# THE DESIGN OF HLS VOLTAGE NETWORK MONITORING SYSTEM BASED ON AD7756

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**Abstract:** The features of a voltage/energy measuring IC AD7756 are introduced in this paper. By using this IC, we designed a voltage network monitoring system for HLS. With the bus interface of RS485, The system can monitor 64 sites simultaneously. Each site module includes 2 ADCs, a voltage reference, a temperature sensor and a relative DSP. It can set the voltage alarm threshold when working, and sample the voltage waveform in real time at the sampling rate as high as 14KSPS. Besides the bus interface of RS485, the common serial interface of RS232 is available too.

**Keywords:** AD7756, SCM，RS232，RS485，voltage monitoring

## 1 Introduction

Many important devices and instruments, such as electrical source for magnets in accelerator, demand for stable power supply without instantaneous breakdown and wide range fluctuation. In that case, real time monitoring of voltage is very important. The traditional way of voltage network monitoring is to isolate and attenuate the AC voltage signal, then input it into a PC data acquisition card. A/D conversion is carried out by the card and all data processing is implemented in PC. The defects of this kind of design are its relatively high cost and low speed. Another kind of design comprises operational amplifier, common ADC and MCU (a SCM). The ADC converts analog voltage signal into digital signal for the MCU to read. The data processing and analyzing is finished by the MCU. Because of low speed of MCU, the processing rate is limited.

For voltage/power measuring, some foreign IC manufacturers have new dedicated ASIC chips, such as CS5460 of CRYSTAL Corp and AD7755/AD7756 of Analog Device Inc etc. The common feature of these IC is to integrate those components for voltage/power measuring, such as operational amplifier, ADC, voltage reference, temperature sensor, DSP, into one single chip. So high speed data processing and analyzing can be achieved. Serial interface is available to communicate with microprocessor. Using these ICs simplifies circuit design and improves stability.

HLS is a dedicated synchrotron radiation facility. In order to guarantee uninterrupted running of many power supply and important instruments, we designed a small, exquisite and reliable voltage monitor by using AD7756 and AT89C2051 of Atmel Corp. as MCU. The monitoring software is running on a PC. The PC communicates with the monitor through RS232/RS485 to form a whole voltage monitoring system. All monitors are distributed in different places and connected through RS485.

## 2 Hardware structure of the system

The diagram of system designing is illustrated in Fig.1. The whole designing is composed of voltage/current sensing circuit, AD7756, AT89C2051 and communicating interfaces. The voltage (220V) is attenuated in the range of 1V required by AD7756 after passing through the voltage and current sensing circuits which can be a resistance voltage division circuit. AD7756 converts the input analog voltage into digital voltage at some rate and store the digital voltage in the registers. At the end of the converting, the IRQ pin of AD7756 becomes high to request an interrupt from the SCM. In the whole system the SCM manages the running of all parts. When the system starts working, the SCM initialize itself to set the parameters of the interrupt/timer and initialize the AD7756, then the SCM goes into the recycling status to wait for a interrupt event to occur. In the interrupt service routine (ISR), the SCM detects the status of the SAG pin. If the SAG pin is high, the SCM sends a predefined alarming character to the upper PC then reads the voltage value in the Waveform Register of AD7756 and sends it to the upper PC. The monitoring software running on the PC communicates with the lower monitor through serial port. In the PC

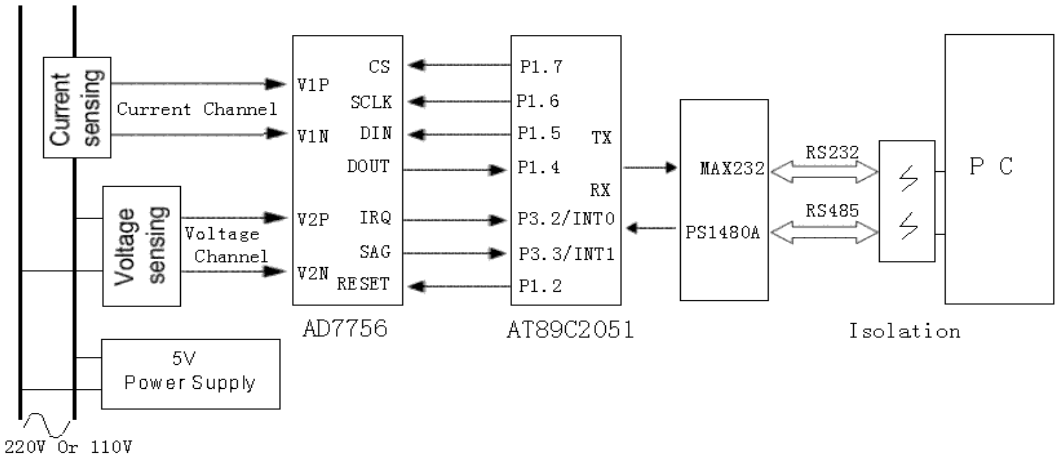


Fig.1 Hardware structure of the system

screen, the current status of monitored voltage is displayed. The alarm voltage threshold value (SAGLVL), SAGCYC value of AD7756 can be set on the PC screen. The real time voltage waveform can be drawn on the screen too with the voltage values sent by the lower monitor.

## *2.1 Introduction of AD7756*

In this design the key component is AD7756. AT7756 is a voltage/energy measuring IC of Analog Device Inc (ADI) and can be purchased in Nanjing Shijian Corp. The features of AD7756 include:

- Two Analog to Digital Converter (ADC) convert two channels separately.
- Integrated digital signal processor (DSP) makes speedy power calculation possible.
- Several Integrated calibration registers calibrate amplitude, gain, phase of input signal to guarantee more accurate calculation result.
- Four sample rates, 28.8K，14.4K，7.2K，3.4K are optional and selected in relative bit of Mode Register.
- SAG pin is available to indicate the status of voltage amplitude. When the monitored voltage amplitude is below the threshold value, the SAG pin becomes low. The principle of SAG signal generating is shown in Fig.4.

## *2.2 The generation of SAG signal*

One of useful features of AD7756 is its ability of SAG detecting for monitored voltage. As shown in Fig.2, when the voltage is less than the alarm threshold value( set in SAGLVL[7:0]) for SAGCYC[7:0] half cycles, ( In Fig. 2 SAGCYC=06H) , and the DISSAG bit in Mode register is 0, the SAG pin changes to low level, at the same time the SAG bit in Interrupt Status Register is set to 1. If the SAG bit of Interrupt Mask Register is 0, the IRQ pin becomes low to request an interrupt from the SCM. In this design, it is in the interrupt service routine that the SCM checks whether the monitored voltage is abnormal by detecting SAG pin status.

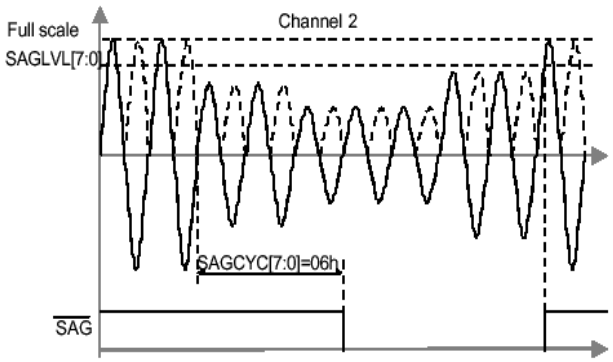


Fig.2. the generation of SAG signal

## *2.3 The SCM and communicating interface ICs.*

The SCM we selected is AT89C2051 of Atmel Corp. At89C2051 is a kind of small size SCM with 2 KB Flash ROM, 128 Byte RAM, 5 interrupt sources, a serial port.

This kind of SCM is suitable for simple application. We program it with Franklin C51. C51 language is a kind of C language derived from ANSI C for C51 SCM. Compared with traditional SCM program in assemble

language, C51 is simple and effective. So by using C51 the developing speed for SCM is much higher. The main routine of SCM is illustrated in Fig.3:

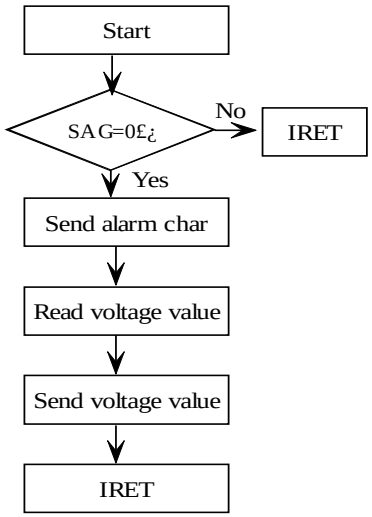


Fig.3. Flow chart of ISR

The lower monitor communicates with the upper PC through RS232/RS485. The RS232 interface IC is MAX232 of MAXIM Corp and the RS485 interface IC is PS1480A of P&S. A PS1480A consists of a transceiver, a photoelectric coupler and a transformer. It is a kind of input-output isolated, semi duplex data communicating interface of RS485. Because of photoelectric isolation, the PS1480A can protect the upper PC.

### *2.4 Read/Write of AD7756*

An AD7756 includes 16 registers which can be read and wrote to set working parameters and obtain measuring results. All read and write are performed with four pins, CS，SCLK，DIN，DOUT which are connected with four I/O ports P1.7, P1.6, P1.5, P1.4 of AT89C2051,. As illustrated in Fig.1. The CS pin is set to low by instruction in SCM, and then the SCLK pin is set to high and low alternately to simulate a clock signal. At the same time, data is read from DOUT or wrote to DIN. Before reading or writing a register, a byte must be written to Communication Register to specify the address of this register.

Among all 16 registers, we used the following registers listed in Table 1.

Table 1. Important registers of AD7756

| Register Name | Address | Function |
|---|---|---|
| WAVEFORM | 00H | Store voltage value |
| RSTSTATUS | 05H | Interrupt Status Register |
| MODE | 06H | Set working Mode |
| SAGCYC | 0FH | Set SAGCYC value |
| MASK | 10H | Interrupt Mask Register |
| SAGLVL | 11H | Set the alarm value |

When the system starts working, firstly the important parameters of AD7756 should be set. The working parameters we set through Mode Register are: voltage measuring, channel 2, 3.4KSPS of sample rate, 0x30 for SAGLVL, 0xFF for SAFCYC. In fact in different situations, suitable parameters can be set. Valid interrupt sources are selected through Interrupt Mask Register. There are totally six interrupt sources for AD7756. We select SAG and A/D converting ending interrupt sources and mask others.

## 3 Software designing

The monitor software running on the upper PC is developed in Visual C++6.0 so that it can run on Windows platform. The software is dialog based and developed in MFC method for high developing speed.

In VC++, A serial port can be read or write by regarding it as a file. It also can be read or write by using specified API functions. Both methods are effective.

## 4 Application Result

By making full use of powerful functions of AD7756 in voltage/energy measuring and with SCM technology, the voltage network monitoring system we designed is of the features of low cost, small size, high accuracy and low power assumption. It works properly in actual situation. The real size of the monitor is shown in Fig.7. The functions of AD7756 have not been fully made use of. The monitor can be used in different situations such as power measuring without hardware changing, only by changing the SCM routine. So AD7756 can be used widely in voltage/energy measuring.

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