Artículo de investigación

"Unerroric" of multistage discrete Fourier transform of digital signal without arithmetic operations of multiplication

"Анэррорика" многоступенчатого дискретного преобразования Фурье цифрового сигнала без выполнения арифметических операций умножения

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Abstract

There are the issues related to improving the quality of the spectral analysis of a polyharmonic signal by recurrent methods of the multistage discrete Fourier transform (DFT) based on differential digital filtering, which does not require multiplication. The concept of "unerroric" of this DFT of a digital signal is introduced only by addition and shift operations. The philosophical aspect of it is described. The aim of the study is to find a solution to the problem of improving the quality of spectral analysis of polyharmonic signal by recursive methods of multistage discrete Fourier transform based on differential digital filtering without performing arithmetic multiplication operations. Methods of research are the following: directed search and comparative analysis of results of multistage discrete Fourier transform on the basis of difference digital filtering of different orders at integer coefficients of this filtering. The study of the philosophical aspect of "unerroric" of digital methods of spectral analysis of a polyharmonic signal based on recurrence algorithms of multistage discrete Fourier transform with the help of difference digital filters with integer numeric filtration coefficients, which do not require arithmetic operations of multiplication, has shown that further development of the theory and methods of this filtration is necessary. As a result of the conducted research it was revealed that the degree of approximation to the desired level of accuracy of this spectral analysis can be raised by increasing the order of difference digital filtering with integer coefficients, as well as by

Аннотация

Рассмотрены вопросы, связанные с проблемой повышения качества спектрального анализа полигармонического сигнала рекуррентными методами многоступенчатого дискретного преобразования Фурье на основе разностной цифровой фильтрации, не требующей выполнения операций умножения. Введено понятие «анэррорики» этого преобразования Фурье цифрового сигнала только операциями сложения и сдвига. Описан философский аспект такой «анэррорики». Целью исследования является поиск решения задачи повышения качества спектрального анализа полигармонического сигнала рекуррентными методами многоступенчатого дискретного преобразования Фурье на основе разностной цифровой фильтрации без выполнения арифметических операций умножения. Методами исследования являются методы направленного перебора и сравнительного анализа результатов многоступенчатого дискретного преобразования Фурье такого сигнала на основе разностной цифровой фильтрации разных порядков и различных порядков разности при целочисленности коэффициентов этой фильтрации. Исследование философского аспекта «анэррорики» цифровых методов спектрального анализа полигармонического сигнала на основе рекуррентных алгоритмов многоступенчатого дискретного преобразования Фурье такого сигнала при помощи разностных цифровых фильтров с

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selecting the order of difference of its algorithm. After philosophical comprehension of the regularities of "unerroric" of digital spectral analysis of polyharmonic signal by multistage discrete Fourier transform recurrence methods on the basis of difference digital filtering only by adding and shifting operations it was suggested to select the element base, technical characteristics of which consider these regularities, for software and hardware implementation of digital algorithms of multistage discrete Fourier transform without performing multiplication operations. It is shown that the use of programmable logic devices (PLD) can be considered as the best variant of the element base for hardware-software implementation of digital algorithms of spectral analysis of a polyharmonic signal by recursive methods of this multistage discrete Fourier transform.

Keywords: Difference digital filtering, DFT, digital signal, spectral analysis, “unerroric”.

целочисленными коэффициентами цифровой фильтрации, не требующей выполнения арифметических операций умножения, показало, что необходимо дальнейшее развитие теории и методов этой фильтрации. В результате проведённого исследования выявлено, что степень приближения к желаемому уровню точности такого спектрального анализа можно повысить увеличением порядка разностной цифровой фильтрации с целочисленными коэффициентами, а также подбором порядка разности её алгоритма. После философского осмысления закономерностей «анэррорики» цифрового спектрального анализа полигармонического сигнала рекуррентными методами многоступенчатого дискретного преобразования Фурье на основе разностной цифровой фильтрации только операциями сложения и сдвига предложено подбирать элементную базу, технические характеристики которой наилучшим образом учитывают эти закономерности, для программно-аппаратной реализации цифровых алгоритмов многоступенчатого дискретного преобразования Фурье без выполнения операций умножения. Показано, что использование PLD можно считать наилучшим вариантом элементной базы для программно-аппаратной реализации цифровых алгоритмов спектрального анализа полигармонического сигнала рекуррентными методами такого многоступенчатого дискретного преобразования Фурье.

Ключевые слова: анэррорика, дискретное преобразование Фурье, разностная цифровая фильтрация, спектральный анализ, цифровой сигнал.

Introduction

The investigation about the causes of the crash of the Boeing 737 MAX has confirmed once again the relevance of the problem of conformity to quality of the software of electronic control systems for aircrafts with the requirements of the aviation rules of the Interstate Aviation Committee and the standards of the International Civil Aviation Organization (ICAO) (Afanasyev, Lebedev, Monakhova, Myshelov, Nozhnitsky, 2013; Burova, 2019). The basis of such systems is computational algorithms for digital processing of the aircraft control signals (Burov, Burova, 2000; Burov, Burova, 2010; Burova, 2019). The capabilities of the microelectronics element base allow these algorithms to be implemented on digital signal processors and (or) PLD (Goldenberg, Matyushkin., Polyak, 1985; Gubanov, Steshenko, 1998). The specific tasks of radio engineering can be solved and should be solved with the help of theoretical material in the field of scientific knowledge, it is required only to determine the necessary and sufficient set of philosophical ideas and principles (Kun, 1977; Lakatos, 1978). The methodology of philosophy has a lot of means of generalizing the laws of experimental results of the development of technical sciences (Stepin, 1989; Shvyrev, 1992; Heidegger, 1993, Radugin, 1998).

The research goal is to find a solution to the problem of improving the quality of the spectral analysis of a polyharmonic signal using recurrent methods of the multistage discrete Fourier transform (DFT) based on difference digital filtering, which does not require arithmetic multiplication operations.

For solving this problem the computational procedures of the finite difference algorithm and the algorithm Coordinate Rotation Digital Computer (CORDIC) are used (Shinakov, Burov, 1998; Burov, Burova, 2010). The use of these procedures allowed reducing the error of spectral analysis of the polyharmonic signal by recurrent methods of multistage discrete Fourier transform on the basis of difference digital filtering only by addition and shift operations while reducing hardware costs for software and hardware implementation of multistage discrete Fourier transform (Burov, Burova, 2010).

We can find the results of well-known research on this problem in a lot of scientific articles (Kuzkin, 1983; Gubanov, Steshenko, 1998; Shinakov, Burov, 1998; Shinakov, Burov, Burova, 2000; Burov, Burova, 2000; Burov, Burova, 2010). The effectiveness of the difference digital filtering method with integer difference coefficients of different order of difference was first noted in one of the articles (Kuzkin, 1983). The method of difference digital filtering of high orders of difference developed and described by V.S. Kuzkin, Yu.S. Shinakov, Yu.Ya. Burov and A.Yu. Burova allows significantly reducing the bit values of both multipliers and memory cells required for hardware implementation of spectral analysis of digital signals by recurrent methods of multistage discrete Fourier transform based on difference digital filtering with integer coefficients (Kuzkin, 1983; Shinakov, Burov, 1998; Shinakov, Burov, Burova, 2000; Burov, Burova, 2000; Burov, Burova, 2010).

As a result of the following research it is revealed that the degree of approximation to the desired level of accuracy of this spectral analysis can be raised by increasing the order of difference digital filtering with integer coefficients, as well as by selecting the order of difference of its algorithm. Moreover, the use of PLD can be the best option element base for hardware and software implementation of digital algorithms of this analysis.

There is the philosophical understanding of the problem in a number of scientific and theoretical articles and monographs (Heidegger, 1993; Kemeny, 1959; Kun, 1977; Lakatos, 1978; Radugin, 1998; Shvyrev, 1992; Stepin, 1989), because the rationalistic approach to the development of problems of scientific research methodology was proposed by R. Descartes (Radugin, 1998).

The study of the philosophical aspect of the proposed solution of the problem showed that it is necessary to further develop the theory and methods of difference digital filtering with integer coefficients.

Theoretical basis

The theoretical basis of “unerroric” multistage discrete Fourier transform of a digital signal without performing arithmetic operations of multiplication can be considered a set of digital methods of this transform (Zalmazon, 1989), finite difference method (Kuzkin, 1983), and CORDIC method (Goldenberg, Matyushkin, Polyak, 1985), providing the performance of spectral analysis of a polyharmonic signal only by operations of addition and shift of its digital samples, each of them is an additive mixture of the harmonic components of this signal and its interference component of the "white noise" type.

The digital algorithm of a multi-stage discrete Fourier transform without performing multiplication operations has a pyramidal structure that ensures the recurrence of the spectral analysis of the polyharmonic signal at all stages of this transform (Burov, Burova, 2010). This algorithm is a set of alternating computational procedures of the CORDIC algorithm and the finite difference algorithm for the formation of difference coefficients of difference digital filtering of different orders of difference (Shinakov, Burov, 1998; Shinakov, Burov, Burova, 2000). The use of differential digital filtering with integer coefficients allows replacing each multiplication operation with a set of addition and shift operations in the algorithm of multistage discrete Fourier transform (Shinakov, Burov, 1998; Shinakov, Burov, Burova, 2000; Burov, Burova, 2000; Burov, Burova, 2010).

Methodology

The research materials are the results of the frequency selection of harmonic signals by difference digital filters of high orders of difference (Shinakov, Burov, 1998; Shinakov, Burov, Burova, 2000; Burov, Burova, 2000; Burov, Burova, 2010). The research methods are the methods of hardware and software modelling of digital spectral analysis algorithms, of directed enumeration and comparative analysis of the results of a multistage DFT of a digital signal on the basis of difference digital filtering of different orders and different orders of difference with integer coefficients of this filtering only by addition and shift operations, as well as philosophical methods of scientific research (Heidegger, 1993; Kemeny, 1959; Kun, 1977; Lakatos, 1978; Radugin, 1998; Shvyrev, 1992; Stepin, 1989). The choice of materials and methods is determine by the diversity of the element base for hardware implementation of digital algorithms for spectral analysis and the dependence of the error of the spectral analysis of digital signals recursive methods multistage discrete Fourier transform on the basis of the differential digital filter from the integrality of its coefficients and its order and order the difference.

Research results

Modern digital signal processing methods can improve the accuracy of spectral analysis with some specific implementations of its algorithms. The basis of the spectral analysis of digital signals can be assumed and should be assumed to be their DFT (Goldenberg, Matyushkin., Polyak, 1985). Multistage DFT is an alternation of computational algorithms CORDIC and differential digital filtering (Goldenberg, Matyushkin., Polyak, 1985; Shinakov, Burov, 1998; Burov, Burova, 2000; Shinakov, Burov, Burova, 2000; Burov, Burova, 2010). Therefore, it is necessary to provide an increase in the quality of the spectral analysis of the polyharmonic signal by recurrent methods of multistage DFT based on differential digital filtering without performing multiplication operations and by sufficiently reducing the error of such filtering. Digitalization of spectral analysis based on difference filtering with integer coefficients provides a qualitatively new opportunity to reduce the level of its error due to the complete rejection of the use of digital multipliers (Burov, Burova, 2000; Burov, Burova, 2010). This error is determined only by the effects of rounding of the processed numbers with possible register overflows in the process of multiple addition operations. Moreover, the quantization effect of filtering coefficients has a strong influence on its accuracy.

The efforts of developers of radio engineering systems to raise the accuracy of spectral analysis by increasing the filtering orders look like the pursuit of Achilles by a turtle from the Zeno's paradoxes. Achilles stays behind the turtle, but while he runs the distance dividing them, the turtle move, etc. Achilles runs this new distance, but during this time the turtle move once again and so on. According to Zeno, although the distance will decrease more and more, it will never disappear.

In radio engineering, such paradoxes usually are contradictions between experimental data and conclusions, which are based on plausible, but not always or not about everything with reasoning.

Obviously, the consideration of the philosophical aspect of increasing the accuracy of difference filtering is interesting for solving general problems of reducing the error of digital spectral analysis. It provides an opportunity to determine the concept and methodology of designing digital devices that provide a high level of accuracy of spectral signal conversion.

Consequently, a philosophical generalization is required in choosing the optimal ratio of the values of digital filtering orders and the difference orders of the algorithms.

The methods of the theory of scientific knowledge allow solving this problem at the empirical and theoretical levels. The process of cognition in radio engineering is the interaction of objective reality and human consciousness. The object is the scope of the application and results of the activity of the subject. At the empirical level, the study of it and their interaction is carried out. It is based on the direct practical interaction of the researcher of the problem (subject) with the studied object and involves the implementation of observations and experiments. At the theoretical level, there is no direct practical interaction of the subject with the object. The study is carried out only indirectly in a thought experiment to cognize the essence and generalize the laws of their interaction.

Rational approach to the development of problems of the methodology of scientific research was proposed by René Descartes. He was working with the experimental data of research in the natural sciences and repeatedly emphasized the importance of experience in scientific knowledge. But scientific discoveries, according to him, are not made as a result of experiments, but as a result of the activity of the mind, which also directs the experiments. Such rationalism is based on the fact that he tried to apply the features of the mathematical method of cognition to all sciences and put forward the idea of the general mathematization of scientific knowledge to obtain accurate reliable conclusions to which the experience cannot lead. And since the conclusion cannot always be presented quite clearly and distinctly, it is necessary to apply the method of “deduction”, through which, from certain premises, certain consequences can be obtained and conclusions can be made (Radugin, 1998).

The essence of reality, from the point of view of Claude Adrien Helvétius, can be known only by the mind. “It is common for the mind to observe, generalize its observations and draw conclusions from them” he wrote in his treatise “On Mind” (Radugin, 1998). Reducing all operations of the human mind to the use of comparative abilities, he proposed a universal practice of four "conclusions" to solve any problem: "GOAL - METHOD - CRITERIA - EVALUATION". In his opinion, correctly formulated conditions of the task determine the desired results of its solution.

“The human mind is limited,” Heinrich Wolf used the frase from A.N. Tolstoy’s novel “The Garin Death Ray” (also known as “The Death Box” and “The Hyperboloid of Engineer Garin”). “But it’s always wiser to rely on it than to doubt it”. In each case, everything will primarily depend on the level of professional training and the experience of the person who solves the problem.

The desired results of its solution can be obtained by him if he remembers Aristotle’s advice: "Neither the knowledge of the subject of your research and the power of your tools, nor the vastness of the knowledge and the accuracy of your plans can ever replace the originality of your thoughts and the vigilance of your observation ..."

Then the optimal choice of methodology for solving the problem will ensure the accuracy of its solution. The development of unambiguous criteria for assessing the expected result will reveal the degree of its reliability. The comparative assessment of the results will make it possible to determine the degree of their adequacy to the requirements of the problem formulation being solved.

If we consider all the obtained results of research work, then the variety of experimental data gets its unity through value perception, provided that we consider "values" the properties of the object to satisfy the needs and desires of the subject. However, according to Heinrich Rickert, “values” should not be confused with assessment, since it is determined by a subjective attitude (Radugin, 1998). It does not go beyond established facts, and they are independent of the subject and priorities. "In some ways, Rickert is right. The values are not the characteristic of an individual, but of a social consciousness, ideal and social forms that function in social interaction, but through an individual consciousness, personality... The principles of the methodology of scientific knowledge formed by Rickert are used in modern society..." (Radugin, 1998).

All technical sciences rely on theoretical judgments and empirical evidence, and philosophy studies the subject's relationship to "value". In fact, it is a normative doctrine of it.

Errors of rounding the results in arithmetic operations on the samples of the digitized signal are similar to the quantization noise of the original signal, but the theoretical analysis of the total noise due to quantization effects is always very complicated. There are many sources of rounding noise. All of them are in different parts of the software or hardware implementation of the algorithm. Each of the errors that occur during signal processing undergoes various transformations during the execution of subsequent computational procedures. Thus, a general analysis of the magnitude of the error in digital signal processing, which is caused by quantization effects and depends on the structure of the computational algorithm and the way numbers are represented in the processor device, is possible.

The use of Descartes '"deductive" methods using the practice of comparative assessments on Helvetius' "conclusions" and taking into account Rickert's "value" criteria allows developing an original approach to considering the philosophical aspect of the problem. To do this, we start to use a new word. It has a Latin root. "Unerroric" (from the Latin "ERRARE" - "make mistakes") for the digitalization of spectral analysis, is the active process of reducing the level of errors of a radio technician (subject) in the selection and digital implementation of spectral analysis algorithms. The basis of the theoretical concept of "unerroric" are two well-known postulates: "It is natural to make mistakes" and "The person who does nothing, does not make mistake". The infological (semantic) model of “unerroric” is the procedure of subjective selection of methods and approaches to the optimal solution of the problem of increasing the accuracy of digital spectral analysis.

To obtain a quantitative assessment of the accuracy of the digital method, a new approach to the accuracy of spectral analysis based on differential digital filtering is proposed. This approach is a further development of the estimating of the error of the digital method as a combination of its methodological, algorithmic and computational ones (Burov, Burova, 2000).

When developing the criteria for this assessment, it is necessary to consider that the comparison of computational algorithms in a theoretical study is usually carried out according to the number of arithmetic operations.

It is obvious that the error of digital information processing in spectral analysis is composed of the following errors in the representation and conversion of real signal and noise components:

- Discretization;
- Digitalization;
- Complexifications (in most cases);
- Conversions to the field of complex numbers;
- Decomplexification;
- Accumulation of processing results (in some cases);
- Evaluation;
- Decision making.

If the error Z_s of digital method of spectral analysis of information can be represented as a combination of its conceptual Z_c, theoretical and analytical Z_t, methodological Z_m, algorithmic Z_a and digital computational Z_d errors by the following formula (1),

$$Z_s = Z_c + Z_t + Z_m + Z_a + Z_d, \quad (1)$$

and the evaluation of the error Z_s can be represented as a combination of the evaluations of the errors ΔZ_c, ΔZ_t, ΔZ_m, ΔZ_a, ΔZ_d by the following formula (2),

$$\Delta Z_s = \Delta Z_c + \Delta Z_t + \Delta Z_m + \Delta Z_a + \Delta Z_d, \quad (2)$$

then the numerical value of this estimation of the method will be approximately equal to numerical value of the estimation of the computational error of its digital implementation: $\Delta Z_s \approx \Delta Z_d$ (Shinakov, Burov, 1998).

The accuracy of digital processing depends mainly and exclusively on the level of errors in the hardware implementation of the algorithms, and therefore on the capabilities of the modern digital element base and the specific implementation of radio engineering devices and systems on it.

The error $Z_F*(n,m)$, $n=1,2,3,...,N$, $m=1,2,3,...,M$, of the multistage DFT can be represented as a combination of its methodological $Z_m*(n,m)$, algorithmic $Z_a*(n,m)$, digital computational $Z_d*(n,m)$ errors by the following formula (3) if any m-th hardware implementation of a software product of every n-th algorithm, due to the features of the used elemental base of digital computing:

$$Z_F*(n,m) = Z_m*(n,m) + Z_a*(n,m) + Z_d*(n,m),$$
$$n=1,2,3,...,N,\ m=1,2,3,...,M. \quad (3)$$

Moreover, the finiteness of the bit sizes of the registers, multipliers, adders and memory cells for storing the values of the filtering coefficients leads to a significant decrease in the theoretically achievable accuracy of the method due to the influence of rounding effects of these coefficients and the processed numbers. The evaluation of $\Delta Z_d*(n,m)$, $n=1,2,3,...,N$, $m=1,2,3,...,M$ of the level Z_d can be obtained by separating the contribution of the error $Z_E*(n,m)$, $n=1,2,3,...,N$, $m=1,2,3,...,M$ of source software product algorithm by the following formula (4):

$$\Delta Z_d*(n,m) = Z_F*(n,m) - Z_E*(n,m),\ n=1,2,3,...,N,$$
$$m=1,2,3,...,M. \quad (4)$$

In spectral analysis based on difference filtering with integer coefficients, the selection of the values of the order of the difference algorithm to obtain integer coefficients provides spectral processing without multiplication operations. It allows an analysis whose error Z_d is due only to rounding and scaling of the processed numbers and equivalent transverse filtering coefficients (Shinakov, Burov, 1998; Burov, Burova, 2000; Shinakov, Burov, Burova, 2000; Burov, Burova, 2010).

It is obviously, that the integer number of difference of coefficients determines the integer number of equivalent filtering. Therefore, when using difference filters with integer coefficients, the influence of stray noise of quantization of equivalent filtering coefficients is on the accuracy of spectral analysis, in most cases performed on the basis of difference methods increases. The natural difference of the optimal equivalent filter performance of a given order with integer coefficients from the required filtering characteristics of the same order leads to the need to increase the difference filter orders (sometimes significant increase) to obtain a sufficient degree of compliance of these characteristics.

The degree of approximation to the desired level of accuracy of digital spectral analysis based on difference filtering can be raised by increasing its order, as well as by selecting the order of the difference in its algorithm. The ways and means of this choice remain the main problem of the philosophical aspect of the “unerroric” of this digitalization of spectral analysis. The additional adders rise, which leads to an undesirable increase in the level of “quantization noise”.

Discussion

The rejection of multipliers in the hardware implementation of digital filtering algorithms will improve the accuracy of digital spectral analysis. However, it is necessary to determine the concept and methodology of designing digital devices that provide a high level of accuracy of signal conversion. John G. Kemeny in his book “Philosophical attitude to science” notes that science cannot unambiguously indicate to us in which way the chosen theoretical direction should be developed. In this particular case we mean radio engineering. But after we make a strong-willed decision, it can indicate the best way to achieve the goal (Kemeny, 1959). In such cases, according to Thomas Kuhn, "the choice is required between alternative methods of scientific research, and, in such circumstances, when the decision should be based more on the prospects of the future than on past achievements" (Kun, 1977).

After philosophical understanding of the laws of "unerroric" of digital spectral analysis, it is necessary to proceed with the selection for a special processor implementation of its algorithms of this elemental base, the technical characteristics of which consider these laws very well. In this case, the problem of difficulty of choice arises once again (Kun, 1977).

Widespread digital signal processing processors (SPP) have arithmetic co-processors for performing multiplication operations. Moreover, in the SPP, the equality of the speeds of the operations of multiplication and addition is achieved due to significant intra-chip hardware costs.

Therefore, we may only focus on obsolete microprocessor sets (MPS), custom-designed ultra-large integrated circuits (ULIC) and PLD. MPS is already out of use. The production of ULIC is too expensive. It is obviously, that the use of PLD is the best option for digital implementation of spectral analysis based on difference filtering without multipliers at all.

PLD allow achieving better performance indicators in comparison with SPP (Gubanov, Steshenko, 1998). They are better suited for the parallel execution of arithmetic operations, due to the peculiarities of their architecture: possibility of programming and configuration changes directly in the implemented SPP system. When developing new algorithms for "moving" spectral analysis for their subsequent implementation on PLD, it is just advisable to exclude multiplication operations, providing the desired processing accuracy by increasing the number of addition and shift operations.

However, the legitimacy of such a choice must be checked from a philosophical point of view.

Specific directions of radio engineering reveal specific regularities of different subject areas of knowledge, and philosophy is designed to direct efforts to cognition and generalization of laws and systematization of scientific knowledge (Heidegger, 1993). At the same time, philosophy should be guided by strict examples of natural science knowledge (Radugin, 1998). Therefore, first of all, both a unified style of thinking and recognition of certain fundamental theories and methods of research are necessary.

Thomas Kuhn called these provisions "paradigm", meaning that "scientific achievements recognized by everybody, which for a certain period of time give the scientific community models of problem statement and solutions" (Kun, 1977). Moreover, the choice of methodology for studying and solving a specific problem, i.e., transition from one paradigm to another, in his opinion, cannot be based only on rational arguments. Although their impact is significant, willful decision is required, which should be based on any rational grounds laid down in the logic of scientific research and new scientific data.

As any activity, scientific cognition is regulated by certain norms that express the values and goals of any science: evidence and validity of knowledge, explanation and description of cognitive actions, as well as the organization of obtaining knowledge. Therefore, the "foundations of science" (Stepin, 1989), in particular for radio engineering, are not only the form of systematization of knowledge in specific areas, but also "research program" (Radugin, 1998). It ensures the purposefulness of the work and the formulation of the tasks of empirical and theoretical search, as well as the choice of means of their solution.

Imre Lakatos proposed a similar theory, it is different from the concept of T. Kuhn in a number of provisions. The basis of his model of science is the "research program", which can be considered as progressive one if its theoretical growth anticipates the empirical (Lakatos, 1978). In other words, it can predict new facts with some success. According to I. Lakatos, the content of science is based on the development of methodological ideas and methods of scientific research. Moreover, if T. Kuhn emphasized the great importance of forms of organization of science and personal factors of scientific research (Kun, 1977), I. Lakatos noted their secondary importance (Lakatos, 1978).

In the Russian philosophy the problems of scientific rationality are developed within the framework of "research programs" of the methodology of scientific cognition by V. S. Stepin and V. S. Shvyrev (Radugin, 1998). Overcoming negativism in relation to scientific rationality, in their opinion, is possible only with a broad comprehensive understanding of the laws of formation and functioning of scientific rationality. This approach provides an analysis of this rationality from the perspective of the concept of "foundations of science". It is a modification of the works of T. Kuhn (Kun, 1977).

V.S. Stepin believes that these "bases of science" organize all the heterogeneous knowledge into some "integrity" and determine the strategy of scientific search (Stepin, 1989). At the same time, they are not only the form of systematization of knowledge in specific areas, but also independent "research program".

However, the possible separation of scientific and technical consciousness, scientific rationality from the real human activity is a danger of suppression by the authority of scientific rationality of the diversity of personal worldview and worldview. According to V.S. Shvyrev, such suppression can be a transformation of theoretical constructions from the means of adequate comprehension of reality into a dogmatic obstacle to such comprehension (Shvyrev, 1992).

Verification of the rightness of the order selection and order of the difference of the differential digital filter, and element base for hardware implementation of digital algorithm of multistage discrete Fourier transform on the basis of this filtering from a philosophical point of view was shown and confirmed, that the problem of improving the quality of spectral analysis of a polyharmonic signal by recurrent methods based on difference digital filtering without performing arithmetic multiplication operations can and should be solved by purposeful selection of the optimal value of the order of difference digital filtering with integer coefficients, as well as the optimal value of the order of difference after directional search and comparative evaluation of the results of this analysis.

Conclusion

Nowadays, with the increasing role of accurate and concrete knowledge in all spheres of human life, a prominent place in the development of the methodology of scientific cognition belongs to various directions of "positivism". This theory claims the role of "philosophy of science" (Radugin, 1998). It is based on the recognition of the existence of a certain reality, which is given directly to a person and can be tested by empirical or logical-mathematical means.

The study of the philosophical aspects of a particular scientific and technical direction gives radio engineering both rich factual material for reflection and very effective tools of thinking activity. This makes it possible to operate freely in terms of concepts, as well as to put forward and justify new judgments, in order to separate in practice the essential from the insignificant to establish the relationship of all the results obtained in the process of work. Moreover, it is clearly dominated by a subjective factor, since the emotional and volitional direction of choice depends on the individual qualities of a particular designer of digital devices and systems of spectral analysis.

Investigations of the philosophical aspect of "unerroric" digital methods of spectral analysis on the basis of differential filtration have clearly shown that further development of the theory and methods of differential filtration. In this case, we can expect new scientific and practical results, which would provide new opportunities for digitization of spectral analysis by different methods.

References

Afanasyev V.A., Lebedev V.A., Monakhova V.P., Myshelov E.P., Nozhnitsky Yu.A. (2013).

Technical regulation and quality management. Moscow: Book House «Librocom».
Burov Yu.Ya., Burova A.Yu (2010). Deductive processing of digital signals based on the method of finite differences and differential methods of digital filtering and multi-step discrete Fourier transform, which does not require performing arithmetic operations of multiplication. Russian scientific and technical society of radio engineering, electronics and communication named after A.S. Popov: 65 Scientific session devoted to radio day: Theses of reports. Moscow: Russian Scientific and Technical Society of Radio Engineering, Electronics and Communication, 425-428.
Burov Yu.Ya., Burova A.Yu. (2000). Synthesis of the recurrence digital filters. Russian scientific and technical society of radio engineering, electronics and communication named after A. S. Popov: LV Scientific session, dedicated to Radio Day: Theses of reports. Moscow: Russian Scientific and Technical Society of Radio Engineering, Electronics and Communication, 261.
Burova A.Yu. (2019). Minimization of asymmetry of thrust of the dual-flow turbojet engines of the airliner in accordance with the results of the system analysis of the thrust parameters. Asia Life Sciences Supplement. 21(2), 629-643.
Goldenberg L.M., Matyushkin B.D., Polyak M.N. (1985). Digital Signal Processing: A Guide. Moscow: Radio and communications.
Gubanov D.A., Steshenko V.B. (1998). Methodology for the implementation of digital filtering algorithms based on PLD. Proceedings of The First International Conference "Digital signal processing and its application" (DSPA’98). 4, 9-16.
Heidegger M. (1993). What is philosophy. Questions of philosophy. 7, 113-123.
Kemeny J. (1959). A Philosopher Looks at Science. NY: Van Nostrand.
Kun T. (1977). The structure of scientific revolutions. Moscow: Progress.
Kuzkin V.S. (1983). Difference digital filtering. Radiotechnics.
Lakatos I. (1978). History of science and its rational constructions. Structure and development of science. Moscow: Progress.
Radugin A.A. (1998). Philosophy: a course of lectures. Moscow: Center.
Shinakov Yu.S., Burov Yu.Ya. (1998). Accuracy of spectral analysis based on a differential digital filter whose coefficients are integers. Moscow technical university of communications and informatics: Scientific-practical Conference: Theses of reports. Moscow: Moscow Technical University of Communications and Informatics.
Shinakov Yu.S., Burov Yu.Ya., Burova A.Yu. (2000). Theory, methods and algorithms of difference digital filtering. Proceedings of The Third International Conference "Digital signal processing and its application" (DSPA’2000). 1, 96-99.
Shvyrev V.S. (1992). Rationality as a cultural value. Philosophy Issues. 6, 91-105.
Stepin V.S. (1989). Scientific knowledge of the values of anthropogenic civilization. Philosophy Issues. 10, 3-18.
Zalmanzon L.A. (1989). Fourier, Walsh, Haar transforms and their application in control, communication, and other fields. Moscow: Nauka.