Criteria For Comparison Of Synchronization Algorithms Spaced Measures Time And Frequency

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Abstract **- The role and gives a classification of synchronization algorithms spatially separated measures time and frequency. For comparison algorithms introduced criteria that consider the example of one of the algorithms.**

Keywords **- Time and frequency standards, precision and measurement uncertainty.**

Synchronicity (comparison or collation) geographically dispersed measures (in particular standards) time and frequency is necessary for time and frequency metrology, navigation, radio astronomy, radar, direction finding, etc. The rate of improving standards, the relative instability of which reached 10^{-15}–10^{-16}, determine the relevance of improving systems to be synchronized [1, 2].

In the systems synchronize geographically dispersed measures (standards) play a special role synchronization algorithms (SA) - the order of the radiation, reception and processing of signals in paragraphs placement standards of time, which, after accounting for the delay in the channel of propagation (CP) and the apparatus measures the shear scales of measurement standards.

In terms of radiation signals in paragraphs SA can be divided into three types [2, 3]: one-way algorithm (the signals are emitted only from one point) algorithm overall coverage («common-view»), based on the input signal is a common source, a group of active algorithms (signals are emitted in each of the points - 1).
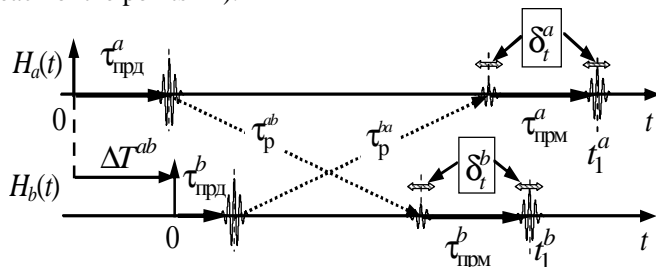

Fig. 1 - The timing diagram of the active algorithm

In Fig. 1 notation: $H_a(t)$, $H_b(t)$ - time scale; ΔT^{ab} - a shift scales; $\tau^a_{\text{ïðä}}$, $\tau^b_{\text{ïðä}}$ - delays in the transmitter; $\tau^{ab}_{\text{ð}}$, $\tau^{ba}_{\text{ð}}$ - the delay in the channel of CP, $\tau^a_{\text{ïðì}}$, $\tau^b_{\text{ïðì}}$ - delays in the receivers; δ^a_t, δ^b_t - interfering error estimates of the temporary regulations (ETR) of signals.

For comparison, the AU proposes criteria: performance accuracy (errors and measurement uncertainty with regard to [4]) components, the correlation and measurement uncertainty; information and energy data, particularly the technical implementation (according to the channel CP, signals and methods for their treatment, methods of measuring apparatus of delays, the need to share the results of the measurements).

The equations for determining the true (reference) values and shear assessment scales, as well as the expression for the total uncertainty of the active SA (see Figure 1) will be:

$$\Delta T^{ab}= 0,5\left(t_1^a - t_1^b - \tau^{ba}_p + \tau^{ab}_p - \tau^a_{\text{ïðì}} + \tau^a_{\text{ïðä}} + \tau^b_{\text{ïðì}} - \tau^b_{\text{ïðä}} - \delta^a_t + \delta^b_t\right); \quad (1)$$

$$\widehat{\Delta T}^{ab}= 0,5\left(t_1^a - t_1^b - \tau^{ba}_{\text{ð}} + \tau^{ab}_{\text{ð}} - \tau^a_{\text{ïðì}} + \tau^a_{\text{ïðä}} + \tau^b_{\text{ïðì}} - \tau^b_{\text{ïðä}}\right); \quad (2)$$

$$\delta^{ab}_{\Delta \hat{O}}\left(\Sigma\right)= \widehat{\Delta T}^{ab} - \Delta T^{ab} = \delta^{ab}_{\Delta T}\left(\text{êàí}\right) + \delta^{ab}_{\Delta T}\left(\tilde{n}/\text{ï}\right) + \delta^{ab}_{\Delta T}\left(\text{àï}\right), \quad (3)$$

where $\delta^{ab}_{\Delta T}\left(\text{êàí}\right)= 0,5\left(\tau^{ab}_{\text{ð}} - \tau^{ba}_{\text{ð}} - \tau^{ab}_{\text{ð}} + \tau^{ba}_{\text{ð}}\right)$,

$\delta^{ab}_{\Delta T}\left(\tilde{n}/\text{ï}\right)= 0,5\left(\delta^a_t - \delta^b_t\right)$,

$\delta^{ab}_{\Delta T}\left(\text{aï}\right)= 0,5\left(\tau^a_{\text{ïðì}} - \tau^a_{\text{ïðä}} - \tau^b_{\text{ïðì}} + \tau^b_{\text{ïðä}} - \tau^a_{\text{ïðì}} + \tau^a_{\text{ïðä}} + \tau^b_{\text{ïðì}} - \tau^b_{\text{ïðä}}\right)$ –

channel respectively, noise and instrumental terms common errors $\delta^{ab}_{\Delta \hat{O}}\left(\Sigma\right)$; $\tau^{ba}_{\text{ð}}$, $\tau^{ab}_{\text{ð}}$, $\tau^a_{\text{ïðì}}$, $\tau^b_{\text{ïðä}}$, $\tau^a_{\text{ïðä}}$, $\tau^b_{\text{ïðì}}$ - evaluation of the delay.

Given the random and uncorrelated errors ETR signals in the settlements, noise the shift measurement error scales can be estimated standard deviation (SD)

$$\sigma^{ab}_{\Delta T}\left(\tilde{n}/\text{ï}\right) = \sigma^{ba}_{\Delta T}\left(\tilde{n}/\text{ï}\right) = 0,5\sqrt{\left(\sigma^a_t\right)^2 + \left(\sigma^b_t\right)^2},$$

where σ^a_t, σ^b_t - SD ETR signals in paragraphs a and b.

Since the SD error of (4) can be determined by statistical processing of measurement results shift the scales, the error estimate corresponds to the standard uncertainty of type A [4]

$$u^{ab}_A\left(\tilde{n}/\text{ï}\right) = u^{ba}_A\left(\tilde{n}/\text{ï}\right) = \sigma^{ab}_{\Delta T}\left(\tilde{n}/\text{ï}\right) = \sigma^{ba}_{\Delta T}\left(\tilde{n}/\text{ï}\right).$$

Channel components and hardware errors from equations (1), (2) and (3) can not be determined on the basis of statistical processing of measurement results. Therefore, according to [4], these errors correspond to uncertainties of type B.

To estimate the uncertainty $u_{\hat{A}}\left(\text{êàí}\right)$ of the standard channel models applicable CP channel and for the instrumental uncertainty $u_{\hat{A}}\left(\text{àï}\right)$ - the measurement apparatus or delay measurements in the "zero base" (equipment items a and b are combined).

The advantage of the active SA is the almost complete exclusion of channel error and shortcoming - the need for radiation signals at points.

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