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Safe Railways

(Review of the monograph «Functional Safety of Railway Control Systems»)

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ABSTRACT

Shubinsky, I. B., Rozenberg, E. N. Functional Safety of Railway Control Systems. Monograph. Moscow, Vologda, Infra-Inzheneria publ., 2023, 360 p. ISBN 978-5-9729-1553-8.

Ensuring safety is one of the main conditions for existence of humanity. Therefore, the concept of «safety» is the focus of attention in various fields of activity, ranging from agriculture, medicine through space. At the same time, the interpretation of the concept of «safety» is still ambiguous. The theory and practice of «functional safety» are currently most developed in the nuclear industry and railway transport. In railway transport, a series of European (CEN), international (IEC), interstate (GOST), national (GOST R) standards have been developed in the field of functional safety. They focus mainly on hardware and software control systems.

The monograph by Igor Shubinsky and Efim Rozenberg «Functional Safety of Railway Control Systems» presents a wide range of issues of functional safety – from scientific foundations (concepts, postulates, principles) to methods and techniques for ensuring the safety of hardware and software of railway control systems, including advanced methods of ensuring safety using virtual channels and digital twins.

The monograph is of interest to researchers, railway industry specialists engaged in management processes, academic staff, graduate students and students of railway transport universities. It may be useful to scientists and specialists in other fields of industry and transport related to problems of functional safety and reliability of control systems and objects.

Keywords: railway transport, functional safety of control systems, safety methods, virtual channels, digital twins, artificial intelligence.

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The full text of the review article in Russian is published in the first part of the issue.
Полный текст статьи-рецензии на русском языке публикуется в первой части данного выпуска.

Issues of functional safety of control systems in industry and transport are paramount. With development of intelligent control technology and the advent of the latest automation tools, they take on a more complex form, and the answers to challenges and subsequent solutions become the basis for safety of developed systems for critical application. An analysis of scientific publications in the field of transport emphasises the relevance of studying methods for implementing functionally safe control systems, including in the railway transport segment.

If the principles of implementing functionally safe control systems on a relay element base are simple and understandable and are based on the use of uncontrolled relays (in common parlance – relays of the first reliability class) in critical circuits and cable networks to control distributed objects, then enormous problems arise in ensuring high levels of reliability and functional safety with the use of devices and systems made using microelectronic elements, on a programmable element base, having both hardware and software components, endowed with artificial intelligence and using wireless paths for transmitting control and diagnostic information, linked with peripheral monitoring systems into complex traffic control systems.

The monograph presented to the reader entitled «Functional Safety of Railway Control Systems» [1], written by the scientists who are well known in the industry, D.Sc. (Eng), professors Igor Borisovich Shubinsky and Efim Naumovich Rozenberg, is truly a fundamental work that summarises key research of the co-authors of the book, as well as of other well-known researchers and scientists in the field of implementation of reliable and safe control systems in railway transport. This monograph is, in general, exactly the book that should stand on a par with the works of such masters of the theory of synthesis of reliable and safe control systems in railway transport, as D.Sc. (Eng), professors Valery Vladimirovich Sapozhnikov, Vladimir Vladimirovich Sapozhnikov and Victor Mikhailovich Lisenkov. Let us highlight their four separate monographs [2–5], two textbooks [6; 7] and a fundamental review [8]. It must be said that, apparently, today we have three main branches and, accordingly, three key scientific schools in the field of reliability and functional safety of railway control systems: that of professors Sapozhnikovs (research in their scientific school has been largely focused on development of methods for ensuring hardware reliability and safety and the synthesis of testable, self-checking and fault-tolerant devices), of professor V. Lisenkov (research in his scientific school has concerned the issues of the statistical theory of train traffic safety and the theoretical foundations of constructing safe microelectronic control systems), and of professors I. Shubinsky and E. Rozenberg (their works has focused on the theory of functional safety of control systems, methods and techniques for ensuring reliability and safety of hardware and software, including addressing more advanced issues of the use of technical vision, virtual data processing channels, digital twins and artificial intelligence).

Let us pay attention to the essence of the monograph under review, which includes seven main sections devoted to the following issues:

1. Basic concepts, postulates and principles of functional safety in railway transport.
2. Graph methods for determining indicators of functional safety and reliability of railway control systems.
3. Models of functional safety of railway control systems.
4. Principles for constructing functionally safe devices.
5. Ensuring functional safety of software.
6. Methods and technologies for creating functionally safe systems.
7. Confirmation of compliance with safety requirements of control systems.

The readers familiar with the subject area of the monograph will be particularly interested in materials devoted to the strict and approximate topological semi-Markov method of moments, the topological semi-Markov method for determining functional safety indicators based on operator transformations, algorithms for calculating reliability and safety indicators of systems using topological methods, models of functional safety of redundant systems, methods for ensuring functional safety of software components, as well as to practical issues of applying the principles developed by the authors to describe functionally safe systems using technical vision, virtual data processing channels, digital twins and artificial intelligence.

The authors of the book not only systematised and enriched knowledge in the field of development, certification and operation of reliable and functionally safe railway control systems, but also created strict and approximate methods for calculating and predicting functional

safety indicators, with the help of which they were able to study models of complex railway control systems.

It should be noted that in the presented monograph, the authors focused their attention on the analysis of functional safety of individual systems, for example, locomotive traffic control using a virtual information processing channel, systems with a digital twin, unmanned control systems, etc. However, currently complex control systems are actively developing in which each of the systems considered by the authors is a subsystem. Data about their work is supplemented by external periodic and stationary monitoring systems, and information flows are also sent to the level of organisation, planning and transportation management to optimise all ongoing processes. As an example of such systems under development, one can pay attention to the automated integrated system for metro train traffic control [9]. In addition, there is currently a need to develop functionally safe stationary monitoring systems for railway infrastructure facilities that are closely integrated with systems for ensuring the safe train traffic, since safety of the transportation process also depends on them [10; 11]. Issues of reliability and functional safety of such complex control systems are also extremely interesting to the reader, and studying them, apparently, is the matter of the nearest future in the subject area of the monograph under consideration.

The book «Functional Safety of Railway Control Systems» should certainly be recommended for reading by any specialist in the field of train control systems, be it a nascent railway engineer, a developer, a researcher or an experienced specialist. The materials in the book are fundamental for a specialist in the field of safe train traffic control systems and should be considered in modern lecturing and practical university courses for students, Ph.D. students and engineers improving their qualifications.

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