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Polarization optical time-domain reflectometer for monitoring of fiber optical lines

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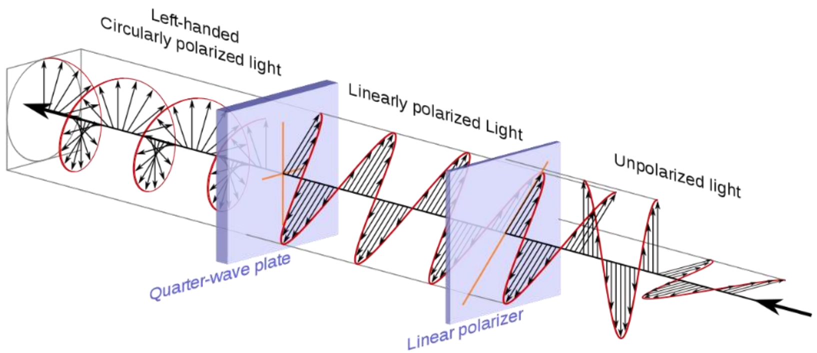
Outline

- **Research motivation**
- **Polarization optical time-domain reflectometer**
  - light polarization
  - POTDR operating principle
- **Experimental POTDR measurements**
  - Location of mechanical impact on optical fiber cable
  - Accuracy dependence on the number of POTDR traces
  - Wavelength impact
  - Length impact
- **Conclusions and future work**

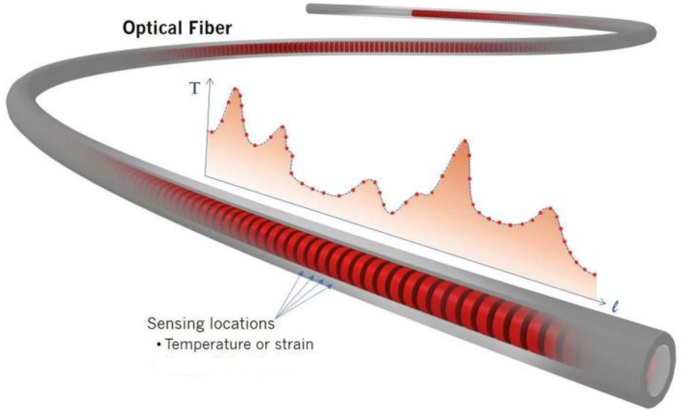
Research motivation

- Location of signal state of polarization (SOP) changes in cable
- Polarization mode dispersion in fiber optic cable lines
- SOP dependence on a wide variety of external impacts including mechanical deformations, vibrations, temperature change, etc.

Equipment for PMD measurements [2]



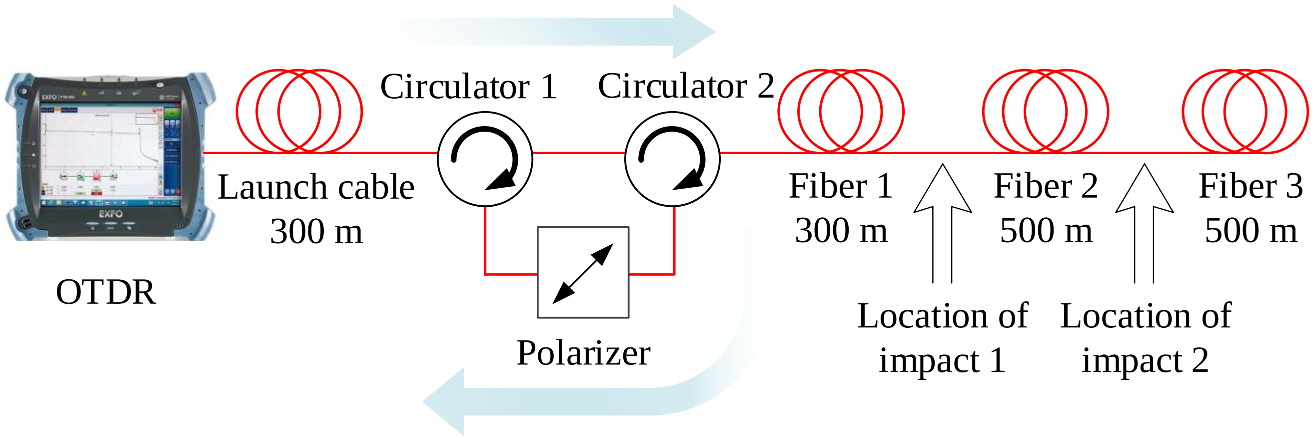
Optical signal state of polarization [1]



Fiber as a distributed sensor [3]

[1] https://images.app.goo.gl/NtWVQNjVHFkViPmP8
[2] https://www.exfo.com/en/support/optical-testing-modules/
[3] https://ati.mydigitalpublication.co.uk/articles/distributed-fiber-optic-sensing-leads-the-way-to-better-bonding-and-welding

Polarization optical time-domain reflectometer



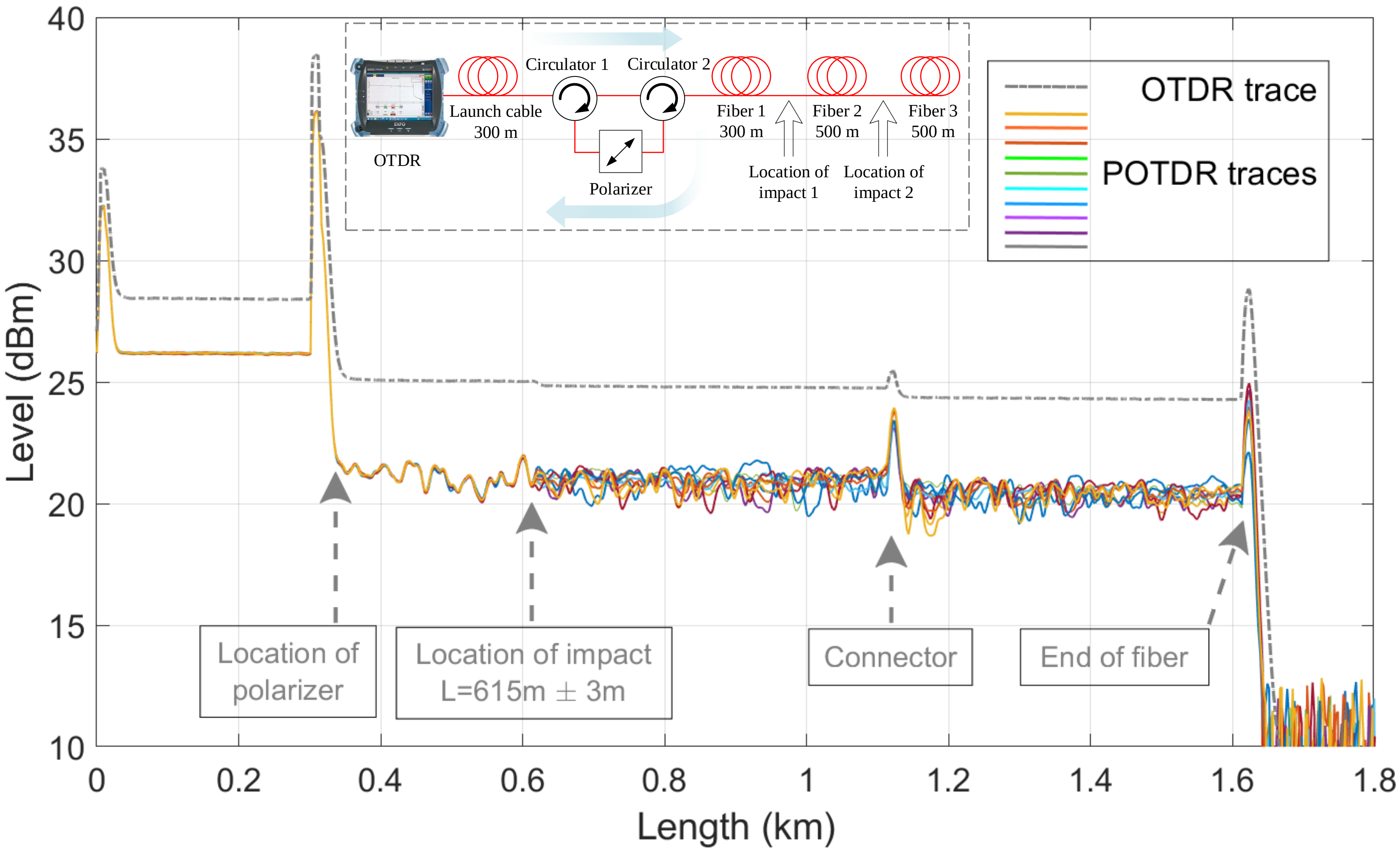
POTDR measurement setup based on the use of OTDR and polarizer.

Selected POTDR setup is based on the use of commercial OTDR and external polarizer circuitry [1]

- EXFO FTB-7300E
- ILP1550PM-APC - In-Line Fiber Polarizer, 1550 ± 50 nm
- ITU G.652 SMF fibers

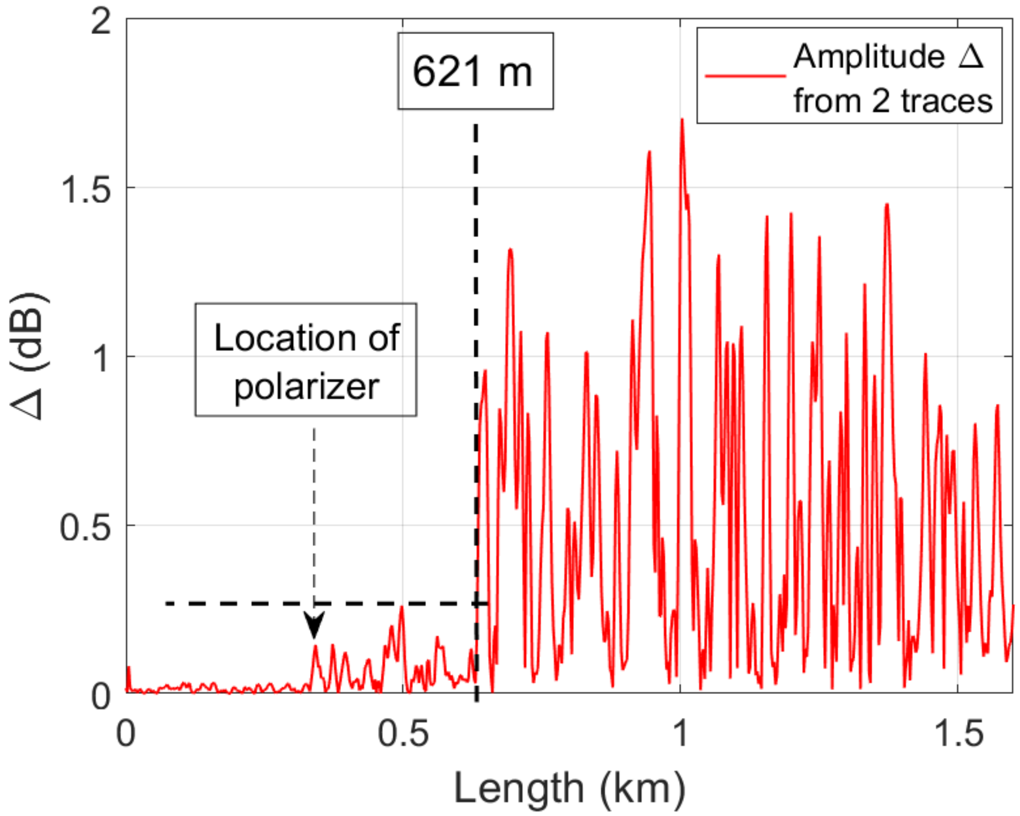
[1] C. Franciscangelis, C. Floridia, G. Simões, F. Schmidt, F. Fruett, On-field distributed first-order PMD measurement based on pOTDR and optical pulse width sweep (2015) Optics Express Vol. 23, No. 10, DOI: 10.1364/OE.23.012582.

Experimental POTDR traces

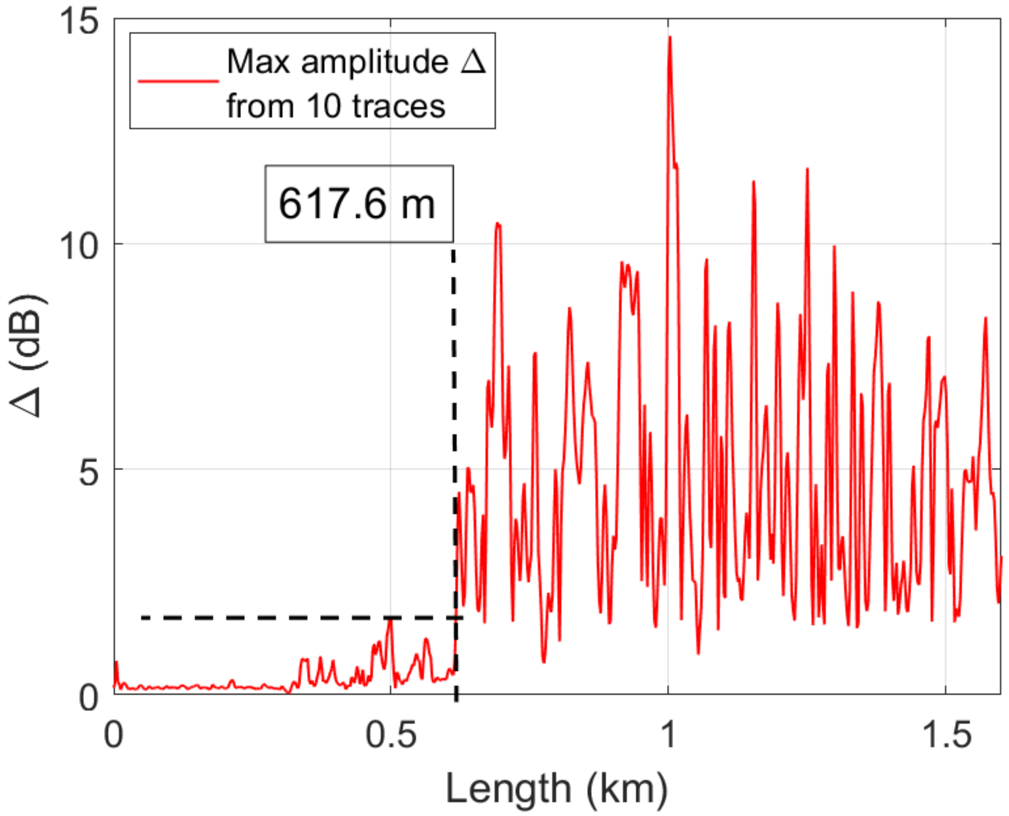


OTDR trace vs POTDR traces. Reflected pulse SOP changes appear as amplitude fluctuations. Ten POTDR traces are shown (each represented using different color).

Data processing



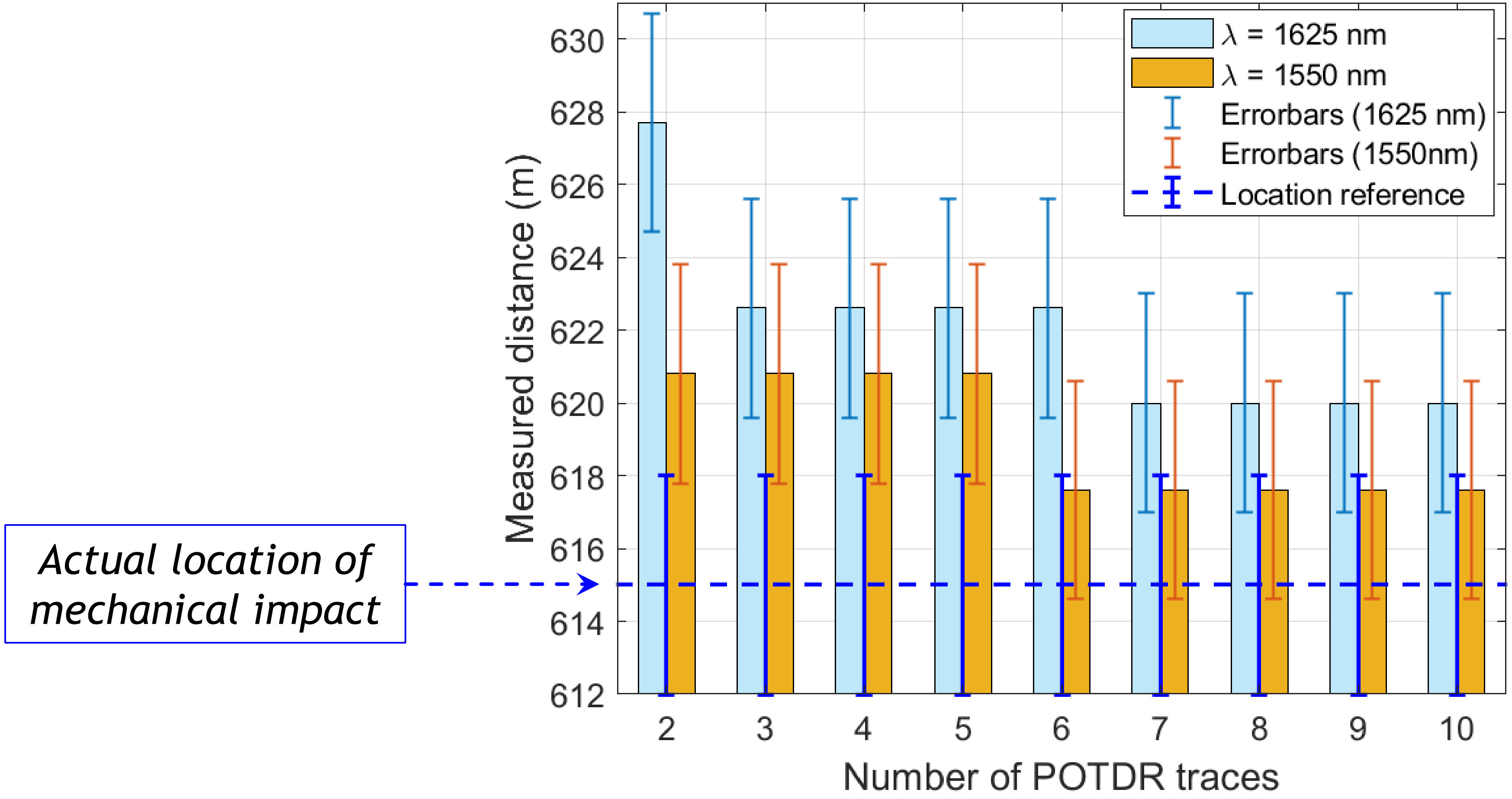
Amplitude difference of **2** real-time **POTDR traces** at 1550 nm wavelength.



Absolute amplitude difference accumulated from **10** real-time **POTDR traces** at 1550 nm

Rapid increase in amplitude difference points to external impact location

Data processing

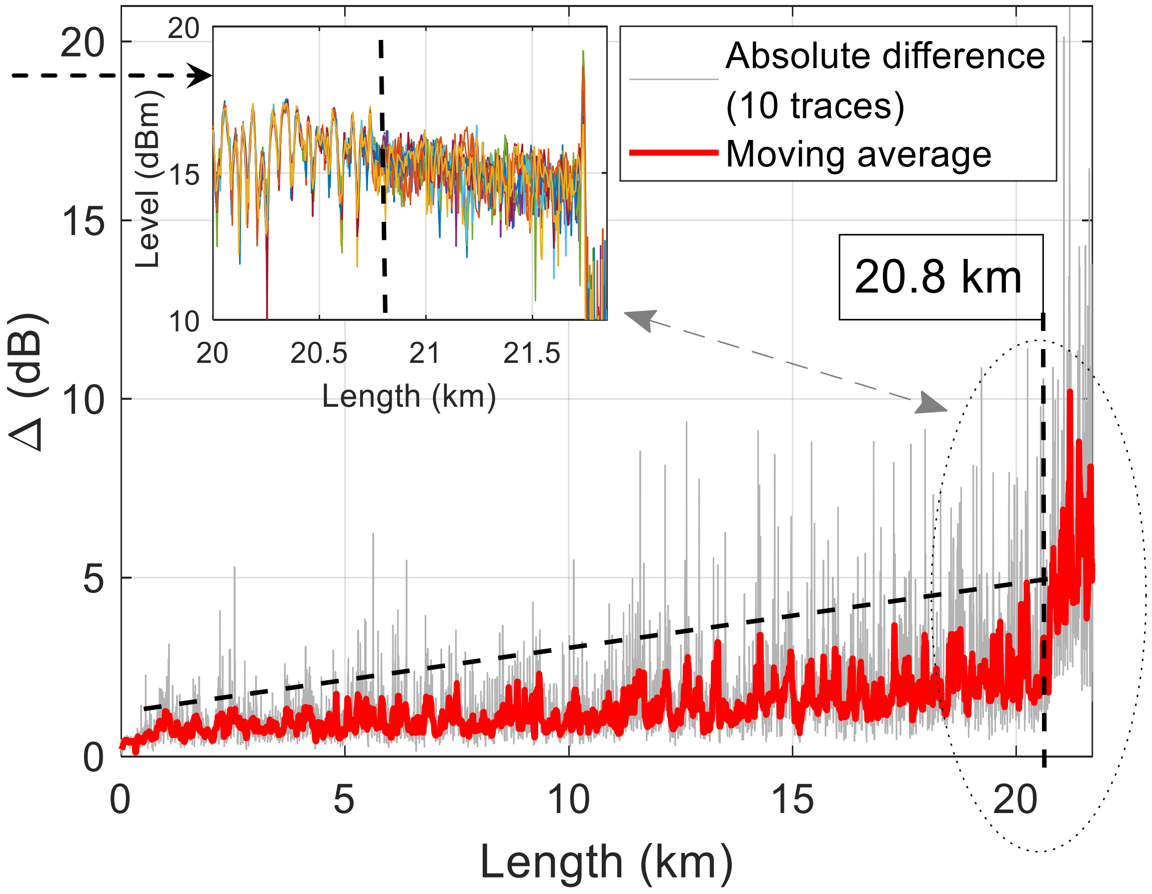


Calculated distance dependence on the number of POTDR traces used in the case of **1550 nm** and **1625 nm** wavelength.

Errorbars represent OTDR measurement uncertainty of ±3.0 m

POTDR measurements in a long distance scenario

Zoomed in area of 10 POTDR traces highlighting the location of the external impact.



Absolute amplitude difference of 10 POTDR traces at 1550 nm. Red line is moving average value for window size of 10 data points. In this case the OTDR measurement error is around ±46 m

Summary

The developed POTDR model is capable to evaluate both: the reflections coming from optical components and connectors and signal amplitude fluctuations due to light SOP changes in the fiber optical communication line depending on its distance. It is found that at 1550 nm and 1625 nm wavelength band a set of 7 POTDR traces is sufficient to get the distance values that overlaps considering OTDR measurement uncertainty window.

Further work

Development of POTDR prototype based on time-amplitude analysis of event flows, which has higher timing resolution (2 – 3ps RMS), high resolution of nanosecond pulse amplitude measurement (8 – 10 bit ADC), and high stability of measurement parameters, and implementation of this technology in testing and monitoring of optical communication lines.

Thank You

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