The Ultimate Guide to Fibre Optic Attenuators

White paper

Introduction

The signal power in fibre optic links is sometimes needed to be strengthened to achieve long-haul data transmission. While under certain circumstances, too much signal power can overload fibre optic receivers and even damage the optical network. To reduce the power in fibre links, fibre optic attenuators are leveraged. This white paper will shed light on the types, working principles, and applications of fibre optic attenuators, which will help you gain a comprehensive understanding of fibre optic attenuator.

Optronics® is one of the few global manufacturers who have developed a process of quality manufacturing and inspection to meet the stringent specification of the premium optical fibre attenuators. This white paper gives a complete illustration of the Optronics® common fibre optic attenuators.

What Are Fibre Optic Attenuators?

Fibre optic attenuators, also called optical attenuators, are passive devices used to reduce the power level of an optical signal. Since too much light may saturate the fibre optic receiver, optical attenuators are often deployed in the system to reduce the light power and achieve the best fibre optic system performance. Generally, multimode systems do not need attenuators as the multimode sources, even VCSELs, rarely have enough power output to saturate receivers. Instead, for single-mode systems, especially the long-haul DWDM network links, fibre optic attenuators are necessary for balancing the optical power during the transmission.

As an optical passive device, fibre attenuator is usually made of attenuation fibre with metal ions. It can adjust the optical power to the required level. It is mainly used in optical communication system to debug the optical power performance, calibrate the calibration of optical fibre instrument and reduce the attenuation of optical fibre signal.

Working Principles of Fibre Optic Attenuators

Optical attenuators achieve the desired attenuation in optical fibre links in three different principles, which relatively are gap-loss principle, absorptive principle, and reflective principle.

Gap-loss Principle:

With the principle of gap loss, power reduction is achieved by inserting the device in the fibre path with an in-line configuration. Gap-loss attenuators are placed close to the transmitter to prevent the saturation of the receiver. They use a longitudinal gap between two optical fibres so that the optical signal passed from one optical fibre to another can be reduced. This principle allows the light from the transmitting optical fibre to spread out as it leaves the optical fibre. When the light gets to the receiving optical fibre, part of the light is lost in the cladding because of a gap and the spreading occurred. These optical attenuators should be kept close to the transmitter to ensure its effective performance. To reduce the signal farther down the fibre path, an optical attenuator using absorptive or reflective techniques would be more suitable.

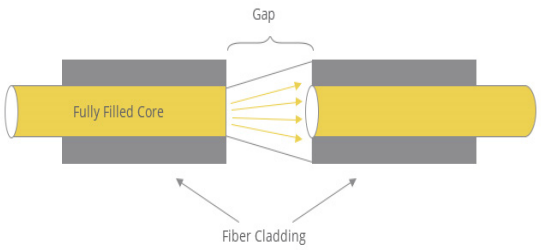


Fig 1: Gap Loss Principle

Absorptive Principle:

The absorptive principle, or absorption, accounts for a fraction of power loss in optical fibre. This is because optical fibre absorbs optical energy and converts it to heat. Absorptive principle can be employed to design an optical attenuator with a known reduction of power. The absorptive principle uses material in the optical path to absorb optical energy. The principle is simple but can be an effective way to reduce the power being transmitted and received.

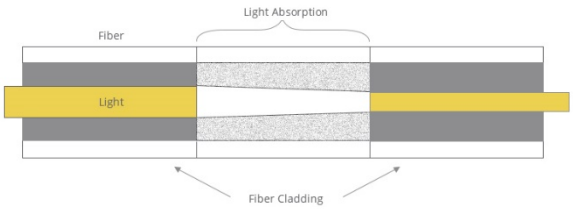


Fig 2: Absorption Principle

Reflective Principle:

The reflective principle, or scattering, accounts for a fraction of power loss in optical fibre and also results from the imperfections of optical fibre. But in this case, it causes the signal to scatter. The scattered light inserts interference in the optical fibre, thereby reducing the amount of transmitted and received light. This principle can be employed in the planned attenuation of a signal. The material used in the fibre optic attenuator is manufactured to reflect a known quantity of the signal, thus allowing only the desired portion of the signal to be propagated.

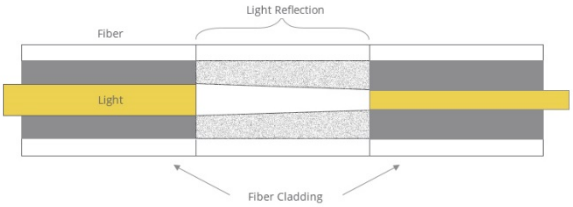


Fig 3: Reflective Principle

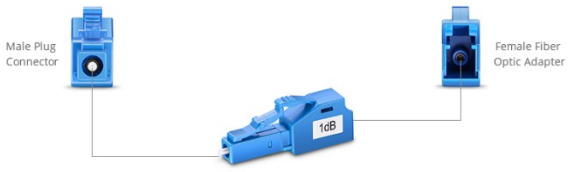
How Many Types of Fibre Optic Attenuators Are There?

Fibre optic attenuator takes a number of different forms. You can find many optical attenuators types in the market with different classification perspectives such as the connector type, cable type, etc. Generally, they are widely accepted to be grouped as fixed optical attenuators (FOA) and optical variable attenuators (VOA). While considering the types of cables, they can also be divided into single-mode and multi-mode attenuators.

Fixed Optical Attenuator

Fixed attenuator, as the name of which has indicated clearly, is designed to have an unchanging level of attenuation in optical fibre, expressed in dB, typically between 1dB and 30dB, such as 1dB, 5dB, 10dB, etc. Fixed optical attenuators may use a variety of principles for their functioning. Preferred optical attenuators often use either doped fibres, or misaligned splices, or total power while non-preferred attenuators often use gap loss or reflective principles.

As shown in the figure below, fixed value attenuators consist of in-line type and connector type. In-line type looks like a plain fibre patch cable. The in-line type optical attenuators are incorporated into patch cables. Connector type attenuator looks like a bulkhead fibre connector. Usually, it has a male plug connector at one side to allow fibre attenuator to be plugged directly into receiver equipment or adapters in patch panel, and at the other side there is a female type fibre optic adapter to allow the patch cords to plug in. There are also female to female optical attenuators, which can be used as adapters and attenuators at the same time. Their applications include telecommunication networks, optical fibre test facility, Local Area Network (LAN) and CATV systems.

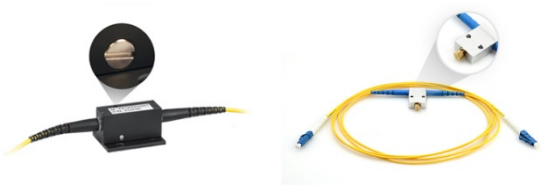


Optical Variable Attenuator

Optical variable attenuator, or variable optical attenuator (VOA), generally uses a variable neutral density filter. VOA is generally used for testing and measurement, but it is also widely adopted in Erbium-Doped Fibre Amplifier (EDFA) for equalizing the light power among different channels. It has advantages of being stable, wavelength insensitive, mode insensitive, and offering a large dynamic range.

Basically, there are two types of optical variable attenuators: stepwise variable attenuators and continuously variable attenuators. Stepwise variable attenuators can change the attenuation of the signal in known steps such as 0.1dB, 0.5dB or 1dB.

Continuously variable optical attenuators can provide a precise level of attenuation through flexible adjustment. Thus, operators are able to adjust the attenuator to accommodate the changes required quickly and precisely without any interruption to the circuit.



Single Mode and Multimode Fibre Optic Attenuator

Since fibre optic attenuators can be used with two types of fibre cables, single mode and multimode, optical attenuators can be classified into single mode type and multimode type. Fibre optic attenuators are usually used in single mode long-haul applications. Accordingly, the commonly used type is also single mode type. However, although fibre optic attenuators are normally used for single mode, there are also multi-mode fibre optic attenuators available to mate with multi-mode fibre cables. When choosing one type of optical attenuator over another one, it is necessary to consider the attenuation range and the wavelength.

Why use Fibre Optic Attenuators?

The intensity of optical signal received by various optical receiving equipment is limited, and the equipment cannot work normally if the optical power is too weak or too strong within a certain range. When the optical power is too strong, the optical power will be adjusted by light attenuation to reduce it to an appropriate range, otherwise even if the equipment can be used, it will affect the service life.

The attenuation power of fixed fibre optic attenuator is fixed (such as 1dB, 5dB, 10dB). The attenuation power of a 3dB fibre optic attenuator is 3dB. This fibre optic attenuator is generally used in telecommunication networks, optical fibre test equipment, local area network (LAN) and cable television (CATV) systems. Fixed fibre attenuators can be divided into on-line and plug-in types.

The shape of plug-in fibre optic attenuator is similar to that of optical connector. The difference is that both ends of plug-in fibre optic attenuator are male connector interface and female connector interface respectively. This fibre optic attenuator either uses air gap to achieve attenuation, or uses metal ions to attenuate optical fibre to achieve attenuation effect.

The attenuation power of adjustable fibre optic attenuator is not invariable, but changes with the change of conditions. Its variation span is 0.5dB, 20dB, 50dB, etc. And some even reach the accuracy of 0.1dB and 0.01dB. Tunable fibre attenuators are generally used for accurate testing and measurement of optical fibres. At the same time, they are also widely used in erbium-doped fibre amplifiers. Their function is to balance the optical signal power in different channels.

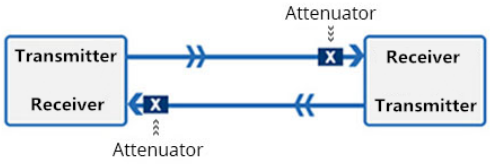
When to Use Fibre Optic Attenuators?

Considering when to use fibre optic attenuators in your system, there are generally two different situations where you will need fibre optic attenuators. One is when fibre optic attenuators are used to reduce the receiver power. There are sometimes when signal arriving at the receiver is too strong and may overpower the receiving elements. Usually, the receiver power depends on two factors: how much power is launched into the fibre and how much power is lost by the attenuator. Too much receiver power can be mainly caused by the mismatch between the transmitters/receivers, or caused by the use of media converters designed for a much longer distance. In this case, optical attenuators can be permanently installed in the fibre optic link to reduce the signal power and properly match the signal level.

The other one is when the attenuators are used for testing the power level margins. When testing the optic power level, the attenuators are used to temporarily add a calibrated amount of signal loss to test the power level margins in the fibre optic system. With the transmitter turned on and using a fibre optic power meter which is set to the system operating wavelength, the attenuator can be used to test the system power.

How to Use Fibre Optic Attenuators in Data Link?

For single-mode applications, especially analog CATV systems, the most important parameter second to the correct loss value is return loss or reflectance. Many types of optical attenuators (especially gap loss types) have the common problem of high reflectance, so they can adversely affect transmitters just like highly reflective connectors.



Considering how to use optical attenuators in link data, first, you need to choose an attenuator with good reflectance specifications. And second, always install the attenuator at the receiver end of the link as shown above. This is because it's more convenient to test the receiver power before and after attenuation or while adjusting it with your power meter at the receiver, plus any reflectance will be attenuated on its path back to the source.

When testing the system power, you need to make sure the transmitter is turned on and the optical attenuator is installed at the receiver. Don't forget to use an optical power meter which is set to the system operating wavelength.

And next, check to see whether the power is within the specified range for the receiver. If the optical power is higher or lower than the configuration required, the optical attenuators should be changed to adjust the power again.

Fibre optic attenuators are divided into the following four categories according to different interfaces

SC fibre optic attenuator: it is applied to SC optical fibre interface, which is similar to RJ-45 interface, but the SC interface is more flat and the contact inside is a copper column.

LC fibre optic attenuator: it is applied to LC optical fibre interface and can be used to connect SFP module. Modular jack (RJ) latch mechanism is adopted, which is easy to operate and commonly used in routers.

FC fibre optic attenuator: it is applied to FC optical fibre interface. The outer sleeve is wrapped with metal sleeve, and the fastening method is turnbuckle. It is generally used on the ODF side and is mostly used for distribution frames.

ST fibre optic attenuator: it is applied to st optical fibre interface. The shell is circular and fastened with turnbuckle. It is commonly used in optical fibre distribution frame.

Conclusion

Fibre optic attenuator is an essential passive component in the optical communication system. The innovation in the fibre optic industry never ceases, and fibre optic attenuators will evolve to have lower cost, faster response time, and enhanced integration of hybrids with other optical communication devices. Good quality connectivity begins with a world class manufacturing, testing and inspection process. Premium Optronics® attenuators are an example of the advances in this technology and Optronics® continue to innovate and meet the demand required for high-speed networks.

www.optronicsplus.net - sales@optronicsplus.net

This white paper has been produced by Khushbu Solanki, on behalf of Optronics®