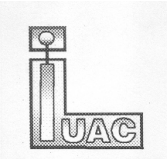

TECHNICAL REPORT ON
PMT base for NAND

Abstract

Specifications

Introduction

Principle of operations

Schematic diagrams

Photos

Troubleshooting guidelines

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PMT base for NAND

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Abstract: After developing various prototype electronics circuits for PMT bases for PMT models XP4512B (Photonis) and R4144 (Hamamatsu) of National Array of Neutron Detector (NAND) with and without built-in high voltage power supply, it was decided to mass produce the PMT bases for R4144 a charge sensitive preamplifier for Dynode section as shown in the block diagram. The tapered voltage divider network as suggested by the manufacturer is assembled right on the socket pins to reduce the stray elements, and the charge sensitive preamplifier for Dynode signal to derive Energy signal mounted within a circular aluminium casing. This report essentially compiles all technical details for operation and future maintenance of these bases.

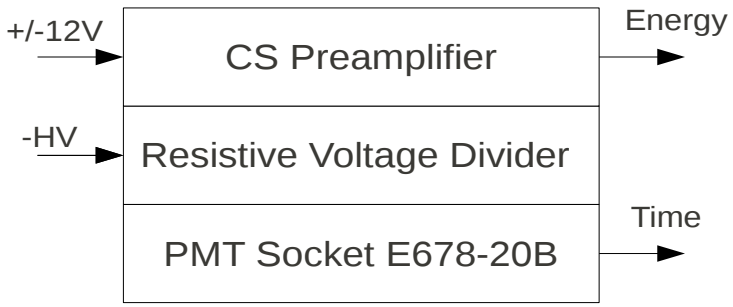

Fig: Block diagram of PMT base for NAND

PMT voltage divider network with Charge sensitive Preamplifier

Specifications

Dimensions	:	~63mm (Diameter), ~110 mm (Length), Aluminium Casing.
Bias Power Supply	:	Not to exceed -2.0KV

PMT Bias Network for pmt R4144

Socket type	:	20 pin E678-20B – M/s.Hamamatsu
Total resistance	:	~5 Mega ohm, 40U (1U = 50V, 125 Kohm)
Power Dissipation	:	~1W maximum
Operation Voltage	:	Typical -1.5 to -1.7KV not to exceed -2KV
Application	:	Fast timing applications (NAND type R4144 PMT)
		Anode grounded (typical 50 ohms)
Adjustments	:	Focus (on PCB)
Signal Outputs	:	Dynode (2.2 Mohms), Anode – Time (51 ohms) BNC Connectors
Monitoring Test points	:	-1000:1 ratio, active buffered and calibrated (optional)

Preamplifier

Type	:	Charge Sensitive type with Operational amplifier
Conversion factor	:	~-44mV/MeV (Si. Equ)
Open loop gain	:	90dB, 100MHz bandwidth (LM6171)
Decay time	:	~50µS (1Mohm, 47pF)
Output	:	Energy - DC blocked and 50 ohm capable
Protection	:	Input section is over voltage protected against spikes
Power	:	+/-12V, <10mA each
Chassis ground	:	3mm screw and spring washer for safety

Introduction

The National Array of Neutron Detectors (NAND) system consists of 5”(diameter) x 5”(depth) BC501A scintillator cell that is optically coupled to 5” (diameter) fast PMT R4144 - Hamamatsu. As per manufacturer's recommended biasing scheme is developed for these PMTs. Gain control of PMT is possible but bypassed in order to gain match the PMTs in the array. To obtain energy information, the signal from dynode (DY7) is also accessed. To preserve signal to noise ratio, a operational amplifier based charge sensitive preamplifier is also incorporated for this application. All these circuits are suitably isolated and packaged in a circular cage and mounted with PMT. These individual circuits are explained in this report.

PMT voltage divider network

The scheme of voltage divider network and voltage distribution among various electrodes of PMT depends upon the mode of operation, that in turn depends upon the performance required from opted PMT. The PMT opted for the array is Fast PMT for pulse applications with grounded anode, and as per manufacturer's [1] recommendation a tapered voltage distribution is opted. The design of network also depends upon the operating voltage, expected anode current and voltage distribution between various electrodes. As a thumb rule, bias current in the divider chain shall be 10- 100 times more than expected anode current for a stable operation during high count rate. The other aspects for considerations are, power dissipation in the network, voltage, power handling capacity and tolerances of individual circuit elements for reliable operations. Equal importance shall be given to isolation of PMT from heat source such as voltage divider network, decoupling capacitor of last stage dynodes as quick charge reservoir for obtaining good quality timing and energy signals. Since ultra fast signals are expected from Anode section to derive time information, the stray elements in the form of interconnection is reduced to a maximum extend.

The total impedance of divider network is ~5 Megaohms. The divider is designed to operate upto -2000 volts, with typical anode current upto -5V across 50 ohms at a expected count rate of 5kcps. The resistors used in voltage divider network are of 1206 type (150 WV), 100PPM, 1% metal film resistors. The decoupling capacitors are wired in series fashion are high quality ceramic chip capacitors (500 V, X7R). The anode is terminated at 51ohm and accessed through BNC connectors. The dynode no: 7 is used to derive energy information. This is suitably dc blocked and accessed through a charge sensitive preamplifier. The grid1 of PMT is adjusted through FOCUS adjustment control potentiometer. The bias voltage supplied can be measured through R21 and used to develop a proportional voltage (-1000:1) for remote measurement. This is optional and not wired for NAND array version-I.

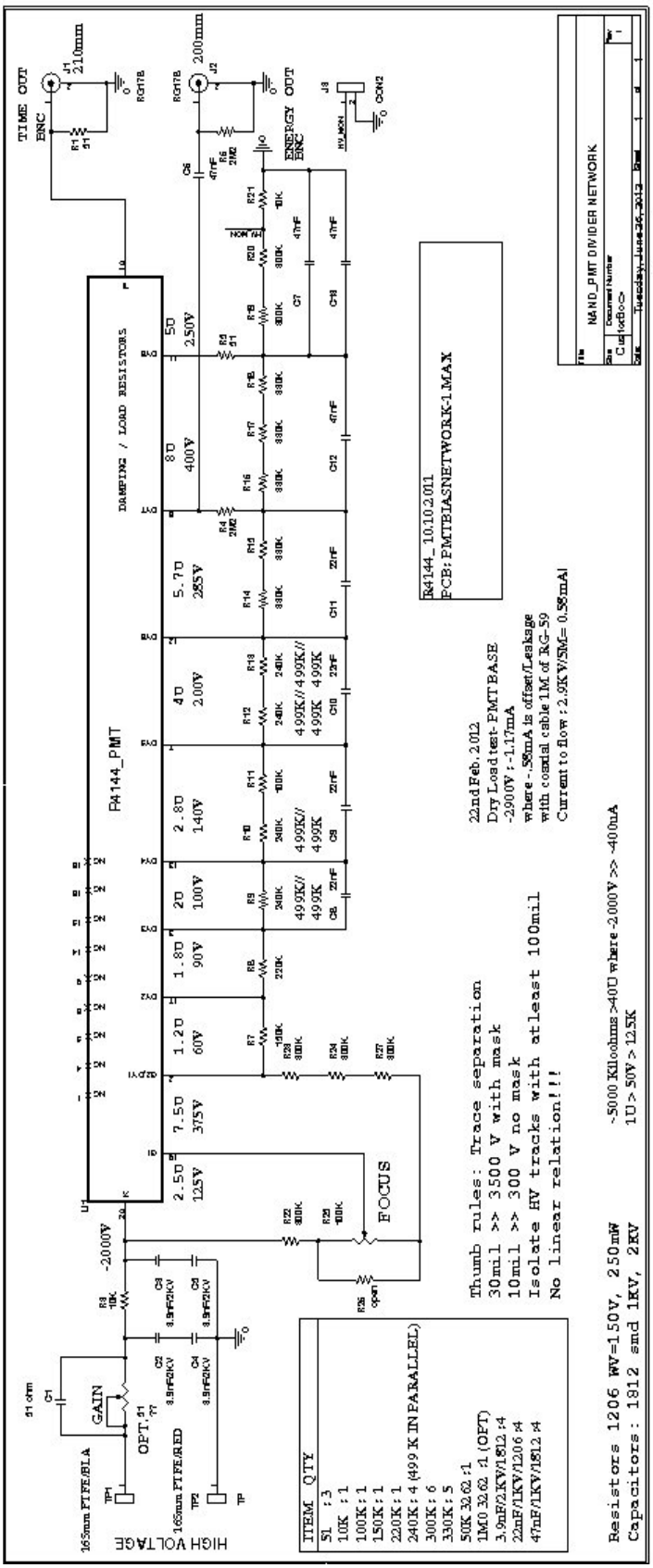

Fig: Schematic of PMT voltage divider network for R4144

Charge sensitive Preamplifier

The signal derived from anode current can be used for timing applications with 50 ohm system directly. Whereas, the signal derived from the last dynode is very useful to derive energy information, as the signal from this stage do not suffer from space charge saturation effect. The output impedance of this stage is usually high, and it is recommended to route the signal through a buffer or charge sensitive preamplifier to obtain better signal to noise ratio. The preamplifier designed for this application is wired with LM6171 a wide band, high open loop bandwidth operational amplifier. The preamplifier is suitable buffered to drive a long coaxial cable of 50 ohms impedance. The charge conversion in preamplifier is set to be -44mV/Mev (Si. Equ) and the decay time constant is around 50µS. The operational amplifier is protected against any spikes.

All the above discussed circuits are assembled on a 2.54mm thick FR-4 substrate. The components are of high quality SMT type to have compact assembly. These boards are mounted in a 63mm diameter aluminium casing.

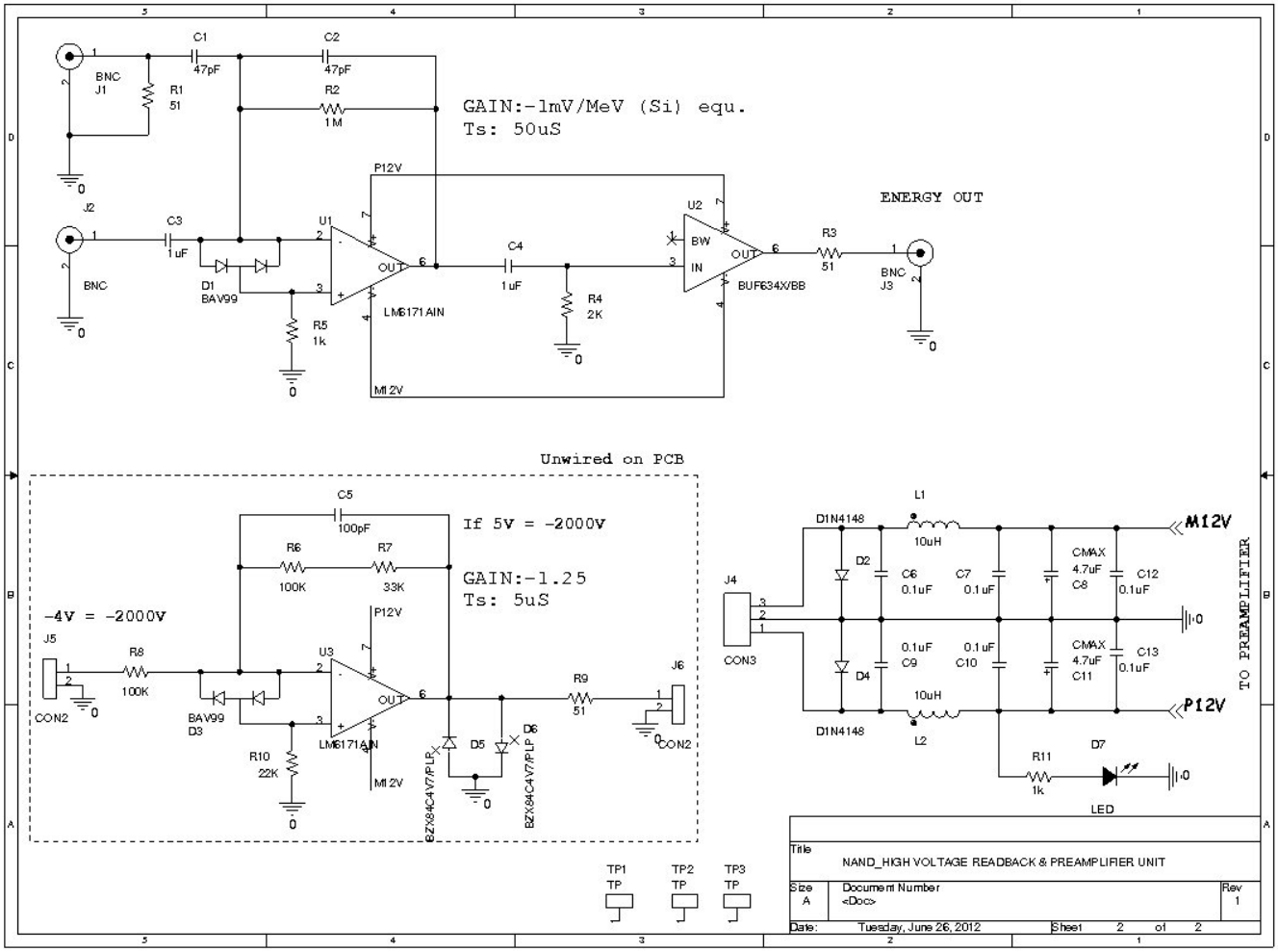

Fig: Schematics of charge sensitive preamplifier

Fig: Photo of PMT base with High voltage divider network and Charge sensitive Preamplifier

Fig: Photo of various components inside the base

Troubleshooting guidelines

Symptom:	Weak signal from Anode for a reference radiation source
Possible reasons:	High voltage not reaching the dynodes due to poor interconnection wiring check the coaxial cable RG-59
	PCB dry solder – resolder the pins with extra solder
	radiation source far away
	Failure of components particularly High voltage capacitors
	Breakage of resistors on PCB
Symptom:	Signal not reaching from Dynode
Possible reasons:	High voltage not reaching the dynodes due to poor interconnection wiring check the coaxial cable RG-59
	Failure of components particularly High voltage capacitors
	Breakage of resistors on PCB
	Preamplifier power not reaching due to poor interconnection
	bad operational amplifier or bad Buffer amplifier
	PCB dry solder – resolder the pins with extra solder
Symptom:	Sparking / chirping sound from base, jumping of signal when seen with CRO
Possible reasons:	Intermittent contact, sparking between component leads
	Replacing the component(s) is a better option

References:

[1]. http://jp.hamamatsu.com/products/sensor-etd/pd002/pd394/index_en.html

[2]. PMT handbook by RCA

[3]. Introduction Bases, Voltage Dividers, and Preamplifiers Accessories for Scintillation Detectors M/s. Saint Gobain crystals