ChinaRxiv

AI translation · View original & related papers at
chinarxiv.org/items/chinaxiv-201709.00002

Design of a Basic Circuit Experimental System Based on LabVIEW

Authors: Lei Yu, Qin Lin, Gu Li, Lei Yu

Date: 2018-06-25T00:00:00+00:00

Abstract

This study presents the design of a basic circuit experiment system using LabVIEW software, introduces the system composition and simulation methods, and analyzes the experimental simulation results. Experimental results demonstrate that the system accurately reflects circuit characteristics and is suitable for promotion in circuit experiment teaching.

Full Text

Design of a Basic Circuit Experiment System Based on LabVIEW

Lei Yu, Qin Lin, Gu Li
(Department of Electronic Technology and Science, University of Science and Technology of China, Hefei, Anhui 230026)

Abstract

This paper presents the design of a fundamental circuit experiment system using LabVIEW software. The system architecture and simulation methodology are introduced, and the experimental simulation results are analyzed. The results demonstrate that the system accurately reflects circuit characteristics and is well-suited for widespread adoption in circuit experiment instruction.

Keywords: LabVIEW, circuit experiment, virtual instrument, experimental system

LabVIEW is a graphical programming environment developed by National Instruments (NI) specifically for virtual instrument applications. Its primary advantages include intuitive usability and high programming efficiency, making it particularly suitable for developing various instruments and virtual circuits.

The core of LabVIEW is the Virtual Instrument (VI), which consists of a user interface—known as the front panel—and a block diagram that functions similarly to source code. The front panel receives instructions from the block diagram. Within the front panel, controls simulate instrument input devices and provide data to the VI, while indicators simulate instrument output devices and display data acquired or generated by the block diagram.

LabVIEW is not only widely used in scientific research and industrial automation but also demonstrates strong potential in university laboratories and supplementary electronics instruction. The control palette in LabVIEW provides highly realistic simulations of various instrument panels, buttons, switches, indicators, waveform displays, and other circuit components, along with user-friendly drawing tools. The educational assistant template includes simulation programs for various waveform signal generators, and the Boolean operations subpalette in the function template contains comprehensive logic operation capabilities. Consequently, LabVIEW can be readily applied to classroom teaching and experimental instruction. In traditional instruction, students often struggle with abstract formulas and theorems in textbooks, where experimental waveforms are monotonous and lack variation. A LabVIEW-based virtual circuit experiment system can dynamically demonstrate circuit performance and rapidly convey diverse data to students, offering an entirely new form of teaching assistance.

1. Overall Design of the Virtual Circuit Experiment System

The virtual circuit experiment system selects several common experiments from circuit laboratories: RLC resonant circuits, operational amplifier circuits, and fundamental circuit theorems. Upon entering the main interface, users select their desired experiment. Within each experiment’ s sub-interface, parameters are entered and the run button is clicked to obtain detailed experimental data and visualizations.

[Figure 1: see original paper] Experiment Project Selection Interface
[Figure 2: see original paper] Block Diagram of the Selection Interface Program

2. RLC Resonant Circuit

(1) Amplitude-Frequency Characteristics The series RLC resonant circuit is shown in [Figure 3: see original paper]. Its circuit equation is:

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

where I and U represent the effective values of complex current and complex voltage, respectively. The phase difference Φ between current and voltage in the circuit is:

$$\Phi = \arctan\left(\frac{\omega L - \frac{1}{\omega C}}{R}\right)$$

When the signal source voltage remains constant and the signal source frequency is varied, the condition $\omega L - \frac{1}{\omega C} = 0$ yields $\Phi = 0$. At this point, the loop current reaches its maximum value, and the corresponding U_R value is also maximized. This condition is defined as circuit resonance, and the corresponding signal source frequency is called the resonant frequency.

(2) Quality Factor Q The Q value indicates the performance quality of a resonant circuit and is defined as the ratio of the circuit' s characteristic impedance to its resistance:

$$Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 C R}$$

When $Q \gg 1$, both U_L and U_C are significantly larger than the signal source output voltage U. At resonance, $U_L = U_C$, meaning the voltage across the pure inductor equals the voltage across the ideal capacitor, and the voltage across either the capacitor or inductor is Q times the signal source output voltage: $U_L = U_C = QU$.

(3) Resonance For any one-port network containing inductance and capacitance, under certain conditions the network can exhibit resistive behavior where the port voltage and current are in phase. This condition is defined as resonance.

(4) Results Analysis [Figure 5: see original paper] RLC Resonant Circuit Resonance Test Section
RLC Resonant Circuit Experimental Data

3. Conclusions

1. The resistor R, source voltage amplitude, and phase are independent of each other. The source voltage amplitude, frequency, and phase are independent of the quality factor Q.
2. The condition for series RLC circuit resonance is $\omega L = \frac{1}{\omega C}$, which can also be expressed as $\omega_0 = \frac{1}{\sqrt{LC}}$.
3. In RLC resonant circuits, a higher Q value results in larger inductor and capacitor voltages for a given source voltage. Moreover, a higher Q value produces a greater rate of change in the resonance curve near the resonant frequency ω_0, causing the response to signals deviating from ω_0 to decrease significantly. In this sense, a higher Q value indicates better selectivity. However, a higher Q value also narrows the bandwidth. For transmitting

voice and images, necessary bandwidth must be maintained, as excessive narrowness degrades signal quality. In series RLC resonant circuits, the trade-off between selectivity and bandwidth can only be balanced, not completely resolved.

3. Operational Amplifier Circuits

(1) Circuit Analysis [Figure 6: see original paper] Inverting Amplifier [Figure 7: see original paper] Non-inverting Amplifier

(2) Conclusions Inverting Amplifier: $U_0 = -\frac{R_f}{R_1} \times u_i$
Non-inverting Amplifier: $U_0 = \left(1 + \frac{R_2}{R_1}\right) u_i$

[Figure 8: see original paper] Operational Amplifier Circuit Window

4. Fundamental Circuit Theorems

[Figure 9: see original paper] Fundamental Circuit Theorems Circuit Diagram

I. Verify KCL, KVL, and Tellegen' s Theorem.
II. Enhance understanding of linear circuit properties—superposition and homogeneity.

[Figure 10: see original paper] Fundamental Circuit Theorems Window
[Figure 11: see original paper] Fundamental Circuit Theorems Superposition Verification Section

5. Conclusion

The LabVIEW-based fundamental circuit experiment system described in this paper demonstrates ideal simulation results that accurately reflect circuit phenomena and principles. The system fully leverages LabVIEW' s characteristic of using software to replace hardware instruments, featuring an excellent user interface, simple operation, and ease of understanding. It addresses issues such as students' inability to intuitively comprehend circuits in classroom settings and insufficient integration between hardware and software in experimental instruction. The system is suitable for widespread promotion in circuit teaching applications.

References

[1] Wu Yi, et al. Digital Circuit Simulation Based on LabVIEW[J]. Microcomputer Information, 2007(10):259-261.
[2] Wang Hongchen. Research on Resonance Characteristics of LRC Series Circuits Based on LabVIEW[J]. Journal of Hainan Normal University (Natural Science Edition), 2009(1):21-22.
[3] Chen Xiyou. Fundamentals of Circuit Theory[M]. Beijing: Higher Education Press, 2007.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv —Machine translation. Verify with original.