



SAMSUNG DISPLAY



Product Specification

CUSTOMER		MODEL NO.	LTN156HL01
DATE OF ISSUE		EXTENSION CODE	

Approved by	
Prepared by	

SAMSUNG DISPLAY

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1. GENERAL DESCRIPTION

DESCRIPTION

The LTN156HL01-101 active matrix TFT (Thin Film Transistor) liquid crystal display (LCD) that uses amorphous silicon TFTs as switching components. This model is composed of a TFT LCD panel, a driver circuit, and a backlight unit. This 15.6" model has a resolution of 1920 x 1080 pixels and can display up to 262,144 colors.

FEATURES

High contrast ratio
FHD (1920 x 1080 pixels) resolution
Low power consumption
Fast Response
LED back light with an embedded LED driver
DE (Data enable) only mode
3.3V eDP Interface
Onboard EDID chip

APPLICATIONS

Notebook PC

If the intent to use this product is for other purpose, please contact Samsung Display.

GENERAL INFORMATION

Item	Specification	Unit	Note
Display area	344.16 (H) x 193.59 (V) (15.6"diagonal)	mm	
Driver Element	a-Si TFT active matrix		
Display colors	262,144 (6bit)		
Number of pixel	1920 x 1080 (FHD)	Pixel	16:9
Pixel Arrangement	RGB vertical stripe		
Pixel pitch	0.17925 (H) x 0.17925 (V) (TYP.)	mm	
Display Mode	Normally black, PLS mode		
Thickness of glass	0.3	mm	
Surface treatment	Haze 25%, Hardness 3H		Anti-Glare
Environmental safe regulation	Pb Free, Halogen Free		
Power Consumption	Total 4.82W(Typ) @Logic 1.39(typ) BLU 3.43W(Typ) Total 5.5W(Max)		Mosaic PTN

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MECHANICAL INFORMATION

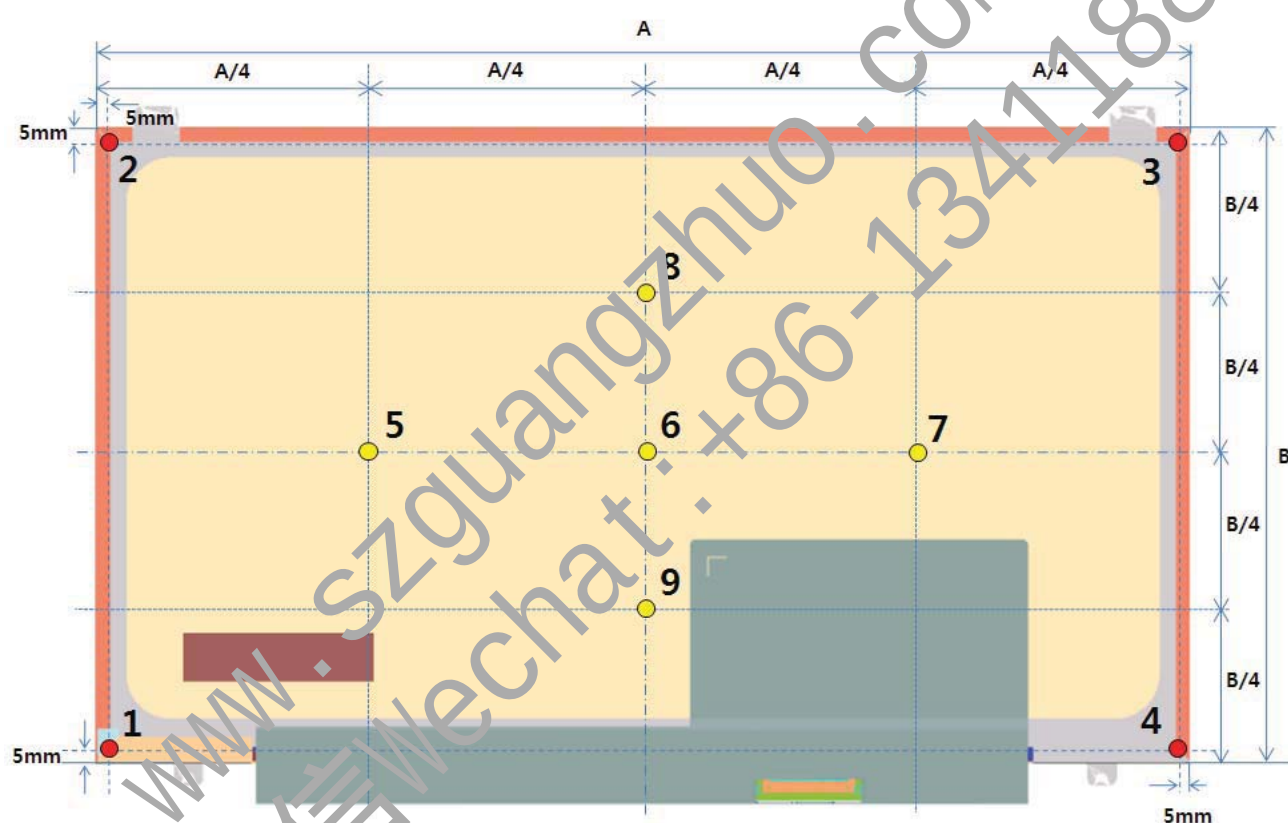
Item		Min.	Typ.	Max.	Unit	Note
Module Size	Horizontal (H)	359.0	359.5	360.0	mm	w/o flange
	Vertical (V)	223.3	223.8	224.3	mm	with flange & PCB
		206.0	206.5	207.0	mm	w/o flange & PCB
	Depth (D)	-	3.05	3.2	mm	(1)
Weight		-	325	350	g	

NOTE (1) Measuring method for thickness

Force to be applied for measurement (1,2,3,4 Part) : The 200gf when using the height gauge.

Force to be applied for measurement (5,6,7,8,9 Part) : The 30gf when using the height gauge.

Force to be applied for measurement (COF Part) : The 50gf when using the height gauge.



This picture is reference for measurement. Appearance may be different according to each model type.

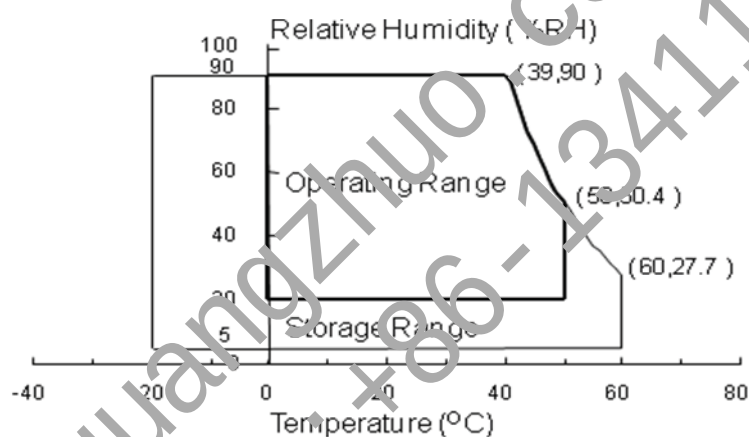
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2. ABSOLUTE MAXIMUM RATINGS

2.1 ENVIRONMENTAL ABSOLUTE RATINGS

Item	Symbol	Min.	Max.	Unit	Note
Storage temperate	TSTG	-20	60	°C	(1)
Operating temperature (Temperature of glass surface)	TOPR	0	50	°C	(1)
Shock (non-operating)	Snop	-	240	G	(2), (4)
Vibration (non-operating)	Vnop	-	2.41	G	(3), (4)

Note (1) The range of temperature and relative humidity is shown in the graph below 90% RH Max. .
(39°C ≥ Ta) If the temperature is higher than 40 °C, the maximum temperature of wet-bulb shall be less than 39°C. No condensation



- (2) Vibrate $\pm X$, $\pm Y$, and $\pm Z$ axis in the shape of the half sine wave one time for 2ms.
- (3) Vibrate the X, Y, and Z randomly within a 5 - 500 Hz range for 30min.
- (4) When testing a vibration and a shock, the fixture, which holds the module to be tested, shall be hard and rigid in order for the module not to be twisted or bent by the fixture.

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2.2 ELECTRICAL ABSOLUTE RATINGS

(1) TFT LCD MODULE

 $V_{LCD_VCC} = 3.3V, V_{SS} = GND = 0V$

Item	Symbol	Min.	Max.	Unit	Note
Power Supply Voltage	V_{LCD_VCC}	$V_{SS} - 0.3$	4.0	V	(1), (2)
eDP Input Voltage	V_{eDP}	$V_{SS} - 0.3$	2.0		

Note (1) Within T_a ($25 \pm 2^\circ C$)

(2) Permanent damage to the device may occur if exceed maximum values.

(2) BACKLIGHT UNIT

 $V_{SS} = GND = 0V$

Item	Symbol	Min.	Max.	Unit	Note
BLU Supply Voltage	V_{BL_PWR}	$V_{SS} - 0.3$	28	V	(1), (2)
BLU Supply Current	I_{BL_PWR}	-	1	A	(1), (2) $V_{in}=12V$ Duty 100%

Note (1) Within T_a ($25 \pm 2^\circ C$)

(2) Permanent damage to the device may occur if exceed maximum values

2.3 THE OTHERS

(1) STATIC ELECTRICITY PRESSURE RESISTANCE

Item	Test Conditions	Remark
CONTACT DISCHARGE	150pF, 330Ω, $\pm 8kV$, 200points, 1 time/point	Operating
AIR DISCHARGE	150pF, 330Ω, $\pm 15kV$, 200points, 1 time/point	Operating

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3. OPTICAL CHARACTERISTICS

The following items are measured under the stable conditions.* The optical characteristics should be measured in the dark room or the equivalent environment by the methods shown in the Note (5).

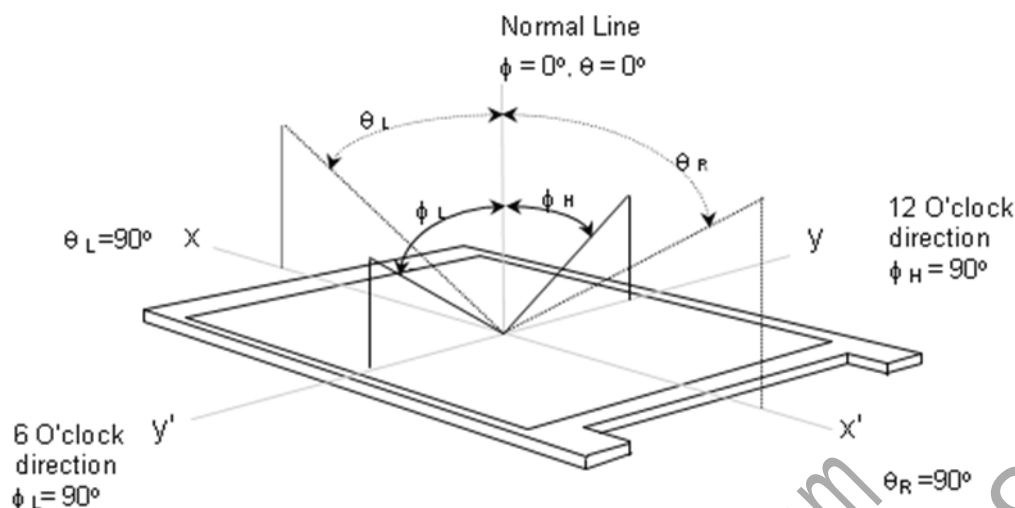
Measuring equipment: TOPCON SR-3

$T_a = 25 \pm 2^\circ\text{C}$, $V_{\text{LCD VCC}} = 3.3\text{V}$, $f_V = 60\text{Hz}$, $f_{\text{DCLK}} = 71.39\text{MHz}$, $I_F = 100\%$ duty

Item		Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Contrast Ratio		CR	Normal Viewing Angle $\phi = 0$ $\theta = 0$	500	600	-	-	(1),(2),(5)
Response time (Rising + Falling)		T _{RT}		-	30	35	msec	(1),(3)
Average Luminance of White (5 Points)		Y _{L,AVE}		255	300	-	cd/m ²	IF=100% Duty (1),(4)
Cross Modulation		DSHA		-	1.0	2.0	%	(7)
Color Chromaticity (CIE)	Red	R _X		-0.03	0.638	+0.03		(1),(5)
		R _Y			0.357			
	Green	G _X			0.295			
		G _Y			0.610			
	Blue	B _X			0.145			
		B _Y			0.065			
	White	W _X	0.313					
		W _Y	0.329					
Viewing Angle	Hor.	θ _L	80	85	-	Degrees	(1),(5)	
		θ _H	80	85	-			
	Ver.	φ _H	20	85	-			
		φ _V	30	85	-			
Color Gamut		CG	68	72	-	%		
White variation (13P)		δ _i		-	1.44	1.6		(6)

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Note (1) The definition of viewing angle: The range of viewing angle ($10 \leq C/R$)

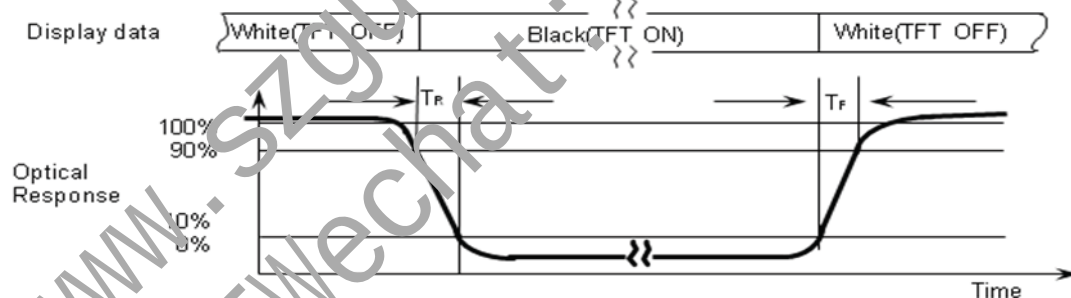


Note (2) The definition of contrast ratio (CR): The ratio of max. gray and min gray at 5 points (4, 5, 7, 9, and 10)

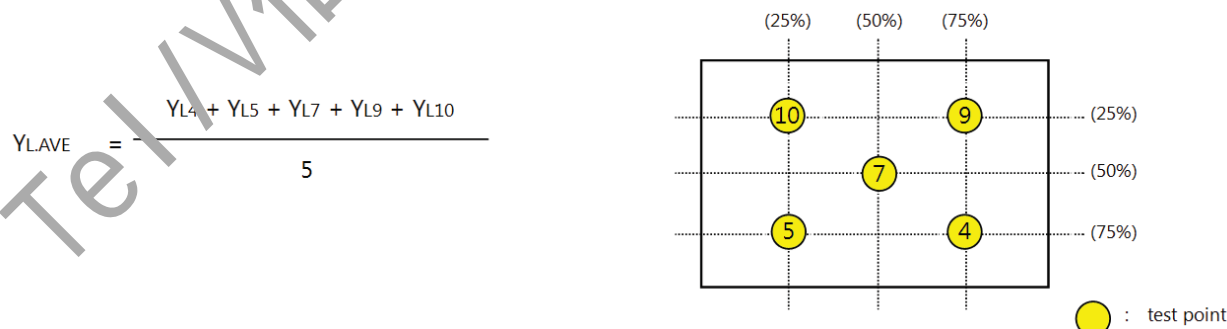
$$CR = \frac{CR(4) + CR(5) + CR(7) + CR(9) + CR(10)}{5}$$

Points = ④, ⑤, ⑦, ⑨, ⑩ at the figure of Note(6).

Note (3) The definition of Response time: Subtotal of the time during which the transmission changes from 10% to 90% when the TFT turns on and off.



Note (4) The definition of average luminance of white: Measure the luminance of white at 5 points.



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Note (7) The definition of crosstalk (Cross modulation)

: The phenomenon, which the contrast ratio is decreased by the interference of signal between pixels
Crosstalk Calculation Method

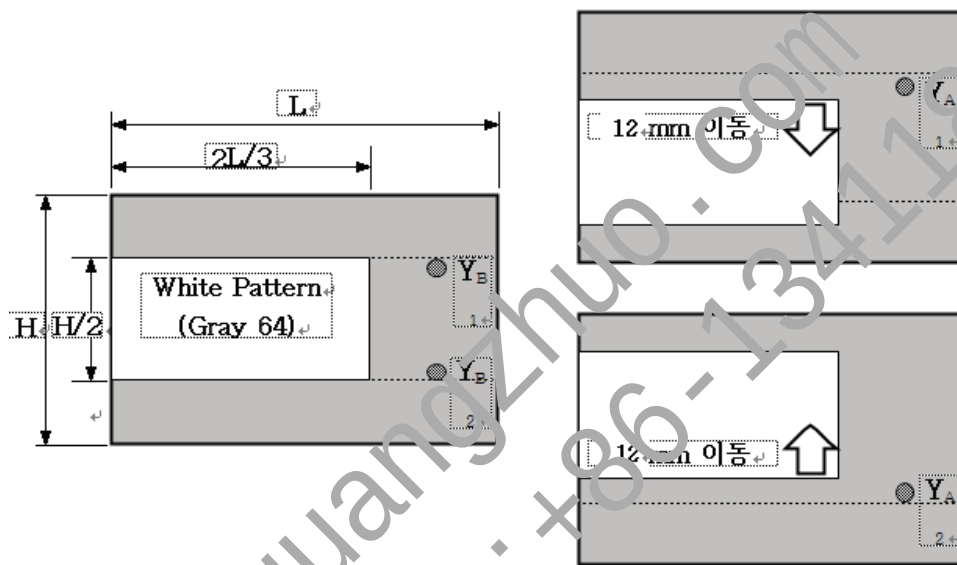
$$\text{Crosstalk Modulation Ratio}(D_{\text{SHA}}) = \frac{|Y_A - Y_B|}{Y_A} \times 100 (\%)$$

Where

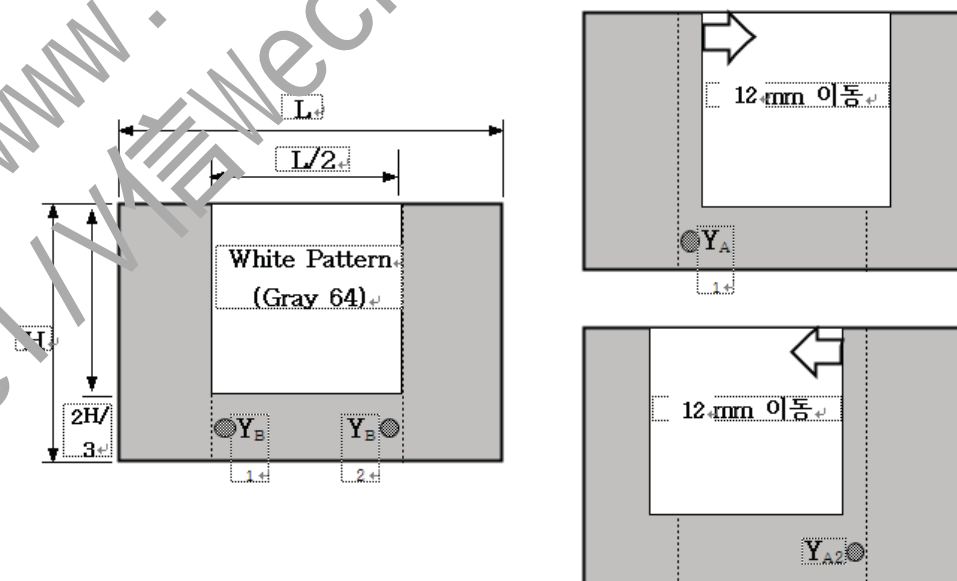
Y_A, Y_B = Measured under the 2° viewing angle (Measured area: $\psi 12 \text{ mm}$)

The rectangle area, which excludes the black-colored rectangle includes the range, which is from 1 gray to 63 gray.

1) The method of measurement for horizontal-crosstalk



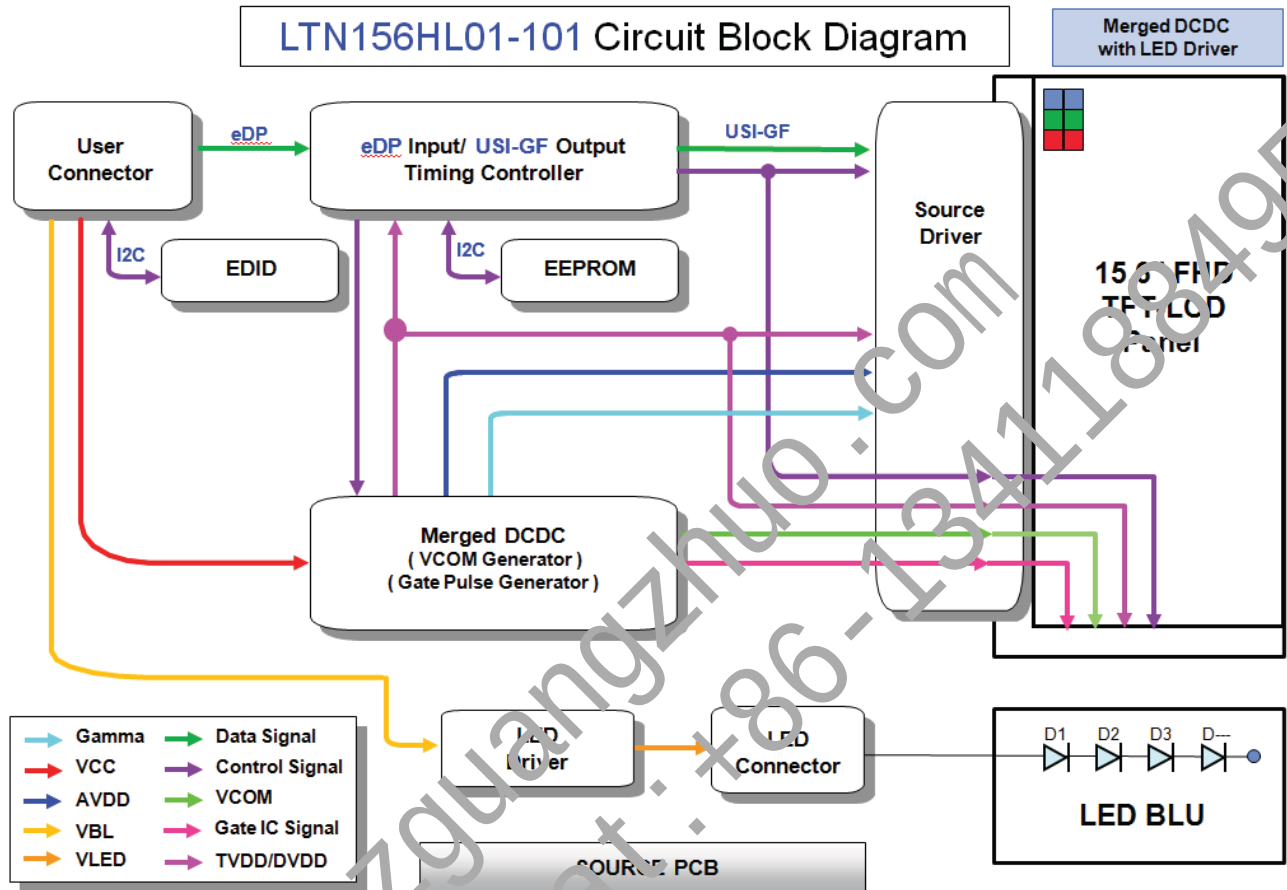
2) The method of measurement for vertical-crosstalk



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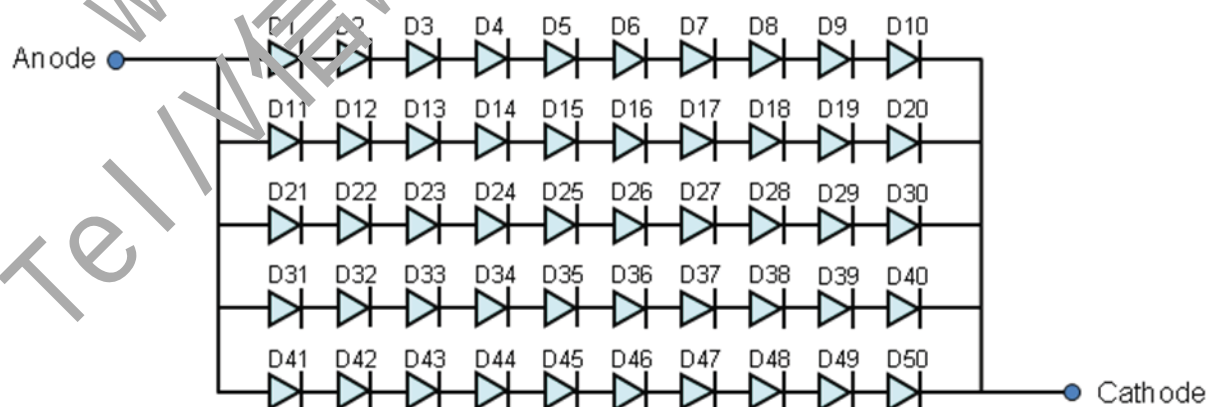
4. BLOCK DIAGRAM

4.1 TFT LCD MODULE



4.2 THE STRUCTURE OF LED PLACEMENT

(5 channels x 10ea = 50ea)



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5. ELECTRICAL CHARACTERISTICS

5.1 TFT LCD MODULE

Ta = 25 ± 2 °C

Item		Symbol	Min.	Typ.	Max.	Unit	Note
Power Supply Voltage		V _{LCD_VCC}	3.0	3.3	3.6	V	
T-CON TTL Input Voltage	High	V _{IH}	0.7 V _{LCD_VCC}	-	-	V	(1)
	Low	V _{IL}	-	-	0.3 V _{LCD_VCC}	V	
Vsync	60Hz	f _V	-	60	-	Hz	(2)
	50Hz	f _V	-	50	-	Hz	
	40Hz	f _V	-	40	-	Hz	
Hsync	60Hz	f _H	66.84	68.64	70.44	kHz	
Main Frequency	60Hz	f _{DCLK}	66.17	71.39	76.78	MHz	(3)
	50Hz	f _{DCLK}	-	59.49	-	MHz	
	40Hz	f _{DCLK}	-	47.59	-	MHz	
Rush Current		I _{RUSH}	-	-	1.5	A	(6)
Input Current	White	I _{LCD_VCC}	-	520	570	mA	(2), (5)
	Mosaic	I _{LCD_VCC}	-	420	484	mA	
	Black	I _{LCD_VCC}	-	330	380	mA	
	V.Stripe	I _{LCD_VCC}	-	470	520	mA	
	Red	I _{LCD_VCC}	-	390	440	mA	(2),(5)
	Green	I _{LCD_VCC}	-	390	440	mA	
	Blue	I _{LCD_VCC}	-	390	440	mA	
	1Dot	I _{LCD_VCC}	-	670	720	mA	(2), (5)
Logic Input Power Consumption		I _{LCD_VCC}	-	1.39	1.60		(5)*(b)
EDID Input Voltage		V _{EDID}	3.0	3.3	3.6	V	
EDID Input Current		I _{EDID}	-	-	5	mA	
Skew		PS	-400	-	400	ps	(2)

Note (1) The data pins for display and signal pins for timing should be connected. (GND= 0V)

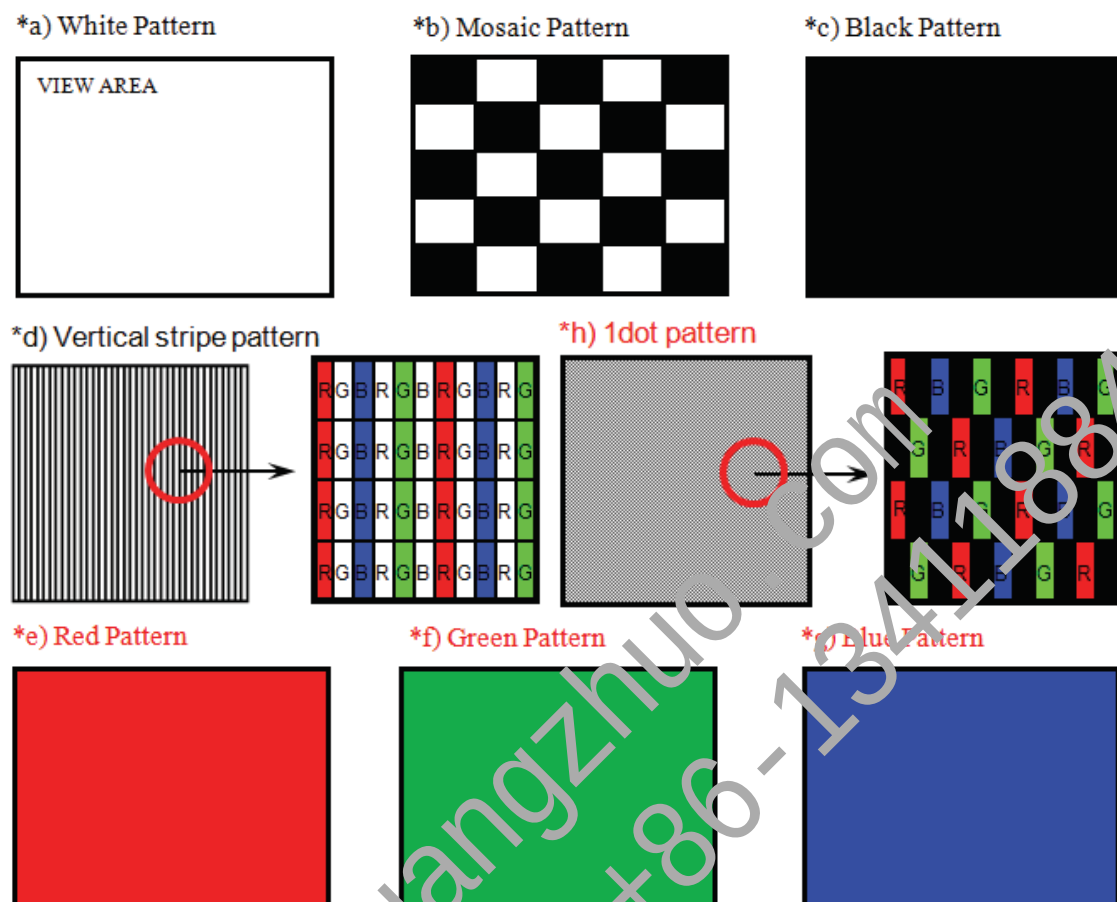
(2) f_V = 60Hz, f_{DCLK} = 71.39MHz, V_{LCD_VCC} = 3.3V, DC Current.

(3) In the case of 40Hz & 50Hz for DRRS, FOS,

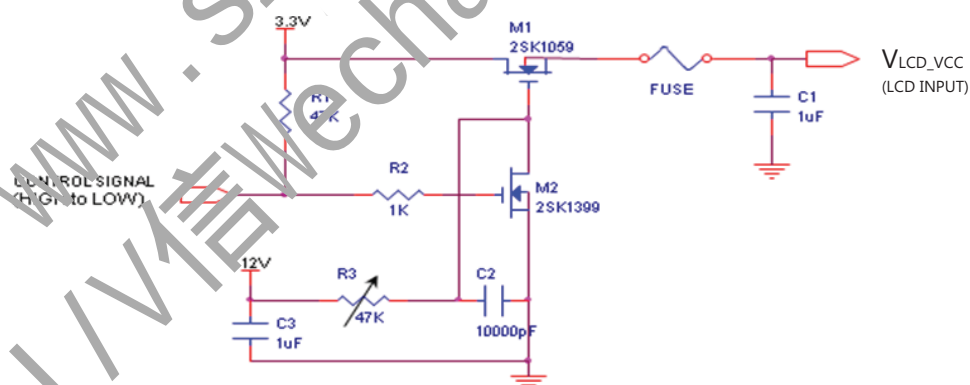
Flicker & Brightness are not guaranteed, because their level might be different from 60Hz operation.

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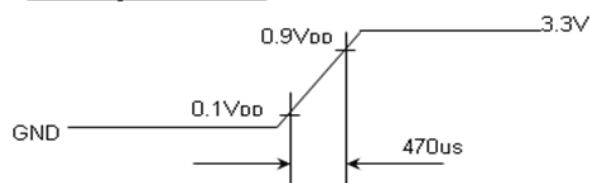
Note (5) The dissipation pattern for power



Note (6) The condition for measurement for rush current



V_{DD} rising time is 470us



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5.2 BACK LIGHT UNIT

Ta = 25 ± 2 °C

Item	Symbol	Min.	Typ.	Max.	Unit	Note
LED Forward Current	IF	-	21.3	-	mA	
LED Forward Voltage	VF	2.7	2.8	2.9	V	IF = 20mA
LED Array Voltage	VP	-	28	-	V	
LED Power Consumption	P	-	3.43	3.9	W	
LED Life time	Hr	15,000	-	-	Hours	(1)
LED Counts	Q	-	50	-	EA	

Note (1) The life time (Hr) of LEDs can be defined as the time during which it continues to operate under the condition, which the Ta is 25 ± 2 °C and IF= 21.3 mA rms until the one of the following events occurs when the brightness becomes 50% or lower than the original.

5.3 LED DRIVER

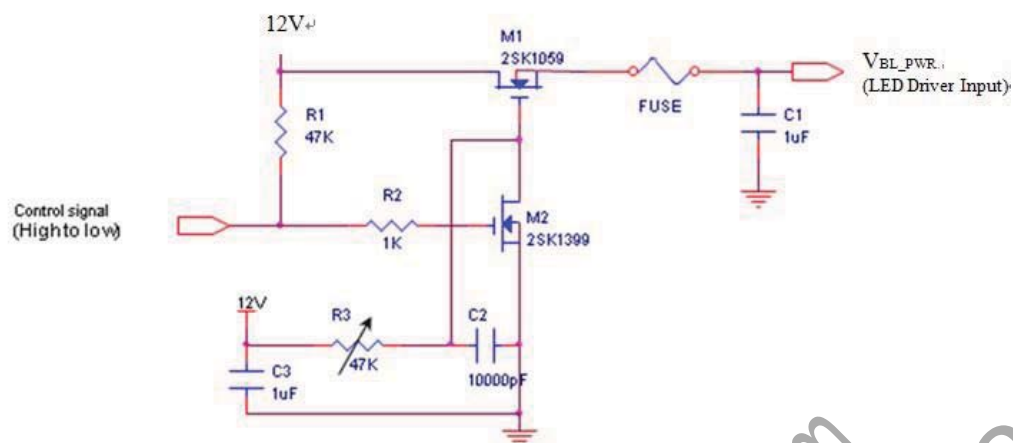
The manufacturer of LED driver: Richtek RT8561A

Ta= 25 ± 2 °C

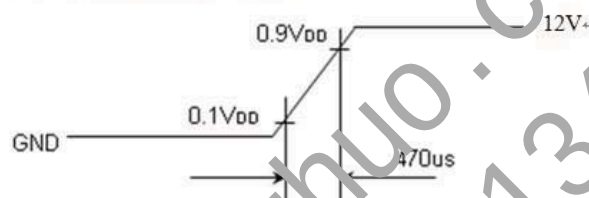
Item	Symbol	Min.	Typ.	Max.	Unit	Note
Input Voltage	V _{BL_PWR}	5	12	20	V	
Input Current	I _{BL_PWR}	-	295	325	mA	Vin=12V Duty 100%
PWM duty Ratio	D _{BL_PWM_DIM}	2	-	100	%	
External PWM Frequency	F _{BL_PWM_DIM}	0.2	1	2	kHz	APS ON
		0.12	1	2	kHz	APS OFF
PWM Resolution	R _{BL_PWM_DIM}	0.6	-	-	%	APS ON
		0.3	-	-	%	APS OFF
In-Rush Current	I _{RUSH_BLM_WK}	-	-	1.5	A	(1)
EN Control Level	High	V _{BL_EN_BLM}	1.5	-	5.0	V
	Low	V _{BL_EN_BLM}	0.0	-	1.0	V
PWM Control Level	High	V _{BL_PWM_DIM}	1.3	-	5.0	V
	Low	V _{BL_PWM_DIM}	0.0	-	1.0	V
VBL_PWR @ LED Driver On	V _{BL_PWR}	5	-	20	V	
VBL_PWR @ LED Driver Off	V _{BL_PWR}	0	-	1.5	V	
Operating frequency	FC	0.8	1.0	1.2	kHz	
Efficiency	η	-	87	-	%	

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Note (1) Rush current measurement condition



The V_{BL_PWR} rising time is 470us.



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5.4 eDP INTERFACE

5.4.1 HDP Characteristics

Item	Symbol	Min.	Typ.	Max.	Unit	Note
HPD voltage	V_{OH_HPD}	2.25	-	3.63	V	
HPD_IRQ pulse width	T_{HPD_IRQ}	0.5	-	1	V	IOH=0mA VDD33=2.25~3.63V

5.4.3 AUX Characteristics

Item	Symbol	Min.	Typ.	Max.	Unit	Note
AUX unit interval	UI_{AUX}	0.4	0.5	0.6	us	
Number of pre-charge pulse	$N_{precharge}$	10	-	16	times	
AUX CH bus park time	$T_{AUX-BUS-PARK}$	10	-	-	Ns	
Max cycle-to-cycle output jitter within a single transaction	$T_{AUX-TX-JITTER}$	-	-	0.04	UI	
Max allowable cycle-to-cycle input jitter within a single transaction	$T_{AUX-RX-JITTER}$	-	-	0.05	UI	
AUX peak-to-peak output differential voltage	$V_{AUX-TX-DIFFp-p}$	0.39	-	1.38	V	(1)
AUX peak-to-peak input differential voltage	$V_{AUX-RX-DIFFp-p}$	0.32	-	1.38	V	(1)
AUX CH termination DC resistance	$R_{AUX-TERM}$	-	100	-	Ohm	
AUX DC common mode voltage	$V_{AUX-DC-CM}$	0	-	2	V	
AUX turn around common mode voltage	$V_{AUX-TURN-CM}$	-	-	0.4	V	(2)
AUX short circuit current limit	$I_{AUX-SHORT}$	-	-	90	mA	(3)

Note(1) $V_{AUX-DIFFp-p} = 2 \times |V_{DP_AUX_P} - V_{DP_AUX_N}|$

Note(2) Stable state common mode voltage shifts between transmit and receive mode

Note(3) Total drive current of the transmitter when it is shorted to its ground.

5.4.3 Main Link Characteristics

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Unit interval for HBR (2.7Gbps/lane)	UI_{HBR}	-	370	-		
Unit interval for RBR (1.62Gbps/lane)	UI_{RBR}	-	617	-	Ps	(1)
RX DC Common mode voltage	$VRX-DC-CM$	0	-	2	Ps	(1)
RX short circuit current limit	$IRX-SHORT$	-	-	50	V	

Note (1) Frequency high limit = +500ppm, Frequency low limit = -5300ppm. Modulation frequency range of 30kHz to 33kHz is supported.

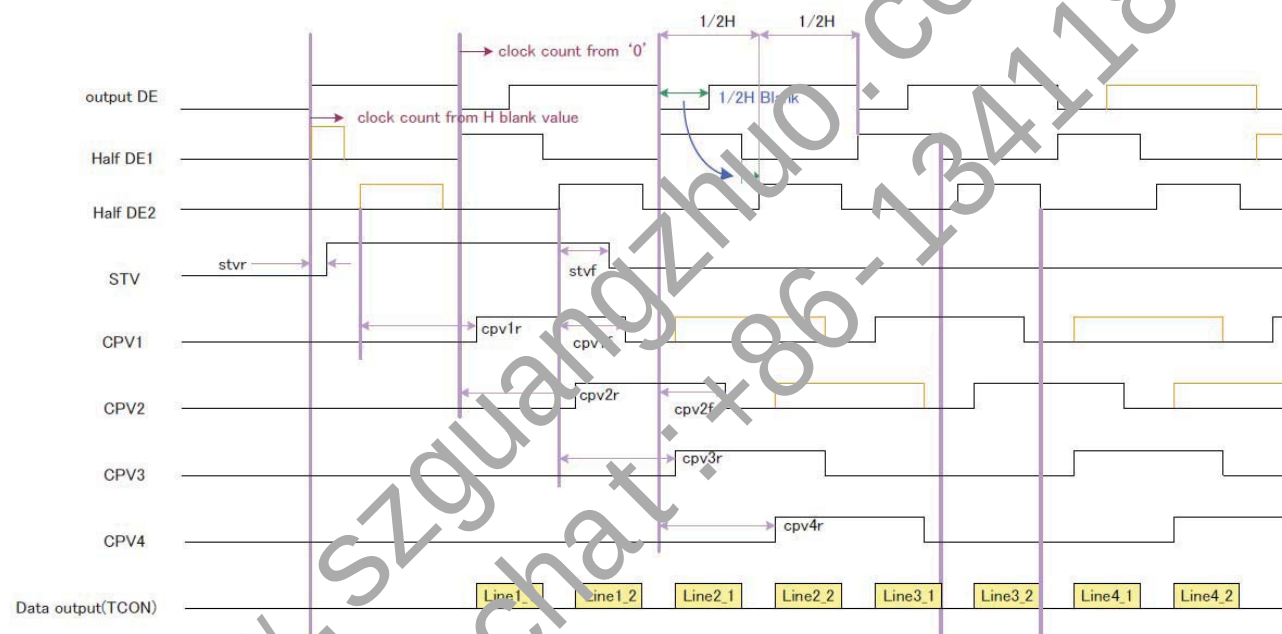
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5.5 INTERFACE TIMING

5.5.1 TIMING PARAMETERS

Signal	Item	Symbol	Min.	Typ.	Max.	Unit	Note
Frame Frequency	Cycle	T_V	1114	1144	1174	Lines	
Vertical active in the display term	Display Period	T_{VD}	-	1080	-	Lines	
Scanning time in one line	Cycle	T_H	990	1040	1090	Clocks	
Horizontal active in the display term	Display Period	T_{HD}	-	960	-	Clocks	

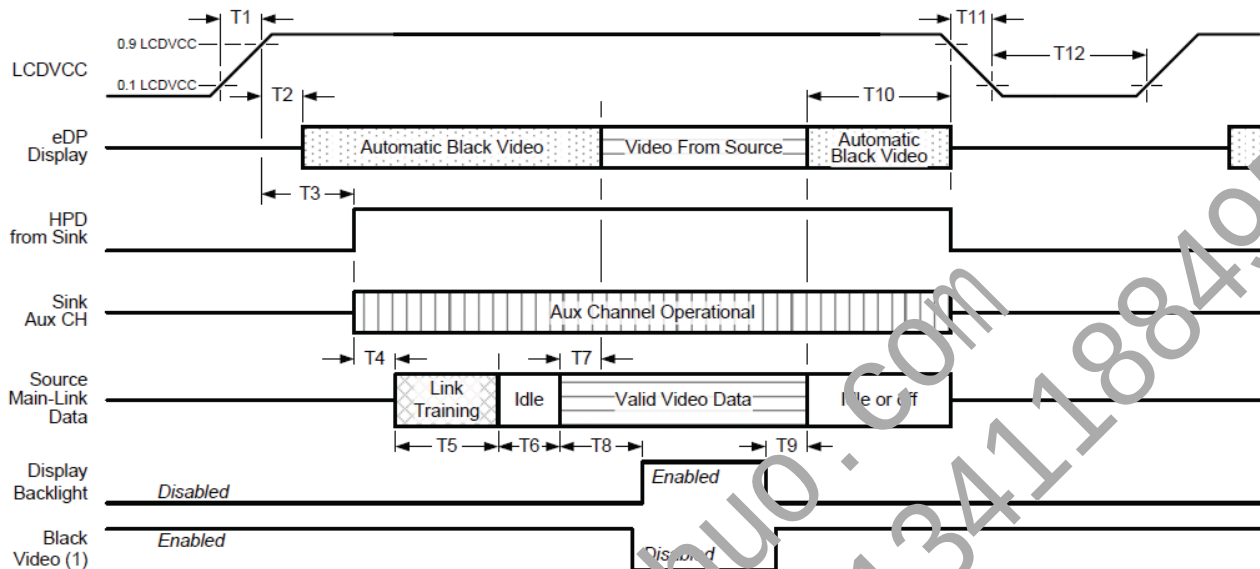
5.5.2 TIMING DIAGRAMS OF INTERFACE SIGNAL



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5.6 POWER ON/OFF SEQUENCE

To prevent the product from being latched up or the DC in the LCD module from starting an operation, the order to turn the power on and off should be changed to the order as shown in the diagram below.



Note 1: Manual control of Black Video (using DPCD register 00720h bit 1) is a system implementation option.

Figure 4-1: eDP Interface Power Up/Down Sequence, Normal System Operation

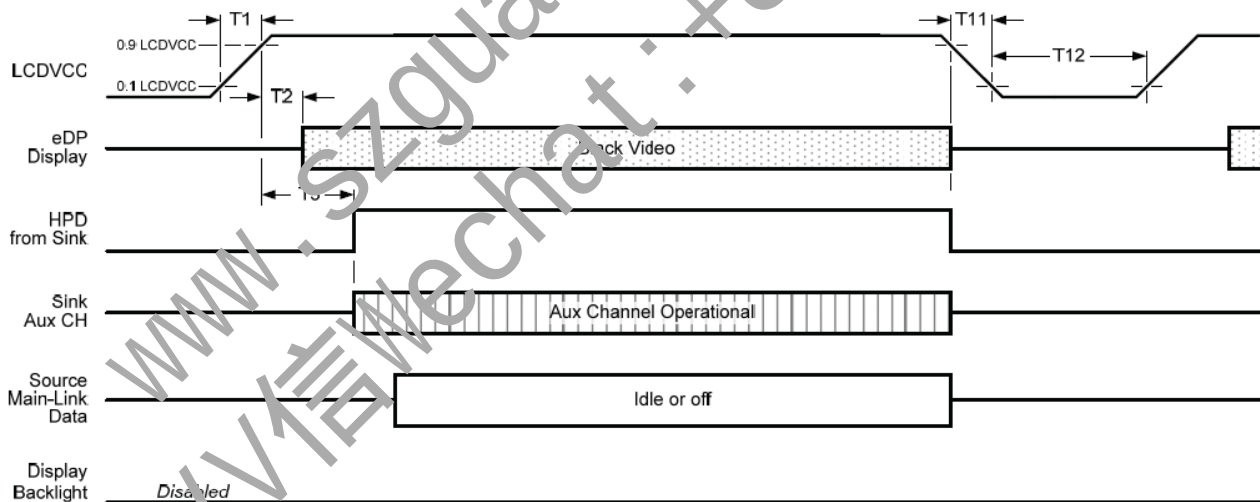


Figure 4-2: eDP Interface Power Up/Down Sequence, AUX Channel Transaction Only

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Timing Parameter	Description	Required By	Limits		Notes
			Min	Max	
T1	Power rail rise time, 10% to 90%	Source	0.5ms	10ms	
T2	Delay from LCDVCC to automatic Black Video generation	Sink	0ms	200ms	Automatic Black Video generation prevents display noise until valid video data is received from the Source (see Notes: 1 and 2 below)
T3	Delay from LCDVCC to HPD high	Sink	0ms	200ms	Sink AUX Channel must be operational upon HPD high (see Note: 3 below)
T4	Delay from HPD high to link training initialization	Source	-	-	Allows for Source to read Link capability and initialize
T5	Link training duration	Source	-	-	Dependant on Source link training protocol
T6	Link idle	Source	-	-	Min accounts for required BS-Idle pattern. Max allows for Source frame synchronization.
T7	Delay from valid video data from Source to video on display	Sink	0ms	50ms	Max value allows for Sink to validate video data and timing. At the end of T7, Sink will indicate the detection of valid video data by setting the SINK_STATUS bit to logic 1 (DPCD 00205h, bit 0), and Sink will no longer generate automatic Black Video.
T8	Delay from valid video data from Source to backlight enable	Source	-	-	Source must assure display video is stable
T9	Delay from backlight disable to end of valid video data	Source	-	-	Source must assure backlight is no longer illuminated. At the end of T9, Sink will indicate the detection of no valid video data by setting the SINK_STATUS bit to logic 0 (DPCD 00205h, bit 0), and Sink will automatically display Black Video. (See Notes: 1 and 2 below)
T10	Delay from end of valid video data from Source to power off	Source	0ms	500ms	
T11	Power rail fall time, 90% to 10%	Source		10ms	
T12	Power off time	Source	500ms	-	

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The backlight may be flashed if the interface signal remains floated when the above-mentioned signal becomes invalid.

Note (1) The Sink must include the ability to automatically generate Black Video autonomously. The Sink must automatically enable Black Video under the following conditions:

Upon LCDVCC power-on (within T2 max)

When the "NoVideoStream_Flag" (VB-ID Bit 3) is received from the Source (at the end of T9)

When no Main Link data, or invalid video data, is received from the Source. Black Video must be displayed within 50ms (max) from the start of either condition. Video data can be deemed invalid based on MSA and timing information, for example.

(2) The Sink may implement the ability to disable the automatic Black Video function, as described in Note 1, above, for system development and debugging purposes.

(3) The Sink must support AUX Channel polling by the Source immediately following LCDVCC power-on without causing damage to the Sink device (the Source can re-try if the Sink is not ready). The Sink must be able to respond to an AUX Channel transaction with the time specified within T3 max.

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5.8 INPUT TERMINAL PIN ASSIGNMENT

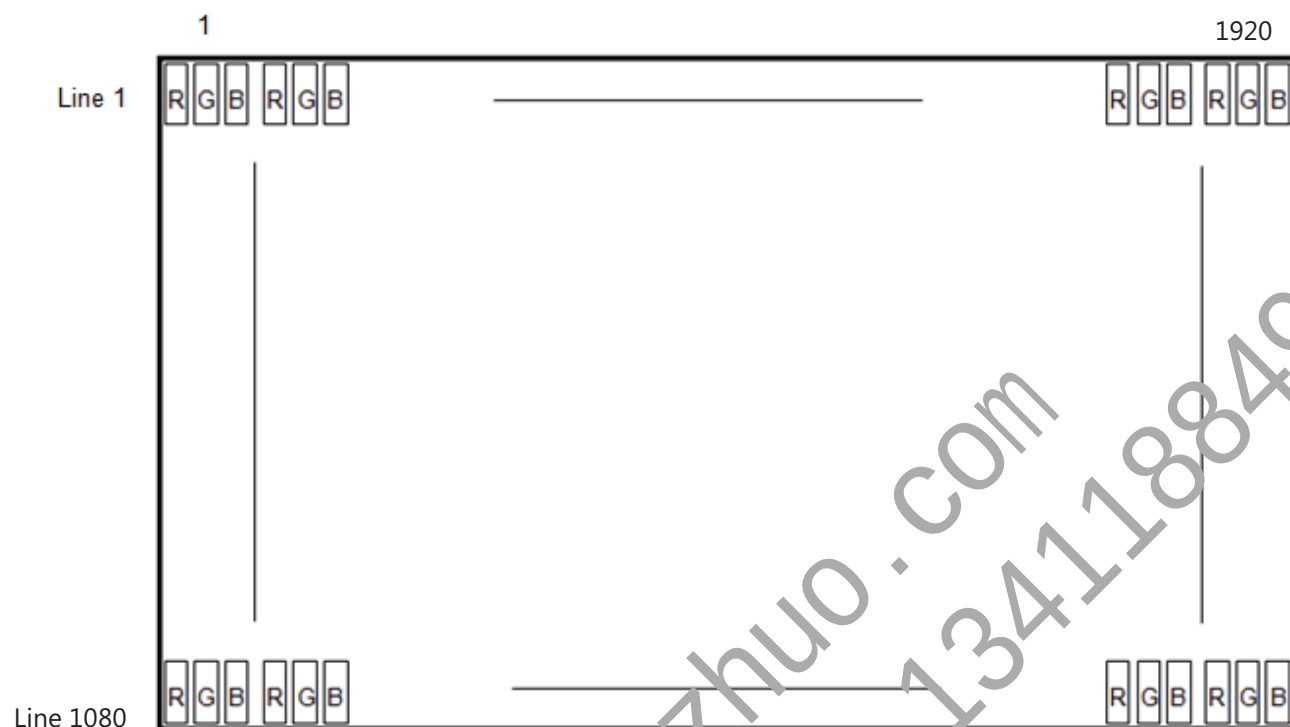
5.8.1 INPUT SIGNAL & POWER

(eDP, Connector: 20455-030E-02R, I-PEX or the equipment with the equivalent capability)

Pin	Symbol	Function
1	APS_EN	APS on/off or No connection(optional)
2	H_GND	High Speed Ground
3	Lane1_N	Complement Signal Link Lane 1
4	Lane1_P	True Signal Link Lane 1
5	H_GND	High Speed Ground
6	Lane0_N	Complement Signal Link Lane 0
7	Lane0_P	True Signal Link Lane 0
8	H_GND	High Speed Ground
9	AUX_CH_P	True Signal Auxiliary Channel
10	AUX_CH_N	Complement Signal Auxiliary Channel
11	H_GND	High Speed Ground
12	LCD_VCC	LCD logic and driver power
13	LCD_VCC	LCD logic and driver power
14	BIST_EN	BIST on/off or No connection(optional)
15	LCD_GND	LCD logic and driver ground
16	LCD_GND	LCD logic and driver ground
17	HPD	Hot Plug Detect
18	BL_GND	Backlight Ground
19	BL_GND	Backlight Ground
20	BL_GND	Backlight Ground
21	BL_GND	Backlight Ground
22	BL_ENABLE	Backlight on/off
23	BL_PWM_DIM	System PWM signal input for dimming
24	NC	No connection
25	NC	No connection
26	BL_PWR	Backlight power
27	BL_PWR	Backlight power
28	BL_PWR	Backlight power
29	BL_PWR	Backlight power
30	CLR_EN	CLR on/off or No connection(optional)

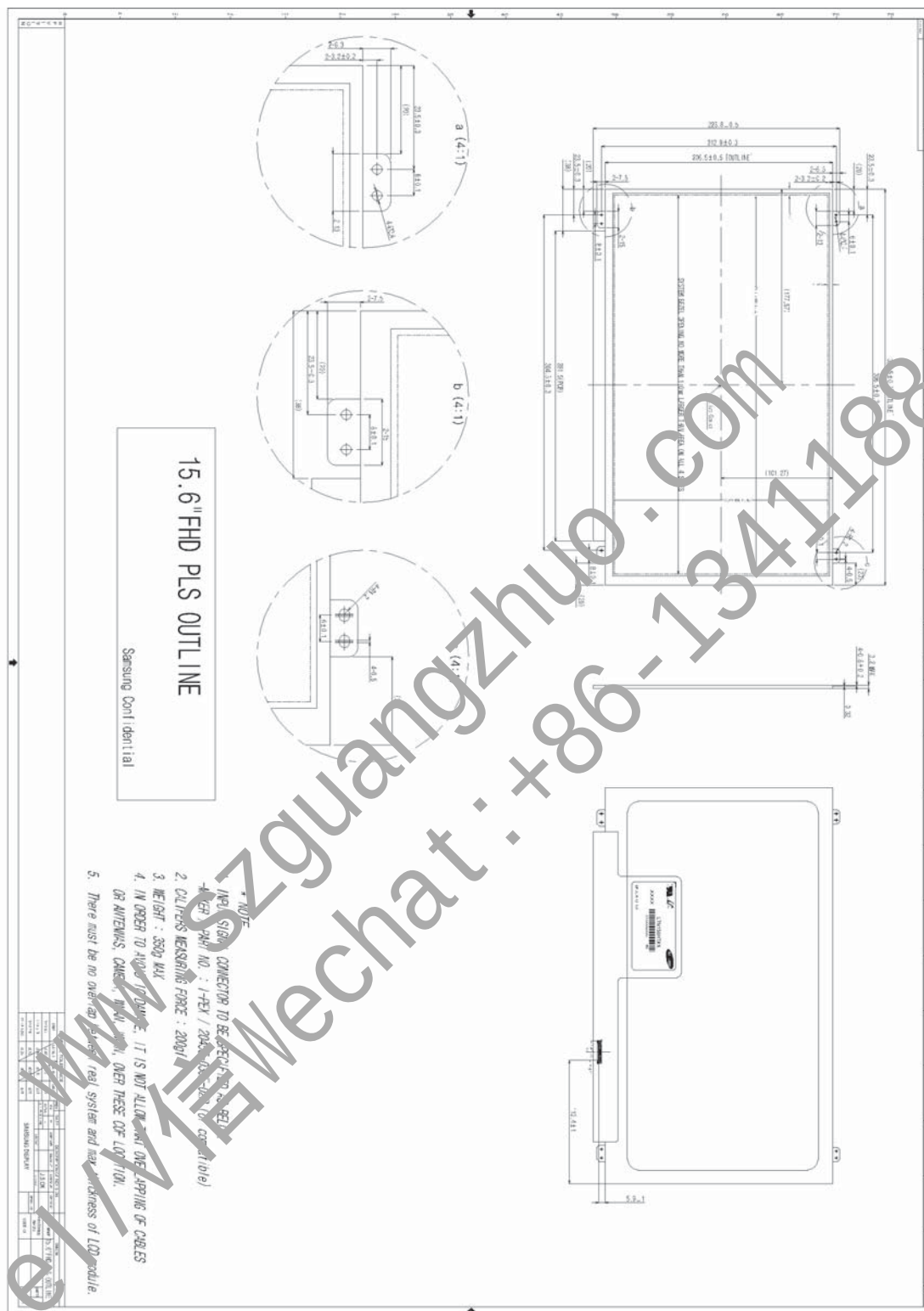
SAMSUNG DISPLAY

6. PIXEL FORMAT



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7. OUTLINE DIMENSION



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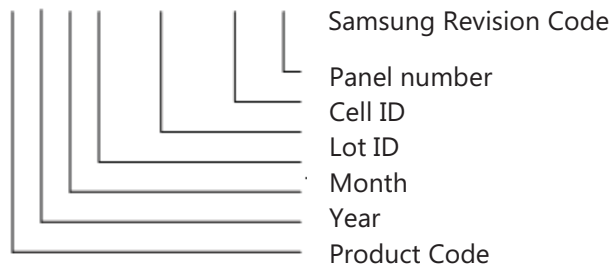
8. MARKING

A nameplate is affixed to the specified location on each product.

(1)Parts number : LTN156HL01

(2)Revision code : 3 letters

(3)Lot number : X X X X XXX XX X 101



9. GENERAL PRECAUTIONS

9.1 STORAGE

We highly recommend to comply with the criteria in the table below

ITEM	Unit	Min.	Max.
Storage Temperature	(°C)	5	40
Storage Humidity	(%RH)	35	75
Storage Life	12 months		
Storage Condition	- The storage room should be equipped with a good ventilation facility, which has a temperature controlling system. - Products should be placed on the pallet, which is away from the wall not on the floor. - Prevent products from being exposed to the direct sunlight, moisture, and water; Be cautious not to pile the products up. - Avoid storing products in the environment, which other hazardous material is placed. - If products are delivered or kept in the storage facility more than 3 months, we recommend you to leave products under the condition including a 20°C temperature and a humidity of 50% for 24 hours. - If you store semi-manufactured products for more than 3 months, bake the products under the condition including the 50°C temp. and the 10% humidity for 24hrs after being used.		

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10. APPENDIX

Only Internal

[OPTICAL CHARACTERISTICS]

The following items are measured under the stable conditions.* The optical characteristics should be measured in the dark room or the equivalent environment by the methods shown in the Note (5).

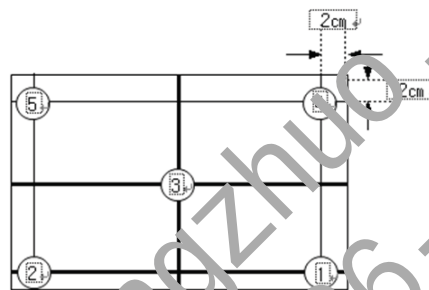
Measuring equipment: TOPCON SR-3

$T_a = 25 \pm 2^\circ\text{C}$, $V_{\text{LCD_VCC}} = 3.3\text{V}$, $f_v = 60\text{Hz}$, $f_{\text{DCLK}} = 71.39\text{MHz}$, IF = 100% duty

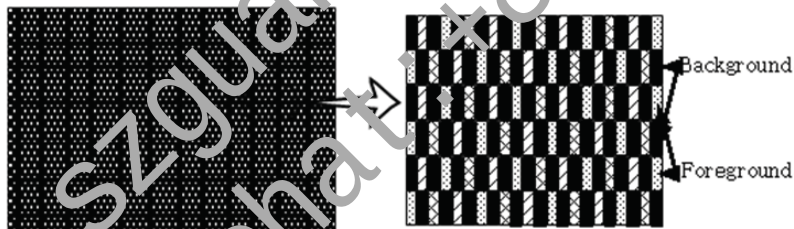
Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Flicker	F		-	3.2	5.2		(8)

Note (8) The definition of flicker: The phenomenon, which the pixel on the screen of LCD panel blinks.

- 1) Calculate the figure with observing the standard for the measurement for the flicker.
- 2) Measurement point



- 3) Pattern to measure the flicker: Inverting driving of DOT



[LED DRIVER]

The manufacturer of LED driver: Richtek RT8561A

$T_a = 25 \pm 2^\circ\text{C}$

		Min.	Typ.	Max.	Unit	Note
OVP driving Voltage	V_{OVP}	-	-	38.8	V	

[ELECTRICAL CHARACTERISTICS]

TFT LCD MODULE

$T_a = 25 \pm 2^\circ\text{C}$

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Power Supply Voltage Ripple	Active Period $V_{\text{LCD_VCC_RI PPLE}}$	-	-	0.05 * $V_{\text{LCD_VCC}}$	V	(1)

Note (1) $f_v = 60\text{Hz}$, $f_{\text{DCLK}} = 71.39\text{MHz}$ $V_{\text{LCD_VCC}} = 3.3\text{V}$, Sub Dot Pattern