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# THE CHOICE OF THE SOLUTION FILTRATION APPROACHES IN TASK OF ORIENTATION

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***Abstract.*** *The choice of the solution filtration approaches in task of orientation is considered.*

**Keywords:** orientation; satellite; navigation**.**

## Introduction

Since the state variable filter is a dynamic operator with a closed structure, the speed of processes occurring there, including their constituents depend on the initial conditions depend on the matrix filter gain and the value of the latter.

Of this the following four approaches improved synthesis filter state variables:

1. Improving filtration efficiency through the introduction of an additional loop filter gain matrix;
2. Improving filtration efficiency due to the synthesis filter state variables in the form of the Wiener filter with the introduction of its outline additional matrix gain;
3. Improving the efficiency of filtering by using estimates of the initial conditions of the state variables of the object defined in some way, to set the initial conditions of state variables of the filter;
4. Improving filtration efficiency due to the synthesis filter state variables in the form of the Wiener filter using the estimates of the initial conditions of the state variables of the object defined in some way, to set the initial conditions of state variables of the filter;
5. Improving the efficiency of filtration through a combined approach based on the first and third approaches;
6. Improving the efficiency of filtration through a combined approach based on the second and fourth approaches.

## The complexing of orientation and navigation systems

The main aim of the orientation system complexing and navigation is to increase the accuracy of the determining the navigational and angular parameters of UAV orientation. Separated sensors of the prime information can be untied (pressure sensors, magneto resistors, accelerometers etc.), that produce the same parameters. During the unify of several navigation meters, two schemes of complexing are the most widely used, as the way for complexing and filtration.

The structural scheme of the complexing by the way of compensation, is below on the fig. 1

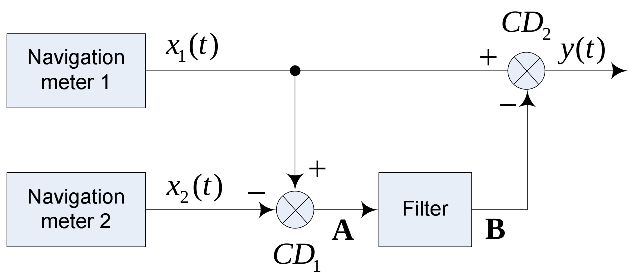


Fig. 1. The structural scheme of the complexing by the way of compensation

The signals on the output of the first and second navigation meters are the next:

$$x_1(t) = x(t) + n_1(t);$$
$$x_2(t) = x(t) + n_2(t), \tag{1}$$

where $x(t)$ – measured navigation parameter (useful signal); $n_1(t)$, $n_2(t)$ – errors of the navigation meters, that are proposed by the stationary random processes.

In appliance with the principle of complexing in the way of compensation, the signals $x_1(t)$ and $x_2(t)$ are sending on the computing device $CD_1$, where the differential signal appears on the output

$$x_a(t) = n_1(t) - n_2(t), \tag{2}$$

that is not containing the measured navigation parameter. The differential signal $x_a(t)$ is sending to the linear filter, which transfer function $F(p)$ should be such accordingly with the chosen criteria to reduce the interference $n_2(t)$ in the greatest degree, and distorted the interference $n_1(t)$ in the minimal way. The signal on the output of the filter with transfer function $F(p)$ in operator form is the next:

$$x_n(p) = F(p) - x_a(p) =$$
$$(n_1(p) - n_2(p))F(p)n_1(p) + F(p)n_2(p). \tag{3}$$

On the computing device CD, creates the next difference

$$y(p)=x_1(p)-x_b(p)=$$
$$=x(p)+n_1(p)-\left(n_1(p)-n_2(p)\right)F(p)= \qquad (4)$$
$$=x(p)+\left(1-F(p)\right)n_1(p)+F(p)n_2(p).$$

The output signal of the complexing navigation system, can be represented in the next form

$$y(p)=x(p)+\varepsilon(p), \qquad (5)$$

where $\varepsilon(t)$ – resulting error of the complexing navigation system, determined in the next way:

$$\varepsilon(p)=\varepsilon_1(p)+\varepsilon_2(p)=\Phi(p)n_1(p)+F(p)n_2(p), \quad (6)$$

where $\varepsilon_1(t)$, $\varepsilon_2(t)$ – components dependent with the processes $n_1(t)$ and $n_2(t)$, correspondingly.

From the relation (6) it can concluded that $\varepsilon(t)$ not depends from $x(t)$. In consequence, the systems, where the errors not depends from the useful signal $x(t)$, are called invariant by the ratio to $x(t)$.

Supose that spectrum densitty $S_1(w)$ of error of the first navigation meter is considered in the low frequency area, and spectrum density of error of the second meter $S_2(w)$ is widely lined fig. 2.

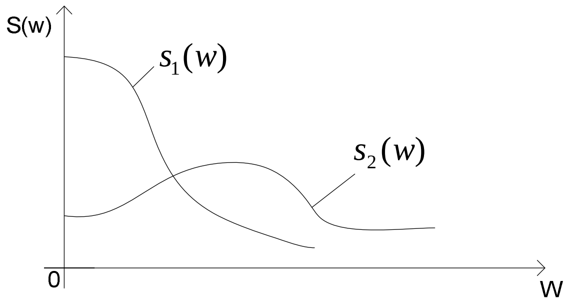


Fig. 2. Spectral planes of the navigation meters errors

It can be shown, that for spectrum densities $S_1(w)$ and $S_2(w)$ the linear filter $F(jw)$ is the filter of low frequencies. There is amplitude-frequency characteristic of low frequency filter and amplitude-frequency characteristic of the high frequency filter $\Phi(jw) = 1 - F(jw)$ on the fig. 3.

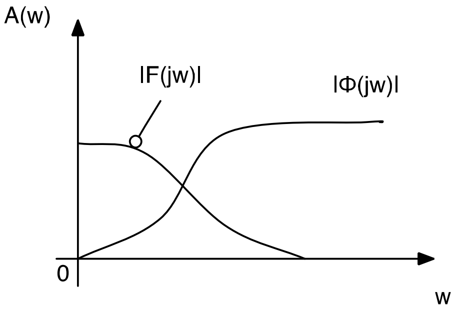


Fig. 3. Amplitude-frequency characteristic of the filters

Practically, the filters in such complexing navigation systems are not optimal. Usually, they are realized with a help of aperiodic link, they have the next transfer function

$$F(p) = 1/(Tp + 1). \qquad (7)$$

The transfer function of the filter of high frequencies in this case

$$\Phi(p) = 1–F(p) = Tp/(Tp + 1). \qquad (8)$$

In the ideal case, when the spectrum densities $S_1(w)$ and $S_2(w)$ not blocks, the signal on the input of the linear filter of complexing system has the next form

$$x_B(p)=F(p)x_A(p)=$$
$$=\left(n_1(p)-n_2(p)\right)F(p)=n_1(p). \qquad (9)$$

The the output signal of the complexing navigation system would be

$$y(t)=x_1(t)-x_B(t)=x(t)+n_1(t)-n_1(t)=x(t). \quad (10)$$

the useful signal would be provided without errors. In the reality, the spectrum $S_1(w)$ and $S_2(w)$ are blocked, because of this, there is the error $\varepsilon(t)$ in the output signal $y(t)$, which dispersion determines with the next equation

$$D_\varepsilon=\int_{-\infty}^{\infty}\left[\left|1-F(jw)\right|^2 S_1(w)+\left|F(jw)\right|^2 S_2(w)\right]dw. \ (11)$$

The dispertion $D_\varepsilon$ is characterizes graphically by the sum of areas of shaded plot (fig. 4).

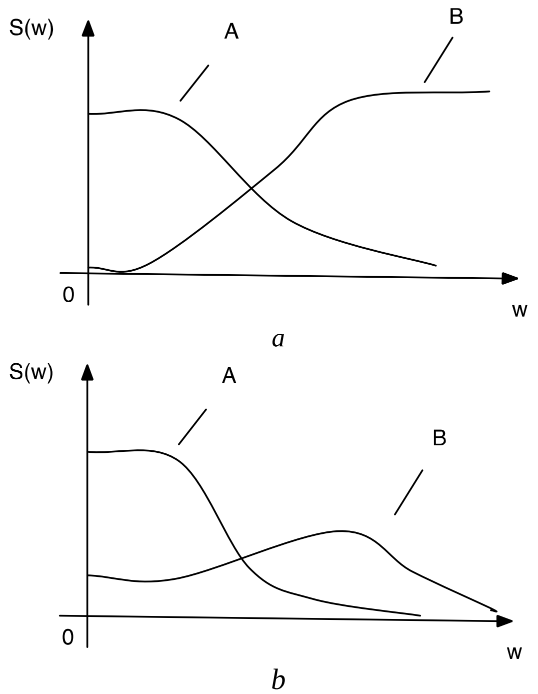


Fig. 4. Errors of the complexing navigation system, caused by: $a - n_1(t)$, (A – $|S(w)|$, B – $\Phi(jw)$); $b - n_2(t)$, (A – $|F(jw)|^2$, B – $S_2(w)$)

**Synthesis of advanced filters based on the error before the effect of the initial conditions of the state variables of the object and the filter**

In this thesis work, improved synthesis filter state variables will be made on the basis of four of the above opportunities to improve the efficiency of filtration, namely on the basis of improvement of the Kalman filter by adding a block to make estimates of the initial conditions of the state variables of the object defined in some way, to set the initial conditions state variable filter.

As stated in the second section of the second principle the possibility of improving the quality of estimates of the state variables is the optimal selection of the initial conditions of the state variables filter. The ideal case is when the latter coincide with the initial conditions of the state variables of the object.

However, in general, the initial conditions of the state variables of the object is unknown. It follows that the initial conditions of the state variables filter can be used estimates of the initial conditions of the state variables of objects found by any of the known or newly established statistical methods to determine ratings. Obviously, the quality of the estimates of the state variables of the object will depend on the quality of the estimates of the initial conditions of the latter.

From the above it follows that the overall structural scheme filters synthesized on the basis of this approach will be given the block diagrams of objects look like this (fig. 5 – for objects of ordinary form).

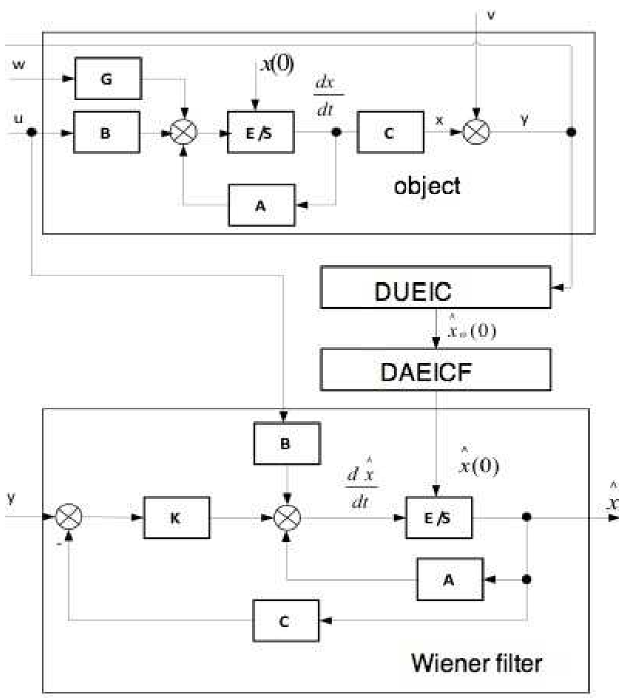


Fig. 5. The block diagram of an improved filter for objects conventional kind

On the fig. 5 DUEIC – determining unit estimates of initial conditions.

As algorithms DUEIC blocks can be used appropriate methods for determining assessments, selected with the dynamic characteristics of objects and noise situations.

According to the above structure charts filters synthesized based approach compensate the mismatch of the initial conditions of the object and the filter quality of the estimates, the improved formulation of the problem will be filtering the appropriate type:

$$\hat{x} = \arg\left\{ \min_{\hat{\varepsilon}(0)} \left[ \sigma^2_{\varepsilon(0)}(t) + trP_{\varepsilon}(t) \right] \middle| \begin{array}{l} \dot{x}(t) = A(t)x(t) + Bu(t) + G(t)w(t), \\ y(t) = C(t)x(t) + v(t), \\ M\hat{x} = Mx(t),\ Mw(t) = 0,\ Mv(t) = 0, \\ Cov\left[w(t),\ w(\tau)\right] = Q_w\delta(t-\tau), \\ Cov\left[v(t),\ v(\tau)\right] = R_v\delta(t-\tau), \\ Cov\left[w(t),\ v(\tau)\right] = 0, \\ Cov\left[\hat{x}(0),\ \hat{x}(0)\right] = P_0 \end{array} \right\}.$$

$K_k$ – optimal matrix of Kalman's filter amplification $B_{\Phi} = B.$

The structure of the filter is linear.

According to this, the method of synthesis of advanced filters based compensate the mismatch of the initial conditions of the state variables in the object and the filter consists of two stages:

1. Synthesis of the Kalman filter based on the standard formulation of the problem filter state variables;

2. Synthesis of block algorithms for the assessment of the initial conditions of the state variables of the object;

3. Synthesis unit set the initial conditions of the state variables filter;

4. Combining the above three algorithms in general filtering algorithm.

**Conclusion**

As a result of research carried out under this article were obtained the following results.

1. Develop standard Kalman filter.

2. The analysis of the shortcomings of the Kalman filter and determine their main source.

3. The approach improved synthesis filter state variables based on the Kalman filter and problem statement before the effect of the error of the initial conditions of the state variables in the object and the filter on the quality of the estimates of the state variables of the object.

On the basis of these results can be made the following conclusions.

1. The developed approach improved synthesis filter state variables based on the Kalman filter and problem statement before the effect of the error of the initial conditions of the state variables of the object and the filter will synthesize improved filters state variables based on the truncated model of the object.

2. Designed Kalman filter will perform experimental studies to evaluate the effectiveness of the theoretical results on the filtering.

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**Ш. І. Аскеров. Вибір підходу рішення проблеми фільтрації в задачі орієнтації**

Розглянуто вибір підходу рішення проблеми фільтрації в задачі орієнтації.

**Ключові слова:** орієнтація; супутник; навігація.

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**Ш. И. Аскеров. Выбор подхода решения проблемы фильтрации в задаче ориентации**

Выбор подхода решения проблемы фильтрации в задаче ориентации.

Ключевые слова: ориентация; спутник; навигация.

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