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Design and Implementation of Smart Home Control System Based on Fpga

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ABSRTACT. *With the rapid development of Internet of Things and mobile communication technology, smart home emerges as the times require and is widely loved by the public. Based on FPGA programmable chip, this paper designs a intelligent home system which runs on the embedded system based on FPGA. The system can be programmed on the spot according to needs, and use FPGA to realize, complete a series of operations such as data verification, analysis and processing, and then transmit to the terminal equipment to check the field information through the interface. In addition, the system can execute multiple tasks at the same time, greatly saving the task execution time and enhancing the user experience.*

KEYWORDS: *Fpga, Smart home, Control system, System design*

1. Introduction

The so-called smart home refers to an efficient residential design and management system for daily household affairs. It uses residential as a platform, using network communication technology, automatic control technology, security technology, integrated wiring technology, security technology, etc., to integrate various equipment related to home life (such as audio and video equipment, lighting equipment, access control equipment, etc.)[1]. Smart home can significantly improve the convenience, comfort, artistry and security of home. With the increasing demand for smart home, personalized customization has become one of the important trends in the development of smart home.

2. System Framework and Working Principle

This system adopts the embedded control mode to control all modules of the system uniformly. The system mainly includes core processor, sensor module (light intensity lighting control module, temperature control module), LED module, Bluetooth module. The core processor mainly implements various functional modules and network connections.

The working principle of the system is as follows: the sensor module will

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transfer the collected indoor information, such as light intensity and temperature, into digital data to the core processor. The core processor connects the collected digital data to the Bluetooth module via UART. The Bluetooth module transmits the digital data obtained from the core processor to the user end. The user's mobile app receives information through Bluetooth module, so as to know the indoor light intensity and temperature in real time. Users can send control instructions to the core processor by collecting app to adjust the light intensity and temperature of indoor environment.

3. The Hardware Design

The system hardware mainly includes Pmod TMP3 (ambient temperature sensor), Pmod ALS (ambient light sensor), Pmod OLED (OLED display), etc. During the operation of the system, the optical intensity sensor, temperature sensor and controller will transmit the received information to the FPGA main control chip, forming the integrated control of peripheral sensors around the FPGA main control chip (see Figure 1).

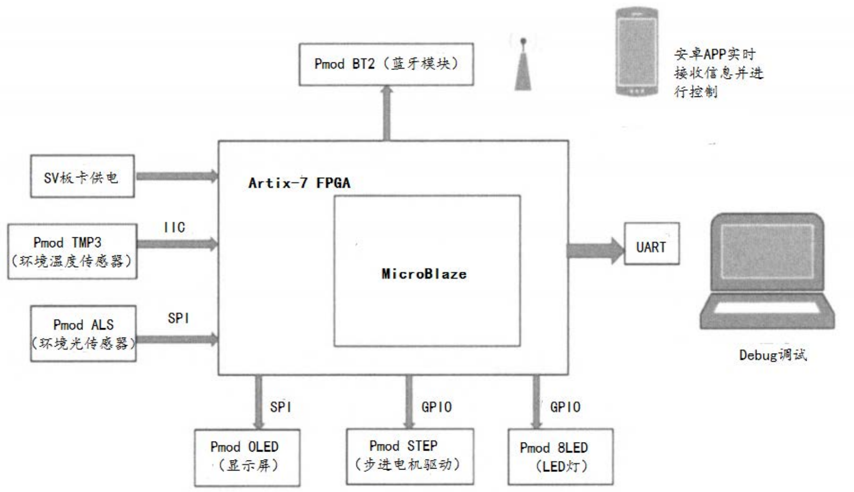

Fig.1 System Hardware

The Pmod TMP3 module is a Microchip®TCN75A ambient temperature sensor. The sensor has a programmable 9 to 12 bit resolution with a typical accuracy of ±1℃. At the same time, the sensor has a 2-wire I2C compatible interface with 8 optional addresses. The sensor is programmable temperature bulletin, and users can set a trigger when it reaches the set dimension threshold according to their own needs.

Pmod ALS module is a Lego building block ambient light sensor. The sensor is

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based on T1 ADC081S021 analog-to-digital converter and Vishay Semiconductor’s TEMT6000X01. The sensor uses a protocol analyzer through which users can convert light into digital data with 8-bit resolution.

Pmod OLED module is a basic OLED module of Solomon Syestech SSD1306. The module can render 128 x 32 pixels in monochrome. Users can program through SPI communication, display various types of graphic design on the module, and send bitmap images. The module is an excellent Zybo Pmod component with up to 16 different brightness settings.

The Pmod STEP module can drive two motors (4-wire stepper motor or 6-wire stepper motor). It can provide a four channel driver for the stepper motor using ST l293DD. The module has GPIO interface. On this module, users can connect two pairs of channels in series and view the status of GPIO signals through a set of user LEDs.

The Pmod BT2 module is a peripheral module based on Roving Networks® RN-42. The module is powerful and has a fully integrated Bluetooth interface. At the same time, the module supports HID configuration file. Users can communicate with the module chip through UART. Because the module has 128 bit encryption, it can ensure the security of user communication.

The Pmod 8LED module consists of eight high brightness LED lights driven by logic transistors. Each LED can control the lighting through a logic high signal less than 1mA.

4. The Software Design

The system adopts MicroBlaze embedded soft core design. MicroBlaze is a RISC processor soft core that can be embedded in FPGA. It has the advantages of fast running speed, less resources, high flexibility and strong configurability[2]. Users can tailor MicroBlaze according to the design needs, and complete the design needs with the least resources. The hardware part adopts Bluetooth wireless communication mode to realize the integration of home system. Through this system, users can realize the global control of home equipment through a terminal.

The software design of the system mainly uses the advantages of FPGA technology, such as multiple ports, high flexibility and strong configurability. Then, combined with MicroBlaze embedded soft core, a series of processes of control center are realized in the process of software writing[3]. After the light sensor and temperature sensor send the digital data, the controller will analyze the collected digital data according to the designed program, so as to display the indoor temperature through the LED display. The execution process of the software can be simply described as: start → system initialization → environmental data (light and temperature) acquisition → data conversion and upload → environmental data acquisition → intelligent control / manual control (see Figure 2).

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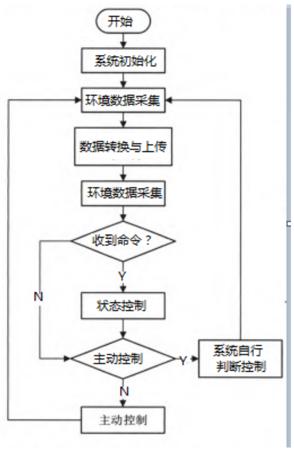

Fig.2 Software Execution Process

5. The Design Effect

In order to visually verify the design effect, this system is specially applied in a simulated house. It has been verified that the home furnishing in the simulated house has achieved the basic expected effect. In a simulated house, users can manually control or intelligently control home equipment through the system.Among them, manual control is that the user sends a Bluetooth signal through the mobile phone to control the smart home, such as curtain switch, light switch, and fan switch. Intelligent control means that the system automatically adjusts indoor lighting and temperature through light sensors and temperature sensors. Intelligent control requires the user to set the dimensional threshold of the temperature sensor of the light sensor in advance[4]. For example, the user sets the dimensional threshold of a light sensor to 50 brightness. When the brightness of the room is less than 50 brightness, the light will automatically turn on; when the brightness is above 50, the light will turn off automatically. For another example, the user sets the dimensionality threshold of the temperature sensor to 26°C. When the indoor temperature exceeds 26°C, the air conditioner will automatically start; when it falls below 26, the air conditioner will automatically turn off.

6. Conclusion

FPGA can be highly flexible and configurable, and users can make real-time changes to the programming language according to different design requirements, thus effectively saving costs in the system development process. The design of this system is based on FPGA, and the design of the core part of smart home system is completed by FPGA technology. The system uses light sensors and temperature sensors as the main environment collection devices, and users can basically realize

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environment collection and control through Bluetooth wireless devices. However, due to the limitation of the transmission distance of Bluetooth wireless devices, the future improvement direction of this system is to change the Bluetooth communication to network communication, so as to realize the effect of users' remote viewing and control of home devices.

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