Capacitance Measuring Instrument Based On Ldc1612

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Abstract. A new type of capacitance measuring instrument includes a microprocessor, a capacitance sensing sensor, a LC oscillation circuit, a computer, a display and a buzzer. The LC oscillation circuit is connected with the measured capacitance CS to generate an oscillation frequency, and the oscillation frequency is sent to the capacitance sensing sensor. After being processed by the capacitance sensing sensor, it is converted into a 28 bit binary number and sent to the said controller through the IIC interface. When a successful measurement is completed, the microprocessor controls the buzzer to sound once and sends the measurement results to the display or computer, which has the advantages of high precision, short measurement time, etc.

Keywords: LDC1612, IIC, Capacitance Measurement

1. Introduction

In the production and maintenance of electronic components, capacitance measurement is often a crucial link. A good electronic product must be composed of qualified electronic components, among which capacitance is one of the basic components, so the measurement of capacitance value is inevitable. Similarly, in the maintenance of electronic products, the detection of the circuit is the most basic. Sometimes it is necessary to detect whether the components in the circuit work normally and whether the capacitor works normally. Therefore, it is necessary to design a reliable, safe and convenient capacitance tester.

At present, there are not many special capacitance measuring instruments on the market. Generally, the more common instruments are used to detect the capacitance. The common capacitance detection methods include multimeter detection method, fuse simple detection method, incandescent bulb and capacitor series detection method, megohmmeter detection method, etc. The basic principle is to use the charging and discharging characteristics of the capacitor to check the voltage value with the instrument, and calculate and push. It is difficult to be popularized because of its low measurement accuracy, complex operation and laborious work. It is generally only used to detect whether the capacitance is good or not, not to measure the capacitance value. At present, there are three common methods to measure capacitance value. One is to use bridge circuit measurement method to convert the measured capacitance value into voltage value, and then measure the voltage value to deduce the measured capacitance value; the other is to use the oscillation circuit method to generate square wave signal which is proportional to the capacitance value, and then measure the output voltage after filtering. The hardware circuit of this method is simple. However, the software implementation is relatively complex; thirdly, the monostable trigger device is used to generate the gate pulse signal.
which is proportional to the capacitance value, and then control the on-off of the standard counting pulse through the counter, and judge the capacitance value according to the charging and discharging time. The hardware circuit of this measurement method is complex, and there is no way to directly display the capacitance value.

In this paper, the most advanced 2-channel 28 bit high-precision inductor digital converter ldc1612 is used as the sensor probe. The chip has a digital IIC interface, which can be easily connected to various low-power MCU for data acquisition and processing. When ldc1612 is used for non-contact induction sensing, winding coil, PCB coil or spring are used for induction. The internal signal conversion circuit can convert the sensing signal into 28 digit words to accurately measure the position, movement or composition of metal or conductive target.

2. System Design
The system block diagram is shown in Figure 1. The main control unit is stm32h743. The MCU is a low-power microprocessor produced by Ti formula, with powerful functions [2]. It is connected with ldc1612 through IIC interface. When the PCB inductance coil at the front end of ldc1612 detects metal objects, different distances will return different digital quantities. MCU calculates the distance between metal objects and coils through the received digital quantities, and then sends them to the display unit segment code LCD for display [3].

3. Detailed Design and Key Technology

3.1. Connection between stm32h743 and ldc1612
The hardware connection between stm32h743 and ldc1612 is shown in Figure 2. Through SDA, SCLK two data lines interconnection to achieve high-speed data transmission. The sequence of reading and writing ldc1612 by stm32h743 is shown in Fig. 3 and Fig. 4. Communication follows the standard IIC communication protocol [1-4]. When reading and writing, the master-slave address is sent first, and then the data.

Figure 1. System design block diagram

Figure 2. Hardware connection between MCU and ldc1612
3.2. Working Principle of Inductive Sensor

3.2.1. Working principle of inductive sensor. The induction detection principle is the electromagnetic induction principle in physics. If an alternating current is added to the PCB coil or self-made coil (as shown in Figure 5), the alternating electromagnetic field will be generated around the coil. At this time, if a metal object enters the magnetic field, eddy current (induced current) will be generated on the metal object. The eddy current is opposite to the coil current direction, and the induced electromagnetic field generated by eddy current is the same as that of the coil. The direction of the magnetic field is opposite. Eddy current is a function of distance, size, and composition of metal objects [5-7].

The corresponding equivalent parallel circuit is shown in Fig.5. The oscillating circuit consists of a closed-loop frequency selection circuit with gain. The criterion of starting vibration is (1) the gain is greater than 1. (2) The closed-loop phase shift is 2π. In oscillatory condition, R-L-C determines frequency selection and phase shift. The frequency selection is shown in formula (1). In the circuit, RP (d) determines the driving current of the sensor, and the calculation method is shown in formula (2).
Figure 5. Equivalent parallel circuit

\[
f_{\text{SENSOR}} = \frac{1}{2\pi \sqrt{LC}} \times \sqrt{1 - \frac{1}{Q^2}} \frac{5 \times 10^{-9}}{Q \sqrt{LC}} \approx \frac{1}{2\pi \sqrt{LC}}
\]  
(1)

Here, C is the induced capacitance (ctank + CPAR) and l is the inductance L (d).

\[
Q = R_p \sqrt{\frac{C}{L}}
\]  
(2)

Here, C and L are defined as formula (1), and RP is RP (d). In practical application, there is a certain curve relationship between RP and test distance, as shown in Figure 6. In the figure, the test coil is 14mm PCB coil, and the test target is 2mm thick stainless steel sheet.

Figure 6. Corresponding curve relationship between RP and test distance

After determining RP and C, the calculation formula of inductance L is shown in formula (3).

\[
L(d) = L_{\text{inf}} - M(d) = \frac{1}{(2\pi \times f_{\text{SENSOR}})^2 \times C}
\]  
(3)

Where linf is the inductance of coil without inductor, m (d) is mutual inductance. Other definitions are the same as those in formulas (1) and (2).

3.2.2 Software

Some of the main codes are as follows\textsuperscript{8-10}.

```c
void LDC1612_IIC_Start(void)
{
```
LDC1612_SDA_OUT();
LDC1612_IIC_SDA=1;
LDC1612_IIC_SCL=1;
delay_us(4);
LDC1612_IIC_SDA=0; //START: when CLK is high, DATA change from high to low
delay_us(4);
LDC1612_IIC_SCL=0;
}

void LDC1612_IIC_Stop(void)
{
    LDC1612_SDA_OUT();
    LDC1612_IIC_SCL=0;
    LDC1612_IIC_SDA=0; //STOP: when CLK is high DATA change from low to high
    delay_us(4);
    LDC1612_IIC_SCL=1;
    LDC1612_IIC_SDA=1;
    delay_us(4);
}

u8 LDC1612_IIC_Wait_Ack(void)
{
    u8 ucErrTime=0;
    LDC1612_SDA_IN(); //SDA
    LDC1612_IIC_SDA=1;delay_us(1);
    LDC1612_IIC_SCL=1;delay_us(1);
    while(LDC1612_READ_SDA)
    {
        ucErrTime++;
        if(ucErrTime>250)
        {
            LDC1612_IIC_Stop();
            return 1;
        }
    }
    LDC1612_IIC_SCL=0; //return 0;
}

void LDC1612_IIC_Ack(void)
{
    LDC1612_IIC_SCL=0;
    LDC1612_SDA_OUT();
    LDC1612_IIC_SDA=0;
    delay_us(2);
    LDC1612_IIC_SCL=1;
    delay_us(2);
    LDC1612_IIC_SCL=0;
}

void LDC1612_IIC_NAck(void)
{
    LDC1612_IIC_SCL=0;
    SDA_OUT();
    LDC1612_IIC_SDA=1;
delay_us(2);
LDC1612_IIC_SCL=1;
delay_us(2);
LDC1612_IIC_SCL=0;
}
void LDC1612_IIC_Send_Byte(u8 txd)
{
    u8 t;
    LDC1612_SDA_OUT();
    LDC1612_IIC_SCL=0;  //
    for(t=0;t<8;t++)
    {
        LDC1612_IIC_SDA=(txd&0x80)>>7;
        txd<<=1;
        delay_us(2);   //
        LDC1612_IIC_SCL=1;
        delay_us(2);
        LDC1612_IIC_SCL=0;
        delay_us(2);
    }
}

4. Test
In the process of testing, a set of fixed capacitance is obtained and stored\textsuperscript{[11-12]}.

Table 1. Comparison table of capacitance measured value and real value

| Capacitance measurement | True value |
|-------------------------|------------|
| 0.1                     | 0.11       |
| 0.2                     | 0.22       |
| 0.3                     | 0.316      |
| 0.4                     | 0.39       |
| 0.5                     | 0.51       |
| 0.6                     | 0.62       |
| 0.8                     | 0.81       |
| 1                       | 1.02       |
| 2                       | 2.01       |
| 3                       | 3.074      |
| 4                       | 4.157      |
| 5                       | 5.252      |

5. Conclusion
In this paper, a multi-channel inductor to digital converter based on ldc1612 is designed. The ultra-low power consumption stm32h743 is used as the main control, and ldc1612 is used as the detection device. The working principle and related parameters of ldc1612 are analyzed carefully, and the high-speed data acquisition is realized through IIC interface. Compared with the prior art, the invention has the following beneficial effects: in order to accurately measure the capacitance, an LC oscillation circuit is designed, in which the value of inductance L is fixed. When the capacitance changes, the capacitance sensor fdc2214 are used to sense the change, and the capacitance can be accurately measured after calculation. The measurement device has high precision, short measurement time, etc advantage.
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