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Michal Kelemen, Jana Ligušová, Ján Liguš, Vladislav Maxim

ADDITIONAL MODULES FOR PROGRAMMABLE LOGIC CONTROLLER BASED TRAINING STANDS

Urgency of the research. *Programmable logic controllers are devices, which are necessary for building of controlling systems mainly for industrial applications. Therefore, there is an effort to make intensive training for knowledge and skills in this area.*

Target setting. *Training stands have been developed of the training purpose. Programmable controllers are used together with sensors and actuators. The aim is to make a training in area for working with sensors and actuators to compose completed project similar as it is required in industry.*

Actual scientific researches and issues analysis. *Training set allows making hardware simulation of control system. But also, it is important to apply it together with other real parts. Practical experience with using of all components together are highly required. There are some effects, which cannot be simulated virtually, and it is necessary to pass it also through the hands of young mechatronic students.*

Uninvestigated parts of general matters defining. *The questions of the networked structure of programmable logic controller devices, sensors and actuators networks are uninvestigated and therefore the next research will be focused on this.*

The research objective. *The main goal is to create a compact device with real models of actuators and sensors for training future application developers with a programmable logic controller. Such real objects as actuators and sensors have many properties and effects, which should be tested experimentally. There are problems with signal noise, hysteresis, dead zones, saturation, backlash, deformation effects, friction effects, thermal effects etc. Influence of these effects to control systems can be explored using the experimental works.*

The statement of basic materials. *Our training stands include free din rails for additional modules, which can be very easy and fast inserted into these stands. DIN rail system is frequently used in industrial racks as well. Every additional module has own screw terminal for connection to power supply and connection to programmable logic controllers.*

Conclusions. *Main contribution is that students will practically work with real systems with programmable logic controllers and with sensors and actuators. All theoretical knowledge can be experimentally verified on these stands equipped with additional modules with sensors and actuators.*

Keywords: *Programmable logic controller; controlling; hardware; sensor; actuator.*
Fig.: 13. References: 3.

Introduction. Training stands (fig. 1) are designed for training process with programmable logic controller (also called as PLC). These stands include programmable logic controller core, human machine interface, industrial switch, power supply, circuit breaker and main backlight power switch, main and additional screw terminal. The main frame is composed of aluminium construction profiles and there are three DIN rails for placement of additional devices. Primary aim was to complete training stands as compact movable stations for fast prototyping of any control system. The idea was to include frequently used sensors and actuators for additional practical work of students in training process. Students can make training in area of sensors and actuators connecting. Understanding of these basic principles and related problems will uncover the bigger creativity of students and better adaptability to complicated industrial conditions.

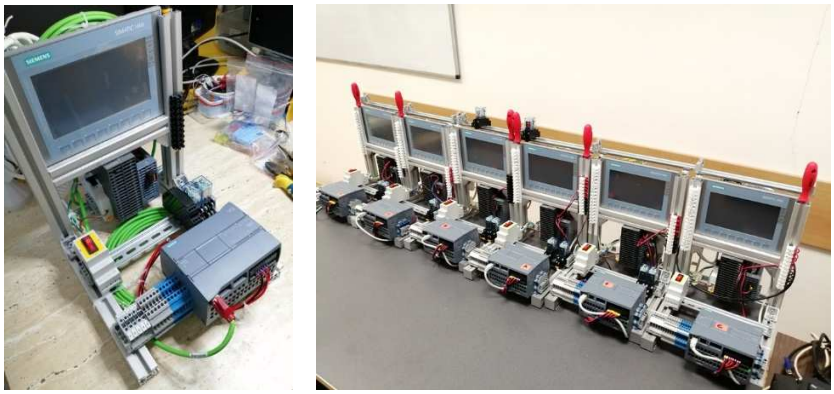

Fig. 1. Training stands with programmable logic controllers

The effort to improve the educational process was the motivation for the developing of additional modules for programmable logic controllers. Button modules and combined modules with switches, buttons, LEDs and buzzers have been created. Inductive and capacitive sensors were

used to build sensor modules. Relay modules will be used to control the actuators. Solenoid actuators were used to build additional actuator modules. Fans with BLDC motors with a size of 80 mm and a pair of fans with dimensions of 40 mm were placed on other actuator modules.

1. Switch and buttons modules. Modules - Hardware simulator (fig. 2) includes parallelly connected four toggle switches and four momentary buttons connected to +24V. It means that there are four channels of generators of logical states S1, S2, S3 and S4. These switches and buttons can simulate the limit switches, proximity switches, level switches, door switches, temperature switches, pressure switches or other two state sensors. So, it is possible to simulate real processes with logical one or logical zero. If PLC sends any logical state to its digital outputs, it is logical zero or logical one. For this purpose, there are four LED diodes with resistor for limiting of current flow to 20mA. These LED diodes can be used for visualisation of output logical state on PLC outputs. LED diodes are used instead of any real controlled devices as actuator, relay, or light tower. The hardware simulator also includes one channel with buzzer, which can be also used for connecting to any PLC digital output. Students can build any application with this hardware simulator instead of real controlled plants. This situation enables to try very dangerous situation in control process without any risk and disaster.

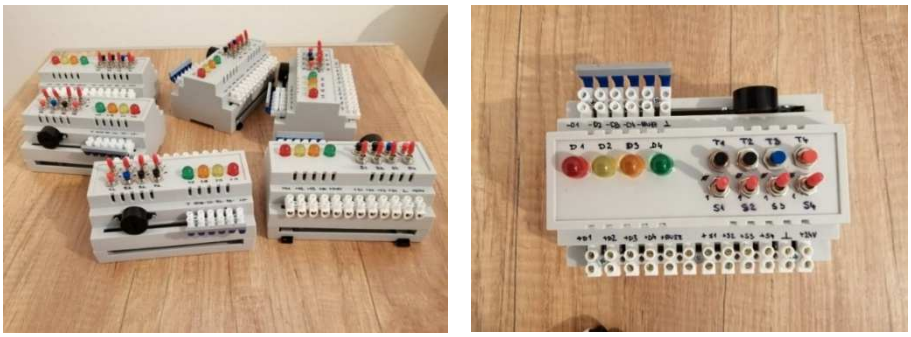

Fig. 2. Hardware simulator with toggle switches, momentary buttons, LEDs and buzzer

Modules – Buttons (fig. 3) include two momentary buttons with possibility to use normally open or normally closed mode. Switching mechanism of both buttons is covered with transparent plastic for the better visibility of working principle.

Fig. 3. Buttons modules

2. Sensor modules. First sensor module (fig. 4) consists of two pieces of inductive PNP three wire sensors. Both sensors are connected to screw terminal. Sensors have indication LED diode for signalization of metal object detection. Next sensor module (fig. 5) holds the capacitive sensor for detecting non-metal object. Detection makes a signal using the built-in LED diode. Detection distance can be adjusted with screwdriver on multi turn potentiometer. Also, this module includes the screw terminal for connecting power supply and signal cables.

3. Actuator modules. First basic part for output systems is electromagnetic relay (fig. 6), which is used for controlling of high power system, which cannot be connected directly to PLC, but it is possible to connect them to relay switching contacts. Relay is mounted on pluggable

DIN socket, which allows to change damaged relay very fast. Solenoid electromagnetic actuator is included in next module (fig. 7). The solenoid actuator is often used to perform linear movements such as servo valves for pneumatic and hydraulic systems, electronic locks, printers, copy machines, fuel systems, starter systems, water systems, gas systems, latching mechanisms, brake systems, transmission mechanisms, etc. When using a solenoid actuator, a situation may occur where the solenoid coil heats up and may be destroyed. This situation can occur if this actuator is activated for a long time. For this reason, a bimetallic thermal switch (fig. 7) is installed on the solenoid actuator coil. So, at an increased coil temperature, the electric current passing through the coils is automatically interrupted.

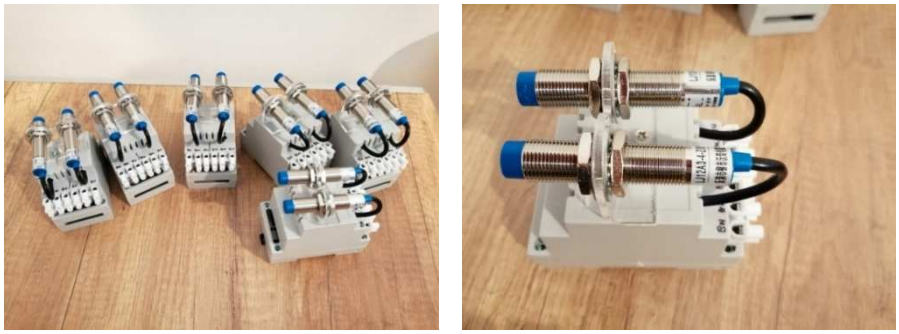

Fig. 4. Modules with inductive sensors

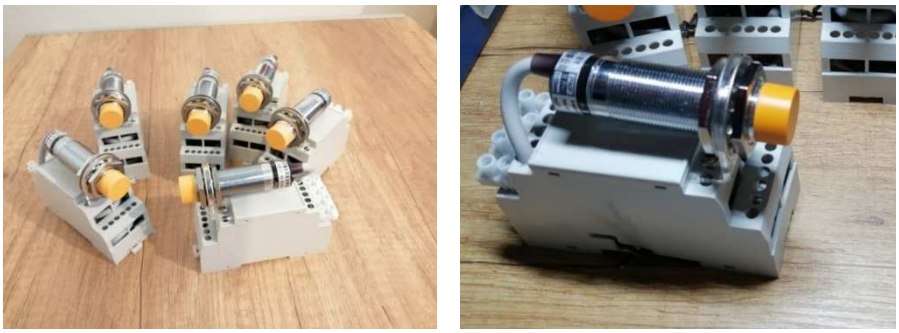

Fig. 5. Modules with capacitive sensor

Fig. 6. Relay mounted on pluggable DIN socket

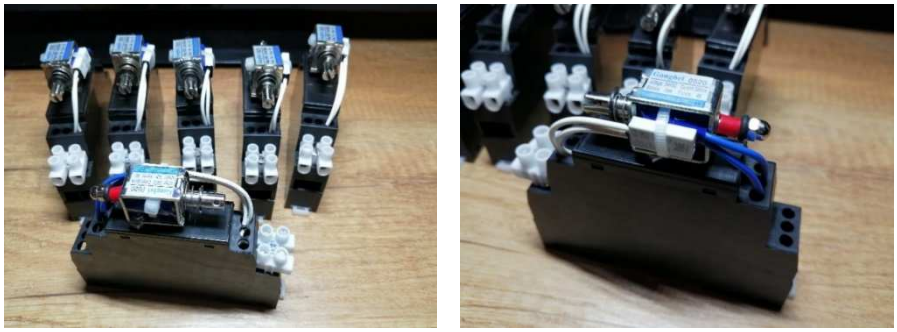

Fig. 7. Solenoid actuator modules

Rotary electrical machines are also often used in automated and mechatronic applications. DC and BLDC motors are often used mainly in smaller devices for the implementation of rotary movements or in combination with gear mechanisms also for the creation of linear motion. BLDC motors with fans are used to create additional modules (fig. 8) for training stands with programmable logic controllers. Modules (fig. 8) with a fan with a diameter of 80 mm with a protective cage and a screw terminal were created. To simulate systems with multiple actuators, modules with two fans with BLDC motors with a diameter of 40 mm with a protective cage and screw terminals were created (fig. 9).

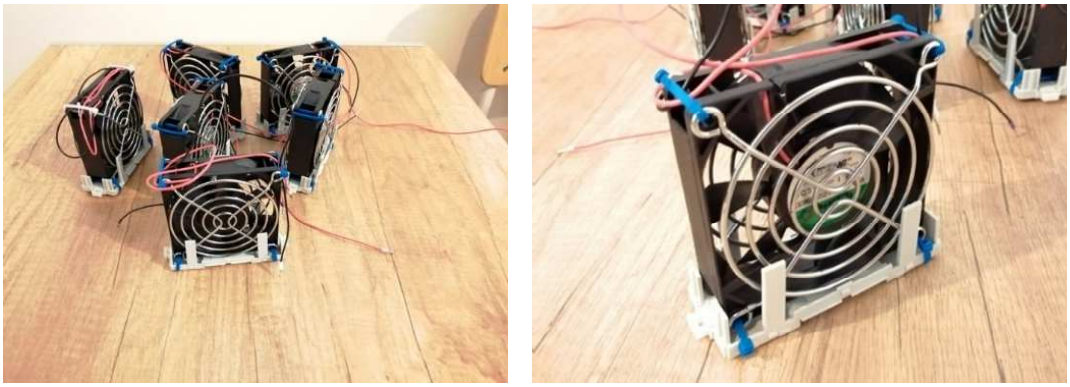

Fig. 8. Modules with 80mm BLDC fans

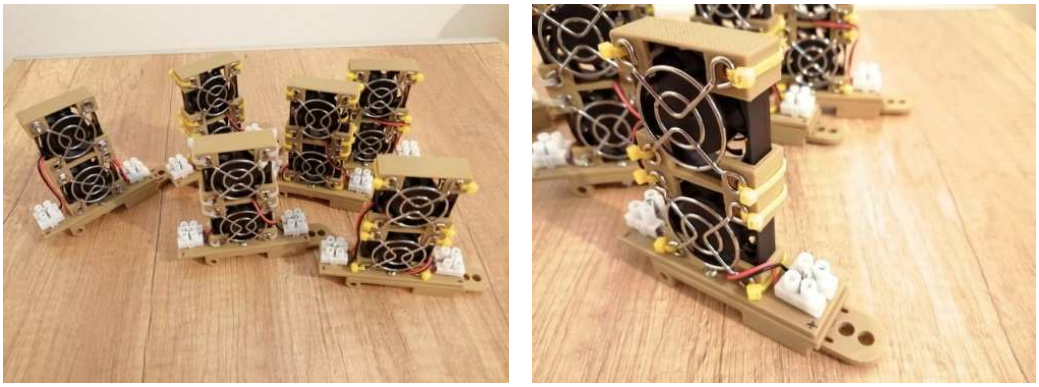

Fig. 9. Modules with double 40mm BLDC fans

4. Fully equipped training stand. The result of the development of training stands and extension modules are fully equipped workstations (fig. 10) for training and simulation of standard and industrial applications with programmable logic controllers. In addition to software, it is also possible to train hardware applications and experimentally verify proposed applications with sensors and actuators. These advanced training stations provide much more space for experimental work and testing of future applications, because in many cases only virtual experiments fail to provide reliable information about the future features of the proposed system. They are therefore a suitable addition to virtual prototypes created in simulation software, because after a successful simulation in a virtual environment, it is possible to create a real experiment with real sensors and actuators. In this concept, six working training stands were created for didactic purposes and for research work in the development of automated, mechatronic and robotic systems (fig. 11).

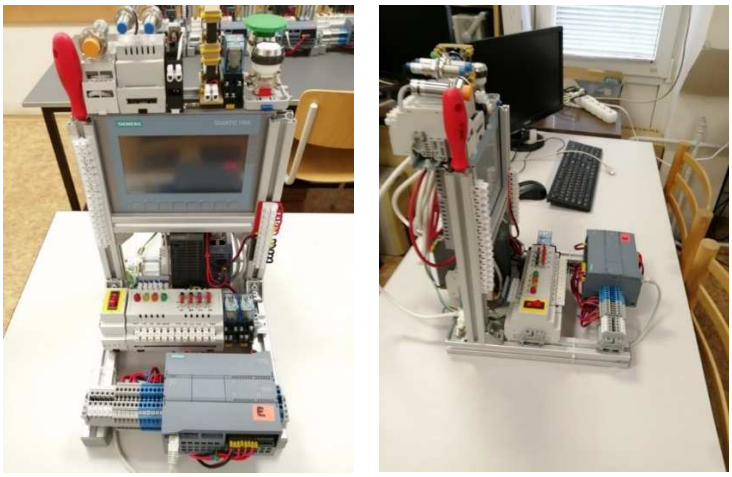

Fig. 10. Fully equipped training stands overall configuration prepared for use.

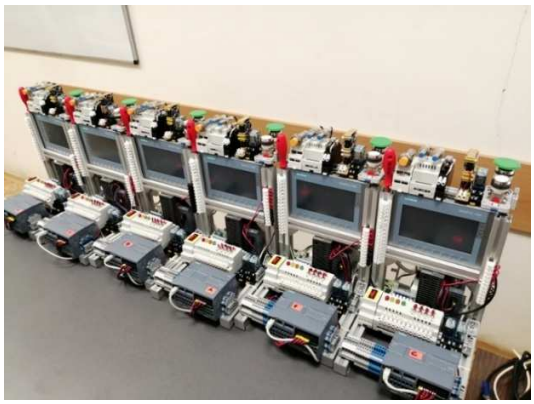

Fig. 11. Fully equipped training stands with programmable logic controllers

5. Conveyor with feed application. Figure 12 shows the example of training on training stands. Designed system consist of conveyor with tank and feed with automatic filling system. Module with inductive sensor (fig. 4) is used as proximity sensor for detection of tank and capacitive sensor (fig. 5) is used as level sensor of filled tank.

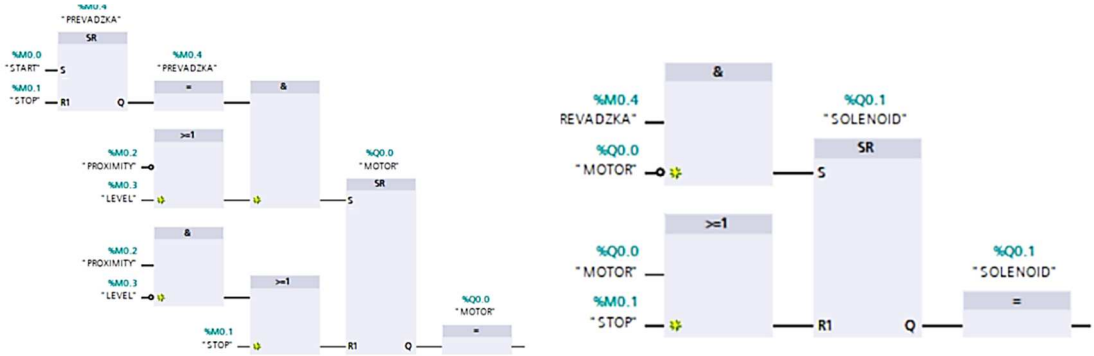

Fig. 12. Ladder diagram for control system for conveyor with tank and feed system

Module with solenoid actuator (fig. 7) is used as model for servo valve filling system and module with BLDC motor (fig. 8) is used as function model of conveyor motor. Both actuators must be used with relay switch module (fig. 6) for safe control of the system. Part of the system solution is also the design of an HMI interface for this application, in which interactive elements for control and animations for realistic display of the current state of the controlled system were also designed.

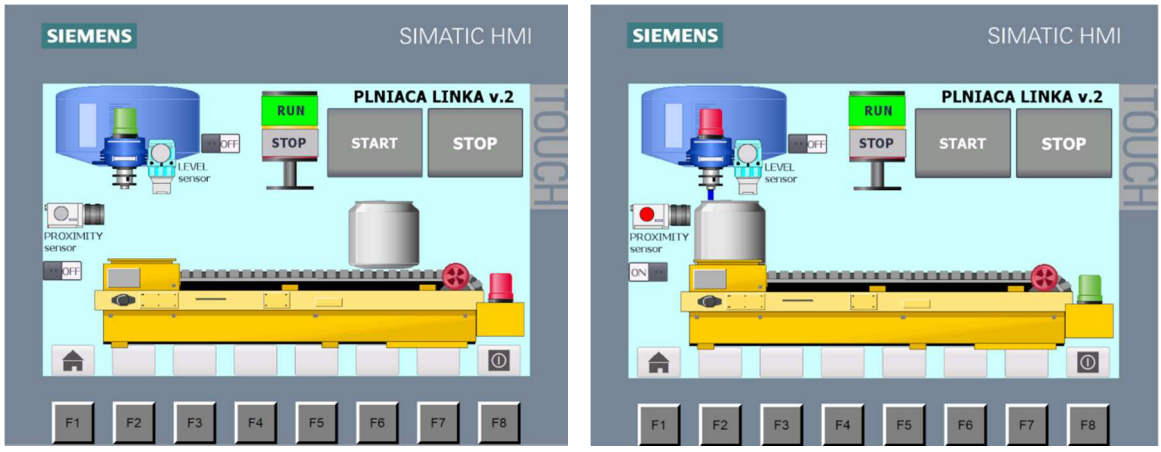

Fig. 13. Human machine interface for solved example of conveyor with tank and feed system

Conclusion. The proposed laboratory stands together with additional modules represent complex platform solutions for training and research work in laboratory conditions. Students working on these sets can verify their theoretical knowledge, but above all, they will also gain practical experience in this area and habits in working with industrial elements and systems. The whole device is compact and so it is very easy to carry it without the need to dismantle the project.

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Міхал Келемен, Яна Лігусова, Ян Лігус, Владислав Максим

ДОДАТКОВІ МОДУЛІ ДЛЯ НАВЧАЛЬНИХ СТЕНДІВ НА ОСНОВІ ПРОГРАМОВАНИХ ЛОГІЧНИХ КОНТРОЛЕРІВ

Актуальність теми дослідження. *Програмовані логічні контролери – це пристрої, які необхідні для побудови систем керування, переважно для промислових застосувань. Тому докладаються зусилля для інтенсивного розвитку знань і навичок у цій галузі.*

Постановка проблеми. *Ці стенди розроблені для навчальних цілей. Програмовані контролери використовуються разом з датчиками та виконавчими механізмами. Мета полягає у проведенні тренінгу з роботи з датчиками та виконавчими механізмами для створення завершеного проекту, подібного тому, який потрібен в промисловості.*

Аналіз останніх досліджень і публікацій. *Навчальний стенд дозволяє зробити апаратне моделювання системи управління, але також важливо застосовувати його разом з іншими реальними частинами. Надзвичайно необхідний практичний досвід спільного використання всіх компонентів. Деякі ефекти, які неможливо змоделювати віртуально, мають бути опрацьовані молодшими студентами у галузі мехатроніки.*

Виділення недосліджених частин загальної проблеми. *Питання мережевої структури програмованих логічних контролерів, мереж датчиків та виконавчих механізмів не досліджені, тому на цьому буде зосереджене наступне дослідження.*

Постановка завдання. *Основна мета полягає у створенні компактного пристрою з реальними моделями виконавчих механізмів та датчиків для навчання роботі з програмованим логічним контролером майбутніх розробників додатків. Такі реальні об'єкти, як виконавчі механізми та датчики, мають багато властивостей та ефектів, які треба перевірити експериментально. Існують проблеми із шумом у сигналах, гістерезисом, мертвими зонами, насиченням, люфтом, ефектами деформації, ефектами тертя, тепловими ефектами тощо. Вплив цих ефектів на системи керування можна дослідити за допомогою експериментальних робіт.*

Виклад основного матеріалу. *Наші тренувальні стенди містять вільні DIN-рейки для додаткових модулів, які можна дуже легко та швидко встановити. Система DIN-рейок часто використовується і в промислових стелажах. Кожен додатковий модуль має власний гвинтовий роз'єм для підключення до джерела живлення та підключення до програмованих логічних контролерів.*

Висновки відповідно до статті. *Головний внесок полягає в тому, що студенти ознайомляться на практиці з реальними системами з програмованими логічними контролерами, з датчиками та виконавчими механізмами. Усі теоретичні знання можна експериментально перевірити на цих стендах, оснащених додатковими модулями з датчиками та виконавчими механізмами.*

Ключові слова: *програмований логічний контролер; керування; апаратне забезпечення; датчик; виконавчі механізми.*
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Kelemen Michal – Prof. Ing., PhD., Faculty of Mechanical Engineering, Technical University of Kosice (Letna 9, 04200 Kosice, Slovakia).
E-mail: michal.kelemen@tuke.sk
ResearcherID: J-2845-2013
Scopus Author ID: 8396804800
ORCID: https://orcid.org/0000-0003-2274-3828

Ligušová Jana – Ing., PhD., KYBERNETES, s.r.o. (Omská 14, 04001 Kosice, Slovakia).
E-mail: jana.ligusova@kybernetes.sk
Scopus Author ID: 6507523454
ORCID: https://orcid.org/0000-0002-2975-3992

Liguš Jan – Ing., PhD., KYBERNETES, s.r.o. (Omská 14, 04001 Kosice, Slovakia).
E-mail: jan.ligus@kybernetes.sk
Scopus Author ID: 56407124300
ORCID: https://orcid.org/0000-0002-3953-8487

Maxim Vladislav – doc. Ing., PhD., KYBERNETES, s.r.o. (Omská 14, 04001 Kosice, Slovakia).
E-mail: vladislav.maxim@kybernetes.sk
Scopus Author ID: 55320976100
ORCID: https://orcid.org/0000-0002-8958-4705

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