

Wideband High-Res FPGA/ASIC Spectrometers

Introduction

One of the Center for Astronomy Signal Processing and Electronics Research (CASPER)'s primary applications of reconfigurable computing platforms is the construction of wideband high-resolution spectrometers. Currently, CASPER has three spectrometers under development or in operation. These include a 128M channel/200 MHz bandwidth BEE2 based spectrometer, a smaller variable channel iBOB based spectrometer we have dubbed the 'Pocket Spec' and a custom 4096 channel spectrometer designed to be implemented on a radiation tolerant ASIC for upcoming NASA missions.



All CASPER spectrometers begin with a Simulink model using CASPER-built custom blocks, such as the complex biphase pipelined FFT and vector accumulator blocks shown in the pocket spectrometer design above.

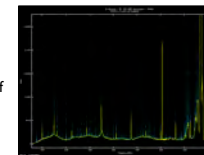
128M Channel SETI Spectrometer



NASA/JPL DSS 13

The BEE2-based SETI Spectrometer was installed at NASA's 34-meter DSS-13 radio telescope in August of 2005. It is capable of performing a 134217728-channel FFT every 0.67 seconds, with a total bandwidth of 200 MHz.

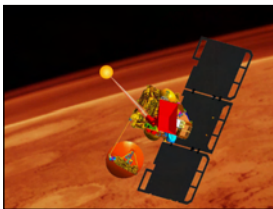
Because of disk access limitations, the spectrometer does not write out every channel of every spectrum. Instead, each channel is divided by the average of 65536 adjacent channels, and only those channels for which this ratio exceeds a user defined threshold are written to disk.



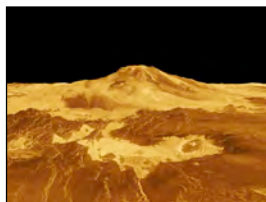
SETI Spectrometer Spectrum Plot

Flight Plan

The NASA Mars Volcanic Emission and Life (MARVEL) mission proposes to globally survey the Martian atmosphere's photochemistry in a search for signs of microbial metabolic activity or active volcanism. The survey will be conducted using high-resolution sub-millimeter spectroscopy in a solar occultation geometry. This mission could potentially put very stringent limits on near-surface microbial activity on Mars and would be a significant step forward in the investigation of life on Mars. The CASPER-built MARVEL spectrometer has been prototyped on an iBOB board, but it is being respun, using BWRC's INSECTA tool-flow, as a radiation-tolerant ASIC-based unit for deployment on the MARVEL orbiter. The spectrometer is currently slated to feature a 1 GHz bandwidth and 4096 spectral channels with power consumption less than 5 Watts.



Artist's concept of Mars Volcanic Emission and Life Scout



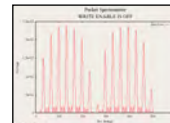
Computer generated picture of Venus's surface - Magellan

The NASA Venus Sounder for Planetary Exploration (VESPER) is a proposed Discovery Mission. The VESPER mission will provide a comprehensive study of Venus with sensitivity levels sufficient to test major models of the constituents and dynamics of Venus's atmosphere. Investigation into using a CASPER built spectrometer for this mission is currently underway.

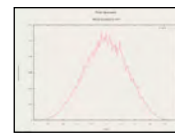


Pocket Spectrometer

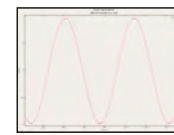
The 1 GHz band / 2048 channel Pocket Spectrometer uses just 1 ADC, 1 iBOB and a laptop computer for data collection and analysis. Using ATMEL ADCs sampling at 2 Gsamples/sec and performing 4 real FFT's in 1 (complex) biphase pipelined FFT module, the Pocket Spectrometer is incredibly powerful for its footprint.



Pocket Spectrometer Test Vector Plot

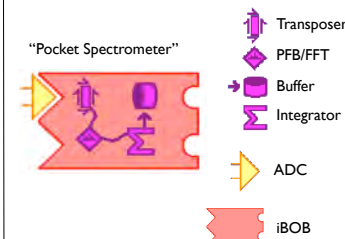


Pocket Spectrometer ADC Histogram Plot



Pocket Spectrometer ADC Plot

Below is a simple diagram of the components of the Pocket Spectrometer which reflects the modular approach to instrument design utilized by the CASPER group.



CASPER

CENTER FOR ASTRONOMY SIGNAL PROCESSING AND ELECTRONICS RESEARCH



Daniel Chapman, Andrew Siemion, Henry Chen, Bora Nikolic, Aaron Parsons, Brian Richards, Dan Werthimer

Berkeley Wireless Research Center - University of California, Berkeley

