



Research Article

ISSN : 0975-7384  
CODEN(USA) : JCPRC5

## Development of virtual instrument motor experiment teaching system based on LabVIEW

Zongjian Huang and Xingju Wang

*Department of Architectural Environment Equipment Engineering, Henan Polytechnic Institute, Henan Nanyang, China*

---

### ABSTRACT

*The hardware platform of the virtual instrument consists of PC computer and data acquisition card (DAQ card). In this paper, virtual instrument technology is applied to the motor teaching laboratory construction. The DAQ system consists of sensors, signal conditioning circuits, data acquisition card, computer which is composed of the hardware, the signal conditioning circuit and data acquisition card. The paper proposes development of Virtual Instrument Motor Experiment Teaching System based on LabVIEW. This paper uses the LabVIEW software as a development platform, using existing equipment conditions of the laboratory to design a motor speed control system, the control of motor speed, the experimental results with high precision and efficiency.*

**Keywords:** Virtual instrument, LabVIEW, Motor, Teaching System.

---

### INTRODUCTION

LabVIEW is the application software of virtual instrument developing an open system, it provides a convenient, easy design environment for designers, designers can use it just as building blocks, easy to set up a measurement system and data acquisition system, and arbitrary structure instrument panel on its own, without writing any tedious the computer program code, which can simplify program design.

Automatic detection system of motor based on traditional development platform, often faces long development cycle, high cost, compatibility and expansibility of the weak, and thus hinders the wide application of automatic motor testing system [1]. Now the application of virtual instrument software by computer and standardization of virtual instrument hardware together, realize the software and module function of traditional instrument, in order to achieve the purpose of automatic detection and analysis. The user can through the technology of virtual instrument graphical programming environment and operation interface, easy to measure the signal conditioning, object of process control, data acquisition, analysis, display and storage functions, greatly shorten the system development cycle; at the same time as the virtual instrument software and hardware using a standardized test, the compatibility of the system and scalability is improved greatly.

Teaching, scientific research requires a lot of measurement and analysis instruments, especially in experimental teaching, each instrument must be configured with multiple sets, and some equipment is expensive, so the equipment required for the huge investment, it is difficult to meet the general school, caused many schools lack of outdated equipment and other phenomena, seriously affects the teaching scientific research. If the use of virtual instrument system, it is not the same. Put into use virtual instrument not only can save a lot of equipment funds, but also can improve the quality and efficiency of teaching and scientific research.

The use of existing computer virtual instrument, special design with hardware and software, forming the basic

function of both ordinary instrument, and it is upscale low price new instrument and the common instrument no special function. Virtual instrument is a new mode of the instrument of computer technology and electronic instrument which combines. It is usually composed of a personal computer, the function of hardware module and used for data analysis, process communication and graphical user interface application software combination, the computer has become a measurement function of digital measurement platform. It uses the software to generate a variety of instrument panel on the screen, complete the processing, transmission, storage, display, expression and function of data. The paper proposes development of Virtual Instrument Motor Experiment Teaching System based on LabVIEW.

### 1. Design of Virtual Instrument LabVIEW

All LabVIEW applications, virtual instrument, which comprises a front panel (front panel), and it is flow chart (block diagram) and the icon and connector (icon/connector) three. The front panel is a graphical user interface; virtual instrument panel is the VI, the interface with the user input and display output of two objects, specific performance of switch, knob, graphics and other control (Control) and display object (indicator).

LabVIEW is an end-user tool. It can enhance your ability to build their own scientific and engineering system, provides a convenient way to instrument programming and data acquisition system [2]. Principle of using it for research, design, test and implement instrumentation systems, it can greatly improve work efficiency. The work of the LabVIEW panel is as shown in figure 1.

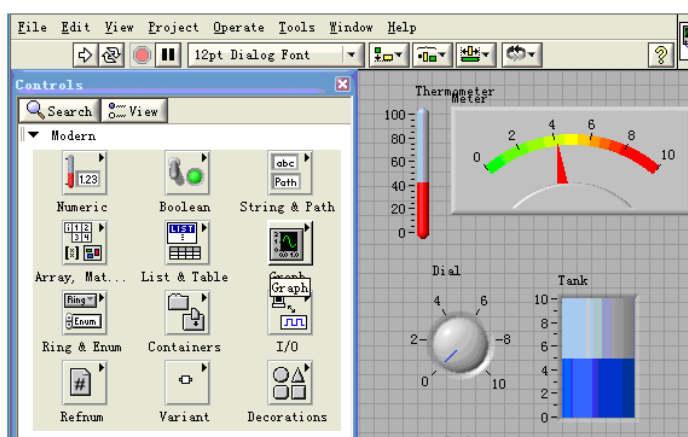


Fig. 1. The work of the LabVIEW panel

The work of LabVIEW interface. Each of the VI prepared by LabVIEW is composed of a front panel, block diagram, icon / connecting port three. The front panel language settings and observing the output input, simulate the real instrument used for front panel. On the front panel, input referred to as control (Controls), output is called the show (Indicators). Control and display is to form various icons appear on the front panel, such as knobs, switches, buttons, charts, graphics etc..

According to the different conditions using the I/O interface to hardware devices of different, such as the data acquisition card (DAQ), GPIB bus, VXI bus instrument instrument module, serial instrument, there are five types of virtual instrument structure. LabVIEW provides a variety of graphics driver, the user does not need to be familiar with PCI bus, GPIB bus, VXI bus, serial bus, I/O interface equipment provided by the use of LabVIEW graphics driver can drive the bus, the measured signal input, data acquisition, amplification and analog / digital conversion, and then for the computer for further processing. Although there are great differences between the five systems, but no matter what kind of VI system, is through the application of software and computer hardware combination.

GPIB (General Purpose Interface Bus) constitute the instrument system is the first step towards the virtual instrument, which uses the GPIB interface card to connect a plurality of GPIB instrument, using the computer to enhance the functions of traditional instruments, organization of large-scale flexible automatic test system, easy upgrade, easy maintenance, instrument panel functions and custom, the development and use of easy. It can be achieved effectively test and measurement task of various scales. Using GPIB technology, which it can be realized by the computer operation and control of the instrument, to replace the traditional manual mode of operation, test and measurement errors caused by human factors of exclusion. At the same time, because of the prepared test procedures, to achieve automatic test, improved the test efficiency.

LabVIEW has a plurality of graphical operation template, used to create and run the program. These templates can

be moved on the screen at random, and can be placed at any location on the screen. There are three types of template, template tool (Tools), control (controls) and function (Functions) template. The tool template (Tools Palette) provides various used to create, modify and debug VI program tool for programmers, when the template choose any kind of tool, the mouse arrow will become the shape of the corresponding tools. Control template (Controls Palette) can add input control and output display as a front panel. Function template (Functions Palette) is to create the block diagram tool.

LabVIEW software platform is the central nervous system, which makes the whole measurement system become an organic whole intelligent, in software guided automatic signal acquisition and storage according to the prescribed procedures, automatic operation data analysis and processing, in an appropriate form output, display or record the measurement results.

For the construction of virtual instrument, LabVIEW has many characteristics and advantages, such as: graphical programming instrument control and data acquisition; intuitive front panel user interface and workflow schema programming style; the built-in compiler can accelerate the speed of execution; the data acquisition of DAQ function library allows users to collect signal or a control signal, suitable for application to control the rapid and direct; the driver can drive 650 kinds of instruments, equipment more than 50 manufacturers; advanced analysis library content rich, signal processing, statistics, curve fitting and complex analysis; using Activex, DDE and TCP/IP network connection and communication process for Windows NT/9X/XP; MacOS, HP2UX, Sun, and Concurrent real-time computer.

Virtual instrument software architecture (VISA -- Virtual Instruments Software Architecture) is designed to improve the efficiency by reducing the system time. With the instrument type and the increasing complexity of test system to improve, people don't want to write a different program for each kind of hardware interface, the I/O interface independence for I/O control software is becoming crucial. Through the VISA user can connect with the majority of instrument bus, including GPIB, USB, serial port, PXI, VXI and ethernet. Regardless of the underlying the hardware interface and it is the user only needs to face the programming -- a unified VISA interface, as is shown by figure2.

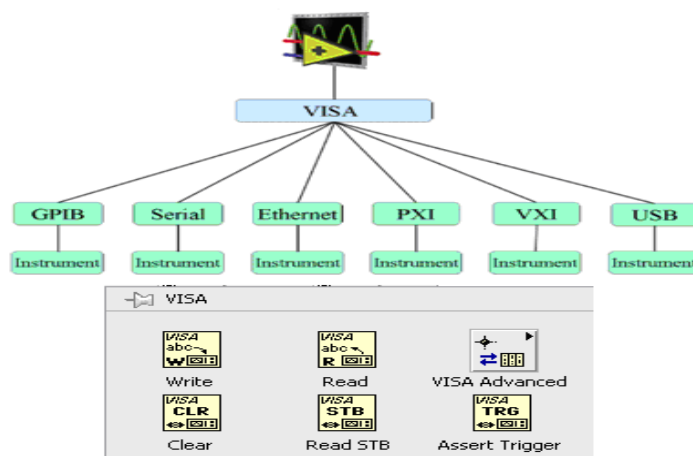


Fig. 2. The Structure of Virtual instrument software architecture

RS-232 bus is a universal serial bus uses most early, the more PC used the USB bus and IEEE 1394 bus. Universal serial bus (Universal Serial BUS, USB) has the advantages of high transmission speed, support asynchronous and isochronous transmission characteristics, suitable for data transmission situation relatively high in the large amount of data, data transmission rate requirements. System of serial port and other industry based on standard bus connects some serial port equipment and industrial control module, real-time monitoring system. No matter what kind of virtual instrument system, the instrument is equipped with the notebook computer hardware, computer or workstation and various computer platforms, coupled with the application software.

Using LabVIEW software, you can build a virtual instrument instead of programming. A software system for interactive control, users can easily build the front panel window. In order to achieve a specific function, the user to flow chart together using the wizard [3]. A front panel: select the object you need from the control board, the front panel on the virtual instrument. The control object template includes a digital display meter, pressure meter, thermal meter, shell, tables, pictures etc.. When your virtual instrument, virtual instrument can work in ten using the front panel to control the whole system, such as the movement of the sliding plate, in the image to the input from the

keyboard, etc.

The powerful function of LabVIEW in the hierarchical structure, users can create VI program as a subroutine call, to create more complex programs, and, calling the order can be arbitrary. Methods LabVIEW that create and call the subroutine to create program modular, easy to debug, understand and maintain. Different method of program design LabVIEW programming with the traditional method, it has the flow chart of program design language, get rid of the shackles of the traditional program language linear structure. The order of execution in accordance with the block diagram of LabVIEW data flow between decisions, and it is unlike the general programming language progressive implementation. In the preparation of block diagram program, only need to use a different function icon from function module, then the lines are connected to each other, can realize data transmission.

Published in the WEB LABVIEW program in a variety of ways, but must use each way before the first open Web server in the release program computer. LABVIEW web server default settings can meet the needs of the general program. That is to say as long as the open web server, not for any of the settings, you can complete the general task. The driver module of each instrument has its own instrument. The essence of instrument driver is provided for operating function more abstract operating instrument set for the user. For the application, the operation of the instrument is realized through the instrument driver; instrument driver for the operation and management of the instrument, and is the unity based and format provided by I/O software library (VISA) calls to achieve. For application designers, as soon as the instrument driver, in the not very understand the process instruments inside the case, the design work can also be carried out in virtual instrument system. The virtual instrument driver is the bridge and ligament between the application and the underlying I / O interface software.

A data acquisition system is based on virtual instrument [4]. This way by means of the insert in the computer data acquisition card and special software such as LabVIEW (LabWindows / CVI) combined with A/D converter, analog, digital signal acquisition to the computer for analysis, processing, display, and through the D/A conversion to realize feedback control.

A sophisticated data flow programming model liberated users to construct the program from the linear text language approach using LabVIEW. Because the execution sequence program in LabVIEW software flow are decided by each block of data. You can also set up the flow chart of synchronous operation. LabVIEW software is a multi thread functions of a multi task system -- with and run multiple virtual instruments.

## 2. Research on Virtual Instrument Motor Experiment Teaching System

The frequency test signal of the system required is very high, according to the requirements of the sampling theorem, the required A / D must be high, reflecting the high speed data acquisition system that the data can be compared to the real measured signals. But with the sampling rate of ADC devices increases, its price is also more expensive, so the choice of ADC devices must be weighed against its performance price ratio. In addition, from the current commonly used instrument - measuring signal oscilloscope, signal measurement system must have at least two signal channels, detection can at the same time signals, so as to observe, compare the relationship between two signals [5]. It has two kinds of acquisition options, which is one of the two channels using switch, turns into the single channel A / D acquisition. However, this alternate mode is sure to lose part of information, after all, two not simultaneously acquisition, it can not be accurate to the observation of the relationship between the signals.

Measurement of three phase circuit power. A three-phase circuit, connection mode load are star connection and a delta connection. Star connection, according to the needs of the three-phase three wires or four wire three-phase power supplies, triangular connection can be used only when the three-phase three wire power supply. Three-phase four wire circuit, the total power consumption load required power were measured A, B, C load of each phase, and then add. That is equation (1).

$$\begin{aligned}
 P_1 + P_2 &= u_{AC}i_A + u_{BC}i_B \\
 &= (u_A - u_C)i_A + (u_B - u_C)i_B \\
 &= u_Ai_A + u_Bi_B - u_Ci_A - u_Ci_B
 \end{aligned} \tag{1}$$

The more digits ADC, resolution is higher, can be distinguished in the smaller voltage. For example, the three bit conversion the analog voltage range is divided into segments, each segment with binary codes in the range 000 to 111 said. Therefore, the digital signal can not reflect the original signal, because some information is missing. If increased to thirteen, the code number increased from 8 to 8192, the digital information so that you can more accurately reflect the original signal.

The modular design of the LabVIEW virtual instrument, so any virtual instrument can run independently, but also can be used as a part of other virtual instrument. You can even create virtual instrument icon of their owns, and it is as to design multi-layer system composed of virtual instrument, and can change it, exchange with other virtual instrument and connected to meet the need of changing application.

LabVIEW development of the VI program, using modular multilayer structures: a VI by multiple VI bottoms of the form, the underlying VI represents the most basic functions -- calculation, input and output operations. The layers of the VI structures have the same, that all levels of VI structure and interface model is consistent, which makes the multilayer VI can realize the interconnection and nested good design, characteristics of whole program has the function of the object, and modular, greatly simplifies the software structure and design; each VI there is a user interface components or front panel (i.e. soft panel correspond with the actual instrument panel), and every VI has a block diagram. The program with a graphical programming language is equivalent to a traditional programming language program source code. Using graphics instead of the traditional code programming is the biggest characteristic of LabVIEW.

Three phase without reactive power and apparent power calculation and single-phase circuit similar. When the three-phase symmetry load, whether star or delta connection, three-phase, and are the same, so each phase power equal to three times, three-phase power single-phase power, three-phase power, as is shown by equation(2) [6].

$$P = 3U_{\phi} I_{\phi} \cos \varphi = \sqrt{3}U_1 I_1 \cos \varphi \quad (2)$$

This part of the circuit provides three functions, one is the value of the amplifying or attenuating the analog output of the converter, in order to meet the requirements of the target: the impedance matching, because the converter output impedance is large and dynamic change, must be operational amplifier circuit is composed of a high input impedance and low output impedance of the output buffer can with the general target load connected; third is to provide low pass filter, the ladder wave output into a smooth waveform, is a must for applications of arbitrary function waveform generated by digital computer in this sequence.

When the sampling of multiple channels, cycle sampling refers to the collection card using multiway switch at a clock frequency will be more channels are access to A/D cycle sampling. Figure 3 gives two channel circular sampling schematic diagram. At this time, all the channels to share the same A/D and S/H equipment, equipped with A/D and S/H respectively, each channel to cheap way. Cycle sampling disadvantage is not on the multi-channel synchronous sampling, scan rate channel is composed of multiplex switching rate average assigned to each channel. Because multiple switch to switch between channels, sampling of two consecutive channels, signal waveform will change with time, the time delay between the channels. If the channel delay between the analyses of the signal is not very important, the use of circular sampling is possible.

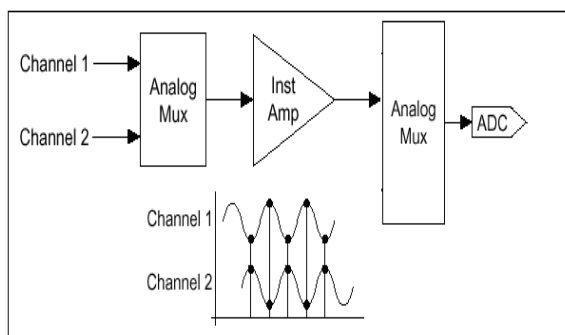


Fig. 3. Schematic diagram of channel cycle sampling

To get data from several channels, usually use multiple switches to each signal terminal is connected to the converter (abbreviated). With the continuous scanning method, than to each channel of an amplifier and to the economy much, but this only applies to not very important occasion at the time of sampling points [7]. If the sampling point of time between strict requirements, we must also capture. For the low frequency signal, can be used to generate interval scanning and sampling effects, without increasing the sample and hold circuit. This method in a certain time interval scanning input channels, with each channel pulse is not calculated two times by the scanning interval.

Signal Generation LabVIEW module under the simulation signal rich production of the VI, such as sine wave

generator, Fang Bo sequence generator, triangle wave sequence generator, the unit pulse sequence generator, wave generator etc.. We will simply take the sub VI into a case structure to form the typical signal generation module, Switch structure and case structure similar to the C language, is a multi branch structure, it according to the input value decision procedures into different branch flow.

Calculation of so many times so that DFT can not be used in practical engineering and it is resulting in various DFT for reducing computation time algorithm. Such as 2 time parity decomposition algorithm. Those who can reduce computation times, shorten the time of calculation, can be used for fast algorithm of DFT computing in engineering practice is called the fast Fu Liye transform, referred to as FFT. In many software toolkit, has a variety of utility function or function template available for use. LabVIEW provides these functions modules. The virtual spectrum analyzer is the main function of the FFT transform is used to simulate the signal to generate, obtain the time domain signal spectrum, The rotor speed  $n_2$  asynchronous motor and a synchronous speed  $n_1$  is the speed difference, ratio of  $S$  velocity difference between the synchronous speed is called the "slip", as is shown by equation(3) [8].

$$S = \frac{n_1 - n_2}{n_1} (\%) \quad (3)$$

$$n_2 = n_1(1-s)(r/\text{min})$$

In the L, R, C measurement system as the signal source, through the measured impedance current limiting resistor is added to the. When A is an ideal amplifier and it is the measured impedance and sampling standard resistor with same current. The vector voltage and direct or data acquisition card after signal conditioning to the corresponding input channel.

The main data signal spectrum analyzer to do the processing analysis of signal transformation of Fu Liye is to get to, its frequency diagram. So is LabVIEW in the frequency domain analysis module provides and signal analysis of a large number of related functions for designers to use, then we call the calculation in real FFT sequence as the main data signal processing sub VI spectrum analyzer.

According to the fundamental frequency of induction motor equivalent circuit diagram, can analyze the steady state characteristics of the motor. Because the harmonic power supplies voltage effect on the characteristics of the motor is very small, therefore, to analyze the sinusoidal voltage balance. If you ignore the skin effect is independent of frequency, resistance, reactance is proportional to the frequency. Rotating magnetic flux in the air gap in the stator windings Induction EMF is  $E_1$ , because of the existence of the stator leakage reactance voltage drop, so the back EMF  $E_1$  less than the voltage  $V_1$ , phase voltage effective value can be expressed as equation(4).

$$E_1 = 4.44 K_w f_1 N_1 \phi$$

$$\vec{V}_1 = (R_1 + jX_1)\vec{I}_1 + \left(\frac{R_1}{S} + jX_1\right)\vec{I}_2 \quad (4)$$

The average value in a cycle is three-phase total instantaneous power in a cycle of an average value. Whatever power or load is symmetrical, regardless of load or triangular load, the above conclusions are correct. So the total power consumption of the three-phase.

The virtual instrument can carry out the following 4 experimental tasks. Among them, can use the software to design the same task 1 ~ 3, because they are testing the continuous waveform. When the motor is started, the motor finally stopped, PCI collected data continuously conveying to the virtual instrument, and then after the simple analysis, using virtual instrument in the waveform display. Objective this experiment mainly, quality inspection, operation, shutdown starting performance of motor. Task 4, is in the stable operation of motor.

Because LabVIEW is a data flow driven programming language, therefore in all the modules are integrated, more attention should be paid to the data flow problem. Especially to the flyout panel module and it is very easy to cause the data flow confusion, error. When necessary, should use the Sequence structure to control the data flow, make it transfer data according to the designer.

An induction motor maximum torque and torque are power frequency relationship. Maximum torque which is composed of type (4) the maximum values calculated, clearly visible, two torques decreased seriously at frequencies

below 10HZ. In order to improve the low-frequency characteristic, in the low voltage / frequency increase must be. This adjustment in the use of variable frequency power supply is not, but in the use of static frequency converter is very easy to implement, because static frequency converter can independently adjust the output voltage and frequency.

LabVIEW front panel is used to set the input and output for observation, the front panel to simulate real oscilloscope. Because the virtual panel directly to consumers, is the core of the virtual oscilloscope control software. Design of front panel, mainly considering the beautiful interface, simple operation, the user can simulate the traditional instrument operation through the front panel switches and knobs, to realize the control of the virtual oscilloscope through the keyboard and mouse. The front panel is provided with each function module button, when you press the corresponding button, you can call the subroutine.

### 3. Development of Virtual Instrument Motor Experiment Teaching System based on LabVIEW

The hardware platform of the virtual instrument consists of a PC computer and data acquisition card (DAQ card). The data acquisition card is an important part of the virtual oscilloscope; its performance will directly affect the main index of the sampling rate, accuracy of the virtual. The task of data acquisition system is a collection of the original signal, the main indexes are sampling precision, sampling rate. Sampling precision by the converter to decide, and the sampling speed is inseparable with sampling frequency. From the point of improving the precision of angle, between the number and the sampling frequency converter is mutual restriction. Select the data acquisition card is mainly related with the sampling rate, the measurement channel, resolution and accuracy.

Data acquisition is the test signal from the analog signal into the computer to process the digital signal receiving and processing. The data acquisition card is an integral part its core is the A/D converter. The input signal of A/D transform in time and amplitude are continuous analog signal changes, the output signal in time and amplitude are discrete digital signals, and process transformation process from the continuous signal to a discrete signal can be seen as the sampling and quantization. According to the principle of A/D conversion can be divided into 3 types: the method of successive approximation A/D, double integral A/D method and parallel comparison method A/D, method of converting more application in DAQ product is the method of successive approximation. To measure the performance of the A/D converter has two main indexes: one is the sampling resolution, i.e. A/D converter number; two is the A/D conversion rate.

The test and analysis system's hardware platform is determined, for different applications, constitute virtual test different analytical instrument. For the analysis of systems with general test, and can be widely suitable for different professional testing requirements, software using modular design, system structure parameters are used in the form of variables. Therefore, the software of the data acquisition module and it is data show that the type and quantity of the measured physical quantity module, data analysis module and data processing module is shown with the structure parameters of the specific numerical changes. For different tasks in different professional, according to the type and quantity of measurement points, only need to re set the parameters of system structure module value, matching will be able to complete the system hardware and software.

In the cut-off frequency, frequency response decreases monotonically. In the pass band is the ideal unit response in the stopband response, zero [9]. The merits of Butterworth filter is decreasing with smooth monotonic frequency response. The steepness of the transition zone is proportional to the order of the filter. Butterworth low pass filter is a kind of the most flat pass band characteristics approximation filters ideal low-pass characteristic, as is shown by equation(5).

$$|H(\omega)| = \frac{1}{\sqrt{1 + \left(\frac{\omega}{\omega_c}\right)^{2n}}} \quad (5)$$

Widely used in automation and control field. The virtual instrument system is commonly used is the data acquisition card system, together with the control system of GPIB, VXI instrument system as well as any combination between the three with. This paper uses the LabVIEW software as a development platform, using existing equipment conditions of the laboratory to design a motor speed closed loop control system, with a small amount of hardware to complete the control of motor speed, with high precision and high efficiency, easy scalability and friendly interface etc..

This is called a cyclic Buffer mechanism. Its principle is as follows: can put read buffer the data at the same time put data into the buffer, when the buffer is full, the buffer at the beginning to store new data, as long as the data and data access speed with the good, can be achieved with a limited storage area, to continuous data transmission. Using a circular buffer in the acquisition of equipment, can continuously in the background were collected at the same time, LabVIEW is in the read buffer data two times the time interval of data processing.

The fundamental frequency and frequency above two kinds of circumstances combined can be shown in Figure 4 of the asynchronous motor variable frequency speed control characteristics. If the motor rated currents at different speeds, which can in temperature permitting conditions are basically long-term operation, torque with magnetic field. In accordance with the electrical transmission principle, at the fundamental frequency, magnetic flux constant torque and constant, which belongs to the "constant torque speed"; and in the fundamental frequency, the speed increases torque reduction, which belongs to the "constant power speed".

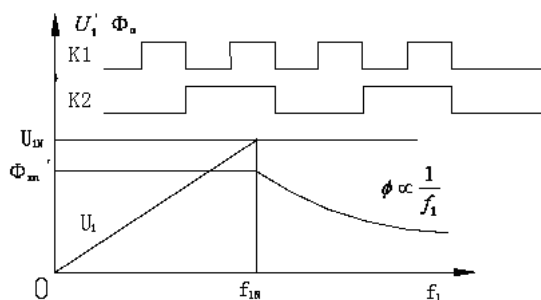


Fig. 4. The asynchronous motor variable frequency speed control characteristics

Some work in this paper is designed for software development and application and LabVIEW virtual instrument technology, used LabVIEW to realize the system front panel, and the data processing method. The experimental system is to use PC computer display (CRT) display function simulation control panel of traditional instrument, with various forms of expression and output detection result using PC computer software can realize the function of signal data calculation, analysis, processing, acquisition, signal conditioning and completed by the I/O interface equipment, to complete a computer instrument system test function.

## CONCLUSION

The paper proposes development of Virtual Instrument Motor Experiment Teaching System based on LabVIEW. In this paper, the virtual instrument technology is applied to the motor in the laboratory construction. Virtual instrument technology that use a powerful computer resources that would require hardware to software of the technology, to achieve different functions of the instrument by calling different software on the same hardware conditions, to complete a variety of parameters testing, in order to minimize system cost, enhance system functionality and flexibility.

## REFERENCES

- [1]Gong Chenglong; Zhang Ming; Zhang Lei; Guo Fengyu. *IJACT*, **2012**, 4( 22), 841 ~ 847.
- [2]Zhenmei Li; Jin Shen; Wei Liu; YaJing Wang. *IJACT*, **2012**, 4( 23), 466 ~ 474.
- [3]Dong Kang-xing; Jiang Min-zheng. *Journal of Chemical and Pharmaceutical Research* ,**2013**,5(9), 182-187.
- [4]Wang Lijun; Xing Long; Zhou Jianbin. *JCIT*, **2012**,7( 22),359 ~ 367.
- [5]Zhihong FENG; Changyun MIAO; Hua BAI, Yanli YANG. *JCIT*, **2013**, 8(9),879 ~ 886.
- [6]Liu Yi. *JCIT*, **2013**,8(3), 11 ~ 18.
- [7]Zheng Han. *Journal of Chemical and Pharmaceutical Research*, **2012**,4(8), 3861-3864.
- [8]Shenshen Gu; Zhijian Chen; FeiWang. *AISS*, **2011**,3( 9), 1 ~ 8.
- [9]Liu Lianxin; Liu Yu; ShiGuangxia. *Journal of Chemical and Pharmaceutical Research*, **2014**,6(2), 83-88.