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ADJACENT-CHANNEL INTERFERENCE COMPENSATOR EFFICIENCY

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Adjacent-channel interference compensator for a wideband navigation system provides high support signals dynamic range. Systems using code-division multiplexing have intrasystem interference level determined by correlation properties. Spread spectrum signals with minimum shift keying are considered. They are determined by

$$s(t) = A \cdot D(t) \cdot \left[I(t)\cos(2\pi f_0 t) - Q(t)\sin(2\pi f_0 t) \right],$$

$$I(t) = \cos\Theta(t),\ Q(t) = \sin\Theta(t),\ \Theta(t) = \frac{\pi}{2T}\int_0^t a(t')\,dt', \qquad (1)$$

where the “*a*” is maximum length sequence (MLS). *D*(*t*) is data binary shift keying function. Basically, normalized maximum length sequences have correlation sidelobe level 1/*N*, where “*N*” is sequence length. So, when N = 16383, MLS sidelobe are less than –80 dB at 80 dB signal dynamic range.

Signal data manipulation causes cross-correlation sidelobe increasing. Two correlated parts of input signal are produced by different data bits (see fig. 1).

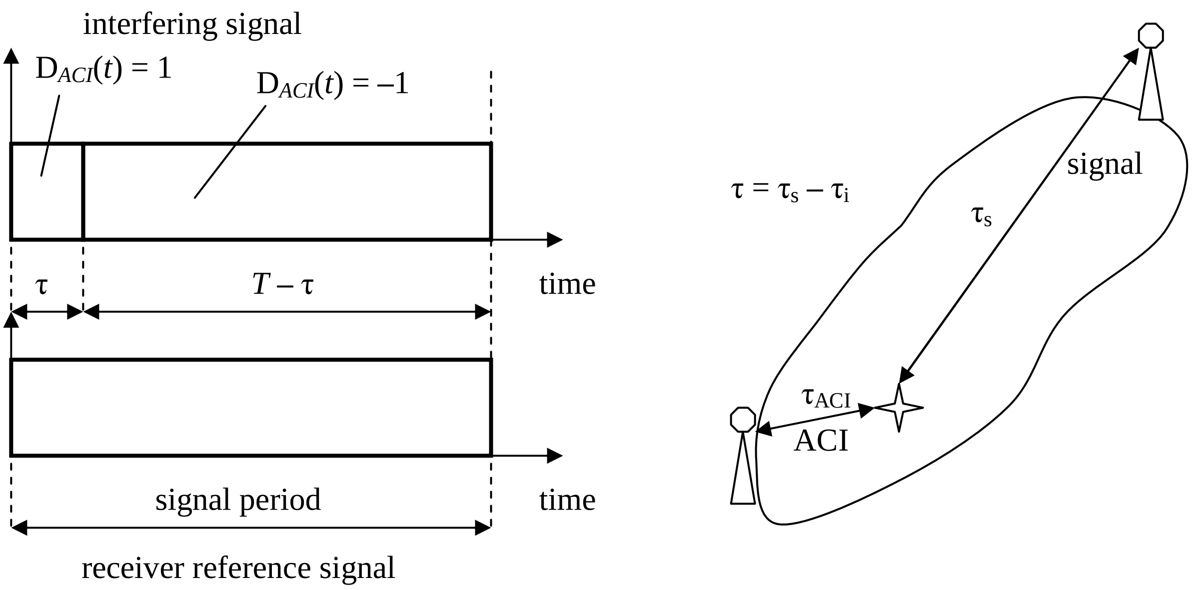

Fig. 1 – Input signal correlation: τ_s – signal propagation delay, τ_{ACI} – adjacent-channel interference propagation delay, τ – relative delay, *T* – signal period

In terms of τ equals 1.5 … 2 ms derived correlation sidelobe level is increased up to –41 dB (see fig. 2). Thus powerful signal of a nearby station puts out of operation the other signal receiver. This fact constrains system working area by minimal distance from nearby stations around 60 km in terms that system distance range is 600 km. Such powerful signal is called adjacent-channel interference, or ACI.

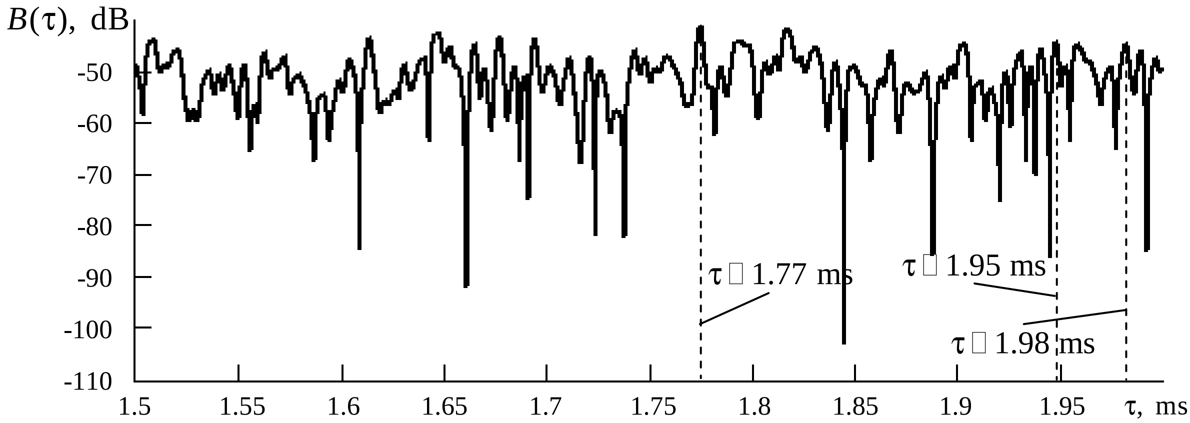

Fig. 2 – Correlation sidelobe level versus relative delay

There is a number of spread spectrum ACI suppression methods, but conditions provide using a compensator that should suppress ACI to –40 dB or less. The compensator is being used before the receiver. Structure circuit is shown below.

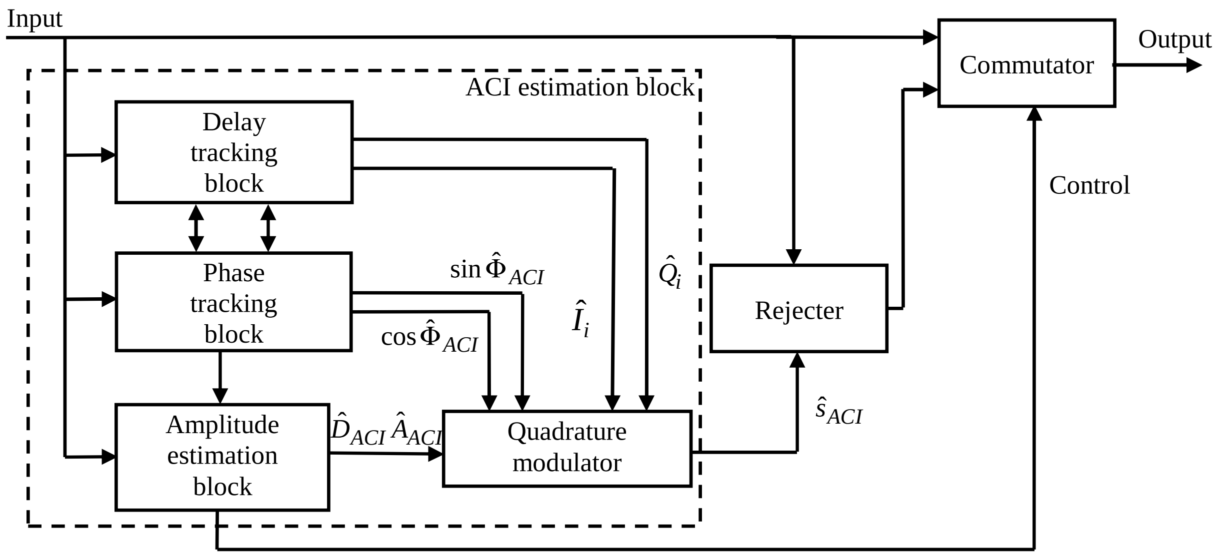

Fig. 3 – Compensator structure circuit

Interference quadrature components are being synthesized by the blocks and then compiled in the quadrature modulator corresponding to equation (1).

Experimental block diagram is shown on fig. 4. Entrance mixture is the sum of a signal, adjacent-channel interference and noise:

$$y(t) = s(t - \tau_s) + s_{ACI}(t - \tau_{ACI}) + \xi(t).$$

This mixture is processed in compensator being supplemented by $\hat{s}_{ACI}$ interference copy. Correlation process of the mixture produces z_1 and z_2 signals:

$$z_1 = \int_0^T \left[y(t) - \hat{s}_{ACI}(t) \right] s_0(t)\,dt = z_{s1} + z_{ACI\ 1} - \hat{z}_{ACI\ 1} + z_{n1},$$

$$z_2 = \int_0^T \left[y(t) - \hat{s}_{ACI}(t) \right] s_{\perp}(t)\,dt = z_{s2} + z_{ACI\ 2} - \hat{z}_{ACI\ 2} + z_{n2}.$$

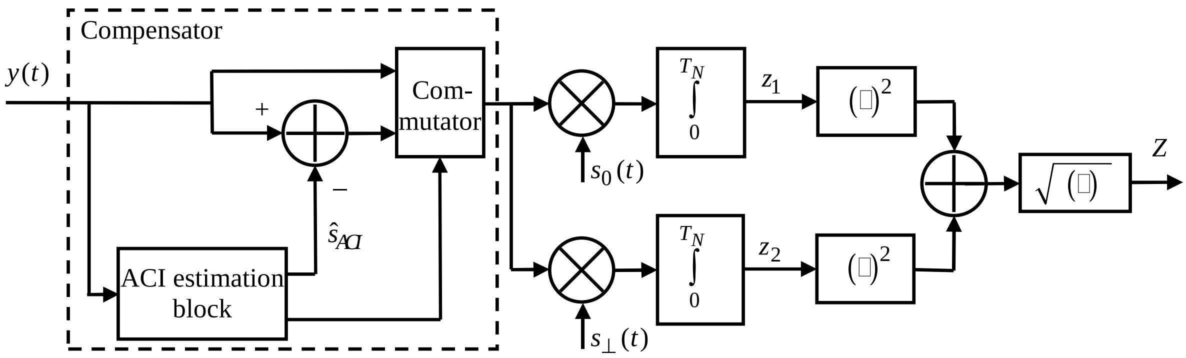

Fig. 4 – Experimental block diagram

These signals are combined according to:

$$Z = \sqrt{z_1^{\,2} + z_2^{\,2}} \,. \qquad (2)$$

Interference compensation efficiency index is interference-to-signal ratio (ISR_O) at the receiver output. Noise was being excluded at the receiver input for purpose to provide accurate ratio measurements:

$$ISR_O = \frac{Z_{s+ACI}}{Z_{ACI}},$$

Z_{s+ACI} – receiver output signal produced by signal and suppressed ACI at the receiver input;
Z_{ACI} – receiver output signal produced by only suppressed ACI.

The measurements were made at three delay values τ of cross-correlation function (see fig. 2). These points provide sidelobe level peaks and following interference-to-signal ratio (ISR_I) at the receiver input and interference-to-noise ratio (INR) with corresponding parameters:

Table 1 – Ratios and parameters at three delay values

Delay	ISR_I, dB	INR, dB	A_s, V	A_{ACI}, V	Noise variance, V^2
τ_1 □ 1.77 ms	40	0	0.0001	0.01	0.0025
τ_2 □ 1.95 ms	60	20	0.0001	0.1	0.0025
τ_3 □ 1.98 ms	80	40	0.0001	1	0.0025

Signal correlation receiver equipped with ACI-compensator is modeled in computer-aided engineering system LabVIEW. The circuit consists of signal generators, correlation receiver, tracking blocks, feedback loops and indicators.

Interference-to-signal ratio time diagrams at the receiver output are shown on fig. 5: curve 1 – ACI Doppler frequency shift (DFS) when equals 0 and curve 2 – ACI DFS when equals 0.2 Hz (maximum DFS for naval customers). Four seconds transient region is cut from plots.

For the third point we have the weakest ISR_O: –27 dB without interference DFS and –22 dB with DFS equals 0.2 Hz. Interference-to-signal ratio less than –20 dB provides very high performance margin. So we have got satisfying simulation results.

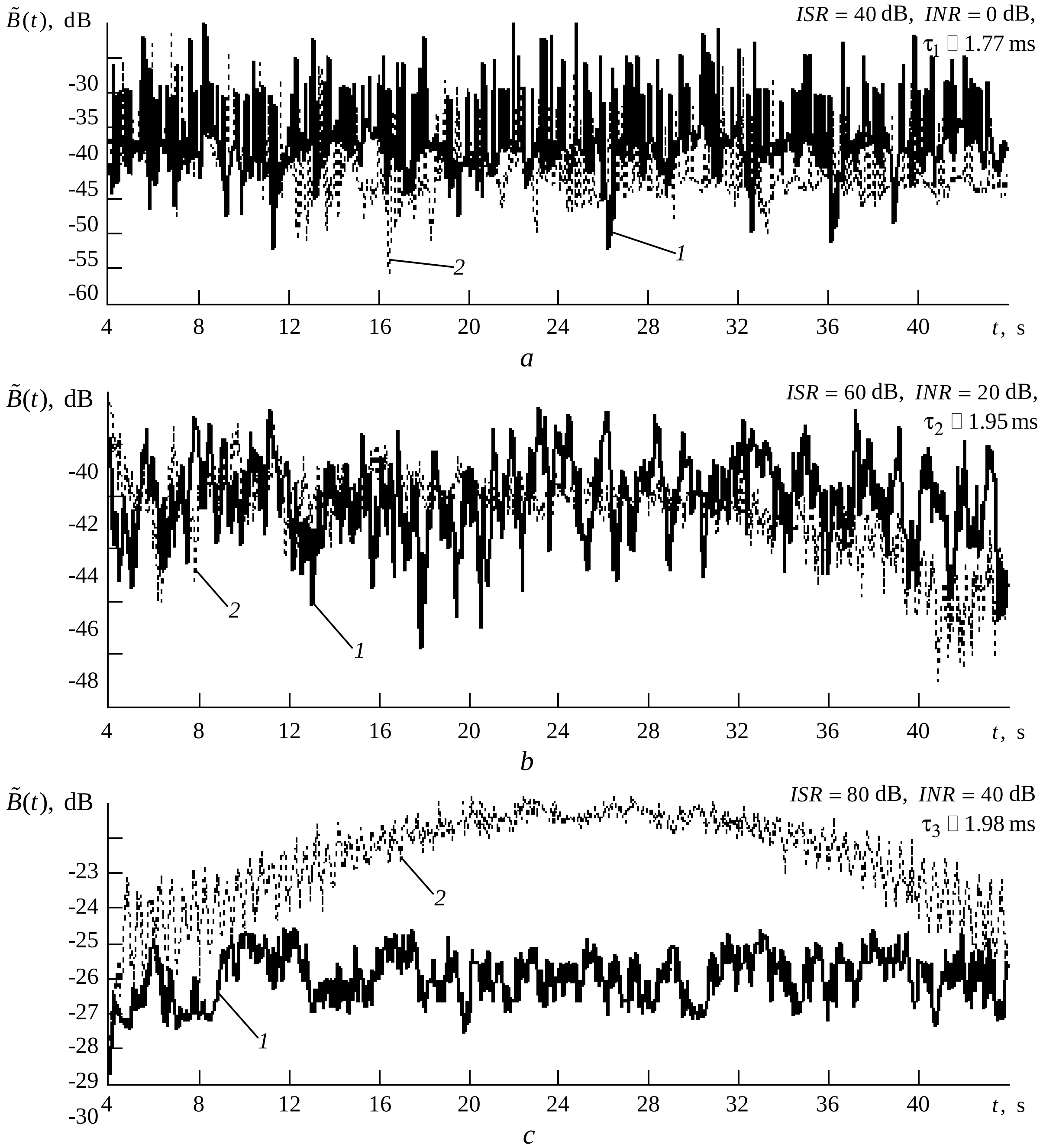

Fig. 5 – Interference-to-signal ratio time diagrams at the receiver output

Noise at the receiver input will cause output signal fluctuation. Then signal parameter tracking loops make output signal fluctuation smooth, providing accurate navigation. It was suggested to implement the compensator on a FPGA.