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THE ASSESSMENT OF PROBING RADAR SIGNALS FLUCTUATION MODULATION INGREDIENTS INFLUENCE ON THE DEGREE OF THEIR RECOGNITION

The article deals with the investigation of the effect of non-deterministic modulation amplitude on angular components of probing radar signals correlation properties. The results of the study demonstrate that the potential properties of the modulated signals with respect to recognition are much higher than the baseband. It can be explained by the presence of modulated fluctuation components, which in a certain form can be perceived as useful.

Статья посвящена исследованию влияния недетерминированных амплитудной модуляции на угловой компоненты зондирующего радиолокационных сигналов свойства корреляции. Результаты исследования показывают, что потенциальные свойства модулированных сигналов в отношении признания намного выше, чем в основной полосе частот. Это можно объяснить наличием модулированных колебаний компонентов, которые в определенной форме может быть воспринято как полезно.

Keywords: radio-location, sounding a radio-location signal, recognition, filter, impulsive radio signal, correlating, component of amplitude modulation, component of angular modulation, density distribution of the amplitude fluctuation component, density distribution of the angular fluctuation component, correlation function of complex circumflex.

Introduction

The development of radiolocation as a separate science is constantly accompanied by a search of the ideal (optimal) methods and means of information obtaining about the object of observation. The key role in this process, first of all, played the development of improved models of probing signals, since it is their properties determined the potential of systems in general. Together with theories development methods of their treatment were created, but almost always in practice, they did not allow to realize the potential that was found in the signals. A significant breakthrough in this area was the development and implementation of digital signal processing techniques. They almost lifted restrictions on potential adoptive resources both in terms of detection and in respect of recognition. As a result of potential restrictions radar signals characteristics were superimposed on the radar signals possibilities.

Main part

Today, a large number of effective models of signals [1,2] were developed, which differ in modulation and energy properties, have different capabilities and require different means for their synthesis. It is because of the complexity of complicated signals in the UHF band, most of the radars today are built with the help of simple probing signals.

Theoretically, the possibility of recognition of the finite in time and frequency axis signals are not infinite, and therefore the potential of radar means, to detect targets and completeness of the information about them in the application of such signals is limited. However, as shown in several studies [3,4,5], the real potential of probing signals, in the implementation of active radar is higher than the theoretical one. This is due to the fact that while the probe signals formation in the transmitter we can observe a number of destabilizing, not deterministic factors that cause certain changes in the properties of the signals. However, as shown in a number of works [3,4,5], real potential possibilities of sounding signals, during realization of active radio-location, higher than theoretical. This is due to the fact that the formation of sounding signals in transmitter operates the row of the non-deterministic destabilizing factors under act of that there is a certain change the properties of signals.

Taking into account the effects of these destabilizing factors, the generalized mathematical model of the limited in time and on frequency axle of the sounding signal can be represented as:

$$s(t) = S(c_S(t),t)\cos(w_0 t + j\,(c_j(t),t)), \tag{1}$$

where $S(c_S(t),t)$ – component of amplitude modulation; $c_S(t)$ – density distribution of the amplitude fluctuation component; $j\,(c_j(t),t)$ – component of angular modulation; $c_j(t)$ – density distribution of the angular fluctuation component. In the case when a radio-location is simple impulsive sounding signals in which absent an angular modulation constituent and amplitude modulation comes true by the impulses of rectangular form, $j\,(c_j(t),t) = j_0 + c_j(t)$, $S(c_s(t),t) = S(t)c_s(t) = \begin{cases} S_o c_s(t), & |t| \le t; \\ 0, & |t| > t; \end{cases}$ expression (1) will look like:

$$S(t) = \begin{cases} S_o c_s(t)\cos(w_0 t + j_0 + c_j(t)), & |t| \le t; \\ 0, & |t| > t; \end{cases} \tag{2}$$

As, correlation properties of signal are determined by a form their complex circumflex, we will write down expression (2) in a complex kind and will distinguish here complex circumflex:

$$S(t) = \mathrm{Re}\{s(t)\} = \mathrm{Re}\{Se^{jw_0 t}\}$$

$$\dot{s}(t) = S_0 c_S(t) e^{jw_0 t} e^{j(j_0 + c_j(t))},\ |t| \le t\ . \tag{3}$$

For simplification of further exposition, we will suppose that $S_0 = 1, j_0 = 0$. Expression (3) will look like:

$$\dot{s}(t) = c_S(t) e^{jw_0 t} e^{j\,c_j(t)},\ |t| \le t\ . \tag{4}$$

Correlation function of complex circumflex such signal will look like:

$$B(t) = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} S(t)S(t-t)dt = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} c_S(t)c_S(t-t)e^{jc_j(t)-c_f(t-t))}dt\,.$$

The absence of fluctuating components or when they are disregarded, correlation function of complex circumflex taking into account adopted in (4) assumptions of signs kind:

$$B(t) = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} S(t)S(t-t)dt = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} dt = t_i - |t|$$

During realization of the agreed-upon filtration in a receiver impulsive description of filter is synthesized by forms complex circumflex of signal and the reaction of filter on a signal will be his autocorrelation:

$$B'(t) = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} \dot{H}(t)\dot{S}(t-t)dt = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} \dot{S}(t_i - t)\dot{S}(t-t)dt = t_i - |t|\,.$$

However, at presence of non-deterministic components in signal what are not taken into account at the synthesis of filter the function of autocorrelation becomes a function of the correlation between the impulsive response of the filter and the real complex circumflex of the signal:

$$B'(t) = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} \dot{H}'(t)\dot{S}(t-t)dt\,, \tag{5}$$

where $\dot{H}'(t) \ne \dot{S}(t_i - t)$.

Depending on the error of reproducing circumflex at forming of sounding signal, will changing the form of review of agreed-upon filter that is actually determined by the type of correlation function (5). As in practice amplitude and angular casual processes in sounding SHF signal is statistically independent for the evaluation of degree of transformation review, it is necessary to set the laws of distributions of casual sizes separately $c_S(t)$ and $c_j(t)$. We will consider one of widespread cases in process impulsive generators of SHF, namely when $c_S(t)$ presents the reaction of RC – circle of chain with permanent to time of **T** on the impulse of rectangular form, that characteristically to distortions that is brought in a modulating impulse parasitic reactances in a keyer and characterized by durations of wavefronts of impulse and unevenness of top, and $c_j(t)$ distributed by a linear law, that characteristically for most impulsive generators SHF dependences of frequency on the change of voltage at their input. As follows:

$$c_S(t) = (1 - e^{-\frac{t}{T}})s(t) - (1 - e^{-\frac{t - t_i}{T}})s(t - t_i), \tag{6}$$

where $s(t)$ – the Heaviside function. Substituting expression (6) and (7) in (4), the complex circumflex of the sounding signal will accept the kind:

$$\dot{S}(t) = ((1 - e^{-\frac{t}{T}})s(t) - (1 - e^{-\frac{t - t_i}{T}})s(t - t_i))e^{jbt^2}.$$

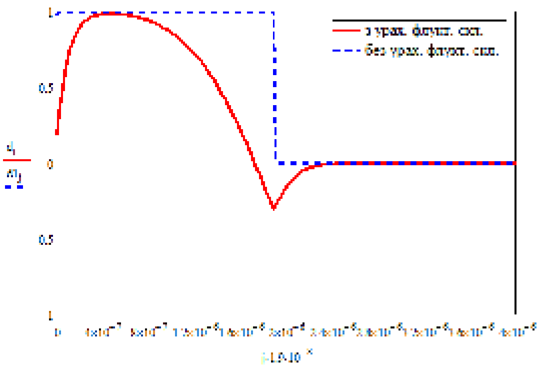
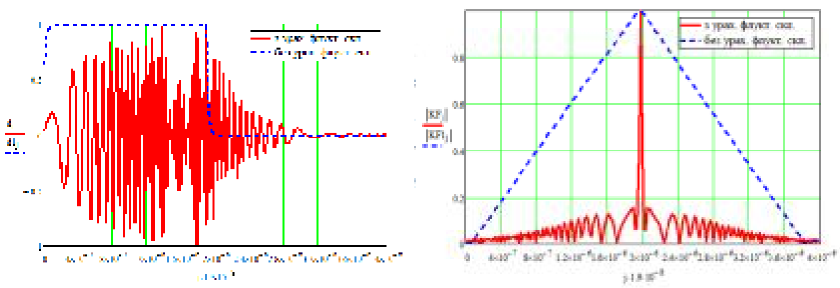


Fig. 1. Dependence of form of complex circumflex and her autocorrelation function

Depending of the parameters of distributions, namely permanent to time of **T** and coefficient of steepness of frequency modulation **b** efficiency of algorithm of optimal treatment will be different, because of their size depends on the degree of "consistency" transition characteristics of the filter and signal. On figure 1 is shown dependence the form of complex circumflex and her autocorrelation function at insignificant angular and amplitude distortions, namely at tightening of wavefronts at the level of 5 % and relative instability of frequency of generator SHF at level of $1{,}5 \times 10^{-5}$, considerable deformation of form is complex circumflex and reduction of interval of correlation on 10-15 %.

For impulsive generators of SHF to provide such stability difficult enough. So, impulsive generators of SHF magnetron type, used in majority impulsive radio-location facilities have relative stability of frequency at level of 1×10^{-2} and keyers provide duration of wavefronts at the level of 20-30 % from duration of impulses. For such case (Fig. 2) there are a considerable change of complex circumflex (Fig. 2, a) and reduction of her interval of correlation (Fig. 2, b) measured is ten times.



a) b)

Fig. 2.

If to confront such properties of sounding signals and algorithm of their consistency treatment not taking into account the presence of casual fluctuation components the form of review of the agreed-upon filter will be formed coming from a form amplitude circumflex and will not contain angular fluctuation components, however at application of quadrature detector or quadrature sampler, these components will result in appearance of sidelobes amplitude limited by to the form of autocorrelation function on amplitude circumflex:

$$B'(t) = \int_{-\frac{t_i}{2}+t}^{\frac{t_i}{2}} \dot{S}(t)\dot{S}(t-t)e^{jb(t-t)^2}dt = (t_i - |t|)f(b,t)$$

In fact, the receiver is processing the signal with which it agreed only partially, giving rise to distortions of the response, to eliminate that as a rule, apply algorithms (schemes) compensation instability of the transmitter. However, as seen from Fig. 2, the presence of angular and amplitude distortions lead to a significant reduction of the interval autocorrelation of probing signals while synthesis of the corresponding transient response of the matched filter potentially increases the degree of recognition.

Conclusion

The presence of an additional modulation of the radio signals, in any case, increases the noise immunity and the degree of recognition. As the result of the study, the gain can range from several times to several tens of times. However, the deterministic nature of the modulation of these components requires additional processing algorithms, namely the constant (dynamic sounding out period) adaptation of the transient response of the matched filter in the receiver. It should be noted that in this approach the potential recognition signals are also limited, but not their duration, and bandwidth of the receiver and the laws of distribution of components in the fluctuation amplitude and phase envelopes.

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КВАНТОВА ТЕОРІЯ ВИМІРЮВАНЬ: ПРИНЦИПИ ТА МЕТОДИ ВИМІРЮВАЛЬНОГО ПЕРЕТВОРЕННЯ АМПЛІТУДНИХ ТА ФАЗОЧАСТОТНИХ ПАРАМЕТРІВ РАДІОСИГНАЛІВ

Стаття присвячена опису методології та принципів нового напрямку у теорії і практиці вимірювань – квантовій теорії вимірювального перетворення фізичних величин, яка вперше дозволила зняти принципове обмеження і одночасно підвищити і точність і швидкодію вимірювань, у 10-100 разів, за рівних умов технологічного рівня елементів. Розроблено ат запропоновано методологію та принципи побудови ЦАП і АЦП нового покоління із програмованою архітектурою та параметрами шляхом використання Атенюатора – подільника Троцишина, та його модифікацій, на основі принципів коінциденції.

Article describes the methodology of a new direction in theory and practice of measurement – quantum theory of measuring conversion of physical quantities, which first allowed to remove the fundamental limitations and simultaneously increase the speed and accuracy and measurement times of 10-100, with equal technological level elements. A proposed in JSC methodology and principles of DAC and ADC's new generation of programmable architecture and parameters by using attenuator – Trotsyshyna divider, and its modifications, based on the principles coincidence.

Ключові слова: квантова теорія вимірювального перетворення фізичних величин, атенюатор-подільник Троцишина, методологія та принципи побудови ЦАП і АЦП нового покоління

Вступ

Будь яка сучасна система оброблення інформації використовує ЦАП і АЦП перетворення які є обов'язковими елементами що пов'язують аналогові та цифрові засоби і системи. Існуючі ЦАП і АЦП побудовані на принципах двійкової арифметики і поділяються на дві групи: паралельної і послідовної дії, та відповідно використовують структури з подільників R-2R (послідовної дії), або подільника Кельвіна (паралельної дії). Сучасна вимірювальна техніка, метрологія та приладобудування мають принципове обмеження і в рамках сучасних уявлень принципово не допускають одночасного підвищення і точності і швидкодії вимірювального цифрового перетворення.

В рамках теорії ФЧВ і ПР авторам проекту вдалося довести і практично досягнути значного збільшення (в 10-100 разів), і покращити суперечливий параметр <u>ТОЧНІСТЬ х ШВИДКОДІЯ ВИМІРЮВАНЬ</u> саме для фазочастотних параметрів радіосигналів [1-12].

Враховуючи, що в основі досягнутих унікальних результатів є заміна у використанні самої