Form 2

**Dissertation Abstract**

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| Report no. | (Course-based)<br>(Dissertation-based) No.1179 | Name | Nasrin Sultana |

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| Dissertation title | Study on Optical Dispersion Spectroscopy and Pre-Compensated Ultrafast Arbitrary Waveform Propagation<br>（光分散スペクトル計測と超高速任意波形の伝播前分散補償の研究） |


Abstract

*※ The abstract should be in keeping with the structure of the dissertation (objective, statement of problem, investigation, conclusion) and should convey the substance of the dissertation.*

Recently, the importance of optics has greatly advanced not only in communication but also in the field of pure science and technology. An optical fiber or device introduces dispersion, as a function of phase velocity depends on optical frequency, originating from refractive index variation with optical frequency. As a result, this dispersion is the crucial constraint to the development, optimization, and quality monitoring of photonic devices and optical fiber communication systems. Dispersion not only affects the original temporal profile of a signal, but also reduces the number of channels that can be transmitted simultaneously. Owing to its importance, it is necessary to consider the dispersion provoked by each optical component of the system. As dispersion is an intrinsic property of materials, waveguides, and polarization mode effects, cannot be neglected. These effects, however, can be compensated in optical domain by using dispersion compensation fiber (DCF), or fiber Bragg grating, or by electronic dispersion compensation (EDC). Therefore, the quantification of dispersion is an important task. Furthermore, optics applications need a wide bandwidth to achieve high speed and definition. Hence, a fast system that measures a wide range dispersion spectrum is desired.

In this study, we present a novel approach to high-speed dispersion spectroscopy that realizes a wide dynamic range, by simultaneous and parallel phase measurement using scanless dual-heterodyne mixing of 50 GHz and 1.4 GHz frequency intervals. Unlike the conventional dual-heterodyne mixing, we devised the scan-less two-wavelength simultaneous heterodyne detection methods by using spaced division delay lines, giving phase difference, which is conducted in the optical path (0°, 90°, and 180°) of the experiment system. This system can realize parallel measurements of the relative phases between adjacent frequencies by introducing an optical frequency comb (OFC) and intensity modulator to generate adjacent frequency and arrayed waveguide grating (AWG) to separate the sidebands. The experimental results using single mode fibers, range from 0 to 92 km, indicated a 26 nm dispersion spectrum, 1785 ps/nm measurement range, and 0.27 ps/nm measurement uncertainty in 1 ms.

To make the distributed control more aggressive, dispersion measurement system combined with high-speed signal processing technology. To apply the measurement system, for waveform control transmitting in a dispersive media, optical pulse synthesizer is introduced to feedback the measured dispersion to the source waveform. We demonstrate a dispersion pre-compensation system for an ultrafast 25.6 Tbps (spectral efficiency 4 bps/Hz) waveform using multilevel 8-ary amplitude and 32-ary phase modulation. The bit period of the waveform was 312.4 fs, which was controlled and compensated by a 200 GHz optical frequency comb synthesizer with a 6.4 THz bandwidth. Dispersion spectra were measured in parallel and simultaneously (within 1 ms), based on single-shot dual-heterodyne mixing by introducing an OFC and AWG to separate sideband. As results, a 25.6 Tbps dispersion-free waveform was successfully transmitted through a 10.55 km fiber.