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Wave Distribution in Wireless Technologies for Adaptive Control System of Aviation Engine

An approach of improving the efficiency of functioning the distributed control system of aviation engine based on wireless technology with high productivity and resolution of wave distributed surface has presented. It can be applied for development of new principles of correct location the nodes, including the data processing equipment, the intellectual sensors, repeaters, central units in adaptive control strategies of aviation engine.

Introduction. One of the factors for increasing the profitability of aviation engines, and also aircrafts production is the development and introduction of new methods and equipment of automating the control and management the technological modes of the power plant machinery. This is facilitated by the appearance on the market of automation equipment the various automated information and control complexes [1], as well as intelligent equipment of local automation based on wireless sensor nets [1,2], which allow building cost-effective distributed control and management systems (DCMS) with technical objects, having different configurations, increased reliability and resolution.

During the designing a telecommunication system, one of the important factors affecting the cost, is the features of the wave resolution surface. It is necessary, for radio channel, that there are no obstacles on the line of sight, which is achieved by using masts for antennas or repeaters.

The goal of this research is to take into account the wave resolution surface to determine the mast height of the data processing equipment for ensure unimpeded signal transmission.

Wave distribution. For a radio channel, a data source can be connected to the data processing equipment (DPE), provided that the distance between them in a straight line is less than the maximum range of the signal, determined by the standard, the transmitter power, the used antennas types. The features of the wave surface on the radio signal propagation path, which connecting the remote object and the relay station, should be taken into account.

Signal waves propagate along a straight line connecting the antennas and called the line of sight. For determine the characteristics of the route, can be introduced the concept of the calculated gap H_0, which is determined from the relations:

$$\mathrm{H}_0 = \sqrt{\frac{1}{3} R_0 \lambda k (1-k)}, k = \frac{R_l}{R_0}, \tag{1}$$

where R_0 is the distance between the antennas;

λ is the wavelength;

R_l - distance from the left end of the interval to the calculated point [].

A path is considered open if the geometric gap $H > H_0$.

The equations of the projections of the line connecting the i-th and the j-th DPE to the XOZ and XOY planes are determined by the formulas:

$$z_{pr} = k_1 \cdot x + b_1,\ y_{pr} = k_2 \cdot x + b_2, \tag{2}$$

where k_1, k_2, b_1, b_2 are the coefficients of the equation of straight lines.

Then, by the condition that the point on the surface with the coordinates (x_r, y_r, z_r) does not create obstacles for the signal propagation is:

$$k_1 \cdot x_r + b_1 - z_r \geq h_0, \tag{3}$$

where h_0 is the value of the calculated gap at the point (x_r, y_r, z_r), defined by (1).

The values of the coefficients k_1 and b_1 depend on the height of the antenna location of the i-th DPE h_i and the j-th IS h_i.

$$h_i = z_i + h_{m.i}, \tag{4}$$

where z_i is the height of the location point on the plane;

$h_{m.i}$ is an altitude, mast height.

For refine the topological model, taking into account the surface, data on surface heights, that obtained from digital maps-scalogramm, are needed. The general structure of the digital map is presented in table 1. The entire region of the map is divided into nx parts along the axis OX and ny along the OY axis. The values of nx and ny determine the accuracy of calculation and the time costs. Each cell of the matrix is given the average height in the given region.

For define a location of DPE and each data source, the condition for the presence of a calculated gap h_0 on the line of sight is checked. For each point of the segment connecting the data source and the data processing facility, the condition (3) is checked. If the condition is not fulfilled, then the value of the coefficient k_1 is corrected and the height of the antenna mast of the data processing device is increased to the value z_s, which is determined by the following expressions:

$$k_1 = \frac{h_0 + z_r + z - b_1}{x_r} \tag{6}$$

$$z_s = k_1 \cdot x_s + b_1, \tag{7}$$

where x_r is the coordinate along the OX axis of the wave surface point, where condition (3) hasn't performed;

x_s is the coordinate along the axis OX of the data processing equipment;

z_s is the coordinate along the OZ axis of the antenna data processing equipment.

Table 1. Wave matrix of the surface height

x/y	1	2	3	4	5	6	7	...	nx
1		$h_{1,2}$	$h_{1,3}$	$h_{1,4}$	$h_{1,5}$	$h_{1,6}$	$h_{1,7}$		$h_{1,nx}$
2	$h_{2,1}$		$h_{2,3}$	$h_{2,4}$	$h_{2,5}$	$h_{2,6}$	$h_{2,7}$		$h_{2,nx}$
3	$h_{3,1}$		$h_{3,3}$	$h_{3,4}$			$h_{3,7}$		$h_{3,nx}$
4	$h_{4,1}$	$h_{4,2}$			$h_{4,5}$	$h_{4,6}$	$h_{4,7}$		$h_{4,nx}$
5	$h_{5,1}$			$h_{5,4}$	$h_{5,5}$	$h_{5,6}$	$h_{5,7}$		$h_{5,nx}$
6			$h_{6,3}$		$h_{6,5}$	$h_{6,6}$	$h_{6,7}$		$h_{6,nx}$
7		$h_{7,2}$	$h_{7,3}$		$h_{7,5}$	$h_{7,6}$	$h_{7,7}$		$h_{7,nx}$
ny	$h_{ny,1}$	$h_{ny,2}$	$h_{ny,3}$	$h_{ny,4}$	$h_{ny,5}$	$h_{ny,6}$	$h_{ny,7}$	..	$h_{ny,nx}$

The height of the DPE mast is selected taking into account the maximum value of z_s for all channels connecting to the data sources. Thus, the considered formulas (1) - (7), the wave distribution matrix allow to estimate the required mast height for the data processing antenna equipment and clarifying the topological model of the distributred control system the aviation engine.

Conclusion. The efficiency of scaling the parallel process of the most demanding structural elements of DCMS of aviation engine by using Wireless technology has been investigated and analyzed. The method of wave distribution surface with calculated gap for data transmission has been considered. It helps to better understand the creation of efficiency path interaction between nodes in automatic control system of aviation engine.

In particular, the scaling technology in the IEEE 802.15.4 implementation can be effectively used as a part of control systems for the organization of data acquisition and transmission systems, based on intelligent nodes: a radio transmitter, sensors, microprocessors, batteries.

References

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