TCSET'2014

"MODERN PROBLEMS OF RADIO ENGINEERING, TELECOMMUNICATIONS, AND COMPUTER SCIENCE"

Proceedings
of the International Conference
TCSET'2014
Dedicated to the 170th anniversary of
Lviv Polytechnic National University

Lviv-Slavske, Ukraine
February 25 – March 1, 2014

Ministry of Education and Science of Ukraine
Lviv Polytechnic National University

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Міністерство освіти і науки України
Національний університет “Львівська політехніка”

СУЧАСНІ ПРОБЛЕМИ РАДІОЕЛЕКТРОНІКИ, ТЕЛЕКОМУНІКАЦІЙ, КОМП’ЮТЕРНОЇ ІНЖЕНЕРІЇ

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SECTION 10
RADIO-TECHNICAL SYSTEMS OF THE COMMUNICATION, POSITION AND CONTROL

Phase-Based Estimation of Range

Slyusar V.I., Zinchenko A.O.

Abstract - **In this paper new method for phase-based estimation of range is proposed.**

Keywords - **Phase ranging, Decimator, Analog-to-digital convertor (ADC).**

I. INTRODUCTION

One of the variants of the phase-based method of the distance measurement consists in the successive object irradiation by signals with different frequencies, which differ one from another on a permanent frequency interval Δf. The digital variant of this phase ranging that converts the task of the distance assessment to the algebraic equalization, which was formed by using signals voltage of output samples of analog-to-digital conversion of different frequencies is proposed in [1]. But in this case it is more effective to use decimation of analog-to-digital convertor (ADC) counts, which allows thinning out information flow with the aim to decrease burden on the processing signal devices. The digital method of the phase-based range estimation with the successive irradiation of objects by signals with different frequencies while using decimation of ADC counts is shown below.

II. MAIN TEXT

Let us form the system of equalizations that allows estimating the distance to the target using a phase-based method. Let us choose a pair of counts of the initial signal of the decimator of different frequencies to form the system of equalizations. Ignoring the presence of noises, we obtain:

$$\begin{cases} U_{1,y} = \dot{a}_1 F_1(r) Z(f_1); \\ U_{2,y} = \dot{a}_2 F_2(r) Z(f_2), \end{cases} \quad (1)$$

where $F_k(r) = \exp\left(j4\pi r f_k c^{-1}\right)$, r – distance of to the target, f_k - frequency of signal in the k^th sounding, c - speed of light, $\dot{a}_k$ - complex amplitude of signal of any frequency (it is considered unchanged during all existence of the signal of any frequency), $Z(f_k)$ - a value of amplitude-frequency characteristic of the decimation on frequency f_k.

Let us divide the second equalization of the system (1) into the first:

$$\frac{U_{2,y}}{U_{1,y}} = \frac{\dot{a}_2}{\dot{a}_1} \frac{F_2(r)}{F_1(r)} \frac{Z(f_2)}{Z(f_1)}.$$

From here, $$\frac{F_2(r)}{F_1(r)} = \frac{U_{2,y}}{U_{1,y}} \frac{Z(f_1)}{Z(f_2)} \frac{\dot{a}_1}{\dot{a}_2}.$$

On the other hand,

$$\frac{F_2(r)}{F_1(r)} = \frac{\exp\left(j4\pi r f_2 c^{-1}\right)}{\exp\left(j4\pi r f_1 c^{-1}\right)} = \exp\left(j\frac{4\pi r \Delta f}{c}\right),$$

where $\Delta f = f_2 - f_1$.

Thus, $\exp\left(j\frac{4\pi r \Delta f}{c}\right) = \frac{U_{2,y}}{U_{1,y}} \frac{Z(f_1)}{Z(f_2)} \frac{\dot{a}_1}{\dot{a}_2}$,

$$r = \mathrm{Re}\left[j\frac{c}{4\pi\Delta f} \ln\left(\frac{U_{2,y}}{U_{1,y}} \frac{Z(f_1)}{Z(f_2)} \frac{\dot{a}_1}{\dot{a}_2} \right) \right]. \quad (2)$$

Thus, to measure the distance to the target using proposed method, it is necessary to have information about correlation of complex amplitudes of two harmonic signals of different frequencies and to calculate correlation of complex voltages of decimator with the identical number of followings in each of two probing periods. It is assumed that frequencies of the signals are known: for example, Doppler shifts were estimated or the frequencies are so insufficient to ignore shifts of the frequencies relating to their values in the moment of radiations.

Expression (2) can be simplified, if the condition of equality of complex amplitudes of signals of two frequencies is executed, i.e. $\dot{a}_1 = \dot{a}_2$, as a result:

$$r = \mathrm{Re}\left[j\frac{c}{4\pi\Delta f} \ln\left(\frac{U_{2,y}}{U_{1,y}} \frac{Z(f_1)}{Z(f_2)} \right) \right]. \quad (3)$$

Implementation of condition of the coincidence of complex amplitudes is based on the signals radiation on identical initial phase and insignificant frequency carrying of signals $\Delta f = f_2 - f_1$, which allows to ignore the display of frequency dependence of complex coefficient of removing signals from a target. The real deviations from this condition will cause appearance of some errors in distance measurement, but it will not deprive the proposed method of its capacity.

III. CONCLUSION

The capacity of the offered method of the phase measuring distance was tested by a mathematical design. Further researches must be focus on the analysis of attainable accuracy of measurement distance, especially at the terms of presence of additive and phase noises.

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