New method for testing of antenna phased array in X frequency range.

V A Lenets¹,², M Yu Tarasenko¹,², V V Davydov¹, ⁴, N S Rodygina³, A V Moroz¹

¹Higher School of applied physics and space technologies, Peter the Great Saint Petersburg Polytechnic University, Saint Petersburg 195251, Russia
²NTC JSC “Zaslon”, Saint Petersburg 196084, Russia
³The Bonch-Bruevich Saint - Petersburg State University of Telecommunications, Saint Petersburg 193232, Russia
⁴Department of Ecology, All-Russian Research Institute of Phytopathology, 143050, Moscow Region, Odintsovo district, B.Vyazyomy, Russia

lenets03@mail.ru

Abstract. The results of the research of the developed fiber-optic transmission systems for analog high frequency signal are represented. On its basis, a new method to identify various structural defects in the active phased antenna arrays is elaborated.

1. Introduction

Now there is a constant improvement of exploited fiber-optic transmission systems (FOTS) of information both trunk and local use and development of new FOTS [1-5]. But in recent years, analog FOTS for transmission of very high frequency signals (radiophotonics) became an important component of development of local area telecommunication networks [2, 6-8]. Analog FOTS are greatly applicable in radar-tracking systems of different function [9-12]. Because in locations of radar-tracking systems the large number of various equipment and power stations are concentrated. In addition, use of FOTS can reduce the weight and size of the radar systems themselves, in case of their use on aircraft, etc.

Nowadays, various modifications of FOTS have been developed using direct and external modulation of laser radiation by an analog microwave signal [1, 2, 8-11]. Their designs and characteristics differ depending on the tasks to be solved with their use in radiolocation under various working conditions [1, 2, 8-11, 13-15]. The most difficult task is the tuning of active phased antenna arrays (APAA) at the stage of designing radar stations.

One of the problem is the distortion of the signal in the transmission from the receiver to the high frequency analyzer at different APAA modes of operation during testing in an anechoic chamber (AC). These distortions are connected with the position of coaxial lines for transmitting signals from nearby high-voltage cables entering the APAA, and also location of the amplifier (without it the signal fades) in the area of direct radiation pattern of high power electromagnetic radiation (since the distance between the transmitter and receiver is smaller than 3 m) [9, 10, 13-16]. In addition, the placement of any signal transforming microwave devices (e.g. network analyzer) in the AC violates its anechoic properties, which makes use of the camera ineffective.

One solution to this difficult problem is to develop special construction of FOTS, where the analog signal from the receiving device placed in AC, transmits the received electromagnetic radiation of APAA in the area of
instrumentation location through the region with a complex electromagnetic environment. Previously developed models of FOTS, as the conducted research has shown, cannot be used for these purposes, since their design does not consider the specific features of APAA testing in AC.

2. Fiber-optic transmission system and measurement technique

Since the distance between the active elements of APAA and the AC receiving device is not more than 3 m, it is necessary to exclude the direct effect of the pattern of the antenna radiation on the case of the optical transmission module. For this purpose, we developed a new design of a measuring probe in the form of a horn. A small design of the transmitting laser module was chosen. For this module, a small power driver has been designed and manufactured. That made it possible to place the transmitting laser module with the power driver behind the receiving horn, so that direct electromagnetic radiation from the antenna pattern did not fall on their cases. Such a construction of the FOTS had never been used before.

In Fig. 1 a block diagram of the stand for testing APAA in AC is represented. In developed by us the fiber-optic communication line the compact high-frequency laser module 1 was used (“Dilaz” company) – it is the transmitter with direct modulation with wavelength of 1310 nm. The receiver is an optical module 2 (“Dilaz” company). The choice of a transmitter with direct modulation is caused by a small length of optical line (350 meters long) and its parameters more stable to temperature changes [1, 2, 6, 9, 10]. As the APAA testing with use of FOTS developed by us must be held in case of ambient temperatures from 233 to 323 K (real operating conditions of radar station) [4, 9, 10, 12]. A part of temperature conditions is provided when testing APAA in AC. Remaining temperature conditions are checked when testing APAA in the conditions of a polygon in the presence of opportunities.

![Figure 1. Block diagram of the test stand for testing APAA in AC: 1- laser module; 2 – receiving module, 3 SFP module, 4 vector network analyzer, 5 – router, 6 – personal computer](image)

The data obtained from measuring probe is coming over FOTS to vector network analyzer 4 with the subsequent processing on the personal computer 6.

Since the signals from the microwave generators are also transmitted to APAA via cables placed near the lines with high voltage for a variety of its devices (in AC there is only one entrance - it's also the output for all switching elements), so for this purpose it is also desirable to use FOTS. This will improve noise immunity in addition to significantly reduce the size of the connections, and unload the platform on which an APAA is placed. Additionally, higher accessibility of the equipment in case of maintenance and testing of APAA will be provided. The load on the mechanical elements providing movement of a platform when scanning the APAA pattern will be less.

3. Results and their discussion

As an example, in fig. 2 amplitude-frequency characteristic (AFC) in case of transmission of analog signals of very high frequency via FOTS developed by us for different temperature conditions of its operation are provided.
The analysis of the received experimental result shows that losses of power during transmission of a very high frequency of a signal on FOTS developed by us in the frequency range of operation of APAA in the range of temperatures of its operation – aren’t essential. It allows using FOTS developed by us for testing of APAA, as in the conditions of AC, and also at a polygon and the place of operation.

As an example, in fig. 3 the dynamic characteristics for FOTS a developed by us at a temperature of 298.4 K are presented. This temperature regime is the main one for testing APAA in AC.

The obtained result shows, that the developed FOTS could be used for radar station testing on frequency range of its exploitation [3, 9, 10, 12]. The output power is changed by less than 1 dB while changing the input power of analog microwave signal in wide range.

As the experiments showed, the use of the developed FOTS allowed us to research besides range of radiation of all APAA in different operation modes, also the ranges of radiation of its single active elements. These
studies weren’t possible earlier because of the existence of different noises, in particular the noise in the transferring path.

As an example, fig. 4 shows the emission spectra of a single active element APAA, transmitted to the control sector from the registration device of high frequency signal over coaxial cable, and developed by authors FOTS.

Figure 4 (a, b, c, d, e, f). The emission spectra of a single active element on 10.5, 9.5, 8.5 GHz frequency transmitted: (a, c, e) through a coaxial cable, (b, d, f) through a FOTS.

Analysis of the results, shows that the use of the developed FOTS allowed us to completely eliminate transmission noise from unpredictable RF disturbances and different induced signals, taking account of which and their further compensation (for example, subtraction) requires numerous additional measurements.

The use of multiple transformations to compensate interference causes additional distortions, both in the spectral line of a single active element and in its pattern. While using FOTS, changes in the registered pattern of the APAA single elements are connected only with the change of parameter of the very high frequency signal radiated by the antenna or defects of montage, and in the emitter itself. At the presence of the defect of the installation construction or in the emitter itself, the change of the pattern form takes place (for example reduction
of amplitude at a maximum, etc.). Comparing the constructed patterns of different emitters allows determining these defects.

4. Conclusions

The carried out research showed that the use of developed FOTS allows us to solve the problems considered earlier arising during testing APAA in AC with use the coaxial cable for transmission of a very high frequency signal. Besides that, the use of FOTS allowed the development of a new technique of determination defects both in assembling of APAA, and in the construction of an individual emitter. It should be noted that our new technique with the use of FOTS for the first time made it expedient to test each emitter of APAA as a part of all operating construction of the APAA, in contrast to the previously used techniques.

The received results confirmed feasibility of the FOTS use for testing APAA and validity of a new developed technique to determine its various defects.

In addition, APAA works in range from 20 to 42 GHz. At these frequencies the testing of APAA with coaxial cable in the anechoic chamber is impossible to carry out. Using this range makes the use of a coaxial cable ineffective for testing an APAA in an anechoic chamber. In addition, the transmission of microwave signals over the optical fiber on sea ships from various antennas (from the mast deck) to the hull of the ship (to the processing device) is becoming of extremely need over distances of 100 meters or more. At the moment, various investigations have been directed at its solutions. One of the directions of our further research will be the search for an optimal solution to this problem.

5. References

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