Project: Automation of the accelerator vacuum system

1. Introduction

Almost every physicist-experimentalist, and, particularly, engineer working with physical equipment, needs a basic experience in automated control systems (ACS). Vacuum equipment, magnet power supplies, diagnostic devices — all this and many other equipment usually is controlled remotely by ACS. This Lab Work is aimed at studying of different control devices and learning the skills of the modern control systems design by assembling the ACS for the model of the accelerator vacuum system.

For better understanding of the controlled object, the 2-days Vacuum Technology Lab Work aimed at studying the basic methods and technologies of vacuum equipment operation is provided.

Of course, obtained skills are not limited by vacuum systems automatization. Principles of remote control and monitoring of different devices are rather similar, so after this Lab Work the student can construct a simple ACS based at PLC (programmable logic controller) for nearly any application.

2. Description

The training starts from the Vacuum Technology Lab Work. It gives hands-on skills of the vacuum system assembly and evacuation, leak detection, and work with the inlet valve. It also provides understanding of the logic of the vacuum system operation needed for its correct automation.

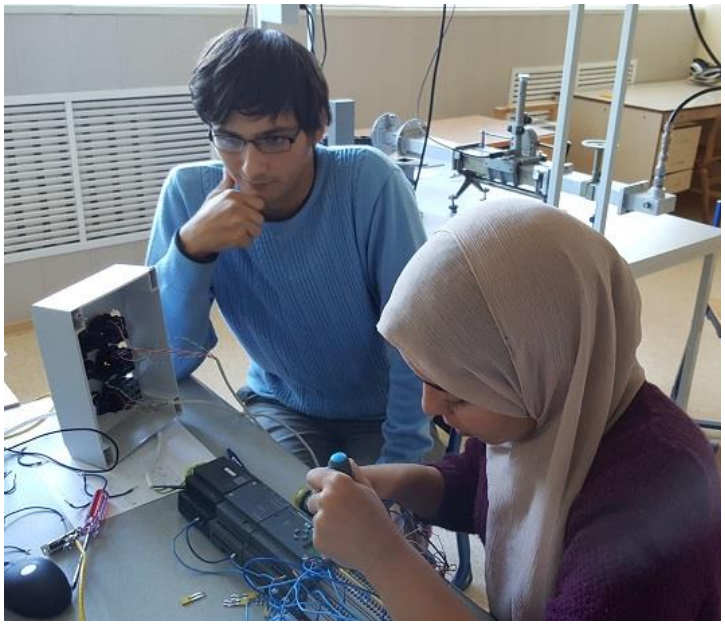
The model of the accelerator vacuum system includes all main vacuum components:

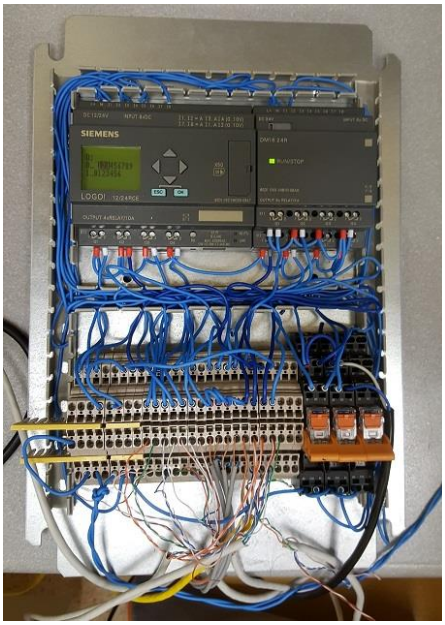
1. Various components with all three of the most frequently used flange types: ISO, KF, CF.
2. Pumps: forevacuum pump and turbomolecular pump.
3. Pneumatic valves: 2 angular valves, 1 gate valve.
4. Low noise compressor for pneumatic equipment.
5. Vacuum measurement: Pirani gauge, ionization gauge and controller for them.

Then the Controls Lab Work proper begins. On the basis of the information received in the Vacuum Technology Lab Work students will develop the design of the ACS and construct it.

There are three stages of the ACS development:

1. Remote control of the pumps and valves.
2. Interlock realization (prohibition of some actions depending on condition of some components — pumps, valves, vacuum levels).
3. One-button system start: user presses a button, and the system automatically and in the correct sequence turns on the pumps, opens and closes the valves and obtains a required vacuum value.





3. Practice plan

3.1. Vacuum Technology

1. Assembling and pumping-out of the model of the accelerator vacuum system.
2. Pumping-out, detecting and eliminating of vacuum leaks.
3. Leakage time estimation, leakage graphs.

3.2. Controls

1. Acquaintance with control elements.
2. Assembling basics (instruments, methods).
3. PLC programming basics.
4. ACS project: structure, schemes, tables etc. Simple (test) project.
5. Development of the project of the ACS for the model of the accelerator vacuum system: requirements, explanatory note, structural and electrical circuits, equipment layout, cable journal, specification, operation manual.
6. ACS assembling, vacuum equipment connection.
7. PLC programming.
5. Operational testing.

Student's Lab Work report should include the ACS project and the working system proper.

4. Prerequisites

1. Knowledge of the basics of electrical engineering:
    a. Basic parameters: voltage, current (DC and AC), power.
    b. Basic devices: power supply, electromagnetic relay, reed switch.
2. Knowledge of the basics of computer networks (IP address, switch, patch-cord).
3. Knowledge of the computer logic basics (logical "0" and "1", logical connectives).

5. Recommended number of participants

2–3 persons.

6. Supervisors

Roman Pivin, senior engineer of the R&D Department of the Nuclotron Injection and Ring.
Vyacheslav Kosachev, engineer of the R&D Department of the Nuclotron Injection and Ring.
Dmitriy Zlydenny, engineer of the Scientific-Engineering Group of the JINR University Centre.
Mikhail Nozdrin, acting leader of the Scientific-Engineering Group of the JINR University Centre.

7. Recommended literature

[1] Nagamitsu Yoshimura. Vacuum Technology: Practice for Scientific Instruments. Springer, 2008.
[2] Siemens LOGO! PLC manual.
[3] Edwards TIC Instrument Controller 6-Gauge Instruction Manual.
[4] Edwards nXDS Scroll Pump Instruction Manual.
[5] Edwards Turbo Controller Instruction Manual.