DANTE, A Compact and Low-Power Digital Pulse Processor to Exploit CUBE Preamplifier Ultimate Energy Resolution and High-Count Rate Capability

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ABSTRACT

An increasing number of X-ray spectroscopy applications (e.g. using synchrotron facilities or adopting high-power X-ray tube generator) require detection systems operating with low energy resolution and high counting rate capability. In order to meet these requirements, Silicon Drift Detectors (SDDs) are widely used both for scientific and industrial applications. New preamplifier technologies have been designed in order to better exploit SDD characteristics, providing excellent energy resolution at short processing times. Nevertheless, in order to fully benefit from such advancements, the read-out electronics has to provide short processing time adding a negligible contribution to the overall measurement noise. A new digital pulse processor (DPP), named DANTE, has been developed taking these considerations into account.

DANTE can be used coupled to X and Gamma-ray detectors equipped with CUBE, the CMOS preamplifier developed by XGLab, or with different pulsed-reset preamplifiers. DANTE is implemented on a single printed circuit board (10 cm x 6 cm in size), it is low-power (2.5W) and it is scalable to multi-channel (by daisy-chain) configuration.

Thanks to a 32ns minimum peaking-time and to an accurate low-noise design, DANTE provides excellent spectroscopic performance even at very high count-rates. Even at the shortest peaking time, the noise introduced by the DPP readout electronics is negligible if compared to the preamplifier noise. Fig. 1 shows an example of the typical achievable energy resolution (at the Mn-Kα line) using a commercially available reference SDD which uses CUBE preamplifier. The remarkably good energy resolution of 123.8 eV has been achieved with a close-to- optimum peaking-time of 1.6 us. Moreover, excellent energy resolutions of 138 eV and 159 eV FWHM have been achieved with peaking times of 100ns and 32ns respectively.

The combination of ultra-short peaking-time and effective pile-up rejection system enables to efficiently detect pile-up and to maximize the throughput even when the input count-rate exceeds the 3Mcps. Fig. 2 shows the output count-rate for different input rates and peaking times. It will be shown that, for such high input count-rate, the dead-time due to the preamplifier reset will be dominant over the pile-up probability of the signal processing.

As an example, we report a measurement campaign performed at ESRF (European Synchrotron Radiation Facility, Grenoble, Fr) – Fluorescence; data collected at BM23-XAS beamline, from a Hitachi 30mm2-area 1mm-thickness Vortex detector (DANTE test report 2016, Cedric Cohen).

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Fig. 1: Measured resolution with DPP, using CUBE preamplifier, and small area SDD at -60°C.

Fig.2. Throughput of DANTE with CUBE for different peaking time, the flattop is set at 80ns in all the measurement