Research on the teaching mode of "Integration of Theory and Virtual Simulation" in the course of "Analog Electronic Technology"

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Abstract: The abstracted model from engineering practice is the research object in the course of “analog electronic technology”, which has strong theoretical characteristics, abstract and obscure knowledge points, and it is difficult to combine with practice. By adopting the teaching mode of “integration of theory and virtual simulation”, Multisim virtual simulation can effectively solve the phenomenon of disconnection between theory and practice and low enthusiasm of students in previous teaching methods. It combines theoretical mastery with practical application, the students' subjective initiative is fully mobilized, and the students' ability is effectively trained and exercised, so the quality of teaching is improved.

1.Introduction

The course of "Analog Electronic Technology" is a compulsory basic course for most engineering majors in colleges and universities, which has strong theoretical and practical characteristics. As the research object of the course is a model abstracted from engineering practice, the content of the course is characterized by more concepts, more symbols, more principles and less practice[1]. It is difficult for teachers to teach and students to learn, the knowledge points of the course are abstract and obscure, and the theoretical knowledge is too much. In addition, the "spoon-feeding" teaching is often used by teachers, so the learning effect of students is not satisfactory[2] and the failure rate is high, which is called "magic electricity" by students.

In the traditional teaching mode of "analog Electronic Technology" course, The theoretical course and the experimental course are separated in time and space, and theoretical learning is carried out first, followed by experiments. Due to the limitation of students' knowledge reserve and experimental study time, experimental classes are often concentrated in the middle and end of the semester. When students start experiments, the theoretical knowledge they learned earlier is gradually forgotten, which leads to the separation of theoretical classes from practice and the lack of theoretical support for practical training.

Based on the above situation, in order to improve students' understanding of analog circuits, the course can adopt the teaching mode of , the teaching mode of "integration of theory, virtual simulation and experiment" can adopted in the course of "analog electronic technology", that is, "integration of theory and virtual simulation" is adopted in class and "integration of virtual simulation and experiment"is adopted in after-class, then theoretical knowledge and experiment are connected through virtual simulation.

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2.Implementation of the teaching model[3-5] of "integration of theory and virtual simulation"

The content of the analog electronic technology course can be divided into four parts[6], the first part is basic knowledge and basic components; The second plate is the basic amplifier circuit; The third section is other basic amplifying circuits, the main content of this section is based on basic amplifying circuits, explaining differential amplifying circuits, feedback amplifying circuits, power amplifying circuits and operational amplifying circuits; The fourth section is the application of devices and amplifying circuits.

In the course of teaching, in addition to the normal use of blackboard writing and multimedia courseware, the practical operation demonstration of Multisim simulation software[7] is introduced in class at a timely time, and the virtual simulation software Multisim is introduced into the class, homework and practice links to integrate with the teaching content. Through the simulation process, students' understanding and mastery of theoretical knowledge are strengthened. At the same time, it is connected with the experimental and practical links of the curriculum. Through the teaching exercise in class and the practical operation training of students after class, the training amount of students is increased, and the result of training is that they can skillfully operate software and build circuits. Simulation training also exercises students' eye for error checking and correction. Students learn from doing, learn to do, learn to think, analyze and solve problems, and naturally improve their ability.

The following is an example to discuss the teaching mode of the integration of theory and virtual simulation for common emission amplifier circuit of transistor based on partial voltage bias.

When explaining the common emission amplifier circuit of transistor, it is mainly divided into two parts: static analysis and dynamic analysis. Static analysis is based on the DC path of the circuit without adding the AC signal. The setting of static operating point directly affects the dynamic performance of the circuit (normal amplification, saturation distortion and cut-off distortion). The dynamic analysis is based on the AC path of the circuit, and the analysis is carried out with the addition of AC signal. By drawing the microvariant equivalent circuit of the circuit, the circuit magnification, input resistance and output resistance and other parameters are obtained. However, there is a difference between the experimental testing process or the practical design process and the theoretical analysis process. Even if the students learn the theory thoroughly, there will be a phenomenon that they are unable to start in the experiment process. In order to solve this problem, after the theoretical analysis and explanation in class, the Multisim circuit is built for simulation test and the circuit function is demonstrated in class. After class, students set up Multisim simulation circuit by themselves and adjust circuit parameters on site according to simulation data, so that students can intuitively observe the changes of circuit output. Supplemented by appropriate theoretical analysis, students can deepen their understanding of theoretical knowledge and stimulate their interest in learning. Experimental phenomena can be observed by adjusting circuit parameters, and problems can be found, analyzed and solved in the experiment. Theoretical knowledge is consolidated in practice.

3.Design and analysis of common emission amplifier circuit of transistor based on simulation

The transistor amplifier circuit can be divided into common emitter connection, common base connection and common collector connection according to the different connection modes of transistor, here the common emitter amplifier circuit with partial voltage bias is taken as an example. The analysis of the amplifier circuit includes static analysis and dynamic analysis. Whether the static operating point is reasonable is closely related to the dynamic performance of the transistor. The analysis of dynamic characteristics is mainly: on the basis of setting a reasonable static operating point, the magnification, the input resistance and the output resistance of the transistor are measured, and the influence of the position of the static operating point on the output waveform is mastered.

3.1.Static operating point adjustment of the common emission amplifier circuit of the transistor

According to the theoretical explanation content and requirements, a common emission amplifier circuit with partial voltage bias is designed in Multisim, as shown in Figure 1. When the input signal is 0, the potential of the corresponding point and the corresponding branch current can be measured by setting the current and voltage probe. The theoretical calculation values, the simulation results of Multisim and the experimental circuit test results are compared and verified.

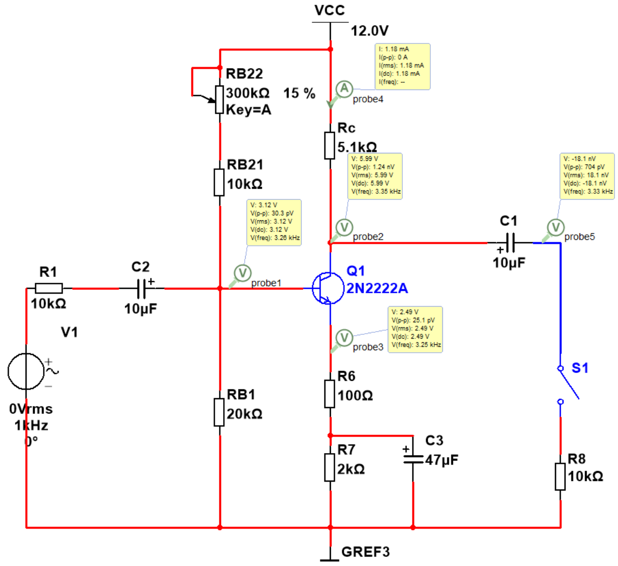


FIG.1 Simulation circuit diagram of static operating point adjustment

When analyzing the circuit theoretically, the base current is usually ignored. The junction voltage between the silicon transistor base and the emitter is usually calculated according to 0.6~0.8V, and here it is calculated according to 0.7V, so that the base potential, collector current and collector and emitter voltage are approximately as follows:

$$U_B \approx \frac{R_{b1}}{R_{b1}+R_{b21}+R_{b22}} \cdot V_{CC} = 3.2V \tag{1}$$

$$I_{CQ} \approx I_{EQ} = \frac{U_B - U_{BE}}{R_{E1}+R_{E2}} \approx 1.19mA \tag{2}$$

$$\begin{aligned} U_{CEQ} &= V_{CC} - I_{CQ}R_C - I_{EQ}\left(R_{E1}+R_{E2}\right) \\ &\approx V_{CC} - I_{CQ}(R_C + R_{E1} + R_{E2}) \\ &\approx 12 - 1.19(5.1+2.1) \approx 3.432V \end{aligned} \tag{3}$$

The specific parameters measured by Multisim simulation circuit are as follows: the base potential is 3.12V, the collector current is 1.18mA, the voltage between the collector and the emitter is 3.5V (the potential difference between probe 2 and probe 3), and the junction voltage between the base and the emitter is 0.63V (the potential difference between probe 1 and probe 3). Through the simulation circuit parameter test and the approximate calculation of the principle circuit parameter, it is found that the two values are similar.

3.2.Dynamic characteristics of the common emission amplifier circuit of the transistor

Dynamic parameters[8] such as magnification, input resistance (Formula 4) and output resistance can be obtained through the microvariant equivalent circuit of the circuit (as shown in FIG.2). While the actual circuit does not draw the microvariant equivalent circuit when calculating dynamic parameters, it can be obtained through the voltage and corresponding resistance at the input and output terminals of the circuit (Formula 5). This is the difference between the theoretical calculation and the actual circuit. At the same time, in the theoretical analysis of the circuit, it is impossible to see the influence of static operating point on the output waveform distortion, while the simulation circuit of Multisim can see the result visually (as shown in FIG. 3-6). This method not only deepens the students' understanding of the theoretical knowledge in class, but also connects with the practical circuit situation.

The specific practice is as follows: the RMS value of the input signal in Figure 1 is set 50mV, the switch S1 of the output loop is closed, multimeters (XMM1, XMM2) at the input and output terminals are added for reading the corresponding voltage, and an oscilloscope (XSC1) is added for observing the input and output waveforms, as shown in Figure 3 (on-load) and Figure 4 (no-load). The red waveform represents the input signal waveform, and the blue waveform represents the output signal waveform in the oscilloscope waveform diagram of Figure 3~6. Comparing the data of probe 5 in Figure 3 and Figure 4, it can be seen that the output voltage value is larger when the load is not loaded than when the load is loaded. The corresponding current and voltage value can be read from the simulation diagram, and the static operating point can be adjusted by adjusting the value of RB22. The influence of improper static operating point setting on the output waveform distortion can be observed in the oscilloscope, as shown in FIG. 5and FIG. 6. Set the range of RB22 to 95% in Figure 4, and the cut-off waveform as shown in Figure 5 can be seen in the

oscilloscope. Set the range of RB22 to 10% in Figure 4, and saturation distortion waveform as shown in Figure 6 can be seen in the oscilloscope.

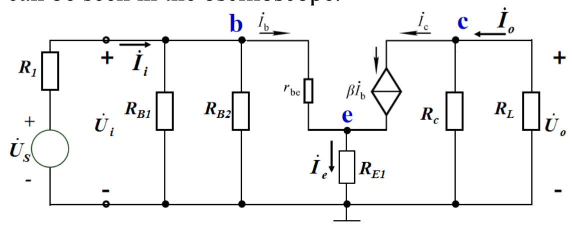
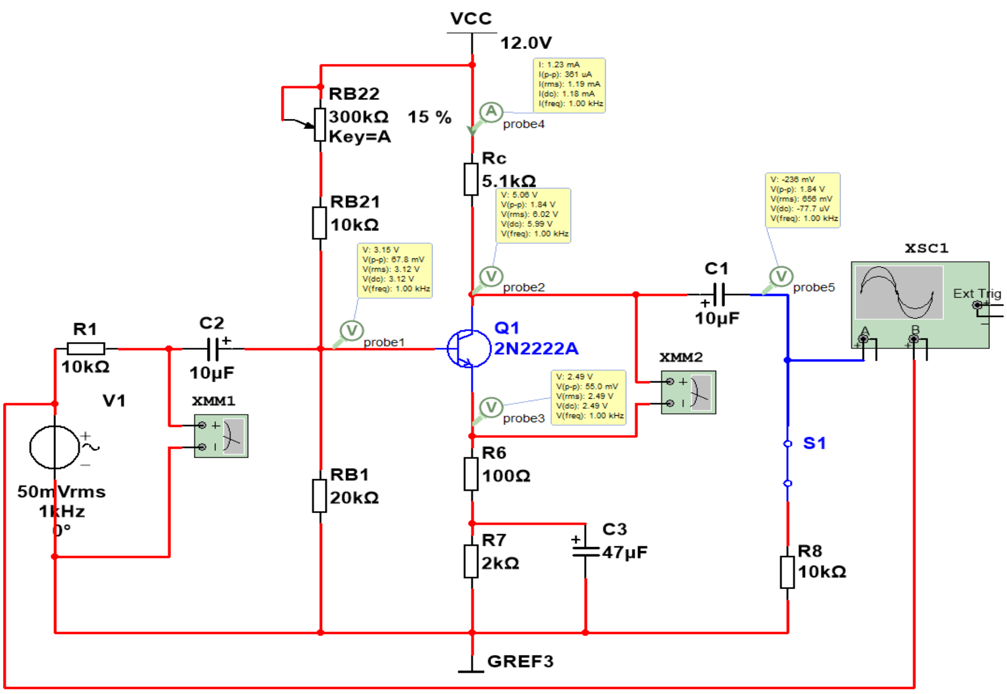


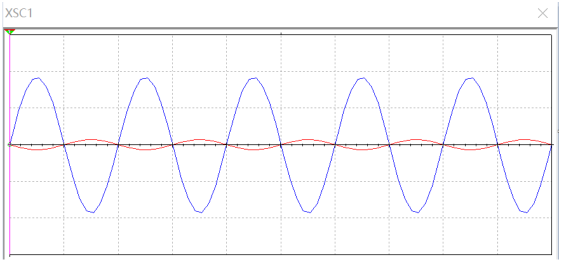
FIG.2 Microvariant equivalent circuit

$$R_i = R_{B1} // R_{B2} // [r_{be} + (1+\beta)R_{E1}] \tag{4}$$

$$R_i = \frac{U_i}{U_S - U_i} R_1 \tag{5}$$



(a)Simulation circuit diagram



(b)Oscilloscope waveform

FIG.3 Dynamic characteristic test simulation circuitdiagramofamplifier circuit (on-load)

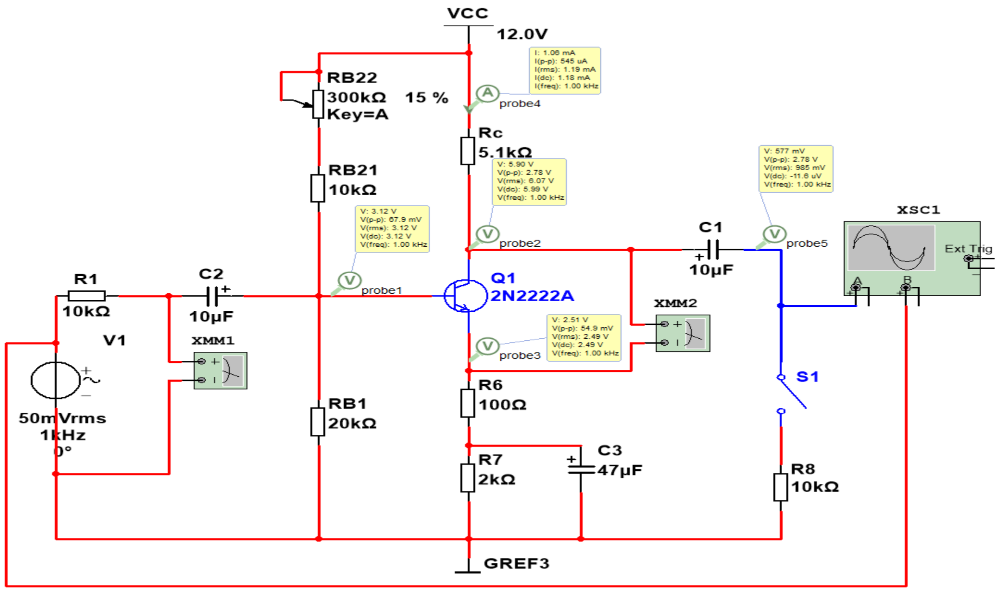


FIG.4 Dynamic characteristic test simulation circuit diagram of amplifier circuit (no-load)

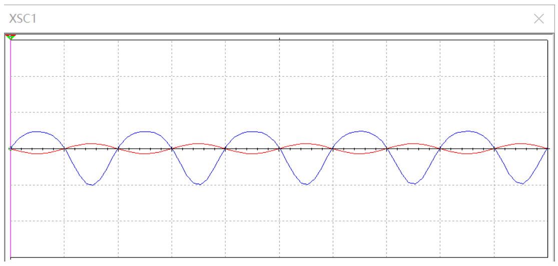


FIG.5 Cut-off distortion waveform

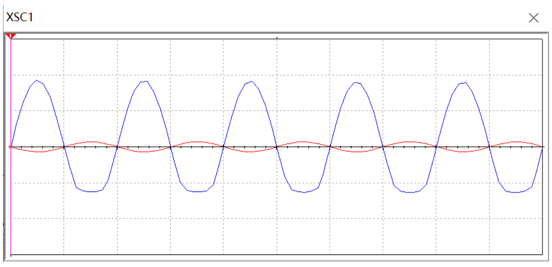


FIG.6 Saturation distortion waveform

4.Conclusion

"Analog Electronic Technology" is a course combining theory with practice. The teaching mode of integration of theory and virtual simulation is adopted in the course, which solves the problems of abstract and obscure knowledge points, excessive and difficult theoretical knowledge, and low enthusiasm of students. At the same time, this teaching mode breaks the barrier of separation of time and space between traditional theoretical teaching and experimental teaching, and teachers teach theoretical knowledge and demonstrate circuit virtual simulation in class. It can vividly solve the abstract theoretical knowledge that students cannot theorize, and students can simulate circuits, build circuits and debug parameters after class, which has a guiding role for experiments or practices. Through the integration of theory and virtual simulation, knowledge can be transformed from difficult to easy, and students' subjective initiative can be fully mobilized , students' professional interest is stimulated, and the quality of course teaching is improved.

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