Design and implementation of microwave transmission courses based on virtual reality and oriented towards future education

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Abstract. "Fundamentals of Microwave Technology" is a compulsory course for undergraduate majors in Electronic Science and Technology, playing a connecting role in the microwave series of courses. The course aims to face future education, and is designed and implemented based on virtual reality systems from aspects such as course characteristics, teaching objectives, learning situation analysis, content design, teaching concepts, and teaching methods. The idea of informatization runs through the entire course, and immersive teaching and experiential teaching are integrated throughout the course. The course design has clear ideas, complete content, and diverse methods, providing reference for the design and implementation of future oriented and virtual reality based courses.

Keywords: Virtual reality; Future education; Design; Implement

1 Introduction

"Fundamentals of Microwave Technology" is a compulsory course for undergraduate majors in Electronic Science and Technology [1], and is one of the microwave series courses. It plays a connecting role in the microwave series courses, mainly studying the basic principles, methods, and applications of microwave passive devices [2]. The microwave series of courses includes "Electromagnetic Fields and Waves", "Fundamentals of Microwave Technology", "Antennas and Wave Propagation", "Microwave Circuits and Systems", "Electronic Measurement Technology", etc. Among them, "Electromagnetic Fields and Waves" explains the theoretical foundation of microwave, "Fundamentals of Microwave Technology" explains microwave transmission and passive transformation, "Antennas and Wave Propagation" explains microwave radiation and propagation, "Microwave Circuits and Systems" explains microwave generation and active transformation, Electronic Measurement Technology "explains microwave measurement. In the early stage, I have taken courses such as "Electromagnetic Fields and Waves" and "Fundamentals of Circuit Analysis". Through studying this course, I have laid the foundation for future courses such as "Microwave Circuits and Systems"

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and "Antenna and Wave Propagation". The course "Fundamentals of Microwave Technology" [3] aims to face future education [4-5], and is designed based on virtual reality systems [6-7]. It integrates information technology teaching methods [8] and educational technology [9] throughout, vigorously improving teaching effectiveness.

2 Course design

2.1 Course features

The characteristics of this course are mainly reflected in the following three aspects:

One is its wide coverage. The teaching content involves transmission lines, microwave components, and microwave devices, with a wide variety and coverage, and high requirements for students' theoretical and practical foundations.

Secondly, it is highly theoretical. The course content includes transmission line theory and microwave Network theory, and also involves the combination of field method and path method. It is difficult to change the thinking of "turning field into path and combining field with path".

Thirdly, it has strong applicability. The course content is closely related to the commonly used devices in radar communication systems, requiring students not only to understand theory, but also to know the devices and be able to apply them.

Fourthly, the knowledge system has strong connectivity. The course content involves circuit knowledge and electromagnetic field knowledge, with strong field circuit integration, close connection between chapters, strong systematicity, and high requirements for comprehensive knowledge.

2.2 Teaching objectives

The overall goal of the course teaching is to gain a deep understanding of the field and path knowledge in the courses "Circuit Analysis" and "Electromagnetic Fields and Waves", to understand the basic idea of "transforming fields into paths, combining fields with paths, and combining paths with paths", to use "field" and "path" knowledge to analyze and solve microwave problems, and to apply the basic microwave theory learned to analyze the characteristics of microwave components and microwave systems, Master the application scenarios of microwave components and systems, preliminarily possess the ability to analyze and apply microwave engineering, and lay a solid foundation for the next job position.

2.3 Analysis of academic situation

The teaching object of this course is undergraduate students majoring in electromagnetic spectrum technology and management. Through pre class research, we learned that:

Firstly, students lack a comprehensive understanding of the course knowledge system and structure, have unclear logic in course design, do not understand the significance of studying this course, and are not clear about the role of the course in their job positions. In response to this situation, explain the knowledge structure system, course content design ideas, and the previous and subsequent knowledge of each chapter of this course, explain the theoretical knowledge involved and the application of microwave components in specific equipment, and clarify the supporting role of the course for job positions.

Secondly, the students in this class have similar educational backgrounds and a solid foundation in their professional knowledge. They have studied field related courses such as "Electromagnetic Fields and Waves" and circuit related courses such as "Fundamentals of Circuit Analysis", but have not formed the idea of using field and circuit combination to analyze problems. In view of this situation, the learned field and path knowledge will be reviewed, the microwave transmission line and microwave Network theory theory will be explained in detail, the thinking mode of electromagnetic field to Lumped-element model and then to distribution circuit will be established, and the students' idea of "turning field into path" will be cultivated. At the same time, the students' understanding of the idea of "turning field into path" will be further deepened by combining the simulation and experiment of microwave components.

Thirdly, students have high learning enthusiasm, strong subjective initiative, a strong desire for knowledge, and a strong interest in electronic component design. However, their understanding of the combination of devices and principles is not thorough enough, and their mastery is not deep enough. In response to this situation, the course specifically sets up microwave component content, explains the principles, arranges ADS and HFSS software simulation and related device measurement subjects to verify the theory, and offers comprehensive design and simulation experiments for microwave devices to improve the high order and challenge, and cultivate students' innovative thinking.

2.4 Content design

The course content consists of two theories, several components, several devices, and one system, oriented towards future educational needs, with actual devices as the guide and virtual reality systems as the support, running through the entire course. In order to achieve the teaching objectives and combine the analysis of the learning situation, the course has set up four parts of content based on the idea of combining theory, application, practice, and virtual reality:

The first part is the basic theory, including the introduction, the first chapter of microwave transmission line theory and the third chapter of microwave Network theory. This section is the theoretical foundation, reflecting the idea of transforming the field into a road, combining the field with the road, and combining the road with the road. It cultivates students' thinking mode of combining the field with the road to analyze problems.

The second part includes the second chapter plane transmission line, the fourth chapter microwave basic components, the fifth chapter power divider and directional coupler, the sixth chapter microwave resonator and RF and microwave filter, and the seventh chapter microwave ferrite devices. This section is the specific application of the first part of the content, verifying the theoretical knowledge in the early stage, and cultivating students' thinking mode that combines theory and practice.

The third part is the experiment, including four experiments: microwave measurement line experiment, Microstrip characteristic measurement and analysis, microwave device characteristic measurement, and microwave device comprehensive design and simulation. These are the practices of the first two parts. Through course experiments, improve students' hands-on abilities and cultivate their innovative thinking.

The fourth part is about virtual reality experience. Adopting a human-machine interactive virtual reality system, the hardware equipment of the microwave technology transmission characteristics system can be dynamically restored one-on-one. It supports logging in to the client, completing parameter configuration, and dynamically observing the disassembly component structure and profile structure of key waveguide devices in 3D. By combining virtual reality systems and experimental equipment in teaching, students can further deepen their understanding of the principles.

3 Teaching implementation

3.1 Teaching philosophy

Based on the actual situation of students and the characteristics of teaching content, the course adheres to the teaching concept of "student-centered" throughout the entire process, following the idea of "transforming the field into a road, combining the field with the road, and combining the road with the road". It comprehensively utilizes various resources such as original and imported MOOCs, micro courses, simulation software, instruments and equipment, as well as microwave human-machine interaction virtual and real integration systems, and adopts a strategy of "transforming intangible into tangible, and complex into simple", Vigorously strengthen independent inquiry based teaching and improve teaching effectiveness.

3.2 Teaching methods and means

In order to implement teaching concepts, achieve teaching objectives, and comprehensively consider the situation of teaching objects and content, the course adopts the method of "combining the three" for teaching.

Firstly, combining classroom teaching with virtual reality. Classroom theoretical teaching is problem-oriented, with students participating in learning. At the same time, microwave simulation software ADS and HFSS are used to visualize abstract concepts and theories, deepening students' understanding. At the same time, combined with a microwave human-machine interaction virtual reality system, the work and testing process of microwave components are fully displayed, transforming intangible into tangible. For example, when teaching filter knowledge, through on-site HFSS simulation

and filter measurement, the characteristics of the filter are visually displayed. At the same time, in a virtual reality system, the internal structure of the filter is observed, and the working process of the filter is dynamically displayed to deepen students' understanding of the filter structure and characteristics.

Secondly, combining teacher leadership with student exploration. During the teaching process, teachers actively design microwave technology and system related issues, actively tap into students' potential, allow them to explore, independently analyze and judge the situation, and seek solutions, continuously enhancing students' ability to understand and solve problems. For example, when explaining the microstrip ring, the teacher will qualitatively analyze and explain the characteristics of the microstrip ring, let students use the odd even mode method to quantitatively calculate the S-matrix, analyze its characteristics, and cultivate students' awareness of inquiry.

Thirdly, combining case teaching with practical teaching. Build a simulation and experiment library for microwave components, and carry out a variety of simulation and test experiments in combination with research hotspots in the microwave field. In addition, integrate components, and carry out comprehensive design experiments, aiming at the "gender first" requirements of the national gold curriculum. Based on national microwave technology development cases, cultivate students' spirit of fearlessness and courage to work hard and dedicate themselves to the microwave industry. The physical structure of the microwave low-pass filter is shown in Figure 1. The circuit diagram of the microwave low-pass filter is shown in Figure 2, and its S parameters are shown in Figure 3.

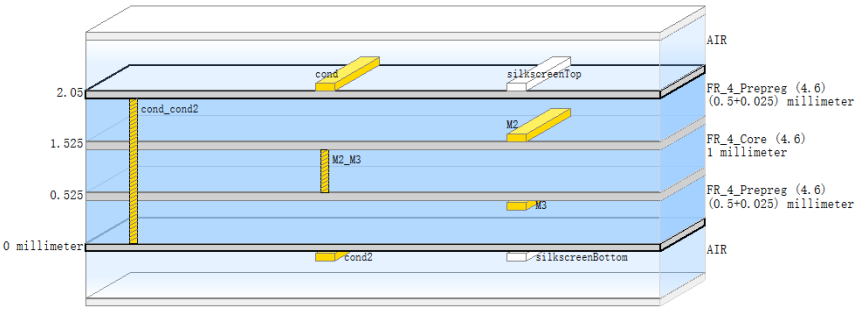

Fig. 1. The physical structure of the microwave low-pass filter

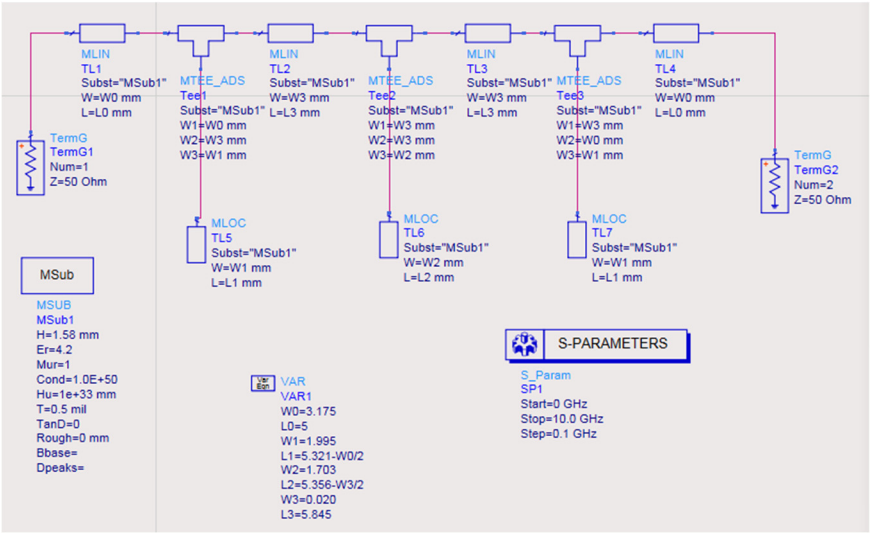

Fig. 2. Circuit diagram of microwave low-pass filter

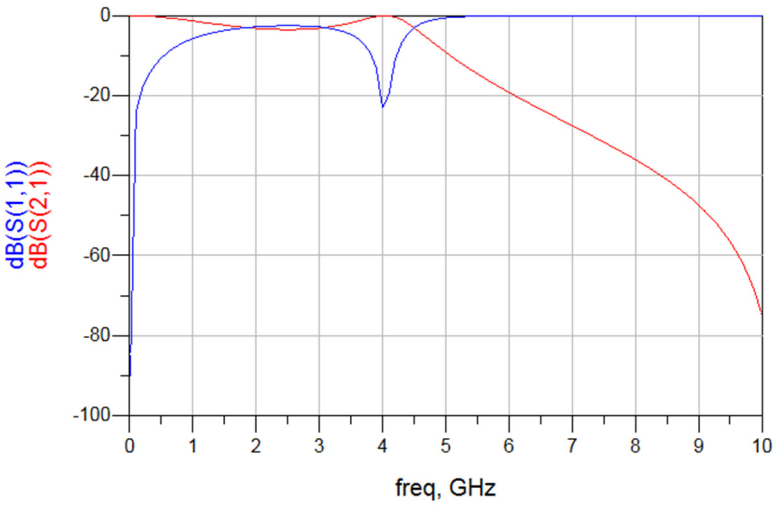

Fig. 3. S-parameters of microwave low-pass filters

3.3 Teaching resources

The course materials are based on the textbook "Microwave Engineering" from the Electronic Industry Press, and the tutoring books are based on the textbooks "Microwave Engineering Fundamentals" and "Microwave Technology Fundamentals" from Tsinghua University Press. The hardware resources include various microwave components, vector network analyzers, etc. The software resources include "Microwave

Technology" MOOC, microwave human-machine interaction virtual reality system, etc.

3.4 Practice link design

In order to strengthen students' ability to combine theory with practice, and cultivate students' innovative thinking, three verification experiments, one design experiment, and one human-computer interaction virtual reality experience are proposed.

4 Conclusions

The course "Fundamentals of Microwave Technology" plays a connecting role in microwave courses, therefore it is of great significance for the teaching design and implementation of the entire course. In terms of content, the explanation will follow the ideas of microstrip transmission lines and network to device. Based on the job requirements of students majoring in spectrum management, provide a detailed explanation of the structure and principles of the components involved in frequency tube equipment such as monitoring equipment and detection equipment. In terms of experimental arrangement, based on hardware measurement design, a new microwave virtual reality experience is added to achieve one-on-one dynamic restoration of microwave devices, 3D stereoscopic observation of the internal structure of 3cm measurement lines demonstration videos, and multiple functions such as experimental login, experimental operation, and experimental assessment are achieved. In terms of methods and means, the microwave human-machine interaction virtual reality system is combined with microwave components to explain and achieve a combination of virtual and real. The construction and design of the course "Fundamentals of Microwave Technology" based on virtual simulation and oriented towards future education provides a new approach for the informationization construction of subsequent courses.

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