Features of the construction of fiber-optic communication lines with code division multiplexing

N I Popovskiy¹, V V Davydov²,³, L R Valiullin⁴
¹The Bonch-Bruevich Saint-Petersburg State University of Telecommunication, Saint Petersburg 193232, Russia
²Peter the Great Saint Petersburg Polytechnic University, Saint Petersburg 195251, Russia
³All-Russian Research Institute of Phytopathology, Moscow Region 143050, Russia
⁴Federal Center for Toxicological, Radiation and Biological Safety, Kazan, 420075, Russia

Abstract. The necessity of research of the fiber-optic communication lines with code division multiplexing is justified. The structural diagrams of transmitters and signal receivers of fiber-optic communication lines with code division multiplexing is presented. The features its design are established. The investigation results are presented.

1. Introduction
The development of modern technologies, communication systems and navigation are demanding the using of the high-speed information transfer systems [1-7]. The optic fibers are used in most airborne communication systems, radar stations, satellite navigation systems for transmitting information and control signals [1, 4, 8-21]. The signals are transmitted, both within the station, for example, radar, and over long distances [19-29]. To ensure the latter, the various information processing methods are used [7, 12-17, 20, 21, 30-36]. Large amounts of information must be transmitted at high speed. For this, standard optical communication systems are used [34-37]. In FOCL for the provision of the high-speed information transfer, the various access methods are used. The application of these methods allows the multiple users together to use the common passband of the optic fiber.

There are three main methods of multiple access: the user is allocated a specific time interval in time division multiple access (TDMA) or a specific frequency (wavelength) slot in a wavelength division multiple access (WDMA) system. Both methods have been widely studied and are currently used in optical communication systems. An alternative method is optical code division multiple access (OCDMA), which is currently gaining ground as it improves information security, simplifies network management, improves spectral efficiency, and increases flexibility in bandwidth allocation [37].

On the other hand, when using this method when constructing the fiber optic design, a number of features arise that must be taken into account when transmitting information in communication channels.

2. The method of phase difference influence estimates between channels at peleng accuracy
The method with code division multiplexing has a number of features that will affect the design of the fiber optic link. Therefore, in our work it is necessary to consider some of them. In OCDMA, different users share a common communication environment in which signals from different transmitters can overlap in both time and frequency. Multiple access is achieved by assigning different code sequences to different transmitters, which are subsequently detected at the receiver in the presence of multiple interference from other users [37, 38].

Statistical distribution of the network bandwidth: any specific OCDMA receiver considers the other users' signals as noise. This means that you can continue to add channels as long as the signal to noise
ratio (SNR) is still low enough to the number of bit error at a constant level. Can customize the number of active connections for each connection so that the overall data traffic is less than the bandwidth of the channel [7, 37]. For example, if several hundred channels of sound were sent using OCDMA, and the average energy was the channel limit, many voice communications could be controlled more than using TDMA or WDMA methods.

In OCDMA, there is another feature associated with a high frequency optical carrier. For this reason, at a high data transfer rate, for example, of several Gbit/s per user, the limit of electronic information processing can be reached [38].

Spectral-amplitude coding (SAC) improves the practical application of OCDMA by reducing the impact of MUI [39, 40]. Due to the support of concurrent communications, SAC is working to simplify the complexity of the system by liberalizing time recovery requirements. The visual spectrum is encoded by code sequences at a fixed mutual value. Merge the code feature with the supplemental subtraction algorithm form the MUI Elimination System known as balanced detection [41]. In the future, multi-transmission encrypted signals, including Target and intersect users, are linked to the local code. Can interpret the bits data "1" of the target user as the peak of the interdependence of self between the code local code target. Correlation values between local codes and overlap codes are deleted through balanced detection.

Since the problem of MUI cancellation has been investigated in detail regarding the CDMA, these plans have also been incorporated into the OCDMA networks [42]. Due to the non-negative of the optical intensity, it is proposed to eliminate the modified parallel interference cancellation (PIC) to fit this latent feature of the optical signals [43]. Compared to the disclosure of the deceased present, the yield of such studies for better performance to some extent, but some bottlenecks still require further investigation - for example, the number of users is limited, and ineffective in improving performance, schedule delays resulting from the processing of electrical signals.

In this paper, we achieve device independence organization intelligently suppress noise, as well as transmission high-speed. Use the structure of the proposed network array waveguide array (AWG), a key optical detectors available to build the scheme ease of trading known as cancellation of trading recursive (RIC). There are several stages in RIC, each assessing overlap and regeneration.

Compared to SIC and PIC, the proposed reception scheme has many advantages. First, instead of MUI, we investigate the noise suppression function, which is rarely investigated in the current intersect elimination schemes before. Second, most noise suppression methods in OCDMA are used to reduce the rate of error in bits (BER), while investigating high-speed transmission applications. Third, rather than ordering multiple decoder devices in PIC or SIC, the proposed RIC reduces the complexity of the system, using a single structure to identify all intersect users [44]. Finally, since the abolition of the MUI is in the visual field, the RIC has the ability to solve the latency signal processing in electrical components.

To prove that RIC has the ability to navigate in the scenario of the operational direction, shows the topology of the PON based on OCDMA communication sources [45]. Supports put operations to send various multimedia, such as images, video and audio via the Access Network optical broadband. At the optical line terminal (OLT), receiving electrical data are first transmitted to the optical pulses and then encoded by an OCDMA transmitter. Is broadcasting the signal OCDMA built-in to many modules optical network (ONUs) by dividing its power among all users. In ONU, the future of OCDMA takes the reverse processes to decode and remove the receiving light signals.

The main purpose is to determine the improvement rate of the bit-rate in the system to take advantage of noise suppression. When the capacitor compares the photovoltaic with the mid-range threshold, there may be an error due to signal variation. To calculate the error rate in bits (BER), we use the mathematical expressions for the average and variance of the output signal in the detector balanced. We point out that the signal means the photovoltaic current and the signal change as a combination of thermal noise and PIN. Given that the number of active users in the OCDMA network is large enough, noise requirements are close to diving distribution. The rate of error in bits (BER) is assessed by calculating the noise signal ratio (SNR) and using the complementary error function.
The fundamental difference between the future of the unity phase and the proposed multi-stage future is the number of overlapping signals received. Ideally, the traditional balanced detector receives $K-1$ overlaps and a single target signal, while the proposed scheme receives only one target [46]. However, in practical decoding, revealing noise leads to a misjudgment of "1s" as "0s".

The relationship between BER and the stage number $S$ with $K = 20$ is presented in Figure 1. The results are indicated that BER lowers as $S$ increases for the same data bit-rate $R_b$. Thus, RIC with a larger $S$ benefits from greater BER performance at the expense of executing additional procedures of interference user elimination. In addition, RIC with a smaller $R_b$ reveals a better performance when $S$ is fixed, as less noise power is allocated in the receiver bandwidth.

![Figure 1. The bit-error rate (BER) versus the stage number of RIC.](image)

Such a design of channels makes it possible to reduce the influence of interference noise, the intensity of which increases with increasing number of channels, on optical signals that carry information.

3. Conclusion

The obtained experimental results showed that the most appropriate direction of research for solving this problem is the development of new orthogonal optical code sequences. Their use will reduce the influence of interference arising from the transmission of signals at the time of separation between different users.

References

[1] Petrov A A, Davydov V V and Myazin N S 2017 Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 10531 LNCS 561-568

[2] Davydov R, Antonov V and Moroz A 2019 Proceedings of the 2019 IEEE International Conference on Electrical Engineering and Photonics, EExPolytech 2019 (Saint-Petersburg) 8906791 p. 42-45

[3] Davydov R V, Antonov V I, Yushkova V V, Grebenikova N M and Dudkin V I 2019 Journal of Physics: Conference Series 1236(1) 012079
[4] Davydov R, Antonov V, Makeev S, Batov Y, Dudkin V and Myazin N 2019 *E3S Web Conference* 140 02001

[5] Yushkova V, Kostin G, Davydov R, Rud S, Dudkin V and Valiullin L 2019 *IOP Conference Series: Earth and Environmental Science* 390(1) 012016

[6] Davydov V V 2016 *Optics and Spectroscopy (English translation of Optika i Spektroskopiya)* 121(1) 18-24

[7] Ermolaev A N, Krishpents G P and Vysoczkiy M G 2016 Journal of Physics: Conference Series 741(1) 012171

[8] Davydov V V, Dudkin V I and Myazin N S 2016 *Journal of Communications Technology and Electronics* 61(10) 1159-1165

[9] Petrov A A and Davydov V V 2015 *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 9247 739-744

[10] Petrov A A, Davydov V V, Vologdin V A and Zalyotov D V 2015 *Journal of Physics: Conference Series* 643(1) 012087

[11] Grebenikova N M, Myazin N S, Rud S, Dudkin V and Valiullin L 2018 *Journal of Physics: Conference Series* 10531 LNCS 177-183

[12] Shcherbakov A S, Ivanov O G and Andreeva E I 1993 *Proceedings of SPIE - The International Society for Optical Engineering* 1806 p. 44-53

[13] Shcherbakov A S and Andreeva E I 1994 *Proceedings of SPIE - The International Society for Optical Engineering* 2429 p. 227-234

[14] Shcherbakov A S, Andreeva E I and Tarasov I S 1996 *Proceedings of SPIE - The International Society for Optical Engineering* 2800 p. 333-340

[15] Shcherbakov A S and Andreeva E I 1996 *Optical Fiber Technology* 2(2) 127-133

[16] Shcherbakov A S, Andreeva E I, Lyutetskii A B, Pikhtin N A and Leshko A Yu 1996 *Technical Physics Letters* 22(5) 344-346

[17] Shcherbakov A S and Andreeva E I 1996 *Technical Physics Letters* 22(6) 464-466

[18] Lenets V A, Tarasenko M Yu, Davydov V V, Rodugina N S and Moroz A V 2018 *Journal of Physics: Conference Series* 1038(1) 012037

[19] Davydov R V, Saveliev I V, Lenets V A, Tarasenko M Yu and Yalunina T R 2017 *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 10531 LNCS 177-183

[20] Podstrigaev A S, Lukyanov A S, Smolyakov A S, Glinushkin A P and Sinicyna E A 2019 *Journal of Physics: Conference Series* 1410(1) 012155

[21] Sinicyna E A, Galichina A A, Lukyanov A S and Podstrigaev A S 2019 *Journal of Physics: Conference Series* 1236(1) 012075

[22] Filatov D L, Galichina A A, Vysoczky M G, Yalunina T R, Davydov V V and Rud' V Yu 2017 *Journal of Physics: Conference Series* 917(8) 082005

[23] Davydov V V, Sharova N V, Fedorova E V, Vologdin V A, Karseev A Yu 2015 *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* 9247 712-721

[24] Kuz'min S V 2004 *Technical Physics Letters* 30(11) 947-949

[25] Shannikov D V, Surikov V V and Kuz'min S V 2005 *Technical Physics* 50(11) 1531-1534

[26] Shannikov D V and Kuz'min S V 2003 *Technical Physics Letters* 29(11) 941-943

[27] Al-odhari A H A, Fokin G and Kireev A 2018 *Proceedings of the Systems of Signals Generating and Processing in the Field of on Board Communications* (Mosecow) p. 1-5

[28] Fokin G 2018 *Proceedings of the 2018 IEEE International Black Sea Conference on Communications and Networking* (BlackSeaCom-2018) Batumi, p. 1-5

[29] Fokin G, Kireev A and Al-odhari A H A 2018 *Proceedings of the 2018 Systems of Signals Generating and Processing in the Field of on Board Communications* (Moscow) p. 1-5

[30] Semenov V V, Nikiforov N F, Ermak S V and Davydov V V 1991 *Soviet Journal of Communications Technology and Electronics* 36 59 – 63
[31] Logunov S E, Koshkin A Yu and Petrov A A 2016 *Journal of Physics: Conference Series* **741**(1) 012092

[32] Logunov S E, Rud V Yu, Davydov R V, Moroz A V and Smirnov K J 2019 *Journal of Physics: Conference Series* **1326**(1) 012024

[33] Valov A P, Davydov R V, Rud V Yu and Grevtseva A S 2019 *Journal of Physics: Conference Series* **1326**(1) 012040

[34] Lukashev N A, Davydov R V, Glinushkin A P and Rud’ V Yu 2019 *Journal of Physics: Conference Series* **1326**(1) 012046

[35] Logunov S E, Davydov R V, Vysotsky M G, Dudkin V I and Rud’ V Yu 2019 *Journal of Physics: Conference Series* **1368**(1) 022056

[36] Davydov V V, Dudkin V I, Petrov A A and Myazin N S 2016 *Technical Physics Letters* **42**(7) 692-696

[37] Shiraz H G and Karbassian M M 2012 *Optical CDMA Networks Principles, Analysis and Applications* (Chichester: John Wiley & Sons Ltd.)

[38] Kitayama K I 2014 *Optical code division multiple access: a practical perspective* (New York: Cambridge University Press)

[39] Nisar K S 2017 *Optik* **130** 619–632

[40] Yeh B C 2017 *Optik* **130** 633–643

[41] Alhassan A M, Badruddin N, Saad N M and Aljunid S A 2012 *Proceedings of the 4th International Conference on Intelligent and Advanced Systems (ICIAS 2012)*, Kuala Lumpur, Malaysia, p. 237–240.

[42] Seleem H, Bentrcia A and Fathallah H 2014 *IET Commun.* **8** 626–638

[43] Seleem H, Bentrcia A and Fathallah H 2012 *IEEE Commun. Lett.* **16** 1721–1724

[44] Cherifi A, Jellali N, Najjar M, Aljunid S A and Bouazza B S 2019 *Opt. Laser Technol.* **109** 233–240

[45] Shalaby H M H 2013 *J. Lightw. Technol.* **31** 1856–1866

[46] Hussein G A, El-Atty S M A, Oraby O A, Mohamed E N A, Elkorany A S, Eldokany I, Dessouky M I, El-Rabaie E M, Alshebeili S A and AbdEl-Samie F E 2014 *Optik* **125** 2995–3000