

Components for Wide Bandwidth Signal Processing in Radio Astronomy

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Abstract

In radio astronomy wider observing bandwidths are constantly desired for the reasons of improved sensitivity and velocity coverage. As observing frequencies move steadily higher these needs become even more pressing. In order to process wider bandwidths, components that can perform at higher frequencies are required.

The chief limiting component in the area of digital spectrometers and correlators is the digitiser. This is the component that samples and quantises the bandwidth of interest for further digital processing, and must function at a sample rate of at least twice the operating bandwidth. In this work a range of high speed digitiser integrated circuits (IC) are designed using an advanced InP HBT semiconductor process and their performance limits analysed. These digitiser ICs are shown to operate at up to 10 giga-samples/s, significantly faster than existing digitisers, and a complete digitiser system incorporating one of these is designed and tested that operates at up to 4 giga-samples/s, giving 2 GHz bandwidth coverage. The digitisers presented include a novel photonic I/O digitiser which contains an integrated photonic interface and is the first digitiser device reported with integrated photonic connectivity.

In the complementary area of analogue correlators the limiting component is the device which performs the multiplication operation inherent in the correlation process. A 15 GHz analogue multiplier suitable for such systems is designed and tested and a full noise analysis of multipliers in analogue correlators presented. A further multiplier design in SiGe HBT technology

is also presented which offers benefits in the area of low frequency noise.

In the effort to process even wider bandwidths, applications of photonics to digitisers and multipliers are investigated. A new architecture for a wide bandwidth photonic multiplier is presented and its noise properties analysed, and the use of photonics to increase the sample rate of digitisers examined.

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