A 16k Compact Multichannel Analyzer for HPGe detector-based gamma spectroscopy applications

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Introduction

The readout and pulse processing electronics required for the HPGe detector instrumentation are designed for ultra-low noise performance to maintain the high measurement resolution of the HPGe detector. This paper presents the design aspects and test results of a low noise, compact 16k multichannel analyzer (MCA) developed for HPGe detector-based gamma spectroscopy applications.

The compact MCA is designed as a standalone bench-top instrument that accepts semi-gaussian shaped input from a standard nuclear spectroscopy amplifier with 0-10 V dynamic range and provides the pulse-height spectrum data through a web-interface, as shown in Fig. 1. The MCA test results with commercial HPGe detector assembly are in-line with the detector manufacturer specifications.

Fig. 1 16k bench-top Compact MCA module

Design Architecture

The design architecture of the 16k MCA is shown in Fig. 2. The analog processing stage of the MCA employs specific design techniques and high precision components to achieve the required linearity and noise performance. It comprises signal pre-processing circuit, a precision low droop rate peak detect & hold circuit and comparators for generating the MCA logic signals for LLD and ULD threshold crossing and peak-detection.

The analog processing stage is followed by a 14-bit fast Successive Approximation Resistor (SAR) type ADC for digitizing the signal peak. An on-board CPLD generates the ADC control signals like start-of-covert (SOC) and peak dump using logic signals obtained from the analog processing stage.

The microcontroller of the MCA receives digitized signal peak data from the ADC and generates pulse-height histogram in its 64 kB internal memory. This microcontroller hosts LwIP protocol-based web server providing Ethernet interface to the computing consol [1].

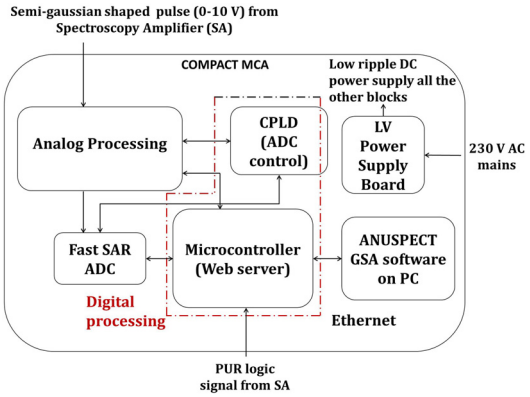

Fig. 2 Block diagram of compact MCA

The compact MCA can be interfaced to .NET based ANUSPECT [2] Gamma Spectrum Analysis (GSA) software client on the computing consol through Ethernet. A custom server-client based protocol is designed for data transfer between the MCA and ANUSPECT package. The measurement parameters like MCA gain, LLD-ULD thresholds and live time can be programmed through the ANUPSECT user interface (UI) panels. Additionally, a LV (low-voltage) supply module is incorporated in the MCA unit to generate low-ripple DC power supplies for all the hardware blocks using external AC mains power, thus making this unit a standalone bench-top instrument.

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Results and Discussion

The compact MCA is tested for its functionality and performance in lab using precision sweeping pulse-generator as per test procedure outlined in [3]. The tested specifications of the compact MCA are summarized in Table-1. A single shot resolution of FWHM < 1-channel (610 µV LSB at 16k gain setting) is achieved.

Table 1 Tested specifications of compact MCA

Parameter	Value
Resolution/ Gain setting	16k, 8k, 4k, 2k, 1k Software settable
ADC conversion time	~1.7 us
Dead time	~ 30 µs (for 6 µs shaping time)
LSB	610 µV (at 16k gain)
DNL	< ±1.5% (over 90% FS)
INL	< ± 0.025% (over 90% FS)

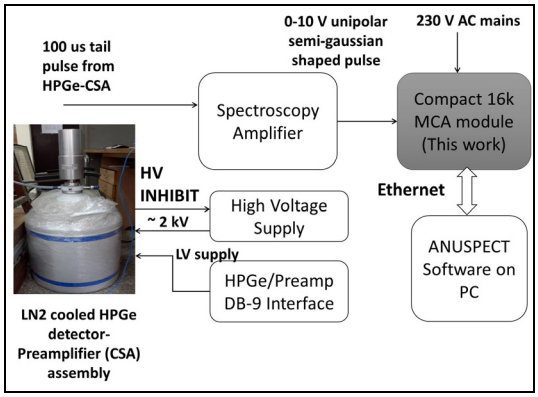

Fig. 3 Test setup for 16k compact MCA with HPGe detector readout system

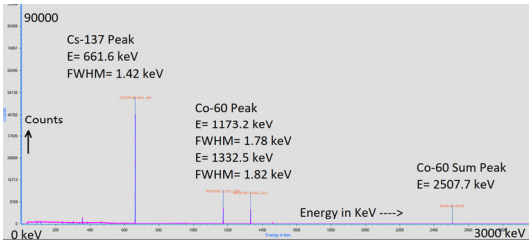

Fig. 4 The compact MCA spectrum on ANUSPECT with commercial HPGe detector-preamplifier using Cs-137 and Co-60 lab sources

The MCA module is also tested with a standard HPGe detector-preamplifier assembly and spectroscopy amplifier, as per the test setup shown in Fig. 3. The gamma spectrum for Co-60 and Cs-137 lab sources was measured using the above test setup for energy calibration as shown in Fig.4. The test results showing measured FWHM resolution are summarized in Table-2. The MCA data can also be used for dose rate measurement through ANUSPECT UI.

Table 2 MCA test results with commercial HPGe detector

Radioisotope	Energy (keV)	Measured FWHM (keV)
Cs-137	661.6	1.42
Co-60	1173.2	1.78
Co-60	1332.5	1.82

Conclusion

The 16k compact MCA is developed as a bench-top standalone instrument for high resolution gamma ray spectroscopy with HPGe detectors. The test results of the compact MCA with the commercial HPGe detectors are in-line with the detector manufacturer data for standard radio-nuclides. The compact MCA has been characterized for high linearity (DNL < ±1.5% and INL < ± 0.025% over 90% FS) and high resolution (LSB < 610 uV) over wide dynamic range (0 - 10 V).

This work is further augmented with integration of detector HV (high-voltage) supply module, preamplifier LV supply module and spectroscopy amplifier in a single standalone instrument.

Acknowledgements

Authors would like to thank NISS, ED, BARC for providing the ANUSPECT software package.

References

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