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NEC Corporation
NEC Electron Devices
Display Device Operations Unit
Color LCD Division
2nd Engineering Department

TFT COLOR LCD MODULE

Type: NL2432DR22-02B
8.9cm (3.5 Type), QVGA

SPECIFICATIONS
（Fourth Edition）

PRELIMINARY

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Application examples recommended by NEC Corporation.

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Specific: Military systems, aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, or any other equipment for which specifically high standard of quality or reliability is required.

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1. DESCRIPTION

The NL2432DR22-02B is a TFT (thin film transistor) active matrix color liquid crystal display (LCD) comprising an amorphous silicon TFT attached to each signal electrode, a driving circuit.
This module is consist of LCD panel, Driver, Front light and Touch panel

The 8.9 cm (3.5 Type) diagonal display area contains 240×320 pixels and can display 262,144 colors simultaneously.

2. FEATURES
Include Front light and Touch panel
Recommended LCD controller: part no.TBD, NEC corp.
High contrast ratio
6-bit digital RGB signals

3. APPLICATIONS

PDA

4. STRUCTURE AND FUNCTION
A reflective TFT (thin film transistor) color LCD module is comprised of a TFT liquid crystal panel structure with LSIs for driving the TFT array. Sandwiching liquid crystal material in the narrow gap between a TFT array glass substrate and a color filter glass substrate creates the TFT panel structure.
RGB (red, green, blue) data signals from a source system are modulated into a form suitable for active-matrix addressing by the onboard signal processor and sent to the driver LSIs, which in turn addresses the individual TFT cells.
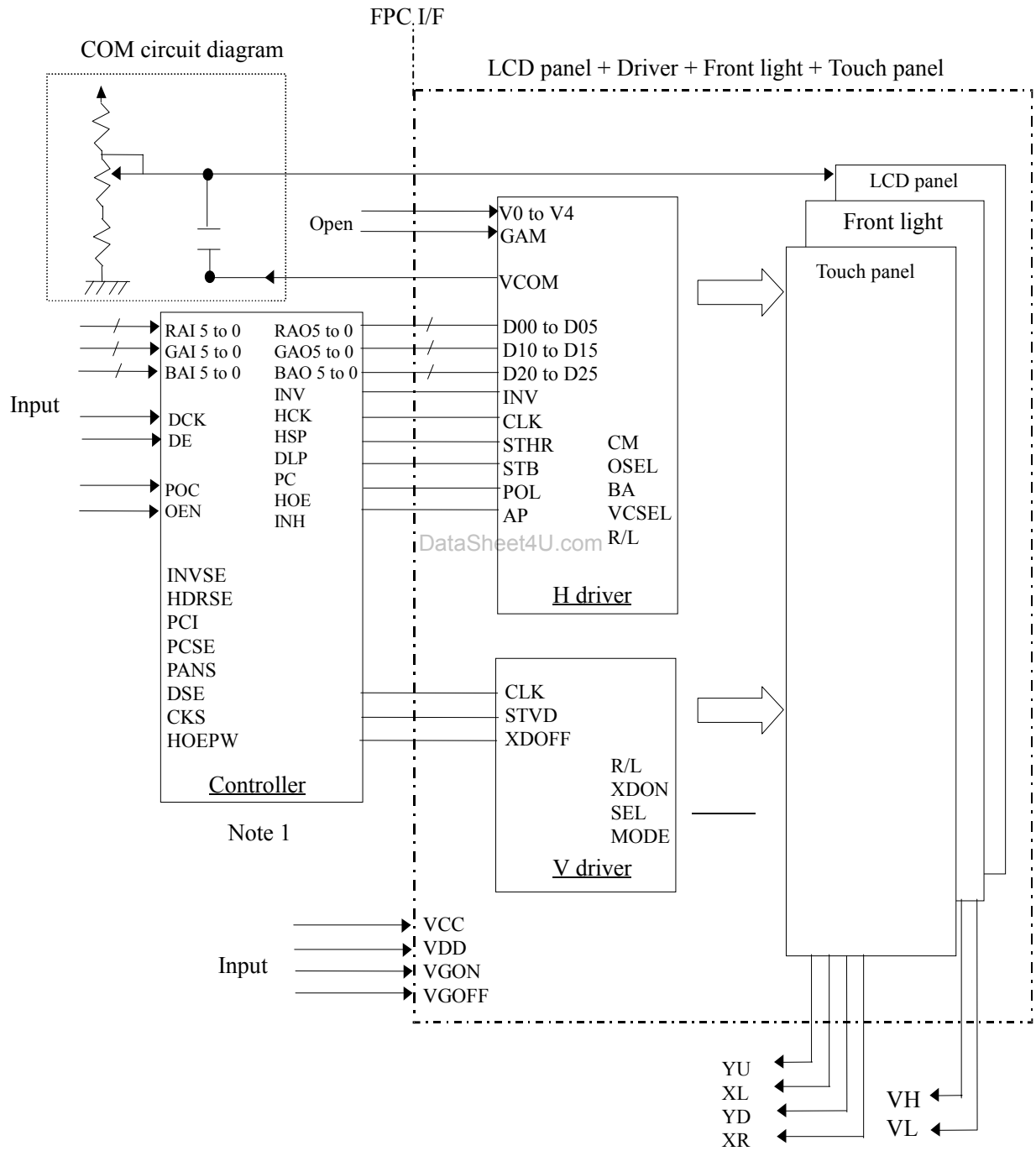Acting as an Electro-optical switch, each TFT cell regulates light from the natural light and so on when activated by the data source. By regulating the amount of light reflection passing through the array of red, green, and blue dots, color images are created with clarity.

UTLINE OF CHARACTERISTICS (at room temperature)

Display area   53.64 (H) × 71.52 (V) mm [Diagonal 8.9 cm]

Drive system   a-Si TFT active matrix

Display colors   262,144 colors

Number of pixels   240 (H) × 320 (V)

Pixel arrangement   RGB vertical stripe

Pixel pitch   0.2235 (H) × 0.2235 (V) mm

Module size   70.0 (Typ., H) × 96.0 (Typ., V) × 4.5 (Typ., D) mm
                                    [D: Not include FPC connector]

Weight   45 g (Typ.)

Contrast ratio   10:1 (Typ.:With Front light and Touch panel)
                        Reference: 40:1 (Without Front light and Touch panel)

Response time   32 ms (Typ., Ton + Toff)

Reflection ratio   17 % (Typ. With Front light and Touch panel)
                        Reference: 35%(Without Front light and Touch panel)

Signal system   Controller input (6-bit signals, DCK, DE, POC, OEN) signals   Note 1

Supply voltage   VCC 3.0 V (typ. Logic)
                      VDD 5.0 V (typ. Υ control)
                      VGON 15.0 V (LCD driving)
                      VGOFF –15.0 V (LCD driving)

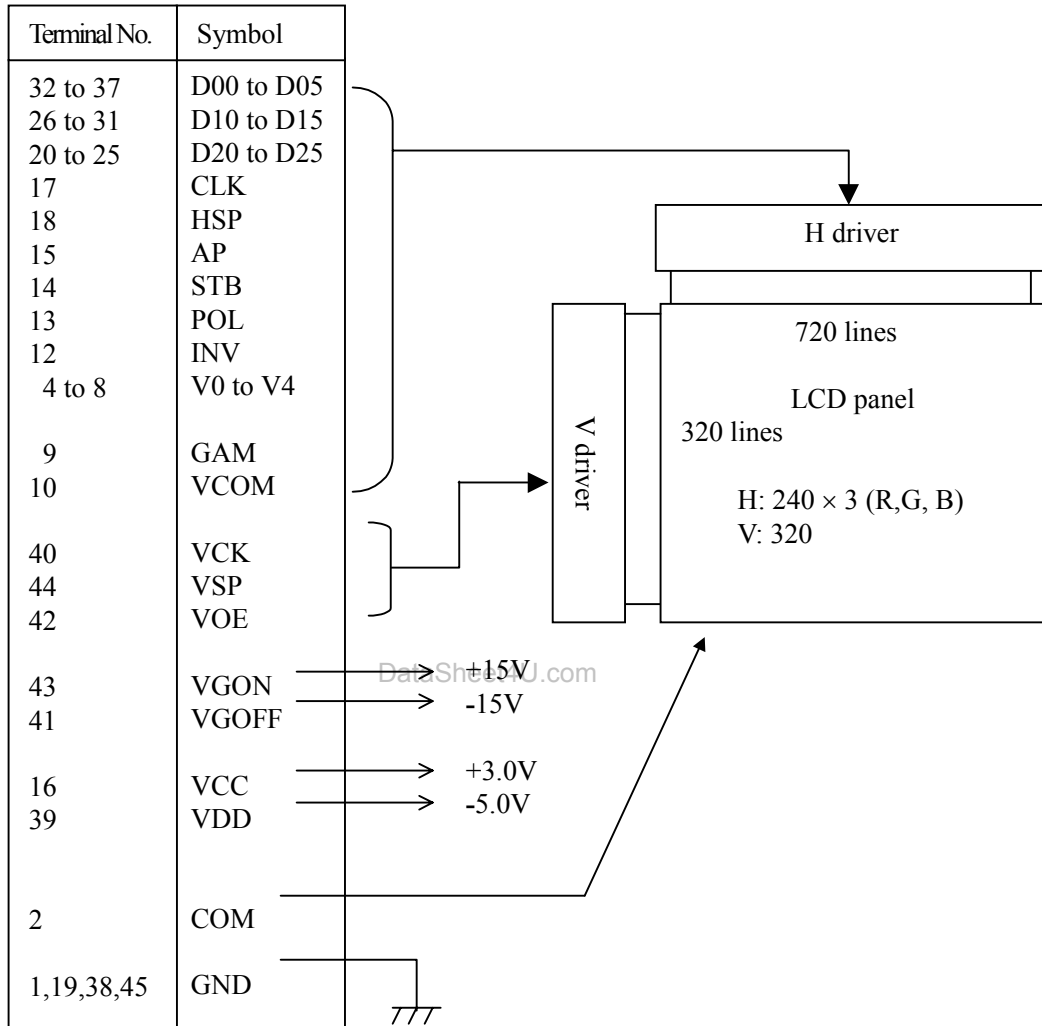Power consumption   25 mW (Typ.) (Gamma and COM circuit in driver are included)

Note 1: Refer to the controller (part no.: TBD) specifications.

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6. BLOCK DIAGRAM

FPC I/F

COM circuit diagram

LCD panel + Driver + Front light + Touch panel

LCD panel

Front light

Touch panel

Open → V0 to V4 / GAM

VCOM

Input

Controller
- RAI 5 to 0 — RAO5 to 0 → D00 to D05
- GAI 5 to 0 — GAO5 to 0 → D10 to D15
- BAI 5 to 0 — BAO 5 to 0 → D20 to D25
- DCK — INV → INV
- DE — HCK → CLK
- — HSP → STHR
- POC — DLP → STB
- OEN — PC → POL
- — HOE → AP
- — INH
- INVSE
- HDRSE
- PCI
- PCSE
- PANS
- DSE
- CKS
- HOEPW

H driver
- CM
- OSEL
- BA
- VCSEL
- R/L

Note 1

V driver
- CLK
- STVD
- XDOFF
- R/L
- XDON
- SEL
- MODE

Input → VCC
Input → VDD
Input → VGON
Input → VGOFF

YU
XL
YD
XR

VH
VL

Note 1: Refer to the controller (part no.: TBD) specifications for input timings.

FPC I/F

Terminal No.	Symbol
32 to 37	D00 to D05
26 to 31	D10 to D15
20 to 25	D20 to D25
17	CLK
18	HSP
15	AP
14	STB
13	POL
12	INV
4 to 8	V0 to V4
9	GAM
10	VCOM
40	VCK
44	VSP
42	VOE
43	VGON
41	VGOFF
16	VCC
39	VDD
2	COM
1,19,38,45	GND

H driver

V driver

720 lines

LCD panel
320 lines

H: 240 × 3 (R,G, B)
V: 320

VGON → +15V
VGOFF → -15V

VCC → +3.0V
VDD → -5.0V

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7. GENERAL SPECIFICATIONS

Items	Specifications	Units
Module size	70.0 ± TBD(H) × 96.0 ± TBD (V) × 4.5 ± TBD (D)	mm
Display area	53.64 (H) × 71.52 (V) [Diagonal display area: 8.9 cm (Type 3.52)]	mm
Number of pixels	240 (H) × 320 (V)	pixel
Dot pitch	0.0745 (H) × 0.2235 (V)	mm
Pixel pitch	0.2235 (H) × 0.2235 (V)	mm
Pixel arrangement	RGB (Red, Green, Blue) vertical stripe	-
Display colors	262,144	color
Weight	TBD (Max.)	g

8. ABSOLUTE MAXIMUM RATINGS

Parameters	Symbols	Ratings	Units	Remarks
Supply voltage	VCC	-0.3 to +4.0	V	Ta = 25 °C
	VDD	-0.3 to +6.0	V	Ta = 25 °C
	VGON	-0.3 to +44.0		
	VGOFF	VGON – 44.0 to +0.3		
Logic input voltage	VI	-0.3 to VCC+0.3	V	Logic signals
γ control voltage	V0 to V4	-0.3 to VDD+0.3	V	-
Storage temperature	Tst	-20 to +70	℃	-
Operating temperature	Top1	0 to +50		Module surface Note: 1
Relative humidity (RH) Note 2		≤ 95	%	Ta≤ 40°C
		≤ 90		40°C <Ta≤ 50°C
Absolute humidity Note 2		Absolute humidity shall not exceed Ta = 50°C, RH = 90%.	g/m³	Ta>50°C
Storage altitude		≤ TBD	m	-25°C ≤ Ta ≤ 70°C
Operating altitude		≤ TBD	m	0°C ≤ Ta ≤ 50°C

Note 1: Measure at the display area
Note 2: No condensation

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9. ELECTRICAL CHARACTERISTICS

(1) Logic/ LCD driving
(Ta = 25°C)

Parameters	Symbols	Min.	Typ.	Max.	Units	Remarks
Logic supply voltage	VCC	2.6	3.0	3.6	V	-
H driver supply voltage	VDD	4.8	5.0	5.5	V	-
V driver(+) supply voltage	VGON	14.0	15.0	16.0	V	-
V driver(-) supply voltage	VGOFF	-16.0	-15.0	-14.0	V	-
Logic input high voltage	VIH	0.7×VCC	-	VCC	V	Logic signal
Logic input low voltage	VIL	0	-	0.3×VCC	V	
γ control supply voltage	V0 to V4	VDD+0.1	-	VDD-0.1	V	
COM voltage input range	COM	VDD	-	-	Vp-p	
COM center voltage note 1	COM/C	1.3	1.8	2.3	V	At (V0-V4)/2=2.5V
VCC supply current	ICC	-	0.9	TBD	mA	VCC= 3.0 V Not include the controller
VDD supply current	IDD	-	4.4	TBD	mA	VDD= 5.0 V
VGON supply current	IGON	-	0.04	TBD	mA	VGON=15.0 V
VGOFF supply current	IGOFF	-	0.04	TBD	mA	VGOFF= -15.0 V

Note 1: An optimal value for COM/C is in the range of 1.3 to 2.3.

(2) Front light

Parameters	Symbols	Min.	Typ.	Max.	Units	Remarks
Lamp current	IL	1.0	1.4	3.0	mA	-
Lamp voltage	VL	-	350	-	Vrms	IL=1.0 mArms
		-	330	-	Vrms	IL=1.4 mArms
		-	320	-	Vrms	IL=3.0 mArms
Lamp turn on voltage Note1	VS	630	-	-	Vrms	Ta = 25°C
		950	-	-	Vrms	Ta = 0°C
Oscillator frequency	Ft	TBD	TBD	TBD	kHz	Note 2

Note 1: The phase of the supply voltage for lamp must keep same one.
Note 2: Recommended value of "Ft"

Ft is within the specification. And $Ft = 1/th \times (2n-1)/4n$, th: TBD period, n: a natural number (1,2,3····)

If Ft is out of the recommended value, interference between Ft frequency and TBD frequency may cause beat on the display.

(2) Touch panel

Parameters	Symbols	Min.	Typ.	Max.	Units	Remarks
Touch panel input voltage	TBD	TBD	5.0	5.5	V	-
	TBD	10	-	-	MΩ	At DC 25 V

Remark 1: Refer to TBD.

10. SUPPLY VOLTAGE SEQUENCE
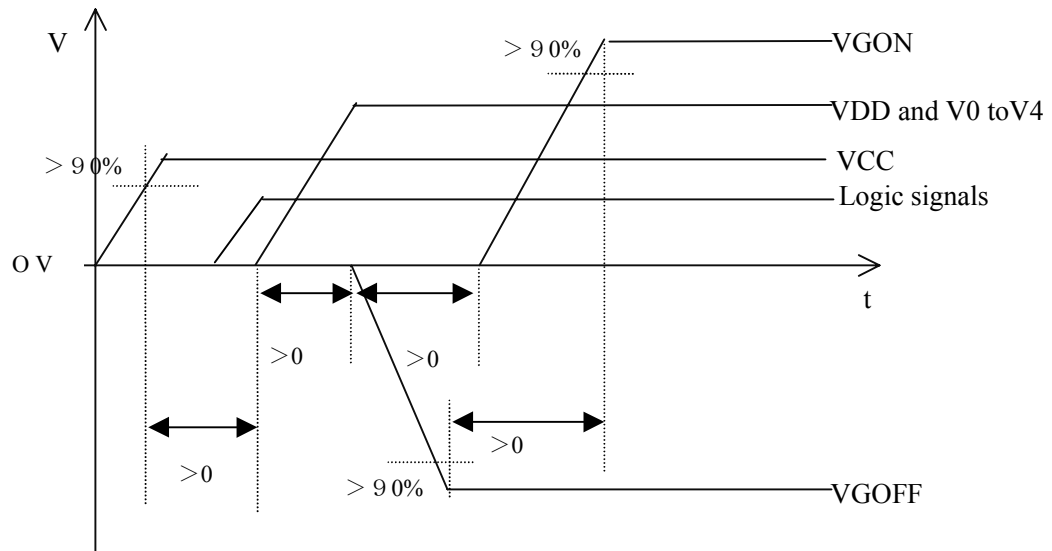
Remark1: Supply voltages must keep above timings or input at the same time. And when supply voltages are blocked, these must be opposite timings.

Remark2: The "OEN" signal of the controller should be "H" after VGON.

Remark3: The signal should not be down during operation. Even if signal could recover, LCD module can not be operated correctly, the display may be un-uniformity. In case signal is down, VCC should be turned off, and then turn VCC and signal on as above sequence.

11. INTERFACE PIN CONNECTIONS

(1) Interface connector for signals and power

CN1

Adaptable socket: FH12-45S-0.5SH (lower terminal type) or FH12A-45S-0.5SH (upper terminal type)

Supplier: Japan Aviation Electronics Industry, Limited.

Pin No.	Symbols	Functions	Pin No.	Symbols	Functions
1	GND	Ground	24	D24	Blue data
2	COM	Signal for common electrode	25	D25	Blue data(MSB)
3	N.C.	Non-connection	26	D10	Green data(LSB)
4	V0	γ control	27	D11	Green data
5	V1		28	D12	Green data
6	V2		29	D13	Green data
7	V3		30	D14	Green data
8	V4		31	D15	Green data (MSB)
9	GAM	External γ signal select	32	D00	Red data(LSB)
10	VCOM	Driver output signal	33	D01	Red data
11	N.C.	Non-connection	34	D02	Red data
12	INV	Data reversal signal	35	D03	Red data
13	POL	Polarity reversal signal	36	D04	Red data
14	STB	H driver latch signal	37	D05	Red data(MSB)
15	AP	H driver inhibition signal	38	GND	Ground
16	VCC	Logic voltage	39	VDD	H driver voltage
17	HCK	H driver shift clock	40	VCK	V driver shift clock
18	HSP	H driver start pulse	41	VGOFF	V driver OFF voltage
19	GND	Ground	42	VOE	V driver output enable ("L" output)
20	D20	Blue data(LSB)	43	VGON	V driver ON voltage
21	D21	Blue data	44	VSP	V driver start pulse
22	D22	Blue data	45	GND	Ground
23	D23	Blue data			

(2) Interface connector for front light

CN2 socket: BHSR-02VS-1 (Supplier: J.S.T. TRADING COMPANY LTD.)

Adaptable plug: SM02B-BHSS-1-TB (Supplier: J.S.T. TRADING COMPANY LTD.)

Pin No.	Symbols	Functions
1	V_{HIGH}	High voltage terminal
2	V_{LOW}	Low voltage terminal

(3) Interface connector for touch panel

CN3 socket: SLW4R-5STE1

Adaptable plug: FCI Japan

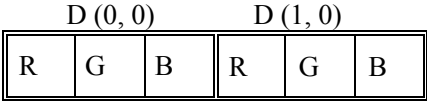| Pin No.	Symbols	Functions
1	YU	Vertical terminal (Up side)
2	XL	Horizontal terminal (left side)
3	YD	Vertical terminal (Down side)
4	YR	Horizontal terminal (Right side)

YU

XL

XR

YD

YU, XL, YD, XR
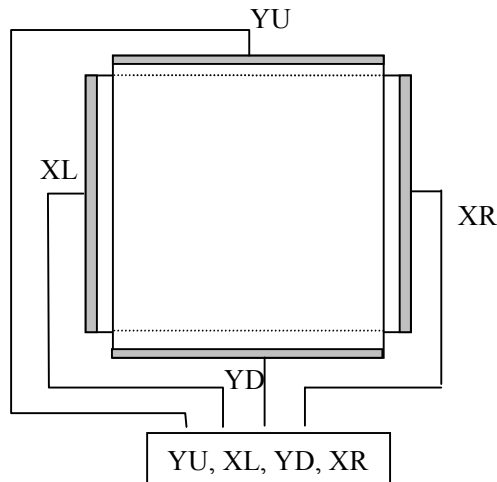
12. DISPLAY COLORS vs. DISPLAY POSITIONS

(1) Display colors

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 grayscale	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 grayscale	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 grayscale	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

Remark 1: Colors are developed in combination with 6-bit signals (64 steps in grayscale) of each primary red, green, and blue color. This process can result in up to 262,144 (64×64×64) colors.

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(2) Display positions of input data

D (0, 0)			D (1, 0)		
R	G	B	R	G	B

D(0, 0)	D(1,0)	•••	D(239,0)
D(0,1)	D(1, 1)	•••	D(239,1)
• • • • • •	• • • • • •	• • • • • •	• • • • • •
D(0, 319)	D(1, 319)	•••	D(239,319)

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13. OPTICAL CHARACTERISTICS

< Front light turning off >   Note 1

Parameters	Symbols	Conditions	Min.	Typ.	Max.	Units	Remarks
Contrast ratio	CR	-	TBD	10:1	-	-	Note 2,3
Reflection ratio	RE	-	TBD	17	-	%	Note 3
Chromaticity Coordinates	W	White (x, y)	-	0.30, 0.31	-	-	Note 4

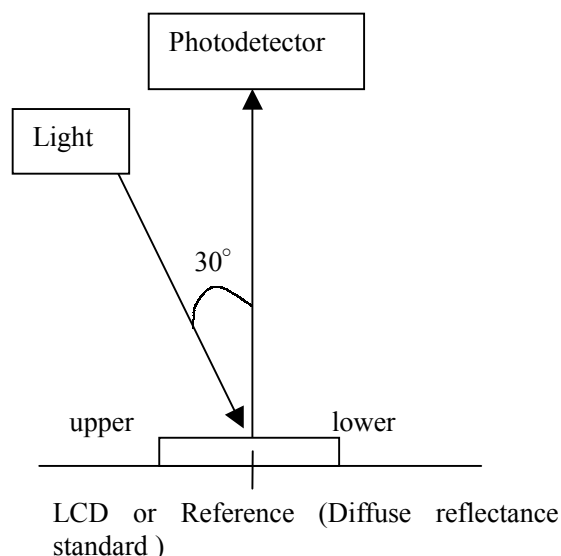< Front light turning on >   Note 1

Parameters	Symbols	Conditions		Min.	Typ.	Max.	Units	Remarks
Contrast ratio	CR	-		TBD	8:1	-	-	Note 2,5
Chromaticity Coordinates	W	White (x, y)		-	TBD	-	-	Note 5
Luminance	Lu	IL= 1.0mA		-	15	-	cd/m^2	Note 5
		IL= 1.4mA			35		cd/m^2	
		IL= 3.0mA			85		cd/m^2	

Reference data

Note 1

Parameters	Symbols	Conditions		Min.	Typ.	Max.	Units	Remarks
Response time (Module front surface temperature = TBD°C)	Ton	White to black	90%→10%	-	15	TBD	ms	Note 6
	Toff	Black to white	10%→90%	-	17	TBD		

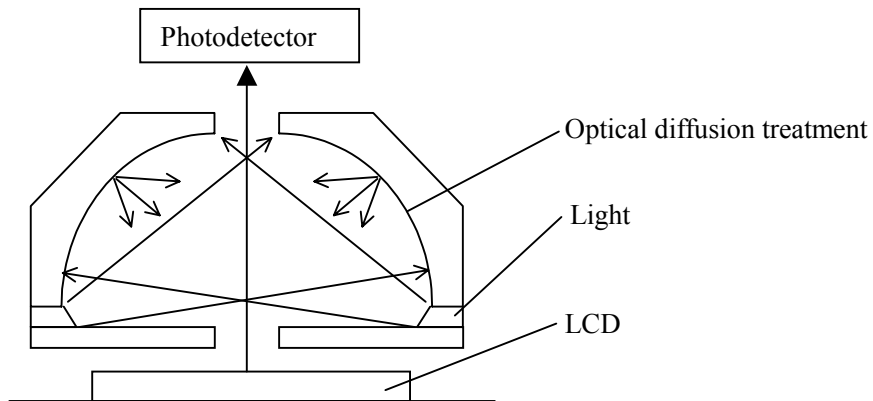Note 1: Ta = 25 °C, VCC= 3.0V, Include front light and Touch panel

Note 2: The contrast ratio is calculated by using the following formula.

$$\text{Contrast ratio (CR)} = \frac{\text{Luminance with all pixels in "white"}}{\text{Luminance with all pixels in "black"}}$$
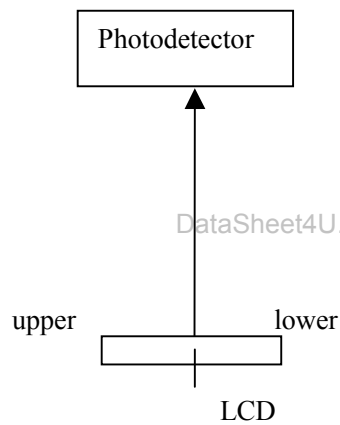
Note 3: Contrast ratio and reflection ratio are measured as follows.

Photodetector

Light

30°

upper   lower

LCD or Reference (Diffuse reflectance standard)

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Note 4: White chromaticity coordinate is measured as follows.

Photodetector

Optical diffusion treatment

Light

LCD

Note 5: Contrast ratio, Chromaticity Coordinates and Luminance are measured as follows.

Photodetector

upper   lower

LCD

Note 6: Definitions of response time is as follows.
　　　　Photo-detector output signal is measured when the luminance changes "white" to "black" or "black" to "white".

White   100%

Luminance

90%

10%

Black   0%

Ton

Toff
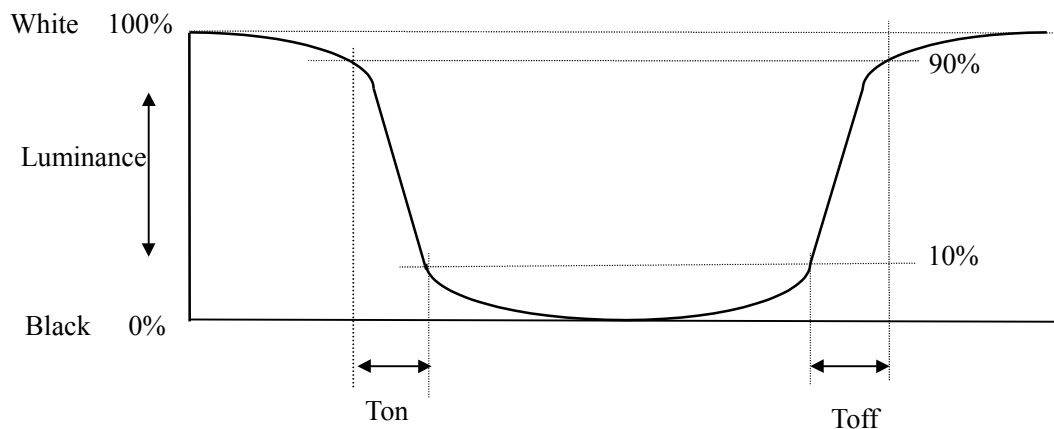
14. GENERAL CAUTIONS

Because the following statements are very important, please be sure you understand their contents completely.

| ⚠ CAUTION | This figure is a warning that you will get hurt and/or the module will be damaged if you make a mistake in operation. |

| ⚠ | This figure is a warning that you will get hurt if you make a mistake in operation. |

⚠ **CAUTIONS**

(1) Caution when taking out the module
① Pick up the pouch only, when removing the module from a carrier box.

(2) Cautions for handling the module
① As the electrostatic discharges may break the LCD module, handle the LCD module with care against electrostatic discharges. Peel protection sheet out from the LCD panel surface as slowly as possible.
② ⚠ As the LCD panel and front light element are made from fragile glass material, impulse and pressure to the LCD module should be avoided.
③ As the surface of polarizer is very soft and easily scratched, use a soft dry cloth without chemicals for cleaning.
④ Do not pull the interface connectors in or out while the LCD module is operating.
⑤ Put the module display side down on a flat horizontal plane.
⑥ Handle connectors and cables with care.
⑦ When the module is operating, do not lose logic signals. If any one or more of these signals is lost, the LCD panel would be damaged.
⑧ Don't push or rub the surface of LCD module please. If you do, the scratches or the marks like rubbing marks may be left on the surface of the module.
⑨ The LCD module should be mounted in strong body such as magnesium alloy. If the press or twist are added to the module, the display may have un-uniformity image. When the module is mounted to customer chassis, please evaluate the display condition carefully.

(3) Cautions regarding atmosphere
① Dew-drop atmosphere must be avoided.
② Do not store and/or operate the LCD module in a high-temperature and/or high-humidity atmosphere. Storage in an anti-static pouch and under the room temperature atmosphere is recommended.
③ Do not operate the LCD module in high magnetic field.

(4) Cautions about the module characteristics
① Do not apply any fixed pattern data for a long time to the LCD module. It may cause image sticking.
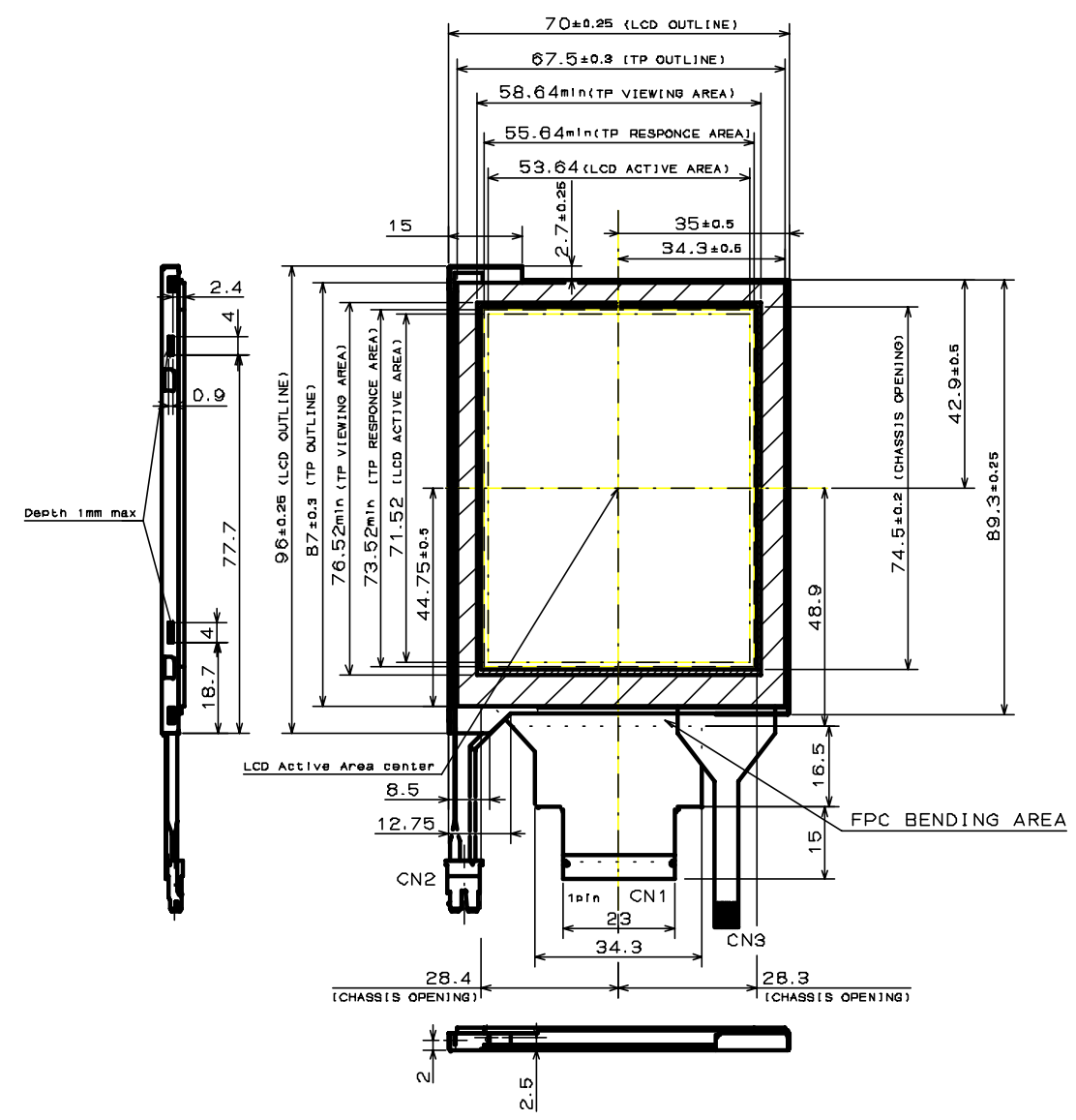
(5) Other cautions
  ① Do not disassemble and/or reassemble the LCD module.
  ② When returning the module for repair, etc., please pack the module properly to avoid any damages. NEC recommends using original shipping packages.

The liquid crystal display has the following specific characteristics. These are not defects or malfunctions.

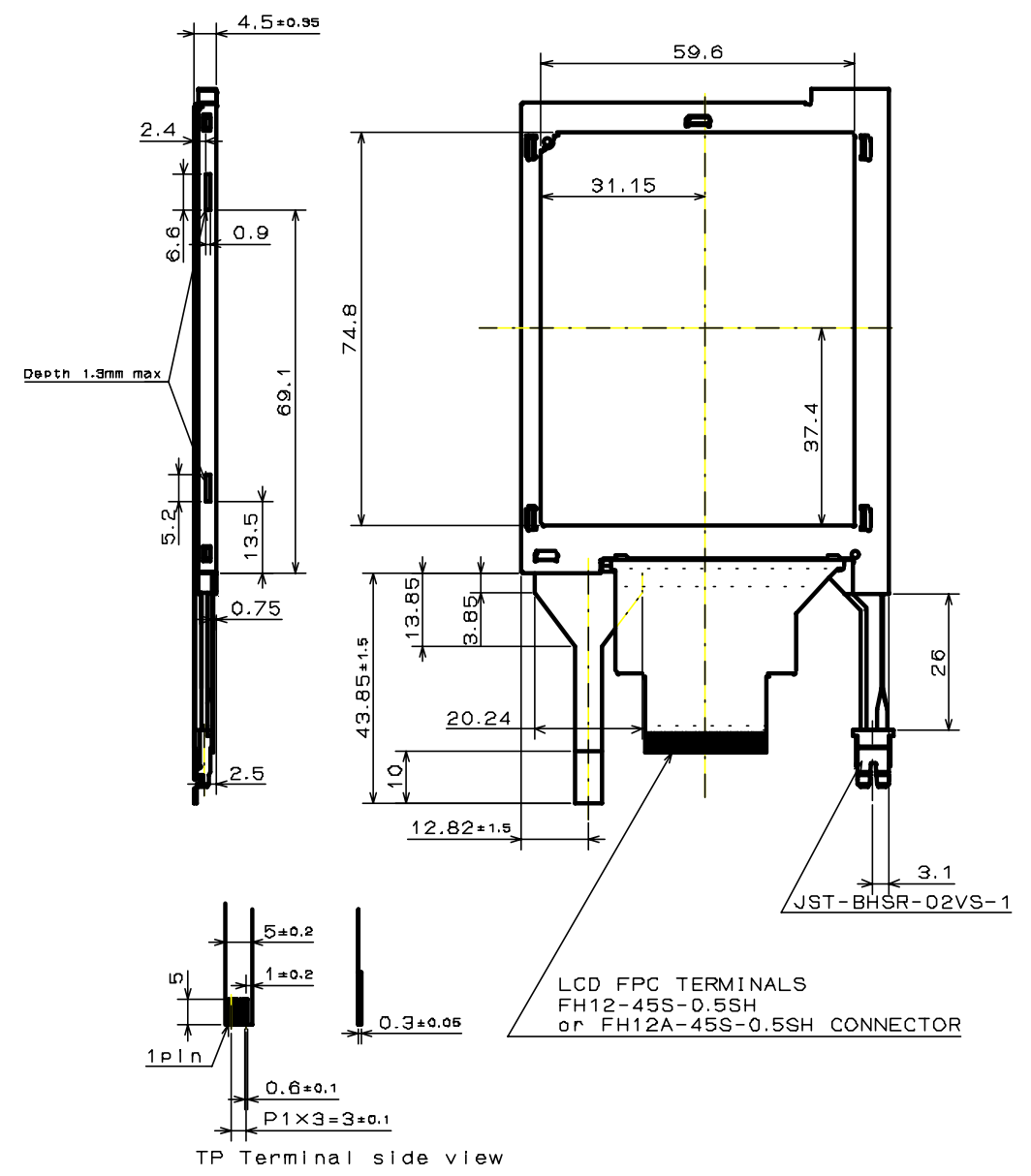The ambient temperature may affect the optical characteristics of this module.

Uneven brightness and/or small spots may be observed depending on different display patterns.

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15. OUTLINE DRAWING

3222R-02B Module Outline
(Preliminary)

2001.6.8
Ver.7

Revision History			DOD-N-0214	18/18
Rev.	Prepared Date	Revision contents	Approved	Checked	Prepared	Issued Date

Rev.	Prepared Date	Revision contents	Approved	Checked	Prepared	Issued Date
1	Mar. 13, 2001	DOD-N-0075	H. Hada	-	T.Kusanagi	-
2	Mar. 29, 2001	DOD-N-0100 • NL2432DR22-0X → NL2432DR22-02B • 3.52 type → 3.5 type	H.Moriyama	-	T.Kusanagi	-

3	May 28, 2001	DOD-N-0184
		• Module size:
		  92.0 (typ.,V) → 96.0 (typ.,V) mm
		• Weight: 50g (typ.) → 45g (typ.)
		• Contrast ratio: TBD → 10:1(typ.)
		• Reflection ration:TBD → 17% (typ.)
		• power consumption:
		  19mW (typ.) → 25mW (typ.)
		•9.ELECTRIC CHARACTERISTICS
		  COM: 5.0V → VDD
		  IDD: 2.7 → 4.4 mA
		  IGON: 0.05 → 0.04 mA
		  IGOFF: 0.1 → 0.04 mA
		• 10.SUPPLY VOLTAGE SEQUENCE
		  The figure is revised.
		• 13. OPTICAL CHARACTERISTICS
		  The value is devided between the front light conditions (turning on/off).
		• 15. OUTLINE DRAWINGS
		  Ver.5 → Ver.6
			H.Moriyama	-	T.Kusanagi	-

4	Jun. 15 2001	DOD-N-0214 • 15. OUTLINE DRAWINGS Ver.6→Ver.7	羽田 (H.Hada)		樫本 (K.Kashimoto)	