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High Resolution Digital Spectrometer with Correlation and Image Rejection Capabilities

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We present a new digital back-end for Correlation and Spectrum Analysis (COSPAN), which will be used for remote sensing of the atmosphere and radio astronomy. Its hardware is based on a commercially available signal analyzer Acqiris AC240 from Agilent, which provides two input channels with 1GS/s sampling rate and an on-board FPGA signal processor. The original FFT firmware of this instrument allows to accumulate a total power spectrum with 1GHz bandwidth and 16384 channels (61kHz resolution) in real-time for a single input channel. Our new COSPAN firmware processes the data from both input channels in two separate FFT pipelines, which results in two 500MHz wide complex spectra with 30.5kHz resolution. These spectra can be then combined or analyzed by different user modes. The most straight forward one is the total power mode where the real and imaginary part is squared and added for each spectrum separately. This mode could be used, for example, to process two pixels of an array receiver. In the correlation mode the real and imaginary part of the product of the two spectra is accumulated, which corresponds to the complex cross-correlation spectrum of the two inputs. This mode has been implemented for our new 22GHz correlation receiver MIAWARA-C, in which the atmospheric signal and a reference signal from an active cold load are combined with an 3dB hybrid coupler and processed in two identical receiver chains. With the correlation mode the two input signals are continuously compared with each other, whereas the uncorrelated noise of the two receivers does not contribute to the accumulated spectra. As a result gain fluctuations are less critical and the stability of the instrument is highly improved. Another application area for the correlation mode are polarimetric observations. The third image rejection mode calculates the total powers of the sum and the difference of the two complex FFT spectra after applying an appropriate phase shift. When the two input channels are fed by an IQ Mixer the two resulting spectra represent the lower and the upper sideband. This mode is the equivalent to a conventional sideband separating mixer in which which the two IFs are combined by an analog hybrid coupler, but it provides a higher image rejection because the digital 90 degree phase shift is more accurate. To further improve the image rejection COSPAN allows to determine and correct the amplitude unbalance of the IQ mixer.