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PHASE MEASURER BASED ON COINCIDENCES OF MULTIPLICITY IMPULSES

Abstract — A significant drawback of nonius methods used to measure the phase shifts of the signals is a need to change the pulse duration at the frequency of the input signals. To eliminate restrictions on the pulse duration nonius methods proposed to use a new method of pulses coincidence packets of digital signals.

Keywords: digital phase measurer, coincidence, programmable logic device

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ИЗМЕРИТЕЛЬ ФАЗЫ С ИСПОЛЬЗОВАНИЕМ МНОГОКРАТНОСТИ СОВПАДЕНИЙ

Аннотация - Существенным недостатком методов нони, используемых для измерения фазовых сдвигов сигналов, необходимо изменить длительность импульса на частоте входных сигналов. Для устранения ограничений на длительность импульса методов нони предлагается использовать новый метод импульсов совпадений пакетов цифровых сигналов.

Ключевые слова - цифровая фаза измеритель, совпадение, программируемого логического устройства

Introduction

The purpose is research of practical realization of phase measurer based on the use of principle of coincidence of multiplicity impulses. In figure 1 represented generic structure of measuring system. Phase measurer is an important part of this system.

I. RESEARCH PROBLEMS

As known, usage of phase measuring method for distances measuring is long-term process. It is known different methods for determination of phase angle between two signals such as: counting method without transformation phase to frequency (on frequency to 1 mc), counting method with transformation to frequency (on frequencies higher than 1 MHz), methods based on nonius measuring (like single and multiplicity) [1].

A counting method has several disadvantages: to increase accuracy required to increase requirement to the element base, measuring time also increased. By use of noniuses methods [2] allows to remove this problem partly. Noniuses methods allow to increase measuring accuracy of phase angle between two signals with use of the same element base. In addition, the method of nonius allows providing higher accuracy of measuring at the use of referencing frequencies of near to frequencies of input signals. By use principle of the nonius measuring allows considerably to decrease duration of one cycle of measuring [3].

But noniuses methods have several disadvantages too. The basic lacks of noniuses methods is a necessity of change duration of equivalent impulses at the change of frequency of entrance signals. I.e. with the increase of frequency of entrance signals, it is necessary to reduce duration of impulses from referencing frequency, that prevent applying of these methods on frequencies higher 1 MHz. In this case, it is required to receive very short impulses in nano - and picosecond duration. Reducing durations of those impulses also require providing higher stability of duration of these impulses in working time.

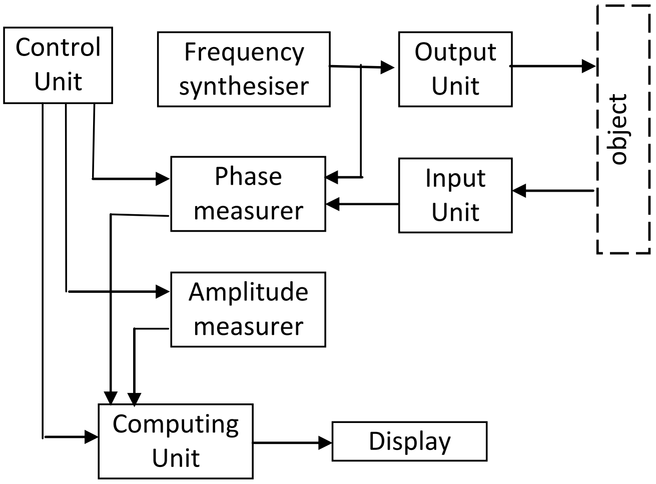

Fig. 1. Generic structure of generating and measuring system of radiolocation information

To remove limits on duration of those impulses in the known noniuses methods suggested utilizing the new method of measuring, based on the use of coincidence of multiplicity impulses.

II. MAIN PART

The coincidence method based on the use of multichannel nonregulated measure. Unlike to the method of single nonius, in the method of coincidence take place multiplicity coincidences between signals, so we have two multichannel facilities. The presences of two multichannel facilities have to determine redundant of method.

Table 1

The optimal duration of reference impulses $\Delta\tau$ for noniuses methods and coincidence method

Frequency	Duration of impulses from referencing generator (in msec), to archive maximal accuracy						
	Up to 10°	Up to 5°	Up to 1°	Up to 0,1°	Up to 0,01°	Up to 0,001°	Up to 0,0015°
1 kHz	$2{,}77\times10^{-5}$	$1{,}385\times10^{-5}$	$2{,}77\times10^{-6}$	$2{,}77\times10^{-7}$	$2{,}77\times10^{-8}$	$2{,}77\times10^{-9}$	$1{,}385\times10^{-9}$
10 kHz	$2{,}77\times10^{-6}$	$1{,}385\times10^{-6}$	$2{,}77\times10^{-7}$	$2{,}77\times10^{-8}$	$2{,}77\times10^{-9}$	$2{,}77\times10^{-10}$	$1{,}385\times10^{-10}$
100 kHz	$2{,}77\times10^{-7}$	$1{,}385\times10^{-7}$	$2{,}77\times10^{-8}$	$2{,}77\times10^{-9}$	$2{,}77\times10^{-10}$	$2{,}77\times10^{-11}$	$1{,}385\times10^{-11}$
500 kHz	$5{,}55\times10^{-8}$	$2{,}775\times10^{-8}$	$5{,}55\times10^{-9}$	$5{,}55\times10^{-10}$	$5{,}55\times10^{-11}$	$5{,}55\times10^{-12}$	$2{,}775\times10^{-12}$
1 MHz	$2{,}77\times10^{-8}$	$1{,}385\times10^{-8}$	$2{,}77\times10^{-9}$	$2{,}77\times10^{-10}$	$2{,}77\times10^{-11}$	$2{,}77\times10^{-12}$	$1{,}385\times10^{-12}$
10 MHz	$2{,}77\times10^{-9}$	$1{,}385\times10^{-9}$	$2{,}77\times10^{-10}$	$2{,}77\times10^{-11}$	$2{,}77\times10^{-12}$	$2{,}77\times10^{-13}$	$1{,}385\times10^{-13}$

An error of measuring of phase angle between two signals in the methods of single nonius, multiscale nonius and classic method of coincidence depends on relations between periods of entrance and referencing signals. For an noniuses methods and classic method of coincidence [1] we have:

$$\begin{cases} T_n \equiv T_c = \left(1 - \dfrac{1}{36 \cdot 10^k}\right) T_x; \\ \tau_n \equiv \tau_c = \dfrac{1}{36 \cdot 10^k} T_x \end{cases}, \qquad (1)$$

where k – accuracy, value selected with following meaning: accuracy in 1°, $k=1$, accuracy in 0,1°, require $k=2$ and so on;

T_x – period of input signal;

T_n, T_c – period of referencing signal for nonius and coincidence methods, respectively;

τ_n, τ_c – impulse duration

For multiscale nonius method used several durations of referencing impulses for each digit of result. For example, for 3 digit measuring required following:

$$\begin{cases} T_{mn1} = \dfrac{26}{36} T_x; \\ T_{mn2} = \dfrac{35}{36} T_x; \\ T_{mn3} = \dfrac{35{,}9}{36} T_x, \end{cases} \quad \begin{cases} \tau_{mn1} = \dfrac{10}{36} T_x; \\ \tau_{mn2} = \dfrac{1}{36} T_x; \\ \tau_{mn3} = \dfrac{1}{360} T_x, \end{cases} \qquad (2)$$

where $T_{mn1}, T_{mn2}, T_{mn3}$ - periods' of referencing signals for each digit;

$\tau_{mn1}, \tau_{mn2}, \tau_{mn3}$ - duration of referencing signals.

A potential resolution in the method of coincidence, similarly as well as in a nonius method determined from the following expression, relating the period of entrance signal and difference of periods between entrance and referencing signals:

$$\Delta\varphi_{pr} = \frac{360 \cdot \Delta\tau}{T_x} = 360 \cdot \Delta\tau \cdot f_x. \tag{3}$$

where $\Delta\tau = |T_x - T_0|$ – ratio between periods of entrance and referencing signals, f_x - frequency of entrance signal.

Equation (3) represent main problem of the high-frequency phase measuring devices. Apparently, at the increase of entrance frequency diminishing $\Delta\tau$ with a permanent value of $\Delta\varphi_{pr}$ is inevitable. However, diminishing of difference requires the use of higher-speed and higher-stable digital element base. As indicated higher, diminishing of $\Delta\tau$ simultaneously means the same diminishing of impulses duration. To receive higher accuracy the generator of referencing impulses must generate short impulses.

To obtain necessary resolution in well-known methods the duration of reference impulses required to meet the following criteria:

$$\tau_n \equiv \tau_{mn} \equiv \tau_c \equiv \Delta\tau \tag{4}$$

where $\Delta\tau = |T_x - T_н|$ – relation between periods of entrance and referencing signals.

Equation (4) had to determine optimal duration of reference impulses as difference between periods of entrance and referencing signals. With increase of frequency of entrance signal, as we can see, duration have to diminish.

The optimal duration of reference impulses $\Delta\tau$ listed in table 1. By use of those values phase measurer have ability to archive necessary resolution on different frequencies.

Values marked by gray colour used to show complication to receive such accuracy with available element base.

Thus, in the noniuses methods and in the classic method of coincidence there is an of principle problem, which is related to increase of frequency of entrance signals for required accuracy. In noniuses methods are utilized generators of nonius sequence in accordance with frequency of entrance signals [4]. That’s why noniuses methods mush be used only on low frequencies.

III. DECISION OF PROBLEM

For the removal of lacks of noniuses methods and classic method of coincidence and removal of limit on duration of impulses, it is suggested to utillize a method, based on principle of method of coincidence. However, unlike to the classic method of coincidence suggested to utilize multiply coincidences of multiplicity impulses.

At first, in a coincidence method of multiply impulses, used frequent coincidences of packages of entrancing and referencing impulses. The second feature is coincidence between multiplicity impulses. This condition allows utilizing duration of referencing impulses on a few orders more than in the noniuses methods of measuring. I.e. it is necessary to provide implementation of condition:

$$\tau_{cbmi} \gg \tau_c, \tag{5}$$

where τ_{cbmi} - duration of multiplicity of impulses.

In this case, optimal duration of the referencing impulses founded from following equation:

$$\frac{T_0}{2} > \tau_{cbmi} \geq \frac{1}{36 \cdot 10^k} T_x \tag{6}$$

where T_0 – period of the reference signal.

As we can see in equation (6), duration of reference signal can be several times more than for well-known methods. This ability allow to use single reference generator without ability to change reference frequency.

In other side, usage of multiplicity allows to reduce effective duration of impulses of coincidence. As we can see in equation (7), we can reduce duration in the amount times of coincidences.

$$\tau_{eff} = \frac{\tau_{cbmi}}{N_{cbmi}}. \tag{7}$$

where N_{cbmi} – times of coincidences.

With continuing growth of $N_{cbmi} \to \infty$ effective duration will diminish to zero ($\tau_{eff} \to 0$). Reducing effective duration will reduce value of error of phase measuring to zero, too. However, reducing error to zero will require $N_{cbmi} \to \infty$. However, from the practical view, it is clearly understand, that achievement $N_{cbmi} \to \infty$ will demand large time infinitely, that is impractical.

Time measurements can be defined as:

$$T = N_{cbmi} \times t_m. \tag{8}$$

where t_m – time between coincidences.

Therefore, for the practical use of the method of multiple coincidence from the expressions (8) we can determine the number of matches. From the expressions (7) and (3) respectively – the desired precision and necessary relationship between the frequency of the input and reference signals.

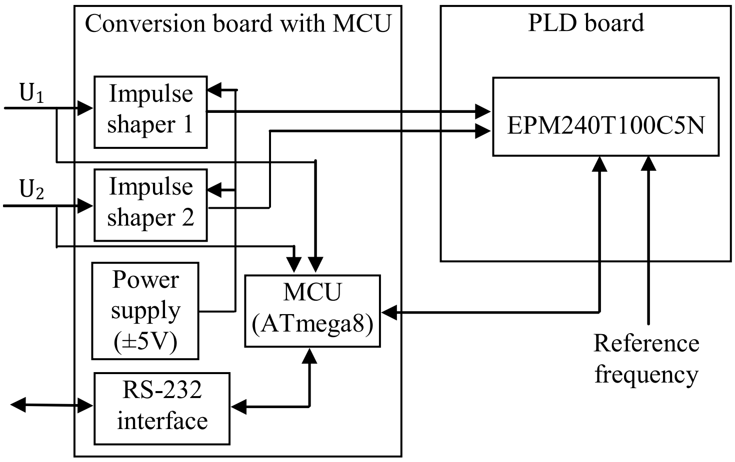

Fig. 2. Block diagram of the phase measurer based on high speed PLD

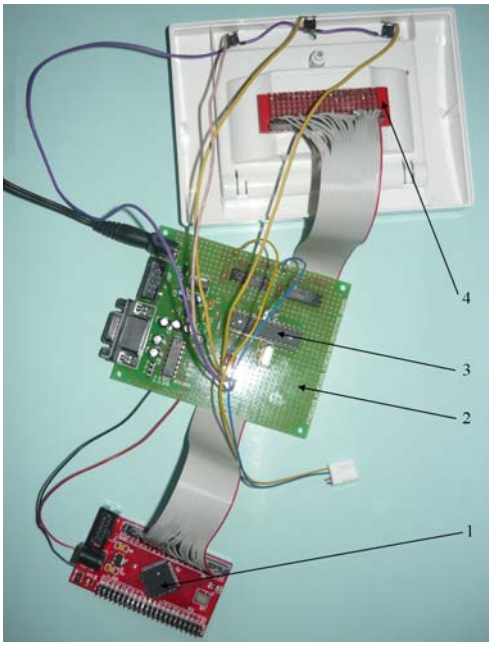

Fig. 3. Automated phase measuser on development boards with external power sources: 1) PLD board with EPM240T100C5N; 2) MCU board with impulse shapers 3) ATmega8-16MHz; 4) display unit

IV. PRACTICAL IMPLEMENTATION AND VERIFICATION OF THE METHOD

For the study of the proposed method, proposed to build phase measurer by using of high-speed programmable logic-based (PLD) EPM240T100C5N by Altera. Block diagram of the phase measurer shown in figure 2. Constructed device shown in figure 3. Usage of high-speed PLD allows to manipulate with short impulses and to calculate huge numbers of impulses. MCU like 8bit ATmega8 allow controlling of measuring process. Software for Windows environment allow end-user to reset phase measurer, set time of measuring and calculate phase between two signals.

Figure 2 show usage of ATMega8 build-in ADC to measure amplitude of input signals.

Series of experiments were made to compare the result obtained in the measurement process with the theoretical result. Result of the experiments shown on figure 4.

For experiments were selected input frequency 1 MHz and reference frequency 1,002004. As source of reference frequency used DDS based on AD9850 with 40 MHz clock. Impulse durations from impulse shaper were selected as 10 ns, 50 ns and 200 ns. Test phase angle 9,36 º.

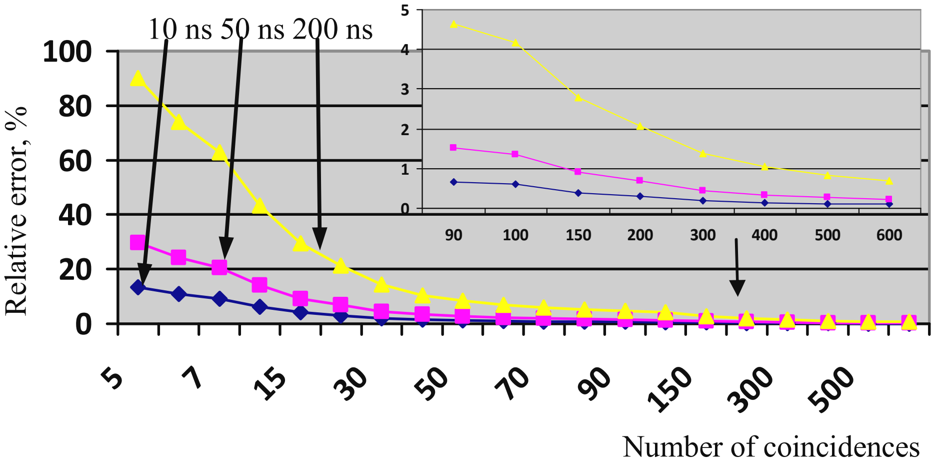

Fig. 4. Change of the relative error depending on the number of matches

V. CONCLUSIONS

To receive high measuring accuracy we require more coincidences. More coincidences require more time to measure. Relative error become less 1% for coincidences above 400 times. Relative error rate does not change for others values of the phase angles. It depends on relations between input and reference frequency and depends on durations of impulses from impulse shapers.

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ESTIMATION OF TRANSMISSION PARAMETERS OF DIELECTRIC SELF-SUPPORTING OPTICAL CABLES IN THE EXPLOITATION CONDITIONS

Abstract. *In this paper, the estimation of transmission parameters of dielectric self-supporting optical cables, which operate in Odessa and Kiev climatic zones, defined and estimated the additional components of the transmission characteristics.*

Keywords: transmission parameters, dielectric self-supporting optical cables, climatic zone operation, physical and climatic loads.

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ОЦІНКА ПАРАМЕТРІВ ПЕРЕДАЧІ ДІЕЛЕКТРИЧНИХ САМОУТРИМНИХ ОПТИЧНИХ КАБЕЛІВ В УМОВАХ ЕКСПЛУАТАЦІЇ

В даній роботі проведено оцінку параметрів передачі діелектричних самоутримних оптичних кабелів в умовах експлуатації в Одеській та Київській кліматичній зонах та визначені й оцінені додаткові складові передавальних характеристик.

Ключові слова: параметри передачі, діелектричні самоутримні оптичні кабелі, кліматична зона експлуатації, фізико-кліматичні навантаження.

Introduction

Todays, advantages of application of self-supporting optical cables with different dielectric power elements (SSOCd) on the overhead fiber-optic communication lines (FOCL) on the transport telecommunication networks and networks of subscriber access cause no doubts [1 – 3].

Clearly, that for providing of transmission of high-quality optical signal for such SSOCd needs, that values of transmission characteristics of cables were expected and corresponded to the requirements of ITU–T recommendations.

In some works, for example, [4, 5] it is indicated that the module constructions of SSOCd are created thus, that to provide surplus of length of optical fiber (OF), placed in a cables core, with the purpose of exception of possibility by applying the mechanical tension to the optical fibers while occurrence of the tensile forces. It is provided the spiral laying of the optical modules with optical fibres round a central power element (CPE) with the certain radius *R* and step *h* (fig. 1). In addition, the optical fibers as a result of material thermocontracting of structural elements during SSOCd making, placed in a middle of OM by gelikoide, that creates additional surplus of OF length. Value of radius *R*, step *h* of spiral laying of OF and distances, between them and the internal surface of OM wall, which enables free movement fibers in the middle of tube of the module, determines the measure of the possible relative lengthening (longitudinal deformation) of cable ε_{pc}, which is the criterion of calculation of the