

Signals and Systems curriculum reform and exploration based on control technology and instruments

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ABSTRACT: *Signals and Systems* is an important basic course, and the nexus of the electrical and electronics curriculum. The course is a challenge for both the teacher and students. In order to make a good lesson, based on the authors' teaching experience in signals and systems, combined with the actual situation of the Institute of Disaster Prevention at Yanjiao, Hebei, People's Republic of China, the authors have made a series of reforms and explorations in the curriculum system, teaching content, curriculum practices, etc. Findings indicate that the application of MATLAB in the teaching process greatly stimulates students' interest, improves students' learning initiative, and increases their ability in engineering practice.

INTRODUCTION

Signals and Systems is an important electrical engineering basic course. The course is tested via a graduate record examination by many colleges and universities. The course is based on Advanced Mathematics, Circuit Theory and other required subjects. At the same time, it is a basic course of Signal Processing and Control Theory specialities [1][2]. It plays a connecting role in teaching, and the teaching quality directly affects the students' understanding of several subjects, as well as their ability to engage in specialised work after graduation.

The students are confronted with abstract theoretical concepts and rich content. It is a challenge both for the teacher and students. Therefore, how to improve the teaching method of this course is the focus of many teachers who have done several of useful attempts. Professor Chen Houjin of Beijing Jiaotong University established a curriculum group to reform the curriculum, created a group of capable teachers, proposed teaching ideas with distinctive characteristics of the times and published high level textbooks. With these fruitful results, his signals and systems courses were named *National Excellent Courses* in 2003 in China [3][4].

The third term undergraduate cohort of control technology and instrument professional is about to study signals and systems courses at the Institute of Disaster Prevention. In order to enhance students' interest, based on their teaching experience in the previous two terms, the authors integrated the MATLAB simulation into the course.

EXISTING PROBLEMS IN THIS COURSE AND THE NECESSITY OF THE REFORM

The main problem of the course is that students tend to learn signals and systems the way they do in mathematics. However, in mathematics, students are required to memorise formulas without understanding. Students trained in this model are capable of solving problems, but lack their own ideas [4]. Thus, their interest in the course decreased [5], because of their lack analysis and judgment.

In addition, many students are not interested in this course due to its abstract nature, which will affect the successful study of the course. Reform in this course is necessary, so the authors introduced the MATLAB simulation program. By using its powerful graphical visualisation functions to present mathematical knowledge graphically, mathematical derivation becomes clearer and the understanding of the formula and its engineering applications is enhanced.

TEACHING REFORM

In a traditional signals and systems course, a continuous system was separated with a discrete system, and more emphasis was placed on continuous time systems. With the rapid development of information technology, the entire

electronic world has completed its conversion from analogue signals to digital signals. The original system is not suitable for the development of modern digital technology.

To this end, the curriculum system needs to be reformed according to the following framework: signal goes before system, time domain goes before transform domain, and a continuous system and a discrete system go in parallel. Emphasis is placed on signal analysis, system description, and the mathematical, physical and engineering concepts established between time domain and transform domain by Fourier transform, Laplace transform and z-transform, which will be within the students' cognitive capacity.

First of all, signal goes before system. Signal analysis is the basis of system analysis. To select and design appropriate systems and to do effective signal processing properly, one must first do the signal analysis and determine what characteristics the signals have [6]. Secondly, time domain goes before transform domain. Since one lives in time and space, one is familiar with the time domain. Hence, a deep understanding of the theory and methods of time domain analysis will naturally lead the students into transform domain analysis. Therefore, they will discover the relationship between time domain analysis and transform domain analysis and their application areas.

During the introduction of the transform domain, mathematical derivation is simplified. Instead, engineering applications are focused on and a MATLAB simulation is brought in, which displays graphically the frequency domain and complex frequency domain. Finally, continuity and discrete go in parallel. To avoid disconnection, the continuous and discrete are tied in the same chapter, which will enable students to understand the characteristics of each system. Continuous signals and systems focus on the content of theoretical analysis, discrete signals and systems focus on computer analysis.

Based on this, the authors chose *Signals and Systems*, by Professor Chen Houjin, as the main textbook. This book belongs to Beijing project quality curriculum materials, based on the national electrical and electronic teaching base at Beijing Jiaotong University, is a high level textbook. The main characteristic of this textbook is that it meets the framework's requirements i.e. signals goes before systems, time domain goes before transform domain, and continuous systems and discrete systems go parallel. Emphasis is placed on signal analysis, system description, the mathematical, physical and engineering concepts established between time domain and transform domain by Fourier transform, Laplace transform and z-transform which will meet the students' cognitive capacity.

Curriculum Reform

Curriculum reform is focused on engineering applications and simplifying mathematical derivation [7][8]. A signals and systems course covers the concepts of signals and systems, signal analysis, continuous time domain and discrete time domain systems, continuous frequency domain analysis, discrete-frequency domain analysis, Fourier transform, Laplace transform, z-transform, involving considerable mathematical abilities, such as proficiency in differential equations, complex variable functions, etc, as such, this course requires students have solid mathematical knowledge.

The students are confronted with abstract theoretical concepts and rich content, hence, it is a challenge both for the teacher and students. Students often feel bored during the class, so, before teaching three questions should be explained to students: what they are going to study in this course; what the function of the course is; and why they should study this course. To put it this way, the teaching content should be reasonably arranged.

Therefore, while teaching, the teacher should place particular attention on the overall grasp of the curriculum, courses mainly for deterministic signals and linear time-invariant systems. In short, the course includes two forms of content, and two analysis methods. Two content forms refer to continuous time signals and systems, discrete-time signals and systems, whereas the two analysis methods refer to time domain analysis and transform domain analysis, transform domain analysis also includes the Fourier transform, Laplace transform and z-transform.

Hence, on the one hand, in the teaching process, mathematics is an unavoidable problem, with its abstract theoretical concept and large numbers of formulae. So, a better way for students to understand the course is the authors' focus in their work. Based on the characteristics of the electronic and electronics major, instead of spending too much time on mathematical derivation and memorising the formulae, the authors strengthen the basic concepts and analytical methods and focus on students' comprehensive ability of knowledge application and self-learning ability.

On the other hand, teachers strengthen the discrete parts, highlight the digitisation, focus on the use of computer technology for scientific computing, so that the formula becomes clear graphics and stresses the mathematical, physical and engineering concepts.

In classroom teaching, the authors have integrated computer-aided teaching, multimedia teaching and traditional blackboard teaching. The most difficult part of the course, including convolution, spectral analysis, Fourier transformation is compiled into visualised courseware by MATLAB, which will be easily understood by students. Thus, abstract questions become concrete, which helps to deepen students' understanding and arouse their interest. The benefits of graphical visualisation can be seen from a simple example as shown in Figure 1.

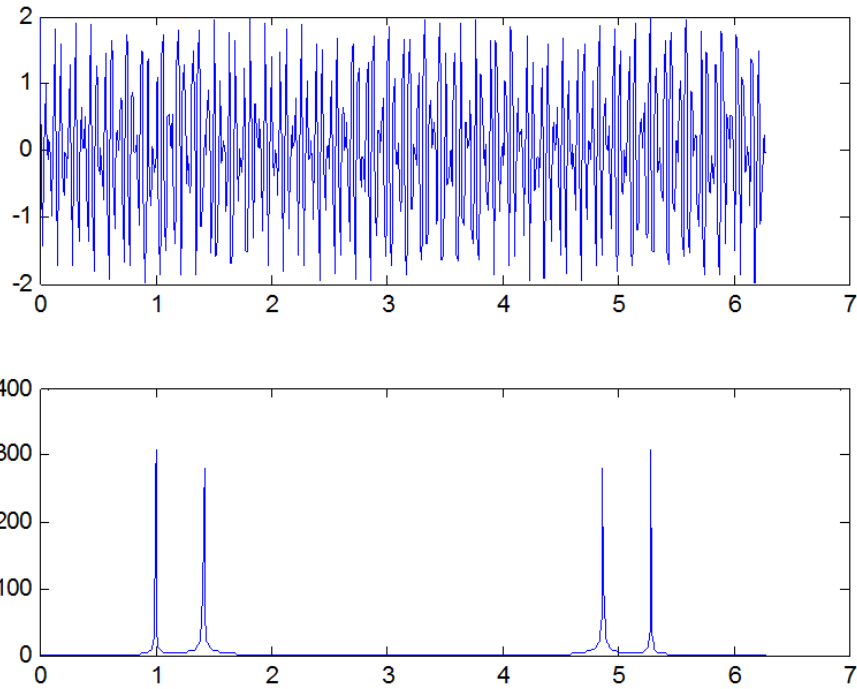


Figure 1: Time domain waveform and frequency spectrum of the audio signal.

As shown above, the figure is a time domain waveform and frequency spectrum of an audio signal. Time domain waveform is very confusing. However, the frequency spectrum clearly shows that the spectrum of the signal energy is concentrated in the vicinity of zero frequency.

Taking the study of shrink characteristics of the Fourier transformation as another example, if the formula is given with Figure 2, the teacher will be able to explain easily the principle of whereby the time domain widens, while the frequency domain narrows, and the time domain narrows, the frequency domain widens. Meanwhile, the students will hear different voices with a sample of voice signal of time domain. If this is explained only by mathematical derivation, the students would not have such a deep understanding of this phenomenon.

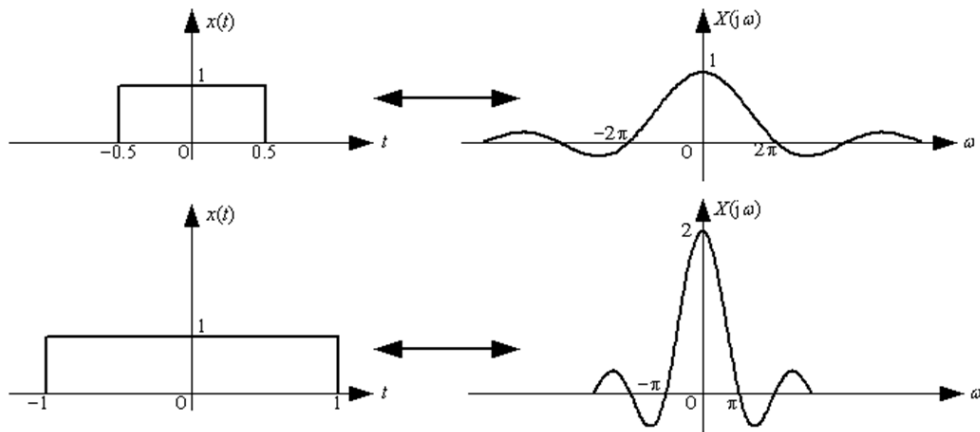


Figure 2: Fourier transforms of the exhibition shrink characteristics.

At the same time, by taking into account the nexus role of the course and the cross-penetration between subjects, the authors hoped to weaken the boundaries between disciplines, and make the course basic and advanced. The curriculum should rely on discipline, in the context of course groups. Because of the overlapping of the content with automatic control courses, the overlapped contents, such as the response of a linear time-invariant system, may be reduced to fewer hours.

CURRICULUM PRACTICE REFORM

MATLAB Simulation

Curriculum reform practice is a useful complement to classroom teaching. In recent years, with the development of digital electronics and computers, the electronic world has basically completed the transition from analogue to digital.

Compared with analogue signals, the analysis of digital signals is more abstract, and have more complex formulae and large computation. The most typical example is discrete Fourier transformation of a digital signal. If the sampling point is 1024, one should calculate complex multiplication 1,04,576 times, and complex additions 1,047,552 times. It is impossible to demonstrate the calculation method and the results on the blackboard even with multimedia courseware. So, how to make students familiar with basic knowledge in a limited teaching time is a difficulty in current teaching. Hence, in the computer-aided teaching reform, the integration of MATLAB in multimedia teaching and in the course practice is an effective way. MATLAB simulation will make the course fun, efficient and provide vivid examples.

MATLAB simulation plays an important part in educational practice. The old laboratory equipment in the authors' Institute is the signal box, which is used for some validation experiments for vocational students. On the one hand, it makes full use of the existing conditions, so that the signals and systems experiment box can be used to carry out one or two preliminary studies, and allow students to connect circuits and commission equipment personally. On the other hand, opening up new virtual software experiments and MATLAB software will be introduced to the educational practice. First, by trying to validate the conclusions of the classical experiments, students will deepen their understanding of what they heard in the classroom. Secondly, by integrating what they learn from the textbook, students will carry out a comprehensive experimental study including programming, which will enhance their comprehensive ability. Thirdly, students with high capacity could design and carry out experiments by using experimental boxes and software simulation.

This virtual simulation, not only improves students' ability of using computer-aided analysis to solve practical engineering problems, but also lays the foundation for subsequent courses and the graduation project.

Open and Independent Experiments

Finally, teachers can also carry out open experiments, including the students' independent experiments [9-11]. This is an effective way to reform the traditional experimental teaching. Students can do projects in the open laboratory not only the experiments in the course, but also carry out science and technology activities related to the project. Students can choose their own combination of laboratory instruments and verify the results.

CONCLUSIONS

Signals and Systems has become one of the courses on the electronic information and related disciplines basic platform. Its importance is more significant, and the authors made some attempts to reform the teaching of the *Signals and Systems* course. Since signals and systems theory involves a wide range of knowledge, and theory and practice in the field is developing rapidly, the authors need to keep learning and improving in the teaching process, and summarise teaching experience constantly to arouse students' positive initiative in the process of teaching, thus improving teaching effectiveness.

MATLAB is a method for algorithm development, data visualisation, data analysis and numerical calculation of technical computing language and programming environment. Simulink is a dynamic and multi-field for embedded system design simulation and modelling graphical environment. The software used has improved students' abilities in engineering practice, and has accelerated the pace of innovation in the automotive, electronics and other industries.

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