SPECIFICATION
FOR
APPROVAL

( ) **Preliminary Specification**

(●) **Final Specification**

Title	98.0” QWUXGA TFT LCD

BUYER	
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LD980DQD
SUFFIX	FLM1(RoHS Verified)

APPROVED BY	SIGNATURE DATE
/	
/	
/	

Please return 1 copy for your confirmation with your signature and comments.

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TV Product Development Dept.
LG Display Co., Ltd.

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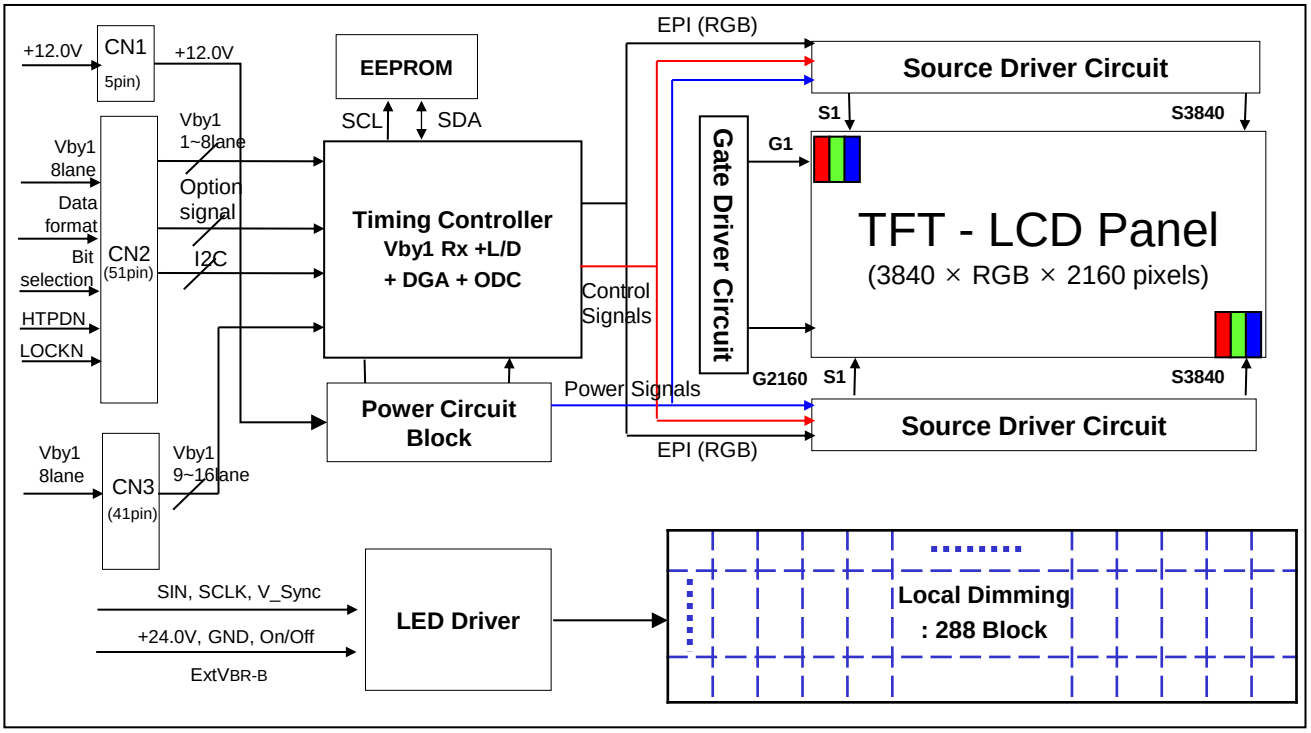
RECORD OF REVISIONS

Revision No.	Revision Date	Page	Description
0.0	Nov, 14, 2017	-	Preliminary Specification (First Draft)
1.0	May, 15, 2018	-	Final Specification

1. General Description

The LD980DQD is a Color Active Matrix Liquid Crystal Display with an integral Light Emitting Diode(LED) backlight system. The matrix employs a-Si Thin Film Transistor as the active element. It is a transmissive display type which is operating in the normally black mode. It has a 97.52 inch diagonally measured active display area with QWUXGA resolution (2160 vertical by 3840 horizontal pixel array). Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arrayed in vertical stripes. Gray scale or the luminance of the sub-pixel color is determined with a 10-bit gray scale signal for each dot. Therefore, it can present a palette of more than 1.07Bilion colors.
It has been designed to apply the 10-bit 16 Lane V by One interface.
It is intended to support LCD TV, PCTV where high brightness, super wide viewing angle, high color gamut, high color depth and fast response time are important.



Active Screen Size	97.52 inches(2476.95 mm) diagonal
Outline Dimension	2187.8(H) X 1242.8(V) X 31.0(B/D) (Typ.)
Pixel Pitch	0.5622mm x 0.5622mm
Pixel Format	3840 horiz. by 2160 vert. Pixels, RGB stripe arrangement
Color Depth	10bit(D), 1.07Billon colors
Luminance, White	500 cd/m^2 (Center 1point ,Typ.)
Viewing Angle (CR>10)	Viewing angle free (R/L 178 (Min.), U/D 178 (Min.))
Power Consumption	Total 453.2W (Typ.) [Logic= 18.1W, LED Driver=435.1W (ExtVbr_B=100%)
Weight	56Kg (Typ.)
Display Mode	Transmissive mode, Normally black
Surface Treatment	Hard coating(3H), Anti-glare treatment of the front polarizer(Haze 28%(Typ.))

2. Absolute Maximum Ratings

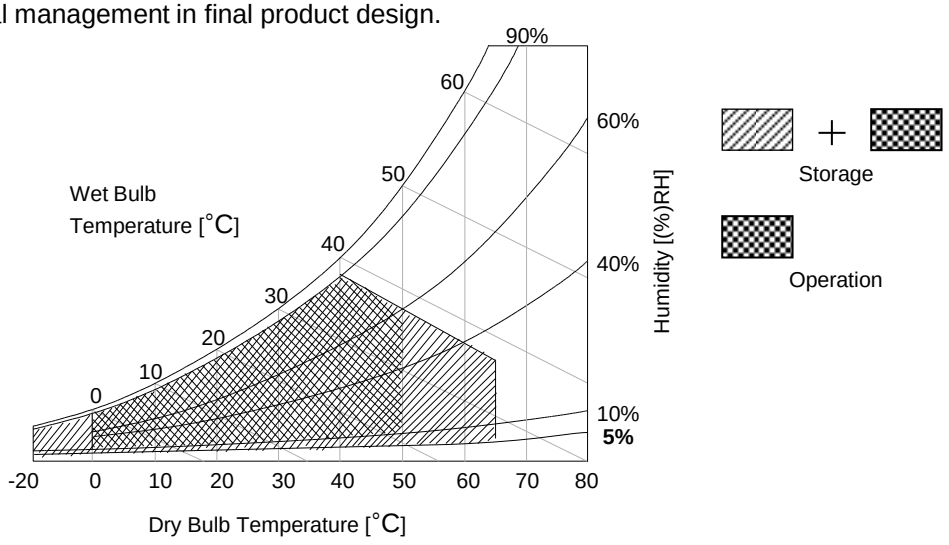
The following items are maximum values which, if exceeded, may cause faulty operation or permanent damage to the LCD module.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter		Symbol	Value		Unit	Notes
			Min	Max		
Power Input Voltage	LCD Circuit	V_{LCD}	-0.3	+14.0	V_{DC}	1
	Driver	V_{BL}	-0.3	+ 27.0	V_{DC}	
Driver Control Voltage	ON/OFF	V_{OFF} / V_{ON}	-0.3	+3.9	V_{DC}	
	Brightness	$EXTV_{BR-B}$	-0.3	+3.9	V_{DC}	
	Status	Status	-0.3	+3.9		
T-Con Option Selection Voltage		V_{LOGIC}	-0.3	+4.0	V_{DC}	
Operating Temperature		T_{OP}	0	+50	˚C	2,3
Storage Temperature		T_{ST}	-20	+65	˚C	
Panel Front Temperature		T_{SUR}	-	+68	˚C	4
Operating Ambient Humidity		H_{OP}	10	90	%RH	2,3
Storage Humidity		H_{ST}	5	90	%RH	

Notes

1. Ambient temperature condition (Ta = 25 ± 2 ˚C)
2. Temperature and relative humidity range are shown in the figure below.
   Wet bulb temperature should be Max 39˚C, and no condensation of water.
3. Gravity mura can be guaranteed below 40˚C condition.
4. The maximum operating temperatures is based on the test condition that the surface temperature of display area is less than or equal to 68˚C with LCD module alone in a temperature controlled chamber. Thermal management should be considered in final product design to prevent the surface temperature of display area from being over 68℃. The range of operating temperature may be degraded in case of improper thermal management in final product design.



3. Electrical Specifications

3-1. Electrical Characteristics

It requires two power inputs. One is employed to power for the LCD circuit. The other Is used for the LED backlight and LED Driver circuit.

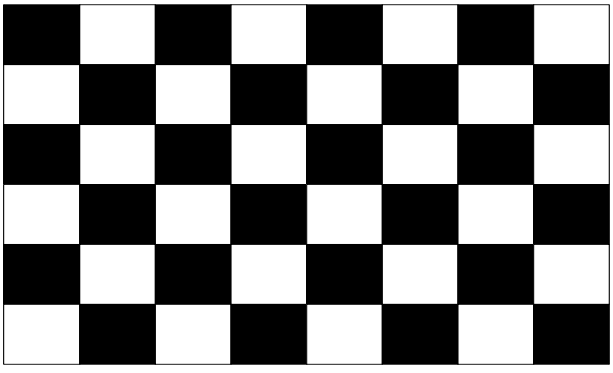
Table 2. ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Value			Unit	notes
		Min	Typ	Max		
Circuit :						
Power Input Voltage	V_{LCD}	10.8	12.0	13.2	V_{DC}	
Power Input Current	I_{LCD}	-	1505	1957	mA	1
		-	5048	6562	mA	2
Power Consumption	P_{LCD}	-	18.1	23.5	Watt	1
Rush current	I_{RUSH}	-	-	14	A	3

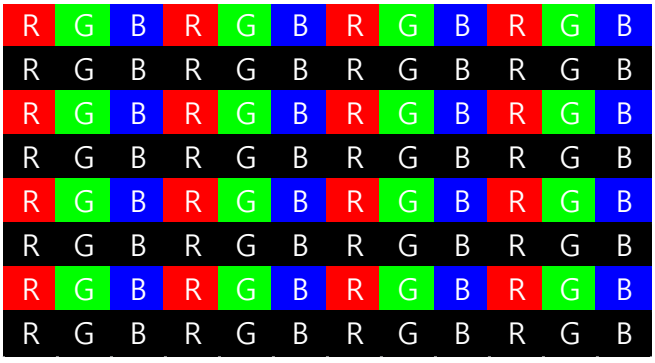
Notes

1. The specified current and power consumption are under the V_{LCD}=12.0V, Ta=25 ± 2°C, f_V=120Hz condition, and mosaic pattern(8 x 6) is displayed and f_V is the frame frequency.
2. The current is specified at the maximum current pattern.
3. The duration of rush current is about 2ms and rising time of power input is 0.5ms (min.).
4. Ripple voltage level is recommended under ±5% of typical voltage

White : 1023 Gray
Black : 0 Gray



Mosaic Pattern(8 x 6)



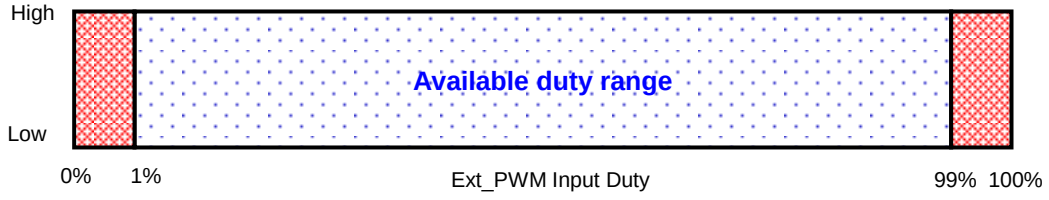
Max Current Pattern

Table 3. ELECTRICAL CHARACTERISTICS (Continue)

Parameter			Symbol	Values			Unit	Notes
				Min	Typ	Max		
LED Driver :								
Power Supply Input Voltage			VBL	21.6	24.0	26.4	Vdc	1
Power Supply Input Current			IBL	-	18.13	22.24	A	1
Power Supply Input Current (In-Rush)			In-rush	-	-	26.7	A	**VBL = 21.6V** ExtVBR-B=100% 4
Power Consumption (Total)			PBL	-	435.1	533.85	W	1
Input Voltage for Control System Signals	Oṅ/Off	On	V on	2.5	-	3.6	Vdc	
		Off	V off	-0.3	0.0	0.7	Vdc	
	Brightness Adjust		ExtVBR-B	1	-	100	%	On Duty
	PWM Frequency for NTSC & PAL		PAL		100		Hz	
			NTSC		120		Hz	
	Pulse Duty Level (PWM)		HighLevel	2.5	-	3.6	Vdc	HIGH : on duty LOW : off duty
			Low Level	0.0	-	0.7	Vdc	
LED :								
Life Time				30,000	50,000		Hrs	2

Notes :

1. Electrical characteristics are determined after the unit has been 'ON' and stable for approximately 60 minutes at 25±2°C. The specified current and power consumption are under the typical supply Input voltage 24Vand V_{BR} ($ExtV_{BR-B}$: 100%), it is total power consumption.
2. The life time (MTTF) is determined as the time which luminance of the LED is 50% compared to that of initial value at the typical LED current (ExtVBR-B :100%) on condition of continuous operating in LCM state at 25±2°C.
3. LGD recommend that the PWM freq. is synchronized with One time harmonic of V_sync signal of system. Though PWM frequency is over 120Hz (max 252Hz), function of LED Driver is not affected.
4. The duration of rush current is about 200ms. This duration is applied to LED on time
5. Even though inrush current is over the specified value, there is no problem if I^2T spec of fuse is satisfied.
6. Ext_PWM Signal have to input available duty range.
   Between 99% and 100% $ExtV_{BR-B}$ duty have to be avoided. (99% < $ExtV_{BR-B}$ < 100%)
   But $ExtV_{BR-B}$ 0% and 100% is possible.



3-2. Interface Connections

This LCD module employs three kinds of interface connection, 5-pin connector, 51-pin connector and 41-pin connector are used for the module electronics and 14-pin,12-pin connector is used for the integral backlight system.

3-2-1. LCD Module

- LCD Connector(CN1) : 20037WR-H05 (manufactured by YEONHO)
- Mating Connector : SMH200-H05M (YEONHO) or compatible

Table 4-1. MODULE CONNECTOR(CN1) PIN CONFIGURATION

No	Symbol	Description
1	GND	Ground
2	GND	Ground
3	VLCD	Power Supply +12.0V
4	VLCD	Power Supply +12.0V
5	VLCD	Power Supply +12.0V

- LCD Connector(CN1): FI-RE51S-HF(manufactured by JAE)
- Mating Connector : FI-R51HL(JAE)

Table 4-2. MODULE CONNECTOR(CN2) PIN CONFIGURATION

No	Symbol	Description	No	Symbol	Description
1	NC	Power Supply +12.0V (reserved)	27	GND	Ground
2	NC	Power Supply +12.0V (reserved)	28	Rx0n	V-by-One HS Data Lane 0
3	NC	Power Supply +12.0V (reserved)	29	Rx0p	V-by-One HS Data Lane 0
4	NC	Power Supply +12.0V (reserved)	30	GND	Ground
5	NC	Power Supply +12.0V (reserved)	31	Rx1n	V-by-One HS Data Lane 1
6	NC	Power Supply +12.0V (reserved)	32	Rx1p	V-by-One HS Data Lane 1
7	NC	Power Supply +12.0V (reserved)	33	GND	Ground
8	NC	Power Supply +12.0V (reserved)	34	Rx2n	V-by-One HS Data Lane 2
9	NC	No Connection(notes 4)	35	Rx2p	V-by-One HS Data Lane 2
10	GND	Ground	36	GND	Ground
11	GND	Ground	37	Rx3n	V-by-One HS Data Lane 3
12	GND	Ground	38	Rx3p	V-by-One HS Data Lane 3
13	GND	Ground	39	GND	Ground
14	GND	Ground	40	Rx4n	V-by-One HS Data Lane 4
15	Data format 0	Input Data Format [1:0] : '00'=Mode1, '01'=Mode2, '10'=Mode3, '11'=Mode4	41	Rx4p	V-by-One HS Data Lane 4
16	Data format 1		42	GND	Ground
17	NC	No Connnection(notes 4)	43	Rx5n	V-by-One HS Data Lane 5
18	NC	No Connnection(notes 4)	44	Rx5p	V-by-One HS Data Lane 5
19	NC	No Connnection(notes 4)	45	GND	Ground
20	NC	No Connnection(notes 4)	46	Rx6n	V-by-One HS Data Lane 6
21	Bit SEL	'H' or NC= 10bit(D) , 'L' = 8bit	47	Rx6p	V-by-One HS Data Lane 6
22	NC	NC (Local dimming default on)	48	GND	Ground
23	GND	Ground (notes 6)	49	Rx7n	V-by-One HS Data Lane 7
24	GND	Ground	50	Rx7p	V-by-One HS Data Lane 7
25	HTPDN	Hot plug detect	51	GND	Ground
26	LOCKN	Lock detect	-	-	-

Notes

1. All GND (ground) pins should be connected together to the LCD module's metal frame.
2. #1~#8 NC (No connection) : These pins are used for back up power source, V_{LCD} (power input) . These pins are should be connected together.
3. All Input levels of V-by-One signals are based on the V-by-One HS Standard Version 1.3.
4. #9, #17, #18, #19, #20, #22 NC (No Connection) : These pins are used only for LGD (Do not connect) If you need to test about local dimming function, Please see the **Appendix IV-3**.
5. About specific pin (#15,#16) , Please see the **Appendix VII**.
6. Specific pin No. **#23** is used for "No signal detection" of system signal interface. It should be GND for NSB (No Signal Black) while the system interface signal is not. If this pin is "H" or "NC", LCD Module displays AGP (Auto Generation Pattern).

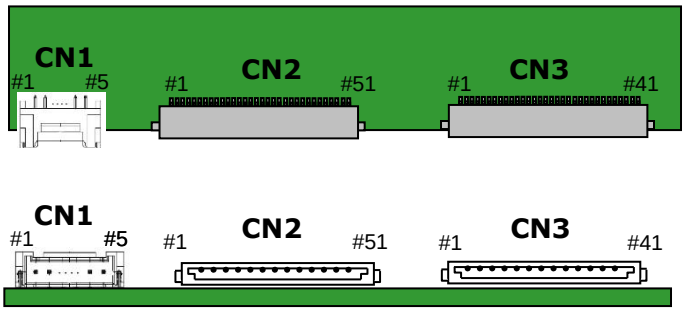
- LCD Connector (CN2) : FI-RE41S-HF (manufactured by JAE)
- Mating Connector : FI-RE41HL

Table 4-3. MODULE CONNECTOR(CN3) PIN CONFIGURATION

No	Symbol	Description		No	Symbol	Description
1	GND	Ground		22	GND	Ground
2	Rx8n	V-by-One HS Data Lane 8		23	Rx15n	V-by-One HS Data Lane 15
3	Rx8p	V-by-One HS Data Lane 8		24	Rx15p	V-by-One HS Data Lane 15
4	GND	Ground		25	GND	Ground
5	Rx9n	V-by-One HS Data Lane 9		26	NC	NO CONNECTION
6	Rx9p	V-by-One HS Data Lane 9		27	NC	NO CONNECTION
7	GND	Ground		28	NC	NO CONNECTION
8	Rx10n	V-by-One HS Data Lane 10		29	NC	NO CONNECTION
9	Rx10p	V-by-One HS Data Lane 10		30	NC	NO CONNECTION
10	GND	Ground		31	NC	NO CONNECTION
11	Rx11n	V-by-One HS Data Lane 11		32	NC	NO CONNECTION
12	Rx11p	V-by-One HS Data Lane 11		33	NC	NO CONNECTION
13	GND	Ground		34	NC	NO CONNECTION
14	Rx12n	V-by-One HS Data Lane 12		35	NC	NO CONNECTION
15	Rx12p	V-by-One HS Data Lane 12		36	NC	NO CONNECTION
16	GND	Ground		37	NC	NO CONNECTION
17	Rx13n	V-by-One HS Data Lane 13		38	NC	NO CONNECTION
18	Rx13p	V-by-One HS Data Lane 13		39	NC	NO CONNECTION
19	GND	Ground		40	NC	NO CONNECTION
20	Rx14n	V-by-One HS Data Lane 14		41	NC	NO CONNECTION
21	Rx14p	V-by-One HS Data Lane 14		-		

Notes

1. All GND (ground) pins should be connected together to the LCD module's metal frame.
2. #26~#41 NC (No Connection) : These pins are used only for LGD (Do not connect)



Rear view of LCM

3-2-2. Backlight Module

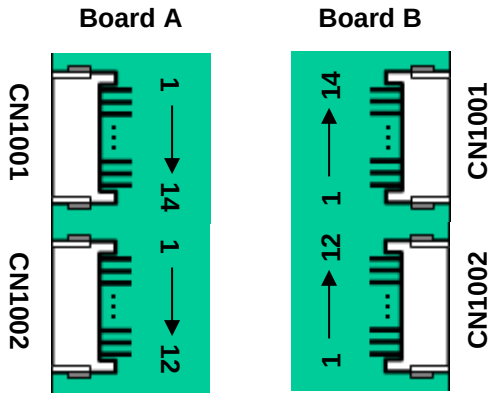
LED Driver Connector
: 20022WR - H14B2(Yeonho) , 20022WR-H12B2(Yeonho)
Mating Connector
: 20022HS-H14B2(Yeonho) or compatible, 20022HS-H12B2(Yeonho) or compatible

Table 5-1. LED DRIVER CONNECTOR PIN CONFIGURATION

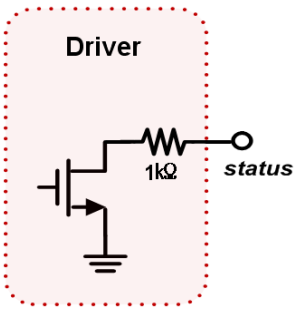
Pin No	Symbol	Description (CN1001)	Description (CN1002)	Note
1	VBL	Power Supply +24.0V	Power Supply +24.0V	
2	VBL	Power Supply +24.0V	Power Supply +24.0V	
3	VBL	Power Supply +24.0V	Power Supply +24.0V	
4	VBL	Power Supply +24.0V	Power Supply +24.0V	
5	VBL	Power Supply +24.0V	Power Supply +24.0V	
6	GND	Backlight Ground	Backlight Ground	1
7	GND	Backlight Ground	Backlight Ground	
8	GND	Backlight Ground	Backlight Ground	
9	GND	Backlight Ground	Backlight Ground	
10	GND	Backlight Ground	Backlight Ground	
11	Status	Backlight Status	Don't care	2
12	VON/OFF	Backlight ON/OFF control	Don't care	
13	NC	Don't care		
14	EXTVBR_B	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 , EXTVBR-B is 100%)
4. Each impedance of pin #12 and 14 is over 50 [KΩ] .

◆ Rear view of LCM



◆ Status



3-3. Signal Timing Specifications

Table 6 shows the signal timing required at the input of the LVDS transmitter. All of the interface signal timings should be satisfied with the following specification for normal operation.

Table 6. TIMING TABLE (DE Only Mode)

ITEM		Symbol	Min	Typ	Max	Unit	Note
Horizontal	Display Period	t_{HV}	240	240	240	t_{CLK}	3840/16
	Blank	t_{HB}	25	35	60	t_{CLK}	1
	Total	t_{HP}	265	275	300	t_{CLK}	
Vertical	Display Period	t_{VV}	2160	2160	2160	Lines	
	Blank	t_{VB}	40 (456)	90 (540)	172 (600)	Lines	1
	Total	t_{VP}	2200 (2616)	2250 (2700)	2332 (2760)	Lines	

ITEM		Symbol	Min	Typ	Max	Unit	Note
Frequency	DCLK	f_{CLK}	67	74.25	78.00	MHz	1188/16
	Horizontal	f_H	244	270	280	KHz	1
	Vertical	f_V	108 (95)	120 (100)	122 (104)	Hz	2 NTSC (PAL)

Notes:

1. The input of HSYNC & VSYNC signal does not have an effect on normal operation (DE Only Mode). If you use spread spectrum of EMI, add some additional clock to minimum value for clock margin.

2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rate and the horizontal frequency

※ Timing should be set based on clock frequency.

3-4. V by One input signal Characteristics

3-4-1. V by One Input Signal Timing Diagram

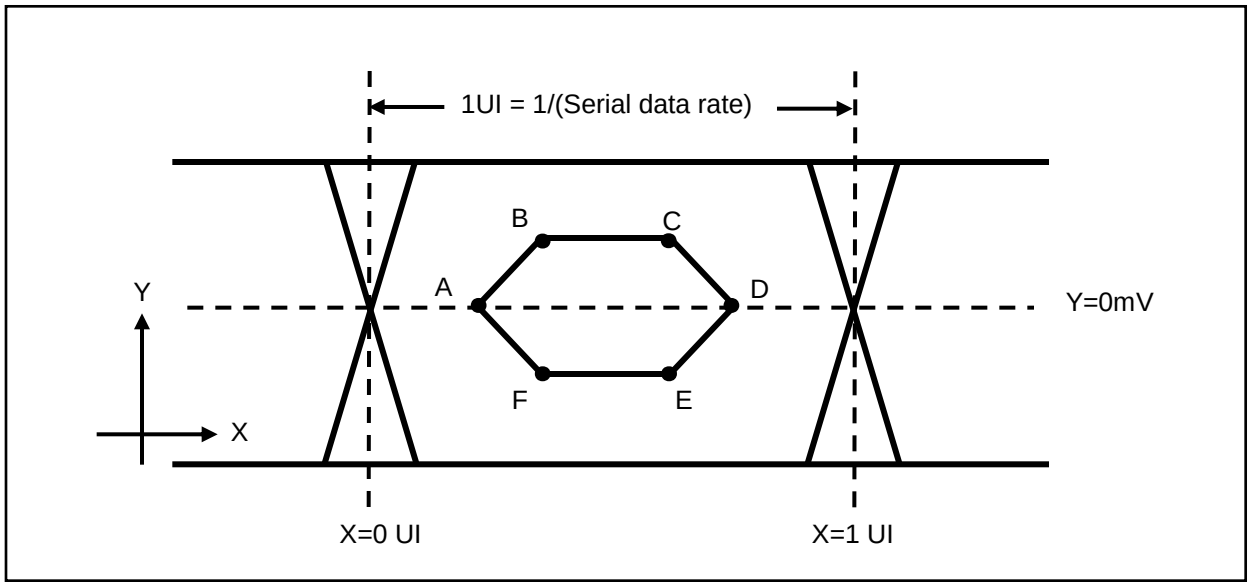


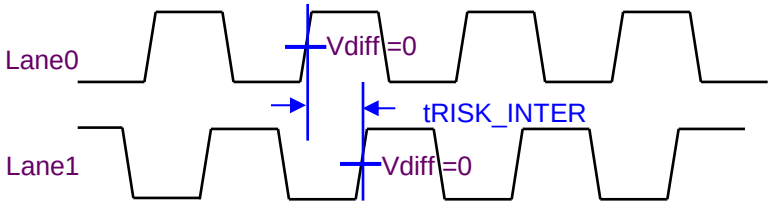
Table7. Eye Mask Specification

	X[UI]	Note	Y[mV]	Note
A	0.25 (max)	2	0	-
B	0.3 (max)	2	50	3
C	0.7(min)	3	50	3
D	0.75(min)	3	0	-
E	0.7(min)	3	I -50 I	3
F	0.3(max)	2	I -50 I	3

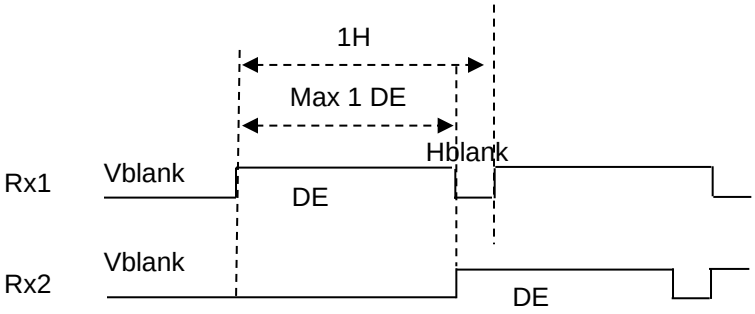
Notes

1. All Input levels of V by One signals are based on the V by One HS Standard Ver. 1.3
2. This is allowable maximum value.
3. This is allowable minimum value.
4. The eye diagram is measured by the oscilloscope and receiver CDR characteristic must be emulated.
   - PLL bandwidth : 20 Mhz
   - Damping Factor : 1.5

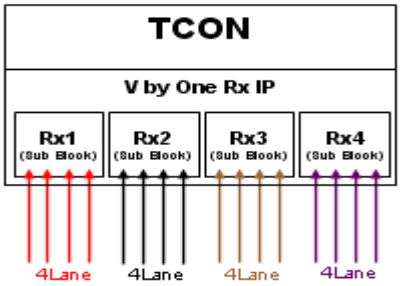
3-4-2. V by One Input Signal Characteristics



<Inter-pair Skew between two Lanes>



<Inter-pair Skew between two sub Blocks>



<TCON – VbyOne Brief Diagram >

Description	Symbol	Min	Max	Unit	notes
Allowable inter-pair skew between lanes	tRISK_INTER	-	5	UI	1,3
Allowable iner-pair skew between sub-blocks	tRISK_BLOCK	-	1	DE	1,4

Notes

1.1UI = 1/serial data rate

2. it is the time difference between the true and complementary single-ended signals.

3. it is the time difference of the differential voltage between any two lanes in one sub block.

4. it is the time difference of the differential voltage between any two blocks in one IP.

3-5. Color Data Reference

The brightness of each primary color (red, green, blue) is based on the 10bit or 8bit gray scale data input for the color.
The higher binary input, the brighter the color. Table 8 provides a reference for color versus data input.

Table 8. COLOR DATA REFERENCE

Packer input & Unpacker output		30bpp RGB (10bit)	24bpp RGB (8bit)
Byte0	D[0]	R[2]	R[0]
	D[1]	R[3]	R[1]
	D[2]	R[4]	R[2]
	D[3]	R[5]	R[3]
	D[4]	R[6]	R[4]
	D[5]	R[7]	R[5]
	D[6]	R[8]	R[6]
	D[7]	R[9]	R[7]
Byte1	D[8]	G[2]	G[0]
	D[9]	G[3]	G[1]
	D[10]	G[4]	G[2]
	D[11]	G[5]	G[3]
	D[12]	G[6]	G[4]
	D[13]	G[7]	G[5]
	D[14]	G[8]	G[6]
	D[15]	G[9]	G[7]
Byte2	D[16]	B[2]	B[0]
	D[17]	B[3]	B[1]
	D[18]	B[4]	B[2]
	D[19]	B[5]	B[3]
	D[20]	B[6]	B[4]
	D[21]	B[7]	B[5]
	D[22]	B[8]	B[6]
	D[23]	B[9]	B[7]
Byte3	D[24]	Don't care	
	D[25]	Don't care	
	D[26]	B[0]	
	D[27]	B[1]	
	D[28]	G[0]	
	D[29]	G[1]	
	D[30]	R[0]	
	D[31]	R[1]	

Notes 1. 30bpp RGB (10bit) is 4 byte mode, otherwise (24bpp RGB) 3byte mode

3-6. Power Sequence

3-6-1. LCD Driving circuit

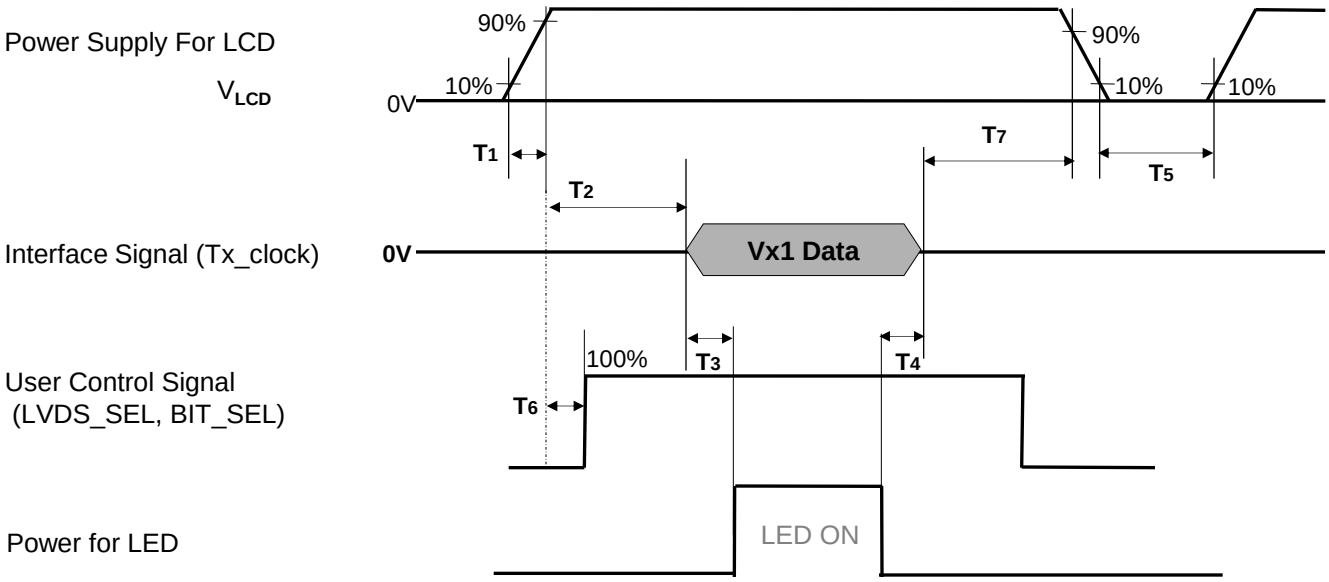


Table 9. POWER SEQUENCE

Parameter	Value			Unit	Note
	Min	Typ	Max		
T1	0.5	-	20	ms	1
T2	100	-	-	ms	2
T3	400	-	-	ms	3
T4	100	-	-	ms	3
T5	1.0	-	-	s	4
T6	0	-	T2	ms	5
T7	0	-	-	ms	6

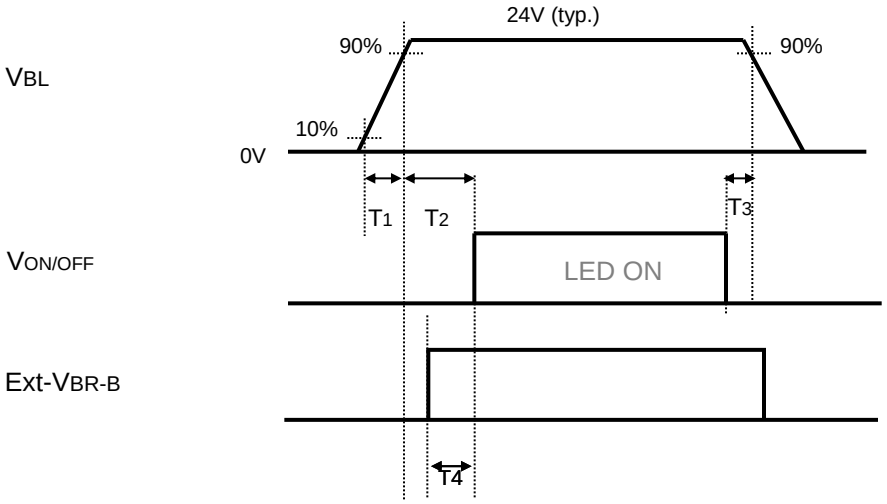
Notes

1. Even though T1 is over the specified value, there is no problem if I2T spec of fuse is satisfied.
2. If T2 is satisfied with specification after removing LVDS Cable, there is no problem.
3. The T3 / T4 is recommended value, the case when failed to meet a minimum specification, abnormal display would be shown. There is no reliability problem.
4. T5 should be measured after the Module has been fully discharged between power off and on period.
5. If the on time of signals (Interface signal and user control signals) precedes the on time of Power (V_{LCD}), it will be happened abnormal display. When T6 is NC status, T6 doesn't need to be measured.
6. It is recommendation specification that T7 has to be 0ms as a minimum value.

※ Please avoid floating state of interface signal at invalid period.
※ When the power supply for LCD (VLCD) is off, be sure to pull down the valid and invalid data to 0V.

3-6-2. Sequence for LED Driver

Power Supply For LED Driver



3-6-3. Dip condition for LED Driver

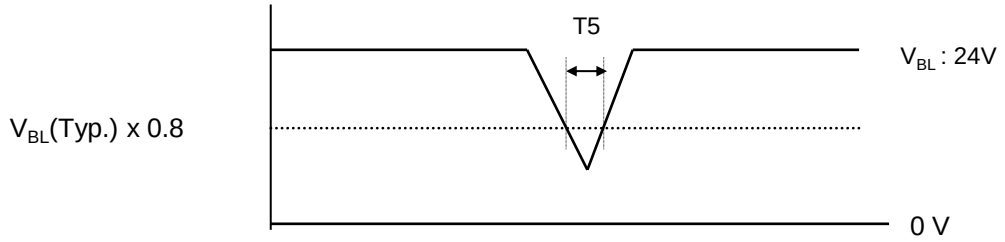


Table 10. Power Sequence for LED Driver

Parameter	Values			Units	Remarks
	Min	Typ	Max		
T1	20	-	-	ms	1
T2	500	-	-	ms	
T3	10		-	ms	
T4	0	-	-	ms	
T5	-	-	10	ms	V_{BL}(Typ) x 0.8

Notes

1. T1 describes rising time of 0V to 24V and this parameter does not applied at restarting time. Even though T1 is over the specified value, there is no problem if I^2T spec of fuse is satisfied.

4. Optical Specification

Optical characteristics are determined after the unit has been 'ON' and stable in a dark environment at 25±2°C. The values are specified at distance 50cm from the LCD surface at a viewing angle of Φ and θ equal to 0 °. FIG. 1 shows additional information concerning the measurement equipment and method.

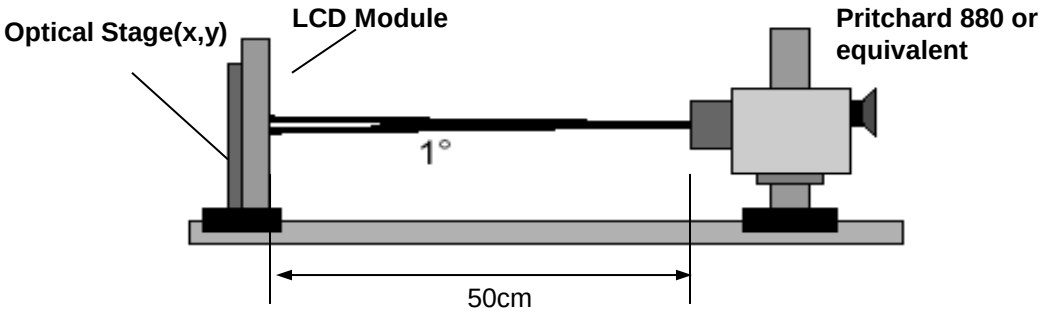


FIG. 1 Optical Characteristic Measurement Equipment and Method

Table 11. OPTICAL CHARACTERISTICS

Ta= 25±2°C, V_{LCD}=12.0V, fv=120Hz, Dclk=74.25MHz, **EXTV**BR-B =100%

Parameter		Symbol		Value			Unit	notes
				Min.	Typ.	Max.		
Contrast Ratio		CR		900	1300	-		1
Surface Luminance, white		L_{WH}	2D	400	500		cd/m²	2
Luminance Variation		δ_{WHITE}	9P	75			%	3
Response Time	Gray-to-Gray	G to G		-	8	12	ms	4
	Uniformity	$\delta_{G TO G}$		-	-	1		
Color Coordinates [CIE1931]	RED	Rx		Typ -0.03	0.656	Typ +0.03		
		Ry			0.333			
	GREEN	Gx			0.312			
		Gy			0.597			
	BLUE	Bx			0.151			
		By			0.058			
	WHITE	Wx			0.281			
		Wy			0.288			
Color Temperature					10,000		K	
Color Gamut					72		%	
Viewing Angle (CR>10)	right(ϕ=0°)	θr (x axis)		89	-	-	degree	5
	left (ϕ=180°)	θl (x axis)		89	-	-		
	up (ϕ=90°)	θu (y axis)		89	-	-		
	down (ϕ=270°)	θd (y axis)		89	-	-		
Gray Scale				-	-	-		6

Notes

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

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

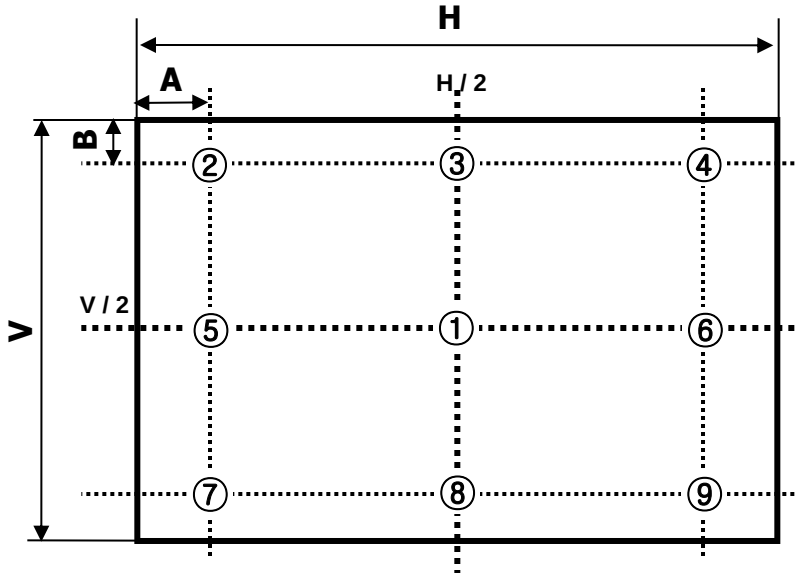
It is measured at center 1-point.

2. Surface luminance is determined after the unit has been 'ON' and 1 Hour after lighting the backlight in a dark environment at 25±2°C. Surface luminance is the luminance value at center 1-point across the LCD surface 50cm from the surface with all pixels displaying white. For more information see the FIG. 2.
3. The variation in surface luminance , δ WHITE is defined as :
   δ WHITE(9P) = Minimum (Lon1,Lon2~ Lon8, Lon9) / Maximum (Lon1,Lon2~ Lon8, Lon9)*100
   Where Lon1 to Lon9 are the luminance with all pixels displaying white at 9 locations
   For more information, see the FIG. 2.
4. Response time is the time required for the display to transit from G(N) to G(M) (Rise Time, Tr_R) and from G(M) to G(N) (Decay Time, Tr_D). For additional information see the FIG. 3. (N<M)
   ※ G to G Spec stands for average value of all measured points.
   Photo Detector : RD-80S / Field : 2°
   ※. Gray to Gray / Response time uniformity is Reference data. Appendix VI
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 module surface. For more information, see the FIG. 4.
6. Gray scale specification
   Gamma Value is approximately 2.2. For more information, see the Table 12.

Table 12. GRAY SCALE SPECIFICATION

Gray Level	Luminance [%] (Typ)
L0	0.077
L63	0.27
L127	1.04
L191	2.49
L255	4.68
L319	7.66
L383	11.5
L447	16.1
L511	21.6
L575	28.1
L639	35.4
L703	43.7
L767	53.0
L831	63.2
L895	74.5
L959	86.7
L1023	100

Measuring point for surface luminance & measuring point for luminance variation.



A : H / 9 mm
B : V / 9 mm
@ H,V : Active Area

FIG. 2 9 Points for Luminance Measure

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

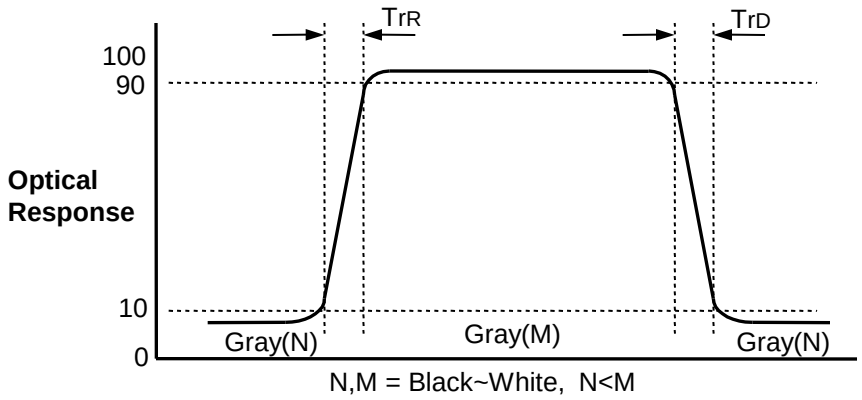


FIG. 3 Response Time

Dimension of viewing angle range

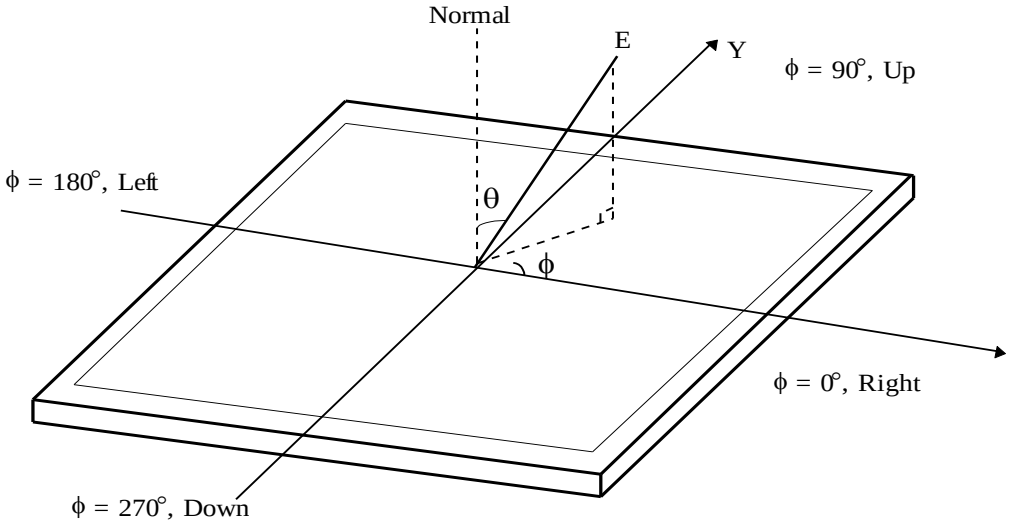


FIG. 4 Viewing Angle

5. Mechanical Characteristics

Table 13 provides general mechanical characteristics.

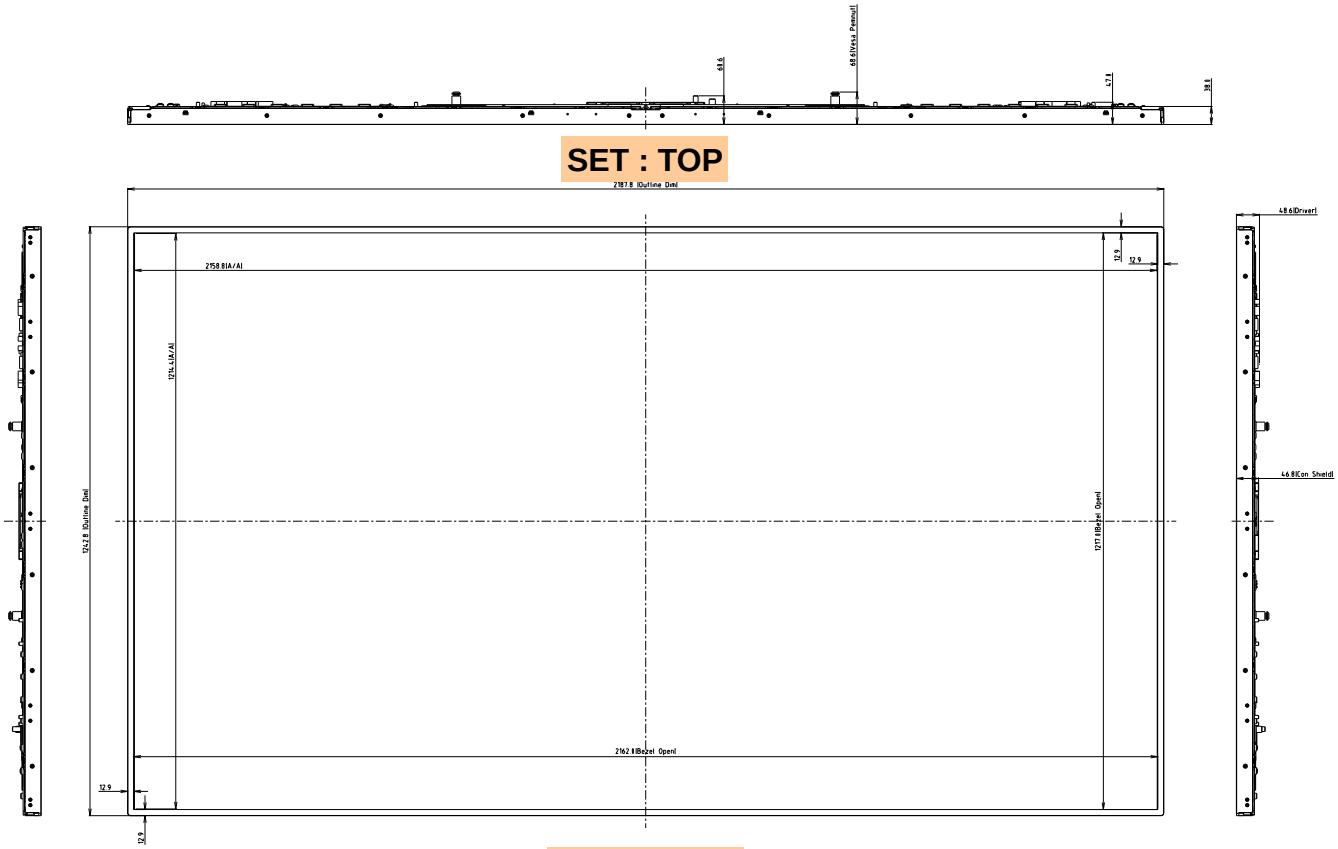
Table 13. MECHANICAL CHARACTERISTICS

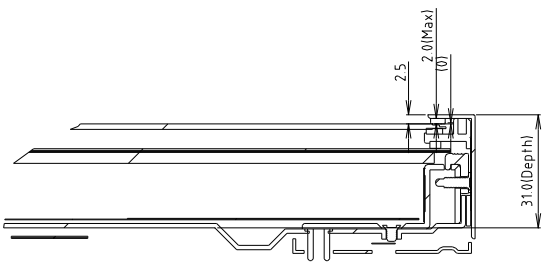
Item	Value	
Outline Dimension	Horizontal	2187.8 mm
	Vertical	1242.8mm
	Depth	31.0 mm
Bezel Area	Horizontal	2162.0mm
	Vertical	1217.0 mm
Active Display Area	Horizontal	2158.848mm
	Vertical	1214.352 mm
Weight	56kg (Typ.), 59 kg (Max.)	

Notes

1. Please refer to a mechanical drawing in terms of tolerance at the next page.

[FRONT VIEW]

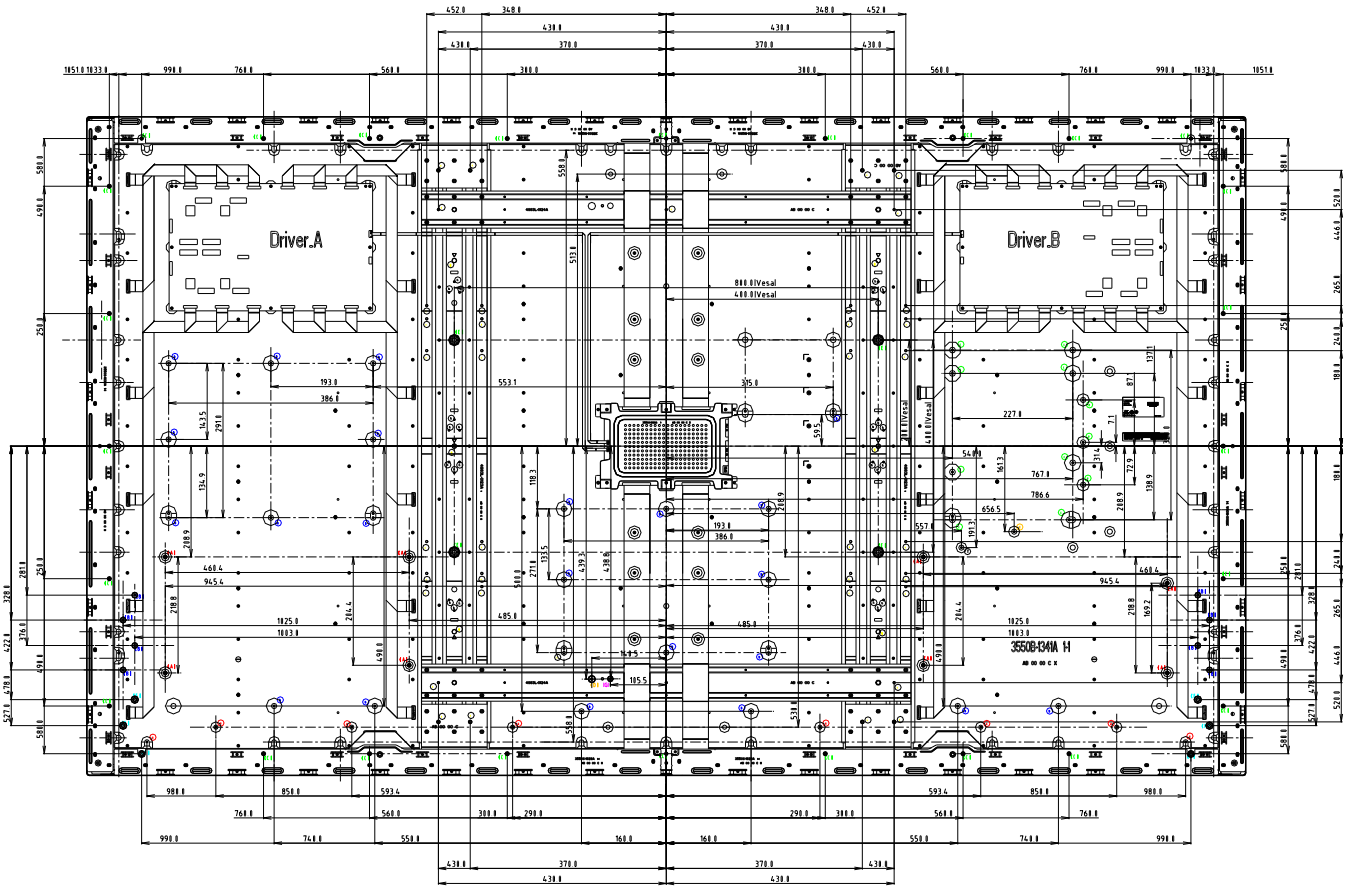




SECTION center_horizon-center_horizon
SCALE 3/4

[REAR VIEW]

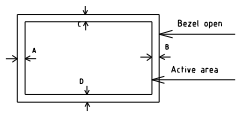
SET : TOP



SET : DOWN

ITEM	TAP	Max Depth [mm]	Torque [kgf.cm]	Height [mm]	Notes
A	M3	5.0	MAX 8.0	6.0	
B	M3	9.0	MAX 8.0	10.0	
C	M3	9.0	MAX 8.0	10.4	
D	M3	4.4	MAX 8.0	5.6	
E	M3	5.0	MAX 8.0	6.0	
F	M3	4.4	MAX 8.0	5.0	
G	M8	5.0	MAX 8.0	8.0	
H	M3	5.0	MAX 8.0	8.0	
I	M4	6.5	MAX 11.0	10.0	
HH	M3	10.0	MAX 8.0	16.0	Pemnut
III	M3	7.0	MAX 8.0	12.0	Pemnut
KK	M3	5.0	MAX 8.0	9.0	Pemnut
JJJ	M4	10.0	MAX 11.0	22.0	Pemnut
LLL	M8	15.0	MAX 15.0	37.6	Wire Pemnut
MM	M6	7.0	MAX 11.0	13.5	Pemnut
NNN	M3	10.0	MAX 8.0	29.6	Pemnut

NOTES
1. Tolerance of Outline Dimension/Body Depth is ±1.0mm
2. Pemnut and UDM Dimension Tolerance is ±0.6mm
3. Unspecified Dimension Tolerance is ±1.0mm
4. Tolerance of Body Depth with Cover shieldis is +2.0/-1.0mm
5. TILT AND PARTIAL DISPOSITION TOLERANCE OF DISPLAY AREA AS FOLLOWING.
(1) Y-DIRECTION: IA-BI≤2.0
(2) X-DIRECTION: IC-DI≤2.0



6. Reliability

Table 14. ENVIRONMENT TEST CONDITION

No.	Test Item	Condition
1	High temperature storage test	Ta= 60˚C 90% 240h
2	Low temperature storage test	Ta= -20˚C 240h
3	High temperature operation test	Ta= 50˚C 50%RH 500h
4	Low temperature operation test	Ta= 0˚C 500h
5	Humidity condition Operation	Ta= 40 ˚C ,90%RH
6	Altitude operating storage / shipment	0 - 16,400 ft 0 - 40,000 ft

Notes

1. Before and after Reliability test, LCM should be operated with normal function.

7. International Standards

7-1. Safety

a) UL 60065, Underwriters Laboratories Inc.
Audio, Video and Similar Electronic Apparatus - Safety Requirements.

b) CAN/CSA-C22.2 No. 60065-03, Canadian Standards Association.
Audio, Video and Similar Electronic Apparatus - Safety Requirements.

c) EN 60065, European Committee for Electrotechnical Standardization (CENELEC).
Audio, Video and Similar Electronic Apparatus - Safety Requirements.

d) IEC 60065, The International Electrotechnical Commission (IEC).
Audio, Video and Similar Electronic Apparatus - 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. Information of LCM Label

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.

Notes

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 Pallet : 4 pcs

b) Pallet Size : 2500mm(W) X 760mm(D) X 1574mm(H)

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 specified mounting holes (Details refer to the drawings).
(2) You should consider the mounting structure so that uneven force (ex. Twisted stress, Concentrated 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 benzine. 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) Touching the LED Driver might cause an electric shock and damage to LED Driver. Please always use antistatic tools when handling the LED Driver

9-2. Operating Precautions

(1) Response time depends on the temperature.(In lower temperature, it becomes longer.)
(2) Brightness depends on the temperature. (In lower temperature, it becomes lower.)
And in lower temperature, response time(required time that brightness is stable after turned on) becomes longer
(3) 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.
(4) When fixed patterns are displayed for a long time, remnant image is likely to occur.
(5) 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.
(6) Please do not give any mechanical and/or acoustical impact to LCM. Otherwise, LCM can't be operated its full characteristics perfectly.
(7) A screw which is fastened up the steels should be a machine screw.
(if not, it can causes conductive particles and deal LCM a fatal blow)
(8) Please do not set LCD on its edge.
(9) The conductive material and signal cables are kept away from LED driver inductor to prevent abnormal display, sound noise and temperature rising.

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.
(3) Storage condition is guaranteed under packing conditions.
(4) The phase transition of Liquid Crystal in the condition of the low or high storage temperature will be recovered when the LCD module returns to the normal condition.

9-6. Appropriate Condition for Public Display

- Generally large-sized LCD modules are designed for consumer applications (TV).
Accordingly, a long-term display like in Public Display (PD) application, can cause uneven display including image sticking. To optimize module's lifetime and function, several operating usages are required.

1. Normal operating condition]
- Temperature: 0 ~ 40℃
- Operating Ambient Humidity : 10 ~ 90 %
- Display pattern: dynamic pattern (Real display)
Note) Long-term static display can cause image sticking.

2. Operating usages under abnormal condition
a. Ambient condition
- Well-ventilated place is recommended to set up PD system.
b. Power and screen save
- Periodical power-off or screen save is needed after long-term display.

3. Operating usages to protect against image sticking due to long-term static display
   a. Suitable operating time on ‘Static Image’ : Under 18 hours a day
      (* The moving picture can be allowed for 24 hours a day)
   b. Static information display recommended to use with moving image.
      - Cycling display between 5 minutes' information(static) display and 10 seconds' moving image.
   c. Background and character (image) color change
      - Use different colors for background and character, respectively.
      - Change colors themselves periodically.
   d. Avoid combination of background and character with large different luminance.
   1) Abnormal condition just means conditions except normal condition.
   2) Black image or moving image is strongly recommended as a screen save.

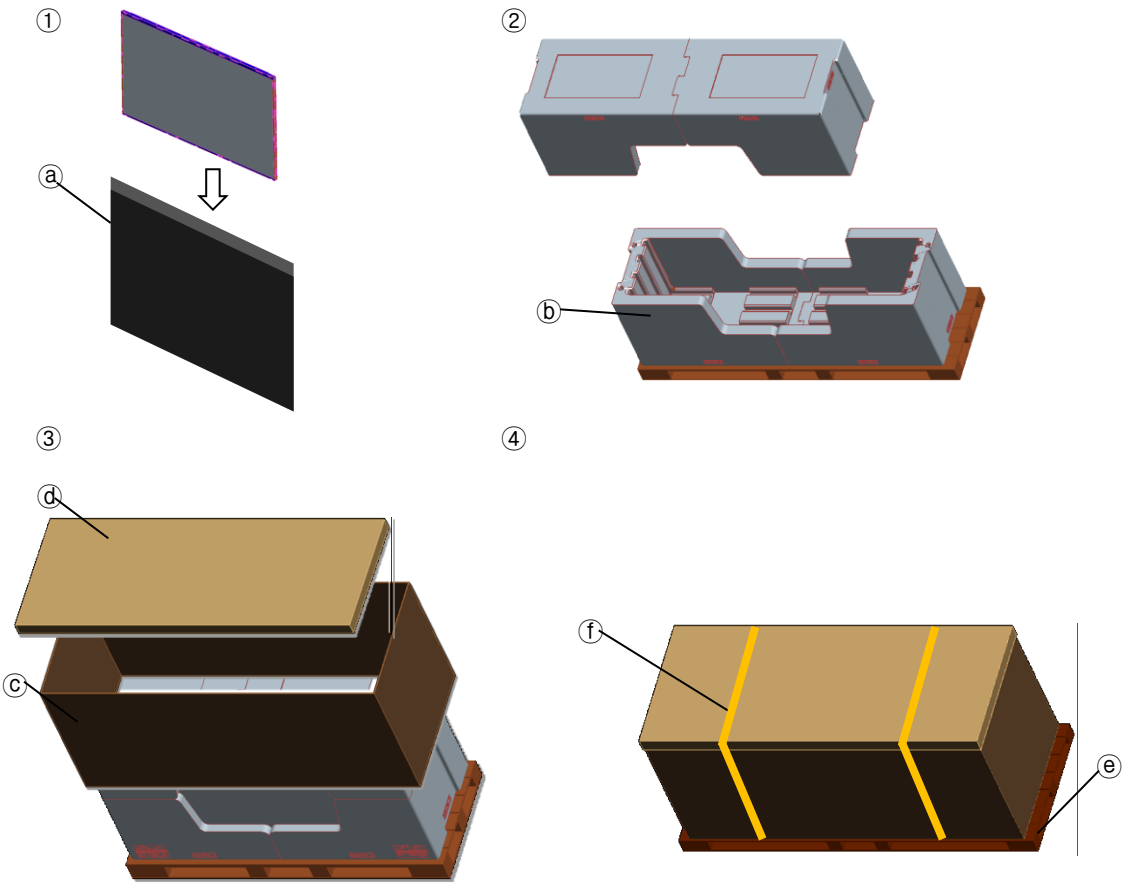
4. Lifetime in this spec. is guaranteed only when PD is used according to operating usages.

5. Module should be turned counterclockwise based on front view when used in portrait mode.

APPENDIX-I

■ Pallet Ass'y

<PJ>



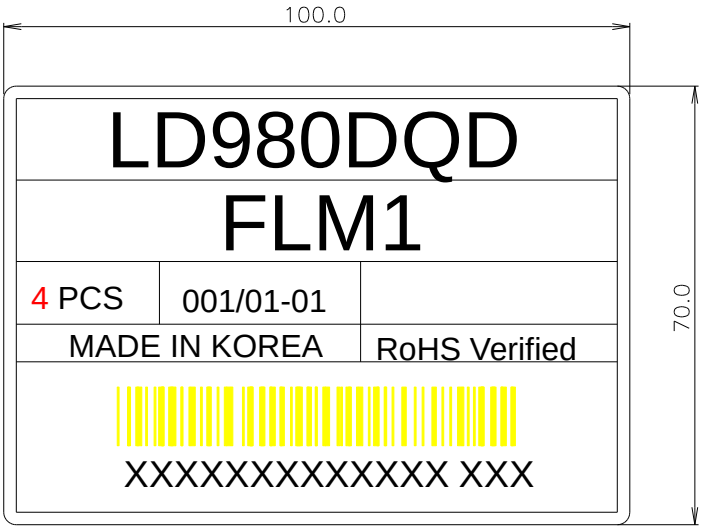
No.	Description	Material
ⓐ	BAG	AL
ⓑ	Packing	EPS
ⓒ	Angle Packing	PAPER
ⓓ	Angle Cover	PAPER
ⓔ	Pallet	Plywood
ⓕ	Band	PP

APPENDIX- II-1

■ LCM Label

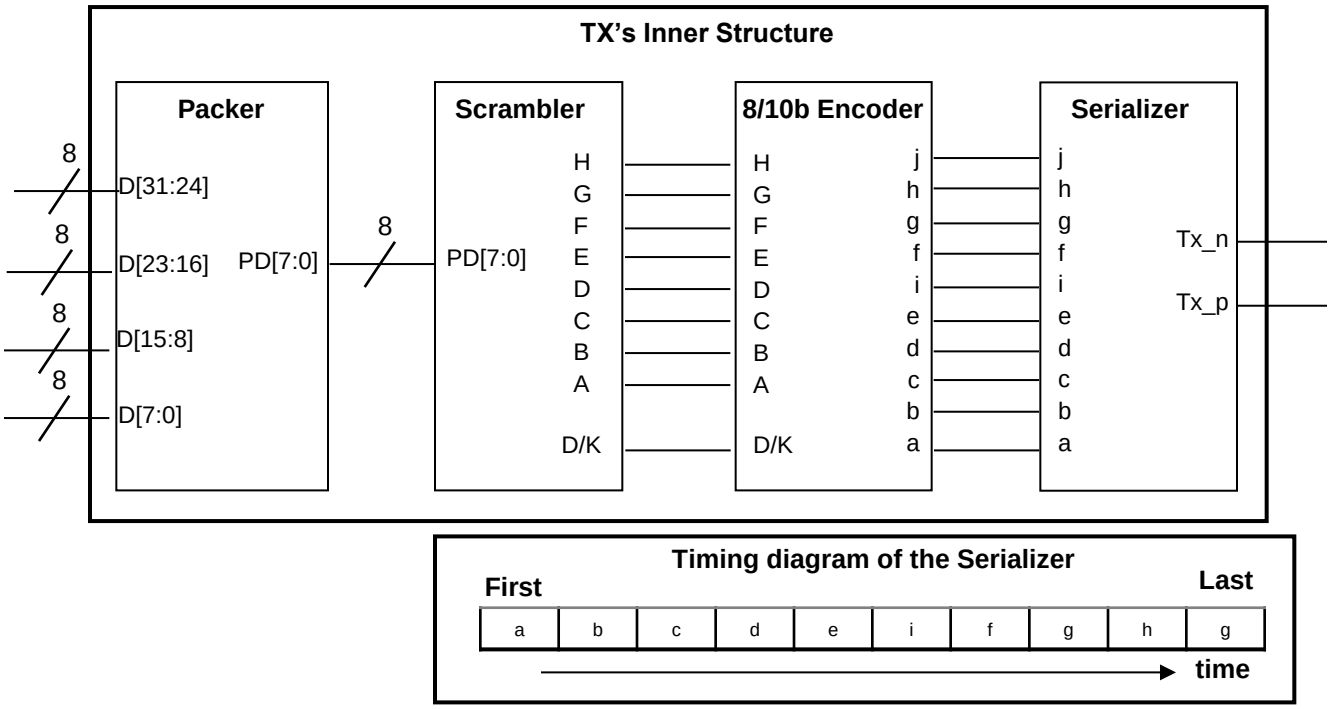
APPENDIX- II-2

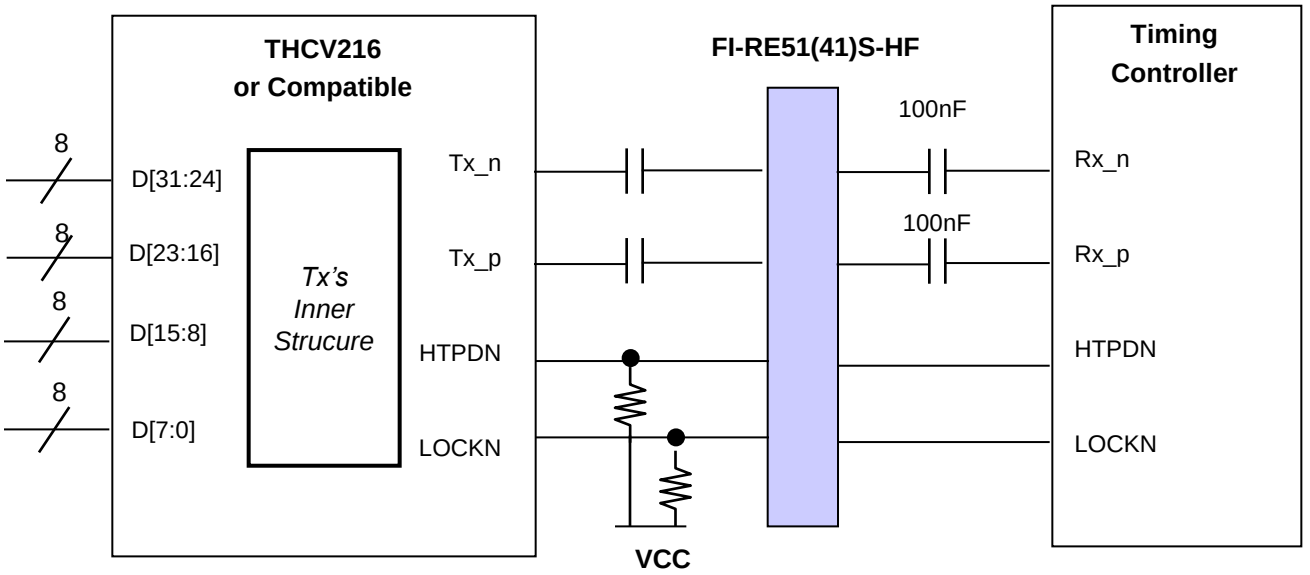
■ Pallet Label



APPENDIX- III-1

■ Required signal assignment for Flat Link (Thine : THCV216) Transmitter





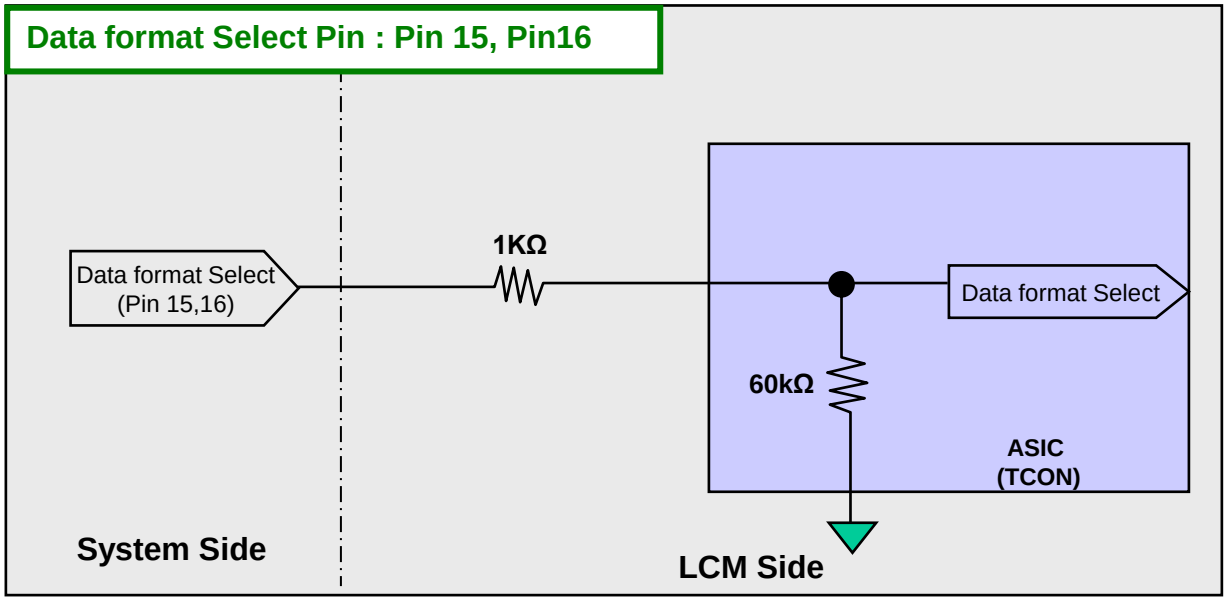
Notes

1. The LCD module uses a 100 nF capacitor on positive and negative lines of each receiver input.
2. Refer to Vx1 Transmitter Data Sheet for detail descriptions. (THCV216 or Compatible)
3. About Module connector pin configuration, Please refer to the Page 8~9.

APPENDIX- IV-1

■ **Option Pin** Circuit Block Diagram

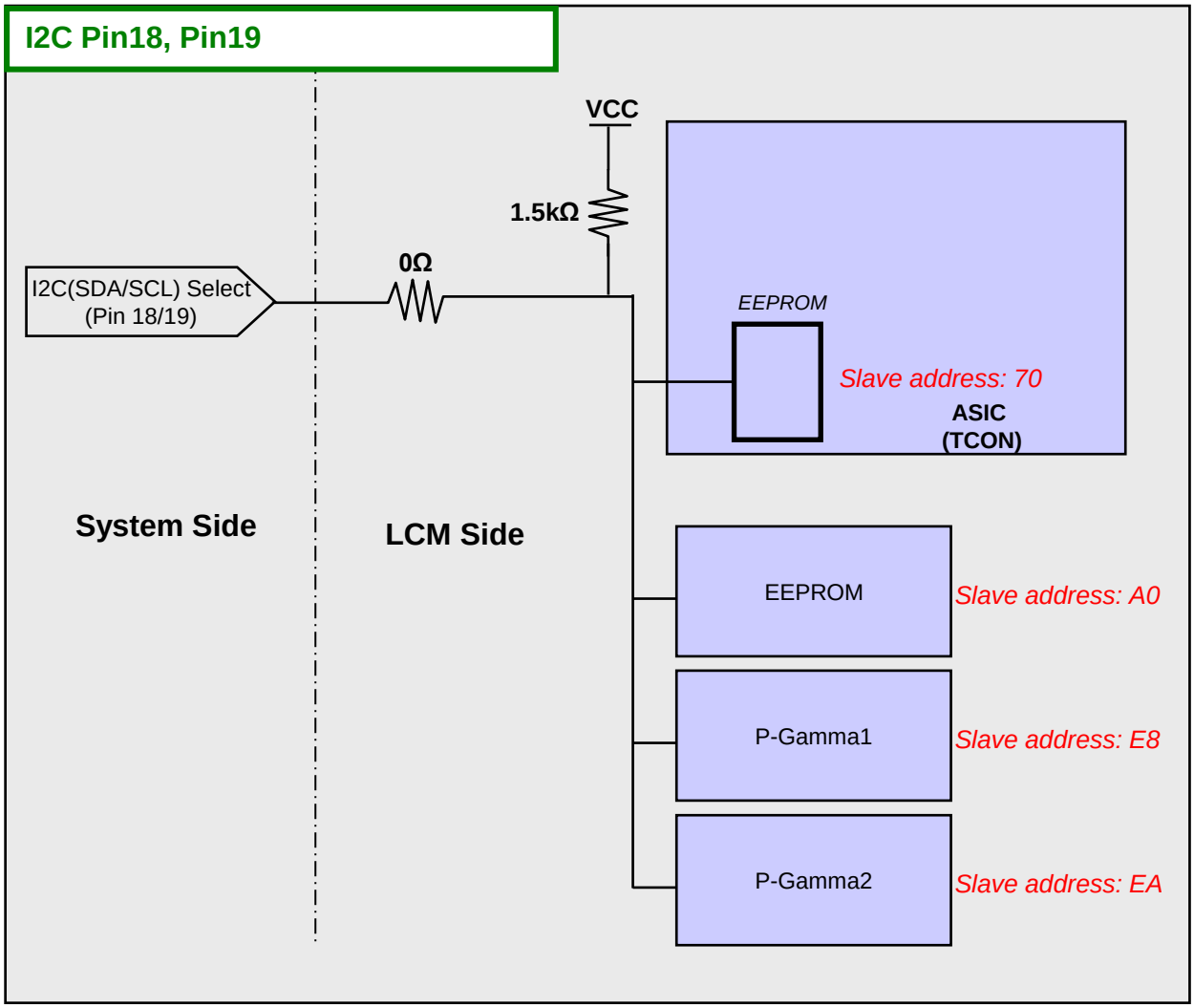
1) Circuit Block Diagram of Data format Selection pin



APPENDIX- IV-2

■ **Option Pin** Circuit Block Diagram

2) I2C(SDA/SCL) Selection pin



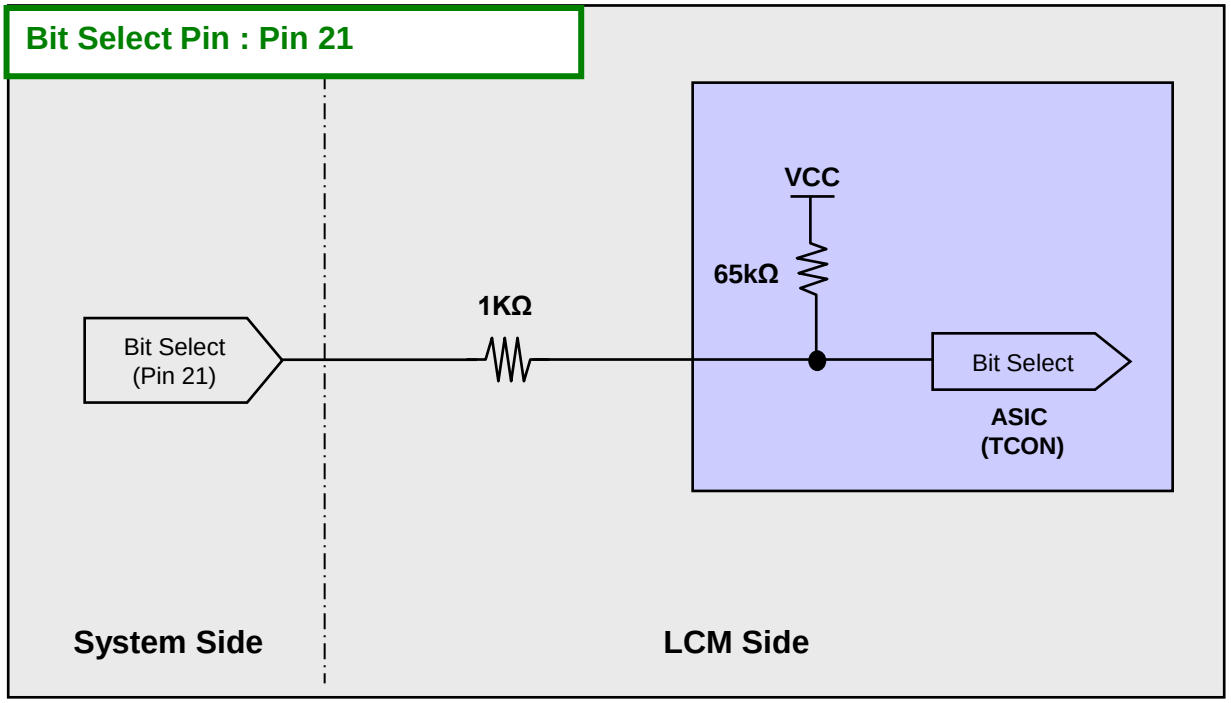
Notes

1. I2C Line of Set SoC avoid using slave address A0,E8,EA because LCD module uses those

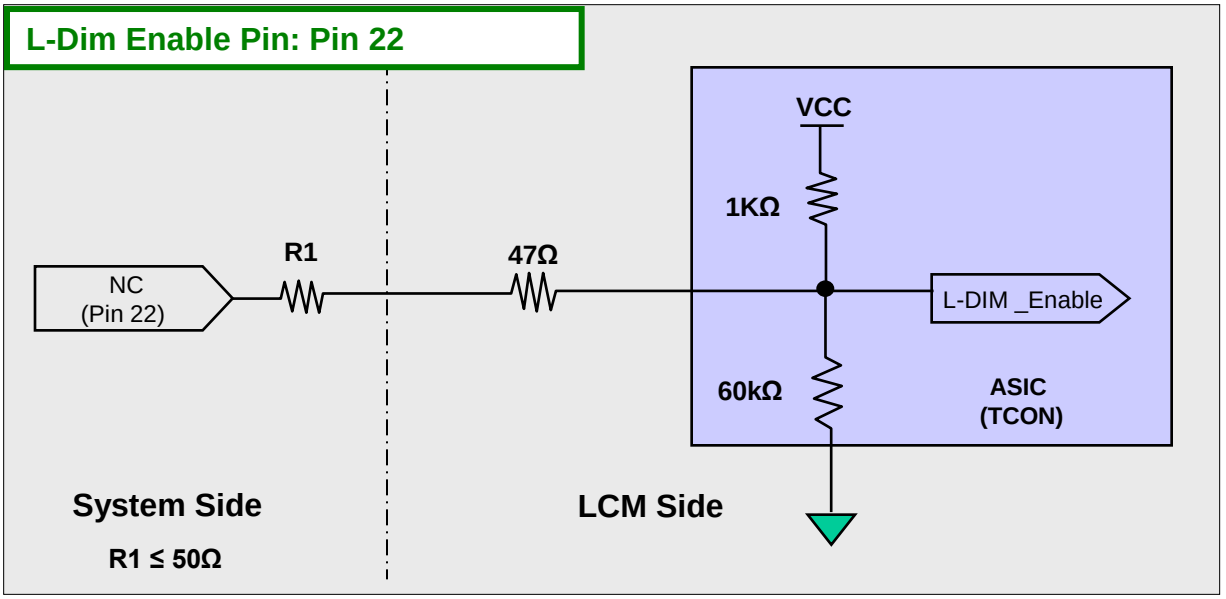
APPENDIX- IV-3

■ **Option Pin** Circuit Block Diagram

3) Circuit Block Diagram of Bit Selection pin



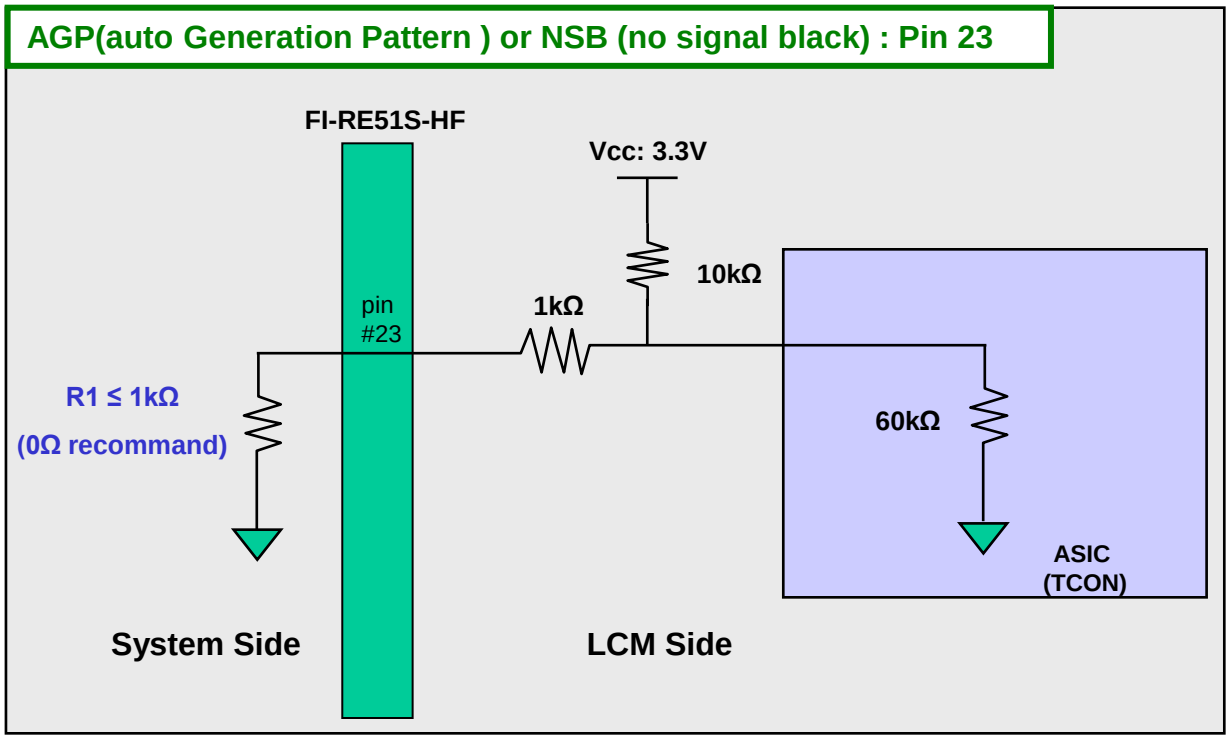
5) Circuit Block Diagram of L-Dim Enable Pin



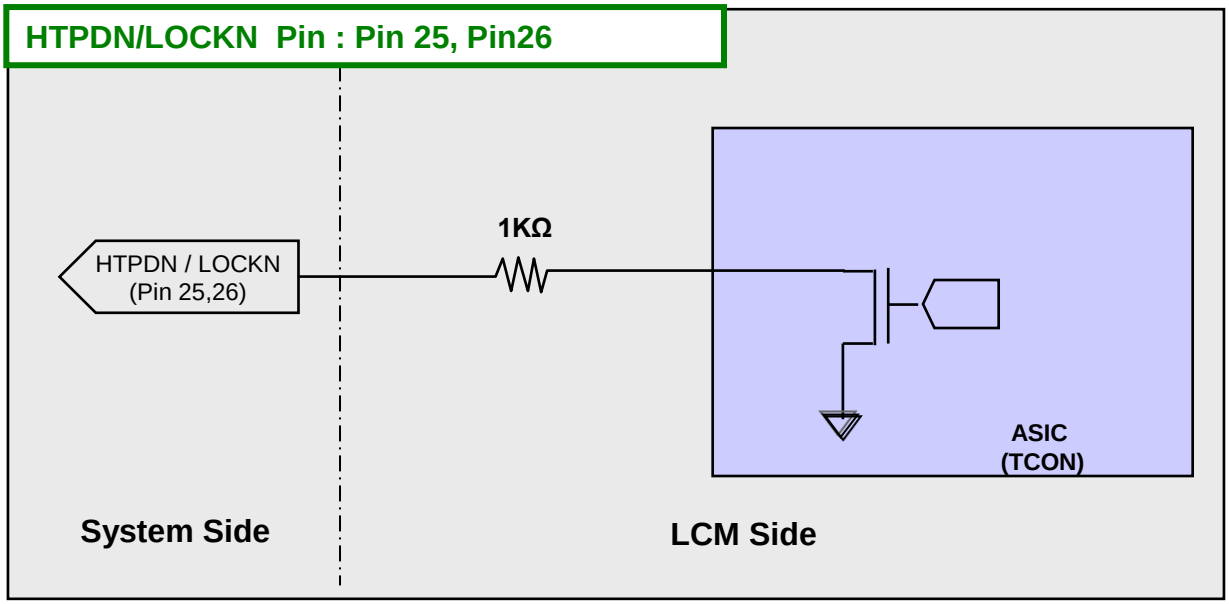
APPENDIX- IV-4

■ **Option Pin** Circuit Block Diagram

4) Circuit Block Diagram of AGP Selection pin



5) Circuit Block Diagram of HTPDN/ LOCKN Selection pin



APPENDIX- V

■ **EXTV**BR-B & **Local Dimming** Design Guide

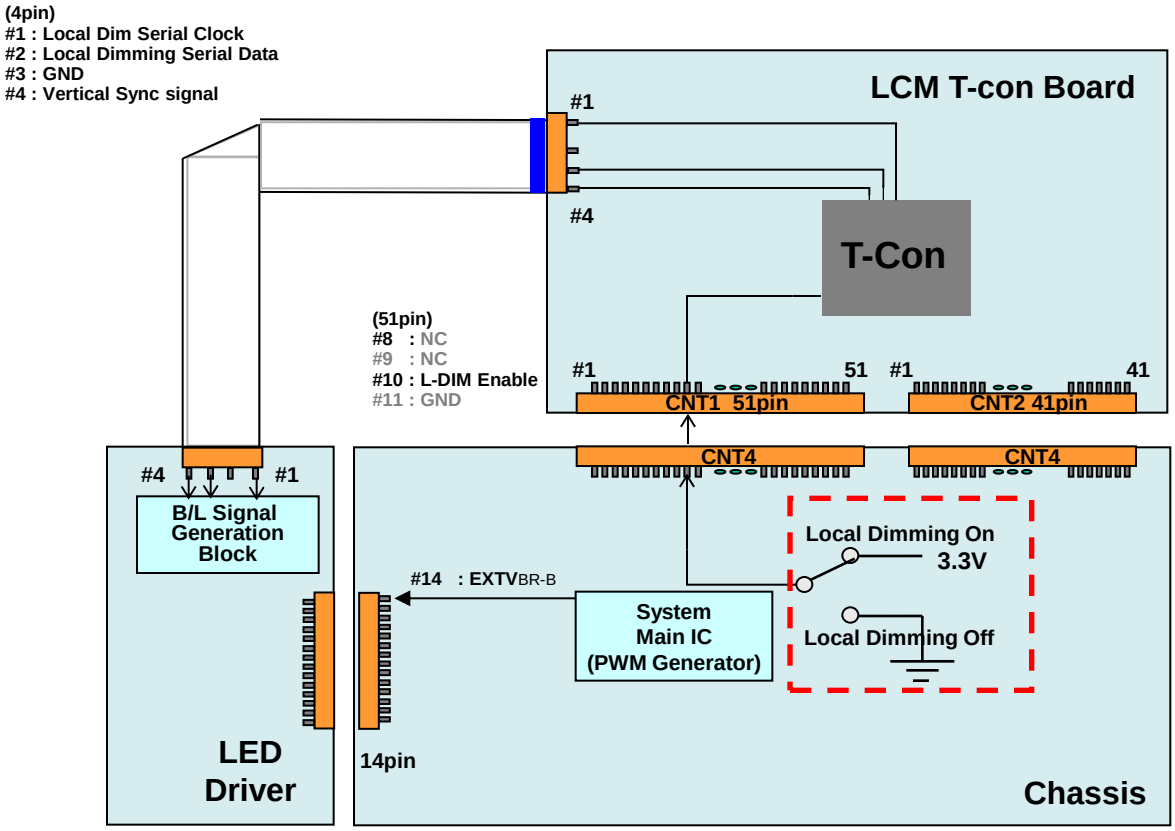
1) When L-Dim Enable is “L", Vertical Sync Signal = System Dimming with 100Hz or 120Hz frequency.

2) Local Dimming signals are synchronized with V-Sync Freq. of System in T-Con Board.

3) EXTVBR-B Specification (VCC = 3.3V) @ Local Dimming

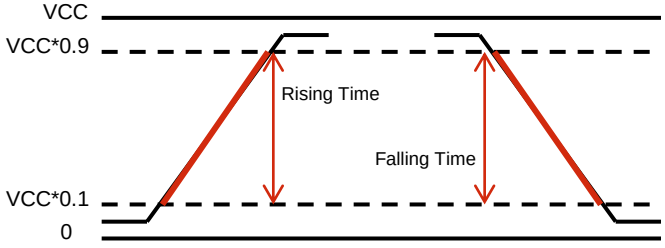
a) High Voltage Range : 2.5 V ~ 3.6 V

b) Low Voltage Range : 0.0 V ~ 0.7 V



<With Driver Model>

EXTVBR-B Frequency	100 Hz for PAL 120 Hz for NTSC
Rising Time	MAX 10.0 μs
Falling Time	MAX 10.0 μs



APPENDIX- VI

■ Gray to Gray Response Time Uniformity

This is only the reference data of G to G and uniformity for LD980DQD-FGM1 model.

1. G to G Response Time :
   Response time is defined as Figure3 and shall be measured by switching the input signal for "Gray (N) " and "Gray(M)".(32Gray Step at 8bit)

2. G to G Uniformity
   The variation of G to G Uniformity , $\delta_{G\ to\ G}$ is defined as :

$$\text{G to G Uniformity} = \frac{Maximum(GtoG) - Typical(GtoG)}{Typical(GtoG)} \leq 1$$

*Maximum (G to G) means maximum value of measured time (N, M = 0 (Black) ~ 1023(White), 128 gray step).

	0Gray	127ray	255Gray	…	895Gray	1023Gray
0Gray		TrR:0G→127G	TrR:0G→255G	…	TrR:0G→895G	TrR:0G→1023G
127Gray	TrD:127G→0G		TrR:127G→255G	…	TrR:127G→895G	TrR:127G→1023G
255Gray	TrD:255G→0G	TrD:255G→127G		…	TrR:255G→895G	TrR:255G→1023G
…	…	…	…		…	…
895Gray	TrD:895G→0G	TrD:895G→127G	TrD:895G→255G	…		TrR:895G→1023G
1023Gray	TrD:1023G→0G	TrD:1023G→127G	TrD:1023G→255G	…	TrD:1023G→895G	

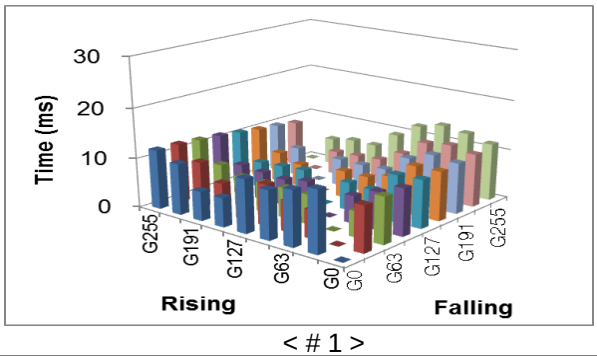
3. Sampling Size : 2 pcs

4. Measurement Method : Follow the same rule as optical characteristics measurement.

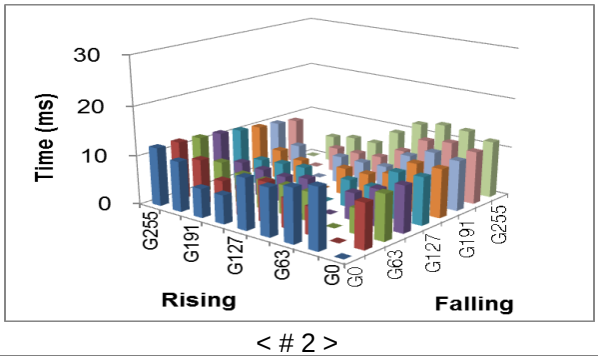
5. Current Status

   Below table is actual data of production on 07. 21. 2014 (LGD RV Event Sample)

	G to G Response Time [ms]		Uniformity
	Min.	Max.	
# 1	4.7	13.4	0.67
# 2	5.0	13.0	0.63



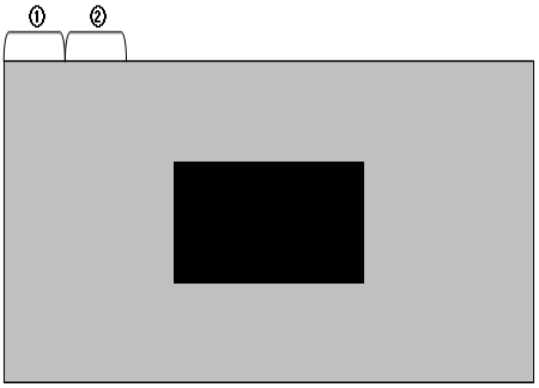
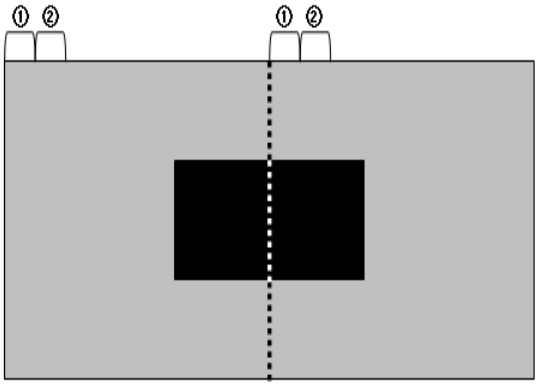
< # 1 >



< # 2 >

APPENDIX- VII-1

■ input mode of pixel data

Mode 1 : Non-Division	Mode 2 : 2 Division
	

	1st Data	2nd Data	Data #
Lane00	1	17	3825
Lane01	2	18	3826
Lane02	3	19	3827
Lane03	4	20	3828
Lane04	5	21	3829
Lane05	6	22	3830
Lane06	7	23	3831
Lane07	8	24	3832

	1st Data	2nd Data	Data #
Lane08	9	25	3833
Lane09	10	26	3834
Lane10	11	27	3835
Lane11	12	28	3836
Lane12	13	29	3837
Lane13	14	30	3838
Lane14	15	31	3839
Lane15	16	32	3840

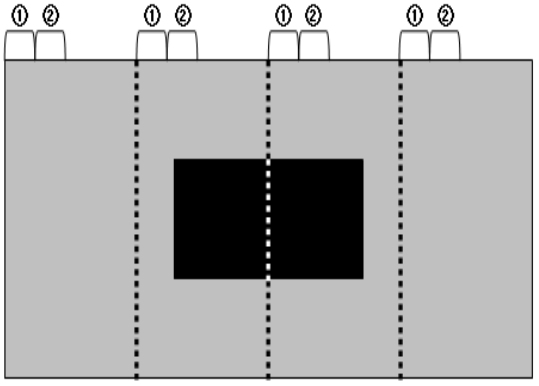
	1st Data	2nd Data	Data #
Lane00	1	9	1913
Lane01	2	10	1914
Lane02	3	11	1915
Lane03	4	12	1916
Lane04	5	13	1917
Lane05	6	14	1918
Lane06	7	15	1919
Lane07	8	16	1920

	1st Data	2nd Data	Data #
Lane08	1921	1929	3833
Lane09	1922	1930	3834
Lane10	1923	1931	3835
Lane11	1924	1932	3836
Lane12	1925	1933	3837
Lane13	1926	1934	3838
Lane14	1927	1935	3839
Lane15	1928	1936	3840

APPENDIX- VII-2

■ input mode of pixel data

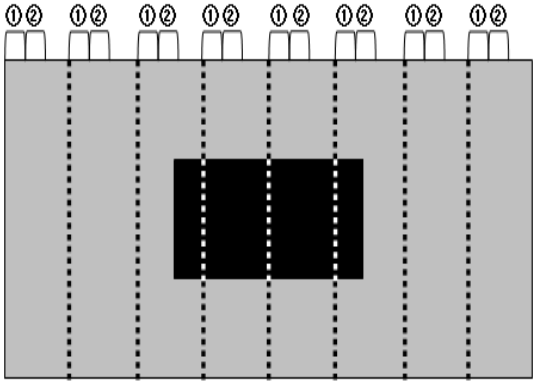
Mode 3 : 4 Division



	1st Data	2nd Data	Data #
Lane00	1	5	957
Lane01	2	6	958
Lane02	3	7	959
Lane03	4	8	960
Lane04	961	965	1917
Lane05	962	966	1918
Lane06	963	967	1919
Lane07	964	968	1920

	1st Data	2nd Data	Data #
Lane08	1921	1925	2877
Lane09	1922	1926	2878
Lane10	1923	1927	2879
Lane11	1924	1928	2880
Lane12	2881	2885	3837
Lane13	2882	2886	3838
Lane14	2883	2887	3839
Lane15	2884	2888	3840

Mode 4 : 8 Division



	1st Data	2nd Data	Data #
Lane00	1	3	479
Lane01	2	4	480
Lane02	481	483	959
Lane03	482	484	960
Lane04	961	963	1439
Lane05	962	964	1440
Lane06	1441	1443	1919
Lane07	1442	1444	1920

	1st Data	2nd Data	Data #
Lane08	1921	1923	2399
Lane09	1922	1924	2400
Lane10	2401	2403	2879
Lane11	2402	2404	2880
Lane12	2881	2883	3359
Lane13	2882	2884	3360
Lane14	3361	3363	3839
Lane15	3362	3364	3840