# Anomaly detection in optical links using state of polarization monitoring

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## Abstract

**We have demonstrated a vibration monitoring method in optical fibers that enables early fiber breakage and eavesdropping intrusion warnings.. The detection sensitivity of vibrations in a fiber-cord laying on a firm surface is characterized by inducing vibrations in the audio frequency range using a loudspeaker. Two examples of vibration patterns, touching the fiber and hammer strikes near the fiber are emulated and characterized.**

## Introduction

Identifying vulnerabilities in optical networks through fiber movement detection

- Potential fiber breaks
- Potential eaves dropping attacks

Distributed acoustic sensing (DAS) systems can detect mechanical movements of fiber cables caused by e.g. trawler boats and digging activity

- Dedicated fiber
- Range limitation (≈200km)

State of Polarization (SoP) monitoring can be added to commercial transmission systems enabling mechanical movement detection.

## Methodology

- A live transmission system consists of two media converters are used as shown in Figure 1.
- Vibrations are induced on a standard G.652 fiber cord by a loudspeaker fed with an audio tone variable from 20 Hz – 20 kHz.

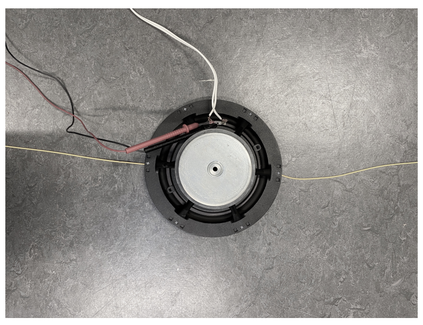


Figure 2: Speaker 2.5 cm above the fiber laying on the floor

- Fiber is tapered to the floor and passing 2.5 cm below the center of a loudspeaker covering 22 cm length of the fiber cord used as the sensing fiber.

## Experimental Setup

Three different configurations: A) Basic, B) Add EDFA, C) Add 50 km fiber

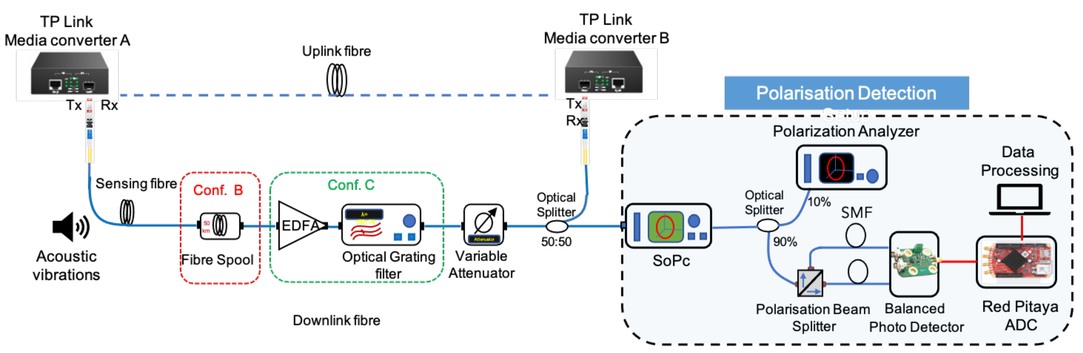



Figure 1: Experimental setup for the three different configurations. Configuration A is the basic configuration with the sensing fiber, without the components in Conf. B and Conf. C

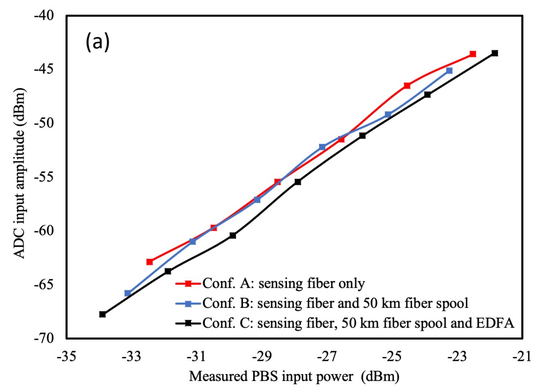
## Results & Discussions

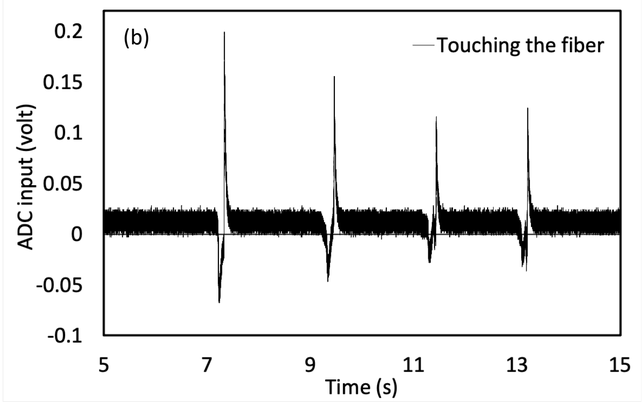
### Impact of EDFA and 50 km fiber on receiver sensitivity

- For each configuration received power is varied for a fixed frequency of 30 Hz.
- Overlapping results shows insignificant impact on sensitivity by adding EDFA and long fiber.

### Vibration impact - examples

- 1) Touching a patch cable 2) Hammer strikes near a patch cable on the floor.
- Touching: 6.5 times higher amplitude than hammer strikes and lower frequency components
- Patterns may be differentiated by amplitude and frequency of the signals



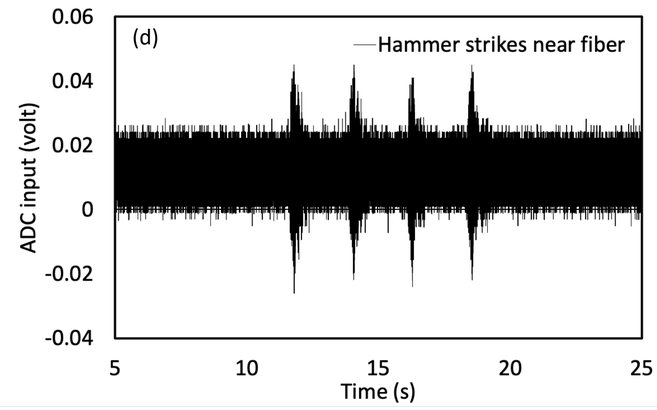




Figure 3: Experimental Results. Upper figure (a) shows received audio power as a function of received optical power, for two different experimental configurations. Lower figure (b) shows the pattern from touching the fiber and figure (c) shows the pattern from hammer strikes near the fiber.

## Conclusions

- Insignificant impact on sensitivity when adding 50 km fiber and EDFA.
- Examples of pattern recognition differentiating touching of a fiber patch cable and hammer strikes near the fiber.
- Further work will focus on identifying network anomalies by differentiating patterns in SoP variations, enabling the fiber network as a sensor network.

## References:

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