A PROGRAMMABLE MULTICHANNEL ANTIAliASING FILTER FOR THE CUORE EXPERIMENT

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The sensitive element is called bolometer. A bolometer is composed by a crystal (absorber) and a Ge NTD thermometer (sensor) glued on it. CUORE bolometers are operated at a temperature of about (8 ± 10) mK inside a He/He dilution refrigerator. An energy release in the crystal is seen as a voltage drop across the thermometer. The typical amplitude signal variation across the thermometer (at the input preamplifier) is in the order of ΔV₁₁₁ = (100 ± 200) μV.

The CUORE experiment

CUORE is a Cryogenic Underground Observatory for Rare Events. It is an experiment under construction at the Laboratori Nazionali del Gran Sasso (LNGS).

CUORE is the Debye Temperature of TeO₂.

1) 98% TeO₂ crystals (bolometric) arranged in 19 towers;
2) Each tower is composed by 4 columns;
3) Each column is composed by 13 crystals;
4) A single bolometer consists of a 5x5x5 cm³ TeO₂ crystal (760g).

The board accommodates 12 channels. The board is equipped with an ARM microcontroller which communicates with the on-board peripherals via I²C and with the remote control via optically coupled CAN-bus. Important features are the low-cost realization and the capability to perform diagnostic routine remotely.

The board accommodates 12 Bessel six-pole antialiasing filters. Each filter type is chosen to:

6-pole LP (or Bessel) Filter:
- maximally linear phase response in the passband
- maximally flat amplitude in the passband

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The figure shows the block-diagram of the antialiasing board. The analog part is composed by twelve identical channels. The cut frequencies are fixed using high-precision resistances (0.1%) and metalized polyester film capacitors (5%). We built 5 prototypes. An automatic set-up was developed to characterize the prototypes that will be used also in the final production. The system is based on a National Instruments® acquisition system and on a Votsch® environmental chamber.

CUORE Bessel Board

 Amplifier

Heat Sink (Copper Holder, Tc = 80 K)

Weak Thermal Coupling (Teflon)

Amplified Signal

Anti-aliasing Filter (6-pole Bessel)

FIR Filter

DAQ

Digital Data

Offset temperature drifts distribution

Sigma = (0.0337 ± 0.0053) Hz

Mean = (8.016 ± 0.007) Hz

Sigma = (0.0886 ± 0.0325) Hz

Mean = (19.97 ± 0.04) Hz

Sigma = (0.1507 ± 0.0932) Hz

Mean = (19.97 ± 0.04) Hz

Sigma = (-0.2768 ± 0.0823) Hz

Mean = (19.97 ± 0.04) Hz

Magnitude Response (Channel 04)

Phase Response (Channel 04)

Cut Frequencies Distribution

References