Autocorrelation Spectrometers for (sub)millimetre Spectroscopy

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ABSTRACT

The autocorrelation spectrometer is one of four types of spectrometers being considered for space based (sub)millimetre heterodyne systems. The advantages of the digital autocorrelation spectrometer compared to Chirp Transform, Acousto Optical and Filterbank spectrometers are; stability, compactness, high reliability and variability in bandwidth and resolution.

The detailed design of three autocorrelation spectrometers will be described, from the ODIN spectrometer currently in operation in space, the TELIS spectrometer delivered to DLR, and for an experiment under development for Venus Express.

ODIN SPECTROMETER

The ODIN satellite is a joint aeronomy and astronomy mission. The main payload consists of four tunable heterodyne schottky receivers in the frequency range 480-570 GHz and one fixed tuned 119 GHz heterodyne system. In addition, there is an UV-spectrometer.

There are four back-end spectrometers connected to the five heterodyne systems, two autocorrelation spectrometers, one AOS and one filterbank. The autocorrelation spectrometer and AOS power consumption are the same, while the size and mass of the AOS is 7 times the correlation spectrometer. The filterbank only consumes 2 W.

The ODIN satellite has been in successful operation for more than 2 years, the design lifetime, and a decision has been made to operate for an additional 2 years.

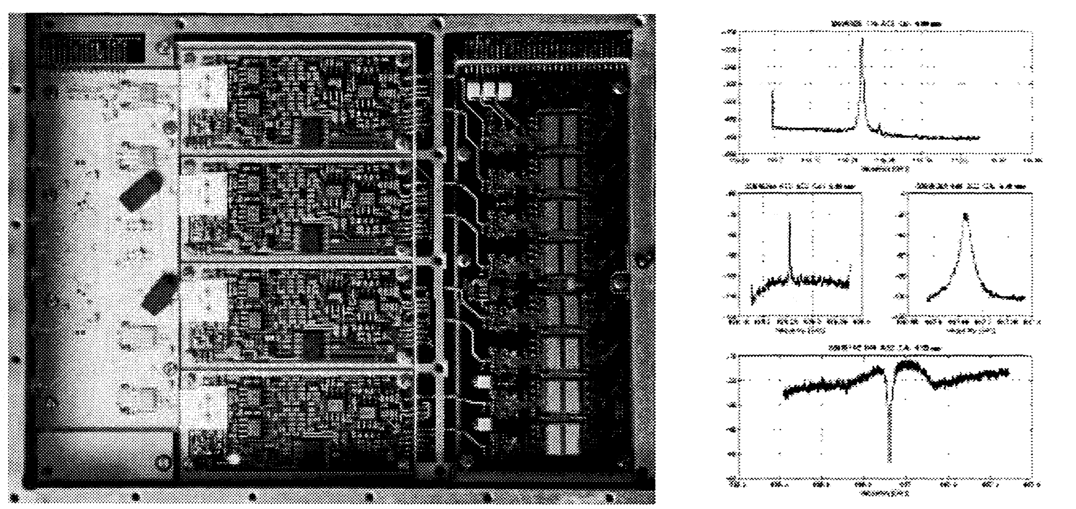

Figure 1. The ODIN spectrometer core. The complete spectrometer has 100-800 MHz bandwidth in steps with 0.13-1.1 MHz resolution. Other specifications are: 1 kg, 220x180x30 mm and 18 W power consumption. The spectra is "first light" from the satellite.

DLR/TELIS SPECTROMETERS

Based on a chip-set developed during 1998-1999, motivated by MASTER and FIRST, 600 MHz coverage and 256 channels resolution is possible with only two chips, one quantiser and one correlator chip.

A "standard" spectrometer with 2x2 GHz bandwidth, and 2 x 1024 channels has been designed, and two of those has been ordered for the DLR TELIS project. These will be shared between three front-ends, through an IF processor, also produced by Omnisys.

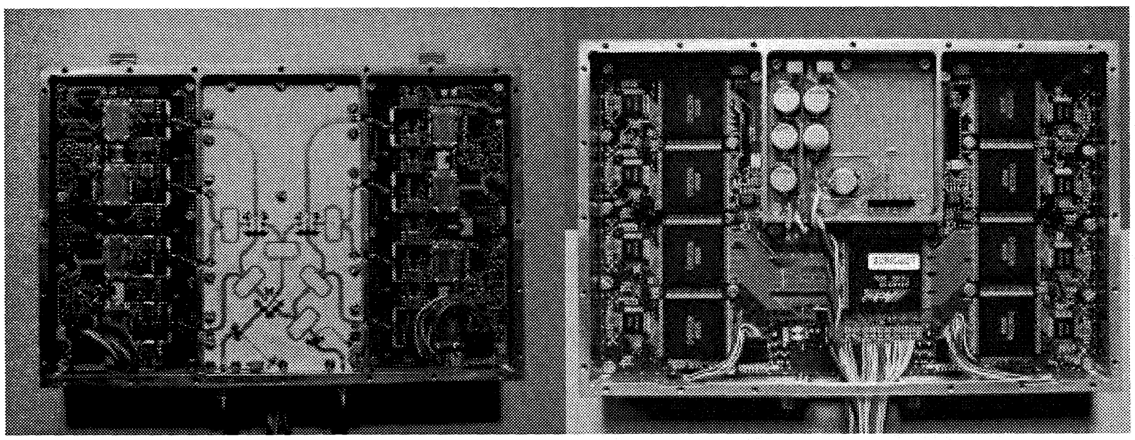

Figure 2. The current generation of spectrometers, with top and bottom views, based on a 256 channel correlator chip and quantizer with 1200 MHz effective sample rate. The box incorporates 2048 channels and could be configured with 1 x 4 GHz bandwidth, 2 x 2 GHz etc. The mass is 900 grams, the size 170 x 110 x 30 mm, and the power consumption is 18 W.

VENUS EXPRESS

Currently a development for a radiometer for the Venus Express mission is under development. For Omnisys part it is based on preliminary design for a similar instrument, Mambo, planned for a Mars mission. The instrument will cover 546-576 GHz, and the autocorrelation spectrometers will be flexible, but covering up to 12 lines between 6-13 GHz, with resolutions from 100 kHz to 20 MHz. The mass will be 500-700 grams, and the power consumption variable, depending on mode, but between 6-12 W.

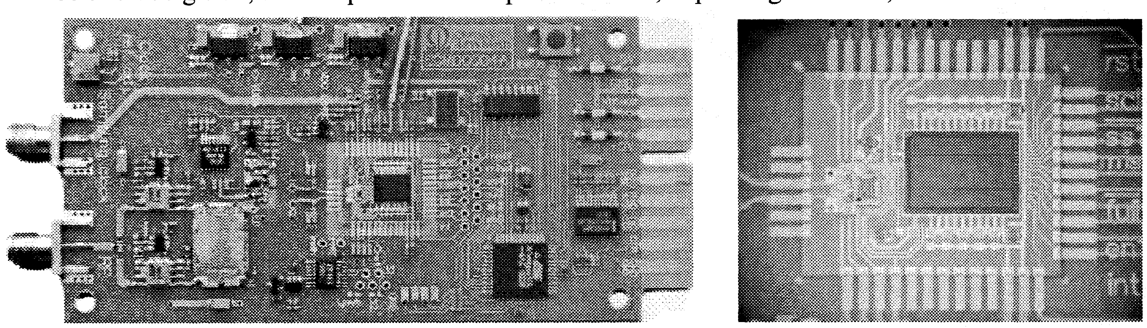

Figure 3. Test set-up of the Venus Express chip-set to the left. This chip set can process up to 2 GHz bandwidth, with 1024 channels. To save power, the number of channels used can controlled, starting from 128. On the right side, the MCM is shown.

CONCLUSION

Now, as a result from the development described above, a general conclusion is that autocorrelation spectrometers are very competitive with other type of spectrometers for space based (sub)millimeter radiometry. The main advantages are: compact implementations, scalability and versatility in bandwidth and resolution, combined with potentially very high stability. In addition, it uses no special technologies and components, such as CCD's, Bragg Cell's or Chirp filters, with concerns regarding availability, radiation tolerance and other quality concerns.

The chip set developments has been supported by the Swedish National Space Board and by ESA.