Tempus

ICo-op
Industrial Cooperation and Creative Engineering Education based on Remote Engineering and Virtual Instrumentation

Presentation of Zaporizhzhya National Technical University *(P08)*

Poliakov Mikhailo

ICo-op – Training Ilmenau, Germany, June 16th – 20th, 2014

Facts about Zaporizhzhya Region

Presentation of the Zaporizhzhya Region

- It is situated in the south-east of Ukraine
- The area of region is 27200 sq. km
- Neighbors are Kherson, Dnipropetrovsk, Donetsk regions
- The southern borders - the Azov Sea
- The population is 1.8 millions people
- More than 160 large industrial enterprises operate in region, such as JSC „Zaporizhstal“, „Dniprospetsstal“, „Ukrgrafite“, „Zaporizhzhya aluminum plant“, „Motor-Sich“-aircraft engines plant, „Zaporizhzhe transformers plant“ etc.
- Zaporizhzhya nuclear power station is the biggest in Europe.

Presentation of Zaporizhzhya National Technical University

- The oldest and largest university in the region.
- Founded in 1900.

ZNTU today consists of:

- 6 institutes, 12 departments;
- 60 chairs;
- more than 13 thousand of students including 8 thousand full-time students;
- bachelors, specialists (engineers) and masters are trained in 51 specialties;

Presentation of Zaporizhzhya National Technical University

Electrical Engineering Department:

- The largest department of university.
- Prepares professionals in the following specialties:
  - Electrical Machines and Apparatuses;
  - Electric Drive and Electromechanical Automation Systems;
  - Electrotechnical Systems of Energy Consumption;
  - Energy Management;
  - Electromechanical Equipment of Power-Consuming Plants.

Control System of Electrical Machines and Apparatus

Professor
Michael Poliakov

Teaching Assistant
Tetiana Larionova

Control System of Electrical Machines and Apparatus
Course Overview

- This course provides students in the field of Electrical Machines and Apparatuses with skills and knowledge required for design and production activity based on programmable logic controllers (PLC).
- **Course Prerequisites:** Students should know Fundamentals of programming, digital electronics and computer architecture. Students should also be familiar with basics of Electronics & Electrotechnics
- After completing this course the student will know the different families of PLC and be able to develop a project based on PLC and FSM model of control system behavior.

Control System of Electrical Machines and Apparatus
Course Overview

- By the end of the semester, students should have gained the following skills and knowledge:
  - exploring new approaches to design and production activity based on virtual engineering;
  - study of PLC systems hardware and software features of realization;
  - study of PLC programming language;
  - study of FSM models of control system behavior;
  - exploring stages and approaches to design of Control System of Electrical Machines and Apparatuses based on PLC.
- During the semester course, students will have one design project related to the development of PLC Control System of Electrical Machines and Apparatus.

Control System of Electrical Machines and Apparatus
Topics of lectures

- Course overview
- Control System of Electrical Machines and Apparatus
- PLC Control System architecture
- IEC61131 programming language overview.
- Ladder Diagram (LD) language: construction and basic instruction
- LD language : advanced instruction
- Tools for work with remote laboratory
- Formalization of control tasks

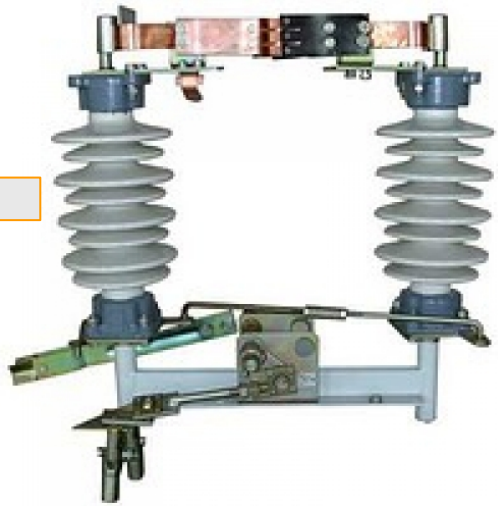
Control System of Electrical Machines and Apparatus
Topics of lectures

- FSM-models of the control system behavior
- Standard tasks of control
- FSM modeling on LD language
- Man Machine Interface Software
- Behavioral synthesis of visualization problems
- Scripting of visualization problems

Control System of Electrical Machines and Apparatus
Introduction

Traditional approach

Technical system



Control System of Electrical Machines and Apparatus
Introduction

cybernetic system

Control System of Electrical Machines and Apparatus
Introduction

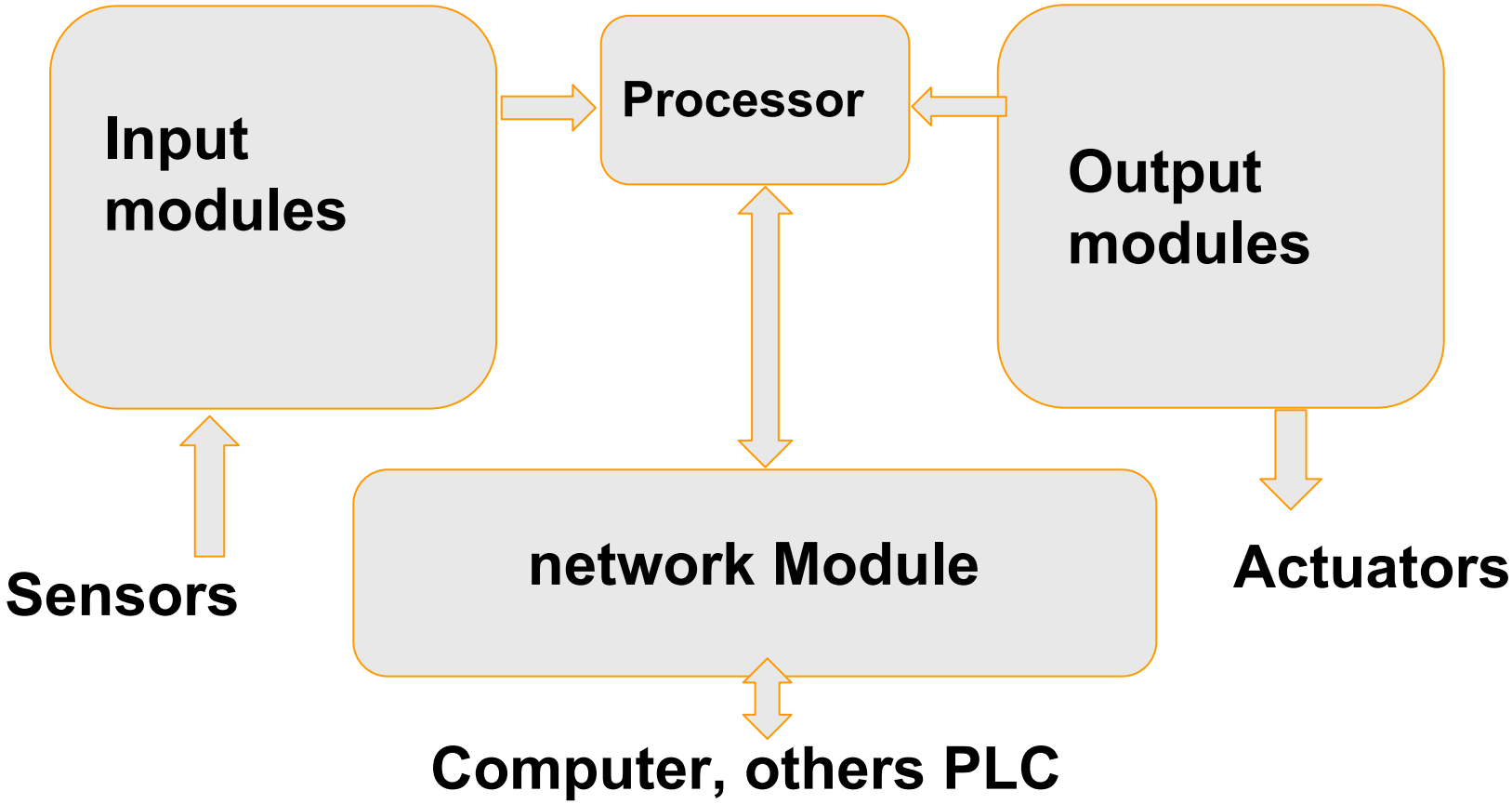
Cybernetic system is able to:

- optimal control based on feedback
- adaptation to the changing conditions of use
- cognitive control

Main way to increase the efficiency of electric machines and apparatus – intelligent control with the use of computers and programmable controllers

Control System of Electrical Machines and Apparatus
Introduction

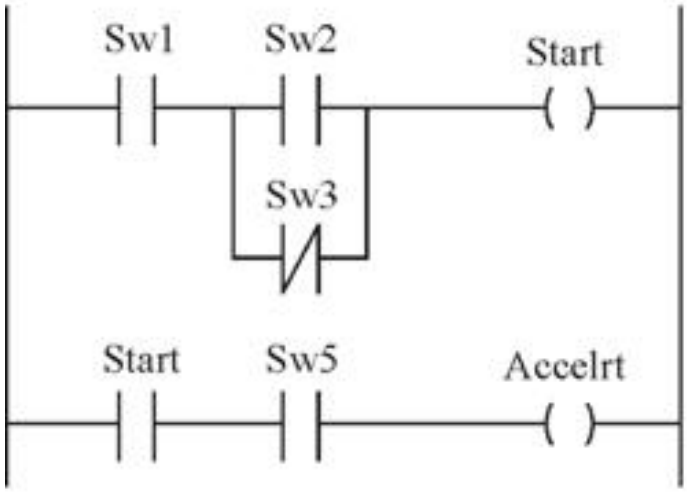
That there is a programmable logic controller (PLC)



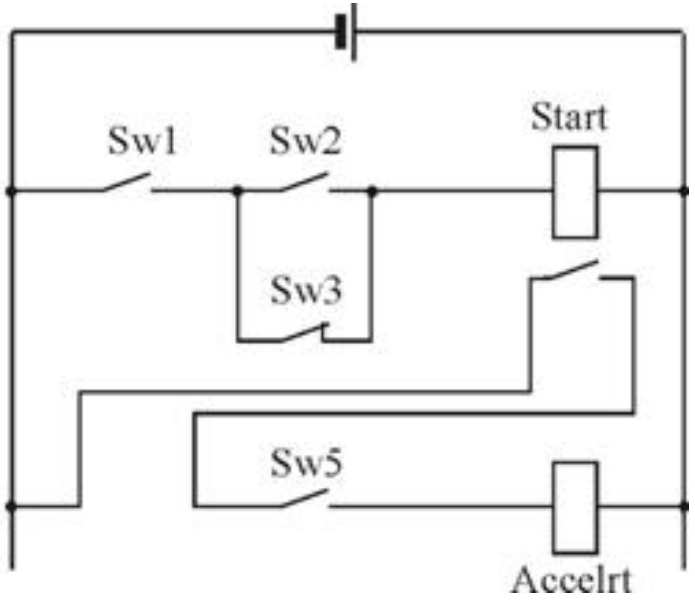
Control System of Electrical Machines and Apparatus
Introduction

Programming languages standard IEC 61131-3

- Ladder diagram: program looks like a circuit Ladder



program

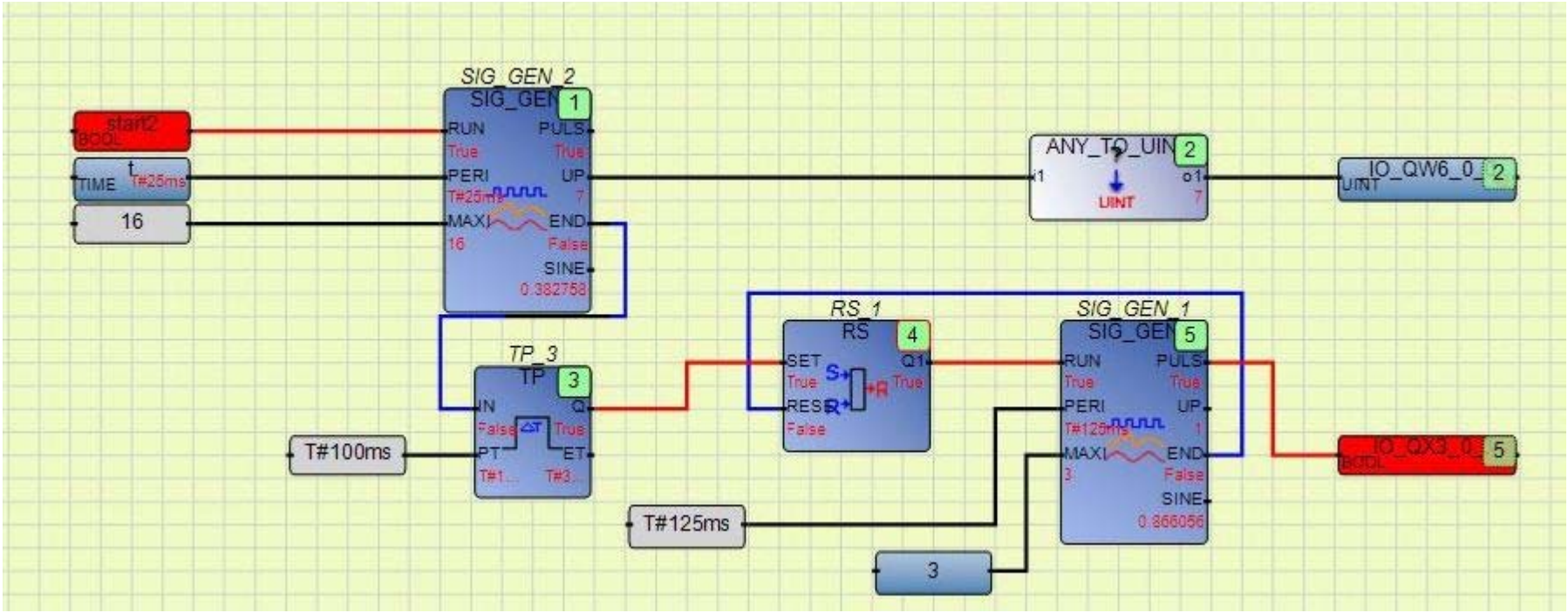


circuit

Control System of Electrical Machines and Apparatus
Introduction

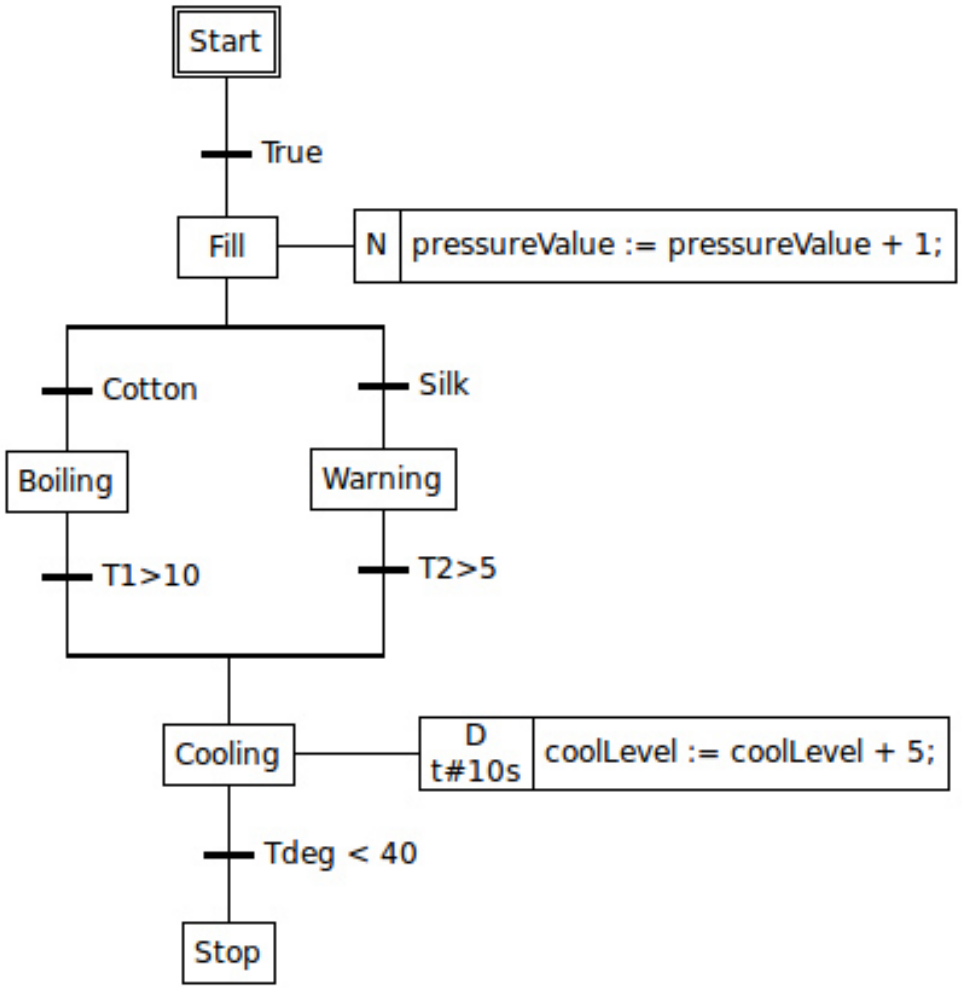
Programming languages standard IEC 61131-3

Function Block Diagram (FBD): program looks like a functional scheme



Control System of Electrical Machines and Apparatus
Introduction

Programming languages standard IEC 61131-3



Sequential Function Chart (SFC) : program looks like a state diagram

Control System of Electrical Machines and Apparatus
Introduction

Programming languages standard IEC 61131-3

```
    END_IF;
Setpoint_IN_STAGE_1_FAILED:
    (* During 'STAGE_1_FAILED': '<S1>:119' *)
    IF (stage3_sensor <= 0) OR (stage2_sensor <= 0) THEN
        (* Transition: '(<S1>:150' *)
        (* Transition: '(<S1>:152' *)
        IF stage2_sensor > 0 THEN
            (* Transition: '<S1>:155' *)
            is_c2_Setpoint := Setpoint_IN_STAGES_1_3_FAILED;
            (* Entry 'STAGES_1_3_FAILED': '<S1>:120' *)
            rtb_stage1_setpoint := L0;
            rtb_stage2_setpoint := L0 - overall_target;
            distributed_target := rtb_stage2_setpoint;
        ELSE
            (* Transition: '<S1>:154' *)
            IF stage3_sensor > 0 THEN
                (* Transition: '<S1>:159' *)
                is_c2_Setpoint := Setpoint_IN_STAGES_1_2_FAILED;
                (* Entry 'STAGES_1_2_FAILED': '<S1>:121' *)
                rtb_stage1_setpoint := L0;
                rtb_stage2_setpoint := L0;
                distributed_target := L0 - overall_target;
            ELSE
                guard_0 := TRUE;
            END_IF;
        END_IF;
    ELSE
        guard_0 := TRUE;
    END_IF;
```

Structured Text language(ST) : program looks like a Pascal program

Control System of Electrical Machines and Apparatus
Introduction

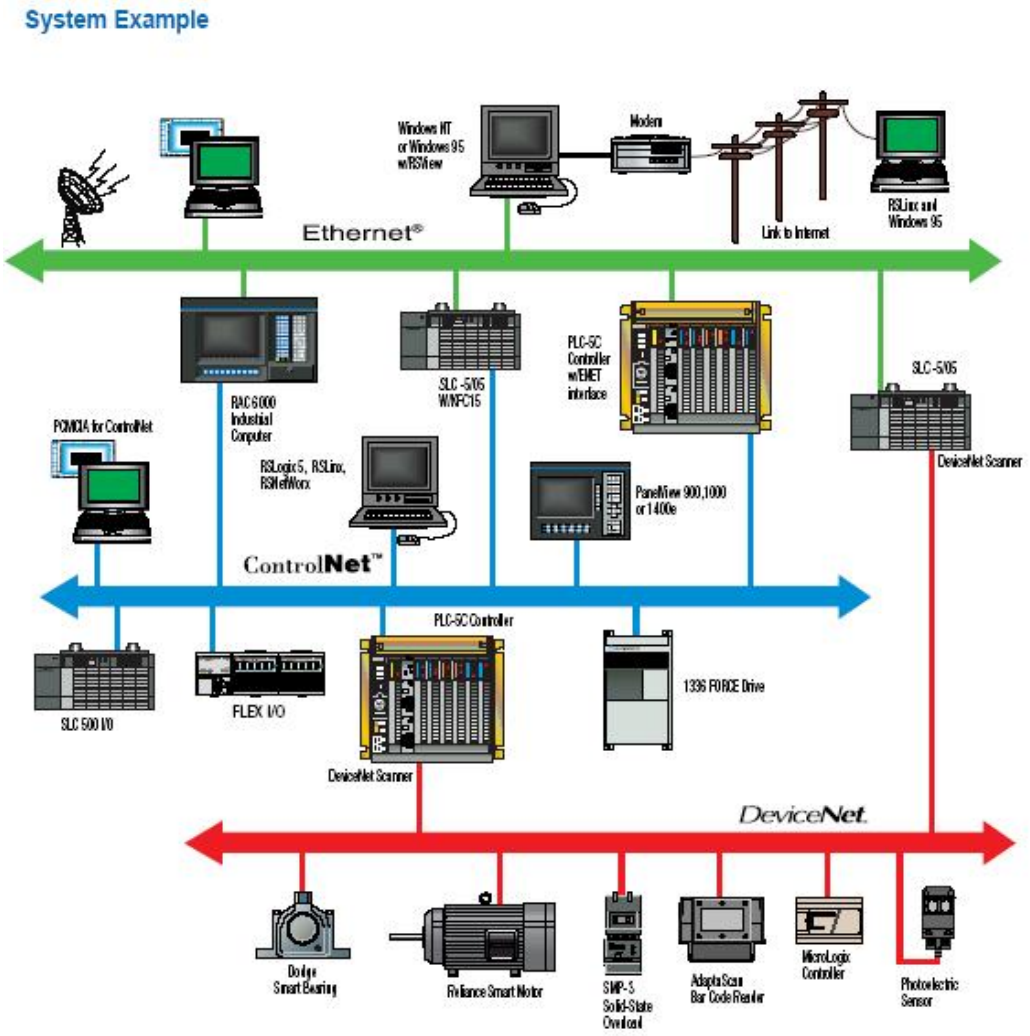
Programming languages standard IEC 61131-3

Instruction language (IL) : program looks like a Assembler program

```
(* sample for language IL *)

LD      il_active
JMPCN   end

        (* drop here only if activated by SFC *)
ld      il_counter
add     1
st      il_counter

(* copy counter value to resource global value *)
ld      il_counter
st      copy_of_il_counter

end:    ret
```

Control System of Electrical Machines and Apparatus

Introduction

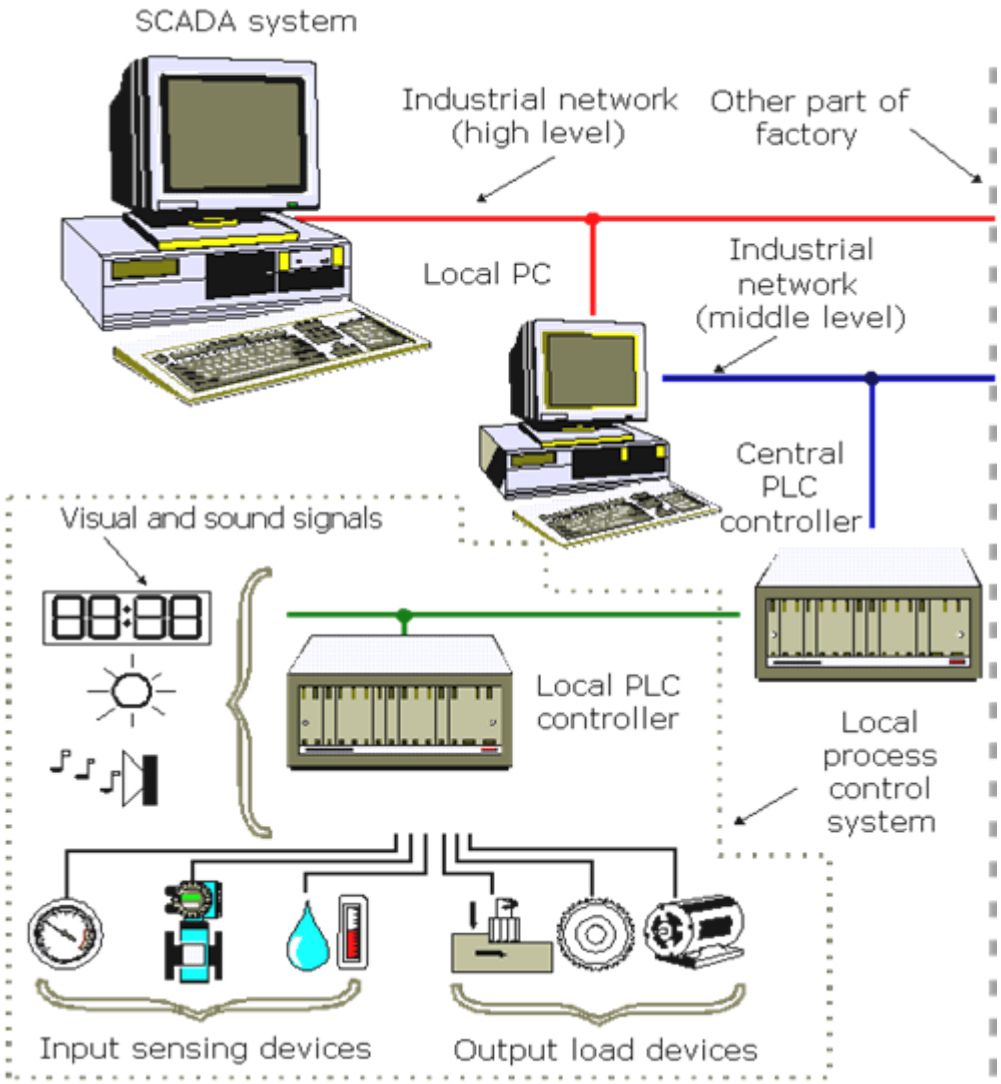


Three levels of automation systems:

- **informational**
- **control**
- **device**

Control System of Electrical Machines and Apparatus

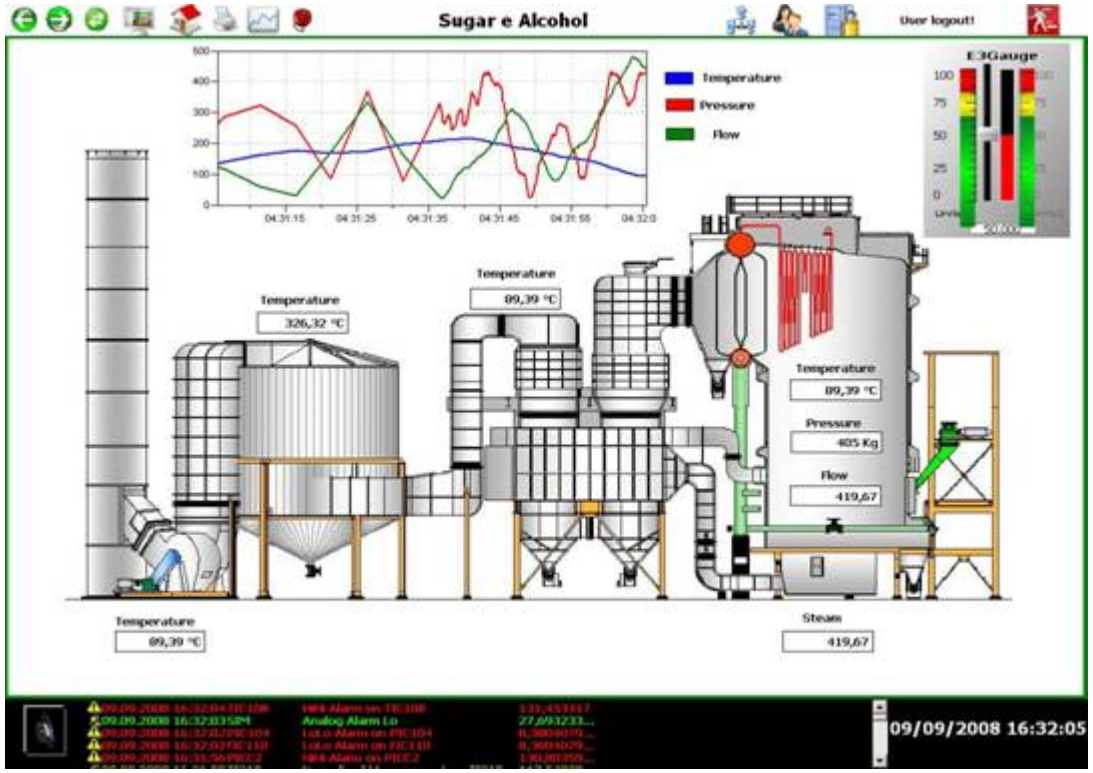
Structure controller system control



- ✓Sensors
- ✓Drives
- ✓Operator Interface
- ✓MMI
- ✓Industrial networks
- ✓programmable controllers
- ✓Software

Control System of Electrical Machines and Apparatus
Introduction

Man-machine interface



Function:
- virtual control screens
- data archiving
- data trends
- alarm
- event Processing
- scripting

Control System of Electrical Machines and Apparatus

Example of practical tasks

Formulation of the problem

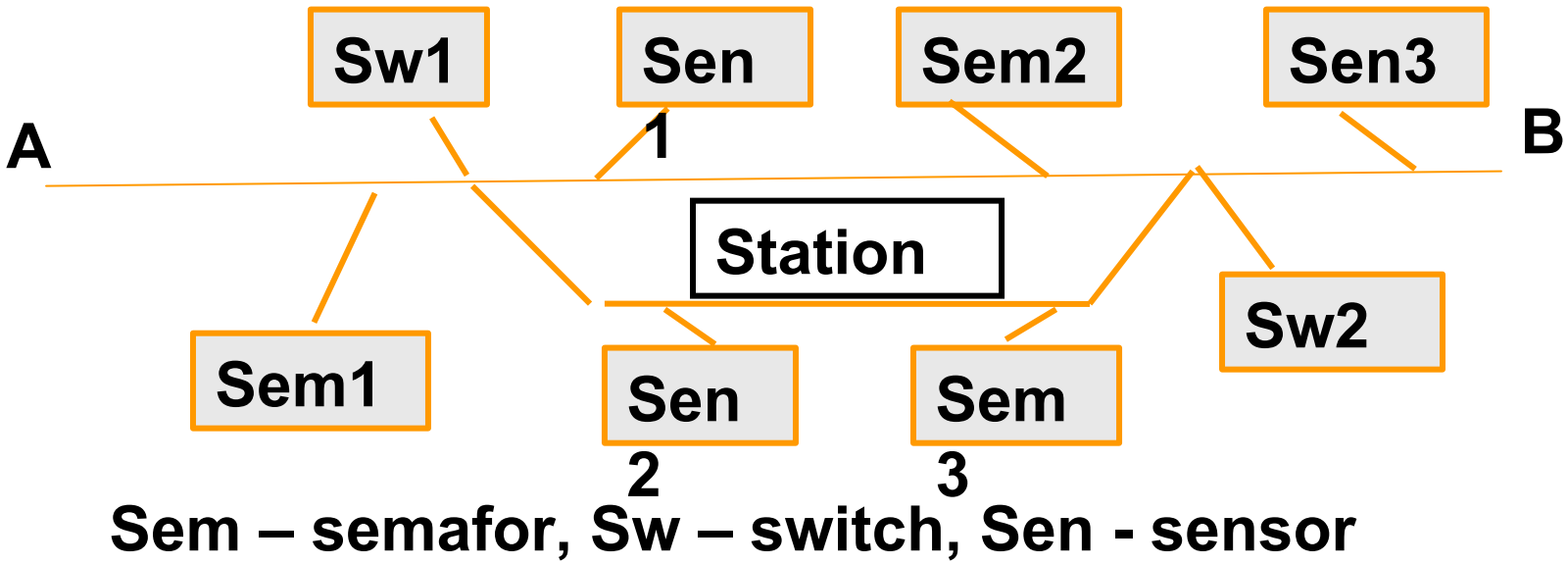
From point A to point B moving train. Between A and B, there is a station, which has two ways. System design requires control of the station which has:

1. Taking the train on the way to 1 and if it is busy, then taking on the way 2
2. Aiming train to point B if the way is not busy
3. Respect the principle of "first in - first out“(FIFO) with the departure of trains.

Control System of Electrical Machines and Apparatus

Example of practical task

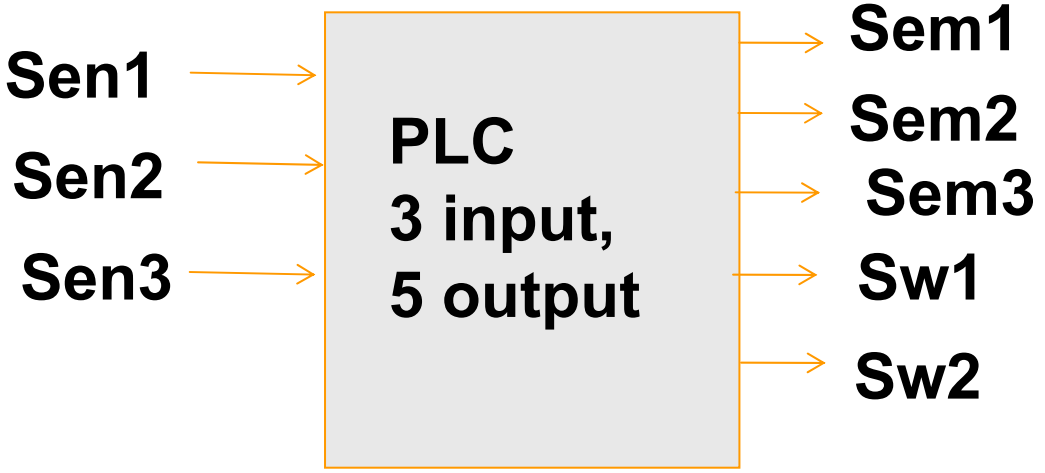
Step1. Selecting the control system equipment



Control System of Electrical Machines and Apparatus

Example of practical tasks

Step2. Controller selection and description of binary variables



Semi=0 if blue and 1if red
Seni=0 if free and 1if busy
Swi=0 if 1 way and 1 if 2 way connected

Control System of Electrical Machines and Apparatus

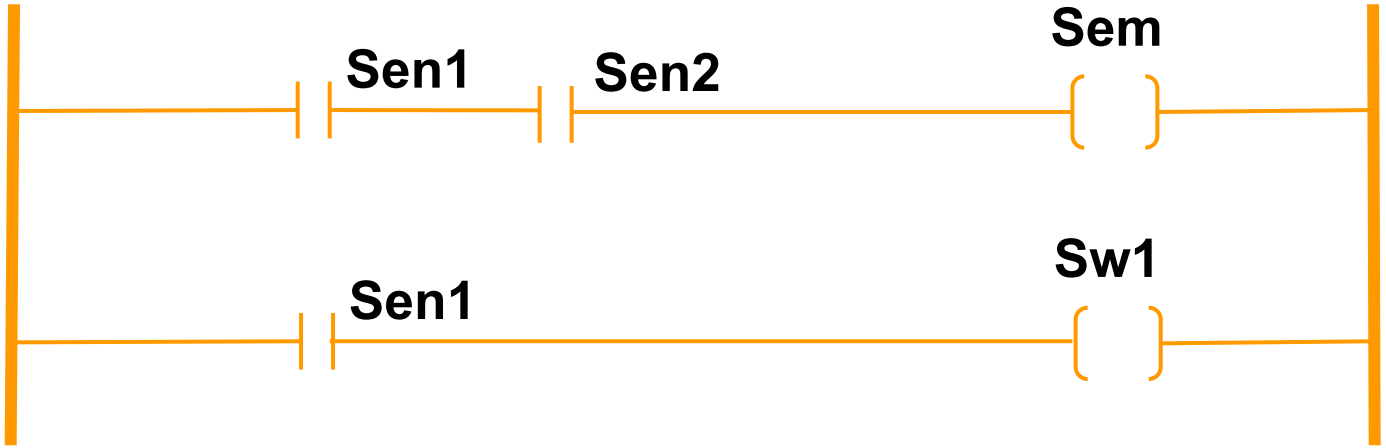
Example of practical tasks

Step3. Control logic

1. Task decomposition: receiving logic and dispatch logic
2. Boolean equation for receiving logic :

   Sem=Sen1&Sen2; Sw1=Sen1.

3. Program rung for receiving logic on LD language:



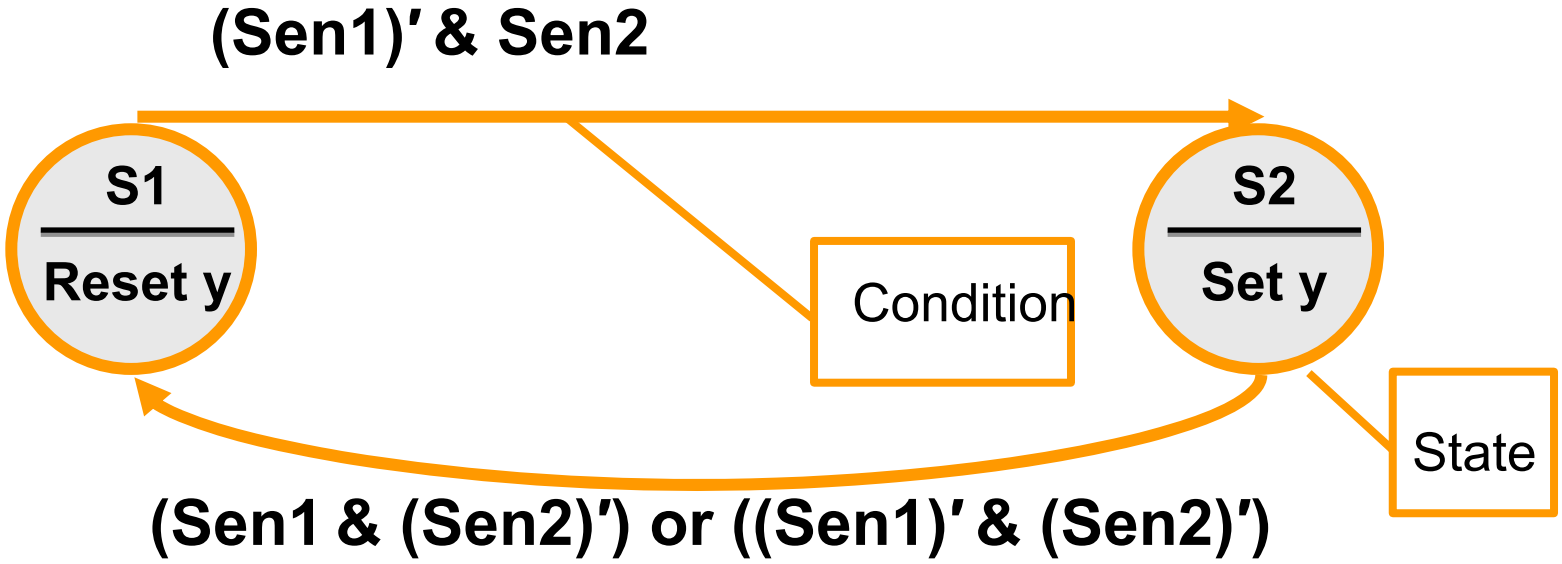
Control System of Electrical Machines and Apparatus

Example of practical tasks

Step4. FSM formalism

- Question for dispatch logic: how to take into account the principle of FIFO? We must remember the sequence of events! Create a state diagram for the control problem

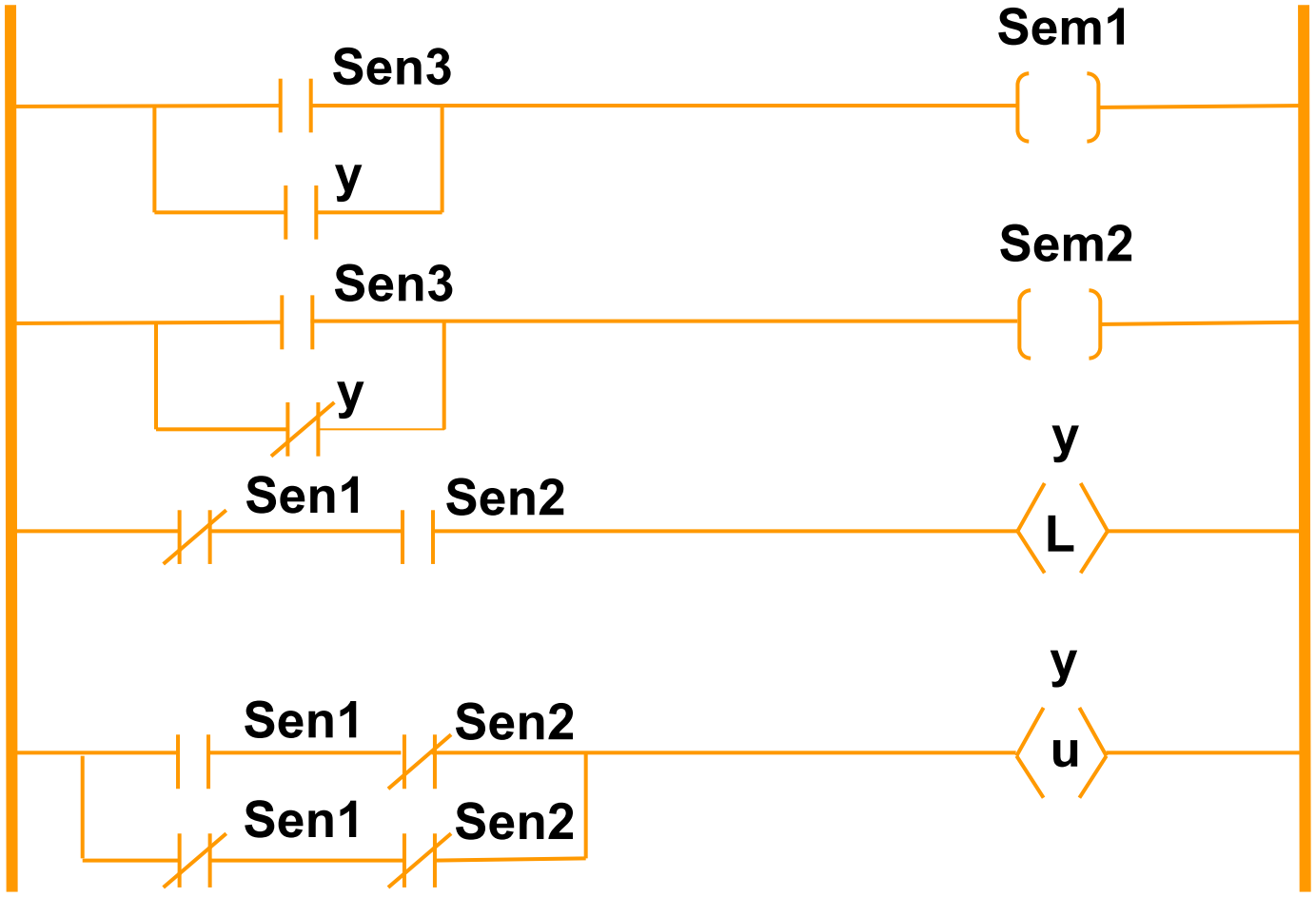
Control System of Electrical Machines and Apparatus
FSM of the Railway Station Control System



S1 – state “priority of the 1st tracking”;
S2 – state “priority of the 2nd tracking”;
y – state variable.

If S1 – y=0 and if S2 – y=1.

Control System of Electrical Machines and Apparatus
Control Logic of Train Dispatch



Control System of Electrical Machines and Apparatus
Example joking FSM

Son takes good (5) or a bad (2) mark at school. Father can use the following types of actions:

- take the belt (y0),
- to scold his son (y1),
- to soothe his son (y2),
- to hope (y3),
- to be glad (y4),
- to rejoice (y5).

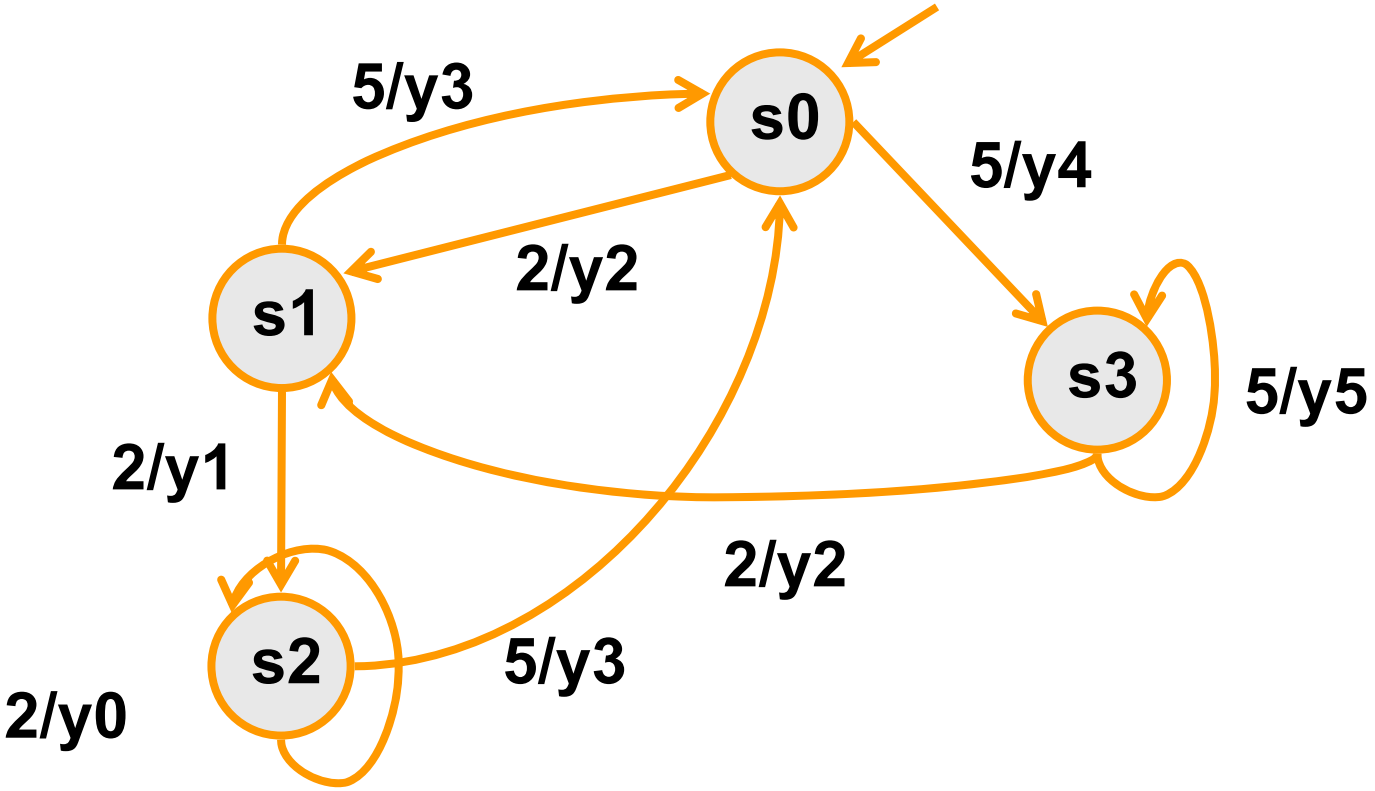
Impact of father should be chosen taking into account prehistory son's marks.

Reference:

Yuri Karpov Automata Theory, St. Petersburg PITER.2002.-224 p.

Control System of Electrical Machines and Apparatus
Example joking FSM

It is required to design a machine for the upbringing of son and to formalize it in the form of FSM.

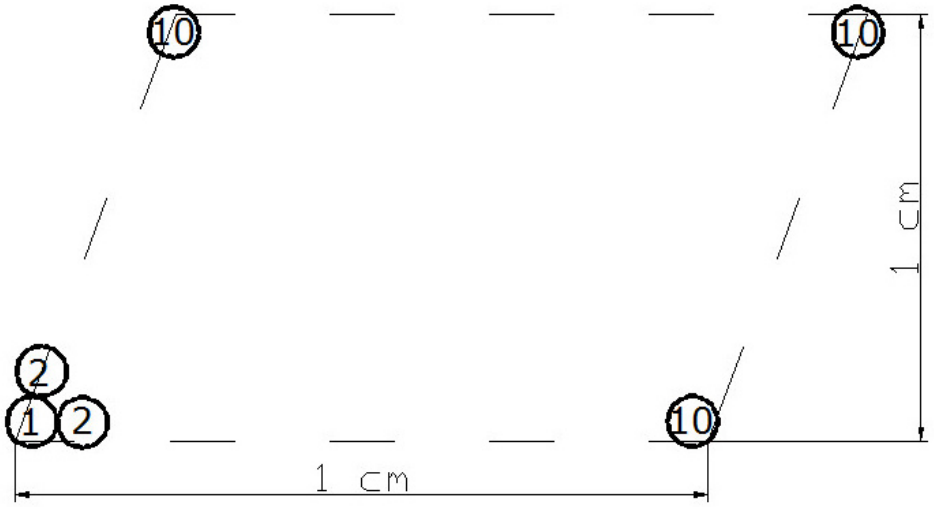


Example of a joke

Approximately evaluate the mass of 1,000 steel balls with Ø 1mm.

Example of a joke

Compare your answer with the correct one.



1 layer – 100 balls
1cm x 1cm x 1mm
10 layers – 1000 balls
1cm x 1cm x 1cm = 1 cm^3

For cubes the mass will be 7.8 g,

for balls the mass will be < 4.0 g.

Control System of Electrical Machines and Apparatus Course Material

Basic literature:

- Parr E.A. Programmable Controllers: An engineer's Tried edition. Oxford: Newnes, 2003 - 429p. ISBN 0-7506-5757-X.
- Парр Э. Программируемые контроллеры: руководство для инженера/ Э. Парр; пер. с англ. изд. - М.: БИНОМ. Лаборатория знаний, 2007.- 516 с.: ил ISBN 978-5-94774-340-1.
- John, K.-H., Tiegelkamp, M. IEC 61131-3: Programming Industrial Automation Systems. Concepts and Programming Languages, Requirements for Programming Systems, Aids to Decision-Making Tools.- Springer. 2001 VI, 376 p.

Control System of Electrical Machines and Apparatus Course Material

Additional information

- Rockwell automation. User manuals/ Access mode: www/ URL:
- http://literature.rockwellautomation.com/idc/groups/public/documents/webassets/browse_category.hcst
- Петров Петров И.В. Программируемые контроллеры. Стандартные языки и инструменты/Под. Ред. Проф. В.П. Дьяконова.-М.: СОЛОН-Пресс,2003.-256с.
- Олсон Г. Пиани Д. Цифровые системы автоматизации и управления. – СПБ.: Невский Диалект, 2001 – 557с.: ил.

Control System of Electrical Machines and Apparatus
Internship course lecturer

Automatic control system technological process laboratory (ZNTU). Since 1999

A.N. Rassalsky, M.A . Poliakov. Learning experience controller contol system management teaching and research laboratories ACS TP Zaporozhye Technical University. / / News natsionalnogo tehnichnogo universitetu "KhPI", 2001, № 16, p.141.

Overview own publications on Remote Engineering and Virtual Instrumentation

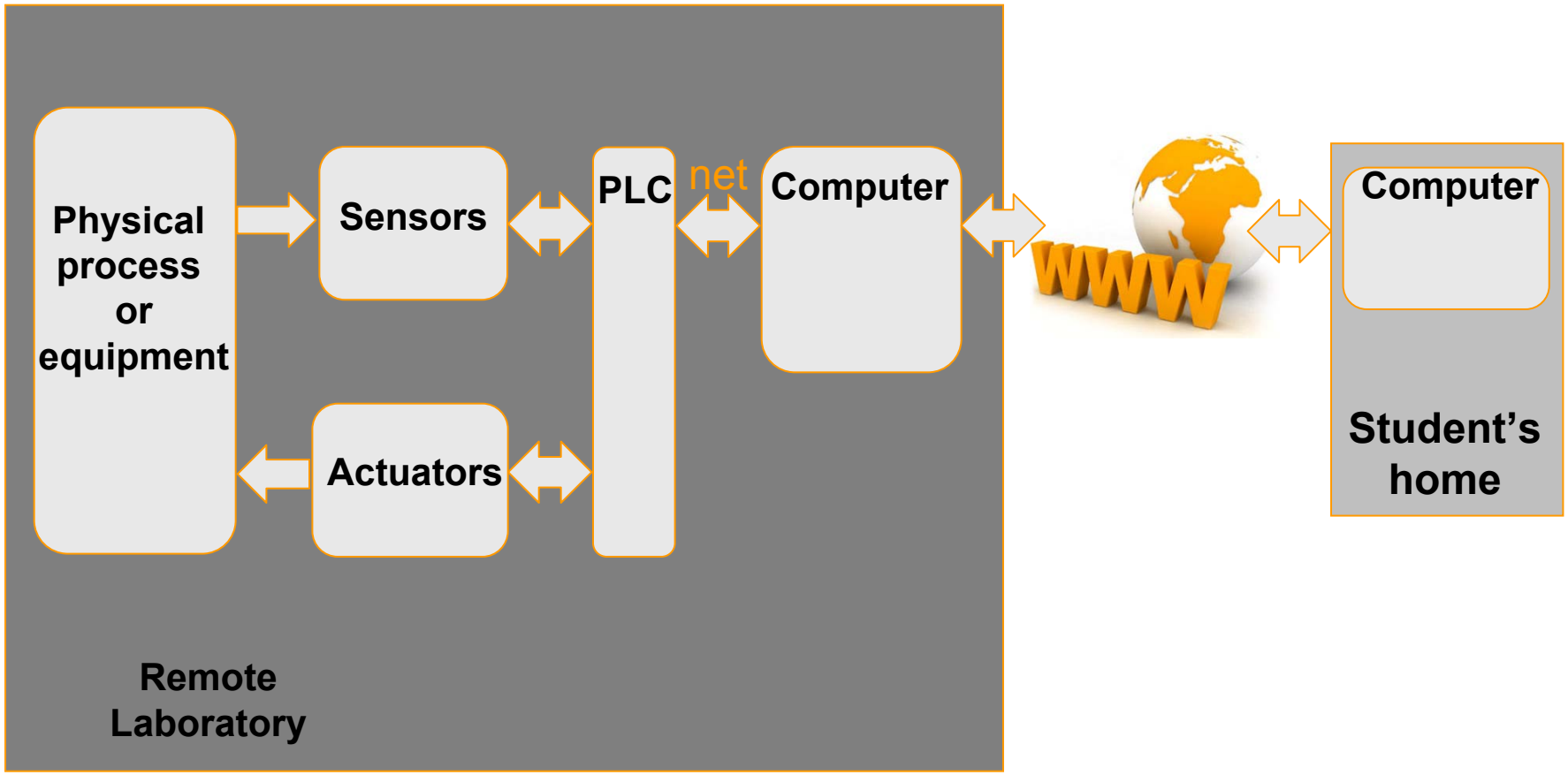
Reference:

A. N. Rasalsky, M.A. Poliakov. Industrial automation learning experience in teaching and research laboratories ACS PT Zaporozhzhye State Technical University // Proceedings of the Fifth International Scientific Conference "New Information Technologies in Education Electrotechnical" - ЦНТЭП LLC, Astrakhan, 2000, p. 199-201.

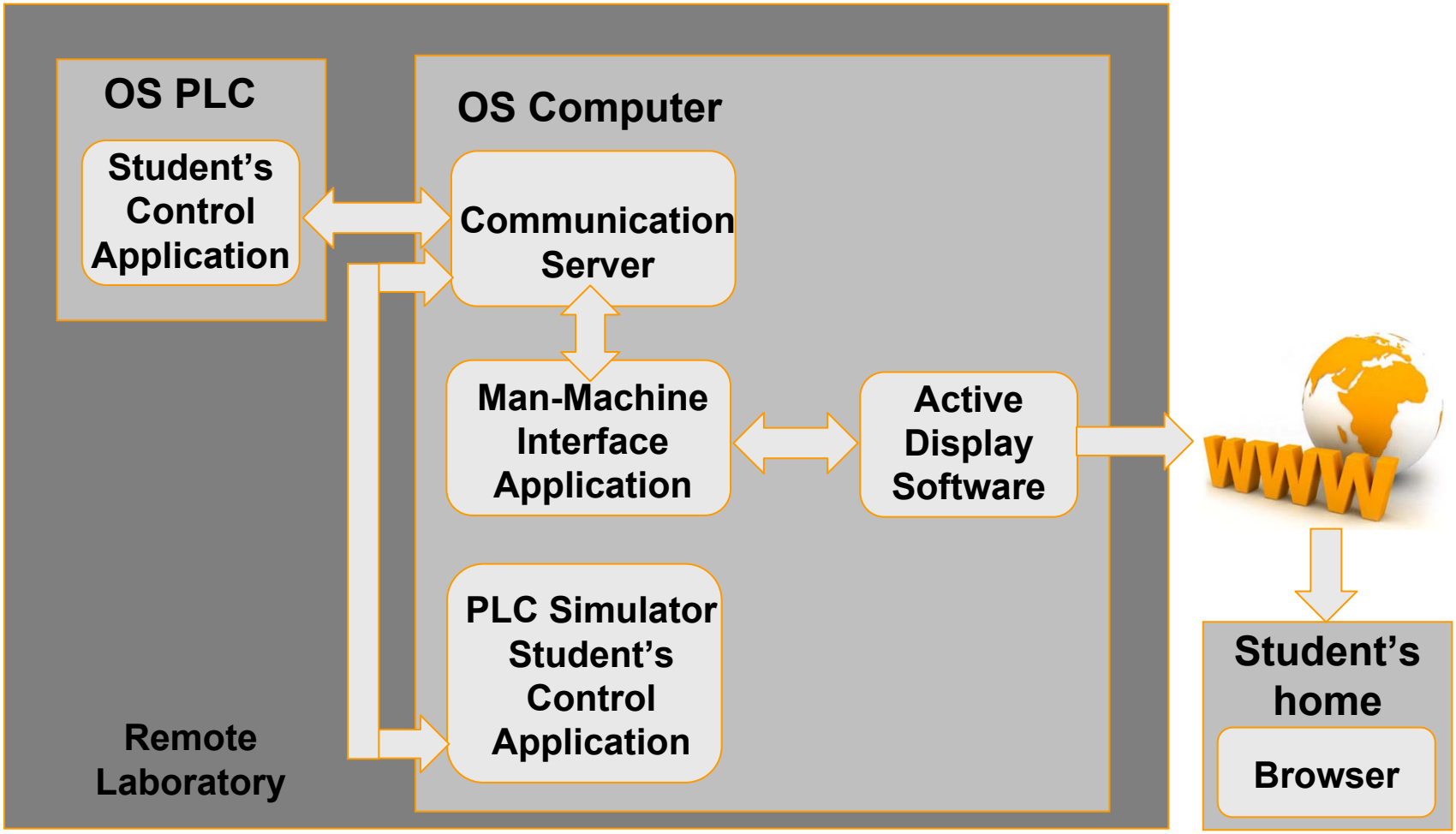
- Remotely open, run, and interact with RSView32 graphic displays from virtually any computer on a network with RSView32 Active Display System.

- View graphic displays, tags, and alarms through any standard Internet browser with RSView WebServer

Remote laboratory: Hardware automation system - subject of study and learning tool



Remote laboratory: software of automation system - subject of study and learning tool Remote laboratory:



Overview own publications on Remote Engineering and Virtual Instrumentation

Reference:

M.A Polyakov, A.N. Rassalsky. Prospects for the application of industrial automation for training / / "New information technologies in regional infrastructure and education": Sat Proceedings of the fourth international scientific-methodical conference. Astrakhan University, TSNTEP, 2001, pp.123-124.

- Using applications HMI to create multimedia textbooks. Material of textbooks is presented in the form of graphic displays containing graphical objects: text, tables, figures, etc. Each object can have up to 12 control types.
-

Activities of our graduates on control system application

Energy Automation

#135-06/14 June 2, 2014

"Energoautomation" LLC produce advanced technical solutions in the field of online monitoring, control and diagnostic of high voltage (35 - 1150kV) equipment. The company provides a full range of services from designing, engineering and manufacturing to installation, commissioning and maintenance of our own online monitoring systems (SAFE - T®). Since 2001, by our systems were equipped more than 200 units of power transformer in Russia, Kazakhstan and Ukraine.
SAFE - T®, are designed to monitor the main types of high-voltage equipment: power transformers (autotransformers), shunt reactors, bushings, switches, instrument current transformers, nonlinear surge arresters.
Hereby, the company "Energoautomation" LLC informs that our specialists, which studied in Zaporizhhya National Technical University were trained in course "Industrial Programmable Controllers" (by Dr. M. Polyakov, Department of "Electrical and electronic devices") and applying knowledge gained in this course in the manufacturing processes of our company.

Deputy Director of Development, PhD A. Sakhno

Tempus

ICo-op
Industrial Cooperation and Creative Engineering Education based on Remote Engineering and Virtual Instrumentation

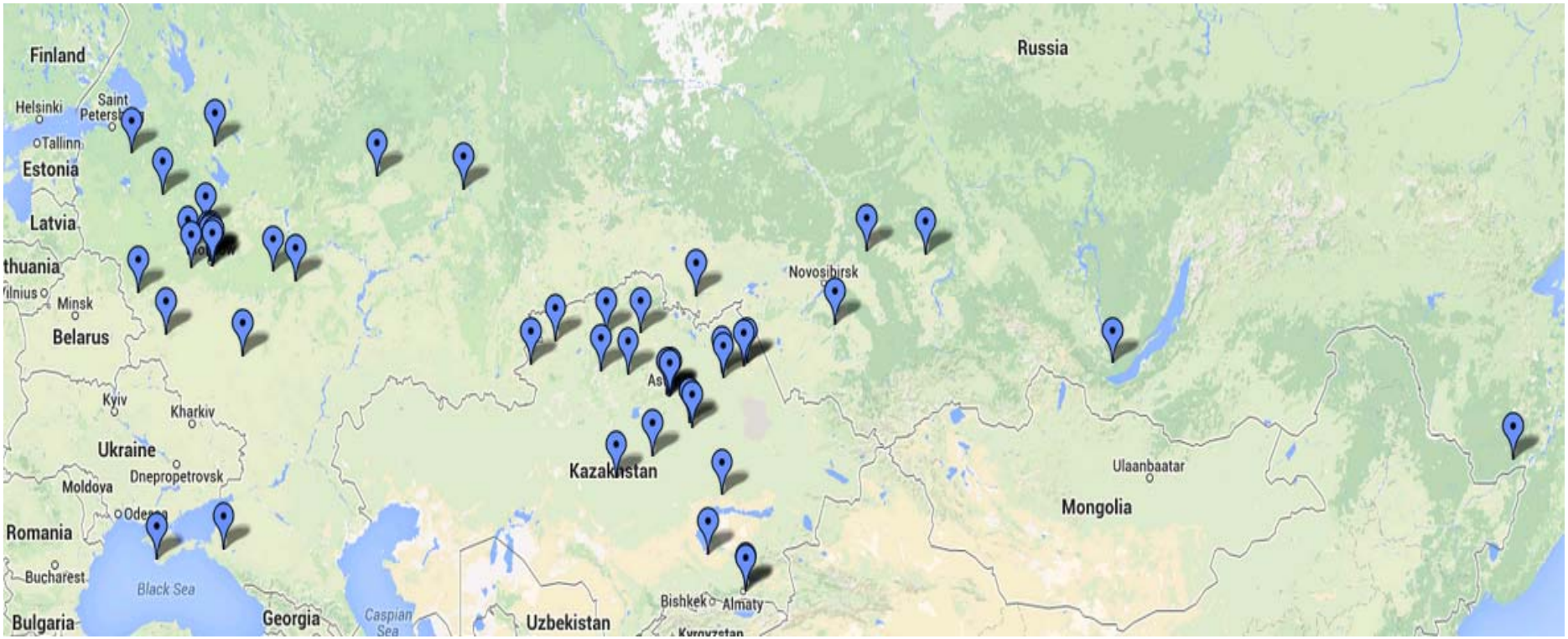
"Energoautomation" LLC

(Ukraine, Zaporozhye, www.enera.com.ua)

Produces advanced technical solutions in the field of online monitoring, control and diagnostic of high voltage (35 - 1150kV) equipment. The company provides a full range of services from designing, engineering and manufacturing to installation, commissioning and maintenance of our own online monitoring systems (SAFE - T®). Since 2001, by SAFE-T® systems were equipped more than 200 units of power transformer in Russia, Kazakhstan and Ukraine.

http://www.enera.com.ua/company/introduction/

Installation of our own online monitoring systems "Energoautomation" LLC



The main Customers of SAFE-T® :

- ✓ **Federal Grid Company of Unified Energy System - Russia;**
- ✓ **Kazakhstan Electricity Grid Operating Company (KEGOC);**
- ✓ **National Power Company "UkrEnergo" - Ukraine;**
- ✓ **National Nuclear Power Company "UkrEnergo" - Ukraine;**
- ✓ **Russian Concern of Electric and Thermal Power Production "RosEnergoAtom";**

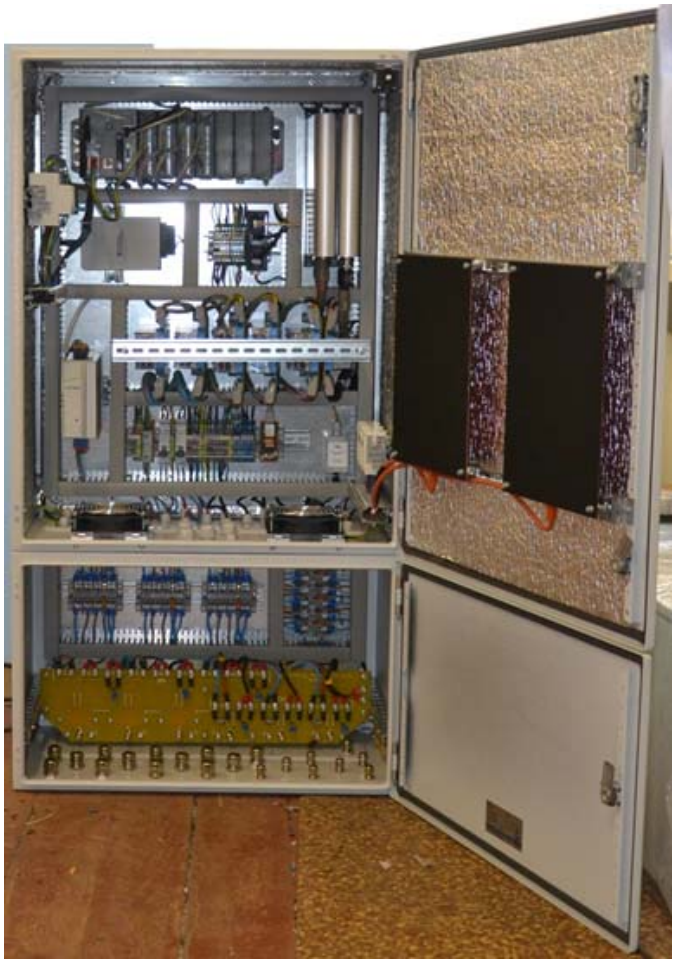
Country	Voltage	Quantity of monitoring blocks,
Russian Federation	220 - 750кВ	120
Republic of Kazakhstan	110 - 500кВ	75
Ukraine	150 - 330кВ	10

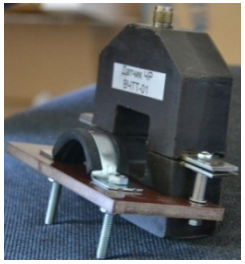
Activities of our graduates

SAFE - T®, are designed to monitor the main types of high-voltage equipment: power transformers (autotransformers), shunt reactors, bushings, switches, instrument current transformers, nonlinear surge arresters (http://www.enera.com.ua/products/SAFE-T/)

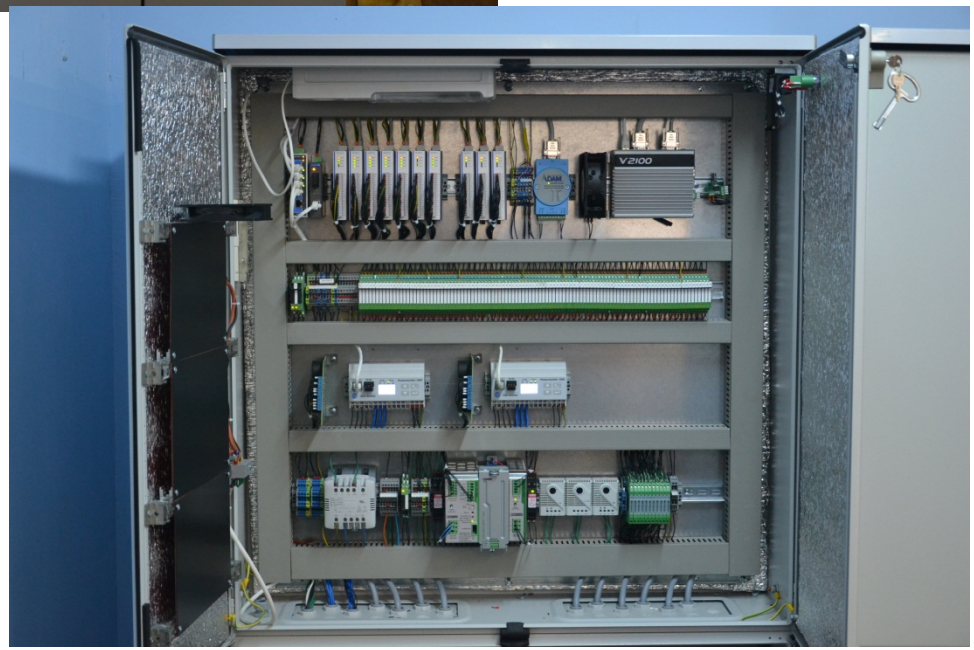
Most specialists of "Energoautomation" LLC, which studied in Zaporizhhya National Technical University were trained in course "Industrial Programmable Controllers" (by Dr. M. Polyakov, Department of "Electrical and electronic devices") and applying knowledge gained in this course in the manufacturing processes of our company.

Monitoring systems "Energoautomation" LLC






Датчик
ДКИВ-03
ввод-220(110)кВ

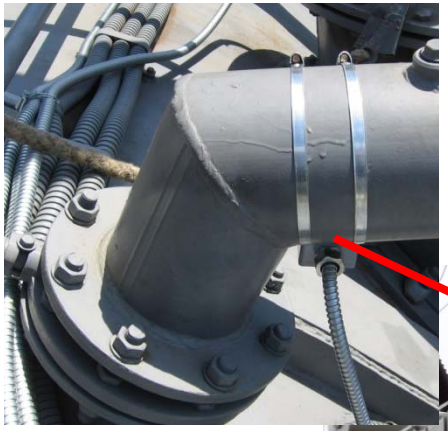


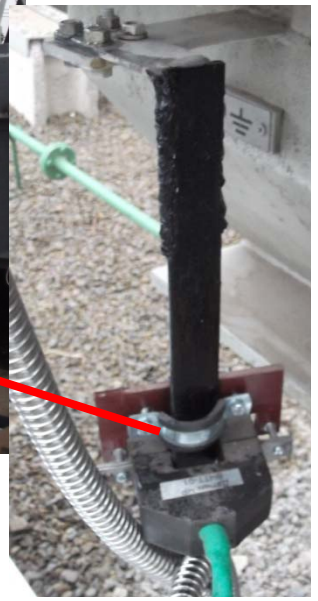
Monitoring block and some sensors for shunt reactors 500kV monitoring

SAFE-*T*

Monitoring block and sensors for bushing monitoring

SAFE-*T*





Activities of our graduates

Hereby I confirm that Andriy Sapronov which studied in Zaporizhzhya National Technical University successfully applying knowledge gained on "Industrial Programmable Controllers" course (by Dr. M. Polyakov, Department of "Electrical and electronic devices") during his job onboard of our ship.

INTERNATIONAL

Royal Caribbean International, owned by Royal Caribbean Cruises Ltd., is a cruise line brand founded in Norway and based in Miami, Florida in the United States of America.
Andriy Sapronov is working onboard of Voyager Of The Seas as an electrical engineer. Ship carrying capacity is 3.840 passengers and crew of 1.180 , a total of some 5,020 persons are onboard the ship at any one time. The main engine power for Voyager of the Seas is provided b six Wärtsilä Vasa 46 diesel engines, giving a total output of 75,600kW and creating a service speed of around 22 knots. The engines have been modified by approximately 5% to accommodate three 14MW Azipods – two azimuthing and one fixed. In addition, there are four bow thrusters and two stern thrusters. Ship main automation system has over 15.000 automatio points and includes vast variety of programmable logic controllers.
Hereby I confirm that Andriy Sapronov which studied in Zaporizhzhya National Technical University successfully applying knowledge gained on "Industrial Programmable Controllers" course (by Dr. M. Polyakov, Department of "Electrical and electronic devices") during his job onboard of our ship.

Mladen Radovanovic
Chief Electrical Engineer
M/S Voyager of the Seas
vy_chiefelectricalengineer@rccl.com

Study and work of our graduates in Europe

The Technical University of Denmark (Copenhagen), College(Teesside University) (Prague) Wroclaw University of Technology(Wroclaw), *Warsaw* University of Technology(Warsaw), Royal Institute of Technology (Stockholm), The Graz University of Technology (Austria) etc.

Contact Information

- Official Website of Zaporizhzhya National Technical University

  www.zntu.edu.ua

- Prof. Mykhailo Poliakov

  Zaporizhzhya National Technical University,

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  Tel. ***+38 066 794 60 37, +38 061 769 83 95***

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Presentation of Zaporizhzhya National Technical University *(P08)*

Poliakov Mikhailo

ICo-op – Training Ilmenau, Germany, June 16th – 20th, 2014

Thank you for your attention