

JLX400-04201-BN 使用说明书

(IPS 全视角)

(插接式 FPC)

目 录

序号	内容标题	页码
1	概述	2
2	特点	2
3	外形及接口引脚功能	3~4
4	基本原理	4
5	技术参数	4~5
6	时序特性	5~7
7	指令功能及硬件接口与编程案例	8~末页

1. 概述

晶联讯电子专注于液晶屏及液晶模块的研发、制造。所生产 JLX400-04201 型 TFT 模块由于使用方便、显示清晰，广泛应用于各种人机交流面板。

JLX400-04201 可以显示 IPS 全视角 320 列*480 行点阵彩色图片，或显示 20 个/行*30 行 16*16 点阵的汉字，或显示 40 个/行*30 行 8*16 点阵的英文、数字、符号，或显示 40 个/行*60 行 8*8 点阵的英文、数字、符号。

2. JLX400-04201 图像型点阵 TFT 模块的特性

2.1 IPS 全视角，结构轻、薄、带背光。

2.2 IC 采用 ST7796S, 功能强大，稳定性好

2.3 显示内容：

- 320*480 点阵彩色图片；

- 可選用 32*32 点阵或其他点阵的图片来自编汉字，按照 32*32 点阵汉字来计算可显示 10 个字/行*15 行。

- 可選用 16*16 点阵或其他点阵的图片来自编汉字，按照 16*16 点阵汉字来计算可显示 20 个字/行*30 行。

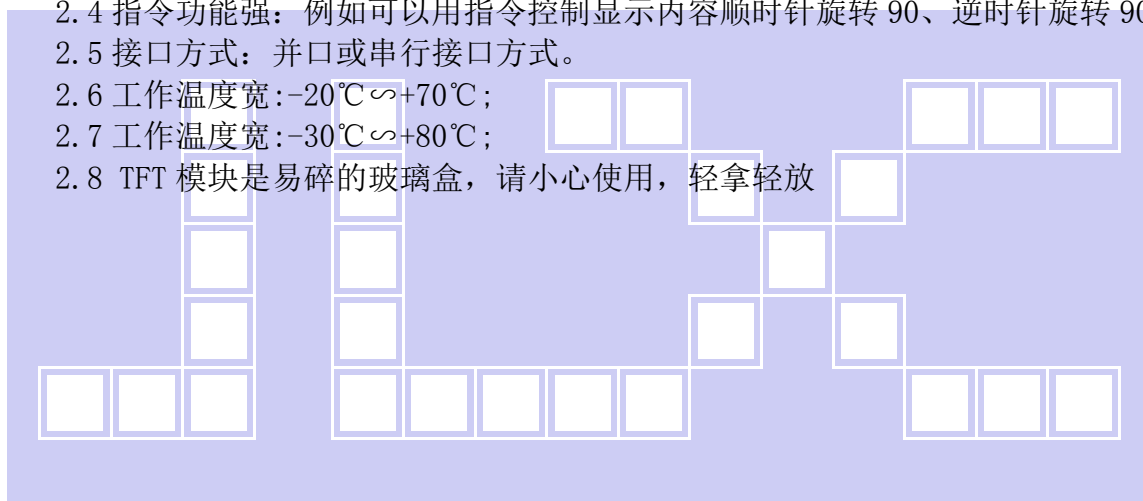
2.4 指令功能强：例如可以用指令控制显示内容顺时针旋转 90°、逆时针旋转 90° 或倒立竖放。

2.5 接口方式：并口或串行接口方式。

2.6 工作温度宽：-20℃~+70℃；

2.7 工作温度宽：-30℃~+80℃；

2.8 TFT 模块是易碎的玻璃盒，请小心使用，轻拿轻放



3. 外形尺寸及接口引脚功能

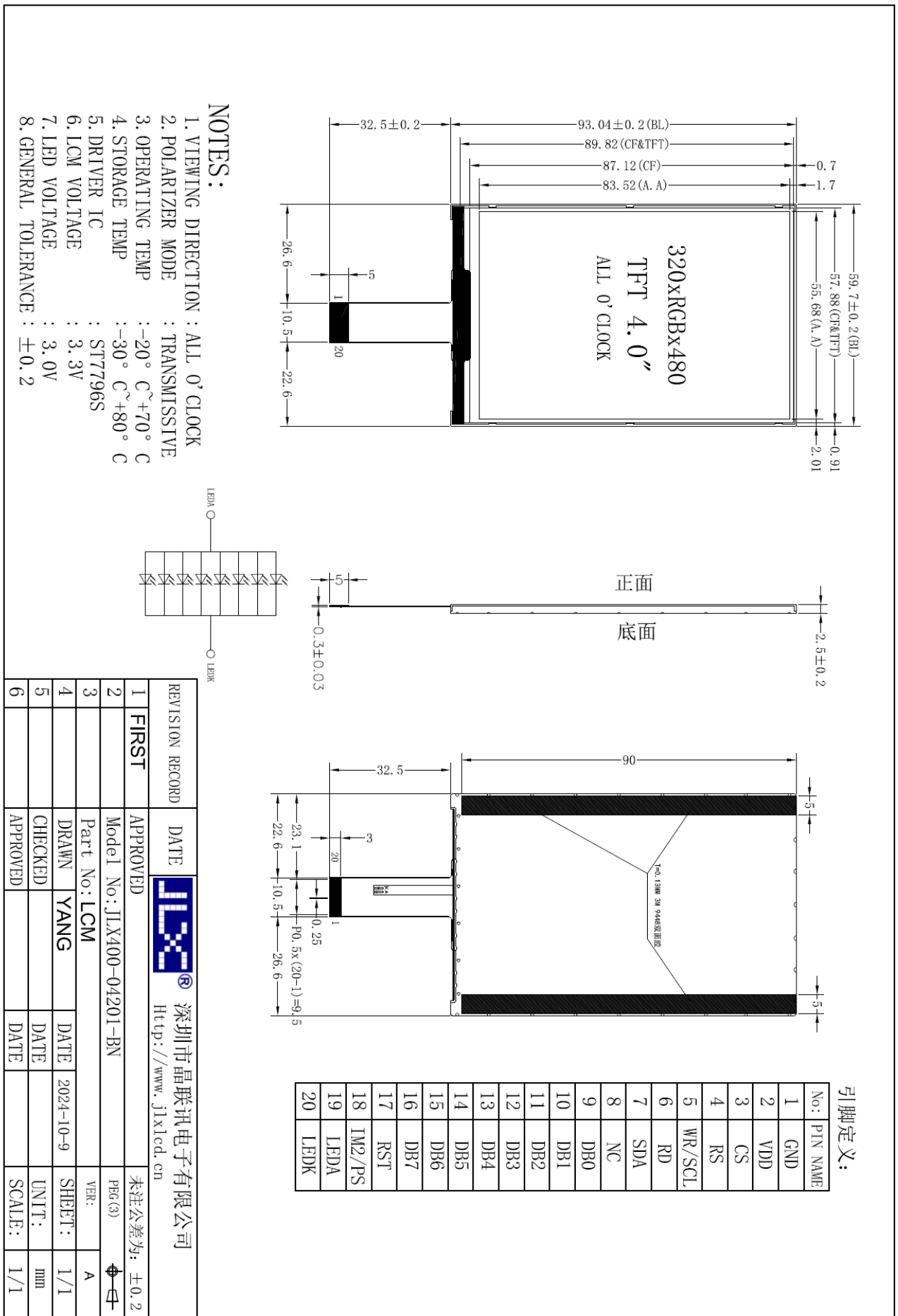


图 1. 带背光的 TFT 模块外形尺寸

模块的接口引脚功能

引线号	符号	名称	功能
1	GND	接地	0V
2	VDD	供电电源正极	供电电源正极 3.3V
3	CS	片选	低电平片选
4	RS	寄存器选择信号	H:数据寄存器 0:指令寄存器
5	WR/SCL	写	并口: 写功能; 串口: 串行时钟
6	RD	读	并口: 读功能, 串口: 建议接 VDD 或 VSS
7	SDA	串行数据	串口: SDA 串行数据, 并口: 空
8	NC	NC	空脚
9	DB0	I/O	并口: 数据总线 DB0, 串口: 建议接 VDD 或 VSS
10	DB1	I/O	并口: 数据总线 DB1, 串口: 建议接 VDD 或 VSS
11	DB2	I/O	并口: 数据总线 DB2, 串口: 建议接 VDD 或 VSS
12	DB3	I/O	并口: 数据总线 DB3, 串口: 建议接 VDD 或 VSS
13	DB4	I/O	并口: 数据总线 DB4, 串口: 建议接 VDD 或 VSS
14	DB5	I/O	并口: 数据总线 DB5, 串口: 建议接 VDD 或 VSS
15	DB6	I/O	并口: 数据总线 DB6, 串口: 建议接 VDD 或 VSS
16	DB7	I/O	并口: 数据总线 DB7, 串口: 建议接 VDD 或 VSS
17	RST	复位	低电平复位, 复位完成后, 回到高电平, TFT 模块开始工作
18	IM2/PS	接口方式选择	并口: VSS 串口: VDD
19	LEDA	背光电源正极	接 3.0V (接 3.3V 串 5.1 欧电阻)
20	LEDK	背光电源负极	接 GND

表 1: 模块的接口引脚功能

4. 基本原理

4.1 TFT 屏 (LCD)

在 LCD 上排列着 320×480 点阵, 320 个列信号与驱动 IC 相连, 480 个行信号也与驱动 IC 相连, IC 邦定在 LCD 玻璃上 (这种加工工艺叫 COG)。

4.2 背光参数

该型号 TFT 模块带 LED 背光源。它的性能参数如下:

工作温度: -20~+70℃;

存储温度: -30~+80℃;

背光板是白色。

正常工作电流为: 64~120mA (LED 灯数共 8 颗, 每颗灯是 8~15mA)

工作电压: 3.0V (接 3.3V 串 5.1 欧电阻)

5. 技术参数

5.1 最大极限参数 (超过极限参数则会损坏 TFT 模块)

名称	符号	标准值			单位
		最小	典型	最大	
电路电源	VDD - VSS	-0.3	3.3	3.6	V

工作温度		-20	+25	+70	°C
储存温度		-30	+25	+80	°C

表 2: 最大极限参数

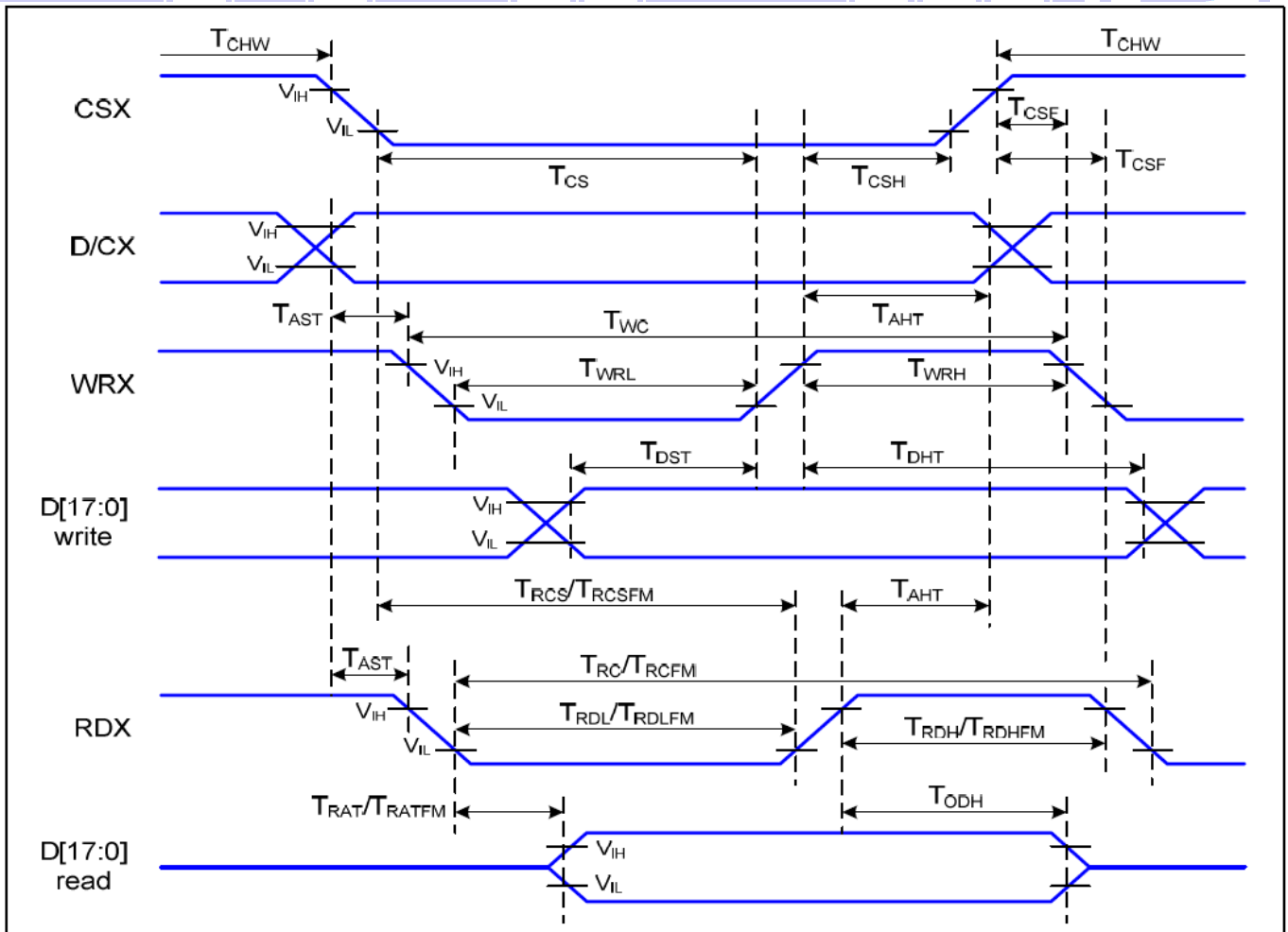
5.2 直流 (DC) 参数

名称	符号	测试条件	标准值			单位
			MIN	TYPE	MAX	
工作电压	VDD		2.7	3.3	3.6	V
背光工作电压	VLED		2.6	2.8	3.0	V
输入高电平	V _{IHC}	-	0.8xVDD	-	VDD	V
输入低电平	V _{ILC}	-	VSS	-	0.2xVDD	V
输出高电平	V _{OHC}	I _{OH} = -0.5mA	0.8xVDD	-	VDD	V
输出低电平	V _{OHC}	I _{OL} = -0.5mA	VSS	-	0.2xVDD	V
模块工作电流	I _{DD}	VDD = 3.3V	-		0.3	mA
背光工作电流	I _{LED}	V _{LED} =3.0V	48	90	120	mA

表 3: 直流 (DC) 参数

6. 读写时序特性

6.1 8080 读写时序特性



Parallel Interface Timing Characteristics (8080-Series MCU Interface)

图 2. 8080 时序图

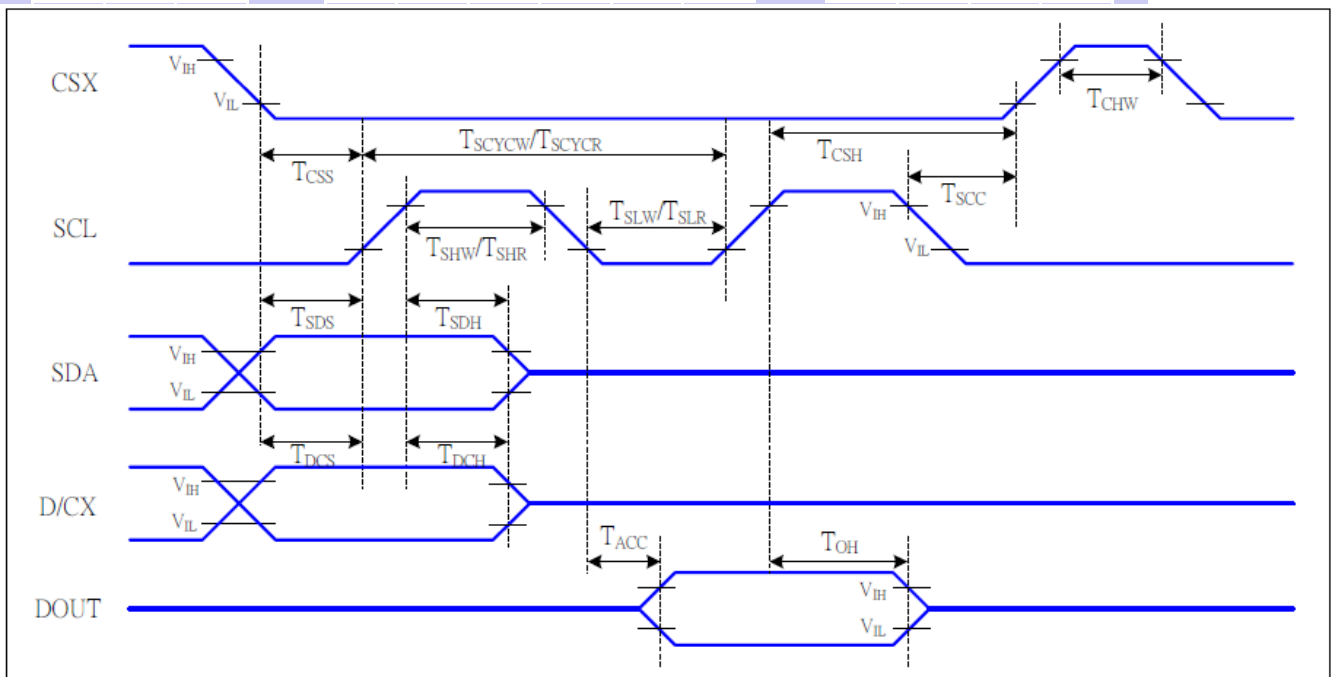
6.2 8080 时序要求 (AC 参数):

表 4.

项目	符号	测试条件	极限值			单位
			MIN	TYPE	MAX	
地址保持时间	A0	T_{Aht}	10	—	—	ns
地址建立时间		T_{Ast}	0	—	—	
芯片选择“高”脉冲宽度	CS	T_{CHW}	0			
芯片选择建立时间(写)		T_{CS}	15			
芯片选择建立时间(读)		T_{RCS}	45			
芯片选择保持时间	WR	T_{CSH}	10			
写周期		T_{WC}	66			
控制脉冲“高”持续时间		T_{WRH}	15			
控制脉冲“低”持续时间	RD	T_{WRL}	15			
芯片选择保持时间		T_{CSH}	10			
读周期		T_{RC}	160			
控制脉冲“高”持续时间	D7-D0	T_{RDH}	90			
控制脉冲“低”持续时间		T_{RDL}	45			
数据建立时间		T_{DST}	10			
数据保持时间	D7-D0	T_{DHT}	10			
读取时间		T_{RAT}		40		
输出禁用时间		T_{ODH}	20	80		

VDD=3.3V Ta=25°C

6.3 4_SPI 读写时序特性



4-SPI Interface Timing Characteristics

6.4 4_SPI 时序要求 (AC 参数):

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
CSX	T_{CSS}	Chip select setup time (write)	15		ns	
	T_{CSH}	Chip select hold time (write)	15		ns	
	T_{CSS}	Chip select setup time (read)	60		ns	
	T_{SCC}	Chip select hold time (read)	65		ns	
	T_{CHW}	Chip select "H" pulse width	40		ns	
SCL	T_{SCYCW}	Serial clock cycle (Write)	66		ns	-write command & data ram
	T_{SHW}	SCL "H" pulse width (Write)	15		ns	
	T_{SLW}	SCL "L" pulse width (Write)	15		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/CX	T_{DCS}	D/CX setup time	10		ns	
	T_{DCH}	D/CX hold time	10		ns	
SDA (DIN)	T_{SDS}	Data setup time	10		ns	
	T_{SDH}	Data hold time	10		ns	
DOUT	T_{ACC}	Access time	10	50	ns	For maximum CL=30pF
	T_{OH}	Output disable time	15	50	ns	For minimum CL=8pF

6.5 电源启动后复位的时序要求 (RESET CONDITION AFTER POWER UP):

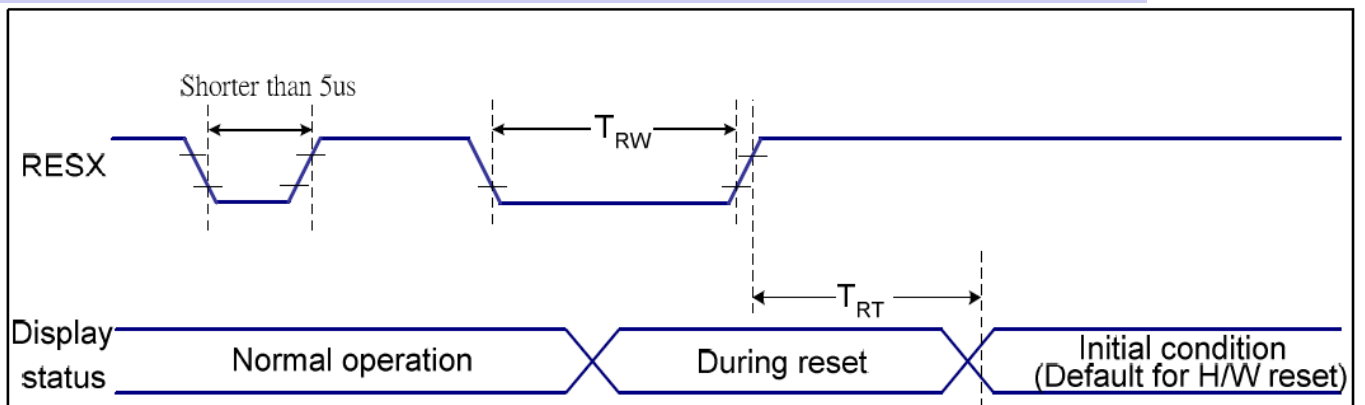


图 3: 电源启动后复位的时序

表 5: 电源启动后复位的时序要求

VDD=3.3V, Ta = 25°C

项目	符号	测试条件	极限值			单位
			MIN	TYPE	MAX	
复位时间	t_R		100	--	--	ms

复位保持低电平的时间	trw	引脚: RES	100	--	--	ms
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7. 指令功能:

7.1 指令表

COMMAND Table 1														
Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
NOP	0	↑	1	-	0	0	0	0	0	0	0	0	(00h)	No operation
SWRESET	0	↑	1	-	0	0	0	0	0	0	0	1	(01h)	Software reset
RDDID	0	↑	1	-	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
Read Number of the Errors on DSI	0	↑	1	-	0	0	0	0	0	1	0	1	(05h)	Read DSI
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	D7	D6	D5	D4	D3	D2	D1	D0		
RDDST	0	↑	1	-	0	0	0	0	1	0	0	1	(09h)	Read display status
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	BSTON	MY	MX	MV	ML	RGB	ST25	ST24		-
	1	1	↑	-	ST23	IFPF2	IFPF1	IFPF0	IDMON	PTLON	SLOUT	NORON		-
	1	1	↑	-	Vscroll	ST14	INVON	ALLON	ALLOFF	DISON	TEON	GCS2		-
	1	1	↑	-	GCS1	GCS0	TEM	ST4	ST3	ST2	ST1	ST0		-
RDDPM	0	↑	1	-	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	↑	1	-	0	0	0	0	1	0	1	1	(0Bh)	Read display
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	MY	MX	MV	ML	RGB	DISDL	0	0		-
RDD Interface Pixel Format	0	↑	1	-	0	0	0	0	1	1	0	0	(0Ch)	Read display pixel
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	R3	R2	R1	R0	0	D2	D1	D0		-

COMMAND Table 1														
Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
RDDIM	0	↑	1	-	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	↑	1	-	0	0	0	0	1	1	1	0	(0Eh)	Read display signal
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	TEON	TEM	HSYN	VSYN	PIXCLK	DATEN	0	DSIER		-
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	D0		-
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
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:
	1	↑	1		XS7	XS6	XS5	XS4	XS3	XS2	XS1	XS0		$0 \leq XS \leq X$
	1	↑	1		XE15	XE14	XE13	XE12	XE11	XE10	XE9	XE8		X address start:
	1	↑	1		XE7	XE6	XE5	XE4	XE3	XE2	XE1	XE0		$S \leq XE \leq X$

COMMAND Table 1														
Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
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:
	1	↑	1		YS7	YS6	YS5	YS4	YS3	YS2	YS1	YS0		$0 \leq YS \leq Y$
	1	↑	1		YE15	YE14	YE13	YE12	YE11	YE10	YE9	YE8		Y address start:
	1	↑	1		YE7	YE6	YE5	YE4	YE3	YE2	YE1	YE0		$S \leq YE \leq Y$
RAMWR	0	↑	1	-	0	0	1	0	1	1	0	0	(2Ch)	Memory write
	1	↑	1	-	D7	D6	D5	D4	D3	D2	D1	D0		Write data
RAMRD	0	↑	1	-	0	0	1	0	1	1	1	0	(2Eh)	Memory read
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	D7	D6	D5	D4	D3	D2	D1	D0		Read data
PTLAR	0	↑	1	-	0	0	1	1	0	0	0	0	(30h)	Partial start/end address set
	1	↑	1	-	PSL15	PSL14	PSL13	PSL12	PSL11	PSL10	PSL9	PSL8		Partial start address:
	1	↑	1	-	PSL7	PSL6	PSL5	PSL4	PSL3	PSL2	PSL1	PSL0		(0, 1, 2, ...P)
	1	↑	1	-	PEL15	PEL14	PEL13	PEL12	PEL11	PEL10	PEL9	PEL8		Partial end address
	1	↑	1	-	PEL7	PEL6	PEL5	PEL4	PEL3	PEL2	PEL1	PEL0		(0, 1, 2, 3, ...P)
VSCRDEF	0	↑	1	-	0	0	1	1	0	0	1	1	(33h)	Vertical scrolling definition
	1	↑	1	-	TFA15	TFA14	TFA13	TFA12	TFA11	TFA10	TFA9	TFA8		
	1	↑	1	-	TFA7	TFA6	TFA5	TFA4	TFA3	TFA2	TFA1	TFA0		
	1	↑	1	-	VSA15	VSA14	VSA13	VSA12	VSA11	VSA10	VSA9	VSA8		
	1	↑	1	-	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0		
	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

COMMAND Table 1														
Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
	1	↑	1	-	-	-	-	-	-	-	-	-	TEM	
MADCTL	0	↑	1	-	0	0	1	1	0	1	1	0	(36h)	Memory data access control
	1	↑	1	-	MY	MX	MV	ML	RGB	MH	0	0		-
VSCRSADD	0	↑	1	-	0	0	1	1	0	1	1	1	(37h)	Vertical scrolling start address
	1	↑	1	-	VSP15	VSP14	VSP13	VSP12	VSP11	VSP10	VSP9	VSP8		
	1	↑	1	-	VSP7	VSP6	VSP5	VSP4	VSP3	VSP2	VSP1	VSP0		
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
Interface Pixel Format	0	↑	1	-	0	0	1	1	1	0	1	0	(3Ah)	Interface pixel format
	1	↑	1	-	R3	R2	R1	R0	0	D2	D1	D0		Interface format
RAMWRC	0	↑	1	-	0	0	1	1	1	1	0	0	(3Ch)	Memory write continue
	1	↑	1	-	D17	D16	D15	D14	D13	D12	D11	D10		
	1	↑	1	-	Dx7	Dx6	Dx5	Dx4	Dx3	Dx2	Dx1	Dx0		
	1	↑	1	-	Dn7	Dn6	Dn5	Dn4	Dn3	Dn2	Dn1	Dn0		
RAMRDC	0	↑	1	-	0	0	1	1	1	1	1	0	(3Eh)	Memory read continue
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy Read
	1	1	↑	-	D17	D16	D15	D14	D13	D12	D11	D10		
	1	1	↑	-	Dx7	Dx6	Dx5	Dx4	Dx3	Dx2	Dx1	Dx0		
	1	1	↑	-	Dn7	Dn6	Dn5	Dn4	Dn3	Dn2	Dn1	Dn0		
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	↑	-	N15	N14	N13	N12	N11	N10	N9	N8		
	1	1	↑	-	N7	N6	N5	N4	N3	N2	N1	N0		

COMMAND Table 1														
Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
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		
RDISBV	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		
WRCABC	0	↑	1	-	0	1	0	1	0	1	0	1	(55h)	Write content adaptive brightness control
	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	0	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		

COMMAND Table 1														
Instruction	D/CX	WRX	RDX	D17-8	D7	D6	D5	D4	D3	D2	D1	D0	Hex	Function
RDFCHKSUM	0	↑	1		1	0	1	0	1	0	1	0	(Aah)	Read First Checksum
	1	1	↑		-	-	-	-	-	-	-	-		Dummy read
	1	1	↑		FCS7	FCS6	FCS5	FCS4	FCS3	FCS2	FCS1	FCS0		
RDCCHKSUM	0	↑	1		1	0	1	0	1	0	1	0	(Afh)	Read Continue Checksum
	1	1	↑		-	-	-	-	-	-	-	-		Dummy read
	1	1	↑		CCS7	CCS6	CCS5	CCS4	CCS3	CCS2	CCS1	CCS0		
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
	1	1	↑	-	-	-	-	-	-	-	-	-		Dummy read
	1	1	↑	-	ID37	ID36	ID35	ID34	ID33	ID32	ID31	ID30		Read parameter

7.2 初始化方法

用户所编的显示程序, 开始必须进行初始化, 否则模块无法正常显示, 过程请参考程序

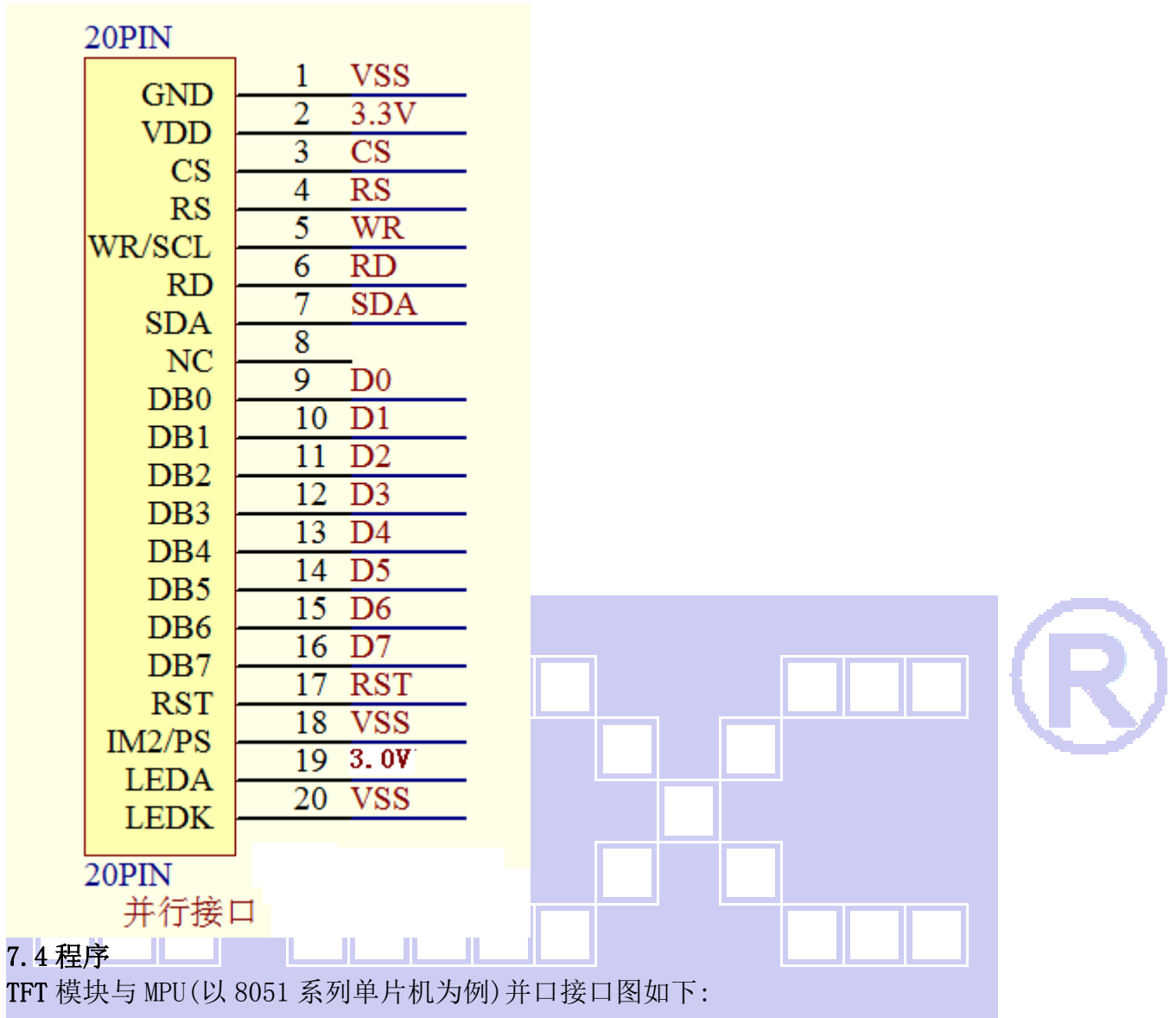
点亮液晶模块的步骤

硬件准备:
开发板 (或专门设计的主板)、单片机、电源、连接线、仿真器或程序下载器 (又名烧录器)

正确地接线
根据说明书正确地与开发板连接, 连接的线包括: 液晶模块电源线、背光电源线、IO端口 (接口)
IO端口包括: 并口时: CS、RESET、RW、E、RS、D0—D7, 串口时: CS、SCLK、SDA、RESET、RS

编写软件
背光给合适的直流电可以点亮, 但液晶屏里面没有程序, 只给电不能让液晶屏显示 (我们通常说“点亮”), 程序须另外编写, 并烧录 (下载) 到单片机里液晶模块才能工作。

7.3 并行原理图



7.4 程序

TFT 模块与 MPU (以 8051 系列单片机为例) 并口接口图如下:

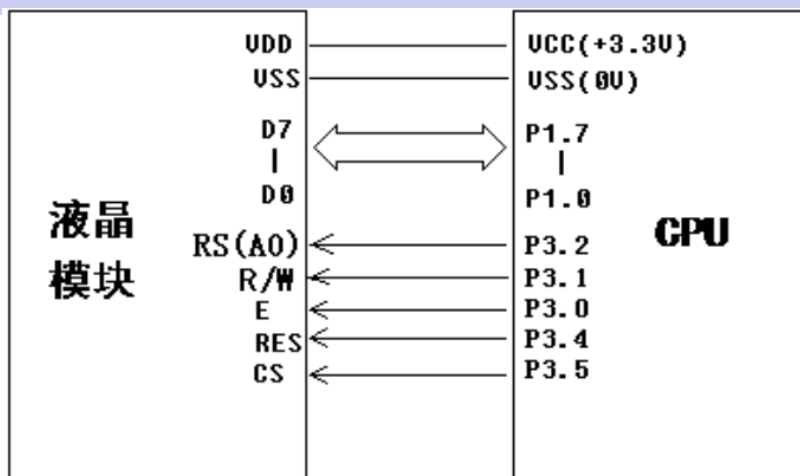


图 4. 并行接口

```
//LCM resolution:320x480,
```

```
//driver IC:ST7796S,
```

```
#include <reg51.h>
```

```
#include <chinese_code.h>
```

```
//液晶屏 IC 所需要的信号线的接口定义
```

```
sbit DC0=P3^1;
```

```
sbit WRO=P3^0;
```

```
sbit RD0=P3^4;
```

```
sbit CS0=P3^2;
```

```
sbit reset=P3^3;
```

```
sbit IM2=P3^6;
```

```
sbit key=P2^0;          //P2.0 口与 GND 之间接一个按键
```

```
void transfer_command(int com1)
```

```
{
```

```
    CS0 = 0;
```

```
    DC0 = 0;
```

```
    RD0 = 1;
```

```
    P1=com1;
```

```
    WRO = 0;
```

```
    delay_us(1);
```

```
    WRO = 1;
```

```
    CS0 = 1;
```

```
}
```

```
void transfer_data(int data1)
```

```
{
```

```
    CS0 = 0;
```

```
    DC0 = 1;
```

```
    RD0 = 1;
```

```
    P1=data1;
```

```
    WRO = 0;
```

```
//    delay_us(1);
```

```
    WRO = 1;
```

```
    CS0 = 1;
```

```
}
```

```
//连写 2 个字节（即 16 位）数据到 LCD 模块
```

```
void transfer_data_16(uint data_16bit)
```

```
{
```

```
    transfer_data(data_16bit>>8);
```

```
    transfer_data(data_16bit);
```

```
}
```

```
void delay(long i)
```



```

{
    int j,k;
    for (j=0;j<i;j++)
    for (k=0;k<110;k++);
}
    
```

```

void delay_us(long i)
{
    int j,k;
    for (j=0;j<i;j++)
    for (k=0;k<1;k++);
}
    
```

```

void Switch()
{
    repeat:
        if (key==1) goto repeat;
        else delay(1000);
        if (key) goto repeat;
        else ;
}
    
```

```

void lcd_initial()
{
    reset=1;
    delay(200);
    reset=0;
    delay(200);
    reset=1;
    delay(200);
}
    
```

```

//***** Start Initial Sequence *****//
transfer_command(0x11); //Sleep Out
delay(200);
transfer_command(0xf0); //
transfer_data(0xc3); //enable command 2 part 1
transfer_command(0xf0);
transfer_data(0x96); //enable command 2 part 2
transfer_command(0x36); //内存数据访问控制
transfer_data(0x48);

transfer_command(0x3a); //16bit pixel
transfer_data(0x55);

transfer_command(0xb4);
transfer_data(0x01);
    
```



```
transfer_command(0xb7);
transfer_data(0xc6);
```

```
transfer_command(0xe8);
transfer_data(0x40);
transfer_data(0x8a);
transfer_data(0x00);
transfer_data(0x00);
transfer_data(0x29);
transfer_data(0x19);
transfer_data(0xa5);
transfer_data(0x33);
```

```
transfer_command(0xc1);
transfer_data(0x06);
```

```
transfer_command(0xc2);
transfer_data(0xa7);
```

```
transfer_command(0xc5);
transfer_data(0x18);
```

```
transfer_command(0xe0); //Positive Voltage Gamma Control
```

```
transfer_data(0xf0);
```

```
transfer_data(0x09);
```

```
transfer_data(0x0b);
```

```
transfer_data(0x06);
```

```
transfer_data(0x04);
```

```
transfer_data(0x15);
```

```
transfer_data(0x2f);
```

```
transfer_data(0x54);
```

```
transfer_data(0x42);
```

```
transfer_data(0x3c);
```

```
transfer_data(0x17);
```

```
transfer_data(0x14);
```

```
transfer_data(0x18);
```

```
transfer_data(0x1b);
```

```
transfer_command(0xe1); //Negative Voltage Gamma Control
```

```
transfer_data(0xf0);
```

```
transfer_data(0x09);
```

```
transfer_data(0x0b);
```

```
transfer_data(0x06);
```

```
transfer_data(0x04);
```

```
transfer_data(0x03);
```



```

transfer_data(0x2d);
transfer_data(0x43);
transfer_data(0x42);
transfer_data(0x3b);
transfer_data(0x16);
transfer_data(0x14);
transfer_data(0x17);
transfer_data(0x1b);

transfer_command(0xf0);
transfer_data(0x3c);

transfer_command(0xf0);
transfer_data(0x69);
delay(120);
transfer_command(0x21); //
transfer_command(0x29); //Display ON
transfer_command(0x2c); // 写数据开始
}

//定义窗口坐标: 开始坐标 (XS,YS)以及窗口大小 (x_total,y_total)
void lcd_address(int XS,int YS,int x_total,int y_total)
{
    int XE,YE;
    XE=XS+x_total-1;
    YE=YS+y_total-1;
    transfer_command(0x2a); // 设置 X 开始及结束的地址
    transfer_data_16(XS); // X 开始地址(16 位)
    transfer_data_16(XE); // X 结束地址(16 位)

    transfer_command(0x2b); // 设置 Y 开始及结束的地址
    transfer_data_16(YS); // Y 开始地址(16 位)
    transfer_data_16(YE); // Y 结束地址(16 位)

    transfer_command(0x2c); // 写数据开始
}

void mono_transfer_data_16(int mono_data,int font_color,int back_color)
{
    int i;
    for(i=0;i<8;i++)
    {
        if(mono_data&0x80)
        {
            transfer_data_16(font_color); //当数据是 1 时, 显示字体颜色
        }
    }
}

```



```

        else
        {
            transfer_data_16(back_color); //当数据是 0 时, 显示底色
        }
        mono_data<<=1;
    }
}

```

//显示 8x16 点阵的字符串

```
void disp_string_8x16(int x, int y, char *text, int font_color, int back_color)
```

```

{
    int i=0, j, k;
    while(text[i]>0x00)
    {
        if((text[i]>=0x20)&&(text[i]<=0x7e))
        {
            j=text[i]-0x20;
            lcd_address(x, y, 8, 16);
            for(k=0;k<16;k++)
            {
                mono_transfer_data_16(ascii_table_8x16[j*16+k], font_color, back_color);
                //a??"ascii_table_8x16[]"?a??ÿy×é?ú"ASCII_TABLE_5X8_8X16_horizontal.h"à?
            }
            x+=8;
            i++;
        }
        else
            i++;
    }
}

```



```
void display_string_16x16(int x, int y, uchar *text, int font_color, int back_color)
```

```

{
    uchar i, j, k;
    uint address;
    j = 0;
    while(text[j] != '\0') //'\0' 字符串结束标志
    {
        i = 0;
        address = 1;
        while(Chinese_horizontal_text_16x16[i] > 0x7e) // >0x7f 即说明不是 ASCII 码字符
        {
            if(Chinese_horizontal_text_16x16[i] == text[j])
            {
                if(Chinese_horizontal_text_16x16[i + 1] == text[j + 1])
                {

```

```

        address = i * 16;
        break;
    }
}
i += 2;
}
if(y > 480)
{
    y=0;
    x+=16;
}

if(address != 1)// 显示汉字
{
    lcd_address(x, y, 16, 16);
    for(i=0;i<2;i++)
    {
        for(k = 0; k <16; k++)
        {
            mono_transfer_data_16(Chinese_horizontal_code_16x16[address], font_color, back_color);
            address++;
        }
        j+=2;
    }
    else //显示空白字符
    {
        lcd_address(x, y, 16, 16);
        for(i = 0; i <2; i++)
        {
            for(k = 0; k < 16; k++)
            {
                mono_transfer_data_16(0x00, font_color, back_color);
            }
        }
        j+=2;
    }
    x=x+16;
}
}

```

//显示 32x32 点阵的单色的图像

```

void disp_32x32(int x, int y, char *dp, int font_color, int back_color)
{
    int i, j;

```

```

    lcd_address(x, y, 32, 32);
    for(i=0; i<32; i++)
    {
        for(j=0; j<4; j++)
        {
            mono_transfer_data_16(*dp, font_color, back_color);
            dp++;
        }
    }
}

```

```

void display_black(void)
{
    int i, j, k;
    transfer_command(0x2c);        // 写数据开始
    for(i=0; i<320; i++)
    {

```

```

        transfer_data_16(0xffff);
    }
    for(i=0; i<478; i++)
    {
        for(k=0; k<1; k++)
        {
            transfer_data_16(0xffff);
        }
        for(j=0; j<318; j++)
        {
            transfer_data_16(0x0000);
        }
        for(k=0; k<1; k++)
        {
            transfer_data_16(0xffff);
        }
    }
    for(i=0; i<480; i++)
    {
        transfer_data_16(0xffff);
    }
}

```

//显示一幅彩图

```

void display_image(int x, int y, uchar *dp)
{
    uchar i, j, k=0;
    lcd_address(x, y, 160, 160);
    for(i=0; i<160; i++)

```



```

{
    for(j=0;j<160;j++)
    {
        transfer_data(*dp);          //传一个像素的图片数据的高位
        dp++;
        transfer_data(*dp);          //传一个像素的图片数据的低位
        dp++;
    }
}
}

```

//全屏显示 RGB 颜色

void display_RGB(void)

```

{
    int i, j;
    lcd_address(0, 0, 320, 480);
    for(i=0;i<320/3;i++)
    {
        for(j=0;j<480;j++)
        {
            transfer_data_16(red);
        }
    }
    for(i=0;i<320/3;i++)
    {
        for(j=0;j<480;j++)
        {
            transfer_data_16(green);
        }
    }

    for(i=0;i<320-2*(320/3);i++)
    {
        for(j=0;j<480;j++)
        {
            transfer_data_16(blue);
        }
    }
}

```

函数名: Gray16

功能: 显示 16 灰阶

*****/

void display_Gray16(void) //color: WHITE, RED, GREEN, BLUE

```

{
    uint dataa;
    uint i, j, k;

    for(i = 0; i < 480; i++)
    {
        for(j = 0; j < 16; j++)
        {
            dataa = ((2 * j) << 11) | ((4 * j) << 5) | (2 * j);
            for(k = 0; k < 320 / 16; k++)
            {
                transfer_data_16(dataa);
            }
        }
    }
}

```

//全屏显示一种颜色

```

void display_color(uint color_data)
{
    int i, j;
    lcd_address(0, 0, 320, 480);
    for(i=0; i<320; i++)
    {
        for(j=0; j<480; j++)
        {
            transfer_data_16(color_data);
        }
    }
}

```



```

void main(void)
{
    IM2=0;
    lcd_initial();
    while(1)
    {
        display_color(0x001f);
        disp_32x32(80+32*0, 32, jing_32x32, white, blue);
        disp_32x32(80+32*1, 32, lian_32x32, white, blue);
        disp_32x32(80+32*2, 32, xun_32x32, white, blue);
        disp_32x32(80+32*3, 32, dian_32x32, white, blue);
        disp_32x32(80+32*4, 32, zi_32x32, white, blue);
    }
}

```

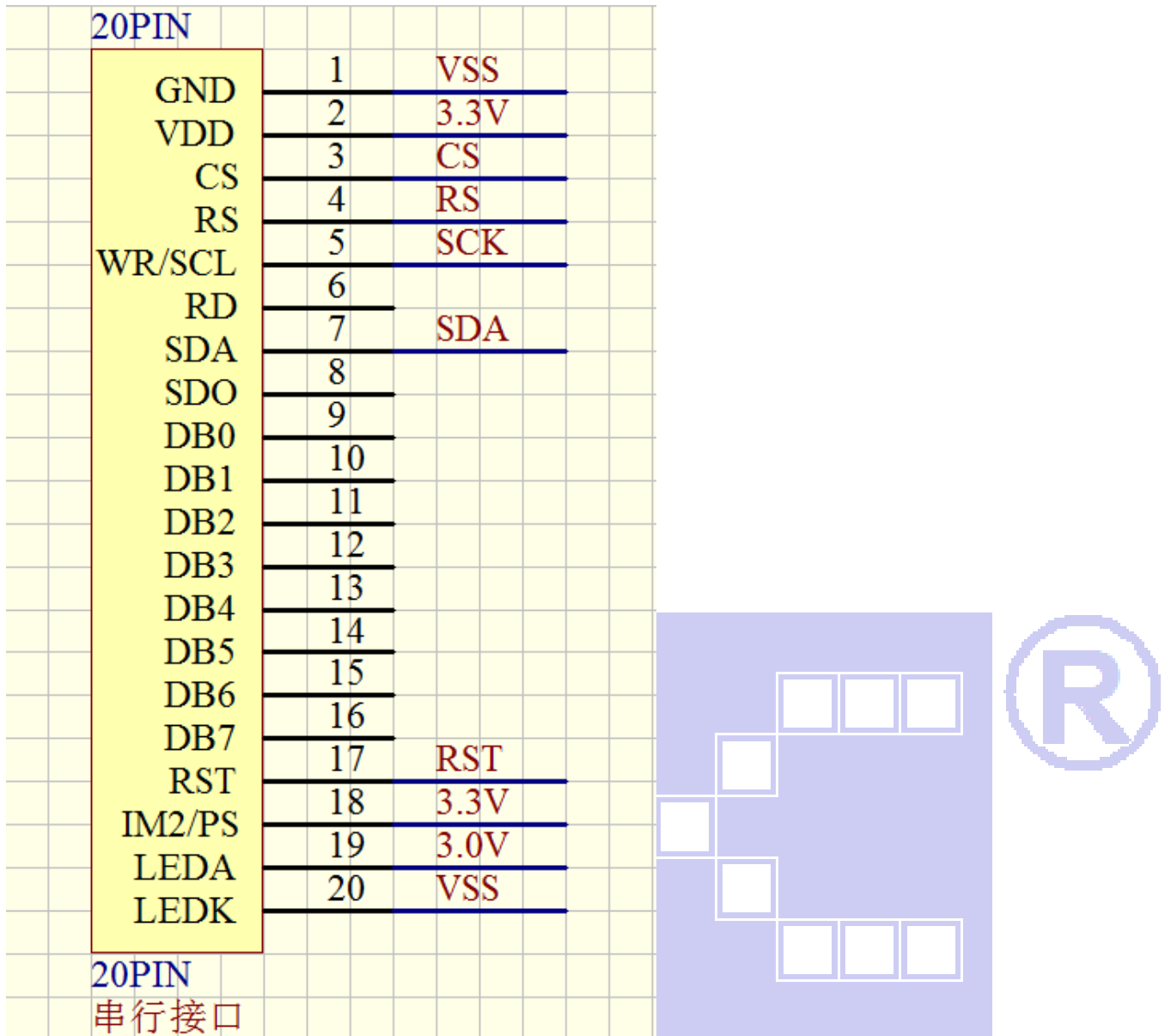


```

display_string_16x16(64, 80, "深圳市晶联讯电子有限公司", white, blue);
display_string_16x16(100, 112, "型号", white, blue);
disp_string_8x16(132, 112, ":JLX400-04201", white, blue);
display_string_16x16(100, 144, "视窗", white, blue);
disp_string_8x16(132, 144, ":57.9x87.2mm", white, blue);
display_string_16x16(100, 176, "驱动", white, blue);
disp_string_8x16(132, 176, "IC:ST7789S", white, blue);
display_string_16x16(40, 204, "经营宗旨: 制造高品质产品及服务", white, blue);
display_string_16x16(40, 236, "质量方针: 客户至上, 质量保障", white, blue);
display_string_16x16(119, 268, "持续改进, 服务到位", white, blue);
display_string_16x16(40, 300, "经营目标: 做最好的液晶模块厂家", white, blue);
display_string_16x16(119, 332, "做客户信得过的企业", white, blue);
Switch();
display_RGB();
Switch();
display_Gray16();
Switch();
display_color(0xf800);
Switch();
display_color(0x07e0);
Switch();
display_color(0x001f);
Switch();
display_black();
Switch();
display_color(0xffff);
Switch();
}
    
```

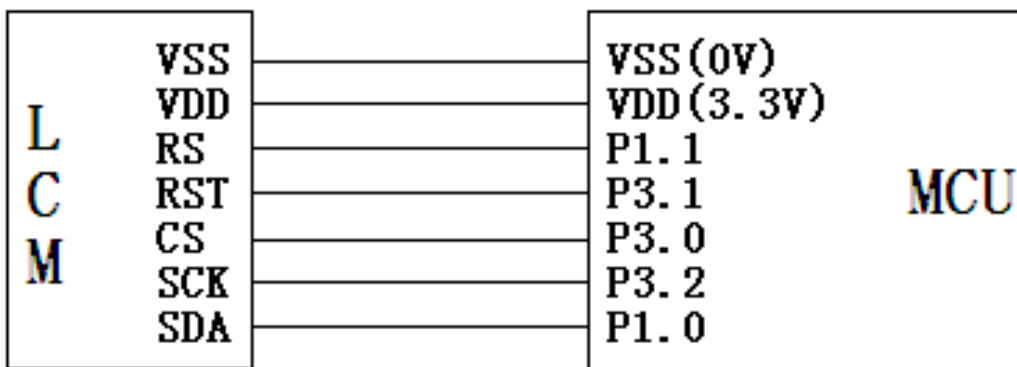


7.5 串行原理图



7.6 程序

TFT 模块与 MPU (以 8051 系列单片机为例) 串行接口图如下:



与并行方式相比较, 只需改变接口顺序以及传送数据、传送命令这两个函数即可:

串行程序:

```

//型号:JLX400-042-BN、横屏;
//驱动 IC:ST7796S;
#include <STC15F2K60S2.H>
#include <chinese_code.h>
//液晶屏 IC 所需要的信号线的接口定义
sbit RS=P1^1;
sbit SCK=P3^2;
sbit SDA=P1^0;
sbit CS=P3^0;
sbit RST=P3^1;
sbit IM2=P3^6;
sbit key=P2^0;          //P2.0 口与 GND 之间接一个按键
void transfer_command(int com1)
{
    char i;
    CS=0;
    RS=0;
    for (i=0;i<8;i++)
    {
        SCK=0;
        if(com1&0x80) SDA=1;
        else SDA=0;
        SCK=1;
        com1=com1<<=1;
    }
}
void transfer_data(int data1)
{
    char i;
    CS=0;
    RS=1;
    for (i=0;i<8;i++)
    {
        SCK=0;
        if(data1&0x80) SDA=1;
        else SDA=0;
        SCK=1;
        data1=data1<<=1;
    }
}
    
```



-END-