TECHNICAL REPORT

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Abstract

The National Array of Neutron Detector (NAND) experimental setup at IUAC consists of thirty 5" x 5" BC501 liquid scintillator coupled to XP4512B PMT. In order to process the detector signals a Charge sensitive preamplifier was developed and implemented with SMD technology successfully. It has been designed for 50uS decay time and ~1mV/MeV sensitivity. The preamplifier specifications and test results are also given.

Acknowledgment

We would like to thank Apprentice trainees participated during assembling. Our sincere thanks to Dr. Amit Roy, and B.P. Ajith Kumar, for their constant encouragement and providing necessary infrastructure in order to complete this project successfully.

<u>Specifications</u>: Charge Sensitive Preamplifier for Neutron Detector Array

Neutron Detector	: BC501: bias = -1.4kV
Output signal Decay Time	: ~50uS
Sensitivity	: ~1mV/MeV
Connectors	: BNC connectors for Input and Output
Cabinet	: G102 Aluminium die cast box
Power required	: +24V, 10mA
Size (W x H x L)	: 1.1” x 0.6” x 2.6”

Introduction

A high density charge-sensitive preamplifier is developed to use with Neutron detector array at IUAC. In these detectors the dynode signal coming from PMT is very large but it's decay time is not standardized. Decay time varies from ~20us to 200us for different PMTs. To handle such pulses we require a preamplifier to standardize the decay time (~50 us) with no further amplification and input FET. Once decay time constant is fixed Shaping amplifier can have fixed pole-zero adjustment. Because of large input signal level feedback capacitor C_f is chosen for a low sensitivity of <1mv/MeV. To minimize the noise due to input cable length preamplifier should be placed as close as possible to the detector.

The preamplifier is assembled on a double sided glass epoxy PCB with surface mount components to achieve the required high density.

Principle of Operation

The preamplifier circuit was implemented using low cost, general purpose, wide bandwidth JFET input Opamp LF356 with +24V supply and the required single supply biasing technique is adopted. The feedback resistor and capacitor of opamp were chosen for decay time of ~50uS and sensitivity of ~1mV/MeV. It accepts the positive dynode signal and gives the inverted output which goes to the shaping amplifier. It has an output impedance of 50 ohm and a dynamic range of +/- 10V.

A 50 ohm terminated TEST input is provided on the pcb which can be connected to the preamp Input connector for testing purpose which is to be replaced by actual input before closing the cabinet. For supply connections a 2-pin receptacle connector, is connected to the pcb through a short twisted pair of wire. As per the requirement of the experimental setup a 3m long twisted pair of wire, with one end connected to 9-pin D-connector which can be plugged-in the 4002P EG&G ORTEC power supply and other end connected to the 2-pin plug connector, has been prepared to provide power connections to preamp.

Test Result

The performance of the Pre-amplifier circuitry is tested with pulser (BNC make model DB-2) . The fall time of the pulser signal was varied to mimic different PMT dynode signals. The linearity of the pre-amplifier was also found to be satisfactory when tested with Canberra Pulser (Model 8210) at different signal amplitude. The stability of the circuitry is found to be independent of time and temperature variations. After completing the performance test with pulser, Pre-amplifier was tested with neutron detector using different gamma ray sources to study the performance at different pulse height ranges under realistic environment. The pre-amplifier is now in use with the existing neutron array and has tested thoroughly with spontaneous fission neutron source, 252Cf. This has been used along with the shaping amplifier for quite a few experiments with beam.

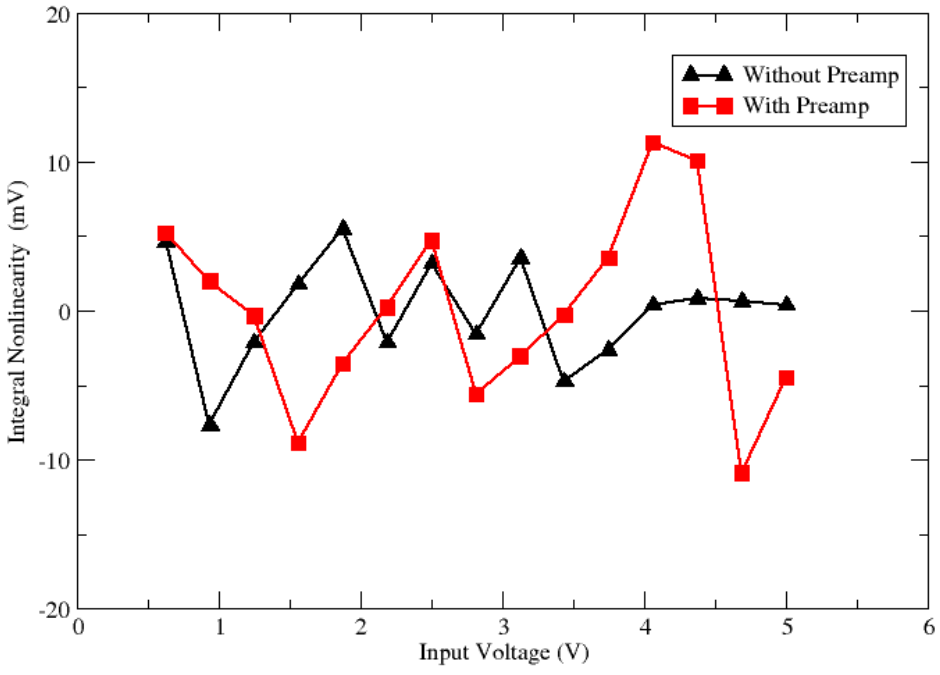

FIG1: linearity error introduced by IUAC Charge sensitive preamplifier in ORTEC 572 amplifier output signal using Canberra pulser 8210.

Troubleshooting Procedure

1. Ensure that +24V supply is not grounded anywhere on the PCB.
2. Provide power connections to the preamplifier. Confirm that +24V is reaching the board.
3. Refer the preamplifier schematic diagram showing dc conditions of the circuit to check dc voltages at various points in the circuit without any input signal. (Annexure 1.1)
4. Connect the TEST input of the preamplifier to the preamp INPUT and apply positive input signal to preamplifier INPUT using BNC pulser model DB-2 (Vin= +10V, Tr=100nS, Td= 100uS).
5. Input and output waveforms should be same as given in Annexture 1.2.

Assembly Procedure

The currently (CSPA_PT1/Aug-2005) available PCB is of glass epoxy, double sided with 0.6mm drill PTH having dimension of 1.1" x 2.6" with all above features.

It is recommended to have solder mask and silk screen printed on both sides for easy assembly as well to protect it from solder bridges etc. Use of 0.8mm sharp solder tip, IC solder tips are recommended in order to solder narrowly spaced SMT devices. SMT devices shall be picked only by fine quality tweezers. While soldering a magnifier x5 (large) and x12 (eye piece) is used to assure the soldering. It is essential to use solder cleaning liquid with cotton swab to remove dust attracting solder paste.

The PCB shall be checked with magnifiers and multimeter for any unwanted connections and PTHs. Then components shall be soldered in a orderly manner, to start with all low profile chip resistors and capacitors. It is essential to check the impedance between various nodes after soldering resistors, capacitors and inductors. Active components like diodes, transistors and ICS are soldered thereafter. At last tantalum capacitors, connectors, jumpers and any non-SMT devices. All PCBs shall be marked distinctly with unique number for any future references.

Conclusion

A high density Charge Sensitive preamplifier is successfully developed, tested and used with Neutron detector array setup at IUAC.

References

1. Application note (AN-581) on biasing and Decoupling Op Amps in Single Supply Applications.