The SpO2 Tester Based on STM32

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Abstract: The purpose of our project is to test your healthy state through your height, weight, and pulse and oximeter data. User can type their height and weight through LCD screen. Also, they should put their finger on the SpO2 sensor, we will get the pulse and oximeter data through the sensor. Finally, the LCD screen will show the result of the health state according to these data (weight, height, sensor data) we get.

I. Introduction

1. Background

With the more and more pressure people have, mentally or physically, the health problem become more and more important. We mainly think about since the much more attention about health, we want to make a system which can let people know their health state at home, just tying some value and put the finger on the tester, which will be convenient for people to know their rough health state. Also, some old meet disease Hypoxemia and this instrument can help them to know whether they need to absorb oxygen.

2. Specifications

① SpO2 Sensor:
- MAX30100 integrated pulse oximetry and heart-rate sensor
- I2C interface
- 3.3V power supply

② LCD is SainSmart 3.2" TFT LCD Display:
- 65K color
- 320*240
- 3.2 inch
- Wide viewing angle
- SSD1289: 240 RGB x 320 TFT Driver
- Integrated Power, Gate and Source Driver With RAM
- XPT2046: wire touch, up tp 125kHz conversion rate, serial interface

II. Architecture

1. Overall Architecture

The design is separated into two parts: 1) SpO2 Sensor; 2) LCD. Here, SpO2 Sensor is used to get the oxygen saturation data and heart rate data. Then, transmit the raw data to STM32 board. After receiving and processing, STM32 board will send specific instruction to LCD. Thus, LCD can show the user processed data.

Overall procedure is show as fig. 2.1.1:

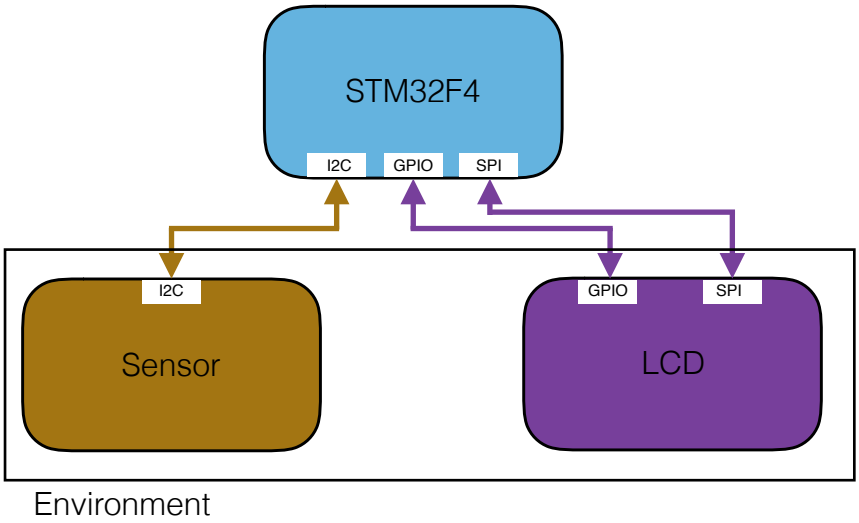


fig. 2.1.1

2. STM32

After sending instruction via I2C, STM32 will get the raw data from sensor. Then micro-controller For LCD module, after getting the data from SPI(touch), micro-controller will process the data and send the display module instruction according to the data get from SPI.Schematic is shown 2.2.1:

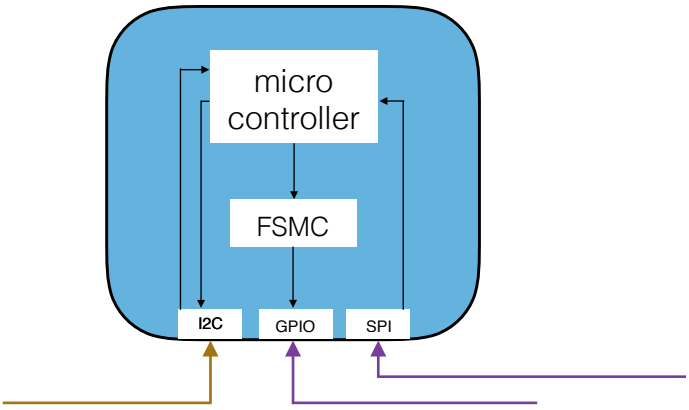


fig. 2.2.1

3. Environment:

SpO2 Sensor:

The specific chip used for SpO2 Sensor is MAX20100. IR is for testing heart rate and RED and IR are combined to test the oxygen saturation. The signal tested by LED will be processed by MAX30100 and the analog signal will be converted to the digital signal for output. Schematic is shown 2.3.1(a).

LCD:

The specific chip used for display is SSD1289 and for touch is XPT2046. When user touch the LCD, XPT2046 will process the data and then transmit the digital data to STM32 micro-controller. Later, give the specific instruction to SSD1289 to operate the LCD. Schematic is shown 2.3.1(b).

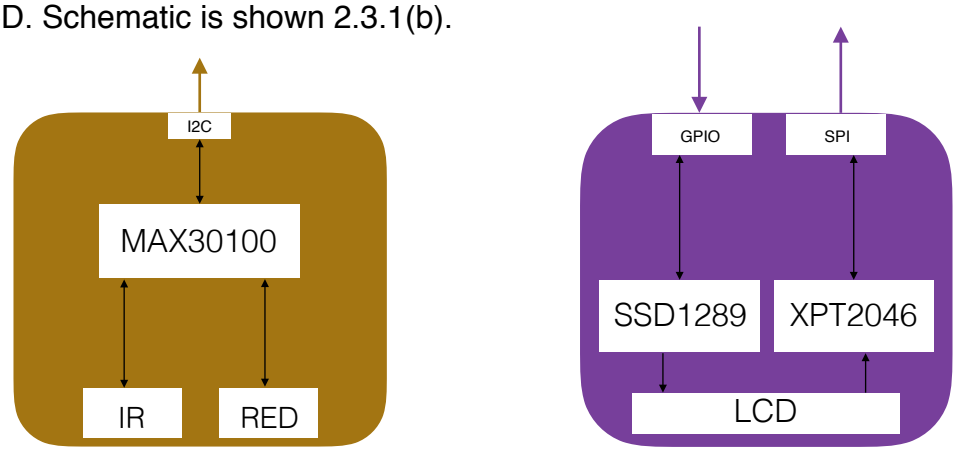


fig. 2.3.1

III. Specific Design

1. SpO2 Sensor module

① Implementation:

HbO2 and Hb are two data which can be got according to IR and RED. They will combined to calculate the oxygen saturation. SpO_2 can be estimated by measuring the absorption of light as it passes through the body. Oximetry is the measurement of blood gas saturation. Pulse oximetry is a non-invasive method of oximetry which involves flashing two LED's alternately. This article describes the principle behind pulse oximetry. (as fig. 3.1.1)

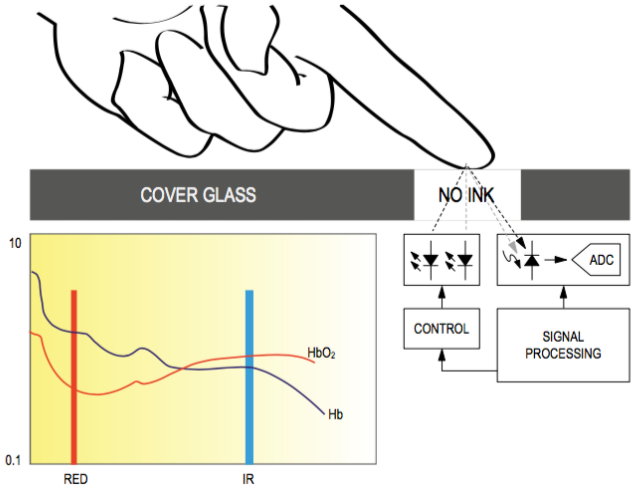


fig. 3.1.1

Use I2C protocol to connect between STM32f4 discovery board and MAX30100 sensor.

The working process is showing as fig. 3.1.2:

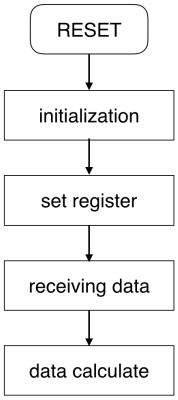


fig. 3.1.2

In initialization, we should enable clock and pins, check clock, set clock, and set values. The port I use is I2C1, and pins packet is TM_I2C_PinsPack_1. In set register, we matching the destination register FIFO_DATA_REG in sensor. In receiving data, we receive the raw data of IR and RED value for the destination register. In data calculate, get the real value of SpO2 and heat beats through calibration rules.

The I2C transmission process of set register and receive data are shown as fig.3.1.1:

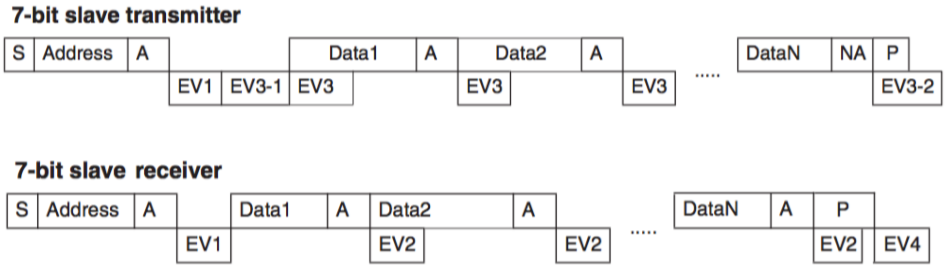


fig. 3.1.3

The raw data formate show as fig. 3.1.4: the high 16 bit is the value of RED and the low 16 bit is the value of IR.

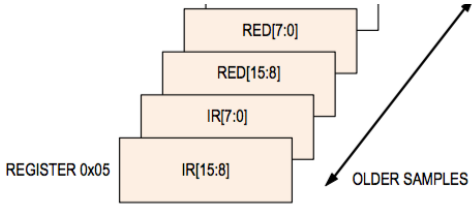


fig. 3.1.4

calibration rules are define as follow:

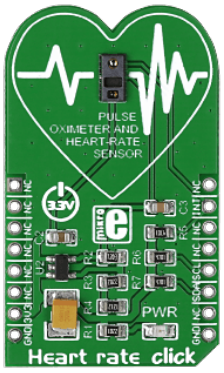
$$\text{oxygen saturation\%} = ([O_2]/[O_{sat}]) \times 100 \quad (3.1.1)$$

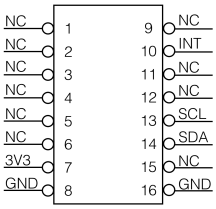
$$SpO_2 = [HbO_2]/([Hb]+[HbO_2]) \quad (3.1.2)$$

Firstly calculate HbO2 and Hb to get SpO2. At the same time, heart beats can be measured by detect IR. To keep the detected current separate and to lower power consumption, neither LEDs are continuously turned on. They are flashed alternately and the detected current is measured. The maximum heat rate is

around 250 beats per minute. Flashing the LEDs at a 100Hz keeps the sampling system well above the Nyquist rate.

② Overall Pins:





SpO2 Sensor(MAX30100)	STM32
3V3	3V
GND	GND
SCL	PB6
SDA	PB7

fig. 3.1.5

2. LCD module

① Implementation:

Display:

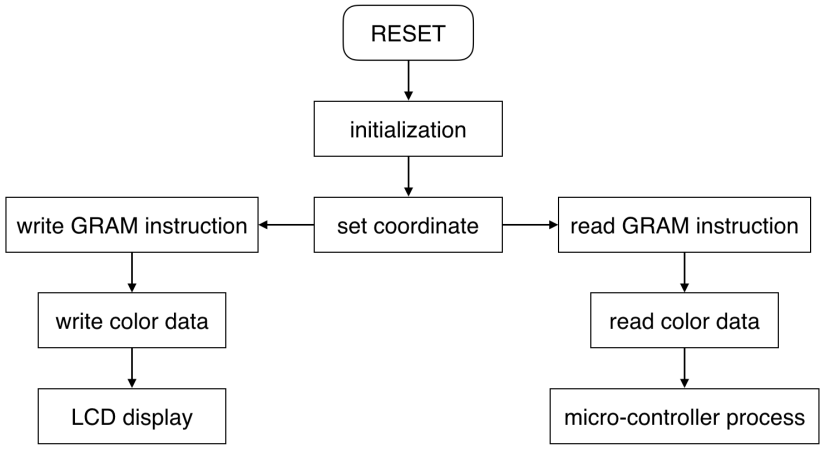


fig. 3.2.1

In this module, we use FSMC to control the LCD as a device like SRAM, SRAM and the LCD have the same ports such as D0-D15, RS, WR, WD and CS.

In initialization, we should set the model of FSMC, enable the clock, initialize the LCD(SSD1289). In set coordinate, that means we should set the curse in the right place every time we print or read something from LCD. In write and read color data, we can print pixels or read the color in some coordination according to the data sheet of SSD1289. The other operations are based on two operation above.

Touch:

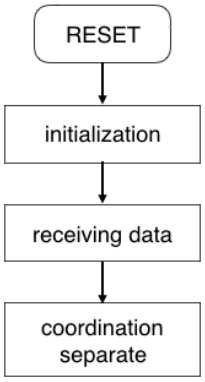


fig. 3.2.2

The process is shown in fig. 3.2.2:

In initialization, set the SPI1 for the connector to XPT2046, and enable the clock and pins.

In receiving data part, get the raw data of XY coordinations from the register of XPT20446 which are in the same u16 variable.

In coordination separate, we should separate the XY coordinations from u16 variable, and fitting them to the real coordination.

GUI:

All graph shown on LCD is using the method of print dots. So the graphical user interface is achieved by using this way as well. Before a complex interface is made, simple graphs, like line, filled square and char, should be designed. With these simple graphs, complicated interface can be made in a easier way.

② Overall Pins:

Here, pins on LCD board can be divided into three parts(in fig. 3.2.3): 1) for display; 2) for touch; 3) for SD card. In this design, all GUI will be achieved by using simple outlines. Thus, for convenience, neglect the SD card pins. And the pins connection is shown in fig. 3.2.4.

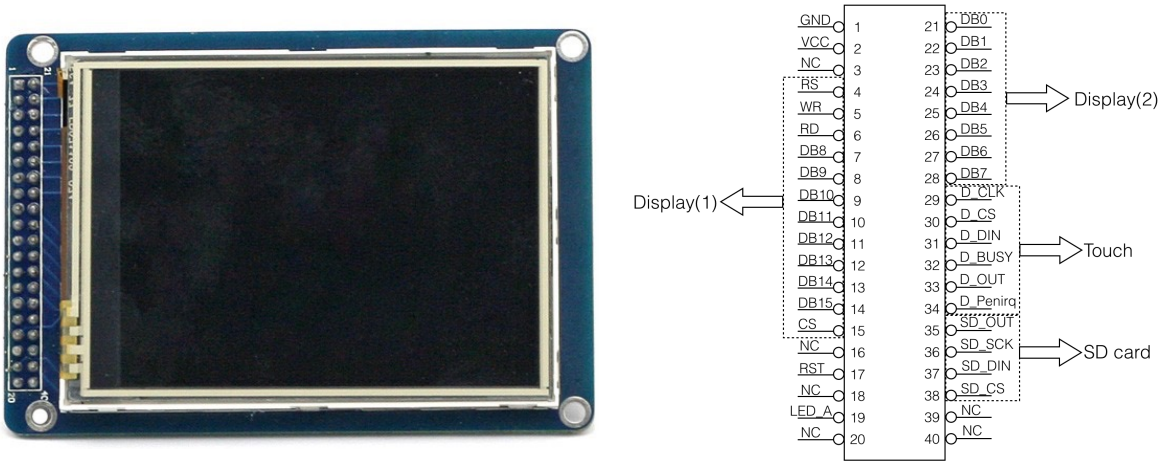


fig. 3.2.3

LCD Display(SSD1289)	STM32	FSMC
CS	PD7	FSMC_NE1
RS	PD11	FSMC_A19
WR	PD5	FSMC_NWE
RD	PD4	FSMC_NOE
DB0	PD14	FSMC_D0
DB1	PD15	FSMC_D1
DB2	PD0	FSMC_D2
DB3	PD1	FSMC_D3
DB4	PE7	FSMC_D4
DB5	PE8	FSMC_D5
DB6	PE9	FSMC_D6
DB7	PE10	FSMC_D7
DB8	PE11	FSMC_D8
DB9	PE12	FSMC_D9
DB10	PE13	FSMC_D10
DB11	PE14	FSMC_D11
DB12	PE15	FSMC_D12
DB13	PD8	FSMC_D13
DB14	PD9	FSMC_D14
DB15	PD10	FSMC_D15

LCD Touch(XPT2046)	STM32	SPI
D_CLK	PA5	SCLK
D_CS	PB14	NSS
D_DIN	PA7	MOSI
D_OUT	PA6	MISO
D_Penirq	PA4	INT

fig. 3.2.4

IV. Experimental Results

1. Raw data and processed data

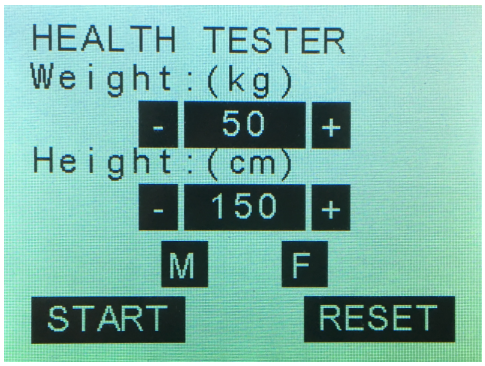
```
The raw IR value is 3812
The raw RED value is 182
The SPO2 is 0
The Heart Rate value is 0
The raw IR value is 37
The raw RED value is 3
The SPO2 is 0
The Heart Rate value is 0
The raw IR value is 1831
The raw RED value is 4012
The SPO2 is 0
The Heart Rate value is 0
```

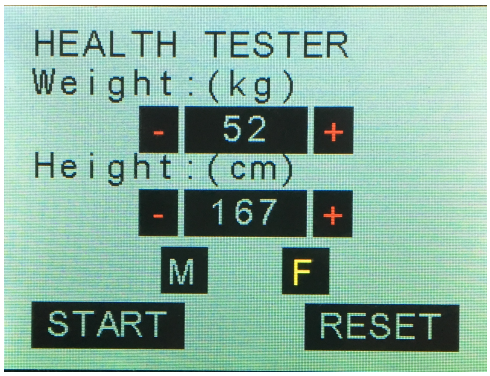
Without finger pressed

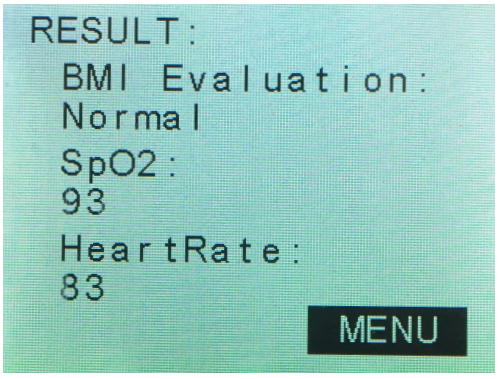
```
The raw IR value is 44774
The raw RED value is 32239
The SPO2 is 91
The Heart Rate value is 74
The raw IR value is 45016
The raw RED value is 32184
The SPO2 is 92
The Heart Rate value is 75
The raw IR value is 45016
The raw RED value is 32184
The SPO2 is 92
The Heart Rate value is 75
```

With finger pressed

2. Display


HEALTH TESTER
Weight:(kg)
- 50 +
Height:(cm)
- 150 +
M F
START RESET


HEALTH TESTER
Weight:(kg)
- 52 +
Height:(cm)
- 167 +
M F
START RESET


RESULT:
BMI Evaluation:
Normal
SpO2:
93
HeartRate:
83
MENU