Advances in Educational Technology and Psychology (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/aetp.2024.080605
ISSN 2371-9400 Vol. 8 Num. 6

Research on the Teaching Reform and Practice Path of Analog Electronic Technology Based on the Combination of New Technology Introductio n and Simulation

Haozhe Liu[a,*], Tao Wu[b]

University of Shanghai for Science and Technology, Yangpu District, Shanghai, 200082, China
[a]liuhaozhe@usst.edu.cn, [b]wutao21y@163.com
[*]Corresponding author

Keywords: Analog electronics, Pedagogical reform

Abstract: This paper discusses the teaching reform and practice path of analog electronic technology based on the combination of new technology introduction and simulation. With the development of science and technology, analog electronic technology is an important basic course of electronic engineering, communication engineering and other engineering majors, and its teaching content and methods need to be reformed to meet the needs of the new era. The course "Analog Electronic Technology" aims to train students to master the basic principles, analytical methods and practical skills of analog circuits. However, there are some problems in current teaching, such as disconnection between theory and practice, lagging teaching content, single teaching method and defect of experimental teaching. In order to solve these problems, this paper proposes reform measures such as introducing cutting-edge technologies (such as 5G communication, Internet of Things, wearable devices, embedded systems, etc.), integrated circuit technology and simulation experiments. Through simulation experiments, students can simulate the real electronic circuit behavior on the computer, deepen their understanding of the principles of electronic technology, and improve their practical ability and innovative thinking. This paper introduces in detail how to introduce Multisim simulation software into the course for simulation teaching of single-tube cofire amplifier circuit, including circuit design and construction, circuit system analysis, parameter adjustment and optimization, and writing of experiment report after class. These reform measures are aimed at improving students' practical ability and innovation ability to meet society's demand for high-quality talents.

1. Introduction

"Analog Electronic Technology" is a very important professional basic course in electronic engineering, communication engineering, computer science and technology and other engineering majors. Its content involves the analysis, design and application of analog circuits, which is a key bridge connecting theoretical learning and engineering practice. The core objective of this course is to train students to master the basic principles, analytical methods and practical skills of analog circuits so that they can be flexibly applied in practical engineering projects.

First, this course provides students with the theoretical foundation of analog circuit design, enabling students to have an in-depth understanding of the working principles and performance characteristics of electronic systems. It is very important to cultivate students' engineering literacy and innovation ability. Secondly, through course experiments and project practice, students can build circuits and debug equipment by hand, and cultivate practical ability and problem-solving ability. These skills will play an important role in the future of work and study. And analog electronic technology has been widely used in communication, power, control and other fields. Through the study of Analog Electronic Technology, students can master the core technologies in related fields and lay a solid foundation for future work in related fields. With the development of science and technology, the integration of electronic technology with computer technology, communication technology, automatic control technology and other disciplines is getting closer and closer. The study of Analog Electronic Technology helps to cultivate students' interdisciplinary thinking ability and comprehensive application ability.

The Notice on the research and Practice of "new Engineering" recently issued by the Ministry of Education stressed that universities should build "new engineering" projects with their own characteristics to meet the development of The Times and national strategic needs. As a key link in higher education, experimental teaching plays an important role in deepening students' understanding of theoretical knowledge, cultivating practical ability and innovative thinking. By participating in experiments, students can directly experience the scientific research process, discover and solve problems, and thus form independent thinking and innovation ability. In addition, experimental teaching can also promote cooperation and communication among students and improve teamwork and communication skills. Experimental teaching is not only related to the accumulation of knowledge, but also an important way to realize the goal of moral cultivation and all-round education. In the context of new engineering and facing the grand blueprint of Made in China 2025, practical teaching plays a core role in shaping students' engineering thinking, critical thinking, independent learning and teamwork abilities. Therefore, curriculum design should closely focus on the training requirements of new engineering, strengthen practicality and innovation, stimulate students' initiative and creativity, cultivate their hands-on ability, and encourage them to flexibly apply theoretical knowledge to solve practical problems. Experimental teaching should be reformed and innovated continuously throughout undergraduate education to meet the needs of high-quality talents training under the new engineering background, shown as Figure 1.

2. Teaching status and existing problems

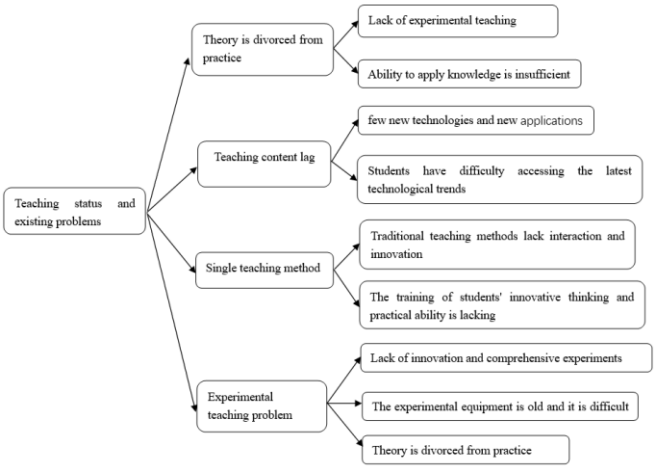

Figure 1: Teaching status and existing problems

2.1. Theory is disconnected from practice

The teaching of analog electronic technology in many universities still stays on the explanation of theoretical knowledge and lacks the experimental teaching link closely combined with practical application. For example, when explaining the operational amplifier circuit, although students can master the basic working principles and theoretical calculation methods, they are often unable to start when facing the actual circuit design and debugging, and the gap between theory and practice leads to the lack of students' ability to apply knowledge.

For example, when learning the basic principles of diodes and transistors, students may have a deep understanding of the working principle of PN junction, but how to choose the right diode or transistor in the real circuit, and how to carry out a reasonable circuit layout, is a difficult problem for them. In addition, students learn the basic properties of capacitors and inductors, but how to choose the appropriate capacitor and inductor values according to circuit requirements in a real environment, as well as their layout and connection in the actual circuit, can be a puzzle for them. Or, in the chapter on the amplification and processing of analog signals, students may be well versed in theoretical formulas, but when it comes to designing an audio amplifier or filter, they may feel lost and not know where to start.

2.2. Teaching content lag

With the rapid development of electronic technology, many new technologies and applications have appeared in the field of analog electronic technology, but the content of teaching materials is often not updated in time, and the teaching content is relatively lagging behind. For example, traditional analog electronic technology textbooks are less about the application of new semiconductor devices and integrated circuits, resulting in students being unable to access the latest technological developments and application trends.

Taking power management as an example, modern electronic equipment has increasingly high requirements for power management, involving many aspects such as efficiency, thermal design, electromagnetic compatibility, and so on. However, the traditional textbooks may only briefly introduce the linear regulated power supply, and the modern switching power supply, DC-DC converter and other contents are less involved. In terms of digital and analog conversion technology, the modern ADC and DAC technology is changing rapidly, but the textbooks may still stay on the older technology and principle, and the introduction of new technology and new applications is lacking. In addition, with the rise of the Internet of Things and smart home, the application of analog electronic technology in this area is also increasing, but the traditional teaching materials rarely involve this content, resulting in students knowing nothing about it.

2.3. Single teaching method

The traditional teaching method often adopts the way of teachers teaching and students listening, which lacks of interaction and innovation. This single teaching method is difficult to stimulate students' learning interest and initiative. For example, in the experimental teaching of analog electronic technology, the way of teachers' demonstration and students' imitation is usually adopted, and students rarely have the opportunity to design experimental schemes and conduct experimental debugging independently, which lacks the cultivation of students' innovative thinking and hands-on ability. In addition to the problem of experimental teaching, theoretical teaching also has the problem of single method. For example, when explaining circuit analysis, many teachers only deduce step by step according to the steps of the textbook, and lack interaction with students, resulting in students only passively accept knowledge, but do not really understand and master.

In the course design, the teacher often gives a clear circuit diagram and parameters, students only need to follow the steps to complete. While this approach can ensure that students complete tasks, it limits students' ability to innovate and think. In addition, modern teaching technology and tools are changing with each passing day, such as simulation software, online learning platform, etc., but many teachers still stay in the traditional blackboard and PPT in teaching, and do not make full use of these modern tools to improve the teaching effect[1].

2.4. The defect of experiment teaching

Traditional teaching often pays too much attention to the explanation of theoretical knowledge, but neglects the combination with practical application. As a result, although students have mastered theoretical knowledge, they are often unable to apply it flexibly when facing practical problems. However, the current experimental teaching mainly focuses on confirmatory experiments, and students complete circuit connection and data recording according to the experimental instruction manual, which lacks innovative and comprehensive experiment design. This leads to the lack of experimental design and innovation ability of students, can not give full play to the practical ability. At the same time, laboratory equipment usually uses older modular circuit boards, which can not keep up with the rapid development of electronic technology. It is difficult for students to access the latest electronic technology and products during the experiment, which affects students' learning and understanding of new technology. Under the traditional experimental teaching mode, students are often in a passive state of accepting knowledge, lacking the opportunity to participate actively and think positively. This leads to students' low interest in the course and poor learning results. In addition, theoretical teaching and practical teaching are often independent of each other and lack of effective integration, so it is difficult for students to deeply understand the importance of theoretical learning in practical application, and it is difficult to effectively use theoretical knowledge in practical operation. This disconnection between theory and practice affects students' ability to master and use analog electronic technology.

3. Curriculum reform and research

3.1. Necessity of reform

With the rapid development of science and technology, the application of electronic technology in various industries is more and more extensive, and the requirements for electronic engineering professionals are also constantly improving. The traditional teaching mode of analog electronic technology is often too theoretical, which leads to insufficient practical ability and limited innovation ability of students, and it is difficult to meet the actual needs of society. The teaching reform ideas is shown in Figure 2.

First of all, teaching reform is very important to improve students' practical ability. As a highly practical course, the teaching purpose of analog electronic technology is not only to let students master the theoretical knowledge, but more importantly to cultivate students' practical ability and practical ability. Through the teaching reform, more experimental teaching links and project-based teaching can be introduced, so that students can learn in practice, learn from doing, deepen their understanding of theoretical knowledge, and improve their ability to solve practical problems.

Secondly, teaching reform is helpful to cultivate students' innovative ability. In today's era of rapid change, innovation ability has become an important indicator to measure a person's comprehensive quality. Through the teaching reform, more innovative teaching methods and means can be introduced, such as heuristic teaching, case teaching, etc., to stimulate students' innovative thinking, cultivate students' innovative ability, so that they can adapt to the development needs of

the future society.

Finally, teaching reform is an important way to meet the needs of society. With the wide application of electronic technology, the demand for electronic engineering professionals is also increasing. However, the traditional analog electronic technology teaching mode is often difficult to train high-quality talents that meet the needs of society. Through the teaching reform, the teaching content can be closer to the actual needs, and more high-quality talents with practical ability and innovative ability can be cultivated to meet the needs of the society for talents[2].

To sum up, it is necessary to reform the teaching of "Analog Electronic Technology". This can not only improve students' practical ability and innovation ability, but also enable them to better adapt to the future development needs of society and make greater contributions to the development of society.

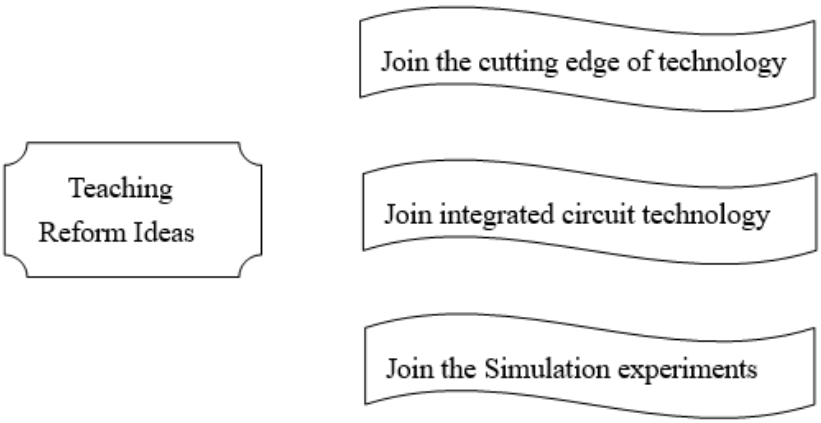

Figure 2: Teaching reform ideas

3.2. Introduce relevant cutting-edge technologies

With the rapid development of science and technology, new technologies, new methods and new applications continue to emerge in the field of analog electronic technology. These cutting-edge technologies not only promote the progress of the industry, but also bring new opportunities and challenges to education and teaching. Introducing cutting-edge technologies into course teaching can help students better understand industry dynamics, broaden their knowledge horizons, and improve their practical ability and innovation ability. The following are relevant cutting-edge technologies that can be introduced in the course:

(1) 5G communication and Internet of Things technology

As the next generation communication technology, 5G has the characteristics of high speed, low delay and large connection. The introduction of 5G communication technology in the course can allow students to understand the 5G network architecture, key technologies and application scenarios, and explore the application and challenges of analog electronic technology in 5G communication. The Internet of Things (iot) technology is the hot spot of current science and technology development, which connects various smart devices to realize data interaction and sharing. The introduction of Internet of Things technology in teaching can help students understand how modern electronic equipment is connected to the Internet, achieve remote control and data collection, and is of great significance for training students to adapt to the future intelligent and networked electronic equipment design trend.

(2) Wearable device technology

Smart watches, health monitoring devices and more have become part of People's Daily lives. In particular, flexible electronics and wearable technology, as an emerging field in recent years, provide more application scenarios and possibilities for electronic devices. Introducing these technologies in the teaching of "Analog Electronic Technology" can broaden students' horizons and stimulate their innovative thinking. At the same time, these technologies also provide students with more career direction and employment opportunities. Introducing the technical principles and design points of wearable devices in the course can help students understand the requirements and innovations of analog electronic technology in miniaturization and low-power design.

(3)Embedded systems and microcontrollers

Embedded systems and microcontrollers are the core components of modern electronic devices, which are responsible for controlling the functions of the device. Introducing these technologies into teaching allows students to have a deeper understanding of the internal control logic of electronic devices and learn how to design and implement complex control systems. This is very helpful to cultivate students' ability of system design and practical operation.

(4)Application of artificial intelligence and machine learning in electronic technology

The rapid development of artificial intelligence and machine learning technology has brought new opportunities and challenges to electronic technology. Introducing these technologies into the teaching of "Analog Electronic Technology" can let students understand how to apply these advanced technologies in the design of electronic equipment, improve the intelligence level of equipment and user experience. It is of great significance to train students to keep up with the development trend of science and technology and have the ability of innovative design.

3.3. Integrated circuit technology is introduced into the curriculum

Integrated circuit is the core of modern electronic technology, which is widely used and increasingly important. With the progress of science and technology, more and more electronic devices use integrated circuits, so it is very necessary for students to understand and master integrated circuit technology. The electronics industry has a great demand for talents who master integrated circuit technology. The introduction of integrated circuit technology in the curriculum helps students better adapt to the needs of future career development. At the same time, integrated circuit technology involves circuit design, manufacturing, testing and other links, the introduction of this technology can cultivate students' comprehensive ability and system thinking, improve their ability to solve practical problems. The following is a detailed explanation of how to introduce integrated circuit technology in teaching, shown as Figure 3.

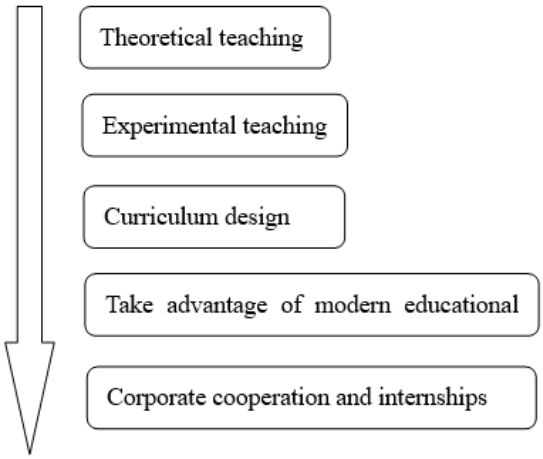

Figure 3: Flow chart of the steps of introducing integrated circuit technology into teaching

3.3.1. Theoretical teaching

The basic principles, design methods and manufacturing processes of integrated circuits are added to the course content, and specific integrated circuit examples are introduced to analyze and demonstrate the application of integrated circuits through cases, so that students can experience the application of modular electrical knowledge from actual cases.

Arrange a special lecture to introduce the internal structure, working principle and its application in modern electronic equipment in detail, and then select a typical integrated circuit (such as operational amplifier), through case analysis, explain its working principle, performance parameters and application in actual circuits. Multimedia teaching resources, such as PPT and videos, can be used to help students understand.

3.3.2. Experiment teaching

First of all, the experimental project based on integrated circuit is designed, and then the students are instructed to use the test equipment to test, and then the students are allowed to operate.

An experimental project of audio amplifier based on integrated circuit is designed. First, the teacher provides experimental instructions and circuit schematics to guide students how to build a simple audio amplifier circuit, the core component of which is an integrated circuit audio amplifier chip. Students built the circuit according to the experimental instructions, and used oscilloscope, signal generator and other test equipment to test and analyze the circuit. Teachers can guide students to understand the role of integrated circuits in audio amplifiers through questions and discussions.

3.3.3. Course design

Special course design sessions are arranged to allow students to use their knowledge comprehensively to design an electronic system containing integrated circuits and encourage students to innovate and try to use different types of integrated circuits to achieve specific functions

A two-week course design project requires students to apply their knowledge to design a temperature monitoring system with integrated circuits. Teachers can provide relevant design requirements and guidance. Students were divided into groups to design the course. Each group selected a suitable integrated circuit (such as a temperature sensor integrated circuit) and designed and made a prototype of the temperature monitoring system. Finally, students present and defend their achievements, and teachers and other students evaluate and give feedback.

3.3.4. Use modern educational technology

With the rapid development of science and technology, modern educational technology can be added to the learning of modular electrical courses. First of all, online course platforms (such as MOOCs, NetEase Cloud classes, etc.) can be used to guide students to watch online video tutorials related to integrated circuits to deepen their understanding of the principle and manufacturing process of integrated circuits. Secondly, the knowledge of analog circuits is relatively abstract and difficult to understand, so we can consider the use of virtual reality (VR) technology to simulate the design and manufacturing environment of integrated circuits. Students can experience the production process of integrated circuits through VR headsets and devices.

3.3.5. Enterprise cooperation and internship

The university establishes partnerships with integrated circuit related enterprises, and provides internship opportunities for its students to experience the design, manufacturing, and testing process

of integrated circuits. Specifically, you can establish a partnership with a local integrated circuit design or manufacturing company to organize students for a one-week internship. During the internship, students will visit the production line and research and development department of the company to learn about the design, manufacturing and testing process of integrated circuits. Subsequently, enterprise engineers can be invited to the school to give a lecture to share the latest trends and cutting-edge technologies in the integrated circuit industry. Students can interact with engineers, ask questions and discuss.

3.4. Introduce simulation experiments into the curriculum

Simulation technology can provide a virtual experimental environment, so that students can simulate the real electronic circuit behavior on the computer, so as to deepen the understanding of the principle of electronic technology, improve the practical ability and innovative thinking. Through simulation, students can design and test circuits in a virtual environment, apply theoretical knowledge to practice, and thus better understand and master the basic concepts and principles of electronic technology.

On the one hand, the traditional electronic technology experiment needs a lot of hardware equipment, the cost is high. Simulation software greatly reduces this cost while avoiding equipment damage due to improper operation. On the other hand, simulation software can quickly simulate circuit behavior, and students can try different design schemes many times in a short time, thus speeding up the learning process. Moreover, the simulation software provides a free design space in which students can try various innovative circuit designs and cultivate innovative thinking and practical ability.

The following takes the simulation of single-tube common-fire amplifier circuit based on Multisim as an example to introduce how to add simulation in the course in detail.

(1) Preliminary preparation

The teacher instructs students to install Multisim software correctly before using the computer, and conducts basic operation training of the software before class, including interface layout, component selection, circuit construction, simulation operation, observation of experimental phenomena, and other basic operations. At the same time, the basic composition, working principle and performance index (such as magnification, input/output resistance, etc.) of the single-tube common emission amplifier circuit are reviewed.

(2) Circuit design

In this experiment, triode is selected as the core component of the amplifier circuit, and the commonly used triode 2SC1815 is selected here. After selecting the core components, the student starts to build the circuit by selecting resistance, capacitor, DC power supply, sliding rheostat, oscilloscope, etc., from the component toolbar. Finally, according to the schematic diagram of the single-tube common emission amplifier circuit, the wire tool is used to connect the components, and adjust the values of resistance and capacitance as required, as well as the voltage of the DC power supply, to ensure that the circuit can work normally. For example, the engineer/student sets the VCC to 12V and selects the appropriate Rb and Rc values to set the static operating point.

Figure 4 shows the complete circuit.

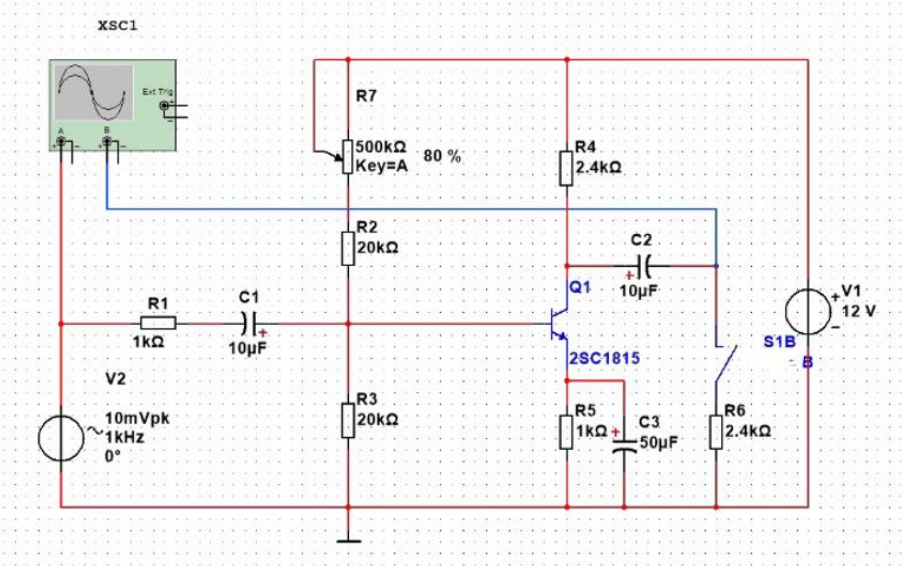

Figure 4: Block diagram of single-tube common-beam amplifier circuit simulation

(3) Experimental analysis

After the simulation circuit is built, the circuit is adjusted with professional knowledge. To simulate its static operating point, the student/engineer selects "Simulate > Analyses and Simulation > DC Operating Point" from Multisim, sets the variables to be analyzed (such as a certain current and a certain voltage), and then runs the simulation. The student views and records the parameter values of the static operating point, and adjusts the resistance value in the circuit according to the simulation results until the static operating point reaches the ideal state. If you want to analyze its dynamic performance, you can use Multisim's AC Sweep Analysis to analyze the dynamic performance of the circuit such as magnification and frequency response. The amplitude-frequency characteristic curve of the amplifier circuit is observed and analyzed by setting different parameters such as starting frequency, stopping frequency, scanning type and number of test points.

Here, the influence of different loads on the amplification of the transistor is analyzed as an example. Firstly, the resistance R6 is disconnected, and the input and output waveform in the oscilloscope is observed, as shown in Figure 5. The red line represents channel A, that is, the input port, and the pink line represents channel B, that is, the output port.

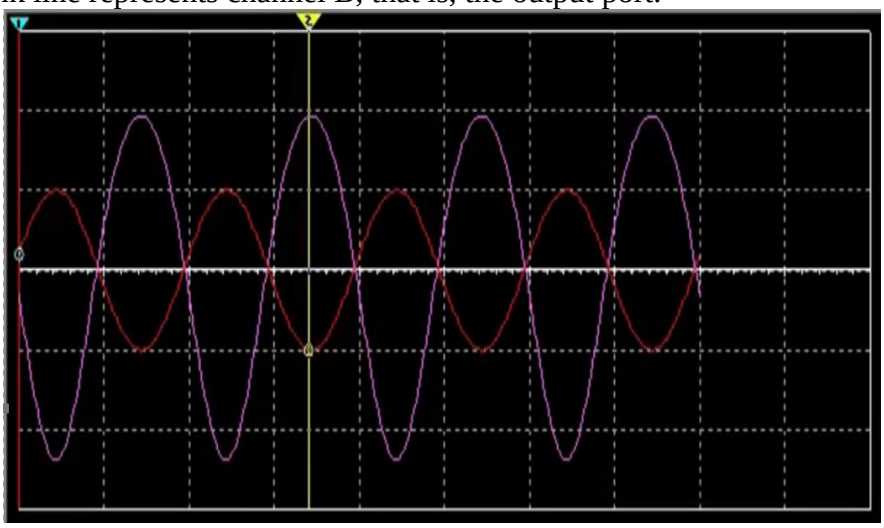

Figure 5: Input and output voltage waveform without load

As the comparison group, close the switch and connect the resistor R6 to the circuit, and then perform the simulation. The circuit is shown in Figure 6 and the oscilloscope waveform is shown in Figure 7.

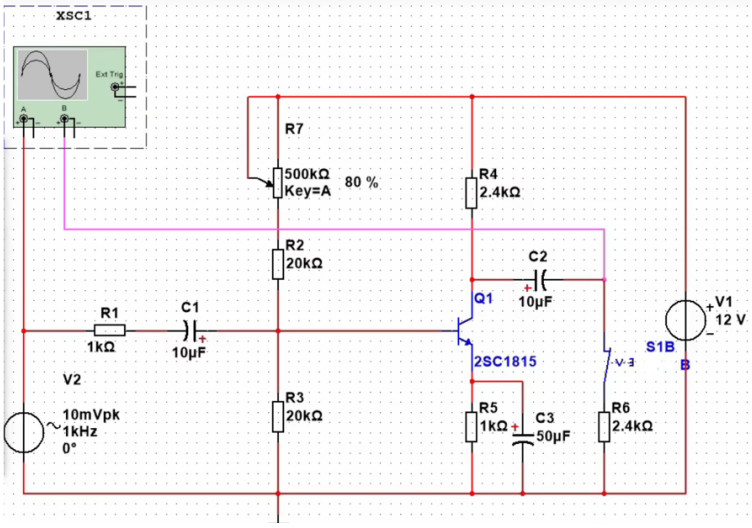

Figure 6: Simulation block diagram of single-tube common-beam amplifier circuit (with load)

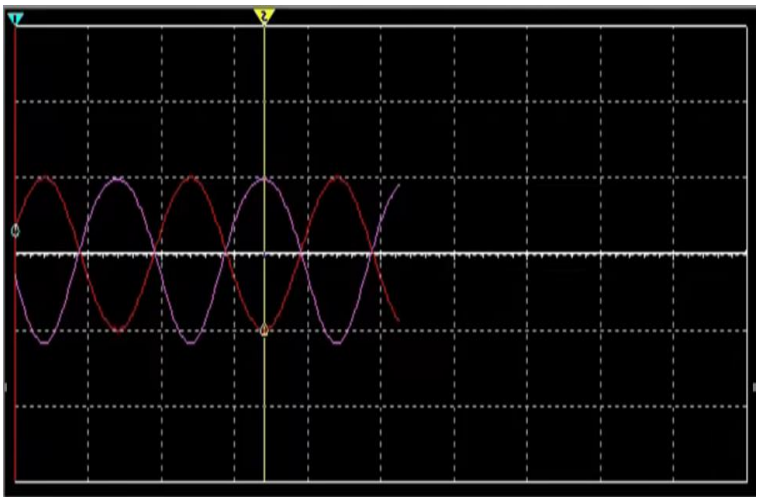

Figure 7: Input and output voltage waveforms under the load

By comparing the differences between the waveforms shown in Figure 5 and Figure 7, the changes in voltage magnification before and after loading can be intuitively felt. At the same time, by setting different types of loads and adjusting different values of loads, the influence of load changes on voltage magnification and the whole circuit can be more obviously realized in the single-tube common emission amplifier circuit.

(4) Experimental report and discussion

After completing the experimental analysis of the third step, students are asked to set various parameters, simulation results and waveform diagrams in the simulation process, and organize students to discuss the simulation results and analyze the changes in circuit performance under different parameter Settings. Finally, as the assessment standard, students are required to write a detailed experiment report, including the experiment purpose, principle, steps, result analysis and conclusion.

(5) Summary and feedback

As a teacher, after the completion of the experiment, they should carefully review each

experiment report, pay attention to the ideas, methods, results and analysis of students in the experiment process, and clearly point out the problems in the report, such as data recording, depth of analysis and rationality of conclusions. At the same time, specific improvement suggestions are given to help students improve their experimental ability and theoretical understanding. In order to promote communication and sharing among students, classroom discussions or group exchanges should also be organized so that students can learn from each other and inspire each other. In this process, the importance of experiment should be emphasized, and students should be encouraged to participate actively and take it seriously. At the same time, we pay attention to the individual differences of different students and give personalized guidance and support. Finally, the feedback of each experiment was recorded, and the progress of students was tracked so as to provide necessary help and guidance in subsequent experiments to further improve the teaching effect[3].

4. Conclusions

Through the in-depth analysis of the current situation and problems of "Analog Electronic Technology" course, this paper puts forward a series of targeted teaching reform measures. The introduction of cutting-edge technology, integrated circuit technology and simulation experiment teaching means can not only make up for the shortcomings of traditional teaching mode, but also stimulate students' learning interest and initiative, and cultivate their practical ability and innovation ability. Through the concrete simulation experiment cases, such as the simulation of single-tube co-emission amplifier circuit based on Multisim, this paper elaborates how to integrate simulation technology in the course teaching, so that students can design and test circuits in a virtual environment, so as to deepen the understanding of the principle of electronic technology.

Looking forward to the future, the teaching reform of "Analog Electronic Technology" course will continue to deepen in order to adapt to the rapid development of electronic technology and the constant change of social needs. With the continuous emergence of cutting-edge technologies such as 5G communication, the Internet of Things, and artificial intelligence, course content will be constantly updated and teaching methods will be constantly innovative. At the same time, strengthening cooperation and exchanges with enterprises and providing students with more internship opportunities and practice platforms will become an important direction of teaching reform. Through these efforts, we hope to train more electronic engineering professionals with solid theoretical foundation and excellent practical ability, and make greater contributions to the country's scientific and technological progress and social development.

Acknowledgement

Thanks for the support by the Training and Funding Program for Young Teacher in University of Shanghai.

References

[1] W. Wei, X. Lijie, W. Shidan, K. Jun , G. Jing, "Research on the reactive power optimization of distribution network including DG," 2012 3rd IEEE International Symposium on Power Electronics for Distributed Generation Systems (PEDG), Aalborg, Denmark, 2012, pp. 207-210.

[2] C. Ma, Q. Duan, H. Wang, Y. Mu, "Multi-objective Dynamic Network Reconstruction Method for Active Distribution Network Including Distributed Generation and Electric Vehicles," 2022 5th International Conference on Energy, Electrical and Power Engineering (CEEPE), Chongqing, China, 2022, pp. 612-617.

[3] J. Yang et al., "Research on the Mechanism of Affecting the Transmission Capability of HVDC Connected to Weak AC System Considering STATCOM," 2018 International Conference on Power System Technology (POWERCON), Guangzhou, China, 2018, pp. 2524-2532.