TFT-Display Datasheet

LB310FTM-SPA2 | LG Display

Features

Active Screen Area	652.68 x 435.12 [mm]
Size | Format	31“ | 3:2
Resolution	4200x2800
Backlight	LED
Brightness	1200 cd/m^2
LED Life Time	50.000 h
Interface	eDP
Viewing Angle	L/R 89/89 - U/D 89/89
Touchscreen	no
Power Supply	10 V [Typ.]
Module Outline	676.9 x 459.7 x 27.55 [mm]
Operation Temperature	-0… + 50°C
Storage Temperature	-20… + 60°C

Contact

HY-LINE Computer Components
Vertriebs GmbH
Inselkammerstr. 10
82008 Unterhaching
Germany

Support
Tel.: +49 89 614 503 40
Fax. +49 89 614 503 50

Send us an email
computer@hy-line.de

SPECIFICATION
FOR
APPROVAL

(●) Preliminary Specification
( ) Final Specification

Title	31" 4K3K TFT LCD (with LED Driver)

BUYER	Barco
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LB310FTM
SUFFIX	SPA2

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

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

APPROVED BY	SIGNATURE DATE
S.H. Lee / G.Manager	
REVIEWED BY	
J.G. Lee / Manager [C]	
J.C. Shin / Manager [M]	
Y.S. Choi / Manager [O]	
J.K. Lee / Manager [P]	
PREPARED BY	
H.H. Son / Engineer	

Product engineering dept.
LG Display Co., Ltd

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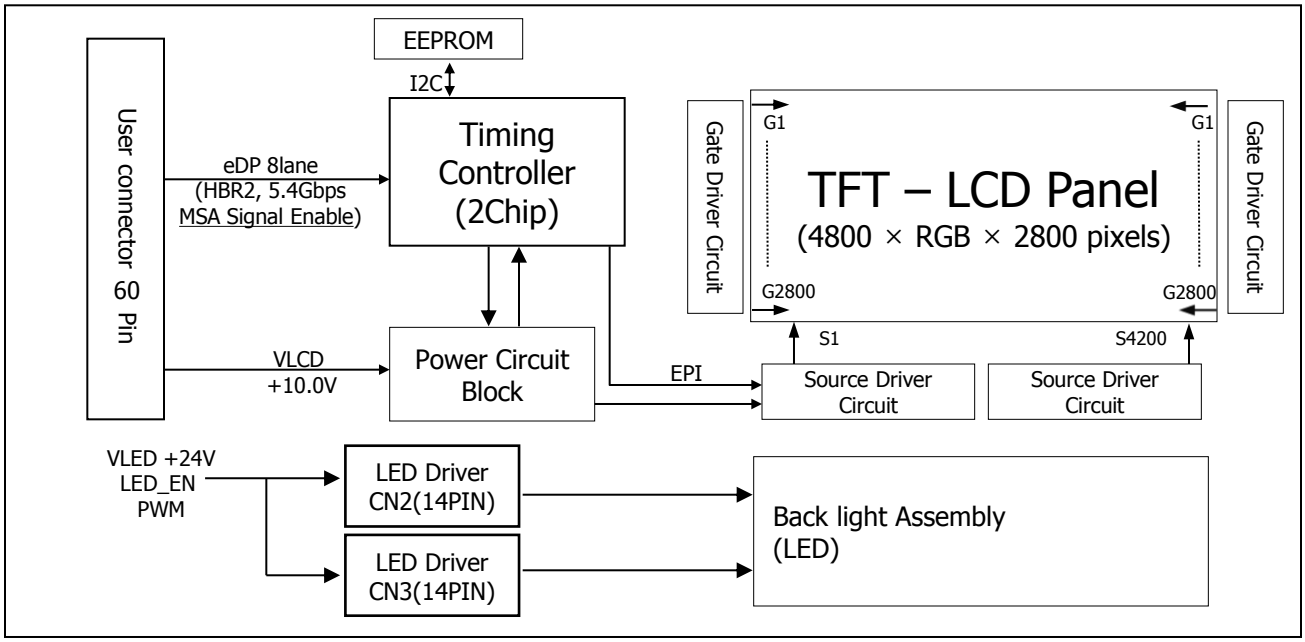
RECORD OF REVISIONS

Revision No	Revision Date	Page	Before	After	Application Date
0.0	Oct. 07. 2019	-	First Draft (Preliminary)		
0.1	Dec. 04. 2019	33	TBD	Packing form updated	

1. General Description

LB310 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 31inch diagonally measured active display area with 4K3K resolution (4200 vertical by 2800 horizontal 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 real 10-bit gray scale signal for each dot, thus, presenting a palette of 1,073,741,824 colors. 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	31inches(78.4cm) (Aspect ratio 3:2)
Outline Dimension	676.9 (H) x 459.7 (V) x 26.25mm(27.55mmLED Driver) (Typ.)
Pixel Pitch	0.1554 [mm] X 0.1554 [mm]
Pixel Format	4200 horiz. By 2800 vert. Pixels RGB stripes arrangement
Color Depth	1,073,741,824 Colors (Real 10bit)
Luminance, White	1200 cd/m^2 (Center 1P Typ.)
Viewing Angle (CR>10)	View Angle (R/L 178(Typ.), U/D 178(Typ.))
Power Consumption	TBDW(Typ.) (Logic : 12.1W@Mosaic, B/L: TBDW @(57)mA)
Weight	6680g(Typ.) 7000g(Max)
Display Operating Mode	Transmissive mode, Normally Black,
Panel type	Reverse type
Surface Treatment	Anti-Glare treatment of the front polarizer(3H)

2. Absolute Maximum Ratings

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

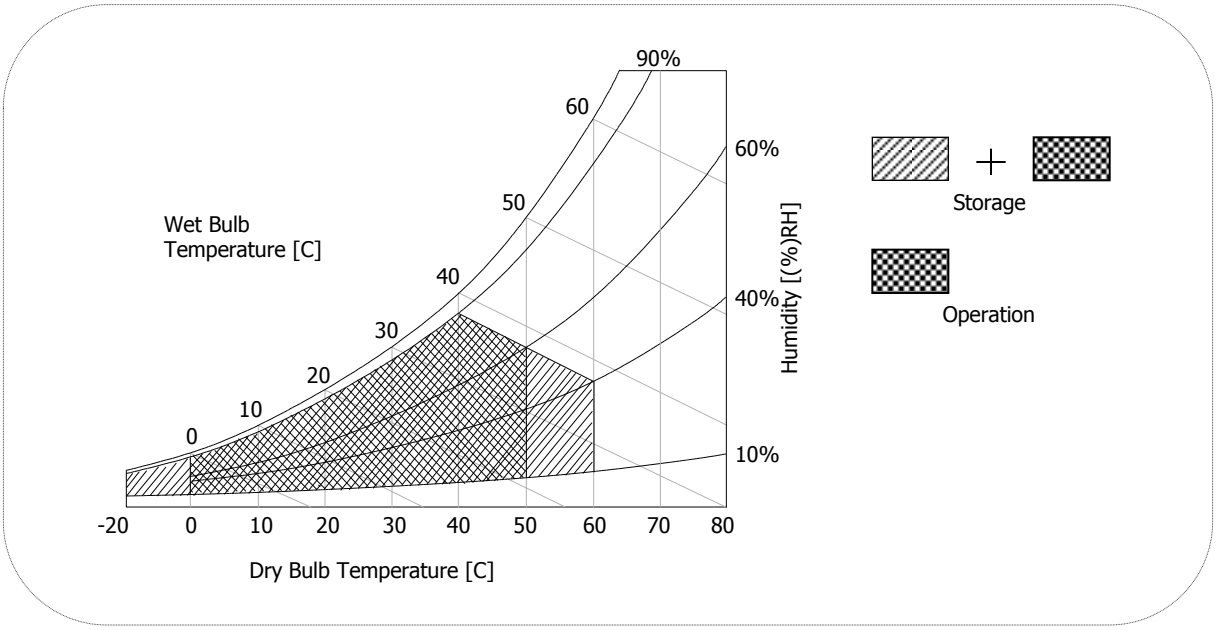
Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Supply Input Voltage	V_{LCD}	-0.3	+12.0	Vdc	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}=10.0V, fv=60Hz, T_a=25℃, no humidity and typical LED string current.
   ※. 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 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

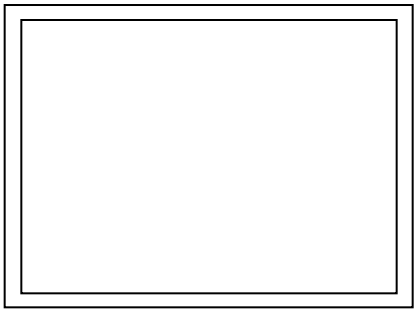
Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input voltage	V_{LCD}	9.5	10.0	10.5	Vdc	4
Permissive Power Input Ripple	V_{dRF}	-		400	mVp-p	1
Power Supply Input Current	$I_{LCD-MOSAIC}$	-	(1.21)	(1.51)	A	2
	$I_{LCD-WHITE}$	-	(1.62)	(2.02)	A	2
Power Consumption	$P_{LCD-MOSAIC}$	-	(12.1)	(15.1)	Watt	2
	$P_{LCD-WHITE}$	-	(16.2)	(20.2)	Watt	2
Rush Current	I_{RUSH}	-	-	3.5	A	3

Notes :

1. Permissive power ripple should be measured under the condition of V_{LCD}=10.0V, 25°C,*fv=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}=10.0V, 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.
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°C, f_V=60Hz)

* fv=frame frequency

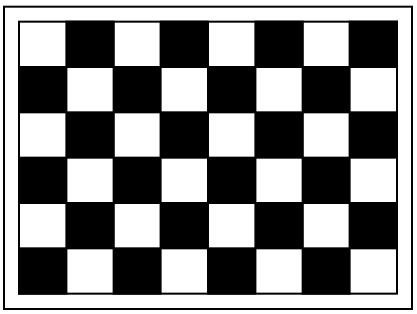
• **Permissive power input ripple** (V_{LCD} =10V, 25°C, fv (frame frequency)=Max. condition)



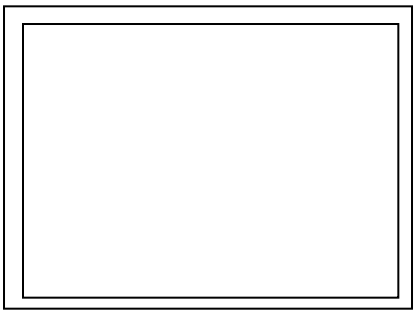
White pattern

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

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



Typical power pattern



Maximum power pattern

[FIG. 3] Mosaic pattern & White pattern for power consumption measurement

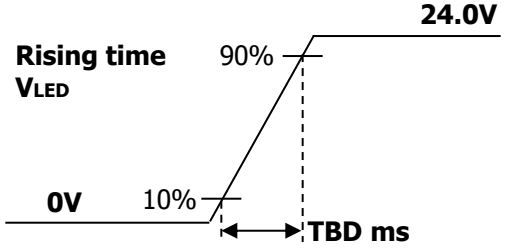
3-2. LED Backlight Electrical Characteristics

Table 2-2. LED B/L ELECTRICAL CHARACTERISTICS

Parameter		Symbol	Values			Unit	Notes
			Min	Typ	Max		
LED Power Input Voltage		V_{LED}	(21.6)	24	(26.4)	V	1
LED Power Input Current		I_{LED}	-	3.87	TBD	A	2
LED Power Consumption		P_{LED}	-	92.95	TBD	W	
LED Power Inrush Current		I_{LED_P}	-	-	TBD	A	3
PWM Duty Ratio			(20)	-	100	%	4
PWM Frequency		F_{PWM}	TBD	(120)	TBD	Hz	5,6
PWM	High Level Voltage	V_{PWM_H}	TBD	3.3	TBD	V	
	Low Level Voltage	V_{PWM_L}	TBD	-	TBD	V	
LED_EN	High Voltage	$V_{LED\_EN\_H}$	TBD	3.3	TBD	V	
	Low Voltage	$V_{LED\_EN\_L}$	TBD	-	TBD	V	
LED Life Time			50,000	-	-	Hrs	7

Note)

1. The measuring position is the connector of LCM and the test conditions are under 25℃.
2. The current and power consumption with LED Driver are under the V_{LED} = 24.0V , 25℃, PWM Duty 100%
3. The V_{LED} rising time is same as the minimum of T9 at Power on sequence.



4. The operation of LED Driver below minimum dimming ratio may cause flickering or reliability issue.
5. This Spec. is not effective at 100% dimming ratio as an exception because it has DC level equivalent to 0Hz. In spite of acceptable range as defined, the PWM Frequency should be fixed and stable for more consistent brightness control at any specific level desired.
6. It is recommended to choose PWM frequency as not occurred wavy noise
7. The life time is estimated value and not guaranteed value.
   The LED life time is defined as the time when brightness of LED itself reach to become 50% or less than the initial value under the conditions at Ta = 25 ± 2°C and LED string current is typical value.

3-3. Interface connections

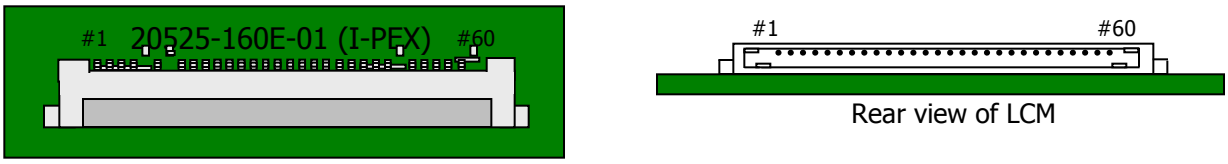
3-3-1. LCD Module

- LCD Connector(CN1): 20525-160E-01 (manufactured by I-PEX) or equivalent.
- Mating Connector : 20523-060T (I-PEX) or compatible

Table 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	GND	Ground	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	GND	Ground

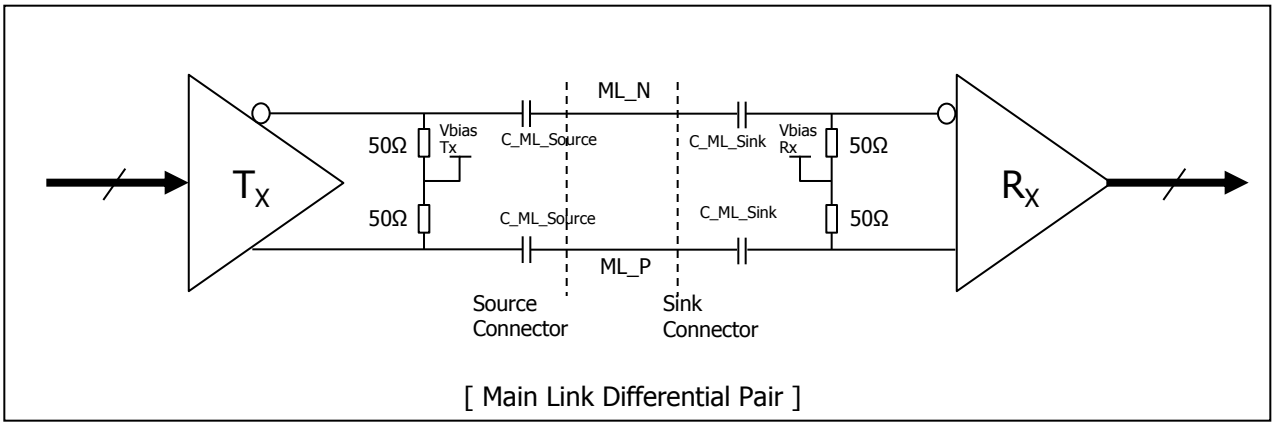
Notes :
1. All GND(ground) pins should be connected together to the LCD module's metal frame.
2. All V_{LCD} (input power) pins should be connected together.



[FIG. 4] Connector diagram

3-3-2. eDP Signal specifications

1. eDP Main link signal

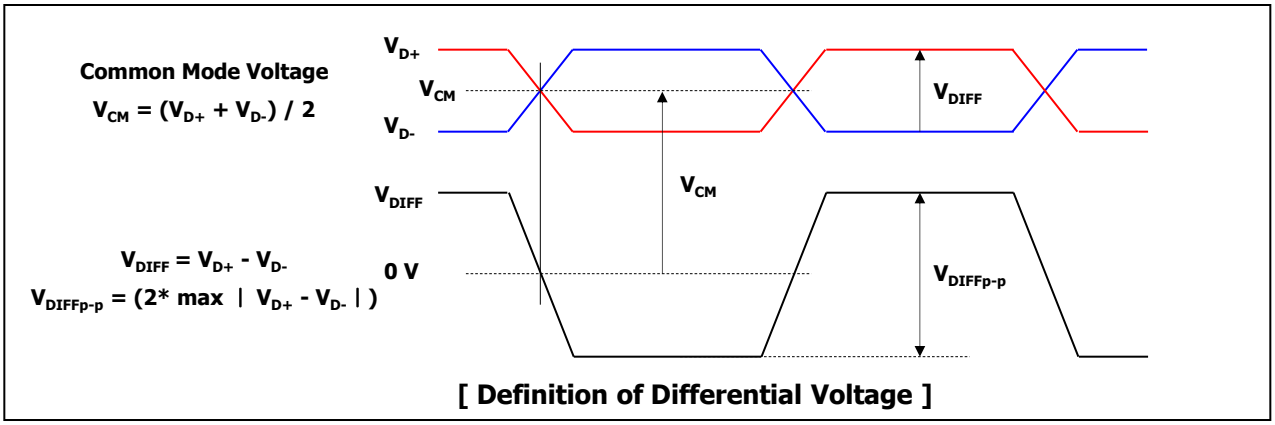


[Main Link Differential Pair]

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	Note 5)
Differential peak-to-peak voltage at Sink side connector	$V_{RX-DIFFp-p}$	0.09	-	-	V	Note 6)
EYE width at Sink side connector	$T_{RX-EYE-CONN}$	0.38	-	-	UI	Note 5, 6)
Lane intra-pair skew	$L_{Rx-SKEW-INTRA\_PAIR}$	-	-	50	ps	
Master Tx –to-Slave Tx skew	Tx-to-Tx_skew	-	-	±0.25	DE	Note 7)
AC Coupling Capacitor	$C_{SOURCE-ML}$	75		200	nF	Source side

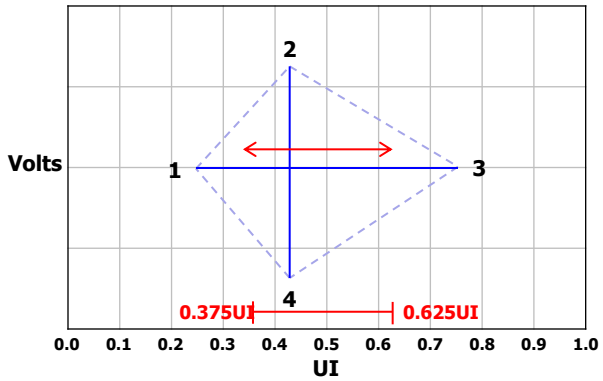
Note)
1. Termination resistor is typically integrated into the transmitter and receiver implementations.
2. In cabled embedded system, it is recommended the system designer ensure that EYE width and voltage are met at the sink side connector pins.
3. Mismatched common mode voltage will occur abnormal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

Note5) Definition of Differential Voltage



[Definition of Differential Voltage]

Note6) Main Link EYE Diagram

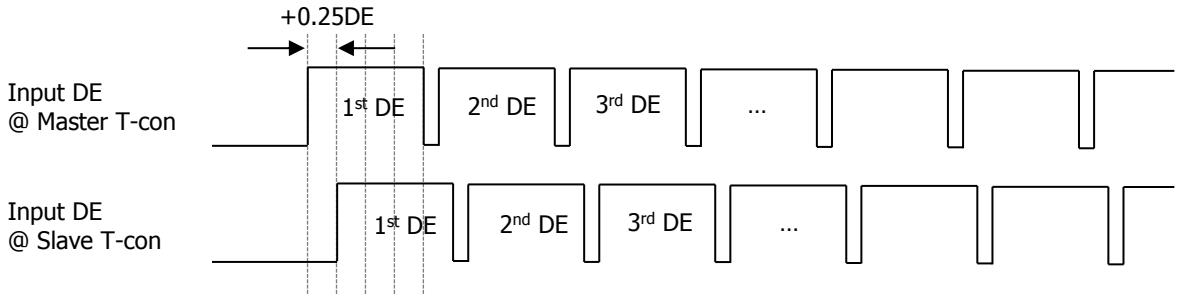


Point	High Bit Rate 2 @ TP3 EQ	
	Time(UI)	Voltage(V)
1	Any UI location (x) where the eye width is open from x to x+0.38UI	0.000
2	Any passing UI location between 0.375UI-0.625UI	0.045
3	Point 1 + 0.38UI	0.000
4	Same as Point 2	-0.045

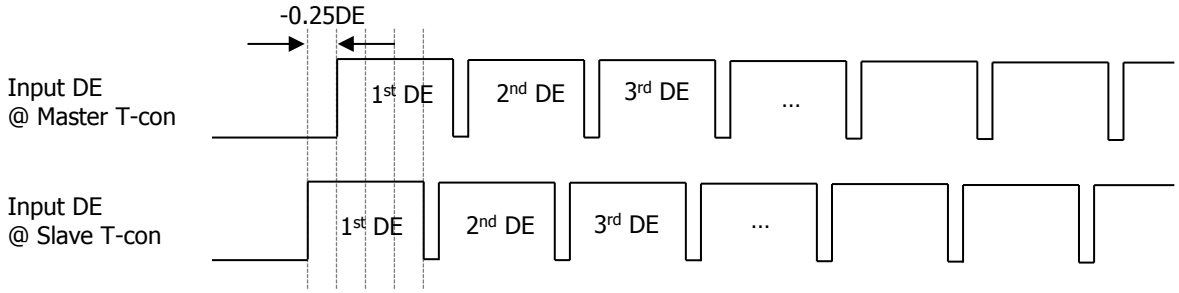
[EYE Mask Vertices at embedded DP Sink Connector Pins]

Note7) Master Tx to Slave Tx skew margin case

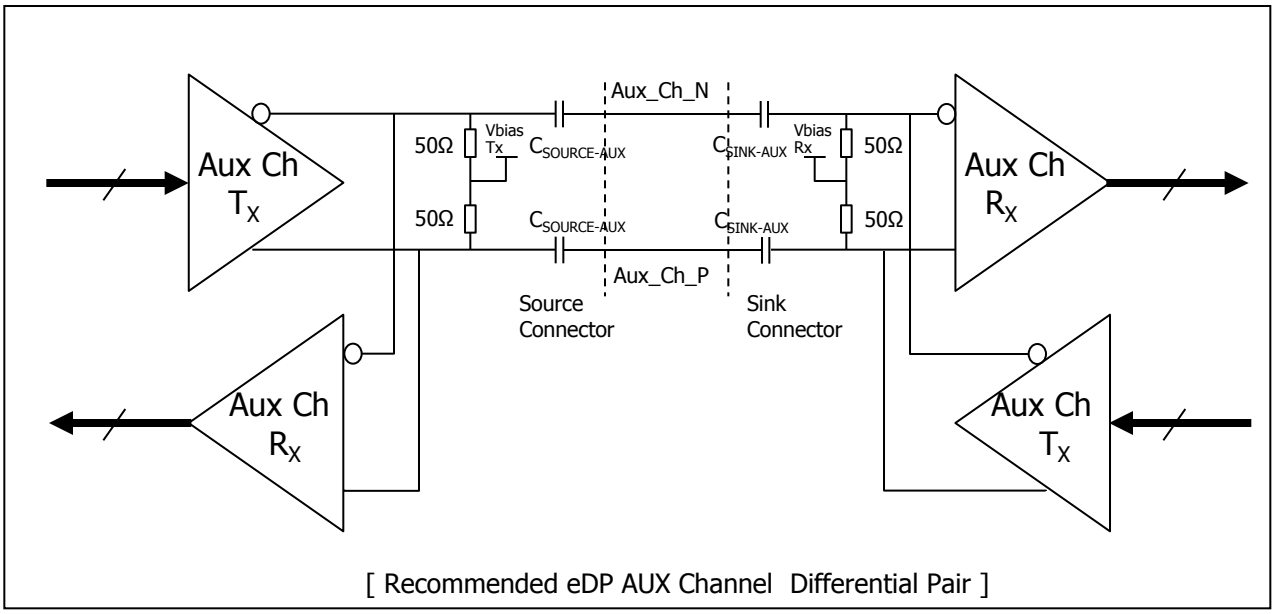
(1) +0.25 DE skew case



(2) -0.25 DE skew case



2. eDP AUX Channel signal

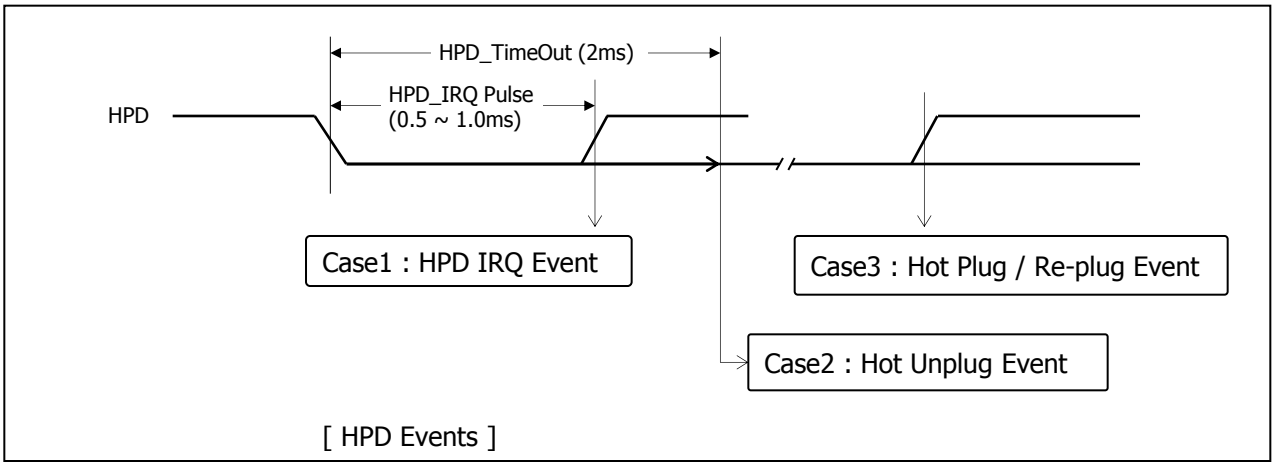


[Recommended eDP AUX Channel Differential Pair]

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

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 50ohm ± 5% at source side to AUX level.
4. 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

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

3-3-3. Backlight Module

The LED Driver interface connector is 20022WR-H14B2 type manufactured by YEON-HO or equivalent.
The mating connector is a 20022HS-14B2 or equivalent.
The pin configuration for the connector is shown in the table below.

Table 4. Backlight connector pin configuration

Pin No.	Symbol	Pin-description	Note
1	VBL	Power Supply +24.0V	
2	VBL	Power Supply +24.0V	
3	VBL	Power Supply +24.0V	
4	VBL	Power Supply +24.0V	
5	VBL	Power Supply +24.0V	
6	GND	Backlight Ground	1
7	GND	Backlight Ground	
8	GND	Backlight Ground	
9	GND	Backlight Ground	
10	GND	Backlight Ground	
11	Status	Back Light Status	2
12	LED_EN	Backlight ON/OFF control	
13	NC	NC	
14	PWM	External PWM	3

Pin No.	Symbol	Pin-description	Note
1	VBL	Power Supply +24.0V	
2	VBL	Power Supply +24.0V	
3	VBL	Power Supply +24.0V	
4	VBL	Power Supply +24.0V	
5	VBL	Power Supply +24.0V	
6	GND	Backlight Ground	1
7	GND	Backlight Ground	
8	GND	Backlight Ground	
9	GND	Backlight Ground	
10	GND	Backlight Ground	
11	Status	Back Light Status	2
12	LED_EN	Backlight ON/OFF control	
13	NC	NC	
14	PWM	External PWM	3

Notes : 1. GND should be connected to the LCD module's metal frame.
2. Normal : Low (under 0.7V) / Abnormal : Open
3. High : on duty / Low : off duty, Pin#14 can be opened. (if Pin #14 is open , PWM duty is 100%)
4. Each impedance of pin #12 and 14 is over 50 [KΩ].

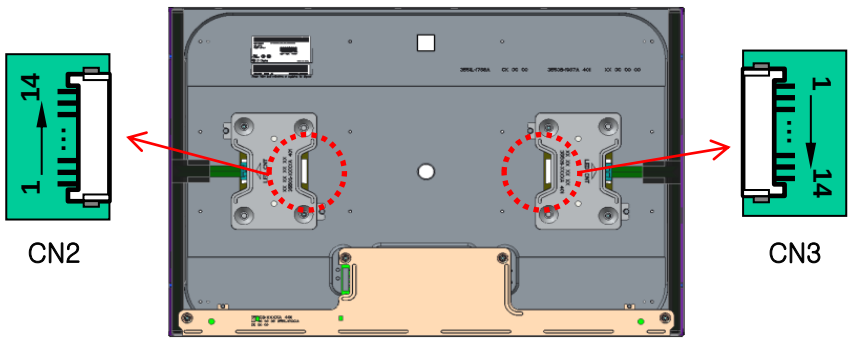


FIG. 5 LED Driver connector view

3-4. Signal timing specifications

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

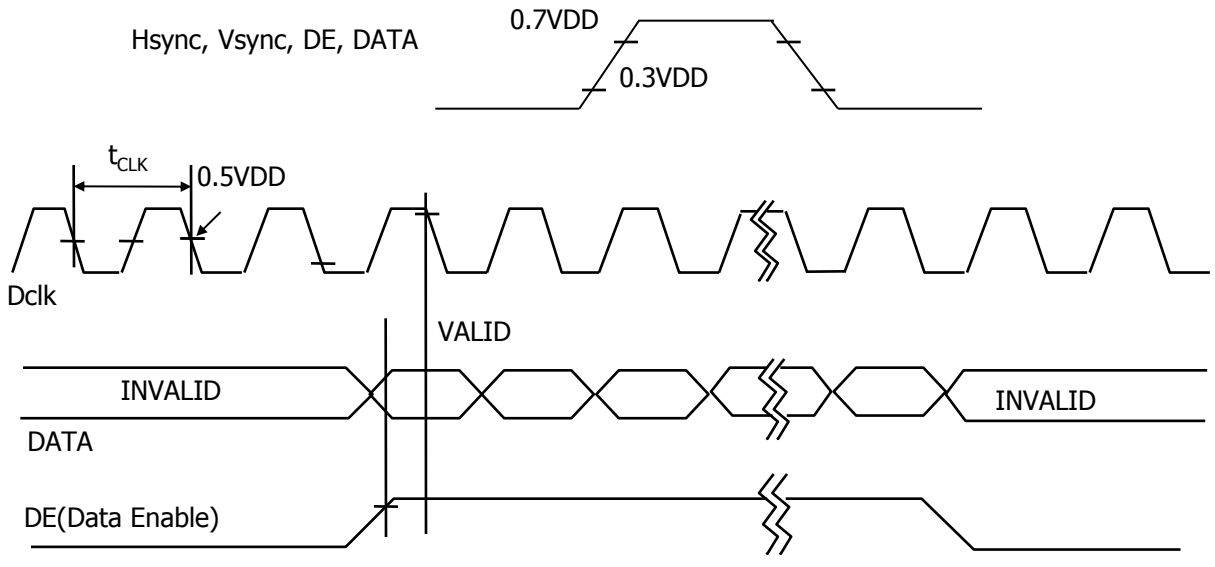
Table 5. Timing table

ITEM	Symbol		Min.	Typ.	Max.	Unit	Note
DCLK	Period	tCLK	(2.617)	(2.682)	(2.75)	ns	Pixel frequency :typ 745.6Mhz @60Hz
	Frequency	-	(363.6)	(372.8)	(382.1)	MHz	
Hsync	Period	tHP	(2182)	(2188)	(2194)	tCLK	1,3,4
	Horizontal Valid	tHV	(2100)	(2100)	(2100)	tCLK	
	Horizontal Blank	tHB	(82)	(88)	(94)		
	Frequency	fH	(166.1)	(170.4)	(174.7)	KHz	
	Width	tWH	(16)	(16)	(16)	tCLK	
	Horizontal Back Porch	tHBP	(44)	(48)	(52)		
	Horizontal Front Porch	tHFP	(22)	(24)	(26)		
Vsync	Period	tVP	2838	2840	2842	tHP	2,4
	Vertical Valid	tVV	2800	2800	2800	tHP	
	Vertical Blank	tVB	38	40	42	tHP	
	Frequency	fV	58.50	60.00	61.50	Hz	
	Width	tWV	8.00	8.00	8.00	tHP	
	Vertical Back Porch	tVBP	24.00	25.00	26.00		
	Vertical Front Porch	tVFP	6.00	7.00	8.00		

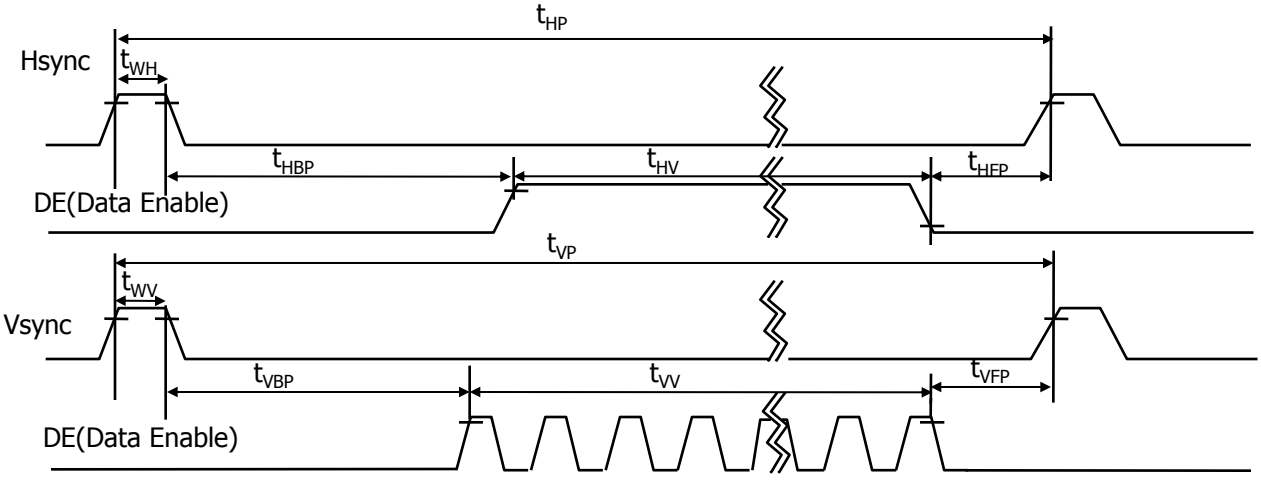
Notes :

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. MSA function @DP Signal must be enabled

3-5. Signal timing waveforms



Data are latched at the falling edge of DCLK



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
	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 (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 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 (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 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 (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

3-7. Power sequence

3-7-1. LCD Driving circuit

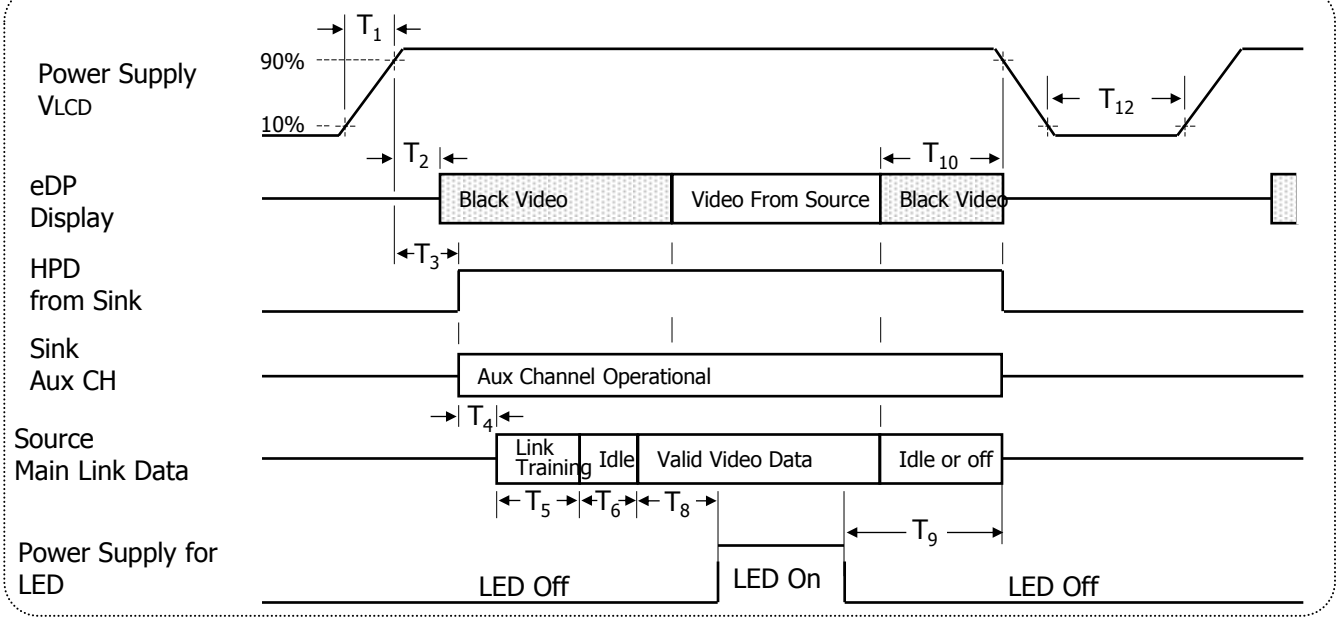


Table 7-1. LCD Power sequence table

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	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	

Note:

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 VLCD.(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 sequence

3-7-2. LED Driver

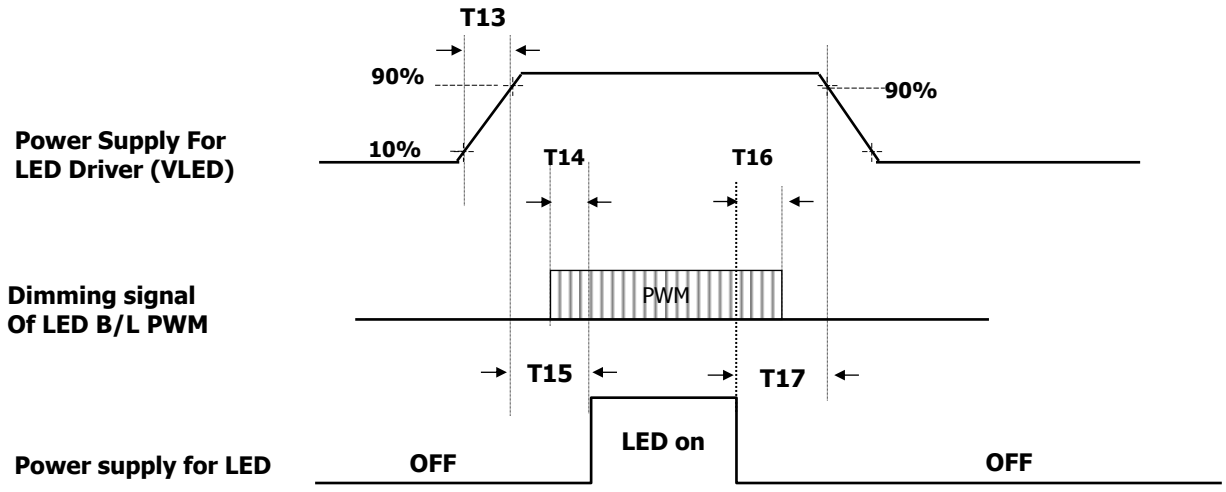


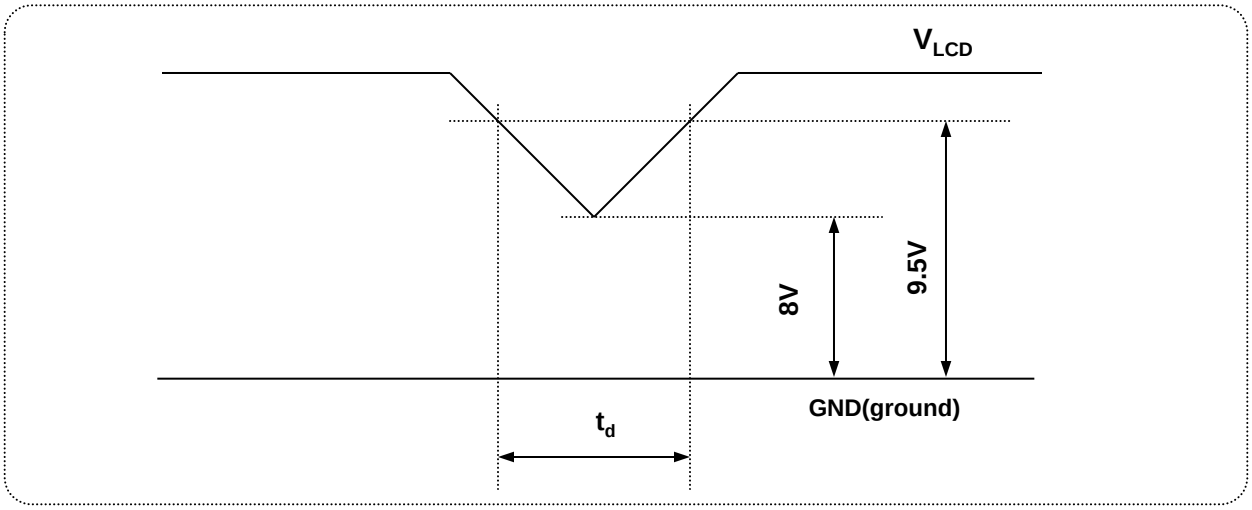
Table 7-2. LED Driver Power sequence table

Parameter	Values			Units
	Min.	Typ.	Max.	
T13	(20)	-	-	ms
T14	(0)	-	-	ms
T15	(500)	-	-	ms
T16	(0)	-	-	ms
T17	(10)	-	-	ms

Notes : 1. T13 describes rising time of 0V to 24V and this parameter does not applied at restarting time.
Even though T13 is over the specified value, there is no problem if I^2T spec of fuse is satisfied.

3-8. Power dip condition

3-8-1. LCD Driving circuit



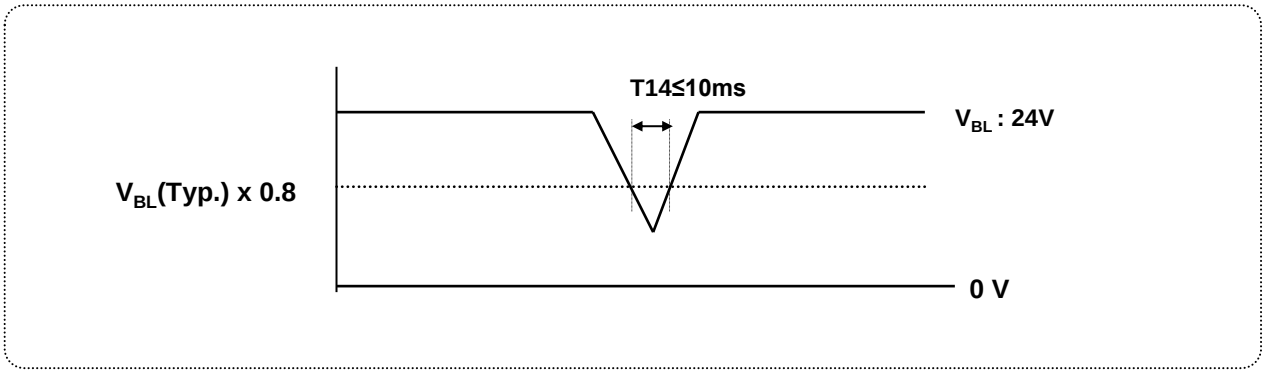
[FIG.6] Power dip condition

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 previous page exactly.

1) Dip condition

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

3-8-2. LED Driver

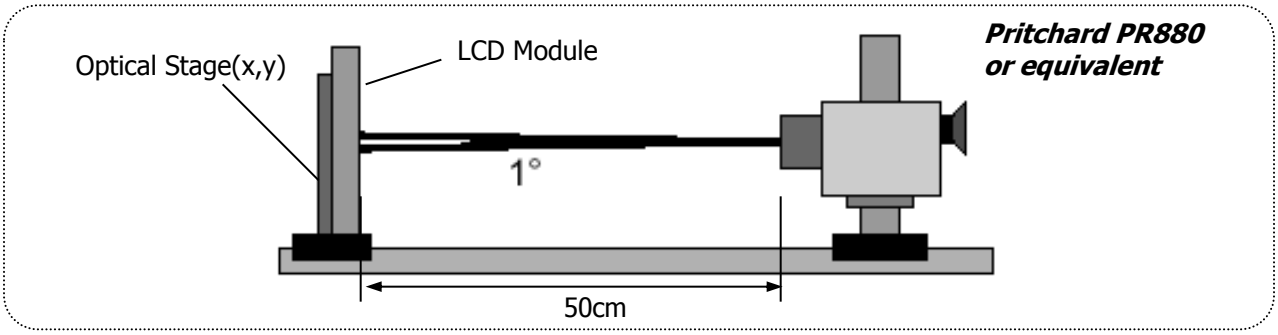


[FIG.7] Power dip condition

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. 8 presents additional information concerning the measurement equipment and method.



[FIG.8] Optical Characteristic Measurement Equipment And Method

Table 8. OPTICAL CHARACTERISTICS (Ta=25°C, V_{LCD}=10.0V, f_V=60Hz, Dclk=745.6MHz, I_{BL}=(57)mA), PWM Duty = 100%

Parameter		Symbol	Values			Units	Notes
			Min.	Typ.	Max.		
Contrast Ratio		CR	1050	1500	-		1
Surface luminance, white		L_{WH}	960	1200	-	cd/m²	2
Luminance variation		δ_{WHITE}	80	-	-	%	3
Response time	Gray To Gray	T_{GTG_AVR}	-	14	25	ms	4
Color gamut (CIE1931)		sRGB	93	97	-	%	
Color coordinates [CIE1931] ***(By PR650)***	Red	Rx	Typ. -0.03	(0.655)	Typ . +0.03		
		Ry		(0.336)			
	Green	Gx		(0.315)			
		Gy		(0.617)			
	Blue	Bx		(0.147)			
		By		(0.052)			
	White	Wx		(0.297)			
		Wy		(0.317)			
Color temperature		-	-	(7600)	-	K	
Viewing angle (CR>10, General)	Horizontal	θ_H	170	178	-	Degree	5
	Vertical	θ_V	170	178	-		
Gray Scale		-		2.2			6

Notes :

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

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

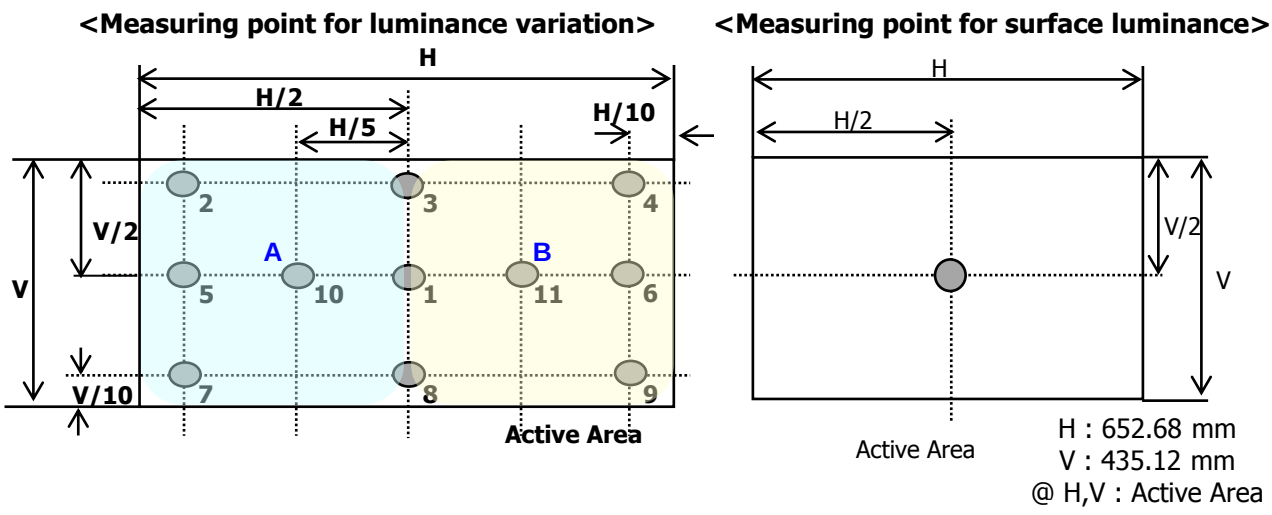
It is measured at center point(Location P1)

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)***

$$\delta_{WHITE} = \frac{\text{Minimum}(L_{P1}, L_{P2}, \ldots, L_{P11})}{\text{Maximum}(L_{P1}, L_{P2}, \ldots, L_{P11})} \times 100(\%)$$

Where L1 to L11 are the luminance with all pixels displaying white at 11 locations.
For more information see FIG.9



[FIG.8] Measure point for luminance

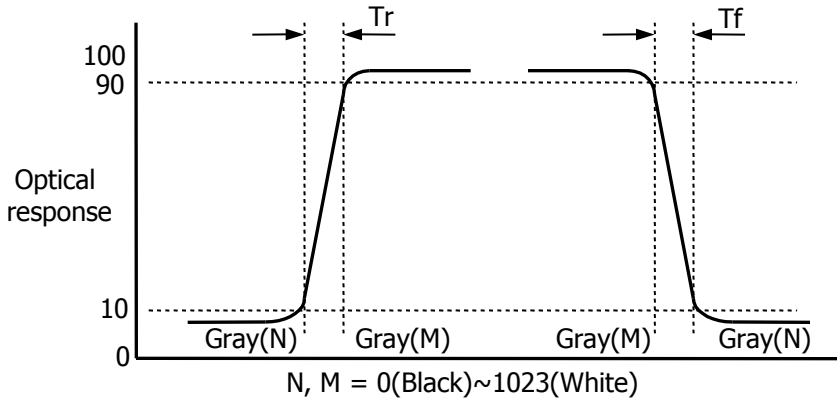
4. The Gray To Gray response time is defined as the following figure and shall be measured by switching the input signal for "Gray To Gray ".

   - Gray step : 5 Step
   - TGTG_AVR is the total average time at rising time and falling time for "Gray To Gray ".
   - By RD80S
   - For the GTG measurement, the sampling rate of oscilloscope is 500k/s.

Table 9. GTG Gray table

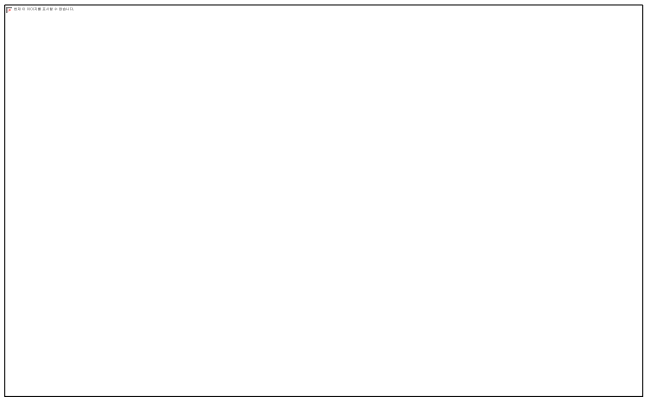
Gray To Gray		Rising time				
		G1023	G767	G511	G255	G0
Falling time	G1023					
	G767					
	G511					
	G255					
	G0					

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



[FIG.10] Response Time

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.11 ***(By PR880)***



[FIG.11] Viewing angle

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

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

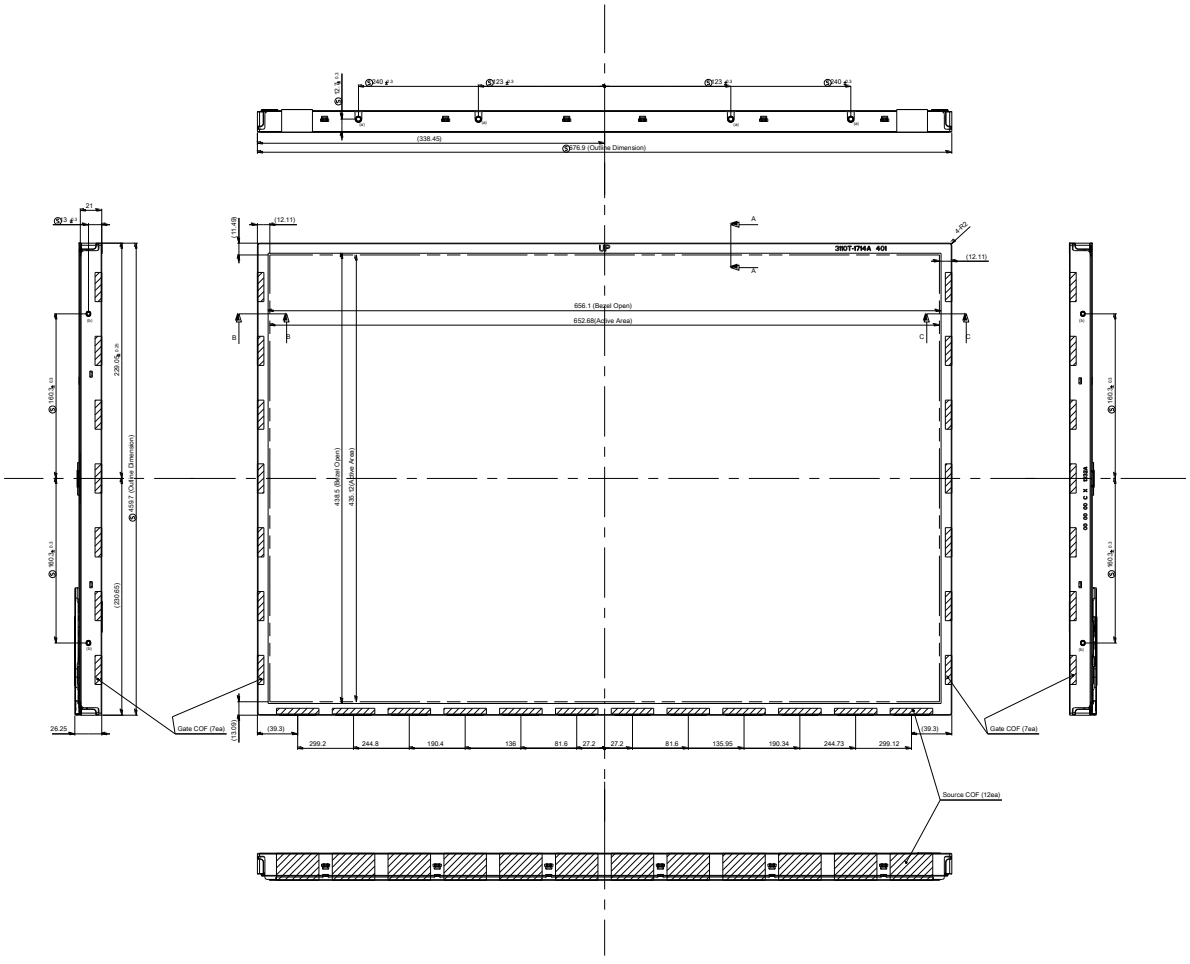
5. Mechanical Characteristics

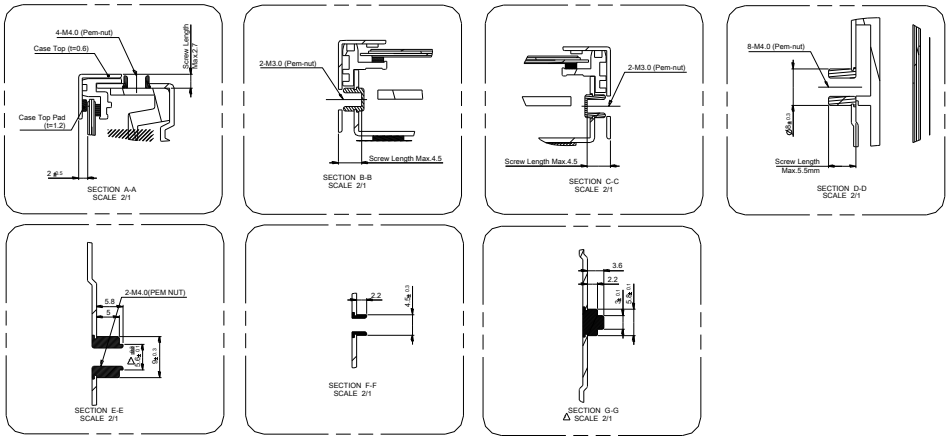
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Outline Dimension	Horizontal	676.9 mm
	Vertical	459.7mm
	Depth	27.55 mm
Bezel Area	Horizontal	(up) 11.49, (down) 13.09
	Vertical	(left) 12.11 (right) 12.11
Active Display Area	Horizontal	652.68mm
	Vertical	435.12mm
Weight	6680g(Typ.)	
Surface Treatment	Anti-Glare treatment of the front polarizer(3H)	

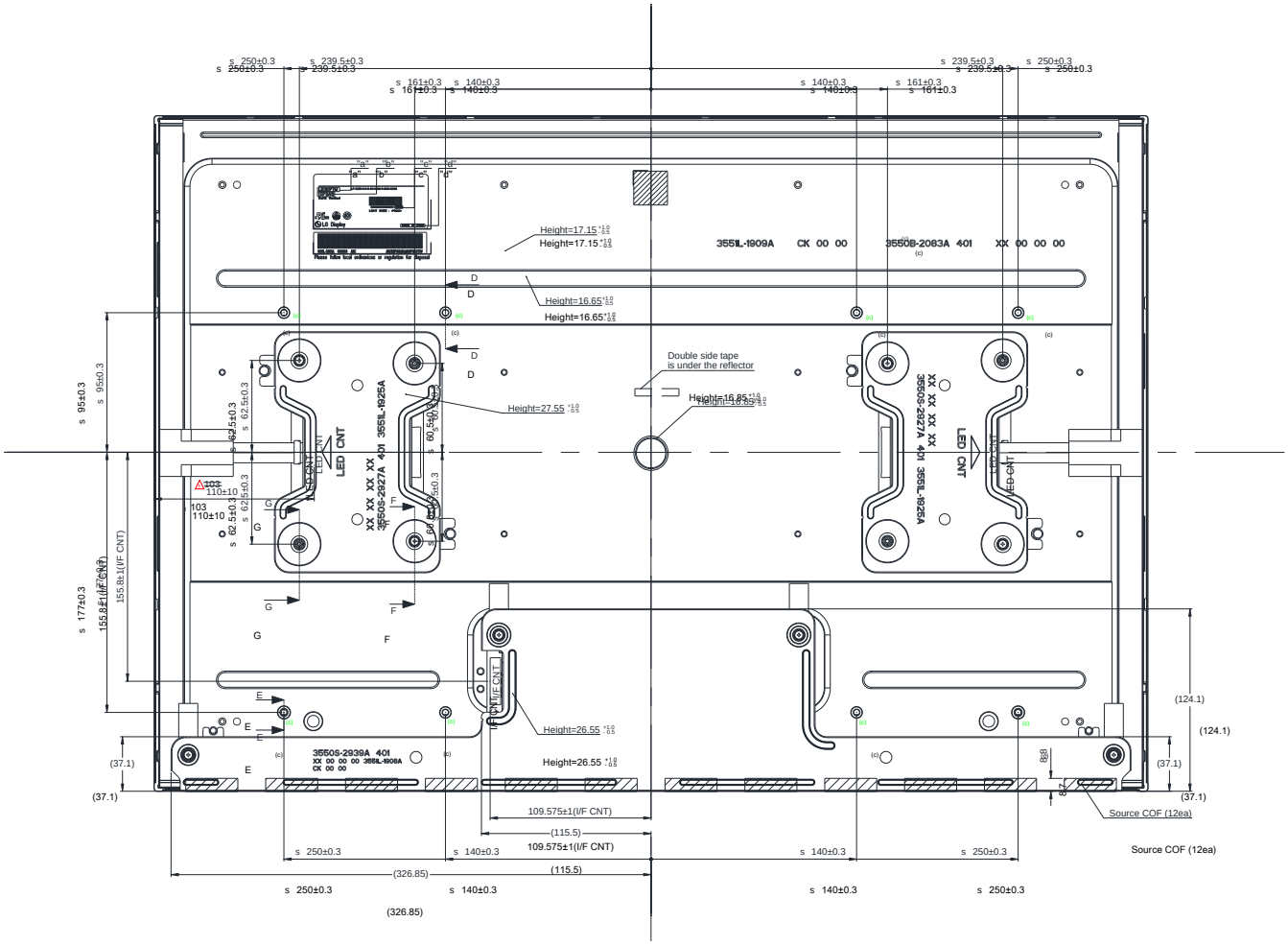
Notes : Please refer to a mechanic drawing in terms of tolerance at the next page.
Outline dimensions (horizontal, vertical and outside depth) are measured by using vernier calipers.

<FRONT VIEW>


(338.45)
676.9 (Outline Dimension)
656.1 (Bezel Open)
652.68(Active Area)
439.7 (Outline Dimension)
438.1(Bezel Open)
438.1(Active Area)
(230.65)
Gate COF (7ea)
Source COF (12ea)
299.2
244.8
190.4
136
81.6
27.2
27.2
81.6
135.95
190.34
244.73
299.12

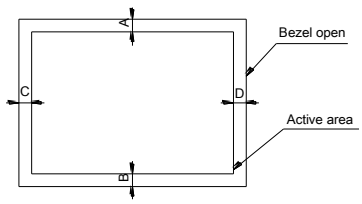

4-M4.0 (Pem-nut)
Case Top (t=0.6)
Case Top Pad (t=1.2)
SECTION A-A
SCALE 2/1
2-M3.0 (Pem-nut)
Screw Length Max.4.5
SECTION B-B
SCALE 2/1
2-M3.0 (Pem-nut)
Screw Length Max.4.5
SECTION C-C
SCALE 2/1
8-M4.0 (Pem-nut)
Screw Length Max.5.5mm
SECTION D-D
SCALE 2/1
2-M4.0(PEM NUT)
SECTION E-E
SCALE 2/1
SECTION F-F
SCALE 2/1
SECTION G-G
SCALE 2/1

<REAR VIEW>



NOTES
1. Unspecified tolerances are to be ±0.5
2. Tilt and partial disposition tolerance of display area are as following.

   (1) Y-direction : I A-B I ≤ 1.4mm
   (2) X-direction : I C-D I ≤ 1.4mm



3. Torque SPEC of Mounting : 3.0~4.0kgf.cm
4. I/F Connector Specification : I-PEX, 20525-060E-01 or Compatible.
5. LED Connector Specification : JST, SM06B-SHJH(HF) or compatible.
6. The LCM warp(warpage) is less than 1.5mm on the surface plate.
7. The COF area is weak and sensitive, so please don't press the COF area.
8. Unspecified height should follow 3D modeling data.

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	Humidity condition Operation	Ta= 40 °C ,90%RH
6	Vibration test (non-operating)	Wave form : random Vibration level : 1.0G RMS Bandwidth : 10-300Hz Duration : X,Y,Z, 10 min One time each direction
7	Shock test (non-operating)	Shock level : 100Grms Waveform : half sine wave, 2ms Direction : ±X, ±Y, ±Z One time each direction
8	Altitude Operating Storage / Shipment	 0 – 10,000 feet (3,048m) 0 - 40,000 feet (12,192m)
9	Maximum Storage Humidity for 4 corner light leakage Mura.	Max 70%RH , Ta=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

7-2. 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

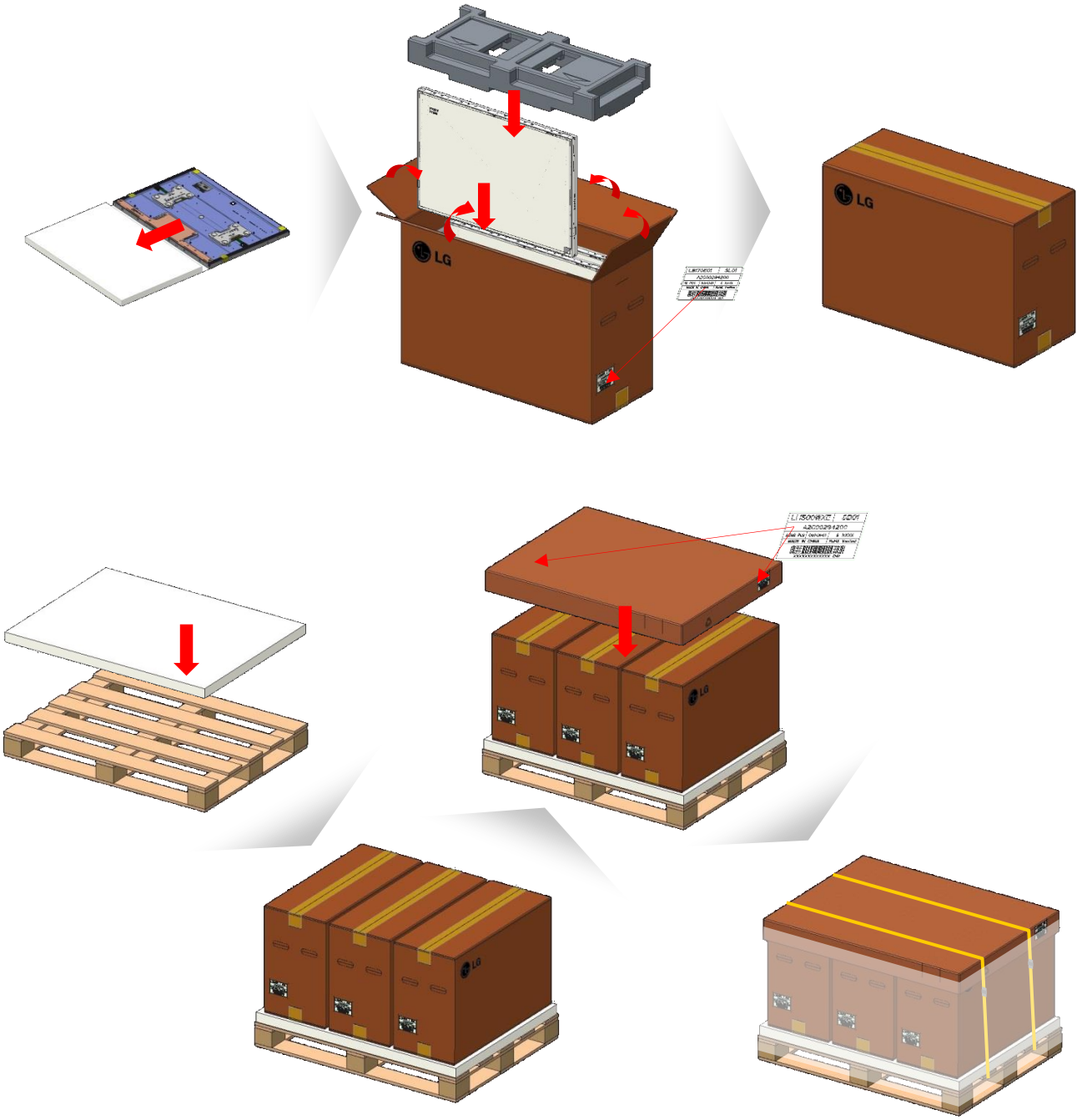
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mark	1	2	3	4	5	6	7	8	9	A	B	C

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 packing : 3ea/Box
   Package quantity in one Pallet : 9ea(3Box/Pallet)
b) Box Outer Size : 840mm X 365mm X 570mm
C) Pallet Ass'y Size: 1140mmX870mmX741.5mn



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 miss-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 guarantee.
(11) LCMs cannot support "Interlaced Scan Method"
(12) 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.
(13) Please conduct image sticking test after 2-hour aging with Rolling PTN 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 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°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.