Performance Evaluation in order to achieve an stabilized output power obtained from EDFA without using an AGC.

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Abstract— **In this paper what we obtain is how we can achieve the same power level at the output irrespective of applying two different input signals having different wavelength at the input end without using any Automatic Gain Controller. In order to achieve that we are using two EDFA and special type of filter. In this an amplification is occurred for a signal passes through the core doped with erbium ion (Er+3) under the effect of pump, absorption, stimulated, and spontaneous emission. The new amplifier requires only a single pump laser. In the experiment, 980nm laser diode was used and the pump power was 100 mW over a wide input-power range of -30 to -10 dBm.**

Keywords-component: BER, DFA, EDFA, ITOP, OFCS, SOA

I. INTRODUCTION

The recent exponential growth in data communication and the internet places urgent demand on high-capacity communication networks. The need for greater transmission capacity through optical fiber has encouraged the increase of Wavelength Division Multiplexing (WDM) channels and the data rate per channel, and furthermore promotes the expansion of the optical band. To increase total capacity, research and development teams must work on the data speed and channel spacing that has been limited by the speed of the electronic devices and fiber nonlinearity.

As the optical amplifiers have overcome on the speed limitation of the optical links, they are one of the most essential components of telecommunications networks and the development of the Erbium Doped Fiber Amplifiers (EDFAs) in particular is affecting all areas of optical communications networks [1]. Indeed as the EDFA gain bandwidth is not spectrally uniform, and exhibit some ripples, gain differences between optical channels having large bandwidth. As the number of channels in wideband and long distance WDM systems increase, broadband and spectrally flat amplification is required.

Erbium doped fiber amplifiers have attracted most because they operate in the wavelength region near 1.55 μm, the wavelength region in which fiber attenuation is small. EDFA amplified simultaneously all channels when a WDM signal was amplified [1]. The gain of EDFA depends upon erbium-ions concentration, amplifier length, and core radius & pump power [2]. The gain of modern EDFA range changes from about 20 dB to 40 dB depending as they act as booster or preamplifier. The optical filter placing before the amplifier increased the noise while placing it after the amplifier reduced the output power.

A combination of several long period fiber grating were acting as the optical filter which can flat the gain within 1dB over the 40 nm bandwidth in wavelength range of 1530-1570 nm[3]. It is found that the usage of gain equalizer filter was the most applicable technique for gain broadening EDFAs, but the hybrid Raman amplifier & EDFAs had the maximum accessible bandwidth without any power consuming in optical filter.

EDFA have a high gain, operating at low pump power and its performance are better in comparison with other similar amplifiers and optical devices [2] Using EDFA in optical

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networks is possible to extend transmission distances and the capacity in optical network [2]. Also, the EDFA have a large bandwidth, a low noise figure and polarization insensitivity [1]. The size and the complexity of DWDM networks growth and appear transient effect, which may become significant for system performances and reliability. The EDFA have the same mechanism as a laser with three levels [2-3]. The EDFA is suited for modern optical transmissions systems because the EDFA have the maximum gain at 1550 nm wavelength, which is used for optical fibers. Wavelength division multiplexing (WDM) and erbium-doped fiber amplifiers (EDFA's) have revolutionized high-capacity long-distance transmission systems. However, the EDFA gain is wavelength dependent causing severe signal power and SNR differential are among several WDM channels after a cascade of amplifiers [2].

EDFA is an optical repeater device that is used to boost the intensity of optical signals being carried through OFCS. It was the first successful optical amplifier. An optical fiber is doped with the rare earth element erbium so that the glass fiber can absorb light at one frequency and emit light at another frequency. An external semiconductor laser couples light into the fiber at infrared wavelengths of either 980 or 1480 nanometers. This action excites the erbium atoms. Additional optical signals at wavelengths between 1530 and 1620 nanometers enter the fiber and stimulate the excited erbium atoms to emit photons at the same wavelength as the incoming signal. This action amplifies a weak optical signal to a higher power, affecting a boost in the signal strength [1].

Before go into the more detail about EDFA, first of all we study whats the need of Optical amplifiers and various other types of Optical Amplifiers.

A.THE NEED FOR OPTICAL AMPLIFICATION

Optical fibre suffers from two principal limiting factors: Attenuation and dispersion. Attenuation leads to signal power loss, which limits transmission distance. Dispersion causes optical pulse broadening and hence intersymbol interference leading to an increase in the system bit error rate (BER). Dispersion essentially limits the fibre bandwidth. The attenuation spectrum of conventional single-mode silica fibre, shown in Fig. 1(A), has a minimum in the 1.55 wavelength region. The attenuation is somewhat higher in the region.

The dispersion spectrum of conventional single-mode silica fibre, shown in Fig. 1(B), has a minimum in the 1.3 region. Because the attenuation and material dispersion minima are located in the 1.55 and 1.3 'windows', these are the main wavelength regions used in commercial optical fibre communication systems. Because signal attenuation and dispersion increases as the fibre length increases, at some point in an optical fibre communication link the optical signal will need to be regenerated i.e we require regenerators. But regenerators are complex systems and often situated in remote or difficult to access location, as is the case in undersea transmission links, network reliability is impaired.

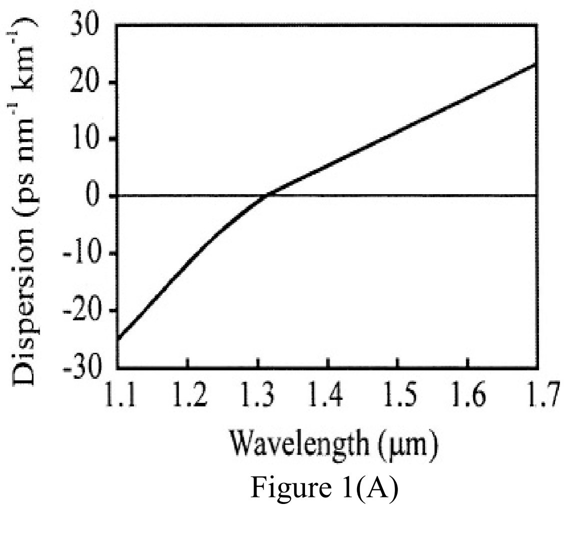

Figure 1(A)

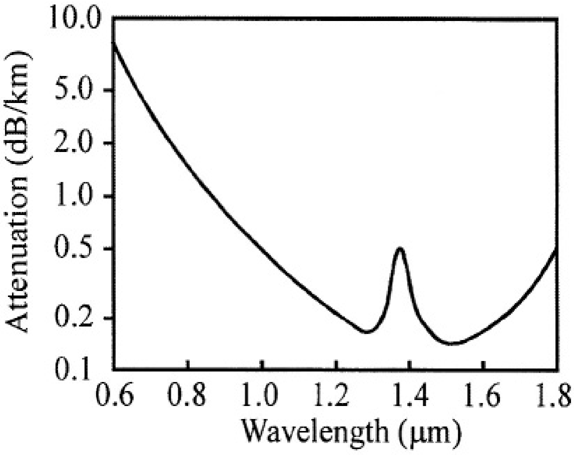

Figure 1(B)

In systems where fibre loss is the limiting factor, an optical amplifier can be used instead of a regenerator. Ideally an optical amplifier impart large gain and be optically transparent (i.e. independent of the input optical signal properties). In addition optical amplifiers can also be useful as power boosters, for example to compensate for splitting losses in optical distribution networks and as optical preamplifiers to improve receiver sensitivity. Besides these basic system applications optical amplifiers are also useful as generic optical gain blocks for use in larger optical systems. The improvements in optical communication networks realised through the use of optical amplifiers provides new opportunities to exploit the fibre bandwidth. In general, optical amplifiers can be divided into two classes: optical fibre amplifiers and semiconductor amplifiers and another is Raman Amplifiers.

After giving the brief literature of EDFA amplifiers, we discuss about the simulation setup used for the EDFA Output Power Level. In the simulation results, analysis of an effect on output power level of EDFA with pump power and wavelength of amplifier has been presented. The simulation results for the various configurations of BER spectrum with pump power of the EDFA are enumerated here. Variation in the noise figure with pump power and EDFA length is depicted and finally the results have been concluded.

II.Simulation setup and Parameters:

In the setup shown in figure 2, we demonstrate the use of two Er-doped fiber is used of the same configuration. These doped fibers are pumped by a single pump laser diode in a co-propagating manner through wavelength division multiplexing [4]. A Inverted Trapezoidal Optical Filter is inserted in between the two EDFs to achieve the inversion of the output of the first EDFA.

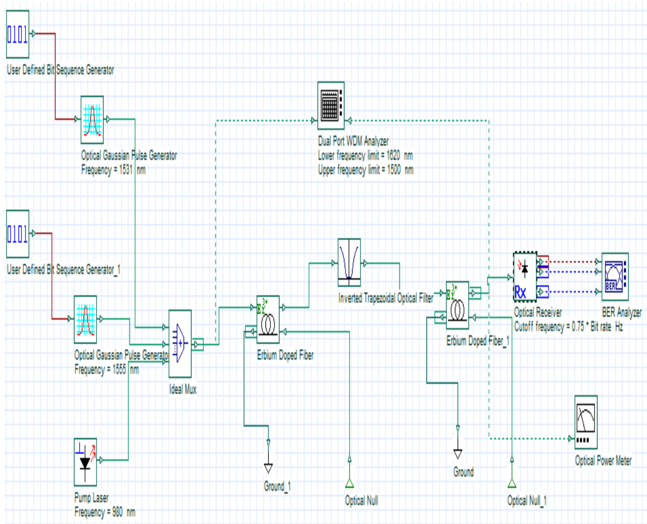

Figure 2: Set up for performance evaluation of EDFA.

Then the output of the filter is fed to the next EDFA in order to achieve the same power level at the output irrespective of both the input signals are of different wavelength [4].

For our calculation and experiment, the following parameters are used. Lengths of both the EDFA is 2.5m respectively. The Er metastable lifetime is 10ms. The concentration of Er and Al in the fibers are 460 and 1400 wt-ppm respectively. The pump wavelength is 980nm and the pump power is 100mw at the input end of first EDFA. The two signal wavelength is 1531nm and 1555nm respectively powered at the same values.

III.Results and Discussion:

Now first of all we see the output of first EDFA, when we are applying two different signals alongwith pumping to the input end of EDFA through multiplexer [4]. We can analyse clearly in figure 3 that the power level corresponding to smaller wavelength is more than that of larger wavelength because wavelength is inversely proportional to frequency. If frequency is more losses are less and we can achieve higher power level corresponding to smaller wavelength. But our aim is to achieve the same power level at the output.

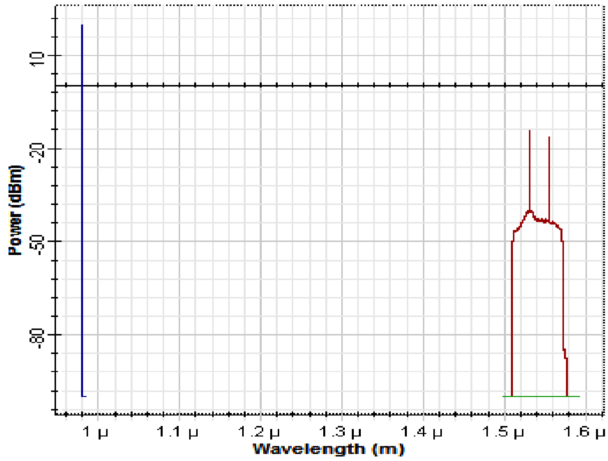

Figure 3: Output Spectrum from Ist EFFA.

So in order to achieve that we have to pass this output to the input of the Inverted Trapezoidal Optical Filter [4]. Now what this filter do is as its name shows it will exchange or convert the power level of two different wavelength with each other with a minimum loss in power level in equal proportion which occurs due to the passing from the filter. The output of this filter is shown in figure 4.

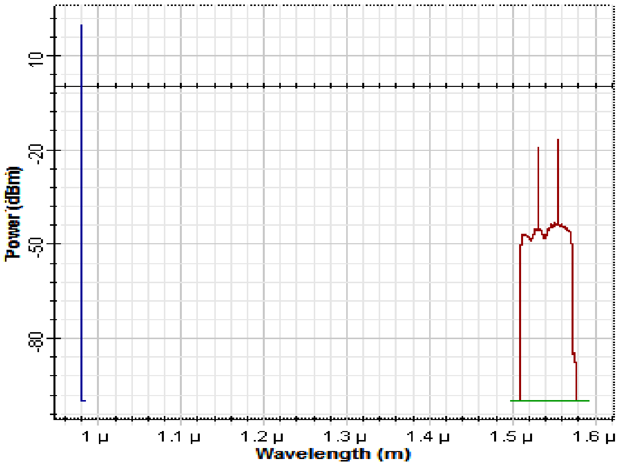

Figure 4:Output spectrum of Inverted Filter.

Now our aim is to achieve the same output power level, so in order to that we are again pass the output of the filter to the input end of the next EDFA.

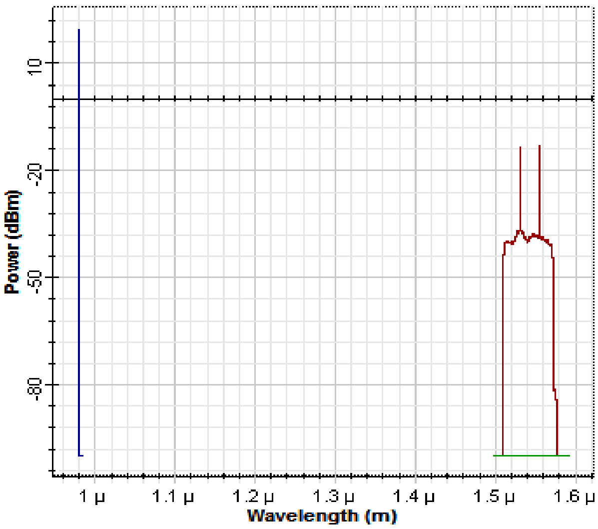

Figure 5: Output spectrum of IInd EDFA.

Figure:5 shows us clearly that we can achieve the same power level of higher values at the output irrespective of transmitting two different signals of different wavelengths.

A.Bit Error Rate

As the name implies, a bit error rate is defined as the rate at which errors occur in a transmission system. This can be directly translated into the number of errors that occur in a string of a stated number of bits. The definition of bit error rate can be translated into a simple formula:

BER = number of errors / total number of bits sent

If the medium between the transmitter and receiver is good and the signal to noise ratio is high, then the bit error rate will be very small - possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered.

The main reasons for the degradation of a data channel and the corresponding bit error rate, BER is noise and changes to the propagation path (where radio signal paths are used). Both effects have a random element to them, the noise following a Gaussian probability function while the propagation model follows a Rayleigh model. This means that analysis of the channel characteristics are normally undertaken using statistical analysis techniques.

For fibre optic systems, bit errors mainly result from imperfections in the components used to make the link. These include the optical driver, receiver, connectors and the fibre itself. Bit errors may also be introduced as a result of optical dispersion and attenuation that may be present. Also noise may be introduced in the optical receiver itself. Typically these may be photodiodes and amplifiers which need to respond to very small changes and as a result there may be high noise levels present.

Unlike many other forms of assessment, bit error rate, BER assesses the full end to end performance of a system including the transmitter, receiver and the medium between the two. In this way, bit error rate, BER enables the actual performance of a system in operation to be tested, rather than testing the component parts and hoping that they will operate satisfactorily when in place.

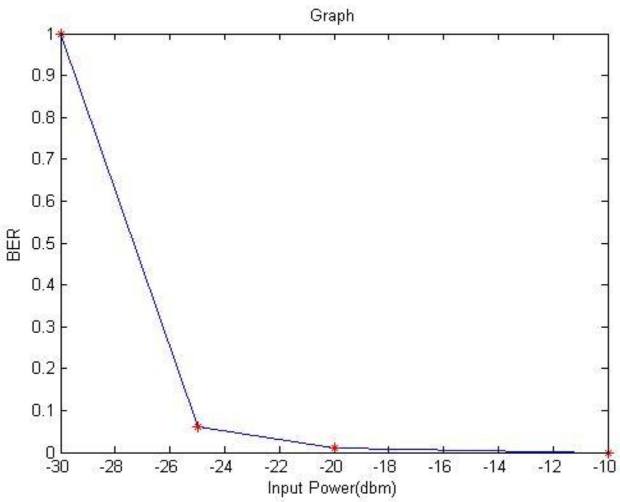

Figure 6: Bit Error Rate

This graph shows us as we increase the input power level, BER tends to decrease. For higher powers, BER tends to be negligible. It must be noted that when input power level is -10dbm, BER is very small which is desirable.

B. Eye Diagram:

The eye diagram is a useful tool for the qualitative analysis of signal used in digital transmission. It provides at-a-glance evaluation of system performance and can offer insight into the nature of channel imperfections. Careful analysis of this visual display can give the user a first-order approximation of signal-to-noise, clock timing jitter and skew.

Eye diagram is an oscilloscope display in which a digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is so called because, for several types of coding, the pattern looks like a series of eyes between a pair of rails.

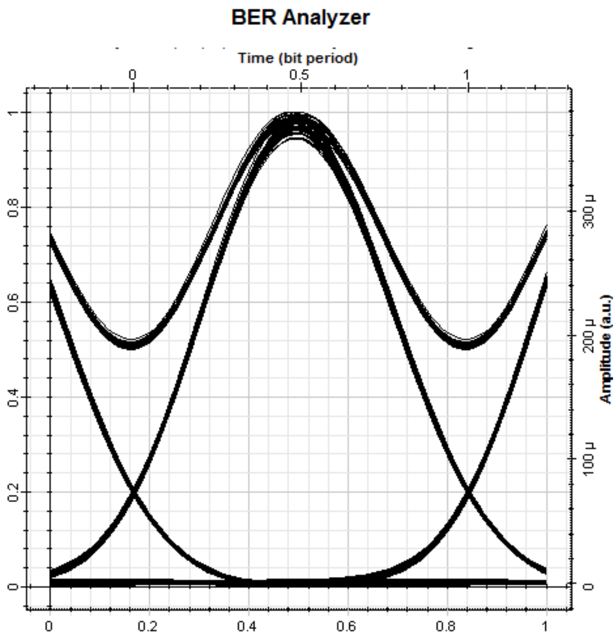

FIGURE 7: EYE DIAGRAM.

SEVERAL SYSTEM PERFORMANCE MEASURES CAN BE DERIVED BY ANALYZING THE DISPLAY. IF THE SIGNALS ARE TOO LONG, TOO SHORT, POORLY SYNCHRONIZED WITH THE SYSTEM CLOCK, TOO HIGH, TOO LOW, TOO NOISY, OR TOO SLOW TO CHANGE, OR HAVE TOO MUCH UNDERSHOOT OR OVERSHOOT, THIS CAN BE OBSERVED FROM THE EYE DIAGRAM. AN OPEN EYE PATTERN CORRESPONDS TO MINIMAL SIGNAL DISTORTION. DISTORTION OF THE SIGNAL WAVEFORM DUE TO INTERSYMBOL INTERFERENCE AND NOISE APPEARS AS CLOSURE OF THE EYE PATTERN. IN ORDER TO OBSERVE THE PERFORMANCE OF EDFA , AS IF WE INCREASE THE LENGTH AND PUMP POWER, GAIN FLATNESS TURNS OUT TO BE DIRECTLY PROPORTIONAL TO THE GAIN AND TO THE FLATNESS OF THE GAIN PROFILE.

Results of different eye diagrams for different iteration and length are shown here. The results of eye diagram tells that as we increase pump power and EDFA length, opening of eye is increased.

Here an eye pattern comes out to be more open which corresponds to minimal signal distortion which is desirable.

Conclusion:

A new Er-doped optical fiber amplifiers is incorporating to achieve the same output power for two different signals having different wavelengths powered at same level in the input side when it passes from EDFA. So we conclude if we pass only these two type of signals having the mentioned wavelength in the multiple succession from the EDFA then there is no requirement to stabilize an output power at the receiver side with automatic gain controller. By using an Inverted Trapezoidal Optical Filter we are able to achieve these by inverting the power level for two different wavelengths with each other and get the desired results.
As also it can be seen, the longest-wavelength signal with its relatively low amplification, is least able to overcome the effects of noise in the link's photo receivers, resulting in a closed eye.

REFERENCE:

1) G. P. Agrawal, Fiber – Optic Communication Systems. New York: John Wiley & Sons Inc, 2002.
2) G. Zeidler and D. Schicetanz, Use of laser amplifiers in glass fibre communication systems, *Siemens Forch. u. Entwickl. Ber.,* **2***,* 227-234 (1973).
3) S. D. Personick, Applications for quantum amplifiers in simple digital optical communication systems, *Bell Syst. Tech. J.,* **52**, 117-133..
4) 2. D.A.O. Davies, Small-signal analysis of wavelength conversion in semiconductor laser amplifiers via gain saturation, *IEEE Photon. Tech. Lett.,* **7**, 617-619 (1995).