Development of Atmospheric-Optical Communication Equipment on Movable Bases for Industrial Applications

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Abstract

The concept of organizing a communication channel based on FSO on movable bases for industrial applications in the premises with increased density of electromagnetic interference. A model of the device based on a wide-aperture optical scheme and wave multiplexing was developed, preliminary tests were conducted at distances to 150 m. Technical solutions for communication distances to 1000 m are proposed.

Keywords: communication, industrial Internet, FSO, atmospheric-optical communication line, automated warehouse, communication between movable objects, communication in the conditions of electromagnetic interference.

Widely applied technical solutions based on the radio channel for data transmission inside premises do not provide the necessary reliability in a number of industrial operating conditions, in particular, in premises with increased density of metal structures saturated with pulsed electromagnetic interference from operating electric motors. Such premises can be industrial shops of metallurgical and metalworking industry, warehouses with moving of cargo by autoloaders, automated or partially automated. The tasks of automating such plants often require a sufficiently large amount and speed of information transfer between movable or partially movable objects, and these tasks can be solved already with the help of atmospheric-optical laser communications (FSO) systems. In particular, the solution of the communication channel between the limited movable objects can be proposed for building information exchange channels in automated systems for storing and moving goods, where the density of communication channels can reach units per meter, and the total number of thousands of pieces. However, the existing FSO systems do not provide the required reliability of the communication channel. For solutions such a problem, it requires the development of a specialized FSO. The main difference between the developed FSO from existing models on the market is the need for the system to work when the receiver and transmitter move relative to each other along the optical axis. In Fig. 1 is presented a schematic diagram of the connection of a single element of an automated warehouse system operating on the principle of vertical and horizontal movement of cargo from one storage cell to another.

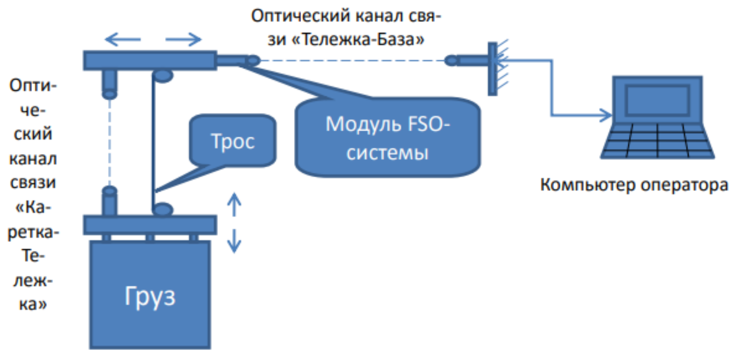

Figure 1. Scheme of communication of a single element of an automated warehouse based on FSO

One pair of transmit and receive modules of the communication system provides a link between a horizontally moving trolley with an established FSO terminal and a fixed base with a second terminal. After the trolley has reached the required shaft its movement is completely blocked and the procedure for lifting the load is started during which it is necessary to maintain the connection between the vertically moving carriage and the fixed trolley.

The peculiarity of designing FSO -systems consists in striving to concentrate the energy of optical radiation in the region of the receiver to achieve high technical and economic indicators. This circumstance imposes restrictions on the possibility of shifting the elements of the system. The movement of the trolley with optical elements leads to random oscillations of the transmitters and receivers relative to each other, in which loss of the optical signal with a communication interruption is possible. Serially produced FSO systems allow angular misalignment of the transmitter and receiver axes in units of mil. Requirements for development correspond to premises in tens of mil. Therefore, a new solution is needed that satisfies the requirements of the problem. A simple increase in the radiating angular aperture of the system leads to a sharp drop in technical and operational indicators, since a decrease in the radiation power density in the reception zone will require either an increase in the dimensions of the optical elements, or a multiple increase in the power of the radiator and the sensitivity of the receiver, which potentially can lead to a decrease in the reliability of the equipment and the communication channel in the presence of crosstalk under conditions of tight parallel installation of dozens of terminals.

The proposed solution of the communication line with movable platforms for the location of FSO terminals is based on the principles of increased angles of divergence of the transmitter and increased angles of view of the receiver of the FSO, on the principles of wave multiplexing in the transmission reception channels.

An increase in the receiver's viewing angles and the divergence of the radiation is used to compensate for random oscillations in the radiation direction and the reception angles of the terminals located on movable platforms. Terminals located on fixed bases have a narrow to 5 mil in full angle radiation pattern of the transmitter and a small angle of view of the receiver up to 5 mil. Terminals on movable platforms have a directivity pattern to 35 mil and a receiver's view angle of up to 2-4 degrees.

In Fig. 2 shows the optical scheme of an optical unit with spectrally separating paths for receiving radiation transmission.

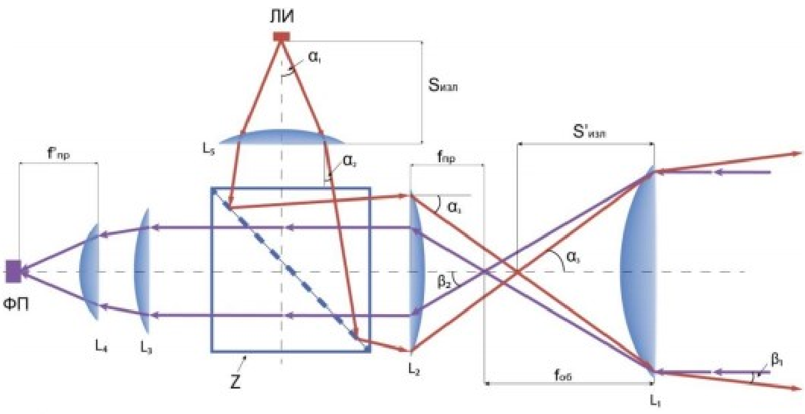

Figure 2. Optical circuit of the FSO terminal with increased angles of divergence and reception of radiation for placement on movable bases

Multiplexing over wavelengths avoids the exposure of the receiver to the reflected radiation of the transmitter from the receiving terminal at close distances of less than 50 m.

Neighboring terminals located on a fixed base have different wavelengths for transmitting and receiving radiation in order to avoid the effect of illumination of the receivers from the terminal transmitters located in the nearest parallel row on the movable platform.

The asymmetry of the divergence angles of the transmitters, as well as of the receiver's viewing angles in movable and fixed devices allows to avoid crosstalk from the nearest parallel lines of the AOLS.

The applied technical solution allows, if necessary, to increase the transmission speed to 100 Mb/s.

Tests of prototype devices on the layout of the automated warehouse showed the possibility of using this technical solution of the FSO terminal for displacement lengths up to 150 m. In view of the uneven illumination field in the receiving area, according to the calculated data for this particular system, distances over 150 m are critical, since the energy reserve for reliable operation at large, above 10 mil, deviation angles of the platform is not sufficient.

A competitive variant to the first solution is a variant with optimization of the optical scheme of the system and the use of elements of self-tuning of the radiation pattern along the corners. The use of auto-adjustment elements at the corners allows to keep the directional pattern, and accordingly the continuity of communication at standard radiation powers of 20-50 W at angles of divergence of the radiator of no more than 3-5 mil at communication distances to 1000 m.

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