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# **4DLCD-28320240-IPS-[RTP/CTP]**

## **2.8" TFT Liquid Crystal Display**

# **DATASHEET**

**Document Date: 24<sup>th</sup> June 2021**

**Document Revision: 1.3**

## Revision History

REVISION	DATE	COMMENT	REMARKS
1.0	01/07/2019	Initial Version	Initial Version
1.1	28/08/2020	Minor Updates / Fixes	
1.2	14/06/2021	Minor Updates	
1.3	24/06/2021	Added logic current consumption data, added backlight circuit example	

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## 1. General Specification

4DLCD-28320240-IPS is a colour active matrix LCD module incorporating amorphous silicon IPS TFT (Thin Film Transistor). It is composed of a colour IPSTFT-LCD panel, driver IC, FPC and a backlight unit and with/without a Resistive/Capacitive Touch Panel (RTP/CTP). The module display area contains 240 x 320 pixels. This product accords with RoHS environmental criterion.

ITEM		CONTENTS	UNIT
LCD Type		TFT / Transmissive / IPS	
Size		2.8	Inch
Viewing Direction		ALL	
Display Mode		Normally Black	
LCD (W × H)		50.00 x 69.20	mm
Active Area (W × H)		43.20× 57.60	mm
Dot Pitch (W × H)		0.180 × 0.180	mm
Number of Dots (Pixels)		240 (RGB) × 320	
Driver IC		ILI9341V	
Backlight Type		4 LEDs	
Surface Luminance	4DLCD-28320240-IPS	300 (typical)	cd/m <sup>2</sup>
	4DLCD-28320240-IPS-RTP	250 (typical)	
	4DLCD-28320240-IPS-CTP	280 (typical)	
Interface Type		MCU-16bit /SPI	
Color Depth		262K	
Pixel Arrangement		RGB Vertical Stripe	
Surface Treatment		AG	
Input Voltage		2.8 (typical)	V
With/Without TP (Touch Panel)		4DLCD-28320240-IPS - Without Touch Panel	
		4DLCD-28320240-IPS-RTP - With Resistive Touch	
		4DLCD-28320240-IPS-CTP – With Capacitive Touch	
Weight	4DLCD-28320240-IPS	13.0	g
	4DLCD-28320240-IPS-RTP	20.0	
	4DLCD-28320240-IPS-CTP	21.4	

**Note 1:** RoHS compliant

**Note 2:** LCD weight tolerance: ± 5%.

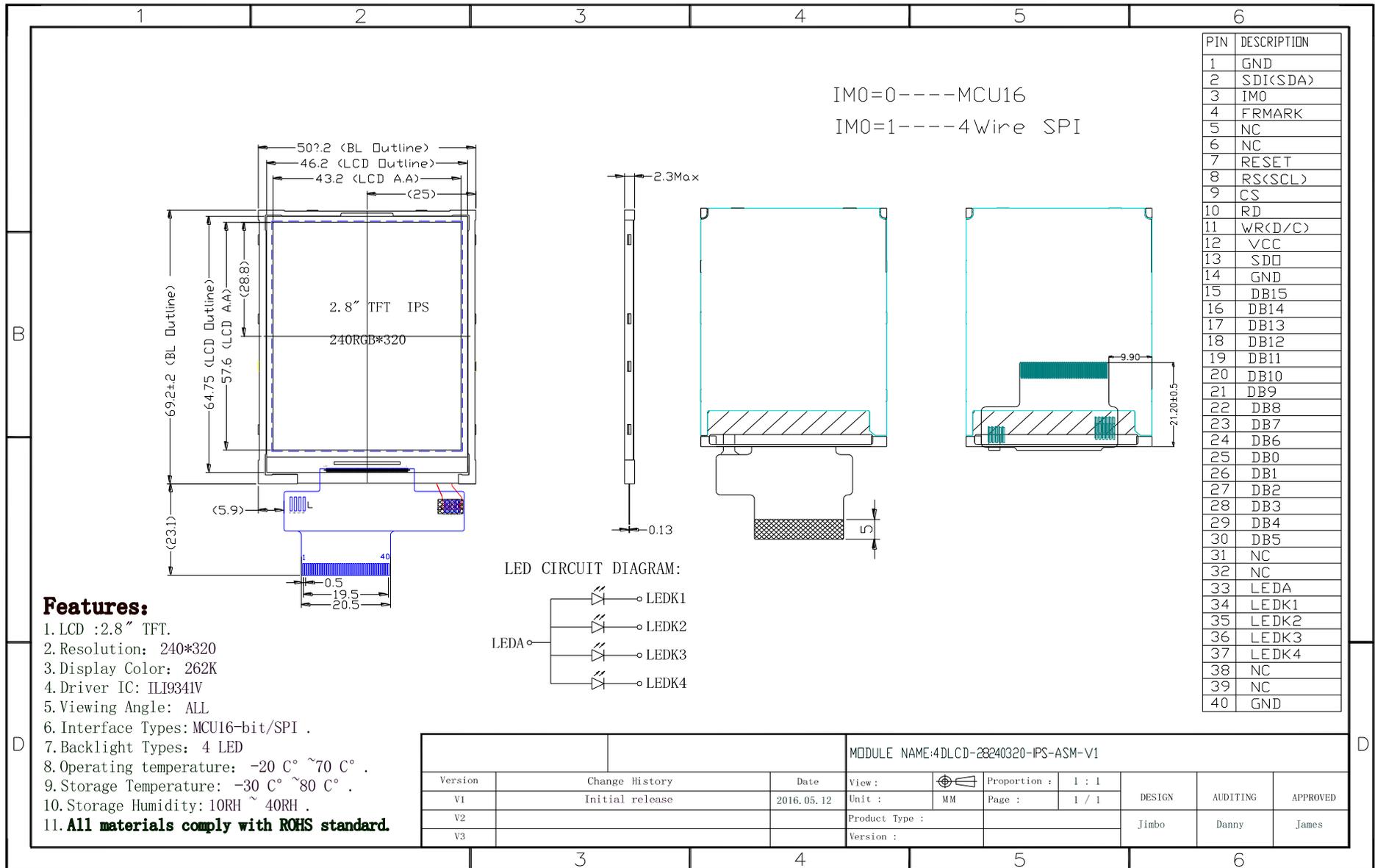
### Part Number Details:

4DLCD      4DLCD LCD Display  
 28320240    2.8-inch, 240 x 320 Resolution  
 IPS         In-plane Switching  
 RTP         Resistive Touch  
 CTP         Capacitive Touch



## 2. TFT LCD Display Drawing (Non Touch Version)

TFT LCD 4DLCD-28320240-IPS-[RTP/CTP]

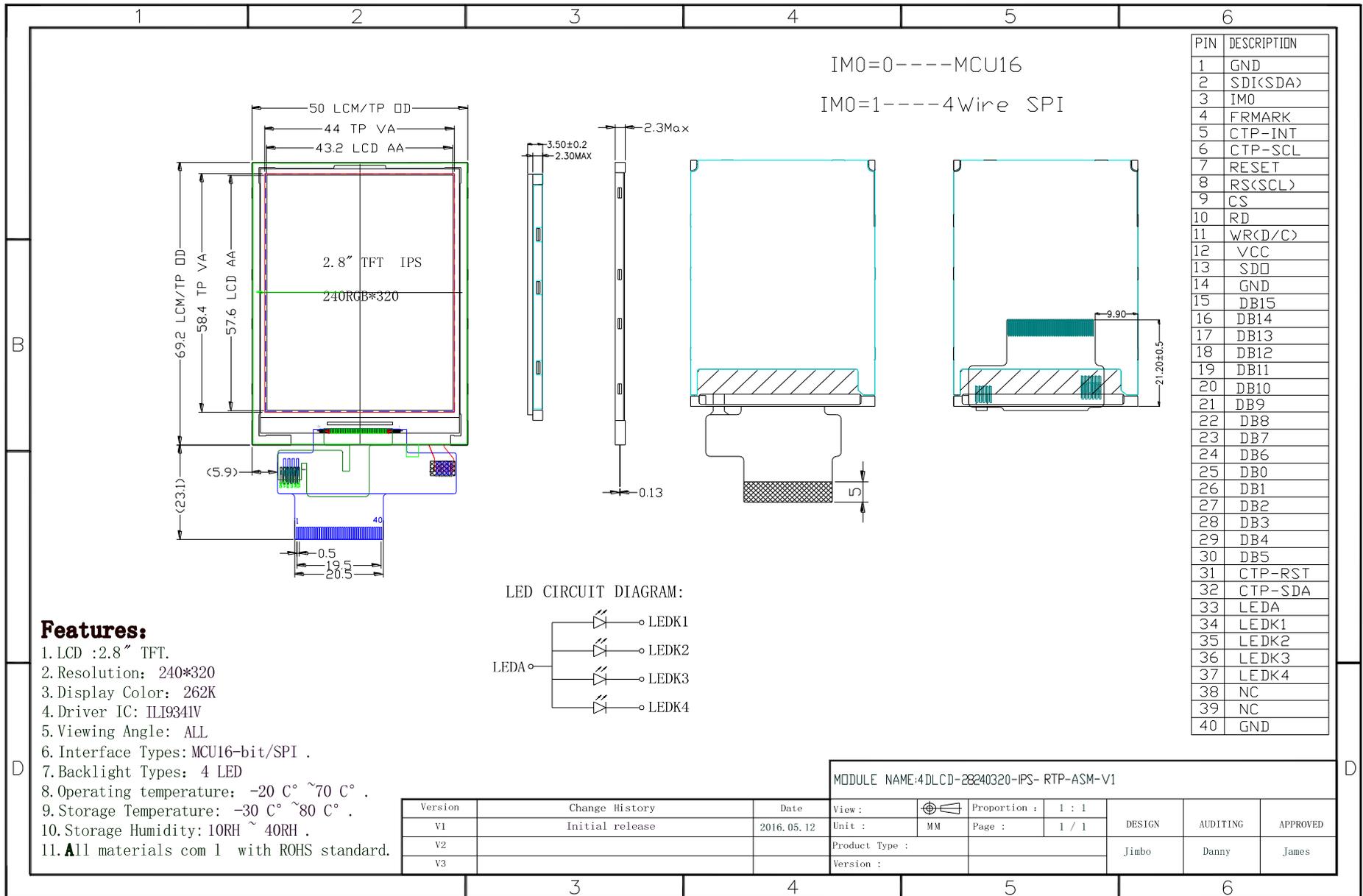


**Features:**

1. LCD :2.8" TFT.
2. Resolution: 240\*320
3. Display Color: 262K
4. Driver IC: ILI934IV
5. Viewing Angle: ALL
6. Interface Types: MCU16-bit/SPI .
7. Backlight Types: 4 LED
8. Operating temperature: -20 C° ~70 C° .
9. Storage Temperature: -30 C° ~80 C° .
10. Storage Humidity: 10RH ~ 40RH .
11. All materials comply with ROHS standard.

Version			Change History		Date	View :			Proportion : 1 : 1		DESIGN			AUDITING			APPROVED		
V1			Initial release		2016.05.12	Unit : MM			Page : 1 / 1		Jimbo			Danny			James		
V2						Product Type :													
V3						Version :													

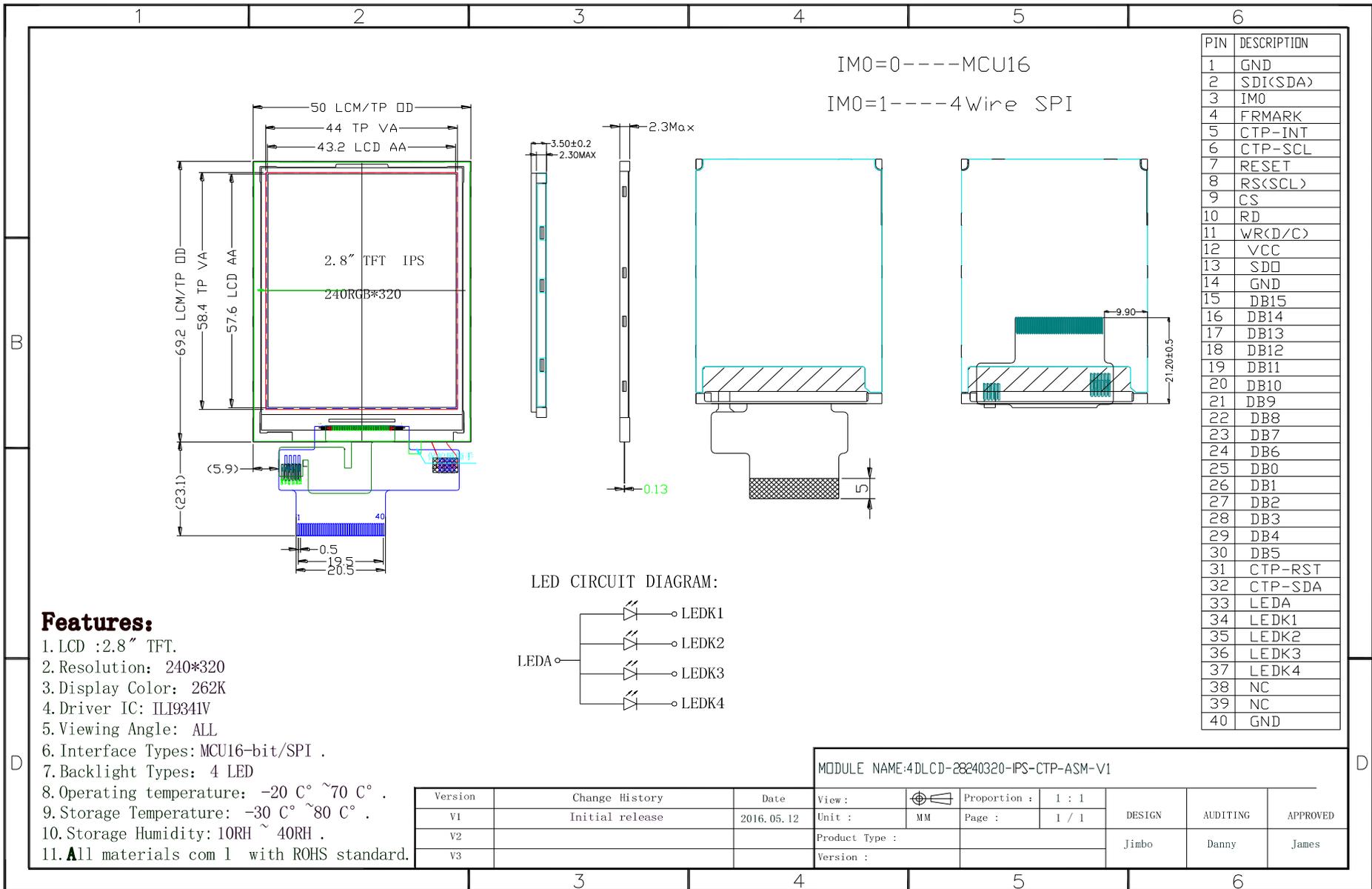
### 3. TFT LCD Display Drawing (Resistive Touch Version)



**Features:**

1. LCD :2.8" TFT.
2. Resolution: 240\*320
3. Display Color: 262K
4. Driver IC: ILI934IV
5. Viewing Angle: ALL
6. Interface Types: MCU16-bit/SPI .
7. Backlight Types: 4 LED
8. Operating temperature: -20 C° ~70 C° .
9. Storage Temperature: -30 C° ~80 C° .
10. Storage Humidity: 10RH ~ 40RH .
11. All materials com 1 with ROHS standard.

### 4. TFT LCD Display Drawing (Capacitive Touch Version)



## 5. Absolute Maximum Ratings

PARAMETER	SYMBOL	MIN	MAX	UNIT
Supply Voltage for LCD Logic	VDD/VCC	-0.3	4.6	V
Input Voltage for Logic	V <sub>IN</sub>	VSS-0.5	VDD	V
LED forward current (each LED)	I <sub>F</sub>	-	25	mA
Operating Temperature	T <sub>OP</sub>	-20	70	°C
Storage Temperature	T <sub>ST</sub>	-30	80	°C
Humidity	RH	-	90% (Max 60°C)	RH

## 6. Electrical Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Power Voltage (Logic)	VDD/DCC	2.6	2.8	3.3	V
Input Current (Logic)	I <sub>VDD</sub>	-	13	-	mA
Input Voltage 'H' Level	V <sub>IH</sub>	0.7 VDD	-	VDD	V
Input Voltage 'L' Level	V <sub>IL</sub>	0	-	0.3 VDD	V

## 7. Electro-Optical Characteristics

ITEM	SYM	CONDITION	MIN	TYP	MAX	UNIT	REMARK
Response Time	Tr+Tf	$\theta=0$	-	30	-	ms	Figure 1 (4)
Contrast Ratio	Cr	°	-	800	-	-	Figure 2 (1)
Luminance Uniformity	$\delta$ WHITE	$\phi=0$	-	60	-	%	Figure 2 (3)
Surface Luminance	Lv	4DLCD-28320240-IPS	-	300	-	cd/m <sup>2</sup>	Figure 2 (2)
		4DLCD-28320240-IPS-RTP	-	250	-		
		4DLCD-28320240-IPS-CTP	-	280	-		
Viewing Angle Range	$\theta$	$\phi = 90^\circ$	-	80	-	deg	Figure 3 (6)
		$\phi = 270^\circ$	-	80	-	deg	
		$\phi = 0^\circ$	-	80	-	deg	
		$\phi = 180^\circ$	-	80	-	deg	
CIE (x,y) Chromacity	Red	x	$\theta=0^\circ$ $\phi=0^\circ$ Ta=25	-0.02	+0.02		Figure 2 (5)
		y					
	Green	x					
		y					
	Blue	x					
		y					
	White	x					
		y					

## 8. Backlight Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Voltage for LED backlight (Each LED)	$V_i$	-	3.2	3.4	V
Current for LED backlight (Each LED)	$I_{i\text{-each}}$	-	20	25	mA
Current for LED backlight (Total – 4 LED's)	$I_i$	-	80	100	mA
LED Life Time (50% of original brightness)	-	30000	-	-	Hrs

**Note:** The LED life time is defined as the module brightness decrease to 50% original brightness at  $T_a=25^\circ\text{C}$ .

**Note 1:** Contrast Ratio(CR) is defined mathematically as below, for more information see Figure 1.

$$\text{Contrast Ratio} = \frac{\text{Average Surface Luminance with all white pixels (P1, P2, P3, P4, P5)}}{\text{Average Surface Luminance with all black pixels (P1, P2, P3, P4, P5)}}$$

**Note 2:** Surface luminance is the LCD surface from the surface with all pixels displaying white. For more information, see Figure 2.

$L_v$  = Average Surface Luminance with all white pixels (P1, P2, P3, P4, P5)

**Note 3:** The uniformity in surface luminance  $\delta$  WHITE is determined by measuring luminance at each test position 1 through 5, and then dividing the maximum luminance of 5 points luminance by minimum luminance of 5 points luminance. For more information, see Figure 2.

$$\delta \text{ WHITE} = \frac{\text{Minimum Surface Luminance with all white pixels (P1, P2, P3, P4, P5)}}{\text{Maximum Surface Luminance with all white pixels (P1, P2, P3, P4, P5)}}$$

**Note 4:** Response time is the time required for the display to transition from white to black (Rise Time,  $T_r$ ) and from black to white (Decay Time,  $T_f$ ). For additional information see FIG 1. The test equipment is Autronic-Melchers ConoScope series.

**Note 5:** CIE (x, y) chromaticity, the x, y value is determined by measuring luminance at each test position 1 through 5, and then make average value.

**Note 6:** Viewing angle is the angle at which the contrast ratio is greater than 2. For TFT module the contrast ratio is greater than 10. The angles are determined for the horizontal or x axis and the vertical or y axis with respect to the z axis which is normal to the LCD surface. For more information, see Figure3.

**Note 7:** For viewing angle and response time testing, the testing data is based on Autronic-Melchers ConoScope series. Instruments for Contrast Ratio, Surface Luminance, Luminance Uniformity, CIE the test data is based on TOPCONs BM-5 photo detector.

Figure 1. The definition of response time

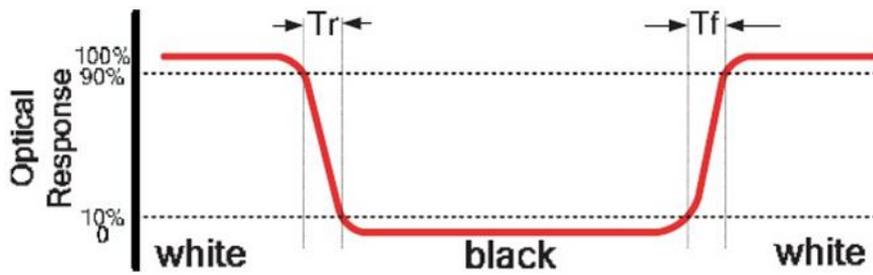


Figure 2. Measuring method for Contrast ratio, surface luminance, Luminance uniformity, CIE (x, y) chromaticity

A : 5 mm  
 B : 5 mm  
 H, V : Active Area  
 Light spot size  $\varnothing=5\text{mm}$ , 500mm distance from the LCD surface to detector lens  
 measurement instrument is TOPCON's luminance meter BM-5

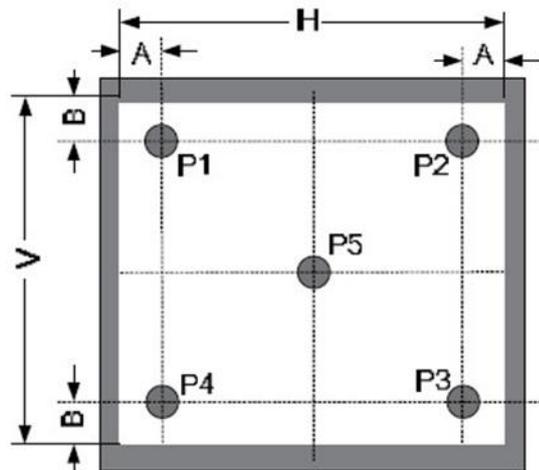
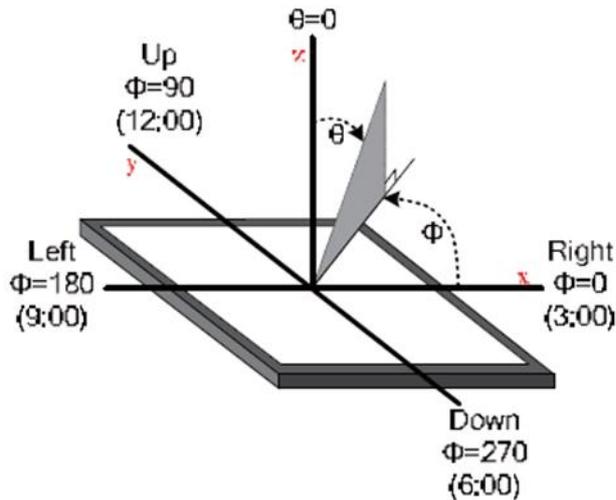


Figure 3. The definition of viewing angle



## 9. Interface Descriptions

### 9.1 LCD Interface

PIN NO.	SYMBOL	DESCRIPTION	REMARK
1	GND	Ground	
2	GND/(SDI)	Ground for MCU mode/Serial Data Input signal for SPI mode	
3	MODE	MCU-16bit / SPI mode selection pin	Note 1
4	FMARK	Tearing effect output signal	
5	YD/CTP_INT	The touch panel Y bottom pin for RTP / Interrupt signal from CTP/No Connection (NC) for Non touch Version	Note 3
6	XL/CTP_SCL	The touch panel X left pin for RTP/ I2C SCL for CTP / No Connection (NC) for Non touch Version	Note 3
7	RESET	Reset input signal	
8	RS/SCL	Instruction Register/Data Register selection pin for MCU mode / SPI Serial Clock for SPI mode	
9	CS	Chip select input pin	
10	RD/(VCC)	Read signal for MCU mode / Tie to VCC for SPI mode	
11	WR/(D/C)	Write signal for MCU mode / Data or Command selection for SPI mode	
12	VCC	Power supply (Logic)	
13	NC/(SDO)	No Connect for MCU mode / Serial Data Output for SPI mode	
14	GND	Ground	
15	DB15/(GND)	Databus DB15 for MCU mode / Tie to GND for SPI mode	Note 2
16	DB14/(GND)	Databus DB14 for MCU mode / Tie to GND for SPI mode	Note 2
17	DB13/(GND)	Databus DB13 for MCU mode / Tie to GND for SPI mode	Note 2
18	DB12/(GND)	Databus DB12 for MCU mode / Tie to GND for SPI mode	Note 2
19	DB11/(GND)	Databus DB11 for MCU mode / Tie to GND for SPI mode	Note 2
20	DB10/(GND)	Databus DB10 for MCU mode / Tie to GND for SPI mode	Note 2
21	DB9/(GND)	Databus DB9 for MCU mode / Tie to GND for SPI mode	Note 2
22	DB8/(GND)	Databus DB8 for MCU mode / Tie to GND for SPI mode	Note 2
23	DB7/(GND)	Databus DB7 for MCU mode / Tie to GND for SPI mode	Note 2
24	DB6/(GND)	Databus DB6 for MCU mode / Tie to GND for SPI mode	Note 2
25	DB0/(GND)	Databus DB0 for MCU mode / Tie to GND for SPI mode	Note 2
26	DB1/(GND)	Databus DB1 for MCU mode / Tie to GND for SPI mode	Note 2
27	DB2/(GND)	Databus DB2 for MCU mode / Tie to GND for SPI mode	Note 2
28	DB3/(GND)	Databus DB3 for MCU mode / Tie to GND for SPI mode	Note 2
29	DB4/(GND)	Databus DB4 for MCU mode / Tie to GND for SPI mode	Note 2
30	DB5/(GND)	Databus DB5 for MCU mode / Tie to GND for SPI mode	Note 2
31	YU/CTP_RST	The touch panel Y up pin for RTP / Reset pin for CTP / No Connection (NC) for Non touch Version	Note 3
32	XR/CTP_SDA	The touch panel X right pin for RTP / I2C SDA Pin for CTP / No Connection (NC) for Non touch Version	Note 3
33	LEDA	Anode of LED Backlight	
34	LEDK1	Cathode1 of LED Backlight	
35	LEDK2	Cathode2 of LED Backlight	
36	LEDK3	Cathode3 of LED Backlight	
37	LEDK4	Cathode4 of LED Backlight	
38	NC	No Connect	
39	NC	No Connect	
40	GND	Ground	

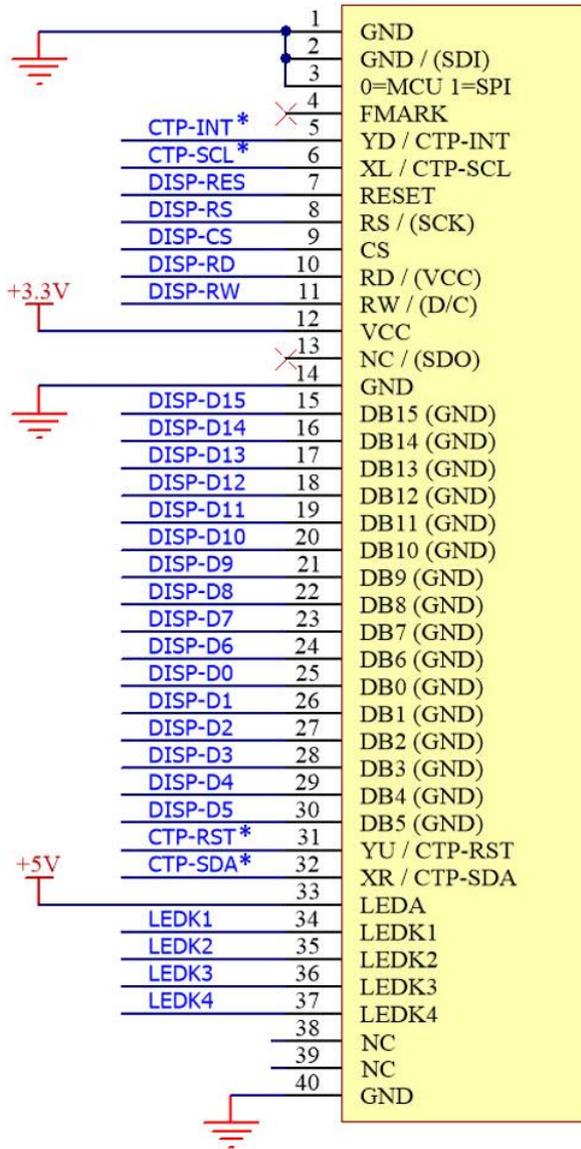
Recommended LCD connector: 40-way, 0.5 mm pitch FFC connector

**Note 1:** Interface Mode Selection (pin 3)

Value	Interface	Remark
0	MCU 16bit	Databus: DB0~DB15
1	SPI	4 wire SPI mode

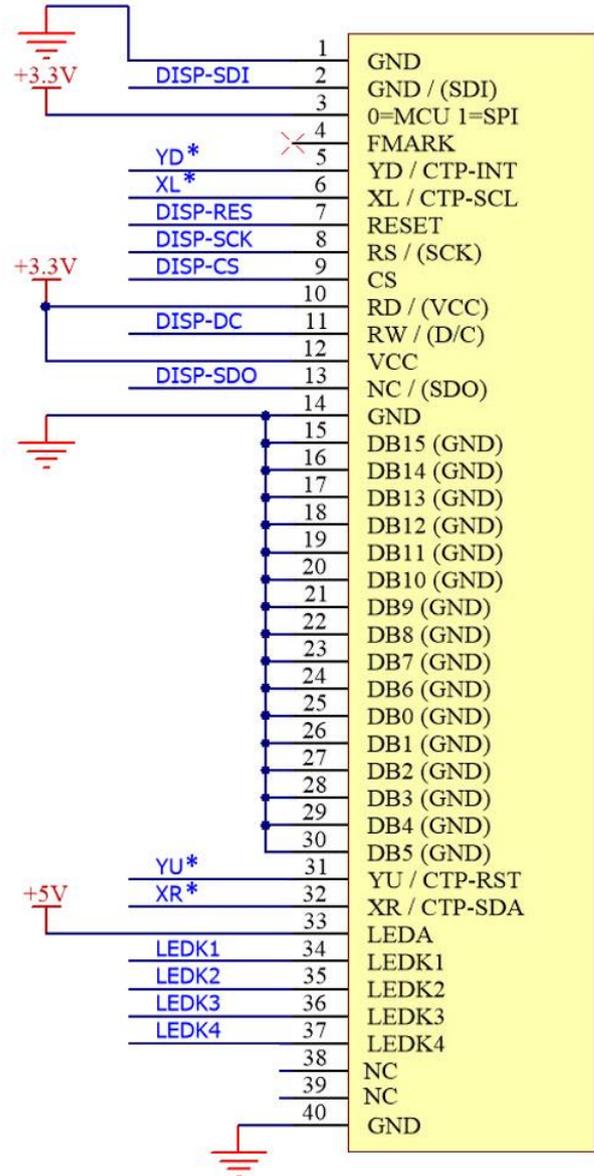
**Note 2:** Pins 15 to 30 are grounded on SPI mode.

**Note 3:** Pins 5,6,31 and 32 are only applicable to touch screen displays (4DLCD-xxxxxxx-RTP).



\* This has no connection (NC) for Non-touch displays

MCU Mode



\* This has no connection (NC) for Non-touch displays

SPI Mode

## 9.2 CTP Interface

The Capacitive Touch is driven by a **Focaltech FT6336** capacitive touch driver IC, which utilizes an I2C interface, and is capable of 1-point touch.

## 10. Backlight Example Circuit

The backlight circuit can be easily driven off a 5V supply. The voltage needs to be higher than the forward voltage of the LED's and other drops in the circuit, which can be found in section 9. A 3.3V supply typically does not meet this requirement, so a 5V supply is normally used.

In this circuit, a simple transistor is used to switch each of the LED's on, where each LED is current limited through its own resistor. The transistor base can be PWM'ed if required (Label BACKLIGHT below), to give dimming control. An example PWM frequency that could be used is 3Khz, however it is up to the Designer to determine what is suitable for the application.

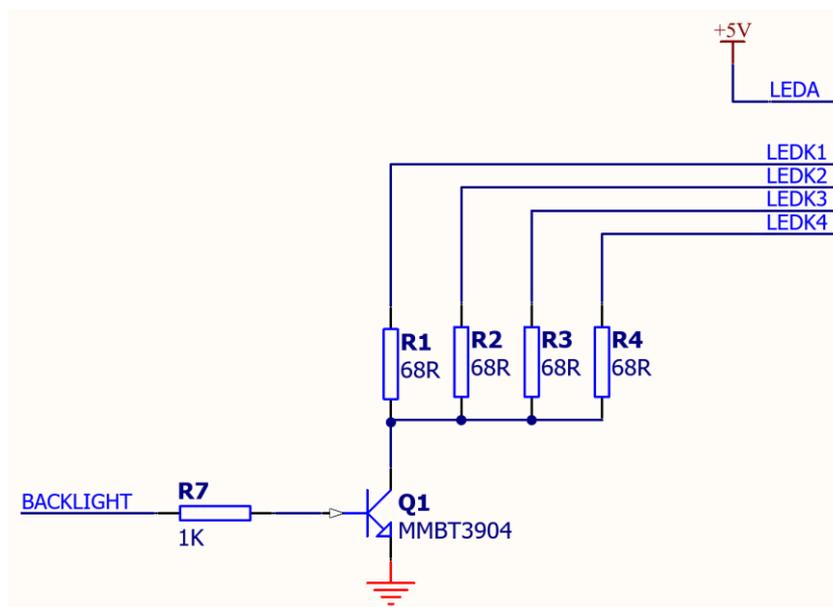
The resistance feeding each LED can be calculated using Ohms Law,  $V=I \cdot R$ . We want to calculate R, so  $R=V/I$   
Supply Voltage = 5V

LED Forward Voltage = 3.2V (see section 9)

Estimated voltage drop over transistor = 0.3V

Target current per LED = 20mA to 25mA (use 22mA in this example) (See section 9)

Formula is then  $R = (5V - 3.2V - 0.3V) / 0.022A = 68\text{ohms}$  for each LED (LEDK1 to LEDK4)



## 11. Initialisation Code

```

RST=1;
    Delay(200);
    RST=0;
    Delay(800);
    RST=1;
    Delay(800);

//***** Start Initial Sequence *****
WriteComm(0xCF);
WriteData(0x00);
WriteData(0xAA);
WriteData(0xE0);
WriteComm(0xED);
WriteData(0x67);
WriteData(0x03);
WriteData(0x12);
WriteData(0x81);
WriteComm(0xE8);
WriteData(0x8A);
WriteData(0x01);
WriteData(0x78);
WriteComm(0xCB);
WriteData(0x39);
WriteData(0x2C);
WriteData(0x00);
WriteData(0x34);
WriteData(0x02);
WriteComm(0xF7);
WriteData(0x20);
WriteComm(0xEA);
WriteData(0x00);
WriteData(0x00);
WriteComm(0xC0); //Power control
WriteData(0x23); //VRH[5:0]
WriteComm(0xC1); //Power control
WriteData(0x11); //SAP[2:0];BT[3:0]
WriteComm(0xC5); //VCM control
WriteData(0x43);
WriteData(0x4c);

WriteComm(0xC7); //VCM control2
WriteData(0xA0);
WriteComm(0x36); // Memory Access Control
WriteData(0x48);
WriteComm(0x3A); // Memory Access Control
WriteData(0x05);
WriteComm(0xB6); //Set Gamma
WriteData(0x0A);
WriteData(0x02);
WriteComm(0xF2); // 3Gamma Function Disable
WriteData(0x00);
WriteComm(0x26); //Gamma curve selected
WriteData(0x01);
WriteComm(0xE0);
    WriteData( 0x1f); //p1 //0f
    WriteData( 0x36); //p2 //30

```

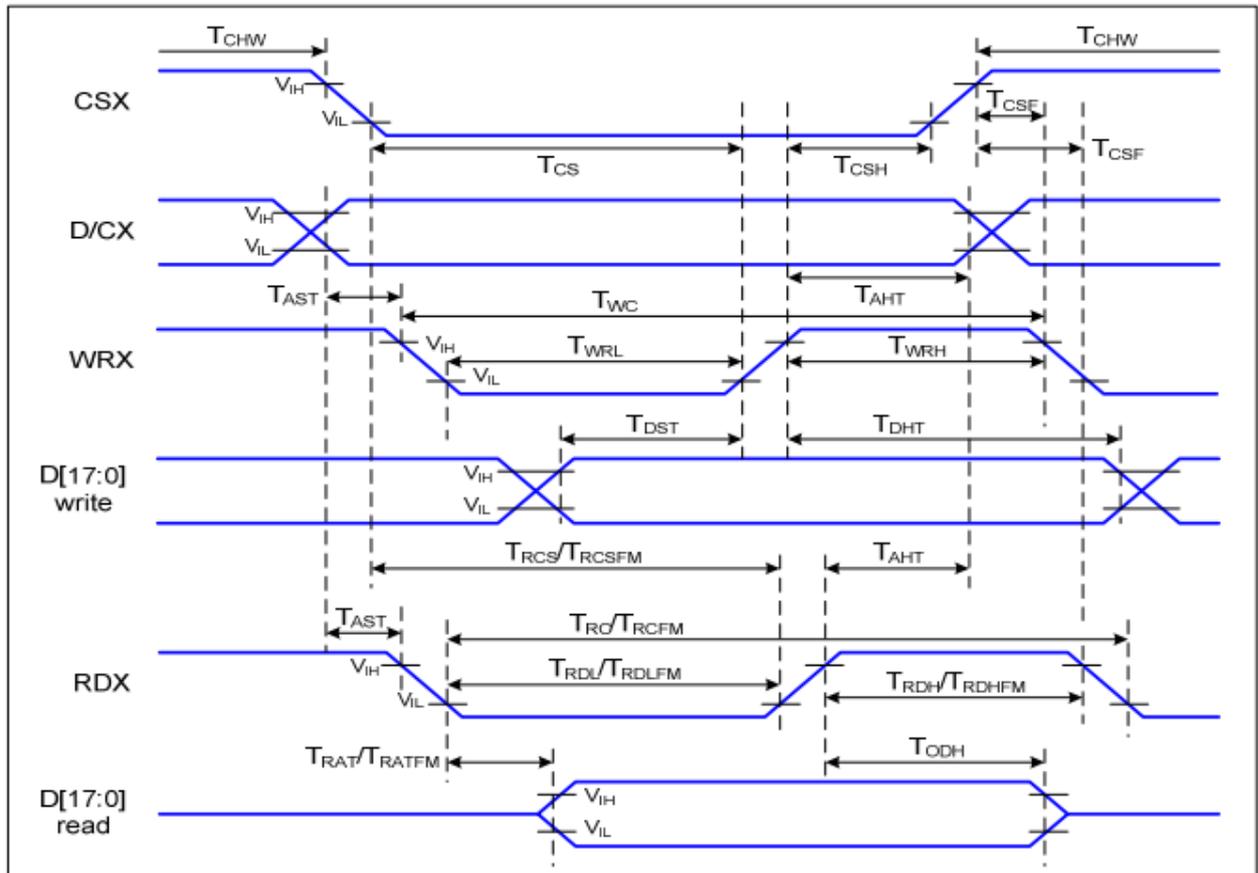
```
WriteData( 0x36);//p3
WriteData( 0x3A);//p4
WriteData( 0x0C);//p5
WriteData( 0x05);//p6
WriteData( 0x4F);//p7
WriteData( 0x87);//p8
WriteData( 0x3C);//p9
WriteData( 0x08);//p10
WriteData( 0x11);//p11
WriteData( 0x35);//p12
WriteData( 0x19);//p13
WriteData( 0x13);//p14
WriteData( 0x00);//p15
WriteComm(0xE1);
WriteData( 0x00);//p1
WriteData( 0x09);//p2
WriteData( 0x09);//p3
WriteData( 0x05);//p4
WriteData( 0x13);//p5
WriteData( 0x0A);//p6
WriteData( 0x30);//p7
WriteData( 0x78);//p8
WriteData( 0x43);//p9
WriteData( 0x07);//p10
WriteData( 0x0E);//p11
WriteData( 0x0A);//p12
WriteData( 0x26);//p13
WriteData( 0x2C);//p14
WriteData( 0x1f);//p15
WriteComm(0x11); //Exit Sleep
Delay(120);
WriteComm(0x21);
WriteComm(0x29); //Display on
```

## 12. LCD Timing Details

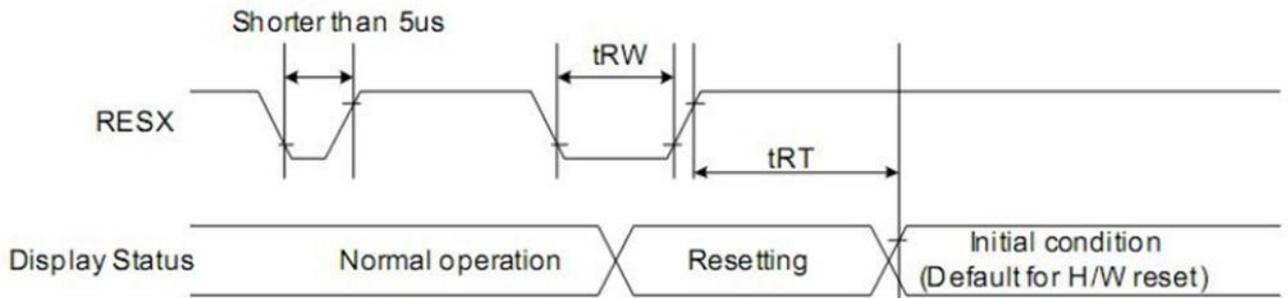
### 12.1 Timing Chart

SIGNAL	SYMBOL	PARAMETER	MIN	MAX	UNIT	DESCRIPTION
DCX	tast	Address setup time	0	-	ns	-
	taht	Address hold time (Write/Read)	10	-	ns	-
CSX	tchw	CSX "H" pulse width	0	-	ns	-
	tcs	Chip Select setup time	15	-	ns	-
	trcs	Chip Select setup time (Read ID)	45	-	ns	-
	trcsfm	Chip Select setup time (Read FM)	355	-	ns	-
	tcsf	Chip Select Wait time (Write/Read)	10	-	ns	-
WRX	twc	Write cycle	66	-	ns	-
	twrh	Write Control Pulse H duration	15	-	ns	-
	twrl	Write Control Pulse L duration	15	-	ns	-
RDX(FM)	trcfm	Read cycle (FM)	450	-	ns	-
	trdhfm	Read Control Pulse H duration (FM)	90	-	ns	-
	trdlfm	Read Control Pulse L duration (FM)	355	-	ns	-
RDX(ID)	trc	Read cycle (ID)	160	-	ns	-
	trdh	Read Control Pulse H duration	90	-	ns	-
	trdl	Read Control Pulse L duration	45	-	ns	-
D[17:0]	tdst	Write data setup time	10	-	ns	-
	tdht	Write data hold time	10	-	ns	-
	trat	Read access time	-	40	ns	-
	Tratfm	Read access time	-	340	ns	-
	trod	Read output disable time	20	80	ns	-

Timing parameter (VDD=3.3V, GND=0V, Ta=25°C)



## 12.2 Reset Timing



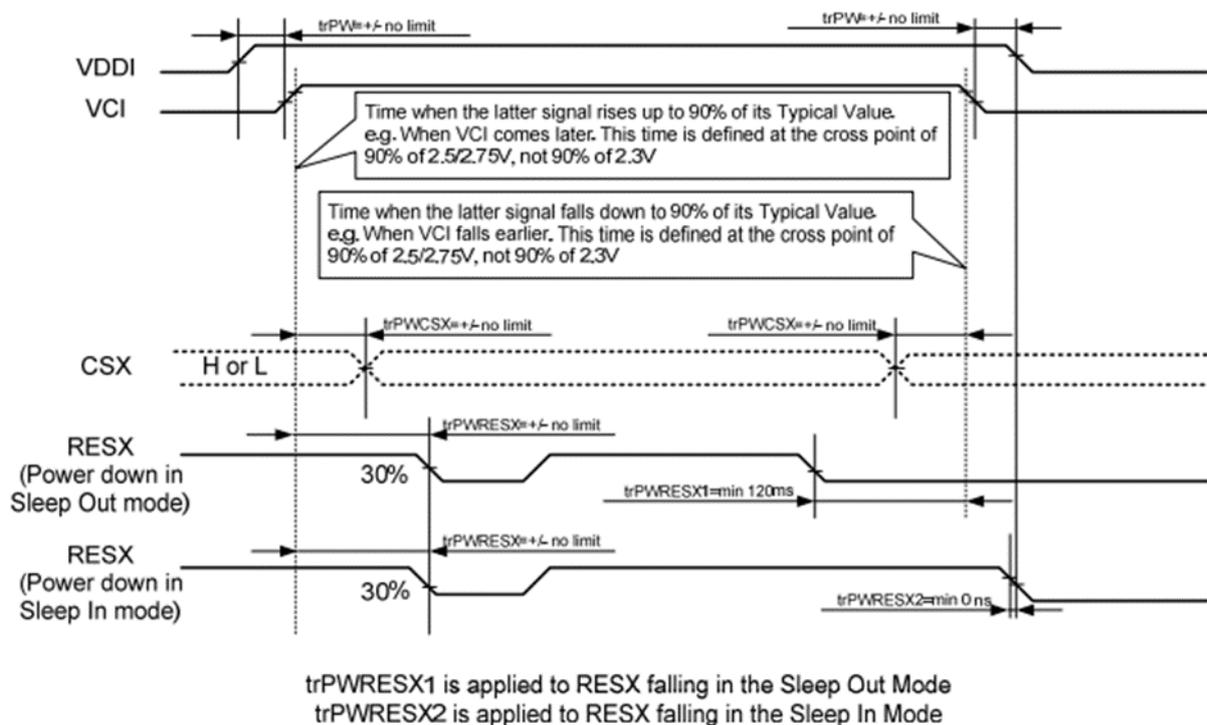
SIGNAL	SYMBOL	PARAMETER	MIN	MAX	UNIT
RESET	$t_{RW}$	Reset low pulse width	10	-	us
	$t_{RT}$	Reset complete time	-	5 (note1)	ms
			-	120 (note2)	ms

**Note 1:** When reset applied during SLPIN mode

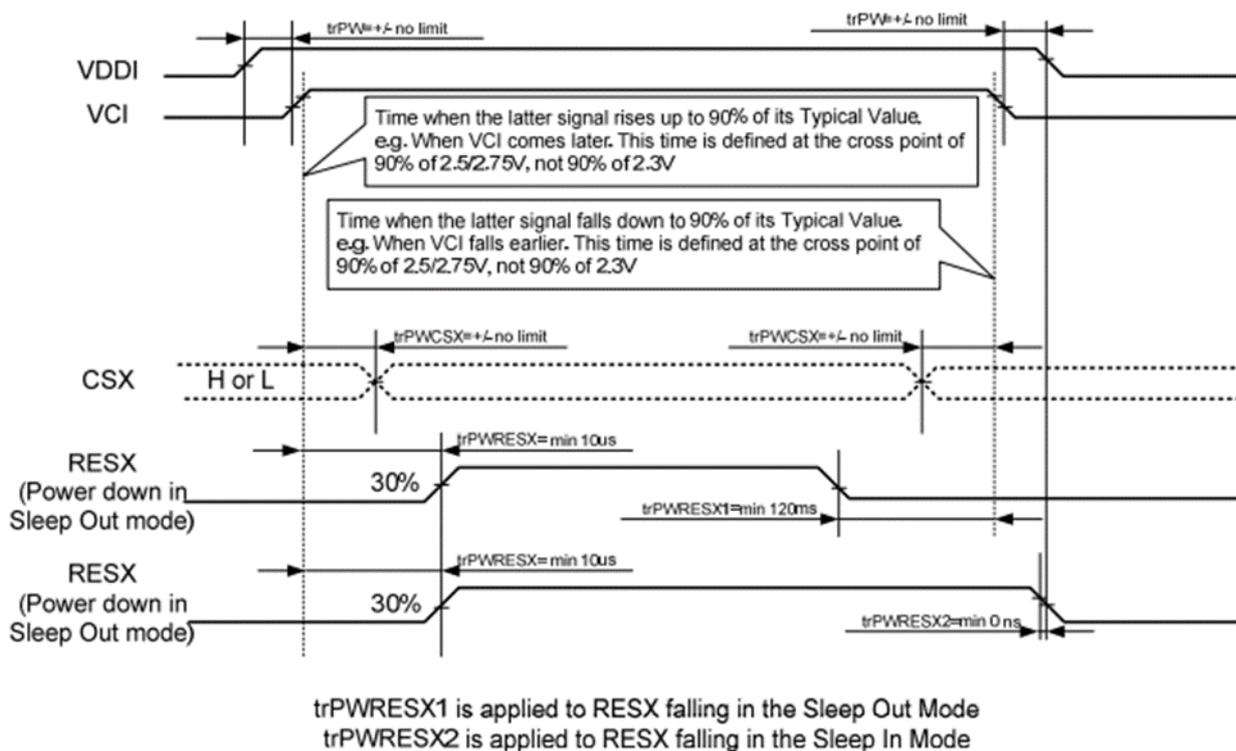
**Note 2:** When reset applied during SLPOUT mode.

## 12.3 Power On Sequence

### 12.3.1 Case 1 - RES line is held High or Unstable by Host at Power ON



### 12.3.2 Case 2 - RES line is held Low by Host at Power ON



### 12.4 Power-off Sequence - Uncontrolled Power Off

Uncontrolled power off is a situation where power is removed unexpectedly, e.g. a battery powering a device is disconnected without using the controlled power off sequence. There will not be any damage to the display module, nor will the display module cause any damage to the host. During an uncontrolled power off event, ILI9341V will force the display to blank its content and there will not be any further abnormal visible effects on the display after 1 second of the power being removed. The display will remain blank until the Power On Sequence occurs.

## 13. Reliability Test

No.	SYMBOL	TEST CONDITION	REMARK
1	High Temperature Storage	80°C±2°C 96H Restore 2H at 25°C Power off	After test cosmetic and electrical defects should not happen.
2	Low Temperature Storage	-30°C±2°C 96H Restore 2H at 25°C Power off	
3	High Temperature Operation	70°C±2°C 96H Power on	
4	Low Temperature Operation	-20°C±2°C 96H Power on	
5	High Temperature & Humidity Operation	60°C±2°C 90%RH 96H Power on	
6	Temperature Cycle	-20°C←→25°C←→70°C 30min 5min 30min  After 10 cycles, restore 2H at 25°C Power off	
7	Vibration Test	10Hz~150Hz, 100m/s <sup>2</sup> , 120min	
8	Shock Test	Half-sinewave, 300m/s <sup>2</sup> , 11ms	

**Note:** The Displays are of the highest rated 'Grade A', which allows for 0-4 defective pixels. A defective pixel could be solid Black (Dead), White, Red, Green or Blue.

## 14. Precautions for Using LCD Modules

### 14.1 Handling Precautions

- The display panel is made of glass and polarizer. The glass is fragile. It tends to be chipped during handling especially on the edges. Please avoid dropping or jarring. Please be careful not subject it to a mechanical shock by dropping it on impact.
- If the display panel is damaged and the liquid crystal substance leaks out, be sure not to get any of it in your mouth. If the substance contacts your skin or clothes, wash it off using soap and water.
- Do not apply excessive force to the display surface or to the adjoining areas since this may cause the color tone to vary. Do not touch the display with bare hands. This will stain the display area and degraded insulation between terminals (some cosmetics are determined by the polarizer).
- The polarizer covering the display surface of the LCD module is soft and easily scratched. Handle this polarizer carefully. Do not touch, push or rub the exposed polarizer with anything harder than an HB pencil lead (e.g., glass, tweezers, etc.). Do not put or attach anything on the display area to avoid leaving marks on it. Condensation on the surface and contact with terminals due to cold temperature will damage, stain or contaminate the polarizer. After products are tested at low temperature they must be warmed up in a container before coming into contact with room temperature air.
- If the display surface becomes contaminated, breathe on the surface and gently wipe it with a soft dry cloth. If it is heavily contaminated, moisten the cloth with one of the following solvents
  - Isopropyl alcohol
  - Ethyl alcohol

Do not scrub hard as it might damage the display surface.

- Solvents other than those mentioned above may damage the polarizer. Especially the following.
  - Water
  - Ketone
  - Aromatic solvents

Wipe off saliva or water drops immediately, contact with water over a long period of time may cause deformation or color fading. Avoid contact with oil and fat.

- Take necessary precautions to minimize corrosion of the electrode. Corrosion of the electrodes is accelerated by water droplets, moisture condensation or current flow in a high-humidity environment.
- Install the LCD Module by using the mounting holes. When mounting the LCD module, make sure it is free of twisting, warping and distortion. In particular, do not forcibly pull or bend the I/O cable or the backlight cable.
- Do not attempt to disassemble or process the LCD module.
- NC terminal should be open. Do not connect anything on it.
- If the logic circuit power is off, do not apply input signals.
- Control Electro-Static Discharge. Since this module uses a CMOS LSI, the same careful attention should be paid to electrostatic discharge as for an ordinary CMOS IC. To prevent destruction of the elements by static electricity, ensure that an optimum work environment is maintained.

- Before removing the LCM from its packing case or incorporating it into a set, be sure that the module and your body has the same electric potential. Be sure to ground your body when handling the LCD modules.
- To reduce the amount of static electricity generated, do not conduct assembly and other work under dry conditions. To reduce the generation of static electricity, please ensure that the air in the work environment is not too dry. A relative humidity of 50%-60% is recommended. As much as possible, make the electric potential of your work clothes and that of the work bench the ground potential.
- The LCD module is coated with a film to protect the display surface. Be careful when peeling off this protective film since static electricity may be generated.
- Since the LCM has been assembled and adjusted with a high degree of precision, avoid applying excessive shocks to the module or making any alterations or modifications to it.
  - Do not alter, modify or change the shape of the tab on the metal frame.
  - Do not make extra holes on the printed circuit board, modify its shape or change the positions of components to be attached.
  - Do not damage or modify the pattern writing on the printed circuit board.
  - Absolutely do not modify the zebra rubber strip (conductive rubber) or heat seal connector.
  - Do not drop, bend or twist the LCM.

## 14.2 Storage Precautions

When storing the LCD modules, the following precautions are necessary.

- Store them in a sealed polyethylene bag. If properly sealed, there is no need for the desiccant.
- Store them in a dark place. Do not expose to sunlight or fluorescent light, keep the temperature between 0°C and 35°C, and keep the relative humidity between 40%RH and 60%RH.
- The polarizer surface should not come in contact with any other objects. (We advise you to store them in an anti-static electricity container in which they were shipped. Some Liquid crystals solidify under low temperature (below the storage temperature range) leading to defective orientation or the generation of air bubbles (black or white). Air bubbles may also be generated if the module is subjected to low temperature.
- If the LCD modules have been operating for a long time showing the same display patterns, the display patterns may remain on the screen as ghost images and a slight contrast irregularity may also appear. A normal operating status can be regained by suspending use for some time. It should be noted that this phenomenon does not adversely affect performance reliability.
- To minimize the performance degradation of the LCD modules resulting from destruction caused by static electricity etc., please avoid holding the following sections when handling the modules'
  - Exposed area of the printed circuit board
  - Terminal electrode sections

## 15. Legal Information

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