Features of use direct and external modulation in fiber optical simulators of a false target for testing radar station

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Abstract. The purpose of this paper was to develop and research the fiber optical simulators of false target with direct and external modulation for testing radar station for the X-range. The modes of testing radar station by simulator depending on external conditions were studied. Temporal and spectral responses have been received. The optimum modes of simulators depending on external conditions have been defined.

1. Introduction

One of the most perspective directions of radio photonics is transmission of analog signals of very high frequency on communication fiber optical systems (FOS). Numerous experiments, and also operating experience showed that analog FOS can effectively be used in different paths of the multielement active phased antenna grids (APAG), switching devices of radar stations, etc. [1]. Use of analog fiber optical systems allows solving the most difficult problems connected to support of reliable operation of the send-receive antenna systems placed on moving platforms of the upper masts of the ships, different airplanes, etc. [2, 3]. But first developers need to set up and check entire antenna system for working capacity, both in the conditions of the laboratory or a polygon, and on the place of its forthcoming dislocation. And in the last two cases the flight purposes for different reasons can be absent.

The solution of this problem is the use of false target simulators, but as the most part of signals is transmitted over the fiber-optic communication line, one should use the reliable fiber optical simulator. Fiber optical simulator has exceptional feature in comparison with other models of simulators working at other physical principles. Delay factor of an analog signal essentially doesn't depend on its frequency. It allows creating false targets even when using broadband sounding pulses. Frequency restrictions on a very high frequency of a signal are only connected to technical features of electrooptical modulators and photoreceiving modules [4]. Remaining advantages of fiber optical simulators: immunity to electromagnetic interferences, low losses (about 0.2 dB/km for external modulation and about 0.35 dB/km for direct modulation in the single-mode fiber), complete galvanic isolation, mechanical flexibility, and also small mass-dimensional characteristics compared with other simulators are well studied.
The most difficult solvable task of fiber optical simulators is determination of the optimum modes of their operation when testing the radar station. It is related to different features used in direct or external modulation in the transmitting modulux [5, 6].

We examined fiber optical simulators of false target with direct and external modulation. Prototypes for this purpose were made and the following characteristics were received: oscillograms of the reflected pulses in case of different duty cycles used in radar station; amplitude-frequency characteristics, spectrum of two types of modulators and response characteristics. Research has been done for two types of FOS: the nature of losses in frequency range from 2 to 18 GHz, response and spectral characteristics. The research looked into very high frequency signals of different forms which are used in radar stations. Research was conducted at different temperatures in the conditions of light modulation phase displacement that corresponds to real operating conditions of FOS on a polygon, etc.

The response characteristic of simulators at different temperatures formed out to be the most interesting as the purpose was to reveal an optimum operation mode depending on external conditions of radar station. Those experimental installations are shown in fig. 1, where the developed samples of simulators are placed into a heat chamber.

2. Experimental methods

The fiber optical simulator of false target is based on the optical fiber coil with receiving and transmitting module. The main difference between two types of simulators is in the transmitting module: the laser with wavelength of 1310 nanometers is used for direct modulation and modulation is performed by a pumping current, for external modulation – a 1550 nm wavelength is used and the external modulator [7]. The difference between two types of simulators [8-10] can be seen in fig. 1 (a, b), where the experimental installations of FOS with two types of modulation are provided.

Based on the features of the tested radar station, FOS’s frequency range is 2 to 18 GHz, provided the required signal power and system performance.
3. Experimental results and discussion

The conducted researches showed that operation of simulators of false targets both types significantly doesn't change in case of different forms of signals and different duty cycles. So, time and spectral characteristics of both simulators aren't perceptible.

Frequency response of FOS with direct and external modulation at three temperatures are shown in fig. 2 (a, b).
The analysis of received frequency response for various ways of modulation shows that with increase in temperature when using external modulation the bandwidth is reduced by transfer analog by the signal microwave compared with direct modulation. It once again proves that it is necessary to use the system of thermostabilization allowing to provide a working point of the transfer characteristic at the segment with the maximum slope for the external modulator.

The response characteristic of simulators is of the greatest interest. Dependences of power output from input for three temperatures (253 K, 293 K and 313 K) are shown in fig. 3. In view of features of a measuring equipment and assembled simulators it was succeeded to take characteristics in range from -20 dBm to 10 for direct modulation and from -20 dBm to 18 dBm for external modulation.
Fig. 3. Dynamic response of FOS with direct (a) and external (b) modulation at a frequency of 9 GHz. Lines 1, 2, 3 correspond to temperatures of 253 K, 293 K and 313 K.

The analysis of the obtained experimental results allow to draw the following conclusions. The mode of external modulation is more sensitive to change of temperature that leads to increase in dynamic transmission losses of a very high frequency signal (violation of the mode of thermostabilizing on 283 K can lead to errors). In case of transmission rate more than 5 Gbit/s the mode of direct modulation enters distortions to the transmitted very high frequency signal, and also losses sharply increase, the linear range in a response characteristic is almost absent. This fact can be explained finite lifetime of carriers of charges and photons in the active layer of the laser diode. It was set that observed distortions of the form of pulses of a very high frequency of signals in case of direct modulation are connected to chromatic dispersion of the spurious frequency shift keying arising in case of distribution of radiation on an optical fiber because of existence.

4. Conclusions

The defined features are necessary to consider when testing radar station with signals of very high frequency and small on-off time ratio. In case of small delay periods of optical signal $\tau$ optical
compensators of chromatic dispersion are necessary. In case of big $\tau$ compensating of dispersion needs to be carried out by electronic methods.

The received results allowed us to develop an algorithm of choice of an optimum operation mode of FOS taking into account features of the modes of modulation and to justify need for extension of its operation capabilities to use in its construction the transferring modules with two types of modulation.

Nowadays the range of applied frequencies tends to extend up to tens of gigahertz in the modern APAG. Therefore it is necessary to use more wide-band simulators. Our research showed that it is possible. Application of the corresponding receiving and transferring modules (it is more preferable with external modulation) is necessary for operation at frequencies up to 40 GHz that will allow to apply the universal fiber optical systems to APAG successfully.

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