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Practice Led Textbook Construction

-- Taking High-frequency Electronic Circuits as an Example

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Abstract

This article introduces the nature and teaching content requirements of the high-frequency electronic circuit course, proposes principles for textbook writing that are suitable for vocational college students, and designs high-frequency electronic circuit textbooks with simulation experiments and comprehensive training projects as the main innovative points.

Keywords

Practice Oriented; High Frequency Electrons; Simulation; Comprehensive Training.

1. Introduction

The course "High Frequency Electronic Circuits" has already been published as a project-based textbook, but for vocational college students, the content of the textbook is too deep and too much. Taking into account the professional direction and course hours, the selected textbooks either delete a considerable amount of content or compress practical class hours, which affects the teaching effectiveness. Therefore, it is very urgent and meaningful to write a practical guidance textbook that simplifies theoretical derivation, strengthens practical operations, and is suitable for vocational college students to integrate "teaching, learning, and doing".

2. Course Nature and Content

This course is an important compulsory vocational ability course and also a highly practical course. The function of the course is to equip students with basic knowledge, skills, and professional abilities such as high-frequency electronic circuit analysis, design, production, and debugging, improve their professional quality, cultivate their innovation awareness, and prepare for subsequent professional studies.

The learning content of this course includes small signal Tuned amplifier, high-frequency power amplifier, high-frequency signal generator, amplitude modulation and demodulation circuit, frequency modulation and demodulation circuit. The content is scattered, and students often find it difficult to learn and will not apply it after learning. In order to cultivate students into application-oriented technical talents, it is necessary to construct a course system that is guided by the work process, with vocational ability cultivation as the main line, and teaching projects as the carrier, combining engineering and learning. This course focuses on 7 work projects and organizes teaching through activities such as simulation, practical operation of high-frequency electronic circuits, and simulation production of electronic products. It connects all related knowledge and skill points together, advocating for students to learn while doing, and gradually cultivate their learning, work, professional, and vocational abilities, in order to achieve the ultimate goal of higher vocational education - to cultivate production High quality skilled talents in managing and serving the frontline. The course content and requirements are shown in Table 1.

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Table 1. Course content and requirements

Work tasks	Content	Teaching requirements
Composition and principle of communication system	Composition and modulation principle of communication system	Understand the composition and functions of wireless broadcasting communication systems, and be able to understand the basic principles of modulation
Testing of Tuned Amplification Circuit	Small signal resonant amplification circuit	Understand the composition, principle analysis and calculation of single Tuned amplifier, and understand the analysis of multi-stage single Tuned amplifier
	Centralized frequency selection amplifier	Understand the basic structure and principle of centralized frequency selection filters, and be able to analyze centralized frequency selection amplifiers
Design and Testing of Power Amplification Circuits	Class C resonant power amplifier	Able to test and calculate the power and efficiency of resonant power amplifiers
	Class D resonant power amplifier	Know the working state and advantages of Class D power amplifier and the working principle of Class C Frequency multiplier
Design and debugging of oscillation circuits	Principles and conditions of oscillation	Knowing the oscillation initiation and balance conditions, and using the instantaneous polarity method to determine whether the circuit meets the oscillation conditions
	LC oscillation circuit	Able to determine the type of oscillation circuit, calculate oscillation frequency, and know frequency stability
	Quartz crystal oscillator	Be able to determine the type of oscillation circuit and understand the role played by quartz crystals in quartz crystal oscillation circuits
Debugging of amplitude modulation and demodulation circuits	Multiplier	Understand the frequency conversion function of multipliers and the commonly used multipliers
	Analysis and Debugging of Amplitude Modulation Circuit	Understand the differences and specific generation circuits of AM, DSB, and SSB waveforms
	Analysis and Debugging of Amplitude Demodulation Circuit	Can analyze and test Envelope detector, and can test MC1496 product synchronous detection circuit
Debugging of frequency mixing circuit	Basic Principles of Frequency Mixing	Understand the principle and function of frequency mixing
Frequency modulation and demodulation circuit	Analysis and Testing of Frequency Mixing Circuits	Knowing the performance requirements of

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	Angle adjustment signal characteristics	frequency mixing circuits, able to analyze and test mixing circuits
	Analysis and Testing of Frequency Modulation Circuits	Know the expression, waveform, and bandwidth calculation of frequency modulation and phase modulation signals
	Discriminator circuit	Know the types and performance indicators of frequency modulation circuits, be able to analyze direct and indirect frequency modulation circuits, and know the method of expanding maximum wave deviation
		Know the implementation method of frequency discrimination and the working principle of slope discriminator

3. Principles of Textbook Writing

(1) Ability based principle: The cultivation of professional abilities is the goal of textbook construction, and textbook development should be enhanced in conjunction with students' comprehensive professional qualities.

(2) Practical guiding principle: Adhere to the teaching philosophy of integrating theory and practice, and moderately combine "doing while learning" and "learning by doing".

(3) The principle of "moderate and sufficient" theoretical knowledge: do not overly emphasize the systematic nature of knowledge, grasp the knowledge points, ability points, and job requirements of the textbook content, make the textbook content focus, have moderate capacity and length, and ensure that it can be accepted and mastered by students during normal teaching hours.

(4) Student centered principle: The construction of textbooks should focus on guiding students to participate in the teaching activity process, so that students can truly become the main body of learning.

(5) Principle of operability: The material content should be easy to implement and have operability.

4. Simulation Experiment Design and Comprehensive Training Project Design

The textbook features simulation design and the design of comprehensive practical projects, as detailed below.

4.1. Resonant Amplifier Simulation

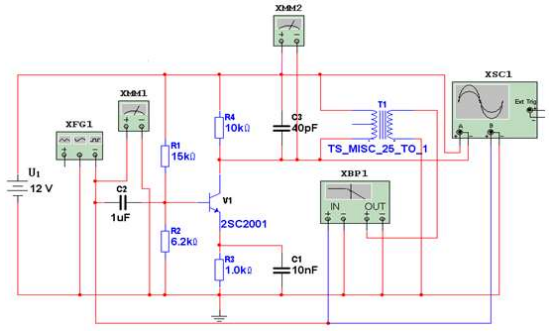

Figure 1. Single Tuned Loop Resonant Amplifier

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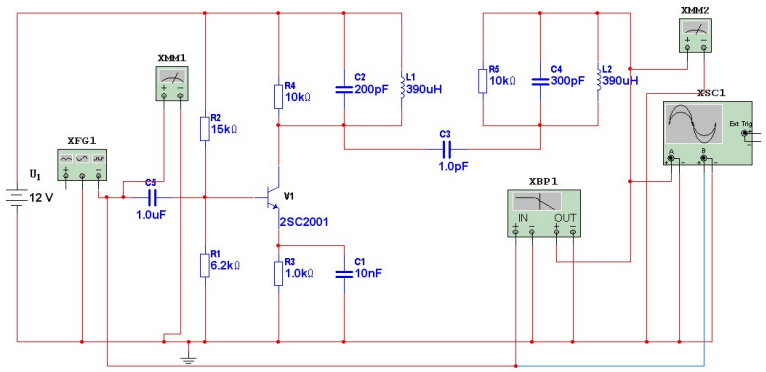

Figure 2. Circuit diagram of dual tuning loop resonant amplifier

The simulation circuit is shown in Figure 1 and Figure 2, completing the calculation and testing of the voltage gain, passband, and selectivity of the resonant amplifier.

4.2. Oscillation Circuit Simulation

Design two types of oscillation circuits, namely LC sine wave oscillator and quartz crystal oscillator, as shown in Figure 3 and Figure 4, to complete the oscillation period, frequency, and amplitude tests of the oscillator.

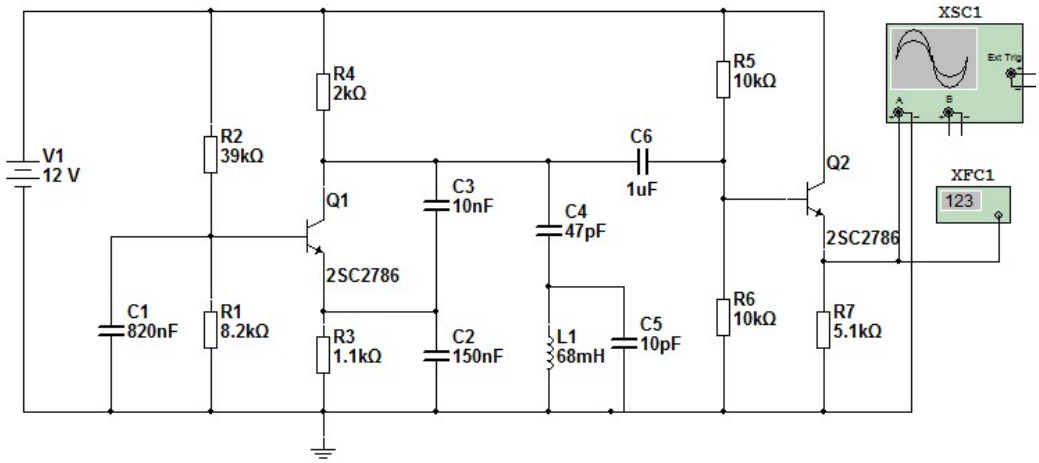

Figure 3. LC Sine Wave Oscillator

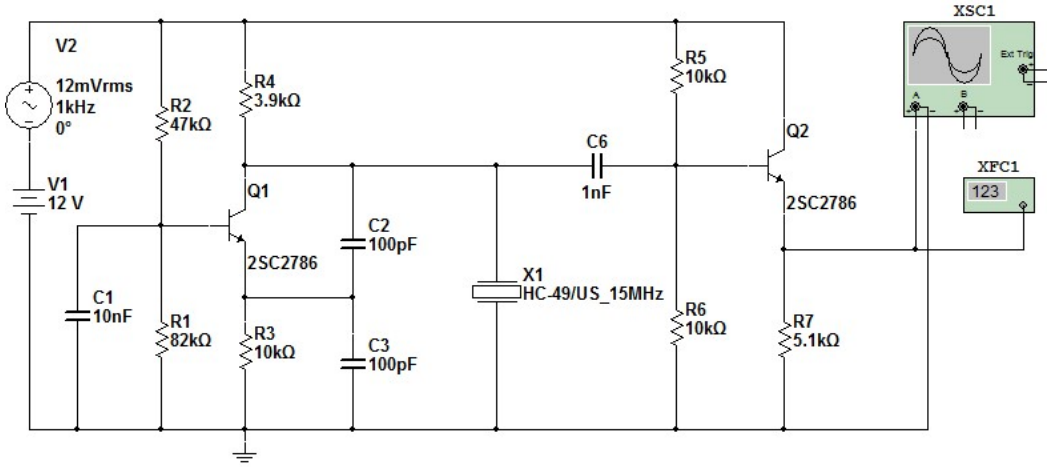

Figure 4. Quartz crystal oscillator

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4.3. Simulation of Class C Resonant Power Amplifier

Through simulation, master the tuning characteristics and dynamic characteristics of Class C resonant power amplifier when the load changes, and master the calculation method of Class C amplifier power and efficiency.

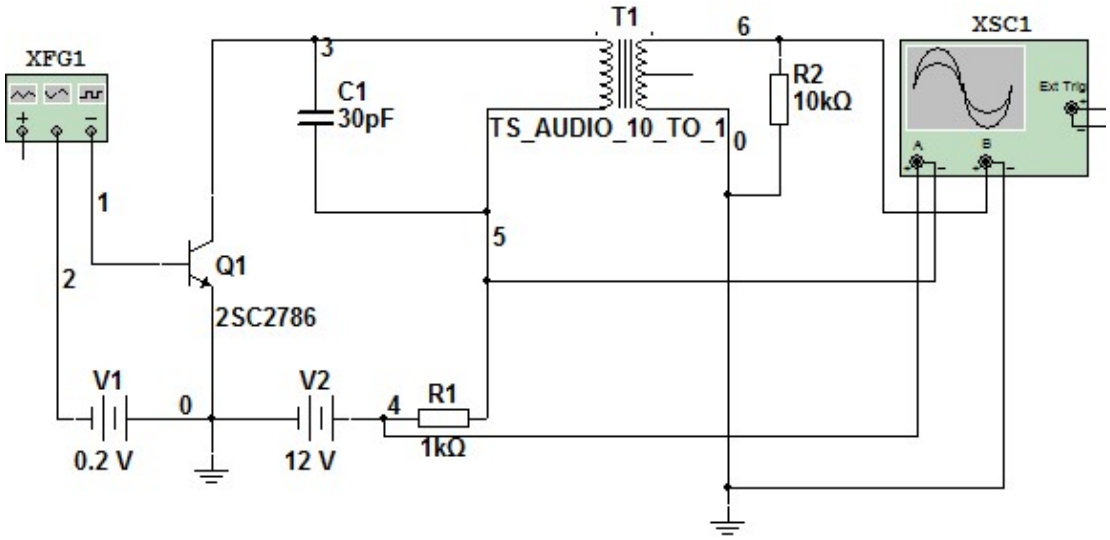

Figure 5. High frequency resonant power amplifier

4.4. Amplitude Modulation Circuit Simulation

Design an amplitude modulation circuit composed of ordinary amplitude modulation circuit, double-sided band amplitude modulation circuit, crystal collector amplitude modulation circuit, and MC1496 integrated circuit, as shown in Figure 6, Figure 7, Figure 8, and Figure 9. Provide testing and analysis of amplitude modulation waveform and spectrum diagram.

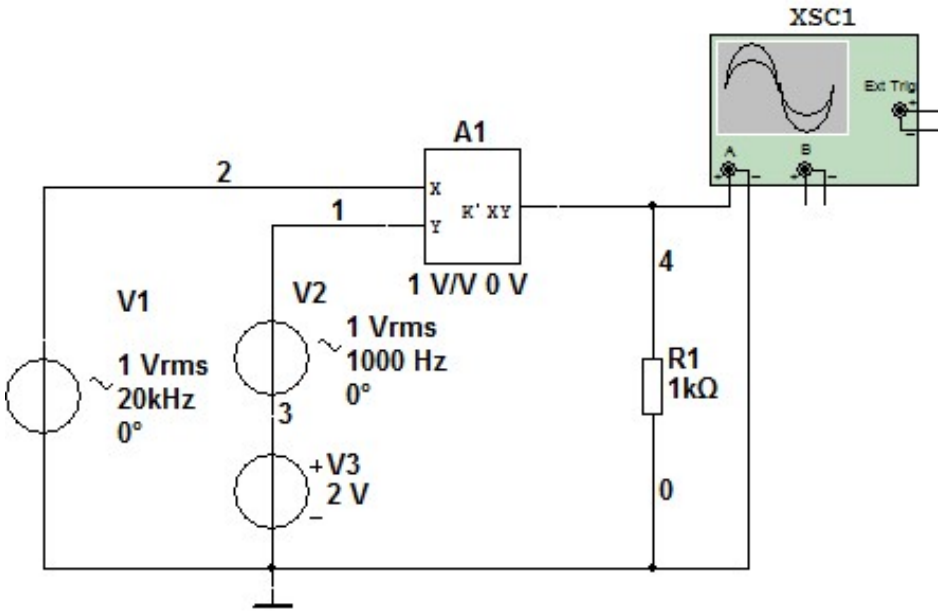

Figure 6. Ordinary amplitude modulation circuit

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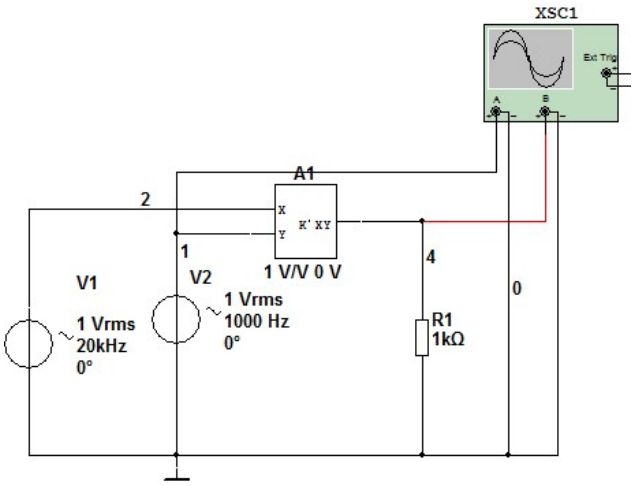

Figure 7. Double sideband amplitude modulation circuit

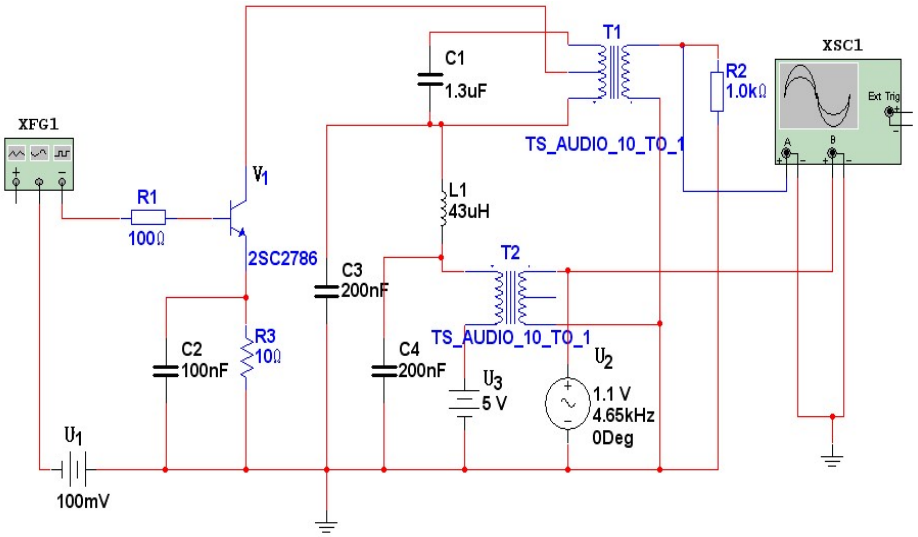

Figure 8. Collector AM

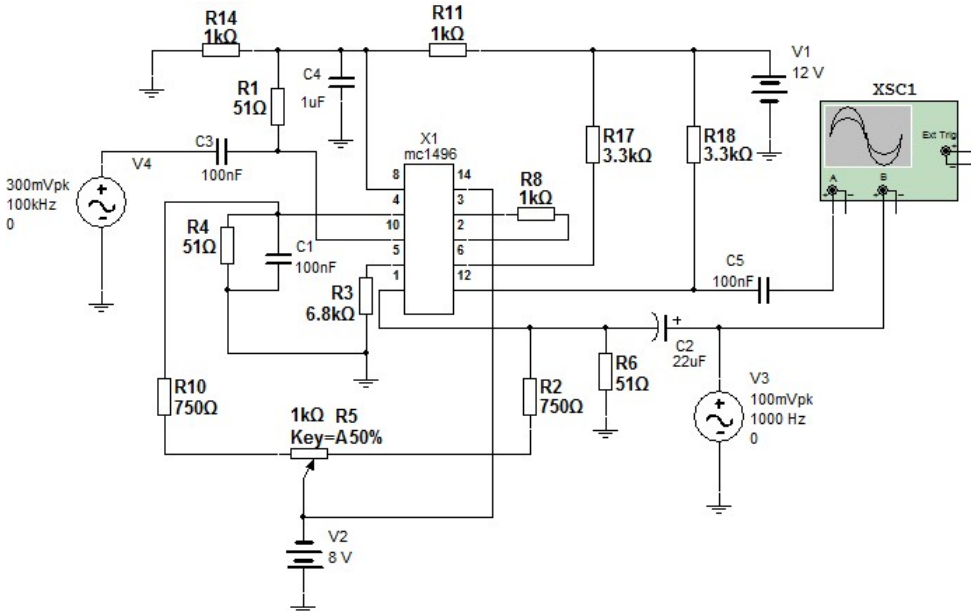

Figure 9. Amplitude modulation circuit composed of MC1496 integrated circuit

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4.5. Simulation of Amplitude Demodulation and Frequency Mixing Circuit

Design the diode envelope detection circuit, product synchronous detection circuit, and transistor mixing circuit as shown in Figure 10, Figure 11, and Figure 12, and complete the output signal waveform and frequency testing.

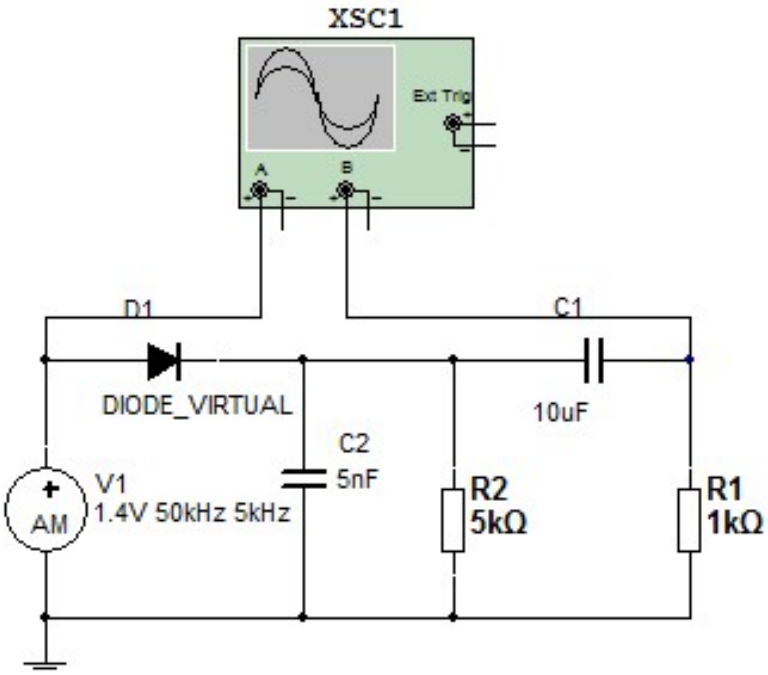

Figure 10. Diode envelope detection circuit

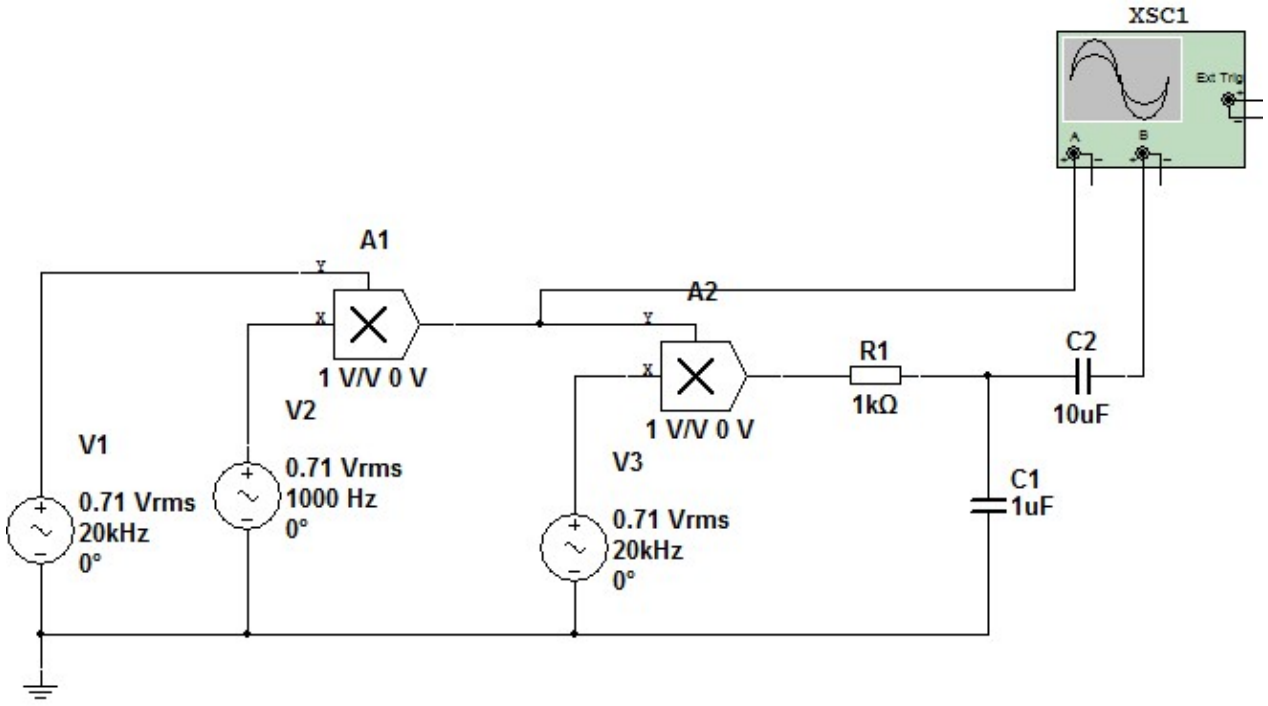

Figure 11. Product type synchronous detection circuit

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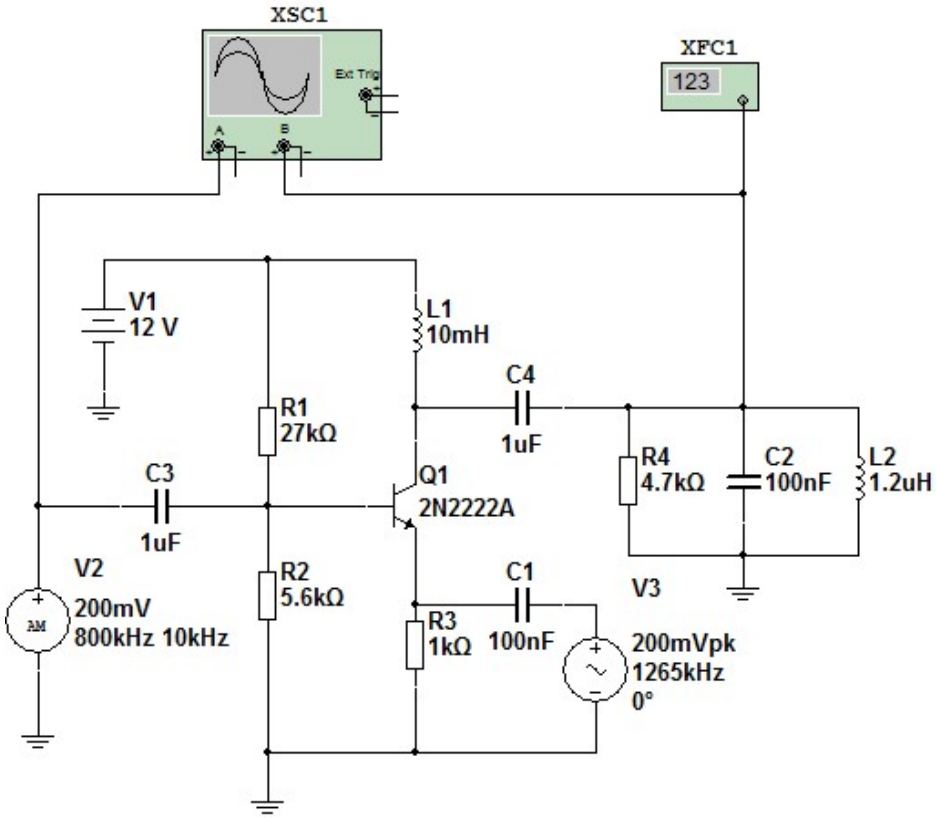

Figure 12. Transistor frequency mixing circuit

4.6. Simulation of Frequency Modulation and Demodulation Circuit

Design the frequency modulation circuit as shown in Figure 13 and the frequency demodulation circuit as shown in Figure 14, observe the input and output waveform transformation of the circuit, and understand the modulation characteristics of the frequency modulation circuit.

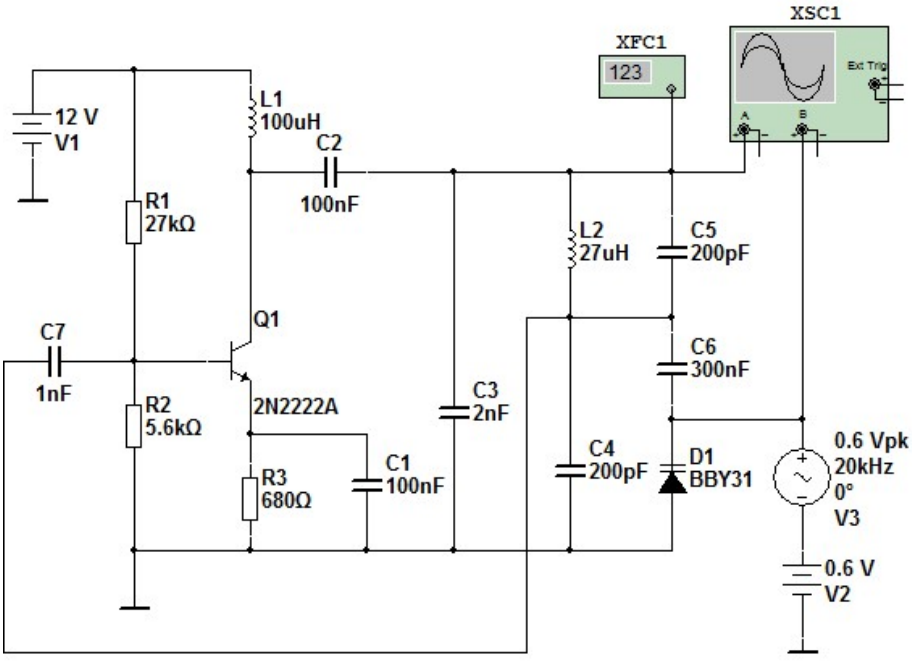

Figure 13. Variable capacitance diode frequency modulation circuit

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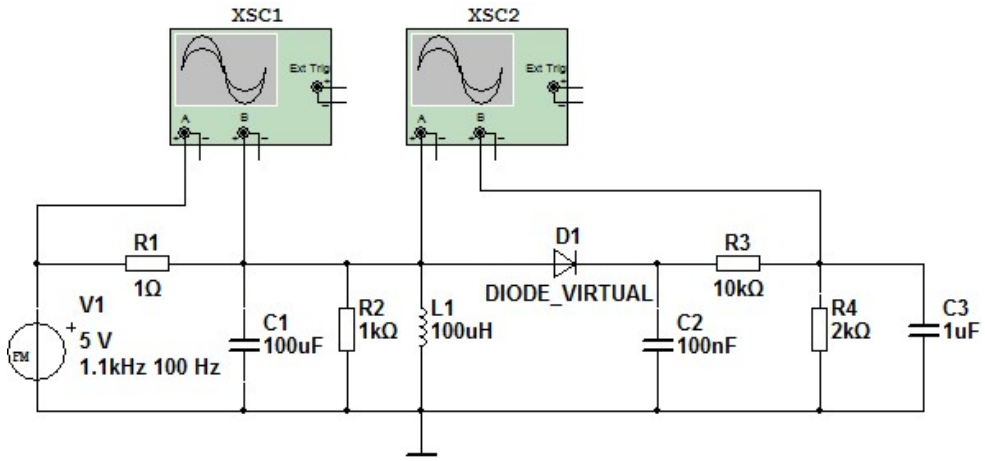

Figure 14. Single detuning loop slope discriminator

4.7. Design of Teaching Cases for Comprehensive Practical Training Projects

The production and debugging of a superheterodyne medium wave amplitude modulation radio is a comprehensive training project that connects most of the knowledge and skills points of this course, improves students' ability to flexibly apply knowledge, and cultivates their innovation ability.The corresponding relationship between the sub tasks of the comprehensive training project and the course knowledge and skill points is shown in Table 2.

Table 2. Correspondence between comprehensive training projects and course knowledge and skill points

Course knowledge points	Course skill points	Project Subtasks
Composition of communication system	Able to understand the basic composition of communication systems and identify the basic composition block diagrams of transmission and reception systems	Analysis of the circuit composition of Superheterodyne receiver
Small signal resonant amplifier	Able to correctly select small signal resonant amplifiers, calculate amplification factor, passband, and selectivity	Installation and debugging of high-frequency amplifier and intermediate frequency amplifier
High-frequency oscillator	Being able to correctly select different types of oscillators and determine the types and oscillation conditions of oscillators	Installation and debugging of local oscillator circuit
Frequency mixing circuit	Understand the principle of mixing and be able to distinguish the differences in signal waveform and frequency before and after mixing	Installation and debugging of frequency mixing circuit
amplitude demodulation	Able to identify envelope detection and synchronous detection, and know how to avoid distortion caused by envelope detection	Installation and debugging of Envelope detector
Feedback control circuit rate	Can understand the structure and working principle of automatic gain control circuits	Analysis of the Function of AGC Circuit

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5. Conclusion

Based on the cognitive characteristics of vocational college students, theoretical derivation and analysis should be minimized as much as possible, and simulation experiments should be added after each chapter to help students consolidate theoretical knowledge and compensate for the inconvenience caused by the limitations of experimental venues and equipment. And use a comprehensive practical project to integrate most of the knowledge and skills points in the book, cultivating students' comprehensive practical abilities. The practice oriented teaching materials are suitable for the short duration of vocational education and the relatively low level of students.

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