NLT Technologies

TFT COLOR LCD MODULE

NL6448AC33-A0D

26cm (10.4 Type)
VGA

DATA SHEET
DOD-PP-2490 (1st edition)

This **PRELIMINARY DATA SHEET** is updated document from DOD-PP-2325(2)

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: Vehicle/train/ship control system, traffic signals system, traffic information control system, air traffic control system, surgery/operation equipment monitor, disaster/crime prevention system, etc.

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Examples: Aerospace system (except seat entertainment monitor), nuclear control system, life support system, 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 NL6448AC33-A0D 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.

Color (Red, Green, Blue) 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

- For industrial use

1.3 FEATURES

- High contrast
- 6-bit digital RGB signals
- Reversible-scan direction
- DE (Data enable) function
- Long life LED backlight built in LED driver
- Replaceable lamp for backlight
- Acquisition product for UL60950-1/CSA-C22.2 No.60950-1-03 (File number: E170632) ☆
- Compliant with the European RoHS directive (2011/65/EU) ☆
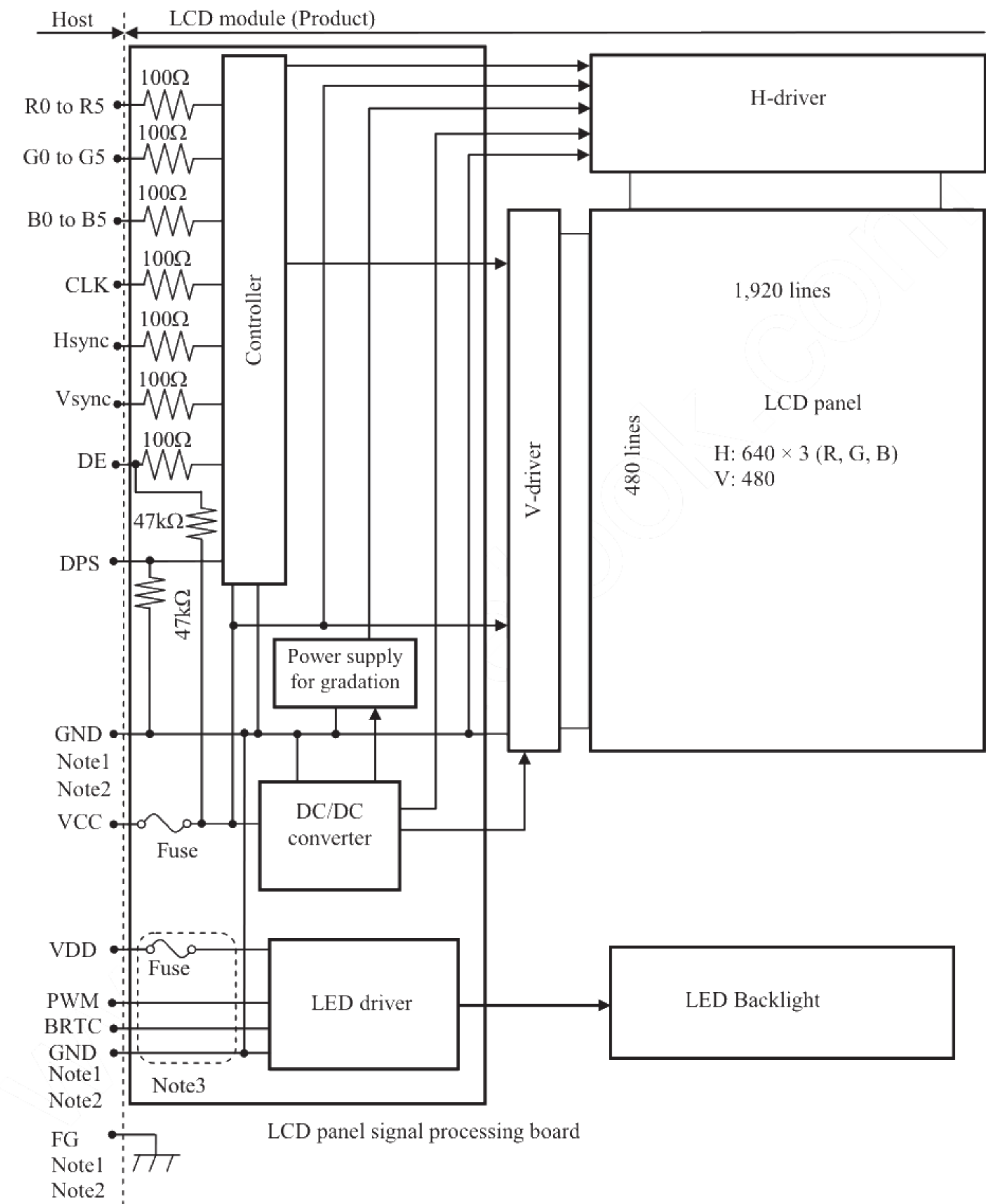
2. GENERAL SPECIFICATIONS

Display area	211.2 (H) × 158.4 (V) mm
Diagonal size of display	26cm (10.4 inches)
Drive system	a-Si TFT active matrix
Display color	262,144 colors
Pixel	640 (H) × 480 (V) pixels
Pixel arrangement	RGB (Red dot, Green dot, Blue dot) vertical stripe
Dot pitch	0.11 (H) × 0.33 (V) mm
Pixel pitch	0.33 (H) × 0.33 (V) mm
Module size	246.5 (W) × 179.4 (H) × 9.5 (D) mm (typ.)
Weight	390 g (typ.)
Contrast ratio	900:1 (typ.)
Viewing angle	*At the contrast ratio ≥ 10:1* • Horizontal: Right side 80° (typ.), Left side 80° (typ.) • Vertical: Up side 80° (typ.), Down side 80° (typ.)
Designed viewing direction	*At DPS= Low or Open: Normal scan* • Viewing direction without image reversal: Up side (12 o'clock) • Viewing direction with contrast peak: Down side (6 o'clock) • Viewing angle with optimum grayscale (γ≒ 2.2): Normal axis (perpendicular)
Polarizer surface	Antiglare
Polarizer pencil-hardness	3H (min.) [by JIS K5600]
Color gamut	*At LC D panel center* 40% (typ.) [against NTSC color space]
Response time	*Ton+Toff (10%←→90%)* 18ms (typ.)
Luminance	*At the maximum luminance control* 500cd/m^2 (typ.)
Signal system	6-bit digital signals for data of RGB colors, Dot clock (CLK), Data enable (DE), Horizontal synchronous signal (Hsync), Vertical synchronous signal (Vsync)
Power supply voltage	LCD panel signal processing board: 3.3V or 5.0V LED driver: 12.0V
Backlight	LED backlight built in LED driver ⎡ Replaceable part ⎣ • Lamp holder set: 104LHS201 ⎤⎦
Power consumption	*At the maximum luminance control, Checkered flag pattern.* 5.0W (typ.)

☆ (Weight row)

☆ (Designed viewing direction row)

☆ (Power consumption row)

3. BLOCK DIAGRAM

Host   LCD module (Product)

```
R0 to R5 ──100Ω──
G0 to G5 ──100Ω──
B0 to B5 ──100Ω──          Controller                    H-driver
CLK ──100Ω──
Hsync ──100Ω──
Vsync ──100Ω──                                           1,920 lines
DE ──100Ω──                                    V-driver  LCD panel
        47kΩ                                   480 lines H: 640 × 3 (R, G, B)
DPS ──                                                   V: 480
        47kΩ
                    Power supply
                    for gradation
GND ──
Note1
Note2
VCC ──  Fuse        DC/DC
                    converter
VDD ──
        Fuse
PWM ──              LED driver                  LED Backlight
BRTC ──
GND ──
Note1
Note2   Note3
FG ──
Note1
Note2
        LCD panel signal processing board
```

Note1: Relation between GND (Signal ground and LED Driver Ground) and FG (Frame ground) in the LCD module is as follows.

GND- FG	Not connected

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

Note3: See "**4.3.4 Equivalent circuit at input part**"

4. DETAILED SPECIFICATIONS

4.1 MECHANICAL SPECIFICATIONS

Parameter	Specification		Unit
Module size	246.5 ± 0.5 (W) $\times$ 179.4 ± 0.5 (H) $\times$ 9.5 ± 0.5 (D)	Note1	mm
Display area	211.2 (H) $\times$ 158.4 (V)	Note1	mm
Weight	390 (typ.), 435 (max.)		g

Note1: See "**8. OUTLINE DRAWINGS**".

4.2 ABSOLUTE MAXIMUM RATINGS

Parameter		Symbol	Rating	Unit	Remarks
Power supply voltage	LCD panel signal processing board	VCC	-0.3 to +6.5	V	Ta= 25°C
	LED driver	VDD	-0.3 to +15.0	V	
Input voltage for signals	Display signals Note1	VD	-0.3 to VCC+0.3	V	
	Function signal Note2	VF		V	
	Function signal for LED driver	PWM	-0.3 to +5.5	V	
		BRTC	-0.3 to +5.5	V	
Storage temperature		Tst	-30 to +80	°C	-
Operating temperature	Front surface	TopF	-30 to +80	°C	Note3
	Rear surface	TopR	-30 to +80	°C	Note4
Relative humidity Note5		RH	≤ 95	%	Ta ≤ 40°C
			≤ 85	%	40°C < Ta ≤ 50°C
			≤ 55	%	50°C < Ta ≤ 60°C
			≤ 36	%	60°C < Ta ≤ 70°C
			≤ 24	%	70°C < Ta ≤ 80°C
Absolute humidity Note5		AH	≤ 70 Note6	g/m^3	Ta= 80°C

Note1: CLK, Hsync, Vsync, DE, DATA (R0 to R5, G0 to G5, B0 to B5)
Note2: DPS
Note3: Measured at LCD panel surface (including self-heat)
Note4: Measured at LCD module's rear shield surface (including self-heat)
Note5: No condensation
Note6: Water amount at Ta= 80°C and RH= 24%

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		VCC	3.0	3.3	3.6	V	at VCC= 3.3V
			4.5	5.0	5.5	V	at VCC= 5.0V
Power supply current		ICC	-	230 Note1	300 Note2	mA	at VCC= 3.3V
			-	150 Note1	200 Note2	mA	at VCC= 5.0V
Permissible ripple voltage		VRPC	-	-	100	mVp-p	for VCC Note3, Note4, Note5
Logic input voltage for display signals	High	VDH	0.7VCC	-	VCC	V	CMOS level
	Low	VDL	0	-	0.3VCC		
Input voltage for DPS signal	High	VFH	0.7VCC	-	VCC		
	Low	VFL	0	-	0.3VCC		
Input current for DPS signal	High	IFH	-	-	300	μA	-
	Low	IFL	-300	-	-		

Note1: Checkered flag pattern [by IEC 61747-6]
Note2: Pattern for maximum current
Note3: This product works even if the ripple voltage levels are over the permissible values, but there might be noise on the display image.
Note4: The permissible ripple voltage includes spike noise.
Note5: The load variation influence does not include.

4.3.2 LED driver

(Ta= 25°C)

Parameter		Symbol	min.	typ.	max.	Unit	Remarks
Power supply voltage		VDD	10.8	12.0	13.2	V	Note1
Power supply current		IDD	-	350	430 Note2	mA	At the maximum luminance control
Permissible ripple voltage		VRP	-	-	200	mVp-p	for VDD Note3, Note4, Note5
Input voltage for PWM signals	High	VDFH1	2.1	-	5.5	V	-
	Low	VDFL1	0	-	0.15	V	
Input voltage for BRTC signals	High	VDFH2	2.1	-	5.5	V	-
	Low	VDFL2	0	-	0.8	V	
Input current for PWM signals	High	IDFH1	-	-	300	μA	-
	Low	IDFL1	-300	-	-	μA	
Input current for BRTC signals	High	IDFH2	-	-	300	μA	-
	Low	IDFL2	-300	-	-	μA	
PWM frequency		f_{PWM}	200	-	1k	Hz	Note6, Note8
PWM duty ratio		DR_{PWM}	10	-	100	%	Note7, Note9, Note10
PWM pulse width		tPWH	100	-	-	μs	Note9, Note10

Note1: When designing of the power supply, take the measures for the prevention of surge voltage.
Note2: This value excludes peak current such as overshoot current.
Note3: This product works if the ripple voltage levels are over the permissible values, but there might be noise on the display image.
Note4: The permissible ripple voltage includes spike noise.
Note5: The power supply lines (VDD and GND) may have ripple voltage during luminance control of LED. There is the possibility that the ripple voltage produces acoustic noise and signal wave noise in audio circuit and so on.
Note6: A recommended f_{PWM} value is as follows.

$$f_{PWM} = \frac{2n-1}{4} \times fv$$

(n= integer, fv= frame frequency of LCD module)

Note7: $DR_{PWM} = \frac{tPWH}{tPW}$

tPWH: PWM pulse width, tPW: PWM dimming cycle (= $1/f_{PWM}$)

Note8: Depending on the frequency used, some noise may appear on the screen, please conduct a thorough evaluation.
Note9: While the BRTC signal is high, do not set the tPWH(PWM pulse width) is less than the minimum value. It may cause abnormal working of the backlight. In this case, turn the backlight off and then on again by BRTC signal.
Note10: Regardless of the PWM frequency, both PWM duty ratio and PWM pulse width must be always more tham the minimum value.

4.3.3 Fuse

Parameter	Fuse		Rating	Fusing current	Remarks
	Type	Supplier			
VCC	FCC16152AB	KAMAYA ELECTRIC Co., Ltd.	1.5A	3.0A 5 seconds maximum	Note1
			36V		
VDD	FCC16152AB	KAMAYA ELECTRIC Co., Ltd.	1.5A	3.0A 5 seconds maximum	
			36V		

Note1: The power supply's rated current must 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.
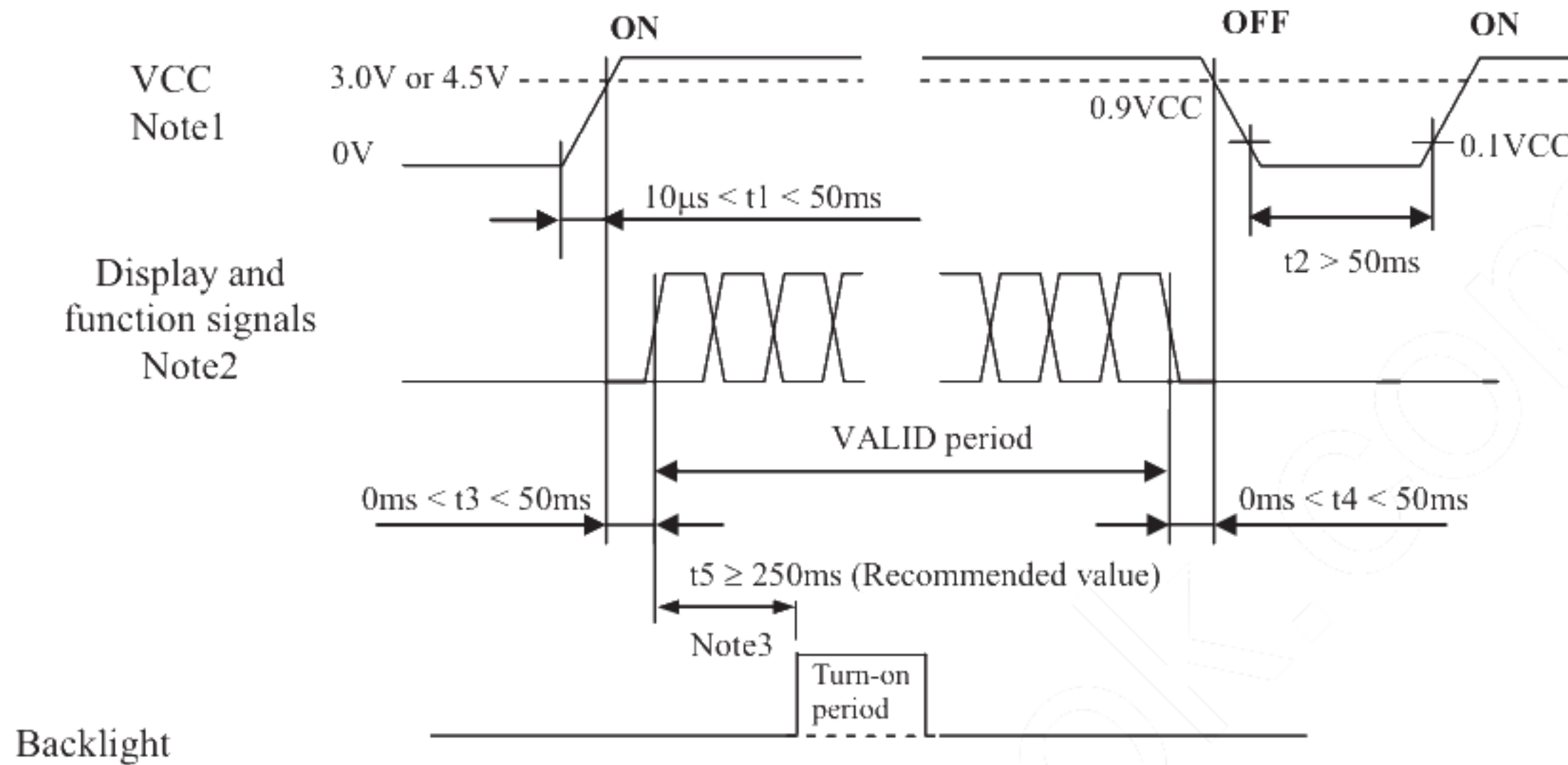
4.3.4 Equivalent circuit at input part
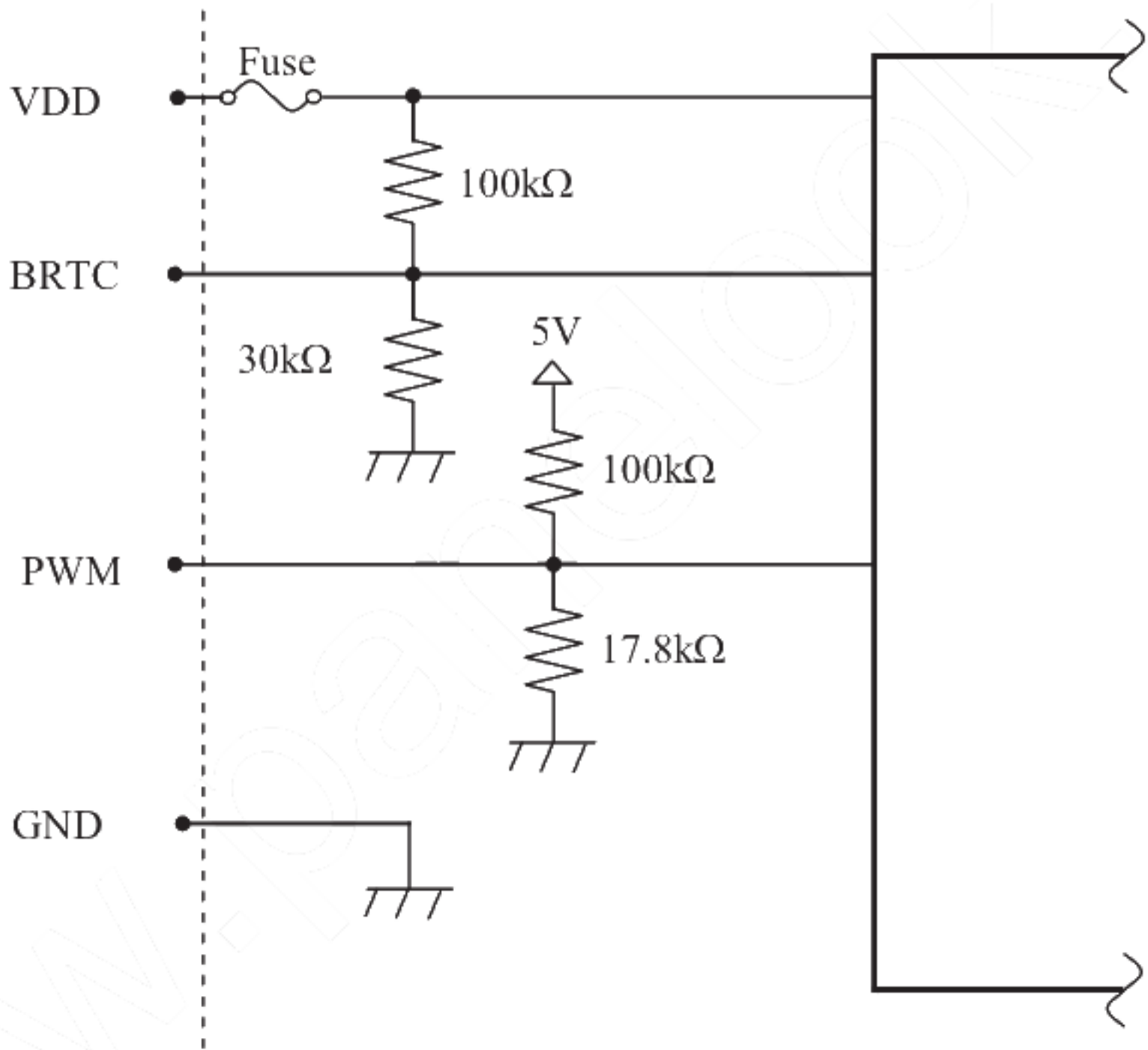
LED driver circuit

4.4 POWER SUPPLY VOLTAGE SEQUENCE

4.4.1 LCD panel signal processing board

Note1: If there is a voltage variation (voltage drop) at the rising edge of VCC below 3.0V in "VCC= 3.3V" or 4.5V in "VCC= 5.0V", there is a possibility that a product does not work due to a protection circuit.

Note2: Display signals (CLK, Hsync, Vsync, DE, DATA (R0 to R5, G0 to G5, B0 to B5)) and function signal (DPS) 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 display and function signals of this product 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: In order to avoid unstable data display, the backlight is recommended to turn on within the valid of display and function signals.
Recommended value: t5 ≥ 250ms

4.4.2 LED driver ☆
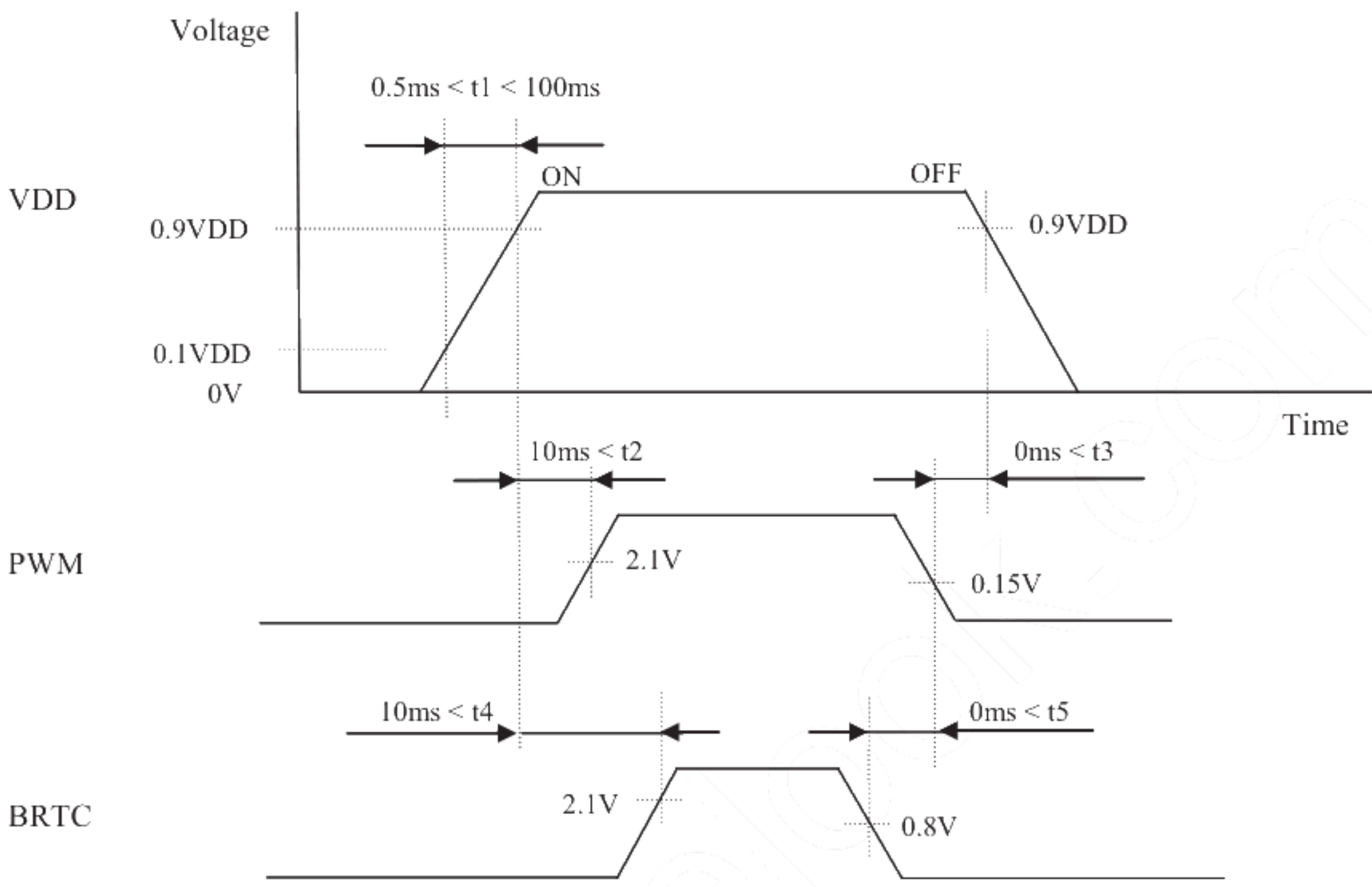
4.5 CONNECTIONS AND FUNCTIONS FOR INTERFACE PINS

4.5.1 LCD panel signal processing board

CN1 socket (LCD module side): DF9C-31P-1V (2∗) (Hirose Electric Co., Ltd. (HRS))
Adaptable plug: DF9-31S-1V (2∗), DF9-31S-1V (3∗) (Hirose Electric Co., Ltd. (HRS))

Pin No.	Symbol	Signal	Remarks
1	GND	Ground	Note1
2	CLK	Dot clock	
3	Hsync	Horizontal synchronous signal	-
4	Vsync	Vertical synchronous signal	
5	GND	Ground	Note1
6	R0	Red data (LSB)	Least significant bit
7	R1	Red data	
8	R2	Red data	
9	R3	Red data	-
10	R4	Red data	
11	R5	Red data (MSB)	Most significant bit
12	GND	Ground	Note1
13	G0	Green data (LSB)	Least significant bit
14	G1	Green data	
15	G2	Green data	
16	G3	Green data	-
17	G4	Green data	
18	G5	Green data (MSB)	Most significant bit
19	GND	Ground	Note1
20	B0	Blue data (LSB)	Least significant bit
21	B1	Blue data	
22	B2	Blue data	
23	B3	Blue data	-
24	B4	Blue data	
25	B5	Blue data (MSB)	Most significant bit
26	GND	Ground	Note1
27	DE	Selection of DE / Fixed mode	High or Open: Fixed mode Data enable signal: DE mode
28	VCC	Power supply	Note1
29	VCC	Power supply	
30	N. C.	-	Keep this pin Open.
31	DPS	Selection of scan direction	High: Reverse scan Low or Open: Normal scan Note2

Note1: All VCC and GND terminals should be used without any non-connected lines.
Note2: See **"4.8 SCANNING DIRECTIONS"**.

4.5.2 LED driver

CN2 socket (LCD module side): FI-S6P-HFE (Japan Aviation Electronics Industry Limited (JAE))
Adaptable plug: FI-S6S   (Japan Aviation Electronics Industry Limited (JAE))

Pin No.	Symbol	Signal	Remarks
1	VDD	Power supply	Note1
2	VDD	Power supply	
3	GND	Ground	
4	GND	Ground	
5	BRTC	Backlight ON/OFF control	High or Open: ON Low: OFF
6	PWM	Luminance control	PWM Dimming Note2

Note1: All VDD and GND terminals should be used without any non-connected lines.
Note2: Please do not leave the PWM terminal Open.

4.5.3 Positions of socket

Rear side
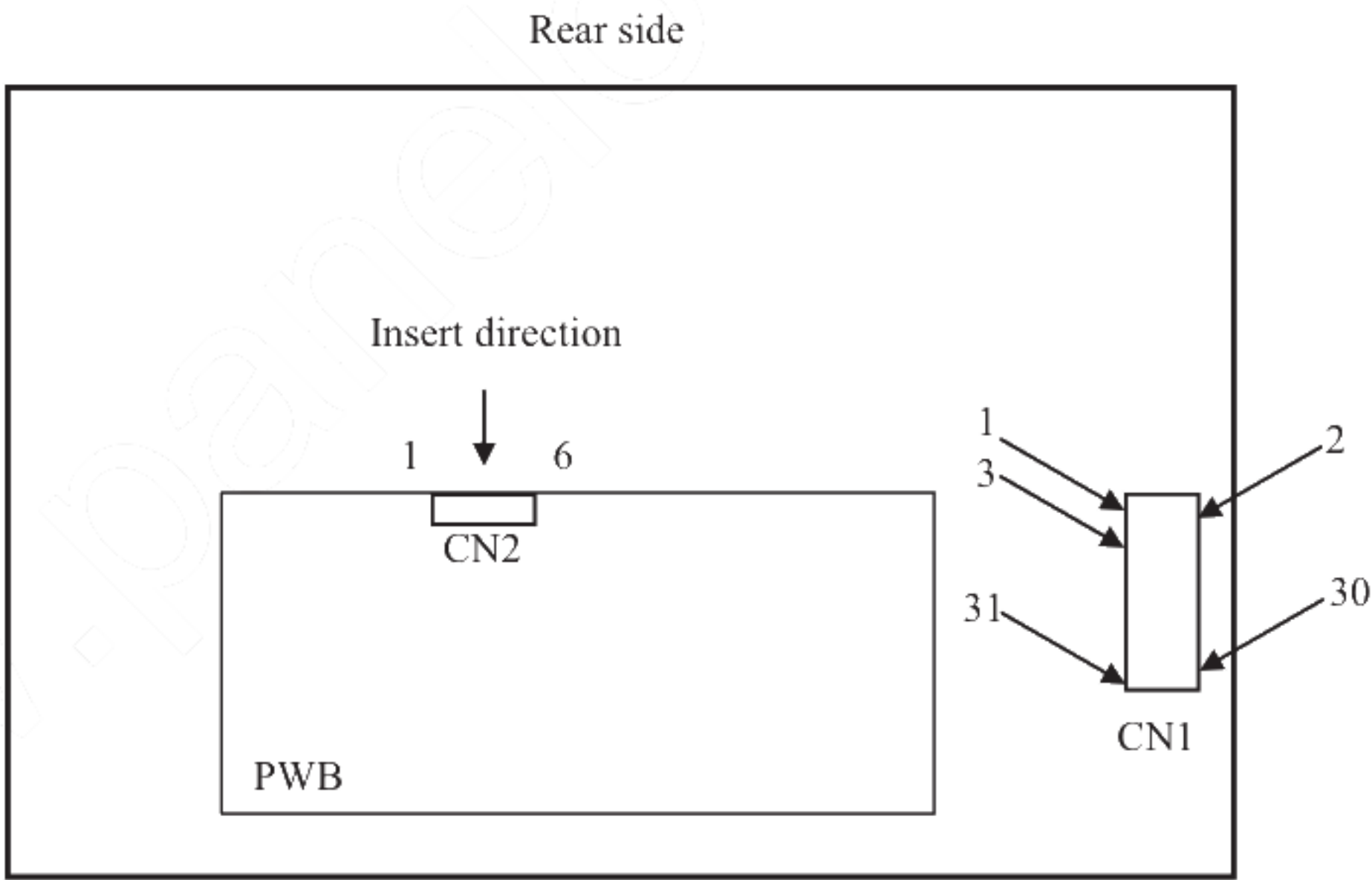
4.6 DISPLAY COLORS AND INPUT DATA SIGNALS

This product can display 262,144 colors with 64 gray scales. Also the relation between display colors and input data signals is as follows.

Display colors		Data signal (0: Low level, 1: High level)																	
		R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0
Basic colors	Black	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	1	1	1	1	1	1
	Red	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Magenta	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1
	Green	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
	Cyan	0	0	0	0	0	0	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	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
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	1	0	0	0	0	0	0	0	0	0	0	0	0
	dark	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	↑				:					:						:			
	↓				:					:						:			
	bright	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Red	1	1	1	1	1	1	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	1	0	0	0	0	0	0
	dark	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	↑				:					:						:			
	↓				:					:						:			
	bright	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0
		0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
	Green	0	0	0	0	0	0	1	1	1	1	1	1	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	1
	dark	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	1	1	1	1	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
	Blue	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1

4.7 DISPLAY POSITIONS

D (1, 1)

R	G	B

D(1, 1)	D(2, 1)	• • •	D(X, 1)	• • •	D(639, 1)	D(640, 1)
D(1, 2)	D(2, 2)	• • •	D(X, 2)	• • •	D(639, 2)	D(640, 2)
• • •	• • •	• • •	• • •	• • •	• • •	• • •
D(1, Y)	D(2, Y)	• • •	D(X, Y)	• • •	D(639, Y)	D(640, Y)
• • •	• • •	• • •	• • •	• • •	• • •	• • •
D(1, 479)	D(2, 479)	• • •	D(X, 479)	• • •	D(639, 479)	D(640, 479)
D(1, 480)	D(2, 480)	• • •	D(X, 480)	• • •	D(639, 480)	D(640, 480)

Note1: See **"4.8 SCANNING DIRECTIONS"**.

4.8 SCANNING DIRECTIONS

The following figures are seen from a front view.
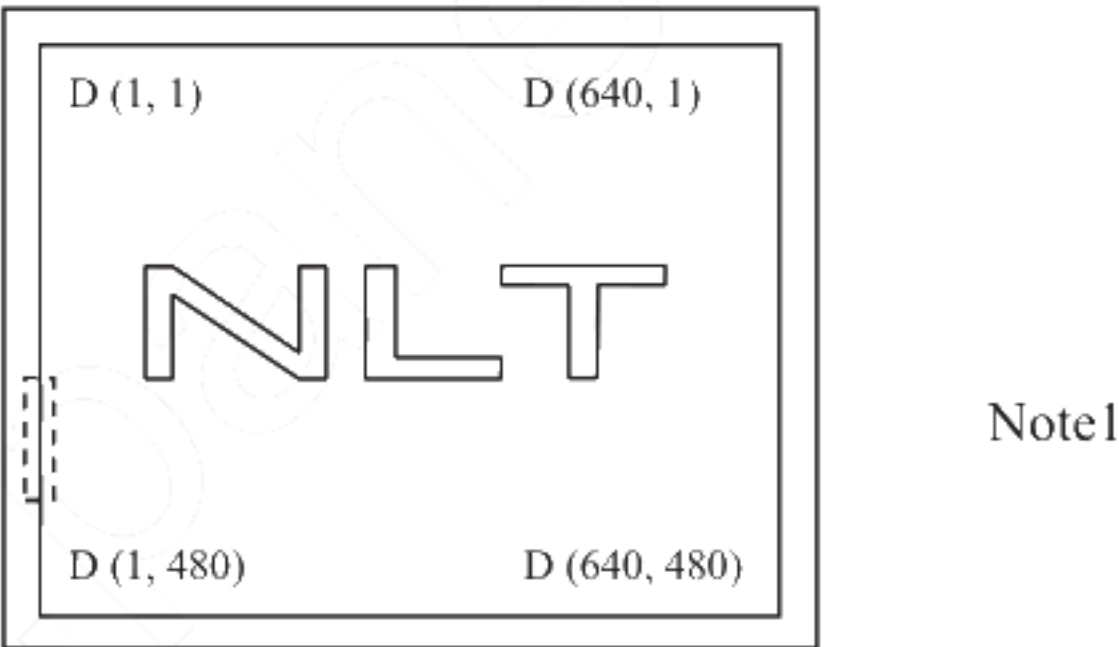
Figure1. Normal scan (DPS: Low or Open)
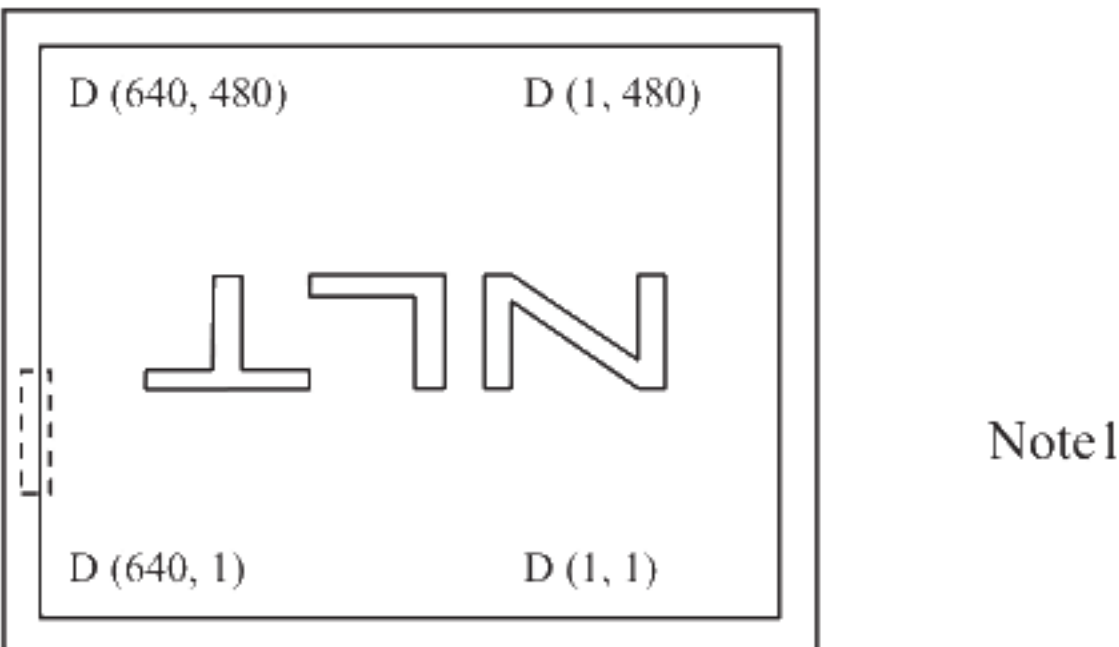
Figure2. Reverse scan (DPS: High)

Note1: Meaning of D (X, Y)
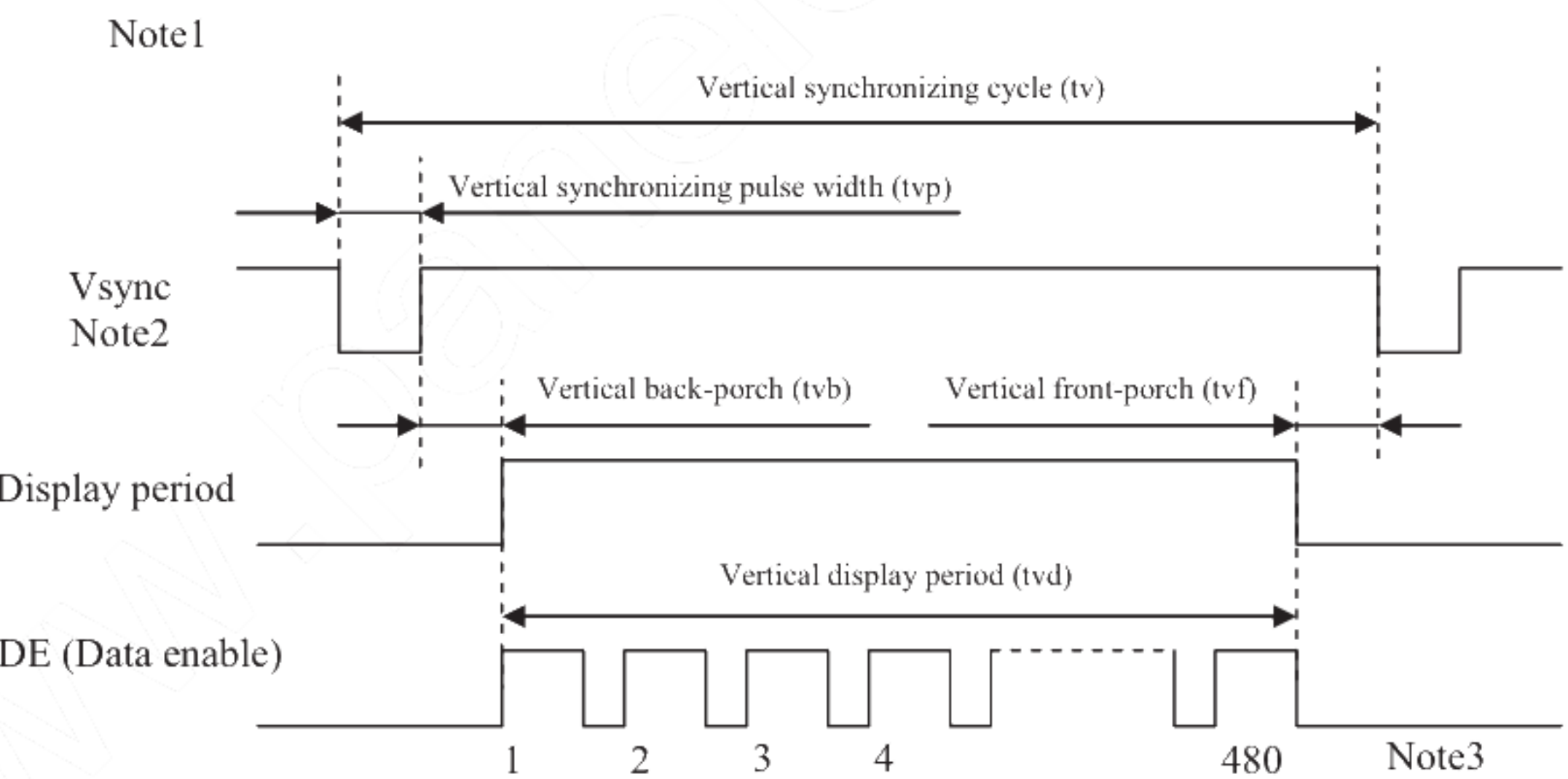D (X, Y): Input data signals for LCD panel signal processing board

4.9 INPUT SIGNAL TIMINGS

4.9.1 Outline of input signal timings

• Horizontal signal

Note1

Horizontal synchronizing cycle (th)

Horizontal synchronizing pulse width (thp)

Hsync
Note2

Horizontal back-porch (thb) Horizontal front-porch (thf)

Display period

Horizontal display period (thd)

DE (Data enable)

• Vertical signal

Note1

Vertical synchronizing cycle (tv)

Vertical synchronizing pulse width (tvp)

Vsync
Note2

Vertical back-porch (tvb) Vertical front-porch (tvf)

Display period

Vertical display period (tvd)

DE (Data enable)

1   2   3   4   480   Note3

Note1: This diagram indicates virtual signal for set up to timing.
Note2: Fixed mode cannot be used while working of DE mode.
Note3: See "**4.9.3 Input signal timing chart**" for the pulse number.

4.9.2 Timing characteristics

(a) Fixed mode

(Note1)

Parameter			Symbol	min.	typ.	max.	Unit	Remarks
CLK		Frequency	1/tc	21.0	25.175	29.0	MHz	39.72ns (typ.)
		Duty ratio	tcd	0.4	0.5	0.6	-	-
		Rise time, Fall time	tcrf	-	-	10	ns	
DATA (R0-R5) (G0-G5) (B0-B5)	CLK-DATA	Setup time	tds	3	-	-	ns	-
		Hold time	tdh	5	-	-	ns	
		Rise time, Fall time	tdrf	-	-	10	ns	
Hsync		Cycle	th	30.0	31.778	33.6	μs	31.468kHz (typ.)
					800		CLK	
		Display period	thd		640		CLK	-
		Front-porch	thf		16		CLK	
		Pulse width	thp	10	96	-	CLK	
		Back-porch	thb	-	48	134	CLK	
		Total of pulse width and back-porch	thp + thb		144		CLK	Note2
	CLK- Hsync	Setup time	ths	3	-	-	ns	-
		Hold time	thh	5	-	-	ns	
		Rise time, Fall time	thrf	-	-	10	ns	
Vsync		Cycle	tv	16.1	16.683	17.2	ms	59.94Hz (typ.)
					525		H	
		Display period	tvd		480		H	-
		Front-porch	tvf		12		H	
		Pulse width	tvp	1	2	-	H	
		Back-porch	tvb	-	31	32	H	
		Total of pulse width and back-porch	tvp + tvb		33		H	Note2
	Hsync-Vsync	Setup time	tvhs	3	-	-	ns	-
		Hold time	tvhh	5	-	-	ns	
		Rise time, Fall time	tvrf	-	-	10	ns	

Note1: Definition of parameters is as follows.
tc = 1CLK, tcd = tch/tc, th = 1H

Note2: Keep tvp + tvb and thp + thb within the table. If it is out of specification, display position will be shifted to right/left side or up/down.

(b) DE mode

(Note1, Note2, Note3)

Parameter			Symbol	min.	typ.	max.	Unit	Remarks
CLK	Frequency		1/tc	21.0	25.175	29.0	MHz	39.72ns (typ.)
	Duty ratio		tcd	0.4	0.5	0.6	-	-
	Rise time, Fall time		tcrf	-	-	10	ns	
DATA (R0-R5) (G0-G5) (B0-B5)	CLK-DATA	Setup time	tds	3	-	-	ns	-
		Hold time	tdh	5	-	-	ns	
	Rise time, Fall time		tdrf	-	-	10	ns	
DE	Horizontal	Cycle	th	30.0	31.778	33.6	μs	31.468kHz (typ.)
				-	800	-	CLK	
		Display period	thd		640		CLK	-
	Vertical (One frame)	Cycle	tv	16.1	16.683	17.2	ms	59.94Hz (typ.)
				-	525	-	H	
		Display period	tvd		480		H	-
	CLK-DE	Setup time	tdes	3	-	-	ns	-
		Hold time	tdeh	5	-	-	ns	
	Rise time, Fall time		tderf	-	-	10	ns	

Note1: Definition of parameters is as follows.
   tc = 1CLK, tcd = tch/tc, th = 1H
Note2: Hsync signal (Pin No.3 of CN1) and Vsync signal (Pin No.4 of CN1) are not used inside the product at DE mode. Do not keep these pins open to avoid noise problem.
Note3: Vertical cycle (tv) should be specified in integral multiple of Horizontal cycle (th).

4.9.3 Input signal timing chart

(a) Fixed mode

Vsync

tvp tvb 1H tvd tvf

33H (fixed)   480H (fixed)   12H (fixed)

Hsync

1 2 3   1

Hsync

DATA
(R0-R5)
(G0-G5)
(B0-B5)

INVALID   D(X,1)   D(X,Y)   D(X,479)D(X,480)   INVALID

(Note: X=1 to 640)

Hsync

DATA
(R0-R5)
(G0-G5)
(B0-B5)

INVALID   D(1,Y)D(2,Y)   D(X,Y)   D(639,Y)D(640,Y)   INVALID

Hsync

1CLK

thp   thb   thd   thf

144CLK (fixed)   640CLK (fixed)   16CLK (fixed)

CLK

1   2   1

DATA
(R0-R5)
(G0-G5)
(B0-B5)

INVALID   D(1,Y)D(2,Y)   D(640,Y)   INVALID

(Note: Y=1 to 480)
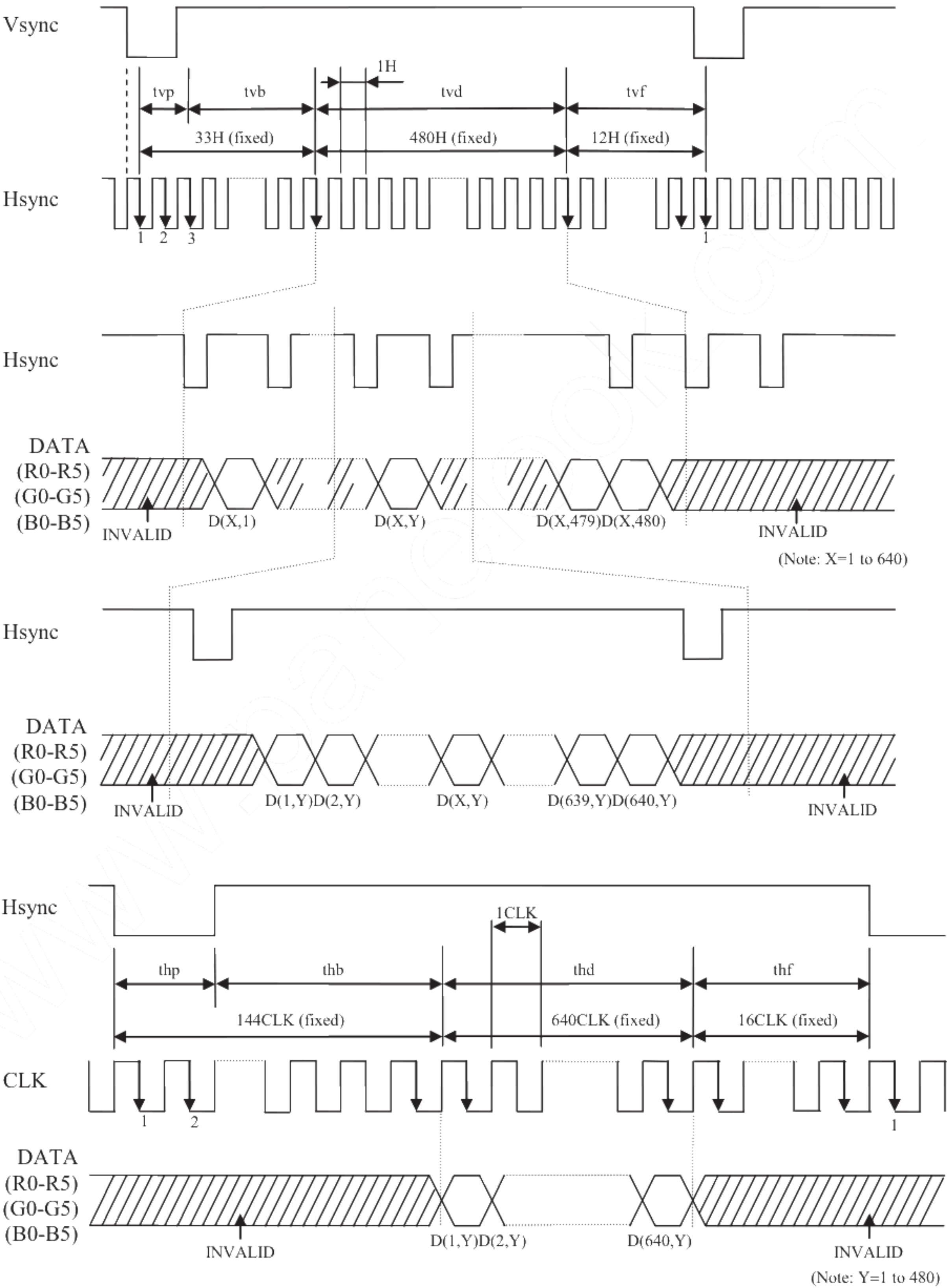
(b) DE mode

Horizontal timing
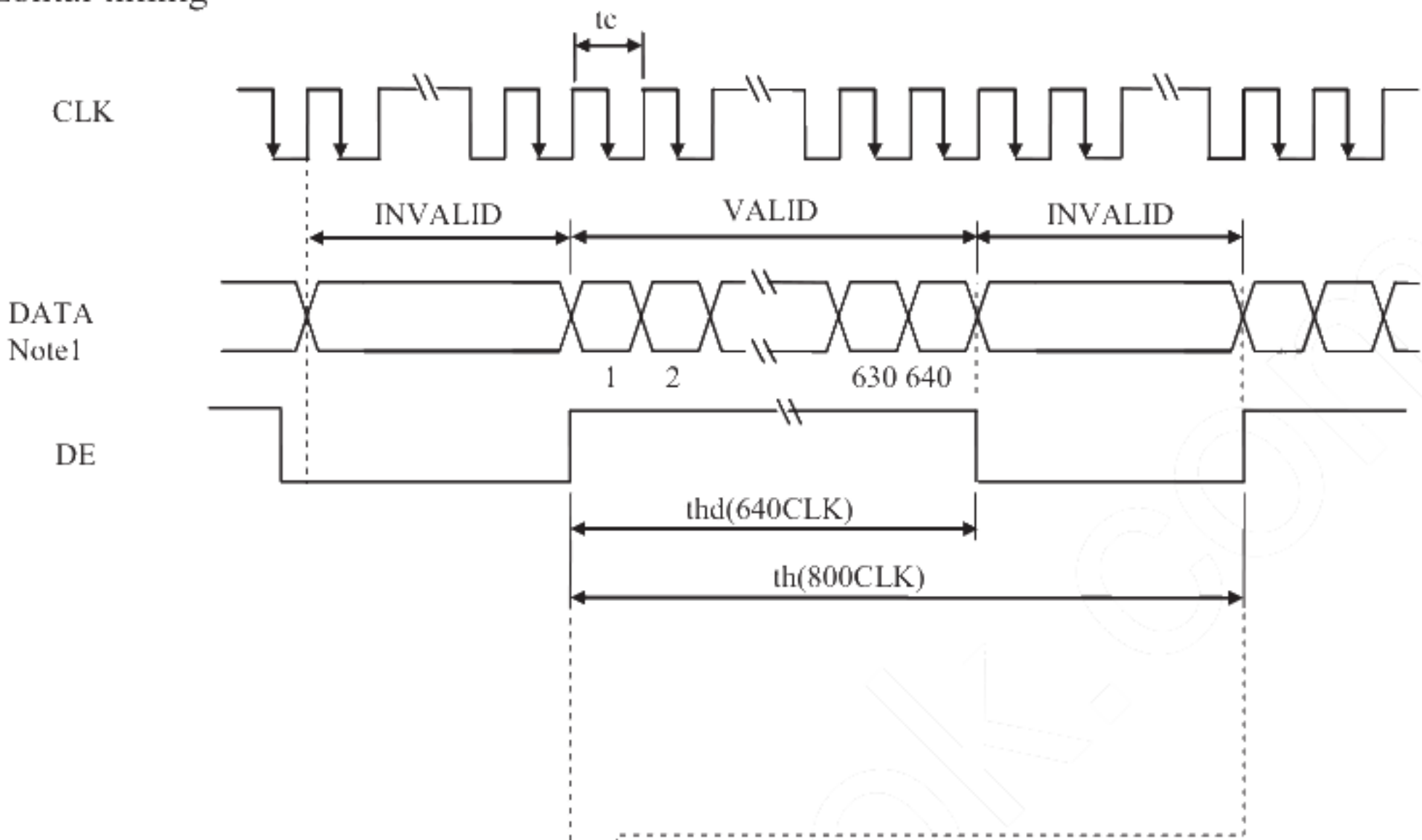
Vertical timing
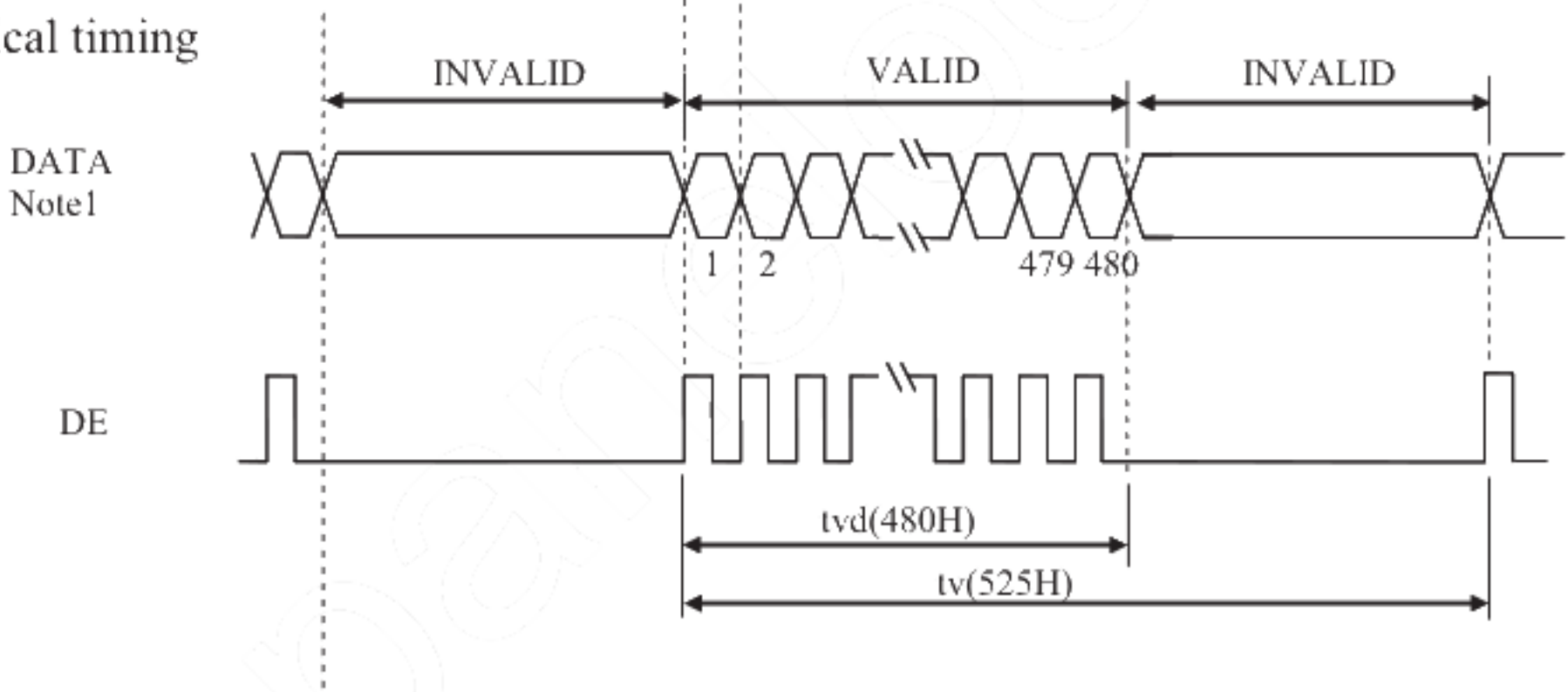
Note1: DATA = R0-R5, G0-G5, B0-B5

(c) Common item of Fixed mode and DE mode
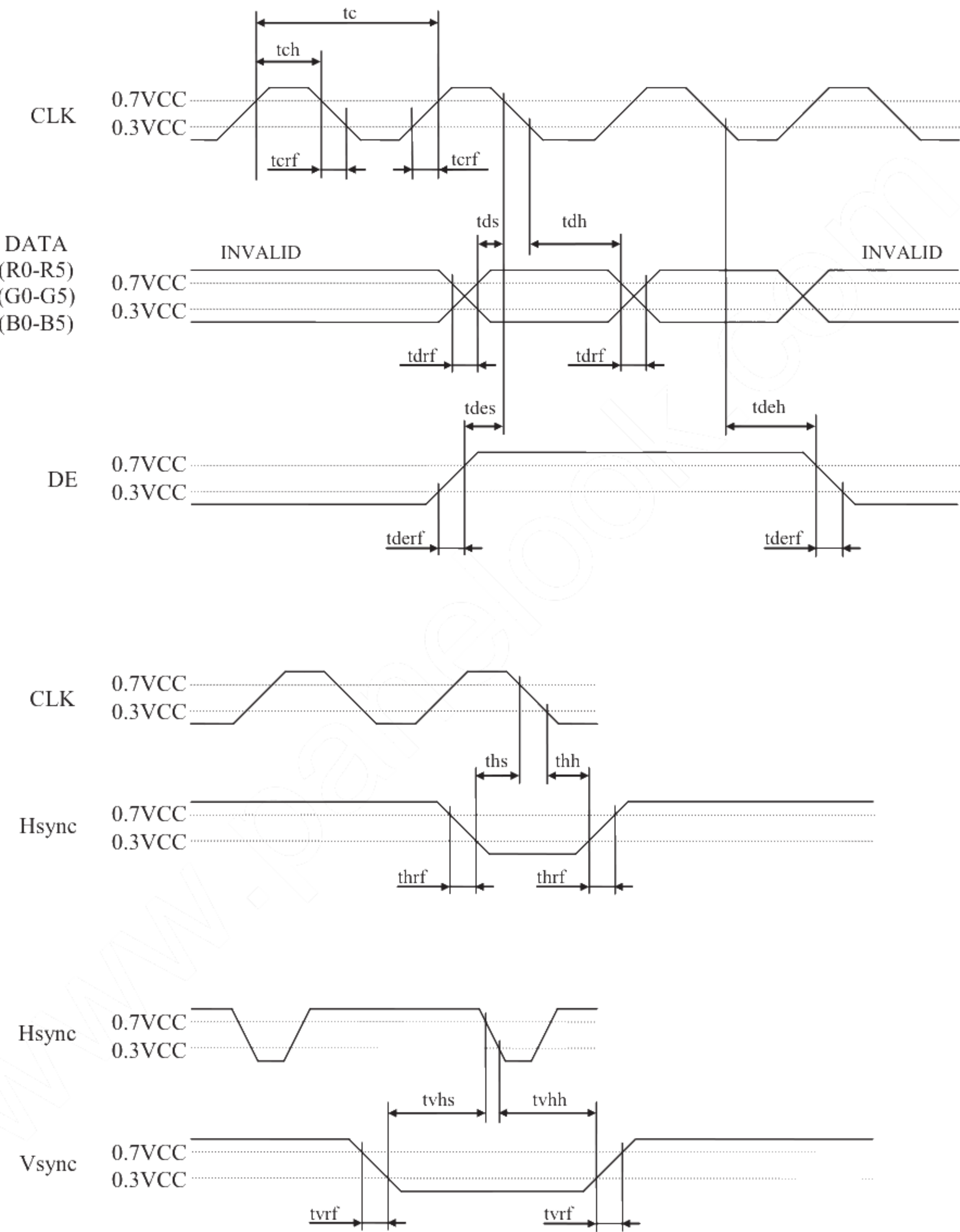
4.10 OPTICS

4.10.1 Optical characteristics

(Note1, Note2)

Parameter		Condition	Symbol	min.	typ.	max.	Unit	Measuring instrument	Remarks
Luminance		White at center $\theta R= 0°, \theta L= 0°, \theta U= 0°, \theta D= 0°$	L	350	500	-	cd/m^2	BM-5A or equivalent	-
Contrast ratio		White/Black at center $\theta R= 0°, \theta L= 0°, \theta U= 0°, \theta D= 0°$	CR	500	900	-	-	BM-5A or equivalent	Note3
Luminance uniformity		White $\theta R= 0°, \theta L= 0°, \theta U= 0°, \theta D= 0°$	LU	-	1.25	1.4	-	BM-5A or equivalent	Note4
Chromaticity	White	x coordinate	Wx	0.263	0.313	0.363	-	SR-3 or equivalent	Note5
		y coordinate	Wy	0.279	0.329	0.379	-		
	Red	x coordinate	Rx	-	0.568	-	-		
		y coordinate	Ry	-	0.347	-	-		
	Green	x coordinate	Gx	-	0.345	-	-		
		y coordinate	Gy	-	0.565	-	-		
	Blue	x coordinate	Bx	-	0.162	-	-		
		y coordinate	By	-	0.145	-	-		
Color gamut		$\theta R= 0°, \theta L= 0°, \theta U= 0°, \theta D= 0°$ at center, against NTSC color space	C	35	40	-	%		
Response time		White to Black	Ton	-	3	5	ms	BM-5A or equivalent	Note6
		Black to White	Toff	-	15	21	ms		Note7
Viewing angle	Right	$\theta U= 0°, \theta D= 0°, CR \geq 10$	θR	70	80	-	°	EZ Contrast	Note8
	Left	$\theta U= 0°, \theta D= 0°, CR \geq 10$	θL	70	80	-	°		
	Up	$\theta R= 0°, \theta L= 0°, CR \geq 10$	θU	70	80	-	°		
	Down	$\theta R= 0°, \theta L= 0°, CR \geq 10$	θD	70	80	-	°		

Note1: These are initial characteristics.
Note2: Measurement conditions are as follows.
    Ta= 25°C, VCC= 5.0V, VDD= 12.0V, PWM duty ratio: 100%, Display mode: VGA,
    Horizontal cycle= 1/31.468kHz, Vertical cycle= 1/59.94Hz, DPS= Low or Open: Normal scan

    Optical characteristics are measured at luminance saturation 20minutes after the product works
    in the dark room. Also measurement methods are as follows.
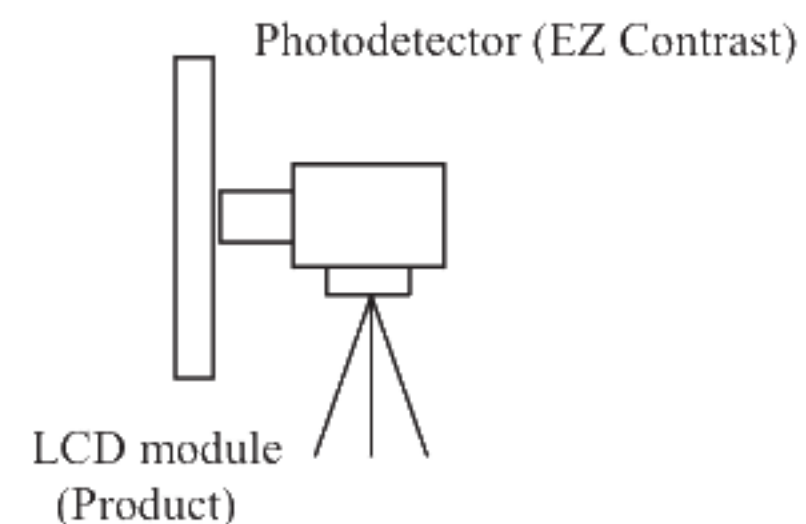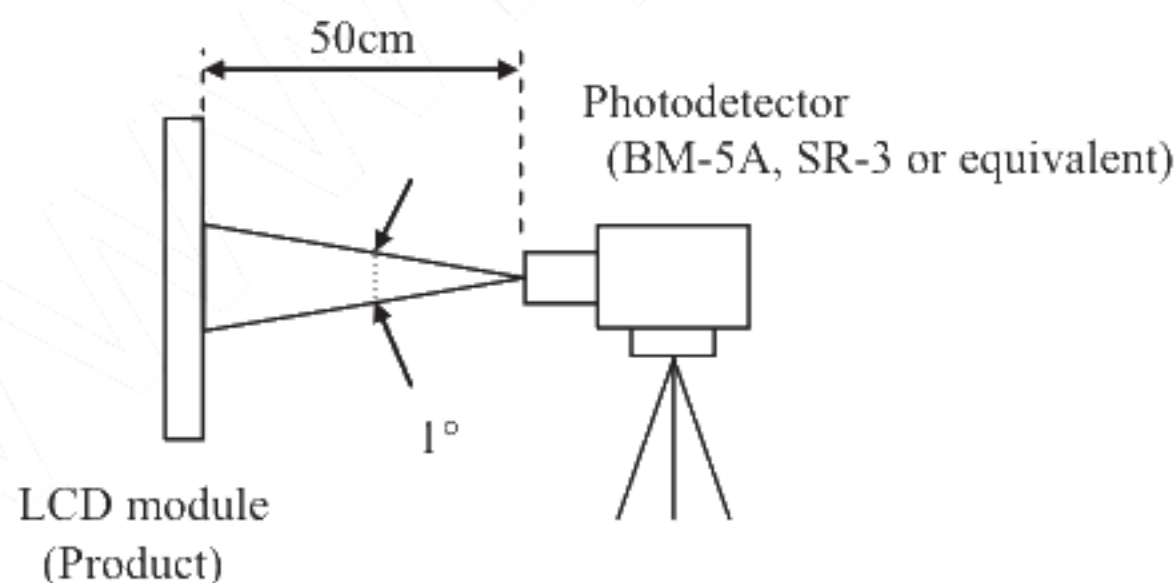
Note3: See **"4.10.2 Definition of contrast ratio"**.
Note4: See **"4.10.3 Definition of luminance uniformity"**.
Note5: These coordinates are found on CIE 1931 chromaticity diagram.
Note6: Product surface temperature: TopF= 29°C
Note7: See **"4.10.4 Definition of response times"**.
Note8: See **"4.10.5 Definition of viewing angles"**.

4.10.2 Definition of contrast ratio

The contrast ratio is calculated by using the following formula.

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

4.10.3 Definition of luminance uniformity

The luminance uniformity is calculated by using following formula.

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

The luminance is measured at near the 5 points shown below.
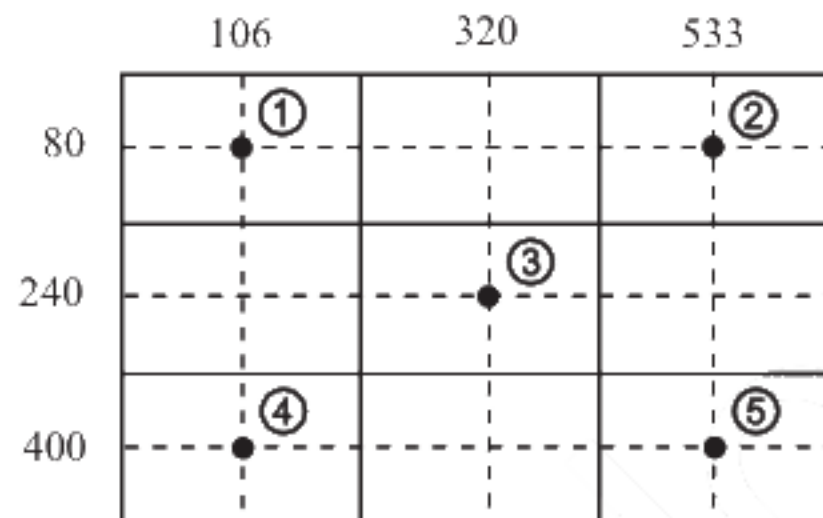
4.10.4 Definition of response times

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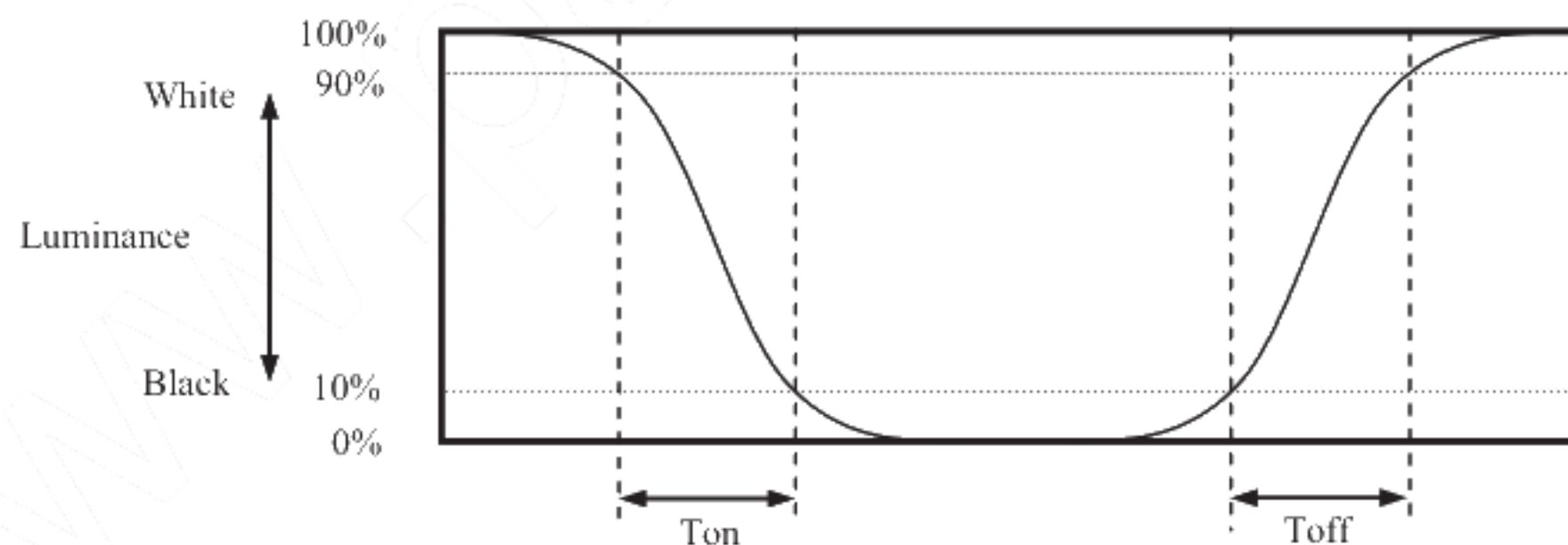
4.10.5 Definition of viewing angles
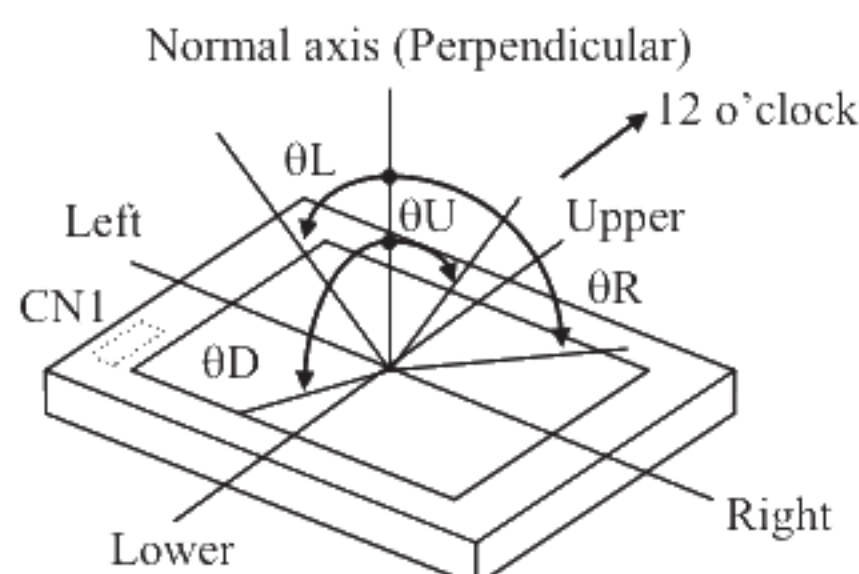
5. ESTIMATED LUMINANCE LIFETIME

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 ratio: 100%	100,000	h
	80°C (Temperature at LCD panel surface and rear shield surface) Continuous operation, PWM duty ratio: 100%	70,000	

Note1: Life time expectancy is mean time to half-luminance.
Note2: Estimated luminance lifetime is not the value for 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 = 90%, 240hours ② Display data is black.	No display malfunctions	
High temperature (Operation)	① 80 ± 3°C, 240hours ② Display data is black.		
Heat cycle (Operation)	① -30 ± 3°C…1hour 80 ± 3°C…1hour ② 50cycles, 4hours/cycle ③ Display data is black.		
Thermal shock (Non operation)	① -30 ± 3°C…30minutes 80 ± 3°C…30minutes ② 100cycles, 1hour/cycle ③ Temperature transition time is within 5 minutes.		
ESD (Operation)	① 150pF, 150Ω, ±10kV ② 9 places on a panel surface Note2 ③ 10 times each place at 1 sec interval		
Dust (Operation)	① Sample dust: No. 15 (by JIS-Z8901) ② 15 seconds stir ③ 8 times repeat at 1 hour interval		
Vibration (Non operation)	① 5 to 100Hz, 19.60m/s^2 ② 1 minute/cycle ③ X, Y, Z directions ④ 120 times each direction	No display malfunctions No physical damages	
Mechanical shock (Non operation)	① 539m/s^2, 11ms ② ±X, ±Y, ±Z directions ③ 5 times each direction		

Note1: Display and appearance are checked under environmental conditions equivalent to the inspection conditions of defect criteria.

Note2: See the following figure for discharge points.
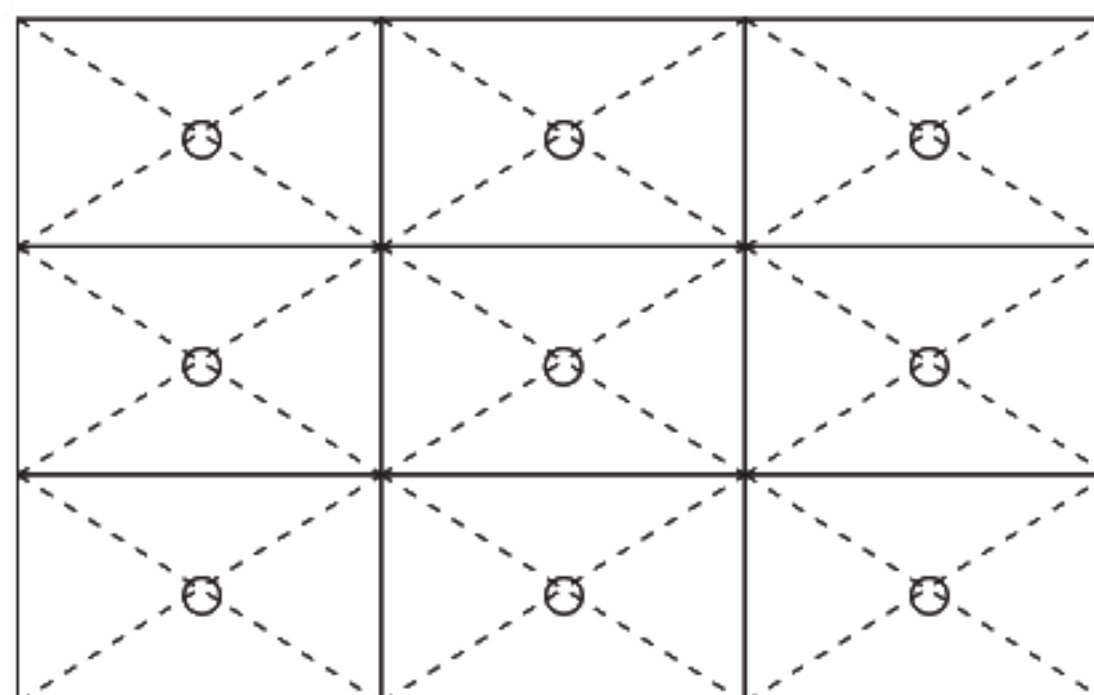
7. PRECAUTIONS

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 539m/s^2 and equal to or no greater than 11ms, Pressure: Equal to or no greater than 19.6 N (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 When the product is put on the table temporarily, display surface must be placed downward.

③ 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.

④ The torque for product mounting screws must never exceed 0.294N·m. Higher torque might result in distortion of the bezel.

⑤ 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.

⑥ Do not press or rub on the sensitive product surface. When cleaning the product surface, wipe it with a soft dry cloth.

⑦ Do not push or pull the interface connectors while the product is working. 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.

⑧ 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 Characteristics of the LCD (such as response time, luminance, color uniformity and so on) may be changed depending on ambient temperature. If the product is stored under condition of low temperature for a long time, it may cause display mura. In this case, the product should be operated after enough time being left under condition of operating 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, VCC and VDD terminals should be used without any non-connected lines.
② Do not disassemble a product or adjust variable resistors.
③ See "REPLACEMENT MANUAL FOR LAMP HOLDER SET", when replacing backlight lamps.
④ 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.
⑤ The information of China RoHS (Ⅱ) six hazardous substances or elements in this product is as follows. ☆

China RoHS (Ⅱ) six hazardous substances or elements					
Lead (Pb)	Mercury (Hg)	Cadmium (Cd)	Hexavalent Chromium (Cr VI)	Polybrominated Biphenys (PBB)	Polybrominated Biphenyl Ethers (PBDE)
×	○	○	○	○	○

Note1: ○: This indicates that the poisonous or harmful material in all the homogeneous materials for this part is equal or below the limitation level of GB/T26572-2011 standard regulation.
× : This indicates that the poisonous or harmful material in all the homogeneous materials for this part is above the limitation level of GB/T26572-2011 standard regulation.
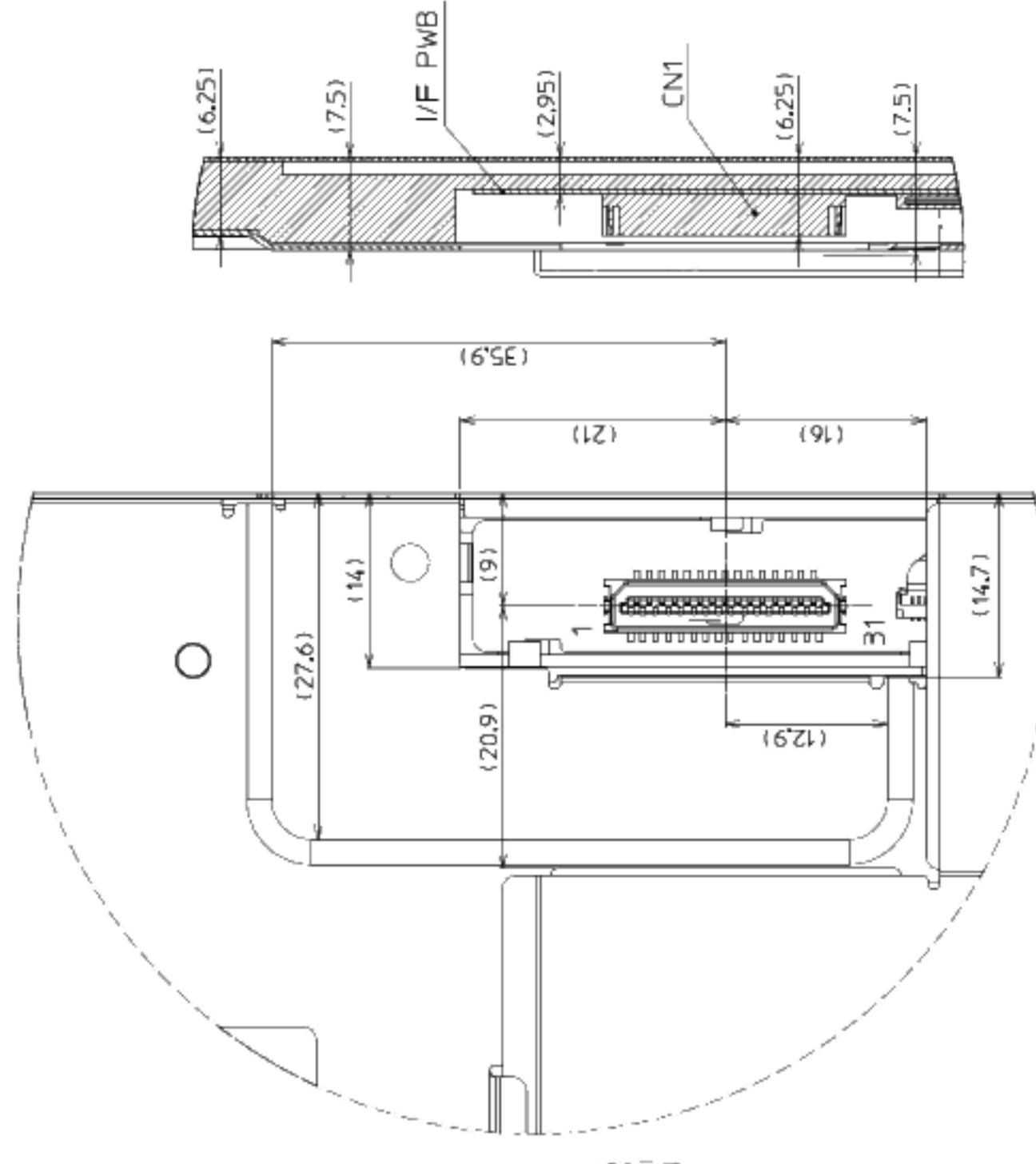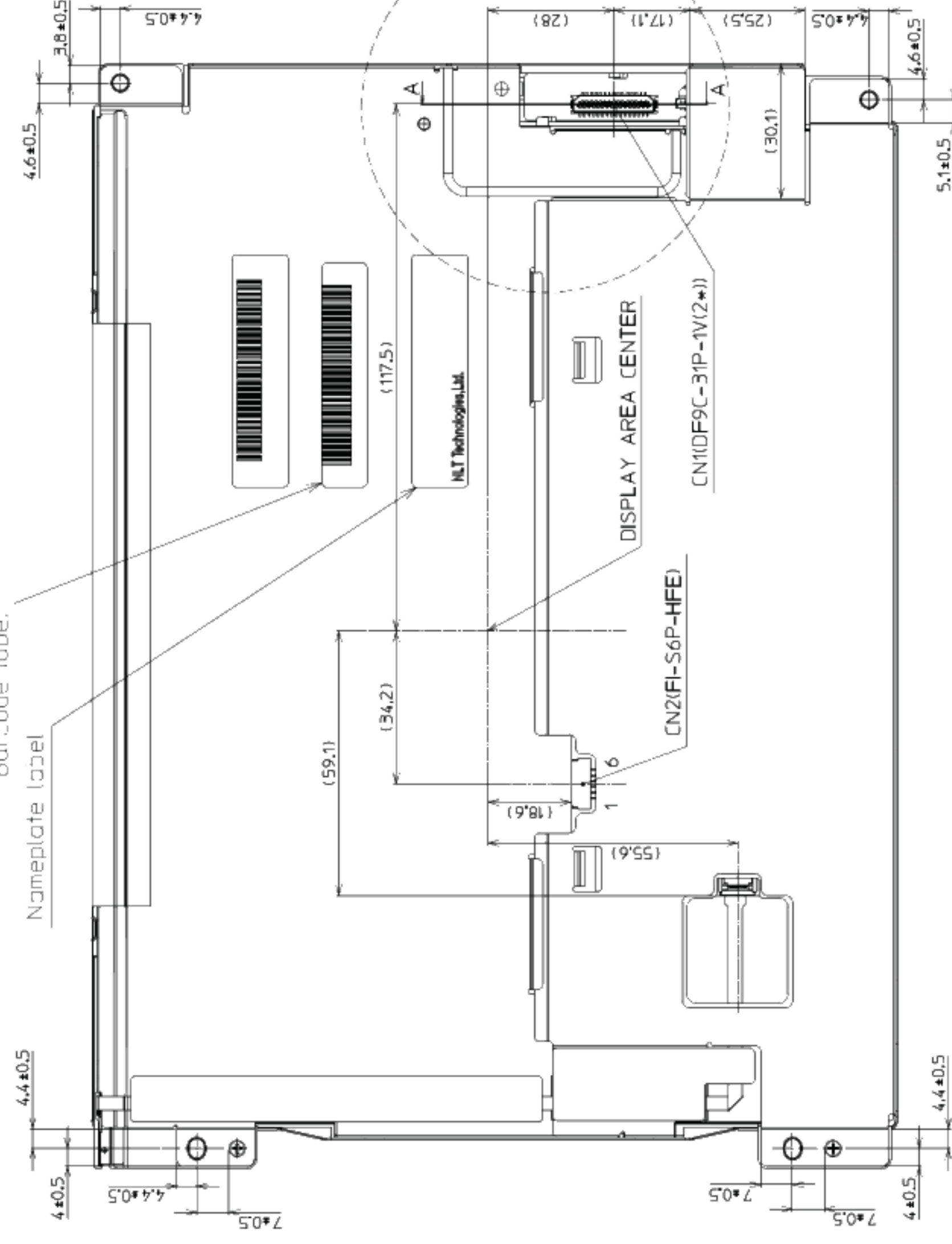
8. OUTLINE DRAWINGS

8.1 FRONT VIEW
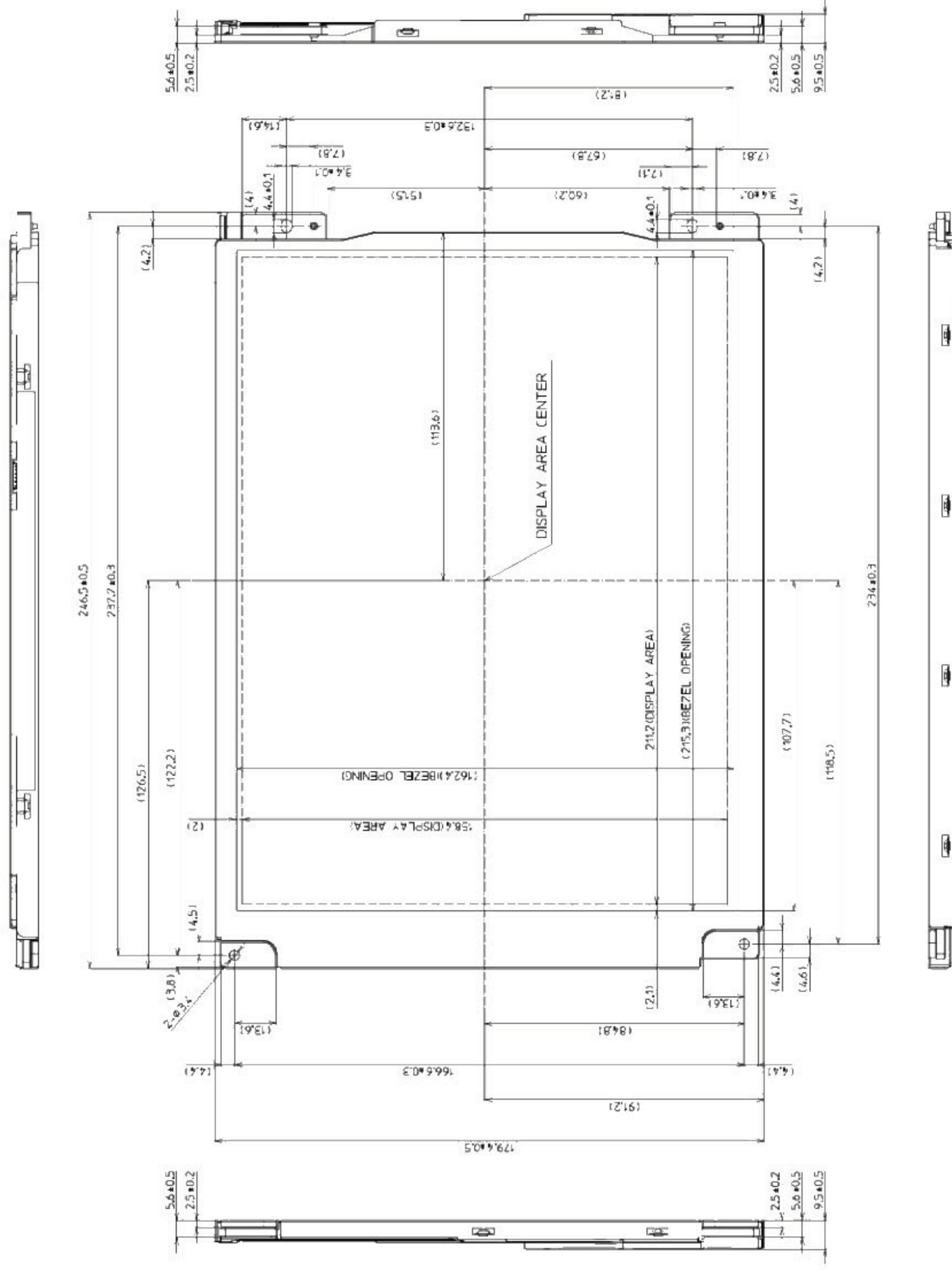
DISPLAY AREA CENTER

Unit: mm

Note1: The values in parentheses are for reference.
Note2: The torque for product mounting screws must never exceed 0.294N·m.

DATA SHEET DOD-PP-2490 (1st edition)

8.2 REAR VIEW

Section: A-A

I/F PWB

CN1

Detail: α

(35.9)

DISPLAY AREA CENTER

CN1(DF9C-31P-1V(2*))

CN2(FI-S6P-HFE)

Barcode label

Nameplate label

NLT Technologies,Ltd.

Note1: The values in parentheses are for reference.
Note2: The torque for product mounting screws must never exceed 0.294N·m.

Unit: mm