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# Ultra-high-resolution spectroscopy: Development and results of a real-time controller for an imaging Fourier Transform Spectrometer

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## Abstract

Spectroscopy in exoplanet imaging has been used to characterize stars and their companions in astronomy for the last few decades. New imaging spectrograph technologies are needed to optimize new promising techniques, such as using very high-spectral resolution to identify exoplanet molecules in a speckle-limited image. These new techniques are difficult to implement as they require both a large field-of-view to search for hidden exoplanets, and a high-resolution spectrum for every resolution element of the field-of-view. The Subaru Pathfinder Instrument for Detecting Exoplanets & Retrieving Spectra (SPIDERS) will showcase a new generation imaging spectrograph, using an imaging Fourier Transform Spectrometer (FTS) to acquire a wide FOV from low R40 to high R20,000 spectral resolution. Off-the-shelf FTS devices have few options for speed and scan control. Typical FTS applications with bright sources and plenty of photons can take advantage of faster scan speeds to mitigate mechanical vibration and increase spectral SNR. Implementing new imaging methods and faster techniques, SPIDERS requires an FTS that can scan much slower than usual to prevent the detector read noise impact whilst prioritizing position and velocity stability. Using an off-the-shelf Michelson interferometer, a custom PCB was developed and implemented to facilitate a voice coil driving and metrology feedback circuit to provide complete control over scan speed, length, and shape. A Helium-Neon laser provides fringe quadrature sine waves that are used to determine nanometer-level position feedback. The C based controller generates a 16-bit current command at 50kHz to provide stable scanning and accurate positioning. Closed-loop testing and tuning is underway with first results proving the success of the drive and metrology electronics, the quadrature algorithm, and the closed-loop control. This paper will present the controller design and implementation, along with an analysis of its performance on the bench under real conditions.

**Keywords:** Fourier, transform, spectrometer, spectroscopy, high, resolution, FTS, controller, voice coil, metrology, fringe, quadrature, closed, loop, metrology

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