

Development of a teaching experiment platform for a signal generator based on LabVIEW

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ABSTRACT: Based on existing teaching conditions and actual needs, a virtual teaching experiment platform for a signal generator has been developed using LabVIEW. The platform realises a simpler function signal generator and a chaotic signal generator that are easy to operate by using virtual technology, which provides students with some simulation experiments without a physical laboratory. Compared with a traditional signal generator, this signal generator has the advantages of low price, easily adjustable parameters and high reliability. The students' active interest in exploring new things is stimulated by improving teaching directions, ideas and methods. In addition, it makes teaching easier and more flexible, and it improves the overall teaching quality. The usage shows that the teaching experiment platform is practicable and expandable. This can enrich teaching means and can improve the comprehensive quality of students.

INTRODUCTION

With the development of the Chinese economy, technology developments toward informatisation mean that the country urgently needs innovative talent. Therefore, the teaching of engineering courses in each university advocates the teaching mode of active practice, innovative practice, and combining theory and industrial technology. While the new technology provided by National Instruments (NI) is introduced into signal processing courses in the theory teaching and experiment teaching, this can lead to abundant hands-on practice and project-based learning experience to the classroom, especially in intelligent instruments, signals and systems, digital signal processing and virtual instruments [1-3].

With the rapid development of electronic and computer technology, test instruments are being developed from traditional hardware devices to measure control instruments based on computers. The so-called virtual instrument is actually just a kind of automated test instrumentation system based on computers. The virtual instrument makes computer hardware resources and instruments hardware blend together organically by means of software. Therefore, it combines the computer's enormous computing power and the ability of instrument hardware to measure and control. The cost and size of instrument hardware is also reduced greatly. Users can use computer software to simulate the instrument panel by designing the graphical interface, control signal acquisition, analysis, display, storage and output, so on with a program to achieve the real function of the instrument. The application of virtual instrument leads to the concept of *the network is the instrument* [4][5].

A signal generator has a wide range of applications in electronic circuit experiments and detection equipment. Through analysing the principle and structure of a waveform generator, it is possible to design the function wave generator that can generate triangle waves, sine waves, square waves and the saw tooth waves, as well as a chaotic signal generator that can generate chaotic signals. Signal generators can be widely used in the field of electronic circuits, automatic control systems, communications security systems and teaching experiments [6][7]. Virtual signal generators do not require actual hardware development, and can be applied to classroom instruction and demonstration, which deepens students' understanding of textbook knowledge, improves school efficiency and teaching effectiveness, and can also be applied in practical engineering [8].

Based on the ideas above, the teaching experiment platform for a signal generator has been developed in this study, mainly including the arrangement of front panel controls and the design of block diagrams. The basic function signal generator and chaotic signal generator were developed in the experiment platform, with basic functions including sine, rectangle, triangle and saw tooth, and the chaotic signals including a three-dimensional Lorenz chaotic signal and a seven-dimensional chaotic signal. The experiment platform reduces the dependence on hardware devices, saves scarce education funds, and can be directly used in multimedia teaching, so that the students' ability to think independently, practical ability and innovation ability can be developed in classroom teaching.

ENTRANCE DESIGN OF A VIRTUAL EXPERIMENT PLATFORM FOR SIGNAL GENERATOR

A virtual instrument is a kind of functional instrument, which makes full use of powerful data processing ability of computer systems. With the support of basic hardware, data acquisition, control, data analysis and processing, and display of test results are completed by software [9]. In the virtual instrument system, the hardware is just used to achieve the signal input and signal output, but the software is the key to the whole instrument system.

A signal generator according to signal waveforms can be divided into function waveform signal generators and random signal generators. Circuits that can generate a variety of waveforms, such as triangle waves, saw tooth waves, square waves, and sine waves are called function signal generators [10]. These wave curves can be expressed by trigonometric equation. In this study, the virtual function signal generator module and random signal generator module based on chaotic signals were developed. And, the function signal generator module can generate sine, triangle wave, square wave and saw tooth signals. At the same time, the random signal generator module can generate three-dimensional chaotic signals and seven-dimensional chaotic signals. In the same way, some other signal generators can be designed. In this study, each module has been integrated into a control panel. The function is mainly achieved by loop structures and conditional structures. Conditional structures are triggered when a user clicks any button on an interface; subroutines run with the dynamic loading of the front panel of the subroutine. The teaching experiment platform entrance is showed in Figure 1. This platform entrance guides students to further analysis of various types of signals, achieving the purpose of assistant teaching.

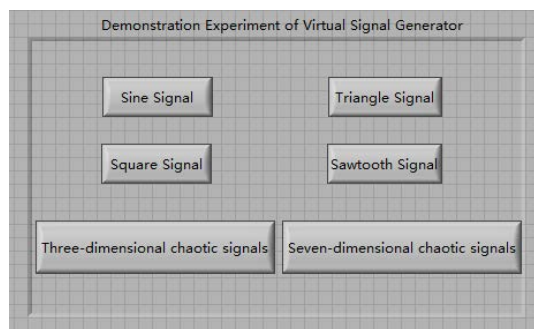


Figure 1: Virtual experiment platform entrance.

MODULE DEVELOPMENT OF FUNCTION SIGNAL GENERATOR

A function signal generator module mainly generates sine, triangle, square and saw tooth waves. It can display the signal waveform and values of signal offset, frequency, amplitude and phase. This module can help students to visualise the signal waveforms that can vary with waveform parameters, so that students can easily understand the role of each parameter. The various types of function signal waveforms are shown in Figure 2.

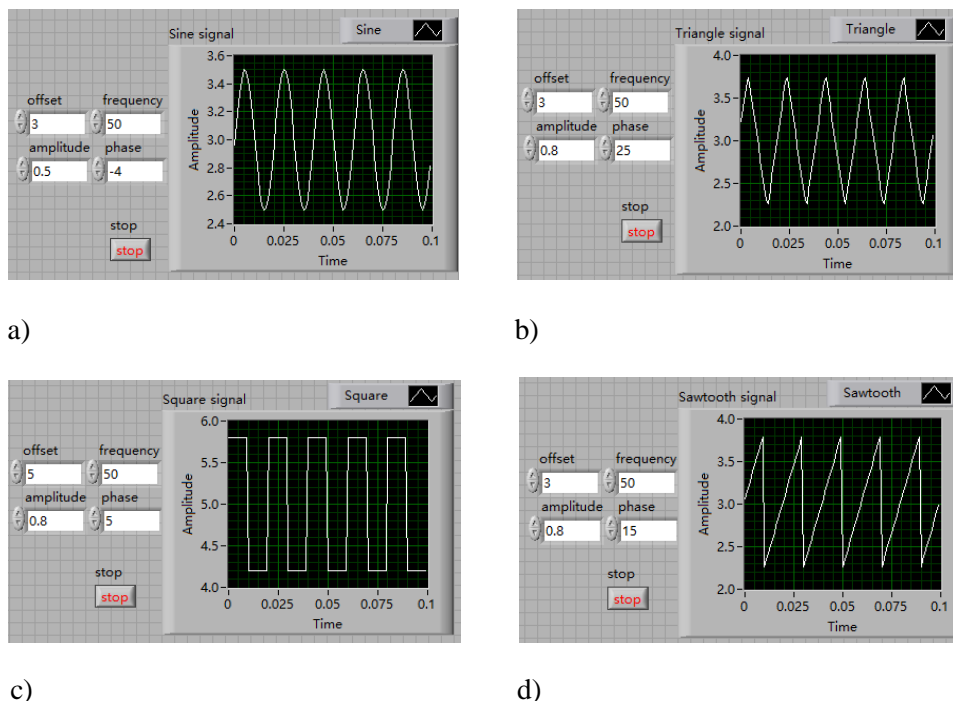


Figure 2: Function signal generator module: a) sine signal; b) triangle signal; c) square signal; and d) saw tooth signal.

MODULE DEVELOPMENT OF CHAOTIC SIGNAL GENERATOR

Chaos is a unique form of movement in non-linear dynamic systems, which widely exists in nature. In the 1960s, the American meteorologist Lorenz found in the study of the atmosphere that an atmospheric convection model described by the certain third-order ordinary differential equations became unpredictable when given certain parameters [11].

If the solutions of differential equations to simulate the atmospheric dynamic characteristics are chaotic, it is impossible to carry out a prolonged weather forecast. Because of an arbitrarily small perturbation, such as the vibration of butterfly wings, weather on the other side of the globe is likely to change sometime in the future: this is the famous butterfly effect.

A chaotic signal is a special kind of random signal, based on which, a three-dimensional and a seven-dimensional chaotic signal generator modules have been developed.

THREE-DIMENSIONAL CHAOTIC SIGNALS

Lorenz first discovered chaotic movement in dissipative systems, which opened the way for the future study of chaos. Equations of Lorenz chaotic system are shown below and are marked Equation (1):

$$\begin{aligned}\dot{x} &= a(y - x) \\ \dot{y} &= bx - y - xz \\ \dot{z} &= xy - cz\end{aligned}\quad (1)$$

Setting $a = 10$, $b = 28$, $c = 8/3$, $x = 1$, $y = 1$, $z = 1$, the Lorenz system has a typical chaotic behaviour. The front panel design of the analysis module for the three-dimensional chaotic signals is shown in Figure 3, in which the top three graphical controls are used to display chaos timing diagrams of the state variables x , y , and z , and the subsequent three graphical controls are used to display the phase plane between each two of the state variables x , y and z .

To allow students to appreciate the function of actual chaotic signal generator, settings screen for initial value of chaotic system, the parameters and sampling step length have been designed. After typing in the front panel $x = 1.00$, $y = 1.00$, $z = 1.00$, $a = 10.00$, $b = 28.00$, $c = 2.67$, $dt = 0.01$, running LabVIEW leads to the generation of the timing diagram and phase plane of the Lorenz system.

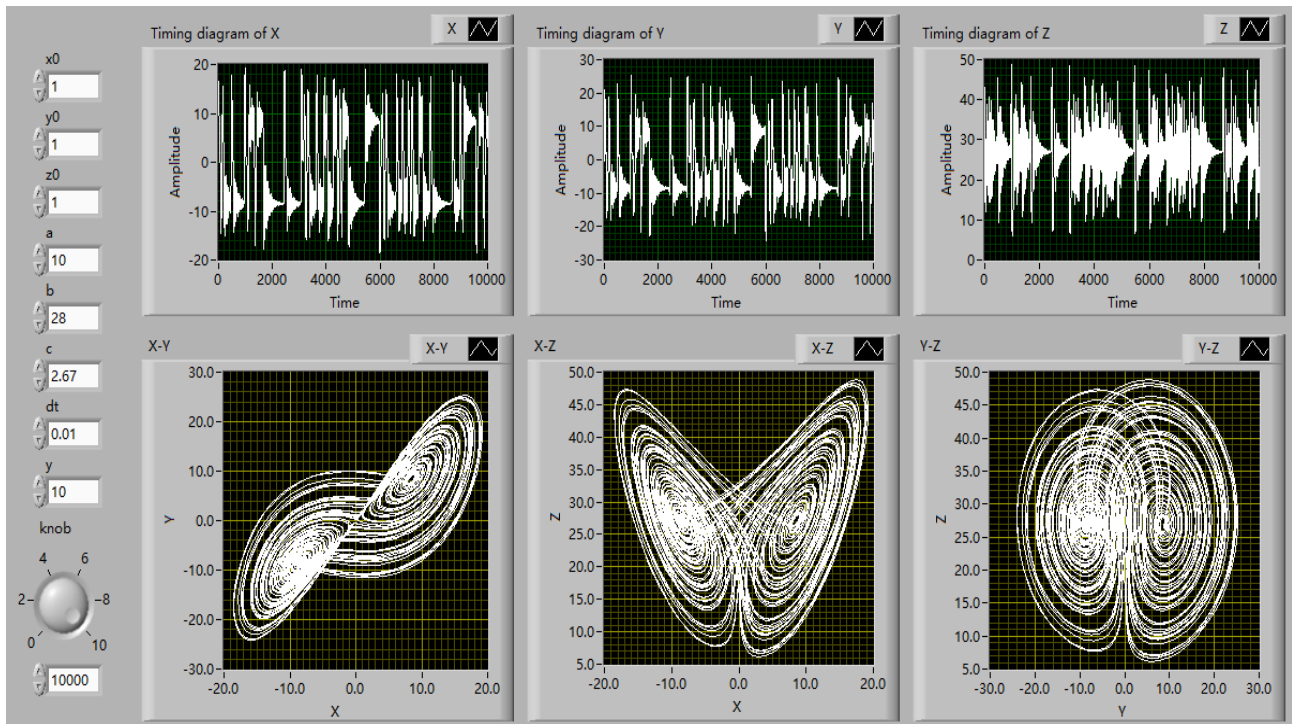


Figure 3: Front panel of the Lorenz chaotic system based on LabVIEW.

SEVEN-DIMENSIONAL CHAOTIC SIGNALS

A set equations for a seven-dimensional chaotic system are shown below and the entire set is marked as Equation (2) [12]:

$$\begin{aligned}
\dot{x}_1 &= -15x_1 + 20x_6 + 0.785x_2x_3x_4x_5x_6x_7 \\
\dot{x}_2 &= -20x_1 - 20x_2 - x_1x_3x_4x_5x_6x_7 \\
\dot{x}_3 &= 20x_2 - 15x_3 - 20x_5 + x_1x_2x_4x_5x_6x_7 \\
\dot{x}_4 &= -5x_4 - 10x_6 - x_1x_2x_3x_5x_6x_7 \\
\dot{x}_5 &= -30x_6 + 19x_6 + x_1x_2x_3x_4x_6x_7 \\
\dot{x}_6 &= 10x_5 + 3.9x_6 - x_1x_2x_3x_4x_5x_7 \\
\dot{x}_7 &= 20x_6 - 15x_7 + 1.5x_1x_2x_3x_4x_5x_6
\end{aligned}
\tag{2}$$

The front panel design of the analysis module for the seven-dimensional chaotic signals is shown in Figure 4. The top four graphical controls are used to display chaos timing diagram of the state variables x_1 , x_2 , x_3 , and x_4 , the subsequent eight graphical controls are used to display some phase planes between each two of the state variables x_1 , x_2 , x_3 , x_4 , x_5 , x_6 , x_7 . After typing in the front panel $x_1 = 1$, $x_2 = -1$, $x_3 = -2$, $x_4 = -2$, $x_5 = 0$, $x_6 = 2$, $x_7 = 2$, $dt = 0.0001$, running LabVIEW leads to the generation of the timing diagram and phase plane of the seven-dimensional chaotic signals are generated.

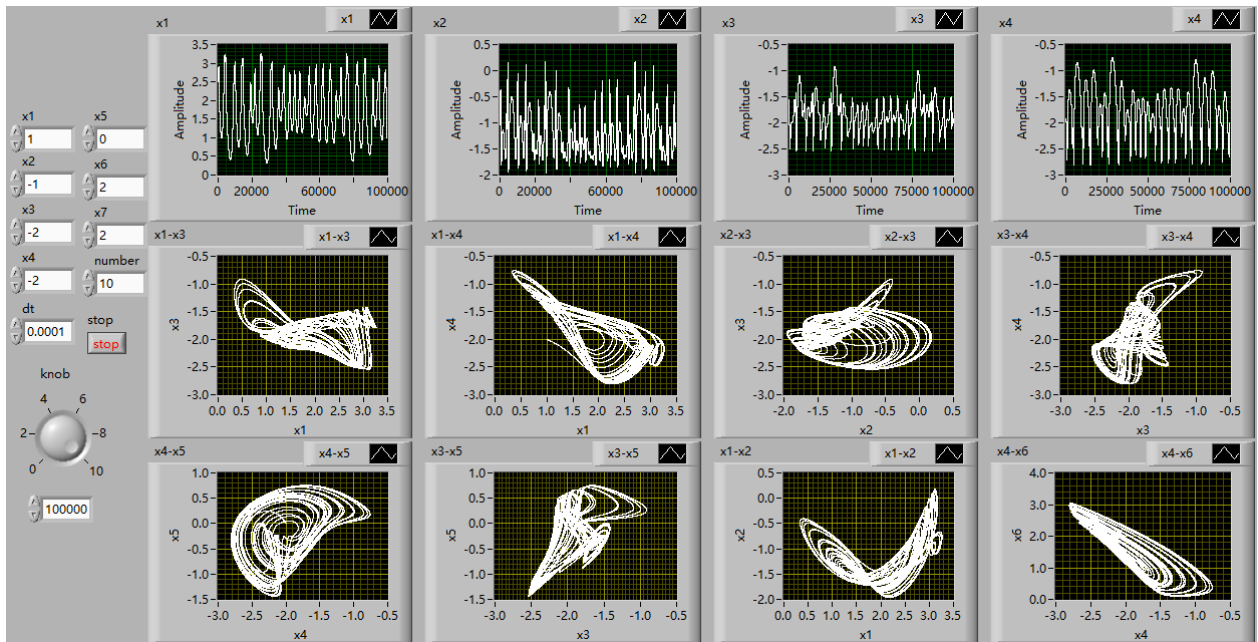


Figure 4: Front panel of a seven-dimensional chaotic system based on LabVIEW.

Signal Output of Signal Generator

When setting parameters after the PCI data acquisition card of NI is installed, signal output of various signal generators is achieved by the data acquisition card, such as attractor phase portraits of state variables x_1 and x_3 , x_1 and x_4 , which are given by seven-dimensional chaotic system. They are shown in Figure 5a and Figure 5b, respectively, corresponding to those in Figure 4. This signal generator system has good experimental results, and compared with the traditional signal generators, it has advantage of convenient adjustment for parameter, easy implementation, high reliability and good real-time.

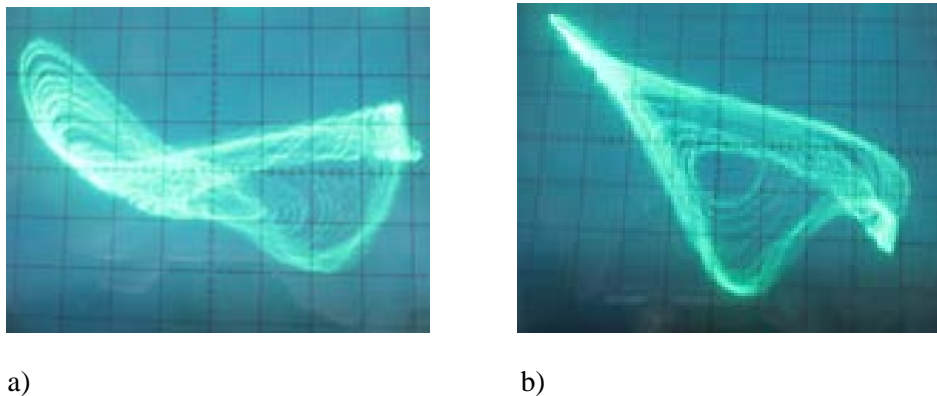


Figure 5: Some attractor phase portraits given by the seven-dimensional chaotic signal generator: a) attractor phase portrait in $x_1 - x_3$ plane; and b) attractor phase portrait in $x_1 - x_4$ plane.

CONCLUSIONS

In this study, a teaching experiment platform for a signal generator based on LabVIEW was developed with the virtual signal generator in the background. Compared with the principle of function signal generators, a typical application module was developed to assist in teaching and the conduct of experiments. At the same time, a chaotic signal generator was developed with a three-dimensional Lorenz chaotic system and a seven-dimensional chaotic system in the background.

The development of a teaching experiment platform for signal generators based on LabVIEW has great significance. It can not only help students to systematically master the basic theory and operation method of the signal generator, but can also fully arouse students' study enthusiasm, raise their interest in the subject, be conducive for them to acquire expertise, and more importantly, it can help to develop their practical ability and ability to solve practical problems.

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