Non-Gaussian Impulse Response of GI-POF and the use of IEC 1.5dB extrapolated optical BW

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Background

In abbott_3dh_01_221130_update_GI_POF_BW_length_dependence.pdf [1], measurements of bandwidth vs. length of GI-POF fiber were reviewed, noting that the roughly square root dependence of length dependence first seen in the 1990s still persists.

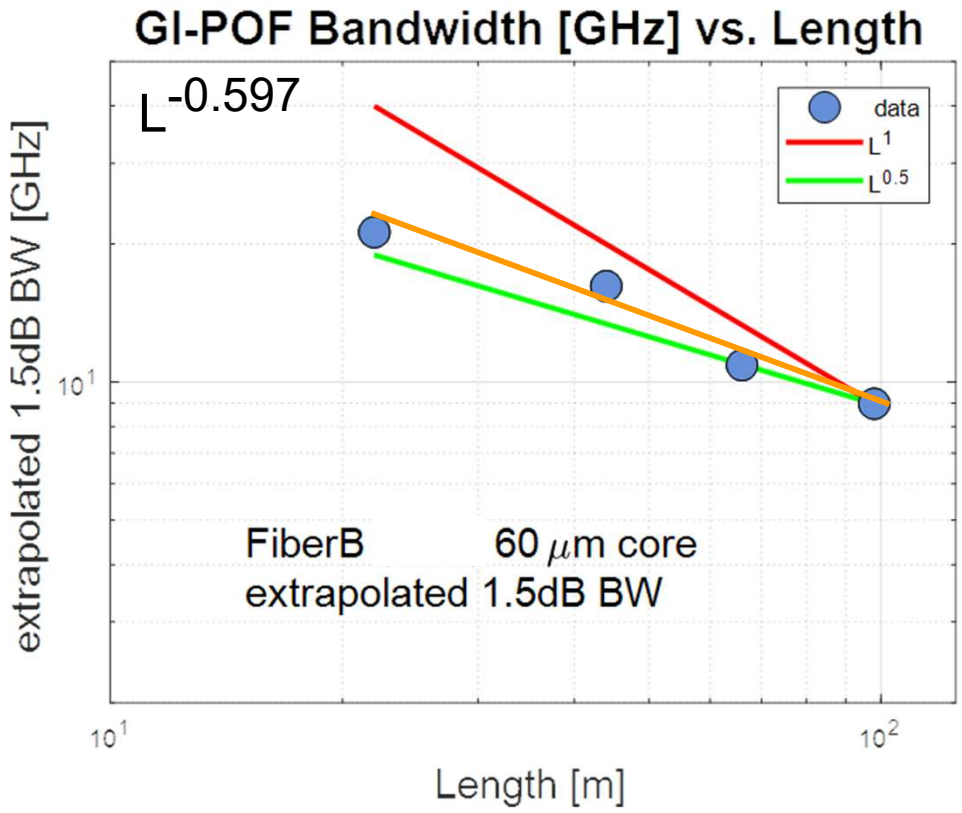
It was also noted that a difference between the 3dB optical BW and the 1.5dB-extrapolated optical BW was seen, indicating a non-Gaussian transfer function |H(f)|. The lower of the two bandwidths was used per IEC specifications for 10Gb/s fiber (OM3) [2]

This presentation explains 1.5dB BW as a tutorial. It is only one of many ways to address non-Gaussian “rolloff” functions [3], but is probably the simplest and is mentioned in IEC spec.

GI-POF BW vs. length from 11/30/2022 presentation

abbott_3dh_01_221130_update_GI_POF_BW_length_dependence.pdf [1]

This presentation explains the 1.414*1.5dB optical BW



Non-Gaussian Transfer Function in MM fibers including GI-POF

A non-Gaussian transfer function such as that seen in small diameter GI-POF fiber with restricted/laser launch is typically caused by a pre- or post-pulse.

The transceiver maker assumes the reported bandwidth is a Gaussian response, and an ‘effective-Gaussian’ BW is needed, like the IEC 1.5dB protocol on next slide developed for high BW OM3 fiber (2000MHz.km).

How to do a Time Domain bandwidth measurement

The input pulse is P_in(t); the output pulse is P_out(t).
The FFT amplitudes are |H_in(f)| and |H_out(f)|.
The 3dB bandwidth is determined by the “rolloff curve” or amplitude of the transfer function
|H(f)| = |H_out(f)|/|H_in(f)| and the frequency f where |H(f)| is 0.5

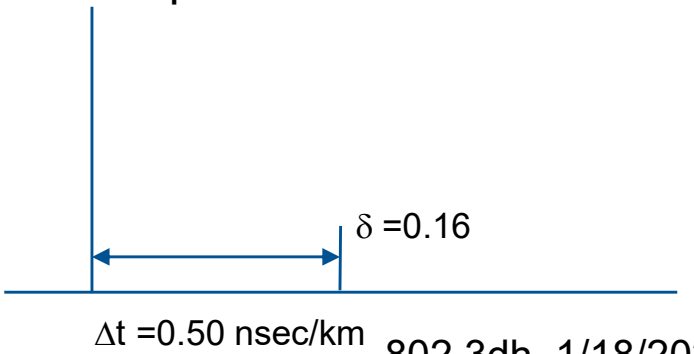
The simplest case is P_in(t) is a Gaussian pulse but P_out(t) can be described as two Gaussians, a main pulse and a side pulse.
The side pulse is offset Δt and had a magnitude δ
The width of the two pulses is the same with a σ which would give BW=2000 MHz.km if amplitude of side pulse δ = 0
Depending on Δt and δ, it may be necessary to use the 1.5dB metric.

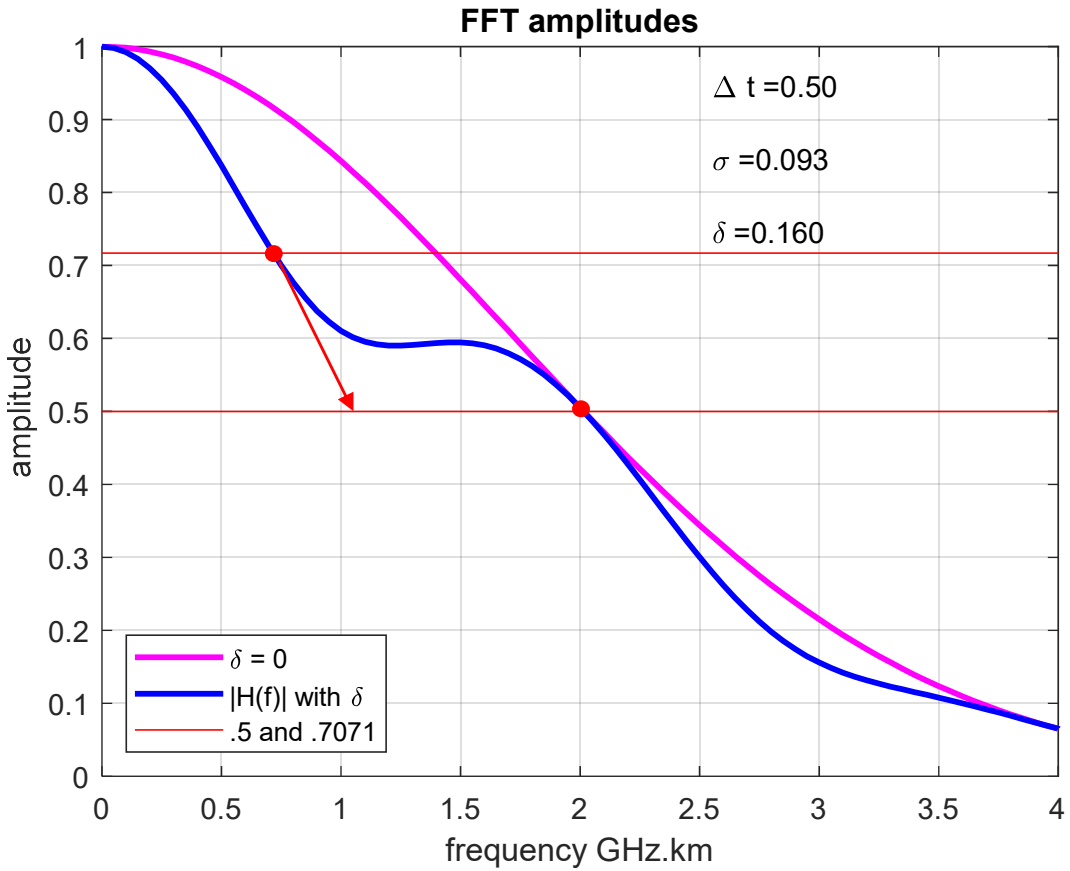
Example 1 – 3dB BW overestimates link performance.

The side pulse causes the |H(f)| curve to have a “shelf”.

The IEC specification recommends taking the 1.5dB value (i.e., frequency where |H(f)|=0.7071) and extrapolating a Gaussian curve to 0.5. (multiply by 1.414)

This example shows that the change in BW can be up to a factor of 2.





Discussion/Conclusion

Use the lower of 3dB Bandwidth and 1.5dB-extrapolated Bandwidth.

The ratio of (3dB BW) / (1.5dB-extrapolated BW) can give information about index profile error.

The 1.5dB-extrapolated BW was developed as part of the multicompany 10GbE development project in TIA, IEC, and IEEE, which assumes MM glass optical fiber and a measurement of a 2000MHz.km fiber over 1km (i.e., 2GHz). The properties of GI-POF fiber and the measurement of very short lengths may require other metrics and measurement techniques and a similar multicompany effort in IEC.

Fibers for Round Robin Testing

55μm GI-POF fibers suitable for A4j testing are still unavailable, which is different from past projects.

During development of 10GbE standard with OM3 fiber by IEEE/IEC/TIA, the "OM3" fiber was the same as existing commercially available OM2 fiber, with modified testing and specifications for 10Gb/s transmission with the new 10Gb/s VCSELs. Roundrobin testing by multiple companies was done to ensure that the measurement methodology and specifications were robust and sufficient to guarantee link performance.

There is nothing analogous to "OM2 fiber" to test….

References

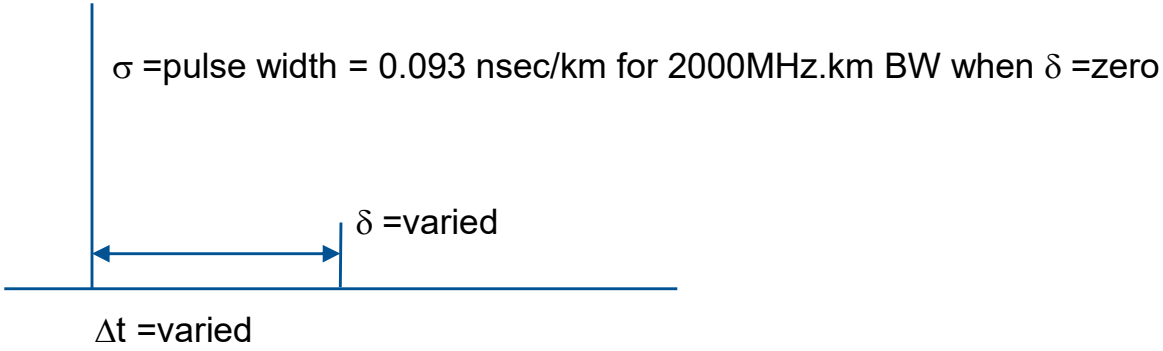
1. 802.3cz and 802.3dh presentations
abbott_3dh_01_221130_update_GI_POF_BW_length_dependence.pdf and references.
https://www.ieee802.org/3/dh/public/Ad_Hoc_Nov%2030_2022/

2. IEC specification
IEC 60793-2-10:2017 See Annex E E.1 Background

3. Reference to 1.5dB-extrapolated BW and other approaches for non-Gaussian transfer functions:
Optical Fiber Telecommunications VIA. Chapter 7: “Fibers for Short Distance Applications”, J.S. Abbott et al. New York: Elsevier, 2013.
https://doi.org/10.1016/B978-0-12-396958-3.00007-X

BACK UP SLIDES

Other Examples with different values of Δt and δ for reference.



Example 2 – extrapolated 1.5dB BW is close to 3dB BW

In this example, side pulse is closer to main pulse and amplitude is lower. IEC recommend is still use 1.414*1.5dB optical BW but this is now close to 3dB optical