Industrial control system software patterns in manufacturing

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Abstract. The technique of pattern designing software for an industrial control system for standard engineering processes has been implemented, where the same type of equipment is used and the same workpiece processing sequence is implemented. Patterns for the user controller program and supervisory control and monitoring software have been developed. Pattern elements are represented by the same type of sensors and actuators, which have the same algorithms for data processing and calculating of control actions. For them data types, data storage, functionality and organization of the exchange between programmable logic controllers and human-machine interface devices are defined. The necessary correspondence was established between template projects of various levels of the control system, which made it possible to organize a network exchange by data blocks.

1. Introduction The diverse relationship of automation objects in mechanical engineering complicates the development of industrial control system (ICS) software [1-6].

The use of modern integrated software development systems for controllers and SCADA-systems simplifies the process of creating a control system greatly [7-9]. But with a large number of sensors and actuators and their complex relationship, the development of industrial control system software requires a lot of time. It should also be borne in mind that the organization of data exchange over the network between the user program of the controller and the software of the human-machine interface is carried out in real-time [10-13].

From the point of view of developing industrial control systems, typical technological processes are of particular interest, where the same type of equipment and the same workpiece processing sequence are used. When automating these typical technological processes, the developed system implements the same control and data processing algorithms, while the processes differ from each other only in the number of sensors and actuators [14-16]. In such cases, the use of template projects for both middle-level software and top-level software development becomes appropriate for the development of industrial control system software [17-18].

2. Methods
The creation of template projects for the development of ICS software for typical technological processes in mechanical engineering is proposed to be carried out on the basis of the pattern-design technique [19]. In accordance with this technique, the same type of sensors and actuators are adopted as pattern elements, which have the same data processing algorithms and control actions calculation. For them, it is necessary to determine the types of data, data storage, functionality and organization of
the data exchange between programmable logic controllers and devices of the human-machine interface [20-23].

Template projects for the automation of typical technological processes of mechanical engineering were developed on the basis of Siemens hardware and software [24-26]. The programmable logic controller software was developed in Step 7 (PLC template project) and is intended for automatic control system. The human-machine interface software developed in the WinCC SCADA system (HMI template project) is intended for monitoring and supervisory control of the technological process.

3. Results and discussion

For pattern elements, data types, data storage, functionality of executive devices, and the organization of the data exchange between lower and upper level software are defined.

For each type of sensor or actuator, user-defined data types are created in the template project of the programmable logic controller, and structural types are created in the template project of the human-machine interface. In a PLC project, type elements are intended for storing object parameters, as well as output and input data. In the structural type of the HMI project, the number of elements is equal to the number of elements in the corresponding user type of the PLC project. Moreover, the types of these elements are similar to the types of data storage in memory in accordance with IEEE standards.

Storage of data related to the same sensors and actuators in a template PLC project is implemented as a data block. It is a one-dimensional array with user-defined data type elements. In a template HMI project for storing data of each type of sensor and actuator, the same type of structural tags are created, which are grouped into the corresponding tag groups.

Each array element in the data block in the user program of the controller must correspond to a structural tag in the application of the human-machine interface. For this, the offset of the array element in the data block is selected as the address of the structural tag.

Calculation of control actions for actuators and data processing of the same sensors in a template PLC project were performed using the corresponding arrays created in the project. The data processing algorithm for each group of objects of the same type is implemented as a function or function block.

In the HMI template project, the functionality of the same type of objects is implemented for supervisory control and monitoring of the process, for setting parameters during commissioning, as well as for alarm logging and tag logging. The graphic part of the template HMI project is a hierarchical system consisting of objects screen and status screens.
Figure 1. Pattern elements for one type of sensor or actuator.

On the objects screen graphical objects of typical actuators and sensors are presented. The current state of these objects is displayed as various visual effects. This is achieved by dynamizing objects using a dynamic dialog or by cyclic execution of VB- and C-scripts.

For each type of actuator or sensor, subordinate process screens are created. These status screens display the values of the object's output and input signals in real-time mode, alarm loggings and signal trends. During commissioning, the status screen allows you to set the parameters of the selected object. Also, the status screen makes it possible to operate and diagnose the process in real-time mode.

Due to the fact that Siemens software for different levels can implement the exchange of data blocks, the simplification of the organization of the exchange between the human-machine interface device and programmable logic controllers is carried out through the use of a data block for storing data [27].

When creating structural data types, the correspondence of elements in structural types in template PLC and HMI projects was already ensured, which allows the exchange of data blocks (Figure 1).

Correspondence of the structural tag of the HMI project to the array element in the data block of the user program of the controller was implemented at the stage of organizing data storage, which also ensures the correct network data exchange.

4. Practical Use
The proposed structure of template projects facilitates their adaptation to the specific requirements of the corresponding control system greatly.

When developing a PLC project for a specific automation object, depending on the number of sensors and actuators, the number of array elements in the data block for each type is determined. In the initialization section of the data block and the initial values are assigned to some elements of the structural type.

When developing an HMI project for a specific automation object, firstly a mimic diagram of the technological process is created by copying graphical objects of typical sensors and actuators from the screen of the template project objects. Next, the structural tags are created in the required quantity. For each structural tag, the data block number and the offset within this block are determined.

5. Conclusion
The developed technique greatly simplifies the software design process for industrial control system with a large number of automation elements of the same type.

In the template projects created on the basis of this technique, the structure and functionality of process control software are predetermined. The use of patterns becomes effective in the development of control system software for typical engineering processes. At the same time, the universality of approaches makes this technique universally valid for the automation of various industrial facilities.

The use of template design significantly reduces the cost of the project by reducing the time of development and implementation, as well as the use of less skilled labor of software developers.

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