(156-158)

Scientific Paradigms for Computer Aided Signal Design

Yaroslav Dragan*, Bohdan Yavorskyy**

Abstract - **In this paper is presented paradigms for developing a message representation as main background for computer aided design of optimal radiosignal.**

Keywords – **Message, Paradigm, Representation, CAD, Radiosignal.**

I. INTRODUCTION

In order of effect of high quality a radiosignal a way of reach it by a computer aided design (CAD) is estate.

It is well known that data is conveying by signal (or, in common sense, information is convey by the signal). It is doing by a material process being transmit throw a space media and in a time in specific ways in the Nature and Technique (hand made nature) resources. In both cases there are a message being sent, a channel in the media for possibility the transmitting, a coder for the message coding and, at last, a modulator for saddle the message code on to the convey process. To say nothing about Nature, the technical signal must be optimal by appropriate criteria are usual at an application branch of the human activity. It was understood for the first time in the radiotechnic (communication, location etc.). So, the radiosignal is electromagnetic waves modulated by the coded message. The criterion is a speed and a capacitance of the information being transmitted, an interchannel interaction and a selection of the message. In order to achieve increasing speed and selectivity, decrease inter channel distortion many coding, modulations were invented. It was like avalanche, spontaneous process called by application needs. The significant problem of optimal signal design had appears (to see, for example, [1]).

It is widely believed that the better a theory concerns signal the simplicity is representation of it and optimally we have manipulated it [2].

In that paper we pick up paradigms for signals message (or signal) representation as main background for far design of radiosignal.

II. SCIENTIFIC PARADIGMS OF SIGNALS AND SYSTEMS THEORY

Physics. From times of Galileo and Newton the determinism was as an armor generated and established in a science (determino - I restrict, I define; the philosophical principle confirming a causal condition of all natural phenomena, societies and thinking). So wrote until recently, forgetting that: D. Bernulli has developed idea that gas is a population of firm blobs, J. Maxwell has given assumption that hit of that molecules of gas will lead not to smoothing of their velocities but to installation of allocation (distribution) of velocities (or molecules on velocities) and has introduced concept of cumulative distribution functions and has define their look, L. Boltzman has given the kinetic equation which features a time variation of these cumulative distribution functions. Slowly in the physics has appear the idea of stochasticity ($\sigma\tau o\chi\alpha\sigma\tau\iota\kappa o\sigma$ — skillful in aiming) as an instrument of study of thermodynamic and classical systems. And from operators by M. Planck there was in the last century a quantum theory as very specific means of study of stochasticity of atomic systems [3]. It has stipulated intensive development of probability theory as a mathematical machinery of theoretical probing as without the theory the empirical facts stay disconnected, separated. And such state gives nothing for understanding of phenomena, for calculations at usage in a practice and scientific predictions.

The Theoretical physics has arisen as classical (deterministic) a mathematical and off target quantum physics. The stochastic (statistical) physics was sideways, as a modification of a paradigm ($\pi\alpha\rho\alpha'\delta\varepsilon\iota\gamma\mu\alpha$ - an exemplar) in sense by Kun, as an exemplar of a formulation and a solution of scientific problems of passage from deterministic models of physical phenomena to probability models. Thus almost imperceptibly was defined concept of the modern probing of phenomena — the concept of a signal and system.

Then the definition of the signal as a physical process which maps in the appropriate form of an information about researched phenomena became already recognized. Consequently it is a tool for transmit of these information in space and time. And at the same time the role of mathematical models of a signal has grown as expositions and incarnations in rigorous mathematical tools of a mode of map of information which, in turn, should determine a mode and tools of their extraction from a signal. Speech here goes about mathematical model which presently can be treated as mathematical objects which embodies, in contracted and constructive in the structure essential from the point of view of a solution of the certain type of tasks of property of researched objects [3, 4].

Systems. Nevertheless, concerning concept of system of such clearness still is not present, despite of determination of concepts the common theory of systems and the systems analysis, and on the statement, that a system paradigm — a new tool of an intensification of intellectual production [5]. Practically still till now stay to a sight: "to lean on the standard or intuitive representations about a system which is included in individual experience of each of us" [6]. More correct is determination: "The system is the separated population of units cooperating among themselves which organizes some wholeness, owns the certain integral properties which allows fulfill the certain function in a medium. As integral properties we shall understand properties, which characteristic of system

*Yaroslav Dragan – CAD/CAM Department, Lviv Polytechnic National University, 12, S. Bandery Str., Lviv, 79013, UKRAINE,
**Bohdan Yavorskyy – Electronic Apparatuses&Computing Systems Department, Ternopil State Technical University named after Ivan Pului, 56, Rus'ka Str., Ternopil, 46001, UKRAINE
E-mail: Kaf_BT@tu.edu.te.ua

as a whole and which any of units" [7] does not own. Such "determination", except for the particular absurdity of expressions, does not envelop, for example, bioobjects, for exposition is characteristic what created the theory of systems by L. Bertalanfy [8]. And even the well-known "black box" from cybernetics as, in particular, in the latter case to speak about a population of interacting units it is not necessary — differently it would be a box not "black", but "transparent".

If to look from a common position the concept of system can be marked as such, that envelops (as model) objects in which properties are proper:

1. The holism — it as the whole is selected from a medium;
2. The structured — is a possibility to select in it building blocks, and, certainly, is not univalent about simplicity; building blocks and their coordination yet do not determine completely property of objects (Aristotle principle: the system is more than something, than a population of its units);
4. Activity (multifunction) - interaction with a surrounding medium, including premise of signals concerning its existential structure;
5. Cognitiveness - cognition of this structure behind signals.

The postulates formulated here define principal properties of systems as objects of scientific study — as natural, and is artificial created, in particular, modern and communication systems become join of reaching of the theory of the abstract algorithms and architectures of computer systems more and more, is the further implementation under title SH-model of algorithm of the concept of hardware-software resources of V.M. Glushkov [9]. Systems as transformers, no less than signal's channels, should be featured by models in view of stochasticity proper in a signal as implies from the nature of signals and their transformers. Besides in a number of devices, in particular, for hiding a signal structure, its statistician use additional artificial "shifts" of randomness of type of superposition as a gamma at encoding.

Detection periodic "black box" by a signal at an assumption, that its periodic "black box" is the typical inverse task. But not as for mathematician, and in stochastic a formulation as it is accepted to admit, that the receiver (the logger and an acceptor of a signal) is linear, invariant for shifts. Thus essential feature of a mathematical means of the analysis will be an expansion on harmonics — eigenfunctions of such systems which owing to an invariance do not change a harmonic composition of signals but only amplitudes and phases of harmonics.

By virtue of certain equal force of statements the valid facts: when the spectrum of a power of stochastic process (mathematical model of a signal) uniform — it is a white noise, and when there is no — it is a random stationary process, its harmonics are not correlated, and when there it is no — it is a nonstationary process; a specific case not stationarities are periodic correlated process.

Mathematics. These facts can be checked up behind properties of estimations of statistical probability characteristics of processes — models of signals. Such estimations calculate by algorithms which imply from structural properties of models of signals and their probability characteristics. In particular, on the basis of the theorem, that periodic correlated process is equivalent to its representation in the form of specific of some converging in the power metric sense [4]

$$\xi(t) = \sum_{k \in Z} \xi_k(t) e^{ik\Lambda t}$$

where $\{\xi_k(t), k \in Z\}$ - infinite-dimensional stationary vector process, $\Lambda = 2\pi / T$ — base frequency of heterodynes-modulators, T — period of process correlation, Z — the set of integers, is visible, that periodic correlation is equivalent to a diversity to a spectrum in the frequency domain. If periodic correlated process has a rank m it is figured by the partial case of the previous expression

$$\xi(t) = \sum_{k=\overline{1,m}} \eta_k(t) p_k(t)$$

where $\{\eta_k(t), k = \overline{1,m}\}$ — vector m-dimension stationary process, and $\{p_k(t), k = \overline{1,m}\}$ — the set from m linearly independent periodic functions of the period T equal to period of a diversity of a spectrum, is well illustrated by an amplitude modulation of oscillation by a random stationary process

$$\xi(t) = \eta(t)\cos(\Lambda t)$$

where $\eta(t)$ — the stationary process with a spectral density, about which C. Shannon has noted, that the amplitude modulation brings phase structure in a signal. Obviously, this process is periodically correlated as a rank 1. Such oscillation has no one-dimensional spectral density, and, being nonstationary, only the double-frequency, extended as D-harmonizable (i.e., with a finite summarized power of harmonics

$$f_\xi(\lambda,\mu) = \frac{1}{4}\begin{Bmatrix} [S_\eta(\lambda+\Lambda) + S_\eta(\lambda-\Lambda)]\delta(\lambda-\mu) + \\ S_\eta(\lambda+\Lambda)\delta(\lambda-\mu+2\Lambda) + \\ S_\eta(\lambda-\Lambda)\delta(\lambda-\mu-2\Lambda) \end{Bmatrix}$$

are cconcentrated not only on a diagonal $\lambda = \mu$ of the double-frequency domain, but also on parallel to it a direct side frequencies 2Λ and -2Λ. An average spectrum in sense Fortet-Kharkevych as a transform of Fourier of the averaged correlation function

$$B(u) = M_t\{r(t, t+u)\}$$

where M_t — the operator of an average on all time axes, is given in square brackets of the formula. In fact the shifts of frequency, its modulation equivalent also carries on to periodic correlate a signal. And handling of a signal as periodically correlated should exhibit presence of periodicity of structure of unknown source — a black box.

Applications. Verification has been computer designed signals yielded by filter, coherent or component methods [3, 4]. Their computational methods are analogies for interference-metric, radiometric, panorama- receive physical methods but are much technology and technical advanced. The expression of correlation function estimation

$$C(t,\tau)=\int_0^{t-\tau}\xi(t-u)\xi(t-u,\tau)h(u)du$$

where $h(t)$ denote the pulse function of coherent (when

$$h(t)\equiv\frac{1}{N}\sum_{n=0}^{N-1}\delta(t-nT_0)$$

or component (when

$$h(u)\equiv\frac{\sin[(N_1+\frac{1}{2})\lambda_0 u]}{(t-t_0)\sin(\lambda_0 u/2)},$$

where N_1 — quantity of components) filter [3]. The function $h(t)$ usually synthesized as an optimal [4].

Estimations of correlation function and mathematical expectation one can have got by narrow band pass filter:

$$r_\xi^{(T)}(l,k)=\sum_{n,m}D_{nm}(l-k)e^{-i\lambda_0(nl-mk)},$$

$$m_\xi^{(T)}(\theta)=\sum_{k=\overline{1,N_1}}m_k e^{-ik\lambda_0\theta},$$

where $k,l,\theta\in Z$,

$$m_k=\lim_{T\to\infty}\frac{1}{2T}\sum_\theta\left\{\left(\Phi_k^{\lambda_0}\xi\right)(\theta)\right\}e^{-ik\lambda_0\theta},$$

where $\Phi_k^{\lambda_0}$ — narrow band pass filter (delta-filter). Estimations of symmetrical correlation components:

$$B_{nm}(u)=\lim_{T\to\infty}\frac{1}{2T}\times$$

$$\times\sum_k\left\{e^{i\lambda_0 n(u+k)}\left(\Phi_n^{\lambda_0}\overset{\circ}{\xi}\right)(u+k)\overline{\left(\Phi_m^{\lambda_0}\overset{\circ}{\xi}\right)(k)}e^{-i\lambda_0 mk}\right\}$$

where $u=l-k$. In general, such filters distributed on entire frequency band the signal occupied.

For periodically correlated stochastic consequences a spectrum concentrate on frequency "diagonals" of $\Lambda\times\Lambda$ square are determine by expression $\Lambda_2=\Lambda_1\pm k\frac{\Lambda}{M}$, $k=\overline{0,M}$, where M— spectral components number, values of Λ is determine by band for carrying frequency, type of modulation and so on. Expressions for M_γ and dispersion V_γ for the likelihood function ratio determined by α_k (distribution the energy onto frequency, α_0 determine distribution of noise) obtained by spectral analysis:

$$M_\gamma=\left[\sum_{k=1}^{M-1}(1-\frac{k}{M})^2(\frac{\alpha_k}{\alpha_0})^2\right]^{-1}$$

$$V_\gamma=\sqrt{2}\Lambda\sum_{k=1}^{M-1}(1-\frac{k}{M})\alpha_k$$

Typical confidence characteristics

$$P_d=1-\Phi(\frac{\nu-M_\gamma}{V_\gamma}),$$

where ν — threshold being determined by noise energy, given by values α_k, $k=\overline{1,M-1}$ by expression

$$\nu=\sqrt{V_0}\Phi^{-1}(P_f)+M_0$$

where $\Phi(\bullet)$ — probability integral, P_f — given fault probability,

REFERENCES

[1] П.Е. Варакин, *Теория систем сигналов*, М.: Сов. радио, 1978, (in Russian).

[2] Paul M.B. Vitбnyi, Ming Li, "Minimum Description Length Induction, Bayesianism, and Kolmogorov Complexity", *IEEE Trans on Information Theory,* vol. 46, pp. 446-464, March 2000.

[3] Я. Драган, *Енергетична теорія лінійних моделей стохастичних сигналів*, Львів: Центр стратегічних досліджень еко- біо- технічних систем, 1997, (In Ukrainian).

[4] Я. Драган, Л. Сікора, Б. Яворський, *Основи модерної теорії стохастичних сигналів: енергетична концепція, математичні моделі, фізичне тлумачення*, Львів: ЦСДЕБТС, 1999, (In Ukrainian).

[5] В.С. Тюхтин, Ю.А. Урманцев, *Система. Симметрия. Гармония.*, М.: Мысль, 1988, (In Russian)

[6] У. Портер, *Современные основания общей теории систем*, М.: Наука, 1971, (In Russian).

[7] О.Г. Старіш, *Системологія*, К.: Центрнавчліт, 2005, (In Ukraine).

[8] Ludvig von Bertalanfy, *General System Theory. Foundation, Development, Application*, N.Y.: George Brazilier, 1968.

[9] В.М. Глушков, "Оценка эффективности сложных систем и организации вычислительных процессов", *Математическое обеспечение ЭЦВМ*, Киев, С. 3-17, 1972, (In Russian).

III. CONCLUSION

In this paper the introduction in the computer aided signal design (CASD) problem is presented. The features of the problem are stated as weak formalize (searching). The ways for resolving this problem lies on the paradigm base. The main direction is defined as stochastic.

Than appeared the next tasks — in what sense (what criteria) and what code for message representation, modulation of carried frequency, channel etc. will be optimal for the application branch. It does the need for approving of exist program systems for CASD: the mathematic (like as MATLAB) and the applied (like as CADENCE).