NEC

TFT COLOR LCD MODULE

NL6448AC30-12

24 cm (9.4 type), 640×480 pixels 4096 colors, incorporated one lamp/edge-light type backlight (inverter-less)

DESCRIPTION

The NL6488AC30-12 is TFT (thin film transistor) active matrix color liquid crystal display (LCD) comprising amorphous silicon TFT attached to each signal electrode, a driving circuit, and a backlight.

The 24 cm diagonal display area contains 640 × 480 pixels and can display 4096 colors simultaneously.

By utilizing one lamp / edge-light type backlight, a very thin profile design and low power consumption have been achieved.

FEATURES

- ○ Thin and light weight
- ○ High contrast ratio, wide color gamut
- ○ Hi-speed response
- ○ Low power consumption
- ○ Incorporated edge light type backlight (inverter-less)
- ○ Data enable function

APPLICATIONS

- ○ Notebook personal computer (PC), word processor
- ○ Display terminals for control system
- ○ New media
- ○ Control board for NC machine
- ○ Monitor for process controller

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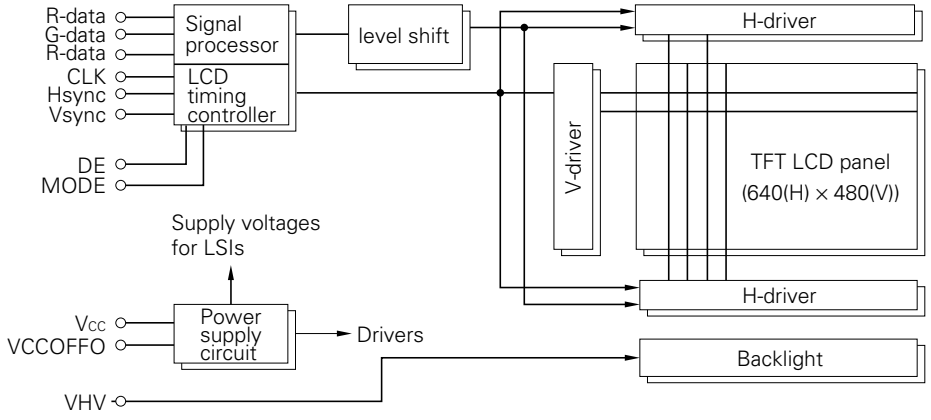
STRUCTURE AND FUNCTIONS

A TFT color LCD module comprises a TFT LCD panel, LSIs for driving liquid crystal, and the backlight. The TFT LCD panel is composed of a TFT array glass substrate superimposed on a color filter glass substrate with liquid crystal filled in the narrow gap between two substrates. The backlight apparatus is located on the backside of the LCD panel.

RGB (Red, Green, Blue) data signals are sent to LCD panel drivers after modulation into suitable forms for active matrix addressing through signal processor.

Each of the liquid crystal cells acts as an electro-optical switch that controls the light transmission from the backlight by a signal applied to a signal electrode through the TFT switch.

BLOCK DIAGRAM



OUTLINE OF CHARACTERISTICS (at room temperature)

Display area	192(H) × 144(V) mm
Drive system	a-Si TFT active matrix
Display colors	4096 colors
Number of pixels	640 × 480 pixels
Pixel arrangement	RGB vertical stripe
Pixel pitch	0.30(H) × 0.30(V) mm
Module size	241.8(H) × 178.8(V) × 10 max.(D) mm
Weight	480 g (typ.)
Contrast ratio	150 : 1 (typ.)
Viewing angle (more than the contrast ratio of 10 : 1)	
	Horizontal : 45° (typ. left side, right side)
	Vertical : 25° (typ. up side), 25° (typ. down side)
Designed viewing direction	Upper direction (wider viewing angle without image reversal)
Color gamut	45 % (typ. center, to NTSC)
Response time	40 msec. (max.), "white" to "black"
Luminance	70 cd / m² (typ.)
Signal system	4-bit digital RGB signals, synchronous signals (Hsync, Vsync), dot clock (CLK)
Supply voltage	5 V (Logic, LCD driving)
Backlight	Cold cathode type one fluorescent lamp, inverter-less
Power consumption	2.7 W (typ.)

GENERAL SPECIFICATIONS

Item	Specification	Unit
Module size	241.8±1(H) × 178.8±1(V) × 10.0 max.(D)	mm
Display area	192(H) × 144(V) (diagonal size 24 cm)	mm
Number of pixels	640(H) × 480(V)	pixel
Dot pitch	0.10(H) × 0.30(V)	mm
Pixel pitch	0.30(H) × 0.30(V)	mm
Pixel arrangement	RGB(Red, Green, Blue) vertical stripe	
Display colors	4096	color
Weight	500 (max.)	g

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Remarks	
Supply voltage	V_{CC}	−0.3 to +6.5	V	Ta = 25°C	
Input voltage	V_I	−0.3 to V_{CC} +0.3	V		
Storage temp.	T_{ST}	−20 to 60	°C		
Operating temp.	T_{OP}	0 to 50	°C	Module surface*	
Humidity		95 % relative humidity	—	Ta = 40°C	no condensation
		85 % relative humidity	—	Ta = 50°C	
		Absolute humidity shall not exceed Ta = 50°C, 85 % relative humidity level.	—	Ta > 50°C	

* measured at center of display area

ELECTRICAL CHARACTERISTICS

(1) Logic, LCD driving

Ta = 25°C

Parameter	Symbol	min.	typ.	max.	Unit	Remarks
Supply voltage	V_{CC}	4.75	5.0	5.25	V	
Logic input "L"	V_{IL}	0	—	0.8	V	TTL
Logic input "H"	V_{IH}	2.2	—	V_{CC}	V	TTL
Supply current	I_{CC}	—	200	350	mA	V_{CC} = 5.0 V **note**

note : at dot-checkered pattern

(2) Backlight

Ta = 25°C

Parameter	Symbol	min.	typ.	max.	Unit	Remarks
Lamp current	I_L	—	3.7	—	mArms	70 cd / m²
Lamp voltage	V_L	—	450	—	Vrms	
Lamp turn on voltage	V_S	—	1200	—	Vrms	
Oscillator frequency	F_t	50	54	58	kHz	**note**

note : Recommended value of "F_t"

• F_t is within the specification.

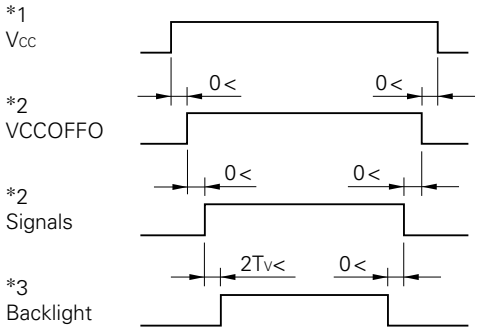
and

• $F_t = \frac{1}{4Th} \times (2n-1)$ Th : Hsync period

n : a natural number (1, 2, 3, • • • •)

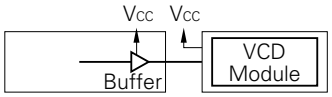
If F_t is out of the recommended value, interference between F_t frequency and Hsync frequency may cause beat on the display.

SUPPLY VOLTAGE SEQUENCE



Signals : CLK, Hsync, Vsync, MODE, DE,
R0~R3, G0~G3, B0~B3

*1 The supply voltage of the external driver for input signals should be the same as V_{CC}.



*2 In the case of VCCOFFO = low level, please keep whole signals low level or high impedance.

*3 When the backlight turns on before LCD operation or the LCD operation turns off before the backlight turns off, the display may momentarily become white.

INTERFACE PIN CONNECTION

(1) Interface signals, power supply

Connector : DF9-31P-1V ••• CN1

Supplier : HIROSE ELECTRIC CO., LTD

Pin No.	Symbol	Function
1	GND	Signal ground
2	N.C. 1)	
3	B0	Blue data (LSB)
4	B1	Blue data
5	B2	Blue data
6	GND	Signal ground
7	B3	Blue data (MSB)
8	N.C. 1)	
9	G0	Green data (LSB)
10	G1	Green data
11	GND	Signal ground
12	G2	Green data
13	G3	Green data (LSB)
14	V_{CC}	Power supply
15	V_{CC}	Power supply
16	VCCOFFO	V_{CC} ON / OFF signal

Pin No.	Symbol	Function
17	N.C. 1)	
18	R0	Red data (LSB)
19	GND	Signal ground
20	R1	Red data
21	R2	Red data
22	R3	Red data (MSB)
23	DE	Data enable
24	GND	Signal ground
25	CLK	Dot clock
26	Hsync	Horizontal sync.
27	Vsync	Vertical sync.
28	GND	Signal ground
29	GND	Signal ground
30	MODE	Timing mode select
31	N.C. 1)	

1) Do not connect anything to N. C. pin.

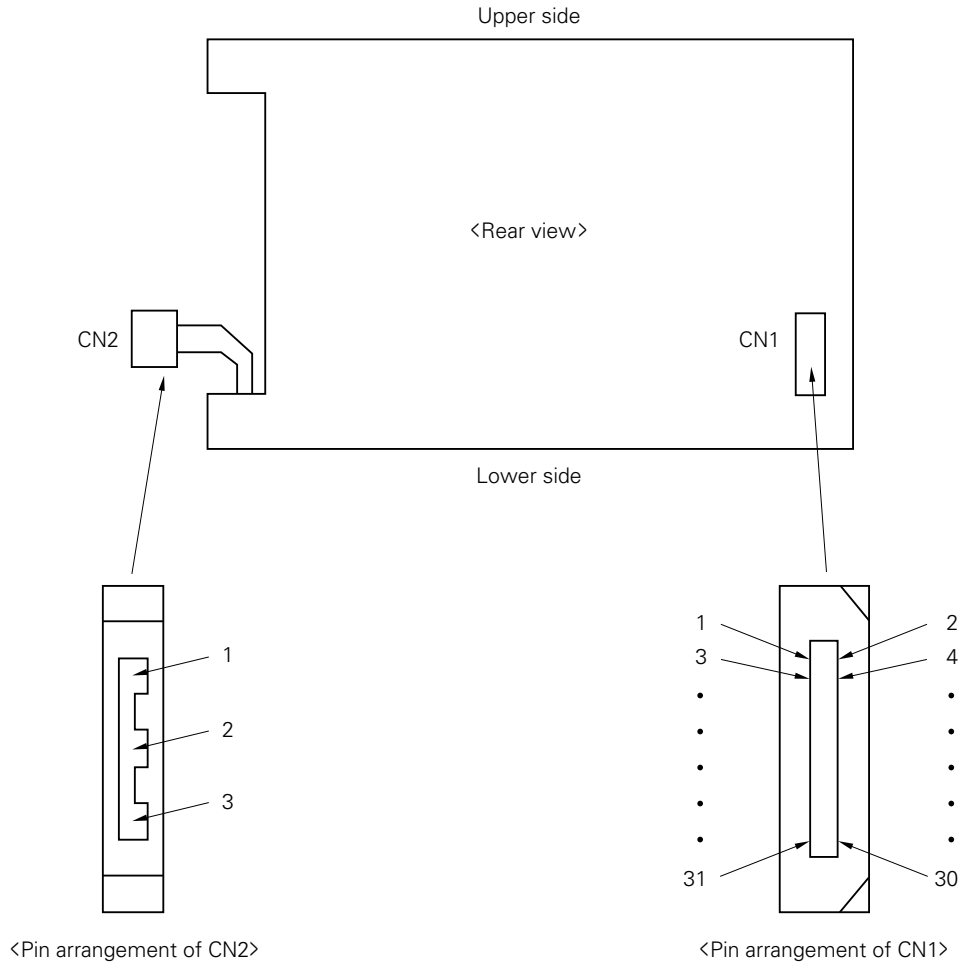
(2) Backlight

Connector : BHR-03VS-1 ••• CN2

Supplier : J. S. T TRADING COMPANY, LTD

Pin No.	Symbol	Function
1	HVH	High voltage terminal
2	N. C.	
3	GND	Backlight ground

(3) Connector location



<Pin arrangement of CN2> <Pin arrangement of CN1>

PIN DESCRIPTION

Symbol	Function	Description
R0 – R3 G0 – G3 B0 – B3	Display data	4-bit digital signals for each of RGB primary colors
Hsync	Horizontal sync.	Horizontal synchronous signal
Vsync	Vertical sync.	Vertical synchronous signal
CLK	Dot clock	Timing signal for display data. Module strobes the display data at the falling edge of CLK.
DE	Data enable	The signal that defines the graphic data that is to be displayed on the screen. When MODE = L, the function of this pin is ignored. (Keep DE high or low) When MODE = H, the period of DE = H is the display period of the module.
MODE	Timing mode select	MODE = H : DE mode (data enable function is active) MODE = L : fixed mode (data enable function is ignored)
VCCOFFO	V_{CC} ON / OFF signal	VCCOFFO = H : Power on inside of the module VCCOFFO = L : Power off inside of the module
V_{CC}	+5.0 V (±5 %)	Power supply for logic and LCD driving
GND	Logic ground	Ground for V_{CC}

DISPLAY COLORS vs. INPUT DATA SIGNALS

	Display	Data signals (0 : Low level, 1 : High level)											
		R3	R2	R1	R0	G3	G2	G1	G0	B3	B2	B1	B0
Basic colors	Black	0	0	0	0	0	0	0	0	0	0	0	0
	Blue	0	0	0	0	0	0	0	0	1	1	1	1
	Red	1	1	1	1	0	0	0	0	0	0	0	0
	Magenta	1	1	1	1	0	0	0	0	1	1	1	1
	Green	0	0	0	0	1	1	1	1	0	0	0	0
	Cyan	0	0	0	0	1	1	1	1	1	1	1	1
	Yellow	1	1	1	1	1	1	1	1	0	0	0	0
	White	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	1	0	0	0	0	0	0	0	0
	Dark	0	0	1	0	0	0	0	0	0	0	0	0
	↑ ↓												
	Bright	1	1	0	1	0	0	0	0	0	0	0	0
		1	1	1	0	0	0	0	0	0	0	0	0
	Red	1	1	1	1	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	1	0	0	0	0
	Dark	0	0	0	0	0	0	1	0	0	0	0	0
	↑ ↓												
	Bright	0	0	0	0	1	1	0	1	0	0	0	0
		0	0	0	0	1	1	1	0	0	0	0	0
	Green	0	0	0	0	1	1	1	1	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	1
	Dark	0	0	0	0	0	0	0	0	0	0	1	0
	↑ ↓												
	Bright	0	0	0	0	0	0	0	0	1	1	0	1
		0	0	0	0	0	0	0	0	1	1	1	0
	Blue	0	0	0	0	0	0	0	0	1	1	1	1

Note : Colors are developed in combination with 4-bit signal (16 steps in grayscale) of each primary red, green, and blue color.
This process can result in up to 4096 ($16 \times 16 \times 16$) colors.

INPUT SIGNAL TIMING

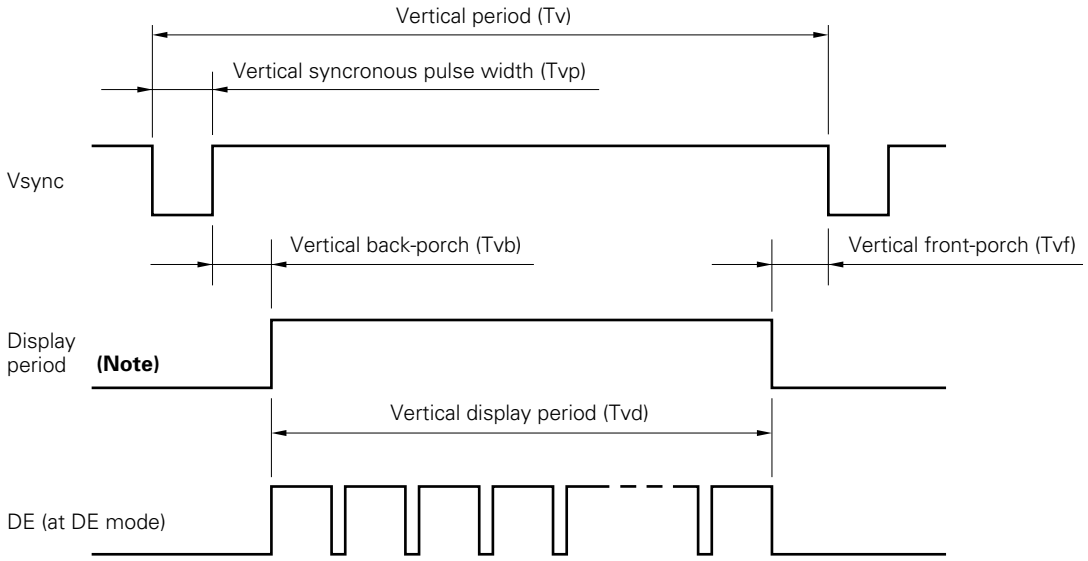
(1) Input signal specifications

Parameter		Symbol	min.	typ.	max.	Unit	Remarks
CLK	Frequency	1 / Tc	21.0	25.175	29.0	MHz	39.722 ns (TYP.)
	Duty	Tch / Tc	0.4	0.5	0.6		
	Rise, fall	Tcrf	—	—	10	ns	
Hsync	Period	Th	30.0	31.778	33.6	μs	31.469 kHz (TYP.)
			—	800	—	CLK	
	Display period	Thd		640		CLK	25.422 μs
	Front-porch	Thf	—	16	—	CLK	fixed timing mode
			0	16	—	CLK	DE mode
	Pulse width	Thp∗)	10	96	140	CLK	fixed timing mode
			10	96	—	CLK	DE mode
	Back-porch	Thb∗)	4	48	134	CLK	fixed timing mode
			4	48	—	CLK	DE mode
	∗) Thp+Thb			144		CLK	fixed timing mode
			14	144	—	CLK	DE mode
	CLK-Hsync timing	Thch	12	—	—	ns	
	Hsync-CLK timing	Thcs	8	—	—	ns	
	Hsync-Vsync timing	Tvh	15	—	—	ns	
	Vsync-Hsync timing	Tvs	15	—	—	ns	
	Rise, fall	Thrf	—	—	10	ns	
Vsync	Period	Tv	16.0	16.683	17.2	ms	59.94 Hz (TYP.)
			—	525	—	H	
	Display period	Tvd		480		H	15.253 ms
	Front-porch	Tvf	—	12	—	H	fixed timing mode
			0	12	—	H	DE mode
	Pulse width	Tvp∗)	1	2	29	H	fixed timing mode
			1	2	—	H	DE mode
	Back-porch	Tvb∗)	4	31	32	H	fixed timing mode
			4	31	—	H	DE mode
	∗) Thp+Thb			33		H	fixed timing mode
			6	33	—	H	DE mode
	Rise, fall		—	—	10	ns	
DATA R0 – R3 R0 – R3 R0 – R3	CLK-DATA timing	Tds	8	—	—	ns	
	DATA-CLK timing	Tdh	12	—	—	ns	
	Rise, fall	Tdrf	—	—	10	ns	
DE	DE-CLK tining	Tes	8	—	—	ns	DE mode
	CLK-DE tining	Teh	12	—	—	ns	
	Rise, fall	Terf	—	—	10	ns	

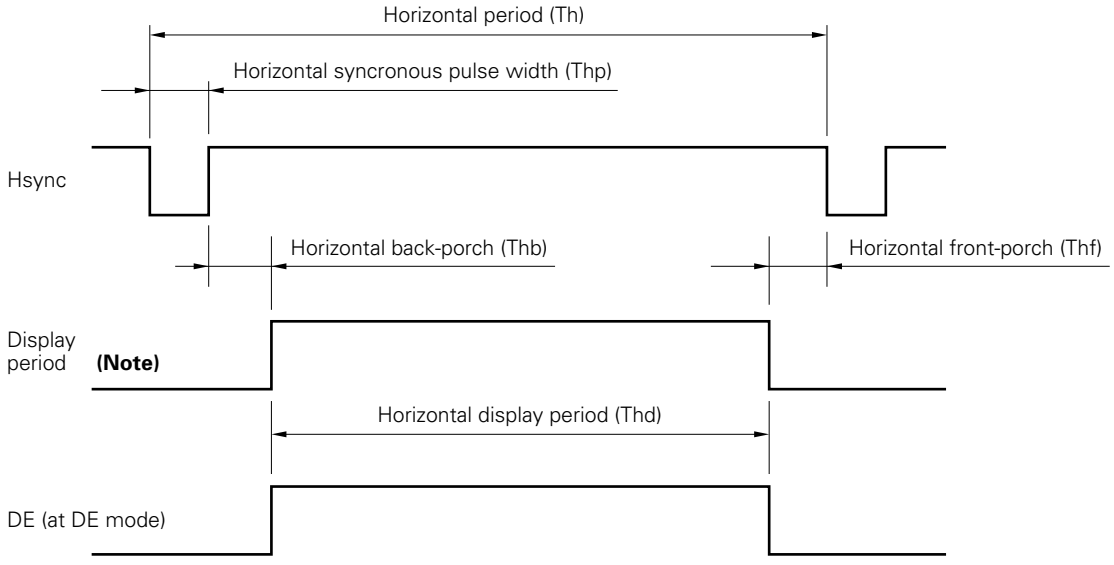
Note : All the parameters should be kept within the specified range.

(2) Definition of input signal timing

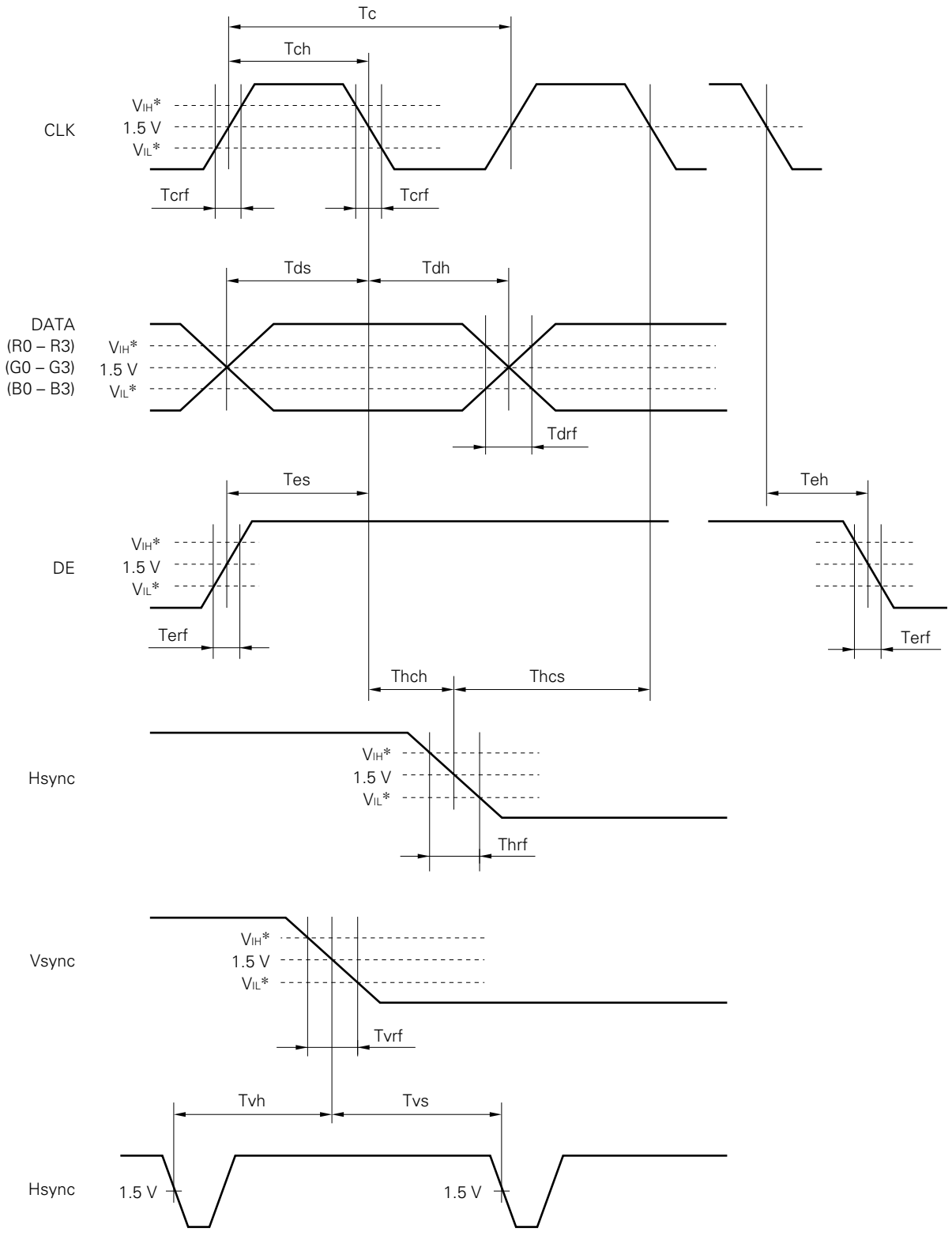
<Vertical>



<Horizontal>



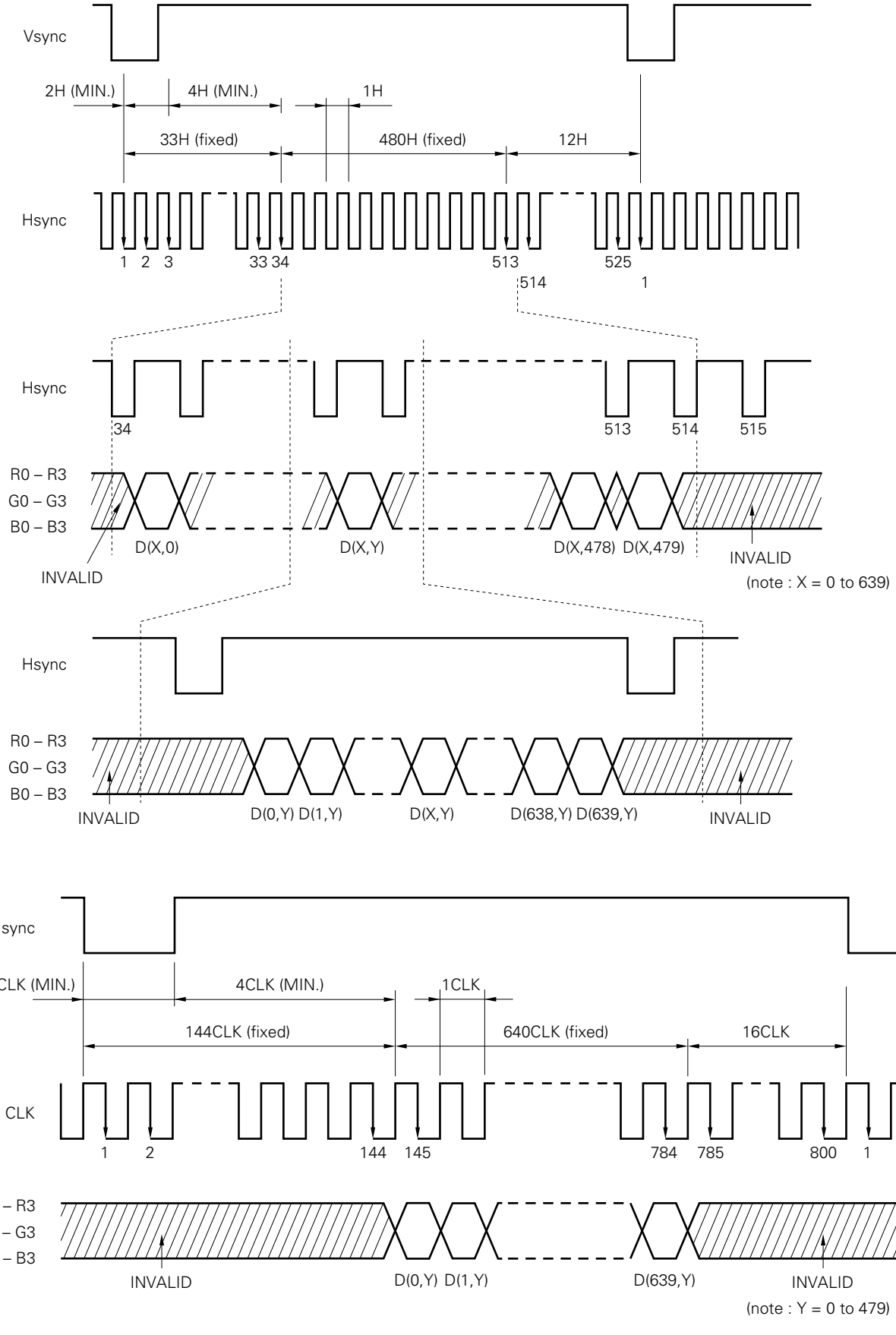
Note : These do not exist as signals.



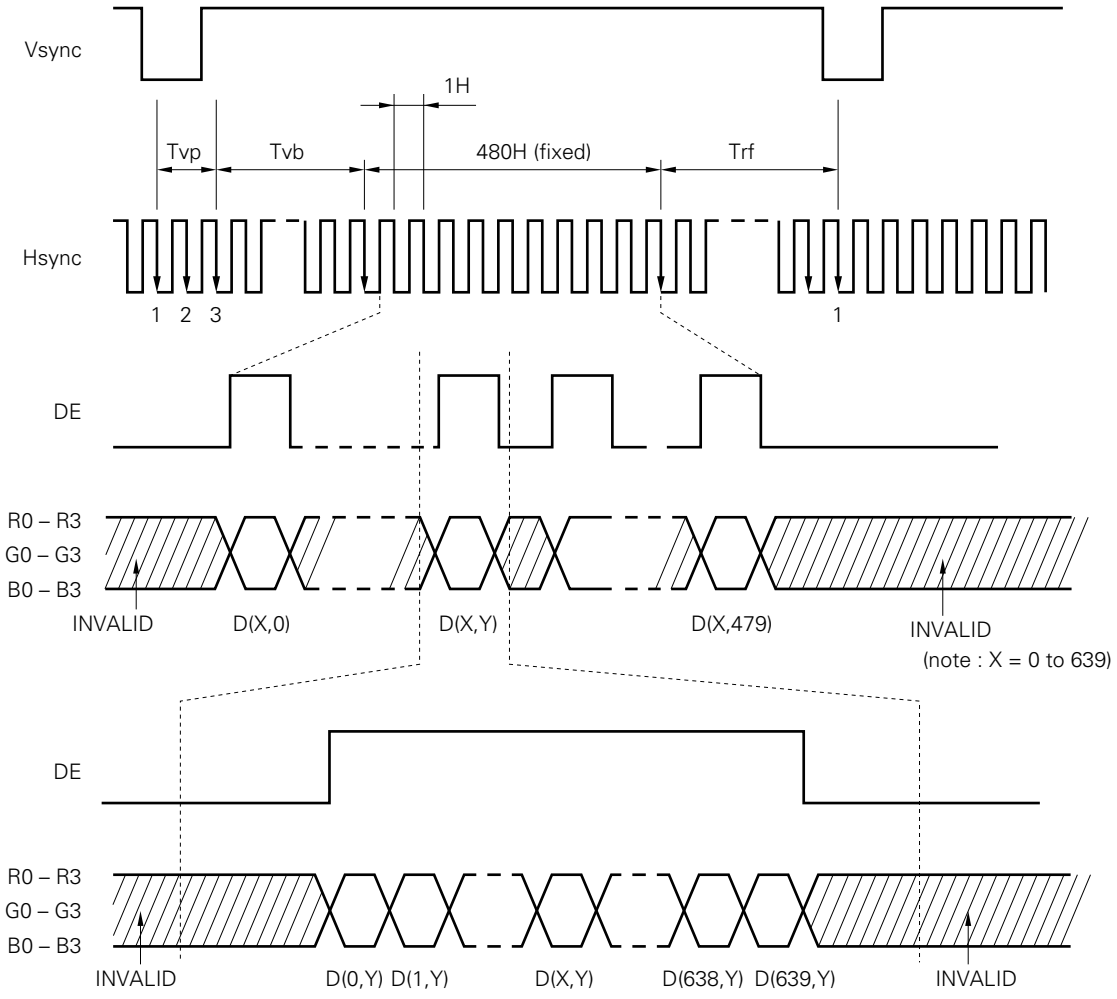
* V_{IH} = 2.2 V (MIN.) to V_{CC} (MAX.)
V_{IL} = 0 V (MIN.) to 0.8 V (MAX.)

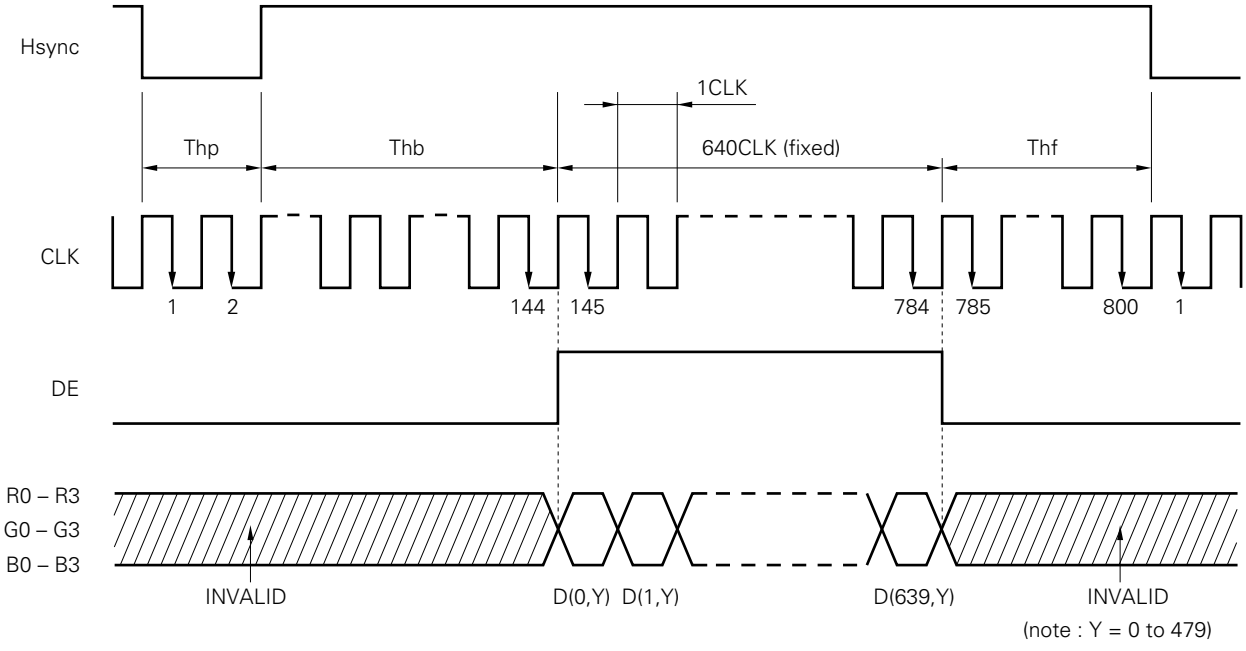
(3) Input signal timing chart

a) fixed timing mode



b) DE mode


Vsync
1H
Tvp
Tvb
480H (fixed)
Trf
Hsync
1 2 3
1
DE
R0 – R3
G0 – G3
B0 – B3
INVALID
D(X,0)
D(X,Y)
D(X,479)
INVALID
(note : X = 0 to 639)
DE
R0 – R3
G0 – G3
B0 – B3
INVALID
D(0,Y) D(1,Y)
D(X,Y)
D(638,Y) D(639,Y)
INVALID


Hsync
1CLK
Thp
Thb
640CLK (fixed)
Thf
CLK
1 2
144 145
784 785
800 1
DE
R0 – R3
G0 – G3
B0 – B3
INVALID
D(0,Y) D(1,Y)
D(639,Y)
INVALID
(note : Y = 0 to 479)

(4) Display position of input data

D (0, 0)	D (1, 0)	- - -	D (X, 0)	- - -	D (638, 0)	D (639, 0)
D (0, 1)	D (1, 1)	- - -	D (X, 1)	- - -	D (638, 1)	D (639, 1)
⋮	⋮	⋮	⋮	⋮	⋮	⋮
D (0, Y)	D (1, Y)	- - -	D (X, Y)	- - -	D (638, Y)	D (639, Y)
⋮	⋮	⋮	⋮	⋮	⋮	⋮
D (0, 478)	D (1, 478)	- - -	D (X, 478)	- - -	D (638, 478)	D (639, 478)
D (0, 479)	D (1, 479)	- - -	D (X, 479)	- - -	D (638, 479)	D (639, 479)

GENERAL CAUTION

(1) Caution when taking out the module
   ① Pick the pouch only, when taking out module from a shipping package.

(2) Cautions for handling the module
   ① As the electrostatic discharges may break the LCD module, handle the LCD module with care. Peel a protection sheet off from the LCD panel surface as slowly as possible.
   ② As the LCD panel and backlight 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.

(3) Cautions for the operation
   ① When the module is operating, do not lose CLK, Hsync, or Vsync signals. If any one of these signals is lost, the LCD panel would be damaged.
   ② Obey the supply voltage sequence. If wrong sequence is applied, the module would be damaged.

(4) Cautions for the atmosphere
   ① Dew drop atmosphere should be avoided.
   ② Do not store and / or operate the LCD module in a high temperature and / or humidity atmosphere. Storage in an electro-conductive polymer packing pouch and under relatively low temperature atmosphere are recommended.

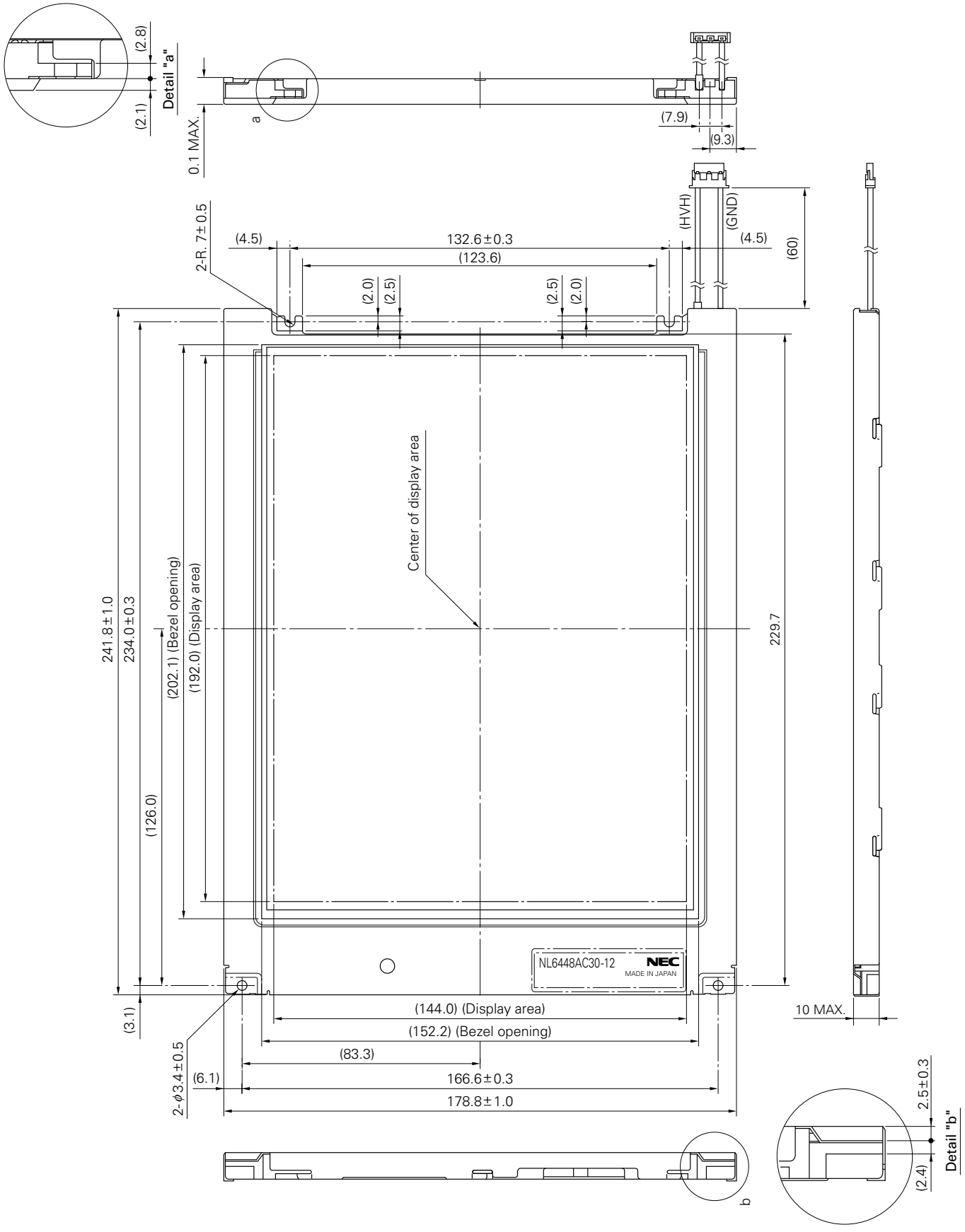
(5) Caution for the module characteristics
   ① Do not apply fixed pattern data signal to the LCD module at product aging. Applying fixed pattern for a long time may cause image sticking.

(6) Other cautions
   ① Do not disassemble and / or re-assemble LCD module.
   ② Do not re-adjust variable resistor or switch etc.
   ③ When returning the module for repair or etc., please pack the module not to be broken. We recommend to use the original shipping packages.

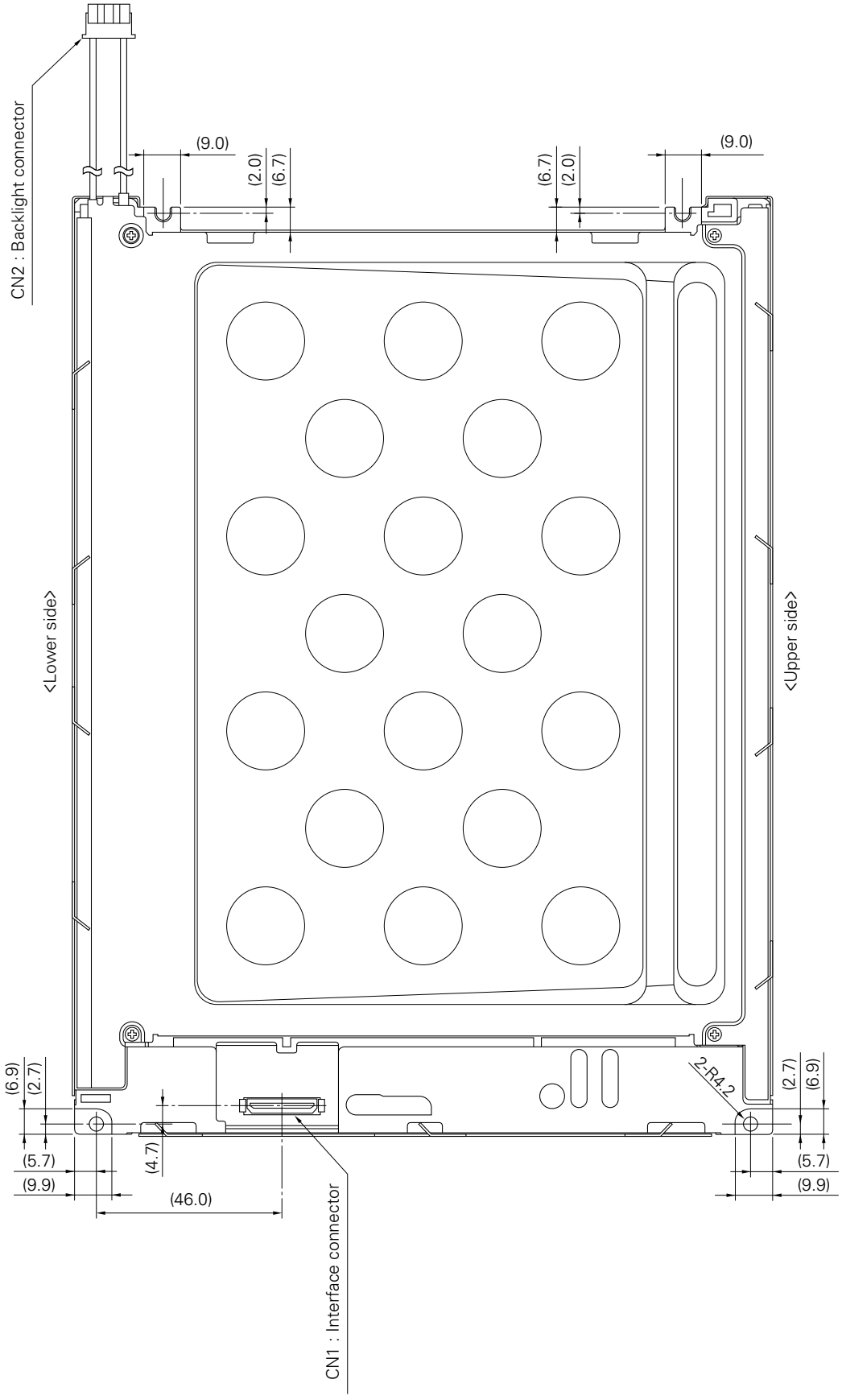
Liquid Crystal Display has the following specific characteristics. These are not defects or malfunctions.
The display condition of LCD module may be affected by the ambient temperature.
The LCD module uses cold cathode tubes for backlighting. Optical characteristics, like luminance or uniformity, will change during life time.
Uneven brightness and/or small spots may be noticed depending display patterns.

OUTLINE DRAWING (Unit in mm)

FRONT VIEW



REAR VIEW


CN2 : Backlight connector
(9.0)
(2.0)
(6.7)
(6.7)
(2.0)
(9.0)
<Lower side>
<Upper side>
(6.9)
(2.7)
(5.7)
(9.9)
(4.7)
(46.0)
2-R4.2
(2.7)
(6.9)
(5.7)
(9.9)
CN1 : Interface connector

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