LG Display

LM270QQ2
Liquid Crystal Display

Product Specification

SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(●) Final Specification

Title	27″ UHD TFT LCD

BUYER	
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM270QQ2
SUFFIX	SPA3

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

APPROVED BY	SIGNATURE DATE
/	
/	
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Please return 1 copy for your confirmation with your signature and comments.

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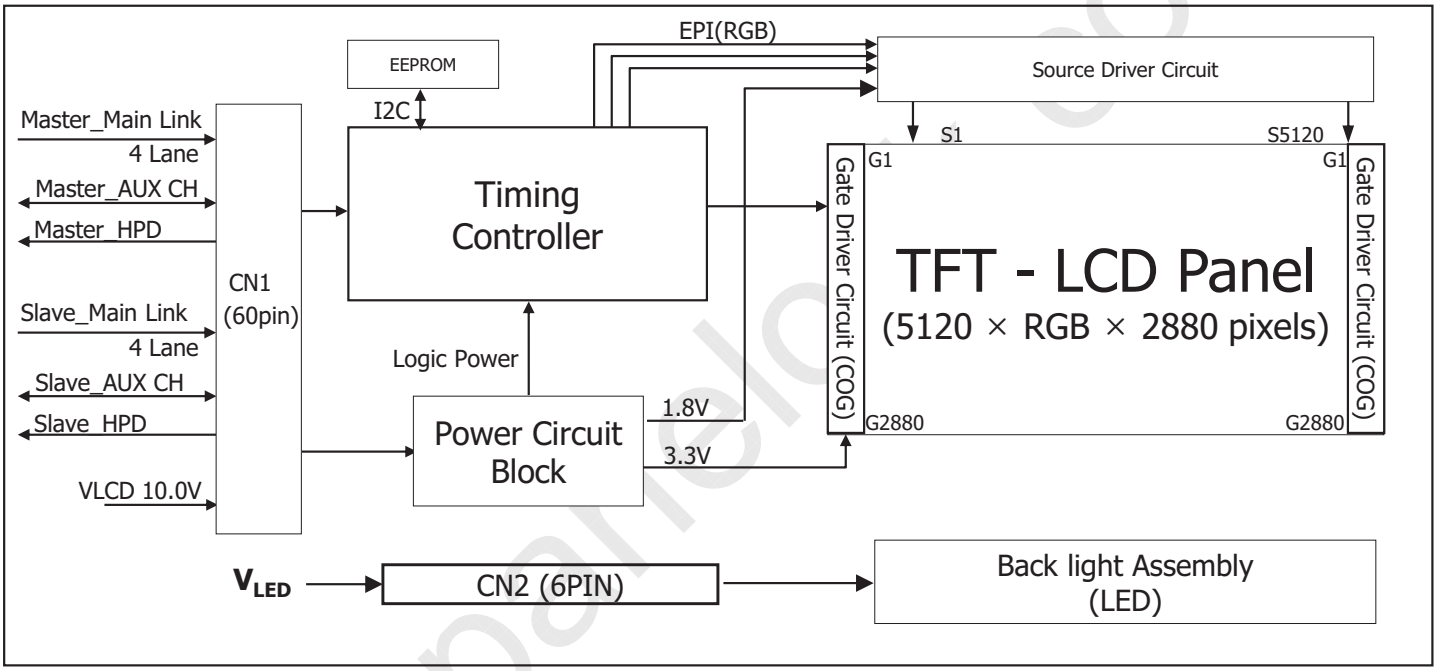
1. General Description

LM270QQ2 is a Color Active Matrix Liquid Crystal Display with a Light Emitting Diode (LED) backlight system 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 UHD resolution (5120 horizontal by 2880 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 8-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(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 (682.901mm) diagonal
Outline Dimension	620.6 x 361.1 x 13.3 mm (Typ.)
Pixel Pitch	0.03895 mm x 0.11685 mm
Pixel Format	5120 horiz. By 2880 vert. Pixels RGB stripes arrangement
Color Depth	1.07 Billion colors, 10Bit (8Bit + A-FRC)
Luminance, White	540 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 (37.65 Watt (Typ.) (3.85 Watt @V_{LCD}, 33.8 Watt @Is=145 mA)
Weight	2,630 g (Typ.)
Display Operating Mode	Transmissive mode, normally black
Surface Treatment	Anti-Reflective treatment of the front polarizer (2H)

2. Absolute Maximum Ratings

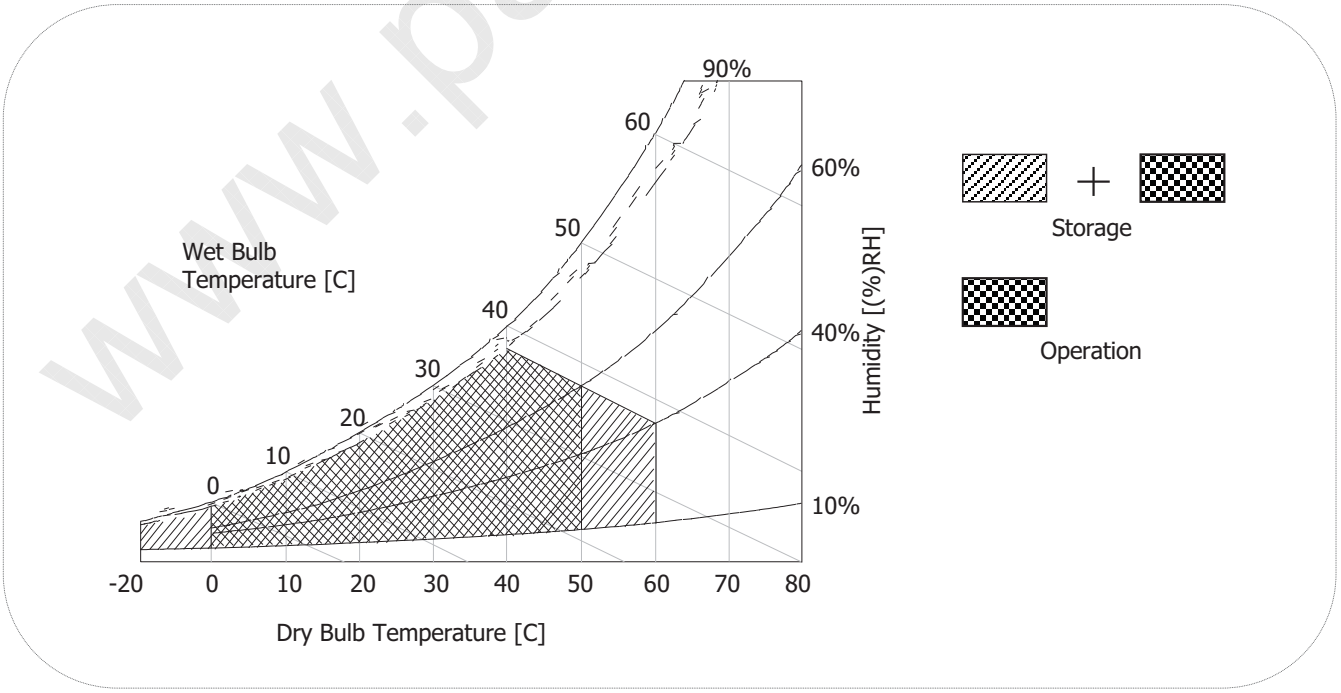
The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Input Voltage	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	
LCM Surface Temperature (Operation)	$T_{Surface}$	0	65	℃	1,4

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

FIG.2 Temperature and relative humidity



3. Electrical Specifications

3-1. Electrical Characteristics

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

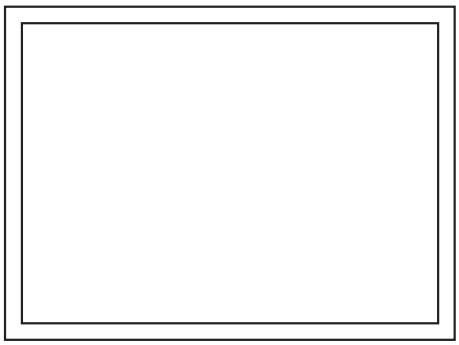
Table 2-1. ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	9.5	10.0	10.5	Vdc	5
Permissive Power Input Ripple	V_{dRF}			400	mV_{p-p}	1
Power Supply Input Current	I_{LCD}	-	385	480	mA	2
		-	900	1120	mA	3
Power Consumption	$P_{C\ TYP}$	-	3.85	4.80	Watt	2
	$P_{C\ MAX}$	-	9.00	11.20	Watt	3
Rush current	I_{RUSH}	-		3	A	4

Note :

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

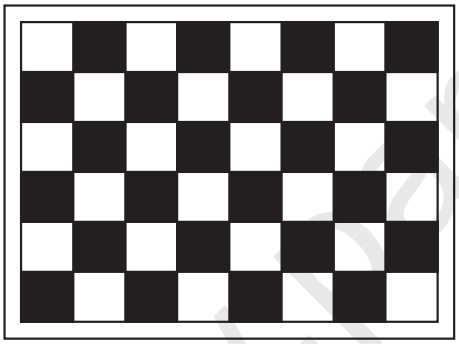
• **Permissive Power input ripple (**V_{LCD} =10.0V, 25°C, fv (frame frequency)=Max. condition**)**



White pattern

Black pattern

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



Typical power Pattern

Maximum power Pattern

FIG.3 Mosaic pattern & 1dot Pattern for power consumption measurement

Table 2-2. LED Bar ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Values			Unit	Notes
		Min.	Typ.	Max.		
LED String Current	Is	-	145	150	mA	1, 2, 5
LED String Voltage	Vs	54.5	58.3	62.1	V	1, 5
Power Consumption	PBar	-	33.8	36.1	Watt	2, 4
LED Life Time	LED_LT	30,000	-	-	Hrs	3

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

LED driver design guide

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

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

3-2. Interface Connections

3-2-1. LCD Module

-. LCD Connector(CN1) : 20525-060E-01 (manufactured by I-PEX)
The pin configuration for the 60 pin connector is shown in the table below.

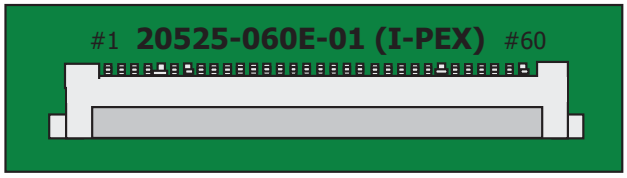
Table 3. MODULE CONNECTOR(CN1) PIN CONFIGURATION

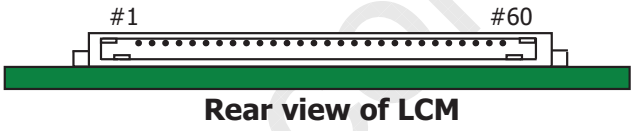
No	Symbol	Description	No	Symbol	Description
1	GND	Ground	31	DP0_L1_N	Master Component Signal for Main Link 1
2	VIN	Power Supply +10.0V	32	GND	Ground
3	VIN	Power Supply +10.0V	33	DP0_L2_P	Master True Signal for Main Link 2
4	VIN	Power Supply +10.0V	34	DP0_L2_N	Master Component Signal for Main Link 2
5	VIN	Power Supply +10.0V	35	GND	Ground
6	VIN	Power Supply +10.0V	36	DP0_L3_P	Master True Signal for Main Link 3
7	VIN	Power Supply +10.0V	37	DP0_L3_N	Master Component Signal for Main Link 3
8	VIN	Power Supply +10.0V	38	GND	Ground
9	VIN	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	BL_EN	Enable signal for backlight (when high)
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

Note: 1. All GND(ground) pins should be connected together and to Vss which should also be connected to the LCD's metal frame.
2. All V_{LCD} (power input) pins should be connected together.
3. BL_EN (Enable signal for backlight) : If you don't use this pin, it should be NC (No connection).

3-2-1. LCD Module

Notes : 1. Connector
2.1 Connector (Receptacle) : 20525-060E-01(I-PEX)
2.2 Mating Connector (Plug) : 20523-060T (I-PEX)





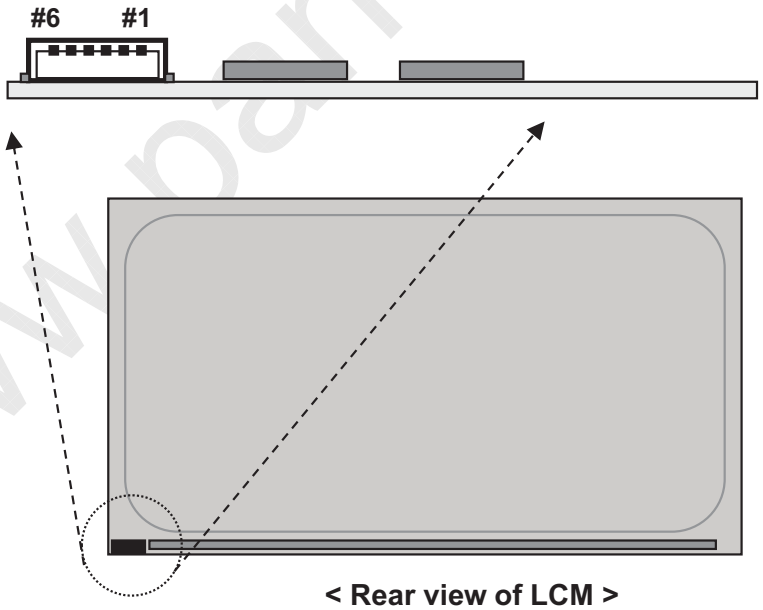
Rear view of LCM

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

The LED interface connector is a model 10035WR-H06D(HF) (Manufactured by Yeonho) or equivalent.
The mating connector is a SHJP-06V-S(HF) or equivalent.
The pin configuration for the connector is shown in the table below.

Table 3-1. LED CONNECTOR PIN CONFIGURATION

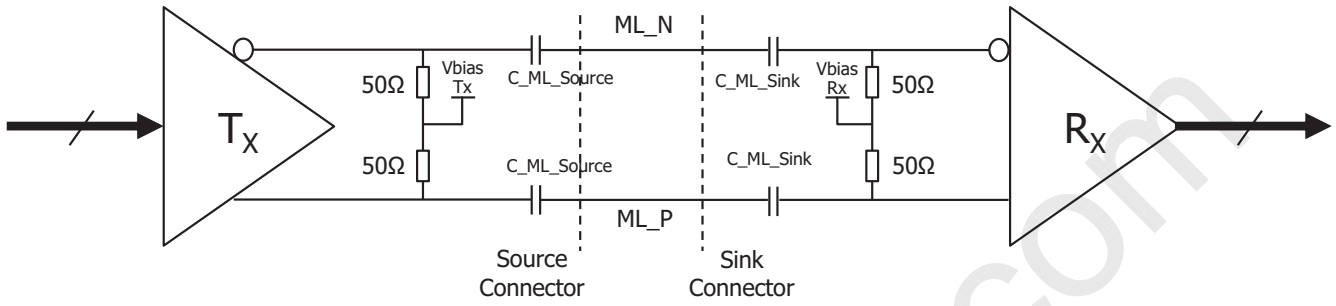
Pin	Symbol	Description
1	FB1	Channel1 Current Feedback
2	FB2	Channel2 Current Feedback
3	VLED	LED Power Supply
4	VLED	LED Power Supply
5	FB3	Channel3 Current Feedback
6	FB4	Channel4 Current Feedback



[FIG. 5] Backlight connector view

3-3. eDP Signal Specifications

3-3-1. eDP Main Link Signal

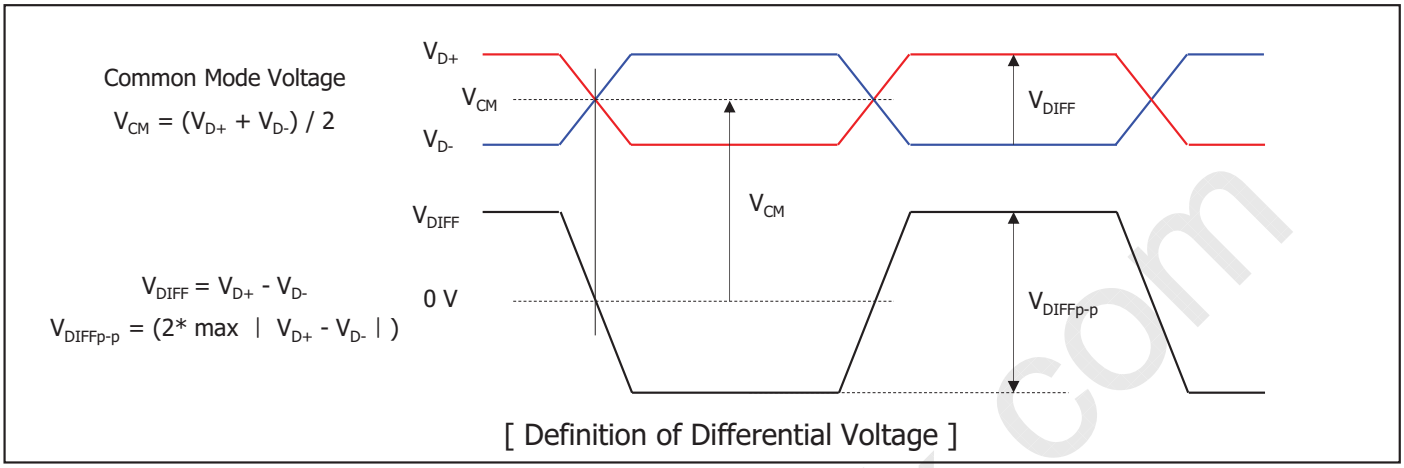


[Main Link Differential Pair]

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	
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	
Master Tx –to-Slave Tx skew	Tx-to-Tx_skew	-	-	±640	clk	
AC Coupling Capacitor	C_{SOURCE_ML}	75		200	nF	Source side

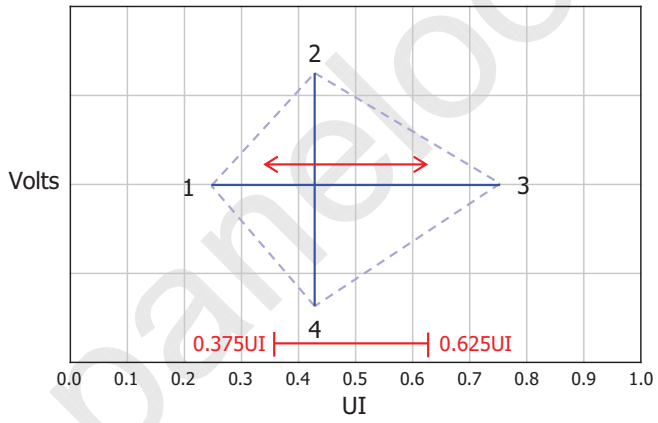
Note)
1. Termination resistor is typically integrated into the transmitter and receiver implementations.
2. In cabled embedded system, it is recommended the system designer ensure that EYE width and voltage are met at the sink side connector pins.
3. Mismatched common mode voltage will occur abnormal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

Note6) Definition of Differential Voltage



[Definition of Differential Voltage]

Note7) Main Link EYE Diagram

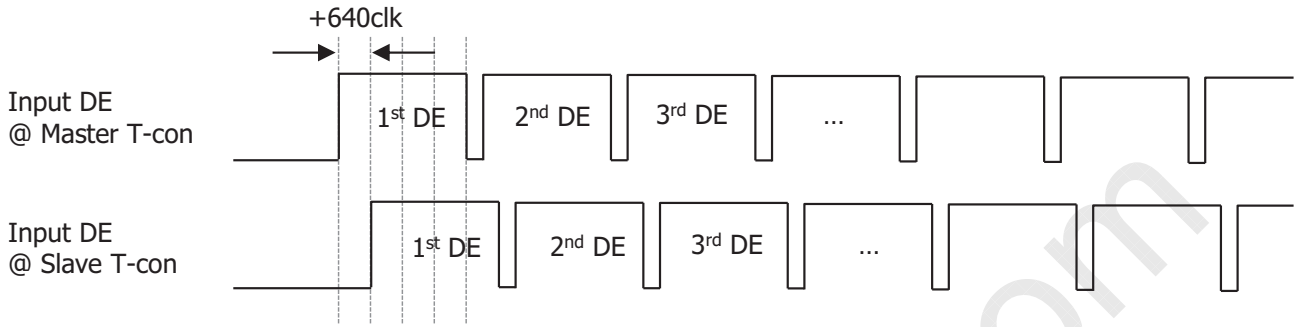


Point	High Bit Rate 2 @ TP3 EQ	
	Time(UI)	Voltage(V)
1	Any UI location (x) where the eye width is open from x to x+0.38UI	0.000
2	Any passing UI location between 0.375UI-0.625UI	0.045
3	Point 1 + 0.38UI	0.000
4	Same as Point 2	-0.045

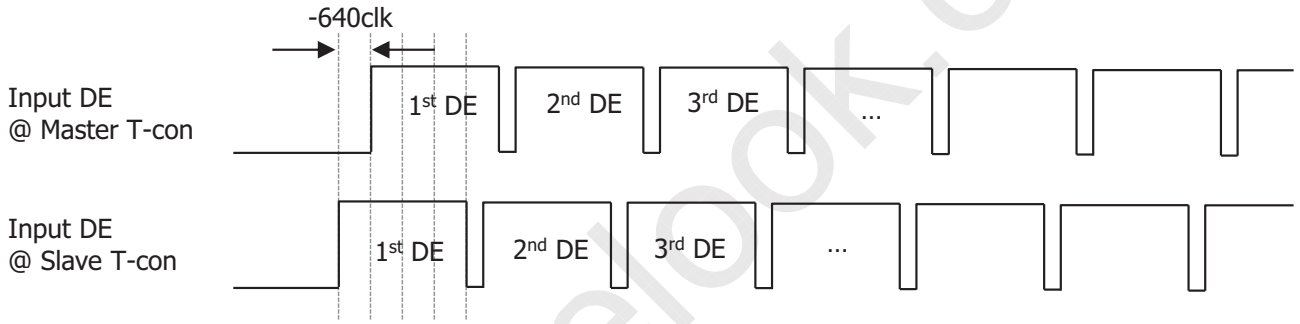
[EYE Mask Vertices at embedded DP Sink Connector Pins]

Note8) Master Tx to Slave Tx skew margin case

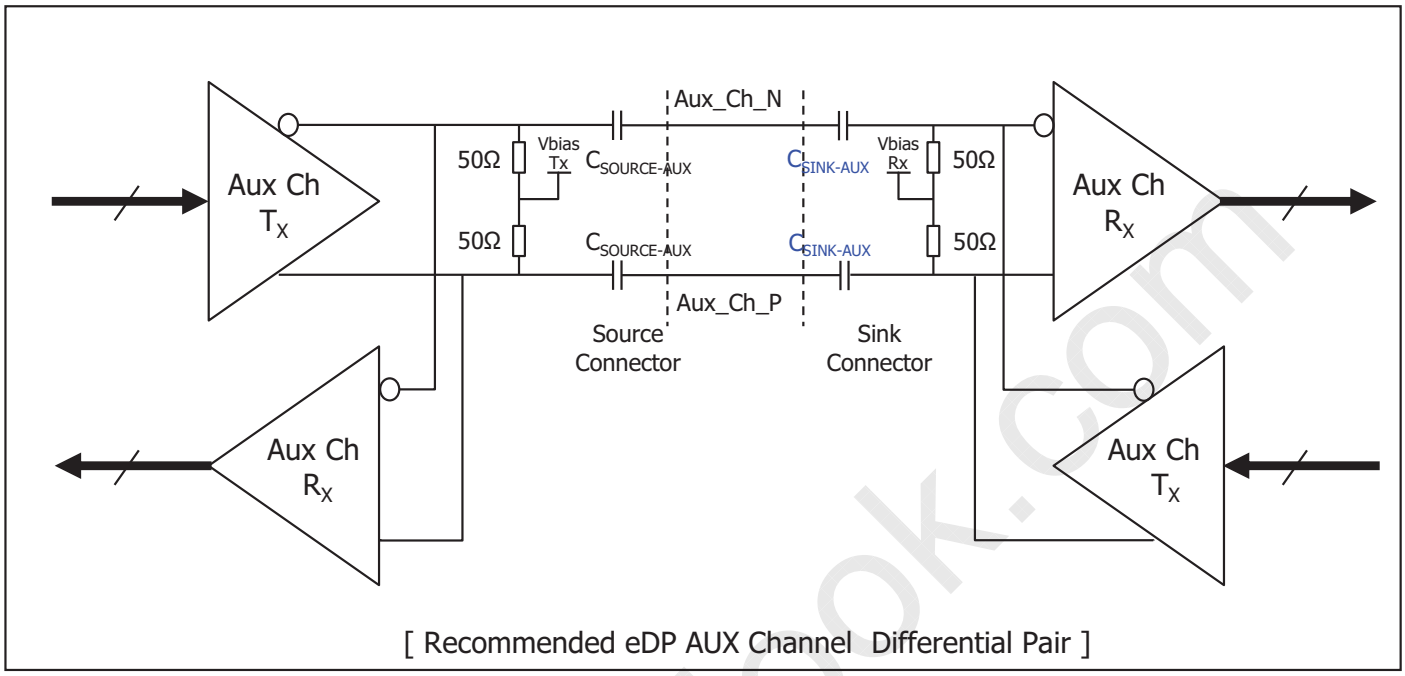
(1) +640clk skew case



(2) -640clk skew case



3-3-2. eDP AUX Channel Signal

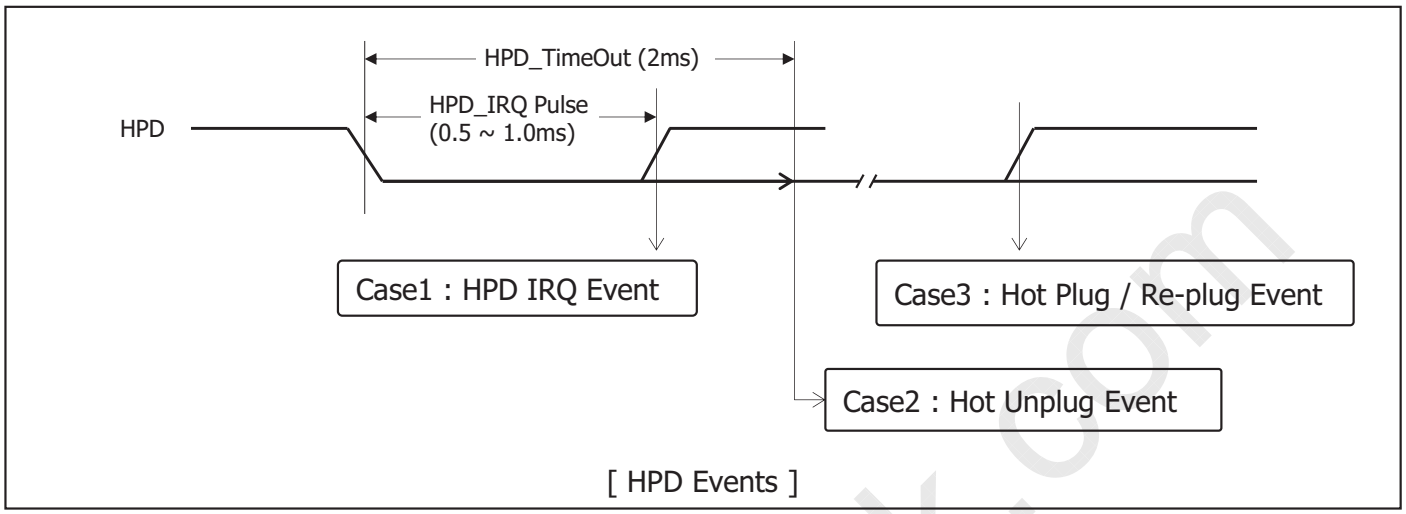


[Recommended eDP AUX Channel Differential Pair]

Parameter	Symbol	Min	Typ	Max	Unit	Notes
AUX Unit Interval	UI	0.4	-	0.6	us	
AUX Jitter at 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 ±50ohm 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.

3-3-5. eDP HPD 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

3-4. Signal Timing Specifications

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

Table 4. TIMING TABLE

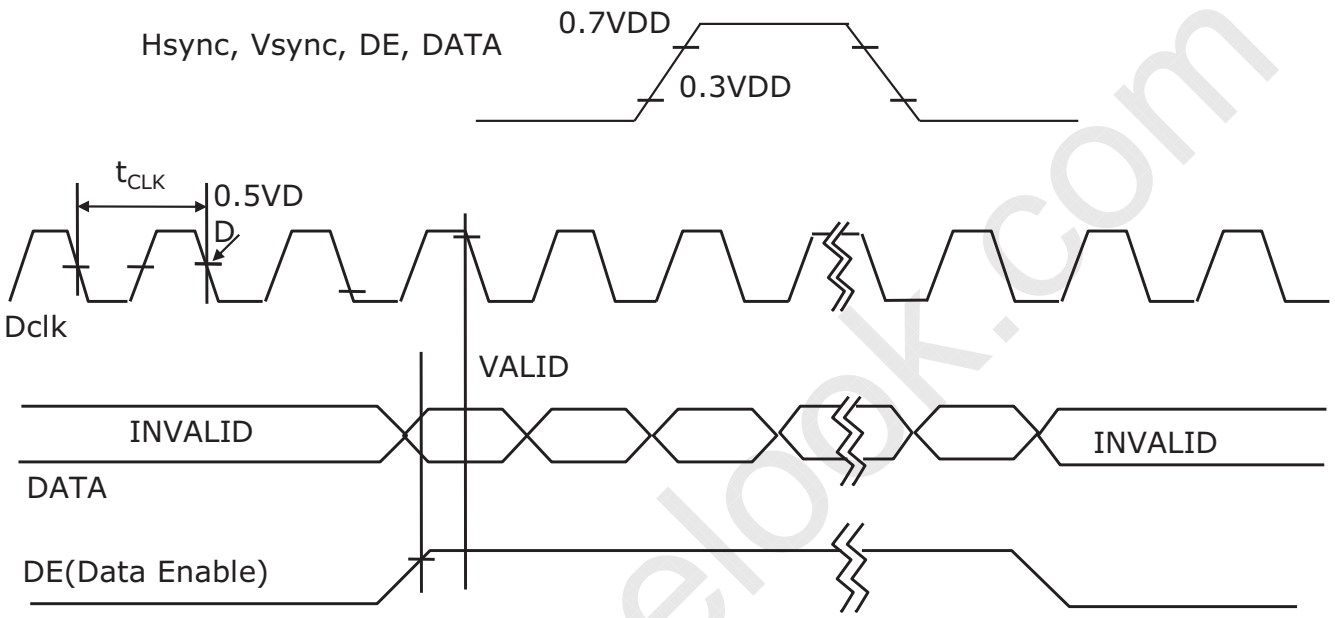
ITEM		SYMBOL	Min	Typ	Max	Unit	Note
DCLK	Period	tCLK	2.07	2.07	2.07	ns	
	Frequency	fCLK	483.4	483.4	483.4	MHz	-
Hsync	Period	tHP	2720	2720	2720	tCLK	
	Width-Active	tWH	32	32	32		
Vsync	Period	tVP	2962	2962	2962	tHP	
	Frequency	fV	60	60	60	Hz	*Adaptive sync: 40~60Hz
	Width-Active	tWV	5	5	5	tHP	
Data Enable	Horizontal Valid	tHV	2560	2560	2560	tCLK	
	Horizontal Back Porch	tHBP	80	80	80		
	Horizontal Front Porch	tHFP	48	48	48		
	Horizontal Blank	-	160	160	160		tWH+ tHBP+ tHFP
	Vertical Valid	tVV	2880	2880	2880	tHP	
	Vertical Back Porch	tVBP	74	74	74		
	Vertical Front Porch	tVFP	3	3	3		
	Vertical Blank	-	82	82	82		tWV+ tVBP+ tVFP

Note:

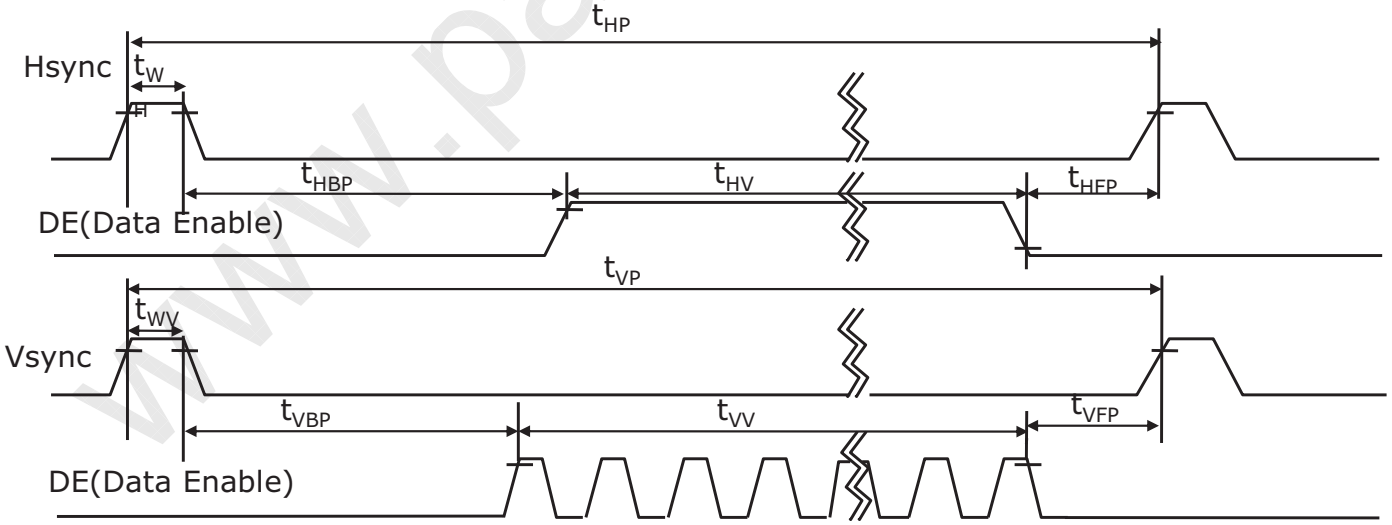
1. DE Only mode operation. The input of Hsync & Vsync signal does not have an effect on LCD normal operation.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3. Horizontal period & width-active should be any times of character number(4).

* This panel supports adaptive sync timing 40~60Hz 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.

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 5. 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. Power Sequence

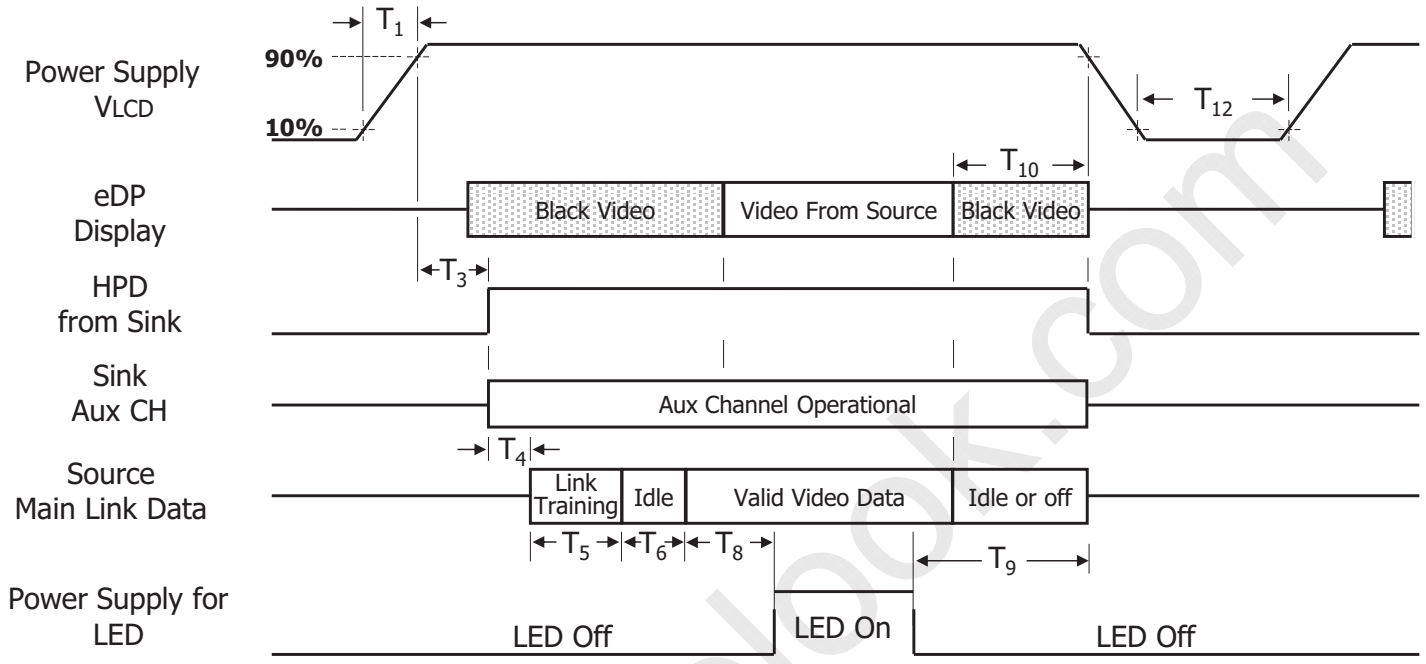


Table 6. POWER SEQUENCE TABLE

Timing	Required By	Limits		Units	Notes
		Min	Max		
T_1	Source	0.5	10	ms	-
T_3	Sink	15	200	ms	-
T_4	Source	-	-	ms	6
T_5	Source	-	-	ms	6
T_6	Source	-	100	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. 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 VLCD 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)

3-7-2. VLCD Power Dip Condition

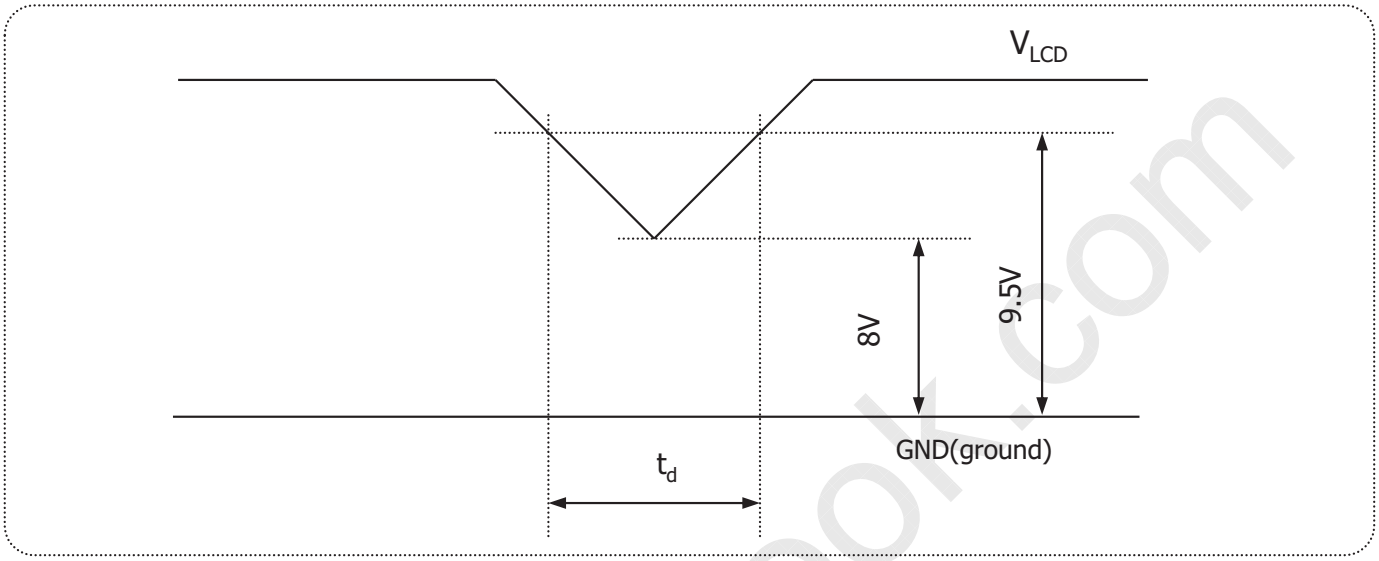


FIG.6 Power dip condition

1) Dip condition

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

2) $V_{LCD} < 8V$

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

4. Optical Specifications

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

FIG. 6 presents additional information concerning the measurement equipment and method.

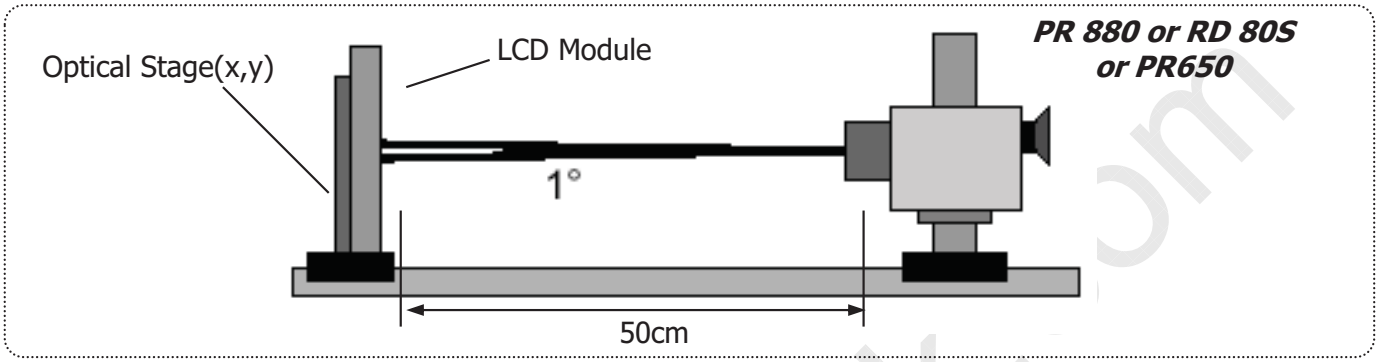


FIG.7 Optical Characteristic Measurement Equipment and Method

Table 7. OPTICAL CHARACTERISTICS (Ta=25 °C, V_{LCD}=10V, f_V=60Hz, Dclk= 590MHz, Is=145mA)

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	770	1100	-		1
Surface Luminance, white		L_{WH}	440	540	-	cd/m²	2
Luminance Variation		δ_{WHITE}	-	-	37	%	3
Response Time	Gray To Gray	T_{GTG_AVR}	-	14	25	ms	4
Color Coordinates [CIE1931] ***(By PR650)***	RED	Rx	Typ -0.03	0.680	Typ +0.03		
		Ry		0.316			
	GREEN	Gx		0.256			
		Gy		0.697			
	BLUE	Bx		0.153			
		By		0.054			
	WHITE	Wx		0.313			
		Wy		0.329			
Color Uniformity	Total Δu'v'	$\Delta u'v'_T$			0.012		5
	u' range	$\Delta u'_T$			0.009		
	v' range	$\Delta v'_T$			0.009		
	Nearest-neighbor uniformity	$\Delta u'v'_N$			0.0050		
Color Shift	Horizontal	θ_{CST_H}	-	178	-	Degree	6
	Vertical	θ_{CST_V}	-	178	-		
Viewing Angle (CR>10)							
General	Horizontal	θ_H	-	178	-	Degree	7
	Vertical	θ_V	-	178	-		
Gray Scale		-	-	2.2	-		8

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 P68)

2. Surface luminance(L_{WH})is luminance value at Center 1 point(P68) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG.8 (By PR880)

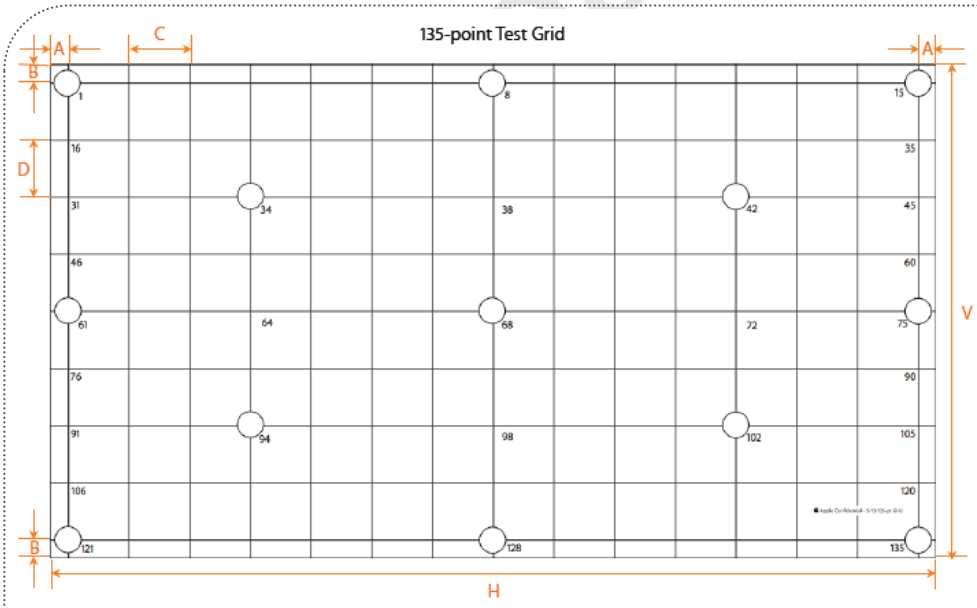
3. The variation in surface luminance , δ WHITE is defined as : ***(By PR880)***

$$\delta_{WHITE} = \frac{\text{Maximum}(P_1, P_8, \ldots..., P_{128}, P_{135}) - \text{Minimum}(P_1, P_8, \ldots..., P_{128}, P_{135})}{\text{Average}\ (P_{34}, P_{42}, P_{68}, P_94, P_{102})} \times 100(\%)$$

Measurement points are P1,P8,P15,P34,P42,P61,P68,P75,P94,P102,P121,P128,P135
For more information see FIG 8.

4. Gray to gray response time is the time required for the display to transition from gray to gray. For additional information see Table 8. ***(By PR880)***

5. Color uniformity is calculated with CIE1976 color and its formula is as follows.
   - -. Total $\Delta u'v'(\Delta u'v'_T)$ = Maximum
     A : measurement point (P1,P8,P15,P34,P42,P61,P68,P75,P94,P102,P121,P128,P135)
     B : 5 points Avg. (P34, P42, P68, P94, P102)
   - -. u' range($\Delta u'_T$) = Maximum u' – Minimum u'
     measurement point (P1,P8,P15,P34,P42,P61,P68,P75,P94,P102,P121,P128,P135)
   - -. v' range($\Delta v'_T$) = Maximum v' – Minimum v'
     measurement point (P1,P8,P15,P34,P42,P61,P68,P75,P94,P102,P121,P128,P135)
   - -. Nearest-neighbor uniformity($\Delta u'v'_N$) = Maximum
     A : neighboring points(up, down, right and left of measurement point)
     B : measurement point (P1,P2,P3…P134,P135)



A : 10.0 mm
(Distance from active area edge)

B : 10.0 mm
(Distance from active area edge)

C : 41.31 mm
(Measurement interval in the horizontal direction)

D : 39.56 mm
(Measurement interval in the vertical direction)

H : 598.272 mm
V : 336.528mm
@ H,V: Active Area

FIG. 8 Measurement Point for Luminance, Luminance Variation , Color Coordinates, Color Uniformity, Contrast Ratio

6. Color shift is the angle at which the average color difference for all Macbeth is lower than 0.02. For more information see FIG.10 ***(By EZ Contrast)***
   - Color difference (Δu'v')

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

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

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

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

7. 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)***

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

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

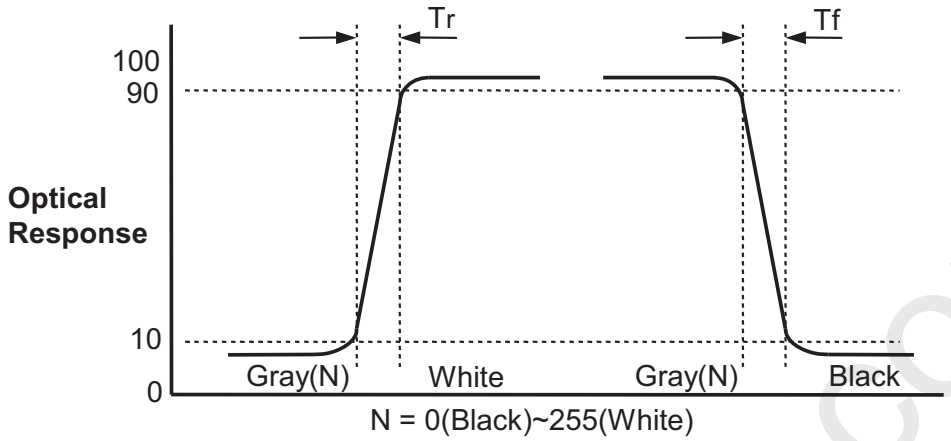


FIG.9 Response time

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

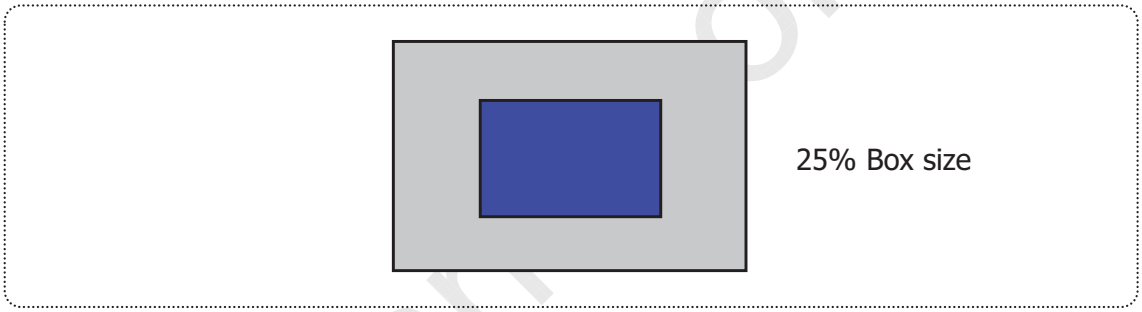


FIG.10 Color Shift Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

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

Dimension of viewing angle range.

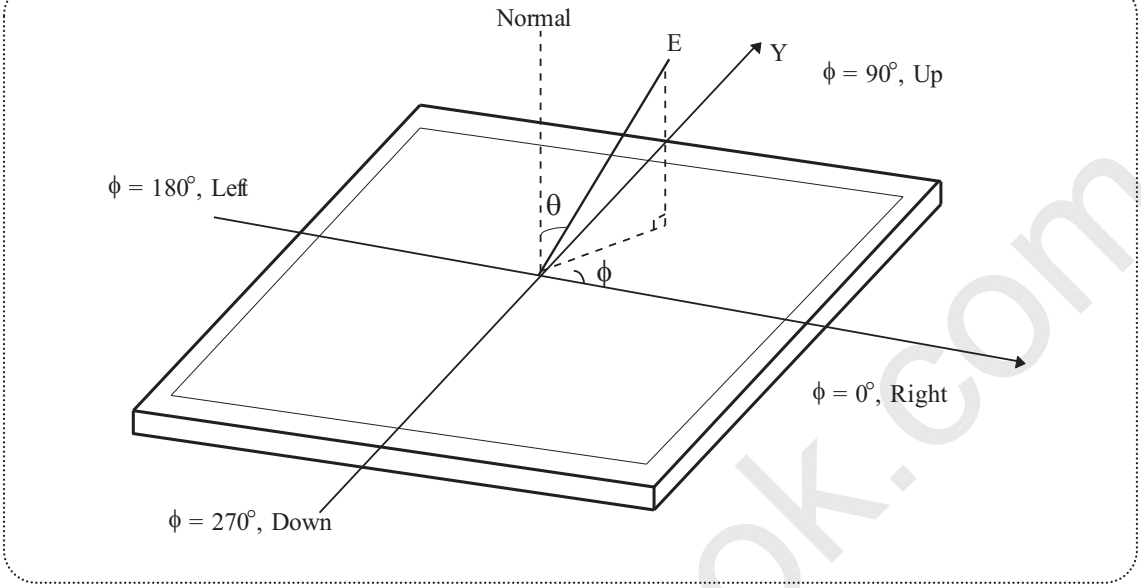


FIG.11 Viewing angle

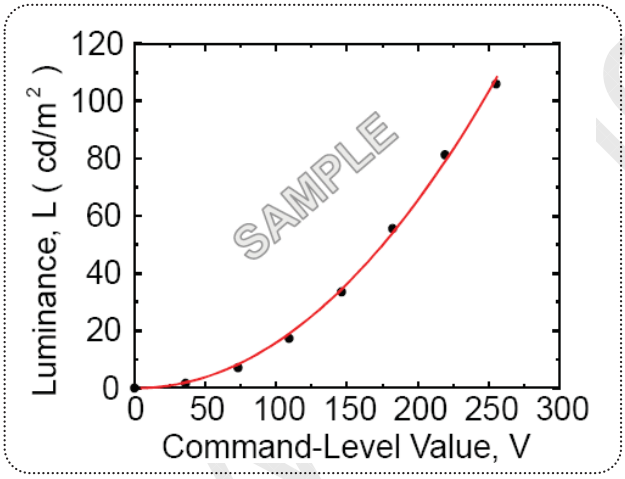


FIG.12 Sample Luminance vs. gray scale (using a 256 bit gray scale)

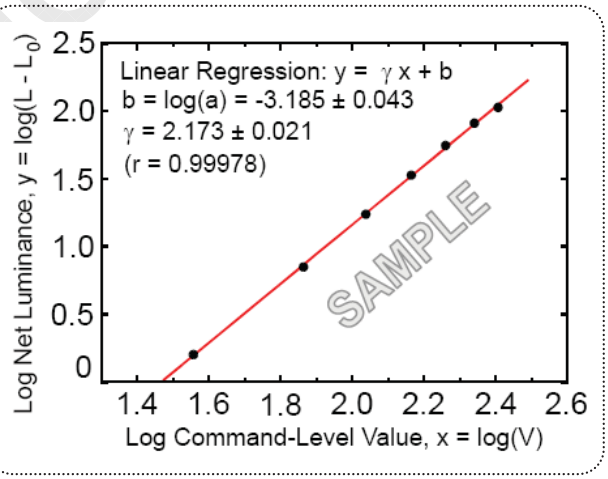


FIG.13 Sample Log-log plot of luminance vs. gray scale

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

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

Here the Parameter α and γ relate the signal level V to the luminance L.
The GAMMA we calculate from the log-log representation (FIG.12)

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 ".

Table 8. Gray to gray response time table

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

Table 9. 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

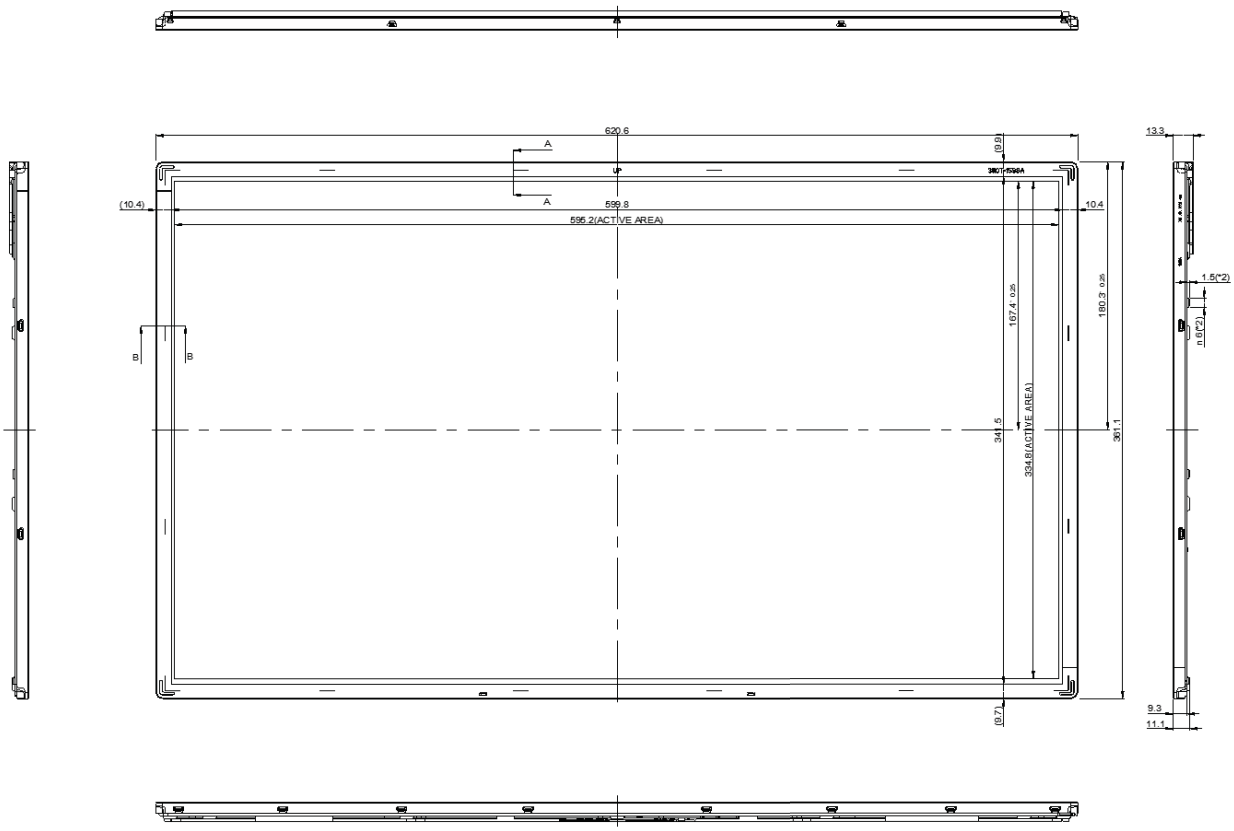
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

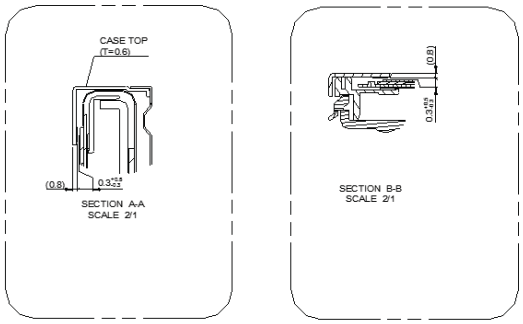
Outline Dimension	Horizontal	620.6mm
	Vertical	361.1mm
	Depth	13.3mm
Bezel Area	Horizontal	599.8mm
	Vertical	341.5mm
Active Display Area	Horizontal	598.272mm
	Vertical	336.528mm
Weight	2630g(Typ.) / 2760g (Max.)	
Surface Treatment	Advanced Anti-Reflective treatment of the front polarizer (2H)	

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

<FRONT VIEW>

Update : 16/11/21

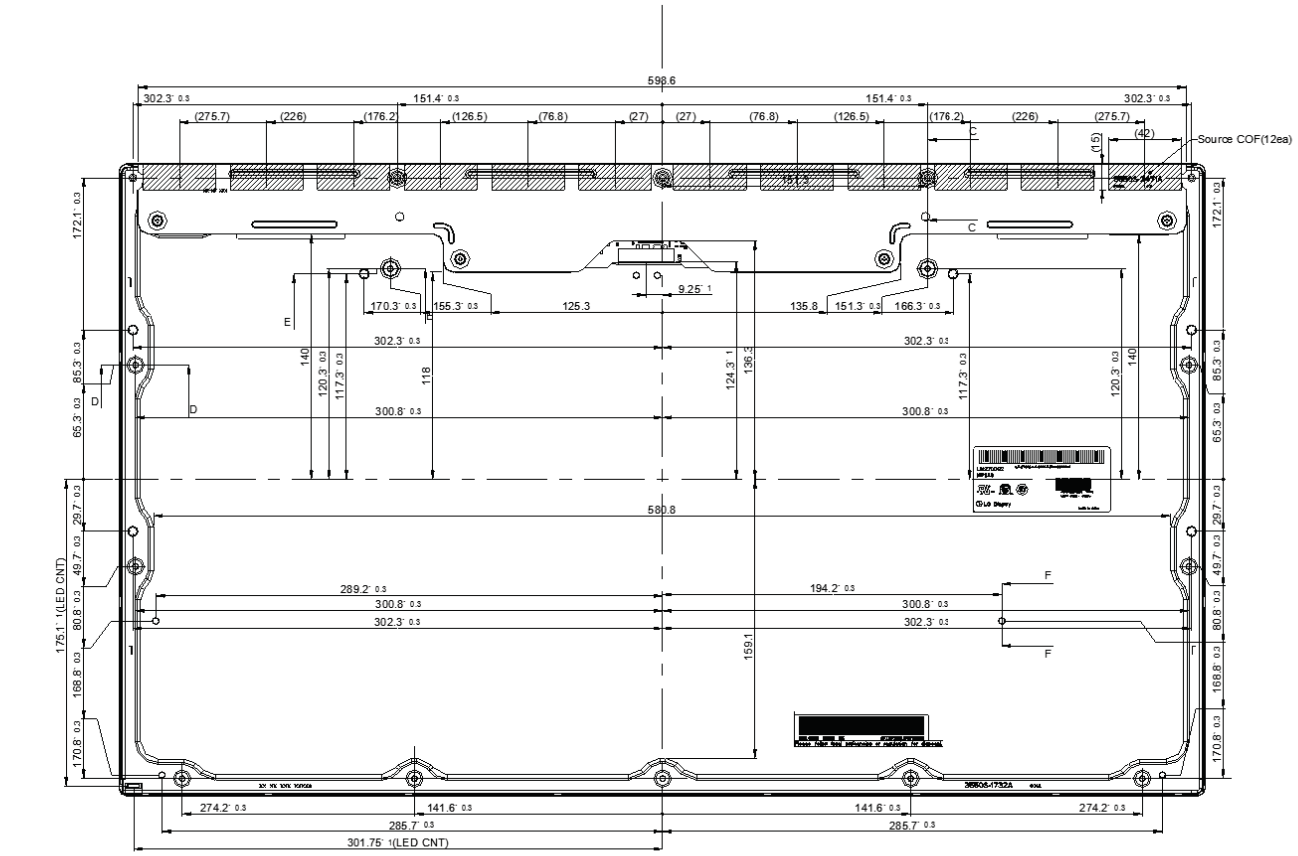


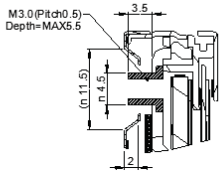


LGD Highly recommendation :
System chassis or frame should be designed to keep the IPS Panel flat as it is vulnerable to panel light-leakage caused by deformation.

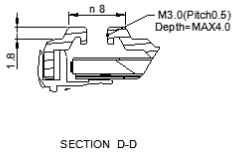
<REAR VIEW>

Update : 16/11/21

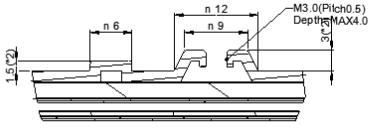




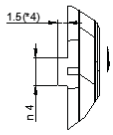
SECTION C-C
SCALE 2/1



SECTION D-D
SCALE 2/1



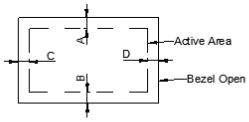
SECTION E-E
SCALE 2/1



SECTION F-F
SCALE 2/1

Notes
1. Unspecified tolerances are to be ` 0.5mm.
2. Tilt and partial disposition tolerance of display area are as following.

(1) Y-direction : I A-B I ≤ 2.1mm
(2) X-direction : I C-D I ≤ 1.4mm



3. Torque SPEC of Mounting : 3.0 ~4.0kgf.cm, M3.0 Machine Screw
4. I/F Connector Specification : 20525-060E-01 (I-PEX) or Compatible.
5. LED Connector Specification : YEONHO, 10035WR-H06D or Compatible.

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℃	

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

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

1) Package quantity in one box : 10 ea

b) Box Size : 710mm X 365mm X 448mm

9. PRECAUTIONS

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

9-1. MOUNTING PRECAUTIONS

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

9-2. OPERATING PRECAUTIONS

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

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.