Spectrometers for (sub)mm radiometer applications

A. Emrich, M. Krus, J. Riesbeck, S. Andersson, Magnus Hjort
Omnisys Instruments AB, Gruvgatan 8, 421 30 Göteborg, Sweden

ABSTRACT

The FFT spectrometer and autocorrelation spectrometers are two of 5 types of spectrometers being considered for space based (sub)millimetre heterodyne systems. The advantages of the digital autocorrelation and FFT spectrometers compared to Chirp Transform, Acousto Optical and Filterbank spectrometers are; stability, compactness, high reliability and variability in bandwidth and resolution. FFT spectrometers based on the latest generation of FPGA devices now promise a cost effective alternative for low to medium bandwidth applications with high resolution requirements.

Omnisys has an FFT spectrometer design optimized for ground based applications. It follows the single Eurocard standard size and provides up to 2 GHz bandwidth and 1-4 inputs. With four inputs, the maximum processed bandwidth is 500 MHz.

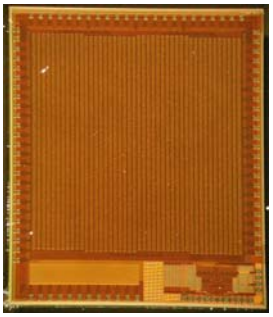
Configurations with polyphase filtering, polarization processing and variable resolution over the processed band have also been tested.

Omnisys FFT board provides 2 GHz processed bandwidth with a power budget of less than 20W. The next generation will provide 4 GHz of bandwidth per board.

For the SuperCAM imaging system, 16 boards will be used in two single height 19" crates to provide 64 spectrometers. It could be upgraded to provide 64 times 1 GHz by simply adding two crates. Test results will be shown in the conference.

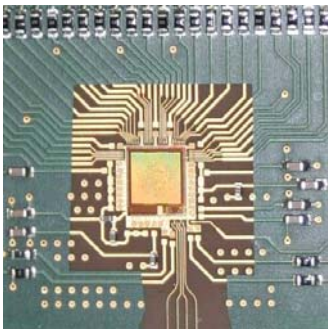
These can be housed in one single height 19" crate together with IF systems and embedded computers providing flexible interfaces to front-ends as well as flexible interfaces for switch synchronization, data readout and other forms of control. The default interface is 100 MBit/s Ethernet. This is a breakthrough for future imaging applications as we can provide spectrometers for 5 kEuro each (in reasonable volume).

Omnisys has designed and implemented several generations of autocorrelation chip sets and spectrometers. This range from the ODIN satellite spectrometers now in LEO to our current 8 GHz single chip spectrometer. The ODIN chip set was a breakthrough at the time (1998). The power consumption was lowered by a factor of 50



HIFAS, Omnisys fifth generation autocorrelation spectrometer ASIC is being developed. It is a full-custom design with over two million transistors, designed for IBM's 180 nm SiGe Bi-CMOS process. Unlike earlier generations, it contains both the bipolar 3-level ("1.5-bit") A/D converter and the CMOS correlator on the same chip. Thereby, the sensitive high-speed digital interface between the two parts gets integrated on the chip.

The chip supports as input either a complex I/Q input signal pair, measuring its spectrum from –fclk/2 to +fclk/2 or a single baseband signal sampled on both clock edges, measuring from 0 to fclk. This choice gives flexibility for the system level design.



The first batch of the chip was produced in 2007. Unfortunately it turned out to have a logic bug that makes it necessary to do a re-run. A second revision of the chip is being designed at the time of this writing, and tape-out is planned for early 2008. Despite these initial problems with the chip, most of the chip's functions have been tested and shown to work. The analog parts work in both of the two input modes with up to 8 GHz sample clock.

The goal is to reach a bandwidth of 8 GHz, a resolution of 1024 channels, and a power consumption of 3-4 W. When finished, this chip will set a new world record in autocorrelator performance, and open for new possibilities in radiometry on both space and ground.