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Two-channel fiber-optic communication line for measuring the parameters of active phased antenna arrays in the far zone a landfill conditions

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Abstract. The necessity of using fiber-optic communication lines (FOCL) for testing active phased antenna arrays (APAA) in landfill conditions in a complex electromagnetic environment is substantiated. The advantages of FOCL application for working with microwave signals during testing of various antennas especially in the far zone are noted. The developed two-channel FOCL for measuring APAA parameters in the far zone is presented. The choice of the components of the optical system for transmitting microwave signals is justified. The results of the study of the characteristics of the fiber optic and directional patterns of antenna arrays are presented

Keywords: fiber-optic communication line, laser radiation, active phased array antenna, microwave signal, far range, dynamic range, radiation pattern.

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Материалы конференции
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Двухканальная волоконно-оптическая линия связи для измерения параметров активных фазированных антенных решеток в дальней зоне в условиях полигона

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Аннотация. Обоснована необходимость использования волоконно-оптических линий связи (ВОЛС) для тестирования активных фазированных антенных решеток (АФАР) в условиях полигона в сложной электромагнитной обстановке. Отмечены преимущества применения ВОЛС для работы с СВЧ сигналами при тестировании различных антенн, особенно в дальней зоне. Представлена разработанная двухканальная ВОЛС для измерения параметров АФАР в дальней зоне. Обоснован выбор компонентов оптической системы для передачи СВЧ сигналов. Представлены результаты исследования характеристик волоконно-оптической системы и диаграмм направленности антенных решеток.

Ключевые слова: волоконно-оптическая линия связи, лазерное излучение, активная фазированная антенная решетка, СВЧ сигнал, дальняя зона, динамический диапазон, диаграмма направленности

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Introduction

In the modern world much attention is paid to the development of systems for transmitting information and determining the position of object coordinates using microwave signals [1–6]. In these systems development is done mainly in three directions: radio navigation, radio bearing in various applications and radar. Among radars a large segment is occupied by stations with active phased array antennas. The use of optoelectronic and optical methods [12–15] for transmitting, generating and processing microwave signals makes it possible to create devices and systems of the microwave range with parameters unattainable by traditional electronic means due to the properties of optical fiber: ultra-low losses and dispersion (for a microwave signal), wide transmission bandwidth, immunity to electromagnetic interference, complete galvanic isolation, mechanical flexibility, low weight and dimensions [9–18].

One of the difficult tasks that developers of antenna arrays solve is related to their testing and configuration [6–8]. Especially the greatest difficulties arise with APAA due to the fact that it is necessary to suppress the side lobes in the APAA directional pattern, and this requires tests in the far zone [19]. This will clearly determine the side lobes of the radiation pattern and the nature of their changes from various parameters as well as other characteristics of the antenna. This is only possible in landfill conditions. In this case it is necessary to solve the problem of transmitting information without distortion in the area of high-power electromagnetic interference. The most appropriate solution for the transmission of information in such conditions is the use of FOCL. The development of a FOCL design for APAA tests in the far zone in landfill conditions is the goal of this work.

Design of fiber-optic system and principle of its operation

To measure the APAA parameters in the far zone in the landfill conditions we have developed the following system the block diagram of which is shown in Fig. 1.

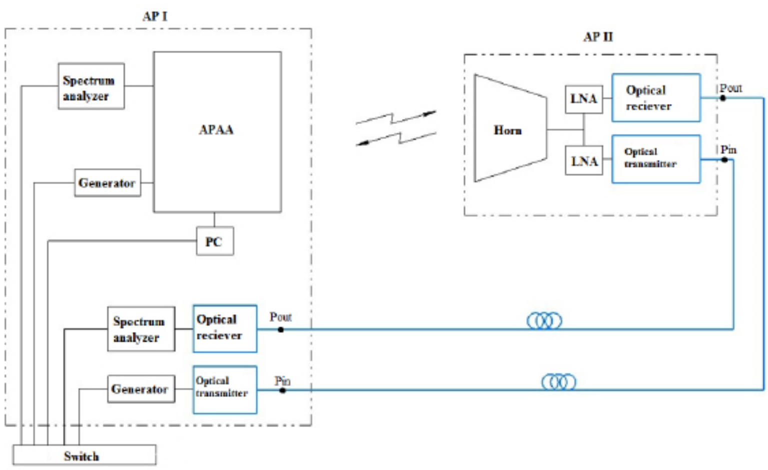

Fig. 1. Developed measuring system for testing APAA with FOCL

The system consists of two antenna posts, the distance between which is 1 km. Antenna post 1 (AP1) includes the investigated APAA, microwave signal generators, spectrum analyzers, as well as PC placed in the operator's post to analyze the results. Antenna post 2 (AP2) contains an auxiliary horn. The signal between the antenna posts is transmitted via a fiber-optic communication line.

This system allows measuring APAA parameters in two modes: transmission mode and reception mode. The system also allows to work in two bands: 1-2 GHz and 8-12 GHz. In the transmission mode the APAA unit connected to a generator and PC which control the APAA with computer simulator installed in it, emits a signal in one of two frequency ranges, which is received by the receiving horn. The signal from the horn goes to a low–noise amplifier (LNA), and then to an optical transmitter. The optical signal is sent via fiber to the receiver in AP1. Then the signal is sent via the switch to the PC at the operator's post. A signal is transmitted from the spectrum analyzer through the switch to the PC, which is emitted by the APAA.

During tests of the APAA in reception mode the signal of one of the ranges from the generator located in AP1 goes to the receiver through second channel of the FOCL, then to the LNA and the horn, which acts as an element of the microwave signal emission. The received APAA signal is sent to the spectrum analyzer, the information from which is displayed on the PC.

Results of experimental investigation and discussion

The main characteristic of any fiber optic cable for transmitting analog microwave signals is the dynamic range. For a stable transmission of information it is necessary to work on a linear section of the amplitude characteristic of the FOCL. The source of the microwave signal was a frequency generator, and the output power was recorded using a spectrum analyzer. In Fig. 2 the obtained amplitude characteristic of the developed FOCL for various frequencies of microwave signal emission is presented.

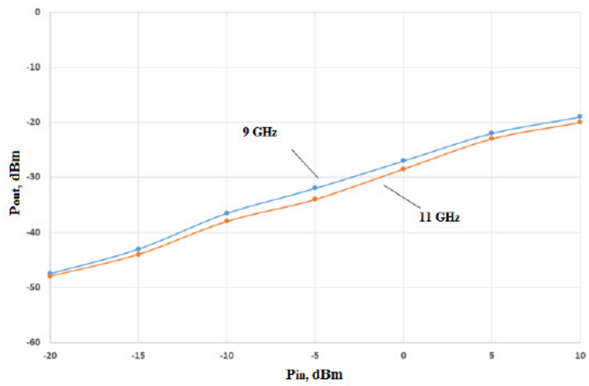

Fig. 2. Amplitude characteristic of the developed FOCL

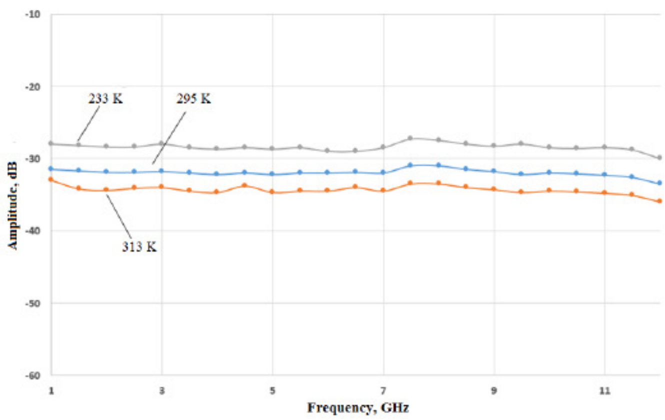

Fig. 3. Frequency response of the developed FOCL at different temperatures

Analysis of the data obtained allows us to establish that the dynamic range of the microwave signal transmission is 60 dBm. This value is sufficient for stable transmission of the microwave signal during APAA tests in various modes.

The frequency response of the FOCL was also measured at various temperatures because of the fact that in the landfill conditions the temperature may be different, and the conditions for temperature stabilization cannot always be fully realized. The measurements were carried out using a vector analyzer of circuits and a thermal camera. Fig. 3 shows obtained amplitude-frequency characteristic of the developed FOCL.

As results show the frequency response of the developed FOCL practically does not change in the operating frequency range of APAA. The unevenness of the transfer characteristic at frequencies of 1–12 GHz is ± 3 dB. At frequencies above 12 GHz, there is a significant decrease in the signal amplitude.

The results obtained also show that the developed FOCL allows transmitting stable microwave signals in the frequency range from 1 to 12 GHz. This conclusion made it possible to conduct studies of changes in the APAA radiation pattern in the landfill conditions with high accuracy and determine the APAA parameters at which the suppression of the side lobes of the directional pattern is the lowest. Fig. 4 shows an example of the APAA radiation patterns obtained in landfill conditions using a coaxial cable and a fiber optic cable.

The analysis of the results obtained (Fig. 4) shows that the use of a fiber optic cable allows to obtain a correct radiation pattern that corresponds to the calculated one for the antenna (Fig. 5). In the directional pattern there is no distortion and broadening along the main lobe and side lobes due to noise and interference. The result obtained allows to adjust the headlights to the desired scanning mode.

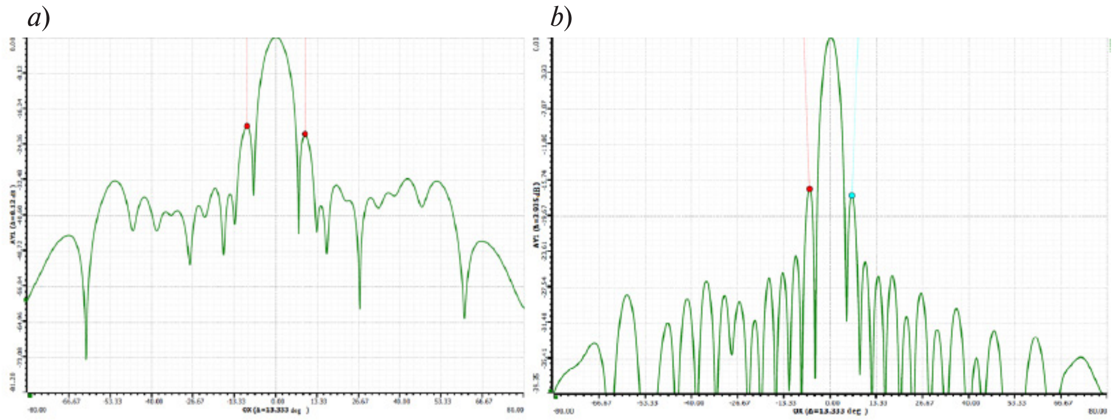

Fig. 4. APAA radiation pattern obtained using a coaxial cable (left) and using the developed FOCL (right) for transmitting microwave signals

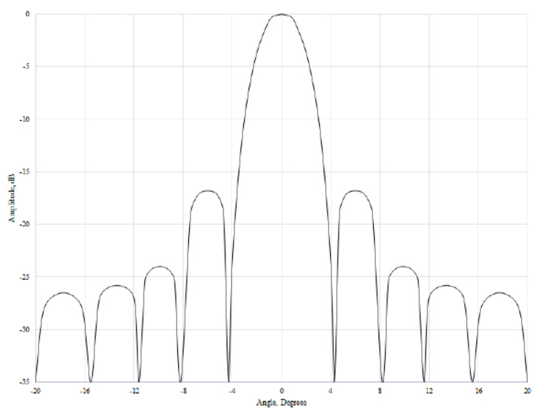

Fig. 5. Calculated radiation pattern for the developed FOCL

Conclusion

The analysis of the data obtained shows that the design we have developed, which includes a two-channel fiber-optic line for transmitting information, can be used to configure and test APAA in a landfill conditions in the frequency range from 1 to 12 GHz.

The results obtained show that the developed design of the fiber optic cable is resistant to temperature fluctuations in a wide range of its changes. This means that the element base used and the principle of building the FOCL can be used for radar with APAA at various facilities (sea and land-based). In addition the temperature drop along its length L, which is possible in landfill conditions, is not substantial for the design of the FOCL (one part of the FOCL can be placed in the air, another part is laid in an aqueous medium). For these reasons the distance L between two antenna posts in the case of high—power APAA studies can be increased up to 10-15 km if necessary.

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