Design and Implementation of Control Unit for Medium and Short Wave Broadcast Exciter Based on STM32

To cite this article: Xi Liu and Qibin Lu 2019 J. Phys.: Conf. Ser. 1213 052066

View the article online for updates and enhancements.
Design and Implementation of Control Unit for Medium and Short Wave Broadcast Exciter Based on STM32

Xi Liu¹ and Qibin Lu²

¹Engineering Research Center of Digital Audio &Video Ministry of Education,
100024 Communication University of China Beijing, China
²Engineering Research Center of Digital Audio &Video Ministry of Education,
100024 Communication University of China Beijing, China

Abstract. This paper designs a control unit of medium and short wave broadcast exciter based on STM32F107 microcontroller and Ethernet PHY device DP83848. It mainly designs and analyses the modules of human-computer interaction and Ethernet communication. The hardware and software design of the control unit is described in detail, and the remote control function is realized by building Web server with LWIP. The test results show that the programme has reliable performance, easy to use, low in cost, and has a good application prospect.

1. Introduction
With the rapid development of economy and information technology, especially the emergence of embedded system technology and mobile intelligent terminals, as well as people's higher requirements for efficiency and security. The research and application of intelligent control system based on embedded technology have become the mainstream trend of development.

The control unit of broadcast exciter acts as the monitoring device of the exciter. The design is based on the Cortex-M3 core STM32F107VCT6 as the processor, the DP83848 is selected as the transceiver device of physical layer Ethernet interface, and the LWIP is used as the communication protocol. The system realizes real-time monitoring and remote control of the operating state of exciter by embedding a Web server in the program.

2. The overall design
The functions of the control unit mainly include four modules, namely: human-computer interaction module, Ethernet communication module, peripheral interface module and the configuration module of the RF exciter unit. The overall functional block diagram is shown in Figure 1:
The human-computer interaction module is composed of Keys and an LCD screen, the user can set and control the exciter through operation of input devices such as Keys, and display the status by LCD; The Ethernet communication module is based on the design of the embedded Web server, the user can remotely access the server through client browser and Ethernet, the real-time display of data is completed on the Web page, and the remote control function is realized by sending control commands; The peripheral interface module mainly realizes the reading and writing of E2PROM and the detection of each semaphore, the semaphore detection includes temperature detection of chassis, RF power detection and fault detection; The control unit communicates with the RF exciter unit via SPI or I2C to set the working parameters and modes of the device.

This design adopts the principle of modular design, the realization of Ethernet communication module is the focus of this paper, and the human-computer interaction module mainly studies the working mode of equipment and realizes the configuration of various parameters.

3. The design of system hardware

The hardware block diagram of the system is shown in Figure 2:

![Figure 2. Block diagram of hardware](image)

3.1. Controller module

As the core device of the control unit, the performance of the microcontroller directly affects the operation of the control system. This design selects the new interconnected series microcontroller STM32F107VCT6 from STMicroelectronics as the main control chip, the on-chip resources are shown in Table 1. The chip uses Cortex-M3 core of ARM advanced architecture, it is a 32-bit processor with powerful functions, fast processing speed and rich on-chip peripherals. It has high performance and low power consumption, and meets the current functional requirements.
Table 1. STM32F107 on-chip resources

| CPU     | FLASH | SRAM | USB | Ethernet | I/O |
|---------|-------|------|-----|----------|-----|
| 72MHz   | 256K  | 64K  | 1   | 10/100M  | 80  |

3.2. Ethernet interface module

The STM32F107VCT6 has a built-in 10/100MB Ethernet MAC controller, which can realize the network communication function only by adding a PHY device. This system selects DP83848 as the Ethernet interface transceiver chip of the physical layer, and uses RJ45 head with network transformer (HR911105A) to form a 10/100MB adaptive network card. The DP83848 supports two interfaces of the IEEE 802.3 standard protocol: the Media Independent Interface (MII) and Reduced Media Independent interface (RMII), the support of MII is flexible, but its port uses more signals and the hardware design is complex; Using RMII interface to communicate with STM32 can reduce the complexity of hardware design for multi-port devices. The network interface module of DP83848 is shown in Figure 3:

![Network interface module of DP83848](image)

3.3. Human-computer interaction interface

The human-computer interaction interface is composed of 6 Keys and a LM16032 liquid crystal module, and it can be used to connect LCD screen and independent keyboard by reserving interface on the control board to realize human-computer interaction.

4. The design of system software

4.1. Realization of Human-Computer Interaction

After the system is powered on and initialized, enter the display interface of main menu and there are eight sub-menus in it, the user controls the upper application program by clicking on the independent keyboard attached to the control board to modify the parameters of device and display it on the LCD. The menu display block diagram of control panel is shown in Figure 4:
4.2. Implementation of Ethernet Communication

The implementation of Ethernet communication mainly includes two parts: the migration of LWIP and the implementation of the Web server.

4.2.1. Migration of LWIP

LWIP (Light Weight IP) is a lightweight IP protocol that is an implementation of TCP/IP. Its biggest advantage is that it can be ported to a multi-tasking operating system, or it can run independently without the support of the operating system, and the code size is small, maintaining the basic functions of Ethernet, and reducing the occupation of storage resources through optimization. This design is based on the implementation of no operating system, the internal functions of the protocol stack are directly called without an operating system, these functions are called RAW functions, although it is difficult to develop, it is more efficiency.

The migration process of LWIP includes the following steps: the programming of driver for the network card, the management of LWIP data package and network interface, the addition of LWIP source files and intermediate files, and the modification and configuration of LWIP source code. The initialization function of LWIP is LWIP_Init(), the initialization of network structure list, memory pool and pbuf structure are completed by calling this function. Then, the initialization of the interface between DP83848 and LWIP is completed by calling netif_add(). In addition, complete the configuration of IP address, netmask, gateway, information pointer of network card, initialization function and input function.

4.2.2. Implementation of Web Server

The system adopts the B/S mode. By embedding the Web server in the STM32, the client browser accesses the Web server by inputting the corresponding IP address, and the browser accesses the Web server using the GET method by default. When the server starts to listen for the connection, the server receives the access request from the browser, and the TCP/IP protocol stack processes the request information and sends it to the HTTP task module. Selecting the corresponding array file of Web page to respond after the CGI program processing the data in the HTTP task. The content of the Web page array is a Web page file written in HTML. Finally, the Web page array is sent to the browser through TCP/IP protocol. The working principle of the Web server is shown in Figure 5:
Use Dreamweaver to write the Web page before software design, currently written Web pages include display and control interfaces, makefsdata tool is used to convert the original Web page file into the Web page array fsdata.c in C language format, and the converted array file is added to the project.

In the design of this module, real-time monitoring of data and remote control need to be realized at the same time, and sending control commands through the browser requires the use of CGI technology. CGI is the interface standard between external applications and Web servers, it is a program that runs on the server and provides the interface with the client HTML page to make the Web page interactive. SSI technology is required to view received data through a Web page. SSI is a server-based technology of Web page making similar to ASP. SSI instructions can be used to include text, graphics, or application information into a Web page before sending content to the browser, the Web page is refreshed every 1s and the data is embedded into the Web page by SSI technology, which can realize real-time monitoring of data.

4.2.3. Implementation of system program

The flow chart of Ethernet communication program is shown in Figure 6.

Firstly, initialize the system, turn on the relevant system clock, configure Ethernet, GPIO, interrupts and related peripherals; The initialization of LWIP, complete the initialization of memory, network interface, IP address and physical address; The initialization of HTTP server, mainly to complete the processing of Web data, Web data processing includes CGI program processing and SSI program processing, the display and control functions of Web pages are realized by calling different programs; Finally, a while loop is used to poll whether the LWIP has received data or is there any data to send.
5. Circuit physical and test results

The physical circuit diagram of the control unit is shown in Figure 7, and Figure 8 is a display interface of human-computer interaction, the configuration and display of the working mode and parameters of the equipment can be realized by testing; Figure 9 is a Web page control interface for Ethernet communication, the remote control function can be realized by sending commands through the “Config” button. At the same time, the Web page display interface is refreshed every 1 s to realize real-time display of data.

6. Conclusion

The control unit of broadcast exciter designed in this paper adopts the current mainstream electronic devices and technologies, which can realize human-computer interaction and Ethernet communication functions and perform remote monitoring and control, it provides a feasible scheme for intelligent control, especially for the control of broadcast exciters. Because it is based on the display control of the Web page, it reduces the difficulty of system development. Compared with the traditional network monitoring system, the system has flexible control mode, high stability and low cost, which is in line with the trend of the development of the Internet of Things. It has high application value and broad market prospects.
Acknowledgment
This work is support by National Key Technology Research and Development Program of the Ministry of Science and Technology of China (2015BAK05B01).

References
[1] K. Shi, Z. Wang, F. Luo and C. Gu, "Design and realization of general matrix keyboard based on STM32," The 2014 2nd International Conference on Systems and Informatics (ICSAI 2014), Shanghai, 2014, pp. 447-453. doi: 10.1109/ICSAI.2014.7009330
[2] J. Shang and H. Ding, "Application of lightweight protocol stack LwIP on embedded Ethernet," 2011 International Conference on Electrical and Control Engineering, Yichang, 2011, pp. 3373-3376. doi: 10.1109/ICECENG.2011.6057234
[3] A. Hanafi and M. Karim, "Embedded Web server for real-time remote control and monitoring of an FPGA-based on-board computer system," 2015 Intelligent Systems and Computer Vision (ISCV), Fez, 2015, pp. 1-6. doi: 10.1109/ISACV.2015.7106185
[4] Chunlong Zhang, Min Zhang, Yongsheng Su and Weilian Wang, "Smart home design based on ZigBee wireless sensor network," 7th International Conference on Communications and Networking in China, Kun Ming, 2012, pp. 463-466.
[5] Q. Li, H. Fang, P. Zhang and J. Chi, "The ARM based hardware system of infrared multi-touch screen design and research," 2012 24th Chinese Control and Decision Conference (CCDC), Taiyuan, 2012, pp. 1477-1481.
[6] S. Mohanty, Bikash Narayan Panda and Bhawani Shankar Pattnaik, "Implementation of a Web of Things based Smart Grid to remotely monitor and control Renewable Energy Sources," 2014 IEEE Students' Conference on Electrical, Electronics and Computer Science, Bhopal, 2014, pp. 1-5.
[7] W. Chen, S. Qiu and Y. Zhang, "The Porting and Implementation of Light-Weight TCP/IP for Embedded Web Server," 2008 4th International Conference on Wireless Communications, Networking and Mobile Computing, Dalian, 2008, pp. 1-4.
[8] D. Adam, Design and Implementation of the LWIP TCP/IP Stack [EB/OL]. [2001-02-20].