Frequency-Agile Brillouin Optical Time-Domain Analysis Fibre Sensor

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Stimulated Brillouin scattering (SBS) is a very efficient and attractive effect for the implementation of distributed temperature and strain measurements in optical fibres [1]. SBS is the interaction of two optical waves via an acoustic wave. Imagine two counterpropagating light waves in a fibre: the pump and the signal (which frequency is slightly downshifted from the pump). If the pump-signal frequency difference is equal to the Brillouin frequency shift of the fibre, energy will be transfered from pump to the signal, leading to an amplification.

One of the sensing techniques used is Brillouin optical time-domain analysis (BOTDA), it uses pulsed pump and continuous signal. While propagating the signal is amplified only at the positions, where the frequency difference is equal to the Brillouin shift (see Fig. 1). Therefore by scanning the frequency difference one can find Brillouin shift for each position in the fibre. And since Brillouin shift depends on temperature and strain, one can extract this data as well. BOTDA systems allow having 1 m spatial resolution over a distance of 30 km.

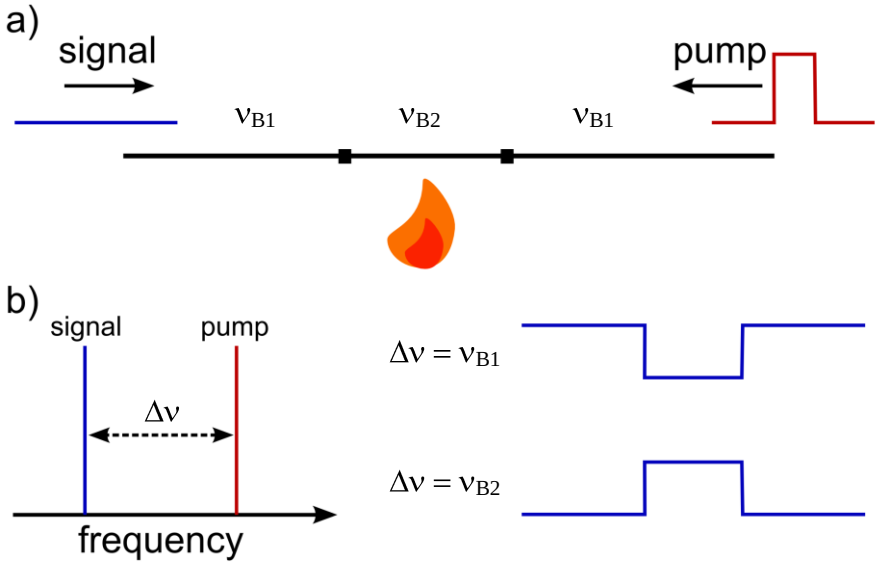

Fig. 1. a) Basics of BOTDA b) output signal for two different frequency shifts.

However, BOTDA systems have a major drawback – a low refresh rate. It requires 5 minutes to scan 300 frequency points, assuming that a single measurement takes 1 second. This drawback can be overcome by using a signal with frequency varying in time. If one can generate a pump-signal frequency difference that exactly matches the Brillouin shift profile of the fibre used, the signal will be amplified along the whole fibre and any change in temperature/strain will be immediately seen as a drop of gain at some position. By analysing this drop one can extract the temperature change and adapt the frequency difference to restore the gain.

A working temperature sensor setup will be presented along with the problems that arised during its implementation. We have shown a refresh time of 5 seconds, while maintaining a temperature accuracy of a few degrees.

References

[1] L. Thévenaz in, *Advanced Fiber Optics - Concepts and Technology*, Chapter 9, L. Thévenaz ed. (EPFL Press, Lausanne, 2011).