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Optimization of Repeater Spacing in Optical Fiber Communication

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***Abstract* — Repeater spacing in fiber optic communication is optimized taking into consideration various parameters such as fiber attenuation, Stimulated Brillouin Scattering (SBS), Stimulated Raman Scattering (SRS), fiber attenuation, photodiode sensitivity and input power. In our work, we have taken different value of input power, change the different property of receiver as like APD Multiplier, different filter. Also, we have obtained results for various length of fiber and try to optimize the distance between two repeaters.**

***Keywords* - Repeater, Stimulated Brillouin Scattering (SBS), Stimulated Raman Scattering (SRS), Fiber nonlinearities, Multi Tone, Optical signal to noise ratio(OSNR).avalanche photo diode(APD).**

I. INTRODUCTION

Information channel is the path among the transmitter and receiver .in fiber optic communication, a glass or plastic fiber is the channel. Necessary features of the information channel include low attenuation and large light acceptance cone angle. optical amplifier boost the power levels of degraded signals. Amplifiers are desirable in very long links to provide sufficient power to the receiver. Repeaters can be used only for digital systems. They translate weak and inaccurate optical signals to electrical ones and then redevelop the original digital pulse trains for further broadcast.

Repeaters are basically used in Long Haul optical fiber communication and undersea fiber optic communication in order to increase the signal power. Generally, when a signal propagates for long distances, its strength degrades and affected by noise. In order to overcome this, we deploy repeaters at regular intervals to boost the signal strength up

A. Optical Amplifier:

fiber attenuation limits the reach of a non-amplified fiber span to approximately 200 km for bit rates in the gigabit-per-second range, wide area purely optical networks cannot exist without optical amplifiers.

Optical amplifiers are naturally used in three different places in a fiber transmission link.

Power Amplifiers

Power amplifiers serve to boost the power of the signal before it is launched on the line, spreading the transmission distance before additional amplification is required.

Line Amplifiers

Line amplifiers are situated at strategic points along a long transmission link to restore a signal to its initial power level. Thereby compensating for fiber attenuation.

Preamplifiers

Preamplifiers increase the signal level at the input of an optical receiver, which serves to improve signal detection performance (i.e., the receiver sensitivity).

In each cases, the desired properties are different. For power amplifiers, the important feature is high gain; preamplifiers require a low noise figure, and line amplifiers require both.

Thus by taking into account all the above parameters we would try reducing the spacing between the repeaters.

C. Erbium-Doped Fiber Amplifiers (EDFAs):

The EDFA belongs to a family of rare-earth-doped fiber amplifiers, the class of other possible do pants, including praseodymium (used for amplification in the 1300-nm range), neodymium (originally used for very high-power lasers), ytterbium (which has been used as a cod pant with erbium), and thulium (amplifying in the S band). The important place of the EDFA in optical communications is due primarily to the fact that the properties of erbium produce amplification in a fairly wide band (approximately 35 nm) within the 1550 nm low-attenuation window in fibers. Furthermore, the EDFA has many other needed features.

EDFA Three-Energy Level System:

Many other forms of amplifiers of electromagnetic radiation, the EDFA operates via a three-energy level system. The model representing this process is shown in the following figure.

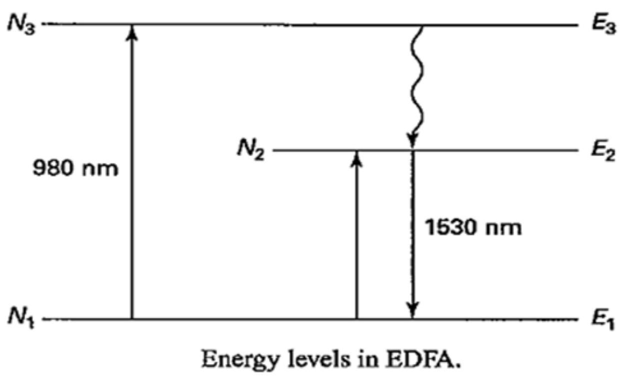

Figure 1:Energy level diagram

Levels E1, E2, and E3 are the ground, metastable, and pump levels, respectively. The populations (fractional densities) of erbium ions in the three energy levels are denoted N1, N2, and N3, where N1> N2> N3 when the system is in thermal equilibrium (no pump or signal present). When pump and signals are existing, these populations change as ions move back and forth between levels, accompanied by the emission or absorption of photons at frequencies determined by the energy-level difference.

The wavelengths related with the dominant transitions are indicated in the above figure. The wavelength λ for each transition is given by the quantum relation $\lambda = hc / \Delta E$, where h is the Planck's constant and ΔE is the difference in energy levels. In actuality, the three levels in the basic diagram are narrow bands, so each transition is actually associated with a band of wavelengths rather than a single line.

Two pump wavelengths are typically used for EDFAs: 980 and 1480 nm..by absorbing energy from a 980 nm pump, Er^{3+} ions in the ground state are raised to state E3. The rate at which these transitions occur is proportional to N1Pp, where Pp is the pump power. These excited ions decay spontaneously to the metastable state E2, and this transition occurs at a rate much faster than the rate from level E1 to level E3. This means that in equilibrium under the action of the pump, the ion population in the ground state is reduced and accumulates largely in state E2. This process is denoted to as population inversion because we now have N2> N1, the reverse of the situation in thermal equilibrium.

The transition rate from level E2 to level E1 is very slow compared with the other transitions, so that the lifetime τ, in the state E2 (the reciprocal of its transition rate to E1) is very long (approximately 10 ms). Similar pumping action can occur at 1480 nm, in which case the ions are raised directly to the upper edge of the E2 band. Reliable semiconductor laser pump sources have been developed for EDFAs at both the 980 and 1480 nm pump wavelengths.

The wavelength band for transitions from state E2 to the ground state is in the 1530 nm range, making it ideal for amplification in the lowest attenuation window of fibers. The dominant transitions from E2 to E1 are radiative, which means that they are of two types: spontaneous emission and stimulated emission. In the case of spontaneous emission, an ion drops spontaneously to the ground state, resulting in the emission of a photon in the 1530 nm band, and this appears as additive noise. Spontaneous emission noise is an necessary by-product of the amplification process, predicted by quantum theory. Its phase, direction, and polarization are independent of the signal.

In the case of stimulated emission, an incident photon in the 1530 nm range stimulates the emission of another photon at the same wavelength in a coherent fashion (with the same direction, phase, and polarization). If the incident photon is from a signal, this produces the preferred amplification of the optical field. However, the incident photon could also have originated as a spontaneous emission "upstream" on the fiber, in which case this is called amplified spontaneous emission (ASE), which represents the major source of noise in amplified fiber transmission systems.

II. PROPOSED METHOD

Used Lpbessel filter, APD multiplier 1,transmitter power 15dbm,

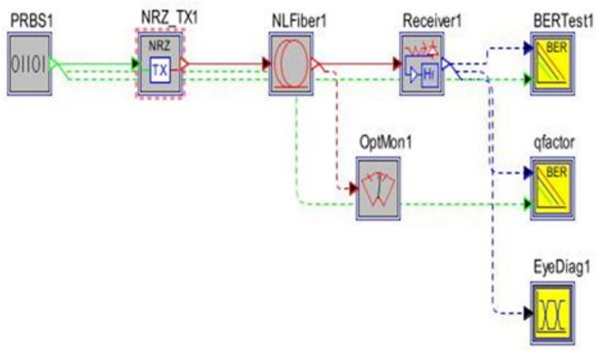

Figure 2:Simulation setup of optical communication system

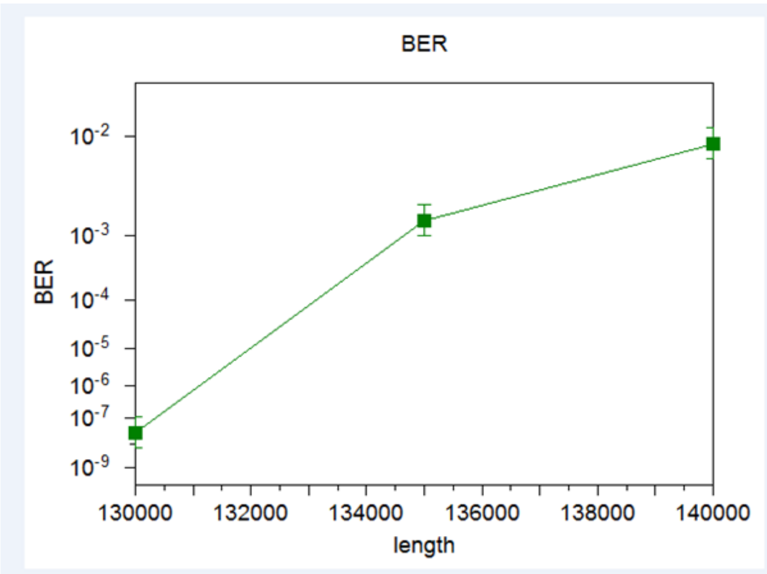

Figure 3:BER VS fiber length(m) for transmitter power 16dbm,APD Multiplier 1, used lpbessel filter

Fiber length(km)	BER
130	2.84×10^{-8}
135	1.54×10^{-3}
140	8.79×10^{-3}

Table 1:BER for transmitter power 16dbm(APD multiplier 1,Lpbessel filter)

Fiber length(km)	BER for 15dbm	BER for 16dbm	BER for 17dbm
130	5.56×10^{-8}	2.84×10^{-8}	1.20×10^{-4}
135	1.30×10^{-3}	1.54×10^{-3}	8.73×10^{-3}
140	9.42×10^{-3}	8.79×10^{-3}	1.00×10^{0}

Table 2:BER for different values of transmitter power (Lpbessel filter and APD multiplier 1)

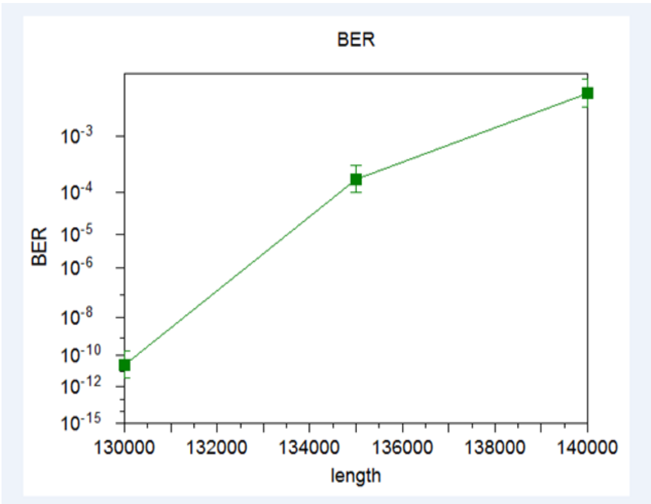

Figure 4:BER vs fiber length(m) (APD multiplier 3,transmitter power 16dbm,Lpbessel)

Fiber length(km)	BER
130	2.86×10^{-11}
135	1.88×10^{-4}
140	3.68×10^{-3}

Table 3:BER for APD multiplier 3 (transmitter power 16dbm,LPbessel filter)

Fiber length(km)	BER for APD 2	BER for APD 3	BER for APD 4
130	1.49×10^{-14}	2.86×10^{-11}	4.06×10^{-7}
135	1.35×10^{-4}	1.88×10^{-4}	8.53×10^{-4}
140	4.04×10^{-3}	3.68×10^{-3}	5.05×10^{-3}

Table 4:Comparison table for different value of APD Multiplier

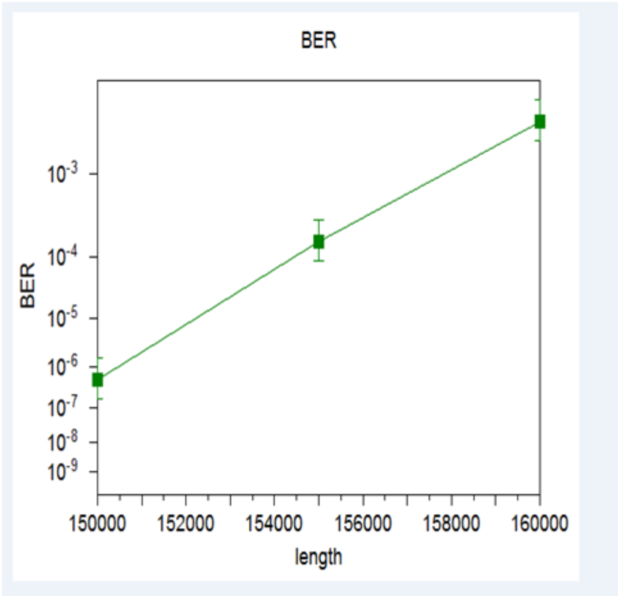

Figure 5:BER vs fiber length(m) (Lpideal filter ,APD multiplier 3 and transmitter power 16dbm)

Fiber length(km)	Ber
150	5.33×10^{-7}
155	1.65×10^{-4}
160	2.99×10^{-3}

Table 5:BER for LPIdeal filter (APD multiplier 3 and transmitter power 16dbm)

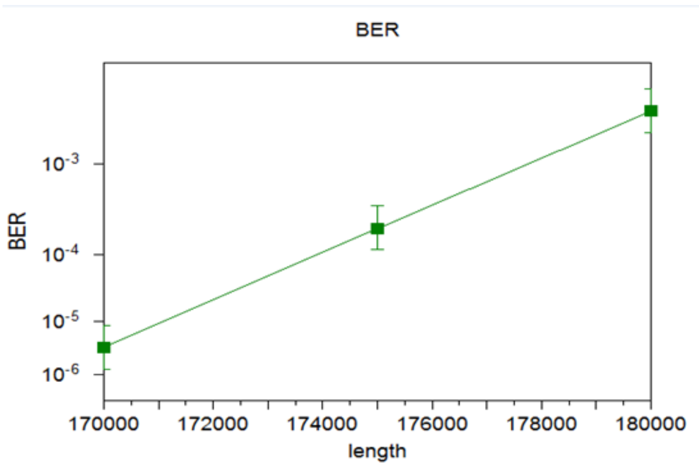

Figure 6:BER results using EDFA amplifier for transmitter power 16dbm, APD multiplier 3,laser power 1mw.

Fiber length(km)	BER
170	3.40×10^{-6}
175	2.12×10^{-4}
180	2.79×10^{-3}

Table 6:of BER(Used EDFA amplifier, transmitter power 16dbm,APD multiplier 3,laser power 1mw)

III. CONCLUSION

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In this paper, we have tried to maximize the distance between two repeater using different parameter of optsim 5.0 software, I have found that at the transmitter side for 16 dbm transmitter power I obtained the less bit error rate (BER) ,Also noted that at the receiver side for low pass ideal filter I obtained the less Bit error rate(BER) compare to other filters. If we use the APD multiplier 3 at the receiver side then we can also minimize the bit error rate .Finally I have transmit the signal at 180 km distance without repeater with maintain the quality of the signal in terms of BER

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