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FIBREOPTIC INDUSTRY ASSOCIATION

SHORT INFORMATION DOCUMENT

MEASURING OPTICAL FIBRE LATENCY & EQUALISING CABLE LENGTH

A summary of what is meant by equal cable length and how to meas- ure it

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An introduction to latency

The latency or delay for a signal at a particular wavelength travelling down or through an optical fibre is determined by the length of the fibre and the group refractive index for the fibre at the wavelength being used. When comparing different cable types, the issues become further complicated as the length of fibre inside each cable type will vary.

A key metric

For those with time sensitive issues, such as banks trading, or those - with optical delay lines in optical and parallel trans- mission systems, any skew can be problematic and latency is a key consideration.

Under MiFID 2, EMSA (European Securities & Markets Authority) has stated that trading venues which offer hosting space to clients must offer this service “under the same conditions, including as regards space, power, cooling, **cable length**, access to data, market connectivity, technology, technical support and messaging types”.

The premise behind the regulation is to set a level playing field for all customers and the premise behind the equal cable length is to provide equal latency across the trading space.

Perhaps a better way to have expressed it may have been ‘equal latency over cabling’ with guidelines on the allowance for tolerance based on length intervals.

A rule of thumb...

As it depends on wavelength and the particular fibre, each 1m length of fibre results in 4-5 ns of latency (a typical value might be around 4.9 ns for 1m). The regulation does not provide a tolerance for what "equal length" means but many financial exchanges have chosen +/- 0.25m or +/- 0.25%, whichever is greater.

Twisted-pair copper cables

Financial exchanges are unlikely to use copper but it illustrates the issues well.

When testing copper cables, the testers measure the core length and then estimates the cable length based on the NVP (Nominal Velocity of Propagation) value.

As an example, if you were to take a 100m length of Cat6A U/UTP cable with a very tight twist ratio with an NVP of 68% and stretch a single core out in a straight line, it would be c. 147m.

By comparison, on a 100m length of Cat6A S/FTP cable with an NVP of 75%, the core length would be c.133m. In order to equalise latency across these cables types, the Cat6A S/FTP would need to be c.10% longer than the U/UTP equivalent.

Optical fibre cables

When looking to equalise latency over optical fibres cables, there are two main issues to consider: The Index of Refraction (IOR) or strictly speaking for fibres the group refractive index (which varies along the length due to manufacturing tolerances) and the core lay within the sheath.

For example, a 100m fibre core with an IOR of 1.467 will have less latency (the signal will arrives quicker) compared to a 100m fibre core with an IOR of 1.468 so, if using both core types, the one with the IOR of 1.468 would need to be shorter to compensate.

The core lay within a cable is often a forgotten or neglected issue, but for some cables a "helix factor" of around 5% indicates that the fibres are approximately 5% longer than the cable they run through.

This will vary from cable to cable and for different fibres within the same cable although for most internal cables the difference is likely to be much less than 5% and typically less than 1%.

The core issue

Most clients are less bothered about the exact length of the fibre cables, and will be focussed on the differences between the lengths of the cores across the whole cable plant – especially the difference between the shortest and longest cores.

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Accurate Fibre Length or Latency Measurement

If the client requires a tolerance of +/- 0.25m or +/- 0.25%, whichever is greater, this cannot beaccurately measured with most test equipment.

The issue of accurate latency or length measuring is often not fully appreciated since common fibretest equipment such as an OTDR will report fibre length with a high precision to fractions of a metre, but this measurement whilst appearing precise is often not as accurate as the user might expect.

The appropriate technique will likely depend on the length of the fibre system under test and whether both ends of the fibre are available/accessible. For single-ended testing a reflectometer technique is required whereas if both fibre ends are available then time-of-flight techniques may be appropriate or for very high accuracy a phase-shift measurement technique can be utilised.

Overview of Test Methods

- **OTDR**
  Good for long distance length measurements but with length/latency accuracy limitations which are likely to be unacceptable to comply with banks' trading requirements. A single-ended test.
- **Time-of-flight techniques**
  Work well for longer fibre lengths but with limited accuracy. The OTDR is effectively a single-ended time-of-flight technique, but others may be available.
- **OFDR**
  Good for accurate length measurements but can have limitations for longer fibre lengths. A single-ended test.
- **Phase-shift technique**
  This can be the most accurate measurement method for latency and can measure the latency of both long and short fibre systems but for the highest accuracy it typically requires a double-ended technique.

The effectiveness of the measurement techniques can be compromised or enhanced by the test equipment user and the care they exercise in applying the test.

To conclude...

Techniques exist to measure latency to a high accuracy, but the most appropriate technique will depend on the length of the fibre to be tested, the degree of accuracy required and the layout of the optical fibre cores within the cables.

Need more help?

For further information on what might be the correct technique to adopt in any given situation please email the FIA's Technical Director.

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