Low Frequency Signal Measuring Device Based on STM32F103

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Abstract: This paper presents a new method of frequency measurement, which does not need complex hardware circuit, and realizes the measurement of signal frequency with the method of pure software. Triangle wave, sine wave, square wave, trapezoid wave and other signals (the highest voltage value is within 5V) can be directly input to the high-performance embedded microprocessor stm32f103zet6 for DMA + A / D acquisition, which can continuously acquire 500 points at a time. The data of 500 points can be processed by software to get the maximum and minimum values, calculate the slope, and judge the input waveform. Because DMA mode can achieve high-speed, mass data transmission, and the acquisition time between each point is fixed, so by counting the number of points between the two maximum values, the cycle and frequency can be obtained. For square wave signal, the duty cycle can be calculated by counting the high and low level data in a cycle. Compared with the traditional measurement method, this method has a simple interface circuit, which can realize the acquisition of low-frequency signal and the calculation of frequency, period, and duty cycle and peak value.

1. Introduction

In engineering and experiment, it is often necessary to measure the frequency, period, duty cycle and other information of signal accurately. There are many kinds of measurement methods. In reference [1], a pulse width measurement method is proposed. Based on STM32 and FPGA, the measurement of high frequency signal frequency is realized. In reference [2], a special chip tdc-gpx2 is used to measure the frequency of high frequency signal. In reference [3], the frequency measurement method of frequency shift filter is proposed, which realizes the measurement of frequency in power system and effectively removes interference.

2. System Design

The system diagram is shown in Figure 1, in which a signal generator is used to generate sine wave, triangle wave, rectangle wave and trapezoid wave signals with an amplitude of 1-5V and a frequency range of 100Hz-10KHz. Connect it to PA1 (A / D acquisition channel) of embedded microprocessor stm32f103zet6. Stm32f103zet6 has a main frequency of 72mhz, 16 channel A / D acquisition pins, each a / D can reach 12 bits, supporting DMA data transmission. 500 data are collected continuously by DMA mode, then interrupted once, processed by software, the maximum value, cycle, frequency and other information are calculated, and the results are displayed on tft1.44 inch real color LCD screen.

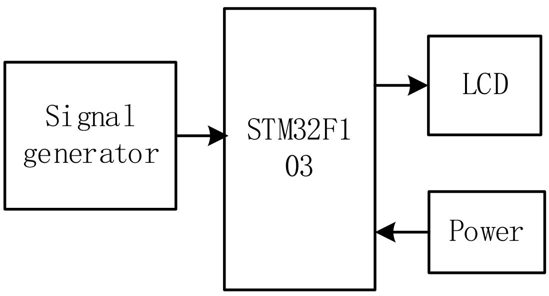

Figure 1. System block diagram

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3. Software Flow Chart and Main Technology

The software flow chart is shown in Figure 2. First, the serial port, SPI, ADC, DMA, timer and so on are initialized. The ADC is initialized as a single channel, DMA mode to generate interrupt after continuously collecting 500 points. After the interruption, the data are analyzed statistically to get the maximum value, that is, the peak value of the input waveform. Find the time interval between two consecutive maximum values, that is, the number of points in a cycle. Because the acquisition time interval between two points is not only fixed, but also known. Multiply the number of points by the interval time, you can get the cycle, and the reciprocal is the frequency. Because the software only method is used to determine the cycle, there is no need for hardware or software synchronization.

As the previous period has been determined, only the slope of any multiple points or two points in a quarter of the period can be taken to judge the input waveform [8]. In order to ensure the reliability of the method, multiple slope judgments are needed. The judgment method of square wave is simpler. In addition to the calculation of over slope, it can also be judged that if there are more than one identical point, it can be determined that it is a square wave. This information can be sent to computer through serial port or displayed on LCD screen.

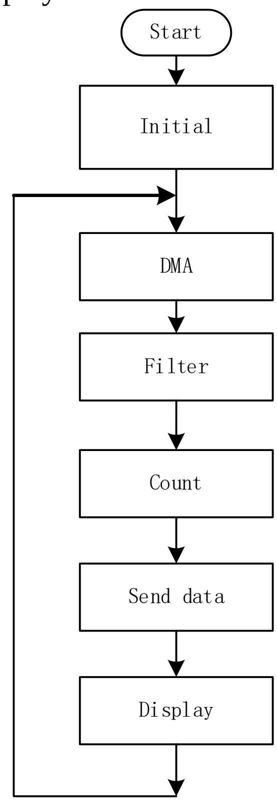

Figure 2. Software flow chart

4. Software

The electronic scale is designed in C language and compiled in keil UV3.

Keil c51 is a 51 series compatible MCU C language software development system produced by keil Software Company of the United States. Compared with assembly, C has obvious advantages in function, structure, readability and maintainability, so it is easy to learn and use.

Keil C51 software provides rich library functions, powerful integrated development and debugging tools, and full windows interface. In addition, if you look at the compiled assembly code, you can realize that the efficiency of the object code generated by keil c51 is very high, and the assembly code generated by most statements is very compact and easy to understand. In the development of large-scale software, it can better reflect the advantages of high-level language.

Keil C51 can complete the whole development process of editing, compiling, connecting, debugging and simulation. Developers can use ide itself or other editors to edit C or assembly source files, then C51 and A51 editors compile and connect to generate executable binary files (. Hex) of single-chip microcomputer, and then burn the hex files into the single-chip microcomputer through the burning software of single-chip microcomputer. The main codes are as follows:

```
void MYDMA_Config(DMA_Channel_TypeDef*DMA_CHx,u32 cpar,u32 cmar,u16 cndtr)
  {
     u32 DR_Base;    RCC->AHBENR|=1<<0;
     delay_ms(50);
     DR_Base=cpar;
     DMA_CHx->CPAR=DR_Base;
     DMA_CHx->CMAR=(u32)cmar;
     DMA1_MEM_LEN=cndtr;
     DMA_CHx->CNDTR=cndtr;
     DMA_CHx->CCR=0X00000000;
     DMA_CHx->CCR|=0<<4;
     //DMA_CHx->CCR|=1<<4;
     //DMA_CHx->CCR|=1<<5;
     DMA_CHx->CCR&=~(1<<5);
     DMA_CHx->CCR|=0<<6;
     //DMA_CHx->CCR|=1<<6;
     DMA_CHx->CCR|=1<<7;
     //DMA_CHx->CCR|=1<<8;
     //DMA_CHx->CCR|=1<<10;
     DMA_CHx->CCR|=2<<8;
     DMA_CHx->CCR|=2<<10;
     DMA_CHx->CCR|=1<<12;
     DMA_CHx->CCR|=0<<14;
     //DMA_CHx->CCR|=1<<14;
     DMA_CHx->CCR|=(1<<1);
     DMA_CHx->CCR&=~(1<<2);
     DMA_CHx->CCR|=1<<3;
     DMA_CHx->CCR&=~(1<<0)
     delay_ms(10);
     DMA_CHx->CCR|=1<<0;
     //MY_NVIC_Init(1,3,DMA1_Channel1_IRQChannel ,2);
     MY_NVIC_Init(3,2,DMA1_Channel1_IRQChannel ,2);
     delay_ms(10);
  }
  void DMA1_Channel1_IRQHandler(void)
  {
     if((DMA1->ISR)&(1<<3))
     {
          DMA1->IFCR|=0x0F0;
          printf("DMA error\r\n");
     }
    else if((DMA1->ISR)&(1<<1))
    {
  //              LED0 =!LED0;
     printf("\r\nDMA\r\n");
     DMA1->ISR&=~(1<<1);
   ADC1->CR2&=~(1<<0);    DMA1_Channel1->CCR&=~(1<<0);//
delay_ms(10);
```

```
                    delay_us(10);
  DMA1->IFCR|=0xFFFFFFFF;
          //printf single sample data of ADC0~ADC15
//                    for(jj=0;jj<16;jj++)
//                    {
//                      //printf("\r\nSendBuff[%d]=%d\r\n",jj,SendBuff[jj]);
    printf("\r\nV[%d]=%f\r\n",jj,SendBuff[jj]*3.3/4096);//single result correct
  }
for (jj = 0; jj < DMA_COUNT*CH_COUNT; jj+=CH_COUNT)
{
for (ii = 0; ii < DMA_COUNT*CH_COUNT- jj; ii+=CH_COUNT)
{
  if (SendBuff[ii] > SendBuff[ii + CH_COUNT]) {
t1 = SendBuff[ii];
SendBuff[ii] = SendBuff[ii + CH_COUNT];
SendBuff[ii + CH_COUNT] = t1;
}
}
}
```

5. Test

According to the above method, the program is written in C language, compiled, connected and debugged in keil MDK 5.0, and then downloaded to stm32f103zet6 development board. Different triangle wave, square wave and sine wave are generated by the signal generator, and the following data are obtained through the test.

Table 1. Square wave measurement frequency

Frequency output(Hz)	Measure frequency(Hz)
100	101
200	201
500	501
1000	1002
2000	2002
3000	3004
4000	4006
5000	5008
6000	609
7000	7010
8000	8012
9000	9014
10000	10020

From the above three tables, it can be seen that the lower the frequency is, the more accurate the measurement is, because the more points are collected, the smaller the error is; the larger the frequency is, the larger the error is, but it is within 1%. Among the three waveforms, square wave is the most accurate; triangle wave and sine wave is the second. Because the duty cycle of square wave is measured by the method of statistics of high and low level points, it is very accurate and basically has no error.

Table 2. Measurement of duty cycle of square wave

Output Frequency(Hz)	Duty (%)	Measure (%)
100	10	10
200	20	20
500	50	50
1000	60	60
5000	70	70
3000	80	80
4000	90	90
5000	80	80
6000	70	70
7000	60	60
8000	50	50
9000	40	40
10000	20	20

6. Conclusion

In this paper, a low-frequency signal measuring device is built to measure a group of data by DMA + ADC. The maximum and minimum values are obtained through data statistics, and the frequency, period, duty cycle and other information of the measured signal are calculated, so as to achieve the purpose of design. The system has the advantages of fast response, high precision and strong anti-interference ability.

Reference

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