Design and Analysis of Optical Amplifiers for 5G Applications: A Survey

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Abstract:

Optical amplifier is the foundational optoelectronic component required for perceiving prolong optical fiber communication links as well as networks. In long haul transmission attenuation and distortion occur and to resolve this problem need of optical amplifiers arises. This paper critically reviewed and analyzed both single and hybrid fiber amplifier for DWDM system. The design is imitated using Optisystem software to attain least BER, output power and large Q-factor. The survey has revealed that hybrid amplifiers performed better compared to existing single amplifier. It is concluded that various combination of hybrid amplifiers enhance the performance of optical networks and reduce issues related to an individual amplifier.

Keywords - Optical fiber amplifiers, WDM, Q-factor, BER, Output power.

I. INTRODUCTION

In recent years, there is increase in transmission of high capacity signals over prolong distances using optical transmission networks and systems. To increase high speed communication, DWDM system prefer in which bandwidth is divided into distinct channels with single information signal at different wavelengths. The transmission of high speed data over telecommunication networks in absence of repeaters will continue to grow exponentially and optical amplifiers will be great preference. Thus to increase efficiency of DWDM system several type of optical fiber amplifiers has been used.

Simply optical amplifiers is a fiber laser with no positive feedback and classified into two different categories such as linear optical fiber amplifiers (Er+ doped fiber amplifier) and non-linear optical fiber amplifier (Brillouin and Raman amplifiers). Most popular linear OFA is EDFA because of low loss in conventional communication band. While RFA is one of the common nonlinear FA due to small size, high coupling losses and noise figure, generation of cross talk with wide amplification bandwidth.

Optical amplifier provides data over large distances without any conversion from optical domain to electronic domain. Following are the types of various optical amplifiers:

A. SOA
It is the small size amplifier which uses semiconductor to amplify signals. An antireflection coat is used at the input along with output faces which leads to the reduction in end-face reflection. The multiple wavelengths get amplified result in quick response provided with crosstalk effects.

B. RAMAN
The amplification results from the signal and pump laser non-linear interactions which require an extreme pump power. It uses raman effect.

C. EDFA
It is widely used for large distance communication. It is formed by doping Er ions which can be efficiently pumped to provide large gain. It gives flat gain characteristics, low noise.

D. HYBRID
The adequate use of bandwidth using combination of optical amplifiers with different wavelengths connected either in series or in parallel results in hybrid amplifier. The various hybrid configurations are EDFAs and EDFAs, EDFAs and SOAs, EDFAs and RAs, TDFAs and FRAs, TDFAs and EDFAs etc. Till now we are dealing with two stage hybrid amplifiers. In future, scope of three stage amplifier may be discovered.
II. LITERATURE SURVEY

In literature survey, numerous WDM configurations using optical amplifiers have been proposed to get improved Q-factor, BER, noise figure, output power, OSNR, eye diagram. A.k.Abass et al. [1] investigated EDFA and RFA for different amplifier length, optimum pump power and get improved gain, noise figure, and 3dB bandwidth. N Saidin et al. [2] reviewed the performance of Raman-EDFA hybrid amplifiers using flat gain bandwidth, flat gain wavelength, flat gain. Anil Agarwal et al. [3] compared various single and hybrid RAMAN and EDFA to get improved output power, least BER, Q-factor where EDFA-EDFA performs better. Jyoti Gujral et al. [4] study WDM system with and without EDFA to get improved Q-factor, BER, Jitter, output power. M.M.Ismail et al. [5] demonstrated 16-channel WDM system with 8m fiber length consist of EDFA with improved output power and noise figure. Inderpreet Kaur et al. [6] presented that T DFA-EDFA gives improved Q-factor for more number of channels than EDFA-T DFA. Priyanka Sharma et al. [7] analyzed 64 channel DWDM system for distance 60km to get improved Q-factor and BER. Mehtab Singh et al. [8] proposed review on hybrid amplifiers in which EDFA-SOA are not generally realized in long-haul communication. Md. Moshiur Rahman et al. [9] proposed 16 and 32 channel DW DDM system with distance 150km to 450km to get improved gain, Q-factor, BER. Bars Altiner et al. [10] investigated 250 channel spacing 15GHz get improved gain, gain flatness for different optimum pump power and fiber length. Banaz O.Rashid et al. [11] demonstrated EDFA at 10Gbps and obtained different variations in gain and noise figure which are the function of fiber length, pump power, Erbium ion density which do not change when bit rate increased. B.Suneetha et al. [12] demonstrated 4channel WDM system with channel spacing 0.3nm in which intraband cross talk result in increase BER with increase number of channels. Seraji FE et al. [13] investigate different amplifier for different distance to get improved performance and Q-factor using different modulation techniques. Simranjit Singh et al. [14] demonstrated Raman-EDFA amplifier with more number of channels to get improved gain without using gain-flattening technique. Yukihiro Tsuchida et al. [15] presented 7-multicore EDFA for Full C-band and get improved gain and low noise figure. Annapurna Kumari et al. [16] proposed WDM system with low number of channels at different data rate and wavelength to get maximum Q-factor and improved flat gain. Prabhdeep Kaur et al. [17] demonstrate 32 channel*10Gbps with wavelength 1550nm using EDFA and NRZ modulation to achieve BER and Q-factor. Navneet Dayal et al. [18] demonstrated performance analysis of WDM system gives better SNR, reliability using optical amplifier after MUX and DEMUX. Deepti Ahlawat et al. [19] compared WDM system having EDFA and FBG combination using RZ and NRZ at different fiber length to get improved Q-factor. Kulwinder Singh et al. [20] compared pumping schemes in Raman amplifier to achieve high OSNR and Q-factor.
It is found that with increase in fiber span, the gain decreases, noise figure increases, BER increases but by using suited hybrid configuration according to the need of the user, improved results has been obtained like improved gain, flat-gain bandwidth, Q-factor and output power, low noise figure and BER for long haul communication.

III. DEMONSTRATION OF EXISTING DESIGNS

There are various proposed models for WDM system integrated with both single and hybrid optical fiber amplifiers. The simulates model consist of DWDM transmitter which includes data source pseudorandom bit sequence generator, NRZ pulse generator, CW laser source, Mach-Zehnder modulator, DWDM multiplexer, single as well as hybrid optical fiber amplifiers, DWDM de-multiplexer, DWDM receiver which include PIN photodetector, BER. The performance of model is analyzed using BER analyzer, Dualport WDM analyzer and Optical spectrum analyzer used for measuring BER, signal power ad spectrum at distinct level. Designs have different number of channel, data rate, channel spacing, input signal power, pump wavelength, fiber span, modulation format. The single and hybrid amplifiers lead us to various designs which is reviewed and critically analyzed below.

| Design no. | Specifications of amplifiers | Configuration |
|-----------|-----------------------------|---------------|
| 1.        | Single EDFA configuration[1,2,3,4,5,7,9,10,11,13,15,17,19] | ![Design 1 Configuration](image1) |
|           | • Frequency= 1530nm         |               |
|           | • Frequency spacing=5 nm    |               |
|           | • Power= -26 dBm            |               |
|           | • Er ion density=1100 ppm   |               |
|           | • EDFA length= 4m           |               |
| 2.        | Single RFA configuration[1,3,13,20] | ![Design 2 Configuration](image2) |
|           | • Frequency= 1520 nm         |               |
|           | • Frequency spacing= 10nm    |               |
|           | • Power= -40dBm             |               |
|           | • Raman length= 45 km       |               |
| 3.        | Hybrid EDFA-EDFA configuration[3] | ![Design 3 Configuration](image3) |
|           | • Frequency= 193.1 THz       |               |
|           | • Frequency spacing= 100 GHz |               |
|           | • EDFA length= 5m           |               |
IV. RESULT AND DISCUSSION

The configurations of distinct single as well as hybrid optical fiber amplifiers such as EDFA, Raman, EDFA-RAMAN, EDFA-EDFA, RAMAN-RAMAN, RAMAN-EDFA are analyzed and compared for 160 channels*10Gbps DWDM system using high Q-factor, output power, low BER at various distances from 50 to 250km using space of 50km. Irrespective of the design studied EDFA-EDFA perform better than any other configurations having 9.38 Q-factor, -20.90 BER, -20dBm output power at 150km distance.

V. CONCLUSION & FUTURE SCOPE

The performance of different single and hybrid amplifiers has been analyzed. Hybrid optical fiber amplifiers proved to be best suited for high transmission capacity telecommunication networks. Based on the above results and its analysis, it is concluded that DWDM system integrate with hybrid configurations for very large distances with refined bandwidth in addition to nonlinear effects and control impairment. In future WDM system performance can be enhanced using illustration of various parameters like BER, gain, output power, Q-factor with the hybrid EDFA-TDFA, EDFA- PDFA and various advanced optical technology configurations having
high performance at lower cost will be an appealing solution for advance telecommunications networks.

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