Development and testing of Front End Electronics (FEE) for Granular charged-particle Multiplicity-filter Detector Array (GMDA) using VECC-002 ASIC

Manish Kumar Jha[1*], Piyush Bahre[1], Devesh Kumar[1,2], Anindita Choudhury[1], Imran Shaik[1], Samir Kundu[1,2], Tanushyam Bhattacharjee[1], Tumpa Bhattacharjee[1,2], Susanta Kumar Pal[1,2]

. [1]Variable Energy Cyclotron Centre, Kolkata - 700 064, India
[2]*Homi Bhabha National Institute, Training School Complex, Anushakti Nagar, Mumbai - 400 094, India*
. * email: mjha@vecc.gov.in

Introduction

The study of the inner composition and structure of nuclear many body systems through the coincident detection of gamma rays with evaporated charged particles is one of the unique tools devised in gamma ray spectroscopy [1-3]. The Granular charged-particle Multiplicity-filter Detector Array (GMDA) with about 96 CsI(Tl) detectors coupled with Si PIN diode will be used as a facility in VECC for advanced gamma spectroscopy [4].
The major complexity in such setup comes from the compact design of the particle detector array that is required to enable high efficient gamma detection by the Clover HPGe detectors to be placed outside such arrays. The power dissipation from the front end electronics is required to be reduced to a great extent in order to minimise the temperature rise within the vacuum chamber and to keep all the detector components in working condition.
The limitation of charge sensitive preamplifiers and shapers, made out of discrete components, is understood from the optimization of power dissipation. In order to resolve this issue, the design and fabrication of an ASIC was carried out and front-end electronics (FEE) are being developed indigenously in VECC. The present abstract reports the design, fabrication and testing of an ASIC based front-end electronics to be used with GMDA.

Design, Fabrication & Simulation:

A prototype ASIC (VECC-002), a charge preamplifier and shaper with pole zero compensation, for the processing of the weak charge signal produced at the output of the PIN diode upon incident of charged particle on CsI(Tl) is designed and developed in-house and shown in Figure 1.

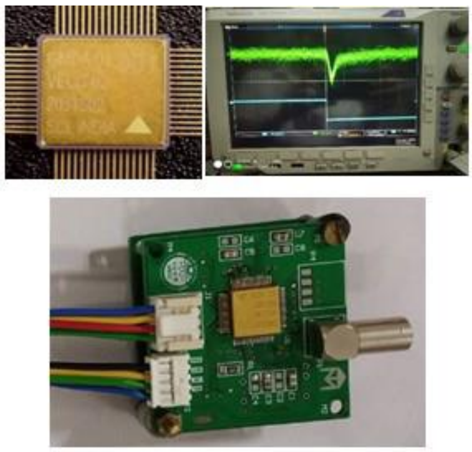

Fig 1: VECC-002 ASIC, typical output and FEE board.

The performance simulation of shaper output for charged-particle identification (PID) was performed. The CsI(Tl) scintillator detectors have the capabilities of particle identification by its two decay components. The first one has a mean decay time about 0.4-1.5 μs and it is possible to achieve excellent PID resolution by pulse shape discrimination (PSD) technique. Figure 2 shows the simulation of the tape-out of VECC-002 for various current pulse at the input of the ASIC with matching decay time of the detector. The difference between the time projections at -10mV shows excellent linear output (Figure 2) which can be utilized to achieve required PID resolution from the shaper output of the ASIC.

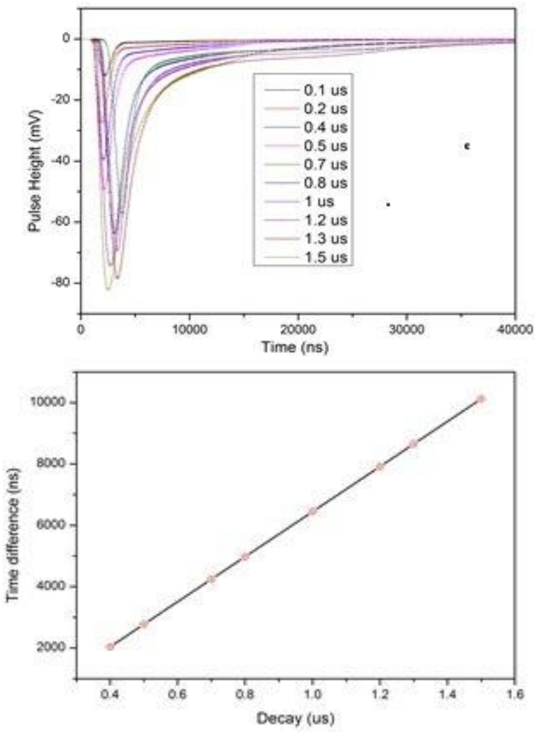

Fig 2: Shaper output of VECC-002 tape-out w.r.t different decay time of input pulse and difference of time projection w.r.t decay time of input pulse.

Testing of ASIC and FEE with detectors

The complete assembly of detector and FEE with ASIC was mounted inside the vacuum chamber and CsI(Tl) coupled with PIN diode was push fitted into the input FEE board as shown in Figure 3(a). The ASIC was tested inside vacuum (~10^{-6} mbar) and both CSA and shaper signals (3μs) were obtained as shown in Figure 3(b) and (c), respectively. The variable decay time of the shaper output for alpha and gamma were observed and this signature will be utilized for PSD circuit being developed in a separate ASIC. The detector was tested inside the vacuum chamber and spectroscopy with Am-241 alpha source was done. Experimental tests were performed for the purpose of selecting and fine tuning the performance characteristics of the GMDA detectors and their associated electronics with ASIC and to finalize the requirement of DAQ and associated electronics to be used or developed further for the successful working of complete array.

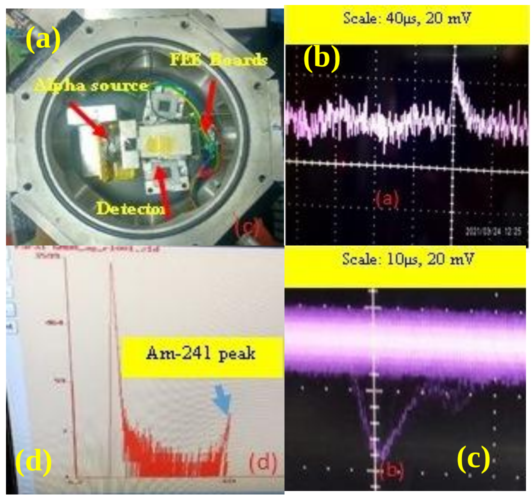

Fig3: (a) detector and source along with compact assembly inside the chamber; (b) CSA and (b) shaper output and (d) spectroscopy with Am-241.

References

[1]D. Rudolph et al., Phys. Rev. C 103, 034306 (2021).

[2]D. Rudolph et al., Phys. Rev. C 102, 014316 (2020).

[3]D. G. Sarentites et al., Nucl. Instr. & Meth. A381, 418(1996).

[4]Detail project report, vision project on Basic Research and Science Education (VS8).