New Sugar Water Sweetness Measuring Instrument Based on Sensor Technology

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Abstract. In order to accurately detect the concentration of sugar water, a new sensing technology based on capacitance sensing is adopted. Based on the capacitance sensing technology, a metal rod is used as a sensor, which can be extended into the sugar water container to produce a variable capacitance value. The data can be collected and processed, and the sweetness of sugar water can be measured.

Keywords: Sugar Water Concentration Measurement, Capacitance Sensing, Stm32h743

1. Introduction
Sugar water concentration detection is widely used in water resource protection, food processing, medical and health care. The commonly used measuring methods are Pycnometer method, balance method, etc.

In order to avoid these shortcomings, this paper proposes a new sugar water concentration measurement method. Based on the non-contact capacitance sensing technology, a new digital capacitance sensor fdc2214 is used to detect the sugar water level and concentration changes [1-4]. First of all, when a single-sided copper clad plate is inserted into the sugar water, the parasitic capacitance will be generated on the copper plate. When the liquid level or concentration changes, the parasitic capacitance will also change. Fdc2214 can sense this weak change and convert it into a binary output of up to 28 bits. At this time, high-performance microprocessor can be used to collect these data. At the same time, the height of liquid level is measured by ultrasonic wave, and the volume of liquid is calculated; the weight of liquid is measured by high-precision electronic scale, so the specific gravity of liquid can be calculated. A variety of data fusion for analysis and processing, the final concentration of sugar water.
2. Hardware Circuit Design and Working Principle

2.1 Circuit design of electronic scale
The bridge pressure sensor is used in the hardware circuit of the electronic scale. When there is a heavy object on the pressure bridge, it will produce deformation, resulting in the change of resistance value. The bridge sensor will generate voltage difference and send it to 24 bit a/D conversion chip hx711. After internal amplification and conversion, it will send it to stm32h743iit6. It can accurately detect the weight of the object, and the calculation of the weight is shown in formula (1). Accuracy up to 1g.

\[ W = \frac{D}{429.5} \]  

In formula (1), D is the number converted by hx711. W is the weight of the object after calculation.

2.2 Design of ultrasonic distance measuring circuit
As shown in Figure 1, the serial port ultrasonic ranging module adopts 5V power supply, the middle pin out is the data output, which can be connected to the RXD pin pc11 of serial port 4 of stm32h743iit6. The received data frame format is: 0xff + H·data + L·data + sum, 0xff is the starting byte, H·data is the high 8 bits, L·data is the low 8 bits, sum is the check sum. The measurement distance D is calculated by formula (2) in mm. The measurement accuracy is as high as 1mm, and the measurement range is 2cm-3.5m \(^{6-7}\).

\[ D = H_{DATA}\times 256 + L_{DATA} \]  

Figure 1 serial port ultrasonic module

3. Software Design

3.1 Software filtering algorithm
In data collection. The values of capacitance sensing, pressure bridge and ultrasonic distance measurement should be collected many times. In the software programming, each kind of data is collected 100 times, and then all data are sorted from small to large. In order to effectively remove interference, 20 maximum and minimum values are removed, and the remaining 60 are used to sum and calculate the mean value as the final value of this collection. This can effectively eliminate
interference and ensure the stability and reliability of data.

3.2 Code

```c
void TIM7_Init(u16 arr,u16 psc)
{
    NVIC_InitTypeDef NVIC_InitStructure;
    NVIC_InitStructure.NVIC_IRQChannel = TIM7_IRQHandler;
    NVIC_PriorityGroupConfig(NVIC_PriorityGroup_2);
    NVIC_InitStructure.NVIC_IRQChannelPreemptionPriority = 1;
    NVIC_InitStructure.NVIC_IRQChannelSubPriority = 1;
    NVIC_InitStructure.NVIC_IRQChannelCmd = ENABLE;
    NVIC_Init(&NVIC_InitStructure);
    RCC_APB1PeriphClockCmd(RCC_APB1Periph_TIM7, ENABLE);
    TIM7->PSC = psc;
    TIM7->ARR = arr; // 5Hz ????
    //TIM6->CR1 = 0x0004 + 0x0001; // URS = 1 CEN = 1
    TIM7->CR1 = 0x0004; // URS = 1 CEN = 1
}

void TIM7_IRQHandler(void)
{
    if(TIM7->SR&0x0001) // ?????
    {
        SPI2_LDC1000_ReadBytes(LDC1000_CMD_PROXLSB,&proximityData2[0],2);
        SPI2_LDC1000_ReadBytes(LDC1000_CMD_FREQCTRLSB,&frequencyData2[0],3);
        proximityDataMAX2 = ((unsigned char)proximityData2[1]<<8) + proximityData2[0];
        frequencyDataMAX2 = frequencyData2[2]*65536 + frequencyData2[1]*256 + frequencyData2[0];
        // frequencyDataMAX2 = frequencyData2[1]*256 + frequencyData2[0];
        Show_Str(0,80,BLUE,WHITE,"PRO2":,12,1);
        LCD_ShowChar(30,80,BLUE,WHITE,(proximityDataMAX2)/10000+0x30,12,1);
        LCD_ShowChar(36,80,BLUE,WHITE,((proximityDataMAX2)%10000)/1000+0x30,12,1);
        LCD_ShowChar(42,80,BLUE,WHITE,(((proximityDataMAX2)%10000)%1000)/100+0x30,12,1);
        LCD_ShowChar(48,80,BLUE,WHITE,(((proximityDataMAX2)%10000)%100)%100+0x30,12,1);
        LCD_ShowChar(100,80,BLUE,WHITE,((frequencyDataMAX2)%10000)/1000+0x30,12,1);
        LCD_ShowChar(106,80,BLUE,WHITE,(((frequencyDataMAX2)%10000)%1000)/100+0x30,12,1);
        LCD_ShowChar(118,80,BLUE,WHITE,(((frequencyDataMAX2)%10000)%100)%100+0x30,12,1);
        ch0=LDC_read_CHx(0);
        ch1=LDC_read_CHx(1);
    }
}
```

ch2=LDC_read_CHx(2);
ch3=LDC_read_CHx(3);

printf("\r\nCH0:%ld ",ch0);
Show_Str(0,60,WHITE,"CH0: ",12,1);
LCD_ShowChar(24,60,RED,WHITE,(ch0)/1000+0x30,12,1);
LCD_ShowChar(88,60,RED,WHITE,((ch1)%1000)/100+0x30,12,1);
LCD_ShowChar(94,60,RED,WHITE,(((ch1)%1000)%100)/10+0x30,12,1);
LCD_ShowChar(100,60,RED,WHITE,(((ch1)%1000)%100)%10+0x30,12,1);
delay_ms(100);
printf("CH1: %ld ",ch1);
Show_Str(0,70,RED,WHITE,"CH2: ",12,1);
LCD_ShowChar(24,70,RED,WHITE,(ch2)/1000+0x30,12,1);
LCD_ShowChar(30,70,RED,WHITE,((ch2)%1000)/100+0x30,12,1);
LCD_ShowChar(36,70,RED,WHITE,(((ch2)%1000)%100)/10+0x30,12,1);
LCD_ShowChar(42,70,RED,WHITE,(((ch2)%1000)%100)%10+0x30,12,1);
OLED_ShowNum(74,2,ch1,4,8);
OLED_ShowNum(24,3,ch2,4,8);
OLED_ShowNum(74,3,ch3,4,8);
OLED_ShowNum(38,2,proximtyDataMAX2,5,8);
OLED_ShowNum(94,3,frequencyDataMAX2,5,8);

u2_printf("F103send %d,%d \r\n",tim7_cnt,tim7_cnt);
if(USART2_RX_STA&0X8000)
{
    if(USART2_RX_STA&0X7FFF)
    {
        USART2_RX_BUF[reclen]=0;
        Show_Str(0,40,BLUE,WHITE,USART2_RX_BUF,12,1);
        USART2_RX_STA=0;
    }
    printf("%c",USART3_RX_BUF[i]);
    printf("\r\n");
}
tim7->SR&=~(1<<0); //???????????
4. Test

During the test, debug the designed hardware and software, and download the program to stm32h743iit6. Then configure different concentrations of sugar water, pour it into a glass container, and read the test data of capacitance sensing fdc2214, ultrasonic distance measurement and pressure sensor hx711. Some data are given below, as shown in Table 1.

| Total weight (g) | Liquid level height (cm) | Capacitance sensing value | Sugar water concentration (%) |
|-----------------|--------------------------|---------------------------|-------------------------------|
| 103             | 53                       | 22289                     | 0.65                          |
| 207             | 58                       | 22278                     | 1.172                         |
| 309             | 63                       | 22271                     | 1.536                         |
| 411             | 69                       | 22264                     | 1.84                          |
| 513             | 73                       | 22257                     | 2.078                         |
| 615             | 78                       | 22251                     | 2.353                         |
| 716             | 83                       | 22245                     | 2.554                         |
| 817             | 88                       | 22239                     | 2.724                         |
| 918             | 93                       | 22233                     | 2.949                         |
| 1018            | 98                       | 22227                     | 3.074                         |
| 1119            | 103                      | 22220                     | 3.157                         |
| 1212            | 108                      | 22215                     | 3.252                         |

It can be seen from Table 1 that with the increase of sugar water concentration, liquid level and total weight, the capacitance sensing value is gradually decreasing.

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