SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(●) Final Specification

TITLE	27.0" QHD TFT LCD

BUYER	DELL
MODEL	

SUPPLIER	LG Display Co., Ltd.
MODEL	LM270WQA
SUFFIX	SSA2

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

APPROVED BY		SIGNATURE / DATE
	/	
	/	
	/	

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

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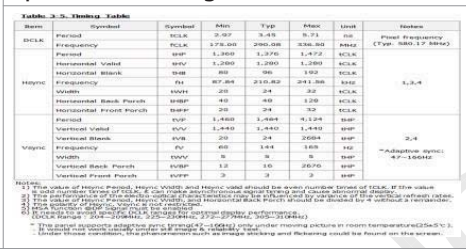
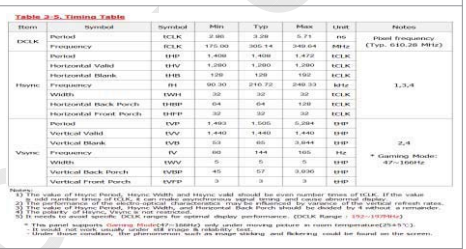
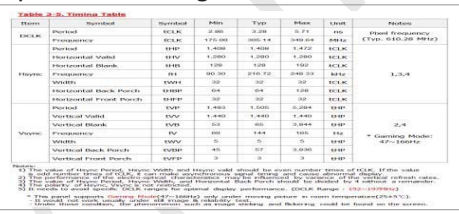
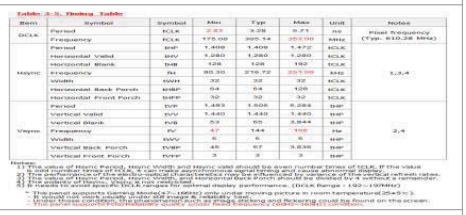
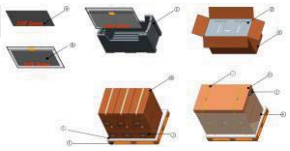
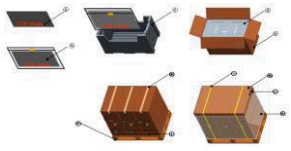
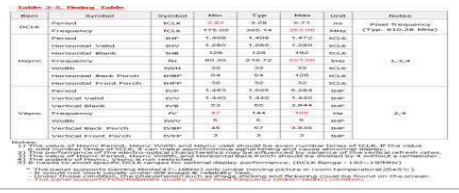
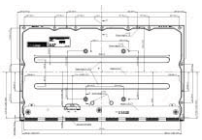
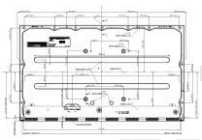
Contents

Record of Revisions

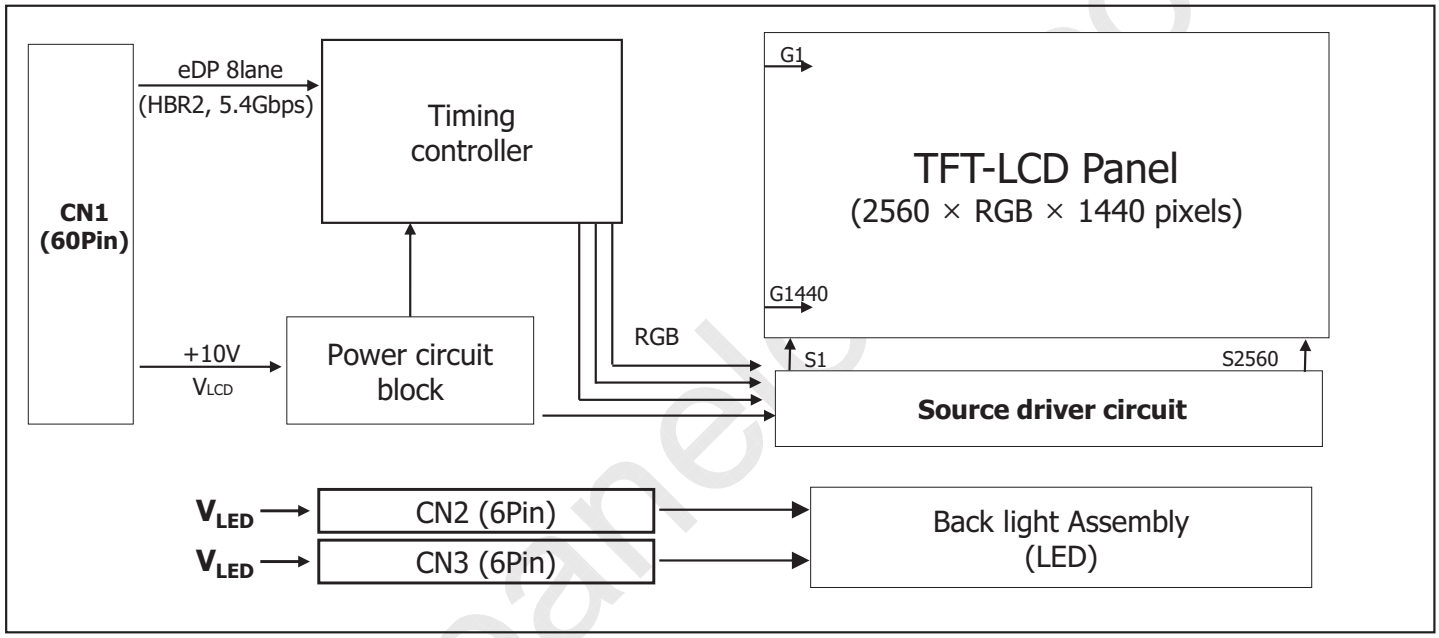
Revision No	Revision Date	Page	Before	After	Application Date
0.1	Aug. 05, 2019	-	-	First Draft(Preliminary)	Aug. 05, 2019
0.2	Aug. 05, 2019	23	Change the format and page about characteristics of peak luminance Table 3-3. Absolute maximum value of LED bar Parameter / Symbol / Values / Unit / Notes Peak LED string current / Is / (110) / mA / 1, 2 Peak luminance / Lp / 500 / nt Notes : 1. Peak LED string voltage at peak current with 100% duty cycle is (46.9±1.6 V) at Ta = 25 ± 2°C. 2. Peak Luminance 500nit is achieved at (110mA), while the specifications for guarantee remains under the normal operating condition specified in Table 2-2. Specifications and condition for evaluation test and mass production shall be applied with conditions specified in Table 2-2. .	4-1. Characteristics of Peak Luminance Table 4-1-1. Absolute Maximum Value of LED Bar and Peak Luminance Parameter / Symbol / Values / Unit / Notes Peak LED String Current / Is / (110) / mA / a,b,c Peak Luminance / Lp / 500 / nit / a,b,c Notes: a) Peak LED string voltage at peak current with 100% duty cycle is (46.9±1.6V) at T_a = 25±2°C. b) Table 4-1-1 is reference data only for HDR Function usage, refer to the appendix of LCM temperature at peak current. c) Peak luminance 500nit is achieved at (110mA), while the specifications for guarantee remains under the normal operating condition specified in Table 3-2. Specifications and condition for evaluation test and mass production shall be applied with conditions specified in Table 3-2.	Aug. 05, 2019
0.3	Aug. 19, 2019	1, 5	Update the model name -. LM270WQA-SSxx	-. LM270WQA-SSA2	Aug. 19, 2019
		17	Update the timing table and notes 		
		23	Update the note (C) about characteristics of peak luminance c) Peak luminance 500nit is achieved at (110mA), while the specifications for guarantee remains under the normal operating condition specified in Table 3-2. Specifications and condition for evaluation test and mass production shall be applied with conditions specified in Table 3-2.	c) Peak luminance 500nit (Min. 400nit) is achieved at (110mA), while the specifications for guarantee remains under the normal operating condition specified in Table 3-2. Specifications and condition for evaluation test and mass production shall be applied with conditions specified in Table 3-2.	
0.4	Aug. 30, 2019	17	Update the timing table and notes 		Aug. 30, 2019
		33	Update the information of Packing form 		
0.5	Sep. 09, 2019	17	Update the timing table 		Sep. 09, 2019
0.6	Apr. 29, 2020	9	Update the LED bar electrical characteristics Parameter / Symbol / Values (Min. / Typ. / Max.) / Units LED string current / Is / - / (85) / (90) / mA LED string votage / Vs / (44.5) / (46.1) / (47.7) / V Power consumption / Pbar / - / (31.3) / (32.4) / Watt	Parameter / Symbol / Values (Min. / Typ. / Max.) / Units LED string current / Is / - / (85) / (90) / mA LED string votage / Vs / (44.4) / (46.0) / (47.6) / V Power consumption / Pbar / - / (31.3) / (32.4) / Watt	Apr. 25, 2020

Record of Revisions

Revision No	Revision Date	Page	Before	After	Application Date
0.6	Apr. 29, 2020	36,37	Update the content of appendix about HDR function		Apr. 29, 2020
			-. To be update	-. Update the content of appendix	
1.0	May. 13. 2020	-	-	**Final Draft**	May. 13. 2020
		29	Update the mechanical drawing		
					
		31	Update the content of safety		
			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 Electro-technical Standardization(CENELEC). Information Technology Equipment - Safety - Part 1: General Requirements. d) IEC 60950-1, The International Electro-technical Commission(IEC). Information Technology Equipment - Safety - Part 1: General Requirements.	**7-1. Safety** a) IEC 62368-1, The International Electro-technical Commission(IEC). Audio/video, Information and Communication Technology Equipment - Safety - Safety Requirements. b) EN 62368-1, European Committee for Electro-technical Standardization (CENELEC) Audio/video, Information and Communication Technology Equipment - Safety Requirements c) UL 62368-1, UL LLC. Audio/video, Information and Communication Technology Equipment - Safety Requirements d) CAN/CSA C22.2 No.62368-1, Canadian Standards Association (CSA). Audio/video, Information and Communication Technology Equipment - Safety Requirements e) IEC 60950-1, The International Electro technical Commission (IEC). Information Technology Equipment - Safety - Part 1 ; General Requirements	

1. General description

LM270WQA-SSA2 is a color active matrix liquid crystal display with a light emitting diode (WLED) backlight assembly without LED driver. The matrix employs a-Si thin film transistor as the active element.
It is a transmissive type display operating in the normally black mode. It has a 27 inch diagonally measured active display area with QHD resolution.(2560 horizontal by 1440 vertical pixels 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 10bit gray scale signal for each dot, thus, presenting a palette of more than 1.07 Billion colors with A-FRC(Advanced Frame Rate Control). It has been designed to apply eDP(HBR2, 5.4Gbps) 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	27 inches(68.47cm) (Aspect ratio 16:9)
Outline dimension	608.8(H) x 355.1(V) x 15.2mm (Typ.)
Pixel pitch	0.2331(H)mm x 0.2331(V)mm
Pixel format	2560(H) x 1440(V) Pixels. RGB stripes arrangement
Color depth	1.07 Billion colors (8bit + A-FRC)
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 36.9Watt (5.6Watt @V_{LCD}, 31.3Watt @Is=85mA)
Weight	2,550g (Typ.)
Display operating mode	Transmissive mode, normally black
Panel type	Reverse type
Surface treatment	Anti-Glare treatment of the front polarizer (Haze25%, 3H)

2. Absolute Maximum Ratings

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

Table 2-1. Absolute Maximum Ratings

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Supply Input Voltage	V_{LCD}	-0.3	+11.0	V_{DC}	At 25℃
Operating Temperature	T_{OP}	0	50	℃	1,2,3
Storage Temperature	T_{ST}	-20	60	℃	
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

Notes:
1) Temperature and relative humidity range are shown in the figure below.
Wet bulb temperature should be 39℃ 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 measured under the condition of V_{LCD} = Typ, f_V = 144Hz, T_a = 25℃, no humidity and typical LED string current.

* f_V = Frame frequency
* T_a = Ambient temperature

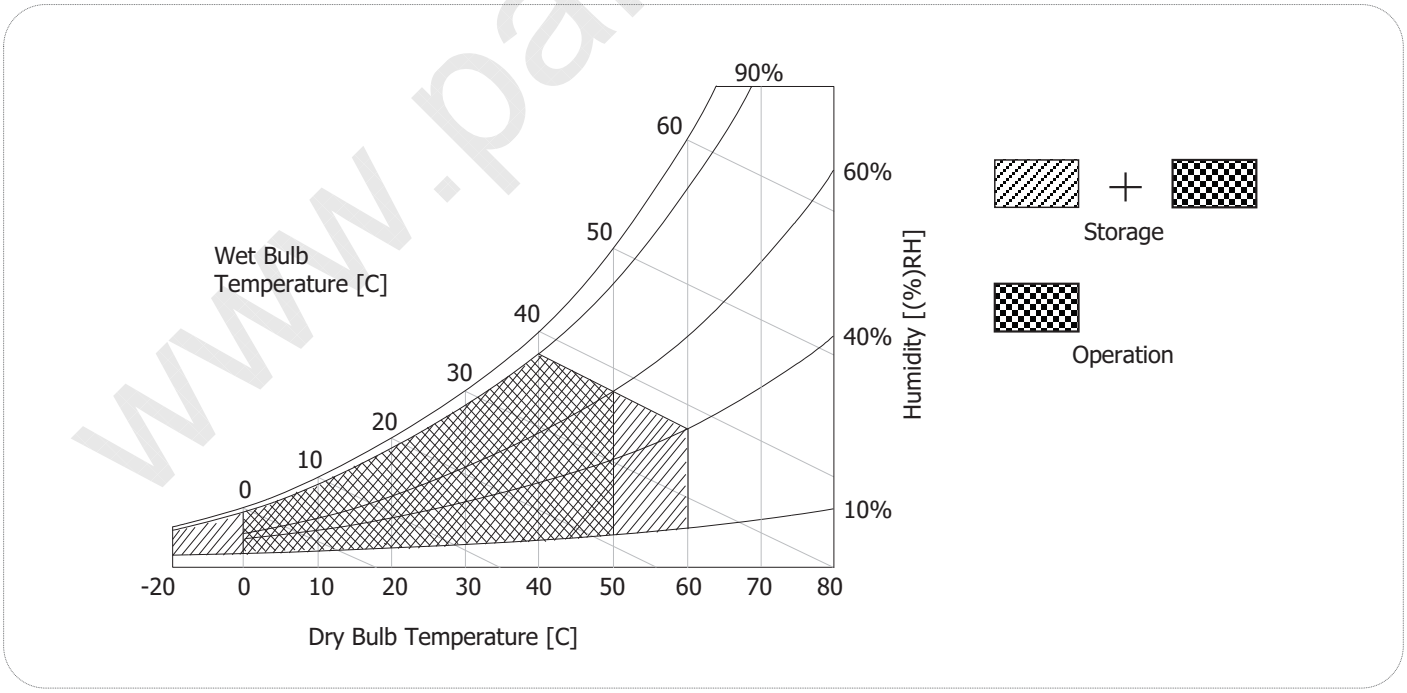


FIG.2 Temperature And Relative Humidity

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 other input power for the LED/Backlight, is typically generated by a LED Driver. The LED Driver is an external unit to the LCDs.

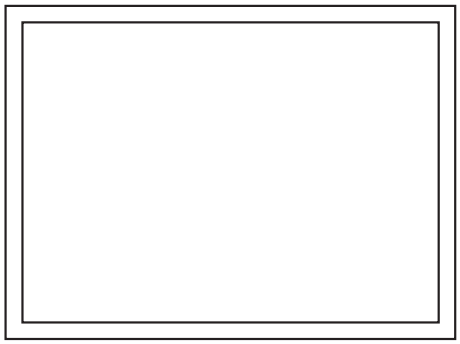
Table 3-1. Electrical Characteristics

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
Module:						
Power Supply Input voltage	V_{LCD}	9.5	10.0	10.5	Vdc	4
Permissive Power Input Ripple	V_{RIPPLE}	-	-	400	mVp-p	1
Power Supply Input Current	I_{LCD} Typ.	-	560	840	mA	2
	I_{LCD} Max.	-	580	870	mA	
Power Consumption	P_{LCD} Typ.	-	5.6	8.4	Watt	
	P_{LCD} Max.	-	5.8	8.7	Watt	
Rush Current	I_{RUSH}	-	-	4.0	A	3

Notes:
1) Permissive power ripple should be measured under the condition of V_{LCD} = Typ, 25±2℃, f_V = Max.
Refer to page 7 for the pattern and more information.
2) The specified current and power consumption can be measured under the V_{LCD} = Typ, 25±2℃, f_V = 144Hz and the pattern should be changed according to the typical or maximum power condition.
The max. current can be measured only with the maximum power pattern. See the page 7 for details.
3) Maximum condition of inrush current:
The duration of rush current is about 5ms and rising time of power input is 500us ±20%.(Min).
4) V_{LCD} level must be measured between two points on PCB of LCM V_{LCD}(test point) ~ LCM Ground.
(Test condition: Maximum power pattern, 25℃, f_V = 144Hz)

* f_V = Frame frequency

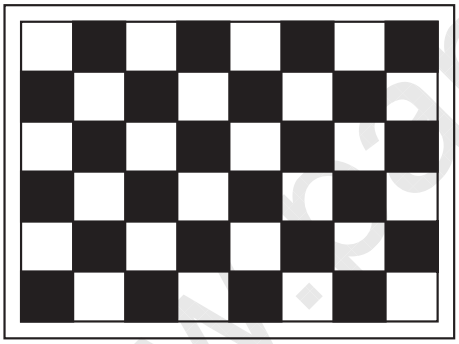
• **Permissive Power Input Ripple**(V_{LCD} = Typ, 25℃, f_V(frame frequency) = Max condition)



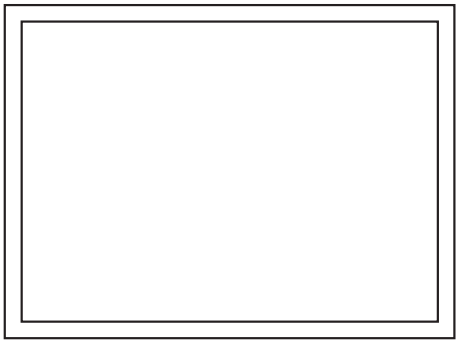
White Pattern

For the exact ripple measurement, the condition of Max 20MHz is recommended in the bandwidth configuration of oscilloscope.

• **Power Consumption**(V_{LCD} = Typ, 25℃, f_V(frame frequency) = 144Hz condition)



Typical Power Pattern



Maximum Power Pattern

FIG.3-1 Mosaic Pattern & White Pattern For Power Consumption Measurement

Table 3-2. LED Bar Electrical Characteristics

Parameter	Symbol	Values			Units	Notes
		Min.	Typ.	Max.		
LED string current	Is	-	85	90	mA	1, 2
LED string voltage	Vs	44.4	46.0	47.6	V	1, 3
Power consumption	P_{Bar}	-	31.3	32.4	Watt	1, 2, 5
LED life time	LED_LT	30,000	-	-	Hour	4

Notes : The LED bar consists of 64 LED packages, 8 strings (parallel) x 8 packages (serial) x 1 bar

1. The specified values are for single LED bar.
2. The specified current is defined as the input current for single LED string with 100% duty cycle.
3. The specified voltage is the input LED string voltage at typical current 100% duty cycle.
4. The LED life time is defined as the time when brightness of LED itself reach to the 50% of initial value under the conditions at Ta = 25 ± 2°C and typical LED string current.
5. The power consumption shown above does not include the loss of external LED driver.
   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.

3-2. Interface Connections

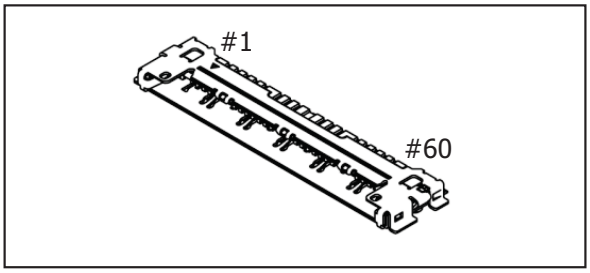
3-2-1. LCD Module

- LCD Connector(Receptacle): 20525-060E-01(Manufactured by I-PEX)
- Mating Connector(Plug): 20523-060T(Manufactured by I-PEX)

Table 3-3. Module Connector(CN1) Pin Configuration

No	Symbol	Description	No	Symbol	Description
1	GND	Ground	31	DP0_L1_N	Master Component Signal for Main Link 1
2	V_{LCD}	Power Supply +10.0V	32	GND	Ground
3	V_{LCD}	Power Supply +10.0V	33	DP0_L2_P	Master True Signal for Main Link 2
4	V_{LCD}	Power Supply +10.0V	34	DP0_L2_N	Master Component Signal for Main Link 2
5	V_{LCD}	Power Supply +10.0V	35	GND	Ground
6	V_{LCD}	Power Supply +10.0V	36	DP0_L3_P	Master True Signal for Main Link 3
7	V_{LCD}	Power Supply +10.0V	37	DP0_L3_N	Master Component Signal for Main Link 3
8	V_{LCD}	Power Supply +10.0V	38	GND	Ground
9	V_{LCD}	Power Supply +10.0V	39	DP1_L0_P	Slave True Signal for Main Link 0
10	GND	Ground	40	DP1_L0_N	Slave Component Signal for Main Link 0
11	GND	Ground	41	GND	Ground
12	GND	Ground	42	DP1_L1_P	Slave True Signal for Main Link 1
13	GND	Ground	43	DP1_L1_N	Slave Component Signal for Main Link 1
14	GND	Ground	44	GND	Ground
15	GND	Ground	45	DP1_L2_P	Slave True Signal for Main Link 2
16	GND	Ground	46	DP1_L2_N	Slave Component Signal for Main Link 2
17	BIST	L(GND): Black, H(3.3V): Rotational Pattern	47	GND	Ground
18	GND	Ground	48	DP1_L3_P	Slave True Signal for Main Link 3
19	NC	No Connection(I2C serial interface for LCM)	49	DP1_L3_N	Slave Component Signal for Main Link 3
20	NC	No Connection(I2C serial interface for LCM)	50	GND	Ground
21	DP0_HPD	Master Hot Plug Detect Signal	51	DP1_AUX_P	Slave True Signal for Auxiliary Channel
22	DP1_HPD	Slave Hot Plug Detect Signal	52	DP1_AUX_N	Slave Component Signal for Auxiliary Channel
23	GND	Ground	53	GND	Ground
24	DP0_AUX_P	Master True Signal for Auxiliary Channel	54	NC	No Connection(I2C serial interface for LCM)
25	DP0_AUX_N	Master Component Signal for Auxiliary Channel	55	NC	No Connection(I2C serial interface for LCM)
26	GND	Ground	56	NC	No Connection
27	DP0_L0_P	Master True Signal for Main Link 0	57	GND	Ground
28	DP0_L0_N	Master Component Signal for Main Link 0	58	NC	No Connection
29	GND	Ground	59	GND	Ground
30	DP0_L1_P	Master True Signal for Main Link 1	60	NC	No Connection

Notes:
1) All GND(ground) pins should be connected together to the LCD module's metal frame.
2) All V_{LCD}(power input) pins should be connected together.
3) BIST(Build In Self Test): If BIST pin is tied to "High(3.3V)", T-con generates rotational pattern. Time to stay at every pattern is about 2sec.



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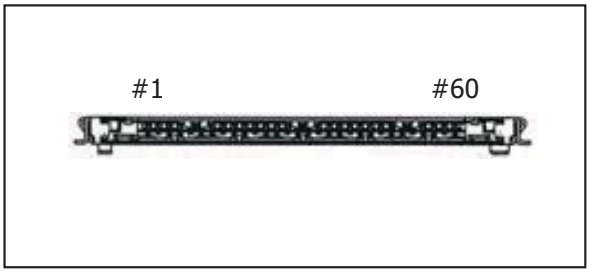
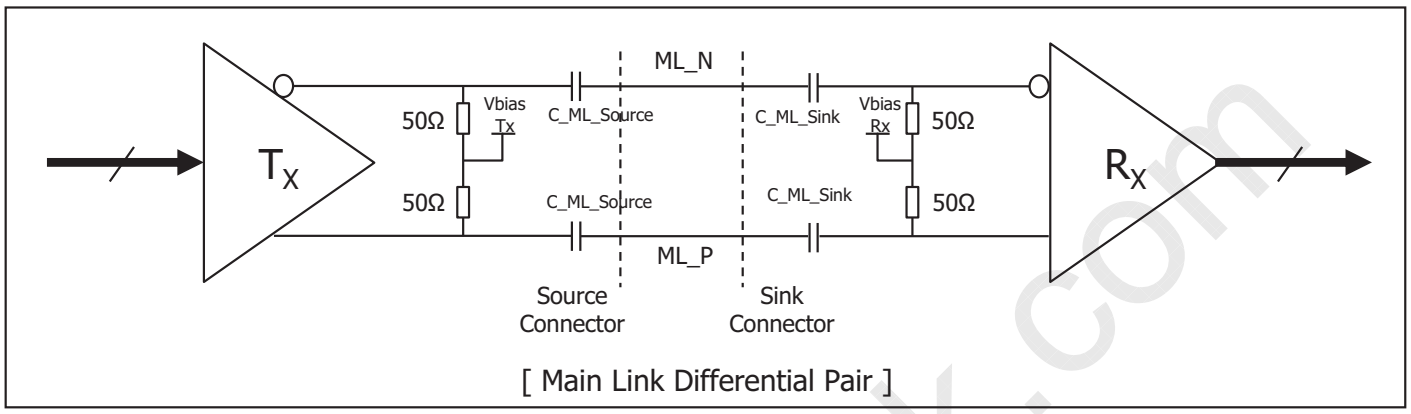


Rear view of LCM

3-2-2. eDP Signal Specifications

1. eDP Main Link Signal

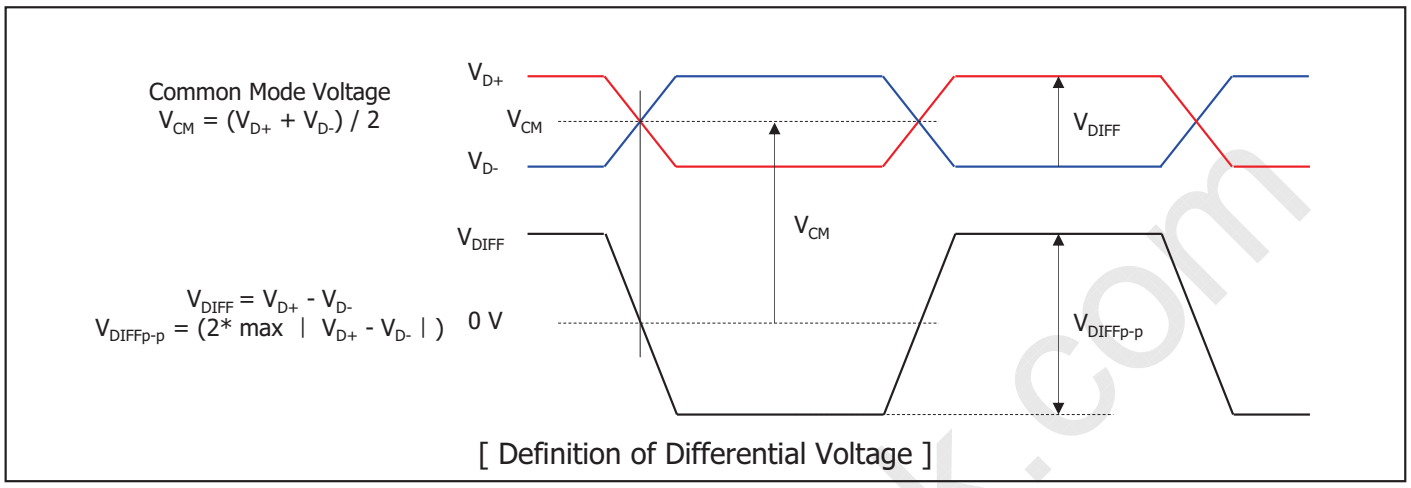


[Main Link Differential Pair]

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Unit Interval for High Bit Rate (5.4Gbps / Lane)	UI_HBR2	-	185	-	ps	
Link Clock Down Spreading	Amplitude	0	-	0.5	%	
	Frequency	30	-	33	kHz	
Maximum Output Voltage Level at Source Side Connector	$V_{TX-DIFFp-p-Max}$	-	-	1.38	V	6
Differential Peak to peak Voltage at Sink Side Connector	$V_{RX-DIFFp-p}$	0.09	-	-	V	7
EYE width at Sink Side Connector	$T_{RX-EYE-CONN}$	0.38	-	-	UI	6,7
Lane Intra-pair Skew	$L_{Rx-SKEW-INTRA\_PAIR}$	-	-	50	ps	
Master Tx to Slave Tx Skew	Tx-to-Tx_skew	-	-	± 0.25	DE	8
AC Coupling Capacitor	C_{SOURCE_ML}	75	-	200	nF	Source side

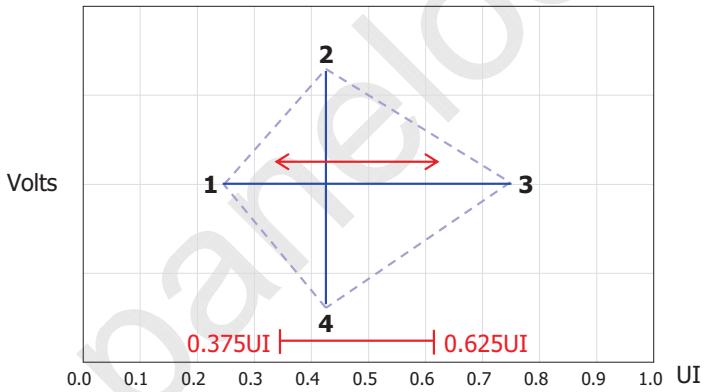
Notes:
1) In cabled embedded system, it is recommended the system designer ensure that EYE width and voltage are met at the sink side connector pins.
2) Mismatched common mode voltage will occur abnormal display.
3) All eDP electrical spec is measured at sink connector side.

Note 6) Definition of Differential Voltage



[Definition of Differential Voltage]

Note 7) Main Link EYE Diagram



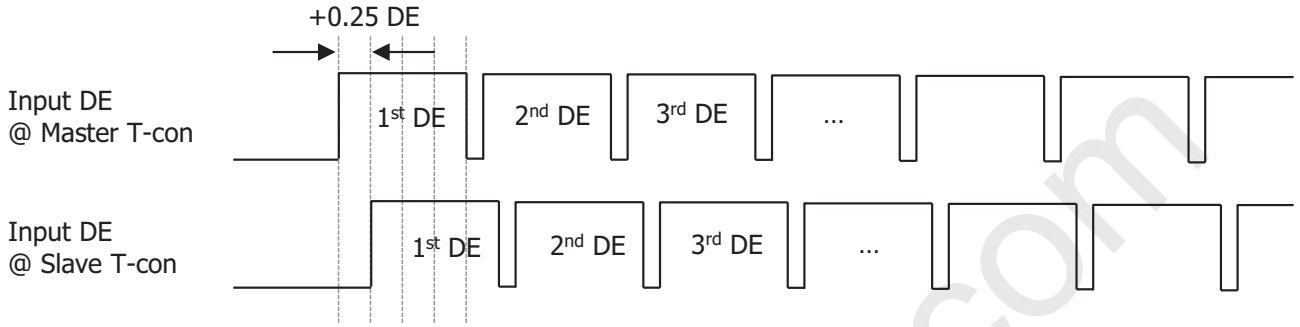
[EYE Mask at Sink Connector Pins]

Point	High Bit Rate 2 @ TP3 EQ	
	Time(UI)	Voltage(V)
1	Any UI location (x) where the eye width is open from x to x + 0.38UI	0.000
2	Any passing UI location between 0.375UI - 0.625UI	0.045
3	Point 1 + 0.38UI	0.000
4	Same as Point 2	-0.045

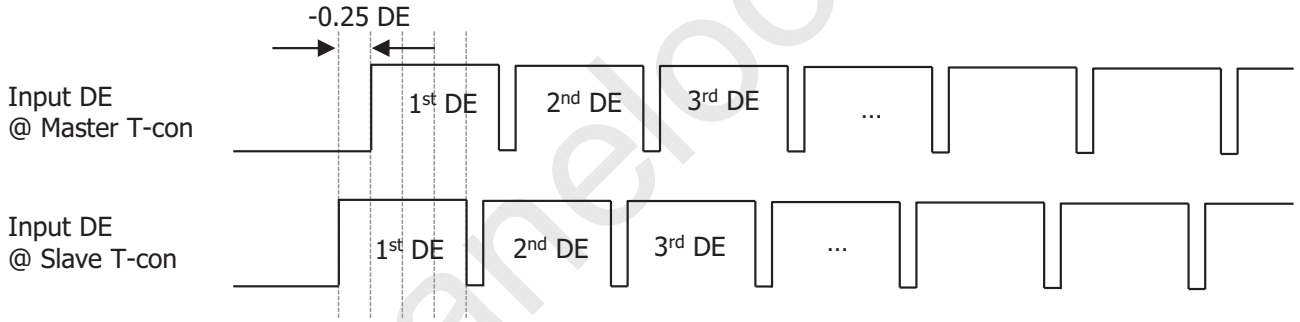
[EYE Mask Vertices at embedded DP Sink Connector Pins]

Note 8) Master Tx to Slave Tx Skew Margin Case

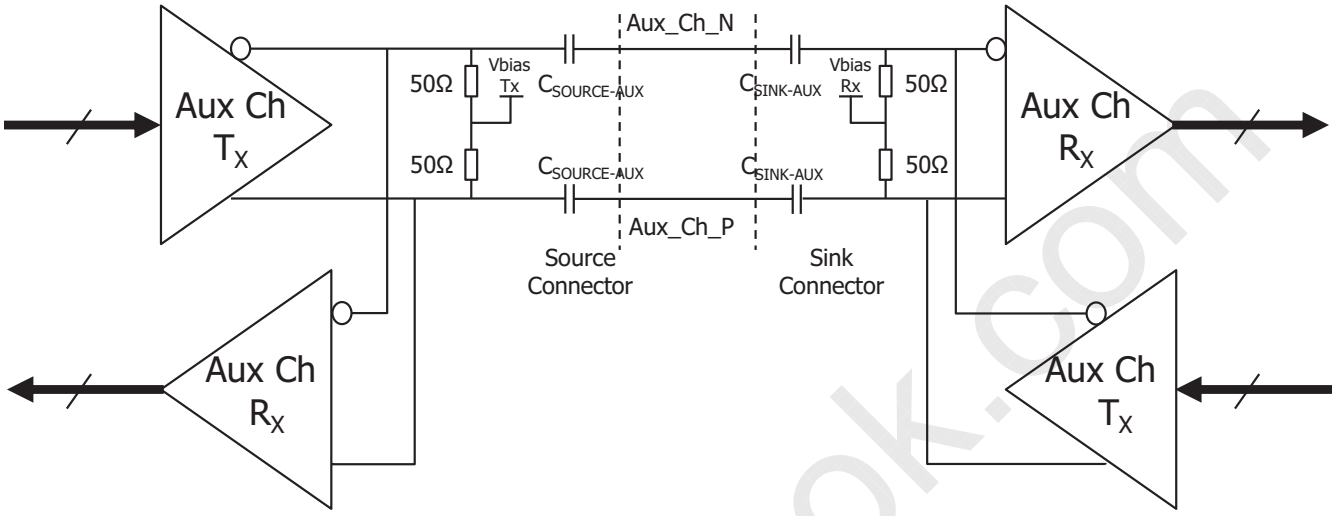
(1) +0.25 DE Skew Case



(2) -0.25 DE Skew Case



2. eDP AUX Channel Signal

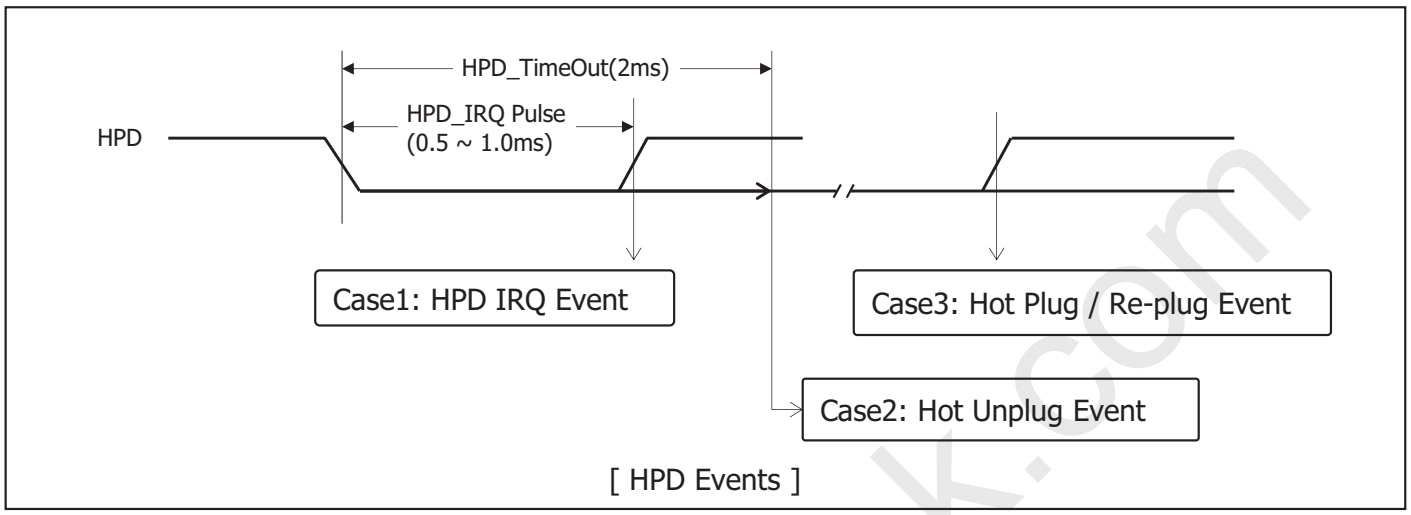


[Recommended eDP AUX Channel Differential Pair]

Parameter	Symbol	Min	Typ	Max	Unit	Notes
AUX Unit Interval	UI	0.4	-	0.6	us	
AUX Jitter at Rx IC Package Pins	T_{jitter}	-	-	0.05	UI	Equal to 30ns
AUX Peak-to-peak Voltage at Connector Pins of Receiving	$V_{AUX-DIFFp-p}$	0.32	-	1.36	V	
AUX Peak-to-peak Voltage at Connector Pins of Transmitting		0.39	-	1.38	V	
AUX EYE width at Connector Pins of Tx and Rx		0.98	-	-	UI	
AUX AC Coupling Capacitor	$C_{SOURCE-AUX}$	75	-	200	nF	Source side

Notes:
1) $V_{AUX-DIFFp-p} = 2 * | V_{AUXP} - V_{AUXN} |$
2) Termination resistor should be 50ohm ± 5% at source side to AUX level.
3) Mismatched common mode voltage will occur abnormal display.

3. eDP HDP Signal



[HPD Events]

Parameter	Symbol	Min	Typ	Max	Unit	Notes
HPD Voltage	HPD	2.25	-	3.6	V	Sink side Driving
Hot Plug Detection Threshold		2.0	-	-	V	Source side Detecting
Hot Unplug Detection Threshold		-	-	0.8	V	
HPD_IRQ Pulse Width	HPD_IRQ	0.5	-	1.0	ms	
HPD_TimeOut		2.0	-	-	ms	HPD Unplug Event

Notes:
1) HPD IRQ: Sink device wants to notify the Source device that Sink's status has changed so it toggles HPD line, forcing the Source device to read its Link / Sink Receiver DPCD field via the AUX-CH.
2) HPD Unplug: The Sink device is no longer attached to the Source device and the Source device may then disable its Main Link as a power saving mode.
3) Plug / Re-plug: The Sink device is now attached to the Source device, forcing the Source device to read its Receiver capabilities and Link / Sink status Receiver DPCD fields via the AUX-CH.

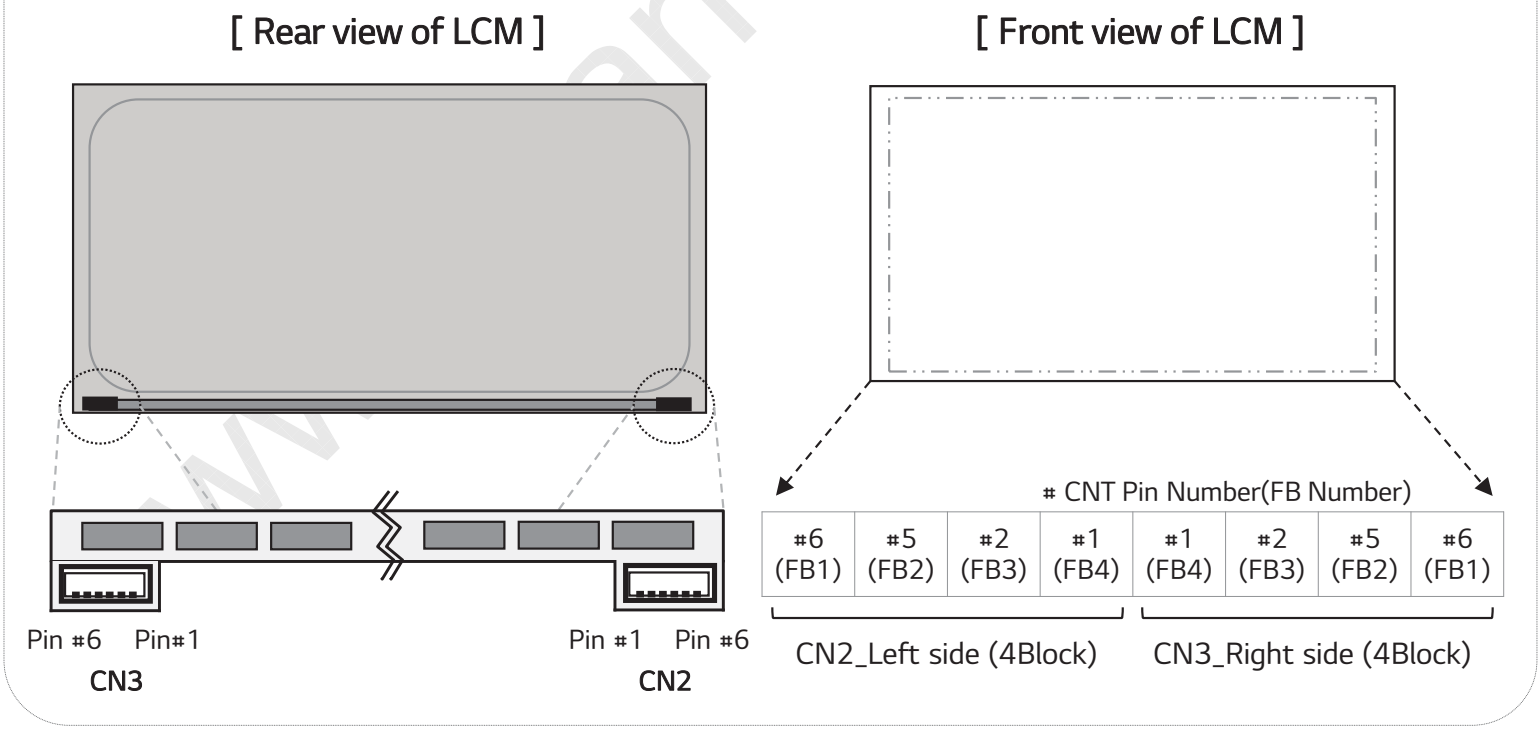
3-2-3. Backlight Connector Pin Configuration

The LED interface connector is 10035WS-H06D(HF)_wire-locking type manufactured by YEONHO.
The mating connector is a SHJP-06V-S(HF) or 10035HS-H06C(HF).
The pin configuration for the connector is shown in the table below.

Table 3-4. Backlight connector pin configuration(CN2, CN3)

Pin	Symbol	Pin-description (CN2)	Remark
#1	FB4	Channel 4 current feedback	Left side in front view
#2	FB3	Channel 3 current feedback	
#3	V LED	LED power supply (common anode)	
#4	V LED	LED power supply (common anode)	
#5	FB2	Channel 2 current feedback	
#6	FB1	Channel 1 current feedback	

Pin	Symbol	Pin-description (CN3)	Remark
#1	FB4	Channel 4 current feedback	Right side in front view
#2	FB3	Channel 3 current feedback	
#3	V LED	LED power supply (common anode)	
#4	V LED	LED power supply (common anode)	
#5	FB2	Channel 2 current feedback	
#6	FB1	Channel 1 current feedback	



[FIG. 5] Backlight connector view

3-3. Signal Timing Specifications

This is the signal timing requirement from the signal transmitter. All of the interface signal timing should be satisfied with the following specifications for its proper operation.

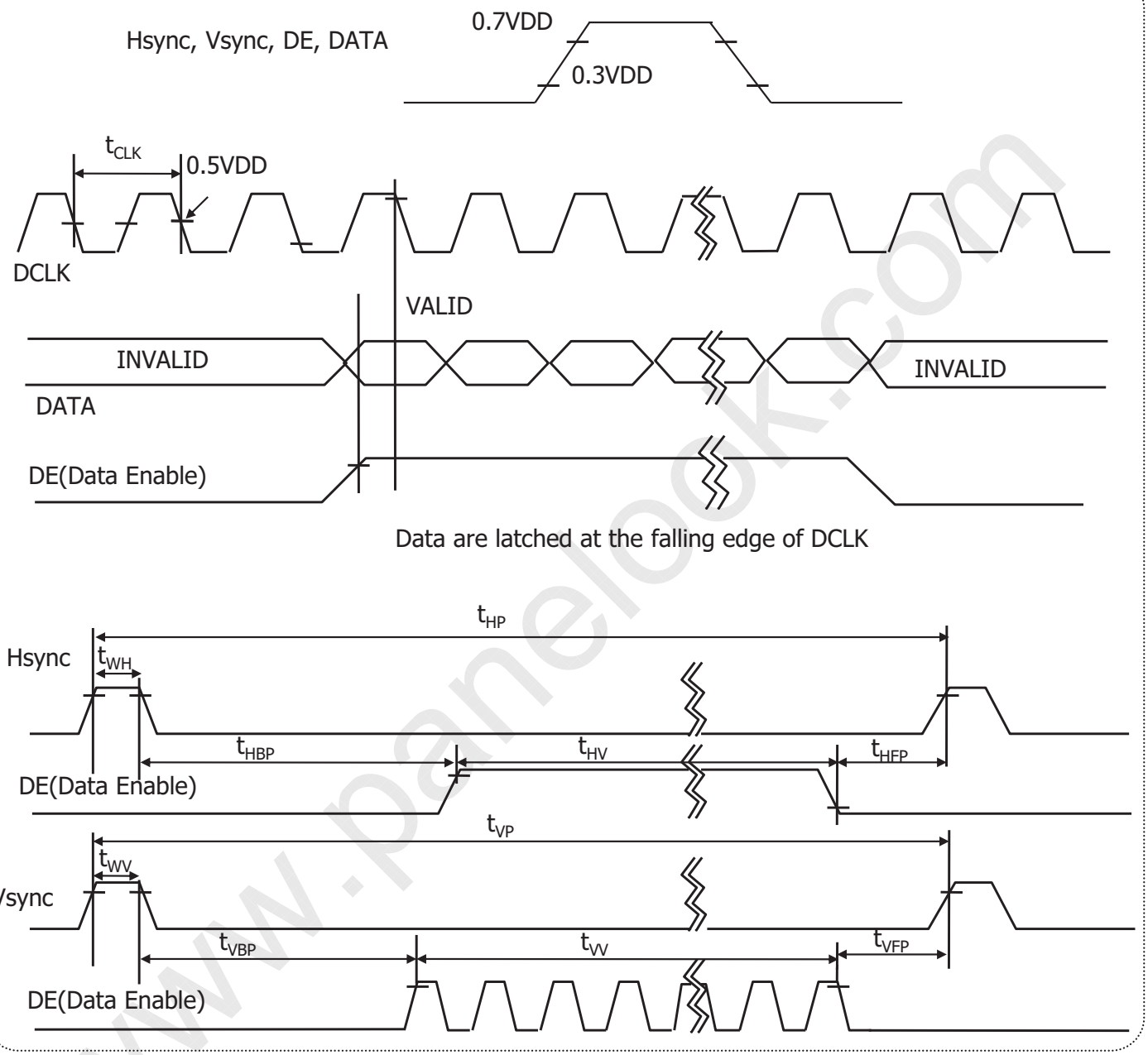
Table 3-5. Timing Table

Item	Symbol	Symbol	Min	Typ	Max	Unit	Notes
DCLK	Period	tCLK	2.86	3.28	5.71	ns	Pixel frequency (Typ. 610.28 MHz)
	Frequency	fCLK	175.00	305.14	350.00	MHz	
Hsync	Period	tHP	1,396	1,408	1,472	tCLK	1,3,4
	Horizontal Valid	tHV	1,280	1,280	1,280	tCLK	
	Horizontal Blank	tHB	116	128	192	tCLK	
	Frequency	fH	90.30	216.72	251.00	kHz	
	Width	tWH	32	32	32	tCLK	
	Horizontal Back Porch	tHBP	52	64	128	tCLK	
	Horizontal Front Porch	tHFP	32	32	32	tCLK	
Vsync	Period	tVP	1,493	1,505	5,284	tHP	2,4
	Vertical Valid	tVV	1,440	1,440	1,440	tHP	
	Vertical Blank	tVB	53	65	3,844	tHP	
	Frequency	fV	47	144	166	Hz	
	Width	tWV	5	5	5	tHP	
	Vertical Back Porch	tVBP	45	57	3,836	tHP	
	Vertical Front Porch	tVFP	3	3	3	tHP	

Notes:
1) The value of Hsync Period, Hsync Width and Hsync valid should be even number times of tCLK. If the value is odd number times of tCLK, it can make asynchronous signal timing and cause abnormal display.
2) The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3) The value of Hsync Period, Hsync Width, and Horizontal Back Porch should be divided by 4 without a remainder.
4) The polarity of Hsync, Vsync is not restricted.
5) It needs to avoid specific DCLK ranges for optimal display performance. (DCLK Range : 192~197MHz)

* This panel supports Gaming Mode(47~166Hz) only under moving picture in room temperature(25±5℃).
- It would not work usually under still image & reliability test.
- Under those condition, the phenomenon such as image sticking and flickering could be found on the screen.
- This panel supports FOS/Reliability quality under fixed frequency (60Hz~165Hz) condition.

3-4. Signal Timing Waveforms



3-5. Color Data Reference

The Brightness of each primary color(Red,Green,Blue) is based on the 10-bit gray scale data input for the color; the higher the binary input, the brighter the color.
The table below provides a reference for color versus data input.

Table 3-6. Color Data Reference

Color		Input Color Data																													
		RED										GREEN										BLUE									
		MSB									LSB	MSB									LSB	MSB									LSB
		R9	R8	R7	R6	R5	R4	R3	R2	R1	R0	G9	G8	G7	G6	G5	G4	G3	G2	G1	G0	B9	B8	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	0	0	0	0	0	0	0
	Red (1023)	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Green (1023)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
	Blue (1023)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
	Cyan	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Magenta	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
	Yellow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	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	1	1	1	1	1	1	1
RED	RED (0)	0	0	0	0	0	0	0	0	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	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	...					...										...										...					
	RED (1022)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RED (1023)	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN	GREEN (0)	0	0	0	0	0	0	0	0	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	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	...					...										...										...					
	GREEN (1022)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
	GREEN (1023)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
BLUE	BLUE (0)	0	0	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	1
	...					...										...										...					
	BLUE (1022)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0
	BLUE (1023)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1

3-6. Power Sequence

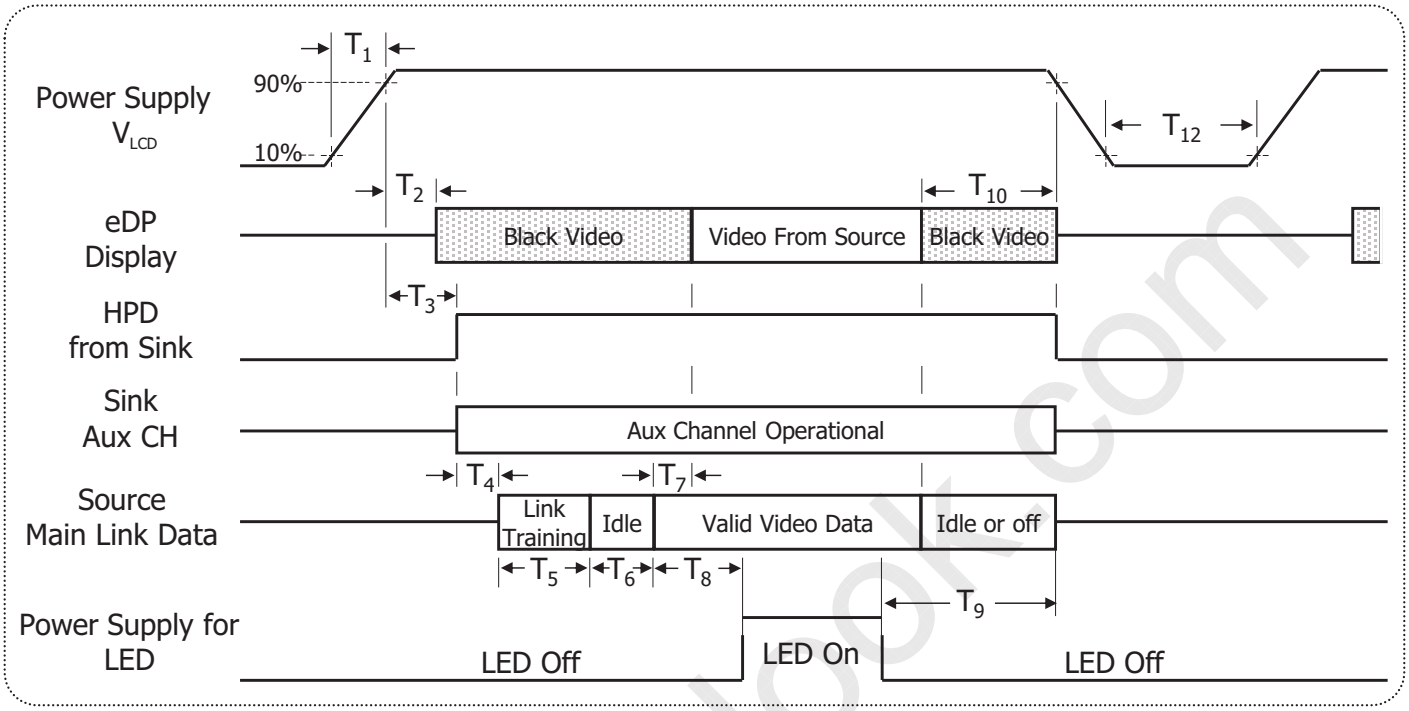


Table 3-7. Power Sequence

Timing	Required By	Limits		Units	Notes
		Min	Max		
T_1	Source	0.5	10	ms	
T_2	Sink	10	200	ms	
T_3	Sink	15	200	ms	
T_4	Source	-	-	ms	5
T_5	Source	-	-	ms	5
T_6	Source	-	100	ms	6
T_8	Source	350	-	ms	
T_9	Source	200	-	ms	4

Timing	Required By	Limits		Units	Notes
		Min	Max		
T_{10}	Source	0	500	ms	
T_{12}	Source	1000	-	ms	

Notes:
1) Power sequence should be kept all the time including below cases for normal operation.
   - AC/DC Power On/Off
   - Mode change (resolution, frequency, timing, sleep mode, color depth change, etc.)
   The violation of power sequence can cause a significant trouble in display and reliability.
2) Please avoid floating state of interface signal during signal invalid period.
3) When the interface signal is invalid, be sure to pull down the V_{LCD}.(0V)
4) Please turn off the power supply for LED when the level of V_{LCD} changes to prevent noise issue.
5) Link training duration is dependent on the customer's system.
6) It includes Source Frame Synchronization time.
   Source Frame Synchronization: Time to prepare before Tx(Source) sends valid data(Invalid period).

3-7. Power Dip Condition

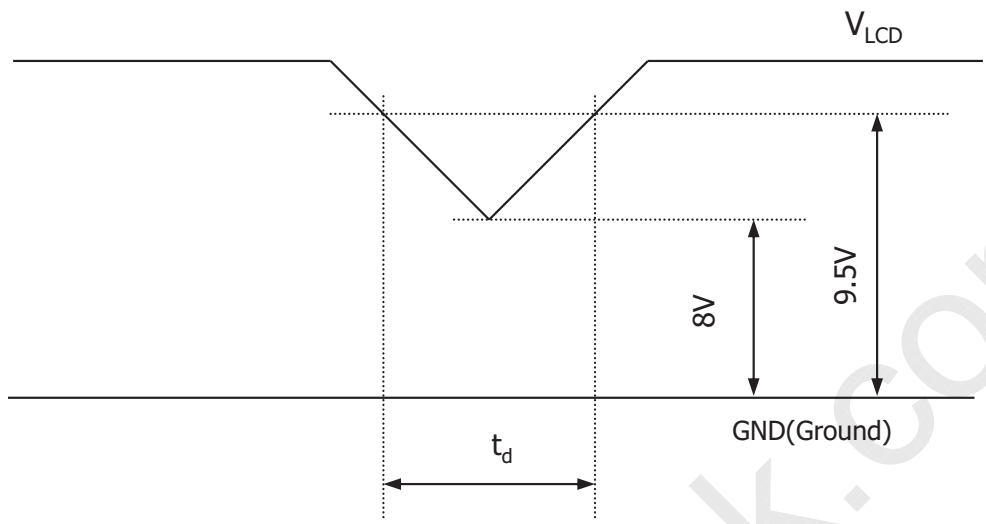


FIG.3-3 Power Dip Condition

For proper operation, stable power supply of V_{LCD} is necessary and power dip is allowed only in below condition. Except this condition, power on/off should follow power sequence specification exactly.

1) Dip Condition

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

4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at 25±2℃. 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.4-1 presents additional information concerning the measurement equipment and method.

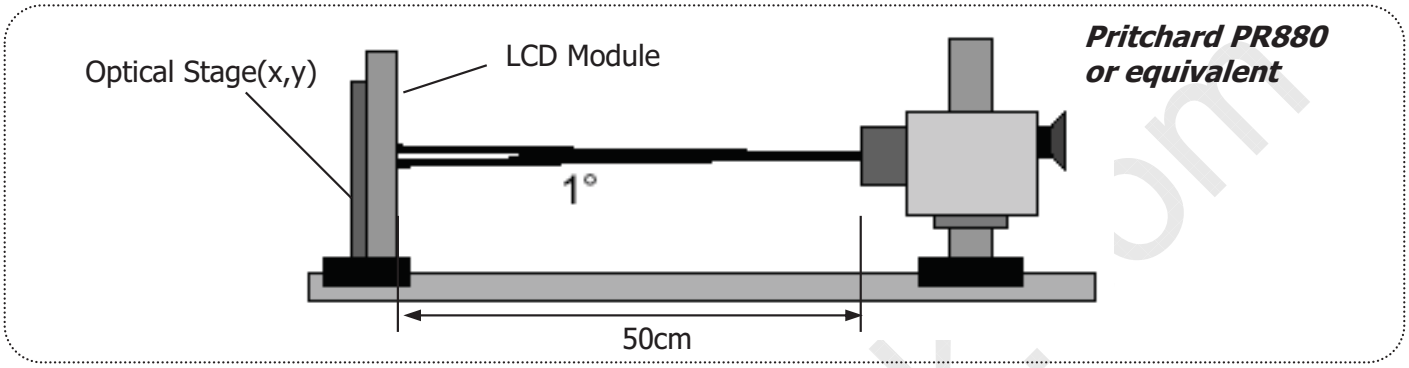


FIG.4-1 Optical Characteristic Measurement Equipment And Method

Table 4-1. Optical Characteristics

(T_a=25 ℃, V_{LCD}=Typ, f_V=144 Hz, DCLK=Typ, I_S=Typ)

Parameter		Symbol	Values			Units	Notes
			Min.	Typ.	Max.		
Contrast Ratio		CR	700	1000	-		1
Surface Luminance, white		L_{WH}	320	400	-	cd/m^2	2
Luminance Variation		δ_{WHITE}	75	-	-	%	3
Response Time	Gray to Gray	T_{GTG_AVR}	-	5	10	ms	4
Color gamut (CIE1976)		DCI	-	98	-	%	
Color Coordinates [CIE 1931] ***(By PR650)***	Red	Rx	Typ -0.03	0.686	Typ +0.03		
		Ry		0.309			
	Green	Gx		0.265			
		Gy		0.668			
	Blue	Bx		0.150			
		By		0.058			
	White	Wx		0.313			
		Wy		0.329			
Color Temperature		-	-	6500	-	K	
Viewing Angle (CR>10, General)	Horizontal	θ_H	170	178	-	Degree	5
	Vertical	θ_V	170	178	-		
Gray Scale		-	-	2.2	-		6

4-1. Characteristics of Peak Luminance

Table 4-1-1. Absolute Maximum Value of LED Bar and Peak Luminance

Parameter	Symbol	Values	Unit	Notes
Peak LED String Current	Is	110	mA	a,b,c
Peak Luminance	Lp	500	nit	a,b,c

Notes:
a) Peak LED string voltage at peak current with 100% duty cycle is 46.9±1.6V at T_a = 25±2℃.
b) Table 4-1-1 is reference data only for HDR Function usage, refer to the appendix of LCM temperature at peak current.
c) Peak luminance 500nit (Min. 400nit) is achieved at 110mA, while the specifications for guarantee remains under the normal operating condition specified in Table 3-2. Specifications and condition for evaluation test and mass production shall be applied with conditions specified in Table 3-2.

Notes:

1) **Contrast Ratio(CR)** is defined mathematically as: ***(By PR880)***
It is measured at center point(1)

$$\text{Contrast ratio} = \frac{\text{Surface luminance with all white pixels}}{\text{Surface luminance with all black pixels}}$$

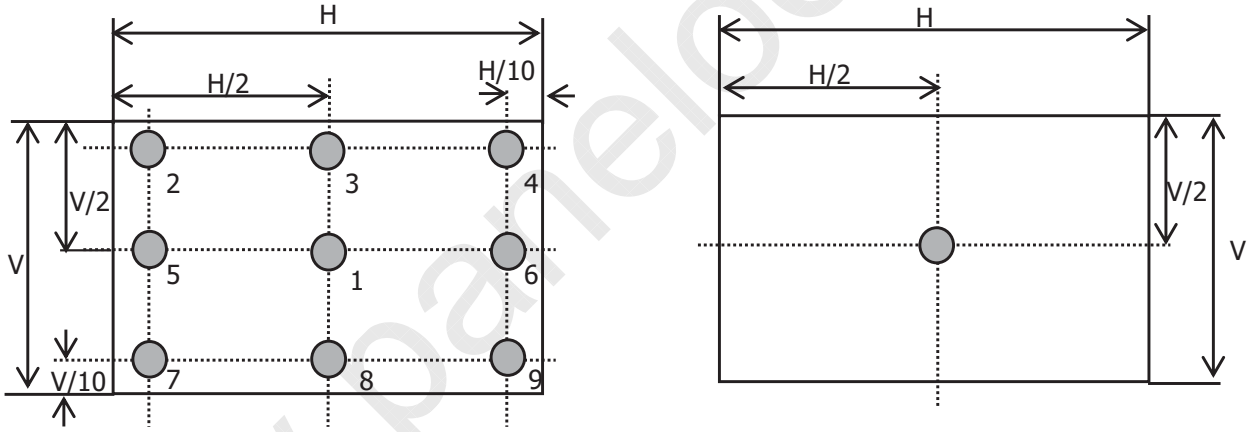
2) **Surface Luminance(L_{WH})** is the luminance value at center 1 point(1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG.4-1. ***(By PR880)***

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.4-2.

<Measuring Point For Luminance Variation> **<Measuring Point For Surface Luminance>**



@ H,V: Active Area

FIG.4-2 Measure Point for Luminance

Notes:

4) 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 ". ***(By RD80S)***
   - Gray step: 5 Step
   - T_{GTG_AVR} is the total average time at rising time and falling time for "Gray To Gray ".
   - For the GTG measurement, the sampling rate of oscilloscope is 500k/s.

Table 4-2. GTG Gray

Gray to Gray		Rising Time				
		G1023	G767	G511	G255	G0
Falling Time	G1023					
	G767					
	G511					
	G255					
	G0					

Response Time is defined as the following figure and shall be measured by switching the input signal for "Gray(N)" and "Gray(M)".

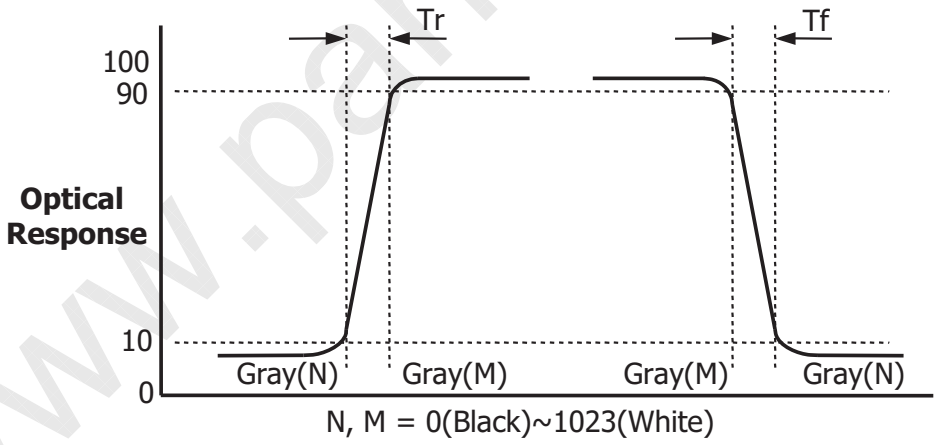


FIG.4-3 Response Time

Notes:

5) **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.4-4. ***(By PR880)***

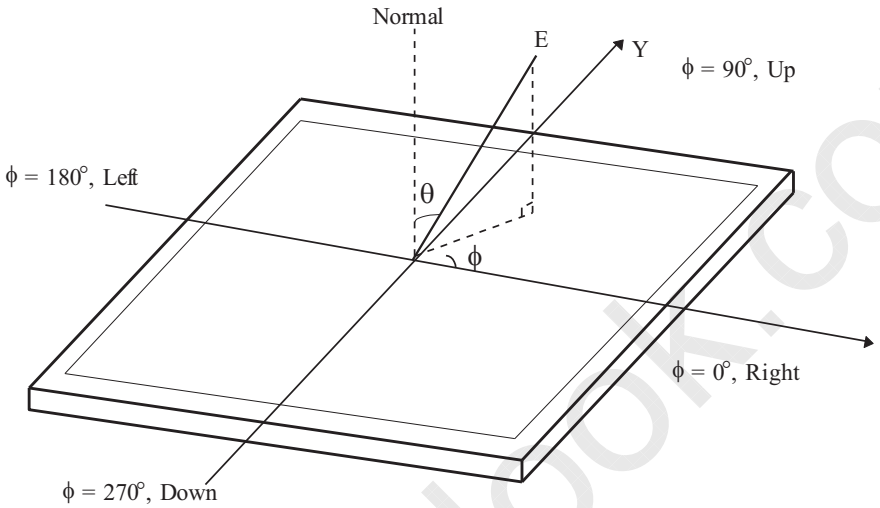


FIG.4-4 Viewing Angle

6) **Gamma Value** is approximately 2.2. For more information see below table.

Table 4-3. Gray Scale Specification

Gray Level	Relative Luminance [%](Typ)
0	0.10
63	0.30
127	1.08
191	2.50
255	4.72
319	7.70
383	11.49
447	16.20
511	21.66
575	28.20
639	35.45
703	43.80
767	53.00
831	63.30
895	74.48
959	86.80
1023	100

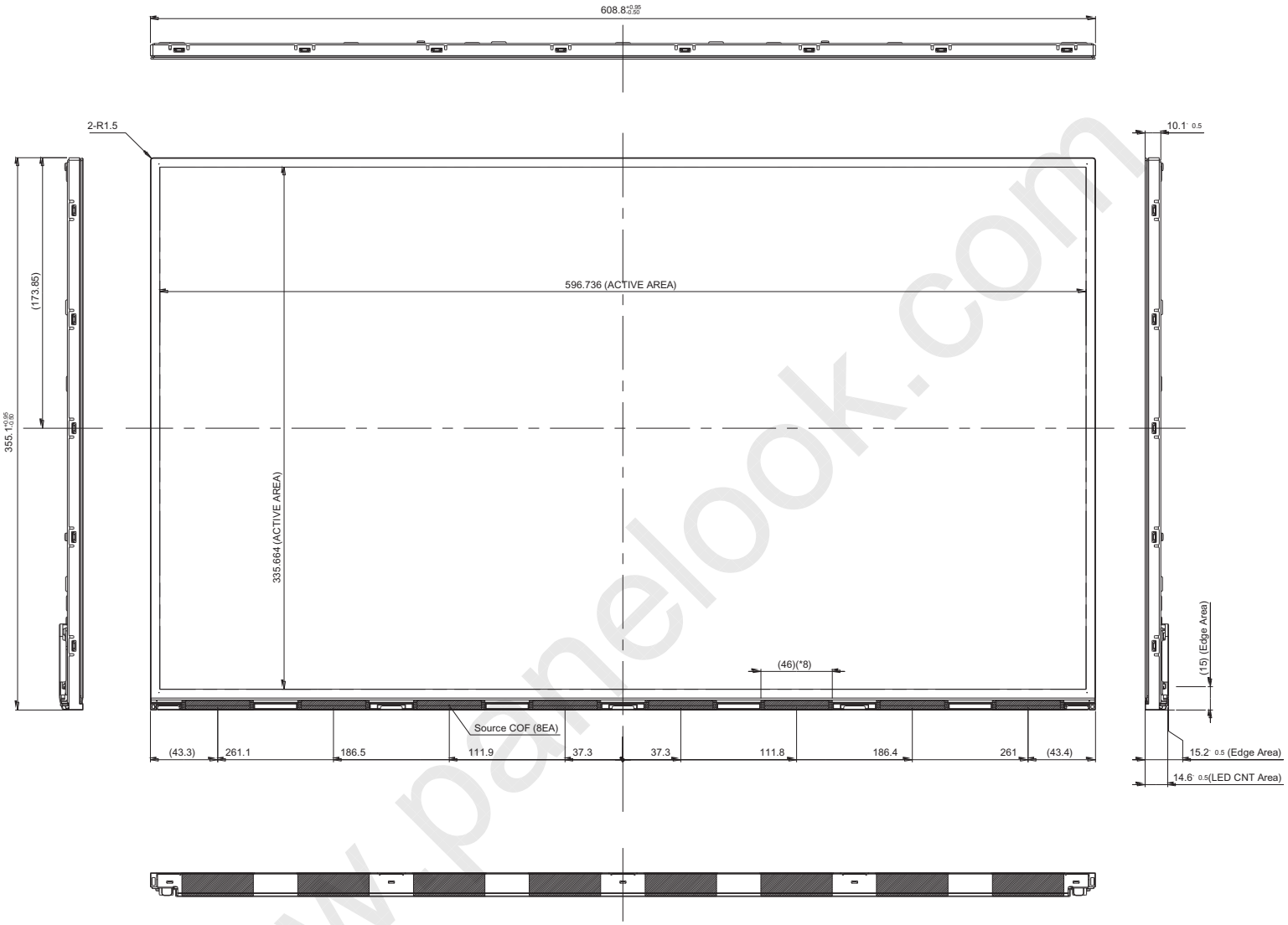
5. Mechanical Characteristics

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

Outline Dimension	Horizontal	608.80 mm
	Vertical	355.10 mm
	Depth	15.20 mm
Bezel Area	Horizontal	-
	Vertical	-
Active Display Area	Horizontal	596.74 mm
	Vertical	335.66 mm
Weight	Typ. : 2,550g, Max. : 2,680g	
Surface Treatment	Anti-Glare treatment of the front polarizer (Haze25%, 3H)	

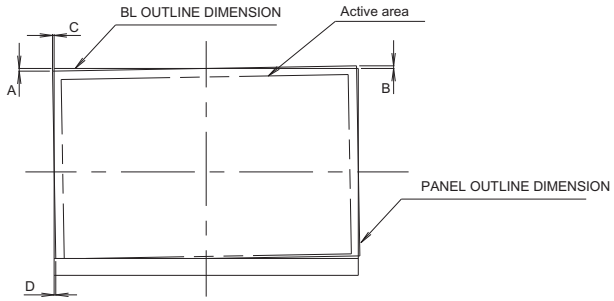
Note: Please refer to a mechanical drawing in terms of tolerance at the next page.
- Outline dimensions (horizontal, vertical and outside depth) are measured by using vernier calipers.
- The inside depth dimensions are measured by using height gauge, when LCM is put face down onto a flat surface.

<Front View>



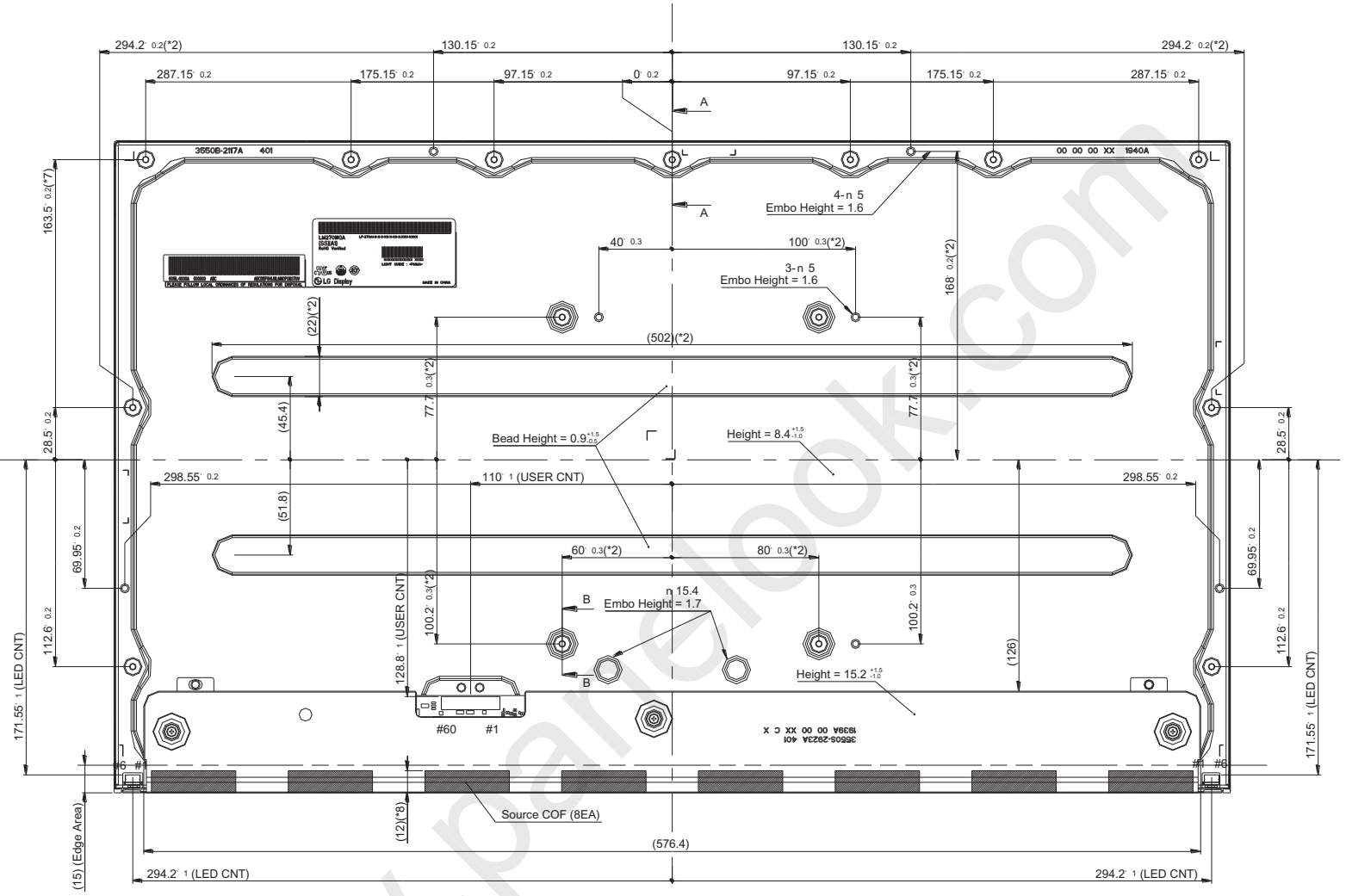
Notes

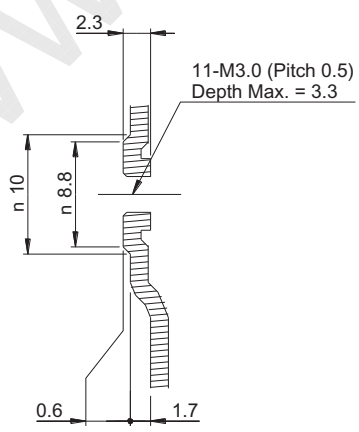
1. I/F connector specification : 20525-060E-01(Manufactured by I-PEX) or Equivalent
2. LED connector specification : YEONHO, 10035WS-H06D or Equivalent
3. Torque of user hole: 3.0~4.0kgf-cm.
4. Tilt and partial disposition tolerance of display area as following
   (1) Y-direction : -0.45≤A≤0.45, -0.45≤B≤0.45
   (2) X-direction : -0.45≤C≤0.45, -0.45≤D≤0.45



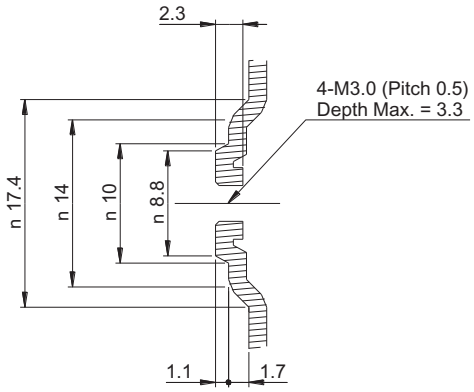
5. Unspecified tolerances to be ` 0.5
6. The LCM warp(warpage) is less than 1.0 on the surface plate
7. The COF area is weak & sensive, so please don't press the COF area
8. Undifined height should follow the 3D modeling data

<Rear View>





SECTION A-A
SCALE 2/1



SECTION B-B
SCALE 2/1

6. Reliability

Environment test condition

No	Test Item	Condition	Notes
1	High temperature storage test	T_a = 60℃, 240h	1
2	Low temperature storage test	T_a = -20℃, 240h	1
3	High temperature operation test	T_a = 50℃, 50%RH, 240h	1
4	Low temperature operation test	T_a = 0℃, 240h	1
5	Humidity condition operation	T_a = 40℃, 90%RH	1
6	Altitude Operating Storage / Shipment	 0 - 16,400 feet (5,000m) 0 - 40,000 feet (12,192m)	
7	Maximum storage humidity for 4 corner light leakage Mura	Max 70%RH, T_a = 40℃	

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) IEC 62368-1, The International Electro-technical Commission(IEC).
Audio/video, Information and Communication Technology Equipment - Safety - Safety Requirements.
b) EN 62368-1, European Committee for Electro-technical Standardization (CENELEC)
Audio/video, Information and Communication Technology Equipment - Safety Requirements
c) UL 62368-1, UL LLC.
Audio/video, Information and Communication Technology Equipment - Safety Requirements
d) CAN/CSA C22.2 No.62368-1, Canadian Standards Association (CSA).
Audio/video, Information and Communication Technology Equipment - Safety Requirements
e) IEC 60950-1, The International Electro technical Commission (IEC).
Information Technology Equipment - Safety - Part 1 : General Requirements

7-2. Environment

a) RoHS, Commission Delegated Directive (EU) 2015/863 of 31 March 2015 amending Annex II to Directive 2011/65/EU of the European Parliament and of the Council

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)
E: Month
D: Year
F ~ M: Serial No.

Notes:

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

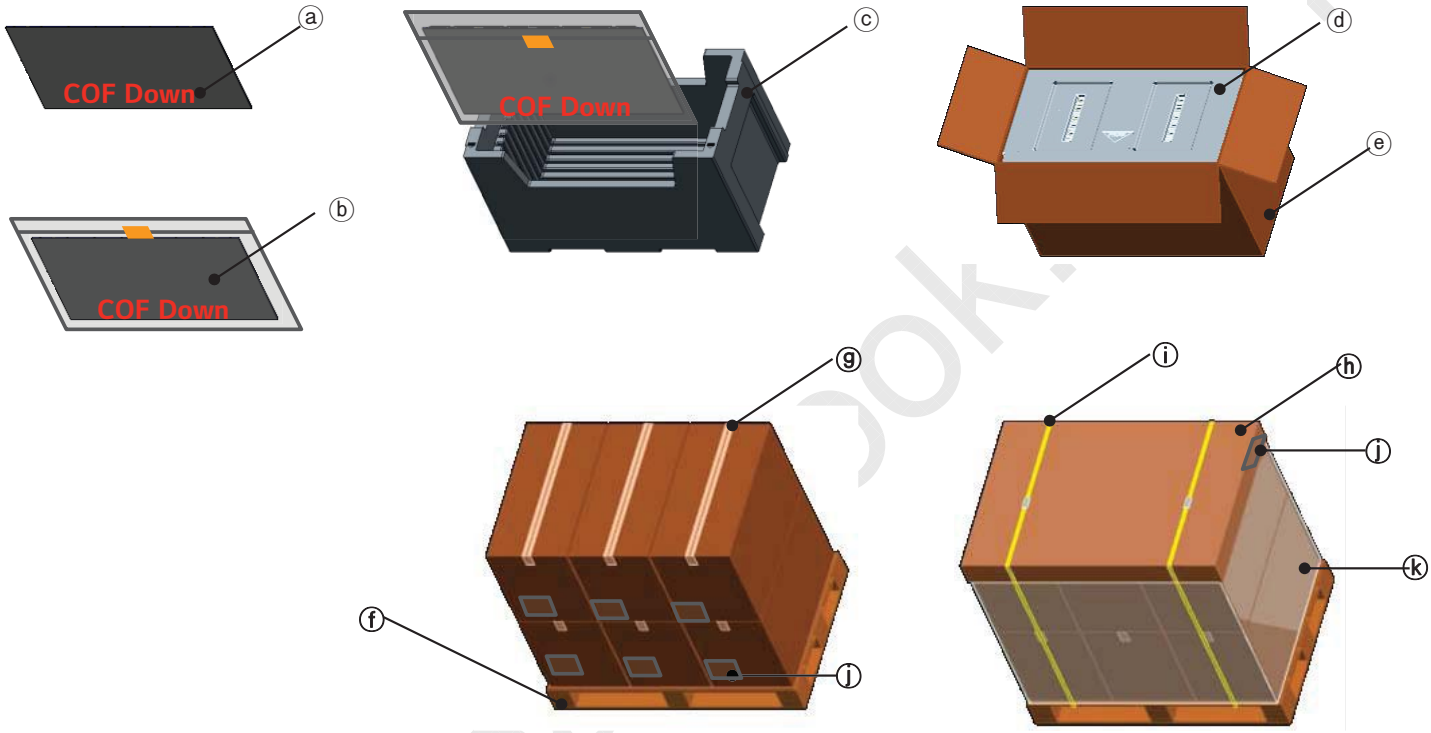
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mark	1	2	3	4	5	6	7	8	9	A	B	C

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 : 10ea
Package quantity in one Pallet : 60ea
b) Box Size : 365mm X 710mm X 448mm
C) Pallet Ass'y Size: 1140mmX740mmX1019mn

* LCM Direction(insert to Bottom Packing) : COF Down



No.	Description	Material
ⓐ	LCM	-
ⓑ	AL-Bag	AL
ⓒ	Packing,Bottom	EPS
ⓓ	Packing,Top	EPS
ⓔ	Box	Paper(SW)
ⓕ	Pallet	Plywood
ⓖ	Tape	OPP
ⓗ	Angle Cover	Paper(SW)
ⓘ	BAND	PP
ⓙ	LABEL	YUPO PAPER
ⓚ	Wrap	-

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 rear side.
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) System frame should not have an interference with panel which can cause LC Leakage/Panel Crack due to the contraction of system frame at low temperature condition or panel damage by any other circumstances.

9-2. Operating Precautions

1) Response time depends on the temperature.(In lower temperature, it becomes longer.)
2) 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.
3) 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.
4) When fixed patterns are displayed for a long time, remnant image is likely to occur.
5) 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.
6) Please do not give any mechanical and/or acoustical impact to LCM. Otherwise, LCM can't be operated its full characteristics perfectly.
7) 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)
8) Please do not set LCD on its edge.
9) When LCMs are used for public display, defects such as Yogore & image sticking can not be guaranteed.
10) LCMs cannot support "Interlaced Scan Method"
11) When this reverse model is used as a forward-type model (PCB on top side) or a Portrait-type mode at storage and operation, LGD can not guarantee any defects of LCM.
12) Please conduct image sticking test after 2-hour aging with Rolling Pattern at 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 and Hazardous Materials Exposure

Strong light exposure causes degradation of polarizer and color filter.
The LCM should be avoided direct contact with hazardous materials such as sulfur, acetic acid, chlorine, etc. These materials may cause chemical reaction such as sulfurization, corrosion, discoloration, etc.

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℃ and 35℃ 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

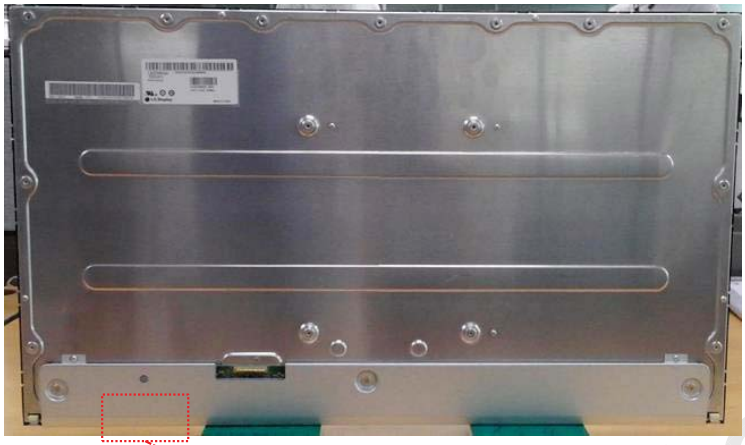
1) The protection film is attached to the bezel with a small masking tape. When the protection film is peeled off, static electricity is generated between the film and polarizer. This should be peeled off slowly and carefully by people who are electrically grounded and with well ion-blown equipment or 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

■ LCM test result for operating HDR function

1) The temperature data of the LCM was measured by using a contact thermocouple (see attached Fig).

Measurement point



#7 COF area

Temperature Meter (Lutron TM-947SD / 4ch)

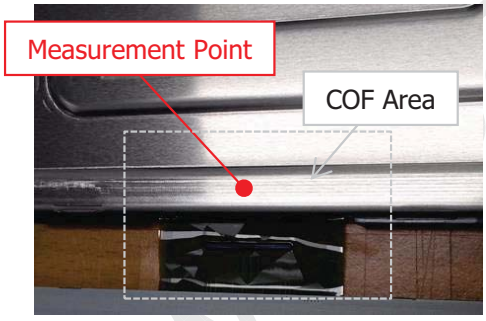
GENERAL SPECIFICATIONS

Circuit	Custom one-chip of microprocessor LSI circuit.
Channels	T1, T2, T3, T4, T1-T2.
Sensor type	Type K thermocouple probe. Type J/T/E/R/S thermocouple probe. PT 100 ohm probe * *Cooperate with an 0.00385 alpha coefficient, meet DIN IEC 751.*
Resolution	0.1℃/1℃, 0.1℉/1 ℉.

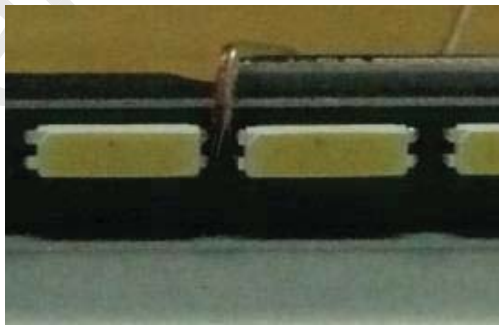
Type K

Sensor	Resolution	Range	Accuracy
Type K	0.1 ℃	-50.1 to -100.0 ℃	± (0.4 % + 1 ℃)
		-50.0 to 999.9 ℃	± (0.4 % + 0.5 ℃)
	1 ℃	1000 to 1300 ℃	± (0.4 % + 1 ℃)
	0.1 ℉	-58.1 to -148.0 ℉	± (0.4 % + 1.8 ℉)
		-58.0 to 999.9 ℉	± (0.4 % + 1 ℉)
	1 ℉	1000 to 2372 ℉	± (0.4 % + 2 ℉)

C/Bottom



LED Ts

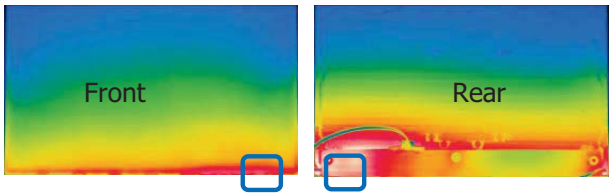


Luminance(nit)	LED String Current(mA)	LED String Voltage(V) (Tolerance : ± 1.6V)
400	(85mA)	(46.1)
450	(95mA)	(46.4)
500	(110mA)	(46.9)

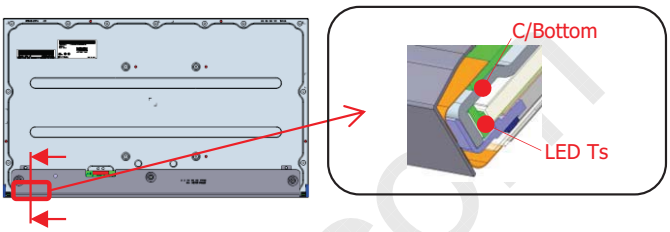
APPENDIX

■ LCM Test Result for Operating HDR Function

1) It is recommended that thermal sensor in system should be placed on the surface of C/Bottom near the LED with high temperature when measured by IR camera.



Measured by IR camera



Thermal data acquisition position

2) Measurement of temperature by time.
When the temperature is over 77.7℃ on C/Bottom, defects are founded due to thermal effect.

Table 1 : Temperature data at typical luminance(85mA), ambient temperature(50℃)

85mA (Typ)	Measure Point Temp. (Ambi. 50℃)		
Time(min)	C/Bottom(℃)	LED Ts(℃)	LED Ts - C/Bottom(℃)
30	75.4	79.6	4.2
60	76.7	80.9	4.2
90	77.6	81.7	4.1
120	77.7	81.9	4.2

Table 2 : Temperature data at peak luminance(110mA), ambient temperature(25℃)

110mA (Peak)	Measure Point Temp. (Ambi. 25℃)			Remark	
Time(sec)	C/Bottom(℃)	LED Ts(℃)	LED Ts - C/Bottom(℃)	Interval	Current
Base	54.7	58.9	3.9	120min	85mA(Typ.)
30	55.8	61.5	5.7	0.5min	110mA(Peak.)
60	56.4	62.3	5.9		
90	56.8	62.7	5.9		
120	57.1	63.0	5.9		
150	57.4	63.3	5.9		
180	57.7	63.7	6.0		
240	58.1	64.1	6.0	1min	
300	58.5	64.4	5.9		
360	58.7	64.7	6.0		
420	59.0	64.9	5.9		
480	59.1	65.2	6.1		
540	59.4	65.4	6.0		
600	59.6	65.6	6.0		
900	60.3	66.3	6.0	5min	
1200	60.6	66.5	5.9		
1500	60.8	66.8	6.0		
1800	61.0	66.9	5.9		