International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-7 Issue-3, July 2018

A Review on Doped Fiber Amplifiers

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Abstract: Optical intensifiers are ordered in light of the system that is fused for enhancement of the flag. Optical amplifiers are helpful in long separation correspondence that requires least weakening misfortune. This datasheet will expand on the development, working guideline and the uses of the different kinds of optical amplifiers. Doped fiber amplifiers (DFAs) are optical amplifiers that use a doped optical fiber as a gain medium to amplify an optical signal. They are related to fiber lasers. The signal to be amplified and a pump laser are multiplexed into the doped fiber, and the signal is amplified through interaction with the doping ions.

Index Terms: Laser, Doped, EDFA and YDFA

I. INTRODUCTION

Optical amplifiers are gadgets that increase an optical flag without changing over it into an electric flag. Optical intensifiers are of two sorts: laser enhancers and criticism amplifiers. Laser intensifiers don't have an optical hole, while the input enhancers comprise of a stifled depression.

Optical intensifiers are ordered in light of the system that is fused for enhancement of the flag. Optical amplifiers are helpful in long separation correspondence that requires least weakening misfortune. This datasheet will expand on the development, working guideline and the uses of the different kinds of optical amplifiers.

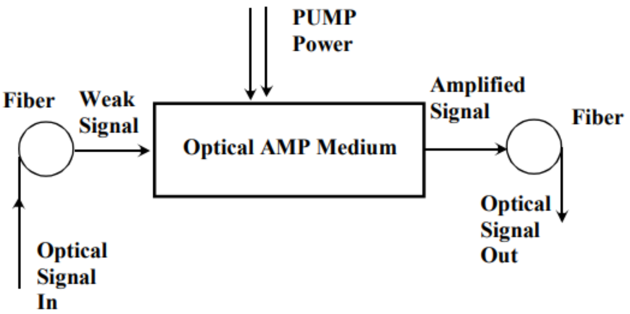

Fig 1: Optical Communication

Optical fiber amplifiers are categorized based upon different physical mechanisms, as follows:

- Doped fiber amplifiers (DFA): Use a doped optical fiber medium for boosting signals in a similar manner to fiber lasers. The signal requiring amplification, along with a pump laser, is multiplexed in a doped fiber medium and intersects with doping ions. Amplified spontaneous emission is the major reason behind the DFA noise. An ideal noise level for DFA is around 3 decibels. Practically, the noise figure is calculated at around 6 to 8 decibels.
- Semiconductor optical amplifiers: Use semiconductors to produce the gain medium in the laser. The analogous structure is made of laser diodes. The recent design of semiconductor optical amplifiers has added antireflective coatings and window regions to minimize the end face reflection.
- Raman amplifiers: Employ Raman amplification techniques to boost optical signals. The two types of Raman amplifiers are distributed, where the transmission fiber is used by multiplexing the pump wavelength along with the signal wavelength as the gain medium, and lumped, where short length and dedicated fibers are used for amplification. Nonlinear fiber is used to increase the intersection between the pump wavelength and the signal to reduce the fiber to the required length.
- Optical parametric amplifiers: Permit the amplification of weak signal impulses to a nonlinear optic medium. They use non-collinear interaction geometry for broader bandwidth amplifications.

II. TYPES OF OPTICAL AMPLIFIER

There are three types of optical amplifiers. These are following:

A. Laser Amplifiers

Almost any laser active gain medium can be pumped to produce gain for light at the wavelength of a laser made with the same material as its gain medium. Such amplifiers are commonly used to produce high power laser systems. Special types such as regenerative amplifiers and chirped-pulse amplifiers are used to amplify ultrashort pulses.

B. Solid-State Amplifiers

Solid-state amplifiers are optical amplifiers that use a wide range of doped solid-state materials and different geometries (disk, slab, rod) to amplify optical signals. The variety of materials allows the amplification of different wavelength while the shape of the medium can distinguish between more suitable for energy of average power scaling.[2]

Revised Manuscript Received on 30 July 2018.
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Beside their use in fundamental research from gravitational wave detection[3] to high energy physics at NIF they can also be found in many today's ultra-ultra short pulsed lasers.

C. Doped Fiber Amplifiers

Doped fiber amplifiers (DFAs) are optical amplifiers that use a doped optical fiber as a gain medium to amplify an optical signal. They are related to fiber lasers. The signal to be amplified and a pump laser are multiplexed into the doped fiber, and the signal is amplified through interaction with the doping ions.

III. AMPLIFIER PARAMETERS

Different parameters that affect the performance of amplifier. These are:

A. Optical Gain

Optical amplifier is a laser without feedback. The optical gain, in general, depends not only on the frequency (or wavelength) of the incident signal, but also on the local beam intensity at any point inside the amplifier.

B. Gain Spectrum and Bandwidth

Optical gain provided by amplifier start decreasing in saturated region is given as

$$g(w) = \frac{g_0}{1+(w-w_0)^2 T_2^2}$$

C. Gain Saturation

The amplification factor *G* decreases with an increase in the signal power. This phenomenon is called gain saturation.

D. Amplifier Noise

All amplifiers degrade the signal-to-noise ratio (SNR) of the amplifier signal because of spontaneous emission that adds noise to the signal during its amplification.

IV. PRINCIPLE OF OPTICAL AMPLIFIER

The working of the optical amplifiers varies with the mechanisms used for amplification. The working of each of the amplifier types is as below:

- Laser/doped fiber amplifier – stimulated emission of the gain medium of the amplifier causes amplification of the input wavelength.
- Semiconductor optical amplifiers (SOAs) – the amplification is brought about by the recombination of the electron hole pairs.
- Raman amplifiers – elastic scattering of the incoming light with the phonons present in the lattice of the gain medium, results in the production of phonons that are coherent with the incoming light.
- Optical parametric amplifier – a weak input signal is amplified in a non-Centro symmetric nonlinear medium.

V. WORKING PRINCIPLE

The working of the optical amplifiers varies with the mechanisms used for amplification. The working of each of the amplifier types is as below:

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VI. APPLICATIONS OF DOPED OPTICAL AMPLIFIER

The applications of the various types of optical amplifiers are given below:

- Doped fiber amplifiers are used in wavelength division multiplexed communication and high power laser systems
- Semiconductor optical amplifiers are used in optical signal processing, wavelength conversion, signal demultiplexing and pattern recognition
- Optical parametric amplifier is used for expanding the tunability of ultrafast solid state lasers.

VII. EDFA AND YDFA

A. Erbium Doped Fiber Amplifiers (EDFA

The most important version is erbium doped fiber amplifiers (EDFAs) due to their ability to amplify signals at the low loss 1.55 m wavelength range.

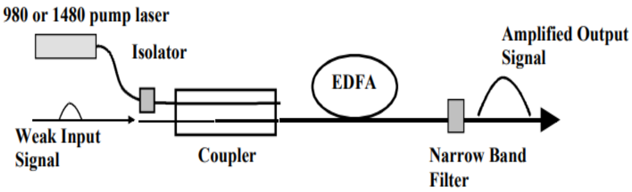

Fig: 2 EDFA Amplifier Configuration

B. YDFA

Ytterbium is a chemical element with symbol Yb and atomic number 70. It is the fourteenth and penultimate element in the lanthanide series, which is the basis of the relative stability of its +2 oxidation state. However, like the other lanthanides, its most common oxidation state is +3, as in its oxide, halides, and other compounds. In aqueous solution, like compounds of other late lanthanides, soluble ytterbium compounds form complexes with nine water molecules. Because of its closed-shell electron configuration, its density and melting and boiling points differ significantly from those of most other lanthanides.

VIII. LITERATURE REVIEW

The indispensible output power spectrum for optical amplifier system in the presence of temperature using EDFA and YDFA is numerically investigated.

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The notion of temperature suggested as −30 °C, 30 °C, 60 °C, 90 °C. Each output spectrum has been analyzed at −30 °C, 30 °C, 60 °C, 90 °C in both EDFA and YDFA systems. The output power at the point of two maxima as 26.829 dBm and 23.260 dBm at wavelengths 1530 nm and 1550 nm for EDFA, maximum output power as −6.499 dBm at wavelength 1043 nm for YDFA system are examined keeping 900mw pump power and 60 °C temperature. Similarly, the maximum output power is analyzed as −6.499 dBm at the wavelength of 1043 nm for the same pump power and temperature in YDFA system[1] the power consumption of optical amplifiers and the trade-off between power consumption and system performance. The power consumption model includes erbium-doped fiber-amplifiers (EDFA), backwards pumped Raman amplification and monitoring and management electronics. Performance is studied using the Gaussian-noise model for nonlinear interference. We find that the power consumption of the monitoring and management electronics has large impact on which system configuration that gives the lowest overall power consumption, where a low value favors shorter spans and EDFA-only amplification, while a high value favors longer spans with Raman amplification[2].

In this paper, 32×10Gb/s DWDM system using hybrid amplifiers (Raman-EDFA and YDFA-EDFA) have been investigated at different channel spacing (100GHz, 75GHz, 50GHz and 25GHz) to analyze the effect of FWM by varying the length of optical fiber from 40-220km. It has been observed that as the channel spacing reduces, the performance of the system degrades drastically. It is reported that Raman-EDFA shows better overall system performance as compared to YDFA-EDFA. The maximum repeaterless transmission distance for the worst case scenario at 25GHz channel spacing is 120 and 100km for Raman-EDFA and YDFA-EDFA respectively. The 32 × 10Gb/s DWDM system has been analyzed using YDFA-EDFA and Raman-EDFA hybrid amplifier having 100GHz, 75GHz, 50GHz and 25GHz channel spacing and performance has been evaluated on the basis of transmission distance. From the results it has been concluded that Raman-EDFA outpower YDFA-EDFA in terms Q-factor at higher channel spacing. As channel spacing reduces and transmission distance increases Raman-EDFA and YDFA-EDFA shows comparable results. At last, from the optical spectrums it has been observed that as the channel spacing reduces the effect of four wave mixing drastically increases[3].

Supercontinuum (SC) generation directly from an Ytterbium-doped fiber amplifierb(YDFA) has many advantages such as high output power, low splicing loss, and high optical to optical conversion efficiency. However, the output spectrum can only extend to longer wavelength. We report a method to further extend the spectral range of SC generated in an YDFA at short wavelength direction by using cascaded double-clad passive fiber tapers. A 750 ps seed pulse at 1060 nm is amplified to 15.9 W and spectrally broadened from 1000 to 1600 nm in an YDFA system. Using this broadband source to pump cascaded double-clad passive fiber tapers, a 14.1WSC source is obtained, covering 630 to 2000 nm, which is in an all-fiber and low-cost structure. It is found that, in fiber tapers, especially at the taper waist, the frequency shift rate of solitons increases significantly, and those red-shifted solitons are group-velocity matched to dispersive waves even in the red wavelength region.[4]

This paper describes the design and implementation of an advanced photonics experiment aimed at the undergraduate students' level. The experiment uses erbium-doped fiber to implement three functions through slight modifications of the setup. The functions are a broadband light source, a multi-wavelength optical amplifier, and a tunable fiber laser. As part of an Optical Communication Systems course, the experiment is targeted towards fourth year engineering students at the University of Toronto. The design of the experiment is especially attractive for large classes, where feasibility and cost effectiveness play a pivotal role.[5]

The scope of this paper is to analyze ASE (Amplified Spontaneous Emission) noise power using the simulation model EDFA(Erbium Doped Fiber Amplifier) cascaded with EYCDFA (erbium-ytterbium co-doped fiber amplifier) in 4-16 channels of transmitters combined by optical multiplexer and sent the output to EDFA in series with EYCDFA in single backward pumping using the wavelength of 980nm. This simulation model performance was analyzed with the parameters Gain, forward output signal power and ASE noise was measured and the values are tabulated. The simulation model consists of 2- 16 channels of RZ transmitter and 2- 16 channels of NRZ transmitter's outputs were multiplexed with optical multiplexer and multiplexed signal sent to cascaded Erbium amplifiers with pumping CW (continuous wave) Laser source with wavelength 980nm and Filter. The resulting model accurately represents EDFA Gain and output signal power and ASE noise. Simulation results shows that by choosing careful fiber length 20m and pump power 1mw in single pumping gives ASE noise 0.005mw using EDFA and EYCDFA gives zero mill watts. In summarize, simulated the Cascaded model EDFA and EYCDFA with the input of 4- 16 channels transmitter output using single pumping scheme of 980nm.[6]

In this paper, 32 × 10Gb/s dense wavelength division multiplexing (DWDM) optical system using ytterbium doped fiber amplifier (YDFA) having 100GHz, 75GHz, 50GHz and 25GHz channel spacing with starting frequency 193.414THz has been investigated. The performance of the end channel (first) has been considered being the worst case scenario to analyze the system. The DWDM system is evaluated by varying the length for the optical fiber from 40- 160km. It has been found that as the channel spacing decreases the performance drastically degrades owing to four wave mixing (FWM) effect. The best results have been reported for the system at the 100GHz channel spacing where the maximum Q factor (23.35dB) and output power (-1.156dBm) is achieved at 40km fiber length.[7]

In this study, importance of optical amplifiers which are used in optical communication systems is explained and gains of EDFA, Erbium Doped Fiber Amplifier, and YDFA, Ytterbium Doped Fiber Amplifier, which are among the most commonly used optical amplifiers today, are analysed based on their performance parameters. The effects of the power of input signal, the power of pump laser, the length of doped fiber which is used for amplification and the wavelength of the input signal on the gains of the optical amplifiers are examined by the setups which are prepared by Opti System 7.0 simulation program.

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The analyses have shown that the gain of EDFA is superior to that of YDFA [8]. In this paper brief description of the pumping techniques is shown and comparison of the pumping techniques is done. We present the results of an investigation of optical gain and noise figure for simultaneous multi-channel amplification of an erbium doped fibre amplifier (EDFA) under optimized pump condition. Different pump configurations with varying input signal levels show interesting features on gain flatness. In the experiment, population inversion along the fibre length which determines the gain-spectra and noise characteristics of the amplifier is adjusted through optimized fibre length and injected pump power in order to minimize the gain-tilt at C-band. It is observed that bi-directional pumping manifests the best combination of low noise and high gain of EDFA which are useful as in-line repeaters in WDM network. We obtain 30 +/- 1.5 dB intrinsically flat small signal gain from 1538 nm to 1558 nm band of wavelength with noise figure < 4 dB for 16-channel simultaneous amplification in a single stage EDFA without gain flattening filter.[9]

IX. CONCLUSION

In this study, importance of optical amplifiers which are used in optical communication systems is explained and gains of EDFA, Erbium Doped Fiber Amplifier, and YDFA, Ytterbium Doped Fiber Amplifier, which are among the most commonly used optical amplifiers today, are analysed based on their performance parameters. The effects of the power of input signal, the power of pump laser, the length of doped fiber which is used for amplification and the wavelength of the input signal on the gains of the optical amplifiers can be examined by the MATLAB.

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