Radioelectronics and Communications Systems
Vol. 47, No. 3, pp. 20–22, 2004

Izvestiya VUZ. Radioelektronika
Vol. 47, No. 3, pp. 30–34, 2004
UDC 621.396.677

AN OPTICAL ANALOG-TO-DIGITAL CONVERTER OF INTERFEROMETRIC TYPE

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The paper is devoted to an urgent problem — design of multidigit high-speed analog-to-digital converters operating at frequencies up to several gigahertz and higher, and ensuring consistent resolution of the problems of development and practical application of digital adaptive antenna arrays for satellite communication systems. It is asserted that such converters have to be built based on the optical interference phenomenon. Advantages of optical interferometric converters over their electronic counterparts are discussed.

Development and wide application of digital methods of information transmission and processing requires the design of multidigit high-speed analog-to-digital converters able to operate at input signal frequencies several gigahertz and up. Most promising is application of such converters in antenna equipment, particularly, in digital adaptive antenna arrays, which permit, in real time, improved effectiveness of reception of legitimate signals against interference background. The use of such antenna arrays in satellite communication systems is hampered by imperfection of digital circuitry, particularly, the small word-length and low speed of contemporary analog-to-digital converters (ADC) used in the channels of processing received signals and in shaping transmitted ones.

Despite some publications devoted to the design of multidigit high-speed ADC [1, 2], a whole number of issues concerning improvement of technical characteristics of the converters remain unresolved. One of such problems consists in the impossibility of quantization of signals whose magnitudes are below the heat noise level, which is typical of satellite communication systems. As becomes clear from our studies, one of promising way of resolving this issue is creation of an interferometric ADC with linear law of conversion.

Consider one variant of a circuit of such an ADC. The functional diagram of the interferometric converter is presented in Fig. 1, where *1* is a plate made of some electrooptical material, *2* is a directing optical system, *3* is a string of N photosensors, OS1 and OS2 are optical systems, M is an electrooptic modulator, and U_{in} is the converted signal in the form of voltage applied to the modulator electrodes.

The system of N photosensors located with a spacing σx along the $0X$-axis is illuminated by two coherent light fluxes. One of the fluxes is considered the reference and is directed by the optical system OS1 to the interference plane at the angle θ_1 with a fixed phase. The other light flux is signal-type: it comes from the direction θ_2, and its phase varies with time in strict correspondence with amplitude variations of the input analog signal U_{in} to be converted to digital form.

In order to modulate the phase of the signal light flux by the converted analog signal, the transversal electrooptical effect realized by the modulator M is used. The amplitude-phase distribution of intensity of the reference light flux $S_1(x)$ with normalized amplitude in the interference plane can be represented in the form $S_1(x) = \exp(\mathrm{i}kx\cos\theta_1)$.

Let us write in the normalized form the distribution, in the same plane, of intensity of the signal light flux $S_2(x) = \exp(\mathrm{i}kx\cos\theta_2 + \mathrm{i}\Delta\varphi(U_{\text{in}}))$, where $\Delta\varphi(U_{\text{in}})$ is variation of the phase of the signal light flux due to the voltage U_{in}, applied to electrodes of the modulator M.

REFERENCES

1. E. I. Gitis and Ye. A. Piskulov, Analog-to-Digital Converters [in Russian], Energoizdat, Moscow, 1981.
2. Ye. A. Kolombet, Microelectronic Aids for Analog Signal Processing [in Russian], Radio i Svyaz', Moscow, 1991.
3. P. P. Unger, Optical Communications [in Russian], Svyaz', Moscow, 1979.
4. G. Korn and T. Korn, Mathematical Handbook for Scientists and Engineers [Russian translation], Nauka, Moscow, 1968.

24 April 2003