PRELIMINARY

NEC NEC LCD Technologies, Ltd.

TFT COLOR LCD MODULE

NL9654HL06-01J

2

6.8cm (2.7 Type)
QHD

PRELIMINARY DATA SHEET
DOD-PP-0499 (2nd edition)

RoHS
Compliant
2002/95/EC

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INTRODUCTION

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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 NL9654HL06-01J is composed of the low temperature poly silicon thin film transistor liquid crystal display (LTPS TFT LCD) panel structure with driver LSIs for driving the TFT (Thin Film Transistor) array and a backlight.

The LTPS 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 the driver LSIs.

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
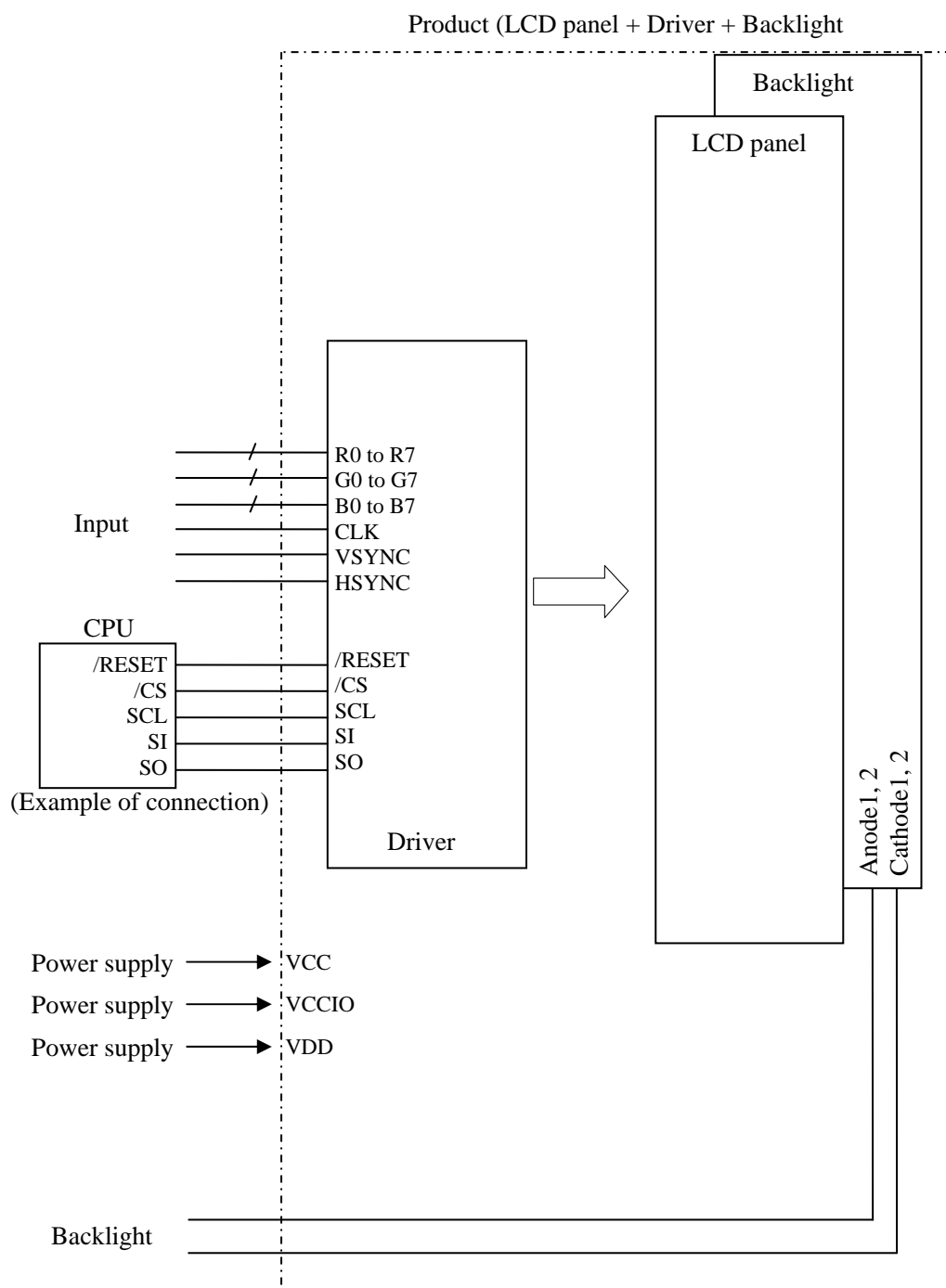
- View finder

1.3 FEATURES

- Adoption of VIT (Value integrated TFT) (Transmissive type)
- High resolution
- High luminance
- High contrast
- Backlight attached
- Including LCD controller and power supply
- 8-bit digital RGB signals

2. GENERAL SPECIFICATIONS

Display area	59.04 (H) × 33.21 (V) mm
Diagonal size of display	6.8 cm (2.7 inches)
Drive system	LTPS TFT active matrix
Display color	16,777,216 colors
Pixel	960 (H) × 540 (V) pixels
Pixel arrangement	RGB (Red dot, Green dot, Blue dot) vertical stripe
Dot pitch	0.0205 (H) × 0.0615 (V) mm
Pixel pitch	0.0615 (H) × 0.0615 (V) mm
Module size	69.0 (H) × 50.8 (V) × 3.6 (D) mm (typ.) [Excluding FPC]
Weight	TBD g (typ.)
Polarizer surface	Clear
Polarizer pencil-hardness	3 H (min.) [by JIS K5400]
Designed viewing direction	• Viewing direction without image reversal: lower side (6 o'clock) • Viewing direction with contrast peak: up side (12 o'clock)
Luminance	*At IL= TBD mA* 300cd/m^2 (typ.)
Contrast ratio	*At IL= TBD mA* 400:1 (typ.)
Response time	*Ton + Toff (10% ←→ 90%)* 25 ms (typ.)
Signal system	8-bit digital signals for data of RGB colors, Dot clock (CLK), Horizontal synchronous signal (HSYNC), Vertical synchronous signal (VSYNC) Serial interface (SPI correspondence) (/CS, SCL, SI, SO)
Supply voltage	VCCIO: 3.0V (typ.) VCC: (2.7)V (typ.) VDD: (6.5)V (typ.)
Power consumption	LCD panel + Driver: TBD mW (typ.) Backlight: TBD mW (typ., at IL= TBD mA)

3. BLOCK DIAGRAM

Product (LCD panel + Driver + Backlight

Backlight

LCD panel

R0 to R7
G0 to G7
B0 to B7
CLK
VSYNC
HSYNC

Input

CPU

/RESET   /RESET
/CS   /CS
SCL   SCL
SI   SI
SO   SO

(Example of connection)

Driver

Anode1, 2
Cathode1, 2

Power supply ⟶ VCC

Power supply ⟶ VCCIO

Power supply ⟶ VDD

Backlight

Pin No.	Symbol
33 to 40	B0 to B7
25 to 32	G0 to G7
17 to 24	R0 to R7
43	VSYNC
44	HSYNC
42	CLK
45	/RESET
12	/CS
15	SCL
14	SI
13	SO
47	VDD
11	VCCIO
48, 49	VCC
5, 10, 16 41, 46, 50	GND
4	ANODE1
3	CATHODE1
2	ANODE2
1	CATHODE2

2880 lines

LCD panel

540 lines

H: 960 × 3 (R, G, B)
V: 540

Driver

Backlight

(+6.5V)

+3.0V

+(2.7)V

4. DETAILED SPECIFICATIONS

4.1 MECHANICAL SPECIFICATIONS

Parameter	Specification		Unit
Module size	69.0 ± 0.3 (W) $\times$ 50.8 ± 0.3 (H) $\times$ 3.6 ± 0.2 (D) Note1	Note2	mm
Display area	59.04 (H) $\times$ 33.21 (V)	Note2	mm
Weight	TBD (typ.), TBD (max.)		g

Note1: Excluding FPC.
Note2: See "**7. OUTLINE DRAWINGS**".

4.2 ABSOLUTE MAXIMUM RATINGS

Parameter		Symbol	Rating	Unit	Remarks
Supply voltage (DC/DC)		VCC	-0.3 to + 3.7	V	Ta= 25°C
Supply voltage (Logic)		VCCIO	-0.3 to + 6.0	V	Ta= 25°C
Supply voltage (LCD)		VDD	TBD	V	Ta= 25°C
Logic input voltage		VI	-0.3 to VCCIO + 0.3	V	Logic signals
Backlight	Reverse voltage	VR	≤ 30	V	Ta= 25°C
	Power dissipation	PD	TBD	mW	
	Forward current	IL	Note1	mA	
	Pulse forward current	IFP	100	mA	Pulse width $\leq$ 10ms, Duty $\leq$ 1/10
Storage temperature		Tst	-30 to +80	°C	-
Operating temperature		Top	-20 to +70		Product surface Note2
Relative humidity Note3		RH	≤ 95	%	Ta$\leq$ 40°C
			≤ 85		40°C <Ta$\leq$ 50°C
			≤ 55		50°C <Ta$\leq$ 60°C
			≤ 36		60°C <Ta$\leq$ 70°C
Absolute humidity Note3		AH	≤ 70 Note4	g/m^3	Ta> 70°C
Storage altitude			$\leq 13,600$	m	-30°C $\leq$ Ta $\leq$ 80°C
Operating altitude			$\leq 4,850$	m	-20°C $\leq$ Ta $\leq$ 70°C

Note1: Allowable forward current

   TBD

Note2: Measured at display area
Note3: No condensation
Note4: Water amount at Ta= 70°C and RH= 36%

4.3 ELECTRICAL CHARACTERISTICS

(1) Logic/ LCD driving

(Ta= 25°C)

Parameter	Symbol	min.	typ.	max.	Unit	Remarks
Supply voltage (DC/DC)	VCC	TDB	(2.7)	TDB	V	-
Supply voltage (Logic)	VCCIO	1.7	3.0	3.3	V	-
Supply voltage (LCD)	VDD	TBD	(6.5)	TBD	V	-
Logic input high voltage	VIH	0.8VCCIO	-	VCCIO	V	Logic signal
Logic input low voltage	VIL	0	-	0.2VCCIO	V	Logic signal
VCC supply current	ICC	-	TBD	TBD	mA	at VCC= (2.7)V Note1
VCCIO supply current	ICCIO	-	TBD	TBD	mA	at VCCIO= 3.0V Note1
VCC standby current	ICCs	-	TBD	TBD	mA	Standby mode at VCC=(2.7)V Note2
VCCIO standby current	ISBIO	-	TBD	TBD	mA	Standby mode at VCCIO=3.0V Note2

Note1: CLK= 32.08 MHz, HSYNC= 32.94 kHz, VSYNC= 60 Hz
Checkered flag pattern (by EIAJ ED-2522)
Note2: CLK, control signals: inactive

(2) Backlight

(Ta= 25°C)

Parameter	Symbol	min.	typ.	max.	Unit	Remarks
Forward Current	IL1,2	-	TBD	TBD	mA	-
Forward Voltage	VL1,2	-	TBD	TBD	V	at IL= TBD mA

4.4 SETTING OF THE INTERNAL RESISTER

Initial setting of the internal Resister is undefined data. So the Resister Data must be written in the Resister, after initialization by the /RESET pin. The Resister Data can be written from serial interface pins (/CS, SCL, SI and SO). This serial interface supports SPI. The setting method is as follows.

(1) Command Byte Function

Bits	Functions	Discription
A7	-	-
A6	-	-
A5	Read / Write	0:Write 1:Read
A4	-	-
A3	-	-
A2	-	-
A1	-	-
A0	Register Number / Data	0:Register Number 1:Register Data

(2) Timing chart

/CS
SCL
SI

A7 A6 A5 A4 A3 A2 A1 A0 D7 D6 D5 D4 D3 D2 D1 D0
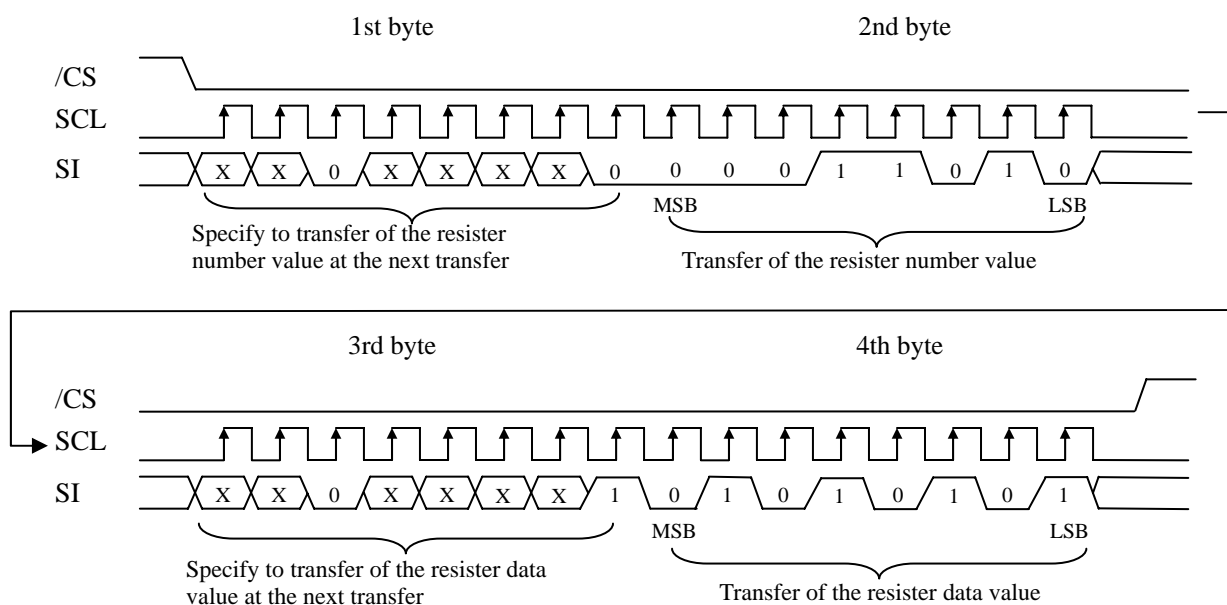
MSB · · · · · LSB

Command Byte

Data Byte
- Register Number or Register Data

Ex) When data 55h is written to Register R26 (R1Ah)

1st byte · · · · · · · · · · · · 2nd byte

/CS
SCL
SI

X X 0 X X X X 0 0 0 0 1 1 0 1 0

MSB · · · · · LSB

Specify to transfer of the resister
number value at the next transfer

Transfer of the resister number value

3rd byte · · · · · · · · · · · · 4th byte

/CS
SCL
SI

X X 0 X X X X 1 0 1 0 1 0 1 0 1

MSB · · · · · LSB

Specify to transfer of the resister data
value at the next transfer

Transfer of the resister data value

Ex) When data 55h is read to Register R26 (R1Ah)

1st byte · · · · · · · · · · · · 2nd byte

/CS
SCL
SI

X X 0 X X X X 0 0 0 0 1 1 0 1 0

MSB · · · · · LSB

Specify to transfer of the resister
number value at the next transfer

Transfer of the resister number value

3rd byte · · · · · · · · · · · · 4th byte

/CS
SCL
SI
SO

SI: X X 1 X X X X 1 X X X X X X X X X

SO: 0 1 0 1 0 1 0 1

MSB · · · · · LSB

Specify to transfer of the resister data
value at the next transfer

Transfer of the resister data value

Note1: During 32-bit transfer of the Resister Data, /CS pin (Pin No.12) must be maintained active.
Note2: "X" is set in accordance with the usage conditions.
Note3: Data transfer should be performed every 32 bit.

(3) Command sequence

①Power On

Sequence	Register Number	Data	Comment	Sequence	Register Number	Data	Comment
1	Power On			46	R83	(40h)	-
2	1ms min. wait.			47	R84	(42h)	-
3	Reset by the /RESET pin(PIN No.45)			48	R85	(41h)	-
4	1ms min. wait after /RESET↑			49	R86	(2Ch)	-
5	R3	01h	-	50	R89	(88h)	-
6	R0	00h	-	51	R90	(01h)	-
7	R1	(00h)	-	52	R91	(00h)	-
8	R4	(00h)	-	53	R92	(1Eh)	-
9	R5	(10h)	-	54	R93	(0Ah)	-
10	R6	(24h)	-	55	R94	(32h)	-
11	R16	(D7h)	-	56	R95	(30h)	-
12	R17	(01h)	-	57	R98	(70h)	-
13	R18	(00h)	-	58	R99	(30h)	-
14	R19	(55h)	-	59	R102	(AEh)	-
15	R20	(01h)	-	60	R103	(30h)	-
16	R21	(70h)	-	61	R112	(04h)	-
17	R22	(26h)	-	62	R113	(04h)	-
18	R23	(25h)	-	63	R114	(02h)	-
19	R24	(25h)	-	64	R115	(18h)	-
20	R25	(02h)	-	65	R118	(00h)	-
21	R26	(02h)	-	66	R121	(10h)	-
22	R27	(A0h)	-	67	R130	(00h)	-
23	R32	(28h)	-	68	R131	(00h)	-
24	R33	(08h)	-	69	R132	(FCh)	-
25	R34	(0Fh)	-	70	R134	(00h)	-
26	R35	(14h)	-	71	R136	(00h)	-
27	R36	(14h)	-	72	R138	(00h)	-
28	R37	(0Fh)	-	73	R139	(00h)	-
29	R38	(10h)	-	74	R140	(00h)	-
30	R39	(00h)	-	75	R141	(FCh)	-
31	R40	(02h)	-	76	R143	(00h)	-
32	R41	(02h)	-	77	R145	(00h)	-
33	R42	(02h)	-	78	R147	(00h)	-
34	R43	(08h)	-	79	R148	(00h)	-
35	R44	(08h)	-	80	R149	(00h)	-
36	R45	(0Fh)	-	81	R150	(FCh)	-
37	R46	(14h)	-	82	R152	(00h)	-
38	R47	(14h)	-	83	R154	(00h)	-
39	R48	(0Fh)	-	84	R156	(00h)	-
40	R49	(10h)	-	85	R157	(00h)	-
41	R50	(00h)	-	86	20us min. wait		
42	R51	(02h)	-	87	Data input start		
43	R52	(02h)	-	88	R2	00h	
44	R53	(02h)	-				
45	R80	(0Ah)	-				

②Power Off

Sequence	Register Number	Data	Comment
1	R16	05h	-
2	20 us min. wait.		
3	R16	01h	-
4	20 us min. wait.		
5	R16	00h	
6	20 us min. wait.		
7	R3	01h	-
8	Data Off		
9	Power Off		

③Stand-by

Sequence	Register Number	Data	Comment
1	R2	01h	-
2	40ms min. wait		

④Wakeup

Sequence	Register Number	Data	Comment
1	R2	00h	-

⑤Reverse Mode

	Register Number	Data	Comment
Horizontal	R1	01h	Normal
		03h	Reverse
Vertical	R121	30h	Normal
		10h	Reverse

Note1: Be sure to perform reset by the /RESET pin (Pin No. 45) every power-on
Note2: Write the Resister Data every power-on, because the data are not stored in the product.
Note3: Due to influence such as static electricity from the outside, data in the register may transform. Data is recommended to be written in the register regularly.

4.5 INTERFACE PIN CONNECTIONS

CN1 (FPC)
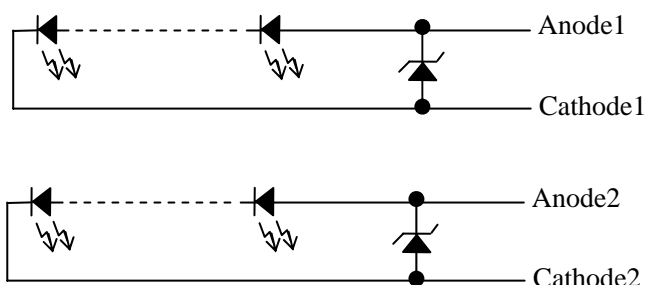Adaptable socket: FH12-50S-0.5SHW (05) (Hirose Electric Co., Ltd. (HRS))

Pin No.	Symbols	Functions	Pin No.	Symbols	Functions
1	CATHODE2	LED2 voltage (Cathode)	26	G6	Green data
2	ANODE2	LED2 voltage (Anode)	27	G5	Green data
3	CATHODE1	LED1 voltage (Cathode)	28	G4	Green data
4	ANODE1	LED1 voltage (Anode)	29	G3	Green data
5	GND	Ground Note1	30	G2	Green data
6	RSVD	Keep this pin Open.	31	G1	Green data
7	RSVD	Keep this pin Open.	32	G0	Green data (LSB)
8	RSVD	Keep this pin Open.	33	B7	Blue data (MSB)
9	RSVD	Keep this pin Open.	34	B6	Blue data
10	GND	Ground Note1	35	B5	Blue data
11	VCCIO	Power supply (Logic)	36	B4	Blue data
12	/CS	Chip selection	37	B3	Blue data
13	SO	Serial output	38	B2	Blue data
14	SI	Serial input	39	B1	Blue data
15	SCL	Serial clock	40	B0	Blue data (LSB)
16	GND	Ground Note1	41	GND	Ground Note1
17	R7	Red data (MSB)	42	CLK	Dot clock
18	R6	Red data	43	VSYNC	Vertical synchronous signal
19	R5	Red data	44	HSYNC	Horizontal synchronous signal
20	R4	Red data	45	/RESET	Reset
21	R3	Red data	46	GND	Ground Note1
22	R2	Red data	47	VDD	Power supply
23	R1	Red data	48	VCC	Power supply
24	R0	Red data (LSB)	49	VCC	Power supply
25	G7	Green data (MSB)	50	GND	Ground Note1

Note1: All GND terminals should be used without any non-connected lines.
Note2: Do not fold the FPC. When folding the FPC, pattern disconnection may occur. In case of bending
FPC, the minimum curvature (R) must be more than 1.0 mm.

Description of terminals

Terminals	Description
/RESET	When /RESET is L, an internal reset is performed. The reset operation is executed at the /RESET signal level. Be sure to perform reset via this pin at power application.
/CS	This pin is used for chip select signals. When /CS= L, the chip is active and can perform data I/O operations including command and data I/O.
SCL	This pin is clock input of serial interface.
SI	This pin is data input of serial interface.
SO	This pin is data output of serial interface.
ANODE1,2 CATHODE1,2	Refer to the below "**Circuits of backlight**".

Circuits of backlight

4.6 DISPLAY COLORS AND INPUT DATA SIGNALS

This product can display in equivalent to 16,777,216 colors in 256 gray scales. 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)																						
		R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	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	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

4.7 DISPLAY POSITIONS

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

C (0, 0)   C (1, 0)

R	G	B	R	G	B

C(0, 0)	C(1, 0)	• • •	C(X, 0)	• • •	C(958, 0)	C(959, 0)
C(0, 1)	C(1, 1)	• • •	C(X, 1)	• • •	C(958, 1)	C(959, 1)
• • •	• • •	• • •	• • •	• • •	• • •	• • •
C(0, Y)	C(1, Y)	• • •	C(X, Y)	• • •	C(958, Y)	C(959, Y)
• • •	• • •	• • •	• • •	• • •	• • •	• • •
C(0, 538)	C(1, 538)	• • •	C(X, 538)	• • •	C(958, 538)	C(959, 538)
C(0, 539)	C(1, 539)	• • •	C(X, 539)	• • •	C(958, 539)	C(959, 539)

4.8 SCANNING DIRECTIONS

The following figures are seen from a front view. Also the arrow shows the direction of scan.

Figure1. Normal scan
(R1:01h, R121:30h)

Figure2. Horizontal Reverse scan
(R1:03h, R121:30h)

Figure3. Vertical Reverse scan
(R1:01h, R121:10h)

Figure4. Horizontal and Vertical Reverse scan
(R1:03h, R121:10h)

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

4.9 INPUT SIGNAL TIMINGS

4.9.1 RGB interface (Ta= 25°C, VCC= (2.7) V, VCCIO=3.0V)

(1) Timing characteristics

Parameter			Symbol	min.	typ.	max.	Unit	Remarks
CLK	Frequency		1/tc	(29.27)	(34.53)	(37.0)	MHz	29ns (typ.)
	Duty		tcd	0.4	0.5	0.6	-	-
	Rise time, Fall time		tcrf	-	-	2	ns	
DATA (D00-07) (D10-17) (R0-27)	CLK-DATA	Setup time	tds	13	-	-	ns	-
		Hold time	tdh	13	-	-	ns	
	Rise time, Fall time		tdrf	-	-	2	ns	
HSYNC	Cycle		th	-	(29.66)	-	μs	33.72 kHz (typ.)
				(971)	(1024)	(1120)	CLK	-
	Display period		thd	960			CLK	
	Front-porch		thf	6	(58)	A	CLK	
	Pulse width		thp	1	(2)	B	CLK	
	Back-porch		thb	(4)			CLK	
	CLK-HSYNC	Setup time	ths	13	-	-	ns	
		Hold time	thh	13	-	-	ns	
	Rise time, Fall time		thrf	-	-	2	ns	
VSYNC	Cycle		tv	-	(16.67)	-	ms	60Hz (typ.)
				(548)	(562)	(640)	H	-
	Display period		tvd	540			H	
	Front-porch		tvf	1	(14)	C	H	
	Pulse width		tvp	1	(2)	D	H	
	Back-porch		tvb	(6)			H	
	Rise time, Fall time		tvrf	-	-	2	ns	

Note1: Definition of parameters is as follows.
   tc= 1CLK, tcd= tch/tc, th= 1H
Note2: All parameters should be kept within the specified range.
Note3: A+B ≤ 156CLK, C+D ≤ 94H

(2) Input signal timing chart

VSYNC

tv

tvp   tvb   1H   tvd   tvf

2H   6H (fixed)   540H (fixed)   14H

HSYNC

1 2 3   1

HSYNC

DATA
(R0-R7)
(G0-G7)
(B0-B7)

INVALID   D(X, 0)   D(X, Y)   D(X, 538) D(X, 539)   INVALID

(Note: X=0 to 959)

HSYNC

DATA
(R0-R7)
(G0-G7)
(B0-B7)

INVALID   D (0, Y)D(1, Y)   D(X, Y)   D(958, Y)D(959, Y)   INVALID

th

HSYNC

1CLK

thp   thb   thd   thf

2H   4CLK (fixed)   960CLK (fixed)   58CLK

CLK

1   2   1

DATA
(R0-R7)
(G0-G7)
(B0-B7)

INVALID   D (0, Y) D(1, Y)   D(959, Y)   INVALID

(Note: Y=0 to 539)

Note1:   Unless otherwise specified, the input level is defined to be VIH= 0.8VCCIO, VIL= 0.2VCCIO.

Note1: Unless otherwise specified, the input level is defined to be VIH= 0.8VCCIO, VIL= 0.2VCCIO.

4.9.2 Serial interface (Ta= 25 °C, VCC= (2.7) V, VCCIO= 3.0 V)

(1) Timing characteristics

Parameter	Symbol	Condition	min.	typ.	max.	Unit	Remarks
Serial clock cycle	tSCYC	SCL	100	-	-	ns	-
SCL high level pulse width	tSHW	SCL	50	-	-	ns	-
SCL low level pulse width	tSLW	SCL	50	-	-	ns	-
/CS rise time, fall time	tcsrf	/CS	-	-	2	ns	-
SCL rise time, fall time	tscrf	SCL	-	-	2	ns	-
SI rise time, fall time	tsirf	SI	-	-	2	ns	-
/CS setup time	tCSS	/CS	50	-	-	ns	-
/CS hold time	tCSH	/CS	50	-	-	ns	-
Data setup time	tSDS	SI	50	-	-	ns	-
Data hold time	tSDH	SI	50	-	-	ns	-
Reset pulse width	tRW	/RESET	10	-	-	μs	-
/RESET↑ to /CS time	tRCS	/RESET↑ to /CS	10	-	-	μs	-
Access time	tACCS	SO	-	-	150	ns	
Output disable time	tOHS	SO	-	-	20	ns	-

Note1: All parameters should be kept within the specified range.

Note2: Unless otherwise specified, the input level is defined to be VIH= 0.8VCCIO, VIL= 0.2VCCIO.

4.10 OPTICAL CHARACTERISTICS

(Note1, Note2)

Parameter	Condition	Symbol	min.	typ.	max.	Unit	Remarks
Luminance	White at center θR= 0°, θL= 0°, θU= 0°, θD= 0°	L	TBD	(300)	-	cd/m^2	-
Contrast ratio	White/Black at center θR= 0°, θL= 0°, θU= 0°, θD= 0°	CR	TBD	(400)	-	-	Note3
Luminance uniformity	White θR= 0°, θL= 0°, θU= 0°, θD= 0° Maximum luminance: 100%	LU	(70)	(85)	-	%	Note4

Reference data

(Note1, Note2)

Parameter		Condition		Symbol	min.	typ.	max.	Unit	Remarks
Chromaticity coordinates		White		Wx	TBD	TBD	TBD	-	Note5
				Wy	TBD	TBD	TBD	-	
Color gamut		θR= 0°, θL= 0°, θU= 0°, θD= 0° at center, against NTSC color space		C	60	70	-	%	
Response time		White to black	90%→ 10%	Ton	-	TBD	TBD	ms	Note6 Note7
		Black to white	10%→ 90%	Toff	-	TBD	TBD		
Viewing angle	Right	θU= 0°, θD= 0°, CR≥ 10		θR	-	80	-	°	-
	Left	θU= 0°, θD= 0°, CR≥ 10		θL	-	80	-	°	
	Up	θR= 0°, θL= 0°, CR≥ 10		θU	-	60	-	°	
	Down	θR= 0°, θL= 0°, CR≥ 10		θD	-	60	-	°	

Note1: Measurement conditions are as follows.
　　　Ta= 25°C, VCC= (2.7)V, VCCIO= 3.0V, IL= TBD mA

Photodetector
(LCD5200 or SR-3)

Upper　　　　Lower

Product

Note2:　Definition of viewing angles

Normal axis (Perpendicular)

12 o'clock
θU
Right
Upper
θR
θD
θL
Lower
Left

Note3: Definition of contrast ratio
The contrast ratio is calculated by using the following formula.

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

Note4: Definition of luminance uniformity

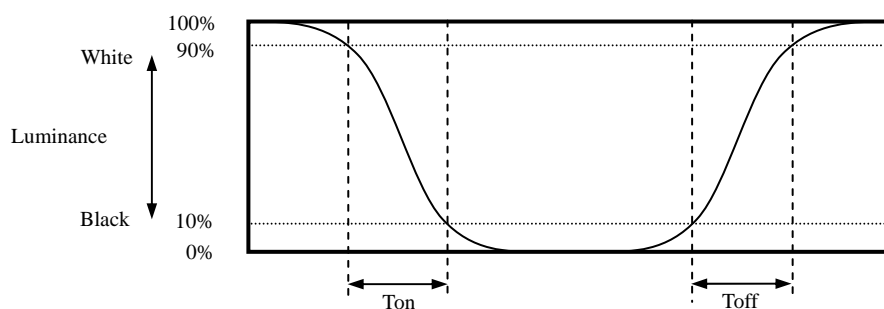Luminance uniformity is calculated by using the following formula.

$$\text{Luminance uniformity (LU)} = \frac{\text{Minimum luminance from A to I}}{\text{Maximum luminance from A to I}} \times 100$$

Note5: The White chromaticity coordinates are deviated by the LED deviation in addition to color filter deviation.

Note6: Definition of response times

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

Note7: Product surface temperature: Top= 25°C

5. RELIABILITY TESTS

Test item	Condition	Judgment Note1
High temperature and humidity (Operation)	① 55 ± 2°C, RH = 85%, 240 hours ② Display data is black.	No display malfunctions
Heat cycle (Operation)	① -20 ± 3°C…1 hour 70 ± 3°C…1 hour ② 50 cycles, 4 hours/cycle ③ Display data is black.	
Thermal shock (Non operation)	① -30 ± 3°C…30 minutes 80 ± 3°C…30 minutes ② 100 cycles, 1 hour/cycle ③ Temperature transition time is within 5 minutes.	
Low pressure (Non operation)	① 15kPa ② -30 ± 3°C…24 hours ③ 80 ± 3°C…24 hours	
Low pressure (Operation)	① 53.3 kPa ② -20 ± 3°C…24 hours ③ 70 ± 3°C…24 hours	
ESD (Operation)	① 150pF, 150Ω, ±10kV ② 3 places on a panel surface 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 (Operation)	① 30 to 100Hz, 19.6m/s^2 ② 30 minutes/cycle ③ X, Y, Z directions ④ 1 times each directions	No display malfunctions No physical damages
Mechanical shock (Non operation)	① 3,920m/ s^2, 2.5ms ② ±X, ±Y, ±Z directions ③ 1 times each directions	

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

PRELIMINARY

6. PRECAUTIONS

6.1 MEANING OF CAUTION SIGNS

The following caution signs have very important meaning. **Be sure to read "6.2 CAUTIONS" and "6.3 ATTENTIONS", after understanding these contents!**

| ⚠ | This sign has the meaning that customer will be injured by himself or the product will sustain a damage, if customer has wrong operations. |

| ⚠ | This sign has the meaning that customer will be injured by himself, if customer has wrong operations. |

6.2 CAUTIONS

⚠
* **Do not touch the working backlight. There is a danger of burn injury.**
* **Do not shock and press the LCD panel and the backlight! There is a danger of breaking, because they are made of glass. (Shock: To be not greater $3,920 m/s^2$ and to be not greater 2.5ms)**

6.3 ATTENTIONS ⚠

6.3.1 Handling of the product

① Pull out the product from side without FPC and take hold of side with out FPC, when the product (LCD module) is picked up from the tray. Do not touch the FPC.
② Do not hook nor pull the FPC 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 product must be installed without any stress such as bends or twist. Bends, twist or any stress to any portion may cause display mura.
⑥ Do not hit or rub the surface of panel with hard materials, because it is easily scratched. (Polarizer pencil-hardness: 3H)
⑦ When cleaning the panel surface, wipe it with a soft dry cloth.
⑧ Do not push nor pull the FPC while the product is working.
⑨ Do not fold the FPC. When folding the FPC, pattern disconnection may occur. In case of bending FPC, the minimum curvature (R) must be more than 1.0 mm.
⑩ When installing the product, do not contact a conductor such as a metal to the FPC excluding the terminal area. There is a risk of short circuit which is caused by breakage of insulation layer of the FPC.
⑪ When installing the product, apply the waterproof design to avoid going of water into the product.
⑫ 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 for the worst, please wash it out with soap.

6.3.2 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 occurring by temperature difference, the product packing box should be opened after enough time being left under the environment of an unpacking room. Evaluate the leaving time sufficiently because a situation of dew condensation occurring is changed by the environmental temperature and humidity. (Recommended leaving time: 6 hours or more with packing state)

  ③ Do not operate in high magnetic field. Circuits may be broken down by it.

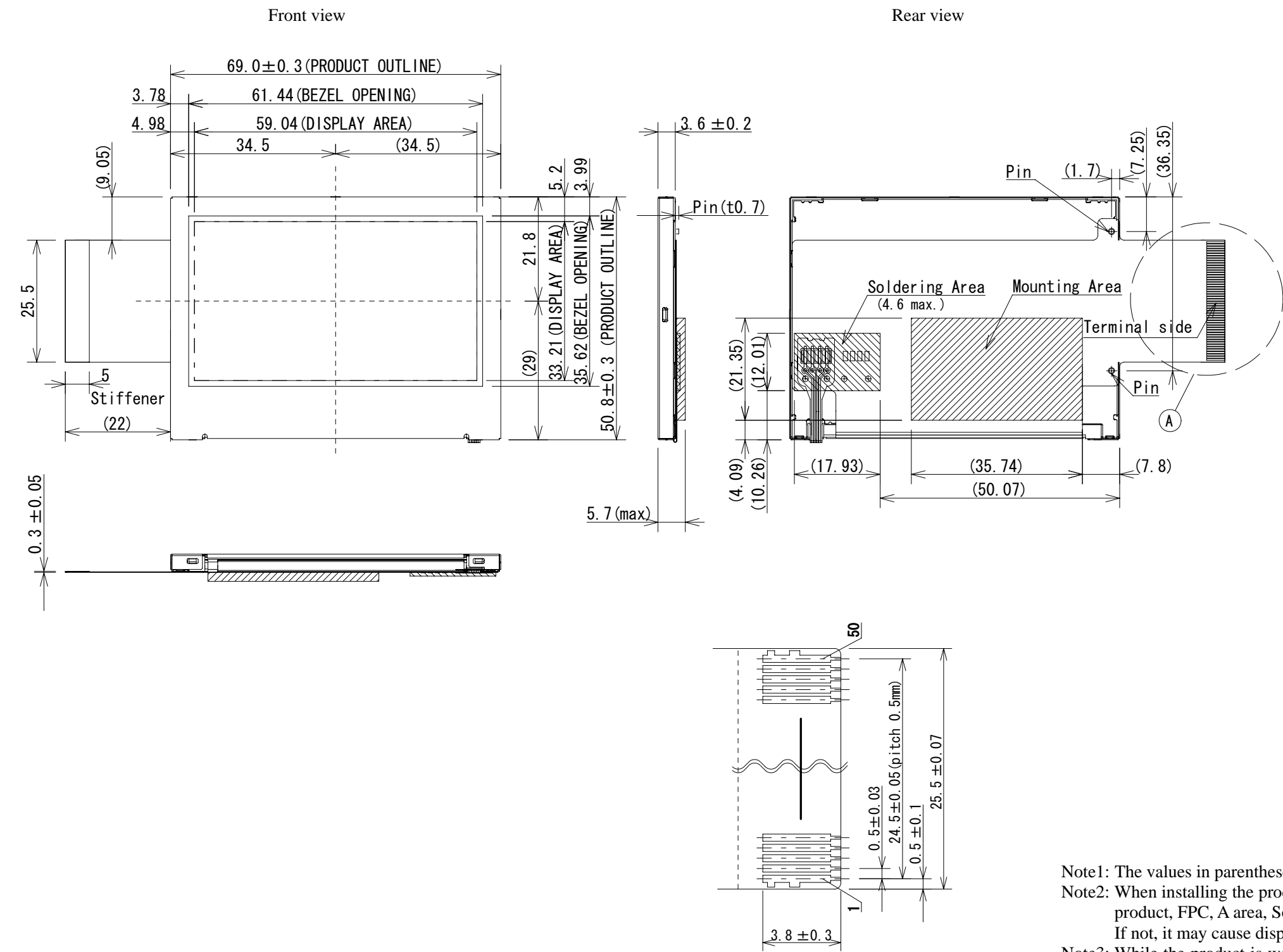 ④ This product is not designed as radiation hardened.

6.3.3 Characteristics

The following items are neither defects nor failures.

  ① Response time, luminance and color may be changed by ambient temperature.

  ② Display mura, flicker, vertical seam or small spot may be observed depending on display patterns.

  ③ Do not display the fixed pattern for a long time because it may cause image sticking.

  ④ Optical characteristics may be changed depending on input signal timings.

6.3.4 Other

  ① All GND terminals should be used without any non-connected lines.

  ② Do not disassemble the product.

  ③ Pack the product with original shipping package, in order to avoid any damages during transportation, when returning the product to NEC.

  ④ When installing the product to the customer equipment, do not apply any stress to the A area, FPC, Soldering Area and Mounting Area. If not, it may cause display un-uniformity or break down of the product.

7. OUTLINE DRAWINGS

Front view

Rear view

Pin No.	Symbols	Pin No.	Symbols
1	CATHODE2	26	D16
2	ANODE2	27	D15
3	CATHODE1	28	D14
4	ANODE1	29	D13
5	GND	30	D12
6	RSVD	31	D11
7	RSVD	32	D10
8	RSVD	33	D07
9	RSVD	34	D06
10	GND	35	D05
11	VCCIO	36	D04
12	/CS	37	D03
13	SO	38	D02
14	SI	39	D01
15	SCL	40	D00
16	GND	41	GND
17	R7	42	CLK
18	R6	43	VSYNC
19	R5	44	HSYNC
20	R4	45	/RESET
21	R3	46	GND
22	R2	47	VDD
23	R1	48	VCC
24	R0	49	VCC
25	D17	50	GND

Detail A

Adaptable connecter : FH12-50S-0.5SH(05) (HIROSE)

Note1: The values in parentheses are for reference.
Note2: When installing the product to customer equipment, do not apply any stress to the rear side of the product, FPC, A area, Soldering Area and Mounting Area.
If not, it may cause display un-uniformity or LCD panel separation or break down of the product.
Note3: While the product is working, do not contact a conductor such as a metal to the Soldering Area and Mounting Area of the FPC.

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-0475	Feb. 22 2008	**Revision contents** new issue **Writer** *Approved by* *Checked by* *Prepared by* T. OGAWA —————— E. KATAYAMA
2nd edition	DOD-PP-0499	Mar. 27 2008	**Revision contents** P1 Module name, P4 Structure and principle • NL9654HL06-01A →NL9654HL06-01J (change) **Signature of writer** *Approved by* *Checked by* *Prepared by* *T. Ogawa* —————— *T. Ogawa* T. OGAWA T. OGAWA