



Review of the book «Proceedings on the Self-Checking Embedded Control Circuits Synthesis Theory Based on Binary Redundant Codes»



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Proceedings on the Self-Checking Embedded Control Circuits Synthesis Theory Based on Binary Redundant Codes. Vol. 2. Moscow, Nauka publ., 2021, 527 p. ISBN 978-5-02-040757-2.

The first volume of the book includes papers devoted to three main areas of research in the field of synthesis of self-checking discrete systems: study of features of classical sum codes (Berger codes), modular sum codes, as well as their modifications proposed by the authors of the articles; study of features of codes for which check bits are obtained using convolutions modulo $M = 2$ of a part of data bits (polynomial codes and classical Hamming codes); research of the Boolean Complement method for organisation of self-checking discrete systems based on redundant binary codes. Materials are provided on detailed characteristics of error detection in data bits of redundant binary codes under the condition of error-free check bits, descriptions of methods for constructing previously unknown modified sum codes and features of methods for

synthesizing self-checking discrete systems based on binary redundant codes.

The second volume of the book includes papers in the field of constructing binary sum codes weighted bits and transitions between bits occupying adjacent positions in data vectors of code words, as well as the results of studying their characteristics and methods of synthesising coding equipment. The issues of application of features of codes in organisation of self-checking discrete systems are considered. The reader will find on the pages of this volume materials on detailed characteristics of error detection in data bits of weight-based sum codes provided that the check bits are error-free, descriptions of methods for constructing previously unknown weight-based sum codes and features of methods for synthesising self-checking discrete systems based on them.

The book can be useful for developers, researchers and engineers working in the field of technical diagnostics of discrete systems and synthesis of systems with fault detection, as well as students studying computer science, computer technology and automation.

Keywords: automation hardware, synthesis of self-checking circuits, embedded control, binary redundant codes, self-checking discrete system.

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Текст статьи на русском языке публикуется в первой части данного выпуска.**

In 2021, the Nauka Editions published a two-volume edition of «Proceedings on the self-checking embedded control circuits synthesis theory based on binary redundant codes», which included the main papers of the team of St. Petersburg scientific school on technical diagnostics under the guidance of professors Valery Vladimirovich and Vladimir Vladimirovich Sapozhnikovs, published in the period from 2009 to 2020. In our opinion, the published work deserves special attention of the scientific community due to the fact that it actually determines the main stages in the development of code methods for synthesising means of detecting errors caused by faults of various physical nature in technical systems.

First, it is necessary to remind the reader that in development and design of technical means of automation, both in industry and in transport, special attention is paid to the issues of not only ensuring correct execution of laid down algorithms, but also to protection against failure, malfunction, and their manifestations in the form of errors in calculation results. This requires the developer to lay down the properties of checkability, self-testing, self-checking, fault-tolerance, safety behaviour in case of failures and other malfunctions at the stage of creating the very prototype of the future device. It is on these properties that the reliability characteristics of the device and the nuances of its operation depend in the future. As a result, all the features of the life cycle of technical means of automation are determined even at the stage of its development, when it is possible to foresee the most rational architecture of the device, the composition, and the need for technical means of diagnostics, to assess the risks of failures and persistent failures.

In the transport industry, information and control systems for critical purposes are often used, the failure of which should not lead to a hazardous event (potentially affecting development of conditions for the occurrence of accidents and disasters or leading to them). It is for this purpose that special requirements have been developed for critical information management systems, which are somewhat similar, but somewhat different in various branches of transport. For example, in the railway sector, in development of microelectronic and microprocessor-based train control systems, the following concept is adhered to [1]: *single defects in hardware and software should not lead to*

dangerous system failures and should be detected during operating or test influences no later than the second defect arises in the system. Hence it follows that the most important in construction of modern control systems are not only the principles of synthesis of systems with controllable structures, but also the principles of implementing diagnostic support.

Diagnostic support of technical systems allows solving problems of test and working (functional) diagnostics [2; 3]. Test diagnostics implies disconnecting an object from performing its main functions in order to apply special testing influences to its inputs. Working diagnostics is connected with the fact that working combinations are at the same time test ones for the object being diagnosed. The diagnostic procedure itself does not require disconnecting the diagnosed object from the controlled devices. In systems of critical application, both of these types of diagnostics are used on an equal footing. This, of course, requires the introduction of both hardware and software redundancy (redundancy and diversity), the use of information and time redundancy. One of the most important approaches to implementation of operational diagnostics procedures is the use of self-checking embedded control circuits (ECC). It is the issues of the synthesis of ECC for devices of automation and computer technology that the published edition is devoted to.

The book «Proceedings on the self-checking embedded control circuits synthesis theory based on binary redundant codes», presented in the form of two multi-page volumes, contains the main scientific works in the field of the theory of synthesis of ECC based on noise-immune redundant codes. The book includes four main sections. The first three form the first volume of the monograph and the fourth constitutes the second volume. A feature of the book and the research of the authors is that they consider not just ECC structures implemented on a specific element base, but the general features of the use of redundant coding for solving technical diagnostics problems. This makes the described results universal and applicable not only to the modern element base, but also to the developed one, which is important under the conditions of constant improvement of computer and information technologies [4].

The first section is devoted to the synthesis of ECC based on codes with summation of single digits and a description of their properties. The





features of classical sum codes (Berger codes) and their modifications obtained by calculating the weight of the data vector in the residue ring according to a predetermined modulus, dividing data bits into subsets with control of the weight of each of them, calculating special correction factors when constructing codes are covered. Separate materials are devoted to the application of the properties of sum codes in the synthesis of ECC.

The second section is devoted to the study of the characteristics of the well-known polynomial codes and Hamming codes in ECC. With regard to the set diagnostic tasks, the detecting abilities of these codes in data bits are considered. The main features of the class of systematic codes are shown, related to the fact that the resulting codes due to the use of modulo two convolutions in the synthesis of their encoders have non-unidirectional functions of the digits, and therefore their use in the synthesis of ECC should consider these circumstances.

The third section covers the results of the authors in the field of development of the Boolean Complement method for the synthesis of ECC. Here, all methods consider the use of constant-weight codes when organizing ECC with transformation of the last values of working functions of the objects to be diagnosed (and not

with concatenation (addition), as in the case of using separable codes). The Boolean Complement method allows synthesising completely self-checking ECC even in the case when this cannot be achieved by classical methods (including duplication with subsequent control of the outputs of the same name of various devices).

The fourth, the largest, section covers the features of the use of weight-based sum codes in the synthesis of ECC. The authors consider various methods of constructing sum codes, between the data bits of which inequality is established. It is achieved by assigning weight coefficients to the digits (or a group of digits) from a natural series of numbers. Such codes are divided by the authors into two classes – codes with summation of weight coefficients of the digits and transitions between the digits (in fact, the weight coefficients of the groups of digits). The monograph «Proceedings on the self-checking embedded control circuits synthesis theory based on binary redundant codes» describes codes with arbitrary weight coefficients, as well as codes, in the construction of which weighting of one and several digits is used, special sequences of weight coefficients are applied. Methods for synthesising ECC using the properties of weight-based sum codes are presented.

The authors show that it is possible to effectively use the properties of detecting errors of various multiplicity and types in the synthesis of ECC. Errors are classified according to the number of distortions of zero and one digits in data vectors into unidirectional and multidirectional, and the latter, in turn, into symmetrical (with the same number of distorted zero and one digits) and asymmetrical (with unequal). It is widely known that modern means of computer-aided design of automation circuits and computer technology consider only the possibility of detecting unidirectional errors by a number of codes. This is also used when choosing controllable structures and methods of error control in ECC at the device outputs. However, the authors have shown that many redundant codes have not only the ability to detect unidirectional errors, but also other types of errors, including up to a certain fixed multiplicity, which can also be applied in practice. In separate articles in the book, algorithms for the synthesis of completely self-checking ECC are given, taking into account such features of redundant codes. The established features should be taken into account in development of automated design tools for devices, which will reduce their structural (and when implemented at the software level – software) redundancy.

It should be noted that the authors are developing code methods for synthesizing ECC, described in the well-known publications of the Soviet and post-Soviet period of development of technical diagnostics [5–7], as well as in foreign publications [8–10]. At the same time, the results presented in this two-volume book are associated with a fairly deep level of research, and not superficial, as it was before, before the publication of the works of the co-authors of the book. Accordingly, the presented theory allows the designer to have a wide field of choice of the coding option when synthesizing ECC.

Unfortunately, in the post-Soviet space, there are not so many scientists who are engaged in the synthesis of completely self-verified ECC, and insufficient attention has been paid to their works.

However, the use of the results and their development allows in practice to more reasonably choose the method of implementing ECC, taking into account the specifics of the diagnostic object itself, which, ultimately, allows not only to reduce the complexity indicators of technical implementation of diagnostic tools, but also to improve economic indicators.

The book covers the results without reference to specific devices and systems, without highlighting any industries and transport, and will be of interest to a wide range of specialists in the field of automation and computer technology, who are engaged in development and improvement of computer and information systems.

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