Automated complex for research of electric drives control

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Abstract. In article the automated complex intended for a research of various control modes of electric motors including the inductor motor of double-way feed is described. As a basis of the created complex the National Instruments platform is chosen. The operating controller built in a platform is delivered with an operating system of real-time for creation of systems of measurement and management. The software developed in the environment of LabVIEW consists of several connected modules which are in different elements of a complex. Except the software for automated management by experimental installation, the program complex is developed for modelling of processes in the electric drive. As a result there is an opportunity to compare simulated and received experimentally transitional characteristics of the electric drive in various operating modes.

1. Introduction

Modern electromechanical systems of responsible installations, such as spacecraft, are subject to increasingly high demands on reliability, accuracy, weight and size and functionality [1-3]. This leads to the search for new directions in the design of electric drives using a modern element base and control methods [4-7]. One of such directions is the use of alternating current motors, including motors of double-way feed. There are two types of motors of double-way feed: on the basis of the induction motor with a wound rotor and inductor motors of double-way feed. For motors of double-way feed all known methods of control of AC motors, as well as methods specific to double-way feed and providing new properties to the electric drive, can be used. One of these methods of control is phase control, which gives new capabilities for the drive in position systems and provides high dynamic and precision values of the electric drive [8-11]. At the Institute of Space and Information Technologies of the Siberian Federal University, on the basis of the National Instruments equipment, a hardware-software automated complex was created. It allows to carry out research of various methods of electric drives control.

2. Hardware-software automated complex for research of electric drives control

For research of characteristics of electric motors and methods of their control, the hardware-software automated complex was created that includes an electric motor, the digital angular position sensor, current sensors, power inverter modules, mechanical load and National Instruments equipment (Fig. 1). The modular platform NI PXI-1042 was chosen as the basis of the created hardware-software complex. It allows you to easily change the structure using the modules according to the needs of the user and has a high performance for processing large data sets. NI PXI-1042 embedded controller NI PXI-8106RT is supplied with a real-time operating system for the creation of measurement and control systems.

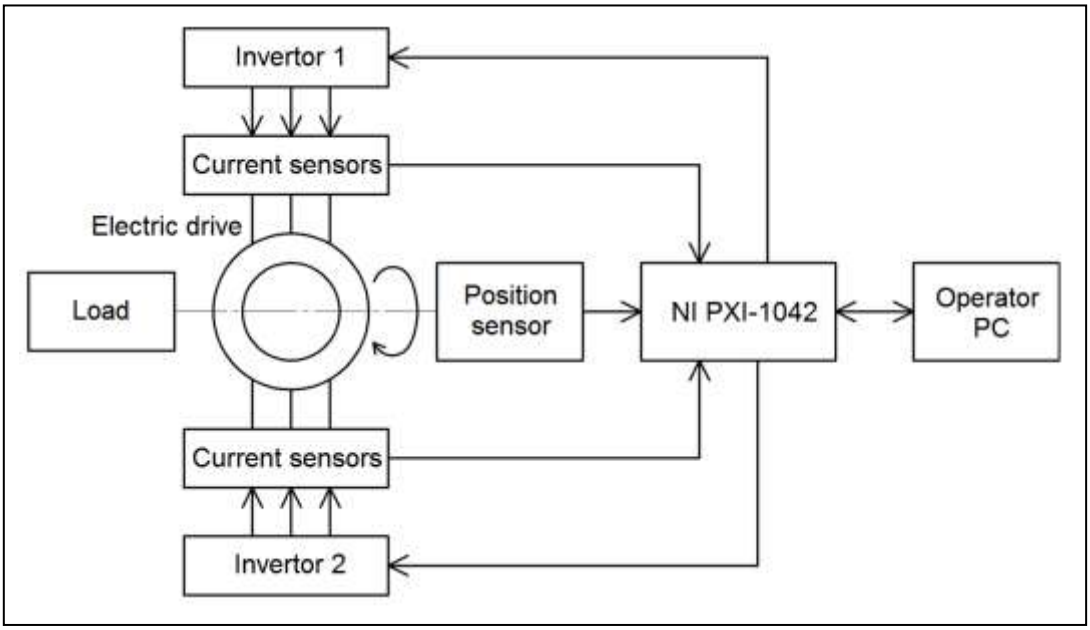

Figure 1. Block diagram of the automated complex

The NI PXI-8106 RT controller uses a PXI bus to communicate with modules installed on the chassis, such as the NI PXI-7833R multifunction RIO device (Fig. 2). This module is hardware-implemented on a programmable logic integrated circuit and has 8 channels of analog input, 8 channels of analog output and 96 digital input/output lines.

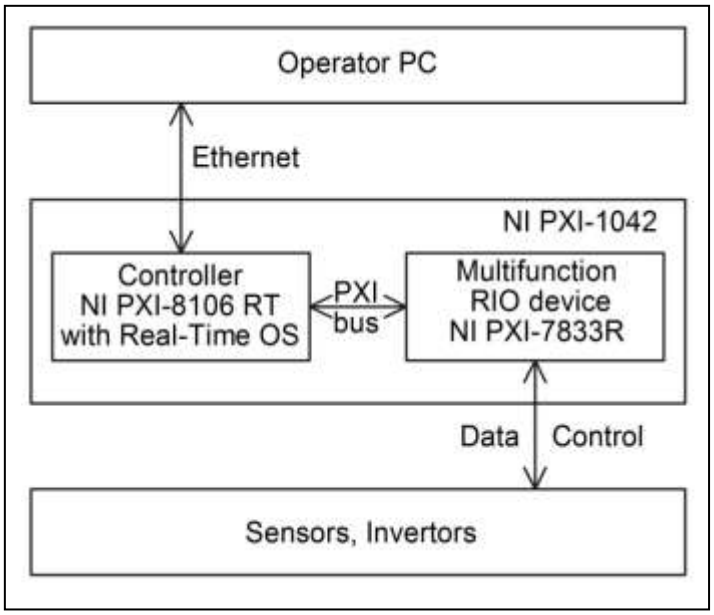

Figure 2. Block diagram of the hardware of the automated complex

The LabVIEW FPGA software module in the national Instruments LabVIEW graphical programming environment was used to develop the management and data collection program for the NI PXI-7833R module. The software developed in the LabVIEW environment (Fig.3) consists of several connected modules that are located on the operator's PC, the NI PXI-8106 RT controller and the NI PXI-7833R module.

The operator's workplace uses a module with a graphical user interface. Here it is possible to select the desired mode of operation of the automated complex and set the parameters of the operating mode of the electric drive, such as frequencies, amplitudes and phase shifts of supply voltages.

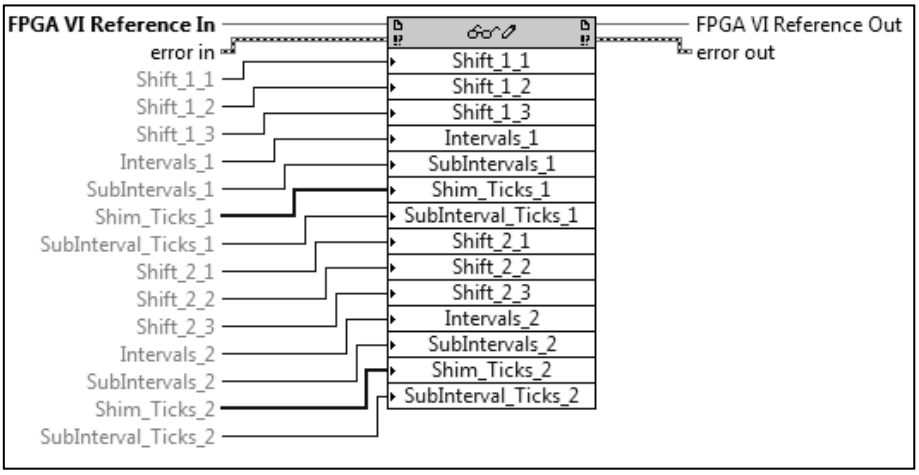

Figure 3. Code fragment of software of the automated complex

Software modules executed on the NI PXI-8106 RT controller and NI PXI-7833R device ensure real-time operation of the system. They allow to form sinusoidal currents in one or two three-phase windings of electric motors (for motors of double-way feed) by means of pulse-width modulation. It is possible to independently change various settings of the PWM and investigate transients.

One of the features of motors of double-way feed, is the presence of two groups of three-phase windings, i.e. to control of such motor requires two three-phase inverters.

The formation of sinusoidal currents in the motor windings occurs by means of a sinusoidal centered pulse width modulation. PWM allows a simple way to change the basic parameters of control signals: frequencies, amplitudes and phase shifts.

The control signal generation diagram for three-phase inverters is shown in Fig. 4. The initial period of the sine is divided into n parts, each of which is represented by a single PWM pulse with a duty ratio proportional to the amplitude of the sine taken at the middle of this segment of the sine period.

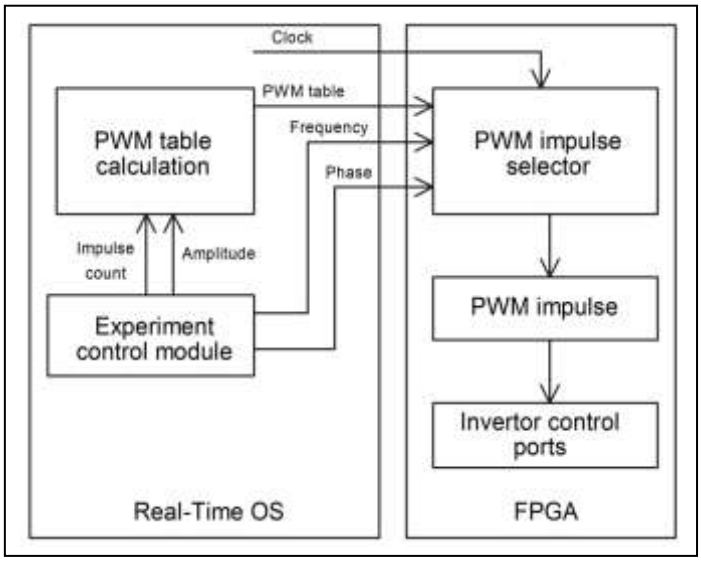

Figure 4. Block diagram of the generation of control signals for three-phase inverters

In the real-time system of the NI PXI-1042 platform, a table of duty factors is calculated for a given amplitude and number of pulses. The table registers in the PWM impulse selector. The selector chooses from the table the necessary impulse, based on a present situation of time, frequency and a phase. The PWM impulse selector receives a fill factor value and sends opening and closing signals to the inverters via the output ports.

As a result, in the windings of the motor are formed sinusoidal currents of a predetermined amplitude and frequency (Fig. 5).

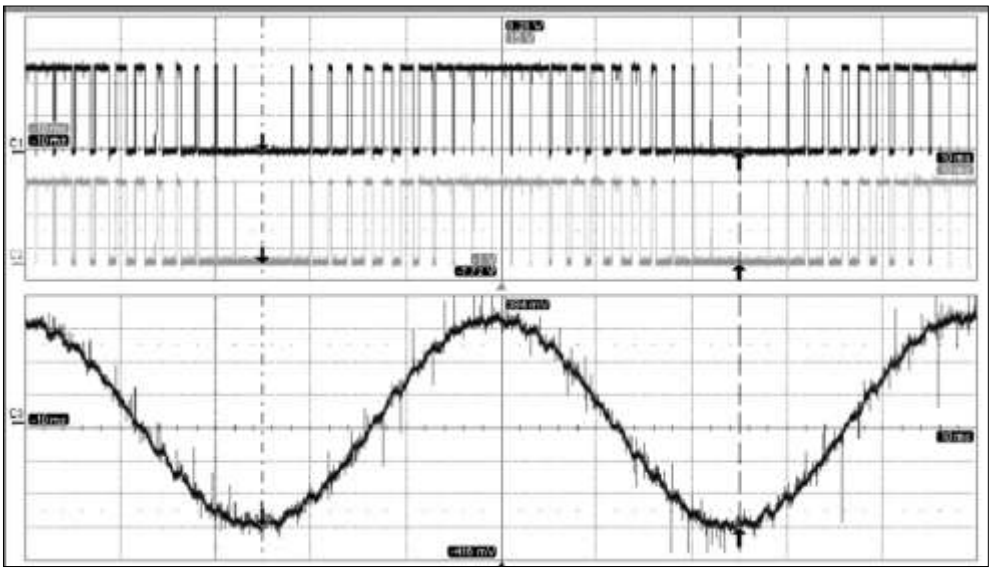

Figure 5. Oscillogram of PWM signals and current form of one of phases

3. Experimental research of electric drive control

The interface of the user of the automated complex displays the data obtained from sensors, for example, of the sensor of angular position (Fig. 6).

For further analysis of transients, data from sensors is exported to a file. After obtaining experimental data, it becomes possible to refine the mathematical models of the motor and use these models in developing new control methods.

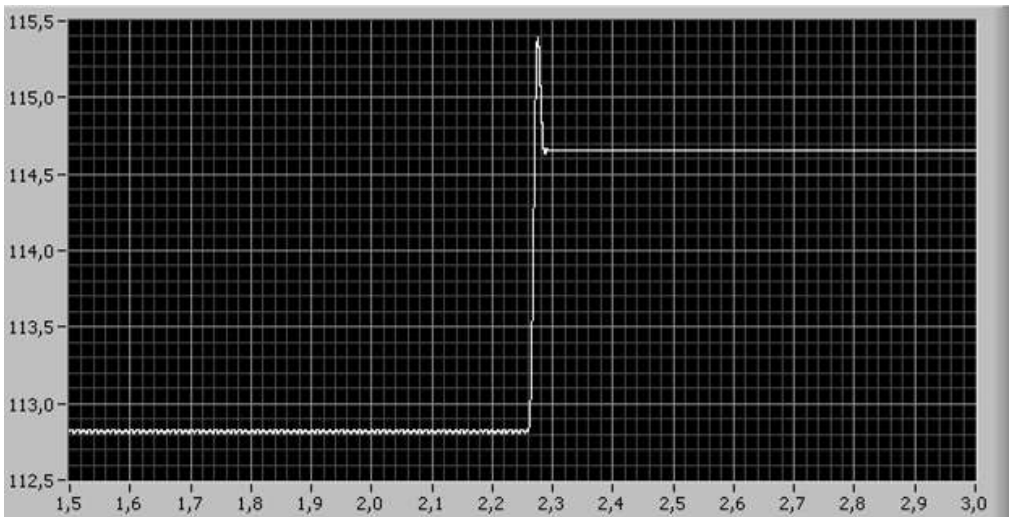

Figure 6. Data visualization of the angular position sensor

Along with the software for management of the automated complex, the program complex for modeling of processes in the electric drive was developed. It includes a system for the automated generation of analytical mathematical models, implemented in the MathCAD program using its character processor, as well as a numerical modeling system using the obtained models. As a result, it is possible to compare the simulated and experimentally obtained transient characteristics of an electric drive in different modes of operation. To do this, first an experiment is carried out, for which all initial conditions, mode parameters, control signals and transient characteristics for the currents and the rotation angle of the rotor are fixed (from which then the flux connections, angular velocity and load angle are calculated). Then, the data stored in the file is transferred to a simulation program that uses the initial conditions and mode parameters recorded in the experiment to model the transient characteristics. After this, it is possible to derive the experimental and model characteristics for the general graph and compare them under identical test conditions.

4. Conclusion

Some electric motors, such as motors of double-way feed, have a large number of control options. This requires their experimental verification. The created hardware-software automated complex for experimental research of electric drives allows implementing various control methods and with high accuracy to investigate transients in the electromechanical system. Technical capabilities of the complex allow flexible implementation of control laws for closed and open systems, as well as quickly analyze the data obtained from experiments.

Acknowledgements

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