Contribution ID: **10** Type: **Oral**

High speed readout electronics development for frequency-multiplexed kinetic inductance detector design optimization

Tuesday 24 September 2013 11:11 (24 minutes)

Microwave Kinetic Inductance Detector (MKID) are a promising solution for space-borne mm-wave astronomy. To optimize their design and reduce the impact of the primary Cosmic Rays interaction with the substrate, the phonon propagation in the silicon substrate must be studied. A dedicated fast readout electronics, using channelized Digital Down Conversion for monitoring up to 16 MKIDs over a 100MHz bandwidth was developed. Thanks to the fast ADC sampling and steep digital filtering, In-phase and Quadrature samples, having a high dynamic range, are provided at 2MSPS. This paper describes the technical solution chosen and the results obtained.

Summary

The microwave kinetic inductance detectors are an alternative to traditional bolometers for mm-wave astronomy. They consist of a high-quality superconducting resonant circuit electromagnetically coupled to a transmission line and they are designed to resonate in the microwave domain. Their resonances lie between 1 to 10GHz and have loaded quality factors exceeding 10ˆ5, corresponding to a typical bandwidth of about 100kHz. As the MKIDs resonant frequency can easily be controlled during manufacturing, it is possible to couple a large number of MKIDs to a single transmission line without interference and therefore to perform a frequency-multiplexed readout. Their self resonant frequencies are proportionally sensitive to the incident sky power, but also to the ballistic phonons induced by cosmic rays direct interaction in the substrate. Indeed, due to the metal layer thinness and a much smaller physical area of the MKIDs compared to the substrate, the MKIDs themselves have a negligible cross section to cosmic rays. To fully study the phonon diffusion, a dedicated fast readout electronics was required. These electronics can be used for different purposes: either for time-resolved phonon-mediated detection of high-energy interactions from cosmic rays or for optimization of the MKID array design.

The required electronic fulfills two purposes. At first, it builds a frequency comb having all its tones adjusted to the different resonators center frequencies; this excitation signal is injected in the detector. Then, at the output of the transmission line coupled with the MKIDs, the resultant signal is acquired and analyzed in order to determine the time dependent phase and amplitude variation of each sinusoids. Since the MKID resonator frequencies are above several GHz, the electronics does not drive directly the array. Consequently, the frequency comb is generated at baseband and up-converted to the frequency band of interest by hybrid mixers. The array output signal is down-converted back to baseband and then processed by the electronics.

A channelized Digital Down Conversion (DDC) solution was implemented to reach high sampling rate (2MSPS) and meanwhile allowing a high dynamic range. Each DDC features a quadrature Direct Digital frequency Synthesis (DDS) (14 bit CORDIC generator), two digital mixers and two multirate steep digital filters. The digital filters are composed of two successive Cascaded Comb Integrator filters (CIC) followed by two polyphase Finite Impulse Response (FIR) filters (40 coefficients). The second CIC filter has a programmable decimator allowing the tuning of the sampling rate.

Consequently, the electronic developed is FPGA centered (Xilinx Virtex6) to provide adequate computing power and features a dual 16 bit DAC and one 14 bit ADC, all clocked at 250MHz. This frequency permits to cover a 100MHz of useful bandwidth, which is sufficient to excite and read-out a transmission line fitted with 16 MKIDs, provided they are adequately separated in frequency.

Each DDC channel is equipped with a trigger system that allows the data recording only when the signal module exceed a threshold.

After a quick overview of the MKID and their readout technique, this presentation will describe the technical solution chosen and the results obtained.

Primary author: BOURRION, Olivier Raymond (Centre National de la Recherche Scientifique (FR))

Co-authors: Mr MONFARDINI, Alessandro (CNRS/Institut Néel); Mr CATALANO, Andréa (CNRS/IN2P3/LPSC); Mr D'ADDABBO, Antonio (CNRS/Institut Néel); Mr VESCOVI, Christophe (CNRS/IN2P3/LPSC); Mr GOUPY, Johannes (CNRS/Institut Néel); Mr MACIAS-PEREZ, Juan (CNRS/IN2P3/LPSC); Mr CALVO, Martino (CNRS/Institut Néel); Mr BOUDOU, Nicolas (CNRS/Institut Néel)

Presenter: BOURRION, Olivier Raymond (Centre National de la Recherche Scientifique (FR))

Session Classification: Systems, Planning, Installation, Commissioning and Running Experience