Teaching Reform and Practice of "Analog Electronics Technique" under the Background of "New Engineering"

Wangping Jiang*, Huifang Tao, Wen Li
Wuhan University of Communication, Wuhan, Hubei, China
**Corresponding Author.*

Abstract: This paper focuses on the current teaching problems in the "Analog Electronics Technique" course, based on the background of "New Engineering" construction and the position of applied talents training. Focusing on the development of the electronic information industry and its contribution to the local regional economy, the emphasis has been placed on cultivating students' practical application abilities and restructuring the course content. Additionally, there is a focus on cultivating students' humanities qualities by incorporating ideological and political education into the curriculum. Using a combination of online and offline learning and project-driven teaching methods, the entire process of student development is showcased in the classroom. Practice has shown that students have made significant progress in terms of learning initiative and enthusiasm, engineering practice and innovation ability.

Keywords: **New Engineering; the Ideological and Political Education; Engineering Practice; Innovation Capacity**

1. Introduction

In order to respond actively to the new round of technological revolution and industrial transformation, and to support the development of innovation-driven services and national strategies such as "Made in China 2025", the Ministry of Education has been actively promoting the construction of "New Engineering" since February 2017[1].The concept of "New Engineering", proposed by the Ministry of Education, is leading the way for the reform of higher engineering education. Following this, the concept of engineering professional accreditation, which focuses on students, outcomes, and continuous improvement, has been put forward, providing guidance and goals for talent cultivation and curriculum development in the field of" New Engineering" [2].

"Analog Electronics Technique" is a foundational course offered within the field of electronic information in the context of the New Engineering Discipline. It is highly practical and plays an important role in cultivating students' vocational abilities. Based on the demand for applied talents, the following course objectives have been determined: 1) To understand the performance characteristics and functions of analog electronic devices, develop an understanding of analog electronic module circuits, and possess the ability to analyze the structure of analog electronic circuits. 2) To master knowledge in electronic device testing and selection, electronic circuit board design, electronic circuit assembly and debugging, and possess the ability to analyze electronic circuits, conduct tests, and design electronic products. 3) To enable students to independently evaluate the correctness of experimental results based on theoretical knowledge, as well as to carry out error analyses. 4) To cultivate in students a spirit of professionalism, lean principles, and concentration, as well as a meticulous and dedicated attitude towards learning, akin to that of a skilled craftsman.

2. Problems in Course Teaching

The application of electronic technology is ubiquitous, ranging from power indicator lights on circuit boards to mobile phone motherboards, laptops, and even dancing robots and lunar rovers. The theoretical foundation of Analog Electronics stems from subjects such as Advanced Mathematics and University Physics. However, due to the limited classroom time, it is challenging to fully comprehend the intricacies of Analog Electronics. Students often lack a solid

understanding of circuit fundamentals and struggle with cultivating a habit of deep thinking. On the other hand, they exhibit a fast learning pace, excellent hands-on skills, and a strong foundation in networking. During teaching, it has been observed that students struggle to grasp the applications of integrated operational amplifiers and the relationship between waveform generation and transformation circuits. Furthermore, the extensive content of the course, involving circuit design and specialized terminology, often dampens students' learning enthusiasm.

Table 1. The Supporting Relationship between Curriculum Objectives and Graduation Requirements

S/N	Indicator points for graduate requirements	Graduate requirements
1	Ability to propose and analyze problems: Mastery of fundamental theories and technologies related to electronic information, with the ability to analyze engineering problems through literature research and scientific methods.	Requirement 3: Proficiency in comprehending fundamental theories and advanced technologies within the realm of electronic information; adept in utilizing scientific methodologies to analyze engineering predicaments. Additionally, understanding the production process and technology of electronic products, as well as the current state and future trends of the profession.
2	Design and analysis proficiency for simplistic engineering dilemmas: Proficiency in using common electronic instruments, with the initial ability to design and carry out engineering experiments in the field of electronic information, and analyze the results.	Requirement 4: Proficiency in operating common electronic instruments and devices, with the initial ability to design and implement engineering experiments in the field of electronic information. Able to analyze and discuss the results. Basic ability to propose, analyze, and solve theoretical or practical problems in the field of electronic information, and participate in system design, operation, and maintenance.
3	Aptitude for unraveling complex engineering quandaries through analysis and debugging: The initial ability to analyze and debug project systems within the field of electronic information, as well as the ability to address practical engineering problems such as product design, technological advancements, engineering design, and analysis.	Requirement 5: Possession of a creative spirit and entrepreneurial mindset, mastery of basic innovation and entrepreneurship methods. The initial ability to design, analyze, and debug project systems within the field of electronic information, and the ability to address practical engineering problems such as product design, technological advancements and innovations, and engineering applications.

Incorporating the background of "New Engineering" in the field of electronic information engineering, a talent development plan and graduate requirements for applied talents have been formulated. This plan aligns with the course objectives of "Analog Electronics" as shown in the supporting matrix in Table 1.

3. Reconstruction and Optimization of Curriculum Knowledge System and Teaching Content

3.1 Selecting and Reconstructing the Teaching Content

The "Analog Electronics Technique" course consists of 32 theory hours and 16 laboratory hours. Based on the objectives of cultivating applied talents, the existing curriculum content has been integrated and optimized, as shown in Table 2. The course is structured around fundamental knowledge, practical applications, and skill enhancement. Starting from the basics of semiconductor devices, with a focus on diodes and transistors, the course builds and analyzes field-effect transistor amplification circuits and negative feedback amplification circuits. Finally, the course emphasizes skill enhancement by integrating the application of integrated operational amplifiers with waveform generation and

transformation circuits, enabling students to form connections between different circuits.

Table 2. Reconstruction of Course Content

Analog Electronics Technique	Basic Knowledge (Theory 8 + Lab 2)	Semiconductor Fundamentals: Intrinsic and Impurity Semiconductors. What are the different types of electronic components?
		PN junction's unidirectional conduction characteristics, capacitance effect, and diode applications. What are the different operating states of a transistor?
	Practical application (Theory 8+ Lab 4)	Principles of amplification circuits, DC operating conditions of amplification circuits, and dynamic analysis of amplification circuits. How can we determine the stability of the static operating point?
		Field-effect transistor parameters, amplification circuits using field-effect transistors, and their distinct applications compared to transistor amplification circuits.
		The four basic configurations of feedback amplifiers and the impact of negative feedback on amplifier performance. How can we understand the application of negative feedback circuits in automatic control systems?
	Skill enhancement (Theory 16+ Lab 10)	Operational circuits, active filters, voltage comparators, etc. What is the relationship between operational circuits and PID control?
		RC sinusoidal oscillator circuits and LC sinusoidal oscillator circuits. How can we load sinusoidal signals using a digital oscilloscope?

3.2 Integration of Ideological and Political Elements

Teaching aims to achieve both education and knowledge transfer, where new engineering talents should possess both moral integrity and expertise.

Table 3. Points of for Integration of Ideological and Political Elements in the Course

Unit	Main knowledge points	Points of for integration of ideological and political elements
Semiconductor Devices	Semiconductor technology and the applications of diodes	Introduce the story of Wang Shouwu, one of the pioneers and founders of Chinese semiconductor science and technology, to inspire students' patriotism and help them establish life goals of studying hard and contributing to the country.
Fundamental Analysis of Amplification Circuits	Analyzing whether amplification circuits can properly amplify AC signals by examining the suitability of the static working point and the smooth transmission of AC signals to the output end.	Emphasize the importance of comprehensive analysis and encourage students to consider multiple aspects when solving problems, in order to cultivate their dialectical thinking abilities.
Applications of Integrated Operational Amplifiers	Teaching the applications of integrated circuit operational amplifiers in the fields of semiconductors, computers, and related areas.	Enhance students' national pride and foster their awareness of innovation through typical cases such as the independent research and development of Huawei HiSilicon and 5G technology. Motivate students to take the responsibility for the prosperity of the motherland and strive for independent intellectual property through dedicated learning.

By integrating ideological and political education into professional knowledge and skills instruction, we can effectively educate and inspire students[3].In-depth analysis is conducted to address the “deficiency of ideological and political education” in traditional teaching objectives, focusing on core technologies in integrated circuits and introducing remarkable scientific researchers who have made significant contributions to national development. Through extensive case studies, students are cultivated with an engineer’s cultural literacy characterized by "inquisitiveness, collaborative abilities, innovative thinking, and professional ethics. Please refer to Table 3 for specific ideological and political case studies in teaching.

4. The Application of Project-Driven Teaching in Curriculum Experiment

Practical teaching is an essential component of curriculum instruction, playing a pivotal role not only in consolidating and reinforcing classroom content but also in cultivating students' comprehensive qualities. It serves as a crucial approach for students to connect theory with practice, enhance their engineering practical skills, and foster their innovative abilities [4]. Currently, the means of practical sessions in the curriculum are relatively outdated, with weakened emphasis on experimental teaching in an engineering context and limited application of technical skills. The experimental types tend to focus more on cognition and validation, lacking comprehensive design projects. In the context of the new engineering disciplines, it is necessary to enhance students’ awareness of engineering innovation. Therefore, developing integrated and design-based experiments is of paramount importance, aiming to enhance students’ abilities to integrate theory with practice, identify and solve complex problems, and nurture their innovation capabilities. This will cultivate students’ application of engineering practices [5].

4.1 Case Design of Innovative and Design Experiments

Experimental task: Soldering the common collector amplifier circuit board to amplify the audio signal through a microphone (sound sensor) and a two-stage amplification circuit, resulting in the illumination of a light-emitting diode (LED) when an input DC regulated power supply signal is applied. The objective is to construct and analyze the common collector amplifier circuit, and to master the measurement method of the amplifier circuit's static operating point. The circuit schematic of the common-collector amplifier is shown in Figure 1.

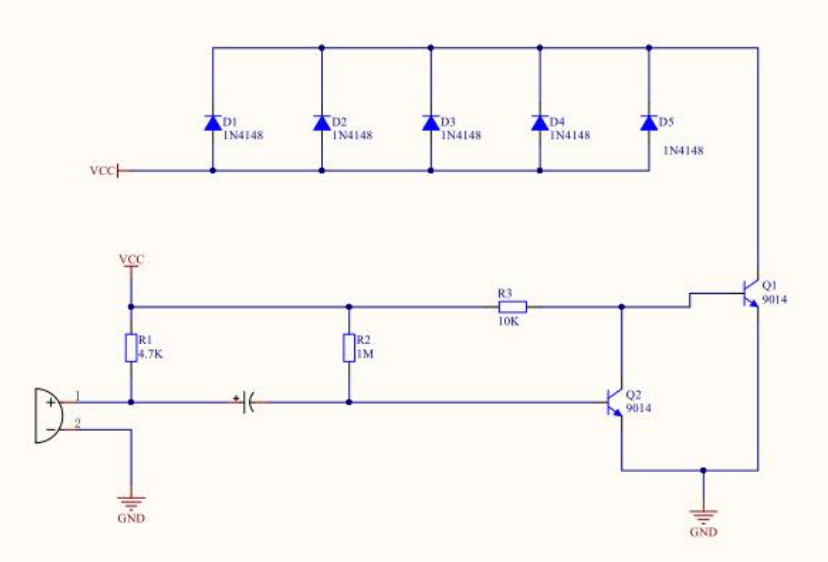

Figure 1. Common Collector Amplifier Circuit

Estimate the static operating point of the amplifier circuit based on its DC path [6].

First, calculate the base current I_{BQ} by analyzing the base circuit at the static state:

$$I_{BQ} = \frac{U_{CC} - U_{BE}}{R_b} \quad (1)$$

Next, determine the collector current I_{CQ} at the static operating point based on the

relationship between the currents of the transistor's various terminals:

$$I_{CQ} = \beta I_{BQ} \quad (2)$$

By considering the collector output circuit, we can calculate the collector-emitter voltage U_{CEQ}

$$U_{CEQ} = U_{CC} - I_C R_c \quad (3)$$

This circuit is a two-stage amplifier with direct coupling. To avoid adverse effects caused by capacitance on slow-varying signals, the collector terminal of the output NPN transistor Q_2 is directly connected to the base terminal of the next-stage transistor Q_1 .In the course of experimental teaching, students refer to relevant materials and verify their proposed solutions. They gradually proceed with hardware design and ultimately complete the physical circuit board along with writing an experimental report. Students mainly document any issues encountered during the measurement of the static operating point and the corresponding problem-solving approaches, as well as any discrepancies between the measured results and the theoretically calculated values.

In this way, the students will be familiarized with the entire lifecycle of electronic product development, including design through drawings, discussion to finalize the plan, creating PCB layouts using PROTEL or EDA software, printing the circuit board, purchasing chips and electronic components, soldering the complete circuit board, and conducting debugging.

4.2 Integrating Academic Competitions into Teaching: Promoting Innovation and Learning through Competitions

By incorporating nationwide technology competitions such as the National College Student Intelligent Vehicle Contest and the National Software and Information Technology Contest (Blue Bridge Cup), practical teaching elements are introduced into the Analog Electronics course. By utilizing real projects from the intelligent vehicle contest, students are able to seamlessly integrate the required knowledge and skills. This approach promotes a hands-on learning experience for students, combining theory with practice. For instance, in the application experiment of operational amplifiers, various knowledge points and skills such as power circuits, voltage regulation circuits, and filtering circuits are covered. This experiment helps students grasp the fundamental principles of circuits, practical soldering techniques, and circuit board debugging. It enables them to apply theoretical knowledge comprehensively.

5. Innovation in Education and Teaching Methods

5.1 Adopting Blended "Online+ Offline" Teaching

"Analog Electronics Technique" primarily adopts a blended learning approach combining online and offline elements, fostering student inquiry-based learning and enhancing their comprehensive capabilities. This approach integrates moral and intellectual education, large-group lectures and small-group seminars, concentrated and autonomous learning, as well as offline and online learning. It emphasizes the active role of students in the knowledge construction process and emphasizes the cultivation of students' autonomous and lifelong learning habits [7]. Utilizing the "Chaoxing Learning" platform, online resources are developed, including complete course teaching materials and accompanying exercise banks, creating optimal conditions for online learning.

5.2 Guiding Students to Draw Mind Maps

Students are guided to use XMind to create mind maps, starting with intrinsic and doped semiconductors leading to the concept of PN junction. The application of PN junction then leads to the next knowledge point - fundamentals of amplifier circuit analysis. Each knowledge point is interconnected, forming a cohesive chain.

6. Conclusions

Under the backdrop of the new engineering disciplines, a pedagogical reform is being implemented for "Analog Electronics Technique" to integrate theory and practice and enhance students' ability to apply theoretical concepts in a practical setting. Students are encouraged to participate in relevant technological competitions and research projects, with the outcomes of these endeavors being incorporated back into the teaching process, igniting students' curiosity

and fostering their research and innovation skills. This approach aims to establish a solid foundation for students' future engagement in the design and production of electronic technologies. The incorporation of ideological and political elements in the course not only allows students to comprehend the significance of a technologically strong nation, but also imparts the spirit of outstanding workers dedicated to their jobs on the production front line. By fostering a correct sense of patriotism and a scientific perspective, students are guided towards a virtuous path.

Acknowledgments

This work was supported by the institutional-level undergraduate course project from Wuhan University of Communication (J.Z. [2023] No. 13), Serial Number: 15, the blended course "Analog Electronics Technique" led by Huifang Tao.

References

[1] Ministry of Education. National Standards for Teaching Quality in Electronic Information Courses, 2018. Available at: https://ishare.iask.sina.com.cn/f/12sLsYI1tHZ3.html.

[2] Zhang Yi. Curriculum System Reform and Practice of “Electrical and Electronic Technology” in the Context of New Engineering. China Electric Power Education, 2022, (9): 77-78.

[3] Li Xiaojuan, Li Jianke et al. Research on the Reform of Teaching Mode for Single Chip Microcomputer Principle and Application Course in the Context of New Engineering. Technology Wind, 2023, (4): 96-98.

[4] Wang Jihuan. Reform of experimental teaching system on mechanical basic courses group for application technology universities. Experimental Technology and Management, 2016, 33 (8): 9-13+17.

[5] Liang Fang, Li Haixia et al. Teaching Reform of Analog Electronic Technology in the Context of New Engineering. Journal of Science of Teachers’ College and University, 2023, 43 (5): 106-110.

[6] Jiang Xiaoan, Fu Shaofeng. Analog Electronic Technology (5th Edition). Xi’an: Xi’an University of Electronic Science and Technology Press, 2021.

[7] Yang Zhengxu. Application of PBL Teaching in Medical Biology Course, China After School Education, 2012, (6): 79.

