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FAST COMPUTATION OF THE INSTANT WALSH SPECTRUM

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Walsh transforms have become a very important instrument in science and technique applications during the recent years. The advantage of Walsh functions are primarily due to the efficiency of implementation and signal manipulation. For digital networks, pulse type waveforms like Walsh functions are more suitable than sinusoidal waveforms. The instant Walsh spectrum transforms are very useful in a lot of applications and due to this the fast computation algorithms and special type of processors for the computations represent a high interest.

Key words: instant Walsh spectrum transforms, fast Walsh transform, algorithms for computation of the instant Walsh transform.

In the theory of spectra transforms certain concepts of spectra were established. Walsh spectrum are factors of transformation in this or that system of ordering Walsh functions from sequence of values of an input signal. This Walsh transforms are carried out with values of an input signal (0 ÷ *N*-1), (*N* ÷ 2*N*-1), (2*N* ÷ 3*N*-1) etc. (where $N = 2^n$), i.e. on compound intervals. Number of operations for computation the factors of Walsh transform at use of fast algorithms of calculations are equal to $N\log_2 N$.

Other concept of a spectrum is the power spectrum.

The third concept of a spectrum is a full power spectrum that is invariant to cyclic shift. There are few algorithms for fast computation of the power spectrum, but these types of spectrums haven't technique applications.

However in the theory and many practical applications, it is important to make a Walsh spectrum estimation on a sliding interval, i.e. to carry out calculation of factors of transformation from the sequences made from *N* of values of an input signal, received after each new value of an input signal. Thus, Walsh transforms from sequences made of $0 \div N-1$, $1 \div N$, $2 \div N+1$ and etc. values of an input signal are carried out.

In the field of harmonic analysis [1] the concept of an instant spectrum, i.e. a spectrum of reflecting property of process time has been entered at present. This concept corresponds to a spectrum on a sliding interval and consequently expediently to enter concept of the instant Walsh spectrum.

If to write down Walsh transform from a vector of an input signal

$$\vec{f}_i = [f_i, f_{i+1}, \ldots, f_{i+N-1}]^T$$

at consecutive change of an index ***i*** the elementary definition of an instant Walsh spectrum in a matrix form will have the following appearance

$$\vec{F} = W_N \cdot \vec{f}_i$$

Computation of an instant Walsh spectrum can be carried out by processor of fast Walsh transform of parallel type, and also by a group of processors of consecutive type. For any estimation of an instant Walsh spectrum it is required $N \cdot \log_2 N$ operations.

For processors of fast Walsh transform of parallel type the following sequence of conversion of an input signal is characteristic. Values of an input signal arrive in the input register of the processor and after N values of an input signal are written down, computation process of coefficients of transform begins. Thus, calculations are carry out in parallel form with all *N* values of an input signal on each iteration and Walsh transform coefficients on a processor output turn out simultaneously (in parallel form). To obtain the instant Walsh spectrum it is necessary to produce calculations of Walsh transform coefficients after arrival of each new value of an input signal. The processor of parallel type admits it.

In processors of serial type values of an input signal arrive sequentially and conversion coefficients on an output appear also sequentially. To carry out calculation of the instant spectrum it is necessary to use *N* processors of serial type. Thus in the first processor values of an input signal arrive immediately, in the second with a time delay on one clock period, in the third with a time delay on two clock periods etc. Values of Walsh coefficients on outputs of processors after 2*N* and more clock periods will represent the instant Walsh spectrum.

However, investigating iterative structure of computation of spectral factors from vectors $\vec{f}_i, \vec{f}_{i+1}, \vec{f}_{i+2}$ etc., it is possible to notice that in these transformations there are common intermediate results of calculations. Using these results of calculation of factors of transformation from a vector $\vec{f}_i$ at calculation of factors of transformation from a vector $\vec{f}_{i+1}$ etc. it is possible to reduce necessary number of operations for any new estimation of an instant Walsh spectrum.

In the report the developed graphs and algorithms of calculation of an instant spectrum in whom the common intermediate results of calculations are used that has allowed to reduce number of operations for each new estimation of an instant spectrum to *2(N-1*) are resulted. In the report special processors of fast calculation of an instant spectrum also are offered, their speed and hardware expenses is analyzed. Considered processors allow to receive also a spectrum on compound intervals and to receive factors of transformation in any system of ordering Walsh functions.

References

1. *Харкевич А.А.* Спектры и анализ. Физмат, М.,1962.