02 TUNING OF CONNECTIONS as a guarantee of low and repeatable values of insertion loss (IL)

Introduction

Fiber optic transmission involves the transmission of an optical signal to long distances.

In every fiber optic line, individual sections of fiber optic cables are connected with each other using fiber optic connections (connectors).

Every such connector-connector link introduces an additional undesirable loss of optical signal, referred to as insertion loss.

This loss depends mostly on the quality of execution (geometrical parameters) of the fiber optic ferrule, located in every optical connection, which is defined by a parameter called concentricity of ferrule.

The better the concentricity of ferrule, the smaller the losses (lower insertion loss), which in turn results in a better quality of the optical signal transmission.

A specialized process of tuning of connections allows to obtain a lower loss and repeatability of the IL value in comparison to standard connections.

At a low cost we obtain very good parameters of connections – in line with IEC 61753 Grade B (or even A).

Tuning of connection - setting the position of ferrule - eliminates the effect of random core positioning in the connection and allows to obtain a good match of the connections in adapters.

Non-centricity of optical connections

In theory, a single-mode optical fiber has an external diameter of 125um, and the core transmitting the optical signal with a diameter of 9um is located exactly in the center of the fiber's cross-section.

The theory also assumes that the opening in the ferrule is located exactly in the middle of the cross-section (axis of symmetry) of the ferrule.

In practice, due to technological limitations and due to tolerances of the core location within the optical fiber, and the opening in the ferrule, the core of the optical fiber may be shifted relative to an ideal axis of symmetry of the ferrule up to 1.2um in any direction, which is shown in the graphic below:

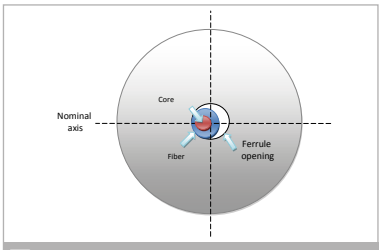


Fig. 1. Non-centricity of optical connections

If connectors, in which the shift of the connector core „A" relative to connector core „B" is extremely unfavorable, meet in an optical adapter (i.e. the shift of the position of core „A" is 1.2um at 12:00 o'clock, and the shift of the position of core „B" is 1.2um at 6:00 o'clock) then the optical signal from connector „A" will partially hit the coating of the optical fiber of connector „B" and will be partially lost

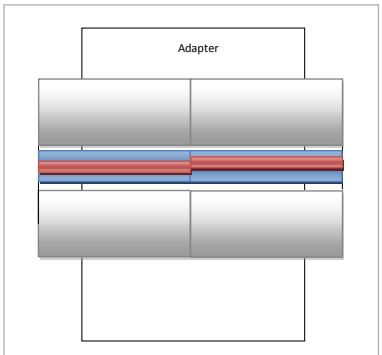


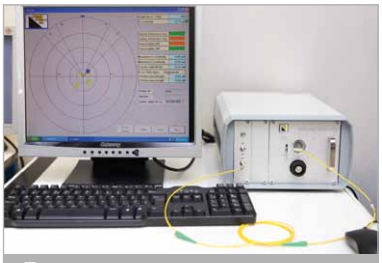
Fig. 2. Flustering of optical signal

Accidental and unfavorable shift of the position of the core significantly deteriorates the results of insertion loss due to losses in the optical signal.

Tuning of connections

Tuning of a connection involves turning the ferrule within the connector and setting it relative to the key in a position, in which the non-centric core of the optical fiber finds itself in a specified position (and not in a random position)

Photograph 1. Connection tuning process



Photograph 2. Tuned connection

In the case of connectors subjected to tuning, the shift of the core is limited to a narrowed-down scope of +/-30° (for E2000 and LC connectors) or +/-45° (for SC connectors):

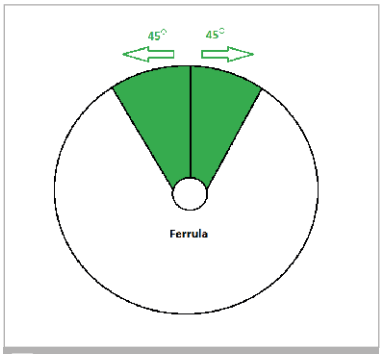


Fig 3. Limiting the core shift as a result of tuning in SC connectors to a narrowed-down scope of +/- 45%.

The following graphic shows a typical random scatter of the position of the core relative to the ferrule:

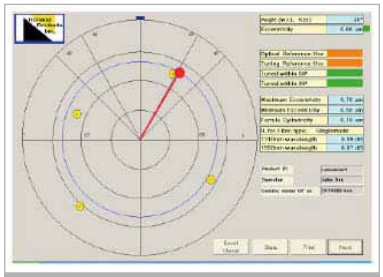


Fig 4. Random scatter of the position of the core relative to the ferrule – connections prior to tuning

Permissible scope of the core position shift for connectors subjected to tuning presented graphically:

Fig. 5. Permissible scope of the core position shift relative to the ferrule - connections after tuning

Tuning of connections allows to lower the insertion loss of the connectors at Grade C level to a level consistent with Grade B (acc. to IEC 61753) or even Grade A, and it is an alternative to the use of more expensive connectors - the so-called Premium (or Low Loss) connectors.

(Insertion Loss)	Values of insertion loss IEC 61300-3-34 wavelength 1310 nm and 1550 nm	
Grade A*	≤ 0.07 dB typically	≤ 0.15 dB Max for >97% samples
Grade B	≤ 0.12 dB typically	≤ 0.25 dB Max for >97% samples
Grade C	≤ 0.25 dB typically	≤ 0.50 dB Max for >97% samples
Grade D	≤ 0.50 dB typically	≤ 1.00 dB Max for >97% samples

*-non-finalized, premium (norma Cellco), standard (norma Cellco)

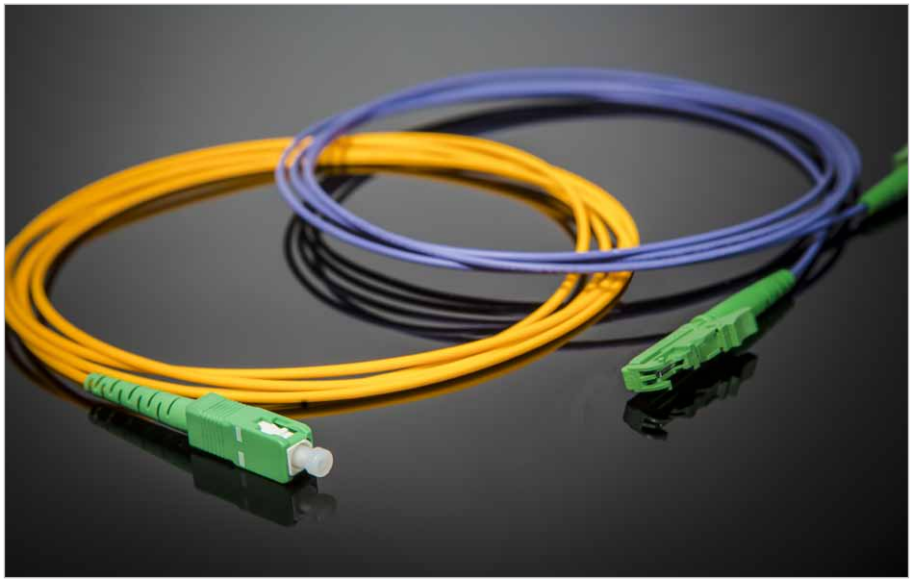
Table 1. Parameters of single-mode connections – IEC 61753 standard - Insertion Loss

Exemplary comparison of the insertion loss values before and after the tuning of the connection is presented in the table below:

Conector no.	Standard IL Before tuning	Premium IL After tuning
1	0.24	0.09
2	0.32	0.06
3	0.28	0.06
4	0.24	0.10
5	0.30	0.02
6	0.29	0.05
7	0.21	0.08
8	0.22	0.10
9	0.27	0.09
10	0.26	0.09

Table 2. IL values before and after tuning.

When using tuned connections in practice, we gain a guarantee of repeatability of parameters of connections regardless of the date of their production.
When using tuned connectors one should remember that we can only use the entirety of their potential if we connect them with other tuned connectors.



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