Research on Experimental Course Reform of On-line Circuit fault Identification

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Abstract: Electrical and electronic technology courses cultivate students' basic knowledge and skills in electrical engineering, and improve students' thinking ability, practical ability, communication and collaboration ability. The requirements for students' experimental hands-on ability are extremely high, to meet the needs of students in the current post. The purpose of circuit fault identification experiment is to train students' ability of circuit fault location and type finding and circuit fault solving. This kind of experiment is usually carried out for students through fixed faults. The fault point and fault type are fixed, which is difficult to change and has poor practicability. Using a remote on-line practice platform based on ELF-BOX, the operation is similar to virtual simulation, and flexible settings can be realized. In fact, the actual components are operated. It can well solve the problems encountered in the current circuit fault identification experiment and improve the experimental effect and thinking ability of students.

1. Introduction

Diagnosing and repairing circuit or system faults is one of the important skills in electronic technology experimental research[1]. Diodes, transistors and integrated operational amplifiers have broad engineering application backgrounds. Students in the field of electronic design need to be familiar with the performance of these devices, and at the same time, they need to be able to find the faults that often occur in these devices and the reasons why they cannot work properly due to circuit design[2].

Most students are good at theoretical analysis and calculation and have little contact with actual components, which leads to serious disconnection between theory and practice[3-4]. This realization is to solve the current situation, improve students' ability to analyze and solve practical circuit faults.

The training of fault identification ability revolves around the two key points of fault identification and fault location, focusing on cultivating the logical thinking ability of combining theoretical knowledge with practice, correctly formulating and adjusting fault identification plan in time[5-6]. Training with the aid of tools, carry out efficient detection, and continuously narrow the scope of failures, until the actual operation ability to find the point of failure.

2. Circuit Fault Identification Methods and Strategies

There are many kinds of circuit failure phenomena, and there are many possibilities for one phenomenon, so it is more necessary to master the correct methods and strategies to troubleshoot[7-8].

One or more problems may cause the same failure phenomenon. Therefore, when the circuit fails, all possible factors that cause the failure should be considered.

2.1. Observation

The first step in troubleshooting is to determine whether there is a fault in the circuit under test through some signs. Some faults are obvious and can be detected with eyes and nose; some faults

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are more concealed and need to be powered on, or even add a debugging signal, and measure with the help of an instrument. Therefore, there are usually two ways to find fault signs.

2.1.1. Detection by Observe

In many cases, the failure of a normal working circuit is not caused by component failure, but caused by open circuit problems caused by loose wiring, poor contact or poor solder joints, or short circuit problems that may be caused by spattering of wire ends and solder swarf. Mistakes such as not plugging in the power supply or disconnecting the signal source often occur. Wrong parameters in the circuit (for example, incorrect resistance value), wrong signal source frequency setting or wrong output connection may also cause the circuit to work abnormally. The above-mentioned fault phenomenon is obvious, and it can be found and corrected by observing it with eyes.

2.1.2. Detection by Measure

If the eye cannot detect the fault, it has to be measured with instruments. Measure the voltage, current or waveform of the key test point or target test point of the circuit or system. When the measured value is inconsistent with the theoretical value (expected value), the circuit or system can be determined to have a fault (need to adjust) and enter the fault removal process.

2.2. Analysis

Analyze the symptoms of the failure and list the possible causes of the failure. In the analysis process, the same failure phenomenon under different application backgrounds should be treated differently. For example, the possibility of failure caused by incorrect or missing components may occur on a newly soldered circuit board; and for a circuit board that has worked normally, the above factors do not need to be considered. The corresponding relationship between the working conditions of the fault circuit and the possible causes of the fault is shown in Table 1.

Table 1 Relationship between the working status and possible causes of fault circuit.

Cause of failure	Circuit working state	
	Not working/not working normally	Working normally
Wrong component connection or improper parameter selection	√	
Circuit connection error	√	
Incorrect connection of instrument power supply and common ground	√	√
The instrument is damaged or improperly used	√	√
Damaged components	√	√
Internal breakage of connecting wire	√	√
The exposed part accidentally touches and short-circuits	√	√
Poor contact of circuit connection points	√	√

2.3. Plan

A variety of failure possibilities need to be eliminated one by one through measurement, and a logical plan for troubleshooting can be made, which can improve the efficiency of detection. Before making a troubleshooting plan, you must review the circuit diagram (schematic diagram), operating instructions, and other related information to clarify the working principle of the circuit. Mark the correct voltage value at each test point on the schematic diagram as a reference for positive and false judgments. Then, according to the possible failure factors listed in step 2, the order of measurement is drawn up, and with the help of tools, a well-thought-out measurement is carried out. Every time you take a measurement, you must make it clear what you are looking for. By fitting the fault symptoms to the measurement results, locate the fault.

2.4. Adjustment

It is rare to develop a complete troubleshooting plan covering all possible failures from the beginning. According to the measurement results, the measurement plan is adjusted time and time again, the fault range is reduced, and small-scale adjustments are made. When there are unexpected results in the measurement, it is necessary to confirm whether the current problem-solving direction is correct, or a new direction should be considered. At this time, a large-scale adjustment of the measurement plan is required. The process of troubleshooting often involves multiple cycles of planning, measurement, adjustment and re-measurement, constantly focusing on the fault target until the exact fault location is found.

3. On-line Circuit Experiment Platform

During the implementation of the circuit fault identification experiment, the circuit test box in the past has a fixed circuit, and the fault location and type are fixed and cannot be changed. As a result, many students do not identify faults by themselves during the experiment, but ask students who have done the experiment in advance to get the location and type of circuit faults.

In order to change this kind of teaching malpractice and improve the exercise effect of experimental courses on students, an on-line circuit experiment platform ELF-BOX is used. Through remote appointment, automatic identification of electronic components, remote connection, remote control of instruments and meters, collection of experimental process data, and submission of experimental reports for teachers to review and other functions, real experiments have been put on the Internet. The platform includes experimental content such as signals and systems, digital-analog electronics, electronic circuits, and electronic competitions. At the same time, teachers and students can design experiments independently according to the open interface of school teaching, which greatly exerts the creativity and design of users, and provides practical and checkable big data for enterprise employment. The typical architecture of the on-line circuit experiment platform ELF-BOX is shown in Figure 1.

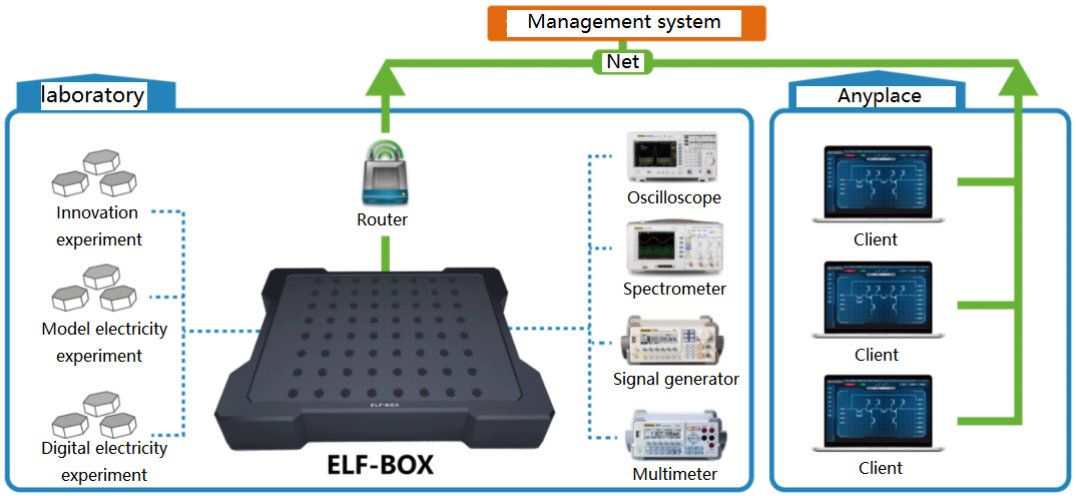

Figure 1 ELF-BOX typical architecture.

4. Design of On-line Circuit Fault Identification Experiment

For the design of the circuit fault identification experiment course, students are given the same circuit diagram, but the type of component failure in the ELF-BOX remote on-line practice platform is unknown, so that students can really master the method of circuit fault identification through the experiment.

Take the characteristic experiment of basic components as an example to illustrate the design. The purpose of this part of the experiment is to let students master the characteristics of resistors, diodes, transistors and integrated operational amplifier devices and their typical circuit working

principles.

In the ELF-BOX remote on-line practice platform software, use the given electronic components (some of which are faulty), and build the circuit according to the experimental circuit diagram 1-3. According to the circuit connection and the voltmeter or current indication, the OAPA fault identification process is used to diagnose circuit faults, and the diagnosis process and diagnosis conclusions are recorded in the "OAPA Fault Identification Process Record".

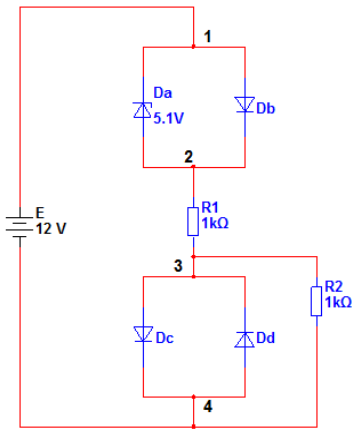

Figure 2 Experimental circuit diagram 1.

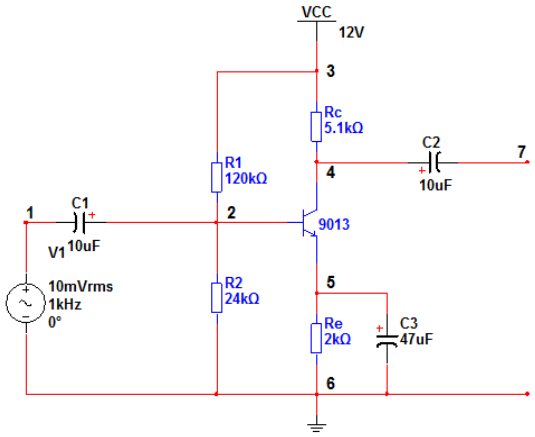

Figure 3 Experimental circuit diagram 2.

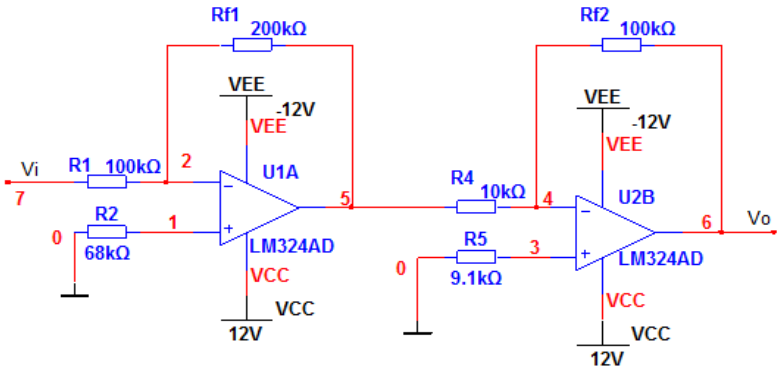

Figure 4 Experimental circuit diagram 3.

Table 2 OAPA Fault Identification Process Record.

Circuit diagram(XXX)		
Fault identification process	Details	Remark
Observation(O)		
Analysis(A)		
Plan 1(P)		
Adjustment 1(A)		
Plan 2(P)		
Adjustment 2(A)		
.....		
Conclusion		

There are faults in the circuit, and every component or even every node may be the target of the fault. The method of sequential inspection one by one is feasible for faulty circuits with few components and simple circuit structure. But for complex circuits, fault identification strategies are needed to improve troubleshooting efficiency. In the OAPA process, analysis and planning measurement are the key links. Only by determining the direction of analysis and planning based on

the symptoms of the faulty circuit and the characteristics of the circuit structure can the effectiveness of each measurement step be improved.

4.1. Sub-Module Processing

If the fault circuit is a system composed of multi-functional modules, the fault system should be divided into several modules according to function in the fault analysis (A). The functional module with the strongest correlation with the fault phenomenon is the first goal of fault identification. If there is no strong correlation, perform functional inspections on each module one by one according to the possibility sequence of the analysis, and lock the faulty module from the inspection results. Such an analysis method is conducive to quickly narrowing down the fault range.

Take Figure 4 as an example, if the fault phenomenon is that the output terminal of the two-stage operational amplifier circuit does not amplify the output signal. The analysis idea can be: the circuit is composed of two stages with independent DC bias. If the first or second stage is faulty, neither can amplify and transmit the signal, so the first and second stages have the same degree of correlation with the failure phenomenon. Then the subsequent planning measurement is divided into the front and the back two levels, and the magnification function is checked, and the fault range is located at the level where the magnification function is abnormal.

4.2. Feature Test Points Finding

Before embarking on fault identification, it is necessary to grasp the material of the node voltage or waveform when the faulted circuit is working normally. In the OAPA fault identification process, plan and measure characteristic circuit nodes first, because such a measurement can often master a large amount of information, which helps to shorten the fault identification process. Characteristic circuit nodes include: power or signal source access terminals; diode ends, regulated output terminals, resistor fixed voltage dividers, clamp circuits, etc., nodes at which the voltage value in the normal state can be ascertained.

Taking Figure 2 as an example, the task of the experiment is to find faulty components and branches in the circuit. Voltage of node 1 and node 2 is characteristic. If U12=5.1V is measured, it means that the parallel diode Db branch is invalid; and if U12=0.6-0.7V, it means that the Db branch is working normally.

Take Figure 3 as an example, if the fault phenomenon is that the amplifier circuit has no output. The measurement sequence of representative nodes for DC measurement is as follows:

(1) UCC: Effective power connection is a prerequisite for DC detection.

(2) U2: Obtained by the partial pressure of R1 and R2, if it is abnormal, check R1 and R2 first.

(3) U_{BE}:Transistor emitter junction voltage, the normal value is 0.6-0.7V, if it is not normal, check the base bias first.

(4) U_{RC}:It indirectly reflects the collector bias state. If the value is larger, the transistor may break down, and if the value is too small, it may open.

5. Conclusion

The circuit fault identification experiment class uses the ELF-BOX remote on-line practice platform, which makes the design of the experimental circuit and the implementation of the fault setting have great flexibility, and it also has the function of the whole process of experiment recording. Students do not know the fault points and fault types of the circuit when doing experiments, and they need to have strong theoretical knowledge and analytical skills. You can also learn about students' mastery through the entire process of experiment records, and guide the design and development of subsequent experimental courses.

In the follow-up, ElF-Box remote on-line practice platform can be used to design more experiments close to actual needs, and at the same time, a complete examination question bank of electrician maintenance skills can be established. Examination Students can perform electrical maintenance skills examination and certification anywhere on the Internet using ElF-Box remote on-line practice platform.

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