World Transactions on Engineering and Technology Education
Vol.11, No.2, 2013

Teaching reform of a *single-chip microcomputer* course based on a portable experimental device

Qianqian Yuan

Weifang University
Weifang City, People's Republic of China

ABSTRACT: The Principles and Applications of a Single-chip Microcomputer (SCM) is a course requiring much practice, but the traditional experimental teaching method is not effective in cultivating students' practical ability. To deal with this problem, experiment reform was analysed, and a portable experimental device was designed which included an Internet Service Provider (ISP) download line. The problems existing in the SCM experimental teaching are introduced first. Second, the whole structure of the system, including the hardware circuit, software and experimental projects are presented in detail. Finally, the application of the portable experimental device is presented. Practice has shown that the device is easy to use, easy to carry and can greatly increase the student's interest in SCM learning.

INTRODUCTION

In recent years, single-chip microcomputer (SCM) technology has been applied widely to many areas affecting people's lives. Computer control, real-time industrial automation and data processing, especially in the field of automatic control of robots are inseparable from SCM technology. The annual demand for microcontrollers is increasing and the single-chip practitioners have increasing difficulty in meeting demand.

Principles and Applications of a Single-chip Microcomputer is a course with a large practical component. The popularity of related education has occurred for many years at the University and, as a result, many engineering majors, such as automation, electronic technology, information engineering and machinery have it as one of their professional foundation courses. The teaching task is to enable students to grasp internal microcontroller principles and master the structure of microcontroller hardware, software and microcomputer applications.

As it is a practical course, it is only through the design of hardware circuits, the preparation of the software and by performing simulation debugging experiments, that the students can deepen their understanding of the theoretical underpinnings, as well as improve their operational ability and problem-solving skills.

But many students cannot develop an application after graduation and some students do not even know the process of single-chip product development. It is difficult to acquire the knowledge associated with actual work in school. Especially for local colleges and universities, practical skills should be developed and cultivated in students. Schools have made a great deal of effort to improve their teaching, but the results are often not as planned and expected.

PROBLEMS EXISTING IN THE SCM EXPERIMENTAL TEACHING

There are many reasons why the desirable learning outcomes do not eventuate, but the key problem here is that there is too much emphasis on theory, and a lack of development of students' practical and innovative abilities. In the laboratory, the SCM experimental device is integrated in a box and purchased from an instrument company. It has a variety of cell circuits on a large printed circuit board forming the complete device. It is simple, mature technology. However, it also has some limitations:

1. Instructions for the experiment are too detailed. Students can only do simple hardware connections and software programming according to the wiring diagram and reference program in the experiment's instructions.
2. Many short cables need to be connected, and so students spend a lot of time doing this and little time designing the experiment.

3. Content of the experiments is unreasonable. The classic experiments are far more detailed and time-consuming than the design of modern experiments. Students cannot design the experiments at will, so it is difficult to develop students' innovative ability. Thus, plagiarism often occurs.
4. Updating experiment equipment is expensive. The circuits are fixed, and so when adding new experiments, the experiment box must be completely changed.
5. The experimental devices are not sufficient. An SCM laboratory will cost a lot of money, and few schools can assign an experimental device to each student. In addition to the limitation of laboratory space and time, students usually have little opportunity to practice on their own time.
6. It is difficult to design comprehensive experiment projects during course design. The passive experiment teaching pattern that results limits the creativeness of students, reducing their engineering design and experimental abilities.

DESIGN PRINCIPLES OF THE EXPERIMENTAL DEVICE

For the above reasons, it is necessary to develop for the course a microcontroller experimental device with broad suitability, high reliability, portability and flexibility. The purpose of this design is to facilitate the development of students' ability to develop comprehensive applications; to make students familiar with the microcontroller product development process; to assist students to develop the professional knowledge behind simple product design; and finally to stimulate students' interest in learning. In the course, it is necessary to take full account of students' cognitive processes, and that they are active in constructing knowledge and meaning. Therefore, the experimental device design must comply with the following principles:

1. Authenticity of the source experiment projects. Projects are relatively complete and independent, thus, almost all of the products can serve as a project. Therefore, the project must relate to real production activities; directly relate to reality; and have practical application.
2. Design comprehensive projects. The teaching should combine theoretical knowledge with practical skills. Thus, students can not only learn new knowledge and review old knowledge, but also make comprehensive use of the knowledge acquired.
3. Experimental device should be portable. Only if the experimental device is cheap and easy to use, will it be able to satisfy the surge in the number of students wishing to use it. A device per student can allow students to carry out experiments in the laboratory or outside at any time. This will alleviate the conflict for the laboratory time and improve the utilisation of that time and, hence, stimulate the enthusiasm and interest of students.
4. Experimental device should have flexibility. The experimental device is designed with a modular structure; the components are independent; all the signals may be stored on the students' own laptops, which provides an effective way to enhance the practical ability of students. At the same time, the experimental project can have multiple connection options, with a variety of connected students forming a community encouraging *left-brain* thinking. This is conducive to the development of students' personality and innovative ability. As well, the functions of the test device can be combined flexibly to meet the needs of students at different levels and with different interests.
5. Focus on students' innovative ability. The device has been designed to realise the combination of practical innovation and practical and creative skills, and to provide a broad experimental space in which to enhance ability and practical scientific training.
6. Autonomy of experiment content. The content of the student practice manual is organised in accordance with the progression from easy to difficult experimental knowledge points. But it differs from the experimental guide books in that there are no detailed experimental procedures and connections. It has only experimental project-related tasks and experimental requirements, accompanied by the corresponding hardware pin diagram. This method can correctly guide students by providing familiarity with the content at the start and, then, gradually developing their proficiency by direct hands-on practice.

STRUCTURE OF THE PORTABLE EXPERIMENTAL DEVICE

The SCM experiment system has a flexible composition with a wealth of experiment circuits. It contains the basic system of an 8051 series microprocessor, serial A/D converter, RS232/485 interfaces, LED display, keyboard control, power driver, isolation circuit, port expansion and other functional modules. It can meet the requirements of experimental teaching, curriculum design and graduate design. The block diagram is shown in Figure 1.

The test board includes a complete control system for all the basic functions, such as inputting, outputting, communication and controlling. The experiment board has an on-line programming capability. Users can master the programming techniques more quickly and download the hex file through the ISP cable. When the system is powered on, the serial port setting is accessed first. Then, it is possible to compile a program in the C51 programming language and conduct simulations. In addition, the experimental device board also can run off-line.

The hardware allows the user to design many experiments. In project design, all knowledge points should be considered carefully and integrated to enable students to design a series of typical and operational projects. This will guide students in exploring knowledge and its application, in developing their creative thinking, as well as their co-operative learning ability and, in general, comprehensively improving their abilities. The projects available according to the experiment board are shown in Table 1 below.

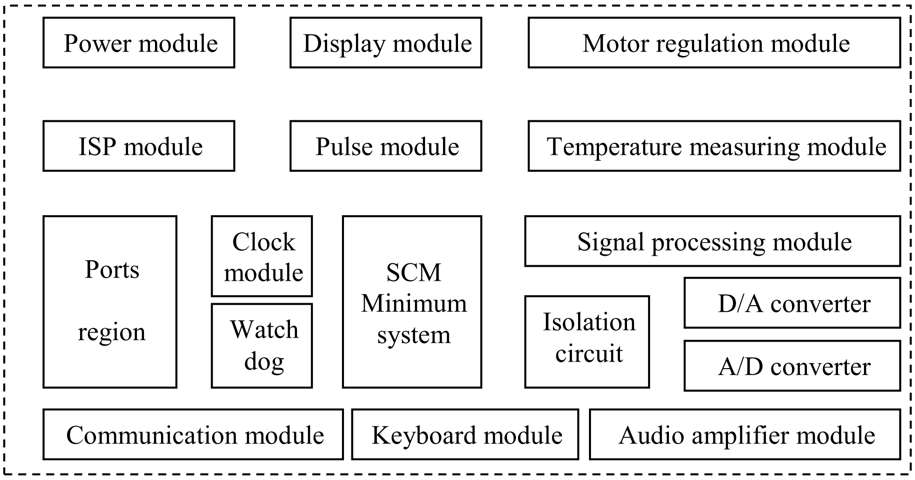

Figure 1: Overall structure of the experimental device board.

Table 1: The experimental projects.

Index	Project
1	Smallest system of SCM
2	One LED lighting
3	Water lamp
4	Keyboard control
5	LED static display
6	LED dynamic display
7	Digital clock
8	Simple music player
9	Temperature measurement
10	Serial communication
11	Motor control
12	Analog/Digital data acquisition

The temperature measurement project may be considered as an example. The overall structure of the thermometer is shown in Figure 2. It is composed of six parts: microprocessor, power module, temperature acquisition, LCD display module, keyboard module and alarms module.

The relationship between modules and the processing: the microcontroller is the core of the whole system, co-ordinating the work of the various parts. When the system is *powered on*, the microcontroller starts the temperature acquisition circuit to complete a conversion; then, reads out the converted digital quantity and shows it on the temperature display module. Meanwhile, the current temperature will be compared with the setting value to allow temperature control. If the current value is approaching the threshold, it will send an alarm.

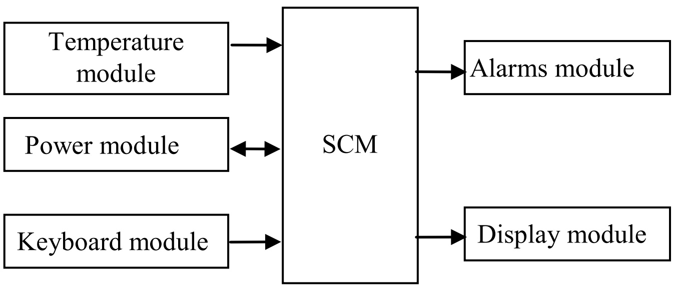

Figure 2: Whole structure of thermometer.

In order to facilitate debugging and improve reliability, the software of the thermometer has a modular design. It is prepared using the C51 programming language, which is composed of subroutines such as an initialisation program, alarms program, data processing program, display program and time delay program. The main program is the core of the software and the flowchart is shown in Figure 3.

The main functions include:

1. Initialisation of the system;
2. Temperature acquisition;
3. External interrupt response;
4. Display;
5. Alarms.

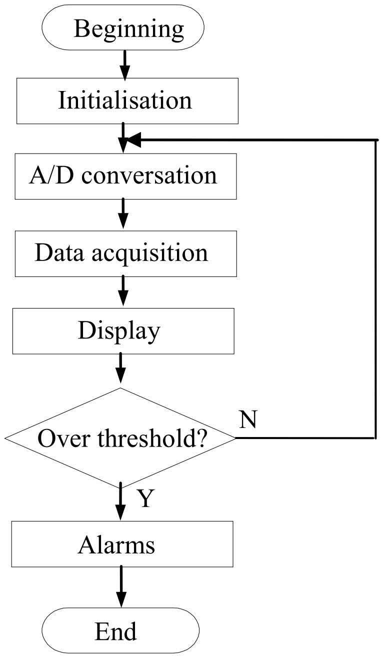

Figure 3: The flowchart of main program.

From this example, it can be seen that the experiment content of the SCM course includes three parts:

1. Hardware and programming of the 51 series chip;
2. On-chip functions and extension of the 51series chip;
3. Design of the peripheral interface and application system.

The hardware structure and instructions are the basis of the theory of the whole course. The on-chip functions, extension, peripheral interface and application system design of the 51 series machine are the basis for the applications that are developed. Through the experimental projects, students can enhance their practical abilities.

CONCLUSIONS

After the successful development of the experimental device, it was applied to the practical teaching of SCM. In the teaching of the *Single-chip Microcomputer* course, the use of the portable experimental device inspired the students' enthusiasm for learning, strengthened their ability in its practical application and conveyed the knowledge needed to resolve difficult cases.

The portable experimental device is simple and cheap, it is equipped with an ISP line, and can replace the expensive programmer and simulator. With the requirements of modern science and technology, it presents an effective way to develop students' practical ability, professional literacy and other key capabilities. Only in this way can talented persons be better trained for society.

REFERENCES

1. Huang, C.S., Design of wireless temperature measurement system based on DS18B20 and MSP430. *J of Hubei University of Technology*, 25, **1**, 69-71(2010).
2. Peng, Y.F. and Zhao, Y.X., High precision temperature acquiring system. *Instrument Technique and Sensor*, **5**, 45-46 (2007).

3. Ling, L., A design of the MCU experiment system based on independent modules. *J. of Southwest University for Nationality*, 36, **3**, 496-500 (2010).
4. Yang, F., Li, G., Zao, D. and Peng, H., Innovation and practice of the course design of sensor theory and application. *J. of Wuhan Institute Technology University*, 29, **5**, 88-90 (2007).
5. Agouridas, V. and Race, P., Enhancing knowledge management in design education through systematic reflection practice. *Concurrent Engng. Research and Applications*, 15, **1**, 63-76 (2007).
6. Lo, W-S., Using an ontological engineering approach and e-learning on instruction of a practical project - a case study of vocational education. *World Transactions on Engng. and Technol. Educ.*, 8, **3**, 273-276 (2010).
7. Li, W., Liu, F. and Wang, L.P., Project teaching courses in the application of microcomputer. *J. of Baicheng Normal College*, 23, **6**, 98-100 (2009).
8. Zhang, X.T., The application of projective teaching method in MCU'S lesson. *Computer Knowledge and Technol.*, 30, **5**, 8481-8482 (2009).