PRELIMINARY

NLT Technologies

TFT COLOR LCD MODULE

NL3224AC36-01D

14cm (5.7 Type)
QVGA
CMOS interface

PRELIMINARY DATA SHEET

DOD-PP-2221 (3rd edition)

This PRELIMINARY DATA SHEET is updated document from DOD-PP-2152(2)

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INTRODUCTION

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The products are classified into three grades: "**Standard**", "**Special**", and "**Specific**".
Each quality grade is designed for applications described below. Any customer who intends to use a product for application other than that of **Standard** is required to contact an NLT sales representative in advance.

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Examples: Office equipment, audio and visual equipment, communication equipment, test and measurement equipment, personal electronic equipment, home electronic appliances, car navigation system (with no vehicle control functions), seat entertainment monitor for vehicles and airplanes, fish finder (except marine radar integrated type), PDA, etc.

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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 NL3224AC36-01D 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

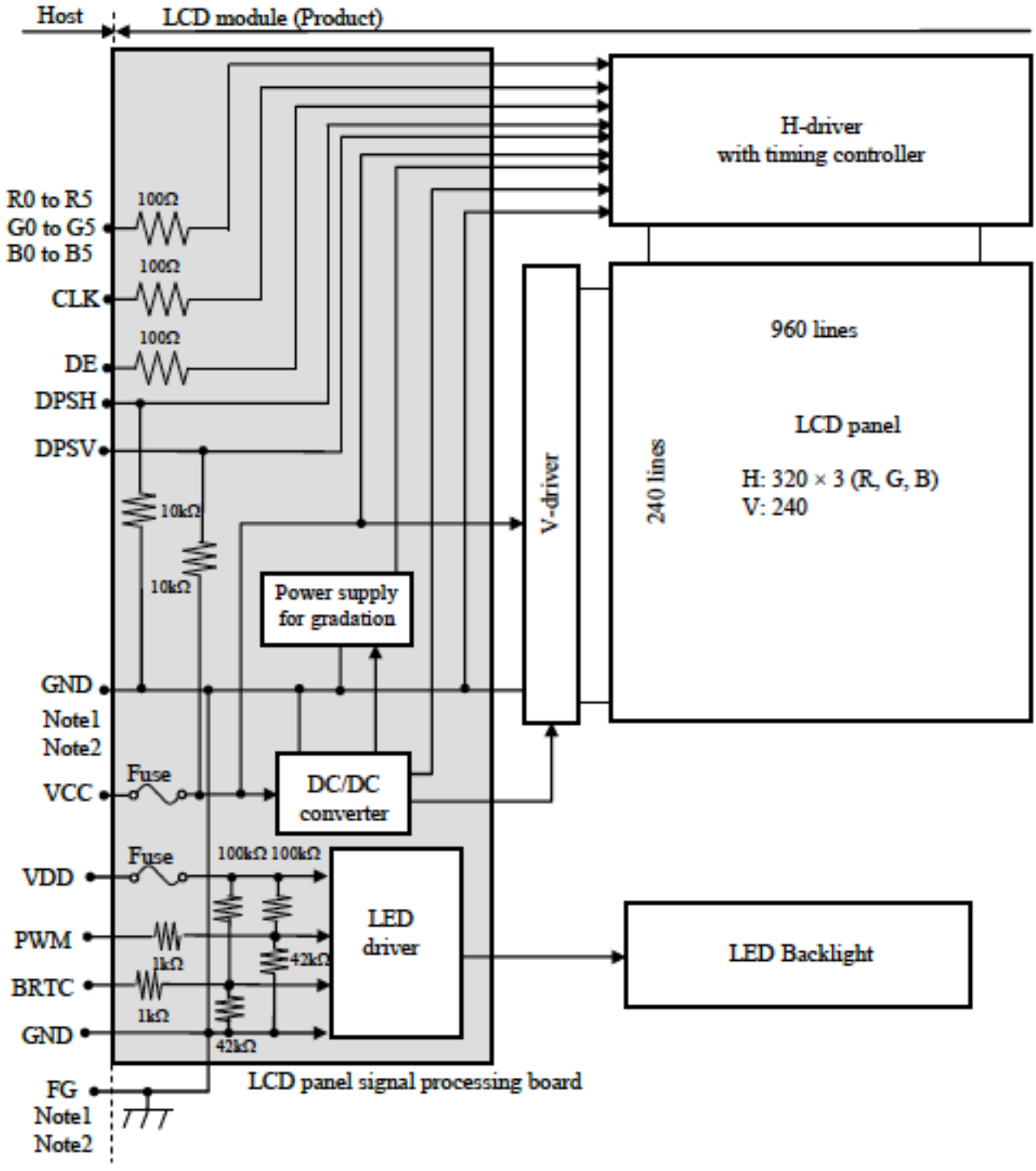
1.3 FEATURES

- High contrast
- 6-bit digital RGB signals
- Reversible-scan direction
- LED backlight built in LED driver
- UL60950-1/CSA C22.2 No.60950-1-03 will be acquired for this product when starting mass production.
- This product will comply with the European RoHS directive (2011/65/EU) when starting mass production.

2. GENERAL SPECIFICATIONS

Display area	115.2 (H) × 86.4 (V) mm	
Diagonal size of display	14cm (5.7 inches)	
Drive system	a-Si TFT active matrix	
Display color	262,144 colors	
Pixel	320 (H) × 240 (V) pixels	
Pixel arrangement	RGB (Red dot, Green dot, Blue dot) vertical stripe	
Dot pitch	0.12 (H) × 0.36 (V) mm	
Pixel pitch	0.36 (H) × 0.36 (V) mm	
Module size	144.0 (W) × 104.6 (H) × 12.3 (D) mm (typ.)	3
Weight	150 g (typ.)	3
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 DPSH = Low or Open, DPSV = High or Open: Normal scan* • Viewing direction without image reversal: Down side (6 o'clock) • Viewing direction with contrast peak: Up side (12 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 LCD panel center* 50% (typ.) [against NTSC color space]	
Response time	*Ton+Toff (10%←→90%)* (18)ms (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)	
Power supply voltage	LCD panel signal processing board: 3.3V LED driver: 12.0V	
Backlight	LED backlight built in LED driver	
Power consumption	*At the maximum luminance control, Checkered flag pattern* (1.6) W (typ.)	3

3. BLOCK DIAGRAM



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

GND - FG	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.

4. DETAILED SPECIFICATIONS

4.1 MECHANICAL SPECIFICATIONS

Parameter	Specification		Unit	
Module size	144.0 ± 0.5 (W) × 104.6 ± 0.5 (H) × 12.3 ± 0.5 (D)	Note1	mm	3
Display area	115.2 (H) × 86.4(V)	Note1	mm	
Weight	150 (typ.), (165) (max.)		g	3

Note1: See "8. OUTLINE DRAWINGS".

4.2 ABSOLUTE MAXIMUM RATINGS

Parameter			Symbol	Rating	Unit	Remarks
Power supply voltage	LCD panel		VCC	-0.3 to +(5)	V	Ta = 25°C
	LED driver		VDD	-0.3 to +(15.0)		
Input voltage for signals	Display signals Note1		VD	-0.3 to VCC+0.3	V	
	Function signals Note2		VF			
	Function signal for LED driver		PWM	-0.3 to +(5.5)	V	
			BRTC	-0.3 to +(VDD+0.1)	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, DE, DATA (R0 to R5, G0 to G5, B0 to B5)
Note2: DPSH, DPSV
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	-	
Power supply current		ICC	-	(120) Note1	(160) Note2	mA	at VCC= 3.3V	3
Permissible ripple voltage		VRPC	-	-	100	mVp-p	for VCC	
Logic input voltage for display signals	High	VDH	0.7VCC	-	VCC	V	CMOS level	
	Low	VDL	0	-	0.3VCC			
Input voltage for DPSH signal	High	VFH1	0.7VCC	-	VCC	V		
	Low	VFL1	0	-	0.3VCC			
Input voltage for DPSV signal	High	VFH2	0.7VCC	-	VCC			
	Low	VFL2	0	-	0.3VCC			
Input current for DPSH signal	High	IFH1	-	-	(800)	µA	-	3
	Low	IFL1	(-800)	-	-			
Input current for DPSV signal	High	IFH2	-	-	(800)			
	Low	IFL2	(-800)	-	-			

Note1: Checkered flag pattern [by EIAJ ED-2522]
Note2: Pattern for maximum current

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 Note2		IDD	-	(100)	(130) Note3	mA	Note4
Permissible ripple voltage		VRPD	-	-	200	mVp-p	for VDD
Input voltage for PWM signal	High	VDFH1	(2.0)	-	(5.3)	V	-
	Low	VDFL1	-	-	(0.8)	V	
Input voltage for BRTC signal	High	VDFH2	(2.0)	-	VDD	V	-
	Low	VDFL2	-	-	(0.8)	V	
PWM frequency		f_{PWM}	200	-	(10k)	Hz	Note5, Note6
PWM duty cycle		DR_{PWM}	(1)	-	100	%	Note7
PWM pulse width		tPWH	(1)	-	-	μs	

Note1: When designing of the power supply, take the measures for the prevention of surge voltage.

Note2: 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. Put a capacitor between the power supply lines (VDD and GND) to reduce the noise if necessary.

Note3: This value excludes peak current such as overshoot current.

Note4: At the maximum luminance control.

Note5: A recommended f_{PWM} value is as follows.

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

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

Note6: Depending on the frequency used, some noise may appear on the screen, please conduct a thorough evaluation.

Note7: While the BRTC signal is high, do not set the tPWH (PWM pulse width) is less than (1)μs. It may cause abnormal working of the backlight. In this case, turn the backlight off and then on again by BRTC signal.

Note8: Regardless of the PWM frequency, both PWM duty ratio and PWM pulse width must be always more than the minimum values.

4.3.3 Power supply voltage ripple

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

Power supply voltage		Ripple voltage Note1 (Measure at input terminal of power supply)	Unit
VCC	3.3V	≤100	mVp-p
VDD	12.0 V	≤200	mVp-p

Note1: The permissible ripple voltage includes spike noise.

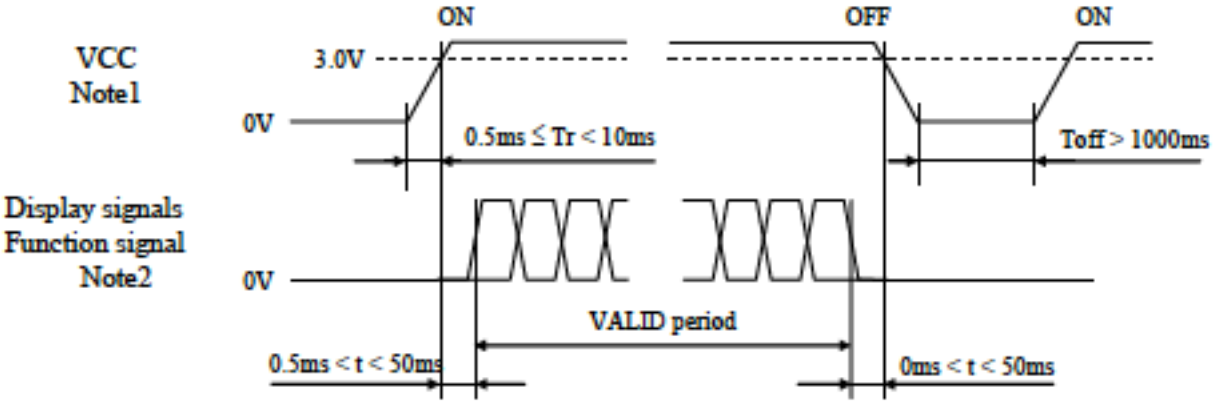
4.3.4 Fuse

Parameter	Fuse		Rating	Fusing current	Remarks
	Type	Supplier			
VCC	FCC16152AB	KAMAYA ELECTRIC CO.,LTD	1.5A 36V	3.0A	Note1
VDD	FCC16152AB	KAMAYA ELECTRIC CO.,LTD	1.5A 36V	3.0A	

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.

4.4 POWER SUPPLY VOLTAGE SEQUENCE

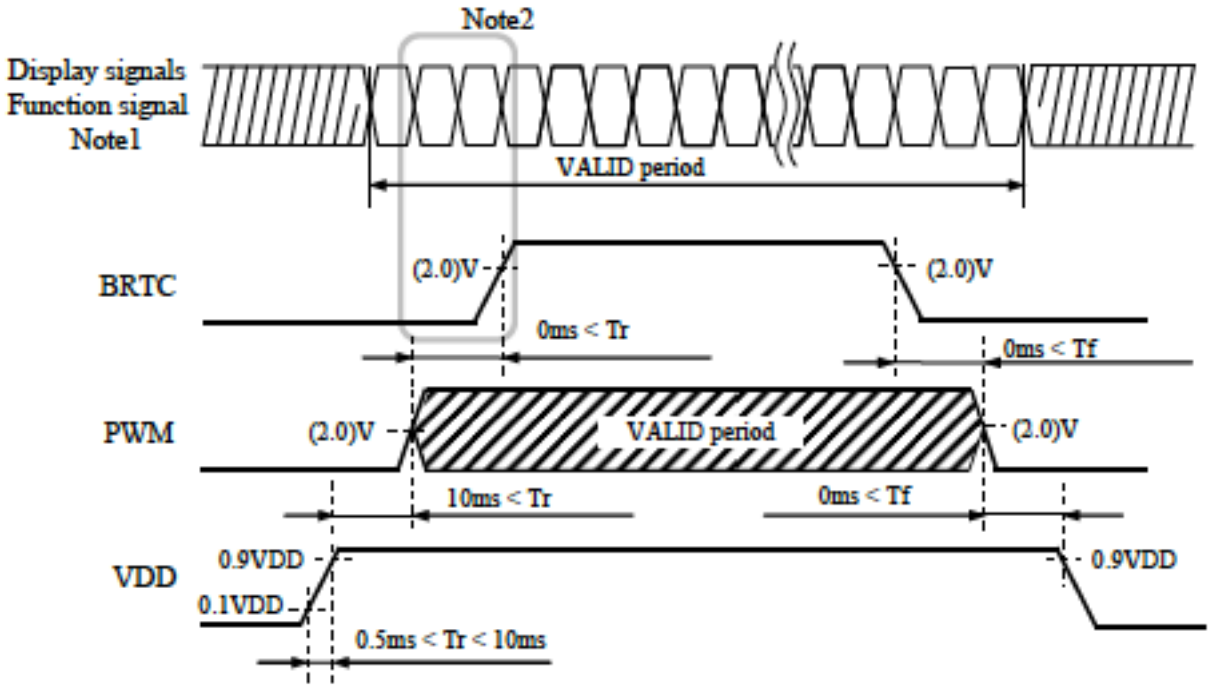
4.4.1 LCD panel signal processing board



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

Note2: Display signals (CLK, DE, DATA (R0 to R5, G0 to G5, B0 to B5)) and function signals (DPSV, DPSH) 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.

4.4.2 LED driver



Note1: These are the display and function signals for LCD panel signal processing board.

Note2: The backlight should be turned on within the valid period of display and function signals, in order to avoid unstable data display.

4.5 CONNECTIONS AND FUNCTIONS FOR INTERFACE PINS

4.5.1 LCD panel signal processing board

CN1 socket (LCD module side): 089H33-000100-G2-R (STARCONN)
Adaptable plug: [0.5mm pitch, Bottom Contact Type]

Pin No.	Symbol	Signal	Remarks
1	GND	Ground	Note1
2	CLK	Dot clock	-
3	N.C.	-	Keep this pin Open.
4	N.C.	-	
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	Data enable signal	-
28	VCC	Power supply	Note1
29	VCC	Power supply	
30	DPSH	Selection of Horizontal scan direction	High : Right and Left reverse scan Low or Open: Normal scan Note2
31	DPSV	Selection of Vertical scan direction	High or Open: Normal scan Low : Up and Down reverse scan Note2
32	N.C.	-	Keep this pin Open.
33	GND	Ground	Note1

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

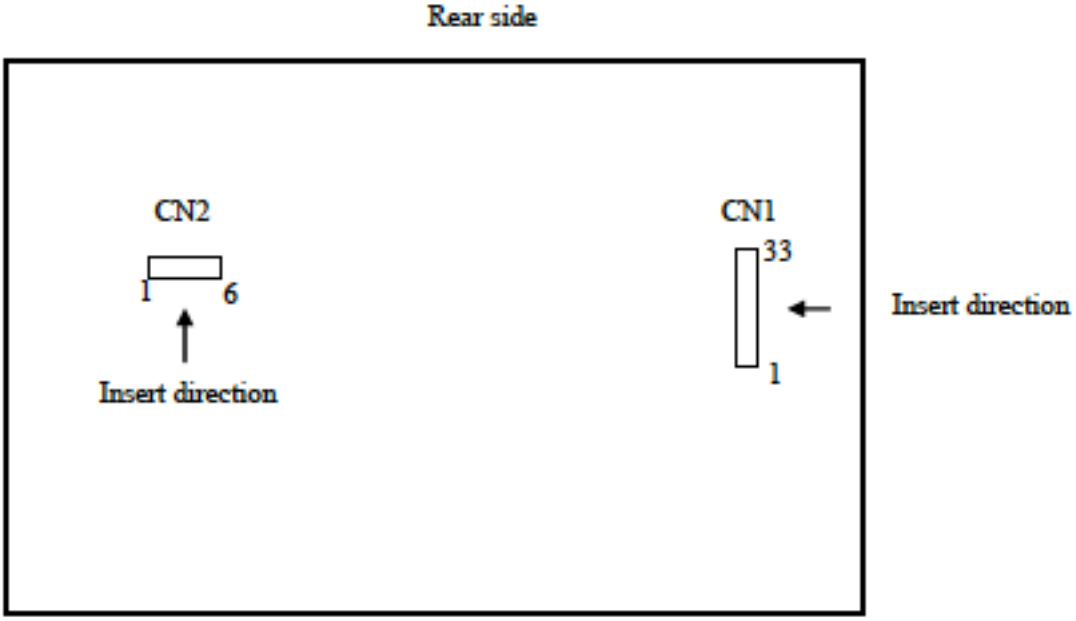
4.5.2 LED driver

CN2 socket (LCD module side): SM06B-SRSS-TB(LS)(SN) (JST Co. Ltd)
Adaptable plug: SHR-06V-S-B (JST Co. Ltd)

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

Note1: All GND and VDD terminals must be connected to appropriate terminals.

4.5.3 Positions of socket



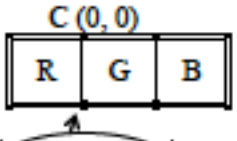
4.6 DISPLAY COLORS AND INPUT DATA SIGNALS

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

The following table is the coordinates per pixel (See "4.8 SCANNING DIRECTIONS".).



C(0, 0)	C(1, 0)	---	C(X, 0)	---	C(318, 0)	C(319, 0)
C(0, 1)	C(1, 1)	---	C(X, 1)	---	C(318, 1)	C(319, 1)
. . .	. . .	. . .	. . .	. . .	. . .	. . .
C(0, Y)	C(1, Y)	---	C(X, Y)	---	C(318, Y)	C(319, Y)
. . .	. . .	. . .	. . .	. . .	. . .	. . .
C(0, 238)	C(1, 238)	---	C(X, 238)	---	C(318, 238)	C(319, 238)
C(0, 239)	C(1, 239)	---	C(X, 239)	---	C(318, 239)	C(319, 239)

4.8 SCANNING DIRECTIONS

3

The following figures are seen from a front view.

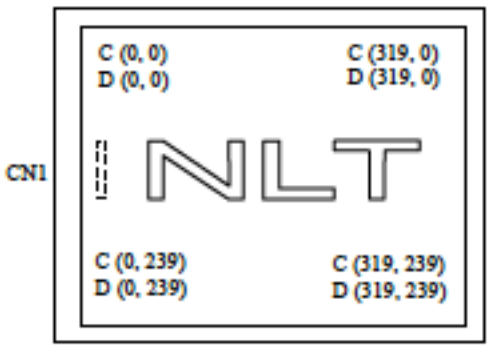


Figure1. DPSH= Low or Open (Normal scan)
DPSV= High or Open (Normal scan)

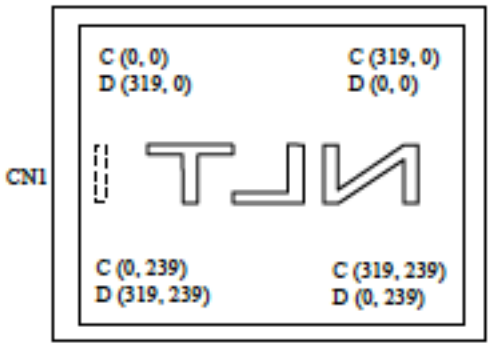


Figure2. DPSH= High (Reverse scan)
DPSV= High or Open (Normal scan)

Note1

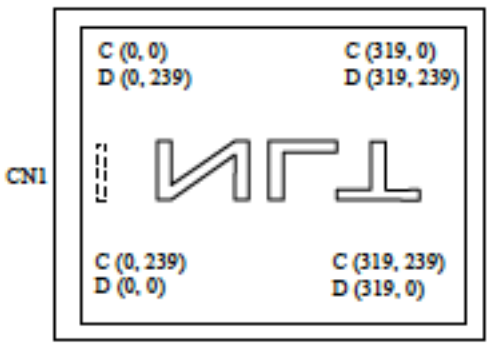


Figure3. DPSH= Low or Open (Normal scan)
DPSV= Low (Reverse scan)

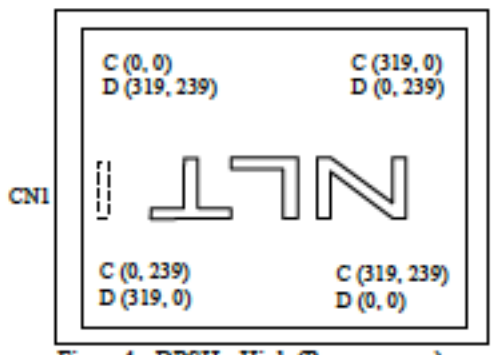


Figure4. DPSH= High (Reverse scan)
DPSV= Low (Reverse scan)

Note1

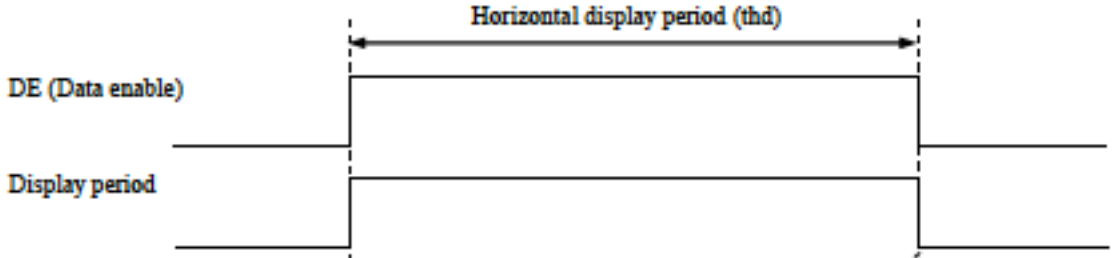
Note1: Meaning of C (X, Y) and D (X, Y)
C (X, Y): The coordinates of the display position (See "4.7 DISPLAY POSITIONS".)
D (X, Y): The data number of input signal for LCD panel signal processing board

4.9 INPUT SIGNAL TIMINGS

4.9.1 Outline of input signal timings

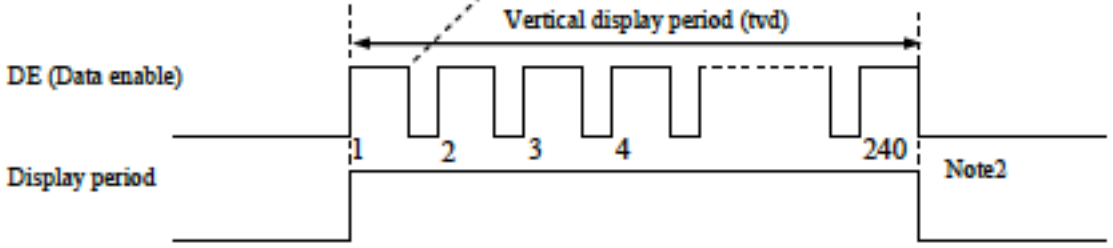
• Horizontal signal

Note1



• Vertical signal

Note1



Note1: This diagram indicates virtual signal for set up to timing.
Note2: See "**4.9.3 Input signal timing chart**" for the pulse number.

4.9.2 Timing characteristics

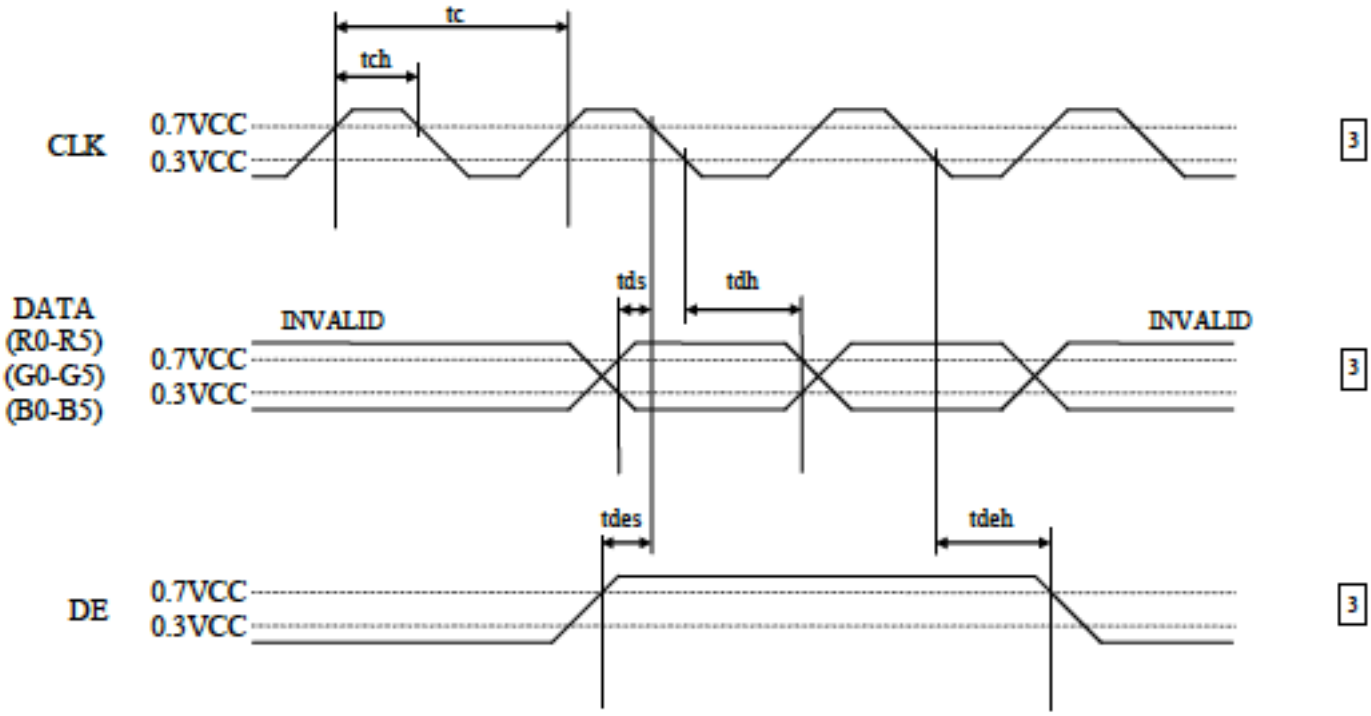
(Note1, Note2)

Parameter			Symbol	min.	typ.	max.	Unit	Remarks
CLK	Frequency		1/tc	6.2	6.4	12.1	MHz	-
	Duty ratio		tcd	0.4	0.5	0.6	-	-
DATA (R0-R5) (G0-G5) (B0-B5)	CLK-DATA	Setup time	tds	8	-	-	ns	-
		Hold time	tdh	8	-	-	ns	
DE	Horizontal	Cycle	th	(57.375)	63.75	(65.484)	µs	15.7 kHz (typ.)
				406	408	560	CLK	
		Display period	thd		320		CLK	-
	Vertical (One frame)	Cycle	tv	(15.084)	16.76	(17.222)	ms	59.6 Hz (typ.)
				254	263	360	H	
		Display period	tvd		240		H	-
	CLK-DE	Setup time	tdes	8	-	-	ns	-
		Hold time	tdeh	8	-	-	ns	

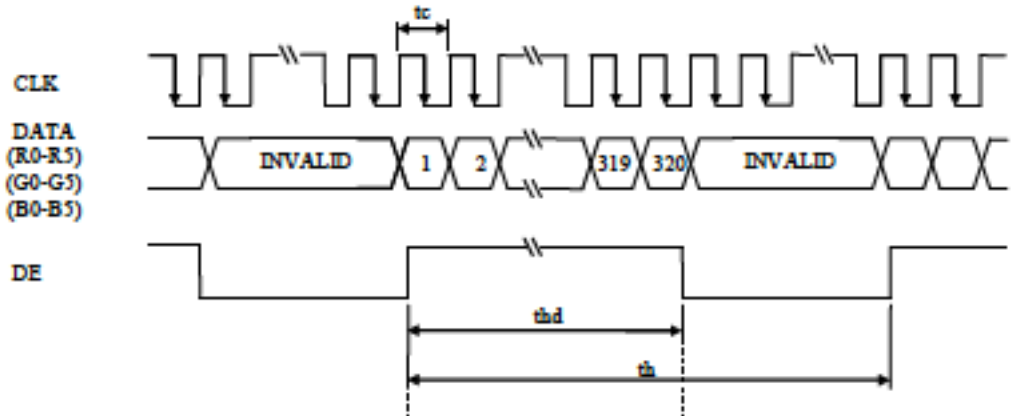
Note1: Definition of parameters is as follows.
tc= 1CLK, tcd= tch/tc, th= 1H

Note2: Vertical cycle (tv) should be specified in integral multiple of Horizontal cycle (th).

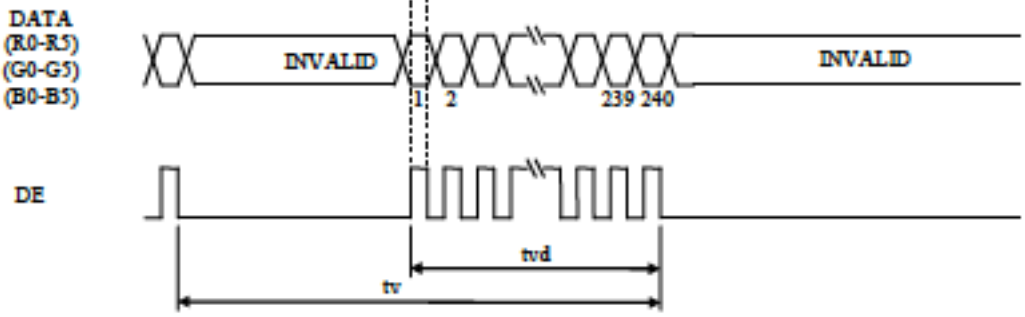
4.9.3 Input signal timing chart



Horizontal timing



Vertical timing



4.10 OPTICS

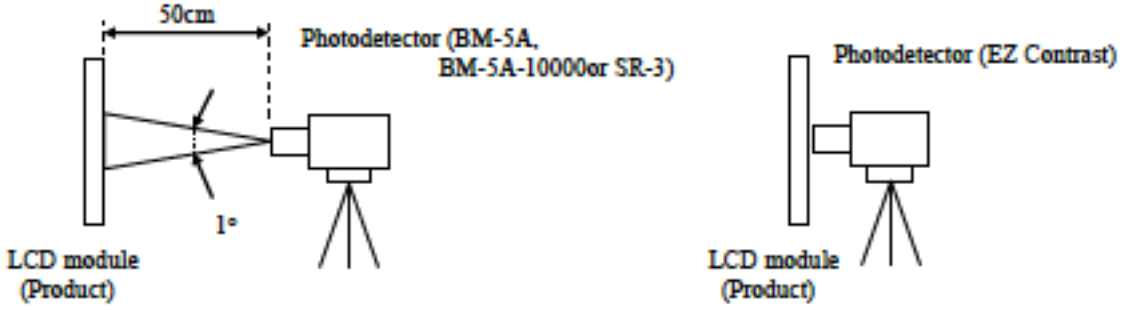
4.10.1 Optical characteristics

(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	(400)	500	-	cd/m^2	BM-5A	-
Contrast ratio		White/Black at center θR= 0°, θL= 0°,θU= 0°,θD= 0°	CR	(500)	(900)	-	-	BM-5A	Note3
Luminance uniformity		White θR= 0°, θL= 0°,θU= 0°,θD= 0°	LU	-	(1.25)	1.4	-	BM-5A	Note4
Chromaticity	White	x coordinate	Wx	0.263	0.313	0.363	-	SR-3	Note5
		y coordinate	Wy	0.279	0.329	0.379	-		
	Red	x coordinate	Rx	-	(0.605)	-	-		
		y coordinate	Ry	-	(0.348)	-	-		
	Green	x coordinate	Gx	-	(0.328)	-	-		
		y coordinate	Gy	-	(0.576)	-	-		
	Blue	x coordinate	Bx	-	(0.144)	-	-		
		y coordinate	By	-	(0.120)	-	-		
Color gamut		θR= 0°, θL= 0°,θU= 0°,θD= 0° at center, against NTSC color space	C	45	50	-	%		
Response time		White to Black	Ton	-	(3)	(5)	ms	BM-5A -10000	Note6 Note7
		Black to White	Toff	-	(15)	(21)	ms		
Viewing angle	Right	θU= 0°, θD= 0°, CR≥ 10	θR	70	80	-	°	EZ Contrast	Note8
	Left	θU= 0°, θD= 0°, CR≥ 10	θL	70	80	-	°		
	Up	θR= 0°, θL= 0°, CR≥ 10	θU	70	80	-	°		
	Down	θR= 0°, θL= 0°, CR≥ 10	θD	70	80	-	°		

Note1: These are initial characteristics.
Note2: Measurement conditions are as follows.
Ta= 25°C, VCC= 3.3V, VDD= 12.0V, PWM duty ratio: 100%,
Display mode: QVGA, Horizontal cycle= 1/15.7kHz, Vertical cycle= 1/59.6Hz

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= 28°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.

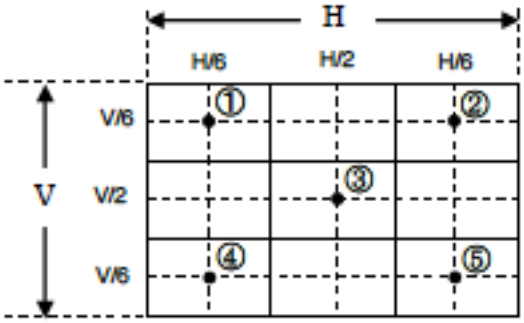
$$\text{Contrast ratio (CR)} = \frac{\text{Luminance of white screen}}{\text{Luminance of black screen}}$$

4.10.3 Definition of luminance uniformity

The luminance uniformity is calculated by using following formula.

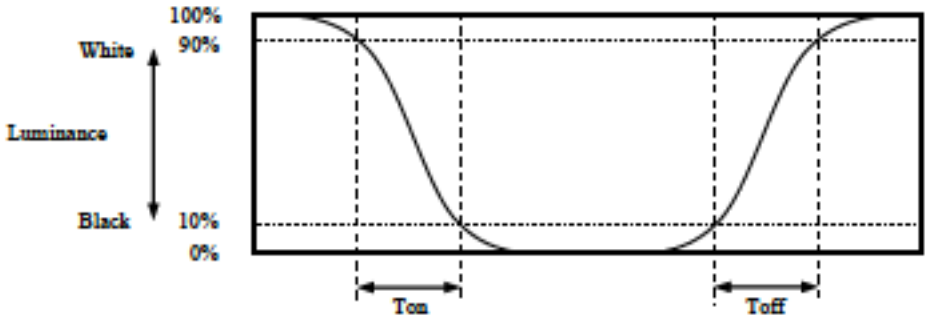
$$\text{Luminance uniformity (LU)} = \frac{\text{Maximum luminance from ① to ⑤}}{\text{Minimum luminance from ① to ⑤}}$$

The luminance is measured at near the 5 points shown below.

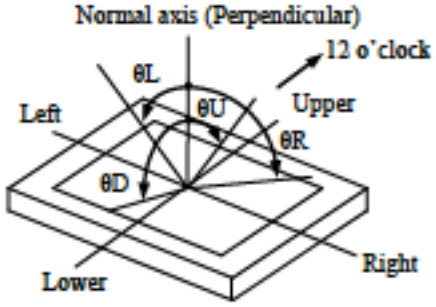


4.10.4 Definition of response times

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%	50,000	h
	(80)°C (Temperature of LCD panel surface and rear shield surface) Continuous operation, PWM duty ratio: 100%	(30,000)	

3

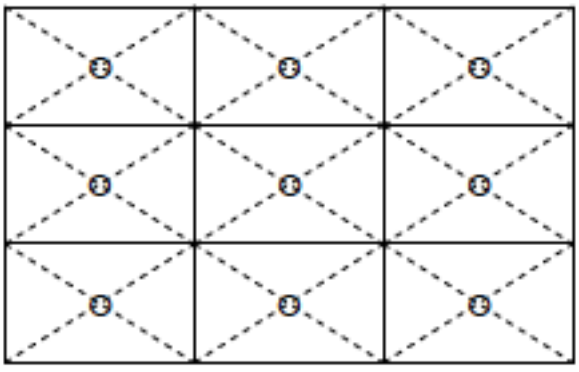
Note1: Life time expectancy is mean time to half-luminance.
Note2: Estimated luminance lifetime is not the value for LCD module but the value for LED elementary substance.
Note3: By ambient temperature, the lifetime changes particularly. Especially, in case the product works under high temperature environment, 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, 4 hours/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 places 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, 19.6m/s^2 ② 1 minute/cycle ③ X, Y, Z directions ④ 120 times each directions	No display malfunctions No physical damages	
Mechanical shock (Non operation)	① 539m/s^2, 11ms ② ±X, ±Y, ±Z directions ③ 5 times each directions		

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 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 (0.200)N-m. Higher torque might result in distortion of the bezel. And the length of product mounting screws must be ≤ 3.5 mm. 3
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.
⑦ Do not press or rub on the sensitive product surface. When cleaning the panel 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.

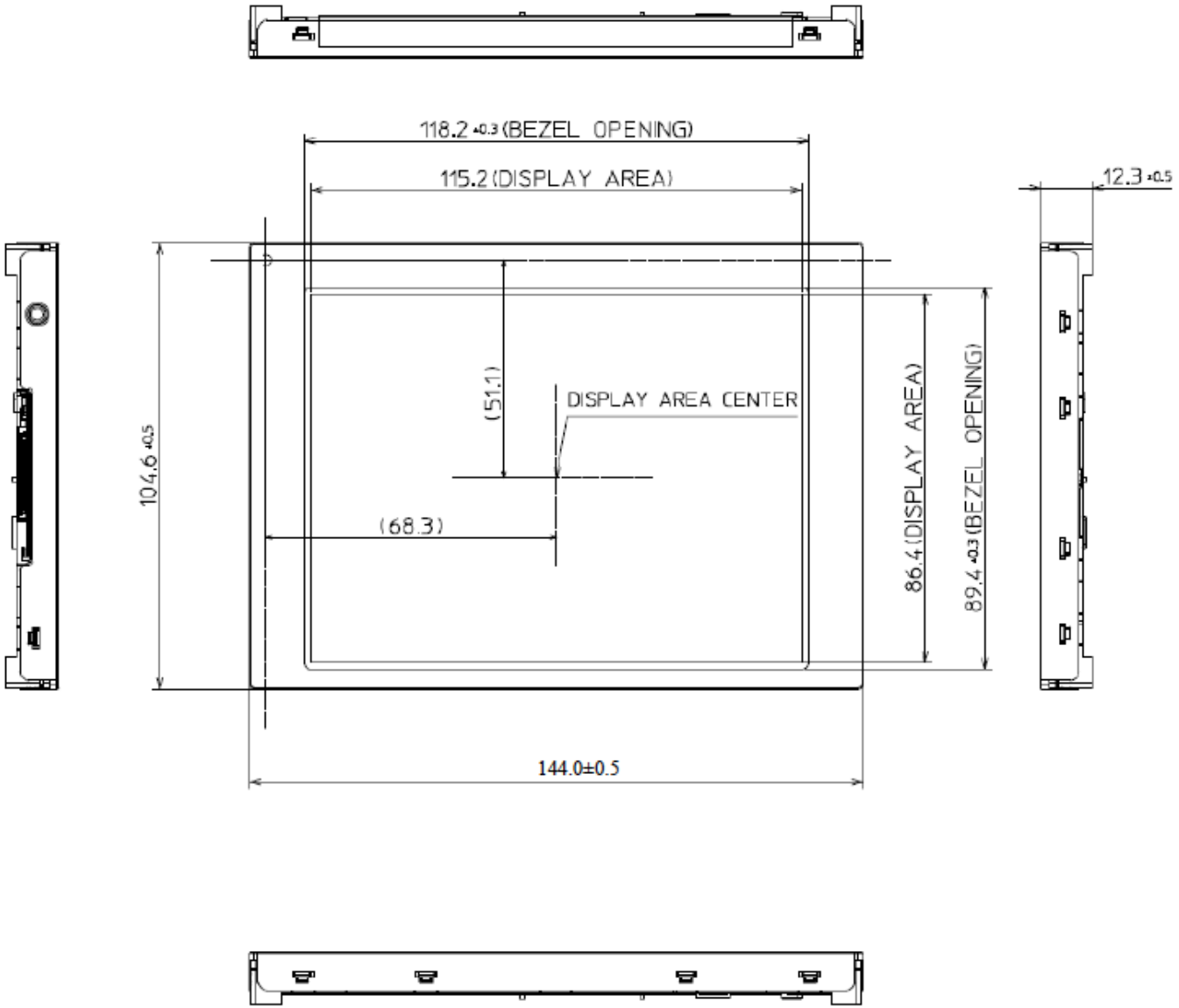
① Characteristics of the LCD (such as response time, luminance, color uniformity and so on) may be changed depending on ambient temperature. If the product is stored under condition of low temperature for a long time, it may cause display mura. In this case, the product should be operated after enough 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 Pack the product with the original shipping package, in order to avoid any damages during transportation, when returning the product to NLT.

8. OUTLINE DRAWINGS

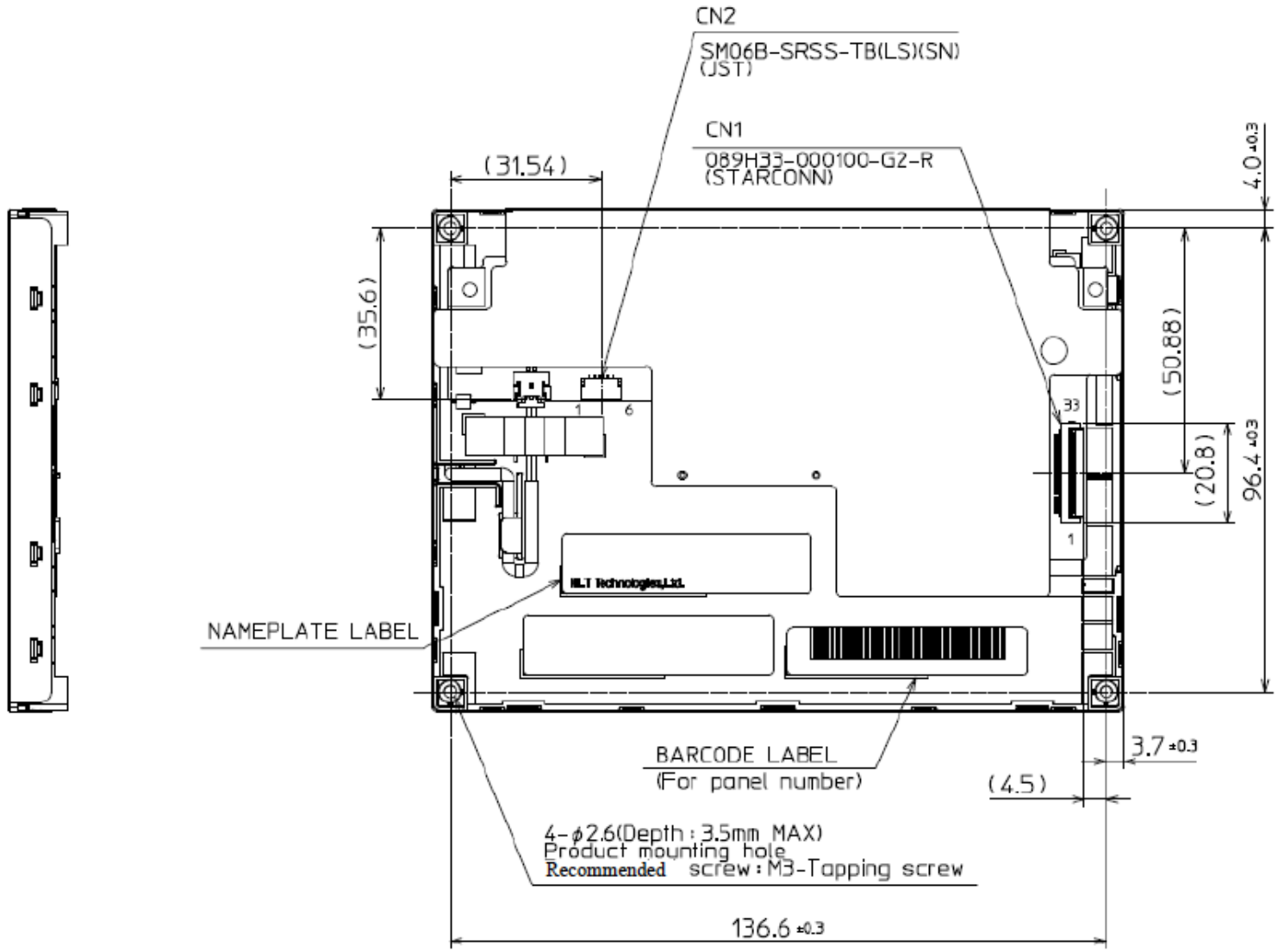
8.1 FRONT VIEW



Unit: mm

Note1: The values in parentheses are for reference.

8.2 REAR VIEW



Unit: mm

Note1: The values in parentheses are for reference.
Note2: The torque for product mounting screws must never exceed (0.200)N·m. And the length of product mounting screws must be ≤ 3.5 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-2120	June 4, 2015	**Revision contents** New issue **Writer** *Approved by* R. KAWASHIMA *Checked by* ——— *Prepared by* E. YOSHIMURA
2nd edition	DOD-PP-2152	July 10, 2015	**Revision contents** P4 Features • This product will comply with the European RoHS directive (2011/65/EU) when starting mass production. (addition) P5 General specifications • Dot pitch: 0.12 (V) mm → 0.36 (V) mm • Designed viewing direction - Viewing direction without image reversal: Up side (12 o'clock) → Down side (6 o'clock) - Viewing direction with contrast peak: Down side (6 o'clock) →Up side (12 o'clock) P7 Detailed specifications - absolute maximum ratings • Function signal for LED driver - BRTC: -0.3 to+(VDD+1.0) V → -0.3 to+(VDD+0.1) V P8 Electrical characteristics - LCD panel signal processing board • Input current for DPSH - IFH1: (-300) (max.) μA → (300) (max.) μA • Input current for DPSV - IFH2: (-300) (max.) μA → (300) (max.) μA P9 Electrical characteristics - LED driver • Input voltage for PWM signal - VDFL1: 0 (min.) V → - (min.) V • Input voltage for BRTC signal - VDFL2: 0 (min.) V → - (min.) V P18 Input signal timings - Timing characteristics • DE - Horizontal - Cycle: (57.375) (min.), 63.75 (typ.), (65.484) (max.) μs (addition) - Cycle: 31.5 kHz (typ.) → 15.7 kHz (typ.) • DE - Vertical - Cycle: (15.084) (min.), 16.76 (typ.), (17.222) (max.) μs (addition) - Cycle: 60.0 Hz (typ.) → 59.6 Hz (typ.) P20 Optics – Optical characteristics • Note2: 1/31.5kHz, 1/60.0Hz →1/15.7 kHz, 1/59.6 Hz P21 Optics - Definition of luminance uniformity (Revised) P27 Outline drawings - Rear view • 96.4± 0.5mm → 96.4± 0.3mm • 136.6± 0.5mm → 136.6± 0.3mm **Writer** *Approved by* R. KAWASHIMA *Checked by* ——— *Prepared by* E. YOSHIMURA
3rd edition	DOD-PP-2221	Nov. 27, 2015	**Revision contents** P5 General specifications • Module size: (12.3) (D) mm (typ.) →12.3 (D) mm (typ.) • Weight: (150)g (typ.) → 150g (typ.) • Power consumption: TBD W (typ.) → (1.6) W (typ.) P7 Detailed specifications - mechanical specifications • Module size: (12.3) (D) mm →12.3± 0.5 (D) mm • Weight: (150) (typ.), TBD (max.) g → 150 (typ.), (165) (max.) g

REVISION HISTORY

Edition	Document number	Prepared date	Revision contents and signature
3rd edition	DOD-PP-2221	Nov. 27, 2015	**Revision contents** P8 Electrical characteristics - LCD panel signal processing board • Power supply current: (100) (typ.), (130) (max.) mA → (120) (typ.), (160) (max.) mA • Input current for DPSH, DPSV signal - IFH1, 2: (300) (max.) μA → (800) (max.) μA - IFL1,2: (-300) (min.) μA → (-800) (min.) μA P15 Scanning directions (Revised) P18 Input signal timing chart • CLK, DATA, DE: TBD V → 0.7VCC, 0.3VCC V (Specified) P19 Optics - Optical characteristics • Viewing angle - θR, θL, θU, θD: TBD (min.) ° → 70 (min.) ° • Note6: TopF=TBD°C → TopF=28°C P21 Estimated luminance lifetime • LED elementary substance: TBD°C, TBDh → (80)°C, (30,000)h P23 Attentions - Handling of the product • ⑧ TBD N·m, ≤ TBD mm → (0.200) N·m, ≤ 3.5 mm P25 Outline drawings - Front view • (12.3) mm →12.3± 0.5 mm P26 Outline drawings - Rear view • Product mounting hole recommended screw (addition) • Note2: TBD N·m, ≤ TBD mm → (0.200) N·m, ≤ 3.5 mm **Signature of writer** *Approved by* R. Kawashima — R. KAWASHIMA *Checked by* — *Prepared by* E. Yoshimura — E. YOSHIMURA