Salt Water Concentration Measuring Instrument Based On fdc2214

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Abstract. In order to accurately detect the concentration of brine, a new sensing technology based on capacitance sensing is adopted. When the salt water concentration changes, the parasitic capacitance of the metal sheet will change. A new type of digital, high-precision capacitance sensor can sense this weak change and convert it into a digital output of up to 28 bits binary number, which is connected to the high-performance microprocessor STM32 through the IIC interface for acquisition and processing.

Keywords: fdc2214, Capacitance Sensing, Electronic Scale

Introduction
Salt 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 recent years, there are also different electronic measurement methods. For example, in literature [1], ultrasonic is used to measure the density of ethanol solution, and the echo signal is analyzed to fit the data to measure the ethanol concentration. In reference [2], the concentration of salt water was measured by ultrasonic, and based on the measurement of sound velocity, the concentration of salt water was measured by curved surface fitting algorithm. In reference [3], the concentration of suspended substance in liquid is measured by ultrasonic wave, and the inversion is carried out by ant colony algorithm, and the minimum measurement error is up to 10%.

In order to avoid these shortcomings, this paper proposes a new method to measure the salt water concentration. Based on the non-contact capacitance sensing technology, a new digital capacitance sensor fdc2214 is used to detect the change of salt water level and concentration. First of all, when a single-sided copper clad plate is inserted into salt water, the parasitic capacitance will be generated on the copper plate. When the liquid level or concentration changes, the parasitic capacitance will also change [4]. 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.

1. System Design
First of all, the system is designed. The main control adopts the new embedded microprocessor stm32h743iit6. Based on the cortex-m7 architecture, it has strong functions, the main frequency is up to 480mhz, and has rich resources and interfaces [5].
The thin copper strip is inserted into the salt water, which is used as the channel 1 of probe fdc2214 to connect with it, to detect the parasitic capacitance value under the liquid environment, and convert it into 28 bit binary number internally, and then transmit it to microprocessor stm32h743iit6 with IIC interface [6]. The electronic scale module in the figure can accurately measure the weight of the container, and the measurement data is transmitted to stm32h743iit6 for processing through a / D interface. The ultrasonic distance measurement module in the figure can accurately measure the liquid level, and transmit the measurement results to stm32h743iit6 through the serial port [7].

2. Hardware circuit design and working principle

2.1 Basic principle of capacitance sensing

The capacitance can be calculated by the following formula:

$$C = 8.85 \times 10^{-12} \times \left( \frac{\varepsilon A}{d} \right)$$

(1)

Where a is the area of a plate, in M2, D is the distance between plates, in M, C is the capacitance, in F, and ε is the dielectric constant relative to air. It can be seen from formula (1) that the capacitance is directly proportional to the dielectric constant ε, the area a of the plate, and inversely proportional to the distance d between the plates. When the medium changes (for example, when the salt water concentration changes), it will cause the change of ε, which will cause the change of capacitance C.

Fdc2214 is a sensor based on capacitance sensing technology, which has four channels, 0-3 respectively. For each channel, its working principle is the same. Taking channel 0 as an example, its equivalent circuit is shown in Figure 2. In the figure, the sensing board 1 and the sensing board 2 constitute the target detection sensor. The oscillation frequency FS is calculated by formulas (2) and (3). Formula (4) calculates the reference frequency fr, and formula (5) obtains the digital quantity up to 28 bits binary number after conversion.

$$f_s = \frac{1}{2\pi \sqrt{L(c+c_s)}}$$

(2)

$$\frac{1}{c_s} = \frac{1}{c_{x1}} + \frac{1}{c_{x2}}$$

(3)

In formula (3), CX is the equivalent capacitance of CX1 and CX2 in series.

$$f_r = \frac{f_{clk}}{ch0 \_sel}$$

(4)

2.2 Capacitance detection principle of brine concentration

Fdc2214 is connected with 40MHz active crystal oscillator, which can improve the speed of data acquisition. When the copper strip is inserted, the sensing capacitance on the copper strip will change with the change of water level. Fdc2214 can sense the change and send it to the microprocessor.

3. Software design

```c
void LDC1314_Init(void)
{
    uint16_t deviceID = 0;
    IIC_Init();
    LCD_write_16bit(LDC13xx16xx_CMD_CONFIG, 0x2801);
    LCD_write_16bit(LDC13xx16xx_CMD_REF_COUNT_CH0, 0xFFFF);
    LCD_write_16bit(LDC13xx16xx_CMD_REF_COUNT_CH1, 0xFFFF);
    LCD_write_16bit(LDC13xx16xx_CMD_REF_COUNT_CH2, 0xFFFF);
}
```
LCD_write_16bit(LDC13xx16xx_CMD_REF_COUNT_CH3,0xFFFF);
LCD_write_16bit(LDC13xx16xx_CMD_SETTLE_COUNT_CH0,0x0100);
LCD_write_16bit(LDC13xx16xx_CMD_SETTLE_COUNT_CH1,0x0100);
LCD_write_16bit(LDC13xx16xx_CMD_SETTLE_COUNT_CH2,0x0100);
LCD_write_16bit(LDC13xx16xx_CMD_SETTLE_COUNT_CH3,0x0100);
LCD_write_16bit(LDC13xx16xx_CMD_CLOCK_DIVIDERS_CH0,0x1002);
LCD_write_16bit(LDC13xx16xx_CMD_CLOCK_DIVIDERS_CH1,0x1002);
LCD_write_16bit(LDC13xx16xx_CMD_CLOCK_DIVIDERS_CH2,0x1002);
LCD_write_16bit(LDC13xx16xx_CMD_CLOCK_DIVIDERS_CH3,0x1002);
LCD_write_16bit(LDC13xx16xx_CMD_ERROR_CONFIG,0x0000);
LCD_write_16bit(LDC13xx16xx_CMD_MUX_CONFIG,0x0C20D);
LCD_write_16bit(LDC13xx16xx_CMD_DRIVE_CURRENT_CH0,0x4800);
LCD_write_16bit(LDC13xx16xx_CMD_DRIVE_CURRENT_CH1,0x4800);
LCD_write_16bit(LDC13xx16xx_CMD_DRIVE_CURRENT_CH2,0x4800);
LCD_write_16bit(LDC13xx16xx_CMD_DRIVE_CURRENT_CH3,0x4800);
xx_CMD_CONFIG,0x1401);  LCD_write_16bit(LDC13xx16xx_CMD_CONFIG,0x1401);
delay_ms(100);

deviceID = LCD_read_16bit(0x7f);
while(deviceID != 0x3055)
{
    printf("\r\nFDC2214 ID:%d",deviceID);
}
// FDC2214_Reset();
printf("\r\nFDC2214 ID:%x",deviceID);
}

u32 LDC_read_CHx(u8 CHx)
{
    u8 reg_addr1 = 0;
    u8 reg_addr = 0;
    unsigned long data = 0,data1 = 0;
    // unsigned long temp = 0;
    switch(CHx)
    {
    case 0:
    {
        reg_addr1 = LDC13xx16xx_CMD_DATA_MSB_CH0;
        reg_addr = LDC13xx16xx_CMD_DATA_LSB_CH0;
    }break;
    case 1:
    {
        reg_addr1 = LDC13xx16xx_CMD_DATA_MSB_CH1;
        reg_addr = LDC13xx16xx_CMD_DATA_LSB_CH1;
    }break;
    case 2:
    {
        reg_addr1 = LDC13xx16xx_CMD_DATA_MSB_CH2;
        reg_addr = LDC13xx16xx_CMD_DATA_LSB_CH2;
    }break;
    case 3:
    {
        reg_addr1 = LDC13xx16xx_CMD_DATA_MSB_CH3;
reg_addr = LDC13xx16xx_CMD_DATA_LSB_CH3;
} break;
  case 4:
  {
    reg_addr1 = 0x7f;
    reg_addr = 0x80;
  } break;

  default: return 0;

} // printf("reg_addr1=%d \n",(reg_addr1));
// printf("%d \n",LCD_read_16bit(reg_addr1));
// printf("%d \n",LCD_read_16bit(reg_addr));
// data = LCD_read_16bit(reg_addr1);
// data = LCD_read_16bit(reg_addr1)<<16;
// printf("reg_addr1=%ld \n",(data));
// data1= LCD_read_16bit(reg_addr);
// printf("reg_addr0=%ld \n",(data1));
data |=data1;

// if(reg_addr1!=0x7f)
// data &= 0x0FFF0000;
// data /=10000;
// return data;

} void KEY1_Init(void)
{

  GPIO_InitTypeDef GPIO_InitStructure;

  RCC_APB2PeriphClockCmd(RCC_APB2Periph_GPIOC,ENABLE);
  GPIO_InitStructure.GPIO_Pin = GPIO_Pin_0|GPIO_Pin_1|GPIO_Pin_2|GPIO_Pin_3;//PC5
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_IPU;
  GPIO_Init(GPIOC,&GPIO_InitStructure);//初始化 GPIOC5

} void EXTI_Initial(void)
{

  KEY1_Init();
  //Ex_NVIC_Config(GPIO_C,0,RTIR);
  Ex_NVIC_Config(GPIO_C,0,FTIR);

  Ex_NVIC_Config(GPIO_C,1,FTIR);
  Ex_NVIC_Config(GPIO_C,2,FTIR);
  Ex_NVIC_Config(GPIO_C,3,FTIR);

  MY_NVIC_Init(0,0,EXTI0_IRQn,2);
  MY_NVIC_Init(0,1,EXTI1_IRQn,2);
  MY_NVIC_Init(0,2,EXTI2_IRQn,2);
  MY_NVIC_Init(0,3,EXTI3_IRQn,2);
}
4. Conclusion
In this paper, a new measuring method of brine concentration is proposed. Based on the capacitance sensing technology, the corresponding hardware circuit is designed. The software is programmed and the sample is made. During the measurement and analysis, the information of liquid level height and weight is integrated, and the function relationship between the brine concentration and the capacitance sensing value is determined through a large number of experiments.

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