Applied problems of information systems operation

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METHOD OF RADIOELECTRONIC MEASURER’S OPTIMIZATION

Abstract. The existing problems in the optimal construction of measuring systems are considered. The solution is shown due to the use of exchange curves by Gutkin L.S. The exchange curves can explain which meters are most optimal, how to agree on metrics quality, how to overcome the need for large a priori uncertainty, without reducing the accuracy, how to explain the contradictions of some theories, how to reconcile the a priori range with the physical range, how to use a priori data, how it affects accuracy measurement of the variable signal level, how the accuracy of the setting affects the accuracy of measurements, how can the signal search time be reduced, how it affects the system of automatic control, the nature of the monitoring process so on. The method of formation of a generalized index of quality of measuring systems is proposed, which is valid for measuring systems of any type and various parameters being measured.

Keywords: optimization; parameter estimation; measurement; accuracy.

Introduction

Formulation of the problem. The rapid development of rocket space science and technology, communications and information technology has led to the already lacking of existing radio measurement methods. In addition to the need for accuracy measurements, there is a need to take into account the wide a priori range of measuring times for rapidly changing processes, reliability in connection of scales, the ratio of signal to noise, also in the use of value.

Modern measurement methods that exist in metrology perform the function of comparing the parameter measured with the corresponding standard (with its share). For electronic measurements, this is the most precise zero-method, as well as the difference method, the functional method is direct-indicating devices, the substitution method, non-native method, and others. But these methods are not enough for electronic measurements, which require: accuracy of evaluation; accuracy of a priori data; speed, or measurement time; confidence probability of scaling; ratio of signal strength to noise; cost to optimize systems; the method of synthesis of systems from common positions, etc. [1, 3–5].

These problems (optimization of measuring systems) are proposed to be solved by using the generalization expression for obtaining exchange curves for qualities by Gutkin L.S. [1]. So, for optimization problems of measuring systems and obtaining curves of exchange, the target function for them can be found for all types of meters.

Optimization tasks will be generated if you find the limitations of cost, peak power, and so on. Thus, the formulation of a generalized indicator of the quality of measuring systems from unified positions is an actual scientific task.

Analysis of literature. As a result of solving tasks of optimization of radio-electronic means Gutkin L.S. [1] found such a feature of their optimal solution that if gradually change the limit values and solve the problem by the main indicator, then it is possible to get interdependence between the optimal indicators - the exchange curve. That is, it will be a whole class of optimization tasks that are being solved.

Results of optimization of a number of problems [6–21] by separable programming method allowed to obtain solutions in analytical form, which can be immediately called curves of exchange. It was found that for tasks of optimization of measuring systems and for obtaining the curves of exchange, the target function for them can be found for all types of meters. Optimization tasks can be generated if you find the limitations of cost, peak power, and so on.

Purpose of the article. If the goal and the main problem of scientific developments is the optimization of measuring systems, then it is usually solved at the stage of obtaining the curves of the exchange of the target function.

Therefore, it is necessary to formulate a generalized indicator of the quality of measuring systems with unified positions.

Basic material

Radio electronic meters may be analog and digital detectors, discriminators, parameter converters within the automatic control system (ACS) or as part of the channel of maintenance by parameter. At the same time, the maintenance of the speed of measurement and restructure of the automatic control system should be no less than the rate of change of the process.

Measurement or transformation of any parameter is realized on the basis of the corresponding functional dependence of the offset from the measured value according to the known law of nature. This requires the greatest sensitivity of the meter to the measured parameter. Therefore, it is often used to measure the frequency of a signal using a sensitive resonance phenomenon, for angular measurements - a directional diagram (DD), for measuring time delay - a pulse or its fronts, for measuring the delay of random processes, an autocorrelation function, etc.

These dependencies are derived from the corresponding signaling functions or from their parts and combinations. Dependence on the conversion to a slider is called a scale. The scoring of the measurement on a scale is the result of its comparison with the corresponding reference value. The scale should be sufficiently stable in size and in adjustment. Then the cursor corresponds to a given mean square error, which, in percent, is a class of accuracy.

Well-known functional meters, where the law of transformation in the form of functional dependence, sometimes called "direct-indicating" meters. The scale may be linear or not. Linear is more desirable, because the average error does not change according to the scale. To do this, and most importantly, in order to identify the important relationship between the quality indicators of the meters, consider Fig. 1.

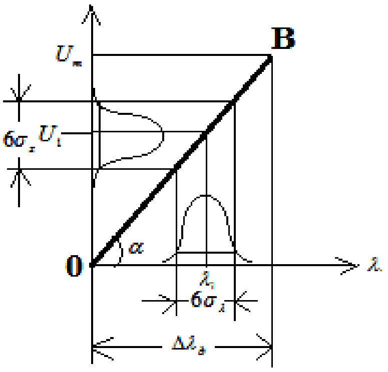

Fig. 1. Characteristic 0B – scale of the meter, where: $6\sigma_z$ – confidentiality interval; $6\sigma_\lambda$ – confidence interval of the parameter; U_m, U_1, λ_1, $\Delta\lambda_d$ – respectively: range of offsets, offset, parameter estimation and aperture (range) of the meter

We find indicators of the quality of the meter. The accuracy will be constant if the characteristic 0B is linear, as in Figure 1.

If the parameter is measured λ_1, then the output will be voltage U_1. In this case, the measurement is obtained with a hindrance. Knowing the accuracy of the measurement, we determine the confidence interval $6\sigma_z$ and $6\sigma_\lambda$.

From Fig. 1 it is clear that the fair relation:

$$6\sigma_\lambda = 6\sigma_\tau = \frac{6\sigma_z}{tg\alpha}.$$

From this:

$$\sigma_\lambda^2 = \frac{\sigma_z^2}{tg^2\alpha} = \frac{\sigma_z^2}{(U_\lambda^1)^2}, \qquad (1)$$

or

$$\sigma_\lambda^2 = \sigma_z^2 \Big/ \left(U_m^2 / (\Delta\lambda_d)^2\right) = = (\Delta\lambda_d)^2 \Big/ q = (\Delta\lambda_d)^2 \Big/ \left(P_m / (N_0 \mathit{\Pi})\right)., \qquad (2)$$

where $q = \frac{U_m^2}{\sigma_Z^2} = \frac{P_m}{P_Z} = \frac{P_m}{N_0 \mathit{\Pi}}$ – ratio of power to signal maximum to noise,

N_0 – spectral density of interference,

$\mathit{\Pi}$ – frequency band of the meter.

So, for optimum choice of meter, its qualities, structure and algorithm, there are five main indicators: accuracy; the a priori range; time of measurement limited by the band P; reliability (or quantile) of adjustments or docking of scales; the signal level, or the ratio of signal strength to noise or cost.

Expression (2) is the basis for the logical connection of existing and new methods of developing electronic meters with any qualities and measurement ranges: discriminator meters; search or panoramic meters; multichannel meters; multi-plate meters; multi-stage meters; digital meters; combined meters. The following are the results of research on the quality of distributed discriminator meters that may be part of the exchange curve and are the basis for use in more complex systems.

The meters may be separate or in the respective channels and ACS.

The value (2) is that the results are universal in nature and are the basis of optimization and relate to any measured parameter.

The analysis of existing alternative measurement theories showed that in the literature on the topic of radio electronic measurements there is a method of likelihood functional (FL) by Woodward F.M. [2] and the concept of "potential" accuracy of measurements causing questions, as well as fragments of the theory of electronic meters, where there is no central idea of evaluating the qualities for the construction of meters, and also there is no systematic analysis of the influence of the essential factors acting on the meter. Woodward F.A. error and his followers is that he reasoned: naturally assume that the parameter λ_i (delay in time), which was transmitted, is known, and the parameter in the mixture is an unknown parameter.

But this assumption can not be done! The difference in parameters in the signal and in the mixture of signal with noise should not be, because this difference between the mixture and the signal should be equal to the noise. That is, the signal in the mixture and in the signal that is subtracted from the parameter must be the same. Otherwise there will be no normal distribution of noise, which leads to such a paradox. It is known that the signal should be much more noise. Therefore, at such a substitution of parameters weak noise is replaced by a large difference of powerful signals with different parameters. This means the voluntarist purpose of the difference in the parameters from which you can get anything, and the incorrectly obtained auto-correlation function of the signal. For receiving which does not need FL, because known coordinated filtering. Further, the main error of followers: from here it is possible (but wrongly) to obtain the algorithm of measurements, "potential" accuracy, "optimal" signals and parameters for complex and different vector parameters and signals.

Such FL also does not support the following facts: it is not necessary to use the autocorrelation function of the signal and in its maximum value in subsequent meters; digital meters also work according to other principles; multi-mass meters do not fit into these theories at all; the increase in the accuracy of the measurements of the signal delay is likely to depend on the width of the spectrum, but this is not clear from this theory of potential precision, but with the fact of increasing the steepness of the fronts of the signal at the receiver output. Generally in metrology, the steepness of the scale is called sensitivity, and it determines the accuracy of measurements. And the steepness is not the center of the auto-correlation function.

Consider the concept of "potential" accuracy in radio electronics, which conflicts with existing measurement methods. It is proved in existing well-known works that it is inappropriate to use this concept to evaluate accuracy in radio measuring systems. However, it is shown that the concept of "potential accuracy" of measurement makes sense, but only for tasks of determining the accuracy of distinguishing signal functions (SF):

$$\sigma^2=\frac{1}{q\psi''(0)}, \qquad (3)$$

where q – signal / noise ratio;

$\Psi(\lambda)=\Psi(0)\psi(\lambda)$ – signal function;

$\Psi(0)$ – maximum signal function;

$\psi''(\lambda)$ – the second derivative from the normalized signal function at the maximum.

However, (3) does not apply to an ordinary rectangular signal for which $\psi''(0)$ endless Then, to distinguish the signal functions, it is necessary to have the form of the signal by the type of the inverted button. But (3) can be used to evaluate signal shifter over time or at angles to distinguish signals in radar.

Signal function – sharp signal shuffle at the receiver output. When measuring a time delay parameter, as an SF, for example, an output signal in the form of an autocorrelation function, for the parameters of the angles measured, the location of the object - may be the envelope of the output signal according to the DD, for the measured frequency, the resonance effect is used, and etc.

Take the truncated Taylor series:

$$\Psi(\lambda)=\Psi(\lambda_0)+\Psi'(\lambda_0)\cdot(\lambda-\lambda_0)+ +\Psi''(\lambda_0)\cdot(\lambda-\lambda_0)^2/2!+\dots .$$

The top of the SF is approximated by a quadratic dependence in the neighborhood of the parameter λ_0, keeping with an accuracy of 1% the steady slope of a quadratic term in the interval

$$\Delta\lambda\le 0,03\cdot\Psi''/\Psi'''.$$

In this case, the linear term

$$\Psi'(\lambda_0)(\lambda-\lambda_0)=0$$

by definition, and $\Psi''(\lambda_0)<0$. The physical model assumes two goals when one SF is set to λ_0, and the other - on λ_1, or it's one SF with some parameter setting λ_1 on the inertial screen to be identified. Compatible impact SF looks like:

$$\Psi_0(\lambda-\lambda_0)+\Psi_1(\lambda_1-\lambda)=\Psi_0(\lambda_0)+\Psi_1(\lambda_1)- -\left|\Psi_0''(\lambda_0)\right|\frac{(\lambda-\lambda_0)^2}{2!}-\left|\Psi_1''(\lambda_1)\right|\frac{(\lambda_1-\lambda)^2}{2!}. \qquad (4)$$

The largest size of the gaps is:

$$\lambda_{\min}=\frac{\Psi_0''\lambda_0+\Psi_1''\lambda_1}{\Psi_0''+\Psi_1''}. \qquad (5)$$

An ideal observer with an obstacle will be able to estimate the shift of the parameter λ_1 relatively λ_0, provided that the size of the gap (negative part (4) in the overall SF for some sorting will be no less than the background noise that is being considered.

We estimate the displacement of the parameter JV in the appearance of gaps at $\lambda=\lambda_{\min}$ in the presence of noise from the following expression:

$$-\left|\Psi_0''(\lambda_0)\right|\frac{(\lambda-\lambda_0)^2}{2!}-\left|\Psi_1''(\lambda_1)\right|\frac{(\lambda_1-\lambda)^2}{2!}=\sigma_{ш}^2.$$

Because $\lambda_{\min}-\lambda_0=\frac{\lambda_1-\lambda_0}{2}$

and

$$\lambda_1-\lambda_{\min}=\frac{\lambda_1-\lambda_0}{2}=\frac{\Delta\lambda}{2},$$

with possible left deviation λ_1 will be

$$2\Delta\lambda=\sigma_\lambda.$$

Then at

$$\Psi_0''=\Psi_1'',$$

write (4) in the form:

$$\Psi_0''\sigma_\lambda{}^2=\sigma_{ш}^2,$$

or

$$\sigma_\lambda^2=\frac{\sigma_{ш}^2}{\Psi_0''}=\frac{\sigma_i^2}{\Psi(0)\psi''(0)}=\frac{1}{q\left|\psi''\right|}. \qquad (6)$$

This implies that if you observe the parameter λ at the position of the maximum of SF, it is possible to estimate its offset by the parameter with the accuracy (6) only when the gap is detected.

Such observation in technology (automation) is called: on the principle of "maximum", or extreme regulation. It is also known, for example, in "hunting for a forest" in a radio broadcast, and so on.

But such observation: does not give an estimate of the side of the deviation; has a significant error for (6), Fig. 2.

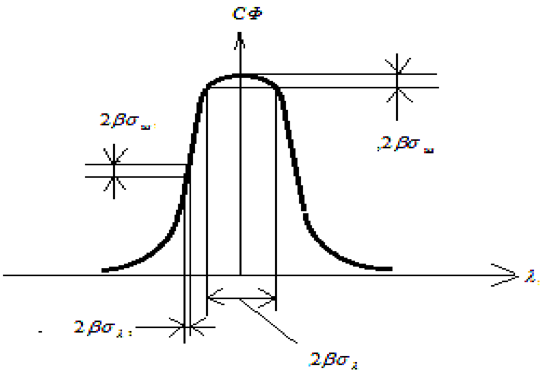

Fig. 2. Trust intervals

Fig. 2 shows confidence intervals according to noise and parameter estimation $2\beta\sigma_ш$, $2\beta\sigma_\lambda$ for two options for the SF setting (extreme evaluation is worse than the method for estimating the parameter at greater lateral slope SF).

It is clear that in order to evaluate the parameter, it is best to have the greatest sensitivity (at the level of maximum steepness of the SF) than the extreme observation of SF.

Thus it is possible to state:

– extreme observations are most useful for distinguishing purposes, but for parameter estimation it does not work because the greatest sensitivity and accuracy should be at estimation at the highest steepness;

– the error of the parameter for distinguishing can be calculated by (6), if the curvature SF is known;

– due to (6), in terms of distinction, it is desirable to have SF with maximum curvature at maximum, but it requires an undesirable large band for the time process, a large antenna for the angular process, and a large *Q* factor for the frequency response.

Consider the coherence factor of the a priori range of the meter with its physical range, that is, with the aperture of the two-channel discriminator, when:

$$2\beta_{a\lambda}\sigma_{a\lambda} < 2\Delta\lambda_d ,$$

where $\beta_{a\lambda}$ – a priori quantum a priori range $\Delta\lambda_d$, which is equal to $2\beta_{a\lambda}\sigma_{a\lambda}$ and less physical range $2\Delta\lambda_d$, that is less aperture of a two-channel discriminator (Fig. 3).

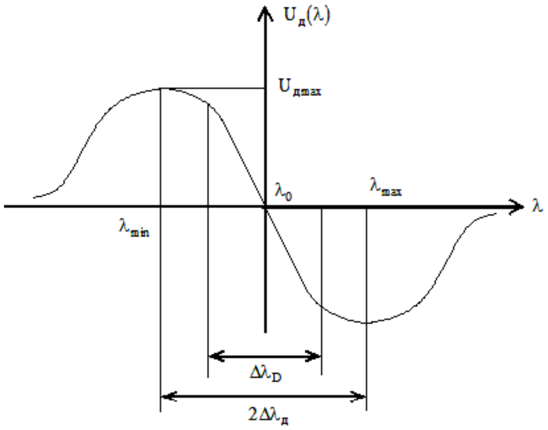

Fig. 3. Apriority range smaller than an aperture Discriminator

In this case, the signal level is more needed. Therefore, it is possible to reduce the separation between the channels so that the ranges are aligned, and thus almost free increase the slope of the discriminator and its accuracy. If you imagine that the a priori range $\Delta\lambda_d$. Exceeds the physical range, in this case ambiguity of measurements is possible. The only optimal matching of the a priori range of a parameter measured with its physical range will be only if they are equal

$$2\beta_{a\lambda}\sigma_{a\lambda} = \Delta\lambda_D = 2\Delta\lambda_d .$$

This is a "little optimization".

Similarly, in the coordinated frequency band P with the spectrum of the signal (1).

This is the optimal value of the band of the receiver or filter by Siforov.

Ability to use a priori data

By (2) it is possible to connect a priori data:

$$\sigma_\lambda^2 = \frac{2\beta_{a\lambda}^2\sigma_{a\lambda}^2}{q} . \quad (7)$$

It is known that if the a priori Gaussian matrix is the probability distribution, then you can increase the accuracy of the measurements. To refine the estimation of the parameter λ.

We need to calculate a weighted estimate for Gaussian distributions $p(\lambda)$ and $p_a(\lambda)$:

$$\lambda_1 = \frac{\sigma_a^{-2}\lambda_a + \sigma_\lambda^{-2}\lambda}{\sigma_a^{-2} + \sigma_\lambda^{-2}} , \quad (8)$$

then the accuracy of the weighted estimation will increase by the value of the a priori accuracy σ_a^{-2}:

$$\sigma_1^{-2} = \sigma_a^{-2} + \sigma_\lambda^{-2} = \sigma_a^{-2}\left(1 + \frac{\beta_{a\lambda}^{-2}}{2} q_1\right) . \quad (9)$$

This is even more generalized curve (9), includes a priori data. At $q > 20\beta^2$ it makes no sense to refine the calculation, since the accuracy increases by only 10%. This is the optimum by type of saturation.

Thus, a priori information can be the result of measurements on the previous scale. Lack of following discriminators in comparison with non-pursuing discriminators – the presence of a dynamic error.

Influence of signal level changes on accuracy of estimation

Almost all radio discriminators have the same feature that the highest voltage (counting) at the output of the discriminator, when the parameter is on the limits of its aperture, is proportional to the amplitude of the input signal, including after the limiters and stabilizers of its amplitude. To estimate the effect of changes in signal amplitude, assume that there are no stabilizers and limiters of the amplitude, and determine how this will affect the error of the discriminator.

Let's have a discriminatory characteristic $U_0(\lambda)$, in which maximum value U_{0m} matches the amplitude of the input signal S_{m2} (Fig. 4).

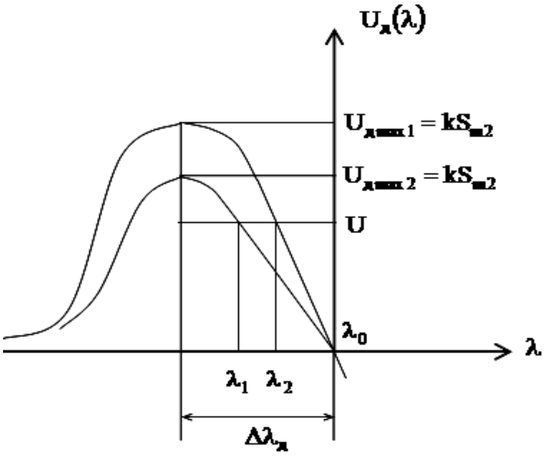

Fig. 4. The effect of the signal level on the measurement

If the amplitude of the input signal changes and becomes S_{m1}, then the discriminatory characteristic will become steeper and its maximum will equal U_m. This will result in an error estimating the signal parameter λ. Indeed, if the output of the discriminator is voltage U_λ and there is no fluctuation interference, then we believe that the measured parameter is equal to λ_1, keeping in mind that we know the former level of the signal. In fact, the signal level has become S_{m1}, the trickiness of the discriminating characteristics has become more and tense U_λ matches the signal parameter λ_2.

So, the error in parameter estimation λ equals:

$$\Delta\lambda = \lambda_1 - \lambda_2 = \Delta\lambda_d \frac{U_\lambda}{U_m} - \Delta\lambda_d \frac{U_\lambda}{U_{m1}}..$$

Then:

$$\Delta\lambda = \lambda_d U_\lambda \left(\frac{1}{U_m} - \frac{1}{U_{m1}} \right) = \Delta\lambda_d \frac{U_\lambda}{U_m} \left(1 - \frac{U_m}{U_{m1}} \right).$$

If the signal level U_m – random variable, then variance σ_2^2, mistakes $\Delta\lambda$ the signal parameter due to the random change in the amplitude of the signal will be:

$$\sigma^2_{\lambda(\mathrm{AM})} = \Delta\lambda_d^2 \left(\frac{U_\lambda}{U_m} \right)^2 \hat{\sigma}^2_{Um}, \qquad (10)$$

when $\hat{\sigma}^2_{Um} = \left(\sigma_u / U_m \right)^2$ – relative variance of the amplitude of the signal.

Thus, the maximum variance $\sigma^2_{\Delta\lambda(\mathrm{AM})}$ estimation errors λ is responsible

$$U_\lambda = U_m$$

and equals:

$$\max_{\{U_\partial\}} \sigma^2_{\lambda(\mathrm{AM})} = \Delta\lambda_d^2 \hat{\sigma}^2_{U_m}.$$

Let the variance $\sigma^2_{\lambda(\mathrm{AM})}$ mistakes $\Delta\lambda$ (due to ignorance of the signal) does not exceed the variance of measurements due to the influence of fluctuation obstacles.

Then we obtain the demand for the accuracy of the amplitude of the signal stabilization:

$$\sigma^2_{\lambda(\mathrm{MM})} \le \sigma^2_\lambda, \qquad (11)$$

from here: $$\Delta\lambda_d^2 \hat{\sigma}^2_{U_m} \le \frac{\Delta\lambda_d^2}{q}$$

or $$\hat{\sigma}^2_{U_m} \le \frac{1}{q}. \qquad (12)$$

Another application (12) obtained for curve (2).

On the curve of the exchange of discriminator measurements, the accuracy of the setting of the scales, the precision of the scale start shift, has a significant effect.

Conclusions

Thus, it is possible to draw the following conclusions from the obtained (1) and (2).

1. Measurement accuracy of any parameter λ the signal does not depend on the gain of the receiver. However, it is not selected arbitrarily, and such that the level of the output signal, which should be known, corresponds to the scale of the final measuring device.

2. The accuracy of the parameter measurement λ the signal as the value of the inverse dispersion of the error is directly proportional to the signal / noise ratio q.

3. Evaluation variance σ^2_λ according to expression (2) is proportional to the square of the aperture of the discriminator. Therefore, to achieve high accuracy (small dispersion σ^2_λ) should strive to reduce the aperture $\Delta\lambda_2$ of the discriminator.

4. The accuracy of the meter also increases with the decrease in the width of the spectrum of the signal. That is why the phase measurements are considered the most accurate.

5. The expression (2) connects all the quality indicators for these meters. After the introduction of restrictions, this will be curves for the exchange of qualities of meters by Gutkin L.S.

The obtained relations (11) and (12) make the following conclusions.

1. The smallest effect of the change in amplitude on the error of discriminatory measurements is manifested at a small deviation of the parameter from the central setting of the discriminator λ_0, that is, at small U_d.

Hence it is clear that in order to control the effect of changing the signal level, it is best to use a watchdog, which is tracking the parameter λ. However, even for the monitor discriminator, the amplitude of the signal stabilization is necessary because the dynamics of its change may affect the quality of the observation of the parameter λ.

2. Stabilization of the amplitude of the signal (measuring it with relative accuracy):

$$\hat{\lambda}^2_{U_m} \le 1/q,$$

allow you to ignore the error due to the ignorance of the amplitude of the signal.

In this case, the relative variance of the amplitude stabilization is compared with the relative dispersion of the fluctuation component of the discriminative measurement error:

$$\left(\sigma_\lambda / \Delta\lambda_d \right)^2 = \hat{\sigma}^2_{U_m} = 1/q..$$

This means that the non-monitored discriminator for (12) is practically inferior to the precision of the monitor being discriminator, with the same effective bandwidth of the frequency filters.

The advantage of monitored discriminators in comparison with non-observable discriminators is to lower the effect of the signal amplitude change, and the advantage of non-observable discriminators is, in comparison with observing discriminators, the absence of a dynamic error of measurement of the signal parameter associated with rebuilding the discriminator and dynamics of changes in signal parameters in time.

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Метод оптимізації радіоелектронних вимірювачів

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Анотація. Розвиток науки і техніки привів до того, що існуючих методів радіовимірювань стало вже недостатньо. Окрім потреби в показниках точності вимірювань з'явилася потреба в врахуванні широкого апріорного діапазону часу вимірювань для процесів, що швидко змінюються, надійності в стикуванні шкал, відношенні сигналу до шуму, а також у використанні вартості. Сучасні методи вимірювань, існуючі в метрології, виконують функцію порівняння параметра, який вимірюється з відповідним еталоном (з його частиною). Для радіоелектронних вимірювачів – це найточніший нуль-метод, а також різницевий метод, функціональний метод – пристрої, що прямо вказують, метод заміщення, конусний метод і інші. Але цих методів вже недостатньо для радіоелектронних вимірювачів, де потрібні: точність оцінки; точність апріорних даних; швидкість або час вимірювань; довірча вірогідність стикування шкал; відношення потужності сигналу до шуму; вартість для оптимізації систем; метод синтезу систем із загальних позицій і так далі. Ці проблеми (оптимізації вимірювальних систем) пропонується вирішувати завдяки використанню узагальненого виразу для отримання кривих обміну якостей за Гуткіним Л. С. Отже, для задач оптимізації вимірювальних систем і отримання кривих обміну, цільову функцію для них можна знайти для усіх типів вимірювачів. Задачі оптимізації будуть сформовані, якщо знайти обмеження за вартістю, піковою потужністю тощо. Таким чином, формулювання узагальненого показника якості вимірювальних систем з єдиних позицій є актуальною науковою задачею. Результати оптимізації ряду задач методом сепарабельного програмування дозволили отримати рішення в аналітичному вигляді, які відразу ж можна назвати кривими обміну. Виявлено, що для задач оптимізації вимірювальних систем і для отримання кривих обміну цільову функцію для них можна знайти для усіх типів вимірювачів. Задачі оптимізації можуть бути сформульовані, якщо знайти обмеження за вартістю, піковою потужністю тощо. Запропоновано метод формування узагальненого показника якості вимірювальних систем. Показано, що узагальнений показник якості справедливий для усіх типів дискримінаторних вимірювачів. При цьому, узагальнений показник якості справедливий як для вимірювачів і каналів будь-якого типу, так і для різних параметрів, що вимірюються. Узагальнений показник якості вимірювальних систем легко доповнюється зв'язками з іншими показниками.

Ключові слова: оптимізація; оцінка параметра; вимірювання; точність.

Метод оптимизации радиоэлектронных измерителей

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Аннотация. Развитие науки и техники привело к тому, что существующих методов радиоизмерений стало уже недостаточно. Кроме потребности в показателях точности измерений появилась потребность в учете широкого априорного диапазона времени измерений для быстро изменяющихся процессов, надежности в стыковке шкал, отношении сигнала к шуму, а также в использовании стоимости. Современные методы измерений, существующие в метрологии, выполняют функцию сравнения параметра, который измеряется с соответствующим эталоном (с его частью). Для радиоэлектронных измерений – это самый точный ноль-метод, а также разностный метод, функциональный метод – прямо указывающие устройства, метод замещения, конусный метод и другие. Но этих методов уже недостаточно для радиоэлектронных измерений, где нужны: точность оценки; точность априорных данных; скорость или время измерений; доверительная вероятность стыковки шкал; отношение мощности сигнала к шуму; стоимость для оптимизации систем; метод синтеза систем из общих позиций и так далее. Эти проблемы (оптимизации измерительных систем) предлагается решать благодаря использованию обобщенного выражения для получения кривых обмена качеств по Гуткину Л. С. Следовательно, для задач оптимизации измерительных систем и получения кривых обмена, целевую функцию для них можно найти для всех типов измерителей. Задачи оптимизации будут сформированы, если найти ограничение по стоимости, пиковой мощностью и так далее. Таким образом, формулирование обобщенного показателя качества измерительных систем с единственных позиций является актуальной научной задачей. Результаты оптимизации ряда задач методом сепарабельного программирования позволили получить решения в аналитическом виде, которые сразу же можно назвать кривыми обмена. Обнаружено, что для задач оптимизации измерительных систем и для получения кривых обмена целевую функцию для них можно найти для всех типов измерителей. Задачи оптимизации могут быть сформулированы, если найти ограничение по стоимости, пиковой мощностью и так далее. Предложен метод формирования обобщенного показателя качества измерительных систем. Показано, что обобщенный показатель качества справедлив для всех типов дискриминатор измерителей. При этом, обобщенный показатель качества справедлив как для измерителей и каналов любого типа, так и для различных измеряемых параметров. Обобщенный показатель качества измерительных систем легко дополняется связями с другими показателями.

Ключевые слова: оптимизация; оценка параметра; измерения; точность.