Integrated Photomultiplier tube base for neutron array

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Introduction

National Array of Neutron Detector (NAND) [1] at IUAC is planned to have 100 numbers of liquid scintillator BC501A cells of 5” X 5” size coupled to a 130mm Photomultiplier tube (PMT). Each PMT requires a dedicated set of front end electronics such as voltage divider network, high voltage power supply, charge sensitive pre-amplifier for dynode signal. Due to large number of these detectors and scarcity of space, it is proposed to have these electronics integrated with detector along with remote control and status read back. We have successfully designed and implemented three prototype integrated PMT bases and tested them recently during an experiment with linac beam.

PMT voltage divider network

The PMT adopted for pulse shape discrimination techniques shall have fast response time with limited distortion. The manufacturer suggested voltage divider scheme is adopted here in order to obtain optimum performance out of the adopted PMT. XP4512B of M/s. Photonis is adopted for testing the scheme for prototyping.

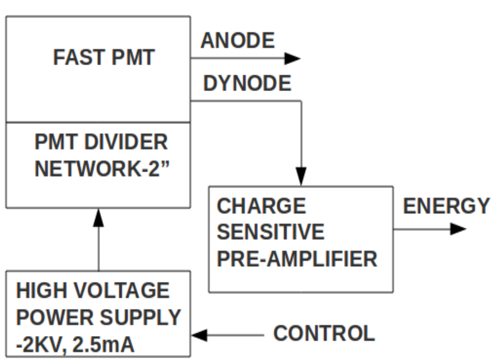

Fig.1. Block diagram integrated PMT base

Final implementation of voltage divider network will be designed for R4144 of M/s. Hamamatsu as this PMT model is finalised for NAND array. Intermediate progressive type voltage divider network [2] is adopted here for optimum pulse height resolution and pulse shape discrimination. Negative high voltage bias is adopted as it is a standard practice, when PMT is used for timing application.

The passive divider bias current is optimsed at 0.5mA for reduced power dissipation and reduced dark current. A series of decoupling capacitors are provided at final dynode stages to obtain linear pulse height even at high count rates. Gain adjustment is possible by adjustment of voltages to intermediate dynode stage. The dynode at final stages are terminated through damping resistors for reflection free anode signal which is very crucial for PSD application.

High voltage power supply

A modular and shielded DC-DC converter type high voltage supply is adopted for each PMT. The high voltage supply is fitted inside PMT divider casing in order to conserve space and avoiding additional high voltage cable. The power supply is of -2KV/2mA having excellent load regulation, line regulation and ripple factor better than 0.01% of output voltage [3]. The remote or local control for programming and read back of power supply status is provided.

Charge sensitive pr-amplifier

In order to calibrate the electronics for energy of incident neutrons, the current from a last dynode of PMT is tapped through a load resistor. In order to drive a long coaxial cable and to maintain better signal to noise ratio, a charge sensitive preamplifier is provided within the base. This circuit is a wired around JFET [4] as a front end amplification element.

PMT base casing

A 3” aluminium circular casing is locally designed and duplicated. The entire resistive divider network is made of high quality SMT components, and assembled on a glass epoxy printed circuit board (PCB). This PCB is mounted on a 20-pin FE1120 type PMT socket to have less parasitic effect. The high voltage power supply and control and read back PCB is mounted vertically on aluminium rails within aluminium casing. The entire electronics is powered through +/-12Volts. The anode and charge sensitive pre-amplifier output signals are terminated on panel with BNC type connectors. Crucial high voltage test points are terminated on panel for quick measurement.

Test results

In order to validate the PMT voltage divider network, high voltage power supply and charge sensitive pre-amplifier circuits, both off-line and on-line tests were conducted at NAND facility of IUAC. The off-line test was carried out for more than 72 hours continuously with 3” x 3” BC-501 liquid scintillator cell coupled to XP-4512B and Am+Be fission radiation source. Both energy and PSD spectrum were obtained with in-house developed PSD module to understand any long term drift and a typical PSD spectrum is shown in fig.2.

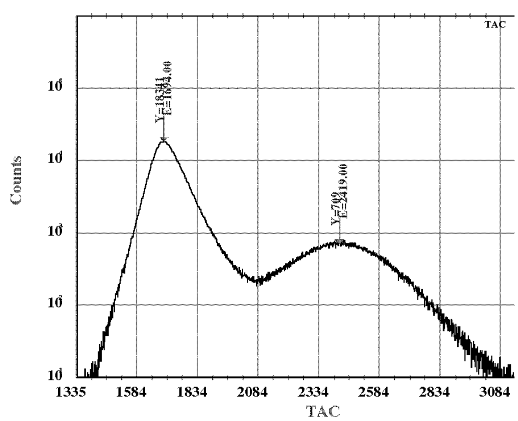

Fig.2. PSD spectrum with Am+Be source

The bases were tested online during an experiment with linac beam using ^{28}Si beam on ^{208}Pb target at an energy of 186MeV. Fig.3. shows a typical 2D histogram displaying clear separation of neutron and gamma discrimination.

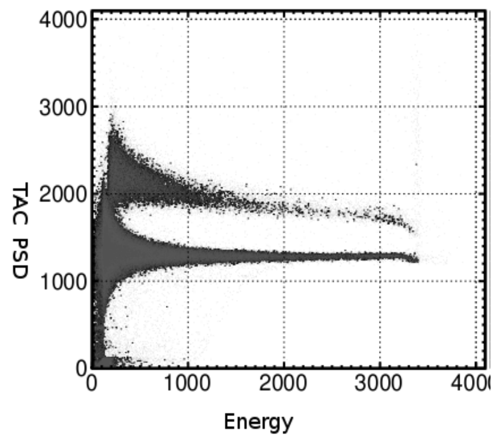

Fig.3. 2D spectrum with energy Vs. TAC-PSD

Acknowledgement

Sincere thanks to workshop group for designing and duplicating the PMT casing as per the requirements.

References

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[2] Photo multiplier tube catalogue of M/s. Photonis.
[3] http://www.picoelectronics.com/dcdclow/peHVP.htm
[4] Technical report on PMT electronics for NAND - IUAC/TR/SV/2010-11/02