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OPTICAL AMPLIFIERS: ENHANCING THE SPEED AND REACH OF FIBER-OPTIC COMMUNICATION. ОПТИЧЕСКИЕ УСИЛИТЕЛИ: ПОВЫШЕНИЕ СКОРОСТИ И ДАЛЬНОСТИ ОПТИЧЕСКОЙ СВЯЗИ.

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Аннотация: Сегодня цифровые коммуникации стремительно растут. Спрос на высокоскоростные интернет-соединения и эффективную передачу данных растет тоже. Поэтому, оптические усилители стали главной частью систем оптической связи, изменяя способ передачи информации на огромнейшие расстояния. В данной статье описан принцип работы оптического усилителя и его виды. Также перечислены преимущества и недостатки каждого вида.

Introduction

An optical amplifier is a device that amplifies an optical signal without converting them into an electrical signal. This works on the principle of stimulated radiation, in which photons of light interact with the active medium of the amplifier and cause the emission of additional photons, amplifying the original signal. The active medium can be different: erbium, semiconductors, solid-state materials or fiber-optic elements.

The amplifier plays a very important role in maintaining signal quality and extending the range of networks. Using the features of light, amplifiers allow you to transmit information over long distances without losing the original power.

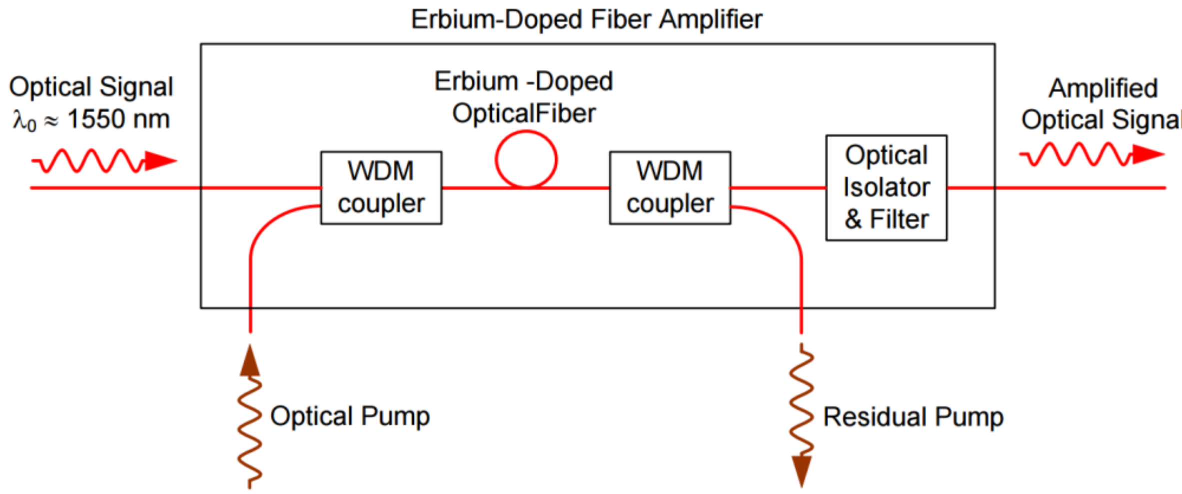
There are several types of optical amplifiers:

1. Erbium-based optical amplifier (EDFA)
2. Raman Optical Amplifier (ROA)
3. Family of semiconductor laser amplifiers (SOA)
4. Optical amplifier based on solid-state laser (SOLA)
5. Optical amplifier based on fiber-optic laser (FOLA)

Each type of optical amplifier has its own characteristics and advantages, as well as disadvantages that may affect the choice of a particular type of amplifier depending on specific requirements and application conditions.

Erbium-doped Optical Amplifiers (EDFA) are the most popular among other amplifiers. They work on the principle of stimulated radiation. It means that photons passing through an erbium-doped fiber optic cable stimulate the emission of additional photons. This process occurs in the wavelength range of 1550 nm, which is used in optical communication systems. Another interesting fact about this amplifier: EDFA has two commonly used pump bands – 980 nm and 1480 nm. The 980 nm band has a higher absorption cross-section and is usually used where a low noise level is required. The absorption band is narrow, therefore, laser sources with a stabilized wavelength are required. The 1480 nm band has a smaller but wider absorption cross-section and is usually used for higher power amplifiers.

The circuit of the amplifier:



Advantages and disadvantages

When compared with conventional electronic amplifiers, optical amplifiers have numerous advantages. Firstly, they eliminate the costly and time-consuming signal conversion, providing faster and more efficient data transmission. Secondly, they can amplify several signals simultaneously, allowing the use of the wavelength-division multiplexing (WDM) method, in which different signals are combined and transmitted over a single optical fiber. This increases the network bandwidth many times and reduces complexity. The third advantage is the ability to restore signals. The light loses power while moving along the cable due to the attenuation of the optical fiber. Amplifiers can recover this loss and restore the signal to its original state. This improves range and reliability.

Optical amplifiers have several disadvantages as well. Some species have the following disadvantages:

1. Erbium-based optical amplifier (EDFA) - high cost and complexity of maintenance, sensitivity to temperature changes.
2. Raman Optical Amplifier (ROA) - low efficiency and relatively small bandwidth.
3. Semiconductor laser amplifier (SOA) family - high noise level, limited power and insufficient stability.
4. Optical amplifier based on solid-state laser (SOLA) - large size and weight, high production cost.
5. Optical amplifier based on fiber optic laser (FOLA) - limited transmission range, high sensitivity to mechanical damage.

Areas of application

Optical amplifiers have found widespread applications in various sectors, including telecommunications, internet data centers, and long-haul communication networks. They have played a crucial role in enabling high-speed internet connections, facilitating video streaming services, and supporting the exponential growth of data traffic. In addition, they are used in the following fields of activity:

1. Telecommunications: Optical amplifiers are used to amplify optical signals in fiber optic networks, increasing the data transmission range and reducing signal loss.
2. Medical diagnostics: Optical amplifiers can be used to amplify optical signals in medical devices such as endoscopes and laser systems for the diagnosis and treatment of various diseases.
3. Laser systems: Optical amplifiers are used to amplify laser signals, which makes it possible to create more powerful and efficient laser systems for various applications.
4. Scientific research: Optical amplifiers are widely used in scientific research, including physics, chemistry, biology and other fields where amplification of weak optical signals is required for analysis and measurement.
5. Military equipment: Optical amplifiers are used in various military applications, including night vision, laser weapons, communication systems and others.
6. Manufacturing and Industry: Optical amplifiers can be used to amplify optical signals in manufacturing and industrial processes such as laser cutting, welding, marking and others.

Conclusion

Optical amplifiers have become an essential tool for enhancing the speed and reach of fiber-optic communication systems. Their ability to amplify and regenerate optical signals without converting them into electrical signals has revolutionized digital communication, making it faster, more reliable, and capable of transmitting vast amounts of data over long distances. As technology continues to advance, optical amplifiers will play a vital role in meeting the growing demands of our increasingly connected world.

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