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Estimation of Bit Error Rate of an Optical OFDM System.

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ABSTRACT

Every Optical Signal Transmission aims to achieve a predetermined bit-error ratio (BER) between any two nodes, in an optical network. The Optical Transmission system has to be properly designed, in order to have a reliable operation during its life span. This includes the management of certain key parameters .In this paper, the maximum Q Factor, Min Bit Error Rate and Bit rate Pattern of an Optical Communication System with various Optical Fibre Cable lengths are discussed.

Keywords: BER, Optical OFDM, Q-factor

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INTRODUCTION

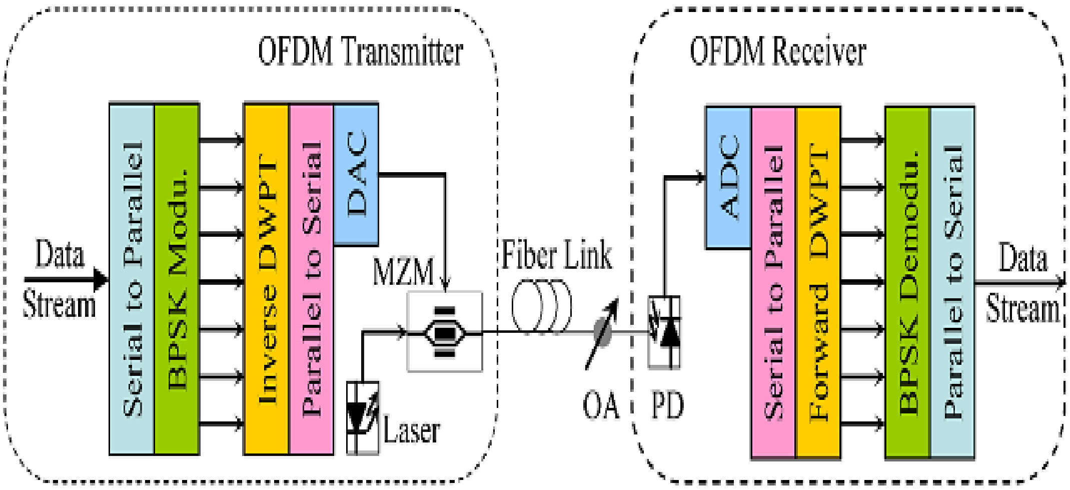
In a Digital Optical Communication System, the ratio of bits in error to the total number of transmitted bits at the destination is known as Bit Error Ratio (BER) . It is commonly used as a figure of merit. The minimum received optical power required to keep on BER below a given value, is known as Receiver Sensitivity.The three important parameters for system engineering are

(1) Optical signal parameters, for finding the signal level
(2) The optical noise parameters to calculate the BER
(3) The impairment parameters to find the power margin to be allocated and to compensate for their impact.

OPTICAL ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

Optical Orthogonal frequency division multiplexing (OFDM) is a modulation technique used in new and emerging broadband wired and wireless communication systems. It is indeed the most effectiveand treasuredsolution to intersymbol interference (ISI), which results in channel dispersion.

Block Diagram of Optical OFDM:



(fig2.1 block diagram of OFDM)

Information Source:

The source (or) input data sequence is a baseband modulated signal, utilized in digital modulation. Various modulation schemes such as BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), PSK (also with their differential form) and including QAM (Quadrature Amplitude Modulation with several different signals could be employed. There are several optical OFDM each with a distinct modulation in each sub channel is performed (e.g. transmitting more number of bits using an adequate modulation).

Baseband Modulation

Data can be encoded (or) converted by the baseband signal modulation and is performed on the serial data, the process is done inside the modulation which is performed on each parallel sub stream, that is on the symbols belongs to nearer DFT frames. The data symbols are parallelized in N (number of) different sub streams.

FFT Modulator:

Each parallel sub stream will modulate a separate carrier signal through the IFFT modulation block, which is the key element of an optical OFDM scheme.

Cyclic Prefixes:

A cyclic prefix is added in order to eliminate the inter-symbol interference (ISI) and inter-block interference (IBI). This cyclic prefix of length L is a circular extension of the IFFT-modulated signal, obtained by repeating the last L samples of the signals in it. The data are converted, forming an optical OFDM signal that will modulate a high-frequency carrier signal before it transmit through the channel. Since the radio channel is generally referred as a linear time-variant system.

Receiver:

To a receiver, the inverse operations are performed and the data are down-converted to the baseband system. The cyclic prefixes are removed. The coherent FFT demodulator ideally retrieves the exact design ofthe transmitted signals. The data are then serial converted and the appropriated demodulation system will be used to estimate the transmitted signals.

BIT ERROR RATE CALCULATION

The quality of Data (or) information can be determined using BER (Bit Error Rate). BER makes it feasible to compare the quality of different systems for data transmission. Bit error rate is defined by the following expression,

$$BER = \frac{n_c}{N_B}$$

Where,

- nc -number of bits received in error
- NB -total number of bits received in the definite time interval

In modern transmission networks,the information is transferred in larger blocks known as packets. The packets consists of a definite number of bits that could be selected or prescribed by the network. The occurrence of improper transmitted bits causes degradation to the entire packet.
In terms of the error rate, the large amount of data (or) information is lost. This error is determined by the below relationship

$$PER = \frac{N_{ERP}}{N_P}$$

Where,

- N_{ERP} - number of transmitted packets with the occurrence of at least one incorrectly transmitted bit
- N_P - total number of transmitted packets

For optical fiber-free connections is defined significant error parameter and it is the relative time interval p, which expresses the percentage of the link downtime ti to the total time of operation Tc according to equation (3). This parameter is based on the possibility of a connection failure due to atmospheric turbulence and fluctuation of received power. For reliable determination of this parameter for a particular connection must be selected sufficiently long period Tc. This is usually the period of one year.

$$p = \frac{\sum_i^{\infty} t_i}{T_c} \cdot 100 \qquad [\%, \ s, s]$$

As the formula shows, For determining the bit error rate, it is compulsory to know the total number of transmitted bits NB. These transmitted bits can be determined by permanent monitoring of the number of transmitted bits. It is important to note that for example BER - 10-12 corresponds to one erroneously transmitted bit attributable to 1012 bits transferred in total. At a communication speed of 155 Mbps occurs one error in the transmission in average once every 6450 s, when the data speed is 2048 kbps even once in 500 000 s. The bit error rate measurement corresponds with the character to a binomial probability distribution PBIN according to the following equation,

$$P_{BIN}\left(n_{c,} N_{B,} BER\right) = \frac{N_B\,!}{(N_B - n_c)!} . BER^{n_c} . (1 - BER)^{N_B - n_c}$$

PBIN value expresses the occurrence probability of a certain number of errors nc to the total number of transmitted bits NB for the BER. [2]

In case that the error rate is relatively low (< 10-4), it is possible to use simpler Poisson distribution. To express theoccurrence probability of a defined number of errors by the Poisson distribution, we had to introduce a parameter µ, whichexpresses the probability of erroneous transmission of one bit. The parameter µ can be defined as follows.

µ = BER . NB (5)

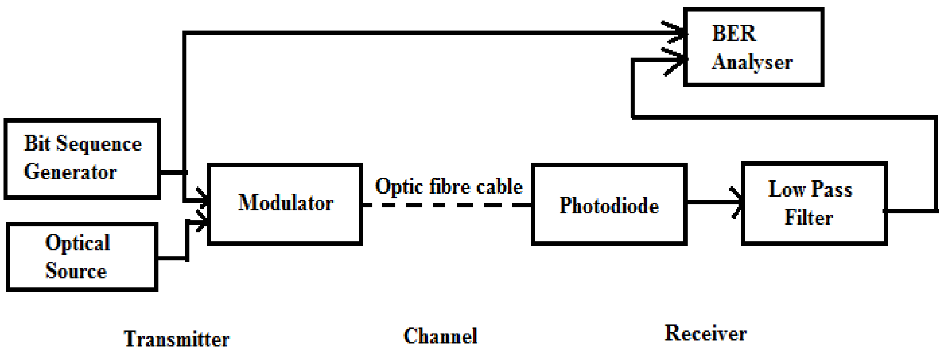
With the relations (4), (5) and the BER value, we are able to determine the probability of the nc erroneous bits delegated in the total number of bits NB. It is also possible to determine the total number of transmitted bits NB to the value ofBER with the desired accuracy. Assuming that we consider only the appearance of one erroneously transferred bit ne = 1, andwe require accuracy in determining the error PPOISS (ne, µ) = 0,99, the minimum and maximum values of the parameter µ canbe derived by numerical methods. For a known value of the parameter BER, according to (5), we are also able to determinethe number of transmitted bits NB. From the total number of bits and transmitted rate vi, we can determine the requiredmeasurement time by the following equation,

$$t_{mer} = \frac{N_B}{v_i}$$

Where,

- vi- transfer speed in bps.

STIMULATION BLOCK DIAGRAM:

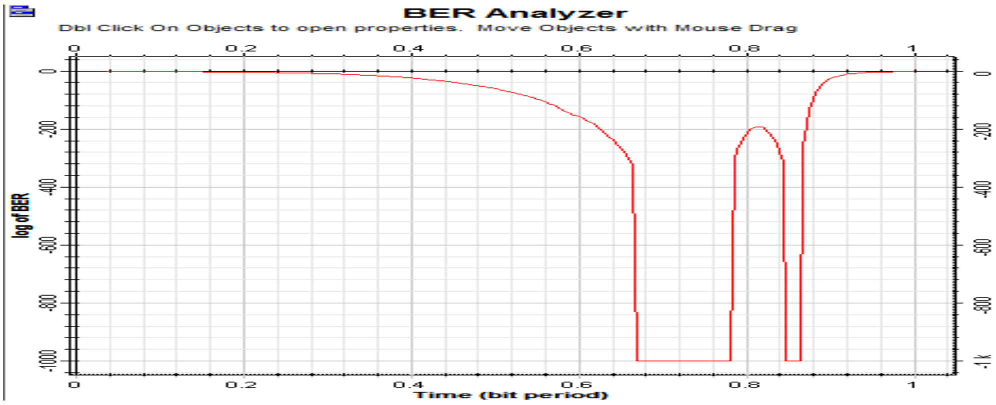


(fig4.1.block diagram of stimulation)

STIMULATION RESULTS

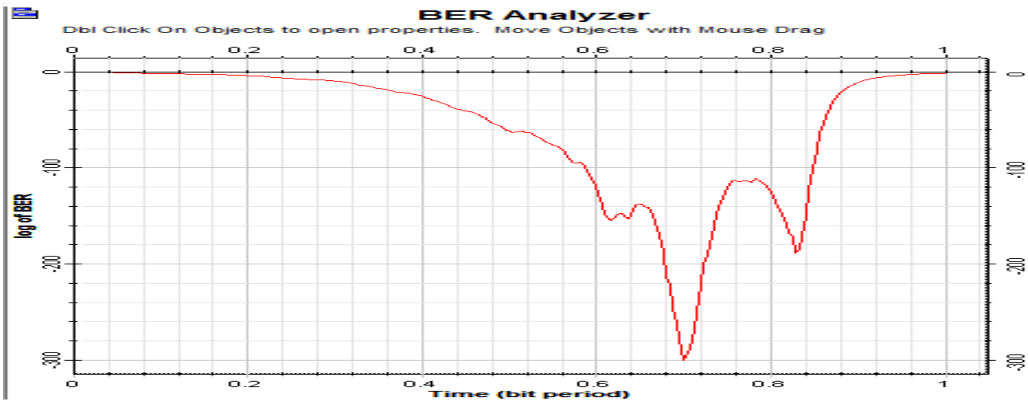
The following results were stimulated using OptiSystem. A reference wavelength of 1550 nm was taken , with the attenuation constant of the fibre fixed to 2.0 dB/km . The bit rate was set to 2.5e+9. The length of the optical fibre were changed , and their corresponding BER were analysed.

For 25 kms :



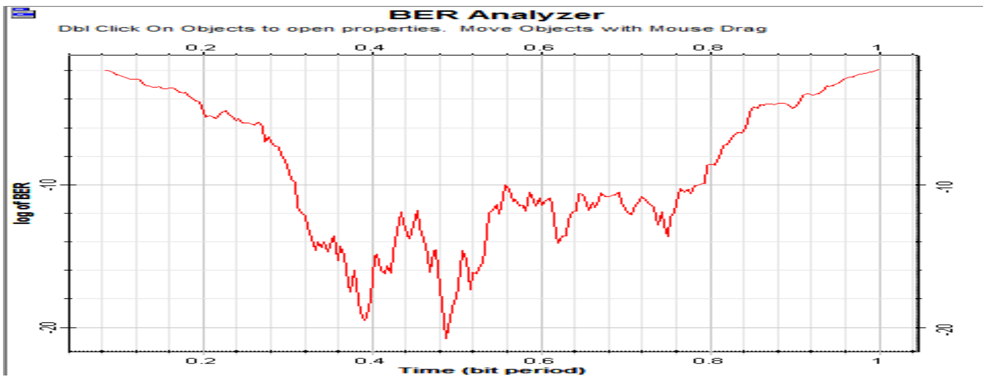
(BER Curve for 25 Km)

For 50 kms



(BER Curve for 50 Km)

For 100 kms



(BER Curve for 100 Km)

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CONCLUSION

It can be observed and shown that the value of Q factor going on Decreases as we going on increases the length of the optic fibre. The Q Factor and Min BER for the different lengths is listed below

Length	Maximum Q Factor	Min Bit Error Rate
25 kms	59.4354	0
50 kms	37.0590	6.39137e-301
100 kms	9.45294	1.61754e-021

Hence this optical system works best when the length of the Optical Fibre is 25kms or lesser.

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