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Correlation Chaotic Optical Time-Domain Reflectometry

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Abstract: A correlation chaotic optical time domain reflectometry is proposed and experimentally demonstrated for detecting reflection events. The results show it has the merit of range-independent spatial resolution of 6cm.

1. Introduction

The developing FTTH and RoF bring a mass of local fiber networks, and thus give a challenge to high-spatial-resolution optical time-domain reflectometry (OTDR). For the conventional OTDR probing fiber with single optical pulse, the trade-off between resolution and dynamic range limits its resolution to about tens of meters [1]. Although the trade-off can be overcome by the correlation OTDR using pseudorandom pulse sequences (PNS), but the resolution is also limited by the electronic bandwidth [2]. By adding a degree of freedom, a laser diode can emit chaotic light with ~GHz bandwidth. Utilizing the correlation of chaotic laser light, Liu *et al*. proposed a concept of chaotic lidar [3]. In this paper, we exploit the application of chaotic laser in OTDR and a correlation chaotic OTDR is proposed and demonstrated experimentally.

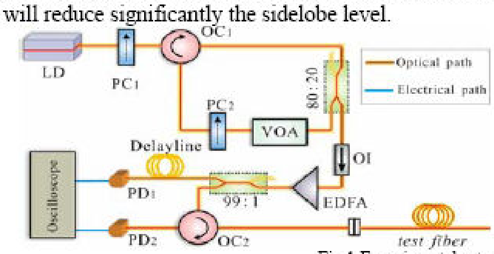
2. Experimental setup and results

The experimental setup of the proposed OTDR is shown in Fig.1. The chaotic light source is a 1.55-μm DFB laser with optical feedback from a 6-m fiber ring cavity, and its output features true randomness and 6.2-GHz bandwidth, as shown in Fig.2(a) and (b). The chaotic output is split into two beams after an amplifier: one serves as the probe light and the other serves as reference light. Both the echo and reference light are converted to electrical signals by two identical photodetectors and recorded by a real-time oscilloscope, and their correlation can be calculated by using a computer.

We used fiber endpoint as reflection event for demonstration. The tested fibers were 1550nm single-mode fibers with loss coefficient 0.2 dB/km. After amplified by EDFA, the average power of the probe and the reference light are 11.2dBm and -8.76dBm, respectively. We firstly calibrated the zero point by adjusting fiber delay-line in the reference channel. Depicted in Fig.2 (c), three correlation traces clearly show each reflection distance from the launching port. Further, the detection of dual-reflection event is demonstrated by injecting the probe light simultaneously into two open-ended fibers with 0.8-m length difference via a 3dB coupler, and the result is shown in Fig.2 (d).

The spatial resolution is only 6cm shown in Fig.2 (e), experimentally examined by using a tunable fiber delay-line with 0.05-mm step. Actually, the resolution only depends on the bandwidth of probe light and is independent of the measuring distance. Note that the 6-cm resolution is limited by the oscilloscope bandwidth of 0.5GHz, and the broadband advantage of chaotic light was not effectively utilized. In fact, it is already enough for diagnoses in small sized network.

To evaluate the actual dynamic range, we studied the effect on the correlation trace's sidelobe level (PSL) of the probe light power loss, which is equivalent to the fiber attenuation or length. Shown in Fig.2 (f), the power loss below 7dB has no effect on the PSL, and when the power loss increases to 17dB, the PSL increases to -3dB. This indicates that the dynamic range of the chaotic OTDR can reach 17dB. The dynamic range can be enhanced by developing a method (like Gray code) which will reduce significantly the sidelobe level.



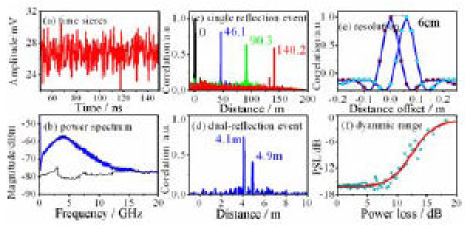


Fig.1 Experimental setup of the proposed chaotic OTDR

Fig.2 (a, b) time series and spectrum of chaotic probe light; (c, d) detection of single- and dual-reflection events; (e, f) resolution and dynamic range

3. Conclusions

We proposed a correlation chaotic OTDR and experimentally achieved measuring reflection events. A range-independent high resolution of 6cm and a dynamic range of 17dB were obtained. We believe it can also measure the fiber loss and Rayleigh scatters just like the conventional correlation OTDR does.

4. References

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