NON-STABILITY OF MM-WAVE RADAR IMAGING OF THE CAR IN DYNAMICS

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Summary

One of the important requirement to the radioimages formed by the systems of the automatic vehicle classification and identification or automobile imaging radar is the quality of forming radioimages. In ideals the quality of radioimages can be equal to optical images, because car radar must not only to determinate availability of the obstacle, but to recognized and identificated it too. The conducted theoretical and first experimental investigations have shown that the radar images of obstacles formed by radar are characterized by the non-stability of the radioimages, which can not permit to identificated and recognized the targets. Unsteadies of the car radar imaging in dynamics are analyzing and discussed in this paper. The methods of the decreasing of the radar imaging unsteadies are discussed.

1. Abstract

At present time the serious problem of safety guaranteeing of automobile transport movement control in conditions of limited optical visibility (fog, snow, rain, dust, smoke and the like) is the creation of radar systems for prevention of collisions with obstacles, located on the road.

One of the cardinal directions of the decision of this problem is the development of a front survey automobile imaging radar (AIR). This system is forming the images of a car, road and various objects, located on a road and near it. For the AIR of this types, some difficult additional problems can be solved.

One of the important requirement to the radioimages formed by the AIR of the third type is the quality of forming radioimages. In ideals the quality of radioimages can be equal to optical images, because AR must not only to determinate availability of the obstacle, but to recognized and identificated it too.

The conducted theoretical and first experimental investigations have shown that the radar images of obstacles formed by radar are characterized by the non-stability of the radioimages, which can not permit to identificated and recognized the targets.

Unsteadies of the car radar imaging in dynamics are analyzing and discussed in this paper. The methods of the decreasing of the radar imaging unsteadies such as isotropic and wide-band methods are discussed.

2. Introduction

At present time the serious problem of safety guaranteeing of automobile transport movement control in conditions of limited optical visibility (fog, snow, rain, dust, smoke and the like) is the creation of radar systems for prevention of collisions with obstacles, located on the road. One of the cardinal directions of the decision of this problem is the development of a front survey automobile imaging radar (AIR). This system is forming the images of a car, road and various objects, located on a road and near it. In dependence of complexity and solved task the developed information systems of this type of transport means can be divided on following types:

1. Radar sensors of measurement of range and relative speed to a front and fellow transport means and some kinds of obstacles. There are simple devices, which must solve the part of the task only – the warning of the dangerous situation in movement process.

2. Multifunctional systems of “radar vision”, which have a large information and permit to obtain the radar images of the road, automobiles, environment. The systems of this type are measured the all parameters of car movement both it’s own and relative.

3. Radar systems, which permit to get the not only radar images but to solve the inverse task of radio location – to identify the object types, obstacle character, road cover condition and etc.

4. Radar systems of third type but used as systems of autonomous and automatic car control – most complicated type of radio systems.

One of the important requirement to the radioimages formed by the AIR of the third type is the quality of forming radioimages. In ideals the quality of radioimages can be equal to optical images, because AR must not only to determinate availability of the obstacle, but to recognized and identificated it too.

For measurements of parameters of the obstacles and their radioimages we used mm-wave radar. This radar (fig.1) has following parameters:

Frequency – **35 GHz**,

Modulation - pulsing; Pulse width – **60 ns,**

Maximum power of radiation - **70 mW**;

Antenna – diffraction mirror type antennas with rotating submirror;

Effective width of antennas beam: azimuth and elevation plane – $\mathbf{1.2^0}$;

Deflection angles - $\mathbf{\pm 20^0}$;

Scanning – electrical-mechanical.

The radar is consist of three functional modules: Antennas block with UHF block, Analog-digital converter and control blocks, Computer and display blocks.

For protection metal (Al) of the diffractional antenna [1] from corrosion, for protection of the reception head at reflection and focusing of light from overheating, the surface of the antenna was executed dim [2]. For this purpose on a surface of the antenna the sheeting (thickness about 10 microns) with the help of a method known as Selicodazing or ANOF-process was rendered [3]. Microarc covering received in water solution $Na_6P_6O_{12}$ is smooth, dim, homogeneous, without stains and divorces. On Al alloys it has white colour with grayish by shade. Drawing of a sheeting (Al_2O_3) was carried out at density of a current 0.05 A/cm^2 and voltage 350 V. A roughness of external surface of the antenna covered of aluminum oxide did not exceed 5-7 microns. Measurement of the reflection factor from metal antenna with the covering and without it have shown, that within the limits of accuracy of measurements factor of reflection has not changed. The experimental gain of such diffractional antenna was about 37.8 dB.

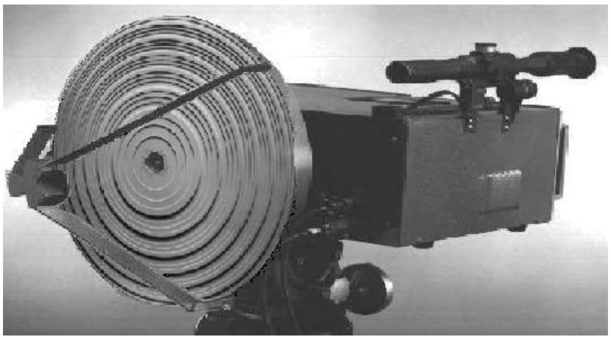

Fig.1. The mm-wave radar with the diffractional mirror antenna.

3. The results of investigations

Below in figure 2 two types of car (cargo (A) and automobile (B)) and their consecutive radioimages in mm-wave band are shown. The cargo (A) is a Russian “KAMAZ” car class, the automobile (B) is a Russian “Moskvich” car class. From submitted given it is clearly visible, that depending on mutual orientation of the automobile – target and mm-wave radar antenna, the radioimages of automobiles change the structure. Moreover, structure and kind of the radioimages of these two types of cars, which essentially were differing in on the sizes, it appear similar.

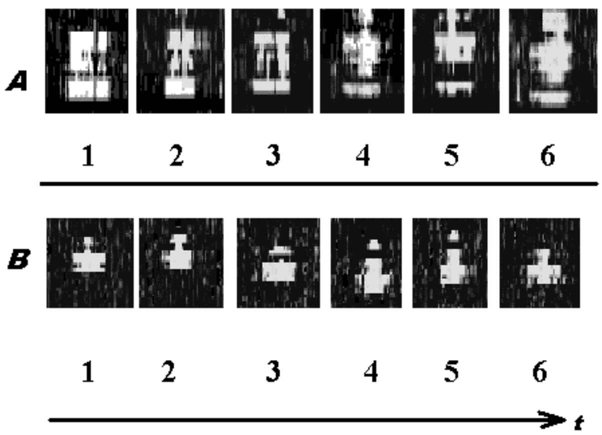

Fig.2. The mm-wave radioimages of the two types of the cars in dynamics.

The given result becomes understandable if to take into account the following. In mm-wave band automobiles represent well reflecting subjects. Their radioimage represents set «of mirror specks» from the separate parts of the object, each of which has the own pattern of scattering.

The fact, that structure of the radioimage of the automobiles does not depend on its types and sizes, and is defined only in radar parameters and set «of mirror specks», confirm results Fig.3. In this figure the diagrams of Fourier spectrum of the radioimages of automobiles shown in figure 2, on all vertical sections of the image are given within the limits of a working zone. Then received spectra of sections being reduced in one spectrum. As it is shown from the given results, the spectra of signals for two specified types of automobiles completely are similar and a little bit differ in the field of low frequencies. The spectra of a signal received on horizontal sections of the radioimages, are completely identical given on figure 3.

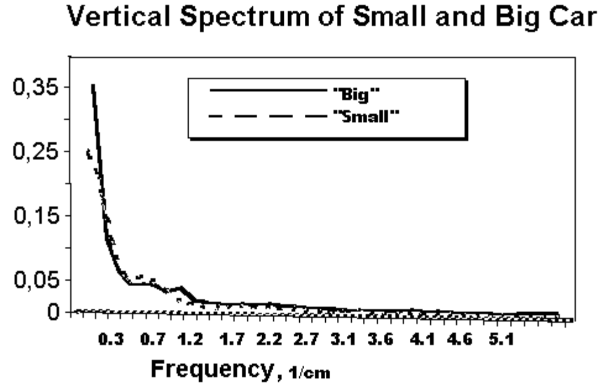

Fig.3. The “vertical” spectrum of the car radioimages.

About that the radioimages of the automobile at each separate moment of time differ from each other and carry «quasi fortuity» character, show the following results. In figure 4 under the appropriate radioimages of the same automobile the kind calculated vector (2D) of auto correlation function of the image on its working zone is given. The module of correlation function is represented as: white colour means 1, black - 0.

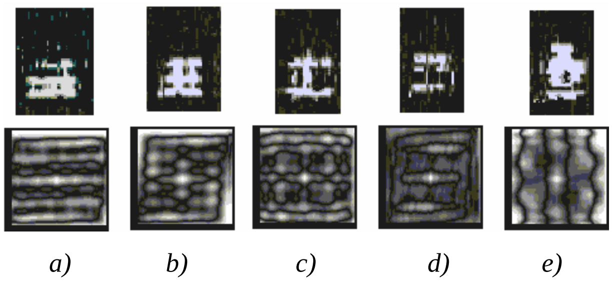

Fig.4. The radioimages of the car and the appropriate auto correlation function.

As it is visible from figure 4, auto correlation functions of the radioimages of the automobile have completely different structure and vary in time.

4. Discussions

Thus it is possible to conclude, that without acceptance of special measures automobile mm-wave radar provides the sure reception of a signal from the automobile - targets (obstacles), however to distinguish the purpose and the more so it to identify practically not probably. It is known [4] that for work automobile radar the narrow enough spectral range is allocated. To solve a problem of reception of the qualitative radioimages of objects with the help of automobile mm-wave radar it is possible by several ways. First, it is possible with the help of various technical means, for example, with the help of rotating diffusers to break the coherentness of used radiation. In second, it is possible to use broadband radiation, but this way is not applicable because of the requirements [4] on frequency range of car radar.

The possible way of the decision of a problem, on our sight, consists in use of isotropic method of the signal reception [2], which is in detail considered in work [5].

The situation is aggravated by that fact, that during mutual movement of two automobiles, or automobile and obstacle, the pattern of scattering of the targets varies depending on a camera angle of supervision. Accordingly and the accepted signal by the radar will vary. In figure 5 the appearance of the automobile and its pattern of scattering in mm-wavelength is shown. The given figure confirms the told above statement.

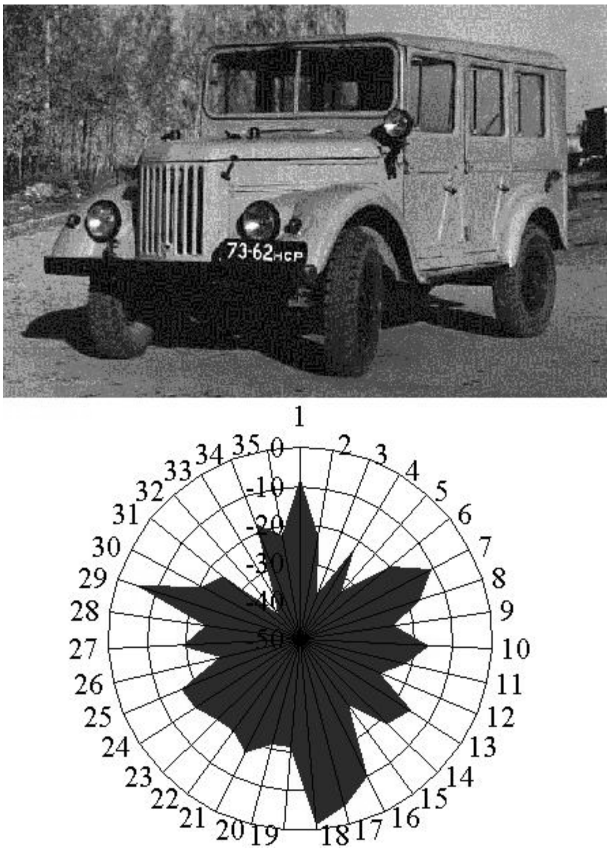

Fig.5. The target and its pattern of scattering in mm-wavelength.

On the other hand, the above mentioned results allow to specify the requirements of width of the diagram of the automobile radar antenna. As have shown additional modeling experiments, for the sure identification of object under its radioimage it is necessary, that on the characteristic size of object «was located» not less than 10 elements of the resolutions. These conclusions completely meet to conclusions of work [6]. Hence, on range up to an obstacle about 100 m and width of the automobile about 2 m, the antenna should provide the beamwidth about 0.2 degrees.

5. Conclusions

The results of the present work allow to make the following basic conclusions.

- The structures of the radioimages of small-sizes and big-sizes automobiles in mm-wavelength are identical.
- The Fourier -spectra of automobiles mm-wave images of the various size and purposes poorly differ among themselves in the area of low frequencies.
- Consecutive in time of the radioimage of the automobile (in dynamics) do not correlate among themselves and carry casual character.
- The radioimage of the driven automobile represents the image of set «of mirror specks» points. For identification and classification of automobiles till them radioimages in mm-wavelength it is necessary to accept special measures on improvement of radioimage quality.

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