Integration and commissioning of data acquisition system for the INO prototype detector

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Abstract

It is proposed to build a 1m^3 prototype detector of magnetised iron calorimeter and study cosmic ray muons using the same, in order to understand and estimate the performance of the final detector proposed by the India-based Neutrino Observatory (INO). Design and fabrication of a data acquisition system for the prototype detector, based on a CAMAC back-end were completed. We are currently integrating and commissioning various subsystems using the RPC test setups. We present in this paper design, implementation, integration and performance related issues of the data acquisition system.

1 Introduction

India-based Neutrino Observatory (INO) collaboration is proposing a large magnetized iron tracking calorimeter (ICAL) of total weight 50 kton, using atmospheric neutrinos as source[1]. It is proposed to build a 1m^3 prototype detector of ICAL and study cosmic ray muons using the same, in order to understand and estimate the performance of the final detector. The prototype detector will comprise of 12 layers of glass Resistive Plate Chambers (RPCs) of about 1m^2 in area and 6 cm thick iron slabs, used as absorber between these active layers. There will be two orthogonal signal pickup layers per active detector layer, placed above and below the RPC. Typical characteristics of the detector signal are a few millivolts in amplitude and less than a nano second in risetime. The electronics, trigger and data acquisition system will need to handle about 1000 channels of information from this detector.Main objective of the data acquisition system is to record information whenever a charged particle passed through the detector leaving a track. This event itself is flagged by an independent trigger system. On every such an event, the DAQ system records strip numbers which were hit by the track as well as the timing of signals on the strips with respect to the trigger event.

2 Scheme of the data acquisition system

Aim of the data acquisition system is to implement the front-end electronics, trigger, data readout and monitoring systems for this detector, offering maximum flexibility in terms of design and operation, particularly in case of the trigger system. While considerable thought was given in terms of its scalability for the full scale detector, the main emphasis of the design is however for quick implementation. Design of the data acquisition system is based on using a CAMAC back-end. Detector signals are preprocessed and multiplexed in the front-end subsections of the system and sent on high speed serial links to the back-end for readout and storage. This approach was chosen in order to exploit the available CAMAC hardware and expertise in the collaboration, which has thus resulted in a shorter design time. Scheme of the data acquisition is shown in Fig. 1.

The analog signals from the detector channels are amplified and converted to logic signals and processed in the front-end circuits, forming hit maps, pre-trigger, timing as well as multiplexed monitoring signals. This crucial front-end subsystem was designed using ultra fast SMD chips in the analog and CPLD devices in the digital sections, thus achieving the required speed and reliability. Dedicated CAMAC modules to control the front-end subsystems were also designed. Kernel level drivers and data acquisition software were developed under Linux.

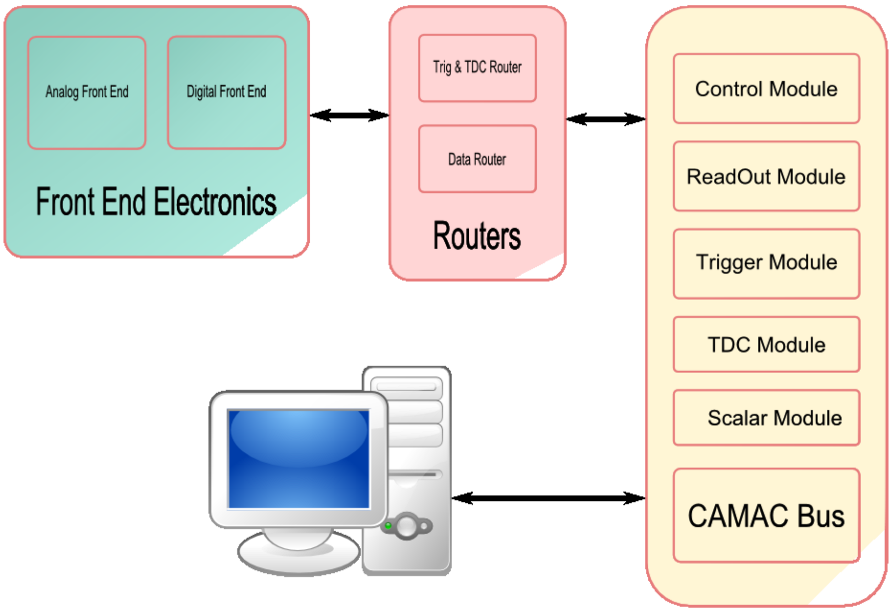

Figure 1: Scheme of the data acquisition system

3 Signal and trigger conditioning

There are two groups of 32 signals each generated by the two planes of pickup panels mounted orthogonally on either side of an RPC. These signals are preamplified by a gain of 50 and are fed to a two 16-channel discriminator modules in the front end. The discriminator modules also incorporate a primitive trigger logic where discriminator outputs of four channels are shaped to 50 nSec pulses and logically ORed to generate level 0 trigger signals. The discriminator signals are further processed by a front-end processing module which mainly consists of three sections, namely event data readout, monitoring and level 1 trigger generation. The strip logic signals are registered on a latch initiated by the final trigger event. The latched information is then flushed out serially to the backend. In the monitor mode, all the strip signals as well as few fixed frequency calibration signals are monitored for their rates sequentially. While, the sequence of signals is initialised by the backend, the subsequent channels are selected locally in the front-end module itself. Event trigger is generated based on a minimum of M $\times$ N fold coincidence of strip signals, where M is the layer coincidence of M consecutive signals out of 32 pickup signals and N is the coincidence of M fold triggers from the consecutive N layers. The coincidences implemented are 1×5, 2×4, 3×3, 4×2. The level 0 trigger signals are logically AND-ed to achieve the required M fold triggers. This level 1 trigger logic is implemented using programmable devices (CPLDs) making it user configurable.

4 Data readout subsystem

The backend system is implemented on CAMAC standard. This layer completes all the requirements of the data acquisition system, taking inputs from and providing interface services to the front-end using fast serial links. On the other hand, this layer is interfaced to a PC based host via an intelligent stand alone ethernet port based CAMAC controller for providing the DAQ, data storage and user interface functions. Apart from this controller, the following modules form the CAMAC backend system. Functions such as final trigger generation (based on the lower level front-end trigger signals), trigger signal fanout, pre-trigger signal scalers, trigger identification latch etc are implemented using a FPGA based trigger module. The readout module supports two serial connections for event data recording and 8 channels for monitoring. During event process, the serial data from front end modules are converted to 16 bit parallel data. This data are written into FIFO memory buffers of size 4K words. The data from both FIFOs are read via CAMAC bus in the program. The event data size is normally much smaller than the buffer size. The FIFO overflow can be read by status port and it also blocks further writing to FIFO. Generation of all the control lines required for the data readout as well as monitoring of various status lines are supported by a control module. Scaler modules used for monitoring strip signals and TDC modules used for timing measurement are also part of the backend system. While the CAMAC controller and TDCs were commercial modules, the rest of the moduled were developed by us.

5 Integration and commissioning of the system

All the subsystems of the data acquisition have been designed and all the required circuits boards as well as modules have been fabricated and tested. We have installed most of these components on existing RPC test stands and they are showing good performance. The data acquisition system therefore is virtually ready for commissioning in the INO prototype detector.

The prototype detector also requires in addition to the data acquisition system, a slow control and monitoring system as well other auxiliary systems such as low voltage and high voltage supplies etc. A number of ambient parameters such as temperature, relative humidity and barometric pressure, RPC bias voltage and currents as well as various parameters of the gas distribution system are to be set and monitored. These functions are achieved by an independent system using appropriate transducers as well as signal conditioning electronics and interfaces.

6 Summary

We have designed and fabricated a suitable electronics, data acquisition and control systems needed for the prototype detector, which is being built for studying feasibility of the INO experiment. These systems meet all the requirements of the detector. Installation and commissioning of these systems are in progress. A fast, high gain and low noise Hybrid Micro Circuit chip was designed and is currently being fabricated. It will be used as the preamplifier on the strip signals.

References

[1] India-based Neutrino Observatory, INO Project Report, INO/2006/01, June 2006