COMPUTATIONAL PROBLEMS OF ELECTRICAL ENGINEERING

Vol. 8, No.2, 2018

ABOUT PRACTICAL PREPARATION OF MARINE ENGINEERS ON THE ELECTROMECHANICAL SYSTEMS LABORATORY

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Abstract. This article discusses the methods and possibilities of using modern laboratory equipment based on PLC-control technology and Variable Frequency Drives in the educational process of the National University "Odessa Maritime Academy" to improve the preparation quality of ship electro-technical officers and mechanical engineers.

Modern tendencies in automation of ship power propulsions, power generation and distribution, ship electromechanical systems and complexes require a high level of cadet training to ensure the successful solution of complex tasks of operation and maintenance of control and automation systems. The paper focuses on the possibilities of laboratory equipment usage, based on Mitsubishi Electric modern programmable logic controllers FX3U, iQ-R and Alpha 2, frequency inverters FR-E700, FR-F800 and graphic operation terminals (Human-Machine Interfaces) GOT 1000 in education process and scientific researches.

Key words: programmable logic controller, inverter, networks, process control, electromechanical systems, training.

1. Purpose, tasks and equipment of the electro-mechanical systems laboratory

Electrical equipment and automation facilities of a modern vessel are characterized by high energy saturation, usage variable frequency drives of ship mechanisms and systems, and a high level of automation based on modern computer control technologies. Modern tendencies in automation of ship power and electromechanical systems require an according high level of specialists training to ensure the successful solution of operation and maintenance of control and automation systems [1]. In educational process for order to improve the preparation quality of marine electro-technical officers (ETO) and marine engineers (ME) and to meet the growing demands of employers are usage the laboratory complex of automated electromechanical systems based on programmable logic controllers and variable frequency drives with typical loads, and was created the certificated authorized teaching center Mitsubishi Electric [2–5]. In These papers provide a more detailed description of the laboratory stands equipment.

The urgency of conducting practical training in the field of modern control systems using laboratory equipment is also determined by the fact that in ship conditions, for objective reasons related to the operational mode of the vessel and ensuring its survivability and safety, most practical tasks and operational situations for managing ship systems and complexes cannot be implemented on the vessel in sufficient volume for the future specialist.

The electromechanical system laboratory is the part of the innovative simulator complex [6], equipped with the most advanced means of shipboard and industrial automation such as programmable logic controllers (PLC), variable frequency drives (VFD), operator panels (human machine interface, HMI) and network communications equipment.

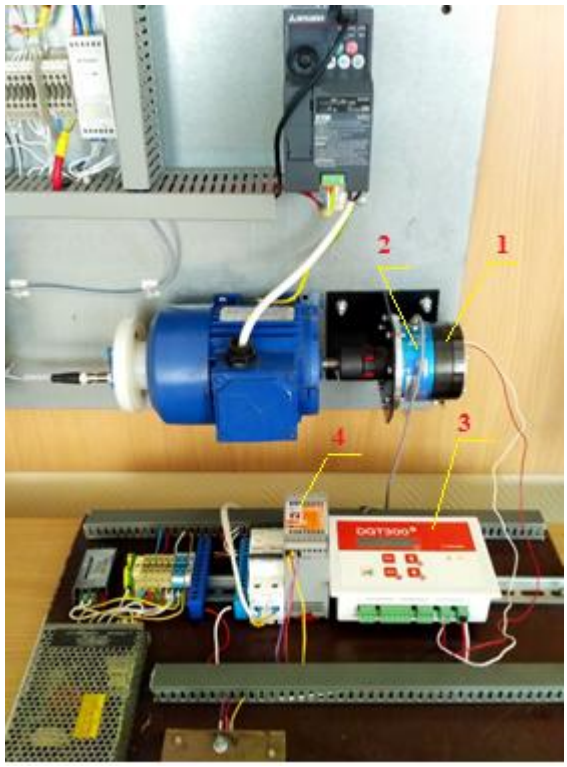

Fig. 1. PLC-adjustable load for asynchronous motor.

Now we have supplemented each laboratory stands by PLC-adjustable load for asynchronous motors, which to modelling on the motor shaft the load of different ship's mechanisms (Fig. 1). To this end, we have used the following torque control equipment produced by MEROBEL:

1. EMP (Electro-Magnetic Particle) Through Bore Brake, model FAT 50;
2. Torque sensor TRS 05;
3. WEB Tension Controller DGT 300+;
4. Power Supply, model PowerBlock2.

Such modernization allows to study the closed-loop control systems of electric drives (see Fig. 3).

PLC-VFD-based educational laboratory stands can be divided into two, to a certain extent, autonomous parts with the conventional names "Automation and Drive" and "Networks, HMI, SCADA" in terms of composition, functionality, educational and laboratory tasks (Fig. 2).

To build a hierarchical structure, both parts of the stand communicate with each other via an Ethernet network. In addition, there is direct communication between the FX3U and the frequency converter via the CC-Link network.

Main idea and tendency during design and realizing of this project was: only actual ship equipment and control systems with maximal approach to nowadays configuration should be used for practical education of marine engineers and electro-technical officers (ETO).

Electromechanical systems laboratory – actually functioning, and as close as possible to the modern configuration of shipboards control equipment and means of automation meets the requirements of standards that define the use of simulators (Section A-I/12, Part 1 – performance requirements), STCW 78 with Manila Amendments [7].

Therefore, the development and creation of specialized, really functioning (not virtual) and as close as possible to the ship configuration of training laboratories based on real equipment and modern controller management technologies will allow to solve very important problems of training future ship engineers.

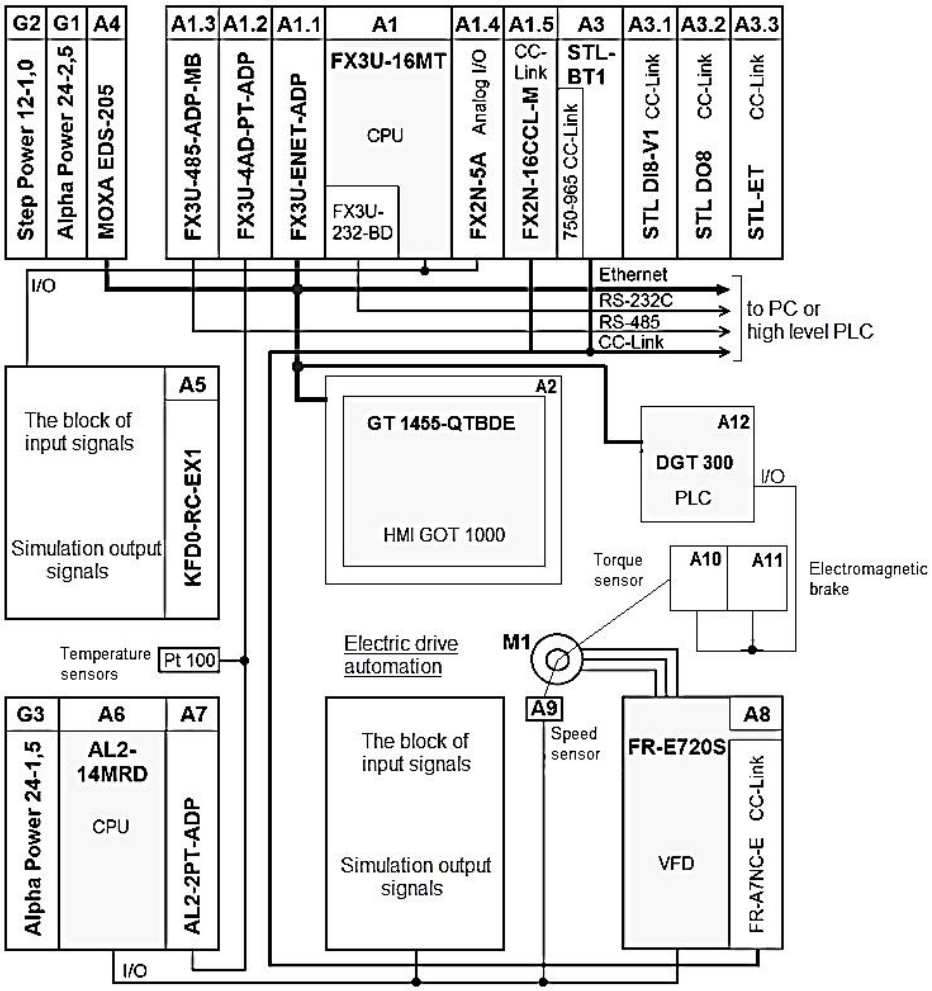

Fig. 2. Functional diagram of laboratory stand.

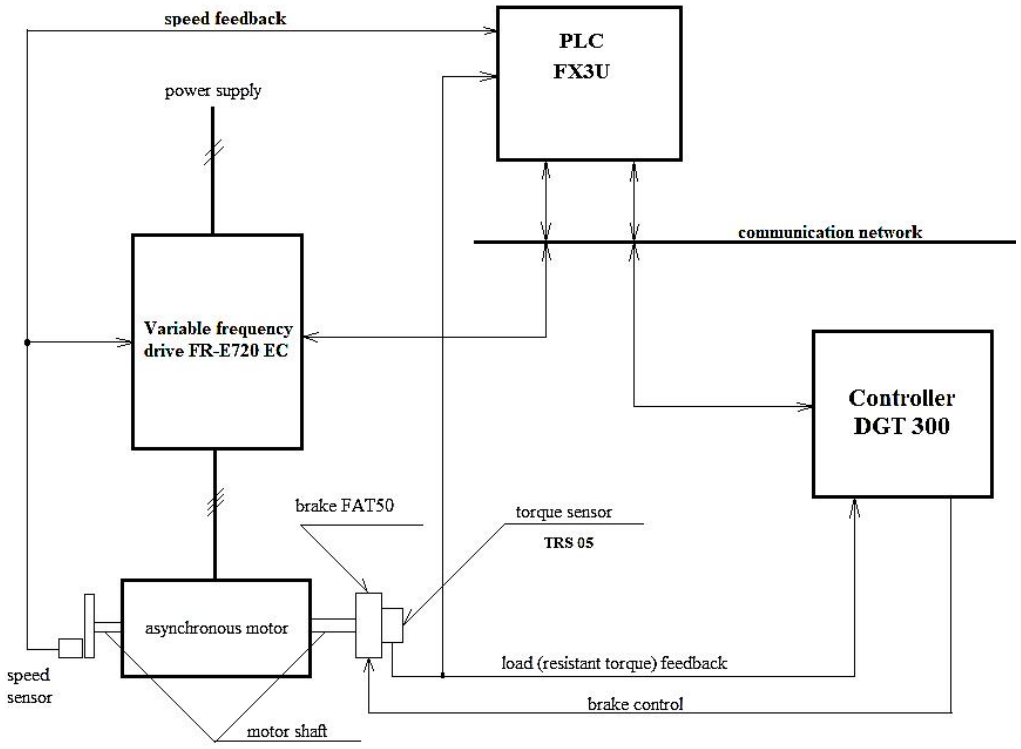

Fig. 3. Closed-loop control systems of electric drive with motor shaft load simulator (resistant torque).

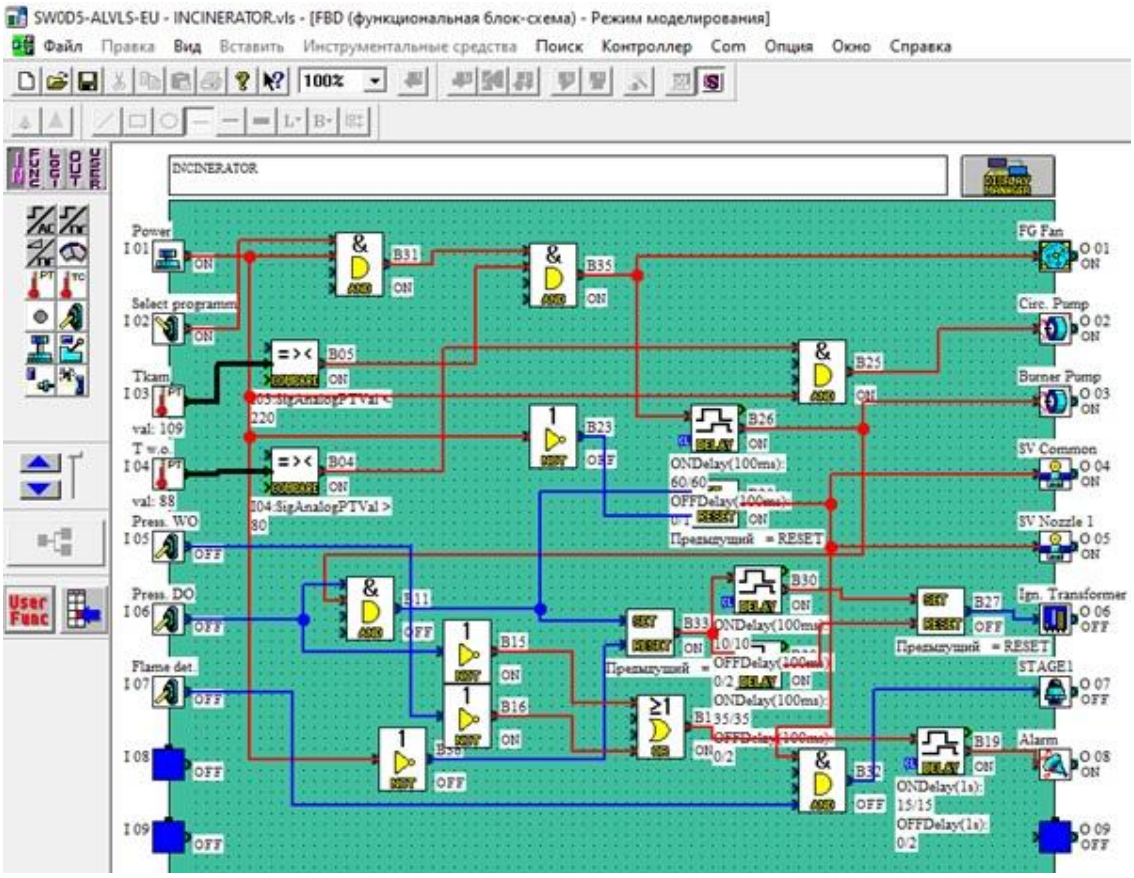

Fig. 4. The fragment of the test task performance by the trainee: Operation mode of ship incinerator.

The composition of training and laboratory stands determines the basic directions of laboratory and practical exercises, which can be carried out using the equipment listed:

– Typical technological tasks automation;

– Variable frequency drive control;

– Industrial data exchange networks organization and operation;

– Interaction of the control system and the operator through the human-machine interface (HMI);

– Monitoring, Control and Data Acquisition (SCADA) learning.

2. Software for educational laboratory stands

Separate attention deserves modern software, which are equipped with laboratory stands. This is a powerful software package Mitsubishi MELSOFT iQ Works, which forms a single environment for the development of automation solutions, covering controllers, motion control and graphic control panels (HMI).

MELSOFT Navigator is a central part of iQ Works. It allows you to easily design complete top-level systems and seamlessly integrate into them other MELSOFT programs included in iQ Works. The package has features such as system configuration design, batch parameter setting, system tags, and batch reading. Several projects, including programmable controllers of different levels, positioning controllers and operator panels, can be centrally controlled from the MELSOFT Navigator workspace, which allows grouping projects into managed modules: ship – technological process – mechanism; diesel engines – generators – MSB – consumers, etc. Functions such as editing a program, setting parameters, and batch reading are performed intuitively and easily via a graphical interface. In addition, the possibility of making errors in the settings of both equipment and programs is minimized, since the entire system is viewed in real time. MELSOFT GX Works2 is a programming and maintenance environment for the PLC itself, developed based on well-proven programming and documentation packages for GX Developer and GX IEC Developer, the latter of which is one of the components of GX Works2.

The modern environment GX IEC DEVELOPER is developed in accordance with the international standard IEC 61131-3 for PLC programming languages. The most significant features of the GX IEC DEVELOPER environment are:

– descending architecture;

– structured programming;

– an overview of the project of the programmable controller and resources;

– the possibility of developing large and complex projects;

– a unified programming environment for modular and compact controllers;

– high-level technology in accordance with the standard IEC 61131-3;

– simultaneous support of various programming languages, allowing parallel development of various software modules using ladder-step diagrams (LD), functional block diagrams (FBD), structured text (ST), instruction list (IL) and sequential function chart (SFC);

– powerful autonomous modeling;

– function libraries using;

– on-line debugging programs.

MELSOFT GT Works3 is a comprehensive software for programming and maintaining operator panels, as well as creating screens.

Development and debugging of application programs for Mitsubishi PLC Alpha2 series is carried out in the software package AL-PCS / WIN-EU. This package is simply indispensable at the initial stage of acquaintance with the PLC. The package allows you to quickly master the techniques of application programming in the language of functional block diagrams (FBD).

To configure and debug a frequency drive, the FR Configurator package is providing to change drive settings, controlling the drive on various modes directly through a computer, track changes in the drive's main parameters, and get the time characteristics of the studied values in real time. The characteristic advantages of the software package are as follows:

– FR Configurator allows you to control the operation of up to 32 converters simultaneously due to the network capabilities of the frequency converter;

– the configuration of various parameters is facilitated using the functions of full and group view;

– convenient and clear display functions that provide output of digital and analog data, fault messages and waveforms;

– advanced diagnostic system allows you to develop and consolidate the skills of quick and effective troubleshooting;

– test mode allows you to simulate the operation of the frequency converter;

– Auto-tuning feature allows you to most accurately control the various motors;

– settings can be saved in a special file, printed out and moved as settings to other drives.

3. Educational and scientific tasks solved based on laboratory stands

The presence of sufficiently extensive hardware with powerful software in laboratory stands clearly makes it possible to focus the goals of educational disciplines on studying hardware, configuring the system, working

together blocks, sensors, actuators, and PLC programming techniques. Training on the equipment of Mitsubishi Electric contributes to the formation of skills in the most modern software shells, allows you to get the final product in the form of application control programs tested and debugged for a specific hardware configuration, executed in full accordance with international standard IEC 61131-3.

The training tasks implemented on the stands can be divided into the following areas:

– mastering software, mastering hardware;

– simple programming tasks based on the Alpha series PLC – advanced programming with the use of modular PLCs of the FX3U series;

– configuration of the frequency converter – control of the frequency converter via the CC-Link network;

– familiarity with hierarchical control structures – use of operator panels and so on.

The laboratory's available software, in general, can be allocated to a separate field of educational and practical tasks that complement the disciplines already existing in the curriculum, such as "Programmable logic controllers", "Ship electric drive", "Power electronics and converting equipment", "Modeling of electromechanical systems", "Intellectual control systems". In addition, the equipment and software of laboratory stands allows you to expand the applied technical problems solved in the diploma process of graduate design.

The presence of a laboratory of this level allows not only training of cadets in accordance with the curricula of the specialties, but also enables the full revival of the research work of cadets. Along with this, modern laboratory equipment is undoubtedly becoming a catalyst for the process of qualifying the growth of the teaching staff of the specialty departments.

At present, the curriculum teachers have developed training programs in several areas of training, a summary of which is given in the table below. An obligatory result of all courses is the fulfilment of an independent task by the trainee, according to which the degree of mastering the material and its competence are assessed.

The fragment of the test task performance by the trainee is shown in Fig. 4.

An example of the educational Courses based on the equipment of electromechanical system laboratory is given in the table below.

Currently, the laboratory has created new stands that use the new-generation FR-F800 frequency converters, which are used to conduct research in the following areas:

– energy efficient marine electromechanical systems;

– vector control of electromechanical systems with asynchronous electric motors;

– power quality of shipboard autonomous power systems with variable-frequency electric drives.

Course description	Course duration
Programmable Logic Controller (Basic, and advanced). The basic course is designed to give an overall understanding of the functions and capabilities of the PLC and important safety aspects of its operation. Course contents: – Programmable logic controllers. An overview; – PLC hardware components: general data of CPU and I/O modules; – Input and Output of PLC and principle of its connection and operation; – Fundamentals of logic. Understanding the configuration of PLCs; – Basic ladder program instructions and simulator exercises; – Function Block Diagram (FBD): FBD components, component location and connections, component settings, simulation mode, reading program from controller, writing program to controller, monitoring mode; – Application of PLC on shipboard (advanced); – Programming PLC, uploading and downloading data (advanced); – Care and maintenance on PLC.	16 hours 24 hours
Control communication and information network. This course is designed to cover basic control communication and information network on shipboard. Teaching objectives: – To learn the operating of computers and computer networks on ships; -To learn the basic communications protocols used on ships, such as Modbus, Fieldbus, CANopen, Ethernet, and with remote control and data transfer; -Training on live simulator complex equipment.	16 hours
Course "Mitsubishi Electric Frequency Converters: setting, starting and diagnostics" (Expert level). Purpose, specialization: selection, tuning, operation, installation and commissioning, diagnostics/ *Course program (3-d level):* A brief summary of the frequency control theory of an asynchronous motor. Familiarity with Mitsubishi Electric frequency inverters. Comparative characteristics of the main series frequency converters. Distinctive features and benefits of the FR-A800 series. Electromagnetic compatibility issues during the operation of the inverter. Overview of the basic parameters, internal and external options of the frequency converter. Power and control terminals – connection information. Schemes and recommendations. Work with remote and built-in control panels. Copy, transfer, compare functions parameters. External and network modes. Work in an external mode of management by means of discrete and analog signals, parameterization and calibration of analog inputs. Brake devices. Selection of a resistor for generator braking mode. Vector control with speed and torque control. Overview of network capabilities for integrating frequency converters into field networks: Modbus RTU, CC link, LonWorks. Features of data transmission settings. Selection of frequency converters using directories for design tasks. Using the My MITSUBISHI platform to find the necessary documentation.	40 hours

4. Conclusions

A short list of the main tasks solved with the help of laboratory equipment:

1. Getting the skills to work with modern programmable logic controllers (PLCs) based on the controllers of the company Mitsubishi Electric series Alpha2, Q, FX3U, on examples of managing various marine electromechanical systems. Familiar with the program for configuring microcontrollers. Setup and monitoring of the microcontroller using the service software. Composition and download of configuration files to microcontroller. Connection to microcontrollers and the use of additional devices (operator panels, remote display, PC). Development of software for various types of PLCs aimed at solving specific problems of control of ship machinery and systems.

2. Acquisition of skills of technical use and maintenance of modern information and control systems. Setting up communication protocols for data exchange between controllers, individual local control objects, remote control and monitoring system using real equipment and automation tools.

3. The use of modern energy-saving technologies used on ships, on the examples of frequency-controlled electric drives of various ship mechanisms and systems.

Training programs based on the laboratory equipment fully provide the minimum qualifications, knowledge, understanding and skills for ship electro-technical officers and marine engineers in the field of modern control and communication technologies, as well as adjustable electromechanical systems with asynchronous motors.

Therefore, the development and creation of specialized educational laboratory, really functioning (not virtual) and maximally close to the ship equipment and systems and based on real equipment and modern control technologies, will solve very important tasks of preparation for future ship engineers.

Today, shipboard electro-technical officers and marine engineers must have a wide range of professional knowledge and skills: from working with hand tools and measuring instruments to using modern computer controlling, monitoring and communication technologies, providing both watch-keeping and non-watch maintenance of ship complexes and systems.

In finally, it should be noted that modern higher education should be aimed at teaching students in accordance with the constantly updated technical base and with the growing needs of employers. In order to meet these objectives, it is necessary to introduce new technologies in the process of education and training of specialists, which not only helps to increase the level of training, but also to orient the educational process to the real problems of maintenance, parameterization of modern shipboard electromechanical systems with PLC control.

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ПРО ПРАКТИЧНУ ПІДГОТОВКУ МОРСЬКИХ ІНЖЕНЕРІВ У ЛАБОРАТОРІЇ ЕЛЕКТРОМЕХАНІЧНИХ СИСТЕМ

Микола Муха, Алла Дранкова

У статті розглянуто методи і можливості використання сучасного лабораторного обладнання на основі технологій ПЛК-управління і частотно-регульованих приводів в навчальному процесі Національного університету

“Одеська морська академія” для підвищення якості підготовки суднових електромеханіків і інженерів-механіків.

Сучасні тенденції в автоматизації суднових силових установок, виробництва і розподілу електроенергії, суднових електромеханічних систем і комплексів вимагають високого рівня підготовки майбутніх суднових спеціалістів для забезпечення успішного вирішення складних завдань із експлуатації та обслуговуванню систем управління і автоматизації. У статті розглянуто можливості використання лабораторного обладнання на базі сучасних програмованих логічних контролерів Mitsubishi Electric FX3U, iQ-R і Alpha2, перетворювачів частоти FR-E700, FR-F800 і графічних робочих терміналів (людино-машинні інтерфейси) серії GOT 1000 в навчальному процесі та наукових дослідженнях.

Короткий перелік основних завдань, що вирішуються за допомогою обладнання лабораторії:

1. Отримання навичок роботи з сучасними програмованими логічними контролерами (ПЛК) на базі контролерів фірми Mitsubishi Electric серій Alpha2, Q, FX3U, на прикладах управління різними судновими електромеханічними системами. Розробка програмного забезпечення для ПЛК різних типів, спрямованих на вирішення конкретних завдань управління судновими механізмами і системами.

2. Набуття навичок технічного використання і обслуговування сучасних інформаційних і керуючих систем. Налаштування комунікаційних протоколів обміну даними між контролерами, окремими локальними об’єктами управління, використовуючи реальне обладнання і засоби автоматизації.

3. Використання сучасних енергозбережних технологій, застосовуваних на суднах, на прикладах частотно-керованих електроприводів різних суднових механізмів і систем.

Розробка і створення спеціалізованої навчальної лабораторії, реально функціонуючої (не віртуальної) і максимально наближеної до обладнання та систем судна і заснованої на реальному обладнанні і сучасних технологіях управління, вирішує дуже важливі завдання підготовки майбутніх суднових інженерів.

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