UDC 004.4:378.14:621.3

MODERN MATERIAL AND TECHNICAL BASE OF THE DEPARTMENTS IS THE GUARANTEE OF THE QUALITY TRAINING O1F THE COMPETITIVE ELECTROMECANICS SPECIALISTS

S. Bondarevskyi, O. Danileyko
State Higher Educational Institution, «Kryvyi Rih National University»
vul. XXII Partz'izdu, 11, Kryvyi Rih, 50027, Ukraine. E-mail: kafEM@mail.ru, kafEM@knu.edu.ua

Problem statement. The whole modern industrial automation is built on the universal devices – programmable logic controllers due to their ample opportunities on the collection, transformation, accumulation and storage of information. Obviously, that by the training of specialists in the field of electromechanics educational institutions faces the problem to acquaint students with the architecture, features, applications, and programming of the controllers. **Work goal.** Today the market of programmable controllers is oversaturated with products of different firms, similar on the functional capabilities, but differ significantly on the quality of their production. In the current situation it makes sense to acquaint students with the controllers of grandees of the world electro-technical industry – ABB Company. At the Department of electromechanics SHEI «Kryvyi Rih National University» in the laboratory «Energy efficient equipment and technology in electromechanics» PLCs AC500-eCo PM564 ETH-T is used. **Work and research results.** In order to study controllers of the AC500-eCo family laboratory stands for laboratory and practical classes are designed, the main task of which to acquaint students with the characteristics, features and programming of controllers of the ABB Company. In this work the structure of the controller AC500-eCo PM564 ETH-T is considered and its basic parameters are given. Particular attention is paid to the important practical issue – the connection of the external devices with the subsequent programming of the controller to create the effect of «running light». For the programming unified programming software of ABB Company is used – software configurator PS501 Control Builder Plus with tool software package for industrial automation CoDeSys, which allow to program on one of five languages according to the IEC 61131-3 standard. **Conclusions.** This example demonstrates the advantages of the controller of the AC500-eCo family and opportunities of its programming in two languages. The stands are used during the laboratory and practical classes.

Key words: PLC, CoDeSys, programming languages, ABB Company, laboratory stand.

СУЧАСНА МАТЕРІАЛЬНО-ТЕХНІЧНА БАЗА КАФЕДР – ЗАПОРУКА ЯКІСНОЇ ПІДГОТОВКИ КОНКУРЕНТНОСПРОМОЖНИХ ФАХІВЦІВ З ЕЛЕКТРОМЕХАНІКИ

С. Л. Бондаревський, О. К. Данилейко
ДВНЗ «Криворізький національний університет»
вул. XXII Партз'їзду, 11, м. Кривий Ріг, 50027, Україна. E-mail: kafEM@mail.ru, kafEM@knu.edu.ua

Для підвищення практичної підготовки студентів на кафедрі електромеханіки ДВНЗ «Криворізький національний університет» впроваджено в роботу лабораторію «Енергоефективні пристрої та технології в електромеханіці». Елементною базою одного з стендів лабораторії є програмований логічний контролер компанії ABB – AC500-eCoPM564 ETH-T. Представлені структура та основні характеристики контролера PM564 ETH-T і можливості його програмування. Наведені властивості п'яти мов програмування, які реалізовані згідно стандарту МЕК-61131-3. Для підвищення рівня знань студентів з використання і програмування ПЛК розроблені та впроваджені в навчальний процес лабораторно-практичні заняття. Розглянуто приклад завдання по створенню циклічного ефекту «бігучий вогник» та його реалізація на графічній мові LD та текстовій ST з використанням єдиного програмного забезпечення компанії ABB – програми-конфігуратора PS501 Control Builder Plus з інструментальним програмним комплексом промислової автоматизації CoDeSys.

Ключові слова: ПЛК, CoDeSys, мови програмування, ABB, лабораторний стенд.

PROBLEM STATEMENT. Ten or fifteen years ago almost all industrial automation was built on the relay-contactor control circuits. Enterprises have relied mainly on devices (relays, timers, triggers, counters, etc.) of the domestic industry. The operation of such equipment required additional power consumption due to power supply installation of the rather high capacity and cost. In addition, the systems based on this principle had a hard logic that was set in the design and did not provide for further changes. In case of the operation algorithm change you should completely remodel mounting scheme that led to the significant capital and material costs.

The rapid development of microprocessor technology contributed to the creation of the fundamentally new control systems of the technological process based on universal devices – the programmable logic controllers (PLC). The popularity and demand for modern PLC due to their ample opportunities – collection, transformation, processing, storage and control of information and with its further transfer to the executive mechanism of the control object. The principal differences of the PLC from the relay circuits: firstly, all the control algorithms implemented in software that greatly improves the reliability; second, the possibility of combining the PLC to the network systems and finally, a slight energy and resource consumption. It is clear, that the operation and management of systems of this type requires appropriate knowledge, skills and abilities.

In view of the above, the departments of the appropriate direction faces task – to give the future graduates not only theoretical knowledge about the operation of the equipment but also to teach them how to manage this equipment, paying considerable attention in the educational process to practical training based on the actual equipment. The use in educational process of the ultramodern equipment of the grants of the global electrical industry – Lenze, Siemens, Schneider-Electric,

ABB and others provides an opportunity to get acquainted with modern trends in the field of the technological processes control as well as energy and resource saving.

In 2015 the Department of Electromechanics of «Kryvyi Rih National University» introduced the laboratory «Energy efficient devices and technologies in Electromechanics». The main directions of the laboratory work are: mastering of the educational stands, which are equipped with semiconductor AC electric drives of the company ABB ACS355 and ACS880 series with the possibility of its remote control via RS485 interface by Modbus protocol and mastering of the universal and modern stands for the operation modes research and power characteristics of the turbomechanisms (fan and pump) – the machines of the mass use, which account for 25 % of all consumption of the electric power produced in the country. One of the lab stands construction detailed described in [1].

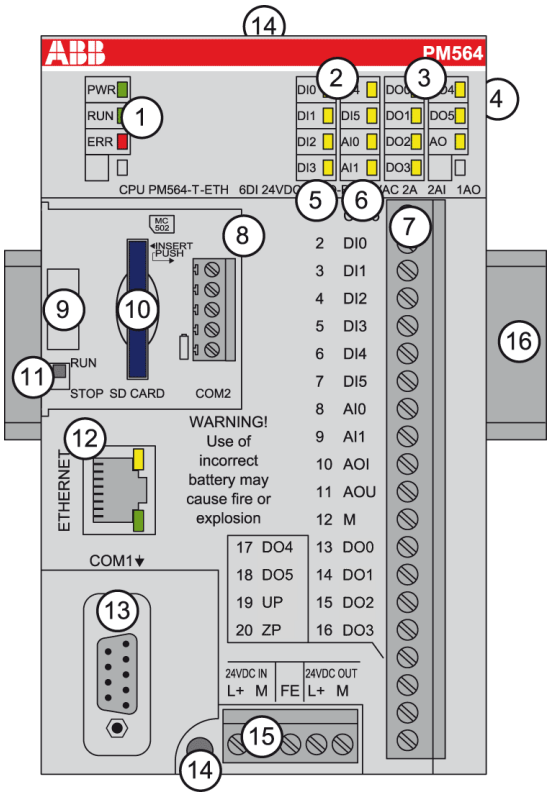
The main element base of the aforementioned stand is a modern PLC AC500-eCo PM564-T-ETH, which has simple architecture and low cost, produced by ABB Company. The use of this PLC provided for the curriculum for students-electromechanics in the specialty «Electromechanical equipment of the energy-intensive industries» by studying of the educational discipline «Energy efficient electromechanical systems and technologies» and «Microprocessor tools in electromechanics».

The purpose of the work is to increase the efficiency and quality of the educational process by acquainting of the students with the structure of the modern PLC and to form the programming skills using configurator software PS501 Control Builder Plus with tool software package for the industrial automation CoDeSys.

EXPERIMENTAL PART AND RESULTS OBTAINED. The structure and operation of the PLC AC500-eCo PM564-T-ETH. The family of the controllers AC500-eCo is flexible and scalable PLC with broad communications capabilities, which include a number of benefits [2]:

– convenience of programming using the proven programming controller environment based on CoDeSys;
– 128 KB user memory, which makes the problem of programs optimization irrelevant;
– interface Ethernet built-in a standard complete set (ETH letters in the PLC type) that allows the network systems constructing;
– serial port with the ability to use it for the programming well as for the communication;
– ability to use *SD*-card.

Appearance and main characteristics [3, 4] of the PLC PM564-T-ETH are shown in Fig. 1 and Table. 1.



1	3 LEDs to display the status of the CPU
2	6 yellow LEDs to display the status of the digital input signals 2 yellow LEDs to display the status of the analog input signals
3	6 yellow LEDs to display the status of the digital output signals 1 yellow LED to display the status of the analog output signal
4	I/O-Bus for connecting additional I/O modules
5	Terminal number
6	Allocation between terminal number and signal name
7	Terminals for the input and output signals (20-pin, not removable)
8	5-pin removable connector for COM2 (optional)
9	Handle bar for opening the cover for the expansion modules
10	SD Memory Card slot (optional)
11	RUN/STOP switch
12	Ethernet interface (depending on model)
13	9-pin SUB-D- jack (COM1) for RS-485 connection
14	2 holes for wall-mounting with screws
15	5-pin removable connector for power supply
16	*DIN*-rail

Figure 1 – The appearance of the PLC with the designation of embedded devices

The basic principle of the PLC operation is the cyclical nature of the work, in which the controller performs alternately certain commands in the order, in which they are written in the program. Usually, at the beginning of each cycle, the program reads the "picture" of the controller inputs state and stores them in the input state table.

After all commands performance and determination for the given situation the actual outputs state the controller writes outputs states to memory, which is a table of the process outputs states and forms the corresponding signals to the outputs, which control the executive mechanisms.

Thus, all signal combinations are send in the input module of the controller, and the program monitors their picture and reacts with the outputs states change based on the embedded algorithm. Therefore, the cycle of the PLC operation can be represented as a sequence of actions: autodiagnostics → input reading → program performance → communication tasks → outputs states setting.

Table 1 – Main technical data of the PLC

The supply voltage	DC - 24 V or AC 100-240 V
Built-in memory and its type	128 KB, flash
Number of I/O – digital – analog	 6/6 2/1
The cycle time for 1000 operations, ms – binary – word – with floating point	 min 0,09 min 0.3 min 6
The digital output type	transistor (T letter in the PLC type)

Programming languages and software of the PLC. According to the approved standard of the International Electrotechnical Commission IEC 61131-3 five programming languages PLC (three graphical and two text) established, the description of which is gathered in Table 2 [5, 6].

Table 2 – The PLC programming languages

English		Description
abbr.	marking	
IL	Instruction List	Hardware-independent low-level assemble-based.
LD	Ladder Diagram	It is a software implementation of the electrical circuits based on the electromagnetic relays.
FBD	Function Block Diagram	Functional block describes (FBD) a subroutine. Each FBD has inputs and outputs. The connecting of the FBD plurality creates the program.
SFC	Sequential Function Chart	High-level language based on the mathematical apparatus of Petri nets describes the states sequence and the transi-tions conditions.
ST	Structured Text	Pascal-based programming language

SFC, FBD, LD are the graphic languages and IL, ST are the text languages. Below will be given an example of the programs implementation in LD and ST languages.

The openness of the IEC standards promoted creation of the firms that are engaged exclusively in PLC programming tools.

The most popular in the world is the industrial automation complex CoDeSys (Controller Development System) [7]. This versatile controller programming tool, which supports the programming languages of IEC, is not connected to any hardware platform and meets all modern requirements. One of the advantages of CoDeSys is the ability to use it free and to download full-featured distribution from the developer's site, which includes an interface and interactive documentation [8].

For the configuration and programming of AC500-eCo the same software PS501 Control Builder Plus is used. Package PS501 Control Builder Plus is a software controller based on CoDeSys software package and meets the requirements of IEC 61131-3 (supports standard programming languages FBD, LD, IL, ST, SFC), providing a unified, simple and convenient solution. Software PS501 Control Builder Plus offers ample opportunities for the user programs establishing, equipment diagnostic, and also allows to create visualization screens.

To acquire practical skills in the PLC programming consider the example of the programs implementation for the ABB AC500 eC0 PM564 ETH-T.

The task. Create a program of the cyclic effect implementation of «running lights» using six external LEDs, which are connected to the digital outputs of the PLC. Implement start/stop of «running lights» by sending the signal to input DI1 and ability to change the direction of «running lights» (without first stopping it) by sending the signal to input DI2 PLC.

Solution. The implementation of the task is performed in two stages: the first is the connection of LEDs and switches according to the scheme shown in Fig. 2, the second is directly programming.

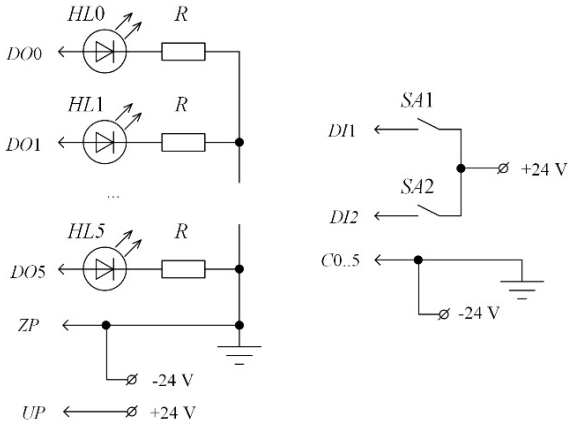


Figure 2 – Principle scheme

The first stage is not difficult, because a standard element base is used: LEDs *HL*0-*HL*5 to current 5 mA, resistors *R*=1 kOm, switsh of any type. On the Fig. 2 signal names are listed according to their functional purpose (see Fig. 1), switch *SA*1 is start/stop, *SA*2 is the direction change of «running lights».

Implementation of the second phase we begin with the launch of the configurator Control Builder Plus (consider that the Control Builder Plus and CoDeSys are already installed on the PC). Following the standard procedure of selecting a new project and the type of controller «PM564 ETH» we perform a typical settings of the Ethernet interface (for connection of the programming system and the PLC) and give a symbolic names for digital inputs and outputs of the controller (di1, di2, do0 ... do5). The PLC configuration page indicating the connection of the symbolic and physical global variables is shown in Fig. 3. We note that in the project interfaces COM1 and SOM2 are not used, so their configuration is not considered.

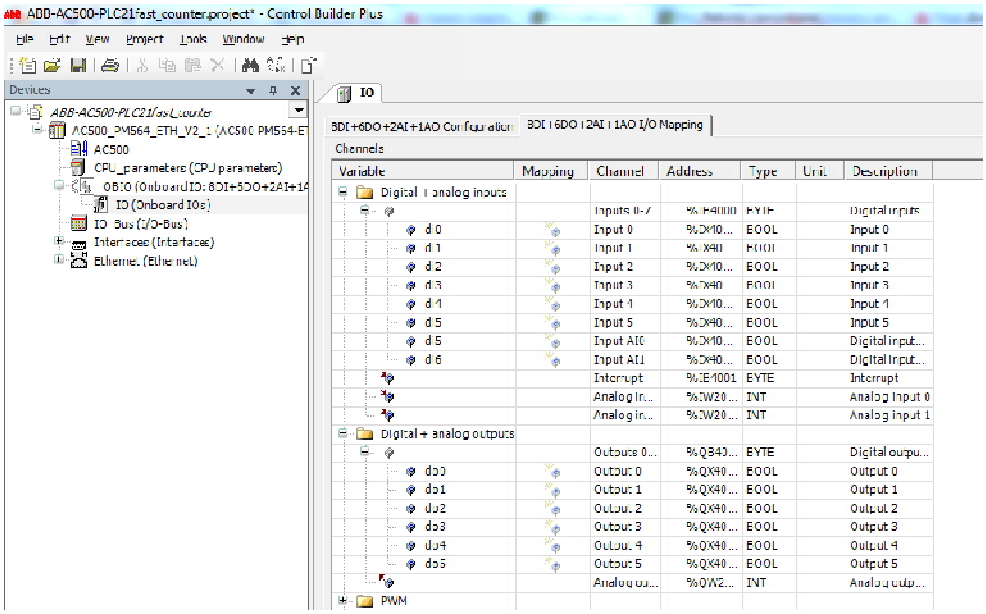
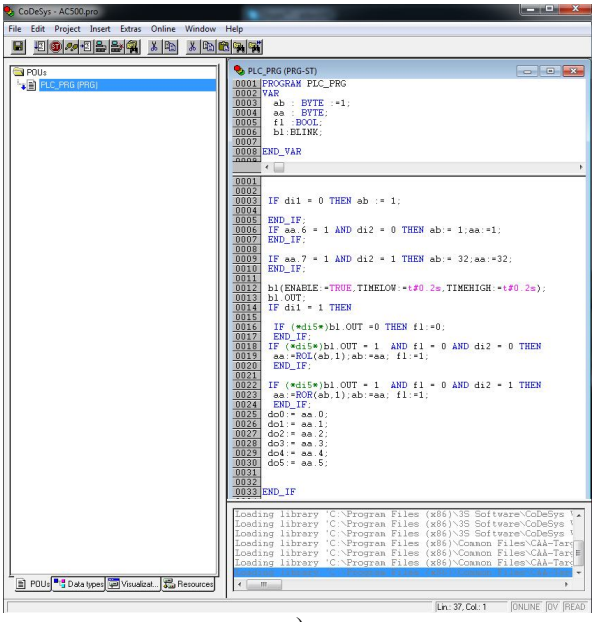


Figure 3 – Screenshot of the PLC configuration

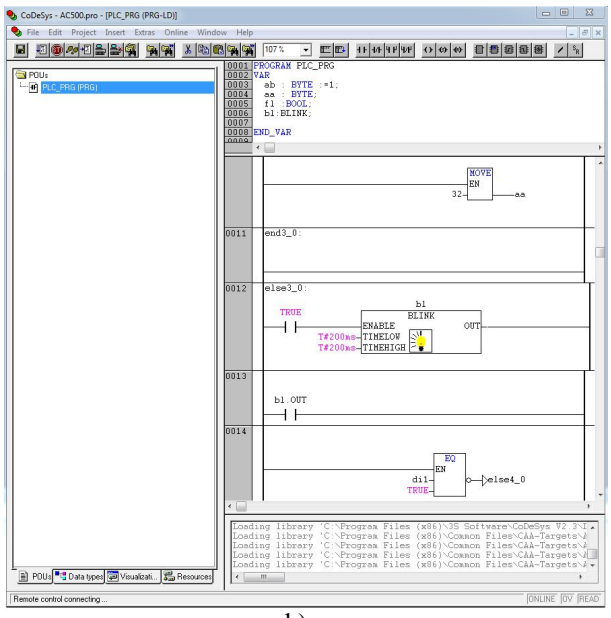
Next step is directly programming in the CoDeSys environment. To go to CoDeSys, you should left double-click on the item «AC500» (see. Fig. 3) in the created project. The program offers you to create the configuration of CoDeSys-project; confirm it by clicking «Yes». After the configuration creating program will start programming environment CoDeSys.

The main project window and the text of the program in the ST language are shown in Fig. 4, a. The obligatory condition of the normal PLC operation is tasks configurator setup for the task management. For this purpose in the tab «Resources» (see at the bottom of the screenshot in Fig. 4) choose «Task Configuration» and set the challenge type of the software module «freewheeling», and in the tab «POUs» – for the item «PLC_PRG» – standard «main» task of the type «PLC_PRG».

Assigned tasks can be written in the LD language as well (see the part of the program. Fig. 4, b.) following the same procedure as it was described above.



a)



b)

Figure 4 – Screenshot of the CoDeSys window with the program:
a – in the ST language, b – in the LD language

The final step is a compilation of the program and downloading it to the PLC. To do this, in the menu «Project» select the item «Rebuild All» and check it for errors absence (Fig. 5) in the message window, which is located at the bottom of the screenshot shown in Fig. 4.

After that the project is ready to be downloaded in the PLC: choose from the menu «Online» the item «Login» (Fig. 4); the system warns about the absence of the program in the PLC and asks to confirm its downloading. After download is finished the program can run the project performing (the item «Run» in the menu «Online»). The program runs in endless loop mode.

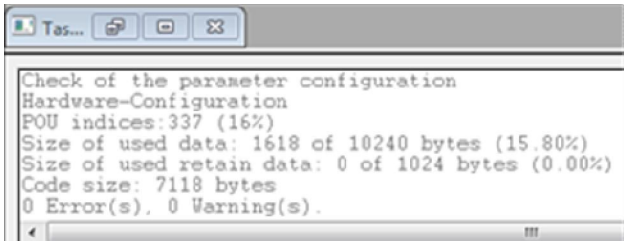


Figure 5 – The Message Window

We note that «running lights» could be implemented, using only work of the LEDs on the PLC to display the status of the digital output signals (see position 3, Fig. 1), but it significantly limits the practical training of students when performing laboratory works (choosing the element base, skills of the working with a soldering iron, etc.).

Considered task illustrates the extensive functional abilities of the PLCs of the AC500-eCo family and is not a primary by studying the basics of the PLC programming. This example is the basis for the next laboratory and practical work – management of traffic lights at the crossroad of two traffic directions. By the presence of the expansion blocks of the digital output signals the programming of the operation of the complex traffic lights at a crossroads is possible. These examples do not exhaust the possibilities of practical use of the considered PLC.

CONCLUSIONS. 1. The use in educational process of the laboratory stands, that on the modern equipment of one of the world leaders in electro-technical products and technologies in the field of energetics and automation are built, can significantly increase the theoretical knowledge and practical skills of the students – the future specialists of Electromechanics.

2. The above example of the programming is widely used in the educational process by the laboratory and practical classes and promotes the acquisition of the working skills of the students with any logic controllers, which support the work with tool software complex of the industrial automation CoDeSys.

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СОВРЕМЕННАЯ МАТЕРИАЛЬНО-ТЕХНИЧЕСКАЯ БАЗА КАФЕДР – ЗАЛОГ КАЧЕСТВЕННОЙ ПОДГОТОВКИ КОНКУРЕНТОСПОСОБНЫХ СПЕЦИАЛИСТОВ ПО ЭЛЕКТРОМЕХАНИКЕ

С. Л. Бондаревский, О. К. Данилейко

ГВУЗ «Криворожский национальный университет»

ул. XXII Партсъезда, 11, г. Кривой Рог, 50027, Україна. E-mail: kafEM@mail.ru, kafEM@knu.edu.ua

Для повышения практической подготовки студентов на кафедре электромеханики ГВУЗ «Криворожский национальный университет» внедрена в работу лаборатория «Энергоэффективные устройства и технологии в электромеханике». Элементной базой одного из стендов лаборатории является программируемый логический контроллер компании ABB – AC500-eCo PM564 ETH-T. Представлены структура, основные характеристики контроллера PM564 ETH-T и возможности его программирования. Приведенные свойства пяти языков программирования, которые реализованы согласно стандарта МЭК-61131-3. Для повышения уровня знаний студентов по использованию и программирования ПЛК разработаны и внедрены в учебный процесс лабораторно-практические занятия. Рассмотрен пример задания по созданию циклического эффекта «бегущий огонек» и его реализация на графическом языке LD и текстовом ST с использованием единого программного обеспечения компании ABB – программы-конфигуратора PS 501 Control Builder Plus с инструментальным программным комплексом промышленной автоматизации CoDeSys.

Ключевые слова: ПЛК, CoDeSys, языки программирования, ABB, лабораторный стенд.

Стаття надійшла 01.09.2015.