Features of signal transmission through a fiber-optic system for an interference compensation module for an active phased array antenna

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Abstract: The article describes the operation of the X-band radar under the influence of active and passive interference. The rationale for using the interference compensation module in a radar station with a small-sized active phased array antenna is presented. A fiber-optic system has been developed for transmitting a signal from a compensation module. The results of experimental studies of the transmission system are presented. The advantages of using a fiber-optic system in a radar station in comparison with a coaxial cable are shown.

1. Introduction
Currently, there is a constant increase in the number of different stations and active objects, as a result of which the number of emitted and reflected signals increases [1-10]. This leads to an increase in the congestion of the frequency ranges in which radar stations operate, and various kinds of interference are also created [1, 2, 6, 10-18]. This interference will cause other systems to malfunction in which the optical signal processing methods and the laser radiation are used [2, 4-7, 19-31]. The greatest influence is exerted by the active interference transmitted at the radar operating frequency. Such interference creates a noise background in which it is impossible to track the useful signal [1-3, 8-10, 15-17, 32, 33].

To eliminate the influence of active interference on the operation of a radar with an active phased antenna array (APAA) operating in the X band (8-12 GHz), we developed a jamming compensation module. But the operation of the module is interfered with interference to which the connecting elements of coaxial cables and other parts of transmission systems are exposed. A malfunction in the operation of the interference compensator is caused by the transmission of the information signal from the antennas through areas with increased electromagnetic load. In our work, one of the solutions to this problem is presented – the use of a fiber-optic transmission system (FOTS) [1-3, 32-39].

2. Features of the transmission of microwave signals and a laboratory model of a fiber-optic transmission system
The most difficult task is the thermal stabilization of the laser transmitting module under various difficult conditions. The use of feedback loops for this has been experimentally proven. Also, when
using four horn antennas in the compensation module, it is rational to use one laser source and an optical divider. Given these features, we have developed new designs of transmitting and receiving modules for FOTS (figure 1).

![Figure 1 (a). Block diagram of transmitting module, where 1 is a laser; 2 - optical divider; 3 - electro-optical Mach-Zehnder modulator; 4 - photodiode providing feedback; 5 is a power supply voltage control circuit; 6 - multifunctional power supply; 7 - optical connector; 8 - microwave connector; 9 - shielded case.](image1)

![Figure 1 (b). Block diagram of receiving module, where 1 is a p-i-n diode based on InGaAs / InP; 2 - power amplifiers and bandpass filters; 3 - input optical connector; 4 - power connector; 5 - output microwave connector; 6 - bias voltage stabilization board.](image2)

Such a construction of the circuit allows to reduce the number of modules in the design that is requiring the regime of the temperature stabilization

**3. Results of experimental studies and their discussion.**

The amplitude-frequency response (AFR) is one of the most important parameters that characterize the operation of the FOTS. In figure 2 shows the frequency response of the system developed by us in the frequency range of 8-12 GHz.
Figure 2. Amplitude-frequency response of FOTS

The result shows that the uneven frequency response in the frequency range (8-12 GHz) is about 4 – 5 dBm. Filters that are used in the photodetector to generate the frequency response do not make significant distortions in the unevenness of the characteristic. This allows the transmission of microwave signals from the horn antenna to the processing devices.

It is also characterized by the tangential sensitivity of the receiving tract. It was found that when connecting to the path of the system developed by us, the value of G did not change significantly and is about 78 dBm. In figure 3 shows the dependence of the tangential sensitivity G of the receiving path on the frequency of the microwave signal.

Figure 3. Dependence of the tangential sensitivity of the receiving path on the frequency of the microwave signal

In the study, developed the design of the FOTS was determined by its dynamic range. The experimental dependence of the power of the $P_{out}$ output signal on the power of the $P_{in}$ input signal is shown in figure 4.
Figure 4. Dynamic characteristics of FOTS

The dynamic range of stable operation of the device was about 112 dBm. This indicator is not worse than that of a coaxial cable. It also shows an insignificant increase in losses with increasing frequency of the transmitted microwave signal, which is more flexible and compact than a coaxial cable.

The system developed by us as part of the interference compensation unit was tested on the model of air-based APAA in the conditions of the polygon. In figure 5 shows as an example images of targets and interference on a radar monitor.
Figure 5 (a, b, c). Image goals and interference on the monitor: (a) without the use of the developed block of interference cancellation, (b) using the composition of APAA we have developed compensation unit noise without FOTS, (c) using the developed FOTS in the interference compensation unit.

Our experiments have shown that the use of the FOTS developed by us in the block of interference compensation allows us to compensate for a significant part of active and passive interference by using this block. The result is a clear position of the target (figure 5 (c)), you can determine the parameters of its movement and carry out tracking.

4. Conclusion
The experimental data indicate that the use of the FOTS developed by us as part of the interference compensation module allows increasing the radar protection efficiency. In addition, the use of the developed FOTS design makes it possible to upgrade the noise compensation unit without making fundamental changes to the design of the optical circuit to increase the number of optical channels to 8 or 12 with an increase in the number of horn antennas to 8 or 12. Experiments have shown that increasing the number of horn antennas will be the next stage of work and further research. The main restriction on the use of the types of compensation antennas that we developed in the airborne APAA with FOTS is the availability of the necessary installation space.
Acknowledgments
This research work was supported by the Academic Excellence Project 5-100 proposed by Peter the Great St. Petersburg Polytechnic University.

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