automatics, linear control system,
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LABORATORY STATION FOR TESTING DYNAMIC PROPERTIES OF LINEAR AND NON-LINEAR REGULATION SYSTEMS

The paper presents a laboratory station enabling modelling and testing of linear and non-linear regulation elements and systems. The station was built by students supervised by employees of the Department of Automatics and Electrical Engineering at the Faculty of Transport and Electrical Engineering of the Technical University of Radom and is used during laboratory classes of the course in Automatics.

STANOWISKO LABORATORYJNE DO BADANIA WŁASNOŚCI DYNAMICZNYCH LINIOWYCH I NIELINIOWYCH UKŁADÓW REGULACJI

Artykuł jest prezentacją stanowiska laboratoryjnego umożliwiającego modelowanie i badanie liniowych i nieliniowych elementów i układów regulacji. Stanowisko zostało wykonane przez studentów pod kierunkiem pracowników Zakładu Automatyki i Inżynierii Pomiarowej, Wydziału Transportu i Elektrotechniki Politechniki Radomskiej i jest wykorzystywane do zajęć laboratoryjnych z przedmiotu Automatyka.

1. INTRODUCTION

Automatics is an area of science and technology dealing with an analysis and mathematical modelling of objects and systems of different nature, such as electrical, mechanical, hydraulic or pneumatic systems. Thus the main focus in conducting laboratory classes in the course subjects: Fundamentals of Automatics and Control Theory is on student's understanding of the essence of the problem without going into details concerning the structure, technology and operation of individual elements of the systems. Then

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laboratory stations become very helpful. They are often created as local didactic packages developed in schools of higher education to cater for their own needs. However, they cannot do everything for the Student, especially when it comes to such activities as an assembly of the system, selection of elements, change in parameters or discussing measurement results. [1], [2]

An example of such an attitude is the system presented in the paper and made by the employees and students of Department of Automatics and Measurement Engineering, at the Faculty of Transport and Electrical Engineering of the Technical University of Radom. The station outlined in the paper enables modelling and testing of linear and non-linear regulation elements and systems. The station is used for didactic purposes.

2. DESCRIPTION OF THE LABORATORY STATION

Figure 1 shows the view of a faceplate for testing linear elements.

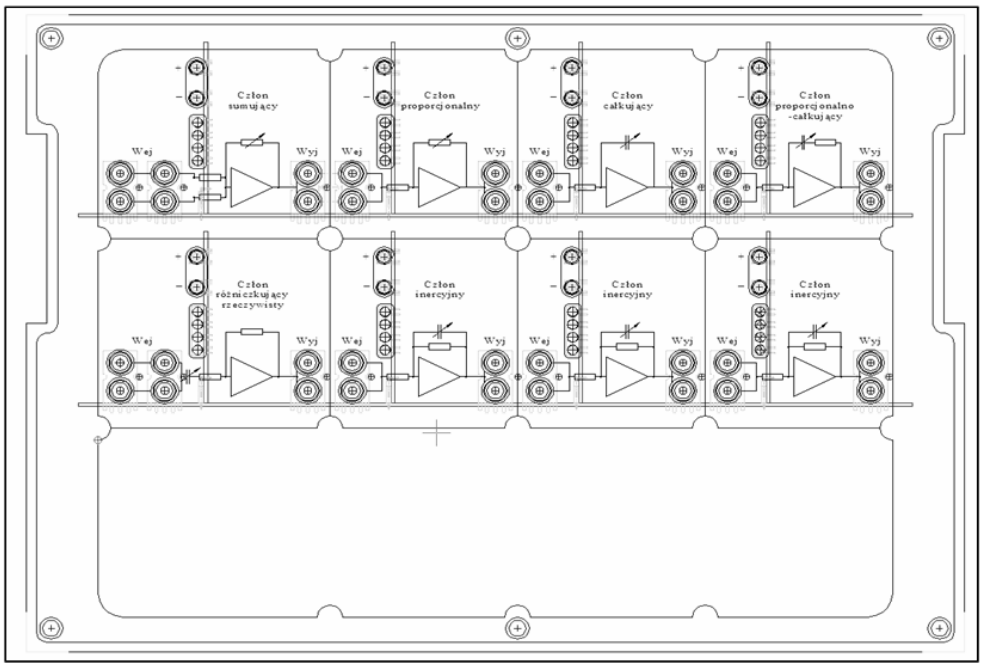

Fig.1. View of a fragment of the faceplate for testing linear elements.

A module enabling testing of the non-linear system dynamic properties is attached to the station (Figure 2). An aluminium tool case is used as a housing. Such a solution ensures a significant mechanical durability and resistance to damage, it makes the device easy to store in the periods between classes and its screening features improve its resistance to interferences.

In the case of electric mains, a highly effective DC/DC-9-18V/±12V converter is used. It ensures:

- Removal of a dangerous 230V voltage outside the housing,

- Elimination of mains transformer as an important element of electromagnetic disturbance,
- Opportunity of supply by an easy to get DC power supply within the range of 9-18V.

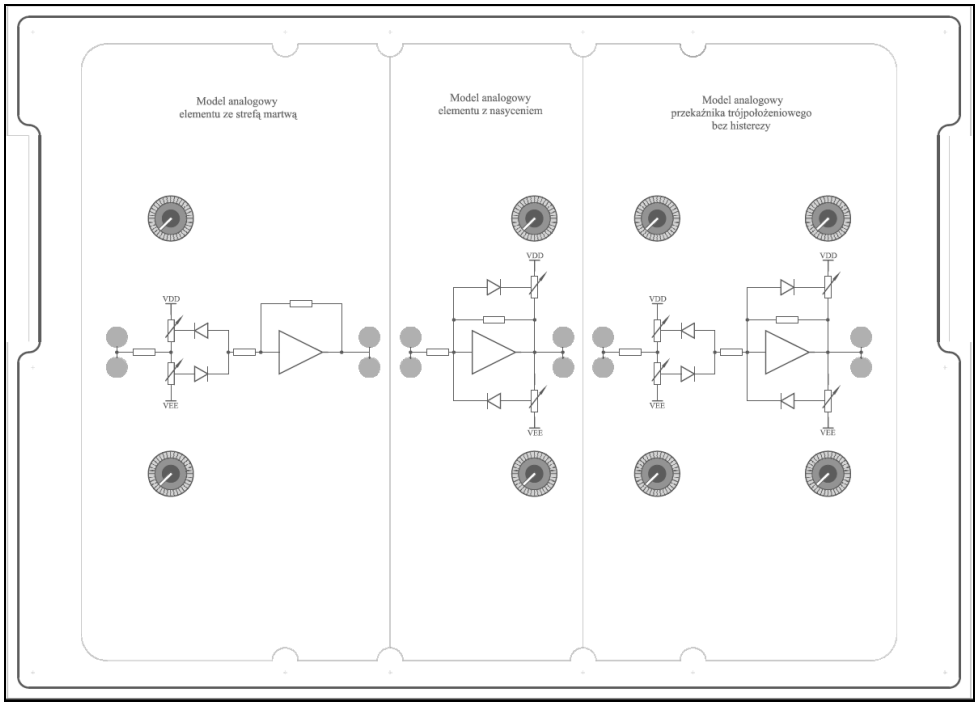

Fig.2. View of the faceplate of the station for non-linear element testing.

The station was made in accordance with the accepted assumptions and it fulfills the basic functions. They can be characterized in the following way:

- housing is an autonomous whole and ensures a durable and aesthetic protection to the equipment comprised in it
- safe voltage (max ±12V) is used for power supply
- the whole apparatus is closed in a screamed enclosure reducing the negative impact of disturbance factors
- the use of electronic keys eliminates long leads connecting regulated elements and at the same time ensures a practically unlimited number of connecting cycles
- standard leads of the “cinch” type are used for connecting individual blocks. This ensures screening of signals and at the same time allows a quick and reliable switching of tested systems
- each regulating module is mounted on a separate printed circuit board attached to the rest of the system via an effective connection of the GOLDPIN type

- in the case the need of servicing arises, the damaged module can be easily dismounted and repaired or replaced by an equivalent one retaining the signal standard on the connection
- integrated circuits are placed on the so called precise stands ensuring a perfect and durable connection and, in other situations, replacement of systems without the use of specialist tools
- the structure makes the extension of the device possible
- the station ensures a possibility of a quick connection of the system with the standard peripheral equipment, such as a generator, oscilloscope, current and voltage measuring instruments
- the device is provided with a set of connecting leads for power supply from external power feeder and for connecting with a generator and an oscilloscope as well as connecting leads to achieve different models of automatic regulation components

The primary element of the regulating module depicted in Figure 3 is an operational amplifier. Discrete elements at the input and feedback were designed in the way enabling performing any of the foreseen configurations. Therefore all modules are mounted on printed circuit boards according to the same design.

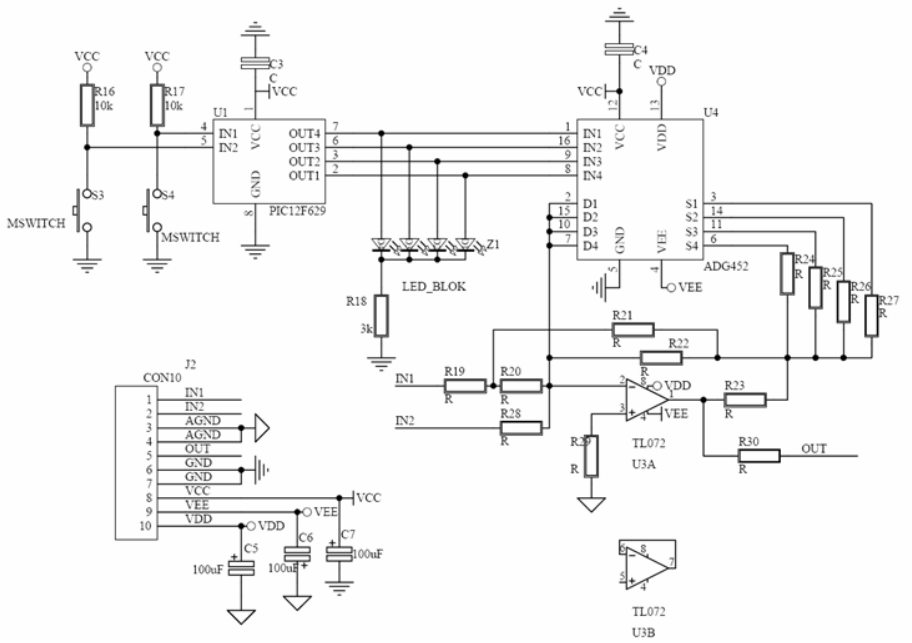

Fig.3. Schematic diagram of the regulating module.

The system assumes a possibility of changing the transmission characteristic via a selection of one of four two-terminal networks (resistors or capacitors) - R24-R27. An ADG452

integrated system was used for switching. In its structure it contains four analog keys led to terminals D1-S1; D2-S2; D3-S3; D4-S4, respectively. While feeding a logical signal "1" to one of the inputs: IN1to IN4, we switch on an appropriate key. The ADG452 system is characterised by low resistance in the switch-on mode and high - in the switch-off mode. Another advantage is easy control by digital devices. In order to avoid mechanical switching elements in the form of rotational switches, it was decided to use a microcontroller together with two astable push-buttons. The microcontroller decodes a suitable push-button and controls outputs in a sequential manner. Control inputs are connected to outputs as well as signal diodes corresponding to them. Owing to this we know visually which branch is currently active. The solution involving the microcontroller was selected on account of its versatility. Other similar solutions required application of three integrated circuits of the CMOS type together with discrete elements. From a wide range available on the market the PIC12F629 was selected. This system proved to be an optimum one for the above mentioned solution; with the DIP8 housing, it makes 6 port lines of input/output accessible. In the entire appliance there are 8 such modules and they are connected to two arterial boards by means of connectors of the GOLDPIN type. The modular structure ensures an easy start-up and, in the future, servicing. [2]

3. POSSIBILITES OF DIDACTIC APPLICATION OF THE LABORATORY STATION

The outlined station is a helpful tool when it comes to running laboratory classes in the courses of Automatics and Theory of Control [5], [7]. The issues listed below are just some of the suggestions for the classes to be focused on which, depending on the inventiveness of the person in charge of the classes and students, can be performed with the use of the prepared system:

- Determination of time and frequency characteristics for the basic elements of the regulation systems
- Modelling of static and astatic objects
- Selection of regulator settings for the set object
- Modelling of the closed regulation objects
- Corrections in automatic regulation systems
- Determination of non-linear static element characteristics
- Determination of time runs for non-linear elements
- Modelling and testing of non-linear regulation systems

Tests on the station are carried out in the Laboratory of Fundamentals of Automatics and are described in the University publication [5]. The tested systems do not require mundane assembly work; what is required are a couple of simple connections and connecting external devices. Therefore, during the classes the main emphasis is put on understanding the essence of a given test without going into assembly or structural details concerning particular elements. The subjects dealt with during classes reflect some subjects dealt with during design classes [3], [4] or the lecture [6]. It must be mentioned here that the bibliography items: [3], [4], [5], [6] were also developed by the employees of the Department of Automatics and Measurement Engineering.

4. CONCLUSIONS

The laboratory station made by the students enables broad testing and verification of the knowledge acquired during lectures and design classes, not only in the field of automatics. Students, supervised by teachers, while making the laboratory station, apart from gaining theoretical knowledge, acquire many practical skills, such as using software for diagram drawing, designing printed circuit boards, assembling and starting up newly designed systems, an ability to use catalogue cards and technical notes of different manufacturers, or CAD programmes for mechanical structure design.

It is worth mentioning that unlike commercial stands, the outlined laboratory station is not very costly and, what is more, its low cost does not have an adverse effect on its didactic advantages.

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