Perspective of Electromagnetics Education

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Abstract— Electromagnetic Field and Wave is the backbone of electricity professional foundation courses. The course involves a large number of field theory and vector analysis relying on mathematical knowledge. The application examples of electromagnetic theory in engineering practice, scientific research and daily life help students understand course contents. Integrated with scientific research and achievements, the teaching conducts undergraduates to research and training programs. The capabilities of problem-solving are strengthened, and initiative and creativity are motivated. Thereby the teaching effect of the course is enhanced.

1. INTRODUCTION

Electromagnetic theory was fully founded by James Clerk Maxwell in 1864. The Maxwell equations govern all electromagnetic phenomena and their engineering applications in modern electronic technology. Many modern technologies, such as telecommunications, broadcasting, television, navigation, radar, remote sensing, monitoring and control, electronic warfare, electronic instrumentation and measurement systems, household appliances, industrial automation, geological exploration, power facilities, transportation, health and so on, are directly or indirectly related to the electromagnetic theory. It is also pregnant with a number of emerging disciplines. Electromagnetic Field and Wave is the backbone of electricity professional foundation courses for undergraduate students. The course involves a large number of field theory and vector analysis relying on mathematical knowledge. Relative to the application-oriented courses, it covers wider contents and requires more theoretical analysis. The subject is very abstract, and is difficult to learn for most students.

Electromagnetic problems arise in diverse areas, such as radar systems, antennas, communication systems, EMC, RFIC, RFID, and other electronic systems. The electromagnetic applications in everyday lives can be used as a vehicle to explain fundamental theoretical concepts. With the extensive use of simulation tools, rigorous analytical methods and their engineering approximations for these application examples can be omitted, and the role of basic electromagnetic theory in engineering practice can be clearly presented. The abstract theories are shown in realistic existence so that students can deepen their understanding of the course contents.

How to make students not only feel the latest developments and applications in the field of electromagnetics, but also with great interest to learn the basic theory is the key to success of teaching, which requires teaching contents to be constantly updated. The integration with the modern science and technology ensures the advanced nature of teaching contents. The introduction to the hot electromagnetic issues in recent years can greatly enhance the student's enthusiasm, and arouse their curiosity to explore the unknown world, which also lays the foundation to learn the basic theory.

Students tend to become best motivated to learn something when they can see its relevance. Integrated with scientific research and achievements, the teaching conducts undergraduates to research and training programs. Many students will relate topics into their own research projects, and present the corresponding small research reports in the end of course. This process helps students understand the abstract theories deeply.

2. VISUALIZATION TEACHING

Electromagnetic field and wave is characterized by vector three-dimensional dynamic distribution. A number of important models, such as field distribution in a variety of transmission lines, the wall current distribution, the antenna radiation patterns, as well as the propagation of three-dimensional electromagnetic waves, etc., should be shown as vivid images to students. This will strengthen the profound understanding of these models built from many concepts. In the course teaching, the use of modern information technology and computer-assisted teaching is essential [1–6]. The aim is to make three-dimensional animation software, combined with the electromagnetic simulation tools. The three-dimensional electromagnetic field distribution under different conditions, the

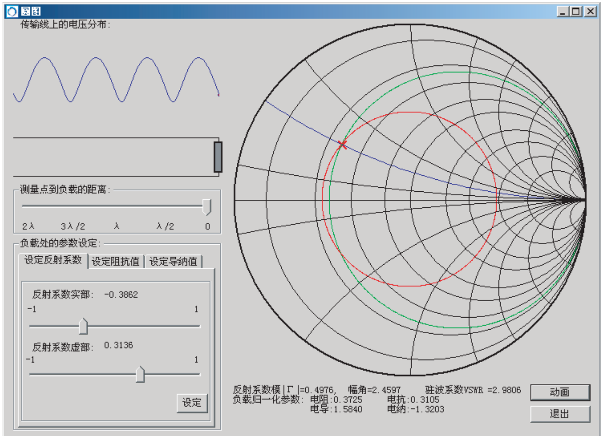

Figure 1: Smith chart courseware.

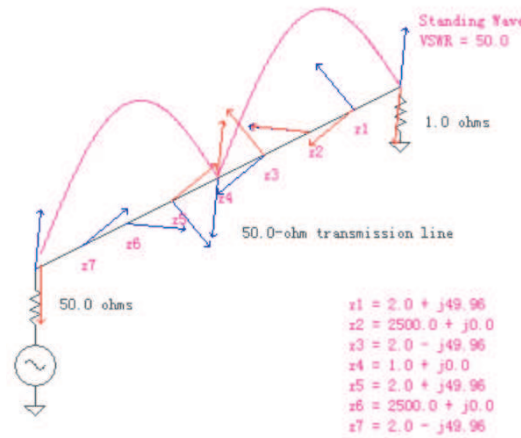

Figure 2: Standing wave in transmission line.

waveform distribution in microwave transmission lines, wall-current distribution, are shown into three-dimensional space to create animated graphics, so that students can observe the full three-dimensional field dynamic distribution patterns. The physical models became vivid images. The models can be demonstrated in the computer, and it also can be made through the Internet web remote teaching. This stimulates student enthusiasm for learning, and improves teaching quality and effectiveness.

The motivation is the key to the success of electromagnetics learning. If we can clearly let students know that the knowledge about electromagnetic waves is the future job needs, it will inspire student interest and motivation to learn this course. The applications of electromagnetic theory in engineering practice, scientific research and everyday life are broad and in-depth. In the teaching process, it will not only help students understand the basic principles and approaches of electromagnetic theory, but also to enable students to appreciate the great vitality of electromagnetic theory, and to understand the important role and significance of electromagnetic theory in many fields.

For example, in the teaching the concept of wave reflection and Brewster angle, the principle of polarized sunglasses can be introduced. Normally, a light source produces waves which go in all directions. Light reflected from surfaces such as a flat road or smooth water is generally horizontally polarized. This means that, instead of light being scattered in all directions in more usual ways, reflected light generally travels in a more horizontally oriented direction. This creates an annoying and sometimes dangerous intensity of light that we experience as glare. A vertical polarizing lens can reduce the brightness of these light waves while still allowing optical information through. Because of their vertical polarizing orientation, polarized sunglasses are ideal for dealing with reflective glare conditions, depending on the angle.

In the teaching the concept of electric dipole, the principles of microwave heating can be introduced in order to enable students to better understand the electric dipole in everyday life. The majority of foods contain water, fiber, fat and other polar molecules. Positive and negative charge center of these molecules do not coincide, which is equivalent to an electric dipole. Under external electric field, electric moment turns to the direction of the external electric field. If the direction of external electric field changes, the orientation of the electric moment corresponds to change. The collision with the surrounding molecules during rotation will convert electrical potential energy into thermal energy of the surrounding molecules.

3. RESEARCH-BASED LEARNING

Electromagnetic technology has now broken through the traditional areas of technology, and becomes one of main factors for the development of new technologies in modern electronics, wireless communications, bio-engineering and nano-technology, etc. Electromagnetic problems and signal integrity has become the main obstacles for development of high-performance integrated circuits, nano-scale electronics, RFIC, and electronic packaging technology. Three-dimensional integrated system packaging, high-performance chip and the electromagnetic propagation in complex biological environment (e.g., Body area network) has become a new and very important discipline.

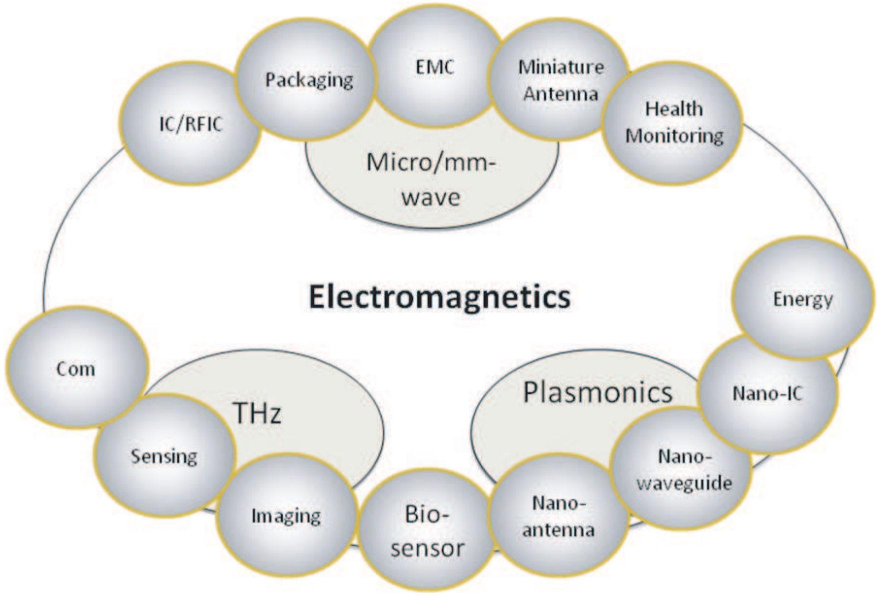

Figure 3: New horizon of electromagnetics.

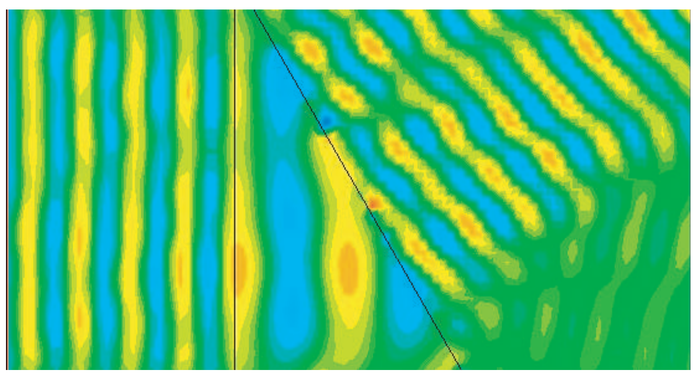

Figure 4: Electromagnetic wave propagation in left-handed meidum.

The integration with the modern science and technology ensures the advanced nature of teaching contents.

From the establishment of Maxwell equations to today, with the development of electromagnetic theory and technology, electromagnetic applications are more and more widely. There are many hot electromagnetic problems in recent years, such as left-handed materials, electromagnetic black hole, electromagnetic invisibility cloak, plasmonics, wireless power transmission, three-dimensional integrated circuit, bio-electromagnetics, etc. By combining the hot electromagnetic problems with the course teaching, it can greatly enhance the student enthusiasm for learning electromagnetics, arouse their curiosity to explore the unknown world.

Many students will choose an interesting topic as their research projects. In the end of the course, they will offer the corresponding research reports. Figure 4 shows the electromagnetic wave propagation in left-handed medium, which is simulated by a student. This research-based learning process helps students understand the abstract theories deeply. Students have also gained self confidence and have improved interest in electromagnetics. Some students will set it to be one of their directions for future efforts.

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