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The use of the Mitsubishi PLC systems in student's preparation for realization of industrial tasks

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Education and research trends

ABSTRACT

Purpose: The aim of this paper is to show the laboratory equipment, the methods of learning and the results of education process in student's preparation for realization of industrial tasks.
Design/methodology/approach: The paper presents the models elaborated by students as results of semestral or BSc Eng. works.
Findings: Contemporary higher education must be directed to educate students according to needs of employers. In order to be up to these needs, a new technology should be presented and used during realization of syllabus. Moreover, the students should solve the real problems from industry.
Practical implications: Working on real industrial problems and developing models introduce a new trend in practical teaching. Student involved in the project gets skills in engineering by completing the tasks from an idea to a working model.
Originality/value: All of the projects presented in the paper have been made by the students according to their original concepts. In the Institute of Engineering Processes Automation and Integrated Manufacturing Systems the emphasis is put on these tasks, which are realized within the confines of diploma thesis, semestral works or researches with employees of the Institute.
Keywords: Manufacturing and mechanical engineering; Automation engineering processes; Robotics and mechatronics

1. Introduction

Automation plays great role in contemporary industries. Through the twentieth century it has been evolved from simple sequential control to the complicated electronics systems. Today it is hard to imagine a factory without robots, numerically controlled machines and programmable logic controllers (PLC). Fast economic growth, searching for new, clearer technologies are the main factors of progress in the industry. Because production becomes more efficient, then controllers become faster and more complicated. Passing over the group of specialized controllers, the most of programmable logic controllers used in industry are modular. In that manner they are more flexible in application.

Contemporary industrial trends require preparation of new engineers that can cope with certain tasks from designing a system, through code development, to set the whole process in motion. The Institute of Engineering Processes Automation and Integrated Manufacturing Systems at the Mechanical Engineering Faculty has five laboratories, where students can evolve their skills. One of these is the Laboratory of Sensors and Industrial Networks. At the laboratory room several types of industrial networks, like AS-I, CAN, Profibus, CC-Link, MelsecNet and Ethernet, are installed. The other meaning system is distributed control based on Profibus network, used in transportation system. Students also have to their disposal several types of programmable logic controllers manufactured by Siemens, GE

Fanuc and Mitsubishi. Other equipment are visualization and control panels, frequency processors, network and PLC expansion modules. The laboratory is intended for individual work of students and scientific staff in following manners:

- realization of semestral work,
- realization of MSc Eng. and BSc Eng. thesis,
- realization of PhD dissertations,
- individual evolve of students' skills within the confines of scientific circles.

A lot of laboratory equipment has been manufactured by Mitsubishi Corporation, thus it is mostly used by students and scientific staff. In this paper some concepts of use of the Mitsubishi PLCs during realization of syllabus is shown. Next, a short description of owned systems is done.

2. Description of the owned PLC systems

2.1. Mitsubishi Alpha controller

The Mitsubishi Alpha controller is a compact type PLC designed for simple control applications, which does not require high speed and many inputs. The controller is equipped with a small LCD screen, on which statements, inputs and outputs status and configuration settings can be displayed. It has also several keys acting as navigation keys through the controller menu and can also be used in program as additional inputs.

Another property of the keys and screen is possibility to edit the program written into the controller without use of a computer with programming software. The controllers used in the laboratory are Alpha XL type, exactly AL2-14MR-D. They have following technical specification [1,2]:

- 24 V DC power supply,
- 14 inputs/outputs connectors:
  - 8 digital inputs, which can be programmably turned into analog inputs with 9 bit resolution and 0-10 V input voltage range,
  - 6 relay outputs,
- slot for EEPROM or personal computer connection,
- wide range of expansion modules:
  - GSM modem connection module,
  - additional input/output module,
  - AS-I network connection module,
  - temperature – analog conversion module

The overall view of Mitsubishi Alpha PLC, on the example of AL2-24MR-D controller, is shown in Figure 1. Both controllers have the same appearance, but different input and output numbers.

The Alpha XL controllers, installed in the laboratory, are supplied from 24 V DC source. The power can be brought from 230V AC/ 24V DC converter or directly from 24V DC laboratory mains. Because of operating on safe voltage, there is no risk of electrocution during the experiments.

Mitsubishi Alpha controllers are programmed in FBD (Function Block Diagram) language [2]. The FBD is a simple representation of real inputs and outputs dependence, thus the program can also be traced and edited directly on controller display. Program has the diagram structure: on the left side the inputs are represented and on the right – the outputs. In order to create a new program the block (or blocks) should be placed between input (inputs) and output and connected by lines. The general principle of programming in FBD is shown in Figure 2.

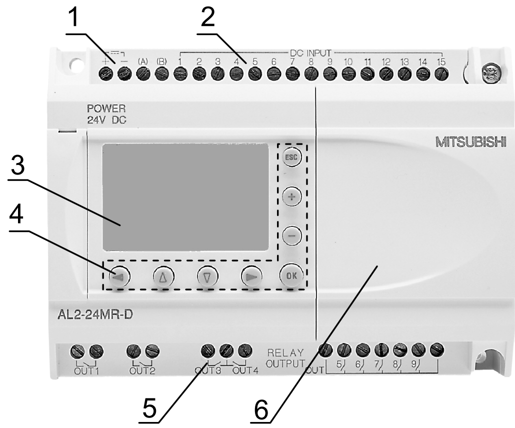

Fig. 1. The Mitsubishi Alpha XL controller [2]. (1) power connectors, (2) inputs, (3) LCD display, (4) navigation buttons for menu, programming and user application, (5) outputs, (6) plug covering expansion module slot

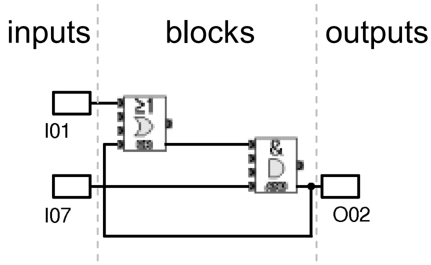

Fig. 2. The general principle of programming in FBD [2]

The program for Alpha controllers are written in AL-PCS/WIN application and then transferred to PLC. Apart from FBD displaying, editing and tracing capabilities the software has also some visualisation abilities, which facilitate program testing and also is one of ways of program documentation. The main windows of the AL-PCS/WIN application is shown in Figure 3.

Due to its simplicity and easy programming, students often use Alpha controllers to develop their BSc. Eng. thesis. Some example results of these works are shown in further part of the paper.

2.2. Mitsubishi FX2N controller

The Mitsubishi FX2N controller is a PLC, which combines the properties of compact and modular system in one. Though its small dimensions the controller is one of the fastest PLC. The controllers installed in the laboratory are FX2N-32T type with following technical specification [3]:

- built-in 230V AC power supply,
- 32 inputs and 32 transistor outputs,

- integrated serial port for communication with PC or visualisation panel,
- wide range of expansion modules:
  - additional I/O modules,
  - network modules for Profibus DP, AS-I, DeviceNet, CC-Link, I/O Link, Ethernet, CAN Open,
  - additional RS485 board,
  - analog modules including thermo element inputs,
  - fast counter modules,
  - positioning modules (for one or one/two axis).
- programming via MELSOFT GX Developer or GX IEC Developer package.

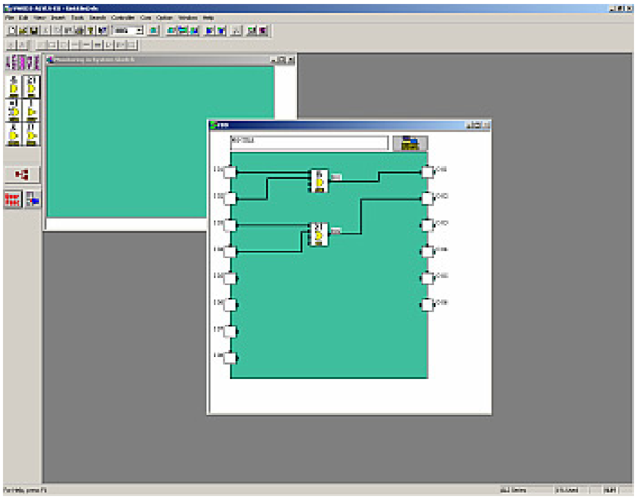

Fig. 3. The AL.-PCS/WIN application used for Alpha controller programming

FX series is programmed similarly to the other, "bigger" PLCs manufactured by Mitsubishi, so practicing with it can be a good preliminary to gain programming skills for working with "A" or "Q" series systems. Because of use the GX Developer software, the FX2N can be programmed in LD, IL and SFC languages. ST (Structured Text) is available only for "Q" systems. There also exist special cut-down versions of GX Developer and GX IEC Developer designed especially for FX series. The other dedicated software is the MELSEC MEDOC FX-PCS/WIN-E [6].

The variety of available programming software makes the FX series very flexible for use on different level of user knowledge.

2.2. The Mitsubishi "A" series and "Q" series modular controllers

Besides Alpha and FX PLC, there are also modular controllers in the laboratory: an old "A" series and new "Q" series.

In the laboratory two "A" series PLC system are installed: one based on A2 CPU and the other on A4 CPU. The A4 system consists of the following modules:

- power supply (A65P),
- CPU (A4U),
- Ethernet interface module (AJ71E71),
- MELSECNET II/B module, coaxial cable (AJ71AR21),
- MELSECNET II/B module, twisted pair cable (AJ71AT21B),
- 16 relay I/O block, 240VAC/24VDC, 2A (AY11),
- 24 relay I/O block, 240VAC/24VDC, 2A (AY15EU).

The A4 system has also connected an extended base unit with two modules mounted on it:

- MELSECNET/MINI-S3 fiberoptic/twisted pair master module (AJ71PT32-S3),
- 32 triac/SSR AC100-240V 0.6A output module (AY23).

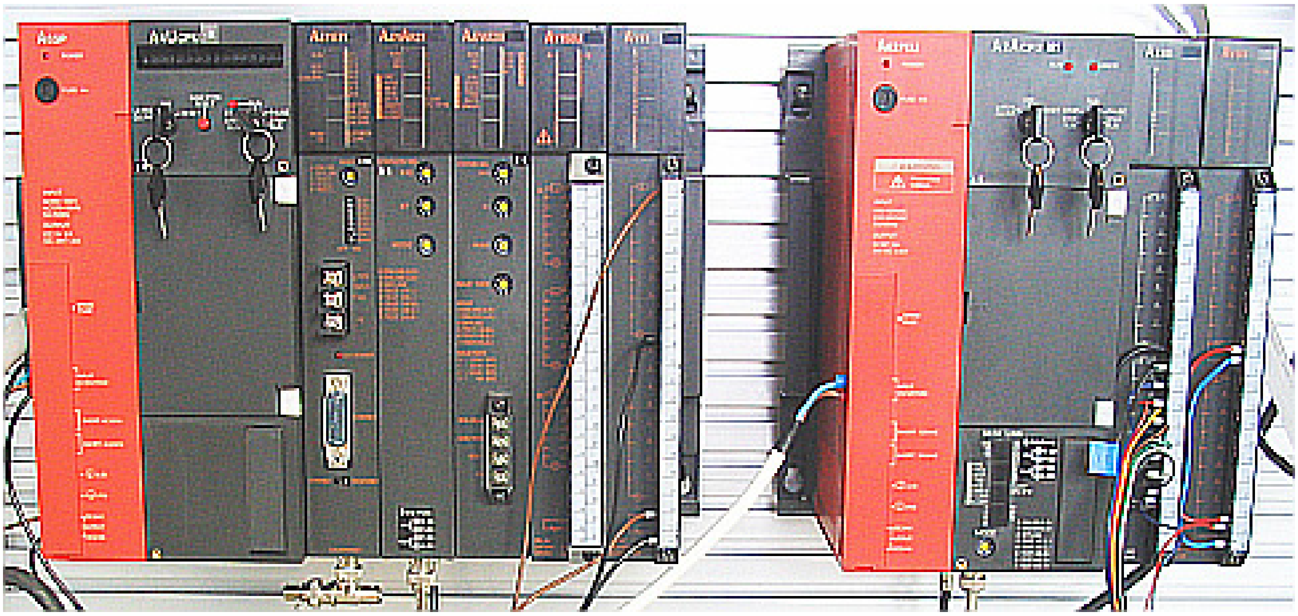

Fig. 4. The A4 (on the left side) and A2 (on the right side) systems installed in the laboratory

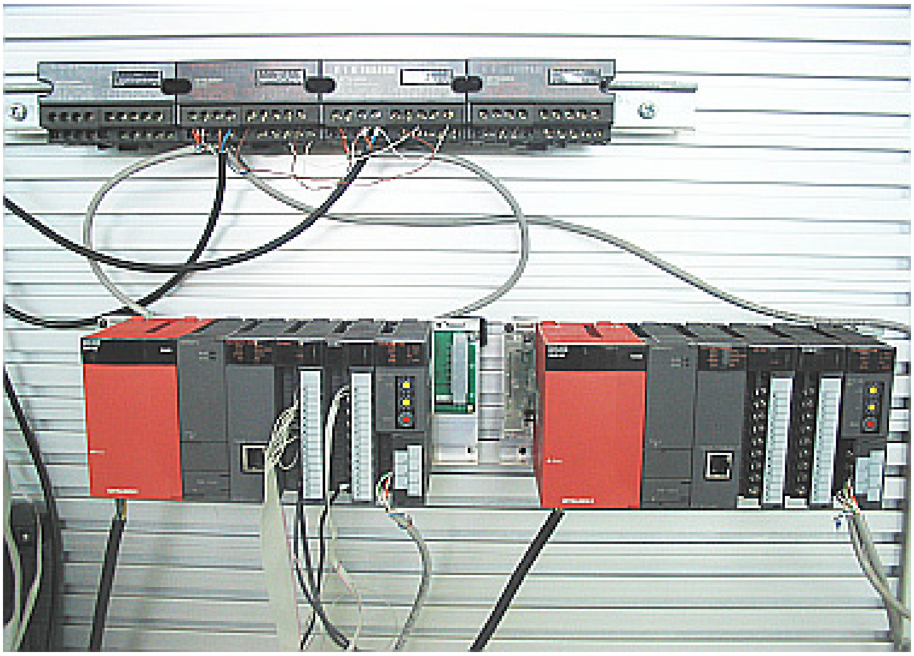

Fig. 5. CC-Link network. At the bottom two “Q” systems are shown with distributed I/O modules overhead

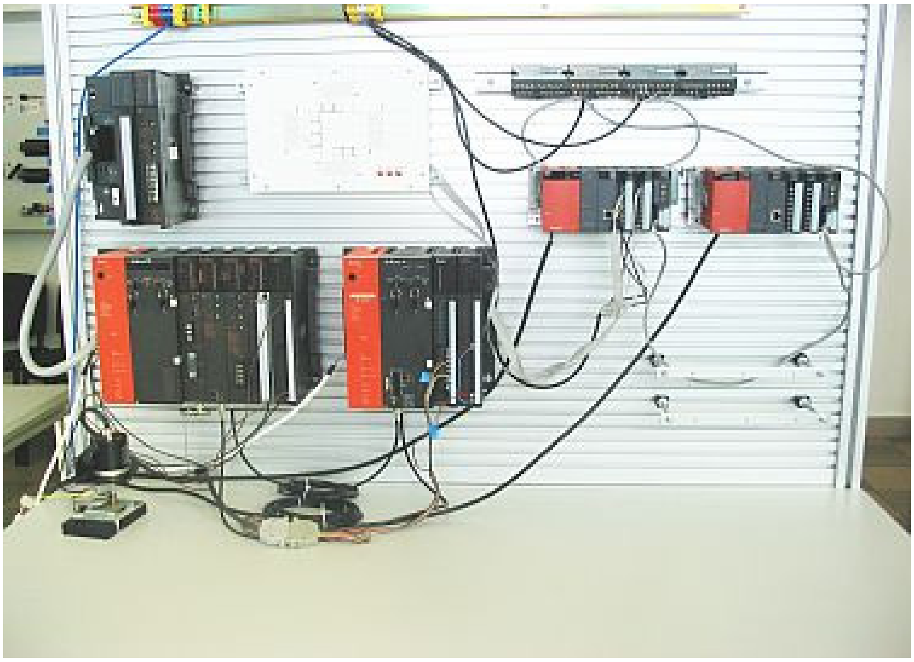

Fig. 6. Overall view of Mitsubishi controllers standing. At the upper right corner the “Q” series and CC-Link modules are shown. At the lower left corner the “A” series is shown.

The A2 system consists of the following modules:

- power supply (A62PEU),
- CPU (A2A),
- 16 DC 12/24V input module (AX 80),
- 16 DC 12/24V, 0.5 A transistor output module (AY80).

Both controllers are connected with the MELSECNET industrial network. Moreover, system based on A4 CPU has also an Ethernet module, which can be used for data exchanging with other controllers or computers with SCADA software installed on them. The A2 and A4 systems are shown in Figure 4.

There are also two "Q" series PLC systems in the laboratory. The configuration of each system is identical and consists of the following modules:

- power supply (Q61P-A2),
- CPU (Q00),
- Ethernet module with twisted pair connector RJ-45, 100 Mbit (QJ71E71-100),
- 16 transistor outputs, 12/24VDC, 0.5 A (QY80),
- 16 12/24VDC input module (QX80),
- CC-Link network master/local module (QJ61BT11N).

Furthermore there are also distributed I/O modules:

- two CC-Link 8 inputs modules, 24VDC (AJ65SBTB1-8D),
- two CC-Link 8 transistor outputs modules, 12/24VDC, 0.1 A (AJ65SBTB1-8TE).

Both "Q" systems are connected via CC-Link network. The first controller is a master station, the other is a slave. Systems can communicate with each other and with distributed input/output modules through a fast field network. CC-Link has also the stand-by master capability (redundant master station), automatic reconfiguration after slave failure/return and advanced monitoring functions [7]. At the moment the CC-Link network in the laboratory is in the phase of construction and testing. Recently the Institute acceded to CLPA (CC-Link Partner Association) as a regular member. This gives a chance to get access to a large information database and quick development of the CC-Link network issues in the future. The view of CC-Link network installed in the laboratory is shown in Figure 5. Figure 6 shows overall view of the standing with Mitsubishi "A" and "Q" series installed on it.

The plans for the future include the expansion of CC-Link network, connection with other PLC devices through industrial networks and purchasing the motion processors with equipment: servo drives and servo amplifiers, in order to build "Q-Motion" system.

3. Examples of the students' works

In this section the examples of students' works have been presented. They have been done on the basis of the Alpha XL controller. It is worth to notice that the projects have been the first contacts with the real tasks for PLC, which have required to design the model and to write the appropriate program.

3.1. The model of the lift

The first project presented here is a model of a lift [5]. It consists of three main parts: a control unit with the Alpha XL controller mounted on it, a control panel (imitates the one mounted in a lift cabin) and a model of the lift shaft with the cabin, floor selection buttons and LED indicators. Figures from 7 to 9 show mentioned parts of the model, however figure 10 shows the complete model.

The lift is completely controlled by Alpha PLC. The control unit box contains power supply for the controller, fuse, power switch and additional relays. These relays are an additional insulation, because the lift's motor is supplied from 230V AC mains. In fact there is a couple of motors driving the common transmission, but each of them has the other direction of revolutions. Floor selection signals are gathered from control panel and buttons mounted in the shaft. As the cabin position sensors reed switches are used, thus the positioning cannot be very precise, but it is enough to satisfy model requirements and is a cheap and simple solution. The model of the lift is also equipped with doors sensors, which eliminate the possibility of setting the cabin in motion while the door is open. There is also a pair of limit switches, which stop the lift when the cabin does not stop on ground or last floor because of position sensor failure. After resetting the emergency stop, cabin continues the realization of calls. Also after some time of inactivity or after power failure the lift automatically goes to ground floor. Due to limited number of inputs of the Alpha PLC limit switches, door sensors and emergency stop button, have been connected in series, so any action can break the circuit and enable the "emergency" signal at adequate input of the PLC.

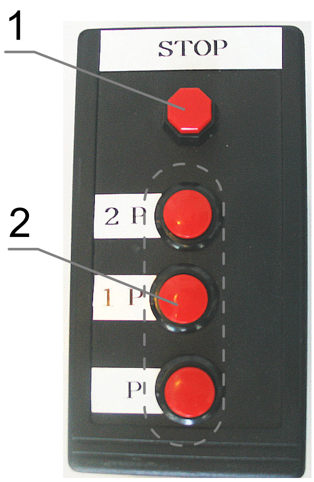

Fig. 7. The control panel of the lift. (1) emergency stop button, (2) floor selection buttons.

Fig. 8. Control unit of the lift with Alpha XL mounted on top of the box.

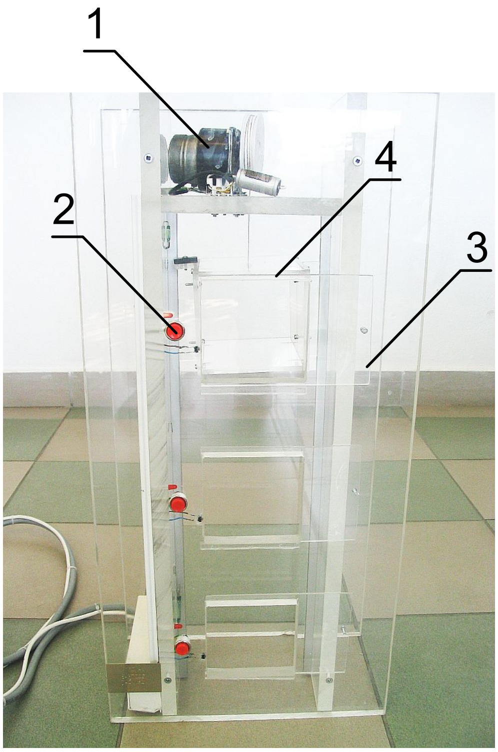

Fig. 9. The shaft of the lift's model. (1) electric motors, (2) call button, (3) cabin door, (4) cabin

Fig. 10. The overall view of the lift's model. The shaft on the right and control unit on the left side.

Presented model has been developed for education purposes. First of all, the abilities of Alpha controller have been presented in order to show simplicity of programming and developing application. The second aim is the presentation purposes of the model and the third are possibilities of further development.

3.2. The model of the automatic door in the public transport

The second project presented here is a model of an automatic door control in a public transport vehicle [4]. The presumption made by student is the existence of master controller and slave controllers. The master gathers information about the vehicle status and commands given by a driver, then sends signal to slaves. The slave controls the door operation and receives "open the door" demand from a passenger. In the project, the one master and one slave have been used and the signals have been simulated by switches. Moreover the simple model of the door has been built using generally available components. The model with removed cover is shown in Figure 11.

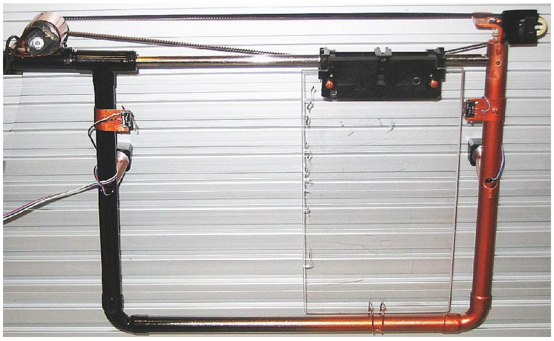

Fig. 11. The model of the doors with removed cover [4]

Both controllers communicate through standard inputs and outputs. The slave controller gathers signals from the master controller (permission for open the door), optic sensor, limit switches, "open the door" demand from passengers and overload sensor. Output signals are door drive control, control of the door lock and failure report. The master controller collects the information about the vehicle state ("stop" or "in motion"), the door state (open or closed), the slave controller state (failure signal) and from a "door open permission" switch. Full description of all states is not necessary here, so only the most important function implemented in the model will be mentioned:

- registration of passenger's "open the door" demand during ride and realization after vehicle stop,
- closing the door automatically after given time,
- detecting the persons and obstacles by optic sensor and overload sensor,
- failure report when the door cannot be opened or closed,
- blocking the "ride permission" signal while door are opened.

This project, similarly like the previous one, has been developed by the student to elaborate a program for the PLC, which can realize intelligent control with the handling of critical situations.

4. Conclusions

Contemporary higher education must be directed to educate the students according to needs of the employers. In order to be up to these needs, a new technology should be presented and used during realization of syllabus. Moreover, the students should solve the real problems from industry. In the Institute of Engineering Processes Automation and Integrated Manufacturing Systems the emphasis is put on these tasks, which are realized within the confines of diploma thesis, semestral works or researches with employees of the Institute.

Acknowledgements

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