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# Research on Independent Experimental Model of Circuit Theorem

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***Abstract*—The circuit theorem in the circuit course is selected as the experimental content. The teacher puts forward the performance index requirements, the student self-learning experimental principle and the related instrument and meter use methods, and then independently designs the experimental instruments, and selects according to the requirements. Experimental measurement of physical quantities, self-developed experimental procedures and experimental data recording forms, and advanced circuit simulation, and finally in the classroom to build their own circuit for experimental operation of an experimental model. Practice shows that the implementation of independent experimental teaching model mobilized the enthusiasm of students, strengthened the basic experimental shills of students, cultivated the students` comprehensive experimental quality and innovative experimental ability, and improved the teaching of follow-up related experimental courses.**

***Keywords—circuit analysis; independent experimental model; experiment features Introduction***

## I. INTRODUCTION

"Circuit analysis" is a professional basic course that must be offered by higher engineering colleges. It is the basis for studying other professional courses. Its teaching links include two parts: Theory and experiment. Experimental teaching is an essential part of teaching.

According to the characteristics of the circuit course, the experimental content is mainly based on confirmatory experiments, followed by design and comprehensive experiments. The purpose of basic confirmatory experiment is to consolidate the students' mastery of theoretical knowledge, to exercise students' hands-on ability and basic experimental skills, including the use of common electronic instruments and instruments, the selection criteria of common components, the measurement methods of basic physical quantities, and the basic methods of troubleshooting of common failures. On the basis of the basic experiment training, the design experiment requires the students to draw up the experimental steps, select the devices and test instruments according to the design task, and independently design the experiment of some common unit circuits that can complete the basic functions. The single experimental teaching mode largely restricts the students' thinking ability and reduces their interest and enthusiasm in learning this course. In combination with the experience of theoretical and experimental teaching for many years, adapting to the needs of the current teaching reform and teaching system, the traditional teaching mode is changed with the experiment box as the basic carrier, the experimental circuit is fixed and modularized, so that the students can design the experimental circuit themselves, choose the appropriate instruments and choose the correct physical quantity to measure the physical quantity. The combination of the verifying experiment and the plan experiment strengthens the students' hands-on ability and self-study ability, and embodies the principle of "scientific, enlightening, and adaptable".

## II. SELECTION OF EXPERIMENTAL CONTENTS

The circuit experiment is the first experiment course of the electrical specialty of our school, and the circuit theorem experiment is an introductory course. For the students, it is equally important to master the method of using instrument and the skillful operation of the experiment. Solid experimental skills and good experimental habits not only lay a solid foundation for the follow-up experiment course, but also lay a good foundation for them to become a qualified engineer.

For students, simple theoretical design and calculation are difficult to bring about their interest in learning. They are more willing to know whether the contents of the study can really solve the practical problems. Teachers easily find that the same knowledge point, teachers design different topics, the use of different experimental teaching methods, the experimental teaching effect is not the same.

The content of experimental teaching is directly related to teaching objects. Students of different levels and different levels must have different levels of teaching content.

According to the needs of teaching at different levels, the experimental content is divided into two parts.

### *A. Basic part*

1) measure the resistance of a fixed resistor with different ranges.

2) verify the superposition principle, which contains at least two independent sources.

3) verify the Thevenin theorem and contain at least one independent source.

4) select appropriate laboratory measurement parameters and fill in the form.

5) according to the knowledge of this experiment, we designed the experimental scheme to verify Thevenin's theorem.

### B. Improvement part

1) design the experimental circuit and verify the maximum power transfer theorem.

2) verification of the principle of superposition of nonlinear circuits.

3) set up faults in any of the above circuits, and master common troubleshooting methods.

According to the different teaching objects, the requirements of the experimental contents are different.

For the students with good foundation: complete the basic part and improve the part.

For students who are weak in foundation, part of the foundation is not completed.

Investigation of knowledge points:

1) Using different ranges to measure the same resistance, let students understand the difference between theoretical value and measured value, so as to guide students to have a sense of engineering background.

2) The superposition theorem is concerned with the application of object voltage and current as well as the direction of voltage and current. Students should choose the right amount of measurement and record the data correctly.

3) The Thevenin theorem focuses on the zero source processing of the independent source when the equivalent resistance is calculated. The voltage source zeroes represent the open circuit, and the current source zero indicates that the short circuit is used instead.

4) The verification of Thevenin theorem focuses on the understanding of the applicable objects of a theorem and a simple method in the case of variable objects. Therefore, the same number of loads (at least three sets) are taken from the original circuit and the equivalent circuit to verify the same physical quantity.

5) The nonlinear proof of the superposition theorem can be used to connect the diodes in the original superposition theorem, and then verify it by comparing the measured values of the same amount before and after the access.

6) The troubleshooting circuit can set fault points in any of the above circuits, and then check the test points with the deskmate to check each other. Explore the students' flexible use of knowledge.

Through this experiment, it not only deepened the students' comprehensive understanding of theoretical knowledge, grasps the number of commonly used instruments and instruments, but also consolidated the students' experimental skills, and laid a solid foundation for the later study and work.

## III. THE PROCESS OF TEACHING IMPLEMENTATION

It includes 3 steps: preview and guidance before class + classroom instruction and operation + summary and answer after class.

### A. Preview and guidance before class

1) a guided mission

According to the specific contents and requirements of the experiment, the relevant chapters of the students' theory of self-study theory are familiar with the principles of the experiment, so as to guide the students to consolidate and apply the knowledge of the theory course to strengthen the effect of the preview.

2) providing independent learning of three-dimensional teaching resources

- instructions for use of instruments, students learn to read and master their usage.

-MULTISIM SIMULATION SOFTWARE.

- Network answer

The emphasis is on the relevant principles and the use of instruments and equipment, reducing the repetition of the fixed content in the classroom, leaving more thinking time to the students, and cultivating the students' ability to read documents and equipment instructions.

3) the students design the experimental circuit and carry out the simulation according to the requirements, and draw up the experimental steps, the selected measurement quantities and the data recording form.

### B. Classroom instruction and operation:

1) take the "start to explain" teaching methods.

On the basis of full preview, students will directly operate in class, and conduct individual guidance according to their needs in the course of practice. Attention should be paid to guiding and finding problems, thinking problems and solving problems independently.

In the 10-15 minutes before class, we will discuss the contents of the experiment, including the problems encountered in the experiment, the problems that should be paid attention to and the related questions.

2) teach students in accordance with their aptitude and guide them flexibly.

According to the specific practice of the teaching object, we should carry out experimental discussions. If the students' foundation is better, the content and time of discussion should be increased.

3) emphasize the skills and matters of attention

Before testing, check whether the instrument is working normally.

When the circuit is connected, all power supplies are shut down.

- it is not charged to measure the resistance.

The DC current meter of the experimental circuit must be connected to the circuit in series.

In the superposition theorem experiment, we should pay attention to the positive and negative numbers when we record voltage (current) data.

The nonlinear superposition theorem can add a nonlinear element (diode) to a branch.

- introduce common faults, allow students to exchange seats and check each other.

- in the equivalent resistance measurement link, it tells the students that a power supply can not be easily short circuited or broken in a practical circuit. This will not only bring danger to the whole actual circuit system, but also cause personal safety, which extends to the knowledge of the actual engineering.

### *C. Summing up and answering questions after class:*

After class, the summary includes two aspects:

Students: communicate with each other, summarize experimental methods, experimental steps and experimental techniques.

Teacher: arrange after-school thinking questions, guide students to explore the results and related knowledge.

Using different ranges to measure the same resistance, let students know the difference between engineering application and theory.

Under what conditions is the superposition principle and Thevenin theorem?

- the verification method and process of the Thevenin theorem?

- what are the testing methods of $R_O$ in Thevenin theorem? When the internal resistance of the voltage source is large, can we use the direct method to calculate the equivalent internal resistance?

In practical engineering, $R_O$ often adopts the combined measurement method, and this method is used to measure the output resistance of the amplifying circuit in the mode electricity experiment.

In the experiment of the Thevenin theorem, the 0 ~ 12V voltage source of the experiment box has been connected to the 12V independent source socket in the experimental circuit. Now the direct test method is to be used to determine the $R_O$. How does the 12V independent source in the experimental circuit deal with it?

## IV. ASSESSMENT REQUIREMENTS AND METHODS

1) preview: submit the preview report and check the students' preparation (10 points).

Assessment criteria and assessment methods: check students' Preview report. There are several schemes in the preview report and 3 points for the proof of withdrawal; the design process and the 4 points of the detailed calculation process; and the 3 points of simulation using the simulation software.

The following points are specifically included:

The purpose and significance of the experiment;

The type of instrument and instrument used in the experiment.

The principle of the experiment and the relative calculation formula;

The circuit diagram and parameters are designed according to the requirements.

Circuit capture, phenomenon capture, simulation data recording, calculation and analysis are simulated by simulation software.

Improve part of the experimental design, circuit diagram, steps, data recording forms. (this part is added)

2) experimental process: observe the practice of students. The test is carried out during the experiment. (15 points)

Assessment criteria and assessment methods: the circuit connection is beautiful and correct 3 points; operation 3 points according to the experimental operating rules; the correct and reasonable 3 points of the measured data; correct use of the instrument and instrument 3 points; correct arrangement of the experimental table and instrument and instrument 3 points.

3) experimental report: submission within one week after class to investigate the completion of the experiment, the normalization of the data records, the correctness of the data calculation, the scientific analysis and conclusion, and the careful writing and handwriting. (5 points)

The following points are specifically included:

Matters needing attention in experimental operation;

The difference between actual measurement data and theoretical design and simulation experiment is analyzed.

Summarize the problems, solutions and gains encountered in the experiment.

Rational use of equipment to find problems in experiments.

Summing up the superposition theorem, the conditions and applications of Thevenin's theorem.

Write out the self-evaluation, experience and other questions about the experiment.

4) comprehensive preview, classroom practice and experimental report were added to the experimental results.

## V. CHARACTERISTICS OF INDEPENDENT EXPERIMENTAL MODEL

Compared with traditional experimental mode, independent mode has distinctive features of novel form, vivid content and main line connection. It can be divided into three aspects:

1) basic + confirmatory + design. The typical classical circuit theorem is selected as the experimental content, which has changed the previous verifying experimental methods and transition to the design experiment, which increases the difficulty of the verifying experiment.

2) initiative + autonomy + systematicness. According to the experimental requirements, the students learn the principles of experiments, instructions for use of instruments and instruments, and independently design experimental circuits. The circuit structure and parameters are autonomous. This way increases the initiative of learning and the interest of the experiment, avoids the students' copying of the data, improves the students' ability to eliminate the common basic faults, improves the basic experimental skills, strengthens the understanding of the theoretical knowledge, and makes

the students learn to transform the books on the books into practical circuits. . It lays a solid experimental foundation for subsequent design, comprehensive and independent experiments.

3) the level is distinct. The advanced experimental content design facilitates different requirements according to different teaching objects. Truly teach students in accordance with their aptitude.

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