DISPLAY Elektronik GmbH

DATA SHEET

TFT MODULE

DEM 376960A VMH-PW-N

2,9“ TFT

Product Specification **Ver.: 0**

11.09.2023

REVISION HISTORY:				
Rev	Date	Description	Written By	Approved By
0	11.09.2023	New release.	WYC	LSB

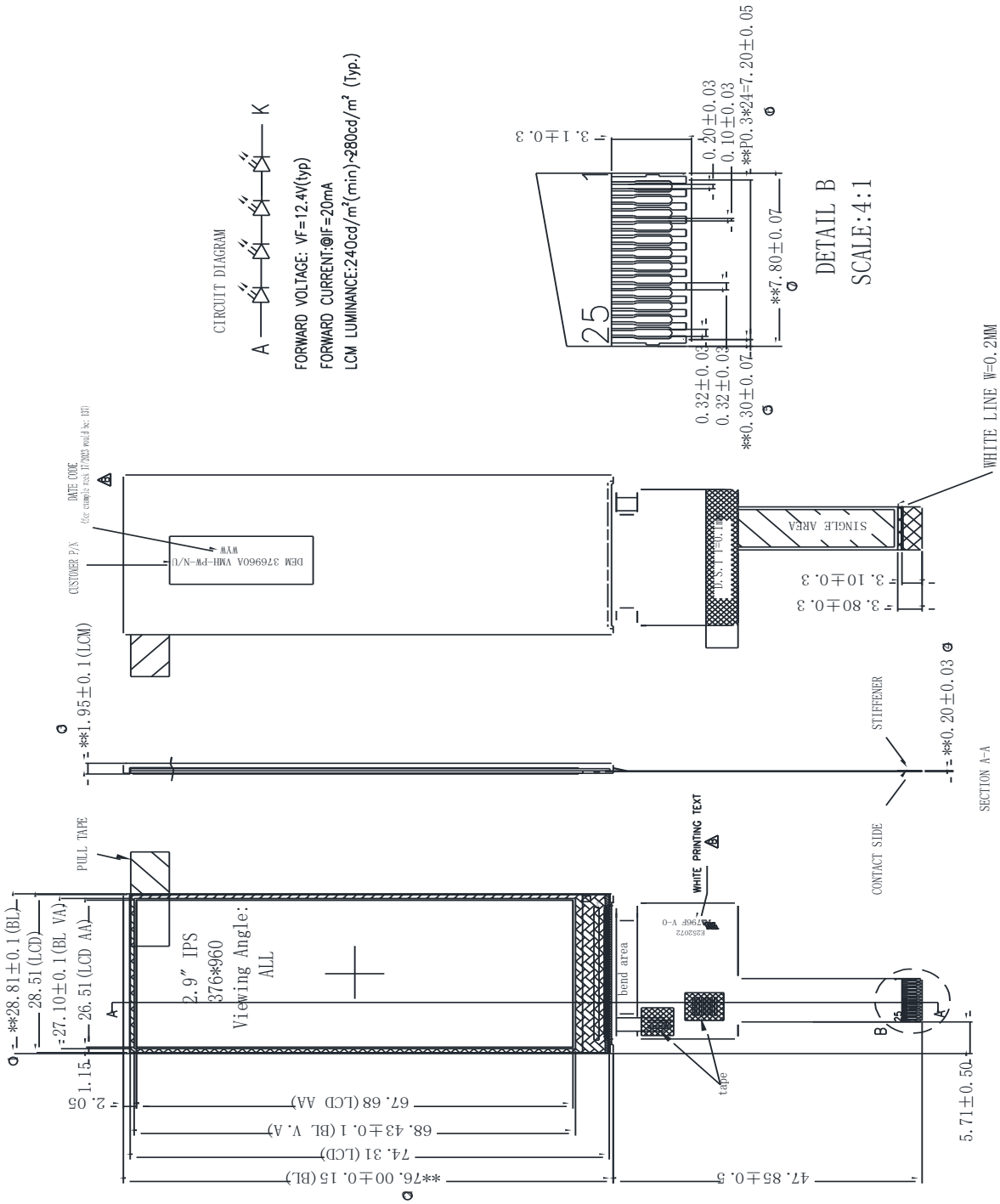
CONTENTS

1.0 GENERAL SPECIFICATION

Item	Contents	Unit
Display Mode	2.9” TFT Transmissive/IPS/Normally Black	-
Module outer dimension	28.81 x 76.0 x 1.95 (Excluded FPC length)	mm
Pixel Size	0.135 × 0.135	mm
Effective display area	26.51 x 67.68	mm
Number of dots	376 x RGB × 960	dots
Viewing direction	Free	O’clock
Pixel Arrangement	RGB Vertical Stripe	-
Backlight	LED white backlight	-
Driver IC	ST7701S-G5	-
Interface type	4 line SPI	-
Number Of Colors	262K	-
Operating temperature	-20 ~ 70	^{o}C
Storage temperature	-30 ~ 80	^{o}C

Remarks: Normal operating condition is temperature 15~35^{o}C, humidity 45%~75%RH, atmospheric pressure 86~106kPa.

2.0 OUTLINE DRAWING



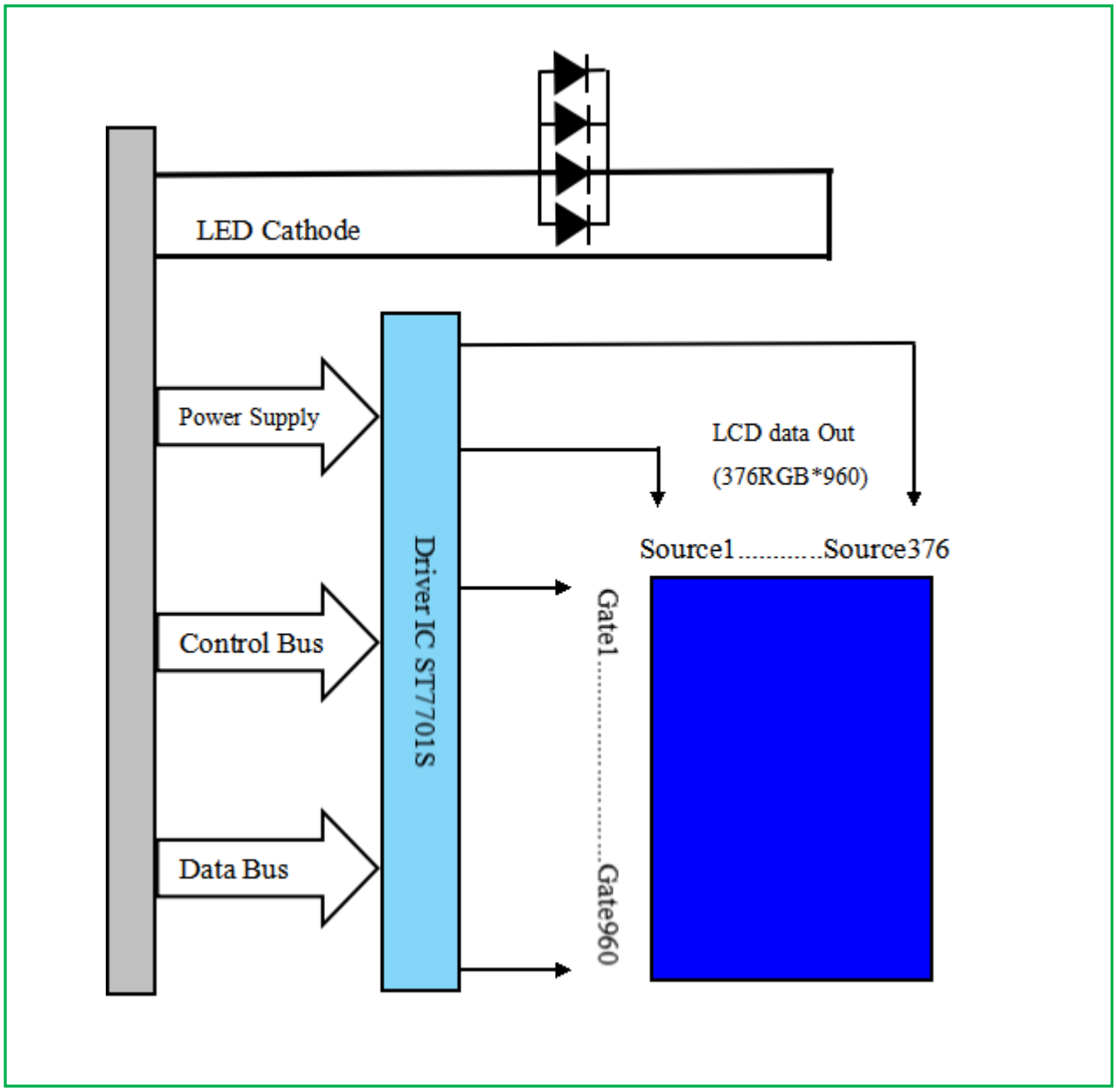
Pin	DESCRIPTION
1	GND
2	VCC
3	IOVCC
4	RESET
5	GND
6	D1P
7	D1N
8	GND
9	CLKP
10	CLKN
11	GND
12	DOP
13	DON
14	GND
15	TE
16	LEDA
17	NC
18	LEDK
19	NC
20	NC (TP-VCC)
21	NC(TP-RESET)
22	NC (TP-INT)
23	NC (TP-SDA)
24	NC (TP-SCL)
25	NC (GND)

NOTE:
1. "?" "SPECIAL DIMENSION(PPK/CPK DATA NEEDED>1.67)
2. "*" "CONTROL DIMENSION
3. No Use of Prohibited Substances defined in SOP-E-QS-009 and Only purchase Designated Raw Materials from Green Partners.
4. DRIVER IC : ST7701S-G5

3.0 INTERFACE PIN DESCRIPTION

Pin No.	Symbol	Pin Description
1	GND	Ground
2	VCC	Power supply voltage
3	IOVCC	Power supply for the logic power and I/O circuit
4	RESET	Reset Signal Input Pin
5	GND	Ground
6	D1P	MIPI DSI data1+
7	D1N	MIPI DSI data1-
8	GND	Ground
9	CLKP	MIPI DSI clock+
10	CLKN	MIPI DSI clock-
11	GND	Ground
12	D0P	MIPI DSI data0+
13	D0N	MIPI DSI data1+
14	GND	Ground
15	TE	Tearing Effect pin.
16	LEDA	LED backlight anode.
17	NC	No connection.
18	LEDK	LED backlight cathode.
19	NC	No connection.
20	NC(TP-VCC)	No connection.
21	NC(TP-RESET)	No connection.
22	NC(TP-INT)	No connection.
23	NC(TP-SDA)	No connection.
24	NC(TP-SCL)	No connection.
25	NC(GND)	No connection.

4.0 BLOCK DIAGRAM



5.0 OPERATING PRINCIPLE & DRIVING METHOD

5.1 Please refer to ST7701SN-1 (Ver N1.0) IC data sheet.

5.2 Instruction Description (based on IC spec ver as stated in 6.1 where the product is designed). This instruction description is for reference only. Customer is encouraged to always refer to the latest IC specification when developing application system platform.

5.3 Recommended initial codes

```
void LCD_Init(void)
{
// VBP=16;VFP=16;
//Line time:16.7

WriteComm (0xFF);
WriteData (0x77);
WriteData (0x01);
WriteData (0x00);
WriteData (0x00);
WriteData (0x13);

WriteComm (0xEF);
WriteData (0x08);

WriteComm (0xFF);
WriteData (0x77);
WriteData (0x01);
WriteData (0x00);
WriteData (0x00);
WriteData (0x10);

WriteComm (0xC0);
WriteData (0x77);
WriteData (0x00);

WriteComm (0xC1);
WriteData (0x0C);
WriteData (0x0C);

WriteComm (0xC2);
WriteData (0x07);
WriteData (0x02);

WriteComm (0xCC);
WriteData (0x10);

WriteComm (0xB0);
WriteData (0x00);
WriteData (0x0C);
WriteData (0x19);
WriteData (0x0B);
WriteData (0x0F);
WriteData (0x06);
WriteData (0x05);
WriteData (0x08);
WriteData (0x08);
WriteData (0x1F);
WriteData (0x04);
WriteData (0x11);
WriteData (0x0F);
```

```
WriteData (0x26);
WriteData (0x2F);
WriteData (0x1D);

WriteComm (0xB1);
WriteData (0x00);
WriteData (0x17);
WriteData (0x19);
WriteData (0x0F);
WriteData (0x12);
WriteData (0x05);
WriteData (0x05);
WriteData (0x08);
WriteData (0x07);
WriteData (0x1F);
WriteData (0x03);
WriteData (0x10);
WriteData (0x10);
WriteData (0x27);
WriteData (0x2F);
WriteData (0x1D);

WriteComm (0xFF);
WriteData (0x77);
WriteData (0x01);
WriteData (0x00);
WriteData (0x00);
WriteData (0x11);

WriteComm (0xB0);
WriteData (0x25);

WriteComm (0xB1);
WriteData (0x76);

WriteComm (0xB2);
WriteData (0x81);

WriteComm (0xB3);
WriteData (0x80);

WriteComm (0xB5);
WriteData (0x4E);

WriteComm (0xB7);
WriteData (0x85);

WriteComm (0xB8);
WriteData (0x20);

WriteComm (0xC1);
WriteData (0x78);

WriteComm (0xC2);
WriteData (0x78);

WriteComm (0xD0);
WriteData (0x88);
```

```
WriteComm (0xE0);
WriteData (0x00);
WriteData (0x00);
WriteData (0x02);
WriteData (0x00);
WriteData (0x00);
WriteData (0x0C);

WriteComm (0xE1);
WriteData (0x02);
WriteData (0x8C);
WriteData (0x04);
WriteData (0x8C);
WriteData (0x01);
WriteData (0x8C);
WriteData (0x03);
WriteData (0x8C);
WriteData (0x00);
WriteData (0x44);
WriteData (0x44);

WriteComm (0xE2);
WriteData (0x03);
WriteData (0x03);
WriteData (0x03);
WriteData (0x03);
WriteData (0x00);
WriteData (0x00);
WriteData (0xD4);
WriteData (0x00);
WriteData (0x00);
WriteData (0x00);
WriteData (0xD4);
WriteData (0x00);

WriteComm (0xE3);
WriteData (0x00);
WriteData (0x00);
WriteData (0x33);
WriteData (0x33);

WriteComm (0xE4);
WriteData (0x44);
WriteData (0x44);

WriteComm (0xE5);
WriteData (0x09);
WriteData (0xD2);
WriteData (0x35);
WriteData (0x8C);
WriteData (0x0B);
WriteData (0xD4);
WriteData (0x35);
WriteData (0x8C);
WriteData (0x05);
WriteData (0xCE);
WriteData (0x35);
```

```
WriteData (0x8C);
WriteData (0x07);
WriteData (0xD0);
WriteData (0x35);
WriteData (0x8C);

WriteComm (0xE6);
WriteData (0x00);
WriteData (0x00);
WriteData (0x33);
WriteData (0x33);

WriteComm (0xE7);
WriteData (0x44);
WriteData (0x44);

WriteComm (0xE8);
WriteData (0x08);
WriteData (0xD1);
WriteData (0x35);
WriteData (0x8C);
WriteData (0x0A);
WriteData (0xD3);
WriteData (0x35);
WriteData (0x8C);
WriteData (0x04);
WriteData (0xCD);
WriteData (0x35);
WriteData (0x8C);
WriteData (0x06);
WriteData (0xCF);
WriteData (0x35);
WriteData (0x8C);

WriteComm (0xEB);
WriteData (0x00);
WriteData (0x01);
WriteData (0xE4);
WriteData (0xE4);
WriteData (0x44);
WriteData (0x00);

WriteComm (0xED);
WriteData (0x77);
WriteData (0x66);
WriteData (0x55);
WriteData (0x44);
WriteData (0xCA);
WriteData (0xF1);
WriteData (0x03);
WriteData (0xBF);
WriteData (0xFB);
WriteData (0x30);
WriteData (0x1F);
WriteData (0xAC);
WriteData (0x44);
WriteData (0x55);
WriteData (0x66);
```

```
WriteData (0x77);

WriteComm (0xEF);
WriteData (0x10);
WriteData (0x0D);
WriteData (0x04);
WriteData (0x08);
WriteData (0x3F);
WriteData (0x1F);

WriteComm (0xFF);
WriteData (0x77);
WriteData (0x01);
WriteData (0x00);
WriteData (0x00);
WriteData (0x13);

WriteComm (0xE8);
WriteData (0x00);
WriteData (0x0E);

WriteComm (0x11);
Delay_ms(120);

WriteComm (0xE8);
WriteData (0x00);
WriteData (0x0C);
Delay_ms(20);

WriteComm (0xE8);
WriteData (0x00);
WriteData (0x00);

WriteComm (0xFF);
WriteData (0x77);
WriteData (0x01);
WriteData (0x00);
WriteData (0x00);
WriteData (0x00);

WriteComm (0x29);

WriteComm (0x35);
WriteData (0x00);//TE ON

WriteComm (0x36);
WriteData (0x00);//FW:00     BW:10
}
```

Notes:

1) These initial codes are only for reference, Customer should optimize above setting according to the display pattern and application used.
2) Customer is advised to refer to “General Handling Precaution of LCD Modules” section in this product specification regarding the operating precaution of LCD modules, when optimizing the display initialization setting.
3) Display Elektronik GmbH will use above initial code for production testing by default. Customer is advised to highlight to Display Elektronik GmbH in case that initial code setting in customer application is different with above initial code. Reason is to ensure Display Elektronik GmbH testing is in-line with customer application as close as possible for good quality control.

5.4 Power on/off sequence

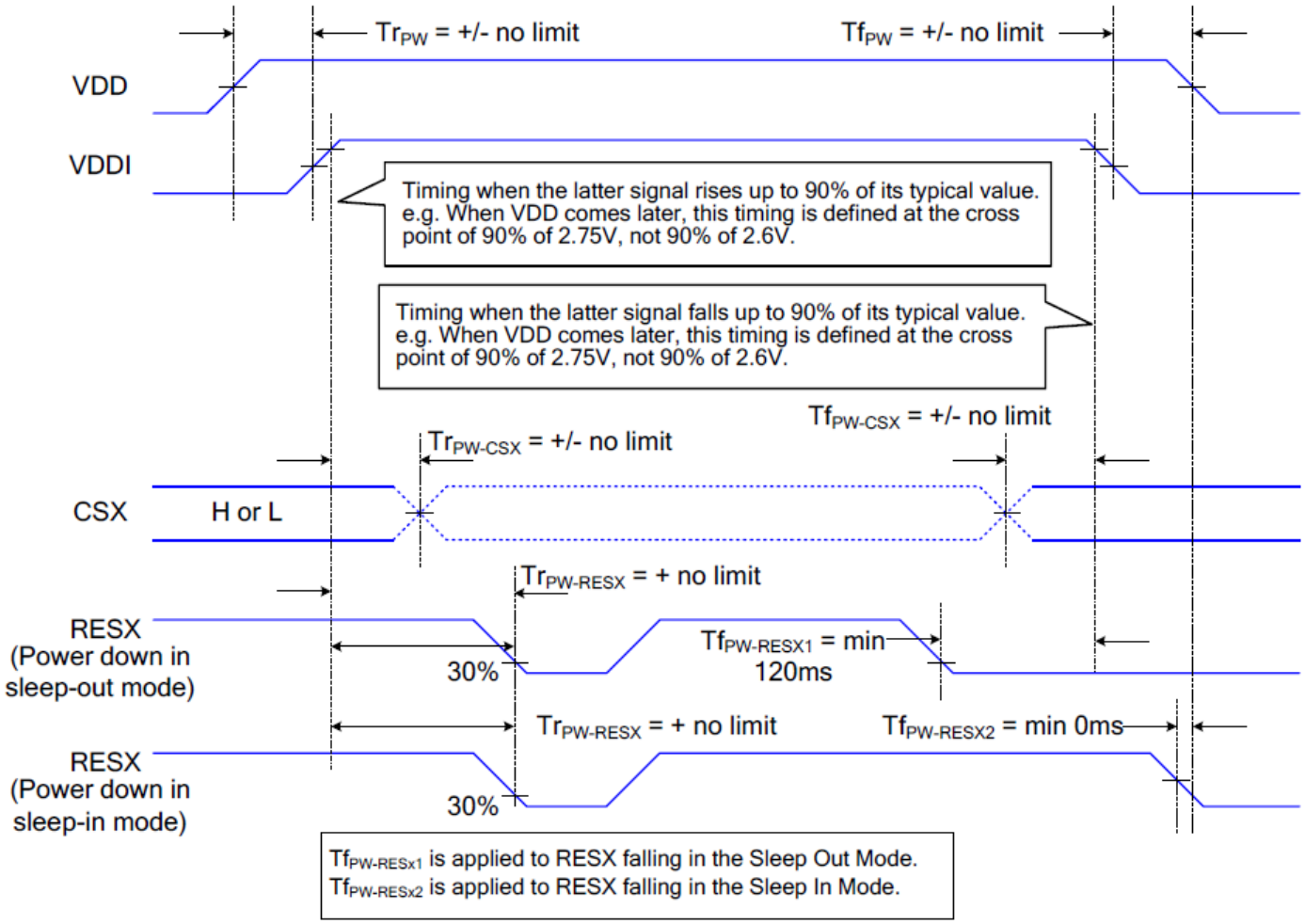
VDDI and VDDA can be applied or powered down in any order. During the Power Off sequence, if the LCD is in the Sleep Out mode, VDDA and VDDI must be powered down with minimum 120msec. If the LCD is in the Sleep In mode, VDDA and VDDI can be powered down with minimum 0msec after the RESX is released.

CSX can be applied at any timing or can be permanently grounded. RESX has high priority over CSX.

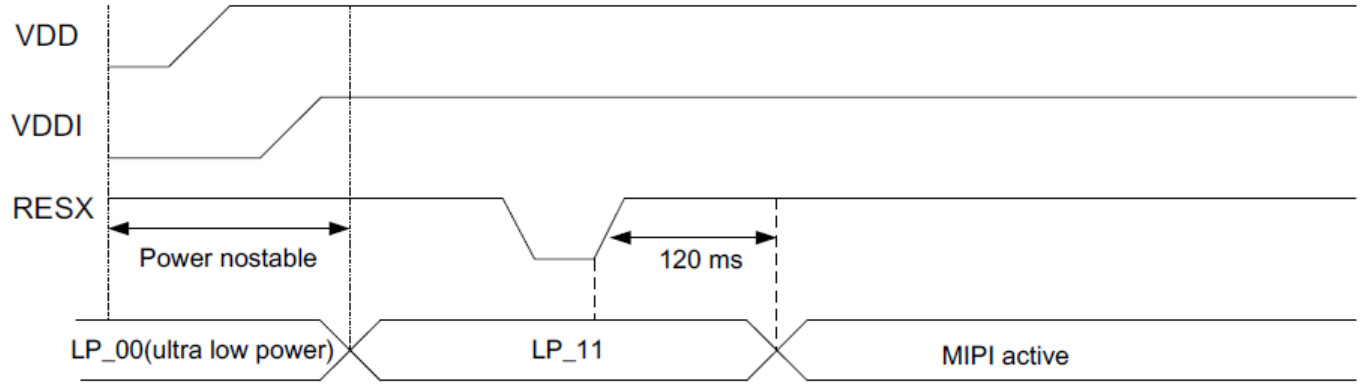
Notes:

1. There will be no damage to the ST7701SN-1 if the power sequences are not met.
2. There will be no abnormal visible effects on the display panel during the Power On/Off Sequences.
3. There will be no abnormal visible effects on the display between the end of Power On Sequence and before receiving the Sleep Out command, and also between receiving the Sleep In command and the Power Off Sequence.
4. If the RESX line is not steadily held by the host during the Power On Sequence as defined in Sections 9.1 , then it will be necessary to apply the Hardware Reset (RESX) after the completion of the Host Power On Sequence to ensure correct operations. Otherwise, all the functions are not guaranteed.
5. When VDDA is in power off State , the MIPI must set in Ultra Low Power Mode (GND Level).

The power on/off sequence is illustrated below



Note5:



9.1 Uncontrolled Power Off

The uncontrolled power-off means a situation which removed a battery without the controlled power off sequence. It will neither damage the module or the host interface.

If uncontrolled power-off happened, the display will go blank and there will not any visible effect on the display (blank display) and remains blank until "Power On Sequence" powers it up.

5.5 Timing Characteristics

High Speed Mode

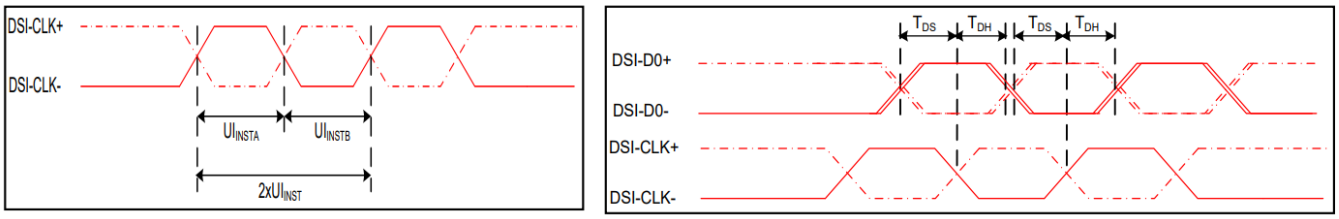


Figure 4 DSI clock channel timing

Figure 5 Rising and falling time on clock and data channel

VDDI=1.8,VDD=2.8, AGND=DGND=0V, Ta=25 ℃

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
DSI-CLK+/-	$2xUI_{INSTA}$	Double UI instantaneous	2.5	25	ns	
DSI-CLK+/-	UI_{INSTA} UI_{INSTB}	UI instantaneous halfs	1.25	12.5	ns	UI = UI_{INSTA}= UI_{INSTB}
DSI-Dn+/-	tDS	Data to clock setup time	0.15	-	UI	
DSI-Dn+/-	tDH	Data to clock hold time	0.15	-	UI	

Table 7 Mipi Interface- High Speed Mode Timing Characteristics

Lowe Power Mode

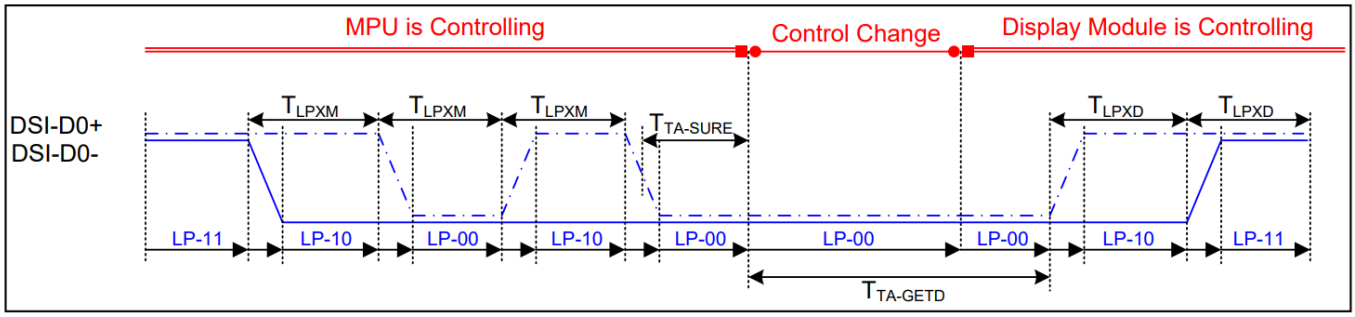


Figure 6 Bus Turnaround (BTA) from display module to MPU Timing

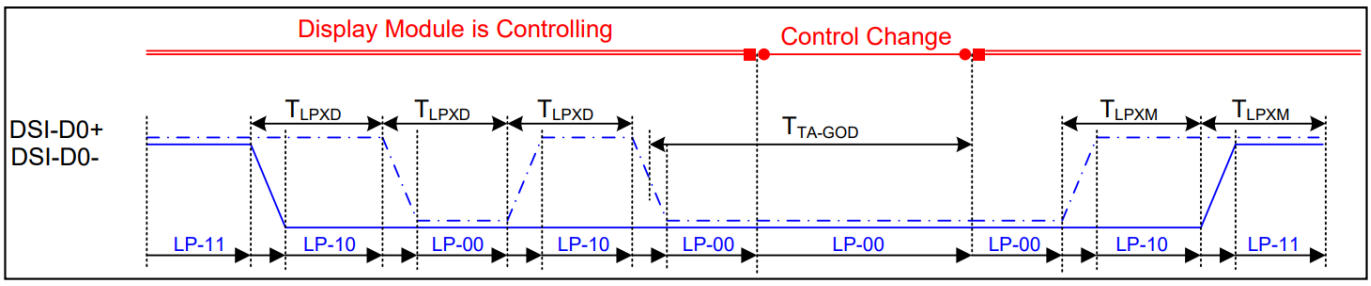


Figure 7 Bus Turnaround (BTA) from MPU to display module Timing

VDDI=1.8,VDD=2.8, AGND=DGND=0V, Ta=25 ℃

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
DSI-D0+/-	TLPXM	Length of LP-00,LP-01, LP-10 or LP-11 periods MPU→Display Module	50	75	ns	Input
DSI-D0+/-	TLPXD	Length of LP-00,LP-01, LP-10 or LP-11 periods MPU→Display Module	50	75	ns	Output
DSI-D0+/-	TTA-SURED	Time-out before the MPU start driving	T_{LPXD}	$2xT_{LPXD}$	ns	Output
DSI-D0+/-	TTA-GETD	Time to drive LP-00 by display module	$5xT_{LPXD}$		ns	Input
DSI-D0+/-	TTA-GOD	Time to drive LP-00 after turnaround request-MPU	$4xT_{LPXD}$		ns	Output

Table 8 Mipi Interface Low Power Mode Timing Characteristics

DSI Bursts Mode

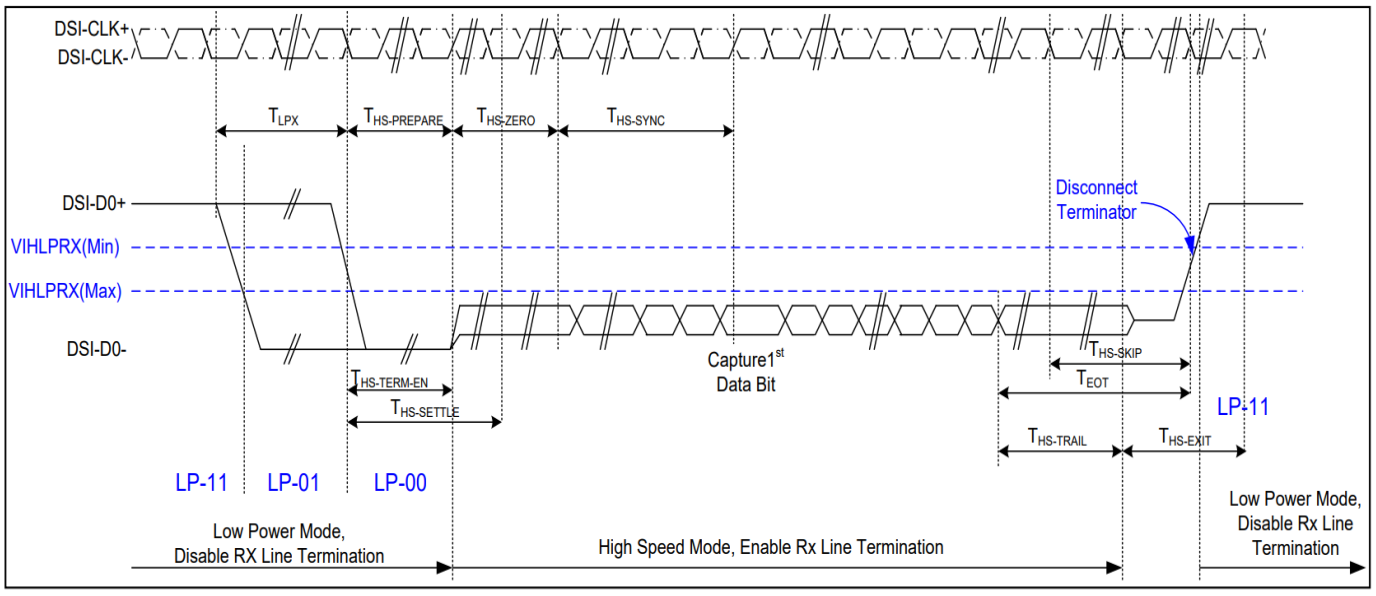


Figure 7 Data lanes-Low Power Mode to/from High Speed Mode Timing

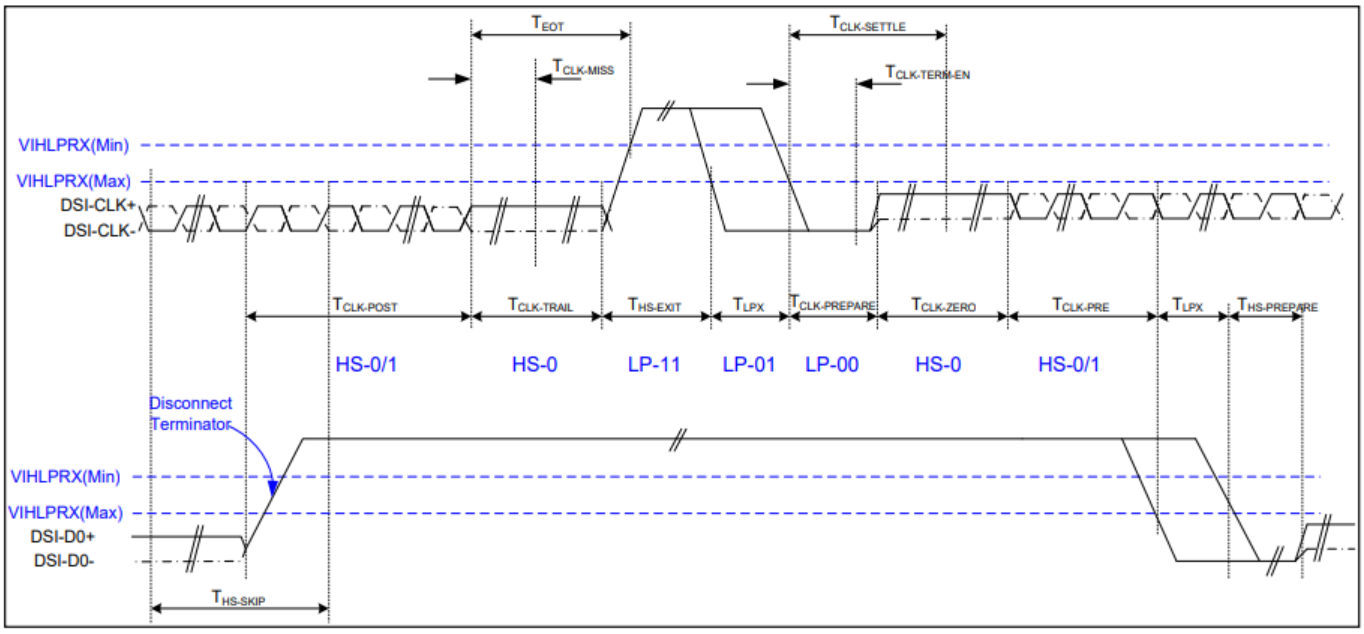


Figure 8 Clock lanes- High Speed Mode to/from Low Power Mode Timing

VDDI=1.8,VDD=2.8, AGND=DGND=0V, Ta=25 ℃

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
Low Power Mode to High Speed Mode Timing						
DSI-Dn+/-	TLPX	Length of any low power state period	50	-	ns	Input
DSI-Dn+/-	THS-PREPARE	Time to drive LP-00 to prepare for HS transmission	40+4 UI	85+6 UI	ns	Input
DSI-Dn+/-	THS-TERM-EN	Time to enable data receiver line termination measured from when Dn crosses VILMAX	-	35+4 UI	ns	Input
DSI-Dn+/-	THS-PREPARE + THS-ZERO	THS-PREPARE + time to drive HS-0 before the sync sequence	140+ 10UI	-	ns	Input
High Speed Mode to Low Power Mode Timing						
DSI-Dn+/-	THS-SKIP	Time-out at display module to ignore transition period of EoT	40	55+4 UI	ns	Input
DSI-Dn+/-	THS-EXIT	Time to drive LP-11 after HS burst	100	-	ns	Input
DSI-Dn+/-	THS-TRAIL	Time to drive flipped differential state after last payload data bit of a HS transmission burst	60+4 UI	-	ns	Input

High Speed Mode to/from Low Power Mode Timing						
DSI-CLK+/-	TCLK-POS	Time that the MPU shall continue sending HS clock after the last associated data lane has transition to LP mode	60+52UI	-	ns	Input
DSI-CLK+/-	TCLK-TRAIL	Time to drive HS differential state after last payload clock bit of a HS transmission burst	60	-	ns	Input
DSI-CLK+/-	THS-EXIT	Time to drive LP-11 after HS burst	100	-	ns	Input
DSI-CLK+/-	TCLK-PREPARE	Time to drive LP-00 to prepare for HS transmission	38	95	ns	Input
DSI-CLK+/-	TCLK-TERM-EN	Time-out at clock lan display module to enable HS transmission	--	38	ns	Input
DSI-CLK+/-	TCLK-PREPARE + TCLK-ZERO	Minimum lead HS-0 drive period before starting clock	300	-	ns	Input
DSI-CLK+/-	TCLK-PRE	Time that the HS clock shall be driven prior to any associated data lane beginning the transition from LP to HS mode	8UI	-	ns	Input
DSI-CLK+/-	TEOT	Time form start of TCLK-TRAIL period to start of LP-11 state	-	105ns+12UI	ns	Input

7.5.5 Reset Timing:

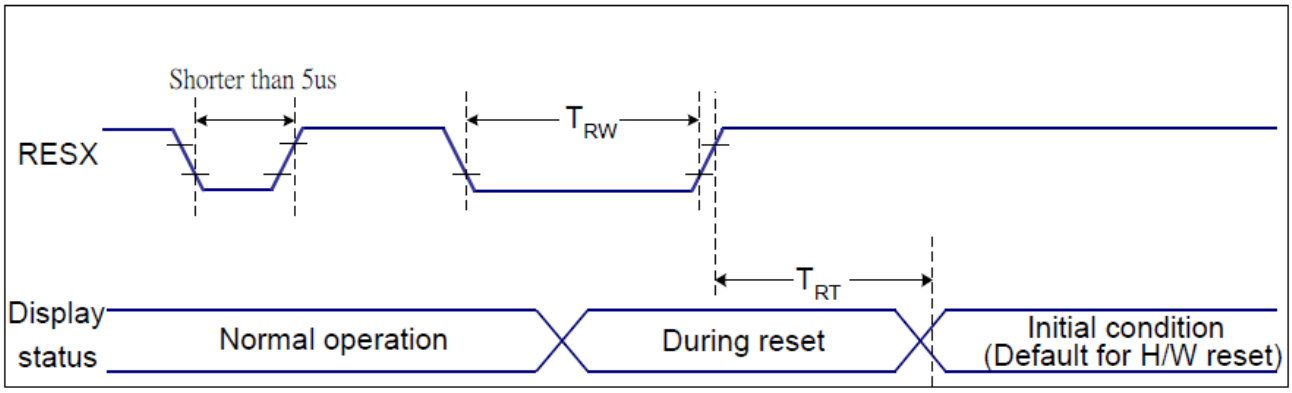


Figure 9 Reset Timing

VDDI=1.8,VDD=2.8, AGND=DGND=0V, Ta=25 ℃

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

Table 9 Reset Timing

Notes:

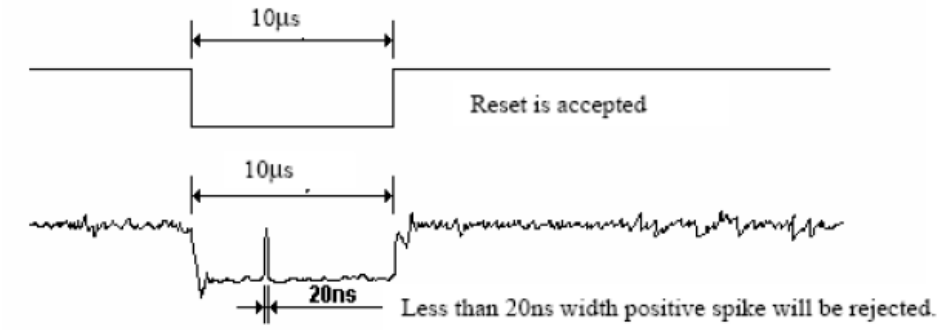
1. The reset cancel includes also required time for loading ID bytes, VCOM setting and other settings from NVM (or similar device) to registers. This loading is done every time when there is HW reset cancel time (tRT) within 5 ms after a rising edge of RESX.

2. Spike due to an electrostatic discharge on RESX line does not cause irregular system reset according to the table below:

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

3. During the Resetting period, the display will be blanked (The display is entering blanking sequence, which maximum time is 120 ms, 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.

4. Spike Rejection also applies during a valid reset pulse as shown below:



5. When Reset applied during Sleep In Mode.

6. When Reset applied during Sleep Out Mode.

7. It is necessary to wait 5msec after releasing RESX before sending commands. Also Sleep Out command cannot be sent for 120msec.

6.0 ABSOLUTE MAXIMUM RATINGS (Ta = 25°C, V_{SS} = 0 V, V_{CC}=V_{DD}, IOVCC=VDDI)

Parameter	Symbol	Min	Typ.	Max	Unit
System voltage	V_{DD}	-0.3	-	4.6	V
Interface Operation Voltage	VDDI	-0.3	-	4.6	
Driver supply voltage	VGH-VGL	-0.3	-	30	V
Input voltage	V_{IN}	-0.3	-	VDDI+0.3	V
Output voltage	Vo	-0.3	-	VDDI+0.3	V
Operating Temperature	Top	-20	-	60	°C
Storage Temperature	Tst	-30	-	70	°C

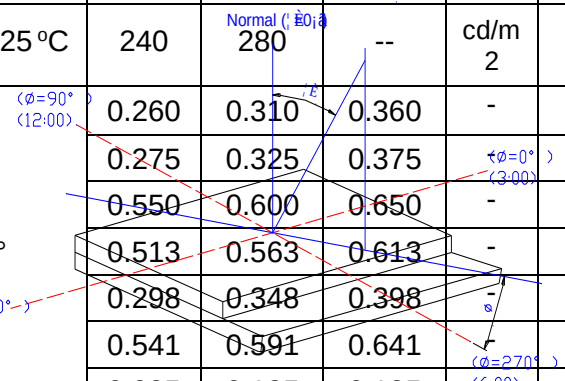
7.0 ELECTRICAL CHARACTERISTICS(Ta = 25°C, V_{SS} = 0 V, V_{CC}=V_{DD})

Parameter	Symbol	Condition	Min	Typ.	Max	Unit
System voltage	V_{DD}	-	2.5	2.8	3.6	V
Interface Operation Voltage	VDDI	-	1.65	1.8	3.3	V
Gate on power	VGH	-	11.5	-	15	V
Gate off power	VGL	-	-10	-	-12	V
Vcom	Vcom	-	-	VSS	-	V
Logic high input voltage	V_{IH}	-	0.7VDDI	-	VDDI	V
Logic low input voltage	V_{IL}	-	Vss	-	0.3VDDI	V
Logic high output voltage	V_{OH}	IOH=-1.0mA	0.8VDDI	-	VDDI	V
Logic low output voltage	V_{OL}	IOL= +1.0mA	Vss	-	0.2VDDI	V
LCM supply current	I_{LCM}	-	-	28	42	mA

8.0 ELECTRO-OPTICAL CHARACTERISTICS

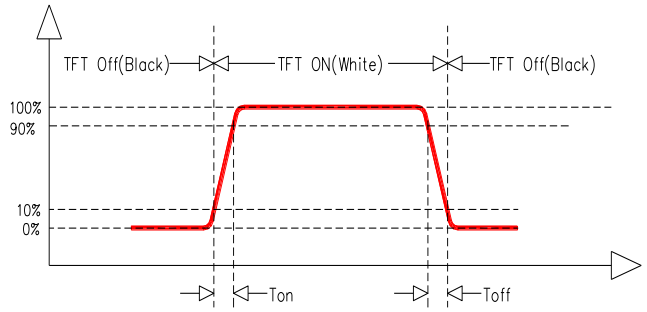
No	Item		Symbol	Condition	Min.	Typ.	Max.	Unit	Note
1	Response Time		T_{on}+T_{off}	θ = ϕ = 0º	-	30	40	ms	(a)
2	Contrast Ratio		CR	θ = ϕ = 0º	1000	1250	-	-	(c)
3	Viewing Angle (CR ≥ 10)		3:00	ϕ = 0º	75	80	-	Deg	(b)
			9:00	ϕ = 180º	75	80	-	Deg	
			12:00	ϕ = 90º	75	80	-	Deg	
			6:00	ϕ = 270º	75	80	-	Deg	
4	Brightness on LCM		L_{LCM}	θ = 0º, ϕ = 0º, 25 ºC	240	280	--	cd/m2	(d)
5	Color Chromaticity (CIE1931)	White	Wx	θ=0°, ϕ=0° Ta=25°C	0.260	0.310	0.360	-	-
			Wy		0.275	0.325	0.375	-	-
		Red	Rx		0.550	0.600	0.650	-	-
			Ry		0.513	0.563	0.613	-	-
		Green	Gx		0.298	0.348	0.398	-	-
			Gy		0.541	0.591	0.641	-	-
		Blue	Bx		0.085	0.135	0.185	-	-
			By		0.027	0.077	0.127	-	-
6	NTSC			57.0%					

Note (b): Definition of Viewing Angle



Remarks:
1) EOC data above is measured using DMS-501 display measurement system.
2) Brightness data is measured using photometer Topcon BM-7.

Note(a): Definition of Response Time

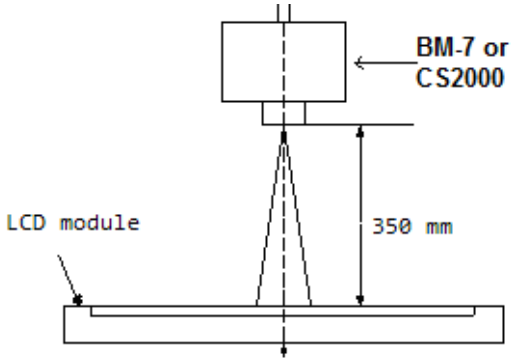


Note (c): Definition of Contrast Ratio

CR = Brightness at all pixels “White” / Brightness at all pixels “Black”

Note (d): backlight driving condition: If = 20mA
Luminance measuring point: Center of the dot matrix under white pattern

measuring setup as below figure:



9.0 BACKLIGHT SPECIFICATION

9.1 LED Backlight Electrical-optical characteristics

Item of backlight characteristics	Symbol	Min	Typ	Max	Unit	Condition
Forward voltage	Vf	11.6	12.4	13.2	V	1.If=20mA, T=25ºC 2.Aperture:1º,5 Points 3.Average=min/max*100%
Uniformity	Δ	80	-	-	%	
Number of LED	-	4			Piece	-
Connection mode	S/P/M	4S			-	-
Life time	30000Hrs (When the LED luminous intensity attenuation to 50% at the beginning of the luminous intensity of time)					1.Ta=25±5 ℃, RH=60%± 10%; If=20mA/LED 2.No other interference, Such as Current, Voltage suddenly rise, Electrostatic shock, etc.

Remarks: chromaticity and luminance data are measured using photometer Topcon BM-7.

10.0 RELIABILITY SPECIFICATION

10.1 Reliability Test Conditions

No	Test Item	Test Conditions
1	High temperature storage	80ºC, 240hrs
2	High temperature operation	70ºC, 240hrs
3	Low temperature storage	-30ºC, 240hrs
4	Low temperature operation	-20ºC, 240hrs
5	High temperature humidity operation	40ºC, 90%RH, 240hrs
6	Temperature shock storage	-30±2˚C(30min) ~ 25˚C(5min) ~ 80±2˚C(30min), 10 cycles.
7	Vibration Test((on packaging)	Frequency:10-55Hz , Amplitude:0.75mm , x,y,z every direction for 0.5 hour
8	Drop test (on packaging)	Drop to the ground from 80cm height, 6 side of carton, each once

Remarks:
1) For operation test, above specification is applicable when test pattern is changing during entire operation test.
2) Inspections after reliability tests are performed when the display temperature resumes back to room temperature.
3) It is a normal characteristic that some display abnormality can be seen during reliability test. If the display abnormality can recover as normal condition within 24 hours at room temperature, there is no permanent destruction over the display. The display still possesses its functionality and considered as acceptable after reliability tests.

10.2 Failure Judgment Criteria

After the reliability tests above, test sample shall be let return to room temperature and humidity for at least 4 hours before final tests are carried out.

Item	Acceptance Criteria
Electrical characteristic	No electrical short and open. Increase in current consumption is less than 2 times of initial value.
Mechanical characteristic	Within mechanical and drawing specification
Optical characteristic	Within appearance standard as specified in this specification. Contrast ratio change & ON-transmission value shall not less than 50% of initial value.

11.0 QUALITY SPECIFICATION

11.1 Acceptable Quality Level (AQL)

Each lot should satisfy the quality level defined as follows:

a) Inspection method: MIL-STD-105E Level II normal one time sampling

b) AQL level

Category	AQL	Definition
Major	0.25%	Functional defective as product
Minor	0.25%	Satisfy all functions as product but not satisfy cosmetic standard

11.2 Conditions of Inspection

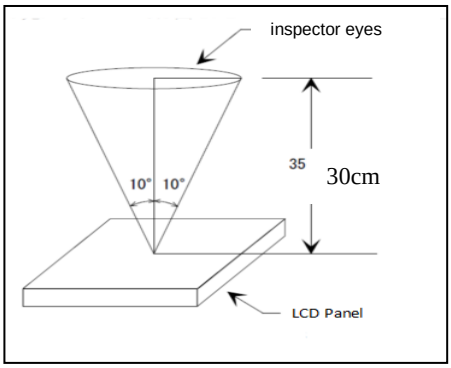
a) Inspection illumination：Function illumination<150Lux;Appearance illumination is 2500±500Lux.

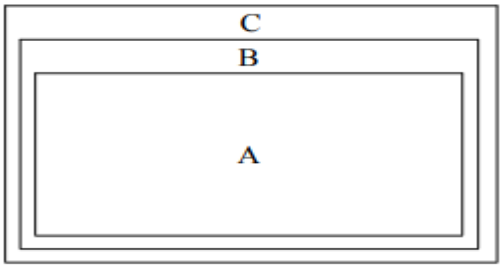
b) Inspection distance: About 30cm between the observer's eyes and the LCD.

c) Inspection angle：Normal inspection angle is +/-10° form LCD.

(Ghost shadow inspection angle is +/-45° ； Light leakage inspection angle is+/-30°)

d) Inspection environment: normal temperature（18～27℃）and normal humidity（50~85%RH）



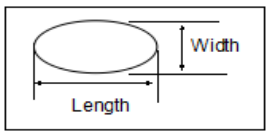
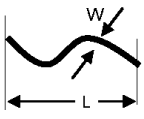


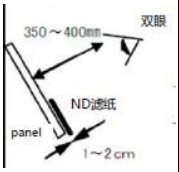
A：viewing area
B：viewing area except A
C：Outside viewing area

Note: As a general rule, visual defects in C is permissible, when it is no trouble for quality and assembly of customer's product.

11.3 Acceptance Criteria (Display Elektronik GmbH internal standard: IS-QC- 089(E)TFT-1)

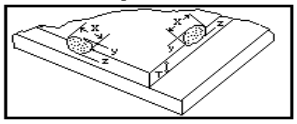
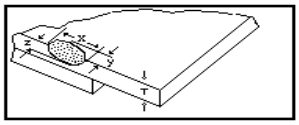
a) Function Inspection

Item	Acceptance/Rejection Criteria				Classification	Method	Method
Functional	1. No-display /abnormal display/line defect etc.are not acceptable. 2.Obvious color deviation in dark/red/green/blue screen is not acceptable. (refer limit sample if application) 3.0 Obvious color deviation in the same screen is not acceptable. (spot、mura which cannot be seen by ND6 % is acceptable; Judgement Methods: The distance from the panel to ND filter paper: 350-400 - mm , put the ND filter paper in 1-2 cm distance away from the eye position, using monocular observation） 3.1The standard of eye Sight for Spot, Mura bad: put the filter paper in the positon in accordance with 3.0, move the eye sight away from the filter paper and turn the sight back to the filter paper. The standard of inspection time for spot, Mura:5 seconds. 4.Current consumption (Idd MAX) shall not exceed the limit specified on the Test Instruction. 5.Display character/ pattern shall be referred to the Test Instruction. 6.Obvious light leakage is not acceptable.				Major	Visual	A
Spot 、Foreign Particle， Dirt under POL or TP	 D=(Length+Width)/2		Zone / Size(mm)	Acc No	Major	Visual (Scale magnifying glass）	A、B、C
			D≤0.15	Unlimited			
			0.15＜D≤0.2	3			
			D＞0.2	0			
Line defect: foreign or Scratch		Defect	Size(mm)	Acc No A、B	Acc No C	Minor	Visual (Scale magnifying glass）	A、B、C
		Foreign body、Pit	W≤0.02	Unlimited	Unlimited			
			0.02＜W≤0.05 and L≤4.0	2（distance ≥ 5mm）				
			W≥0.05	Define as spot defect				
		Polarizer fibrous foreign body	W≤0.02	Unlimited	Unlimited			
			0.02＜W≤0.05 and L≤4.0	2（distance ≥ 5mm）				
			W≥0.05	Define as spot defect				
		BL fibrous foreign body	W≤0.02	Unlimited	Unlimited			
			0.02＜W≤0.05 and L≤4.0	2（distance ≥ 5mm）				
			W≥0.05	Define as spot defect				
Polarizer Air or TP film bubble	N/A		Size(mm)	Acc No A、B	Acc No C	Minor	Visual (Scale magnifying glass）	A、B、C
			D≤0.15	Unlimited	Unlimited			
			0.15＜D≤0.2	3				
			0.2＜D≤0.25	1				

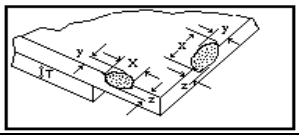
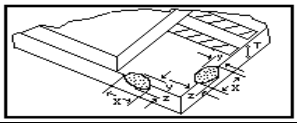
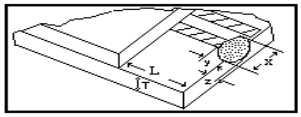
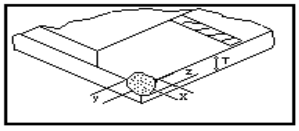
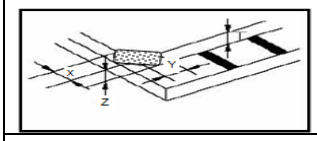
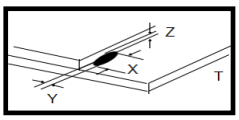
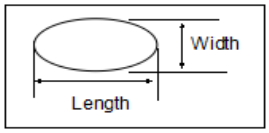
<table>
<tr><th>Item</th><th colspan="4">Acceptance/Rejection Criteria</th><th>Classification</th><th>Method</th><th>Method</th></tr>
<tr><td></td><td colspan="3"></td><td>D＞0.25</td><td>0</td><td></td><td></td><td></td></tr>
<tr><td>Light dot
Dark dot
Definition</td><td colspan="5">1). Pixel definition: Pixel is made of three sub-pixels (Red + Green +Blue)
2). Dot definition: Dot is a sub-pixel (Red or Green or Blue) 或 或
3). Light / Dark dot definition: A sub-pixel is on or off when the function testing.
Light dot appears in dark picture usually.
Dark dot appears in R\G\B color picture or the white picture usually.
4). Adjacent dot definition: Adjacent dot is made of two or three sub-pixels(R+G or G+B or B+R or R+G+B);</td><td>Minor</td><td>Visual
(Scale magnifying glass）</td><td>A</td></tr>
<tr><td>Bright dot/dark dot</td><td colspan="5">1. If the bright/dark dot size is less than 1/2 size of sub-pixel, ignore the dot.
2. If the bright/dark dot size is equal or more than 1/2 size of sub-pixel, follow the acceptable number of dot defect specified in the table on the right.
3.Bright dot can not be seen by ND 5% shall follow the tiny bright dot inspection standard.
4.Bright dot/dark dot can be seen by ND5% press Acc Qty standard judgement.
<table><tr><td>Defect</td><td>Acc No.</td><td>Remark</td></tr><tr><td>light dot</td><td>3</td><td>0</td></tr><tr><td>light dot two-connection</td><td>1</td><td>vertical and diagonal connetion are not allowed</td></tr><tr><td>dark dot</td><td>3</td><td>1</td></tr><tr><td>dark dot two-connection</td><td>1</td><td>vertical and diagonal connetion are not allowed</td></tr><tr><td>dark dot three-connection</td><td>3</td><td>1</td></tr><tr><td>Total</td><td>≤3</td><td>a two-connection dot count as 2 dots.</td></tr></table></td><td rowspan="2">Minor</td><td rowspan="2">Visual
(Scale magnifying glass）
See the judgement method as below
 

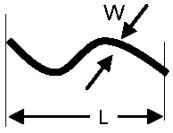
1.0 ND filter paper judgement method for bright dot and tiny bright dot: Distance from the ND filter paper to panel: 1-2 cm position, binocular observation
2.0The standard of eye-sight inspection for Bright dot and tiny Bright dot : put the filter paper in the position in accordance with 1.0,move the eye-sight away from the filter paper and then turn the sight back to the filter paper. The standard of inspection time for Light spot, Light spot 5 seconds.</td><td rowspan="2">A</td></tr>
<tr><td>Tiny Bright dot</td><td colspan="5">5.Tiny Bright dot definition, The bright dot cannot be seen by ND 6%.
Tiny bright dot judgement,
If the bright dot cannot be seen with ND6%, the acceptable Number is unlimited.
If the bright dot can be seen with ND6%, the acceptable Number shall ≤10.</td></tr>
<tr><td>Distance 、Defect number</td><td colspan="5">* 1 Distance between two detects must be more than 5 mm. *2.Total number of defects ≤3.</td><td>Minor</td><td>Visual
(Scale magnifying glass）</td><td>A</td></tr>
</table>

b) Appearance Inspection

<table>
<tr><th>Item</th><th colspan="4">Acceptance/Rejection Criteria</th><th>Classification</th><th>Method</th><th>Method</th></tr>
<tr><td>Chip-out</td><td colspan="4">A.General chip-out
 
 
 

<table><tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr><tr><td>≤4.0</td><td>Outside 1/3 S</td><td>Ignore</td></tr></table>S：Innerborder line of the seal</td><td>Minor</td><td>Visual
(Scale magnifying glass）</td><td>Out of A</td></tr>
</table>

<table>
<tr><th>Item</th><th>Acceptance/Rejection Criteria</th><th>Classification</th><th>Method</th><th>Method</th></tr>
<tr><td rowspan="8"></td><td>B. Chip-out on the back of terminal ledge
 
<table>
<tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr>
<tr><td>Ignore</td><td>≤0.3</td><td>≤1/2t</td></tr>
<tr><td>≤4.0</td><td>≤1/4L</td><td>≤t</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>C. Chip-out on the terminal ledge but not exactly on the ITO electrode.
 
<table>
<tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr>
<tr><td>Ignore</td><td>≤0.3</td><td>≤1/2t</td></tr>
<tr><td>≤4.0</td><td>≤1/4L</td><td>≤t</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>D. Chip-out on ITO electrode
 
<table>
<tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr>
<tr><td>Ignore</td><td>≤0.3</td><td>≤1/2t</td></tr>
<tr><td>≤2.0</td><td>≤0.8</td><td>≤1/2t</td></tr>
<tr><td>≤3.0</td><td>≤0.5</td><td>≤t</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>E. Chip-out at corner
 
<table>
<tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr>
<tr><td>≤3.0</td><td>≤3.0 or ≤1/4L (whichever is less）</td><td>≤T</td></tr>
</table></td><td rowspan="3">Minor</td><td rowspan="3">Visual (Scale magnifying glass）</td><td rowspan="3">Out of A</td></tr>
<tr><td>F. Chip-out at corner
 
<table>
<tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr>
<tr><td>≤3.0</td><td>≤3.0</td><td>≤T</td></tr>
<tr><td colspan="3">Remark: L= contact pad length, T=Single thickness galss</td></tr>
</table></td></tr>
<tr><td>G. Bur
 
<table>
<tr><td>x（mm）</td><td>y（mm）</td><td>z（mm）</td></tr>
<tr><td>unlimited</td><td>≤0.2</td><td>≤t</td></tr>
</table></td></tr>
<tr><td>H. Crack line
  </td><td>Extended crack is not allowed</td><td>Majoy</td><td>Visual</td><td>Out of A</td></tr>
<tr><td>Foreign material、Black dot、White dot、Pit、Dent Bubble etc.</td><td> 

D=(Length+Width)/2</td><td>
<table>
<tr><td>Zone / Size</td><td>Acc No. A、B</td><td>Acc No. C</td></tr>
<tr><td>D≤0.15</td><td>Unlimited</td><td rowspan="3">Unlimited</td></tr>
<tr><td>0.15＜D≤0.2</td><td>3</td></tr>
<tr><td>D＞0.2</td><td>0</td></tr>
</table></td><td>Minor</td><td>Visual (Scale magnifying glass）</td><td>A</td></tr>
<tr><td>Foreign material、Bubble etc.</td><td> 
</td><td>
<table>
<tr><td>Defect</td><td>Size（mm）</td><td>Acc No. A、B</td><td>Acc No. C</td></tr>
<tr><td rowspan="3">Foreign body、Pit、Polarizer fibrous foreign body</td><td>W≤0.02</td><td>Unlimited</td><td rowspan="2">Unlimited</td></tr>
<tr><td>0.02＜W≤0.05 and L≤4.0</td><td>2（distance ≥ 5mm）</td></tr>
<tr><td>W≥0.05</td><td colspan="2">Define as spot defect</td></tr>
</table></td><td>Minor</td><td>Visual (Scale magnifying glass）</td><td>A</td></tr>
<tr><td>Polarizer</td><td>N/A</td><td>Size(mn)</td><td>Acc No</td><td>Minor</td><td>Visual</td><td>A、B、</td></tr>
</table>

<table>
<tr><th>Item</th><th colspan="4">Acceptance/Rejection Criteria</th><th>Classification</th><th>Method</th><th>Method</th></tr>
<tr><td rowspan="5">bubble or TP film bubble</td><td rowspan="5"></td><td></td><td>A、B</td><td>C</td><td rowspan="5"></td><td rowspan="5">(Scale magnifying glass）</td><td rowspan="5">C</td></tr>
<tr><td>D≤0.15</td><td>Unlimited</td><td rowspan="4">Unlimited</td></tr>
<tr><td>0.15 < D≤0.2</td><td>3</td></tr>
<tr><td>0.2 < D≤0.25</td><td>1</td></tr>
<tr><td>D > 0.25</td><td>0</td></tr>
<tr><td>Distance</td><td colspan="4">Distance between two detects must be more than 5 mm.</td><td>Minor</td><td>Visual (Scale magnifying glass）</td><td>A</td></tr>
<tr><td>LC bubble</td><td colspan="4">Not acceptable.</td><td>Minor</td><td>Visual (Scale magnifying glass）</td><td>A</td></tr>
<tr><td>Polarizer</td><td colspan="4">1.Polarizer dimension & position shall meet the requirement indicated on the drawing.
2.Polarizer orientation shall meet the requirement indicated on the drawing. (Background color shall be consistent with the sample)。</td><td>Minor</td><td>Visual (Scale magnifying glass）</td><td>Out of A</td></tr>
<tr><td>Protective film</td><td colspan="4">1.Protective film separating in Active Area is not acceptable.
2.Fingerprint\ Massive dirt in the polarizer by protective film separating is not acceptable.
3.Erasable smudginess must be cleaned, unerasable smudginess is allowed. .</td><td>Minor</td><td>Visual (Scale magnifying glass）</td><td>All</td></tr>
<tr><td>FPC cosmetic defect</td><td colspan="4">According to IPC-6013A.</td><td>-</td><td>Visual</td><td>-</td></tr>
<tr><td>RTV
（Tuffy）</td><td colspan="4">1.Coating location shall meet the manufacturing instruction or drawing; Coating shall cover all terminal tracks.
2.RTV pin holes and bubble shall not cause ITO tracks exposed.
3.RTV foreign material shall not cause ITO short-circuit.
4.Uncured coating is not acceptable.
5.RTV Coating cannot be damaged. (Include irregular deformation)
6.RTV coating shall not exceed the height of the polarizer. RTV coating shall not spread over to the polarizer or the interface components.
7.Massive dirt on the coating is not acceptable.</td><td>Majoy</td><td>Visual</td><td>Out of A</td></tr>
<tr><td rowspan="3">BLU</td><td colspan="4">1. Backlight unit dimension and form shall meet the requirement on the drawing.</td><td>Majoy</td><td>caliper</td><td>Out of A</td></tr>
<tr><td colspan="4">2.Backlight not light up, or wrong lighting color is not acceptable.
3. Acceptance criteria for dark spot, bright spot, and scratch mark shall refer to the spot defect and the line defect of the LCD.4. Uneven brightness in the Viewing Area Zone A is not acceptable. (Refer to the limit sample if applicable).
5.Light leak is not acceptable in main viewing direction. (Refer to the limit sample if applicable).
6. LCD shall not be lifted after assembly.</td><td rowspan="2">Minor</td><td rowspan="2">Visual</td><td rowspan="2">Out of A</td></tr>
<tr><td colspan="4">7.Backlight reflecting film can't separate with BL.</td></tr>
<tr><td>Label Printing</td><td colspan="4">1.Label printing must clearly visible; fuzzy printing missing printing and pin hole are not allowed.
2.Date label on LCD cannot be more than 1mm over the BC edge and cannot seen after assembly</td><td>Minor</td><td>Visual</td><td>Out of A</td></tr>
<tr><td rowspan="2">The product shall be free of dirt.</td><td colspan="4">1.The outer dimension shall meet the specification the drawing.</td><td>Major</td><td>caliper</td><td>Out of A</td></tr>
<tr><td colspan="4">2.The product shall be free of dirt.</td><td>Minor</td><td>Visual</td><td>Out of A</td></tr>
</table>

12.0 ENVIRONMENTAL SPECIFICATION

This product is designed, manufactured and compliant to below RoHS standard:

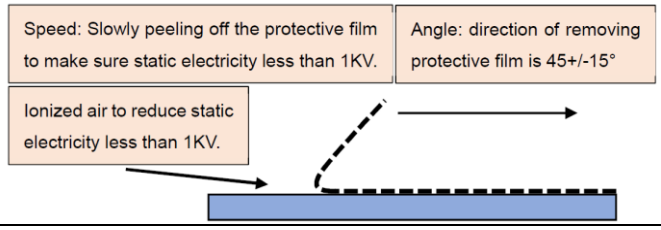
1. Cadmium and Cadmium Compounds Less than 100ppm
2. Hexavalent Chromium Compounds Less than 1000ppm
3. Lead and Lead Compounds Less than 1000ppm
4. Mercury and Mercury Compounds Less than 1000ppm

5. Polybrominated Biphenyls (PBBs)	Less than 1000ppm
6. Polybrominated Diphenyl ethers (PBDEs)	Less than 1000ppm
7. Butyl benzyl phthalate (BBP)	Less than 1000ppm
8. Bis (2-ethylhexyl)phthalate (DEHP)	Less than 1000ppm
9. Dibutyl phthalate (DBP)	Less than 1000ppm
10. Diisobutyl phthalate(DIBP)	Less than 1000ppm

13.0 GENERAL PRECAUTIONS FOR USING LCD MODULES

<table>
<tr><th>Handling Precaution</th><th>Operation Precautions</th></tr>
<tr><td>
• No strong mechanical shock. LCD may be broken because it is made out of glass.
• Do not work on PCB. PCB may be cracked or damaged.
• Do not bend or process metal bezel positioning tab. LCD maybe shifted and LCD-PCB interconnection may be damaged,
• Do not scratch. Polarizer is soft material and can be easily scratched.
• Liquid crystal may leak when LCD/LCM is broken. Please wash your hands if you touch the liquid crystal.
• Wear gloves when handling LCD/LCM to avoid damage to LCD/LCM. Please do not touch electrodes with bare hands to avoid any contamination on connection.
</td><td rowspan="3">
• Viewing angle can be adjusted by varying driving voltage, V_0 or Vop.
• Display performance may vary or show abnormal electro-optical performance when viewed at angle beyond the specified viewing angle range.
• Display color may change under extreme temperature. This is not destructive symptom and display color will resume back to normal when temperature goes back to normal temperature.
• Driving voltage shall be kept within the specified range as stated in this product specification. Over-voltage may shorten the LCD/LCM lifetime.
• No DC voltage to LCD/LCM. Electrical characteristics and reliability of LCD/LCM will deteriorate under DC. Please control the DC content in application driving circuit.
• Avoid using the same display pattern for long time (continuous ON segment). It is a normal phenomena observed for passive driven display where image retention is observed when LCD is displayed with same pattern over 1 hour under temperature > 55^{o}C. Customer is advised to design application software where display pattern will be changed from time to time, or using the N-line inversion function comes with the display driver IC.
• If the LCM is using master-slave configuration, customer is strongly recommended to use external Vo.
• If the LCM comes with MTP/OTP function, customer is recommended to use this MTP/OTP function for the best optical performance.
</td></tr>
<tr><th>Soldering Precaution on LCD/LCM</th></tr>
<tr><td>
• Use soldering iron with proper grounding and no AC leakage.
• Temperature at tip of soldering iron: 330±10^{o}C
• Type of solder: lead-free solder with resin flux fill.
• Soldering time: < 3sec.
• Soldering on LCD/LCM I/O terminal only.
• Do not apply force on the LCD metal pin when soldering. Metal pin connection to LCD terminal will be damaged or loosen by this external force under soldering temperature.
• Do not solder and de-solder for more than 3 times because metal pin connection or soldering pads will be damaged.
</td></tr>
<tr><th>Static Electricity</th><th>FPC cleanness</th></tr>
</table>

- Avoid static electricity. Please have proper ESD control and ground the human body and any electrical tools when assembling the LCD/LCM.
- Static electricity will be generated when peeling the protective film. It is a normal behavior that LCD/LCM will response to the static charges generated and will resume back to normal condition slowly. Peeling off the protective film in a correct way is very important to reduce the static electricity and its influence on LCD/LCM. It's recommended that the static electricity is controlled less than 1KV by using ion fan and peeling off protective film slowly and in 45° angle, etc.



- If ACF bonding is applied at customer side between FPC and PCB, cleaning on FPC and PCB bonding area (just before bonding) is a must to reduce risk of bonding reliability (eg bonding delamination/spring back phenomenon, low pull strength etc)

Long-term Storage Conditions

- Store LCD/LCM in dark area and keep LCD/LCM away from direct sunlight and fluorescent light.
- Store LCD/LCM under temperature range of 0~35°C and room humidity of 50~60%RH.
- Possible Vop adjustment might be needed at customer side after prolong storage over 1 year from date of manufacturing.

14.0 APPENDIX

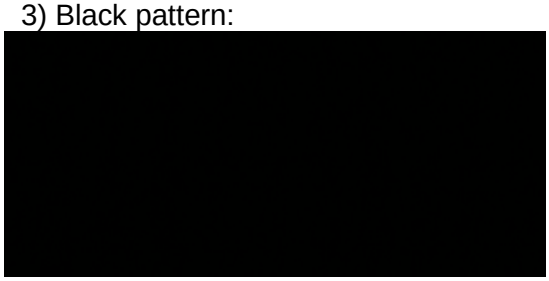
14.1 Functional testing pattern

Below test patterns will be used at all LCM functional tests at mass production stage. Acceptance of a product during inspection will be judged based on these test patterns only. Customer should notify Display Elektronik GmbH if different test patterns being used at customer side to ensure same testing platform between Customer and Display Elektronik GmbH, especially on those defects (flickering, image sticking, cross-talk, black/white line) which are pattern-dependent. These test patterns are by default agreed by both Customer and Display Elektronik GmbH, unless notified by Customer to revise such test patterns. If the defect listed in above description is seen in below pattern, LCD module should be judged as NG and vice versa.

1) Picture1:

2) White pattern:

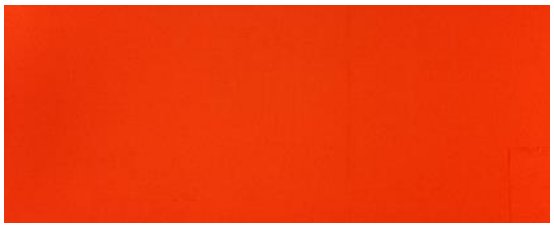
3) Black pattern:

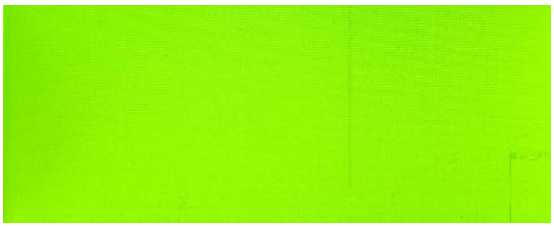


4) Gray scale pattern:

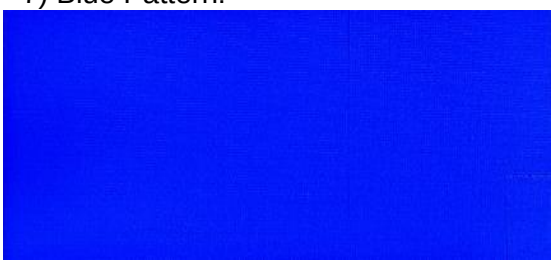
5) Red pattern:

6) Green pattern:





7) Blue Pattern:



8) Picture2: