A method for multiple soft fault diagnosis of linear analog circuits

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A method for multiple soft fault diagnosis of linear analog circuits

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Abstract

The problem of testing and diagnosing multiple soft faults in analog linear electronic circuits is discussed in this paper. An efficient method which detects faulty elements and evaluates their parameters is developed. The algorithm employs two diagnostic tests, carried out in AC state, providing rms values of the measured voltages. One of them, called a principal test, is used by the diagnosis procedure whereas the other test serves the validation purpose. Each of the voltages is an algebraic function of the tested parameters. The proposed algorithm solves least squares problem by minimizing the sum of squares of the differences between the measured voltages and the parametrized functions using the Levenberg-Marquardt method. The algorithm is applied to all testable sets of the elements and every time the result is verified using the validating test. The method may provide more than one set of the parameters which satisfy both tests due to ambiguity groups existing in the circuit. To adapt the method to the conditions encountered in practice, perturbations of the fault–free parameters and measurement uncertainty are taken into account. For illustration of the method the diagnoses of three benchmark linear electronic circuits are discussed using laboratory performed tests.

Keywords: analog circuits, Levenberg-Marquardt method, multiple fault diagnosis, parametric faults.

1. Introduction

Fault diagnosis of analog electronic circuits has been an active topic over the last decades [1-33] and is still an important problem of design validation. Although numerous strategies have been developed in this field the problem remains open and new diagnostic methods are needed. In general, analog circuit testing has three objectives: fault detection, identification of faulty elements, and estimation of their values. Fault is called soft if the parameter deviations exceed its tolerance scope, but do not cause catastrophic changes such as open circuits or short circuits. Methods for soft fault diagnosis start from some measurement data obtained while a diagnostic test is carried out.

Numerous reported works in the fault diagnosis field relate to circuits with single faulty element, e.g. [5,13,19,32-33]. It is justified because the single fault case is the most frequent, double or triple fault cases are less frequent. Multiple fault diagnosis, what is the subject of this paper, is a more difficult task. Several authors have discussed the problem of multiple soft fault testing and diagnosing of linear and nonlinear circuits. As a result different methods and computational techniques have been developed. They are based on a measurement test arranged in DC, AC, or transient state, leading to a system of test equations with the parameter values as the unknown variables. These equations are nonlinear, even in the case of linear circuits, and effective calculating their solutions is a crucial point of the diagnosis. When the number of variables increases determining the solutions becomes complex and requires very effective computational tools. Moreover, in entire multiple fault diagnosis this