A Variational Approach of Optimization the Signal Form in the Radio Communication Systems

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Abstract – **The paper presents the criteria of quality of optimization the signal form, the general kind of the functional and the complementary conditions as well as the methods of its examination.**

Keywords **– Variational approach, optimal signals synthesis quality**

I. INTRODUCTION

The signals transmitting information along the channels of connection are a function of the real time defining their forms and of the message characterizing the type of modulation [1]. To define the form, it is necessary to know the signal coordinates in the signal space. In that sense the form is an individual feature of the signal.

In cases when there is signal receiving at noise background it asymmetrical and non-monotonous probability of density [1], it is possible to assign the task of optimization: to define those signals, which, passing through the channel of connection, would create fluctuations at its output maximally far away from one to another.

Optimization tasks are of extreme nature that predetermines the variation approach [3] for solving them.

The paper presents the results of defining the criteria of quality of optimal signals synthesis quality, the general kind of the functional and the complementary conditions as well as the methods of its examination.

II. FORMULATION OF THE PROBLEM OF OPTIMIZATION THE TRANSMISSION SIGNALS

The channel of connection is described by an “input-output” integral-and-differential equation in the kind of:

$$s(t)=\sum_{r=-q}^{l}\alpha_r(t)x^{(r)}(t), \qquad (1)$$

where $s(t)$ is the input signal,

$x(t)$ is the output signal,

$\alpha_r(t)$ - coefficients before $x(t)$ and its derivatives from “r”–th order, $r=-q...0...l$.

The functional of the quality can be definite as [3,4]:

$$I=\sum_{i=1}^{n}\sum_{j=1}^{n}\left[\frac{1}{\Delta\tau}\int_{\tau_1}^{\tau_2} f_{ij}\left[x_i(t),x_j(t),V(t),t\right]dt\right] \qquad (2)$$

where $V(t)$ is the vector function of the disturbing signals,

$[\tau_1,\tau_2]$ is the interval of examination of the output signal.

The function $f_{ij}[.]$ is the distance between the i-th and j-th signals at the output of the channel of connection and the functional (2) takes the kind of:

$$I=\left[\frac{1}{\Delta\tau}\int_{\tau_1}^{\tau_2}\left|x_i(t)\right|^m dt\right]^{1/m}, \qquad (3)$$

where $|x_i(t)|^m$ is the norm of m- order of the output signal $i=1,2,..n$.

When m=1, the functional of the quality is commensurable to the average rectified value of the output signal $x(t)$.

When m→∞ - the functional is commensurable to the crest value of the output signal.

When m=2 - the functional of the quality is commensurable to the energy of the output signal.

A characteristic peculiarity of the form optimization problem is that it is a problem of limitations . They determine a close area in the signal space where the signals searched for are found.

The most spread limitation in practice is that of the average value of p– th order of the signal being optimized [5]:

$$\left[\frac{1}{\Delta T}\int_{t_1}^{t_2}\left|s_j(t)\right|^p dt\right]^{1/p}\le S_p, \qquad (4)$$

he value of p in equation (4) depends on the kind of limitation imposed by the transmitter. The possible cases are as follows:

- limitation of the peak value of the signal ($p\to\infty$).

- limitation of the average rectified value of the signal (p=1).

- limitation of the average square value of the signal (p=2).

So the problem of optimization the transmission signals can be formulated in such a way: within the class of signals $L_p[t_1,t_2]$ determined by limitations of (4) to find those $s_j(t)$, that maximize the functional of the quality (3).

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It is assumed that the most common case in practice is the one with coincidence of the intervals of examination $[\tau_1, \tau_2]$ and signal existence $[t_1, t_2]$.

Expressing the output signal by the input one, the functional, which has to be maximized, takes the kind of:

$$I = \int_{t_1}^{t_2} \dots \int_{t_1}^{t_2} s(t_1)\dots s(t_\nu) H_\nu(t_1 \dots t_\nu) dt_1 \dots dt_\nu \ . \qquad (5)$$

where $H_\nu(t_1, \dots, t_\nu)$ is the kernel of the functional.

When the model of channel of connection is linear (Fig.1), the kernel of the functional depends on the channel pulse characteristics *h(t)*:

$$H_\nu(t_1,..,t_\nu) = \int_{\max(t_1, t_2, \tau_1)}^{\tau_2} m_1\{h(t,t_1)\dots h(t,t_\nu)\} dt \ . \qquad (6)$$

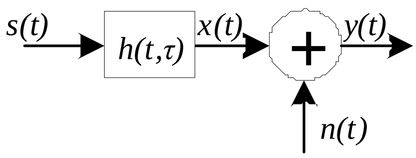

Fig. 1 A linear model of communication channel

The solution of this optimization task is carried out according to the method of double-sided variations of searching signals. This method consists in substituting the functional argument by an argument in the kind of a real variable and obtaining a homogeneous differential equation of boundary conditions at the end points of the harmonized signal localization interval, i.e. it is a boundary problem.

IV. CONCLUSION

The paper presents a variational approach in the purpose of optimization of the transmitted signal form in the connection channel. The approach is based on the definition of a functional that is used to describe the quality criteria of synthesis and to determine the kernel of the optimal operator operating on the input signal with which the functional reaches its extreme. The functional of the quality depends on an integral operator connected with a defined function in the linear standardized signal area. The kernel of the functional is determined by the necessary and sufficient conditions of the functional extreme. Thus the signals searched for are obtained as a solution of a system of integral equations.

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