OPTICAL AMPLIFIERS: CONCISING THE OPTICAL NETWORK

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Abstract:Optical amplifiers have found widespread use in optical networks.Altogether with the wavelength-division multiplexing (WDM) technology.Thus, enabling the transmission of multiple channels over the same fibre.Optical amplifiers have made it possible to transmit many terabits of data over distances from a few hundred kilometers and up to transoceanic distances, meeting the ever growing capacity of current and future communication networks.

Keywords: optical amplifiers, gain, multiplexing, booster amplifiers, optical networks, etc.

I. INTRODUCTION

To amplify an optical signal with a conventional repeater, one used to perform photon-to-electron conversion, electrical amplification, retiming, pulse shaping and then electron-to-photon conversion. Although this process works well for moderate-speed single-wavelength operation, it can be fairly complex and expensive for high speed multi-wavelength systems. Thus, a great deal of effort has been expended to develop all-optical amplifiers. These devices operate completely in the optical domain to boost the power levels of light wave signals for the two long-wavelength transmission windows [1-4]. An optical amplifier is a device that amplifies an optical signal directly, without making a compulsion to convert it into an electrical signal. An optical amplifier can work on lines of lasers without an optical cavity or one in which feedback from the cavity is suppressed. It holds great importance in optical communication and laser physics.

Amplification of light signals can be carried out through different physical mechanisms, thus, leading to numerous optical amplifiers.

In-line optical amplifiers:-In a single–mode link, the effects of fibre dispersion may be small so that the main limitation to repeater spacing is fibre attenuation. Since such a link does not necessarily require a complete regeneration of the signal, simple amplification of the optical signal is sufficient. Thus, optical amplifiers can be used to compensate for transmission loss and increase the distance between regenerative repeaters.

Preamplifier: -a weak optical signal is amplified before photodetectionso that the signal-to-noise ratio degradation caused by thermal noise in the receiver can be suppressed. Optical preamplifier provides a larger gain factor and a broader bandwidth.

Booster amplifiers: - booster amplifiersinclude placing the device immediately after an optical transmitter to boost up the transmitted signal. It can also be employed in a local area network to compensate for couple-insertion loss and power-splitting loss.

1. A.ERBIUM - DOPED FIBRE AMPLIFIER

In doped fibre amplifiers and bulk lasers, stimulated emission in the amplifier's gain medium causes amplification of incoming light. The optical fibre can be doped with any of the rate earth element, such as Erbium(Er),Ytterbium(Yb), Neodymium(Nd), or Praseodymium(Pr) . The host fibre material can be either standard silica, a fluoride based glass or a multi component glass. The operating regions of these devices depend on the host material and doping elements. Fluorozirconate glasses doped with Pr or Nd are used for operation in the 1300nm window, since neither of these ions can amplify 1300nm signals when embedded in silica glass [2, 13, 18]. The most popular material for long haul telecommunication applications is a silica fibre doped with Erbium, which is known as an EDFA [3, 5, 7, 8, 11, 20]. In some cases, Yb is added to increase the pumping efficiency and the amplifier gain [4] .The operation of an EDFA by itself normally is limited to the l530-1560 nm region. However, when combined with a Raman fiber amplifier that boosts the gain at higher wavelength, a 3-dB gainbandwidth of 75 nm has been achieved over the 1531 to 1616nm region [10].Amplification is achieved by stimulated emission of photons from dopant ions in the doped fiber. The pump laser excites ions into a higher energy from where they can decay via stimulated emission of a photon at the signal wavelength back to a lower energy level. The excited ions can also decay spontaneously or even through non-radioactive processes involving interactions with phonons of the glass matrix. These last two decay mechanisms compete with stimulated emission reducing the efficiency of light amplification. The signal to be amplified and a pump laser are multiplexed into the doped fibre, and the signal is amplified through interaction with the doping ions[17].

2. B.SEMICONDUCTOR OPTICAL AMPLIFIRS

The two major types of semiconductors optical amplifiers are the resonant, Fabry-Perot amplifier (FPA) and the no-resonant, travelling –wave amplifier (TWA)[9, 14, 15, 19]. In an FPA, the two cleaved facets of a semiconductor crystal act as partially reflective end mirrors that form a Fabry-Parot cavity [1, 16]. The natural reflectivity of the facets is approximately 32%. It can be enhanced through reflective dielectric coating deposited on the ends. Optical signal on entering the FPA gets amplified as it is reflected back and forth between the mirrors unless it is emitted at a higher intensity. Fabrication and designing of FPAs are simpler. However, the optical signal gain is very sensitive to variations in amplifier temperature and injection current.

The travelling-wave amplifier is fabricated on similar ground as of FPA; the only difference is that the end facets are either antireflection-coated or cleaved at an angle. So, that the internal reflection does not take place. Thus, the input light gets amplified only once during a single pass through the TWA. They hold more practical applications as they have a large optical bandwidth, high saturation power and low polarization sensitivity.

3. C.RAMAN AMPLIFIER

In a Raman amplifier, the signal is amplified by a process called stimulated Raman scattering (SRS),in which light is scattered by atoms from a lower wavelength to a higher wavelength. When sufficient pump power is present at a lower wavelength, stimulated scattering can happen in which a signal with a higher wavelength is amplified by Raman scattering from the pump signal. SRS is a nonlinear interaction between the signal (higher wavelength) and the pump (lower wavelength). The efficiency of the SRS process is low in most fibers, meaning that high pump power (typically >1 W) is required to obtain useful signal gain, so in most cases Raman amplifiers cannot compete effectively with EDFAs. The main advantage of Raman amplifier is that its gain spectrum is very wide (upto 10 nm), and its shape can be changed by varying the number of pumps and their pump wavelengths and it also has relatively low NF making it more efficient. These two aspects make Raman amplifiers the main component of optical systems, as they can be used to broadening and equalizing the gain spectrum of a particular amplifier, with addition of very little noise to the amplified signal. They can be combined with EDFAs to expand optical gain flattened bandwidth. Disadvantages of Raman amplifiers are the pumping efficiency at lower signal power is poor, and the use of costly high power lasers capable of delivering great powers into single mode fibers. Basically two types of Raman amplifiers as given below: Distributed Raman amplifier is one in which the transmission fiber is utilized as the gain medium by multiplexing a pump wavelength with signal wavelength and generally length of fiber is longer(~100 km). Discrete Raman amplifier utilizes a dedicated, shorter length of fiber (~20km) to provide amplification, reason for reduced length is highly non linearfiber with a small core is used to increase the interaction between signal and pump wavelengths [17]

D.OPTICAL AMPLIFIERS AS OPTICAL – GATING WAVELENGTH CONVERTERS

An optical wavelength converter is a device that can directly translate information contained on an incoming wavelength to a new wavelength without entering the electrical domain. This is an important component in all optical networks, since the wavelength of the incoming signal may already be in use by another information channel residing on the destined outgoing path. Converting the incoming signal to new wavelength will allow both the information channels to traverse the same fiber simultaneously. In various optical –gating techniques semiconductor optical amplifiers are used. Wavelength conversion based on non-linear optical wav mixing offers important advantages compared with other methods [6,12]. These include a multi wavelength conversion capability and transparency to the modulation format. The mixing results from non-linear interactions among optical waves traversing a non-linear material. The outcome is the generation of another wave whose intensity is proportional to the product of the intensities of the interacting waves. The phase and frequency of the generated wave are a linear combination of those of the interacting waves. Therefore, the wave mixing preserves both amplitude and phase information and consequently, is the only wavelength conversion category that offers strict transparency to the modulation.

II. CONCLUSION

Optical amplifiers play a major role in optical communication as they provide amplified signal as well as optimum parameters for the transmission of the data. The input wavelength is taken in the range of 1520-1617nm. An optical amplifier enhances the gain band width and reduces the noises in the signal. EDFA ensures high power efficiency. Raman amplifiers give broad amplification and lesser signal distortions.

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