

**SAMSUNG DISPLAY**

Product Specification

CUSTOMER		MODEL NO.	LTN156FL02
DATE OF ISSUE		EXTENSION CODE	

Approved by	
Prepared by	

Samsung Secret



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1. GENERAL DESCRIPTION

DESCRIPTION

The LTN156FL02-L01 uses a color 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 3840 x 2160 pixels and can display up to 16,777,216 colors.

FEATURES

High contrast ratio
UHD(3840 x 2160 pixels) resolution
Low power consumption
Fast Response
LED back light with an embedded LED driver
eDP(V1.3) Interface

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	344.45 (H) x 193.75 (V) (15.6"diagonal)	mm	
Driver Element	a-Si TFT active matrix		
Display colors	16,777,216 (24bit)		
Number of pixel	3840 * 2160 (UHD)	Pixel	16:9
Pixel Arrangement	Green		
Pixel pitch	89.7 x 89.7	um	
Display Mode	Normally Black, PLS mode		
Thickness of glass	0.3	mm	
Surface treatment	Haze 0%		Glare
Environmental safe regulation	Pb Free, Halogen Free		

MECHANICAL INFORMATION

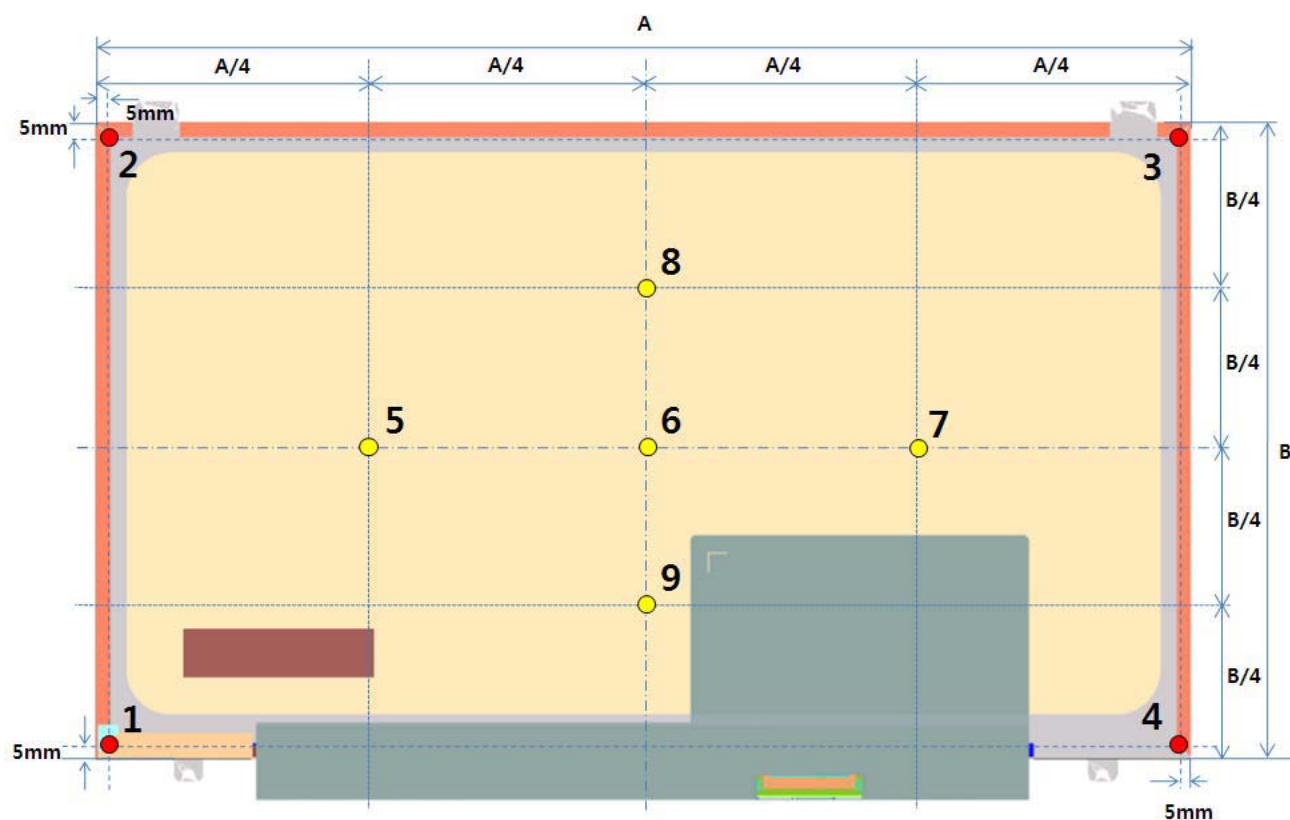
Item		Min.	Typ.	Max.	Unit	Note
Module Size	Horizontal (H)	359	359.5	360	m	
	Vertical (V)	223.3	223.8	224.3	mm	with PCB
		206	206.5	207	mm	w/o PCB
	Depth (D)	-	-	2.6	mm	(1)
		-		3.0	mm	@PCB part
Weight		-	-	290	g	

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 Micrometer.



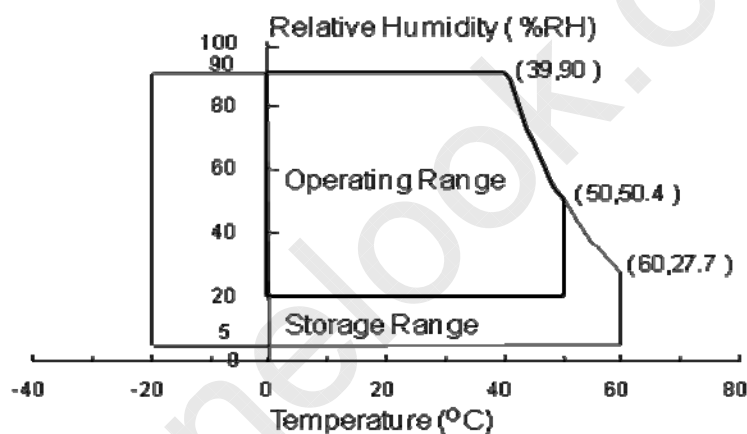
2. ABSOLUTE MAXIMUM RATINGS

2.1 ENVIRONMENTAL ABSOLTE 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 are 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 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}	$V_{SS} - 0.3$	2.3		

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}	$V_{SS} - 0.3$	26.5	V	(1), (2)
BLU Supply Current	I_{BL_PWR}	-	0.9	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, 330 Ω , $\pm 8kV$, 200points, 1 time/point	Operating
AIR DISCHARGE	150pF, 330 Ω , $\pm 15kV$, 200points, 1 time/point	Operating

3. OPTICAL CHARACTERISTICS

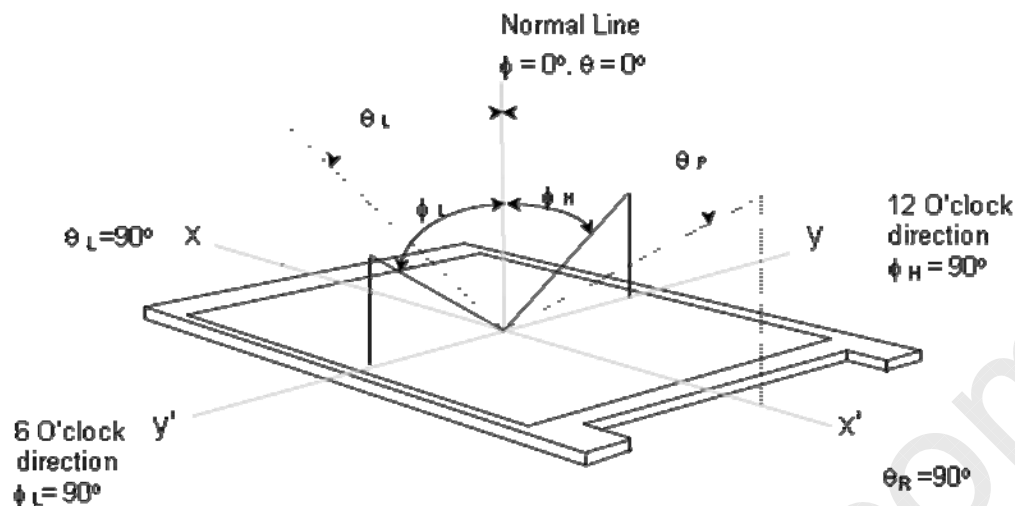
The following items are measured under the stable conditions.* The optical characteristics should be measured in the dark room or the equivalent environment by the methods shown in the Note (5).

Measuring equipment : TOPCON SR-3

Ta = 25 ± 2 °C, V_{LCD_VCC} = 3.3V, f_v = 60Hz, f_{DCLK} = TBD MHz, IF = TBD, DBLC mode = TBD

Item		Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Contrast Ratio (w/o TSP)		CR	Normal Viewing Angle φ = 0 θ = 0	500	700	-	-	(1),(2),(5)
Response time (Rising + Falling)		T _{RT}		-	16	32	msec	(1),(3)
Average Luminance of White (5 Points) (w/o TSP)		Y _{L,AVE}		229	270	-	cd/m ²	(1),(4)
Cross Modulation		DSHA		-	1.0	2.0	%	(7)
Color Chromaticity y (CIE)	Red	R _X		-0.03	0.640	+0.03		(1),(5)
		R _Y			0.340			
	Green	G _X			0.310			
		G _Y			0.610			
	Blue	B _X			0.150			
		B _Y			0.080			
	White	W _X			0.313			
		W _Y			0.329			
Viewing Angle	Hor.	θ _L	CR ≥ 10 At center		85	-	Degrees	(1),(5)
		θ _H			85	-		
	Ver.	φ _H			85	-		
		φ _L			85	-		
Color Gamut		CG			72	-	%	
White variation (13P)		δ _L		-	-	1.6	%	(6)

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

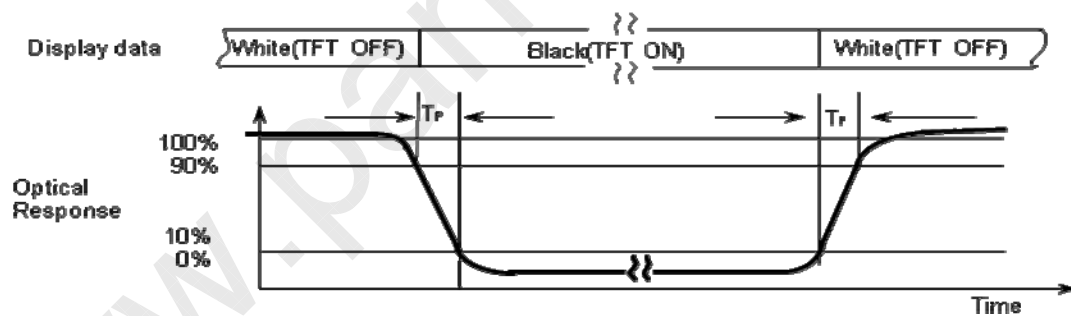


Note (2) The definition of contrast ratio (CR) : The ratio of max. gray and min gray at 5 points (4, 5, 7, 9, and 10)

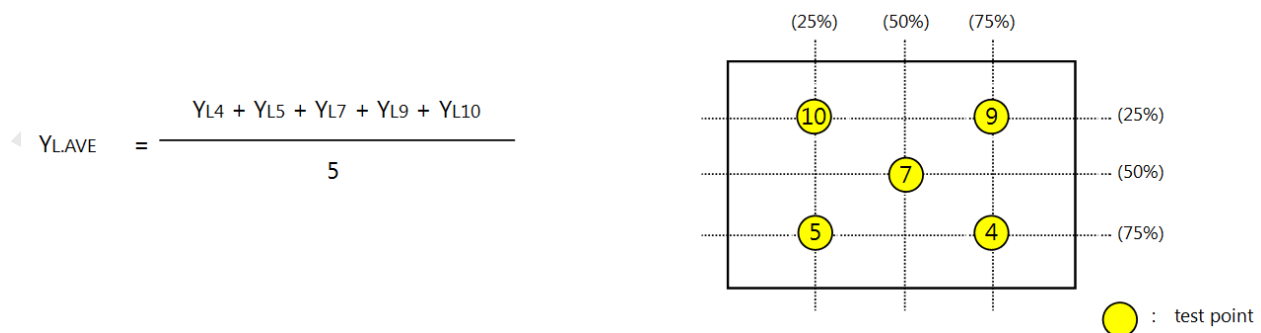
$$CR = \frac{CR(4) + CR(5) + CR(7) + CR(9) + CR(10)}{5}$$

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

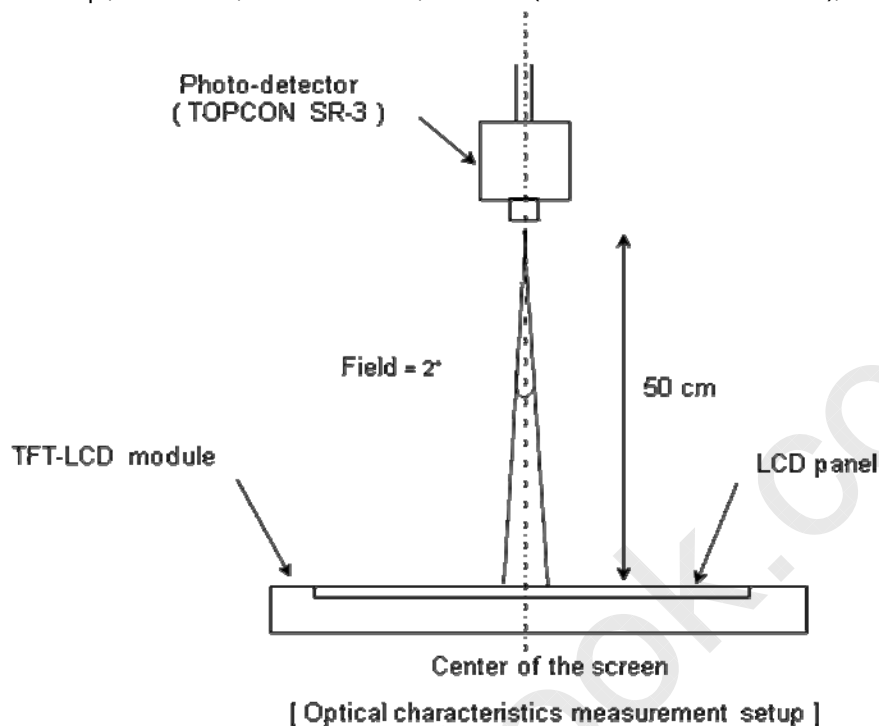
Note (3) The definition of Response time : Subtotal of the time, during which the transmission changes from 10% to 90% when the TFT turns on and off.



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

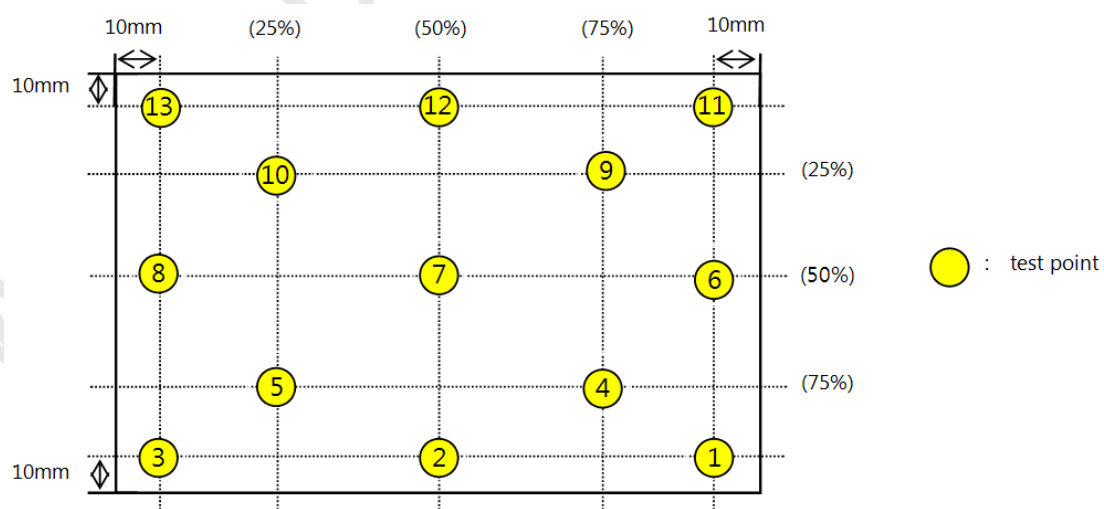


Note (5) Measure the panel, which is left for 30 min. at the normal temp. after leaving it for 30 min with turning the back light on at the rating. The measurement should be executed under the condition including the ambient temp., $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, the dark room, windless (removed the direct wind), and no vibration.



Note (6) The definition of white variation at 13 points (δ_L)

$$\delta_L = \frac{\text{Maximum luminance of 13 points}}{\text{Minimum luminance of 13 points}}$$



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

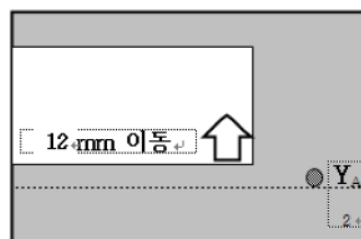
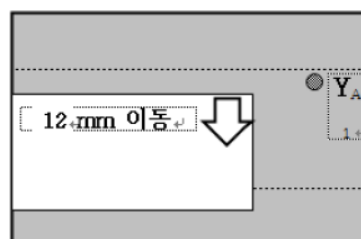
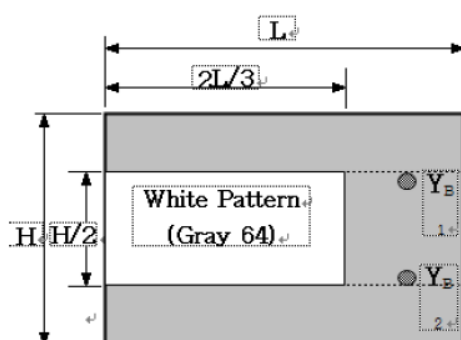
$$\text{Crosstalk Modulation Ratio}(D_{\text{SHA}}) = \frac{|Y_A - Y_B|}{Y_A} \times 100 (\%)$$

Where

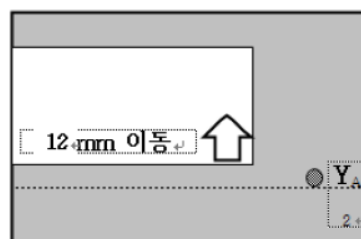
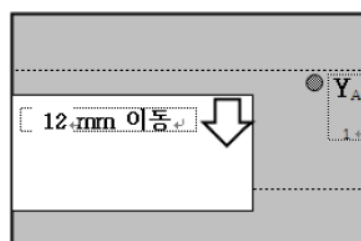
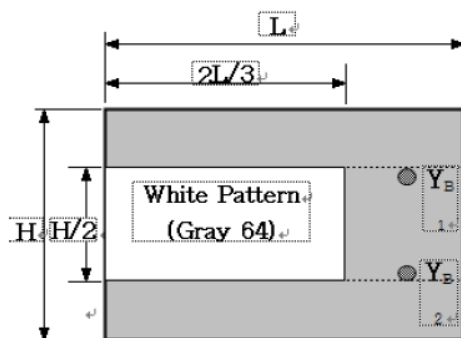
Y_A, Y_B = Measured under the 2° viewing angle (Measured area: $\psi 12$ mm)

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

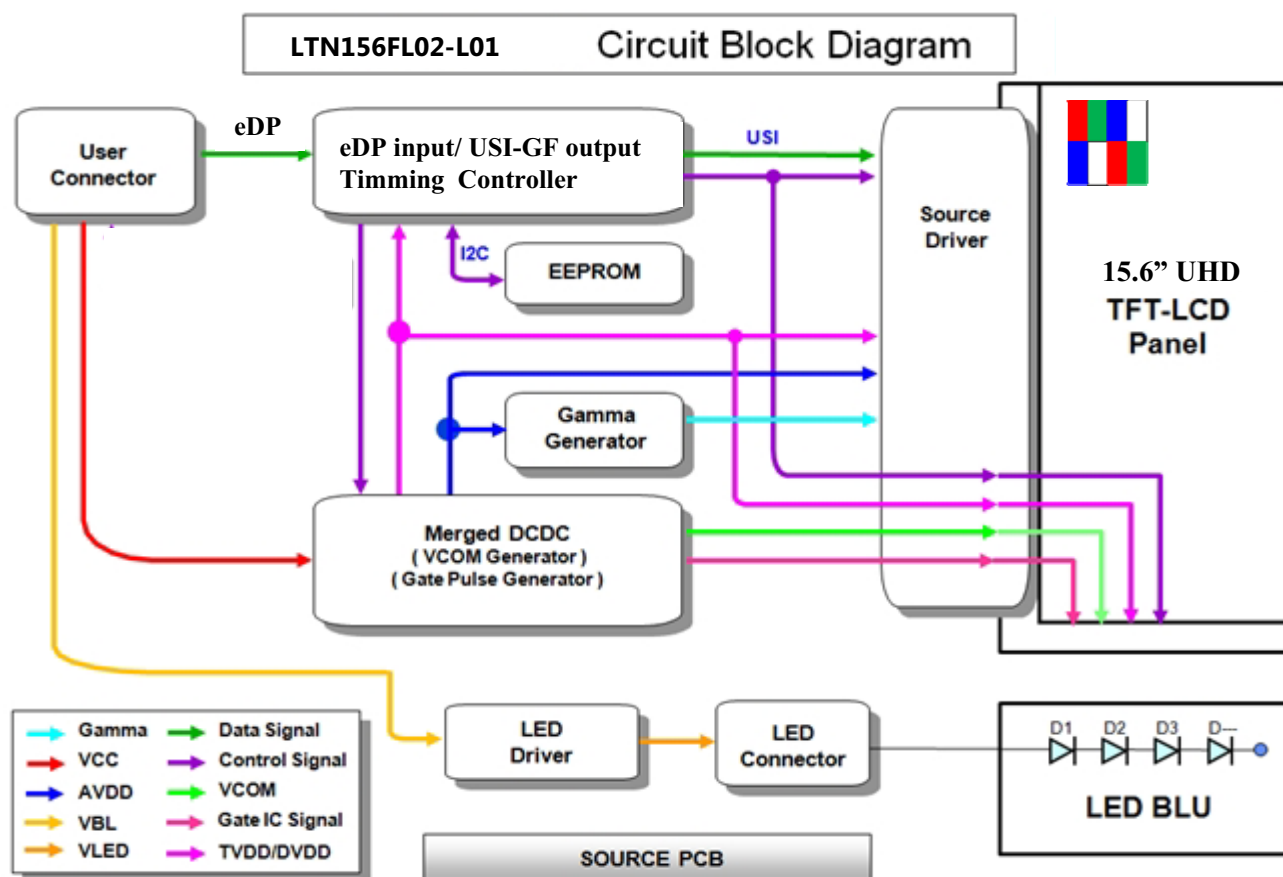


2) The method of measurement for vertical-crosstalk

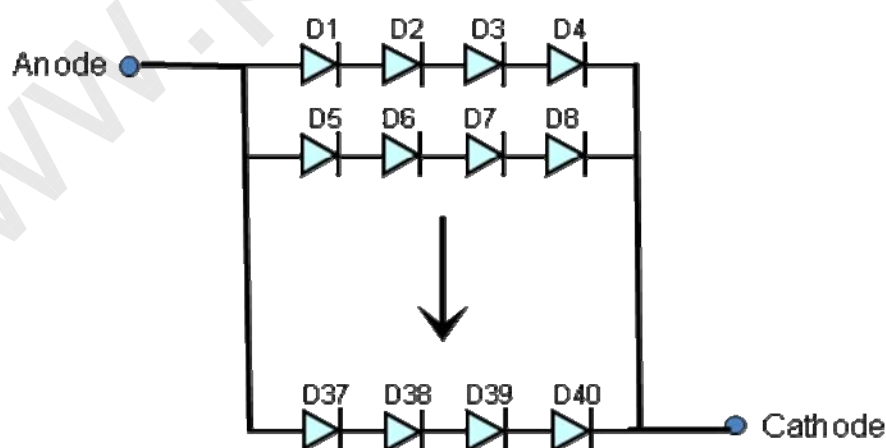


4. BLOCK DIAGRAM

4.1 TFT LCD MODULE



4.2 THE STRUCTURE OF LED PLACEMENT



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}	1.3 V _{LCD_VCC}	-	-	V	(1)
	Low	V _{IL}	-	-	0.5 V _{LCD_VCC}	V	
Vsync	60Hz	f _V	-	60	-	Hz	(3)
	50Hz	f _V	-	50	-	Hz	
	40Hz	f _V	-	40	-	Hz	
Hsync	60Hz	f _H	-	130.56	-	kHz	
Main Frequency	60Hz	f _{DCLK}	-	516.5	-	MHz	(3)
	50Hz	f _{DCLK}	-	430.4	-	MHz	
	40Hz	f _{DCLK}	-	344.3	-	MHz	
Rush Current		I _{RUSH}	-	-	1.5	A	(5)
Input Current	White	I _{LCD_VCC}	-	790	-	mA	(2)
	Mosaic	I _{LCD_VCC}	-	670	728		
	Black	I _{LCD_VCC}	-	575	-		
	V.Stripe	I _{LCD_VCC}	-	740	-		
	Red	I _{LCD_VCC}	-	700	-		
	Green	I _{LCD_VCC}	-	700	-		
	Blue	I _{LCD_VCC}	-	700	-		
	1Dot	I _{LCD_VCC}	-	705	-		
Logic Input Power Consumption (@Mosaic,300nit)		P _{LCD_VCC}	-		2.4	W	
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} = 516.5Mhz, V_{LCD_VCC} = 3.3V , DC Current., DBLC mode = Dynamic 84%

(3) In the case of 48Hz for sDRRS, FOS,

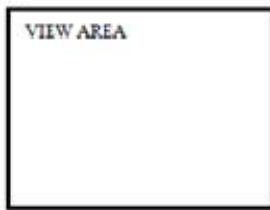
Flicker & Brightness are not guaranteed, because their level might be different from 60Hz operation.

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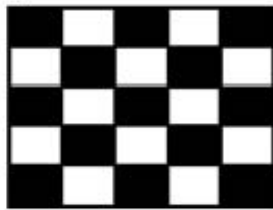
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Note (4) The dissipation pattern for power

a) White pattern..



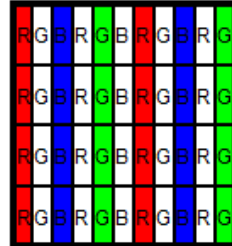
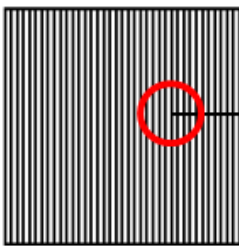
b) Mosaic pattern..



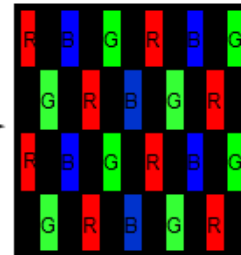
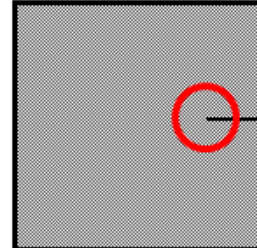
c) Black pattern..



*d) Vertical stripe pattern



*h) 1dot pattern



*e) Red Pattern



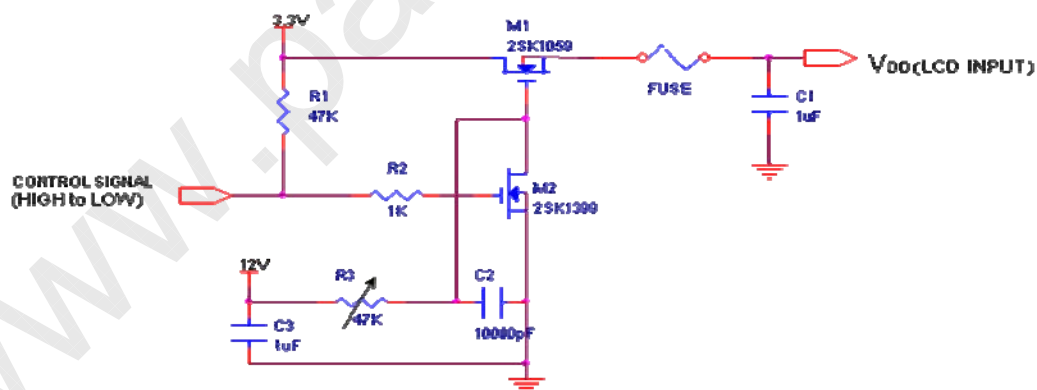
*f) Green Pattern



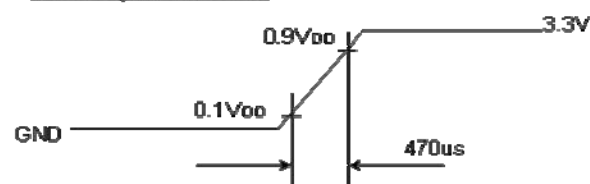
*g) Blue Pattern



Note (5) The condition for measurement for rush current



V_{DD} rising time is 470us



5.2 BACK LIGHT UNIT

Ta = 25 ± 2 °C

Item	Symbol	Min.	Typ.	Max.	Unit	Note
LED Forward Current	IF	-	24.5	-	mA	
LED Forward Voltage	VF	5.6	-	6	V	IF = 20mA
LED Array Voltage	VP	22.4	-	24	V	VF * LED Counts
LED Power Consumption	P	-	3.2	3.9	W	@300nit, (2)
		-	TBD	TBD	W	@Saturated color, (2)
LED Life time	Hr	15,000	-	-	Hours	(1)
LED Counts	Q	-	40	-	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= 24.5 mArms until the one of the following events occurs when the brightness becomes 50% or lower than the original..

Note (2) DBLC mode = Dynamic 84%

5.3 LED DRIVER

The manufacturer of LED driver: Richitek RT8543

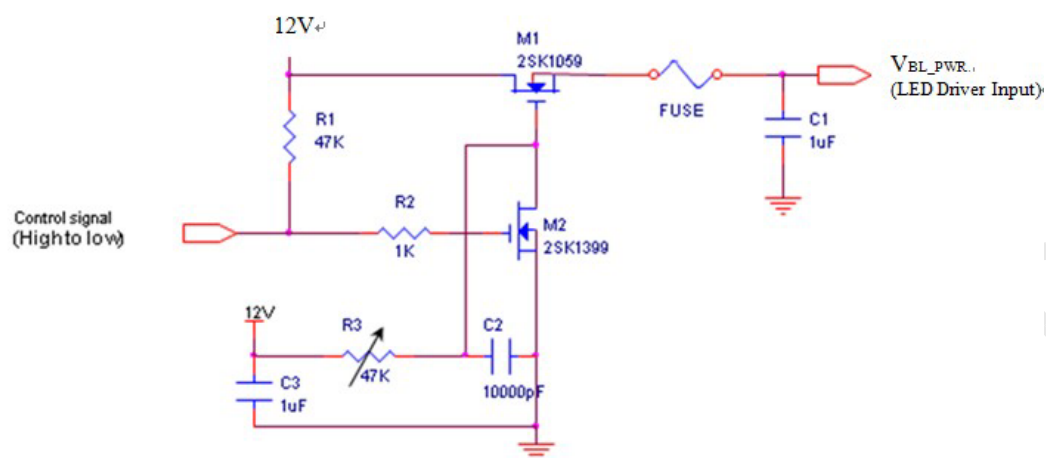
Ta= 25 ± 2 °C

Item		Symbol	Min.	Typ.	Max.	Unit	Note
Input Voltage		V _{BL_PWR}	5.5	12	21	V	
Input Current		I _{BL_PWR}	-	280	325	mA	Vin=12V Duty 100% @300nit
PWM duty Ratio		D _{BL_PWM_DIM}	1	-	100	%	
External PWM Frequency		F _{BL_PWM_DIM}	0.2	-	20	kHz	
PWM Resolution		R _{BL_PWM_DIM}	1	-	-	%	
In-Rush Current		I _{RUSH BL_PWR}	-	-	1.5	A	(1)
EN Control Level	High	V _{BL_ENABLE}	1.3	-	-	V	
	Low		-	-	0.8	V	
PWM Control Level	High	V _{BL_PWM_DIM}	1.3	-	-	V	
	Low		-	-	0.8	V	
V _{BL_PWR} @ LED Driver On		V _{BL_PWR}	6	-	-	V	
V _{BL_PWR} @ LED Driver Off		V _{BL_PWR}	-	-	5.5	V	
Operating frequency		FO	0.6	1	1.2	MHz	
Efficiency		η	-	85	-	%	

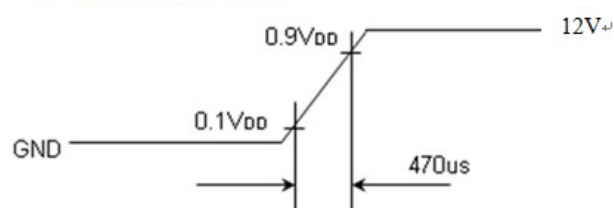
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Note (1) Rush current measurement condition



The V_{BL_PWR} rising time is 470us.

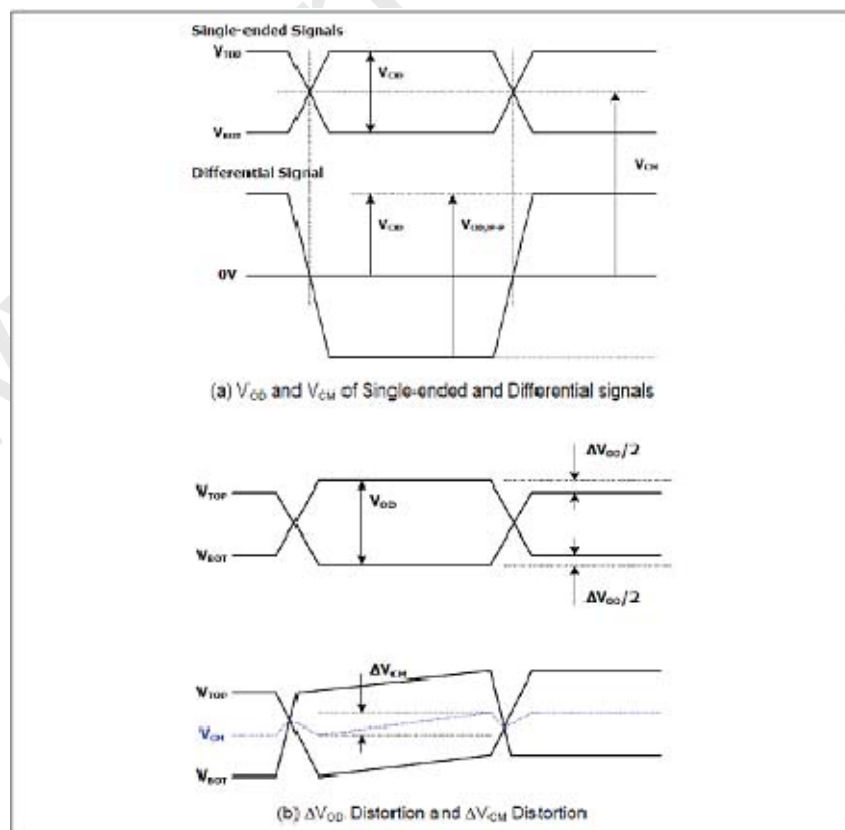


5.4 eDP INTERFACE

5.4.1 eDP Input Specifications

Symbol	Parameter	Min	Typ	Max	Unit
V_{OD}	Output differential voltage $ V_{TOP} - V_{BOT} $ 1	75	100	130	mV
		150	200	250	
		250	300	350	
		320	400	480	
		400	500	600	
		500	600	700	
V_{CM}	Output common mode voltage $(V_{TOP} + V_{BOT})/2$	0.4	0.55	0.65	V
ΔV_{OD}	Variation in V_{OD} between 0 and 1	-	-	30	mV
ΔV_{CM}	Variation in V_{CM} between 0 and 1	-	-	30	mV
R_{TX}	Transmitter differential output impedance ₂	70	100	130	ohm
		84	120	156	
		91	130	169	
		98	140	182	
		119	170	221	
		129.5	185	240.5	
		140	200	260	
		154	220	286	
		224	320	416	
		252	360	468	
		308	440	572	

1. $|V_{TOP}-V_{BOT}|$:To reduce power consumption and peak current, V_{OD} is programmed by an external EEPROM.
2. R_{TX} is programmed by an external EEPROM. This is for EMI reduction by controlling rising and falling time of output signals.





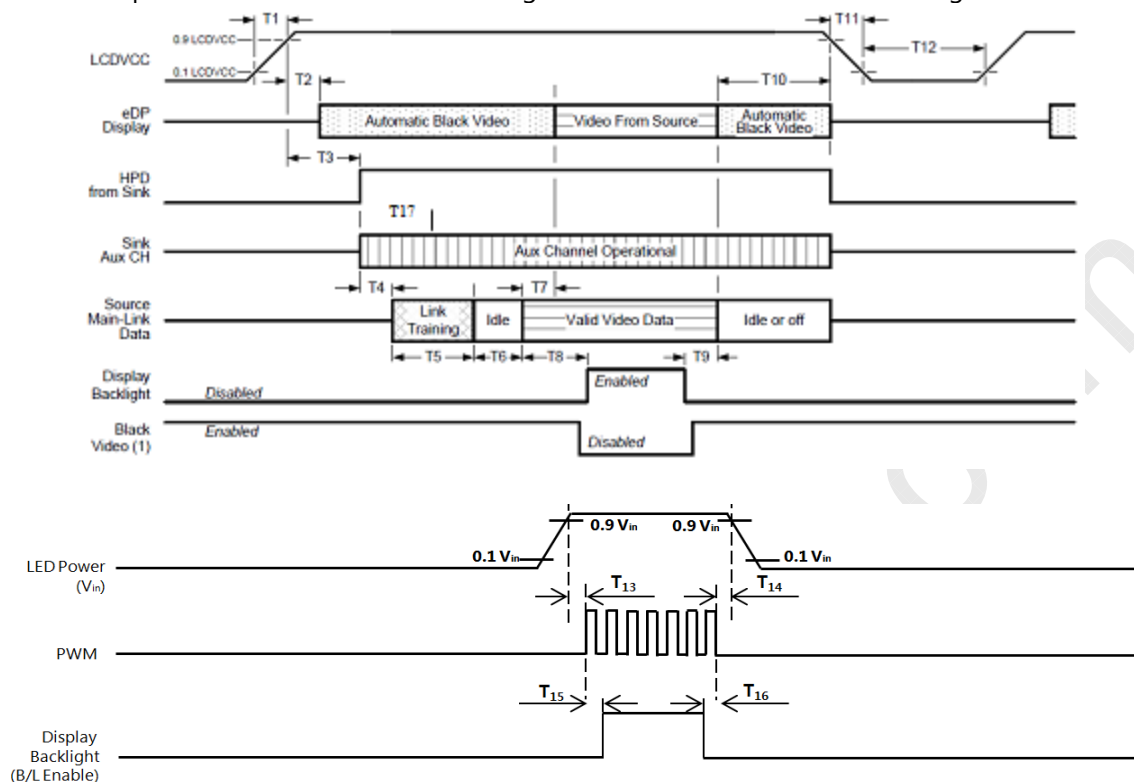
5.5 INTERFACE TIMING

5.5.1 TCON Video Format Margin

Signal	Min.	Typ.	Max.	
H active	-	3840	-	pixel
H blank	100	160	250	Pixel
H Total	3940	4000	4090	Pixel
V active	-	2160	-	Line
V blank	8	20	70	Line
V Total	2174	2180	2230	Line
Horizontal refresh rate	130.4	130.8	133.8	Khz
Vertical refresh rate	35	60	66	Hz

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.



Timing (ms)	Remarks	Note
$0.5 < T_1 \leq 10$	Power rail rise time, 10% to 90%	
$0 < T_2 \leq 200$	Delay from LCDVCC to automatic Black Video generation	(1)(2)
$0 < T_3 \leq 100$	Delay from LCDVCC to HPD high	(3)
$0 \leq T_4$	Delay from HPD high to link training initialization	
$0 \leq T_5$	Link training duration	
$0 \leq T_6$	Link idle	
$0 < T_7 \leq 50$	Delay from valid video data from Source to video on display	
$50 < T_8$	Delay from valid video data from Source to backlight enable	
$50 < T_9$	Delay from backlight disable to end of valid video data	(1)(2)
$0 < T_{10} \leq 500$	Delay from end of valid video data from Source to power off	
$0 < T_{11} \leq 20$	Power rail fall time, 90% to 10%	
$500 < T_{12}$	Power off time	
$0 < T_{13}$	Interval from LED driver Vin rising time 90% to PWM ON	
$0 < T_{14}$	Interval from PWM Off to LED driver Vin falling time 90%	
$0 \leq T_{15}$	Interval from PWM ON to B/L Enable ON	
$0 \leq T_{16}$	Interval from B/L Enable Off to PWM Off	
$300 \leq T_{17}$	Before the Green IP, register access such as ad mod change, To avoid malfunction	

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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.



5.7 INPUT TERMINAL PIN ASSIGNMENT

5.7.1 INPUT SIGNAL & POWER

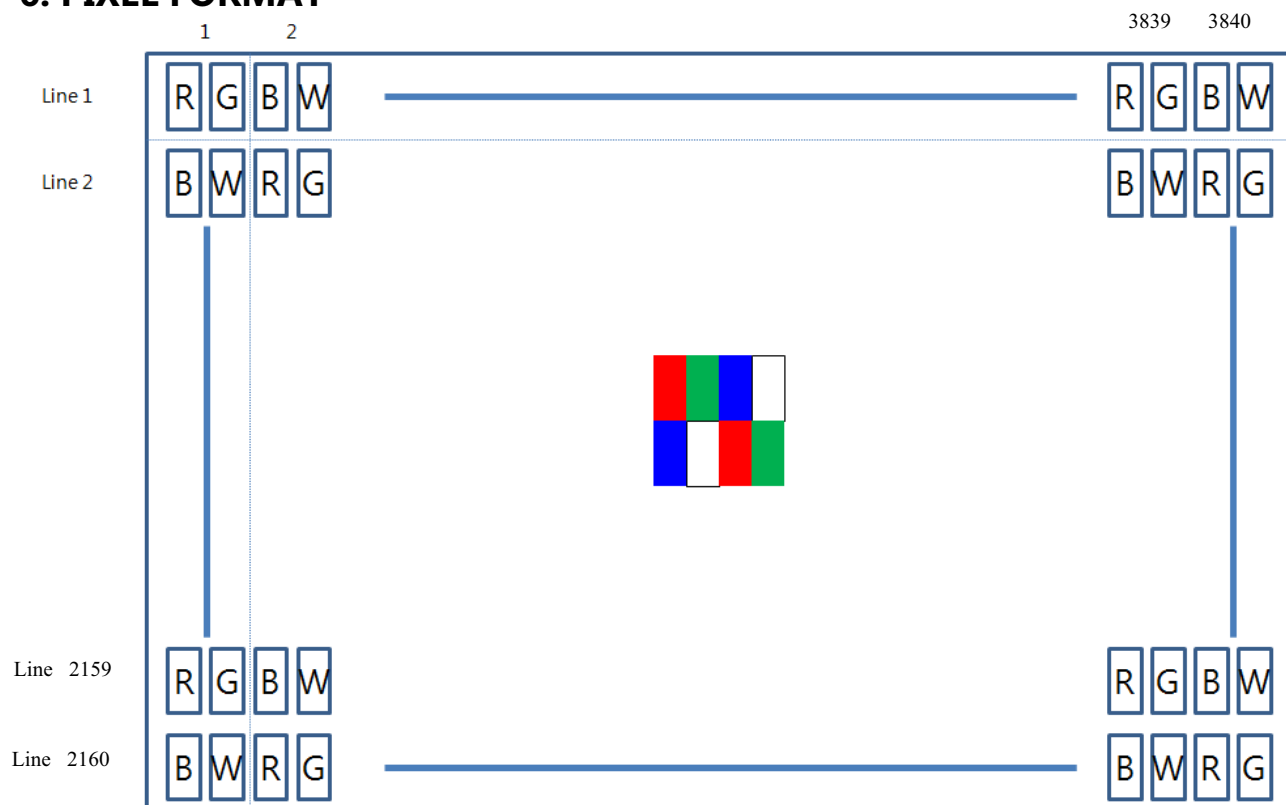
(eDP, Connector : 104062-4011 , Molex or the equipment with the equivalent capability)

Pin	Symbol	Function
1	DE_EN	APS on/off or No connection (optional)
2	H_GND	High Speed Ground
3	Lane3_N	Complement Signal Link Lane 3
4	Lane3_P	True Signal Link Lane 3
5	H_GND	High Speed Ground
6	Lane2_N	Complement Signal Link Lane 2
7	Lane2_P	True Signal Link Lane 2
8	H_GND	High Speed Ground
9	Lane1_N	Complement Signal Link Lane 1
10	Lane1_P	True Signal Link Lane 1
11	H_GND	High Speed Ground
12	Lane0_N	Complement Signal Link Lane 0
13	Lane0_P	True Signal Link Lane 0
14	H_GND	High Speed Ground
15	AUX_CH_P	True Signal Auxiliary Channel
16	AUX_CH_N	Complement Signal Auxiliary Channel
17	H_GND	High Speed Ground
18	LCD_VCC	LCD logic and driver power
19	LCD_VCC	LCD logic and driver power
20	LCD_VCC	LCD logic and driver power
21	LCD_VCC	LCD logic and driver power
22	BIST_EN	Reserved for LCD manufacturer's use (BIST_EN)
23	LCD_GND	LCD logic and driver ground
24	LCD_GND	LCD logic and driver ground
25	LCD_GND	LCD logic and driver ground
26	LCD_GND	LCD logic and driver ground
27	HPD	Hot Plug Detect
28	BL_GND	Backlight Ground
29	BL_GND	Backlight Ground
30	BL_GND	Backlight Ground
31	BL_GND	Backlight Ground
32	BL_ENABLE	Backlight on/off
33	BL_PWM_DIM	System PWM signal input for dimming
34	NC	No connection
35	NC	No connection
36	BL_PWR	Backlight power
37	BL_PWR	Backlight power
38	BL_PWR	Backlight power
39	BL_PWR	Backlight power
40	NC	No connection

SAMSUNG DISPLAY

Samsung Secret

6. PIXEL FORMAT



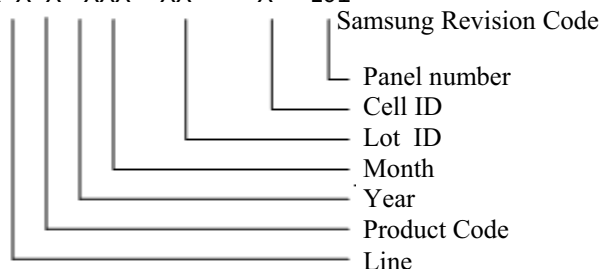
8. MARKING

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

(1)Parts number : LTN156FL02

(2)Revision code : 3 letters

(3)Lot number : X X X X XXX XX X L01



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.		

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

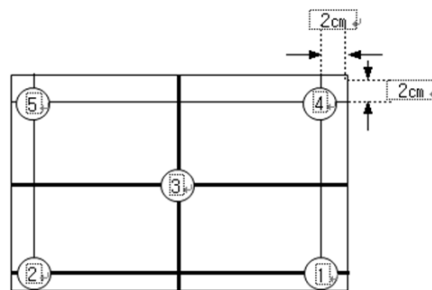
$T_a = 25 \pm 2^\circ\text{C}$, $V_{\text{LCD_VCC}} = 3.3\text{V}$, $f_v = 60\text{Hz}$, $f_{\text{DCLK}} = 361.31\text{ MHz}$, $I_F = \text{TBD}$

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

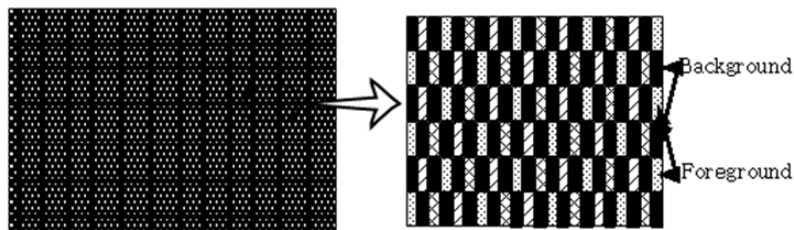
Note (8) The definition of flicker : The phenomenon, which the pixel on the screen of LCD panel blinks.

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 RT8510

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

Item	Symbol	Min.	Typ.	Max.	Unit	Note
OVP driving Voltage	V_{OVP}	-	-	TBD	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) $f_v = 60\text{Hz}$, $f_{\text{DCLK}} = \text{TBD}$, $V_{\text{LCD_VCC}} = 3.3\text{V}$, Sub Dot Pattern