Research on Data Acquisition Method Based on ADC+DMA

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Abstract. In order to effectively measure low frequency signals, this paper proposes a new method and theory. The low-frequency signal is input to the A/D acquisition pin of the embedded microprocessor STM32F103ZET6, five hundred data are continuously collected in DMA mode.Five hundred data can be processed by software, it can measure the input signal frequency, period， amplitude, peak to peak value； calculate the slope can determine the input wave form.For the square wave signal, the duty cycle can be calculated by counting the data of the high and low level in a period.Compared with the traditional measurement method, the method has no complicated analog circuit, and has the advantages of simple interface circuit, powerful function and high precision.The test results show that this method can accurately measure and identify sine wave, triangle wave and rectangular wave signal with peak amplitude at 1~5V and 100Hz~10kHz in frequency range.Frequency error is less than 1%.The peak to peak error is less than 1%, and the square wave duty is accurate, almost without error.

1. Introduction

In production practice and experiment, it is often necessary to measure various waveform signals to determine their period, frequency, peak value, duty cycle and other information. For this reason, a lot of theories and methods have been put forward. For example, for frequency measurement, there are "time gate method" and "pulse width measurement method". For the time gate method, a counter is used to collect the jump edge of the input signal and count the times of the jump edge in one second to get the frequency of the input signal. For the "pulse width measurement method", it is to measure the width of the main pulse width in a period of the input signal, first measure the rising edge, then start timing, then capture the falling edge, stop timing, get the time value of the whole main pulse width, then divide by the duty cycle of the main pulse width (the duty cycle of the input square wave is 50%) to get the periodic value. The reciprocal is the frequency. Documents [1-3] use the signal link form of DDS, analog circuit, AD acquisition chip and single chip computer to test the frequency characteristics of the input signal.

2. System Design

In the system structure, the waveform needed by DG3131A is generated by a signal generator, which can generate sinusoidal, triangular and rectangular waveforms with amplitude ranging from 1 to 5 V and frequency ranging from 100 Hz to 10 kHz. Then it is directly connected to the PA0 of embedded microprocessor STM32F103ZET6 (the first channel of AD acquisition). STM32F103ZET6 is a high-performance microprocessor, based on ARM Cortex-M3 technology, the main frequency is 72MHz, with 16 channels of 12-bit AD, each channel supports DMA data transmission. In the test, 500 data were collected by DMA, and then the maximum value, period, frequency and other information were obtained by calculation. The results were displayed on TFT 1.44 inch real-color LCD screen, and 500 data were used to draw continuous dots and draw waveforms. The power supply unit adopts 3.3V DC [6-7].

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3. Software

3.1 ADC Initial

The ADC initialization program mainly completes the following functions. PA0 is chosen as the ADC acquisition channel, and the single cycle acquisition mode is adopted. The acquisition time interval is set, and the DMA data transmission mode is opened. After the completion of the DMA transmission, the interruption occurs.

3.2 DMA Initial

DMA initialization mainly calls the following functions: DMA1_Channel1 is the channel 1 of selecting DMA1, ADC1->DR is the external input data, that is, the data collected by PA0, ReciBuff is the receiving buffer, and DMA1_MEM_LEN specifies the size of the buffer, with an initial value of 500.

```
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(0,0,DMA1_Channel1_IRQChannel ,2);

  delay_ms(10);
}
```

3.3 Algorithm

It mainly deals with 500 data collected by software to obtain peak value, period and frequency, and automatically judge waveform.

3.3.1 Calculation of Peak and Peak Values

Firstly, Kalman filter is applied to 500 data to eliminate interference signals, and then 500 data are compared one by one to get the maximum value, which is the peak value of the input signal. The code is as follows:

```
for(ii = 0;ii <500;ii++)
{
if(SendBuff[ii]>a0_max1)
a0_max1=SendBuff[ii];
}
```

3.3.2 Frequency Calculation

For high performance microprocessor STM32F103ZET6, the ADC sampling clock interval can be set to a minimum of 1.5ns. Converting 1.5ns to frequency, approaching 667KHz, is enough to complete the signal acquisition in the frequency range of 100Hz to 10kHz.

3.3.3 Judgment of Different Input Waveforms

When the input is triangular wave, square wave and sine wave, there are many ways to judge the input waveform by software.

Among them, the method of judging square wave is the simplest. If there are many points with the same or similar values in a period, the square wave can be judged, or the slope can be judged, the slope is 0 or close to 0, or the square wave can also be judged. For triangular wave, triangular wave can be determined as long as the slope of any two points from the minimum to the maximum is the same. For sinusoidal wave, the slope of the point from the minimum to the maximum can also be determined. If the slope of different points is different, it can be determined as sinusoidal wave.

```
 for(ii = 0;ii <DMA1_MEM_LEN;ii++)      {if((SendBuff[ii]>a0_max*0.95))
                fangbo_ii++;
                else if(SendBuff[ii]<a0_max*0.05)
                     fangbo_ii++;    //find max if((500-fangbo_ii-fangbo_jj)<20)
                     vpp_flag=3;
//              else
//                   vpp_flag=0;
        }
//      ADC1_DR = sum[ii]/(DMA_COUNT-20); //printf("AD%d=%d\r\n",ii,ADC1_DR);
  TEMP=(float)a0_max*(3.3/4096);
        voltage[0]=TEMP*1000;       a0_average=sum_a0/(DMA1_MEM_LEN);
  TEMP=(float)a0_average*(3.3/4096);a0_average=TEMP*1000;
```

3.3.4 Calculation of Duty Cycle of Waveform

The calculation of square wave duty cycle is simpler, because as long as the maximum and minimum values are counted, the duty cycle can be calculated by counting the number of maximum and minimum values in a cycle, as shown in formula (2):

$$P=N_H/(N_H+N_L) \qquad (2)$$

Formula (2) NH is the number of maximum, NL is the number of minimum, P is the duty cycle. The duty cycle calculated by this method is very accurate and almost without error.

4 Test

After compiling, connecting and debugging under Keil MDK5.0, the program is downloaded to STM32F103ZET6 development board. Different triangular wave, square wave and sinusoidal wave are generated by signal generator, and a set of data [9-10] is obtained by testing.

From the test results, it can be seen that the lower the frequency, the more accurate the measurement, because the more points collected, the smaller the error; the larger the frequency, the greater the error, but all within 1%. Among the three waveforms, square wave is the most accurate, followed by triangular wave and sinusoidal wave.

5 Conclusion

In this paper, a new method for measuring the parameters of input waveform is proposed. Through the method of A/D acquisition and DMA, the waveform judgment, peak value, frequency, period, duty cycle and other information are measured. Its working principle and measurement method are described. Compared with other measurement methods, this method saves complex analog circuits and is suitable for the measurement of low frequency and amplitude signals in a certain range. If we want to improve the frequency range of measurement, we need to choose a microprocessor with higher main frequency; if we want to increase the measurement amplitude, we need external voltage divider circuit to achieve. This method has certain practical value and has been applied in the

second teacher electronic competition in Shaanxi Province.

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