Single Mode Optical Fibre Pattern for Signal Processing

Kalin Dimitrov[1] and Lidia Jordanova[2]
[1]Kalin Dimitrov is with the Faculty of Telecommunications at Technical University of Sofia
8 Kl. Ohridski Blvd, Sofia 1000
Bulgaria
kld@tu-sofia.bg
[2]Lidia Jordanova is with the Faculty of Telecommunications at Technical University of Sofia
8 Kl. Ohridski Blvd, Sofia 1000
Bulgaria
jordanova@tu-sofia.bg

ABSTRACT: *In the single mode optical fibre system, the digital signal transmissions have some problems. To offset them we have developed dependencies adapted for online application. We have identified the issues and benefits of the client-server architecture design for optical communication lines. For smaller level systems the developed application has potential to get used.*

Keywords: Fiber Optics, Nonlinear Efects, Distance Learning

Received: 6 June 2022, Revised 11 August 2022, Accepted 13 August 2022

DOI: 10.6025/dspaial/2022/1/4/142-145

1. Introduction

An optical fiber communication system aims at transmitting the maximum number of bits per second over the maximum possible distance with the fewest errors. Among the major transmission media for long distance communication, we can consider single mode optical fibers, which have very few losses and wide-bandwidth. System performance is essentially affected by fiber attenuation, dispersions and nonlinearities.

It is very difficult to evaluate the performance of optical fiber communication systems by applying only analytical techniques. It is important to use computer aided techniques in such cases, in order to study the performance of these systems [1].

Many of the programs require essential calculating power, whose installation for the users is not always justified. Another problem is the necessity to issue new program versions or correct old ones, which is due to the development of calculation algorithms.

Nowadays, the programs which are adapted for distance application and use client-server technology are becoming more and more important. The application of such programs is a step forward towards the wider introduction of the so-called cloud technologies [2]. Generally, this gives one the opportunity to use software applications provided in the form of web services, while at the same time one basically counts on the access to the hardware and system resources of the data centers offering these services.

In the contemporary optical communication systems, the technology wavelength-division multiplex (WDM) is used more and more often. This technology makes it possible to increase the transport capacity by using multiple wavelengths. Considering the constant boosting of information flows, this technology will tend to be used more often in the future. Not only will it be applied for long haul but also for metro and shorter lines.

In WDM systems, the greatest challenge is to achieve simultaneously smaller channel separation as well as higher bit rates of the optical carrier with the aim to increase transmission capacity. At a certain point these goals become contradictory, because of dispersion and nonlinear effects in the single mode optical fiber [3-5].

Of course, for such lines it is necessary to train many people for design and exploitation [6-8].

2. Limitations

2.1. Attenuation

Modern optical fibers have low attenuation coefficients (about 0.2 dB/km) but if the optical signals are carried at a long distance, they must be amplified at every 80 to 120 km. Erbium-doped fiber amplifier are used very often. When the power of the transmitted signal turns out to be higher than a predefined threshold level, some nonlinear effects can appear in the optical fiber thus causing noise and distortion.

2.2. Dispersion

Chromatic dispersion and polarization mode dispersion (PMD) are the two main sources of dispersion in the singlemode optical fibers. The first one is due to frequency dependence of the fiber refractive index. The spectral components of the transmitted pulse travel at different velocities and arrive at the fiber end at different times, thus causing some pulse broadening. PMD takes place when the fiber core is not perfectly circular, which causes the two polarizations of light to travel at different velocity. The different arrival times of the two polarizations will cause the pulse to broaden in a similar way as the chromatic dispersion.

2.3. Nonlinear effects

There are two types of nonlinear effects in the optical fibers: scattering effects and Kerr effects. Stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS) are associated with the first type. They are due to non-elastic interaction between a pump wave and the fiber core. Kerr effects occur because of the dependence of the refractive index on the power density inside the fiber core. Three types of Kerr effects are considered to be important for modern optical communications: four-wave mixing (FWM), selfphase modulation (SPM) and cross-phase modulation (XPM).

3. Online Calculations

3.1. Choice of Platform and Implementation

In this section we have considered the open-source clientserver option. We use Apache, PHP and MySQL. The advantages in comparison with Matlab®, for example, are that it is not necessary to pay license fees, and the fact that they are relatively widespread (because they are used for the distribution of classic web pages). The application of these environments makes possible the relatively easy integration of the results in open systems for e-learning such as Moodle. The main disadvantage is that to date there are relatively few specialized papers on simulations suitable for training or calculations in telecommunications.

Considering the above-mentioned facts, we have created a PHP script to calculate the restrictions and suitable web pages for data input and output (figure 1).

3.2 Example Calculation

In t.he numerical tests we have used the data for the current single mode fibers of the company Corning - SMF 28, SMF 28e and SMF 28?+. We have used formulas from our previous papers [5, 9, 10].

Some of the results for SMF 28e+ are:

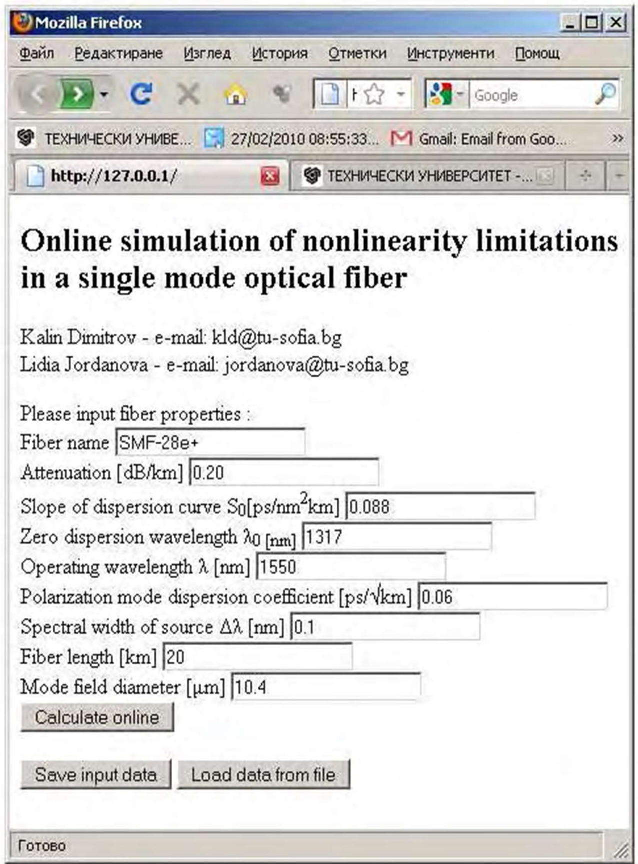

Figure 1. Page view with the input data for SMF 28e+, Corning® fiber

- Pulse spread due to chr. dispersion Δt_{ch} = 37.99ps;

- Pulse spread due to PMD Δt_{PMD} = 0.9ps;

- Maximum NRZ bit rate limited by dispersion BR = 9.09Gbps;

- Effective area $A_{eff} = 84.95 um^2$;

- Effective length of fiber L_{eff} = 13.07km;

- Stimulated Billouin Scattering power threshold P_{th} (SBS) = 4.36dBm;

- Stimulated Raman Scattering power threshold P_{th} (SRS) = 0.17dBm;

- Nonlinear propagation threshold $\gamma = 1.53e-3$, .

4. Conclusion

We have developed an open source environment for calculation of the restrictions resulting from nonlinearities and dispersion effects in single-mode optical fibers. This paper is suitable for integration into e-learning systems. It is also adequate for general use and upgrading while complying with the main principles of open source.

Acknowledgement

The research described in this paper is supported by the Bulgarian National Science Fund under contract No ДДВУ 02/74/2010.

References

[1] Binh, L.N. Optical fiber communication systems. *Theory and Practice with Matlab and Simulink Models. CRC Press: Boca Raton*, USA (2010).

[2] Angeli, D. & Masala, E. (2012) A cost-effective cloud computing framework for accelerating multimedia communication simulations. *Journal of Parallel and Distributed Computing*, 72, 1373–1385 [DOI: 10.1016/j.jpdc.2012.06.005].

[3] Agrawal, P. (2001). Nonlinear Fiber Optics. Academic Press: Cambridge, USA.

[4] Tahar, J.B.H. (2007) Theoretical and simulation approaches for studying compensation strategies of nonlinear effects digital Lightwave links using DWDM technology. *Journal of Computer Science. Science Publications,* 3, 887–893 [DOI: 10.3844/jcssp.2007.887.893].

[5] Jordanova, L., Dobrev, D. (2007). *Fiber Nonlinearity Limitations in WDM CATV Systems*, ICEST Conference. Ohrid, Macedonia, pp. 279–282.

[6] Zhang, Q. (2007). *GUI based computer modeling and design platform to promote interactive learning in fiberoptic communications, Conference on Frontiers in Education* – FECS, 19 (Supplement 3H), S3H–S14.

[7] Saeid Al-Bazzaz, S.H. (2008) Simulation of single mode fiber optics and optical communication components using VC++, IJCSNS. *International Journal of Computer Science and Network Security*, 8, 300–308.

[8] Saeid, S.H. (2012) Computer simulation and performance evaluation of single mode fiber optics. *In: Proceedings of the World Congress on Engineering*, pp. 1007–1012.

[9] Jordanova, L., Dobrev, D. (2004). *Influence of Dispersion and Non-linear Effects in Optical Fiber on the Parameters of CATV System*, ICEST Conference. Bitola, Macedonia, pp. 199–202.

[10] Jordanova, L., Dobrev, D. (2008). *Fiber Nonlinearity Limitations in WDM CATV Systems, ICEST Conference*, Vol. 1. Nis, pp. 16–19.