# Application of Runner's Open Virtual Lab in the Reform of Analog Circuit Experiment Teaching

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**Abstract:** The analog circuit is a discipline with strong professionalism and many experiments. Therefore, it is necessary to reform not only in the teaching of this subject, but also to apply the virtual laboratory to teaching reasonably to improve teaching efficiency and teaching quality. Combined with the actual situation, the reform in the teaching of analog circuit is expounded, and the application of Runnier Open Virtual Lab is introduced. I hope it can help the relevant teachers.

## 1. Introduction

Virtual simulation experiment teaching is an important part of the construction of higher education information construction and experimental teaching demonstration center, and it is the product of deep integration of subject professional and information technology. In order to implement the "Opinions of the Ministry of Education on Comprehensively Improving the Quality of Higher Education" (Teacher [2012] No. 4), according to the "Education Informationization Decade Development Plan (2011-2020)" [1, 2], The Ministry of Education decided to launch the construction of a national-level virtual simulation experiment teaching center in 2013, one of the important contents of the management of virtual simulation experiment teaching. In the reform of modular teaching, we combined the Runner Open Virtual Lab with our school to solve the passive nature of student design experiment courses, improve students' interest in learning, and improve the solution to practical problems.

## 2. Problems in traditional simulation experiment teaching

At present, most colleges and universities have experimental teaching software for the course, but because of the different conditions of each major or course, the working environment, architecture, programming language, and development methods used in the purchased software are also different. Due to the complexity of school management, the experimental teaching construction of each school and even the majors in the school is mostly self-contained, and they are independent, forming an "information island" [3]. Mainly face the following problems:

(1) Confused management, lack of unified centralized management of various experimental teaching simulation software

The diversity of laboratory courses determines the diversity of simulation software. The simulation software installed in a laboratory is varied, the functions are not uniform, the versions are not uniform, and even different versions are installed due to the replacement of teaching materials, thus resulting in experimental teaching simulation. The software lacks unified centralized management.

(2) Poor scalability, unable to support the expansion of the course and the corresponding experiment

The factors of simulation software price, often colleges and universities cannot afford to purchase full scalability, often resulting in only the basic version, can only simulate simple experiments and cannot further improve and support the course update.

(3) The data of each system cannot be shared, and it is easy to form an "information island"

Due to the diversity of simulation software purchased, different simulation software is impossible or difficult to exchange and combine with other different types of simulation software, so that the data cannot be further comprehensively utilized.

(4) Lack of sufficient openness

The simulation software of most colleges is a stand-alone version or does not support the intra-campus LAN. That is, students must go to the laboratory to complete the experiment, or the students can use the extracurricular time to perform the experiment and review in the laboratory, which is subject to time and space constraints.

## 3. Based on Runnel Open Virtual Lab

To achieve effective management of experimental teaching resources, to achieve the sharing of experimental teaching resources within and outside the school, the region and a wider range [4], to meet the needs of multi-regional, multi-school and multi-disciplinary virtual simulation experiment teaching. Our school can realize the experimental teaching of computer, electronic and communication. It can be accessed at any time on campus, thereby realizing the experiment anytime and anywhere, getting rid of the time and space restrictions of the laboratory, greatly facilitating the students' learning.

It provides a full range of virtual experimental teaching support functions, including: theoretical study before experiment, experimental start-up management, maintenance of typical experimental library, experimental teaching arrangement, intelligent guidance of experimental process, automatic correction of experimental results and statistical results of experimental results, and the automatic correction of the experimental results greatly reduces the burden on the experimental teachers.

## 4. Discussion on teaching mode

Combining our school's Runnier open virtual laboratory platform, we use the model power as an example to explore the practical teaching mode. The platform provides 120 experimental equipment models in the model:

Signal source library: 10 common signal sources, 8 independent voltage sources, 7 independent current sources;

Basic component library: 2 kinds of resistors, 3 kinds of capacitors, 1 type of inductor;

Diode library: 10 common diodes, 10 Zener diodes, 5 rectifier bridges, 5 switching diodes, 3 Schottky diodes, 3 thyristors, 3 bidirectional switching diodes, 5 bidirectional, thyristors, 5 PINs Diode, 5 varactor diodes;

Transistor library: 14 NPN transistors, 13 PNP transistors;

Analog integrated component library: 5 common operational amplifiers;

Virtual instrument: dual channel oscilloscope, four channel oscilloscope, eight channel oscilloscope, spectrum analyzer, frequency meter, Bode plot analyzer, voltage probe, differential voltage probe, DC voltmeter, AC voltmeter, DC ammeter, AC ammeter Victory multimeter VC9802A, fixed-latitude signal generator AFG-2005, Tektronix oscilloscope TBS1102, current probe.

### 4.1 Ideas

Under normal circumstances, in the teaching of analog circuits, the theoretical and experimental courses are separate, and the two are independent of each other, so in the actual teaching process, there will inevitably be a disconnect between theory and practice, mainly in the disconnection between time and content, the verification test in the teaching process cannot deepen the students' understanding of the teaching content in time, which leads to the greatly reduced teaching effect. In the process of teaching, for the sake of completeness, some experiments with simple operations and obvious conclusions are often arranged, which wastes the experimental course. In the process of teaching, this phenomenon should be rationally reformed, and the content of classroom teaching and experimental teaching should be coordinated. After the end of classroom teaching,

corresponding verification experiments should be arranged; part of the theoretical course can be carried out on the experimental course, and the theoretical knowledge can be taught while doing experiments [6]. For each verification experiment, design the corresponding preview, use the open virtual laboratory instead of the physical experiment content, let the students complete it in the dormitory or the library, and automatically correct the experimental results to know how they master the experiment.

It has been proved by practice that the adoption of this teaching method not only solves the teaching time, but also improves the management ability of students in self-learning. In addition, the open virtual lab simulates the experimental conditions and environment through a computer. Students can conduct multiple experiments and modify the parameters during the experiment to exercise the students' innovative ability.

## 4.2 Teaching examples

The transistor common-emitter single-tube amplifying circuit in the analog circuit is taken as an example.

The purpose of this experiment is to learn the debugging method of the static working point of the amplifier and analyze the influence of the static working point on the performance of the amplifier. Master the test methods for amplifier voltage amplification, input resistance, output resistance, and maximum undistorted output voltage. Familiar with the use of common electronic instruments and analog circuit experimental equipment.

Experimental equipment: signal generator, oscilloscope, DC power supply, multimeter, transistor, resistor and capacitor, etc.

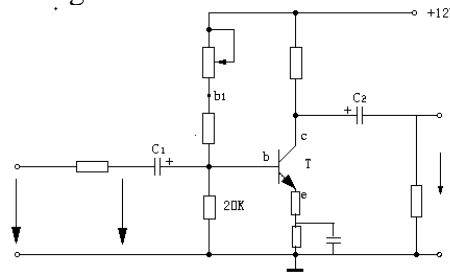The circuit diagram is shown in Figure 1.



Figure 1. Experimental circuit diagram.

Through the purpose of the experiment, one of the purposes of the experiment is to familiarize with the use of experimental equipment. The most difficult equipment in this experiment is an oscilloscope. In the above discussion, the freedom and initiative to familiarize themselves with the experimental objectives of the experimental equipment can be delivered to the students, let them complete the familiar equipment in the dormitory or other places on the campus time, thus saving the time for formal classes and improving the students' ability to learn independently [5].

According to the circuit diagram requirements, the connection of each experimental component is completed as shown in Figure 2.
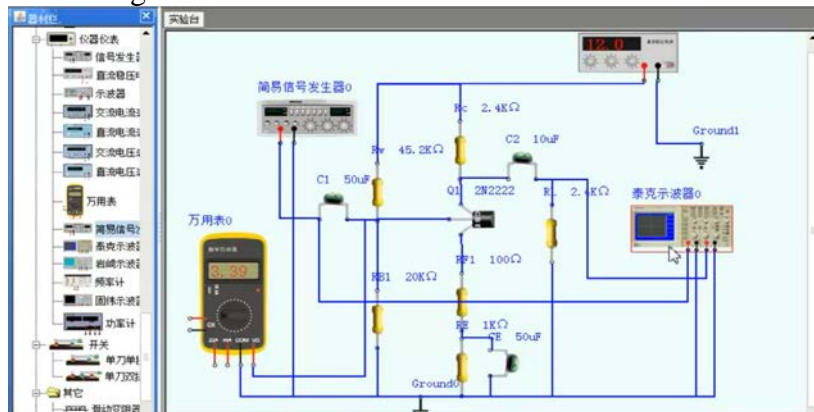


Figure 2. Link completion of the experimental components.

The experimental results of the connection completion are very different. The experimental link diagrams with neat and clear lines are often refreshing, but these require time and repeated practice, this content can reserve students to complete their own after class, exercise the meticulous spirit of the experiment.

The debugging of the static working point of the amplifier refers to the adjustment and testing of the collector current IC (or UCE) of the tube.

Whether the static operating point is appropriate or not has a great impact on the performance and output waveform of the amplifier. If the working point is too high, the amplifier will easily produce saturation distortion after adding the AC signal. At this time, the negative half cycle of UO will be cut off, as shown in (a) of Figure 3; if the operating point is low, the cutoff distortion is easy to occur. That is, the positive half of the UO is shrunk (generally the cutoff distortion is not as obvious as the saturation distortion), as shown in Figure (b). None of these conditions meet the requirements for undistorted amplification. Therefore, dynamic debugging must be performed after the selected working point, that is, a certain input voltage ui is added to the input end of the amplifier to check whether the size and waveform of the output voltage uO meet the requirements. If not, adjust the position of the static working point.
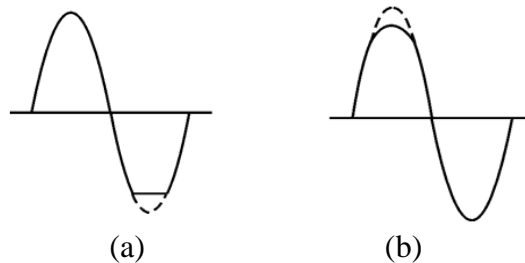


(a)                    (b)

Figure 3. Effect of static operating point on uO waveform distortion.

Changing the circuit parameters UCC, RC, RB (RB1, RB2) will cause a change in the static operating point, as shown in Figure 4. However, the method of adjusting the bias resistor RB2 is often used to change the static operating point. For example, if the RB2 is reduced, the static operating point can be increased.
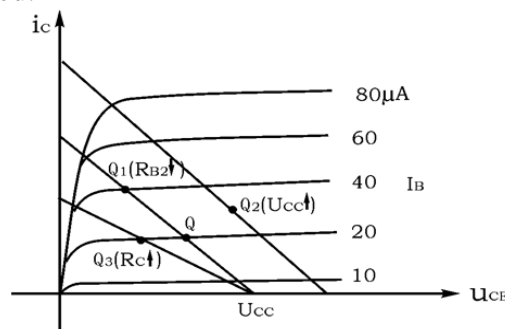


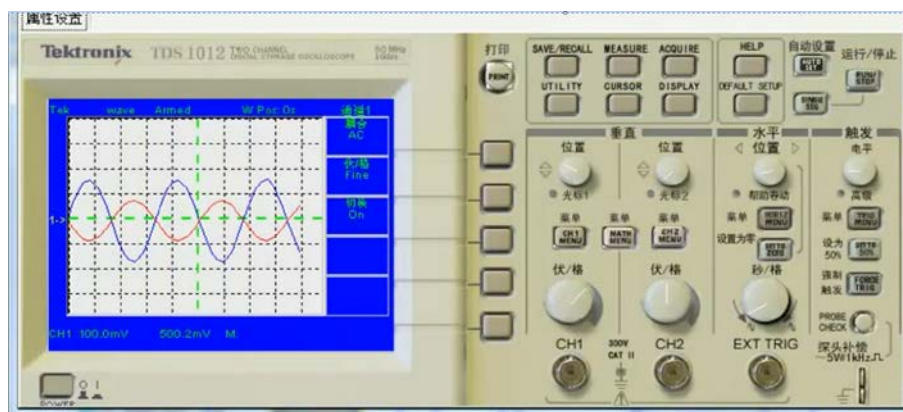Figure 4. Effect of circuit parameters on static operating points.



Figure 5. Virtual interface and result waveform of the virtual oscilloscope.

From the above analysis, we can see that there are many parameters affecting the results of this experiment. If the verification time may not be allowed in the traditional experiment, it is completely feasible in the open virtual laboratory. The time in the classroom can only complete the adjustment of the waveforms of some parameters, and the completion of all the parameter adjustment results can be reserved for the students to complete independently after class, and exercise the ability of students to learn independently.

Figure 5 shows the virtual interface and resulting waveforms of the virtual oscilloscope.

## 5. Conclusion

Apply the open virtual laboratory to the experimental teaching of analog circuit, and classify according to the difficulty of teaching content [5]. For simple, you can give the initiative to students, exercise self-learning ability, and improve their ability to solve problems independently. For complex experiments, it can be done in the laboratory under the guidance of a teacher [7]. This teaching method and means of reform effectively matched the implementation of open virtual experiment teaching, promoted the development of high-level experimental teaching activities, and achieved good results.

## Acknowledgments

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