PRELIMINARY

NLT Technologies, Ltd.

TFT COLOR LCD MODULE

NL160120AC27-32B

54 cm (21.3 Type)
UXGA
LVDS Interface (2 port)

PRELIMINARY DATA SHEET

DOD-PP-1313 (2nd edition)

This PRELIMINARY DATA SHEET is updated document from DOD-PP-1257(1).

All information is subject to change without notice. Please confirm the sales representative before starting to design your system.

INTRODUCTION

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Examples: Computers, office automation equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment, industrial robots, etc.

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Examples: Control systems for transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, medical equipment not specifically designed for life support, safety equipment, etc.

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Examples: Military systems, aircraft control equipment, aerospace equipment, nuclear reactor control systems, medical equipment/devices/systems for life support, etc.

The quality grade of this product is the **"Standard"** unless otherwise specified in this document.

CONTENTS

1. OUTLINE

1.1 STRUCTURE AND PRINCIPLE

Color LCD module NL160120AC27-32B is composed of the amorphous silicon thin film transistor liquid crystal display (a-Si TFT LCD) panel structure with driver LSIs for driving the TFT (Thin Film Transistor) array and a backlight.

The a-Si TFT LCD panel structure is injected liquid crystal material into a narrow gap between the TFT array glass substrate and a color-filter glass substrate.

Grayscale data signals from a host system (e.g. signal generator, etc.) are modulated into best form for active matrix system by a signal processing board, and sent to the driver LSIs which drive the individual TFT arrays.

The TFT array as an electro-optical switch regulates the amount of transmitted light from the backlight assembly, when it is controlled by data signals. Color images are created by regulating the amount of transmitted light through the TFT array of red, green and blue dots.

1.2 APPLICATION

- Color monitor system

1.3 FEATURES

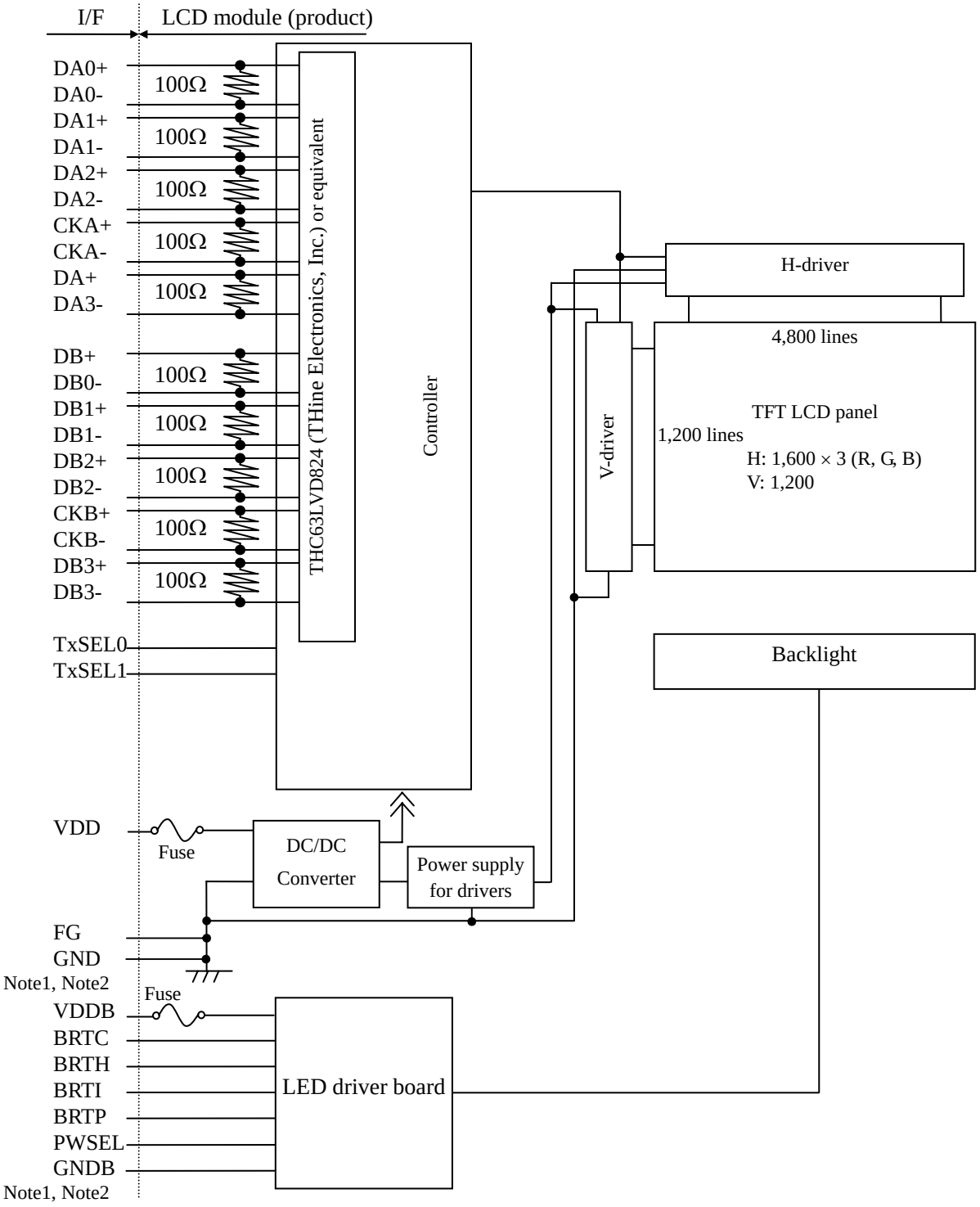
- Ultra-wide viewing angle (Ultra-Advanced Super Fine TFT (UA-SFT))
- High luminance
- High contrast
- High resolution
- Low reflection
- Wide color gamut
- 256 gray scale in each R, G, B sub-pixel (8-bit), 16,777,216 colors
- LVDS interface
- Selectable LVDS data input map
- Small foot print
- Long life LED backlight type with an LED driver board

2. GENERAL SPECIFICATIONS

Display area	432.0 (H) × 324.0 (V) mm
Diagonal size of display	54 cm (21.3 inches)
Drive system	a-Si TFT active matrix
Display color	16,777,216 colors
Pixel	1,600 (H) × 1,200 (V) pixels (1 pixel consists of 3 sub-pixels (RGB).)
Pixel arrangement	RGB (Red dot, Green dot, Blue dot) vertical stripe
Dot pitch	0.090 (H) × 0.270 (V) mm
Pixel pitch	0.270 (H) × 0.270 (V) mm
Module size	457.0 (W) × 350.0 (H) × 21.5 (D) mm (typ.)
Weight	(2,700) g (typ.)
Contrast ratio	1200:1 (typ.)
Viewing angle	*At the contrast ratio ≥ 10:1* • Horizontal: Right side 88° (typ.), Left side 88° (typ.) • Vertical: Up side 88° (typ.), Down side 88° (typ.)
Designed viewing direction	Viewing angle with optimum grayscale (γ≒ DICOM): Normal axis (perpendicular) Note1
Polarizer surface	Antiglare
Polarizer pencil-hardness	2H (min.) [by JIS K5600]
Color gamut	*At LCD panel center* (72) % (typ.)[against NTSC color space]
Response time	*Ton+Toff (10%←→90%)* (40) ms (typ.)
Luminance	*At the maximum luminance* 760 cd/m^2 (typ.)
Signal system	2 ports LVDS interface (THC63LVD824A THine Electronics, Inc. or equivalent) ☆ [RGB 8-bit signals, Data enable signal (DE), Dot clock (CK)]
Power supply voltage	LCD panel signal processing board: 12.0V LED driver board: 12.0V
Backlight	LED backlight type with LED driver board
Power consumption	*At checkered flag pattern, the maximum luminance* (57) W (typ.)

Note1: When the product luminance is 450cd/m^2, the gamma characteristic is designed to γ≒ DICOM.

3. BLOCK DIAGRAM



Note1: Relations between GND (Signal ground), FG (Frame ground) and GNDB (LED driver board ground) in the LCD module are as follows.

GND - FG	Connected
GND - GNDB	Not connected
FG - GNDB	Not connected

Note2: GND, FG and GNDB must be connected to customer equipment's ground, and it is recommended that these grounds be connected together in customer equipment.

4. DETAILED SPECIFICATIONS

4.1 MECHANICAL SPECIFICATIONS

Parameter	Specification		Unit
Module size	457.0 ±0.5 (W) × 350.0 ±0.5 (H) × 21.5 (typ., D) 23.0 (max. D)	Note1, Note2	mm
Display area	432.0 (H) × 324.0 (V)	Note2	mm
Weight	(2,700) (typ.), (2,980) (max.)		g

Note1: Excluding warpage of the cover for LED driver board.
Note2: See "**8. OUTLINE DRAWINGS**".

4.2 ABSOLUTE MAXIMUM RATINGS

Parameter			Symbol	Rating	Unit	Remarks
Power supply voltage	LCD panel signal processing board		VDD	-0.3 to +14.0	V	Ta = 25°C
	LED driver board		VDDB	-0.3 to +15.0	V	☆
Input voltage for signals	LCD panel signal processing board Note1		Vi	-0.3 to +3.45	V	VDD= 12.0V
	LED driver board	BRTI signal	VBI	-0.3 to +1.5	V	VDDB= 12.0V
		BRTP signal	VBP	-0.3 to +5.5	V	
		BRTC signal	VBC	-0.3 to +5.5	V	
		PWSEL signal	VBS	-0.3 to +5.5	V	
Storage temperature			Tst	-20 to +60	°C	-
Operating temperature		Front surface	TopF	(0 to +60)	°C	Note2
		Rear surface	TopR	(0 to +60)	°C	Note3
Relative humidity Note4			RH	≤ 95	%	Ta ≤ 40°C
				≤ 85	%	40°C < Ta ≤ 50°C
				≤ 70	%	50°C < Ta ≤ 55°C
Absolute humidity Note4			AH	≤ 73 Note5	g/m^3	Ta > 55°C
Operating altitude			-	≤ 4,850	m	0°C ≤ Ta ≤ 55°C
Storage altitude			-	≤ 13,600	m	-20°C ≤ Ta ≤ 60°C

Note1: DA0+/-, DA1+/-, DA2+/-, DA3+/-, CKA+/-, DB0+/-, DB1+/-, DB2+/-, DB3+/-, CKB+/-
Note2: Measured at LCD panel surface (including self-heat)
Note3: Measured at LCD module's rear shield surface (including self-heat)
Note4: No condensation
Note5: Water amount at Ta= 55°C and RH= 70%

4.3 ELECTRICAL CHARACTERISTICS

4.3.1 LCD panel signal processing board

(Ta= 25°C)

Parameter		Symbol	min.	typ.	max.	Unit	Remarks
Power supply voltage		VDD	10.8	12.0	13.2	V	-
Power supply current		IDD	-	(500) Note1	(700) Note2	mA	at VDD= 12.0V
Permissible ripple voltage		VRP	-	-	100	mVp-p	for VDD
Differential input threshold voltage	High	VTH	-	-	+100	mV	at VCM= 1.2V Note3, Note4
	Low	VTL	-100	-	-	mV	
Input voltage swing		VI	0	-	2.4	V	Note4
Terminating resistance		RT	-	100	-	Ω	-

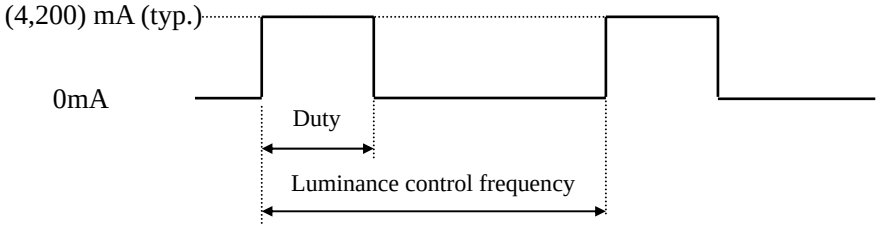
Note1: Checkered flag pattern (by EIAJ ED-2522)
Note2: Pattern for maximum current
Note3: Common mode voltage for LVDS driver
Note4: DA0+/-, DA1+/-, DA2+/-, DA3+/-, CKA+/-, DB0+/-, DB1+/-, DB2+/-, DB3+/-, CKB+/-

4.3.2 LED Driver board

(Ta= 25°C)

Parameter			Symbol	min.	typ.	max.	Unit	Remarks
Power supply voltage			VDDB	(11.4)	12.0	(12.6)	V	-
Power supply current			IDDB	-	(4,200)	TBD	mA	VDDB= 12.0V, At the maximum luminance control
Input voltage for signals	BRTI signal		VBI	0	-	1.0	V	-
	BRTP signal	High	VBPH	2.0	-	5.25	V	
		Low	VBPL	0	-	0.8	V	
	BRTC signal	High	VBCH	2.0	-	5.25	V	
		Low	VBCL	0	-	0.8	V	
	PWSEL signal	High	VBSH	2.0	-	5.25	V	
		Low	VBSL	0	-	0.8	V	
Input current for signals	BRTI signal		IBI	TBD	-	TBD	μA	
	BRTP signal	High	IBPH	-	-	TBD	μA	
		Low	IBPL	TBD	-	-	μA	
	BRTC signal	High	IBCH	-	-	TBD	μA	
		Low	IBCL	TBD	-	-	μA	
	PWSEL signal	High	IPSH	-	-	TBD	μA	
		Low	IPSL	TBD	-	-	μA	

4.3.3 LED driver board current wave



At the maximum luminance control: 100%
At the minimum luminance control: (1)% (At frequency: 325 Hz)
Luminance control frequency: (255)Hz (typ.)

Note1: Luminance control frequency indicate the input pulse frequency, when select the external pulse control. See "**4.6.2 Detail of BRTP timing**".

Note2: The power supply lines (VDDB and GNDB) have large ripple voltage during luminance control. There is the possibility that the ripple voltage produces acoustic noise and signal wave noise in audio circuit and so on. Put a capacitor (5,000 to 6,000μF) between the power supply lines (VDDB and GNDB) to reduce the noise, if the noise occurred in the circuit..

4.3.4 Power supply voltage ripple

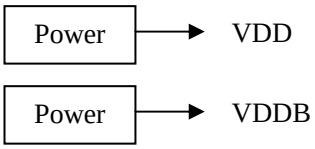
This product works, even if the ripple voltage levels are beyond the permissible values as following the table, but there might be noise on the display image.

Power supply voltage		Ripple voltage Note1 (Measure at input terminal of power supply)	Unit
VDD	12.0V	≤ 100	mVp-p
VDDB	12.0V	≤ 200	mVp-p

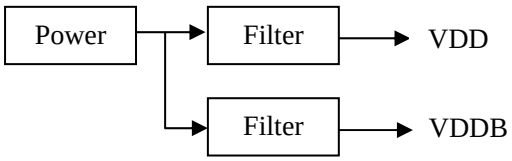
Note1: The permissible ripple voltage includes spike noise.

Example of the power supply connection

a) Separate the power supply



b) Put in the filter



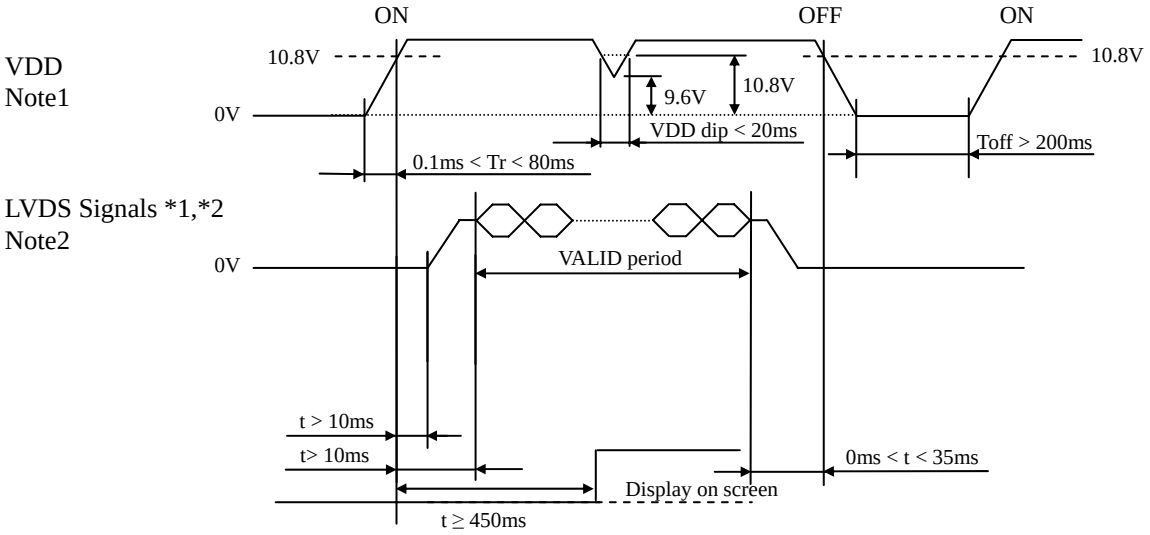
4.3.5 Fuse

Parameter	Fuse		Rating	Fusing current	Remarks
	Type	Supplier			
VDD	FCC16132AB	KAMAYA ELECTRIC Co., Ltd.	1.25A 32V	2.5A, 5 seconds maximum	Note1
VDDB	CCF1N10	KOA Corporation	10A 60 V	20 A, 1 seconds maximum	

Note1: The power supply capacity should be more than the fusing current. If it is less than the fusing current, the fuse may not blow in a short time, and then nasty smell, smoke and so on may occur.

4.4 POWER SUPPLY VOLTAGE SEQUENCE

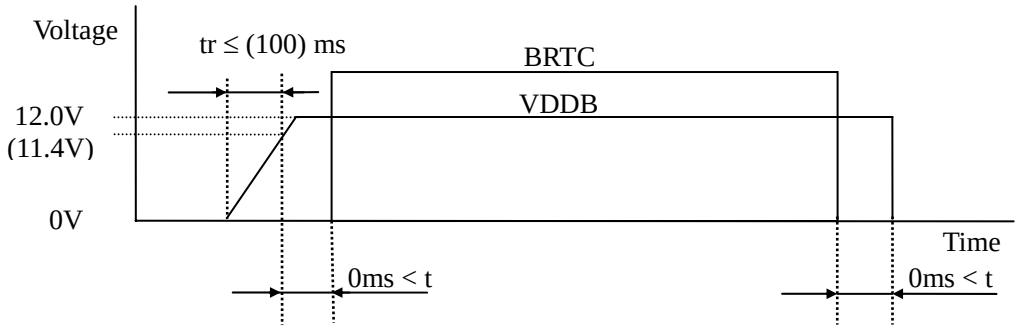
4.4.1 LCD panel signal processing board



*1: DA0+/-, DA1+/-, DA2+/-, DA3+/-, CKA+/-, DB0+/-, DB1+/-, DB2+/-, DB3+/- and CKB+/-
*2: LVDS signals should be measured at the terminal of 100Ω resistance.

Note1: If there is a voltage variation (voltage drop) at the rising edge of VCC below 10.8V, there is a possibility that a product does not work due to a protection circuit.
Note2: LVDS signals must be set to Low or High-impedance, except the VALID period (See above sequence diagram), in order to avoid the circuitry damage.
If some of signals are cut while this product is working, even if the signal input to it once again, it might not work normally. If a customer stops the display and function signals, VCC also must be shut down.
Note3: The backlight should be turned on within the valid period of LVDS signals, in order to avoid unstable data display.

4.4.2 LED driver board



Note1: The backlight should be turned on within the valid period of LVDS signals, in order to avoid unstable data display.
Note2: If tr is more than (100)ms, the backlight will be turned off by a protection circuit for LED driver board.
Note3: When VDDB is 0V or BRTC is Low, PWSEL must be set to Low or Open.

4.5 CONNECTIONS AND FUNCTIONS FOR INTERFACE PINS

4.5.1 LCD panel signal processing board

CN1 Socket (LCD module side): DF19G-30P-1H (56) (Hirose Electric Co., Ltd. (HRS))
Adaptable plug: DF19-30S-1C (Hirose Electric Co., Ltd. (HRS))

Pin No.	Symbol	Signal	Remarks
1	DA0-	Pixel data A0	Odd pixel data Input (LVDS differential signal) Note1
2	DA0+		
3	DA1-	Pixel data A1	Odd pixel data Input (LVDS differential signal) Note1
4	DA1+		
5	DA2-	Pixel data A2	Odd pixel data Input (LVDS differential signal) Note1
6	DA2+		
7	GND	Ground	Signal ground Note2
8	CKA-	Pixel clock	Odd pixel clock Input (LVDS differential signal) Note1
9	CKA+		
10	DA3-	Pixel data A3	Odd pixel data Input (LVDS differential signal) Note1
11	DA3+		
12	DB0-	Pixel data B0	Even pixel data Input (LVDS differential signal) Note1
13	DB0+		
14	GND	Ground	Signal ground Note2
15	DB1-	Pixel data B1	Even pixel data Input (LVDS differential signal) Note1
16	DB1+		
17	GND	Ground	Signal ground Note2
18	DB2-	Pixel data B2	Even pixel data Input (LVDS differential signal) Note1
19	DB2+		
20	CKB-	Pixel clock	Even pixel clock Input (LVDS differential signal) Note1
21	CKB+		
22	DB3-	Pixel data B3	Even pixel data Input (LVDS differential signal) Note1
23	DB3+		
24	GND	Ground	Signal ground Note2
25	TxSEL0	Selection of LVDS data input map	Note3, Note4
26	TxSEL1		
27	GND	Ground	Signal ground Note2
28	VDD	Power supply	12V Note2
29	VDD		
30	VDD		

TxSEL1	TxSEL0	Mode
Open	Open	A
Open	Low	B
Low	Open	C
Low	Low	A

Note1: Twist pair wires with 100Ω (Characteristic impedance) should be used between LCD panel signal processing board and LVDS transmitter.
Note2: All GND and VDD terminals should be used without any non-connected lines.
Note3: This terminal is pulled-up in the product.
Note4: See "**4.7 LVDS DATA INPUT MAP**".

4.5.2 LED driver board

CN201 socket (LCD module side): DF3Z-10P-2H (2*) (HIROSE ELECTRIC Co,. Ltd.)
Adaptable plug: DF3-10S-2C (HIROSE ELECTRIC Co,. Ltd.)

Pin No.	Symbol	Function	Description
1	GNDB	LED driver board ground	Note1
2	GNDB		
3	GNDB		
4	GNDB		
5	GNDB		
6	VDDB	Power supply	Note1
7	VDDB		
8	VDDB		
9	VDDB		
10	VDDB		

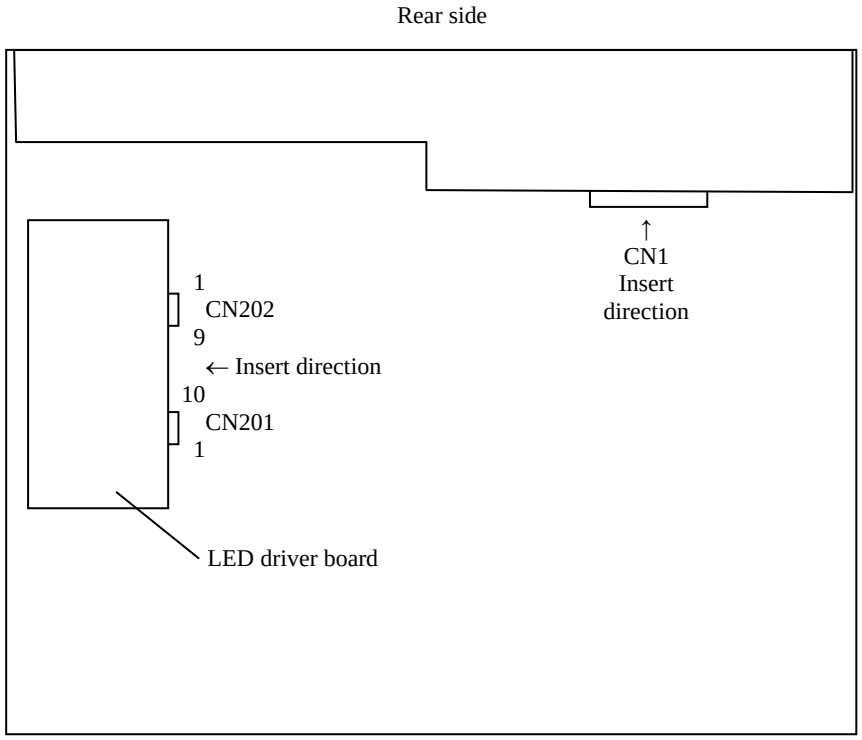
Note1: All VDDB and GNDB terminals should be used without any non-connected lines.

CN202 socket (LCD module side): IL-Z-9PL-SMTYE (Japan Aviation Electronics Industry Limited (JAE))
Adaptable plug: IL-Z-9S-S125C3 (Japan Aviation Electronics Industry Limited (JAE))

Pin No.	Symbol	Function	Description
1	GNDB	LED driver board ground	Note1
2	GNDB		
3	N.C.	-	Keep this pin Open.
4	BRTC	Backlight ON/OFF control signal	High or Open: Backlight ON Low: Backlight OFF
5	BRTH	Luminance control terminal	Note2
6	BRTI		
7	BRTP	BRTP signal	
8	GNDB	LED driver board ground	Note1
9	PWSEL	Selection of luminance control signal method	Note2, Note3

Note1: All GNDB terminals should be used without any non-connected lines.
Note2: See "**4.6.1 LUMINANCE CONTROL** ".
Note3: When VDDB is 0V or BRTC is Low, PWSEL must be set to Low or Open.

4.5.3 Positions of socket

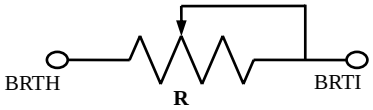


4.6 LUMINANCE CONTROL

4.6.1 Luminance control methods

<table>
<tr><th>Method</th><th>Adjustment and luminance ratio</th><th>PWSEL terminal</th><th>BRTP terminal</th></tr>
<tr><td>Variable resistor control

Note1</td><td>• Adjustment

The variable resistor (R) for luminance control should be 10kΩ ±5%, 1/10W. Minimum point of the resistance is the minimum luminance and maximum point of the resistance is the maximum luminance.
The resistor (R) must be connected between BRTH-BRTI terminals.
 

• Luminance ratio Note3
<table><tr><th>Resistance</th><th>Luminance ratio</th></tr><tr><td>0 Ω</td><td>0% (Min. Luminance)</td></tr><tr><td>10 kΩ</td><td>100% (Max. Luminance)</td></tr></table></td><td rowspan="2">High or Open</td><td rowspan="2">Open</td></tr>
<tr><td>Voltage control

Note1</td><td>• Adjustment

Voltage control method works, when BRTH terminal is 0V and VBI voltage is input between BRTI-BRTH terminals. This control method can carry out continuation adjustment of luminance.
Luminance is the maximum when BRTI terminal is Open.

• Luminance ratio Note3
<table><tr><th>BRTI Voltage (VBI)</th><th>Luminance ratio</th></tr><tr><td>0V</td><td>0% (Min. Luminance)</td></tr><tr><td>1.0V</td><td>100% (Max. Luminance)</td></tr></table></td></tr>
<tr><td>Pulse width modulation

Note1
Note2
Note4</td><td>• Adjustment

Pulse width modulation (PWM) method works, when PWSEL terminal is Low and PWM signal (BRTP signal) is input into BRTP terminal. The luminance is controlled by duty ratio of BRTP signal.

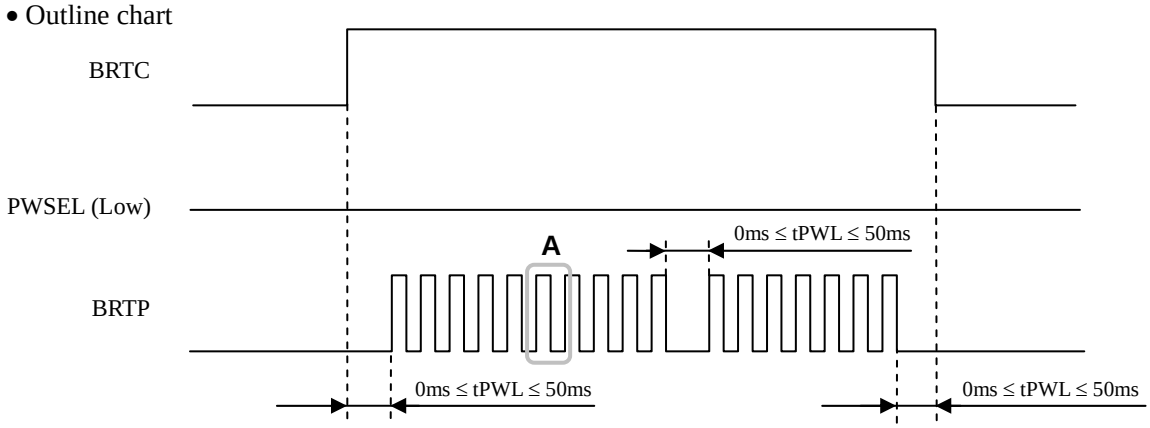
• Luminance ratio Note3
<table><tr><th>Duty ratio</th><th>Luminance ratio</th></tr><tr><td>(0.01)</td><td>(1)% (Min. Luminance)
(At frequency: 325 Hz)</td></tr><tr><td>1.0</td><td>100% (Max. Luminance)</td></tr></table></td><td>Low</td><td>BRTP signal</td></tr>
</table>

Note1: In case of the variable resistor control method and the voltage control method, noises may appear on the display image depending on the input signals timing for LCD panel signal processing board.
Use PWM method, if interference noises appear on the display image!
Note2: The LED driver board will stop working, if the Low period of BRTP signal is more than 50ms while BRTC signal is High or Open. Then the backlight will not turn on anymore, even if BRTP signal is input again. This is not out of order. The LED driver board will start to work when power is supplied again.
Note3: These data are the target values.
Note4: See "**4.6.2 Detail of BRTP timing**". ☆

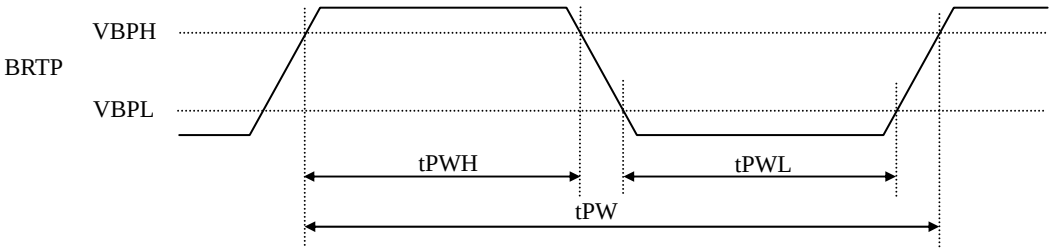
4.6.2 Detail of BRTP timing

(1) Timing diagrams

• Outline chart



• Detail of **A** part



(2) Each parameter

Parameter	Symbol	min.	typ.	max.	Unit	Remarks
Luminance control frequency	FL	(185)	-	(1,000)	Hz	Note1, Note2
External PWM pulse width	tPWH	(30)	-	-	μs	Note1, Note3

☆

Note1: Definition of parameters is as follows.

$$FL = \frac{1}{tPW} \quad DL = \frac{tPWH}{tPW}$$

Note2: See the following formula for luminance control frequency.
Luminance control frequency = 1/tv × (n+0.25) [or (n + 0.75)]
n = 1, 2, 3 · · · · · ·
tv: Vertical cycle (See "**4.9.1 Timing characteristics**".)

The interference noise of luminance control frequency and input signal frequency for LCD panel signal processing board may appear on a display. Set up luminance control frequency so that the interference noise does not appear!

Note3: See "**4.6.1 Luminance control methods**".

4.7 LVDS DATA INPUT MAP

4.7.1 Mode A

Input data			Transmitter Pin	THC63LVDF83A		Transmitter Pin	THC63LVD823		CN1 Pin	CN1 Symbol
Odd pixel data and control signal		RA2 →	51	TA0		53	R12	Note2		
		RA3 →	52	TA1		54	R13	TA1- →	1	DA0-
		RA4 →	54	TA2		57	R14	TA1+ →	2	DA0+
		RA5 →	55	TA3		58	R15			
		RA6 →	56	TA4		59	R16	TB1- →	3	DA1-
		RA7 →	3	TA5		60	R17	TB1+ →	4	DA1+
		GA2 →	4	TA6		63	G12			
		GA3 →	6	TB0		64	G13	TC1- →	5	DA2-
		GA4 →	7	TB1		65	G14	TC1+ →	6	DA2+
		GA5 →	11	TB2		66	G15		7	GND
		GA6 →	12	TB3		67	G16	TCLK1- →	8	CKA-
		GA7 →	14	TB4		68	G17	TCLK1+ →	9	CKA+
		BA2 →	15	TB5		73	B12			
		BA3 →	19	TB6		74	B13	TD1- →	10	DA3-
		BA4 →	20	TC0	1st	75	B14	TD1+ →	11	DA3+
		BA5 →	22	TC1		76	B15			
		BA6 →	23	TC2		77	B16			
		BA7 →	24	TC3		78	B17			
	Note3	RSVD →	27	TC4		7	RSVD			
	Note3	RSVD →	28	TC5		8	RSVD			
		DE →	30	TC6		9	DE			
		RA0 →	50	TD0		51	R10			
		RA1 →	2	TD1		52	R11			
		GA0 →	8	TD2		61	G10			
		GA1 →	10	TD3		62	G11			
		BA0 →	16	TD4		69	B10			
		BA1 →	18	TD5		70	B11			
	Note3	RSVD →	25	TD6		-				
		CLK →	31	CLKIN		10	CLK			
Even pixel data		RB2 →	51	TA0		81	R22			
		RB3 →	52	TA1		82	R23	TA2- →	12	DB0-
		RB4 →	54	TA2		83	R24	TA2+ →	13	DB0+
		RB5 →	55	TA3		84	R25		14	GND
		RB6 →	56	TA4		85	R26	TB2- →	15	DB1-
		RB7 →	3	TA5		86	R27	TB2+ →	16	DB1+
		GB2 →	4	TA6		91	G22		17	GND
		GB3 →	6	TB0		92	G23	TC2- →	18	DB2-
		GB4 →	7	TB1		93	G24	TC2+ →	19	DB2+
		GB5 →	11	TB2		94	G25			
		GB6 →	12	TB3		95	G26	TCLK2- →	20	CKB-
		GB7 →	14	TB4		96	G27	TCLK2+ →	21	CKB+
		BB2 →	15	TB5		99	B22			
		BB3 →	19	TB6		100	B23	TD2- →	22	DB3-
		BB4 →	20	TC0	2nd	1	B24	TD2+ →	23	DB3+
		BB5 →	22	TC1		2	B25		24	GND
		BB6 →	23	TC2		5	B26		25	TxSEL0
		BB7 →	24	TC3		6	B27		26	TxSEL1
	Note3	RSVD →	27	TC4		-			27	GND
	Note3	RSVD →	28	TC5		-			28	VDD
	Note3	RSVD →	30	TC6		-			29	VDD
		RB0 →	50	TD0		79	R20		30	VDD
		RB1 →	2	TD1		80	R21			
		GB0 →	8	TD2		89	G20			
		GB1 →	10	TD3		90	G21			
		BB0 →	16	TD4		97	B20			
		BB1 →	18	TD5		98	B21			
	Note3	RSVD →	25	TD6		-				
		CLK →	31	CLKIN		-				

4.7.2 Mode B

Input data		Note1		Transmitter Pin	DS90CF383, C385			CN1 Pin	CN1 Symbol
Odd pixel data and control signal		RA7	→	51	TXIN0		Note2		
		RA6	→	52	TXIN1		TA1- →	1	DA0-
		RA5	→	54	TXIN2		TA1+ →	2	DA0+
		RA4	→	55	TXIN3				
		RA3	→	56	TXIN4		TB1- →	3	DA1-
		RA2	→	3	TXIN6		TB1+ →	4	DA1+
		GA7	→	4	TXIN7				
		GA6	→	6	TXIN8		TC1- →	5	DA2-
		GA5	→	7	TXIN9		TC1+ →	6	DA2+
		GA4	→	11	TXIN12			7	GND
		GA3	→	12	TXIN13		TCLK1- →	8	CKA-
		GA2	→	14	TXIN14		TCLK1+ →	9	CKA+
		BA7	→	15	TXIN15				
		BA6	→	19	TXIN18		TD1- →	10	DA3-
		BA5	→	20	TXIN19	1st	TD1+ →	11	DA3+
		BA4	→	22	TXIN20				
		BA3	→	23	TXIN21				
		BA2	→	24	TXIN22				
	Note3	RSVD	→	27	TXIN24				
	Note3	RSVD	→	28	TXIN25				
		DE	→	30	TXIN26				
		RA1	→	50	TXIN27				
		RA0	→	2	TXIN5				
		GA1	→	8	TXIN10				
		GA0	→	10	TXIN11				
		BA1	→	16	TXIN16				
		BA0	→	18	TXIN17				
	Note3	RSVD	→	25	TXIN23				
		CLK	→	31	CLKIN				
Even pixel data		RB7	→	51	TXIN0				
		RB6	→	52	TXIN1		TA2- →	12	DB0-
		RB5	→	54	TXIN2		TA2+ →	13	DB0+
		RB4	→	55	TXIN3			14	GND
		RB3	→	56	TXIN4		TB2- →	15	DB1-
		RB2	→	3	TXIN6		TB2+ →	16	DB1+
		GB7	→	4	TXIN7			17	GND
		GB6	→	6	TXIN8		TC2- →	18	DB2-
		GB5	→	7	TXIN9		TC2+ →	19	DB2+
		GB4	→	11	TXIN12				
		GB3	→	12	TXIN13		TCLK2- →	20	CKB-
		GB2	→	14	TXIN14		TCLK2+ →	21	CKB+
		BB7	→	15	TXIN15				
		BB6	→	19	TXIN18		TD2- →	22	DB3-
		BB5	→	20	TXIN19	2nd	TD2+ →	23	DB3+
		BB4	→	22	TXIN20			24	GND
		BB3	→	23	TXIN21			25	TxSEL0
		BB2	→	24	TXIN22			26	TxSEL1
	Note3	RSVD	→	27	TXIN24			27	GND
	Note3	RSVD	→	28	TXIN25			28	VDD
	Note3	RSVD	→	30	TXIN26			29	VDD
		RB1	→	50	TXIN27			30	VDD
		RB0	→	2	TXIN5				
		GB1	→	8	TXIN10				
		GB0	→	10	TXIN11				
		BB1	→	16	TXIN16				
		BB0	→	18	TXIN17				
	Note3	RSVD	→	25	TXIN23				
		CLK	→	31	CLKIN				

4.7.3 Mode C

	Input data	Note1		Transmitter Pin	DS90CF383, C385		Note2	CN1 Pin	CN1 Symbol
Odd pixel data and control signal		RA0	→	51	TXIN0				
		RA1	→	52	TXIN1		TA1- →	1	DA0-
		RA2	→	54	TXIN2		TA1+ →	2	DA0+
		RA3	→	55	TXIN3				
		RA4	→	56	TXIN4		TB1- →	3	DA1-
		RA5	→	3	TXIN6		TB1+ →	4	DA1+
		GA0	→	4	TXIN7				
		GA1	→	6	TXIN8		TC1- →	5	DA2-
		GA2	→	7	TXIN9		TC1+ →	6	DA2+
		GA3	→	11	TXIN12			7	GND
		GA4	→	12	TXIN13		TCLK1- →	8	CKA-
		GA5	→	14	TXIN14		TCLK1+ →	9	CKA+
		BA0	→	15	TXIN15				
		BA1	→	19	TXIN18		TD1- →	10	DA3-
		BA2	→	20	TXIN19	1st	TD1+ →	11	DA3+
		BA3	→	22	TXIN20				
		BA4	→	23	TXIN21				
		BA5	→	24	TXIN22				
	Note3	RSVD	→	27	TXIN24				
	Note3	RSVD	→	28	TXIN25				
		DE	→	30	TXIN26				
		RA6	→	50	TXIN27				
		RA7	→	2	TXIN5				
		GA6	→	8	TXIN10				
		GA7	→	10	TXIN11				
		BA6	→	16	TXIN16				
		BA7	→	18	TXIN17				
	Note3	RSVD	→	25	TXIN23				
		CLK	→	31	CLKIN				
Even pixel data		RB0	→	51	TXIN0				
		RB1	→	52	TXIN1		TA2- →	12	DB0-
		RB2	→	54	TXIN2		TA2+ →	13	DB0+
		RB3	→	55	TXIN3			14	GND
		RB4	→	56	TXIN4		TB2- →	15	DB1-
		RB5	→	3	TXIN6		TB2+ →	16	DB1+
		GB0	→	4	TXIN7			17	GND
		GB1	→	6	TXIN8		TC2- →	18	DB2-
		GB2	→	7	TXIN9		TC2+ →	19	DB2+
		GB3	→	11	TXIN12				
		GB4	→	12	TXIN13		TCLK2- →	20	CKB-
		GB5	→	14	TXIN14		TCLK2+ →	21	CKB+
		BB0	→	15	TXIN15				
		BB1	→	19	TXIN18		TD2- →	22	DB3-
		BB2	→	20	TXIN19	2nd	TD2+ →	23	DB3+
		BB3	→	22	TXIN20			24	GND
		BB4	→	23	TXIN21			25	TxSEL0
		BB5	→	24	TXIN22			26	TxSEL1
	Note3	RSVD	→	27	TXIN24			27	GND
	Note3	RSVD	→	28	TXIN25			28	VDD
	Note3	RSVD	→	30	TXIN26			29	VDD
		RB6	→	50	TXIN27			30	VDD
		RB7	→	2	TXIN5				
		GB6	→	8	TXIN10				
		GB7	→	10	TXIN11				
		BB6	→	16	TXIN16				
		BB7	→	18	TXIN17				
	Note3	RSVD	→	25	TXIN23				
		CLK	→	31	CLKIN				

Note1: LSB (Least Significant Bit) – RA0, GA0, BA0, RB0, GB0, BB0
MSB (Most Significant Bit) – RA7, GA7, BA7, RB7, GB7, BB7

Note2: Twist pair wires with 100Ω (Characteristic impedance) should be used between LCD panel signal processing board and LVDS transmitter.

Note3: Input signal RSVD is not used inside the product, but do not keep pin open to avoid noise problem.

4.8 DISPLAY COLORS AND INPUT DATA SIGNALS

This product can display in equivalent to 16,777,216 colors in 256 gray scales in each RGB sub-pixel. Also the relation between display colors and input data signals is as the following table.

Display colors		Data signal (0: Low level, 1: High level)																									
		RA7	RA6	RA5	RA4	RA3	RA2	RA1	RA0	GA7	GA6	GA5	GA4	GA3	GA2	GA1	GA0	BA7	BA6	BA5	BA4	BA3	BA2	BA1	BA0
		RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0	GB7	GB6	GB5	GB4	GB3	GB2	GB1	GB0	BB7	BB6	BB5	BB4	BB3	BB2	BB1	BB0
Basic Colors	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
	Blue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Red	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Magenta	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Green	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	Cyan	0	0	0	0	0	0	0	0	1	1	1	1	1	1	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	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
Red gray scale	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	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	dark	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	↑					:								:								:			
	↓					:								:								:			
	bright	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Red	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green gray scale	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	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	↑					:								:								:			
	↓					:								:								:			
	bright	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
	Green	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Blue gray scale	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	↑					:								:								:			
	↓					:								:								:			
	bright	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
	Blue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

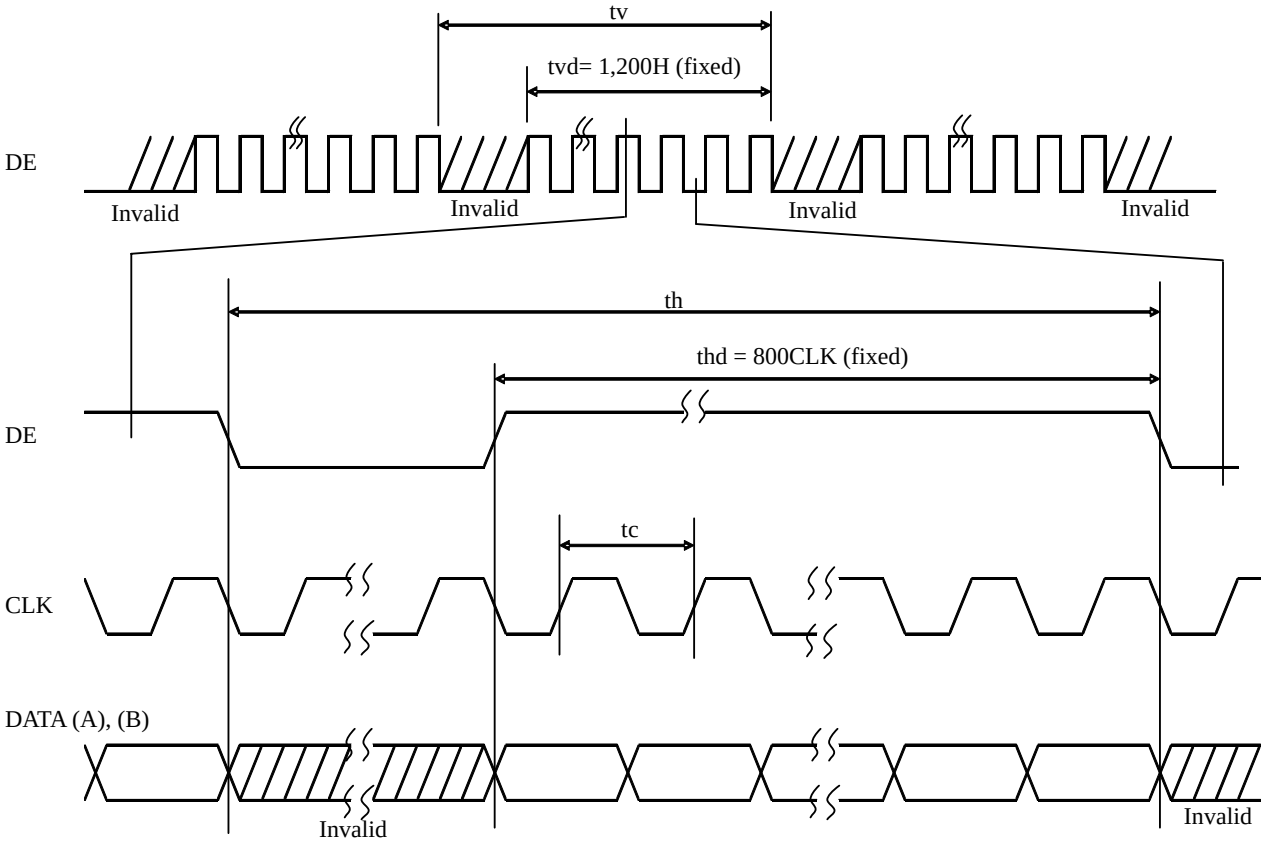
4.9 INPUT SIGNAL TIMINGS

4.9.1 Timing characteristics

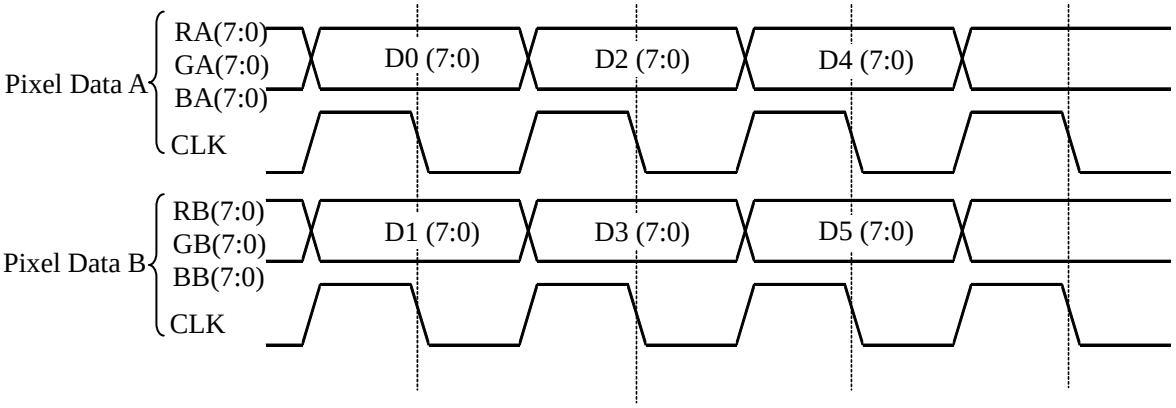
Parameter		Symbol	min.	typ.	max.	Unit	Remarks
CLK	Frequency	1/ tc	60.0	64.5	65.0	MHz	LVDS transmitter input
	Pulse width	tc	15.38	15.5	-	ns	
	Duty	-	See the data sheet of LVDS transmitter.			-	-
	Rise, fall	-				ns	
Horizontal	Cycle	th	13.1	13.3	19.2	µs	Note1
			848	860	1,156	CLK	
	Display period	thd	800			CLK	-
Vertical	Cycle	1/tv	59	60	61	Hz	-
		tv	1,206	1,250	-	H	
	Display period	tvd	1,200			H	-
DE, DATA	Setup time	-	See the data sheet of LVDS transmitter.			ns	-
	Hold time	-				ns	
	Rise, fall	-				ns	

Note1: During operation, fluctuation of horizontal cycle should be within ±1 CLK.

4.9.2 Input signal timing chart



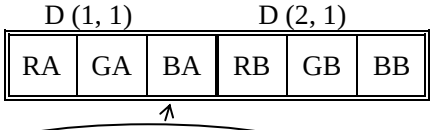
4.10 LVDS DATA TARANSMISSION METHOD



4.11 DISPLAY POSITIONS

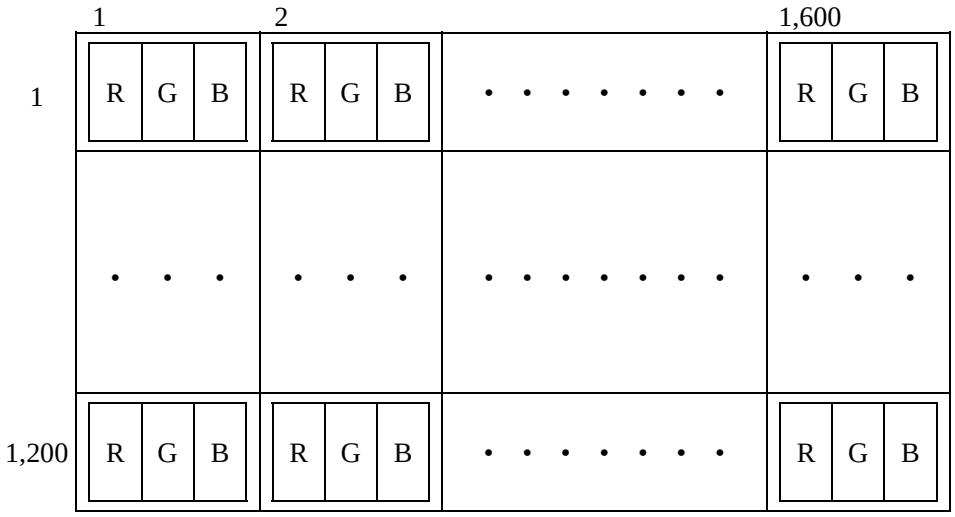
Odd pixel: RA= Red data
GA= Green data
BA= Blue data

Even pixel: RB= Red data
GB= Green data
BB= Blue data



D(1, 1)	D(2, 1)	• • •	D(X, 1)	• • •	D(1599, 1)	D(1600, 1)
D(1, 2)	D(2, 2)	• • •	D(X, 2)	• • •	D(1599, 2)	D(1600, 2)
• • •	• • •	• • • • • •	• • •	• • • • • •	• • •	• • • • • •
D(1, Y)	D(2, Y)	• • •	D(X, Y)	• • •	D(1599, Y)	D(1600, Y)
• • •	• • •	• • • • • •	• • •	• • • • • •	• • •	• • •
D(1, 1199)	D(2, 1199)	• • •	D(X, 1199)	• • •	D(1599, 1199)	D(1600, 1199)
D(1, 1200)	D(2, 1200)	• • •	D(X, 1200)	• • •	D(1599, 1200)	D(1600, 1200)

4.12 PIXEL ARRANGNMENT



4.13 OPTICS

4.13.1 Optical characteristics

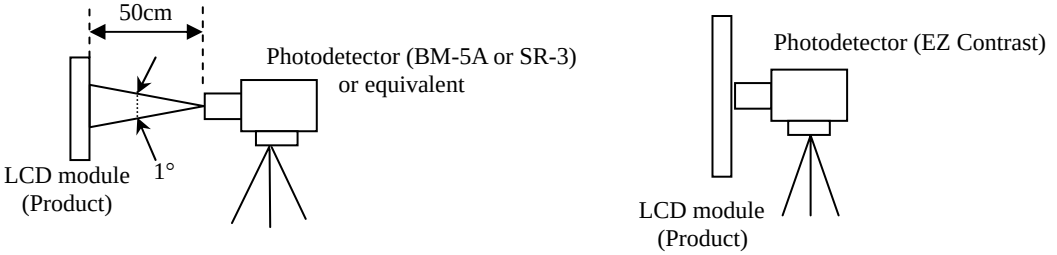
(Note1, Note2)

Parameter		Condition	Symbol	min.	typ.	max.	Unit	Measuring instrument	Remarks
Luminance		White at center θR= 0°, θL= 0°, θU= 0°, θD= 0°	L	TBD	900	-	cd/m^2	BM-5A or SR-3	Note3
Contrast ratio		White/Black at center θR= 0°, θL= 0°, θU= 0°, θD= 0°	CR	TBD	1,400	-	-	BM-5A or SR-3	Note3 Note5
Luminance uniformity		255/255 gray scale θR= 0°, θL= 0°, θU= 0°, θD= 0°	LU_{1023}	(80)	-	-	%	BM-5A or SR-3	Note4 Note6
Chromaticity	White	**x** coordinate	Wx	(0.269)	0.299	(0.329)		SR-3	Note3 Note8
		y coordinate	Wy	(0.285)	0.315	(0.345)	-		
	Red	**x** coordinate	Rx	-	(0.65)	-	-		
		y coordinate	Ry	-	(0.33)	-	-		
	Green	**x** coordinate	Gx	-	(0.29)	-	-		
		y coordinate	Gy	-	(0.60)	-	-		
	Blue	**x** coordinate	Bx	-	(0.15)	-	-		
		y coordinate	By	-	(0.07)	-	-		
Color gamut		θR= 0°, θL= 0°, θU= 0°, θD= 0° at center, against NTSC color space	C	(65)	(72)	-	%	SR-3	Note3
Color uniformity		204/255 gray scale θR= 0°, θL= 0°, θU= 0°, θD= 0°	Δu'v'	-	-	0.01	-	SR-3	Note4 Note7
Response time		Black to White	Ton	-	(20)	(30)	ms	BM-5A	Note3 Note9
		White to Black	Toff	-	(20)	(30)	ms		
Viewing angle	Right	θU= 0°, θD= 0°, CR≥ 10	θR	70	88	-	°	BM-5A or EZ Contrast	Note3 Note10
	Left	θU= 0°, θD= 0°, CR≥ 10	θL	70	88	-	°		
	Up	θR= 0°, θL= 0°, CR≥ 10	θU	70	88	-	°		
	Down	θR= 0°, θL= 0°, CR≥ 10	θD	70	88	-	°		

Note1: These are initial characteristics.

Note2: Measurement conditions are as follows.
Ta = 25°C, VDD = 12.0V, VDDB = 12.0V, PWM: Duty 100%, Display mode: UXGA,
Horizontal cycle = 1/75.19 kHz, Vertical cycle = 1/60.0Hz

Optical characteristics are measured after 20 minutes from working the product, in the dark room. Also measurement methods are as follows.



Note3: Product surface temperature at the maximum luminance control: TopF = 32°C

Note4: Product surface temperature at 450cd/m^2 luminance control: TopF = 30°C
Temperature difference in display area: ΔTBD°C

Note5: See "**4.13.2 Definition of contrast ratio**".
Note6: See "**4.13.3 Definition of luminance uniformity**".
Note7: See "**4.13.4 Definition of color uniformity**".
Note8: These coordinates are found on CIE 1931 chromaticity diagram.
Note9: See "**4.13.5 Definition of response times**".
Note10: See "**4.13. Definition of viewing angles**".

4.13.2 Definition of contrast ratio

The contrast ratio is calculated by using the following formula.

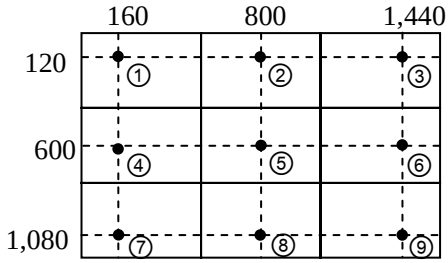
$$\text{Contrast ratio (CR)} = \frac{\text{Luminance of white screen}}{\text{Luminance of black screen}}$$

4.13.3 Definition of luminance uniformity

The luminance uniformity is calculated by using following formula.

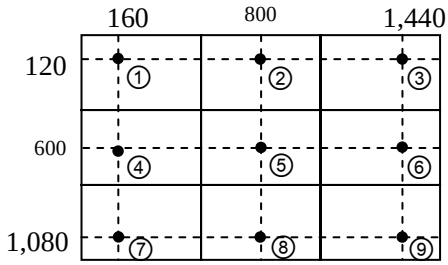
$$\text{Luminance uniformity (LU)} = \frac{\text{Minimum luminance from ① to ⑤}}{\text{Maximum luminance from ① to ⑤}}$$

The luminance is measured at near the 9 points shown below.



4.13.4 Definition of color uniformity

The color (u', v') is measured at near the 9 points shown below.



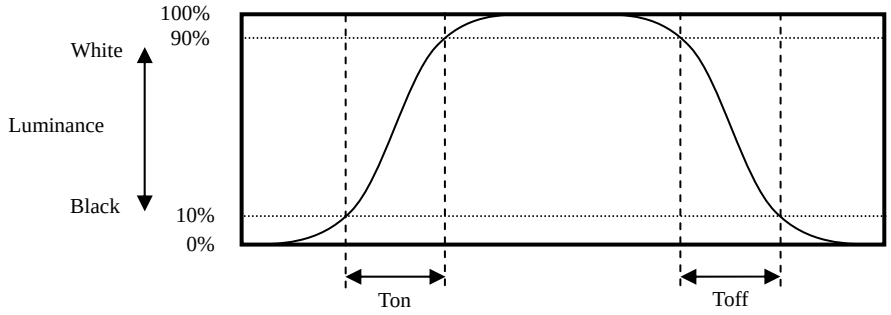
The color uniformity in each measuring point is calculated by using the following formula.

$$\text{Color uniformity}(\Delta u'v') = \sqrt{(u'_x - u'_y)^2 + (v'_x - v'_y)^2}$$

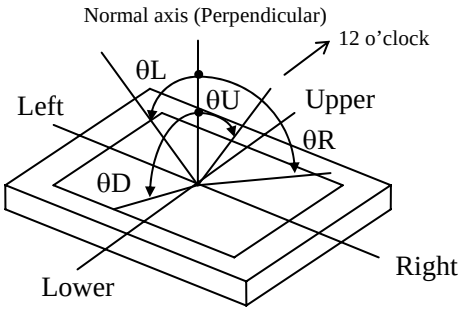
u'_x, v'_x: u', v' value at measuring point x.
u'_y, v'_y: u', v' value at measuring point y.

4.13.5 Definition of response times

Response time is measured at the time when the luminance changes from "black" to "white", or "white" to "black" on the same screen point, by photo-detector. Ton is the time when the luminance changes from 10% up to 90%. Also Toff is the time when the luminance changes from 90% down to 10% (See the following diagram.).



4.13.6 Definition of viewing angles



5. ESTIMATED LUMINANCE LIFETIME

The luminance lifetime is the time from initial luminance to half-luminance.

This lifetime is the estimated value, and is not guarantee value.

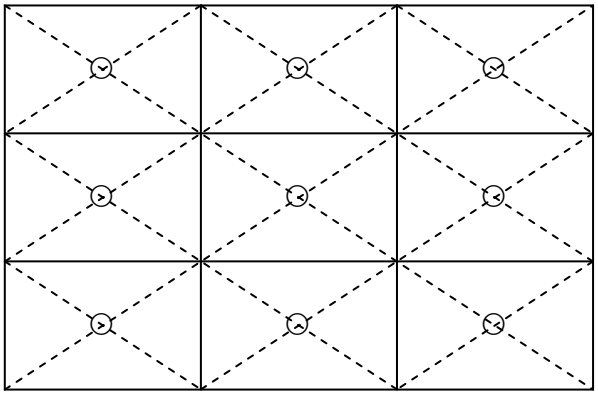
Condition		Estimated luminance lifetime (Life time expectancy) Note1, Note2, Note3	Unit
LED elementary substance	25°C (Ambient temperature of the product) Continuous operation, PWM: Duty 100%	70,000	h
	60°C (Surface temperature at screen) Continuous operation, PWM: Duty 100%	TBD	

Note1: Life time expectancy is mean time to half-luminance.
Note2: Estimated luminance lifetime is not the value for an LCD module but the value for LED elementary substance.
Note3: By ambient temperature, the lifetime changes particularly. Especially, in case the product works under high temperature environment, the lifetime becomes short.

6. RELIABILITY TESTS

Test item		Condition	Judgment Note1
High temperature and humidity (Operation)		① 60 ± 2°C, RH = 60%, 500hours ② Display data is white. Note2	No display malfunctions
Heat cycle (Operation)		① 0 ± 3°C 1hour 60 ± 3°C 1hour ② 50cycles, 4hours/cycle ③ Display data is white. Note2	
Thermal shock (Non operation)		① -20 ± 3°C 30minutes 60 ± 3°C 30minutes ② 100cycles, 1hour/cycle ③ Temperature transition time is within 5 minutes.	
Vibration (Non operation)		① 5 to 100Hz, 11.76m/s^2 ② 1 minute/cycle ③ X, Y, Z directions ④ 10 times each directions	No display malfunctions No physical damages
Mechanical shock (Non operation)		① 294m/s^2, 11ms ② X, Y, Z directions ③ 3 times each directions	
ESD (Operation)		① 150pF, 150Ω, ±10kV ② 9 places on a panel surface Note3 ③ 10 times each places at 1 sec interval	No display malfunctions
Dust (Operation)		① Sample dust: No.15 (by JIS-Z8901) ② 15 seconds stir ③ 8 times repeat at 1 hour interval Note2	
Low pressure	Non-operation	① 15 kPa (Equivalent to altitude 13,600m) ② -20°C±3°C 24 hours ③ +60°C±3°C 24 hours	No display malfunctions
	Operation	① 53.3 kPa (Equivalent to altitude 4,850m) ② 0°C±3°C 24 hours ③ +60°C±3°C 24 hours Note2	

Note1: Display and appearance are checked under environmental conditions equivalent to the inspection conditions of defect criteria.
Note2: Luminance: 450cd/m^2 at luminance control.
Note3: See the following figure for discharge points



7. PRECAUTIONS

7.1 MEANING OF CAUTION SIGNS

The following caution signs have very important meaning. **Be sure to read "7.2 CAUTIONS" and "7.3 ATTENTIONS"!**

This sign has the meaning that a customer will be injured or the product will sustain damage if the customer practices wrong operations.

This sign has the meaning that a customer will be injured if the customer practices wrong operations.

7.2 CAUTIONS

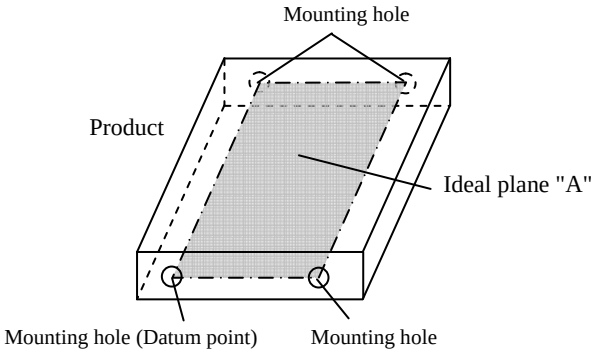
- **Do not shock and press the LCD panel and the backlight! There is a danger of breaking, because they are made of glass. (Shock: Equal to or no greater than 294m/s^2 and equal to or no greater than 11ms, Pressure: Equal to or no greater than 19.6N (ϕ16mm jig))**

7.3 ATTENTIONS

7.3.1 Handling of the product

① Take hold of both ends without touching the circuit board when the product (LCD module) is picked up from inner packing box to avoid broken down or misadjustment, because of stress to mounting parts on the circuit board.
② Do not hook nor pull cables such as lamp cable, and so on, in order to avoid any damage.
③ When the product is put on the table temporarily, display surface must be placed downward.
④ When handling the product, take the measures of electrostatic discharge with such as earth band, ionic shower and so on, because the product may be damaged by electrostatic.
⑤ The torque for product mounting screws must never exceed 0.735N·m. Higher torque might result in distortion of the bezel. And the length of product mounting screws must be ≤ 5.0mm.

⑥ The product must be installed using mounting holes without undue stress such as bends or twist (See outline drawings). And do not add undue stress to any portion (such as bezel flat area). Bends or twist described above and undue stress to any portion may cause display mura. Recommended installing method: Ideal plane "A" is defined by one mounting hole (datum point) and other mounting holes. The ideal plane "A" should be the same plane within ±0.3 mm.



⑦ Do not press or rub on the sensitive product surface. When cleaning the product surface, wipe it with a soft dry cloth.
⑧ Do not push or pull the interface connectors while the product is working.
⑨ When handling the product, use of an original protection sheet on the product surface (polarizer) is recommended for protection of product surface. Adhesive type protection sheet may change color or characteristics of the polarizer.
⑩ Usually liquid crystals don't leak through the breakage of glasses because of the surface tension of thin layer and the construction of LCD panel. But, if you contact with liquid crystal by any chance, please wash it away with soap and water.

7.3.2 Environment

① Do not operate or store in high temperature, high humidity, dewdrop atmosphere or corrosive gases. Keep the product in packing box with antistatic pouch in room temperature to avoid dusts and sunlight, when storing the product.
② In order to prevent dew condensation occurred by temperature difference, the product packing box must be opened after enough time being left under the environment of an unpacking room. Evaluate the storage time sufficiently because dew condensation is affected by the environmental temperature and humidity. (Recommended leaving time: 6 hours or more with the original packing state after a customer receives the package)
③ Do not operate in high magnetic field. If not, circuit boards may be broken.
④ This product is not designed as radiation hardened.

7.3.3 Characteristics

The following items are neither defects nor failures.

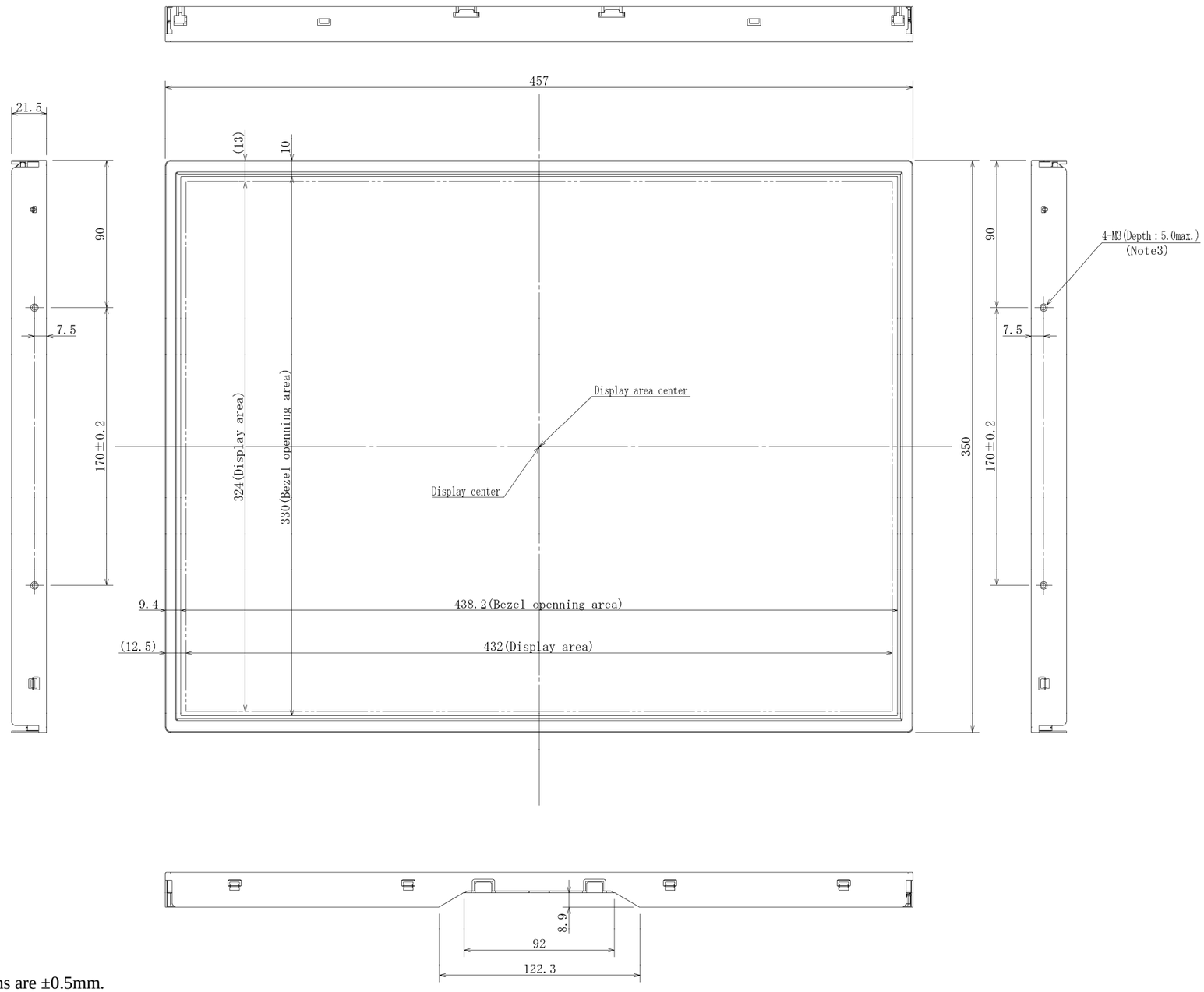
① Response time, luminance and color may be changed by ambient temperature.
② Display mura, flickering, vertical streams or tiny spots may be observed depending on display patterns.
③ Do not display the fixed pattern for a long time because it may cause image sticking. Use a screen saver, if the fixed pattern is displayed on the screen. ☆
④ The display color may be changed depending on viewing angle because of the use of condenser sheet in the backlight.
⑤ Optical characteristics may be changed depending on input signal timings.

7.3.4 Others

① All GND, GNDB, VDD and VDDB terminals should be used without any non-connected lines.
② Do not disassemble a product or adjust variable resistors.
③ Pack the product with the original shipping package, in order to avoid any damages during transportation, when returning the product to NLT for repairing and so on.
④ The LCD module by itself or integrated into end product should be packed and transported with display in the vertical position. Otherwise the display characteristics may be degraded.

8. OUTLINE DRAWINGS

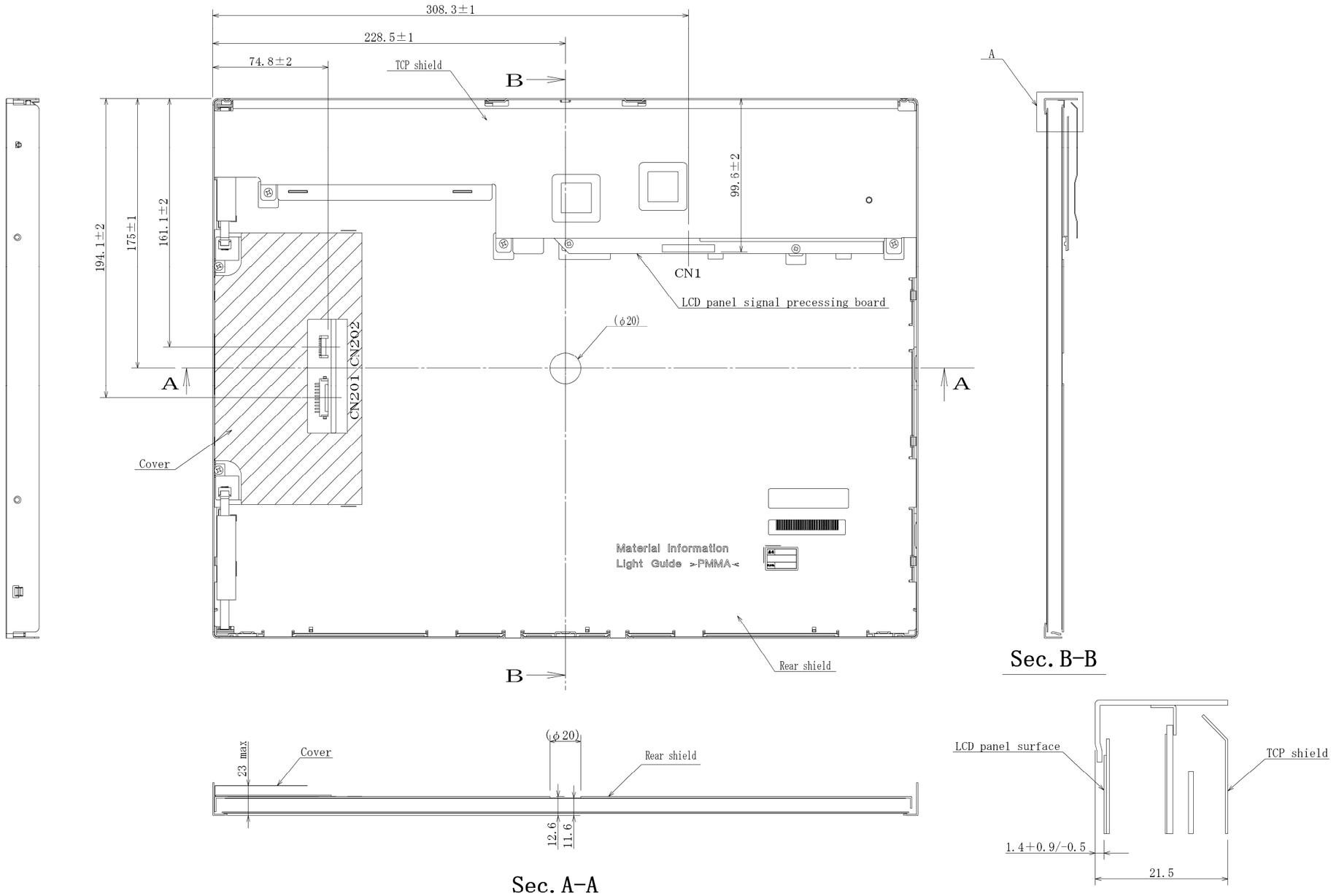
8.1 FRONT VIEW



Note1: Not shown tolerances of the dimensions are ±0.5mm.
Note2: The torque for product mounting screws must never exceed 0.735N·m.
Note3: The length of product mounting screws from surface of plate must be ≤ 5.0mm.
Note4: The values in parentheses are for reference.

Unit: mm

8.2 REAR VIEW



Note1: Not shown tolerances of the dimensions are ±0.5mm.
Note2: The torque for product mounting screws must never exceed 0.735N·m.
Note3: The length of product mounting screws from surface of plate must be ≤ 5.0mm.
Note4: The values in parentheses are for reference.

Unit: mm

REVISION HISTORY

The inside of latest specifications is revised to the clerical error and the major improvement of previous edition. Only a changed part such as functions, characteristic value and so on that may affect a design of customers, are described especially below.

Edition	Document number	Prepared date	Revision contents and signature
1st edition	DOD-PP-1257	Aug. 5, 2011	**Revision contents** New issue **Writer** *Approved by* T. OGAWA *Checked by* _____ *Prepared by* T. OGAWA
2nd edition	DOD-PP-1313	Dec. 16, 2011	**Revision contents** Preliminary data sheet DOD-PP-1257(1) → Data sheet DOD-PP-1313(2) P5 GENERAL SPECIFICATIONS- Signal system • LVDS interface: THC63LVD824 → THC63LVD824A P7 DETAILED SPECIFICATIONS- ABSOLUTE MAXIMUM RATINGS • Power supply voltage- LED driver board- VDDB: -0.3 to +27.0 → -0.3 to +15.0 P15 LUMINANCE CONTROL- Luminance control methods • Note4: See "4.6.3 Detail of BRTP timing". → "4.6.2 Detail of BRTP timing". P16 LUMINANCE CONTROL- Detail of BRTP timing • Each parameter- Unit: μm → μs P30 ATTENTIONS- Characteristics • ③ Optical characteristics … cold cathode fluorescent lamps. (elimination) **Signature of writer** *Approved by* T. OGAWA *Checked by* _____ *Prepared by* M. HASEGAWA