

Application of Virtual Instrument Technology in the Teaching of "Signal and System"

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Abstract. Application of virtual instrument technology can effectively solve the problem of "signal and system" teaching, which is abstract and closely linked with mathematics. Based on the analysis of the current situation of the course and characteristics of virtual instrument technology, the key points and difficulties in teaching content are summarized, typical experiments through classroom teaching are researched, and the LabVIEW simulation results are introduced with an example from signal analysis.

Introduction

Signal and system course is a core course in professional foundation of the local universities and military academies. Its theoretical system plays a vital role in the teaching process. However, due to the abstraction of theory and complexity of compute, the previous students generally reflected the course was difficult to learn. How to help the students to grasp the macro context of knowledge, understand and master the basic principle and analysis of the course, so as to use the knowledge to analyze and solve practical problems, is the focus of teaching and the difficulty of the course.

At present, with the rapid development of information technology and engineering technology, the Ministry of Education established the strategic position of education informationization. Virtual simulation experiment teaching is an important part of higher education information construction and experimental teaching demonstration center, and it is the product of the depth integration of subject and information technology. On this basis, in order to follow the core of international teaching concept better, and play a role in cultivating innovative talents with information technology, the introduction of virtual instrument technology into the theoretical teaching is an effective method to solve the "signal and system" course theory abstract and computational complexity.

1. The Present Situation of the Curriculum

The prelect object of "signal and system" in our school is the students of communication and electronic information major. The last two years, in order to adapt to the requirements of the new situation, all kinds of local colleges and universities have to change the thoughts of running schools, adjust the direction and orientation of personnel training. For our school, the goal of personnel training has changed from technical personnel to junior commanding officers. So the personnel training programs and the curriculum standards are modified correspondingly. Specific to the "signal and system", the hours for communications specialty are changed from the original 64 hours to 60 hours now, and the hours for electronic information specialty are changed from the original 48 hours to 40 hours. "Signal and System" course is characterized by a wide range of content, theoretical abstraction, complex calculation, easy to make students feel boring and abstract. These are many problems needed to face and solve in the teaching process. Such as how to optimize the curriculum content, improve the teaching mode, make good use of information teaching methods to improve teaching efficiency, guide students to think about signal and system problems in the

limited teaching time, and how to get the ability to grasp the macro science and technology frontier and analyze and solve problems.

2. Characteristics and Advantages of Virtual Instrument Technology

In the mid-1980s, National Instruments (abbreviated NI) proposed the concept of virtual instrument (abbreviated VI). It is a kind of input and output system of all kinds of instrument function is realized through the computer software. The electronic instrument is transplanted to the computer platform, which is based on the general computer hardware and operating system. The core idea of the virtual instrument is "software is the instrument". Compared with the traditional programming language, it has very obvious characteristics and advantages. (I) graphical instrument programming environment; (II) the built-in program compiler; (III) the powerful data analysis toolbox; (IV) instrument driver; (V) support multiple platforms; (VI) an opening platform of development.

3. Analysis of the Heavy and Difficult Points of "Signal and System"

Signal and system course research signal and system basic law and analysis method with the application background of communication and control system, which organize the structure from signals to systems, from time domain analysis to transform domain analysis and from continuous time systems to discrete time systems. There are many methods to analyze signal and system and each method has its superiority. Method of signal and system analysis from the time domain analysis has the characteristics of direct and easy to understand. Fourier transform allows us to understand the relationship between time domain and frequency domain, and Laplace transform make us to know the time domain system changes with algebraic method, and research system performance conveniently. In the paper, the contents are chosen and organized from these three kinds of analysis methods based on the systematic and important principle, which is including the signal analysis, the system characteristic analysis and the engineering application. The three parts of the content layer by layer, and gradually realize the theory to the application, knowledge to the ability of the transformation. The overall design is shown in Figure 1.

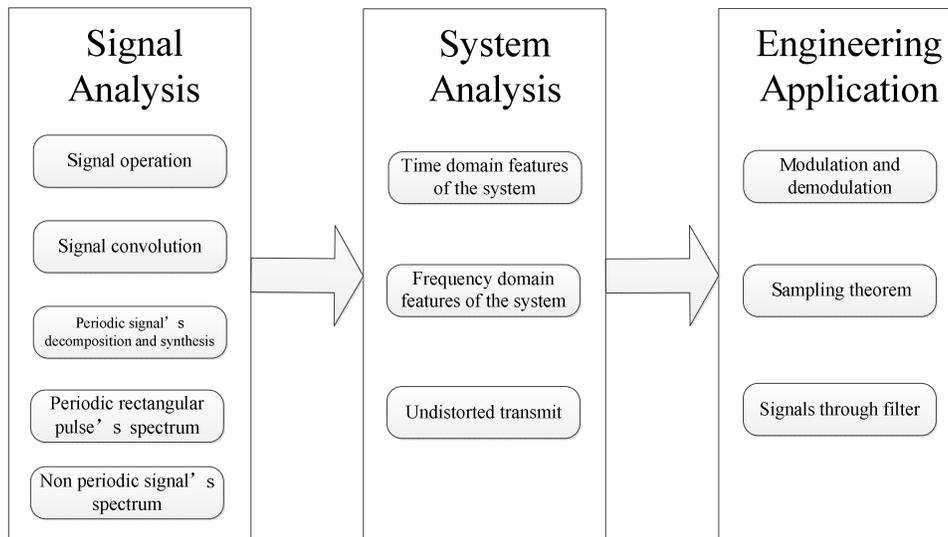


Figure 1. The Overall Design.

3.1 Signal Analysis

The signal analysis includes the description, the characteristic, the transformation and the basic operation of the signal. On the basis of mastering the description method and waveform characteristics of the common signal, the complex signal is transformed into the linear superposition of simple signal through the signal decomposition method, and then the complex signal analysis is

realized. According to the different form of simple signal, the method of signal decomposition is divided into time domain analysis, frequency domain analysis and complex-frequency domain analysis.

(I) The time domain analysis method is to decompose an arbitrary signal into a sum of a number of narrow pulse components. In order to approximate the original signal, the limit of the combination of narrow pulse is the superposition of impulse signal. The mathematical formula is expressed as:

$$f(t) = \int_{-\infty}^{\infty} f(\tau)\delta(t-\tau)d\tau \quad (1)$$

The above equation shows, choose $\delta(t)$ as the basic signal, arbitrary signals can be decomposed into summation of $\delta(t)$ with different intensities at different times. This form of decomposition provides the basis for the time domain analysis of the system.

(II) Frequency domain analysis method is based on the sine signal as the basic signal, using the Fourier transform to analysis signal characteristics. Expressed as by using Fourier inverse transform:

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(j\omega)e^{j\omega t} d\omega = \frac{1}{\pi} \int_0^{\infty} |F(j\omega)| \cos[\omega t + \varphi(\omega)] d\omega \quad (2)$$

The above equation shows, any signal that satisfies absolutely integrable can be decomposed into a superposition of sine components of different frequencies from zero to infinity. $F(j\omega)$ is Fourier transform for the signal. Through the frequency domain decomposition of the signal, the signal spectrum is established, which lays a theoretical foundation for the application of communication.

In summary, for the analysis of continuous time signals, regardless of the time domain or frequency domain analysis method, the core idea is the idea of mathematical simplicity, and the complex signal is decomposed into summation form of basic signal. The only difference is the type of the basic signal. In addition to the continuous time signal, for the analysis of discrete time signal, the core idea is also the decomposition. Here is no longer to sum up.

3.2 System Characteristics Analysis

System characteristic analysis is the basis of the system analysis, only in the premise of mastering the characteristics of the systems. It is able to select the appropriate analysis method to solve the system response.

(I) The excitation signal can be decomposed into the sum of the different intensity $\delta(t)$ at different time in the time domain. When the base element signal is acting on the system, the impulse response is generated. Not only is the different system bound to have a different response, but the impulse response $h(t)$ has the form of a zero input response. $h(t)$ reflects the characteristics of the system itself, and can be used as the characterization quantity for system's time domain characteristics. Through the research of $h(t)$, it can judge the stability of the system and the realization of the physical characteristics, and it has a very important role in the time domain analysis of the system.

(II) Everything's characteristics are diverse. Laplace transform transforms the system's time domain characteristic $h(t)$ to the s domain function $H(s)$; On the contrary, Laplace inverse transform transforms $H(s)$ into the original function $h(t)$. Because of the relationship between $h(t)$ and $H(s)$, some of the inherent characteristics of the system can be seen from the form of $H(s)$. The system function can be used to judge the stability of the system, analyze the time-domain characteristics and frequency-domain characteristics of the system, and can simulate the system to provide support for deeper system design.

3.3 The Engineering Application of System Analysis

The main task of the system analysis is to solve the response of the system under the action of incentive. After mastering the signal and system analysis method, the engineering application of the system builds a bridge from mathematics to physics and engineering technology, which is aimed at

the engineering application for traction, not only strengthen students' engineering awareness and literacy, but also cultivate the ability to analyze and solve problems in practice.

(I) After the signal carrier modulation, the signal spectrum from the low frequency moved to the high-frequency, easy to achieve long-distance signal transmission and frequency division multiplexing applications. When the signal reaches the receiving end, in order to restore the transmission signal, the modulated signal also needs to demodulate, so that the received signal can be back to low frequency. Through the LabVIEW simulation experiment, we can observe the whole process of the modulation and demodulation.

(II) Different types of filters can be used to select different frequency signals to achieve signal processing. How to filter out the noise by adding noise signal, it guides the students to think, and combine the knowledge of the signal spectrum and the filter to solve the problem.

(III) The sampling of sine signal and periodic signal clearly demonstrates the process of the analog signal to the sampling signal, and recovering the original signal from the sampling signal. In order to recover the original signal without distorting from the sampled signal, the sampling theorem can be verified by the dynamic adjustment of the sampling frequency.

4. Examples of Application of Virtual Technology

LabVIEW software has a good interface design capability and rich function library, which provides a powerful tool for the realization of signal visualization and system analysis. Aiming at the core content in the course of signal and system, using the virtual technology to carry on the theory of auxiliary teaching can achieve twice the result with half the effort, improve the teaching quality.

4.1 Convolution of the Signals

To calculate the zero state response of a linear time invariant system to an arbitrary excitation, it is concluded that the impulse response and the convolution integral $y_{zs}(t) = f(t) * h(t)$. The convolution of the signal has become a difficult point in the study of previous students. To achieve the solution of the two signal convolution, a very important problem lies in the convolution integral interval and the results of the time wide interval how to determine. Using LabVIEW can visually present the process of graphic method, and then help students to observe the integral limit, integral conditions, and deeply understand the convolution operation. Graphic steps are divided into:

- (I) Select two signals $f(t)$ and $h(t)$ that need to be done with a convolution integral;
- (II) Horizontal coordinate t replaced by τ
- (III) Deconvolution: Turn the function $h(\tau)$ by the ordinate axis, get $h(-\tau)$;
- (IV) Translation: Move the function $h(-\tau)$ along the horizontal axis, get $h(t-\tau)$;
- (V) Multiplication: Multiply $f(\tau)$ and $h(t-\tau)$. The overlapping parts of the two waveforms are multiplied by a value, and the product of the non-overlapping parts is zero.
- (VI) Integration: With t as the horizontal coordinate, The integral value correspond to t is plotted as a curve, that is the waveform of $y(t) = e(t) * h(t)$.

Set the type of $f(t)$ to a rectangular pulse, amplitude is 1, width is 50, the type of $h(t)$ is also a rectangular pulse, amplitude is 1, width is 60, the simulation results are shown in Figure 2.

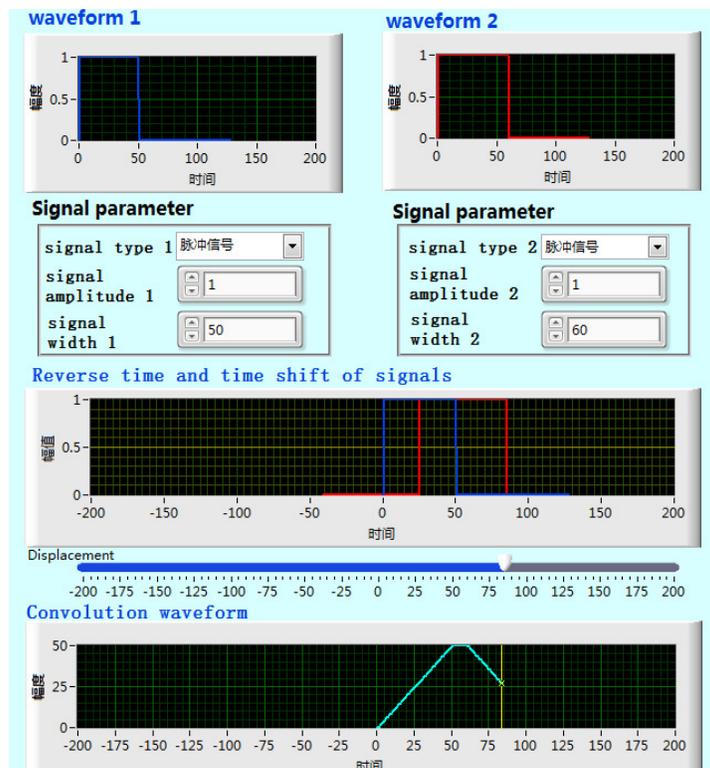


Figure 2. The Simulation Results of Convolution.

4.2 Signal Analysis in Frequency Domain

Frequency domain analysis is a very important method in the analysis of signal and system. It has a great value in engineering application. However, due to the frequency domain analysis method is not direct and clear. Students generally reflect the frequency domain analysis method is difficult to understand. It is the most difficult chapter to learn in the course. In order to realize the system analysis and then carry on the engineering application, we must first understand and grasp the signal analysis in frequency domain. Different frequency sine signal synthesized periodic signals. In view of the above, we inspire students to review Fourier series of the periodic signal, by a series of periodic signal expansion raise signal's frequency spectrum, and then use rectangular pulse signal to discuss the influence on the spectrum by cycle and pulse width. The methods of signal analysis in frequency domain are the foundation for system analysis. When the type of signal is a periodic rectangular pulse, the signal amplitude is 1, the frequency is 1, the number of harmonics extracted is 5, the simulation results of decompose shown in Figure 3-1. When the number of harmonics extracted is 3, the signal synthesis simulation results shown in Figure 3-2.

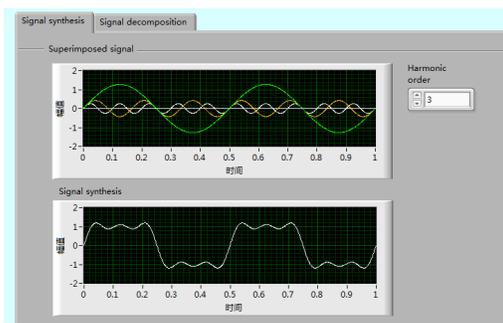
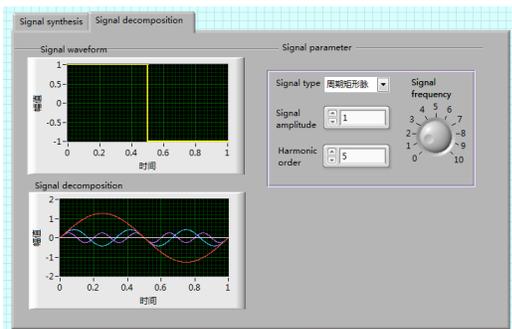


Figure 3-1. The Simulation Results of Decompose. Figure 3-2. The Simulation Results of Synthesis.

When the signal period is 10, the duty cycle is 20%, the signal amplitude is 1, and the signal amplitude spectrum is shown in Figure 4.

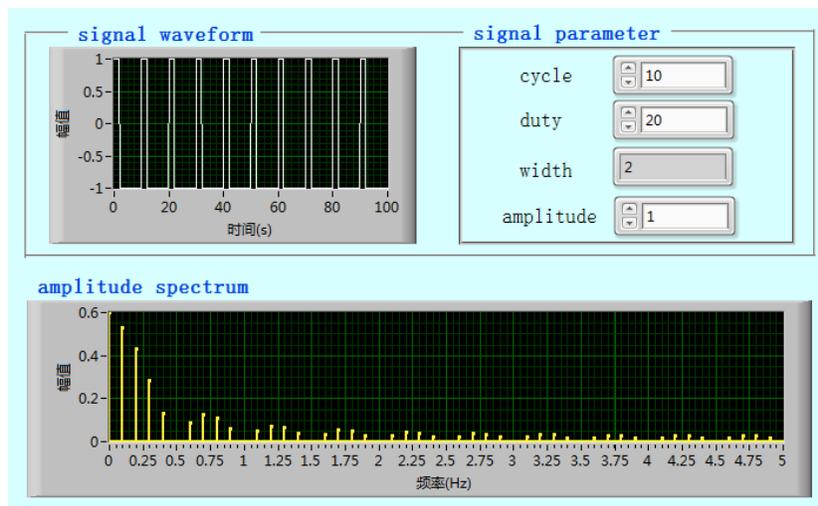


Figure 4. The Amplitude Spectrum of Rectangular Pulse.

Summary

Nowadays, with the rapid development of information technology, the new theory and technology are emerging in an endless stream. Signal and system course must keep up with the times, and constantly update teaching methods, to adapt to the new situation of teaching requirements. LabVIEW has many advantages, such as powerful, flexible, easy to connect with the network, with low cost, general good, strong function, easy to upgrade and expansion, etc. Through the introduction of LabVIEW virtual simulation experiment in the theory of signal and system teaching, it guides students to use information learning means, intuitively understand and grasp the difficulties of the content. It can stimulate students' interest in learning, train thinking method, and deepen the essential understanding of the course of the main stem, so as to improve the teaching effect. Virtual simulation technology has become an important means of teaching construction and reform in colleges and universities, and its functions need to further study, summarize and expand, so that it can play a greater role in teaching.

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