STRUCTURAL VIBRATION SENSING IN A DEPLOYED PON INFRASTRUCTURE

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Deployed Passive Optical Network (PON) infrastructures are proved to potentially support remote structural vibration monitoring while simultaneously downstreaming 10Gbit NRZ transmission.

Keywords: passive optical networks, fiber optic sensors, structural monitoring

Abstract

Fixed access networks are nowadays undergoing a disruptive transition from the old twisted pair toward fiber-based solutions, with a forecast that most of the population will be soon reached by Fiber to the Home (FTTH), at least in urban areas [1]. The capillarity of this growing fiber optic infrastructure opens up the possibility of new applications that can run in parallel to the telecom traffic, providing new added value to fiber optic access networks. The already deployed fiber can turn into a pervasive sensing network offering a large-scale environmental monitoring system, e.g. to detect structural road failures or the onset of seismic and ground motions [2].
In this paper the peculiar architecture of Passive Optical Networks (PONs) is exploited in combination with a interferometric sensing approach, as shown in Fig.1, to achieve a remote structural monitoring of buildings and civil infrastructures, using two fibres after the PON splitter.
The proposed sensing approach was demonstrated on an installed SMF link running in the city of Turin with the co-presence of a 10Gbit NRZ transmission. As shown in Fig.2, at the transmission side a CW optical source at 1550 nm, used for sensing purposes, was combined to a downstream 10Gbit NRZ signal at 1310 nm. At the output of the urban deployed fiber, a 1xn passive optical splitter was placed to emulate a PON architecture. Two fibers of the splitter, meant for the sensing application, were terminated with Faraday Rotator Mirrors (FRM) to backreflect the 1550 nm signal. These fibers constitute the sensing and reference arms of a Michelson interferometer where the demodulation of the interferometric signal occurs inside the splitter [3]. A piezoelectric (PZT) transducer was applied to the sensing fiber to induce slow dynamic strain variations in the range of few Hz, to emulate structural vibrations. The proposed PON layout has been tested

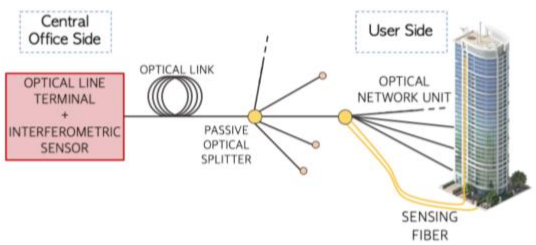

Fig. 1 PON access network architecture where 2 optical ports of the last PON splitter are reserved for building structural monitoring.

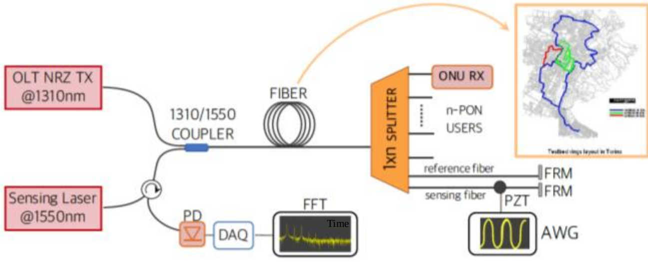

Fig. 2 Experimental PON layout with coexisting vibration sensing system and 10Gbps NRZ transmission.

for different splitting ratios and different fiber link lengths (up to 22 km) to assess how the presence of the PON link can impair the final accuracy of the vibration monitoring system. Thanks to the PON layout, the trunk fiber from the central office to the splitter does not introduce any phase noise contribution as phase modulation induced by the PZT vibration is immediately converted into amplitude modulation at the splitter. On the other hand, the overall losses introduced by the PON architecture, i.e. losses of the roundtrip on the link and the double passage in the splitter, combined to backreflections from ONUs and Rayleigh backscattering along the link, can severely affect the accuracy in the recovery of the vibration phase signal. Instead, concerning the data transmission side of Fig. 2, both the 1310 nm NRZ signals back-reflected by the two FRM and the backscattering generated by the NRZ signal along the link do not affect the sensing system performance because all these contributions are filtered by the 1300/1550 coupler at the front end. Measurements carried out on both 11 km and 22 km PON links proved the feasibility of the proposed solution with good performances in the detection of dynamic structural strains for PON splitting ratio up to 1x16.
Moreover, the impact of the sensing signal on the downstream NRZ 10G received after the 1xn splitter has also been evaluated and no significant detrimental effect of the sensing system were observed on the performance of the PON system.

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