4 **ТЕХНІЧНІ ЗАСОБИ ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В СИСТЕМАХ УПРАВЛІННЯ**

WORKBENCH FOR CONTROL SYSTEMS TRIALS BASED ON VIPA 300 CONTROLLER AND ADVANTECH INPUT/OUTPUT CARD

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Abstract

The topic is about workbench creation for control systems trials based on VIPA 300 industrial PLC and model of control object which is implemented in MatLab Simulink program on PC. Connection between controller and the PC is provided by the Advantech PCI-1711 input/output card of discrete and analog signals. Object identification, control system synthesis, creation of control device structure and its parametrical identification, as a rule, is done on a PC in a modelling environment, e.g. in MatLab. But often, using this PC modelling, the hardware and software features of algorithms which were obtained during system synthesis are not considered in a specific industrial PLC. It is considered a good idea to use a composite version where obtained algorithms are tested in a real industrial PLC and control object is substituted by a model which is working on a PC in real time scale. In this case software realization of algorithms in a specific PLC are fully taken into account and substitution of real control object by its model considerably reduces the costs for carrying out experiments and allows to study the system behavior when control object parameters and modes of operation vary greatly. The creation of workbench stipulates several stages: configuration and programming of industrial PLC VIPA 313 SC, installation and configuration of Advantech PCI-1711 input/output card, tuning of Simulink modelling environment for working in real time scale using Real-Time Windows Target Library, testing of workbench by using constant and harmonic signals of different frequencies. Work results of virtual stabilization system are compared with combined version. In virtual stabilization system PID governor and control object are implemented in Simulink. In combined version control object is still implemented in Simulink and PID governor - in VIPA 313 SC controller (using functional block FB58 from Step7 standard library).

Key words

Control system, controller, workbench, trials, input/output card, VIPA 300, Advantech, MatLab, Simulink.

Developing modern control systems requires absolutely necessary testing of algorithms and software which are used in industrial PLCs. Carrying out full-scale on-location testing of control object is often very expensive and potentially dangerous that's why checking of algorithms functionality is being done only for specific modes of operation and in strict limits of control object parameters variation.

Control systems synthesis usually is being done on a PC using different modeling environments, e.g. MatLab/Simulink. Having obtained control object model in the results of its identification, control algorithms are being developed then research of control system on the whole is being done. Modeling on a PC provides an opportunity to analyze control system quality indexes in various modes of operation and in wide range of control object and external disturbances parametric changes. But often, using PC modeling, the hardware and software features of algorithms which were obtained during system synthesis are not considered in a specific industrial PLC.

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Most brimful testing can be done using composite version of the system when control algorithms are implemented in the program form in industrial PLC and control object is being studied on a PC in modeling environment in real time scale. In this case the connection between a controller and a PC is provided by Advantech PCI-1711 discrete and analog signals input/output card.

The **object of this article** is to show an example of workbench creation for control systems trials based on VIPA 313SC controller and Advantech PCI-1711 discrete and analog signals input/output card and also to compare stabilization systems' operation: in one of them controller is implemented in Simulink/MatLab environment in the other – real PLC is used.

The creation of workbench stipulates several stages. Primarily the installation and the setup of Advantech PCI-1711 card should be done. The driver PCI1711.exe can be downloaded by clicking the link [1]. For the card functionality testing an Advantech Device Manager_32bit.exe should be installed also.

After that electrical connections mounting between PCI-1711 card (its PLCD-8710 terminal) and VIPA 313 SC controller is carried out in accordance with technical documentation.

Hardware configuring of VIPA 313SC-5BF03 PLC should be done on the second stage (following recommendations [2]). After that test program in STL language for transmission of analog signals from inputs to outputs of PLC should be written.

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The absence of any dynamic transformations and conversions inside the program allows to sort out and evaluate only hardware possibilities of the workbench. Modeling of control object hereinafter is planned to do in real time scale in MatLab R2010a modeling environment. That's why third step implements appropriate tuning of MatLab [3]. In command line execute the instruction: *rtwintgt –setup*. Then launch Simulink and select Real-Time Windows Target Library. Create a new model and in menu select: *tools>>Real-Time Workshop>>options>>system target file>>browse>>rtwin.tlc*. In model choose *external* way of modelling and deploy necessary input and output blocks. Then execute command in menu *tools>>Real-Time Workshop>>build model.* After successful completion of building model, in the instruments panel click icon *connect to target*, then *start simulation* [3].

For functionality testing of workbench the following were done:
- constant and harmonic signals were generated in Simulink;
- these signals were sent to VIPA 313SC-5BF03 PLC using Advantech PCI-1711 card;
- after that these signals were received back.

As this experiment has shown, the amplitudes of received signals were less by 0,05V compared to amplitudes of sent signals (defined by amplitude quantization). And time lags were not more than 0,2s which corresponds to cumulative time quantization step of PLC and card.

Taking into account that models of modern technological control objects have detention lags of tens and hundreds of seconds, the signal errors which emerge in technical appliances of the workbench, can be considered insignificant.

After workbench testing, a comparison between virtual stabilization system and combined version of the system was made. In virtual stabilization system PID-controller and control object are implemented in Simulink. In combined version of the system control object is still implemented in Simulink and VIPA 313SC carry out PID-controlling using functional block FB58 from Step 7 Standard Library.

For creating automatic control system let's have a look on one of possible versions of signals transmissions in modern industrial control system.
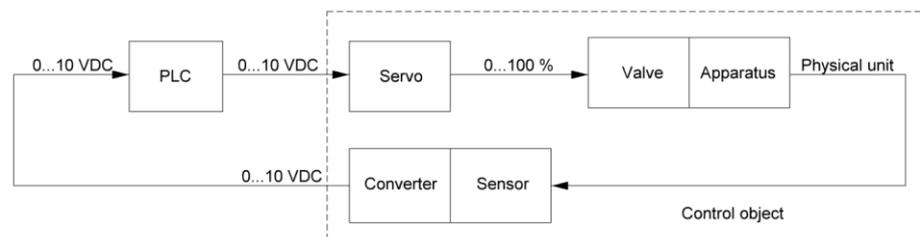
Pic. 1 Possible option of signals transmissions in modern automatic control system

Control signal from controller (PLC) goes to actuator (Servo), which changes position of the valve stem (Valve) and, therefore, changes product or energy flow rate to technological control object (Apparatus). This leads to control parameter value change (some physical unit) which is measured by sensor (Sensor), and then scaled by normalizing converter

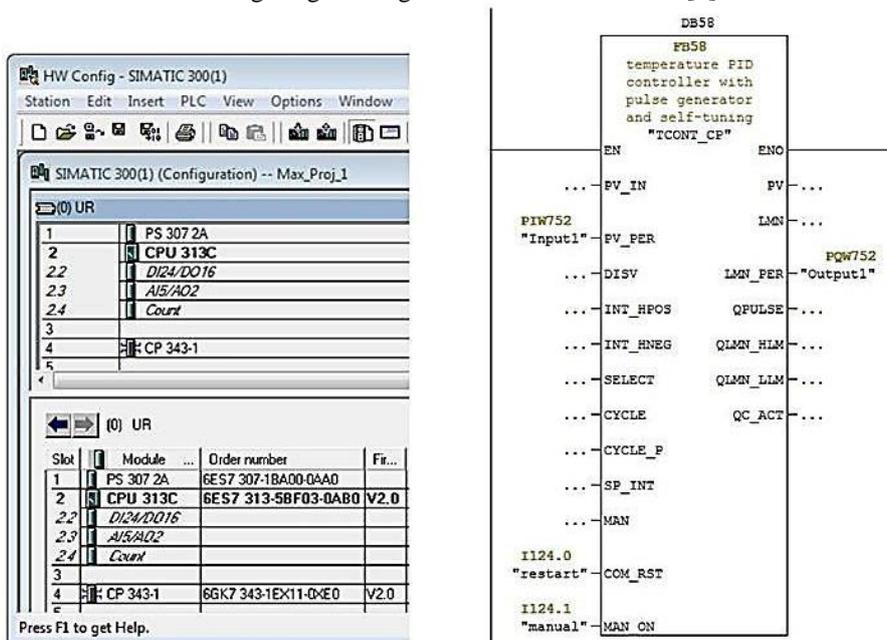**4** **ТЕХНІЧНІ ЗАСОБИ ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В СИСТЕМАХ УПРАВЛІННЯ**

(Converter) to the levels of standard signals. In this way control object can receive control signal and send back to the controller process value signal from range 0…10 V DC. Advantech PCI-1711 card sends and receives signals of the same range. In that way in combined version of the workbench VIPA 313SC-5BF03 PLC operates with virtual control object like with the real one.

Model with dynamic qualities described by transfer function $W_o(s) = \dfrac{1}{(T \cdot s + 1)^2} \exp(-\tau \cdot s)$ is taken as control object

model. Static qualities are represented by linear dependence, e.g. y(bar)=x(V), which is implemented by LookUpTable in Simulink (pic. 2). This model with satisfactory accuracy describes many real control objects in stabilization systems with small deviations from setpoint value. Models of sensor and normalizer converter: y(V)=x(bar). Transfer function of PID-

controller: $W_r(s) = kr \cdot \left(1 + \dfrac{1}{Ti \cdot s} + \dfrac{Td \cdot s}{0,2 \cdot Td \cdot s + 1} \right)$. Saturation blocks in model of automatic control system correspond to real

limitations of technical appliances: 0…10 V.
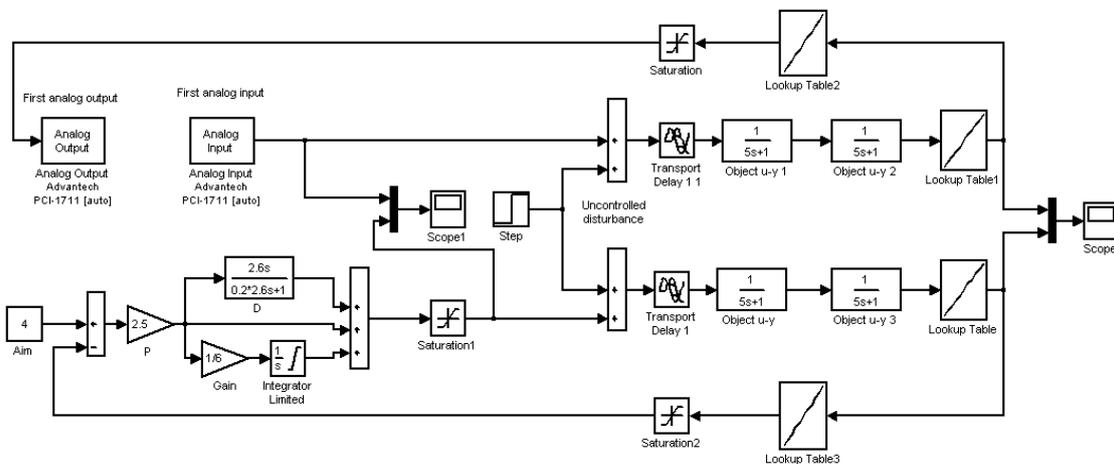
Pic. 2 Model of automatic control system in Simulink

VIPA 313SC-5BF03 PLC hardware configuring is being done in accordance with [2].


Pic. 3 Example configuration of VIPA 313SC-5BF03 PLC
and PID-controller FB58 block call in Step 7

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PID controller settings in Simulink and in functional block FB58 are the same.

Modeling results (pic. 4) have shown than in the region of small deviations of process value from setpoint value when both PID-controllers work without limits in range 0…10V, process values and control impacts are almost the same. But in starting modes of control system control impacts are limited and that's why modeling results do not match.
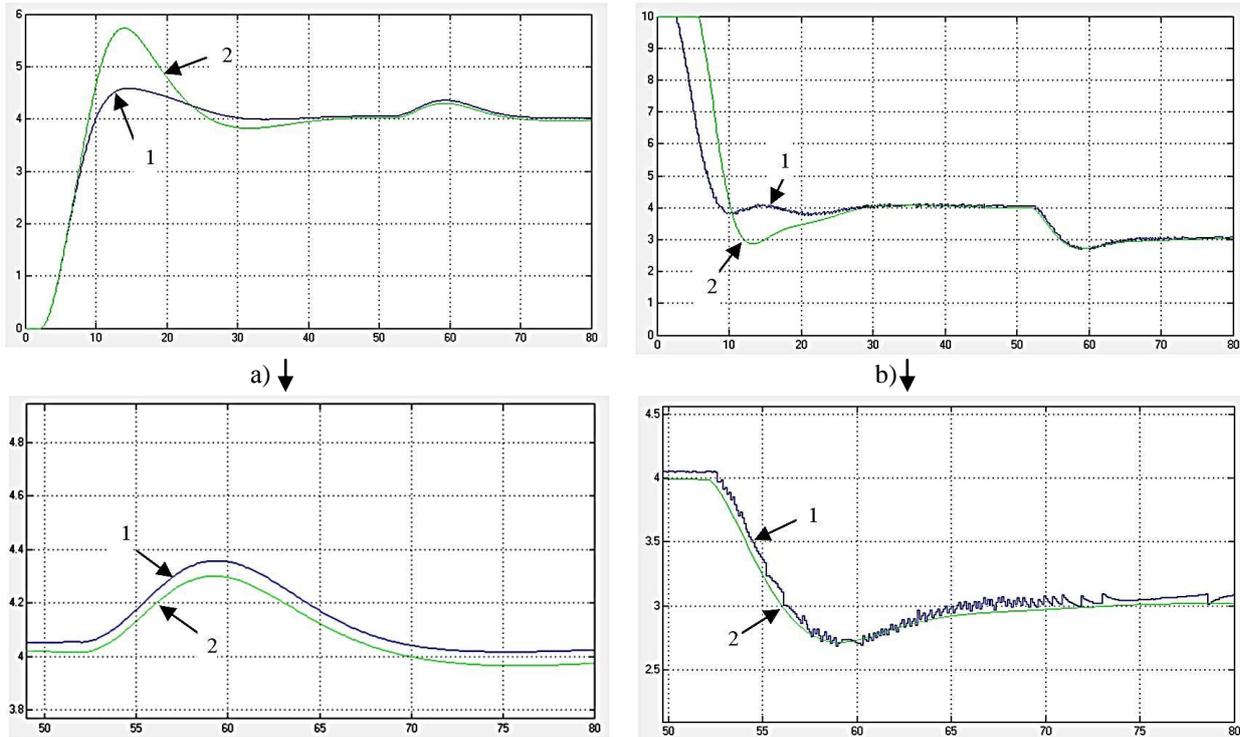
Pic. 4 Modeling results of two different control systems:
1 – PID controller is implemented in VIPA 313SC PLC;
2 – PID controller is implemented in Simulink;
a) changes of process values;
b) changes of control impacts.

Conclusions

1. Workbench is capable of combined automatic control system implementation (with virtual control object and industrial PLC). Control object operates in real time scale and PLC works with physical values. In this case algorithms program implementation specifics in particular PLC are fully accounted for. And substitution of real control object by its model greatly decreases the cost of experiments plus provides opportunity to check system functionality in most various modes of operation and in wide range of control object parameters change.;

2. Using the workbench demonstrated the opportunity of transferring PID-controller settings from Simulink environment to functional block FB58 of program package Step 7 by Siemens. If identification results produce model identical to the real control object then in automatic control system project stage it is possible to check its functionality with optimal settings of controller. There is no need to develop and debug personal programs of PID-controllers. It is possible to use functional blocks of ready-made PID-controllers from Step 7 Standard Library which withstood the test on many industrial facilities.

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