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Optical communication channel for multifunctional ecological monitoring complex

S. A. Rodin [1]✉, V. V. Davydov [2], B. K. Reznikov [1],
D. I. Isaenko [1], D. V. Vakorina [1]

[1] Bonch-Bruevich Saint Petersburg State University of Telecommunications, St. Petersburg , Russia;
[2] Peter the Great St. Petersburg Polytechnic University, St. Petersburg , Russia
✉ psnp.174.sut@gmail.com

Abstract. The necessity of transmitting information from a multifunctional complex for environmental monitoring located on a high-voltage power line via a fiber-optic communication line is substantiated. The features of the transmission of this information are noted. A fiber-optic communication line has been developed to transmit information over distances up to 200 km without the use of optical amplifiers. The research results of its main characteristics are presented. The prospects for further use of this type of FOCL are determined.

Keywords: environmental monitoring, information transmission, electromagnetic environmental, optical communication line, losses, time separation of information, dispersion

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Оптический канал связи для многофункционального комплекса экологического мониторинга

С. А. Родин [1]✉, В. В. Давыдов [2], Б. К. Резников [1],
Д. И. Исаенко [1], Д. В. Вакорина [1]

[1] Санкт-Петербургский государственный университет телекоммуникаций им. проф. М.А. Бонч-Бруевича, Санкт-Петербург, Россия;
[2] Санкт-Петербургский политехнический университет Петра Великого, Санкт-Петербург, Россия
✉ psnp.174.sut@gmail.com

Аннотация. Обоснована необходимость передачи информации от многофункционального комплекса для экологического мониторинга, размещенного на высоковольтной линии электропередачи по волоконно-оптической линии связи. Отмечены особенности передачи данной информации. Разработана волоконно-оптической линии связи для передачи информации на расстояния до 200 км без использования оптических усилителей. Представлены результаты исследования ее основных характеристик. Определены перспективы дальнейшего использования данного типа ВОЛС.

Ключевые слова: экологический мониторинг, передача информации, электромагнитный фон, оптическая линия связи, потери, временное разделение каналов, дисперсия

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Introduction

The deterioration of ecology and emergence of different negative factors for various reasons led to a decrease in the quality of the air environment [1–2], that affects the person health [2–3]. Especially in areas that are at distances of 200 km or less from industrial areas [2–5]. With strong wind currents, various contaminants are carried in the air [3–4], which then fall out in the form of precipitation, etc. Therefore, the state of the environment must be monitored continuously. This also allows new sources of pollution to be identified.

To implement measures to control the environment state, a large number of different devices (nuclear-magnetic, optical, etc.) have been developed [5]. All of them are designed to determine a certain type of pollution. Taking into account the fact that now pollution is complex in composition and type, the spread of such control is clearly not enough. Therefore, various environmental measuring systems are used, which should operate in a continuous mode. In areas where there are sources of electrical energy, there are no problems with the placement of environmental measuring complexes. Difficulties arise in remote areas from settlements. In these cases, we propose to place an environmental measuring complex in the upper part of a high-voltage power transmission line (TL). Information about the state of the environment can be transmitted via a communication system that is attached to the neutral cable. Taking into account the large number of electromagnetic interferences in the signal transmission zone and large distances, it is most expedient in this case to use a fiber-optic communication line (FOCL). Optical fiber does not respond to various electromagnetic interferences.

In our work, one of the possible variants of this measuring complex for environmental monitoring with a unidirectional fiber-optic communication line for information transmission is presented. The task to be solved also included the requirements related to the fact that the design of the FOCL was low-budget, since an optical channel with a single-mode fiber is allocated for the transmission of each measured parameter of the state of the environment.

Multifunctional ecological monitoring complex design

Fig. 1 shows a diagram of a multifunctional environmental monitoring complex with an optical communication channel. The scheme includes power supply, sensors, transceiver, microcontroller.

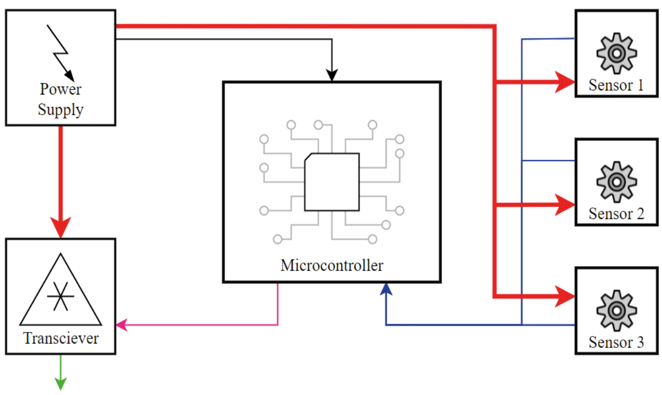

Fig. 1. Scheme of the environmental monitoring complex

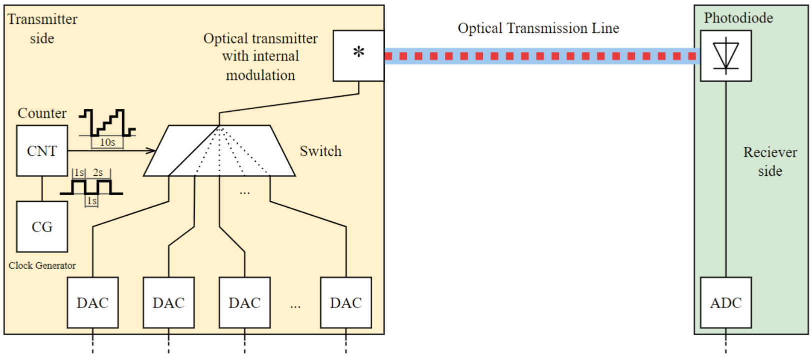

Fig. 2. Structural diagram of a fiber-optic transmission system

It assumes the use of a low-power DC power supply powered by a 220 V (50 Hz) mains. However, when the monitoring complex is placed in close proximity to power transmission towers or on the towers themselves, it is possible to organize power supplies from a strong electromagnetic field. In this case, an inductor and a voltage equalizing circuit are used up to the required 5 V for operation. In this case, the parameters of the inductor are determined individually, depending on the power of the electromagnetic field and the power consumption of sensors used.

Optical channel of communication

In the environmental monitoring complex, an important component is a fiber-optic communication channel. This is necessary if the multifunctional complex is located on high-voltage power lines, in which case there will be no problems with electrical energy. The block diagram of the fiber-optic communication channel is shown in Fig. 2.

A one-way fiber-optic communication system is used to transmit information. The amount of transmitted information is not large (only values from environmental parameters). Therefore, it is more expedient to use direct modulation in a transmitting optical module with a wavelength of $\lambda = 1550$ nm.

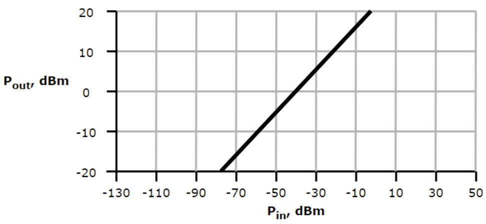

Fig. 3. Dynamic range of the optical communication channel

A feature of the developed optical communication channel is the temporal division of the transmitted information about the state of the environment over one single-mode fiber. This allows, on the one hand, to optimize the design of the FOCL for information transmission. On the other hand, to provide a higher stability of the optical communication channel from various factors. For this, a clock generator is used. The signal from this generator is fed to the counter, which alternately closes and opens the electronic keys. Through these switches, the input of the transmitting laser module receives an analog signal from the measuring sensors, which modulates the laser radiation in amplitude.

A standard single-mode G.652 fiber is used to transmit information. Optical isolators when transmitting information in one direction are not advisable to use.

Experiments

To determine the functionality of developed optical channel were calculated to most important parameters such as system speed and energy balance.

The results of the experiments and calculations show that system speed is only 11.72 ns which is fully associated with the specified requirements. Also, as a result of calculations, a positive value of the energy balance which is 6.7 dB was obtained, therefore, the balance is observed.

The modulated optical signal is recorded by a photodiode, which converts the received optical signal into an electrical voltage. This signal is then sent to an analog-to-digital converter. The most important characteristic in this case is the dynamic range of the developed optical communication channel. The results of measuring the dynamic range are presented in Fig. 3.

Analysis of the obtained results shows that the dynamic range is more than 40 dBm, which is sufficient for stable information transmission. This shows a possibility of transmitting the necessary information over distances up to 250 km with high stability.

Conclusions

The obtained results show the reliability of the developed optical information transmission channel. The information is stably transmitted in a complex electromagnetic environment over distances up to 250 km.

It should be noted that the developed optical communication channel is universal. It can be expanded to transmit information from up to 32 sensors and measurement systems in real time. In this case, only one single-mode fiber is used for information.

Unlike other structures of this type, the developed optical communication channel for analog signals has low power consumption and low cost.

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THE AUTHORS

RODIN Sergei
psnp.174.sut@gmail.com
ORCID: 0000-0001-7722-3323

DAVYDOV Vadim
davydov_vadim66@mail.ru
ORCID: 0000-0001-9530-4805

REZNIKOV Bogdan
rznkff@gmail.com

ISAENKO Dmitry
isaenko-d@mail.ru

VAKORINA Daria
vakorina.dv@mail.ru

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