Dynamic strain sensing with 1MSa/s Brillouin optical correlation domain analysis

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Distributed optical fiber sensors are a branch of sensors that utilizes the entire length of a fiber optic as a sensing medium to detect various external physical quantities such as temperature, strain, pressure, and vibration. Distributed fiber optic sensors provide several advantages, including low cost, ease of scalability, immunity to electromagnetic interference, and durability, making them suitable solutions for real-time monitoring of large structures like buildings, bridges, and railways. The Brillouin Optical Correlation Domain Analysis (BOCDA), a subset of distributed fiber optic sensor schemes, offers spatial resolution of centimeter order, MHz order sampling rates, and random access, enabling the measurement of strain distributions and vibration analysis of structures. By eliminating a lock-in amplifier that was a bottleneck in high-speed measurements of typical BOCDA and employing orthogonally polarized probe sidebands with balanced detection, we implemented a high-speed BOCDA system with MHz-order sampling rates, standing out as the fastest measurement speed ever reported in BOCDA. The demonstrated system allowed the monitoring of a 10 m single-mode fiber with a repetition rate of 20 kHz and 50 measurement points of 3 cm spatial resolution, facilitating the detection and analysis of induced vibrations at the kHz order or acoustic shockwaves propagating along the optical fiber.