

Application of Virtual Instrument LabVIEW in Variable Frequency and Speed Motor System

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Abstract

The working process of the virtual instrument system: first the signal input signal system acquired by a sensor conditioning circuit, the signal conditioning circuit for amplifying, filtering, and then through the data acquisition card into the memory, then carries on the data analysis and processing of the collected data. This paper uses virtual instrument environment LabVIEW to the transmission, processing and graphic signal data acquisition system for motor experiment. The method proposed in this paper can analysis electrical parameters in different circumstances of variable frequency motor performance.

Keywords: virtual instrument, LabVIEW, variable frequency, motor

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1. Introduction

Virtual Instrument (VI) development is the characteristics of automation instrumentation field. Virtual instrument is mainly used in the construction of computer test and analysis system and automatic control system. It software to replace the traditional electronic instrument, give full play to the new generation of computer of large capacity, high speed CAT, CAE potential, is an important signal acquisition and analysis methods [1]. Virtual instrument is the electronic circuit in a specific software support to replace the corresponding function, make full use of the software and hardware resources of computer, and complete the traditional instrument part or all of their function with the computer, in order to have soft instrument control, processing and analysis software as the core.

LabVIEW uses a graphical programming language, in block diagram form programming, most scientists, using charts and icon equipment engineers used are basically the same, which makes the programming process and thinking processes are very similar. Provides a lot of functions and subroutines to support user tasks LabVIEW, also provides some special procedures such as GPIB control, VXI bus control, serial port control, and data analysis, display and storage. LabVIEW provides specially used for program development tool, allowing the user to set a breakpoint, dynamic program execution to observe the process of data transmission, in order to facilitate debugging.

The development of motor experiment system based on virtual instrument, using the most popular virtual instrument software development environment LabVIEW, the transmission, processing and graphic signal data acquisition system of motor experiment, the ultimate goal is to make the data acquisition card and the software of independent development of the combination, realization of spectrum analyzer digital storage oscilloscope, function, used for electrical parameters, analysis in different scenarios of variable frequency motor performance etc. Also a continuous power signals to the acquisition of motor for further processing in time domain and frequency domain.

In this paper, it is based on analysis of curve of variable frequency speed regulation motor starting. The computer aided design of large amounts of data and different types of load starting analysis of the characteristics of this kind of motor starting must meet the requirements, and according to different types of load, the required design principles.

The sensor signal, it will be measured parameters can be converted into the corresponding output signal. The output signal from the sensor is usually weak signal or non voltage signal containing noise, so after signal conditioning. The output signal through the data acquisition card, converted to digital signals into the PC computer, data processing is done by

Labview. Motor control is completed by frequency conversion power supply, speed encoder and Labview. This paper realizes in the LabVIEW data acquisition on the independent development of the control card, to transmit the data collected and stored in the computer: through the development of software panel, realized the virtual digital storage oscilloscope with function of spectrum analyzers, can be carried out on the signal processing and display.

2. Design Platform of Virtual Instrument (LABVIEW)

In LabVIEW, a virtual instrument (VI) program consists of two parts: the front panel (Front Panel) and the flow chart (Block Diagram). The front panel control panel to the corresponding traditional electronic instrument, graphical user interface, users can set up through the front panel instrument. On the front panel, the user input through the input control is known as the implementation of Control, the result of running the program output is realized by the Indicator output. Virtual instrument output is very rich, can output data, and can output a variety of graphics, can also save the text or binary file.

LabVIEW is a general purpose programming system can be extended function library and subroutine library. It provides for the GPIB device control, VXI bus control, and serial port control, and data analysis, display and storage application module. LabVIEW can be easily dynamic link library functions calls the Windows dynamic link library and user defined in; LabVIEW also provides CIN (C Interface Node) nodes so that a user can use the C or C++ language, such as ANSI C compiled program module, LabVIEW has become an open development platform. LabVIEW also directly supports dynamic data exchange (DDE), structured query language (SQL), TCP and UDP network protocol.

Virtual instrument using powerful personal computer graphics environment and online help function, establish complete virtual instrument panel, instrument control, data analysis and display, instead of the traditional instrument, change the traditional instruments use, improve the instrument function and the use efficiency, greatly reduced price of the instrument, the user can according to their own functions need to be defined instrument. Virtual instrument is widely used in signal processing, electronic measurement, power engineering, mine detection, medical, vibration analysis, acoustic analysis, fault diagnosis and teaching and scientific research etc.. Among them, it is the most widely used to replace the conventional bench top instruments.

In the LabVIEW user interface, special attention should be paid to providing operation template, including tool (Tools), control (Controls) template template and function (Functions) template. These templates reflect the function and characteristic of the software [2]. The template provides various used to create, modify and debug VI program tool, as shown in Figure 1. If the template does not appear, can be in the Windows menu and select Show Tools Palette command to display the template. When the templates choose any kind of tool, the mouse arrow will become the shape of the corresponding tools.

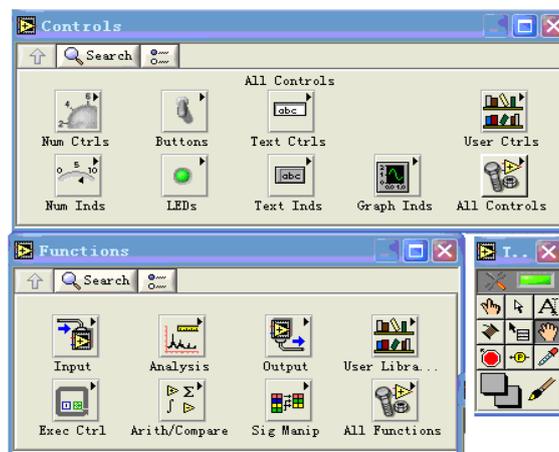


Figure 1. LabVIEW Tools, Functions and Control Template

The output of the template used to give the front panel set various required display objects and input control object. Each icon represents a class template. If the control templates are not shown, you can open it in Windows Show Controls Palette menu function, also can be in the blank front panel, and click the right mouse button, the pop-up control template. Control template as shown in Figure 1.

Function template is to create the program flow chart tool, as shown in Figure 1. Each top-level icon on the template represents a sub template. If the function template does not appear, you can open it with the Show Functions Palette under the Windows menu function.

Developed by LabVIEW virtual instrument program step. 1) To determine the overall design scheme in the preparation procedure of virtual instrument program before, must first carry out the overall design analysis on the program: one is to determine the program to realize the function, graphic image to display, to output report; two is to determine the hierarchy process, such as the relationship between the main program and the subroutine, program of virtual instrument and hardware connection etc. 2) Determine the virtual instrument front panel in the completed the overall design program of virtual instrument, can be arranged on the front panel display the required object function, these objects include switch knob control, data display, header, waveform display, pharos diagram, graph display, the front panel arranged these objects, engineering and technical personnel through the keyboard can operate like traditional instruments to operate the virtual instrument.

Graphical LabVIEW program design is modern software with object oriented technology and the data stream technology which is developed based on. Data flow programming says only when all inputs are available; an object to perform, similarly, only when the object function is completed, the output is only valid object. In this way, each other in the object data flow control the execution order, the order of execution is not limited to linear order from the text type of program design, it can not restricted. The user can through the rapid application development own connection module, even can use multiple data channels, to achieve synchronous operation.

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, and it is 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. The graph editor: on many occasions, the process speed is the key. LabVIEW software is the only with the editor's graphical programming environment, can produce optimized code, the speed of operation and compile the C speed is. The drawing device built-in can even on and time part of the code is crucial for analysis and optimization. So, it is not because the graphical programming reduces efficiency. Graphical program programming is simple and intuitive, the development of high efficiency.

In the computer testing system for the center, the analog signal $x(t)$ before entering the computer through a data acquisition card (DAQ) in the sampler, the continuous time signal into a discrete time signal, a signal after the A/D converter in the amplitude quantization for discrete digital signal.

Periodic function satisfies that condition in finite interval, the $x(t)$ can be expanded into Fu Liye series. There are two kinds of expressions of Fu Liye series, Fu Liye series expansion of trigonometric function as in Equation (1) [3].

$$\begin{aligned}
 x(t) &= \sum_{n=1}^{\infty} b_n \sin n\Omega t + \sum_{n=1}^{\infty} a_n \cos n\Omega t \\
 &= \frac{a_0}{2} + \sum_{n=1}^{\infty} (b_n \sin n\Omega t + a_n \cos n\Omega t) \\
 &= \frac{a_0}{2} + \sum_{n=1}^{\infty} A_n \sin(n\Omega t + \varphi_n)
 \end{aligned} \tag{1}$$

Where $a_0 = \frac{2}{T} \int^{+T} X(t)dt$ is the DC component, $A_n = \sqrt{a_n^2 + b_n^2}$ is the amplitude of each frequency component, the angular frequency of $n\Omega$ is as the abscissa axis, amplitude A_n or phase angle φ_n as the horizontal mapping, respectively get the amplitude spectrum and phase spectrum, they are one-sided spectrum, $n\Omega \rightarrow \infty$.

For non periodic signal, T can be regarded as a periodic cycle of T signal of infinity.

When the cycle tends to infinity, the base spectral line and line interval $\Omega = \frac{2\pi}{T}$ reaching infinitesimals, thus the discrete spectrum becomes continuous, so the spectrum of non periodic signal is continuous.

As the cycle T is non periodic signal infinite, when the cycle $T \rightarrow \infty$, spectral line interval $\frac{2\pi}{T} \rightarrow d\omega$, $T \rightarrow d\omega$, discrete variables as continuous variables, $m\Omega \rightarrow \omega$ summation operation becomes quadrature operation. Then get the formula 2.

$$\begin{aligned} x(t) &= \lim_{T \rightarrow \infty} \frac{1}{T} \sum_{m=-\infty}^{\infty} C_m T e^{jm\Omega t} \\ &= \lim_{d\omega \rightarrow \infty} \frac{2\pi}{d\omega} \int_{-\infty}^{+\infty} X(\omega) e^{j\omega t} \\ &= \frac{1}{2\pi} \int_{-\infty}^{+\infty} X(\omega) d\omega \end{aligned} \quad (2)$$

Based on data collected in this way virtual instrument data acquisition system with the help of insert in the computer card and special software such as LabVIEW (or LabWindows / CVI) combined with A/D converter, analog, digital signal acquisition to the computer for analysis, processing, display, and through the D/A conversion of feedback control. According to the need, it can join the signal conditioning and real-time DSP hardware module.

GPIB system is a general purpose interface test system. It is composed of a PC, a GPIB interface card and a plurality of GPIB instrument subsystem. Each instrument subsystem is a GPIB interface with a single instrument. Even though different manufacturers of the products are compatible with interchangeability, assembly system is very convenient, separated the instrument system can also be used as a single instrument used independently. A GPIB interface card can take up to 14 instruments. Using GPIB technology, realize the operation and control of the instrument can be used in computer, to replace the traditional manual mode of operation, test and measurement errors caused by human factors of exclusion. At the same time, 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.

Sampling the continuous time signals is into discrete time series process. This process is equivalent to the continuous time signals "from" many discrete time it ($i=0, 1, 2, \dots$) is the

signal of instantaneous value. Where T is the sampling interval, the $\omega_s = 2\pi/T$ is the sampling frequency, their value is a very important question. The relationship between sampling frequency, must meet the following formula [4].

$$\omega_s \geq 2\omega_m \quad (3)$$

Where ω_m is the highest frequency component signal. When $\omega_m \leq \frac{\pi}{T}$ also is the sampling frequency $\omega_s = 2\pi/T \geq 2\omega_m$, we can add an ideal low-pass filter to extract the

principal component, remove all $m \geq 1$ high-frequency component, which consists of $X(x)$ to restore the original signal $X(\omega)$ without error in theory.

Measurement channel is the number of signals, the whole system is needed to measure the products of different channel number, can be measured in different. Need to pay attention to in the selection of products: whether the measured channel number and meet the demand of the system; when the differential input when measuring, the board without number channel differential input and differential input; in the measurement channel number, we should pay attention to product can be extended and can be expanded the number of. Measurements are required to analog signal by the A/D is converted into digital signal and binary, resolution is the full range signal by the A/D conversion N_{ai} to two numbers. The higher the resolution, means that the voltage changes can be detected more small, it and the measurement range (the highest level can be measured) and gain (amplification board) that together determine the minimum voltage change of the board can be measured.

A/D converter is the input analog devices for the digital output, but also the core of the DAQ hardware. The working principle, there are 3 kinds of methods: A/D conversion method of successive approximation A/D, double integral A/D method and parallel comparison method A/D. Methods used in DAQ products is the method of successive approximation A/D. Double integral method of A/D is mainly applied to the speed requirement is not high, but the reliability and higher anti-jamming occasions, such as digital millimeter etc.. Parallel comparison method of A/D is mainly used in the high speed sampling, such as digital oscilloscope, digital sampler and other applications. To measure the performance of A/D converter has two main indexes, one is sampling resolution, i.e. A/D converter digit, and two is the A/D conversion rate.

LabVIEW supports three formats for file input and output, i.e. text file, binary file and data file. The spreadsheet file is a special type of text file, the file is still in ASCII format to store the data for Microsoft Excel spreadsheet software can directly read the data file; data records in a file containing a known as waveform file format, it records the occurrence of some of the basic waveform information, such as the initial time, waveform sampling interval time.

LabVIEW platform is in the development of a virtual signal spectrum analysis instrument. The instrument should be the typical experimental signal generation, FFT transform is performed on a typical experiment signal, analyzes its frequency spectrum, and display the results. To sum up the main functions include: signal generation, signal analysis and processing, data file storage and reading. Because LabVIEW is a modular program based on the design idea, therefore in the development process is basically follows the basic idea, in the overall scheme, various functional modules are set up according to the different function, finally, integration and debugging.

3. Research and Basic Principle of Variable Frequency and Speed Motor and TD3000 Converter

Asynchronous motor speed is determined by the supply frequency and pole pairs. So change the frequency of the motor can drive operation. But the change frequency, impedance motor internal change, will produce tiny excitation caused by torque down; because the excitation caused by magnetic saturation phenomenon, is a motor factors, efficiency decreased significantly. Therefore, changes in the frequency at the same time, always maintain the terminal voltage of the motor coordinated control, the ratio of the two is a constant, the purpose is to ensure that the air gap flux invariant, so the V/F control mode is also called constant ratio of voltage and frequency control method.

The sensor to the physical signals is converted into electric signals. For example: thermocouples, thermostats, integrated circuit, sensor, the temperature into the voltage and the resistance. And as the strain gauges, flow sensors, pressure gauge, pressure, flow rate, the pressure is converted to electrical signals. For each sensor, signal is directly proportional to the physical parameters of the monitored. 6 sensors are used in this design. Among them, 3 current sensors, 3 voltage sensors, respectively, the three-phase voltage of asynchronous motor, current measurement.

Slip frequency control, the speed of the motor is detected, the output frequency and then to the motor speed and slip frequency and a given inverter. To slip frequency is directly related to any control and torque, current. Compared with V/F control and it is the acceleration and deceleration characteristics and limitations of current capacity. It also has a speed

controller, the speed feedback speed closed loop control, is suitable for the automatic control system.

The timing relationship between data acquisition system of each part is relatively strict, if not the appropriate timing will be seriously affected the accuracy of. The timing circuit is to produce a variety of timing signals according to each circuit unit of work order, and the control unit is produced in the control timing signal control signal. Figure 2 shows a typical acquisition system sequence diagram.

The V/F control of asynchronous motor mechanical properties, when the frequency is reduced, curve to the longitudinal coordinate translation, the maximum torque point drop [5]. As in the low frequency, torque is not enough, can be taken to improve the torque voltage compensation, the compensation by the frequency converter to complete, usually no more than 10%, can also be considered from the motor design. This can make the maximum torque under different frequency invariant.

Motor vector control and direct current machine with the same torque generation mechanism, namely the current magnetic field perpendicular with the product of the basic principles of torque. Using DC motor commutator and brush to keep both vertical relationships in machinery, and can supply. While the asynchronous motor stator current in electromotor, by electromagnetic induction in the electrical is decomposed as the excitation current and torque current are vertical, arbitrary control, at the same time, both synthesized as the stator current supplied to the motor.

In the following basic frequency motor VVVF, requirements of voltage to the motor with the stator frequency is proportional to the must change, to ensure that the air gap flux is constant, at any speed, torque motor can generate stable. However, the stator voltage increases have certain limit, subsequent to the rated voltage, the voltage can be kept constant, and then improve the speed, can only make the frequency is increased, that is to say, the basic speed, with the increase of frequency, the air gap flux will decrease, the torque decreases.

You can clearly see that the basic speed of motor, torque range show that the envelope is constant, called the constant torque operation; when more than basic speed. Torque range show that the envelope is decreased. This operation mode of variable frequency speed regulation electric hunger and DC motor speed regulator and weaken the special speed is very similar to magnetic field [6]. Slip is small, torque of asynchronous motor for the Equation (4).

$$T = K \left(\frac{V_1}{f_1} \right)^2 f_2 \quad (4)$$

Where, V_1 is constant stator voltage and rotor frequency, f_2 is torque decreases with the increase of power frequency. If the F_2 increased linearly with increasing F_1 , the torque is directly proportional to F_1 , the output torque of the motor rotation speed approximately reciprocal changes; this is the constant power operation.

TD3000 converter is a high quality, multi-function, low noise vector control inverter. Through decoupling control of the motor flux current and torque current, to achieve rapid response and accurate torque control, speed can be wide range in high control precision.

The TD3000 converter has three control modes: no PG vector control, vector control and V/F control with PG. Operation and control mode selection by the function code F0.02. Mode 0: no PG vector control, the speed sensor less vector control, also known as the open loop vector control. Do not apply to the installation disc, high starting torque and speed control accuracy, conventional V/F control can not meet applications. Mode 1: PG vector control, the speed sensor vector control, also known as the closed loop vector control.

Starting from the function in the inverter shutdown state, and it is effectively re entering the work state. That is the first time in power, instantaneous power failure is restored, after the failure is reset when shutdown normally, free, under such circumstances, put into operation again, frequency conversion will be starting mode settings selection of starting [7]. When set to 0, from the starting frequency starting converter is put to use, according to the function code F2.01 and F2.02 settings, from the starting frequency (F2.01) starting, and run the set in the frequency time (F2.02): and then the acceleration time, set parameters such as acceleration and deceleration mode, enter the speed stage normal to set the frequency, acceleration, as is shown by Figure 2.

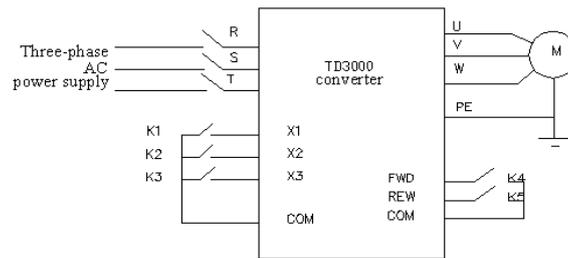


Figure 2. Multi Segment Speed Wiring Diagram

Parameter is correctly set TD3000 converter, is the premise to fully play its performance. The operating process is as follows, press the shift key will switch parameters (i.e. change the flashing position), the keys with unidirectional cyclic shift function. Parameter setting is completed continuous press the menu button two times; it will exit the program state. Once again into the program state, automatically enter the first operation function code (with memory).

4. Using Virtual Instrument LabVIEW to Design of Variable Frequency and Speed Motor System

Debugging is established on the LabVIEW platform, if from the LabVIEW it will not be able to run. That is to say, users in the use of the virtual instrument front, LabVIEW must be pre installed on your computer [8]. Debugging purposes is to check the program can be run in accordance with the user intended way, achieve the requirement of design procedure. Debugging process in general is to find syntax errors and logical errors and correct them.

The data acquisition module is the core software of virtual digital oscilloscope, control mainly complete data collection, including the trigger control, access control, timing control etc.. Trigger control including trigger mode, trigger slope and trigger level control. The channel control main control single or dual channel measurement.

The motor speed, usually an important factor to consider, that the flux per pole motors for ratings, and remain unchanged. If the flux is too weak, did not make full use of the motor core, is a kind of waste: if the excessive increase of flux, and make the core saturation, resulting in excessive excitation current is large, serious when can motor damage due to overheating winding.

LabVIEW allows a program running in single step mode, also supports run-time highlighted. Step three control buttons, respectively is: step into said one step into the program flow and stopped at the next node data; step over said one step into the program flow and stop in the implementation of next node data; step out said the step stop mode.

The most common acquisition card has a plurality of analog input channels, but not every channel configuration of a A/D, but they share a set of A/D, before A/D had a multiplexer (MUX), and the amplifier (AMP), a sampling holder (S/H) etc. By scanning the switching the switch, multi channel sampling [9]. There are three kinds of multi-channel sampling methods: cycle sampling, synchronous sampling and sampling interval. In a scanning (scan), data acquisition card will conduct a sampling of all the channels; the scan rate (scan rate) is the number of times per second scan data acquisition card.

Display signal time is domain (sampling point amplitude) by the discrete Fu Liye transform (DFT) method are transformed into the frequency display. For fast computation of DFT, often using a fast Fu Liye transform (FFT) method. When the sampling signal is a power of 2, you can use this method. The output of FFT is bilateral; it also shows the positive and negative frequency information. By using only half of the FFT output sampling point into the unilateral FFT. Frequency spacing between sampling point of FFT is f_s/N , where f_s is the sampling frequency.

In order to make the voltage vector of inverter output nearly circular, and finally get the rotary flux circular, must use the inverter output voltage time combination, form polygon voltage vector locus, which is more close to round [10]. This is the basic starting point of sine PWM

principle. For example: when the rotating flux I zone, with the voltage vector synthesis of two adjacent to, and in accordance with the volt second balance principle, to the following formula (5).

$$T_6U_6+T_4U_4+T_0U_0=T_sU_{out} \quad (5)$$

Where, T_n is the voltage vector for U_n time corresponding, T_s is the sampling period; U_{out} is for the synthesized voltage vector.

Commissioning and operation of the design is based on the debugging and operating on basic. Build a good hardware platform and software platform, tested motor parameters, by the sensor signal into signal reference data transmitted to the data acquisition system through various channels, and then transmitted to the LabVIEW software platform for the inspection to view and print the results.

The design of the virtual experiment instrument is refer to the dual channel benchtop digital storage oscilloscope general functions, and expanded in instrument analysis. The main function of instrument consists of double channel signal input, trigger control, access control, timing control, waveform display, spectrum analysis, waveform storage and read.

5. Conclusion

The function of virtual instrument is defined by the software; the software is the key technology of virtual instrument. Virtual instrument software system should include the operation panel design, data acquisition, waveform display, signal analysis and processing and I/O equipment management etc. It is composed of two parts, namely the application program and the I/O interface driver. Virtual instrument applications will be optional hardware (such as GPIB, VXI, RS-232, DAQ board) and repeated together with the library function software, realized the function of communication module, timing and triggering. The original code library function for users to construct their own virtual instrument (VI) system provides a software module basic. Because of VI's modular, openness and flexibility, and the software is the key features, when the user test requirements change can be conveniently software modules or hard, by the users themselves, or reconfigure existing systems to meet the new testing requirements.

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