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COMPARISON OF SIMULATION RESULTS OF COMPUTER ANALYSIS OF GUARDED HAMON TRANSFER DEVICES WITH THE RESULTS OF EXPERIMENTAL RESEARCH

One of the methods of guarded Hamon transfer devices ratio accuracy analysis are simulations done with dedicated computer software. In the paper results of comparison of such simulations with the results of experimental research are presented.

Keywords: Resistance measurement, resistance transfer, computer simulations

PORÓWNANIE WYNIKÓW ANALIZY SYMULACYJNEJ TRANSFERÓW HAMONA Z PODWÓJNĄ IZOLACJĄ Z WYNIKAMI BADAŃ EKSPERYMENTALNYCH

Analizę dokładności stosunków rezystancji transferów Hamona z podwójną izolacją i podnoszeniem potencjału ekranu, można przeprowadzić za pomocą dedykowanego oprogramowania komputerowego, umożliwiającego symulacyjne wyznaczenie rezystancji transferów. W niniejszej pracy przedstawiono porównanie wyników przeprowadzonych symulacji z wynikami badań eksperymentalnych.

Słowa kluczowe: pomiary rezystancji, transfer rezystancji, symulacje komputerowe

1. INTRODUCTIONS

Guarded resistance transfer device (also called guarded Hamon transfer) consists of two networks of resistors: the main and guarding. Each of them has 10 precise high value resistors connected permanently in series. The resistors are connected with coaxial Triax type connectors, which allows to change configurations of resistors from a series to a series-parallel and parallel configuration with proper coaxial plugs with shunts.

A resistance ratio of ten resistors connected in series to the same ten resistors in parallel configuration equals 100. The resistance ratio of ten resistors in a series configuration to the resistance of three parallel rows consisting of three resistors connected in series (serial-parallel configuration) equals 10. Hamon transfer devices are used in systems for resistance scaling in many National Metrological Institutes (such as National Institute of Standards and Technology in USA or National Institute of Metrological Research in Italy). They allow to scale from one resistance level to higher resistance levels [1-3].

Currently, as a part of Applied Research Programme of The National Centre for Research and Development project, the authors are developing resistance transfer devices. In the research, a lot of attention is paid to the analysis of the factors that can affect the accuracy of high resistance transfer devices.

The subject of this paper is to compare results of computer simulations with the results of Hamons transfers resistance measurements. The paper focused on (10 – 100 – 1000) GΩ, (1-10-100) GΩ and (0.1-1-10) GΩ guarded resistance transfers devices in series, series-parallel and parallel configuration.

2. COMPUTER SIMULATIONS

To predict resistance of (10 – 100 – 1000) GΩ, (1-10-100) GΩ and (0.1-1-10) GΩ Hamon transfer devices in series, series-paraller and paraller configuration, object-oriented modeling and computer simulation program have been used. Computer analysis were done based on the model shown in Figure 1 (in which R_1,… R_k,… R_{10} are transfer resistors, R'_1,… R'_k,… R'_{10} are guarding resistors R_{i1},…R_{ik},… R_{i10} and R'_{i1},… R'_{ik},… R'_{i10} are values of insulation resistance). A detailed description of the presented in figure 1 model and more information on the simulations studies carried out by the authors can be found in [4].

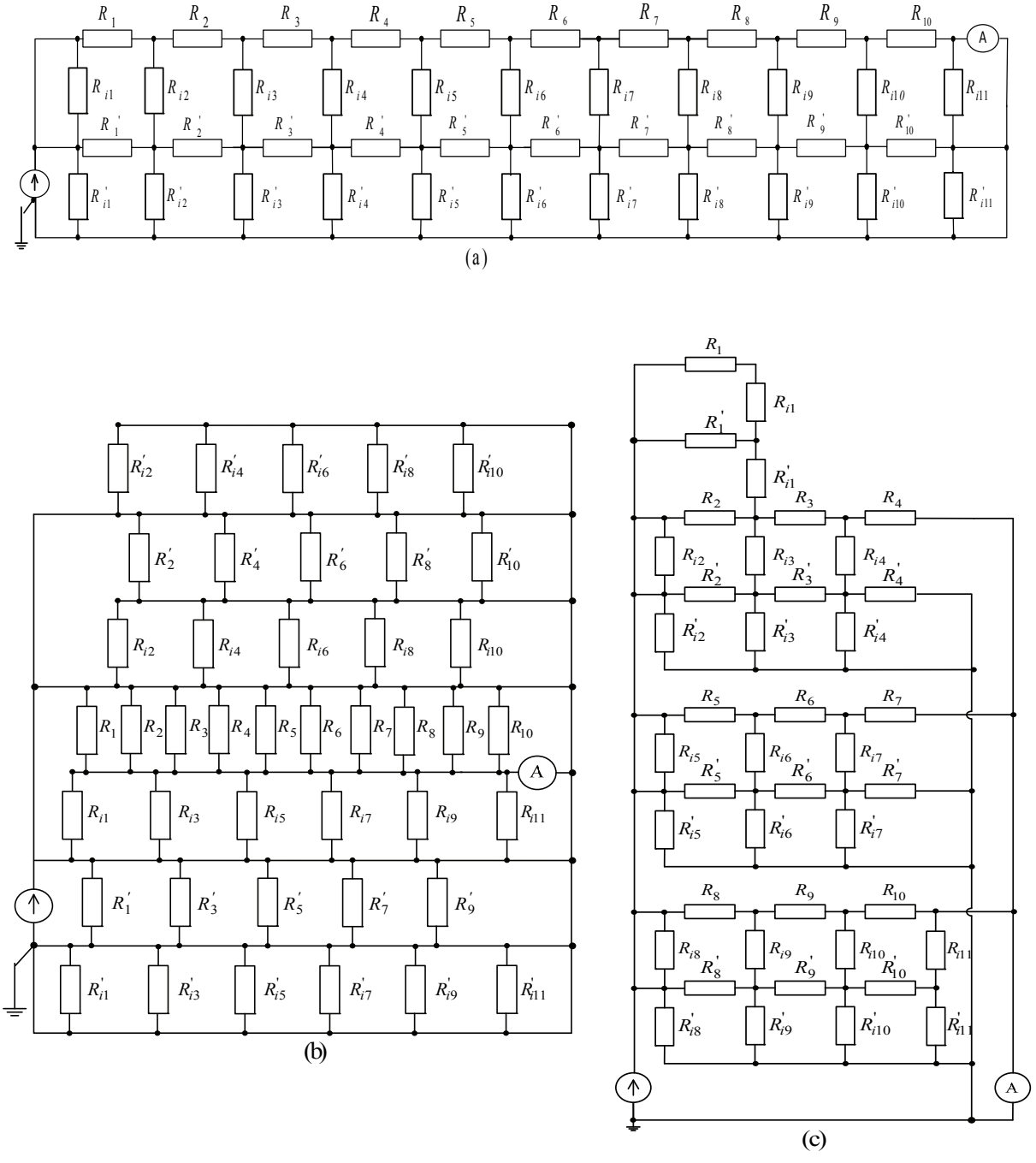

Fig. 1. Models of guarded high-resistance transfer devices in a series (a), parallel (b) and in series-parallel (c) configuration

3. MEASUREMENTS OF HAMON TRANSFER DEVICES RESISTANCE

Measurements were done with high value resistance meter Keithley 6517B in thermostabilized conditions. The substitution method (ratio 1:1) was used.

If measured value of standard resistor is

$$R_N = R_1, \tag{1}$$

and measured value of Hamon transfer device resistance is

$$R_X = R_2, \tag{2}$$

where R_N – standard resistance, R_X – unknown resistance, R_1 and R_2 – resistances read from high value resistance meter. Then, after dividing sides and simplifying R_X equal

$$R_X = R_N \cdot \frac{R_2}{R_1}. \tag{3}$$

Uncertainty $u(R_X)$ can be determined by the expression

$$u(R_X) = \sqrt{c_{R_1}^2 \cdot u^2(R_1) + c_{R_2}^2 \cdot u^2(R_2) + c_{R_N}^2 \cdot u^2(R_N)}, \tag{4}$$

$$c_{R_1} = -\frac{R_2 R_N}{R_1^2}, \tag{5}$$

$$c_{R_2} = \frac{R_N}{R_1}, \tag{6}$$

$$c_{R_N} = \frac{R_2}{R_1}. \tag{7}$$

Because $R_1 \approx R_2$, the systematic errors of the high value resistance meter are abolished, it means that $u(R_1)$ and $u(R_2)$ contain only type A uncertainty. As a standard resistors R_N precision Zelap and Guildline standard resistors were used.

4. MEASUREMENTS AND SIMULATION RESULTS

Tables 1-3 present the results of computer simulations and results of measurements of Hamon transfers resistance value.

Table 1
Comparison of (10-100-1000) GΩ Hamon transfer device resistance simulation results with the results of measurements

(10-100-1000) GΩ transfer device		
Configuration	Results of measurements [GΩ]	Results of simulations [GΩ]
Series	(996.3÷1002.3)	999.9
Series-parallel	(99.95÷100.08)	100.00
Parallel	(9.932÷10.070)	9.999

Table 2
Comparison of (1-10-100) GΩ Hamon transfer device resistance simulation results with the results of measurements

(1-10-100) GΩ transfer device		
Configuration	Results of measurements [GΩ]	Results of simulations [GΩ]
Series	(99.912 ÷100.083)	99.912
Series-parallel	(9.929÷10.067)	9.991
Parallel	(0.99905÷1.00031)	0.99912

Table 3
Comparison of (0.1-1-10) GΩ Hamon transfer device resistance simulation results with the results of measurements

(0,1-1-10) GΩ transfer device		
Configuration	Results of measurements [GΩ]	Results of simulations [GΩ]
Series	(9.9965 ÷10.0057)	9.9965
Series-parallel	(0.99939÷0.99973)	0.99958
Parallel	(0.0999647÷0.0999722)	0.0999648

5. CONCLUSION

As a part of the research, (10-100-1000) GΩ, (1-10-100) GΩ, (0.1-1-10) GΩ Hamon transfer devices resistance measurements were done. Then the determined resistance values were compared with the results of computer simulations. As can be seen from the data presented in tables 1-3, measurements results match the predicted values. It is worth to notice that computer simulations are a reliable tool for analyzing the accuracy of resistance transfer devices.

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