ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Methods For Determining The Informative Parameters When Processing The Measuring Signals Of Capacitive Transducers.

Maxim Alekseevich Mastepanenko[1]*, Shaliko Zhorayevich Gabriyelyan[1], Igor Nikolaevich Vorotnikov[1], Sergei Vladimirovich Mashkov[2], and Egor Vladimirovich Kulaev[1].

[1]Stavropol State Agrarian University, Zootekhnicheskiy lane 12, Stavropol 355017, Russia.
[2]Samara State Agricultural Academy, Uchebnaya str. 2, Kinel 446442, Samara Region, Russia.

ABSTRACT

The article presents the results of determining the informative parameter when processing the recorded quasideterministic signal of capacitive transducers of various physical quantities. This parameter is characterized by the independence of measurements from the beginning of the transition process, automatic compensation of the error from the zero offset of the measuring channel. These advantages speak about its efficiency and prospects when measuring various non-electric quantities by capacitive transducers.
Keywords: informative parameter, converters, transients.

**Corresponding author*

INTRODUCTION

In the general case, the problem of measuring capacitance at a direct current is solved by organizing a transient process in an measuring RC circuit when it is connected to a constant voltage source with zero initial conditions, as shown in Figure 1.

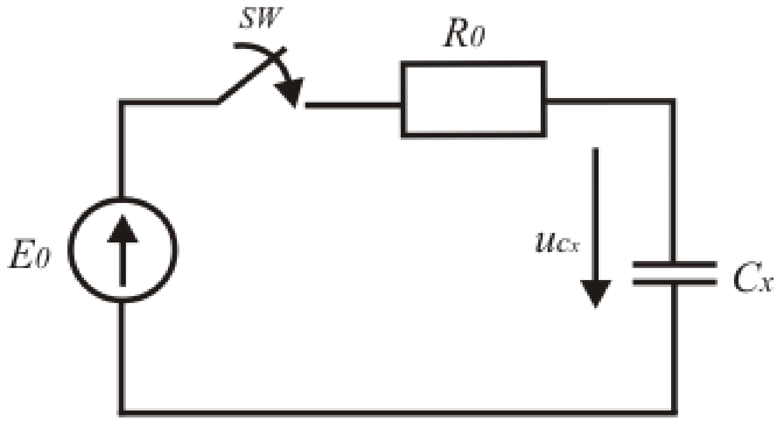

Figure 1: The equivalent circuit of the measuring circuit

RESULTS AND DISCUSSION

In this case, the desired value C_x is the capacity of the measuring transducer; the value of R_0 is known and is part of the measuring circuit. The voltage u_{Cx} (t) will change according to the law of aperiodic capacitor charge:

$$u_{Cx}(t) = E_0(1 - \exp\left(-\frac{t}{\tau}\right)), \quad (1)$$

where: ***E₀*** – Emf energy source;
t – current time;
τ – time constant.

$$\tau = R_0 \cdot C_x. \quad (2)$$

Obviously, it is the value of τ that contains information about the measured value of C_x, i.e.:

$$C_x = \tau / R_0, \quad (3)$$

Thus, it is the time constant that is the decisive informative parameter of the recorded quasideterministic signal, on which the accuracy and speed of the processing result largely depends.

Analysis of expression (1) shows that ***τ*** can be determined by the following known dynamic measurement methods (DI):

1. By logarithm of the exponent, which is part of expression (2.2) at a certain point in time:

$$\mathrm{E}_0 \cdot \exp(-\frac{t}{\tau}) = E_0 - u_{Cx}(t), \quad (4)$$

$$\ln\left(\exp\left(-\frac{t}{\tau}\right)\right) = \ln(\frac{(E_0 - u_{Cx}(t))}{\mathrm{E}_0}), \quad (5)$$

$$\tau = -\frac{t}{\ln(\frac{(E_0 - u_{Cx}(t))}{\mathrm{E}_0})}. \quad (6)$$

2. Using the value of the function of the voltage on the capacitor and the rate of its change at a certain point in time, namely:

$$u'_{Cx}(t) = -E_0\left(-\frac{1}{\tau}\right)\exp\left(-\frac{t}{\tau}\right) = \frac{E_0}{\tau}\exp\left(-\frac{t}{\tau}\right), \quad (7)$$

$$\tau \cdot u'_{Cx}(t) = E_0 \cdot \exp\left(-\frac{t}{\tau}\right). \quad (8)$$

Substituting (1.18) into (1.11) we get:

$$u_{Cx}(t) = E_0 - \tau \cdot u'_{Cx}(t)\,, \quad (9)$$

from where:

$$\tau = \frac{E_0 - u_{Cx}(t)}{u'_{Cx}(t)}. \quad (10)$$

3. Using the ratio of the first and second derivatives of the voltage function on the capacitance C_x at a certain point in time.

Really,

$$u''_{Cx}(t) = -\frac{E_0}{\tau^2}\exp\left(-\frac{t}{\tau}\right). \quad (11)$$

Dividing (1.17) by (1.21) we get:

$$\frac{u'_{Cx}(t)}{u''_{Cx}(t)} = \frac{\frac{E_0}{\tau}\exp\left(-\frac{t}{\tau}\right)}{-\frac{E_0}{\tau^2}\exp\left(-\frac{t}{\tau}\right)} = -\tau, \quad (12)$$

or

$$\tau = -\frac{u'_{Cx}(t)}{u''_{Cx}(t)}. \quad (13)$$

The reasoning presented in the author's works [1, 2, 3].

Methods for determining the informative parameters of the recorded signals, when the type of model can be predicted with high accuracy based on a priori information, and the random variables of the monitored variables are due only to induced interference, are often distinguished into separate approaches, called measurement-modeling.

At the same time, for solving problems of describing non-random signals, in which the value of one or several parameters is not known a priori and are considered random variables, approximation hikes are used with a small random component. The essence of the approach is as follows. In case the recorded signal x (t) is approximated by a model $x_M(t, \varphi_1, \dots \varphi_m)$, then, after measuring the m values of the signal for various arbitrary values of the argument *t*, we can make a system of *m* equations:

$$\begin{cases} x_{\mathrm{M}}(t, \varphi_1, \dots \varphi_m) = x(t_1) \\ \dots \\ x_{\mathrm{M}}(t_m, \varphi_1, \dots \varphi_m) = x(t_m) \end{cases} \quad (14)$$

For cases where the model $x_{\mathrm{M}}(t, \varphi_1, \dots \varphi_m)$ is non-linear with respect to parameters $\varphi_1, \dots \varphi_m$ function and values $t_1, \dots t_m$ chosen arbitrarily, system (14) may be difficult for an analytical or explicit numerical solution. In this case, the solution of the system can be simplified by selecting the values $t_1, \dots t_m$. Based on this, the use of a priori information to predict the shape of the recorded signal allows replacing the integral transforms with arithmetic operations with point estimates.

Of particular interest in the study of methods for determining informative parameters (in particular the time constant) of the recorded signal is an approach based on the use of instantaneous voltage values during a developing transient process.

The main advantage of this approach, namely the use of instantaneous values, is to reduce the time for determining the time constant, due to the appropriate choice $t_1, \dots t_m$. Those, eliminating the need to wait for the end of the transition process or the moment of determining the controlled variable.

The main parameters of the considered circuit are: voltage U_0, тcurrent time t and time constant τ.

For our research, of particular interest is the approach [4], which is related to determining the parameters of electrical circuits from instantaneous transients, not related to the moment when the voltage is connected to the measuring RC circuit for the case **when the measurement time is less τ** [2, 5, 6].

The instantaneous values of the voltage on the capacitor in accordance with (14) are determined by:

$$\begin{cases} u_C(t_1) = E_0\left(1 - \exp\left(-\frac{t_1}{\tau}\right)\right) \\ u_C(t_2) = E_0\left(1 - \exp\left(-\frac{t_2}{\tau}\right)\right) \\ u_C(t_3) = E_0\left(1 - \exp\left(-\frac{t_3}{\tau}\right)\right) \end{cases} \qquad (15)$$

To simplify the solution of the system, the choice of the time points t_1, t_2, t_3 should not be arbitrary. Therefore, the instantaneous values at the midpoint are taken at the same time intervals Δt, after the arbitrarily taken first moment t_1.

$$\begin{cases} u_C(t_1) = E_0\left(1 - \exp\left(-\frac{t_1}{\tau}\right)\right) \\ u_C(t_2) = E_0\left(1 - \exp\left(-\frac{t_1+\Delta t}{\tau}\right)\right) \\ u_C(t_3) = E_0\left(1 - \exp\left(-\frac{t_1+2\Delta t}{\tau}\right)\right) \end{cases} \qquad (16)$$

The timing diagram of the voltage is shown in Figure 2.

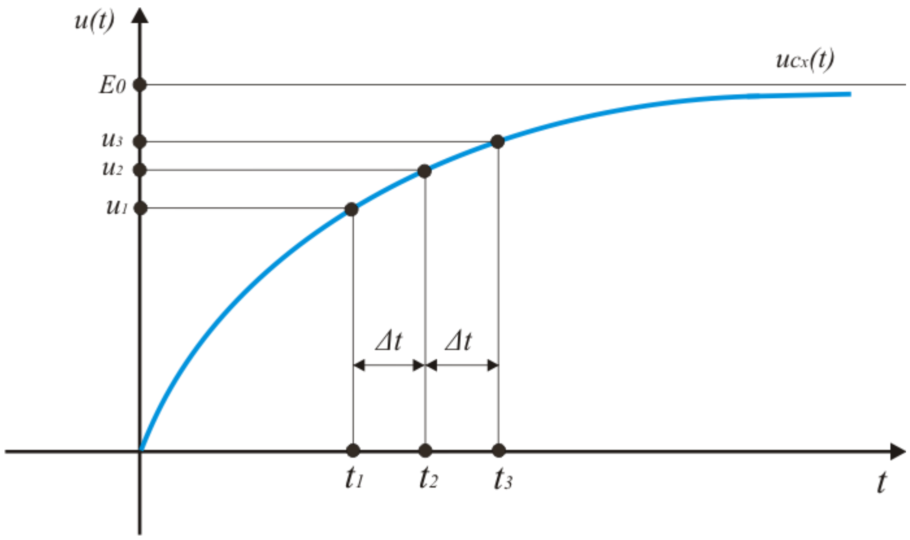

Figure 2: Timing diagram of the voltage at the middle point of the measuring RC circuit (capacitor Cx)

Using (16) at equidistant moments of time, an estimate of the time constant is given by (6):

$$\frac{u_C(t_3)-u_C(t_2)}{u_C(t_2)-u_C(t_1)} = \frac{\exp\left(-\frac{t_1}{\tau}\right)\cdot\exp\left(-\frac{\Delta t}{\tau}\right)\cdot\left(1-\exp\left(-\frac{\Delta t}{\tau}\right)\right)}{\exp\left(-\frac{t_1}{\tau}\right)\cdot\left(1-\exp\left(-\frac{\Delta t}{\tau}\right)\right)} = \exp\left(-\frac{\Delta t}{\tau}\right). \qquad (17)$$

Where do we get:

$$\tilde{\tau} = -\frac{\Delta t}{\ln\frac{u(t_3)-u(t_2)}{u(t_2)-u(t_1)}}, \qquad (18)$$

where: $u(t_1)$, $u(t_2)$, $u(t_3)$ - value of the voltages at the midpoint of the measuring RC circuit at time t_1, t_2, t_3, respectively.

Δt is the time between adjacent samples.

CONCLUSION

Such an approach to the determination of the informative parameter when processing the recorded quasideterministic signal of capacitive transducers of various physical quantities has the following advantages:

- independence of measurements from the beginning of the transition process, which expands its scope;
- automatic compensation of the error from the zero offset of the measuring channel.

The indicated advantages of the method undoubtedly indicate its efficiency and prospects for measuring various non-electric quantities by capacitive transducers [5, 6].

REFERENCES

[1] Vorotnikov, I.N. Study of methods for measuring electrical capacitance on direct current / I.N. Vorotnikov, M.A. Mastepanenko // Methods and means of increasing the efficiency of technological processes in the agro-industrial complex: a collection of scientific articles based on materials from the International Scientific and Practical Conference. - Stavropol: AGRUS Stavropol State. Agricultural un-that. - 2013. - P. 66 - 68.

[2] Vorotnikov, I. N. Estimation of the influence of sampling error on the result of estimating the time constant / I. N. Vorotnikov, M. A. Mastapanenko, A. A. Gurkovsky, D. S. Taranukha, K. A. Falco // Methods and technical means of increasing the efficiency of using electrical equipment in industry and agriculture: a collection of scientific papers / SSAU. - Stavropol: AGRUS. - 2013. - P. 175 - 177.

[3] Minaev, I.G. A universal way to control the level of various liquids and the hardware complex for its implementation / I.G. Minaev, I.N. Vorotnikov, M.A. Mastepanenko // Bulletin of the APK of Stavropol. - 2012. - № 5. P. - 55–58.

[4] Melentiev, V.S. Methods and tools for measuring the parameters of electrical circuits on DC / V.S. Melentiev. - Samara: Samara. Tech. University, 2004. - 120 p.

[5] Vorotnikov, I.N. Methods of measuring electrical capacitance by the parameters of the transition process / I.N. Vorotnikov, M.A. Mastapanenko // Devices and systems. Management, monitoring, diagnostics. - 2013. - № 10. - P. 60 - 65.

[6] Vorotnikov, I.N. Capacitive method for measuring the level of electrically conductive and dielectric liquids / I.N. Vorotnikov, M.A. Mastepanenko // Quality management: materials of the International Scientific and Practical Conference. - Moscow: University of Mechanical Engineering Publishing. - 2013. - P. 99 - 105.

[7] Gorlov I.F., Lebedev A.T., Galkov V.Y., Orlyanskiy A.V., Shlykov S.N. Effects of feed additives "Yoddar-Zn" and "Glimalask-Vet" on the productivity of beef cattle. Research journal of pharmaceutical biological and chemical sciences. 2016. 7(5) pp. 2518-2522.

[8] Gorlov, Ivan Fiodorovich; Titov, Evgeniy Ivanovich; Semenov, Gennadiy Viacheslavovich, Slozhenkina, Marina Ivanovna; Sokolov, Aleksandr Yurievich; Omarov, Ruslan Saferbegovich); Goncharov, Aleksandr Ivanovich; Zlobina, Elena Yurievna; Litvinova, Elena Viktorovna; Karpenko, Ekaterina Vladimirovna. INTERNATIONAL JOURNAL OF FOOD PROPERTIES Volume: 21. Issue: 1. 2018. P. 1031-1042.

[9] Omarov, Ruslan Saferbegovich; Antipova, Lyudmila Vasilevna; Konieva, Oksana Nikolaevna; Meshcheryakov, Vladimir Anatolyevich; Shlykov, Sergei Nikolaevich. Biotechnological Aspects In The Development Of Functional Food Products. Research journal of pharmaceutical biological and chemical sciences. Volume: 9. Issue: 3. P.: 751-755. Publ: MAY-JUN 2018.

[10] Gorlov, Ivan Fedorovich; Omarov, Ruslan Saferbegovich; Slozhenkina, Marina Ivanovna; Zlobina, Elena Yuryevna; Mosolova, Natalia Ivanovna; Shlykov, Sergei Nikolaevich. Study Of The Influence Of Beef With An Improved Fatty Acid Composition On The Development Of Atherosclerosis In Animal Experiments. Research journal of pharmaceutical biological and chemical sciences Volume: 9 Issue: 4 P: 1159-1162 Publ: JUL-AUG 2018.

[11] Shlykov, Sergei Nikolayevich, Omarov, Ruslan Saferbegovich. Analyzing Methods For Improving Beef Tenderness. research journal of pharmaceutical biological and chemical sciences Volume: 9. Issue: 4. P.: 1135-1137. Publ: JUL-AUG 2018.
[12] Omarov, Ruslan Saferbegovich; Nesterenko, Anton Alekseyevich; Chimonina, Irina Victorovna; Sangadzhieva, Lyudmila Khalgaevna; Sangadzhieva, Olga Stanislavovna; Shlykov, Sergei Nikolayevich. Development Of Food Products Enriched With Biologically Active Form Of Iron. Research journal of pharmaceutical biological and chemical Volume: 9. Issue: 4. P.: 902-905. Publ: JUL-AUG 2018.