ERROR ESTIMATION IN REAL-TIME TELEMETRY SYSTEMS

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I. INTRODUCTION

Multidimensionality and ambiguity of behavior, structural hierarchy, territorial distribution of components and functioning in real-time mode are characteristic of modern complex dynamic objects (flight vehicles or nuclear reactors). The mentioned factors become evident in the peculiarities of information received while working with such objects [1]. It is an important to consider such peculiarities while developing information model.

II. MODEL

Data about the functional status of a complex dynamic object are transmitted in form of current values of telemetric information (TMI), and represent discrete stochastic process. According to the analysis of the existing models for description of the processes, the model of abnormally contaminated distribution by Tukey-Huber is the most adequate model [2]:

$$y(t_i)=\left[1-a(t_i)\right]\left[\lambda(t_i)+\varepsilon_{н}(t_i)\right]+a(t_i)\varepsilon_{ан}(t_i) \quad (1)$$

where $\lambda(t_i)$ – is information component; $\varepsilon_i(t_i)$ – is regular error component; $\varepsilon_{ài}(t_i)$ – is abnormal error component. $a(t_i)$ – realization of binary switching random function, assuming with a probability of $P_{ài}$ the value of $a(t_i)=1$ and with a probability $(1-P_{ài})$ the value of $a(t_i)=0$.

For all that, the probability $P_{ài}$ includes the probability of multiplicative component, as well as the probability of additive component of the error:

$$P_{ан}=P_{mult}+P_{add} \quad (2)$$

The TMI analysis shows that more than 90% of abnormal measurements falls to multiplicative component [3], related to changes in the state of the system's measuring route.

The probabilistic characteristics of the multiplicative component of the abnormal error and characteristics of regular error should be estimated.

III. ABNORMAL ERROR COMPONENT

Abnormal errors are presented in only some of the measurement results, with a determined probability, but they can assume large values, comparable to the scale of measuring message (fig. 1). There can appear single as well as several running abnormal outliers.

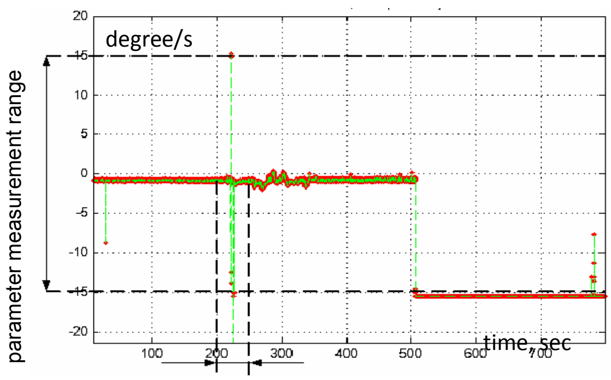

Fig. 1. Graphic representation of TMI with grouped abnormal outliers (angular rate sensor of a flight vehicle)

Usually, distribution of values of abnormal errors differs from Gaussian [4]. However, distribution of durability of abnormal measurement results, which is similar to presented in the work [2] τ^+ characteristics (duration of the process's being above the preset level), is the most interesting. Empirical distribution of P_{mult} value was obtained as a sample analysis result of 500 thousand measurements. This distribution is presented in fig. 2.

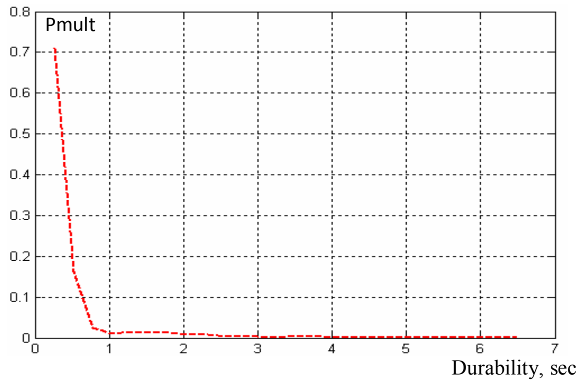

Fig. 2. Distribution of durability of abnormal measurement results

IV. REGULAR ERROR COMPONENT

The reason for occurrence of this error type can be changing in the properties of measuring elements, ageing effect, sensor chatter, as well as manifestations of other factors, the influence of which cannot always be reasonably considered [5].

More than 80% of realizations of regular error component are approximated by random processes of two types, with the following correlation functions (CF) [1]:

$$R_i(i) = \sigma_i{}^2 e^{-|i|/T_0}$$

$$R_н(i) = \sigma_н{}^2 (1 + \frac{|i|}{T_0}) e^{-|i|/T_0} \quad (3)$$

where T_0 – is duration of discretization interval of measurement information; i – number of samples, according to which the CF is calculated; $\sigma_i{}^2$ – mean-square deviation squared.

There arises the task of real-time distinction of process type with different spectral-correlation characteristics. To solve this task in metric space (space of singular points) Z [2] characteristics is introduced:

$$Z = \frac{n^+(H, T_a)}{n_{\max}(T_a)} \quad (4)$$

where $n^+(H, T_a)$ – number of positive crossovers of the H level in time interval T_a [2]; $n_{\max}(T_a)$ – number of extremums in time interval T_a [2].

Fig. 3 presents standard values of Z characteristic for two types of processes and their average value, allow to decide if the analyzed sample belong to the first type or to the second type.

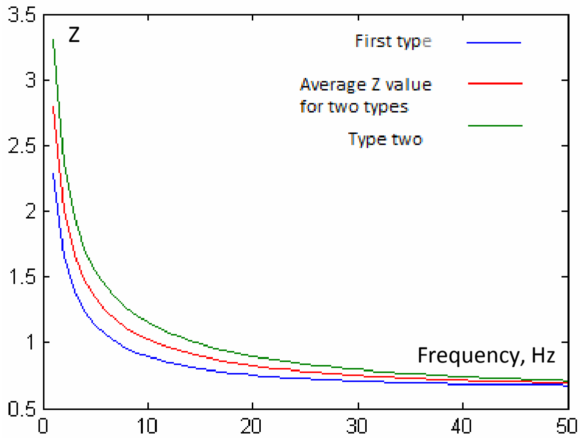

Fig 3.Graph of Z characteristic for two types and the average value.

V. CONCLUSION

TMI model based on abnormally contaminated distribution by Tukey-Huber was selected as a result of analysis of the subject area. The basic probabilistic error characteristics were estimated. The theory of random processes outliers was applied for estimation of probabilistic characteristics. The application of singular points characteristics allows synthesizing processing algorithm in real-time mode.

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