

Product Specification

SPECIFICATION

FOR

APPROVAL

(●) Preliminary Specification
() Final Specification

Title	23.8" UHD TFT LCD
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BUYER	GENERAL
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM238WR3
SUFFIX	SSB1

*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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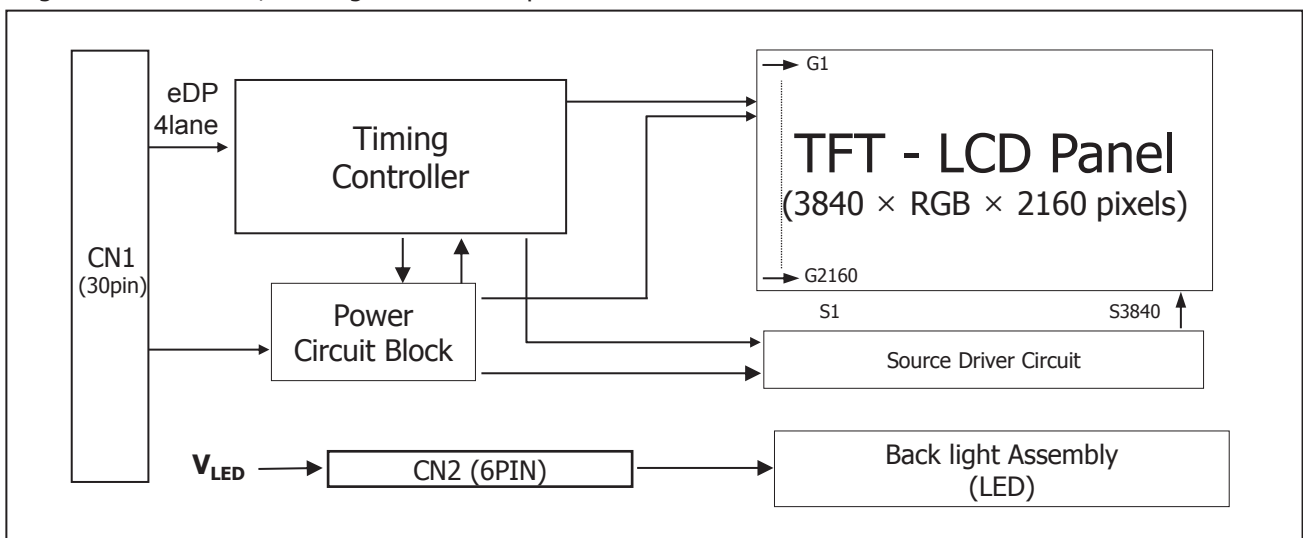
RECORD OF REVISIONS

Revision No	Revision Date	Page	Before	After	Application Date
0.1	Feb. 27. 2017	-	First Draft, Preliminary Specifications	-	-

Product Specification

1. General Description

LM238WR3 is a Color Active Matrix Liquid Crystal Display with a Light Emitting Diode (LED) 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 23.8 inch diagonally measured active display area with UHD resolution (3840 horizontal by 2160 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 with A-FRC (Advanced Frame Rate Control). It has been designed to apply eDP 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	23.8 inches(60.31cm) (Aspect ratio 16:9)
Outline Dimension	536.3(H) x 313.9(V) x 12.9(D) mm (Typ.)
Pixel Pitch	0.13690 mm x 0.13690 mm
Pixel Format	3840 horiz. By 2160 vert. Pixels RGB stripes arrangement
Color Depth	1.07 Billion colors, 10Bit (8Bit + A-FRC)
Luminance, White	350 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 25.7 Watt (6.3 Watt @VLCD 19.4 Watt @Is=120mA)
Weight	Typ : 1610g, Max : 1690g
Display Operating Mode	Transmissive mode, normally black
Panel type	Reverse type
Concept	3-side borderless
Surface Treatment	Advanced Anti-glare treatment of the front polarizer (3H)

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2. Absolute Maximum Ratings

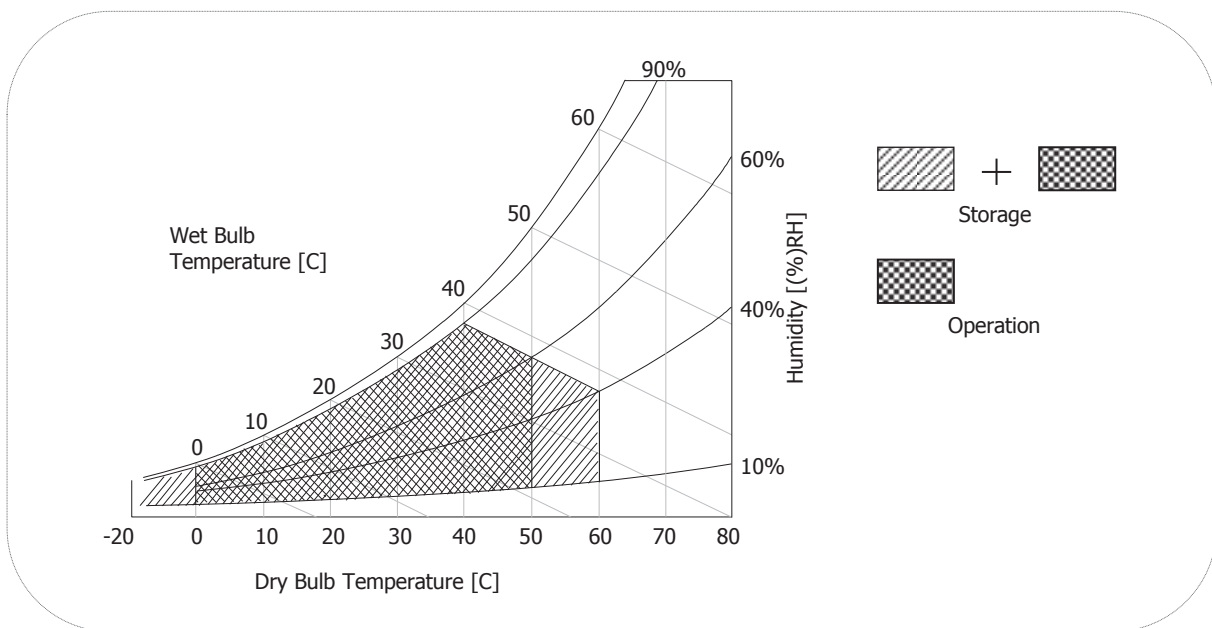
The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Input Voltage	VLCD	-0.3	12	Vdc	at 25 ± 2°C
Operating Temperature	TOP	0	50	°C	1, 2, 3
Storage Temperature	TST	-20	60	°C	
Operating Ambient Humidity	HOP	10	90	%RH	
Storage Humidity	HST	10	90	%RH	

- 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°C, 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°C and Max. 65°C under the VLCD=10V, fV=60Hz, 25°C ambient Temp. no humidity controlled and LED string current is typical value.

FIG.2 Temperature and relative humidity



Product Specification
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	4
Permissive Power Input Ripple	V _{ripple}			400	mV _{p-p}	1
Power Supply Input Current	I _{LCD}	-	630	788	mA	2
		-	840	1050	mA	2
Power Consumption	P _c TYP	-	6.3	7.88	Watt	2
	P _c MAX	-	8.4	10.5	Watt	2
Rush current	I _{RUSH}	-		3	A	3

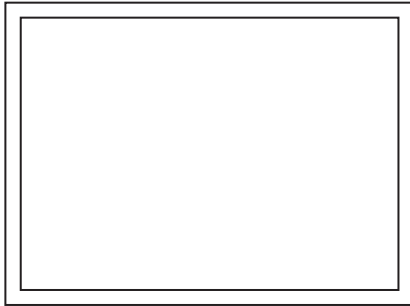
Note :

- Permissive power ripple should be measured under the condition of V_{LCD}=5.0V, 25°C, *fv=max. Refer to page 7 for the pattern and more information.
- The specified current and power consumption can be measured under the V_{LCD}=5.0V, 25°C, f_v=60Hz 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.
- Maximum Condition of Inrush current :
The duration of rush current is about 5ms and rising time of power Input is 500us ± 20%. (min.).
- 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°C, f_v=60Hz)

*fv=frame frequency

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- **Permissive Power input ripple** ($V_{LCD} = 10.0V$, $25^{\circ}C$, f_v (frame frequency)=MAX condition)

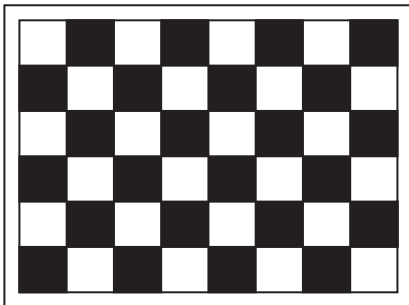


White pattern

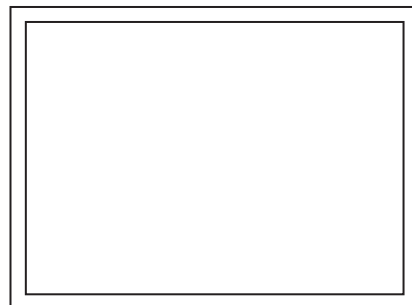


Black pattern

- **Power consumption** ($V_{LCD} = 10V$, $25^{\circ}C$, f_v (frame frequency)=60Hz condition)



Typical power Pattern



Maximum power Pattern

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

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Table 2-2. ELECTRICAL CHARACTERISTICS of LED bar

Parameter	Symbol	Values			Unit	Notes
		Min.	Typ.	Max.		
LED String Current	Is	-	120	125	mA	1, 2
LED String Voltage	Vs	50.4	54.0	57.6	V	1, 3
Power Consumption	PBar	-	19.4	20.7	Watt	1, 2, 5
LED Life Time	LED_LT	30,000	-	-	Hrs	4

Notes) The LED Bar consists of 54 LED packages, 3 strings (parallel) x 18packages (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 the LED PKG brightness reach to the 50% of initial value under the conditions at $T_a = 25 \pm 2^\circ\text{C}$ 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 $P_{\text{Bar}} = V_s(\text{Typ.}) \times I_s(\text{Typ.}) \times \text{No. of strings}$.
 The maximum power consumption is calculated as $P_{\text{Bar}} = V_s(\text{Max.}) \times I_s(\text{Typ.}) \times \text{No. of strings}$.

LED driver design guide

: 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.

Product Specification

3-2. Interface Connections

Table 3. MODULE CONNECTOR(CN1) PIN CONFIGURATION

Pin	Symbol	Description	Notes
1	VIN	Power Supply +10.0V	<div style="margin-bottom: 10px;">[Connector] GT05Q-30S-H10-MN, LSMtron, 30pin, 0.5pitch or equivalent</div> <div>[Connector pin arrangement]</div> 
2	VIN	Power Supply +10.0V	
3	VIN	Power Supply +10.0V	
4	VIN	Power Supply +10.0V	
5	VIN	Power Supply +10.0V	
6	NC	No Connection	
7	GND	Ground	
8	NC	Reserved for LCD manufacture's use	
9	NC	Reserved for LCD manufacture's use	
10	GND	Ground	
11	HPD	Hot Plug Detect Signal	
12	GND	Ground	
13	AUX_CHN	Component Signal for Auxiliary Channel	
14	AUX_CHP	True Signal for Auxiliary Channel	
15	GND	Ground	
16	Lane0P	True Signal for Main Link 0	
17	Lane0N	Component Signal for Main Link 0	
18	GND	Ground	
19	Lane1P	True Signal for Main Link 1	
20	Lane1N	Component Signal for Main Link 1	
21	GND	Ground	
22	Lane2P	True Signal for Main Link 2	
23	Lane2N	Component Signal for Main Link 2	
24	GND	Ground	
25	Lane3P	True Signal for Main Link 3	
26	Lane3N	Component Signal for Main Link 3	
27	GND	Ground	
28	BIST	L(GND): Black, H(3.3V): Rotational Pattern	
29	NC	No Connection	
30	GND	Ground	

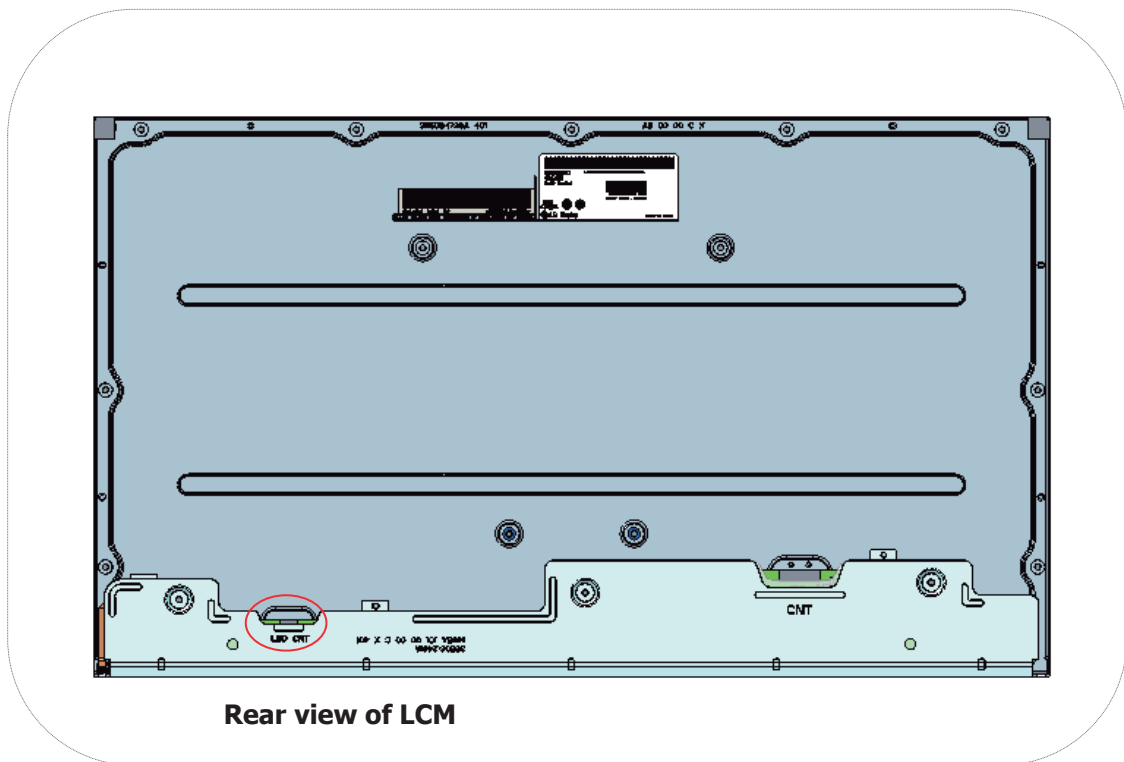
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3-2-2. BACKLIGHT CONNECTOR PIN CONFIGURATION(CN2)

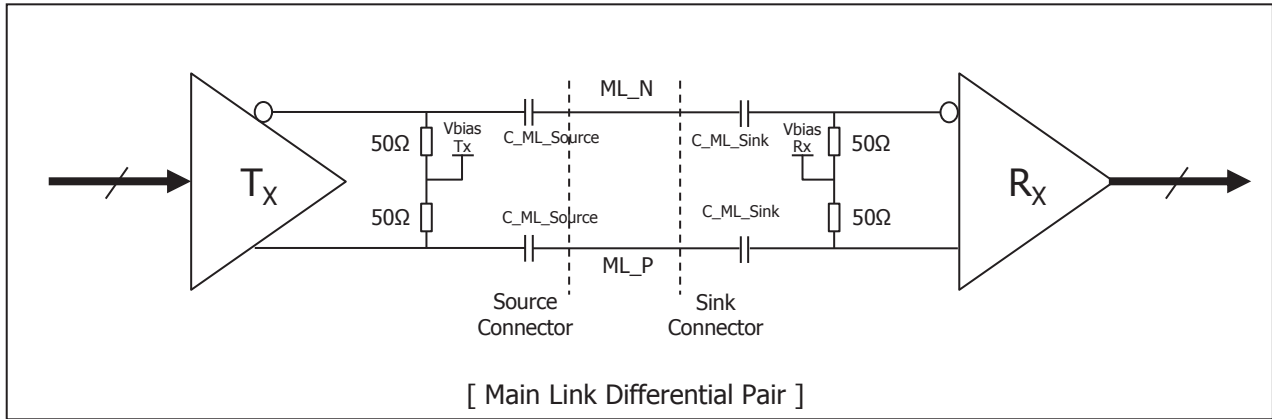
- Connector : SM06B-SHJH (HF) (Manufactured by JST) or Yeonho
- Mating Connector : SHJP-06V-S(HF) or SHJP-06V-A-K(HF) or Equivalent

Table 4. LED CONNECTOR PIN CONFIGURATION

Pin	Symbol	Description
1	FB1	Channel1 Current Feedback
2	NC	No Connection
3	VLED	LED Power Supply
4	VLED	LED Power Supply
5	FB2	Channel2 Current Feedback
6	FB3	Channel3 Current Feedback



[Figure 4] Backlight connector view

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3-3. eDP Signal Specifications
3-3-1. eDP Main Link Signal


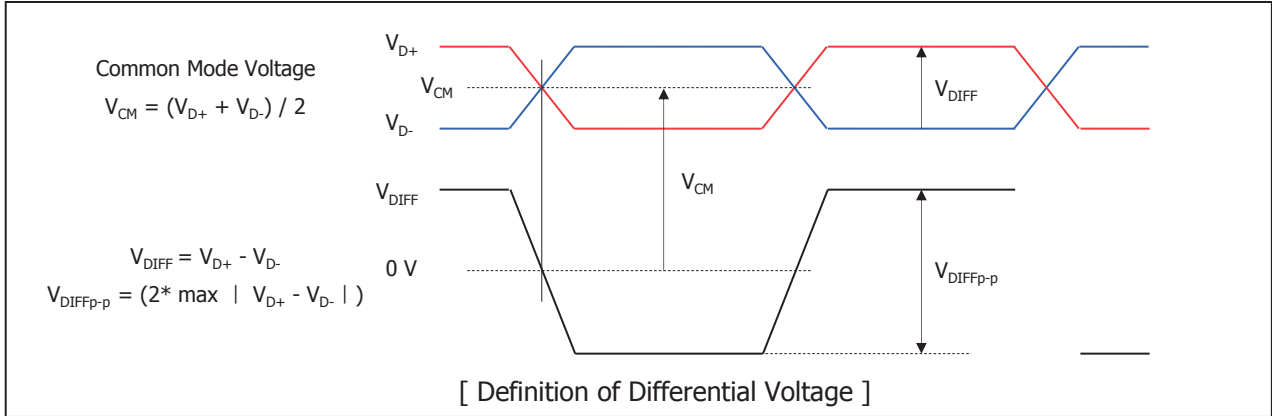
Parameter	Symbol	Min	Typ	Max	Unit	Notes
Unit Interval for high bit rate (5.4Gbps / lane)	UI_HBR2	-	185	-	ps	
Link Clock Down Spreading	Amplitude	0	-	0.5	%	
	Frequency	30		33	kHz	
Differential peak-to-peak voltage at Sink side connector	$V_{RX-DIFFP-P}$	-	-	1.38	V	Note 6,7)
EYE width at Sink side connector	$T_{RX-EYE-CONN}$	0.38	-	-	UI	Note 6,7)
Lane-to-Lane skew	$L_{RX-SKEW-INTER_PAIR}$	-	-	4UI+ 500ps		
Lane intra-pair skew	$L_{RX-SKEW-INTRA_PAIR}$	-	-	50	ps	
AC Coupling Capacitor	C_{SOURCE_ML}	75		200	nF	Source side

Note)

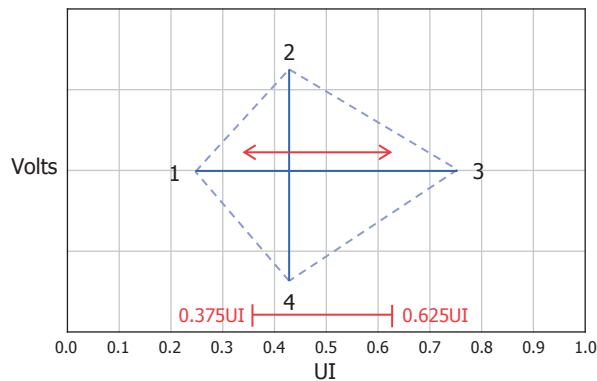
1. Termination resistor is typically integrated into the transmitter and receiver implementations.
2. In cabled embedded system, it is recommended the system designer ensure that EYE width and voltage are met at the sink side connector pins.
3. Mismatched common mode voltage will occur abnormal display.
4. All eDP electrical spec is measured at sink connector side.
5. eDP cable Impedance recommend 100ohm \pm 5%.

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Note6) Definition of Differential Voltage

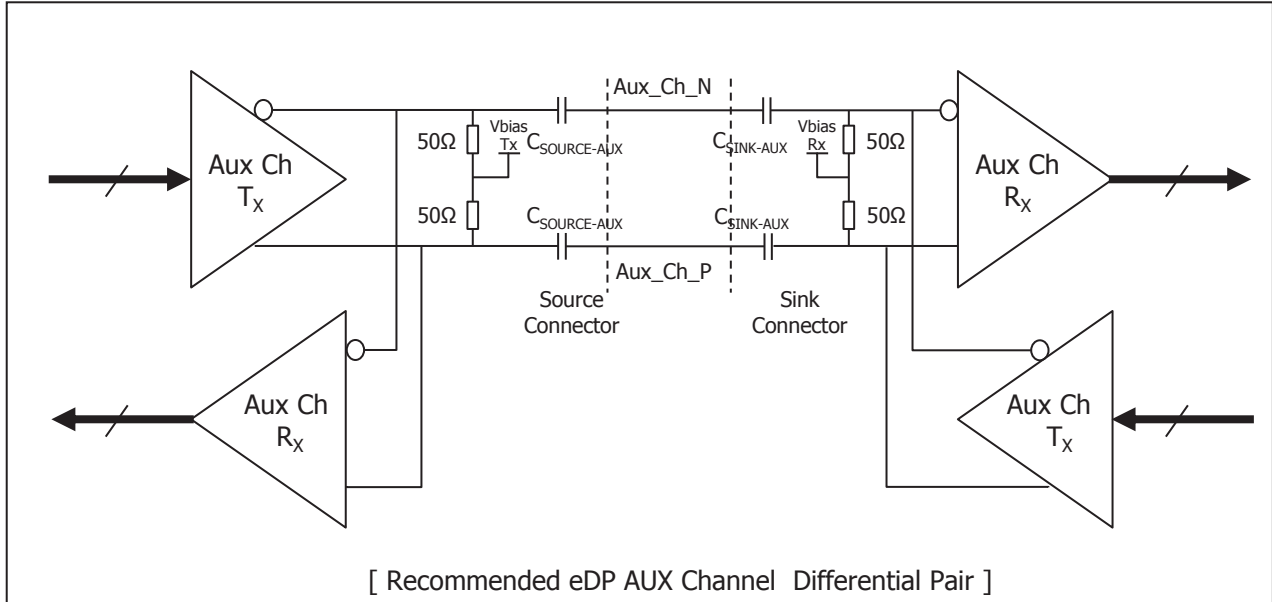


Note7) Main Link EYE Diagram



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]

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3-3-2. eDP AUX Channel Signal


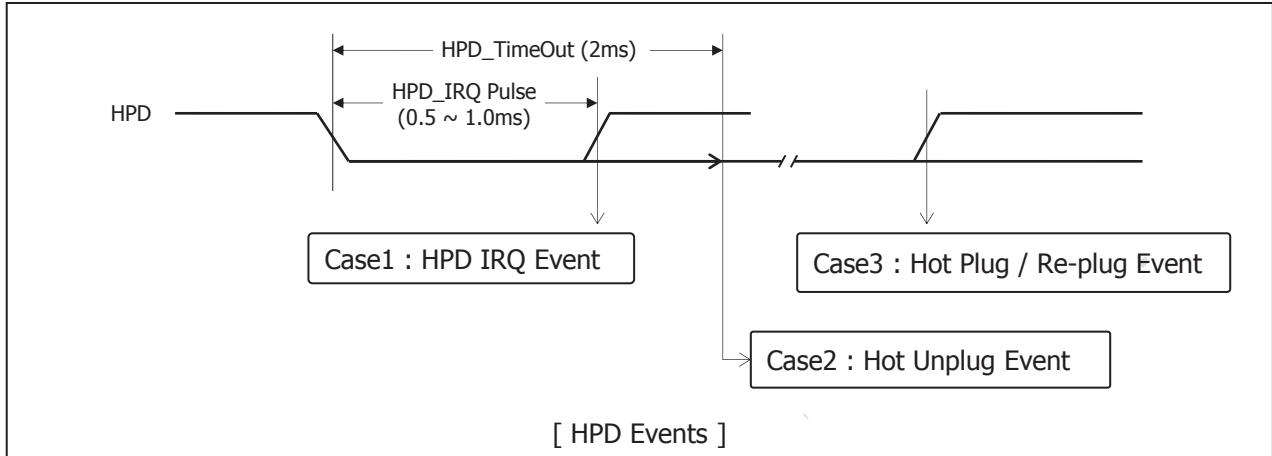
Parameter	Symbol	Min	Typ	Max	Unit	Notes
AUX Unit Interval	UI	0.4	-	0.6	us	
AUX Jitter at Tx IC Package Pins	T_{jitter}	-	-	0.04	UI	Equal to 24ns
AUX Jitter at Rx IC Package Pins		-	-	0.05	UI	Equal to 30ns
AUX Peak-to-peak voltage at Connector Pins of Receiving	$V_{AUX-DIFFp-p}$	0.32	-	1.36	V	
AUX Peak-to-peak 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 DC common mode voltage	V_{AUX-CM_Rx}	-	0	2.0	V	
	V_{AUX-CM_Tx}	-	0.15	2.0	V	
AUX AC Coupling Capacitor	$C_{SOURCE-AUX}$	75		200	nF	Source side

Note)

1. Termination resistor is typically integrated into the transmitter and receiver implementations.
2. $V_{AUX-DIFFp-p} = 2 * |V_{AUXP} - V_{AUXN}|$
3. Termination resistor should be $\pm 50\Omega$ at source side to AUX level.
4. At sink side AUX cap. are for protection ESD/EOS damage.
5. Mismatched common mode voltage will occur abnormal display.

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3-3-3. eDP HPD Signal



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

Note)

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

Product Specification
3-4. Signal Timing Specifications

All of the interface signal timing should be satisfied with the following specifications for its proper operation.

Table 5. TIMING TABLE

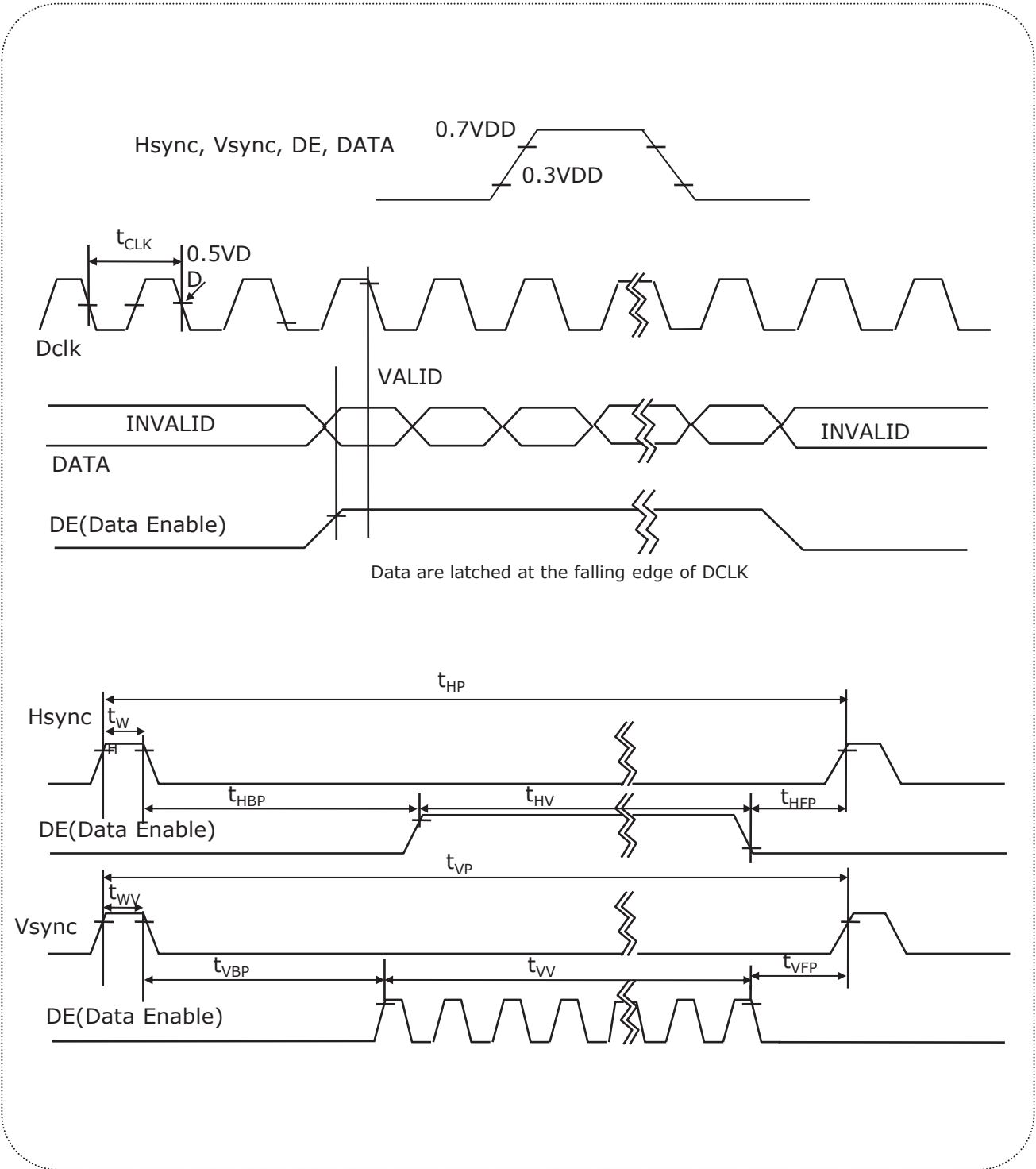
ITEM		SYMBOL	Min	Typ	Max	Unit	Note
DCLK	Period	tCLK	1.82	1.875	1.93	ns	
	Frequency	fCLK	518.25	533.25	548.25	MHz	-
Hsync	Period	tHP	3968	4000	4040	tCLK	
	Width-Active	tWH	28	32	36		
Vsync	Period	tVP	2220	2222	2268	tHP	
	Frequency	fV	58.2	59.997	61.68	Hz	
	Width-Active	tWV	5	5	5	tHP	
Data Enable	Horizontal Valid	tHV	3840	3840	3840	tCLK	
	Horizontal Back Porch	tHBP	52	80	116		
	Horizontal Front Porch	tHFP	48	48	48		
	Horizontal Blank	-	128	160	200		tWH+ tHBP+ tHFP
	Vertical Valid	tVV	2160	2160	2160	tHP	
	Vertical Back Porch	tVBP	52	54	100		
	Vertical Front Porch	tVFP	3	3	3		
	Vertical Blank	-	60	62	108		tWV+ tVBP+ tVFP

Note:

1. DE Only mode operation. The input of Hsync & Vsync signal does not have an effect on LCD normal operation.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3. Horizontal period should be even.

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3-5. Signal Timing Waveforms



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3-6. Color Input 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 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	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	0
	Green (1023)	0	0	0	0	0	0	0	0	0	0	1	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	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	1
	Magenta	1	1	1	1	1	1	1	1	1	1	0	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	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	1
RED	RED (000)	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 (001)	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 (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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
GREEN	GREEN (000)	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 (001)	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 (1022)	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	0	
	GREEN (1023)	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	
BLUE	BLUE (000)	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 (001)	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	

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3-7. Power Sequence

3-7-1. Power Sequence

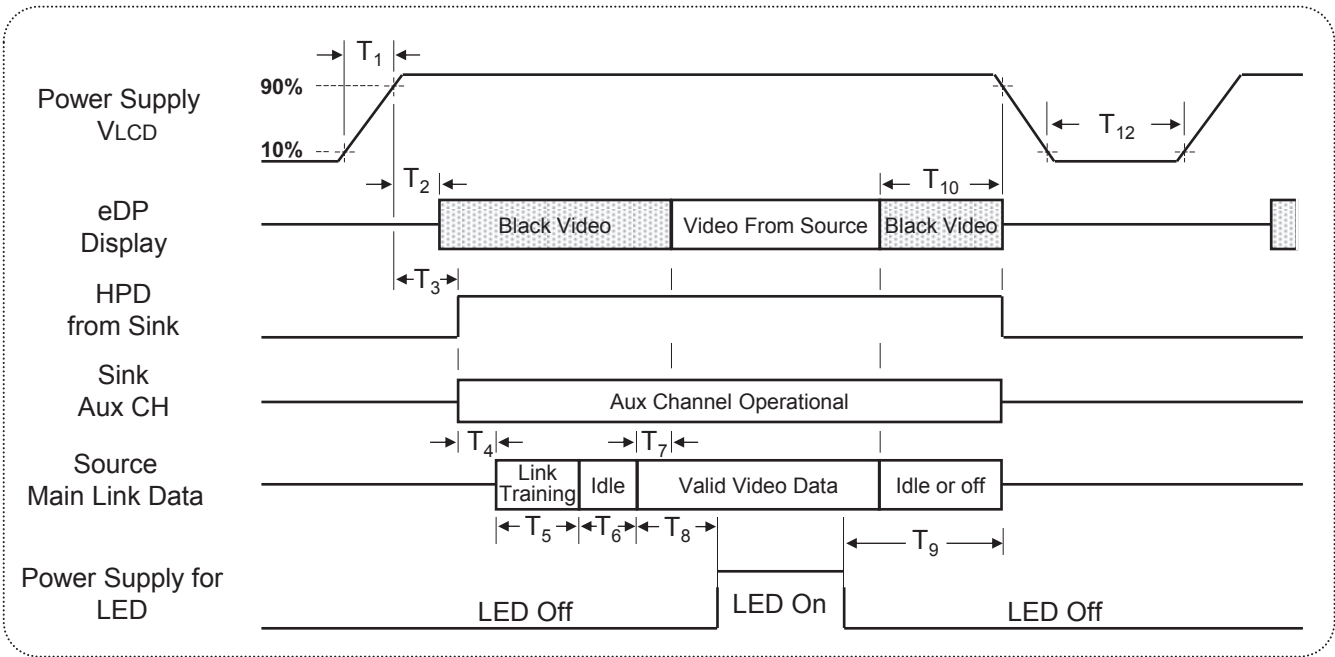
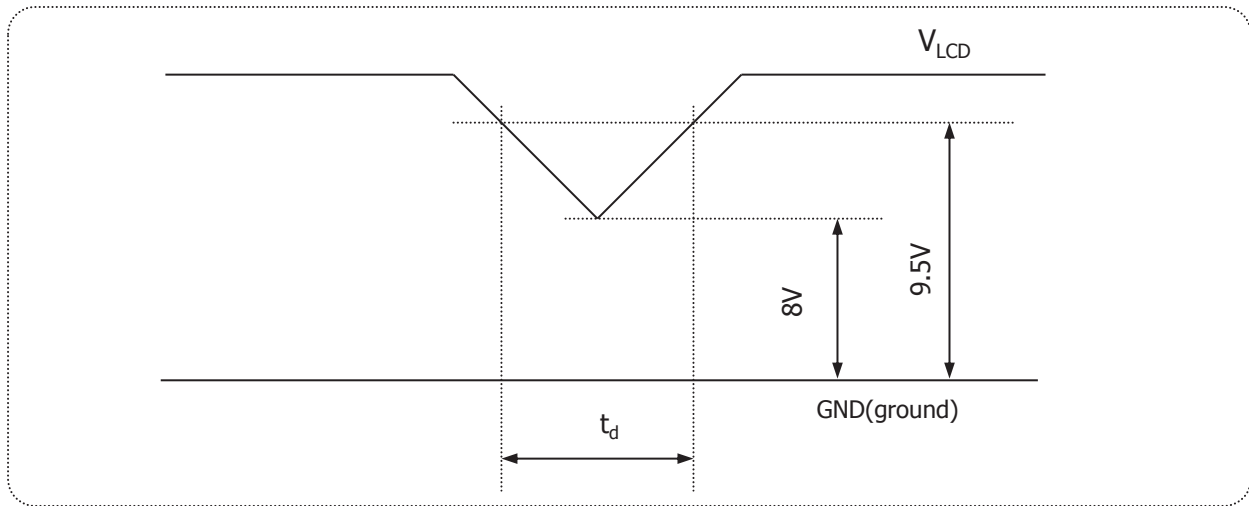


Table 7. POWER SEQUENCE TABLE

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	6
T ₅	Source	-	-	ms	6
T ₆	Source	-	100	ms	-
T ₇	Sink	0	50	ms	-
T ₈	Source	200	-	ms	
T ₉	Source	200	-	ms	7

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

- Note) 1. Do not insert the mating cable when system turn on.
 2. Valid Data have to meet "3-3. Signal Timing Specifications"
 3. When the Video signal is invalid, be sure to pull down the power supply for LCD VLCD to 0V.
 4. The above power sequence should be satisfied the basic power on/off and resolution, timing transition.
 5. LED power must be turn on after power supply for LCD and valid status of Video Signal.
 6. Link training duration is dependent on the customer's system.
 7. LED power must be turned off while Video data signal is valid

3-7-2. V_{LCD} Power Dip Condition

FIG.5 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 in page 17 exactly.

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.

Product Specification
4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at $25 \pm 2^\circ\text{C}$. 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. 6 presents additional information concerning the measurement equipment and method.

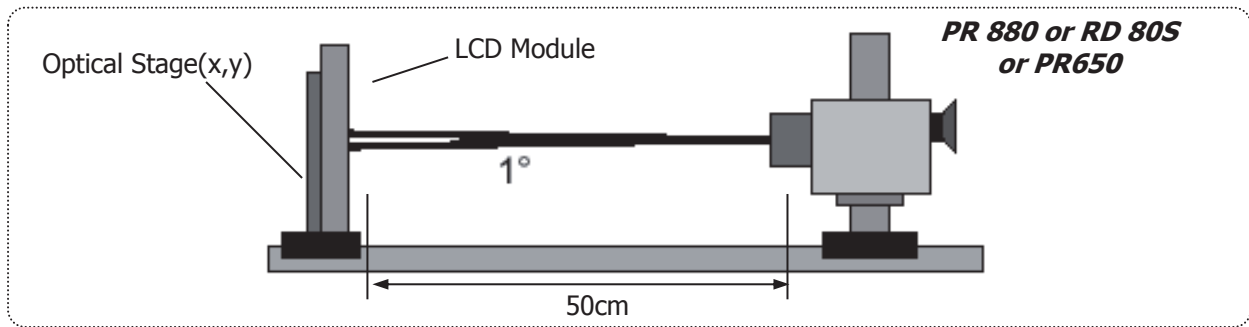


FIG.6 Optical Characteristic Measurement Equipment and Method

Table 8. OPTICAL CHARACTERISTICS

($T_a=25^\circ\text{C}$, $V_{LCD}=10\text{V}$, $f_v=60\text{Hz}$ Dclk=533.25MHz) $I_s=120\text{mA}$

Parameter	Symbol	Values			Units	Notes	
		Min	Typ	Max			
Contrast Ratio	CR	910	1300	-		1	
Surface Luminance, white	L_{WH}	280	350	-	cd/m ²	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	0.655	Typ +0.03		
		Ry		0.333			
	GREEN	Gx		0.304			
		Gy		0.637			
	BLUE	Bx		0.151			
		By		0.056			
	WHITE	Wx		0.313			
	Wy	0.329					
Color Shift	Horizontal	θ_{CST_H}	-	178	-	Degree	5
	Vertical	θ_{CST_V}	-	178	-		
Viewing Angle (CR>10)							
General	Horizontal	θ_H	170	178	-	Degree	6
	Vertical	θ_V	170	178	-		
Gray Scale		-		2.2			7

Product Specification

Notes

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

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

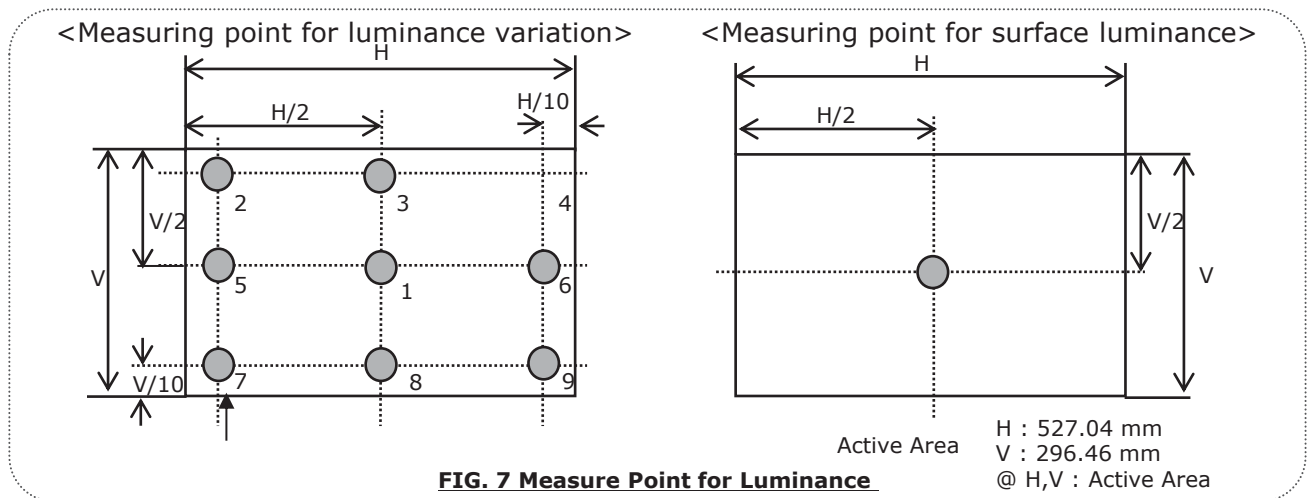
It is measured at center point(Location P1)

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.7 (By PR880)

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

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

Where L1 to L9 are the luminance with all pixels displaying white at 9 locations.
For more information see FIG.7



Product Specification

4. Gray to gray response time is the time required for the display to transition from gray to gray. For additional information see Table 9. (*By PR880*)

Table 9. Gray to gray response time table

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

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

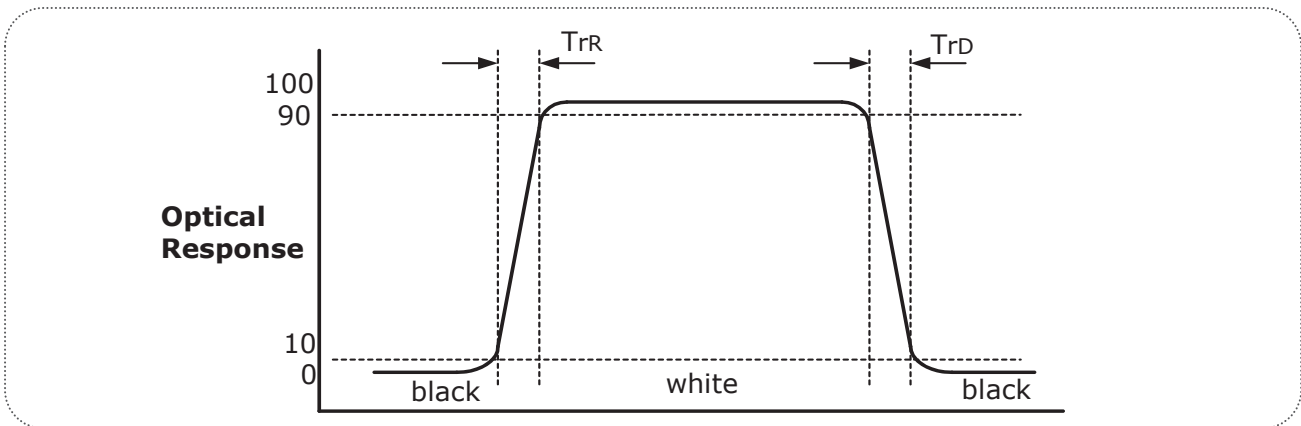


FIG.8 Response time

Product Specification

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.9 **(By EZ Contrast)**

- Color difference ($\Delta u'v'$)

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

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

u'_1, v'_1 : $u'v'$ value at viewing angle direction

u'_2, v'_2 : $u'v'$ value at front ($\theta=0$)

i : Macbeth chart number (Define 23 page)

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

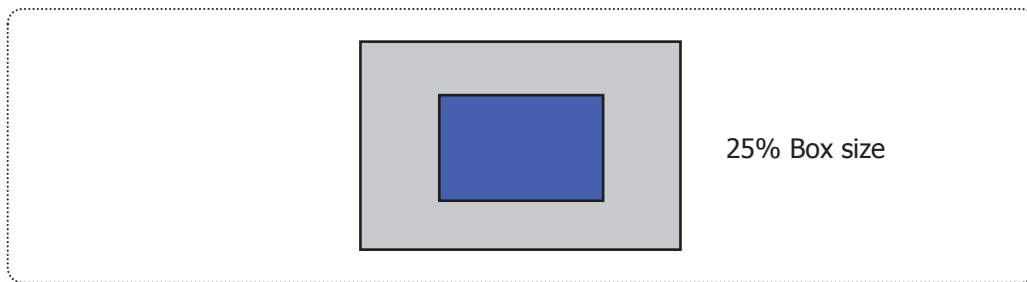


FIG.9 Color Shift Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

	Dark skin	Light skin	Blue sky	Foliage	Blue flower	Bluish green
R	395	827	343	311	519	459
G	227	571	451	411	475	799
B	183	495	647	187	743	715
	Orange	Purplish blue	Moderate red	Purple	Yellow green	Orange yellow
R	879	227	847	307	643	923
G	419	279	271	159	775	651
B	99	699	351	347	235	119
	Blue	Green	Red	Yellow	Magenta	cyan
R	107	291	791	967	831	143
G	131	595	111	851	251	507
B	583	263	151	147	607	691
	White	Neutral 8	Neutral 6.5	Neutral 5	Neutral 3.5	black
R	963	827	623	443	255	91
G	963	827	623	443	255	91
B	963	827	623	443	255	91

Product Specification

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.10 **(By PR880)**

Dimension of viewing angle range.

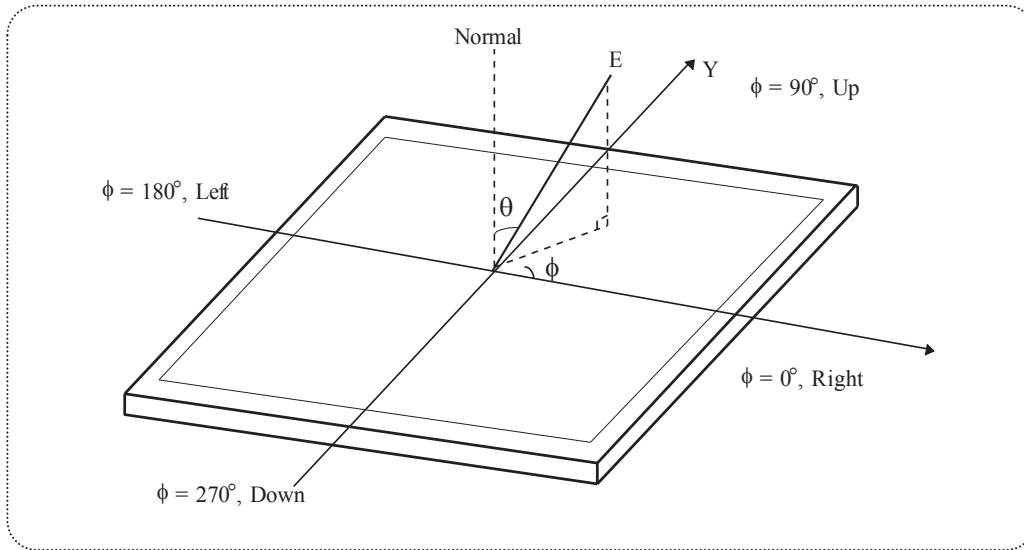


FIG.10 Viewing angle

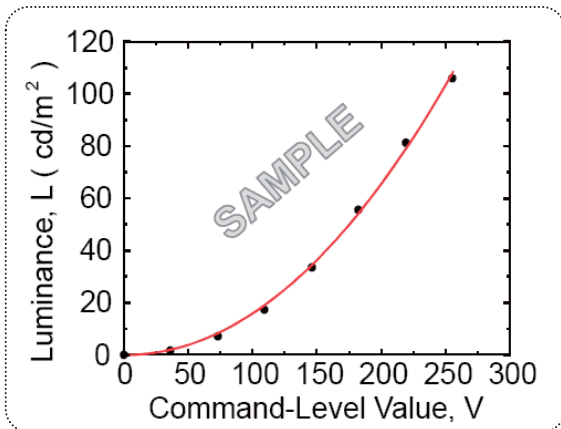


FIG.11 Sample Luminance vs. gray scale (using a 256 bit gray scale)

$$L = aV^r + L_b$$

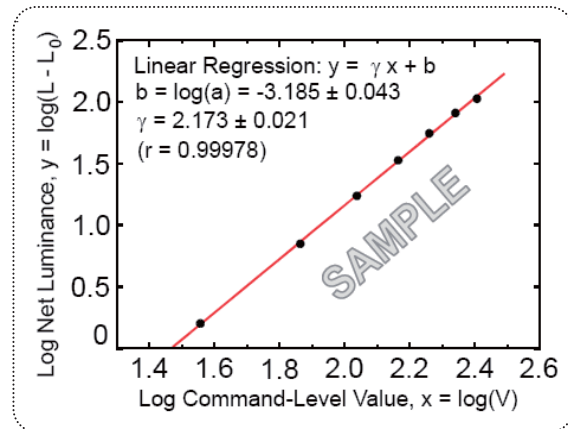


FIG.12 Sample Log-log plot of luminance vs. gray scale

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

Here the Parameter a and γ relate the signal level V to the luminance L.
The GAMMA we calculate from the log-log representation (FIG.10)

Product Specification

7. Gamma Value is approximately 2.2. For more information see Table 10.

Table 10. Gray Scale Specification

Gray Level	Relative Luminance [%] (Typ.)
0	0.10
63	0.30
127	1.08
191	2.50
255	4.71
319	7.70
383	11.52
447	16.18
511	21.72
575	28.15
639	35.51
703	43.81
767	53.07
831	63.30
895	74.52
959	86.75
1023	100

Product Specification

5. Mechanical Characteristics

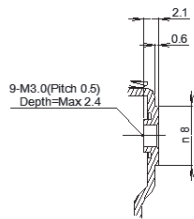
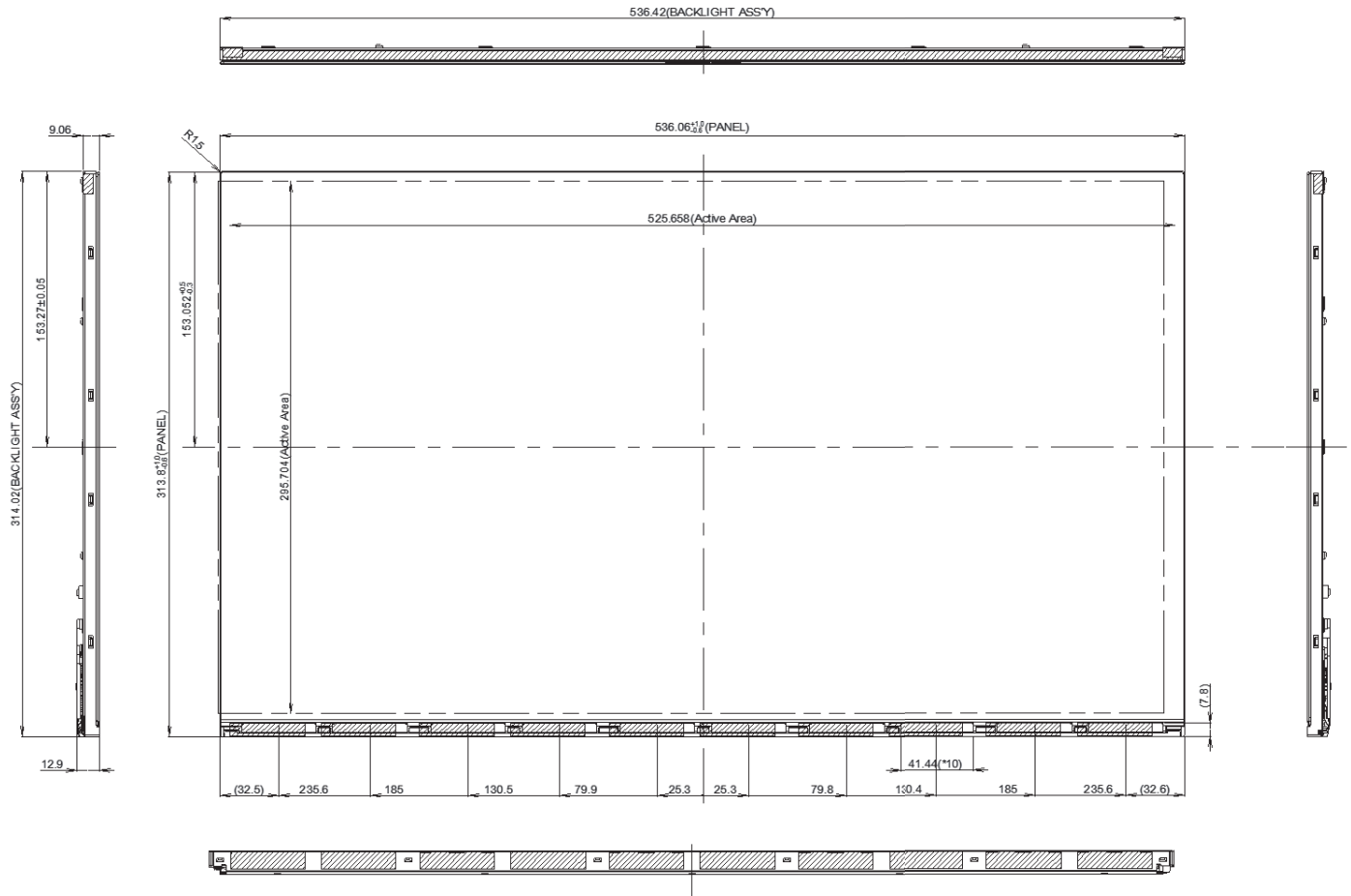
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Outline Dimension	Horizontal	536.3mm
	Vertical	313.9mm
	Depth	12.9 mm
Bezel Area	Horizontal	-
	Vertical	-
Active Display Area	Horizontal	525.66mm
	Vertical	295.70mm
Weight	1610g (Typ.) 1690g (Max.)	
Surface Treatment	Advanced Anti-glare treatment of the front polarizer (3H)	

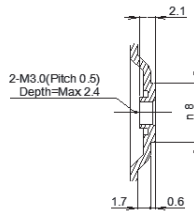
Notes : Please refer to a mechanic drawing in terms of tolerance at the next page.

Product Specification

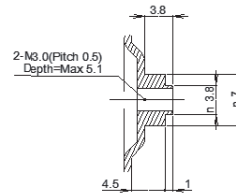
<FRONT VIEW>



SECTION A-A
SCALE 2/1



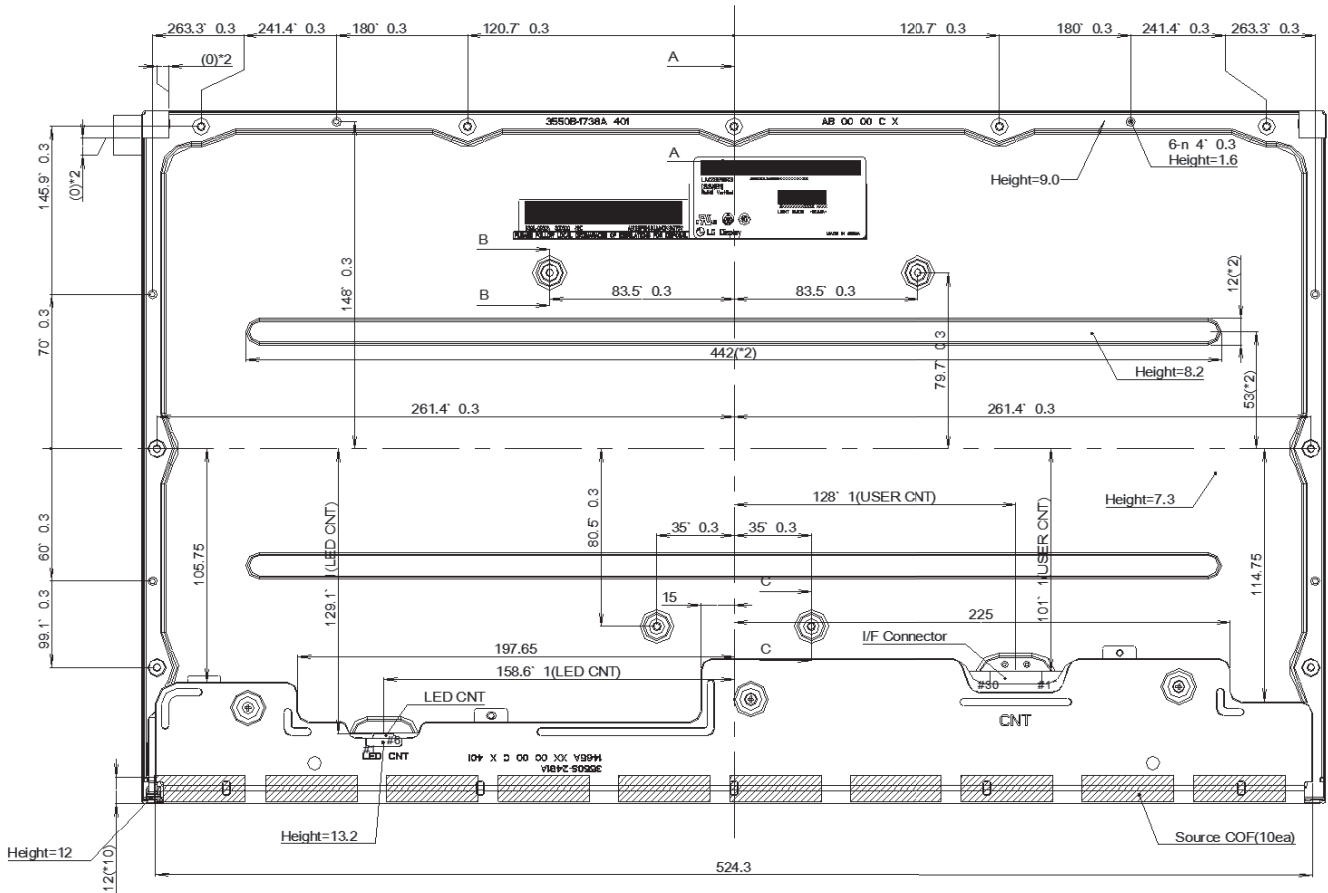
SECTION B-B
SCALE 2/1



SECTION C-C
SCALE 2/1

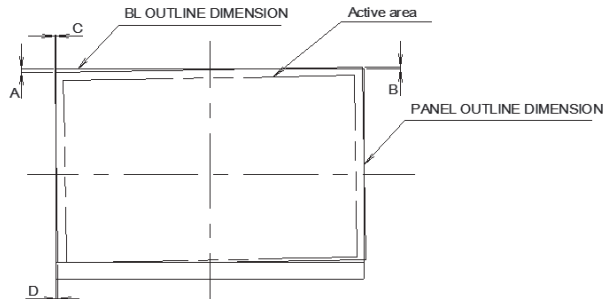
Product Specification

<REAR VIEW>



Notes

1. I/F connector specification : GT05Q-30S-H10-MN(LSMtron) or Equivalent.
2. LED connector specification : SM06B-SHJS(HF)(Manufactured by JST) 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 : $-0.45 \leq A \leq 0.45$, $-0.45 \leq B \leq 0.45$
 - (2) X-direction : $-0.45 \leq C \leq 0.45$, $-0.45 \leq D \leq 0.45$



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 & sensitive, so please don't press the COF area

Product Specification

6. Reliability

Environment test condition

No	Test Item	Condition	Notes
1	High temperature storage test	Ta= 60°C 240h	1
2	Low temperature storage test	Ta= -20°C 240h	1
3	High temperature operation test	Ta= 50°C 50%RH 240h	1
4	Low temperature operation test	Ta= 0°C 240h	1
5	Humidity condition Operation	Ta= 40 °C ,90%RH	
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 , Ta=40°C	

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. Environment

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

Product Specification

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.

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

1) Package quantity in one box : 10 pcs

b) Box Size : 635mm X 370mm X 400mm

Product Specification**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 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 :
 $V = \pm 200\text{mV}$ (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 guarantee.
- (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 PTN and normal temperature (25~40°C)

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.