- **International Conference. August 20, 2020. San Francisco, California, USA SCIENTIFIC ENQUIRY IN THE CONTEMPORARY WORLD: THEORETICAL BASICS AND INNOVATIVE APPROACH 15th edition**

http://doi.org/10.15350/L_26/15

THE PROBABILITY OF BIT ERRORS (BER) AND THE MODE OF NOISE DIVISION OF THE TRANSMISSION LASER MODES IN DIGITAL-FIBER-OPTIC TRANSMISSION SYSTEMS

Revaz Svanidze [1]
Nana Rostiashvili[2]
Jumber Chincharauli[3]

[1]Doctor of Technical Sciences. Full professor. Georgian Technical University, Georgia
[2]PhD student. Georgian Technical University, Georgia
[3]PhD student. Georgian Technical University, Georgia

http://doi.org/10.15350/L_26/15.10

Abstract.

This paper presents the impact of the transmission mode of the digital fiber-optic transmission system - the noise mode of laser modes on the probability of the probability of bit errors (BER). It is established that the noise of split mode has a significant impact on BER. A power fine is used to estimate it, which itself determines the coefficient of division of modes. The graphs of the dependence of the power on the fashion segment of the power fine as well as the dependence of the quality factor of the connection $Q = \Psi(BER)$ factor on the fashionable segment coefficient are constructed. The value of the BER coefficient is estimated.

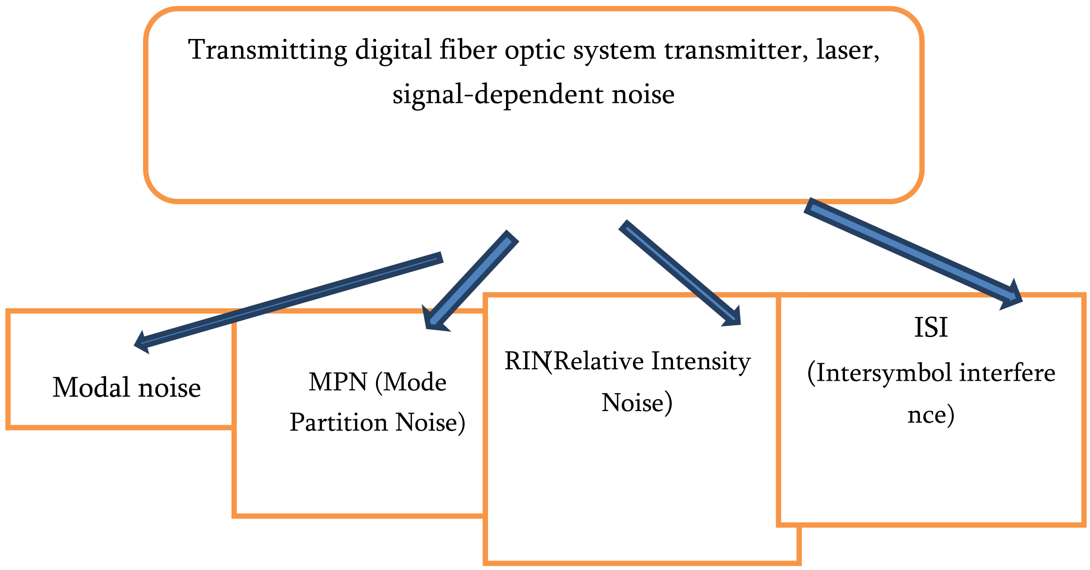
Keywords: BER- bit error rate. MPN - Mode Partition Noise RIN - Relitive Intensaity Noise, ISI- Intersymbol Interferene, Q- factor.

As mentioned in / 1 / transmission, some types of distortions in digital fiber-optic systems can have a significant impact on the transmission of useful signal. Such violations lead to deterioration in the number of parameters of the system and overall productivity, in particular, as a result of the increase in the probability of errors according to bits and a fine in terms of capacity. In optical transmission systems, these disturbances can be divided into four main groups: thermal noise, scattering noise, signal-dependent noise, which is divided into: MPN (Mode Partition Noise), RIN (Relitive Intensaity Noise) and ISI- Intersymbol Interferene)

See Figure. 1.

http://doi.org/10.15350/L_26/15

.



Consider the mode of noise division of modes of transmission in digital fiber optic systems and its impact on the probability of bit errors and the penalties caused by this mode. In general, the probability of bit errors significantly worsens if the optical system has an abnormal mileage coefficient. It should be noted that if the threshold in the receiver's decisive device is selected incorrectly, in order to maintain a constant value of BER, it is necessary to increase the power at the input of the receiving device. This means that BER permanence requires a fine. Optimization of the threshold level of the receiving device was presented in the paper / 2 /. In semiconductor lasers, the intensity of each longitudinal fashion varies by random law, even when the power output of the laser output is constant. These oscillations take place both inside the impulse and from impulse to impulse. Even when the lateral transverse modes are not sufficiently suppressed, the changes occur as a result of internal fluctuations caused by the operation of the laser by the impact of the connecting fibers and the reflected beams reflected from the ends of the connectors / 3 /.

Along the dispersion fiber, each longitudinal mode moves at a different speed and the receiver reaches a different point in time. When recording the digital signal in the receiver's decisive device, the optimal time for strobulation of impulses changes; Accordingly, the origin of the temporal jitter occurs, these issues have been investigated / 3,4 /.

The combination of intensity fluctuations between longitudinal modes and the delay of these modes caused by optical fiber dispersion leads to the reduction in the probability coefficient of bit errors. The combination of intensity fluctuations between the longitudinal modes and the delay in each fashion time caused by the dispersion of the optical fiber leads to deterioration in the probability of bit errors in the transmission of digital fiber optic systems.

The ratio of the signal / noise, which is due to the noise distribution of the modes, does not depend on the signal strength, since this event is a consequence of the physical process taking place in the laser of some constructions. The noise capacity is proportional to the signal strength and the intensity distribution of the transverse modes. The noise separation of the modes leads to a lower achievement of the bit rate error for the system; Therefore, if the power supplied to the optical fiber is increased, the bit error rate cannot be improved upon. For higher bit rate speeds, the transition processes in the lateral modes occupy a large part of the transmitted pulses, while increasing the number of injectable electrons causes a significant increase in lateral modes in the initial transition process. If we assume that the total output power of the laser is constant, and the probability of splitting the modes is subject to the Gaussian law of interval in the spectrum time, we can say that the ratio signal / noise due to splitting modes is rated as / 5 /:

http://doi.org/10.15350/L_26/15

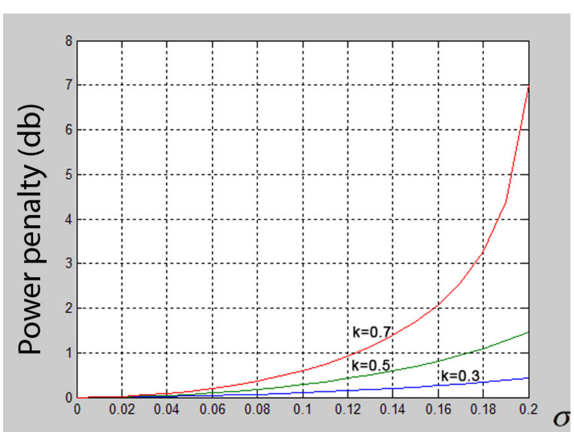
$$SNR = \frac{1}{\sigma_{pc}^{2}}; \quad (1)$$

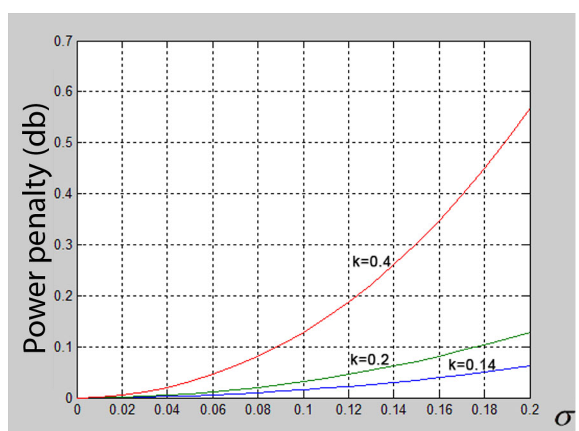
SNR-ratio signal / noise, conditioned by split mode noise σ^{2}_{pc} noise separation noise, noise capacity due to separation of noise mode. And, the power of fine modes for split noise $\sigma_{pc}{}^{2}$ due to it is defined by the formula / 3 /:

$$P_{mod\ pen} = -5log\left(1 - Q^{2}\sigma_{pc}k^{2}\right); \quad (2)$$

Where, - the Q - factor is related to the probability of bit errors (BER) approaching Gauss. For example, when BER = 10-9, Q = 6. The mode divider coefficient K indicates the characteristic of the mode of mode separation in the laser diode. For large K-months the split mode is high. This coefficient is measurable and there are simple methods for measuring it. Under different operating conditions K varies for multidimensional optical fibers in the range K = 0,14-0,7. When K increases with the amplitude of the transmitted impulse, i.e. at the low speed of the transmission, the noise of the division of the modes decreases. In single-mode optical systems, K = 0.4-0.7, if single-mode long-range lasers are used, with a narrow width of the spectrum emitted in optical systems, the noise-sharing noise is considered to be the dominant limiter. According to the transmission fiber-optic system's dampe/dispersion and hierarchical level (STM-1… STM-256), transmitters are used as transmitters, lasers that emit multiple transverse waves and lasers that emit one transverse wave. Generally, a nominal type of transmission source is selected for each hierarchical system.

However, it is not necessary for any hierarchy to determine the source of any transmission. For example, a single-source transverse source can be used for any hierarchical system in which a laser or multi-wave transverse laser is used as a nominal source, and a multi-channel transverse source can be used for any hierarchical system in which the LED is used as a nominal source without compromising the operation of the system. Figures 2.1a, b show the dependence of the fine power on the noise of the modes segment, for the different values of the coefficient of the modes segment (k): a) k = 0.3; 0.5; 0.7. Q = 6, BER 10-9.b) k = 0.14; 0.2; 0.4. Q = 6, BER $\approx 10^{-9}$.





- **International Conference. August 20, 2020. San Francisco, California, USA SCIENTIFIC ENQUIRY IN THE CONTEMPORARY WORLD: THEORETICAL BASICS AND INNOVATIVE APPROACH 15th edition**

http://doi.org/10.15350/L_26/15

Fig. 2.1.a) The dependence of the power penalty on the noise of the modes segment, for the different values of the coefficient of the modes segment (k): a) k = 0.3; 0.5; 0.7. Q = 6; BER 10-9.b) k = 0.14; 0.2; 0.4. Q = 6, BER $\approx 10^{-9}$.

Fig.2.2a presents the power fine dependence on the noise of the modes segment for different values of the coefficient of the modes segment (k). k = 0.3; 0.5; 0.7. Q = 7, BER 10-12.b) k = 0.14; 0.2; 0.4. Q = 7, BER $\approx 10^{-12}$. And, Fig .2.3., A).

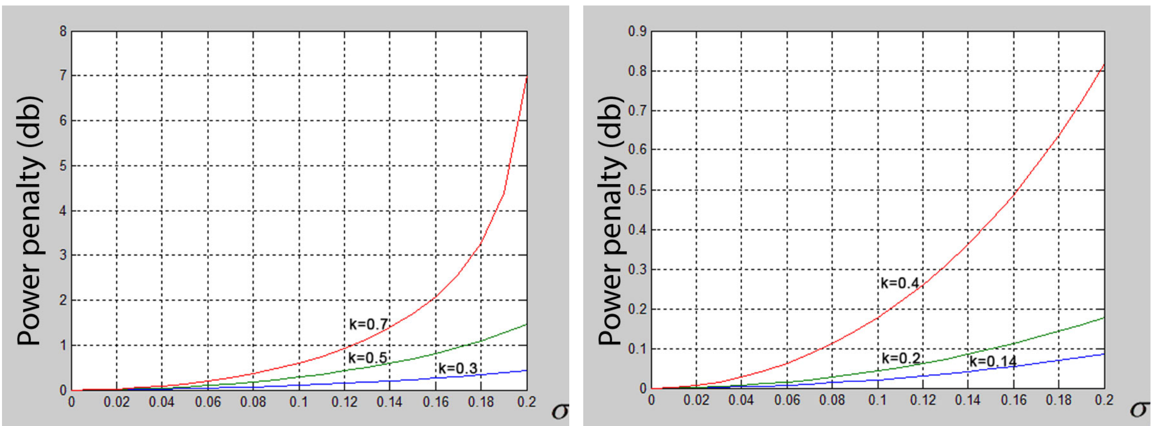
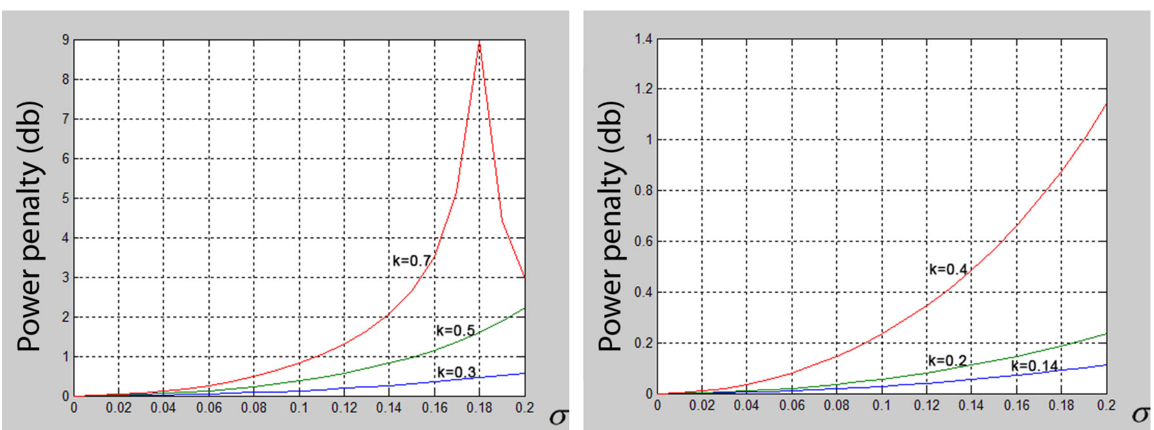


Fig.2.2 a) The dependence of the power fine on the noise of the modes segment, for the different values of the coefficient of the modes segment (k). k = 0.3; 0.5; 0.7. Q = 7, BER 10-12.b) k = 0.14; 0.2; 0.4. Q = 7, BER $\approx 10^{-12}$.

The dependence of the power penalty on the noise of the mode segment, for the different values of the mode division (segment) coefficient (k). k = 0.3; 0.5; 0.7. Q = 8, BER 10-15.b) k = 0.14; 0.2; 0.4. Q = 8, BER $\approx 10^{-15}$.



http://doi.org/10.15350/L_26/15

Fig. 2.3., A) The dependence of the power penalty on the noise of the modes segment, for different values of the coefficient of the modes segment (k). k = 0.3; 0.5; 0.7. Q = 8,
BER 10-15.b) k = 0.14; 0.2; 0.4. Q = 8, BER ≈ 10^{-15}.

(2) Determine Q from the image:

$$Q = \sqrt{1 - \frac{10^{-P_{Mod\,\text{pen.}}/5}}{\sigma_{pc} k^2}} \quad ; \qquad (3)$$

The Q factor depends on the coefficient of the modes segment (k). The noise of the modes segment $\sigma_{pc}^2 = 0.18$ power penalty P $_{\text{mod.seg noise}}$ =0.1 db. is presented in Fig.2.4

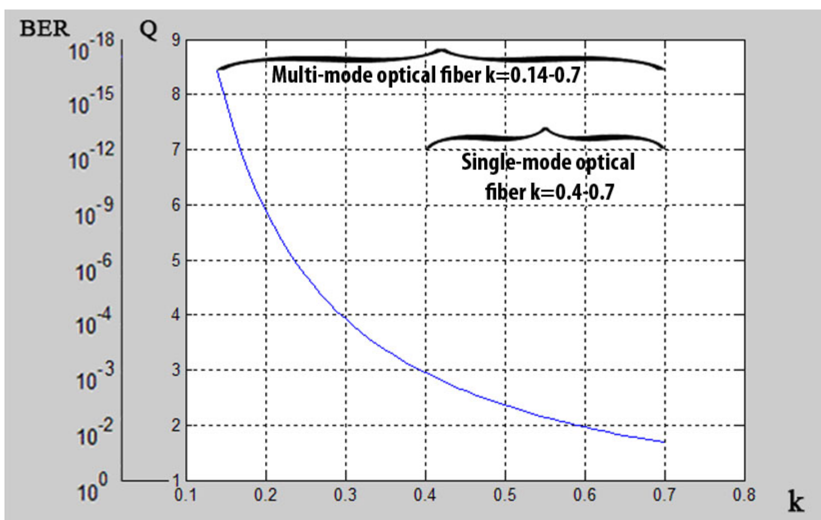


Fig.2.4. Q factor depends on the coefficient of the modes segment (k). The noise of the modes segment $\sigma_{pc}^2 = 0.18$ power penalty P $_{\text{mod.seg noise}}$ =0.1 db.

Thus

1. The penalty noise of the power distribution over the noise segment (segment) depends on the K noise distribution of the mode noise; The greater the noise capacity of the modes $\sigma^2{}_{pc}$ in particular, when, (Fig. 2.1a, b) $\sigma^2{}_{pc}$ =0,18; BER =10^{-9}; K=0,3;0,5; 0,7 respectively, the power penalty Φ =0,24; 0,75, 1,84 db). And, the noise is the same $\sigma^2{}_{pc}$ =0,18 for meaning and BER =10^{-9}, when K=0,14; 0,2; 0,4 (Fig. 2.2a, b) The power fine is Φ =0,05;0,1; 0,25 db, so $\sigma^2{}_{pc}$ =0,18 and for BER=10^{-12} meaning when K=0,3; 0,5; 0,7 , respectively Φ =0,3;;1;3 db., and K=0,14;0,2; 0,4 Φ =0,08; 0,15; 0,6 db.

http://doi.org/10.15350/L_26/15

2. From the dependence of Q-factor and BER (Fig. 2.4), when the power penalty Φ =0,1 dB, and K = 0.2,

BER $=10^{-9}$; Q=6; K=0,15; , BER $=10^{-12;}$ Q=7.

3. Noise due to splitting of modes may be reduced if the probability of bit errors decreases, or the working length of the operating wave is equal to the length of the zero dispersion wave. Transmission digital fiber optic systems are characterized by high data transfer speeds and low noise levels. Therefore, it is necessary to find approaches for minimizing the transmission speed to minimize the effect of mode splitting. Even if a laser with distributed feedback (DFB-distributed feedback laser) is used to solve the dispersion problem along the wavelength, which is far from the zero dispersion wavelength, noise splitting can cause a systemic problem. The reason is that the basic mode of distributed feedback laser (DFB) is accompanied by many side modes of smaller amplitude. These side effects can cause the mode to fluctuate, causing the mode to split. It has been suggested that by shifting the laser point of silence above the threshold value, may cause lateral mode suppression, and therefore reduce the error of mode split noise. Nevertheless, the reduction in the power factor and the strong thermal effects are eternally opposed to this improvement. Thus, this method is not a good way to divide modes noise.

References.

1. Svanidze R. Rostiashvili N. Chincharauli J. Factors affecting the probability of bit errors and energy potential in digital fiber-optic transmission systems (present collection)

2. Svanidze R.G, Chkhaidze M.T, Kodalashvili A.D. - Determine the optimal value of the error probability coefficient (BER) in the decisive device of the receiver of the digital fiber-optic system of the transmission. Georgian Engineering News, .2, 2017, p. 34-37.

3. Svanidze RG, Chkhaidze M.T. - Evaluation of bit probability coefficient (BER) in the transmission of fiber-optic systems in the transmission of time jitter. Georgian Engineering News, .2, 2017, p. 42-46

4. Chkhaidze M., Svanidze R. Determine the optimal value of the error probability coefficient in the decisive device of the receiver of the digital fiber-optic system of the transmission. Georgian Engineering News, №4,2016

5. Surachet Kanprachar Dr. Ira Jacobs, Chairman Electrical Engineering Modeling and analysis of the effects of impairments in fiber optic linkshttps://pdfs.semanticscholar.org/8b23/6ff4a50cd73280bb949f8b6e6317a83b5458.pdf