Implementation of GSM SMS Remote Control System Based on FPGA

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Abstract—**A design of a GSM SMS(Short Message Service) remote appliance control system based on FPGA is completed in this paper. The paper based on the original telephone remote control system, mainly designs a remote appliance control system using the GSM SMS to finally achieve the dual-mode control of phone and SMS control, which makes the remote appliance control system more perfect. As the control core, FPGA enables this system to be nimble to dispose and have an extended function. The main works completed in this paper include hardware module design (GSM SMS module, RS232 interface module, and the temperature monitor module), FPGA logic design, and system board-level verification. The testing result indicates that the designed long-distance electrical control system meets the designing goal and has application potential.**

Keywords- -FPGA; GSM SMS; Remote control; Temperature Monitor

I. INTRODUCTION

With the improved quality of life, people have a willingness to control family's electrical appliances from a long distance. The remote control system makes all of these possible.

Telephone remote control as a new remote control mean, compared with the conventional control method shows very strong advantages obviously. At the same time, GSM SMS for remote wireless communications, has various characteristics of lower communication cost, less limits of communication lines and regions, high reliability and security, strong anti-interference, being easy to use, flexible and efficient communication and so on[1]. Wireless communications using GSM SMS system also has a two-way data transmission function, stable performance which provides a strong support platform for remote data transmission and the communication of monitoring equipment, based on which the remote control system described in this paper is completed[2]. The system has a high degree of intelligence and convenience, which can be used in occasion related to smart home. It also has feature of low cost, high reliability and is worthy to be popularized.

II. GSM OVERVIEW

A. GSM System Overview

GSM system is a digital cellular mobile communication system, which consists of several sub-systems, with a variety of public communication networks such as PSTN, ISND, PLMN and PSPDN and so on. GSM system is the main body of China's current cellular mobile communication system.

B. GSM SMS

With the GSM mobile communication network quickly spreading and competition becoming increasingly fierce, SMS as basic GSM network service , attracts a growing number of system operators and developers' attention. Various applications are also vigorously developed based on this service.

SMS is a communication mechanism which sends and receives short text messages by cell phone through mobile network. SMS adopts storing and forwarding mode, that is, a short message is sent out not directly to the receiver, but is stored in Short Message Center (SMSC) firstly and forwarded to the receiver by the SMSC. If the receiver turns off or it is out of service area, SMSC will automatically keep this short message, and wait until the

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receiver is again in the service area to send to it[3].

III. SYSTEM HARDWARE DESIGN

As shown in Figure 1, the block diagram of the whole system, it mainly includes the telephone remote control module, temperature measurement module, GSM SMS Module, FPGA core control module and the RS232 Interface module. Telephone remote control module has existed in my lab, the design of this paper mainly uses the FPGA of which to develop.

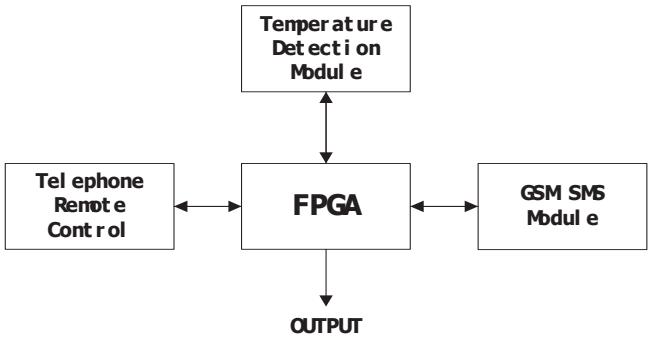

Figure 1. System block diagram

A. GSM SMS Module

GSM SMS Module makes TC35 as the core. GSM communication module is the key component to achieve data transmission of the system and which is the system's wireless interface part. The system mainly communicates through the GSM SMS.

TC35 Series modules of Siemens can work under the GSM900MHz and GSM1800MHz band. It is designed to provide users with a solution of convenient wireless voice and data connectivity that can be widely used in GSM-related platform, which allows users to build their own minimum cost wireless solutions. TC35 module integrates the baseband processing unit and RF radio modules, and provides a external 40-PIN ZIP connector. Then users through the connector can achieved the functions including system control, data input/output, voice input/output and power input. TC35 also provides a good user interface RS232.

TC35 external circuits mainly include power circuit, SIM card circuit, the state display circuit, electrical level transfer circuit as shown in Figure 2.

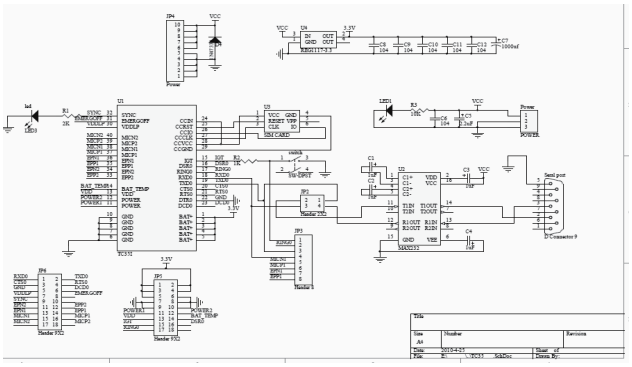

Figure 2. TC35 external circuit

B. Temperature Monitor Module

In order to achieve humanity design, we increase a GSM SMS temperature detection and the message alarm function in abnormality.

Dallas 1-Wire Digital Temperature Sensor DS18B20 produced by Dallas Corporation is a 3-pin TO-92 package; Temperature measurement range is -55 ℃ ~ +125 ℃; The settings is 9~12-bit resolution when programming. Site temperature is directly by 1-Wire digitally transmitted, which greatly improves anti-interference performance. Because it uses a single-bus transmission, DS18B20 data I/O line is only one line, but read and write operations' timing requirement is very strict.

DS18B20 supports the parasitic power to supply. This way is no need to provide specialized power. The power and ground of the chip are both connected to ground, which achieves the communication with the host and access to power. A 5K pull-up resistor is connected with the bus, which builds a charge and discharge circuit with the DS18B20 internal capacitance. The internal capacitance obtains charge from DS18B20 internal capacitance when the bus is in high level, and provides power supply when the bus is in low level. Therefore, the bus should be in high level when the state is idle.

C. RS232 Interface Module

Because of the difference of the electrical characteristics of RS-232 and the FPGA pins, they can not be directly connected with each other. To the data bus of RS-232, when the logic is "1", the corresponding level is-15V ~-3V; when the logic is "0", the corresponding level is 15V ~ 3V. Thus, before connected with FPGA, the level should be converted by the MAX232 level converter[5].

IV SYSTEM FPGA LOGIC DESIGN

FPGA programming is the key of the whole system. If there is no support of FPGA logic design, the hardware system is no availability. Figure 3 is the block diagram of the system logic control.

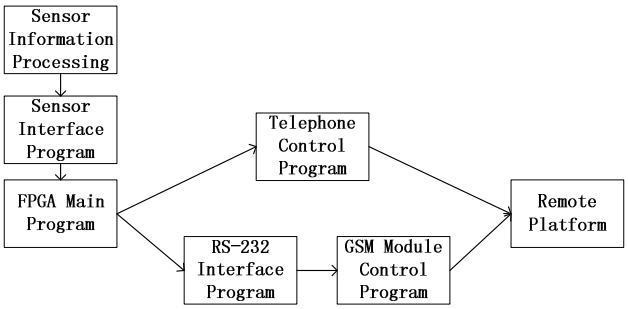

Figure 3. Block diagram of the system logic control

The system chooses QurtusII development environment, designs code with Verilog HDL hardware description language for the FPGA controller, and make functional simulation in the Modelsim_SE environment. The whole system functions include system initialization, parameter setting, telephone remote control, sensor signal acquisition, RS232 interface driver and the GSM module control part. The telephone module and GSM module operate independently. There is no conflict. Here is only system message part flow as shown in Figure 4.

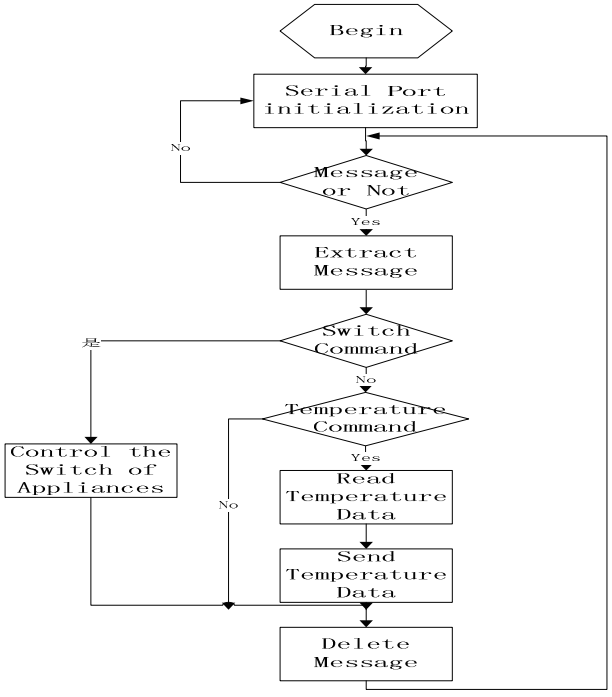

Figure 4. System message flow

A. GSM module controller design

The control of GSM module control mainly refers to the start, close, sending AT commands and setting working parameters. TC35 actually acts as a DCE device (data communications equipment). So it supports standard AT command sets, along with some extended AT commands of Siemens. The operation concentrates in the AT command control, among which, the key is to deal with messages.

When sending message, UART can only send a 8-bit binary number in each clock cycle, so it is necessary to make the data join the queue and wait to send. Every time when it finishes sending data, there will be a sign signal idle. When the idle is low, it indicates UART is idle and the next data is allowed to be sent. This signal can indicate the state of UART when sending data. When receiving messages, every time UART only can receive a 8-bit binary number, so it necessary to store the receiving data storage, and finally the whole data is judged. When it meet pre-set condition, the corresponding program will be performed. This part adopts a Finite State Machine(FSM). When the trigger signal of sending appears, it will begin to sent or receive in accordance with the state of FSM to achieve the message functions.

B. Temperature Test Module

FPGA need to complete the initialization of DS18B20, reading 48-bit ID number of DS18B20, starting temperature conversion of DS18B20, reading temperature conversion results. When reading 48-bit ID number and reading temperature conversion results, FPGA have to complete CRC checksum calculation to ensure the reliability of data communication.

The overall framework of this module are explained as follows: First it changes into 1MHz clock signal through a Frequency Divider, and then give the temperature signals by the temperature measurement module, while the temperature measurement module control DS18B20 to get the temperature information. D port and DQ port need to be controlled by a tri-state gate. Thus only one DQ signal line can control DS18B20 and also can get the data.

C. RS232 Interface Design

FPGA connects with the GSM module via RS232 interface, and sends AT commands to control GSM

module through the RS232 interface. RS232 interface relies on UART module to realize. FPGA-based UART includes three sub-modules: Transmitting module, receiving module, band rate generator module.

UART transmitting module function: When receiving the sent instruction, it outputs the data according to UART protocol. The first output is a low start bit, the second is 8 data bits from low to high bit. The following is an optional parity bit and finally a high stop bit.

UART receiving module function: It monitors the line. When the line generates a falling edge, there is data transmission in the line, then it starts the process of receiving data to receive data from low bit to high bit. Baud rate generator is actually a simple frequency divider. The receiving and sending of UART follow the same baud rate.

The clock frequency from baud rate generator is not the baud rate clock frequency, but 16 times of the baud rate clock frequency, the purpose of which is to sample precisely when the receiving in order to extract asynchronous serial data. We have to calculate band rate divisor according to the given crystal clock and the requested baud rate.

By the design and simulation of baud rate generator, transmitter and receiver module, we more easily achieve the total UART module which can be flexible to change the sent or received data frames and the baud rate clock frequence. Also we don't need too more resources during the hardware implement, especially it can be embedded into the development of FPGA flexibly.

V. SYSTEM VERIFICATION

Finally, we have board-level verification. Fig.5 shows the circuit board of this system. After the logic design synthesis, placement and route and the download, the system verification is completed. We can see that the LED1 is lighten up when we send the message "Open Switch No.1" using mobile phone to the system SIM card number from Figure 5.

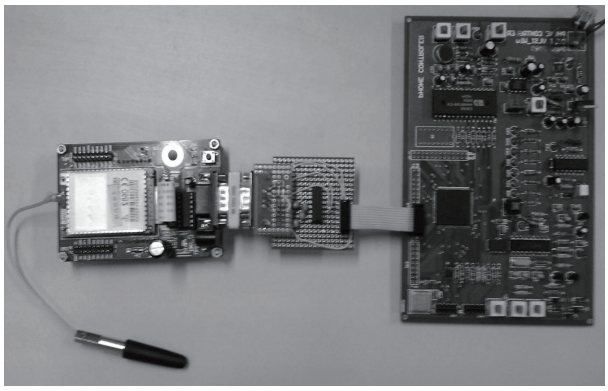

Figure 5. The circuit board of this system

VI. Conclusion

This paper completes a whole design program of a FPGA-based remote appliance control system. Based on maintaining the original telephone remote control system, a GSM SMS remote control mode is designed. The whole system has passed the final board-level verification.

Test verification result shows that the system performs well, it can send and receive text messages, can achieve the remote control of appliances' switches by the communication between the system and mobile phone. In addition, it increases the function of temperature detection by SMS. All of which provide a practical solution for the humanity remote control of home appliances.

ACKNOWLEDGMENT

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REFERENCES

[1] Young L C.Yoshiro Imai,Makoto Ooga,et.al,"Mobile Phone-enhance User Interface of Remote Monitoring System",IEEE Proceedings of the International Conference on Mobile Business,2005,pp.63-68

[2] Yang Lili, Yang Shuang-Hua, Yao Fang, "Safety and security of remote monitoring and control of intelligent home environments", Proceedings - IEEE International Conference on Systems, Man and Cybernetics, 2007, p 1149-1153.

[3] CAO Wei, WANG Guo-hui (2007). "Design of Transformer Terminal Unit Based on GSM". Journal of Harbin University of Science and Technology, vol. 12, no. 4, pp.1-4

[4] G. Aranguren, L. Nozal, A. Blazquez, and J. Arias, "Remote control of sensors and actuators by GSM", IEEE 2002 28th Annual Conference of the Industrial Electronics Society IECON 02, vol. 3 , 5-8 Nov. 2002, pp..2306 - 2310.

[5] A. Alheraish, "Design and Implementation of Home Automation System," IEEE Transactions on Consumer Electronics, vol. 50, no. 4, Nov. 2004, pp. 1087-1092.