CORRELATION METHOD OF HEIGHT MEASUREMENT

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In conditions of increasing intensity of air traffic, the performance of safe and regular flights of aircraft requires the use of high-precision means of measuring low altitudes. The most common are three methods of measuring height: amplitude, frequency and phase. In recent years, the J-correlation method has also been developed.

In this method, the probing signal is an oscillation that is frequency-modulated with a single-tone harmonic component:

$$u(t) = U_0 \cos[w_c t + \beta \sin(\Omega t + \varphi_0) + \varphi_1],$$

where U_0 – signal amplitude, w_c – carrier frequency, β – modulation index, Ω – frequency of the modulating oscillation, φ_0 – the initial phase of the modulating oscillation, φ_1 – the initial phase of the carrier oscillation.

A reference oscillation is formed from the probing signal by transferring it to the frequency $(w_c - w_\text{r})$ with a delay θ_x. The correlation integral is formed by convolution of the spectra of the reflected and reference signals:

$$u_1(t) = U_1' \cos[w_\text{r} t + \beta' \sin(\Omega t + 0{,}5\Omega(\tau + \theta_x) + \varphi_0) + \varphi'],$$

where U_1' – converted signal amplitude, w_r – local oscillator frequency, $\beta' = 2\sin[0{,}5\Omega(\tau - \theta_x)]$ – transformed modulation index, τ – spatial time delay, θ_x – adjustable time delay, φ'– transformed phase of the carrier oscillation.

As a result of correlation detection of this signal, a harmonic component is formed, the amplitude of which depends on the difference $(\tau - \theta_x)$ and changes according to the behavior of the first-order Bessel function:

$$u_2(t) = U_2 J_1(2\beta\sin[0{,}5\Omega(\tau - \theta_x)]\,)\cos(\Omega t + \varphi_0),$$

where $J_1(2\beta\sin[0{,}5\Omega(\tau - \theta_x)]\,)$ – first-order Bessel function.

The condition when $u_2(t) = 0$ is achieved by changing the delay θ_x. Under this condition, the time delay θ_x is equal to the spatial time delay τ. Therefore, the height is equal to $R = \frac{c\theta_x}{2}$, where c – speed of light.

The characteristic of the meter has a sawtooth shape with a pronounced extremum and when passing through an extreme point (when $= \theta_x$) its steepness changes its sign to the opposite, which provides high measurement accuracy.

Reference:

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