

# Electric Parameter Acquisition System Based On ARM

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With distribution networks, the requirements for the collection and transmission of the electrical parameters are getting higher and higher. In order to improve the real-time performance and reliability of the electric parameter acquisition system, distribution networks provide a practical method for the real time acquisition and transmission of the electric parameters of the distribution system. This paper gives a new electric parameter acquisition system based on ARM. It presents the working principle, hardware design and function realization of the acquisition system. By experimentation it was proven that the method increases the real time and stability of the data acquisition system and plays an important role in the development of the electric parameter acquisition system.

## 1. Introduction

The core of the S3C2440 processor is based on the 5 stage pipeline core, which is integrated with branch prediction, single cycle multiplication, hardware division, and so on (X. Zhang (2014)). It has been widely used throughout the world. Due to its high transmission rate, long distance transmission, distributed system for networking, and high noise rejection capability, serial bus RS485 is widely used in the fields of industrial control, electric communication, and intelligent instruments. In theory, the RS485 can access 32 devices (affected by chip drivers) and work in half duplex or full duplex mode. The maximum transmission distance is about 1,219 m, and the maximum transmission rate is about 10 Mb/s.

Modbus protocol is widely used in the industrial equipment, supporting the traditional RS232, RS485 and ethernet equipment. Many pieces of industrial equipment (including PLC, DCS, intelligent instruments, etc.) uses Modbus protocol as the communication standard, so that the production of different manufacturers can be connected into the industrial network to centralize monitoring (F.L. Huang and H.F. Lu (2014)). A solution for the power distribution network, which is used to collect, process and transmit the electric parameters of the distribution network, can be obtained by combining the Modbus protocol with the powerful processor S3C2440. This design takes full advantage of the rich resources and powerful processing ability of S3C2440 to solve problems of the traditional design for electric parameters collection information, such as low measurement accuracy, weak parallel processing ability and so on. Through Modbus protocol, the RS485 bus combines with the host computer for a network to operate the real-time reporting of the power grid. This solves the problem of traditional power, voltage monitoring instruments, which cannot upload the real-time performance of the power grid monitoring system.

## 2. Overview of the electric parameter acquisition system

The electric parameter acquisition system is composed of two parts as shown in Figure 1: the host and data acquisition equipment. In the design of the system, a PC is used as the host. Through the RS485 interface, the host which is able to correctly identify and initialize the device is connected with data acquisition equipment.

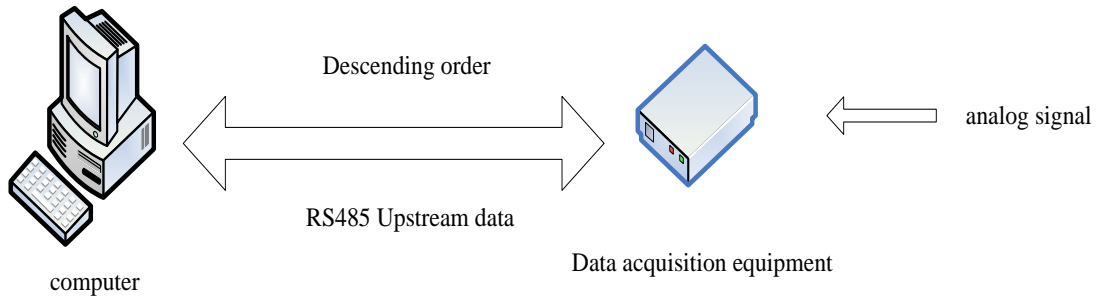


Figure 1: Composition of electric parameter acquisition system

After the initialization of the equipment, the host sends the data acquisition module to the data acquisition module to collect the command and the task parameters. After the acquisition module receives the command, the command is parsed and executed, and the data is uploaded to the host by the RS485 interface.

The RS485 standard relies only on the interface electrical characteristics to make the regulations, and it does not involve the connector, cable or agreement. Therefore, the user needs to establish their own application layer communication protocol based on the RS485 network application. This design uses Modbus protocol.

The hardware and software resources of the acquisition system can be divided into 3 layers: the interface layer, the device layer and the function layer. The layers are shown in Figure 2. The interface layer is specifically a physical layer, which mainly realizes the interaction between the data packet and the physical signal. It includes: the packet transmission mechanism, electrical signal environment, and physical link. The device layer provides the RS485 basic protocol stack, the implementation various operations and request command through the general RS485. Logically speaking, it is the data exchange between the system software and the logic device. The function layer provides the specific functions required for each acquisition device, including customer application software and equipment function block. There is a direct logical relationship between them.

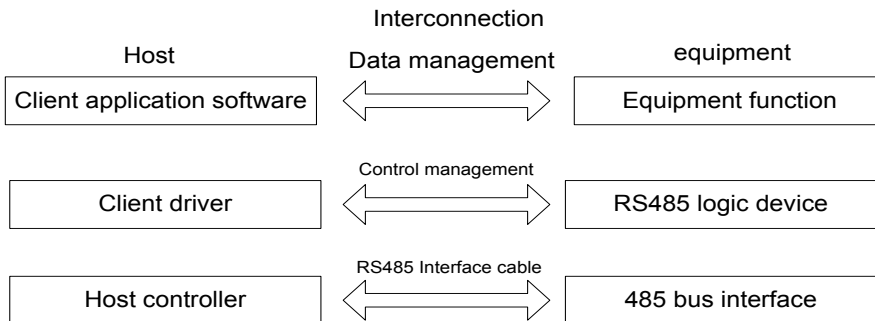


Figure 2: Hierarchy graph

### 3. Hardware design of the electric parameter acquisition module

The hardware structure of the data acquisition module is shown in Figure 3. It is a 32 bit microprocessor based on the ARM920T kernel, equipped with an Analog to Digital Converter (ADC) with 8 channels to sample. Its main frequency is 200 MHz and it can do real-time calculation of the power grid frequency, voltage (current) and power factor, etc. SP3485 made by Sipex is used as the network communication chip and its speed can be as high as 10 Mb/s. SP3485 is connected by the photoelectric isolation method to ensure the accuracy and stability of data transmission. Each module is connected to the host through the RS485 bus, and the RS485 bus supports multi point connection. It uses the balanced transmission and differential receiver, with high resistance of common mode interference (H.Z. Yang et al. (2014)), and high communication rate to meet the real-time transmission requirements.

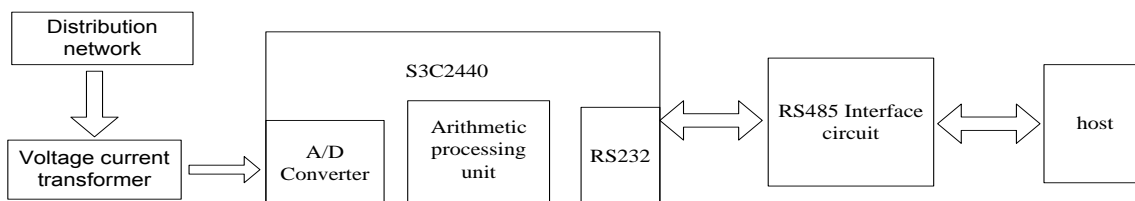


Figure 3: Hardware structure diagram of data acquisition module

#### 4. The design of software for the electrical parameters acquisition system

The design of the software is related to the accuracy and stability of the electrical parameters, and the choice of the protocol is very important to the real-time and reliability of the system data transmission. The software design of the module includes Modbus protocol selection, the realization of serial communication software and S3C2440 real-time sampling program.

##### 4.1 Modbus protocol selection

Modbus protocol adopts master-slave mode, allowing a host and multiple units to communicate. The address of the units is set by the users, and its range is 1-255. Address 0 is used as a broadcast address, and all the hosts take it as a command to execute while units give no response (X.Y. Liang et al. (2013)). This system uses Modbus to regulate the default configuration as shown in Table 1.

Table 1: Configuration of Modbus protocol

Address range from machine	Baud rate	Parity check	Transmission mode	Electrical interface	Connector type
1-127	115200	Parity check	RTU	RS485	RJ-45

Standard Modbus protocol supports two effective transmission modes: ASCII mode and RTU mode. When the controller is set as RTU (Remote Terminal Unit) mode to communicate in the Modbus network, each 8 bit byte in the message contains two 16-bit characters with 4 bits (J.L. Fan et al. (2013)). The main advantage of this method is that it can transmit more data than ASCII in the same baud rate. As the distribution network has a high demand for collection of the electric parameters in real-time, the system uses RTU mode.

RTU's typical message frame is shown in Table 2 T1-T2-T3-T4. Using the RTU mode, the message is sent in at least 3.5 characters long pause intervals. At the end of the last transmission character, there is a minimum of 3.5 character time at the end of a pause calibration message.

Table 2: RTU message frame

Starting position	Device address	Function code	Data	CRC Check	End operator
T1-T2-T3-T4	8 bit	8 bit	Bytes	16 bit	T1-T2-T3-T4

##### 4.2 The design of software of serial communication

The serial communication module uses C language which is written in the uVision4 integrated development environment to realize the frame format, check method and timeout control in the protocol. This means that the equipment can run reliably in the Modbus bus system (J. Zu and R.K. Hao (2013)). In the design stage, a request must be transmitted through the host to the acquisition device to start the transmission process. Therefore, the units must receive the host's request command before sending commands to the host.

The units receive data from the host computer by serial port interrupting mode byte by byte, and go in a serial port interrupt byte by byte. The system hosts are constantly detecting the network bus, including the pause interval. When the first domain (address domain) receives the data, each device decodes it to determine its belonging. If it belongs, the devices continue to receive other data, if not, they exit the interrupt. After receiving the message, the CRC check is performed. If the check result is in good agreement with the CRC check code, the communication is normal and the function code calls the data acquisition subroutine, then returns the response frame.

If the function code is not listed in the function code, it exits the interrupt and sends an abnormal data frame to the host. This system uses the two functional code of analog quantity of reading and writing in Modbus protocol: 03 Read hold register; 06 write hold register. The host sets up the operation parameters by write hold

register and obtains the data and result of the acquisition by read hold register. The communication process Modbus is as shown in Figure 4.

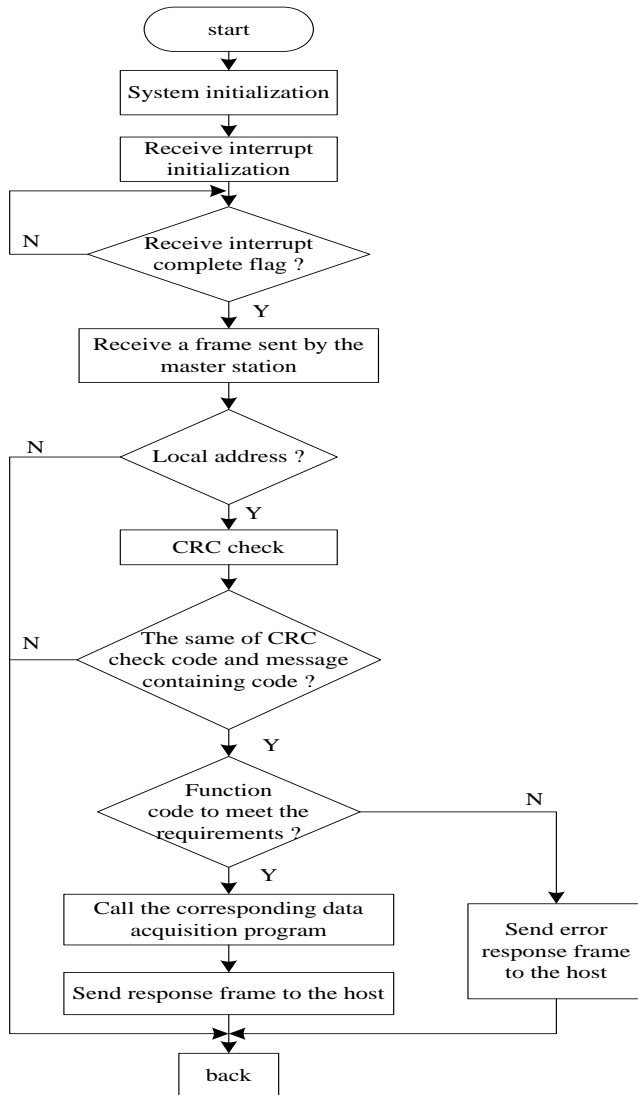


Figure 4: Flow chart of Modbus protocol

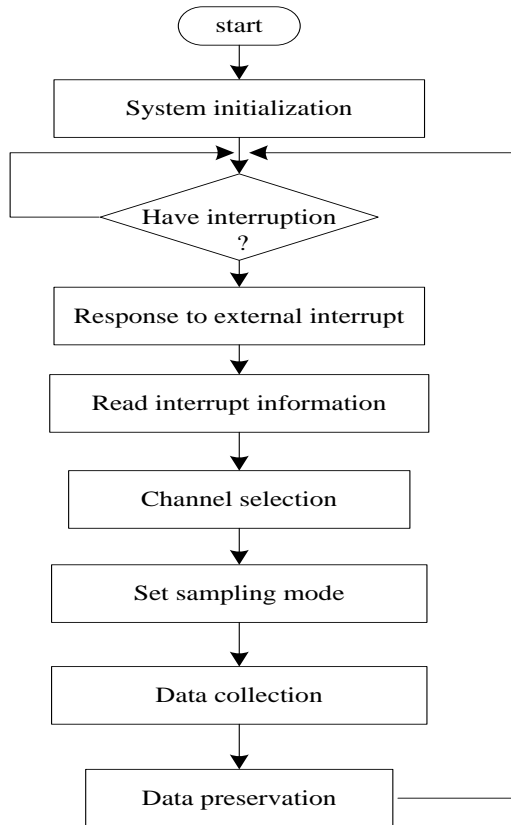


Figure 5: Flow chart of the main program

### 4.3 Procedures of S3C2440 sampling process

The key to electric parameter acquisition system is the data acquisition and reliable transmission. In this module, the real-time data acquisition and analysis are carried out simultaneously.

Data acquisition and transmission is completed in the interrupt by timer T2 of S3C2440. It triggers synchronous conversion of the ADC rule set and channel conversion. ADC produces the request DMA to transfer the conversion value of ADC to improve data transmission efficiency. The conversion result is stored in the 16 bit data memory.

After the conversion, the conversion result is obtained and processed to calculate the real time frequency, three-phase current or voltage RMS, active power and power factor. This is shown in Figure 5.

## 5. Experimental results and analysis

Firstly, the electric parameter acquisition equipment was received to power of 220 V. The lamps of 25 W, 40 W, 50 W, (A, B, C respectively), were three-phase load, the measured part of the data is shown in Table 3.

Table 3: Experimental results

	A phase	B phase	C phase
Voltage (V)	220.1	219.8	220.2
Electric current (mA)	128.6	2002.9	254.4
Active power (W)	25.02	39.89	49.92
Reactive power (W)	12.15	20.03	23.96
Power factor	0.9	0.9	0.9

From Table 3 it can be seen that the accuracy and precision of the test data is good, the data is stable and meets the requirements of the design accuracy.

The communication interface of RS485 and the PC was then connected by twisted-pair under Modbus protocol. The electric parameter value of the PC was completely consistent with the electric parameter value of the acquisition equipment, and achieved successfully.

## 6. Conclusions

In the proposed design, S3C2440 was used as the core controller because of its powerful processing ability and rich functional module. It broke the limitations of the traditional acquisition of power data which was limited to storage space and the communication interface of a 16 bit microcontroller, expanded the collection of information, and raised the measurement accuracy and parallel processing ability. Simultaneously, the Modbus protocol was adopted to provide real time and reliable transmission of data through the RS485 bus. The system was stable and had good real-time performance by testing, able to meet the needs of the actual power system dispatching and management.

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