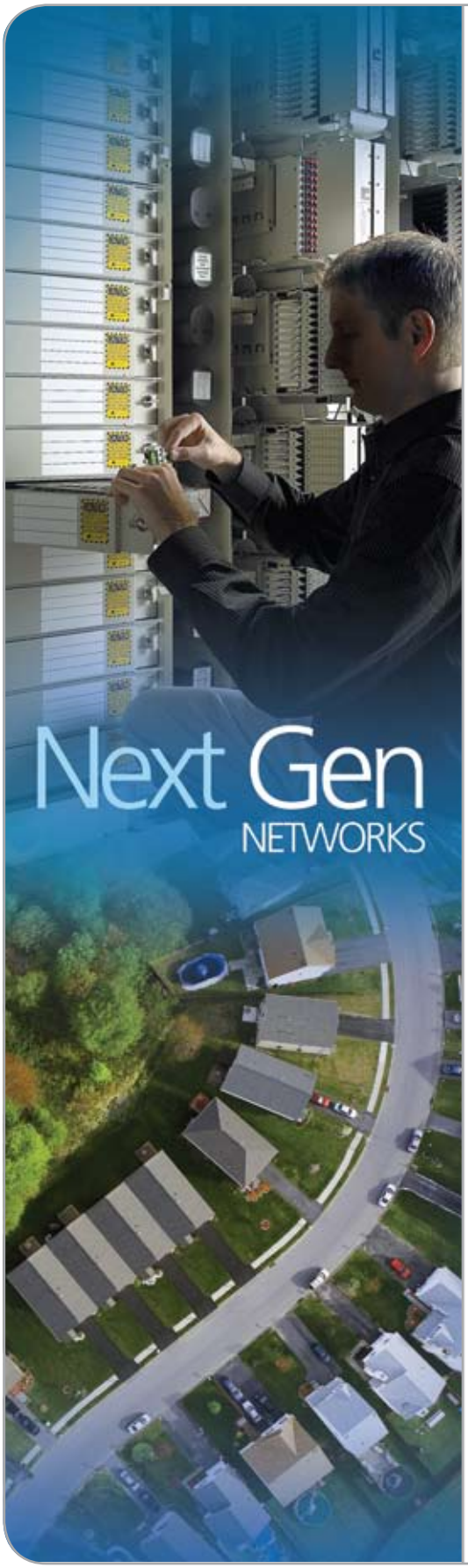


WHITE PAPER

Choosing the right connector

APC vs. UPC

ADC®

The choice between angle-polished connectors (APC) and ultra-polished connectors (UPC) can make a significant impact on how a particular network will perform. There are several considerations to make, including the network design or purpose and the types of services that will be transported over the fiber. This paper will compare and contrast these two categories of connectors, highlighting their differences in terms of physical appearance, insertion loss and return loss characteristics, as well as their overall performance in particular applications.

Passive Optical Network (PON) infrastructures deployed in fiber-to-the-premises (FTTP) networks require numerous fiber connections to achieve the distribution of services to multiple homes. Although splicing has its place in these systems, use of reliable APC connectors provide numerous advantages in terms of overall network flexibility, testing and troubleshooting. For more detail regarding connector choice in PON video applications, please see the white paper *Connectors in FTTP Networks: Which Connector Do I Use in My FTTP Network?* Literature #103178AE on www.adc.com.

Historically, UPC connectors have been the top performers, particularly with regard to insertion loss. For that reason, they are considered the legacy connector and have been deployed in many networks to handle digitally-transmitted information. However, due to the improved manufacturing techniques being used today, APC connectors are now on par with UPC connectors in terms of insertion loss.

There are many other benefits provided through the use of APC connectors, and each should be carefully considered during the network design process, particularly, within the FTTX network architecture, where numerous fiber connections are required to achieve the distribution of multiple services (triple and quadruple play) to multiple customers.

Physical attributes

The generally accepted color code for connector bodies and/or boots is beige for multimode fiber, blue for singlemode fiber, and green for APC connectors. UPC connectors are easily identifiable by their blue color on the connector boot. Both are available in SC (most common), LC®[1], and FC style connectors.

The major physical difference between APC and UPC connectors is the endface geometry. The APC ferrule endface radius is polished at an 8° angle while UPC connectors are polished at a 0° angle. The significance of this 8° angle becomes apparent when addressing return loss issues, which will be discussed later in this paper.

Standards

Today, the SC connector type is a standard in both inside plant and outside plant applications. *Telcordia® GR-326-CORE, Issue 3 Generic Requirements for Singlemode Optical Connectors and Jumper Assemblies* is the guiding document for fiber optic standards. ADC's optical performance specifications fall well within these guidelines and are listed below:

SC UPC Connector Specifications

Insertion Loss	0.2 dB max.
(1310 and 1550 nm)	0.09 dB typical
Return Loss	-57 dB min.
(1310 and 1550 nm)	
Fiber Recess	± 50 nm
Apex Offset	50 µm max.
Radius of Curvature	10-25 mm

SC APC Connectors

Insertion Loss	0.35 dB max.
(1310 and 1550 nm)	0.15 dB typical
Return Loss	-65 dB min.
(1310 and 1550 nm)	
Polished Endface Radius	5 - 15 mm
Fiber Recess	-100 to +50 nm
Apex Offset	50 µm
Endface Angle	8° ± 0.5

[1]LC is a registered trademark of OFS.

Insertion Loss

The performance difference between APC and UPC connectors begins with insertion loss. Insertion loss is defined as the measurement for the amount of optical power lost through a mated connector pair. The connector insertion loss can be used with the cable length loss to determine the allowable loss budget for an installed link. The formula for insertion loss is:

$$dB = -10\log_{10}\frac{\text{Output Power}}{\text{Input Power}}$$

In the past, low insertion loss using APC connectors was difficult to achieve due to air gaps in the apex offsets which caused substantial loss. However, due to improved connector designs and manufacturing processes, insertion loss differences between APC and UPC connectors have diminished. Most advertised typical insertion loss characteristics range from 0.14 dB to 0.18 dB for both connector types. ADC's typical insertion loss values range from .09 dB to .15 dB for both connector types.

Today, the factors that relate to insertion loss are the same for both connector types. All four of these factors are identical for todays APC and UPC connectors.

- outside diameter (OD) of the fiber
- concentricity of the fiber core
- inside diameter (ID) of the ferrule
- concentricity of the ferrule's ID

Return Loss

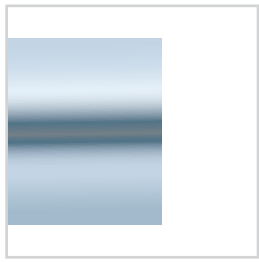
The more significant performance characteristic between APC and UPC connectors is their return loss. Return loss is a measurement of the light reflected back to the source at an optical interface. The formula for return loss in optics is:

$RL = -10 \times \text{Log}(P_R/P)$

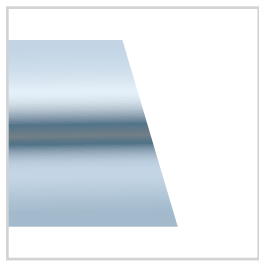
where P_R = power reflected at connector interface

APC connectors are superior to UPC connectors in this performance category because of their angle-polished endface geometry. When light is reflected at the connector interface of a UPC connector, it is reflected straight back at the source, increasing the return loss value. However, when the same signal passes through the APC connector, the 8° angle causes the reflected light to be absorbed by the cladding material.

The value of return loss for mated APC connectors in the field will typically be greater than -65 dB. For a UPC connection, it is normally -55 dB. When connectors are unmated—such as unused ports in an FTTP distribution frame—the return loss for APC connectors is -65 dB or greater, compared to UPC connectors that will be in the neighborhood of 14 dB. This is an important consideration for building today's FTTX architectures.



UPC Polish
Light is reflected back down to the core
Return Loss = -55 dB
(Adequate for most applications)



8° Angled Polish
Light is reflected into the cladding
Return Loss = -65 dB
(0.0001% of power reflected back)
(ideal for video and single fiber applications)

With APC connectors, a slight 8° angle is introduced to the end face allowing improved performance at the fiber/air interface. This improved performance is due to limiting the reflectance upstream, back into the downstream optical signal. When reflecting an analog optical signal into the initial downstream signal, two things occur: the reflected signal tends to degrade or attenuate the downstream signal, and there is a cross-modulating effect in the analog signals when converting back to an analog RF signal.

For systems such as RF video, the APC connector is preferred because these particular systems are extremely sensitive to any back reflections from connectors within the network. In general, UPC connectors are deployed in transport systems designed for digital signal transport, while APC connectors are preferred for RF video signal transport. APC connectors are also preferred where there are open ports at the other end of splitters, very typical in FTTP network designs.

Endface Geometry Issues

In order to demonstrate the recent strides that have made APC the preferred connector in outside plant and passive optical networks, a brief discussion of APC endface geometry is important.

During the manufacturing process, it is critical to control the endface geometry parameters: apex offset, radius of curvature, and fiber height. Preventing ferrule rotation that can change the apex offset of an APC connector to an unacceptable standard has been a critical manufacturing issue. Changing and inconsistent interfaces, which allow ferrule rotation about the ferrule axis, have the potential to create air gaps between the mated pair fiber cores. This results in significantly degraded, if not interrupted, transmission performance.

ADC has developed an anti-rotational feature on its APC connectors that corrects ferrule rotation. This feature forces the ferrule back into its original position if the ferrule is rotated either clockwise or counter-clockwise within the housing. This guarantees apex measurements will be maintained throughout the life of the connector, regardless of how many matings and unmatings are performed.

Conclusion

The manufacturing techniques used today have greatly improved the performance for both the UPC and APC connectors. When considering your unique network design, the APC connector is a good all-around connector choice, although the decision will ultimately come down to return loss requirements. In the end, ADC can help you examine all the considerations and issues regarding which connector—the APC or UPC—will best perform in your unique deployment scenario.

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