SYNTHESIS OF THE ERROR CORRECTION TECHNIQUES FOR THE LINEARIZED FOUR – ARM BRIDGE CIRCUIT MEASURING DEVICES

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Abstract − *The paper considers the problem of the synthesis for the impedance parameters measuring devices having high metrological characteristics and new functional possibilities. The Winston bridge is selected as the measuring circuit for the similar measuring means design and the structural methods (structural-algoritmic ones) are taken as the methods for the measuring devices properties improvment.*

Keywords – measuring circuit, impedance parameters, structural method, measuring accuracy.

The development of science and technology sets higher requirements to the existing park of the electromeasuring devices both by the metrological characteristics and by the functional capacities. Hence the measuring devices improvement continues to be an actual problem for the designers of the electromeasuring devices and the present work is devoted to its investigation.

The said devices are known to use the four – arm bridge measuring circuit (BMC) by which properties the main technical data of the electron measuring devices are defined.

The author has already synthesized the structural techniques of the convergence, sensitivity and linearization improvement of BMC [1], the ways of measurement accuracy increase excluding the influence of the non-informative parameters in series connected with the informative parameter of the investigated object [2]. However with the help of these structural techniques one cannot decide all problems concerning. The BMC measurement accuracy increase for example, the correction of the additive, multiplicative errors and so on. While searching new structural ways of the measurement accuracy increase, the author paid his attention to the synthesis of the so-called structural-algoritmically ways. Such a name of these ways results from the necessity to change BMC structure while conducting the measurements by the certain algorithm and these measurement results processing using the known calculating formula.

The results and the advantage of the work are maintly proved by the solution of the problem concerning the new technical ways synthesis by the determination of a number of the structural-algorithmical ways subsequently used for the set problem solution of the signal graphs. The latter greatly accelerates and simplifies the problem solution.

The synthesis of the impedance parameters measuring devices with the errors correction was stuided using Winston bridge as an example in which one of the structural methods suggested in [1] was used. Based on this bridge we also considered the evolution of the structural methods, new structural measuring circuits having improved metrological and functional possibilities development.

Fig.1a shows graph BMC indicating that the measurement object is included into the down branch surrounded by the positive back coupling. Such a graph has a linear output value in relation to $Z_{xp}=Z_1+ Z_x+ Z_2$, where Z_1 and Z_2 – modulates by itself the non-informative parameters, Z_x - the impedance of the measurement object. It becomes possible to carry out the direct conversion of the scalar values obtaining proportional to Re Z_x and Im Z_x in BMC (the functional converters indicated as F_1 and F_2 on the graph are used for these values). For the time being it was considered to be a step forward in the development of the design principles of the impedance parameters measuring devices.

Later to avoid the influence of Z_1 and Z_2 on the measurement accuracy, the new structural methods were developed, so the new structural circuits BMC appeared.

The example of the graph BMC excluding the influence of Z_1 and Z_2 on the measurement accuracy is given on Fig.1b. As it is seen, first the value A_{10} independent on Z_1 and Z_2 is formed in the graph which further is summed up with the value A_e. As a result the output value of BMC − A_{20} becomes independent on Z_1 and Z_2. The compete variants of the similar graphs, their variations are considered in [2] in details. The development of the measuring devices on the basis of these graphs was very important. But now the new structural methods are required as the problem of the error correction including the additive, multiplicative and others ways remains urgent.

To solve this problem the author developed new structural methods, which will be considered on the example of the graph on Fig.1c. It is clear that the graph structure changes according to the certain algorithm with the elements designated as M_1 and M_2 which in the first time tact is provided with the parameters Re Z_x and Im Z_x measurement with the error influence, the second interval – correspondingly Re Z_{01} and Im Z_{01} , in the third interval - Re Z_{02} and Im Z_{02}.

Thus, the measured values of the measuring device designed on the basis of such a graph are

$$Y_{11}= Re(a+bZ_x+cZ_x^2)$$
$$Y_{21}= Im(a+bZ_x+cZ_x^2)$$
$$Y_{12}= Re(a+bZ_{01}+cZ_{01}^2)$$
$$Y_{22}= Im(a+bZ_{01}+cZ_{01}^2)$$
$$Y_{13}= Re(a+bZ_{02}+cZ_{02}^2)$$
$$Y_{23}= Im(a+bZ_{02}+cZ_{02}^2).$$

The computer-aided solution of the system allows determining Re Z_x and Im Z_x without the influence of the coefficients a, b, c, determining the measurement channel errors.

It is also important to show how to minimize the graph by the knots amount in which the active values are formed.

Such minimization will provide the essential simplification of the measuring device design. It is worth paying attention to the fact that in the graph – Fig.1c the active values A_{10}, A_{11}, A_{12} are formed in three knots, the realization of which in the measuring device will require 3 subtraction devices.

It turns out that the number may be reduced to one as it is shown on Fig.1d. Such graph is added with the element designated as M_3 but the values A_{10}, A_{11}, A_{12} are formed consequently in the time in the knot pointed g.

The graph also uses the designations: C_1, C_2 – analog – digital converters; L – computer.
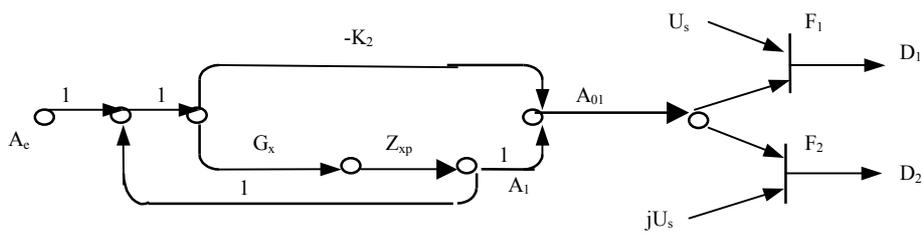
On the basis of the obtained graph the precise measuring device was designed and it is given on Fig.2 in which the voltage repeatitors (R), amplifiers (S_1, S_2), scale amplifier (S_3), summarizer with the addition coefficient 1 (S_4, S_5).

Fig.2 also shows that the measurement objects are switched on along the 4-wired switching circuit although the 3 – wired on could be also used.
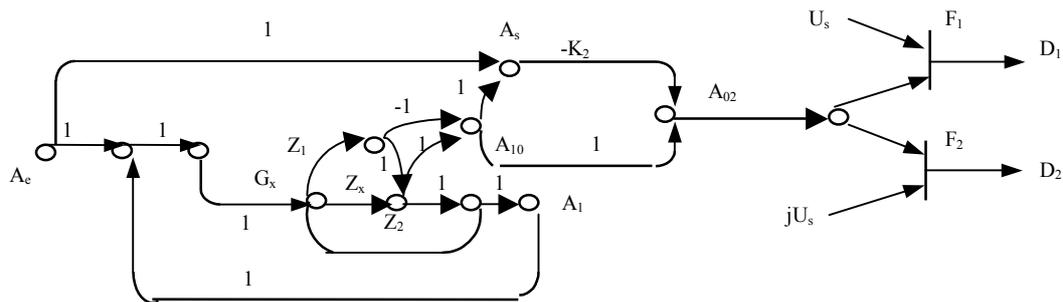
The work also suggests the technique of the structural-algorithmically ways synthesis, which may be used for the ways synthesis applied in the other classes of the measuring circuits. The author comes to the conclusion of the substantial development of the BMC structural improvement theory resulted from the structural-algorithmically ways synthesis. The work gives the research results of the got ways, characterizes their advantages and disadvantages, shows the BMC accuracy measurement degree, suggests the variants of the perspective BMC design which can be widely used in measurement of many electrical and physical parameters. The BMC described in the work can be effective by used during the biomedical investigations.
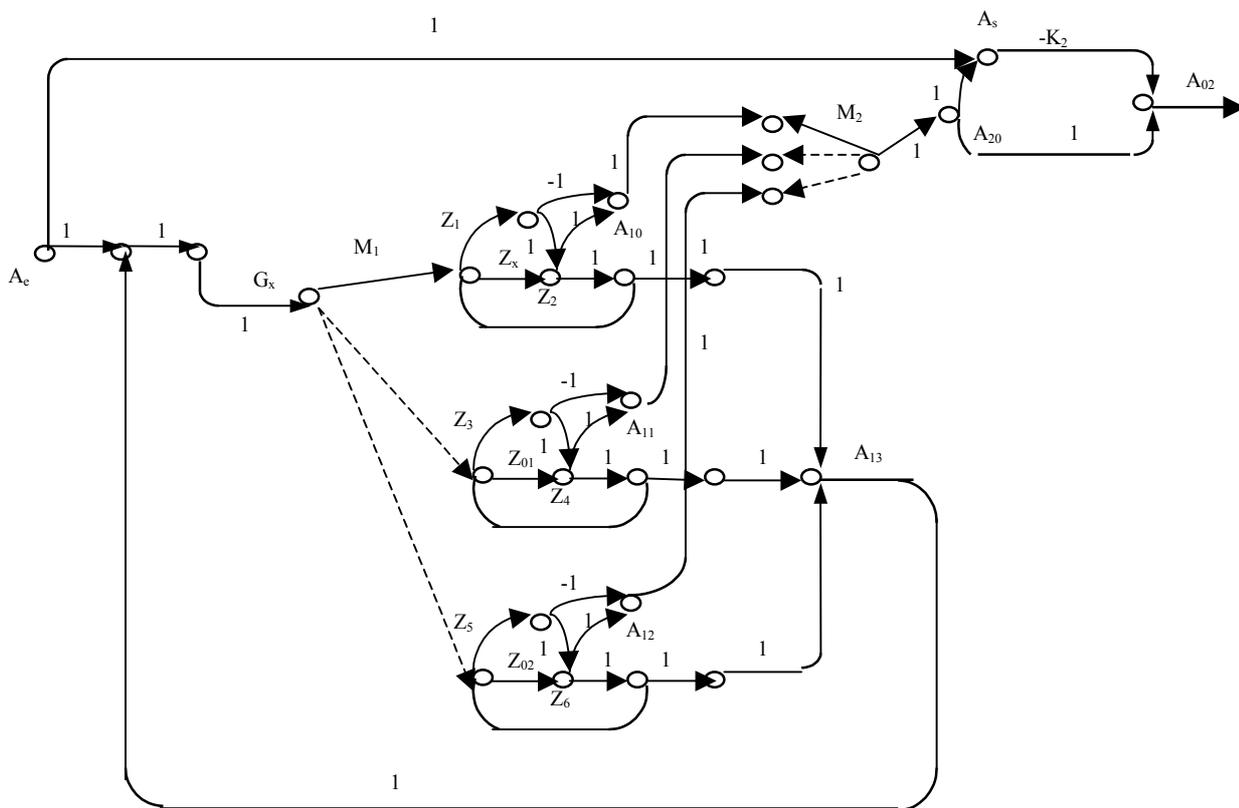
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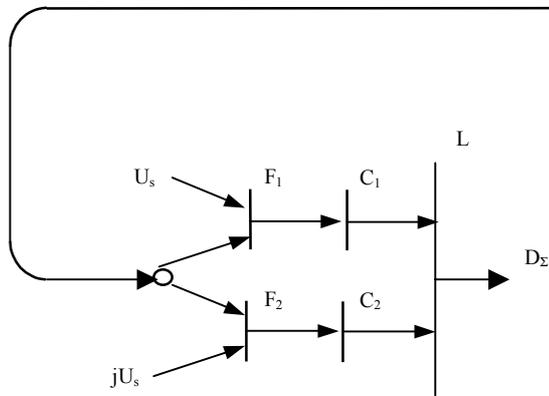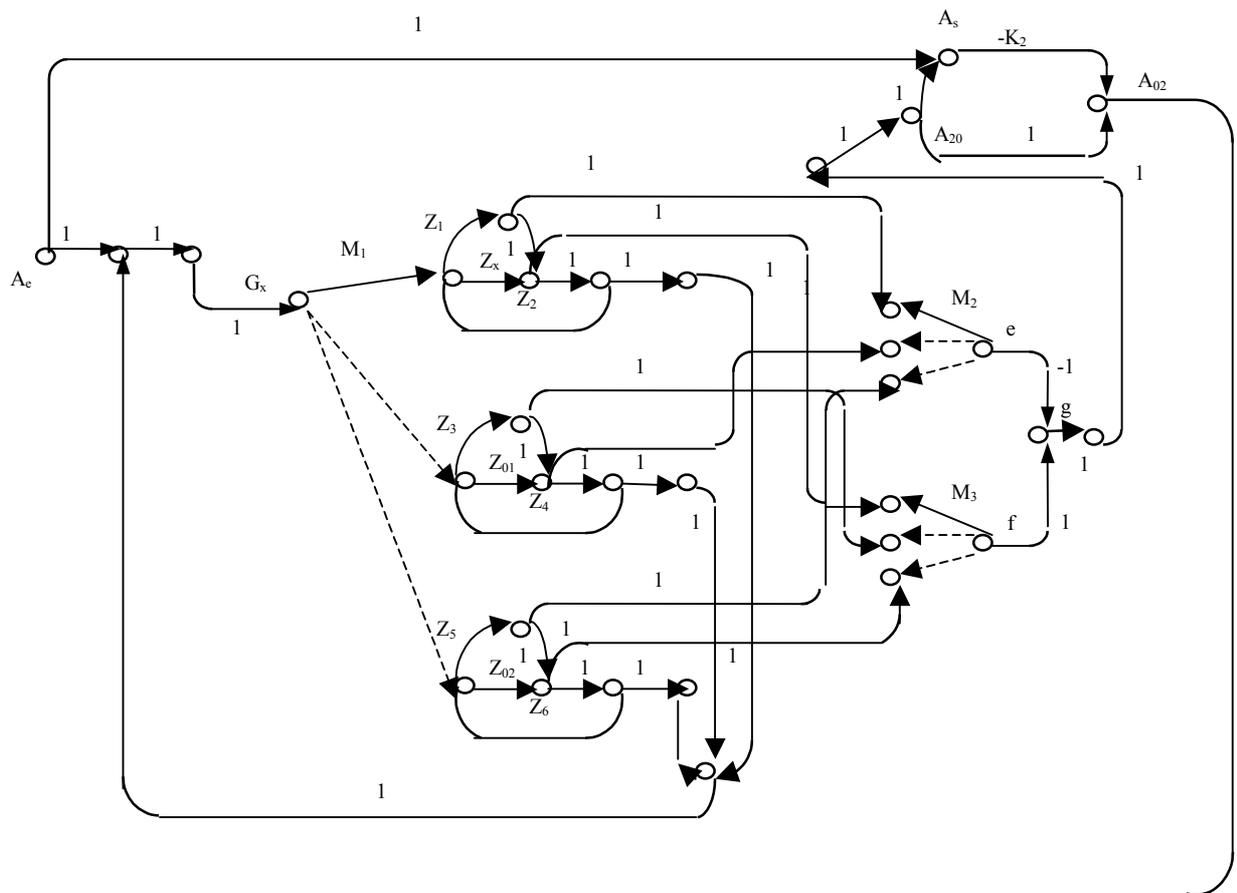[2] B. Khastsaev. Synthesis of impedance meters invariant to uninformative parameters, ACTA IMEKO, 1995.

a

b

c

A_s $-K_2$ A_{02}

1

A_{20} 1 1 1

Z_1

Z_x 1 1 1

M_1 Z_2 1

G_x M_2 e -1 g

A_e 1 1 1

1

Z_3

Z_{01} 1 1 1

Z_4 M_3 f 1

1

1

Z_5 1

Z_{02} 1 1

Z_6 1

1

L

U_s F_1 C_1

D_Σ

jU_s F_2 C_2

d