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Hardware and software for electronic circuit diagnostics

Streszczenie. *Rozpatrzono teoretyczne i praktyczne aspekty diagnostyki układów elektronicznych przy prądzie stałym i w dziedzinie częstotliwości oraz niezbędne dla tego oprogramowanie i sprzęt pomiarowy. Przedstawiono opis wbudowanego systemu mikroprocesorowego dla pomiaru węzłowych potencjałów, oprogramowanie oraz przykłady diagnostyki układów elektrycznych przy prądzie stałym i w dziedzinie częstotliwości*

Abstract. *Theoretical and practical aspects of the electric circuits diagnostics in DC and in the frequency domain, and required for this purposes hardware and software were considered. The embedded microprocessor system of node potentials measurement, software and examples of electric circuits diagnostics in DC and in frequency domain were described.*

Słowa kluczowe: pomiar, testowanie, wykrywanie uszkodzeń w układach elektronicznych, potencjały węzłowe.
Keywords: measuring, testing, diagnostics of electronic circuits, node potentials.

Electronic circuit diagnostics includes two stages: experimental and computational. During the experimental stage the investigator works with the real circuits (measures the circuit response to different input signals). The goal of the computational stage (when the investigator works with the model of the circuit) is to find the parameters of the diagnosed circuit elements using the results obtained during the experimental stage.

Multi-test DC and frequency domain diagnostics method is used for the determination of the parameters of faults elements [1, 2]. Main problems of the procedure are related to the choice of measured quantities, test sources and their internal resistances, test elements and frequency points. The selection of measurement equipment is also important as the error in the measurement of node potentials has an influence on the overall diagnostics results [3].

Developing the diagnostics software we have taken into account the peculiarities of the diagnostic equation formation by multi-test method and problems that arise during solving of the equations. Hardware was developed on the base of microprocessor system allowing to measure node potentials in DC mode and real/imaginary parts of node potentials in frequency domain

In order to form the diagnostic equations describing electronic circuits the node potentials method is used. Necessary and sufficient conditions of the solution existence are fulfilled due to using accessible and partially accessible nodes testing. Such testing also allows for solving the ambiguity groups problems. Testing of the electronic circuits is performed by connecting test voltage sources as well as by connecting test RLC- elements. In most cases this allows to exclude the influence of elements of ambiguity groups. The diagnostics results depend on test sources and their parameters, frequency points, techniques of the node potential measurements and node potentials measurement error values.

Implemented a method and algorithm for modeling of error parameters diagnosed dependence from the error of ADC used of the measure the nodal potentials.

Diagnostics hardware is the embedded microprocessor system for the measurements of the node potentials in DC mode and real/imaginary parts of node potentials in frequency domain. The system is designed as a PCB to which the circuit under study is connected. The PCB consists of two main modules: the control module and the measurement module. The system also includes LCD indicator, keyboard, sinewave generator, filter and amplifier. The core of the system is the C8051FX352 microcontroller which is used for system control, signal generation and node potential measurements.

LCD indicates the system modes and shows the results. 4-keys keyboard allows switching between modes, setting selected mode parameters and saving selected mode into system memory.

Sinewave generation is realized on the base of direct digital synthesizer AD9832 from Analog Devices. LC-filter is connected to the synthesizer output in order to eliminate digital noise. FSYNC input of the synthesizer is driven by 24 MHz pulses from an external generator. The necessary level of the generated signals is ensured by exploiting transistor power amplifier.

Measurements are performed using 16-bit serial ADC embedded into microcontroller chip. Measured signal is transferred to ADC input from programmatically controlled pre-amplifier. In order to determine real and imaginary parts of node potentials the measurements are performed at fixed moments, shifted in phase for 90 degrees.

This paper show the importance choice available and party available nodes (topological conditions) the measurement of nodal potentials in diagnosed scheme in terms of its diagnosis. Two versions of multi-test diagnostics method software were developed – DIAGNDC (DC mode measurements) and DIAGNFREQ (frequency domain measurements). Both versions includes circuit topology description module, DC analysis module, frequency domain analysis module, module for the calculations of node potential sensitivity depending on the elements parameters, diagnostics equation formation module, module for the solution of the system of equations by modified Newton method and module for linear system solution using parametric regularization.

Testability algorithm of the electronic circuits is considered on the low-pass active filter. Examples of the diagnostics of linear resistive circuit using DC measurements of node potentials and the diagnostics of 2T-bridge using frequency domain measurements of real/imaginary parts of node potentials.

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