Propagation Impairment in Single-Wavelength, Single-Fiber Bidirectional Optical Transmission

(Article begins on next page)

Propagation Impairment in Single-Wavelength, Single-Fiber Bidirectional Optical Transmission

Emanuele Virgillito[1,*], Stefano Straullu[2], Andrea Castoldi[3], Rudi Bratovich[3], Andrea Bovio [3], Rosanna Pastorelli[3] and Vittorio Curri[1]

[1] *Politecnico di Torino, Corso Castelfidardo, 39, 10129, Torino, Italy; *emanuele.virgillito@polito.it*
[2] *Links Foundation, Torino, Italy,* [3] *SM-Optics, Vimercate, Italy*

Abstract: We experimentally observe bidirectional transmission of two same wavelength coherent channels on a single fiber. We show that Rayleigh backscattering and, especially, lumped reflections are additional impairments and provide QoT mathematical modeling.

1. Introduction

Bidirectional transmission is a convenient opportunity to double the overall capacity for every fiber strand. This may be particularly useful in the context of metro and access network, where the capacity demand due to the ongoing expansion and new fiber's deployment would require substantial investments. The standard approach to bidirectional transmission is to spectrally separate the flows in opposite directions, using one upstream (US) and one downstream (DS) channel band and employing band splitters/combiners in each node to separate the flows. While this approach is convenient for low cost 10 Gbps transceivers, it becomes less appealing when applied to more costly coherent interfaces, where the transmitter share of the total system cost is significantly higher. The issue with coherent channels is that the local oscillator at the receiver needs a signal at the same wavelength of the incoming signal, hence the spectral separation technique would double the required interfaces. A possible approach to simplify the coherent receiver structure and enable the 100 Gbps and beyond would be to use the same wavelength for both directions, using an optical circulator to discriminate flows in opposite directions in place of the band splitter/combiner [3,6]. However, this may bring some peculiar impairments that do not exist in case of unidirectional transmission, which must be entirely encompassed within a QoT figure used to assess the physical transmission feasibility. For unidirectional coherent transmission the GSNR can be used as a unique QoT figure [2] if all the propagation impairments can be modeled as additive white Gaussian noise (AWGN) sources. The same reasoning can be thus extended to the bidirectional transmission. We have first observed the involved phenomena in a laboratory setup. Although similar observations have been previosly reported in other works [4,6], here we focus on a single span system with two counterpropagating coherent channels at 100 Gbps on the same wavelength, generated with modern and commercial hardware. The extension to multi-channel propagation is instead devoted to future investigation. We show that the significant additional impairments on the received channel are the Rayleigh backscattering reflection and, especially, lumped reflections, originated by the counterpropagating channel. We also provide a simple mathematical model to estimate the QoT degradation due to such impairments, targeted to the control plane of optical system exploting bidirectional transmission.

2. Experimental Results and QoT Modeling

The experimental setup to investigate the aforementioned problem (Fig.1(a)) is based on a single spool of Standard Single Mode Fiber (SMF) of $L_s = 54.76$ km and overall loss of $A_s = 10.61$ dB ($\alpha_{dB} = 0.194$ dB/km) which has been characterized with an Optical Time Domain Reflectometer (OTDR). On this fiber, two independent, same-wavelength, channels, are simultaneously counter-propagated and separately received thanks to an optical circulator at one fiber end. We refer to the channel under test (CuT), colored red in Fig.1(a), as the downstream (DS) channel, whereas the interfering, counterpropagating channel (colored blue) is the upstream (US). Transmission and detection of both channels are managed by a commercial AS7716-24SC Cassini transponder, along with two independent Lumentum CFP2-DCO modules, generating and detecting a R_s = 32 GBaud, dual polarization (DP)-QPSK modulated signal delivering 100 Gbps per channel. At the receiver, an EDFA forces the DS CuT received power to the optimum value of $P_{DS,RX} = -4$ dBm. The DS signal is progressively loaded with a variable

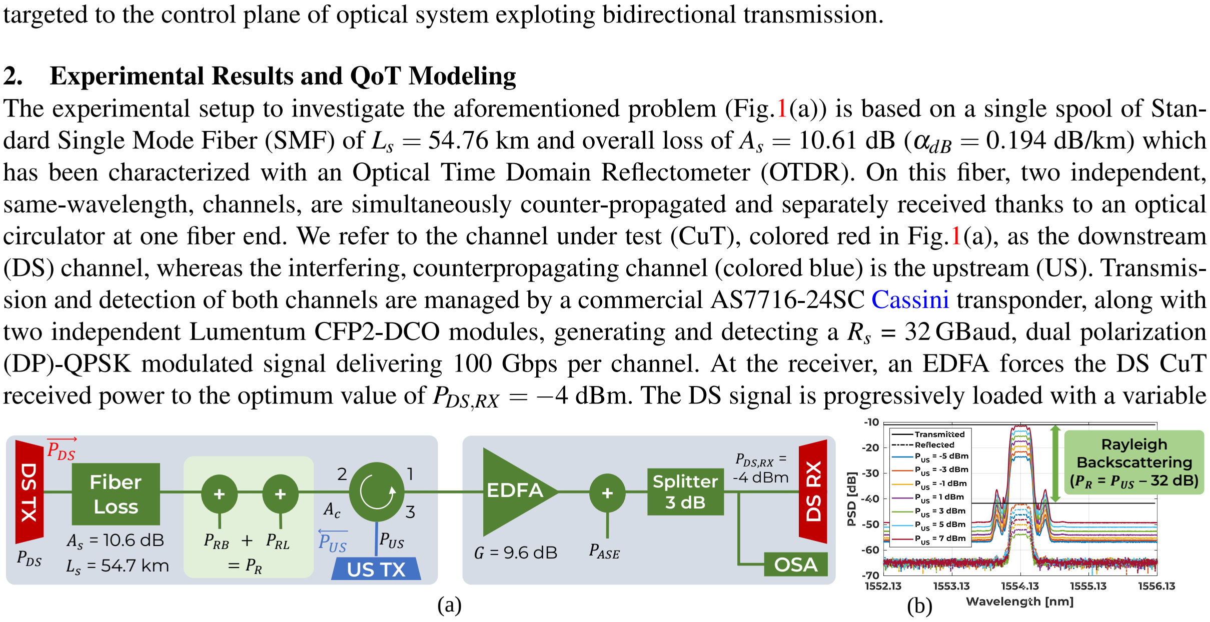

Fig. 1. (a) Experimental setup abstraction for the DS channel. Reflected US power $P_R = P_{RB} + P_L$ modelled as AWGN noise at the DS fiber end. (b) OSA PSD of the US signal backscattered fraction vs launch power P_{US}.

Original

Availability:

Publisher:

Published

Terms of use:

Publisher copyright