南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Embedded System and Microcomputer Principle

LAB10 Resistive touch screen

2023 Fall
wangq9@mail.sustech.edu.cn

南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

CONTENTS

南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

01

Principle Description

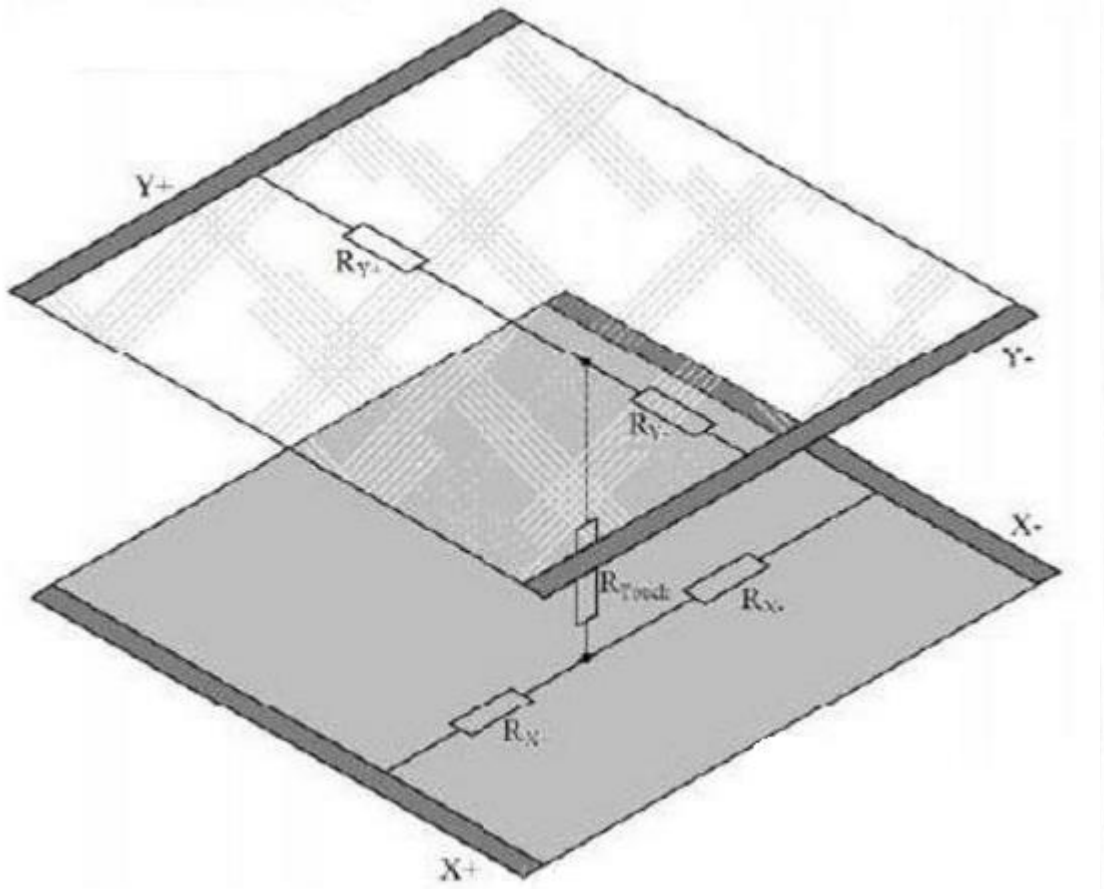
1. Principle Description
-- Classify of touch screen

- 按照触摸屏的工作原理和传输信息的介质分类
  - 电阻式：定位准确，单点触摸（Mini开发板使用）
  - 电容式：多点触控
  - 红外线式：价格低廉，曲面情况下失真
  - 表面声波式：解决各种缺点，但是屏幕表面如果有水滴和尘土会使触摸屏变的迟钝

1. Principle Description

-- Working principle of touch screen

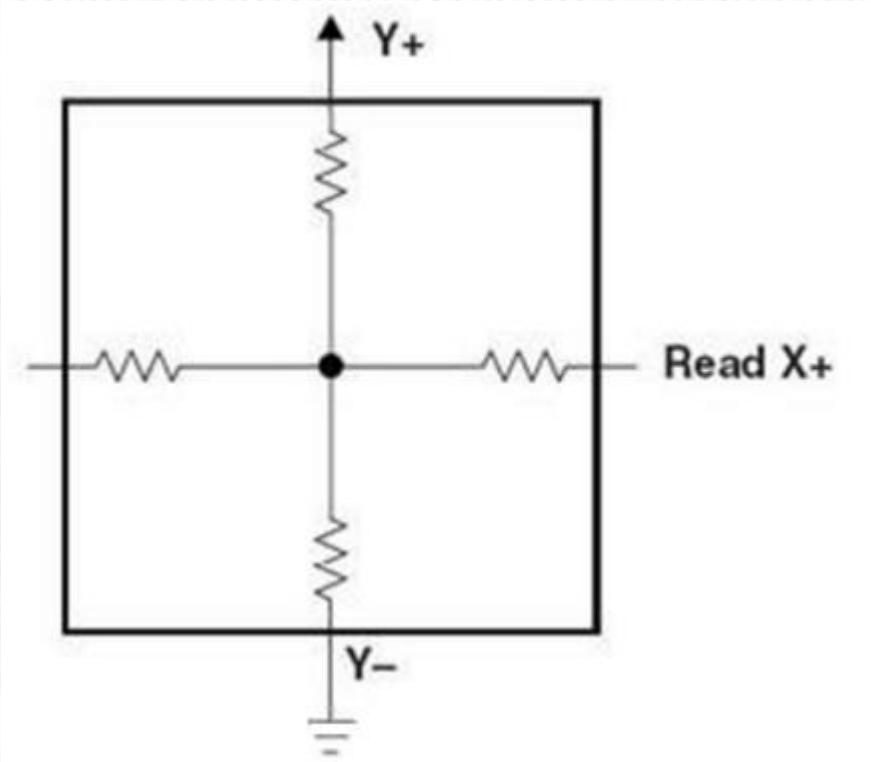
- 电阻屏分为上下两层（为X层和Y层），中间由隔离支点隔开。
- 上下两层相邻面均涂有ITO涂层，为导电涂层。
- 在X层的两侧和Y层的两侧分别连接电路。
- X层上X-到X+，Y层上Y-到Y+的电阻是均匀分布的。



Schematic diagram

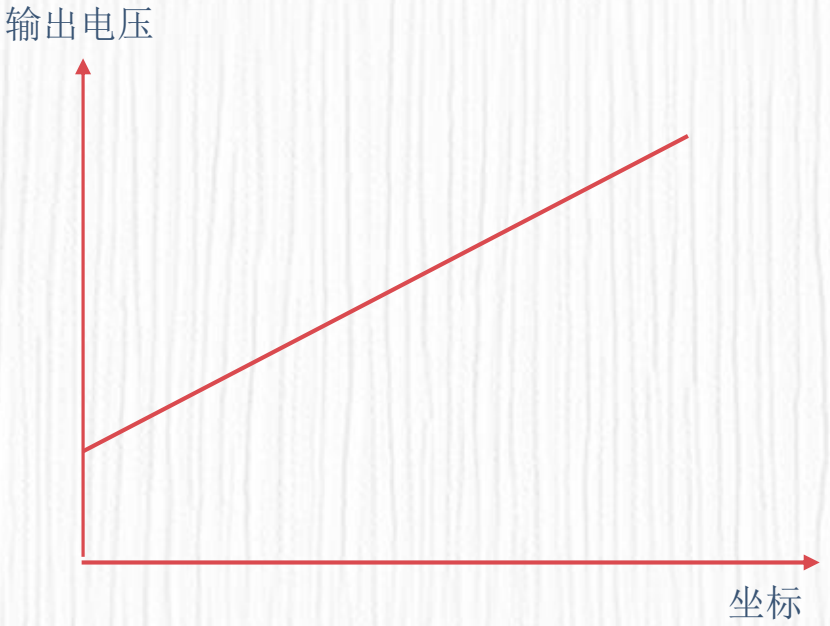
1. Principle Description -- Measuring touch points

- 计算Y坐标时，在Y+电极施加驱动电压V，Y-接地，芯片通过X+测量接触点的电压。



等效示意图

- 由于ITO层均匀导电，触点电压与V电压之比等于触点Y坐标与屏高度之比。因此实际测量时，可以求得电压与距离的关系方程。



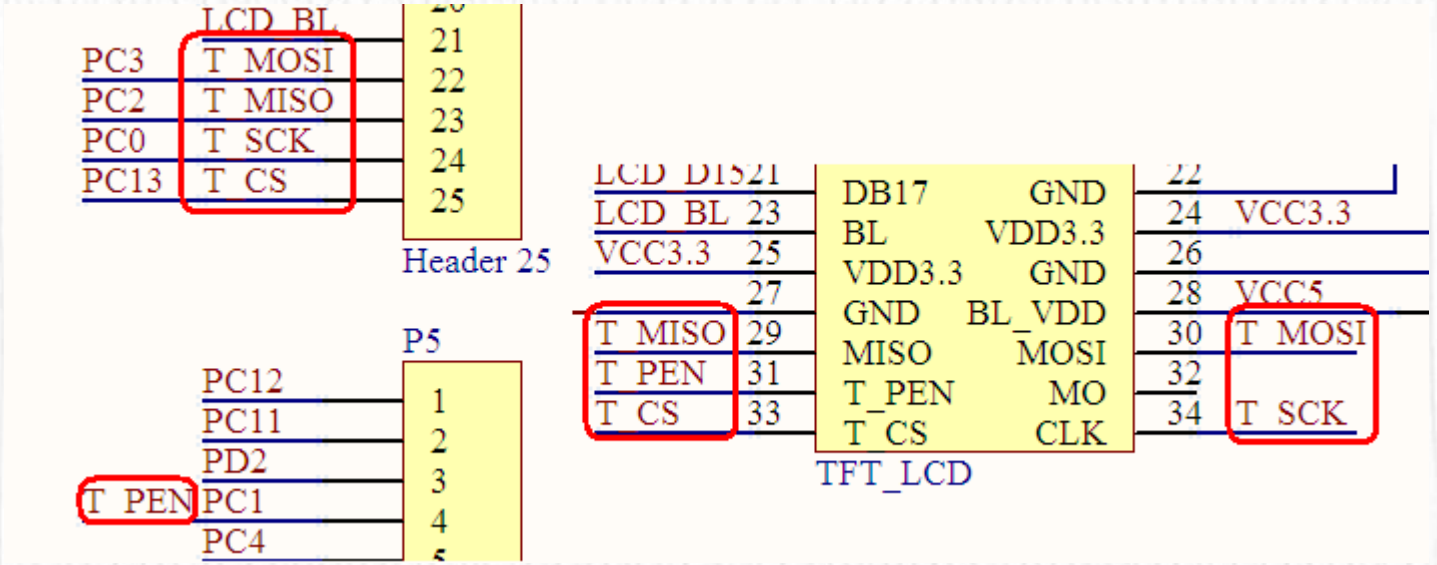
南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

02

Control Principle Description

2. Control Principle Description -- STM32 touch screen

- ALIENTEK TFTLCD 模块选择的是四线电阻式触摸屏。
- ALIENTEK TFTLCD 模块自带的触摸屏控制芯片为 XPT2046。
- T_CS: 片选
- T_CLK: 时钟信号
- T_MISO: 触屏数据读入
- T_MOSI: 数据输出
- T_PEN: 中断输出端



Circuit connection diagram between touch screen and STM32

2. Control Principle Description
-- XPT2046 chip

- 4导线制触摸屏控制器。
- 内含12位分辨率125KHz转换速率逐步逼近型A/D转换器。
- 支持从 1.5V 到 5.25V 的低电压 I/O 接口。
- 能通过执行两次 A/D 转换查出被按的屏幕位置。
- 还可以测量加在触摸屏上的压力。
- 内部自带 2.5V 参考电压可以作为辅助输入、温度测量和电池监测模式之用，电池监测的电压范围可以从 0V 到 6V。
- 片内集成有一个温度传感器。

2. Control Principle Description
-- SPI protocol

- Serial Peripheral interface，串行外围设备接口。
- 一种高速的，全双工，同步的通信总线。
- 在芯片的管脚上占用四根线。
- SPI 物理接口含义：
  - SCLK：时钟信号，由主设备产生，主从设备根据时钟传输数据。
  - CS：从设备片选信号，由主设备控制。多个从设备，主设备选择哪一个从设备通信，从设备相对应的片选拉低。
  - MISO：主设备数据输入，从设备数据输出。
  - MOSI：主设备数据输出，从设备数据输入。
- SPI 接口主要应用在 EEPROM，FLASH，实时时钟，AD 转换器，还有数字信号处理器和数字信号解码器之间。

03

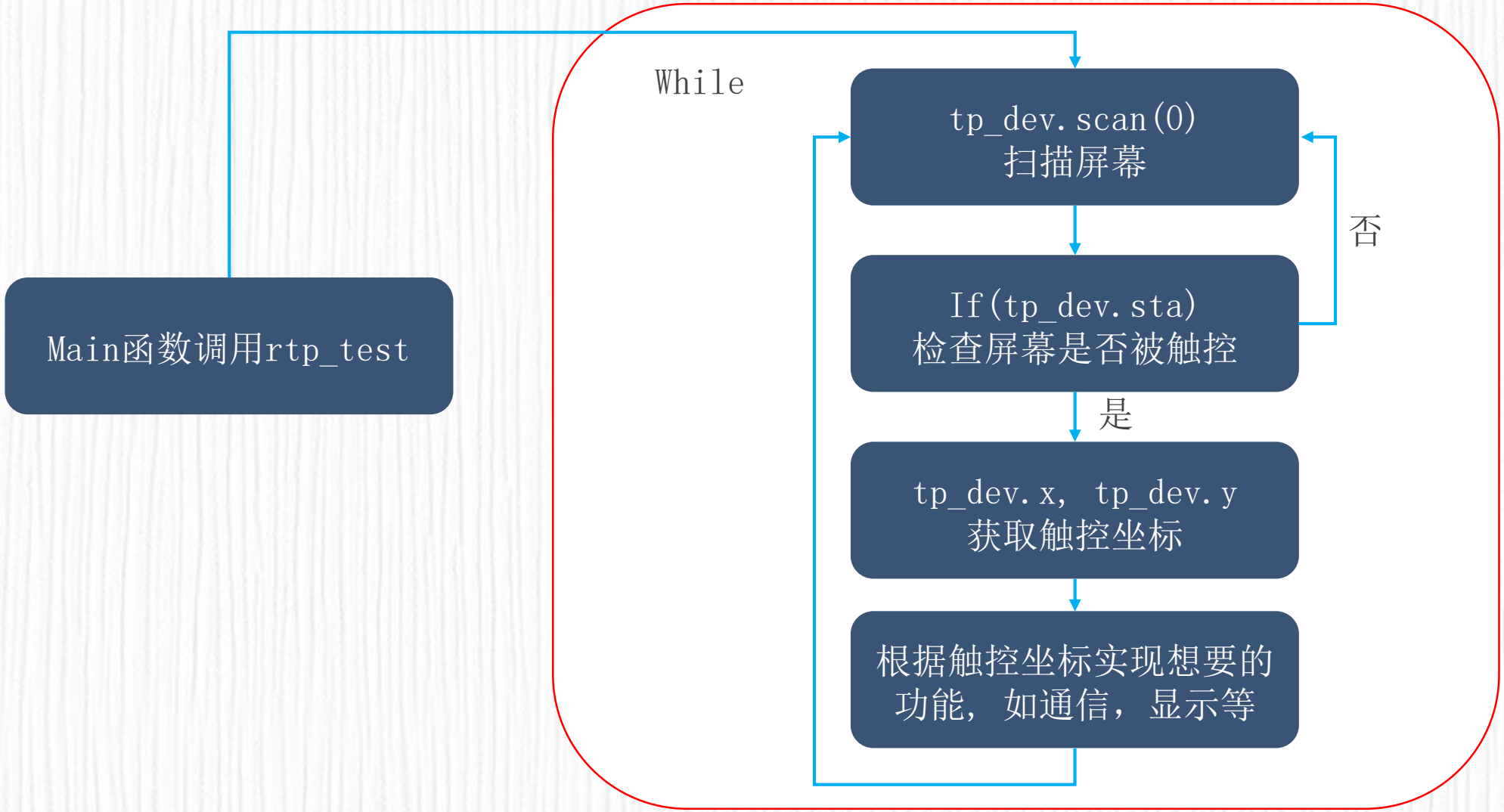
How to Program

3. How to program
-- Touch screen control structure

- 电阻屏的驱动代码实现均在touch.h和touch.c中
- 在touch.h中定义了结构体_m_tp_dev

```
//触摸屏控制器
typedef struct
{
    u8 (*init)(void);              //初始化触摸屏控制器
    u8 (*scan)(u8);                //扫描触摸屏.0,屏幕扫描;1,物理坐标;
    void (*adjust)(void);          //触摸屏校准
    u16 x[CT_MAX_TOUCH];           //当前坐标
    u16 y[CT_MAX_TOUCH];           //电容屏有最多5组坐标,电阻屏则用x[0],y[0]代表:此次扫描时,触屏的坐标,用
                                   //x[4],y[4]存储第一次按下时的坐标.
    u8  sta;                       //笔的状态
                                   //b7:按下1/松开0;
                                   //b6:0,没有按键按下;1,有按键按下.
                                   //b5:保留
                                   //b4~b0:电容触摸屏按下的点数(0,表示未按下,1表示按下)
//////////////////////触摸屏校准参数(电容屏不需要校准)//////////////////////
    float xfac;
    float yfac;
    short xoff;
    short yoff;
//新增的参数,当触摸屏的左右上下完全颠倒时需要用到.
//b0:0,竖屏(适合左右为X坐标,上下为Y坐标的TP)
//   1,横屏(适合左右为Y坐标,上下为X坐标的TP)
//b1~6:保留.
//b7:0,电阻屏
//   1,电容屏
    u8 touchtype;
}_m_tp_dev;
```

3. How to program
-- Working process



3. How to program -- Some functions

- TP_Scan
  - 触摸屏按键扫描
  - 参数:tp （0:屏幕坐标；1:物理坐标)
  - 返回值: 0:触屏无触摸；1:触屏有触摸
- TP_Adjust
  - 触摸屏校准代码
  - 得到四个校准参数
  - 校准参数保存在AT24CXX芯片中
- TP_Init
  - 触摸屏初始化
  - 返回值: 0:触屏无校准；1:触屏有校准

3. How to program
-- Main function

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

```
int main(void)
{
  HAL_Init();
  /* USER CODE BEGIN Init */
  Stm32_Clock_Init(RCC_PLL_MUL9);          //设置时钟,72M
    delay_init(72);                        //初始化延时函数
//  uart_init(115200);                     //初始化串口
//  usmart_dev.init(84);                   //初始化USMART
    LED_Init();                            //初始化LED
    KEY_Init();                            //初始化按键
    LCD_Init();                            //初始化LCD
    tp_dev.init();                         //触摸屏初始化

  SystemClock_Config();
  MX_GPIO_Init();
  MX_SPI1_Init();
  MX_USART1_UART_Init();
  /* USER CODE BEGIN 2 */
  POINT_COLOR=RED;
    LCD_ShowString(30,50,200,16,16,"Mini STM32");
    LCD_ShowString(30,70,200,16,16,"TOUCH TEST");
    LCD_ShowString(30,90,200,16,16,"ATOM@ALIENTEK");
    LCD_ShowString(30,110,200,16,16,"2019/11/15");
        if(tp_dev.touchtype!=0XFF)
    {
        LCD_ShowString(30,130,200,16,16,"Press KEY0 to Adjust");//电阻屏才显示
    }
    delay_ms(1500);
    Load_Drow_Dialog();

    if(tp_dev.touchtype&0X80)ctp_test();//电容屏
    else rtp_test();                       //电阻屏
  /* USER CODE END 2 */
}
```

3. How to program
-- rtp_test function

南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

```
void rtp_test(void) { //电阻触摸屏测试函数
    u8 key;
    u8 i=0;
    while(1){
        key=KEY_Scan(0);
        tp_dev.scan(0);
        screen_norm_print();
        if(tp_dev.sta&TP_PRES_DOWN) {        //触摸屏被按下
            if(tp_dev.x[0]<lcddev.width&&tp_dev.y[0]<lcddev.height){
                if(tp_dev.x[0]>(lcddev.width-24)&&tp_dev.y[0]<16){
                    screen_print();//清除
                }
                else if(tp_dev.x[0]<80&&tp_dev.y[0]<24){
                    LCD_ShowImage2(40,80);
                }
                else if(tp_dev.x[0]>60&&tp_dev.y[0]>60&&tp_dev.x[0]<180&&tp_dev.y[0]<100){
                    sprintf(DATA_TO_SEND, "SEND DATA");
                    HAL_UART_Transmit(&huart1, (uint8_t*)DATA_TO_SEND, strlen(DATA_TO_SEND), HAL_MAX_DELAY);
                }
                else if(tp_dev.x[0]>0&&tp_dev.y[0]>lcddev.height-24&&tp_dev.x[0]<80&&tp_dev.y[0]<lcddev.height){
                    change_state();
                }
                else {
                    TP_Draw_Big_Point(tp_dev.x[0],tp_dev.y[0],RED);//画图
                }
            }
        }else delay_ms(10); //没有按键按下的时候
        if(key==KEY0_PRES) {     //KEY0按下,则执行校准程序
            LCD_Clear(WHITE);    //清屏
            TP_Adjust();         //屏幕校准
            TP_Save_Adjdata();
            Load_Drow_Dialog();
        }
        i++;
        if(i%20==0)LED0=!LED0;
    }
}
```

3. How to program -- References

- Video：https://www.bilibili.com/video/BV1Lx411Z7Qa?p=67&vd_source=ce498dc8db119fb370d9404aff550452

- Information download：http://www.openedv.com/docs/boards/stm32/zdyz_stm32f103_mini.html
  http://www.openedv.com/docs/boards/stm32/zdyz_stm32f103_miniV4.html (V4 version)

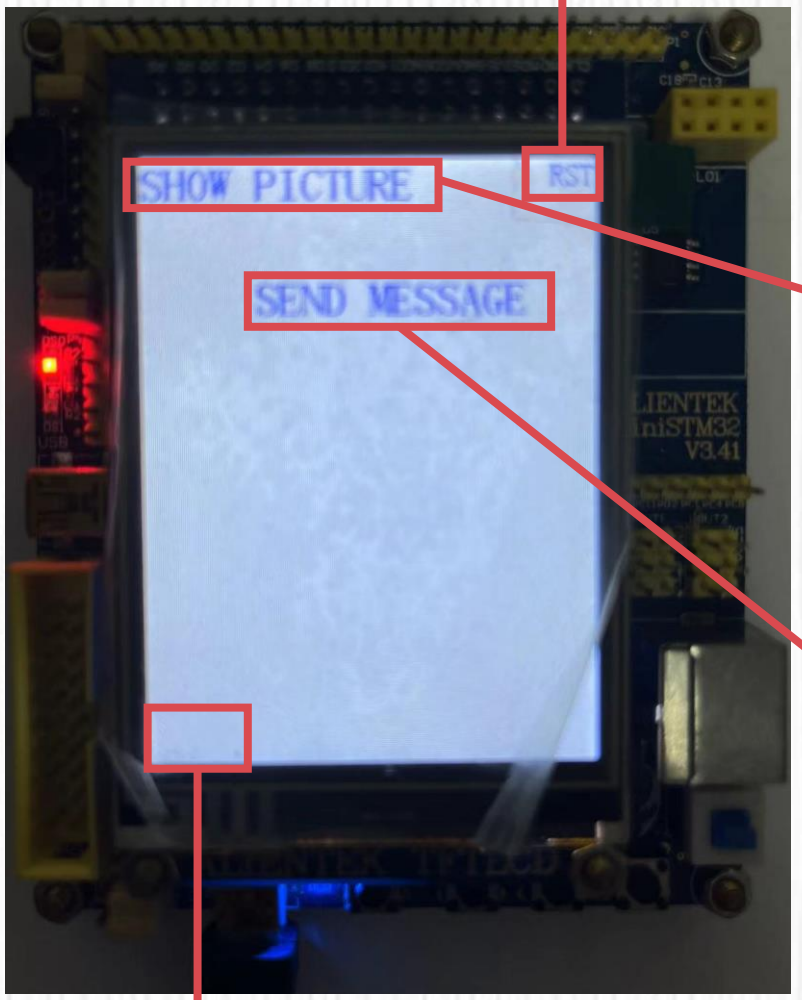
3. How to program
-- Results 1

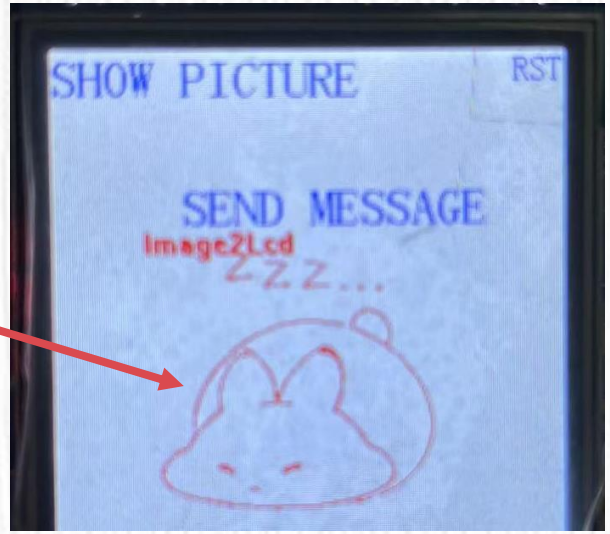
Adjust interface

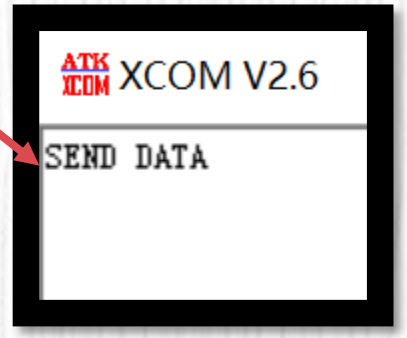
Main interface

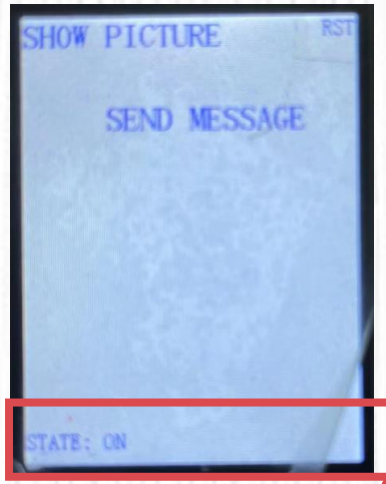
Writing on screen

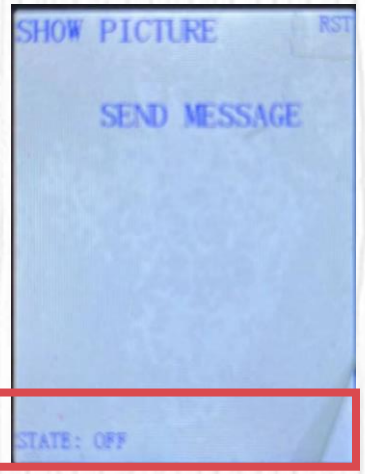
3. How to program
-- Results 2



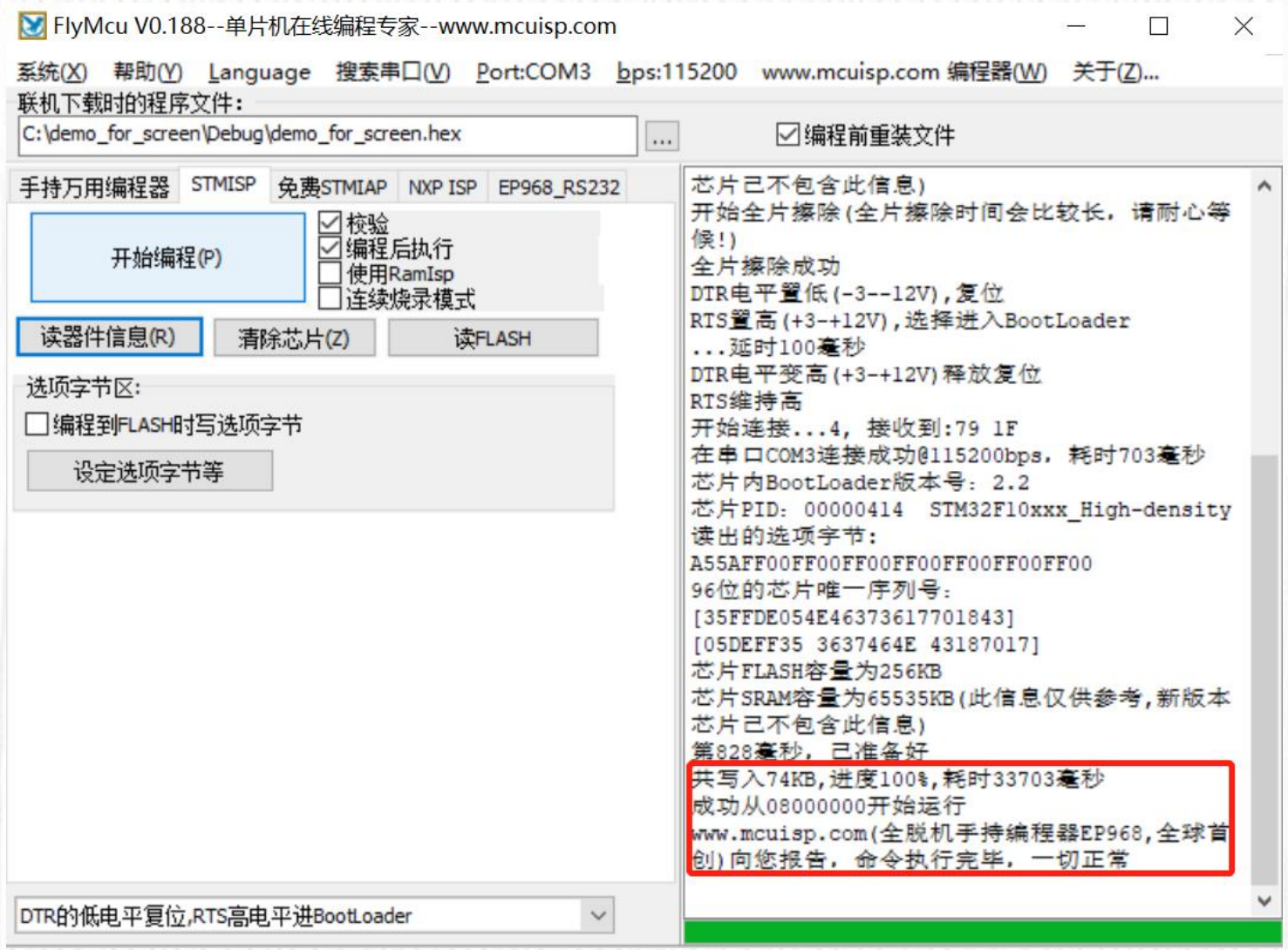




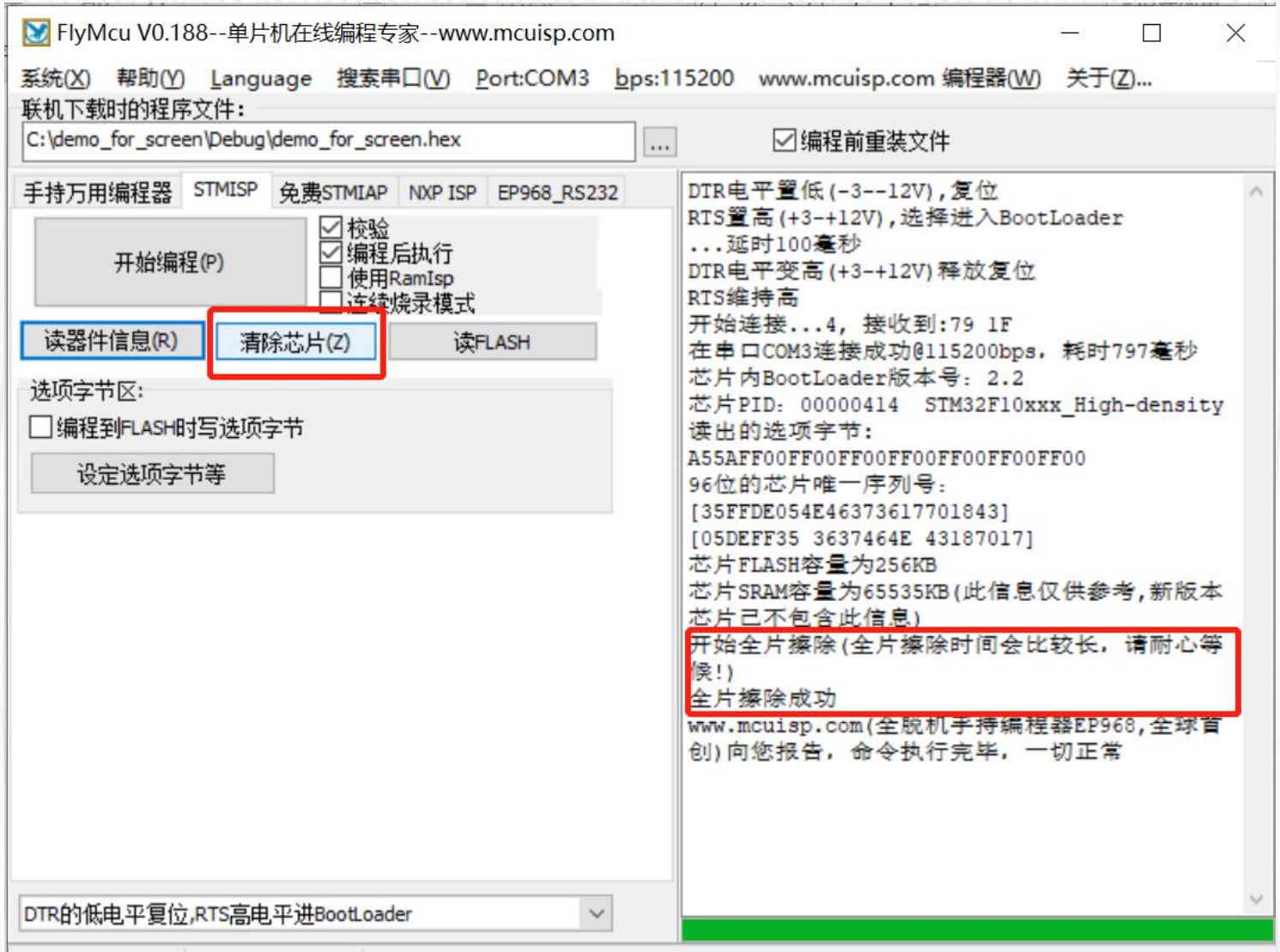




3. How to program
-- Programming complete



3. How to program
-- Chip erase



南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

04

Practice

4. Practice

- Run the demo on MiniSTM32 board.
- Complete a new buttons to realize an independently designed function to show a true 16bit color picture.

TIPS: How to Display a true 16bit color picture

- Step1：Add the following function and prototype into lcd.c and lcd.h (lcd_v4.c and lcd_v4.h for V4 board.)

```
void LCD_ShowPicture(uint16_t x,uint16_t y,uint16_t column,uint16_t row,unsigned short *pic)
{
uint16_t m,h;
uint16_t *data=(uint16_t *)pic;
    for(h=0+y;h<row+y;h++) //60
    {
        for(m=0+x;m<column+x;m++) //180
        {
            LCD_Fast_DrawPoint(m,h,*data++);
        }
    }
}
```

```
void LCD_ShowPicture(uint16_t x,uint16_t y,uint16_t column,uint16_t row,unsigned short *pic);
```

TIPS: How to Display a true 16bit color picture

- Step2： Load the Image into Image2Lcd(download from blackboard), set the correct size and save it as C file


```
const unsigned char gImage_logo[113768] = {
0X00,0X10,0XF0,0X00,0XED,0X00,0X01,0X1B,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
```

(240， 237) -> size of the picture

TIPS: How to Display a true 16bit color picture

- Step3： Copy the char array declaration into main.c and display the picture using `LCD_ShowPicture()`

```
/* Private user code ---------------------------------------------------------*/
/* USER CODE BEGIN 0 */
const unsigned char gImage_logo[113768] = { 0X00,0X10,0XF0,0X00,0XED,0X00,0X01,0X1B,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,0XFF,
```

```
LCD_ShowPicture(0,0,240,237,(uint16_t*)gImage_logo);
```