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DIGITAL RECEIVER PRODUCTIVITY AND BIT ERROR PROBABILITY

Abstract: *The paper presents the optimal value of BER by selecting the threshold current. By optimizing the threshold current, we should get the optimal value of BER. The change of the threshold level in the decision device has a great influence on the optimization of the Q=(BER) parameter. The threshold Ith should be chosen so as to minimize the BER. The paper presents a BER= Ψ (Q) graph where even a small change in Q leads to a significant reduction (improvement) in BER.*

Performance degradation/disruption of an optical telecommunication system, among other factors, is uniquely dependent on the receiver noise, transmitter intensity noise (RIN), which requires proper design and selection of operating modes considering the operating conditions of the transmission line.

Key words: *BER - Bit Error rate; RIN - Relative Intensity Noise; DFOTS - Digital fiber-optic transmission system.*

Language: *English*

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Introduction

Productivity of the digital receiver is the technical ability of the receiver to maintain the main characteristics of the receiver, both under the conditions of its standard (normal) operation and during the emergency mode. One of the important characteristics of the connection is the high bit error probability (BER), completely above the designed level. Performance degradation/disruption of an optical telecommunication system, among other factors, is uniquely dependent on the receiver noise, transmitter intensity noise (RIN), which requires proper design and selection of operating modes considering the operating conditions of the transmission line.The presence of noise degrades the quality of the connection as a whole, as the quality of the useful signal deteriorates.

As mentioned many times, the error probability (BER) in the case of a uniform distribution of data is the same as the bit error probability coefficient K. In general, optical systems are characterized by high quality of connection. For satisfactory quality of connection in optical systems, BER should be higher than 10-9 In particular, in high-quality optical systems, BER=10^{-9}-10^{-15} is within the limits.

In order to determine the BER, we must assume that the noise is described by a Gaussian (normal) distribution law as a standard deviation from symbols 0 and 1. The probability of these deviations is usually different for months 0 and 1, however, in the case of the dominant mode of thermal noise, both become the same σ T .σs.

fig. 1.1 presents several cases: as we can see, among these distributions is the Ith decision-making threshold (threshold).

If I ≥ I th =1 the bit is 1

If I < I th = 0 the bit is 0

Thus, if the curves of probabilities 1 and 0 cross each other, the area between the curves determines the probability of error.

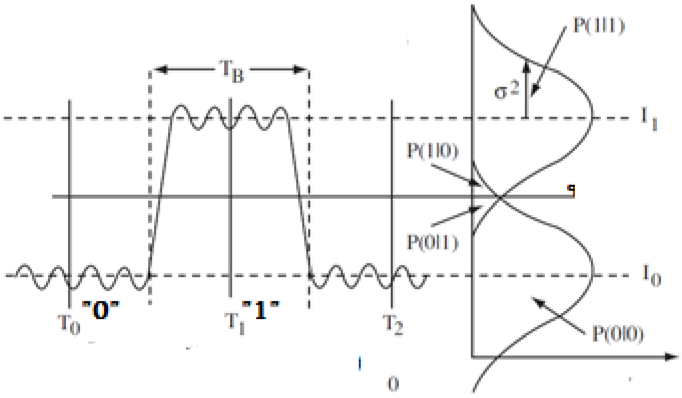

fig. 1.1. Receiving data in the optical receiver P(1/0) Probability of transition from "1" to "0"

Receiving data in the optical receiver P(1/0) transition of "1" to "0"

Probability, (0/1) i.e., error occurs when bit 0 is defined as and bit 1 is defined as I<Ith.I<I.

For BER data with a statistically equal bit value (that is, the number of 1s and 0s in the total signal is distributed equally, (statistically equal) as 50%/50%), then:

$$BER = \frac{1}{2}\left(P\left(0\ /1\right)+P\left(1/\ 0\right)\right) \qquad (1.1)$$

where P(1/0) is the probability of an error in bit-1, i.e. the probability that the current will remain below the threshold, when the decision device actually received bit 1. And, P(0/1) is the probability of an error in bit 0, that is, the probability that the current will remain below the threshold (threshold), in fact, when the current becomes greater than or equal to the value of the threshold (threshold) and a 0 bit is obtained. then,

$$P\left(0/1\right)=\frac{1}{\sigma_1\sqrt{2\pi}}\int_{\infty}^{I_{th}}\left[\frac{(I-I)^2}{2\sigma_1}\right]dI=\frac{1}{2}\mathrm{erfc}\left(\frac{I-I_{th}}{\sigma_1\sqrt{2}}\right) \qquad (1.2)$$

$$P\left(0/1\right)=\frac{1}{\sigma_0\sqrt{2\pi}}\int_{I_{th}}^{\infty}\left[\frac{(I-I_0)^2}{2\sigma^2{}_0}\right]dI=\frac{1}{2}\mathrm{erfc}\left(\frac{I_{th}-I_0}{\sigma_0\sqrt{2}}\right) \qquad (1.3)$$

$$\mathrm{erfc}\left(x\right)=\frac{2}{\sqrt{\pi}}\int_x^{\infty}\exp(y^2)dy \qquad (1.4)$$

There are standard tables for reporting additional error functions. In case of using additional error function, BER for binary signals is given as

$$BER=\frac{1}{4}\left[\frac{1}{2}erfc\left(\frac{I_1-I_{th}}{\sigma_1\sqrt{2}}\right)+\frac{1}{2}erfc\left(\frac{I_{th}-I_0}{\sigma_0\sqrt{2}}\right)\right] \qquad (1.5)$$

Thus, BER represents the current decision function with respect to the Ith threshold (threshold) current. Therefore, by selecting this threshold current, we need to get its optimal value, that is, by optimizing the threshold current, we need to get the optimal value of BER. i.e. the threshold Ith should be chosen so as to minimize the BER,

$$Q_1=\frac{I_1-I_{th}}{\sigma_1} \qquad (1.6)$$

$$Q_2 = \frac{I_{th} - I_0}{\sigma_0} \quad (1.7)$$

So,

$$Q_1 = \frac{I_1 - I_{th}}{\sigma_1} = Q_2 = \frac{I_{th} - I_0}{\sigma_0} = Q \quad (1.8)$$

then

The optimal value of the threshold Ith opt will be the minimum of BER:

$$I_{thopt} = \frac{\sigma_0 I_1 + \sigma_1 I_0}{\sigma_0 + \sigma_1} \quad (1.9)$$

The change of the threshold level in the decision device has a great influence on the optimization of the Q=(BER) parameter. The optimal threshold setting is selected by selecting all four (I_1, I_0, σ_1, σ_0) parameters in this formula. The parameters I_1, I_0, are the input signal levels, and σ_1 , σ_0 are the thermal and quantum mean square deviation values from the I_1, I_0, levels. Since the average current Ip is different for levels 1 and 0, the scatter noise and thermal noise levels and variances will be different. In the case when the thermal mode dominates ($\sigma_0 >> \sigma_1$ thermal noise (σ_0 =σT) the threshold will be the average value, that is, the threshold will be at half of the 1 and 0 levels.

$$I_{th} = \frac{I_1 - I_0}{2} \quad (1.10)$$

In the case of the dominance of the scattering mode (scattering noise σ 1 =σs) σ 0 <<σ1 the threshold approaches the threshold (below the threshold) for the optimal threshold

$$BER = \frac{1}{2} erfc\left(\frac{Q}{\sqrt{2}}\right) \quad (1.11)$$

where, the Q -factor is defined as

$$Q = \frac{I_1 - I_0}{\sigma_1 + \sigma_0} \quad (1.12)$$

In the case of Q>3, the probability function, which, as mentioned above, is given by the tables can be approximately approximated in the following simplified form:

$$BER \approx \frac{1}{Q\sqrt{2\pi}} \exp\left(-\frac{Q^2}{2}\right) \quad (1.13)$$

This formula essentially gives us the noise margin of the binary signal. The relationship BER=Ψ(Q) can be determined from the graph (Fig. 1.2.)

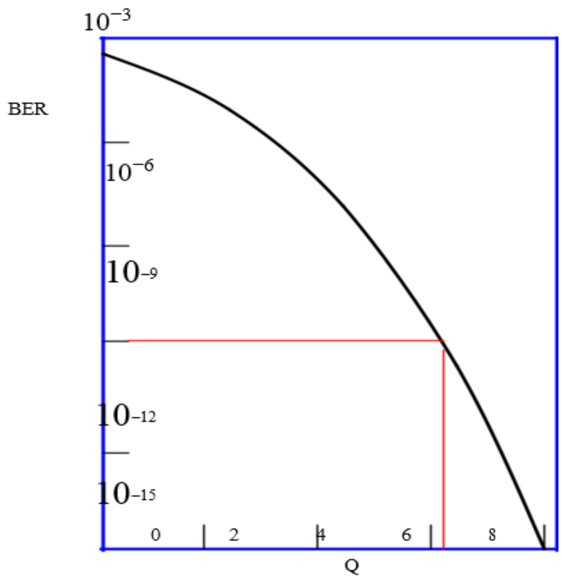

Fig. 1.2. BER= Ψ (Q) dependence graph

The given graph shows that Q=6 (BER=-10-9) to the right (Q=7,8) in the middle, when the value of BER changes very quickly, by several orders of magnitude (BER=10-10-10-15), this In between, the BER=Ψ (Q) dependence curve changes very steeply, and even a small change in Q leads to a significant reduction (improvement) in BER. Which is technically difficult to achieve but very important.

Results and its discussion. Optimizing the receiving threshold of the GSM is of great importance in improving the overall optical communication. By decisively optimizing the receiver, we ensure that the probability of bit errors is optimized. Maintaining a critical threshold optimization position in the following: In such a selection of parameters, when among all possible cases of the threshold of the decisive device, the best (optimal) value is obtained, which guarantees the best value of BERopt.

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