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Front end strategy for the daq system of a Kinetic inductance detector

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Cosmology studies call for accurate measurements of cosmic microwave background radiation anisotropies. A promising technique to achieve the required precision is based on big arrays of Kinetic Inductance Detectors (KID). In this paper, we describe, a new strategy to stimulate and read a KID array of 128 pixels based on FPGAs and analog to digital converters. The project can reach an analog bandwidth as high as 250 MHz and all pixels can be stimulated and read continuously and in parallel. Results are sent to an on-line PC based farm via Ethernet or PCIexpress protocol.

Summary

Cosmic microwave background radiation anisotropies calls for extreme precision measurement of photon energy in the range of 70 to 900 GHz. Recently, Kinetic inductance detectors, (KID) produced using silicon technique, have been shown to be useful to build big arrays. KIDs are superconductive bolometers, electrons are organized in Cooper pairs and an incident photon can break a pair, generating two quasi-particles. Thus changing their inductance. A measurement of the variation of the resonant properties of this detector permits to measure the energy of the impinging photon. each pixel is a resonator tuned on its own frequency. A feedline (composed of two strips) passes near each pixel. This feedline delivers a stimulus signal. If the stimulus signal is tuned on the resonant frequency of the pixel, the intensity of the signal is reduced and its phase is shifted. All pixels can be stimulated by a signal which contains all resonant frequencies: the comb signal. A simple and effective way to produce a comb signal is to produce N sinusoids (one for each pixel's proper oscillation frequency) and add them up. Digital system can generate sinusoids and make samples at regular interval of time. Each resonator has about 500 kHz of FWHM, so 2 resonant frequencies must be parted by a minimum of 1 MHz to be clearly distinguishable. Therefore a minimum bandwidth of 100 MHz (200 MHz clock frequency) is needed to stimulate the tones of 100 pixels. Field programmable gate arrays (FPGA) can be used in this environment because of their intrinsic capability of performing parallel computation. In this paper we describe a project and the strategy we have followed to create a stimulus which can be used to read 128 pixels. The FPGA chip we have used is XC7VX485T from Virtex 7 family of Xilinx. This chip has 2800 DSP48Es that are useful to generate sinusoids, add them up and to analyze on-board signal processed by KID array. We have successfully simulated a project that generates 128 tones with a period of clock of 2 ns, so we have 250 MHz of analog bandwidth. The same project, with on-chip signal analysis, can run at 300 MHz to achieving a bandwidth of 165 MHz. The signal after stimulating the KID array is received to be synchronized with itself and averaged in time. After this stage, data are delivered to a computer system. Data transmission protocols with the computer system are based on Ethernet and/or PCIexpress. Under normal circumstances earth microwave telescopes are modulated by a 10 Hz maximum oscillating signal. The bandwidth needed is about 50 Hz. Transmission rate can be computed multiplying the number of tones (128) by the rate modulation (50 Hz) and by the number of bits (16) of the cosine and sine signals results. This amounts to 205 kbps. The communication methods we use guarantee that data flowing at the expected physical rate can be collected since the Ethernet and the PCIe bandwidths are much higher.

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