SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(●) Final Specification

Title	31.5" QUHD TFT LCD

BUYER	
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM315QU1
SUFFIX	SSA2

*When you obtain standard approval,
please use the above model name without suffix

SIGNATURE	DATE
/	
/	
/	

Please return 1 copy for your confirmation
With your signature and comments.

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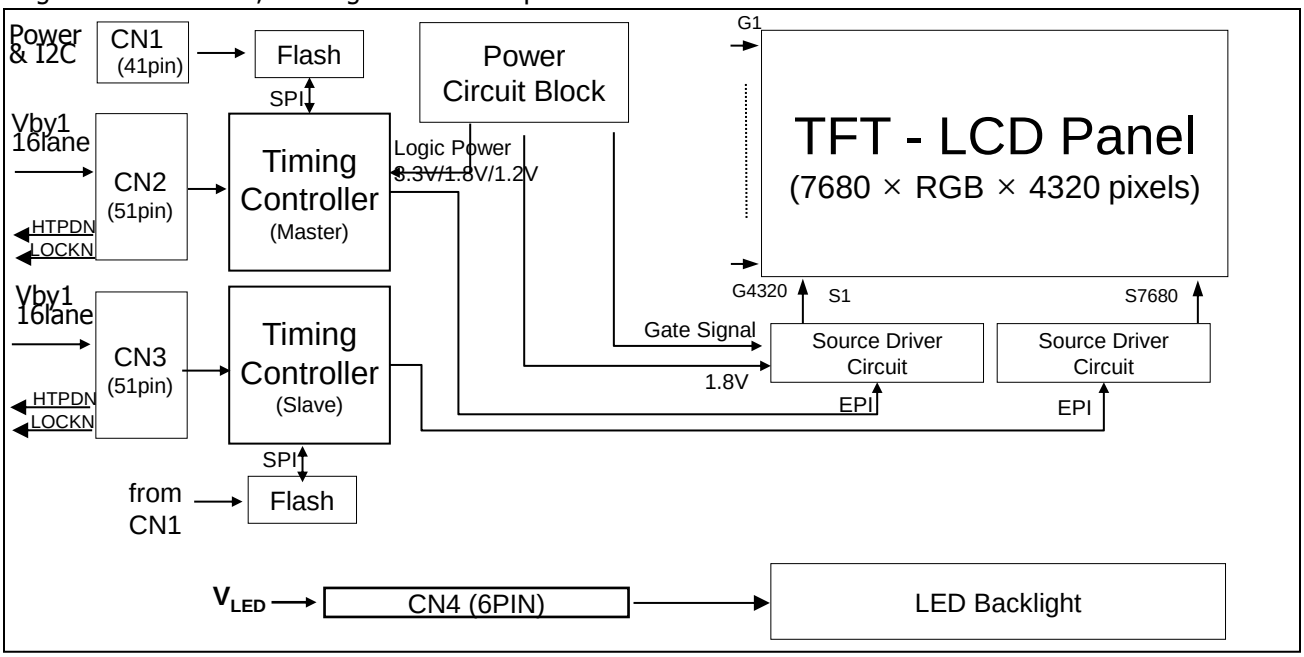
Contents

RECORD OF REVISIONS

Revision No	Revision Date	Page	Before	After	Application Date
0.0	Apr. 22. 2019	-	First Draft, Preliminary Specifications		
1.0	Jul. 24. 2019	-	First Draft, Final Specifications		

1. General Description

LM315QU1 is a Color Active Matrix Liquid Crystal Display with a Light Emitting Diode (WLED) backlight system without LED driver. The matrix employs Oxide Thin Film Transistor as the active element. It is a transmissive type display operating in the normally black mode. It has a 31.5 inch diagonally measured active display area with QUHD resolution (7680 horizontal by 4320 vertical pixel array) Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes. Gray scale or the brightness of the sub-pixel color is determined with a 10-bit gray scale signal for each dot, thus, presenting a palette of more than 1.07Billion colors.
It has been designed to apply the 10-bit 16 Lane VbyOne interface.
It is intended to support displays where high brightness, super wide viewing angle, high color saturation, and high color are important.



[FIG.1] Block diagram

General Features

Active Screen Size	31.5 inches(80.0977cm) (Aspect ratio 16:9)
Outline Dimension	717.8(H) x 412.3(V) x 16.6(D) mm (Typ.)
Pixel Pitch	0.0303(H) x 0.0909(V) mm
Pixel Format	7680(H) x 4320(V) Pixels. Pixels RGB stripes arrangement
Color Depth	1.07 Billion colors, 10 Bit
Luminance, White	400 cd/m^2 (Center 1 Point, Typ.)
Viewing Angle(CR>10)	View Angle Free (R/L 178(Typ.), U/D 178(Typ.))
Power Consumption	Total 79.3W (20.0W @ V_{LCD} , 59.3W @ Is=130mA)
Weight	3,710g (Typ.)
Display Operating Mode	Transmissive mode, normally black
Panel type	Reverse type
Surface Treatment	Anti-Reflective treatment of the front polarizer (2H)

2. Absolute Maximum Ratings

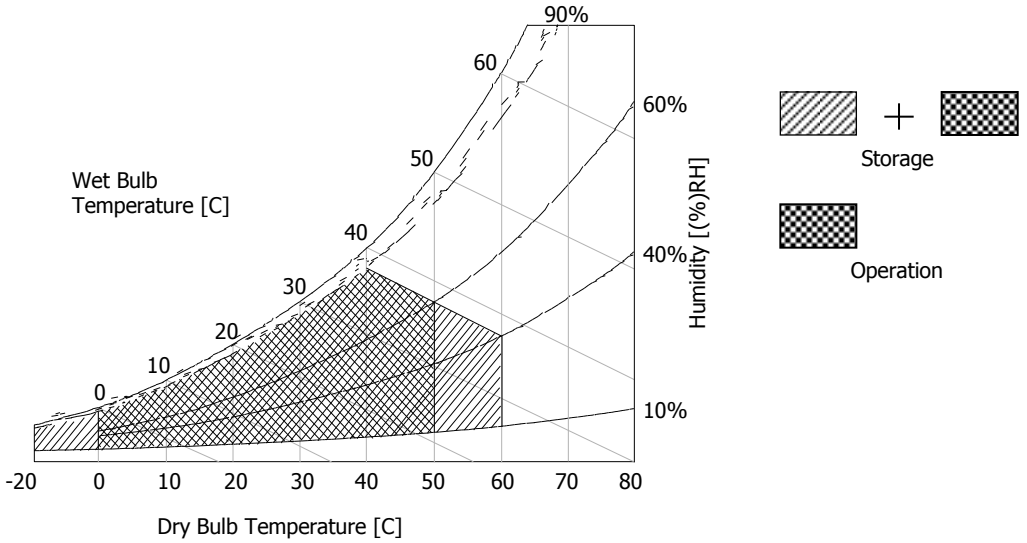
The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Input Voltage	V_{LCD}	-0.3	12	Vdc	at 25 ± 2°C
Operating Temperature	T_{OP}	0	50	°C	1, 2, 3
Storage Temperature	T_{ST}	-20	60	°C	
Operating Ambient Humidity	H_{OP}	10	90	%RH	
Storage Humidity	H_{ST}	10	90	%RH	
LCM Surface Temperature (Operation)	$T_{Surface}$	0	65	℃	1,4

Note : 1. Temperature and relative humidity range are shown in the figure below.
Wet bulb temperature should be 39 °C Max, and no condensation of water.
2. Maximum Storage Humidity is up to 40℃, 70% RH only for 4 corner light leakage Mura.
3. Storage condition is guaranteed under packing condition
4. LCM Surface Temperature should be Min. 0℃ and Max. 65℃ under the VLCD=10.0V, fV=60Hz, 25℃ ambient Temp. no humidity control and LED string current is typical value.

FIG.2 Temperature and relative humidity



3. Electrical Specifications

3-1. Electrical Characteristics

It requires two power inputs. One is employed to power the LCD electronics and to drive the TFT array and liquid crystal. The second input power for the LED/Backlight, is typically generated by a LED Driver. The LED Driver is an external unit to the LCDs.

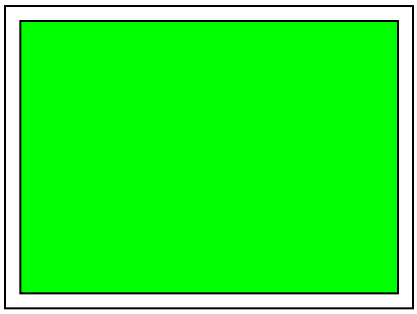
Table 2-1. ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	9.5	10.0	10.5	Vdc	5
Permissive Power Input Ripple	V_{dRF}			400	mV_{p-p}	1
Power Supply Input Current	I_{LCD}	-	2000	2500	mA	2
		-	3200	4000	mA	3
Power Consumption	$P_{C\ TYP}$	-	20.0	25.0	Watt	2
	$P_{C\ MAX}$	-	32.0	40.0	Watt	3
Rush current	I_{RUSH}	-		7	A	4

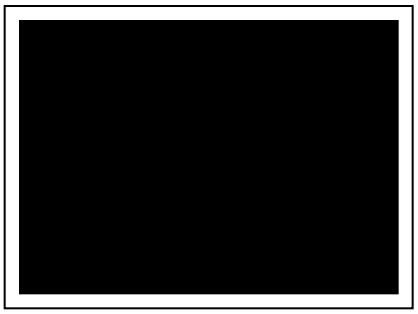
Note :

1. Permissive power ripple should be measured under V_{LCD}=10.0V, 25 ± 2°C, f_V=60Hz condition and at that time, we recommend the bandwidth configuration of oscilloscope is to be under 20Mhz.
2. The specified current and power consumption are under the V_{LCD}=10.0V, 25 ± 2°C, f_V=60Hz condition whereas mosaic pattern(8 x 6) is displayed and f_V is the frame frequency.
3. The current is specified at the maximum current pattern.
4. The duration of rush current is about 2ms and rising time of power Input is 1ms(min.).
5. VLCD level must be measured at two points on LCM PCB - between VLCD(test point) and LCM Ground. The measured results need to meet the Power supply input voltage spec. (Test condition : maximum power pattern , 25± 2°C, fV=60Hz)

• **Permissive Power input ripple (**V_{LCD} =10.0V, 25°C, fv (frame frequency)=Max. condition**)**

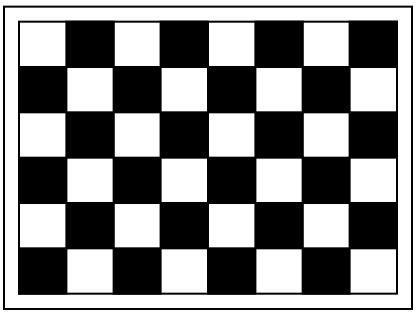


R/G/B pattern

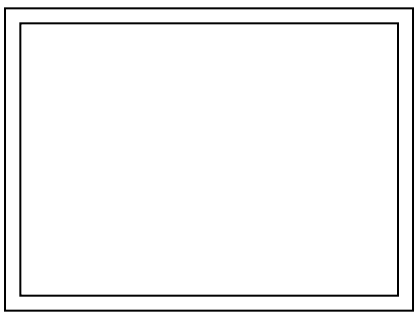


Black pattern

• **Power consumption (**V_{LCD} =10V, 25°C, fV (frame frequency=60Hz condition**)**



Typical power Pattern



Maximum power Pattern

FIG.3 Mosaic pattern & White Pattern for power consumption measurement

Table 2-2. LED Bar ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Values			Unit	Notes
		Min.	Typ.	Max.		
LED String Current	Is	-	130	135	mA	1, 2, 5
LED String Voltage	Vs	53.2	57	60.8	V	1, 5
Power Consumption	Pbar(total)	-	59.3	63.2	Watt	2, 4
LED Life Time	LED_LT	30,000	-	-	Hrs	3

Notes) The LED Bar consists of 76ea LED packages, 4 strings (parallel) x 19 packages (serial)

LED driver design guide

1) The design of the LED driver must have specifications for the LED in LCD Assembly.
The performance of the LED in LCM, for example life time or brightness, is extremely influenced by the characteristics of the LED driver.
So all the parameters of an LED driver should be carefully designed and output current should be Constant current control.
Please control feedback current of each string individually to compensate the current variation among the strings of LEDs.
When you design or order the LED driver, please make sure unwanted lighting caused by the mismatch of the LED and the LED driver (no lighting, flicker, etc) never occurs.
When you confirm it, the LCD module should be operated in the same condition as installed in your instrument.
2) LGD strongly recommend Analog Dimming method for Backlight Brightness control for Wavy Noise Free. Otherwise, recommend that Dimming Control Signal (PWM Signal) should be synchronized with Frame Frequency.

1. The specified values are for a single LED bar .
2. The specified current is defined as the input current for a single LED string with 100% duty cycle.
3. The LED life time is defined as the time when brightness of LED packages become 50% or less than the initial value under the conditions at Ta = 25 ± 2°C and LED string current is typical value.
4. The power consumption shown above does not include loss of external driver.
The specified values are for dual LED bar. Pbar(total) = Pbar (upper) + Pbar (bottom)
The typical power consumption is calculated as P_{Bar} = Vs(Typ.) x Is(Typ.) x No. of strings.
The maximum power consumption is calculated as P_{Bar} = Vs(Max.) x Is(Typ.) x No. of strings.
5. LED operating conditions are must not exceed Max. ratings.

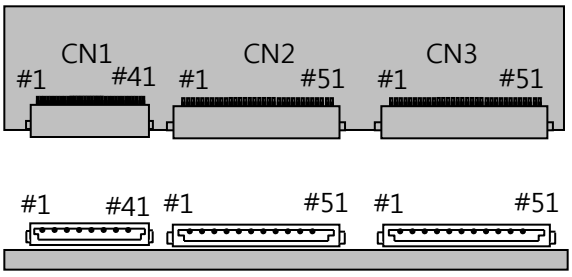
3-2. Interface Connections

3-2-1. LCD Module

- LCD Connector(CN1) : IS050-C41B-C39-A(UJU), FI-RE41S-HF(JAE) or Equivalent

Table 3-1. MODULE CONNECTOR(CN1) PIN CONFIGURATION

No	Symbol	Description	No	Symbol	Description
1	VIN	Power Supply +10.0V	22	NC	No connection
2	VIN	Power Supply +10.0V	23	GND	Ground
3	VIN	Power Supply +10.0V	24	NC	No connection
4	VIN	Power Supply +10.0V	25	NC	No connection
5	VIN	Power Supply +10.0V	26	GND	Ground
6	VIN	Power Supply +10.0V	27	NC	No connection
7	VIN	Power Supply +10.0V	28	NC	No connection
8	VIN	Power Supply +10.0V	29	GND	Ground
9	GND	Ground	30	NC	No connection
10	GND	Ground	31	NC	No connection
11	RBF	L=Black , H=AGP when no signal input	32	NC	No connection
12	GND	Ground	33	NC	No connection
13	GND	Ground	34	NC	No connection
14	GND	Ground	35	GND	Ground
15	GND	Ground	36	NC	No connection
16	GND	Ground	37	NC	No connection
17	PWM_Sync	PWM_Sync signal out	38	NC	No connection
18	GND	Ground	39	NC	No connection
19	NC	No connection	40	NC	No connection
20	GND	Ground	41	GND	Ground
21	NC	No connection	-		



[CN1]
- Part/No. : IS050-C41B-C39-A(UJU)
  FI-RE41S-HF(JAE)
- Mating connector : FI-RE41HL
  (Manufactured by JAE)

[CN2,CN3]
- Part/No. : IS050-C51B-C39-A(UJU)
  FI-RE51S-HF(JAE)
- Mating connector : FI-RE51HL
  (Manufactured by JAE)

FIG.4 Connector diagram

3-2. Interface Connections

3-2-1. LCD Module

- LCD Connector(CN2) : : IS050-C51B-C39-A(UJU), FI-RE51S-HF(JAE) or Equivalent

Table 3-2. MODULE CONNECTOR(CN2) PIN CONFIGURATION

No	Symbol	Description	No	Symbol	Description
1	HTPDN_Master	Hot plug detect for Master T-con	27	GND	Ground
2	LOCKN_Master	Lock detect for Master T-con	28	M_Vx1_N8	Master Vx1 Data Lane 8
3	GND	Ground	29	M_Vx1_P8	Master Vx1 Data Lane 8
4	M_Vx1_N0	Master Vx1 Data Lane 0	30	GND	Ground
5	M_Vx1_P0	Master Vx1 Data Lane 0	31	M_Vx1_N9	Master Vx1 Data Lane 9
6	GND	Ground	32	M_Vx1_P9	Master Vx1 Data Lane 9
7	M_Vx1_N1	Master Vx1 Data Lane 1	33	GND	Ground
8	M_Vx1_P1	Master Vx1 Data Lane 1	34	M_Vx1_N10	Master Vx1 Data Lane 10
9	GND	Ground	35	M_Vx1_P10	Master Vx1 Data Lane 10
10	M_Vx1_N2	Master Vx1 Data Lane 2	36	GND	Ground
11	M_Vx1_P2	Master Vx1 Data Lane 2	37	M_Vx1_N11	Master Vx1 Data Lane 11
12	GND	Ground	38	M_Vx1_P11	Master Vx1 Data Lane 11
13	M_Vx1_N3	Master Vx1 Data Lane 3	39	GND	Ground
14	M_Vx1_P3	Master Vx1 Data Lane 3	40	M_Vx1_N12	Master Vx1 Data Lane 12
15	GND	Ground	41	M_Vx1_P12	Master Vx1 Data Lane 12
16	M_Vx1_N4	Master Vx1 Data Lane 4	42	GND	Ground
17	M_Vx1_P4	Master Vx1 Data Lane 4	43	M_Vx1_N13	Master Vx1 Data Lane 13
18	GND	Ground	44	M_Vx1_P13	Master Vx1 Data Lane 13
19	M_Vx1_N5	Master Vx1 Data Lane 5	45	GND	Ground
20	M_Vx1_P5	Master Vx1 Data Lane 5	46	M_Vx1_N14	Master Vx1 Data Lane 14
21	GND	Ground	47	M_Vx1_P14	Master Vx1 Data Lane 14
22	M_Vx1_N6	Master Vx1 Data Lane 6	48	GND	Ground
23	M_Vx1_P6	Master Vx1 Data Lane 6	49	M_Vx1_N15	Master Vx1 Data Lane 15
24	GND	Ground	50	M_Vx1_P15	Master Vx1 Data Lane 15
25	M_Vx1_N7	Master Vx1 Data Lane 7	51	GND	Ground
26	M_Vx1_P7	Master Vx1 Data Lane 7	-	-	-

Notes : 1. All GND(ground) pins should be connected together to the LCD module's metal frame.
2. All V_{in} (power input) pins should be connected together.
3. All NC (No Connection) : These pins are used only for LGD (Do not connect)
4. All Input levels of V-by-One signals are based on the V-by-One-HS Standard Version 1.4

3-2. Interface Connections

3-2-1. LCD Module

- LCD Connector(CN3) : : IS050-C51B-C39-A(UJU), FI-RE51S-HF(JAE) or Equivalent

Table 3-3. MODULE CONNECTOR(CN3) PIN CONFIGURATION

No	Symbol	Description	No	Symbol	Description
1	HTPDN_Slave	Hot plug detect for Slave T-con	27	GND	Ground
2	LOCKN_Slave	Lock detect for Slave T-con	28	S_Vx1_N8	Slave Vx1 Data Lane 8
3	GND	Ground	29	S_Vx1_P8	Slave Vx1 Data Lane 8
4	S_Vx1_N0	Slave Vx1 Data Lane 0	30	GND	Ground
5	S_Vx1_P0	Slave Vx1 Data Lane 0	31	S_Vx1_N9	Slave Vx1 Data Lane 9
6	GND	Ground	32	S_Vx1_P9	Slave Vx1 Data Lane 9
7	S_Vx1_N1	Slave Vx1 Data Lane 1	33	GND	Ground
8	S_Vx1_P1	Slave Vx1 Data Lane 1	34	S_Vx1_N10	Slave Vx1 Data Lane 10
9	GND	Ground	35	S_Vx1_P10	Slave Vx1 Data Lane 10
10	S_Vx1_N2	Slave Vx1 Data Lane 2	36	GND	Ground
11	S_Vx1_P2	Slave Vx1 Data Lane 2	37	S_Vx1_N11	Slave Vx1 Data Lane 11
12	GND	Ground	38	S_Vx1_P11	Slave Vx1 Data Lane 11
13	S_Vx1_N3	Slave Vx1 Data Lane 3	39	GND	Ground
14	S_Vx1_P3	Slave Vx1 Data Lane 3	40	S_Vx1_N12	Slave Vx1 Data Lane 12
15	GND	Ground	41	S_Vx1_P12	Slave Vx1 Data Lane 12
16	S_Vx1_N4	Slave Vx1 Data Lane 4	42	GND	Ground
17	S_Vx1_P4	Slave Vx1 Data Lane 4	43	S_Vx1_N13	Slave Vx1 Data Lane 13
18	GND	Ground	44	S_Vx1_P13	Slave Vx1 Data Lane 13
19	S_Vx1_N5	Slave Vx1 Data Lane 5	45	GND	Ground
20	S_Vx1_P5	Slave Vx1 Data Lane 5	46	S_Vx1_N14	Slave Vx1 Data Lane 14
21	GND	Ground	47	S_Vx1_P14	Slave Vx1 Data Lane 14
22	S_Vx1_N6	Slave Vx1 Data Lane 6	48	GND	Ground
23	S_Vx1_P6	Slave Vx1 Data Lane 6	49	S_Vx1_N15	Slave Vx1 Data Lane 15
24	GND	Ground	50	S_Vx1_P15	Slave Vx1 Data Lane 15
25	S_Vx1_N7	Slave Vx1 Data Lane 7	51	GND	Ground
26	S_Vx1_P7	Slave Vx1 Data Lane 7	-	-	-

Notes : 1. All GND(ground) pins should be connected together to the LCD module's metal frame.
2. All V_{in} (power input) pins should be connected together.
3. All NC (No Connection) : These pins are used only for LGD (Do not connect)
4. All Input levels of V-by-One signals are based on the V-by-One-HS Standard Version 1.4
5. Pin No. CN3's #1, #2 are connected Master T-con's HTPDN and LOCKN. If they are not needed anymore they should be disconnected any signal even if GND.

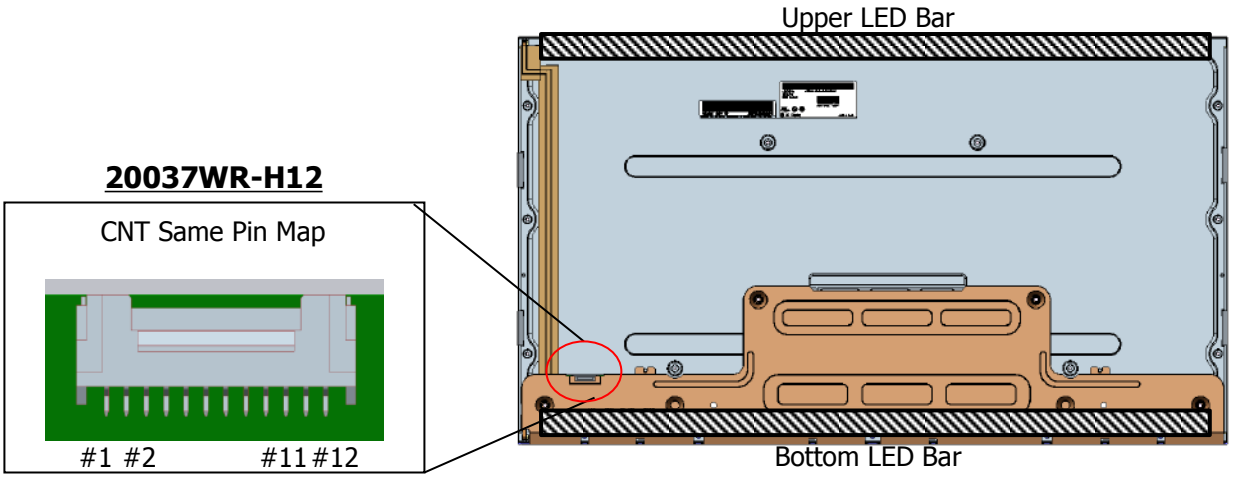
3-2-2. BACKLIGHT Interface

- LED Connector : 20037WR-H12 (Manufactured by Yeonho) and Equivalent
- Mating Connector : SMH200-12 (Manufactured by Yeonho) and Equivalent

Table 3-1. LED CONNECTOR PIN CONFIGURATION

Pin No.	Symbol	Description	Note
1	FB1	Channel1 Current Feedback	Upper LED Bar
2	FB2	Channel2 Current Feedback	
3	VLED	LED Power Supply	
4	VLED	LED Power Supply	
5	FB3	Channel3 Current Feedback	
6	FB4	Channel4 Current Feedback	
7	FB5	Channel5 Current Feedback	Bottom LED Bar
8	FB6	Channel6 Current Feedback	
9	VLED	LED Power Supply	
10	VLED	LED Power Supply	
11	FB7	Channel7 Current Feedback	
12	FB8	Channel8 Current Feedback	

Notes : 1. LED Power Supply [pin No. 3,4,9,10] must be connected electrically for stable operation.



[FIG. 5] Backlight connector view

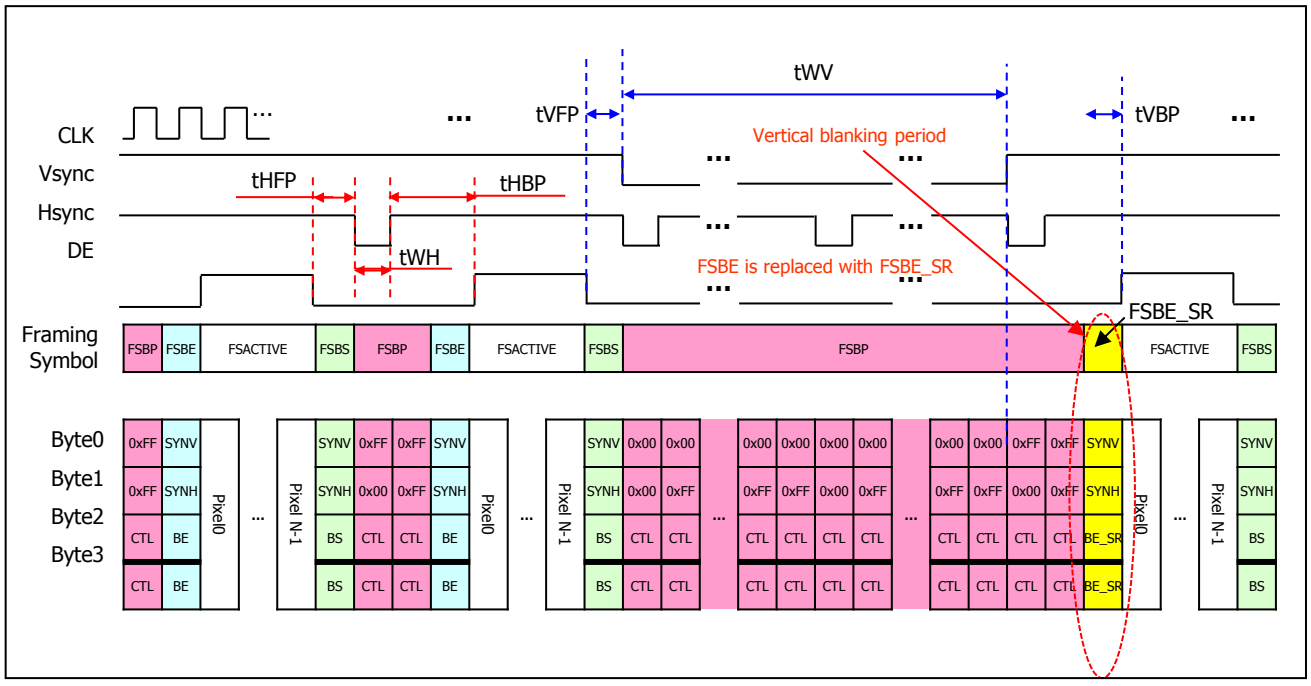
3-3. Signal Timing Specifications

This is signal timing required at the input of the TMDS transmitter. All of the interface signal timing should be satisfied with the following specifications for it's proper operation.

Table 4. TIMING TABLE

ITEM	Symbol		Min	Typ	Max	Unit	Note
DCLK	Period	tCLK	0.16	0.13	0.13	ns	Pixel frequency : Typ.2320MHz
	Frequency	-	61.4	72.5	72.5	MHz	
Hsync	Period	tHP	264	272	272	tCLK	
	Horizontal Valid	tHV	240	240	240	tCLK	
	Horizontal Blank	tHB	24	32	32		
	Frequency	fH	213	266	266	KHz	
	Width	tWH	8	8	8	tCLK	
	Horizontal Back Porch	tHBP	12	12	12		
	Horizontal Front Porch	tHFP	4	12	12		
Vsync	Period	tVP	4352	4443	4443	tHP	
	Vertical Valid	tVV	4320	4320	4320	tHP	
	Vertical Blank	tVB	32	123	123	tHP	
	Frequency	fV	48	60	60	Hz	
	Width	tWV	5	5	5	tHP	
	Vertical Back Porch	tVBP	20	100	100		
	Vertical Front Porch	tVFP	7	18	18		

Note:
1. The input of Hsync & Vsync signals should be follow timing table and active low refer to Fig #.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3. Horizontal period should be even.
4. If use spread spectrum for EMI, add some additional clock to minimum value for clock margin. Spread Spectrum Rate (SSR) is limited to ±0.5% center spread at 30KHz



[FIG. 6] Relationships between Video Timing and Framing Symbols

3-4. V by One input signal Characteristics

3-4-1. V by One Input Signal Timing Diagram

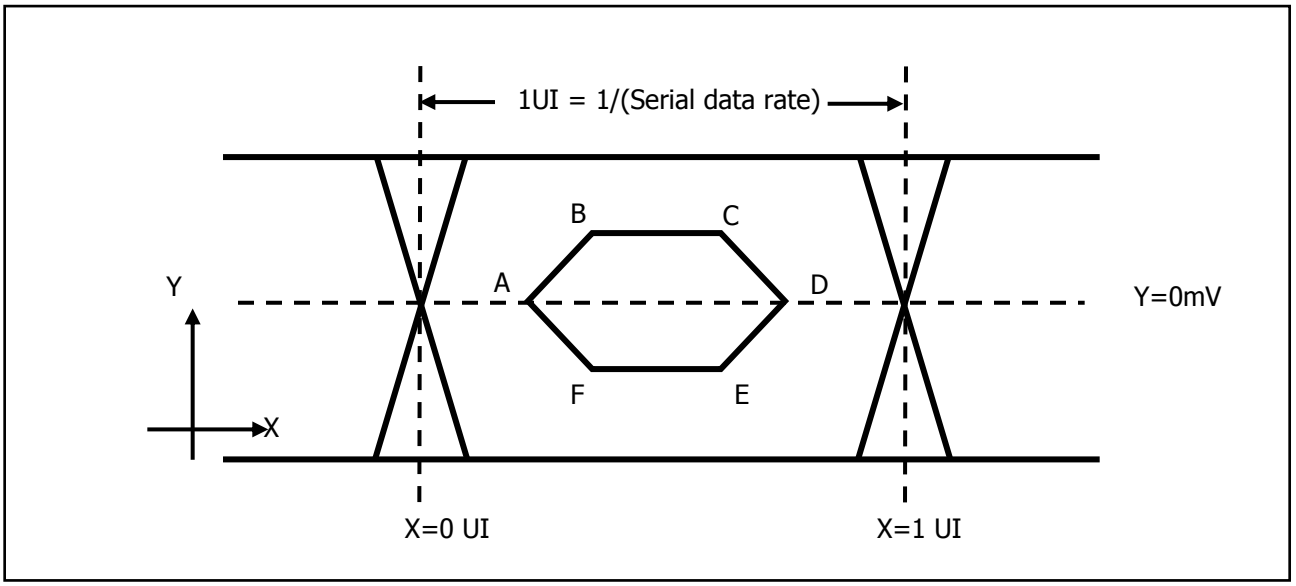


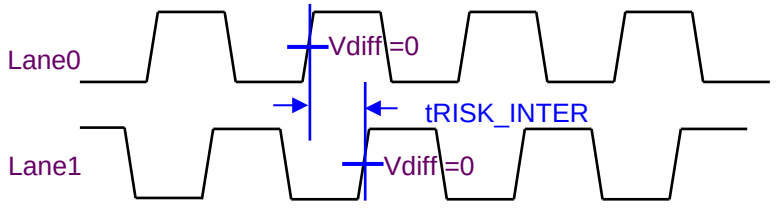
Table 6. Eye Mask Specification

Symbol	X[UI]	Note	Y[mV]	Note
A	0.25 (max)	2	0	-
B	0.3 (max)	2	55	3
C	0.7 (min)	3	55	3
D	0.75 (min)	3	0	-
E	0.7 (min)	3	I -55 I	3
F	0.3 (max)	2	I -55 I	3

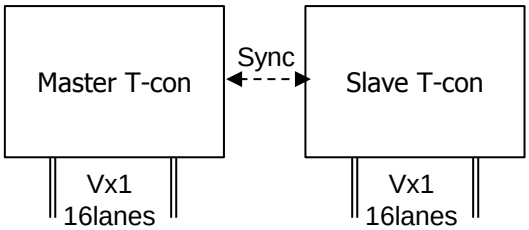
Note

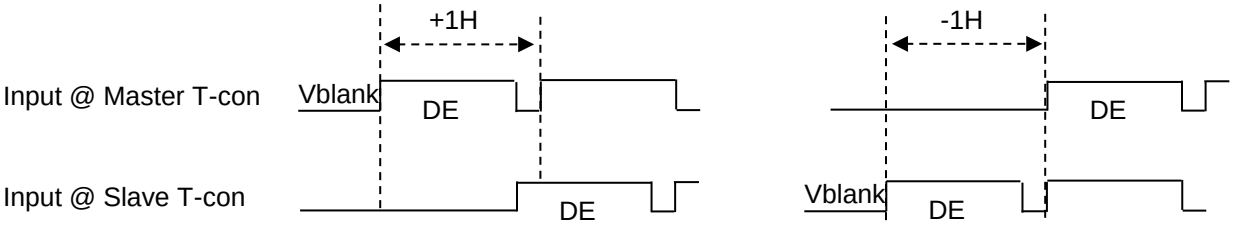
1. All Input levels of V by One signals are based on the V by One HS Standard Ver. 1.4
2. This is allowable maximum value.
3. This is allowable minimum value.
4. The eye diagram is measured by the oscilloscope and receiver CDR characteristic must be emulated.
   - 2nd order PLL loop bandwidth : 15MHz
   - Damping Factor : 1.0

3-4-2. V by One Input Signal Characteristics



<Inter-pair Skew between two Lanes>





<T-con Skew between Vx1 16lanes>

Table 7. Vx1 Signal Skew Specification

Description	Symbol	Min	Max	Unit	Note
Allowable inter-pair skew between lanes	tRISK_INTER	-	5	UI	1,3
Allowable T-con skew between Vx1 16lanes	tRISK_T-con	-	±1	DE	1,4

Note

1.1UI = 1/serial data rate
2. it is the time difference between the true and complementary single-ended signals.
3. it is the time difference of the differential voltage between any two lanes in one sub block.
4. it is the time difference of the differential voltage between two T-con.

3-5. Color Data Reference

The brightness of each primary color (red, green, blue) is based on the 10bit gray scale data input for the color.
The higher binary input, the brighter the color. Table 8 provides a reference for color versus data input.

Table 8. COLOR DATA REFERENCE

Packer input & Un-packer output		30bpp RGB (10bit)
Byte0	D[0]	R[2]
	D[1]	R[3]
	D[2]	R[4]
	D[3]	R[5]
	D[4]	R[6]
	D[5]	R[7]
	D[6]	R[8]
	D[7]	R[9]
Byte1	D[8]	G[2]
	D[9]	G[3]
	D[10]	G[4]
	D[11]	G[5]
	D[12]	G[6]
	D[13]	G[7]
	D[14]	G[8]
	D[15]	G[9]
Byte2	D[16]	B[2]
	D[17]	B[3]
	D[18]	B[4]
	D[19]	B[5]
	D[20]	B[6]
	D[21]	B[7]
	D[22]	B[8]
	D[23]	B[9]
Byte3	D[24]	Don't care
	D[25]	Don't care
	D[26]	B[0]
	D[27]	B[1]
	D[28]	G[0]
	D[29]	G[1]
	D[30]	R[0]
	D[31]	R[1]

3-6. Power Sequence & Dip condition for LCD Module

3-6-1. Power Sequence

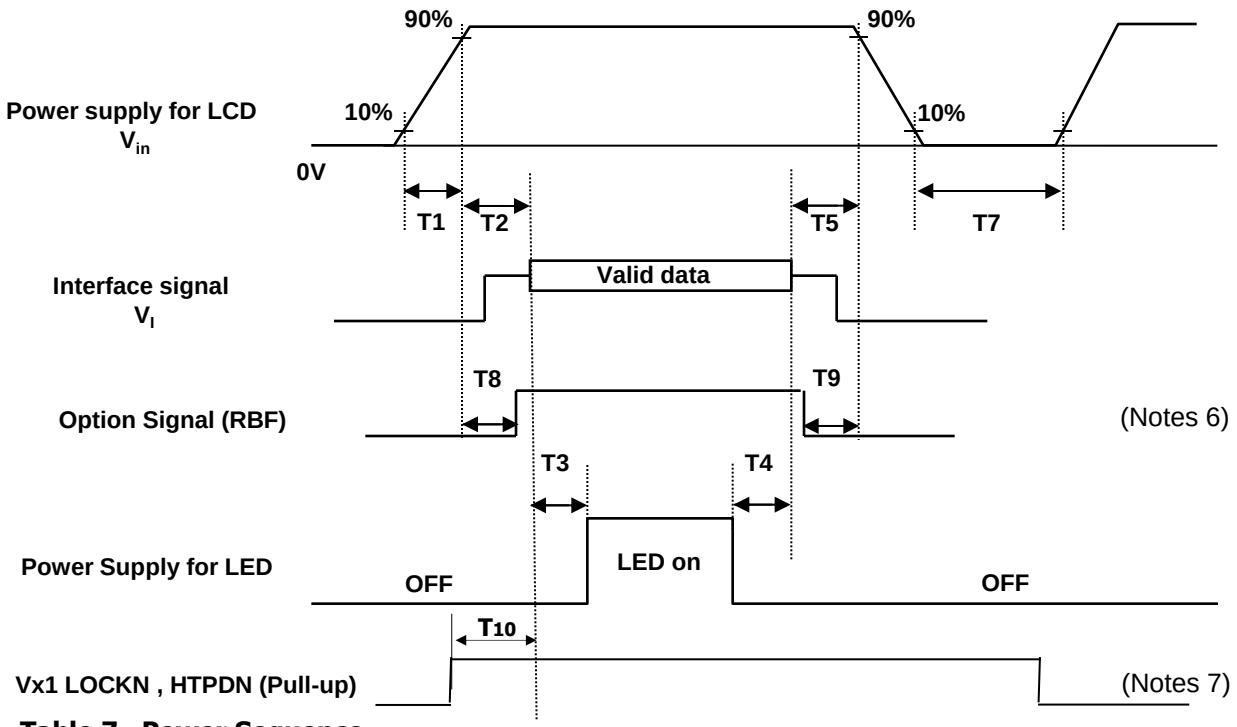


Table 7. Power Sequence

Parameter	Values			Units
	Min	Typ	Max	
T1	0.5	-	10	ms
T2	0	-	100	ms
T3	500	-	-	ms
T4	200	-	-	ms
T5	0.01	-	50	ms
T7	1000		-	ms
T8 (option signal)	20 (After T-con reset)	-	T2	ms
T9	0	-	-	ms
T10	0	-	-	ms

Notes :

1. Recommend to follow Power sequence at these case
   -.AC/DC Power On/Off
   -.Mode change (Resolution, frequency, timing, sleep mode, Color depth change, etc.)
   If not to follow power sequence, there is a risk of abnormal display.
2. Please avoid floating state of interface signal at invalid period.

Notes :

3. When the interface signal is invalid, be sure to pull down the power supply for LCD V_{in} to 0V.
4. LED power must be turn on after power supply for LCD an interface signal are valid.
5 . If Vin Power is Changed during on status, be sure to Pull down the LED Power on to 0V
6. If RBF=H when Power on , LCM will be display BIST mode.
7. HTPN is going to low when Tx is ready. LOCKN is going to low when All lane CDR training is done.

3-6-2. V_{LCD} Power Dip Condition

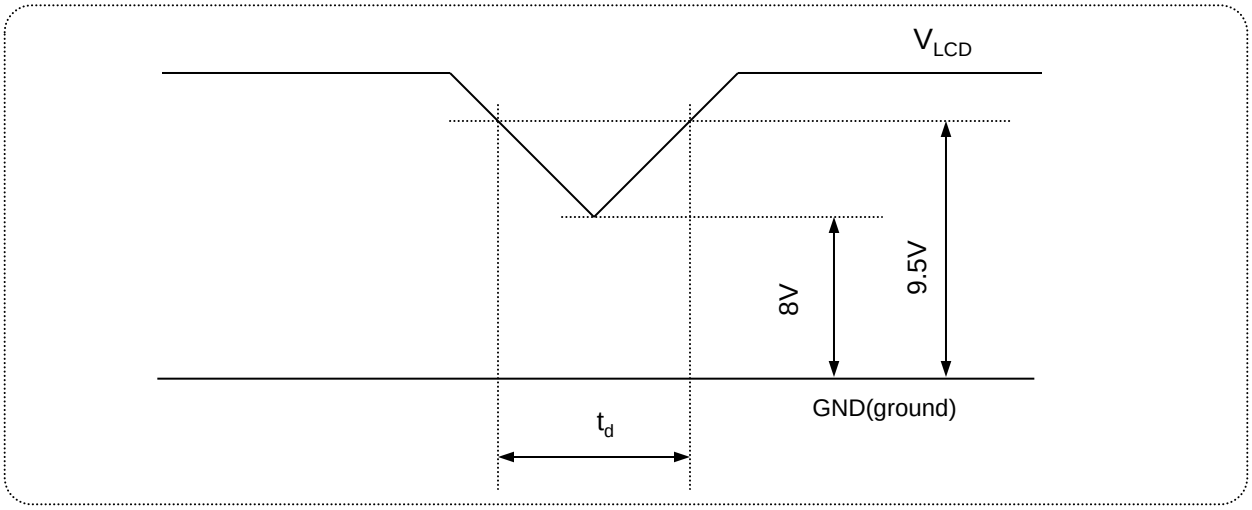


FIG.7 Power dip condition

1) Dip condition

$8V \leq V_{LCD} < 9.5V$, $t_d \leq 20ms$

2) $V_{LCD} < 8V$

V_{LCD}-dip conditions should also follow the Power On/Off conditions for supply voltage.

4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at 25±2°C. The values specified are at an approximate distance 50cm from the LCD surface at a viewing angle of Φ and θ equal to 0 ° and aperture 1 degree.

FIG. 1 presents additional information concerning the measurement equipment and method.

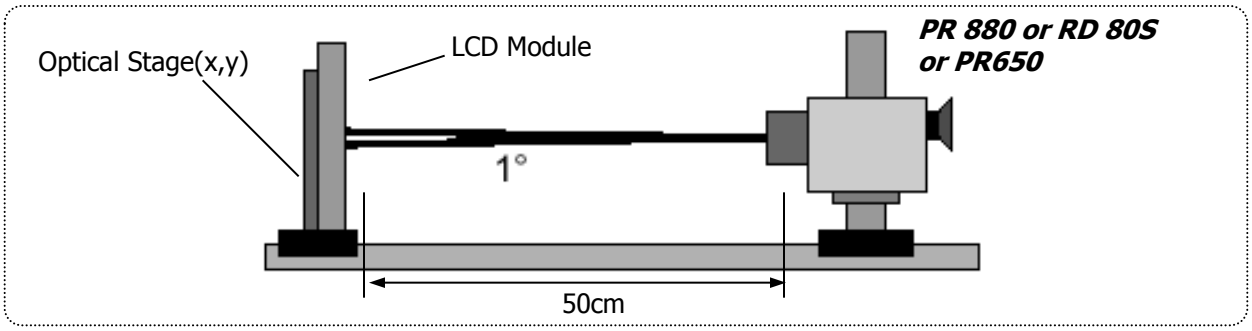


FIG.8 Optical Characteristic Measurement Equipment and Method

Table 9. OPTICAL CHARACTERISTICS (Ta=25 °C, V_{LCD}=10V, f_V=60Hz Dclk=2320MHz, I_S=130mA)

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	910	1300	-		1
Surface Luminance, white		L_{WH}	320	400	-	cd/m²	2
Luminance Variation		δ_{WHITE}	75	-	-	%	3
Response Time	Gray To Gray	T_{GTG_AVR}	-	14	25	ms	4
Color Coordinates [CIE1931] ***(By PR650)***	RED	Rx	Typ -0.03	0.681	Typ -0.03		
		Ry		0.319			
	GREEN	Gx		0.208			
		Gy		0.729			
	BLUE	Bx		0.149			
		By		0.051			
	WHITE	Wx	Typ -0.025	0.313	Typ -0.025		
		Wy		0.329			
Color Shift (Avg. Δu'v' < 0.02)	Horizontal	θ_{CST_H}	-	140	-	Degree	5
	Vertical	θ_{CST_V}	-	100	-		
Viewing Angle (CR>10)							
General	Horizontal	θ_H	170	178	-	Degree	6
	Vertical	θ_V	170	178	-		
GSR @ 60degree (Gamma shift rate)	Horizontal	δ_{Gamma_H}	-	-	20	%	7
	Vertical	δ_{Gamma_V}	-	-	20		
WPT (White Point Tracking)		-	-300	G255 CCT	+700	K	8
Gray Scale		-	-	2.2	-		9

Notes 1. Contrast Ratio(CR) is defined mathematically as : ***(By PR880)***

$$\text{Contrast Ratio} = \frac{\text{Surface Luminance with all white pixels}}{\text{Surface Luminance with all black pixels}}$$

It is measured at center point(Location P1)

2. Surface luminance(L_{WH})is luminance value at Center 1 point(P1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG.9 (By PR880)

3. The variation in surface luminance , δ WHITE is defined as : ***(By PR880)***

$$\delta_{WHITE} = \frac{\text{Minimum}(L_{P1}, L_{P2}, \ldots . L_{P9})}{\text{Maximum}\ (L_{P1}, L_{P2}, \ldots . L_{P9})} \times 100$$

Where L1 to L9 are the luminance with all pixels displaying white at 9 locations.
For more information see FIG.9

4. Gray to gray response time is the time required for the display to transition from gray to gray. For additional information see Table 10. ***(By RD80S)***

5. Color shift is the angle at which the average color difference for all Macbeth is lower than 0.02. For more information see FIG.11 ***(By EZ Contrast)***
- Color difference (Δu'v')

$$u' = \frac{4x}{-2x+12y+3} \qquad v' = \frac{9y}{-2x+12y+3} \qquad \Delta u'v' = \sqrt{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2}$$

$$Avg(\Delta u'v') = \frac{\sum_{i=1}^{24} (\Delta u'v')i}{24}$$

u'1, v'1 : u'v' value at viewing angle direction
u'2, v'2 : u'v' value at front (θ=0)
i : Macbeth chart number (Define 23 page)

- Pattern size : 25% Box size
- Viewing angle direction of color shift : Horizontal, Vertical

6. Viewing angle is the angle at which the contrast ratio is greater than 10. The angles are determined for the horizontal or x axis and the vertical or y axis with respect to the z axis which is normal to the LCD surface. For more information see FIG.12 ***(By PR880)***

7. GSR is the rate of gamma shift at up, down, left and right 60 degree viewing angle compare with center gamma. For more information see FIG.13 and FIG.14 ***(By EZ Contrast)***
- GSR (δ_{Gamma}) is defined as :

.

$$GSR = \left(1 - \frac{\text{View angle Gamma Value (Up, Down, Reft, Light 60 Degree)}}{\text{Center Gamma Value (0 Degree)}}\right) \times 100$$

8. WPT (White Point Tracking) is the variation of color temperature between G255 and G63. ***(By PR650)***

Notes 9. Gamma Value is approximately 2.2. For more information see Table 11.

Measuring point for surface luminance & measuring point for luminance variation.

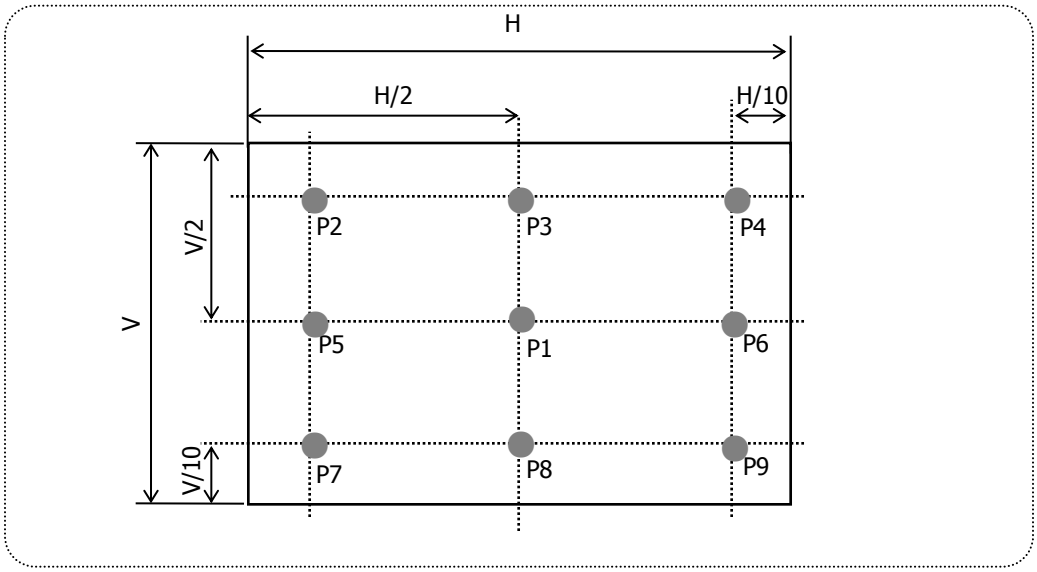


FIG.9 Measure Point for Luminance

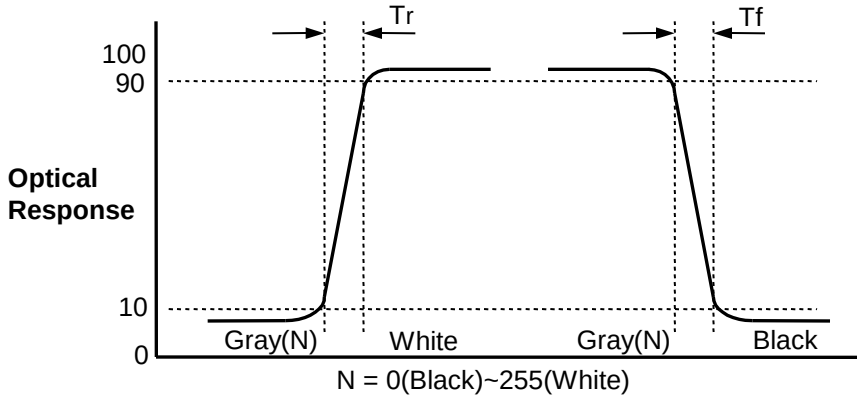
The Gray to Gray response time is defined as the following figure and shall be measured by switching the input signal for "Gray To Gray ".

- Gray step : 5 Step
- TGTG_AVR is the total average time at rising time and falling time for "Gray To Gray ".
- if system use ODC (Over Driving Circuit) function, Gray to Gary response time may be 5ms~8ms GtG
  * it depends on Overshoot rate.

Table. 10 GTG Gray Table

Gray to Gray		Rising Time				
		G255	G191	G127	G63	G0
Falling Time	G255					
	G191					
	G127					
	G63					
	G0					

G to G(BW) Response time is defined as the following figure and shall be measured by switching the input signal for “Gray(N)” and “Black or White”.



Color shift is defined as the following test pattern and color.

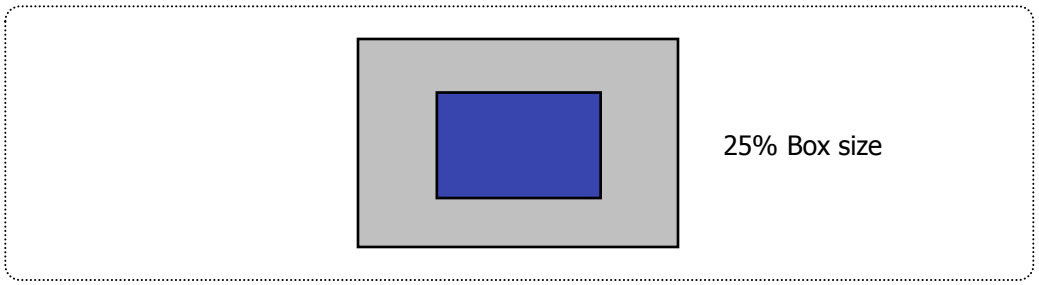


FIG.11 Color Shift Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

	Dark skin (i=1)	Light skin	Blue sky	Foliage	Blue flower	Bluish green
R	98	206	85	77	129	114
G	56	142	112	102	118	199
B	45	123	161	46	185	178
	Orange	Purplish blue	Moderate red	Purple	Yellow green	Orange yellow
R	219	56	211	76	160	230
G	104	69	67	39	193	162
B	24	174	87	86	58	29
	Blue	Green	Red	Yellow	Magenta	Cyan
R	26	72	197	241	207	35
G	32	148	27	212	62	126
B	145	65	37	36	151	172
	White	Neutral 8	Neutral 6.5	Neutral 5	Neutral 3.5	Black
R	240	206	155	110	63	22
G	240	206	155	110	63	22
B	240	206	155	110	63	22

Dimension of viewing angle range.

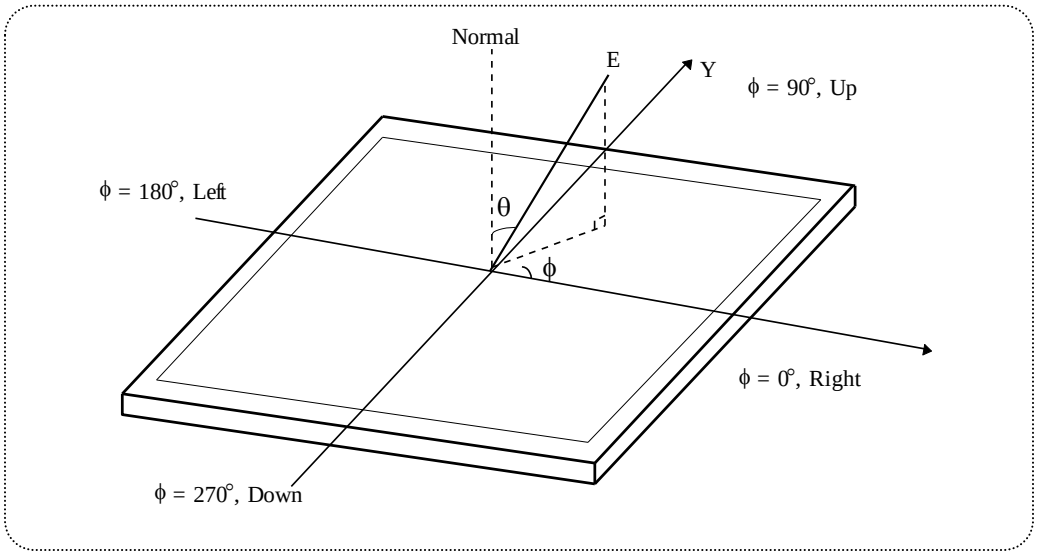


FIG.12 Viewing angle

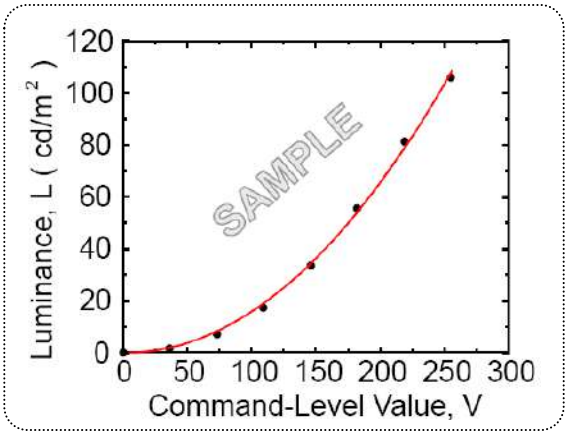


FIG.13 Sample Luminance vs. gray scale (using a 256 bit gray scale)

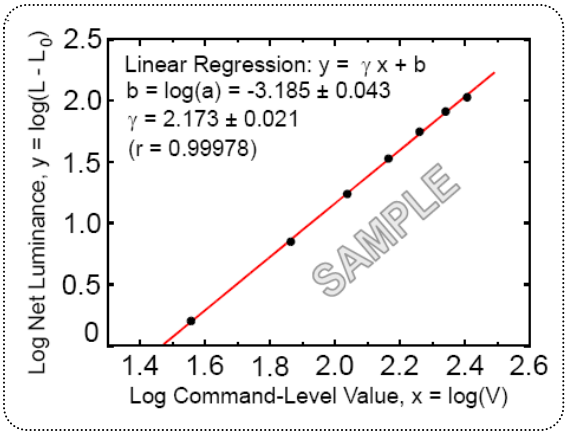


FIG.14 Sample Log-log plot of luminance vs. gray scale

$$L = aV^{r} + L_b$$

$$\log(L - L_b) = r\log(V) + \log(a)$$

Here the Parameter α and γ relate the signal level V to the luminance L.
The GAMMA we calculate from the log-log representation (FIG.11)

Table 11. Gray Scale Specification

Gray Level	Relative Luminance [%] (Typ.)
0	0.11
31	1.08
63	4.72
95	11.49
127	21.66
159	35.45
191	53.00
223	74.48
255	100

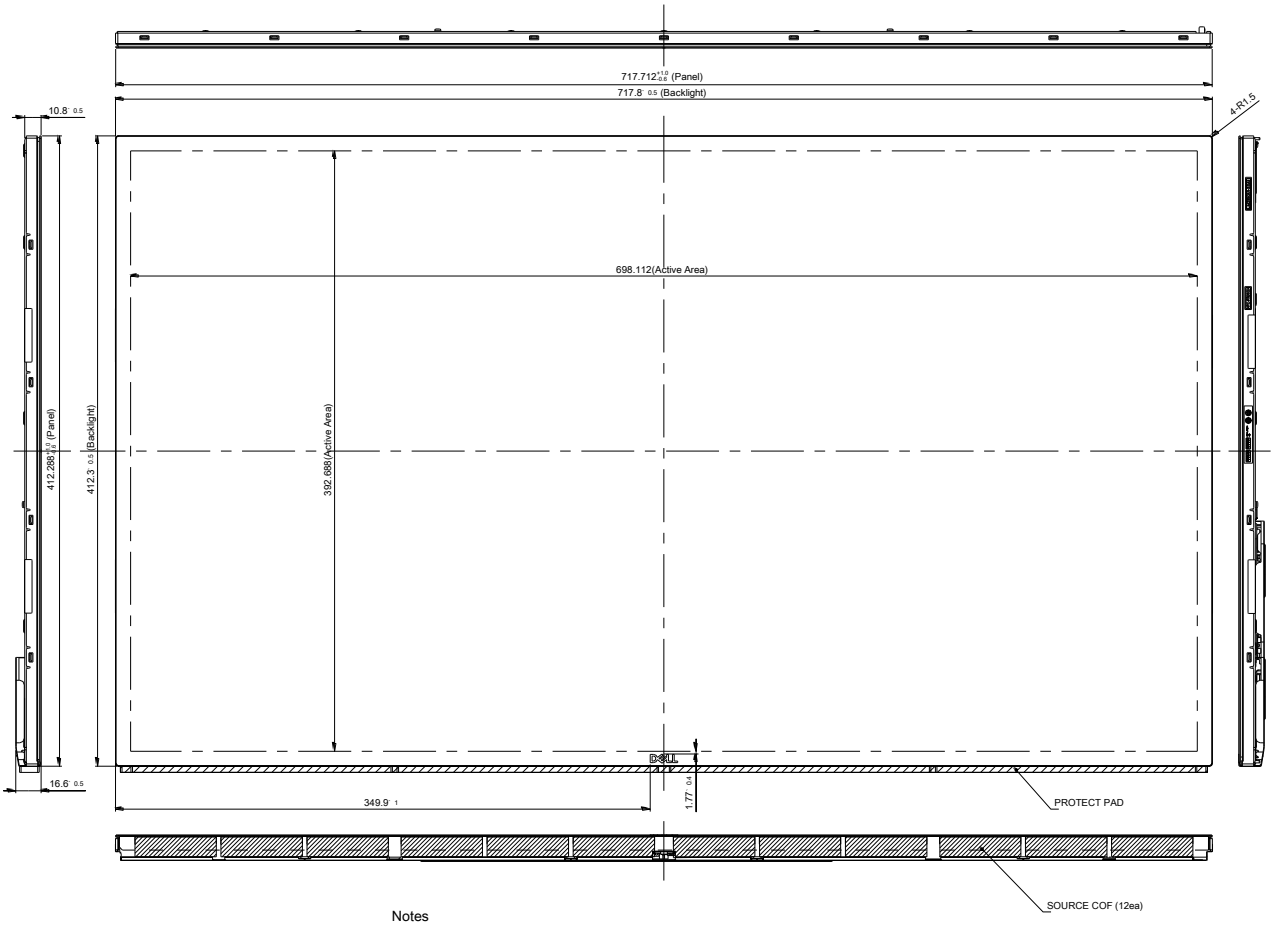
5. Mechanical Characteristics

The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

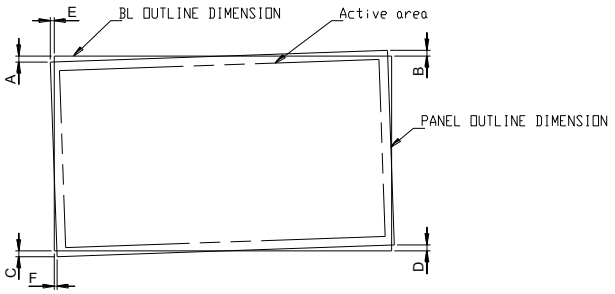
Outline Dimension	Horizontal	717.8 mm
	Vertical	412.3 mm
	Depth	16.6 mm
Bezel Area	Horizontal	-
	Vertical	-
Active Display Area	Horizontal	698.112mm
	Vertical	392.688mm
Weight	Typ : 3,710g , Max : 3,900g	
Surface Treatment	Hard coating(2H) Anti-glare treatment of the front polarizer	

Notes : Please refer to a mechanic drawing in terms of tolerance at the next page.

<FRONT VIEW>



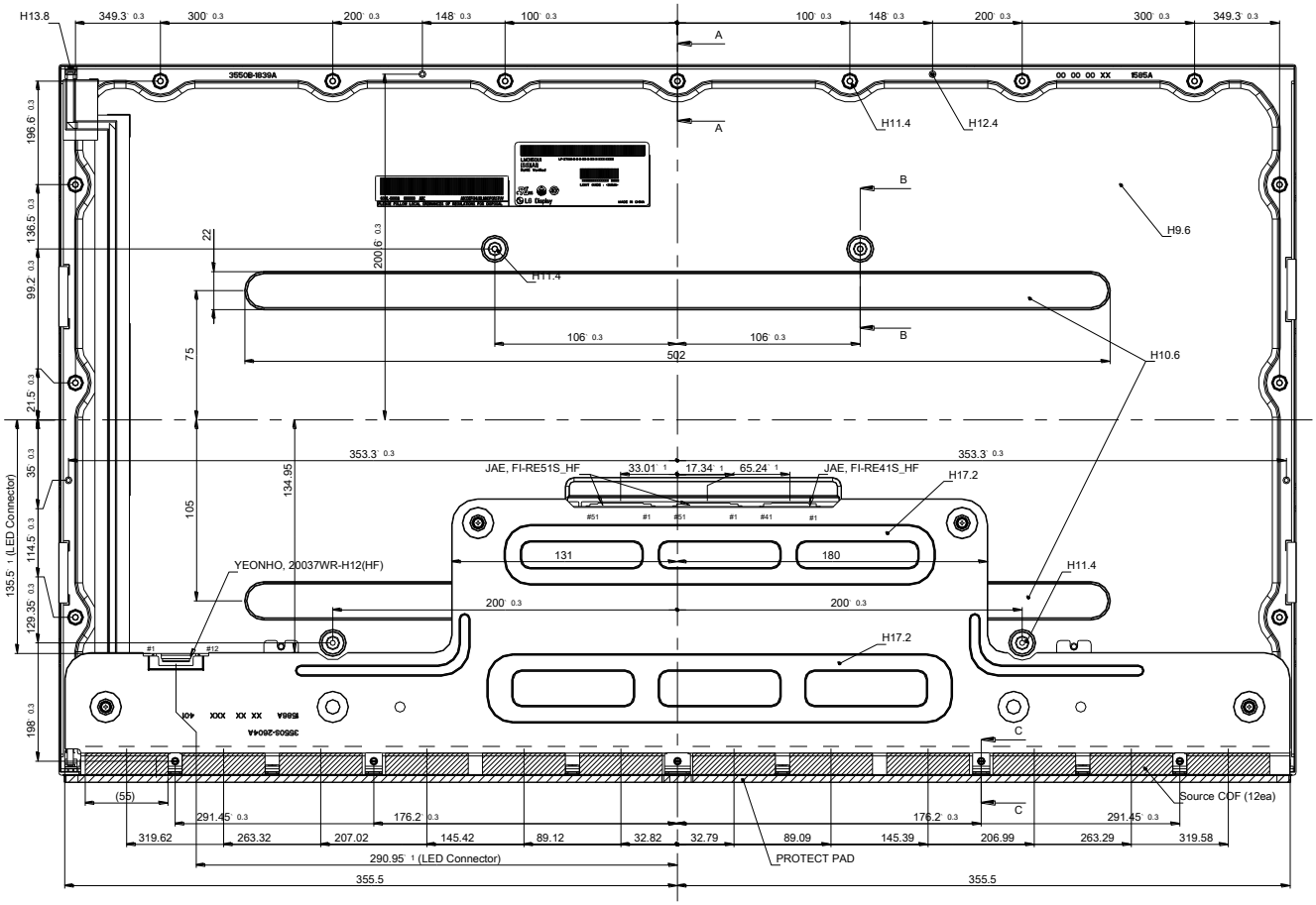
Notes
1. I/F Connector specification : JAE, FI-RE51S_HF & JAE, FI-RE41S_HF or Equivalent
2. LED connector specification : 20037WR-H12(HF) (Manufactured by YEONHO) or Equivalent
3. Torque of user hole : 3.0~4.0kgf.cm
4. Tilt and partial disposition tolerance of display area as following
   (1) Y-direction
      a. Upper side : -0.45 ≤ A ≤ 0.45, -0.45 ≤ B ≤ 0.45
      b. Lower side : -0.45 ≤ C ≤ 0.6, -0.45 ≤ D ≤ 0.6
   (2) X-direction : -0.45 ≤ E ≤ 0.45, -0.45 ≤ F ≤ 0.45

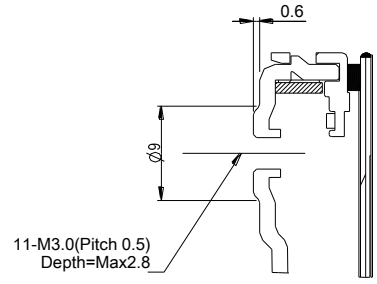


5. Unspecified tolerance is ` 0.5
6. The LCM warp(warpage) is less than 1.0 on the surface plate
7. The COF area is weak & sensitive, so please don't press the COF area
8. Protect Pad should not be removed unless system assembling

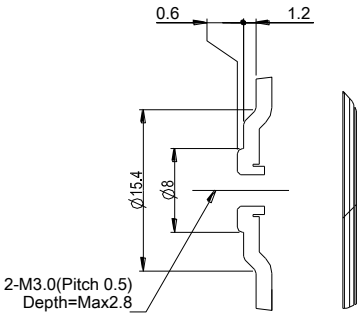
LGD Highly recommendation :
System chassis or frame should be designed to keep the IPS Panel flat as it is vulnerable to panel light-leakage caused by deformation.

<REAR VIEW>

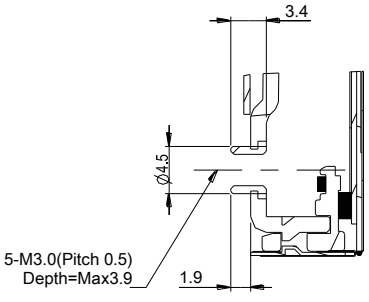




SECTION A-A
SCALE 2/1



SECTION B-B
SCALE 2/1



SECTION C-C
SCALE 2/1

6. Reliability

Environment test condition

No	Test Item	Condition
1	High temperature storage test	Ta= 60°C 240h
2	Low temperature storage test	Ta= -20°C 240h
3	High temperature operation test	Ta= 50°C 50%RH 240h
4	Low temperature operation test	Ta= 0°C 240h
5	Altitude operating storage / shipment	 0 – 16,400 feet(5,000m) 0 - 40,000 feet(12,192m)

Note 1. Result Evaluation Criteria:
TFT-LCD panels test should take place after cooling enough at room temperature.
In the standard condition, there should be no particular problems that may affect the display function.

※. T_a= Ambient Temperature

7. International Standards

7-1. Safety

a) UL 60950-1, Underwriters Laboratories Inc.
Information Technology Equipment - Safety - Part 1 : General Requirements.
b) CAN/CSA-C22.2 No. 60950-1-07, Canadian Standards Association.
Information Technology Equipment - Safety - Part 1 : General Requirements.
c) EN 60950-1, European Committee for Electrotechnical Standardization (CENELEC).
Information Technology Equipment - Safety - Part 1 : General Requirements.
d) IEC 60950-1, The International Electrotechnical Commission (IEC).
Information Technology Equipment - Safety - Part 1 : General Requirements

7-2. EMC

a) ANSI C63.4 "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz." American National Standards Institute (ANSI), 2003.
b) CISPR 22 "Information technology equipment – Radio disturbance characteristics – Limit and methods of measurement." International Special Committee on Radio Interference (CISPR), 2005.
c) CISPR 13 "Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and method of measurement." International Special Committee on Radio Interference (CISPR), 2006.

7-3. Environment

a) RoHS, Directive 2011/65/EU of the European Parliament and of the council of 8 June 2011

8. Packing

8-1. Designation of Lot Mark

a) Lot Mark

A	B	C	D	E	F	G	H	I	J	K	L	M

A,B,C : SIZE(INCH)
D : YEAR
E : MONTH
F ~ M : SERIAL NO.

Note

1. YEAR

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Mark	A	B	C	D	E	F	G	H	J	K

2. MONTH

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mark	1	2	3	4	5	6	7	8	9	A	B	C

b) Location of Lot Mark

Serial No. is printed on the label. The label is attached to the backside of the LCD module.
This is subject to change without prior notice.

8-2. Packing Form

a) Package quantity in one box : 14 pcs (1 Module is packed in 1 Al Bag)
b) Box quantity in one pallet : 2

9. PRECAUTIONS

Please pay attention to the followings when you use this TFT LCD module.

9-1. MOUNTING PRECAUTIONS

(1) You must mount a module using holes arranged in four corners or four sides.
(2) You should consider the mounting structure so that uneven force (ex. Twisted stress) is not applied to the module. And the case on which a module is mounted should have sufficient strength so that external force is not transmitted directly to the module.
(3) Please attach the surface transparent protective plate to the surface in order to protect the polarizer. Transparent protective plate should have sufficient strength in order to the resist external force.
(4) You should adopt radiation structure to satisfy the temperature specification.
(5) Acetic acid type and chlorine type materials for the cover case are not desirable because the former generates corrosive gas of attacking the polarizer at high temperature and the latter causes circuit break by electro-chemical reaction.
(6) Do not touch, push or rub the exposed polarizers with glass, tweezers or anything harder than HB pencil lead. And please do not rub with dust clothes with chemical treatment.
Do not touch the surface of polarizer for bare hand or greasy cloth.(Some cosmetics are detrimental to the polarizer.)
(7) When the surface becomes dusty, please wipe gently with absorbent cotton or other soft materials like chamois soaks with petroleum benzene. Normal-hexane is recommended for cleaning the adhesives used to attach front / rear polarizers. Do not use acetone, toluene and alcohol because they cause chemical damage to the polarizer.
(8) Wipe off saliva or water drops as soon as possible. Their long time contact with polarizer causes deformations and color fading.
(9) Do not open the case because inside circuits do not have sufficient strength.
(10) As The IPS panel is sensitive & slim, please recommend the metal frame of the system supports the panel by the double side-mount.

9-2. OPERATING PRECAUTIONS

(1) The spike noise causes the mis-operation of circuits. It should be lower than following voltage :
V=±200mV(Over and under shoot voltage)
(2) Response time depends on the temperature.(In lower temperature, it becomes longer.)
(3) Brightness depends on the temperature. (In Higher temperature, it becomes lower.)
And in lower temperature, response time(required time that brightness is stable after turned on) becomes longer.
(4) Be careful for condensation at sudden temperature change. Condensation makes damage to polarizer or electrical contacted parts. And after fading condensation, smear or spot will occur.
(5) When fixed patterns are displayed for a long time, remnant image is likely to occur.
(6) Module has high frequency circuits. Sufficient suppression to the electromagnetic interference shall be done by system manufacturers. Grounding and shielding methods may be important to minimized the interference.
(7) Please do not give any mechanical and/or acoustical impact to LCM. Otherwise, LCM can't be operated its full characteristics perfectly.
(8) A screw which is fastened up the steels should be a machine screw.
(if not, it causes metallic foreign material and deal LCM a fatal blow)
(9) Please do not set LCD on its edge.
(10) When LCMs are used for public display defects such as Yogore, image sticking can not be guaranteed.
(11) LCMs cannot support "Interlaced Scan Method"
(12) When this reverse model is used as a forward-type model (PCB on top side), LGD can not guarantee any defects of LCM.
(13) Please conduct image sticking test after 2-hour aging with Rolling Pattern and normal temperature.(25~40℃)

9-3. ELECTROSTATIC DISCHARGE CONTROL

Since a module is composed of electronic circuits, it is not strong to electrostatic discharge. Make certain that treatment persons are connected to ground through wrist band etc. And don't touch interface pin directly.

9-4. PRECAUTIONS FOR STRONG LIGHT EXPOSURE

Strong light exposure causes degradation of polarizer and color filter.

9-5. STORAGE

When storing modules as spares for a long time, the following precautions are necessary.

(1) Store them in a dark place. Do not expose the module to sunlight or fluorescent light. Keep the temperature between 5°C and 35°C at normal humidity.
(2) The polarizer surface should not come in contact with any other object.
It is recommended that they be stored in the container in which they were shipped.

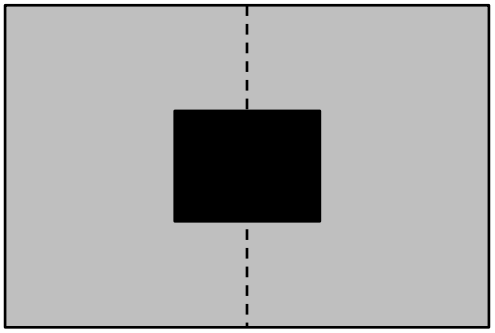
9-6. HANDLING PRECAUTIONS FOR PROTECTION FILM

(1) The protection film is attached to the bezel with a small masking tape.
When the protection film is peeled off, static electricity is generated between the film and polarizer.
This should be peeled off slowly and carefully by people who are electrically grounded and with well ion-blown equipment or in such a condition, etc.
(2) When the module with protection film attached is stored for a long time, sometimes there remains a very small amount of glue still on the bezel after the protection film is peeled off.
(3) You can remove the glue easily. When the glue remains on the bezel surface or its vestige is recognized, please wipe them off with absorbent cotton waste or other soft material like chamois soaked with normal-hexane.

APPENDIX

■ pixel data mapping

[Image]



[Fig #] Data mapping

Left					Right				
Lane No.	1th Data	2nd Data	#th Data	240th Data	Lane No.	1th Data	2th Data	#th Data	240th Data
Lane00	0	16		3824	Lane16	3840	3856		7664
Lane01	1	17		3825	Lane17	3841	3857		7665
Lane02	2	18		3826	Lane18	3842	3858		7666
Lane03	3	19		3827	Lane19	3843	3859		7667
Lane04	4	20		3828	Lane20	3844	3860		7668
Lane05	5	21		3829	Lane21	3845	3861		7669
Lane06	6	22		3830	Lane22	3846	3862		7670
Lane07	7	23		3831	Lane23	3847	3863		7671
Lane08	8	24	...	3832	Lane24	3848	3864	...	7672
Lane09	9	25		3833	Lane25	3849	3865		7673
Lane10	10	26		3834	Lane26	3850	3866		7674
Lane11	11	27		3835	Lane27	3851	3867		7675
Lane12	12	28		3836	Lane28	3852	3868		7676
Lane13	13	29		3837	Lane29	3853	3869		7677
Lane14	14	30		3838	Lane30	3854	3870		7678
Lane15	15	31		3839	Lane31	3855	3871		7679

Note

(1) Fig # image is example to understand pixel mapping.