SENKO
SENKO GROUP® Advanced Components

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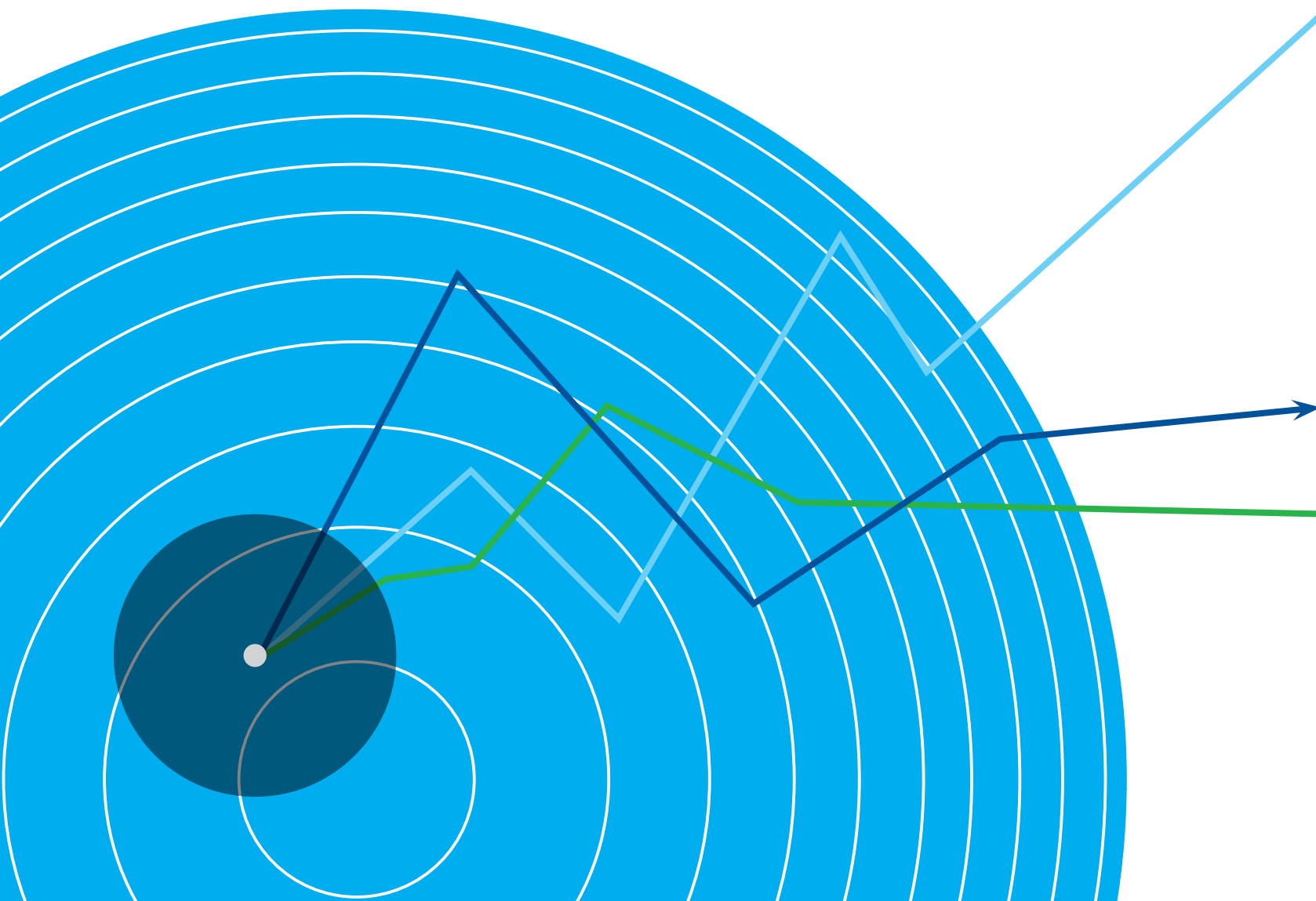
KEY ERROR APEX OFFSET

By SENKO Advanced Components



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KEY ERROR / **APEX** OFFSET

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Introduction

Optical fiber, like metallic signal propagating mediums are prone to signal reflection, known as Return Loss (RL). In a metallic conductor this is caused by a discontinuity (impedance mismatch), whilst in an optical fiber, it is caused by discontinuity of refractive index such as at the air-glass interface of mated fiber cores.

An air gap in the connection point is one typical cause. Reflected signals create a significant undesired affect for optical fiber systems, potentially causing the laser diode power output to become unstable and/or reduce output power, due to the incorporated back-facet monitor and feedback circuitry to reduce the likelihood of overheating and burnout.

Traditionally, Ultra Physical Contact (UPC) connectors with RL of up to -55dB have been good enough to reduce the undesired RL. Since the introduction of the Angled Physical Contact (APC) connectors and, the improvements to manufacturing and polishing techniques required for its more challenging geometric endface attributes, RL of -65dB or better is now achievable.

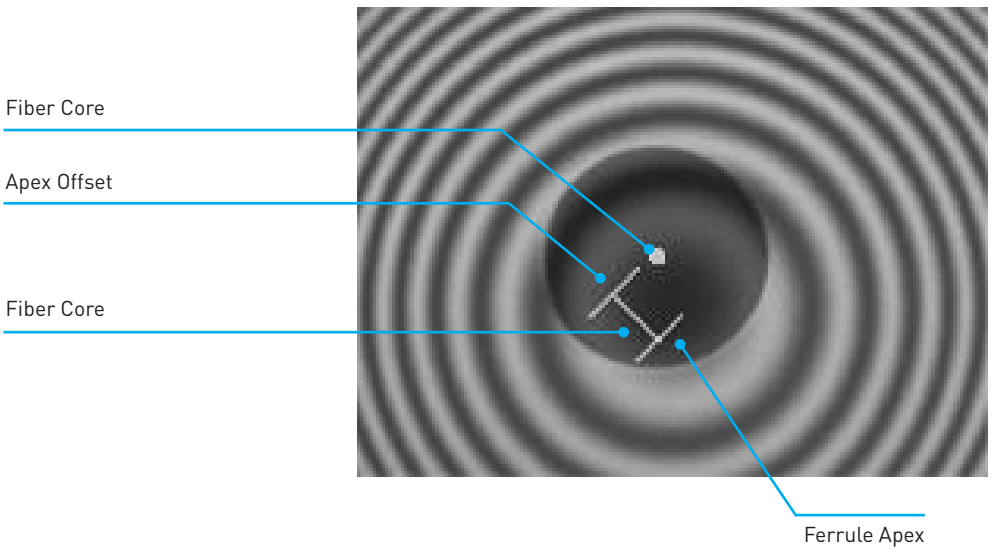
An APC connector by virtue of its spherical angular endface produces an extremely high performance fiber-to-fiber interface. However, this alone is not a guarantee of fiber core-to-core alignment or correct physical contact. Well designed, high quality connector components and keying feature are also required in order to achieve the best possible fiber core-to-core alignment and physical contact.

One aspect of geometric (interferometry) measurement is the distance between the apex of the ferrule endface and center of the fiber core. This distance is known as the Apex Offset, and is set at 50µm in accordance with the industry standard specifications IEC 60874-14-n and Telcordia GR-326-CORE issue 4, section 4.4.5.n.

In theory, mated ferrules with centered Apex Offsets, should have perfect fiber core-to-core connection and alignment, with no air gap. If however, there is large Apex Offset, an air gap can be created resulting in high Insertion Loss (IL) and RL.

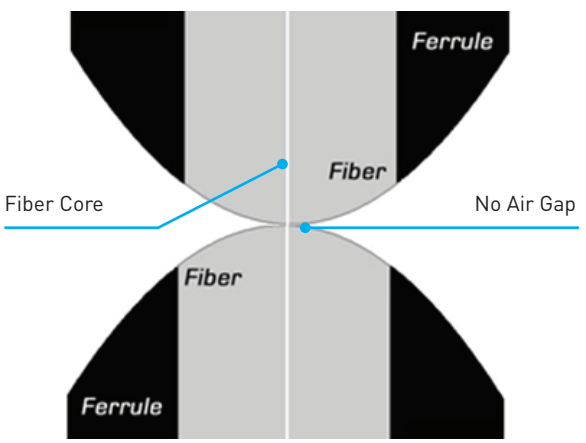
Interferometry Fringe showing Apex Offset

The image shows a typical image of a ferrule endface during interferometry measurement.



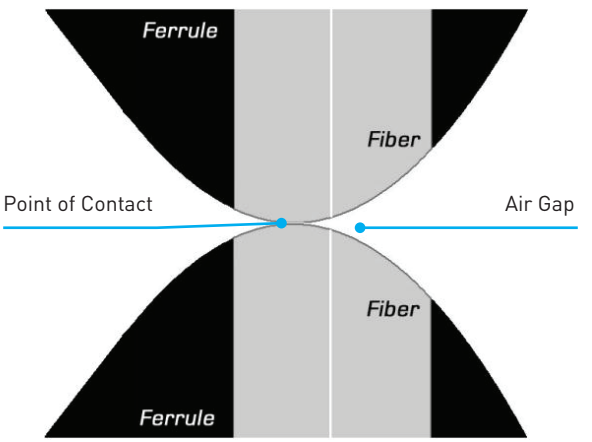
0 Apex Offset (PC Ferrule)

The below image shows a UPC connection with the Apex of the polish at the center of the fiber



High Apex Offset Creates an Air Gap (PC Ferrule)

The image below shows two mated UPC ferrules with poor Apex Offset, resulting in an air gap and, as a consequence, will give poor IL and RL performance.



Angle Physical Contact (APC) vs. Physical Contact (PC)

Typically PC connector ferrules of Ø2.5mm have a spherical endface polish, with a specified Radius of Curvature (RoC) of 10-25mm and Apex Offset ≤50µm, as specified in Telcordia GR-326, IEC and TIA/EIA industry standards. Ø2.5mm APC connectors however, have an angled polished endface (typically of 8°), with a RoC of 5-12mm and the same Apex Offset of ≤50µm according to the same industry standards.

With its additional geometric parameters of angular endface and smaller RoC, APC connectors incorporate a keying feature by design to minimize rotational movement of the ferrule and assure physical contact. The geometric parameter Key Error shown by Interferometers is a measure of ferrule rotational expressed in Degrees, although it is seen as a vertical shift in Apex Offset. Apex Offset shifts in the horizontal axis is caused by the deviation of the endface angle from 8°.

It is not well known the fundamental role that the Key Error parameter has on Apex Offset, so it has been somewhat over looked or even ignored, with the focus instead placed almost solely on endface angle.

The Importance of Key Error

Manufactures have invested significant resources in high quality polishing equipment, and refining polishing processes to produce the best polish and endface geometry for APC Connectors. Whilst this approach is not wrong, it only addresses one of the two variables that affect Apex Offset, namely, endface angle.

If Apex Offset and Apex Offset repeatability are to be improved, then resources and focus must also be placed on connector design implementations to improve Key Error and Key Error repeatability, which can significantly change Apex Offset repeatability.

Even if the polishing process produces endfaces with very good Apex Offsets, poorly designed connector with bad Key Error repeatability can potentially change the Apex offset by more than 30µm during mating repeatability. This means a connector with an Apex Offset of 30µm (in spec) can potentially have an Apex Offset of 60µm, 10µm above the industry standard specification of 50µm. Needless to say, this produces fiber misalignment resulting in poor IL and RL performance.

When selecting an APC Connector, it is critical that Key Error repeatability be given just as high a priority as Apex Offset and endface angle.

Solution

SENKO has found and demonstrated how critical it is to minimize ferrule rotation, and to keep the key error repeatability as small as possible. This can dramatically change the apex offset repeatability of an APC connector.

It has been proven that by maintaining tight tolerances on the ferrule key dimensions and unique flange design, the rotation around the axis of the ferrule of SENKO's new Premium SC APC connector has been minimized. This has greatly improved Key Error repeatability, and also significantly improved Apex Offset repeatability.

The new Premium SC APC connector series was developed with these improvements in mind, enabling them to exceed the industry standard requirements.

A comparison of SENKO's new Premium SC APC connector with high quality competitors during testing are shown in the tables below:

New SENKO SC APC Premium

Apex Offset Av Δ (µm)	Key Error Av Δ (°)
2.31	0.033

From 80 measurements.

High Quality Competitor A

Apex Offset Av Δ (µm)	Key Error Av Δ (°)
8.18	0.109

From 120 measurements.

High Quality Competitor B

Apex Offset Av Δ (µm)	Key Error Av Δ (°)
6.83	0.086

From 80 measurements.

* Key Errors of 0.1Ð can affect Apex Offset repeatability by more than 15µm, and Key Errors of →0.05Ð can affect Apex Offset by up to 10µm.
** Both wet and dry cleaning of the ferrule endface was performed before each Apex Offset measurement to more accurately simulate in-the-field usage.

Terms and Definitions

Apex Offset

This is defined as the linear distance between the center of the fiber or fiber hole and the highest point on the ferrule. This value is measured in (µm) Microns.

Key Error

Any apex offset in the vertical axis is caused by an error in the polishing or mounting of the ferrule with respect to the key. This offset in the vertical axis is resolved into an angular format and reported as the key error.