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Nonlinear Power Measurement Algorithm of the Input Mix Components of the Noise Signal and Pulse Interference

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Abstract**—**A power measurement algorithm of the input mix components of the noise signal and pulse interference is considered. The algorithm efficiency analysis has been carried out for different interference-to-signal ratio. Algorithm performance features have been explored by numerical experiment results.

Keywords—Noise signal, pulse interference, signal power, spectrum width, detection.

I. Introduction

THIS paper presents a method of measurement of power of components of input mix of the noise signal and pulse interference.

In various applications there is a problem of measurement of characteristics of signal in the presence of interferences [1], [2].

In practice of radio measurements for an estimation of power of weak radio signals wide application was received with radiometric measuring instruments (radiometers). Radiometers are used in radio astronomy, a passive radar-location and at antenna measurements. There is actual problem of measurement of noise in radio engineering systems. In all specified cases of use of radiometric receivers, on result of measurements essential influence the external electromagnetic influences shown in a measuring section in the form of pulse interferences.

The algorithm developed on the basis of this method, can be used, for example, in the structure of radiometer at radio-astronomical and other precision measurements of power of noise signals of a small level in the presence of pulse interference with simultaneous measurement of its mean power [3]-[7].

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II. Principle of Algorithm Work

In Fig. 1 the block diagram of the offered algorithm of measurement of power of noise signal and pulse interference is presented.

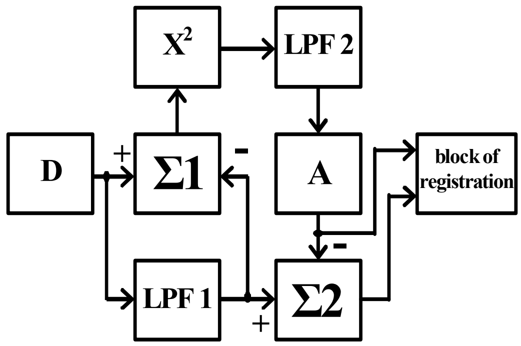

Fig. 1 Block diagram of the algorithm of measurement of power of noise signal and pulse interference

In the input of the detector (D) the additive mix of the noise signal and pulse interference from the output of high-frequency (HF) section of measuring system is present.

In Fig. 2 realization of additive mix of the noise signal and pulse interference from the output of high-frequency (HF) section of measuring system is presented.

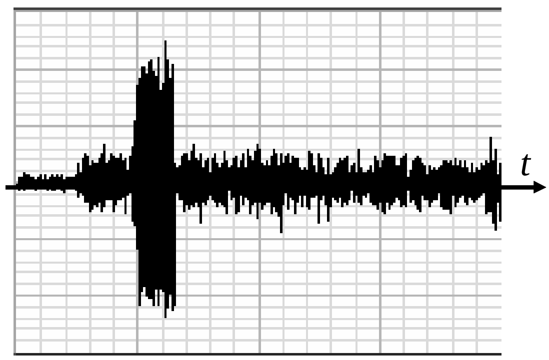

Fig. 2 Realization of additive mix of the noise signal and pulse interference from the output of high-frequency (HF) section of measuring system

In Fig. 3 spectrum of additive mix of the noise signal and pulse interference from the output of high-frequency (HF) section of measuring system is presented.

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The voltage in the output of the detector (D) contains a constant component and noise component, caused by sum of low frequency fluctuations of noise signal and pulse interference [6].

Constant component is extracted by the first low-pass filter (LPF 1) and pass in the inverse input of the first adder (∑1). In Fig. 4 spectrum of constant component from the output of the first low-pass filter (LPF 1) is shown.

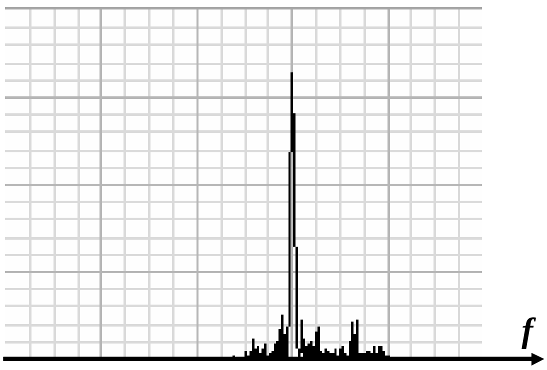

Fig. 3 Spectrum of additive mix of the noise signal and pulse interference from the output of high-frequency (HF) section of measuring system

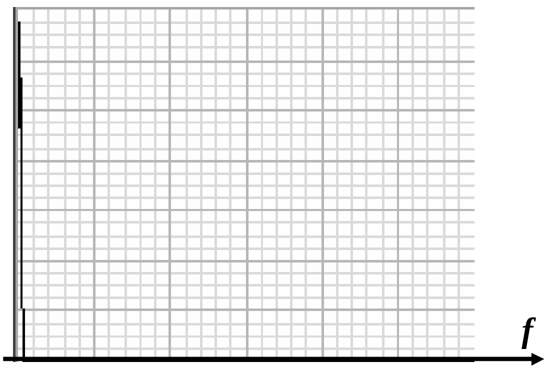

Fig. 4 Spectrum of constant component from the output of the first low-pass filter (LPF 1)

In the forward input of the first adder (∑1) we have signal from the output of detector (D).

Therefore, in the output of the first adder (∑1) the fluctuation component of the signal from the output of detector (D) is extracted.

The voltage in the output of the square-law device (X^2) contains a constant component is proportional to the mean power of pulse interference and small low frequency fluctuations of noise signal. In Fig. 5 spectrum of constant component and small low frequency fluctuations of noise signal from the output of the square-law device (X^2) is shown.

This component is extracted by the second low-pass filter (LPF 2) and thru attenuator (A) pass in the inverse input of the second adder (∑2) and in the second input of the block of registration. In Fig. 6 spectrum of constant component from the output of the second low-pass filter (LPF 2) is shown.

In the forward input of the second adder (∑2) pass the voltage from the output of the first low-pass filter (LPF 1), proportional to the total average power of noise signal and pulse interference. Therefore, the voltage in the output of the second adder (∑2) is proportional to the subtract of the constant components of the output voltage of the first low-pass filter (LPF 1) and the output voltage of the second low-pass filter (LPF 2).

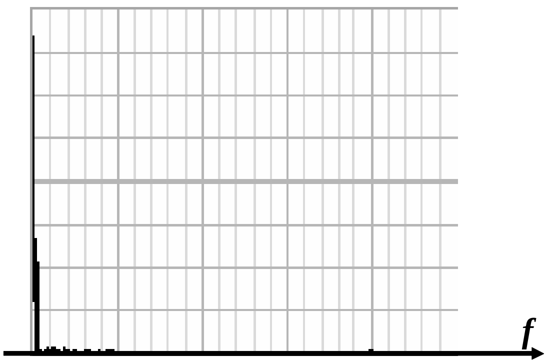

Fig. 5 Spectrum of constant component and small low frequency fluctuations of noise signal from the output of the square-law device (X^2)

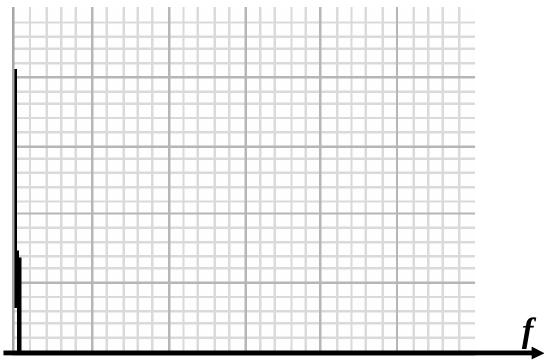

Fig. 6 Spectrum of constant component from the output of the second low-pass filter (LPF 2)

The transfer factor of attenuator (A2) must be chosen so that at switched off source of noise signal and switched on source of pulse interference the voltage on the output of the second adder (∑2) equal zero. Thus, the voltage in the first input of the second adder (∑2) does not depend on a source of pulse interference. As a result the voltage in the second input of the block of registration depends on the power of pulse interference.

III. Simulation Results

In this section, we give simulation results for the power measurement algorithm of the input mix components of the noise signal and pulse interference, based on the method described in the previous sections.

The offered algorithm is based on modeling of work of typical elements of a low-frequency section of measuring system [8]-[19]: the square-law device, the first low-pass filter, the first adder, the second low-pass filter, the second adder and the block of registration. It is realized in program environment LabVIEW 7.0 [20]. The pulse interference was modeled by a square pulse of constant amplitude and duration with radio frequency carrier. The noise signal from the output of a high-frequency section was modeled by white Gaussian noise from standard library of LabVIEW 7.0 passed through the band-pass filter. On the input we have the additive mix of a noise signal and pulse interference. We vary amplitude and duration of a pulse interference, and dispersion of noise in the input. Relative pulse duration: τ_1=0.025, τ_2=0.075 and τ_3=0.15.

Dependence of error of measurement of average power of noise signal ε_n on the ratio interference/(noise signal) ρ (see Fig. 7) has been investigated.

Here ε_n – relative error of measurement of average power of noise signal $\varepsilon_n=|(\sigma_n^2 - \sigma_{no}^2)/\sigma_n^2|$, where σ_n^2 – average power of input noise signal, σ_{no}^2 – estimation of average power of noise signal in the output; $\rho=\sigma_p^2/\sigma_n^2$ – the ratio of the average power of pulse interference in the input to the average power of noise signal in the input.

Besides, in Fig. 7 is shown ε_1 - a relative error of measurement of average power of noise signal in the presence of pulse interference without any additional processing. ε_1 is defined by relation $\varepsilon_1=|(\sigma_n^2 - \sigma^2)/\sigma_n^2|$, where σ^2 an estimation of average power of mix.

For convenience of the analysis of the obtained dependences, relative error of measurement of average power of noise signal ε_n and ε_1 are shown in Fig. 7.

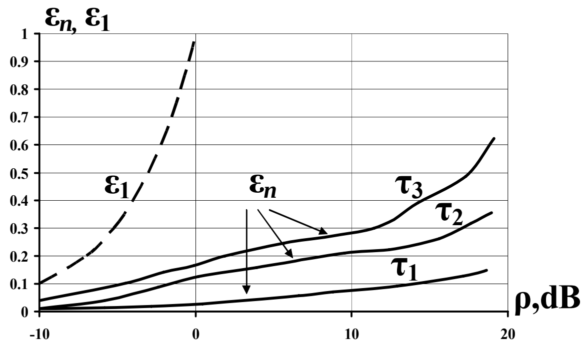

Fig. 7 Dependence ε_n and ε_1 on ρ

From Fig. 7, it is seen, that for relative pulse duration τ_1=0.025 down to $\rho \leq 10$ dB relative error of measurement of average power of noise signal ε_n not exceed 10 %. For relative pulse duration τ_2=0.075 and τ_3=0.15 down to $\rho \leq 10$ dB relative error of measurement of average power of noise signal ε_n not exceed 20 % and 30 % accordingly.

As it seen from Fig. 7, if we measure power of noise signal in the presence of pulse interference without offered method, error of measurement of average power of noise signal (curve ε_1 in Fig. 7) many times over exceeds corresponding error in case of using the method (curve ε_n in Fig. 7).

Dependence of error of measurement of average power of pulse interference ε_p on the ratio interference/(noise signal) ρ (see Fig. 8) has been investigated.

Here ε_p – relative error of measurement of average power of pulse interference $\varepsilon_p=|(\sigma_p^2 - \sigma_{po}^2)/\sigma_p^2|$, where σ_{po}^2 – estimation of average power of pulse interference in the output.

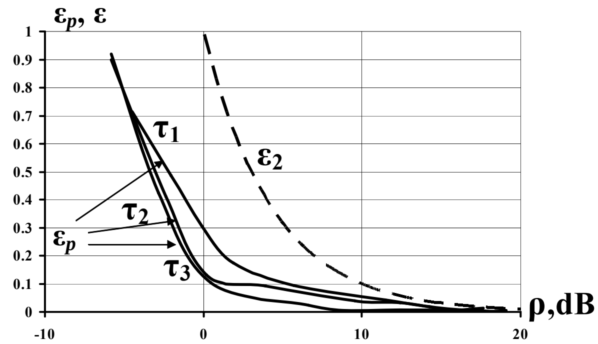

Fig. 8 Dependence ε_p and ε_2 on ρ

Besides, in Fig. 8 is shown ε_2 - a relative error of measurement of average power of pulse interference in the presence of noise signal without any additional processing. ε_2 is defined by relation $\varepsilon_2=|(\sigma_p^2 - \sigma^2)/\sigma_p^2|$, where σ^2 an estimation of average power of mix.

For convenience of the analysis of the obtained dependences, relative error of measurement of average power of pulse interference ε_p and ε_2 are shown in Fig. 8.

From Fig. 8 it is seen, that for relative pulse duration τ_1=0.025, τ_2=0.075 and τ_3=0.15 for $\rho \geq 5$ dB relative error of measurement of average power of pulse interference ε_p not exceed 10 %. For $\rho \geq 15$ dB relative error of measurement of average power of pulse interference ε_p not exceed 1 % for duration τ_1=0.025, τ_2=0.075 and τ_3=0.15.

As it seen from Fig. 8, if we measure power of pulse interference in the presence of noise signal without offered method, error of measurement of average power of pulse interference (curve ε in Fig. 8) exceeds corresponding error in case of using the method (curve ε_p in Fig. 8).

Through analysis of algorithm work, it is shown that when the ratio interference/(noise signal) increase, the error of measurement of average power of noise signal increase, and the error of measurement of average power of pulse interference ε_p decrease.

IV. Conclusion

In this paper, we have presented the power measurement algorithm of the input mix components of the noise signal and pulse interference. Results are confirmed by numerical experiments. It is shown, that with increasing of the ratio interference/(noise signal) the error of measurement of the average power of noise signal increases. Application of the considered algorithm allows receiving more than tenfold increase of accuracy of measurement of average power of noise signal. Results of work have practical value for designing real systems of measurement of power of noise signals in the presence of pulse interferences.

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