TOMSK POLYTECHNIC UNIVERSITY

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COMPUTER TECHNOLOGIES OF ENERGY SUPPLY

LABORATORY PRACTICE

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A study guide "Computer technologies of energy supply. Laboratory practice" is focused on a design of control systems of production processes; the study guide is prepared on the basis of support materials offered by TRACE MODE system made by AdAstrA company. The study guide offers an opportunity to tackle on tasks in a tool-associated system without detailed examination of all documentation.

TRACE MODE system makes it possible to control power and electricity consumption, voltage level and network frequency: data collection and storage from meters, input and control of power consumption targets, development of charts of control measurements and charts of active power, preparation of summary reports on energy consumption.

The laboratory practice has been prepared on the basis of the original Russian-language materials and it is fully consistent with the course of «Computer technologies of energy supply».

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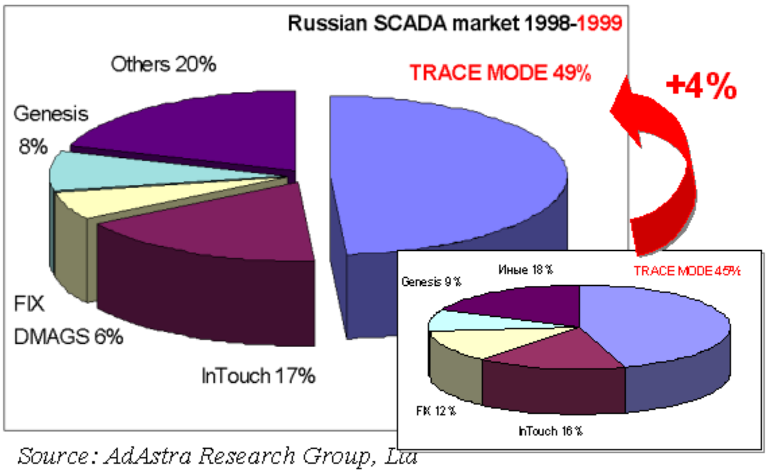
INTRODUCTION

Utility metering systems (UMS) allow a user to reduce financial costs both by reduction of energy costs and above the limit consumption. UMS also allow a user to switch to a more profitable tariff system.

A package TRACE MODE was chosen as a tool for UMS implementation due to existance of the Russian version of the program, positive dynamics of program installations in Russia, high quality of the product compared to foreign analogues (Genesis); and also economic factors.



Source: AdAstra Research Group, Ltd

6.06 TRACE MODE version provides an integrated tool for controllers programming (Softlogic), development of operator interface (SCADA – Supervisory Control And Data Acquisition), control of manufacturing tasks (MES – Manufacturing Execution System), human resource management (HRM – Human Resources Management) and the main funds (EAM – Enterprise Asset Management).

Laboratory works are based on support materials of AdAstrA company. Support materials were edited: their volume was reduced and errors were corrected. Some of the data required for tasks completion were replaced.

A virtual computer workshop includes tasks aimed at design of a grapchics screen of operator workstation (WS), autodesign of channels, programming, development of alarm reports, data archiving, connection a shell with means of MS Office through DDE (Dynamic Data Exchange) protocol.

This virtual laboratory workshop covers main sections of the course "Computer technologies of energy supply" for students with a major 140200 "Industrial electric power supply".

LABORATORY WORKS

Laboratory work № 1

DEVELOPMENT OF A BASIC WORKSTATION

Objective: to develop a basic workstation which will perform scanning functions, update and store data from peripheral sensors.

Technical tips

In general, control, monitoring and protection systems (CMPS) at enterprises comprise several levels:

• level of instrumentation and equipment,

• level of controllers (traditional PLCs and Softlogic),

• level of workstations (WS).

Software of SCADA level has the following functions:

• Visualization - to display information about the process at the symbolic circuits in a form of numerical data, trends, animations, ActiveX components, etc. Control actions of operators are also provided;

• Data exchange with controllers in real time - exchange of information with controllers through a serial interface, Ethernet network;

• Archiving – storage of information;

• Process documentation – generation of reports according to pre-established patterns and their subsequent transfer through different exchange channels;

• Receiving and sending information to other software packages – exchange of operational and archival data with specialized software;

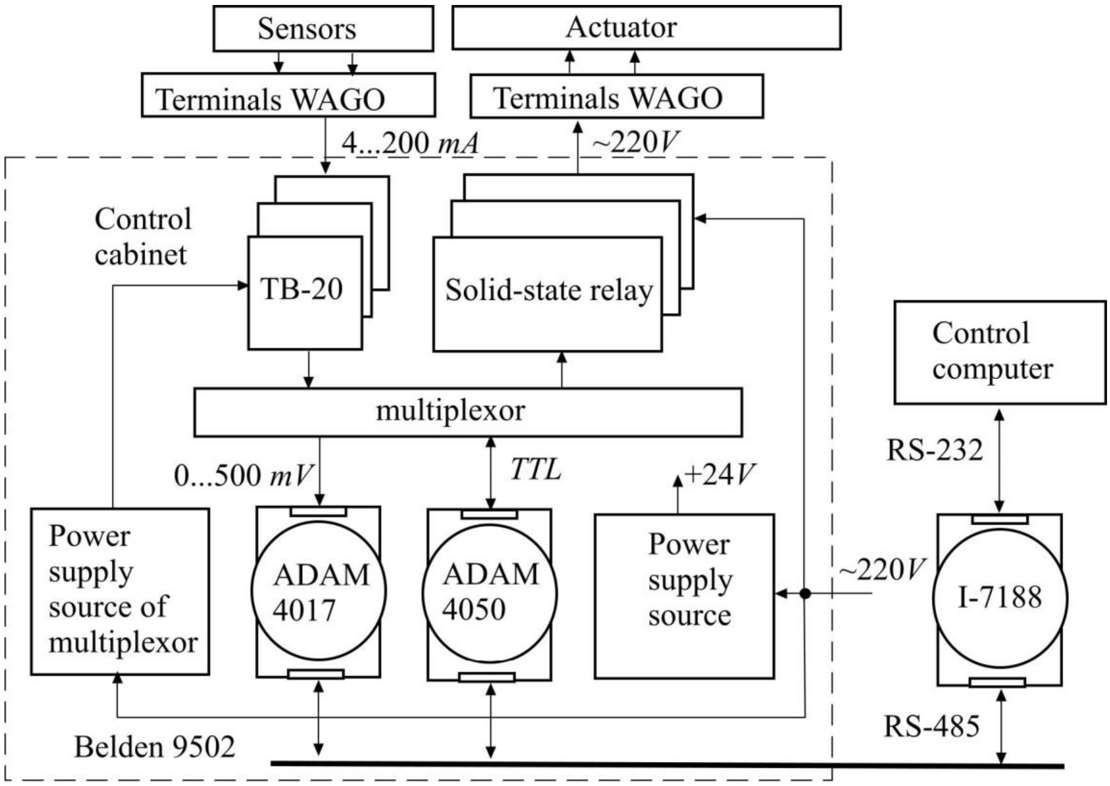
• Nonoperative data processing – calculation of statistical information, control of slow processes;

• Alarm control – a list of alarms, events filter, and acknowledgment.

The term Softlogic implies:

Use of controllers with PC-compatible architecture. Programming of these controllers is carried out in such languages as assembler or C++, it is also can be carried out with a development package in visual languages of the upper level, for instance a language of function blocks or a language of instructions that are compatible with МЭК61131-3 standard.

Block diagram of the control system can be represented as shown in the figure.



Control functions are performed by a channel controller I-7188 which has 256 KB of RAM, flash memory is 512 KB, console port, serial ports RS-232 and RS-485, a watchdog timer, real time clock and it is compatible with an operating system ROM-DOS. A controller is connected to a control computer through RS-232, and via an RS-485 cable (Belden 9502) it is connected to a control cabinet.

Analog input modules *ADAM*-4017, digital input-output module ADAM-4050 made by Advantech, a multiplexor module and registers, modules of solid-state relays (Cosmo) and power supply sources are installed in a control cabinet. Terminal plates *TB*-20 (*Fastwel*) are used to connect analog signals to a multiplexor module. A control cabinet is connected by cables to sensors and actuators.

A multiplexor (and register module) can increase the number of analog and digital inputs.

In a controller's flash memory parameters of process equipment, parameters of PID controllers, normalizers of input signals, digital filters, a table of logical channels, access keys, etc are saved during installation. Software of a controller can be written in C + + language. A control computer running under SCADA system provides a color graphic display of equipment operation.

Laboratory work №2

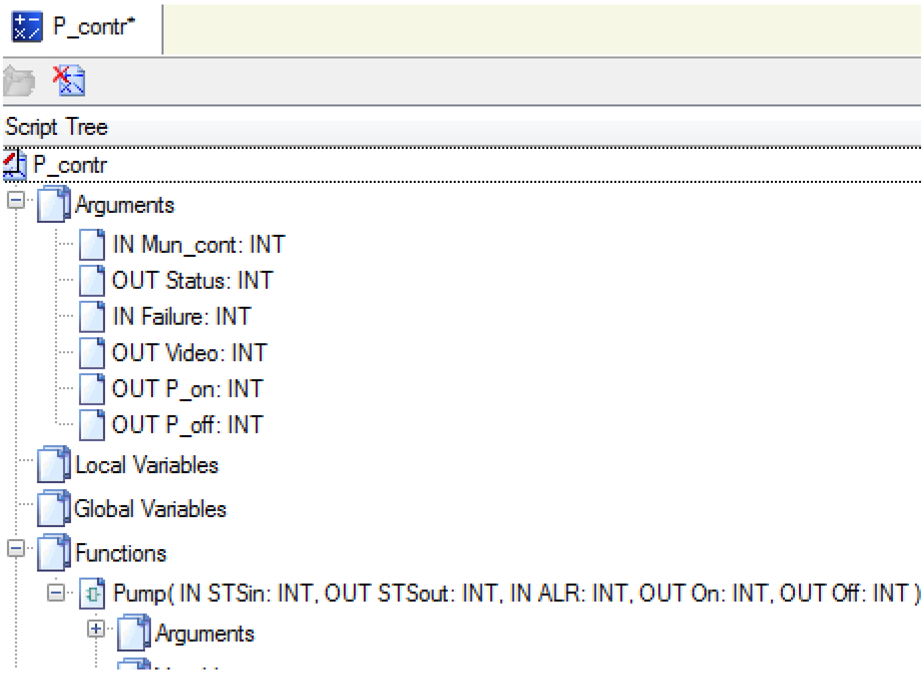
EXAMPLE OF OBJECT DEVELOPMENT

Purpose: development of a basic WS of a pump station by the example of object development.

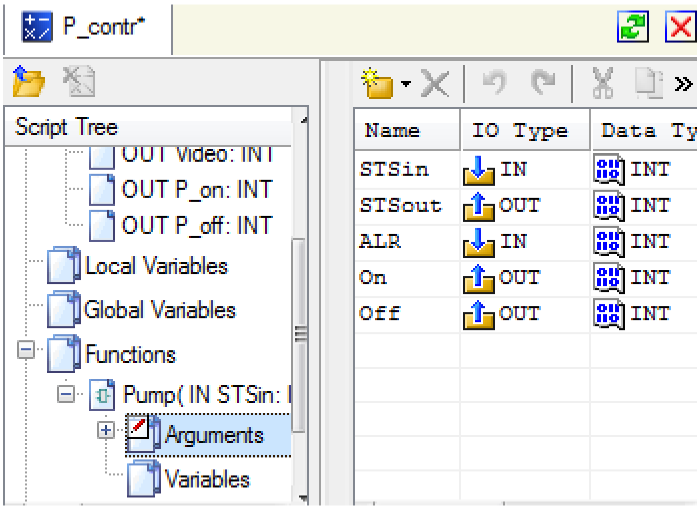
Technical tips

Create a template of a program **P_contr** of pump control with an argument to manage a video.

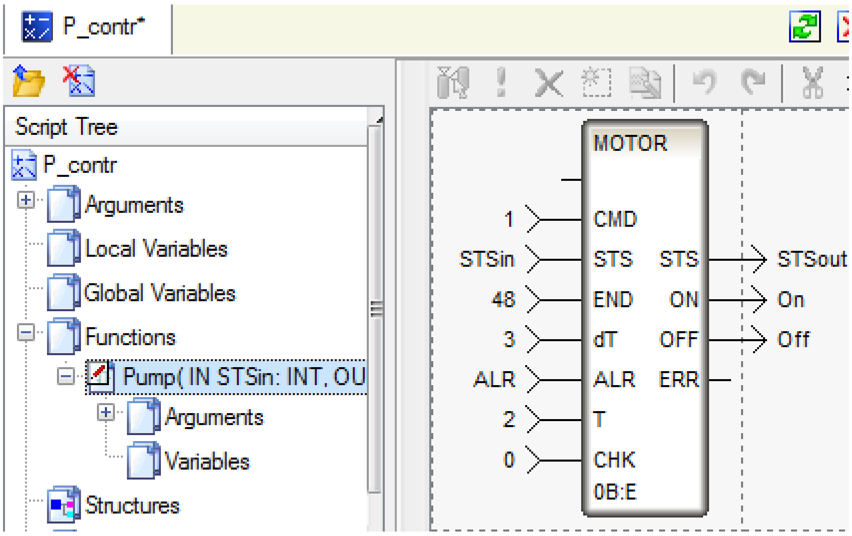
Program structure:



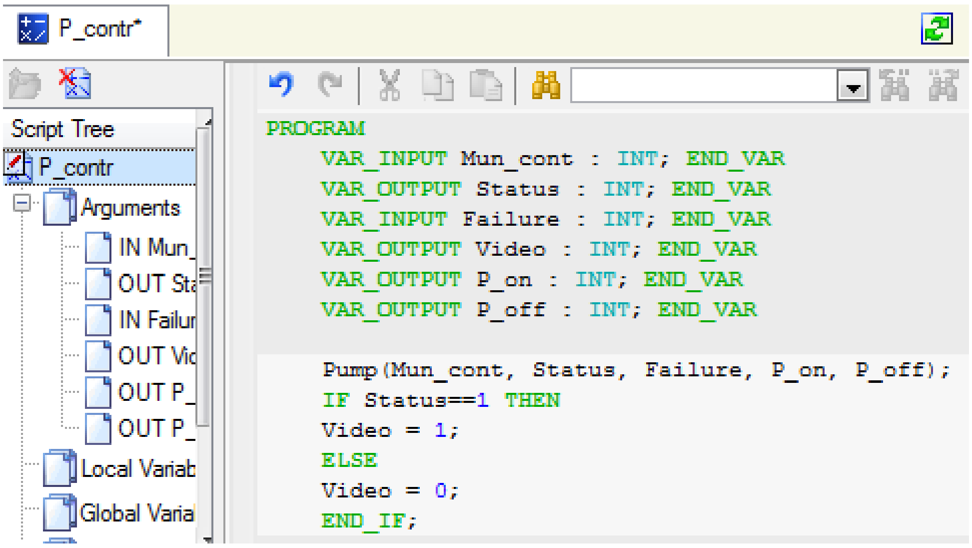
Function arguments of the pump control:



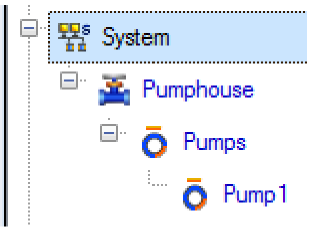
The most convenient way to develop a function of the pump control is a **Techno FBD** language – one block **MOTOR** is required for this purpose:



Arguments of the basic ST-program.
Listing:



Consider creation of a **PUMP1** object. For this purpose knot **Pumphouse** with the following structure will be created in the first place.



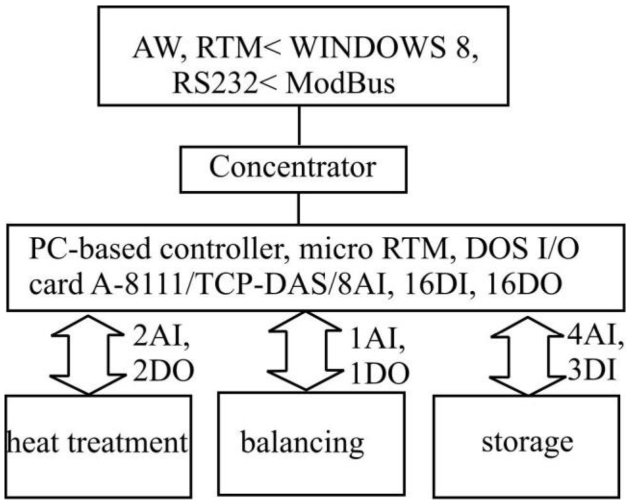
Laboratory work №3

RESEARCH OF INFLUENCE OF PROPORTIONALLY-DIFFERENTIAL-DIFFERENTIAL CONTROLLER ON QUALITY OF THE CONTROL PROCESS

Objective: develop a control and monitor system of technological process (TP) of a heat treatment cell and to estimate influence of parameters of a proportionally-differential-differential controller (PDDC) on quality of the control process.

Technical tips

The TP is carried out on three cells: heat treatment, storage and balancing. It is necessary to design the control system and TP control taking into account existing control points, actuating units and hardware automation. All cells are controlled by a PC-based controller.



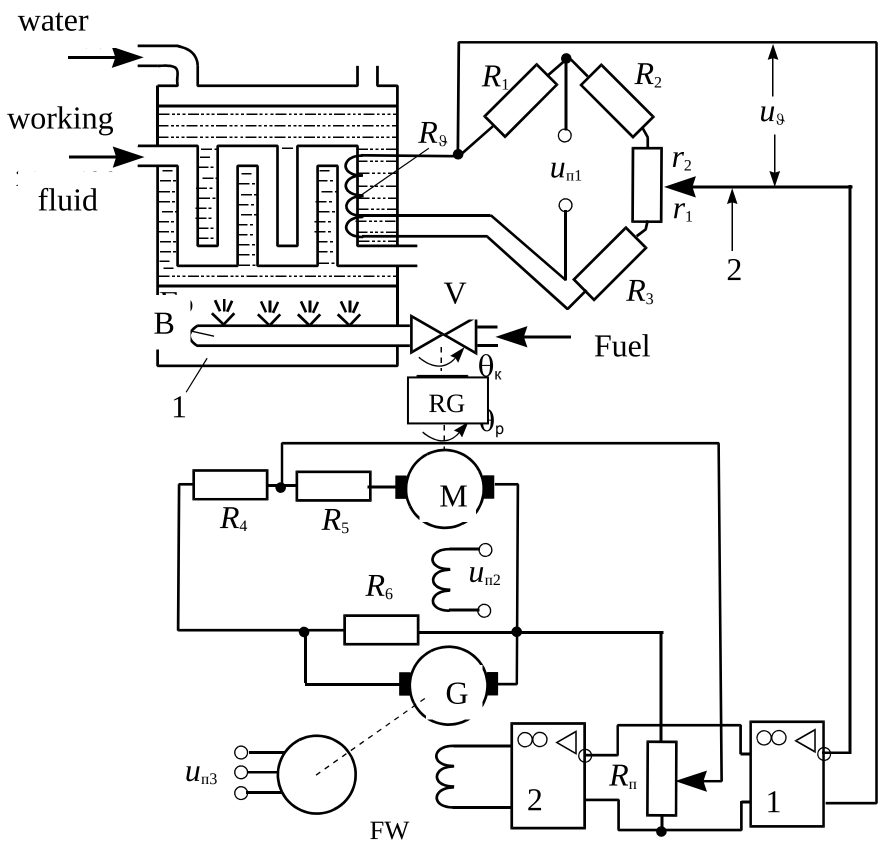
Heat treatment cell uses two analog input signal – 2AI and two discrete outputs – 2DO. The technological task – to maintain constant temperature in the apparatus – a technological device that carries out a long heating of raw materials (regulation function). Temperature regulation is provided by the flow rate change of a heat-transfer agent. Control algorithm is proportional-differential-differential (PDD). Control of the actuating unit – pulse-width modulation (PWM). Analog signals in a PC-based controller are handled by a 12 bit analog-to-digital converter (ADC) and displayed in the codes (0 – 4095). Range of input codes for the measured temperature correspond to the temperature sensor (0 – 100) C for the flow rate of a heat-transfer agent – (0 – 10) m3/h.

WS controls technological parameters (monitoring function) connected to a PC-based controller and sets regulator options (control function).

A PC-based controller is connected to WS via the network by a concentrator and a network protocol – TCP/IP. A usual PC-compatible computer with an input/output board I/O A-8111 with 8AI, 16DI and 16DO/ICP DAS/ integrated in a system ISA bus is used as a controller and runs under OS DOS (this product is not subject to modeling, and is replaced by a simulator).

Description of control and monitor system development

Consider the operating principle of automatic temperature control system.



Thermometer R_ϑ changes its resistance according to the temperature of the working fluid flowing in the pipeline through the furnace 1. Move the slider of the set point 2 and break bridge balance.

When the bridge has full balance

$$R_\vartheta = \frac{(R_2 + r_2)R_3}{R_1 + r_1}$$

When you move the slider of the set point to the left r_1 decreases, r_2 increases, which leads to increase of R_ϑ and vice versa. The bridge is supplied by an alternating current, so the amplitude of the voltage unbalance depends on the temperature $\vartheta_П$ deviation from the set $\vartheta_З$, and the phase – the sign of this deviation.

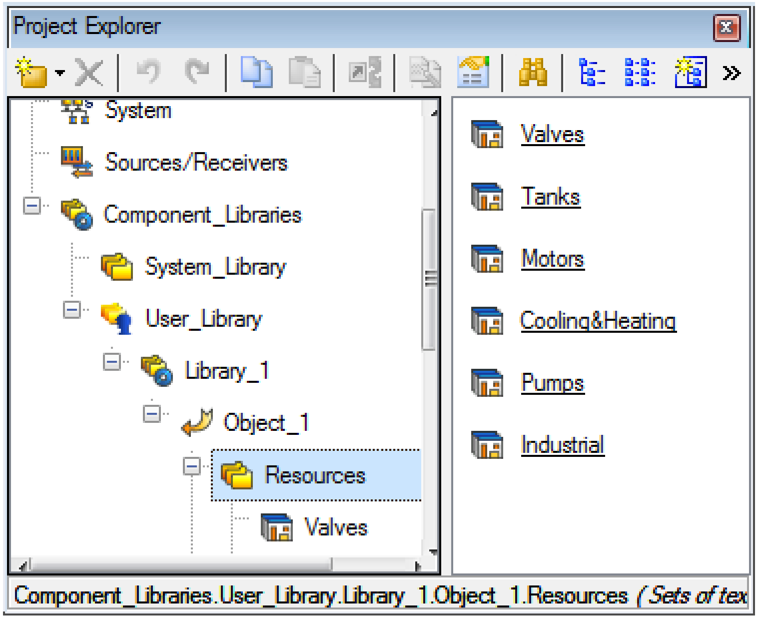
Voltage of unbalance u_ϑ is proportional to furnace temperature and is fed to the input of the operational amplifier OA1. The amplified voltage after the second operational amplifier OA2 is fed to the field winding FW of a DC generator G which feeds the electric motor M. The armature through a reduction gear RG rotates the valve V changing the amount of fuel supplied to the burners B. In case of bridge balance, the error voltage is $u_\vartheta = 0$ and the valve takes a definite position that corresponds to temperature equality of the set point $\vartheta_З$ and the furnace $\vartheta_П$.

Tachometer feedback, as indicated in the example above, is seen as an alternative method. At the present stage PDD are used – regulators and actuating units – PWM.

Description of the virtual laboratory setup

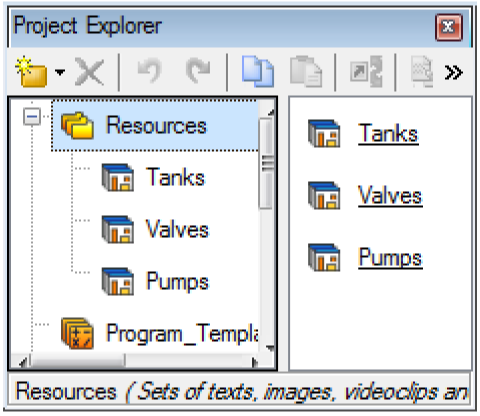
Automation systems with "templates" design will be presented, i.e., project information base will be created – channels according to the arguments of developed screen templates and programs complementing the basic approach by the methods of autobuilding and channel bonding in the nodes of the project.

Open IDE and create a new project. Choose **Standard** as a style of development.



Move to a layer **Components_Libraries**, in the section **User_Library** open the library **Library_1**. The object **Object_1**, stored in this library, contains its own layer **Resources** that is required for further development, a set of graphical objects – images of valves, tanks, pumps, etc.

Drag the groups in the layer **Resources** of the current project by drag-and-drop and rename them as shown below.



In the layer **Resources** create the group **Images** where textures will be contained. The textures will be applied in the design of graphics displays. Create a new component – **Image_Library#1** in the group **Images**.

By a double left-button (LB) click open a newly created library for editing. For its filling use the icon  with the "Import" button on the toolbar. In the dialog box of files to import specify the subdirectory **...\Lib\Texture**. Select all the files and click **Open**.

In the same way as described above create a group **Animation** in the layer **Resources**. In the group create the library **Video_Library#1**. Fill it with the following content ...\Lib\Animation. After preparatory activities save

Laboratory work №4

ARCHIVES AND ALARM REPOR

Objective: Build a control and monitor system of technological process (TP) of storage and dozing (balancing), implement archiving and report alarms.

Technical tips

Storage cell uses three discrete input signal – 3DI and four analog input – 4AI which perform monitoring functions. Data on the status signals of the entrance door to the store (0 – Closed 1 – open), ventilation (0 – off, 1 – on) and fire alarms (0 – no smoke, 1 – smoke) are stored at the controller input. Indicators characterizing parameters such as a reservoir filling level, temperature in the storage, pressure and humidity are under control. Analog values are converted in a 12-bit analog-digital converter (code 0 – 4095), controlled values have the following ranges (0 – 5) m, (0 – 100) C and (0 – 100) %.

Dozing (balancing) cell is controlled by an analog input signal – 1AI and one output discrete – 1DO. According to the instructions received from WS, a finished product supply takes place, its control is carried out by meter readings ((codes 0 – 4095), consumption (0 – 100 l/min)), a metering pump is applied as control equipment (turn-on – supply logical "1" from the controller on a bypass isolation module, which uses a pump as load turning – off - logical "0").

A PC-based controller is connected to workstation via the network through a hub, protocol – TCP/IP is used. As a controller (not modeled) serves PC-compatible computer with the ISA bus to the system board I/O A-8111, is running DOS.

Data on storage parameters (level, temperature, pressure and humidity) must be saved during operation in a table DBMS (data base management system) MS ACCESS with a five-minute time stamp.

Two users must have an access to the system - a developer and operator. The operator, in contrast to the developer, is not able to make changes in the structure of the system.

Description of the virtual laboratory setup

Arguments for the screen template **Storage** are as follows:

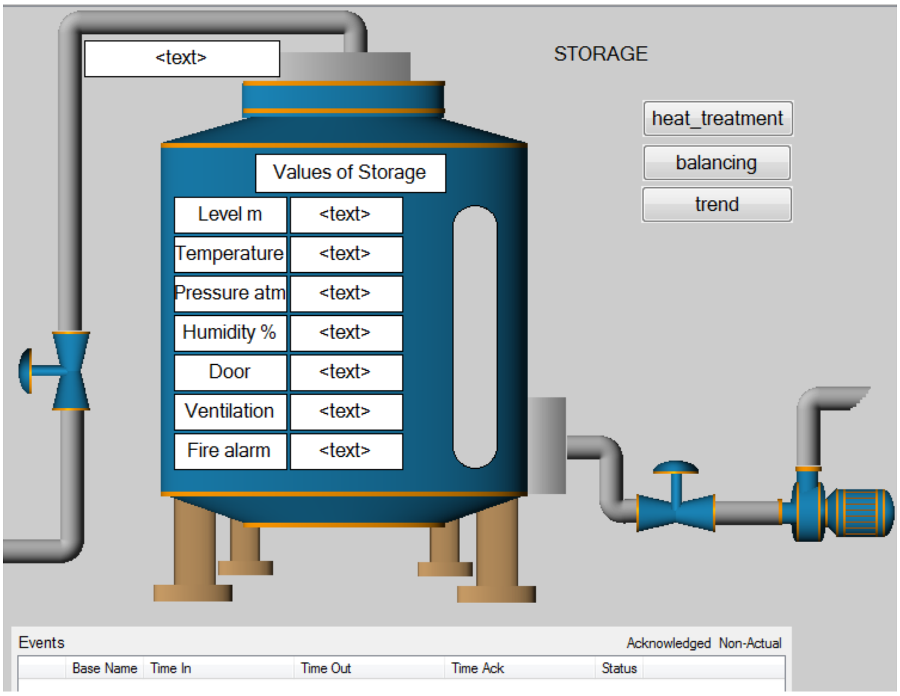
System.RTM_1.Storage.Storage:1

Info | Flags | Arguments | Attributes

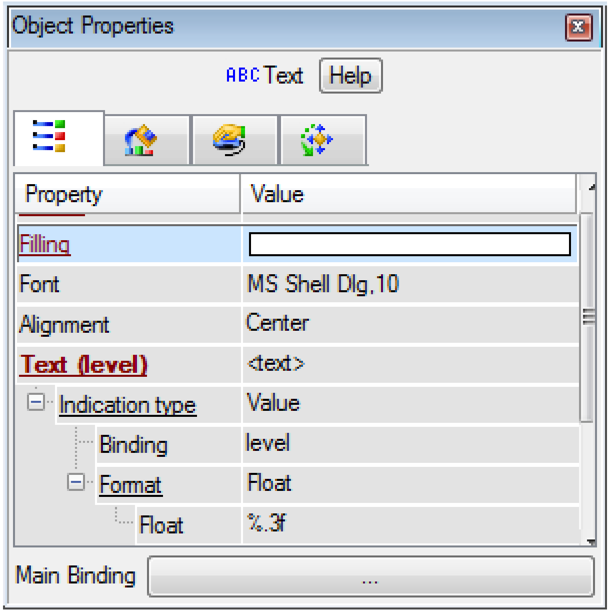
Name	IO Type	Data Type	Def. Value	Link	Flags	Group
Level	IN	REAL				
Temperature	IN	REAL				
Pressure	IN	REAL				
Humidity	IN	REAL				
Door	IN	BOOL				
Ventilatoin	IN	BOOL				
Fire_alarm	IN	BOOL				
Event_door	IN/OUT	REAL			NP	
Event_vent	IN/OUT	REAL			NP	
Event_fire	IN/OUT	REAL			NP	
Main_Layer	IN/OUT	BOOL			NP	
Trend_Layer	IN/OUT	BOOL			NP	

Arguments **Event_door**, **Event_vent** and **Event_fire** are designed to display and acknowledgment of Events with GE **Events** . Arguments **Main_Layer** and **Trend_Layer** – to control the visibility of screen layers. The first layer will be displayed mimic of a storage cell, the second – trend of storage parameter values. **NP** indicator is set to the arguments and doesn't allow creating appropriate channels for autobuilding operations.

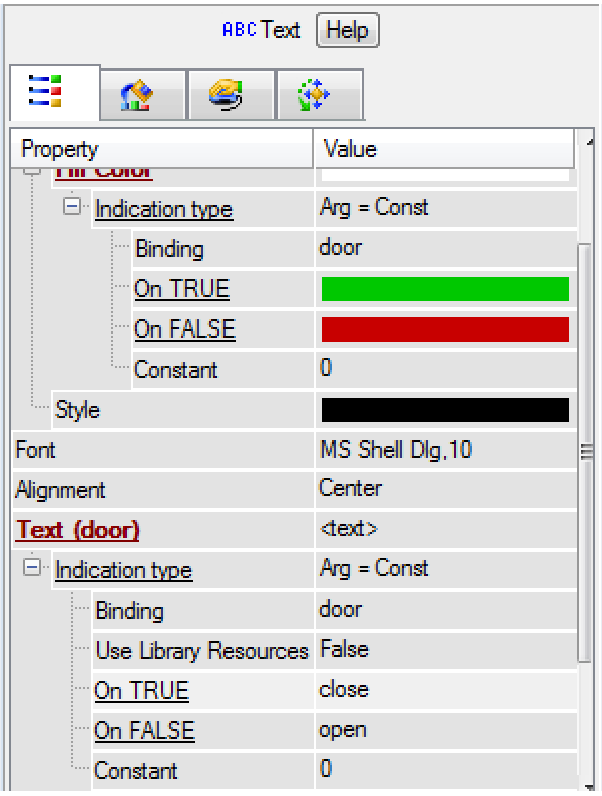
Set one of the textures available in the library for a background of the screen. With the help of GO and GE , carry out a static part of the picture as shown below.



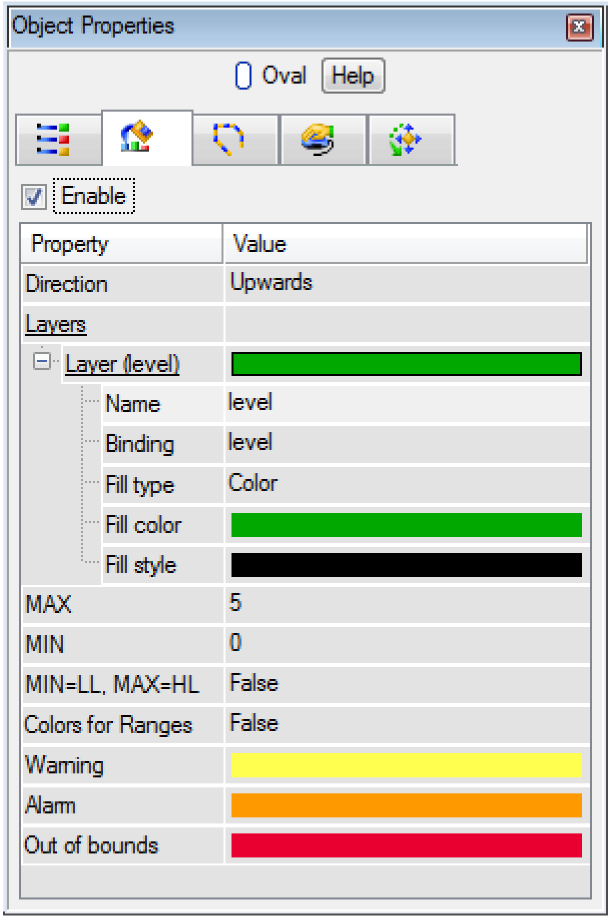
Output storage parameters are set by GE . Bind GE pattern to the arguments of the screen template. Set the format of the output values, such as level:



To display the status of discrete signals the opening/closing door to the storage, ventilation and fire alarm system turn-on/off apply the following color and display indication text defined for GE .

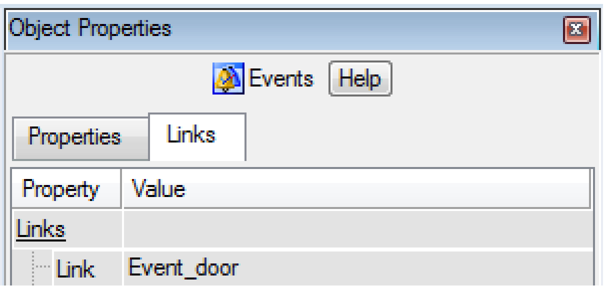


Properties for the rest GE are set the same way. The product level in the capacity is displayed by a histogram of arbitrary shape which will be created by GE **Oval**. For this GE set a dynamic GE filling and bind it to a corresponding argument of the screen template by setting a background color and filling. Consistently copy **heat_treatment** from the screen template and move it to the template **Storage_site** GE to display current time and navigation screen button. By a LB click select the required GE (to select multiple GE press and hold **Ctrl** key or select the area holding LB) and use  on the toolbar. To paste  use keyboard shortcuts for clipboard - **Ctrl-C** and **Ctrl-V**. After inserting GE bind them to the arguments of the current screen template.



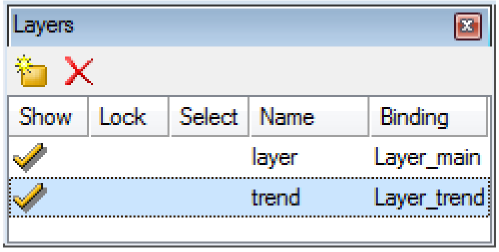
Place GE Events  at the bottom of the screen. LB click to center it horizontally with the appropriate menu item.

Leave the main GE properties  unchanged, in the tab Bindings set three bindings to template arguments of the screen: Event_door, Event_vent, Event_fire.



An additional storage layer for a graphics screen template **Storage_site** must be created to output current trends of parameter values on the trend.

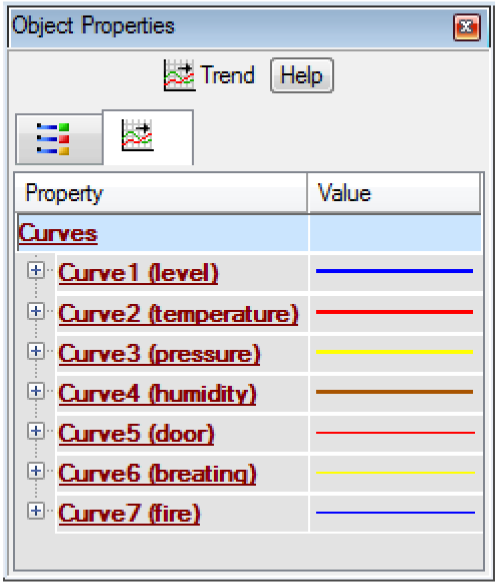
Through the point **View** of the main menu open the window of graphics layers. In the layers window an existing layer should be renamed to Layer and attached to the argument of the template Main_layer. By clicking create a new layer, rename it to Trend and link to the argument **Trend**.



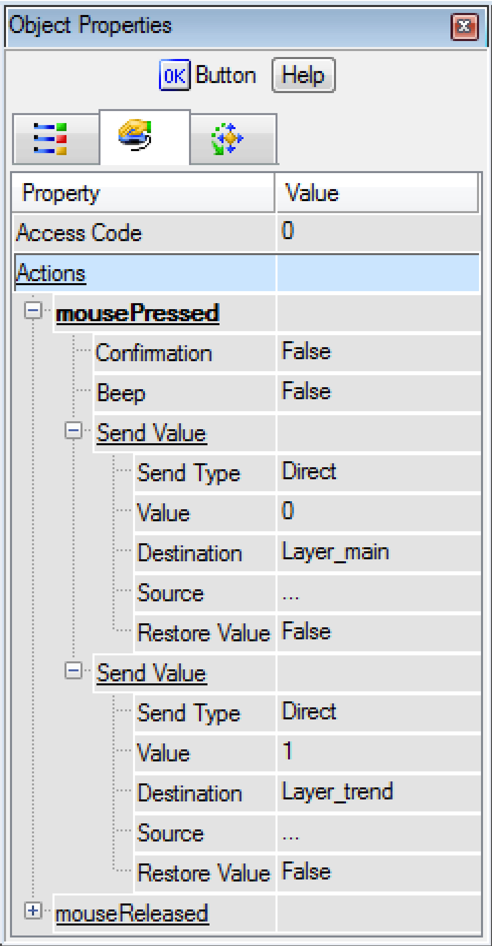
A newly created layer can be available for editing and display by clicking LB.

GS Trend and button should be placed in this layer (in the window it should be highlighted by LB).

Set seven new curves for the trend and define basic properties such as:



Bindings to arguments, color and line thickness, limits and headings to identify them on GS must be set for the curves. A property **Event** for GE located below is defined in such a way that when you click on arguments of screen template, their bindings to graphic layers have been defined, direct sendings are carried out. The values that are sent to these arguments, control layers visibility 0 – a layer is shown, 1 (any value other than 0) – a layer is hidden.



GS Text used to display current time and name of the site is copied into a layer Trend from a layer Layer. The layer Trend of a screen template Storage_Site will look like:

Contents

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