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Research on a new metal detector based-on LDC1000

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Abstract: A new metal detector is designed.Using LDC1000 digital inductance sensor and self-made coil as the metal detection sensor, based on eddy current principle. When the metal near the coil, because of the mutual inductance, the LC oscillation circuit's frequency changed, the changed frequency can be converted to the digital output data, through the SPI interface send to STM32 for process and display. When the test value exceed threshold value, will cause sound and light alarm. The test metal can detect 0.6mm diameter of thin wire. Can be used to food processing、security check and other fields. Added Bluetooth and wireless communication, it can be used for the web of things security work.

1. Introduction

In industrial production and food processing, metal material is often mixed into the raw material, affecting the quality of the product or damaging the equipment. To solve this problem, metal detection instruments and equipment are necessary. At present, the principle of electromagnetic induction is used to detect metal, but most analog circuits are used to output analog signals. Therefore, there are many shortcomings, such as big error and poor precision.

In order to improve the accuracy and reliability, a new digital inductance sensor named LDC1000 is adopted as a sensor, and the metal coil is detected by the self-made inductance coil. LDC1000 is based on the principle of eddy current, which can output 28 bits of digital quantity and connect with microprocessor by SPI bus to collect and process data. Up to 28 bits of digital quantity can realize the high resolution and high-precision detection of metal objects, and can be widely used in food processing, industrial production, security inspection and other fields.

2 System Design

System design, the main control using STM32F103RBT6, the processor has 3 hardware SPI interface, 8 timers, 3 serial ports, 144 pins, is based on the Cortex M3 32 bit microprocessor, powerful, rich in resources. LDC1000 as a metal detector, the front end of the coil is equipped with a self-made coil. When it detects the metal, it will output a 28 bit binary, which is a digital quantity. Through the hardware interface of SPI2 transfer to STM32 to STM32 processing, the processed data through the hardware SPI1 to 1.44 inch TFT true color display. Data can be transmitted over a long distance via Bluetooth or wireless module to a control center. When the detected value exceeds the set threshold, sound and light alarm is sent out.

3 Hardware Design

3.1 LDC1000 Sensor Design

The schematic diagram of the LDC1000 is shown in figure 1. In order to improve the speed of data acquisition and transmission, the hardware SPI interface is adopted. The PB12, PB13, PB14, and PB15 are the STM32F103RBT6 hardware SPI2 interfaces in the diagram. SPI2_NSS PB12 produced SPI2 chip select signal, clock signal SPI2_SCK PB13 SPI2, from the main data transmission signal into SPI2_MISO PB14 SPI2, PB15 SPI2 the main line connected hardware SPI2 from above into data transmission signal SPI2_MOSI. 4 signal lines, finish data read and write operations. Figure PC6 through the STM32F103RBT6 timer to produce 6MHz Fang Bo, input to the LDC1000 as a clock signal, can make the hardware SPI2 read and write rate reached 4.5MB/S., LDC1 in the diagram for socket interface, connect the homemade inductance coil.

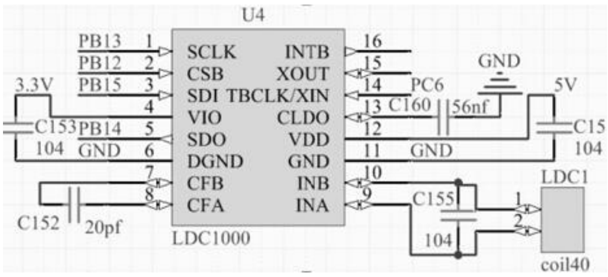

Figure 1 STM32 and LDC1000 connection diagram

The self-made coil is made of 0.15mm fine copper wire, and the diameter is 4cm. The inductance of the coil is measured by a multimeter and reaches 0.18uH. The inductor is configured with a 1.8nf capacitor. When a metal object approaches, it produces a LC resonance. The resonant frequency of the LC is calculated by formula (1).

$$F_{sen} = \frac{1}{3} \times \frac{F_{ex}}{F_{cnt}} \times RT \quad (1)$$

The Fsen is the LC resonant frequency, the Fex is the external clock reference frequency, the value is 6MHz, the Fcnt is the internal counter value of the LDC1000, and the RT is the response time set by the LDC1000 internal register. A formula (2) can be obtained by reciprocal counting of the two sides of the formula (1) and making proper changes*RT*(1/Fsen)=3*Fcnt*(1/Fex)* (2)

In formula (2), the 1/Fsen is the LC resonant period, and the 1/Fex is the reference clock period. The formula (2) shows that in RT LC resonance cycles, the LC resonant frequency is calculated using the Fcnt counter of the LDC1000 to record the number of reference clocks.

4. Software Program

In this design, under KEIL 5, programming with C language. Achieve the initialization of LDC1000 and data reading and writing, and set threshold, control sound and light alarm, the following part of the code:

```
void SPI_LDC1000_Init(void)
{
      SPI_LDC1000_WriteByte(LDC1000_CMD_RPMAX,TEST_RPMAX_INIT);
      SPI_LDC1000_WriteByte(LDC1000_CMD_RPMIN,TEST_RPMIN_INIT);
      SPI_LDC1000_WriteByte(LDC1000_CMD_SENSORFREQ,0x94);
      SPI_LDC1000_WriteByte(LDC1000_CMD_LDCCONFIG,0x17);
      SPI_LDC1000_WriteByte(LDC1000_CMD_CLKCONFIG,0x00);
       SPI_LDC1000_WriteByte(LDC1000_CMD_INTCONFIG,0x02);
       SPI_LDC1000_WriteByte(LDC1000_CMD_THRESHILSB,0x50);
       SPI_LDC1000_WriteByte(LDC1000_CMD_THRESHIMSB,0x14);
       SPI_LDC1000_WriteByte(LDC1000_CMD_THRESLOLSB,0xC0);
       SPI_LDC1000_WriteByte(LDC1000_CMD_THRESLOMSB,0x12);
       SPI_LDC1000_WriteByte(LDC1000_CMD_PWRCONFIG,0x01);
}
u8 SPI_LDC1000_ReadBytes(char ReadAddr,char* pBuffer,u8 NumByteToRead)
{
      u8 i,readback;
      u8 txReadAddr;
      txReadAddr = ReadAddr | 0x80;
      SPI_LDC1000_CS=0;
       SPI1_ReadWriteByte(txReadAddr);
       for(i=0;i<NumByteToRead;i++)
      {
            pBuffer[i]=SPI1_ReadWriteByte(0XFF);
```

```
    }
    SPI_LDC1000_CS=1;
    return readback;
}
```

5.Summary

In this paper, a metal detector based on LDC1000 digital inductance sensor is used to detect metal objects. With the self-made coil, the larger the coil winding, the greater the inductance, the farther the metal detection distance. In laboratory tests, a wound coil with a diameter of 10cm can be used to increase the effective detection distance of the metal to 10cm and to detect fine metals with a diameter of 0.6mm. It can be used in food processing, industrial production, security inspection and other fields, and has certain practical value.

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