PROJECT-BASED COURSE IN ELECTRONIC ENGINEERING EDUCATION

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ABSTRACT

In the teaching of electronic engineering, some practical projects need to be added in order to connect various courses together. To strengthen the connections between courses, the project-based teaching method proposed in this paper advocates linking the knowledge of different courses through the combination of theory and practice. With this as a guide, projects have been set up for students. One of them is about designing and making a managed ethernet switch. In the process of making and completing this project, the students' ability has been significantly improved, which fully proves the benefits of the teaching method.

Keywords—Course-related projects, Practical ability, Engineering education, Teaching method

1. INTRODUCTION

With the continuous development of electronic technology, the company needs innovative graduates with a high level of technology and practical experience. The key is whether the college can play a correct and positive role. This article attempts to enhance students' ability by encouraging students to actively participate in projects. This can help students understand the relationship between the various disciplines and build up their learning confidence.

Many students have doubts now: What is the connection between the courses? Although there are many courses for students that will not be used all the time, learning them can teach students to stand in a higher position to think about problems and help them improve their learning ability. The reasons for such doubts including outdated teaching methods and the inappropriate assessment mechanism. For example, some of the documents and PPT were written more than a decade ago, which has not been revised in time, resulting in a disconnection between the content of the documents and the actual situation. Besides, the students' practical ability is generally insufficient. This is a bad trend, students are not sure how to use what they have learned. Some students do not even know the commonly used instruments or how to use them, which is very unfavorable for students to participate in research. Therefore, we must update the methods of teaching [1][2][3].

A project-based course has been designed to achieve these goals. We provide students with a list of projects from which they can choose to complete. These projects involve a wide range of knowledges and closely related to many other courses. After the students participate in the project, the boring knowledge of many courses in the textbook can be integrated through practice. Such practical projects will play an important role in the teaching of students in universities [5][6].

2. TEACHING THEORETICAL KNOWLEDGE BEROFE PROJECT

Before starting this course, students should have studied C language, Circuits and Electronics, Principle and Application of MCU, PCB Design and Computer Network. These are the basics necessary to participate in these programs. This practical project-based course is mainly for senior students who should have already taken these courses. If students have a good understanding of these courses, they will be more successful in completing the project.

Circuits and Electronics is the most basic course of electric engineering. This course provides students with an understanding of analog and digital circuits, as well as common circuit analysis methods, so that they can prepare for the next part of the project involving hardware design. Since most microcontrollers support C development, the C language is used in most practical projects related to electronic engineering. To improve the effectiveness of teaching theoretical knowledge, we must first ensure the quality of teaching [8][9]. The primary source of knowledge for students is classroom teaching. To explaining theoretical knowledge, software simulation and physical demonstration should be added to make the course content easier to understand. In these processes, we should enhance the interaction with students.

3. TEACHING BASED ON PROJECT

In addition to the contents in classroom, we should also pay attention to the students' practical ability. Otherwise,

it is easy to cause students to be confused and create an illusion that the course is understood through a test paper. Based on a wealth of practical experience, students will find problems and solve problems with more confidence. Setting up some projects related to the course and encouraging students to make some improvements on this basis is one of the methods. The project should be designed in the basis of their average knowledge level so that most students can find their point of interest. We also need to pay attention to the link between project and real life. When students understand the principles of electronic devices common in daily life, they will be confident about other projects they may encounter in the future.

One of our projects is "Smart Layer-2 Managed Gigabit Switch". Ethernet switch is a common network device in daily life. In our project goals, in addition to achieving its basic switching functions, some new features should be added by students. This will get students interested in this project, and also encourage students to invest more time. The purpose of setting up the project is to develop students' practical and innovative abilities so that students can make use of the knowledge they have learned. One group of our students did a good job on this project, which is presented below as an example.

3.1. Project Description

As the speed of home broadband networks has been continually improved, people have put forward more demands on the delay, speed and function of network devices. Upgrading old switches to gigabit can greatly improve the user experience of wired networks. Adding management functions such as Virtual Local Area Network (VLAN), Quality of Service (QoS), etc., which can be configured through the web pages, can make the local area network more flexible and efficient. The switch can also connect to the Internet of Things, to achieve timing, event triggering, and other functions [10].

When students choose this project, the teacher should completes the explanation of the basic concepts, the group assignment, the task arrangement and deadlines. Then, give them some reference documents. The contents of references are decided by the hours students have. Then the students will complete the design in groups. A group usually consists of three people, two writing the code and debugging, one designing the hardware (usually, but not always). Since there are different projects to choose from, students may not have a deep understanding of the project, it is necessary for us to teach students the knowledges involved in the selected project. We make short videos for each point about the project in advance, provide some sample code, and answer questions online at specific times. Each project corresponds to a number of videos that students can choose to watch that they are not familiar with. By programming, debugging, testing, the understanding of related courses can be deepened.

3.2. Hardware Design

The hardware of the switch is mainly composed of the microcontroller, the switch chip, and the DC-DC power supply. The board that is built and welded completed by one of our group of students is shown in Figure 1. The microcontroller controls the switch chip and provides web services for configuration. The system requires a microcontroller with powerful networking abilities. Development platforms such as ESP8266, Arduino, Raspberry Pi and STM32 have been compared. The ESP8266-based development board NodeMCU has been chosen finally as the main controller of the switch. ESP8266 is a Wi-Fi SoC that supports 802.11n Wi-Fi. It connects to external Wi-Fi in STA mode and serving web pages for switch configuration [11][12][13]. It is connected to the switch chip through the Serial Management Interface (SMI).

The Realtek's RTL8367RB, which supports some Layer 2 management functions with low power consumption, has been selected as the switch controller. It can be controlled via the SMI interface and it is easy to get the driver on the internet. The chip requires only a 2-layer PCB to complete the layout. This chip is packaged in an LQFP128 package and is suitable for manual soldering to improve students' skills. The board requires a total of 3.3V and 1.0V power supply, students need to make two sets of the DC-DC converter. It is necessary to have enough redundancy for the DC-DC converter when designing the schematic and layout to prevent it from unstable [14][15]. The web-based EDA tool, EasyEDA is selected as the PCB design environment.

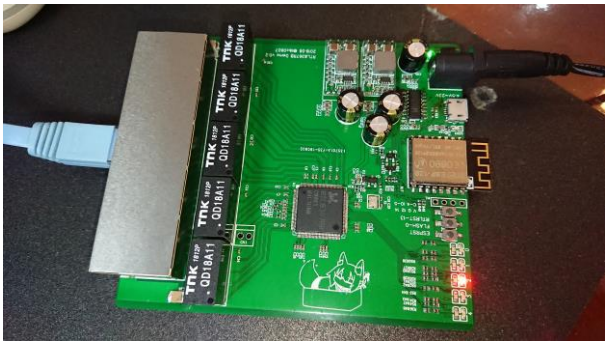

Figure 1 The working ethernet switch

Students should read the documents of the chip and external devices to design appropriate peripheral circuits. Besides, students are encouraged to search for other similar hardware designs for reference. Common switch chips usually need some peripheral circuits, such as power decoupling circuit, oscillating circuit, reset circuit. Students need to understand the functions and principles of these circuits to make them work properly. For example, they need to learn how to choose the value of the resistor and capacitor, how to design the DC-DC

converter circuit, so that they can deeply understand the concepts such as the RC time constant, the Equivalent Series Resistance (ESR) of a capacitor, the peak current of inductor, etc. The peripheral circuit of ESP8266 involves an RF circuit, which could be difficult for some students. So, they can use the NodeMCU board or can use a module like ESP-12 and build their own circuit by referring the demo board. The board in Figure 1 uses a CH340 chip for debugging. The hardware block diagram of the board is shown in Figure 2.

For PCB boards with many components, the layout should be considered first. Good layout can reduce wiring difficulty, get less interference between components and wires. Students can also add different interfaces when designing the hardware. The following pictures show the designing and manufacturing process of a board. The PCB layout is shown in Figure 3. The PCB with some components soldered as shown in Figure 4.

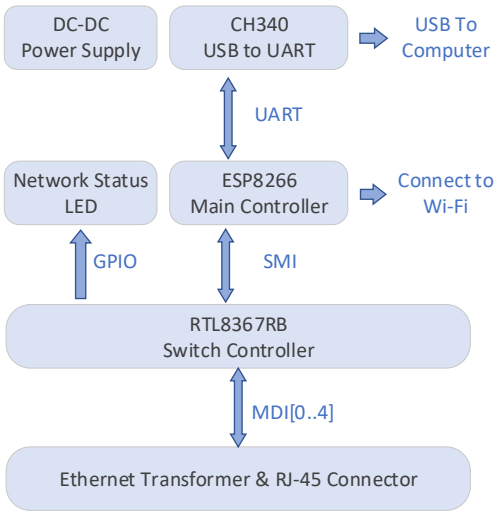

Figure 2 Hardware block diagram

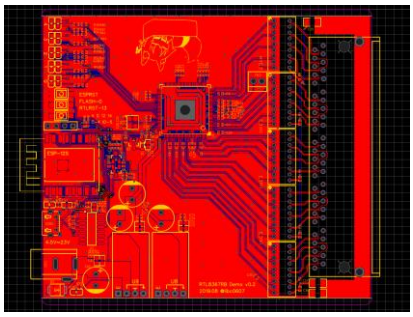

Figure 3 The PCB layout of the switch

Figure 4 The PCB with some SMT components soldered

3.3. Software Design

The ESP8266 can be programmed in C language. The software architecture block diagram is shown in Figure 5. First, the driver of the switch must be ported. For the RTL8367RB chip selected here, it's easy to find its driver's source code in many open source projects. When porting the driver of the chip, only the read and write functions of the SMI bus are necessary to be re-implemented. These functions should be simulated by using ESP8266's GPIO, after reading the timing diagram of the SMI.

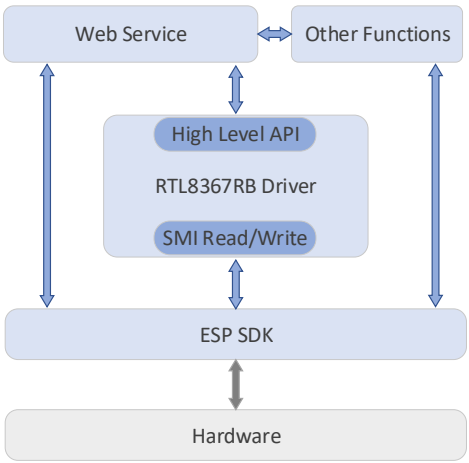

Figure 5 Software block diagram

Since the function of the switch chip is closely related to the network, students should have a certain understanding of the computer network. For example, when the IEEE 802.1Q-based VLAN function is enabled, the switch uses a VLAN tag to associate received packets. We recommend using Linux for testing. Common Linux distributions have powerful network functions and rich network tools, requiring students to have a certain understanding of Linux and its network configuration. For example, a virtual network interface should be established when testing the VLAN function. Also, Wireshark or tcpdump can be used to capture the ethernet frame to see the effect.

Students should learn HTML, CSS and JavaScript to create a simple configuration webpage. For the students not familiar with web development, the teacher can give them demo code with some key functions replaced by

comments. A screenshot of a demo webpage made by our students is shown in Figure 6. When the page is opened by the user, the page makes a request to the backend using the jQuery library. Then the backend calls APIs in the switch chip's driver, the web frontend gets the data and displays it in the right position. students should write the test code, complete modules' testing, then test the function of the entire project. Students who are willing to learn can add features such as making a PC or Android app, using IFTTT to automate a process and so on.

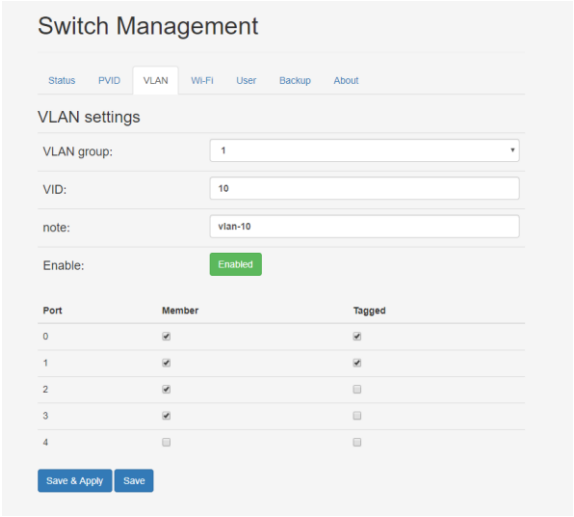

Figure 6 The web configuration page (screenshot)

3.4. Assessment Methods

The assessment of the project should be carried out in multiple directions. Team members need to make PPT and report the completion and process of the project. Each person needs to elaborate on what he or she is involved in, and give an overview of the work of others. This kind of project involves a wide range of knowledge, and we want students to do their part while also knowing what others in the group are doing. Then, the teacher will ask questions including the theoretical knowledge involved, possible problems encountered in the practice process and the situation in the teamwork process. In addition, about the additional goals set in each of the above sections, teachers should also encourage students to share their ideas, difficulties encountered and how they have tried to solve them even if they have failed. Finally, each student is required to submit a report on his or her work. The scoring is a combination of the above processes.

4. CONCLUSION

We selected a project in project-based engineering teaching as an example. This project draws inspiration from the network equipment that is essential in everyday life. It is designed to connect different courses better. After a semester of teaching experiments, by completing projects like this, students' ability to design a complex system has been greatly enhanced, and their interest in electronic engineering has been significantly improved. Most of them can basically complete the project of their choice. They have a deeper understanding of circuit design, PCB design, programming, computer network, web design, and many other aspects. It can also help students accumulate engineering experience and prepare them for the company after graduation. We will continue this course, make adjustments and improvements to this type of project based on feedback from students.

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