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TFT | CHARACTER | UWVD | FSC | SEGMENT | CUSTOM | REPLACEMENT

TFT Display Module

Part Number

E35RG13248LW6M250-N

Overview:

- 3.5-inch TFT: 320x480 (55.5x84.96)
- 16/18-bit RGB
- 8/9/16/18-bit MCU
- 3/4-wire Serial Interface
- White LED back-light
- Transmissive/ Normally White
- No Touch Panel
- 250 NITS
- Controller: ILI9488
- RoHS Compliant

Description

This is a color active matrix TFT (Thin Film Transistor) LCD (liquid crystal display) that uses amorphous silicon TFT as a switching device. This model is composed of a Transmissive type TFT-LCD Panel, driver circuit, back-light unit. The resolution of a 3.5" TFT-LCD contains 320X480 pixels and can display up to 65K/262K colors.

Features

Low Input Voltage: 3.3V (TYP)

Display Colors of TFT LCD: 65K/262K colors TFT

Interface: 8/9/16/18Bit MCU;

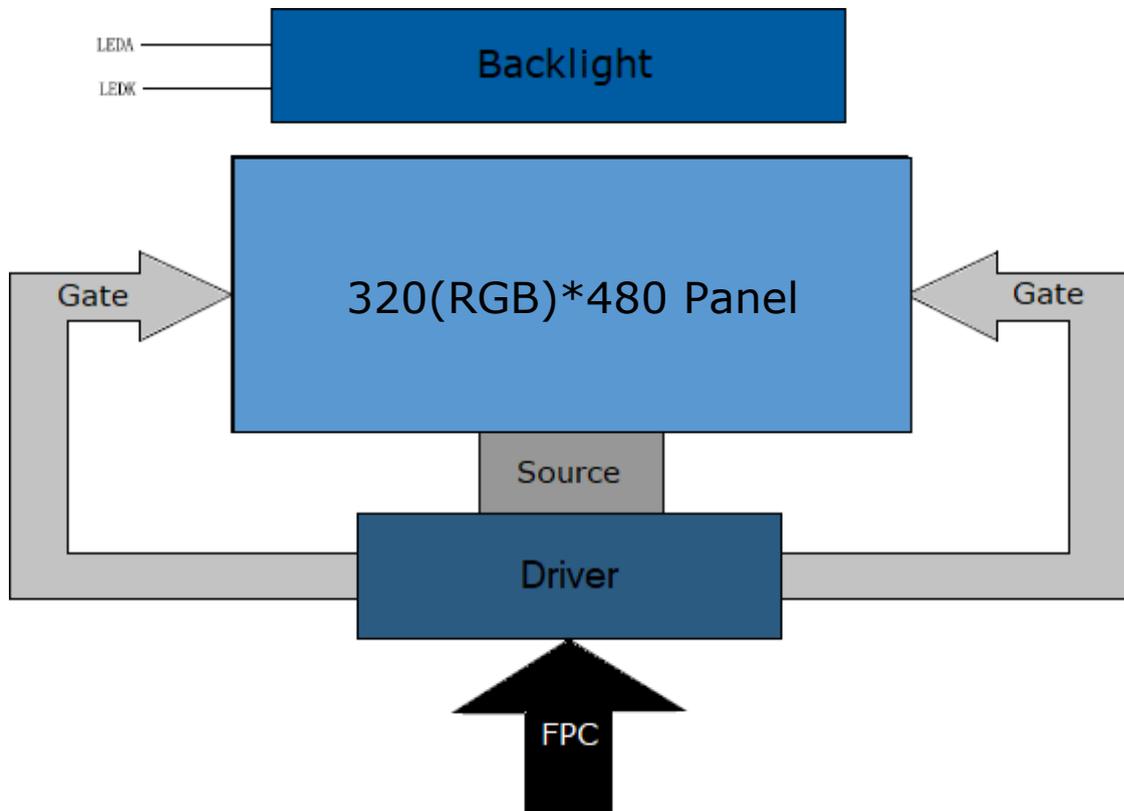
3/4SPI+16/18Bit RGB

General Information Items	Specification	Unit	Note
	Main Panel		
Display area (AA)	48.96(H) *73.44(V) (3.5 inch)	mm	-
Driver element	TFT active matrix	-	-
Display colors	65K/262K	colors	-
Number of pixels	320(RGB)*480	dots	-
TFT Pixel arrangement	RGB vertical stripe	-	-
Pixel pitch	0.153 (H) x 0.153 (V)	mm	-
Viewing angle	6:00	o'clock	-
TFT Controller IC	ILI9488	-	-
Display mode	Transmissive/Normally White	-	-
Operating temperature	-20~+70	°C	-
Storage temperature	-30~+80	°C	-

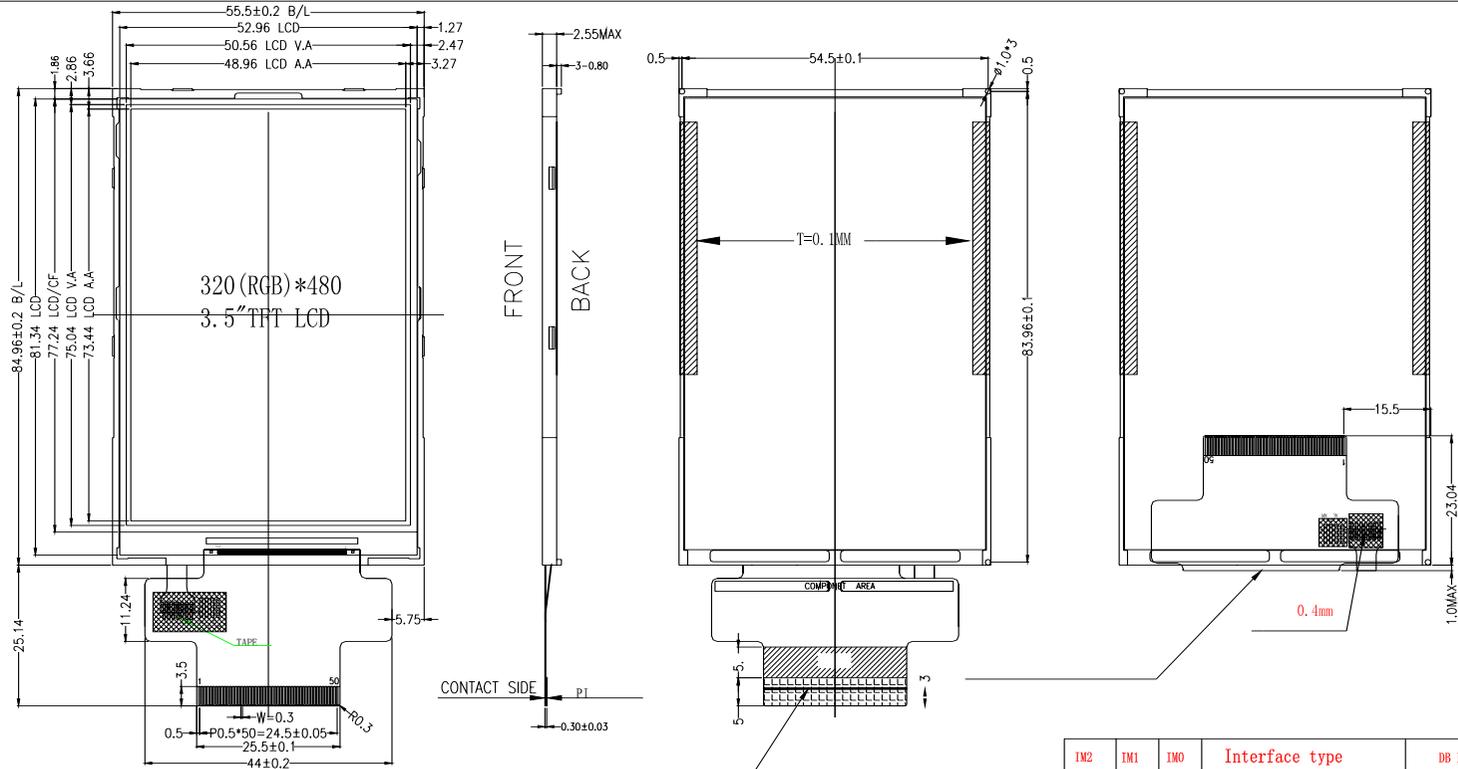
Mechanical Information

Item		Min	Typ.	Max	Unit	Note
Module size	Horizontal(H)		55.50		mm	-
	Vertical(V)		84.96		mm	-
	Depth(D)		2.55		mm	-
Weight			TBD		g	-

1. Block Diagram



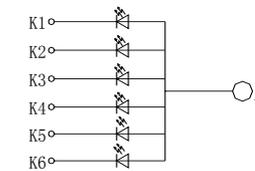
2. Outline Dimensions



NOTE: RGB interface

RGB Interface	DB Pin in use
16 Bit RGB interface	DB15-DB0
18 Bit RGB interface	DB17-DB0

NOTE: If used RGB mode must select serial interface!



LED (B/L) CIRCUIT

NO.	Pin Name
1	GND
2	LEDA
3	LEDK1
4	LEDK2
5	LEDK3
6	LEDK4
7	LEDK5
8	LEDK6
9	GND
10	GND
11	VCC
12	VCC
13	RESET
14	CSX
15	RS
16	WRX(SPI-SCL)
17	RDX
18	SPI-SDA
19	SDO
20	DB0/BO.LSb
21	DB01/B1
22	DB02/B2
23	DB03/B3
24	DB04/B4
25	DB05/B5.MSb
26	DB06/G0.LSb
27	DB07/G1
28	DB08/G2
29	DB09/G3
30	DB10/G4
31	DB11/G5.MSb
32	DB12/R0.LSb
33	DB13/R1
34	DB14/R2
35	DB15/R3
36	DB16/R4
37	DB17/R5.MSb
38	DE
39	PCLK
40	HSYNC
41	VSYNC
42	IM2
43	IM1
44	IM0
45	GND
46	YU(NC)
47	XL(NC)
48	YD(NC)
49	XR(NC)
50	GND

IM2	IM1	IM0	Interface type	DB Pin in use
0	0	0	DBI Tyb_18-bit interface	DB17-DB0
0	0	1	DBI Tyb_9-bit interface	DB8-DB0
0	1	0	DBI Tyb_16-bit interface	DB15-DB0
0	1	1	DBI Tyb_8-bit interface	DB7-DB0
1	0	1	3-Wire 9 BIT data serial interface. (TYP Used)	SDI SCL CS
1	1	1	4-Wire 8 BIT data serial interface	SDI SCL CS RS

NOTE:
If not used PIN, fix to the GND, IOVCC or NC.

NOTES:

1. DISPLAY TYPE: 3.5", TFT-LCD, 262K COLORS
2. DISPLAY MODE: T/N NORMALLY WHITE
3. VIEWING DIRECTION: 6:00
4. DRIVER IC: ILI9488 (COG)
5. VCI: 3.3V(TYP)
6. OPERATING TEMP: -20°C TO 70°C
STORAGE TEMP: -30°C TO 80°C
7. BACK LIGHT: LED WHITE, 6 LED, 90mA, 3.2V±0.3V
8. RoHS COMPLIANT.



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TOLERANCE()		DRAWING NAME		E35RG13248LW6M250-N	
TOLERANCE UNLESS OTHERWISE SPECIFIED		PARTS NO.			
X.X±0.3		Drawn		Unit	
X.XX±0.2		Checked		mm	
Scale 1:1		Approve		Page 1/1	

3. Input Terminal Pin Assignment

Recommended Connector: FH12S-50S-0.5SH(55)

NO.	Symbol	Description	I/O
1	GND	Ground	P
2	LEDA	Anode pin of backlight	P
3	LEDK1	Cathode pin of backlight	P
4	LEDK2	Cathode pin of backlight	P
5	LEDK3	Cathode pin of backlight	P
6	LEDK4	Cathode pin of backlight	P
7	LEDK5	Cathode pin of backlight	P
8	LEDK6	Cathode pin of backlight	P
9	GND	Ground	P
10	GND	Ground	P
11	VCC	Supply voltage (3.3V)	P
12	VCC	Supply voltage (3.3V)	P
13	RESET	Reset of the device, must be applied to properly initialize the chip	I
14	CSX	Chip select input pin ("low" enable). Fix this pin to VCI or GND when not used.	I
15	RS	This pin is used to select "Data or Command" in the parallel interface. When D/CX = '1', data is selected. When D/CX = '0', command is selected. This pin is used serial interface clock in 3-wire 9-bit / 4-wire 8-bit serial data interface. Fix this pin at VCI or GND when not in use.	I
16	WRX(SPI-SCL)	The data is applied on the rising edge of the SCL signal. If not used, Second Data lane in 2 data lane serial interface. Fix this pin at VCI or GND when not in use.	I
17	RDX	The data is applied on the rising edge of the SCL signal. If not used, Second Data lane in 2 data lane serial interface. Fix this pin at VCI or GND when not used.	I
18	SPI-SDA	Data lane in 1 data lane serial interface. The data is latched on the rising edge of the SCL signal.	I
19	SDO	SPI interface output pin. The data is output on the falling edge of the SCL signal. If not used, let this pin open.	I
20-37	DB0-DB17	18-bit parallel bi-directional data bus for MCU system and RGB interface mode. Fix to GND level when not in use	I/O
38	DE	Data enable signal for RGB interface operation	I
39	PCLK	Dot clock signal for RGB interface operation. Fix to VCI or GND when not in use.	I
40	HSYNC	Line synchronizing signal for RGB interface operation. Fix this pin at VCI or GND when not in use.	I
41	VSYNC	Frame synchronizing signal for RGB interface operation. Fix this pin at VCI or GND when not in use.	I
42	IM2	MPU Parallel interface bus and serial interface select. If use RGB Interface must select serial interface. Fix this pin at VCI and GND.	I
43	IM1		I
44	IM0		I
45	GND	Ground	P
46	YU(NC)	Touch panel top film terminal	A/D
47	XL(NC)	Touch panel left glass terminal	A/D
48	YD(NC)	Touch panel bottom film terminal	A/D
49	XR(NC)	Touch panel right glass terminal	A/D
50	GND	Ground	P

4. LCD Optical Characteristics

4.1 Optical Specifications

Item		Symbol	Condition	Min.	Typ.	Max.	Unit.	Note
Contrast Ratio		CR	$\Theta=0$	-	500	--		(1)(6)
Response time	Rising+	TR+TF	Normal viewing angle	--	20	40	msec	(4)
	Falling							
Color gamut		S (%)		57	60	--	%	(2)
Color Filter Chromaticity	White	W _X		0.292	0.307	0.322		(2)
		W _Y		0.312	0.327	0.342		
	Red	R _X		0.609	0.624	0.639		
		R _Y		0.316	0.331	0.346		
	Green	G _X		0.281	0.296	0.311		
		G _Y		0.562	0.577	0.592		
	Blue	B _X		0.128	0.143	0.158		
		B _Y		0.094	0.109	0.124		
Viewing angle	Hor.	Θ_L	CR>10	-	70	--		(1)(5)(6)
		Θ_R		-	70	--		
	Ver.	Θ_U		-	60	--		
		Θ_D		-	70	--		
Cross talk	Ct			-	-	2	%	
Transmittance	Trans			-	5.5	-	%	(3)

4.2 Measuring Conditions

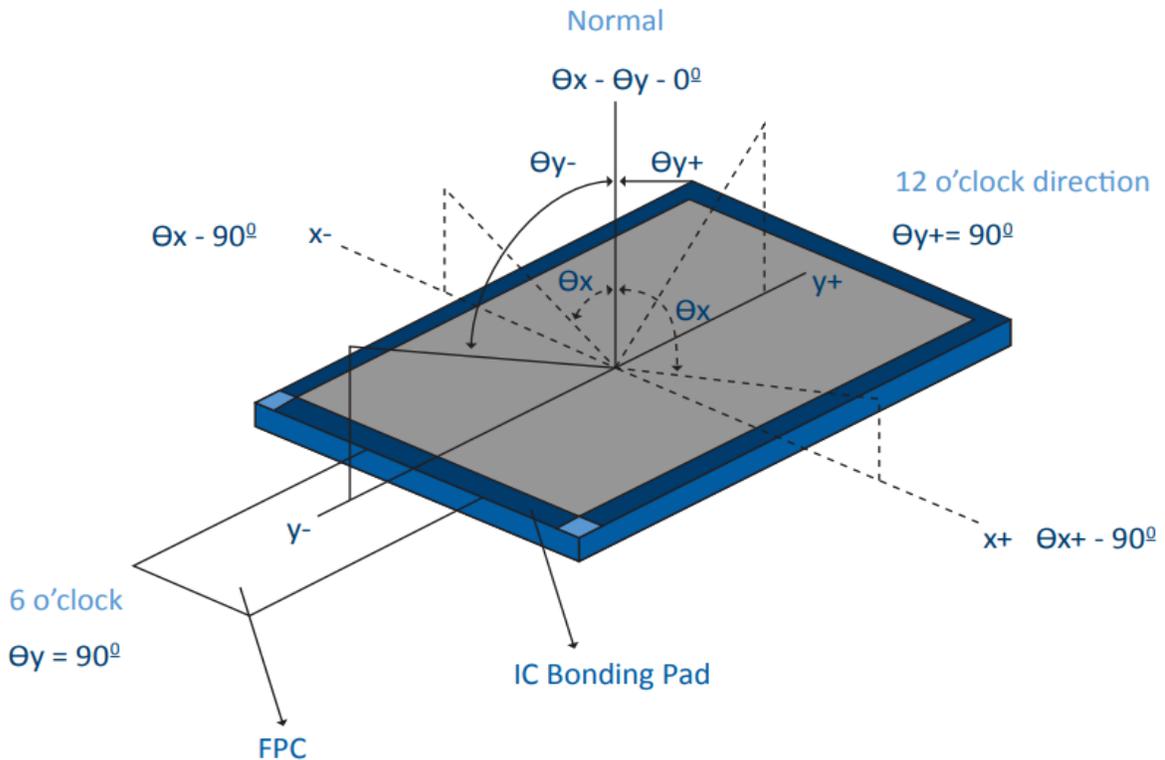
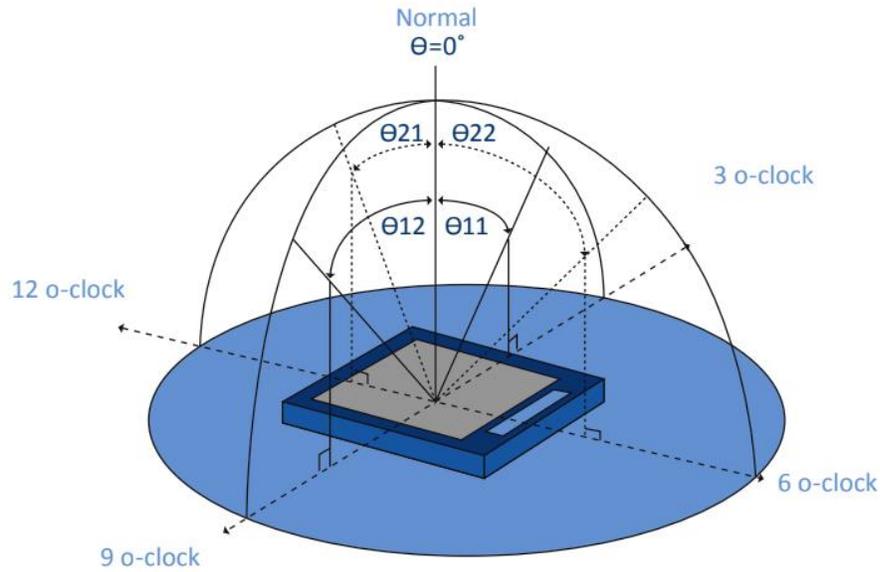
Measuring surrounding: dark room

Ambient temperature: 25 ± 2°C

15min. warm-up time

Optical Specification Reference Notes:

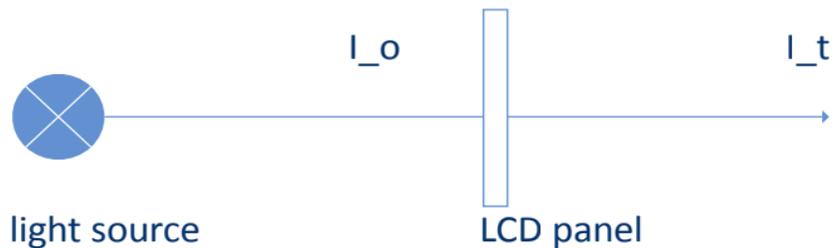
(1) Definition of Viewing Angle: The viewing angle is the angle at which the contrast ratio is greater than 10. The viewing angles are determined for the horizontal or 3,9 o'clock direction and the vertical or 6,12 o'clock direction with respect to the optical axis which is normal to the LCD surface.



(2) Definition of Contrast Ratio (Cr): measured at the center point of panel. The contrast ratio (Cr) measured on a module, is the ratio between the luminance (Lw) in a full white area (R=G=B=1) and the luminance (Ld) in a dark area (R=G=B=0).

$$Cr = \frac{Lw}{Ld}$$

(3) Definition of transmittance (T%): The transmittance of the panel including the polarizers is measured with electrical driving.



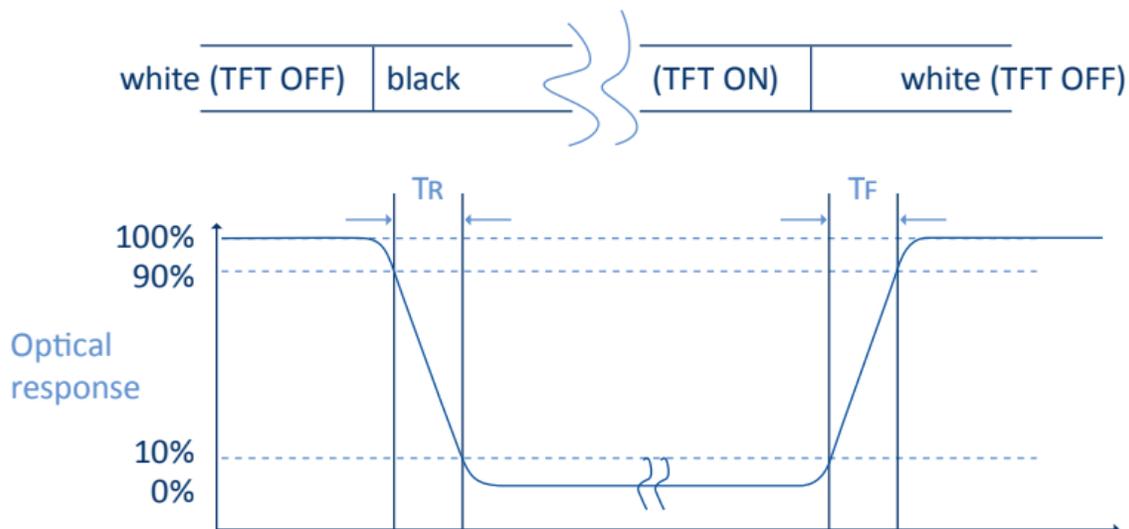
The transmittance is defined as:

$$Tr = \frac{I_t}{I_o} \times 100\%$$

I_o = the brightness of the light source.

I_t = the brightness after panel transmission

(4) Definition of Response Time (Tr, Tf): The rise time 'Tr' is defined as the time for luminance to change from 90% to 10% as a result of a change of the electrical condition. The fall time 'Tf' is defined as the time for luminance to change from 10% to 90% as a result of a change of the electrical condition.



(5) Definition of Color Gamut: Measuring machine CFT-01. NTSC's Primaries: R(x,y,Y),G(x,y,Y), B(x,y,Y). FPM520 of Westar Display Technologies, INC., which utilized SR-3 for Chromaticity and BM-5A for other optical characteristics.

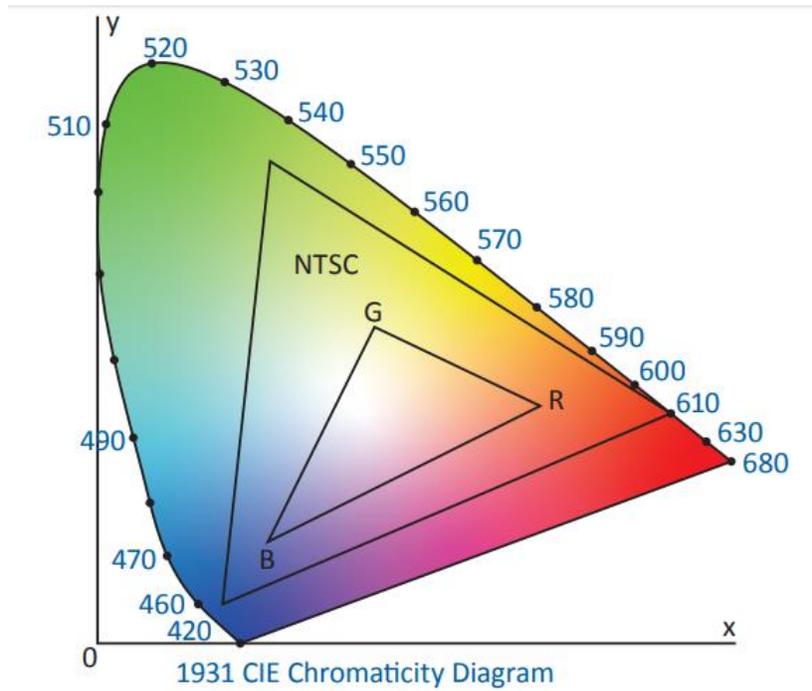
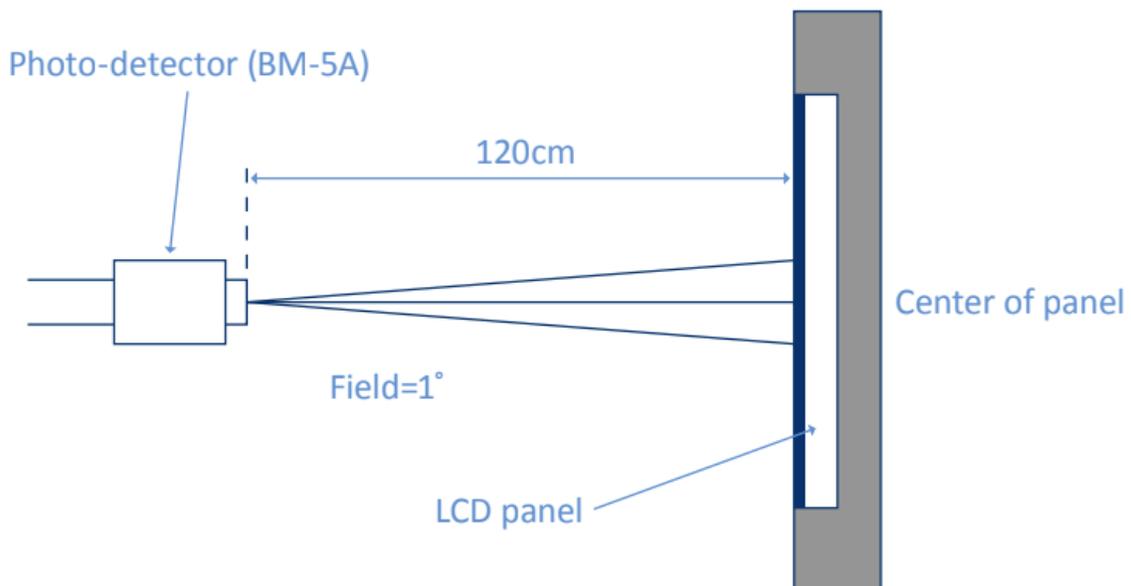


Fig. 1931 CIE chromacity diagram

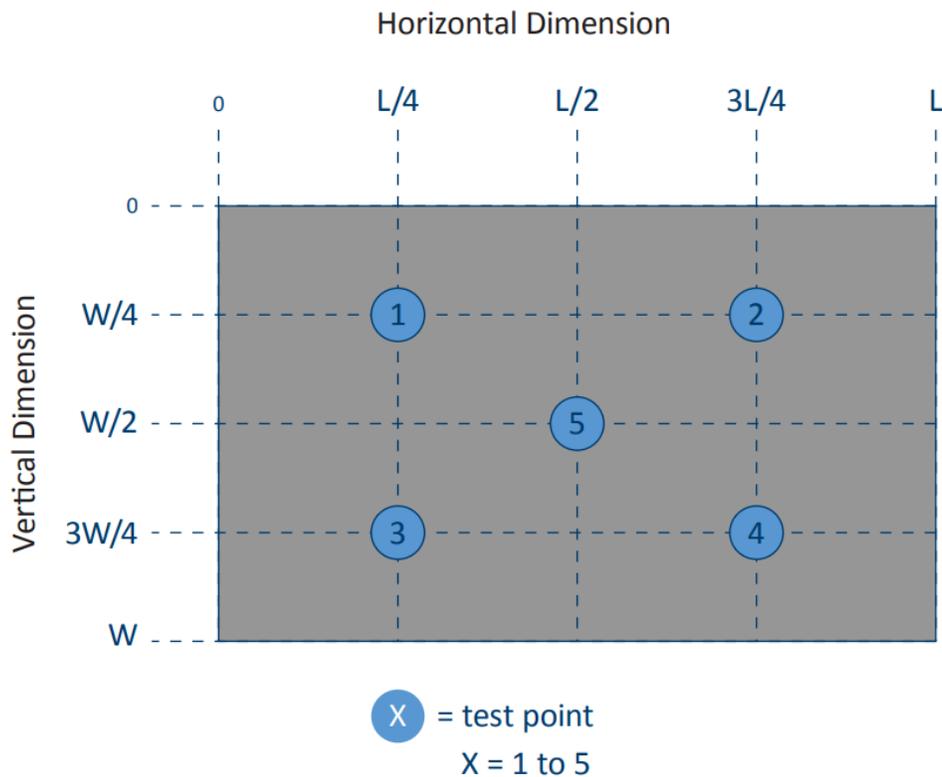
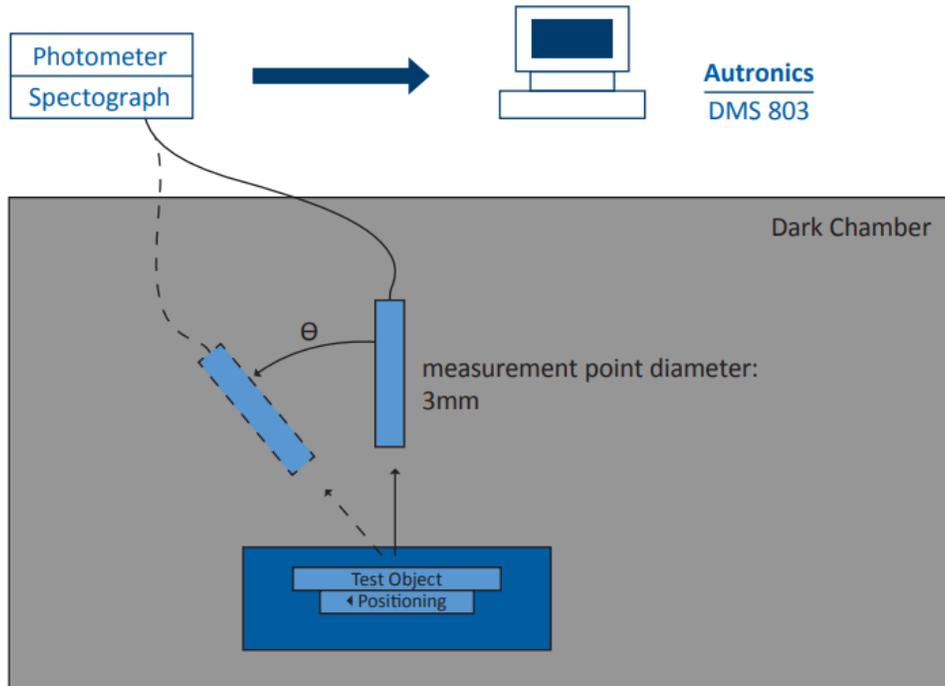
$$\text{Color gamut: } S = \frac{\text{Area of RGB triangle}}{\text{Area of NTSC triangle}} \times 100\%$$

(6) Definition of Optical Measurement Setup:



(6) Optical Measurement Setup Continued:

The LCD module should be stabilized at a given temperature for 20 minutes to avoid abrupt temperature change during measuring. In order to stabilize the luminance, the measurement should be executed after lighting backlight for 20 minutes.



5. Electrical Characteristics

5.1 Absolute Maximum Rating (Ta=25 VSS=0V)

Characteristics	Symbol	Min	Max	Unit
Digital Supply Voltage	VDD	-0.3	4.6	V
Interface Operation Voltage	VDDIO	-0.3	4.6	V
Operating temperature	TOP	-20	+70	°C
Storage temperature	TST	-30	+80	°C

NOTE: If the absolute maximum rating of even is one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. Absolute maximum ratings, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the range of the absolute maximum ratings.

5.2 DC Electrical Characteristics

Characteristics	Symbol	Min.	Typ.	Max.	Unit	Note
Digital Supply Voltage	VDD	2.4	3.3	4.2	V	
Interface Operation Voltage	VDDIO	1.65	3.3	4.2	V	
Normal Mode Current Consumption	IDD	--	8	--	mA	
Level input voltage	VIH	0.7 VDDIO		VDDIO	V	
	VIL	GND		0.3 VDDIO	V	
Level output voltage	VOH	0.8 VDDIO		VDDIO	V	
	VOL	GND		0.2 VDDIO	V	

5.3 LED Backlight Characteristics

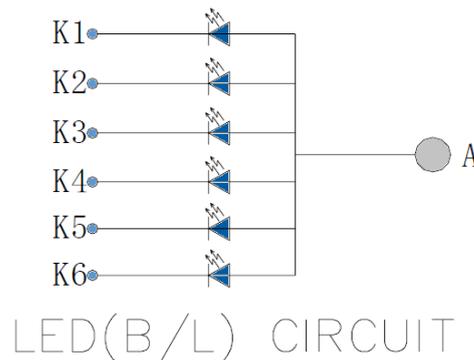
Item	Symbol	Min	Typ.	Max	Unit	Note
Forward Current	IF	80	90	--	mA	
Forward Voltage	VF	--	3.2	--	V	
LCM Luminance	LV	250	--	--	cd/m ²	Note 3
LED lifetime	Hr	50000	--	--	hour	Note1 & 2
Uniformity	AVg	80	--	--	%	Note 3

The back-light system is edge-lighting type with 6 chips White LED

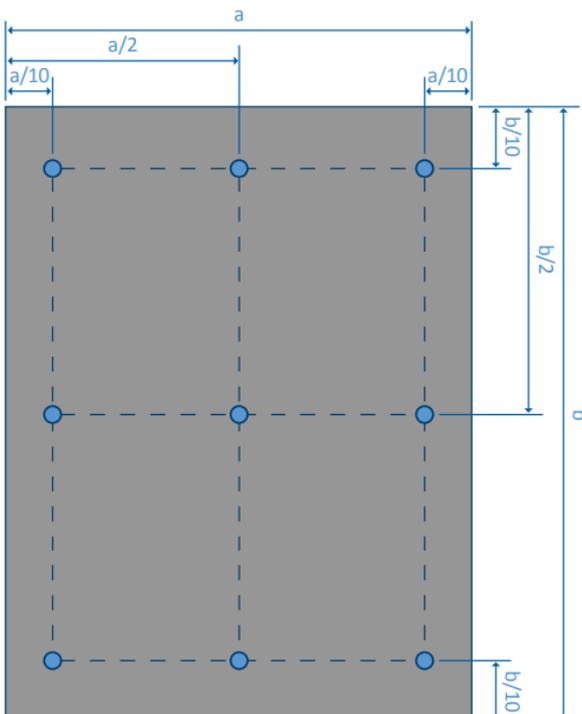
Note 1: LED lifetime (Hr) can be defined as the time in which it continues to operate under the condition:

Ta=25±3 °C, typical IL value indicated in the above table until the brightness becomes less than 50%.

Note 2: The “LED lifetime” is defined as the module brightness decrease to 50% original brightness at Ta=25°C and IL=90mA. The LED lifetime could be decreased if operating IL is larger than 90mA. The constant current driving method is suggested.



Note 3: Luminance Uniformity of these 9 points is defined as below:



$$\text{Luminance} = \frac{\text{Total Luminance of 9 points}}{9}$$

$$\text{Uniformity} = \frac{\text{minimum luminance in 9 points(1-9)}}{\text{maximum luminance in 9 points(1-9)}}$$

6. AC Characteristic

6.1 Parallel RGB Interface Timing Characteristics

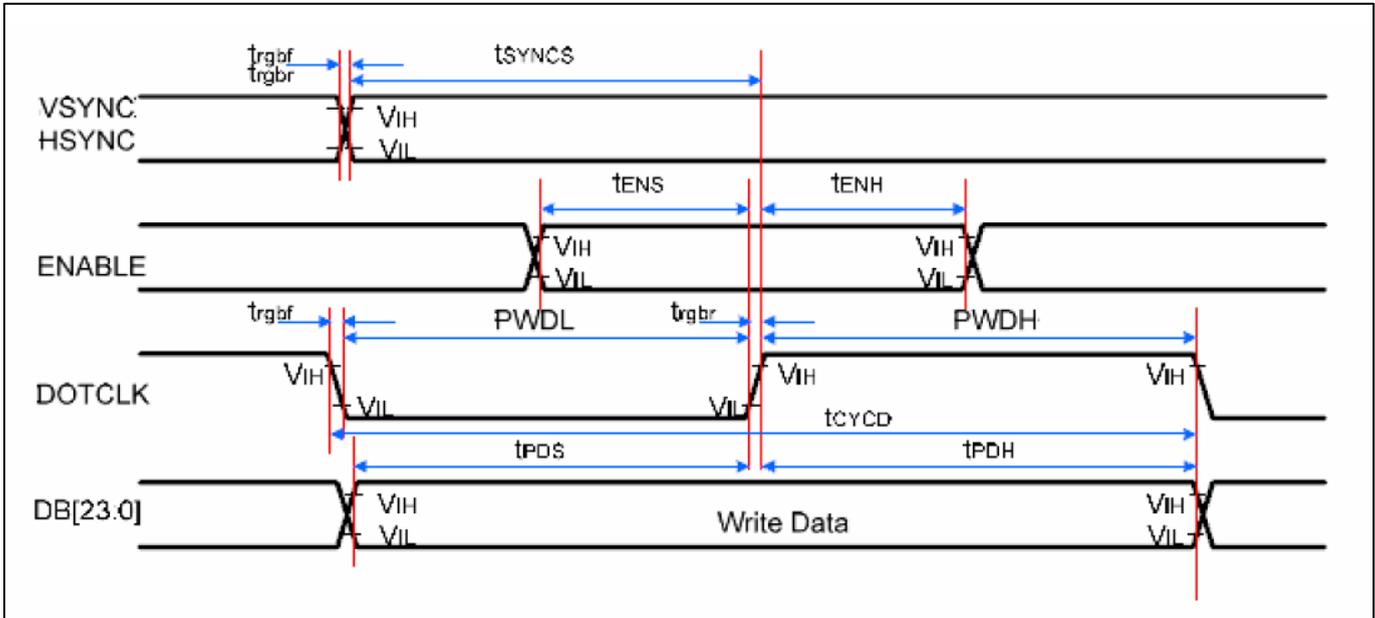
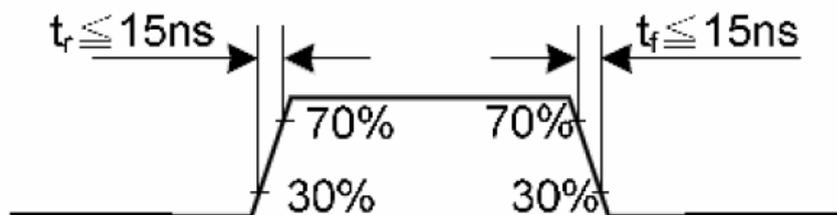
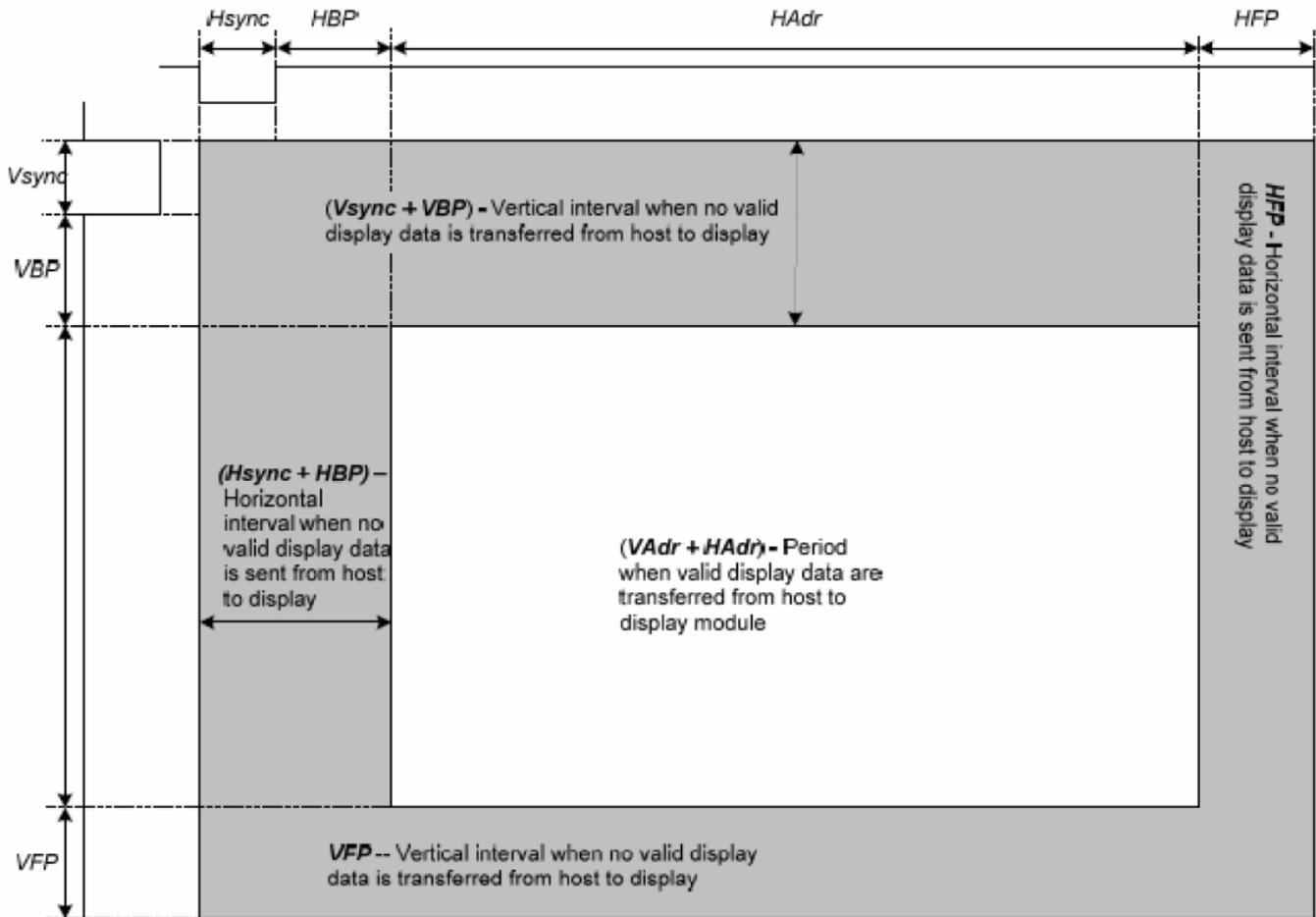


Figure 6.1: Parallel RGB Interface Timing Diagram

Signal	Symbol	Parameter	Min	Max	Unit	Description
HSYNC/ VSYNC	TSYNCS	VSYNC/HSYNC Setup Time	15	-	ns	16/18/24-bit bus RGB interface mode
	TSYNCH	VSYNC/HSYNC Hold Time	15	-	ns	
ENABLE	TENS	Enable Setup Time	15	-	ns	
	TENH	Enable Hold Time	15	-	ns	
DOTCLK	PWDH	DOTCLK High-level Pulse Width	20	-	ns	
	PWDL	DOTCLK Low-level Pulse Width	20	-	ns	
	TCYCD	DOTCLK Cycle Time	50	-	ns	
	Trghr, Trghf	DOTCLK Rise/Fall Time	-	15	ns	
DB[23:0]	TPDS	PD Data Setup Time	15	-	ns	
	TPDH	PD Data Hold Time	15	-	ns	

Table 6. 1: 8/16 Bits RGB Interface Timing Characteristics





Parameters	Symbols	Min	Typ.	Max	Units
PCLK cycle	PCLKcyc	100	80	66.6	Ns
Horizontal synchronization	Hsync	3	3	-	PCLK
Horizontal back porch	HBP	3	3	-	PCLK
Horizontal address	HAdr	-	320	-	PCLK
Horizontal front porch	HFP	3	3	-	PCLK
Vertical synchronization	Vsync	2	2	-	Line
Vertical back porch	VBP	2	2	-	Line
Vertical address	Vadr	-	480	-	Line
Vertical front porch	VFP	2	2	-	Line
Vertical frequency(*)		50	60	80	Hz
Horizontal frequency(*)		-	33	-	kHz
PCLK frequency(*)		10	12.5	15	MHz

Table 6. 2: Parallel RGB Interface Vertical and Horizontal Timing Characteristics

Notes:

- (1) Vertical period (one frame) shall be equal to the sum of $Vsync + VBP + VAdr + VFP$.
- (2) Horizontal period (one line) shall be equal to the sum $Hsync + HBP + HAdr + HFP$.
- (3) Control signals PCLK and Hsync shall be transmitted as specified at all times while valid pixels are transferred between the host processor and the display module.

6.2 8080 Series MCU Parallel Interface Characteristics: 18/16/9/8-bit Bus

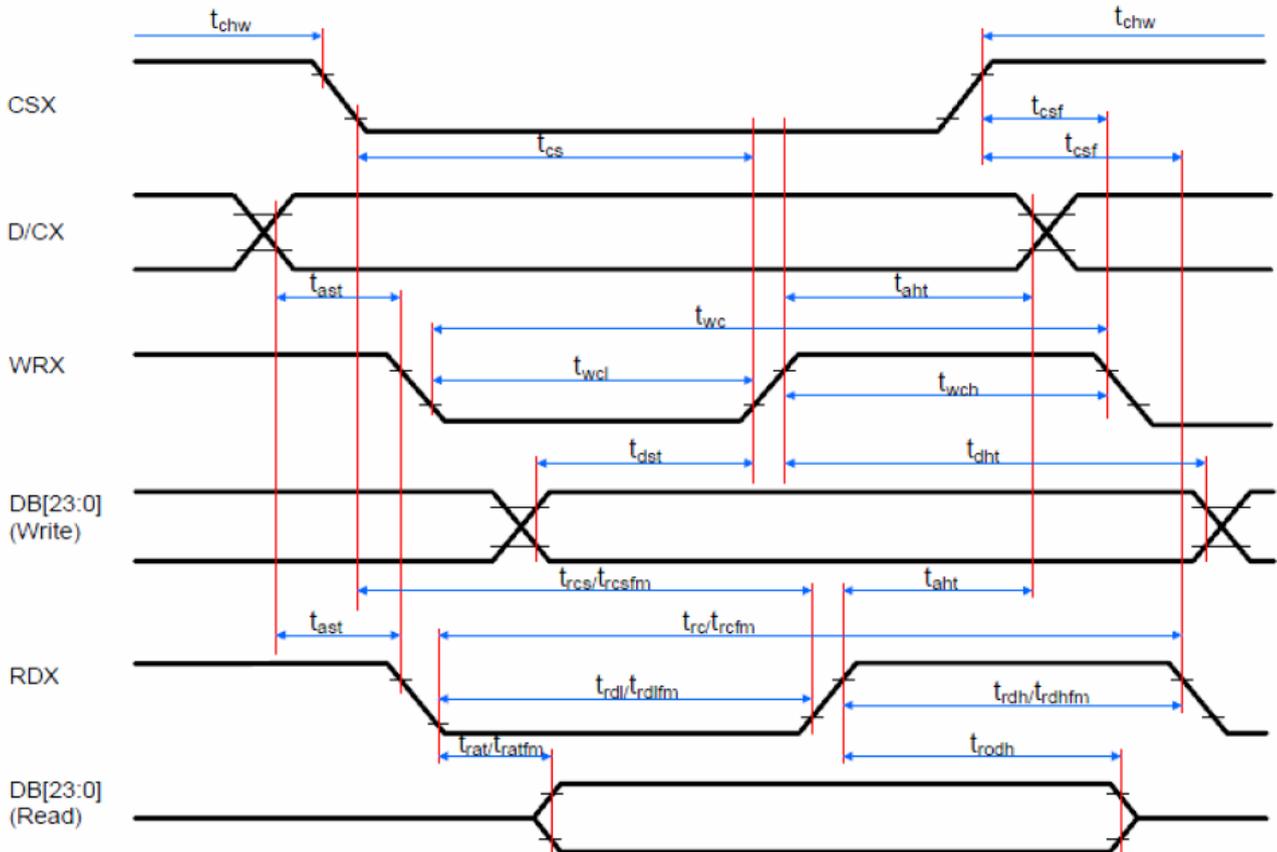


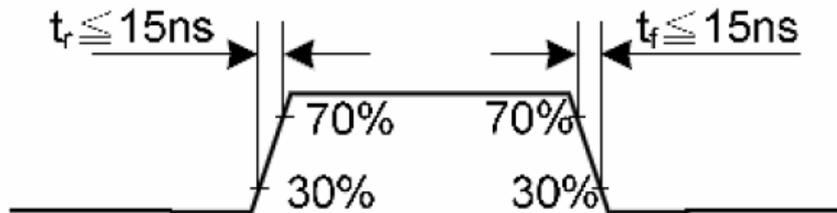
Figure 6.2: Parallel Interface Timing Diagram (8080-Series MCU Interface)

Signal	Symbol	Parameter	Min	Max	Unit	Description
D/CX	T_{AST}	Address setup time	0		ns	-
	T_{AHT}	Address hold time (Write/Read)	0		ns	
CSX	T_{CHW}	Chip select "H" pulse width	0		ns	-
	T_{CS}	Chip select setup time (Write)	15		ns	
	T_{RCS}	Chip select setup time (Read ID)	45		ns	
	T_{RCSFM}	Chip select setup time (Read FM)	355		ns	
	T_{CSF}	Chip select wait time (Write/Read)	0		ns	
WRX	T_{WC}	Write cycle	40		ns	-
	T_{WRH}	Control pulse "H" duration	15		ns	
	T_{WRL}	Control pulse "L" duration	15		ns	
RDX (ID)	T_{RC}	Read cycle (ID)	160		ns	When read ID data
	T_{RDH}	Control pulse "H" duration (ID)	90		ns	
	T_{RDL}	Control pulse "L" duration	45		ns	
RDX (FM)	T_{RCFM}	Read cycle (FM)	450		ns	When read from frame memory
	T_{RDHFM}	Control pulse "H" duration (FM)	90		ns	
	T_{RDLFM}	Control pulse "L" duration (FM)	355		ns	
D[23:0] D[17:0] D[15:0] D[8:0] D[7:0]	T_{DST}	Data setup time	10		ns	For max CL=30pF For min CL=8pF
	T_{DHT}	Data hold time	10		ns	
	T_{RAT}	Read access time (ID)	-	40	ns	
	T_{RATFM}	Read access time (FM)	-	340	ns	
	T_{ODH}	Output disable time	20	80	ns	

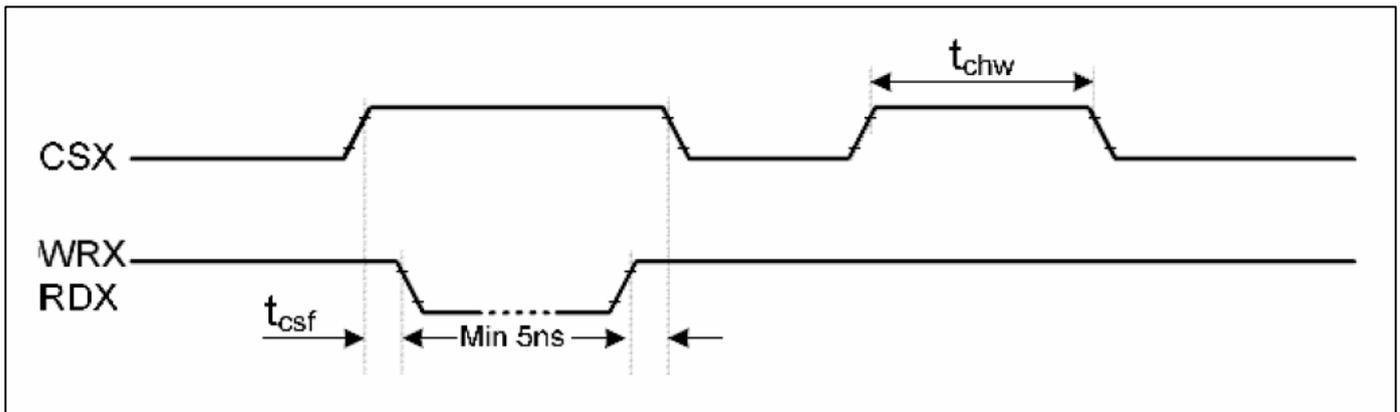
Table 6.3: Parallel Interface Timing Characteristics (8080-Series MCU Interface)

Notes:

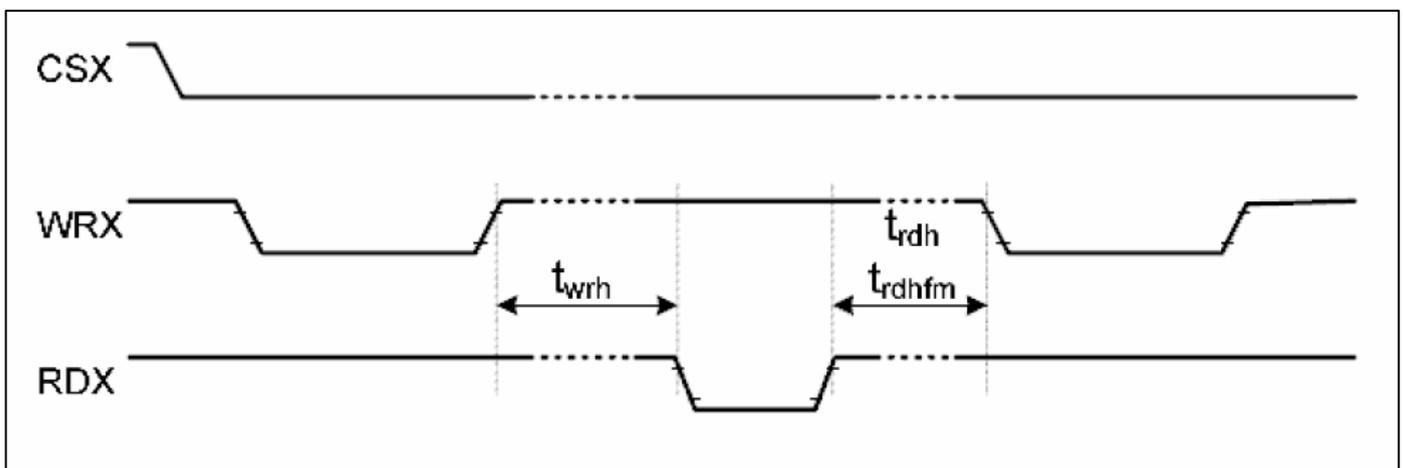
- (1) $T_a = -30$ to $70\text{ }^\circ\text{C}$, $\text{IOVCC} = 1.65$ to 3.3V , $\text{VCI} = 2.5$ to 3.3V , $\text{AGND} = \text{DGND} = 0\text{V}$
- (2) Logic high and low levels are specified as 30% and 70% of IOVCC for input signals.
- (3) Input signal rising and falling time:



- (4) The CSX timing:



- (5) The write to read or read to write timing:



6.3 Display Serial Interface Characteristics (3-line SPI system)

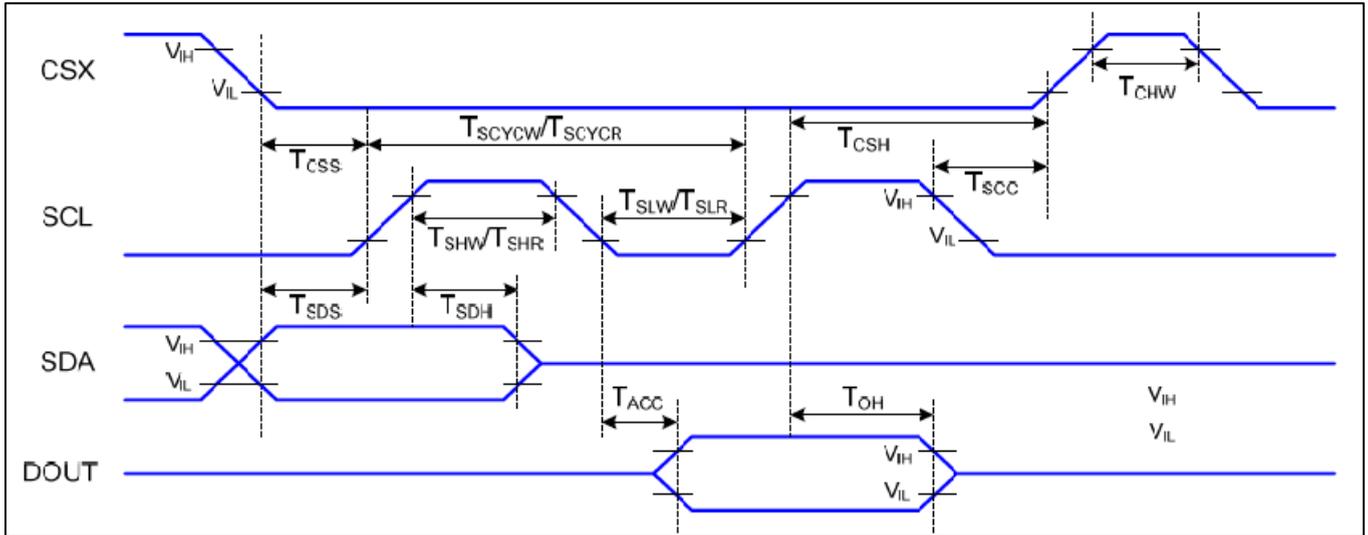


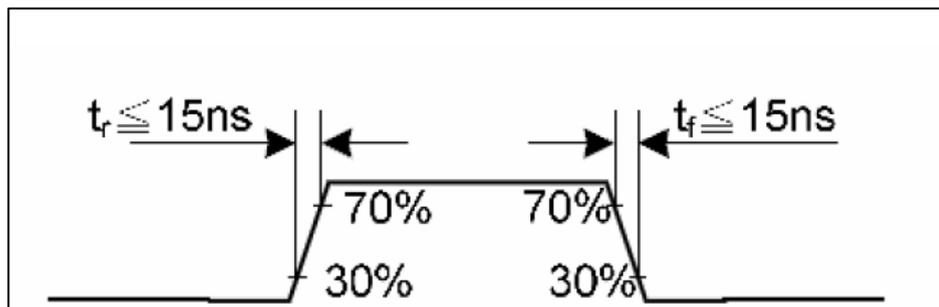
Figure 6.3: 3-line Serial Interface Timing Diagram

VDDI = 1.64 to 3.3V, VDD = 2.4 to 3.3V, AGND=DGND=0V, Ta=-30 to 70 CC⁰⁰

Signal	Symbol	Parameter	Min	Max	Unit	Description
CSX	T_{CSS}	Chip select setup time (write)	15		ns	
	T_{CSH}	Chip select hold time (write)	15		ns	
	T_{CSS}	Chip select setup time (read)	60		ns	
	T_{SCC}	Chip select hold time (read)	65		ns	
	T_{CHW}	Chip select "H" pulse width	40		ns	
SCL	T_{SCYCW}	Serial clock cycle (write)	66		ns	
	T_{SHW}	SCL "H" pulse width (write)	15		ns	
	T_{SLW}	SCL "L" width (write)	15		ns	
	T_{SCYCR}	Serial clock cycle (read)	150		ns	
	T_{SHR}	SCL "H" pulse width (read)	60		ns	
	T_{SLR}	SCL "L" pulse width (read)	60		ns	
SDA (DIN)	T_{SDS}	Data setup time	10		ns	
	T_{SDH}	Data hold time	10		ns	
SDA/SDO (DOUT)	T_{ACC}	Access time	10	50	ns	For max CL=30pF
	T_{OH}	Output disable time	10	50	ns	For min CL=8pF

Table 6.4: 3-line Serial Interface Timing Characteristics

Note: The rising time and falling time (t_r , t_f) of input signal are specified at 15 ns or less. Logic high and low levels are specified as 30% and 70% of VDDI for Input signals



6.4 Serial Interface Timing Characteristics (4-line SPI system)

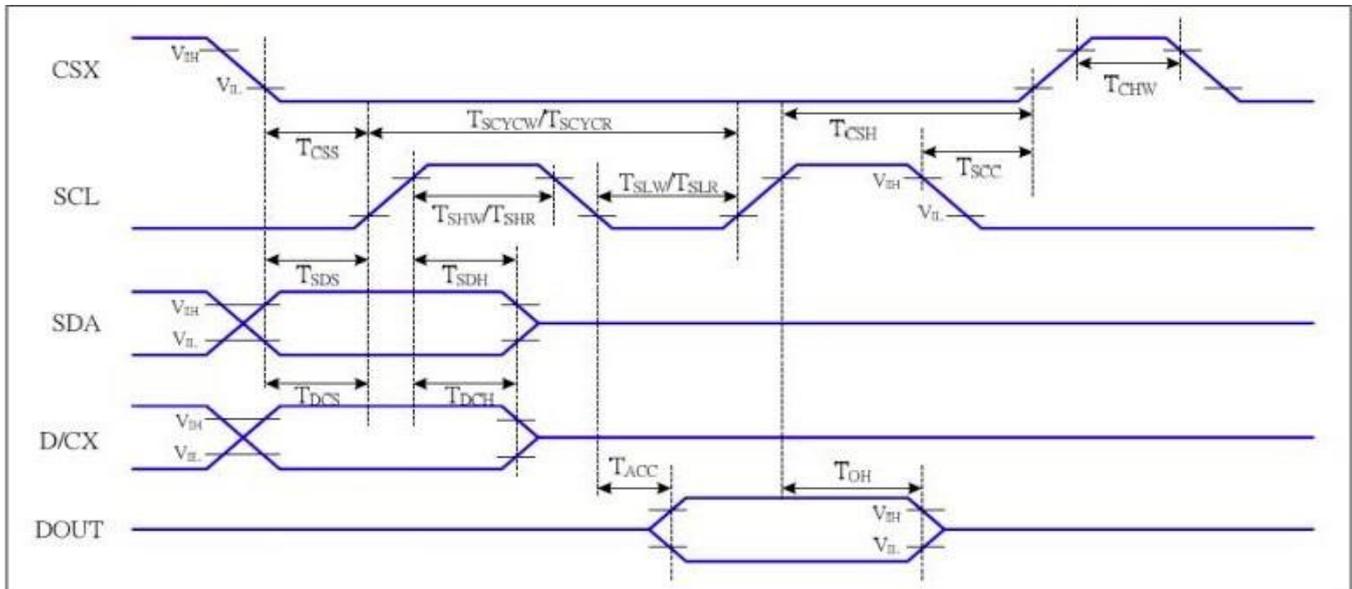


Figure 6.4: 4-line Serial Interface Timing Diagram

IOVCC=1.65 to 3.3V, VCI=2.4 to 3.3V, AGND=DGND=0V, Ta=-30 to 70 C, T=10±0.5ns

Signal	Symbol	Parameter	Min	Max	Unit	Description
CSX	T_{CSS}	Chip select setup time (write)	15		ns	
	T_{CSH}	Chip select hold time (write)	15		ns	
	T_{CHW}	Chip select "H" pulse width	40		ns	
SCL	T_{SCYCW}	Serial clock cycle (write)	50		ns	
	T_{SHW}	SCL "H" pulse width (write)	10		ns	
	T_{SLW}	SCL "L" width (write)	10		ns	
	T_{SCYCR}	Serial clock cycle (read)	150		ns	
	T_{SHR}	SCL "H" pulse width (read)	60		ns	
	T_{SLR}	SCL "L" pulse width (read)	60		ns	
D/CX	T_{DCS}	D/CX setup time	10		ns	
	T_{DCH}	D/CX hold time	10		ns	
SDA (DIN)	T_{SDS}	Data setup time	10		ns	
	T_{SDH}	Data hold time	10		ns	
DOUT	T_{ACC}	Access time	10	50	ns	For max CL=30pF
	T_{OH}	Output disable time	15	50	ns	For min CL=8pF

Table 6.5: 4-line Serial Interface Timing Characteristics

Note: Does not include signal rising and falling times.

6.5 Reset Timing

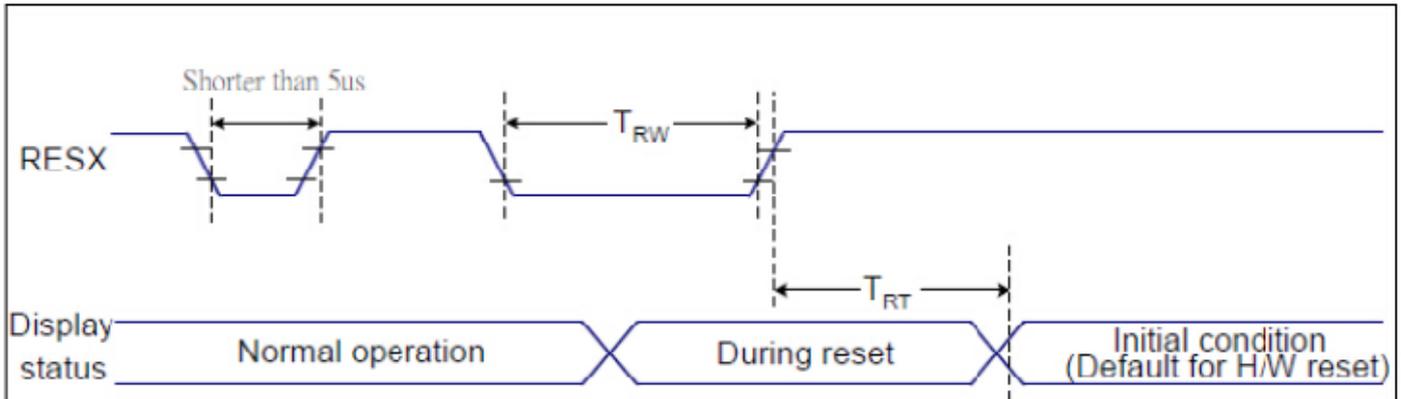


Figure 6.5: Reset Timing Diagram

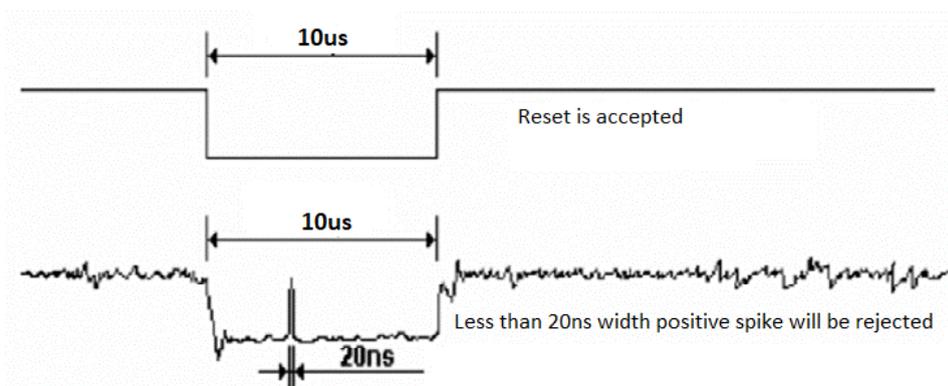
Related Pins	Symbol	Parameter	Min	Max	Unit
RESX	TRW	Reset pulse duration	10	-	us
	TRT	Reset cancel	-	5 (Note 1,5)	ms
				120 (Note 1, 6, 7)	ms

Notes:

- The reset cancel includes also required time for loading ID bytes, VCOM setting and other settings from NVM (or similar device) to registers. This loading is done every time when there is HW reset cancel time (tRT) within 5ms after a rising edge of RESX.
- Spike due to an electrostatic discharge on RESX line does not because irregular system reset according to the table below:

RESX Pulse	Action
Shorter than 5us	Reset Rejected
Longer than 9us	Reset
Between 5us and 9 us	Reset starts

- During the resetting period, the display will be blanked (the display is entering blanking sequence, which maximum time is 120ms, when reset starts in Sleep Out mode. The display remains the blank state in Sleep in mode) and then return to Default condition for Hardware Reset.
- Spike Rejection also applies during a valid reset pulse as shown below:



- When Reset applied during Sleep In Mode.
- When Reset applied during Sleep Out Mode.
- It is necessary to wait 5ms after releasing RESX before sending commands. Also Sleep Out command cannot be sent for 120ms.

7. Cautions and Handling Precautions

7.1 Handling and Operating the Module

1. When the module is assembled, it should be attached to the system firmly. Do not warp or twist the module during assembly work.
2. Protect the module from physical shock or any force. In addition to damage, this may cause improper operation or damage to the module and back-light unit.
3. Note that polarizer is very fragile and could be easily damaged. Do not press or scratch the surface.
4. Do not allow drops of water or chemicals to remain on the display surface. If you have the droplets for a long time, staining and discoloration may occur.
5. If the surface of the polarizer is dirty, clean it using some absorbent cotton or soft cloth.
6. The desirable cleaners are water, IPA (Isopropyl Alcohol) or Hexane. Do not use ketene type materials (ex. Acetone), Ethyl alcohol, Toluene, Ethyl acid or Methyl chloride. It might permanent damage to the polarizer due to chemical reaction.
7. If the liquid crystal material leaks from the panel, it should be kept away from the eyes or mouth. In case of contact with hands, legs, or clothes, it must be washed away thoroughly with soap.
8. Protect the module from static; it may cause damage to the CMOS ICs.
9. Use fingerstalls with soft gloves in order to keep display clean during the incoming inspection and assembly process.
10. Do not disassemble the module.
11. Protection film for polarizer on the module shall be slowly peeled off just before use so that the electrostatic charge can be minimized.
12. Pins of I/F connector shall not be touched directly with bare hands.
13. Do not connect, disconnect the module in the "Power ON" condition.
14. Power supply should always be turned on/off by the item Power On Sequence & Power Off Sequence

7.2 Storage and Transportation.

1. Do not leave the panel in high temperature, and high humidity for a long time. It is highly recommended to store the module with temperature from 0 to 35 °C and relative humidity of less than 70%
2. Do not store the TFT-LCD module in direct sunlight.
3. The module shall be stored in a dark place. When storing the modules for a long time, be sure to adopt effective measures for protecting the modules from strong ultraviolet radiation, sunlight, or fluorescent light.
4. It is recommended that the modules should be stored under a condition where no condensation is allowed. Formation of dewdrops may cause an abnormal operation or a failure of the module. In particular, the greatest possible care should be taken to prevent any module from being operated where condensation has occurred inside.
5. This panel has its circuitry FPC on the bottom side and should be handled carefully in order not to be stressed.