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COMPUTATION OF SPECTRAL EVLUATIONS OF FAST PHYSICAL PROCESSES BY THE STRUCTURES OF PARALLEL A/D CONVERTERS, APPLYING PLIC – TECHNOLOGY

The paper suggests hardware-software method of computation of spectral evaluation of fast physical processes, enabling at the expense of the line of parallel A/D converters with serial delay of triggering strobe-pulse to increase resolution characteristics. Time of results computation decreases L times , where L – is the amount of identical, serially operating A/D converters, L takes the values from 2 to 16.

Key words: *resolution, fast algorithm, supervision interval, line of parallel A/D converters, PLIC-technology.*

Introduction

While investigating spectral characteristics of laser radiation impact on materials fast processes occur. Such processes can be investigated applying the methods of digital spectral processing of signals, these method provide the possibility to increase the accuracy of fast processes characteristics computation occurring in modern high technologies. Digital processing of signals of fast physical processes requires determination of spectral characteristics by the algorithm of fast Fourier transform (FFT) [1, 2]. Frequency of signals digitization of fast processes is limited by operation rate of existing analog-to-digital converters (A/DC). There exists the method of parallel analog-to-digital conversion by means of the line of parallel A/D converters with serial delay triggering strobe-pulse to increase digitization frequency [3]. Increase of digitization frequency of the input signal by the line of parallel A/D converters improves the resolution of spectral evaluations [3, 4]. The structure of parallel A/D converters line gives the possibility to increase digitization frequency proportionally to the amount of parallel A/DC1—A/DCL, where L – is a number of similar serially operating parallel A/D converters. Control of such line is performed by triggering strobe-pulses with delay of 1/Fd * L in delay units DU1 – DUL, where Fd – is frequency of digitization. The information, regarding phase-shift arrives at ADC1 – ADCL from corresponding units of phase delay DU1 – DUL. In [5] modules of ADC – 9KM and ADC – 18 L with digitization frequency 105/125 MHz and digital control of triggering of each next ADC by means of phase delay units DU1…DUL with the step 10 ps are given. These modules are configurated as programmable logic matrix (PLIC). Large amount of computational operations while computing spectral characteristics with their averaging require the elaboration of optimum algorithm of the sequence of computations performing to decrease the time.

The aim of the paper is the elaboration of the algorithm of the sequences of computations organization, averaging of spectral evolutions of fast physical processes from the structures of parallel ADC lines, enabling to increase digitization frequency, proportionally to the number of parallel ADC1 – ADCL.

Algorithm of the sequence of spectral evaluations computation of fast physical processes

Let us consider the averaging of spectral evaluations of digital Fourier transform (DFT)[3, 4]:

$$\mathrm{F(f)}=\frac{1}{L}\sum_{i=1}^{L} x_i(f), \qquad (1)$$

where $x_i(f)$ – is DFT of the input values of signals *r(i)*; L – is the number of signal supervision intervals of parallel ADC, which determine interval $\mathrm{T} = L \cdot P \cdot \Delta t$.

Constrain of this method application [3, 4] in real time systems is large volume of L – DFT D – computation sequences calculations, where L takes values from 2 to 16, and P can change from 32

to 2048 [2].

Let Δf –be spectral resolution. If we denote by P the number of resolution elements by frequency, and by B – the frequency range of signal spectrum, then $P = \frac{B}{\Delta f}$. In accordance with the expression (1), it is necessary to perform L– P – point fast Fourier transforms (FFT) and then carry out their averaging.

Performing of computation by the expression (1) in real time systems requires the search of efficient modifications of computation sequence. Main computational procedure is digital Fourier transform, applying FFT algorithm. Let us consider digital Fourier transform in time interval

$$P \cdot L \cdot \Delta t: \; x(p \cdot \Delta f) = \frac{1}{P \cdot L} \sum_{i=0}^{P \cdot L - 1} r(i \cdot \Delta t) \cdot W_{P \cdot L}^{i \cdot P \cdot l}. \qquad (2)$$

Taking into account the specific feature of $W_{P \cdot L}^{P \cdot l}$: $W_{P \cdot L}^{P \cdot l} = \exp\left\{-j\frac{2\pi pL}{PL}\right\} = \exp\left\{-j\frac{2\pi p}{P}\right\}$ [2].

The expression (2) takes the form:

$$x(p \cdot \Delta f) = \frac{1}{P \cdot L} \sum_{i=o}^{PL-1} r(i \cdot \Delta t) \cdot W_L^{i \cdot l}. \qquad (3)$$

We introduce the substitution $i = l \cdot P + p$, where l = 0,1,..., L-1; p = 0,1,..., P-1, and present (3) in the form of double sum:

$$X(p \cdot \Delta f) = \frac{1}{P} \sum_{p=0}^{P-1} W_P^p \cdot 1/L \cdot \sum_{l=0}^{L-1} r(l \cdot P + p) \cdot \Delta t. \qquad (4)$$

Computation of spectral characteristic values by the expression (4) for all components can be realized by PLIC-structure of calculator with the line of parallel ADC [5], shown in Fig. 1, at two stages.

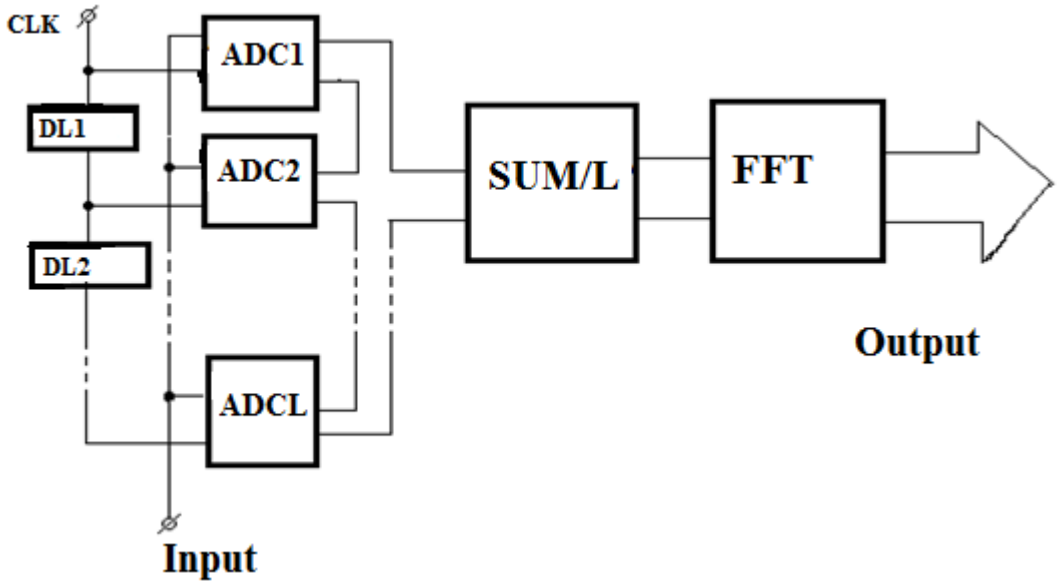

Fig. 1. PLIC-structure of calculator with the line of parallel ADC

At the first stage the averaging of thinned out signal values from ADC1…ADCL in CMAK unit is performed, at the second stage fast Fourier transform is performed in FFT unit over the output values from CMH/L unit, realized on PLIC-technology [5]. The gain in time of computations by means of suggested algorithm of spectral characteristics averaging equals the relation:

$$\frac{V_n}{V} = \frac{L\frac{P}{2}\log P}{\frac{P}{2}\log P} \approx L,$$

where V_n – is the amount of computational operations by the method of spectral components averaging; V – is the amount of computational operations, applying the algorithm, presented by the expression (4), where only one computation by FFT algorithm is performed [2].

Conclusions

In accordance with the suggested algorithm of computations sequence organization of spectral evaluations of fast physical processes signals for realization of computational blocks by computers structures with parallel ADC applying PLIC-technology the time of computation results decreases L times, L takes values from 2 to 16 by the amount of parallel ADC in PLIC-structure.

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