American Journal of Circuits, Systems and Signal Processing
Vol. 1, No. 3, 2015, pp. 56-59
http://www.aiscience.org/journal/ajcssp

Conversion and Initial Processing Errors of Measurement Results

Mehdiyeva A. M.[1, *], Mehdiyev K. A.[2], Abdullayev S. A.[3], Aliyeva L. A.[1]

[1]Automation of Production Processes, Azerbaijan State Oil Academy, Baku, Azerbaijan
[2]Institute of Chemical Problems, Azerbaijan National Science Academy, Baku, Azerbaijan
[3]Automation and Management, Azerbaijan Technical University, Baku, Azerbaijan

Abstract

The offered systematic approach to creation of information-measuring systems of considered parameters consists of cumulative analysis of measurement processes and a correcting filtration for the purpose of achievement of the balanced metrological, structurally-algorithmic and functional efficiency indicators of developed means. The operators of preprocessing and representation of measuring data have particular filtering (correcting) properties. Therefore, with the purpose of rational hardware and software implementation of correcting filtration problems and in order to prevent superfluity of additional data, inlet into a measuring channel, it is expediently effectively to use filtration properties of reference operators of preprocessing and representation of the measuring information.

Keywords

Non-Sinusoidal Signal, Digital Measurements, Error of Measurement, Information-Measuring Systems, Correcting Filtration, Measuring Channel, Structurally-Algorithmic, Measurement Processes

Received: April 26, 2015 / Accepted: June 17, 2015 / Published online: July 7, 2015

1. Introduction

Signals of alternating current in many events have nonsinusoidal nature. The cause of the appearance of the high harmonics during digital measurements of nonsinusoidal signals is noises added on useful signal. In nonsinusoidal signals (NSS) high (usually odd) harmonics are connected with processes of production and consumption of electric energy. Though curves of instant values of continuous signals are more informative, they not always are easy understood. Therefore determination of integral parameters of signals (IPS) in real time for control and analysis of controlled processes and objects is important. On production these parameters characterize a total amount of material and energy entered and got in determined time lag, operating factors, consisting of average values of measured parameters of the object. Determination originality of IPS by digital methods and means is a realization of the discrete averaging (DA) or discrete integration (DI) of continuously variables in the observation interval.

A broader use of software tools in digital measuring technology in the first place must be directed on more efficient (optimal or quasioptimal) decision of measuring problems. Need of the technical condition estimation of automation object on basis of fuller and more correct information translates results accuracy into foreground not of separate measurements, but dynamic measurements of collections of physical quantities, executed on background of noises in real time. In this sense making the new generation of the processor measuring instruments developed measuring-computing techniques as a whole.

Software tools in modern systems are not broadly used only for measurement results processing and measuring experiments control, but also for measurement results getting.

---

* Corresponding author
E-mail address: almazmehdiyeva@yahoo.com (Mehdiyeva A. M.)

This factor was a reason of the change the structure IMS i.e. a reason of the transition from the centralized structure to the partly centralized and local (distributed) structure. In such systems getting and processing of measuring information are realized on basis of microcontrollers, microcomputers and other microprocessor sets. That is why the numerical methods get deeper into measurement and processing processes.

Use of software tools as elements of a measuring circuit in information-measuring systems (IMS) of distributed structure provides in many events measuring information interchange in real time. Thus a process of measuring and processing its results are combined (on time). That is why the main requirements to functional units of the information processing tract translate compatibility of their parameters and principle of operation with methods and means of digital signal processing (DSP) into foreground. And this, in its turn, conditions a broader use of recurrent algorithms during DSP. Exactly for this reason an interest to DSP methods increases at the last years and first of all this is explained by broad using of the computer technology and digital technology in different areas of science and technology.

From a standpoint of using to measuring technology the main purpose of DSP using is directed to greater increasing of the signal/noise ratio on the path to the decision of the problem of getting of maximum of reliable information from a noisy measurement's results.

2. Methods of Solution

Instrumental errors appeared because of "faultiness" of methods and means, as well as elements and units used during realization "measurement-processing" tracts of nonsinusoidal signals are different. Their composition, quantitative and qualitative factors depends on a construction principle of the "measurement-processing" tract. But in any event the following stages must be executed:

1) Transformation of the controlled parameters vector $\Lambda = \{\lambda_1(t), \lambda_2(t), ..., \lambda_\ell(t)\}$ of the automated object into the analog signals vector $X = \{x_1(t), x_2(t), ..., x_m(t)\}$ by means of sensors of source information i.e. $X = \varphi[\Lambda]$;

2) Transformation of the signal collection X into the digital signals vector $Y_\xi = \{y_1(t_i), y_2(t_i), ..., y_q(t_i)\}$, $i = \overline{0, M-1}$ by means of operators $F = \{F_1, F_2, ..., F_n\}$ in the continuous or discrete time domain i.e. Y_i= F(X);

3) Calculating (an estimation) of integral parameters $I = \{I_1, I_2, ..., I_p\}$ of the digital signals collection Y_ξ , i.e.

$$I = I\left[Y_\xi\right],\ i = \overline{0, M-1}.$$

For simplicity we shall consider possible algorithms of a single-channel "measurement-processing" tract.

1) Getting of measuring signals, functional analog conversion, coding and digital processing of results

$$\lambda(t) \to x(t) \to y(t) \to y(t_i) \to I, \tag{1 a}$$

2) Getting of measuring signals, analog-digital functional conversion and digital processing of results

$$\lambda(t) \to x(t) \to y(t_i) \to I, \tag{1 b}$$

3) Getting of measuring signals, linear analog-digital conversion, digital functional conversion and processing of results

$$\lambda(t) \to x(t) \to x(t_i) \to y(t_i) \to I. \tag{1 c}$$

In all three directions heavy research-and-practical and design work is executed for a long time. Results of these work are relatively analyzed in [3]. Considering development trends of the information-measuring system investigated by us, for more solid use of digital technology advantages and herewith from a standpoint of getting balanced collection of hardware-software the algorithm (1c) is more expedient and perspective. That is why the following our studies we shall make for this direction.

In the algorithm (1c), either as in the other algorithms, transformation $\lambda(t) \to x(t)$, i.e. $x(t) = \Phi[\lambda(t)]$, because of interconnection "automated object + a sensor of information", being a problem of information-measuring technology and by reason of "faultiness" of a sensor of information is accompanied by noise pollution of the measuring signal $x^*(t) = x(t) + \Delta x(t)$. That is why an inverse problem $\lambda(t) = \Phi^{-1}\left[x^*(t)\right]$, as an incorrect problem is still actual.

A linear analog-digital functional conversion $x^*(t) \to x_i^*$, being a problem of dynamic measurements, is accompanied by corresponding errors (noises) in the processes of sampling D $[\cdot]$ and quantization KV $[\cdot]$. During the $x^*(t) = x(t) + \Delta x(t)$ sampling and quantization of the noisy measuring signal $\lambda(t) \to x(t)$ getting from the first stage, the hereditary error creates additional problems, i. e. a real result is getting as $x_i^{**} = x(t_i) + \Delta x^*(t_i) + \varepsilon_{KVi}$ (here ε_{KVi} is a quantizing error).

The conversion $x_i^{**} \to y_i^*$ i.e. digital functional conversion $y_i^* = F\left[x_i^{**}\right]$ executed in the discrete time domain is accompanied by some truncation error (approximation of functional dependence) and instrumental error (round-up) in the process of realization of corresponding operator F $[\cdot]$. As a result a noisy digital signal $y_i^* = y_i + \Delta y_i$ is got.

Discrete averaging (or discrete integration) of noisy minorant function occurs in the conversion process and herewith the got result is accompanied by round-up noises and operator noises ΔI.

As it is seen, in the process of real measuring information interchange numerous errors (noises) of different form and nature appear and they are transformed in the "measurement-processing" tract.

Considering factors, specified above, we shall present the metrological model of the single-channel "measurement-processing" tract as shown in fig. 1.

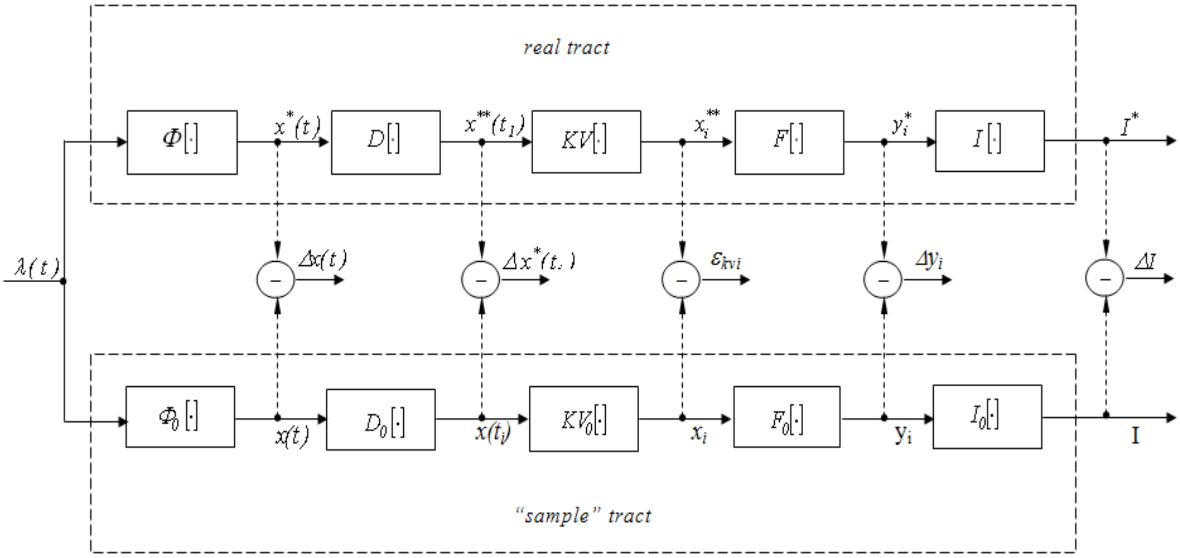

Fig. 1. A metrological model of the single-channel "measurement-processing" tract.

In this fig. the real tract is shown by the operators Φ, D, F, KV, I and the "standard" tract is shown by the corresponding operators Φ_0, D_0, F_0, KV_0, I_0.

It is necessary to mention that in existing work, executed in this area, there was not a system approach to the processes of "measurement-processing", but approach was from a standpoint of errors of the methods and means of the separate conversions.

Founding on the offered metrological model we shall systematically approach to analysis of real interchange errors of nonsinusoidal signals.

We shall take the following conditions comparatively to operators, characterizing the "sample" tract;

- The operator $\Phi_0[\cdot]$ is described by nominal conversion function of the sensor of information (here $\Phi_{nom}[\lambda(t)] = \sum_{j=0}^{p-1} a_j[\lambda(t)]^j$). The coefficients a_0, a_1, a_{p-1} and order of the polynomial are valued during the production of the sensor of information on basis of its metrological tests.
- Operators $D_0[\cdot]$ and $KV_0[\cdot]$ correspond to the analog-to-digital converter, operating in dynamic mode, built on basis of a "standard" digitizer and "sample" quantizer having an infinitely large number of levels.

The "sample" digitizer has the following conversion function

$$x(t) = \sum_{n=0}^{\infty} x(nT_0)\delta(t - nT_0)\,. \qquad (2)$$

Here δ(t) is a delta function.

The "sample" quantizer fulfills the following conversion

$$x_i = \underset{h\to 0}{\ell im}\left[h\cdot\left(\frac{x(t_i)}{h}\right)\right] \equiv x(t_i)\,. \qquad (3)$$

Here h is a quantization step.

As it is shown from the formula (3), the condition $\underset{h\to 0}{\ell im}\left[h\cdot\left(\frac{x(t_i)}{h}\right)\right] \equiv 0$ is accepted i.e. a fractional part of $x(t_i)/h$ ratio goes to zero.

- The operator $F_0[\cdot]$ corresponds to the discrete functional converter with an "infinitely" large number of bits (a truncation error is closer to zero) and realizing approximation of the F(x) function with "infinitely" small intervals.

- The operator $I_0[\cdot]$ satisfying to conditions M→∞ and $Q_0(M, y) \to 0$, is a device of the discrete averaging with truncation, methodical and instrumental errors close to zero.

It is possible to analyze appearance and transformation processes corresponding to errors along a tract on basis of outputs differences of corresponding real operators and "standard" operators.

3. Conclusion

Thus, in this paper we have got corresponding analytical expressions for estimation of errors of generalized functional blocks, executing transformation and primary processing of nonsinusoidal signals in the single-channel real "measurement-processing" tract. For this purpose, following characteristics and advantages of the methods designed by us were noted:

- a system approach to problem and considering not a concrete device (scheme), as functional units of the tract, but their general characteristics (functional and algorithmic purposes);
- besides errors analysis of separate functional units, the estimation and considering their transformations in the tract (it is very important from a standpoint of more natural and objective estimation of the resulting error in the output of the tract);
- universality of the methods i.e. got results can belong to "measurement-processing" tracts of any structure and with any amount of channels and at the same time the signal x(t) can enter not only the class $\tilde{C}^{(m)}[0,T]$, but also the class of any one-dimensional signals.

References

[1] Telman Aliyev. Robust Technology with Analysis of Interference in Signal Processing. New-York: Kluwer, 2003. 199 p.

[2] W.Stewen Smit. Digital Signal Processing. California Technical Publishing. ISBN 0-9660176-3-3. 1997. 630 p.

[3] Abdullayev I. M. Analysis and synthesis of complexes optimum conversion and digital processing of continuous signals in IMS: Diss. doctor. tech. sciences. Baku, 1992.

[4] Evans J. R., Lindsay W. M. The measurement and Control of Quality. Southwestern College Publishing, Cincinnati, Ohio, 1999, 785 p.

[5] Abdullayev I. M., Allakhverdiyeva N. R., Aliyeva A. D. The modified finite-difference filter / 2nd International Symposium On Electrical, Electronic And Computer Engineering- NEU CEE 2004 Proceedings, 11-13 March 2004, Nicosia, North Cyprus.

[6] Abdullayev I. M., Mehdiyeva A. M. Algorithm of decision-making on the condition of asynchronous engines / Interactive Systems: The problems of human-computer interaction proceedings of the international conference, 23-27 september 2003, Ulyanovsk, p.134.

[7] Abdullayev I. M., Xu Dianguo, Wang Yan. Optimization of the Measurement System // Journal of Harbin Institute of Technology. 1987, №2. p. 115-118.

[8] Aqayev F. H., Aliyeva L. A., Mehdiyeva A. M. Comparative analysis of discrete averaging subtracts of the measuring channel. The second International Conference, "Problems of cybernetics and informatics", V.II, 10-12 September, 2008, pp.119-121.

[9] Mehdiyeva A. M. The conversion of non-sinusoidal signals and digital processing tracts of instrumental analysis of errors // News of the Academy of Sciences, Volume XXVIII, №6, Baku 2008, pp.133-137.

[10] Allahverdiyeva N. R., Mehdiyeva A. M., Mehdizade E. K. Increasing the accuracy of conversion and digital processing of electrical signals. "Information-measuring and operating system." Moscow, 2010, №9, V.8, pp.69-74.

[11] Allahverdiyeva N. R., Mehdiyeva A. M. Correcting filtration of metrical signals / Proceeding of the International Conference 22-24 September 1999, Ulyanovsk, п.134.

[12] Kimery J. The next generation of measurements // Sensors, June, 2000, 40 p.

[13] Laduzinsky A. J. Computer trends in Data Acqisition // Sensors, December, 1999, 5 p.

[14] Mehdiyeva A. M. Modern principles of measurement and processing of non-sinusiodal signals. The second International Conference, “Problems of cybernetics and informatics”, V.II, 10-12 September, 2008, pp.122-123.