

# Research on the Curriculum Integration of “Signals and Systems” and “Digital signal processing”

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**Abstract.** The two courses of “Signals and systems” and “Digital signal processing” play a very important role in the Electronic Information Institute, they are compulsory subjects, and the credits are very high, but there are many problems in the teaching process of “Signal and system” and “Digital signal processing”. On the basis of the practice teaching module towards the personnel training of college, the two courses are integrated from curriculum system, teaching methods to the construction of teacher team. The project type and practical teaching methods have been introduced to improve the teaching effect of the course and promote the construction of the signal course group.

## 1. The necessity of integrating “Digital signal processing” and “Signals and systems”

On the background of the problems about the transmission and processing of signals, the course “Signal and system” is a theoretical foundation course, formed through a series of analysis and summary. The research direction of digital signal processing is very wide. In general, the main research of digital signal processing is the transformation, enhancement, compression and filtering of the signal. “Signal and system” is the theoretical basis of “Digital signal processing”, “Signal processing” takes the “Digital signal processing” as the further deepening of the discrete domain. From the above discussion we can see that, the connection of the “Digital signal processing” and “Signal and system”, is very close, so we can integrate these two courses.

After investigating and studying a series of problems in the teaching of the two courses, it is found that there are some problems in the teaching process:

- (1) Many schools arrange the two courses in the last term and next term separately by different teachers which break the contact of the two courses completely. Sometimes some knowledge points are repeated teaching, or sometimes some of the key points are missing. Moreover, the teaching content and angles of the two courses are various. So the students are confused.
- (2) It is possible to cause the confusion of the symbols in the different course but the same signal as two courses are used in different teaching materials. For example, the symbol of the unit step signal, some books use  $u(t)$ , some textbooks use  $\varepsilon(t)$ . The symbol of the excitation signal in signal and systems is  $f(t)$ , but with  $x(t)$  or  $x(n)$  to replace.

In summary, it is very necessary to integrate the two courses based on the analysis and planning of the signal course group which can improve the teaching effect of the course.

## 2. Integration of the two courses

### 2.1 Research and results of curriculum integration about the two courses

In this competitive era, we should cultivate students’ ability of innovation, which requires students to be autonomous and independent to accomplish a complete experiment by some simulation software combined with the theoretical knowledge they have learned. I also put forward the proposal about the integration of curriculum content, we all know that the “Signal and system” is the theoretical basis of “Digital signal processing”, “Signal processing” takes the “Digital signal

processing” as the further deepening of the discrete domain, so there are the same contents of the “Signal processing” and “Digital signal processing”, thus, the course which has been studied before will be learned again afterwards, not only the time is wasted, but also the students feel very dull as ditch water and the effect is not good. Therefore, after the integration, the content of Signal processing is:

- (1) The classification of the signal, the basic operation of the signal, the system and the description of system, the analysis methods of system characteristic are all included in the first chapter, the signal and the system.
- (2) The response of LTI continuous system, jump function and impulse function, jump response and impulse response, convolution integral are all included in the second chapter, the time-domain analysis of continuous system.
- (3) The response of LTI discrete system, convolution sum, sequence of units and response to units sequence, and deconvolution are included in the third chapter, the time-domain analysis of discrete system.
- (4) The signal decomposed into orthogonal function, Fourier series, spectrum of periodic signals, spectrum of non-periodic signal, properties of Fourier transform, energy spectrum and power spectrum, Fourier transform of periodic signals, frequency domain analysis of LTI system, sampling theorem etc. are included in the fourth chapter, Fourier transform and frequency domain analysis of system.
- (5) Laplace transform, Laplace inverse transform, and complex frequency domain analysis, the three parts of the contents are included in the fifth chapter, the S domain analysis of continuous signals.
- (6) The z-transform, the properties of z-transform, inverse z-transform, analysis of z-domain and so on are included in the sixth chapter, the z-domain analysis of discrete system.
- (7) The system functions and features of the system, causality and stability of the system, the signal flow graph, the system structure etc. are included in the seventh chapter, system function.
- (8) The state quantity and state equation, the establishment of the state equation of continuous system, the establishment and the simulation of the state equation of discrete system are included in the eighth chapter, analysis of state quantity.

After the integration, the contents of Digital signal processing are:

- (1) The contents of the discrete time signal, the linear shift invariant system, Linear difference equations with constant coefficients are included in the first chapter, discrete signals and systems.
- (2) The relation of Z transform of sequence and Laplace transform of continuous signal, Fourier transform, discrete time Fourier transform, some symmetry properties of Fourier transform are all included in the second chapter, z transform and discrete time Fourier transform.
- (3) Several possible forms of Fourier transform, discrete Fourier series, discrete Fourier transform, and sampling theorem of frequency domain are all included in the third chapter, the discrete Fourier transform.
- (4) Some problems about the direct calculation of DFT and the improvement method, FFT algorithm selected by time, FFT algorithm, FFT algorithm selected by frequency, fast algorithm for inverse discrete Fourier transform etc. are included in the fourth chapter, the fast Fourier transform.
- (5) Structure representation method of digital filter, the basic structure of the digital filter etc. are included in the fifth chapter, the basic structure of the digital filter.
- (6) All-pass system, design of IIR digital filters with analog filters, impulse invariance method, step response invariant method and bilinear transformation method etc. are included in the sixth chapter, the design method of IIR digital filter.
- (7) The characteristics of linear phase FIR filter, design method of window function, design method of frequency sampling and method for optimized designing FIR digital filter are all included in the seventh chapter, the design method of FIR digital filter.

## 2.2 Optimization and integration of teaching methods

As to the multimedia teaching mode, we can mark the important contents on the blackboard, or combining with the multimedia technology, to show some contents which are abstract and difficult to

understand to the students visually, so the teacher will be much relaxed than before, and the students will be up much easier. In addition, the simulation software can be introduced to improve the teaching and experimental results both in the experimental class and theory teaching, such as the use of MATLAB software which can be applied in all kinds of signal courses. It can effectively realize the analysis, processing and design of various types of signal and system by its super powerful computing capability and rich signal processing library.

In addition, in order to make the signal class group integrated effectively, the task group designed a set of project based on MATLAB experimental system which divorced from the traditional verification experiment. In the course of signal processing, it introduces the processing project of noisy speech signal. And this project is divided into 4 small experiments. Experiment one let students learn how to produce all kinds of signals with MATLAB software and use computer and microphone to recorded a voice signal. This experiment can be taught at the beginning of the semester which let the students have a personal understanding of the signal. The student should carry on compression and expansion, and the Fourier transform to his recorded voice in experiment two. Students can feel the different characteristics of the signal in time domain and frequency domain. The concepts of sampling and discrete also can be added in the experiment which can pave the way for the study of digital signal processing in the future. In the third experiment, a noisy signal is need to be added on the original signal. A corresponding filter function should be called to deal with the sound signal containing noise. Finally, it needs to be compared before and after the filtering in time domain and frequency domain to the characteristics. Experiment four is given a noisy ECG signal, in the premise of a given good filter function, students should design a system to complete the processing of the ECG signal.

Indeed, the shadow of the digital filter is included in experiment three and four, which should be set in the course of digital signal processing. Since it has the special filter function can be called, students can accept and complete the two experiments better. In the experiment of the digital signal processing, a project of the recognition to the car number plate is introduced by the research group. At the same time, the knowledge which is closely linked to the course in this experiment is divided into a number of small experiments to enable students to achieve and complete.

In addition, the teachers also regularly communicate and discuss in the experimental reform and curriculum integration. We integrate these projects into the practical teaching and the theory teaching, realize the unity of theory teaching and experimental teaching, realize the unity of theory and practice teaching and realize the unity of project teaching and teaching skills which achieve better teaching effect.

### 2.3 The construction of the teaching staff and the requirement of the teachers' knowledge structure

In the integration teaching of Signal and system, Digital signal processing, the two courses form a new curriculum system, which puts forward new requirements for the teachers engaged in teaching. As to the new curriculum system, teachers should be able to stand on the height of the basic information processing theory, fully grasp the overall development trend of information science, with teaching ability of combining the global and local, theory and practice, scientific research and teaching of the new curriculum system. Here I put forward some requirements about the teaching staff after the integration:

#### (1) Grasp the global and local relationship of the system

After the integration of teaching, teachers should highlight the mathematical concepts, physical concepts and engineering concepts contained in the new curriculum system, and realize the effective combination of the principles and methods.

(2) Teachers should strengthen the theoretical learning ability, enhance the strength of scientific research, and strive to further strengthen the practice of teaching in the classroom teaching. Teachers should actively transform their research achievements and projects into classroom teaching, and promote classroom teaching by means of experimental methods and experimental results.

### 3. Summary

After the optimization and integration to two classes, it constitutes a unified whole while maintaining the original independence and integrity. Through this kind of integration, the better effect is obtained in the teaching process. This paper is one of the research results of the research on teaching reform of higher education in Jiangxi Province -- Application of teaching skills in "signal curriculum group" (JXJG-15-33-2). This paper is also the research results of the science and technology research project of Education Department of Jiangxi Province -- "Research on emotional information processing system of infant based on pattern recognition" (GJJ-151169).

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