

Smart Home Electricity Management and Control Based on Power-line Carrier Communication

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Abstract. This paper designs smart home electricity management system based on power line carrier communication. Firstly, the paper makes the ARM Cortex-M3 as a central controller and ports the uC/OS-II operating system on the ARM, then designs Web Serve program to mornitor and control equipment remotely using the power line carrier module. Finally, this paper designs the related software to complete a smart home system.

Introduction

Power Line Communication (PLC) is a communication protocol that uses electrical wiring to simultaneously carry both data, and Alternating Current (AC) electric power transmission or electric power distribution^[1]. It can be a means of extending an existing network into new places without adding new wires. In terms of the control and monitoring to home appliances, each conductive socket is a network access point, which has a large number and is so convenient that can be connected to the website without dialing, as long as the socket is energized.

Smart Home Management System Overall Structure

Smart home system generally consists of two parts: a central controller and function modules. Smart home center controller as central brain of the system controls all functional modules such as temperature, light control, doors, windows and water meters. At the same time the functional modules will bring some information back to the central controller, so that people stay on top of the situation. In order to configure the intelligent home easier and experience a better effect for users, we add the interactive interface and Web Server to the central controller. So users can access the central controller easily through a remote PC to keep abreast of the various home appliances. The central controller is an embedded system, so choosing the right embedded system is important. The overall block diagram is shown as Fig.1.

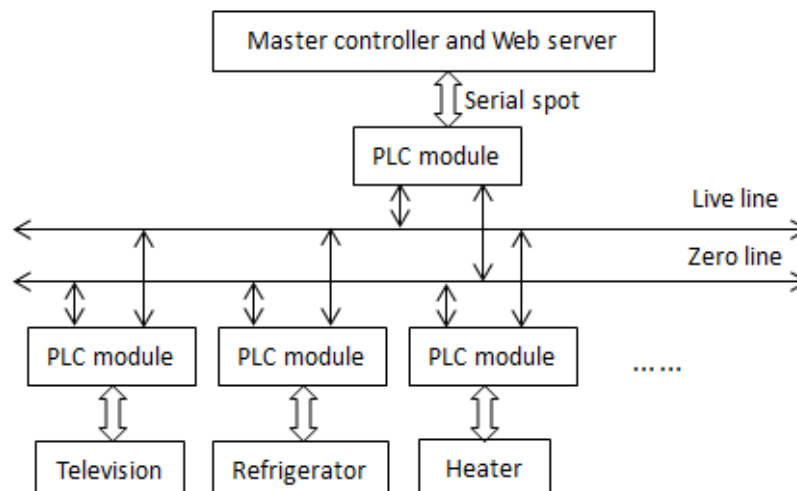


Fig.1 Smart Home System Overall Block Diagram

The core hardware of central controller is a microcontroller core based on second-generation ARM Cortex-M3^[2], and the software includes system software and application software two parts. The system software is uC/OS-II operating system^[3] and the application software is a Web application providing remote access. The application software can easily provide users some electrical household operation.

The core hardware of function module core hardware is a PLC modem and advanced PLC analog front end AFE031. The module is a power line carrier module, which makes the mounting system more convenient and saves the installation costs. The function module realizes the communication between the central controller and the execution module. And the function module is connected with the execution module distributed in every corner of the family. The central controller is connected with function module through serial spot. The central controller sends data to the functional module (PLC module) through the serial port firstly, and another functional modules (PLC module) receives the data to the execution module.

The Design of System Hardware

Processor

Taking a variety of factors into account, we select the reduced instruction set architecture of the ARM microprocessor. As the embedded systems are increasingly being used, we select the uC / OS-II embedded system, which is a preemptive real-time multitasking operating system kernel.

Power line carrier module

The advantage of power line carrier communication technology is no need to re-wiring and home appliances can plug and play at any time. With the development in recent years, PLC has been greatly improved in the jamming, anti-signal attenuation and other aspects. Power line carrier module used here is based on narrow band carrier communication technology. Here we select KQ-330 power line carrier made by Sichuan Keqiang Company^[4]. The Power Line Carrier (PLC) modules can use the power line as a transmission medium to transmit data flexibly and efficiently.

The communication module is a key part of smart home system, therefore the normal communication between the power module carrier (PLC) determines success.

Single chip microcomputer(SCM)

We use LED lights to simulate the switch control of variety of electrical equipment. The central controller issues the lights on or off command firstly, then the command is transmitted through PLC module to microcomputer, which operate the I / O port to control LED lights switch after receiving the command. We choose the 16F877A SCM made by Microchip Company. The device has a high speed, low driving voltage, low power consumption, a large drive capability and low price. The microcontroller can directly drive LED lights through I / O port.

The Power line carrier module connection diagram is shown as Fig.2.

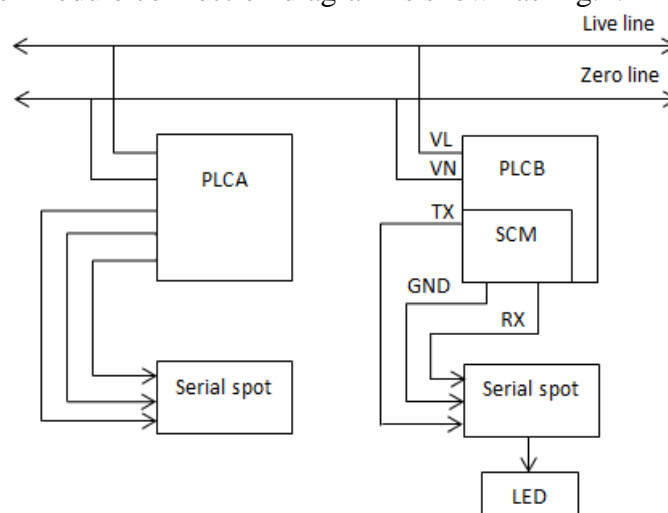


Fig.2 Power line carrier module connection diagram

The Design of System Hardware

In the program design of the lights simulation control module, we use Mplab to compile the software. The program flow^[5] is to initialize the registers related the serial ports firstly, and then initialize the used I/O port, at this time wait for the commands from the host computer, parse the received command and finally execute the command. For example, the host computer sends the eight-octet command frame, then reserves the received data to an array $a[7]$, only when the values in $a[0]$ to $a[3]$ equal the set values, then determine whether $a[6]$ is equal to 'ff', if is, the executive light is on, otherwise the executive light is off. The flow chart is shown as Fig.3.

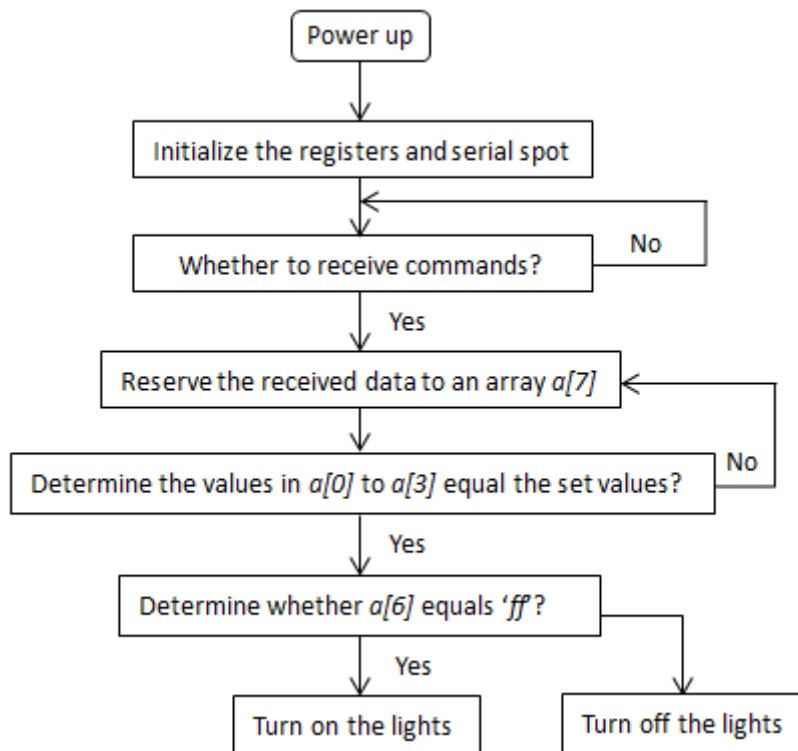


Fig.3 The flow chart of program design

The core hardware of central controller is a development board that provides a serial port to connect to PLC module. The development board also provides a network port so that we can use the cable to connect to the Internet. LED lights on the development board can be developed as signal lights to display the running operating system. The realization of the controller network portion is to design an embedded WEB server, whose entire network structure is a typical B/S structure.

Embedded Web Server

Web Server process is the realization of HTTP communication. Web Server works that specified data is stored in the SCM web page, the server parses the request message when the client accesses the specified address through the browser, and returns the specified page's HTML code to the corresponding browser^[6].

We use ordinary PC as the client and connect PC with the development board to a LAN. Meanwhile we set up the IP address, gateway and MAC address to response. Open IE, enter the IP address in the address bar and press Enter to display the login page just as Fig.4. Then enter the correct passcode to display the control interface shown as Fig.5. Here we use light-emitting diodes of the development board to simulate the electrical switches. At this time we can complete the switching operation by clicking on the appropriate button.

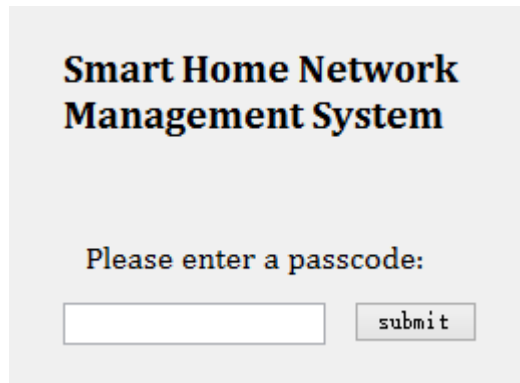


Fig.4 Login Interface

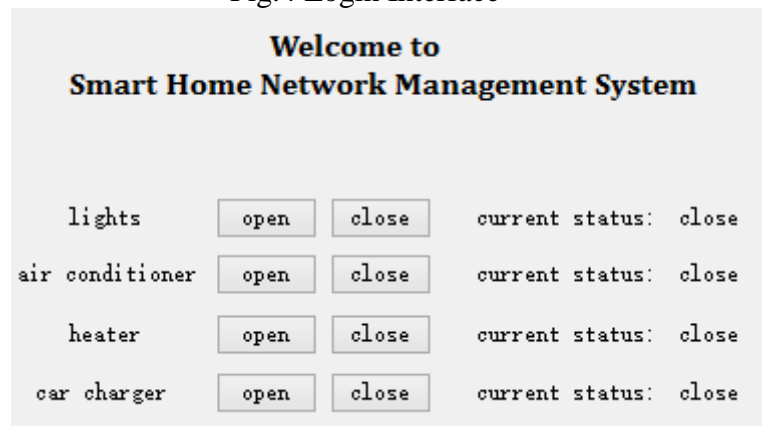


Fig.5 Control Interface

Summary

This paper proposes smart home management system overall structure based on the design principles of smart home. Then, in the design of the central controller, the paper selects the uC/OS-II system and briefly explains the system. In the design of network architecture, power line carrier communication(PLC) has enough superiority. In terms of smart home system implementation, the paper gives detailed description of the communication module, execution nodes and the design on Web Serve. Finally, the whole system was tested successfully and the paper verifies the effectiveness of the design of the system.

References

- [1] https://en.wikipedia.org/wiki/Power-line_communication
- [2] Joseph Yiu. The Definitive Guide to the ARM Cortex-M3. Beijing University of Aeronautics and Astronautics Press, 2007
- [3] Zongde Yang, Bing Zhang. uC-OS-II Combustion. People Post Press, 2009
- [4] Zhou Yuan. The Design of Streetlight Monitoring System Based on Power Line Carrier Communication[D]. Chengdu: University of Electronic Science and Technology of China, 2014
- [5] Qingbo Hou. Smart Home System Design and Implementation Based on OFDM Power Line Communication[D]. Kunming: Yunnan University, 2013
- [6] Chenglei Liu. Design and Implementation of Network Smart Home Controller Based on WEB, Shandong Argriculture University, 2009