3) Weak point defect will be defined as Bright Dot if it can be observed through ND filter 5%(Full Screen Black Inspection)				MI
Line Defect	Obvious vertical or horizontal line defect is not allowed.			
Mura	Not allowed if it can be observed through ND Filter 5 %			
Foreign Material in spot shape *Note-3	$D \leq 0.2\text{mm}$: Ignored $0.2\text{mm} < D \leq 0.5\text{mm}$: $N \leq 8$ $D > 0.5\text{mm}$: Not allowed			
Foreign Material in line or spiral shape *Note-4	$W \leq 0.05\text{mm}$ or $L \leq 5\text{mm}$: Ignored $0.05\text{mm} < W \leq 0.2\text{mm}$ and $L 1.0\text{mm} \leq 5\text{mm}$: $N \leq 8$ $W > 0.2\text{mm}$ or $L > 5\text{mm}$: Not allowed			
Display Function Abnormal	No Malfunction can be allowed			

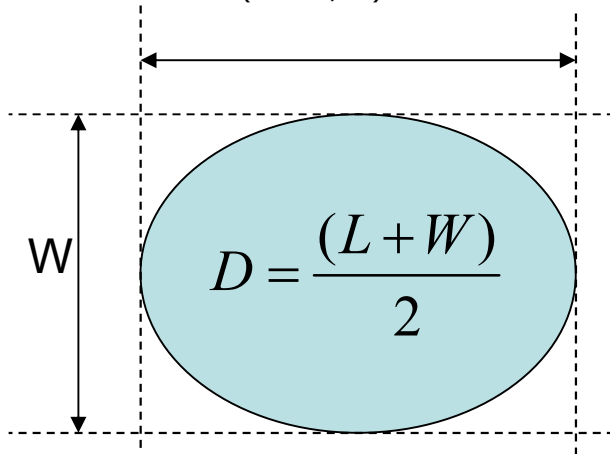
Note-1 : I/O Area Definition



Note-2 : Polarizer Scratch



Note-3 : Spot Foreign Material
($W \geq L / 4$)



Note-4 : Line or Spiral Foreign Material
($W < L / 4$)

