

Design of the Chaotic Signal Generator Based on LABVIEW

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Abstract: We introduces a new method that can achieve the generation of Colpitts chaotic signal The system is based on virtual instrument platform and combined with MATLAB calculation to achieve the generation of Colpitts chaotic signal and making it analysis with autocorrelation and power spectrum at the same time. Signal channel output of chaotic signal was realized through USB-6009 acquisition module extending DA5405 high-speed DAC (Digital-to-Analog Converter) chip. The system can adjust parameters based on customers' requirements to achieve different frequency chaotic signal generation. Compared with the traditional autonomy Colpitts chaotic signal generator, this generator is simple and clear in structure, simple to operate, strong stability, easy to achieve etc. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Colpitts chaotic, LabVIEW, MATLAB, Acquisition module, Autocorrelation.

1. Introduction

The research on chaotic science has developed from theoretical research and controlling chaotic to how to utilize chaotic effectively. While the Colpitts chaotic signal is research hotspots which belong to chaotic signal [1, 12]. At present, the research on Colpitts chaotic signal mainly shown in the following several aspects: the internal relation between Colpitts circuit and Chua's circuit; analyzing Colpitts circuit's functional mode through researching the characteristic root of circuit for differential equation; analysis parameter relationship of differential equation of Colpitts chaotic signal; research on the nonlinear mechanism of Colpitts chaotic signal; Analyze the bifurcation and chaos. There are three defects for Colpitts circuit: unsteadiness of chaotic signal, complicated debugging step and the

obstruction of parasitic capacitance to chaotic circuit. Based on above-mentioned defects of Colpitts circuit board, we want to generate chaotic signal through Colpitts circuit by LabVIEW.

With the development of modern testing technology, Virtual instrument technology has become the main methods and means of which designed a complex test system and test instruments. Literature [2] used virtual instrument platform design to achieve Lorenz chaotic signal generator system. The literature [3-5] referred to the research and study on Colpitts chaotic circuits. In this experiment we generate Colpitts chaotic signal by LabVIEW and then we output chaotic signal through single-channel with USB-6009 acquisition module extending DA5405 high-speed DAC (Digital-to-Analog Converter) chip. There are several advantages for Colpitts chaotic signal by LabVIEW: overcoming the

influence of the circuit board transistor parasitic capacitance and the advantages of complex debugging, having strong visualization which can observe the animation of chaotic signal intuitively, and can proceed chaotic signal autocorrelation analysis and power spectrum analysis on the same interface. According to the demand it can adjust the parameter of different frequency signals at the same time, etc. Above-mentioned chaotic signal was more suited to signal source of exploratory radar, and then enhance the stability of exploratory radar.

Chaotic nonlinear dynamical systems have been peculiar to a form of motion [6], and widely exist in nature which is a kind of random special signal of internal certainty external similar. The most common type of chaotic signals is Duff chaotic signal, Lorenz chaotic, as well as Colpitts chaotic signal. Among them, Colpitts chaotic signal is typical sinusoidal oscillation circuit chaotic signal [7], under the certain condition of the circuit parameters which can achieve chaotic oscillation, then, generate a single vortex roll of chaotic attractor. Owing to the system algebraic equations of Colpitts oscillator circuit is relatively simple, moreover, only a nonlinear exponential term contains in the equation, Accordingly, in this model it can achieve a new synchronizations of chaotic system which has important theoretical value and engineering application value.

Below were normalized equations of State of Colpitts chaotic system:

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{pmatrix} = \begin{pmatrix} \frac{g^*}{Q(1-k)}[-n(x_2)+x_3] \\ \frac{g^*}{Qk}x_3 \\ -\frac{Qk(1-k)}{g^*}[x_1+x_2]-\frac{1}{Q}x_3 \end{pmatrix}, \quad (1)$$

There $n(x_2) = \exp(-x_2) - 1$. In (1) the characterization of the chaotic system, the state variables of chaotic characteristic only related with $g^* Q, K$ just changes the extent of state variables, while it does not cause chaotic system of the state (chaos, balance, etc.) change. Therefore, to make the system (1) in a chaotic state, we just need to choose the appropriate $g^* Q$ value.

Colpitts circuit is designed to make it produce chaotic signal frequency bandwidths, namely 100 MHz, 500 MHz and 1 GHz system normalization equation of state parameters, which has suitable parameter values. Now, takes the chaotic signal bandwidth of 100 MHz as example, set the parameters of the equation: g value for 16.53 and Q is 1.786, K is 0.5, in which the MATLAB the sequence diagram generated in simulation and phase diagram are shown in Fig. 1.

2. Colpitts Chaotic Signal Generator is Designed Based on Virtual Instrument

There were three modes in the chaotic signal generator: LabVIEW interface module calculator module of MATLAB, acquisition module of AD. The flow chart of chaotic signal generated shown in Fig. 2.

LabVIEW calling MATLAB program were conducted by using MATLAB [11] Script node, MATLAB Script node communication via the Active X control with MATLAB Server [5]

LabVIEW and MATLAB both support Active X technique, essentially, an Active X server who regard the MATLAB as set up the Active X channel. The LabVIEW function or order was sent to MATLAB by Active X channel, and implemented by MATLAB in the background [9].

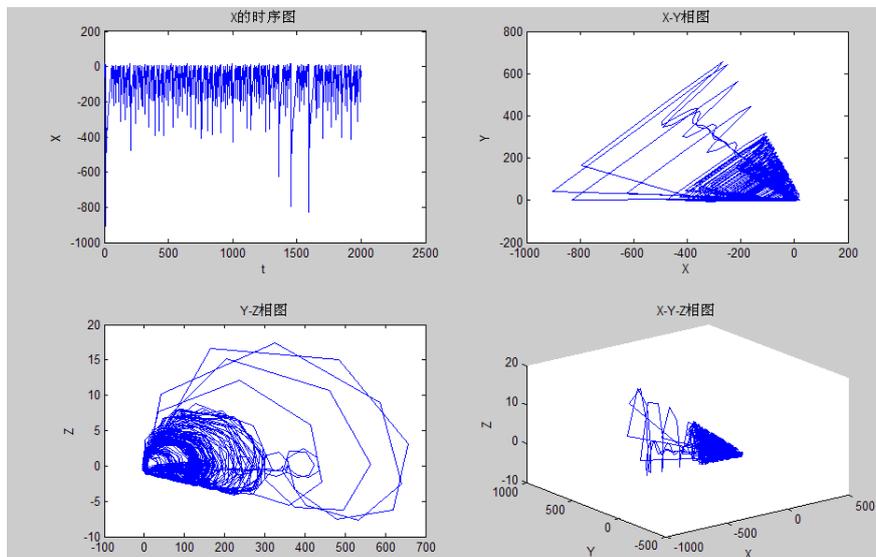


Fig. 1. Waveform and phase portraits of Colpitts chaotic signal.

AD collection module use a data acquisition card (USB-6009) from NI (National instrument) company which is used to acquire signal acquisition and digital-analog conversion transformed by extending AD5405 high-speed ADC chip.

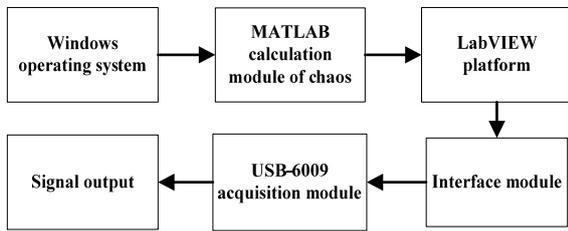


Fig. 2. System flowchart.

System work procedure: Place the algorithm sub-components of MATALB chaotic equation under the LabVIEW default path. In the MATLAB Script node of the LabVIEW edit chaotic equation calculation module, and the chaotic signal autocorrelation and power spectrum analysis are achieved, running LabVIEW, the chaotic signal generated will be displayed in LabVIEW waveform window, and output the signal through the AD collection module.

2.1. The USB - 6009 Acquisition Card and the Selection of DAC Chip AD5405

NI USB - 6009 provides eight analog input channels (AI), Two analog output (AO) channel, 12 digital input/output (DIO) channel and A 32-bit with full speed USB interface calculator. AI resolution for 14 check grades, 13 single-ended, Maximum AI sampling rate, single channel for 48 Ks/s, multi-channel for 48 Ks/s, with low price,

sample rate can satisfy requirements. D5405 is a dual-channel, CMOS, 12-bit, current output Digital-Analog Converter (DAC). Its trait is the write cycle of rapid parallel interface for 58MSPS; 40 pin packages (LFCSP); Ensure the monotonic property, Power-On Reset, Read back capability. Establishment time of AD5405 for 80 ns, which can meet the requirements. As a result of the upper limit of output frequency of USB - 6009 DAC can only achieve 150 Hz; can't satisfy the requirement of the chaotic signal output. The article extending an AD5405 chip on the USB - 6009 DIO line of acquisition module, its extended principle diagram is shown in Fig. 3. Connect the USB - 6009 acquisition card 12 bit DIO output port to the AD5405 data output port, output the chaotic signal.

2.2. Colpitts Program Design and Experiment Results of Chaotic Signal

Transfer the MATLAB edited calculation module of Colpitts chaotic signal into the MATLAB Script footer text in LabVIEW, place MATTLAB operator module of Colpitts chaotic signal under the LabVIEW default path, and make corresponding data type conversion. Program chart in LabVIEW as shown in Fig. 4, in the flow chart, take X, Y, Z as the output variable, bundle X, Y, Z into every two clusters, the output variable of the cluster is Colpitts chaotic signal phase diagram.

The front panel of the signal generator is shown in Fig. 5, three waveforms in Fig. 5, X sequence diagram, Y sequence diagram, Z sequence diagram, respectively. Three XY waveforms were XY phase diagram, YZ phase diagrams, XZ phase diagram, respectively.

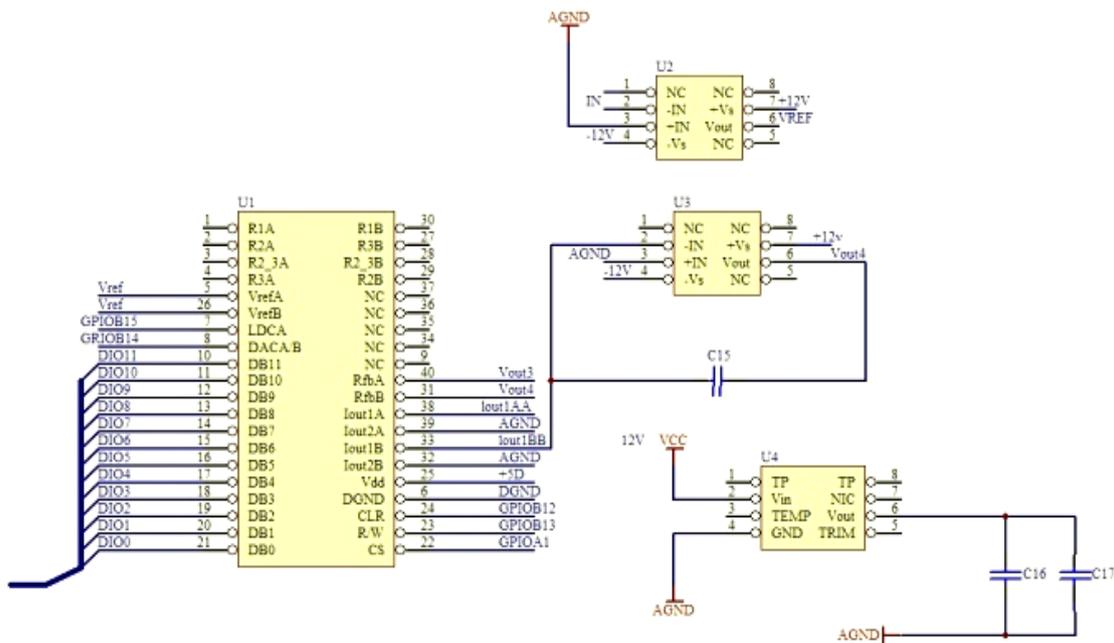


Fig. 3. Schematic diagram of AD5405.

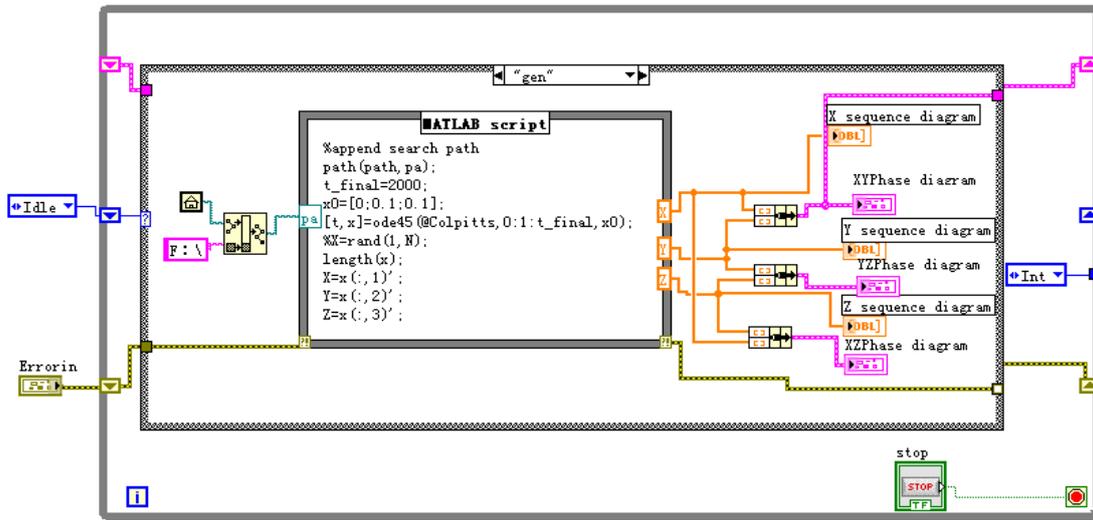


Fig. 4. Block diagram for Colpitts chaotic signal.

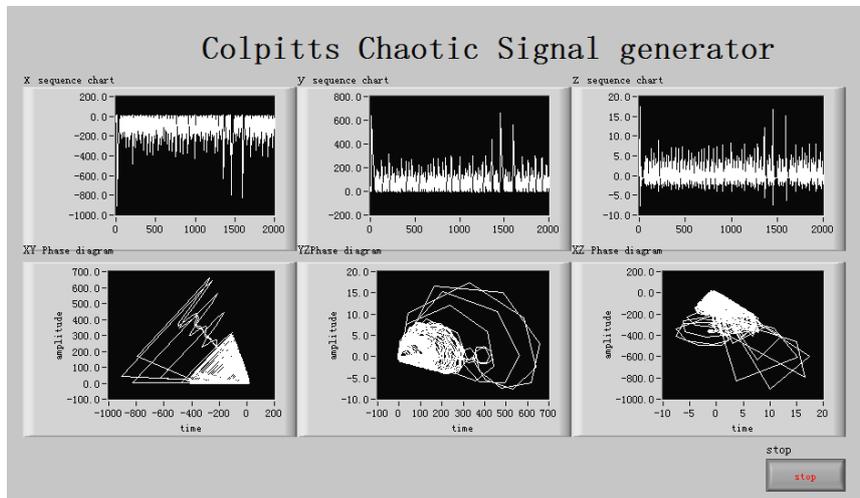


Fig. 5. Front panel of Colpitts chaotic signal generator.

The signal generated wave can be seen in the waveform is a periodic waveform, as can be seen from the three phase diagram, these are three different attractors, accordingly, it could indicate that the signature generated is a chaotic signal.

Switch the generated variables X, Y, Z date in the MATALB to the DAC module by shift-registers [8] (see Fig. 6). To obtain a continuous chaotic signal, in order to avoid the signal exceeding the range of collection card, and the signal can be showed on the oscilloscope display normally, normalize the signal to keep it between -1 and 1, multiplying by the amplitude of the range between 0 to 10, then select the suitable two or three signals among them, Finally, write the frequency and phase of signals to AD5405 chip.

Fig. 7 shows the data acquisition card USB - 6009 dynamic link library modules, realize the communication between the acquisition card and computer by calling the dynamic link library.

Install the data acquisition card (USB-6009) from NI (National instrument) company and set the parameters, connect acquisition card and completed circuit board based on AD5405 extended schematic drawing, connect the circuit board and Agilent's oscilloscope, then run programs, The signal generated is shown in Fig. 8.

2.3. Correlation Analysis and Power Spectral Analysis of Signal

Correlation analysis and power spectral analysis are the important methods of random signal characteristic parameters distribution in time domain and frequency domain analysis, respectively [10]. The correlation of signal is a functional that responds signal waveform close interconnecting, correlation analysis is divided into autocorrelation analysis and cross-correlation analysis. Autocorrelation analysis is a codependent relationship between the instantaneous value of signal at a moment and another moment.

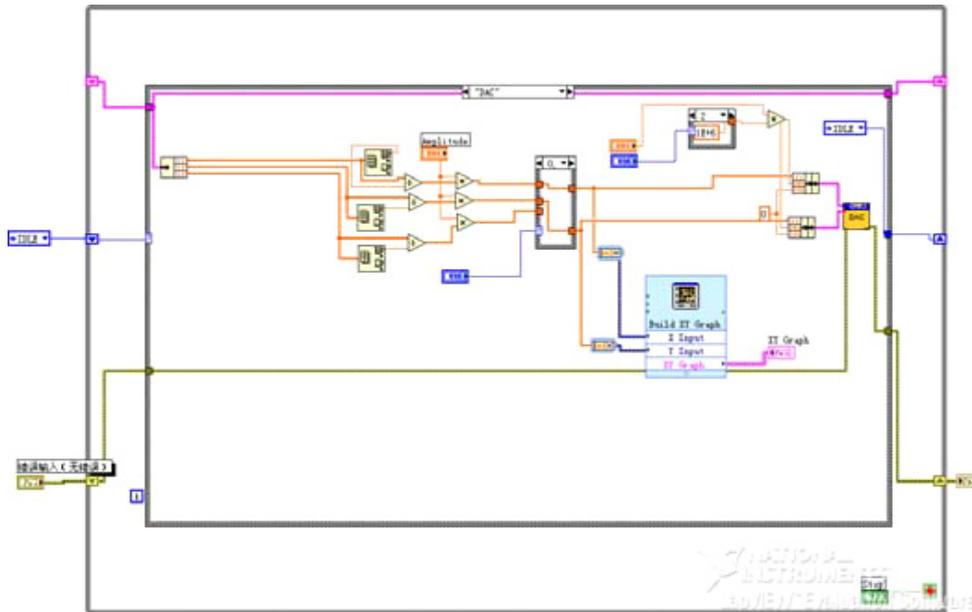


Fig. 6. DAC module of Colpitts chaotic signal.

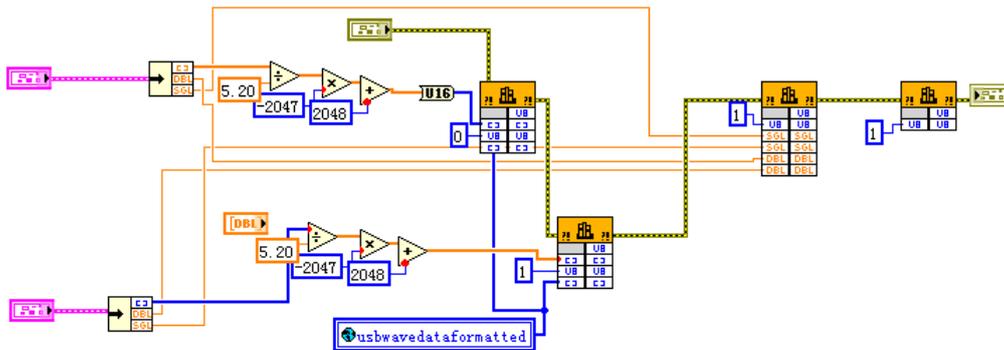


Fig. 7. Dynamic link library module.

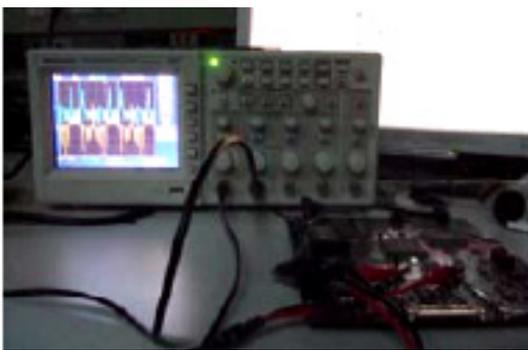


Fig. 8. Data acquisition object graph.

As a result of the autocorrelation function described that the similarity between signal waveform and after the time shifts of the waveform. Nevertheless, different types of signals have different autocorrelation function features, such as: autocorrelation function of periodical signal is still

the periodic function. Therefore, judge whether a continuous random signal contains periodic function elements, need judge by observing the signal characterize on the autocorrelation function waveform, the feature has important significance for us to judge whether or not the signal generated is the chaotic signal. Since the signal power spectrum describe the power of signal distribution along the frequency axis, which describe the relationship between the signal power and frequency. Take any variables X, Y, Z as the variable of the power spectrum and autocorrelation function in Fig. 5, Colpitts electric chaotic signal autocorrelation analysis and power spectrum analysis program diagram are shown in Fig. 9.

Fig. 10 is Colpitts autocorrelation chart and power spectrum chart. From the autocorrelation diagram of function can draw autocorrelation coefficient is 1, which demonstrates that the correlation degree of signal generated is very good. From autocorrelation figure can be seen the signal

has no period, low side-lobe, it proved that signal generated is relatively good, as can be seen from the power spectrum of the function that power in about 100 MHz frequency attenuation of the signal is larger, after that it's smooth, that can illustrate that the signal frequency is 100 MHz.

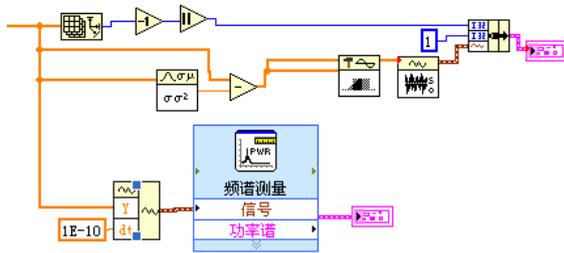


Fig. 9. The block diagram of autocorrelation and power spectrum analysis of colpitts chaotic signal.

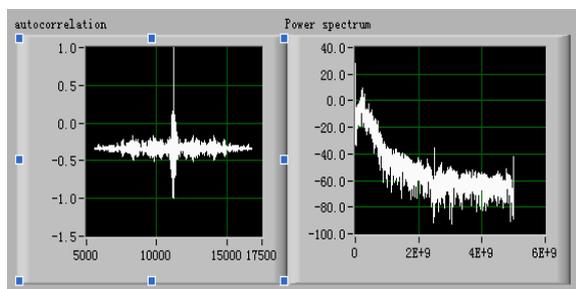


Fig. 10. The autocorrelation and power spectrum analysis of colpitts chaotic signal.

3. Conclusions

This paper puts forward a new method of Colpitts chaotic signal generated, that is, realize the Colpitts chaotic signal producing through virtual instrument platform invoking MATLAB calculation module, and output the signal through the USB - 6009 acquisition card extending DAC IC AD5405. Experiments have shown that virtual instrument technology is a feasible method of designing the Colpitts chaotic signal occurs. The chaotic signal generator has many advantages such as: it can generate different frequency signal according to users' requirements, strong intuitive, easy to be implemented, Compared with the made circuit board, it has strong stability and simple operation, at the same time it provides a new method to research nonlinear dynamics. Because of the system is mainly through the virtual instrument platform invoking the MATLAB program, so its timeliness is not very satisfactory, we will figure out a way to solve the problem in the future.

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