Development of a Fiber Infrared Fourier Transform Spectrometer

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Introduction

Fourier transform spectroscopy (FTS) is way of estimating the optical spectrum using an interferogram. The latter is produced at the output of an interferometer. By vibrating one of the mirrors of the interferometer (see Figure 1), the path difference between the beams is changed. This results in fringes forming at a rate determined by the wavelength of the source and the velocity of the mirror. This "down-conversion" of the frequency means that the optical signal can now be measured on an oscilloscope as the Fourier Transform (FT) signal is in the Hertz or kilohertz range. FTS has several advantages over conventional spectrometers. Most importantly all wavelengths present in the source are measured simultaneously [1]. To ensure that the developed Fourier transform spectrometer is low cost, small and vibrates with high precision, a square gold plated mirror (2 mm×2 mm) was fitted on a compact disc (CD) pick-up head by removing its lens. Using optical fibre improves the robustness of the system and maximizes efficiency by reducing light losses that occur in bulk optic systems.

Down-conversion of frequency

Down–converted frequency of light is given by the frequency of fringes:

$$f_{FT} = (2 \times v_m \times f) / c$$

where c is the velocity of light, v_m the velocity of mirror, f_{FT} is the frequency of FT signal, and f is the frequency of light

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Experimental set up and procedure

- Two laser beams, at wavelengths of 1550 nm and 1565 nm, are fed to the spectrometer through a 3 dB coupler.
- With path length matching and proper alignment of the mirror, we observe interference fringes with high visibility and a maximum coupling back of light returning to the system.
- The mirror was vibrated with a sine wave of 19 Hz and a peak to peak voltage of 1.5 V. A characterization experiment showed that the traveled maximum distance at this value of voltage and frequency. The distance traveled by the mirror is related to the resolution of the spectrometer as:

$$R = c/4d$$

where R is the resolution in frequency, c is the velocity of

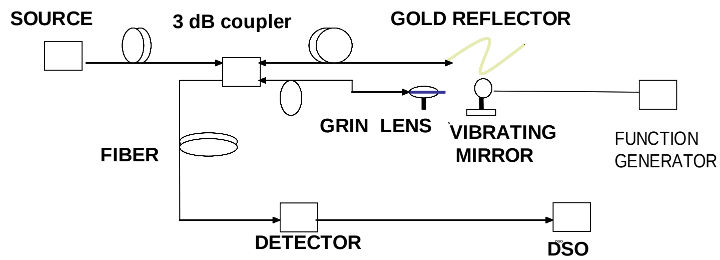

Figure 1: Experimental setup

light and $2d$ is the distance traveled by the mirror in one direction.

- The output FT pattern was stored on a digital oscilloscope, also shown in Figure 2. The arrows show the peaks of the FT frequencies corresponding to source wavelengths 1550 nm and 1565 nm.

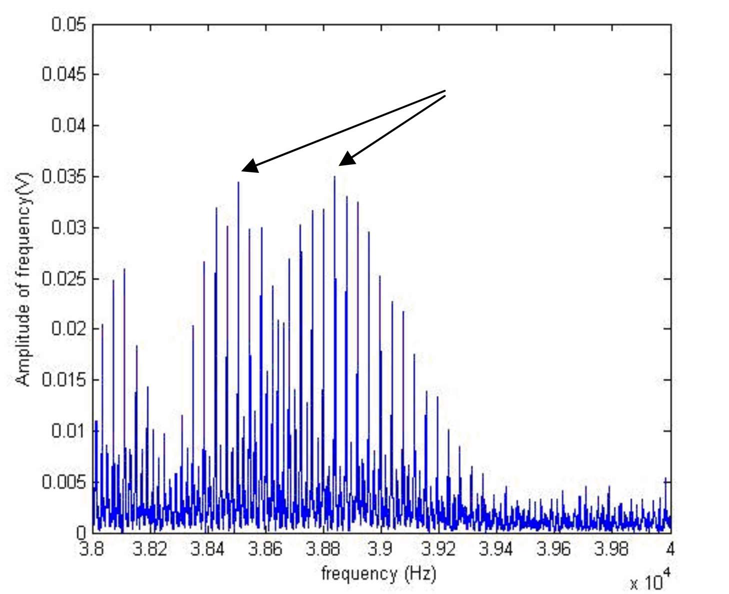

Figure 2: FT output of interferometer. The arrows mark the two source wavelengths at 1550 nm and 1565 nm.

Results

The resolution for the particular set-up used was found to be 15 nm. Many applications require much higher resolution than this and future work will look at improving resolution. The present setup could be used in Course Wavelength Division Multiplexing, where the wavelength spacing is about 20 nm.

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