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The Design of a Low Power Consumption High-voltage Side for Current Transducer

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Abstract

Traditional current transformer (CT) has more and more problems in the process of development, and a new hybrid current transformer (HOCT) obvious advantages, still need to focus on one of the core problems is the problem of high voltage side processing system power. The greater the power consumption of high end processing system, power link the more complex the cost is higher; Reduce the power consumption of the high pressure end processing system can well solve the problem. The low power design of high pressure end processing system are introduced, the main measures are given, and mainly introduces the program design. After data results confirmed that the design in this paper, high pressure processing system can greatly reduce power consumption.

Keywords*: HOCT; low power consumption; MSP430*

1. Introduction

With the rapid development of power system, the traditional current transformer gradually exposed many deficiencies, such as magnetic saturation, ferromagnetic resonance and eddy current effect, *etc*. New optoelectronic current transformer (HOCT) along with the development of the electronic and optical conveniently, has many advantages: short response time, wide measuring range and good insulation, low cost, and due to the high voltage and low voltage side with optical fiber connection, electrical isolation completely, there is no secondary open question [1-4]. Figure 1 is a schematic diagram of HOCT, divided into high pressure, optical fiber, low pressure and power supply sections. In high pressure parts, Rogowski coil to measure the current of the electromagnetic wave is converted into voltage changes, and to the high pressure end processing system, the processed signals into light through the optical fiber to low voltage side processing system, and finally realize the relay protection and power metering applications. High end processing system depends on the laser power supply system, the low voltage side laser will produce the high power laser transmission through optical fiber to high end photovoltaic system, after converted into electricity can give high end processing system for power supply.

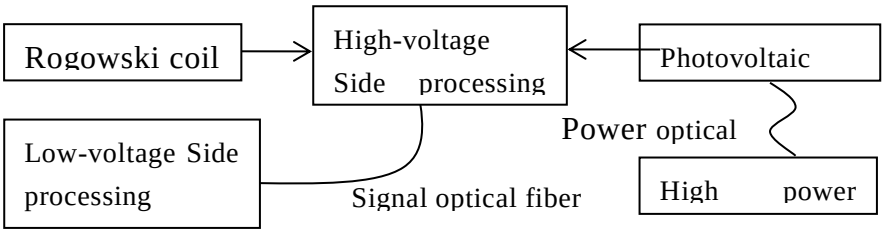

Figure 1. Block Diagram of HOCT

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At present in the high end of power supply method, laser power supply is a relatively stable way, just because of the cost and technical difficulties, can provide electric power limited [5-8] , so reduce the power consumption of the high pressure end processing system is very important.

In this article, high pressure processing system is shown in Figure 2. Roche coil is differential operation, so the output voltage and current to be measured phase difference of 90 ° , the phase can be corrected only after integration. MSP430 MCU is responsible for the control of MAX1246 chip module conversion process. The analog-to-digital conversion, single-chip microcomputer to digital signal according to the serial asynchronous communication mode of transmission, next serial asynchronous communication mode can greatly reduce the power consumption of the system, and moreover, the function of the inverter in the figure is plastic.

Figure 2 is high pressure end processing system schematic diagram in this paper. Including roche coil, integral circuit, analog-to-digital conversion, MSP430 single chip microcomputer, inverter and electro-optical converters.

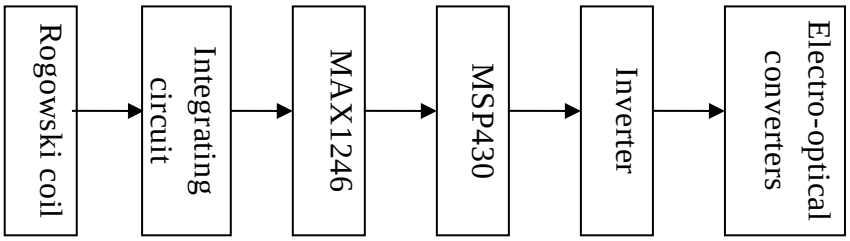

Figure 2. Block Diagram of High-voltage Side

2. Hardware Design Scheme

2.1. MAX1246

MAX1246 (pictured) is A new type of channel 4, 12, in turn, comparison of type A/D converter. It is characteristic of low power consumption, the sampling rate is 133 KSPS, power consumption is only 3.6 mW.

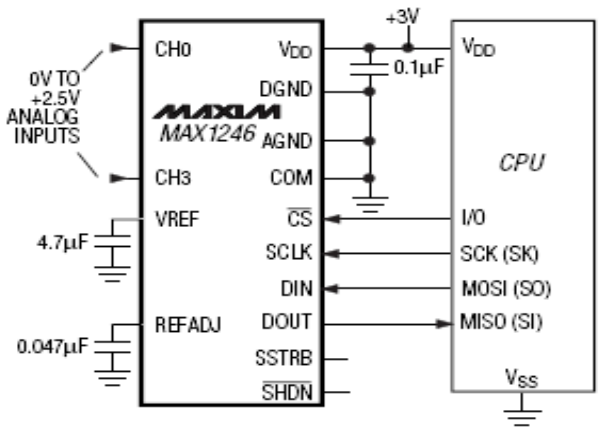

Figure 3. MAX1246

Work mode choice: clock, CH0 input single polarity, conversion, double polarity;

Input voltage range for - VREF / 2 ~ + VREF / 2, is converted to binary 000 h ~ FFFH. Accordingly, the control word should be 96 h. MAX1246 work process can be divided into three parts: (1) the conveyor control word; (2) transformation; (3) data. When the sampling rate is 133 KSPS, power consumption is only 3.6 mW.

(1) The control word

At the start of the piece will choose signal from high level to low level, and then began to transfer control word, which is 96 h. Concrete is at the beginning of the first clock pulse rising along the a START signal through the DIN pin into the shift register, along the control word in each pulse rising after 96 h the rest who, in turn, move into the shift register MAX1246, after all to START the AD conversion process, SSTRB should be a low level at this moment.

(2) AD conversion

Control word into began after the modulus conversion, after 7.5 (including s modulus conversion is complete, then SSTRB level to high level, to the processor signal conversion to end. In the process of transformation, in order to avoid mistake, should choose signal into a high level.

(3) The output data

After the selected signal to a low level, the result of the transformation under the clock signal output. The specific process is that the first clock signal rising along the "zero" to the DIN, the conversion result after falling down the first output is located in the DOUT, after every clock signal rise along the "0" into the DIN, falling edge to the data bits from the DOUT output again. "0" move to DIN is to prevent work mode change eventually lead to errors. Finally, to remove the other four invalid "0", which constitutes the 16-bit adc result.

Table 1. Format of Conversion Result

D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	0	0	0	0
data												invalid “0”			

2.2 Select MCU Way of Working

MSP430 single chip microcomputer (as shown in figure 4) produced by American TI company, is a powerful ultra low power 16-bit microprocessor. It is characterized by low power consumption [9]. In addition, the strong treatment ability can be competent for high voltage side plate of all functions.

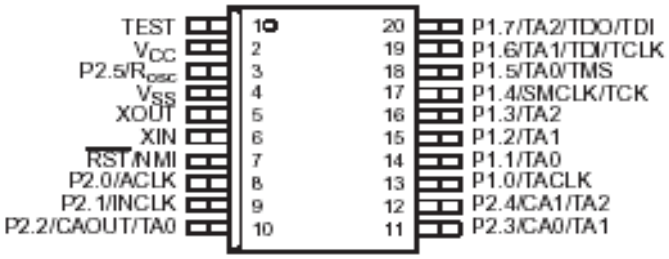

Figure 4. MSP430 SCM

(1) choose the crystals

To meet the real time data collection and send, need to select crystal vibration natural frequency is 3.59 MHz.

(2) the choice of the master clock frequency

Master clock frequency is the CPU clock frequency, the higher the frequency the system power consumption. But in order to improve the processing speed, then the master clock directly use crystal vibration input frequency.

(3) the choice of auxiliary clock frequency

Auxiliary to Timer_A clock frequency signal. Timer_A features include two in this paper, one is to provide the interrupt signal, the second is to generate transmit baud rate. When MSP430 single chip microcomputer is of low power consumption mode, to the Timer_A transmission frequency, make CCR0 timing start MSP430 interrupt; When the data collection is complete, give Timer_A transmission frequency signal make CCR1 produces the baud rate when transmitting data, the process does not need to use high frequency signal. Auxiliary clock frequency, therefore, was selected as the crystal frequency binary frequency, so can meet the need, but also reduce the power consumption of the microcontroller.

(4) select data baud rate

Main consideration stability and real-time performance. Baud rate if too fast will lead to the lack of stability of data; If too slow to affect the real-time performance, can not achieve real-time sampling.

(5) choosing the way of data transmission

Data communication can be divided into parallel communication and serial communication mode. Parallel communication is through multiple transmission line at the same time all of the bits of a data transmit at the same time, its characteristic is the transport process is very fast, mainly is suitable for short distance communication and transport; Serial communication is through the same root transmission line, the data in the order a a bit by bit transmission, main characteristic is wiring simple, often use the telephone or telegraph lines which can complete the communication process, the cost is low. Suitable for long distance communication in serial communication, but the drawback is slower transmission process. Serial communication is still can be divided into two kinds of synchronous communication mode and asynchronous communication way. Among them, the asynchronous communication based on a single character as a transmission unit, in the process of communication, each interval between two characters are not fixed, but the interval between adjacent to a fixed within the same character. Usually, when the communication distance far mostly adopt asynchronous communication, in this article the serial asynchronous communication mode is used to complete the data transmission, this way can greatly reduce the power consumption of the processing system working in high voltage side.

2.3 The Working Process of the System

Use MCU peripheral modules are mainly WDT (watchdog timer) and Timer_A. Among them, the Timer_A is mainly to control the sampling rate and generate send data baud rate, sampling rate control is achieved by CCR0 module, CCR0 time to wake up, in a low consumption mode of the CPU wake cycle is the sampling period. In addition, the WDT can prevent program in infinite loop situation.

(1) to collect data

System initialization process is complete, the command MAX1246 start data sampling. The first step, reduce the selected signal level, MAX1246 which begin to work. Second step, the pulse signal transmitted to the SCLK, and in each pulse signal rise along when moved into its MAX1246 control word register, after the control word to complete the move, to wait for signal analog-to-digital conversion is complete, at this time to continue to judge whether the current SSTRB level is high, such as high level change began to take out the complete transformation results, pay attention to in the process of fetching data to make the slice to keep low level selected signals, at the same time send SCLK continuous pulse signal, but also to deliver the zero signal in pulse signal rise along with DIN, and convert the result data on the falling edge the pulse. Take results, remove top first, then remove all in turn. When 16 at the end of the pulse signal, extraction and conversion results end of work.

(2) to send data

Sending process adopts the first high low eight and eight ways, by comparing CCR1 capture, function is complete. In serial asynchronous way, this way only one optical fiber, does not need the clock signal, can greatly reduce the power consumption of the processing system. The specific transmission process is that CCR1 first set fixed baud rate signal, CCR1 after each interruption, then combine the data in shift, to control the interruption of CCR1 next jump. CCR1 each jump are corresponding to each of the data transmission and transmission process from a lower place to start. Every time before sending have started, and you have stop bit is sent and random free, in order to reduce energy consumption and MSP430 single chip microcomputer after complete collection and send data, it will clear up in low power mode, until CCR0 it to wake up again.

3. The Program Design

There are mainly three program module.

(1) controlling sampling rate

Power frequency conditions, each cycle design sampling point 32, so the sampling frequency is 1600 s/s, the sampling period is 0.625 ms, general requirements for more than 13 times harmonic in power system, the sampling rate can completely meet the need. Application process as shown in figure 5.

(2) collect data

In this article, the control word is 96 h. Analog-to-digital conversion process is completed, will be held in MAX1246 register, and wait for the single chip microcomputer to take out the data. This application process as shown in figure 6.

(3) to send data

CCR1 function modules to implement the data need send baud rate, this article is about 57.6 kbaud/s, the program design process as shown in figure 7, is divided into two steps: first of all get high eight and sending; And then take low eight sent.

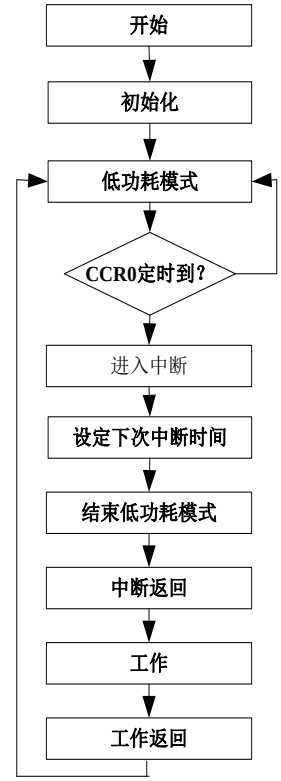

图5 采样速率控制流程图
Fig.5 Flow chart for sampling speed

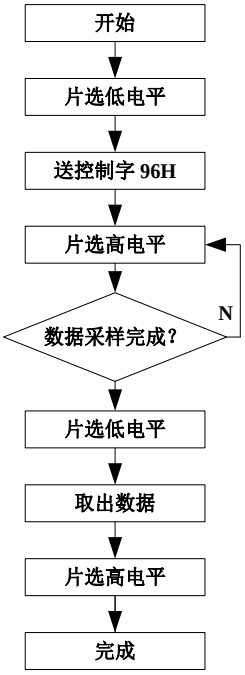

图 6 数据采集流程图
Fig.6 Flow chart for sampling

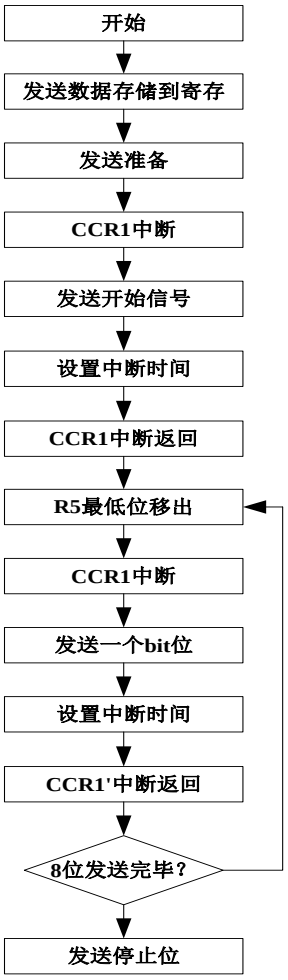

图 7 数据发送流程图
Fig.7 Flow chart for data sending

4. Experimental Data

In the experiment, make the system work mode, namely data collection and send are ongoing, and electro-optic switch also at work at the same time, the measured power consumption is the actual power consumption at work, the experiment data are shown in Table 2. By the experimental data, the system of the actual power consumption is lower than 30 milliwatts.

Table 2. Particular List of Consumption

module	MSP430	MAX1246	HFBR-1414	total
Power consumption (milliwatts)	0.4	7.8	20	28.2

The precision of the system test results such as Table 3. Mutual - 8 magnitude 0.5 error limits specified requirements such as Table 4, it serves to show this system fully meet the provisions of the 0.5 -magnitude accuracy requirement.

Table 3. Experiment Result of Precision

	System contrast (±%)				Angle difference (′)			
range	5%	20%	100%	120%	5%	20%	100%	120%
error	0.5536	-0.4494	-0.2363	-0.0391	13.6	3.29	0.350	−1.37

Table 4. Error Limit of 0.5 Grade for OECT

precision	error (±%)				Phase error (′)			
	5%	20%	100%	120%	5%	20%	100%	120%
0.5	1.5	0.75	0.5	0.5	90	45	30	30

Power system is a standard power frequency 50 hz. According to the analysis of 13 harmonic requirements, according to the sampling theorem, the system sampling frequency should be at least 1300 hz, that is, a power frequency sampling at least 26 points. In this paper, the sampling frequency is 1600 hz, that is, a power frequency sampling just 32 points, so the sampling rate can meet the requirements.

5. Final Conclusion

After low power hardware and software design, finally the experimental data show that in the high pressure side can processing system has the lowest power consumption control in less than 30 milliwatts, actual measurement precision is 0.5 class standard and system, at the same time, the sampling rate can achieve power system basic requirements.

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