ISSN 0735-2727, Radioelectronics and Communications Systems, 2014, Vol. 57, No. 11, pp. 489–494. © Allerton Press, Inc., 2014.
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Estimation of Flight Altitude in the Aperture Synthesizing Mode for Altimeter with Continuous Probing Signal

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Received in final form June 5, 2014

Abstract—It is proposed the function, defining phase modification of point, ground located reflector at the aperture synthesizing interval of radar altimeter with continuous LFM signal. It is carried our general function shape in wave domain and its expansion by "fast" time. We synthesized the algorithm of the altitude estimation, taking into account the carrier movement during process of beating signal shape. There are represented the results of full-scale experiment.

DOI: 10.3103/S0735272714110028

Traditional radar altimeter (RA) is radar, located on an aircraft and measuring radiated signal delay in case of its propagation in a channel "radar–surface–radar". Radiated signal can be pulse or frequency-modulated continuous wave (FMCW) [1]. In the last case due to altitude modification methods, based on estimation of energy mean (dominating) beating signal frequency, which is proportional to measured distance to the earth surface [2, 3], are used. This estimation can be based on calculation of amount of transitions through zero level in the beating signal [4]. An error, connected to principal discreteness of such estimation in case of enough value of estimation interval is small [5]. Essential increase of accuracy and noise immunity [6] is achieved by means of circuits of automatic frequency control (AFC) and phase-locked-loop frequency control (PLFC), where frequency and phase detectors are applied [1, 2] as a discriminator.

Main source of the errors in case of the altitude measuring is a length of earth surface as a radio location target. At that beating signal spectrum has inevitably finite length [7, 8]. Application the methods of digital spectrum analysis can compensate partially such kind of errors [9].

But RA with coherent signal can be considered as a side looking radar and the processing algorithms, used in radar with synthesized antenna aperture can be applied for altitude measure [10-12]. Such approach allows to decrease the errors of altitude measuring, related to the length of surface part, shaping reflected signal, by modified parameter. In this paper we consider one of such algorithms with regard to RA with continuous LFM-signal.

We assume RA carrier flight is rectilinear and horizontal with known velocity. Information about the carrier velocity can be obtained from the on-board navigation system. Account of possible vertical velocity is represented further.

Considering pulse radar system we suppose the incline distance of the target is constant. In case of radar with continuous signal such supposing is not correct. This fact is expressed in formula for delay time of reflected pulse.

Let x is the radar coordinate, x_0 is a coordinate of reflecting part of earth surface, h is current altitude, V is radar movement velocity. Then delay time τ can be defined using following expression:

$$c\tau = \sqrt{h^2 + (x_0 - x)^2} + \sqrt{h^2 + (x_0 - x - V\tau)^2} \quad (1)$$

and it is