Asymptotically Optimal in Reliability Circuits in Two Bases Under Failures of 0 ($k − 1$) Type at the Outputs of Elements

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Abstract—We consider a problem of the realization of k-valued logics functions ($k \geq 3$) by circuits in two bases: in the Rosser–Turkett basis and in its dual basis. We assume that the basis gates are exposed to faults at outputs: only of type 0 or only of type $k − 1$, and they pass into faulty states independently of each other. We describe a constructive method for the synthesis of an asymptotically optimal reliable circuit for almost any function of k-valued logic, we found the upper and lower bounds of circuits unreliability and the class of functions for which the lower bounds are true.

INTRODUCTION

Historically, at first when constructing reliable circuits (nonbranching programs), consisting of unreliable gates (operators) and realizing Boolean functions (i.e., $k = 2$), inverse faults at gates' outputs were investigated ([1–3]). Later, the possibility of implementing Boolean functions by circuits from unreliable gates, exposed to single-type constant faults of type 0 (or 1) at the outputs of gates was considered (for example, [4, 5]).

Like in the case of Boolean functions, the problem of constructing reliable circuits that realize the functions of three-valued (and generally k-valued) logic was also first solved in the assumption that the functional gates are exposed to inverse faults at their outputs [6–9]. In [10–12], properties of k-valued functions ($k \geq 2$) whose circuits can be used to increase the reliability of an original circuit are described, and an appropriate synthesis method is described. In [7, 13, 14], the problem of synthesis of asymptotically optimal with respect to reliability circuits over the Rosser–Turkett basis $\{0, 1, \ldots, k − 1, J_0(x_1), J_1(x_1), \ldots, J_{k−1}(x_1), \min\{x_1, x_2\}, \max\{x_1, x_2\}\}$ ($k \geq 3$) with inverse faults at gates' outputs is solved.

In this paper, we consider a realization of functions of k-valued logic ($k \geq 3$) by circuits from unreliable gates in two bases: The Rosser–Turkett basis and its dual basis, and for the first time investigate the single-type constant faults at gates' outputs: only of type 0 or only of type $k − 1$.

The purpose of this paper is to construct asymptotically optimal with respect to reliability circuits over two bases: The Rosser–Turkett basis and its dual basis for $k \geq 3$ and for single-type constant faults of type 0 ($k − 1$) at the gates' outputs.

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