International Journal of Computational Intelligence and Informatics, Vol. 2: No. 4, January - March 2013

Simulation and Analysis of GFF at WDM Mux Bandwidth of 13GHz

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***Abstract*- Gain Flattening Filter (GFFs), also known as gain equalizing filters, are used to flatten or smooth out unequal signal intensities over a specified wavelength range. This unequal signal intensity usually occurs after an amplification stage (e.g., EDFA and/or Raman). In this simulation model an attempt is made theoretically to flatten the gain of the EDFA which is the vital issue in the DWDM long haul communication. In our proposed design we optimized the GFF to achieve 23.73 dB gain in all associated channels. From the simulation study it is quite clear that the transmission spectrum of the GFF is complimentary to the ASE of the EDFA. The uneven gain of the EDFA is 0.003 dB due to the ASE of the EDFA**

Keywords-Gain Flattening Filter (GFF), Erbium Doped Fiber Amplifier (EDFA), Wavelength division Multiplexing (WDM), Amplified Spontaneous Emission (ASE)

I. INTRODUCTION

GFFs are used in conjunction with gain amplifiers to ensure that the amplified channels all have the same gain. Gain equalization means achieving identical gains for a discrete number (two or three) of optical channels. Gain flattening means achieving a spectrally uniform gain bandwidth. The quality of a GFF is best described by the peak-to-peak error function (PPEF) because it represents the maximum flatness of the transmitted signal[1]. The PPEF is calculated by comparing the spectral performance of the manufactured filter to the target curve specification. In general, the factors that determine the minimum PPEF that can be achieved are the maximum slope and the smoothness of the target curve. Some applications require multiple flattening regions or the addition of pass band outside the flattening region; these may increase the complexity of the filter. Gain equalizing filter is used to reduce variation in amplifier gain with wavelength, used in DWDM systems. The gain equalization is realized by inserting tapered long period gratings within the erbium doped fiber. Designed to have approximately the opposite spectral response to that of an EDFA. Wavelength division multiplexed (WDM) technology employing erbium-doped fiber amplifiers (EDFA's), however, provides an immediate Cost effective alternative for increasing network capacity[2]. In a multichannel environment optical amplifiers should provide a flat gain spectrum, independent of input parameters; however, this is not the case with erbium-doped fiber amplifiers. Indeed, the EDFA exhibits a non-uniform and dynamic gain spectrum, so that each channel input (at different wavelengths) to the amplifier experiences a different gain. When EDFA's are cascaded, this wavelength-dependent gain spectrum produces an accumulated imbalance (between different channels) in both the received power and signal-to-noise ratio (SNR) as signals propagate along the amplifier chain. The accumulated power and SNR imbalance can limit system performance in three different ways. The gain spectrum isn't flat, so there is power deviation between amplified signals If there are differences between optical signals transmitted by amplifiers, optical signals with low signal to noise ratio are more and more deteriorated at WDM as that are transmitted by EDFA. So as the transmission distance becomes more then the number of signal channels decrease. Therefore, it is needed that the gain of EDFA be flat in the range of signals for getting an adequate signal to noise ratio at each wavelength. One of the methods to flatten gain of EDFA is using an optical gain-flattening filter. This is the method to flatten the gain of EDFA by using a filter with reverse loss spectrum against the gain spectrum. This filter is called the optical gain-flattening filter.

This paper deals with gain flattening of EDFA using gain flattening filter.The problem of EDFA is ASE noise which results in uneven gain[3]. This paper is divided into two sections, in Section I we have described the gain flattening filter device through which we have flattened the gain of EDFA.In Section II we have designed the simulation model of gain flattening of EDFA using GFF and discussed its result in which we have shown the gain variation before passing through the GFF and after passing through the GFF which shows the equalised gain after passing through the GFF. This gain is flattened because the spectrum of the GFF is just opposite of the ASE generated by the conventional EDFA .We have then analysed the gain v/s wavelength plot in which small spike of 0.003 dB at 1530 nm wave length is shown. Band of spike is visible at the range of 1530 to 1540 nm wavelength due to the ASE of the EDFA.

II. SIMULATION MODEL OF GAIN FLATTENING OF EDFA USING GFF

Step 1: Designing the simulation model

In this simulation model we optimise the gain of the 8 DWDM channel over entire conventional band i.e. C band .EDFA has high gain, large bandwidth, and low noise but has uneven gain. This unevenness reduces the transmission bandwidth and degrades the performance of system[4]. The gain flattening is done with the help of the Gain Flattening Filter (GFFs). We approach to the external modulation in the proposed model. Numerical simulation result shows that this technique can minimise unevenness up to 0.003dB gain from 23.7371 db to 23.7341 dB in all the prescribed channels

Our proposed model is shown in the Figure 1 which consists of the WDM transmitter having the frequency of the 1525 nm with the spacing of the 5 nm at -20 dBm power. The signal is then routed to the WDM MUX whose properties are almost same to that of the WDM transmitter having the bandwidth of 13 GHz. The signal is than passed through the optical fiber through the EDFA. The WDM MUX receives the signal at the ONU side after passing through the GFF. The property of the ONU WDM MUX is similar to the transmitter. Finally the signal is retrieved by the photo detector as shown in Figure 5.2. The photo detector convert the optical signal to electrical signals which is processed to exact information. Low pass Bessel filter is used to limit the noise power BER analyzer is a universal component for performance indicators, which analyzes and show the BER, Q factor, Eye height and the threshold. The set up model in form of block diagram is shown in Figure 1, 2.

The WDM Transmitter generates eight channels from 1525 nm to 1560 nm, with power of -20 dBm per channel. The Gain Flattening Filter component is placed after the EDFA and it will equalize the amplifier gain. The user can change the filter parameters manually or use the Gain Flattening Filter Optimization of OptiSystem. The optimization engine is built specifically for the Gain Flattening Filter component and the Dual Port WDM Analyzer. Both modules must be present in the layout in order to use the optimization. The filter can be placed anywhere in a layout, for example, between two stages of an optical amplifier[5].

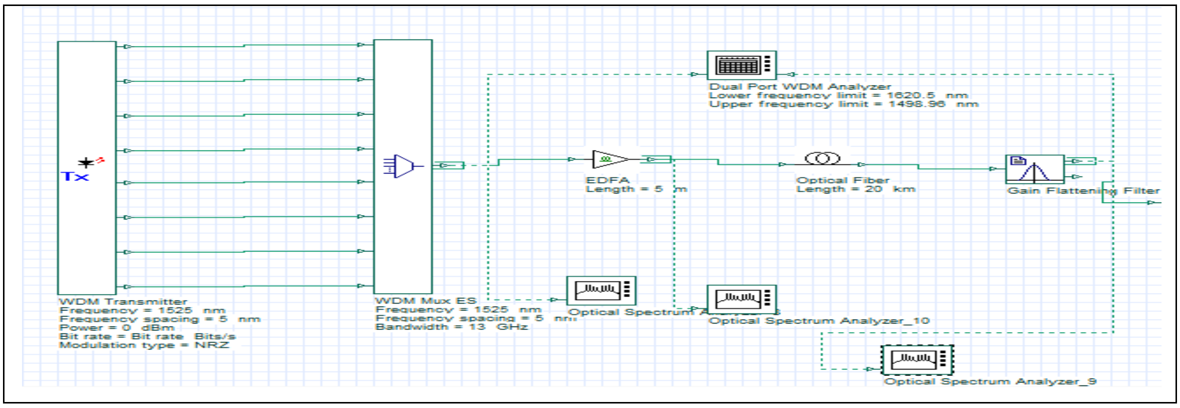

Figure 1 Set up Model of Gain flattening of EDFA using GFF (Transmitter Section)

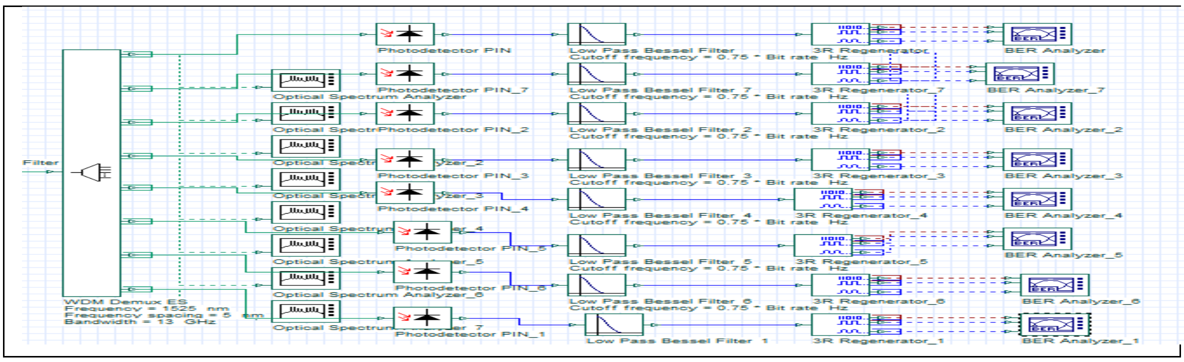

Figure 2 Set up model of Gain flattening of EDFA using GFF (Receiver Section)

The global parameter setup used in simulation of Gain flattening of EDFA using GFF

TABLE I .GLOBAL PARAMETER SETUP FOR GAIN FLATTENING OF EDFA USING GFF

Parameter	Value
Bit rate	10 Gbps
Time window	1.28e-008 s
Sampling rate	64 GHz
Sequence length	128 bits
Sample per bit	64
No of samples	8192

TABLE II COMPONENT VALUES OF TRANSMISSION LINKS FOR GAIN FLATTENING OF EDFA USING GFF

Component	Value
WDM Transmitter frequency	1525nm
WDM Transmitter frequency Spacing	5nm
WDM Transmitter Power	-20dBm
WDM Mux ES Bandwidth	13 GHz
EDFA length	5 km
Forward Pump Power	100mW
Backward Pump Power	0mW
WDM Demux Bandwidth	13GHz
WDM Demux frequency spacing	5nm
Optical fiber length	20Km

Step II. Simulation Result of Gain flattening of EDFA using GFF

Gain Flattening Filter (GFF) provides a simple and compact solution to flat the gain, when placed at transmission channel in a WDM-PON network, along with low power consumption[6]. In addition, the low cost and simple circuit make GFF very attractive for WDM-PON applications. This component provides a very large dynamic range (entire C band) to flat the gain of channels passing through it. This helps improve the modulation bandwidth, and reduce the non-linear effects and chirp. As a result high bit-rates can be achieved with minimal device and management cost. In this result analysis GFF is evaluated in detail. The issue with gain flattening due to various non-linear effects and their managements are addressed.

The under mentioned figure demonstrate the un-even gain of the conventional amplifier due to the non linear effect, which is responsible for the reducing the performance of the leading devices connected in the network. So in order to enhance the performance its important to flat the gain of the amplifier. This gain flattening is possible with the help of the GFF (Gain Flattening Filter).

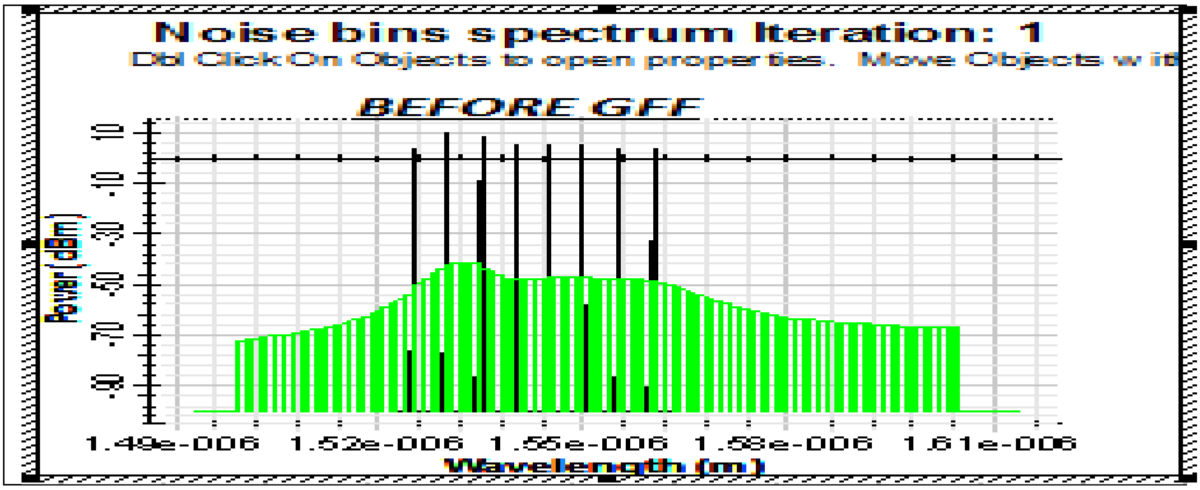

Figure 3 Gain before GFF

As the signal passes through the GFF the gain of the amplifier is flattened due to reduction in the uneven signal intensity over a specified wavelength range. The aspect is fully cleared with the help of the Figure 3, 4. The first

Figure 3 shows the gain variation before passing through the GFF, where as Figure 4 shows the equalised gain after passing through the GFF.

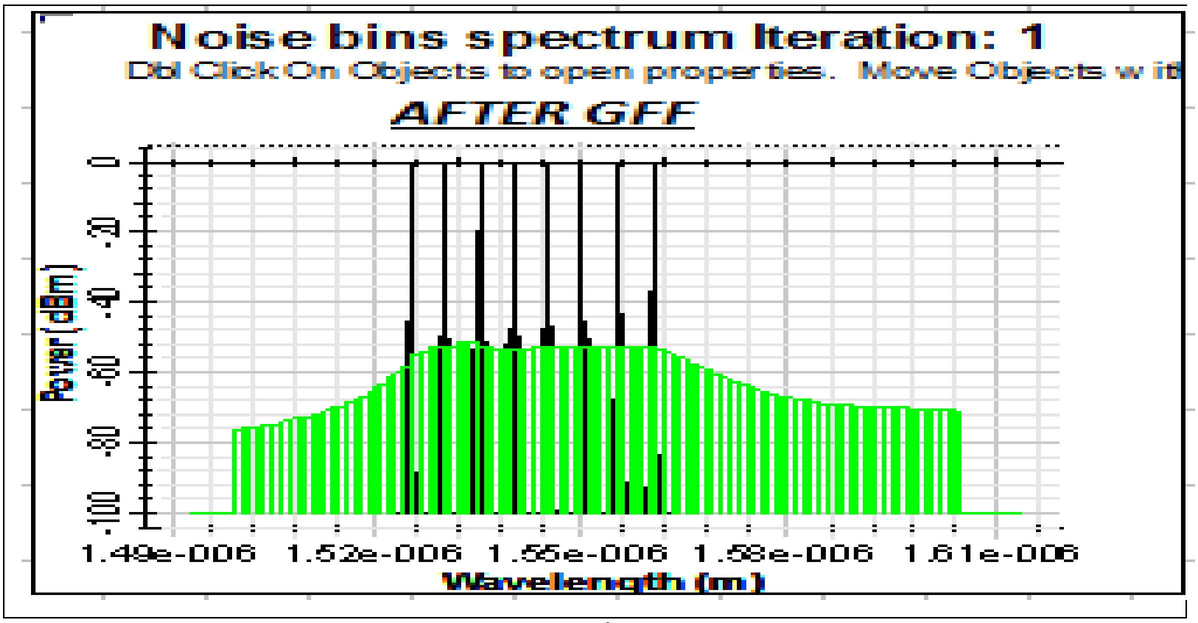

Figure 4. Gain after GFF

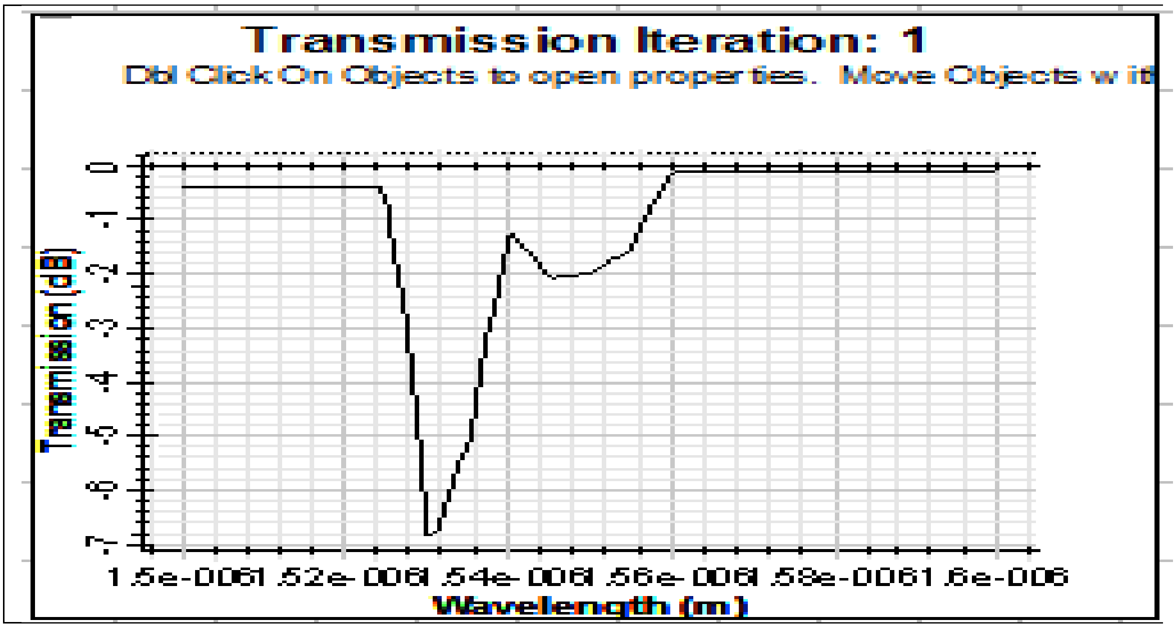

Figure 5 GFF spectrum

The spectrum of the GFF is demonstrated in the Figure 5 which is just opposite of the ASE generated by the conventional EDFA in order to compensate the unequal variation in the channels gain.

Step III. Analysis of Gain v/s Wavelength plot

The typical plotting of the graph between the gain and wavelength after GFF is shown in the Figure 6. As from the figure it is clear that the gain of the channels is almost flat ranging from 1525 to 1560 nm which is the range of the conventional band. Whereas a small spike of 0.003 dB at 1530 nm wave length is shown. Band of spike is visible at the range of 1530 to 1540 nm wavelength due to the ASE of the EDFA. The reason of this spike that frequency 1530 nm put a longer distance from 1550 nm window so this get more attraction with amplified spontaneous emission noise[7].

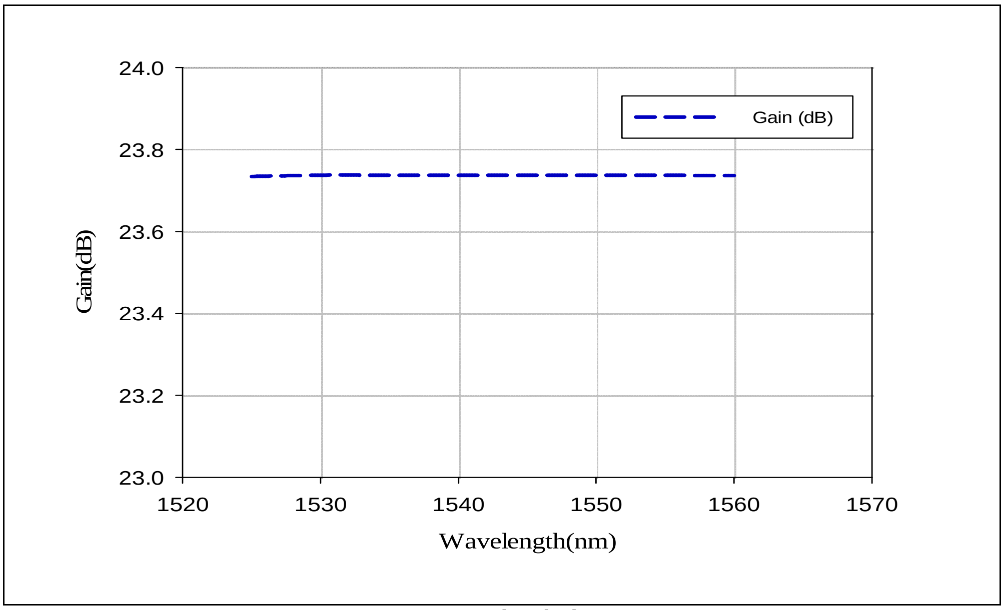

Figure 6 Gain v/s wave-length plotting

TABLE III SIMULATION READINGS OF GAIN FLATTENING OF EDFA USING GFF

Wavelength (nm)	**Gain(db)**
1525	23.734112
1530	23.737168
1535	23.736963
1540	23.737003
1545	23.736924
1550	23.736995
1555	23.736979
1560	23.735920

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ACKNOWLEDGMENT

This research project has been carried out in the optical communication laboratory under the Dept. of Electronics and Communication, BIST Bhopal. All authors and co-authors have contributed in this project.

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