METHOD OF HETERODYNE DETECTION OF OPTICAL SIGNALS BASED ON BRILLOUIN SCATTERING

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Problems with detection of signals are the main constraint in evolution of all types of communication systems. A heterodyne technique of detection optical signals is researched to find the gain in sensitivity in comparison with the conventional types of detection. Performed calculations show that the goal in sensitivity is up to 3 dB. Based on equations the structure of future detection system will be developed.

Brillouin based distributed optical fiber detectors have been studied for more than two decades because they have incomparable abilities over the pointed or multiplexed fiber-optic sensors based on fiber Bragg grating and/or inline Fabry-Perot resonator [1]. They originated from the intrinsic fiber-optic nonlinearity in optical fibers, i.e. Brillouin scattering, and have many distinguished advantages, such as high accuracy due to the frequency revolved interrogation, multiple sensitivities of measurands (strain, temperature etc.), no dead zones of sensing location due to the distributed sensing ability, and immunity to the electro-magnetic interference. Nowadays, they are thought to be effective in industrial applications to smart materials and smart structures.

The first report of Brillouin based distributed optical fiber sensors was based on the same principle as that of optical time domain reflectometry (OTDR) or Raman based OTDR (ROTDR) technique as a non-destructive attenuation measurement technique for optical fibers. In that proposal, SBS process was performed by injecting an optical pulse source and a continuous-wave (CW) light into two ends of FUT. When the frequency difference of the pulse pump and CW probe is tuned offset around ν_B of the FUT, the CW probe power experiences Brillouin gain from the pulse light through SBS process. Similarly like the case of OTDR, the SBS distributed measurement could measure attenuation distribution along the fiber having no break from an interrogated optical power as a function of time, but it has much higher signal-to-noise ratio (more than ~10 dB) than OTDR due to SBS high gain [2].

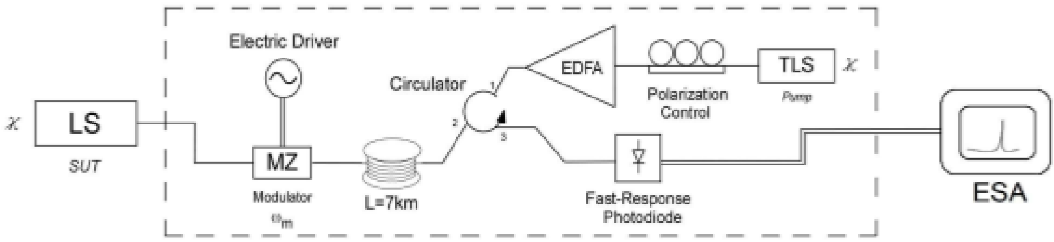

Figure 1 – Schematic of the detection system

The signal tracked in the photodiode contains the beat between carrier and Brillouin backscattered wave stimulated by either of the modulation bands. As the phase noise of pump laser is incorporated into the Brillouin-backscattered wave, and SUT and pump originate from lasers devices with uncorrelated phase variations, this technique has the characteristics of a heterodyne one, so that delay line required in conventional homodyne and selfheterodyne detection for coherence loss is no longer necessary. The presence of this line has been reported as the main drawback of these techniques because the narrower the laser spectrum the longer the delay line required, so loss became a concern and signal interpretation is not straightforward. On the other hand, heterodyne techniques suffer from a lack of effective resolution due to relative frequency jitter between SUT and probe laser, which is not present in the Brillouin induced self-heterodyne method because of the properties of Brillouin backscattering generation. Considering the stimulation mode case, Stokes backscattered wave and stimulus are frequency locked so sudden relative frequency variations between pump and stimulus can be neglected as far as the stimulus lays in the Brillouin Stokes wave gain width, i.e. 10MHz.

This requirement is easily satisfied in the experimental conditions for which this measurement technique is considered , and consequently the measurement can be thought as jitter free.

Список использованных источников:

1. Brillouin Scattering in Optical Fibers and Its Application to Distributed Sensors / Weiwen Zou, Xin Long, Jianping Chen// Advances in Optical Fiber Technology: Fundamental Optical Phenomena and Applications

2. Brillouin induced self-heterodyne technique for narrow line width measurement / Pascual Sevillano, Javier Pelayo// Optics Express July 2010