Timing enhancer module for INGA Clover detector

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Introduction

Clover detectors are made of hyper pure germanium (Ge) crystals and are used for high resolution gamma ray spectroscopy. Each detector consists of four crystals with independent energy and timing signals. In the existing INGA Clover detector electronics setup at IUAC, timing signal for Time to Digital Converter (TDC) is generated by prompt Constant Fraction Discriminator (CFD) signal in anti-coincidence with Anti Compton Shield (ACS). This CFD signal is the logic sum of individual crystal CFD signal. In the earlier CAMAC based system the custom made IUAC ADCs had the provision for individual crystal anti Compton gate. With the newly installed VME based DAS, individual crystal timing signal is required to have individual gating for ADCs. This would improve Peak-to-Background ratio and also help determine the nuclear isomeric states with lifetime in nano and sub-nanosecond (ns) range with better precision. This will be possible due to better time alignment from each crystal of the detector resulting in better time resolution and individual crystal time gate.

The required modifications cannot be implemented in the existing Clover electronics modules [1], it was decided to make separate module and split the required electronics, to process 24 detector signals, into 3 units while each unit would accommodate electronics requirements of eight detectors in one 2U 19" Aluminium cabinet.

Timing enhancer module

The module accommodates eight identical and independent channels of Anti-coincidence logic card in daughter card form, to process the prompt timing signals corresponding to each detector. The module will receive 40 signals through LEMO connectors mounted on rear panel and provide differential ECL signals through two 34 pin FRC connector on the front panel to feed VME based CAEN TDC V775. It is powered with 230V AC through lockable connector on the rear panel. The required dc supplies are generated using SMPS and the total power consumed by the module is ~100W. The cabinet has been designed to have sufficient ventilation. A small fan with high rpm has also been mounted on the rear panel for heat transfer. All the components of the module are neatly mounted on the baseplate with sufficient spacing for comfortable handling. DC power supply connections are given to Anti-coincidence logic cards in daisy chain manner.

Anti-Coincidence logic card

Each card accepts Fast NIM (F/NIM) CFD prompt signals corresponding to four crystals of a Clover detector & ACS through 50ohm RG178 coaxial cable, It has four identical channels based on Emitter Coupled Logic (ECL) design and block diagram of one channel is as shown in Fig. 1. All the F/NIM input signals are first converted into ECL logic signal. Each crystal signal is further delayed to bring it in the middle of ACS signal to allow for the jitter in the signal from the Ge crystal. Anti-coincidence logic signal is generated by performing AND logic operation between crystal and inverted ACS signals and further delayed by ~250nS to provide differential ECL timing signal for TDC and terminated on 34 pin FRC connector, mounted on front panel, through twisted pair ribbon cable. To simplify troubleshooting, dc power supply and signal connections are provided through plug-in connectors. PCB traces have been made wide to carry high supply current. Differential pair signals of 100ohm impedance with strict routing guidelines were adhered to minimize crosstalk [2]. In each card, -2V is generated locally and suitable heatsink is put for efficient heat dissipation. High quality SMT components have been used to keep the boards compact.

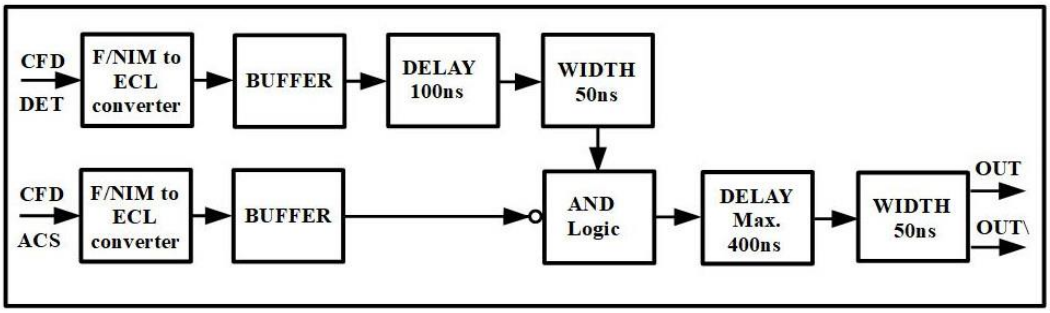

Fig. 1: Block diagram of one channel of Anti-coincidence logic card

Test with radioactive source

Timing enhancer module performance was evaluated with INGA Clover setup using ^{60}Co radioactive source. The count rate in each crystal was about 400 per second. We have measured the time resolution for the self-triggered peak and the Peak-to-Total (P\T) ratio of energy spectrum with and without Timing enhancer module. We are also planning to conduct a test at high count rate in the range of 3k to 4k per second in each crystal. More improvement is expected in the crystals during in-beam experiments.

Observation

It was observed that the time resolution and P\T ratio from a single crystal, directly from the existing setup and through Timing enhancer module, is same (Table I & II). Similar P\T ratio performance was also measured in add-back spectrum. To test stability, data collected for ~120 hours showed peak shift of < +/-200pS (< +/-0.025%) in 800ns TDC range.

Table I: Time Resolution comparison

Crystal No.	Without Timing enhancer module (ps)	With Timing enhancer module (ps)
1	394.5	390.63
2	453	414
3	352	344
4	381	410.2

Table II: Peak-to-Total ratio comparison

Crystal No.	Without Timing enhancer module	With Timing enhancer module
1	17.68	17.54
2	17.54	18.13
3	17.65	17.69
4	17.49	17.46

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References

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