Design of RTU based on LPC2294

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***Abstract*—The remote terminal unit (RTU) is an important part of the power grid dispatching automation in the distribution automation (SCADA).The design of LPC2294 RTU based on ARM7TDMI(-S) chip has been discussed. The hardware and software design of 2294 has been introduced in detail.**

Keywords-IEC60870-5-103protocol;LPC2294;RTU;μC/OS-Ⅱ; Communication ;Monitoring system;Substation

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The breakdown information are accurately fast transmitted, and has the big processing ability that is the current trend of RTU, in other word, integrating some functional module of the master station, for reducing the pressure of the master station t [4]. Obviously, the traditional RTU which kernel was formed by monolithic machine has very difficult to satisfy the request of real time, such as the core chip formed by 80C196[7] which abilities and operation processing and hardware expansion have affected the performance of RTU; and at present ,there was parts of RTU using the DSP chip integrated circuit or FPGA. Although being able to satisfy the requirements, cost increase highly, the difficulty must increase and periodic development must be lengthen with by using more integrated modules. LPC2294 offered by PHILIPS is a 32 bit core chip which has solved this difficulty, it not only have 16KB inner SRAM, 256KB INNER flash,60 MHz frequencies, more powerful control, and the expanding of the hardware circuit would be more easier. Certainly, it can be satisfied all the function called for RTU Therefore this article introduce the design of RTU based on LPC2294 and its hardware circuit design ,the software design; Using The operating system named μC/OS-Ⅱ,at last the communication method by using the 103 Protocol was discussed emphatically.

1 The hardware design

1.1 Structure diagram of hardware system

The hardware design which divides RTU into high level and low level. The low level are formed by information collector and a controller, including PT , CT, photo-coupler, controlling relays, stringing electrical transformer, communication module and so on; Above one is the CPU board, it contains LPC2294pack chip ,and some modules such as data handling, digital signal processing or switch. This structure system made the RTU more structured, more modularized, anti-jamming, more facilitated more simplified debugged. The structure diagram of hardware system as follows Fig.1.

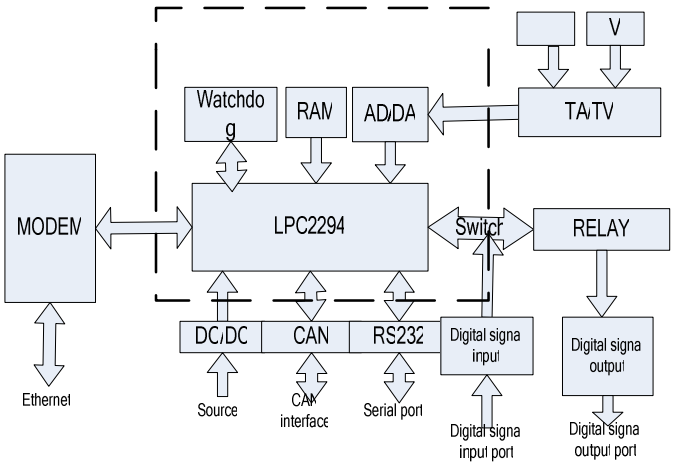

Fig.1 Structure diagram of hardware system

1.2 The hardware schematic diagram of UART

LPC2294 has two full-duplex SCI (Serial Communication Interface) generally regarded as UART, in order to suit to 103 protocols correspondence transmissions, UART0 switch RS485 level by using SP3485E; UART1 uses SP3243ECA which has 8 group chains.

As shown in Figure 2, there are two asynchronous serial interfaces. UART0 keep correspondence with outside through SP3485E, so as to the UART1 through SP3243; in addition you also can choose the Modem connection by using telephone line to cascade, which just through to reset the PINSEL0 register. If you needn't the Modem, only TxD1, RxD1, GND three pins need be connected.

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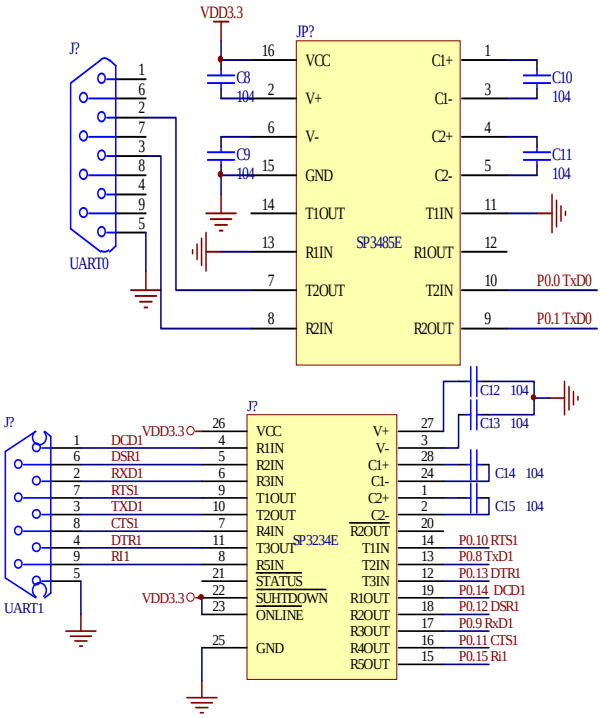

Fig.2 The hardware schematic diagram of UART

1.3 The hardware schematic diagram of CAN

LPC2294 has CAN register and the controller, which has 2 group interfaces integrated as a module, as shown in Figure 3, probing two CAN transceiver TJA1050, you can get information from others. Hardware connection: H-H, L-L. Under interrupts mode, ARM get data through RS232, then send the data to a CAN channel which has assigned ,at last CAN send the data others by RS232.

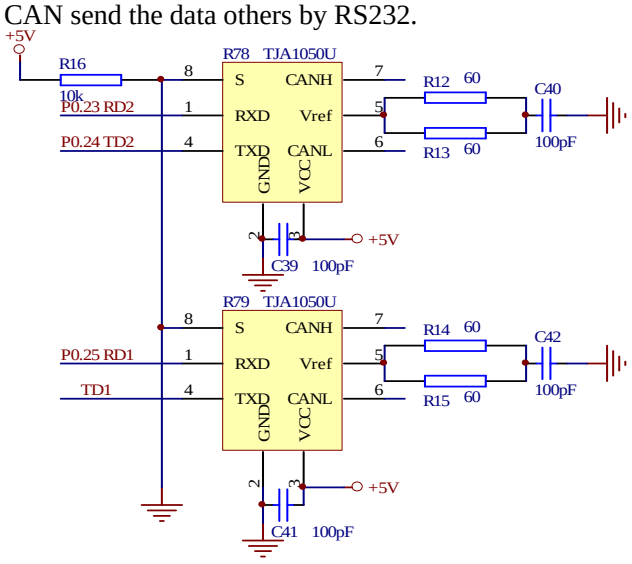

Fig.3 The hardware schematic diagram of CAN

1.4 The hardware schematic diagram of Ethernet network

Because of the 103 protocol's second kind of transmission mode correspondence request we have designed Ethernet interface. Select the RTL8019AS network controller and the HR901170A network transformer, hardware circuit schematic diagram as shown in Figure 4. RTL8019AS is the quite commonly chip used for 10MBPS embedded Ethernet control, which has integrated the DMA controller in the chip interior, the ISA bus control unit and 16KSRAM, and he network PHY transceiver. The read and write of data can through the DMA way. Sending and receiving can all in working under the full-duplex pattern. Therefore the RTL8019AS chip is a very good choice.

In network controller RTL8019AS and in the LPC2294 connection schematic diagram, the network controller RTL8019AS chip work in jumps the line pattern, its base address is 0X300, therefore on the electric circuit SA6, SA7, SA10~SA19 earth, SA9 receives a telegram the source, SA8 and A22 connection, SA5 and LPC2294 exterior memory BANK3 selects patches or strips of land as worth saving for seed the CS3 connection, when SA8 is 1, SA5 is 0, selects the RTL8019AS chip, its operation address is 0X83400000~0X8340001F. LPC2294 bus is open-type, therefore this design is carries on by 16 bits bus visit to network controller RTL8019AS, namely LPC2294 data bus D0~D15 and network controller RTL8019AS SD0~SD15 connection. However the network controller RTL8019AS work power source is 5V, LPC2294's I/O voltage is 3.3V, so that must connect 470Ω protective resistor on the bus line.

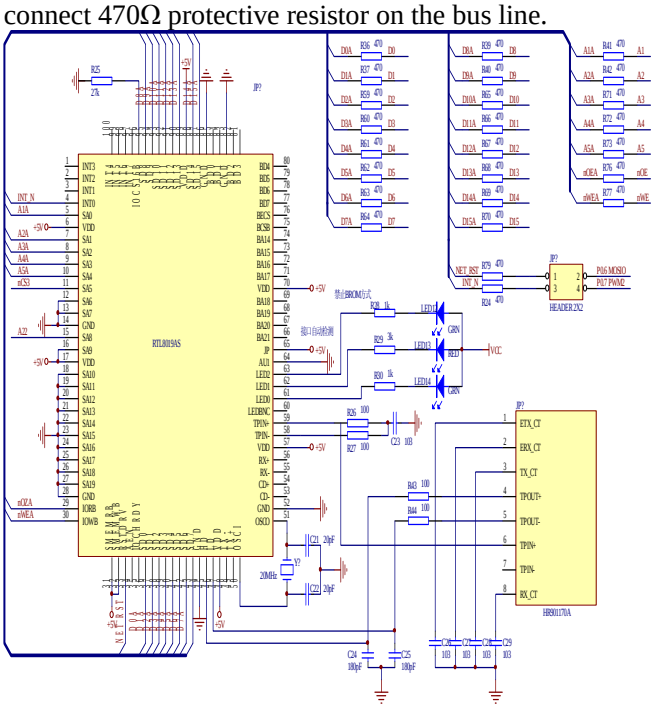

Fig.4 The hardware schematic diagram of Ethernet network

2 The software design

2.1 The whole design

Transplants in the hardware design foundation μC/OS-Ⅱ The operating system, RTU completes the function duty mainly has the sampling, the computation, the control, the protection, the warning and

correspondence processing and so on several parts. These duties carry on the compilation with ANSI C, according to priority by μC/OS-Ⅱ The unification carries on the dispatch and the management. regarding the construction of data, refers to 103 protocols stipulations frame structure and the application service data unit form, all transmission data may define by three kind of structure, namely masthead structure which by the start character, the frame length, the control word as well as the address character is composed, according to the application service data unit form definition's data unit structure, the newspaper tail which is composed of the frame verification and the conclusion character ties the body. regarding program structure, because 103 protocols had stipulated the transmission frame's form has two kinds, when data processing, strictly divides the module according to the frame form, transmits the data according to the frame form's in data order, the procedure realizes conveniently, moreover may cause the procedure 1fsdastructurization, the modulation, to be advantageous for the maintenance.

2.2 μC/OS-Ⅱ

μC/OS-Ⅱ[3] is one free, the source code open real-time embedded essence, including the task scheduling, the task management, time management, the essence management and the duty asks the correspondence and the synchronization and so on basic function. μC/OS-Ⅱ has the probability, to be possible the reduction and opens the source, the user may according to own need to increase each kind of service. Its essence belongs to the deprivable essence, is based on the task priority real-time essence. The system hangs up or the waiting status on own initiative through the clock ticks and other hardware interrupt as well as the duty carries on the task scheduling. μC/OS-Ⅱ The majority of codes are carry on the compilation with ANSI C, only then carries on the compilation with processor hardware related part of codes with the assembly language. And has OS_CPU.H, OS_CPU_A.ASM, OS_ CPU_C.C to make the essential revision. This mayμC/OS-Ⅱ Transplanted to LPC2294 on.

2.3 The brief introduction of the 103 protocol

The 103 protocol[9] is IEC 60870-5-103, published by the international electrician committee and reformulated by Chinese Electric power Department, which is supported by majority electrical automation product. Therefore, used 103 protocols as communication protocol between RTU and the master station or other RTU, the product has a better compatibility, more openness and more standard. The protocol was refers to SAC, from the technological progress Limited company transformer substation protection and the observation system stand 103 protocols, two transmission modes. Non-balanced way and balanced way. The 485 network selects the non-balanced method, and Ethernet selects the balanced method. The 103 protocol has two kinds of frames: constant frame and invariable long frame.

START（10H）
C
A
CS
OVER（16H）

Fig.5 constant

TYP
VSQ
COT
APA
FUN
INF
AND SO ON

Format of long frame

Fig.6 Format of variable long frame

2.4 Processing flow chart of Receive data

The entire signal procedure flow mentality is: Between the receive interrupt function basis frame and the frame time-gap, differentiates each, and will have received a data stores the memory, then opens the receive data processing function; Is different in the receive data processing function according to the frame outset character, distinguishes this data is the constant frame or the invariable frame , presses the different frame the form to carry on the verification again, after the address, the length, the frame verification and, the conclusion character examined correctly, entered the fixed frame or the invariable frame bale breaking processing module; In the frame bale breaking processing module, according to this data's functional code and the user data, establishes corresponding processing to symbolize, after completing, opens the transmission data processing function; In the transmission data processing function, the processing symbol which and master routine establishment processing establishes according to the receive data processing function symbolized that carries on the pack to the corresponding concrete data according to the frame structure, after the pack had ended, enables LPC2294 to transmit the interrupt; The transmission interrupt will pack a data which completes to transmit, sends after completely, closure transmission interrupt. To this, a complete receiving and dispatching data processing process ended. Take receives the data processing function as an example, gave its software architecture flow chart as shown in Figure 7.

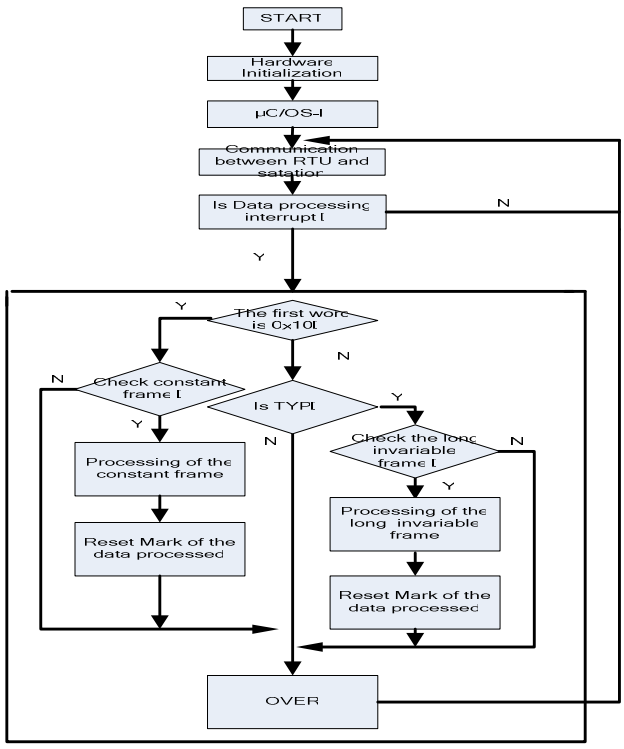

Fig.7 Processing flow chart of Receive data

2.5 Application of the 103 Protocol in the RTU

According to the distribution network automated system's request, RTU has mainly realized in 103protocols following function collections: The link replacement, the link requested that always summons, the grouping to summon (telemeter ring, remote letter), the remote control, the remote letter dislodgement, the smooth event record (SOE), orders and so on clock synchronization, parameter downloading, file transfer. These orders are 103 protocol application strike user open use connections, their transmission completes by the frame transmission, therefore to these order data's receive and transmission processing may in the above data, the program structure facilitate realizes.

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3 Conclusion

The circuit part has used voltage transformer, current transformer and photo-coupling isolator to have carried out isolation without exception in getting in touch with the power grid , added the watchdog circuit for self checking up at the regular intervals, which can reset immediately when process running out , and also added the redundancy code for protection of the software. This RTU have a pair of SPI, CAN interface, modem interface and Ethernet interface, so that this RTU can cascade connected many RTU according to MODEM or CANBUS , moreover make group net to work by using the Ethernet interface , so it can satisfy most needs.

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