Development of prototype RPC and LVDS/NIM-ECL translator for the INO-DAQ system

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Resistive plate chambers (RPCs) are going to be used as the active detector element of the INO-ICAL experiment. We have developed a glass RPC (named AB08) consisting of two parallel electrodes of glass plates separated by a distance of 2 mm through which a gas mixture of Freon, SF6 and isobutene is flown. The detector is operated in avalanche mode at high voltage. The efficiency and time resolution of the RPC have been studied. The signal from the RPC is processed through NIM/CAMAC based INO-DAQ system. Monitoring of the RPC's strip is required to record the noise and its health information. This noise may be due to radioactivity, the electrical noise, cosmic ray charged particles of multiple scattering and the dark current of the chamber. To reduce the turnaround of the monitoring frequency we have designed a LVDS/NIM-ECL translator NIM module to interface between Monitor Scalar and Control and Data Router.

Keyword: Resistive plate chamber (RPC); Data acquisition system (DAQ); Translator.

Introduction

Resistive plate chambers (RPCs) are gaseous parallel float glass plate detectors with high efficiency, excellent temporal and spatial resolutions, making them attractive for trigger and time-of-flight applications in high energy and astroparticle physics experiment [1]. India-based Neutrino Observatory (INO) is a proposed experimental project primarily to study atmospheric neutrinos and to make precision measurement of the neutrino oscillation. The experiment will consist of a 50 Kilotons of lateral size 48×16×12 m^3 magnetized Iron Calorimeter (ICAL) with RPC as the active detector element. ICAL detector will consist of a stack of 140 layers of 6 cm iron plates interleaved with 2.5 cm gaps to house the RPC detector layers. About 27000 RPCs of dimension 2×2 m^2 will be needed for the INO experiment [2].

At TIFR Mumbai, a set of 12 RPCs are arranged in a test stack with an external trigger set up of cosmic ray muon scintillation telescope. The RPC consists of two resistive glass electrodes with a bulk resistivity of about 10^{12} Ω-cm separated by a 2 mm gap using a 2 mm thick spacer through which a suitable gas mixture is flown at atmospheric pressure. We have used the gas composition of Freon R134A, SF6 and isobutene in a ratio of 95.5:0.2:4.3 by volume for the RPC operation in avalanche mode. A high DC voltage of 9800V is applied to the plates via semi-resistive graphite paint on their external surface. The readout of the RPC has been performed by external orthogonal pickup strip panels. The panels, one each for X and Y plane readout are made of 32 copper strips of 50 Ω characteristic impedance. A charged particle traversing the gap initiates an avalanche in the gas volume resulting in a local discharge of the electrodes [3]. The discharge induces an electrical signal on external pickup strips, which are sent to the INO data acquisition (DAQ) system through double stage preamplifiers. INO-DAQ mainly consists of three parts: front end (basically it consists of analog front end (AFE) and digital front end (DFE) modules), routers and back end Computer Automated Measurement and Control (CAMAC) crate modules. The front end is connected to the CAMAC crate through two data routers namely Trigger and TDC router (TTR) and Control and data routers (CDR). The event and monitoring data are stored in an INO-DAQ PC. The event data are used to get the strip hit (1 bit per strip) and TDC relative time information, while the monitoring data are used to record the noise rate and ambient parameters (such as pressure, temperature and relative humidity) of the RPC's [4].

Development of RPC

We have fabricated a 1×1 m^2 RPC (named AB08) using 3 mm thick ASAHI float glass plates. Initially these glasses are cleaned by Lebolene solution and distilled water. To apply high voltage across the electrodes, one side of the glass is coated with a mixture of dry colloidal graphite industrial lacquer in about 1:8 ratio by using a standard paint spray gun. The surface resistance of this conductive paint is measured to be about 400k-ohm/cm^2. The two glass plates with comparable resistance are placed one over the other with a gap of 2mm separated by polycarbonate buttons and T-shaped insulated shapers. The above said assemblies are glued by using a special 3N SCOTCH-WELDE epoxy. The leak test of the RPC is done by flowing Freon gas at atmospheric pressure and checked for any leak using a gas sensor FLON GH-202F. The RPC is now sandwiched between 2 honeycomb pickup panel placed orthogonal to each other to get special X-Y coordinate of the hit and then packed in an aluminium case. The pickup panel is prepared using 32 strip copper foils on one side and aluminium on the other side. Each strip of the copper foils is terminated on the non readout end with a 50 Ω resistance to match the characteristic impedance of preamplifier. A photograph of fabricated RPC packed in the aluminium case is shown in fig. 1.

Fig. 1 Fabricated RPC packed in the aluminium case

Test and characterization of RPC

The fabricated RPC is placed on a test stack with an external trigger system of cosmic ray muon scintillation telescope. The current vs. voltage characteristics of RPC is shown in fig. 2(a). At lower applied voltage, the chamber offers very high resistance and hence it's V-I characteristics in this region is mainly characterized by the insulating spacers placed between the electrodes. At higher voltage, the resistance of the gas gap drops and thus the characteristic is determined only by the resistivity of the glass electrodes.

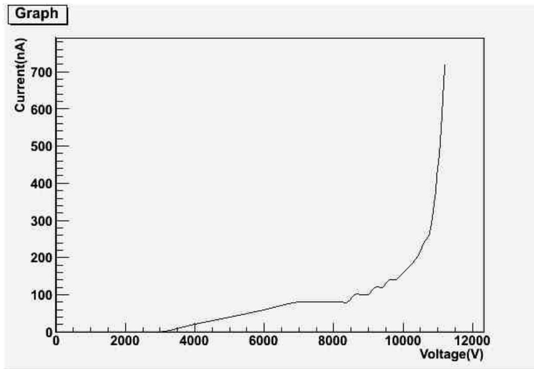

Fig. 2(a) Voltage-current characteristics of the RPC.

The efficiency of the glass RPC, which is defined as the number of coincident muon recorded in the RPC to the number of muon recorded by the telescope is also studied. An average efficiency of 87.5% has been achieved as shown in fig. 2(b).

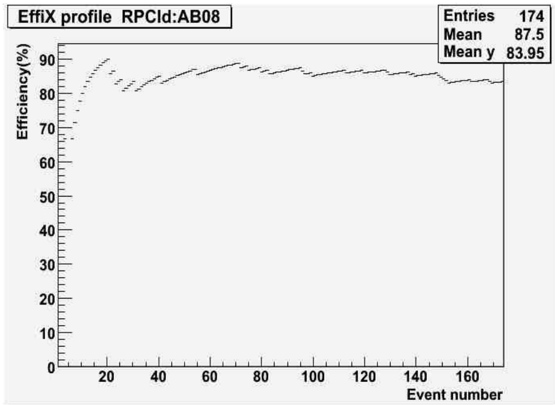

Fig.2(b) RPC Efficiency.

The time resolution is an important parameter of the RPC which is essential to find out the direction of the muon passing through the detector. A typical TDC histogram (with a Gaussian fit) for the RPC (σ = 2.92 ns) with scintillation as reference is shown in fig. 3(a). We also looked at the RPC efficiency by using another RPC (AB04) in the stack as reference. TDC relative histogram of AB08 (σ = 1.80 ns) with respect to AB04 as reference RPC is shown in fig. 3(b). This result shows that an improved time resolution can be achieved by using an RPC.

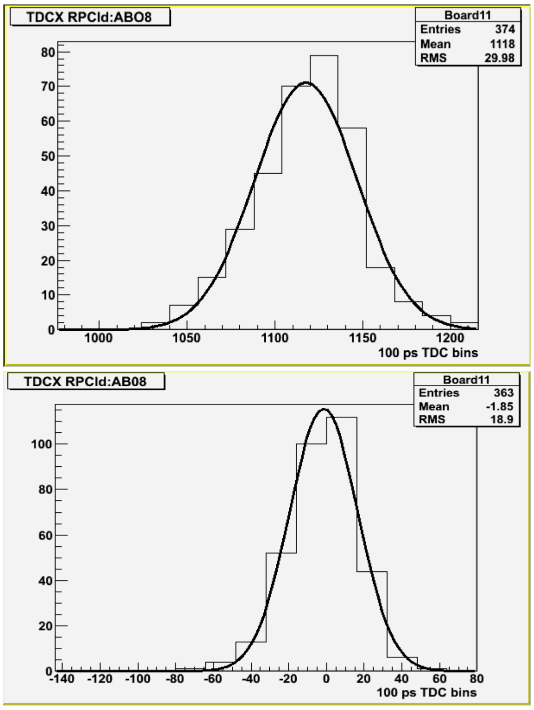

Fig. 3(a) TDC histogram for RPC AB08 (σ = 2.92ns) and fig. 3(b) TDC relative histogram of RPC AB08 with respect AB04 (σ = 1.80 ns).

Development of LVDS/NIM–ECL translator

The noise rate of an RPC is the individual counting rate of its signals above an operating threshold. These signals are produced by cosmic ray charged particles of multiple scattering as well as due to dark current of the chamber [5]. This rate per unit cross-section area of a particular RPC should be constant when integrated for a reasonably long period of time. The noise rate serves as a good measure to monitor long term stability of an RPC and the dark current of the chamber [2]. Each strip of RPC monitored cyclically and noise rates are recorded. The signals which are monitored go through a fold logic, wherein 1 fold, 2 fold, 3 fold and 4 fold coincidences in the RPC strips are recorded. Further, some fixed frequencies are fed to the electronics of the DFE module to monitor their status.

Present scheme of Monitoring cycle system

At present the DFE modules of both X and Y planes are daisy chained into 2 groups for event data recording and 12 groups for monitoring using differential interface signals namely Eve-com bus and Mon bus. The CDR module is used as buffer and establishes interface link to INO controller, daisy chains DFE modules and INO Readout modules. All the input and output signals of the CDR are of LVDS standard. It receives 13 control (Sox, CLKx, Soy, CLKy, A1, A2, A3, A4, E/M, T, MO, CLK, MR) signals from the INO control module and fan-out them as Eve-com and Mon outputs to the DFE modules. Each of the DFE modules has an access address for event and monitoring process which are set by user. The DFE module will be active during a process if the set address of INO controller matches with its access address. CDR then receives the process event and monitoring data through Eve-com and Mon inputs where these data are regrouped and fed to the readout module. The readout module is used as an interface, which performs the following two functions-

1. It converts the incoming serial data to parallel data and sends this data to a PC via the CAMAC interface.

2. It translates the monitoring signals from LVDS to differential ECL logic to make it compatible to CAMAC based scalar module where rates are monitored.

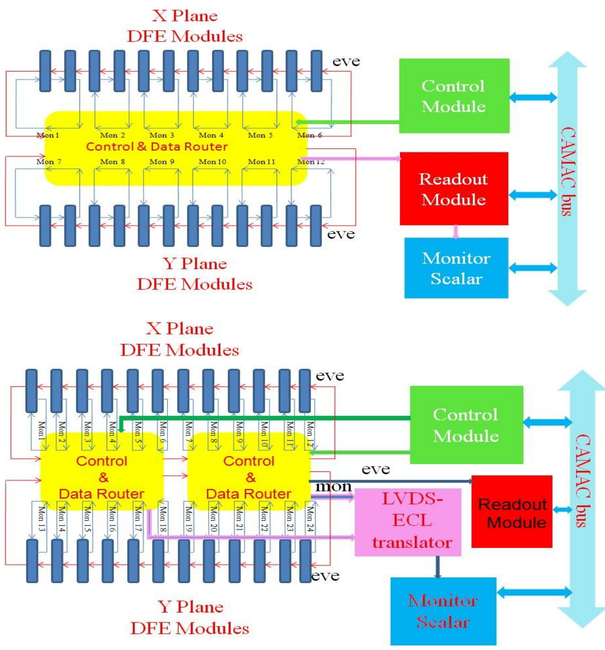

Fig. 4(a) Present scheme of monitoring cycle system and fig. 4(b) Future scheme of monitoring cycle system.

Since each individual RPC has 64 (32 for X plane and 32 for Y plane) strips, so the total number of strips in a 12 stack RPC becomes 768. The present scheme takes about 2.15 hours to monitor the whole stack.

Future scheme of monitoring cycle system and development of LVDS-ECL translator

To reduce the turnaround of the monitoring cycle it has been decided to monitor the individual DFE module. However, in this scheme we require one more 8-channel readout module for monitoring. To avoid the usage of one additional readout module, we have designed a 32 channel LVDS-ECL translators and a 2 channel NIM-ECL translators NIM module. This translator will be used as an interface between the monitoring scalar and the control and data routers. In future scheme the individual DFE module will be monitored by two CDRs and LVDS-ECL translator NIM module. Fig 4(a) and (b) shows the present and future scheme of monitoring cycle system.

The LVDS–ECL translator is designed by using two IC's DS90C032B (LVDS- TTL converter) and MC 10H124 (TTL-ECL) converter. We have designed the schematic diagram of these translators by using ORCAD software and Layout and Artwork have been done by CIRCUIT MAKER software. The PCB board has already been fabricated, a photograph of which is shown in fig. 5.

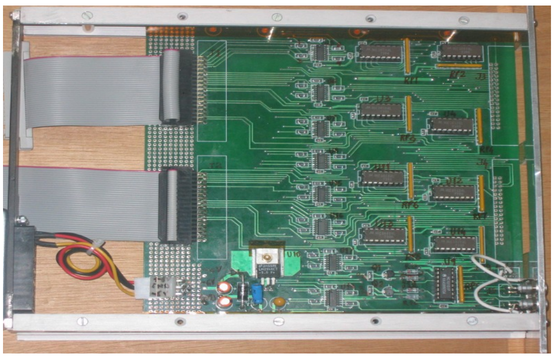

Fig. 5 Photograph of a LVDS/NIM-ECL NIM module

By using this module, the DFE module will be daisy chained into 2 groups for event data recording and 24 groups for monitoring purpose.

Conclusion

We have developed a 1×1 m^2 RPC (AB08) and studied its current vs. voltage characteristics. The efficiency and time resolution of the RPC have been calculated. An LVDS/NIM-ECL translator NIM module has also been designed to reduce the turnaround of the monitoring cycle of the INO-DAQ system.

Acknowledgement

I would like to thank Deepa Thomas, Sindhu Mandari , Rohin Narayan (Mysore University) and Rahul Arora (Panjab University) for their valuable support and suggestions.

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