National Aeronautics and Space Administration

PanFTS—DFPA Electrical/Data Interface, Real-Time Processing, and Validation at CLARS

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Decadal Survey Instruments - Strategic Initiative Leader: Eastwood Im

Objectives:

The primary objective was to advance the technical maturity of PanFTS in preparation for submission of an Earth Science Explorer proposal (AURORA mission)
The secondary objectives were to:

1. Acquire one or two MIT-Lincoln Lab digital focal plane arrays and Interface Control Document (ICD) to enable JPL to design and build an FPGA-based high-speed interface that integrates fringe data from the interferometer's metrology laser ("Lighthouse" interface).
2. Demonstrate system-level performance by obtaining atmospheric spectra from Fourier Transform Spectrometer (FTS) instruments in B306 and JPL's California Laboratory for Atmospheric Remote Sensing (CLARS) lab on Mt. Wilson.

Approach and Results

- The main focus of activities in FY21-22 was the testing of hardware and Field Programmable Gate Array (FPGA) code for the "Lighthouse" board, which provides the interface to the MIT-Lincoln Labs Digital Focal Plane Array (DFPA).
- The Lighthouse board also has the ability to collect the digitized fringes from the metrology laser in the interferometer and synchronize them with IR data frames from the DFPA.
- The Lighthouse board consists of a Xilinx Kintex Ultrascale FPGA that interfaces to the Lincoln Lab Digital Readout Integrated Circuit (DROIC). It performs readout and pre-processing including flat- field calibration, pixel binning, and windowing. The pre-processed data is transmitted off board through either a standard RJ45 Gigabit Ethernet port, or an SFP+ 10G Ethernet port.
- The board also possesses an interface to the Laser Analog-to-Digital Converters (ADCs) for synchronizing the metrology with the frame capture, as well as on-board MRAM for non-volatile storage of parameters. The Lighthouse board is shown in **Figure 1**.
- We elected to test the Lighthouse board on a spare unhybridized bare DROIC supplied by MIT-LL.

Milestones

- Received and checked out several bare DROICs provided by MIT-LL
- Adjusted current limits for the DROIC bias voltages
- Successfully tested the DROIC frame read functionality
- Successfully wrote into and read out data from the DROIC's frame buffer

The DFPA was integrated into the interferometer in B306-231A which was used to obtain high-resolution spectra of lab air using a high-intensity quartz halogen light source. Sample interferograms from four of the pixels in the 640x480 High Operating Temperature Barrier Infrared Detector (HOT-BIRD) array shown in **Figure 2**, along with the simultaneously sampled metrology laser fringes. The phase-corrected and Fourier-transformed interferograms (optical spectra) from the four pixels are shown in **Figure 3**.

Background:

- The need to understand the causes and consequences of climate change and provide useful data to policy makers, the National Research Council was commissioned by NASA to write the 2018 Earth Sciences Decadal Survey (DS). The DS contains prioritized recommendations for global measurements from space including greenhouse gases (GHG), ozone and trace gases (OTG), and many others.
- One of the mission lines recommended in the DS is the Earth System Explorer (ESE). These are 2-step competed PI-led missions which address one or more of the designated observables identified in the DS.
- The Panchromatic Fourier Transform Spectrometer (PanFTS) is an imaging spectrometer that provides measurements of atmospheric composition from geostationary or highly elliptical orbits. It offers high spatial resolution (2-4 km/pixel), wide wavelength coverage (TIR to near-UV) and short revisit times for observations several times per day. The imaging focal planes that meet the instrument requirements must operate at high data rates, up to 5 Gb/s.

Significance and Benefits to JPL

- The most significant milestone reached in FY22 includes bench testing of the Lighthouse DROIC interface board interfaced to a MIT-LL DFPA and acquisition of high resolution imaging IR spectra using the PanFTS in B306.
- Since the hardware and firmware for the interface originated at JPL, future projects employing this hardware will have full control over the FPA subsystem, and not be reliant on a hardware/firmware solution from another vendor which would likely be proprietary.
- Many JPL projects will benefit from this work, especially those that contain imaging subsystems such as cameras, hyperspectral imagers, Fourier transform spectrometers, etc.

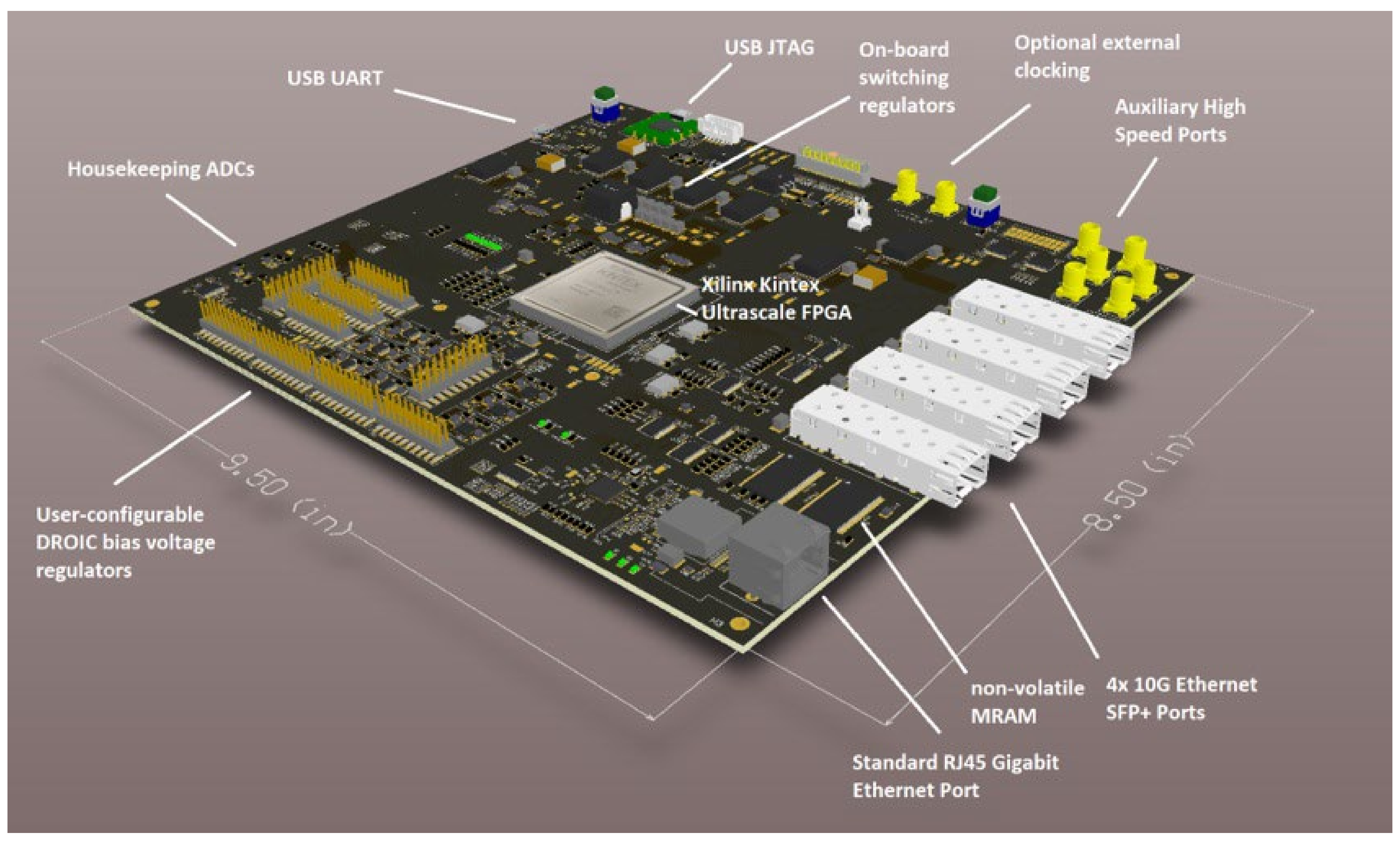

Figure 1. Lighthouse DFPA interface designed and built at JPL for this project

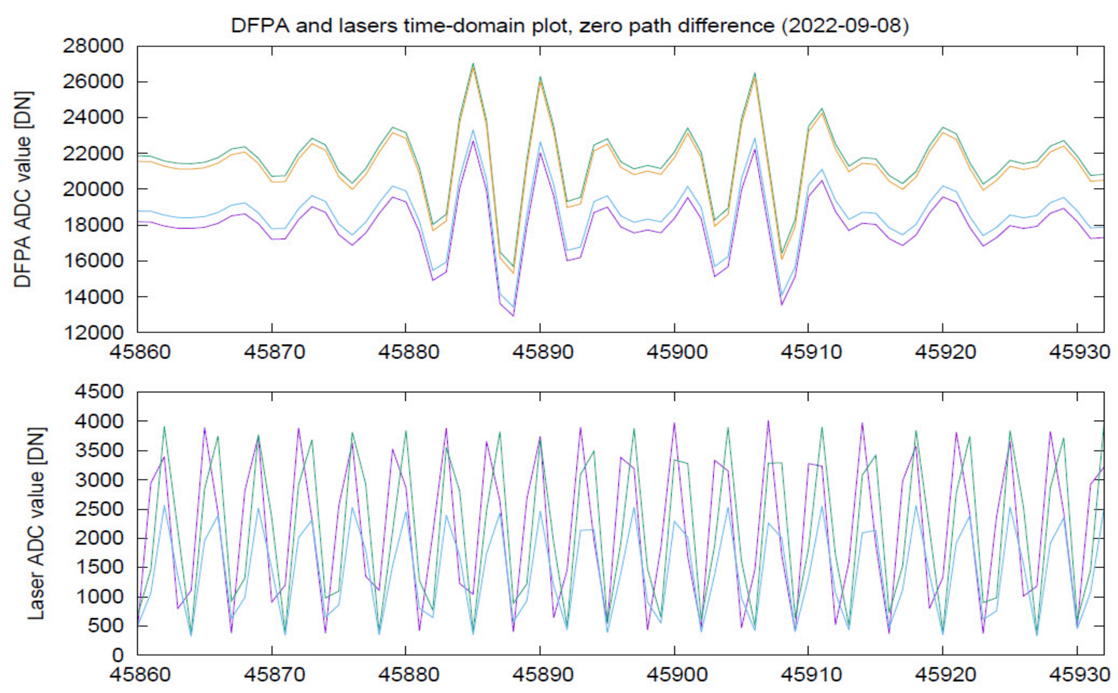

Figure 2. Time-domain interferometer data captured by the Lighthouse interface near the zero path difference (ZPD) point. Upper trace: science frames from four pixels (out of 307,200 pixels). Lower trace: synchronously captured laser metrology fringes.

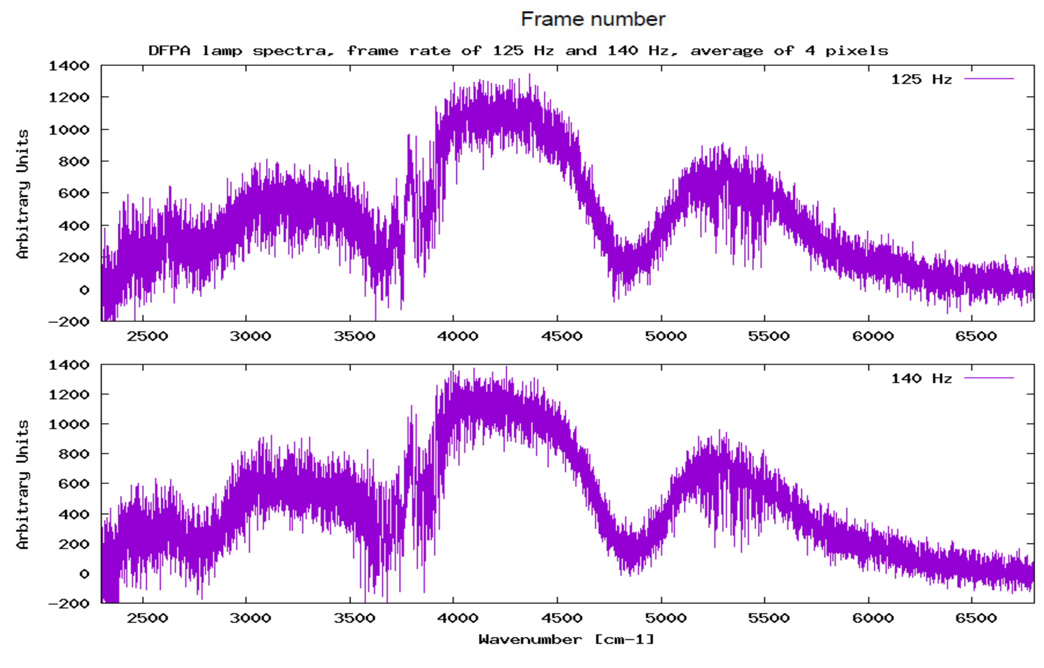

Figure 3. Lab spectra corresponding to the four DFPA pixels shown in Figure 2. The interferograms have been phase corrected and Fourier transformed. The frequency scale is in cm^{-1}. Upper panel: DFPA frame rate = 140 Hz, Lower panel: DFPA frame rate = 125 Hz

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