Features of transmission at analog intermediate frequency signals on fiber – optical communication lines in radar station.

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Abstract. Features of transmission at analog intermediate frequency signals on fiber – optical communication lines are considered. In view of these features the technique for check of developed optical transmission systems at analog intermediate frequency signals is offered. The results of experimental investigations are presented.

1. Introduction.

On of the principle problems that are solved with the help of radiophotonics is the reliability ensuring of radar (RLS) work at different conditions of operation [1-4]. Besides that in many cases it is necessary the weight loading on the scanning antenna platform, especially in case when it is placed on flying device or at the top part of the ship mats. And one needs ensure a free access to equipment of its repair at unfavorable conditions [2, 4]. It is necessary to note also, that in case of radar placing the non – stable object the electromagnetic disturbances level in the area of the communication network location is several times greater than that observed at the ground station. The modern methods of the coaxial connections screening almost exhausted their resources from the point of view of creating new methods of protecting from electromagnetic disturbances. The additional protection is realized in the main by the increase both the number screening cover and its thickness. It leads to increase of the cable weight and volume, also to decrease its flexibility that creates difficult problems during radar operation [2, 4-7].

In the given situation the effective protection of signal, coming to the antenna complex especially the intermediate frequency signal (IF) that is the most sensitive to different disturbances appears to be rather difficult problem. As the IF $f_i$ in the given case is taken frequency $f_i$ in which the signal frequency transformed at the intermediate period of its processing in the radioelectron setup (superheterodyne receiver). Depending upon the radar exploitation condition $f_i$ represent the sum or different between the received signal frequency and that of heterodyne. As a result all signal processing is carried out at the fixed frequency that is much easier than to readjust the whole receive path in the order to find the necessary signal.

In transmission IF signal tract occurs the frequency $f_i$ offset value on random law, if there is interference in it. The automatic frequency control system (AFC) in most cases does not have time that to follow up bias $f_i$, that leads to the appearance of various errors (for example, In determining the distance to the target, the size and speed of the target, etc.).

One of its solution this task can be constructed by us fiber – optical transmission system (FOTS) of analog IF signal from the master generator to heterodyne located at the antenna past.
2. Peculiarities of analog intermediate frequency signals transmission through fiber – optical communication system.

But during the FOTS application for the IF signal transmission a number of peculiar properties appear that must be taken into account during its construction. The investigations carried out showed that they can be divided into three groups. The first group is connected with energy and frequency characteristics: amplitude frequency characteristic (AFC), amplitude characteristic, the loss coefficient at the frequency of the transmitted analog signal, etc. It is connected with the fact that the heterodyne is placed at the antenna past in the area of great number of different disturbances. That is why the signal from the optical receiver must be immediately sent to the heterodyne input. In case of a low power of the optical receiver output signal the application of the low–noise amplifier, as was shown by the experiments carried out, must be eliminated. The measurements error, for example, of the distance to the target during the received SHF signal, reflected from it, can be increased by the order and greater.

The second group is connected with the fact, that a part of FOTS is located in the area where the temperature change from 213 to 332 K is possible. The performed experiments showed that in transmitting and receiving optical modula (Dilaz company) the supply driver with the thermostabilizer doesn’t provide the necessary stability for the IF signal transmission. Therefore is necessary to search for new solutions of this problem.

The third group - is connected with high requirements which is applied to the IF signal itself. During transmission it to FOTS should not happen pulse shape distortion (even minor) compared to other analogue signals which are also transmitted in RLS by the FOTS. Especially in case of impulses with high pulsing ratio. On figure 1 the structural scheme for research of FOTS developed by us is presented.

![Figure 1. The structural scheme of IF signal transmission: 1 – laser (λ = 1550 nm); 2 - power supply; 3 – generator IF; 4 - Mach -Tsendera modulator (Oplilab company); 5 - source DC bias; 6 - bias source (+12 V); 7 – heterodyne; 8 - optical detector (Miteq); 9 – oscilloscope.](image)

The division of the transmitting laser module allowed to make for 1 and 4 more reliable stabilization circuits comparing to the previous single optical transmitting module, and also to increase the optical laser radiation power up to 12 dBm. In addition, experiments have shown that the use of the displacement mode in the optical modulator (in case of temperature shift) enabled to adjust the point of minimum attenuation of signals IF for different $f_i$ at the level of the output signal from the optical sensor up to a certain limit.

In the range of operating temperatures of the radar (RLS) from 223 to 333 K the location of the operating point in the linear portion of the modulation transfer characteristic will provide quite difficult. Therefore, to solve this task, a new scheme of operating point control was developed. On figure 2 the his structural scheme is presented. Through the optical divider (points 3 and 4) part of input and output radiation arrives at the control photodiodes. The output voltages from the photodiodes through the amplifier 6 and low frequency filter 7 are transmitted to the adder inputs 8. At its output the error signal is
formed (the operating point shift from the given value). The error signal is fed to the proportional regulator 9. Integral part of the regulator allows to take into account the history of changes output value.

**Figure 2.** The structural scheme of modulator operating point control: 1 – transmitting laser module; 2 – electro-optical modulator; 3, 4 – optical divider; 5 – photodetector; 6 – operational amplifier; 7 – low frequency filter; 8 – adder; 9 – proportional regulator; 10 – zone switch; 11 – Input of high frequency signal.

In the absence of temperature fluctuations the constant bias at the output of the switch 10 is stabilized. The integral part of the regulator 9 provides a constant bias voltage $U_b$.

**3. Results and its discussion.**

In order to determine the functional possibilities of the application in RLS the constructed FOTS were investigated following characteristics: AFC; dynamic characteristic; the loss coefficient at the frequency of the transmitted analog signal on the environment temperature $T$ change. As an example the AFR of the output signal for the different $T$ are represented in the figure 3.

**Figure 3.** AFC, charts 1, 2 and 3 corresponds to $T$ in K: 231.2; 293.1; 333.4.
The analyses of the received results shows that the developed by us device of electro-optical modulator 2 operating point and the scheme thermal stabilization of the transmitting laser module 1 allows to make insignificant the influence of temperature T change (over the whole range of the RLS operation) upon the value of optical signal power loss at it travels along the FOTS. It gives a possibility to transmit IF signals along it without loss and distortions.

As an example in the figure 4 are represented the IF signals in the from rectangular impulses transmitted to the heterodyne input from the master generator by its developed FOTS and coaxial cable.

Figure 4. The form of the pulses of the output signal: 1 – generator 3; 2 - at the exit FOTS (input oscilloscope 9); 3 - at the exit a coaxial cable.

The analyses of the received results shows that there are not distortions of the impulses from in the IF signal supplied to the heterodyne 7 input from the optical detector 9 output. It allows to use this signal for the processing of the received RLS signal, reflected from different targets. In the coaxial cable of distortions the substantially changes the IF signal impulses form, that does allow to use them in this form without additional processing in the heterodyne.

Besides it was found in results of performed experiments that for ensuring reliable work of radar (RLS) with using the FOTS in a given part of it’s the following has to be carried out:

1. Unevenness of amplitude frequency characteristic FOTS in the range of the transferred frequencies has to be less than ±3 dB.
2. Change of coefficient of losses in FOTS from the frequency of the transmitted microwave signal shouldn't exceed ± 2 dB
3. Phase deviation of modulation at distribution of a signal on FOTS from temperature in the range from 238 to 323 K shouldn't exceed 3 degrees.

4. Conclusion
The obtained results show that technical solutions offered by us allowed to make insignificant the influence of considered negative factors connected with features to transmission of signal IF on heterodyne work results. The developed FOTS can be used for various types of RLS in the entire frequency range of IF signals.

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