# METROLOGY, QUALITY, STANDARDIZATION AND SERTIFICATION

## MEANS OF MEASUREMENT OF RELATIVE QUALITY INDICATORS BY IMMITTANCE PARAMETERS

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**Abstract.** The paper describes the problems of implementation of the differential method of product quality assessment using the immittance method. The differential method of quality control is realized through a comparison of parameters of the immittance of the controlled and reference samples. The application of traditional meters of CLR-parameters complicates the process of the differential method implementation. Such units cannot directly measure relative quality. Virtually all models of such measuring instruments measure only the parameters of the monitored object through the input device. Thus, they are not adapted to the direct measurement of relative quality indicators. The authors propose to introduce a product pattern with the values of the code-controlled measure of admittance. These values are obtained by measuring the parameters of a standard pattern of products of a given quality level with a traditional immittance meter. The structure of the measuring instrument for the direct measurement of the relative quality index is given. The method is realized by comparing the parameters of the controlled object and the electrical standard pattern in the form of a code-controlled measure of admittance. This allows building quality control means for any non-electrical products. Controlled products are supplied by electrical parameters of immittance with means of capacitive primary converters. Direct application of the differential method of quality assessment allows simplifying the measuring instrument as much as possible and reduce the time of product quality assessment. The proposed structure of the unit enables us to determine the deviation of the relative indicator from the value one. According to the obtained value of the indicator, products can be quickly classified by quality levels.

**Key words:** Differential Method, Code-Controlled Measure of Admittance, Active Component of Admittance, Reactive Component of Admittance, Standard Sample.

### 1. Introduction

Immittance analyzers with a wide frequency range of the test signal are widely used to control the quality of non-electrical objects. According to the physical state of the object, the corresponding primary transducers are used additionally [1]. The following algorithm is the basis of such measurements. Any object of control with different levels of electrical conductivity is presented in the form of an electric bipolar, the immittance parameters of which can be analyzed by traditional meters of CLR parameters [2]. Such parameters are mostly active resistance and conductivity, capacitance and inductance, active and reactive components of impedance or admittance. Such control objects in the frequency range are described by bipolar poles with multi-element substitution circuits. At the same time, traditional meters of immittance parameters carry out measurements according to two-element schemes. Therefore, the measured parameters of the bipolar schemes will be only equivalent to the set measurement frequency.

To implement the differential method of quality control by the relative indicator, the use of traditional immittance meters [3, 4] requires time-consistent measurement. First, the monitored object is connected to the measuring instrument, and then to the standard pattern. The reason for this is the presence of only one input device of the measuring instrument. The implementation of the differential method is possible even under these conditions. To do this, the search for the ratio of the obtained values of the active and reactive components of the admittance of the controlled and base patterns at each measurement frequency is necessary. However, ensuring the condition of exactly accurate measurements is important. Placing an additional controlled switch at the input of the meter is impractical due to the introduction of uninformative imitation in the measuring circuit, especially since the input circuits of such means are different. That is, to implement a differential method of quality control in this way (consistently over time), additional memorization of the results of each measurement and their processing is necessary. This leads to a deterioration in the efficiency of quality control. That is why the development of specialized means of measuring the parameters of immittance is appropriate for qualimetry problems to apply a differential imitation method of quality control of non-electrical products.

### 2. Disadvantages

Virtually all models of traditional CLR meters can measure the parameters of only one control object (one input device) [5–7]. Thus, they are not adapted to the implementation of the differential method. Accordingly, they cannot directly measure relative quality parameters. However, another problem of relative control is the introduction of a standard product pattern in the measurement process. This creates a problem of its stability due to limited shelf life, damage to deterioration, etc. Therefore, the task of the study is to create an operational means of product quality monitoring for its relative quality indicators using a stable electrical base pattern. This will significantly simplify the process of assessing the quality of non-electrical nature products.

## 3. The Goal of the Work

The purpose of the study is to create an operational means of product quality monitoring by their relative quality indicators concerning a permanent electrical standard pattern.

## 4. Implementation of the differential method

### 4.1. Analysis of ways to implement a differential method of quality control

As is known from [8], according to the differential method of product quality assessment, the quality indicators of controlled products are compared with similar indicators of the standard pattern of these products. Preferably the standard pattern is a portion of the same product with normalized values. This corresponds to the standard level of its quality or safety. Since the individual indicators of product quality of non-electrical nature are of different nature, it is necessary to use different types of measuring instruments for their measurement. According to the results of measurements and their processing, a complex relative indicator is found. According to him, the level of quality is assessed. The implementation of the differential method of quality control by the imitation method makes it possible to obtain a relative quality indicator of electrically conductive products on the generalized parameter. To do this, a measuring instrument of one type – CLR-meter is used.

Known methods of application differential imitation quality control of non-electrical nature products involve simultaneous and consistent in time measurement of the relative quality indicator [9–11]. Thus the traditional standard pattern is used directly both at simultaneous and consecutive measurements. During the measurement process, the parameters of the pattern must be converted into electrical parameters. Such parameters, in particular, may be equivalent to the capacitance and conductivity of the admittance of a multi-element bipolar. In this case, the traditional standard pattern according to the measurement results can be replaced by an electric measure with the appropriate parameters. The results of measurements on a two-element circuit at different frequencies will differ. Accordingly, the electrical measure, as a standard pattern, must reproduce exactly the values of equivalent capacitances and conductivities at fixed frequencies. In this case, the relative indicators at the selected frequencies are recorded by the relations:

$$\left(\frac{C_{x1}}{C_{01}}\right)_{f1}, \left(\frac{C_{x2}}{C_{02}}\right)_{f2}, \left(\frac{C_{x3}}{C_{03}}\right)_{f3}, \ldots, \left(\frac{C_{xn}}{C_{0n}}\right)_{fn}, \quad (1)$$

$$\left(\frac{G_{x1}}{G_{01}}\right)_{f1}, \left(\frac{G_{x2}}{G_{02}}\right)_{f2}, \left(\frac{G_{x3}}{G_{03}}\right)_{f3}, \ldots, \left(\frac{G_{xn}}{G_{0n}}\right)_{fn}, \quad (2)$$

where $C_{x1}$, $C_{x2}$, $C_{x3}$, $C_{xn}$ and $C_{01}$, $C_{02}$, $C_{03}$, $C_{0n}$ are the equivalent capacities of the controlled object and the electrical standard pattern, respectively, at frequencies $f_1, f_2, f_3, f_n$; $G_{x1}$, $G_{x2}$, $G_{x3}$, $G_{xn}$ and $G_{01}$, $G_{02}$, $G_{03}$, $G_{0n}$ are the equivalent conductivities of the controlled object and the electrical standard pattern respectively at frequencies $f_1, f_2, f_3, f_n$.

The measure of admission can be implemented using sets of capacitance and conductivity or individual capacitors and resistors. In this case, the values must be selected manually. This method of implementation does not ensure the efficiency of control. The measuring process can be automated using a code-controlled measure of admittance. The use of a code-controlled measure of the admittance as an electrical standard pattern eliminates the disadvantages of the known methods of implementing the differential method.

### 4.2. The structure of the mean for direct measurement of the relative quality indicators of products

The structure of the unit for the measurement of the relative indicator of product quality is proposed. The controlled object is supplied by a multi-element capacitive-type bipolar. Equivalent capacitances and conductivities are taken as an informative electrical parameter of the bipolar. Accordingly, the code-controlled measure of admittance is used as a standard pattern.

The block diagram of the measuring instrument (Figure) contains the source of the test signal STS, code-controlled measure CCM, vector converter “admittance-voltage” VC1 and VC2, converters “vector-scalar” CVS1 and CVS2, controller C and indicator I.

Vector converters VC1 and VC2 are made on operational amplifiers OA1 and OA2. The elements of the negative feedback OA1 are the immittance primary converter (immittance sensor of the capacitive IS type) with a controlled pattern with an admixture and a pattern resistor. Similarly, the elements of OA2 are a code-controlled measure of CCM with an admixture and an exemplary resistor. Converters VC1 and VC2 convert admittances into vector voltages $\dot{U}_x$ and $\dot{U}_0$. CVS1 and CVS2 converters are connected to outputs VC1 and VC2. They convert vector voltages into reactive and active components. The obtained DC voltages are fed to the input of the controller K, the output of which is connected to the indicator I.

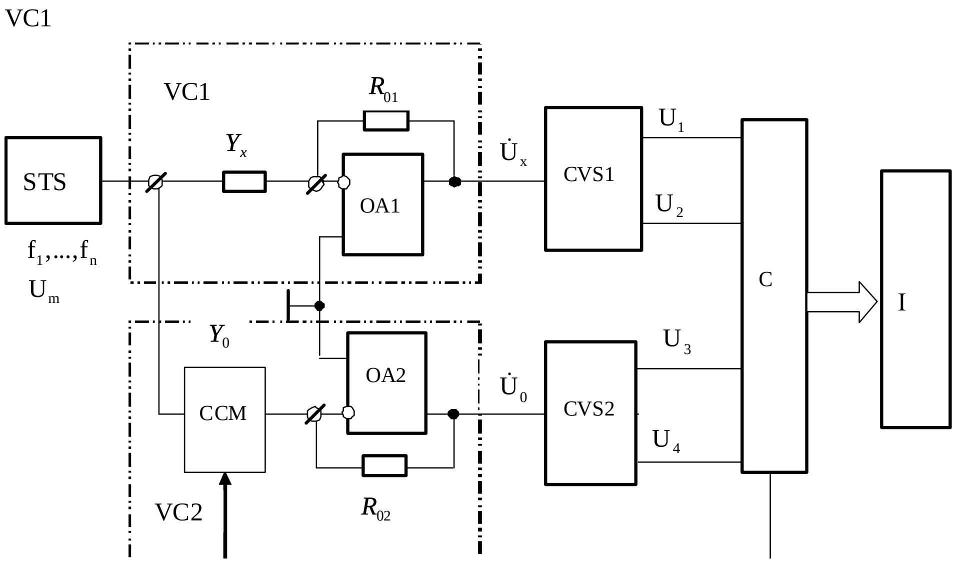


*Figure. Block diagram of the means with parallel vector transformation*

Code – controlled measure reproduces the normalized values of the standard pattern of controlled products in the form of equivalent capacities and conductivities. Such values are obtained by measuring the equivalent capacitance and equivalent conductivity of the standard pattern with the meter of the parameters of the admittance. They are stored in the controller's memory as a code.Vector voltages are formed under the action of the test sinusoidal signal of the set level and frequency by vector converters VC1, VC2

$$\dot{U}_x = a_1 U_m R_{01} Y_x = a_1 U_m R_{01} \left( G_{xi} + j\omega C_{xi} \right), \quad (3)$$

$$\dot{U}_0 = a_2 U_m R_{02} Y_N = a_2 U_m R_{02} \left( G_{0i} + j\omega C_{0i} \right). \quad (4)$$

Accordingly, the reactive $\mathrm{Im}\left(\dot{U}_x\right)$, $\mathrm{Im}\left(\dot{U}_0\right)$ and active components $\mathrm{Re}\left(\dot{U}_x\right)$, $\mathrm{Re}\left(\dot{U}_0\right)$ are emitted in the form of DC voltages by the converters PVS1 and PVS2, namely:

$$U_1 = a_1 b_1 U_m R_{01} \omega C_x , \quad (5)$$

$$U_3 = a_2 b_3 U_m R_{02} \omega C_0 , \quad (6)$$

$$U_2 = a_1 b_2 U_m R_{01} G_x , \quad (7)$$

$$U_4 = a_2 b_4 U_m R_{02} G_0 , \quad (8)$$

where $a_1$, $a_2$ are the conversion factors of vector converters VC1 and VC2; $b_1, b_3$ are the conversion factors of reactive components of admittance, and $b_2, b_4$ are the conversion factors of active components of admittance of converters CVS1, CVS2; $G_x, C_x$ are the equivalent active conductivity and equivalent capacity of the controlled object. $G_0, C_0$ are the equivalent active conductivity and equivalent capacitance of the code-controlled measure.

Conversion of voltages (5), (6), and (7), (8) into digital codes is carried out by operation of division of voltages with the controller C:

$$N_1 = \frac{U_1}{U_3} = \frac{a_1 b_1}{a_2 b_3} \frac{R_{01}}{R_{02}} \frac{C_x}{C_0} , \quad (9)$$

$$N_2 = \frac{U_2}{U_4} = \frac{a_1 b_2}{a_2 b_4} \frac{R_{01}}{R_{02}} \frac{G_x}{G_0} . \quad (10)$$

If the equations $\frac{a_1 b_2}{a_2 b_4} \frac{R_{01}}{R_{02}} = 1$ $\frac{a_1 b_1}{a_2 b_3} \frac{R_{01}}{R_{02}} = 1$ are provided, then expressions (1), (2) are obtained at the set control frequency.

Similar results can be obtained at other values of the frequency of the test signal. The values of the code-controlled measure at different frequencies for the controlled products are set by the source code of the controller. As can be seen from expressions (9), (10), the measurement result does not depend on the level of the test signal.

The values of relative quality indicators are obtained during direct measurement at different frequencies and are recorded by the indicator.

## 5. Conclusions

Based on the proposed structure of the measuring instrument, the quality of non-electrical products can be monitored regarding an electrical measure as their standard pattern. Direct measurement of the relative quality indicators simplifies the implementation of the differential method of quality assessment. According to the obtained value of each indicator, products can be successfully classified by quality levels. The efficiency of monitoring and stability of the parameters of the standard pattern is ensured.

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## 7. Conflict of Interests

There is no conflict of interest while writing, preparing, and publishing the article, as well as mutual claims by the co-authors.

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