深圳市拓普微科技开发有限公司
SHENZHEN TOPWAY TECHNOLOGY CO., LTD.

LMT028ENHFWA-NAN

LCD Module User Manual

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Caiwei		
Date: 2023-04-11	Date:	Date:

Rev.	Descriptions	Release Date
0.1	Preliminary New release	2020-05-06
0.2	Modify 1. General Specifications ,1.2 Terminal Functions(Pin number of K2) and 3.1 DC Characteristics	2022-09-30
0.3	Update Outline Dwg	2022-12-10
0.4	Modify 1.2 Terminal Function Description	2023-04-11

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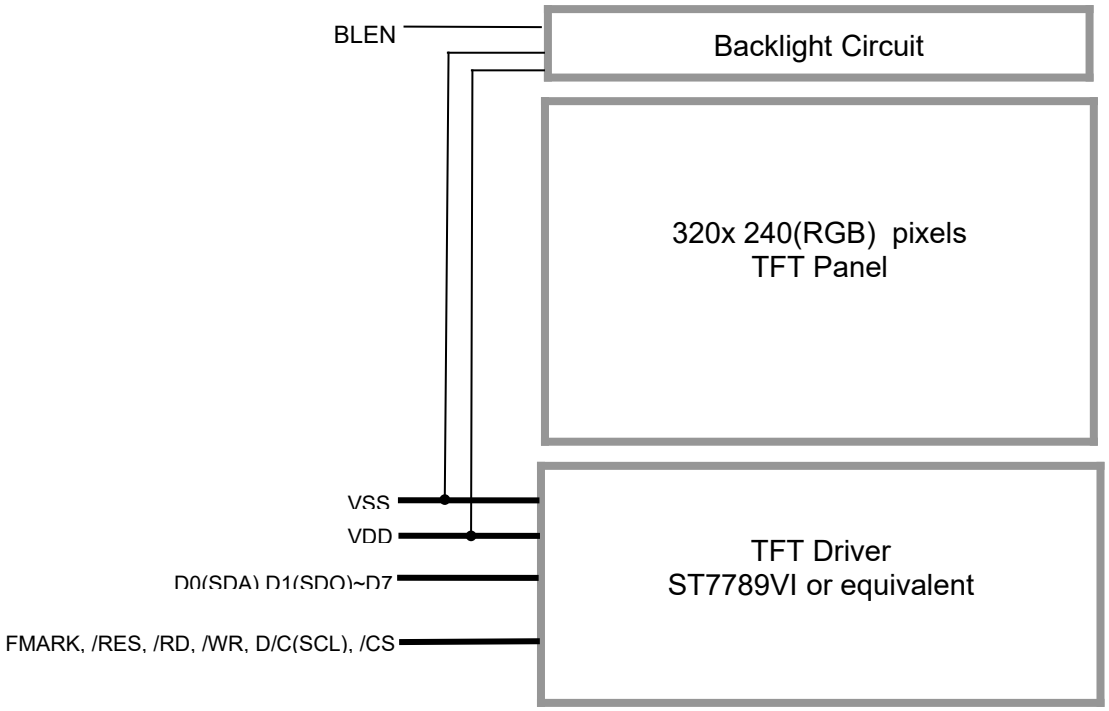
1. General Specifications

Screen Size(Diagonal) :	2.8”
Active Area :	57.6x43.2 (mm)
Number of dots :	320 x 240 (RGB)
Pixel Pitch：	0.18x0.18(mm)
Color Depth:	65k colors
Display Technology :	a-Si TFT active matrix
Display Mode :	Transmissive with Normally black
Display Interface :	MCU 8bit/SPI
Viewing Direction :	Full View
Touch Panel :	-
Surface Treatment :	HC
Touch Interface:	-
Operating Temperature :	-20 ~ +70°C
Storage Temperature :	-30 ~ +80°C

Note:
1. Color tone may slightly change by temperature and driving condition.

1.1 Block Diagram



1.2 Terminal Functions

Pin No. (K1)	Pin No. (K2)	Pin Name	I/O	Descriptions	
				80-8bit(default)	4-SPI
1	1	VSS	P	Negative power supply,0V.	
2	2	VSS			
3	3	BLEN	I	Backlight enable BLEN = H: turn off Backlight. BLEN = L: turn on Backlight. *1	
4	4	VDD	P	Positive power supply.	
5	5	VDD			
6	6	/RD	I	Read enable input, active low.	Please fix this pin at IOVDD
7	7	/WR(D/C)	I	Write enable input, active low.	Display data/command selection pin in 4-line serial interface.
8	8	D/C(SCL)	I	Register Select D/C=H, Transferring the Display Data. D/C = L, Transferring the Control Data.	This pin is used to be serial interface clock.
9	9	/CS	I	Chip Select /CS=L, enable access to the LCD module. /CS=H, disable access to the LCD module.	
10	10	D0(SDA)	I/O	Data Input.	The data is latched on the rising edge of the SCL signal.
11	11	D1(SDO)	I/O		SPI interface output pin. The data is output on the rising edge of the SCL signal.
:		:	:		Please fix this pin at IOVDD or GND level.
17	17	D7	I/O		
18	18	/RES	I	Reset signal /RES = L, Initialization is executed. /RES = H, Normal running.	
19	19	FMARK	O	Displaying Timing Frame Signal.	
20~28	20~30	NC	-	-	

*1 :The PWM frequency is between 2k Hz and 10kHz.

Mode	Install	No install
80-8bit (default)	R8,R13(0R,0603,5%)	R10,R11,R12
4-SPI	R12(0R,0603,5%) R10,R11(100R,0603,5%)	R8,R13

2. Absolute Maximum Ratings

VDD =5V, VSS=0V, T_{OP}=25°C

Items	Symbol	Min.	Max.	Unit	Condition
Supply Voltage	VDD	-0.3	+5.5	V	VSS= 0V
Input Voltage	V_{IN}	-0.3	+4.6	V	VSS = 0V
Operating Temperature	T_{OP}	-20	+70	°C	No Condensation
Storage Temperature	T_{ST}	-30	+80	°C	No Condensation

Cautions:
Any Stresses exceeding the Absolute Maximum Ratings may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

3. Electrical Characteristics

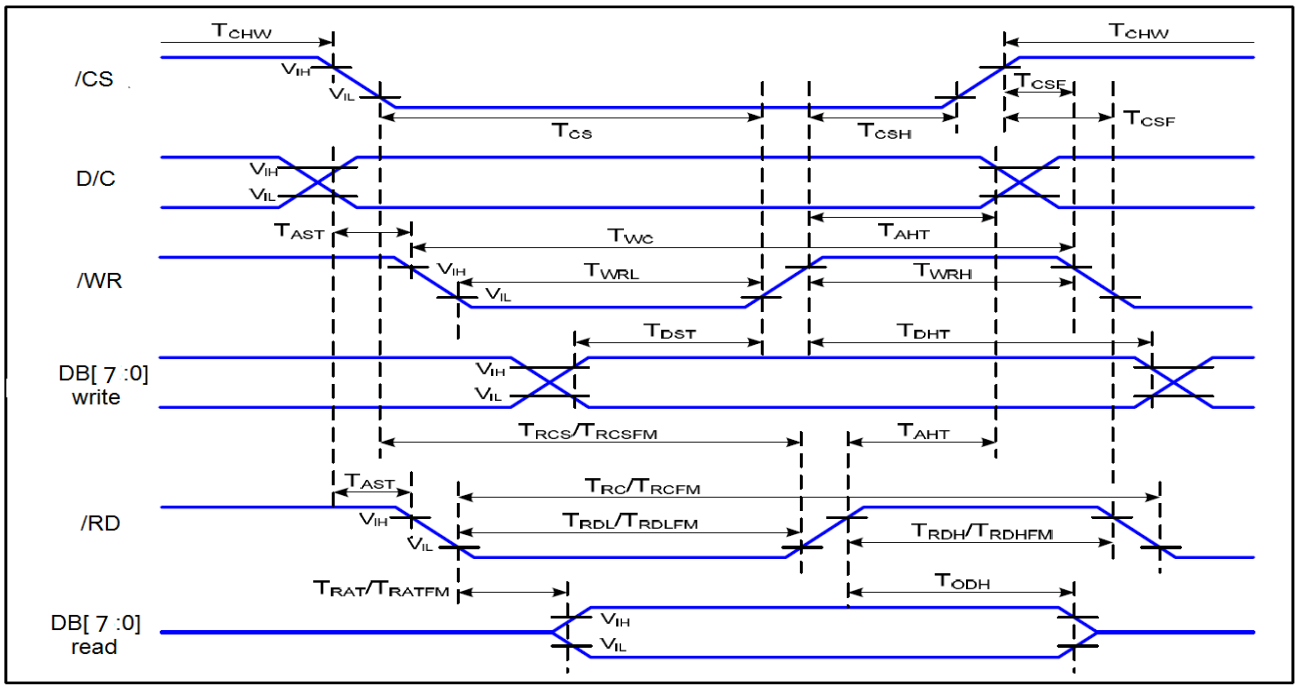
3.1 DC Characteristics

VDD =5V, VSS=0V, T_{OP}=25°C

Items	Symbol	MIN.	TYP.	MAX.	Unit	Condition / Application Pin
Operating Voltage	VDD	4.8	5.0	5.2	V	VDD
	IOVDD	3.2	3.3	3.4	V	IOVDD
Input High Voltage	V_{IH}	0.7* IOVDD	-	IOVDD	V	/RES,D0(SDA),D1~D7, /CS,/RD,/WR,BLEN, D/C(SCL)
Input Low Voltage	V_{IL}	0	-	0.3* IOVDD	V	
Output High Voltage	V_{OH}	0.8* IOVDD	-	IOVDD	V	D0~D7, SDO,FMARK
Output Low Voltage	V_{OL}	0	-	0.2* IOVDD	V	
Operating Current	I_{DD}	-	80	-	mA	Backlight are ON
	I_{DD}	-	10	-	mA	Backlight are OFF

3.2 AC Characteristics

8080 Mode System Bus Timing

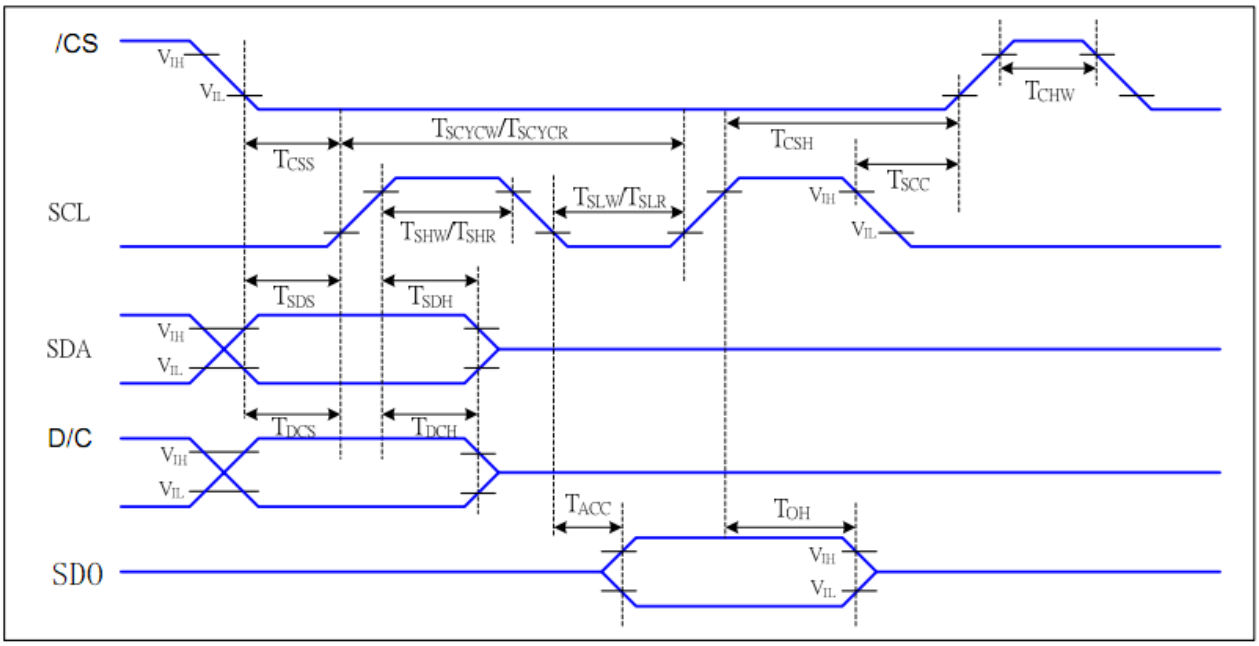


VDD =5V, VSS=0V, T_{OP}=25°C

Signal	Symbol	Parameter	Spec.		Unit	Description
			Min.	Max.		
D/C	T_{AST}	Address setup time	5	-	ns	-
	T_{AHT}	Address hole time(Write/Read)	13	-		
/CS	T_{CHW}	Chip select “H” pulse width	5	-	ns	-
	T_{CS}	Chip select setup time(Write)	20	-		
	T_{RCS}	Chip select setup time(Read ID)	60	-		
	T_{RCSFM}	Chip select setup time(Read FM)	460			
	T_{CSF}	Chip select wait time(Write/Read)	13			
	T_{CSH}	Chip select hold time	13			
/WR	T_{WC}	Write cycle	86	-	ns	-
	T_{WRH}	Control pulse “H” duration	20	-		
	T_{WRL}	Control pulse “L” duration	20	-		
DB[7:0]	T_{DST}	Data setup time	13	-	ns	For maximum CL=30pF For minimum CL=8pF
	T_{DHT}	Data hold time	13	-		
	T_{RAT}	Read access time(ID)	-	52		
	T_{RATFM}	Read access time(FM)	-	442		
	T_{ODH}	Ouput disable time	14	104		
/RD(ID)	T_{RC}	Read cycle(ID)	208		ns	When read ID data
	T_{RDH}	Control pulse “H” duration(ID)	120			
	T_{RDL}	Control pulse “H” duration(ID)	60			
/RD(FM)	T_{RCFM}	Read cycle(FM)	585			When read from frame memory
	T_{RDHFM}	Control pulse “H” duration(FM)	120			
	T_{RDLFM}	Control pulse “H” duration(FM)	460			

Note:
*1. Input signal rise/fall time should be less than 15ns .
*2. All timing is using 20% and 80% of VDD as the reference.
*3. Please refer to ST7789VI datasheet for details

4 line SPI Timing

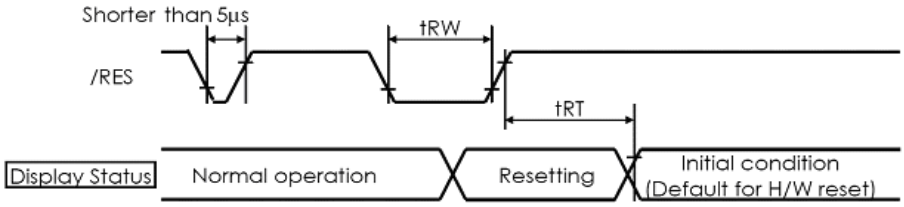


VDD =5V, VSS=0V, TOP=25°C

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
/CS	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)	16		ns	-write command & data ram
	T_{SHW}	SCL "H" pulse width (Write)	7		ns	
	T_{SLW}	SCL "L" pulse width (Write)	7		ns	
	T_{SCYCR}	Serial clock cycle (Read)	150		ns	-read command & data ram
	T_{SHR}	SCL "H" pulse width (Read)	60		ns	
	T_{SLR}	SCL "L" pulse width (Read)	60		ns	
D/C	T_{DCS}	D/CX setup time	10		ns	
	T_{DCH}	D/CX hold time	10		ns	
SDA (DIN)	T_{SDS}	Data setup time	7		ns	
	T_{SDH}	Data hold time	7		ns	
SDO	T_{ACC}	Access time	10	50	ns	For maximum CL=30pF
	T_{OH}	Output disable time	15	50	ns	For minimum CL=8pF

Note : The rising time and falling time (Tr, Tf) 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.

3.3 Reset Timing



VCC=3.3V, GND=0V, T_{OP}=25°C

Item	Symbol	MIN.	TYP.	MAX.	Unit
Reset LOW pulse width	t_{RW}	10	-	-	us
Reset time	T_{RT}	-	-	170	ms

4. Functions

4.1 Display Commands

Instruction	D/C	/WR	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
NOP	0	↑	-	0	0	0	0	0	0	0	0	(00h)	No operation
SWRESET	0	↑	-	0	0	0	0	0	0	0	1	(01h)	Software reset
RDDID	0	↑	-	0	0	0	0	0	1	0	0	(04h)	Read display ID
	1	1	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	-	ID17	ID16	ID15	ID14	ID13	ID12	ID11	ID10		ID1 read
	1	1	-	ID27	ID26	ID25	ID24	ID23	ID22	ID21	ID20		ID2 read
	1	1	-	ID37	ID36	ID35	ID34	ID33	ID32	ID31	ID30		ID3 read
RDDST	0	↑	-	0	0	0	0	1	0	0	1	(09h)	Read display status
	1	1	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	-	BSTON	MY	MX	MV	ML	RGB	MH	ST24		-
	1	1	-	ST23	IFPF2	IFPF1	IFPF0	IDMON	PTLON	SLOUT	NORON		-
	1	1	-	ST15	ST14	INVON	ST12	ST11	DISON	TEON	GCS2		-
	1	1	-	GCS1	GCS0	TEM	ST4	ST3	ST2	ST1	ST0		-
RDDPM	0	↑	-	0	0	0	0	1	0	1	0	(0Ah)	Read display power
	1	1	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	-	BSTON	IDMON	PTLON	SLPOUT	NORON	DISON	0	0		
RDD MADCTL	0	↑	-	0	0	0	0	1	0	1	1	(0Bh)	Read display
	1	1	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	-	MY	MX	MV	ML	RGB	MH	0	0		-
RDD COLMOD	0	↑	-	0	0	0	0	1	1	0	0	(0Ch)	Read display pixel
	1	1	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	-	0	D6	D5	D4	0	D2	D1	D0		-
RDDIM	0	↑	-	0	0	0	0	1	1	0	1	(0Dh)	Read display image
	1	1	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	-	VSSON	0	INVON	0	0	GC2	GC1	GC0		-
RDDSM	0	↑	-	0	0	0	0	1	1	1	0	(0Eh)	Read display signal
	1	1	-	-	-	-	-	-	-	-	-		Dummy read

Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
	1	1	↑	-	TEON	TEM	0	0	0	0	0	0		-
RDDSDR	0	↑	1	-	0	0	0	0	1	1	1	1	(0Fh)	Read display self-diagnostic result
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	D7	D6	0	0	0	0	0	0		-
SLPIN	0	↑	1	-	0	0	0	1	0	0	0	0	(10h)	Sleep In
SLPOUT	0	↑	1	-	0	0	0	1	0	0	0	1	(11h)	Sleep out
PTLON	0	↑	1	-	0	0	0	1	0	0	1	0	(12h)	Partial mode on
NORON	0	↑	1	-	0	0	0	1	0	0	1	1	(13h)	Partial off (Normal)
INVOFF	0	↑	1	-	0	0	1	0	0	0	0	0	(20h)	Display Inversion off
INVON	0	↑	1	-	0	0	1	0	0	0	0	1	(21h)	Display Inversion on
GAMSET	0	↑	1	-	0	0	1	0	0	0	0	1	(26h)	Display Inversion on
	1	↑	1	-	0	0	0	0	GC3	GC2	GC1	GC0		
DISPOFF	0	↑	1	-	0	0	1	0	1	0	0	0	(28h)	Display off
DISPON	0	↑	1	-	0	0	1	0	1	0	0	1	(29h)	Display on
CASET	0	↑	1	-	0	0	1	0	1	0	1	0	(2Ah)	Column address set
	1	↑	1	-	XS15	XS14	XS13	XS12	XS11	XS10	XS9	XS8		X address start: 0≤XS≤X
	1	↑	1		XS7	XS6	XS5	XS4	XS3	XS2	XS1	XS0		
	1	↑	1		XE15	XE14	XE13	XE12	XE11	XE10	XE9	XE8		X address start: S≤XE≤X
	1	↑	1		XE7	XE6	XE5	XE4	XE3	XE2	XE1	XE0		
RASET	0	↑	1	-	0	0	1	0	1	0	1	1	(2Bh)	Row address set
	1	↑	1	-	YS15	YS14	YS13	YS12	YS11	YS10	YS9	YS8		Y address start: 0≤YS≤Y
	1	↑	1		YS7	YS6	YS5	YS4	YS3	YS2	YS1	YS0		
	1	↑	1		YE15	YE14	YE13	YE12	YE11	YE10	YE9	YE8		Y address start: S≤YE≤Y
	1	↑	1		YE7	YE6	YE5	YE4	YE3	YE2	YE1	YE0		
RAMWR	0	↑	1	-	0	0	1	0	1	1	0	0	(2Ch)	Memory write
	1	↑	1	D1[17:8]	D1[7]	D1[6]	D1[5]	D1[4]	D1[3]	D1[2]	D1[1]	D1[0]		Write data
	1	↑	1	Dx[17:8]	Dx[7]	Dx[6]	Dx[5]	Dx[4]	Dx[3]	Dx[2]	Dx[1]	Dx[0]		
	1	↑	1	Dn[17:8]	Dn[7]	Dn[6]	Dn[5]	Dn[4]	Dn[3]	Dn[2]	Dn[1]	Dn[0]		
RAMRD	0	↑	1	-	0	0	1	0	1	1	1	0	(2Eh)	Memory read

Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	D1[17-8]	D1[7]	D1[6]	D1[5]	D1[4]	D1[3]	D1[2]	D1[1]	D1[0]		
	1	1	↑	Dx[17-8]	Dx[7]	Dx[6]	Dx[5]	Dx[4]	Dx[3]	Dx[2]	Dx[1]	Dx[0]		Read data
	1	1	↑	Dn[17-8]	Dn[7]	Dn[6]	Dn[5]	Dn[4]	Dn[3]	Dn[2]	Dn[1]	Dn[0]		
	0	↑	1	-	0	0	1	1	0	0	0	0	(30h)	Partial start/end address set
PTLAR	1	↑	1	-	PSL7	PSL6	PSL5	PSL4	PSL3	PSL2	PSL1	PSL0		Partial start address: (0, 1,2, ...P)
	1	↑	1	-	PEL7	PEL6	PEL5	PEL4	PEL3	PEL2	PEL1	PEL0		Partial end address (0, 1,2, 3, , P)
	0	↑	1	-	0	0	1	1	0	0	1	1	(33h)	Vertical scrolling definition
	1	↑	1	-	TFA7	TFA6	TFA5	TFA4	TFA3	TFA2	TFA1	TFA0		
	1	↑	1	-	TFA15	TFA14	TFA13	TFA12	TFA11	TFA10	TFA9	TFA8		
	1	↑	1	-	VSA15	VSA14	VSA13	VSA12	VSA11	VSA10	VSA9	VSA8		
	1	↑	1	-	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0		
VSCRDEF	1	↑	1	-	BFA15	BFA14	BFA13	BFA12	BFA11	BFA10	BFA9	BFA8		
	1	↑	1	-	BFA7	BFA6	BFA5	BFA4	BFA3	BFA2	BFA1	BFA0		
TEOFF	0	↑	1	-	0	0	1	1	0	1	0	0	(34h)	Tearing effect line off
TEON	0	↑	1	-	0	0	1	1	0	1	0	1	(35h)	Tearing effect line on
	1	↑	1	-	-	-	-	-	-	-	-	TEM		
MADCTL	0	↑	1	-	MY	MX	MV	ML	RGB	0	0	0	(36h)	Memory data access control
	1	↑	1	-	-	-	-	-	-	-	-	-		-
VSCRSADD	0	↑	1	-	0	0	1	1	0	1	1	1	(37h)	Vertical scrolling start address
	1	↑	1	-	VSP7	VSP6	VSP5	VSP4	VSP3	VSP2	VSP1	VSP0		
	1	↑	1	-	VSP15	VSP14	VSP13	VSP12	VSP11	VSP10	VSP9	VSP8		
IDMOFF	0	↑	1	-	0	0	1	1	1	0	0	0	(38h)	Idle mode off
IDMON	0	↑	1	-	0	0	1	1	1	0	0	1	(39h)	Idle mode on

Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
COLMOD	0	↑	1	-	0	0	1	1	1	0	1	0	(3Ah)	Interface pixel format
	1	↑	1	-	0	D6	D5	D4	0	D2	D1	D0		Interface format
RAMWRC	0	↑	1	-	0	0	1	1	1	1	0	0	(3Ch)	Memory write continue
	1	↑	1	D1[17:8]	D1[7]	D1[6]	D1[5]	D1[4]	D1[3]	D1[2]	D1[1]	D1[0]		Write data
	1	↑	1	Dx[17:8]	Dx[7]	Dx[6]	Dx[5]	Dx[4]	Dx[3]	Dx[2]	Dx[1]	Dx[0]		
	1	↑	1	Dn[17:8]	Dn[7]	Dn[6]	Dn[5]	Dn[4]	Dn[3]	Dn[2]	Dn[1]	Dn[0]		
RAMRDC	0	↑	1	-	0	0	1	1	1	1	1	0	(3Eh)	Memory read continue
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy Read
	1	1	↑	D1[17:8]	D1[7]	D1[6]	D1[5]	D1[4]	D1[3]	D1[2]	D1[1]	D1[0]		
	1	1	↑	Dx[17:8]	Dx[7]	Dx[6]	Dx[5]	Dx[4]	Dx[3]	Dx[2]	Dx[1]	Dx[0]		
	1	1	↑	Dn[17:8]	Dn[7]	Dn[6]	Dn[5]	Dn[4]	Dn[3]	Dn[2]	Dn[1]	Dn[0]		
TESCAN	0	↑	1	-	0	1	0	0	0	1	0	0	(44h)	Set tear scanline
	1	↑	1	-	N15	N14	N13	N12	N11	N10	N9	N8		
	1	↑	1	-	N7	N6	N5	N4	N3	N2	N1	N0		
RDTESCAN	0	↑	1	-	0	1	0	0	0	1	0	1	(45h)	Get scanline
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy Read
	1	1	↑	-	-	-	-	-	-	-	N9	N8		
	1	1	↑	-	N7	N6	N5	N4	N3	N2	N1	N0		
WRDISBV	0	↑	1	-	0	1	0	1	0	0	0	1	(51h)	Write display brightness
	1	↑	1	-	DBV7	DBV6	DBV5	DBV4	DBV3	DBV2	DBV1	DBV0		
RDDISBV	0	↑	1	-	0	1	0	1	0	0	1	0	(52h)	Read display brightness value
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	DBV7	DBV6	DBV5	DBV4	DBV3	DBV2	DBV1	DBV0		
WRCTRLD	0	↑	1	-	0	1	0	1	0	0	1	1	(53h)	Write CTRL display
	1	↑	1	-	0	0	BCTRL	0	DD	BL	0	0		
RDCTRLD	0	↑	1	-	0	1	0	1	0	1	0	0	(54h)	Read CTRL value display
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	0	0	BCTRL	0	DD	BL	0	0		

Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
WRCACE	0	↑	1	-	0	1	0	1	0	1	0	1	(55h)	Write content adaptive brightness control and Color enhancemnet
	1	↑	1	-	CECTRL	0	CE1	CE0	0	0	C1	C0		
RDCABC	0	↑	1	-	0	1	0	1	0	1	1	0	(56h)	Read content adaptive brightness control
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	0	CECTRL	0	0	0	0	C1	C0		
WRCABCMB	0	↑	1	-	0	1	0	1	1	1	1	0	(5Eh)	Write CABC minimum brightness
	1	↑	1	-	CMB7	CMB6	CMB5	CMB4	CMB3	CMB2	CMB1	CMB0		
RDCABCMB	0	↑	1	-	0	1	0	1	1	1	1	1	(5Fh)	Read CABC minimum brightness
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	CMB7	CMB6	CMB5	CMB4	CMB3	CMB2	CMB1	CMB0		
RDABCSDR	0	↑	1	-	0	1	1	0	1	0	0	0	(68h)	Read Automatic Brightness Control Self-Diagnostic Result
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	D7	D6	0	0	0	0	0	0		-
RDID1	0	↑	1	-	1	1	0	1	1	0	1	0	(DAh)	Read ID1
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	ID17	ID16	ID15	ID14	ID13	ID12	ID11	ID10		Read parameter
RDID2	0	↑	1	-	1	1	0	1	1	0	1	1	(DBh)	Read ID2
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	ID27	ID26	ID25	ID24	ID23	ID22	ID21	ID20		Read parameter
RDID3	0	↑	1	-	1	1	0	1	1	1	0	0	(DCh)	Read ID3

Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑		ID37	ID36	ID35	ID34	ID33	ID32	ID31	ID30		Read parameter

Notes:
1. There will be no abnormal visible effects on the display when S/W or H/W Reset are applied.
2. Please refer to ST7789VI datasheet for details

4.2 Power off the LCD Module

It recommends that enter Sleep Mode before power off the LCD module.

4.3 Refreshing The LCD Module

It recommends that the operating modes and display contents be refreshed periodically to prevent the effect of unexpected noise.

5. Optical Characteristics

Item		Symbol	Condition	Min	Typ	Max	Unit	Remark
View Angles		θT	CR≧10	70	80	-	Degree	Note2,3
		θB		70	80	-		
		θL		70	80	-		
		θR		70	80	-		
Contrast Ratio		CR	θ= 0°	600	800	-		Note 3
Response Time		TON	25℃	-	25	35	ms	Note 4
		TOFF						
Chromaticity	**White**	x	Backlight is on	0.237	0.287	0.337		Note 1,5
		y		0.265	0.315	0.365		
	Red	x		0.586	0.636	0.686		
		y		0.286	0.336	0.386		
	Green	x		0.285	0.335	0.385		
		y		0.564	0.614	0.664		
	Blue	x		0.099	0.149	0.199		
		y		0.021	0.071	0.121		
Uniformity		U		75	80	-	%	Note 6
NTSC		S	Θ= 0° Φ=0°	65	70	-	%	Note 5
Luminance		L		230	280	-	cd/㎡	Note 7

1. the ambient temperature is 25℃.

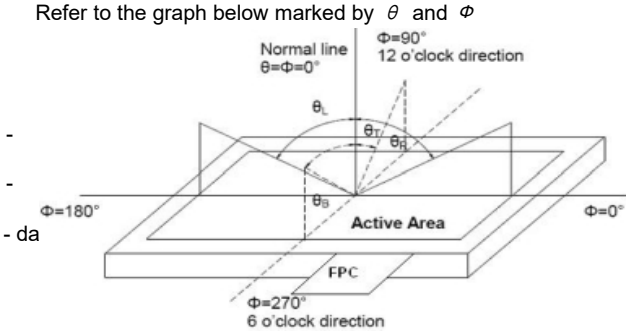
2. The test systems refer to Note 1 and Note 2.

Note 1: Definition of optical measurement system.
The optical characteristics should be measured in dark room. After 5 Minutes operation, the optical
properties are measured at the center point of the LCD screen. All input terminals LCD panel must
be ground when measuring the center area of the panel.

Measuring surroundings: Dark room

Measuring temperature: Ta=25℃.

Note 2: Definition of viewing angle range and measurement system.
The definition of viewing angle:
Refer to the graph below marked by θ and Φ

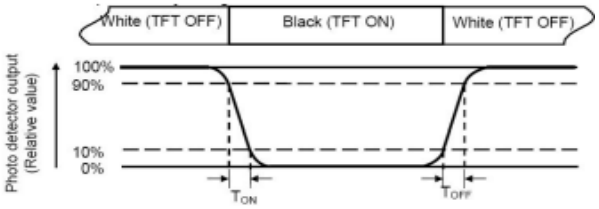


Note 3: Definition of contrast ratio
The definition of contrast ratio (Test LCM using SR-3A (1°)):

$$\text{Contrast Ratio(CR)} = \frac{\text{Luminance When LCD is at "White" state}}{\text{Luminance When LCD is at "Black" state}}$$

(Contrast Ratio is measured in optimum common electrode voltage)

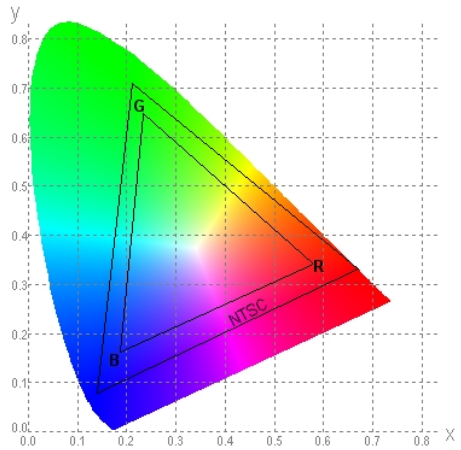
Note 4: Definition of Response time
Definition of Response time.
The response time is defined as the LCD optical switching time interval between "White" state and
"Black" state. Rise time (T_{ON}) is the time between photo detector output intensity changed from 90%
to 10%. And fall time (T_{OFF}) is the time between photo detector output intensity changed from 10%
to 90%.



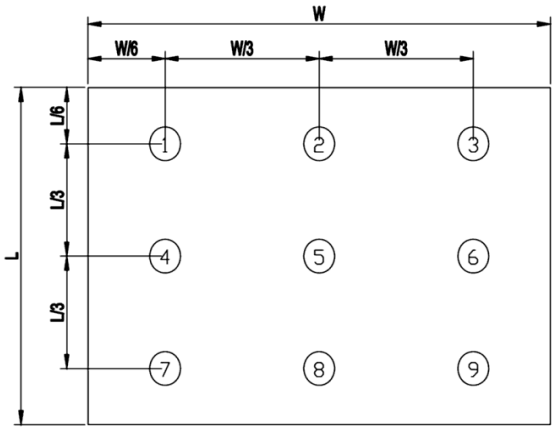
Note 5: Definition of color chromaticity (CIE1931)
Definition of Color of CIE1931 Coordinate and NTSC Ratio.

Color gamut:

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



Note 6: Definition of Luminance Uniformity
Active area is divided into 9 measuring areas (Refer Fig. 2). Every measuring point is placed at the
center of each measuring area.
Luminance Uniformity (U) = Lmin/ Lmax
L-------Active area length W----- Active area width
Lmax: The measured Maximum luminance of all measurement position.
Lmin: The measured Minimum luminance of all measurement position.



Note 7: Definition of Luminance:
Measured the luminance of white state at center point

6. LCD Module Design and Handling Precautions

- Please ensure V0, VCOM is adjustable, to enable LCD module get the best contrast ratio under different temperatures, view angles and positions.
- Normally display quality should be judged under the best contrast ratio within viewable area. Unexpected display pattern may come out under abnormal contrast ratio.
- Never operate the LCD module exceed the absolute maximum ratings.
- Never apply signal to the LCD module without power supply.
- Keep signal line as short as possible to reduce external noise interference.
- IC chip (e.g. TAB or COG) is sensitive to light. Strong light might cause malfunction. Light sealing structure casing is recommended.
- Make sure there is enough space (with cushion) between case and LCD panel, to prevent external force passed on to the panel; otherwise that may cause damage to the LCD and degrade its display result.
- Avoid showing a display pattern on screen for a long time (continuous ON segment).
- LCD module reliability may be reduced by temperature shock.
- When storing and operating LCD module, avoids exposure to direct sunlight, high humidity, high or low temperature. They may damage or degrade the LCD module.
- Never leave LCD module in extreme condition (max./min storage/operate temperature) for more than 48hr.
- Recommend LCD module storage conditions is 0 C~40 C <80%RH.
- LCD module should be stored in the room without acid, alkali and harmful gas.
- Avoid dropping & violent shocking during transportation, and no excessive pressure press, moisture and sunlight.
- LCD module can be easily damaged by static electricity. Please maintain an optimum anti-static working environment to protect the LCD module. (eg. ground the soldering irons properly)
- Be sure to ground the body when handling LCD module.
- Only hold LCD module by its sides. Never hold LCD module by applying force on the heat seal or TAB.
- When soldering, control the temperature and duration avoid damaging the backlight guide or diffuser which might degrade the display result such as uneven display.
- Never let LCD module contact with corrosive liquids, which might cause damage to the backlight guide or the electric circuit of LCD module.
- Only clean LCD with a soft dry cloth, Isopropyl Alcohol or Ethyl Alcohol. Other solvents (e.g. water) may damage the LCD.
- Never add force to components of LCD module. It may cause invisible damage or degrade the module's reliability.
- When mounting LCD module, please make sure it is free from twisting, warping and bending.
- Do not add excessive force on surface of LCD, which may cause the display color change abnormally.
- LCD panel is made with glass. Any mechanical shock (e.g. dropping from high place) will damage the LCD module.
- Protective film is attached on LCD screen. Be careful when peeling off

6. 液晶显示模块设计和使用须知

- 请注意 V0, VCOM 的设定，以确保液晶显示模块在不同的使用温度下以及在不同的视角和位置观察模块显示，均能达到最佳对比度，请务必将应用电路上设置为对比度可调。
- 请注意液晶显示模块的显示品质判定是指在正常对比度下以及视窗(V.A)范围内进行的，非正常对比度下液晶可能会出现非预期的显示不良，应注意区分。
- 请勿在最大额定值以外使用液晶显示模块。
- 请勿在没有接通电源的条件下，给液晶显示模块输送信号。
- 请尽可能缩短信号线的连接，以避免对液晶显示模块的信号干扰。
- 集成电路因 IC 芯片(如 TAB 或 COG)对紫外线极为敏感，强光环境下可能会引起液晶显示模块功能失效，故应采用不透光的外壳。
- 请在液晶显示模块与外壳之间保留足够的空间(可使用衬垫)，以缓冲外力对液晶显示模块的损坏或因受力不均而产生的显示不匀等异常现象。
- 避免液晶显示屏在某一画面下长时间点亮，否则有出现残影的风险；请通过软件每隔一段时间改变一次画面。
- 液晶显示模块的可靠性可能因温度冲击而降低。
- 请勿在阳光直射、高湿、高温或低温下储存和使用液晶显示模块，这将造成液晶显示模块的损坏或失效。
- 请勿在极限环境(最大/最小存储/工作温度)下使用或放置液晶显示模块超过 48 小时以上。
- 液晶显示模块建议存储条件为：0 C~40 C <80%RH。
- 请勿让液晶显示模块存储于带有 酸性，碱性，有害气体环境之中。
- 在运输过程中，请勿让液晶显示模块跌落与猛烈震动，同时避免 异常挤压，高湿度，与阳光照射.
- 液晶显示模块极易受静电损坏，请务必保证液晶显示模块在防静电的工作环境中使用或保存。(如：烙铁正确接地，等)
- 拿取液晶显示模块时需注意操作人员的接地情况。
- 请手持液晶显示模块的边沿取放模块，防止热压纸或 TAB 部位受力。
- 焊接液晶模块时，请注意控制烙铁的温度、焊接时间，以免烫坏导光板或偏光片，导致显示不匀等不良现象发生。
- 请勿使用洗板水等腐蚀性液体接触液晶模块，以免腐蚀导光板或模块电路。
- 仅可使用柔软的干布，异丙醇或乙醇清洁液晶屏表面，其他任何溶剂(如:水)都有可能损坏液晶模块。
- 请勿挤压液晶显示模块上的元器件，以避免产生潜在的损坏或失效而影响产品可靠性。
- 装配液晶显示模块时，请务必注意避免液晶显示模块的扭曲或变形。
- 请勿挤压液晶显示屏表面，这将导致显示颜色的异常。
- 液晶屏由玻璃制作而成，任何机械碰撞(如从高处跌落)均有可能损坏液晶显示模块。
- 液晶屏表面带有保护膜，揭除保护膜时需要注意可能产生

this protective film, since static electricity may be generated.
- Polarizer on LCD gets scratched easily. If possible, do not remove LCD protective film until the last step of installation.
- When peeling off protective film from LCD, static charge may cause abnormal display pattern. The symptom is normal, and it will turn back to normal in a short while.
- LCD panel has sharp edges, please handle with care.
- Never attempt to disassemble or rework LCD module.
- If display panel is damaged and liquid crystal substance leaks out, be sure not to get any in your mouth, if the substance comes into contact with your skin or clothes promptly wash it off using soap and water.

的静电。
- 因液晶显示屏表面的偏光片极易划伤，安装完成之前请尽量不要揭下保护膜。
- 请缓慢揭除保护膜，在此过程中液晶显示屏上可能会产生静电线，此为正常情况，可在短时间内消失。
- 请注意避免被液晶显示屏的边缘割伤。
- 请不要试图拆卸或改造液晶显示模块。
- 当液晶显示屏出现破裂，内部液晶液体可能流出；相关液体不可吞吃，绝对不可接触嘴巴，如接触到皮肤或衣服，请使用肥皂与清水彻底清洗.

7. CTP Mounting Instructions

7.1 Bezel Mounting (Figure 1)
- The bezel window should be bigger than the CTP active area. It should be≥0.5mm each side.
- Gasket should be installed between the bezel and the CTP surface. The final gap should be about 0.5~1.0mm.
- It is recommended to provide an additional support bracket for backside support when necessary (e.g. slim type TFT module without mounding structure). They should only provide appropriate support and keep the module in place.
- The mounting structure should be strong enough to prevent external uneven force or twist act onto the module.

7. 电容触摸屏安装指导

7.1 面框安装（附图 1）
- 客户面框窗口应大于 CTP 动作区域，各边离动作区应≥0.5mm.
- 面框与 CTP 面板间应垫有胶垫，其最终间隙约为 0.5～1.0mm.
- 建议必要时在背面提供附加支架(例如无安装结构的薄型 TFT 模块)，应仅利用适当支撑以保持模块位置.
- 安装结构应具有足够的强度，以防止外部不均匀力或扭曲力作用到模块上.

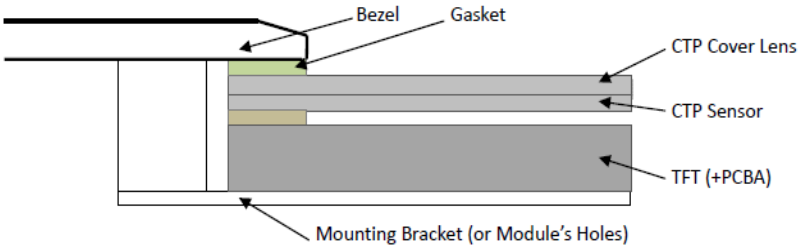


Figure 1

7.2 Surface Mounting (Figure 2)
- As the CTP assembling on the countersink area with double side adhesive.
  The countersink area should be flat and clean to ensure the double side adhesive installation result.
- The Bezel is recommend to keep a gap (≥0.3mm each side) around the cover lens for tolerance.
- It is recommended to provide an additional support bracket with gasket for backside support when necessary (e.g. TFT module without mounding structure). They should only provide appropriate support and keep the module in place.
- The mounting structure should be strong enough to prevent external uneven force or twist act onto the module

7.2 嵌入安装（附图 2）
- 客户面框应具有使用双面胶粘贴 CTP 的结构沉台面，其粘贴面要求平整且洁净无污以保证粘贴牢靠.
- 考虑到制作误差，建议面框与 CTP 盖板之间四周留有≥0.3mm 间隙.
- 建议必要时在背面提供垫有胶垫附加支架(例如无安装结构的 TFT 模块)，应仅利用适当支撑以保持模块位置.
- 安装结构应具有足够的强度，以防止外部不均匀力或扭曲力作用到模块上。

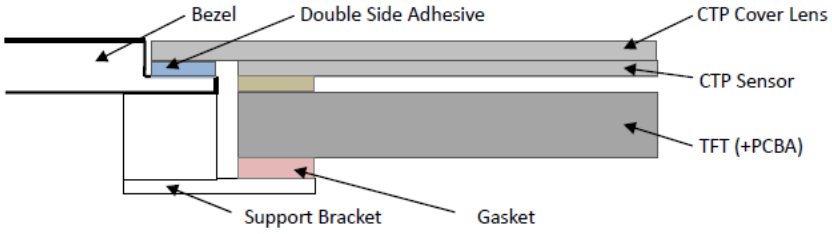


Figure 2

7.3 Additional Cover Lens Mounting (Figure 3)

- For the case of additional cover Lens mounting, it is necessary to recheck with the CTP specification about the material and thickness to ensure the functionality.
- It should keep a 0.2~0.3mm gap between the cover lens and the CTP surface..
- The cover lens window should be bigger than the active area of the CTP.It should be≥0.5mm each side.
- It is recommended to provide an additional support bracket for backside support when necessary (e.g. slim type TFT module without mounding structure). They should only provide appropriate support and keep the module in place.
- The mounting structure should be strong enough to prevent external uneven force or twist act onto the module.

7.3 覆加盖板（附图 3）

- 需要覆加玻璃盖板的安装，为确保其功能，有必要查看产品规格书中有关盖板材料和厚度的说明.
- 玻璃盖板与 CTP 表面之间应留有 0.2～0.3mm 间隙.
- 玻璃盖板视窗应大于 CTP 动作区域，各边离动作区应≥0.5mm。
- 建议必要时在背面提供附加支架(例如无安装结构的薄型 TFT 模块)，应仅利用适当支撑以保持模块位置.
- 安装结构应具有足够的强度，以防止外部不均匀力或扭曲力作用到模块上.

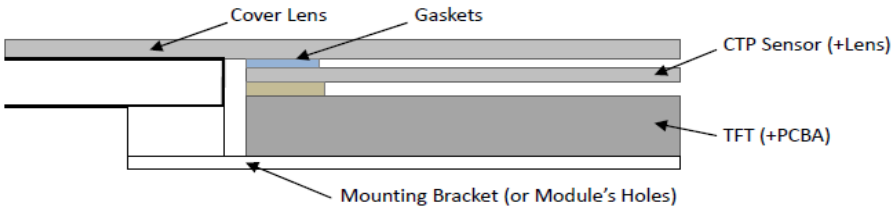


Figure 3

8. RTP Mounting Instructions

- It should bezel touching the RTP Active Area (A.A.) to prevent abnormal touch.It should left gab D=0.2~0.3mm in between. (Figure 4)
- Outer bezel design should take care about the area outside the A.A. Those areas contain circuit wires which is having different thickness. Touching those areas could de-form the ITO film. As a result bezel the ITO film be damaged and shorten its lifetime.
  It is suggested to protect those areas with gasket (between the bezel and RTP).The suggested figures are B≥0.50mm; C≥0.50mm. (Figure 4)
- The bezel side wall should keep space E= 0.2 ~ 0.3mm from the RTP. (Figure 4)

8. 电阻触摸屏安装指导

- 为避免面框直接压在动作区(A.A.)上造成误动作，面框与电阻触摸屏(RTP)之间应留有一定的空隙 D=0.2~0.3mm 之间.(附图 4)
- 设计面框时，要注意用面框保护触摸屏四周的非保证操作区域，因为布线区域在此处形成一台阶，在此区域附近操作时 ITO Film 变形较大，容易导致 ITO 损坏而降低寿命。为保护 RTP 和避免误操作，在 RTP 与面框之间垫缓冲物（Gasket），我们建议设计面框应覆盖动作区的边缘，面框边缘到 V.A.区的距离 B≥0.50mm; 垫圈内边缘到 V.A.区的距离 C≥0.50mm. (附图 4)
- 在设计面框与 RTP 组装时，应考虑到面框内侧与 RTP 外侧的间距 E≥0.2mm. (附图 4)

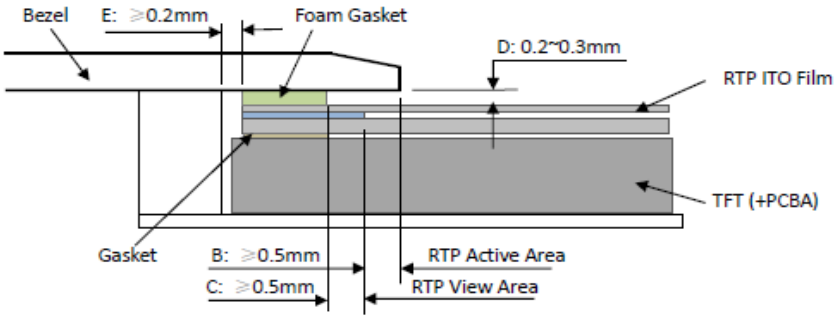


Figure 4

- In general design,
  RTP V.A. should be bigger than the TFT V.A.
  and RTP A.A. should be bigger than the TFT A.A.
  (Figure 5)

- 通常设计时：
  RTP 的可视区 V.A. 应不小于 TFT 的可视区 V.A.
  及 RTP 的动作区 A.A. 应不小于 TFT 的动作区 A.A.
  (附图 5)

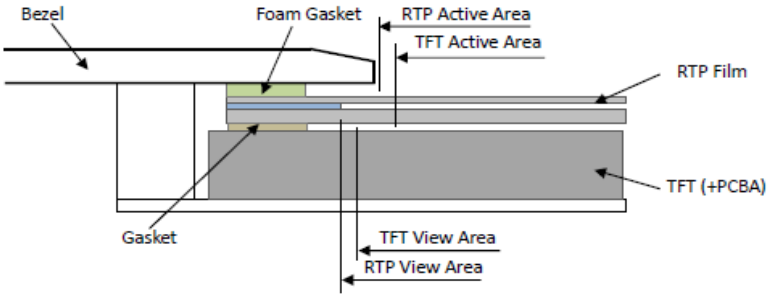
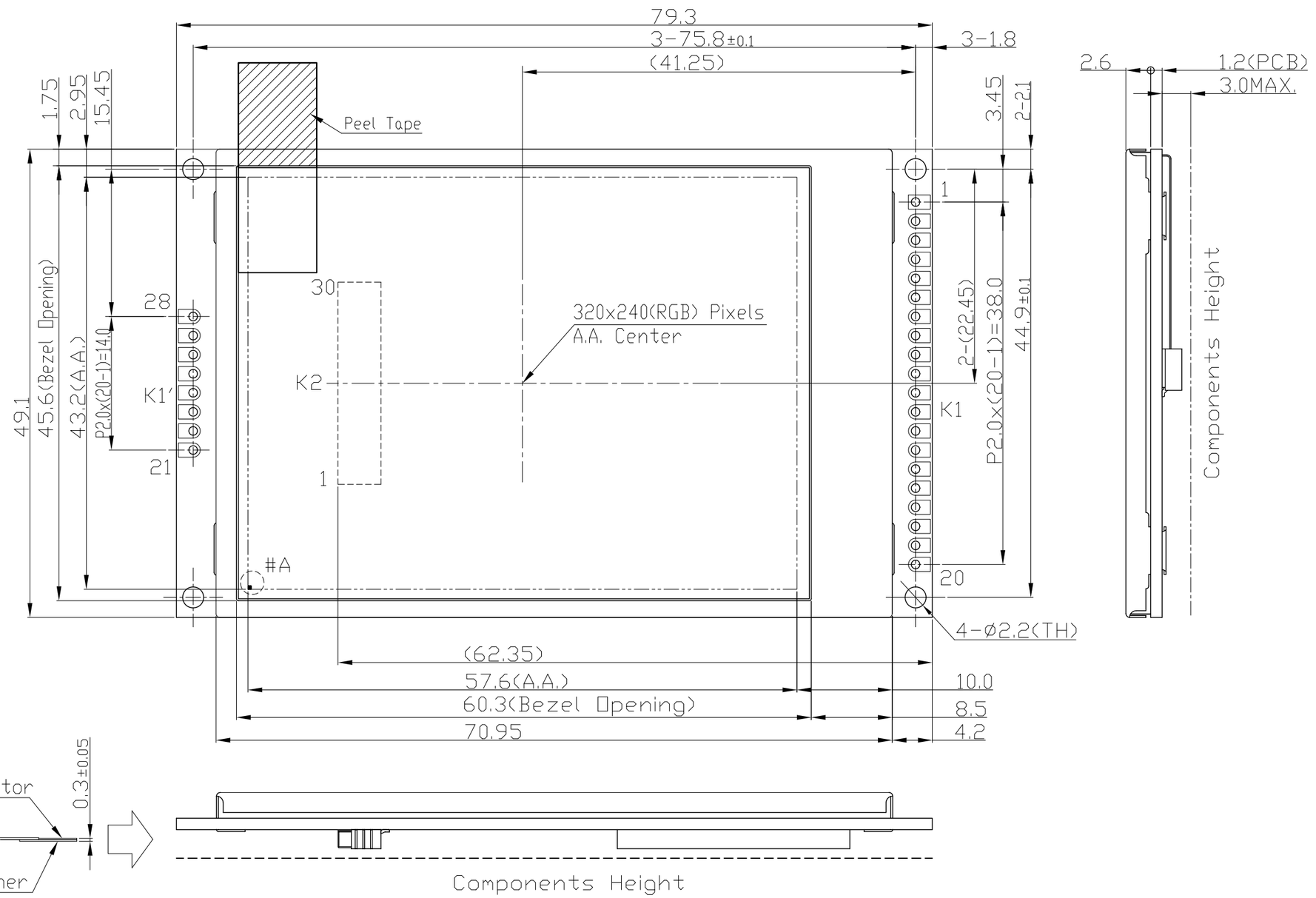


Figure 5

Warranty

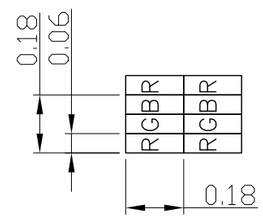
This product has been manufactured to our company's specifications as a part for use in your company's general electronic products. It is guaranteed to perform according to delivery specifications. For any other use apart from general electronic equipment, we cannot take responsibility if the product is used in medical devices, nuclear power control equipment, aerospace equipment, fire and security systems, or any other applications in which there is a direct risk to human life and where extremely high levels of reliability are required. If the product is to be used in any of the above applications, we will need to enter into a separate product liability agreement.

- We cannot accept responsibility for any defect, which may arise form additional manufacturing of the product (including disassembly and reassembly), after product delivery.
- We cannot accept responsibility for any defect, which may arise after the application of strong external force to the product.
- We cannot accept responsibility for any defect, which may arise due to the application of static electricity after the product has passed our company's acceptance inspection procedures.
- When the product is in CCFL models, CCFL service life and brightness will vary according to the performance of the inverter used, leaks, etc. We cannot accept responsibility for product performance, reliability, or defect, which may arise.
- We cannot accept responsibility for intellectual property of a third part, which may arise through the application of our product to our assembly with exception to those issues relating directly to the structure or method of manufacturing of our product.



K2 Terminal	
No	Pin Name
1	VSS
2	VSS
3	BLEN
4	VDD
5	VDD
6	/RD
7	/WR(D/C)
8	D/C(SCL)
9	/CS
10	D0(SDA)
11	D1(SDO)
12	D2
13	D3
14	D4
15	D5
16	D6
17	D7
18	/RES
19	FMARK
20	NC
21	NC
22	NC
23	NC
24	NC
25	NC
26	NC
27	NC
28	NC
29	NC
30	NC

K1 Terminal	
No	Pin Name
1	VSS
2	VSS
3	BLEN
4	VDD
5	VDD
6	/RD
7	/WR(D/C)
8	D/C(SCL)
9	/CS
10	D0(SDA)
11	D1(SDO)
12	D2
13	D3
14	D4
15	D5
16	D6
17	D7
18	/RES
19	FMARK
20	NC
21	NC
22	NC
23	NC
24	NC
25	NC
26	NC
27	NC
28	NC



#A Details
Scale=50/1

Note:
*1. LCD Display Type : TFT, Transmissive (Full View)
*2. Operating Voltage : 5.0V, Logic Voltage : 3.3V
*3. Backlight : White LEDs
*4. Pixel Arrangment : RGB-STRIPE
*5. Color Depth : 65k Colors
*6. Signal Interface : MCU 8bit/SPI
*7. Connector:
K1: P2.0,1x20+1x8 PCB Pad
K2: 30Pin P0.5 FFC Socket Or Equivalent B
*8. Operating Temperature : -20°C~70°C
*9. Storage Temperature : -30°C~80°C
*10. It should keep a gap of at least 0.2mm between the case and module surface

K2 Host FFC Detailes
Scale=2/1
Conductor Side B

Rev	Note	Date
C		
B	Add K2 FFC Socket	Luo Lin 2022-11-01
A	Remove the FFC Socket	Luo Lin 2020-05-07

Dwg Title	LMT028ENHFWA-NAN Outline Dwg		
Dwg No.	MK-006849b-1-1		Date 2020-03-27
Scale 2/1	Tol. ±0.3	Unit mm	Paper Size A3
Approved	Checked	Drawn Luo Lin	

TOPWAY