MODELING OF A GROUP LOCATION OBJECT'S SIGNAL PROCESSING CHANNEL

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Abstract

Functional capabilities of modern radio apparatuses for air traffic control, provides controlling spatial coordinates of several radio-locating objects at the same time. It is rather unprimitive technical problem that requires considerable improvement of primary radio-locating signal processing quality. Therefore improvement of receiving channel quality requires. Necessity of high separability of several radio-locating objects signals at receiving channel shows requirement of wide-spread theoretical research, using group reflected signal and real receiving channel models. Hence, offers to create simulation computer model of added signals passing through the nonlinear channel. This model will provide researching of different spectral component developments by a number of modeling realization, using a simple mathematical apparatus and low computational power.

I. INTRODUCTION

Current paper is about nonlinear properties of receiving channel influence on spectral characteristics of sum of location signals by the example of sum of location signals with different Doppler frequency and different widths of power density spectrum. The most essential nonlinear effect is a signal amplitude limitation. This effect characterizes the limitation of dynamic range in receiving channel and could de introduced purposely for signals with phase or frequency modulation. For better demonstration noises inside the receiver is ignoring.

The examples of different Doppler frequency signals adding are the cases then flying object throwing out passive location distortion, such as chaff dipoles (foil bands). Distortion area appears around the location object (fig.1), and leads a tracking loss for radio-locating apparatuses. There is no way to separate this distortion by the distance or the angular data. But throwed foil is slowing down by the contrary blast, and separates from fast flying air object, using Doppler frequencies, clearly.

Distortion will have wider Doppler frequencies band than location object, but this band will be shifted from object center frequency. So, distortion and flying object will become separated.

In the situation, when inside the main lobe of directional diagram of receiving aerial are two location objects – observed and interacting, separating is possible only by the differ in their radial speed (Doppler frequency shift). Separating by distance or angular data will be considered to be impossible in spite of some difference between viewing directions (inside the directional diagram). This situation (fig.1) appears, for example, during measurement of group object parameters, and also then volume-distributed passive distortion takes place, or in case a low power of location object signal.

In the best case, then the receiver channel has an ideally linear amplitude characteristic, receiving signals, came after reflection from each of both flying objects, processing separately. The Doppler filters turned on a first's signal frequency provides it's passing, and maximizing observed signal to interacted signal energy ratio.

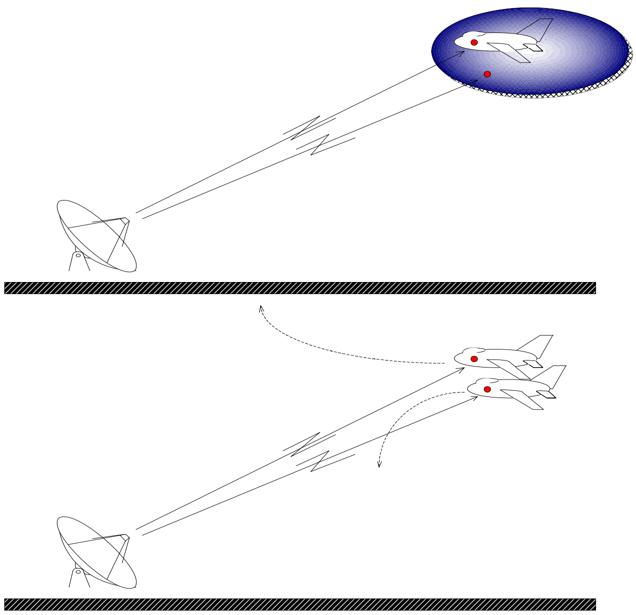

Fig.1 Situations then Doppler frequency resolving is useful

Real receiving channel of radiolocation receiver is characterized by its nonlinear properties, defined by receiver dynamic range limitation, curved amplitude characteristics, and also by frequency shifter schematic features (converters, detection stages) that leads to increasing of crosstalk distortions. Nonlinearity of receiving channel is disfiguring the additive superposition of location signals and bringing there multiplicative components - harmonic beating of initial signals. Nonlinear conversion of signals leads to “reproduction“ of signals due to combination frequencies components [3]. Signals on initial Doppler frequencies enriching with several additional combination components.

This paper is describing the dependences of entering signals distorting after nonlinear conversation of two signals sum at the receiving channel and following Doppler frequency filtering of this additive signal.

Effects, concerned with nonlinear conversation of two added location signals, will be researched using the most frequent nonlinear type – amplitude limiting. This case of nonlinear conversion shows the dynamic range limitation in the receiving channel, and also could be put purposely. It is known, that a hard amplitude limitation is widely used at receiving channel with wideband regulation of radio-location signals, parasite amplitude fluctuation removal during phase or frequency modulation and so on.

II. MODEL SPECIFICATIONS

Developed model provides following features showed in interface.

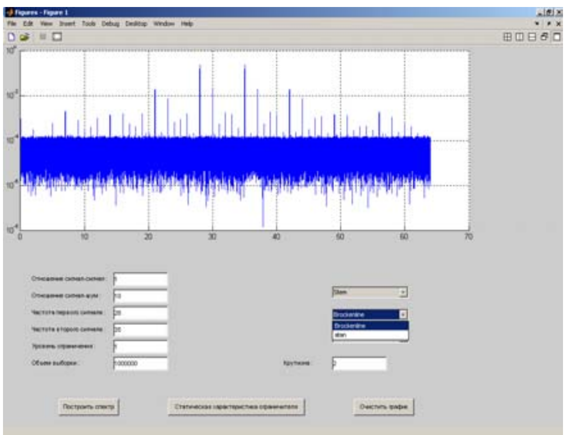

Fig. 2 Program interface

Program interface will content:

– graphical dependences drawing area;
– ordinate axis scale settings (logarithmic or linear);
– doppler frequencies of signals settings;
– distribution law’s parameter settings;
– graphic type settings (discrete, stem or analog) ;
– fast fourier transform settings (sampling rate, selection size);
– noise-to-signal ratio (power-to-noise ratio);
– signals ratio settings;
– amplitude limitation level;
– choosing of amplitude limiter type and parameters (chain function, arc tangential). in arc tangential case, arc tangency coefficient settings.
– limiter amplitude characteristic viewing ability.

This interface elements provides user to view different graphical dependences, such as signal’s spectrum and limiter amplitude characteristics graphical interpretation at the same drawing, compare visual results, obtained with different initial parameters.

III. OBTAINED RESULTS

The goal of developing this model was graphing main signal’s spectrum to limiting type, parameters, and dynamic range dependences. Hence in this chapter puts graphical dependences, gathered using this model.

It’s provides, for example, to plot graphs showing depending input signal’s first and second harmonics power from limiting level. Different noise-to-signal ratio “q” is used. This dependences showed at figures 3 and 4.

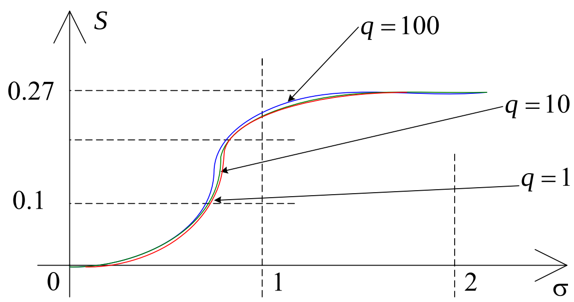

Fig. 3 First harmonic amplitude dependence from limitation level

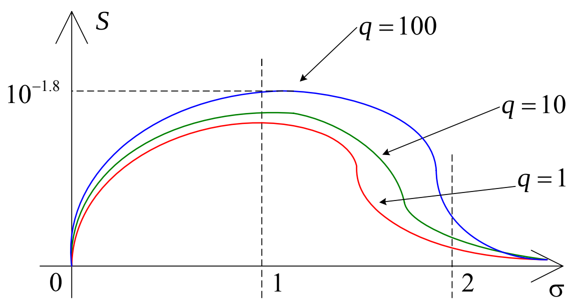

Fig. 4 Second harmonic amplitude dependence from limitation level

REFERENCES

[1] Forsythe G. E., Malcolm M. A., Moler C. B. Computer Methods for Mathematical Computations. Prentice-Hall, 1977.

[2] Евсиков Ю.А., Чапурский В.В. Преобразование случайных процессов в радиотехнических устройствах. М.: Высш. Шк., 1977.

[3] Павлов В.С., Турнецкий Л.С., Турнецкая Е.Л, Преобразование спектральных характеристик смеси двух локационных сигналов в приемном тракте с амплитудным ограничением. // Вычислительная техника и автоматика: Сб. науч. тр. СПбГТУ №457/ СПбГТУ СПб., 1995. С. 50-58.204 с.